JWST

User Documentation for Cycle 1:

Proposing Tools

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JWST Exposure Time Calculator Overview

The JWST Exposure Time Calculator (ETC) performs signal-to-noise ratio calculations for all JWST observing modes. Scenes, sources, and calculations can be created, copied, and modified by users, and organized in workbooks.

On this page

Video Tutorials:

ETC Home Page Overview,

ETC General Overview,

ETC Workbooks,

ETC Scenes and Sources

JWST's Exposure Time Calculator (ETC) is built on Pandeia, a pixel-based exposure time calculator paired with a modern graphical user interface. While Pandeia was developed for JWST, it is a general framework, data-driven ETC capable of supporting multiple missions. It includes advanced features that go well beyond what has been available in previous ETCs, such as algorithms that accurately model both data acquisition and post-processing of data, and it provides functionality for users to efficiently explore and compare a large volume of parameter space in their calculations.

The JWST implementation of Pandeia supports all JWST observing modes: imaging, spectroscopy (slits, slitless, MOS, and IFU), coronagraphy, and aperture masking interferometry. Its graphical user interface provides enhanced capabilities supporting multiple workflows. For example, users can create workbooks to manage related sets of calculations, create complex astronomical scenes with multiple sources, and compare the results of multiple calculations. The ETC interface is built to encourage a "copy and modify" workflow: users can copy and modify individual calculations, individual sources and scenes, or whole workbooks.

Under the hood: The ETC engine

The JWST ETC engine uses a pixel-based 3-dimensional approach to perform calculations on small (typically a few arcseconds) 2-dimensional user-created astronomical scenes. It models both the spatial and the wavelength dimensions, using realistic point spread functions (produced using WebbPSF) for each instrument mode. It natively handles correlated read noise, inter-pixel capacitance, and saturation. Since the signal and noise are modeled for individual detector pixels, the ETC is able to replicate many of the steps that observers will perform when calibrating and reducing their JWST data. This simplifies interpretation of the extracted signal-to-noise ratio (SNR) calculated by the ETC.

> While the JWST ETC includes many effects not typically included in other ETCs, it is not an observation simulator. It does not simulate the full detector, nor does it include 2-dimensional effects such as distortion.

Details on the algorithms used to compute signal and noise on the detector and the strategies used to compute the extracted products can be found in Pontoppidan et al. 2016.

Workbooks: Organize and save your ETC calculations

ETC calculations are organized and saved in workbooks. Workbooks consist of a library of sources and scenes, calculations based on the source and scene library, as well as any spectra uploaded by users to that workbook.

Users who wish to save their work in the workbooks should obtain a single sign-on account using MyST accounts. Upon logging in to the JWST ETC via STScI's single sign-on authentication, users are provided with a list of their existing workbooks, if any, from which to choose. They can choose to create a new workbook from scratch, retrieve copies of sample workbooks that have been designed for tutorials or starter use, or copy and modify an existing workbook. If users choose to begin working anonymously, and later decide they would like to save their work, they can authenticate at any time and their current workbook(s) will be saved under their user account.

The name and description of a workbook can be modified after opening the workbook. Workbooks also include a section for writing notes regarding the contents of the workbook: this is found at the bottom of the **Calculations** page*.

Sample and example science program workbooks

Sample workbooks have been designed to aid users in orienting themselves in the JWST ETC. The set of sample workbooks include calculations for all 4 JWST instruments. Calculations are organized into workbooks by topics or categories such as the observing mode (imaging, slits, slitless, and IFU spectroscopy, coronagraphy and target acquisition). Each sample workbook includes pre-defined sources and scenes for use in the calculations.

Example science program workbooks have been designed to present realistic examples for users to explore the process of creating a proposal. The programs also have associated JDOX articles and APT files for the full start-to-finish experience.

A more detailed overview can be found on JWST ETC Using the Sample Workbooks.

Shared workbooks

Workbooks can be shared with collaborators. Each individual with whom users share a workbook can be given permissions to read, write, grant access to others, and/or revoke access from others.

To share a workbook or change the permissions for a shared workbook, select a workbook from the list of available workbooks by clicking anywhere on its row. The users with whom the workbook is shared will appear in the **User Access Permissions** pane below the list of available workbooks, along with their individual permissions. Users can share the notebook with new collaborators by adding the e-mail addresses connected with their MyST accounts.

The system allows multiple users with write access to modify the same workbook simultaneously.

> Be aware that an inherent risk of allowing multiple users to edit workbooks simultaneously is "clobbering." If another user is editing the same workbook, and they change something in any editable field, it will overwrite any edits that are in process in that same field by another user. Thus, collaborators are strongly encouraged to communicate and coordinate their work. To reduce this risk, only "read" permissions are set by default when sharing workbooks, and we recommend that users should always coordinate when granting write access.

A more detailed overview can be found on the JWST ETC Sharing Workbooks page.

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Build your own scenes and sources library

Each new workbook includes a default point source, which is placed in the center of a default scene. If this is adequate, users can proceed from the **Calculations** page and begin performing calculations. Sample workbooks often include more complex sources and scenes.

The **Scenes and Sources** page allows users to create multiple, unique sources, each with their own set of individual specifications, and to place those sources within small scenes (typically a few arcseconds). Each scene can include as many sources as required, and sources can overlap within a scene. Individual sources from the source library can be used in multiple scenes. Adding a source to a scene creates an association between the source and scene, so that any future update to that source will result in changes to every scene in which that source is placed. Likewise, the use of sources and scenes in calculations is a dynamic link, and any update to a source or scene will affect all calculations in which that source or scene is used.

> ⓘ Both sources and scenes can be shared across calculations. When changes to a source or a scene are saved, all calculations that depend on the source or scene will be automatically rerun.

For each new source, users can specify the spectrum (choosing from provided libraries or spectra they have uploaded) and choose whether to redshift the spectrum, apply extinction, add emission lines, or renormalize at a specified wavelength or bandpass. For extended sources, users will specify the shape and flux distribution. Finally, once a new source is added to a scene, users can choose where to place the source within the scene. If users want to mostly duplicate an existing source, making only minor modifications (for example, placing it at a different position in the scene), they can efficiently do so by copying the existing source and modifying the copy.

In addition to tables of existing scenes and sources, and a **Source Editor** for specifying the properties of a source, the **Scenes and Sources** page includes several items to aid users in visualizing their sources and scenes, including the interactive **Scene Sketch** pane, the ability to plot the input spectra of sources, and a list of calculations that will be affected by changes to the selected scene or source.

A more detailed overview can be found on the JWST ETC Scenes and Sources Page Overview.

Uploading spectra

Users can choose to upload their own set of sample spectra for use in the **Source Editor**. Spectra can be uploaded as either ascii or binary FITS files and the accepted formats are described on the JWST ETC User Supplied Spectra page.

Build a set of calculations

Once users have defined the necessary sources and scenes for their intended calculations, or chosen to proceed with the existing scene(s) and source(s), they will move to the **Calculations** page.

A new calculation is initialized by choosing the instrument and mode; a set of default values are assigned to parameters upon initialization. In general, users will then need to modify the default values and click the **Calculate button** to perform their desired calculation. Users will specify the following parameters for each calculation: a scene from the **Scenes** pane, background model parameters, instrument and detector setup (e.g., filters, gratings, and exposure specifications), and extraction strategies for the source and background. The scene used in the calculation, and the sources within that scene, can also be modified from the **Calculations** page, although this does not provide the detailed reporting (including the number of calculations affected by any changes) that is provided on the **Scenes and Sources** page.

Alternatively, if users have an existing calculation in their workbook for the instrument and mode of interest, they can simply copy and modify an existing calculation. Copying calculations provides an efficient way to explore variations of the observation setup and extraction strategies, or to calculate the SNR on multiple sources or locations in a scene using identical observation and extraction strategies. Batch expansions can be used to automate the process of copying calculations multiple times and systematically varying filters (for imaging modes) or the exposure specifications (number of groups or integrations).

A more detailed overview can be found on the JWST ETC Calculations Page Overview.

The background model

The ETC background model includes celestial sources (zodiacal light, interstellar medium, and cosmic infrared background) as well as telescope thermal and scattered light. Users can choose a dated or dateless background. A dated background utilizes the specified sky position and a date. Alternatively, users can choose a dateless background: a pre-calculated percentile of the range of backgrounds predicted at the specified sky position over the window of visibility. The percentile choices are Low (10%), Medium (50%), or High (90%). The ETC uses the measured Galactic emission at the input RA and Dec. The effects of additional sources of astrophysical backgrounds (e.g., diffuse nebular emission) can be modeled by adding to the scene a large, spatially flat source that covers the full scene.

Analyze the results

Each calculation results in 2-dimensional images, one-dimensional plots, and scalar diagnostics. Users can view 2-dimensional images of per pixel SNR, count rate at the detector, and saturation of the selected calculation. Users can also view plots of the flux from sources in the scene in the extraction aperture, the extracted flux from the background, and SNR versus wavelength, as well as SNR versus exposure time and contrast versus separation (coronagraphy only). The 2-dimensional images and scalar values are displayed for the selected calculation, while multiple calculations can be simultaneously plotted in the one-dimensional plots.

The **Reports** pane presents scalar results, warnings, and errors for the selected calculation, as well as a download link. Downloads include all 2- and one-dimensional products, the 3-dimensional data cube for IFU calculations, and a FITS table of the calculated background spectrum.

A description of the output products is on JWST ETC Images and Plots and JWST ETC Reports.

References

Go to the on-line JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, *Proc. SPIE 9910*, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

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Latest updates	• 09 Oct 2019 Updated for ETC v1.5. Video links added. • 05 Nov 2018 Updated for ETC v1.3

JWST ETC New User Guide

The JWST Exposure Time Calculator (ETC) requires various input parameters and configuration settings. Users can get started quickly with these easy steps.

On this page

Video Tutorials:

ETC Home Page Overview,

ETC General Overview,

ETC Workbooks,

ETC Scenes and Sources

The JWST Exposure Time Calculator (ETC) allows a user to define sources, place them in scenes, and use the scenes in calculations. Sources may be used in multiple scenes, and scenes may be used by multiple calculations, which will be automatically recalculated to reflect any changes made to the scenes or sources. These calculations are organized and saved in workbooks, along with the library of sources and scenes. Workbooks for users who are logged-in using MyST accounts are automatically saved and will be available in the workbook list upon return. Workbooks created as an anonymous user are not preserved.

The recommended workflow is "copy and modify": create a default object (source, scene, or calculation), then modify it, then copy it and modify it further. Calculation results can be over-plotted for easy comparison.

Generally speaking, new ETC users have 3 different ways to get started:

1. Follow the **Quick Start** walk-through
2. Experiment with a copy of a Sample or Example Science Program Workbook
3. Starting from scratch with an empty workbook

Quick Start mode

The **Quick Start** mode is an interactive walk-through designed to help new users quickly navigate through the ETC. Access to **Quick Start**[*] mode is available at the ETC home page and is activated by clicking the QUICK START button.

In order to keep this workbook, you will need to login or create an account. You may save the workbook once you are logged in as a registered user. Upon completion of the "Quick Start" tutorial, a pop-up box will present information on how to save the workbook.

Even if you are logged in, clicking on the **Quick Start** button logs you out and makes you an anonymous user. To save your work for future access or access previously saved workbooks, you will need to log in again.

[*] ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Working with a workbook

Within the **Quick Start** tutorial, the user is navigated by text and touch-points that introduce the application's features and prompts the user to take compulsory action steps. For example, once the tutorial is launched, the user is greeted by a welcome message and prompted to select an instrument and mode by selecting one of the highlighted Instrument tabs; it is only then that access to the configuration pane is made available. Users are guided through the basics before being encouraged to click the CALCULATE button, at which point the tutorial concludes and the user is left to independently explore the application.

Depending on how you have chosen to proceed—whether by completing the **Quick Start** tutorial, creating a new empty workbook, or by retrieving a copy of one of the pre-populated sample or example science program workbooks—you will now have access to a workbook with which to edit. What follows is a set of easy steps designed to help users familiarize themselves with the ETC.

On the Scenes and Sources page

1. Create one or more sources.
   A default scene, populated by one default source, is made available when a new *empty* workbook is created (sample and example science program workbooks contain scenes that are pre-populated with sources). The default source is a point source with a flat continuum spectrum. Sources contain the spatial and spectral information that will be used in the scenes and calculations. For each source, you may

specify the **Continuum**, **Renorm** (normalization), **Redshift**, **Extinction**, emission **Lines**, and **Shape**. Be sure to click **Save** before moving to a different source.

- Create a new source via the NEW button within the **Select a Source** pane will result in a new default source (point source, flat spectrum).
- Initially, a new source is not associated with any scene and must be explicitly added to a scene. Select the source in the **Select a Source** pane and a scene from the **Select a Scene** pane, and click the ADD SOURCE button. The source will be added to the the center of the scene.

2. Edit one or more sources using the **Source Editor** pane.
   In order to select a source for editing, click on a row in the **Select a Source** pane. When a source is selected in the **Source** table, all scenes containing that source will be highlighted in green in the **Scene** table. Navigation is done by selecting a tab within the **Source Editor** pane:
   - Add scene and source identity information into the **ID** tab.
   - Change the source's shape using the **Shape** tab and specify any required parameters, depending on the chosen morphology.
   - Position the source in the scene using the offset options in the **Offset** tab. Spatial offsets are defined with respect to the center of the scene.
     - The offset parameters link the source and the scene; check that the source is added to a scene, in order for the offset parameters and orientation to take effect.
   - Supply information for the source's spectrum in the **Continuum** tab.
   - To renormalize the source's spectrum, specify the flux at either a particular wavelength, or in a normalization bandpass, in the **Renorm** tab.
   - To upload your own spectrum, select the **Upload Spectra** tab. You may upload one or more spectra. When you return to **Scenes and Sources**, your uploaded spectra will appear in a drop-down menu in the **Continuum** tab under the **Source Editor** pane.
   - To add emission lines to a source continuum, select the **Lines** tab and use the available options to specify the properties of the line. Click the ADD button and the line will be added to the table of lines, which is populated with the input parameters supplied by the user.
     - Use the UPDATE and REMOVE buttons to modify the parameters of an emission line, or to remove it from the line list.

3. Examine the sources.
   Sources that are created may be examined in the **Scene Sketch** and **Source Spectrum Plots** panes:
   - Examine the morphology of the sources and their location in the scene using the graphical representation displayed in the **Scene Sketch**.
   - If a source is missing from a scene: select the source in the **Select a Source** pane. Then, in the **Select a Scene** pane, select the correct scene and click the ADD SOURCE button. Likewise, to remove a source from the scene use the REMOVE SOURCE button.
   - Select one or more ***Plot*** checkboxes in the **Select a Source** pane to display the source spectrum in the **Source Spectrum Plots** pane. Use these plots to verify that the source spectrum is correct.
   - Click on a source in the **Select a Source** pane and determine which calculations it used by looking at the **Calculations** tab in the pane below the **Source Editor**.

4. Create one or more scenes.
   Scenes are idealized representations of spatial (2 angular coordinates) and spectral brightness distributions (prior to being observed by a telescope). The default and maximum scene size depend on the

chosen instrument/mode pairing. They may contain the source targets of an observation, and all other nearby sources that could contribute to both the observed target and background fluxes.

- Click on a row in the **Select a Scene** pane to select a scene for editing. When a scene is selected in the scene table, all sources contained in that scene will be highlighted in green in the **Source** table.

> ⓘ Clicking on a scene in the **Scene** table will highlight that row in yellow. Any sources in that scene will be highlighted in green in the **Source** table. Conversely, selecting a source will highlight in green any scenes that source is in. Highlighting a scene and a source within that scene will highlight both in yellow and green striping. To clear scene and source selections, refresh the page.

- This new scene is empty and sources can be added to it. To associate a source with a scene, select both the scene and source in the **Select a Scene** and **Select a Source** panes (causing them to both be highlighted yellow), and click the ADD SOURCE button.
- Verify that scenes and sources are linked. If you click on the scene, is the "associated" source highlighted green? Does the source appear in the **Scene Sketch** pane?
- For each source, specify its offset from the center (and orientation, for extended sources) for the scene. Be sure to click SAVE in the **Source Editor** pane before moving on to a different source.
- Changes will automatically update the **Scene Sketch** pane.
- An empty scene (with no sources) can be useful for examining the sky background. Defining the sky background parameters can be done under the **Backgrounds** tab on the **Calculations** page.

On the Calculations Page

1. Create a calculation.
   A new calculation may be created using 2 methods: (1) selecting an instrument and mode or (2) copying and modifying an existing calculation. For each calculation, you may specify the calculation ***ID*, Scene**, **Backgrounds**, **Instrument Setup**, **Detector Setup**, and **Strategy** parameters.
   - To create a new calculation, click on one of the instrument buttons and select a mode.
   - Click on a row in the **Calculations** table to select a calculation, highlighting it in yellow. This activates a calculation editor pane to the right of the table.
   - Edit the calculation to modify the ***ID***, **Scene**, **Backgrounds**, **Instrument Setup**, **Detector Setup**, and **Strategy**.
     - Click on the **Scene ★** tab; in ***Scene for Calculation***, select a scene for the calculation. This action populates the ***Sources in the Scene*** pull-down parameters with all sources associated with that scene; select one of them for the calculation. Note that the **Scene ★** tab provides the same parameters as those in the **Source Editor** pane in the **Scenes and Sources** page.

> Note that changes to source properties made in the Calculation Editor pane modify that source in the source library in the **Scenes and Sources** page, affecting all calculations for that source.
>
> *The recommended workflow for changing the property of a given source is to copy and modify the source in the* ***Scenes and Sources*** *page, and use this "new" source in the desired scene before performing the calculation.*

- Click on the **Detector Setup** tab to specify the ***Subarray*** configuration, ***Readout pattern***, ***Groups per integration***, ***Integrations per exposure***, and ***Exposures per specification.*** These parameters control the exposure time (photon-collecting duration). If an invalid value is provided for one of the detector parameters, it will appear in red and the calculation will not be completed.
- Under the **Strategy** tab, define the extraction parameters for the source flux. To include background subtraction in the calculation, define a background region for extracting the background flux.

- After all the above-mentioned parameters are set, click the CALCULATE button to perform the calculation.
- In the main menu at the top of the page, you can use **Edit** for copying and deleting calculations, and **Expand** for systematic explorations of parameter space.

2. Examine the output information from a selected calculation.
   Results may be viewed in the **Images** pane (lower left of the page), **Plots** pane (lower center) and **Reports** pane (lower right).
   - Click on a row in the calculations table to view the 2D output images for that calculation. Use the **2D SNR**, **Detector**, **Saturation**, and **Groups Before Saturation** tabs to view the images under each of those conditions.
     - The image contains the entire scene used in the calculation.
     - Check saturation levels and the exact locations of saturated pixels, if any, to determine if the data would be useful.
   - Check the **Reports** pane for saturation warnings in the **Warnings** tab. If saturation has occurred, the **Warnings** tab will appear in red. The warning message will indicate the number of pixels with full and partial saturation.
   - Review the summary of the calculation under the **Reports** pane. It provides a summary of the input parameters and output scalar values associated with the selected calculation.
   - Manually check the checkboxes in the calculation rows to see the plots produced by the calculation.
     - The checkboxes serve dual purposes: to select calculation rows to display plots or to delete marked calculations.
     - Multiple calculations may be over-plotted for easy comparison. Different colors indicate the different calculations
   - In order to view all calculations in a given workbook, simultaneously over-plotted, click on the checkbox symbol between the ***ID*** and ***Mode*** columns in the **Calculation** table and select the ***All*** option. Use this feature to compare calculated parameters for different filters/gratings of the same instrument, or for different instruments.

- Create a batch expansion over one of the **Detector Setup** parameters (groups or integrations) or over any of the **Instrument Setup** parameters (dependent on observing mode).

3. Download the output products and intermediate products from the ETC calculations.
    - Click the link under the **Downloads** tab in the **Reports** pane. The tarball contains FITS files of the 3D data cube for the IFU calculation and the 2D images. The extracted flux, backgrounds, contamination, and SNR used for the line plots are available as FITS tables.
    - Widgets at the top of the **Plots** pane allow users to download the plots. (To see them, move your cursor over the plot.)
    - To download one of the calculation images, click on the link below the image in the **Images** pane. (To see them, move your cursor over the image.)

4. Modify the name and description of the workbook.
   By default, whenever a new workbook is created, it is named "New Workbook" and described as "An Empty Workbook."
    - **Notes** about the workbook can be entered at the bottom of the **Calculations** Page.
    - Organize your calculations and save your workbook. A MyST account is required to save the workbook.

References

JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, *Proc. SPIE* 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

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JWST ETC Scenes and Sources Page Overview

The **Scenes and Sources** page in the JWST Exposure Time Calculator (ETC) contains an overview of all scenes and sources in a workbook. Users can also create, edit, and inspect their scenes and sources.

On this page

Video Tutorials:

ETC Scenes and Sources,

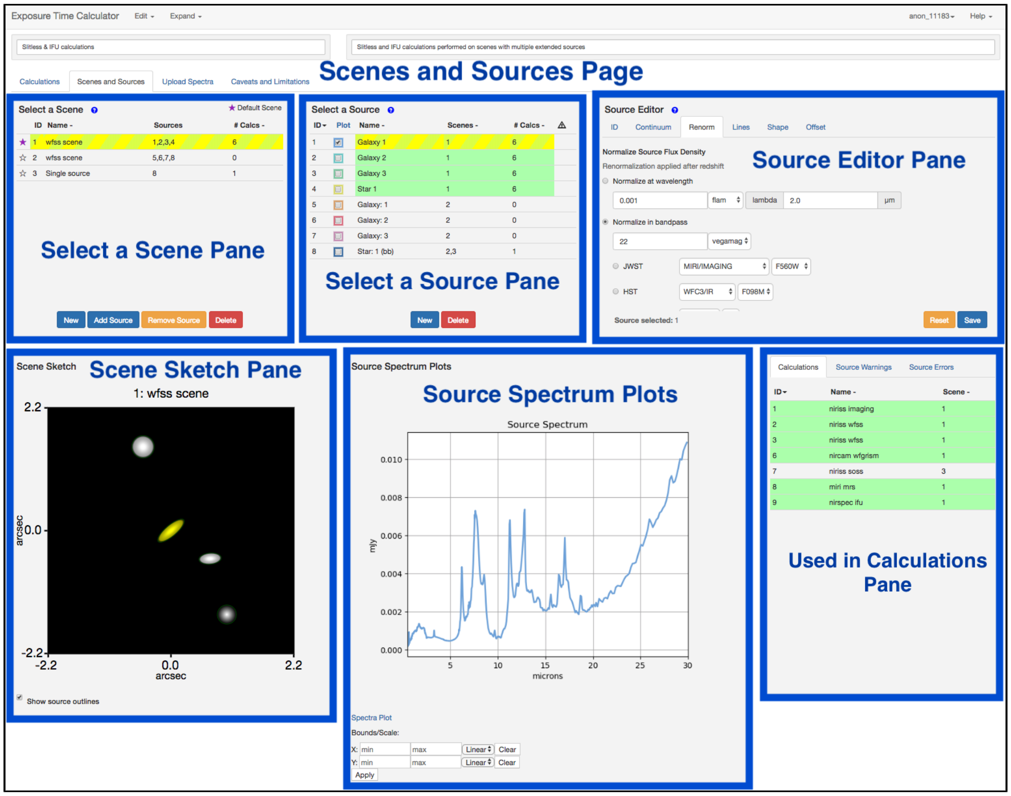
Adding Emission Lines in the ETC

The **Scenes and Sources** page contains an overview and an editor for all scenes and sources within the workbook. From this page, it is possible to create new scenes, associate sources with scenes, edit scene and source parameters, view a representation of the scenes, inspect the spectrum of the sources, and view which calculations currently contain your sources.

Scenes and Sources page layout

Figure 1 shows the layout of the **Scenes and Sources** page, labeled in blue to identify its panes, tabs, and sub-tabs in the graphical user interface.

Figure 1. The Scenes and Sources page with labels on its various panes



New scenes and sources can be created using the* NEW *button within the Select a Scene and Select a Source pane. Initially the source is not associated with any scene and must be explicitly added to a scene. Yellow indicates a selected scene and source. Green highlighted rows are those affected by the selected row in other tables. The newly added source will now be visible at the center of the scene sketch. The striped green and yellow indicates that a row is both selected and affected. Use the copy scene or copy source options in the Edit drop-down menu to modify the scenes and sources, and use them in a new calculation to avoid auto-update of all affected calculations when an existing scene or source is modified. A shaded star next to the left of the scene ID in the Select a Scene table indicates which scene will be used as a default for calculations, this can be changed. The Source Editor pane is where users can specify the following parameters: ID, Continuum, Renormalization, Lines, Shape and Offsets. Scenes and source properties are presented in the two lower panes: Scene Sketch pane, and Source Spectrum plots.

Scene and source tables

Tables in the **Scenes and Sources** page are interactively linked, and provide visual cues for the relationship of scenes and sources. When a scene is selected in the **Scene** table, all sources contained in that scene will be highlighted in green in the **Source** table. Conversely, when a source is selected in the **Source** table, all scenes containing that source will be highlighted in green in the **Scene** table. For convenience, we refer to green highlighted rows as *affected* by the selected row in the other table. It is possible for a row to be both selected in its own table (yellow) and affected by the selection in the other table (green): in this case, the row appears with yellow and green striping.

Both tables are also interactively linked with the Used in Calculations pane in the lower right. This table lists all calculations in the workbook. All calculations that are affected by the selected scene (i.e., it uses that scene) or source (i.e., the scene it uses contains that source) will be highlighted in green. All affected calculations will be automatically updated when the selected source or scene is changed.

These tables allow the user to see and manage the scope of any changes to sources and scenes. A recommended workflow is to perform detailed manipulation only on sources and scenes that are not yet used by any calculations. Use the ***copy scene*** or ***copy source*** options in the **Edit** drop-down menu to modify the scenes and sources, and use them in a new calculation to avoid auto-update of all affected calculations when an existing scene or source is modified.

Defining scenes and sources

Sources

Creating a source

Sources contain the spatial-spectral information that will be used in the scenes and calculations. Creating a new source via the NEW button within the **Select a Source** pane will result in a new default source (point source, flat spectrum). This source is initially not associated with any scene, and must be explicitly added to a scene using the ADD SOURCE button within the **Select a Scene** pane.

Editing a source

The specific information for the source can be edited in the **Source Editor** pane. To edit the source information, the user must first select a source from the **Select a Source** pane. Navigation is done by selecting a tab within the editor, as listed below:

ID

Contains the identity information for both the source and the scene. It is where the user can change the default name and create descriptive references to the source or scene.

Continuum

Contains options for the spectral energy distribution, extinction to be applied, and the redshift information for the source's spectrum.

Renormalization

Allows a user to renormalize a source spectrum by specifying the flux either at a particular wavelength, or in a normalization bandpass. Instrument-specific HST and JWST bandpasses are offered, as well as more general photometric bandpasses.
The source flux distribution may be specified in integrated flux or magnitude, and for extended sources there is also the option to specify the normalization in surface brightness units.

Lines

Allows the user to add spectral lines to the source spectrum. Currently, only emission features are supported.

- To add a line, the user must first input four values: a user-defined name for the line, the line center (in µm), the line width (in km/s), and the line strength (in erg/cm2/s). Once these values have been provided in their respective fields, clicking the ADD button will include the line in the line table. Click the SAVE button to apply this change. The source spectrum with the emission lines added to it, may be viewed by using the checkbox in the **Select a Source** table to plot the source spectrum.
- To edit a line, simply select the line by clicking the appropriate row in the line table. The input fields will be automatically populated with the current values of that line. Simply change the values displayed in the input fields to edit the currently selected line. Once changes have been made, click the UPDATE button. The line table row should now be updated with the new values.
- To remove a line select the appropriate row in the line table and click the REMOVE button.

⚠ After defining all the lines, you must click the SAVE button to apply them to the source spectrum.

Shape

Allows the user to define the source as either a point source or an extended source. Choosing extended allows for flux distribution, normalization, and axial extent options. The flux normalization for extended sources may be done in integrated magnitudes or surface brightness units, and the selection made in the **Shape** tab will be reflected in the units used in the **Renorm** tab.

Offset

Contains options for the position of the selected source within the selected scene such as adding spatial offsets, or giving the source some orientation.

⚠ There must be a source added to a scene before entries in the Offset tab will take effect.

Saving and Resetting

You may move between these tabs while editing the source, but you must click SAVE before selecting a different source in the source table, or your changes will be lost. Clicking the RESET button will revert your changes to the most recently saved values.

Scenes

Scenes are idealized representations of spatial (two angular coordinates) and spectral brightness distributions, before being observed by a telescope. They are composed as 'postage stamps,' that is, relatively small areas of ~10–20 square arc seconds (Table 1 shows the default and maximum scene size that will be used in the calculation, centered on scene center for each instrument/mode pairing). Although not a fundamental limitation, this restriction conserves computational resources and reduces the time for calculations. Scenes also contain the source targets of an observation, and all other nearby sources that could contribute to both the observed target and background fluxes.

Placement of two or more sources within the limits of the default scene size, then centering the extraction aperture and background annulus on a source not in the center of the scene could result in a portion of the extraction aperture or background annulus (or both) falling outside the scene limits. This will prevent the calculation from running. The workaround for this is to add a new source to the scene, offsetting it to a larger distance from the center. This expands the scene size beyond the default size. Note, however, that this works only for modes that use dynamic scene sizes, as indicated in the table below.

Table 1. Default and maximum scene size used in the calculation

Instrument	Mode	Default scene size (arcsecs)[a]	Max scene size (arcsecs)[a]	Dynamic[†]
MIRI	Imaging	6.05	40.0	True
	LRS Slitted	6.05	10.0	True
	LRS Slitless	6.00	30.0	True
	MRS IFU (ch1)[b]	4.17		False
	MRS IFU (ch2)[b]	4.51		False
	MRS IFU (ch3)[b]	6.13		False
	MRS IFU (ch4)[b]	7.92		False
	Coronagraphy	8.91		False
NIRCAM	LW Imaging	4.00	20.0	True
	SW Imaging	2.00	10.0	True
	SS Grism	2.00	10.0	True
	WF Grism	2.00	10.0	True
	Coronagraphy	3.33 (SW) 6.36 (LW)		False
NIRISS	Imaging	4.00	20.0	True
	SOSS	16.9	16.9	False
	WFSS	15.0	75.0	True
	AMI	5.31		False
NIRSPEC	Fixed Slit	3.00	20.0	True
	Imaging	3.00	20.0	True
	MSA	3.00	20.0	True
	IFU	2.99		False

[a] The scene sizes refer to the width on each side.

[b] MIRI MRS sizes refer only to the Y axis dimension of the non-square field of view.

[†] Indicates whether the scene is dynamic. If true, the scene will grow to encompass all specified sources up to the maximum scene size. Not all modes support dynamic scenes. If Dynamic scene is False, the scene size is set by the PSF footprint taken from the PSF library, which varies based on the observing mode settings.

Adding sources to scenes

A new workbook created by a user will initially contain a default scene and a default point source. To add a scene, click the NEW button at the bottom of the **Select a Scene** pane. The user will find that the table has been populated with a new scene, and selecting this scene will allow the user to view an idealized representation in the **Scene Sketch** pane below. The new scene is empty and sources can be added to it.

To create a new source, a user must click the NEW button in the **Select a Source** pane, to the right.

After having created a new source object, the user will have to explicitly associate the source with a scene, as it is possible to have multiple scenes that contain the same source. To do so, the user must select the desired source in the source pane, select the scene to which the source will be associated, and click the ADD SOURCE button. The previously yellow highlighting of the selected scene and source will now be visible as a striped green and yellow pattern. The newly added source will now be visible at the center of the scene sketch. You may now use the **Offsets** tab to place it at the desired location (refer to the **Sources and Scene** Tables section for a more in-depth explanation of the color scheme). Likewise, the **Scene Sketch** pane should now display the idealized 2D representation of the scene.

To remove a source from a scene, select the scene and the associated source and click the REMOVE SOURCE button. This will not ***delete*** the source, but only remove its association with the scene object. Again, the user will notice that the source has been removed from the **Scene Sketch** pane.

To delete a scene, select a scene and click the DELETE button at the bottom of the pane.

Note that if there exists a calculation that contains the scene, the user will not be able to remove the scene without first modifying the calculation to use a different scene, or simply deleting the calculation. The column ***# Calcs*** displays the number of calculations that contain the scene.

The default scene in a workbook is used for any default calculation that is triggered when an observing mode is selected from the instrument tabs on the **Calculations** pane. The default scene provided with a new workbook has a single default point source with a flat continuum, located at the center of the scene. However, the user has the option to change the default scene to any of the new scenes that they have created in the **Select a Scene** table. Clicking on the star in the row containing a scene will make that the default scene as indicated by the purple star. Users are advised to use a simple scene with simple source properties as the default scene. A more complex scene or scene containing complex sources that is assigned to be the default scene, can slow down the default calculations considerably.

Viewing scenes and source

Scenes and source properties are presented in the two lower panes: **Scene Sketch** and **Source Spectrum Plots**. The Scene Sketch is interactively linked with the Source Table. A selected source will appear yellow in the sketch, and clicking on a source in the sketch will select its row in the Source Table. Selecting a scene will automatically update the **Scene Sketch** pane with an idealized (i.e. before being observed by a telescope) representation of the sources within that scene. The source is directly influenced by the settings within the **Source Editor** pane; e.g. the idealized sources will reflect the shape and offset parameters defined by the user.

Selecting a source will automatically check its ***Plot*** checkbox and show its spectrum in the **Source Spectrum Plots** . Multiple sources can be compared by manually checking their ***Plot*** check boxes. For convenience, the ***Plot*** column heading is a drop-down that allows the user to check ***All*** or ***None*** of the entries for plotting. The extent of the plot axes may also be controlled by setting the bounds below the spectra plot and clicking the APPLY button.

While the ***# Calcs*** column of the **Select a Scene** and **Select a Source** panes tell the user how many calculations the scene(s) and/or source(s) are used in, users may wish to refer to the Used in Calculations pane to view the specific calculations affected by a change in the selected source or scene. The Used in Calculations pane displays any calculations that any source or scene are actively used in, but selecting a source or scene will correspondingly highlight the associated calculation(s) in green.

References

Go to the on-line JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, *Proc. SPIE* 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

Published	30 Dec 2016
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. Video links added. • 05 Nov 2018 Updated for ETC v1.3

JWST ETC Defining a New Source

The JWST Exposure Time Calculator (ETC) uses a library of sources to be included in the astronomical scene for the ETC calculations. The sources are described by parameters that characterize their brightness, spectral properties, and shape.

On this page

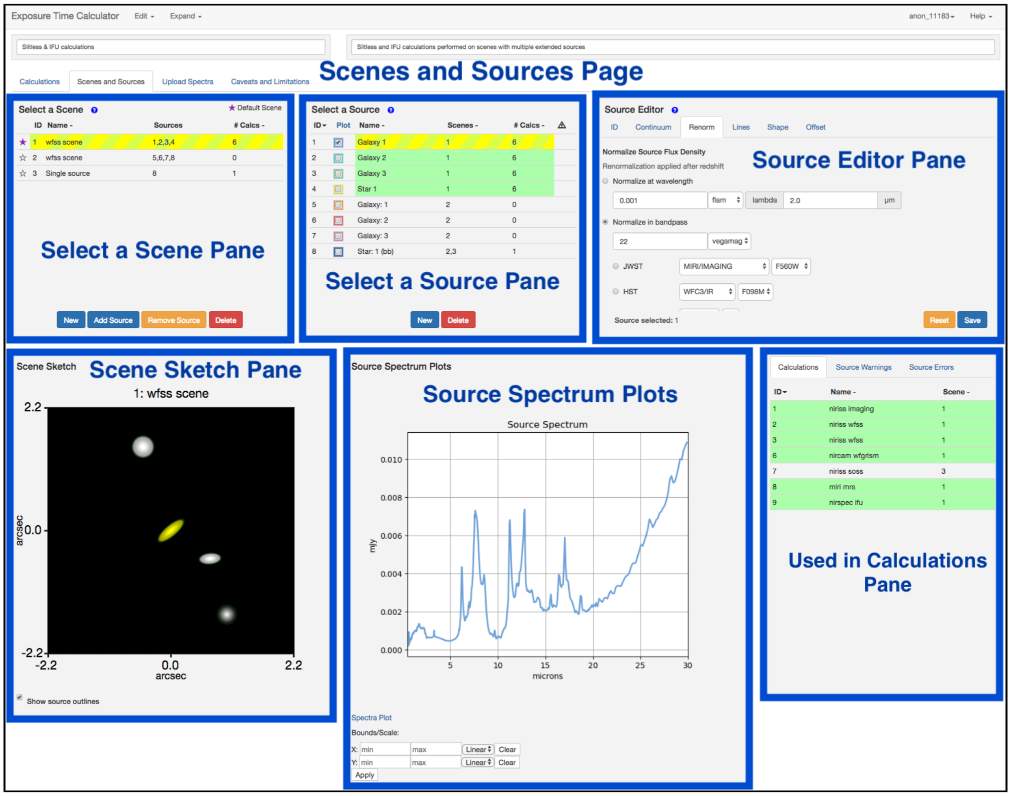
Video Tutorials:

ETC Scenes and Sources,

Adding Emission Lines in the ETC

The JWST Exposure Time Calculator (ETC) allows a user to define sources that are persistent and reusable. A source can be newly created, or copied from the available library of sources on the Scenes and Sources page and modified. The **Source Editor** allows the user to assign the source properties such as shape, brightness, and spectrum. The **Scene Sketch** provides a graphical representation of the source in the scene, and the source spectrum plots can also be viewed. An existing sample workbook may have one or more sources provided as examples, while a new workbook will have one default point source with a flat continuum to serve as an example. This page describes how to define a new source, edit the source properties, and associate the source with a scene.

Figure 1. The Scenes and Sources page layout



The functionality of the different panes, tabs, and sub-tabs are described in the Scenes and Sources overview.

Create a new source

A new source can be created by clicking the NEW button within the **Select a Source** pane. This creates a new row in the source table with a default name, and shows the number of calculations equals 0 implying that this source is initially not associated with any scene or calculation. The default new source is a point source with a flat continuum. A new source may also be created by using the ***Copy Source*** option available under the drop-down menu of the ***Edit*** button at the top of the Scenes and Sources page. This will create a new row in the source table with the same source ID, but is not associated with any scene or calculation. Once the source is added to a scene and used in a calculation the information gets updated in the **Select a Source** pane. The scenes and sources are interactively linked.

Defining the properties of the new source

To modify the properties of the new source, first select it by clicking the row to highlight the source. The source editor has various tabs that can be used to change the source properties as described below. Note that the changes made using the source editor under each tab are applied to the selected source only when the SAVE button is activated.

ID

The ID allows the user to change the default name to a new desired name for the source.

Continuum

The **Continuum** tab allows to assign a spectrum to the new source by choosing a user-supplied spectrum, an analytic spectrum (such as, flat continuum, power-law continuum, blackbody spectrum) or one of the template spectra (stellar spectra, extragalactic spectra) available in the spectral templates library.

The menu under ***Uploaded Spectra*** is populated with the list of user-supplied spectra.

When an analytic spectrum is selected the user will be presented with options to specify the parameters relevant to the chosen analytic spectrum, such as, the flux units, the exponent for the power-law, or temperature for the black-body spectrum.

The stellar spectral templates include the Phoenix models (specified by their spectral type, effective temperature, and log g values), and HST standard stars.

The extra-galactic spectral templates include an ensemble from Brown et al. (2014) with wavelength coverage spanning from the ultraviolet to the mid-infrared, and are representative of diverse galaxy spectral shapes. There is an option for ***No Continuum*** which is useful for specific cases, such as when only spectral lines are being used.

The **Continuum** tab also allows to specify the redshift of the source and the extinction to be applied. The extinction laws available are from Weingartner & Draine (2001), and Chapman et al. (2009). The extinction in magnitudes is specified in a chosen bandpass (V, J, H, or K).

Renormalization

The user can choose to normalize the spectral energy distribution for the source by providing the integrated magnitude (in AB magnitude or Vega magnitude units) of the source at a particular wavelength, or in a specified bandpass. The selection for JWST bandpass offers all the imaging filters on the JWST instruments. Alternatively, the user can also renormalize to the total magnitude in an HST (ACS, WFC3/UVIS, WFC3/IR, or NICMOS) bandpass or other available standard photometry filters (e.g., Bessell, Cousins, SDSS, Johnson, or Spitzer).

The normalization may also be specified in flux units either in flam (erg/s/cm^2/Å), or fnu (erg/s/cm^2/Hz), or in terms of spectral flux density in Jansky units.

For extended sources, if the normalization is selected to be in surface brightness units in the **Shape** tab, the units presented in the normalization tab will be per arcsec or per steradians.

Lines

The user can add emission lines to the source continuum using the options available under the **Lines** tab (Figure 2). An emission-line is defined by the following parameters: a user-defined line name, the line center in microns, a line width in km/s, and the line strength in erg/cm^2/s. The line center should correspond to the redshifted wavelength because the lines are applied after redshift and renormalization. Once the line is added using the ADD button, the table of lines is populated with the input parameters. Multiple lines may be added to this list of lines to be applied to the source spectrum. To change the input parameters, select the emission line by clicking the row on the table, modify the parameters and click the UPDATE button. Lines may be deleted from the list by using the REMOVE button. Remember that the ADD, UPDATE, and REMOVE buttons will only modify the properties of the line that is being edited in the line list. For the emission lines to be applied to the source continuum, use the SAVE button.

Figure 2. The Lines tab on the Source Editor pane of the ETC

The layout of the Lines tab in the Source Editor pane shows how the properties of the emission lines can be specified. The lines can be added to, updated, or removed from the lines library using the buttons to perform those functions. The changes are applied to the source spectrum only when the Save button is activated.

Shape

The source morphology can be specified as a point source or an extended source. For extended sources, the flux distribution may be selected to be ***flat***, ***2D Gaussian***, ***power-law*** or two flavors of ***Sersic*** profiles (since ETC version 1.3) with a specified ***Sersic index*** (ranging from 1 to 4). In the case of an extended source, the parameters that specify the extent of the source in arc seconds must also be provided (such as, **σx** and **σy** for the ***2D Gaussian***, or semi-major and semi-minor axes for flat source or ***Sersic*** profiles). To assign the shape parameters to the source, use the ***Save*** button. See JWST ETC Defining an Extended Source for more in-depth descriptions of the different flux distributions.

Offset

The offset has options to position the source anywhere in a scene. The spatial offsets are defined with respect to the center of the scene, and using large offsets will make the scene accordingly bigger and more computationally intensive. The default and maximum scene size depends on the instrument and mode as given in the table on the Scenes and Sources Page Overview. The offset parameters link the source and the scene, so it is important that the source is added to a scene for the offset parameters and orientation to take effect.

Examining the source

The sources that are created may be examined in the **Scene Sketch** and the source spectrum plots to ensure that the desired parameters for spectral characteristics, morphology, and location in the scene have been applied. The source spectrum plots display the spectrum for all the sources that have been selected using the checkboxes in the **Select a Source** pane. Use these plots to make sure that the source spectrum is correct (such as, the emission lines have been applied with the correct wavelength, and line strength).

The **Scene Sketch** requires that the sources to be examined are already placed in a scene. This sketch can be used to examine the source location, and orientation. The **Scene Sketch** is also useful to examine complex 2D source geometries that can be created by adding multiple sources to describe different components of an astronomical source or scene.

Deleting a source

A source can be removed from the current source library by using the DELETE button in the **Select a Source** pane. When the source to be removed is selected by highlighting the row in the source table, all the scenes that use the source will be indicated by the rows that are highlighted in green on the **Select a Scene** pane. Similarly, all the calculations which use the scenes containing the selected source will also be highlighted green in the Used in Calculations pane.

> ⓘ The green highlight is intended to make the user aware of the scenes and calculations that are affected by deleting or modifying the selected source. This feature is particularly important because the scenes, sources, and calculations are interlinked in the ETC.

References

JWST Exposure Time Calculator Tool

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The Mid-Infrared Extinction Law in the Ophiuchus, Perseus, and Serpens Molecular Clouds

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Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

Weingartner, J. C. and Draine, B. T. 2001, ApJ, 548, 296
Dust Grain-Size Distributions and Extinction in the Milky Way, Large Magellanic Cloud , and Small Magellanic Cloud

Published	30 Dec 2016
Latest updates	• 24 Oct 2019 Updated for ETC v1.5. Video links added. • 05 Nov 2018 Updated for ETC v1.3. Updated information on Sersic profiles. • 08 Oct 2018 Sersic and power law profiles for ETC v1.3 • 26 May 2017 Modifications in section "Defining the properties of the new source"

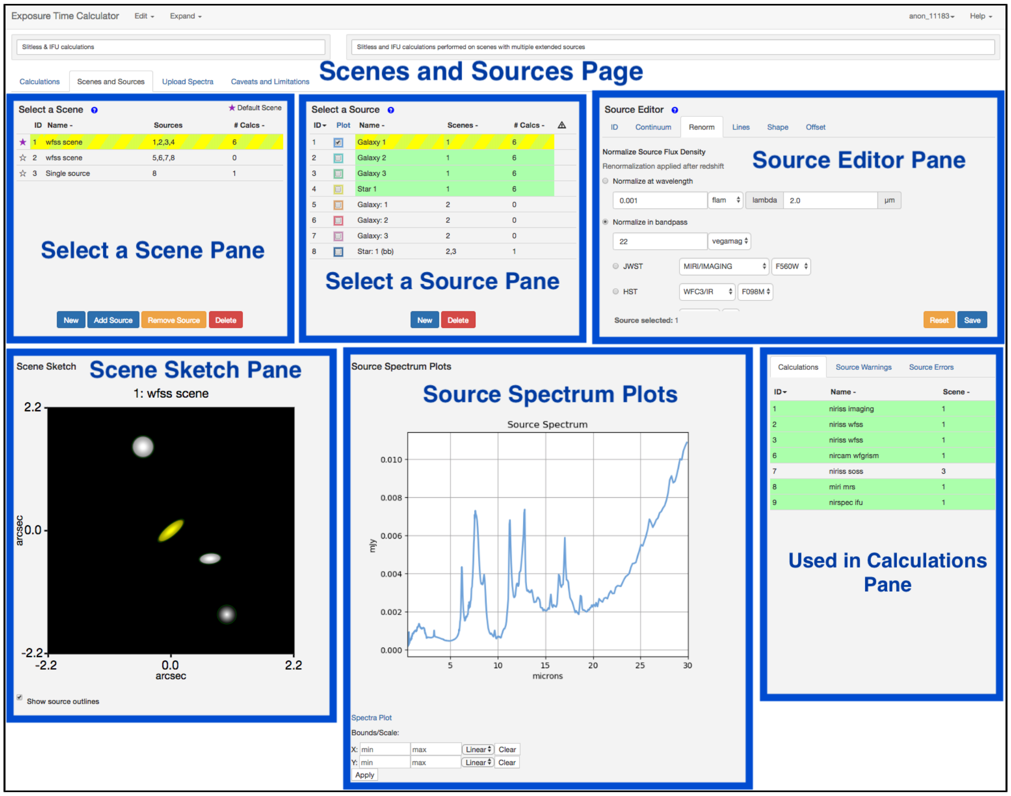
JWST ETC Defining an Extended Source

The JWST Exposure Time Calculator (ETC) can perform calculations using extended sources that may be a better fit to a science target than a point source. Users can create an extended source and alter it size, orientation, flux distribution profile, and flux normalization.

On this page

The JWST Exposure Time Calculator (ETC) allows a user to define sources that are persistent and reusable. A source can be newly created, or copied from the available library of sources on the Scenes and Sources page and modified. The **Source Editor** allows the user to assign the source properties such as shape, brightness, and spectrum. The **Scene Sketch** provides a graphical representation of the source in the scene, and the source spectrum plots can also be viewed. An existing sample workbook may have one or more sources provided as examples, while a new workbook will have one default point source with a flat continuum to serve as an example. This page describes how to define a new extended source, edit the extended source's properties, and associate the extended source with a scene.

Figure 1. The Scenes and Source Page layout



The functionality of the different panes, tabs, and sub-tabs are described in the Scenes and Sources overview.

Create a new extended source

A new source can be created by clicking the NEW button within the **Select a Source** pane. This creates a new row in the source table with a default name, and shows the number of calculations equals 0 implying that this source is initially not associated with any scene or calculation. The default new source is a point source with a flat continuum. A new source may also be created by using the ***Copy Source*** option available under the drop-down menu of the ***Edit*** button at the top of the Scenes and Sources page. This will create a new row in the source table with the same source ID, but is not associated with any scene or calculation. Once the source is added to a scene and used in a calculation the information gets updated in the **Select a Source** pane. The scenes and sources are interactively linked.

To change the default point source to an extended source, select the **Shape** tab in the **Source Editor** pane. Click the radio button for ***Extended***. New options for defining the properties of the extended source will appear; these are described in more detail in the next section below.

Figure 2. Selecting between Point and Extended sources

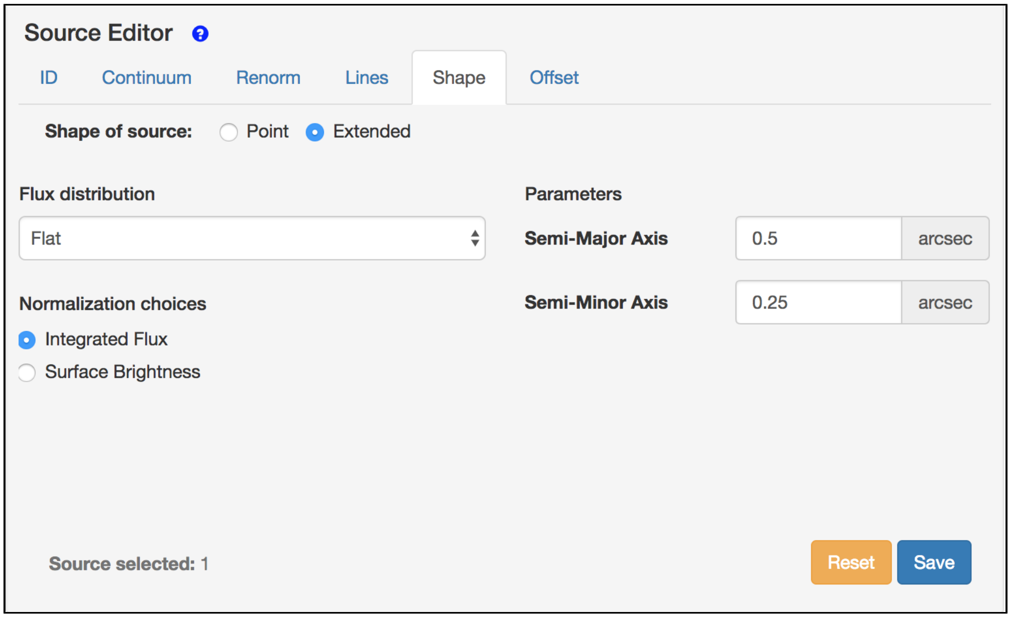
Define the properties of the new extended source

Flat

The ***flat*** profile is a simple uniform ellipse whose dimensions are defined by the semimajor and semiminor axes. Because there is a stair-step discontinuity at the outer edge, flat profiles cannot be normalized to surface brightness at the scale radius.

The user can define the ***Semi-Major Axis*** and ***Semi-Minor Axis*** for this flux distribution. These values may be equal, in which case a circular source is defined.

Figure 3. Flat flux distribution options



2-D Gaussian

For the ***2D Gaussian*** profile the specified ***σx*** and ***σy*** correspond to the Gaussian sigma along the two axes. It corresponds to the ***Sersic (Scale Radius)*** case when n=0.5 and the scale semi-major axes are increased by a factor of sqrt(2).

Figure 4. 2-D Gaussian flux distribution options

Sersic (Effective Radius)

The ***Sersic (Effective Radius)*** profile is defined such that half the flux lies within the specified radius (Graham, A. & Driver, S.P. 2005 equation 1). The intensity profile is described by the equation:

I(r) = I(0) * exp(-b * (r/r_eff**(1/n) - 1)),

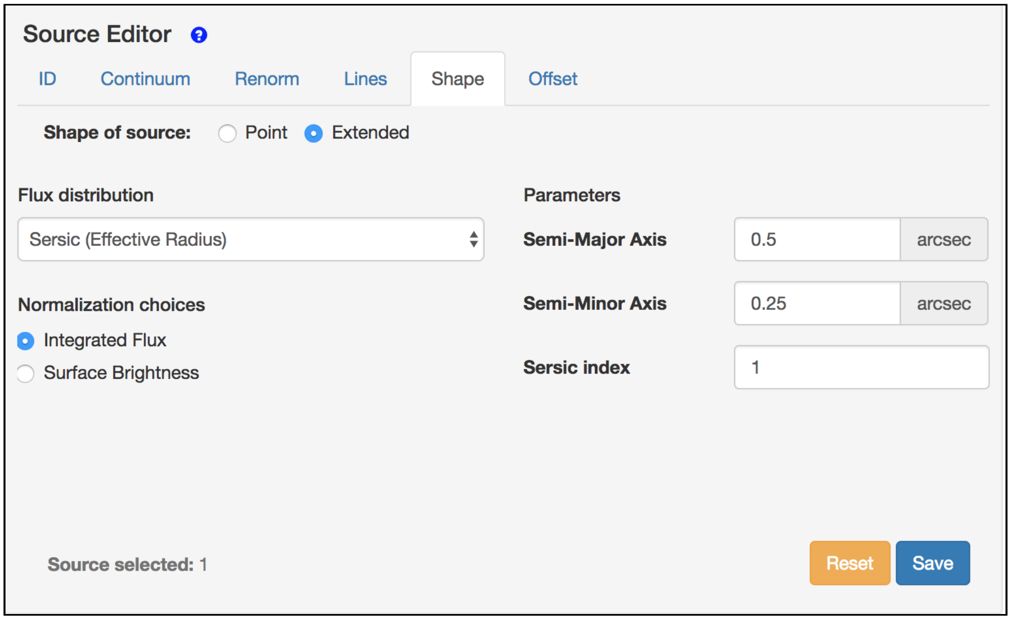
where r_eff is the effective radius, n is the ***Sersic index***, and b is the shape parameter calculated such that half the flux will lie within the effective radius:

dist = sqrt((x/semi-major)**2.0+(y/semi-minor)**2.0),

profile = exp(-b * (dist**(1.0/n)-1))

The user can define the ***Semi-Major Axis*** and ***Semi-Minor Axis*** for this flux distribution. These values may be equal, in which case a circular source is defined.

Figure 5. Sersic flux distribution options



Sersic (Scale Radius)

The ***Sersic (Scale Radius)*** profile is defined using scale-lengths (Graham, A. & Driver, S.P. 2005 equation 14). The intensity profile is described by the equation:

I(r) = I(0) * exp(-(r/r_scale)**(1/n)),

where r_scale is the scale length where I(r)=I(0)/e and n is the ***Sersic index***. The ellipticity is governed by specifying the semi-major and semi-minor axis, and they are used as follows:

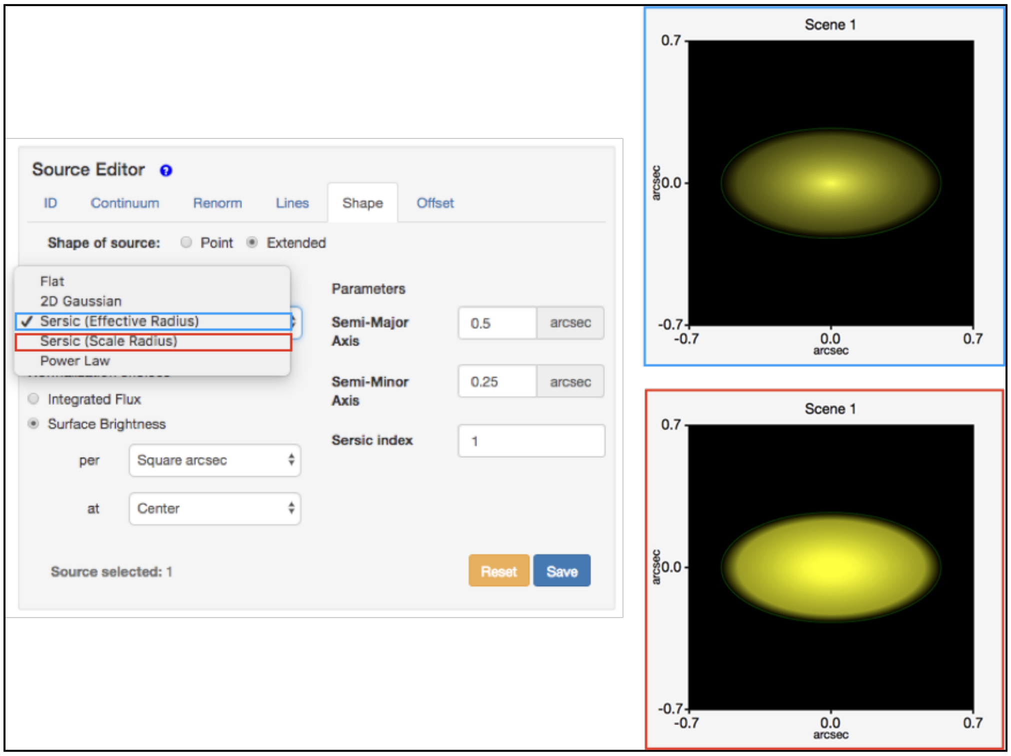
dist = sqrt((x/semi-major)**2.0+(y/semi-minor)**2.0),

profile = exp(-dist**(1.0/n))

The integration is performed in 2D from infinity to +infinity and is not truncated at the axes, as it may appear from the **Scene Sketch**.

The options for this flux distribution are identical to those for the ***Sersic (Effective Radius)*** shown in Figure 5 above.

Figure 6. Normalization in Surface Brightness units for extended sources and *Sersic* profiles



The options to specify the normalization in surface brightness units or integrated magnitudes for extended sources are available in the Shape tab, along with parameters that define the axial extents of the source. Two types of Sersic profiles are available: the Effective Radius profile and the Scale Radius profile. The right panes show how the two Sersic profiles differ while created with the same parameters as shown on the left pane.

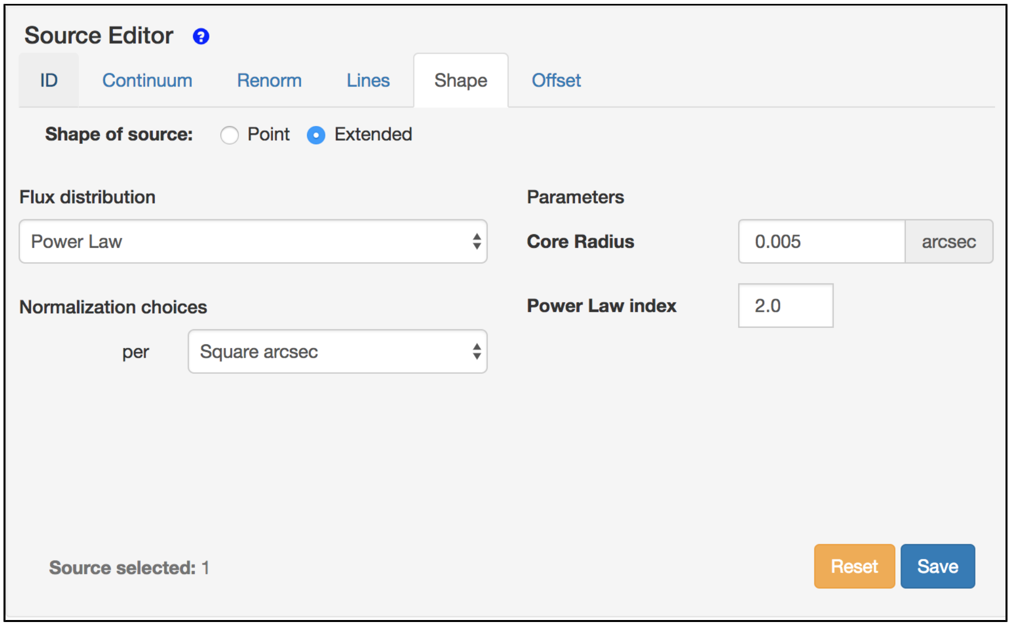
Power Law

The ***power law*** profile is defined as an r**-k profile with a small flat central core to avoid the singularity at r=0.

The configurable parameters for this profile are the ***Core Radius***, which defines the size of the flat central circular core, and the ***Power Law index*** (k) which must be a positive value between 0 and 10.

Because this power law does not converge for k < 2, the only available normalization option is to normalize to the surface brightness at the center (the flat core).

Figure 7. Power Law flux distribution options

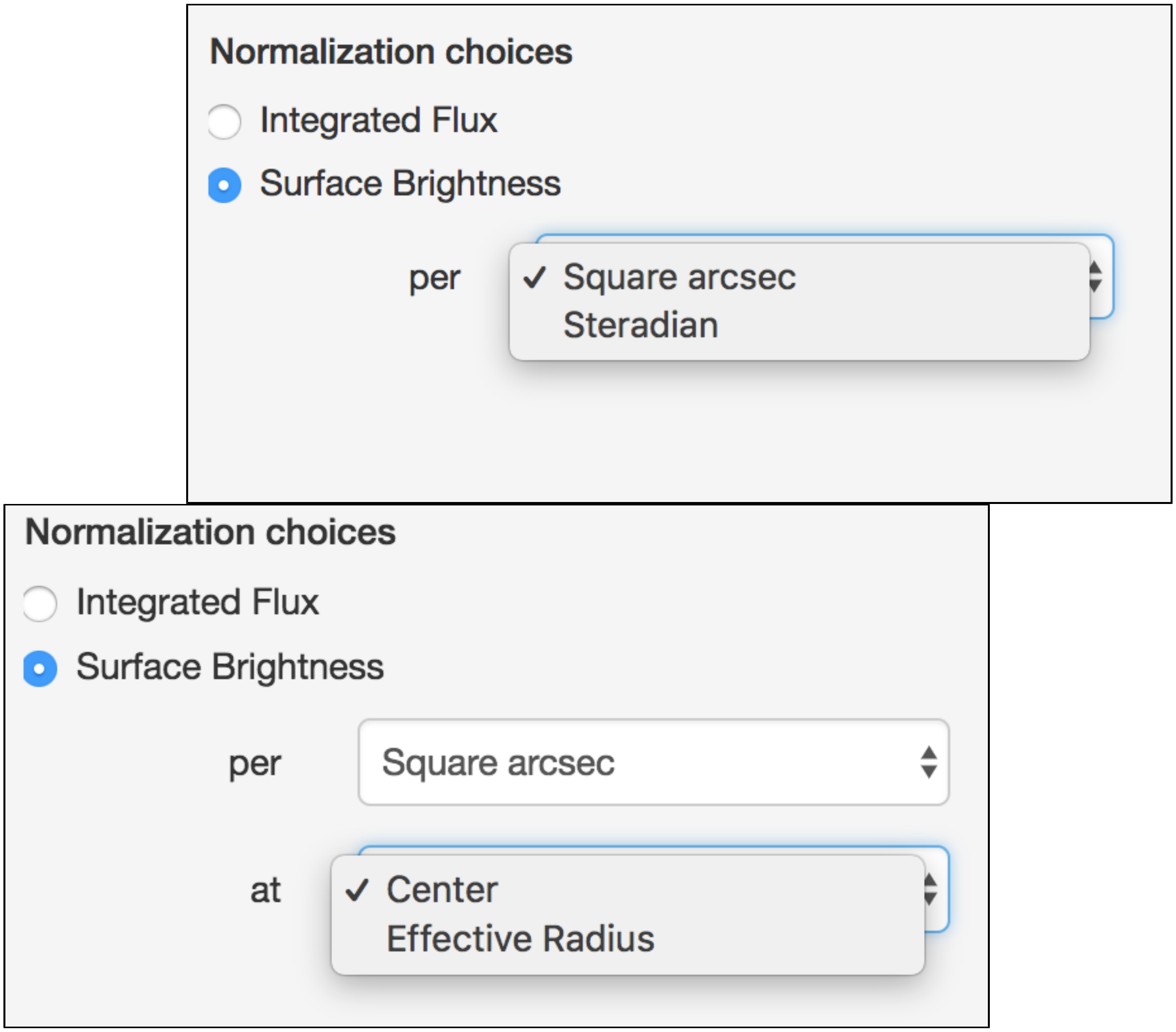


Normalization choices

Selecting ***Surface Brightness*** as the **Normalization choices** option automatically changes the units under the **Renorm** tab to read either ***per Square arcsec*** or ***per Steradian***.

The ETC is unable to distinguish between units of integrated flux (i.e., mJy or MJy) from surface brightness (i.e., mJy/sr or MJy/square arcsec) in user-supplied spectra. If the user uploads a spectrum with the second column in surface brightness units, the source that the spectrum is applied to must be an ***Extended*** source with ***Surface Brightness*** selected as the **Normalization choices** option, otherwise the spectrum will not be properly applied to the source.

Figure 8. Surface Brightness units and normalization locations



The source profile is normalized to a user-specified integrated magnitude (Integrated Flux option) or Surface Brightness for extended sources. Top. The normalization in Surface Brightness may be specified in per square arcsecond or per steradian (square radian). Bottom. For the 2D Gaussian, Sersic (Effective Radius) and Sersic (Scale Radius) flux distributions, the surface brightness may be defined at the Center of the profile, at the Scale Radius (only for the Sersic (Scale Radius) flux distribution), or at the Effective Radius (only for the 2D Gaussian and Sersic (Effective Radius) flux distributions).

Other extended source properties

All other extended source properties defined under the **Continuum**, **Renorm**, **Lines**, and **Offset** tabs are handled in the same manner as for point sources, as described in the JWST ETC Defining a New Source article.

Examining the extended source

The extended sources that are created may be examined in the **Scene Sketch** and the **Source Spectrum Plots** pane to ensure that the desired parameters for spectral characteristics, morphology, and location in the scene have been applied. The **Source Spectrum Plots** pane displays the spectrum for all the sources that have been selected using the checkboxes in the **Select a Source** pane. These plots can be used to ensure that the source spectrum is correct (e.g., checking that the emission lines have been applied at the correct wavelength and line strength).

The **Scene Sketch** requires that the sources to be examined are already placed in a scene. This sketch can be used to examine the source location and orientation. The **Scene Sketch** is also useful for examining complex 2D source geometries that can be created by adding multiple sources (point and/or extended) to describe different components of an astronomical source or scene.

> There is no limit to the size of an extended source that can be created, but the user should be aware of the maximum scene size for each observing mode. The **Scene Sketch** axes are dynamic and will show the full extent of a source of any size; this does not mean the whole scene is used in the calculation.

Deleting the extended source

A extended source can be removed from the current source library by using the DELETE button in the **Select a Source** pane. When the source to be removed is selected by highlighting the row in the source table, all the scenes that use the source will be indicated by the rows that are highlighted in green on the **Select a Scene** pane. Similarly, all the calculations which use the scenes containing the selected source will also be highlighted green in the Used in Calculations pane.

> The green highlight is intended to make the user aware of the scenes and calculations that are affected by deleting or modifying the selected source. This feature is particularly important because the scenes, sources, and calculations are interlinked in the ETC.

References

Graham, A.W., Driver, S.P., 2005, Publication of the Astronomical Society of Australia, Vol. 22, pg. 118-127

A concise reference to (projected) Sérsic $R^{1/n}$ quantities, including concentration, profile slopes, Petrosian indices, and Kron magnitudes

Published	13 Nov 2018
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. • 27 Jun 2019 Added reference section, uploaded reference, and fixed reference link in the text.

JWST ETC Point Spread Functions

The JWST Exposure Time Calculator (ETC) uses point spread functions (PSFs) from a precomputed library of PSFs produced by WebbPSF. (For more details on WebbPSF's optical model, check out the WebbPSF documentation pages.)

On this page

The PSF library

Each instrument aperture is represented by a precomputed set of roughly 30 PSFs, generated at log-normal wavelength intervals that span the entire wavelength range of all filters and dispersers used with that aperture. With the exception of coronagraphic imaging, all PSFs are generated on-axis, centered on the detector, and are thus devoid of any optical aberrations that may impact real PSFs at locations far from the detector center. Given that the ETC models sources close to the center, the effect is likely to be minimal.

Coronagraphic observations have multiple sets of roughly 30 PSFs each, generated at log-normal wavelength intervals in multiple spatial locations, to account for the effects of coronagraphic spots.

The PSFs are generated to relatively small sizes—the largest are the MIRI 4QPM PSFs (used in MIRI Coronagraphic Imaging), which cover 8.9" on a side; the smallest are NIRISS Imaging PSFs that are only 1.64" on a side. Nevertheless, the PSFs cover more than 99.9% of the expected flux.

ETC version 1.5.1 uses WebbPSF version 0.8.0, WebbPSF Data version 0.8.0, and POPPY version 0.8.0 to construct the PSF library for all science instruments (MIRI, NIRCam, NIRISS, and NIRSpec). Compared to ETC 1.5, the PSFs have been flipped vertically to reflect the actual orientation of the installed optical elements, which mainly affects modes with non-axisymmetric PSFs like the MIRI 4QPMs, NIRCam weak lenses, and NIRISS AMI and SOSS.

How the library is used

For a given observation, the entire set of PSFs for a given aperture are loaded into the ETC.

The scene generation process creates a cube with both spatial and wavelength dimensions for each source in the scene. It then takes those cubes and convolves each wavelength plane with the appropriate PSF; this PSF is produced by interpolating the set of PSFs at the specific wavelength of the cube slice. Thus, the apparent PSF in the output 2D images is the sum of multiple wavelength-dependent PSFs, scaled by the filter throughput curve.

The model cubes for each scene are then added together to form a combined scene cube, which is then "observed" onto a detector, and results extracted by use of the strategy.

The reason that the PSF convolution is done before the combination of all of the sources is to make it easier to use a positionally-dependent PSF, which is done for coronagraphy.

Position-dependent coronagraphic PSFs

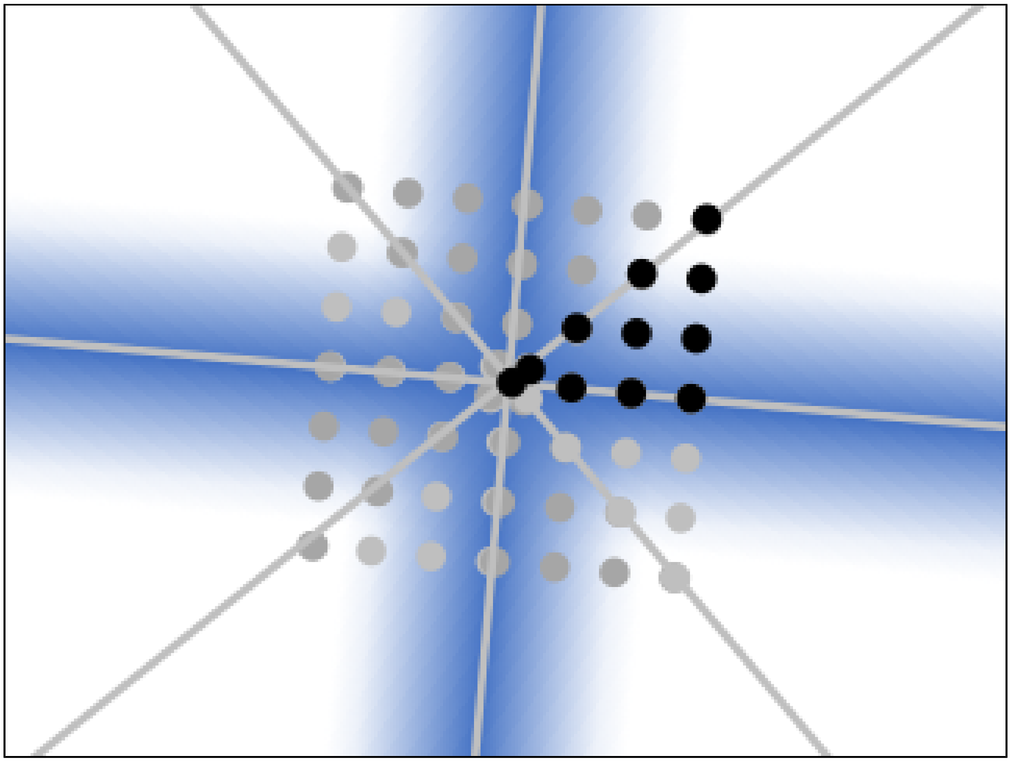
The positionally-dependent PSFs are generated in a variety of patterns to suit the shape of the occulting elements. Though they are generated for different spatial positions, they are not interpolated spatially; instead, the ETC's code selects the closest PSF to the target location. This can result in step-function behavior with various sources.

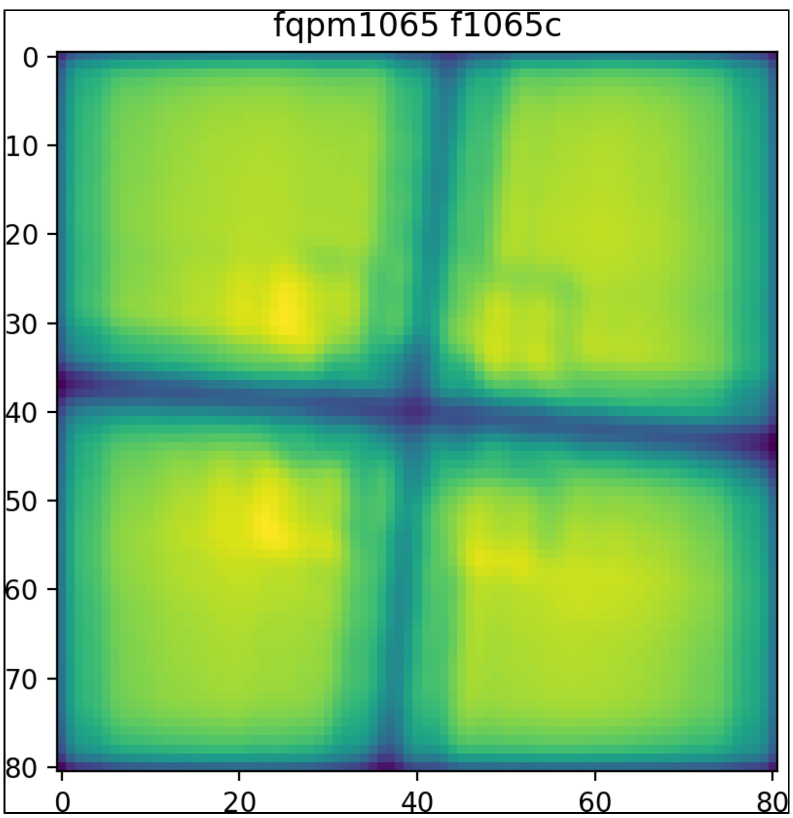
MIRI

4QPM

The MIRI 4-quadrant phase masks (4QPM) used for coronagraphic imaging are assumed to have eight-fold symmetry: they can be reflected across each of the quadrant axes and across the primary axes of the detector (which is approximately correct). PSFs were generated in a triangular shape, covering the 0%, 33%, 66%, and 99% unobscured positions. The positions take into account the roughly 5° clockwise rotation of the MIRI masks.

Figure 1. MIRI 4QPM PSF positions



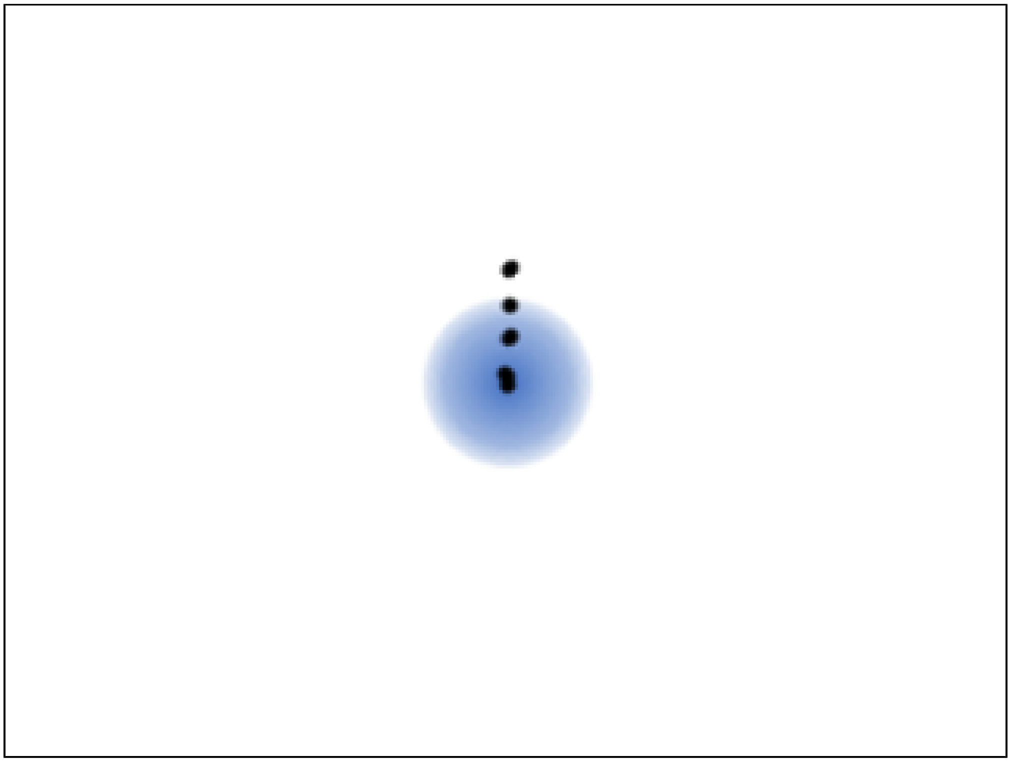


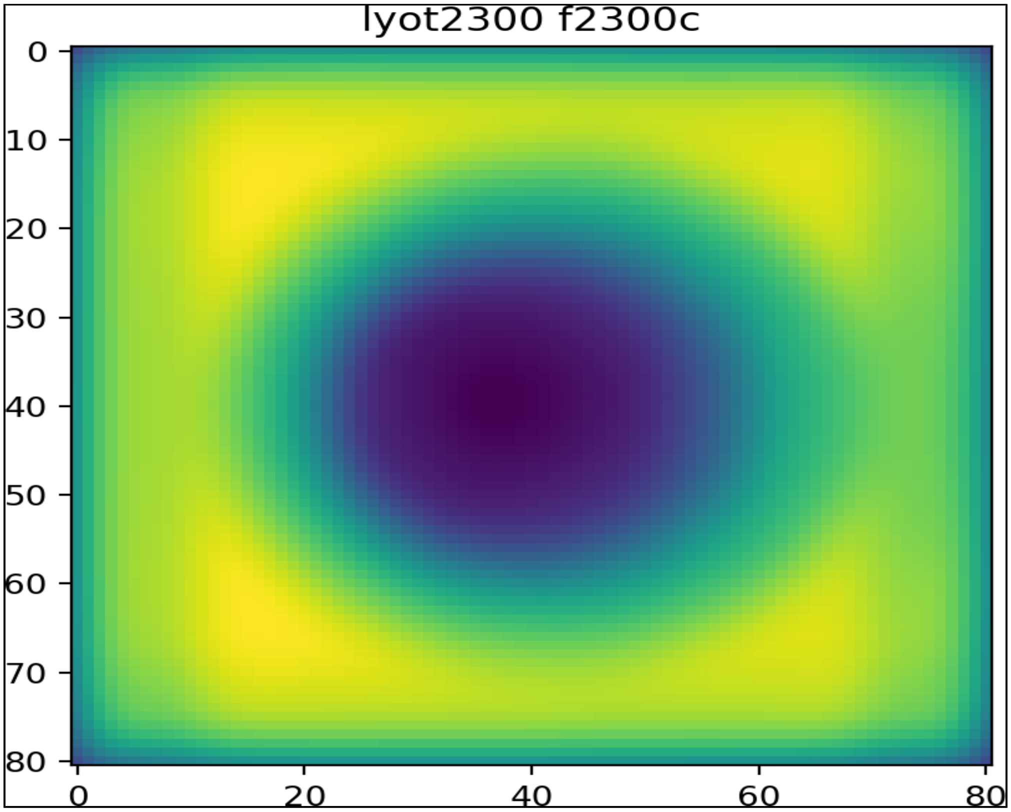
Top: A schematic view of the MIRI PSF grid and symmetry.
Bottom: a dense grid of point sources run through the ETC traces out the resulting shape of the MIRI 4QPM obscuring elements.

LYOT2300

The MIRI ***LYOT2300*** mask is assumed to have radial symmetry. PSFs were generated along the Y-axis, at points that are 0%, 25%, 50%, 75%, and 99% unobscured.

Figure 2. MIRI LYOT2300 PSF positions





Top: A schematic view of the MIRI PSF symmetry.

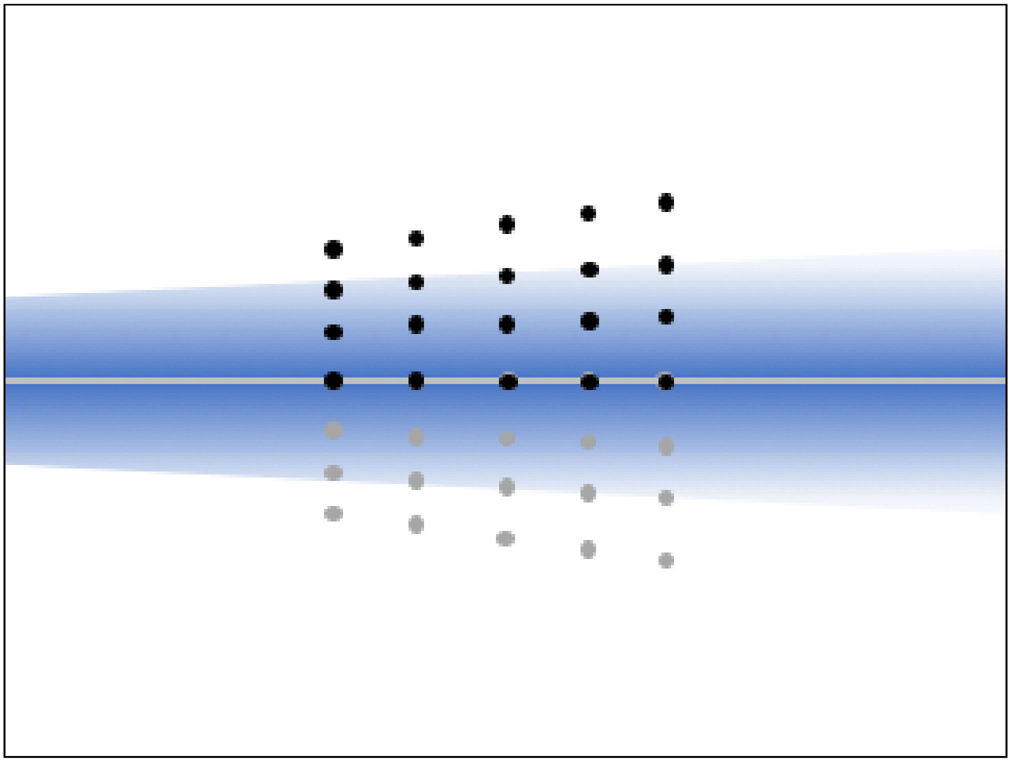
Bottom: a dense grid of point sources run through the ETC traces out the resulting shape of the MIRI LYOT2300 obscuring element.

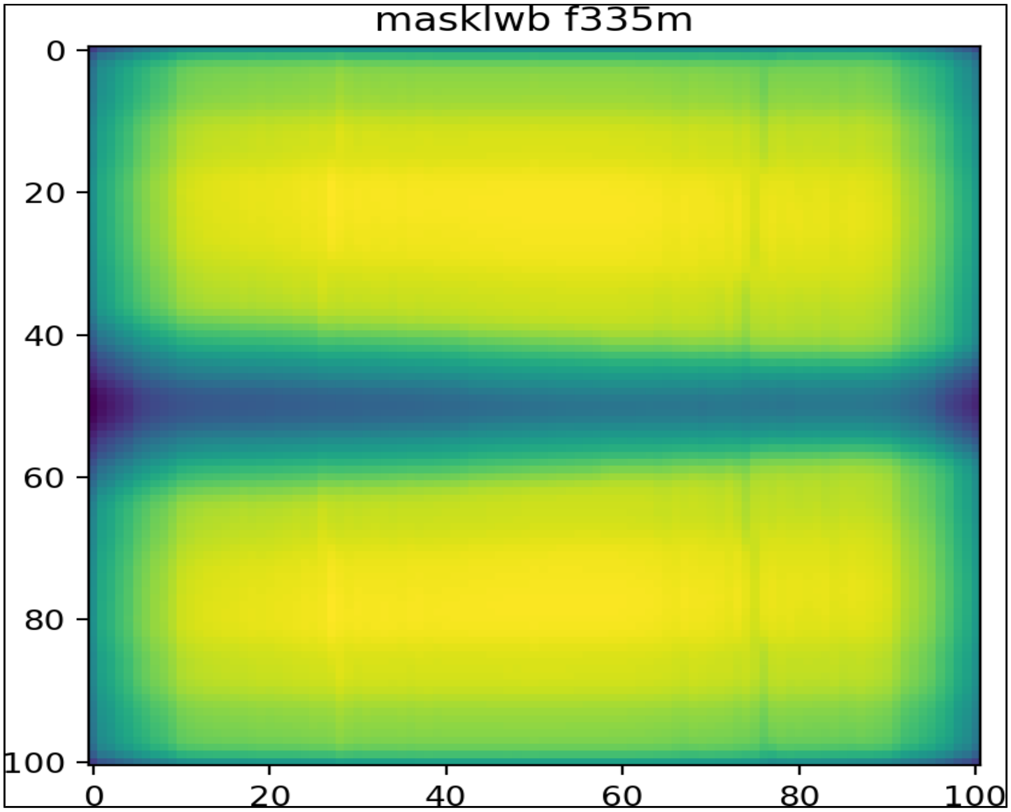
NIRCam

MASKSWB/*MASKLWB*

The NIRCam ***MASKSWB*** and ***MASKLWB*** masks are assumed to have vertical symmetry. They are tapered wedges (where ***MASKSWB*** tapers toward negative X, and ***MASKLWB*** tapers toward positive X), such that each filter has an optimal position along the wedge where a point source is just barely fully obscured. Sets of five PSFs were generated at the optimal position, positions 1" and 2" on either side of the optimal position, and positions above the bar that are 33%, 66%, and 99% unobscured.

Figure 3. NIRCam bar mask PSF positions



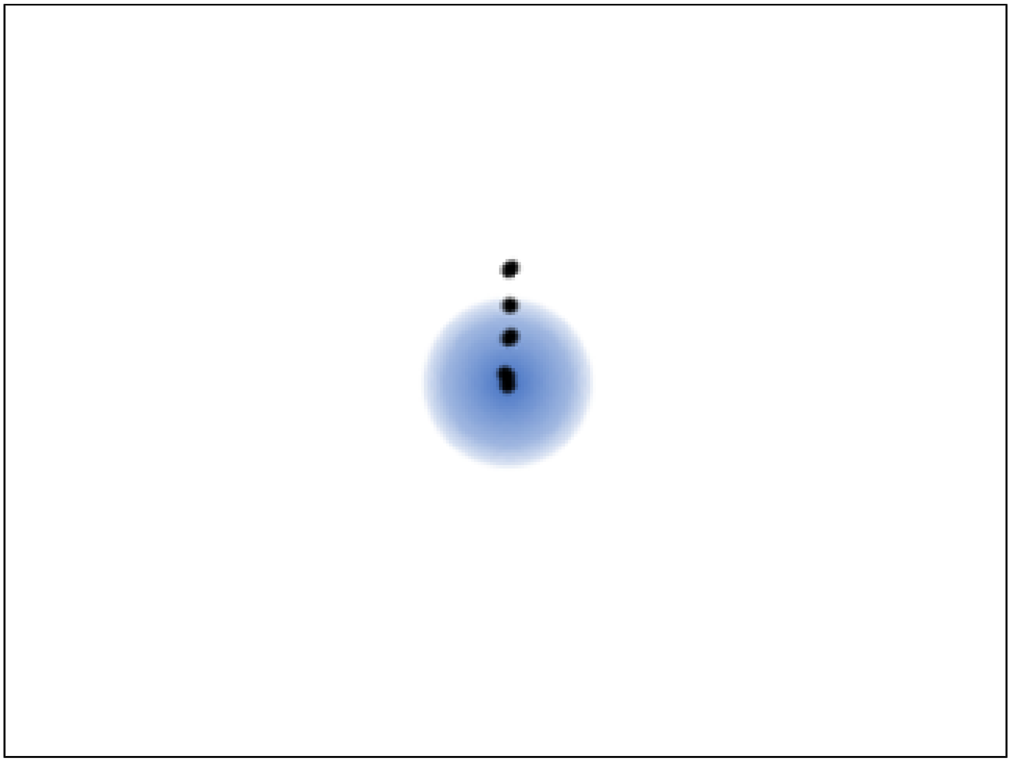


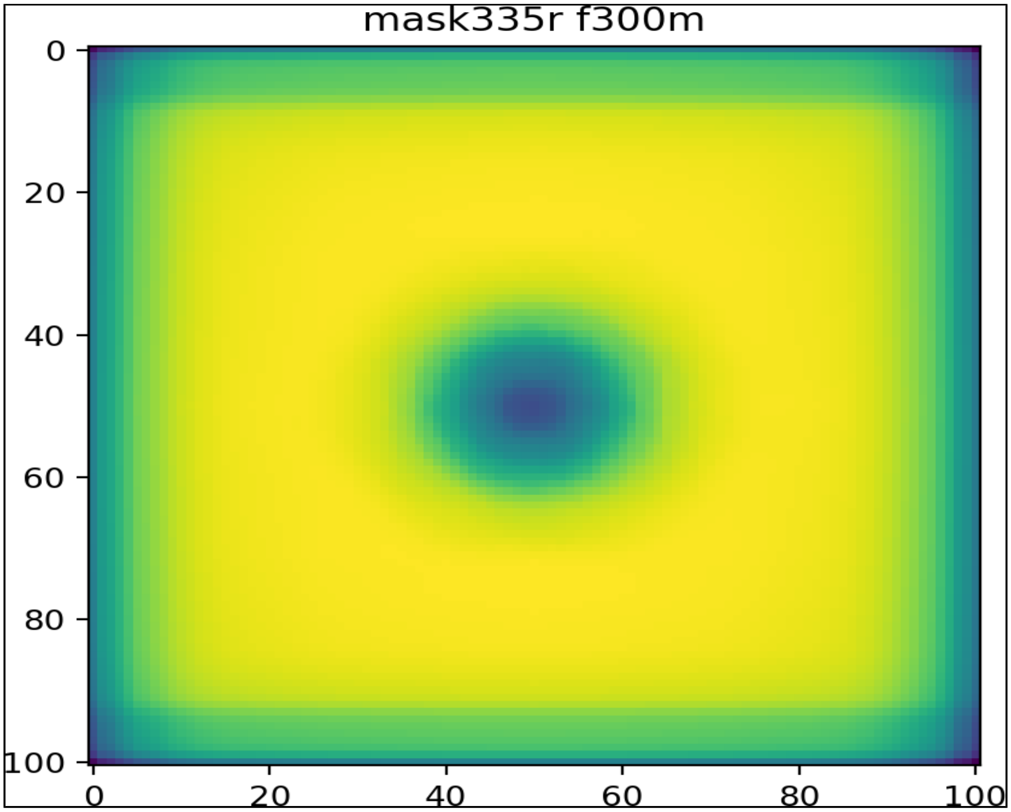
Top: A schematic view of the NIRCam MASKSWB PSF grid and symmetry (tapering toward negative X).
Bottom: a dense grid of point sources run through the ETC traces out the resulting shape of the NIRCam MASKLWB obscuring element (tapering toward positive X).

MASK210R/MASK335R/MASK430R

The NIRCam ***MASK210R***, ***MASK335R***, and ***MASK430R*** masks are assumed to have radial symmetry. PSFs were generated along the Y-axis, at points that are 0%, 25%, 50%, 75%, and 99% unobscured.

Figure 4. NIRCam round mask PSF positions





Top: A schematic view of the NIRCam symmetry.
Bottom: a dense grid of point sources run through the ETC traces out the resulting shape of the NIRCam MASK335R obscuring element.

References

WebbPSF webpage

Published	13 Nov 2018
Latest updates	• 07 Jan 2020 Updated for ETC 1.5.1. • 09 Oct 2019 Updated for ETC 1.5. • 27 Jun 2019 Fixed incorrect links.

JWST ETC Defining a New Scene

The JWST Exposure Time Calculator (ETC) uses a scene for the calculations. A scene may contain one or multiple sources; it is an idealized representation of the spatial distribution of a target and nearby sources with defined intrinsic spectral properties.

On this page

Video Tutorial:

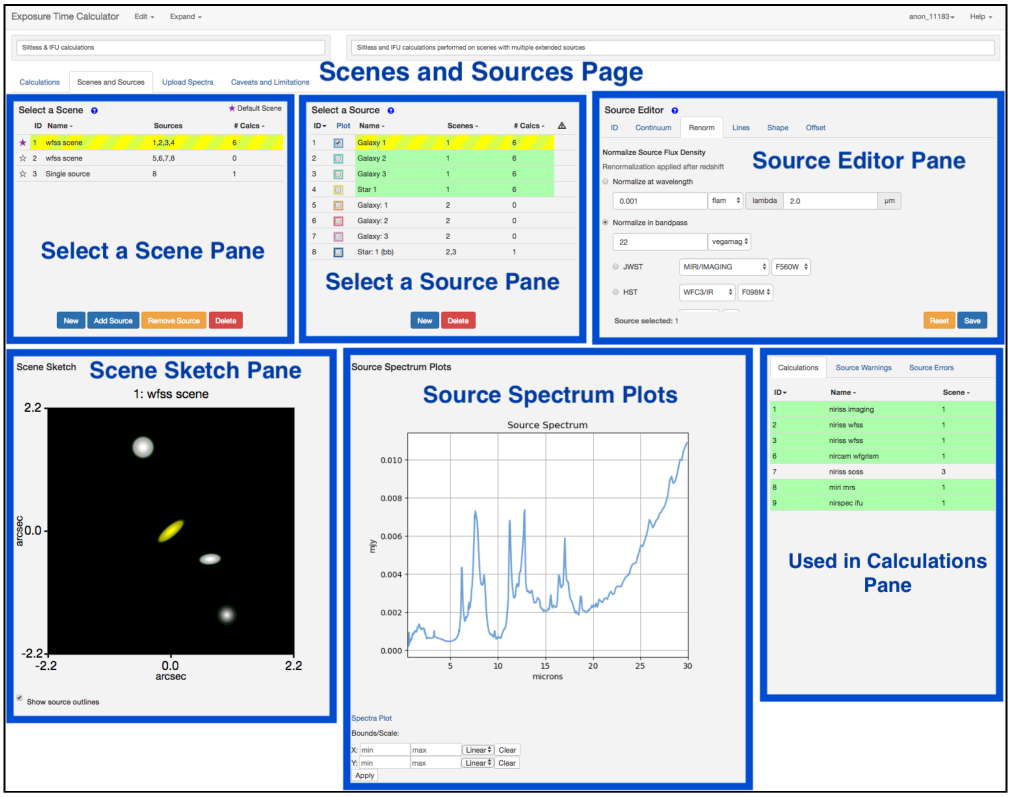
ETC Scenes and Sources

The JWST Exposure Time Calculator (ETC) uses a scene for performing its calculations, and a scene can include one or more sources. Scenes are idealized representations in two spatial dimensions (angular coordinates) with sources properties determining the brightness distribution and shapes. The scene sizes are roughly 10–20 square arcseconds depending on the instrument and mode. The user can create many scenes and have a scene library with unique scene IDs or names. The scenes and sources defined in a workbook are persistent and can be reused in various calculations.

Creating a new scene

The default workbook that is created when a user creates a new workbook contains a default scene with one default source (a point source with flat continuum) on the Scenes and Sources page (Figure 1). The user can create a new scene by clicking on the NEW button in the **Select a Scene** pane. The new row in the scene list will show that there are no sources and that the scene has not yet been used in any calculations. When the scene is populated with sources, and then used in the ETC calculations, the information about sources and number of calculations in which the scene is used gets updated. An empty scene with no sources can be useful for examining the sky background by using it in a calculation and defining the sky background parameters under **Backgrounds** in the **Calculations** page. To add sources to the new scene, there must be an existing list of one or more sources in the **Select a Source** pane.

Figure 1: The Scenes and Sources page layout



Adding sources

The source to be added to a scene is first selected by clicking the row containing the source in the **Select a Source** pane. The scene into which the source has to be placed is selected by clicking the row in the **Select a Scene** pane. The selected rows are indicated by yellow highlighting. From the **Select a Scene** pane click on the ***Add Source*** button and the scene is populated with the currently selected source. The same procedure can be repeated by selecting the desired sources from the source list one at a time. At every step make sure that the correct source and scene are highlighted in yellow.

Source offsets

The **Offset** tab under source editor (see Figure 1) is directly linked to the scene. The offsets and orientation define the placement or location of the sources in the scene and their orientation. To change the offsets of a source in a scene, both the source and the scene for which the change is to be applied has to be highlighted in yellow. This is particularly important because the same source may be used in multiple scenes, and when the source is selected, all the scenes that contain the source will be highlighted in green. Clicking on a particular scene will activate the yellow highlighting to indicate this is now the active scene. On the **Source Editor** pane, edit the X- and Y-offsets and orientation and use the save button to apply the changes. The offsets are defined in arcsecs with respect to the center of the scene, and orientation in degrees.

The use of larger offsets will make the scene bigger. While there is no fundamental limitation to how big a scene can be, the restrictions offered by the maximum scene size conserves computational resources and reduces the time for the calculations.

Removing sources

A source that has already been placed in a scene can be removed by using the ***Remove Source*** button in the **Select a Scene** pane. Before this task is performed, make sure that the source to be removed is highlighted yellow by selecting it from the source list, and the scene from which it needs to be removed is also highlighted.

Viewing the scene

The newly created scene can be selected and viewed in the **Scene Sketch** pane. The **Scene Sketch** is interactively linked to the source table, such that a source selected in the source table will appear yellow in the sketch. Similarly if the source is selected in the sketch then it is also selected in the table. The scene sketch has a size that shows all the assigned sources, and does not always correspond to the maximum scene size allowed for ETC calculations for a given instrument mode. To enlarge the scene sketch that is displayed, add a faint source at a large offset not exceeding the maximum scene size limit.

Default Scene

The default scene in a workbook is used for any default calculation that is triggered when an observing mode is selected from the instrument tabs on the **Calculations** pane. The default scene provided with a new workbook has a single default point source with a flat continuum, located at the center of the scene. However, the user has the option to change the default scene to any of the new scenes that they have created in the **Select a Scene** table. Clicking on the star in the row containing a scene will make that the default scene as indicated by the purple star. Users are advised to use a simple scene with simple source properties as the default scene. A more complex scene or scene containing complex sources that is assigned to be the default scene, can slow down the default calculations considerably.

Deleting a scene

To delete a scene, select the row corresponding to that scene by clicking it and it will be highlighted in yellow. If the scene has been used in any ETC calculation after it was created, this information will be displayed in the Used in Calculations pane, with all the calculations using the selected scene shown highlighted in green. Users should be aware of the calculations that will be affected, before performing the scene deletion. The scene may be deleted by using the DELETE button on the **Select a Scene** pane.

References

Go to the on-line JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, *Proc. SPIE* 9910
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

Published	30 Dec 2016
Latest updates	• 24 Oct 2019 Updated for ETC v1.5. Video links added. • 05 Nov 2018 Updated for ETC v1.3

JWST ETC Source Spectral Energy Distributions

The JWST Exposure Time Calculator (ETC) offers a series of spectral energy distributions (SEDs) that may be used when building a source. Templates include many flavors of stellar and extragalactic spectra, and analytic spectral distributions. A user-supplied spectrum may also be uploaded to the ETC for use in calculations.

On this page

When creating a new source in the Exposure Time Calculator (ETC), the user may choose to apply a template spectrum for the source's continuum. Many of the commonly used stellar and extragalactic templates have been provided, which cover a wide range of observed spectral energy distributions, along with several analytic functions. The **Continuum** tab is also where the redshift and extinction parameters may be entered. The available choices for source spectral energy distributions are described below. There are two ways to access the **Continuum** tab of the **Source Editor**, as shown in Figures 1 & 2 below.

Figure 1. Calculations Select calculation Scene   Continuum

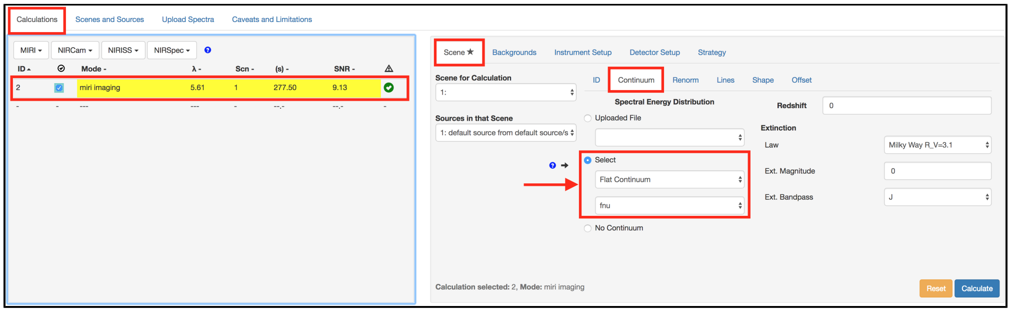
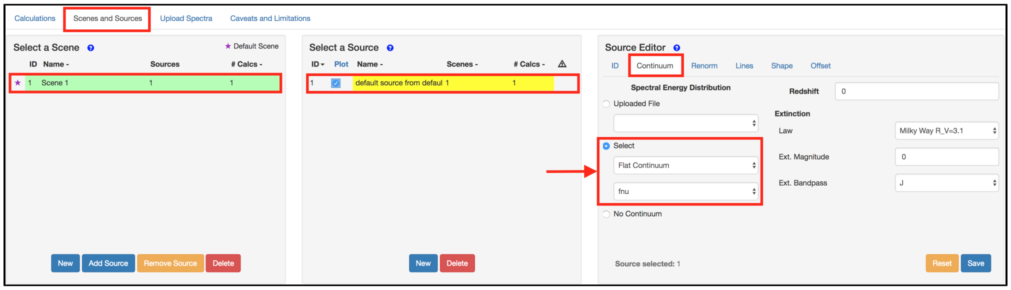


Figure 2. Scenes and Sources Select scene Select source Continuum



Analytic spectra

Analytic spectral energy distributions include a ***Flat Continuum***, ***Power-law Continuum***, and a ***Blackbody Spectrum*** .

Power-law Continuum

The power-law continuum is defined as $F(\lambda) \sim \lambda^n$, where n is specified by the user in the ***exp*** box. Units of ***flam*** (wavelength units of erg/s/cm^2/Å) or ***fnu*** (frequency units of erg/s/cm^2/Hz) can be chosen from a drop-down menu. The ***Power-law Continuum*** is converted to ***fnu*** units (if necessary) and normalized to 1 mJy at 1 μm before being re-normalized to the value input by the user under the **Renorm** tab.

Flat Continuum

A flat continuum is a special case of the power law spectrum, where n=0. This distribution is so-named because the spectrum has constant energy per unit wavelength (***flam***) or unit frequency (***fnu***). The source spectrum plot will show a straight line profile for a ***Flat Continuum*** in ***fnu*** units but a curved profile when ***flam*** is selected due to the conversion factor between ***fnu*** and ***flam***.

Blackbody Spectrum

The ***Blackbody Spectrum*** is computed at the temperature of the blackbody specified by the user using the equation:

$$B_\nu(\nu, T) = \frac{2h\nu^3}{c^2} \frac{1}{e^{\frac{h\nu}{kT}} - 1}.$$

The units are ignored and the blackbody profile is normalized such that the value under the curve is the flux density (in mJy) at each wavelength of the input spectrum.

Stellar spectra

Stellar template spectral energy distributions include a library of ***Phoenix Stellar Models*** and spectra of ***HST Standard Stars***.

Phoenix Stellar Models

The pull-down menu of Phoenix stellar models contains synthetic spectra spanning spectral types from O3 to M5, obtained using the Star, Brown Dwarf, and Planet Simulator. They use static, spherically symmetric, 1D simulations to completely describe the atmospheric emission spectrum. The models account for the formation of molecular bands, such as those of water vapor, methane, or titanium dioxide, solving for the transfer equation over more than 20,000 wavelength points on average, resulting in synthetic spectra with 2 Angstrom resolution. The line selection is repeated for each iteration of the model until it has converged and the thermal structure obtained. The models here are calculated with a cloud model, valid across the entire parameter range. Each model's name contains a concatenation of the spectral type, effective temperature, and gravity (log g value).

Known issue: The effective temperature and gravity values for the G2V and G5V spectral types are identical, resulting in identical source spectra. A solution to this issue is currently being investigated.

HST Standard Stars

Several HST calibration standard star spectra are available. These spectra are stored in the Calibration Database System (CDBS) and were originally chosen from the paper *Spectrophotometric Standards from the Far-UV to the Near-IR on the White Dwarf Flux Scale* by Bohlin (1996) and later updated as new data became available. See also *Comparison of White Dwarf Models with ACS Spectrophotometry* by Bohlin et al. (2001).

More information, along with a list of the complete set of files, including older versions, can be found in the CALSPEC Calibration Database**.** This page provides a table with the available Flux Standards and their CDBS name. In this table the order of preference for the choice of a standard flux distribution is from left to right in the table, i.e., from the best in column 6 to the last choice with the lowest quality in column 9. In this case, models have higher fidelity and extend to longer wavelength ranges while the more outdated are those derived applying corrections to the original IUE and optical fluxes. Note that for the cases when the CALSPEC data are updated after the ETC software is released, the ETC will not be able to access the most recent files, but only those that were available at the time of the build. If the ETC produces an error when trying to access an ***HST Standard Star*** spectrum, review the update history at the bottom of the CALSPEC page to determine when the spectrum was updated. If it was updated after the current ETC version, you may want to use the previous version of the model, or download the most recent spectrum, and apply it as a user-supplied spectrum.

Each stellar model's spectral type and related identifying information is shown in the pull-down menu listing the star by name. The related information includes the spectral type and V magnitude in parentheses, and wavelength range in Angstroms in brackets.

> ⚠ The use of spectra that do not fully overlap with the wavelength range corresponding to the selections under the **Instrument Setup** tab will cause warnings or errors in the calculation. Typically, HST calibration spectra will be useful only for near-IR (λ<5 μm) calculations.

Extragalactic spectra

Extragalactic template spectral energy distributions include models from Brown et al. (2014). Wavelength coverage for these models spans UV to mid-infrared wavelengths. The atlas includes a broad range of galaxy types, including ellipticals, spirals, merging galaxies, blue compact dwarfs and luminous infrared galaxies.

References

Go to the online JWST Exposure Time Calculator Tool

Brown et al. 2014, ApJS, 212,18
An Atlas of Galaxy Spectral Energy Distributions from the Ultraviolet to the Mid-infrared

Bohlin et al. 1996, AJ, 111, 1743
Spectrophotometric Standards From the Far-UV to the Near-IR on the White Dwarf Flux Scale

Bohlin et al. 2001, AJ, 122, 2118
Spectrophotometric Standards from the Far-Ultraviolet to the Near-Infrared: STIS and NICMOS Fluxes

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, Proc. SPIE 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

Published	30 Dec 2016
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. • 27 Jun 2019 Fixed incorrect links.

JWST ETC User Supplied Spectra

The JWST Exposure Time Calculator (ETC) allows users to upload a spectrum for a new source. This capability is especially helpful in cases where the ETC's library of template spectra does not contain the desired spectrum or spectral features.

On this page

Video Tutorial:

Uploading Spectra to the ETC

One of the features of the JWST ETC is its ability to handle a spectrum supplied by the user. This is accomplished by a direct upload from the machine where the user is running the web browser.

To use this option, you will need to:

- Prepare your spectrum file
- Specify your spectrum file on the **Upload Spectra** page

Use the **Upload Spectra** page to upload and manage your spectra for a given workbook. On this page, you will find a list, if any, of previously uploaded spectra, including filename, wavelength range, and an optional note. Spectra can be selected and uploaded in the usual way for your web browser; the controls are located at the bottom of the **Upload Spectra** page. If the file is large or the computer has a slow internet connection it will take more time for the browser to send the file to the ETC server.

Filename Length

The maximum filename length for an uploaded file is 100 characters.

Prepare your file

The user-specified spectrum file should be in one of the following two file formats:

- ASCII table, with the extension *.dat or .txt*
- FITS table, with an extension *.fits*

Try to use a unique filename for this file, for example, by using your last name as part of the filename.

Prepare your ASCII input spectrum file with two columns:

- column 1: wavelength
- column 2: flux density

Column 1 should be the wavelength in µm and column 2 should be the flux density in mJy.

For FITS format files, the format must be *pysynphot* compatible.

For either file format, the wavelengths in the first column must be in increasing order, and there may not be duplicate wavelengths. Please note that if your spectrum has negative flux values, they will be clipped to zero and the calculation will proceed.

The wavelength range covered by the uploaded spectrum should cover the wavelength range of any instrument configurations one intends to use. If there is only partial coverage, the calculation will proceed with a warning, but may return a less accurate result. No spectral overlap with the instrument configuration will result in an error.

You may use *pysynphot* locally to validate your file by using the following command:

```
>>> import pysynphot as psyn

>>> sp = psyn.FileSpectrum('myfile.dat')
```

(The same command will also work for a FITS file.) If this command succeeds (i.e., no error messages), then your input spectrum file meets the necessary requirements.

Spectrum file format

ASCII

If the file is an ASCII file, it must contain two columns (one for wavelength in µm and one for flux density in mJy) separated by one or more spaces. Any comment lines in the file must start with the # symbol to avoid confusion when it is used in the calculation.

FITS

If the file is a FITS binary table, it should have two columns labeled “WAVELENGTH” and “FLUX”, with the units specified for each column.

Wavelength and flux units must be compatible with *pysynphot*. Acceptable units are shown in table 1.

Table 1. Acceptable units for *pysynphot*

Wavelengths		Flux
angstrom, angstroms		flam = erg cm^{-2} s^{-1} $Å^{-1}$
hz		fnu = erg cm^{-2} s^{-1} Hz^{-1}
nm		photlam = photons cm^{-2} s^{-1} $Å^{-1}$
micron, microns, µm		photnu = photon cm^{-2} s^{-1} Hz^{-1}
inversemicron, inversemicrons		jy = 10^{-23} erg cm^{-2} s^{-1} Hz^{-1}
µm		mjy = 10^{-26} erg cm^{-2} s^{-1} Hz^{-1}
mm		abmag
cm		stmag
m, meter		obmag
		vegamag
		count, counts

In addition, the header of the FITS table should include lines similar to these describing the content of the file:

PCOUNT = 0 /
GCOUNT = 1 / Only one group
TFIELDS = 2 / Number of fields per row
EXTNAME = ’f4v_v15_flam.tab’ / Name of extension
TTYPE1 = ’WAVELENGTH’ /
TBCOL1 = 1 /
TFORM1 = ’E15.7 ’ /
TUNIT1 = ’angstroms’ /
TDISP1 = ’G15.7 ’ /
TTYPE2 = ’FLUX ’ /
TBCOL2 = 17 /
TFORM2 = ’E15.7 ’ /
TUNIT2 = ’flam ’ /
TDISP2 = ’G15.7 ’ /

Specify your spectrum

On the **Upload Spectra** page, you may upload spectra in the usual way for your browser. Notes can be added in the pane next to the uploaded spectrum table after selecting a spectrum.

Apply your spectrum to a source

To use the uploaded spectrum, go to the **Scenes and Sources** page. You may either add a source with this new spectrum, or edit an existing source to apply this spectrum.

To apply the new spectrum to an *existing source*, first select the source in the **Select a Source pane**. Go to the **Source Editor** pane. Click the **Continuum** sub-tab and then click the radio button titled **Uploaded File** and select your spectrum from the pull-down menu. After you click the ***Save*** button, all edits made to the source will be automatically applied to all scenes using that source.

To add a new source with this spectrum to a scene, first select the **Scene**, then begin to define a new source by clicking ***New*** below the **Select a Source** pane. Select the source by clicking on the appropriate row in the **Select a Source** pane. Provide additional source details, if desired, via the different items in the sub-tabs located in the **Source Editor** pane. In the **Continuum** sub-tab, click the **Uploaded File** radio button, and select the newly uploaded spectrum from the pull-down menu, and click ***Save***. The desired uploaded spectrum is now assigned to the source. The new source can be selected and be added to the selected scene by using the ***Add Source*** button under the **Select a Scene** pane.

If you uploaded a spectrum in surface brightness units (e.g., mJy/square arcsecond) instead of flux density units (e.g., mJy), you will need to specify an ***Extended*** source under the **Shape** tab in the **Source Editor** pane. Then under **Normalization choices**, click the ***Surface Brightness*** radio button and select the correct units from the dropdown menu. For additional information on how to create an ***Extended*** source, see JWST ETC Defining an Extended Source.

References

JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, *Proc. SPIE* 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

Published	30 Dec 2016
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. Video link added. • 05 Nov 2018 Updated for ETC v1.3 • 14 Mar 2018 Note added to include upload spectra filename limitation

JWST ETC Calculations Page Overview

The JWST Exposure Time Calculator initializes a calculation once the user chooses an instrument and mode. Multiple calculations can be compared, copied, and modified in the ETC workbook.

On this page

Video Tutorial:

ETC General Overview

The **Calculations** page in the JWST ETC is where a user specifies an instrument and mode, the background, instrument and detector configuration, and observing setup and extraction strategy for a given calculation. This is typically done after scene(s) and source(s) of interest have been defined on the Scene and Sources page, although a default scene containing a central point source is always available. The **Calculations** page offers users the ability to do a comparative analysis of multiple sources or locations in the scene to determine which calculation offers the best signal-to-noise ratio (SNR).

List of articles

1. **JWST ETC Creating a New Calculation**: Instructions for setting up, editing, and running calculations in the ETC.
2. **JWST ETC Backgrounds**: Description of the available background options including example positions, dated backgrounds, and percentile options.
3. **JWST ETC Wavelength of Interest/Slice**: Explanation of the Wavelength of Interest/Wavelength of Slice option and how to make best use of it in ETC calculations.
4. **JWST ETC Batch Expansions**: Details on the various batch expansion options that can be used for quick exploration of SNR for different filters and detector parameters.
5. **JWST ETC Strategies**: Landing page with links to individual articles on all of the available extraction strategies in the ETC.
6. **JWST ETC Target Acquisition**: Landing page with links to individual articles detailing target acquisition (TA) calculations with all 4 science instruments.

Published	30 Dec 2016
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. Video link added. • 05 Nov 2018 Updated for ETC v1.3

JWST ETC Creating a New Calculation

In the JWST Exposure Time Calculator (ETC) a new calculation can be initiated by choosing an instrument and mode, or copying and modifying an existing calculation. The calculation requires an existing library of scenes and sources.

On this page

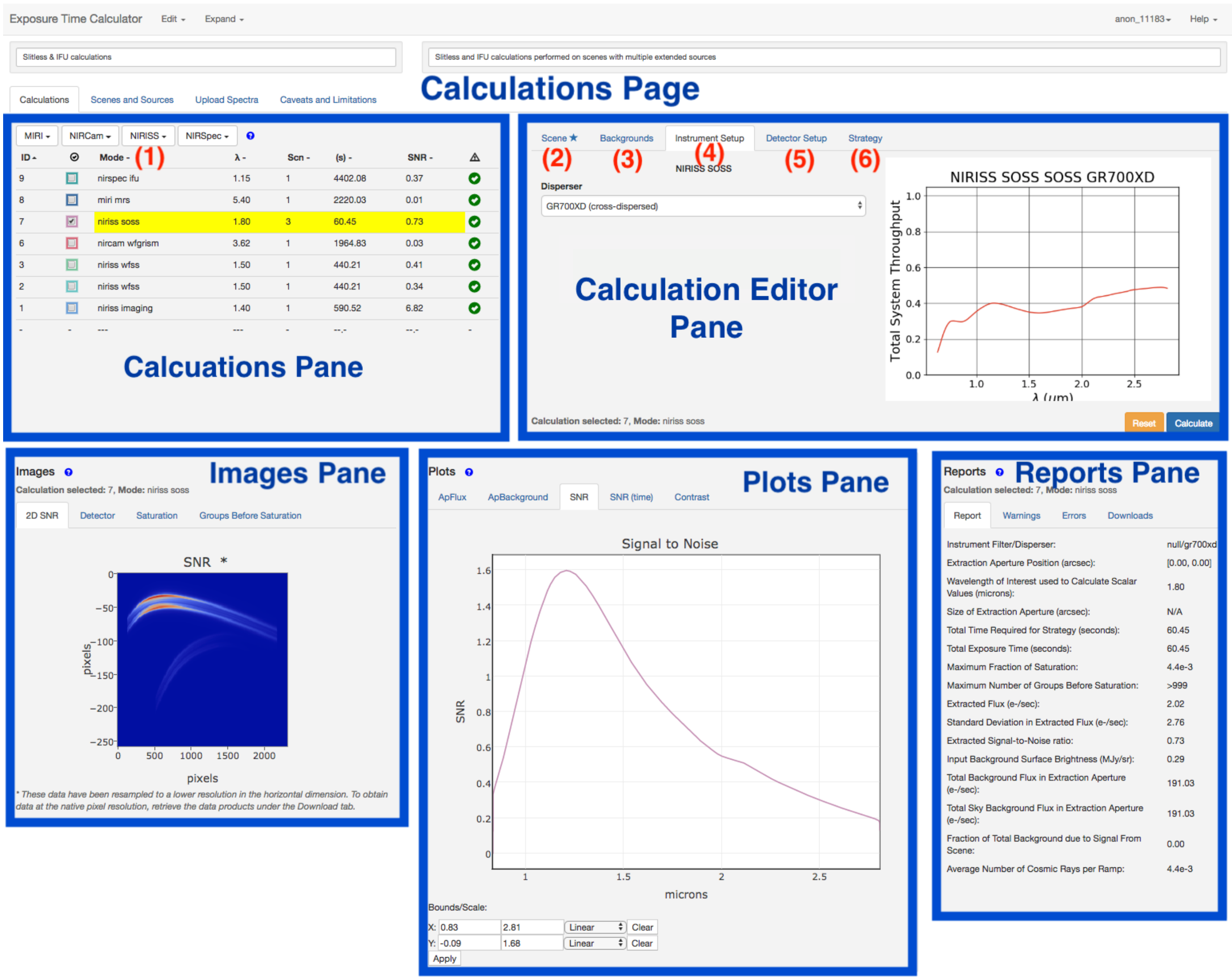
Video Tutorials:

ETC General Overview,

ETC Backgrounds

The JWST Exposure Time Calculator (ETC) calculation is performed from the **Calculations** page where the user chooses the input parameters which include: (1) instrument and mode, (2) a scene containing one or more sources, (3) background model parameters, (4) instrument configuration, (5) detector setup, and (6) the strategy for calculation of the signal-to-noise. The location of the tabs where the input parameters can be provided on the **Calculations** page is shown in Figure 1 by the numbers in red.

Figure 1. Calculation page layout



> **Video Tutorial**
>
> The video tutorial ETC General Overview provides a walk-through of setting up a calculation in ETC.

Create a new ETC calculation

A new calculation may be created by two methods: selecting an instrument and mode, or copying and modifying an existing calculation. The **Calculations** page has instrument buttons for the JWST instruments, and each instrument button has a drop-down menu with all the modes offered for that instrument. Selecting an instrument and the mode immediately initiates a calculation using the default scene with default source. The new calculation can then be edited for the desired input parameters as described in the following sections. If the user wants to copy and modify an existing calculation that is provided in a sample workbook, this is accomplished by using the ***Copy Calculation*** option from the drop-down menu under **Edit** button at the topmost left corner. This creates an exact copy of the calculation and the user can modify the calculation by changing the input parameters as described below.

Editing an ETC calculation

To edit a calculation, select it by clicking on the row corresponding to that calculation so that it is highlighted. The Calculation Editor pane (in the top right) is activated and the input parameters can now be modified to change the scene, backgrounds, instrument setup, detector setup, and strategy.

Scene

On the Calculation Editor pane, click on the **Scene** tab. This offers a drop-down menu of all the scenes available in the scene library, which is used to specify which scene should be used for the existing calculation. Often, this is the only thing users need to manipulate on the **Scene** tab.

Choosing a scene automatically populates the **Source** tab with all the sources present in that scene. The Calculation Editor pane provides all the same input parameters offered under the **Source** editor of the **Scenes and Sources** page and can be directly modified on this pane in the **Calculation** page.

> Remember that when a change is made to the source properties from the Calculation Editor pane, it modifies the source in the source library on the **Scenes and Sources** page and affects all the calculations that use that particular source. If you are not sure you want to change the property of a given source and affect all the calculations involving that source, then go to the **Scenes and Sources** page, copy and modify the source and use it in the desired scene before performing the calculation.

Backgrounds

The ETC calculations can include **Background** from the expected in-field zodiacal light (within the FOV) and stray light (scattered from the outside into the FOV), which is the total input sky background for a given set of celestial coordinates and optionally a specified date. The thermal self-emission of JWST will be characterized on-orbit, and currently the ETC assumes that the thermal self-emission is constant with time and pointing. The ETC can use and report a dated sky background or a non-dated sky background. When a date is specified, the ETC will use the background model generator to generate the background for the specified sky position (RA, Dec) for that date. The non-dated background offers a choice of low, medium, or high which corresponds to the 10th, 50th, or 90th percentile of the sky background over the period of visibility for that sky position.

Instrument setup

The **Instrument Setup** tab offers the choice of filters, grisms, dispersers, and slits for the different JWST instruments. For imaging modes, the **Instrument Setup** has a drop-down menu with the choice of filters that can be used for the imaging calculation. For the wide-field slitless spectroscopy mode—available with NIRISS and NIRCam—there are two drop-down menus, one for the grisms and the other for the blocking filters that are used in combination with the grism. The MIRI MRS mode has options for choosing the channel and disperser. NIRSpec IFU calculations require the grating/filter pair to be selected. The NIRSpec MSA setup is specified by choosing the grating/filter pair, slitlet shape, and MSA location. The NIRSpec fixed slit requires the grating/filter pair and slit to be selected. For spectroscopy modes that do not require a blocking filter, only a menu for the disperser is provided (eg; NIRISS SOSS, MIRI LRS).

Detector setup

The **Detector Setup** allows the user to specify the following parameters: ***Subarray***, ***Readout pattern***, ***Groups per integration***, ***Integrations per exposure***, ***Exposures per specification***. All of these parameters control the exposure time and photon-collecting duration.

Helpful Tips

All JWST detectors integrate using MULTIACCUM readout, which consists of "up-the-ramp" sampling.

- ***Groups per integration*** = number of groups in an integration (each group can have a number of frames that may be averaged, depending on readout pattern)

  A group consists of one or more consecutively read frames with no intervening resets. A frame is the result of sequentially clocking and digitizing all pixels in a rectangular area of a sensor chip assembly (SCA).

- ***Integrations per exposure*** = number of integrations in a single exposure

  An Integration is the end result of resetting the detector and then non-destructively sampling it one or more times over a finite period of time before resetting the detector again. This is a unit of data for which signal is proportional to intensity, and it consists of one or more GROUPS.

- ***Exposures per specification*** = number of exposures

  The end result of one or more INTEGRATIONS over a finite period of time. EXPOSURE defines the contents of a single FITS file.

The number of groups and the number of integrations vary by instrument, and users are advised to consult the documentation on JWST Astronomer's Proposal Tool (APT) and JWST instruments for more information on the allowed range of values for these detector parameters. The ETC does not support NGROUPS=1 and will alert the user with red color if Groups per integration is set to 1 and will prevent the ETC calculation from being completed. The detector parameters available for the different instruments and modes are set to be consistent with that offered by the APT. However there are cases in which ETC allows the number of groups, the number of integrations and the number of exposures to exceed the limits imposed by APT, so it is important for users to check with APT to ensure what the limits are while planning observations.

For subtle interface differences, please visit the JWST ETC to APT Interface Support article.

As mentioned above, the ETC does not support single-group (Ngroups = 1) readout modes.

Strategy

The **Strategy** tab is where the user defines the extraction parameters for the source flux and for the background to be used for background subtraction. There are different strategies implemented depending on the mode, for example, imaging, slit spectroscopy, slitless spectroscopy, and coronagraphy.

In general terms, the strategy defines the location of the aperture for extracting the source flux, and the size of the aperture. There is also an option to define a region for extracting the background flux if background subtraction is required. The background in the region defined for background flux extraction will include the sky background as well as any other flux from nearby overlapping sources that contribute to the defined background region. For the IFU modes the background is estimated by using the IFU Nod off scene option.

If a background region is not specified, then a noiseless sky background is subtracted from the source aperture. The total sky background includes the contribution to the FOV from the in-field zodiacal light and the stray light from outside that is scattered into the FOV.

Running the edited ETC calculation

After all the above mentioned parameters have been set, the calculation is performed by clicking on the **Calculate** button. If the sources used in the newly created calculation are included in other existing calculations, then all of those calculations will be run simultaneously. If the user wants to delete a calculation, there is a ***Delete Calculation*** option available in the drop-down menu under **Edit** dropdown in the top left corner. There is also an option to delete multiple calculations at once by choosing ***Delete Marked Calculations***. Once the calculation is completed the results may be viewed in the **Images** pane, **Plots** pane, and the **Reports** pane.

References

Go to the on-line JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, *Proc. SPIE* 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

Published	30 Dec 2016
Latest updates	• 29 Oct 2019 Updated for ETC v1.5. Video links added. • 05 Nov 2018 Updated for ETC v1.3. Many links to other articles added. • 04 Oct 2018 Updated definitions of exposure parameters in the Helpful Tips box. Added information about ETC and APT interface between exposure parameters. • 26 Sep 2018 Updated to include in-line links to relevant articles for ETC v1.3 upgrade

JWST ETC Backgrounds

The JWST ETC incorporates the JWST backgrounds in the calculation of signal-to-noise for a specified exposure time. JWST backgrounds vary with position on the sky and time of the year. The user may use a dated or dateless background option for a given celestial position.

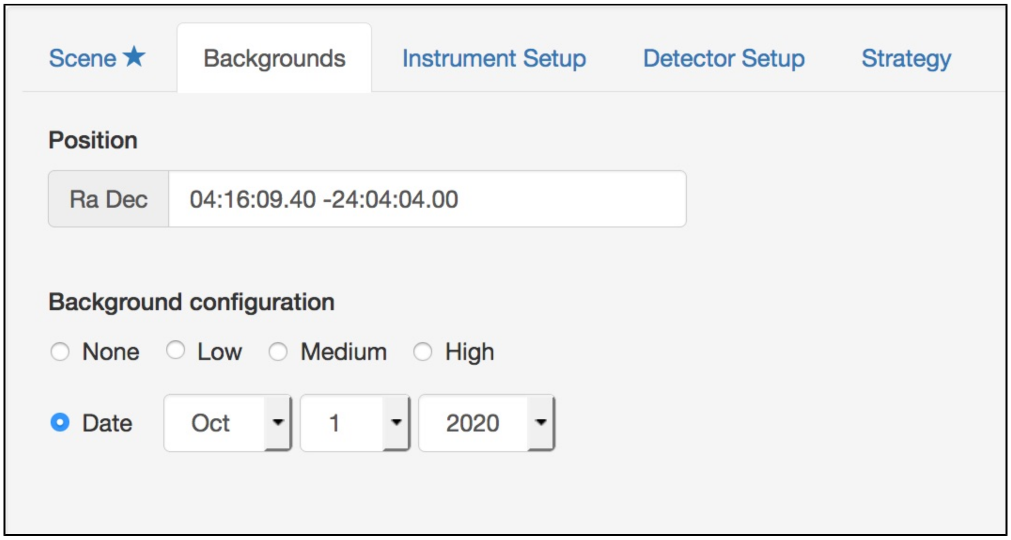
Video Tutorial:

ETC Backgrounds

Backgrounds in the JWST Exposure Time Calculator (ETC) are obtained using the Backgrounds Model Generator (BMG), and account for the various components that contribute to the JWST background. This includes the in-field components from the zodiacal cloud and the Milky Way, out-of-field stray light, and thermal self-emission from the telescope (dominates the background at wavelengths >15 μm).

The JWST ETC calculates backgrounds for a given celestial position. The J2000 RA and Dec for the position in the sky can be provided in the following formats: "hh mm ss.s ±dd mm ss.s" or "hh:mm:ss.s ±dd:mm:ss"

Figure 1. The Backgrounds tab in the JWST ETC



Layout of the Background tab where the celestial position and options for dated or dateless backgrounds are specified. The Position should be specified for whichever Background configuration option is selected.

If the user specifies a date, the ETC will give the best estimate for the background on that date for the given celestial position. Alternatively, the user can choose a low background (10th percentile), a medium background (50th percentile), or high background (90th percentile), all calculated for the selected celestial position over the period of visibility. Figure 1 shows the options in the **Backgrounds** tab in the ETC. When the dated background is chosen, the ETC will give an error if the specified celestial position is not observable on the selected date. Users are advised to use the General Target Visibility Tool (GTVT) to determine the dates when the specified celestial position is observable.

JWST ETC Reports provide the "Input Background Surface Brightness" (in MJy/steradian), as well as the "Total Background Flux in Extraction Aperture" and "Total Sky Background Flux in Extraction Aperture" (both in units of e^{-}/s). The "Total Sky Background Flux in Extraction Aperture" can also be seen graphically in the ***ApBackground*** tab in the **Plots** pane (see JWST ETC Images and Plots). The computed background spectrum can be downloaded as a FITS table as described in the JWST ETC Downloads article.

The JWST ETC can be used to check whether the observations will be background limited, and whether background-limited special requirement special requirement should be specified in the JWST Astronomers Proposal Tool Overview (APT). The procedure to determine whether the observations are background-limited is described in the article on Background-Limited Observations.

Example positions

The default background position is RA=00:00:00.00, Dec=00:00:00.0. A list of other potentially useful positions are included in Table 1. This table also includes visibility windows (valid for ETC v1.5) for each of the positions in 2021 to avoid receiving an error message in the ETC. These dates depend on the exact orbit of JWST about L2 and so are subject to change once on-orbit. Users are advised to use the General Target Visibility Tool (GTVT) to determine the dates when a specified celestial position is observable.

Table 1. List of background positions

Name	RA	Dec	Visibility (2021)
North Ecliptic Pole (NEP)	18:00:00.00	66:33:38.5	Year-round
South Ecliptic Pole (NEP)	06:00:00.00	-66:33:38.5	Year-round
Hubble Deep Field North (HDF-N)	12:36:49.50	62:12:58.0	11/11-5/29
Hubble Deep Field South (HDF-S)	22:32:56.00	-60:33:00.0	4/25-11/12
Hubble Ultra-Deep Field (HUDF)	03:32:39.00	-27:47:29.0	7/27-10/22, 11/16-2/7
North Celestial Pole (NCP)	00:00:00.00	90:00:00.0	9/9-4/2
South Celestial Pole (SCP)	00:00:00.00	-90:00:00.0	3/7-10/6
Galactic Center	17:45:40.04	-29:00:28.1	3/12-5/2, 8/3-9/25
Kepler FOV Center (Primary mission)	19:22:40.00	44:30:00.0	4/14-11/12
Lockman Hole	10:45:00.00	58:00:00.0	10/31-5/13
Default	00:00:00.00	00:00:00.0	6/16-8/7, 11/7-12/27

Published	29 Nov 2017
Latest updates	• 29 Oct 2019 Updated for ETC v1.5. Video link added. • 05 Nov 2018 Updated for ETC v1.3. Quantity names changed to match the Reports quantities in the ETC. Table of useful background positions added.

JWST ETC Wavelength of Interest /Slice

For spectroscopic calculations in the JWST Exposure Time Calculator (ETC), users have the option to specify a **Wavelength of Interest** (or **Wavelength of Slice**) in the **Strategy** tab that affects the outputs that are displayed.

Video Tutorial:

ETC IFU Strategies

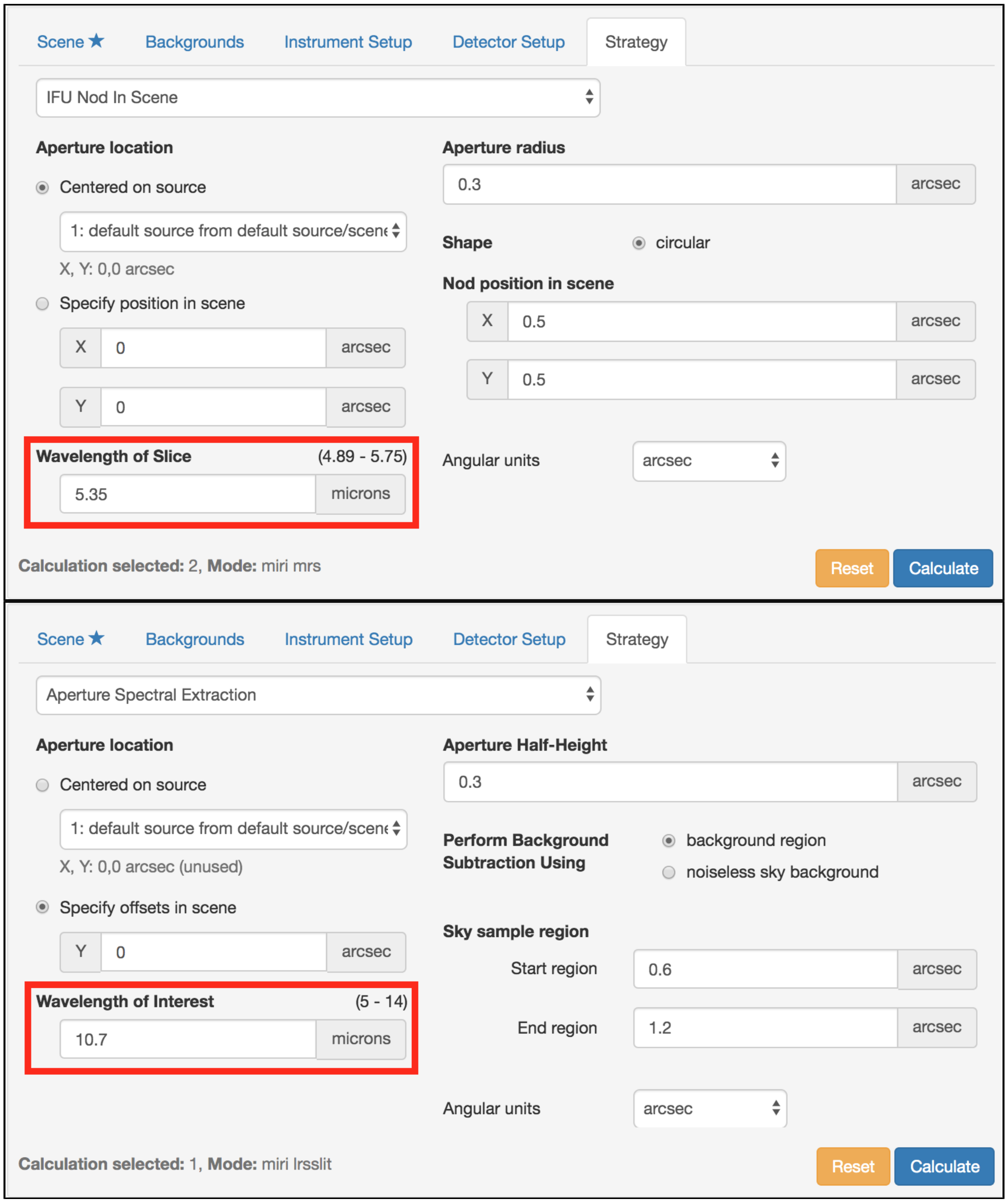
For spectroscopic calculations in the ETC, one of the required **Strategy** tab parameters is called the **Wavelength of Interest** or **Wavelength of Slice**, depending on the observing mode (Figure 1). These two parameters are equivalent, so **Wavelength of Interest** will be used to refer to both parameters for the remainder of this article. The **Wavelength of Interest** comes pre-filled with a default value, but the user can change this to any other valid wavelength within the grating's wavelength range (denoted by the values in parentheses above "microns"). This quantity is to determine the wavelength of the images displayed and the scalar values presented in the **Reports** pane. The **Wavelength of Interest** is listed as the "Wavelength of Interest used to Calculate Scalar Values" in the **Reports** pane.

Keep in mind that changing the **Wavelength of Interest** value requires the calculation to be re-run. Changing this value does not change the calculation results, only the images displayed and the values shown in the **Report**. Download the tar file or examine the plots to see the results over the full wavelength range.

The **Wavelength of Interest** is provided for the following calculation types: MIRI Low Resolution Spectroscopy (LRS) Slit, MIRI Low Resolution Spectroscopy (LRS) Slitless, NIRCam Grism Time Series, NIRCam Wide Field Slitless Spectroscopy, NIRISS SOSS, NIRISS WFSS, NIRSpec Multi-Object Spectroscopy, and NIRSpec Fixed Slit /BOTS. The **Wavelength of Slice** is provided for MIRI Medium Resolution Spectroscopy (MRS) and NIRSpec IFU.

There is no equivalent parameter to the **Wavelength of Interest** specifiable by the user for imaging and coronagraphic imaging calculations. In these instances, the "Wavelength of Interest used to Calculate Scalar Values" listed in the **Report** tab is the flux-weighted average of the input spectrum convolved with the filter transmission profile, and cannot be changed by the user.

Figure 1. Location of Wavelength of Interest and Wavelength of Slice in the Strategy tab



Wavelength of Interest Error Message

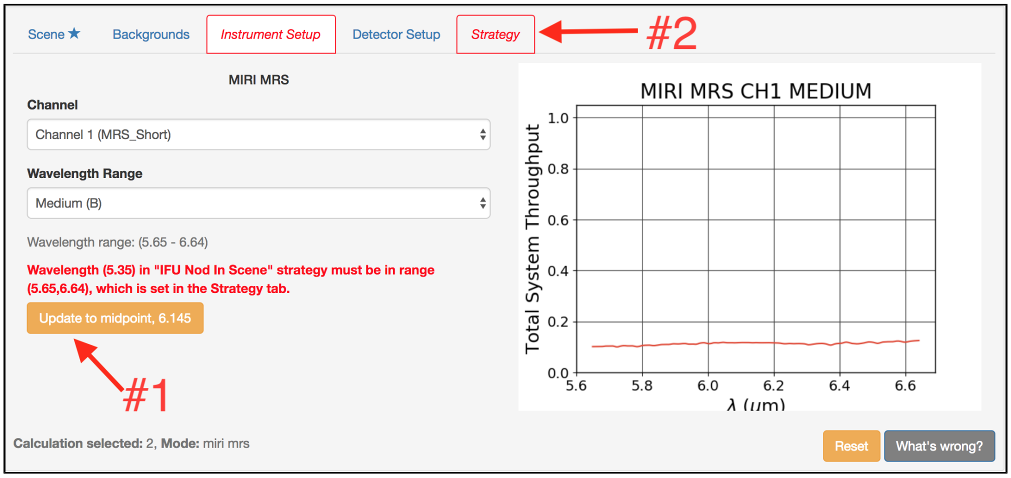
Specifying a value for the **Wavelength of Interest** that is outside the grating's wavelength range will result in an error message. Changing the configuration on the **Instrument Setup** tab will also result in an error message, but only if the chosen **Wavelength of Interest** is not valid for the new configuration.

> ⚠ The ETC does not automatically update the **Wavelength of Interest** when the user changes the configuration in the **Instrument Setup** tab. The only time this value is automatically populated is when a new calculation is created. This is in order to prevent the ETC from making changes to a workbook that the user may not be aware of.

There are two options for removing the error message (Figure 2):

1. Click on the ***Update to midpoint*** button on the **Instrument Setup** tab. This will update the value in the **Wavelength of Interest** to the value specified on the button without requiring the user to manually input a valid wavelength under the **Strategy** tab.
2. Manually update the value under the **Strategy** tab.

Figure 2. Two options for updating the Wavelength of Interest



Published	13 Nov 2018
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. Video link added.

JWST ETC Batch Expansions

Batch expansion with the JWST Exposure Time Calculator (ETC) makes copies of a calculation to show corresponding results for a number of different groups, integrations, filters, coronagraphic masks, or dispersive elements.

On this page

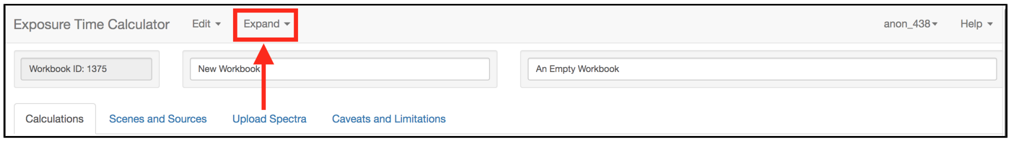
Video Tutorial:

ETC Batch Expansions

Unlike other exposure time calculators, the JWST Exposure Time Calculator (ETC) does not provide an option for reverse calculation of exposure duration parameters starting from a given signal-to-noise ratio (S/N) because there is often no unique solution for a given subarray/readout combination in terms of groups, integrations, and exposures. Instead, a *batch expansion* capability is available to test a number of different detector parameters (groups or integrations) to determine which set of parameters results in the desired S/N. Users desiring a quick check of the sensitivity in different imaging filters may also find useful the batch expansion over filters; coronagraphic imaging may additionally be expanded over masks. The MIRI Medium-Resolution Spectroscopy mode may be expanded over channels, wavelength ranges, or both.

At the top of the ETC calculations page there is an **Expand** menu of possible selections that, depending on the observing mode, may include ***Groups per integration***, ***Integrations per exposure***, ***Filters***, ***Masks***, ***Channels***, or ***Wavelength Ranges*** (Figure 1). Starting from an existing selected calculation in the **Calculations** table, these options can be used to expand the calculation over several iterative values found under the **Detector Setup** tab or different instrument components found under the **Instrument Setup** tab while holding all other parameters constant. Batch expansion will generate a number of new entries in the **Calculations** table and it is possible to select the corresponding checkboxes to compare the results of multiple calculations.

Figure 1. Location of the Expand menu in the ETC web interface



Expansion types

Batch expansion can currently be performed by iterating over a set of groups, integrations, imaging filters, coronagraphic masks, channels (MIRI MRS only), and wavelength ranges (MIRI MRS only). The user must first select or highlight a calculation in the table to be expanded. Then the user should select one of the items in the **Expand** menu near the top of the ETC pane. After determining parameter values, if applicable, clicking SUBMIT will initiate the simultaneous batch expansion. This will generate the same number of new entries or rows in the **Calculations** table as the number of iterations selected.

> Note that only the parameter selected for batch expansion (and the Wavelength of Interest/Slice) will vary in the newly created calculations; all other parameters of the original calculation are held fixed. This includes the source parameters, instrument parameters, exposure setup parameters, etc. In particular, the extraction strategy remains the same; the new calculations utilize the same extraction aperture radius and annulus or extraction box height and width. The Wavelength of Slice will be automatically updated to the midpoint wavelength for each setting in order to prevent errors.

> The ***Expand Groups*** option is available for every instrument mode. The ***Expand Integrations*** option is available for every instrument mode except target acquisition (TA). The presence of the other potential options (***Expand over Filters***, ***Expand over Masks***, ***Expand Channels***, ***Expand Wavelength Ranges***, ***Expand Channels and Wavelength Ranges***) in the **Expand** menu depends on the instrument mode of the given calculation.

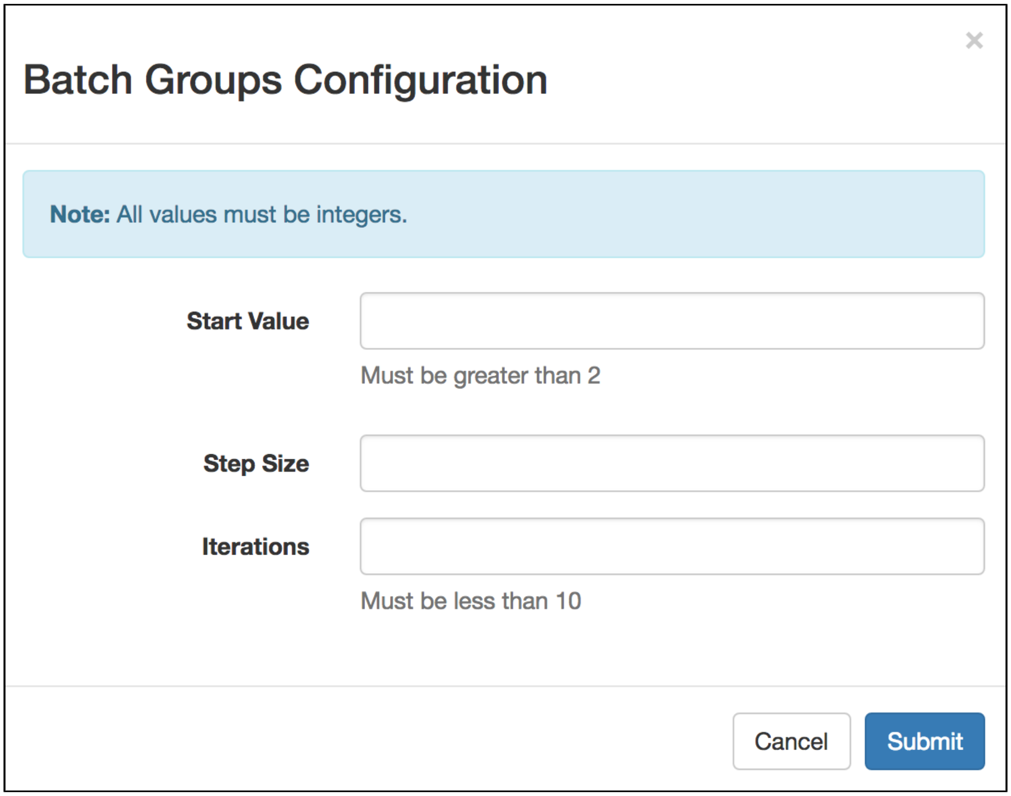
> If changes are made to the settings on the **Instrument Setup** tab, the CALCULATE button should be clicked to "save" the new settings and re-run the calculation with the new settings before using options in the **Expand** menu. Failure to do so will result in expansion over the original settings.
>
> *Example*: In a NIRCam SW Imaging calculation, the ***F070W*** filter is selected on the **Instrument Setup** tab and the user changes the filter to ***F090W***, but does not click the CALCULATE button. The user then chooses to ***Expand over Filters***. In this case, batch expansion will create new calculations for every NIRCam SW filter except the ***F070W*** filter.

Groups

A batch expansion over the number of groups is initiated by selecting the **Expand** menu at the top of the ETC window, then choosing the ***Expand Groups*** option. A pop-up window (Figure 2) will appear to prompt the user for the ***Start Value***, ***Step Size***, and ***Iterations***. The ***Start Value*** is the starting number of groups for the first calculation of the expansion and must be larger than 2 (this is the minimum number of groups allowed in the ETC). The ***Step Size*** is the increase in the number of groups to be tested at each iteration. ***Iterations*** is the number of new calculations to perform and must be less than 10 to keep the number of simultaneous calculations manageable.

Example: Specify ***Start Value***=10, ***Step Size***=2, and ***Iterations***=10. This will create 10 new calculations starting with groups=10 and ending with groups=28.

Figure 2. Pop-up window for batch expansion over groups

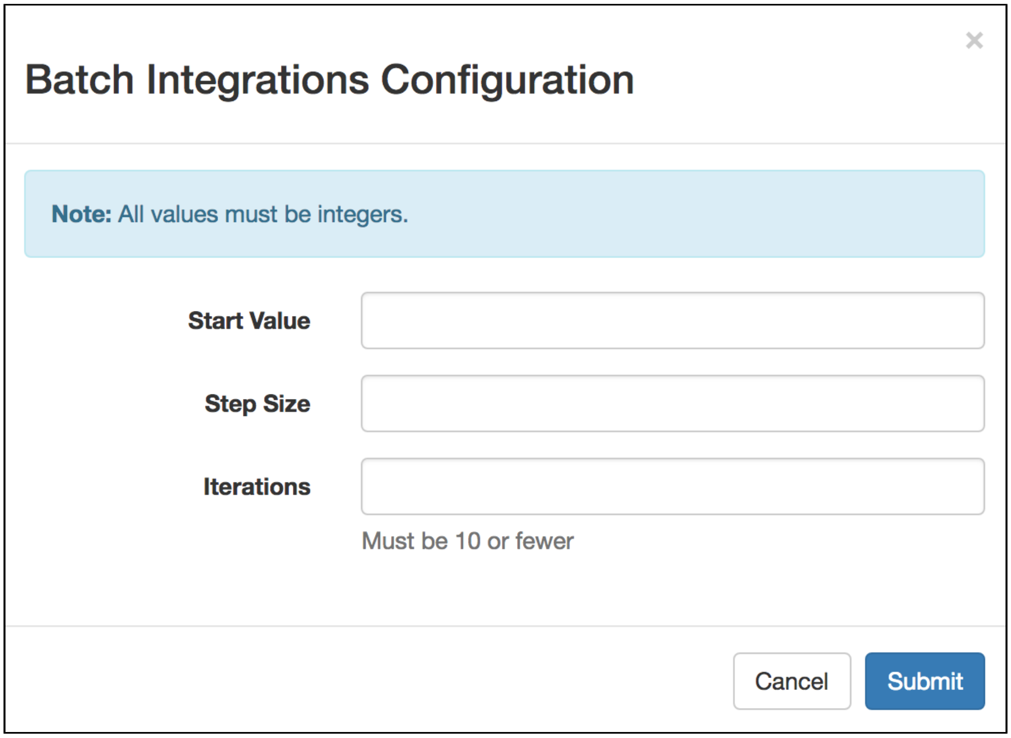


Integrations

A batch expansion on the number of integrations is initiated by selecting the **Expand** menu at the top of the ETC window, then choosing the ***Expand Integrations*** option. A pop-up window (Figure 3) will appear to prompt the user for the ***Start Value***, ***Step Size***, and ***Iterations***. The ***Start Value*** is the starting number of integrations for the first calculation of the expansion. The ***Step Size*** is the increase in the number of integrations to be tested at each iteration. ***Iterations*** is the number of new calculations to perform and must be less than 10 to keep the number of simultaneous calculations manageable.

Example: Specify ***Start Value***=1, ***Step Size***=1, and ***Iterations***=10. This will create 10 new calculations starting with integrations=1 and ending with integrations=10.

Figure 3. Pop-up window for batch expansion over integrations



Filters

A batch expansion over imaging filters is initiated by selecting the **Expand** menu at the top of the ETC window, then choosing the ***Expand over Filters*** option. If this option is chosen, a set of calculations will be initiated immediately by simultaneously expanding upon all filters available for that instrument mode. Batch expansion over filters is available for the following modes: MIRI Imaging, MIRI Target Acquisition, NIRCam SW Imaging, NIRCam LW Imaging, NIRCam SW Time-Series Imaging, NIRCam LW Time-Series Imaging, NIRCam Coronagraphic Imaging, NIRISS AMI, NIRISS Imaging, NIRISS WFSS, NIRSpec Target Acquisition.

Example: In a NIRCam Coronagraphic Imaging calculation, if the ***MASK201R*** mask and ***F182M*** filter are selected on the **Instrument Setup** tab and the ***Expand over Filters*** option is chosen, five new calculations will be created for each of the other unused filters associated with this mask. All other parameters will remain unchanged.

Note that if a user wants to adjust the extraction aperture in different filters to account for changing PSF size, this will need to be done by-hand for each individual calculation; there is currently no batch expansion for ***Aperture radius***.

Masks (NIRCam Coronagraphic Imaging only)

A batch expansion over coronagraphic masks is initiated by selecting the **Expand** menu at the top of the ETC window, then choosing the ***Expand over Masks*** option. If this option is chosen, a set of calculations will be initiated immediately by simultaneously expanding upon all masks associated with the selected coronagraphic imaging filter. Batch expansion over masks is only currently available for NIRCam Coronagraphic Imaging.

Example: In a NIRCam Coronagraphic Imaging calculation, if the ***MASK201R*** mask and ***F182M*** filter are selected on the **Instrument Setup** tab and the ***Expand over Masks*** option is chosen, one new calculation will be created for the ***MASKSWB*** mask. This is because the ***F182M*** filter is only used in conjunction with the ***MASK201R*** and ***MASKSWB*** masks. See a full list of mask/filter combinations on the NIRCam Coronagraphic Imaging page.

Channels (MIRI MRS only)

A batch expansion over MIRI Medium Resolution Spectroscopy (MRS) channels is initiated by selecting the **Expand** menu at the top of the ETC window, then choosing the ***Expand Channels*** option. If this option is chosen, a set of calculations will be initiated immediately by simultaneously expanding upon all channels for the selected wavelength range.

Example: ***Channel 2 (MRS_Short)*** and ***Long (C)*** are selected for ***Channel*** and ***Wavelength Range***, respectively. The user selects ***Expand Channels***. Three new calculations are created so that all 4 choices of ***Channel*** are represented for the ***Wavelength Range*** selection of ***Long (C)***.

Wavelength Ranges (MIRI MRS only)

A batch expansion over MIRI Medium Resolution Spectroscopy (MRS) wavelength ranges is initiated by selecting the **Expand** menu at the top of the ETC window, then choosing the ***Expand Wavelength Ranges*** option. If this option is chosen, a set of calculations will be initiated immediately by simultaneously expanding upon all wavelength ranges for the selected channel.

Example: ***Channel 2 (MRS_Short)*** and ***Long (C)*** are selected for ***Channel*** and ***Wavelength Range***, respectively. The user selects ***Expand Wavelength Ranges***. Two new calculations are created so that all 3 choices of ***Wavelength Range*** are represented for the ***Channel*** selection of ***Channel 2 (MRS_Short)***.

> Selecting the option to ***Expand Channels and Wavelength Ranges*** will result in a total of 12 MIRI MRS calculations covering all the possible combinations of ***Channel*** and ***Wavelength Range***.

References

JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, *Proc. SPIE* 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

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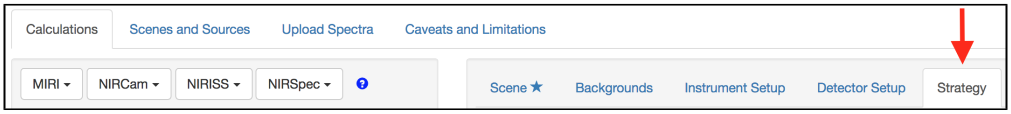
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. Video link added. • 05 Nov 2018 Information added for the new batch expansions available in ETC v1.3

JWST ETC Strategies

The JWST Exposure Time Calculator (ETC) reports the results of calculations performed using a specified strategy that includes information about location and size of the extraction aperture, wavelength of interest, and choice of regions for background subtraction.

The JWST ETC enables exposure time calculations for a variety of instrument modes, including direct imaging, slit spectroscopy, slitless spectroscopy, integral field unit (IFU) spectroscopy, and coronagraphic imaging. The signal-to-noise ratio is computed using extraction strategies that are specific to the different modes. After the user has selected the scene, backgrounds, instrument setup, and detector setup, as described in the article Creating a JWST ETC Calculation, the next step is to define the strategy to be used for computing the signal-to-noise. The **Strategy** tab, shown below, provides choices for the extraction strategy, background subtraction, size and position of the background region, and the wavelength of interest/slice for spectroscopic calculations.

Figure 1. Location of the strategy tab in the ETC web application



The strategies are set using the Strategy tab on the Calculations tab page.

List of articles

1. **JWST ETC Imaging Aperture Photometry Strategy**: Information on the strategy used for MIRI, NIRCam, and NIRISS imaging calculations.
2. **JWST ETC Aperture Spectral Extraction Strategy**: Details of the extraction strategy available for slitted mode calculations, such as MIRI LRS Slit and NIRSpec Fixed Slit/BOTS.
3. **JWST ETC MSA Full Shutter Extraction Strategy**: Information specific to the extraction strategy for NIRSpec MSA calculations.
4. **JWST ETC IFU Nod In Scene and IFU Nod Off Scene Strategy**: A description of the two strategies available for MIRI MRS and NIRSpec IFU calculations.
5. **JWST ETC SOSS Spectral Extraction Strategy**: Specific information on the extraction strategy for NIRISS SOSS calculations.
6. **JWST ETC Coronagraphy Strategy**: Information on the strategy used for MIRI and NIRCam coronagraphic imaging calculations.
7. **JWST ETC MSA Aperture Photometry Strategy**: Details on the extraction strategy for the NIRSpec MOS Verification Imaging mode.
8. **JWST ETC MSA Shutter Photometry Strategy**: Details on the extraction strategy for the NIRSpec MOS Confirmation Imaging mode.

For additional instrument/mode specific ETC strategies please refer to NIRISS AMI Recommended Strategies, NIRISS Imaging Recommended Strategies and NIRISS WFSS Recommended Strategies articles.

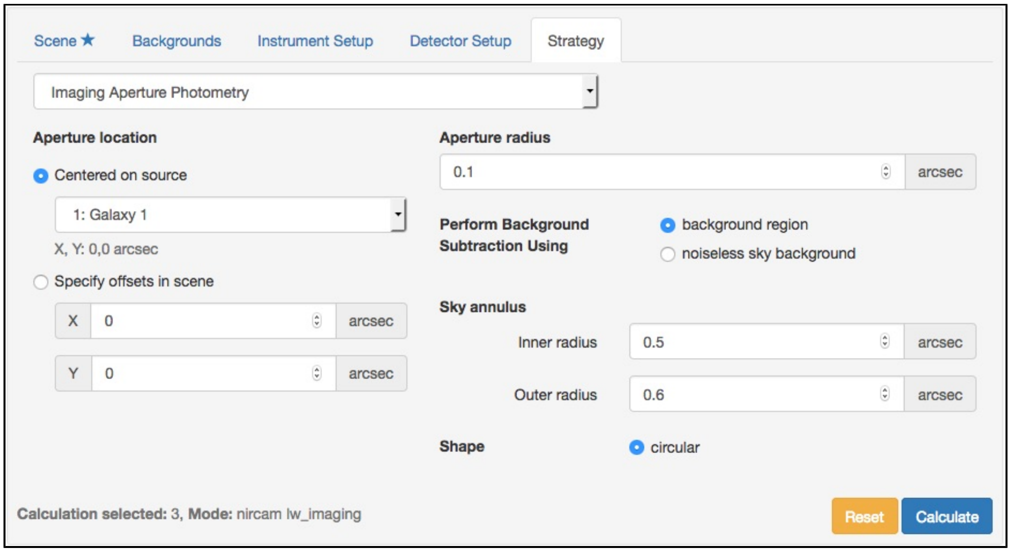
Published	05 May 2017
Latest updates	• 23 Dec 2019 Updated for ETC v1.5. • 05 Nov 2018 Updated for ETC v1.3.

JWST ETC Imaging Aperture Photometry Strategy

The JWST Exposure Time Calculator (ETC) calculates the signal-to-noise ratio for imaging modes of all JWST instruments, and for the NIRISS aperture masking interferometry mode, using the ***Imaging Aperture Photometry*** strategy. The user specifies the apertures for extracting the source flux and background flux.

The ***Imaging Aperture Photometry*** strategy presents users with various options to define the size, and location for the photometry aperture used for extracting the source flux. The background flux is determined from the **Sky annulus** whose ***inner radius*** and ***outer radius*** are also provided as input parameters.

Figure 1. Layout of the strategy tab for ETC calculations for the imaging modes



The following parameters are to be provided for ***Imaging Aperture Photometry***:

- **Aperture location**: (1) The aperture may be centered on any desired source within the scene used for the calculation. The drop-down menu is populated with a list of the sources available in the scene from which the selection can be made. (2) The aperture may be chosen to be at any desired location within the scene (that is, not necessarily centered on a source) by specifying the X- and Y-offsets in arcsec from the scene center.

- **Aperture radius**: The aperture used for imaging aperture photometry is circular, and this parameter specifies the radius in arcsec of the circular aperture used for extraction.

- **Perform Background Subtraction Using**: There is an option to perform background subtraction using the background estimated from a ***background region*** specified by the user, or using a ***noiseless sky background***. The ***background region*** is defined by specifying the ***inner radius*** and ***outer radius*** parameters for the **Sky annulus**.

  Note that when a **Sky Annulus** is specified, it includes contamination from all sources within the scene that contribute to the annulus in addition to the sky, e.g., when overlapping sources are present, or extended profile wings of the source itself contributes to the background extraction aperture. When the background subtraction is performed, the contamination and sky contributions are subtracted. The estimated contamination from sources within the scene over the sky background is reported in the ETC output Reports pane as "Fraction of total background due to signal from the scene."

  If the option to use the ***noiseless sky background*** is selected, then the count rate corresponding to the sky background chosen in the Backgrounds tab is used for background subtraction. When the ***noiseless sky background*** is opted for background subtraction, the contamination from within the scene is not subtracted from the extracted source flux. The users may want to consider using a ***noiseless sky***

background in some cases, for example, when performing photometry of a source that is located on a bright extended background with significant gradient within the background annulus. Also, a ***noiseless sky background*** may be preferred when performing point source photometry with a constant aperture radius and doing a batch expansion over filters, to account for the larger PSF at longer wavelengths.

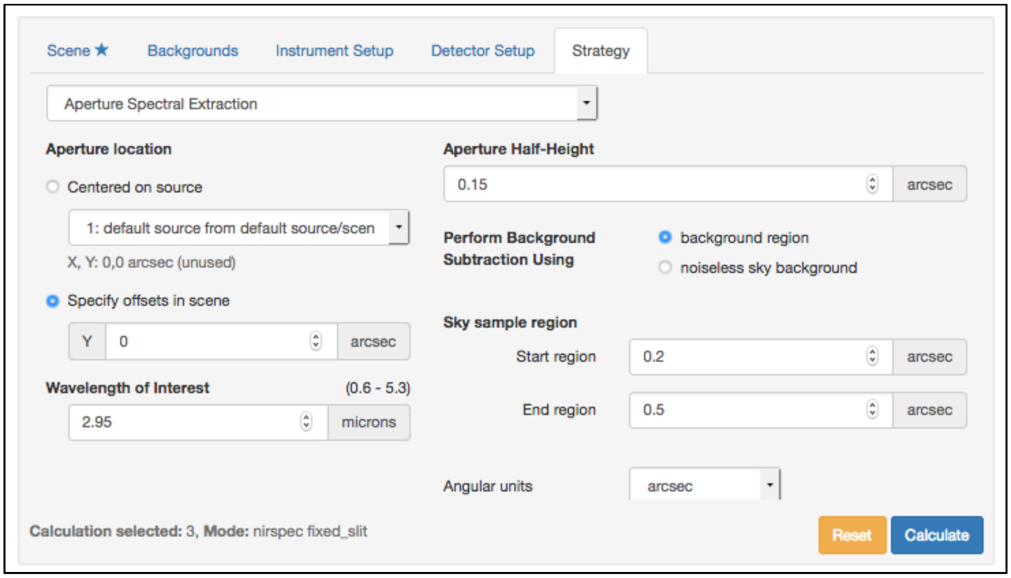
- **Shape:** The imaging aperture photometry uses a ***circular*** aperture.

Published	01 May 2017
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. • 05 Nov 2018 Updated for ETC v1.3 • 26 May 2017 additional text about background

JWST ETC Aperture Spectral Extraction Strategy

The JWST ETC ***Aperture Spectral Extraction*** strategy is used for spectroscopic modes, including slit spectroscopy with NIRSpec and MIRI, and slitless spectroscopy modes (NIRISS wide field slitless spectroscopy, NIRCam wide field slitless spectroscopy, and MIRI low-resolution spectroscopy).

Figure 1. Layout of the Strategy tab for spectroscopy calculations



The following setup parameters are available for the ***Aperture Spectral Extraction*** strategy:

- **Aperture location:**

    a. ***Centered on source***: The aperture may be centered on any desired source within the scene used for the slitless spectroscopy calculation. The drop-down menu is populated with a list of the sources available in the scene from which the selection can be made. For fixed slit spectroscopy, if there are multiple sources located within the slit along the cross-dispersion direction, they may be selected from the drop-down menu.
    b. ***Specify offsets in scene***: The aperture can be chosen to be at any desired location within the slit along the cross-dispersion direction (for slit spectroscopy and X-dispersed slitless spectroscopy) by specifying the Y-offset in arcsec from the slit center.

> ⚠ There is currently no option to provide an X-offset when the *Specify offsets in scene* option is selected. This prevents proper manual placement of the extraction aperture for slitless spectroscopy when the source is offset within the scene. **For this reason, it is highly recommended that you select the *Centered on source* option, otherwise the wavelength grid may be shifted with respect to the spectrum**. The *Centered on source* option is currently the default option for NIRISS WFSS, but *Specify offsets in scene* is the default for MIRI Low Resolution Spectroscopy (LRS) Slitless, NIRCam LW Grism Time Series, and NIRCam Wide Field Slitless Spectroscopy.

- **Aperture Half-Height:** This corresponds to the half-height of the extraction aperture in the cross-dispersion direction. The spectral extraction is performed over the full extent of the specified extraction aperture.

- **Perform Background Subtraction Using:** As in the case of imaging, there is an option to perform background subtraction using the background estimated from a ***background region*** specified by the user, or using a ***noiseless sky background***. The latter may be preferred when the scene has other sources that may contribute a non-uniform background to the aperture. The effect of non-uniform backgrounds may be estimated by performing two calculations; with and without the background contamination from within the other sources in the scene.

The **Sky sample region** is specified by using the ***Start region*** and ***End region*** parameters. These parameters correspond to the inner and outer bounds of the sky region in cross-dispersion direction. If the option to use the ***noiseless sky background*** is selected, the count rate corresponding to the sky background chosen under the **Backgrounds** tab is used for background subtraction. Note that when a ***background region*** is specified, it also includes contamination from other overlapping regions when multiple sources are present, extended emission if present, or extended profiles that contribute to the background extraction aperture. When the background subtraction is performed, the contamination and sky contribution are subtracted. When the ***noiseless sky background*** is opted for background subtraction, the contamination is not subtracted from the extracted source flux.

- **Wavelength of Interest/Slice:** This specifies the wavelength at which the scalar quantities are reported in the **Reports** pane.

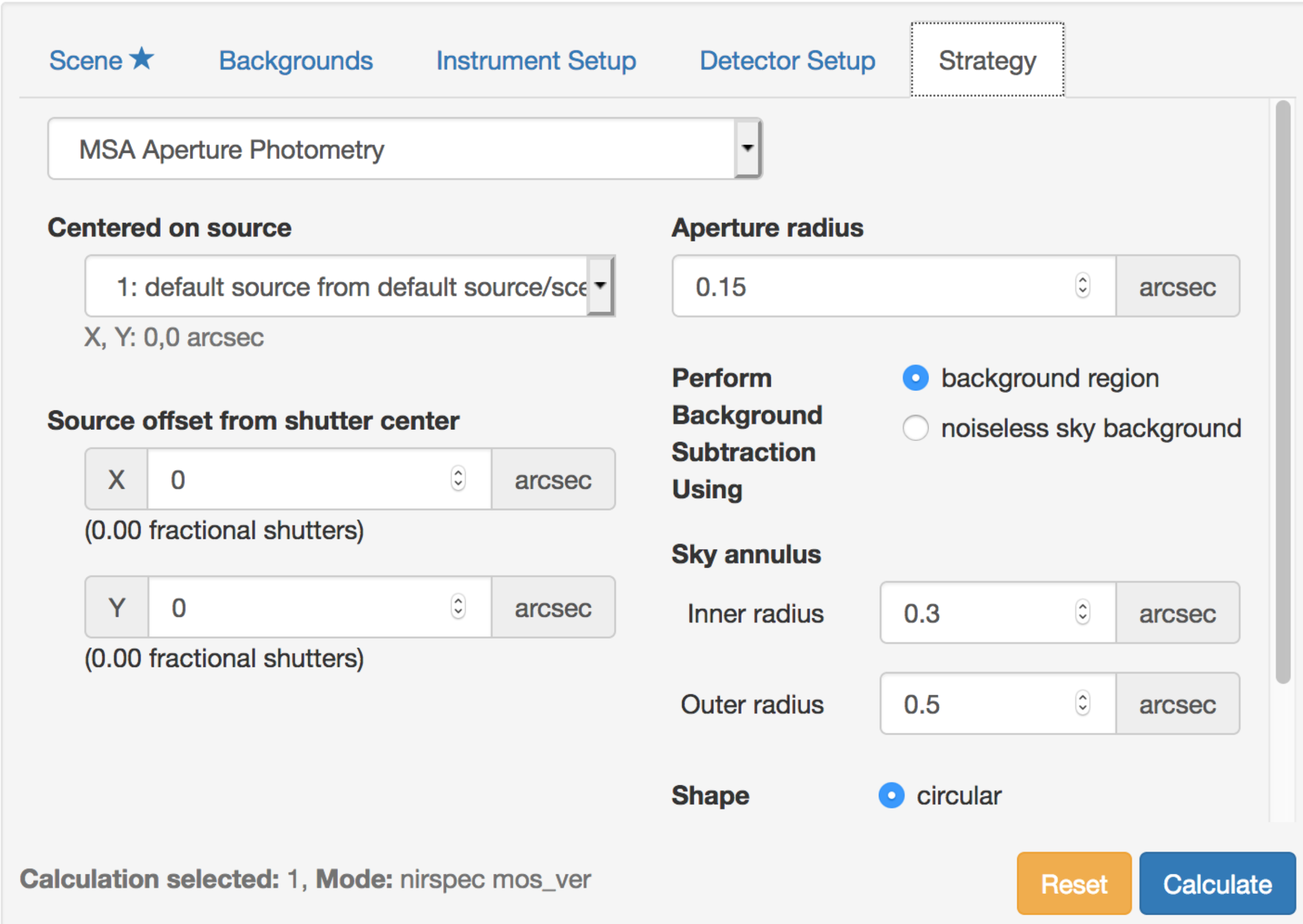
Published	05 May 2017
Latest updates	• 20 Dec 2019 Added warnings about current default options. • 09 Oct 2019 Updated for ETC v1.5. • 05 Nov 2018 Updated for ETC v1.3

JWST ETC MSA Full Shutter Extraction Strategy

The ***MSA Full Shutter Extraction*** strategy is only available for the JWST NIRSpec multi-object spectroscopy mode.

The NIRSpec multi-object spectroscopy mode has two strategies that can be used for determining signal to noise in the ETC calculations; (1) ***Aperture Spectral Extraction*** and (2) ***MSA Full Shutter Extraction***. The ***MSA Full Shutter Extraction*** strategy is useful when a source fits entirely into a single shutter.

Figure 1. Layout of the Strategy tab for *MSA Full Shutter Extraction*



The ***MSA Full Shutter Extraction*** strategy is setup using the following parameters:

- **Centered on source:** The extraction region can be centered on a source that is selected from the sources available in the drop-down list.
- **Source offset from shutter center:** The extraction region may be specified by providing the X- and Y-offset from the shutter center. The number of "fractional shutters" that an X- or Y-offset corresponds to is reported below each input box. Note that "1.00 fractional shutters" equates to one shutter half-width or half-height; the source is now on the edge of the shutter. Equivalently, "2.00 fractional shutters" equates to a full shutter width or height; the source is now in the center of an adjacent shutter.
- **Perform Background Subtraction Using:** The background subtraction can be done using background estimated from the ***background region***, or by subtracting the ***noiseless sky background***. If the option to use the ***noiseless sky background*** is selected, the count rate corresponding to the sky background chosen under the Backgrounds tab is used for background subtraction. This option may be preferred when the scene has other sources that may contribute a non-uniform background to the aperture. If the ***background region*** option is selected, then the background is estimated from shutters in the slitlet that are adjacent to

the shutter where the source is located. For example, in the instrument setup case of a slitlet having 3 shutters (-1,0,1), if the source is located in shutter 0, then the background is estimated from shutters -1 and 1.

- **Wavelength of Interest/Slice:** The selected wavelength of interest/wavelength of slice must be within the wavelength range for the chosen instrument setup. It specifies the wavelength at which the scalar quantities are reported in the Reports pane.

Published	05 May 2017
Latest updates	• 06 Dec 2019 Added clarification on what "fractional shutters" refers to. • 09 Oct 2019 Updated for ETC v1.5. • 05 Nov 2018 Updated for ETC v1.3

JWST ETC IFU Nod in Scene and IFU Nod off Scene Strategy

The JWST Exposure Time Calculator (ETC) **Strategy** tab for the NIRSpec IFU and MIRI MRS modes offers two options: ***IFU Nod In Scene*** and ***IFU Nod Off Scene***. These options allow users to specify how and from where the background flux should be extracted for the signal-to-noise calculation.

On this page

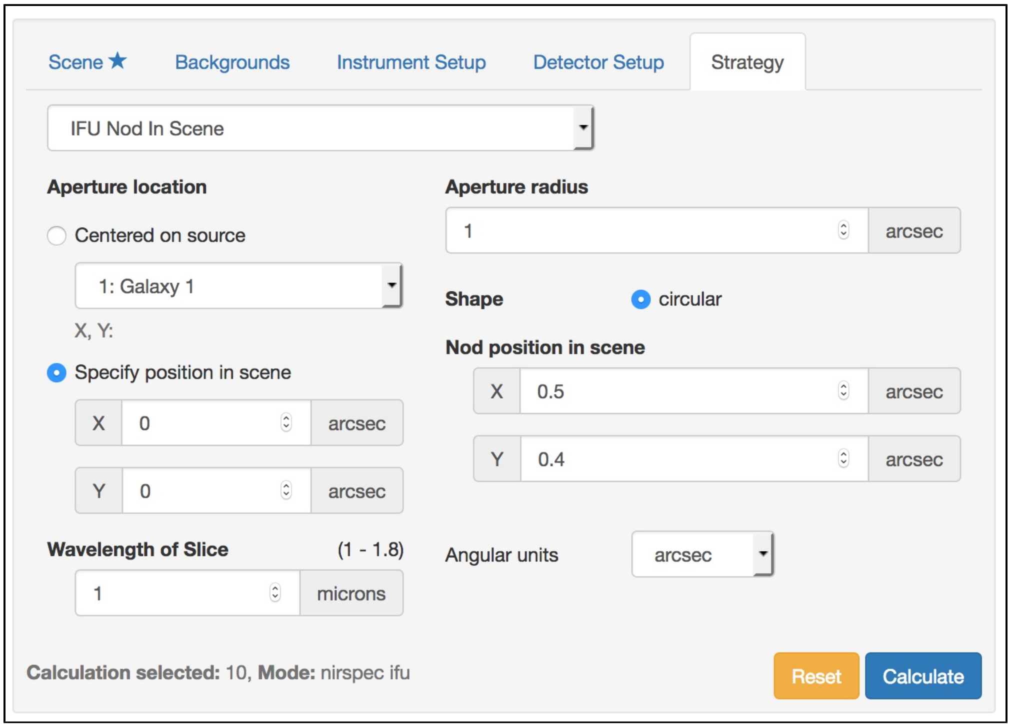
Video Tutorial:

ETC IFU Strategies

IFU Nod In Scene will produce a higher SNR for the same Detector Setup parameters compared with ***IFU Nod Off Scene*** because the source flux is being accumulated both at the initial position and at the nod position. For ***IFU Nod Off Scene***, there is no source flux in the off-source nod position because it is completely off the scene and only contains the sky background. Only half of the exposure time requested for the ***IFU Nod Off Scene*** strategy is on-source and hence the SNR is lower.

IFU Nod In Scene

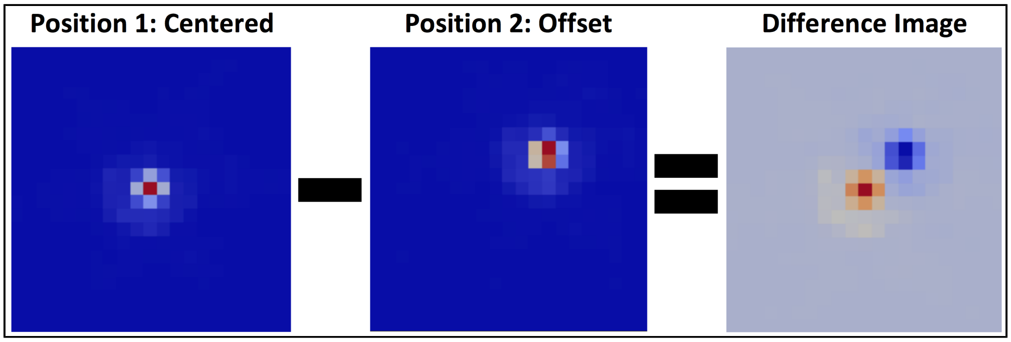
Figure 1. Layout for *IFU Nod In Scene* under ETC strategy



Selecting the ***IFU Nod In Scene*** option allows the user to set the strategy for the sources in the IFU scene. The following are sub-options within this strategy:

- The **Aperture location** can be specified to be centered on a source which can be selected from the drop-down menu, or can be specified as an X- and Y-offset from the scene center.
- The **Shape** of the aperture for this strategy is circular with the radius measured in units of arcseconds. A default value is provided but can be changed by the user. **Note**: For point sources, the SNR can be highly dependent on the choice of aperture radius. It is recommended that users test different values for the aperture radius to optimize the SNR in the calculation.
- The **Nod position in scene** is used for background determination from within the scene and is specified by providing the X- and Y-position in arcseconds. The second nod (the offset nod) is subtracted from the first nod (see Figure 2), then flux is extracted within the specified aperture at each position and co-added. The number of integrations, which is specified under the Detector Setup tab, is multiplied by a factor of 2 to account for both nods.
- The **Wavelength of Slice** corresponds to the wavelength at which the 2D images are displayed in the output and the scalar values are reported in the **Reports** pane. A default value is provided but can be changed by the user. The allowed wavelength range depends on the choices made in the **Instrument Setup** tab (i.e., depending on the channel and disperser combination for the MIRI MRS and the Grating/Filter Pair for the NIRSpec IFU). If the **Wavelength of Slice** provided is invalid, the affected tab names will turn italicized in red and an explanatory red text will appear to indicate the incorrect parameter.

Figure 2. Schematic diagram showing the *IFU Nod In Scene* strategy



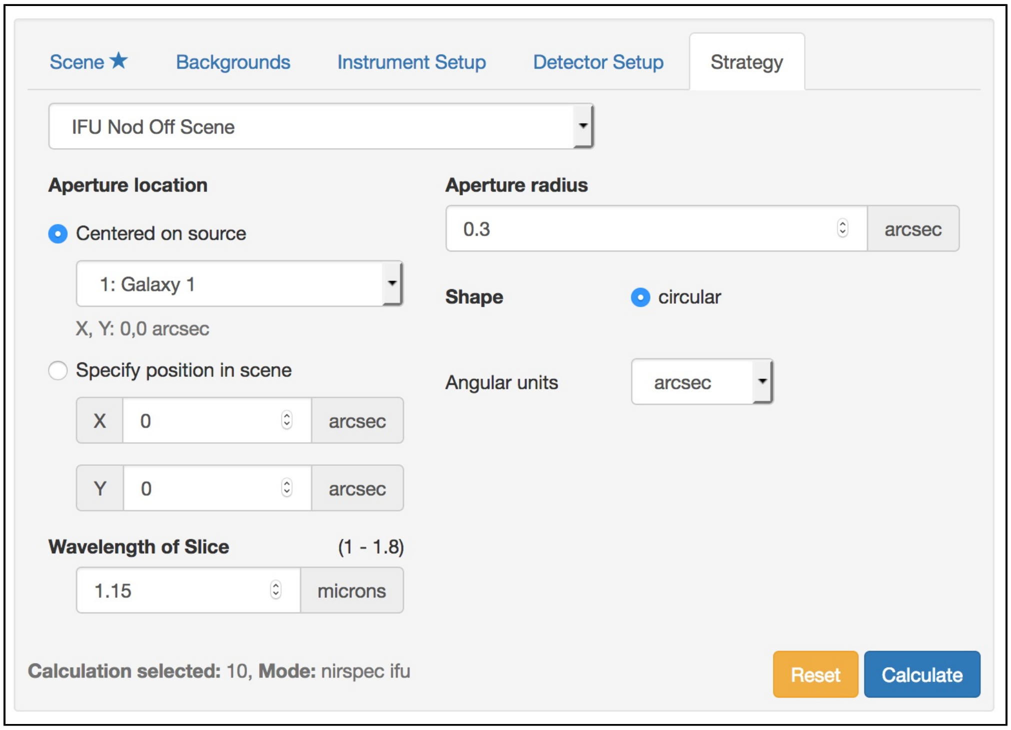
Position 1: Source and scene specified by user. The source may be offset from the center of the scene, but here we present a source centered in the middle of the scene.

Position 2: Nod position specified by the user under the Strategy tab. Default values are provided but can be changed.

Difference image: Position 2 subtracted from Position 1. Red in this image indicates a positive value, while blue indicates a negative value. The SNR is the co-addition of both positions.

IFU Nod Off Scene

Figure 3. Layout for *IFU Nod Off Scene* under ETC strategy



For the IFU modes, the background can also be estimated by using the ***IFU Nod off Scene*** option to mimic a dedicated sky observation. The following are sub-options within this strategy:

- The **Aperture location** can be specified to be centered on a source, which can be selected from the drop-down menu, or can be specified as an X- and Y-offset from the scene center.
- The **Shape** of the aperture for this strategy is circular with the radius measured in units of arcseconds. A default value is provided but can be changed by the user. **Note**: For point sources, the SNR can be highly dependent on the choice of aperture radius. It is recommended that users test different values for the aperture radius to optimize the SNR in the calculation.
- The **Wavelength of Slice** corresponds to the wavelength at which the 2D images are displayed in the output and the scalar values are reported in the **Reports** pane. A default value is provided but can be changed by the user. The allowed wavelength range depends on the choices made in the **Instrument Setup** tab (i.e., depending on the channel and disperser combination for the MIRI MRS and the Grating/Filter Pair for the NIRSpec IFU). If the **Wavelength of Slice** provided is invalid, the affected tab names will turn italicized in red and an explanatory red text will appear to indicate the incorrect parameter.

Published	05 May 2017
Latest updates	• 20 Dec 2019 Wording changes and clarification. • 05 Nov 2018 Updated for ETC v1.3

JWST ETC SOSS Spectral Extraction Strategy

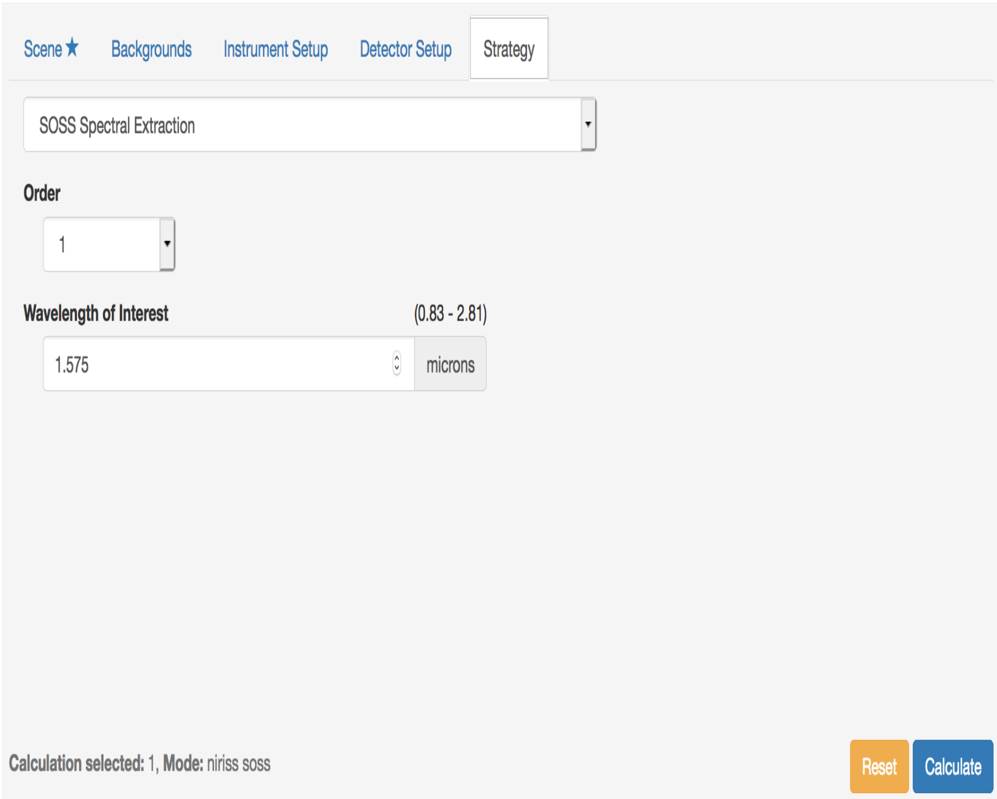
The JWST Exposure Time Calculator (ETC) ***SOSS Spectral Extraction*** strategy is only used for the NIRISS single object slitless spectroscopy mode, and allows extraction of the signal to noise for 2 spectral orders that will be used for science observations.

NIRISS Single Object Slitless Spectroscopy (SOSS) covers the wavelength range 0.63 to 2.81 µm and has 2 spectral orders that are scientifically useful, with order 1 covering 0.83 to 2.81 µm and order 2 covering 0.63 to 1.26 µm. The ***SOSS Spectral Extraction*** strategy in the ETC provides an option to specify the order for which the signal-to-noise ratio should be reported (Figure 1).

SOSS offers full-frame readout and two subarray options, ***SUBSTRIP256***, which samples both orders, and ***SUBSTRIP96***, which captures only the 1st spectral order (an error will be returned when attempting to run a calculation with ***SUBSTRIP96*** and order set to 2). The wavelength range covered by the 2 spectral orders are different and the wavelength at which to report the SNR should be specified accordingly.

The readout pattern and subarray options are specified in the **Detector Setup** tab. Both ***NIS*** and ***NISRAPID*** are supported for full-frame readout, but only ***NISRAPID*** is supported when using either the ***SUBSTRIP256*** or ***SUBSTRIP96*** subarray. An error will be returned when selecting ***NIS*** readout and the ***SUBSTRIP256*** or ***SUBSTRIP96*** subarray.

Figure 1. Layout of the Strategy tab for *SOSS Spectral Extraction*



The extraction height of the SOSS spectrum in the cross-dispersion direction is determined by the PSF. The PSF for NIRISS SOSS is extended due to slight defocus that is built-in to allow observations of bright targets without causing saturation. The sky background is extracted for the same aperture set by the PSF, and there is no contaminating background flux in this case. The sky background is set by the options under the Backgrounds tab.

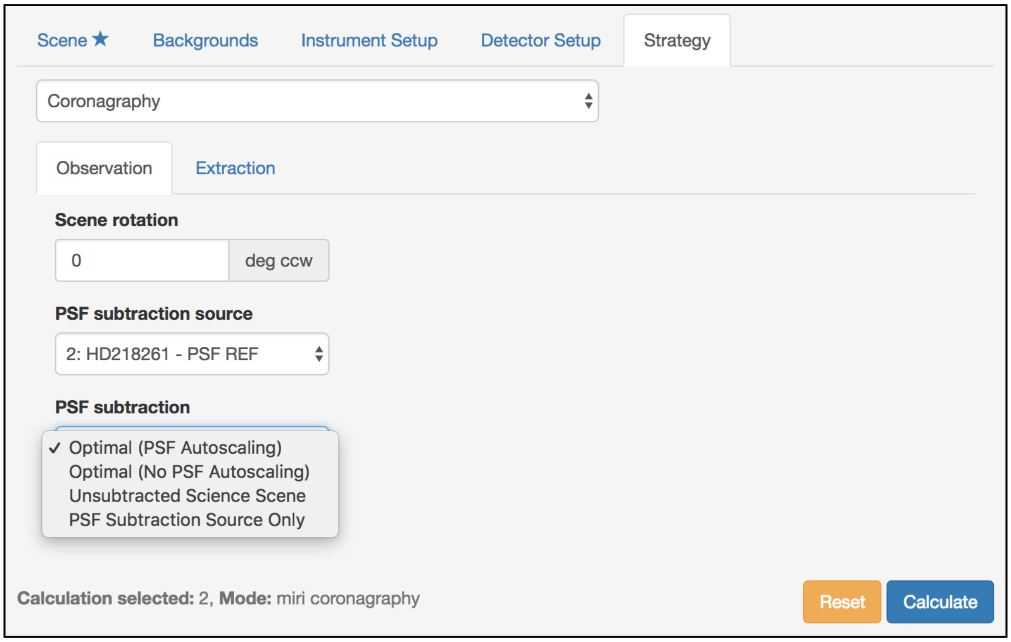
Published	05 May 2017
Latest updates	• 09 Oct 2019 Updated for ETC v1.5

JWST ETC Coronagraphy Strategy

The JWST Exposure Time Calculator (ETC) ***Coronagraphy*** strategy is used for calculating the signal-to-noise ratio and contrast for MIRI and NIRCam coronagraphy ETC calculations.

For coronagraphic ETC calculations, a user would be interested in the signal-to-noise ratio (SNR) that can be achieved for a faint companion that is close to a bright star, or for circumstellar features around a bright host star. The bright star in this case can be many orders of magnitude brighter than the faint features of science interest. The ETC provides predictions for coronagraphic observations by including reference PSF stars for PSF subtraction from the source of interest. There are two tabs under **Strategy** for coronagraphy in the ETC: (1) **Observation** and (2) **Extraction**.

Figure 1. Layout of the Observation under the Strategy tab for *Coronagraphy*



(1) Observation: Parameters for the PSF calibration are set under this tab.

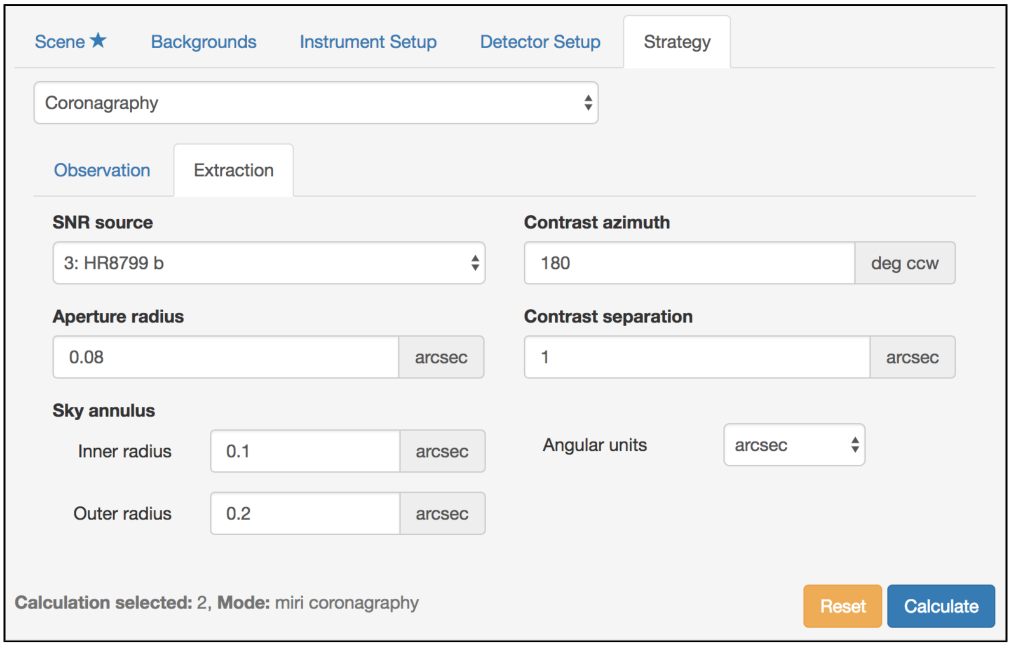
- **Scene rotation:** This allows rotation of the scene with respect to the non-azimuthally symmetric structure of the coronagraph's focal plane (such as cross pattern for the MIRI FQPM, or bars for NIRCam) . When used in conjunction with the coronagraph visibility tool (at the page JWST Coronagraphic Visibility Tool Help), this feature allows the user to determine the optimal aperture position angle special requirement for the scene of interest.
- **PSF subtraction source:**The reference star that should be used for PSF subtraction can be selected from the drop-down menu that has a list of all the sources in the scene.
- **PSF subtraction:** The default PSF subtraction strategy, whereby four options are available:
  - ***Optimal (PSF Autoscaling)***: (*Default*) assumes that thermal and dynamical changes do not occur in the optical system between observations of the science target and the reference PSF star exposures. Residual noise, in this case, is driven solely by the shot noise in the wings of the host star and reference PSF source profiles, and SNR for the detection of the faint source depends on the exposure time. Ideally, the reference PSF star would be brighter and will be re-scaled for PSF subtraction. However, as currently implemented in the ETC, the user must set the magnitude and stellar type of the reference star to closely match that of the target star in order to yield a realistic result. Choosing different magnitudes and/or stellar types for the target and reference star will not trigger a warning in the ETC, but the user should be aware that such results might not be accurate.
  - ***Optimal (No PSF Autoscaling)***: will not scale the PSF subtraction source to match the central source before subtracting.
    Note: this was the default behavior in v1.1.1 and earlier of the Exposure Time Calculator).
  - ***Unsubtracted Science Scene***: displays only the science scene, with no subtraction and only the coronagraphic mask suppressing the central source.

- ***PSF Subtraction Source Only***: displays the PSF subtraction source by itself, under the coronagraphic mask.
  Note: contrast and SNR estimates are reported for all options, though they are not particularly meaningful for the ***Unsubtracted Science Scene*** or ***PSF Subtraction Source Only*** options (particularly the ***PSF Subtraction Source Only*** option, where the SNR source is not present). Those two options are primarily provided for users who wish to download (separately) the simulated data and analyze the observations themselves. It is particularly useful, for instance, for users who wish to use a brighter reference PSF star with possibly its own set of readout parameters.

The **Images** (**2D SNR**, **Detector**, **Saturation**, and **Groups Before Saturation**) and **Reports** (**Report**, **Warnings**, **Downloads**) displayed change depending on which ***PSF subtraction*** option is selected.

In order to have correct saturation information regarding the science scene and/or the ***PSF Subtraction Source***, the latter needs to be positioned away from the science scene (e.g. by 10 arcsec). This is done via the **Offset** sub-tab of under Scene or using the Source Editor when defining the scene(s) and sources.

Figure 2. Layout of the Extraction under the Strategy tab for *Coronagraphy*



(2) Extraction: The details of the extraction aperture and background subtraction are set under this tab.

- **SNR source:** From the drop-down menu, which lists all the sources in the scene, the user can choose the faint source for which the SNR has to be calculated. The SNR source must lie within a square, centered on the coronagraphic mask and aligned with the detector rows and columns, with sides of 101 pixels for NIRCam or 81 pixels for MIRI.
- **Aperture radius:** The coronagraphy strategy uses a circular aperture and this refers to the radius of the extraction aperture in arcsec.
- **Contrast azimuth:** This sets the angle at which the contrast plot will be computed, and is expected to be the angle along which the faint source of interest is located.
- **Contrast separation:** This is the separation along the direction specified by the azimuth angle at which the scalar values are reported.

Coronagraphy is the only mode for which the contrast plots and corresponding reports are available in the **Plots** pane and **Reports** pane, respectively.

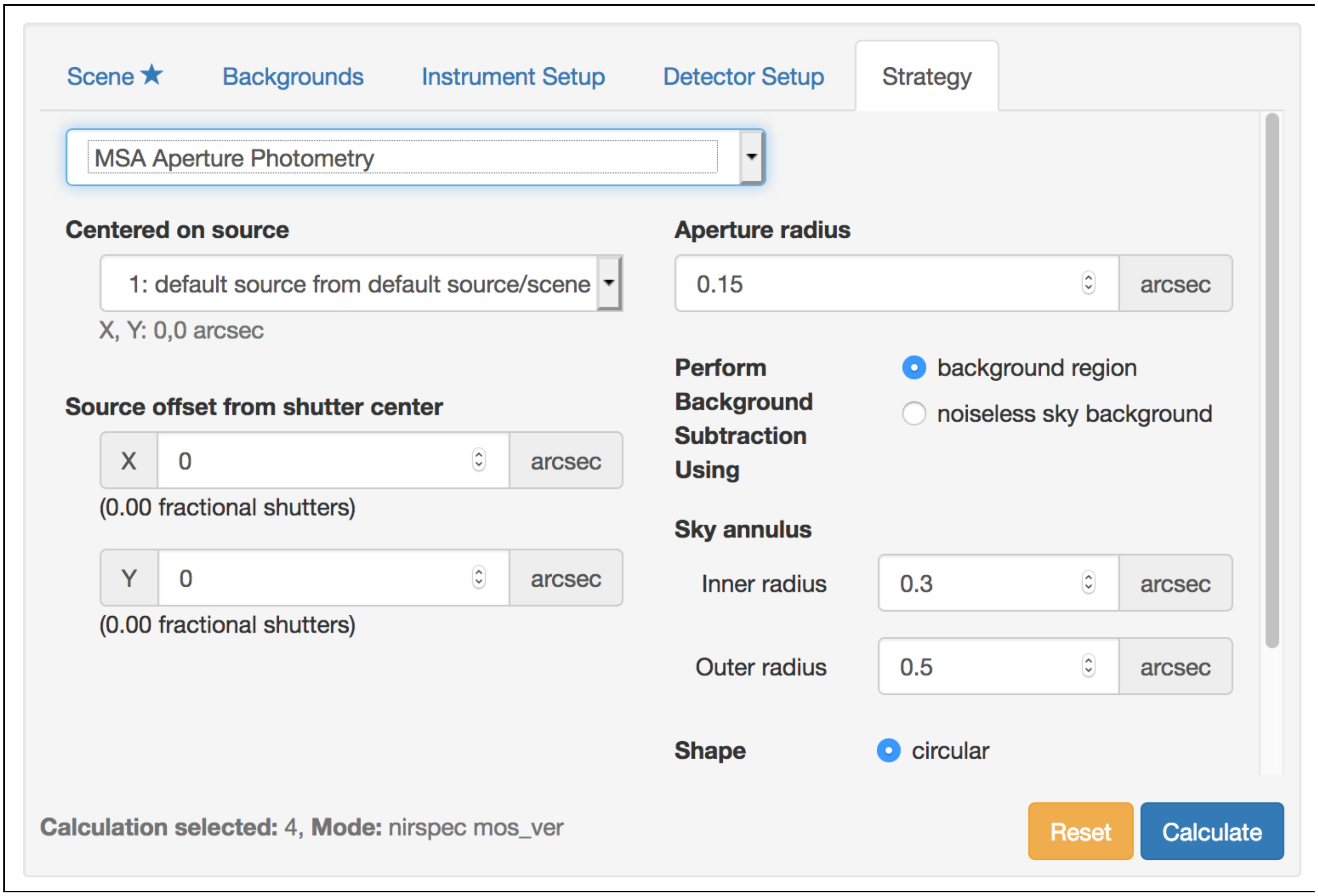
Published	05 May 2017
Latest updates	• 29 Oct 2019 Updated for ETC v1.5. • 05 Nov 2018 Updated for ETC v1.3. • 16 Mar 2018 To reflect changes in the ETC v1.2.2 patch release (PSF subtraction options).

JWST ETC MSA Aperture Photometry Strategy

The ***MSA Aperture Photometry*** strategy is used for the NIRSpec MOS Verification imaging mode in the JWST ETC.

The NIRSpec MOS Verification Imaging mode is the ETC equivalent of the ***VERIFY_ONLY*** target acquisition option in the JWST Astronomer's Proposal Tool (APT). This is an imaging mode that allows aperture photometry through the ***ALLOPEN*** MSA configuration after the science observations are executed and uses the target acquisition filter set. It is designed to allow the target to be offset within the source shutter and perform aperture photometry including signal from all open shutters and excluding the signal blocked by the MSA bars. A detector readout pattern is selected from among those available to target acquisition mode. An exposure time is specified through the number of ***Groups per integration***, which allows for only a single-ramp observation.

Figure 1. Layout of the Strategy Tab for *MSA Aperture Photometry*



The following parameters are available for the ***MSA Aperture Photometry*** strategy:

- **Centered on source** - From the drop-down menu in the **Scene** tab, select a source within the scene to use for the calculation. "Centered" refers to the center of an MSA shutter.
- **Source offset from shutter center** – The extraction region may be specified by providing the X- and Y-offset from the shutter center. This moves the selected source off the shutter center. Throughput is dependent on the exact location in the shutter and will affect the signal. The number of "fractional shutters" that an X- or Y-offset corresponds to is reported below each input box. Note that "1.00 fractional shutters" equates to one shutter half-width or half-height; the source is now on the edge of the shutter. Equivalently, "2.00 fractional shutters" equates to a full shutter width or height; the source is now in the center of an adjacent shutter.
- **Aperture radius** – The aperture used for imaging aperture photometry is circular, and this parameter specifies the radius in arcsec of the circular aperture used for extraction.
- **Perform Background Subtraction Using** - There is an option to perform background subtraction using the background estimated from a ***background region*** specified by the user, or using a ***noiseless sky background***. The ***background region*** is defined by specifying the ***inner radius*** and ***outer radius*** parameters for the **Sky annulus**. If the option to use the ***noiseless sky background*** is selected, then the count rate corresponding to the sky background chosen in the **Backgrounds** tab is used for background subtraction.

When the ***noiseless sky background*** is opted for background subtraction, the contamination from within the scene is not subtracted from the extracted source flux. The users may want to consider using a ***noiseless sky background*** in some cases, for example, when performing photometry of a source that is located on a bright extended background with significant gradient within the background annulus. Also, a ***noiseless sky background*** may be preferred when performing point source photometry with a constant aperture radius and doing a batch expansion over filters, to account for the larger PSF at longer wavelengths.

- **Sky annulus** – Note that when a **Sky Annulus** is specified, it includes contamination from all sources within the scene that contribute to the annulus in addition to the sky, e.g., when overlapping sources are present, or extended profile wings of the source itself contributes to the background extraction aperture. When the background subtraction is performed, the contamination and sky contributions are subtracted. The estimated contamination from sources within the scene over the sky background is reported in the ETC output **Reports** pane as "Fraction of total background due to signal from the scene."
- **Shape** - The imaging aperture photometry uses a ***circular*** aperture.

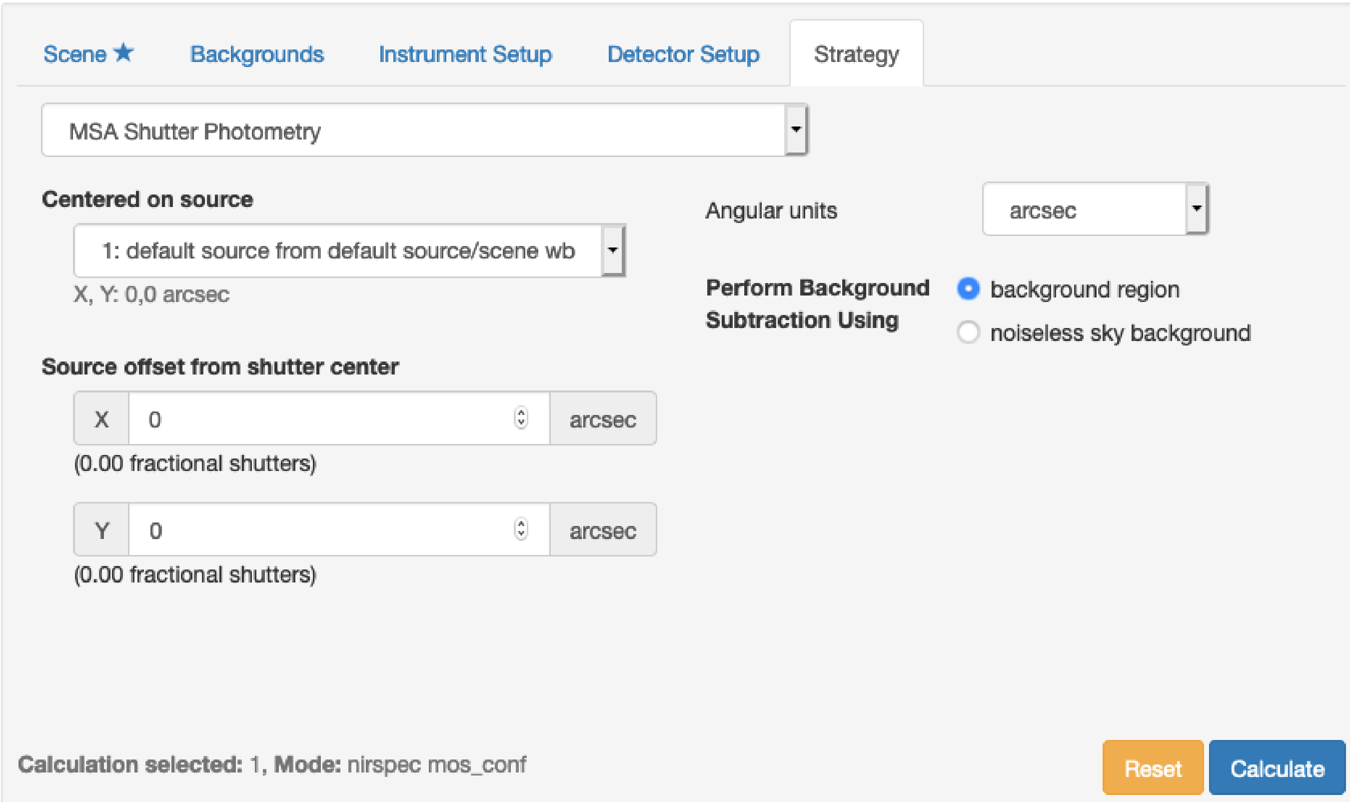
Published	23 Dec 2019
Latest updates	

JWST ETC MSA Shutter Photometry Strategy

The ***MSA Shutter Photometry*** strategy is used for the NIRSpec MOS Confirmation Imaging mode in the JWST ETC.

NIRSpec MOS Confirmation Imaging is an imaging mode that allows photometry after the science observations are executed, through an MSA shutter within a user selected **Slitlet Shape** and a selected science filter (***F070LP***, ***F100LP***, ***F170LP***, ***F290LP***, ***CLEAR***). The selection of **Slitlet Shape** and filter follows the selection of the associated MOS science observation. This imaging strategy is designed to allow the target to be offset within the source shutter and performs full shutter photometry with optional background subtraction. Detector readout patterns are limited to either ***NRS*** or ***NRSRAPID.*** An exposure time is specified through the number of ***Groups per integration***, which allows for only a single-ramp observation. This is the ETC equivalent of the **Confirmation Images** option on the MOS template in the JWST Astronomer's Proposal Tool (APT).

Figure 1. Layout of the Strategy Tab for *MSA Shutter Photometry*



The following parameters are available for the ***MSA Shutter Photometry*** strategy:

- **Centered on source** - From the drop-down menu in the **Scene** tab, select a source within the scene to use for the calculation. "Centered" refers to the center of an MSA shutter.
- **Source offset from shutter center** – The location of the source within the shutter can be specified by providing the X- and Y-offset from the shutter center. This moves the selected source off the shutter center. Throughput is dependent on the exact location in the shutter and will affect the signal. The number of "fractional shutters" that an X- or Y-offset corresponds to is reported below each input box. Note that "1.00 fractional shutters" equates to one shutter half-width or half-height; the source is now on the edge of the shutter. Equivalently, "2.00 fractional shutters" equates to a full shutter width or height; the source is now in the center of an adjacent shutter.
- **Perform Background Subtraction Using** - The background subtraction can be done using background estimated from the ***background region***, or by subtracting the ***noiseless sky background***. If the option to use the ***noiseless sky background*** is selected, the count rate corresponding to the sky background chosen under the **Backgrounds** tab is used for background subtraction. This option may be preferred when the scene has other sources that may contribute a non-uniform background to the aperture. If the ***background region*** option is selected, then the background is estimated from shutters in the slitlet that are adjacent to the shutter where the source is located. For example, in the instrument setup case of a slitlet having 3

shutters (-1,0,1), if the source is located in shutter 0, then the background is estimated from shutters -1 and 1. For the selection of a **Slitlet Shape** of 1 shutter, background subtraction is treated as ***noiseless sky background.***

Published	23 Dec 2019
Latest updates	

JWST ETC Target Acquisition

The JWST Exposure Time Calculator (ETC) offers target acquisition (TA) modes for all the JWST instruments, which allows users to estimate the exposure time required to obtain the required signal-to-noise for the TA source.

A majority of spectroscopic and coronagraphic observations will require a science instrument assisted target acquisition (TA) procedure. TA is used to place sources accurately in apertures or subarrays that are comparable in size to the 3σ blind pointing accuracy of ~0.30", or when precise placement in an aperture is required. The on-board system uses the measurement of the source position and the known central position of the aperture of interest to perform a small move of the telescope to put the source in the aperture.

List of articles

1. **JWST ETC MIRI Target Acquisition**: Details of TA procedures in the ETC for the various MIRI observing modes.
2. **JWST ETC NIRCam Target Acquisition**: Details of TA procedures in the ETC for the various NIRCam observing modes.
3. **JWST ETC NIRISS Target Acquisition**: Details of TA procedures in the ETC for the various NIRISS observing modes.
4. **JWST ETC NIRSpec Target Acquisition**: Details of TA procedures in the ETC for the various NIRSpec observing modes.

Published	04 Oct 2017
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. • 05 Nov 2018 Updated for ETC v1.3 • 16 Nov 2017 Corrected 30" to 40" in MIRI Spectroscopic TA required separation Provided link to MRS Best Practices page for explanation for this separation

JWST ETC MIRI Target Acquisition

The Exposure Time Calculator provides a target acquisition (TA) mode for the Mid-Infrared Instrument (MIRI) that allows users to determine the exposure time required to obtain a sufficient signal-to-noise ratio (SNR) for the TA procedure to achieve the desired centroid accuracy.

On this page

Creating a TA calculation

The procedure for creating a new TA calculation shares many commonalities with regular science exposures. The calculation requires a scene populated with at least one source with appropriate brightness distribution and shape properties. Once the scene and source(s) are defined, the user may specify the instrument and detector setups for the procedure (see Calculations).

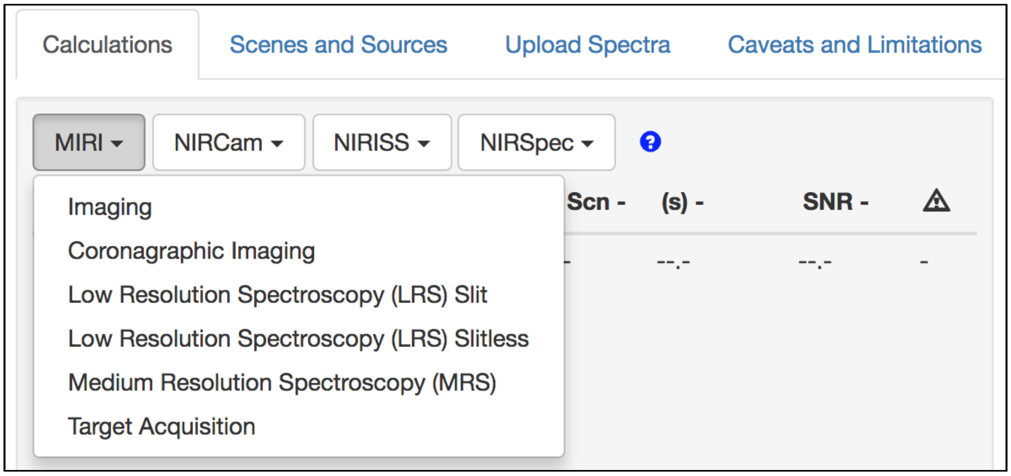
Defining the TA scene and source

For TA calculations, the scenes and sources are defined in the same way as for science calculations. The constructed scene will act as an idealized 2D representation of the target and nearby sources with their defined spectral properties. When populating the scene, users should consider the type of sources supported by each acquisition mode (see mode specific TA calculations).

Creating a calculation

To initialize a MIRI TA calculation, select ***Target Acquisition*** from the MIRI instrument drop-down menu. The scene to be used for the TA calculation can be selected in the **Scene** ★ tab in the Calculation Editor pane (top right pane).

Figure 1. Creating a MIRI Target Acquisition Calculation



Create a target acquisition calculation by selecting the Target Acquisition mode from the MIRI instrument drop-down.

What's supported

The ETC allows the user to perform TA calculation for all MIRI modes for which a TA capability is currently supported:

- Low-resolution spectroscopy (slit and slitless)
- Medium-resolution spectroscopy
- Coronagraphic imaging

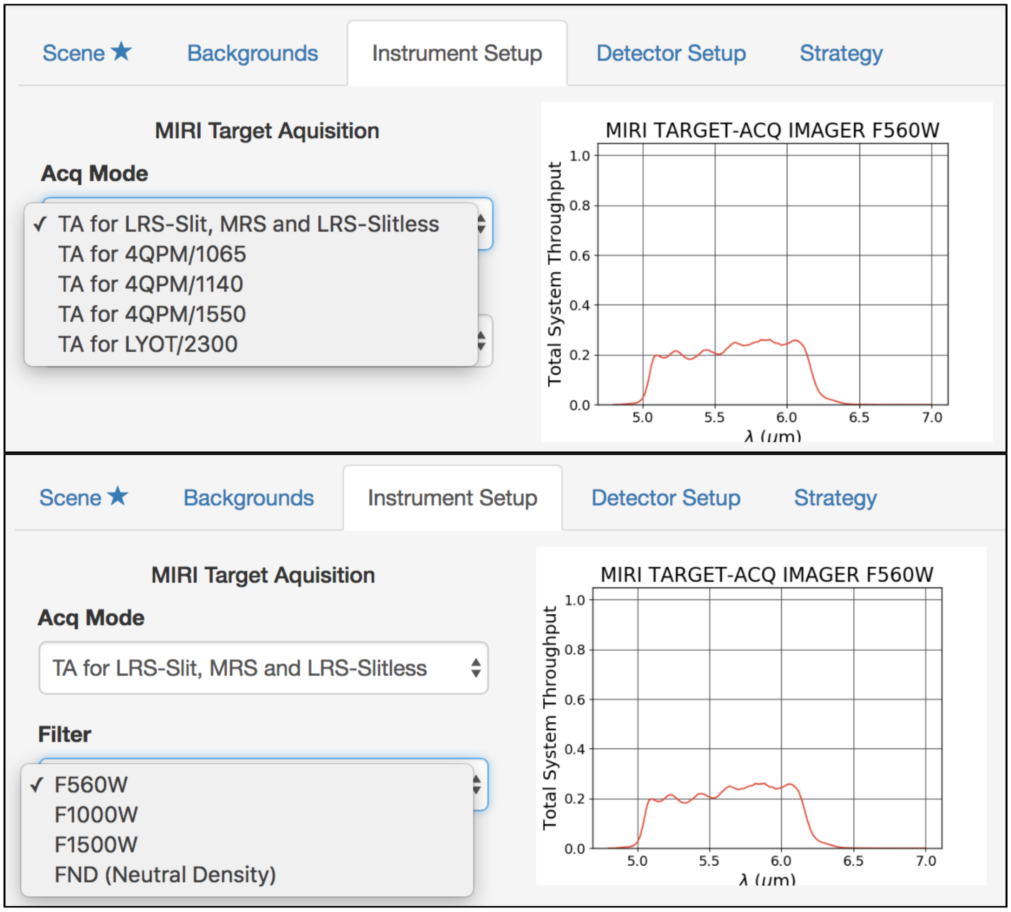
TA is not currently supported for MIRI Imaging.

Instrument Setup

The **Instrument Setup** tab has an acquisition mode option which is common to LRS Slit, MRS, and LRS Slitless; this is because the TA for these modes are operationally similar except that their subarrays are located in different regions on the detector. Separate options are listed for each of the coronagraphic masks.

Four filters are available for all MIRI TA observations: ***F560W***, ***F1000W***, ***F1500W*** and a ***neutral density filter (FND)***. The filter can be chosen in the **Filter** drop-down in the **Instrument Setup** tab. By default, the ***F560W*** filter is automatically selected for all acquisition modes.

Figure 2. MIRI TA Supported Modes and Filters



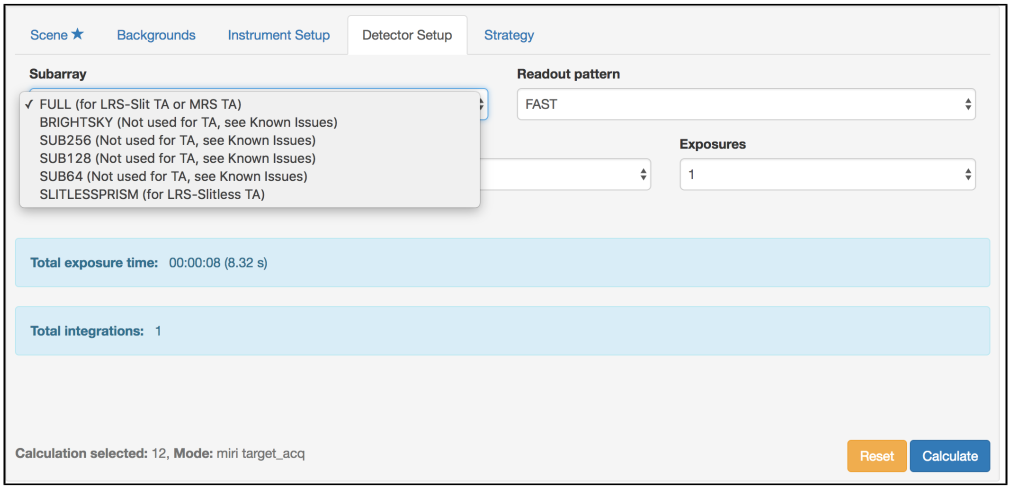
Top: The ETC supports TA for LRS-Slit, MRS and LRS-Slitless, TA for 4QPM/1065, TA for 4QPM/1140, TA for 4QPM/1550, and TA for LYOT/2300. Bottom: Filters F560W, F1000W, F1500W and the FND (Neutral Density) are available for all acquisition modes.

Detector Setup

The **Subarray**, **Readout pattern** and exposure configuration (i.e. **Groups**, **Integrations**, **Exposures**) are specified in the **Detector Setup** tab. Each coronagraphic imaging mode uses its own unique detector subarray for both science and TA exposures, i.e., *MASK1550, MASK1140, MASK1065* and *MASKLYOT*. For non-coronagraphic acquisition modes, a single drop-down menu lists the available subarrays, which includes *FULL, BRIGHTSKY, SUB256, SUB128, SUB64* and *SLITLESSPRISM*. In order to easily distinguish which subarrays are available for each acquisition mode, the applicable modes are clearly indicated alongside the subarray within the drop-down.

⚠ Only the *FULL* and *SLITLESSPRISM* subarrays are currently supported for non-coronagraphic target acquisition.

Figure 3. MIRI TA Subarrays



The Detector Setup tab, showing the available subarrays in the drop-down menu.

During TA, the selected **Subarray** will be read out in its entirety; the target will, however, be placed in a dedicated region of interest (ROI), which represents the "search box" in which the centroiding algorithm operates.

Readout pattern

MIRI TA offers a variety of **Readout patterns: *FAST*, *FASTGRPAVG***, ***FASTGRPAVG8***, ***FASTGRPAVG16***, ***FASTGRPAVG32***,and ***FASTGRPAVG64***.

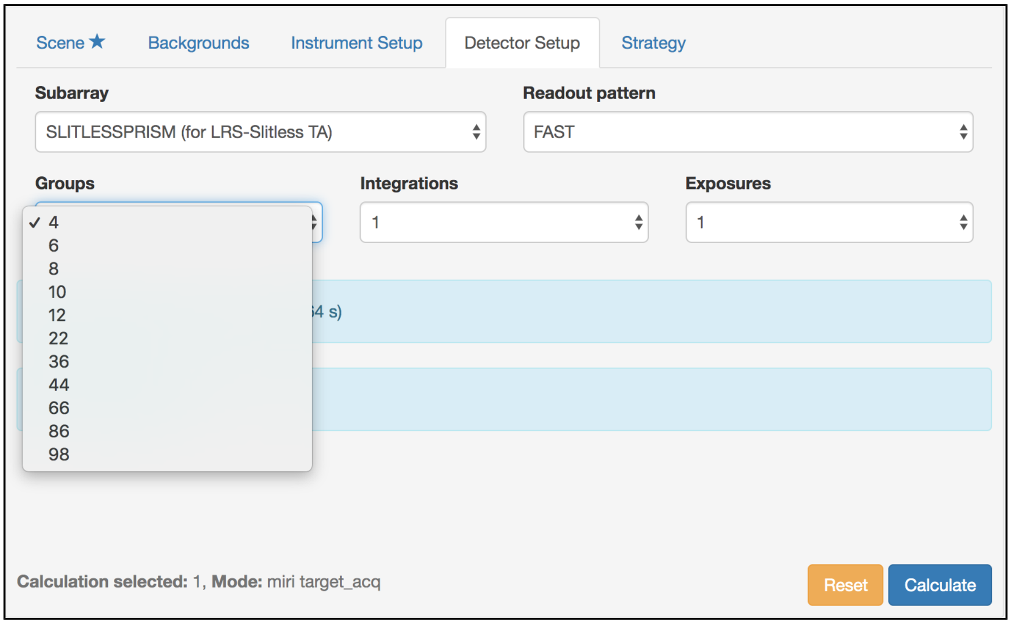
MIRI's ***FAST*** readout pattern is the default for target acquisition. The maximum value for ***NGROUPS*** depends on the **Subarray** selected (see next section below). If more time is required than can be provided by the maximum value of ***NGROUPS*** and the ***FAST*** readout pattern for a particular **Subarray**, then one of the ***FASTGRPAVG*** readout patterns should be used instead. For ***FASTGRPAVG***, each group consists of 4 co-added ***FAST*** frames; while for ***FASTGRPAVG8***, each group consists of 8 co-added ***FAST*** frames, and so on.

Groups, integrations and exposures

For TA calculations in the ETC, the number of **Groups** is selected from a pre-defined dropdown menu, which is dependent on the **Subarray** selected. For the ***SUB256***, ***SUB128***, ***SUB64***, and ***SLITLESSPRISM*** subarrays, the pre-defined list contains even integers between 4 and 98. Due to data storage constraints, the available values for the ***BRIGHTSKY*** subarray are a subset of the full list, with a maximum value of 36. For similar reasons, the ***FULL*** subarray only allows 4, 6, 8, or 10 to be selected.

The ETC only allows for even numbers of **Groups** in order to remove the influence of the last-frame effect on the TA centroiding algorithm. The TA algorithm accepts groups in a single integration to perform centroiding; the number of integrations and exposures is therefore fixed at 1.

Figure 4. MIRI Detector Setup tab: Number of Groups for *SLITLESSPRISM* subarray



The number of Groups is selected from a pre-defined list. Integrations and Exposures remain fixed at 1.

Outputs

The exposure specification for TA should be chosen to obtain the minimum required SNR of 20 within the extraction aperture defined in the **Strategy** tab. If the calculation returns a SNR below this threshold, the ETC will issue a "TA may fail" warning. Saturation can also affect the accuracy of the centroiding procedure. Whilst a small number of saturated pixels can still allow accurate centroiding, we recommend avoiding saturation during target acquisition for optimal performance. If any fully or partially saturated pixels are present in the TA exposure, the ETC will issue a warning. The recommendation is to adjust the parameters in the **Detector Setup** tab (e.g., by decreasing the number of groups) or the **Instrument Setup** tab (e.g. changing filter selection) to avoid saturation.

Mode-specific TA calculations

Coronagraphic imaging target acquisition

For an in-depth description of target acquisition with this mode, visit MIRI Coronagraphic Imaging Target Acquisition.

Each coronagraphic mask has its own acquisition mode listed under the **Instrument Setup** tab.

The **Filters** available to users for all coronagraphic imaging modes are ***F560W***, ***F1000W***, ***F1550W***, and ***FND (Neutral Density)***. The ***FND (Neutral Density)*** provides the strongest flux attenuation and is recommended to avoid saturation and persistence when observing bright targets.

In general, users should consider using the ***FAST*** readout pattern. However, for TA of a faint star with the Lyot coronagraph (where longer integration times are needed) one of the ***FASTGRPAVG*** readout patterns should be used. This will allow such observations to reach the SNR threshold for TA; using the ***FAST*** readout pattern could cause data volume issues. In general, the ***FASTGRPAVG*** patterns are recommended for mitigating data volume issues.

Low Resolution Spectrometer (LRS) target acquisition

For an in-depth description of target acquisition with this mode, visit MIRI LRS Slit Target Acquisition.

To set up a TA calculation for LRS Slit or LRS Slitless through the ETC User Interface, select the ***TA for LRS-Slit, MRS and LRS-Slitless*** option in the **Acq Mode** drop down (see Fig. 2). For LRS Slitless, the user should select the ***SLITLESSPRISM*** subarray; LRS Slit TA uses the ***FULL*** array.

The filters available for LRS TA are ***F560W***, ***F1000W***, ***F1550W***, and ***FND (Neutral Density)***.

Target acquisition of faint sources can be accomplished using long exposures (up to approximately 1000s), but may require one of the ***FASTGRPAVG*** readout patterns.

Medium Resolution Spectrometer (MRS) target acquisition

For an in-depth description of target acquisition with this mode, visit MIRI MRS Target Acquisition.

To set up a TA calculation for the MRS through the ETC web application, select the ***TA for LRS-Slit, MRS and LRS-Slitless*** option in the **Acq Mode** drop down (see Fig. 2).

The filters available for MRS TA are ***F560W***, ***F1000W***, ***F1500W***, and ***FND (Neutral Density)***.

Observers are prompted to use the ***FULL*** subarray for MRS TA procedures. The ***FAST*** readout pattern is recommended.

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JWST ETC NIRCam Target Acquisition

The JWST Exposure Time Calculator (ETC) has a NIRCam target acquisition (TA) mode which allows the user to estimate the exposure time necessary to achieve the signal to noise for the required centroid accuracy.

On this page

The JWST Near Infrared Camera (NIRCam) instrument uses target acquisition (TA) for its Coronagraphy, Time Series and Grism Time Series observing templates. The JWST ETC includes a ***Target Acquisition*** calculation mode for NIRCam. This mode can be used to calculate the signal-to-noise ratio (SNR) for user specified exposure parameters, and covers all three of the relevant templates. The minimum recommended integrated (within the extraction aperture) SNR is ≥ 30 for NIRCam TA which is required to obtain centroid accuracy better than 0.1 pixels.

Creating a TA calculation

The steps involved in creating a TA calculation are: (1) define the TA scene with a source having appropriate spectral type and magnitude on the Scenes and Sources page, and (2) Specify the instrument and detector setup on the Calculations page.

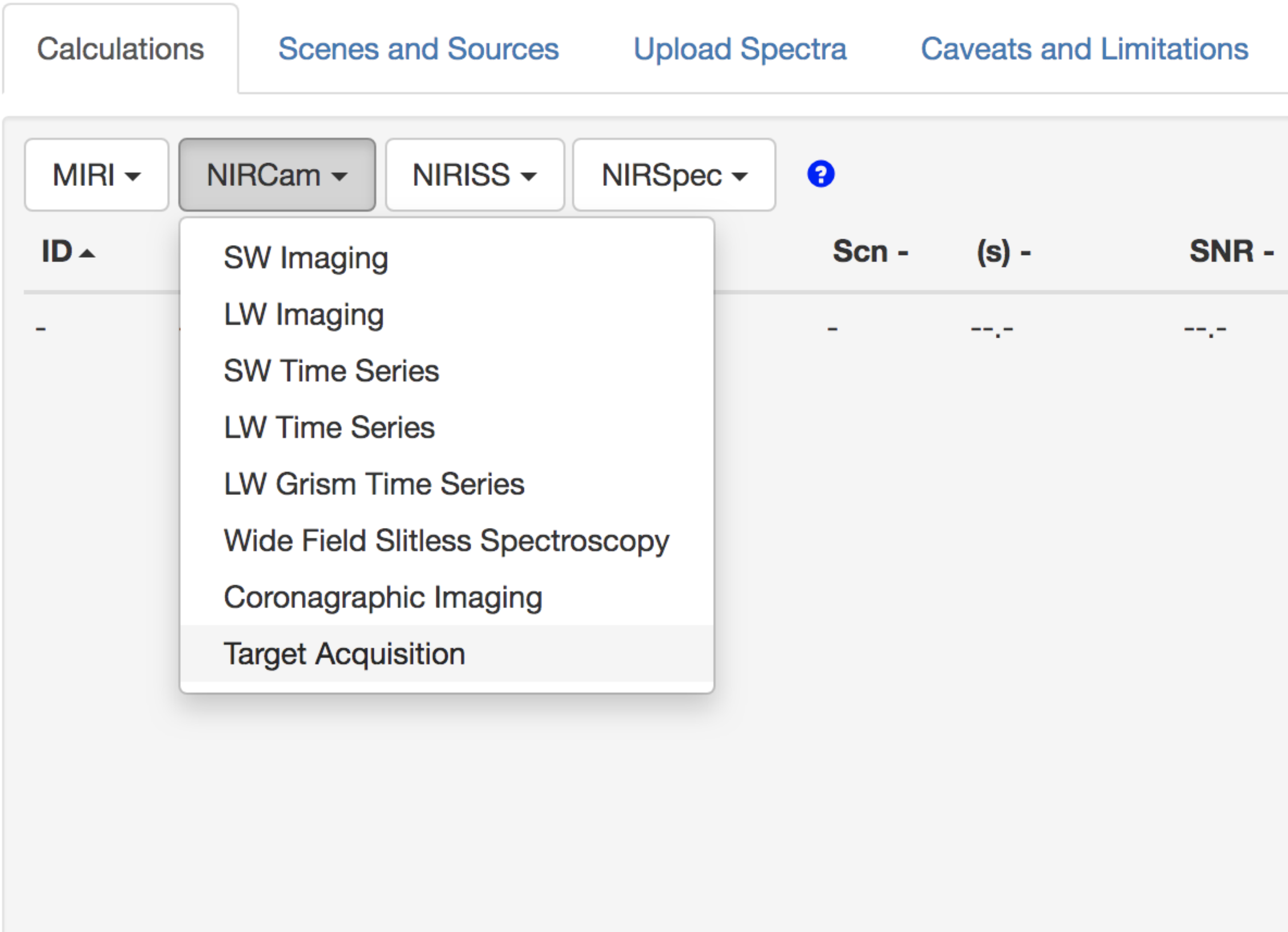
Defining the TA Scene and Source

The scene definition and source definition for the TA calculations are done along the same lines as for the other observing modes.

Creating a calculation

Target Acquisition is one of the modes available for all JWST instruments within the ETC. To initialize a TA calculation select ***Target Acquisition*** from the NIRCam instrument drop-down menu. Once selected, the calculation will utilize a default scene and source. This can be changed at the users discretion by accessing the Configuration pane where you can select the **Scene** tab to change the pre-defined TA source.

Figure 1. Creating a NIRCam Target Acquisition Calculation



Creating a target acquisition calculation by selecting the Target Acquisition mode from the NIRCam instrument drop-down.

What's supported

The ETC supports TA for the following NIRCam observing templates: Coronagraphy, Time Series and Grism Time Series. For each mode, there are only a few choices users can make regarding the **Instrument Setup**. The **Detector Setup** is much less restricted, allowing use of all exposure patterns, but values of **Groups** are limited to a few values ranging from 3 to 65 (the maximum is determined by limitations in the on-board data acquisition system).

Instrument setup

Time Series and Grism Time Series Target Acquisition

Target acquisition for both Time Series and Grism Time Series observations utilizes subarrays on the LW detectors that are 32 pixels (2.16") on a side. The only filter supported is ***F335M***. The **Instrument Setup** for these target acquisitions is therefore very simple, involving only a single choice in the **Acq Mode** menu.

Coronagraphic target acquisition

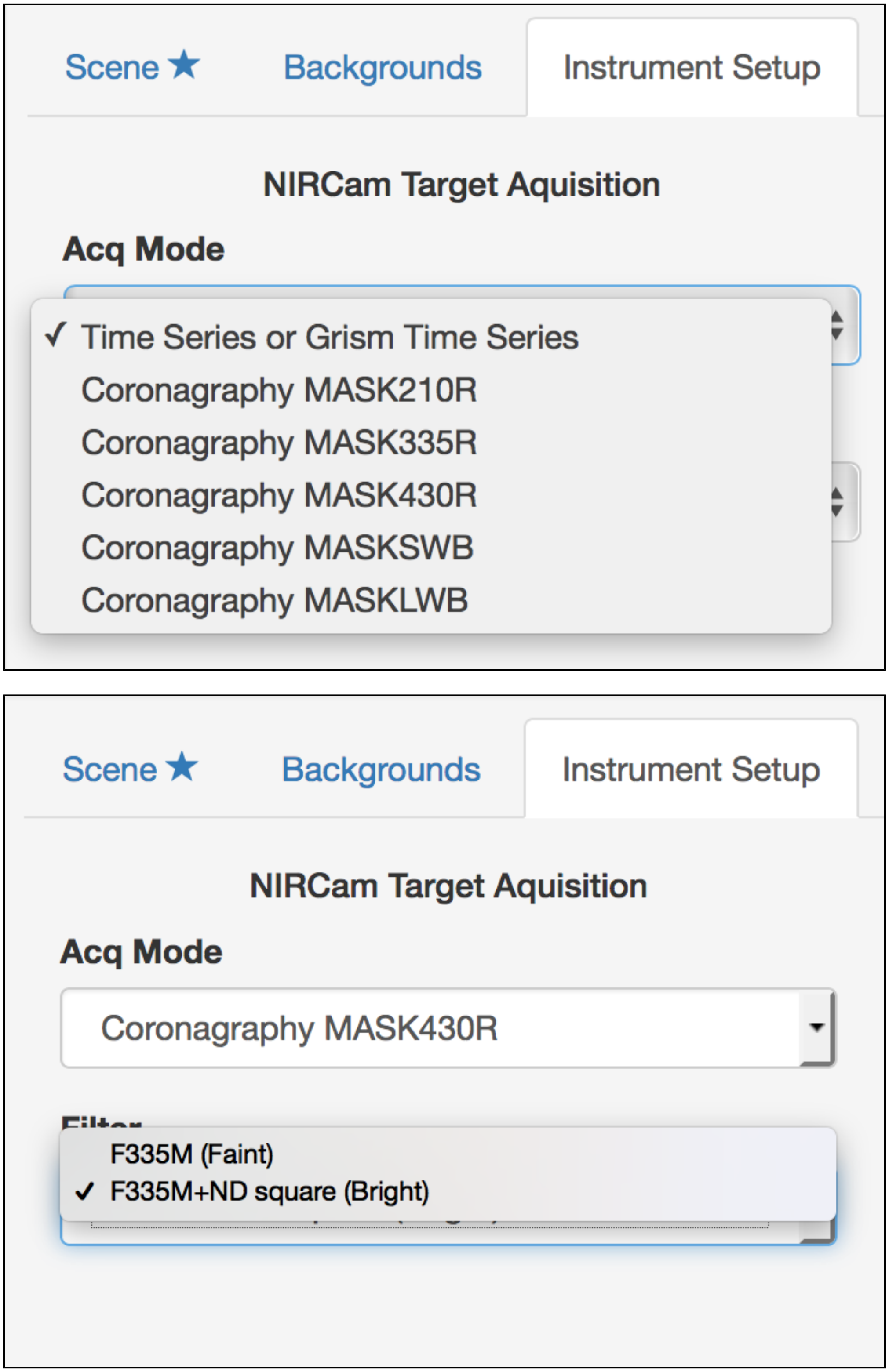
For the Coronagraphic Imaging template, the instrument configuration includes choosing the desired occulting mask from the list of 5 available masks:

- For ***MASK210R*** and ***MASKSWB*** (in the SW channel), the TA subarray is 128 pixels (4.0") square.
- For ***MASK335R***, ***MASK430R*** and ***MASKLWB*** (in the LW channel), the TA subarray is 64 pixels (4.0") square.

The next choice is whether the target that will be used for TA is in the "bright" or "faint" regime. For "bright" targets, the source will be placed behind a neutral density square for the TA exposure; for "faint' targets the source will be imaged through a transparent region. The division between "bright" and "faint" targets depends on the target spectrum, and on whether the SW or LW channel will be used. Roughly speaking the division occurs at K_{Vega} = 6.1 (SW) and K_{Vega} = 4.7 (LW) for early type main sequence stars.

- For ***MASK210R*** and ***MASKSWB*** the filter choices are ***F210M*** (Faint) or ***F210M + ND square*** (Bright).
- For ***MASK335R***, ***MASK430R*** and ***MASKLWB*** the filter choices are ***F335M*** (Faint) or ***F335M + ND square*** (Bright).

Figure 2. NIRCam TA supported modes



(Top) The 5 NIRCam TA modes include one that applies for Time Series or Grism Time Series observations, and 5 for Coronagraphic Imaging. (Bottom) Filter selection for coronagraphic TA includes the choice between "bright" and "faint" modes (see details in text).

Detector Setup

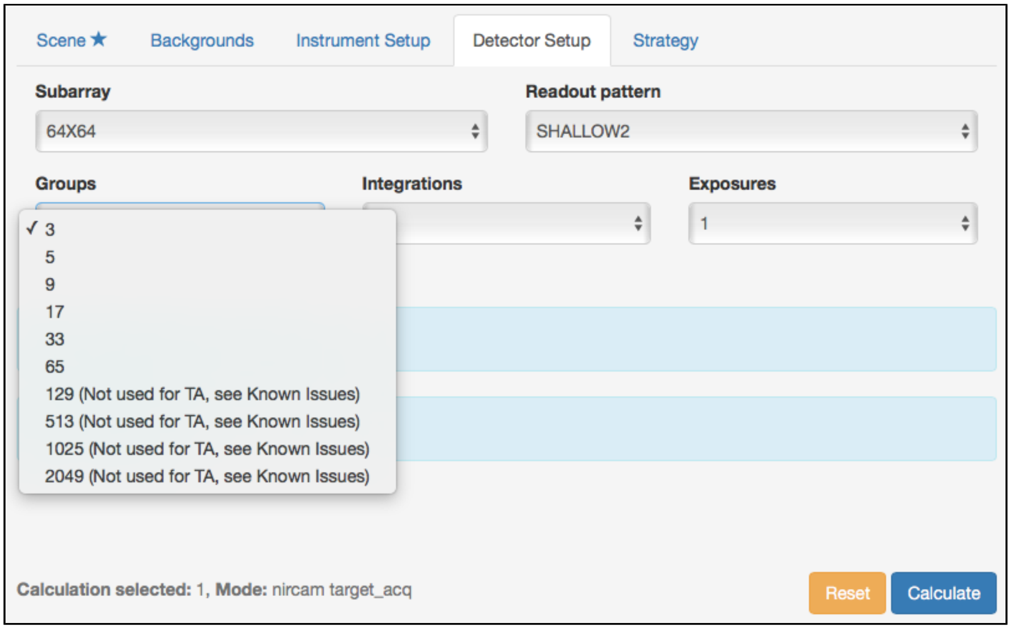
Target acquisition for Coronagraphic Imaging, Time Series, and Grism Time Series uses specific subarrays as noted above under **Instrument Setup**. The subarray sizes can not be selected by users.

Users must choose the exposure pattern to use, and the value for **Groups**. For all TA modes the allowed selections are:

- **Readout pattern** = [***RAPID***, ***BRIGHT1***, ***BRIGHT2***, ***SHALLOW2***, ***SHALLOW4***, ***MEDIUM2***, ***MEDIUM8***, ***DEEP2***, ***DEEP8***] (i.e., all NIRCam patterns are available)
- **Groups** = [***3***, ***5***, ***9***, ***17***, ***33***, ***65***] (additional options are available but not used for TA)

The maximum value of ***Groups*** is limited by on-board data acquisition limitations.

Figure 3. NIRCam TA Detector Setup



UI screen shot of supported NIRCam TA Detector Setup tab. Note that values of Groups larger than 65 are not actually supported, and will issue a warning in the Reports pane.

Table 1. NIRCam target acquisition modes, subarrays, and filters supported by ETC

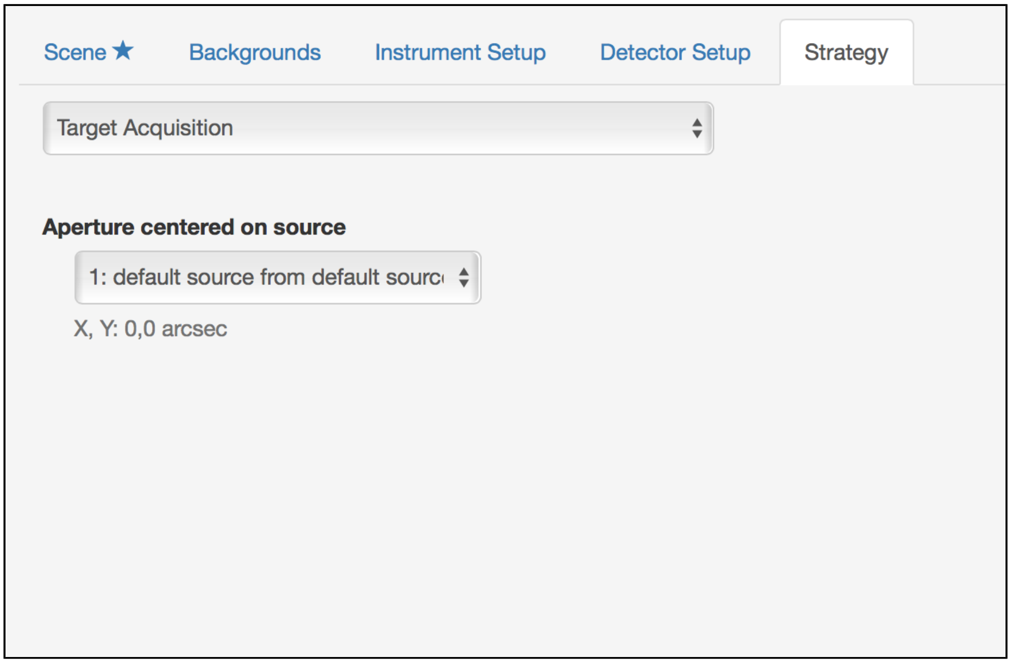
TA Acq Mode	Coronagraphic mask	Subarray	Filter
Time Series or Grism Time Series†	--	***SUB32*** Time Series TA	***F335M***
Coronagraphy	***MASK210R***	***SUB128*** (128 × 128)	***F210M*** (Faint) Use for sources fainter than K_{Vega} =6.0
			F210M+ND square (Bright)
	MASK335R	***SUB64*** (64 × 64)	***F335M*** (Faint) Use for Kmag fainter than K_{Vega}=4.6
			F335M+ND square (Bright)
	MASK430R	***SUB64*** (64 × 64)	***F335M*** (Faint)
			F335M+ND square (Bright)
	MASKSWB	***SUB128*** (128 × 128)	***F210M*** (Faint)
			F210M+ND square (Bright)
	MASKLWB	***SUB64*** (64 × 64)	***F335M*** (Faint)
			F335M+ND square (Bright)

† Time Series and Grism Time Series have identical configurations in the ETC.

Strategy

Target Acquisition is the only offered strategy for NIRCam TA. It consists of a square aperture 9 × 9 pixels on the side, and no sky subtraction. There are no user selectable parameters. If the scene has multiple sources, the user should select the intended TA source from the **Aperture centered on source** drop-down menu in the **Strategy** tab.

Figure 4. NIRCam *Target Acquisition* Strategy options



The strategy tab allows users to allocate which of the sources defined in their scene the aperture should be centered on, following the TA procedure.

Outputs

Minimum recommended SNR

The exposure specification for the TA should be chosen to obtain at least the minimum recommended integrated (within the extraction aperture) SNR (~30). At lower SNR a warning will be issued, and centroid accuracy may not be adequate to fully support acquisition of the target and/or calibration of the data.

Saturation limits for target acquisition

Saturation is also a concern for TA exposures, and should be avoided if possible. Assuming an early type main sequence spectral type, the brightest targets that can be observed in the various TA modes are:

- Short wavelength Coronagraphic Imaging: K_{Vega} = -1.2
- Long wavelength Coronagraphic Imaging: K_{Vega} = -2.1
- Time Series and Grism Time Series: K_{Vega} = See "Time Series Saturation Limits" section below

Time Series Saturation Limits

For Imaging Time Series and Grism Time Series templates, targets that cause saturation in some pixels can still be used for target acquisition, depending on the centroid accuracy required for a particular observation. The NIRCam Time-Series Imaging Target Acquisition and NIRCam Grism Time-Series Target Acquisition pages, in figures 3 - 5, present the observed centroid accuracy versus K_{Vega} and number of saturated pixels. Observers are encouraged to check these plots in order to determine the limiting magnitude or number of saturated pixels which can be tolerated for their required accuracy and science case. For sources which are too bright and saturate too many pixels for the required centroid accuracy, users may be required to perform TA on a nearby offset target with a more suitable brightness.

For the particular case of full saturation (in the 1st group) of one pixel, the ETC will report an SNR of 0, but TA will still work. Approximate magnitude ranges corresponding to these cases are:

No saturation: K_{Vega} = 7.1

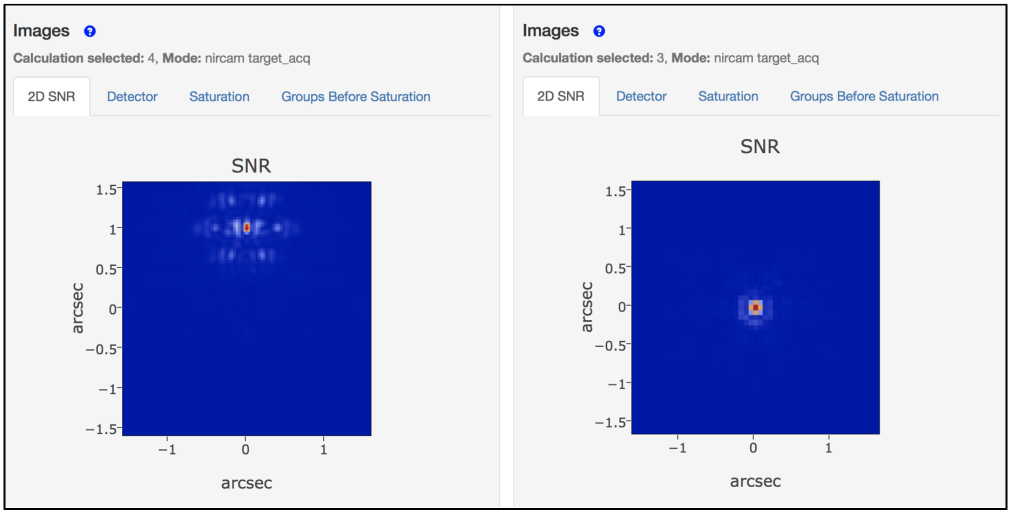
Partial Saturation: 6.6 < K_{Vega}< 7.0

Full Saturation: 6.2 < K_{Vega}< 6.5 (ETC reports SNR=0, but TA will still work)

TA Failure

The ETC will issue a "TA May Fail" if the number of saturated pixels in the centroid box exceeds one pixel. TA will still work in this case, although observers are encouraged to check figures 3-5 on the Grism Time-Series Target Acquisition or Time-Series Imaging Target Acquisition pages to see that their analysis can accept the number of ETC-reported saturated pixels.

Figure 5. ETC Output 2D SNR plots for NIRCam TA



ETC output 2D SNR for NIRCam TA setup. Left: example using coronagraphic MASK210R TA on a bright K_{Vega}=5 target through a neutral density square. Note that the target is offset from the center of the scene in order to avoid falling behind the coronagraphic mask, which is centered at (0,0). Time Series TA setup (right) using a very faint K_{Vega}=15 target.

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JWST ETC NIRISS Target Acquisition

The JWST Exposure Time Calculator (ETC) has a target acquisition (TA) mode for the Near infrared Imager and Slitless Spectrograph (NIRISS) which allows the user to estimate the exposure time required to obtain sufficient signal to noise for the TA source to achieve the desired centroiding accuracy.

On this page

The JWST Near Infrared Imaging and Slitless Spectroscopy (NIRISS) instrument uses Target Acquisition (TA) for two of its observing modes, Single Object Slitless Spectroscopy (SOSS) and Aperture Masking Interferometry (AMI). The NIRISS SOSS mode enables slitless spectroscopy of a bright target and is a key mode for exoplanet transit spectroscopy, while AMI enables high contrast imaging to identify faint companions close to bright targets. The NIRISS ETC TA mode can be used to estimate the exposure times to obtain the required signal-to-noise ratio (SNR) for the NIRISS TA by using options available under instrument and detector setups. The recommended SNR for the NIRISS Target Acquisition is an integrated SNR = 30 or higher to obtain a centroid accuracy of 0.15 pixels for the TA source. The centroiding accuracy improves to about ≤0.10 pixel at SNR = 50 and to about ≤0.05 pixel at SNR = 100.

How to create a TA calculation

The steps involved in creating a TA calculation are: (1) define the TA scene with a source having appropriate spectral type and magnitude on the Scenes and Sources page, and (2) Specify the instrument and detector setup on the Calculations page.

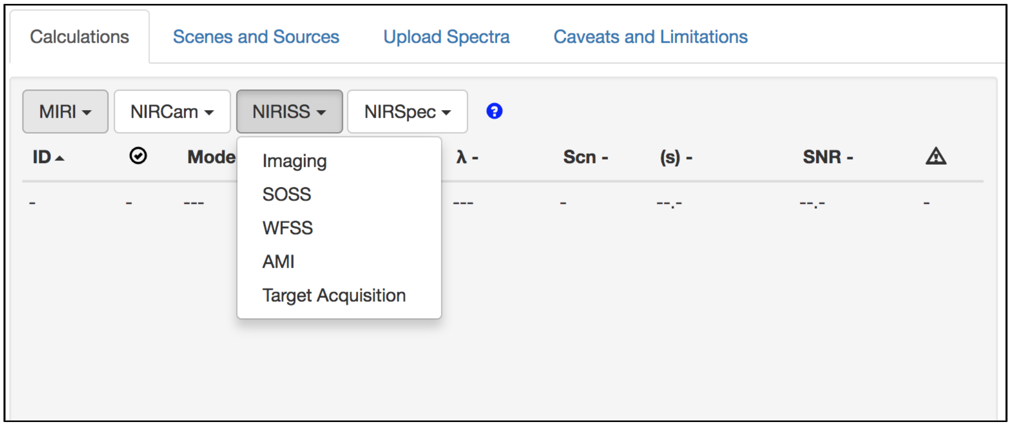
Defining the TA Scene and Source

The scene definition and source definition for the TA calculations are defined along the same lines as for the other observing modes. The default ETC TA scene has a single TA source located in the center of the scene. The spectral type for the source can be selected from the various options available for the continuum, and be normalized as required.

Creating a TA calculation

The ***Target Acquisition*** is one of the mode options available for each instrument. To initialize a NIRISS TA calculation select ***Target Acquisition*** from the NIRISS instrument drop-down menu. This default calculation uses the default scene with a single point source with flat continuum. If the user wishes to change the default to a pre-defined TA source, use the **Scene** tab on the Configuration pane to select the scene that contains the pre-defined TA source.

Figure 1. Creating a NIRISS Target Acquisition Calculation



What's supported

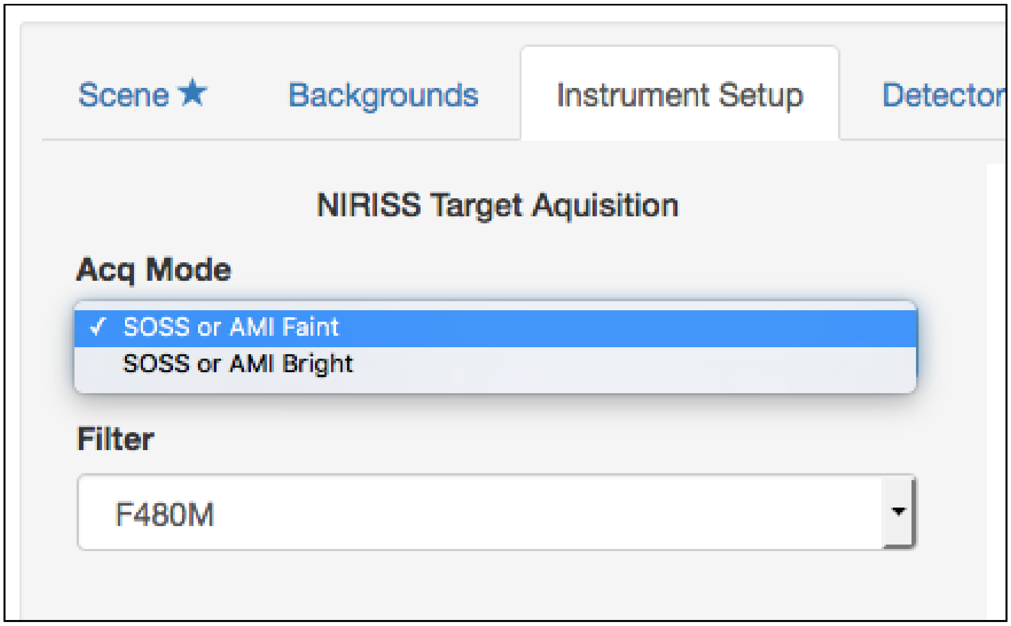
The ETC supports TA for the following NIRISS observing modes: Single Object Slitless Spectroscopy (SOSS) and Aperture Masking Interferometry (AMI).

Instrument Setup

The **Instrument Setup** has options which are common to SOSS and AMI because the TA for both these modes are operationally similar except that the 64 × 64 pixels subarrays are located in different regions on the detector. The ***SOSS or AMI Faint*** option performs a normal imaging calculation using the imager or ***CLEARP*** aperture, while the ***SOSS or AMI Bright*** will use the ***NRM*** aperture to reduce the flux from very bright targets. See the NIRISS Target Acquisition article for information on how the "bright" and "faint" are defined for NIRISS TA.

The only filter choice available is ***F480M*** which is the filter used for SOSS and AMI TA.

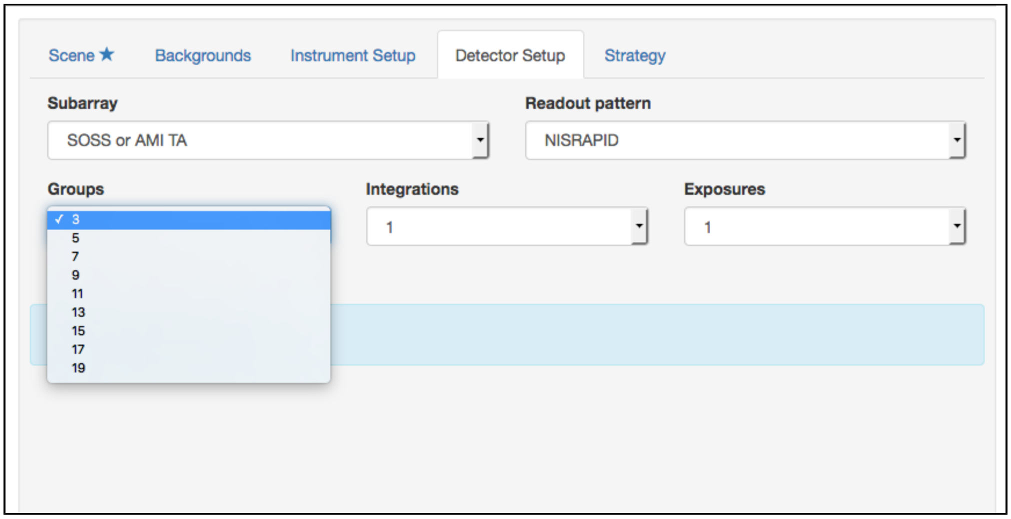
Figure 2. NIRISS TA Instrument Setup with the supported modes and Filters



Detector Setup

The detector subarray setup for NIRISS TA uses ***SOSS or AMI TA*** sub-array which is 64 × 64 pixels. Both SOSS and AMI TA observations use the same size for the subarray. While the two TA subarrays are on different locations on the NIRISS detector, the ETC does not take detector location into account. The TA region for SOSS is located at 1923 ≤ X ≤ 1986 and 1167 ≤ Y ≤ 1230 on the detector (in the science coordinate frame), while it is at 1054 ≤ X ≤ 1117 and 81 ≤ Y ≤ 144 for AMI.

Figure 3. NIRISS TA Detector Setup showing the supported subarray and readout pattern



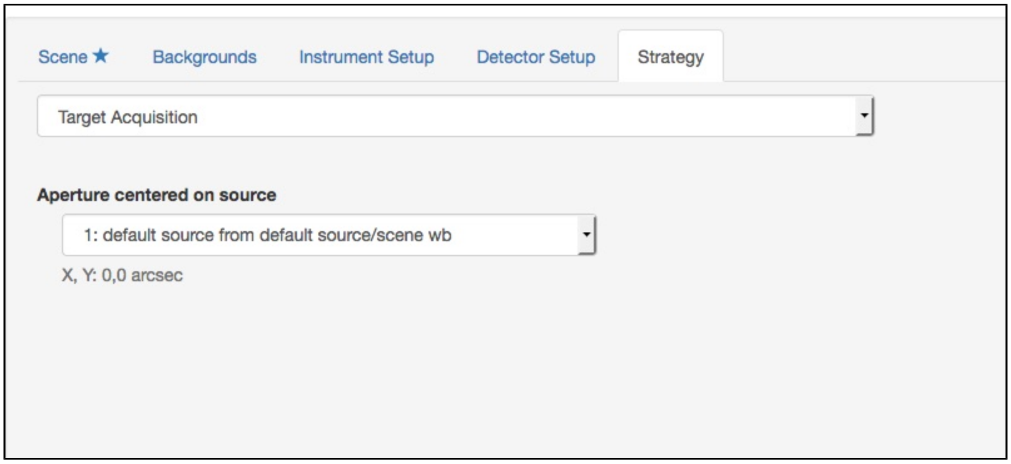
Readout Pattern

The readout pattern used for NIRISS TA in the ETC is ***NISRAPID*** when using the ***SOSS or AMI Bright*** mode. Both the ***NISRAPID*** and ***NIS*** readout patterns are available when using the ***SOSS or AMI Faint*** mode. The subarray (***SOSS or AMI TA***) is a fixed value and no choices are available to the user. The number of groups available are from 3 to 19 and allow only odd numbers to account for the weighting scheme used by the TA observing program scripts. The minimum number of groups is 3. The TA mode allows only one exposure with one integration and cannot be changed by the user.

Strategy

The NIRISS TA mode only offers ***Target Acquisition*** as the option for strategy. The signal to noise is computed within a region of size 5 × 5 pixels. There is no background subtraction that is currently implemented for the TA strategy. It is assumed that the SNR is dominated by the photon noise from the bright target and the contribution from the sky is negligible. If the scene has multiple sources, the user should select the TA source from the **Aperture centered on source** drop-down menu in the **Strategy** tab.

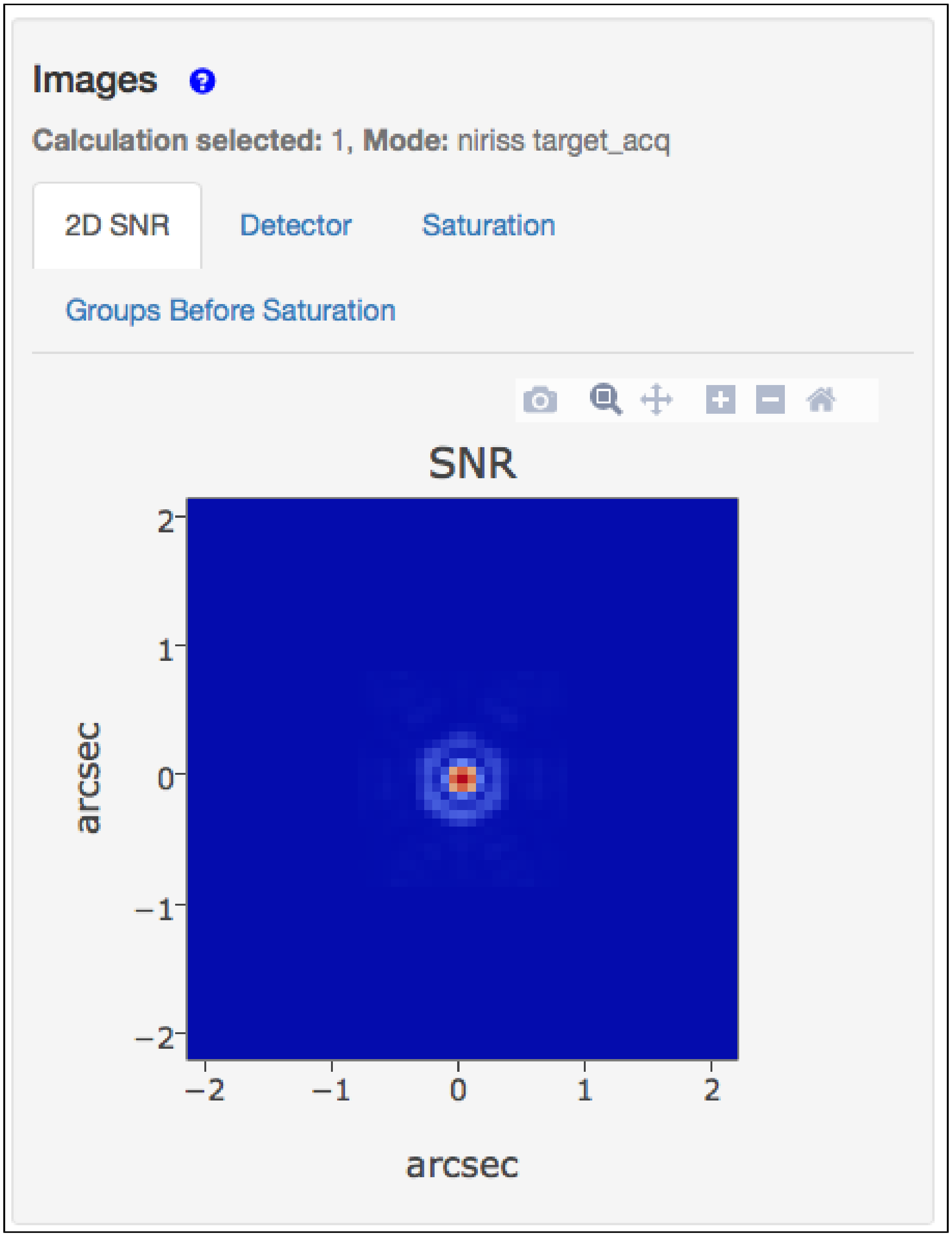
Figure 4. NIRISS TA Strategy options

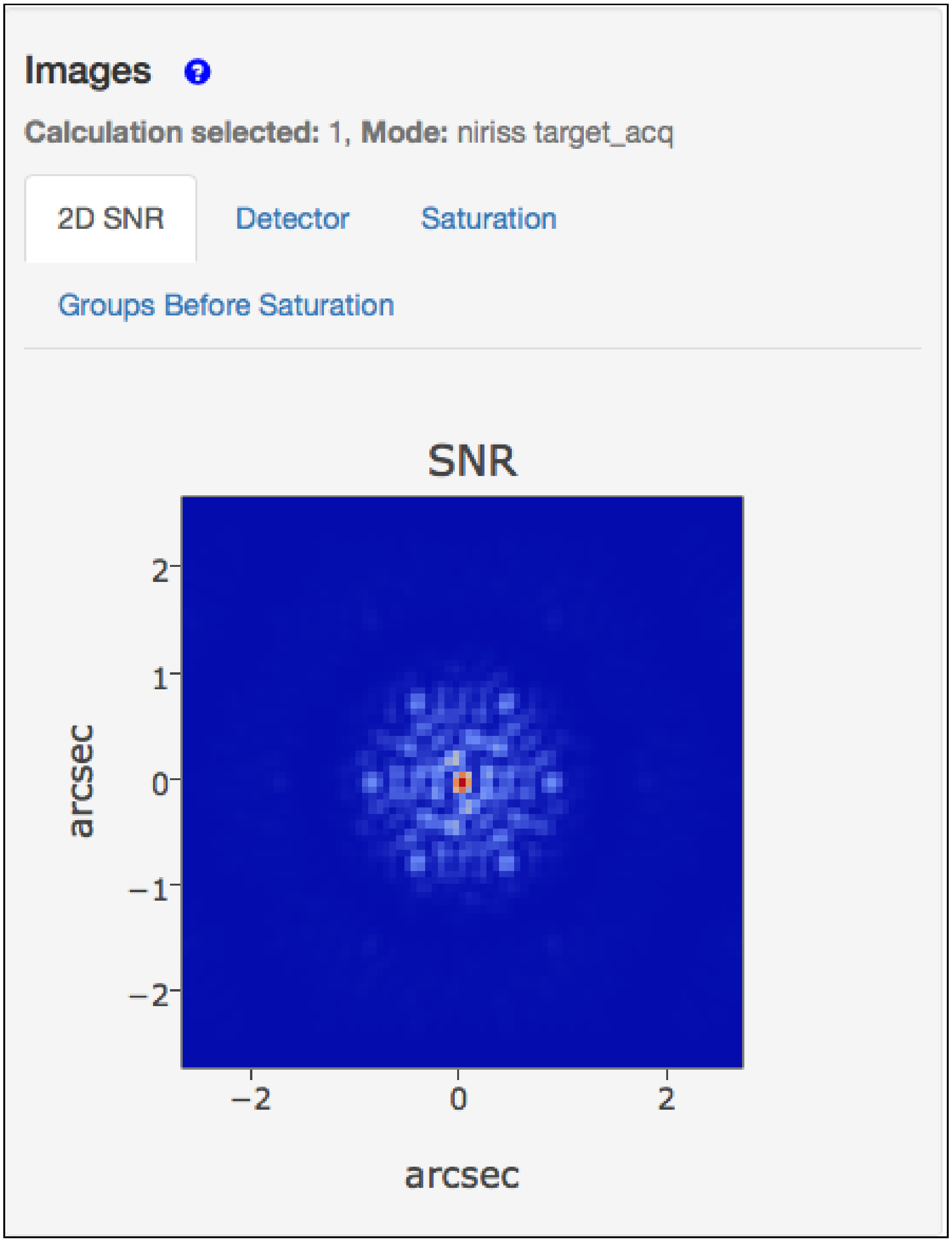


Outputs

The exposure specification for the TA should be chosen to obtain *at least* the minimum required SNR = 30 to achieve a centroiding accuracy of ≤0.15 pixel for the TA source. The ETC will issue a "TA may fail" warning if the SNR is below the required value. However, increasing the exposure time for TA (by increasing the value of **Groups**) will infringe only slightly on the time needed for the TA procedure, and this should be considered while planning observations for which accurate centroiding is deemed crucial. For example, the centroiding accuracy improves to about ≤0.10 pixel at SNR = 50 and to about ≤0.05 pixel at SNR = 100.

Figure 5. ETC Output 2D SNR plots for NIRISS TA





NIRISS TA using the SOSS or AMI Faint setup (top; 3 groups) which is calculated using the imaging aperture, and the SOSS or AMI Bright setup (bottom; 19 groups) which is calculated using the NRM. The magnitude of the target is 8 (Vega) through the NIRISS F480M filter with a flat continuum.

The TA procedure uses bright targets and it is important to note whether there is saturation and how it affects the TA. For NIRISS, it is possible to accommodate up to 5 partially saturated pixels in the 5 × 5 pixel aperture used for the TA strategy. However, the TA will likely fail if there are *fully* saturated pixels, or if the number of partially saturated pixels exceeds the maximum number of pixels (5) allowed to ensure a successful target acquisition. The recommendation is to adjust the detector setup (e.g., decreasing the number of groups) or instrument setup (e.g., by using ***SOSS or AMI Bright***) to avoid saturation.

References

Goudfrooij, P. 2017, JWST-STScI-005934
NIRISS Target Acquisition: the sensitivity of centroid accuracy to the presence of saturated pixels

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JWST ETC NIRSpec Target Acquisition

The JWST Exposure Time Calculator has a NIRSpec Target Acquisition (TA) mode that will allow the user to choose instrument and detector parameters that will achieve the necessary signal-to-noise ratio for the TA source. The TA procedures are important to be able to place the targets into one of the FSs, the IFU, or within the MSA shutters.

On this page

After a JWST slew, the NIRSpec Target Acquisition (TA) will fine-tune the telescope’s pointing to align the target within the specific aperture of the observation.

As presented in the Astronomer's Proposal Tool (APT), NIRSpec has four options for TA: ***Micro-Shutter Array TA (MSATA)***, ***Wide Aperture TA (WATA)***, ***VERIFY_ONLY TA***, and ***NONE***. The ***VERIFY_ONLY*** option is an imaging mode that is executed at the end of the observation and does not run the TA algorithm, it is meant to enable the assessment of fine field pointing in post-analysis. The ***NONE*** option forgoes the TA algorithm as well, and additionally, it skips the TA verification imaging. Fixed Slit (FS) NIRSpec spectroscopy can use the ***WATA***, ***MSATA***, or ***NONE*** options. Bright Object Time Series (BOTS) observations can use either the ***WATA*** or ***NONE*** options. NIRSpec Integral Field Unit (IFU) and Multi-Object Spectroscopy (MOS) can use any of the four TA options.

MSATA, WATA and ***VERIFY_ONLY*** modes can use brightness estimates from the ETC calculations. ***MSATA*** observations are always acquired in ***FULL*** subarray detector readout, while ***WATA*** observations can be obtained with the ***FULL***, ***SUB32***, or ***SUB2048*** subarrays. For NIRSpec ***MSATA*** and ***WATA*** modes, the detector setup has a fixed number of groups (3), integrations (1), and exposures (1), which cannot be altered. Beside these choices for subarray with WATA, the readout pattern and the filter are the only parameters that can be adjusted (NIRSpec Readout Patterns). Their selection can tune the S/N for the TA observation. For ***FULL*** subarray, the allowed readout patterns result in saturation limits with the approximate magnitudes AB ~ 19.5 for ***NRSRAPID*** or AB ~ 21 for ***NRS***, while for the smallest subarray, ***SUB32***, saturation occurs around magnitude AB ~ 11.9. More information is in Table 2 for MSATA and Table 2 for WATA.

Creating a TA calculation

Users will first create a source and a scene in the **Scenes and Sources** tab (or modify the default source if this is the first calculation of the workbook), and then specify parameters for the instrument and detector setups in the **Calculations** tab after selecting ***Target Acquisition*** mode from the NIRSpec dropdown menu.

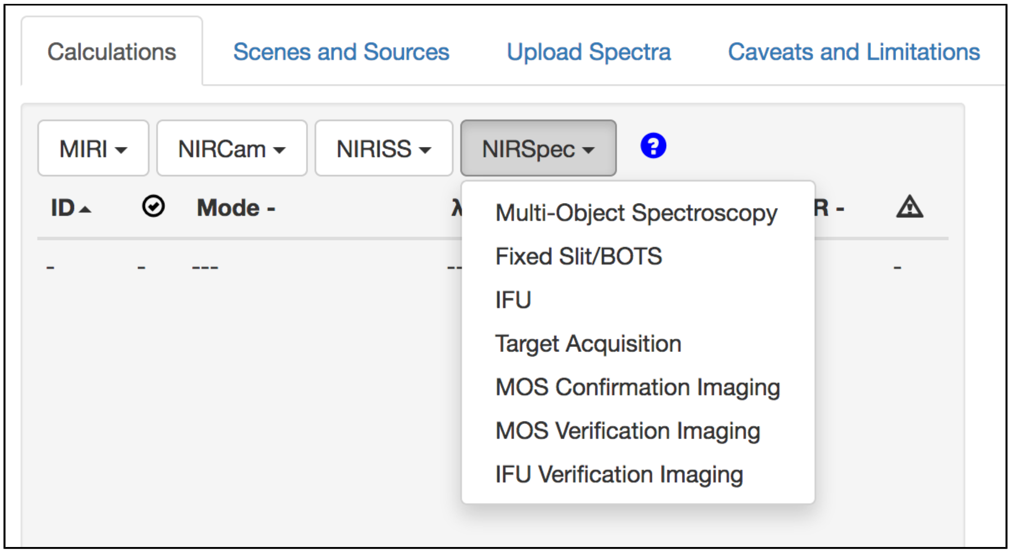
Defining the TA scene and source

The scene definition and source definition for TA calculations are defined along the same lines as for the other observing modes.

Creating a calculation

Target Acquisition is one of the modes available for all JWST instruments within the ETC. To initialize a TA calculation, select ***Target Acquisition*** from the NIRSpec instrument drop-down menu. Once selected, the calculation will load a default scene and source. This can be changed at the user's discretion by accessing the **Scenes and Sources** tab where the **Select a Scene** pane can be selected to change the pre-defined TA source.

Figure 1. Creating a NIRSpec Target Acquisition Calculation

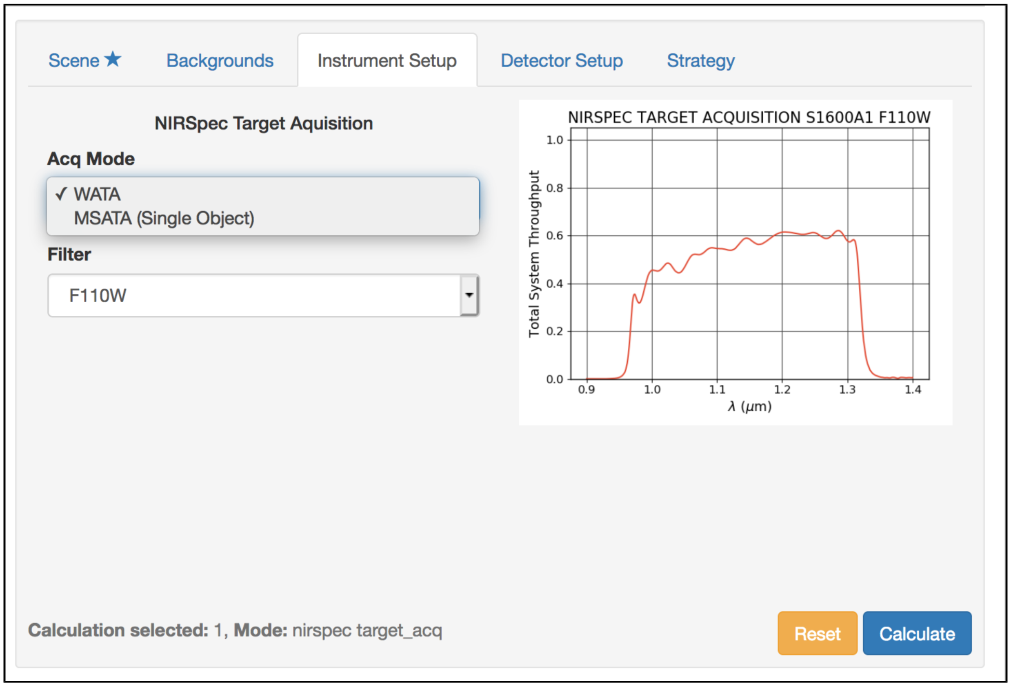


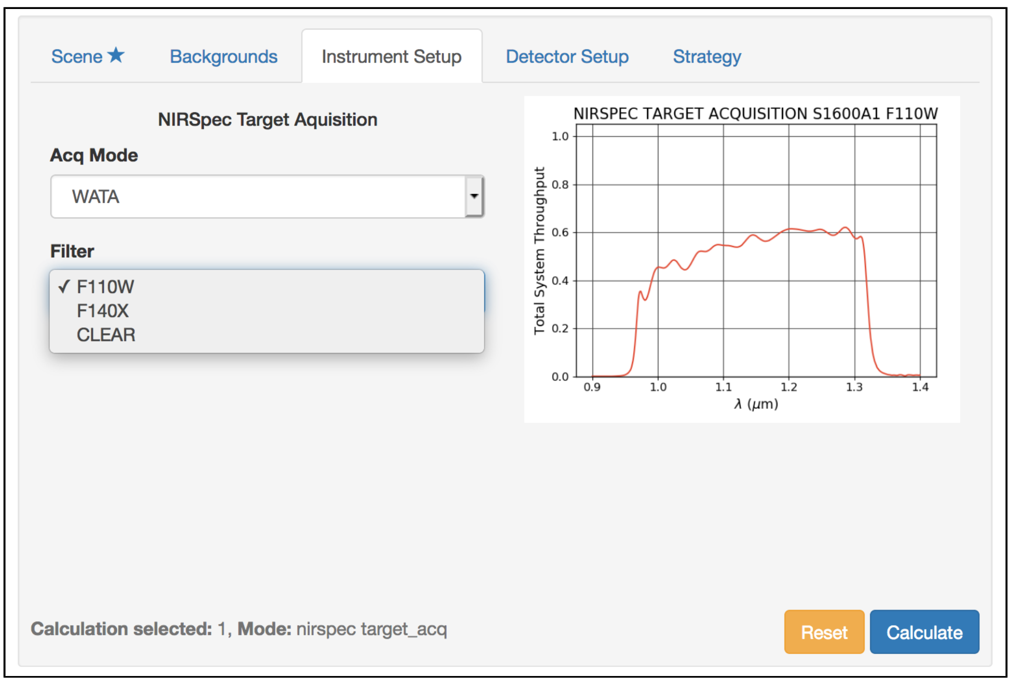
Create a target acquisition calculation by selecting the Target Acquisition mode from the NIRSpec instrument drop-down.

What's supported

The ETC currently supports two TA modes: ***WATA*** and ***MSATA (Single Object)***. The ***WATA*** mode always uses the ***S1600A1*** aperture. The ***MSATA (Single Object)***, which is appropriate for ***MSATA*** standard TA calculations, does a full detector readout (no subarray) calculation using the MSA model. Both ***WATA*** and ***MSATA*** have a fixed number of groups (3), integrations (1), and exposures (1) and cannot be changed by the user in the ETC. Therefore, to increase the S/N for either ETC TA mode, it is recommended that users choose another star for TA, or select different filter and/or readout options in the instrument and detector configuration areas in the **Calculation** tab.

Figure 2. NIRSpec TA Supported Modes and Filters



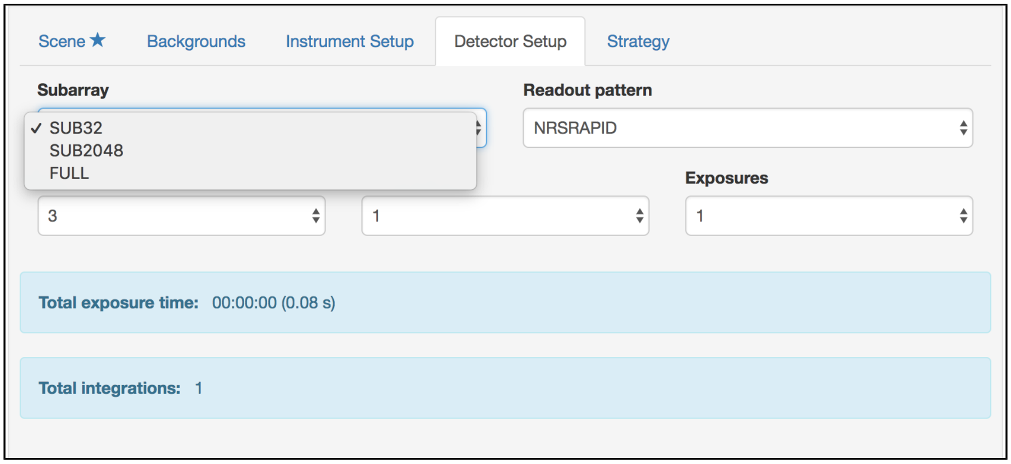


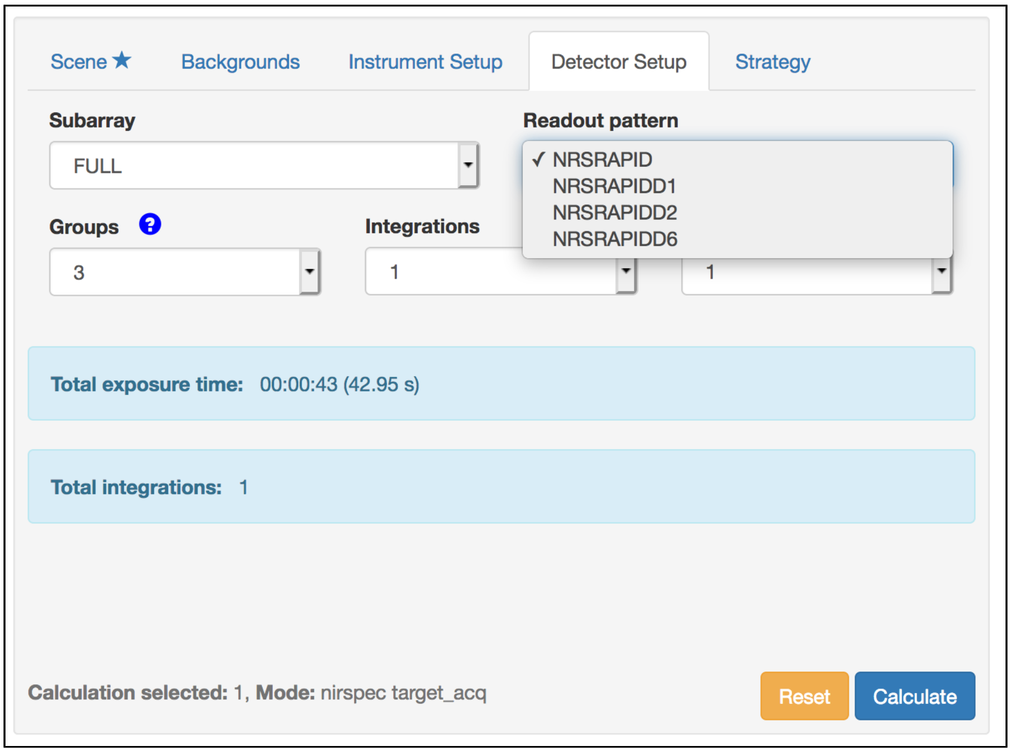
Top: The ETC supports the Wide Aperture Target Acquisition (WATA) and Micro-Shutter Array Target Acquisition (MSATA). Bottom: Filters F110W, F140X, and CLEAR are available for both acquisition modes.

The readout patterns available for ***MSATA*** mode are ***NRSRAPID***, ***NRSRAPIDD1***, ***NRSRAPIDD2*** and ***NRSRAPIDD6***. For ***WATA*** mode, ***NRSRAPID***, ***NRSRAPIDD1***, ***NRSRAPIDD2*** and ***NRSRAPIDD6*** are also available. Selection of the readout pattern defines the TA exposure duration (more information on readout patterns can be found at

NIRSpec Readout Patterns). ***NRSRAPIDD1*** and ***NRSRAPIDD2*** readout patterns are available for the ETC, and are not currently supported by the Astronomer's Proposal Tool (APT).

Figure 3. NIRSpec TA Subarrays and Readout Patterns





The Detector Setup tab, showing the Subarrays (top) and Readout patterns (bottom) available for NIRSpec TA.

WATA mode

This ETC mode corresponds to the ***WATA*** TA in the NIRSpec BOTS observing mode. ***WATA*** is the only TA mode available for high S/N spectrophotometric observations using the BOTS, FS, MOS or IFU templates.

The ETC ***WATA*** mode can be used with the following filters: ***CLEAR***, ***F110W***, or ***F140X***, just as in APT. Both the mode and the filter are selected in the **Instrument Setup** sub-tab within the Calculation Editor pane. With the choice of filter, a throughput versus wavelength plot is presented.

The subarray choices for the ETC ***WATA*** mode are ***FULL***, ***SUB32***, and ***SUB2048*** subarrays. The ***SUB32*** subarray reads a window of 32 × 32 pixels, while the ***SUB2048*** reads a window of 32 × 2048 pixels. The ***FULL*** subarray reads 2048 × 2048 pixels.

The readout patterns available for the ETC ***WATA*** mode are ***NRSRAPID, NRSRAPIDD1, NRSRAPIDD2 and NRSRAPIDD6***.

MSATA (Single Object) mode

MSATA mode can be used with FS, IFU and MOS templates.

The ETC ***MSATA (Single Object)*** mode can be used with the ***CLEAR***, ***F110W***, or ***F140X*** filter. As previously mentioned, the mode and the filter are selected in the **Instrument Setup** sub-tab within the Calculation Editor pane.

The single subarray choice for the ***MSATA (Single Object)*** mode uses the ***FULL*** subarray, which reads the entire 2048 × 2048 pixel array.

The readout patterns available for ***MSATA (Single Object)*** mode are ***NRSRAPID, NRSRAPIDD1, NRSRAPIDD2 and NRSRAPIDD6.*** .

VERIFY_ONLY mode

For ***VERIFY_ONLY***, ***NRSRAPIDD1*** and ***NRSRAPIDD2*** are not currently supported in APT.

> For ***VERIFY_ONLY***, the pointing relies only on the guide star acquisition performed by the FGS. This method will be used for placing extended objects in the field for IFU observations, or when using the MSA as a long slit, or when using the FS ***S1600A1*** aperture. ***VERIFY_ONLY*** is an imaging mode in the ETC and can be found at IFU Verification Imaging and MOS Verification Imaging.

Outputs

For ETC TA calculations, the optimal range for the signal-to-noise ratio is 20 at the faint end all the way to saturation at the bright end. If the S/N of the calculation does not reach 20, the ETC will issue a warning that "TA may fail." However, it is possible that TA could be successful at lower S/N ratios, and these thresholds may be revised in the future.

For the centroiding algorithm to work properly, at most only 1 pixel can be saturated. Otherwise, the coarse location routine in the centroid algorithm may fail and the TA process will derive an inaccurate slew to place science targets in their observing apertures. The ETC will issue a warning when one or more pixels is saturated.

Published	04 Oct 2017
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. • 27 Jun 2019 Fixed incorrect links • 05 Nov 2018 Updated for ETC v1.3

JWST ETC Cosmic Ray Implementation

The JWST Exposure Time Calculator (ETC) accounts for the effects of cosmic rays in calculations.

Cosmic rays are charged particles that originate from the Sun or outside the solar system and move at nearly the speed of light. These may impact a detector during an exposure and immediately saturate a central pixel and some of the surrounding pixels. Cosmic ray studies based on data from detectors in low-Earth orbit and at the Earth-Sun L2 point have been used to estimate the expected cosmic ray rates and behavior for the JWST detectors.

The ETC does not model cosmic ray events in the Images themselves. Instead, the implementation is a purely statistical one that effectively reduces the integration ramp length used in signal-to-noise calculations. The cosmic ray implementation depends on only two fixed parameters: the cosmic ray flux and the number of pixels affected by each cosmic ray. As of ETC 1.5.1, the cosmic ray flux is set to 8 events/sec/cm^2 (0.6366 events/sec/cm^2/steradian) and the number of pixels affected is set to 9 (a central pixel as well as all 4 adjacent and all 4 diagonal pixels). Oblique cosmic ray strikes are not modeled. For every calculation:

1. The number of events/sec/cm^2 is converted to events/sec/pixel using the pixel scale for that particular observing mode, and is multiplied by the number of pixels affected by the event. This is the *cosmic ray pixel rate*.
2. The fraction of each ramp lost to an average cosmic ray event is then determined, taking into account that there is a discrete number of groups per integration ramp, and a minimum usable number of groups. In the limit as the number of groups goes to infinity this is 0.5 because they are equally likely to hit at any time. Thus, the *ramp loss per pixel* is half of (number of groups - minimum number of groups for the observing mode) divided by (number of groups - 1).
3. Multiplying the *ramp loss per pixel* by the *cosmic ray pixel rate* and the photon collecting time gives the statistical average *fraction of groups lost* to cosmic rays for a given total time.
4. The number of remaining groups after cosmic rays have affected the exposure is calculated as (1 - fraction of groups lost) times the number of groups. This new value is used for all noise calculations.

The Reports tab provides the "Average Number of Cosmic Rays per Ramp," the number of events/sec/pixel multiplied by the integration ramp length.

Published	07 Jan 2020
Latest updates	

JWST ETC Saturation

The instrument mode-specific saturation limits in the JWST Exposure Time Calculator (ETC) are conservative estimates that in most cases are lower than the threshold for non-linearity determined during testing.

On this page

Video Tutorials:

ETC General Overview

Calculation and warnings

The ETC checks for saturation by first calculating the slope of the integration ramp in units of e^-/second, then multiplying by the length of the integration in seconds. If the resulting value exceeds the limit set in the ETC (see Table 1), a warning will be given. There are two types of saturation that may be encountered:

- *Partial saturation*: Saturation occurs in the third group or a later group of the integration ramp. These integration ramps are still usable up to when saturation occurs; extending the integration ramp beyond saturation results in unusable data and should be avoided.
- *Full saturation*: Saturation occurs in the first or second group of the integration ramp. The warning is raised because at least two groups are needed for the slope calculation. The only way to avoid full saturation is to change to a smaller subarray or use a readout pattern with a shorter group time. Visit the Recommended Observing Strategies and Understanding Exposure Times articles for further understanding and advice on adjusting these parameters.

ETC saturation limits

The table below presents detector full-well depths and compares them to the saturation limit for specific instrument modes in the ETC.

Table 1. Detector full-well depths and ETC saturation limits.

Instrument/Detector	Full-well depth (e^-)	ETC limit (e^-)	% of full-well depth
MIRI	250,000	*All modes*: 193,655	~78%
NIRCam/Short-wavelength (SW)	105,750	*Coronagraphic Imaging*: 100,415	~95%
		Imaging: 100,415	~95%
		Target Acquisition: 100,415	~95%
		Time Series: 73,990	~70%
NIRCam/Long-wavelength (LW)	83,300	*Coronagraphic Imaging*: 78,850	~95%
		Grism Time Series: 58,100	~70%
		Imaging: 78,850	~95%
		Target Acquisition: 78,850	~95%
		Time Series: 58,100	~70%
		Wide Field Slitless Spectroscopy: 78,850	~95%
NIRISS	95,000	*AMI*: 30,000	~32%
		Imaging: 72,000	~76%
		SOSS: 72,000	~76%
		Target Acquisition: 72,000	~76%
		WFSS: 72,000	~76%
NIRSpec	65,000	*FULL subarray*: 45,000	~70%
	77,000	*All other subarrays*: 65,000	~84%

Published	07 Jan 2020
Latest updates	

JWST ETC Residual Flat Field Errors

The JWST ETC includes pixel-to-pixel noise due to an imperfectly corrected flat field. This noise source is often mitigated by dithering. Since the ETC currently does not model dithers, except in a limited sense for a few special cases, such as coronagraphy and IFU spectroscopy, the absence of dithers will limit the sensitivity for very deep (>10,000 s) imaging observations and will also limit the signal-to-noise ratio that can be achieved for bright sources.

On this page

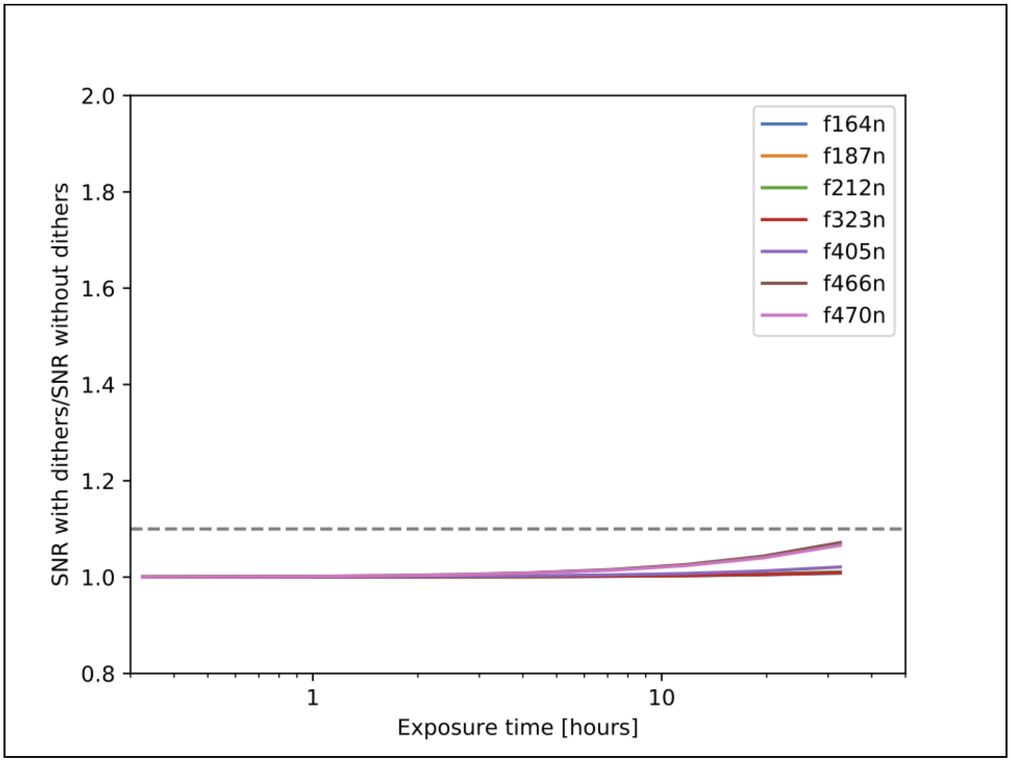
Users should be aware that the issues presented in this article are now fixed in the ETC v1.2.2 release and beyond. Specifically, the "number of exposures" in the ETC are interpreted as "number of dithers", and will decrease the residual flat field error by $\sqrt{n_{\mathrm{exp}}}$. Conversely, multiple integrations will not decrease the residual flat field error. This way it is possible to investigate the effect of dithering on the predicted SNR.

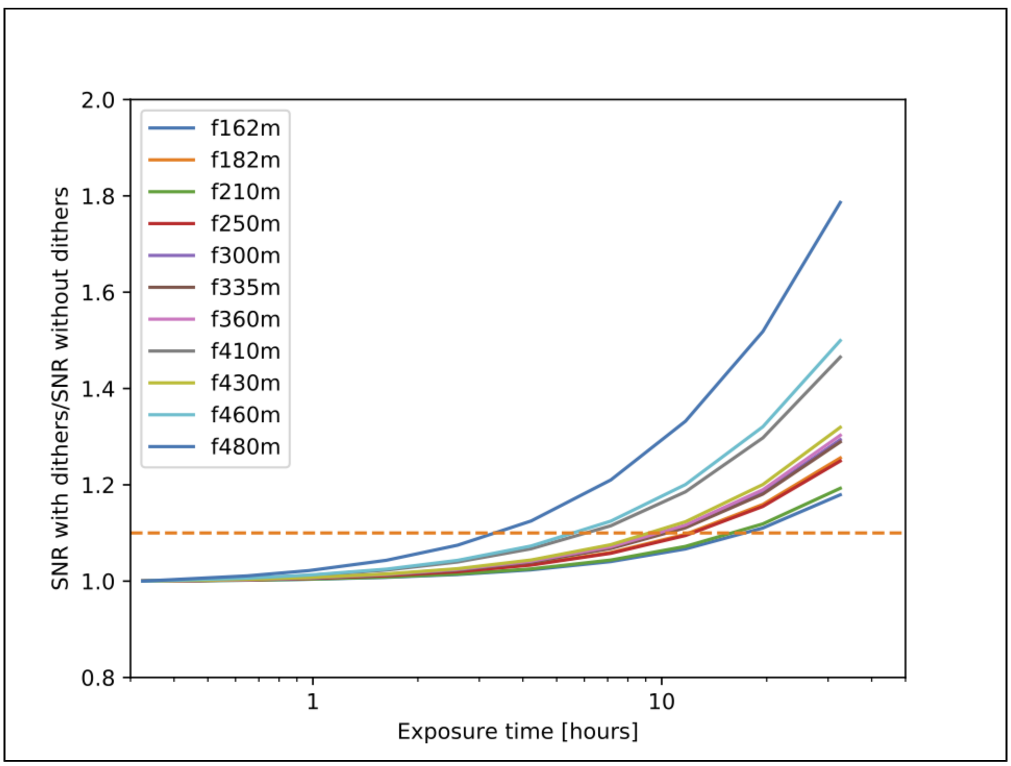
In its error model, the ETC includes an error term that models residual flat-field errors. For a typical observation, each exposure will be divided by a pixel flat field, which is intended to normalize the relative response (quantum efficiency) of each pixel. However, the flat field is an imperfect measurement itself, and consequently, there will always be some residual pixel-to-pixel response variation, even after division by the flat field. In the absence of dithers, where the pointing of the telescope is the same for multiple exposures, the light from a source will occupy the same pixels on the detector for each exposure. In this case, the presence of a residual flat field error may eventually limit the depth of an observation. JWST detectors are required to have flat fields with pixel-to-pixel variations <10%. In the ETC, the residual flat field error, after flat-field correction, is typically assumed to be in the range of 0.1 to 1.0%. Currently, the ETC only models dithers in a very limited sense, and may, therefore, underestimate the sensitivity of very deep observations.

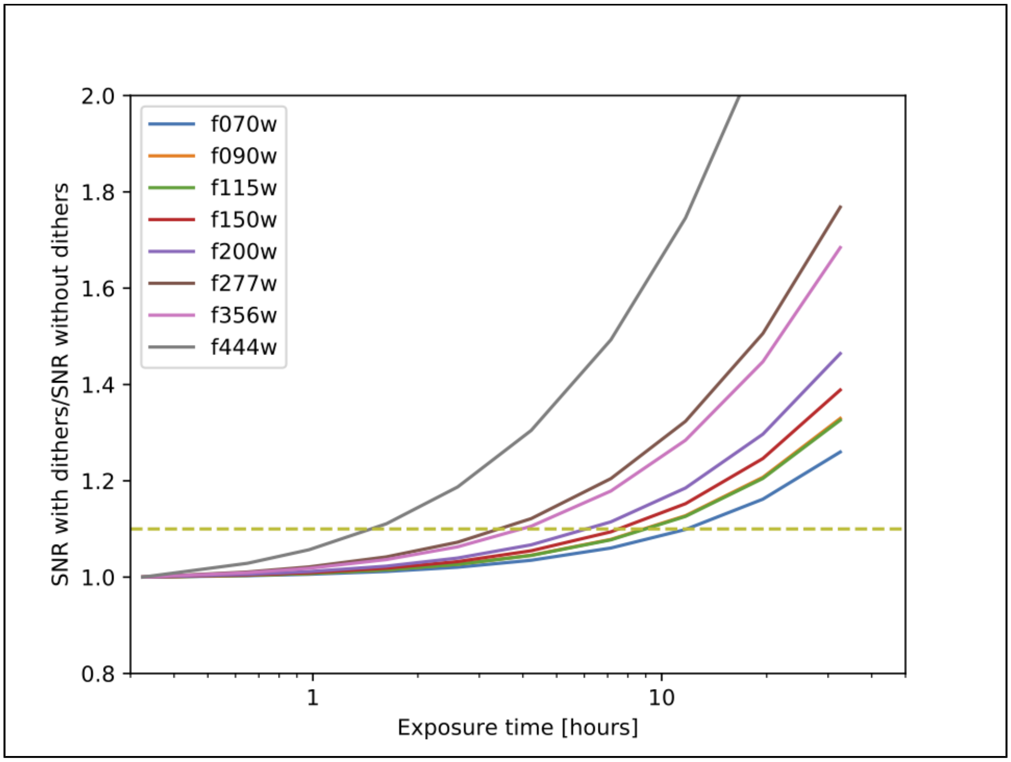
Effects of the residual flat field error on deep observations

As a rule of thumb, observers dependent on total exposure times in excess of ~10,000 seconds for broad-band imaging (and somewhat longer for most spectroscopy modes) should be aware of the effects of residual flat field errors. In the limit of extremely long total exposure times, in the absence of dithers, all observations will eventually be limited by the residual flat field error. The practical effect is that ETC calculations will have a "noise floor", beyond which observations with increasing numbers of exposures no longer increase the signal-to-noise ratio by $\sqrt{n_{\mathrm{exp}}}$. This is true both for faint and bright sources. Further, in the case of faint sources, background-limited observations (i.e. with high background levels compared to the source) are particularly susceptible to residual flat-field errors. That, for instance, means that narrow band filters will take longer to be limited by the flat-field error, and spectroscopy is similarly less affected.

Figure 1. Relative effect of dithering in decreasing residual flat field error as a function of total exposure time for NIRCam imaging







The relative effect of dithering decreasing the residual flat-field error for NIRCam imaging as a function of total exposure time. This calculation assumes ~1,000 s exposures. Departures above 10% (dashed line) indicates that the non-dithered ETC sensitivities may be conservative if significant numbers of dithers are used.

Effects of the residual flat-field error on observations of bright sources

Another effect of the residual flat-field error is that there is a limit on how high the signal-to-noise ratio will get for bright sources. The signal-to-noise ceiling will depend on the flat-field error assumed for each instrument, as well as the number of pixels the signal is spread over. For most modes, observations of point sources will be limited to signal-to-noise ratios of a few 100. Note that time series observations (e.g., of exoplanet transits) are immune to this, as they rely on relative measurements on the same pixels.

But my observation will have lots of dithers. What should I do?

The ETC currently presents a scenario for deep observations that is likely somewhat conservative, and essentially assumes that the observer does not dither, except in a few cases where dithers are implemented for other reasons (specifically IFUs and coronagraphy). However, most observing programs will naturally include significant numbers of dithers. The basic effect of dithers will be to decrease the flat-field noise by $\sqrt{n_{dither}}$, as long as the dither is larger than 1 pixel. While the ETC does not provide an explicit way to include this effect, it is easy to include it in the following way:

1. Create an ETC calculation for a single dither. Note that a single dither may include both multiple integrations and multiple exposures, provided that the telescope does not change pointing between exposures.
2. Note the signal-to-noise (SNR) ratio for a single dither reported by the ETC.
3. Determine the number of dithers n_{dither} for which the telescope offsets to a new pointing, either from APT, or using the dither table relevant for the instrument and mode.
4. Scale the single-dither SNR with $\sqrt{n_{dither}}$ to determine the final sensitivity: $SNR_{total} = SNR_{dither} * \sqrt{n_{dither}}$
5. To estimate the relative effect of the flat-field error, create a new ETC calculation for the total exposure time by assuming the dithers are regular ETC exposures.

Note that scaling with the number of dithers in this way may be optimistic; the ultimate performance is likely bounded by the ETC prediction and the scaling described above.

The special case of NIRSpec MSA

Observers using the multi-shutter array (MSA) with NIRSpec should be aware that the residual flat-field error is significantly worse than for other modes, as the flat fields for the many individual shutters are necessarily of lower quality than what can be done (e.g., by imaging). In this case, it is not expected that the noise floor can be improved using the above method, and it is recommended that the ETC n_{exp} parameter is used to predict NIRSpec MSA performance also for long total exposure times.

Published	23 Jan 2018
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. • 05 Nov 2018 Updated for ETC v1.3 • 14 Mar 2018 Warning added to reflect changes in the ETC v1.2.2 patch release in regards to the residual flat field err

JWST ETC Outputs Overview

The JWST ETC provides 2D images, line plots, scalar values, warnings, and FITS downloads for evaluating calculations.

Video Tutorial:

ETC General Overview

The JWST Exposure Time Calculator outputs 2D images, line plots, and scalar values for all the calculations it performs. Saturation warnings are provided for instances when pixels partially or fully saturate. All ETC output products and some intermediate products can be downloaded as FITS files for additional analysis.

List of articles

1. **JWST ETC Images and Plots**: Description of the 2D images and line plots presented following the completion of a calculation.
2. **JWST ETC Reports**: Summary of the input parameters and output values for each calculation.
3. **JWST ETC Downloads**: Details of final and intermediate data output products for each calculation.

Published	30 Dec 2016
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. Video link added.

JWST ETC Images and Plots

The JWST Exposure Time Calculator outputs 2D images and line plots for all the calculations it performs. These outputs enable visual inspection of the results of a chosen set of input parameters.

On this page

Video Tutorial:

ETC General Overview

Images

Types of Images

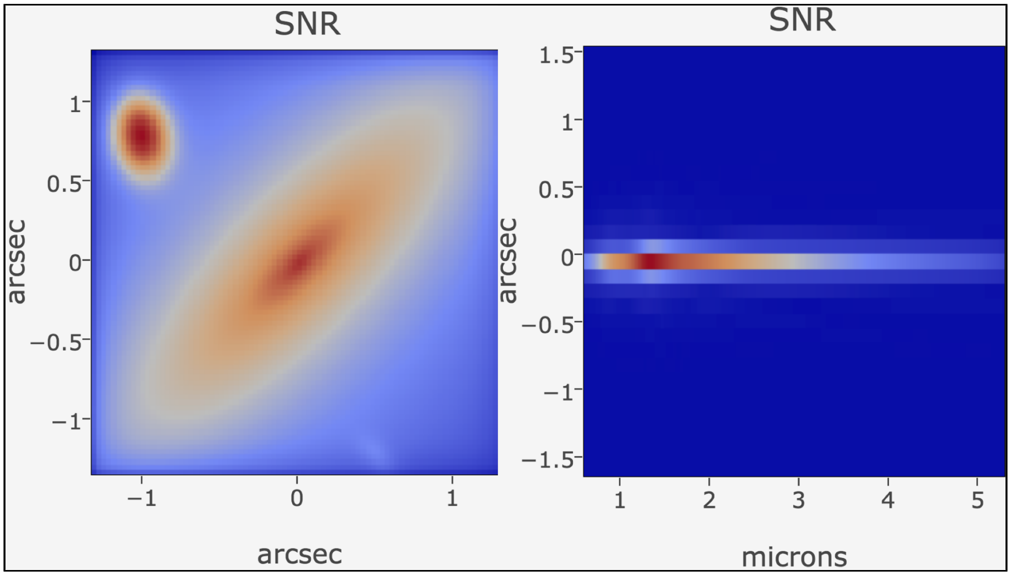
The 2D images shown in the output **Images** pane are associated with the calculation selected by clicking a row in the **Calculations table.** The selected calculation is highlighted in yellow in the **Calculations** pane**.** The ETC displays various 2D output images for a calculation and these can be selected using one of the four tabs: (1) **2D SNR**, (2) **Detector**, (3) **Saturation**, and (4) **Groups Before Saturation**. The images contain the entire scene used in the calculation.

- **2-D SNR** - Image showing the signal-to-noise ratio (SNR) per pixel over the 2D scene (Figure 1)
- **Detector** - Image showing the count-rate (in e^-/sec) for each detector pixel.
- **Saturation** - Image showing the 2-D distribution of the saturated pixels, allowing the user to examine the exact locations of saturated pixels and decide whether the data would be useful even with saturation in a few pixels. When there are saturated pixels, the status column of the calculations table shows a warning sign (yellow exclamation point). In the **Reports** pane, the **Warnings** tab will appear in red indicating that there is a warning message which will inform the user about the number of pixels with partial and full saturation.

> **Saturation Warning**
>
> Partial saturation implies that partial ramps may still be used in some cases. Full saturation implies that some of the pixels are saturated at the end of the first two groups and cannot be recovered. Note that the ETC does not support single-group (**Groups per integration** = 1) readout modes.

- **Groups Before Saturation** - Image showing the maximum number of **Groups** the user can specify before that pixel saturates. The value for the brightest pixel is given in the **Reports** pane as the "Maximum Number of Groups Before Saturation."

Figure 1. 2D SNR output images



The 2D SNR images are from a NIRCam SW imaging calculation using a scene with multiple sources (left) and from a NIRSpec fixed slit spectroscopy calculation using a single source (right).

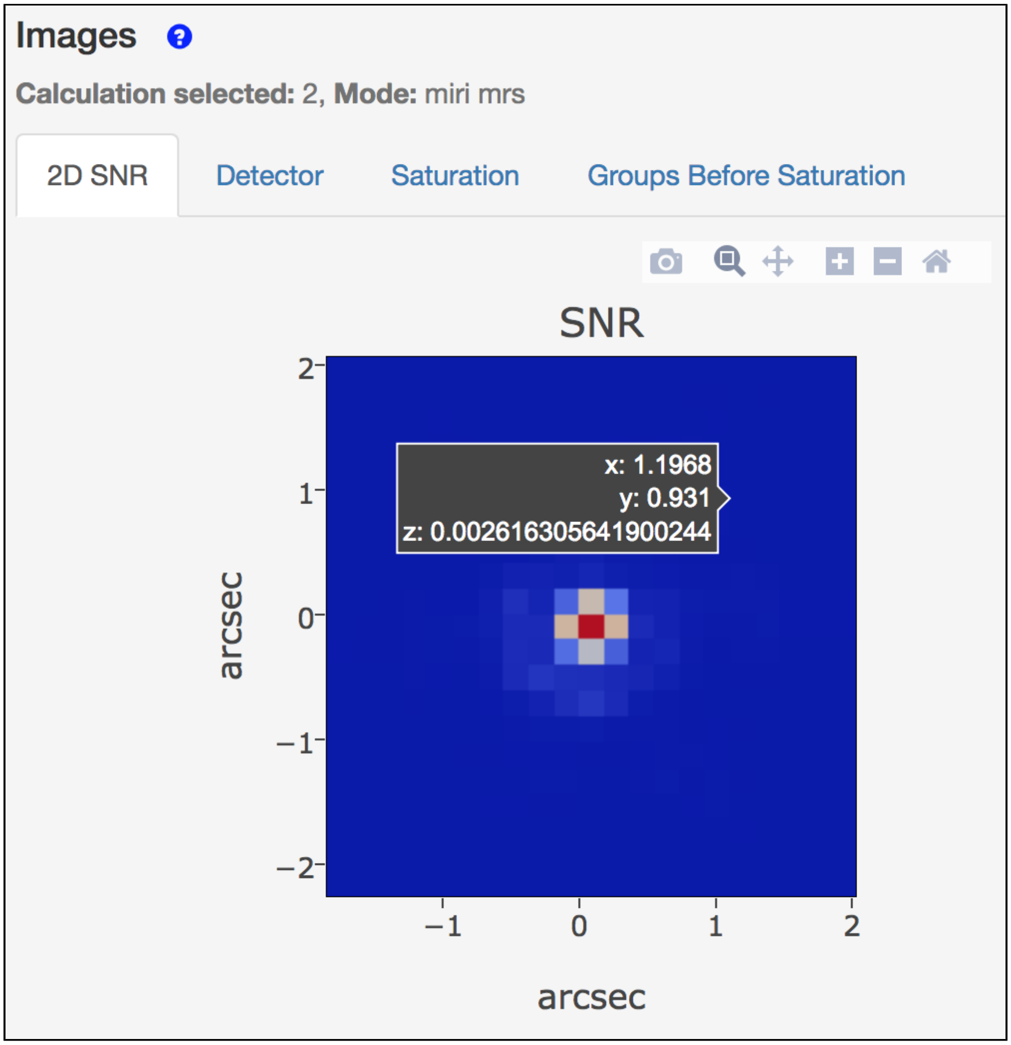
Navigating Images

The interactive plot (Figure 2) allows individual pixel values to be displayed by hovering the cursor over each pixel. A pop-up box appears when hovering over pixels. The ***x*** and ***y*** values correspond to the horizontal and vertical locations in the scene, respectively. The ***z*** value corresponds to the value in that pixel, which depends on the image being examined.

From left to right, the different labels and functions are:

- ***Download plot as PNG***
- ***Zoom***: User-specified zoom box. Drag a box in the image to zoom in on that box.
- ***Pan***: Hover the cursor in the image, click and hold, then move the cursor to examine different regions of the image.
- ***Zoom in***
- ***Zoom out***
- ***Reset axes***: Return the image to its original state.

Figure 2. Examining images



Plots

The ETC **Plots** pane serves two purposes: (1) to visualize the output from a single calculation, and (2) to compare the results from multiple calculations within a workbook.

Visualizing the results from a calculation

The results shown in the **Plots** pane correspond to the selected calculation that is checked using the checkbox in the calculations table. The color and linestyle in the plot corresponds to the color and linestyle of the checkbox.

⚠ Plots do not always correspond to the displayed images unless the checkbox for that calculation is checked.

The desired output quantity to plot can be selected using one of the tabs within the **Plots** pane:

- **ApFlux** - shows the extracted flux (e^-/s) from the source in the aperture versus wavelength.
- **ApBackground** - shows the extracted sky background flux (e^-/s) versus wavelength.
- **SNR** - shows the signal-to-noise ratio (SNR) versus wavelength. The SNR in the extracted spectrum is per pixel along the wavelength axis, and not per resolution element. For imaging calculations, the SNR value is shown at the wavelength of interest (the effective wavelength of the filter, which is a flux-weighted average that depends on the filter and the input source spectrum).
- **SNR (time)** - shows the SNR versus on-source time. For imaging calculations, the **SNR (time)** value is shown at the wavelength of interest (the effective wavelength of the filter).
- **Contrast** - shows the contrast versus separation, and is only for coronagraphic imaging modes. This shows the limiting contrast, the faintest possible point source that can be detected for the chosen observation strategy, as a function of angular separation from the host source.

Navigating Plots

The **Plots** pane provides options for more in-depth exploration of the plots. Hovering the cursor over the plot brings up a list of options in the top right of the pane. From left to right, the different labels and functions are:

- ***Download plot as PNG***
- ***Zoom***: User-specified zoom box. Drag a box in the image to zoom in on that box.
- ***Pan***: Hover the cursor in the image, click and hold, then move the cursor to examine different regions of the image.
- ***Zoom in***
- ***Zoom out***
- ***Autoscale***: Automatically set the x- and y-axes to the optimal ranges. Similar to ***Reset axes***.
- ***Reset axes***: Return the image to its original state.
- ***Show closest data on hover***: Default. Hover over the plot to get a pop-up showing the value for the nearest data point (imaging or spectroscopy).
- ***Compare data on hover***: Hover over the plot to get pop-ups showing the values at each wavelength for multiple over-plotted calculations (imaging or spectroscopy).

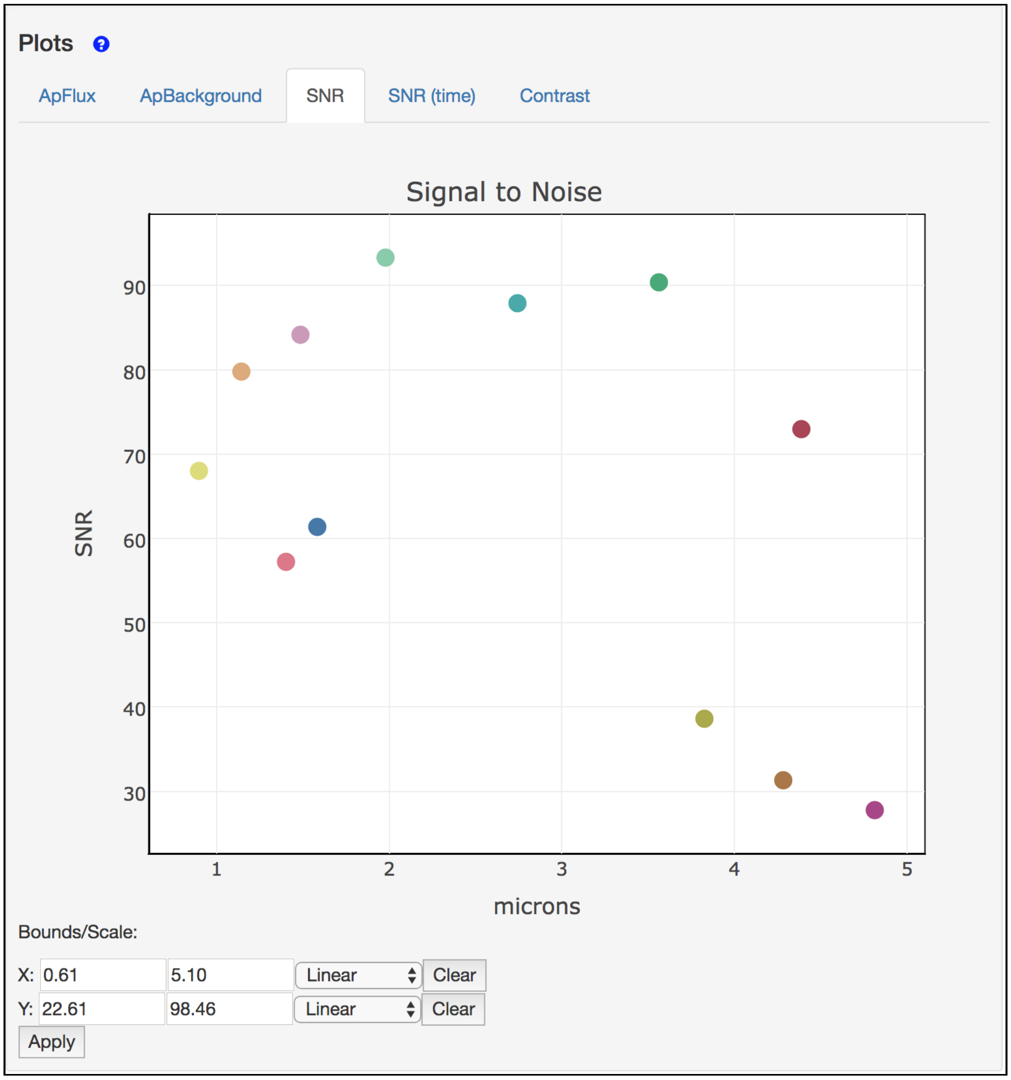
Comparing results from multiple calculations

The ETC allows users to easily compare the results from multiple calculations by over-plotting them. The desired calculations can be selected from the **Calculations** pane by clicking on the checkboxes, and the results from all of them will be displayed in the same plot. The color of the outline for each checkbox corresponds to the color in the plot.

All calculations in a given workbook may be over-plotted simultaneously by using the ***All*** option in the drop-down menu that is available on the checkbox pull down menu above the **Calculation** pane. This feature is useful for comparison of the calculated parameters for different filters/grisms of the same instrument, or for different instruments. This feature also makes it possible to compare the SNR vs. wavelength for multiple filters (Figure 3) and across instruments covering a broad spectral range, by selecting the calculations to be plotted simultaneously.

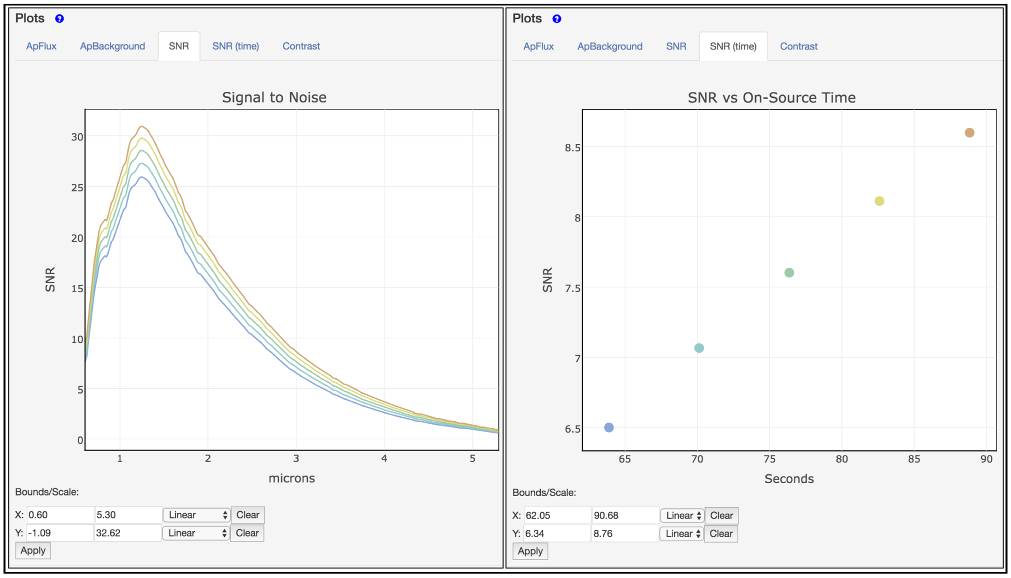
The ability to compare multiple calculations using the plot is especially useful to analyze the outputs from batch expansions (over filters, groups, integrations, etc.). The **SNR (time)** plot can be used to determine the exposure required to achieve a given SNR by performing an expansion over groups or integrations. When expanding over the time parameters (**Groups per integration** or **Integrations per exposure**), all the results from the calculations done in batch expansion can be selected by using the checkbox and plotted simultaneously, and the exposure time required to obtain the desired SNR can be directly read off the graph (Figure 4).

Figure 3. The SNR versus wavelength from multiple imaging calculations



The results shown are from multiple calculations performed using a batch expansion over all the broad-band and medium-band filters for the NIRISS imaging mode. Each point corresponds to a different calculation that uses a different imaging filter.

Figure 4. The SNR versus wavelength from multiple spectroscopy calculations



The SNR of extracted spectra from multiple calculations performed using a batch expansion over groups for NIRSpec fixed slits spectroscopy of a single source (left panel). The batch calculation provides SNR for different exposure times resulting from the different number of groups, and the result has been plotted to show the SNR versus on-source time (right panel) for the wavelength of interest, which was set to 3 m.

Published	13 Nov 2018
Latest updates	• 29 Oct 2019 Updated for ETC v1.5. Video link added.

JWST ETC Reports

The JWST Exposure Time Calculator (ETC) **Reports** pane provides a summary of the calculation that is selected in the calculation table. The **Reports** pane provides a report on the scalar output values, warnings, error messages, and a link to the downloads associated with the highlighted calculation.

On this page

Video Tutorial:

ETC General Overview

Reports

The Reports pane includes four separate tabs, **Report**, **Warnings**, **Errors**, and **Downloads**, that are described in more detail below.

Report

The report provides a summary of the input parameters and output scalar values associated with the selected calculation. This includes:

- *Instrument Filter/Disperser*: Input instrument configuration from the **Instrument Setup** tab (e.g, filters, grisms).
- *Extraction Aperture Position*: The (x, y) coordinates (in arcseconds) of the center of the extraction aperture specified by the user with either the **Centered on source** or **Specify position in scene** option under the **Strategy** tab.
- *Wavelength of Interest used to Calculate Scalar Values*: Corresponds to the desired wavelength specified by the user for spectroscopy modes under the **Strategy** tab or the effective wavelength of the filter for the imaging modes (in microns). The effective wavelength for a filter is the flux-weighted average and depends on the selected filter and the source spectrum.
- *Size of Extraction Aperture*: The **Aperture radius** value under the **Strategy** tab (in arcseconds).

- *Total Time Required for Strategy*: Total time for the full observation (in seconds), calculated based on the parameters specified by the user under the **Detector Setup** and **Strategy** tabs.
- *Total Exposure Time*: Total time spent on-target (in seconds), calculated based on the parameters specified by the user under the **Detector Setup** and **Strategy** tabs. It accounts only for time spent on-target (i.e., this value will be half the value of *Total Time Required for Strategy* for the ***Nod Off Scene*** strategy).
- *Maximum Fraction of Saturation*: Ratio of the *Total Exposure Time* to the saturation time for the brightest pixel.
- *Maximum Number of Groups Before Saturation*: Largest number of groups that prevents saturation in the brightest pixel. If the value is 10,000 groups or larger, ">9999" is reported.
- *Extracted Flux*: Extracted flux corresponds to the measured count rate (e^-/sec) within the extraction aperture for the source after background subtraction.
- *Standard Deviation in Extracted Flux*: Variance includes various noise terms as described in Pontoppidan et al. (2016). The square root of the variance is reported here (in e^-/sec).
- *Extracted Signal-to-Noise ratio*: The signal-to-noise ratio is computed directly as the ratio of *Extracted Flux* and *Standard Deviation in Extracted Flux*.
- *Input Background Surface Brightness*: Surface brightness of the background (in MJy/steradian) depending on the **Position**, **Background configuration**, and **Date** specified by the user under the **Backgrounds** tab.
- *Total Background Flux in Extraction Aperture*: If a background region was selected, the total background flux corresponds to the count-rate (e^-/s) from the sky background and contamination from any signal that contributes counts to the background extraction aperture (e.g., from overlapping sources or extended wings of the source). If no background region is specified, a noiseless sky background is reported.
- *Total Sky Background Flux in Extraction Aperture*: Count rate from the total sky background (for the configuration selected by the user). If no background region is specified in the **Strategy** tab, the contamination from within the scene is not accounted for and the total background is equal to the total sky background.
- *Fraction of Total Background due to Signal from Scene*: Fraction of the total background contributed by any other signal from within the scene that is contaminating the total background flux. If no background region is specified, this fraction is zero.
- *Average Number of Cosmic Rays per Ramp*: Computed by multiplying the assumed cosmic ray flux (in events/sec/pixel) by the ramp time.

For Coronagraphy, the report also includes:

- *Radius at which Contrast is Measured*: Distance in arcseconds from the center of the field of view where the contrast is measured.
- *Azimuth at which Contrast is Measured*: Angle in degrees measured clockwise from the positive y-axis where the contrast is measured.
- *Contrast*: The unitless companion-to-host flux ratio at the specified radius and azimuthal angle.

Warnings

If there are warnings, this is indicated in the calculations table by the orange exclamation point in the status column. An explanation for the warnings issued are provided under the **Warnings** tab of the reports pane. The warnings imply that there are problems that the user should be aware of that do not prevent the calculation from running. Some of the common warnings include information about partial or full saturation, background aperture definition which either overlaps the photometry aperture or extends outside the image, or a message that the SNR is less than 20 for target acquisition calculations.

Errors

An error is indicated by the red cross in the status column of the calculation table. The errors indicate that the calculation did not complete and may be due to problems with the input parameters. The message in the **Errors** tab will provide additional information.

Downloads

All the output products and intermediate products from the ETC calculations are available for download using the link under the **Download** tab. See JWST ETC Downloads for a full listing and descriptions of the files included in the download.

References

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, Proc. SPIE 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

Published	13 Nov 2018
Latest updates	• 23 Oct 2019 Updated for ETC 1.5. Video link added. • 27 Jun 2019 Added references section, added reference, and fixed incorrect links in text.

JWST ETC Downloads

The JWST Exposure Time Calculator provides an option to download the final and intermediate output products, along with input data used for an ETC calculation. The data products are available for downloads as FITS files.

On this page

Video Tutorial:

ETC General Overview

The JWST ETC outputs 2D images and line plots as well as scalar values for every ETC calculation that is performed using scene and sources, background spectrum, instrument configuration, observing setup and extraction strategy selected by the user.

All the final output products and intermediate products from the ETC calculations are available for download using the link provided under the download tab. The tarball contains FITS files of the 3D data cube for the IFU calculation, and 2D images that may be used for more detailed and specific analysis as desired by the ETC user. The extracted flux, backgrounds, contamination, and SNR used for the line plots are available as FITS tables.

Image directories

Background

backgrounds.fits: Contains background flux for the field of view at the time of observation requested. Background components are assumed to be uniform across the field, dependent on wavelength. The *background.fit*s file has an array in its second header (hdu 1) which has five records: the first column is wavelength (microns), the second column is the total combined background (MJy/str), and the last 3 columns are the thermal, stray light, and infield components of the total combined background, respectively.

Cube

- *3d/cube_flux.fits*
- *3d/cube_flux_plus_background.fits*

These contain the scene "observed" by the ETC, with sources convolved by instrument PSFs. It is the scene cube incident on the detector, in units of millijanskies. The difference between the two is that *cube_flux_plus_background.fits* contains additive background noise (scaled to the wavelength-dependent fluxes in *backgrounds.fits*).

First header (hdu 0) contains a three-dimensional array whose dimensions are wavelength, then x, then y. Pulling out a single slice of the array will provide the scene at a particular wavelength. The values of *CRVAL1* and *CDELT1*, *CRVAL2* and *CDELT2* are referring to the spatial position of the 0,0 pixel and scale (in arcseconds) of each of those slices.

Second header (hdu 1) has two fields: wavelength (in microns), and index number. Those index numbers map the wavelengths to the slices of the 3D array in the first header.

If you've used an IFU mode, you will have different 3D output files:

- *3d/cube_reconstructed.fits* - A cube of the reconstructed flux, in units of electrons/s
- *3d/cube_reconstructed_noise.fit*s - A cube of the noise (including all noise sources), in electrons/s
- *3d/cube_reconstructed_snr.fits* - The above two cubes divided by each other
- *3d/cube_reconstructed_saturation.fits* - 3D Saturation map, where 1=partially saturated, and 2=fully saturated.

These files represent the scene as reconstructed from the "observation". All files have a single header containing a 3-dimensional array with the axes in order wavelength, x, and y. All information for reconstituting the coordinates and wavelengths is given in the single header. Note that the header is for a linear wavelength scale, while the actual wavelength scale may not be linear (see *lineplots/lineplots_wave_pix.fits* for the actual wavelength scale).

There will also be files in the "model" directory.

- *3d/model/cube_flux_n.fits*
- *3d/model/cube_flux_plus_background_n.fits*

These files are equivalent in format and content to the *3d/cube_flux.fits* and *3d/cube_flux_plus_background.fits* files obtained from the other modes and described above, with the difference that each of the files is a Y-axis slice through the input scene cube. Within each file, only two Y-axis locations in the array are populated for all values of X and wavelength, corresponding to one IFU element. The rest of the cube is zeroes.

Image

- *image/image_detector.fits* - The signal, in electrons/s
- *image/image_saturation.fits*- The SNR

- *image/image_snr.fits* - The saturation, where 1=partially saturated, and 2=fully saturated.
- *image/image_ngroups_map.fits* - A map giving the number of groups before a given pixel will saturate.

These are the 2-D images displayed by the ETC. First header (hdu 0) contains a two-dimensional array of all of the values. As with the scene cubes, the header contains the spatial information for the scene.

For coronagraphic imaging, these files correspond to the chosen PSF subtraction strategy.

Plot directories

Lineplot

All of these files have two FITS headers, with an array of data (and explanatory headers) in the second header (hdu 1)

- *wave_calc*- 1-dimensional wavelengths (in microns), corresponding to the spectra (whether input from the user or from the ETC library) input into the calculation.
- *wave_pix* - 1-dimensional wavelength (in microns), corresponding to the output of the calculation. Unless a spectroscopic mode is specified, this file will have a single record with a single entry, which is the wavelength of the requested observation.

Some of these correspond to the line plots displayed in the ETC, but many do not.

These files contain inputs to the calculated observation, and have two records, wavelength (equivalent to wave_calc) and the specified value, in their second header (hdu 1):

- *target* - combined flux of all the targets in the scene re-sampled onto the calculation's input wavelength grid, in milli-Janskys (as a function of wavelength)
- *fp* - the combined flux in electrons/s incident on the detector focal plane
- *bg* - the (assumed uniform) background flux input into the calculation, in megaJanskys per steradian
- *bg_rate* - the background flux input into the calculation in electrons/s

The following files are extracted from the calculation observation. The data are stored in the second header (hdu 1), and consist of two records: wavelength (equivalent to wave_pix) and value. Unless a spectroscopic mode is used, the records will only have one entry - for the wavelength of the observation - in each. The values correspond to the scalar values displayed in the **Reports** pane of the ETC. For spectroscopic modes, the ETC reports the value at the reference wavelength in the **Reports** pane.

- *total_flux* - the total flux onto the detector extracted from the calculation, in electrons/s
- *extracted_flux_plus_bg* - the flux of the target extracted from the calculation, in electrons/s
- *extracted_flux* - the flux of the target extracted from the calculation, with background subtracted, in electrons/s
- *extracted_noise* - the extracted noise (incorporating all instrumental noise sources), in electrons/s

- *sn* - the extracted SNR (calculated as extracted_flux/extracted_noise)
- *extracted_bg_only* - the background flux extracted from the output of the calculation, in electrons/s
- *extracted_bg_total* - the background plus contamination from sources in the scene, in electrons/s
- *extracted_bg_contamination* - just the background contamination, in electrons/s
- *n_partial_saturated* - number of partially saturated pixels in the output, as a function of wavelength
- *n_full_saturated* - number of fully saturated pixels in the output, as a function of wavelength
- *contrast* (coronagraphic imaging only) - companion-to-host flux ratio, as a function of wavelength

Input Data

input.json- a JSON-formatted text file containing a complete record of the inputs to the ETC. This can be used as input to the ETC when run as a script-able python program.

Published	08 Feb 2018
Latest updates	• 24 Oct 2019 Updated for ETC v1.5. Video link added. • 05 Nov 2018 Updated for ETC v1.3. Added description of coronagraphy-only lineplot.

JWST ETC Workbooks Overview

The JWST Exposure Time Calculator (ETC) organizes calculations in workbooks that can be saved for future use and shared with colleagues. Sample workbooks are available to help users get started.

Video Tutorial:

ETC Workbooks

The JWST ETC provides a wide variety of sample and example science program workbooks for users to explore the available parameter options for every observing mode. The ETC also enables collaboration through the process of sharing workbooks with other registered users. This workflow is simple to use and allows a range of options for sharing, from read-only to write access.

List of articles

1. **JWST ETC Using the Sample Workbooks**: Details for making use of sample and example science program workbooks.
2. **JWST ETC Sharing Workbooks**: Description of how to share workbooks with other registered users.

Published	01 May 2019
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. Video link added.

JWST ETC Using the Sample Workbooks

Sample workbooks are designed with illustrative calculations to help users get started in using the JWST Exposure Time Calculator (ETC).

On this page

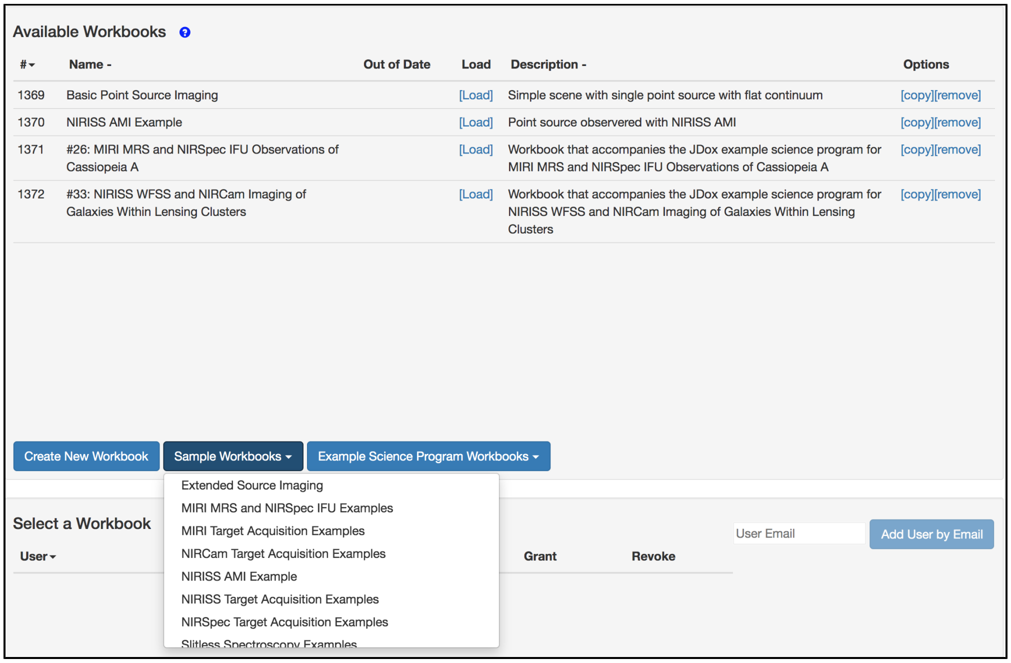
Video Tutorial:

ETC Workbooks

The **Available Workbooks** pane can be populated by retrieving a set of sample workbooks for all four JWST science instruments which include imaging, slitted, slitless, and IFU spectroscopy, and coronagraphic imaging calculations. These workbooks are organized in alphabetical order in the drop-down menu. Workbooks include pre-defined sources and scenes for calculations. The sample workbooks can assist users in scenes, sources, and calculations from basic to more complex calculations.

Page layout

Figure 1. Layout of the Available Workbooks page



Available workbooks

Workbooks available to users are listed in the **Available Workbooks** pane. This list can be populated by shared workbooks from other users, adding workbooks from the sample workbooks list, or by creating a new workbook by clicking the ***Create New Workbook*** button. Please visit the sharing workbooks page to learn more about sharing workbooks.

A description of each column name is below:

#: Workbooks can be referenced by an ID number.

Name: The name of the available workbook.

Out of Date: Workbook was created in a previous version of the ETC.

Load: Load and access sample workbook.

Description: Brief description of the calculations contained in the workbook.

Options: Users can create a new copy or remove the workbook from their list of available workbooks.

Sample workbooks

Sample workbooks are designed to help users become acclimated with the Exposure Time Calculator (ETC) and various instrument modes. This can include basic point source imaging for utilizing sensitivity calculations of each JWST instrument, imaging with multiple extended sources, coronagraphic imaging, slitted spectroscopy, and IFU calculations.

Example science program workbooks

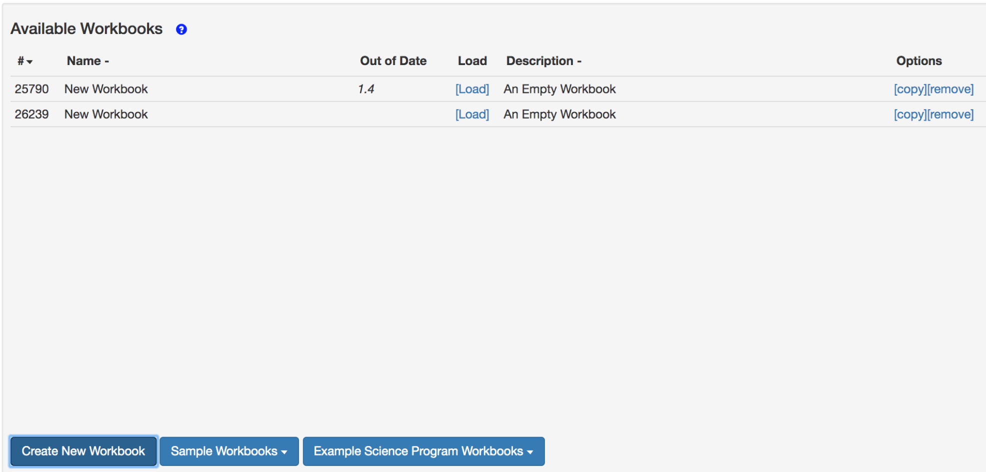
These workbooks are associated with the Example Science Programs, which present realistic science programs for users to explore the steps in creating a proposal from scratch. These include observations of stars, galaxies, and solar system targets with the full range of observing modes. ID numbers in the titles of each workbook are provided for easy matching of JDOX articles, ETC workbooks, and APT files for each Example Science Program.

Getting started

From the **Available Workbooks** pane, click the ***Sample Workbooks*** or ***Example Science Program Workbooks*** button to obtain a list of pre-made workbooks. Once a workbook of interest is clicked, an independent copy is added to a user's list of available workbooks. To access the workbook, click ***Load***. The user can modify these workbooks for their own ETC calculations. The sample workbooks that have been copied are independent copies, so modifying them does not affect the master workbook. Users can always go back to the landing page and get another copy of the sample workbook provided with the ETC. When a workbook is opened it is on the **Calculations** tab by default. There are pre-defined scenes and sources already available, and they have been created to illustrate the features that are most relevant to the observing mode with the given instrument. Note that any given workbook (for example, with slitless spectroscopy calculations) contains calculations for different instruments that allow that specific observing mode. In the case of the sample workbooks, the **Calculations** tab has a **Notes** pane at the bottom explaining each calculation.

Page layout

Figure 2. Out-of-date workbooks



Out-of-date workbooks

During a new ETC release, the workbooks from the previous ETC version that have been migrated to the current ETC are marked as "Out-of-date" (as seen in Figure 2 above).

When you load the old workbooks, they will open in "Read-only" mode. This ensures that the results from the previous version are not overwritten and will be retained for reference.

To update your old workbooks and work with them in the current ETC:

- Identify the workbook you want to use from the list of available workbooks.
- Click ***Load*** to open the read-only version of the old workbook.
- Click ***Copy*** on the right-hand side of the row that contains the workbook. This creates an exact copy of the selected workbook and appears on the list of available workbooks.
- Click ***Load*** to open the copied workbook in a separate tab.
- All the calculations in the workbook will be automatically updated using the current version of the ETC software.
- Compare the new results with those of the previous ETC version in the other tab.

References

JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, Proc. SPIE 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

Published	30 Dec 2016
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. Video link added. • 05 Nov 2018 Updated for ETC v1.3

JWST ETC Sharing Workbooks

Sharing workbooks within the JWST Exposure Time Calculator (ETC) allows for effective collaboration between multiple users.

On this page

Video Tutorial:

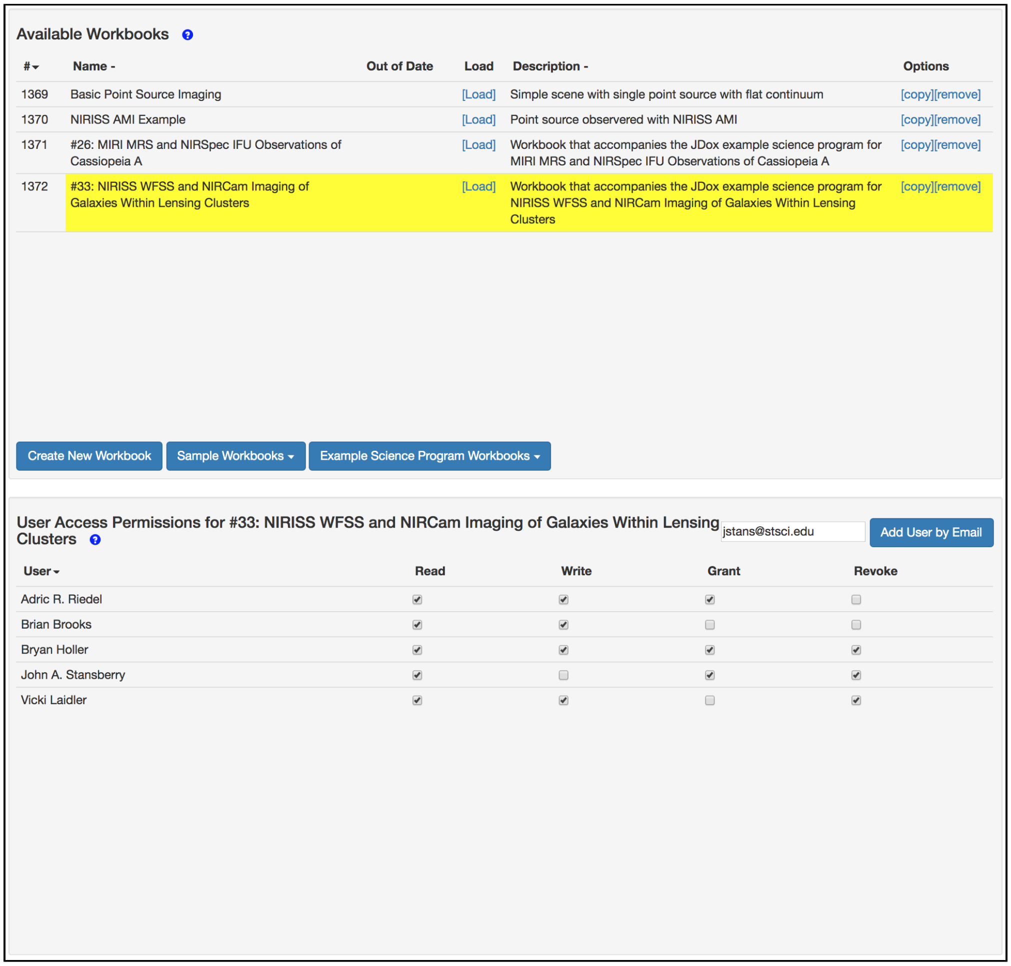
ETC Workbooks

Once a user has created a workbook with a set of calculations for a proposal, it is possible to easily share the workbook(s) with collaborators. Multiple users with "write" access can modify the same workbook simultaneously. Below is a page layout to help guide and familiarize users with the process of sharing workbooks.

Be aware that an inherent risk of allowing multiple users to edit workbooks simultaneously is "clobbering." If another user is editing the same workbook, and they change something in any editable field, it will overwrite any edits that are in process in that same field by another user. Thus, collaborators are strongly encouraged to communicate and coordinate their work. To reduce this risk, only ***Read*** permissions are set by default when sharing workbooks, and we recommend that users should always coordinate when granting write access. Collaborators can always copy a workbook that has been shared, make changes and then share their copy of the workbook with the person who created the original workbook and other collaborators.

Page layout

Figure 1. The layout of the Workbook Lists page



Start sharing

You can only share a workbook with users who have already logged in to the ETC with their user account at least once. To obtain an account, users must register with MyST accounts.

(1) In the **Available Workbooks** pane, highlight the saved workbook to share.

> ⚠ If there are no workbooks in the **Available Workbooks** pane, a sample workbook can be obtained from the ***Sample Workbooks*** dropdown, an Example Science Program workbook can be obtained from the ***Example Science Program Workbooks*** dropdown, or the ***Create New Workbook*** button can be used to create a new, blank workbook.

If a workbook was shared, and then there is a new ETC release, the workbook will need to be copied and shared again.

(2) In the **User Access Permissions** pane, enter the email of the collaborator you wish to share the workbook with then click the ***Add User by Email*** button. Sharing is verified once the user name is populated in the pane. Now your collaborator will be able to see the shared workbook under their **Available Workbooks** when they login. When sharing with multiple users, the names will appear in alphabetical order by first name.

Warning

Sharing workbooks while logged in as an anonymous user is not allowed.

Permissions

In the **User Access Permissions** pane, each individual with whom users share a workbook can be given the permissions to ***Read***, ***Write***, and ***Grant*** or ***Revoke*** access. Multiple users can have different permissions for a given workbook. When a workbook is shared, initially the new user only has ***Read*** access by default. The permission for write access can be granted by the collaborators who have the ***Grant*** access. The numbered list below describes the allowed permissions for workbooks.

1. ***Read***: allows to view the workbook and not re-run the calculation or change any parameters.
2. ***Write****:* allows to re-run the calculation and alter the saved parameters.
3. ***Grant****:* allows to share the workbook with others and grant them read and write permissions.
4. ***Revoke****:* allows to revoke access to the workbook by other users.

Stop Sharing

To stop sharing a workbook with a given user, uncheck all permissions for that user.

References

Go to the online JWST Exposure Time Calculator Tool

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, *Proc. SPIE* 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

Published	30 Dec 2016
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. Video link added. • 05 Nov 2018 Updated for ETC v1.3. • 26 Sep 2018 Updated text to suggest copying a workbook and then making changes when working with collaborators. Also updated text about sharing a workbook when ETC version changes.

JWST ETC Pandeia Engine Tutorial

A tutorial on how to use the JWST ETC as a python module.

In addition to its web UI, the JWST ETC (hereafter Pandeia) may be used as a Python module, and incorporated into Python scripts or programs. This tutorial provides information for installing the JWST ETC as a Python module, on the JWST ETC Python programming API, and on producing calculations with the JWST ETC Python interface that might be difficult or impossible to generate through the web interface.

List of articles

1. Installing Pandeia: Information on how to create an AstroConda environment that includes Pandeia, and on Pandeia's package requirements and data files.
2. Pandeia Quickstart: Basic information on importing Pandeia into a python script, on creating (or importing) configuration dictionaries, on running Pandeia calculations, and on interpreting Pandeia result reports.
3. Pandeia Reference Data: Information on Pandeia's data files and metadata.
4. Pandeia Configuration Dictionaries: An annotated Pandeia configuration dictionary showing the names and types of the included parameters, and providing information on modifying configuration dictionaries and valid values for the various parameters.
5. Pandeia Reports: Information on the reports produced from running Pandeia, and examples of interpreting the reports or using their values.
6. Pandeia Backgrounds: Information on how to specify background fluxes in Pandeia.
7. Pandeia Batch Mode: Information on making multiple Pandeia calculations in order to optimize the output.
8. Pandeia Guides and Examples: A collection of Pandeia examples from these documents as well as additional examples designed around particular scenarios.
9. Pandeia Order of Operations: Information on Pandeia's order of operations.

Published	02 May 2018
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. • 05 Nov 2018 Updated to account for article name changes and to include links to new articles. Title of article changed.

Installing Pandeia

Introduction to JWST Pandeia python interface tutorial.

On this page

This tutorial is intended for users who need to use Pandeia's python interface. If you are interested in doing JWST exposure time calculations for just a few observing scenarios, the JWST ETC Web UI is the recommended tool. The tutorial will assume that you have a basic working knowledge of python, and at least a passing familiarity with Conda and, preferably, AstroConda as well. This page provides a quick guide to installing Pandeia. Note that this tutorial is currently written for Pandeia 1.5.1.

Installing Pandeia

In order to install Pandeia, you must either have Conda and AstroConda installed, or you must have Python 2.7 or later (as well as a number of additional modules) installed.

This tutorial does not provide a complete guide to installing and using AstroConda, but should be able to act as a quick reference if you are already familiar with Conda and AstroConda. Pandeia may be installed with either Python 2 or Python 3, but it has been more thoroughly tested with Python 2.

Installing Anaconda (if necessary)

- Go to the Anaconda download page, and download the appropriate version of Anaconda
- Install Anaconda according to its documentation

Installing AstroConda

- Once you have Anaconda installed, from a terminal with access to the conda environment, type "`conda config --add channels http://ssb.stsci.edu/astroconda`".
- Create an AstroConda environment with the STScI package installed. For example, to create an environment named "pandeia" working under python 2.7, type "`conda create -n pandeia stsci python=2.7`" from a terminal with access to the conda environment.

Setting up the Pandeia Environment

Data Files

Pandeia RefData:

The first is a set of files for pandeia itself, which can be downloaded here: https://stsci.app.box.com/v/pandeia-refdata-v1p5p1

Download and unpack these files to an appropriate location; we recommend "$HOME/data/pandeia".

Pandeia requires that the "pandeia_refdata" environment variable be set to the location of its data files.

Pysynphot Data:

The second set of data files are for pysynphot. Pandeia uses pysynphot internally for handling spectra. The pysynphot reference files may be downloaded here.

Note that the tar.gz files will untar into the directory structure "`grp/hst/cdbs`", with the actual data files in an assortment of directories under "`cdbs`". pysynphot (and pandeia) expect that the "`PYSYN_CDBS`" environment variable will point to the "`cdbs`" directory. As such, you can either move the files out of "`grp/hst/`" to wherever you would like to store them, or point "`PYSYN_CDBS`" to "`/path/to/data/files/grp/hst/cdbs`" in order to allow pysynphot and pandeia to properly detect the reference files.

⚠ *Note* that pandeia does not require that pysynphot data be installed in order to operate, although it will generate warnings if the data is not available, or if the PYSYN_CDBS environment variable does not exist (or does not point to a valid pysynphot reference directory). Pandeia uses pysynphot data for the following:

- Retrieving phoenix stellar spectra
- Using HST filter bandpasses
- Normalizing spectra in non-pandeia units (e.g., Johnson bandpasses)

If you do not require the above functionality, running pandeia without these pysynphot data files is entirely possible - warnings will be issued, but pandeia will otherwise function. The AstroConda environment does include pysynphot by default.

AstroConda configuration

Setting conda to automatically set these environment variables when the environment is activated can be done as follows:

1. Find your anaconda installation (for the rest of this example, it will be assumed to be at "`$HOME/anaconda/`"). Likewise, as in the previous example, your Pandeia environment will be assumed to have the name "`pandeia`". Finally, your pysynphot reference data will be assumed to be located at "`$HOME/data/pysynphot`", and your pandeia reference data at "`$HOME/data/pandeia`".
2. Go the "`$HOME/anaconda/envs/pandeia/`". If there is not a directory named "`etc`", create one there. In the "`etc`" directory, if there is not a directory named "`conda`", create one.
3. In "`$HOME/anaconda/envs/pandeia/etc/conda/`", create the directories "`activate.d`" and "`deactivate.d`". In each of these directories, create a text file named "`env_vars.sh`".
    a. The text file "`$HOME/anaconda/envs/pandeia/etc/conda/activate.d/env_vars.sh`" should contain the following lines:

    activate.d/env_vars.sh

    ```
    #!/bin/sh

    export PYSYN_CDBS={$HOME}/data/pysynphot
    export pandeia_refdata={$HOME}/data/pandeia
    ```

    b. The text file "`$HOME/anaconda/envs/pandeia/etc/conda/deactivate.d/env_vars.sh`" should contain the following lines:

    deactivate.d/env_vars.sh

    ```
    #!/bin/sh

    unset PYSYN_CDBS
    unset pandeia_refdata
    ```

Installing Pandeia

If you have not done so already, activate your Pandeia conda environment by typing "source activate pandeia". Then, in the same window, type "`pip install pandeia.engine==1.5.1`" to install pandeia itself.

Test your installation

Test your installation by running the following command in python:

```
import pandeia.engine

pandeia.engine.pandeia_version()
```

which should print out the version number of the installed engine and data version, and location of your Pysynphot data.

Installing Pandeia without AstroConda

It is **strongly** recommended that you install pandeia via AstroConda. Whilst some information is provided below for installing pandeia without AstroConda, it is entirely unsupported, and any issues you encounter will likely be much more difficult to resolve. This section assumes that you have python installed, that you are familiar with installing modules via pip, and that you are familiar with installing command-line software in general. If any of these do not apply, you should use the above instructions on installing Pandeia through AstroConda.

Pandeia requires the following python packages to operate:

- astropy
- numpy
- scipy
- pysynphot
- photutils

Sample code

Setting up conda environment, activating conda, and installing Pandeia

This assumes that you have conda installed at "`$HOME/anaconda`", that you have the pysynphot data files installed at "`$HOME/data/pysynphot`", and that you have the pandeia data files installed at "`$HOME/data/pandeia`".

Environment Setup Script

```
conda config --add channels http://ssb.stsci.edu/astroconda
conda create -n pandeia stsci python=2.7
mkdir -p ~/anaconda/envs/pandeia/etc/conda/activate.d
cat >>~/anaconda/envs/pandeia/etc/conda/activate.d/env_vars.sh <<EOF
#!/bin/sh
export PYSYN_CDBS={$HOME}/data/pysynphot
export pandeia_refdata={$HOME}/data/pandeia
EOF
mkdir -p ~/anaconda/envs/pandeia/etc/conda/deactivate.d
cat >>~/anaconda/envs/pandeia/etc/conda/deactivate.d/env_vars.sh <<EOF
#!/bin/sh
unset PYSYN_CDBS
unset pandeia_refdata
EOF
source activate pandeia
pip install pandeia.engine==1.5.1
```

This sample setup does the following:

- Adds the STScI astroconda channel to an existing conda installation
- Creates a conda environment named "pandeia" which uses python 2.7 and includes all of the python packages from astroconda
- Creates a configuration file in the anaconda directory belonging to the "pandeia" environment to hold instructions on setting up appropriate environment variables whenever the pandeia environment is activated
    - Sets up the PYSYN_CDBS and pandeia_refdata environment variables in the created file so that they will automatically be set to the correct value when the environment is activated.
- Creates a configuration file in the anaconda directory belonging to the "pandeia" environment to hold instructions on removing environment variables whenever the pandeia environment is deactivated
    - Sets up the PYSYN_CDBS and pandeia_data environment variables in the created file so that they will be automatically removed when the environment is deactivated.
- Activates the pandeia environment
- Installs pandeia version 1.5.1 into the pandeia environment.

The above sample code *will only need to be run once*. After it has been run, typing "`source activate pandeia`" in a terminal window will activate the pandeia environment (which will now already have the pandeia module installed), and automatically set the environment variables PYSYN_CDBS and pandeia_refdata.

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	• 09 Oct 2019 Updated for ETC 1.5. Updated the link for the Pandeia reference data download. • 22 May 2019 Updated for ETC 1.4. Updated the link for the Pandeia reference data download. • 18 Mar 2019 Replaced data download link • 28 Feb 2019 Removed instructions for the pysynphot anonymous FTP download, which is no longer supported. • 12 Nov 2018 Updated the link for the Pandeia reference data download. • 05 Nov 2018 Updated for ETC v1.3.

Pandeia Quickstart

This article describes how to create a default Pandeia calculation with "`build_default_calc`" or by importing a JSON file from the web UI, how to make basic configuration edits, how to run the calculation, and how to get commonly-used elements of the results.

On this page

Creating a Pandeia observation requires a configuration dictionary, which is most easily created with either the "`build_default_calc`" function, or by importing a JSON file created by the JWST ETC Web UI. Running a Pandeia calculation is relatively straightforward, and obtaining useful information (e.g. observation time, signal-to-noise, or saturation) from the calculation results is also relatively easy. Whilst there are more advanced operations that can be performed with Pandeia via python, a significant number of useful operations can be performed just by editing the default configuration.

Pandeia configuration files

Creating a Pandeia configuration dictionary

Importing a JSON configuration file from JWST ETC Web UI

When running the JWST ETC Web UI, at the bottom right of the page (when a calculation is selected) is a tabbed interface containing the option **Downloads**. From this, it is possible to download your calculation result as a gzipped tar file. Inside the results is a file named "input.json", which contains the calculation parameters that were used in the calculation you prepared. It is possible to create a configuration dictionary from this file with the following python code (assuming that python is running in the directory containing input.json):

Importing JWST ETC Configuration JSON

```
import json
with open('input.json', 'r') as inf:
    calculation = json.loads(inf.read())
```

Once you have done this, "calculation" is a standard python dictionary of key-value pairs that you can change as you would for any other python dictionary (see examples below).

Creating a default configuration dictionary

You can create a Pandeia configuration dictionary by running the built-in Pandeia convenience function "`build_default_calc`". In order to do so, enter the following commands whilst running python from within your Pandeia environment:

Creating Default Pandeia Configuration

```
from pandeia.engine.calc_utils import build_default_calc
calculation = build_default_calc(<telescope>, <instrument>, <mode>)
```

where "telescope", "instrument", and "mode" are the telescope you are using (here "jwst"), the instrument (one of "nircam", "miri", "niriss", or "nirspec"), and the observation mode of interest (see below for a list of modes).

Regardless of the values of "telescope", "instrument", and "mode", the "`build_default_calc`" function will create a scene with a single object. That object will be a point source with x and y offsets of zero, and a flat spectrum in f_nu normalized to 2.0 mjy at 0.001 microns. The source will have zero redshift, zero extinction, and no applied emission or absorption lines.

Three instrument modes have multiple possible data reduction strategies. For NIRSpec's IFU mode and MIRI's MRS mode, there are options of "ifunodinscene" (the default) and "ifunodoffscene"; for NIRSpec's MOS mode (called "msa" internally) there are options of "msafullapphot" (the default) and "specapphot". These can be set with a fourth option to "`build_default_calc`", so that it produces a properly configured calculation:

Select Data Reduction Strategy

```
calculation = build_default_calc("jwst", "nirspec", "msa", "specapphot")
calculation = build_default_calc("jwst", "miri", "mrs", "ifunodoffscene")
```

Editing Pandeia configuration files

Changing the observation filter

Changing Observation Filter

```
calculation['configuration']['instrument']['filter'] = <filter>
```

Where "filter" is the filter you wish to use (see below for a full list).

Changing the disperser

Changing Observation Disperser

```
calculation['configuration']['instrument']['disperser'] = <disperser>
calculation['configuration']['instrument']['filter'] = <matching_filter>
```

Where "disperser" is one of the available dispersers (see below), and <matching_filter> the filter that goes along with it (again, see below).

Changing the scene

Changing Scene

```
scene = {<dictionary_designing_scene>}
calculation['scene'][0] = scene
```

The "scene" in the configuration is a list of all the sources in the calculation. There are a number of examples of creating scene dictionaries below.

Running Pandeia

Once you have a configuration dictionary, running a Pandeia calculation on that dictionary may be done as follows:

Running Pandeia

```
from pandeia.engine.perform_calculation import perform_calculation
report = perform_calculation(calculation)
```

Pandeia Calculation Results

When run using its default parameters, Pandeia returns a python dictionary reporting on the results of the simulation. Amongst the useful contents of this dictionary are:

- "`report['warnings']`" contains any warnings generated by the calculation
- "`report['input']`" contains a copy of the configuration dictionary (which may be useful)
- "`report['scalar']`" contains
  - The exposure time in "`report['scalar']['exposure_time']`"
  - The signal-to-noise ratio in "`report['scalar']['sn']`"
  - The extracted flux in "`report['scalar']['extracted_flux']`"
  - The extracted background counts in "`report['scalar']['background']`"

Appendices

Observing modes

- MIRI
  - coronagraphy - (Coronagraphic Imaging)
  - imaging - (Imaging)
  - lrsslit - (Low Resolution Spectroscopy (LRS) Slit)
  - lrsslitless - (Low Resolution Spectroscopy (LRS) Slitless)
  - mrs - (Medium Resolution Spectroscopy (MRS))
  - target_acq - (Target Acquisition)
- NIRCam
  - coronagraphy - (Coronagraphic Imaging)
  - lw_imaging - (Long Wavelength Imaging)
  - sw_imaging - (Short Wavelength Imaging)
  - ssgrism - (Time Series Grism)
  - wfgrism - (Wide Field Slitless Spectroscopy)
  - target_acq - (Target Acquisition)
- NIRISS
  - imaging - (Imaging)

    - soss - (SOSS)
    - wfss - (WFSS)
    - ami - (AMI)
    - target_acq - (Target Acqusition)
- NIRSpec
    - msa - (Multi-Object Spectroscopy)
    - fixed_slit - (Fixed Slit/BOTS)
    - ifu - (IFU)
    - target_acq - (Target Acquisition)

Observation filters

- MIRI
    - F560W
    - F770W
    - F1000W
    - F1130W
    - F1280W
    - F1500W
    - F1800W
    - F2100W
    - F2550W
- NIRCam
    - Short Wavelength
        - F070W
        - F090W
        - F115W
        - F140M
        - F150W
        - F162M
        - F164N
        - F182M
        - F187N
        - F200W
        - F210M
        - F212N
    - Long Wavelength
        - F250M
        - F277W
        - F300M
        - F323N
        - F335M
        - F356W
        - F360M
        - F405N

        - F410M
        - F430M
        - F444W
        - F460M
        - F466N
        - F470N
        - F480M
- NIRISS
    - F090W
    - F115W
    - F140M
    - F150W
    - F158M
    - F200W
    - F277W
    - F356W
    - F380M
    - F430M
    - F444W
    - F480M
- NIRSpec
    - F110W
    - F140X

Dispersers and associated filters

- NIRCam
    - GRISMC
        - F250M
        - F277W
        - F300M
        - F322W2
        - F335M
        - F356W
        - F360M
        - F410M
        - F430M
        - F444W
        - F460M
        - F480M
    - GRISMR
        - F277W
        - F322W2
        - F356W
        - F444W

- NIRISS
    - GR150R/GR150C
        - F090W
        - F115W
        - F140M
        - F150W
        - F158M
        - F200W
    - GR700XD: None
- NIRSpec
    - G140H
        - F070LP
        - F100LP
    - G140M
        - F070LP
        - F100LP
    - G235H
        - F170LP
    - G235M
        - F170LP
    - G395H
        - F290LP
    - G395M
        - F290LP
    - PRISM
        - CLEAR

Sample code

Creating a Scene with a centered flat-spectrum point source normalized to 2 mJy at 2.5 µm

Scene: Flat Spectrum

```
# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
```

```
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section

from pandeia.engine.calc_utils import build_default_calc

configuration = build_default_calc('jwst', 'nircam', 'sw_imaging')
scene = {}
scene['position'] = {'x_offset': 0., 'y_offset': 0., 'orientation': 0., 'position_parameters': ['x_offset',
'y_offset', 'orientation']}
scene['shape'] = {'geometry': 'point'}
scene['spectrum'] = {'name': 'Flat Source', 'spectrum_parameters': ['sed', 'normalization']}
scene['spectrum']['sed'] = {'sed_type': 'flat', 'unit': 'flam'}
scene['spectrum']['normalization'] = {'type': 'at_lambda', 'norm_wave': 2.5, 'norm_waveunit': 'um',
'norm_flux': 2., 'norm_fluxunit': 'mjy'}
configuration['scene'][0] = scene
```

Note that the supplied instrument and mode are examples intended for illustration only.

Creating a Scene with a 50,000 K blackbody spectrum gaussian extended source

Scene: Gaussian Extended Blackbody

```
# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section

from pandeia.engine.calc_utils import build_default_calc

configuration = build_default_calc('jwst', 'nircam', 'sw_imaging')
scene = {}
scene['position'] = {'x_offset': 0., 'y_offset': 0., 'orientation': 0., 'position_parameters': ['x_offset',
'y_offset', 'orientation']}
scene['shape'] = {'geometry': 'gaussian2d', 'major': 3.5, 'minor': 1.5, 'norm_method': 'integ_infinity',
'surf_area_units': None} #major and minor in arcseconds
scene['spectrum'] = {'name': 'Blackbody Source', 'spectrum_parameters': ['sed', 'normalization']}
scene['spectrum']['sed'] = {'sed_type': 'blackbody', 'temp': 50000.}
scene['spectrum']['normalization'] = {'type': 'photsys', 'bandpass': 'bessell,j', 'norm_flux': 20.,
'norm_fluxunit': 'abmag'}
configuration['scene'][0] = scene
```

Note that, again, the supplied instrument and mode are intended for illustration only.

Creating and observing a scene with Pandeia

Full Example

```
# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section

from pandeia.engine.calc_utils import build_default_calc
from pandeia.engine.perform_calculation import perform_calculation

configuration = build_default_calc('jwst', 'miri', 'imaging')
scene = {}
scene['position'] = {'x_offset': 0., 'y_offset': 0., 'orientation': 0., 'position_parameters': ['x_offset',
'y_offset', 'orientation']}
scene['shape'] = {'geometry': 'point'}
scene['spectrum'] = {'name': 'Phoenix Spectrum', 'spectrum_parameters': ['sed', 'normalization']}
scene['spectrum']['sed'] = {'sed_type': 'phoenix', 'key': 'g2v'}
scene['spectrum']['normalization'] = {'type': 'jwst', 'bandpass': 'miri,imaging,f560w', 'norm_flux': 2.,
'norm_fluxunit': 'mjy'}
configuration['scene'][0] = scene
configuration['configuration']['instrument']['filter'] = 'f1000w'

report = perform_calculation(configuration)
print(report['scalar']['sn'])
```

The resulting SNR is 917.2384300572811.

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Pandeia Reference Data

Information about JWST reference data and how to find the source of the reference data from the reference data files.

On this page

Types of Reference Data

The JWST ETC reference data folder contains a number of types of data, including:

- Background spectra
- Extinction spectra
- Throughput files for JWST
- Normalization bandpasses (except HST filters, in the Pysynphot data package)
- Source spectral libraries (except the Phoenix model grid, in the Pysynphot data package)

Throughput files

The JWST throughput files are found in the pandeia data directory at "`$pandeia_refdata/jwst/`". Each instrument is in its own subdirectory, along with general telescope and detector information. The origin of particular reference data can often be found in the "`config.json`" file within a directory. For example, in "`$pandeia_refdata/jwst/miri/config.json`", lines 1369-1386 show the source information as follows:

$pandeia_refdata/jwst/miri/config.json

```
        "meta": {
            "author": {
                "2016-07-21": "T. E. Pickering",
                "2017-03-31": "B. Nickson, S. Kendrew",
                "2019-08-07": "B. Holler"
            },
            "history": {
                "2016-07-21": "Create initial template from pandeia config file",
                "2017-03-31": "Inclusion of the FASTGRPAVG read out pattern and updated nframe value for SLOW
mode.",
                "2019-08-07": "Add additional FASTGRPAVG readout patterns."
            },
            "litref": {
```

```
            "2016-07-21": "pandeia_data master",
            "2017-03-31": "None",
            "2019-08-07": "JETC-361"
        },
        "pedigree": {
            "2016-07-21": "pandeia_data master",
            "2017-03-31": "ground",
            "2019-08-07": "ground"
        }
    },
```

Spectral libraries

The spectral libraries used by Pandeia are also found in the reference data directory, inside the "`$jwst_refdata/sed`" subdirectory. General information can be found in "`$jwst_refdata/sed/config.json`", whilst information about individual sources can be found at "`$jwst_refdata/sed/<type>/spectra.json`", with by replacing "`<type>`" with an available type, e.g. brown for the Brown et al. (2014) galaxy spectra. In the case of the Brown et al. galaxy spectra, the README file also contains useful information as to the source of the spectra:

pandeia_refdata/sed/brown/README

```
These data are taken from "An Atlas of Galaxy Spectral Energy
Distributions from the Ultraviolet to the Mid-Infrared" by
Brown et al. (2014) http://dx.doi.org/10.5072/03/529D3551F0117

The FITS files contain the spectra in the form of restframe wavelength
(Angstroms) and flux per unit wavelength (ergs/s/cm^2/Angstrom).  The FITS
files were generated from the original ASCII files using ../../devtools/brown2fits.py.

The 'summary.csv' file provided with the spectra was used as the basis for the JSON
config files. The script ../../devtools/brown2json.py parses summary.csv and produces
spectra_all.json.  A display key is added to each entry to toggle whether or not the galaxy
will show up in the UI.  Edits to this key are done to spectra_all.json and then ../../devtools/brown2disp.py
run to generate a trimmed catalog, spectra.json.
```

References

Brown, M. J. I. et al. 2014, ApJS, 212, 18
An Atlas of Galaxy Spectral Energy Distributions from the Ultraviolet to the Mid-Infrared

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Latest updates	

	• 09 Oct 2019 Updated for ETC v1.5. • 27 Jun 2019 Added references section, added reference, and fixed link in the text. • 05 Nov 2018 Updated for ETC v1.3.

Pandeia Configuration Dictionaries

This page describes the keywords in the JWST Pandeia configuration dictionary, provides valid keyword values (when applicable), and provides examples of adjusting Pandeia configuration dictionaries to produce particular outputs.

On this page

Pandeia configuration dictionaries are python dictionaries, and may be created or edited as such. Whilst it is possible to create a Pandeia configuration dictionary from scratch, it is generally preferable to modify an existing dictionary.

Creating Pandeia configuration dictionaries

Pandeia configuration dictionaries may be created entirely from scratch, imported from JSON files, or created by using Pandeia's "build_default_calc" function. Instructions on importing pandeia configuration information from JSON files can be found in the Pandeia Quickstart article.

Configuration dictionary structure

The Pandeia configuration dictionary has the following structure:

- *calculation*: optional dictionary, contains flags to turn on and off the various calculation parameters. If set to True, the effect is on; if set to False, the effect is off; if set to None, the effect is set to the default.
  - *noise*: dictionary, contains flags to turn on and off the available noise parameters
    - *crs*: boolean/None, flag to turn on and off the cosmic ray contribution to the noise value.
    - *ffnoise*: boolean/None, flag to turn on and off the flat field contribution to the noise

    - *effects*: dictionary, contains flags to turn on and off detector and sky effects
        - *saturation*: boolean/None, flag to turn on and off checks for saturation, and the effects of saturation and signal-to-noise
- *configuration*: dictionary, contains parameters related to the scene being observed and the instrument configuration.
    - *scene_size*: floating point value, the default size of the scene in arc seconds (the scene will always be a square, with size values referring to the length of a single side)
    - *max_scene_size*: floating point value, the maximum size to which the scene can grow in order to include all sources.
    - *dynamic_scene*: boolean, whether the scene should dynamically grow to include all sources (up to a maximum of max_scene_size)
    - *instrument*: dictionary, contains the instrument configuration parameters
        - *aperture*: string, the aperture to be used.
        - *disperser*: string, the disperser to be used (if any)
        - *filter*: string, the filter to be used (if any)
        - *instrument*: string, the instrument to be used (if using build_default_calc, the value provided for instrument will be set here)
        - *mode*: string, the mode to be used (if using build_default_calc, the value provided for mode will be set here)
    - *detector*: dictionary, contains the detector configuration
        - *ngroup*: integer, the number of groups in each ramp
        - *nint*: integer, the number of ramps in each exposure
        - *nexp*: integer, the number of exposures
        - *subarray*: string, which subset of the detector to use (or 'full' to use the entire detector)
        - *readout_pattern*: string, which readout pattern to use
- *strategy*: dictionary, what observing strategy to use. The exact contents vary by strategy, but a typical strategy contains:
    - *aperture_size*: floating point, the size of the exposure aperture
    - *sky_annulus*: list of 2 floating point values. The inner and outer radius of the annulus in which the sky count rate will be measured
    - *units*: string, the units of the aperture size and sky annulus
    - *background_subtraction*: boolean, flag to turn realistic background subtraction on and off. If on, the sky background is measured through the sky annulus or similar special region. If off, the sky background is set to the estimated value through the aperture.
    - *target_type*: string, optional: the type of target being observed.
    - *target_source*: integer, which source to include in the observation. Only checked if 'target_type' is 'source'.
    - *display_string*: string, for information, the name of the observing method being used.
    - *method*: string, the internal function name of the observing method being used.
    - *target_xy*: list of 2 floating point values: the pixel location of the target.
- *background*: the background value. Either a string with value 'none', 'minzodi', or 'ecliptic', or a list of 2 arrays containing the wavelength (microns) and background flux (MJy/sr).

- *background_level*: the background level. A string with the value 'low', 'medium', or 'high'; if background is 'minzodi', the value 'benchmark' is also allowed.

- *scene*: list of dictionaries, one for each source in the scene. Each source dictionary includes:
    - *position*: dictionary, containing information about the source position. By default, all parameters should always be present in the position dictionary, but Pandeia will interpret any missing parameter as having the value 0.
        - *position_parameters*: list of strings, one for each parameter present. Possible parameters are:
            - *x_offset*: float, the offset of the source in the x direction from the centre of the scene, in arcseconds
            - *y_offset*: float, the offset of the source in the y direction from the centre of the scene, in arcseconds
            - *orientation*: float, the angle of the source with respect to the positive scene x axis, in degrees
        - Each parameter named in the position parameters list must be present in the position dictionary as a separate key of the defined type.
    - *shape*: dictionary, containing information about the source shape
        - *geometry*: string, one of 'point', 'flat', 'gaussian2d', 'sersic', 'sersic_scale', or 'power'. Different shapes require different shape parameters, as follows:
            - *point*: Does not require any other parameters. Parameters present will be ignored.
            - *flat*: Requires the parameters 'major' and 'minor' to be present.
            - *gaussian2d*: Requires the parameters 'major' and 'minor' to be present.
            - *sersic*: Requires the parameters 'major', 'minor', and 'sersic_index' to be present.
            - *sersic_scale*: Requires the parameters 'major', 'minor', and 'sersic_index' to be present.
            - *power*: Requires the parameters 'r_core' and 'power_index' to be present.
        - *shape_parameters*: list of strings, one for each parameter present. Possible parameters are:
            - *major*: float, length of the major axis, in arcseconds.
            - *minor*: float, length of the minor axis, in arcseconds.
            - *sersic_index*: float, index of the sersic profile. An index of 1.0 yields an exponential profile, 0.5 a gaussian profile, and 4.0 a de Vaucouleurs profile.
            - *power_index*: float, index of the power law spatial profile.
        - *norm_method*: string, defines where the profile is to be normalized. Possible values are "integ_infinity", "surf_center", and "surf_scale". For flat profiles, "surf_scale" is not valid; for power law profiles, neither "surf_scale" nor "integ_infinity" are valid.
        - *surf_area_units*: string, defines the area unit of the surface brightness normalization. Possible values are "null" (for integ_infinity only), "arcsec^2", or "sr".
        - Each parameter named in the shape parameters list must be present in the shape dictionary as a separate key of the defined type.
    - *spectrum*: dictionary, containing information about the source SED.
        - *name*: string, name of the source. Provided for information, not referenced by the engine during the calculation.

- *spectrum_parameters*: list of strings, one for each parameter present. Possible parameters are:
    - *redshift*: float, redshift of the source. Redshift is applied after the spectrum has been created, but before extinction has been added, before continuum normalization, and before any emission lines have been added.
    - *lines*: list of dictionaries, giving information on each line to be added to the SED. NOTE that redshift, extinction, and normalization will not be applied to any lines specified here. Each line dictionary has the following parameters:
        - *id*: string or integer. Identifier given to the line. Not used internally.
        - *name*: string. Name of the line. Not used internally.
        - *emission_or_absorption*: string, line type. Currently, all lines are treated as emission lines.
        - *center*: float, central wavelength of the line, in microns.
        - *width*: float, FWHM of the line in km/s.
        - *strength*: float, line strength, definition depends on line type:
            - Emission Lines: line strength in erg/cm^2/s
            - Absorption Lines: central optical depth
        - *profile*: string, line profile, currently the only supported value is 'gaussian'
    - *sed*: dictionary, provides the parameters of the source continuum SED. Contains the following keys:
        - *sed_type*: string, defines the type of SED. Possible values are 'no_continuum', 'flat', 'powerlaw', 'blackbody', 'phoenix', 'hst_calspec', 'brown', and 'input'. Depending on the SED type chosen, other parameters may be needed.
            - *no_continuum*: takes no parameters
            - *flat*: takes 'unit'
            - *powerlaw*: takes 'unit' and 'index'
            - *blackbody*: takes 'temp'
            - *phoenix*: takes 'key' (if perform_calculation is run with webapp=True) or takes 'teff', 'log_g', and 'metallicity' (if perform_calculation is run with webapp=False)
            - *hst_calspec*: takes 'key'
            - *brown*: takes 'key', galaxy models based on Brown et al. (2014).
            - *input*: takes 'spectrum',
        - *unit*: string, either 'fnu' or 'flam'. Used by flat and power law spectra.
        - *index*: float, exponent of the power law. Used by power law spectra.
        - *temp*: float, temperature of the blackbody. Used by blackbody spectra.
        - *key*: string, the type of source to model. Used by phoenix, hst_calspec, and galaxies spectra. Valid values are shown below in the appendix.
        - *t_eff*: float, effective temperature of the phoenix model star, in K. Allowed range is 2000 to 70,000.
        - *log_g*: float, logarithm of the surface gravity of the phoenix model star, in cgs units. Allowed range is 0.0 to 5.5.

    - *metallicity*: float, logarithm of the metallicity of the phoenix model star, relative to solar metallicity. Allowed range is -4.0 to 0.5.
    - *spectrum*: list of 2 arrays, or ndarray. The wavelength (micron) and flux (mJy) arrays of the SED to use. In an ndarray, wavelength is the 0th index, and flux the 1st index.
- *normalization*: dictionary defining the source brightness. Contains the following keys:
    - *type*: string, defines the type of normalization. Possible values are 'at_lambda', 'hst', 'jwst' 'photsys', and 'none'. Depending on the normalization type chosen, other parameters may be needed.
        - none takes no parameters.
        - hst takes 'bandpass', 'norm_flux', and 'norm_fluxunit'
        - jwst takes 'bandpass', 'norm_flux', and 'norm_fluxunit'
        - photsys takes 'bandpass', 'norm_flux', and 'norm_fluxunit'
        - at_lambda takes 'norm_wave', 'norm_waveunit', 'norm_flux', and 'norm_fluxunit'
    - *norm_wave*: float, reference wavelength in units of 'norm_waveunit', used by 'at_lambda'.
    - *norm_waveunit*: string, specifies the wavelength units used for normalization, used by 'at_lambda'. Available values are 'm', 'nm', 'um' (micron), 'mm', 'micron', 'microns', 'angstrom'
    - *norm_flux*: float, reference flux value in units of 'norm_fluxunit', used by all normalization methods other than 'none'.
    - *norm_fluxunit*: string, specifies the flux units used for normalization. Used by all methods other than 'none'. Available values are 'flam', 'fnu', 'vegamag', 'abmag', 'mjy', 'ujy' (micro-Jansky), 'njy', 'jy'
    - *bandpass*: string, specifies the bandpass for 'hst', 'jwst', and 'photsys' normalizations. Possible values are shown in the appendix
- *extinction*: dictionary defining the wavelength-dependent extinction between the source and the observer. Contains the following keys:
    - *law*: string, the extinction law being used. Values include seven models from Weingartner & Draine (2001) (3 generic Milky Way models: 'mw_rv_31', 'mw_rv_40', 'mw_rv_55'; 2 LMC models: 'lmc_avg' and 'lmc_2'; one SMC model: 'smc_bar', and the 'hd210121' model), and one Chapman (2009) model: 'chapman09'.
    - *value*: float, the extinction value, in units of 'unit'
    - *unit*: string, the units of the extinction value, either 'nh' for hydrogen column density or 'mag' for magnitudes.
    - *bandpass*: the bandpass in which the extinction is measured, only used if the unit is 'mag'.

Sample code creating a background spectrum using the JWST Background Tool (JBT)

jbt_background

```
# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section

from pandeia.engine.calc_utils import build_default_calc
from jwst_backgrounds import jbt

# The following are parameters which can easily be changed
ra = 27.5
dec = -12.7
background_primary_wavelength = 4.0 # in microns, doesn't actually matter as we want the full spectrum.
day_of_interest = 0 # the first day of visibility for the target sky co-ordinates in the current cycle
telescope = 'jwst'
instrument = 'nircam'
mode = 'sw_imaging'
configuration = build_default_calc(telescope, instrument, mode)

bg = jbt.background(ra, dec, background_primary_wavelength)
wave_array = bg.bkg_data['wave_array']
flux_array = bg.bkg_data['total_bg'][day_of_interest]
configuration['background'] = []
configuration['background'].append(wave_array)
configuration['background'].append(flux_array)

print(configuration)
```

Note that, in order to use the JWST backgrounds tool (JBT), it must be installed in your conda environment (i.e. by typing "pip install jwst_backgrounds" at the command line). For more information on the JBT, see the JBT documentation page.

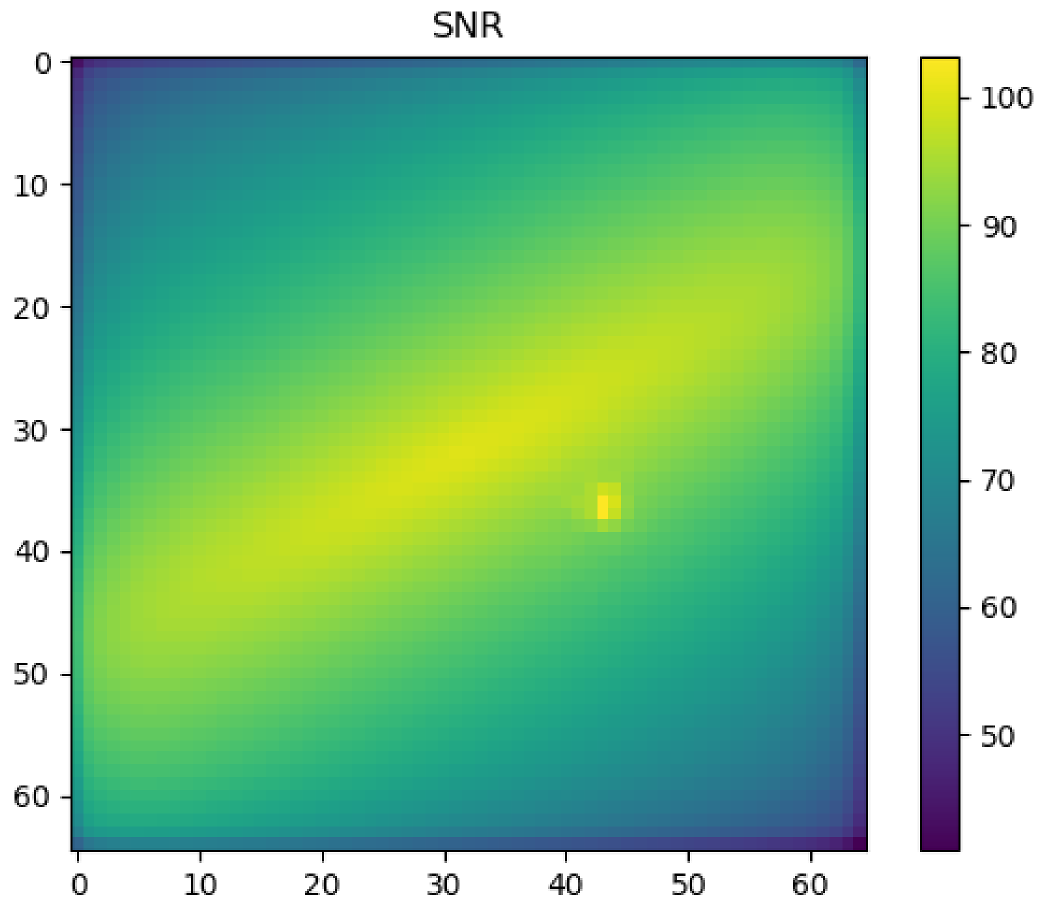
Creating a scene with a custom galaxy spectrum and a foreground star

custom_background_scene

```
# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section

from copy import deepcopy
import pysynphot
from matplotlib import pyplot as plt
from pandeia.engine.calc_utils import build_default_calc
from pandeia.engine.perform_calculation import perform_calculation

# The following are parameters which can easily be changed
telescope = 'jwst'
instrument = 'nircam'
mode = 'sw_imaging'
configuration = build_default_calc(telescope, instrument, mode)

# The following are values that can be set to anything desired.
custom_galaxy_name = 'My Background Galaxy'
custom_galaxy_spectrum_file = '/path/to/galaxy/spectrum/gal_spec.fits'
custom_galaxy_orientation = 27.1 #degrees
custom_galaxy_major_axis = 18.0
custom_galaxy_minor_axis = 2.5
custom_galaxy_sersic_index = 1.5
custom_galaxy_norm_method = 'surf_scale'
custom_galaxy_surf_area_units = 'arcsec^2'
custom_galaxy_redshift = 0.1
custom_galaxy_extinction = 0.6 # magnitudes
custom_galaxy_brightness = 19.9
custom_galaxy_bandpass = 'johnson,v'
custom_galaxy_fluxunit = 'abmag'

spec = pysynphot.FileSpectrum(custom_galaxy_spectrum_file)
spec.convert('microns')
spec.convert('mjy')

source_gal = deepcopy(configuration['scene'][0])
source_gal['position']['orientation'] = custom_galaxy_orientation
source_gal['shape']['geometry'] = 'sersic'
source_gal['shape']['shape_parameters'] = ['major', 'minor', 'sersic_index', 'norm_method', 'surf_area_units']
source_gal['shape']['major'] = custom_galaxy_major_axis
source_gal['shape']['minor'] = custom_galaxy_minor_axis
source_gal['shape']['sersic_index'] = custom_galaxy_sersic_index
source_gal['shape']['norm_method'] = custom_galaxy_norm_method
source_gal['shape']['surf_area_units'] = custom_galaxy_surf_area_units
source_gal['spectrum']['name'] = custom_galaxy_name
source_gal['spectrum']['redshift'] = custom_galaxy_redshift
source_gal['spectrum']['extinction']['value'] = custom_galaxy_extinction
source_gal['spectrum']['sed'] = {'sed_type': 'input', 'spectrum': [spec.wave, spec.flux]}
source_gal['spectrum']['normalization'] = {}
source_gal['spectrum']['normalization']['type'] = 'photsys'
source_gal['spectrum']['normalization']['bandpass'] = custom_galaxy_bandpass
```

```
source_gal['spectrum']['normalization']['norm_flux'] = custom_galaxy_brightness
source_gal['spectrum']['normalization']['norm_fluxunit'] = custom_galaxy_fluxunit

# The following are values that can be set to anything desired
star_type = 'g2v'
star_position_x = 0.35 # arcseconds
star_position_y = -0.14 # arcseconds
star_norm_bandpass = 'johnson,v'
star_norm_flux = 22.2
star_norm_fluxunit = 'abmag'
source_star = deepcopy(configuration['scene'][0])
source_star['position']['x_offset'] = star_position_x
source_star['position']['y_offset'] = star_position_y
source_star['shape'] = {'geometry': 'point', 'shape_parameters': []}
source_star['spectrum']['name'] = 'G2V Star'
source_star['spectrum']['redshift'] = 0.
source_star['spectrum']['extinction']['value'] = 0.
source_star['spectrum']['normalization'] = {}
source_star['spectrum']['normalization']['type'] = 'photsys'
source_star['spectrum']['normalization']['bandpass'] = star_norm_bandpass
source_star['spectrum']['normalization']['norm_flux'] = star_norm_flux
source_star['spectrum']['normalization']['norm_fluxunit'] = star_norm_fluxunit
source_star['spectrum']['sed'] = {'sed_type': 'phoenix', 'key': star_type}

configuration['scene'] = [source_gal, source_star]

result = perform_calculation(configuration)

plt.imshow(result['2d']['snr'])
plt.title("SNR")
plt.colorbar()
plt.show()
```

If the scene above is run through Pandeia, the resulting output image will be generated:



Creating a sample slitless spectrograph observation of a superimposed star and galaxy

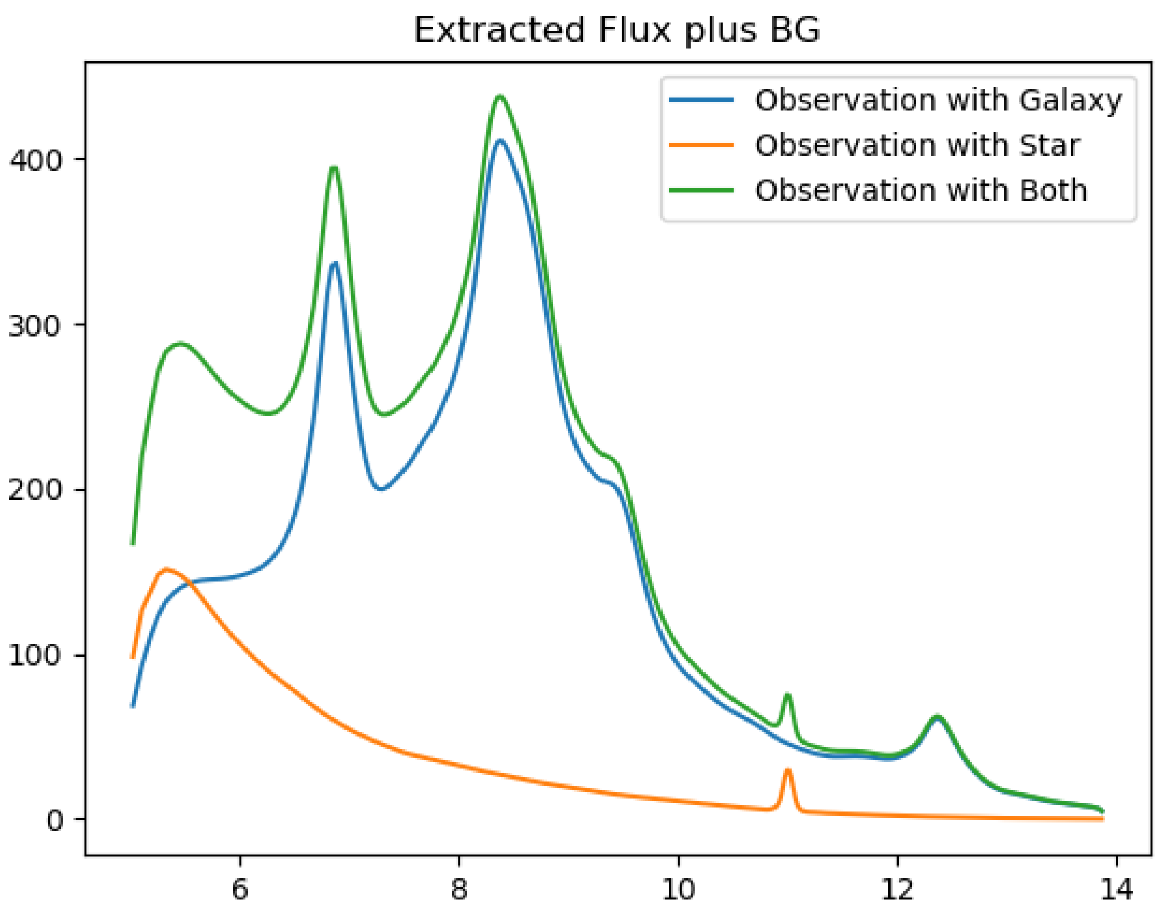
sample_slitless_spectrograph

```
# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section
# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section
```

```
from copy import deepcopy
from matplotlib import pyplot as plt
from pandeia.engine.calc_utils import build_default_calc
from pandeia.engine.perform_calculation import perform_calculation

# The following are parameters which can easily be changed
telescope = 'jwst'
instrument = 'miri'
mode = 'lrsslitless'
configuration = build_default_calc(telescope, instrument, mode)

# The following are values that can be set to anything desired.
galaxy_name = 'NGC 3521-type Galaxy'
galaxy_orientation = 77.3 #degrees
galaxy_y_offset = -0.13 # arcseconds
galaxy_major_axis = 22.0 #arcseconds
galaxy_minor_axis = 4.5 #arcseconds
galaxy_sersic_index = 3.7
galaxy_norm_method = 'integ_infinity'
galaxy_surf_area_unit = None
galaxy_redshift = 0.1
galaxy_extinction = 0.3
# magnitudes
galaxy_sed = 'ngc_3521'
galaxy_brightness = -2.0
galaxy_bandpass = 'miri,imaging,f560w'
galaxy_fluxunit = 'abmag'
source_gal = deepcopy(configuration['scene'][0])
source_gal['position']['orientation'] = galaxy_orientation
source_gal['position']['y_offset'] = galaxy_y_offset
source_gal['shape']['geometry'] = 'sersic_scale'
source_gal['shape']['shape_parameters'] = ['major', 'minor', 'sersic_index', 'norm_method', 'surf_area_unit']
source_gal['shape']['major'] = galaxy_major_axis
source_gal['shape']['minor'] = galaxy_minor_axis
source_gal['shape']['sersic_index'] = galaxy_sersic_index
source_gal['shape']['norm_method'] = galaxy_norm_method
source_gal['shape']['surf_area_unit'] = galaxy_surf_area_unit
source_gal['spectrum']['name'] = galaxy_name
source_gal['spectrum']['redshift'] = galaxy_redshift
source_gal['spectrum']['extinction']['value'] = galaxy_extinction
source_gal['spectrum']['sed'] = {'sed_type': 'brown', 'key': galaxy_sed}
source_gal['spectrum']['normalization'] = {}
source_gal['spectrum']['normalization']['type'] = 'jwst'
source_gal['spectrum']['normalization']['bandpass'] = galaxy_bandpass
source_gal['spectrum']['normalization']['norm_flux'] = galaxy_brightness
source_gal['spectrum']['normalization']['norm_fluxunit'] = galaxy_fluxunit

# The following are values that can be set to anything desired
star_type = 'f5v'
star_position_y = 0.25 # arcseconds
star_norm_bandpass = 'miri,imaging,f560w'
star_norm_flux = 18.0
star_norm_fluxunit = 'abmag'
emission_line_center = 11. #microns
emission_line_width = 1500. #km/s
emission_line_strength = 1.e-15
source_star = deepcopy(configuration['scene'][0])
source_star['position']['y_offset'] = star_position_y
source_star['shape'] = {'geometry': 'point', 'shape_parameters': []}
source_star['spectrum']['name'] = 'F5V Star'
source_star['spectrum']['redshift'] = 0.
source_star['spectrum']['extinction']['value'] = 0.
```

```
source_star['spectrum']['normalization'] = {}
source_star['spectrum']['normalization']['type'] = 'jwst'
source_star['spectrum']['normalization']['bandpass'] = star_norm_bandpass
source_star['spectrum']['normalization']['norm_flux'] = star_norm_flux
source_star['spectrum']['normalization']['norm_fluxunit'] = star_norm_fluxunit
emission_line = {}
emission_line['id'] = 0
emission_line['name'] = 'Sample Emission Line'
emission_line['emission_or_absorption'] = 'emission'
emission_line['center'] = emission_line_center
emission_line['width'] = emission_line_width
emission_line['strength'] = emission_line_strength
emission_line['profile'] = 'gaussian'
source_star['spectrum']['lines'] = [emission_line]
source_star['spectrum']['sed'] = {'sed_type': 'phoenix', 'key': star_type}

# Just the galaxy
configuration['scene'] = [source_gal]

result1 = perform_calculation(configuration)
print(result1['1d'])
plt.plot(result1['1d']['extracted_flux_plus_bg'][0],result1['1d']['extracted_flux_plus_bg'][1],
label='Observation with Galaxy')

# Just the star
configuration['scene'] = [source_star]

result2 = perform_calculation(configuration)
plt.plot(result2['1d']['extracted_flux_plus_bg'][0],result2['1d']['extracted_flux_plus_bg'][1],
label='Observation with Star')

# Both pieces
configuration['scene'] = [source_gal, source_star]

result3 = perform_calculation(configuration)
plt.plot(result3['1d']['extracted_flux_plus_bg'][0],result3['1d']['extracted_flux_plus_bg'][1],
label='Observation with Both')

plt.legend()
plt.title("Extracted Flux plus BG")
plt.show()
```

The figure below shows a set of three slitless spectra created with the MIRI ***P750L*** slitless spectrograph, one of each scene source individually, and a final observation of the combined scene. Note that the three separate spectra result from three separate Pandeia observations with the same instrument and detector settings, but different source lists.



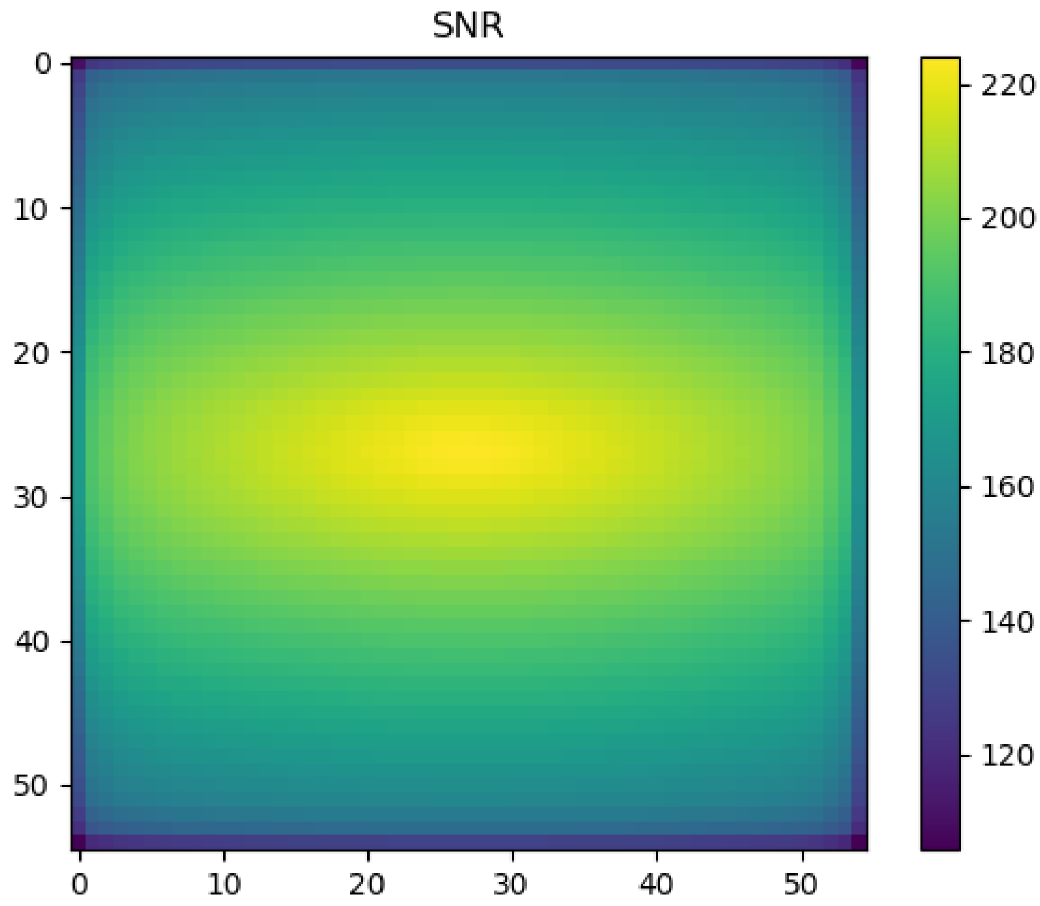
Sample code

Creating a source galaxy with a redshifted emission line

galaxy_redshifted_emission

```
# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
```

```
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section
from copy import deepcopy
from pandeia.engine.calc_utils import build_default_calc

# The following are parameters which can easily be changed
telescope = 'jwst'
instrument = 'miri'
mode = 'imaging'

configuration = build_default_calc(telescope, instrument, mode)

# The following are values that can be set to anything desired.
galaxy_name = 'NGC 3521-type Galaxy'
galaxy_major_axis = 12.5 #arcseconds
galaxy_minor_axis = 4.0 #arcseconds
galaxy_sersic_index = 1.0
galaxy_norm_method = 'integ_infinity'
galaxy_surf_area_unit = None
galaxy_redshift = 1.5
galaxy_extinction = 0.3 # magnitudes
galaxy_sed = 'ngc_3521'
galaxy_brightness = 9.0
galaxy_bandpass = 'miri,imaging,f560w'
galaxy_fluxunit = 'abmag'
emission_line_center = 0.65628 #H alpha, microns
emission_line_width = 150. #km/s
emission_line_strength = 1.e-15

source_gal = deepcopy(configuration['scene'][0])
source_gal['shape']['geometry'] = 'sersic_scale'
source_gal['shape']['shape_parameters'] = ['major', 'minor', 'sersic_index', 'norm_method', 'surf_area_unit']
source_gal['shape']['major'] = galaxy_major_axis
source_gal['shape']['minor'] = galaxy_minor_axis
source_gal['shape']['sersic_index'] = galaxy_sersic_index
source_gal['shape']['norm_method'] = galaxy_norm_method
source_gal['shape']['surf_area_unit'] = galaxy_surf_area_unit
source_gal['spectrum']['name'] = galaxy_name
source_gal['spectrum']['redshift'] = galaxy_redshift
source_gal['spectrum']['extinction']['value'] = galaxy_extinction
source_gal['spectrum']['sed'] = {'sed_type': 'brown', 'key': galaxy_sed}
source_gal['spectrum']['normalization'] = {}
source_gal['spectrum']['normalization']['type'] = 'jwst'
source_gal['spectrum']['normalization']['bandpass'] = galaxy_bandpass
source_gal['spectrum']['normalization']['norm_flux'] = galaxy_brightness
source_gal['spectrum']['normalization']['norm_fluxunit'] = galaxy_fluxunit
emission_line = {}
emission_line['id'] = 0
emission_line['name'] = 'Redshifted H-alpha emission'
emission_line['emission_or_absorption'] = 'emission'
emission_line['center'] = emission_line_center * (1 + galaxy_redshift)
emission_line['width'] = emission_line_width * (1 + galaxy_redshift)
emission_line['strength'] = emission_line_strength
emission_line['profile'] = 'gaussian'
source_gal['spectrum']['lines'] = [emission_line]

configuration['scene'] = [source_gal]
```



Appendices valid values for configuration dictionary

The following are valid values for configuration dictionaries:

config['spectrum']['sed']

- sed_type = 'phoenix'
    - key may have the following values:
        - o3v
        - o5v
        - o6i
        - o7v
        - o8i

    - o9v
    - b0v
    - b0iii
    - b0i
    - b1v
    - b3v
    - b5iii
    - b5v
    - b5i
    - b8v
    - a0i
    - a0v
    - a1v
    - a5i
    - a3v
    - a5v
    - f0i
    - f0v
    - f5i
    - f2v
    - f5v
    - f8v
    - g0v
    - g0iii
    - g2v
    - g5v
    - g0i
    - g8v
    - g5iii
    - g5i
    - k0v
    - k0iii
    - k2v
    - k0i
    - k5v
    - k5iii
    - k7v
    - k5i
    - m0i
    - m0iii
    - m0v
    - m2i
    - m2v
    - m5v
- sed_type = 'hst_calspec'

    - key may have the following values:
        - gd71
        - gd153
        - g191b2b
        - hz43
        - p330e
        - sirius
        - vega
        - wd0308-565
        - wd1057+719
- sed_type = 'brown'
    - key may have the following values:
        - Values present in the web UI
            - ngc_3690
            - ngc_6240
            - ngc_5953
            - ic_4553
            - ngc_5256
            - ngc_3521
            - ngc_4125
            - ngc_4552
            - cgcg_049-057
            - ngc_0337
            - ngc_4138
            - ii_zw_096
            - ngc_0695
            - ngc_4725
            - ugca_219
            - ngc_3079
            - ngc_6090
            - mrk_33
        - Values that will work, but are not present in the web UI
            - ngc_4579
            - ngc_4670
            - ugc_05101
            - ngc_4860
            - ugc_04881
            - cgcg_436-030
            - ngc_0520
            - ngc_1144
            - ngc_7673
            - ngc_7674
            - ngc_7679

- ngc_7771
- ngc_3627
- mrk_0475
- ngc_0584
- ic_5298
- ngc_0628
- ngc_4385
- ngc_5653
- ngc_4387
- ngc_4660
- iras_08572+3915
- ngc_2388
- ic_0691
- ngc_4473
- ngc_4889
- mrk_0930
- ngc_5257
- ugc_12150
- ngc_3938
- ngc_0750
- ngc_4551
- ngc_4550
- ngc_4559
- ngc_4926
- arp_118
- ngc_1614
- ngc_7591
- ngc_7592
- ngc_5258
- ugc_08335_nw
- arp_256_s
- iii_zw_035
- arp_256_n
- ngc_4486
- iras_17208-0014
- ugca_166
- ugc_09618_n
- ngc_2537
- ngc_6052
- ngc_2623
- mrk_1490
- ngc_1275
- ngc_0855
- ngc_3265
- ngc_4254
- ngc_5992

- ngc_4536
- ngc_4826
- ngc_4631
- ngc_2798
- ugc_06850
- ugc_06665
- ngc_4321
- ugc_09618_s
- ngc_5033
- ngc_7585
- ngc_1068
- ic_0860
- ngc_3379
- ngc_5055
- ngc_0660
- ngc_5194
- ngc_5195
- ngc_4621
- ngc_3310
- ngc_4625
- ngc_5713
- ugca_410
- haro_06
- ngc_4088
- ngc_7331
- ngc_0474
- ngc_5866
- mrk_0331
- cgcg_453-062
- ngc_4168
- ic_0883
- ngc_3870
- ngc_4676_a
- mrk_1450
- ugc_08696
- ic_4051
- ngc_5104
- ngc_4194
- ngc_7714
- ngc_2403
- ugc_08335_se
- ngc_4365
- ngc_3190
- um_461
- ugca_208
- ngc_3198

- ngc_3351
- ngc_4569
- ugc_09618
- ngc_3049
- ngc_4594
- ngc_4458
- ngc_4450
- ngc_3773

config['spectrum']['normalization']

- type = 'hst'
    - bandpass may have the following values:
        - wfc3,uvis1,f336w
        - wfc3,uvis1,f555w
        - wfc3,uvis1,f775w
        - wfc3,uvis1,f850lp
        - wfc3,ir,f098m
        - wfc3,ir,f105w
        - wfc3,ir,f110w
        - wfc3,ir,f125w
        - wfc3,ir,f140w
        - wfc3,ir,f160w
        - acs,wfc1,f435w
        - acs,wfc1,f606w
        - acs,wfc1,f814w
        - nicmos,2,f110w
        - nicmos,2,f160w
- type = 'jwst'
    - bandpass may have the following values:
        - nircam,sw_imaging,f070w
        - nircam,sw_imaging,f090w
        - nircam,sw_imaging,f115w
        - nircam,sw_imaging,f150w
        - nircam,sw_imaging,f200w
        - nircam,sw_imaging,f212n
        - nircam,lw_imaging,f277w
        - nircam,lw_imaging,f356w
        - nircam,lw_imaging,f444w
        - niriss,imaging,f090w
        - niriss,imaging,f115w
        - niriss,imaging,f140m
        - niriss,imaging,f150w
        - niriss,imaging,f277w

        - niriss,imaging,f480m
        - miri,imaging,f560w
        - miri,imaging,f770w
        - miri,imaging,f1000w
        - miri,imaging,f1280w
        - miri,imaging,f1500w
        - miri,imaging,f1800w
        - miri,imaging,f2100w
        - miri,imaging,f2550w
        - miri,imaging,fnd
- type = 'photsys'
    - bandpass may have the following values:
        - bessell,j
        - bessell,h
        - bessell,k
        - cousins,i
        - johnson,v
        - johnson,i
        - johnson,j
        - johnson,k
        - sdss,u
        - sdss,g
        - sdss,r
        - sdss,i
        - sdss,z
        - spitzer,irac3.6
        - spitzer,irac4.5
        - spitzer,irac5.8
        - spitzer,irac8.0
        - spitzer,mips24

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Pandeia Order of Operations

How to use JWST Pandeia from python, as well as a number of important considerations about how Pandeia runs.

From within python, in order to import and start running a Pandeia calculation, simply enter the following on the command line:

Running Pandeia

```
from pandeia.engine.perform_calculation import perform_calculation

report = perform_calculation(configuration)
```

as long as a configuration dictionary exists. Running "`perform_calculation(configuration, dict_report=False)`" will generate output in the form of a pandeia Report object rather than a dictionary.

Pandeia Order of Operations

It is important to consider the order in which pandeia performs calculation tasks. The pandeia order of operations for each source in the observation is as follows:

1. Pandeia loads all of the sources listed in the Scene
2. Then, it loads the Instrument configuration, as well as any instrument-specific parameters like PSFs, and computes the exposure time.
3. Then, it configures the required Strategy, as defined in the strategy section of the calculation.
4. The Instrument configuration, sky background configuration, Scene, and Strategy are bundled together into an Observation.
5. The Observation is used to generate a Model Scene Cube.
6. For each source, the spectrum is processed:
    a. Create the source SED, using information in the "`source['scene']['spectrum']`" dictionary, except that redshift, extinction, and normalization are not yet applied.
    b. Apply the redshift defined in "`source['scene']['spectrum']['redshift']`"
    c. Apply the extinction defined in "`source['scene']['spectrum']['extinction']`"
    d. Apply the normalization defined in "`source['scene']['spectrum']['normalization']`"
    e. Update any warnings generated by creating the SED or applying normalization
    f. Add all emission lines specified in "`source['scene']['spectrum']['lines']`"
7. For each source, the spatial information is processed.
    a. A properly-defined shape is created and positioned on a 2D array.
    b. The 2D array is multiplied by the spectrum to form a 3D flux cube of the source at every wavelength
    c. The 3D flux cube is convolved by the appropriate PSFs (for each wavelength) from the pre-generated PSF library.

   d. The background (if any is specified) is converted from MJy/sr/microns to mJy/pixel/microns and added to each slice of the 3D flux cube (for the first source only).
8. The 3D flux cubes of all of the sources are added together to form a Convolved Scene Cube.
9. The convolved scene cube is projected onto a "detector" according to the observation type - imaging-like, spectroscopy, slitless spectroscopy, multiorder spectroscopy - and converted from mJy to electrons/s
10. The detector flux and noise are passed to the Strategy, which extracts flux, SNR, and most other reported parameters of interest.
11. The Report class creates realistic 2D images of the detector (and SNR) with appropriately randomized noise, and collects all the properties to be reported (in a python dictionary, the web interface, or the Downloads file)

Note that, as a result of the order of operations in step 6, extinction will not be applied to emission lines, nor will redshift. Whilst a zero-continuum source with only emission lines *can* be created, and any or all of redshift, extinction, or normalization *can* be applied to it, none of those parameters will actually change the emission lines as input. In addition, if you create a continuum source with emission (or absorption) lines in the normalization bandpass, these lines will not be present when the source is normalized, so the final source flux in that bandpass will differ from the normalization value you entered. If you wish to normalize or redshift a spectrum with lines, you will need to generate the spectrum with lines outside of the engine and input it:

Custom spectrum upload

```
source['scene']['spectrum']['sed']['sed_type'] = 'input'
source['scene']['spectrum']['sed']['spectrum'] = [<wavelength array>, <flux array>]
```

For more information on the inner workings of Pandeia, consult Pontoppidan et al. (2016).

References

Pontoppidan, K. M., Pickering, T. E., Laidler, V. G. et al., 2016, Proc. SPIE 9910, Observatory Operations: Strategies, Processes, and Systems VI, 991016
Pandeia: a multi-mission exposure time calculator for JWST and WFIRST

Published	02 May 2018
Latest	

updates	• 09 Oct 2019 Updated for ETC v1.5. • 27 Jun 2019 Added references section, added reference, and fixed link to reference in text. • 05 Nov 2018 Updated for ETC v1.3. Title changed. Some material moved to Pandeia Configuration Dictionaries article.

Pandeia Reports

A description of the structure and content of JWST Pandeia output reports.

On this page

Pandeia can produce two possible outputs from run_calculation. If the command is run as "`perform_calculation(<configuration>, dict_report=True)`", (or simply as "`perform_calculation(<configuration>)`"), since "`dict_report`" defaults to True), it will return a dictionary with various information about the calculation inputs and results. If, instead, the command is run as "`perform_calculation(<configuration>, dict_report=False)`", it will return a "pandeia.engine.Report" object, which will have the same information available, and which can output a dictionary (with exactly the same contents as if "`dict_report`" had been set to true) via the "`as_dict()`" method. In general, the dictionary report is recommended unless there some specific output information is desired but not obtainable from the dictionary (see below for examples of this).

Pandeia report dictionary structure

The pandeia report dictionary contains the following keys and content:

- *sub_reports*: list, containing information on each exposure for multiple exposures (e.g. IFU dither patterns or coronagraphic imaging). Each report in the sub_reports list will be in the same format as a standard dictionary report.
- *information*: dictionary, containing information on the exposure specifications that Pandeia used to generate its result. It contains
  - *calc_type*: string, the type of projection performed. One of 'slitless', 'multiorder', 'image', 'spec'
  - *exposure_specification*: dictionary. Contains information on how the exposure was conducted and the assumed telescope and instrument status. Contains the following:
    - *exposure_time*: floating point, seconds of exposure time for each exposure.

    - *total_exposure_time*: floating point, total number of seconds spent observing the target. Equal to exposure_time multiplied by the number of exposures.
    - *measurement_time*: floating point, number of seconds between the first and last measurements of a pixel in an integration multiplied by the number of integrations per exposure.
    - *saturation_time*: floating point, number of seconds from the reset of a pixel to the final read of that pixel in an integration multiplied by the number of integrations per exposure
    - *duty_cycle*: floating point, the fraction of the exposure time that was devoted to observing the target. duty_cycle = measurement_time/exposure_time
    - *nexp*: integer, number of exposures
    - *nframe*: integer, number of frames per group
    - *tframe*: floating point, number of seconds per frame
    - *nskip*: integer, number of skipped frames per group. Only supported by some readout patterns.
    - *frame0*: boolean, whether the first frame was downlinked and used in the ramp fit. Only applies to some detectors.
    - *ngroup*: integer, number of groups per integration
    - *tgroup*: floating point, seconds of telescope time per group.
    - *nprerej*: integer, either 0 or 1 (default 0). Applies only to MIRI. Number of groups at the beginning of the ramp that were rejected by the pipeline.
    - *nint*: integer, number of integrations per exposure
    - *npostrej*: integer, either 0 or 1 (default 0). Applies only to MIRI. Number of groups at the end of the ramp that were rejected by the pipeline.
    - *total_integrations*: integer, number of integrations in all exposures combined.
    - *nramps*: integer, total number of ramps in the observation. nramps is equal to nint multiplied by the number of exposures
    - *pattern*: string, name of the readout pattern
    - *subarray*: string, name of subarray used for the exposure
    - *det_type*: string, type of detector involved (e.g. 'h2rg' for NIRCam short-wavelength detectors)
    - *nsample*: integer, number of samples averaged when reading a single pixel. Applies only to MIRI.
    - *tsample*: floating point, time averaged when reading a single pixel. Applies only to MIRI.
    - *nsample_skip*: integer, number of samples skipped while reading a single pixel. Applies only to MIRI.
    - *nsample_total*: integer, total number of samples
    - *tfffr*: integer, extra time factor.
- *warnings*: dictionary, contains all warnings generated by the exposure. Warnings can include:
    - *<instrument>_missing_instrument_aperture*: generated if the supplied configuration dictionary did not include the aperture information. The warning text will indicate what the aperture has been set to.
    - *partial_saturated*: indicates partial saturation of at least one pixel. The warning text will include the number of partially saturated pixels.
    - *full_saturated*: indicates full (unrecoverable) saturation of at least one pixel. The warning text will include the number of fully saturated pixels.

- *transform*: dictionary, containing the coordinate transform information that describes the image axes for the 2D and 3D data. Contains the following values:
    - *wave_refpix*: integer, the reference pixel of the wavelength arrays
    - *wave_refval*: floating point, the value (in microns) of wave_refpix
    - *wave_step*: floating point, interval (in microns) between successive points in the wavelength array.
    - *wave_size*: integer, the size of the wavelength axis, in pixels
    - *wave_min*: floating point, the minimum wavelength value (in microns) of the 2D and 3D data
    - *wave_max*: floating point, maximum wavelength (in microns) of the 2D and 3D data
    - *x_refpix*: integer, the reference pixel for the x-axis in the 2D and 3D data
    - *x_refval*: floating point, the value (in arcseconds) of the x_refpix pixel of the x-axis of the 2D and 3D data
    - *x_step*: the per-pixel size (in arcseconds) of the x-axis of the 2D and 3D data
    - *x_size*: integer, the size of the x-axis of the 2D and 3D data supplied in the report.
    - *x_min*: floating point, the minimum value (in arcseconds) of the x-axis of the 2D and 3D data
    - *x_max*: floating point, the maximum value (in arcseconds) of the x-axis of the 2D and 3D data.
    - *y_refpix*: integer, the reference pixel for the y axis in the 2D and 3D data
    - *y_refval*: floating point, the value (in arcseconds) of the y_refpix pixel of the y axis of the 2D and 3D data
    - *y_step*: floating point, the per-pixel size (in arcseconds) of the y-axis of the 2D and 3D data
    - *y_size*: integer, the size of the y-axis in the 2D and 3D data
    - *y_min*: floating point, the minimum value (in arcseconds) of the y-axis in the 2D and 3D data
    - *y_max*: floating point, the maximum value (in arcseconds) of the x-axis in the 2D and 3D data
    - *wave_det_refpix*: integer, the detector reference pixel in wavelength space (if applicable).
    - *wave_det_refval*: floating point, the value (in microns) of wave_refpix on the detector (if applicable)
    - *wave_det_step*: floating point, the distance in wavelength space between adjacent pixels on the detector (if applicable).
    - *wave_det_size*: integer, the length of the wavelength axis of the detector, in pixels
    - *wave_det_min*: floating point, the minimum wavelength value (in microns) of the detector
    - *wave_det_max*: floating point, the maximum wavelength value (in microns) of the detector
- *scalar*: dictionary, contains scalar values of interest from the observation. Includes the following values:
    - *exposure_time*: floating point, the same value as exposure_time in the '`information: exposure_specification`' part of the report
    - *aperture_size*: floating point, size of the extraction aperture in arcseconds.
    - *cr_ramp_rate*: floating point, expected cosmic rays per pixel per ramp
    - *reference_wavelength*: floating point, wavelength (in microns) used for determining scalar outputs
    - *extraction_area*: floating points, area (in square arcseconds) from which data is extracted for scalar outputs
    - *all_dithers_time*: floating point, total time (in seconds) spent during the observation during all exposures/dithers, whether on-target or off-target
    - *total_integrations*: integer, the same value as total_integrations in the '`information: exposure_specification`' part of the report
    - *saturation_time*: floating point, the same value as saturation_time in the '`information: exposure_specification`' part of the report
    - *measurement_time*: floating point, the same value as measurement_time in the '`information: exposure_specification`' part of the report

  - *fraction_saturation*: floating point, the fraction describing how close to saturation the brightest pixel on the detector is.
  - *detector_ngroups*: integer, the maximum number of groups that can be requested *before* the brightest pixel on the detector saturates.
  - *sn*: floating point, signal-to-noise ratio for the observation
  - *extracted_noise*: floating point, total noise counts extracted in the background region
  - *extracted_flux*: floating point, total flux extracted from the extraction aperture
  - *duty_cycle*: floating point, the same value as duty_cycle in the '`information: exposure_specification`' part of the report
  - *background*: floating point, flux of the background spectrum at the reference wavelength
  - *contamination*: floating point, flux from contamination by other (non-target) sources in the background region
  - *background_sky*: floating point, flux in the background extraction region contributed by the sky
  - *disperser*: string, the grating/prism/grism in use, if any
  - *filter*: string, the filter in use, if any
  - *y_offset*: floating point, the y-offset of the target
  - *x_offset*: floating point, the x-offset of the target
  - *background_area*: floating point, the background extraction area in square arcseconds
  - *background_total*: floating point, the background flux including both sky and contamination
  - *total_exposure_time*: floating point, the same value as total_exposure_time in the '`information: exposure_specification`' part of the report
- *1d*: dictionary, Contains 1D spectra representing various aspects of the observation, presented either as a function of wavelength or alongside the reference wavelength. In the descriptions below, names in italics are single values presented against the reference wavelength if the calculation is an 'imaging' calculation. Values include:
  - *fp*: count rate at the focal plane
  - *extracted_contamination*: flux from contamination
  - *total_flux*: combined target and background flux
  - *bg*: background flux
  - *extracted_noise*: standard deviation of the extracted flux
  - *bg_rate*: background flux at the focal plane
  - *extracted_bg_only*: extracted background flux not including contamination (if any)
  - *n_partial_saturated*: number of partially saturated pixels
  - *n_full_saturated*: number of fully saturated pixels
  - *sn*: signal-to-noise ratio
  - *wave_pix*: single array containing the reference wavelength as its only value
  - *extracted_flux*: total extracted flux from the target
  - *extracted_flux_plus_bg*: total countrate including both target and background
  - *wave_calc*: single array containing the wavelengths over which the exposure was calculated
  - *extracted_bg_total*: total extracted background flux
  - *target*: target flux as a function of wavelength
- *2d*: dictionary, contains 2D images of the on-detector observation. Values include
  - *snr*: 2D numpy array of floating point values, the signal-to-noise ratio for each pixel in the observation

    - *detector*: 2D numpy array of floating point values, the on-detector countrate for each pixel in the observation
    - *saturation*: 2D numpy array of floating point values, the detector saturation information. Pixels have the value of 0 (unsaturated), 1 (partial saturation), or 2 (full saturation).
    - *ngroups_map*: 2D numpy array of integer values, the maximum number of groups *before* a given pixel on the detector would saturate.
- *3d*: dictionary, contains 3D datacubes of the on-detector observations. Values include
    - *flux*: 3D numpy array of floating point values, contains flux as a function of wavelength for each pixel at each wavelength in pandeia's internal observation measurement.
    - *flux_plus_background*: 3D numpy array of floating point values, contains flux and background together for each pixel at each wavelength.
- *input*: dictionary, containing information about the calculation inputs. When running Pandeia from python, this should simply be a copy of the configuration dictionary (see Pandeia Configuration Dictionaries for more information on the configuration dictionary). As such, its contents will not be further discussed here.

Pandeia report fits object

Pandeia can also output a dictionary of fits objects, by outputting a report object (created by running "`perform_calculation(<configuration>, dict_report=False)`" and running the '`as_fits()`' method on the resulting Report object)

- *1d*: dictionary, with a fits hdulist for every item in the regular 1D report dictionary mentioned above. All of the fits headers except wave_calc and wave_pix will have two fields in the first header: wavelength (either wave_calc or wave_pix) and the property in question.
- *2d*: dictionary, with a fits hdulist for every item in the regular 2D report dictionary. All of the fits headers have WCS information extracted from the detector pixel grid. These headers are, for 2D spectroscopic modes, assumed to be linear wavelength scales; it may be necessary to use the 1D wave_calc value to generate accurate wavelengths.
- *3d*: dictionary, with a fits hdulist for every item in the regular 3D report dictionary. All of the fits headers have WCS information extracted from the detector pixel grid. These headers are assumed to be linear in wavelength scale; it may be necessary to use the 1D wave_calc values to generate accurate wavelengths.

Pandeia report object

The pandeia '`Report`' object contains the same data as the report dictionary (and can be converted into the report dictionary via its '`as_dict()`' method, or fits dictionary via its '`as_fits()`' method), but also contains some additional information.

Per-pixel background count rate

The Pandeia Report object stores the per-pixel background count rate in the internal property '`bg_pix`'. This contains a 2D array of the entire simulated region of the detector with the per-pixel sky background for each pixel, and could potentially be useful in determining background flux in order to compare observations when looking for the lowest possible background.

Interpreting downloads from the JWST ETC website

When running simulations on the JWST ETC website, you can download the result of a particular simulation. In addition to the input values used for the simulation (discussed in the Pandeia Quickstart, the download also contains many FITS files which provide information about the simulation, and which often correspond to the content of a Pandeia report.

Structure of a JWST ETC result download

JWST ETC downloads contain the following files and folders. Note that these files are also discussed on the JWST ETC Downloads page.

- backgrounds.fits: FITS file containing the spectrum used to determine background count rates
- cube (non-IFU observations)
  - cube_flux_plus_background.fits
  - cube_flux.fits
  - model (empty folder)
- cube (IFU observations)
  - cube_reconstructed.fits
  - cube_reconstructed_noise.fits
  - cube_reconstructed_snr.fits
  - cube_reconstructed_saturation.fits
  - model
    - cube_flux_n.fits (one for each IFU element, with the n replaced by the element number)
    - cube_flux_plus_background_n.fits (one for each IFU element, with the n replaced by the element number)
- image
  - image_detector.fits
  - image_saturation.fits
  - image_snr.fits
- input.json (discussed in the Pandeia Quickstart)
- lineplot
  - lineplot_bg_rate.fits
  - lineplot_bg.fits
  - lineplot_extracted_bg_only.fits
  - lineplot_extracted_bg_total.fits

- lineplot_extracted_contamination.fits
- lineplot_extracted_flux_plus_bg.fits
- lineplot_extracted_flux.fits
- lineplot_extracted_noise.fits
- lineplot_fp.fits
- lineplot_n_full_saturated.fits
- lineplot_n_partial_saturated.fits
- lineplot_sn.fits
- lineplot_target.fits
- lineplot_total_flux.fits
- lineplot_wave_calc.fits
- lineplot_wave_pix.fits

Accessing downloaded FITS files

If you have astroconda installed, FITS files are most easily accessed via the astropy module, in particular astropy.io.fits. Below is an example of obtaining data from a lineplot file, assuming that python is run from the base directory of the download:

access_download_fits_file

```
import astropy.io.fits as f

with f.open('lineplot/lineplot_extracted_bg_total.fits', 'r') as input_file:
    reference_wavelength = input_file[1].data[0]['WAVELENGTH']
    extracted_flux = input_file[1].data[0]['extracted_flux']
```

Correspondences with the Pandeia report dictionary

File	Extension	Equivalent Key
cube/cube_flux_plus_background.fits	0	report['3d']['flux_plus_background']
cube/cube_flux.fits	0	report['3d']['flux']
image/image_detector.fits	0	report['2d']['detector']
image/image_saturation.fits	0	report['2d']['saturation']
image/image_snr.fits	0	report['2d']['snr']
image/image_ngroups_map.fits	0	report['2d']['ngroups_map']
lineplot/lineplot_bg_rate.fits	1	report['1d']['bg_rate']
lineplot/lineplot_bg.fits	1	report['1d']['bg']

lineplot/lineplot_extracted_bg_only.fits	1	report['1d']['extracted_bg_only']
lineplot/lineplot_extracted_bg_total.fits	1	report['1d']['extracted_bg_total']
lineplot/lineplot_extracted_contamination.fits	1	report['scalar']['contamination']
lineplot/lineplot_extracted_flux_plus_bg.fits	1	report['1d']['extracted_flux_plus_bg']
lineplot/lineplot_extracted_flux.fits	1	report['1d']['extracted_flux']
lineplot/lineplot_extracted_noise.fits	1	report['1d']['extracted_noise']
lineplot/lineplot_fp.fits	1	report['1d']['fp']
lineplot/lineplot_n_full_saturated.fits	1	report['1d']['n_full_saturated']
lineplot/lineplot_n_partial_saturated.fits	1	report['1d']['n_partial_saturated']
lineplot/lineplot_sn.fits	1	report['1d']['sn']
lineplot/lineplot_target.fits	1	report['1d']['target']
lineplot/lineplot_total_flux.fits	1	report['1d']['total_flux']
lineplot/lineplot_wave_calc.fits	1	report['1d']['wave_calc']
lineplot/lineplot_wave_pix.fits	1	report['1d']['wave_pix']

Downloaded background file

The backgrounds.fits file included in the download contains a data table in its first extension. This table includes the following columns:

- *wavelength*: the wavelength in microns
- *background*: total background flux
- *thermal*: the thermal component of the total background flux
- *straylight*: the stray light component of the background flux
- *infield*: the sky component of the background flux

Sample code

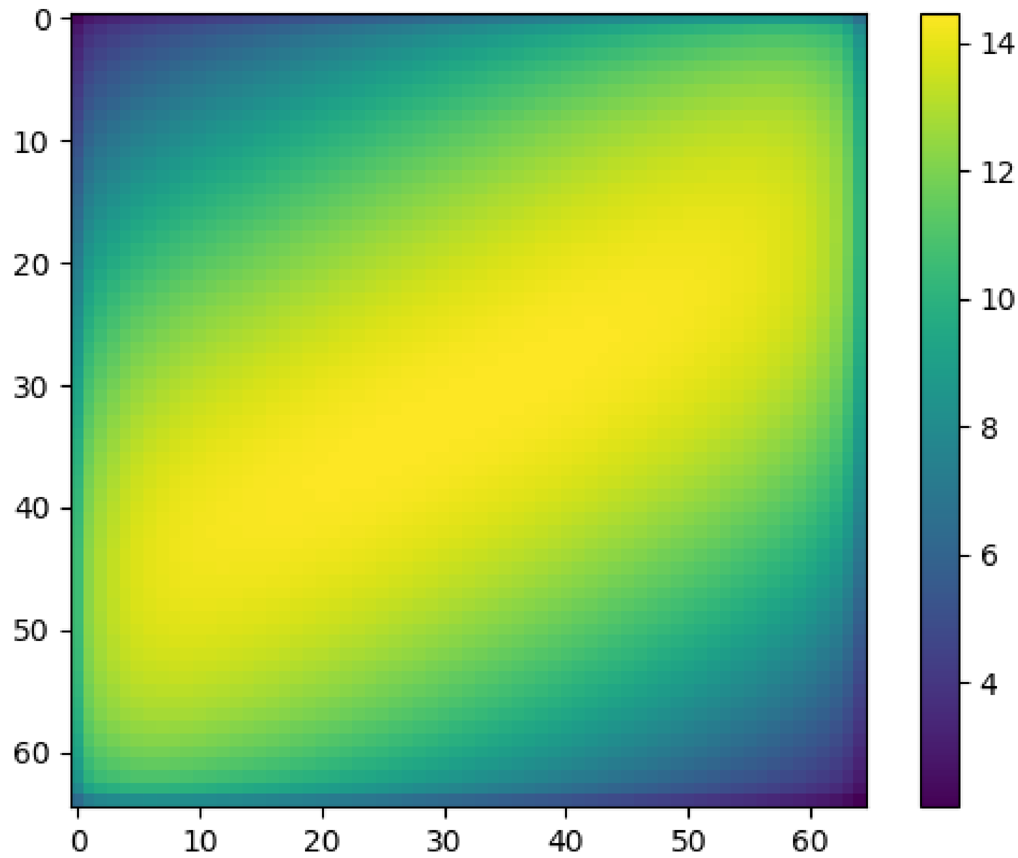
Displaying an image of the signal-to-noise ratio of a Pandeia imaging observation

display_snr_image

```
# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section
import matplotlib.pyplot as plt
from pandeia.engine.calc_utils import build_default_calc
from pandeia.engine.perform_calculation import perform_calculation

# The following are parameters which can easily be changed
telescope = 'jwst'
instrument = 'nircam'
mode = 'sw_imaging'

# Source parameters
offsets = {'x': 0., 'y': 0.}
orientation = 27.
geometry = 'gaussian2d'
major_axis = 8.5 # arcseconds
minor_axis = 0.75 # arcseconds
name = 'Blackbody'
sed = 'blackbody'
temp = 50000.
bandpass = 'bessell,j'
magnitude = 18.

configuration = build_default_calc(telescope, instrument, mode)
scene = {}
scene['position'] = {'position_parameters': ['x_offset', 'y_offset', 'orientation']}
scene['position']['x_offset'] = offsets['x']
scene['position']['y_offset'] = offsets['y']
scene['position']['orientation'] = orientation
scene['shape'] = {'geometry': geometry, 'major': major_axis, 'minor': minor_axis, 'norm_method':
'integ_infinity', 'surf_area_units': 'arcsec^2'}
scene['spectrum'] = {'name': name, 'spectrum_parameters': ['sed', 'normalization']}
scene['spectrum']['sed'] = {'sed_type': sed, 'temp': temp}
scene['spectrum']['normalization'] = {'type': 'photsys', 'norm_fluxunit': 'abmag'}
scene['spectrum']['normalization']['bandpass'] = bandpass
scene['spectrum']['normalization']['norm_flux'] = magnitude
configuration['scene'][0] = scene

report = perform_calculation(configuration)

plt.imshow(report['2d']['snr'])
```

```
plt.colorbar()
plt.show()
```

Note that the above is being done in a very simplistic way, and that matplotlib, in particular, has many options that aren't on display here. See the matplotlib user's guide for many more details.

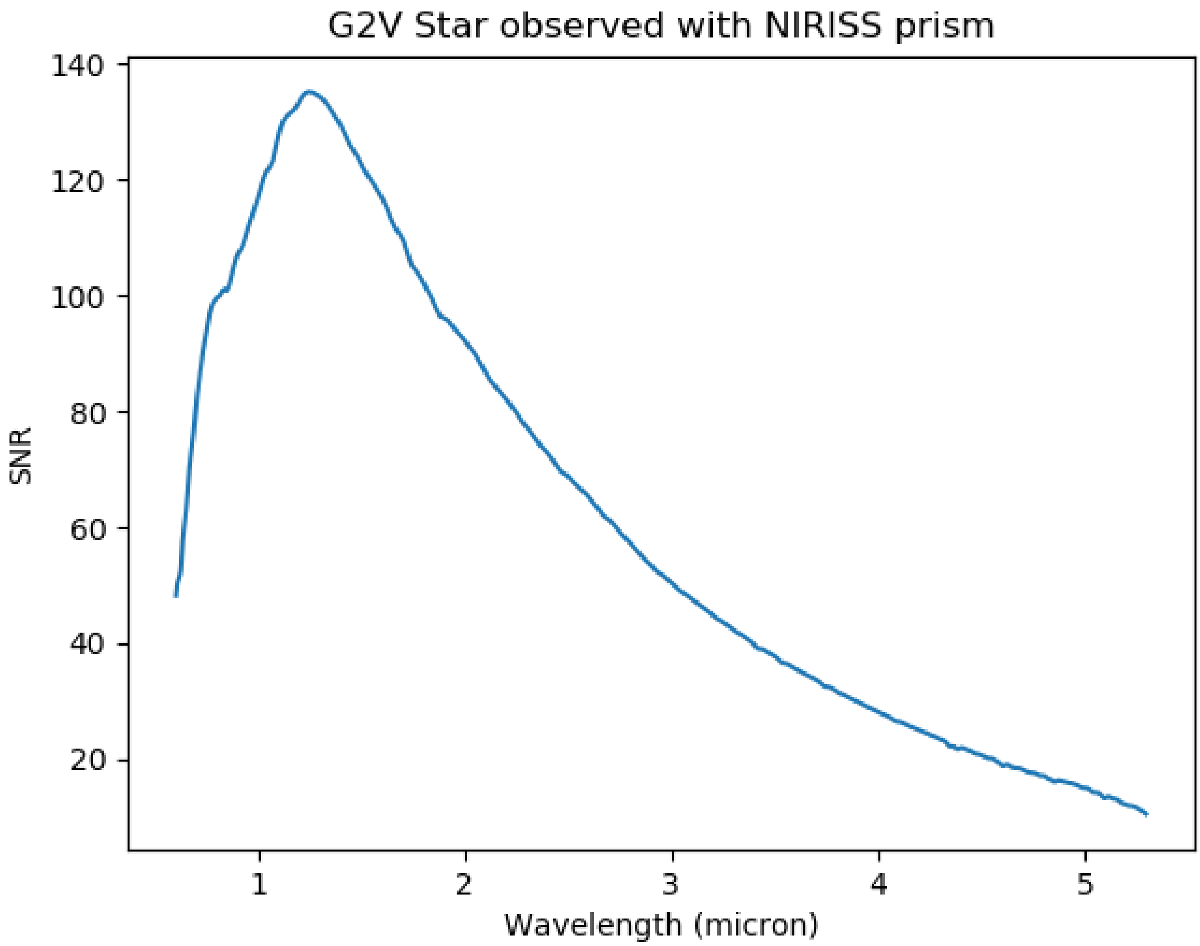


Displaying the signal-to-noise ratio of a spectrum as a function of wavelength:

display_snr_spectrum

```
# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section
import matplotlib.pyplot as plt
from pandeia.engine.calc_utils import build_default_calc
from pandeia.engine.perform_calculation import perform_calculation

# The following are parameters which can easily be changed
```

```
telescope = 'jwst'
instrument = 'nirspec'
mode = 'fixed_slit'

# Source parameters
offsets = {'x': 0., 'y': 0.}
geometry = 'gaussian2d'
major_axis = 8.5 # arcseconds
minor_axis = 0.75 # arcseconds
name = 'G2V Star'
sed = 'phoenix'
key = 'g2v'
bandpass = 'sdss,r'
magnitude = 18.

configuration = build_default_calc(telescope, instrument, mode)
scene = {}
scene['position'] = {'position_parameters': ['x_offset', 'y_offset']}
scene['position']['x_offset'] = offsets['x']
scene['position']['y_offset'] = offsets['y']
scene['shape'] = {'geometry': 'point'}
scene['spectrum'] = {'name': name, 'spectrum_parameters': ['sed', 'normalization']}
scene['spectrum']['sed'] = {'sed_type': sed, 'key': key}
scene['spectrum']['normalization'] = {'type': 'photsys', 'norm_fluxunit': 'abmag'}
scene['spectrum']['normalization']['bandpass'] = bandpass
scene['spectrum']['normalization']['norm_flux'] = magnitude
configuration['scene'][0] = scene

report = perform_calculation(configuration)

disperser = configuration['configuration']['instrument']['disperser']
fig, ax = plt.subplots()
ax.plot(report['1d']['sn'][0], report['1d']['sn'][1])
ax.set(xlabel='Wavelength (micron)', ylabel='SNR', title='G2V Star observed with NIRISS {}'.format(disperser))
plt.show()
```



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Pandeia Batch Mode

This document describes running JWST Pandeia calculations inside a loop in order to zero in on the best settings for particular observations.

On this page

Sometimes, in order to optimize JWST observations, it may be necessary to run multiple ETC simulations in order to select the best possible settings. By running Pandeia inside a python loop, much of the work involved in this can be automated.

Sample code

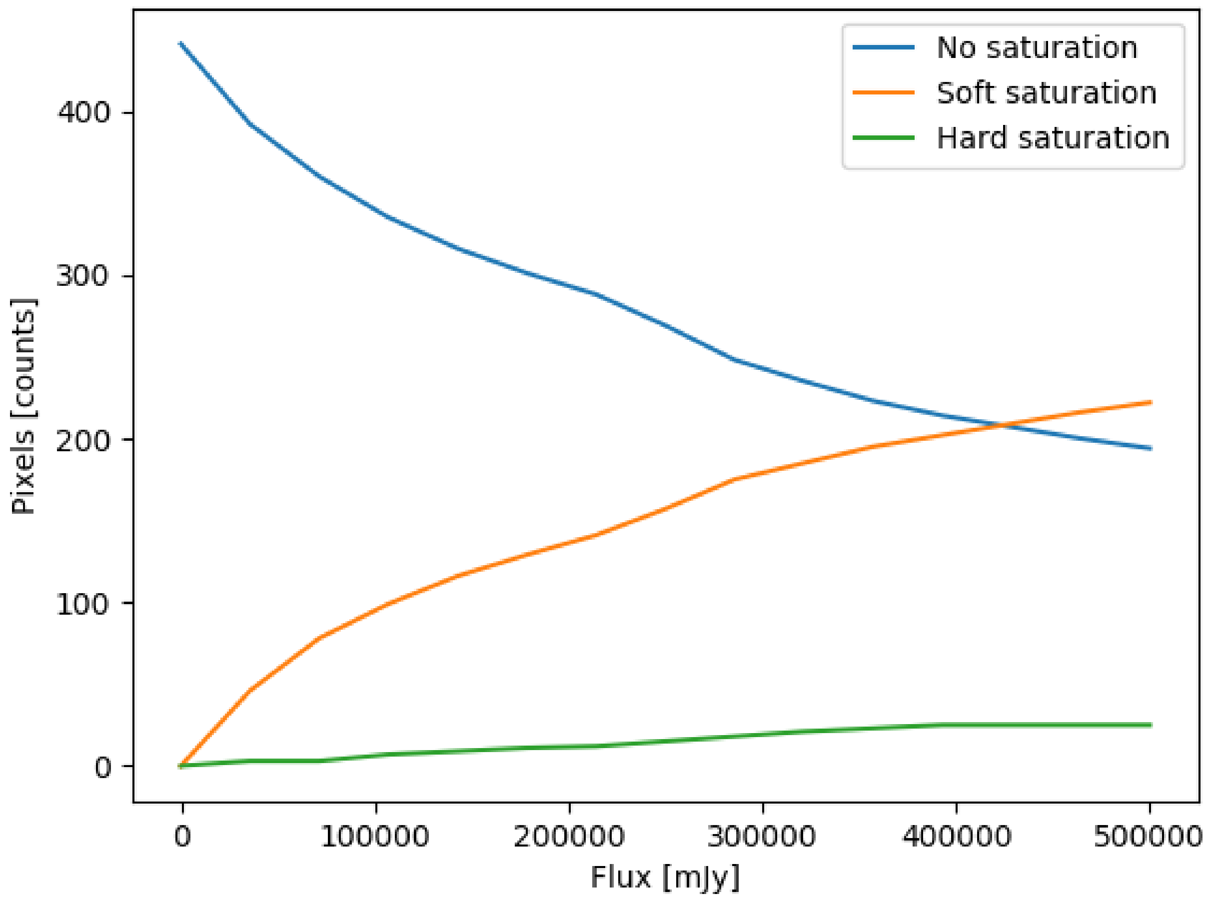
Checking saturation as a function of flux for MIRI coronography

batch_saturation_flux_miri

```
# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
import os

location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section
import numpy as np
from matplotlib import pyplot as plt
from pandeia.engine.calc_utils import build_default_calc
from pandeia.engine.perform_calculation import perform_calculation

# The following are parameters which can easily be changed
```

```
telescope = 'jwst'
instrument = 'miri'
mode = 'coronography'

# Flux Range parameter
flux_range = np.linspace(0.1, 5e5, 15) #mJy

# Create lists to store the output data
tot_none, tot_soft, tot_hard = [], [], []

for flux in flux_range:
    configuration_dictionary = build_default_calc(telescope, instrument, mode)
    configuration_dictionary['scene'][0]['spectrum']['normalization']['norm_flux'] = flux
    report_dictionary = perform_calculation(configuration_dictionary)
    saturation = report_dictionary['2d']['saturation']

    unsaturated = len(saturation[saturation==0.])
    soft_saturated = len(saturation[saturation==1.])
    hard_saturated = len(saturation[saturation==2.])

    tot_none.append(unsaturated)
    tot_soft.append(soft_saturated)
    tot_hard.append(hard_saturated)

plt.plot(flux_range,tot_none, label='No saturation')
plt.plot(flux_range,tot_soft, label='Soft saturation')
plt.plot(flux_range,tot_hard, label='Hard saturation')
plt.xlabel('Flux [mJy]')
plt.ylabel('Pixels [counts]')
plt.legend()
plt.show()
```

The result of the above is shown in the figure below.



Determining the number of groups needed to reach a signal-to-noise of 40 in a NIRCam SW observation

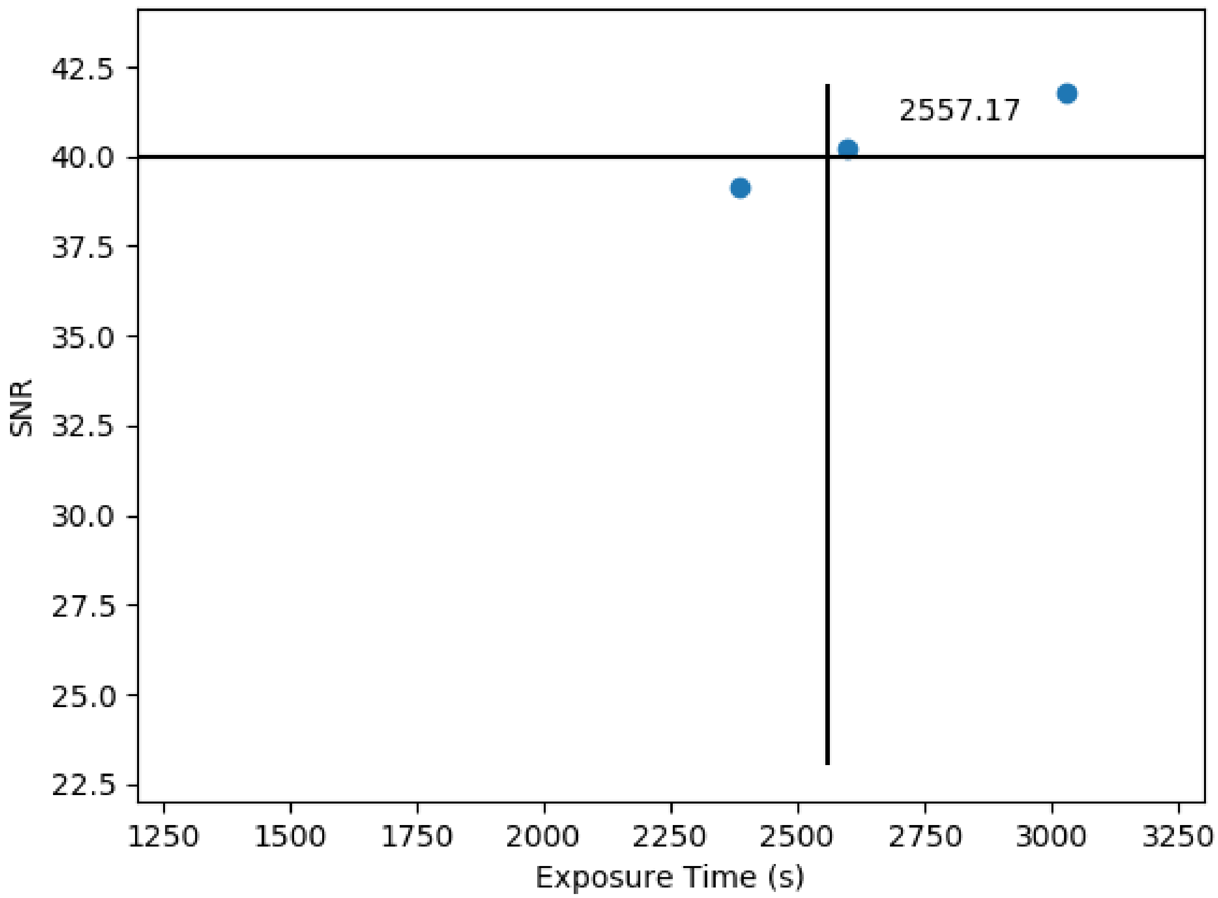
batch_snr_time_nircam

```
from __future__ import division

# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
```

```
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section
from matplotlib import pyplot as plt
from pandeia.engine.calc_utils import build_default_calc
from pandeia.engine.perform_calculation import perform_calculation
from scipy import interpolate

# The following are parameters which can easily be changed
telescope = 'jwst'
instrument = 'nircam'
mode = 'sw_imaging'
filter = 'f115w'

# Source parameters
offsets = {'x': 0., 'y': 0.}
geometry = 'point'
name = 'G2V Star'
sed = 'phoenix'
key = 'g2v'
bandpass = 'sdss,r'
magnitude = 26.

scene_dictionary = {}
scene_dictionary['position'] = {'position_parameters': ['x_offset', 'y_offset']}
scene_dictionary['position']['x_offset'] = offsets['x']
scene_dictionary['position']['y_offset'] = offsets['y']
scene_dictionary['shape'] = {'geometry': 'point'}
scene_dictionary['spectrum'] = {'name': name, 'spectrum_parameters': ['sed', 'normalization']}
scene_dictionary['spectrum']['sed'] = {'sed_type': sed, 'key': key}
scene_dictionary['spectrum']['normalization'] = {'type': 'photsys', 'norm_fluxunit': 'abmag'}
scene_dictionary['spectrum']['normalization']['bandpass'] = bandpass
scene_dictionary['spectrum']['normalization']['norm_flux'] = magnitude

# Number of observation Groups for search
min_groups = 0
max_groups = 24

# Target SNR
target_sn = 40.

# Create lists to hold the results
sns, exptimes = [], []

while min_groups <= max_groups:
    configuration_dictionary = build_default_calc(telescope, instrument, mode)
    configuration_dictionary['scene'][0] = scene_dictionary
    configuration_dictionary['configuration']['instrument']['filter'] = filter
    current_groups = (min_groups+max_groups)//2
    configuration_dictionary['configuration']['detector']['ngroup'] = current_groups
    report_dictionary = perform_calculation(configuration_dictionary)
    current_sn = report_dictionary['scalar']['sn']
    sns.append(current_sn)
    exptimes.append(report_dictionary['scalar']['total_exposure_time'])
    if current_sn <= target_sn:
        min_groups = current_groups + 1
    else:
        max_groups = current_groups - 1


interpolator = interpolate.interp1d(sns,exptimes)
exptime_target = interpolator(target_sn)
```

```
print("For SNR=40: {:.2f}s".format(exptime_target))
print("Groups: {} Exptime: {:.2f}s SNR: {:.2f}".format(min_groups,exptimes[-1], sns[-1]))

plt.scatter(exptimes,sns)
plt.hlines(40,1200,3300)
plt.vlines(exptime_target,23,42)
plt.xlabel('Exposure Time (s)')
plt.ylabel('SNR')
plt.text(2700,41,"{:.2f}".format(exptime_target))
plt.xlim((1200,3300))
plt.show()
```

The result of the above is shown in the figure below.



Determining date with Lowest Background flux at given co-ordinates

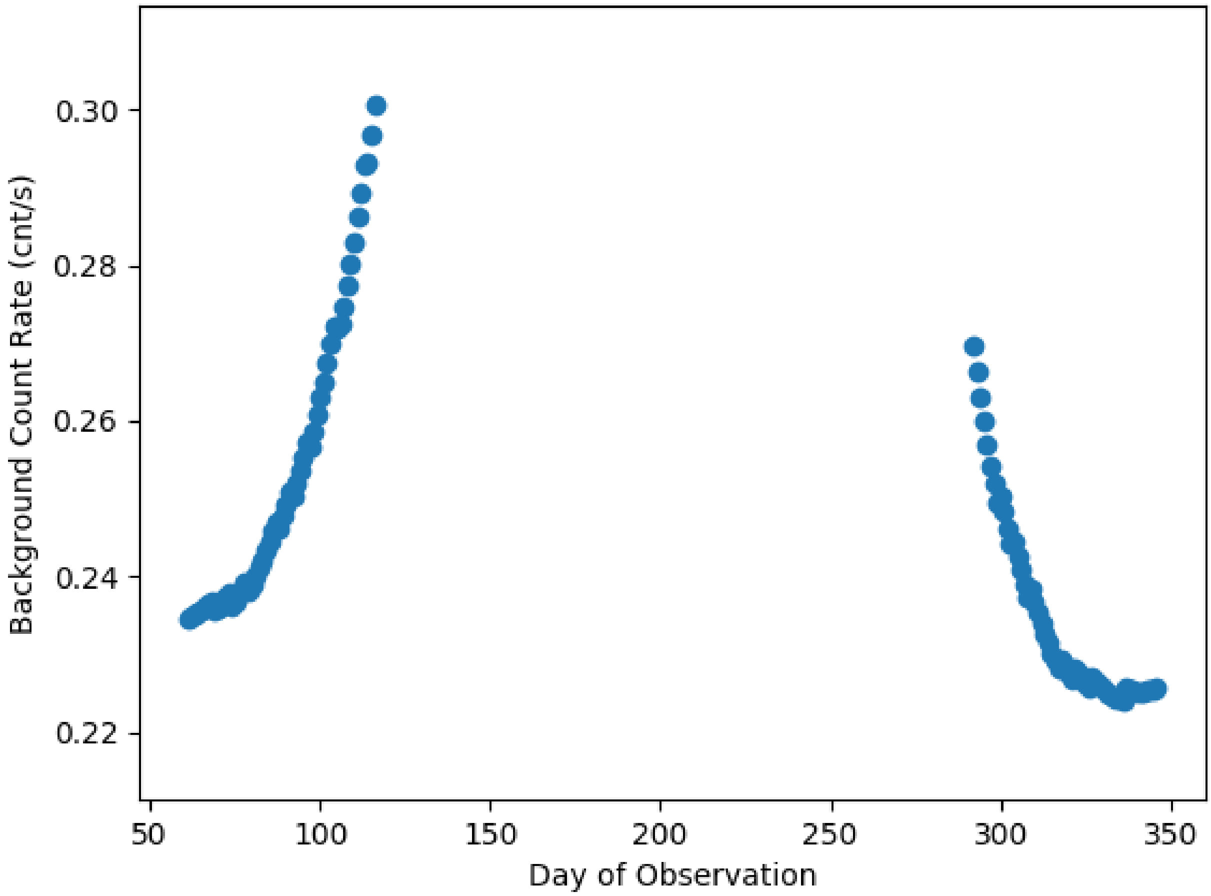
batch_background_time

```
from __future__ import division

# The following section is only needed if the PYSYN_CDBS environment variable is not already set.
# The PYSYN_CDBS environment variable should point to the path of the CDBS data files
import os
location_of_cdbs = "/path/to/cdbs/files"
os.environ['PYSYN_CDBS'] = location_of_cdbs
# End section

# The following section is only needed if the pandeia_refdata environment variable is not already set
# The pandeia_refdata environment variable should point to the path of the pandeia reference data
```

```
import os
location_of_pandeia_refdata = "/path/to/pandeia/refdata"
os.environ['pandeia_refdata'] = location_of_pandeia_refdata
# End section
import numpy as np
from matplotlib import pyplot as plt
from pandeia.engine.calc_utils import build_default_calc
from pandeia.engine.perform_calculation import perform_calculation

from jwst_backgrounds import jbt

# Background Flux Parameters
ra = 129.4
dec = 41.1
background_primary_wavelength = 4.0 # in microns, doesn't actually matter as we want the full spectrum.


# General Observation Parameters
telescope = 'jwst'
instrument = 'nircam'
mode = 'sw_imaging'
filter = 'f090w'

# Source parameters
offsets = {'x': 0., 'y': 0.}
geometry = 'point'
name = 'G2V Star'
sed = 'phoenix'
key = 'g2v'
bandpass = 'sdss,r'
magnitude = 22.

bg = jbt.background(ra, dec, background_primary_wavelength)
wave_array = bg.bkg_data['wave_array']
observability_calendar = bg.bkg_data['calendar']

scene_dictionary = {}
scene_dictionary['position'] = {'position_parameters': ['x_offset', 'y_offset']}
scene_dictionary['position']['x_offset'] = offsets['x']
scene_dictionary['position']['y_offset'] = offsets['y']
scene_dictionary['shape'] = {'geometry': 'point'}
scene_dictionary['spectrum'] = {'name': name, 'spectrum_parameters': ['sed', 'normalization']}
scene_dictionary['spectrum']['sed'] = {'sed_type': sed, 'key': key}
scene_dictionary['spectrum']['normalization'] = {'type': 'photsys', 'norm_fluxunit': 'abmag'}
scene_dictionary['spectrum']['normalization']['bandpass'] = bandpass
scene_dictionary['spectrum']['normalization']['norm_flux'] = magnitude

# Create lists to hold the results
dates, fluxes = [], []


for i, day in enumerate(observability_calendar):
    configuration_dictionary = build_default_calc(telescope, instrument, mode)
    configuration_dictionary['scene'][0] = scene_dictionary
    configuration_dictionary['configuration']['instrument']['filter'] = filter
    flux_array = bg.bkg_data['total_bg'][i]
    configuration_dictionary['background'] = [wave_array, flux_array]
    report_object = perform_calculation(configuration_dictionary, dict_report=False)
    background_rate = np.median(report_object.bg_pix) # median per-pixel background count rate
    print("Day {} has flux {}".format(day, background_rate))
    dates.append(day)
    fluxes.append(background_rate)
```

```
plt.scatter(dates,fluxes)
plt.xlabel("Day of Observation")
plt.ylabel("Background Count Rate (cnt/s)")

plt.show()
```

The figure below shows the background count rate on each day over the next year that the target is observable. As can be seen, observations near the start and end of the year offer the lowest background rate, although the overall difference is relatively small.



Published	02 May 2018
Latest updates	• 18 Jan 2020 Updated examples for ETC 1.5.1. • 09 Oct 2019 Updated for ETC 1.5. • 05 Nov 2018 Updated for ETC 1.3. Code updated.

Pandeia Guides and Examples

This page contains links to the JWST Pandeia coding guides across the entire tutorial, links to Pandeia code samples found elsewhere, and complete guides that have been specifically requested.

On this page

Guides linked here have been confirmed to work on the version of Pandeia covered by this tutorial *as of when they were linked*. If a guide linked from here provides inaccurate information, please contact us via the JWST Helpdesk Portal.

Coding Guides

Installing Pandeia

- Installing Pandeia

Complete Pandeia Observation

- Creating and Observing a Scene (Quickstart)
- Displaying SNR as a Function of Location on Detector
- Displaying SNR as a Function of Wavelength for Longslit Spectroscopy

Creating Pandeia Scenes

- Creating and Normalizing a Flat-Spectrum Source
- Creating a Blackbody Source
- Creating a background spectrum using JBT
- Adding a Custom Galaxy Spectrum
- Creating a Slitless Spectroscopy Observation with Multiple Sources
- Creating a redshifted galaxy with an included emission line

Running Pandeia inside loops

Published	02 May 2018
Latest updates	• 09 Oct 2019 Updated for ETC v1.5. • 05 Nov 2018 Updated for ETC v1.3.

Pandeia Backgrounds

When running Pandeia as a scriptable python module, different background options are used than with the web client.

On this page

The Background API

Within Pandeia, the background is defined by two values in the configuration dictionary: *background* and *background_level*. The two values are used in concert to either load a background, or identify a pre-computed background to use in the calculation.

background: is either a string defining the name of a background ("ecliptic" or "minzodi", or you can conceivably create your own), or the word "none" for no background, or a list of arrays forming a spectrum

background_level: is either "low", "medium", or "high" (or, for the "minzodi" case, "benchmark"). It does not need to be specified at all if *background* is none, or a list of arrays.

Canned backgrounds

Canned backgrounds have been pre-generated by the JWST Backgrounds Tool at two locations: along the ecliptic at ecliptic coordinates Lat = 90, Lon = 0; and at the Minzodi location (Lat = 266.3, Lon = -50). The canned backgrounds have been generated at low (10% of max), medium (50% of max), and high (90% of max) background levels as determined from estimating the combined interstellar cirrus, zodiacal light, and internal straylight contributions over the entire period that the locations are in the JWST field of regard.

```
calculation['background'] = 'ecliptic'
calculation['background_level'] = 'high'
```

For the Minzodi location, we have also defined a "benchmark" level, which is the Minzodi location on June 19, 2020.

```
calculation['background'] = 'minzodi'
calculation['background_level'] = 'benchmark'
```

The option for no background is also available:

```
calculation['background'] = 'none'
```

Custom backgrounds

Custom backgrounds are a list containing wavelength and flux arrays (denoted by square brackets) that define the background. You can define them yourself, use the JWST Backgrounds Tool to generate them (as the Web version of the ETC does), or download a calculation from the web ETC that will have a background filled in, and can be run through Pandeia directly.

The below example is of a JSON-formatted numerical background (as it would appear in the input.json file in a web ETC download) for the Hubble Deep Field on 1 January 2021, pointing at RA = 12:36:49.4, Dec = +62:12:58. The first array contains wavelength values. The second array contains the corresponding background values.

JSON-formatted numerical background from input.json


```
{
    "background":[
        [
            0.5,
            0.6000000238418579,
            0.699999988079071,
            0.800000011920929,
            0.8999999761581421,
            1.0,
            1.100000023841858,
            1.2000000476837158,
            1.2999999523162842,
            1.399999976158142,
            1.5,
            1.600000023841858,
            1.7000000476837158,
            1.7999999523162842,
            1.899999976158142,
            2.0,
            2.0999999046325684,
            2.200000047683716,
            2.299999952316284,
            2.4000000953674316,
            2.5,
            2.5999999046325684,
            2.700000047683716,
            2.799999952316284,
            2.9000000953674316,
            3.0,
            3.0999999046325684,
            3.200000047683716,
            3.299999952316284,
            3.4000000953674316,
            3.5,
            3.700000047683716,
```

```
4.0,
4.25,
4.5,
4.75,
5.0,
5.099999904632568,
5.199999809265137,
5.300000190734863,
5.400000095367432,
5.5,
5.699999809265137,
5.900000095367432,
6.099999904632568,
6.300000190734863,
6.5,
6.699999809265137,
6.900000095367432,
7.099999904632568,
7.300000190734863,
7.5,
7.699999809265137,
7.900000095367432,
8.100000381469727,
8.300000190734863,
8.5,
8.699999809265137,
8.899999618530273,
9.100000381469727,
9.300000190734863,
9.5,
9.699999809265137,
9.899999618530273,
10.100000381469727,
10.300000190734863,
10.5,
10.699999809265137,
10.899999618530273,
11.100000381469727,
11.300000190734863,
11.5,
11.699999809265137,
11.899999618530273,
12.100000381469727,
12.300000190734863,
12.5,
12.699999809265137,
12.899999618530273,
13.100000381469727,
13.300000190734863,
13.5,
13.699999809265137,
13.899999618530273,
14.100000381469727,
14.300000190734863,
14.5,
14.699999809265137,
14.899999618530273,
15.100000381469727,
15.300000190734863,
15.5,
16.5,
17.5,
18.5,
```

```
            19.5,
            20.5,
            21.5,
            22.5,
            23.5,
            24.5,
            25.5,
            26.5,
            27.5,
            28.5,
            29.5,
            30.5,
            31.0
        ],
        [
            0.1531117285921693,
            0.2092165913789387,
            0.23506451247755927,
            0.24387688791350565,
            0.24277532182701037,
            0.24128830458114275,
            0.22860416522123134,
            0.21303268147031135,
            0.20098598517615573,
            0.1924922915642501,
            0.18400246173584303,
            0.17570808294765167,
            0.16714529742597162,
            0.15614162743260643,
            0.1484705880667788,
            0.14183056987524995,
            0.13591249404165623,
            0.1304210845164106,
            0.12397736659487979,
            0.11803495817387152,
            0.11249905864349247,
            0.10740031792192586,
            0.102681230042769,
            0.09748979929887966,
            0.08843152864684274,
            0.08383024772131081,
            0.08021812654934297,
            0.07729718166281412,
            0.07582572037173775,
            0.07102890629331567,
            0.08614716116587136,
            0.09768449076151914,
            0.13219626400710116,
            0.18107548153244085,
            0.2563870348601526,
            0.35894892058466055,
            0.4866335837361104,
            0.5605877719575548,
            0.6401997260374637,
            0.7294213203582277,
            0.8239250387311442,
            0.932278882645071,
            1.16826423112882,
            1.4378382126473466,
            1.7549381673557565,
            2.1220400518091167,
            2.4701888442368825,
            2.8732659105459053,
```

```
            3.3145244692772744,
            3.784674751418082,
            4.291235176486179,
            4.836894573651525,
            5.394606936036856,
            5.940103660309018,
            6.49756823108879,
            7.08616427215754,
            7.698410243853719,
            8.314998562471027,
            8.929024120309064,
            9.565253804089139,
            10.214183564354707,
            10.874046090600674,
            11.545157215546233,
            12.227013688011084,
            12.915451940029303,
            13.61505358560525,
            14.332942966213764,
            15.067246303538738,
            15.824306443039939,
            16.62035356821776,
            17.450674505884653,
            18.268531330320922,
            19.106909052427547,
            20.00727014614531,
            21.012687671471074,
            22.130776824714438,
            23.308607943051438,
            24.55004824997389,
            25.855424223471882,
            27.23250553285639,
            28.698465033630725,
            30.253809628901585,
            31.90325798447872,
            33.6506209487392,
            35.513106219069826,
            37.48364749330286,
            39.57840925292605,
            41.80483155768504,
            44.169993991898785,
            46.683179580219715,
            49.35118129515844,
            55.05436888840708,
            69.4750271039678,
            92.51115043183295,
            123.48097917249477,
            165.0497355389275,
            220.68108372099786,
            294.69274917385354,
            392.2832417959625,
            519.6827932604449,
            683.8513487752906,
            892.2339319665946,
            1153.1756797885548,
            1475.6470710508243,
            1868.0202150734551,
            2339.8924286287597,
            2822.3775818457393,
            1881.7713060461292
        ]
    ]
}
```

Published	13 Nov 2018
Latest updates	• 18 Jan 2020 Updated for ETC 1.5.1. • 09 Oct 2019 Updated for ETC 1.5. • 27 Jun 2019 Fixed incorrect link.

JWST ETC Instrument Throughputs

Throughputs for all four JWST science instruments can be calculated with the Pandeia engine using files found in the *pandeia_data* directory.

On this page

An important component of the Pandeia engine download is the data directory, referred to as *pandeia_data*. This directory contains all the data files necessary for running calculations in Pandeia engine calculations. These data are also identical to those used in calculations with the JWST Exposure Time Calculator (ETC) web application. These data may also be used to compute throughputs for the various instruments and observing modes.

Instructions for downloading and installing the Pandeia engine and the *pandeia_data* directory are found in the Installing Pandeia article.

Calculating throughputs

All files relevant for calculating throughputs for the four JWST science instruments are found in the *jwst* folder of *pandeia_data*. The sub-directories in this folder are *detector*, *miri, nircam, niriss, nirspec*, and *telescope*. Relevant sub-directories in each of the instrument folders are *filter*, *optical*, and *qe*.

Users interested in throughputs for the various instrument modes should use the *get_total_eff()* function included in the Pandeia engine. This function considers all files for relevant instrument elements and properties (listed in the sections below) and outputs the throughput across a desired wavelength range. Below is a code snippet showing the use of the *get_total_eff()* function.

```
from pandeia.engine.instrument_factory import InstrumentFactory

# set up your wavelengths
wave = [wavelengths_you_want]

# create a configured instrument
instrument_factory = InstrumentFactory(config=conf)

# where conf is a configuration dictionary for a calculation:
```

```
#   conf={
#         "detector": {
#             "nexp": 1,
#             "ngroup": 10,
#             "nint": 1,
#             "readout_pattern": "deep2",
#             "subarray": "full"
#         },
#         "dynamic_scene": true,
#         "instrument": {
#             "aperture": "sw",
#             "disperser": null,
#             "filter": "f150w2",
#             "instrument": "nircam",
#             "mode": "sw_imaging"
#         }

# get the throughput of the instrument over the desired wavelength range
eff = instrument_factory.get_total_eff(wave)
```

The total throughput calculated using the procedure above does not include pupil losses, which can be significant for coronagraphic imaging and the NIRISS AMI mode. Pupil losses can be extracted from the PSF files using the FITS keyword PUP_THRU. These pupil losses are achromatic, so can be ignored for color calculations, but should be considered for absolute photometry. The code snippet below, which is a continuation of the code above, shows how to account for pupil losses:

```
pupil = instrument_factory.psf_library.get_pupil_throughput(wave[0],conf['instrument']['instrument'],
conf['instrument']['aperture'])
eff = eff * pupil
```

Detector

- The quantum efficiency (QE) files in this directory are not used by the ETC or the Pandeia engine. The relevant QE files for the science instruments are in the */miri/qe*, */nircam/qe*, */niriss/qe*, and */nirspec/qe* sub-directories.

MIRI

- The */miri/optical* sub-directory contains files for the three MIRI MRS dichroics that split the light into the four separate IFUs (channels). Reflection and transmission profiles are provided for each of the three dichroics. As shown in the schematic in the MIRI Optics and Focal Plane article, the light path to the four different channels is complex. Two separate wheels contain three dichroics for each of the three wavelength ranges (***Short (A)***, ***Medium (B)***, and ***Long (C)***). In the file names, the dichroics are labeled "dich1", "dich2", and "dich3", followed by an "*s*" for the *short wavelength* range, "*m*" for the *medium wavelength* range, or "*l*" for the *long wavelength* range, and "trans" for transmission or "refl" for reflection.

The light paths taken to each channel are outlined below and indicate which files are used in calculating the throughput for each:

- ***Channel 1***: Reflection off dichroic 1.
- ***Channel 2***: Transmission through dichroic 1, reflection off dichroic 2.
- ***Channel 3***: Transmission through dichroics 1 & 2, reflection off dichroic 3.
- ***Channel 4***: Transmission through dichroics 1, 2, & 3.

- The */miri/optical* sub-directory also contains transmission files for the germanium coatings on the four-quadrant phase masks (4QPMs) for coronagraphic imaging. Keep in mind that these transmission files are also relevant for target acquisition (TA) using the 4QPMs.
  - The *jwst_miri_ge_ar1_trans* file applies to the ***F1065C*** and ***F1140C*** 4QPMs.
  - The *jwst_miri_ge_ar2_trans* file applies to the ***F1550C*** 4QPM.
- The QE file for the MIRI imaging detector, *jwst_miri_imager_qe*, is used for calculating throughputs for MIRI Imaging, MIRI Low Resolution Spectroscopy (LRS) Slit, MIRI Low Resolution Spectroscopy (LRS) Slitless, and MIRI Coronagraphic Imaging.
- The MIRI MRS is composed of two separate detectors. The *jwst_miri_mrs-sw_qe* file is the relevant QE file for ***Channel 1*** and ***Channel 2*** of the MRS ("sw" stands for "short wavelength"). Similarly, *jwst_miri_mrs-lw_qe* is the relevant QE file for ***Channel 3*** and ***Channel 4*** of the MRS (*lw* stands for "long wavelength").

NIRCam

- The *jwst_nircam_sw-lyot_trans_modmean* and *jwst_nircam_lw-lyot_trans_modmean* files in the */nircam/optical* sub-directory are the average transmissions of Module A and Module B for coronagraphic imaging with the Lyot spots.
- The *jwst_nircam_wlp4* and *jwst_nircam_wlp8* optical transmission files correspond to the weak lenses, used in the NIRCam SW Time Series mode.
- The *jwst_nircam_sw_dbs* and *jwst_nircam_lw_dbs* files are the dichroic beam splitter (DBS) for each channel which directs incoming illumination to the shortwave (SW) or longwave (LW) channel.
- The *jwst_nircam_moda_com_substrate_trans* is for the coronagraphic optical substrate for ***Module A*** which is used for coronagraphic imaging mode.
- The *jwst_nircam_sw_qe* and *jwst_nircam_lw_qe* files apply to any observations made from 0.6 to 2.3 µm and 2.4 to 5.0 µm, respectively.

NIRISS

- The *jwst_niriss_nrm_trans* file under the *filter* sub-directory is used for the Aperture Masking Interferometry (AMI) mode. "NRM" refers to the non-redundant mask that enables the AMI mode.
- Three options are available in the */niriss/optical* sub-directory:
  - *jwst_niriss_internaloptics_throughput*: Used when neither the ***CLEAR*** nor ***CLEARP*** slots are selected in the filter and pupil wheels, respectively.
  - *jwst_niriss_internaloptics-clear_throughput*: Used when the ***CLEAR*** slot is selected in the filter wheel and a filter or grating is selected in the pupil wheel.
  - *jwst_niriss_internaloptics-clearp_throughput*: Used when the ***CLEARP*** slot is selected in the pupil wheel and a filter or grating is selected in the filter wheel.

NIRSpec

- Under */nirspec/optical*, the *jwst_nirspec_mos_internaloptics_throughput* file is applicable to the fixed slits.

Telescope

- The *telescope* sub-directory contains the throughput of the optical telescope element (OTE), *jwst_telescope_ote_thruput*. This file is relevant for calculating throughputs for all observing modes since all light first passes through the OTE before entering the optical paths of the science instruments.

Published	13 Nov 2018
Latest updates	• 09 Oct 2019 Updated for ETC v1.5.

JWST ETC Video Tutorials

The article provides a connection to short video tutorials demonstrating various aspects of the online version of the JWST Exposure Time Calculator (ETC).

On this page

See also: Video Tutorials Master List

The videos linked below were created to walk the user through general use of the ETC (first table) or provide additional details on specific ETC features (second table). For new ETC users, we recommend watching the "Introductory Series" in the order listed below. For more advanced users, or those looking to learn more about a specific feature, we recommend looking at the "Specific ETC Features" list. All currently available ETC video tutorials are listed on this page.

Also, look out for the

symbol on other ETC pages that link to a relevant video tutorial on YouTube.

The videos below, unless otherwise noted, were recorded in ETC version 1.4.

Introductory Series

	Length	Description
ETC Home Page Overview	3:49	This video provides a good entry point for learning how to use the JWST Exposure Time Calculator (ETC). It presents the different options available on the home page for working in the ETC and provides guidance for obtaining additional information.
ETC Available Workbooks	4:36	This video discusses how to create a new ETC workbook, load existing example workbooks to use as starting point, and share ETC workbooks with other MyST users and collaborators.
ETC General Overview	5:51	This video is a walkthrough that briefly presents the

		capabilities and layout of the JWST Exposure Time Calculator (ETC).
ETC Scenes and Sources	6:27	This video demonstrates how to create scenes, add sources, and modify sources as part of performing calculations in the ETC.

Specific ETC Features

	Length	Description
Uploading Spectra to the ETC	3:41	This video describes how to upload user-supplied spectra to the ETC, including the proper file format to use.
ETC Backgrounds	3:15	This video describes the various ways to specify a background in the ETC.
ETC Batch Expansions	4:51	This video describes how to use the batch expansion feature to quickly explore a range of instrument or exposure parameters in the ETC.
Adding Emission Lines in the ETC	2:53	This video describes the process of adding, updating, and removing emission lines to a source continuum in the ETC.
ETC IFU Strategies	3:53	This video describes the two extraction strategies for the MIRI MRS and NIRSpec IFU and how to handle errors when switching strategies in the ETC. (This video was recorded in ETC version 1.5.)

Published	21 Oct 2019
Latest updates	

JWST Astronomers Proposal Tool Overview

The Astronomer's Proposal Tool (APT) is a stand-alone GUI-based software package used by proposers to write, validate, and submit proposals for the James Webb Space Telescope.

The JWST Astronomer's Proposal Tool is under continuous development and improvement, and subject to updates. Current documentation is based on APT v2020.1.1, and may be revised with future APT releases.

See also: JWST APT Help and Table of additional video tutorial help with APT.

APT GUI Overview Video Tutorial

APT is the official submission tool for *all* JWST proposals, including archival and other proposals that do not entail specifying new observations. All proposals, except Guaranteed Time Observer (GTO) proposals, go through a selection process prior to acceptance.

APT has had a long history with the HST project; a separate branch of APT is used for HST proposals. However, the JWST APT branch has many differences that are specific to the requirements and restrictions imposed by JWST and its instruments.

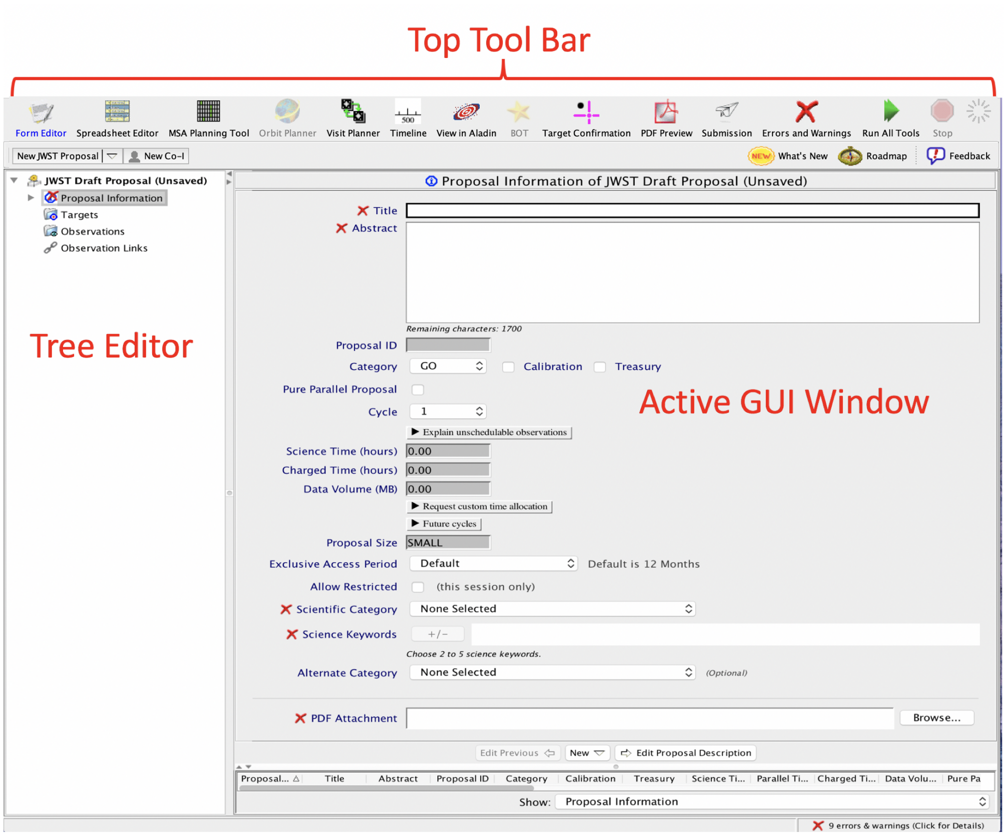
Download the Current Version of APT

On this page

Basics of the APT GUI

APT runs on your local machine, but accesses various tools and databases over the internet for performing certain tasks. After opening APT, a new JWST proposal is created by selecting the **JWST Proposal*** option from the **New Document** pull-down menu at upper left of the window, just below the top tool bar that extends across the GUI as shown in Figure 1. After that, the user will only see the JWST-related options in APT.

Figure 1. The annotated front page of a new JWST APT proposal



Appearance of a new JWST proposal in APT. The pull-down menu from the New Document tab (upper left, under the top tool bar) allows a user to choose a new HST or JWST proposal in APT. Here, New JWST Proposal has been selected, so HST-only functions such as the Orbit Planner and "BOT" (Bright Object Tool) are grayed out and unavailable on the top tool bar. Selecting different icons from the top tool bar menu or a different element from the tree editor changes the contents of the active GUI window.

In Figure 1, several portions of the APT GUI are labeled. In this and other APT articles in the JWST documentation, we will refer to these areas of the APT GUI using these names.

The tree editor is basically a navigation tool, allowing you to jump at will from one section of a proposal to another. The top tool bar controls whether you are in a data entry mode (especially the **Form Editor** tool) or whether you are using one of a number of tools within APT to perform various tasks. The active GUI window is the place where various data are entered or selections are made for your proposal. The active GUI window changes based on your selection from the tree editor in conjunction with a selection from the top tool bar. Additionally, certain tasks within APT will open a separate pop-up window to supply additional functionality.

ⓘ Context Sensitive Help in APT

Note: many of the parameters on the left side of the active GUI window are links to context sensitive help in the JWST documentation—they have a dark blue color and hovering your mouse over them will display a question mark icon. Clicking on these items will take you directly to an article about that item.

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

APT Functionality

See also: JWST Cycle 1 Proposal Opportunities and Getting Started Guide

APT allows JWST users to perform a number of key functions in the proposal process:

- specify general proposal information (e.g., **Title**, **Abstract**, PI, Co-Is, etc.);
- specify proposed targets;
- enter detailed observation specifications including instrument observing modes, mosaics, and special requirements;
- visualize the field of view on the sky for planned JWST observations;
- check the schedulability of observations using the APT visit planner;
- calculate the total science time and total time allocation request including overheads;
- check against existing and planned JWST observations for possible duplications;
- submit JWST proposals (including archival/theory proposals) to STScI for review.

Each short section below will point you to more detailed information on that topic. (Note: topic headings are clickable.) In addition, there are several ways to get help with APT, including a number of short training videos on various topics.

Proposal information

Supporting information is entered in the proposal information GUI; click on the **Form Editor** tool in the top tool bar, then click on **Proposal Information** in the tree editor on the left, as shown in Figure 1. The JWST APT proposal information form contains entry areas for required information about each JWST proposal, such as **Title**, **Abstract**, proposal **Category**, and so forth. Red X icons indicate errors in APT, but can also simply indicate required fields for which relevant data have not yet been entered.

Targets

JWST proposers must specify a list of targets, and in most cases, the target positions for each proposed JWST target. Targets may be fixed targets, solar system (moving) targets, or generic targets (e.g., ToO—target of opportunity). To verify positions on the sky, you can view and save target confirmation charts using the icon on the top tool bar.

Observations

Users can specify o*bservations* for a target using instrument-specific *observation templates*; these appear in the ***Template*** parameter pull-down menu after an ***Instrument*** selection is made in the active GUI window.

Based on parameter values entered by the user, APT will decide whether an observation needs to be broken into multiple pieces called *visits*, and each visit may involve one or more *exposures* on a target. Details are controlled by the *exposure specification* provided by the user. At the user's discretion, observations can be grouped into ***Observation Folders*** to help organize your proposal.

Observation templates

Standard observing templates are available for each science instrument observing mode. Each template is tailored to a specific instrument and mode of operation and only includes information needed in that mode. For example, if a target acquisition is allowed for a given mode, supporting information will be requested; otherwise, no target acquisition information is shown.

Additional tabs in the lower half of the observing template GUIs allow the user to design mosaics with identical observation specifications, to specify special requirements for the observation timing, position angle, and background, or enter other template-specific options. Certain observation templates allow selection of coordinated science parallel observations that use 2 JWST instruments simultaneously.

Because each template is unique to an instrument and mode of use, template guide articles are available in the JWST documentation for each template. Remember that context sensitive help is available directly from within APT that points you to the relevant item in each guide article.

Visualization of observations in Aladin

See also: video help Aladin Overview in APT

The Aladin tool within APT may be used to visualize proposed JWST observations as they are developed. Aladin is useful for verifying coordinates with respect to the Digitized Sky Survey (DSS) or other images, viewing dither patterns, displaying mosaic coverage and tile overlaps, and verifying the effects of fixed position angles. This tool includes a control GUI within the Active GUI WIndow and a separate pop-up window for the actual Aladin display.

Visit planner

See also: video help APT Visit Planner

After one or more observations are specified in APT, the user can select an observation (or observation folder) and activate the APT Visit Planner (VP) from the top tool bar. This step opens a tool in the active GUI window that can be run to verify the schedulability of your proposed observations and provide diagnostics (in the case of problems). The JWST VP capabilities are more extensive compared to that used for HST. For instance, it includes a check not only of target visibility as a function of time, but also an assessment of whether guide stars are available as a function of time.

> **Separate Target Visibility Tools**
>
> For certain cases, the user may find it valuable to perform preliminary checks of a target's visibility with JWST using one of the JWST target visibility tools. Note, however, that these tools do not include guide star availability checks.

Total time accounting

Once all the observations in a proposal have been specified, the VP needs to be run on the entire set of observations and green checks must appear on all observations for the proposal to be considered ready for submission. At this point, the user must execute the Smart Accounting tool to produce the final proposal-level assessment of science time and total wall-clock time needed for the program, including all the major observatory slews. Most users will find that this step reduces their overheads, as APT assesses what observations can potentially be scheduled together. The results of Smart Accounting are automatically updated on the proposal information (cover) page.

If you are interested in understanding more about the overheads ascribed to each observation, APT contains a Timeline Tool that shows this information in a handy graphical format.

Duplication checking

> *See also: Identifying Potential Duplicate Observations for JWST and Policies about what constitutes a duplication.*

You may find it beneficial to check for possible duplications before getting serious about your APT proposal, but once you have all the details in hand, you may need to double check that you have not specified an observation that duplicates a previously obtained or planned opbservation. (If a duplication is being proposed for scientific reasons, such as target variability, you must discuss this in your PDF attachment.)

Eventually, observers will be able to access a duplication checking tool from an interface within APT. Until that interface is ready, users can query the Mikulski Archive for Space Telescopes (MAST) directly for existing and approved but not yet executed JWST programs.

JWST proposal submission

> *See also: Getting Started Guide*

When you have a clean run of the VP and Smart Accounting and any errors and/or warnings have been cleared[1], you are ready to submit your JWST proposal! Make sure you attach the science and technical description PDF file in the **Proposal Information** GUI, and select the **Submission Tool** icon from the top tool menu. The GUI and pop-up menus will guide you.

If desired, you can obtain a full PDF of the proposal (including the APT pages and the science PDF) prior to (or after) submission.

> [1] If you are unable to resolve APT errors, you should contact the JWST Help Desk for assistance. If the error cannot be resolved prior to the JWST proposal deadline, fill out the "explain errors" pop-up box on the proposal submission GUI prior to submitting your proposal.

Getting help

See also: JWST APT Video Tutorials and JWST APT Help

See also: video help with APT Errors and Warnings

Warnings (yellow caution icons) and error messages (red X's) generated by APT are intended to help users identify and resolve the easiest problems or inconsistencies. Hover the cursor over these icons for pop-up help with a short description. You can also get summaries of these messages by clicking the **Errors and Warnings** icon on the top tool bar or the "errors and warnings" box at bottom right in the GUI.

A number of Example Science Programs are also available within JDox. These worked examples have accompanying ETC workbooks and APT files that users will find instructive.

Related links

JWST Observing Overheads and Time Accounting Overview

Acronyms and Abbreviations

Published	30 Dec 2016
Latest updates	• 22 Jan 2020 Final updates for SPT 2020.1.1. • 27 Sep 2019 Updated video links for cycle 1.

	• 16 Aug 2019 APT Overview article elevated to the landing page position and updated. Old overview page deprecated. • 11 Mar 2019 Updated for APT 27.1 release, including figures. • 02 Nov 2018 Article significantly streamlined and redundancy removed where possible. • 27 Nov 2017 Updated Figure 1 • 16 Nov 2017 Made everything compatible with APT 25.4.1 release to the extent possible. Added sentences regarding the ETC workbook and calc ID box on target acq and science exposure specs. • 28 Mar 2017 Figure 3 updated • 22 Feb 2017 Significant changes to text

APT Changes Anticipated for APT 2020.2 release in March 2020

APT version 2020.1.1, to be released in January 2020 in conjunction with the JWST cycle 1 call for proposals, can be used for preliminary planning of proposals. However, a number of updates are being planned for APT 2020.2, which will be released on or around March 5, 2020.

> *APT version 2020.2 must be used to submit all proposals for JWST Cycle 1* (the deadline is May 1, 2020). This is because APT 2020.2 will include additional timing model changes, and will be the official accounting tool for Cycle 1.

Changes anticipated in APT 2020.2 are listed below so users can determine if any significant changes are anticipated that would affect their science proposal strategy:

- Updates to the moving target timing model;
- Further possible updates to science instrument timing models (e.g., a change in MIRI target acquisition (TA) overhead due to a reduction in the size of the TA subarray);
  - All known timing updates as of December 2019 (except the moving target timing model) will be in APT 2020.1.1. However, additional timing updates may be added—any such updates will be included in APT 2020.2;
- NIRISS filter-dependent dithering specifications;
- new apertures for specifying post-small angle maneuver (SAM) exposures for NIRCam coronagraphy;
- Removal of science time from the TAC version of the PDF attachment. (Science exposure times and the total times including overheads are provided in APT as a reference for the proposer community. However, STScI does not want this level of detail to be provided to the TAC panels, so science time will be removed from the version of the PDF that goes to to the TAC.)

Published	20 Dec 2019
Latest updates	

APT Workflow Articles

Filling out a JWST proposal in the Astronomer's Proposal Tool involves entering proposal information, specifying information about the target(s), setting up the observation(s) (including target acquisitions, if needed), defining any special requirements, and ensuring the program can be scheduled as specified. The following articles can help you through this process.

Expand all Expand all Collapse all Collapse all

There are also articles describing additional APT functionality that will be helpful for proposal preparation.

JDox contains many example science programs that have corresponding ETC workbooks and APT files that you may find helpful.

Published	03 May 2017
Latest updates	• 19 Aug 2019 Modified title for clarity in menu. • 11 Mar 2019 Updated for APT 27.1 release • 05 Nov 2018 Updated for ETC v1.3.

APT Proposal Information

The JWST **Proposal Information** section of APT can be found in the tree editor (left column in the APT GUI). It provides a place to enter details of a supporting nature for your proposal. Much of this information will ultimately appear on the cover page of the formatted APT proposal. Opening the **Proposal Information** tab in the tree editor shows additional subsections for entering information. This GUI also contains a field for adding the name of your science and technical PDF file for uploading prior to submission of your proposal.

Dark gray boxes hold information that is automatically filled by APT, and are not editable. The **Proposal Information** GUI contains several such boxes that will be filled and adjusted as you edit your proposal. For example, when your proposal is complete and you have run Smart Accounting, the official ***Science Time, Charged Time, and Data Volume*** for your proposal will be automatically filled. The ***Allocated Time*** box will only be filled in for accepted proposals.

Proposal Information

The **Form Editor** at the top tool bar is used to fill the **Proposal Information** GUI. Click on **Proposal Information** in the tree editor to see it in the active GUI window. It contains entry areas for required information about each JWST proposal. Required parameters are:

- ***Title***
- ***Abstract***
- ***Category*** (a pull-down menu shows ***GO***, ***GTO***, ***DD***, ***ERS***, ***AR***, ***SURVEY***, and ***NASA***, as well as checkboxes for ***Calibration*** and ***Treasury***)
- ***Pure Parallel Proposal*** [1] (check this box if you're submitting a pure parallel program)
- ***Cycle***
- Requested ***Exclusive Access Period*** for new data (the default is ***12 Months*** for GO proposals)
- ***Scientific Category*** and ***Science Keywords*** (note that an ***Alternate Category*** can also be selected)
- ***PDF Attachment*** (science justification/description of observations; prepare this separately and attach it prior to submitting your proposal)

As proposed observations are entered, APT calculates the science time request and total time request (including overheads) for all observations specified, and displays these values in the **Proposal Information** GUI. These values are a point of reference used by the JWST time allocation committee in reviewing the proposal.

Proposers may edit the following additional parameters if needed:

- ***Explain unschedulable observations*** (in small font under ***Cycle***) is used to explain unresolved APT errors or warnings at the time of submission. In most cases, proposers are expected to resolve errors prior to submission, but if an unanticipated situation is encountered and an STScI exception is obtained, this text section can be used to provide the relevant information.

- ***Request custom time allocation*** (in small font under ***Data Volume***) is for special situations where normal accounting in APT may be inaccurate. If the requested time allocation for your proposal is different from that calculated by APT, proposers may enter a "custom time allocation." However, an explanation is required for a custom time allocation (e.g., like a target of opportunity observation). The APT-calculated times cannot be modified and will remain visible.

- Request time in ***Future cycles*** (in small font under ***Data Volume***)—such requests must be scientifically justified.

- Request observations with ***Coordinated telescopes*** (in small font under ***Alternate Category***); see the current JWST Call for Proposals for a description of available coordinated observing opportunities with other facilities.

Selecting the small arrow to the left of items in the tree editor will show subordinate sections, known as *containers*, that can be selected to enter information. For **Proposal Information**, this includes **Proposal Description** and **Team Expertise**, as well as containers to enter the proposal's principal investigator and/or co-investigator information.

The **Proposal Description** and **Team Expertise** containers provide free-format text boxes where you should enter any relevant details about your proposal that may be useful for future reference. The **Unnamed PI** and **Unnamed CoI** containers include a search box that can be used to find and enter contact information directly from an STScI database (or you can enter new investigator information, if needed). They change to show the PI or CoI name in the tree editor when completed.

[1] Normal proposals can contain *primary observations* and *coordinated parallel observations*, but pure parallel proposals are completely separate proposals and are handled differently. See JWST Parallel Observations to understand the specifics of these different kinds of parallel observations.

[*] ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Published	13 Nov 2018
Latest updates	• 10 Dec 2019 Article updated for Cycle 1 Call for Proposals release.

APT Targets

JWST observing proposals must specify the proposed targets (and as appropriate, coordinates) in the Astronomer's Proposal Tool. Allowed types are: fixed targets, Solar System (moving) targets, or generic targets that have unknown coordinates at the time of the proposal. A special case called "target groups" is also available.

On this page

An astronomical target for JWST refers to any position on the celestial sphere at which the telescope needs to point. The target may be a physical object, a portion of an object, a background region, or even an unknown target at the time of proposal writing.

The Astronomer's Proposal Tool accepts 3 primary types of targets:

- Fixed targets, typically associated with known astronomical objects outside the Solar System whose positions can be defined by specific celestial coordinates;
- Solar System targets (also known as moving targets);
- Generic targets, typically used for target of opportunity observations or pure parallel proposals where specific targets are not known at the time of the proposal submission.

Additionally, APT has the ability to ingest a catalog of targets from an appropriately formatted ASCII file.

The links above take you to *proposal parameter articles* on each target type; these articles contain technical details and legal values for many of the parameters listed in the APT target entry section.

A special use case called Target Groups may be useful for users proposing closely spaced targets that need to be observed with very similar observation specifications. (For cycle 1, the allowed templates include MIRI LRS, MIRI MRS, NIRSpec fixed slits, and NIRSpec IFU.)

Due by the single stream approach for JWST proposing, most proposers are required to submit a full list of targets with coordinates in order to accurately compute the total time allocation request. Exceptions to this rule may be described in JWST Opportunities and Policies for each cycle; such exceptions may include targets of opportunity and NIRSpec multi-object spectroscopy proposals, where it is impossible to know all relevant details at the time of initial proposal submission.

Fixed targets

> *See also: proposal parameters article on valid specifications for Fixed Targets.*

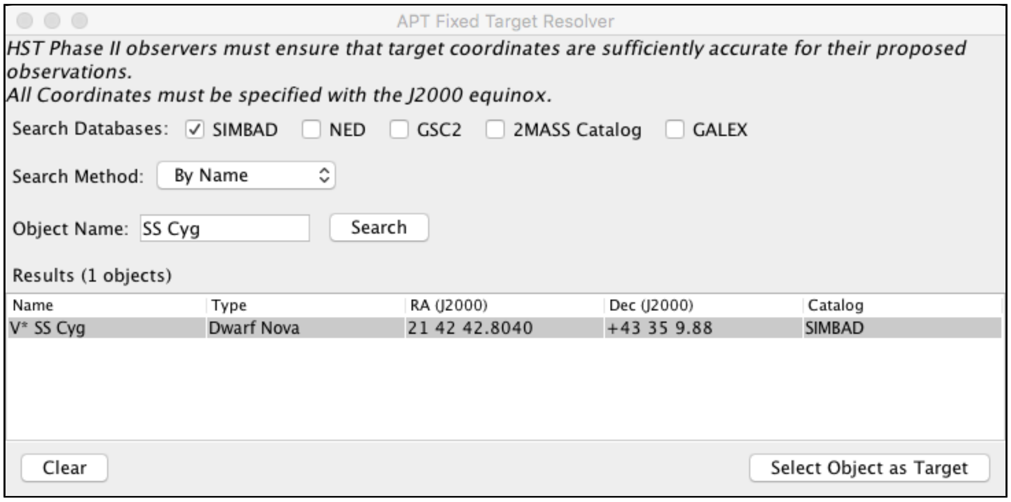
Fixed targets may be entered in APT by hand (including the coordinates), found using the **Fixed Target Resolver** tool, or imported as a formatted ASCII table. Select **Targets** in the tree editor (in the left column), as shown in Figure 1. The active GUI window on the right displays the options for entering targets.

Figure 1. **Target entry menu in APT**

The target entry GUI contains options for entering a new fixed target, Solar System target, or generic target. For fixed targets, you can enter them manually by selecting New Fixed Target, use the Fixed Target Resolver tool to search for your targets, and Import Targets to load a list of targets from a file. There is also a special use case called New Target Group that will be discussed further below in this article.

The **Fixed Target Resolver** tool opens a separate window where you can select a catalog(s) to search for your target, specify a search method, and enter search values based on the search method you specified. A simple example is shown in Figure 2. If more than one catalog entry is returned, you can select the target of interest. If you commit a target from this search to your proposal, a note is automatically generated in the ***Comments*** section of the target GUI. (This comment can be edited by the proposer, if desired.)

Figure 2. The Fixed Target Resolver tool GUI



APT's Fixed Target Resolver tool is run in a separate pop-up window. Entering a resolvable target name (e.g., "SS Cyg" in this example) and selecting Search returns the coordinates from one of several catalog services (SIMBAD by default, but one or more catalogs can be selected). If a list of targets is returned, select one of the entries and click Select Object as Target to commit that object as a new target in the proposal.

Importing from a bulk target list

See also: JWST Bulk Target Ingest

In the APT **Targets** form, users can upload a file containing a list of fixed targets into a proposal. Allowed file formats include comma-separated, tab-separated, and whitespace delimited values, as well as a Virtual Observatory format table. Additional details are available in JWST Bulk Target Ingest.

If you update your targets after ingesting the target list, you can also *export* your APT targets to a list. In the APT main menu, go to **File → Export → Export Fixed Target list**. Please note that APT exports all coordinate uncertainties in arcsec, regardless of the units set in APT, and only supports the CSV output format.

Fixed target form GUI

Each target is described in its own form, listed under **Fixed Targets** in the tree editor. Each fixed target form has a number of parameters—some are required but many are optional, depending on your use case.

Required parameters:

- ***Number:*** Each target in APT is assigned a number. These numbers can be edited as desired by the user. They are useful for referencing a particular target in various pull-down menus and formatted listings elsewhere in APT.
- ***Name in Proposal:*** Although this is a required entry, the name can be chosen at the user's discretion, and can help you in organizing your proposal.

- ***Category*** and ***Description****:* These keywords are needed by the archive.
- ***J2000 Coordinates:*** Use J2000 epoch coordinates.

Optional parameters:

- ***Name for the Archive:*** *A* standard searchable (resolvable) name should be entered for future use in archive searches.
- ***Uncertainty*** (for J2000 Coordinates):The required accuracy depends on the observations you plan to obtain. High accuracy is not required for some observations such as imaging, but placing a particular object in a fixed slit for spectroscopy requires higher accuracy.
- ***Proper Motion, Annual Parallax*****:** Enter these values if they're relevant to your use case. If it's used, you must also specify the ***Epoch*** for your values.
- ***Extended*****:** Select ***YES*** or ***NO*** from a pull-down menu (the default is ***Unknown***) to inform the data processing pipeline whether the extraction algorithm should consider the extent of the source or not. This is particularly relevant for spectroscopic observations where the source may or may not fill the aperture.
- ***Comments:*** Enter anything you might find useful for future reference.

Below these parameters is the **Background Target** section that provides an optional check box where you can tell APT that observations of this target will require a separate background observation for use in data processing. If you have not yet entered the background target(s), the GUI box in this section will be empty. After you have entered the background targets, return to your science target and select the desired background target(s). (This information gets passed downstream to the data processing system.)

Special fixed target cases: mosaics, multi-object spectroscopic targets, and background targets

See also: JWST Position Angles, Ranges, and Offsets
See also: Background-Limited Observations

Special target cases include target positions provided for mosaic observations and for NIRSpec multi-object spectroscopy.

Mosaics are defined by a single coordinate position (the center of the mosaic) and a pattern of fields around this position. The (X,Y) positions of the individual mosaic fields are described in arcseconds relative to the central coordinates, in the reference frame of the detector used for the mosaic observation. A mosaic pattern rotates around the center coordinates, and so the position of each mosaic tile changes position in RA and Dec coordinates, but the (X,Y) coordinates remain fixed.

For NIRSpec multi-object spectroscopy, the target coordinates in APT serve as a reference position on the celestial sphere for the micro-shutter array. Target coordinates are not intended to indicate the position of a particular science target, pointing, or shutter coordinate. A fixed position angle is assigned prior to planning exactly what pointings and micro-shutters need to be opened to capture the spectra of particular objects in the field. The NIRSpec MSA Planning Tool l is used to ingest a catalog of candidate multi-object spectroscopy sources and to define the shutter configurations for each exposure in the observation.

For targets that require a dedicated background observation, a separate "background" target should be defined, and the observation of this target should be linked to the science observation of interest. (The observer should verify that the chosen coordinates provide a suitably clear field.) To create a background target: (1) add a new target with the coordinates for the background pointing. (2) Go back to the science target, and check the box for ***Observations of this target require companion background observation(s)***. (3) When that box is checked, a new field appears below it containing a list of other targets in your proposal. (4) Select the just-created background target by its name in the ***Target selection*** box.

In the observation template, you will see an error if the observational parameters (in this case, the need for a linked background observation) are not as expected. APT has special requirements that should be used to create an uninterruptible sequence that links the science observation and the separate background observation. A given background can be used for multiple observations provided that these observations use the same science target. To use different backgrounds for other observations of the same target, different background targets with relevant coordinates will need to be defined. See the proposal parameters article on this topic for more details.

> Note that targets chosen to be background targets cannot also be science targets. If your proposal has targets that serve as both science targets and background targets, you will need to create the target twice with slightly different names.

Solar System targets

See also: Proposal Parameters article on valid specifications for Solar System Targets

How to retrieve minor body orbital elements from Horizons

Solar System targets ("moving targets") are specified in APT by selecting **New Solar System Target** in the **Targets** page. The APT user has tremendous flexibility to identify specific targets and pointing positions relative to targets using a system of target Levels and pick list information provided. ***Level 1*** targets are solar system bodies directly orbiting the Sun (planets, comets. or asteroids), while ***Level 2*** and ***Level 3*** targets are moons of, or positions on or relative to, the specified Level 1 or Level 2 target.

Another APT distinction between types of moving targets is between Standard Targets and minor bodies (Asteroids and Comets). For Standard Targets, ephemerides can be computed using information directly accessible to and maintained by APT. For the minor bodies, the user must supply orbital elements, either manually or by retrieving them from the JPL Horizons system using the built-in APT function.

Note that many of the high level APT entries for moving targets are analogous to the Fixed Target case (e.g. ***Name in Proposal***, ***Name for the Archive***, ***Description***, and so forth). Observers familiar with specifying moving targets for HST observations will see that the functionality for JWST is identical.

For many more details about specifying solar system targets in APT, see the Solar System Targets proposal parameters article. Also, information is available on Special Requirements needed for many moving target observations.

Generic targets

> *See also: Proposal Parameters article on valid specifications for Generic Targets.*

Generic targets are targets that can only be described in terms of astronomical characteristics or general location in the sky at the time of the initial proposal. This category is used for Targets of Opportunity programs (i.e. where the details of the target or targets are not known until something happens at a later date). This category is available for both Fixed and Solar System targets. Another use case will be for pure parallel proposals where the parallel observation slots can only be defined on the characteristics of the type of primary observation they may be attached to after acceptance. Target of Opportunity observations are automatically ***ON HOLD*** and do not need the Special requirement, but any other observations using Generic Targets should have an ***ON HOLD*** special requirement placed on them, to prevent the observations from being considered by the long range planning system until details are known. When the target is fully specified, the ***ON HOLD*** is removed and the proposed observation then flows into the scheduling system.

Because of the nature of generic targets, the APT fields available in the target GUI are adjusted somewhat. The ***Name in the Proposal*** field is still present (and required), but an entry for ***Criteria*** is provided. This is where you provide the criteria for the unknown target selection. You may also wish to use the ***Comments*** box provided to specify further details about the target selection.

At such time that your proposal is accepted and a given target's details are known, the target information will need to be added into the appropriate Fixed target (or Solar System target) form in APT, including filling out keywords and all other relevant information in those forms.

For full details regarding specifying generic targets, refer to the Generic Targets proposal parameters article.

The Special Case of Target Groups

For JWST, APT supports the creation of a special target case known as a *Target Group*. A target group is a set of closely-spaced (within one guide visit-splitting distance) fixed targets that are intended to be observed together and for which the observation specification is intended to be identical. By placing targets in a target group, the user can specify the observational details once in the relevant observation template and then select the target group as the "target" of the observation. The observational details will then be applied to all of the individual targets automatically. Note that no changes in the template are allowed for the individual targets if using this configuration.

Because of the specific functionality of the target group concept, it is only applicable for use with four observation templates that involve small fields of view or apertures: the MIRI LRS, MIRI MRS, NIRSpec Fixed Slit and NIRSpec IFU templates.

Target Groups were created for a very specific use case, but excellent gains in efficiency and a tremendous reduction in mechanism motions can be garnered when that use case applies. For a set of targets needing identical observation and exposure specifications, and are within the visit splitting distance on the sky so that the targets can be observed sequentially in the same visit, unnecessary guide star acquisitions can be avoided and the ordering of activities can be adjusted for both efficiency and to save wear and tear on the filter/grating wheels of the affected instrument.

An example might be a grouping of pre-main sequence stars, all to be observed with the NIRSpec fixed slit or IFU. To the extent that such a grouping lies within the visit splitting distance for a given place on the sky (typically 40 - 80 arcsec or so; reported in APT for reference), the observations can be accomplished very efficiently, since no new guide star acquisition is required for the individual targets. Furthermore, let's assume a use case where the NIRSpec IFU is being used to create a small mosaic using multiple gratings/filters. The Target Group concept allows the entire set of mosaic tiles to be observed with one grating/filter combination prior to moving the mechanism to the next grating/filter combination, instead of completing all gratings/filters on the first tile before moving to the next. For a 5x5 IFU mosaic, this reduces 25 mechanism motions down to one for each grating/filter combination.

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APT Bulk Target Ingest

JWST APT includes a capability to ingest a file containing fixed target information directly into the APT target section.

On this page

For programs involving a large number of targets, APT supports the ingest of catalogs or lists of targets and target information in various formats.

File formats for importing targets

The are 4 supported file formats:

- White space separated
- Comma separated values (CSV)
- Tab separated values (TSV)
- Virtual Observatory table (VOT)

Here is an example of a CSV file for fixed targets. (Solar System targets are not supported for bulk entry.)

```
# Name, RA, DEC, RA Uncertainty, Dec Uncertainty, RA PM, RA PM units, DEC PM, DEC PM units,
Epoch, Annual Parallax, "Comments"
#
SDSS2346-0016,23 46 25.6700,-00 16 0.05,0.1,0.1,3.4, MAS/YR,1.0,MAS/YR,1989.9,,"From the Sloan
Survey"
#
V-V1343-AQL,19 11 50,4 58 58,,,,,,,,,"This object is from SIMBAD"
#
HD76932,08 58 43.9300,-16 07 57.90,,,,,,,,,
#
RW-AUR-A,76.95629,+30.40153,,,,,,,,0.1,
```

There are several items to note about the format:

- Lines starting with a "#" are comment lines.

- The first line in the file (there can be other comment lines between this line and the data) contains the names of the columns; the column names in the file must be unique, and they are not case sensitive. The names above are the names that APT uses, but you can use other names for some columns and APT may properly interpret them (e.g. RA can be RA, Right Ascension, or R.A.) If you do not supply a column identification line, or if your column names cannot be interpretted by APT, you can manually assign the columns.

- You do not need to supply values for all of the APT fields (e.g., you can skip the RA Uncertainty field and populate it in APT after ingest).
- Each line must contain the exact same number of entries. For CSV format, you can use extra commas to represent missing data (e.g. for SDSS2346-0016, there is one comma between the Epoch and Comment to indicate that the Annual Parallax field is not populated. Note that for Whitespace and Tab separated, this method will not work (i.e. you cannot have extra whitespace or tabs to indicate blank fields).

- The coordinate fields can support multiple formats, as shown above. For RA, you can use 19 09 53.0 (no units), 16h 22m 31s (units), or 118.77170 (decimal degrees). For Dec, you can use 4 53 16 (no units), -17d 52m 44.0s (units), or 22.00137 (decimal degrees); note that you cannot use ' (minutes) or " (seconds) for the units.

- Note that text fields need to use double quotes (") and not single quotes (').

- To specify quotes within a text field, use double double quotes (e.g., "This will preserve the ""quote"" mark.")

- For some text field data, you will need to use quotes around the text. In white space separated files, quotes are needed around all text fields that contain white space (e.g. "19 09 53.0"). In CSV files, quotes are needed if the text field contains a comma (e.g., "This object, from my list, is interesting").

Accessing the Importer

To ingest a target list into APT:

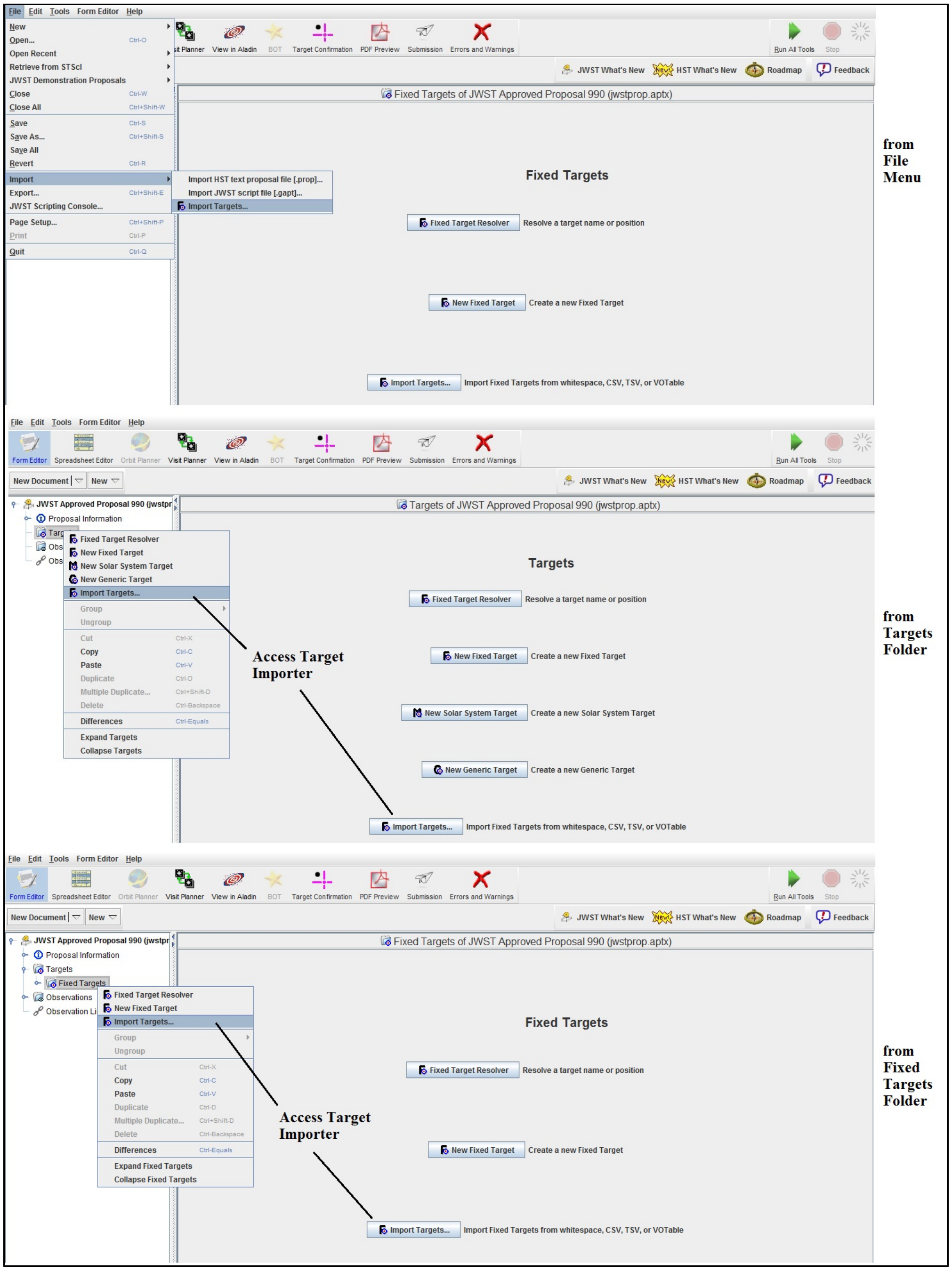
- Go to **File** → **Import** → **Import Targets...** , or

- Select the **Targets** folder in the Tree Editor and click on the ***Import Targets*** button in the APT window (or right click on the **Targets** folder and select **Import Targets...** from the menu), or

- Select the **Fixed Targets** folder in the Tree Editor and click on the ***Import Targets...*** button in the APT window (or right click on the **Fixed Targets** folder and select **Import Targets...** from the menu).

These options are shown in Figure 1.

Figure 1. **Options for Accessing the Target list importer in APT**

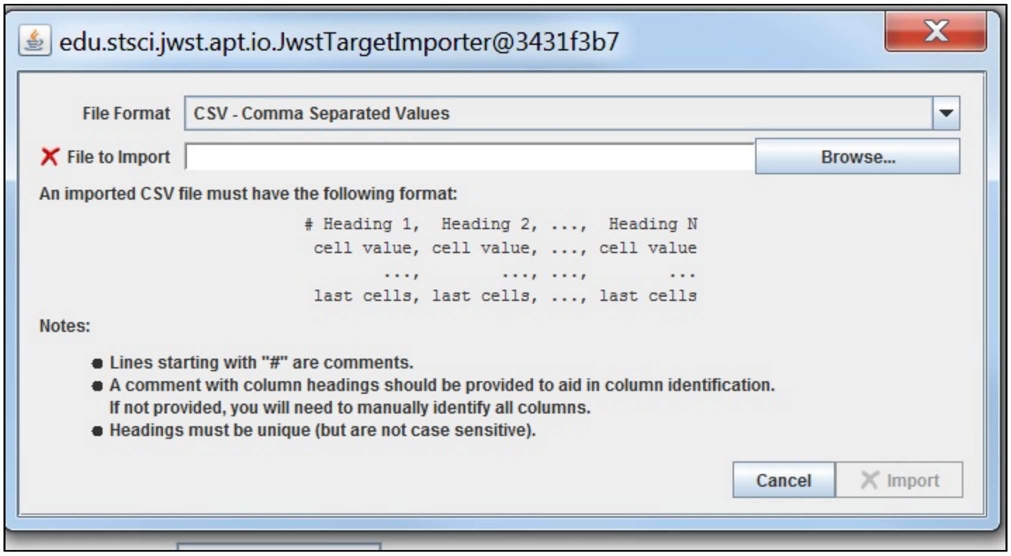


The target importer can be accessed in several different ways, as shown in the 3 panels above.

Assigning Column Names

After launching the importer, click ***Browse...*** to select the target list you wish to import. APT will attempt to automatically identify the file format. If it cannot, select the correct format from the drop down menu. For an example of each format, select it in the ***File Format*** menu with no file specified. See Figure 2.

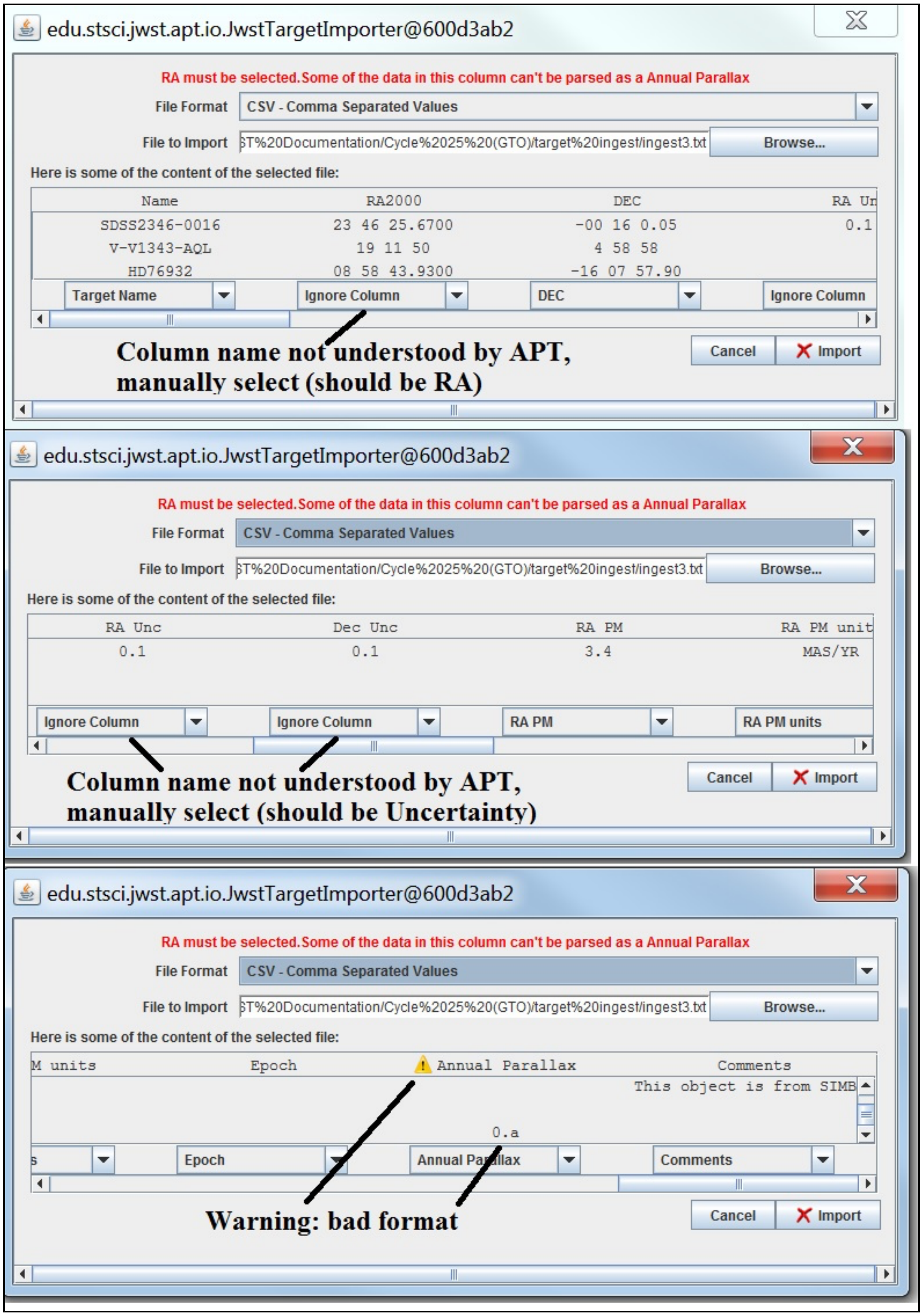
Figure 2. **The Target list import interface GUI**



This GUI permits the file type and file name to be selected for import.

Once you enter a file name, the importer will attempt to match the column names in your file (if you provided any) with the APT field names.

Figure 3. Import GUI attempts to identify columns in the input file



These panels show several outcomes from the tool's attempt to identify columns in the input file.

In the examples shown in Figure 3, the field names for Right Ascension, RA Uncertainty, and Dec Uncertainty were not understood by APT, so these will need to be manually selected. Note that the importer requires the ***Name in the Proposal***, ***RA***, and ***DEC*** fields to be identified before it will accept the file for import. You can view all the objects in the file by scrolling down.

Also, the entry in the ***Annual Parallax*** column has an incorrect format. You may import a file with this type of error, although the object with the error will NOT be imported (but all the other targets will be). However, if all the entries in a given column are improperly formatted, the Importer will not accept the file for import.

With all the columns identified, click on the ***Import*** button to load the targets into APT.

Besides the ***Name in the Proposal***, ***RA***, and ***DEC***, two other fields are required for a minimal, complete target specification: ***Category*** and ***Description 1***. These fields may be entered manually if not given in your file. See this table for allowed target categories and descriptions.

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APT Observations

An APT *observation* is the basic proposal design element, consisting of one astronomical target and one JWST observing mode using a corresponding APT observation template.

On this page

See also: APT Observation Templates

Observations are the basic proposal element specified by a user to request new JWST data. Each observation uses a single APT Template corresponding to an instrument observing mode (e.g., NIRCam Imaging, MIRI MRS, etc.) to observe a single astronomical target. Any number of observations involving one or more instruments can be entered into a given proposal, as required by the proposed science. Multiple observations may be linked together in time and/or position angle if necessary, using special requirements. In APT, multiple observations can also be grouped into observation folders to keep the proposal organized.

Each observation will contain one or more *visits*, with each visit requiring a guide star acquisition. The user defines observations, and APT will determine if the observations need to be broken into multiple visits, based on various operational constraints. One common example is that of an imaging mosaic: the user defines an observation with the mosaic tile pattern, and APT defines the visits within that observation based on the separation of the tiles, with knowledge of the visit splitting distance at the target position.

In turn, each visit is defined as a group of *exposures* of the same astronomical field, with the same guide star, and with the same instrument observing mode (and template form). Multiple dithered exposures (offset from one another on the sky) may be obtained in a single visit if the same guide star can be used for all exposures.

Observations versus Visits

Users specify observations of a target using instrument-specific *observation templates*, which appear when choices are made for instrument and mode in the active GUI window. Based on the inputs from the user, APT decides whether an observation needs to be broken into multiple pieces called *visits*, and each visit may involve one or more *exposures* on a target. Details are controlled by the *exposure specification* provided by the user.

Visits are the scheduling units used by the downstream scheduling system and have implicit overheads applied, but observations are what the user specifies in APT by filling out an observation template. The number of assumed visits and information about the assumed visit-splitting distance for each observation are reported in the template GUI.

APT uses a timing model to calculate the statistical and fixed observational **overheads** for each set of observations in order to compute the total time allocation request for the proposal. The accounting for each observation is reported in the individual observation templates in APT. Insight into these overheads can be obtained by viewing the observation in the APT Graphical Timeline tool. A procedure called Smart Accounting is ultimately run on the entire proposal to update the proposal-level accounting prior to submission. APT's computed total time allocation request for the entire proposal is reported on the cover page and is available to the JWST TAC panels as part of the proposal assessment process. Estimated total data volume is also reported for information.

Observations and observation folders

Observations in APT reside in one or more observation folders under the main **Observations**[*] folder in the tree editor panel that's to the left of the APT display. An example is shown in Figure 1.

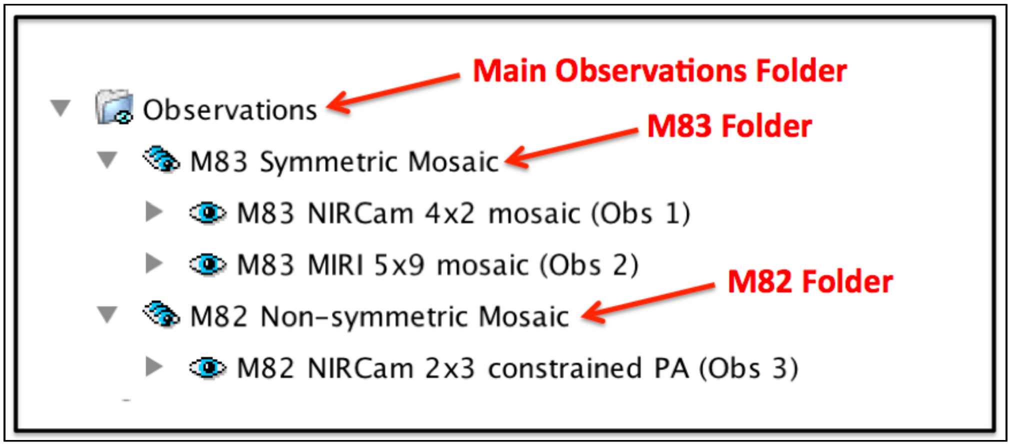
To view existing folders, click on the arrow to the left of **Observations**. Click on the arrow next to an **Observation Folder** to see the observations filed in that location.

To create a new folder, click on **Observations**. A tab called **New Observation Folder** will appear in the main GUI. Clicking on that button creates a new observation folder and a new blank observation form inside that folder.

You can add more folders, and add more observations in those folders, all under **Observations** in the tree editor. These folders and observations can be rearranged simply by dragging them. Using the **form editor** tool selection from the top tool bar, each folder and observation can be given a unique name (see Figure 1) by entering its name in the **label** field.

It's easy to use the form editor to create or edit an observation. First, click on the **Form Editor** button in the top tool bar. Then click on an **Observation** in a folder. The observation form will appear in the GUI. If it's a new observation, you'll select an instrument, a template and a target. When the template is selected, fields associated with that instrument mode appear in the active GUI window—for example, if the instrument mode requires target acquisition information, a section about it will appear in the template. You can also specify offsets such as dithering and mosaicking in most templates.

Figure 1. Example of APT Observation folders



This is a way for users to organize and annotate their observations as they craft their proposal. The figure shows the main Observations folder in the APT tree editor for an example proposal in the APT Simple Mosaic Example page. The main Observations folder contains 2 additional folders created for organizational purposes. The first folder contains 2 observations of the galaxy M83, and the second folder contains a single observation of M82. Each folder and observation title was made by entering descriptive information in the label field in the relevant GUI.

Folders are provided as a convenience for users to help organize their observations. If you are requesting observations of the same target with multiple instruments, you may use the folder structure to keep all observations of a given target together. Another user might be requesting multiple epochs of data for a target, and may organize observations into their respective folders by epoch. A user requesting a sequence of coronagraphic observations may want to gather the relevant observations into the same folder.

The only exception to this concept of folder organization is if/when one or more tiles must be split off from a mosaic due to guide star restrictions. The tool that does tile splitting for problem mosaic cases creates a mosaic folder containing both the main mosaic and the separate tile observations. In this case, this special folder keeps the separate tiles associated for data processing purposes (so a single mosaic data product can be created).

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

The Observation GUI

See also: Visit Splitting, Overheads, Data Volume, APT Errors and Warnings (prepared for HST but useful for JWST proposers as well).

There is also video help on this topic:

APT Errors and Warnings.

As with other parts of APT, user interaction with the GUI is fairly straightforward and self-explanatory. Pull-down menus show the options for various parameters, and buttons like ***Add*** will display pop-up menus with selectable choices.

Dark gray boxes in the GUI cannot be edited; they are there to report information back to the user. For instance, when a target is selected, two gray boxes on the line labeled Visit Splitting are filled in: the box labelled **Splitting Distance** displays the value that APT will use for that target when deciding whether it needs to split the observations into multiple visits, based on the dither steps, mosaic tile separation or other parameters. This value is determined as a function of galactic latitude, which is related to the expected availability of guide stars, and cannot be changed by the user. Likewise, as appropriate observation specifications are entered into the template, APT will report the **Number of Visits** it has determined in the labeled box. Gray boxes (including the **Duration** boxes) will update automatically as the proposal is developed.

APT also reports the **Science** time and **Total Charged** time (including overheads) for your observation on the line labeled **Duration**. Note that this is an observation-level assessment, and only includes overheads internal to the observation. You will see these fields update as you enter and change parameters in the observation specification. Finally, although is is not in a gray box, APT reports the **data volume** it ascribes to the observation. This is for information only and also updates as changes are made to the observation specification. A roll-up of the proposal's total data volume is reported on the Proposal Information page.

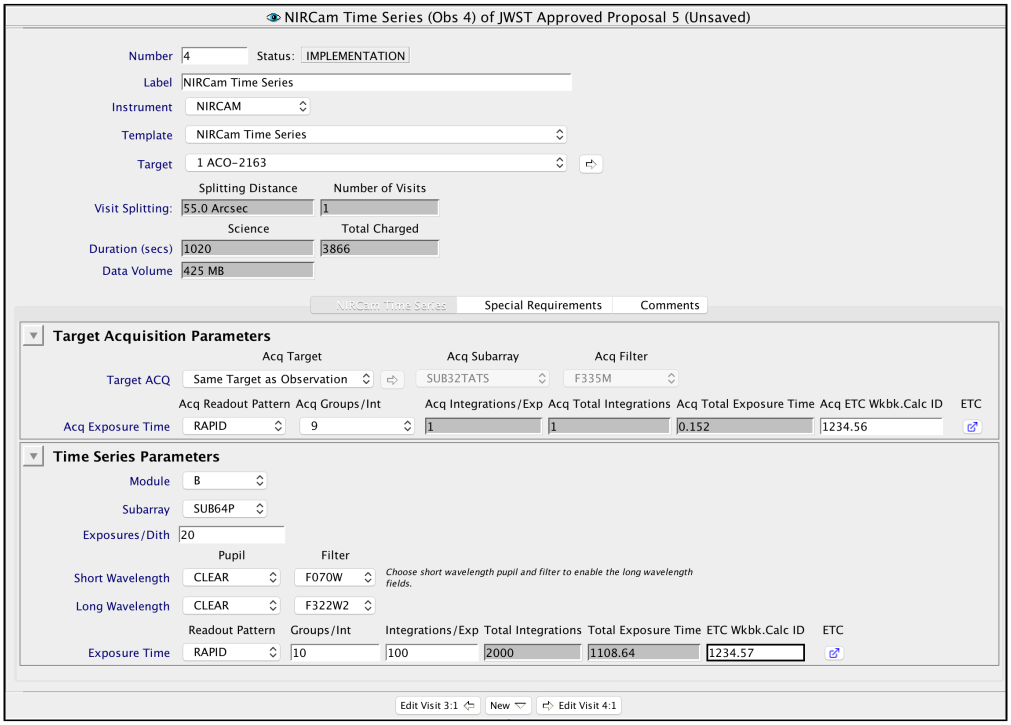
For observing modes that require information for a target acquisition, the observation template contains a labeled section for this information (see Figure 2). The observation specifications for the target acquisition should be brought forward from an appropriate ETC calculation. See JWST APT-ETC Connectivity for how to annotate this information in APT.

Various science parameters in an observing template are entered in a panel in the lower half of the observation form in the active GUI window. This section usually has up to four tabs;

1. The first tab’s name is usually the same as the selected template’s name. Clicking on it opens a view containing parameters for that template’s observing specifications. Exposure information entered here should generally be based on ETC calculations. Depending on the selected template, target acquisition and dither parameter values are entered in this portion of the template.
2. If the template allows mosaicking, clicking on the **Mosaic Properties** tab opens a view for specifying mosaic control parameters for the observations.
3. The **Special Requirements** view provides access to the controls for adding any special requirements that may be needed to constrain the scheduling of this observation, including constraints relative to other observations if needed.
4. The final tab called **Comments** opens a window for users to document details they wish to keep track of for their own purposes, or to provide information to technical staff who may review the proposal information. (There are several different Comment areas within APT; this one is for describing observational details or strategies that may not be obvious from the template entries by themselves.)

Users can leave and return to a given observation template as many times as needed as they iterate various options in their proposal preparation. Red X's indicate errors, which might indicate something as simple as missing information or improperly specified parameters that need to be corrected. Hover the cursor over any items with red X's for a tip on what the problem is. Once an observation template is cleared of errors, it can be run through the **Visit Planner** to check its schedulability.

Figure 2. NIRCam time-series template with science parameters panel



A NIRCam time-series observation template with the science parameter panel at the lower half of the page. Contents of the NIRCam Time Series form are displayed, showing sections for target acquisition and time series parameters. Note that there are no dither parameters because it's not allowed for this time series mode. The Mosaic Properties tab is not there because it's not relevant to time series observations. The last two tabs, Special Requirements and Comments are present in all science parameter panels.

Observation links

In the APT tree editor, there's an item called **Observation Links**. It contains an overall summary of any and all special requirements specified for linking observations in the proposal. This provides a way to quickly verify whether the links have been set as intended, and is particularly useful if you have specified repeated observations that should be similar to each other.

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APT Special Requirements

Special requirements in APT are defined parameters used to constrain observation scheduling for scientific reasons, or to indicate other situations requiring specific actions.

On this page

See also: JWST APT Help Features

Adding Special Requirements in APT Video Tutorial

Special requirements (SRs) in APT are defined keywords that communicate, to the JWST planning and scheduling system, additional constraints that need to be placed on requested observations. SRs are applied at the observation level and pertain to all visits within a given observation. While they are normally used for scientific reasons, SRs can result in significant constraints on the schedulability of the affected observations. Thus, they should only be used if justified by the science goals.

The sections below provide a high-level view of the most used SRs with links to proposal parameters articles containing detailed technical specifications, along with information on how to specify SRs in APT.

Categories of special requirements

Timing SRs

See also: Timing Special Requirements (a proposal parameters article)

Timing SRs apply constraints on when an observation needs to occur, either as an isolated observation or in relation to another observation. They also allow a user to request grouping or sequencing for sets of observations, and to make the grouping execute back-to-back (e.g., ***NON-INTERRUPTIBLE****). Observations controlled by a periodic phenomenon can use the ***Phase*** SR with various keywords to specify when an observation can occur.

Aperture position angle (APA) SRs

> *See also: Aperture Position Angle Special Requirements (a proposal parameters article); JWST Position Angles, Ranges, and Offsets.*

Aperture position angle (APA) SRs are used to constrain the orientation, on the celestial sphere, of a particular observation request. They are also used to constrain the relative or absolute orientation or orientation range that's allowed between observations. While these SRs permit the user to work in the parameter space of interest to their science, from a scheduling standpoint, APA constraints effectively become timing constraints on when the observation can be scheduled. Observers with angular constraints will find it useful to get an overview of their target visibilities and available angles versus time by using the target visibility tools.

Solar System (aka "moving target") SRs

> *See also: Solar System Special Requirements (a proposal parameters article)*

Solar System SRs for observations of solar system objects can be challenging for a number of reasons. Not only do targets move on the celestial sphere as a function of time, but a number of additional constraints come into play, such as observing at a particular longitude on a resolved planet, observing a moon relative to its host planet at a given phase, etc. APT supports a number of SRs that help users describe the needs of their science program.

General or miscellaneous SRs

General or miscellaneous SRs are a few other SRs of potential interest to most general users (although there are a number of limited access parameters in this category that are only used by engineers for testing and calibration activities). The ***ON HOLD*** SR is used to indicate an observation that depends on the prior occurrence of another activity; for example, a NIRSpec MOS observation may need to await the availability of NIRCam pre-images. A SR for use with targets of opportunity (ToO) is also available, and serves two purposes: (1) to indicate that the observation is for a ToO, and (2) provide a required response time for a given instance of the triggering event. An ***OFFSET*** SR is also provided to permit the placement of a given target position at a position away from the defined fiducial point of a given instrument or aperture.

Background Limited SR

> *See also: JWST Background Model; General Special Requirements (a proposal parameters article)*

The ***Background Limited*** SR is called out here due to its potential importance, and also because it was defined late in the JWST APT development process. If you have used the ETC to assess the sensitivity of your proposed observations to the time-variable infrared background levels and made the decision to limit the scheduling windows based on this assessment, the ***Background Limited*** SR may be selected in APT. By default, selecting this SR means that the observation will be scheduled only at a time where the expected background levels are within 10% of the minimum background expected at that position on the celestial sphere.

The extent to which this SR will restrict the schedulability can be assessed using the JWST Backgrounds Tool (JBT) . If the default of the "within 10%" is overly restrictive for your use case, the ***Background Limited*** SR provides a small selection of less-restrictive options to choose from (e.g., within 20%, 40%, and 80% of the lowest background level).

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

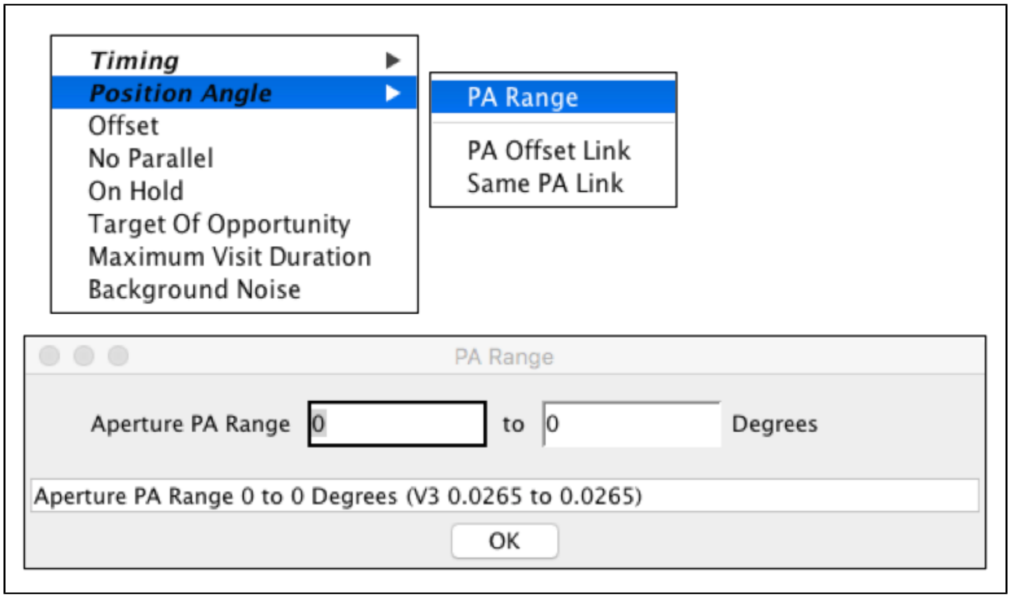
Accessing special requirements in APT

Each observation template in APT has a tab labeled **Special Requirements**. Upon clicking on this tab, two boxes appear in the GUI, one for **Implicit Requirements** and one for user-specified (or explicit) **Special Requirements**.

Implicit requirements are placed on observations automatically by the scheduling system, and are not editable; they are shown to the user for information only. For example, for any multi-visit observations (like mosaics), the system places an implicit ***GROUP WITHIN 53 DAYS*** special requirement to prevent the visits from being spread out unnecessarily.

Explicit SRs are SRs requested by users to control or link their observations. They can be accessed by clicking the ***Add...*** button below the **Special Requirements** box. The user is provided with a pop-up menu of possible SRs. The first two options, ***Timing*** and ***Position Angle,*** have an additional layer of options, as shown in Figure 1. Other choices work in a similar fashion, popping up the relevant interface and asking for user inputs.

Figure 1. Example of a cascade of windows for selecting and setting an observation's position angle range



Selecting Add... in the APT SR GUI, then moving right on the Position Angle option allows the PA Range option to be selected. This pops up the box shown below it where the user can enter the desired range of position angles. Note that in this example, a range of 0° to 0° results in a highly constrained observation. For reference, differences between the astronomical PA and the V3PA of the observatory are shown directly above the OK button. (Some APT constraints reports express angles in units of V3PA.) By clicking OK after entering the SR values, the SR will be displayed in the Special Requirements box in the GUI.

The use of ***Position Angle*** can be confusing. In this context, it refers to the observation being edited, and hence means the aperture position angle for the selected instrument and mode. Since certain controls in APT allow the user to work in observatory V3PA coordinates or Aperture PA, both are reported in APT. In the Figure 1 example, one can see that they are very close, but his is not always the case, depending on instrument and position on the celestial sphere.

See also: JWST Position Angles, Ranges, and Offsets; JWST Observatory Coordinate System and Field of Regard

After specifying SRs for an observation, the visit planner needs to be run (or re-run) to evaluate the schedulability of the newly constrained observation. If necessary, any SRs can be subsequently edited or removed by highlighting the SR of interest, and clicking the appropriate box in the SR GUI (buttons adjacent to the ***Add...*** button).

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APT Target Acquisition

Some JWST observation templates require a target acquisition to be specified, or include target acquisition as an option, depending on the target and positioning accuracy needed.

On this page

The need for separate target acquisition (TA) exposures is driven by the requirements of a particular science program as well as the particular observation template being used. Observations needing the highest positional accuracy for a target relative to an aperture or reference point require TA as part of the setup for the science observation. Other modes such as imaging do not generally require high positional accuracy to observe the relevant field of view. Between these extremes are special cases that may or may not require high positional accuracy, depending on the science goals. The table below shows the TA options for all APT observation templates.

TA exposure information generally needs to be obtained using the JWST Exposure Time Calculator, and those APT observation templates needing TA will have a GUI section in the template for entering the TA exposure specifications. The APT GUI contains a box to enter a tracking number ([ETC workbook ID].[calculation number]) to provide tracking information. Entering this information os optional, and so the yellow caution shown is just a warning, not an error, if no entry is present.

APT template target acquisition requirements

The following table shows the target acquisition status of the various APT observation templates as of APT 2020.1.1:

Table 1. JWST target acq versus instrument observation template

Instrument /mode	TA required	Selectable	No TA allowed	Comments
MIRI				
Image Full			X	TA as an option is under consideration for Cycle 2.
LRS (SLIT)		X		Default=yes, with NONE as an option.

LRS (SLITLESS PRISM)	X			
MRS		X		Default=yes, with NONE as an option.
Coron/Lyot	X			
Coron/4QPM	X			
NIRCam				
Image			X	
Image SUB64P			X	Users should consider using the SUBARRAY_DITHER pattern to ensure there target is covered in both the short-wavelength and long-wavelength channels.
Coron	X			TA using the neutral-density squares for bright targets, and through clear portions of the coronagraph mount for faint targets.
Time Series		X		TA is recommended for observations that require <1% precision.
Grism Time Series		X		TA is recommended for observations that require <1% precision.
WFSS			X	
NIRSpec				(See note 1 below.)
MOS		X		Default=yes (WATA), but MSATA, NONE and VERIFY_ONLY are other options. (See note 2 below.)
IFU		X		Default=yes (WATA), but MSATA, NONE and VERIFY_ONLY are other options. (See note 2 below.)
FS		X		Default=yes (WATA), but MSATA and NONE are other options.
BOTS		X		Default=yes (WATA), but NONE is an option.
NIRISS				
Image Full			X	

AMI		X		Default=yes, but NONE is an option when AMI used in full-frame mode. TA is strongly recommended though.
SOSS		X		Default=yes, but NONE is an option when SOSS used in full-frame mode. TA is strongly recommended though.
WFSS			X	

Table notes:

1) Any NIRSpec modes that use MSATA target acquisition will not need to have TA fully defined at the time of submission, since MSATA depends on the assigned orient, which is only available after the observation is accepted and assigned a place in the Long Range Plan. See NIRSpec MOS Observing Process for details.

2) Some NIRSpec templates offer the option to skip target acquisition. If the selected option is VERIFY_ONLY, a science pointing verification image can be specified; if the selected option is NONE, no verification image is taken.

Calculating target acquisition exposure specifications

See also: JWST ETC Target Acquisition

For TAs to be successful, the exposures of the TA target must provide at least the SNR recommended for the given instrument and mode (refer to instrument articles) but generally not saturate the detector of interest. Because of the importance of the TA for the success of the following science observation, great care must be taken in specifying the TA exposure parameters. Thus, the use of the JWST Exposure Time Calculator for calculating TA exposure specifications is highly recommended to determine the exposure parameters to enter into APT.

The TA sections of the relevant APT templates contain a box for you to enter the ETC workbook and specific calculation ID within the workbook that was used to provide the TA exposure specifications. Each ETC workbook created has not only a name, but a numerical designation, and this is the identifier needed. Also, each calculation within the workbook has a calculation number. So as specific example, if your ETC workbook is number 1234, and your TA calculation of interest is calculation number 9, the entry in the ETC box in APT would be 1234.9. (Note: no leading zeroes.) Lack of a relevant entry in this box results is an APT warning. You should take care, however, not to update the indicated calculation in your ETC workbook after you enter the info in APT or it will no longer be representative of what you have entered in APT.

Adding ETC info to APT

NOTE: ETC workbook and calculation ID info in this same format can optionally also be added to science exposure specifications. You may find this a convenient way to track for future reference which ETC calculations you used to determine the exposure specifications you enter into APT.

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APT Visit Planner

The APT visit planner tool performs a detailed check of the schedulability of observations specified in APT, including visibility, constraints checking, and whether guide stars are available to support the observation. Diagnostic information is provided when scheduling checks fail.

On this page

APT Visit Planner Video Tutorial,

Using Aladin and APT Visit Planner Video Turorial

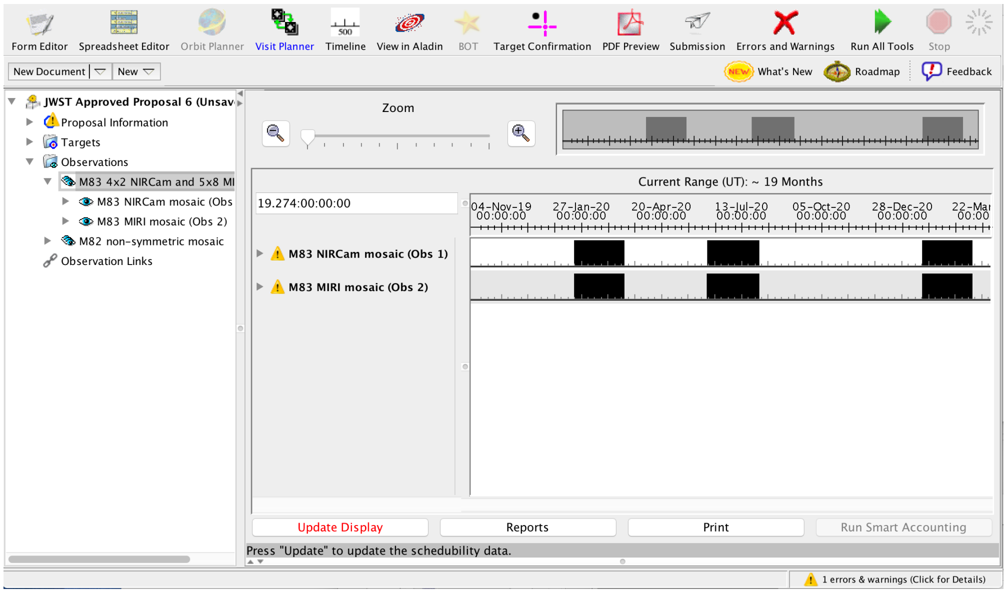
The visit planner (VP) for JWST observations is a tool in the Astronomer's Proposal Tool (APT) that performs a detailed schedulability assessment of proposed observations. Elements checked by the VP include the general visibility of a target to the observatory as a function of time, the impact of any constraints or special requirements levied on the observations, and whether guide stars are available as a function of time. The VP may be run on individual observations, on collections of observations, and ultimately on the entire set of proposed observations prior to submitting a proposal. Any time a parameter is changed for a given observation, the VP must be re-run to verify the schedulability analysis is still valid.

Running the Visit Planner

In the form editor in APT, select the observation or observation folder to be processed, and then select the **Visit Planner**[*] icon from the top tool bar in APT.

If the observations have not yet been checked for schedulability, or if a change has been made since the observation was last checked, the VP GUI will show a yellow warning sign on the observation(s) and the ***Update Display*** button in the active GUI window will be highlighted in red, as shown in Figure 1. Clicking that button will start the VP running on the selected observations and their associated visits.

Figure 1. The VP GUI showing that the VP needs to be run on a selected observation



The yellow caution symbols indicate the need to validate the observation by running the VP. Click the red Update Display button to run the VP.

Depending on the number of observations selected and their complexity, the VP execution may vary from a few seconds to a few minutes.

When the VP run completes, there will either be joy (green checks on the observations) or no joy (red X's, indicating there were problems detected that prevent the observation from being schedulable). Generally speaking, the less constrained your proposed observations are, the more likely that they will be schedulable without further interaction.

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Help with diagnosing and fixing problems

See also: JWST Observatory Coordinate System and Field of Regard

Observations with timing or angular special requirements or other constraints can restrict the scheduling windows significantly, and in the worst cases can actually make it impossible to schedule the observations as specified. Such cases need to be diagnosed to understand the problem so that corrective actions can be considered.

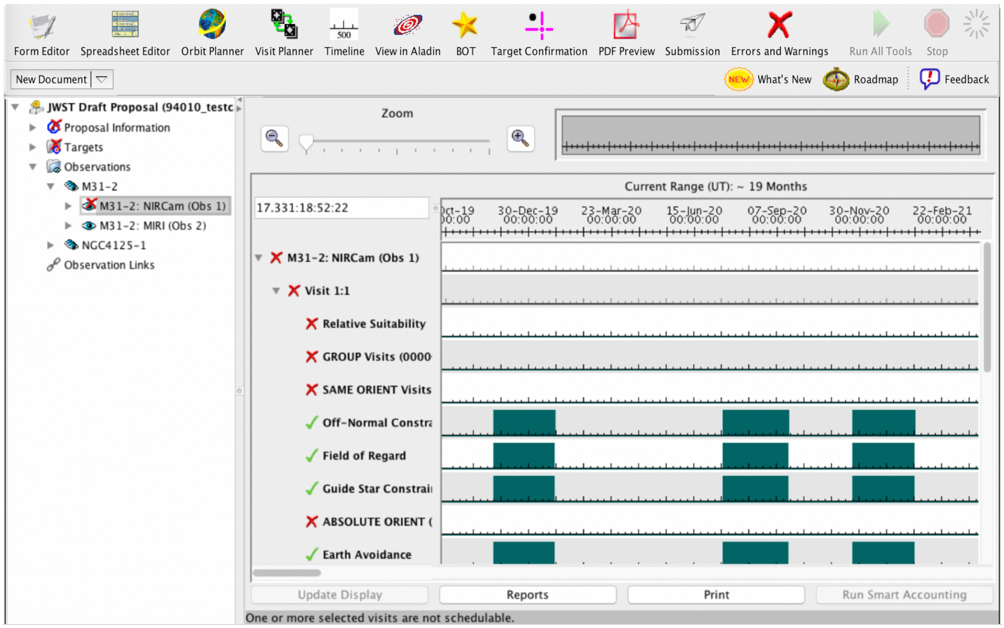
Since it can be difficult to diagnose such problems within APT, you may want to use one of the free-standing target visibility tools to get an overview of the visibility and angular information for the instrument fields of view on the sky as a function of time. Indeed, to avoid possible frustration, users with significant timing or angular constraints are encouraged to *run one or more of these tools prior to getting into APT*. Note, however, that these visibility tools look at the visibility of targets versus time, not at the entire schedulability of a particular observation of the target. An observation's schedulability depends on several conditions, including availability of guide stars, and can only be verified using the APT VP.

APT contains significant diagnostic help in the form of graphics and reports that can be accessed with knowledge of the appropriate usability tricks, many of which are described below. For example, after running the VP,

- you can click the small arrow to the left of an observation to open a view at the individual visit level;
- click on the arrow next to a visit and see the detailed diagnostics at the visit-level;
- a right-click on an observation or visit provides access to a menu of options for diagnostic plots or shortcuts to expanding or collapsing the display of details.

At the visit-level, you will see a set of bar graphs showing the visibility impacts induced by various constraints such as guide stars, observatory field of regard, angular constraints, and so forth. Red X's on one or more of these constraints can provide clues to why a visit is not schedulable. For the overall observation to be schedulable, all constraints for all visits need to have a window of schedulability at the same time. The bar graph at the observation level shows a roll up of the available times that satisfy the constraints at the visit level. Useful reports (described further below) are accessed from the top **File** → **Export** menu in APT.

Figure 2. An unsuccessful run of the VP showing observation and first visit diagnostics

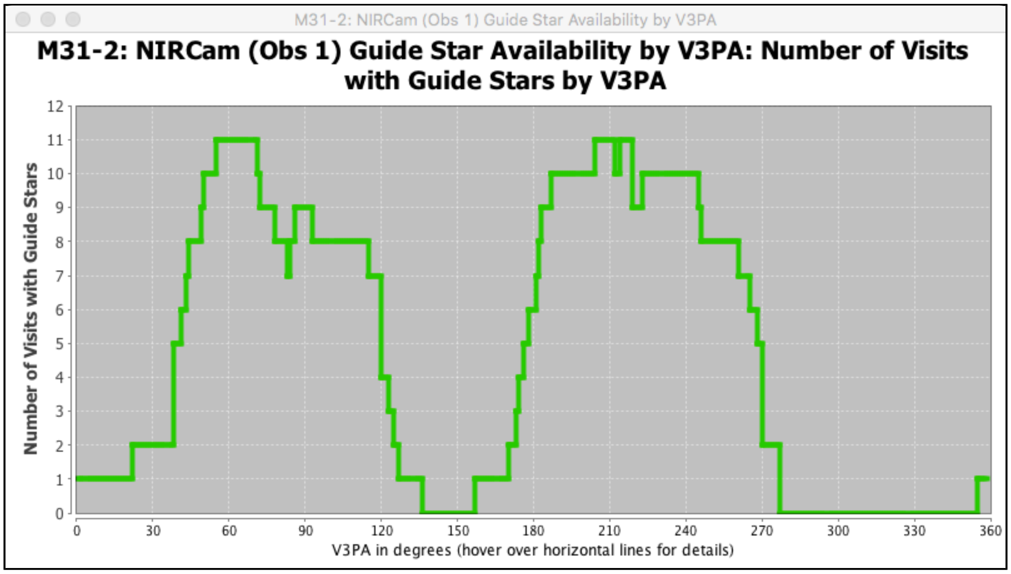


An unsuccessful run of the VP is shown, with the observation and first visit diagnostics shown. These were opened by clicking the small arrows to the left of each item in the active GUI window. In this example, the red X on ABSOLUTE ORIENT indicates a position angle has been selected that is not allowed.

You can right-click on an observation in the VP and access a pull-down menu with two additional plots that provide detailed information on the guide star availability.

- Choosing the ***Guide Star Availability by Time for Observation*** option produces a set of bar graphs showing the guide star availability at the *visit level* for the observation.
- Choosing the ***Guide Star Availability by V3PA for Observation*** option produces an *observation-level* summary plot of the number of visits with guide stars as a function of observatory V3 axis position angle. This plot is calculates over the entire range of V3PA and shows valid data at values of V3PA where the target specified can be observed. See Figure 3 for an example.

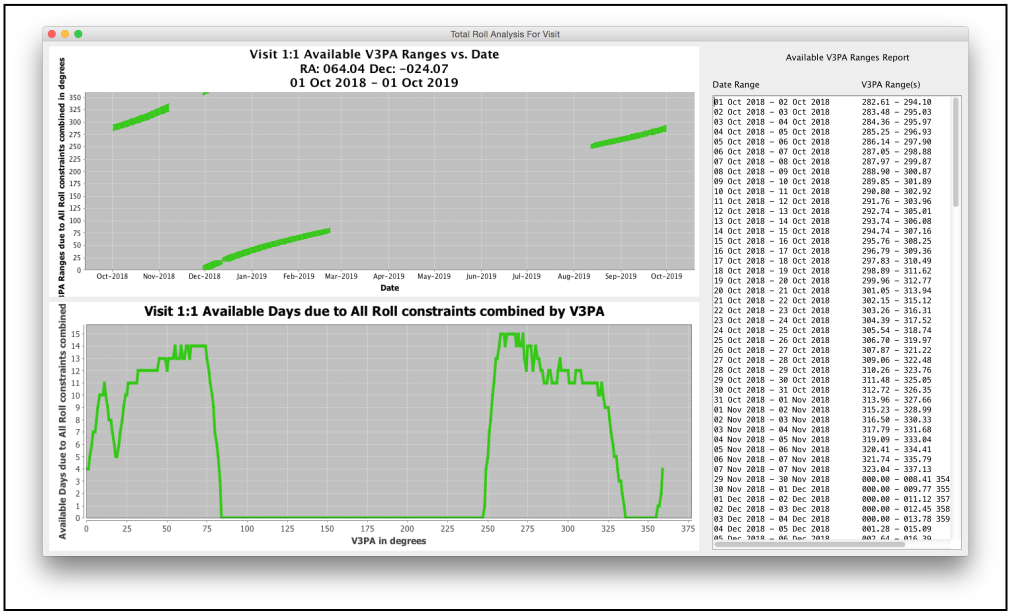
Figure 3. V3PA guide star plot shown for a modest NIRCam mosaic containing 12 visits



A V3PA guide star plot is shown for a modest NIRCam mosaic containing 12 visits. The plot shows that there is no V3PA (and hence no time) when all 12 visits (in this case, each tile of the mosaic is a visit) can get guide stars simultaneously. This makes the entire observation unschedulable in APT. Luckily, in this case, there are several windows where 11 of the 12 visits can get guide stars. Hence, this situation could be addressed by removing the problem tile to a separate observation where that tile has a guide star available. In some cases, multiple tiles may need to be removed to make the overall mosaic schedulable.

The last piece of missing information the may be of interest is the length of time the target can be observed at any particular legal V3PA. This can be checked in the VP by opening a given observation to the visit-level, and then right-clicking on the visit to access visit-level plots of guide star and angular information. Figure 4 shows the diagnostic plot produced by the ***Total Roll Analysis for Visit*** option. The top plot shows observable V3PAs as a function of time, and the bottom plot shows the length of time the observatory can point at a given V3PA. Users with large or long duration mosaics may need to pick an angle with sufficient visibility to make the observation schedulable.

Figure 4. An example "Total Roll Analysis for Visit" diagnostic plot



This visit-level report shows available V3PA angles as a function of time in the top plot, the number of days available at each allowed V3PA in the bottom plot, and a tabular listing of dates and V3PAs on the right. This can be used to establish how long the "best" angles in Figure 3 are actually observable by JWST, thus closing the loop on what is needed for schedulability.

> Note: some users may prefer to run one of the JWST Target Visibility Tools earlier in the planning process to obtain overall summary information on the angles available for their targets. If that information was available already, you could use it to quickly establish whether the best angles in Figure 3 were available or not. This might be easier than pulling up the visit-level plot shown in Figure 4.

If there are valid V3PA ranges where all visits can get guide stars simultaneously and the angle is valid for the observatory, those are the windows of schedulability. If there are no times when all visits can simultaneously get guide stars, this will also be obvious (see Figure 3); hovering your cursor over the green line in the plot will display a pop-up window detailing which visits are causing the problem at that particular V3PA.

An example of where these diagnostics becomes most helpful arises for planning mosaic observations. The operations concept for normal mosaics is that APT looks for a time when all tiles of the mosaic can be scheduled *at the same time.* The larger the mosaic (that is, the more tiles that are specified), the more likely it will be that one or more tiles cannot get a guide star at the same time as the other tiles. When this happens, the entire mosaic is declared unschedulable by APT. It then becomes a process of understanding which tile or tiles caused the problem, and figuring out how to mitigate the problem. A separate article is available that details the process of splitting off problem tiles into separate observations.

Finally, there are reports generated by the APT VP that can be viewed for further insight into how APT is breaking observations into visits, and how it calculates such things as the timing, pointing, and overheads involved. These reports are accessed the main APT menu, **File → Export**, and the reports of most interest are called the ***times file*** and the ***pointings file***. (The report produced by the Smart Accounting tool is also available in this list.) At this writing, these files are not very user-friendly, but may provide some assistance in diagnosing the most problematic cases.

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APT Smart Accounting

The Smart Accounting tool in APT should be run after the ensemble of proposed observations has been specified, to update the full proposal's resource estimates and remove excess overheads.

On this page

See also: JWST Observing Overheads and Time Accounting Overview

APT Visit Planner section on Smart Accounting in this Video Tutorial.

APT keeps track of the requested science exposure time, and produces an estimate of the total time needed to execute a proposal by adding the appropriate overhead times. As a proposer enters each new observation into APT, the resource estimate will be tallied and the current total for the proposal is reported in the **Proposal Information*** section (see the tree editor in the GUI's left sidebar). This information can be viewed via the form editor tool.

Because of this piecemeal approach, there is the possibility of overestimating the overheads a given proposal requires. Thus, after designing an observing program in its entirety, it is important for all proposers to re-run a full accounting on their proposal to remove any excess overhead charges and obtain a final, improved resource estimate. This step is called S*mart Accounting*. The resources shown in the **Proposal Information** GUI when the proposal is submitted will show up on the printed proposal cover page, and will be the official resource request for the proposal.

The Smart Accounting tool looks at the ensemble of proposed observations in a given proposal and decides which sub-groupings might logically be scheduled together in what is termed as a *same scheduling set* (SSS). If SSSs are identified, APT can reduce the number of assumed major slews required to support your proposal, and this can have a significant and positive effect by lowering the total resource estimate reported for the proposal. Smaller changes may also be taken into account (for instance, if the number of assumed visit slews or guide star acquisitions can be streamlined), but the reduction in major slew changes assumed will make the largest difference in the total overheads needed. Proposals with observations grouped closely on the sky, with separations less than ~20 degrees, will see the greatest reduction in total time.

Same scheduling sets are a statistical accounting tool and do not guarantee that the set of observations will be grouped by the actual JWST scheduling system. If a set of observations *must be* scheduled together, use the appropriate special requirements to GROUP or SEQUENCE your observations.

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

How to run Smart Accounting

In addition to the description below, you may find this additional help file useful for reference. However, due to late developments in the APT Smart Accounting interface (described below), this help file is not entirely current to APT 2020.1. We have chosen to keep this link here because elements of the help file may still be useful.

As mentioned above, as you have built your observations in APT, the tool attempts to estimate the resources. You may have even run the Visit Planner piecemeal on your observations to check their schedulability. However, once your observations have been completely specified, it is time to run Smart Accounting on the ensemble of proposed observations to see whether charged overhead time can be reduced.

There are a number of ways to run Smart Accounting, one implicit and three explicit. The implicit way is to simply select the entire observation folder section of the proposal in the tree editor in APT and run the Visit Planner on the entire set of proposed observations in one pass; *Smart accounting is run as part of validating the entire proposal*. However, any time an update is made to anything in the proposed observations of an APT proposal, APT will conclude that Smart Accounting is out of date needs to be run again.

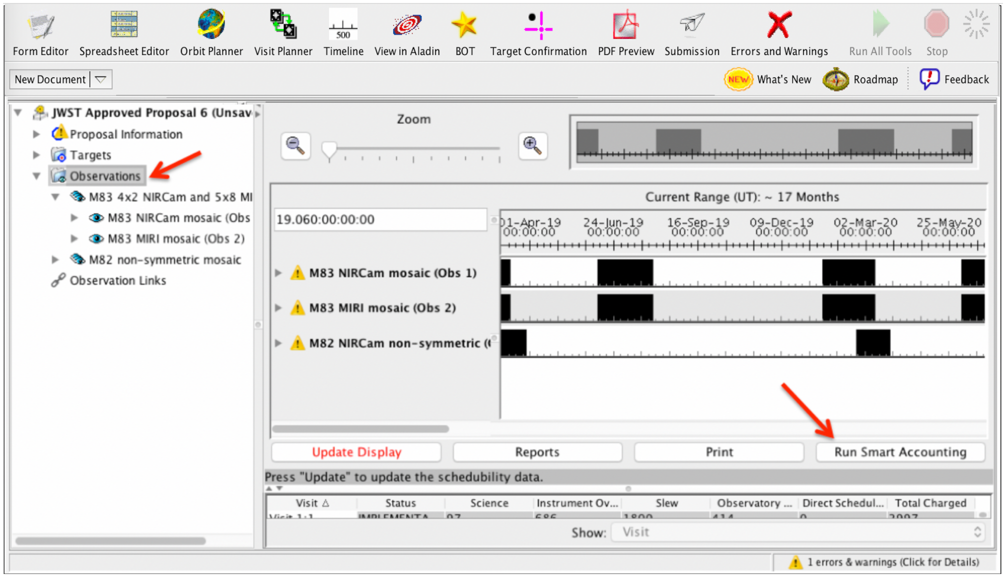
As a proposal is in its final stages of preparation, you may want to have explicit knowledge about when Smart Accounting has been run, so this can be accomplished in several ways:

1. Select the main **Observations** folder in the Tree editor and then select the **Visit Planner** tool in the top menu. This should provide access to the ***Run Smart Accounting*** button in the Visit Planner GUI itself (see Figure 1). This button is normally grayed out if less than the total observation folder is specified, and will also remain grayed out if Smart Accounting is current and does not need to be run.
2. With the Visit Planner active and green checks indicating all observations are schedulable, select **Visit Planner → Run Smart Accounting** from the main APT menu at the top of your screen (see Figure 2). This forces Smart accounting to run at any time the user desires.
3. Finally, if APT thinks the accounting is out of date, it provides a reminder on the **Proposal Information** page next to the listed accounting information. Selecting the ***Run Smart Accounting*** button at this location opens the Visit Planner and runs Smart Accounting. See Figure 3.

Depending on the number and complexity of observations in your proposal, it can take some time for Smart Accounting to complete. When it does, you can look at the cover page to see the final resource estimate for the proposal.

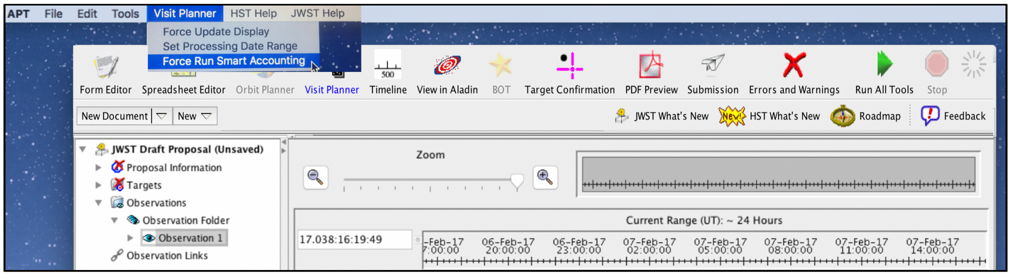
A cautionary note: the Smart Accounting step can time out on very large or complex proposals and thus not complete the assessment of the proposal. If you have large link sets with greater than 200 visits (for example a large mosaic), consider breaking it into smaller pieces. If you encounter this problem and cannot resolve it, contact the JWST Help Desk.

Figure 1. The VP GUI showing the main Observation folder selected and the Run Smart Accounting tab active.



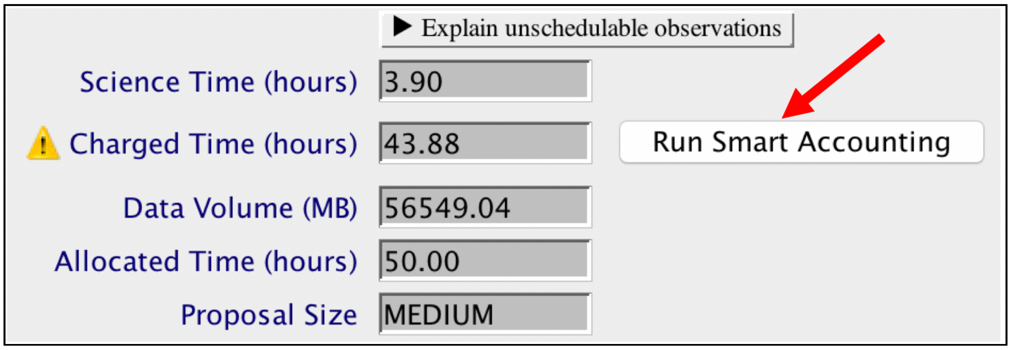
With the main Observation folder in the tree editor selected and the VP active, the Run Smart Accounting button becomes active. Selecting this button causes APT to run smart accounting. Note: you do not need to run the VP on the listed observations first to check schedulability (i.e. green checks on the individual observations) as it will be done as part of the Smart Accounting process. However, if any observations have schedulability issues, the smart accounting run will not be valid, and the individual observations with problems will need to be addressed prior to re-running Smart Accounting.

Figure 2. The VP GUI showing the pull-down menu to access the "Force Run Smart Accounting" task



With the VP active and green checks on each observation indicating schedulability has been confirmed, run the Smart Accounting task via the pull-down menu as shown. This example shows the appearance on an Apple Mac computer. On a PC, the APT menu bar is at the top left of the APT GUI itself.

Figure 3. A small portion of the Proposal Instructions GUI showing the *Run Smart Accounting* button activated.



If APT senses that the accounting for a proposal is out of date, it places a yellow caution symbol on the Charged Time entry on the Proposal Information GUI and activates a Run Smart Accounting button. Selecting this button will then run Smart Accounting on the entire proposal and update the display, removing the caution. This was added to raise visibility and help proposers remember to run Smart Accounting if they have forgotten.

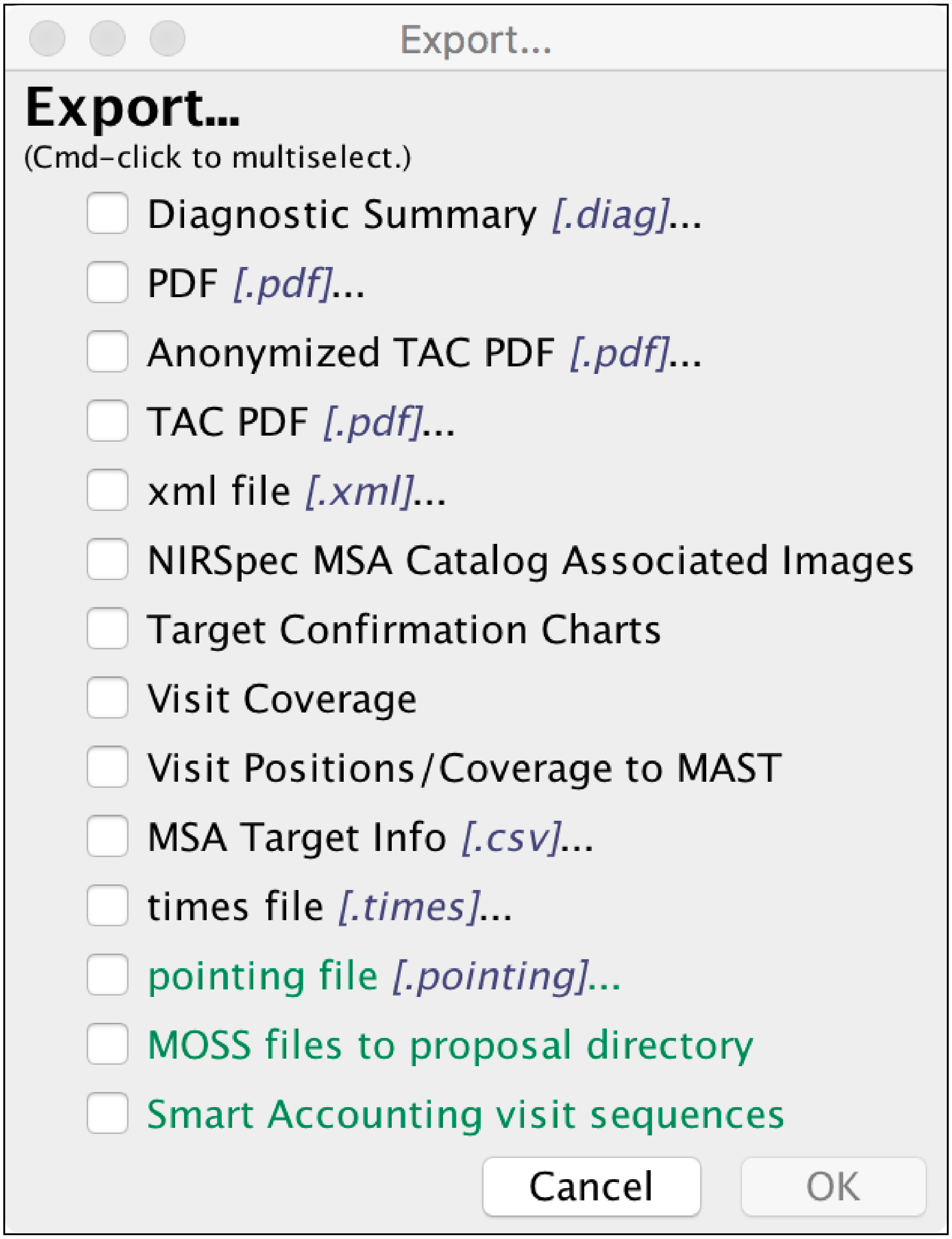
Further insights: the Smart Accounting report

After running Smart Accounting, you can view the revised total resource assessment in the proposal cover page. You may or may not see a substantial change, depending on the details of your observing program and how recently accounting has been checked for your proposal. Note that accounting information for each specified observation is also provided in each observing template, showing up as a science and total charged duration, but this information is internal to that observation and does not include the major slews between observations.

Additional details of the APT overhead charges are available in a report that provides a summary of where the tool was able to find economies, group observations into SSSs, and possibly reduce visit slew times. This report shows the before and after overhead estimates broken down by observation and visit.

To access this report, go to the top APT menu bar and click on **File → Export...** A window similar to that shown in Figure 4 will appear.

Figure 4. The Export menu, showing the selection of the smart accounting report



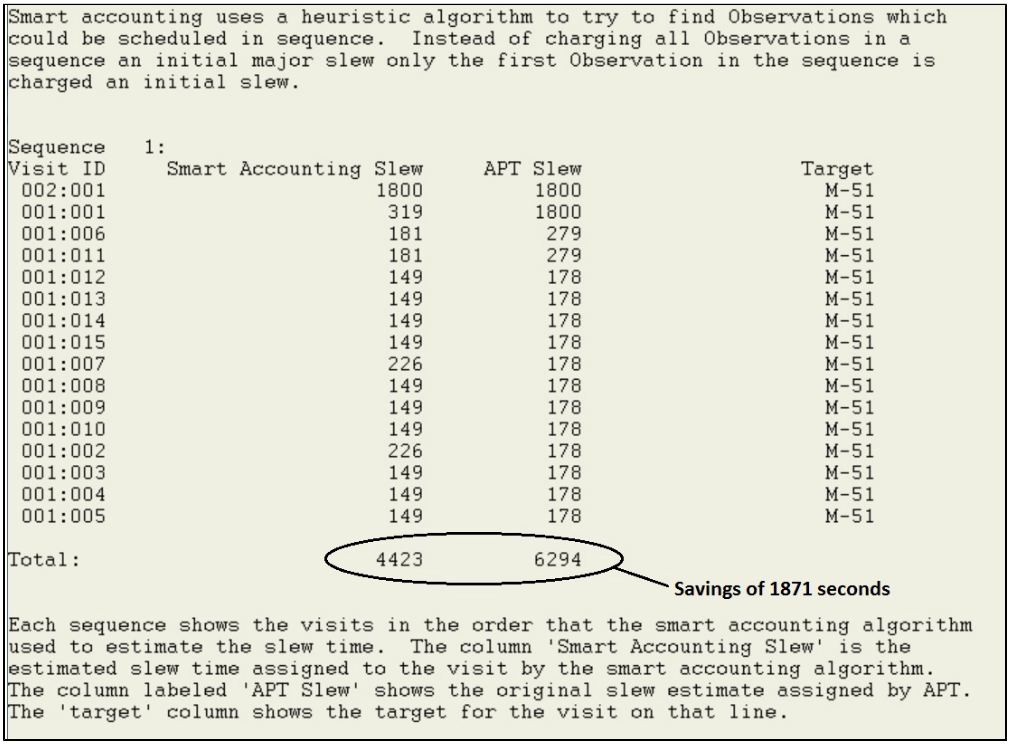
Checking the Smart Accounting visit sequences box and clicking OK in the Export... menu allows you to specify a file name for the output file.

Check the ***Smart Accounting visit sequences*** box (and click ***OK***) to save the report to your local disk. This will be a flat (ASCII) file that can be viewed with any editor.

> Helpful Hint: If you want to select more than one entry in the **Export...** pull-down for outputting to a file, hold down the "command" key (Macintosh) or "control" key (Windows and Linux) prior to each click. The most useful reports are generally the times file, the pointing file, and the Smart Accounting visit sequences file.

Figure 5 shows an abbreviated example of the Smart Accounting report output. In this example of a mosaic, the Smart Accounting tool assessment reduced the resource estimate by roughly 1900 s by accounting one fewer major slew and reducing the visit slew times for the tiles of an assumed mosaic. The "APT Slew" column lists the "before" numbers, and the "Smart Accounting Slew" column shows the corrected values.

Figure 5. An example of the Smart Accounting report output



```
Smart accounting uses a heuristic algorithm to try to find Observations which
could be scheduled in sequence.  Instead of charging all Observations in a
sequence an initial major slew only the first Observation in the sequence is
charged an initial slew.


Sequence   1:
Visit ID     Smart Accounting Slew     APT Slew                 Target
 002:001                      1800         1800                   M-51
 001:001                       319         1800                   M-51
 001:006                       181          279                   M-51
 001:011                       181          279                   M-51
 001:012                       149          178                   M-51
 001:013                       149          178                   M-51
 001:014                       149          178                   M-51
 001:015                       149          178                   M-51
 001:007                       226          178                   M-51
 001:008                       149          178                   M-51
 001:009                       149          178                   M-51
 001:010                       149          178                   M-51
 001:002                       226          178                   M-51
 001:003                       149          178                   M-51
 001:004                       149          178                   M-51
 001:005                       149          178                   M-51

Total:                        4423         6294
                                                   Savings of 1871 seconds

Each sequence shows the visits in the order that the smart accounting algorithm
used to estimate the slew time.  The column 'Smart Accounting Slew' is the
estimated slew time assigned to the visit by the smart accounting algorithm.
The column labeled 'APT Slew' shows the original slew estimate assigned by APT.
The 'target' column shows the target for the visit on that line.
```

The Smart Accounting report is a flat (ASCII) file showing APT's assessment of slew times before and after smart accounting processing. In this example, one major slew has been reduced and the Small Angle Maneuver times have been recalculated for the proposed mosaic in M51.

Initially, APT charges each new observation with an initial "major slew" assumption, because it assumes that the scheduling of the observation may come from a distant position on the celestial sphere. By looking within a proposal and defining possible observations that could schedule together, Smart Accounting can charge a single major slew for the group and calculate actual (assumed) slews between the members of the group, thus reducing the total slew time charged. This assessment is non-binding in the sense that the actual scheduling system may do something different than assumed by the Smart Accounting algorithm, but overall this method produces a more accurate picture of the resources needed to support a given proposal.

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APT Target Confirmation Charts

Target coordinates and JWST pointing can be verified by viewing the coordinate position superimposed onto digital sky data.

See also: a static walkthrough example, and also a video help example:

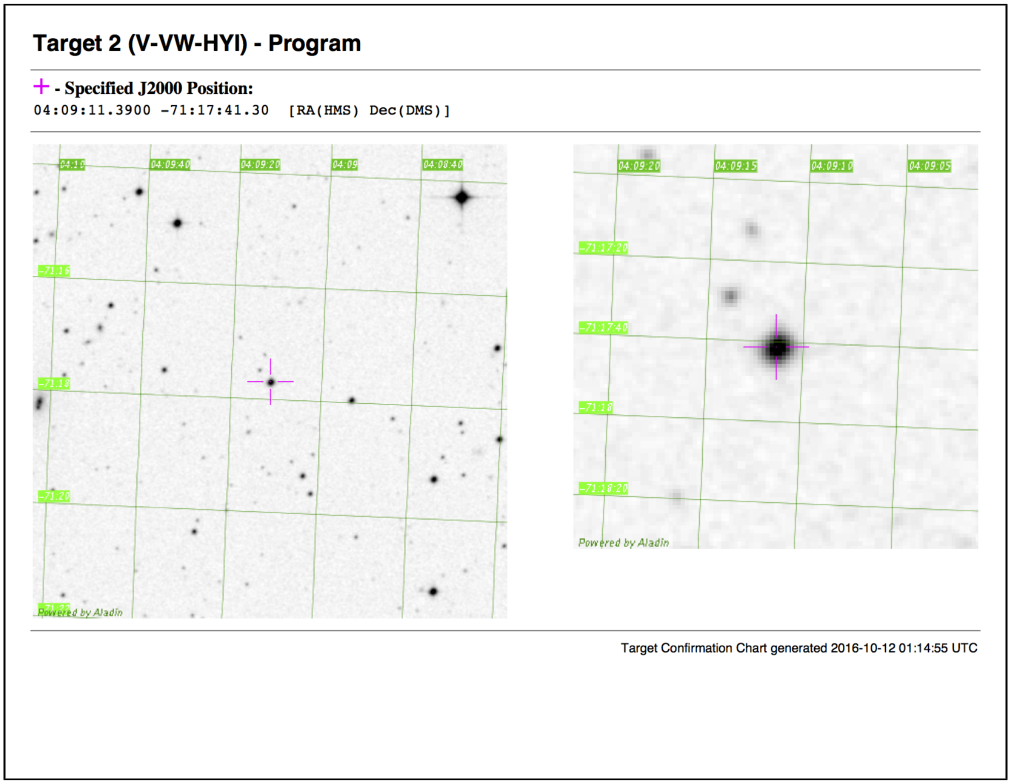
Making APT Target Confirmation Charts.

Target Confirmation* charts are a functionality within APT that provides users with a convenient way to verify that their target coordinates are going to position the telescope in the expected place. This functionality works exactly the same between the HST and JWST branches of APT. For each fixed target, a target confirmation chart appears in a separate pop up window from within APT. If you have entered proper motion information into the APT target GUI for a target, this gets applied to the position shown on the PDF chart. If desired, they can be saved as PDF files into your local directory space for future reference. Figure 1 shows an example.

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

An Example target confirmation chart

Figure 1. An example of a target confirmation chart



An example target confirmation chart, which can be viewed in your screen or saved to a PDF file for future reference. The panel of the left is approximately 8 arcmin on a side, while the panel at right zooms in to a 1.5 arcmin region near the target position.

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APT Submitting Your JWST Proposal

Notes regarding the submission of completed JWST proposals.

The proposal submission process requires that

1. your JWST scientific proposal PDF file is complete and has been attached via the link at the bottom of the APT Proposal Information page;
2. your observation specifications in APT have been entered and processed by the proper APT tools (e.g., Visit Planner, Smart Accounting);
3. any APT warnings have been reviewed and all errors have been resolved.

Additionally, Target confirmation charts can be viewed and/or saved as PDF files, and used to verify that each of the target coordinates entered in APT correctly positions the telescope as requested.

To submit a proposal, click on the APT **Submission**[*] icon in the top tool bar and follow the instructions in the active GUI window. If any errors remain unresolved in your submission, comments may be entered in the pop up box provided. Except in the most extenuating circumstances, it is expected that any errors remaining in the proposal will have been discussed with STScI support staff or the Help Desk, and this can also be noted. In the **Submission Log** window, you will see a message giving the time of the submission, the assigned proposal ID (if it's a new proposal), and the submission status.

After submission, you can choose to save a PDF of the entire proposal (science section plus a formatted APT file). This PDF will include the proposal number, which will be useful for future tracking purposes.

[*] ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Re-submissions

After the initial submission, proposals can be resubmitted as needed (up to the stated deadline), so consider making an initial submission early. The resubmission process will not assign a new number, but will track and acknowledge that this is a resubmission.

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Latest updates	13 Dec 2019

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Additional APT Functionality

The Astronomer's Proposal Tool supports creation of mosaicked observations and parallel observations to be defined. The layout of the the proposed observations can be visualized in Aladin and users have the option to download target confirmation charts.

Expand all Expand all Collapse all Collapse all

Many example science programs demonstrate the functionalities described in these articles in more detail.

Also see APT Video Tutorial help for these topics.

Published	03 May 2017
Latest updates	• 23 Dec 2019 Reviewed and updated prior to 2020 Cycle 1. • 16 Aug 2019 Added Graphical Timeline link.

APT Mosaic Planning

Many JWST instrument modes permit users to specify mosaics to increase overall the field of view of their proposed observations. Mosaic properties can be set in the Astronomers Proposal Tool (APT) and viewed on Aladin.

On this page

See also: JWST Mosaic Overview and the APT Simple Mosaic Example

Specifying Mosaics in APT Video Tutorial

The mosaic functionality in APT allows you to define patterns of instrument fields of view (FOVs) that cover regions of the sky that are larger than that available for a single pointing. Each element of the mosaic is referred to as a tile. Mosaicking can be appropriate for both imaging and spectroscopic modes, and also for multi-visit or intra-visit applications, depending on the FOV that is being mosaicked). Table 1 shows the instrument templates for which the mosaic functionality is allowed by APT.

Table 1. APT science templates allowing mosaics

Instrument	Template
NIRCam	Imaging
NIRCam	Wide field slitless spectroscopy (grism)
MIRI	Imaging
MIRI	Medium resolution spectroscopy (IFU)
MIRI	Low resolution spectroscopy
NIRSpec	Integral field unit (IFU)

NIRSpec	Fixed slit
NIRISS	Imaging
NIRISS	Wide field slitless spectroscopy (grism)

Table notes:

- The MIRI MRS is a special case since the field of view sizes for the 4 MRS wavelength ranges are different from each other.
- Time series modes, coronagraphy, NIRSpec multi-object spectroscopy, and templates for observations of individual targets are not useful for mosaics; to avoid confusion, mosaics have been disallowed in those templates.

The Mosaic Parameters page in the Proposal Parameters documentation section has more details and example figures. Also, see a video help example:

Specifying Mosaics in APT.

The screenshots below are from APT version 25.4, Nov. 2017, using the APT Simple Mosaic Example demo proposal.

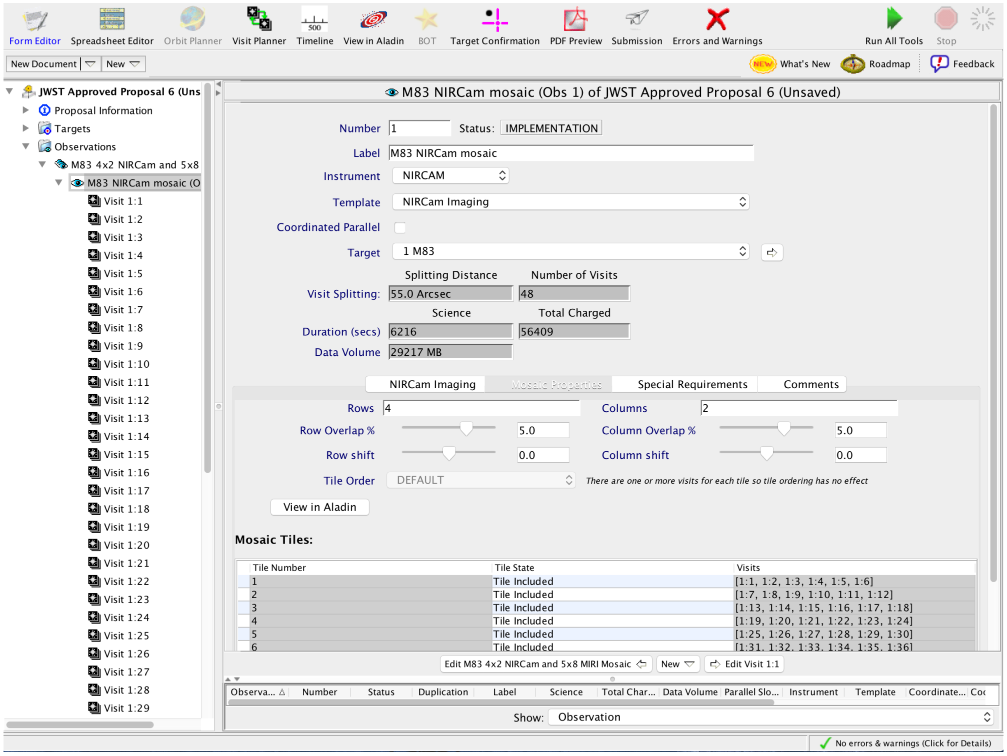
Planning mosaic observations in APT

Basic functionality

An instrument configuration that's compatible with mosaics is first specified in the APT observation form's ***Instrument****[*] and ***Template*** fields. To enter mosaic properties, click on the **Mosaic Properties** tab to show parameters such as the number of tiles in rows and columns, and the amount of overlap to assume. APT and Aladin will position the mosaic tiles using information about the defined instrument aperture or FOV that's stored in the Science Instrument Aperture File (SIAF). As of APT 25.1 and following, the instrument displays are accurate, including detector gaps and offset angles as appropriate.

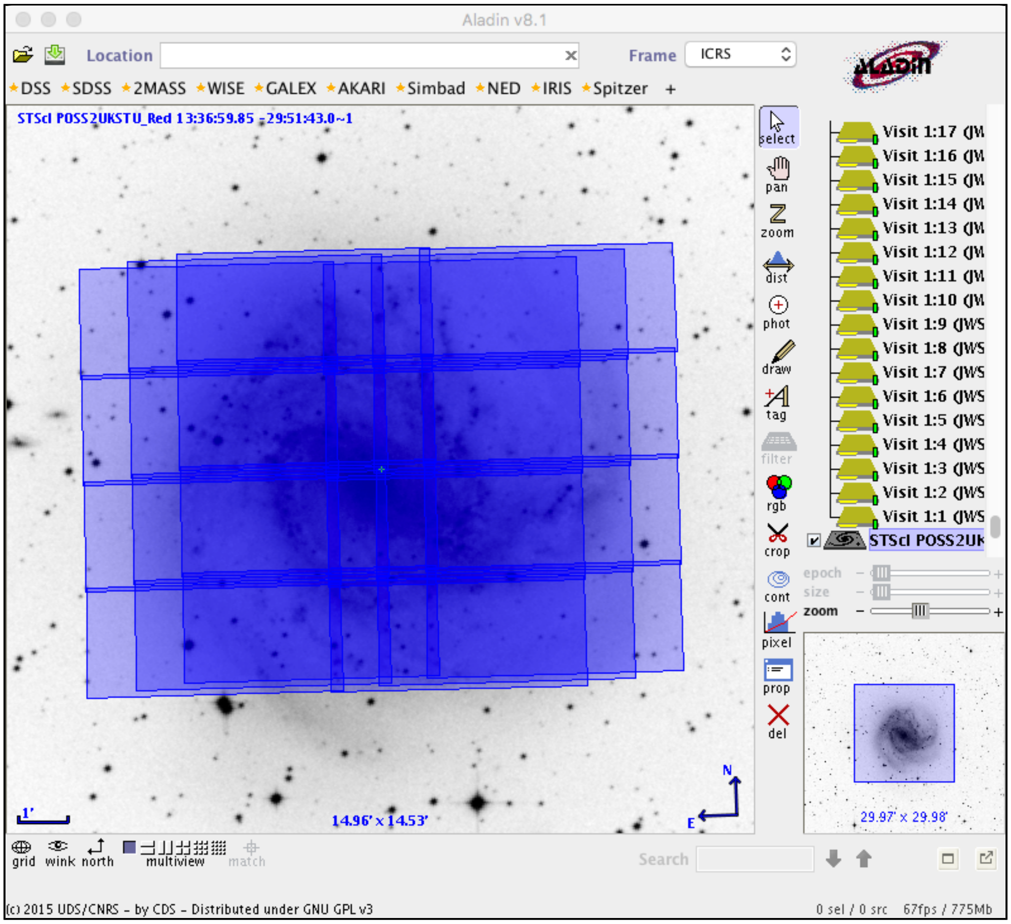
An initial selection of rows and columns creates a tile pattern that is symmetrical (rectangular or roughly square, depending on FOV shape and row/column selection). APT also provides a row/column shift option that can be used to skew the tile pattern for certain asymmetrical cases. (See the Mosaic Parameters page for details.) You can visualize the resulting mosaic in the Aladin viewer (Figure 2). By iterating between various assumptions for number of rows and columns, and using the Aladin display, you can adjust those assumptions as necessary for a given science program or sky area to be covered. The following figures demonstrate a few basics in APT and Aladin.

Figure 1. APT control panel for mosaics showing a simple 4 × 2 NIRCam imaging mosaic



The APT control panel for mosaics is shown for a simple 4 × 2 NIRCam imaging mosaic. A 10% tile overlap is the default but you can change this value as desired. (5% is used in the example.) Although this figure is for NIRCam, the mosaic interface for the other instruments is exactly the same. In the Visit Splitting field, above Mosaic Properties, the Splitting Distance is calculated by APT for each target. Its value is reported, for your information, in the gray field box but cannot be edited. In some cases the tile overlap can be increased to obtain more than one mosaic tile in a single visit, thus reducing overheads from guide star changes.

Figure 2. The default Aladin display based on Figure 1 projected onto DSS imaging data



The resulting Aladin display from the Figure 1 example, projected onto DSS imaging data for M83. Note: The NIRCam field of view shown here was displayed using a new feature as of APT 25.1: the "Single Aperture" option in the APT Aladin control window. This hides the dithers and field of view details (likes detector gaps) and simplifies the visualization of source coverage. In practice, as in this NIRCam example, dithers and mosaics should be used in combination to observe a large area without gaps in sky coverage.

Mosaic rotations and skews

> *See also: JWST APT Help Features page or these tutorial videos: Aladin Overview in APT, Using Aladin and APT Visit Planner, and Specifying Mosaics in APT.*

To understand mosaic planning, it is important to know how APT defines a mosaic. A single target coordinate at the center of the tile pattern defines the mosaic pointing. APT (and Aladin) then calculates the offset positions of each tile relative to that reference coordinate based on the selected instrument/FOV, the specified overlap, and the assumed position angle (PA). Here, "position angle" refers to the angle (degrees eastward from north) of the particular instrument's reference axis (also referred to as "aperture position angle" or APA elsewhere). See JWST Position Angles, Ranges, and Offsets.

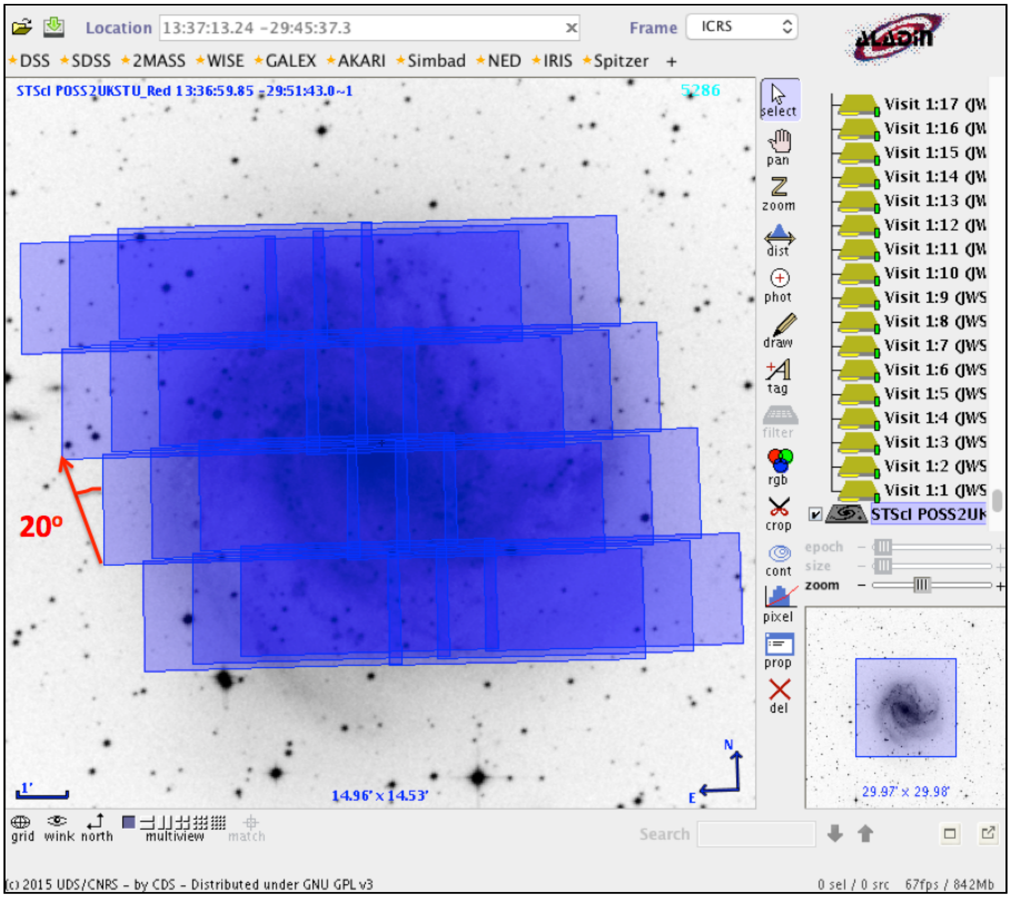
As the assumed position angle of the mosaic on the sky changes, the entire pattern rotates about the mosaic coordinate. If the region to be observed is circular or at least nearly symmetrical, the rotation of the tile pattern on the sky is of little consequence and scheduling flexibility is maintained, based on other considerations or limitations of the observatory pointing constraints. If the region of interest is significantly asymmetric, it may be necessary to restrict the position angle range of the mosaic (perhaps modulo 180° if visibility allows) in order to maintain efficient coverage of the region of interest. This should only be done in cases where the science drives the constraint, as too many constrained mosaic observations may cause scheduling issues for the observatory. Also, constraining the position angle of a mosaic is a constraint in time as well. Since the IR background at a given position on the sky is also time dependent, imposing orientation constraints may conflict with the desire for low zodiacal background.

See also: JWST ETC Backgrounds

The Aladin viewer is an important and useful tool, but some aspects of its functionality for JWST are still not fully developed. The Aladin display will show a default orientation (north up for the reference axis of a given instrument FOV). However, the actual position angle will depend on the ultimate scheduling of the observation, including whether special requirements are added to restrict the observation.

The Aladin display can show the positioning of the mosaic overlayed on the Digitized Sky Survey (DSS) or other images, and can also overlay the positions of catalogued sources. Changes in the positioning of the mosaic are reported back to APT and can be commmited into the target specification in APT (if desired) with a simple click. However, neither APT nor Aladin checks the visibility constraints automatically. You need to run the **Visit Planner** separately to investigate whether your chosen position angles can be scheduled. Checking the modulo 180° option requires specifying the alternate PA range and running the **Visit Planner** again. Once the **Visit Planner** has been run, the Aladin display will then provide visual aids to show the allowed PA range(s) by selecting the observation of interest in the APT form editor, clicking **View in Aladin**, then in the Aladin interface, click the ***Orient ranges*** icon.

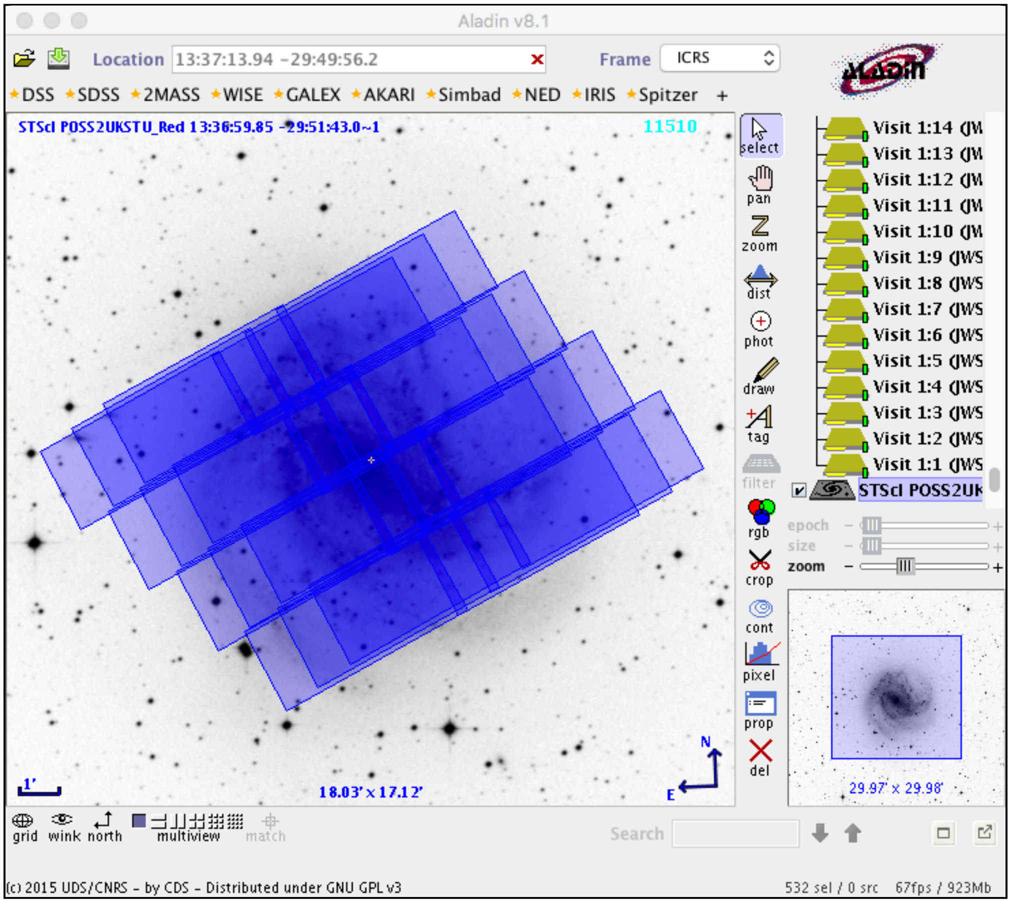
Figure 3. Mosaic from Figure 2 shown with a row shift set to 20



A row shift of 20 applied to the mosaic from Figure 2, which offsets the rows as shown. Note that "20" actually refers to the angle between the same tile corner on two adjacent rows. Column shifts can also be applied, either separately or in conjunction with row shifts. Figure 1 shows the controls for adjusting these parameters.

> The numbers used in the mosaic row shift and column shift are actually angular units in degrees. (Figure 3 shows how the row shift of 20 is applied as the 20° reference angle.) Because this can be non-intuitive, it is always a good idea to use the Aladin display when adjusting and selecting values for these parameters.

Figure 4. Result of manually rotating the mosaic from Figure 3



The result of manually rotating the mosaic from Figure 3. Note that the reference position has remained constant but the entire mosaic tile set is rotated. If this represented a real angle of interest, the schedulability at this angle would need to be verified separately by running the Visit Planner on the observation.

Note that some JWST instruments have gaps between detectors or detector segments that may affect the uniformity of spatial coverage in the resulting mosaic. Some smaller gaps can be covered by dithering, but uniformity may still be an issue. The situation can be judged by careful inspection of the Aladin display, using the full details (Not the "Single Aperture" display option that simplifies the display). Consult the individual instrument specifications for NIRCam, and MIRI in particular, to understand the geometry of their fields of view.

Small FOV mini mosaics

Most of the information above applies to imaging mosaics, but smaller FOV mosaics are also possible, and have some differences from standard imaging mosaics. For example, a mosaic with the NIRSpec IFU (which only has a 3” FOV) or the MIRI MRS (several overlapping small FOVs) will likely all be within one guide star region and can be scheduled within the same visit. Because of this, the ordering of activities in a mini mosaic is handled differently from regular mosaics, both for reasons of efficiency and to save mechanism motions. (This is not obvious to APT users but you should be aware it is happening behind the scenes.) There are 4 APT observation templates that are in the category of mini mosaics, where the revised ordering of activities is applied. These include: NIRSpec IFU, NIRSpec Fixed Slit, MIRI MRS, and MIRI LRS modes. Note, however, that this activity ordering does not apply to other templates, such as NIRCam mosaics with subarrays, until further development in APT is undertaken to support it.

Another functionality that may find utility more so in mini-mosaics (although it is technically available for larger mosaics as well) is the idea of a *sparse mosaic*, or a mosaic with a *negative overlap* of the tiles (e.g. gaps between the tiles that are not observed). An example might be a small planetary nebula or a Herbig-Haro object that is extended by ~20"–40". Performing a full IFU mosaic over such an object would likely be prohibitive (if not overkill from a science perspective). A sparse mosaic might be used to sample across such a structure at a regular separation but without full spatial coverage. In this case, the sparse mosaic model does apply to NIRCam subarrays, which can be used to mosaic bright objects such as Solar System targets (e.g., planets).

[*] ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Schedulability checking and problem resolution

See also video help:

APT Visit Planner

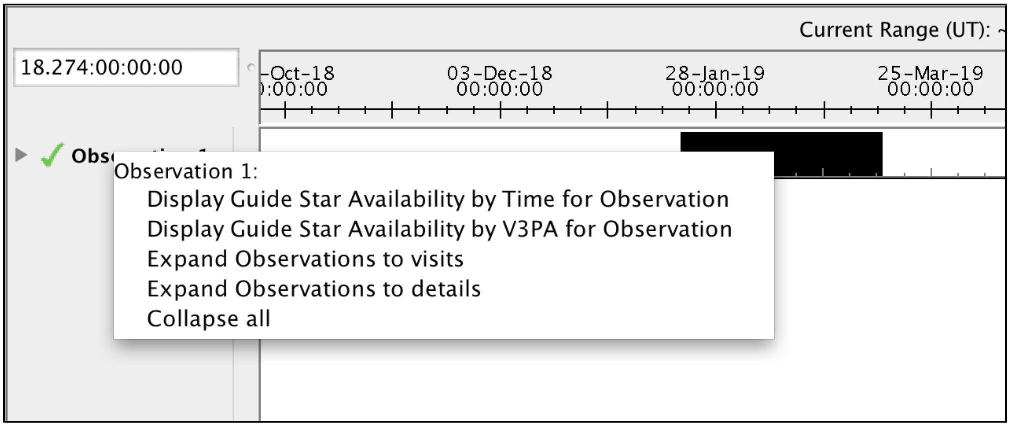
Once a desired mosaic observation has been fully specified in APT (including position angle constraints, if needed), the observation should be run through the **Visit Planner**, which checks the schedulability of the request.

For larger FOVs like the imagers, it is likely that many mosaic tiles will each have their own visit. The **Visit Planner** not only looks at the available target visibility windows but also steps through the allowed position angles looking at other factors such as guide star availability for each tile as a function of time/position angle.

For mosaics with just a handful of tiles, it is almost always the case that all the tiles have available guide stars so that the entire mosaic can be scheduled in the same visibility window. However, it must be expected that there will be situations that are more pathological, e.g., no visibility period when ALL tiles have guide stars simultaneously. This might be more likely for highly constrained asymmetrical mosaics or larger mosaics (under the assumption that the more tiles you have, the more likely that one or more tiles may not have a guide star available at a given time).

The APT Visit Planner provides feedback in cases such as this to help diagnose which constraints are preventing the observations from scheduling. For instance, a right-click on an observation in the **Visit Planner** window brings up a menu of options, as shown in Figure 5.

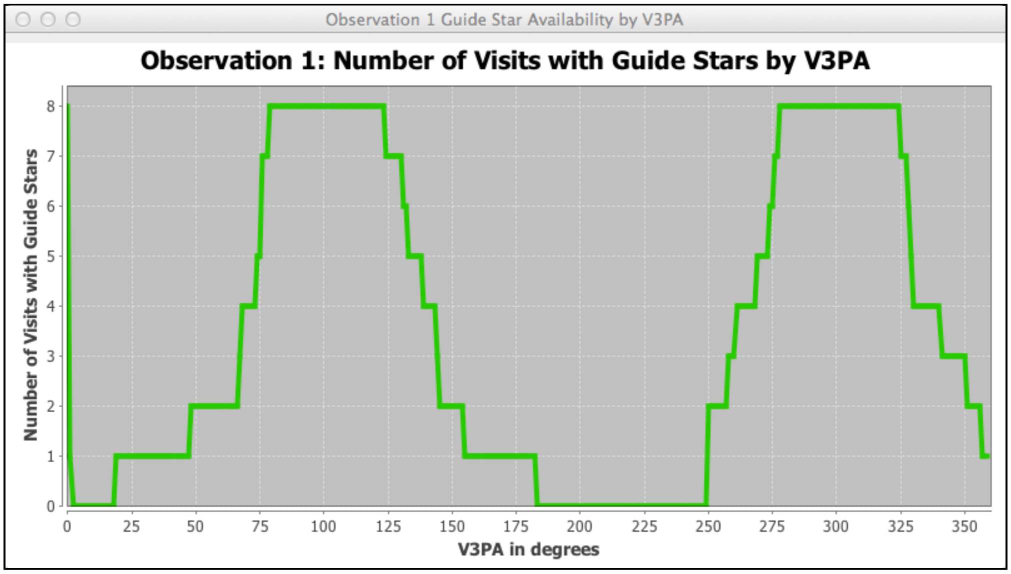
Figure 5. Menu of available options displayed by right-clicking in the APT Visit Planner



A screen grab from APT shows the menu of options available with a right-click in the Visit Planner that provide feedback on the schedulability of selected observations.

You can experiment with these options to see the available feedback. One useful tool for mosaic planning is to select the **Guide Star Availability by V3PA for Observation** option, which produces the graph in Figure 6.

Figure 6. Diagnostic graph showing number of visits with available guide stars as a function of V3 axis position angle



This diagnostic graph shows the number of visits (tiles in this case since each tile is a visit) that have guide stars available, as a function of V3 axis position angle, but this is effectively versus time. In this case, there are two periods where all 8 tiles are judged to have guide stars, If there were no periods when all 8 tiles had guide stars at the same angle/time, then the visit planner would have said the observation was unschedulable and corrective action to remove the problem tile (or tiles) would be needed.

In the exceptional case where all of the tiles cannot be observed simultaneously but full spatial coverage is required, there are mitigation techniques that can be applied, as explained below.

Tile splitting and removal process

See also: APT Mosaic Tile Splitting Activity

What should you do if there is no time when all tiles can be scheduled simultaneously? Diagnostic plots and other information in APT can be used to find the problem visits/tiles. Depending on the specifics, one or more tiles can be removed from the mosaic (if the remaining coverage is acceptable to your science case), or the problem tiles can to be removed from the primary mosaic and scheduled at a different angle/time from the remainder of the mosaic.

For example, let's say there is a window where all but one of the tiles are schedule. Your may split the problem tile out of the mosaic and create a separate observation for the problem tile, which can then be observed at another time (and angle) when it has guide stars. If one or more tiles need to be split from the mosaic, this splitting must be done in such a way that the split tiles remain associated with the main mosaic for data processing purposes. Since the split tiles will only be schedulable at a different aperture PA (APA) from the main mosaic, this may leave gaps in the coverage. If this is unacceptable to the science case, then a new tile or tiles can be added to the split observations to cover the missing region.

The tile splitting functionality is complicated enough that it is described in a separate article.

Strategies for planning large mosaics

Although it is not a hard and fast rule, in general, the larger the mosaic the more unlikely it will be that all tiles can obtain guide stars simultaneously. Since removal of individual tiles is cumbersome, you may wish to try other strategies for covering a region of interest.

One such strategy is to define a number of smaller mosaics that cover the region of interest. Letting each smaller mosaic schedule without constraining the PA may make them schedulable, but may also create holes in the desired spatial coverage. This can be partially addressed by increasing the amount of overlap between the smaller mosaics or adding more tiles (the latter being at the expense of additional resource usage). It is left to you to experiment with these techniques and decide how best to proceed for your particular situation.

Another potential caveat may arise for large mosaics (large number of tiles and/or multiple filter imaging mosaics, etc.). If an observation specification contains too many visits, linking the visits properly in APT can take a long time to process **Visit Planner** runs (if indeed it does not crash APT altogether). Currently, up to ~200 linked visits can be processed in reasonable time, and performance degrades quickly above this value. The number of visits in your observation can be judged from within the **Visit Planner**, before attempting to process it.) For practical reasons, then, it makes sense to limit the size of mosaics. The goal of scheduling larger mosaics can likely be accomplished by scheduling two or more smaller mosaics covering the desired region.

Uniformity of coverage in mosaics

See also: examples in the articles on NIRCam Primary Dithers and MIRI Imaging Dithering.

Uniformity of coverage for mosaics is dependent on several things: any gaps in the pattern of detectors used for a given instrument, the dither pattern specified for a given observation, and on the mosaic parameters chosen (like degree of tile overlap).

As also mentioned in the article on dithering, the choice of dither pattern affects the overall size of a given mosaic tile footprint, and thus also impacts the assessment of the uniformity of coverage within a given mosaic. Tile overlap in the mosaic definition can also improve coverage of "edge effects" from the dithering of each tile and improve the uniformity of coverage.

Published	30 Mar 2017
Latest updates	• 02 Oct 2019 Updated Figure 1 and video help links for cycle 1.

	• 16 Aug 2019 Removed NIRSpec MOS from allowed mosaics, per NIRSpec team instruction. • 21 Nov 2017 Text and links updated • 14 Jun 2017 Figure 2 and caption updated, Figures 3 and 4 updated

APT Mosaic Tile Splitting Activity

In certain cases, it may be necessary to split off one or more tiles from a larger mosaic in order to find guide stars. This page describes how to do that task.

On this page

Specifying Mosaics in APT Video Tutorial

Mosaicking in APT is a key functionality for many science use cases. In certain circumstances, usually because of guide star availability versus time, one or more tiles of a larger mosaic need to be split off from the main mosaic in order to permit the main mosaic to be schedulable. The simplest situation is if the problem tile or tiles can simply be dropped. However, if complete spatial coverage is required, these split tiles need to be scheduled at a different time when guide stars are available for them. (Often, other adjustments are also needed to fill the gap or gaps left by the removal of a tile.) Furthermore, for data processing purposes, the observations of the split tile (s) need to stay associated with the main mosaic observation in order for the Data Management System (DMS) to produce the final mosaic.

The APT **Visit Planner**[*] provides diagnostic plots and other information that allows the user to identify problem tile (s). Then, special requirements and a tool within the mosaic environment of APT allow the user to split off the problem tile or tiles while maintaining the necessary associations for the data processing system downstream.

[*] ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

How to split mosaic tiles

The steps for finding and scheduling problem tile(s) are outlined below. It assume that the Visit Planner (VP) has been run on a mosaic observation that has unschedulable tiles.

Find the problem tile or tiles

- Take note of the total number of visits in your observation.
- In the visit planner window, right click on the observation and select **Display Guide Star Availability by V3PA** (V3 position angle) for the diagnostic plot.
- Determine the number of problem tiles.
    - For example, if the mosaic contained 12 visits but the plot only has 11 visits, then (a) there is no time when all 12 visits get guide stars simultaneously, and (b) the best you can do is to schedule at a time (an angle) when all but one tile have guide stars.
- Hover the cursor over the green line in a section where most visits have guide stars, and note the visit(s) and V3PA at those time. (You will need this for the next steps outlined below.)

Removing the problem tile or tiles

- Click on **Form Editor** to return to your mosaic observation, then click on the **Special Requirements** tab to open the special requirements (SR) panel.
- Select a SR for specifying the aperture position angle (APA) range and enter the V3PA obtained in the previous section. (That is, set the mosaic to a V3PA where most of the tiles are schedulable.)
    - For example, if the analysis from the previous section showed that 11 visits were schedulable at a V3PA of 263°, set the **PA Range** (position angle range) SR to the values 263 to 263.
    - Note: the APA is often close to the V3PA, but it's not exactly the same; for some targets and/or instrument configurations, it can be significantly different. After entering the APA values in the **PA Range** SR, the SR panel in the GUI will also display the V3PA values, in parenthesis, that corresponding to the APA . Adjust the APA, if necessary, to get the V3PA derived from the diagnostic plot.
- Next, click on the **Mosaic Properties** tab for the observation to see the mosaic panel. There is a table at the bottom of it that shows which visits correspond to which tiles in the mosaic. Identify the tile(s) that contains the problem visit or visits. For those tiles, click the column tab that says, **Split tile to new observation**. Wait for the GUI to update (which may take a few seconds).
- When the GUI has been updated, here's what you should see:
    - A new target has been automatically created for the removed tile.
    - A new mosaic observation folder has been created. In this folder you should see (a) the original mosaic observation, minus the problem tile, and (b) a new observation for the missing tile. The presence of both these observations together in the mosaic observation folder will tell the data management system to associate the observations in data processing.

Fixing the problem tile or tiles

- In the form editor, select the newly-created problem tile observation.
- Click on the **Special Requirements** tab to remove the APA range special requirement from the SR panel.

- Go to the visit planner, and run the scheduler by clicking **Update Display**. If the processed observation comes back with a green check mark, that means there is a time slot when the problem tile has guide stars. If the observation comes back with a red X, then there are no time slot when this visit (tile) will have guide stars.
- Look at the V3PA diagnostic messages (click on the **Reports** button to select the appropriate report) as before. Hover over a horizontal line segment in the plot line for a schedulable time, and record the V3PA. Note: you may want to choose a V3PA as close to the original main mosaic angle to minimize the problem of filling the gap left by the tile removal, but this is not always possible.
- Go to the form editor for the new observation, click on the **Special Requirements** tab to open the SR panel, and fix the orientation of the new observation using the value determined above.
- Run the visit planner again on this observation to confirm its schedulability.
- View the new observation folder in Aladin. What do you see?
    - You should see the main mosaic at the prescribed APA, and the new split observation showing the problem tile at the other fixed orientation you specified. Note that since the angles have been set to specific values in this process, Aladin is showing the exact coverage that can be expected from the actual observations.
    - It is likely that the new observation does not fill the gap in the original mosaic very well, depending on the angular offset of the new observation relative to the main mosaic. So now what do you do?
- The split observation has simply inherited whatever properties were in the original mosaic observation. The selected dither pattern may not work well in the new orientation, so you may need to adjust it.
- Also, you may need to add an additional tile to the new observation and adjust the positions to obtain complete spatial coverage of the gap from the removed tile.

Restrictions and planned improvements

APT version 25.4.2 (January 2018), still only allows the removal of a single tile at a time. Plans are under discussion for allowing the removal of multiple problem tiles (and possibly the fixing thereof) simultaneously.

Another functionality under discussion is the idea that one could use the mosaic tool to define a mosaic, then explode each tile out into a separate observation. (This functionality has been useful for HST mosaic planning but is not yet in the JWST part of APT.) Then the Smart Accounting tool would take care of removing the unnecessary slews and perform the proper accounting for the separated observations.

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Latest updates	02 Oct 2019 Added link toivideo help.

APT Simple Mosaic Example

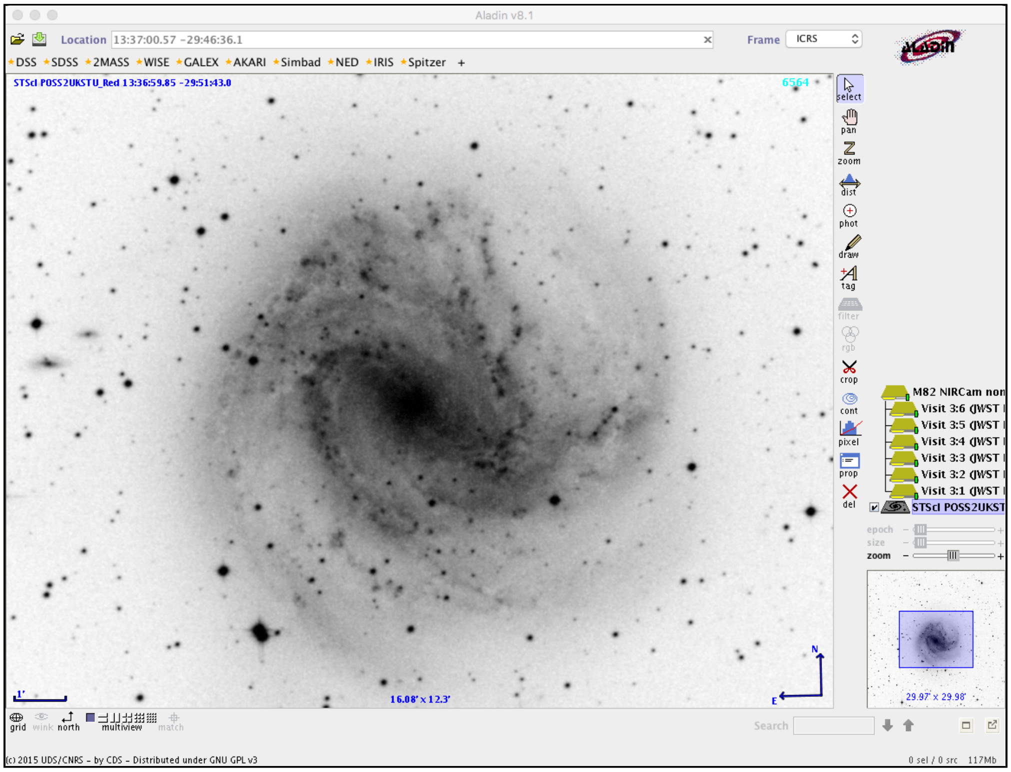
A walkthrough of a simple APT mosaic example is described for MIRI and NIRCam.

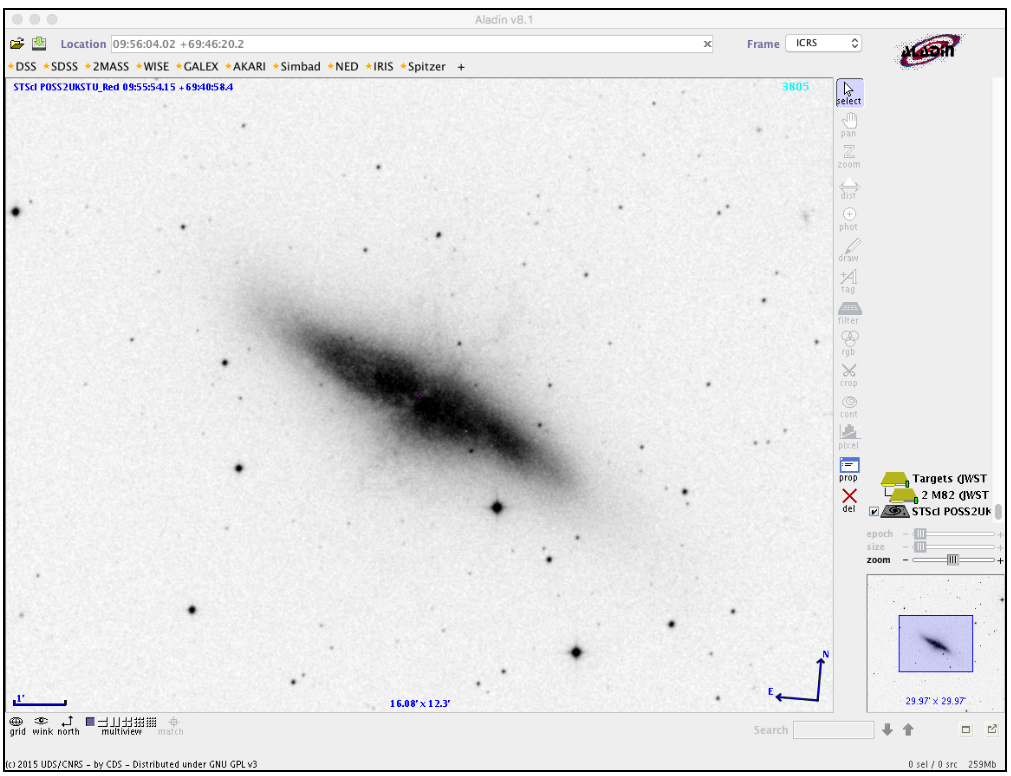
On this page

Specifying Mosaics in APT Video Tutorial

This example walks the user through a simple APT mosaic program. An accompanying APT example file is available within APT, using the **File → JWST Demonstration Proposal**[*] option. Grab the file called **Mosaic Example**. Two targets have been entered in the program: M83 and M82. A simple pair of NIRCam and MIRI mosaics are created using galaxy M83 as an example, followed by an example for a non-symmetrical mosaic case (M82), where the NIRCam field orientation must be restricted using special requirements. The user is encouraged to download the accompanying APT file, follow along in APT, and experiment with the various control features on their own. A view of the targets in Aladin using the DSS and no overlays, is shown below. Figure 1 shows the Aladin visualization display for these 2 galaxies, displayed using the DSS (Palomar Digital Sky Survey) display option.

Figure 1. M83 (top) and M82 (bottom) as seen in Aladin using the DSS option



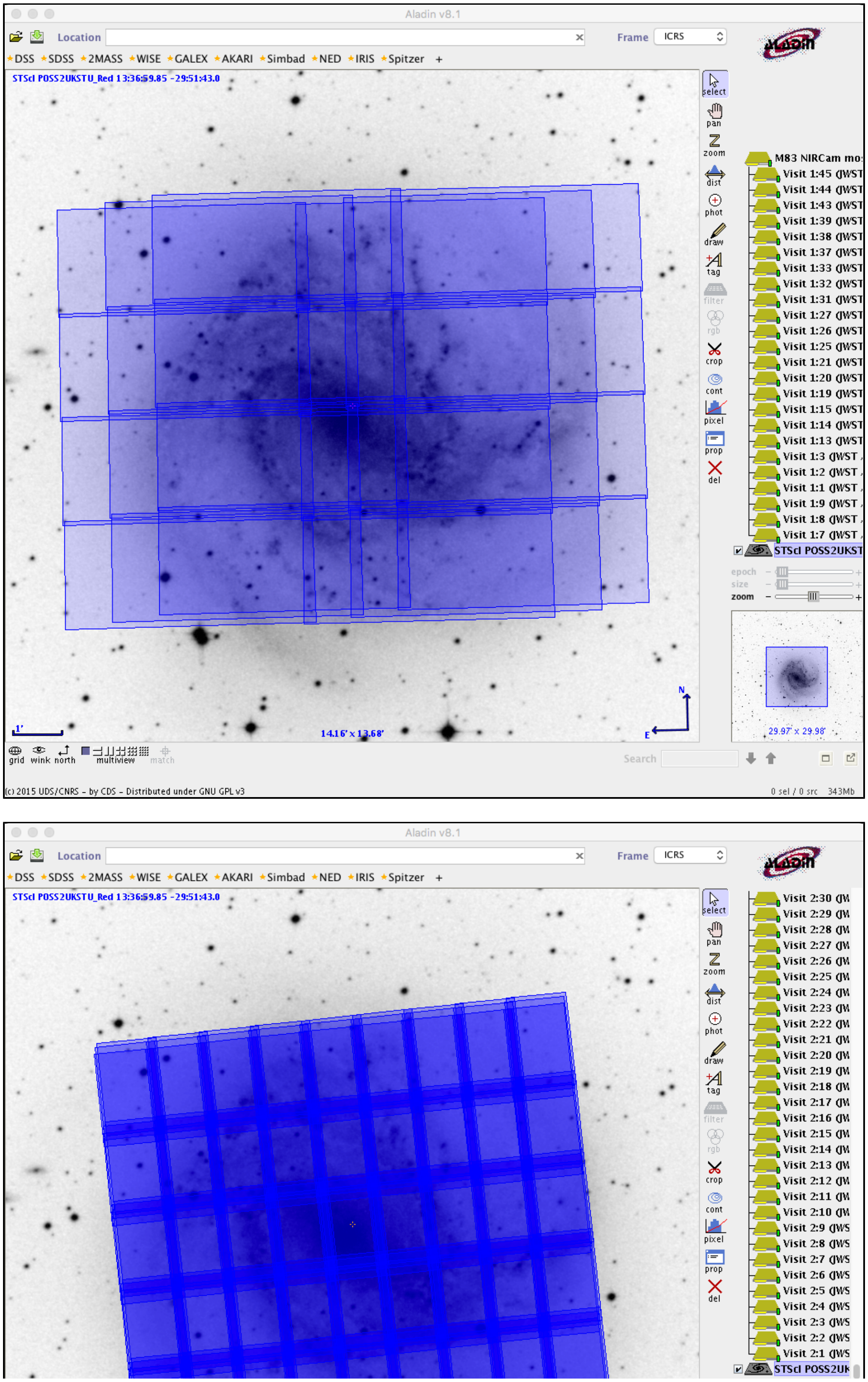


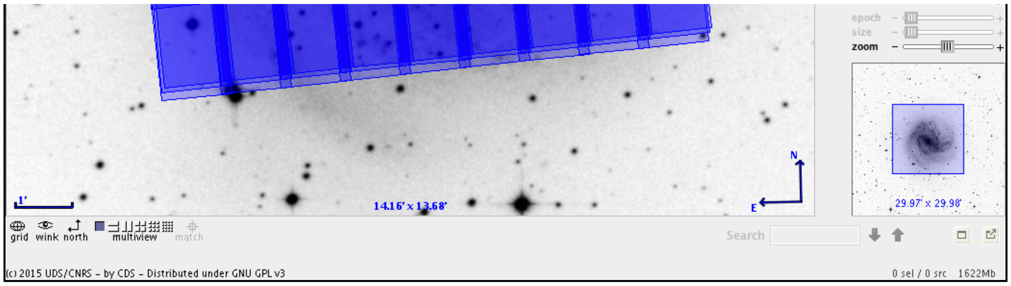
* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Symmetrical mosaics covering M83

The example file contains 2 simple mosaic definitions covering the bright disk of M83. Observation 1 is a NIRCam 4 × 2 mosaic that covers an approximately square region, using the 3-TIGHT dither pattern, while observation 2 shows a MIRI imaging 5 × 9 mosaic covering approximately the same region. Overlays of the instrument fields of view are shown in Figure 2. Note that for NIRCan, a simplified version of the filed overlay is shown here, selected using the "Single Aperture" control option in the Aladin control panel. This feature is new as of APT 25.1.1.

Figure 2. The nominal mosaic definitions for NIRCam (top) and MIRI bottom)

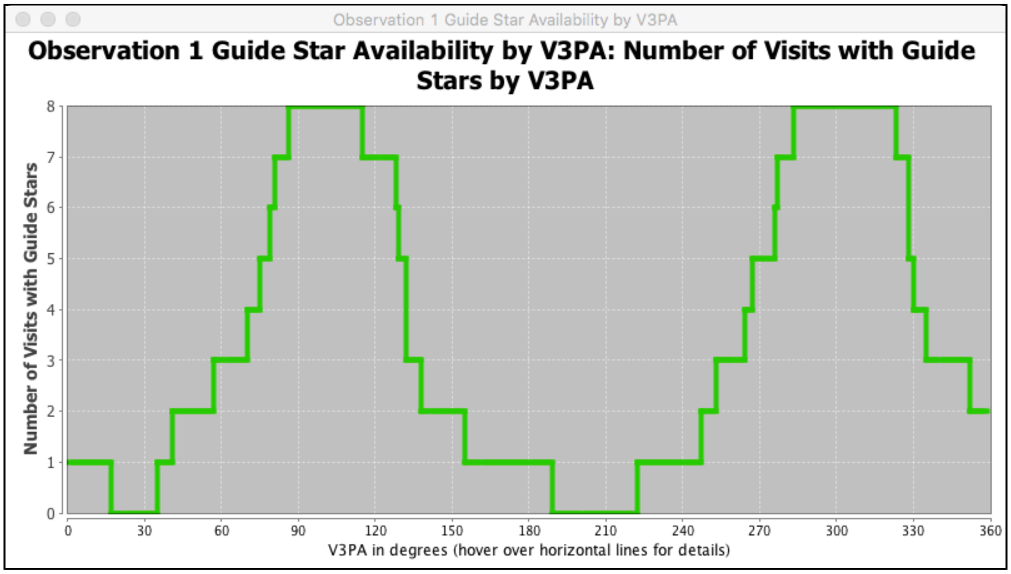




Since no PA constraints have been placed on these observations, Aladin simply shows a default orientation. You should be aware of whether you are viewing a fixed orientation you have chosen or whether the observation is unconstrained, in which case the pattern of tiles shown may rotate with time. No position angle constraints have been placed on these proposed observations, and so a run of the Visit Planner is free to rotate the pattern to assess if there are times when all of the proposed tiles can obtain guide stars simultaneously.

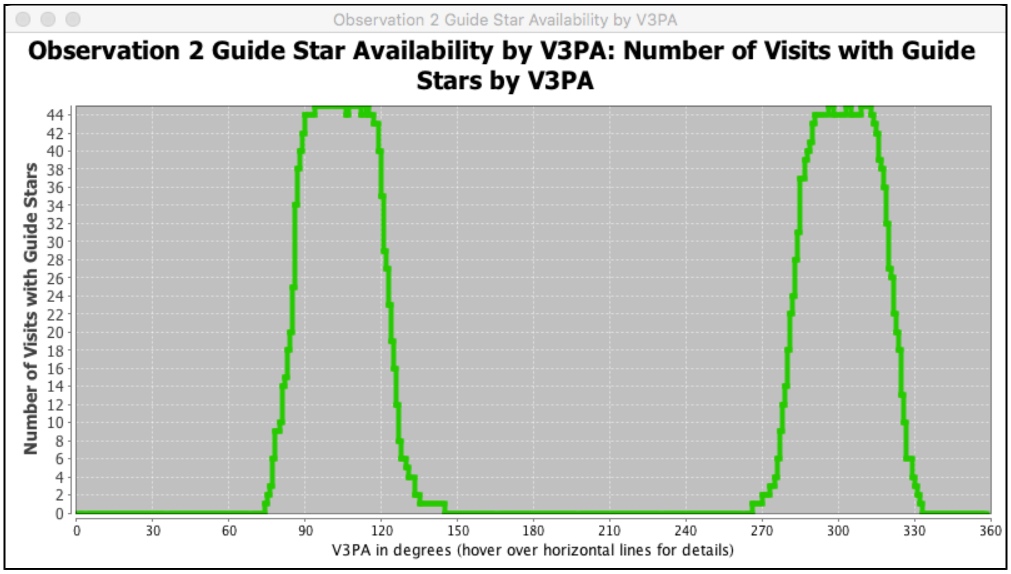
The NIRCam mosaic has 8 visits (one for each tile), and the Visit Planner's assessment returns with a green check on the observation, indicating there are times when all tiles can get guide stars simultaneously and all other visibilities are good. A check of the guide star situation against the V3PA is shown in Figure 3, and indicates there are 2 solid windows of schedulability.

Figure 3. Guide star availability for the 8-visit NIRCam mosaic versus the observatory V3PA



Likewise, the MIRI mosaic in observation 2 passes the Visit Planner check, even though in this case there are 45 visits involved. Figure 4 confirms that there are 2 good windows where all 45 visits can get guide stars, and the green check in the VP confirms schedulability against all constraints.

Figure 4. The guide star assessment for the MIRI mosaic in observation 2



If an observer was happy with all other observation settings for these observations, they could be submitted.

What if all of the tiles had not been able to get guide stars at the same time?

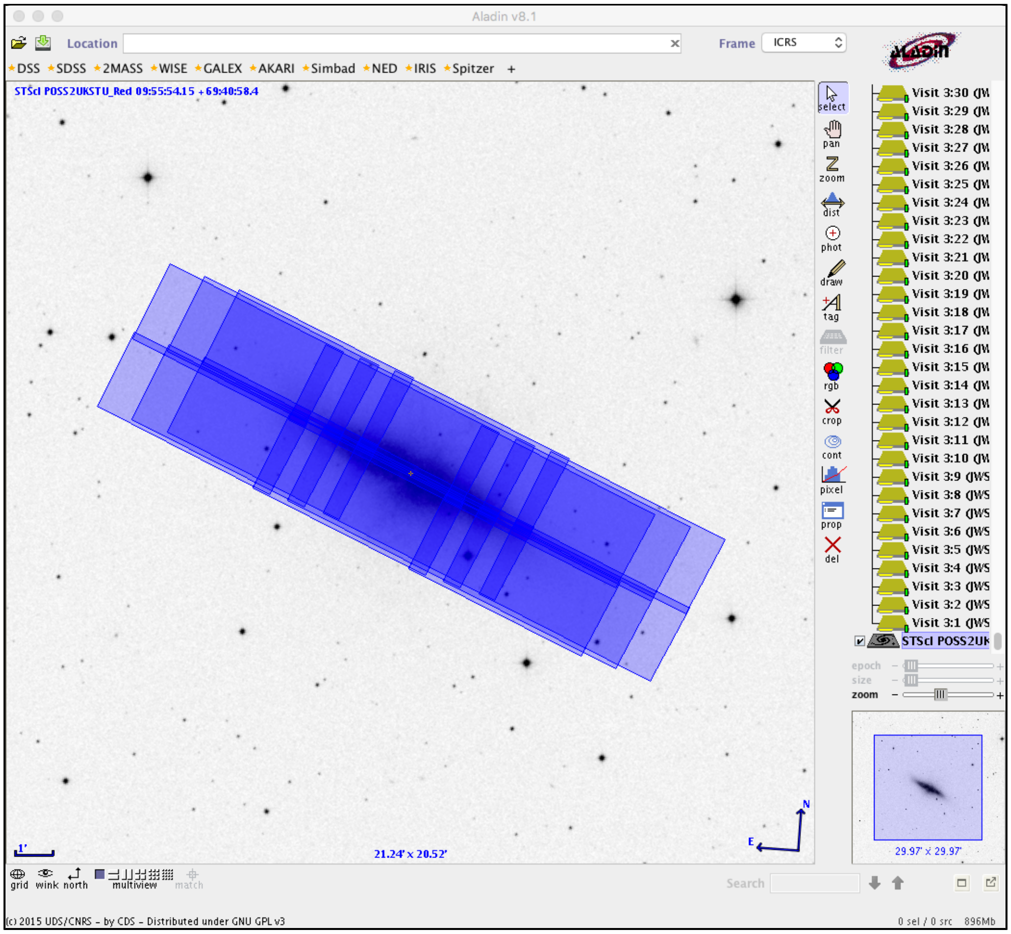
APT provides a way for splitting off problem tiles to a separate associated observation.

A non-symmetrical case: M82 with NIRCam

The situation in the previous section worked well because both the region to be observed and the shape of the mosaic itself were symmetrical, so that the angle of the mosaic at the time of actual scheduling was not critical to the success of the observation. This is ideal, as it provides the most scheduling flexibility. However, as the situation with M82 demonstrates (Figure 1 right), this is not always the case.

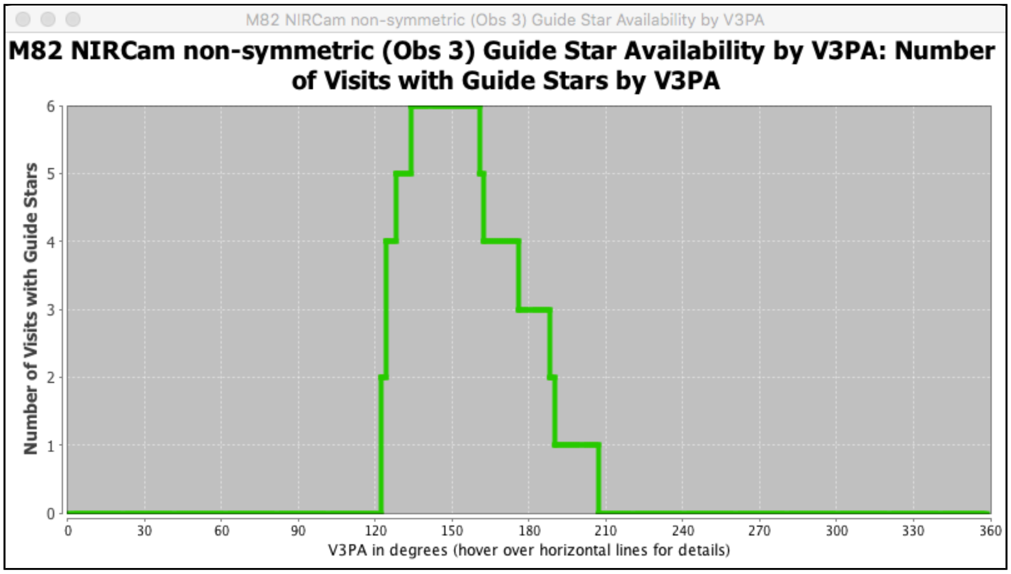
In observation 3, a mosaic has been defined that is long and narrow, to cover the edge-on disk of the target. However, if this mosaic is rotated, it will no longer cover the region of interest. Hence, one must restrict the permitted position angle of this mosaic in order to force the mosaic into the desired position, as shown in Figure 5.

Figure 5. A 3 × 2 NIRCam mosaic projected onto M82; again the "Single Aperture" display option has been chosen for simplicity



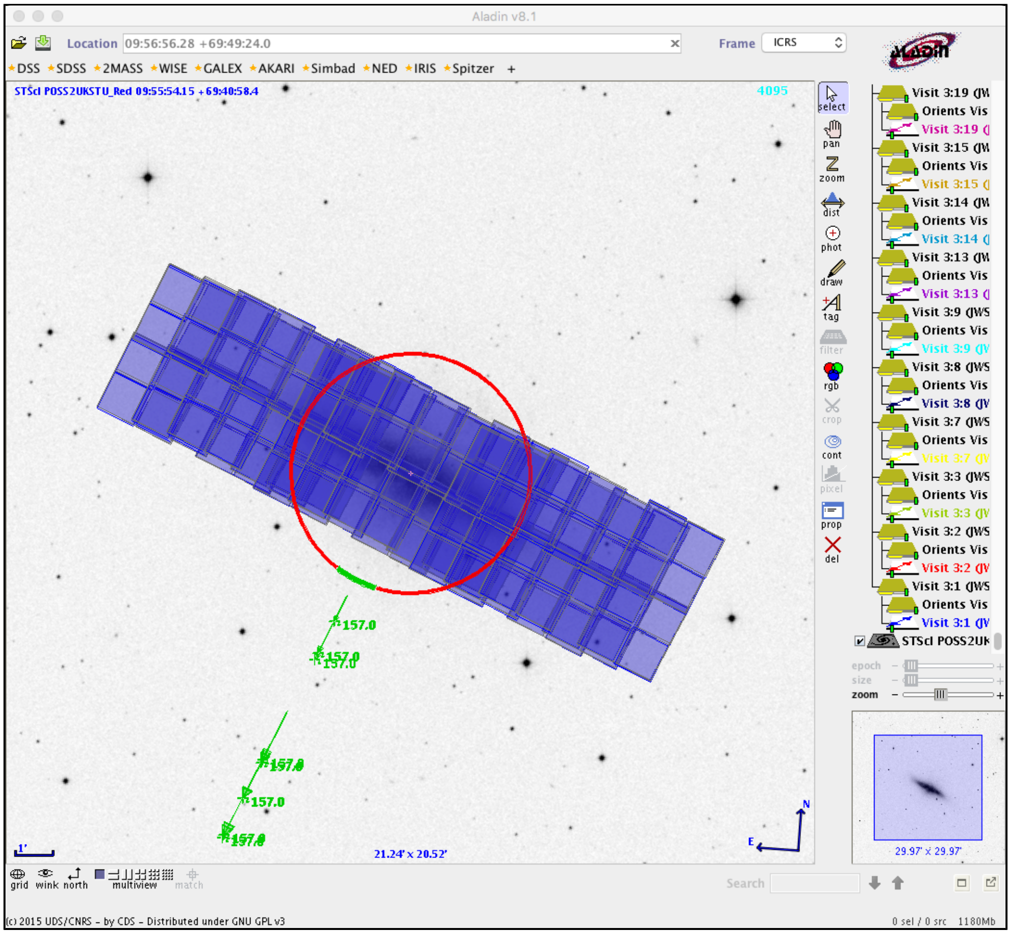
Whenever possible, however, it increases scheduling flexibility significantly if a range in position angle is allowed, instead of a fixed angle. In this example, the special requirement set on the observation allowed a 20° range centered on APA = 157°, which still maintains the alignment of the mosaic on the object well enough. Once the special requirement is set, one can run the VP to check the schedulability at the angles allowed. In this case, the VP returns a green check, indicating all is good with schedulability at these angles. A check of the V3PA diagnostic confirms a good window for guide star availability, as shown in Figure 6.

Figure 6. The V3PA diagnostic for observation 3 confirms good guide stars over the requested APA range of 157° ± 10°



As a double check, one can return to the Aladin display and turn on the "Orient ranges" tab, which returns the display shown in Figure 7, where the green part of the circle indicates the amount of APA range allowed.

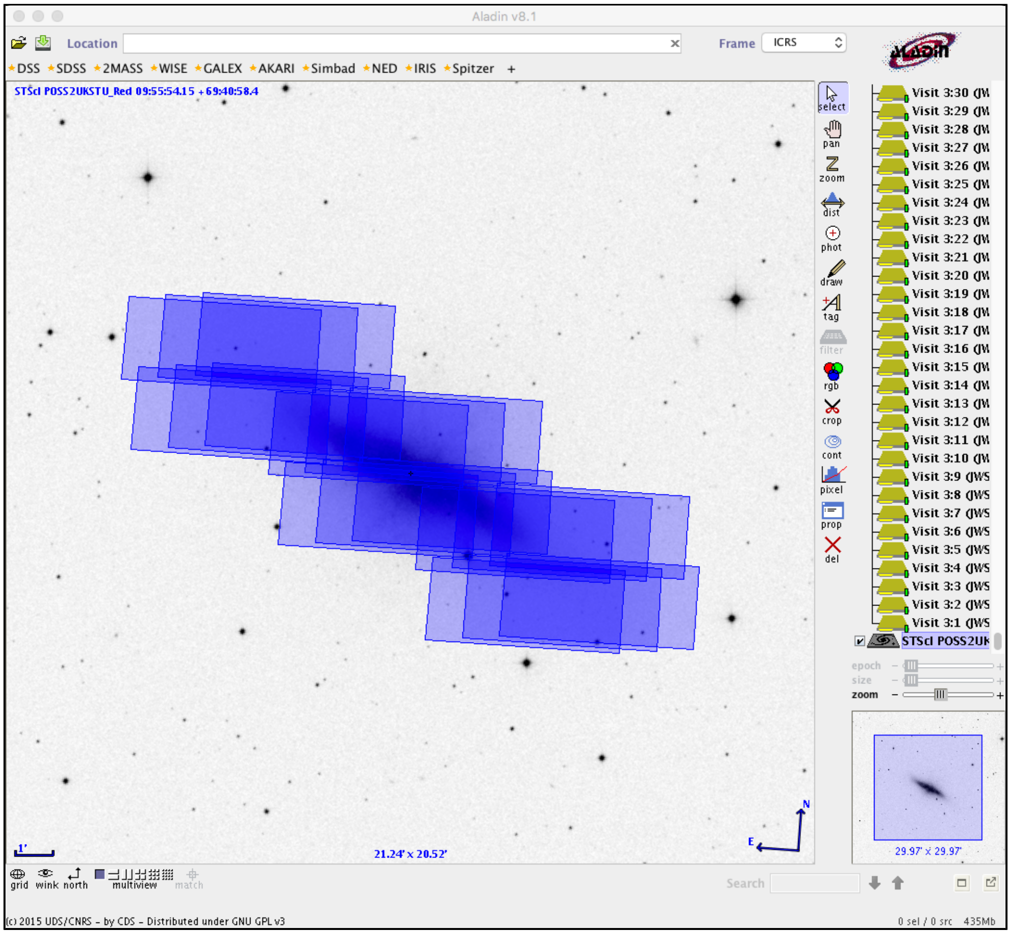
Figure 7. After setting the range of APA , the Aladin display can be used to verify the allowed flexibility range



Note the "Single Aperture" display option has been turned off in this example, showing the full complexity of the FOV pattern in the observation. (Compare with Figure 5.)

If it turned out that the desired optimal position angle range was not available for your target, the area of interest can still be covered by skewing the mosaic and using the mosaic overlap controls to position the tiles. Figure 8 shows an example, where offsetting the columns and allowing more tile overlap have covered approximately the same region of M82.

Figure 8. A non-optimal skewed mosaic covering approximately the same region



Practice exercises

Here are some things to try with the mosaic examples.

1. Display M83 and the Observation 1 (NIRCam) field overlay in Aladin. Toggle between the full FOV display and the "Single Aperture" display option to see the difference.

2. Select an observation in the form editor and open the Mosaic tab. Adjust the percentage of allowed overlap in one or both directions and compare the appearance in the Aladin display. Change the number of tiles in one or both directions of the mosaic and note the change in the Aladin display.

3. In the form editor, choose observation 3, open the Special Requirements tab, and edit the allowed range of APA. Then run the VP and check the schedulability.

4. Select an individual visit in observation 3 and display in Aladin. In the Aladin GUI, select the GS check option, and potential guide stars should be indicated with green symbols. If the "FOV" option is checked in the Aladin control panel, a display showing all of the JWST instrument footprints should appear. Verify there are one or more green guide stars in at least one of the boxes that represent the position of the FGS guider.

Published	12 May 2017
Latest updates	• 23 Dec 2019 Reviewed and updated for Cycle 1 release. • 02 Oct 2019 Added video link. • 12 Jun 2017 Figures 2, 5, 7, and 8 updated

APT Graphical Timeline

APT contains a graphical timeline tool to provide a high level insight to users on the detailed components comprising requested observations.

> *See also: JWST Observing Overheads and Time Accounting Overview, APT Smart Accounting*
>
> *APT Graphical Timeline Video Tutorial*

When developing a proposal, APT uses a timing model and standard assumptions about overheads to report both the science time and the total time (including overheads) that will be needed to execute a given visit and observation. Running Smart Accounting at the end of your proposal development looks at the proposal in its entirety and adjusts the charged overheads to provide a total accounting of the resources needed for the program. However, just reporting a total roll-up of overhead time often leaves users wondering about the details, which are difficult to discern with the reports and information previously available.

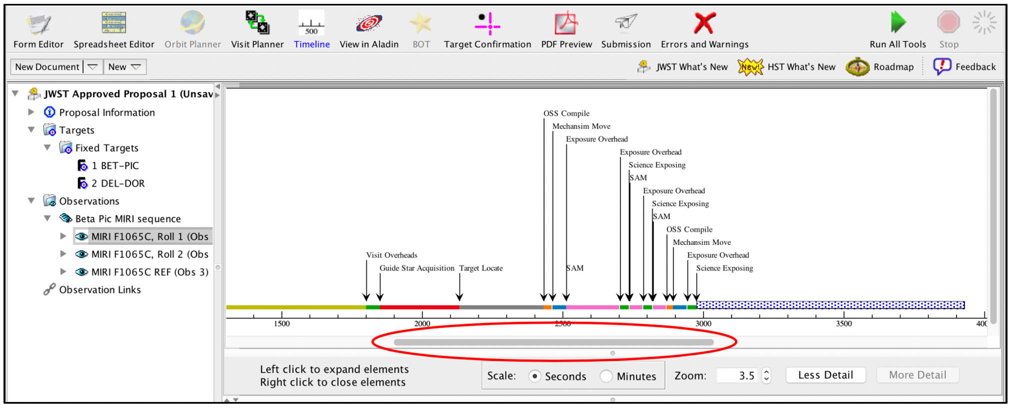
Beginning with APT version 27.1 released in winter 2019, the JWST branch of APT now includes a graphical **Timeline**[*] tool that provides the user with a breakdown of the various overheads affecting their proposed observations. Labeled color bars show the different components of the overheads in the context of each selected visit or observation. Controls for zooming the display in the time dimension or providing additional details and labeling are available, as shown in the Figures below. Also, hovering the cursor over a color bar results in a pop-up window with additional information.

The graphical timeline is not meant to represent the actual detailed set of events that occur in the onboard execution of the observation. Rather, it is a tool to provide the user with insight into the major steps that occur and the times accounted to each within the APT timing model.

Figure 1. Example View of APT Graphical Timeline

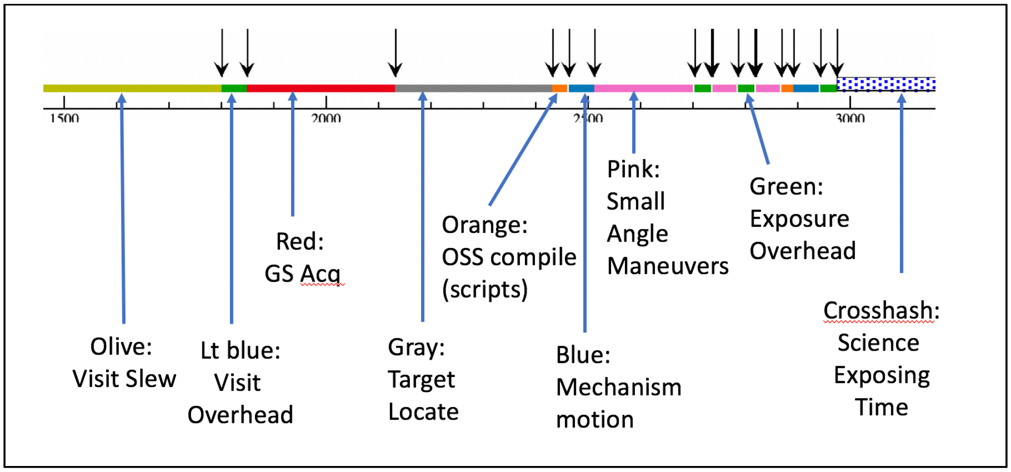
To access the APT Graphical Timeline, select an observation or visit in the Tree editor at left, and then select Timeline on the top tool bar (red oval #1). The timeline tool then becomes active in the main GUI window as shown above. Use the Zoom (red oval #2) and the More or Less Detail buttons (red oval #3) to adjust the display to your liking. Note that left and right mouse clicks can also activate actions. Hovering your cursor over a given color bar provides a pop-up with more information. This example uses a simple observation from APT Demonstration proposal #6 on Mosaics.

Figure 2. Accessing more detailed Information



This example shows a more complicated observation from APT Demo proposal #7 (MIRI Coronagraphy) fully expanded to show detailed labels and additional colors. The Visit Slew (olive bar at left) has been cut off to focus on the details of the observational setup. Note that in addition to Zooming in and showing More Detail, the slider bar (red oval) has been used to position the display to the region of interest.

Figure 3. A Key to Graphical Timeline Colors



Hovering your cursor over any of the color bars in the timeline plot provides more information as to what it is, but the colors are used consistently, according to the labeled example above. The color bars are also labeled directly in the timeline plot if the More Detail button is selected. Also, hovering the cursor momentarily over a color bar results in a pop-up window containing additional information.

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Published	12 Jul 2019
Latest updates	• 02 Oct 2019 Added video link; minor updates. • 12 Jul 2019 Initial publication.

APT Aladin Viewer

The JWST Aladin visualization tool has been integrated into APT to allow users to visualize their observations onto the celestial sphere.

On this page

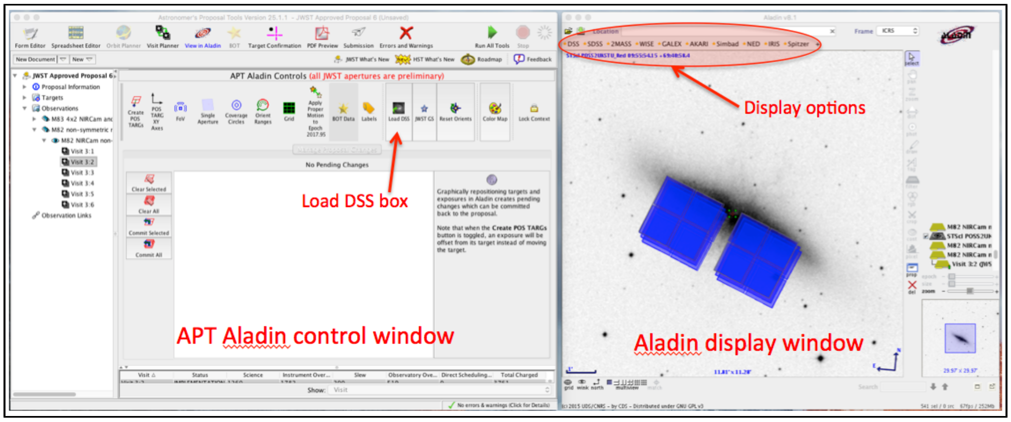
Brief overview

Aladin Overview in APT Video Tutorial,

Using Aladin and APT Visit Planner Video Tutorial

The Aladin Visualization tool is software from the Centre de Données astronomiques de Strasbourg that has been integrated into APT to assist users with visualizing their proposed observations onto various sky views such as the Palomar Digitized Sky Survey, 2MASS, Galex, SDSS, or a number of other selectable options. The Aladin tool is accessed in APT by selecting one or more visits or observations in the tree editor on the left side of the APT GUI and selecting the **View in Aladin**[*] icon on the APT top tool menu bar. The APT GUI changes to show Aladin control options and a separate window opens to show the visualization. Users can move back and forth between the form editor and the APT Aladin control panel as needed to change what is being displayed, but the visualization display window stays open until closed by the user.

Figure 1. The screen view after opening Aladin and display the DSS image for a particular visit from a mosaic of M82.



The screen view showing the APT Aladin control panel at left and the Aladin display window at right. The windows are separate and can be moved and resized independently. The Load DSS box is highlighted at left, and the background display options are highlighted in the right panel.

Hint: after opening the **View in Aladin** tool and selecting an observation, click the **Load DSS** box in the APT Aladin control window to see the background image in the Aladin display window. If a different sky survey is desired for the display, the options are selected directly from within the Aladin display window

Note: The target shown in the Aladin display does not update automatically when observations or visits from a different target are selected in the APT tree editor. The user must click the **Load DSS** box in the APT Aladin control window to force display of the new target.

Our goal here is not to provide a complete overview of this tool, but rather highlight a few aspects that should be most useful to proposers. The implementation in APT is largely the same for the HST and JWST branches of APT, but there are aspects that are specific to one or the other branches. Video training help is available and recommended for learning some of the ins and outs of Aladin, but many features are intuitive. You are encouraged to play around with the many options provided by the Aladin tool itself and the APT interface to it.

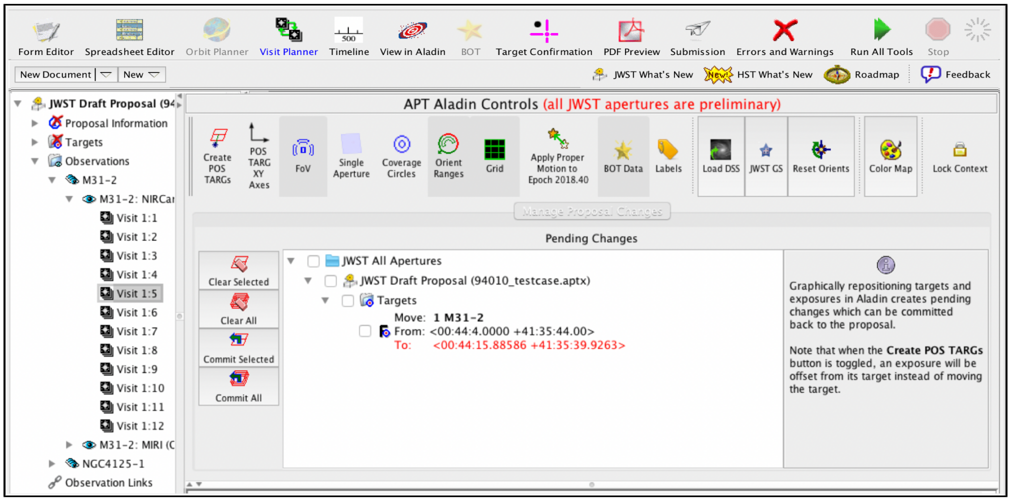
The APT Aladin control window in the APT GUI contains a number of helpful features that can be turned on and off as desired, depending on the application (see Figure 2). The **Load DSS** box has already been mentioned, but a few others of special interest include:

- **FoV button**: toggles the entire set of JWST instrument footprints, showing the the entire JWST focal plane. Of course, unless the position angle of the selected observation or visit has been set, this is just provisional. But if the position angle has been fixed (or a range provided), this display will show the actual expected relative positions of the different instrument FoVs with respect to the selected visit or observation.
- **Orient Ranges** button: When a position angle or range HAS been set on a given observation, this display is useful for showing the allowed range of motion for the reference angle of the selected instrument. A circle is displayed, where the green portion indicates the allowed PA range and the red portion shows disallowed ranges.

- **Coverage Circles** button: this display simply shows what happens when the selected field of view is rotated on the sky. So for example, if an imaging mosaic has been specified, but the position angle has not been restricted, this display shows the full area that in principle might be within the filed of view at the time of the observation.
- **Grid** button: simply displays a coordinate grip over the Aladin display.
- **Single Aperture** button: (Added APT 25.1.1) For certain modes (mainly NIRCam), this toggles to a simplified view of the field overlay.
- **JWST GS** box (next to Load DSS box):

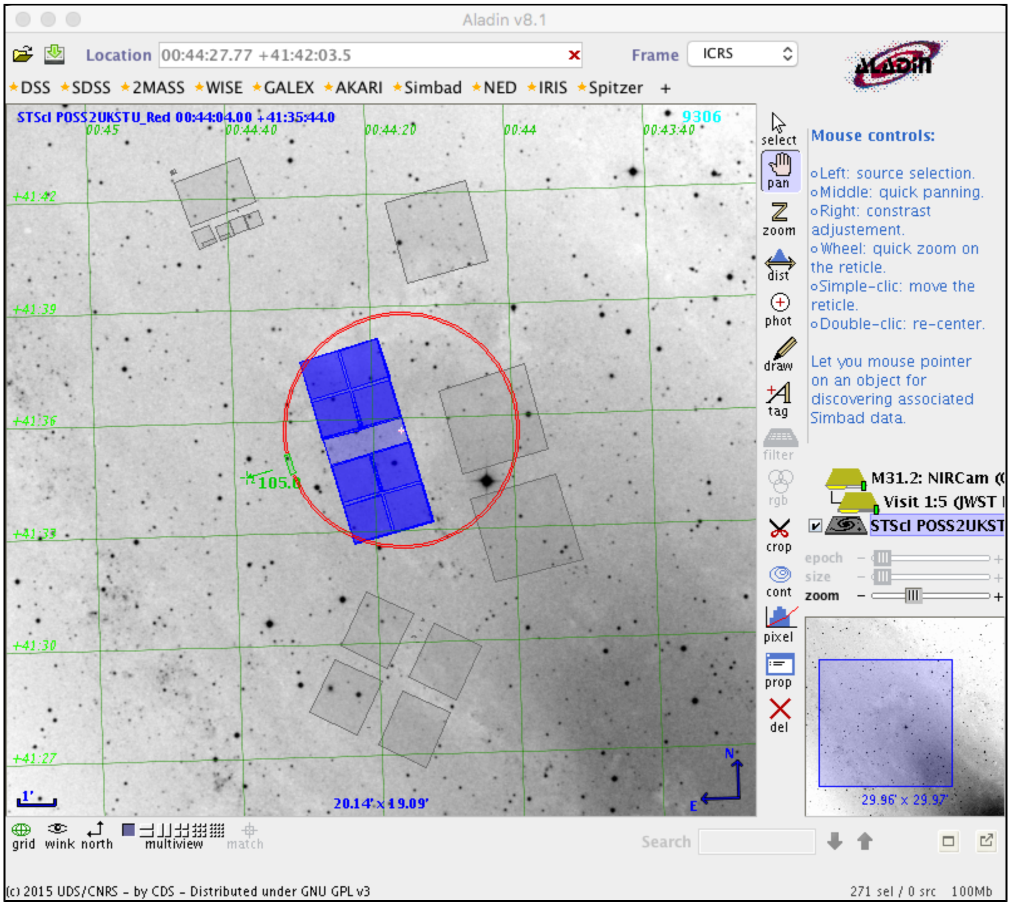
Figure 3 shows the Aladin display resulting from selecting a few of these options for a particular example. The display of the JWST instrument fields of view for each elected template mode have undergone a major upgrade as of APT 25.1.1 release in June 2017.

Figure 2. The APT Aladin Control window showing several of the features described in the text.



In this example, the FoV, Orient Ranges, and Grid buttons have been selected for a single visit. (The BOT Data button is also grayed out, but for a different reason:The Hubble Bright Object Tool is not relevant for JWST.) The results of these choices are shown in Figure 3. Note that a potential change in position of the selected visit has been made in the display, resulting in the red information in the Pending Changed GUI. This change will not be saved unless you use one of the "Commit" buttons at left, in which case the change is fed back into this target in the proposal.

Figure 3. The Aladin display window showing several of the features described in the text.



The results of the choices shown in Figure 2 can be seen in this figure. The positions of other JWST instrument FoVs (gray boxes) can be seen relative to the selected NIRCam visit (shown in blue). A coordinate grid is overlaid on the display. The green portion of the circle shows that an orient range has been selected for this visit. The display is shown at the midpoint of the range. There are many Aladin display controls along the right side of the image window that are not described here.

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Interactions between Aladin and APT

One of the most useful interactions between the Aladin display and APT is the ability rotate or move a displayed JWST field of view by grabbing it with the cursor. These manual adjustments show up in the APT Aladin GUI, as shown in Figure 3. If you decide to keep the indicated change, you can either commit a particular selected change or commit all listed changes back into your proposal by electing the appropriate button on the left side of the APT Aladin control window.

A word of caution regarding position angle changes: Aladin will allow you to rotate a given field of view through the entire 360^{o} range, but this does not mean that all angles are necessarily allowed for JWST observations of a particular target. It is only by running the visit planner with a given position angle (or range) specified that actual schedulability can be verified.

If a mosaic observation is displayed, grabbing a tile and rotating it to a new position angle is followed very shortly be a repositioning of the entire mosaic pattern in the display. This is a result of the way mosaic observations are defined. See the APT Mosaics article for more information.

Aladin visualization tool information

Copyright

Acknowledgement

If the *Aladin Sky Atlas* was helpful for your research work, the following citation would be appreciated: *This research has made use of "Aladin sky atlas" developed at CDS, Strasbourg Observatory, France → 2000A&AS..143...33B and 2014ASPC..485..277B.*

Published	17 Jun 2017
Latest updates	• 27 Sep 2019 Added revised video help links. • 11 Mar 2019 Updated for APT 27.1 release, including figures • 04 Feb 2018 Added links to three new Aladin tutorial videos • 27 Nov 2017 Figures 2 and 3 updated to APT 25.4.1.

APT Visit Splitting

APT uses the target position and information about guide star availability to decide if a proposed observation needs to be performed in a single visit or multiple visits.

Users specify observations in APT by filling in the requested information in a selected observation template. However, the unit for actual JWST scheduling is a *visit*; Observations may consist of a single visit or multiple visits, depending on a number of conditions, only some of which are under a user's control. It is the user's job to specify observations, and it is APT's job to determine the number of visits.

A visit is that portion of a requested observation that can be performed on a single guide star selection. If dither motions or other offsets in an observation are larger than a specified size, APT will break the observation into another visit and add a new guide star acquisition activity. A likely example might be an imaging mosaic observation: all of the requested mosaic tiles are part of the same observation request, but if the motion from one tile to another is too large, APT will break the observation into multiple visits and add a guide star acquisition onto each visit as needed.

Splitting of an observation into multiple visits incurs additional overhead for the new guide star acquisition. If accumulated dithers or other motions within an observation can be kept below the visit splitting distance, this additional overhead can be avoided. See Slew Times and Overheads for more information.

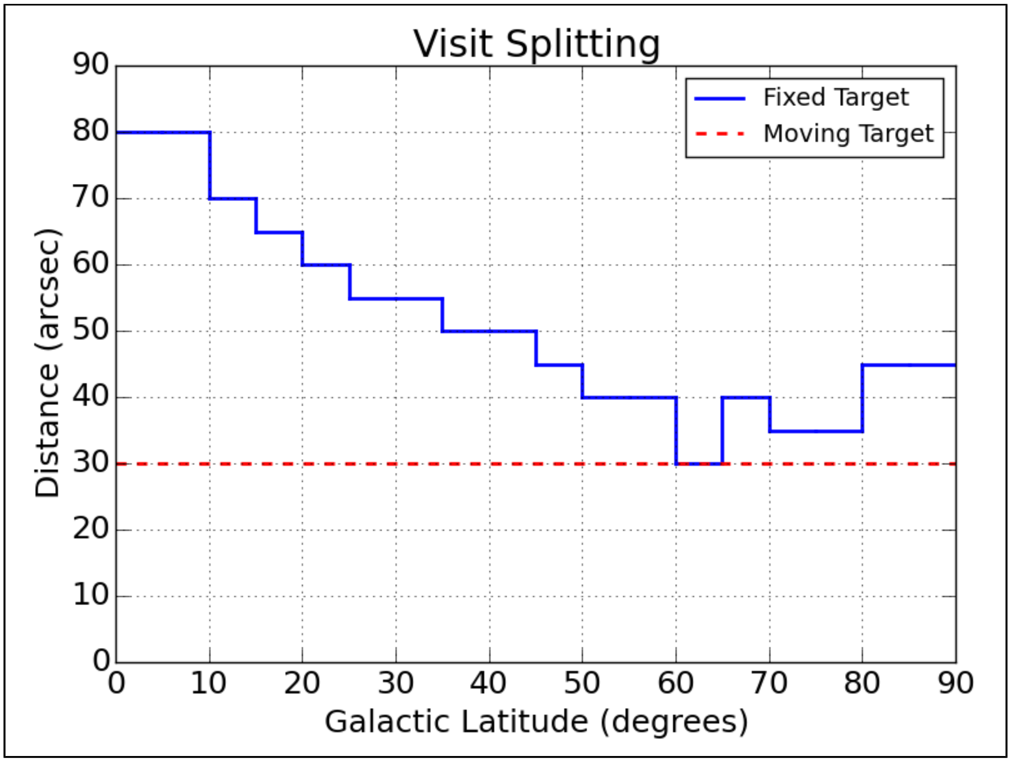
Visit splitting distance

The allowed distance assumed for offsets within a given visit is a function of the galactic latitude of your target position, because the number of potential guide stars drops off toward higher galactic latitudes. Alternatively, one can say that larger areas are serviceable by a single guide star at lower Galactic latitudes where more stars are available. A statistical analysis using the JWST guide star catalog was used to define the Visit Splitting Distance vs. Galactic latitude rules plotted in Figure 1. These are the assumed visit splitting distances used by APT. The Visit Splitting Distance ranges between 30"–80" depending on the Galactic latitude of the target. Any observation requiring motions or offsets greater than this distance will require visit splitting.

For convenient reference, APT reports the visit splitting distance it is using and the number of visits for each observation in the APT observation template GUI directly beneath the target selection box.

APT visit splitting logic is only applied to fixed targets. All moving target observations are assigned a Visit Splitting Distance of 30" by default, with the exception of the WATA target acq for NIRSpec, where the value is set to 38".

Figure 1. Visit splitting distance used by APT



The Visit Splitting Distance [*] *used by APT for a given target galactic latitude. For a fixed target, the visit splitting distance varies as a function of Galactic latitude as shown above. These distances were determined based on statistical analysis of guide star availability in the JWST guide star catalog. Any slew (or combination of slews) larger than this distance causes a new visit and new guide star acquisition to be applied by APT.*

[*] ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Published	05 Nov 2018
Latest updates	• 11 Mar 2019 Updated for APT 27.1 release

APT Coordinated Parallel Observations

Coordinated parallel observations can be specified in APT for certain combinations of templates, and are defined within the same APT proposal as the primary observations.

On this page

See also: JWST Parallel Observations for an overview.

Parallel observing is a technique that allows more than one instrument to be simultaneously operated to collect data, thus maximizing the scientific return from JWST. However, because of various operational constraints, including data rate and data downlink restrictions, there needs to be a science-driven justification for parallel observing. A separate article, JWST Parallel Observations, describes the high-level considerations.

Science parallels come in two basic varieties, *coordinated parallels* and *pure parallels*, and they are handled differently in APT. This article concentrates on coordinated parallels.

Coordinated parallels

Coordinated parallel observations are requested in the same proposal as their primary counterparts since they're intended to directly support the science goals of the program. Its implementation depends on the requested template combinations and characteristics of the individual instruments being used together, as well as which instrument is considered primary and which is parallel.

Combined templates for coordinated parallels

Table 1 shows the observing template combinations that have been approved for use in DD-ERS programs and cycle 1 of JWST operations. Support for other modes are planned for future cycles, and will be announced when they become available.

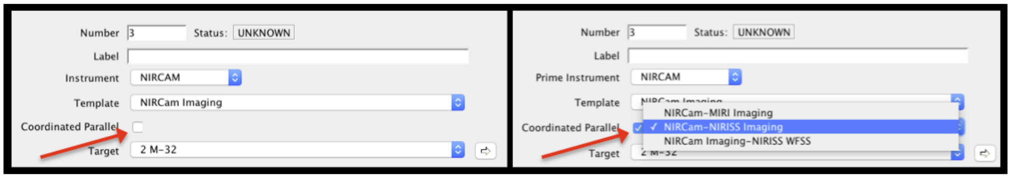
Table 1. Compatible observing template combinations

Ref no.	Template combination	Comments
1	MIRI Imaging – NIRCam Imaging	Either can be primary
2	NIRCam Imaging – NIRISS WFSS	Either can be primary
3	MIRI Imaging – NIRISS WFSS	Either can be primary
4	NIRSpec MOS – NIRCam Imaging	NIRSpec MOS must be primary
5	NIRCam Imaging – NIRISS Imaging	NIRCam must be primary
Modes added in January 2020		
6	NIRCam WFSS – MIRI Imaging	NIRCam must be primary
7	NIRCam WFSS - NIRISS Imaging	NIRCam must be primary
8	NIRSpec MOS - MIRI Imaging	NIRSpec MOS must be primary

Note: for options 1, 2, and 3, either instrument can be the primary; for options 4 through 8, only one of the instruments can be the primary.

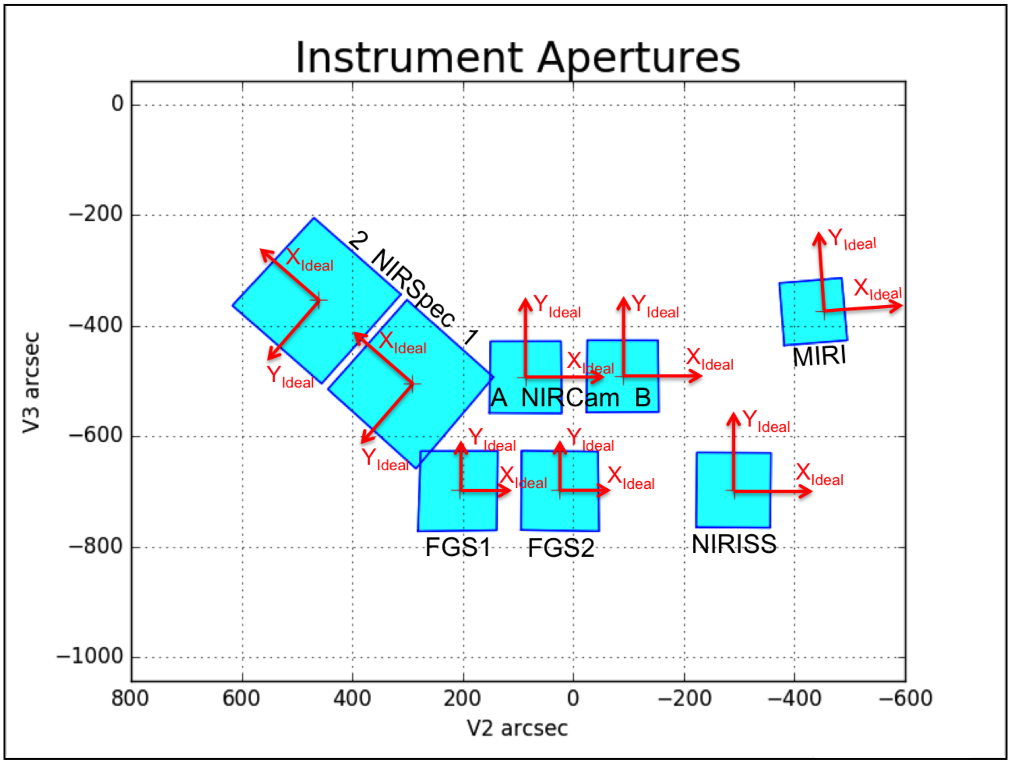
For any of the (primary) templates that permit coordinated parallels, the coordinated parallel option is invoked by checking the coordinated parallel button in the APT observation template GUI, then selecting the secondary (parallel) template option from the pull-down menu, as shown in Figure 1.

Figure 1. Selecting a coordinated parallel observation in the primary instrument observing template



The footprints of each instrument in the JWST focal plane are offset from each other, as shown in Figure 2. Hence, parallel observations do not view the same location, but rather are offset. Also, th exact regions to be observed will depend on the observatory position angle at the time the observation is scheduled. Note that the "Y" axes indicated in the figure are the reference vectors for measuring aperture position angles (APAs) for each instrument. See JWST Position Angles, Ranges, and Offsets.

Figure 2. JWST instrument detector locations in the JWST focal plane and ideal coordinate systems



JWST Focal Plane V2–V3 coordinate system with instrument fields of view shown as cyan rectangles. (For NIRCam, only the 2 long-wavelength detectors are shown.) For one SIAF aperture on each detector, the right-handed ideal coordinate system is shown in red.

General considerations

a. For coordinated parallel observations, every exposure of the primary instrument must have a parallel counterpart and vice versa. (This rule avoids mechanism moves with one instrument during an exposure with the other instrument. Such mechanism moves may in principle cause noticeable jitter.)

b. Every exposure with the parallel instrument must have an exposure *duration* (exposure time plus overheads) that is less than or equal to that of the corresponding exposure duration of the primary instrument. (This rule is enforced by APT, which will give an error if the rule is violated.)

c. Dither specifications are handled differently for NIRCam and MIRI. For NIRCam, a dither pattern is selected and applied to the (whole) observation. (For instance, multiple parallel exposures attached to the multiple primary visits/exposures of a NIRCam observation can only use a single dither pattern.) For MIRI, dithers are specific for a given filter choice, so in principle the dither patterns can change within a visit.

d. Using NIRCam WFSS or NIRISS WFSS in coordinated parallel mode involves complications, because of the need for direct images before and/or after the WFSS grism exposure(s). This forces "extra" exposures onto the other instrument to provide primary exposures that these direct images can be attached to (more details provided below).

Details of specific combinations (given as primary + parallel)

NIRCam Imaging + MIRI Imaging

In the coordinated parallel mode, there is no change in the way that NIRCam primary dithers are selected. At the sub-pixel dither selection, you can choose to just stay with the normal NIRCam options or choose any of a number of other "custom" dither patterns that provide a level of optimization of dither step sizes for the parallel instrument while retaining optimal pixel phase sampling for the primary instrument. A complication in this context is that the MIRI dither options are filter specific (to accommodate the varying PSF size of MIRI), but the selection made in APT applies to all exposures associated with the observation in question. Hence, some compromises are sometimes necessary for parallel observing. For example, you may need to choose a dither for a longer wavelength filter to accommodate some exposures, but that may be sub-optimal for any parallel exposures in the same observation for which MIRI actually observes at shorter wavelengths.

For MIRI Imaging in a prime+parallel combination, the exposures/dither parameter value can only be "1".

MIRI Imaging + NIRCam Imaging

With MIRI imaging as prime, the primary dither selection is where a standard MIRI dither or a custom dither for coordinated parallels would be selected. As mentioned above, MIRI dithers are filter-specific. Hence, different MIRI-optimized dither patterns can be selected for each individual NIRCam parallel exposure specification. (In other words, the NIRCam parallels may not all be done with similar dithers, unlike in the "NIRCam prime + MIRI parallel" case.)

NIRCam Imaging + NIRISS Imaging

NIRISS imaging is not offered as a primary mode, and so this pairing is always NIRCam primary. Similar to the NIRCam imaging + MIRI imaging combination, you can choose standard NIRCam dither options as well as a number of custom dither patterns that provide optimized PSF sampling for NIRISS and NIRCam simultaneously.

NIRCam Imaging + NIRISS WFSS, MIRI Imaging + NIRISS WFSS (or vice versa)

NIRISS WFSS observations (whether in primary or parallel) require a direct image before and after the grism exposures (with a given grism and blocking filter). This complicates matters in coordinated parallels because it requires that "prime + parallel sets" of exposures come in groups of 3 exposures instead of one. Specifically, each set of exposure sequences specified in the NIRISS WFSS template (consisting of a line of grism exposures plus a line of direct image exposures) requires 3 exposure specifications with the other instrument (NIRCam or MIRI). Of these three, the *second* exposure specification will be associated with the (dithered, typically relatively long) grism exposures of NIRISS WFSS, while the *first and third* exposure specifications will be associated with two (typically relatively short) direct images of NIRISS WFSS. By default, the latter two exposures are single (undithered), and taken at the *first and last* dither position of the primary instrument's dither pattern. However, *if NIRISS WFSS is the parallel instrument*, the user has the option of imposing the full dither pattern of the primary instrument also on the direct images of NIRISS WFSS (this option is available in APT by setting the "Direct Image Exposures" pull-down selector to "DITHER_DIRECT_IMAGES").

The best way to accommodate this strategy is to add two (otherwise unnecessary) exposure lines under which you will specify the NIRCam or MIRI imaging exposures associated with the first and third exposures in the NIRISS WFSS sequence (i.e., the WFSS direct images). This breaks one of the key tenants of parallel observing, which is that parallel observations should not impact the primary observations, but it is the only way to properly accommodate NIRISS WFSS in coordinated parallel mode. In terms of dithers, you can choose all standard dither patterns for the prime instrument as well as a number of custom dither patterns that provide optimized PSF sampling for both the prime and parallel instruments. A PDF file is available to show you how to create a set of prime+parallel exposures using the NIRCam imaging APT template, and using NIRISS WFSS in coordinated parallel mode.

NIRCam WFSS + MIRI Imaging, NIRCam WFSS + NIRISS Imaging

These cases are similar to the combinations involving NIRISS WFSS mentioned above, with the following differences: (1) direct images for NIRCam WFSS are *optional* rather than mandatory, *except for the last exposure specification in the Observation*, in which case they *are* mandatory; (2) direct images for NIRCam WFSS are (only) taken *after* the grism exposures (with a given grism and SW/LW filter set), and they come in two separate sets (one called "Direct Image", the other called "Out of Field" images). As such, each set of exposure specifications in the NIRCam WFSS template requires either 1 or 3 exposure specifications of the parallel instrument mode (MIRI Imaging or NIRISS Imaging). The first exposure specification of the parallel instrument mode will be associated with the dithered (and typically relatively long) grism exposures of NIRCam WFSS, while the (optional) second and third exposure specifications of the parallel instrument mode will be associated with (typically relatively short) direct images of NIRCam WFSS. The latter (optional) exposures will be taken at three different locations on the sky (for details on that, see the NIRCam WFSS article).

NIRSpec MOS + NIRCam Imaging

This combination is only offered with NIRSpec MOS as the primary so it drives the pointing. If this coordinated parallel combination is selected, the NIRSpec MOS template includes the option to add customized sub-pixel dithers to the nominal moves of the field of view by integer shutters of the Micro-Shutter Assembly (MSA; i.e., the "nods" in the MSA Planning Tool). The sizes of these sub-pixel dithers are chosen to improve NIRCam image pixel sampling while staying small enough to avoid incurring significant slit losses with the NIRSpec MOS exposures.

NIRSpec MOS + MIRI Imaging

This combination is also only offered with NIRSpec MOS as the primary, which drives the pointing. There is no option to add customized dithers for this coordinated parallel combination, because the nominal moves of the field of view by integer MSA shutters (i.e., the "nods" in the MSA Planning Tool) already provide adequate pixel sampling for MIRI Imaging, and small sub-pixel dithers would not add any significant improvement to the data quality of the resulting MIRI Images. The spatial offsets in MIRI pixels associated with nominal nods between MSA shutters are tabulated below in Table 2.

Table 2. MIRI spatial offsets associated with NIRSpec nods between MSA slitlet shutters

MSA Shutter Setup	MIRI Pixel Offsets	MIRI Pixel Phases
2 shutter slitlet	(0.000, 0.000), (3.363, 3.192)	(0.000, 0.000), (0.363, 0.192)
3 shutter slitlet	(0.000, 0.000), (3.363, 3.192), (-3.363, -3.192)	(0.000, 0.000), (0.363, 0.192), (0.637, 0.808)
5 shutter slitlet (shutters 1, 3, 5)	(0.000, 0.000), (3.363, 3.192), (6.725, 6.384), (-3.363, -3.192), (-6.725, -6.384)	(0.000, 0.000), (0.363, 0.192), (0.725, 0.384), (0.637, 0.808), (0.275, 0.616)

Published	30 Mar 2017
Latest updates	• 02 Jan 2020 Updated to include descriptions for Coordinated Parallel combinations implemented in APT 2020.1. • 11 Mar 2019 Updated for APT 27.1 release • 08 Feb 2018 Updated with current capabilities being offered for Cycle 1 • 16 Nov 2017 Previously called "JWST APT Parallels." This article is specific to coordinated parallels. Pure

	parallel section was split off to a separate new article. • 14 Jun 2017 Added some “warning” information related to APT 25.1

APT Pure Parallel Observations

Pure parallel science observations are proposed and implemented differently in JWST APT from regular observations and from coordinated parallel observations.

On this page

See also: JWST Parallel Observations for an overview and templates allowing pure parallel attachments.

Pure parallel observations form entirely separate programs from the primary science observations they will be attached to, and hence involve a separate APT proposal. Pure parallel programs will use observing slots created by approved "regular" proposals that will be identified for possible use with pure parallel observing. However, by the nature of these proposals, the details cannot be known at the time of initial submission.

For pure parallel proposing, you will not specify targets initially but rather enter some number of realistic placeholder observations into APT to indicate the kinds of pure parallel exposures that are needed for your proposed science. You must decide what kind of slots and pointing constraints will accommodate your science goals and the number of slots needed to accomplish the science you propose, and you will need to specify a reasonable estimate of the exposure specifications and total amount of observing resources that will be used if the proposal is accepted (see below). This information is needed so that you (and the TAC) will have an assessment of the total potential impact of the proposal, should it be approved. Details must be provided in your science justification, which will be attached to your APT file prior to submission (as with other programs).

After acceptance, and when the available pure parallel slots are known, you will develop a detailed APT proposal and attach proposed observations to actual parallel slots. This process is described in more detail below.

Pure parallel observing was not permitted as part of GTO or DD-ERS proposing, but is being made available to cycle 1 proposers on a shared risk basis. Ongoing development is needed to support a full implementation in the scheduling system.

> As with coordinated parallels, pure parallel exposures nominally hide completely under the primary exposures to which they attach. However, because of the way the onboard scripts operate, the script compile times must be done serially for the primary and parallel exposures. Hence, it is recognized that adding pure parallel exposures will have some modest impact on the resources accounted to the primary program. The magnitude of this impact is not currently known, and is not modeled in the APT accounting process, but this impact will not in actuality be accounted against the primary proposal.

Proposing for pure parallels

See also: Cycle 1 Call for Proposals

Proposers must decide what kind of parallel observations (observing mode, filters and/or grisms, minimum exposure times needed, etc.) will accommodate their proposed science, and how many such observations would be needed. (If appropriate, a *range* in the number of observations that would be acceptable may be given.) Furthermore, pure parallel proposers will have to specify any other restrictions on the desired slots to which their parallel observations are to be attached (e.g., allowed ranges of galactic or ecliptic latitude). These details must be described in the "Description of the Observations" section of the science PDF proposal attached to APT prior to submission. Pure parallel observations are not allowed to place timing or position angle constraints on the proposed observations.

How to use APT to prepare a pure parallel proposal: After opening a new JWST APT proposal, select the ***Pure Parallel Program*** check box on the Proposal Information page, which designates the APT file as being a pure parallel proposal. This removes the *Targets* section of the APT file, and a value of "Parallel" is entered automatically into your example observations templates. The proposer should fill out one or more observing templates in APT (one typical example for each observing mode being requested) to indicate the relevant parameters of the exposures being requested. Details on how to fill out the relevant APT templates and estimate the observing resources being requested are given below.

> The "normal" proposal accounting numbers produced by APT will not not meaningful for pure parallel proposals and can be ignored, but an alternate method of calculating an estimated resource time to enter into the Proposal Information form of APT must be provided. See below for details.

After acceptance of a pure parallel program, actual observing slots must be assigned to your observations. A helper tool within APT may be made available in the second half of 2020 to assist successful proposers with this task, or STScI may simply provide a listing of available observing slots for pure parallel science that will include the characteristics of each slot, so users can judge their appropriateness for their science goals. Depending on the number of pure parallel proposals accepted and the severity of the competition for available slots, STScI may convene the accepted PIs of pure parallel programs into a negotiation process to assign the slots. Once the slots are assigned, each PI will need to prepare an APT proposal specifying the actual observational details for each slot and submit it for use in scheduling. This needs to happen as soon as feasible after acceptance because the details are needed to construct a valid long range plan, which drives the scheduling process for each new observing cycle. STScI will contact accepted proposal PIs with the details and schedule.

Filling out APT forms for pure parallel proposals

1. In the ***Proposal Information***[*] section, check box ***Pure Parallel Proposal***.

2. In the ***Observations*** section, click on ***New Observation Folder***.

3. Create one observation for each type of observation and exposure required to execute the proposed pure parallel science. In this context, "type of observation and exposure" means a combination of instrument, observing mode, optical element selection (filter(s) or grism), and minimum exposure duration. **Note that if more than one exposure setup is proposed to be obtained at a given position on the sky** (e.g., imaging with more than one filter per filter wheel, or WFSS observations with a grism as well as direct images), **one observation needs to be created for each of those exposure setups**. This is different from regular observation template specifications where multiple filters could just be listed sequentially within a given instance of the observation template.

4. For each of the observations specified, fill out the exposure specifics. This is done as follows for the observing modes available for pure parallel observations:
   a. For the *NIRCam Imaging* template (Instrument = NIRCam, Template = NIRCam Imaging):
      i. Select desired ***Module*** and ***Subarray***.
      ii. Select desired ***Short Filter***, ***Long Filter***, ***Readout Pattern***, ***Groups/Int***, and ***Integrations/Exp***.
      iii. Read off duration of Observation in "Total Charged" box in top area of the template. *Note down this value for this Observation*.
   b. For the *MIRI Imaging* template (Instrument = MIRI, Template = MIRI Imaging):
      i. Select desired ***Subarray***.
      ii. Select desired ***Filter, Readout Pattern, Groups/Int***, and ***Integrations/Exp***.
      iii. *Select* ***Exposures/Dith = 1****.*
      iv. Read off duration of Observation in "Total Charged" box in top area of the template. *Note down this value for this Observation*.
   c. For the *NIRISS Imaging* template (Instrument = NIRISS, Template = NIRISS Imaging):
      i. Select ***Subarray = FULL***.
      ii. Select desired ***Filter, Readout Pattern, Groups/Int***, and ***Integrations/Exp***.
      iii. Read off duration of Observation in "Total Charged" box in top area of the template. *Note down this value for this Observation*.
   d. For the *NIRISS WFSS* template (Instrument = NIRISS, Template = NIRISS Wide Field Slitless Spectroscopy):
      i. Select ***Mode*** ("DIRECT", "GR150C", or "GR150R"). *Note that for NIRISS WFSS Pure Parallel proposals, one of the Observations needs to specify a Direct Image exposure*. (To direct the user in this respect, the ***Mode*** is defaulted to "DIRECT".) For Cycle 1, we recommend that one Direct Imaging Observation be created for each Filter used in the proposal.
      ii. Select desired ***Filter, Readout Pattern, Groups/Int***, and ***Integrations/Exp.***

5. For each of the Observations created as described above, evaluate how many distinct pointings (meaning distinct targets of the primary observations, i.e., *ignoring dithers*) will be required at a minimum to fulfill the science goals laid out in the proposal. Make sure these numbers are mentioned and justified in the *Description of Observations* section of the proposal PDF attachment.

6. Calculate the grand total duration of the pure parallel observations proposed. Calling the durations of the *m* different Observations "Dur_i" and the associated minimum number of pointings for each Observation "N_i", this grand total duration is equal to the following: $\Sigma_{i=0}^{m} N_i \; Dur_i$

7. In the "Proposal Information" section in APT, click on "Request custom time allocation" button.

8. In the "Requested Time" box that shows up, enter the grand total duration value calculated in the previous step. Make sure you choose the correct time unit (which is currently defaulted at "Days"). You can ignore the accounting numbers produced by APT automatically, as they are not relevant for pure parallel proposals.

9. In the "Time Req Explanation" box, enter the following: "Pure Parallel proposal. Allocation value entered following prescription given in the **JWST APT Pure Parallel Observations** article."

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

Published	30 Nov 2017
Latest updates	• 11 Oct 2019 Minor updates in preparation for Cycle 1. • 11 Mar 2019 Updated for APT 27.1 release • 09 Feb 2018 Changes made for consistency with current Cycle 1 expectations for pure parallel support.

JWST APT Help

There are a number of ways to get help both within APT and from additional sources.

On this page

See also: APT training examples and video tutorials and JWST Help Desk

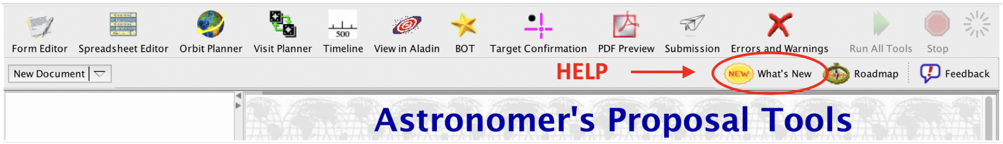
APT is one of the primary tools needed by JWST observers to plan and submit their observing proposals. JWST APT has an invaluable heritage from a similar tool use by the Hubble Space Telescope, and as such there are a number of ways to get help with questions both large and small. There are general topical support articles, each covering some aspect of the APT suite of tools and/or techniques used by multiple instruments (e.g. mosaicking or dithering). There are descriptive articles on each of the observation templates to help the user in entering specific observation information. If you are unfamiliar with the JWST implementation of APT, you should refer to the APT Overview to obtain a grasp on the overall workings of this important tool. There are also a number of short video tutorials on APT that you may want to watch.

The remainder of this article addresses some other ways to get help with APT.

Help within APT

On the top toolbar of the APT GUI is a link to **What's New***. Selecting this link opens a separate window containing APT version comments and links to training materials. With each new release of APT, a section is added highlighting the major changes from the previous version. In addition, direct links to APT training exercises including video example walkthroughs for some functionalities items are available through this link for quick reference. Figure 1 shows the location of the **What's New** link on the toolbar.

Figure 1. APT top toolbar with "JWST What's New" highlighted



The APT Top Toolbar menu highlighting the location of the What's New link.

Within APT itself, a number of checks are performed in an ongoing way as you enter information and warnings and errors are reported to the user. Red X's appear when required information is missing or if unsupported values have been selected or entered into a field. For example, a red X will appear on your proposal cover page until such time that your science PDF proposal is completed and attached to your APT file. Yellow caution icons indicate warnings that may or may not be a real problem, depending on the context, so you need to check. Since warnings are conditional, APT programs can be submitted even if warnings are present.

Hovering the cursor over either error or warning icons provides a pop-up box with a short text description of the condition generating the flag. These are necessarily terse, and some are more descriptive than others. A more detailed summary of errors and warnings can be obtained via the red X icon on the top menu bar, where a "list" and "summary" tab allows viewing of the compiled errors in the proposal in different formats. Alternatively, one can select the errors and warnings box that remains at the lower right corner of the APT GUI no matter which section of the tool one is using at a given time. Often times, the information provided in these pop-up boxes or summary lists is sufficient to allow a user to correct a given situation.

Errors come in 2 varieties: (1) missing information that is required, and (2) invalid entries or problems that affect the schedulability of the proposed observations. Obviously, the former errors are removed when valid entries are entered in the required fields. Errors affecting schedulability are more serious, especially in the mode of single-stream processing where accepted proposals flow quickly into scheduling. Ideally, ***no errors should remain in the proposal at the time of submission.*** Exceptions are allowed only in cases where the error cannot be resolved with a reasonable amount of effort or if an unanticipated condition has arisen that APT cannot handle. In such cases, it is recommended that you check the JWST Help Desk for any reported exceptions and/or discuss the problem with STScI support personnel. Upon submission, you will be asked to supply a description of any remaining errors in your proposal at the time of submission.

Context-Sensitive help is another form of assistance available with APT. If you hover the cursor over many of the sectional titles in the APT GUI, a small "?" appears next to the cursor if context-sensitive help is available for that item. Clicking on the heading will pop up a separate window and connect you to relevant text descriptions within the JWST user documentation articles. In some cases, secondary links are then available for more detailed information.

* ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

APT practice files and examples

The design of the JWST branch of APT uses a concept called observation templates to make it as straightforward as possible to enter the required information for each of the instrument modes available to users. For users who want example APT programs for each instrument and available template, a "retrieve" option is available directly from within APT. After opening APT, use the **File --> JWST Demonstration Proposals** option to access a list of prototype programs by instrument. *These are not intended to be valid science use case examples, although effort has been made to enter values that remove as many warning and error indicators as possible.* Alternatively, you can simply open a new JWST proposal and start from scratch to practice using APT. You can choose to save your practice proposal(s) to your local disk or discard them at the end of your session. (APT will prompt you when you exit.)

While these examples are useful for getting you started with a practice program, there are any number of more complicated aspects to specifying JWST observations in APT that are more difficult. For these situations, several JWST APT functionality examples (for mosaics, coronagraphy, and solar system programs) are available in the APT Demonstration Proposals listing that users can study to understand these more complicated activities.

The JWST instrument teams have crafted a number of Example Science Programs that are detailed walk-throughs of various science use cases, including background on why various choices are being made in the example. Each of these programs also has a step-by-step guide for ETC and APT, as well as associated ETC workbooks and APT files you can load in the tools and follow along with the example program.

Finally, the Workshop in a Box materials that were derived from the JWST Master Class training materials in November 2019 have a range of topical APT materials that may be of interest for new users.

APT video tutorial help

APT is used by both HST and JWST proposers to plan and submit their observing proposals.. There are generic aspects of APT that are used by both branches, and then there are aspects that are specific to one or the other of these missions. Since APT has been around for a number of years on the HST side, there are HST or generic APT training materials and videos available, some of which are general enough to be useful for JWST users as well. STScI has also provided a number of JWST-specific video tutorials. The APT-specific materials are available in the article APT training examples and video tutorials, or you can link directly to the JWST Observer YouTube channel where many of the videos are hosted.

If you have specific suggestions for additional APT help support that is needed, we suggest providing this input via the JWST Help Desk.

Published	03 May 2017

Latest updates	• 10 Dec 2019 Totally revamped APT Help page in support of cycle 1.

JWST APT Video Tutorials

The article provides connection to short video tutorials demonstrating various aspects of the Astronomers Proposal Tool and the Aladin visualization tool within APT.

On this page

See also: JWST APT Help

Video Tutorials Master Listing

APT is used by both HST and JWST proposers to plan and submit their observing proposals. There are generic aspects of APT that are used by both branches, and then there are aspects that are specific to one or the other of these missions. The first table below lists Video help specifically made for the JWST branch of APT. Since APT has been around for a number of years on the HST side, there are HST or generic APT training materials and videos available as well, some of which may be useful for JWST users as well. These *Legacy Videos* are provided in a second table below, with the caveat that the details may be different as these videos were made for older versions of APT.

Documentation for JWST APT and Aladin*

Title	Video Length
APT GUI Overview	5:06
APT Visit Planner	8:49
Adding Special Requirements in APT	5:44
Specifying Mosaics in APT	13:40
APT Errors and Warnings	3:06
APT Graphical Timeline	6:20
Aladin Overview in APT	9:13
Using Aladin and APT Visit Planner	5:00

Legacy APT/Aladin*

Training materials written for HST (but possibly useful for JWST)

Title	Video Length
Using the Find feature	3:30
The Differencing Tool	5:30
How to use the MAST Portal from APT	7:00
How to retrieve minor body orbital elements from Horizons	2:00
Using the Aladin Multiview Function	1:30

If you have specific suggestions for additional help support that is needed, contact the JWST Help Desk.

* Aladin is the tool for visualizing observations within APT.

Published	15 Nov 2017
Latest updates	• 13 Dec 2019 Article updated for Cycle 1 Call for Proposals release.

APT Observation Templates

JWST observations of a given target are planned in APT using observation templates for a given JWST instrument and observing mode.

On this page

Observations are specified in the Astronomers Proposal Tool, APT, by selecting a target and an instrument observing mode. Each observing mode has a corresponding APT template that allows the user to specify parameters appropriate to that mode of operation. A JWST observing proposal is a set of observations specified by filling out one or more of these templates in APT. A proposal may call for multiple templates from any of the four JWST instruments, depending on the science goals of the program. Separate observations must be specifiied when using different JWST instruments or observing modes for a given target, except when used in coordinated science parallels.

MIRI APT Templates

- MIRI Imaging APT Template
- MIRI LRS APT Template
- MIRI MRS APT Template
- MIRI Coronagraphic Imaging APT Template

NIRCam APT Templates

- NIRCam Imaging APT Template
- NIRCam Coronagraphic Imaging APT Template
- NIRCam Time-Series APT Template
- NIRCam Grism Time-Series APT Template
- NIRCam Wide Field Slitless Spectroscopy APT Template

NIRSpec APT Templates

- NIRSpec Multi-Object Spectroscopy APT Template
  - MOS Roadmap
  - NIRSpec MSA Planning Tool, MPT
- NIRSpec IFU Spectroscopy APT Template
- NIRSpec Fixed Slit Spectroscopy APT Template
  - NIRSpec FS and IFU Mosaic APT Guide
- NIRSpec Bright Object Time-Series APT Template

NIRISS APT Templates

- NIRISS Wide Field Slitless Spectroscopy APT Template
- NIRISS Single-Object Slitless Spectroscopy APT Template
- NIRISS Aperture Masking Interferometry APT Template
- NIRISS Imaging APT Template

Creating Coordinated Science Parallel Observations

Coordinated parallel observations can be specified in APT for the combinations of templates mentioned below. Such observations are defined within the same APT proposal as the primary observations. More information about specifying coordinated parallel observations is provided in the APT Coordinated Parallel Observations article.

- NIRCam Imaging + MIRI Imaging (and vice versa)
- NIRCam Imaging + NIRISS Imaging
- NIRCam Imaging + NIRISS WFSS (and vice versa)
- NIRCam WFSS + MIRI Imaging
- NIRCam WFSS + NIRISS Imaging
- MIRI Imaging + NIRISS WFSS (and vice versa)
- NIRSpec MOS + NIRCam Imaging
- NIRSpec MOS + MIRI Imaging

Published	15 May 2017

Latest updates	16 Dec 2019 Added coordinated parallel combinations that were added in PPS 14.9

JWST ETC to APT Interface Support Information

There are a number of subtle differences at the interface of the JWST Exposure Time Calculator and the Astronomer's Proposal Tool about which users should be aware.

On this page

See also: JWST Exposure Time Calculator Overview, JWST Astronomers Proposal Tool Overview
See also: JWST APT-ETC Connectivity

The JWST Exposure Time Calculator (ETC) and Astronomer's Proposal Tool (APT) are 2 of the primary tools that proposers must use in constructing viable JWST proposals. For JWST Cycle 1, the tools will be used separately, with relevant information transferred from ETC to the appropriate APT templates by the user. Significant effort has been expended in development of these tools to coordinate the interface, but there are a number of subtle differences between the tools that remain. This article provides a vehicle for highlighting these interface issues while providing links to more information where it is needed.

> The JWST Astronomer's Proposal Tool and Exposure Time Calculator are under continuous development and subject to future updates. Current documentation is best effort based on ETC v1.5.1 and APT v2020.1.1.

Tracking ETC assumptions in APT

In the APT observation templates, the exposure specification sections for both target acquisitions (if present), and science exposures contain a box where you can enter, for future reference, the ETC workbook and specific calculation ID that was used to determine the entered exposure specifications. The use of this box on your science observations is entirely optional, but entering this information may help you to track the assumptions used in specifying your APT observations by tying them back to your ETC workbook. Because the use of the ETC for specifying target acquisition information is particularly important to the success of your observations, APT places a warning on this field if no entry is provided. For accepted proposals, technical reviewers may contact you for more details about your assumptions.

Details on the use of these boxes and handy examples are provided in JWST APT-ETC Connectivity.

General interface issues

APT warnings and errors are not always reflected in ETC: The ETC needs to be able to support engineering users as well as astronomers. Hence, it was developed to allow a user to choose values for various parameters that are not available by default, but can be accessed for engineering purposes. APT contains numerous warnings and errors that alert users when they are attempting to select options that are not available by default. Unfortunately, those errors and warnings are not always reflected directly in the ETC. That is, the ETC may let you select options that will be considered invalid when the information is transferred to the appropriate APT template.The number of groups and the number of integrations vary by instrument, and users are advised to consult the documentation on JWST Astronomer's Proposal Tool (APT) and JWST instruments for more information on the allowed range of values for these detector parameters. The ETC does not support NGROUPS=1 and will alert the user with red color if Groups per integration is set to 1 and will prevent the ETC calculation from being completed. The detector parameters available for the different instruments and modes are set to be consistent with that offered by the APT. However there are cases in which ETC allows the number of groups, the number of integrations and the number of exposures to exceed the limits imposed by APT, so it is important for users to check with APT to ensure what the limits are while planning observations.The instrument sections below highlight some of the more obvious and significant examples that may occur for normal users.

ETC-APT nomenclature differences: A significant effort has been made to standardize the use of keywords and parameter names between the 2 tools. However, there are many details involved, with some depending on context, that have made it impossible to be entirely consistent. While further improvements are being made, users should just be aware that there may be some minor differences, usually understandable with the help of the documentation below and the links provided.

Handling of dithered observations: The templates of nearly all modes in APT allow the user to select various dither patterns, and sub-dithers in some cases, that are not handled explicitly in ETC. To first order, if one assumes the total number of exposures to be made in the full dither pattern in APT and uses that number of exposures in the ETC, you are approximating the situation fairly well. But there can be exceptions to this general rule that need to be considered. These cases are also called out in the sections below, as appropriate.

NIRCam interface issues

Nomenclature inconsistencies: In APT, there are separate NIRCam imaging and a NIRCam Time Series imaging templates, which each include both the short-wavelength (SW) and long-wavelength (LW) detector setups. In ETC, however, these are split in 2 modes: SW imaging (SW Time Series) and LW Imaging (LW Time Series).

Subarray inconsistencies between APT and ETC: The imaging templates in the ETC include subarrays meant only for use in grism mode. These will be labeled as unavailable for imaging in future ETC versions. See the NIRCam Detector Subarrays article for more information. As of ETC 1.2, a warning message is generated that the grism subarrays may not be supported in NIRCam imaging.

*Neutral density squares:*In ETC, neutral density (ND) squares are listed as options for coronagraphy. ND squares should only be used for target acquisition. This is specified in APT when choosing *Acq Target Brightness* = BRIGHT. As of ETC 1.2, a warning message is generated that this is an unsupported option and ND squares are for TA only.

Readout output channels: In the APT grism time-series template, users can choose to use either 1 or 4 output channels when reading out the detector, with more channels resulting in shorter exposure times. In ETC, users will be able to choose between 2 options for a given subarray, e.g., "SUBGRISM64" or "SUBGRISM64 (noutputs=1)". Choosing the option that does not specify the number of outputs results in noutputs = 4, which is the default.

Uneven spatial coverage with primary NIRCam dithers in the ETC: In general, dithers are approximated in the ETC by increasing the number of exposures in the *Detector Setup* tab. Since most dither options only move the position by a small number of pixels, putting the number of total dither steps in the Exposures box is sufficient for estimating the total S/N over the majority of the spatial coverage in most cases.

However, NIRCam primary dither patterns are designed to cover detector and module gaps, and therefore take large steps (≈1′ for some patterns). These steps result in uneven depth across the mapped coverage. Users should carefully consider what to enter as the number of exposures in the ETC based on the coverage maps of the implemented dither pattern. In the case of the FULL patterns, the average frame depth is ≈70% of the number of dithers such that including 3 dithers results in a depth of 2 frames across most of the spatial coverage. In this example, users should specify *Exposures* = 2 in the ETC to avoid over-estimating the S/N. In the case of the INTRAMODULE and INTRASCA patterns, the depth is decreased in the center of the SW coverage.

Note also the message above about the actual S/N being higher than the ETC estimates when flat fielding is accounted for.

MIRI interface issues

Potential confusion regarding exposures in ETC: Since MIRI can have multiple exposures per dither, one must use 2 fields in APT (exposures/dither and Total Number of Dithers) to get the right number of exposures to use in the ETC calculation.

Backgrounds in ETC: In the ETC, the "IFU Nod In Scene" strategy is equivalent to an APT dither, while the "IFU Nod Off Scene" strategy indicates a separate background pointing. The latter would actually be 2 separate observations in APT.

Observing modes vs. subarrays: The MIRI Low Resolution Spectroscopy (LRS) observing mode allows users the option of using a Slit or observing in Slitless mode. In APT, the user selects "MIRI Low Resolution Spectroscopy" from the "Template" drop-down menu and is given the option under "LRS Parameters" for a "Subarray" of either "FULL" or "SLITLESSPRISM." The "FULL" subarray is for LRS Slit observations. In the ETC, there are 2 separate options in the MIRI drop-down menu for "Low Resolution Spectroscopy (LRS) Slit" and "Low Resolution Spectroscopy (LRS) Slitless" calculations.

Readout patterns: The readout pattern options in APT and ETC may be somewhat different in the 2 tools. For the low resolution spectroscopy (LRS) slitless and coronagraphic imaging modes, the ETC allows the user to choose FAST or SLOW readout, while APT only allows FAST. This is to accommodate engineering users of ETC, as described in the general section above. Refer to APT and the relevant template, which shows the correct readout patterns allowed for Cycle 1 General Observers.

MIRI MRS: Each observation specification in the APT corresponds to 4 separate calculations in the ETC (Channels 1-4 for the specified Wavelength Range). To cover the full MRS wavelength range, 3 separate observations must be specified in the APT, one for each Wavelength Range: SHORT(A), MEDIUM(B), and LONG(C). This corresponds to 12 separate calculations in the ETC. Additionally, simultaneous imaging calculations must be specified separately in the ETC using a MIRI Imaging calculation.

NIRSpec interface issues

As with other instruments, one needs to understand the total number of exposures (including dither steps) to use in ETC to estimate the expected S/N that will be achieved.

NIRSpec available science modes in the ETC: The NIRSpec instrument observing mode options within the ETC include: Multi-Object Spectroscopy (MOS), IFU spectroscopy, and Fixed Slit (FS) and Bright Object Time Series (Fixed Slit/BOTS) spectroscopy. There is no mode in the ETC that is specified only for NIRSpec Bright Object Time Series (BOTS) observing. Sensitivity calculations for the BOTS observing mode are carried out using the FS /BOTS spectroscopy option in the ETC, using the ***S1600A1***[*] slit, which is the 1.6" x 1.6" square aperture that is designed for the time series observations in BOTS. All of the available science subarrays for BOTS mode observations are accessible and labeled as such in the ETC detector ***Subarray*** pull-down menu in the **Detector Setup** tab.

NIRSpec dithers: In general, for all modes, dithering strategies are mimicked in ETC by the number of exposures in the **Detector Setup** tab. For example, in the NIRSpec IFU Nod in Scene strategy, if you wish to use a 4-point observing dither pattern, the number of integrations per exposure should be specified as 2, since each integration in this mode accounts for 2 dither positions in the ETC.

NIRSpec imaging calculations: As of ETC 1.5, there is the option to calculate signal-to-noise in user-selected exposure times in NIRSpec imaging data acquired with the mirror in the grating wheel assembly. NIRSpec imaging observations that might require different exposure times include "Verify_Only" pointing verification exposures, as present in the ETC as modes “IFU Verification Imaging” and “MOS Verification Imaging”, as well as NIRSpec MOS "Confirmation Images", which is specified using the “MOS Confirmation Imaging” mode. The NIRSpec "Target Acquisition" (TA) ETC calculation mode delivers signal-to-noise in the fixed exposure time set by the detector readout pattern NRS, NRSRAPID1, NRSRAPIDD2, or NRSRAPIDD6 (traditional readout) used for the ngroups=3 image acquired for TA.

NIRSpec IFU "Nod in Scene" in the ETC: The default background subtraction in the **Strategy** tab in the NIRSpec IFU ETC is for 2-point nodding in-scene. This option uses an offset pattern of x=0.5", y=0.5", which is not the same as the 2-point nod positions that are available as observing options in the APT. However, the values can be edited by the user to agree with the APT 2-point nod positions. Nodding in-scene should only be used for very compact (<0.3") science sources. For sensitivity calculations on all spatially extended science sources, the ***Nod Off Scene*** option in the **Strategy** tab is encouraged for use.

NIRSpec IRS2 detector readout patterns and subarrays: The noise reducing IRS2 detector readout patterns (***NRSIRS2*** and ***NRSIRS2RAPID***) cannot be used with subarray readouts of the detector. APT will give an error if these IRS2 readouts are selected with subarray detector patterns in FS mode. (IRS2 readout patterns must be used with FULL readout of the array.) As of ETC 1.2, the detector setup does not allow to choose IRS2 detector readout patterns with subarray readouts. This is only an issue in the ETC when distinguishing between the FS science mode and the BOTS mode of NIRSpec because subarrays are not permitted in MOS or IFU science modes. The BOTS mode cannot use IRS2 readout patterns.

NIRSpec BOTS integrations: A single integration should be specified to compute the S/N. Otherwise, the ETC will calculate the S/N over all integrations, averaging as it does for a FS calculation. Multiple integrations should not be averaged for S/N, as the scene is changing during a time-series observation.

[*] ***Bold italics*** style indicates words that are also parameters or buttons in software tools (like the APT and ETC). Similarly, a **bold** style represents menu items and panels.

NIRISS interface issues

SOSS GR700XD/F277W combination: As of APT v. 2020.1, users have the option to include an exposure using the F277W filter crossed with the GR700XD grism. As of ETC v. 1.5.1, the ETC does not yet offer the GR700XD /F277W combination. The throughput of the F277W filter is about 90% that of the CLEAR filter, so users can estimate the SNR for the GR700XD/F277W exposure by multiplying the SNR of a GR700XD/CLEAR calculation in the ETC by a factor sqrt(0.9) ~ 0.95.

Detector readout pattern inconsistencies: For the single object slitless spectroscopy (SOSS) mode, only the NISRAPID readout pattern is supported when using the SUBSTRIP96 and SUBSTRIP256 subarrays. ETC allows the use of the NIS readout pattern for SOSS subarrays when performing calculations, but will issue a warning if the NIS readout pattern is selected when using a subarray. The NIS option is not allowed in the SOSS APT template when using a subarray. Both NIS and NISRAPID readout patterns are supported for full frame readout.

Direct imaging in wide field slitless spectroscopy (WFSS) and aperture masking interferometry (AMI) modes: The APT template for WFSS includes a required field for direct imaging, before and after a set of dithered grism observations. The APT template for AMI includes an optional field for direct imaging. ETC calculations for these modes do not include a direct imaging component. To run calculations for direct imaging, use the NIRISS imaging mode in ETC. If the direct imaging for AMI requires use of a subarray it is okay to use the subarrays marked as engineering mode only in ETC.

Exposure times in APT and ETC include reset frames: For science cases where the aim is to detect a total number of photons (e.g., to achieve a specific contrast ratio when observing with AMI), recall that the total exposure time is *(Number of groups + 1) x Number of integrations x frame time,* while the total photon collecting time is *Number of groups x Number of integrations x frame time*. The *+1* factor in the total exposure time reflects the frame reset time, when no photons are detected.

Published	20 Nov 2017
Latest updates	• 06 Jan 2020 Updated for Cycle 1 APT 2020.1.1 and ETC 1.5.1. • 13 Feb 2019 Updated NIRISS section to be consistent with ETC v.1.3 and APT v. 27.0

JWST APT-ETC Connectivity

JWST APT contains boxes on exposure specification lines that permits users to to enter tracking information to specific ETC workbooks and calculations for reference. A handy link also allows users to enter the ETC directly from within APT, if desired.

On this page

See also: JWST ETC to APT Interface Support Information

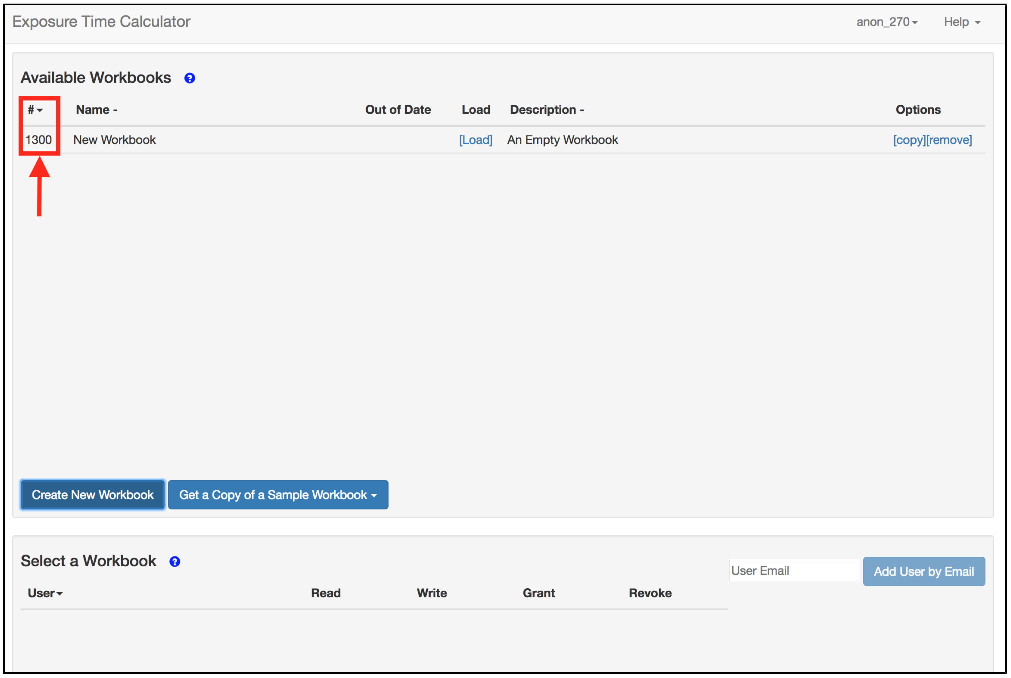
APT contains data entry boxes (referred to here as the “ETC Wkbk.Calc ID boxes”) on the exposure specification lines in each observation template where the user can (at their discretion) add cross-reference information to a specific ETC workbook (WB) and calculation (CALC) ID within the notebook. For templates that include target acquisition (TA) exposures, entry of a cross reference to an ETC calculation is strongly encouraged to add confidence that the TA will be successful. For the science exposures, the user may find it useful for future reference to annotate one or more exposure specs with the ETC WB and CALC ID to inform the exposure information provided in APT, as described in more detail below.

Using the ETC Wkbk.Calc boxes

The use case assumed here is that the user has used the ETC to create one or more ETC WBs and generated any number of calculations within each; some CALCs may have been test calculations and others may represent the “final” CALC the user wants to transfer to a particular APT observation and exposure specification. It is the user’s responsibility to track which CALC(s) is (are) relevant for actual use in APT, perhaps using the “Notes” area within a given ETC WB and/or within APT Comment blocks.

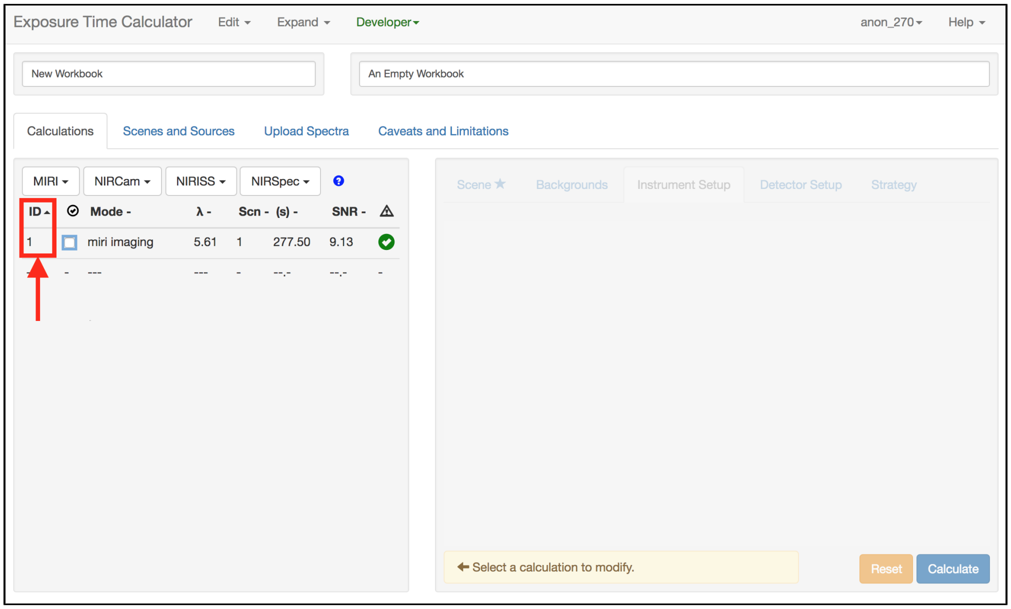
While each ETC WB is given a name, it is also assigned an unique ID number; it is this number that is used for cross referencing in APT. Currently, the WB ID number can be found in the listing of your notebooks after you sign in to the ETC (Figure 1). Also, within each WB, each calculation is numbered (Figure 2). Hence, the combination of WB ID and CALC ID points to a unique calculation.

Figure 1. Locating the ETC Workbook ID



On the Available Workbooks pane, the workbook ID number is located on the far left, before the workbook name (denoted by the box and arrow). Each workbook receives an unique ID number; this value cannot be changed by the user.

Figure 2. Locating the Calculation ID



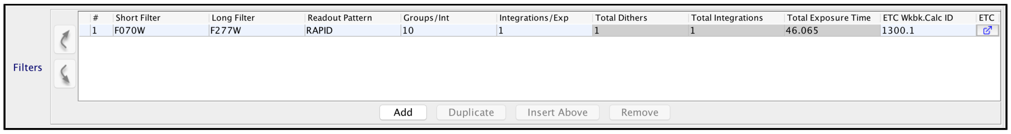
After opening a workbook, the calculation ID number can be found on the far left in the "Calculations" tab (denoted by the box and arrow). This calculation ID is unique within each workbook and cannot be changed by the user. If a calculation is deleted, the ID number of that calculation will not be re-used within the workbook.

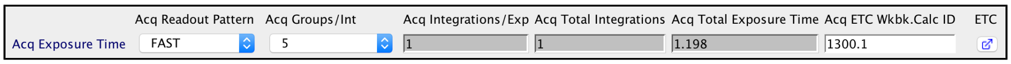
The format expected for the ETC Wkbk.Calc ID Boxes in APT are a combination of the WB ID and the CALC ID, separated by a decimal point: NNNNN.mmm, where NNNNN is the WB ID and mmm is the CALC ID (no leading zeroes needed).

For example, if the WB ID is 1300 and the relevant calculation is #1, the user would enter 1300.1 into the relevant ETC Wkbk.Calc ID Box in APT.

If the user has kept track of the relevant WB.CALC numbers separately, they can be entered directly into the ETC Wkbk.Calc ID Boxes in APT. The user can also validate these entries by opening the ETC directly from within APT (Figure 3).

Figure 3. ETC Wkbk.Calc ID examples in APT





Examples of the ETC Wkbk.Calc ID boxes filled out in APT for a NIRCam imaging observation (top) and a MIRI target acquisition (bottom). Clicking on the button below "ETC" in both cases will take the user to the specified workbook and calculation.

Connectivity between APT and ETC

As of version 26.1, APT provides a way to open a relevant ETC WB directly from within APT, and even open a specific CALC if the number is known. Here are some example use cases where this functionality might be useful.

Use case 1: user is entering info into a new APT Observation template exposure specification

(a) If the user knows the relevant WB.CALC information for a given exposure, it can be entered directly into the relevant ETC Wkbk.Calc ID Box in APT.

(b) If the user only knows the WB ID but not the CALC ID to reference, enter only the WB ID and select the button to the right of the ETC Wkbk.Calc ID box. (Hovering over this button shows the pop up “Open ETC in separate browser window.”) Assuming it is a valid ETC WB ID number, the referenced WB will open in a separate browser window. You can then inspect the calculations and/or any tracking notes you may have entered in the ETC WB to identify the specific CALC you want to reference, and add that CALC ID to the entry in the ETC Wkbk. Calc ID Box in APT.

(c) If the user knows neither of these numbers, clicking on the "Open ETC" button will point the user to the ETC "Available Workbooks" pane (Figure 1) where a WB can be selected if desired. If an invalid ETC WB ID is entered, the user will see an error message “404: Not Found” in the browser. Of course, the user can just open the ETC separately on their own rather than using the APT-ETC connectivity capability to find the correct ETC WB to reference, if desired.

Use case 2: validating a previously entered ETC Wkbk.Calc ID entry in APT

If the user wants to open a specified ETC Wkbk.Calc ID to inspect or confirm the information, select the button to the right of the ETC Wkbk.Calc ID box, and the referenced ETC WB (and CALC if provided) will open in the browser. You can then confirm the information in the referenced CALC.

> Since ETC WBs are confidential, a user must have permission to view the indicated WB; if not, an error message ("404: Not Found") is produced in the browser. If you are a collaborator, contact the ETC Workbook owner and have them provide permission to the ETC WB.

Additional information and caveats

- Entering an ETC Wkbk.Calc ID into the box in APT is not validated unless the user tries to open the ETC from within APT. If the WB ID was valid but the CALC ID is not valid, the ETC WB will still be opened, and it will be up to the user to select and enter a valid CALC ID in APT. If the entered ETC WB ID is invalid, you will receive an error message in the browser ("404: Not Found").

- Some users may have multiple ETC WBs and want to reference CALCs from them. This is not a problem as each ETC Wkbk.Calc ID Box in APT is independent and can point to different ETC WBs as needed. However, since each call to “Open ETC” will open a new instance of ETC in a separate browser window, users should take care to avoid confusion with multiple WBs being open.

- Another situation that may arise for some users is that a particular ETC calculation may be used as a template for scaling to additional target/observation combinations (as opposed to running a separate calculation for each target/observation combination). It is up to the user to track any such situations, either with annotations in the ETC WB or using the “Comment” blocks within APT. It is also up to the user as to whether they choose to indicate the ETC Wkbk.Calc ID in APT for this situation or track this information separately.

- The use of ETC Wkbk.Calc ID boxes in APT is optional (although strongly encouraged for any target acquisition specifications), and is primarily there to help the user keep track of their assumptions, especially when looking back at the proposal after the fact. ETC workbooks are considered proprietary and will not be made available to reviewers of JWST proposals. However, for accepted proposals, users may be contacted by technical review staff requesting more information about the assumptions used so they can be verified (again, especially for target acquisitions) and having this information documented in APT will be beneficial and will speed up the review process for accepted proposals.

> There are no protections in place to keep a user from changing a referenced CALC after the fact. To maintain the viability of the cross referencing from APT to ETC, users should take care not to change or update calculations that they are cross-referencing to APT. To reduce this risk, only "read" permissions are set by default when sharing workbooks.

Published	13 Nov 2018
Latest updates	

Video Tutorials

This article provides a complete tabular listing of all of the JWST video help and tutorials that are available on all topics. The JWST-specific videos are hosted on the *JWST Observer YouTube channel.* Also, some generic legacy video help is provided in a separate table below. Links to many of these resources are also linked directly into JDox articles at the point of need.

On this page

See also: Exposure Time Calculator and JWST Astronomers Proposal Tool Overview
See also: The JWST Observer YouTube channel (linked outside of JDox)

Due to the dynamic development environment and the effort required to remake videos, you might see small differences between the displays in some help videos relative to the released versions of the tools. Most of the help being provided in the videos is general in nature and does not depend on the specific tool versions. If you detect any serious problems due to versions that would cause a video to be incorrect, please help us by contacting the JWST Help Desk.

The Tables below include links to both videos that have been posted to the JWST Observer YouTube channel as well as existing video help (made for HST, but with relevance to JWST) that are still hosted locally at STScI.   These Legacy Videos are listed in a separate Table toward the bottom of this page.

Video help is linked directly into many articles where it is relevant. Look for the JWST Video icon:

YouTube features

For the YouTube videos, users should be aware of some nice features provided by the controls at the lower right corner of the video window. These include the ability to go to full screen (to better see details), the "CC" button, which provides automatic closed captioning of the audio stream, and the Setting–Quality option, that permits the user to control the resolution and file size that fits their needs.   Controls at lower left allow the user to start and stop the video and mute the sound if needed.

Master list of available video help on JWST Observer Channel

The following Table lists the video tutorial help being prepared in support of Cycle 1 of JWST along with short descriptions for each video. Links on the video titles in the first column will connect you to each video directly. (If a title is not linked, the video has not been posted yet–stay tuned!)

Note: The JWST Observer YouTube channel also hosts Webinars, recorded JWST Town Halls from AAS meetings, and other recordings not listed here. When you go to the JWST Observer channel, be sure to SUBSCRIBE to see updates.

JDox Overview

	Length	Description
JWST Documentation Overview	7:25	This video provides a brief introduction to the JWST User Documentation System, including tips on navigation and searching.

APT and Aladin Video help

	Length	Description
APT GUI Overview	5:07	This video walks through the basics of the APT user interface and describes each of the tools within APT that are needed to prepare and submit JWST proposals.
APT Visit Planner	8:50	This video provides examples of various tasks performed with the Visit Planner tool within APT, including the use of diagnostics to fix various problems you may encounter. It concludes with an example of running Smart Accounting to minimize overheads in your proposal.
Adding Special Requirements in APT	5:45	This video provides examples of entering and editing Special Requirements in APT, including for both fixed and moving targets.
Specifying Mosaics in APT	13:41	This video demonstrates the ways of defining and manipulating mosaics within APT. Advanced sections

		include adding and removing tiles from a mosaic as well as other special cases.
APT Errors and Warnings	3:06	This video highlights the various ways you can get diagnostic information about errors and warnings in APT as you develop a proposal for submission.
APT Graphical Timeline	6:21	This video describes the functionality of the graphical timeline tool within APT.
Aladin Overview in APT	9:14	This video walks through the basic functionality of the Aladin visualization tool within the APT environment, and provides several examples of interactions between Aladin and APT itself.
Using Aladin and APT Visit Planner	5:00	This video shows how Aladin and the Visit Planner in APT can be used together to help prepare your proposal.

ETC Video Help

	Length	Description
ETC Home Page Overview	3:49	This video provides a good entry point for learning how to use the JWST Exposure Time Calculator (ETC). It presents the different options available on the home page for working in the ETC and provides guidance for obtaining additional information.
ETC General Overview	5:51	This video is a walkthrough that briefly presents the capabilities and layout of the JWST Exposure Time Calculator (ETC).
ETC Workbooks	4:36	This video discusses how to create a new ETC workbook, load existing example workbooks to use as starting point, and share ETC workbooks with other MyST users and collaborators.
ETC Scenes and Sources	6:27	This video demonstrates how to create scenes, add sources, and modify sources as part of performing calculations in the ETC.
ETC Backgrounds	3:15	This video describes the various ways to specify a background in the ETC.

Adding Emission Lines in the ETC	2:52	This video describes the process of adding, updating, and removing emission lines to a source continuum in the ETC.
Uploading Spectra to the ETC	3:40	This video describes how to upload user-supplied spectra to the ETC, including the proper file format to use.
ETC Batch Expansions	4:50	This video describes how to use the batch expansion feature to quickly explore a range of instrument or exposure parameters in the ETC.
ETC IFU Strategies	3:52	This video describes the two observing strategies for the MIRI MRS and NIRSpec IFU backgrounds and how to quickly fix errors when switching strategies in the ETC.

NIRSpec Tools Video Help

	Length	Description
NIRSpec Observation Visualization Tool	4:24	This video demonstrates use of the NOVT, which is used for planning NIRCam pre-imaging observations for NIRSpec MSA. The tool allows the user to visualize the NIRCam field of view with various dither patterns relative to the NIRSpec MSA footprint.

List of available Legacy video help (hosted locally at STScI)

Here are the links and short descriptions for each video. URLs are encoded in the first column.

Legacy APT and Aladin Video help (produced for HST but with some application to JWST users.

	Length	Description
The Differencing Tool	5:30	This tutorial describes using the differencing tool in APT to compare two proposals. It was made for HST but has relevance to JWST users.
Using the Find feature	3:30	This tutorial describes how to use the "Find" functionality in APT. It was made for HST but has relevance to JWST users.
How to retrieve minor body orbital elements from Horizons	2:30	This tutorial demonstrates accessing orbital elements for known moving targets from within APT. It was made for HST but works exactly the same way for JWST.
How to use the MAST Portal from APT	7:00	This tutorial demonstrates how to access and use the MAST Discovery Portal interface from APT. It was made for HST but works exactly the same way for JWST.
Using the Aladin Multiview Function	1:30	This video demonstrates the multiview functionality of Aladin.
Making APT Target Confirmation Charts	4:13	This video shows how to use APT to make target confirmation charts.

If you have questions beyond the information covered in these help videos, please look elsewhere in the JWST user documentation or contact the JWST Help Desk.

Published	15 Nov 2017
Latest updates	

	• 08 Jan 2020 Updated JDox video for Cycle 1. • 27 Sep 2019 Updated Listing for JWST Cycle 1 videos and current tool versions. • 02 Feb 2018 Added new YouTube links for 3 Aladin-APT articles, consistent with APT 25.4.2 • 04 Dec 2017 Added new YouTube links for 5 APT articles, consistent with APT 25.4.1

JWST Other Tools

There are a number of different software tools available to assist JWST users as they investigate various proposal options for viability, and ultimately generate a proposal for submission the the JWST Time Allocation process. This article provides a quick look overview of what is available.

On this page

See also: Master list of JWST Proposing Help videos on all topics

The primary JWST tools needed to support proposal writing include the JWST Exposure Time Calculator and the Astronomer's Proposal Tool. However, the JWST project supports a number of other specialized tools that can be great time-savers for those investigating special cases. These tools typically are used to provide a quick look into parameters such as visibility, sensitivity, or variations in background levels as a function of time.

Additional proposal preparation support tools

- JWST Target Visibility Tools (to obtain information on target visibility windows and available position angles versus time).
  - JWST General Target Visibility Tool Help (GTVT; python command line tool for all JWST instruments; Help article and install notes).
    - Note: A version of GTVT that handles moving targets, the MTVT, is also available.
  - JWST Coronagraphic TVT (CVT, specifically for NIRCam and MIRI coronagraphic modes; Help article and install notes).

- The JWST Backgrounds Tool provides insight into variations of infrared backgrounds as a function of wavelength and time.

- The JWST Interactive Sensitivity Tool (JIST) can provide a quick look into feasibility of planned observations prior to in-depth work with the ETC.

- NIRSpec Observation Visualization Tool (NOVT) provides a simultaneous view of both NIRSpec and NIRCam fields of view on a given sky position, for assistance in planning NIRCam pre-imaging for NIRSpec MOS observations.

- NIRSpec MSA Spectral Visualization Tool (MSAViz) allows you to visualize the layout of MOS spectra on the NIRSpec detectors.
- NIRSpec MSA Planning Tool (MPT) (used within APT, to specify detailed multi-object spectroscopy plans).

Tools for simulating JWST performance

- WebbPSF Tool (Generate accurate point-spread functions for JWST instruments); WebbPSF is used within the ETC to generate PSFs, but certain users may want to investigate further on their own.
- Mirage is a python code that can be used to generate simulated NIRCam, NIRISS, or FGS imaging data.
- Awesimsoss simulates scenes generated by the NIRISS Single Object Slitless Spectroscopy mode. (Links outside of JDox.)

External Tools of interest to proposers

The following tools have been developed by external community members, and are not supported directly by STScI. However, many in the broader community may find them useful, and so we provide links here for visibility and convenience.

- MIRISIM – can generate imaging, as well as low- and medium-resolution spectroscopic data simulations for MIRI. These simulated observations can help proposers to better understand the capabilities of the instrument, prepare their own observations, and plan ahead for data analysis. MIRISIM was developed and is supported by the MIRI consortium.
- ExoCTK, the Exoplanet Toolkit, and PandExo, the ETC specifically for exoplanets – These tools, while hosted in the STScI domain, were developed and made available by Natasha Batalha and colleagues. They are heavily used by the Exoplanet community.

Help for these tools is not available through the JWST Help Desk since these tools are external to STScI control.

Published	15 May 2017
Latest updates	• 20 Dec 2019 Updated Tools list in support of Cycle 1. • 08 Mar 2018 Added link to new moving target version of the GTVT

	• 25 Nov 2019 Revised page for current ancillary tools that will be supported for JWST Cycle 1.

Backgrounds Tool

The JWST Backgrounds Tool (JBT) is a a simple command line tool that accesses the JWST background models to return the total background intensity and its components as a function of time. This can be useful for estimating and visualizing the impact of the background on the schedulability of JWST observations. It can also be used to retrieve the background intensity spectra and their components.

On this page

See also: JWST Background Model and Background-Limited Observations

The JWST Backgrounds Tool (JBT) offers a convenient way to display observing dates for which the JWST background is within a given fraction of the minimum possible background for a given position on the celestial sphere. The tool is written in python and accesses an online repository of the same background model cache that is used by the JWST ETC and the JWST scheduling system.

What does the JBT do?

For a given target (RA, DEC in decimal degrees), and wavelength (in microns), the JBT can do the following:

- Plot the spectrum of the background for that target on a given calendar day.
- Plot the total background for that target versus calendar day.
- Compute and plot the number of days per year that the target is observable at low background, for a given wavelength and a selectable threshold. (We refer to this plot as a "bathtub curve" or "bathtub plot.")
- Write the ASCII data for the background spectrum and bathtub curves to output files for use by other programs you may have or develop.

Bathtub curves

A bathtub curve is the total background intensity (in MJy/sr) at a single wavelength of interest as a function of day of the year. These curves often have steep sides with a central trough, reminiscent of a bathtub shape.

The JWST background cache

The JBT accesses a precompiled cached background model that was prepared by Space Telescope Science Institute. The background cache is hosted by the Mikulski Archive for Space Telescopes (MAST), so you need internet access to run the tool with the remote cache. For offline use, it is possible to download the full background cache to your local machine, although it is a large file (~50 GB). Instructions for downloading the background cache can be found in this MAST Newsletter article from August 2017.

Installation

The easiest way to install the JBT is to first install healpy, a required dependency, via:

```
$ conda config --add channels conda-forge
$ conda install healpy
```

JBT can then be installed using pip:

```
$ pip install jwst_backgrounds
```

If you have installed the tool previously and want to check for and install updates,

```
$ pip install jwst_backgrounds --upgrade
```

Alternatively, you can also install the JBT manually as follows:
1) Download jwst_backgrounds source code from https://github.com/spacetelescope/jwst_backgrounds

2) Unpack the archive:

```
gunzip jwst_backgrounds_xx.tar.gz
tar -xvf jwst_backgrounds_xx.tar
```

3) Install jwst_backgrounds:

```
cd jwst_backgrounds
python setup.py install
```

Running the JBT from the command line

You can run the tool from the command line (easiest for casual use), or you can import it as a python module, which is useful for writing scripts to carry out more detailed parameter studies. A complete description of available command line options and arguments can be displayed using the command:

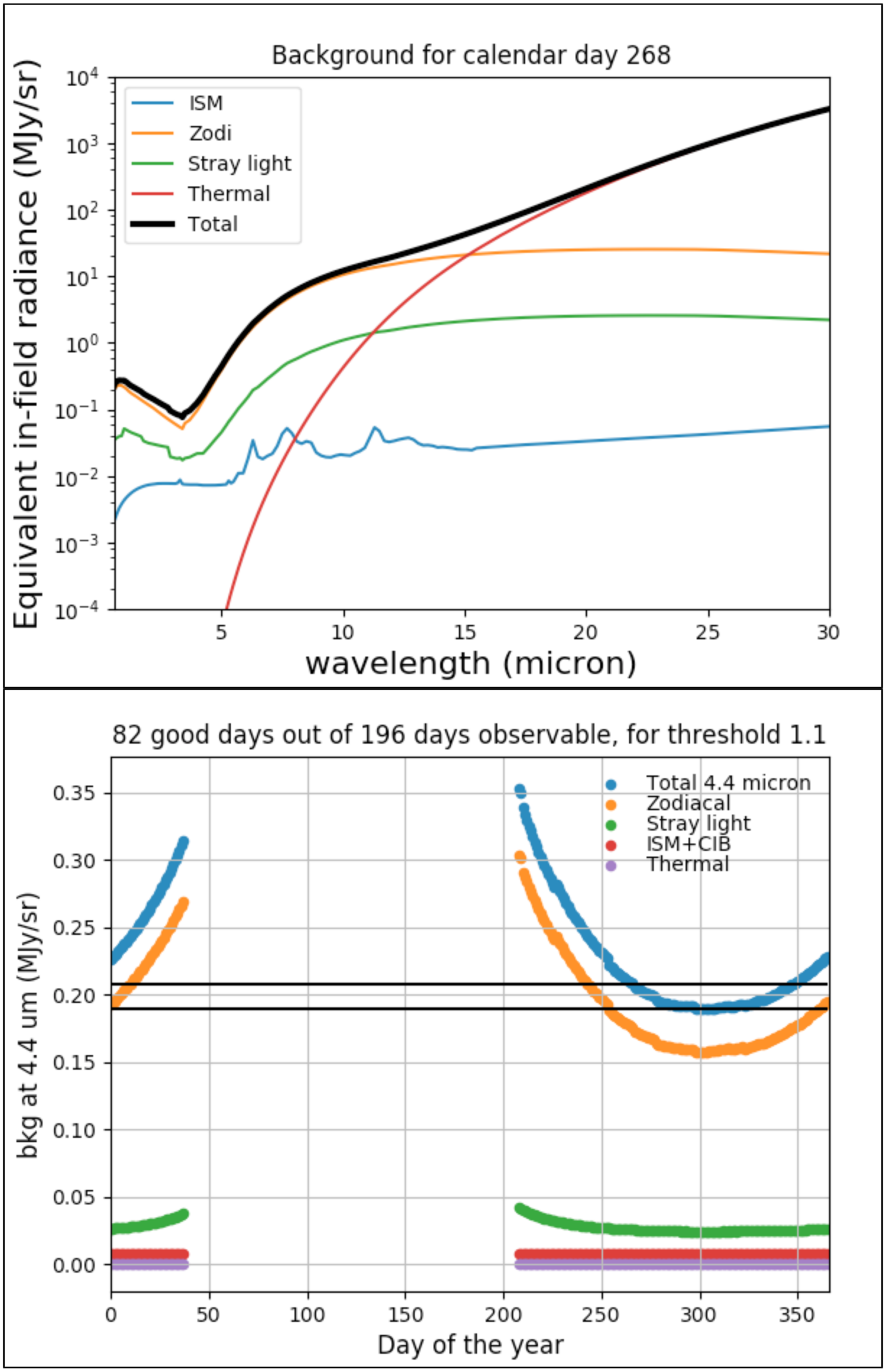
```
jwst_backgrounds --help
```

Using the command line, the following command will plot the bathtub curve for a given RA, DEC and wavelength, and will also plot the background intensity spectrum for day 268 (where day=1 is January 1st). Note that the options (identified with "--") must come first.

```
jwst_backgrounds --day 268 --showsubbkgs 53.1625 -27.7914 4.4
```

This command will open a GUI plot window and cause the background data to be plotted for RA=53.1625 degrees and DEC=-27.7914 degrees; closing this plot will expose the second plot of the bathtub curve at 4.4 µm (in this example). Closing this plot will return control to the command line. Figure 1 shows the plots resulting from this example.

Figure 1. Example of JBT output



Top: The total background intensity spectrum and its components for the specified day of the year.
Bottom: The bathtub curve for the pointing at a specific wavelength. Only days for which the pointing is observable with JWST are displayed. The two horizontal lines mark the minimum value of the total background and the minimum value times the threshold factor.

Note that if you want to save one or both plots to a file, each GUI plot window has controls at lower left; select the disk icon to save the plot (png by default). Other controls in the GUI allow you to pan and zoom within a given plot as desired.

Some users may find it useful to have the data generated by the tool in ASCII files for use by other programs. By default, the tool outputs files **background.txt** and **background_versus_day.txt** to the current working directory**.** However, if you want to redirect this output to file names of your choosing, the tool help contains instructions to do this. Here is an example:

```
jwst_backgrounds --day 268 --showsubbkgs --background_file targ1_bkgd.txt --bathtub_file targ1_bathtub.txt
53.1625 -27.7914 4.4
```

Scripting the JBT

The JBT can be more flexible when imported into python as a module. For instance, the following lines will replicate the command line example using the convenience method bg_tools.get_background().

```
python
>>>from jwst_backgrounds import jbt
>>>jbt.get_background(223.555, -54.395, 2.15, thresh=1.1, plot_background=True, plot_bathtub=True,
write_bathtub=True)
```

However, a primary reason to use the JBT python module, rather than the command line, is to explore a parameter space. For that, we can access the background class, which will return the data, but will not create the plots. For instance, the following script will retrieve the backgrounds for the Hubble Ultra Deep Field, the Orion Trapezium cluster and the Galactic Center and print their relative values at 4.4 micron, for the first day in the year for which they are visible.

```
from jwst_backgrounds import jbt

pointings = [{'ra':53.1625,'dec':27.7914,'name':'HUDF'},
             {'ra':83.8187,'dec':-5.3872,'name':'Trapezium'},
             {'ra':266.41683,'dec':-29.00781,'name':'Galactic Center'}]

wavelength = 4.4 #micron

for pointing in pointings:
    bg = jbt.background(pointing['ra'],pointing['dec'],wavelength)
    print(pointing['name'], bg.bathtub['total_thiswave'][0], 'MJy/sr')
```

Which returns:

```
HUDF 0.295932846194 MJy/sr
Trapezium 0.9383086522 MJy/sr
Galactic Center 13.2075661373 MJy/sr
```

Published	28 Nov 2017
Latest updates	• 05 Dec 2017 Added clarifications to these instructions based of actual testing of the tool

JWST Target Visibility Tools

Link to JIST page

Two standalone target visibility tools are available to help proposers evaluate the visibility of targets, and their allowed position angles on the sky, for potential observations by JWST instruments. Using these tools prior to developing a proposal in APT could save time and provide insight into observability.

On this page

See also: JWST General Target Visibility Tool Help, JWST Moving Target Visibility Tool Help, and JWST Coronagraphic Visibility Tool Help.
See also: JWST Position Angles, Ranges, and Offsets and JWST Observatory Coordinate System and Field of Regard

While the Astronomers Proposal Tool (APT) provides detailed schedulability information for each target, there may be instances where you'd want an overview of target visibilities and their available position angle ranges prior to entering them in your proposal in APT. For example, JWST pointing constraints may restrict position angles for targets near the ecliptic plane; in such a scenario, you may want to know upfront if observations at a particular position angle are feasible. (See the Specifying JWST Positions Angles, Ranges, and Offsets page for more information on this topic.)

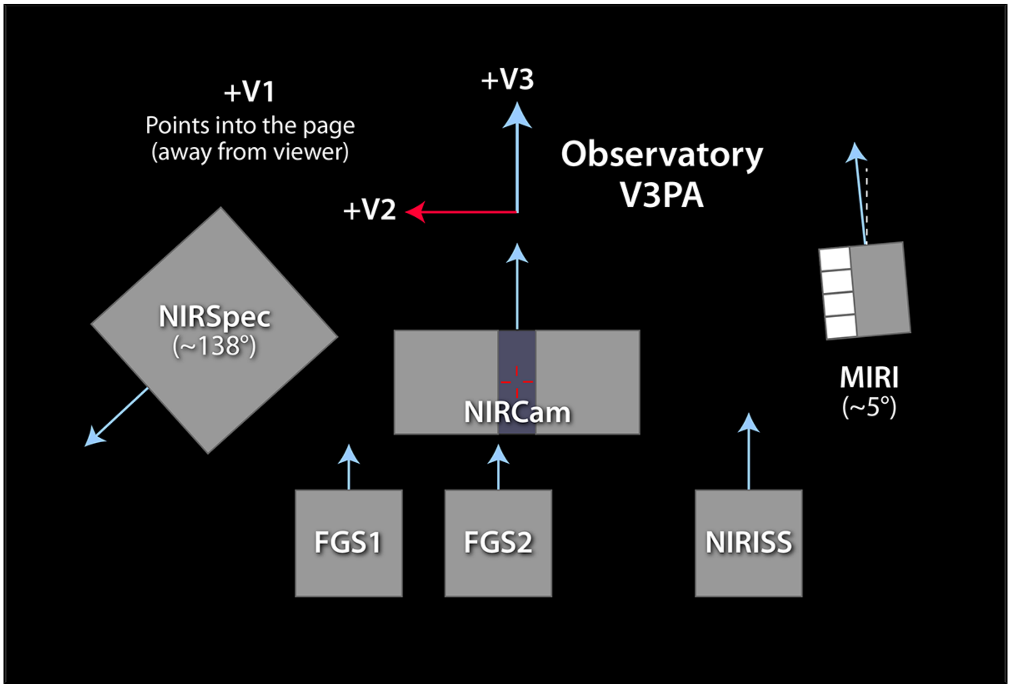
The JWST project provides two quick-look target visibility tools to help in pre-planning observations, and for determining their feasibility, prior to entering them in APT: the General Target Visibility Tool (GTVT) predicts visibility windows and position angles for all instruments, and the Coronagraphic Visibility Tool (CVT) provides target visibility information for the NIRCam and MIRI coronagraphic modes.

For given target coordinates, both tools report (1) the ecliptic latitude, and (2) the target visibility windows and allowed position angles versus time. These tools have been vetted for accuracy against APT calculations, but are primarily intended to provide an overview capability that complements APT.

You should note that the checks made by the APT Visit Planner include other aspects of schedulability beyond just visibility, including the availability of guide stars at relevant position angles, and any special requirements levied on your observations in APT. *APT is the final arbiter of schedulability.*

For all JWST instruments, the "science-y" axis of each detector is used as the reference angle for specifying position angles. Many of the instruments are essentially aligned with the observatory V3 axis within a fraction of a degree, but MIRI and NIRSpec have offsets counter-clockwise relative to V3. Figure 1 provides a schematic of the reference axes for each instrument in the JWST focal plane, showing the V3 axis direction for reference. See JWST Observatory Coordinate System and Field of Regard for details on the observatory coordinate system.

Figure 1. Reference axes for measuring JWST position angles



In this schematic view from the perspective of the instruments, through the telescope and onto the sky, the blue arrows indicate the approximate reference axis directions for each instrument and for the observatory V3 reference axis. When projected onto the sky, the position angle of the V3 axis (V3PA, degrees east of north) provides a reference for projecting the instrument fields of view onto the sky. Only MIRI and NIRSpec are significantly offset from the observatory V3 axis direction, as shown in the figure.

The JWST General Target Visibility Tool (GTVT) for all instruments

The GTVT is a Python command-line-driven tool that allows you to get a quick look at the visibility of a given target versus time, and the available position angles in those visibility windows. The calculations are performed for a single primary reference axis for each of the 4 science instruments, the FGS, and for the observatory "V3PA" (V3 position angle) reference angle, as highlighted in Figure 1. This feature is useful for observers planning multiple observations with absolute and/or relative timing or position angle constraints, target of opportunity (TOO) programs, or any case where the overall observing windows for a target are needed for planning observations.

This tool can be run interactively, producing results like diagnostic plots and ASCII tables on the screen. In the interactive plot mode, you can pan and zoom within the individual panels for a more detailed view. Command-line options can also be used to save output to files. For bulk processing, you can write a simple script to run the GTVT in batch mode.

As of early March 2018, the GTVT contains an option for use with moving targets as well as fixed targets. If you downloaded the GTVT prior to that time and want the version that permits moving targets to be assessed, you will need to re-install. See *JWST Moving Target Visibility Tool Help* for further details.

The GTVT tool help page has a detailed description of the tool, including examples.

The JWST Coronagraphic Visibility Tool (CVT)

Users planning observations for coronagraphy have additional constraints beyond target visibility, such as the position angle of a disk or the placement of a known companion relative to the host star. The CVT provides a GUI-based tool specifically for helping you pre-plan JWST coronagraphic observations with NIRCam and MIRI, and to verify that they will work in APT. This tool provides overall target visibility information as well as information on the location of assumed companions relative to instrumental structures such as occulting bars in NIRCam or boundaries in the MIRI 4-quadrant phase mask (4QPM) coronagraphs and a function of time. It also shows how the instantaneous roll flexibility changes (from approximately ±3.5° to ±7° from nominal) over the visibility period, which is an important consideration for many coronagraphic observations.

The CVT is written in Python, but can be installed as an app that launches a GUI. Like the GTVT, the GUI can be manipulated to pan and zoom on the plots.

A more detailed description and help file is available.

Accessing the target visibility tools

GTVT and the CVT are distributed as part of the AstroConda python software release. AstroConda, maintained by the Space Telescope Science Institute (STScI), provides tools and utilities for working on data from HST, JWST and other telescopes. Installation instructions are available at the AstroConda website. AstroConda in turn runs under the Conda package management system, and in particular is compatible with the Continuum Analytics, Inc.’s Miniconda and Anaconda distributions, one of which must be dowloaded and installed prior to installing AstroConda. Information is available to help you decide what download is right for you.

The visibility tools should be run in the AstroConda environment to ensure connectivity to all dependencies such as Python or Matplotlib code libraries. Future updates to the tools will be readily available by executing a single command in the AstroConda environment. Contact the JWST Help Desk with any questions.

Specific details for using the target visibility tools are provided in these help files:

GTVT help

CVT help

Synergy between the tools

The GTVT and CVT have been tested against each other and against APT for consistency. Hence, the visibility windows and angles found in the CVT for NIRCam or MIRI coronagraphs will be consistent with the general results for NIRCam and MIRI in the GTVT. (The reference axes for the imagers and the coronagraphs are aligned.)

Some details are different between the tools. For example, the CVT has a name resolver to obtain coordinates while the GTVT does not. Meanwhile, the GTVT will accept coordinates in decimal or sexagesimal formats, but the CVT only uses decimal format. Also, since the GTVT is a command-line tool, a script can be used to run in batch mode whereas the CVT is designed to look at individual objects in detail. You may want to familiarize yourself with both tools to understand the pros and cons of each.

Published	22 Feb 2017
Latest updates	• 06 Mar 2018 Added a note and link regarding the moving target option of GTVT

JWST General Target Visibility Tool Help

The JWST General Target Visibility Tool (GTVT) is a command-line Python tool that provides quick-look assessments of target visibilities and position angles for all JWST instruments.

On this page

See also: JWST Moving Target Visibility Tool Help
See also: JWST Position Angles, Ranges, and Offsets
See also: JWST Observatory Coordinate System and Field of Regard

The JWST General Target Visibility Tool (GTVT) is a Python command-line tool for calculating target visibility windows as a function of time. GTVT is one of two tools for investigating JWST target visibilities. In mid-2018, the assumed orbital ephemeris and default time period over which the calculations run were modified to accommodate the expected launch date of March 2021.

For a given RA and Dec, the GTVT provides the reference position angle (PA) information for all 4 science instruments and the FGS within the allowed visibility windows. It also outputs the V3 axis PA for reference. Results are in the form of an ASCII file as well as one or more summary plots. A number of options are available from the command line for tailoring the output to your needs. Once the plot is displayed, icons can be selected to pan and zoom in on the plot to see detailed information.

As of early March 2018, the GTVT contains an optional aspect that permits the easy inclusion of moving targets instead of just fixed coordinate targets. To access this version, you will need to re-install the GTVT is you have installed it prior to that time. See JWST Moving Target Visibility Tool Help for more information on this option.

The schedulability of a given target observation is more complex than just its visibility. It also involves the availability of guide stars as a function of time and other constraints that may be set with Special Requirements in APT. The GTVT is a "quick look" tool for pre-planning purposes, but the Astronomers Proposal Tool is the true arbiter of schedulability for a given proposed observation.

Dependencies

The GTVT requires a few packages and libraries, all of which are included in the STScI AstroConda python distribution. These dependencies include NumPy, Matplotlib, and AstroPy. Therefore, to avoid problems, we recommend that you download and install AstroConda so that GTVT can be run in the AstroConda environment.

AstroConda runs from within the bash shell. If TCSH or CSH are your default shells, either change your terminal window to the bash shell (type "bash -l") before running the program, and/or consider changing your default shell to the bash shell.

Further information on setting up AstroConda for your machine is available in the AstroConda documentation. Help can also be obtained by contacting the JWST Help Desk.

Installation and usage

⚠ The GTVT is currently incompatible with Windows operating systems.

One can download a .zip file or clone the repository for GTVT from the following GitHub link:

https://github.com/spacetelescope/jwst_gtvt

and install the tool inside the resulting "jwst_gtvt-master" directory (you should see a file called "setup.py" in this directory) with the command

```
python setup.py install
```

Alternatively, if you are familiar with "pip", you can install the tool directly with

```
pip install git+https://github.com/spacetelescope/jwst_gtvt.git
```

These options assume you have separately verified that your computer has access to the dependencies listed above.

Once successfully installed, the program can be run from the command line, as described below.

At present, the GTVT cannot be installed using the "conda install" command. We hope to provide this installation path as an option again in the near future.

Usage Tips

To see the GTVT help information, type "jwst_gtvt -h".

```
$ jwst_gtvt -h
usage: jwst_gtvt [-h] [--pa PA] [--save_plot SAVE_PLOT]
[--save_table SAVE_TABLE] [--instrument INSTRUMENT]
[--name NAME] [--start_date START_DATE] [--end_date END_DATE]
ra dec
positional arguments:
ra           Right Ascension of target in either sexagesimal
                (hh:mm:ss.s) or degrees
dec          Declination of target in either sexagesimal
                (dd:mm:ss.s) or degrees
optional arguments:
-h, --help   show this help message and exit
--pa PA      Specify a desired Position Angle
--save_plot SAVE_PLOT
                 Path of file to save plot output
--save_table SAVE_TABLE
                 Path of file to save table output
--instrument INSTRUMENT
                 If specified plot shows only windows for this
                 instrument
--name NAME  Target Name to appear on plots
--start_date START_DATE
                 Start date for visibility search in yyyy-mm-dd format
--end_date END_DATE   End date for visibility search in yyyy-mm-dd format
```

GTVT command line examples

When using GTVT in the command line, you only need to specify RA and Dec (the default input values). Observability windows are shown on the terminal, and plots of visibility windows for each instrument are displayed. However, there are other useful command-line options, as shown in the examples below. each command is followed by a text description,

```
jwst_gtvt 325.678 43.586 --name "SS Cyg"
```

This command runs and produces an interactive visibility plot on the screen for all instruments. No files are saved to disk. Note that enclosing the target name in double quotes allows for spaces in the text. To exit the program, close the plot window. Alternatively, if you want access to the terminal window from which the tool was run prior to exiting the program, add an ampersand "&" at the end of the command-line entry above to run the program in the background.

```
jwst_gtvt 325.678 43.586 --name "SS Cyg" --save_plot SSCyg_all.png
```

This command only saves a plot to a file; no interactive plot is displayed.

```
jwst_gtvt 325.678 43.586 --name "SS Cyg" --instrument v3 --save_plot SSCyg_v3.png
```

This command shows a single instrument panel for (in this case) the V3PA. The allowed values for "--instrument" are "nircam", "nirspec", "niriss", "miri", "fgs", and "v3" (case insensitive). To exit the program, close the plot window.

```
jwst_gtvt 325.678 43.586 --name "SS Cyg" --save_table SSCyg.dat
```

The command produces a plot on the screen for all 6 instruments. Tabular data are sent to a file instead of being displayed on the screen. To exit the program, close the plot window.

```
jwst_gtvt 325.678 43.586 --name "SS Cyg" --save_plot SSCyg_all.jpg --save_table SSCyg1.dat
```

This command saves both outputs to the specified files; there is no interactive plot.

```
jwst_gtvt 325.678 43.586 --name "SS Cyg" --start_date 2020-06-01 --end_date 2021-05-30
```

An interactive plot is displayed for all 6 instruments, starting at June 1, 2020 and running for one year. To exit the program, close the plot window.

The example below shows the top portion of an ASCII output file from a simple run of GTVT. The top section provides a summary of the target and windows, and the bottom table (truncated) shows the day by day minimum and maximum allowed angles in each of the visibility windows for each instrument. The nominal angles are approximately midway between the two limits shown.

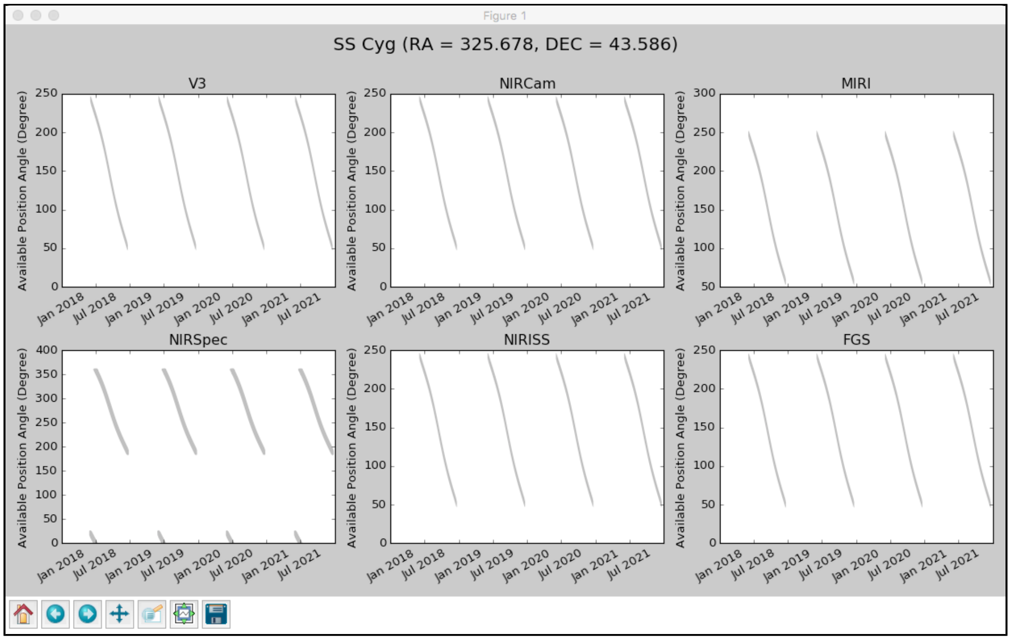
```
Using Equatorial Coordinates
    Target              ecliptic
RA          Dec       latitude
325.678  43.586  52.656
Checked interval [2019-06-01, 2019-12-30]
|           Window [days]                 |    Normal V3 PA [deg]    |
   Start          End         Duration Start         End          RA              Dec
 2019-06-02 2019-12-21 201.93     244.06365  50.05444 325.67800  43.58600
             V3PA           NIRCam           NIRSpec        NIRISS           MIRI              FGS
 Date         min    max      min    max       min    max     min    max      min    max      min    max
2019-06-03   240.63 247.46   240.60 247.44    18.11  24.95   240.06 246.89   245.64 252.48   239.38 246.21
2019-06-04   239.50 247.06   239.47 247.03    16.99  24.54   238.93 246.49   244.51 252.07   238.25 245.80
2019-06-05   238.37 246.65   238.34 246.63    15.86  24.14   237.80 246.08   243.39 251.67   237.12 245.40
2019-06-06   237.24 246.25   237.22 246.22    14.73  23.74   236.67 245.68   242.26 251.26   235.99 245.00
2019-06-07   236.12 245.85   236.09 245.82    13.61  23.34   235.55 245.28   241.13 250.86   234.87 244.60
2019-06-08   235.12 245.33   235.09 245.30    12.61  22.81   234.55 244.76   240.13 250.34   233.87 244.08
2019-06-09   234.36 244.56   234.33 244.54    11.85  22.05   233.79 243.99   239.37 249.58   233.11 243.31
2019-06-10   233.60 243.80   233.57 243.77    11.09  21.29   233.03 243.23   238.61 248.82   232.35 242.55
2019-06-11   232.84 243.04   232.81 243.01    10.33  20.53   232.27 242.47   237.85 248.05   231.59 241.79
```

...(full table truncated)

Example plots from GTVT

By default, a plot showing 6 panels (one for each instrument, the FGS and the observatory V3PA) will be displayed by GTVT on the screen or sent to a named output file. The y-axis of each plot shows valid aperture PAs for each instrument as a function of time. These values can be entered into the relevant APT Special Requirements as needed for a given science case.

Figure 1. The default 6-panel GTVT output plot



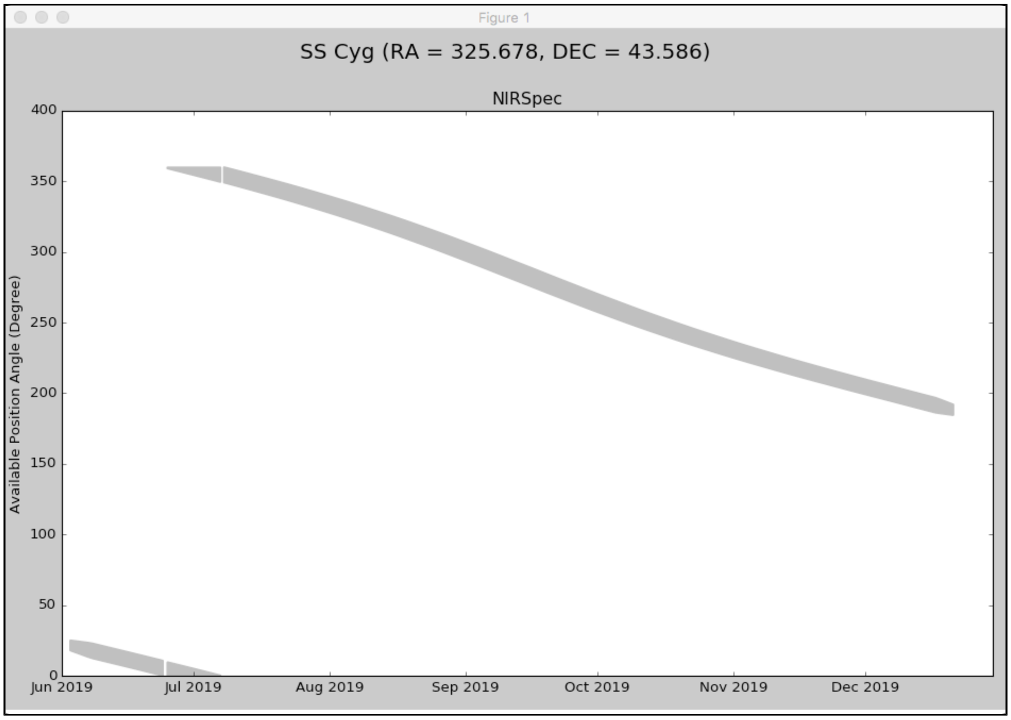
Note that over time, a large range of potential positions angles are available for this target, which is at ecliptic latitude 52.6°, and the pattern repeats closely from one year to the next.

This summary plot may not be that useful when saved as a file. But in interactive mode, icons at the lower left of the plot window allow you to pan and zoom within each panel for a closer look at the figures. After panning and zooming in the interactive plot, the right-most icon provides another way to save the current view of the interactive plot.

Alternatively, for viewing a single instrument, use the '--instrument' argument to specify an instrument; this produces a display with a single panel plot for that instrument. Also, the time range on the default plot covers the entire current period with a preliminary orbital ephemeris. You can also use the '`--start_date`' and '`--end_date`' arguments to shorten the time range that's plotted. Figure 2 shows an example made with the following command:

```
jwst_gtvt 325.678 43.586 --name "SS Cyg" --instrument nirspec --start_date 2019-06-01 --end_date 2019-12-30
```

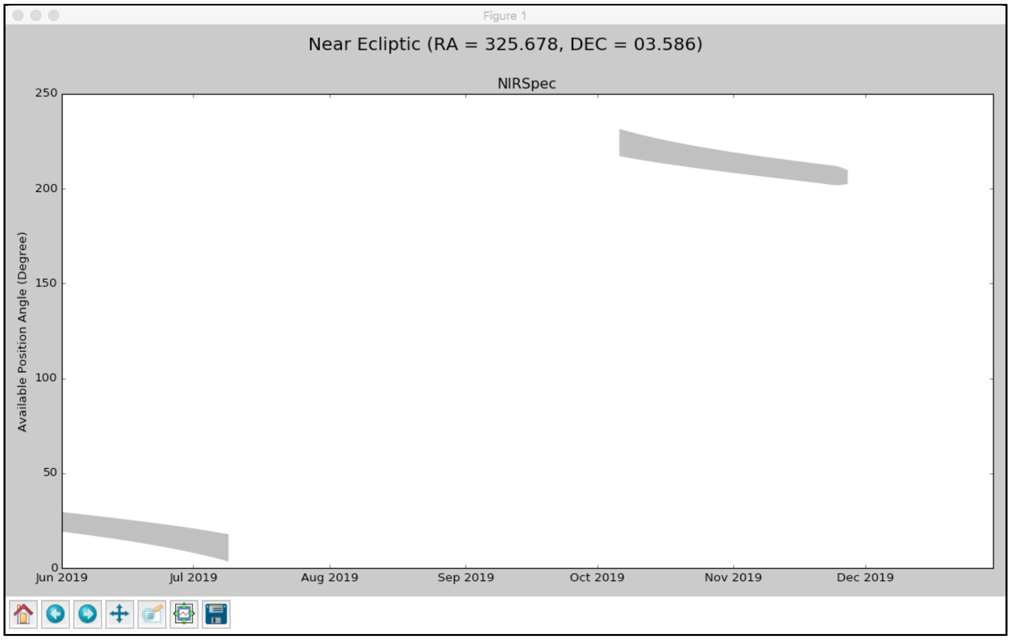
Figure 2. A GTVT plot for a single instrument and a restricted time range



This target is at an ecliptic latitude of 52.6° and has a single, long visibility period. A wide range of position angles is available for such a target.

Figure 3 is a similar plot for an assumed target near the ecliptic plane (in this example, the ecliptic latitude is only 16.3°). Note how the available angles are restricted to two narrow ranges near 20^{o} and 200^{o}, and there are large ranges of position angle that are unavailable at ANY time for this target due to the JWST observatory constraints.

Figure 3. A target position at ecliptic latitude of only 16.3°



Note that while there are two visibility periods for this target, the allowed position angles (near 20º and 200º) are severely limited. Certain position angles are simply not observable for a target such as this.

Additional information on JWST's pointing restrictions, and how those affect target visibility and available position angles are included in the article JWST Position Angles, Ranges, and Offsets.

Published	22 Feb 2017
Latest updates	• 06 Dec 2019 Added a note about incompatibility with Windows. • 15 Feb 2019 Removed "conda install" instructions for the time being. • 30 Oct 2018 Comment added regarding updated ephemeris. • 06 Mar 2018 Added a note and link regarding the moving target option of GTVT.

JWST Moving Target Visibility Tool Help

The JWST Moving Target Visibility Tool (MTVT) is a command-line Python tool that provides quick-look assessments of moving target visibilities and position angles for all JWST instruments.

On this page

GTVT article: JWST General Target Visibility Tool Help
See also: JWST Position Angles, Ranges, and OffsetsSolar System Special Requirements
See also: JWST Observatory Coordinate System and Field of Regard

The JWST Moving Target Visibility Tool (MTVT) is a Python command-line tool for calculating moving (solar system) target visibility windows as a function of time. It has similar functionality to that of the JWST General Target Visibility Tool (GTVT), with a few additional features specific to moving targets. The MTVT is bundled with the GTVT, and is automatically installed when users install the GTVT (no stand-alone installation process is provided for the MTVT). Additional documentation can be found at this GitHub page. Both the GTVT and MTVT currently use assumed pre-launch JWST orbital parameters.

Unlike the GTVT, users input a solar system target designation, rather than a fixed RA, Dec sky position. The designation can be an official name (e.g. Saturn, Gaspra, Encke), number (e.g., 599, 20000), or provisional designation (e.g., 1992 QB1). MTVT uses the JPL Horizons system to resolve the designation, and retrieves the target ephemeris (RA, Dec) at one day intervals. At that point, the functionality of the MTVT is identical to that of the GTVT.

For a given RA and Dec, the MTVT provides the reference position angle information for all 4 science instruments and the FGS within the allowed visibility windows. It also outputs the V3 axis position angle (PA) for reference. Results are in the form of an ASCII file as well as one or more summary plots. A number of options are available from the command line for tailoring the output to your needs (examples are provided below). Once the plot is displayed, icons can be selected to pan and zoom in on the plot to see detailed information. To execute a new run of the MTVT the plot window must first be closed.

The allowable position angles output by the MTVT can, for example, be used to help users plan observations of giant planet satellites to ensure that the giant planet avoids falling on a nearby science or FGS aperture, or to determine the visibility windows and durations for fast moving near-Earth objects (NEOs). In order to visualize an observation in APT using Aladin, users should add a PA Range special requirement that reflects the range of allowed position angles from MTVT, and create a fixed-target proxy with coordinates consistent with those position angles. Once that is done, visualization can proceed as described in the Visualizing Dithers of a Solar System Observation in APT tutorial.

Note: Use of a fixed target proxy is for planning and visualization purposes only. You should not submit your APT file with the fixed target proxy in place of the moving target.

The schedulability of a given target observation is more complex that just its visibility. It also involves the availability of guide stars as a function of time and other constraints that may be set with Special Requirements and/or Solar System Special Requirements in APT. The MTVT is a "quick look" tool for pre-planning purposes, but the Astronomers Proposal Tool is the true arbiter of schedulability for a given proposed observation.

Installation and dependencies

The GTVT is currently incompatible with Windows operating systems.

The MTVT comes packaged with the GTVT as of January 1, 2018. The user is referred to the "Installation and usage" section on the JWST General Target Visibility Tool Help page for instructions on how to install (or update if an older version of GTVT was installed) GTVT/MTVT. Note that the assumed orbital ephemeris and time period of the default calculation was updated in mid-2018 to accommodate the revised launch assumption of March 2021.

Similarly, the user should refer to the "Dependencies" section on the JWST General Target Visibility Tool Help page for information on the packages and libraries required to run GTVT/MTVT. In addition to those packages and libraries, MTVT also requires the *astroquery* Python package. This package can be installed in a conda environment with the following command:

```
conda install astroquery
```

Alternatively, if you are familiar with "pip", you can install the package with the following command:

```
pip install astroquery
```

Once successfully installed, MTVT is run from the command line, as described below.

Usage tips

To see the MTVT help information, type "jwst_mtvt -h".

Note that the "--v3pa" optional argument in MTVT is identical to the "--pa" optional argument in GTVT.

```
$ jwst_mtvt -h

usage: jwst_mtvt [-h] [--smallbody] [--v3pa V3PA] [--save_plot SAVE_PLOT]
                 [--save_table SAVE_TABLE] [--instrument INSTRUMENT]
                 [--name NAME] [--start_date START_DATE] [--end_date END_DATE]
                 desg [desg ...]

positional arguments:
  desg                  Moving target designation.

optional arguments:
  -h, --help            show this help message and exit

  --smallbody           Set if the designation is that of a comet or asteroid.
                        This is required for periodic comets with multiple
                        orbit solutions in JPL/HORIZONS.

  --v3pa V3PA           Specify a desired V3 (telescope frame) Position Angle.

  --save_plot SAVE_PLOT
                        Path of file to save plot output.

  --save_table SAVE_TABLE
                        Path of file to save table output.

  --instrument INSTRUMENT
                        If specified plot shows only windows for this
                        instrument. Options: nircam, nirspec, niriss, miri,
                        fgs, v3 (case insensitive).

  --name NAME           Target Name to appear on plots. Names with space
                        should use double quotes e.g. "NGC 6240".

  --start_date START_DATE
                        Start date for visibility search in yyyy-mm-dd format.
                        Earliest available is 2018-01-01.

  --end_date END_DATE   End date for visibility search in yyyy-mm-dd format.
                        Latest available is 2021-12-31.
```

MTVT command line examples

The user is referred to the "GTVT command line examples" section of the JWST General Target Visibility Tool Help page for basic GTVT/MTVT commands.

Basic use of the MTVT is shown with the example command below

```
jwst_mtvt Ceres
```

Note that the following command will produce the same results

```
jwst_mtvt ceres
```

After running this command, a table will be output in the terminal and a plot will open in a new window that includes the allowable position angles as a function of time for the V3 axis, the 4 science instruments (NIRCam, MIRI, NIRSpec, NIRISS), and the FGS. Examples of these outputs are shown in the section below, "MTVT outputs."

Evaluating planet visibility

An example command for running MTVT for a planet is shown below

```
jwst_mtvt Jupiter
```

However, running the above command will result in the following message

```
*******************************************************************************
 Multiple major-bodies match string "JUPITER*"

  ID#      Name                               Designation  IAU/aliases/other
  -------  ---------------------------------- -----------  -------------------
        5  Jupiter Barycenter
      599  Jupiter

    Number of matches =  2. Use ID# to make unique selection.
*******************************************************************************
```

In order to obtain a result from the MTVT, the user must select either Jupiter Barycenter as the target using ID# 5

```
jwst_mtvt 5
```

Or Jupiter as the target using ID# 599

```
jwst_mtvt 599
```

The ID# of the planet barycenters and the planets themselves used by JPL Horizons are presented in Table 1.

Table 1. JPL Horizons planet ID numbers

ID#	Name
4	Mars barycenter

5	Jupiter barycenter
6	Saturn barycenter
7	Uranus barycenter
8	Neptune barycenter
9	Pluto barycenter
499	Mars
599	Jupiter
699	Saturn
799	Uranus
899	Neptune
999	Pluto

Evaluating minor body visibility

An example command for running MTVT for a minor body using its name is shown below.

```
jwst_mtvt Makemake
```

An example command for running MTVT for a minor body using its provisional designation is shown below.

```
jwst_mtvt 2007 OR10
```

An example command for running MTVT for a minor body using its number and the "--smallbody" optional argument is shown below. This purpose of this optional argument is to remove ambiguity between low-numbered minor bodies and major bodies. The below example will return information on the asteroid 4 Vesta; without the "--smallbody" optional argument, the MTVT would return infromation on Mars.

```
jwst_mtvt 4 --smallbody
```

For higher-numbered minor bodies, the "--smallbody" optional argument is not necessary, as shown below for the dwarf planet Haumea.

```
jwst_mtvt 136108
```

The special case of comets

An example command for running MTVT for a comet using its name shown below.

```
jwst_mtvt Encke
```

An example command for running MTVT for a comet using its designation is shown below. Use of the "--smallbody" optional argument is not necessary for comets when using the designation as the identifier.

```
jwst_mtvt 2P
```

The above commands are equivalent and will both result in the following message.

```
*******************************************************************************
JPL/DASTCOM3           Small-body Index Search Results     2018-Mar-02 19:16:20

 Comet AND asteroid index search:

   NAME = ENCKE;

 Matching small-bodies:

    Record #  Epoch-yr  Primary Desig  >MATCH NAME<
    --------  --------  -------------  -------------------------
       9134             4822 P-L        Encke
     900034     1786    2P              Encke
     900035     1796    2P              Encke
     900036     1805    2P              Encke
     900037     1819    2P              Encke
     900038     1822    2P              Encke
     900039     1825    2P              Encke
     [ ... additional records not shown ... ]
     900088     1990    2P              Encke
     900089     1994    2P              Encke
     900090     1995    2P              Encke
     900091     1998    2P              Encke
     900092     2004    2P              Encke
     900093     2015    2P              Encke

 (61 matches. To SELECT, enter record # (integer), followed by semi-colon.)
*******************************************************************************
```

JPL Horizons contains multiple orbital solutions for periodic comets, so the user must select one option to proceed. The user is less likely to receive this message for long-period comets. If the user does not know the Record # for the orbital solution of interest ahead of time, this is an easy way to see a list of possible values. If the user knows the Record # ahead of time, they can skip the step of viewing the list. If the user wants the most recent orbital solution for 2P/Encke, they would type the following command:

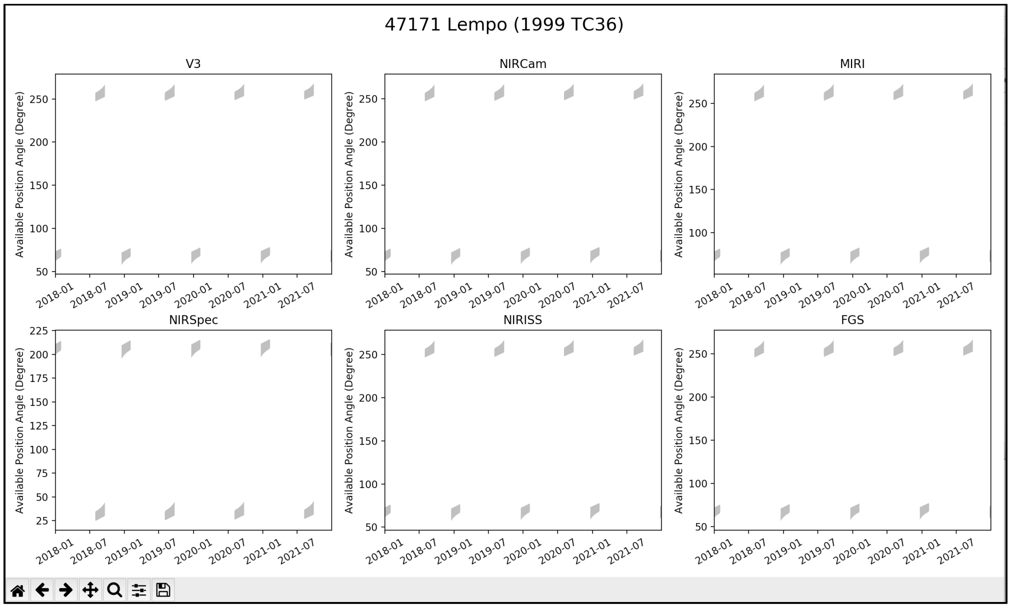
```
jwst_mtvt 900093
```

Note that the most recent orbital solution is not selected as a default when running the MTVT.

MTVT outputs

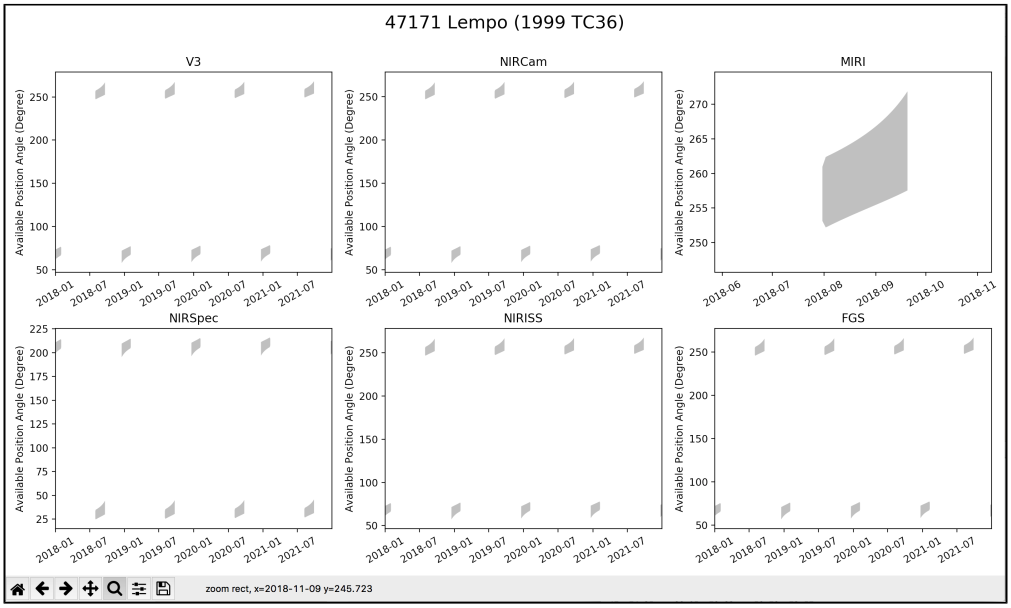
The default outputs for the MTVT are identical to the GTVT: a 6-panel plot showing the allowable position angles for the V3 axis, the 4 science instruments, and the FGS; and an ASCII table containing the information in the plot in table form. See the "Example plots from GTVT" section of the JWST General Target Visibility Tool Help page for instructions on how to output a plot for only one instrument.

Figure 1. Default 6-panel MTVT output plot



Allowable position angles are shown on the y-axis in degrees plotted against date on the x-axis. The allowable position angles for each date can be found in the ASCII output table. In general, the visibility windows for solar system objects along the ecliptic will be separated by position angles of ~180°; see the Moving Target Field of Regard page for a diagram of the JWST focal plane orientation for observations along the ecliptic. For a more distant, slower-moving target like the KBO 47171 Lempo, the range of allowable position angles will be very small. Objects closer to JWST will have a larger range of allowable position angles.

Figure 2. Zoom in on a MIRI visibility window



The Zoom tool (magnifying glass icon in the lower left corner of the plot window) can be used to zoom in on visibility windows of interest in individual plots. In the image above, the Zoom tool was used to focus on one particular visibility window for MIRI, showing the allowable position angles in more detail.

The table below shows the dates and duration of each visibility window when the target is in JWST's field of regard, as well as the allowable position angles and the start and end RA and Dec values for these dates. The RA and Dec, along with the allowable position angles for the V3 axis, each of the 4 science instruments, and the FGS, are output for each date that the object is observable by JWST. The table written to the terminal is much longer than shown but has been truncated for the purpose of presentation in this article. The table can be scrolled horizontally to reveal the hidden columns.

```
$ jwst_mtvt Lempo

Using Equatorial Coordinates

       Target

Checked interval [2018-01-01, 2021-12-31]
|           Window [days]                 |    Normal V3 PA [deg]    |            RA              |
Dec            |
   Start          End         Duration         Start         End        Start          End
Start          End
 2018-01-01     2018-02-01        31.90      67.67509      72.04345      37.01916      36.98653
6.93678      7.07620
 2018-07-30     2018-09-20        52.00     252.02545     259.92882      41.67917      41.47575
8.68297      8.44445
 2018-12-16     2019-02-03        49.08      64.86793      72.54123      39.45384      39.17978
7.86610      7.99322
 2019-08-01     2019-09-23        53.00     252.59432     260.44129      43.88871      43.67978
9.55869      9.32632
 2019-12-19     2020-02-06        49.00      65.77751      73.16926      41.64973      41.38678
8.77599      8.90424
 2020-08-03     2020-09-24        52.00     253.30775     260.72663      46.11396      45.90641
10.41771     10.20009
```

```
 2020-12-20     2021-02-08       50.00     66.48428     73.83054     43.86959     43.60062
9.67304      9.80034
 2021-08-06     2021-09-27       52.00    254.04550    261.26677     48.34573     48.12252
11.25900     11.04993
 2021-12-23     2021-12-31        7.10     67.48006     68.90828     45.96765     45.96765
10.54498     10.54498


                               V3PA         NIRCam          NIRSpec         NIRISS          MIRI
FGS
   Date      RA     Dec      min    max      min    max       min    max     min    max      min    max
min    max
2018-01-01    37.02   6.94    61.98  73.37    61.95  73.35   199.46 210.86    61.41  72.80    66.99  78.39
60.73  72.12
2018-01-02    37.01   6.94    62.19  73.49    62.16  73.46   199.67 210.97    61.62  72.92    67.20  78.50
60.94  72.24
2018-01-03    37.00   6.94    62.39  73.60    62.36  73.57   199.88 211.09    61.82  73.03    67.41  78.61
61.14  72.35
2018-01-04    36.99   6.94    62.59  73.71    62.56  73.68   200.08 211.20    62.02  73.14    67.61  78.72
61.34  72.46
2018-01-05    36.99   6.94    62.79  73.82    62.76  73.79   200.27 211.31    62.22  73.25    67.80  78.84
61.54  72.57
2018-01-06    36.98   6.95    62.98  73.93    62.95  73.91   200.46 211.42    62.41  73.36    67.99  78.95
61.73  72.68
2018-01-07    36.97   6.95    63.16  74.04    63.14  74.02   200.65 211.53    62.59  73.47    68.18  79.06
61.91  72.79
2018-01-08    36.97   6.95    63.34  74.16    63.32  74.13   200.83 211.64    62.77  73.59    68.36  79.17
62.09  72.91
2018-01-09    36.96   6.95    63.52  74.27    63.49  74.24   201.01 211.76    62.95  73.70    68.54  79.28
62.27  73.02
2018-01-10    36.95   6.96    63.69  74.38    63.67  74.35   201.18 211.87    63.12  73.81    68.71  79.40
62.44  73.13
2018-01-11    36.95   6.96    63.86  74.49    63.84  74.47   201.35 211.98    63.29  73.92    68.88  79.51
62.61  73.24
2018-01-12    36.95   6.96    64.03  74.61    64.00  74.58   201.52 212.09    63.46  74.04    69.05  79.62
62.78  73.36
2018-01-13    36.94   6.97    64.19  74.72    64.17  74.69   201.68 212.21    63.62  74.15    69.21  79.73
62.94  73.47
2018-01-14    36.94   6.97    64.35  74.83    64.33  74.81   201.84 212.32    63.78  74.26    69.37  79.85
63.10  73.58
2018-01-15    36.94   6.97    64.51  74.95    64.48  74.92   202.00 212.44    63.94  74.38    69.52  79.96
63.26  73.70
2018-01-16    36.94   6.98    64.66  75.06    64.64  75.04   202.15 212.55    64.09  74.49    69.68  80.08
63.41  73.81
2018-01-17    36.93   6.98    64.81  75.18    64.79  75.15   202.30 212.67    64.24  74.61    69.83  80.19
63.56  73.93
2018-01-18    36.93   6.99    64.96  75.30    64.93  75.27   202.45 212.78    64.39  74.73    69.98  80.31
63.71  74.04
2018-01-19    36.93   6.99    65.11  75.41    65.08  75.39   202.59 212.90    64.54  74.84    70.12  80.43
63.86  74.16
2018-01-20    36.93   7.00    65.25  75.53    65.22  75.51   202.74 213.02    64.68  74.96    70.26  80.55
64.00  74.28
[ ... Additional output not shown ... ]
```

Credits

The MTVT was developed by Michael S. P. Kelley, University of Maryland.

Published	06 Mar 2018
Latest updates	• 06 Dec 2019 Added a note about incompatibility with Windows. • 15 Feb 2019 Removed mention of callhorizons and added installation instructions for astroquery. • 30 Oct 2018 Added notation regarding updated orbital ephemeris.

JWST Coronagraphic Visibility Tool Help

The JWST Coronagraphic Visibility Tool (CVT) is a GUI-based target visibility tool for assessing target visibilities and available position angles versus time relative to the MIRI and NIRCam coronagraphic masks. Placement of up to 3 companions relative to the primary target can be entered for judging impacts from obscurations in the coronagraph fields of view.

On this page

Main article: JWST Target Visibility Tools
See also: HCI Roadmap

JWST observations have pointing constraints because the visibility of a target depends on the target's ecliptic latitude and time of observation. In addition, the allowed roll angle range depends on the solar elongation of the target's position at the time of observation. Allowed position angles (PAs) for a target can thus be a complicated function of time within each allowed visibility window. As a result, it can be difficult to:

- understand the possible orientations of a given target on the detector, especially in relation to any instrumental obscurations,
- determine the ideal roll angles and offsets for multi-roll observations, and
- determine the visibility of two or more targets that need to be observed simultaneously.

The JWST Coronagraph Visibility Tool (CVT) was created to address these issues and assist in planning MIRI and NIRCam coronagraphic programs prior to entering targets and observations into APT. The CVT will help you avoid problems in later APT scheduling and/or help diagnose scheduling errors that may crop up in APT. It is one of two tools available for investigating JWST target visibilities.

Note that the CVT is designed to provide quick illustrations of allowable observation orientations for a given target. While it approximates JWST’s pointing restrictions, it does not query the official JWST Proposal Constraint Generator (PCG) or check for guide star availability, as is done in APT. Therefore, CVT results should be treated as useful approximations that may differ from official APT constraints by a small amount (a degree or so).

Downloading and installing the CVT

The CVT is distributed as part of the AstroConda package from STScI. AstroConda is the preferred release channel for JWST Python-related tools. For more information, see the AstroConda installation instructions. Also note that AstroConda runs from the bash shell, not CSH or TCSH.

Further information on setting up AstroConda for your machine is availble in the AstroConda documentation. Help can also be obtained by contacting the JWST Help Desk.

If you've already installed AstroConda for macOS or Linux, you can install CVT as follows in the AstroConda environment:

```
$ source activate astroconda
(astroconda)$ conda install jwst_coronagraph_visibility
# ... installation output ...
(astroconda)$ jwst-coronagraph-visibility-gui &    # to launch the GUI
```

If you're running macOS and want a double-clickable app:

1. Download the double-clickable app archive (e.g. `jwst_coronagraph_visibility_calculator_macos_v0.1.0.zip`) from https://github.com/spacetelescope/jwst_coronagraph_visibility/releases/latest
2. Extract the .zip file to get the .app bundle
3. Double-click the .app bundle

If you see a message warning you about opening an app from an unidentified developer, right-click (or control-left click) the icon and choose "Open". This is a security feature of macOS.

If you're using Python with pip:

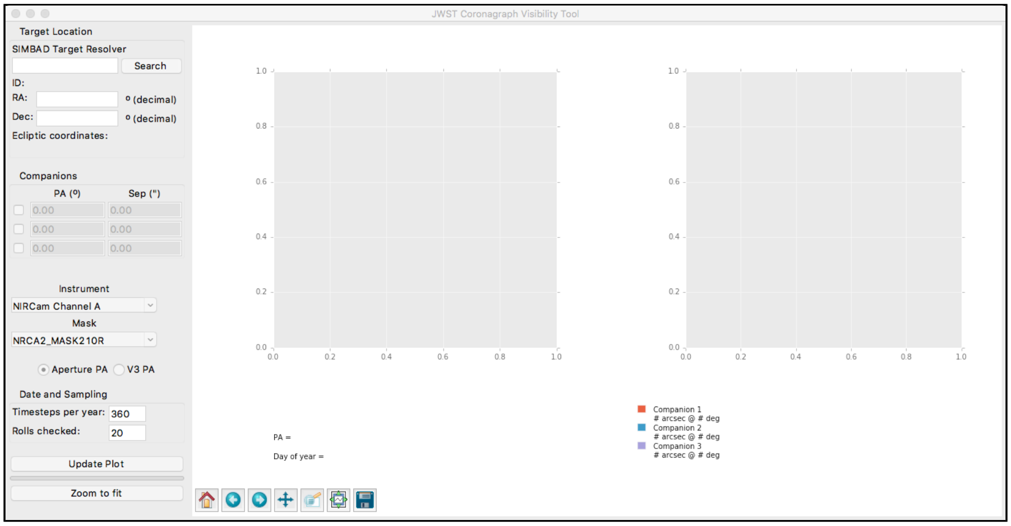
```
$ pip install jwst-coronagraph-visibility
# ... installation output ...
$ jwst-coronagraph-visibility-gui &    # to launch the GUI
```

Using the coronagraphic visibility tool: a step by step example

> *See also: JWST Position Angles, Ranges, and Offsets.*

Depending on how it was installed, you can open CVT from its app or from the command line. Double-clicking the app should open it, or on the command line in an AstroConda-active window, enter "`jwst-coronagraph-visibility-gui`". After opening the program, a GUI should appear, as shown in Figure 1. (Initial startup may take a few seconds.) From here, everything is done through the GUI.

Figure 1. The CVT GUI at startup



There is a control panel to the left of the GUI. Two summary plot windows appear in the center and right. The icons at the lower left are for interacting with the plots. Hovering over each icon produces pop-up information about its functionality.

In the GUI you will see a control panel on the left and a double plot panel on the right. The control panel has **SIMBAD Target Resolver** fields, input boxes for decimal **RA** and **Dec**lination coordinates, a **Companions** frame, **Instrument/Mask Selector** fields, controls for **time sampling**, and an **Update Plot** button.

You can type coordinates into the **RA** and **Dec** boxes or use the target name resolver to get coordinates. To find a target, type the target name into the **SIMBAD Target Resolver** box and click **Search**. If SIMBAD is unable to find a match, the result "No object found for this identifier" will be displayed. If SIMBAD finds a match, the target's SIMBAD ID, RA, and declination will be displayed. If SIMBAD cannot resolve a target, you may supply the RA and declination yourself (in decimal degrees).

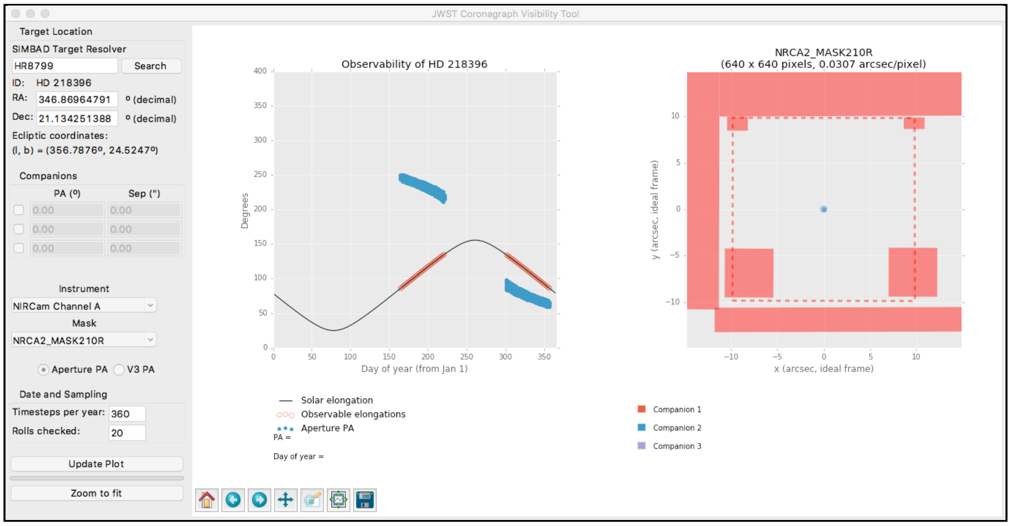
The program also returns the ecliptic coordinates of the entered coordinate. The ecliptic latitude is of particular interest as the range of available position angles for a given target depends on it. Low ecliptic latitude targets may not be observable at certain angles—you will want to know this prior to specifying it for an APT observation.

Running the calculation

Once an RA and Dec are available in the tool, select the instrument and mask (defaults are NIRCam channel A and NRCA2_MASK210R), then click **Update Plot** to calculate the target's visibility.

Figure 2 shows an example for the target HR 8799. The left plot shows the target's visibility windows. The red highlights on the solar elongation line indicate the valid windows. The blue tracks show the allowed position angles for the selected instrument and mask over those windows. The right panel shows the selected mask's field of view (red dashed line), where areas shaded in pink represent various obscurations due to hardware. These will change for different masks after the plot is updated.

Figure 2. Basic visibility output for HR 8799 (left plot panel)



The left plot panel shows the overall target visibility in a manner similar to the GTVT. The time axis shows days since January 1 for a generic year. (The pattern repeats from year to year.) The right panel contains no useful information unless or until one or more "companions" are added.

The visibility plot shows the solar elongation for the target as a black line, with the observable portions (85° –135°) highlighted in red. This target has two valid windows over the year, read from the x-axis. For each red portion, the plot shows the range of allowed position angles in blue, read from the y-axis. ("Aperture PA" denotes the standard position angle, viz., the angle east from North to the instrument y-axis of the selected science instrument and mask.)

Note that although there are two good windows of visibility for this target, the range of allowed position angles for each of them is fairly restricted. Checking below the coordinate boxes in the control panel, you will see that the ecliptic latitude of HR 8799 is only 24.5°, which restricts the range of allowed angles available at any time for JWST.

You can do things like zoom in on any region of the plot, save the figure to a file, and reset to the original plot using Matplotlib's standard plot interactions, controlled by the icon bar at the lower left of the plot region. Hovering over each icon produces pop-up information about its functionality.

> ⓘ To plot the PA of the observatory V3 axis instead of the instrument/mask combination, click on the **V3 PA** button on the control panel and then **Update Plot**. The blue points will be replaced by purple points at the **V3 PA** values allowed for the observable periods.

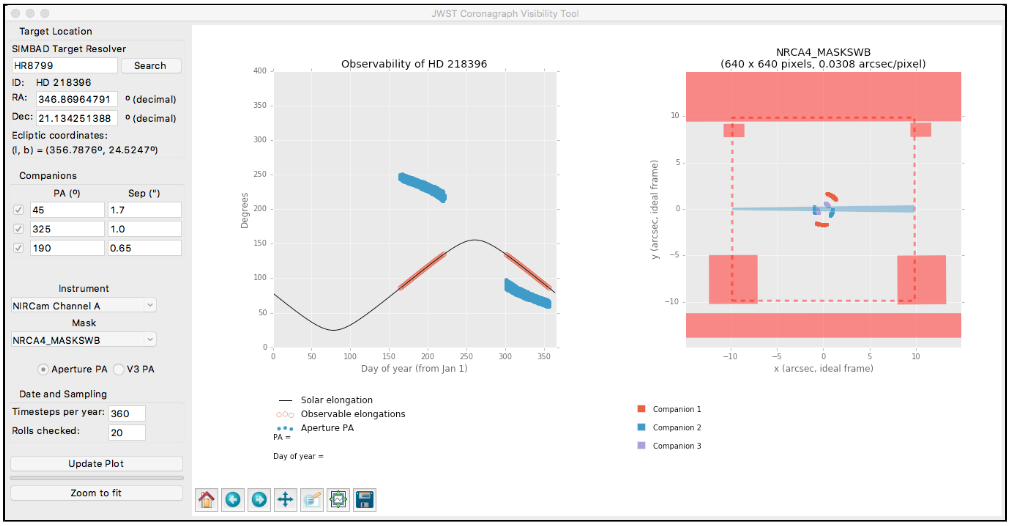
Adding companions to the primary target

To plan observations of known companions, disks, or other structures, enable one of the **Companions** boxes by clicking on the check box in the left column. Specify the companion’s **PA** (in degrees E of N) and separation, **Sep**, (in arcseconds) from your primary target. A companion can be thought of as a binary star, an exoplanet, the location of a disk's major or minor axis, or any sort of reference applicable to the astrophysical scene of interest. One can add up to 3 companions. The locations over time of the 1st, 2nd, and 3rd companions will be marked as tracks in the right panel plot with red, blue, and purple, respectively.

Before you update the plot, select or verify the instrument and coronagraphic mask that you'd like to use to observe the target using the drop-down menus. In this example, we select NIRCam and one of the wedge occulters.

Finally, click **Update Plot** again to refresh the plots. Figure 3 shows an example for HR 8799 in which we have plotted 3 companions to be observed with the NIRCam SWB mask.

Figure 3. The CVT output for HR 8799 when plotting the detector locations of three known exoplanets



The occulting wedge for the selected mask is shown in the right panel along with the companions' positions as a function of time within the visibility window(s).

You can now click on a blue point in the left visibility plot to select it; the corresponding companion points in time are marked on the right science detector panel in white. The north and east axes are also shown on the science frame as a solid red and yellow line, respectively. The default active field of view size for the selected mask and detector is also displayed on the science frame as a red dashed border. This is useful in scenarios where the astrophysical scene may exceed the aperture size.

You can zoom in on the plot using the plot controls at lower left. Also, when the cursor is within an active plot region, the cursor values appear at the lower right of the overall plot frame when the zoom controls are not active, so values can be seen directly (rather than reading them off the axes). The units on the left panel are degrees on the y-axis and days on the x-axis, referenced to January 1 of a generic year. (The pattern repeats from year to year.)

Use the zoom icon on the toolbar below the plots to enter zoom mode, which will let you enlarge the plot region of interest in either plot panel. Note that an indicator appears at lower right to indicate when the zoom mode is active. (Alternatively, one can select the pan and zoom feature, but the regular zoom is likely more appropriate for these plots.)

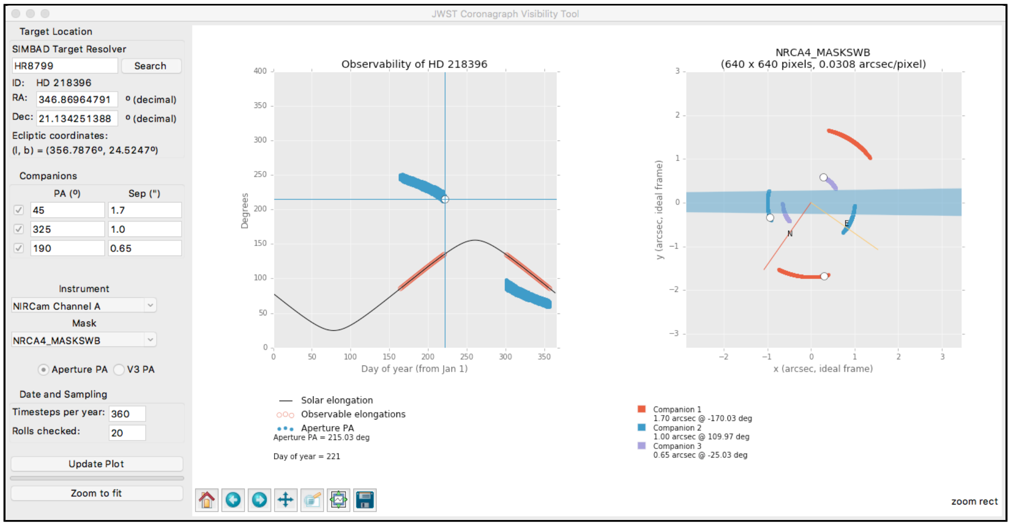
> When using the plot icons, you need to click the icon again to leave the active mode and return to the normal click behavior of selecting points.

Note that each plot is cached, so you can use the forward and back arrow icons to navigate through previous plots. The home icon restores the original plot.

Alternatively, one can select a companion position in the right panel (click on a red, blue, or purple point) and see the corresponding position appear on the left visibility plot. The corresponding companion points are highlighted in white, and the corresponding PA is highlighted in white in the left panel.

Below the science panel, the separation (in arcsec) and angle on the detector (CCW relative to +y axis) are displayed for each white point. Figure 4 shows a particular observation date and roll angle for the HR 8799 system when all three companions are visible without obscuration.

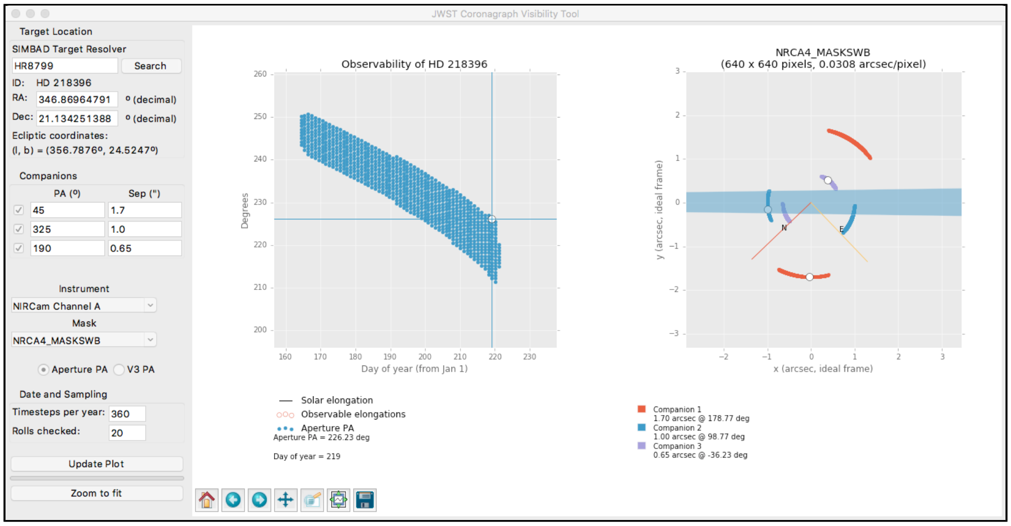
Figure 4. The same CVT output for HR 8799 with a particular orientation selected



In this figure, we have selected a specific time/angle in the left visibility panel and zoomed in on the science panel to show the companion tracks in more detail.

So far, this exercise has determined a time/angle (aperture PA of approximately 215°) when all 3 companions are nominally visible outside the obscuration of the mask. But for many coronagraphic applications, you may want to observe the target with a roll dither. Figure 5 shows what Figure 4 looks like when we zoom in on the visibility window in the left plot panel.

Figure 5. Checking the visibility and PA range allowed by zooming in on the visibility window

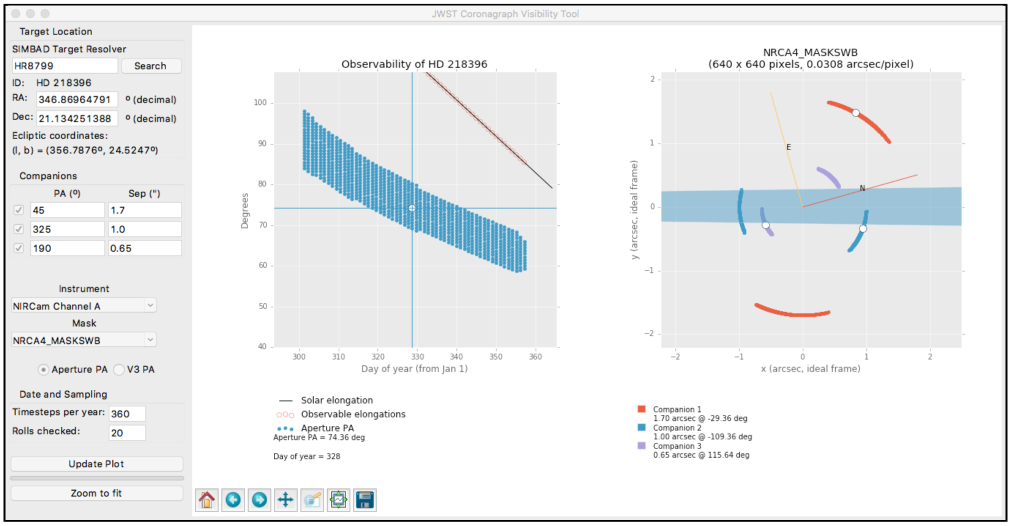


By clicking alternately on the bottom and top of the blue range in the left plot panel, you can check the companion positions assuming a maximal roll dither, and also estimate the allowed range available at a given time. In this example, you can see that at the top of the range one of the companions is hidden behind the occulting bar.

The vertical width of the blue region in the left panel shows the range of allowed angles available at that particular time. The selection of companion positions in the right panel corresponds to a time when the position angle is skewed toward the bottom of the allowed region in the left panel. If a roll dither is desired, you should check the other extreme of allowed angles 9top of the blue region) to see how a roll dither will change the position of the companions relative to the mask obscuration in the right panel.

For this example, you will see that the companion on the blue track in the right panel rotates into the mask and becomes unobservable when the top of the blue range is selected in the left panel. You can use this sort of analysis to decide on how to restrict the size of the allowed roll offset to prevent this obscuration from happening, or investigate visibility in the other observing window to see if there is an alternative configuration that works better.

Figure 6. Another possible observation time in the other visibility window, which has been zoomed in the left panel



As in Figure 5, clicking at the top and bottom of the available y-range shows very limited visibility because the companions are so close the the occulting bar.

In Figure 6, we have now zoomed in on the first visibility window in the left plot and highlighted a time when all three companions are visible outside the wedge obscuration. However, two of the companions are very close to the mask, and once again, checking the availability for roll dithering shows problems. At this point, you will need to decide whether the former option is better, whether to include the small roll dither or not, and/or whether it would be more beneficial to make two observations of the field separated in time instead of using a roll dither.

Finally, for systems with other structure around the primary target, such as a disk with some known orientation on the sky, you can define a "companion" (or two diametrically opposed companions if desired) at the relevant position angle to act as a proxy for the disk structure's position angle versus time in the selected instrument and mask.

Saving plots

The rightmost icon in the plot control menu saves a file with the current plot view. The target name and instrument/mask information is encoded in the plot headers. However, the control panel (including any definitions of companions) is not saved. If needed, we suggest the option of performing a screen grab to save the desired display for your reference.

Checking visibility of PSF reference stars

The other important aspect of visibility for coronagraphic observers is the visibility of an appropriate reference star for point spread function (PSF) subtraction. In the vast majority of cases, the standard observation sequence includes an observation of the nominal science target and the PSF reference star in a contiguous, non-interruptible sequence, meaning that both objects need to be observable at the same time. Hence, once any restrictions on the observability of the science target are known, the CVT should be run on the potential PSF reference star or stars to verify that it's visible at the same time. For a PSF reference star, only the left panel (the visibility plot) is needed. (This can also be done using the General Target Visibility Tool (GTVT) since it does not require information about the coronagraphs.)

Final notes

The example above demonstrates the utility of looking at the details of potential coronagraphic observations prior to entering observations in APT. APT can provide accurate assessments of visibility windows and check such things as guide star availability for a particular time, but it is not optimized to provide assessments of how the NIRCam and/or MIRI masks impact the observability of known companions or disks. By checking such things within the CVT, you will be able to identify appropriate times and/or angles, and have good confidence that observations will be schedulable when their details are entered into the appropriate APT observation template (s). Alternatively, if the CVT shows that a particular target cannot be observed at the desired angle, it may be time to find a different target; at least you will have found this out prior to entering and trying to process a non-schedulable observation in APT.

The CVT, GTVT, and APT have been tested against each other for consistency. However, as stressed in the introduction, the CVT does not generate official pointing restrictions; you should consider the results as approximate and plan accordingly. For example, you should not rely on this tool to ensure that the orientation on the detector is accurate to within a degree of the reported angle or within a day of the beginning or end of the calculated visibility windows. This tool is not to be used for assessing the placement of any companion on a given pixel of the selected detector. It is for quick look and preliminary planning purposes only, but should result in a significant time savings for coronagraphic proposers.

Additional information on JWST's pointing restrictions, and how those affect target visibility and available position angles are included in this page: JWST Position Angles, Ranges, and Offsets.

This version was updated Aug. 2, 2017, for compatibility with v 0.3.0 of the CVT tool.

Published	22 Feb 2017
Latest updates	• 02 Aug 2017 Figures 1, 2, 3, 4, 5, and 6 updated

JWST Interactive Sensitivity Tool

The JWST Interactive Sensitivity Tool (JIST) is a quick-look tool that allows exploration of observation feasibility for all JWST basic observing modes. JIST allows you to explore signal-to-noise values in real time by adjusting source flux density or telescope exposure time.

On this page

JIST uses a pre-computed grid of simple point-source calculations made with the ETC engine (Pandeia) and interpolates within that grid to provide you with insight into the S/N you can obtain in potential JWST integrations. JIST is designed using the bokeh python plot functionality to provide a flexible, interactive environment.

JIST runs directly in your browser window. To access JIST, use this link: jist.stsci.edu

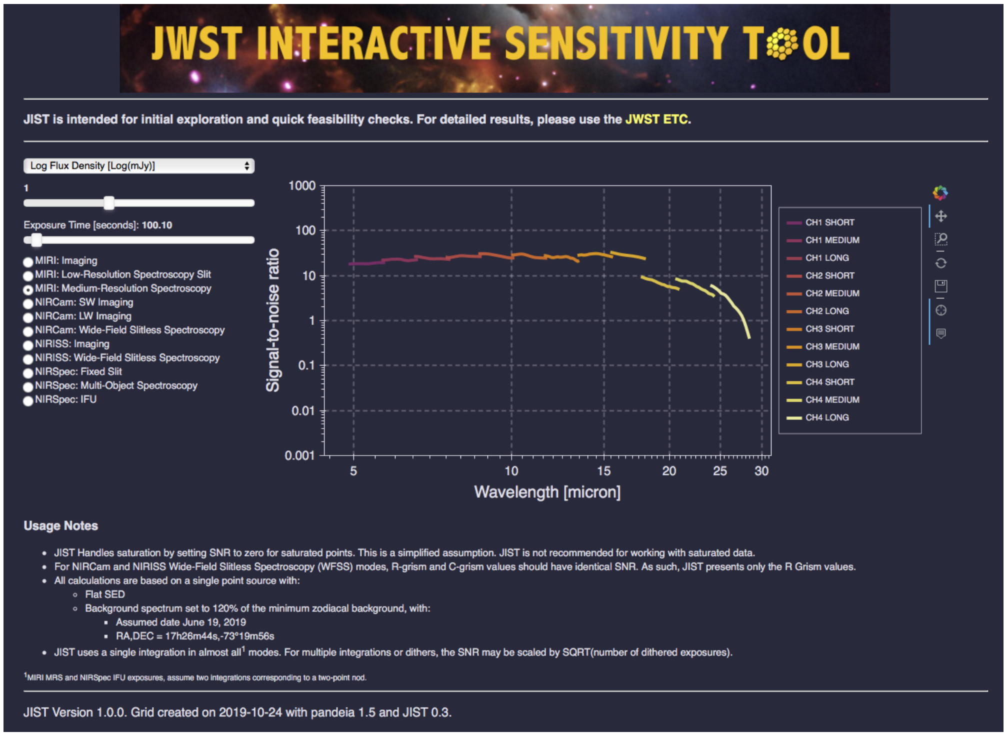
By design, JIST offers less flexibility than the JWST ETC in exchange for faster operation. As such, there are a number of factors you should be aware of when using JIST:

- JIST offers only a flat-spectrum point source target input. Hence, for different source spectral shapes or for extended sources, the JWST ETC will be more accurate.
- JIST offers only a single background option of 1.2 times the minimum zodiacal background. A higher fidelity treatment of background and more options are available in the JWST ETC.
- JIST offers only a single integration, which in turn gives it a maximum exposure time.
  - For observations with multiple integrations, the expected S/N can be scaled as the square root on N_{int}.
  - If you increase the flux density enough to cause saturation, saturated points start disappearing from the display.

After exploring the possibilities with JIST, you should use the JWST ETC to determine the specific exposure specifications you will need for entry into APT.

The JIST Interface

Figure 1. **The JIST GUI**



This is a screenshot of the GUI interface you will see when you open JIST. By selecting an observing instrument/mode on the left, the plot will change as needed for that mode. Adjusting the sliders then results in the plotted information adjusting accordingly.

The main JIST interface is shown in Figure 1. It consists of a flux density slider, an exposure time slider, a group of mode selection radio buttons, and the bokeh plot itself. The interactable parts of the plot are:

- Sliders: The source brightness and exposure time sliders allow you to adjust the assumed flux density or AB Magnitude of the point source, and the integration time on the detector (note that all bokeh plots are for a single integration). The range of the sliders varies depending on the mode chosen.
- Mode Selection Buttons: These allow you to choose the instrument and observing mode. The wavelength range on the plot changes automatically as different modes are selected.
- Bokeh Widgets: These will be described from top to bottom.
  - Bokeh website widget (
    
    ): This opens a link to the bokeh website.
  - Pan control (
    
    ): This allows you to pan the plot (without changing its scale).
  - Box Zoom (
    
    ): This allows you to zoom in on a particular part of the plot (by drawing a box on the plot). The box you draw will zoom in to occupy the entire plot.
  - Reset (
    

): This allows you to reset the plot to its original range and scale.

- Save (

): This allows you to save the current plot as an image file.
- Crosshair (

): This toggles a crosshair on and off over the plot. It is on by default.
- Hover Tool (

): This toggles on or off whether the plot should show annotations (e.g. grating/filter information) when you hover the cursor over a data point. It is on by default.

- Legend: This shows the currently displayed modes. For spectroscopic data, clicking on a legend entry will hide the corresponding mode from the plot.

Units Conversion

JIST allows the user to specify inputs as Flux Density (in mJy) or as AB magnitudes. If you need to convert your source information, there is a handy conversion tool available.

Moving from JIST to the JWST ETC

JIST is an exploratory tool for basic checking of feasibility. Once you have used JIST to determine the feasibility of your observation, you can move on to using the online JWST ETC tool to continue planning your observations. In many cases, it will be possible to improve signal-to-noise ratios by fine-tuning exposure parameters and observing strategies in the ETC.

After obtaining an overview of the ETC and its functionality, you can go directly to The ETC Quick Start mode to start using the ETC. Once you are comfortable, actually sign in to the ETC so you can save your work.

Use the navigation menu at left to access any of a number of topical articles covering various aspects of the JWST ETC. Also, there are a number of video help tutorials **(<–future link to ETC videos page)** available to help get you started using the JWST ETC.

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Mirage Data Simulator

On this page

The Multi-Instrument Ramp Generator, or Mirage, is a Python software package that creates simulated data for a significant subset of the science observing modes of NIRCam and NIRISS, as well as imaging mode with the JWST Fine Guidance Sensor (FGS). Simulated data from Mirage can provide JWST observers with a deeper understanding of the quality and layout of JWST data. They can also help observers develop their own data processing workflows and practice analyzing JWST data before real data are available.

Typical Workflow

The most common way to use Mirage begins with an APT file. Mirage will ingest the APT file and produce an individual parameter file for each exposure. Working with each parameter file, in addition to several types of source catalogs, Mirage combines a scene of simulated astronomical sources with dark current data collected during ground testing to produce high fidelity simulated exposures. These data can then be processed through the JWST calibration pipeline in the same way as real observations will be.

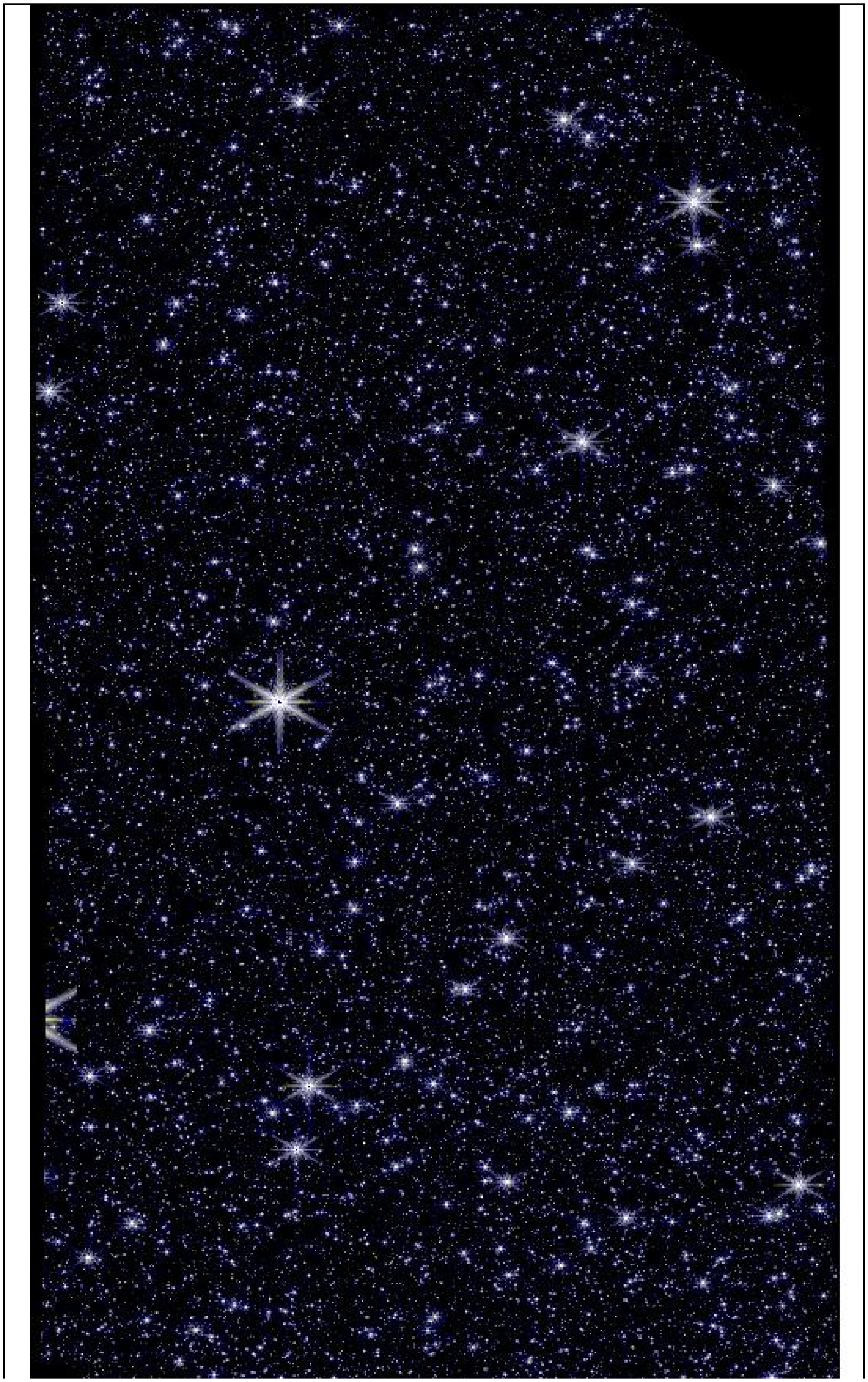
Documentation and Examples

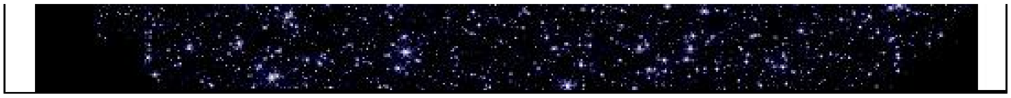
A general overview of Mirage is provided in a JWST Proposal Planning Toolbox article.

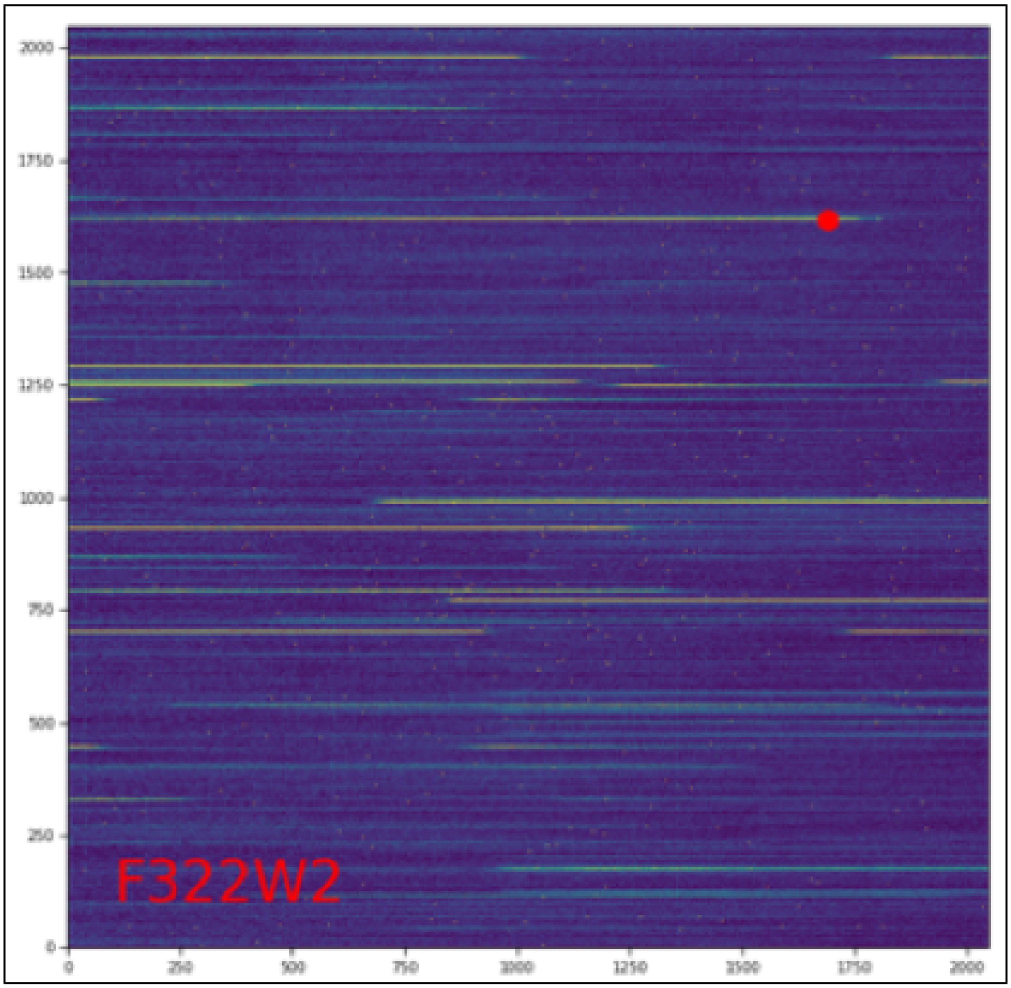
Full documentation, including Installation instructions is available on Read The Docs.

The Mirage repository contains example Jupyter notebooks for each observing mode.

Figure 1. Mirage data simulations







Top: Portion of a simulated NIRCam image of the Large Magellanic Cloud.
Bottom: Simulated NIRCam WFSS exposure. The red dot indicates the position of the target on the detector.

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