Microwave Kinetic Inductance Detectors for the PICTURE-C Mission

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The Planetary Imaging Concept Testbed Using a Recoverable Experiment – Coronagraph (PICTURE-C) will directly image debris disks and exozodiacal dust around nearby stars from a high-altitude balloon using a vector vortex coronagraph and Microwave Kinetic Inductance Detectors (MKIDs). We present the design and preliminary characterization of the MKID instrument. The cryostat uses liquid helium and an Adiabatic Demagnetization Refrigerator to maintain a detector temperature of 100 mK, well below the superconducting transition of the Platinum Silicide MKIDs. The 10,000 pixel MKID array will be optimized for 600nm with a 20% bandpass, and will be read out by ten ROACH2 and custom ADC/DAC boards.

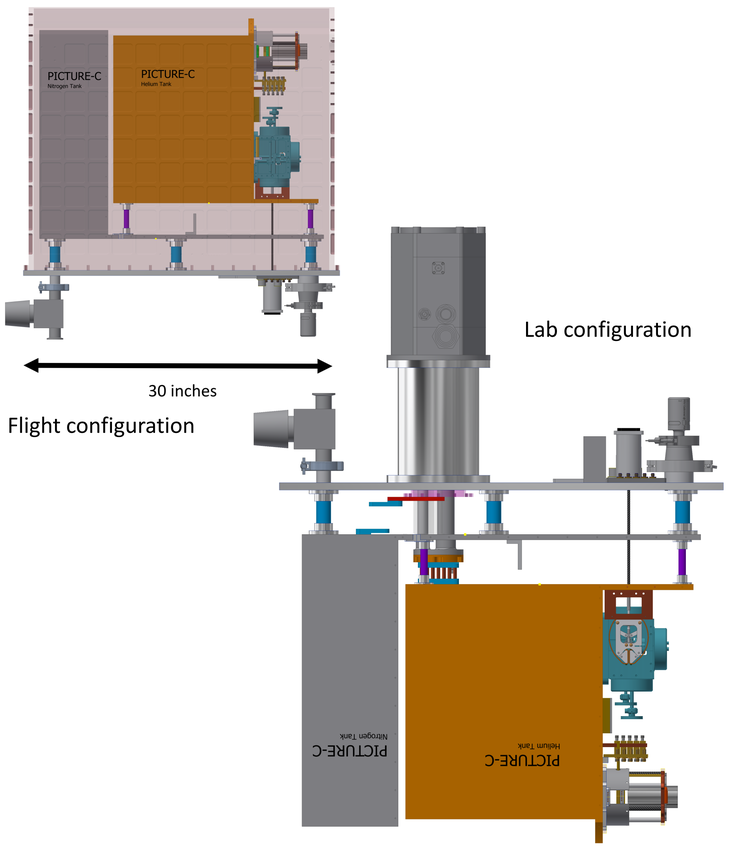
Introduction

- Planetary Imaging Concept Testbed Using a Recoverable Experiment – Coronagraph (PICTURE-C) is a mission that will use adaptive optics, a coronagraph, and an optical MKID camera to observe and characterize the scattered light from nearby debris disks
- **UCSB is constructing the MKID camera**

Wavelength	**600 nm**
Bandpass	**20% (540nm to 660nm)**
Contrast at IWA	**10^{-7}**
Resolution (λ/Δλ)	**20**
Control Region	**Half-plane from 1.7 to 10 λ/D (0.35” to 2.1”)**

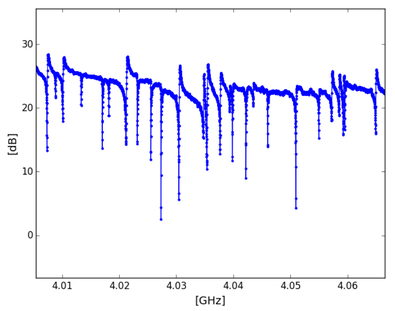
Cryostat

- Liquid helium/nitrogen
- Designed hold time ~50 hrs
- Adiabatic Demagnetization Refrigerator
- ~115 kg full
- NbTi flex cables from 4 K to 100 mK for low loss and low thermal loading
- 5 HEMTs with ~40 dB of gain at 4 GHz
- Pulse tube cooler for in-lab testing

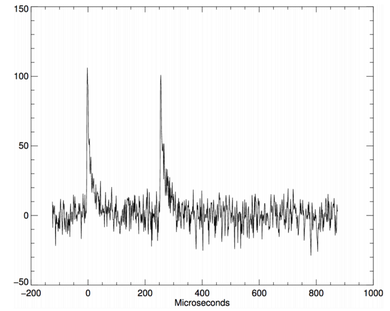


MKIDs

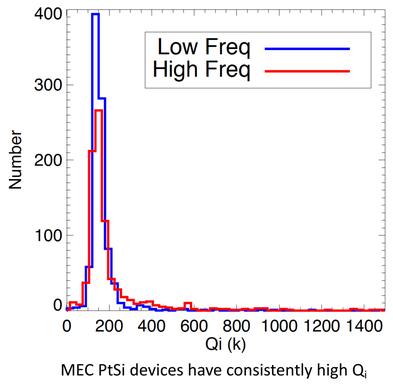
Superconductor	**Platinum Silicide**
Pixel Count	**10,000**
Operating Temperature	**100 mK**
Maximum Count Rate	**~2500 photons/sec (soft limit)**
Resonator Q_i	**~100,000**
# of microwave feedlines	**5**
Frequency Range	**4-8 GHz**
Photon timing resolution	**~1 µs**



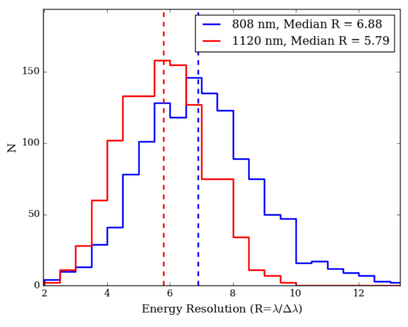
S_{21} from MEC device. Resonators have f_0 within a few MHz of design frequencies.



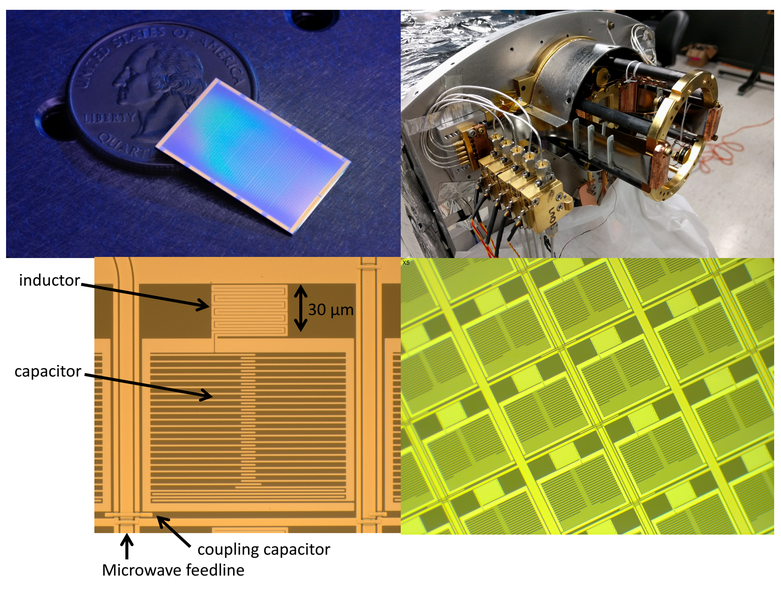
808 nm photons measured with a DARKNESS device



MEC PtSi devices have consistently high Q_i

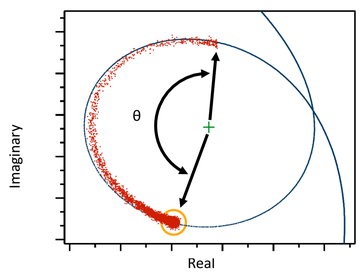


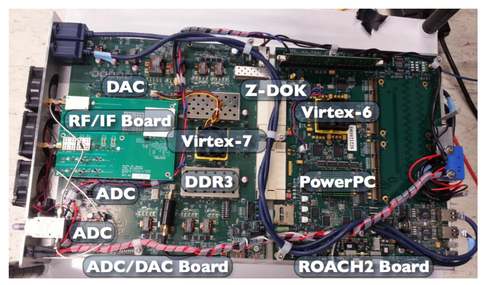
Work is ongoing to increase the energy resolution.



Readout

- Pulse detection readout based on DARKNESS firmware
- 10 ROACH2 boards
- 10 custom ADC/DAC boards
- 10 custom IF boards
- ~1400 W, will require large radiator panel





Telescope and Optics

- 60 cm off-axis paraboloid primary
- 2 deformable mirrors will actively maintain a “dark hole” in the focal plane
- Vector vortex coronagraph will suppress on-axis starlight