OPTICAL SEARCHES FOR INTELLIGENT EXTRATERRESTRIAL INTELLIGENCE

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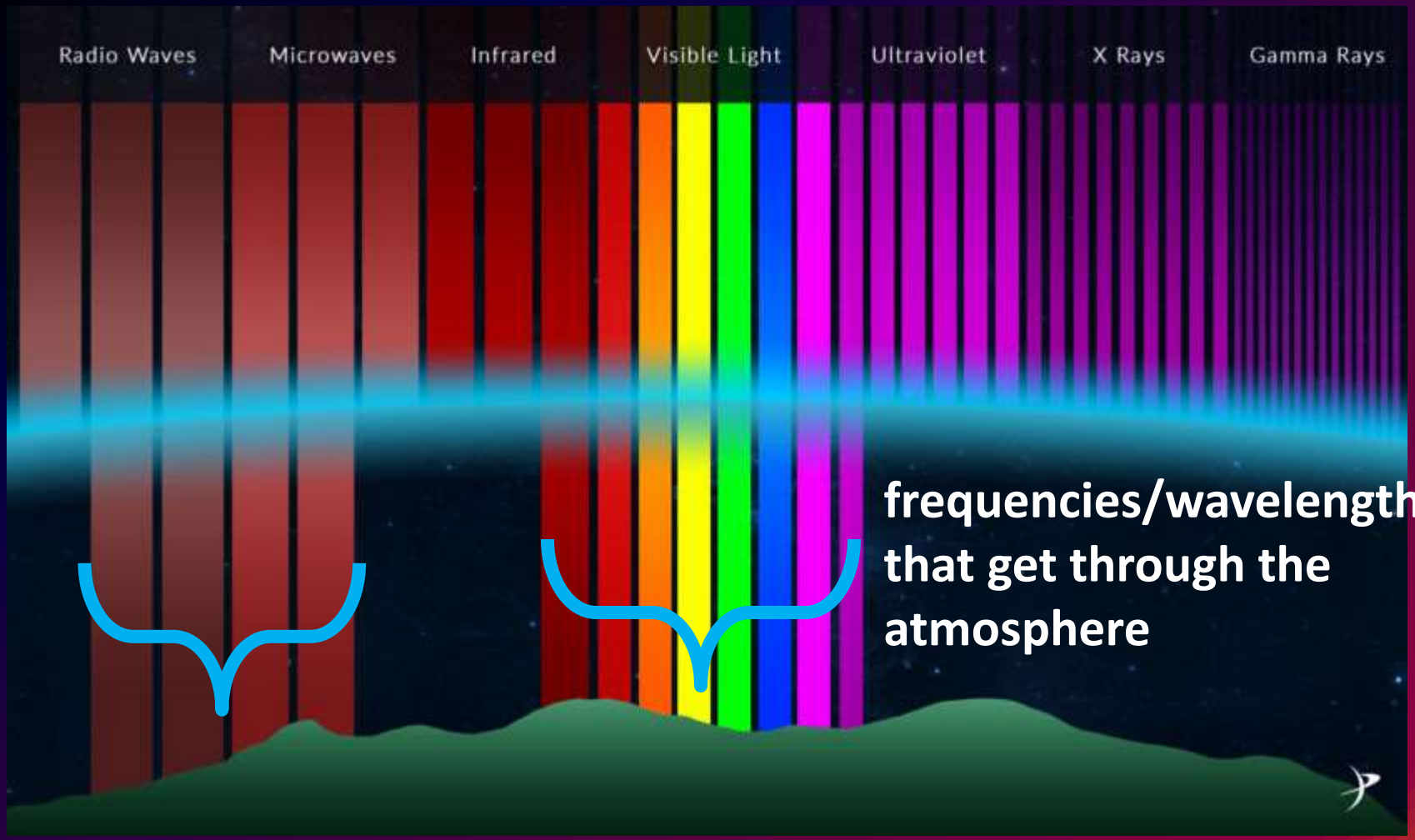
class 4



The Planetary Society
http://www.planetary.org/blogs/jason-davis/2017/20171025-seti-anybody-out-there.html

THE ATMOSPHERE'S EFFECT ON ELECTROMAGNETIC RADIATION

Earth's atmosphere prevents large chunks of the electromagnetic spectrum from reaching the ground, providing a natural limit on where ground-based observatories can search for SETI signals.

Searching for technology that we have, or are close to having:
Continuous radio searches
Pulsed radio searches
Targeted radio searches
All-sky surveys

Allen Telescope Array, built and operated by the SETI Institute. Credit: Seth Shostak/SETI Institute.

Optical:
Continuous laser and near IR searches
Pulsed laser searches

a hypothetical laser beacon

watch now:

https://www.youtube.com/watch?time_continue=41&v=zuvyhxORhkI

Theoretical physicist Freeman Dyson's "First Law of SETI Investigations:"
Every search for alien civilizations should be planned to give interesting results even when no aliens are discovered.

Interview with Carl Sagan from 1978:
Start at 6:16

https://www.youtube.com/watch?v=g-Q8aZoWqF0&feature=youtu.be

IS ANYONE THERE?

SETI CLOSE CALLS

The Wow! Signal

1977: Big Ear radio observatory picks up an unexplained signal from the constellation Sagittarius. It was never heard again.

Hello, out there?

OSU astronomers have been listening for extraterrestrials for years, via the Big Ear project. Stuart Kingsley thinks the method's all wrong, though, and he's doing it his way—in Bexley.

Extraterrestrials are taken very seriously in Columbus.

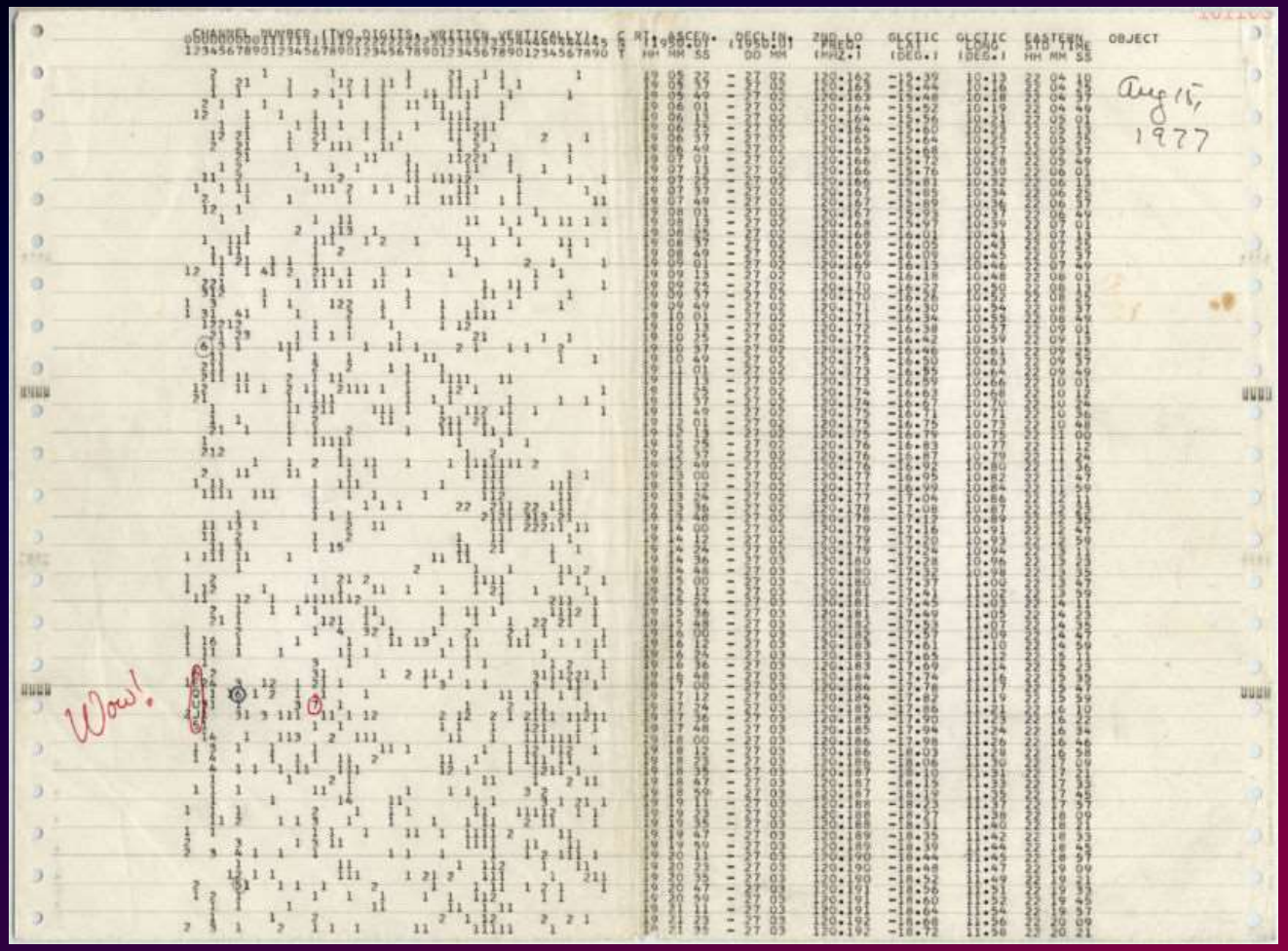
Many highly intelligent people with respectable day jobs have spent a lot of time thinking about creatures in outer space, and how, if at all, we should communicate with them. And with the National Aeronautics and Space Administration (NASA) just off on a $100 million, 10-year attempt to intercept messages from outer space, local scientists are working hard to have a say in how that money is spent.

Astronomers at Ohio State University are veterans at this. They have listened full-time for messages from space longer than anyone else. Their work began in 1973. When OSU's huge radio observatory in Delaware County finished up its original job of helping chart the universe, Robert Dixon, a young electrical engineering Ph.D., suggested the telescope be devoted to SETI, the Search for Extraterrestrial Intelligence. The observatory's founder, John Kraus, agreed, and the project known since as "Big Ear" was born.

The telescope listened 24 hours a day, rotating with the earth, and a computer typed out the signals received in each of 50 channels. Each day or so a volunteer would sit down with piles of printouts and page through to see if any unusually strong signals had come in, indicating that an alien might have "called."

On an August night in 1977, the phone rang. A volunteer named Jerry Ehman, who now is a college math instructor, found a signal that, for 59 seconds late the night before, had swelled to about 30 times stronger than normal. "I just instantly, without thinking, wrote 'Wow!' in the margin," he says. For two months listen-

Stuart Kingsley, with the 10-inch telescope he's set up in his back yard.



Anomalous signal recorded by Big Ear Telescope at Ohio State University. Big Ear was a flat, aluminum dish three football fields wide, with reflectors at both ends. Signal was at 1,420 MHz, the hydrogen 21 cm 'spin flip' line.

http://www.bigear.org/Wow30th/wow30th.htm

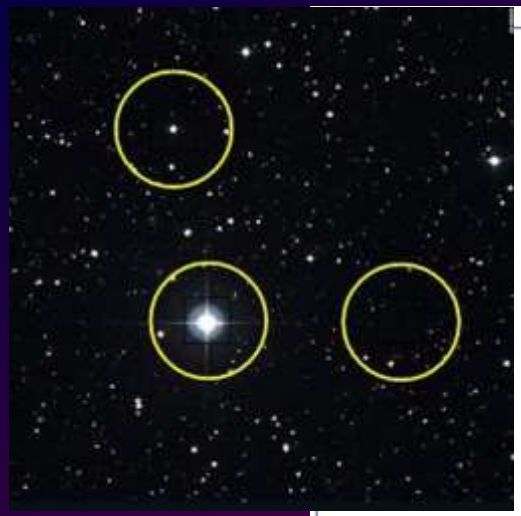
May 15, 2015

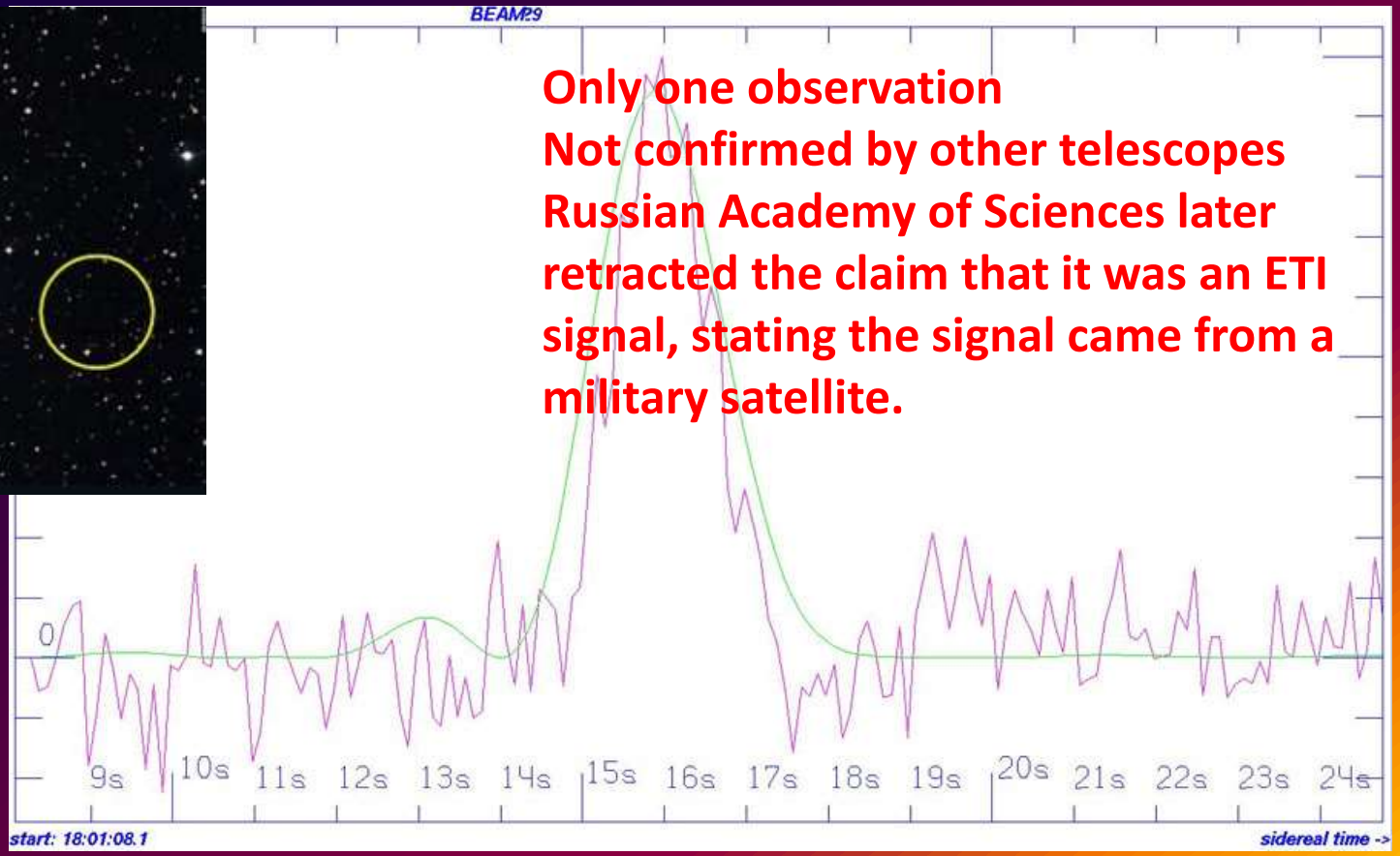
A Russian observatory reports a strong signal from a Sun-like star. Possibly from advanced alien civilization.

The RATAN-600 radio telescope in Zelenchukskaya, at the northern foot of the Caucasus Mountains

location: star HD 164595

G-type star (like our Sun)
94.35 ly away, visually located in constellation Hercules
1 planet that orbits it every 40 days
unusual radio signal detected – 11 GHz (2.7 cm)
claim: Signal from a Type II Kardashev civilization





Only one observation
Not confirmed by other telescopes
Russian Academy of Sciences later retracted the claim that it was an ETI signal, stating the signal came from a military satellite.

THE NATIONAL RADIO ASTRONOMY OBSERVATORY'S VERY LARGE ARRAY IN NEW MEXICO

Meerkat Radio telescope array in South Africa

Allen Telescope Array in northern California

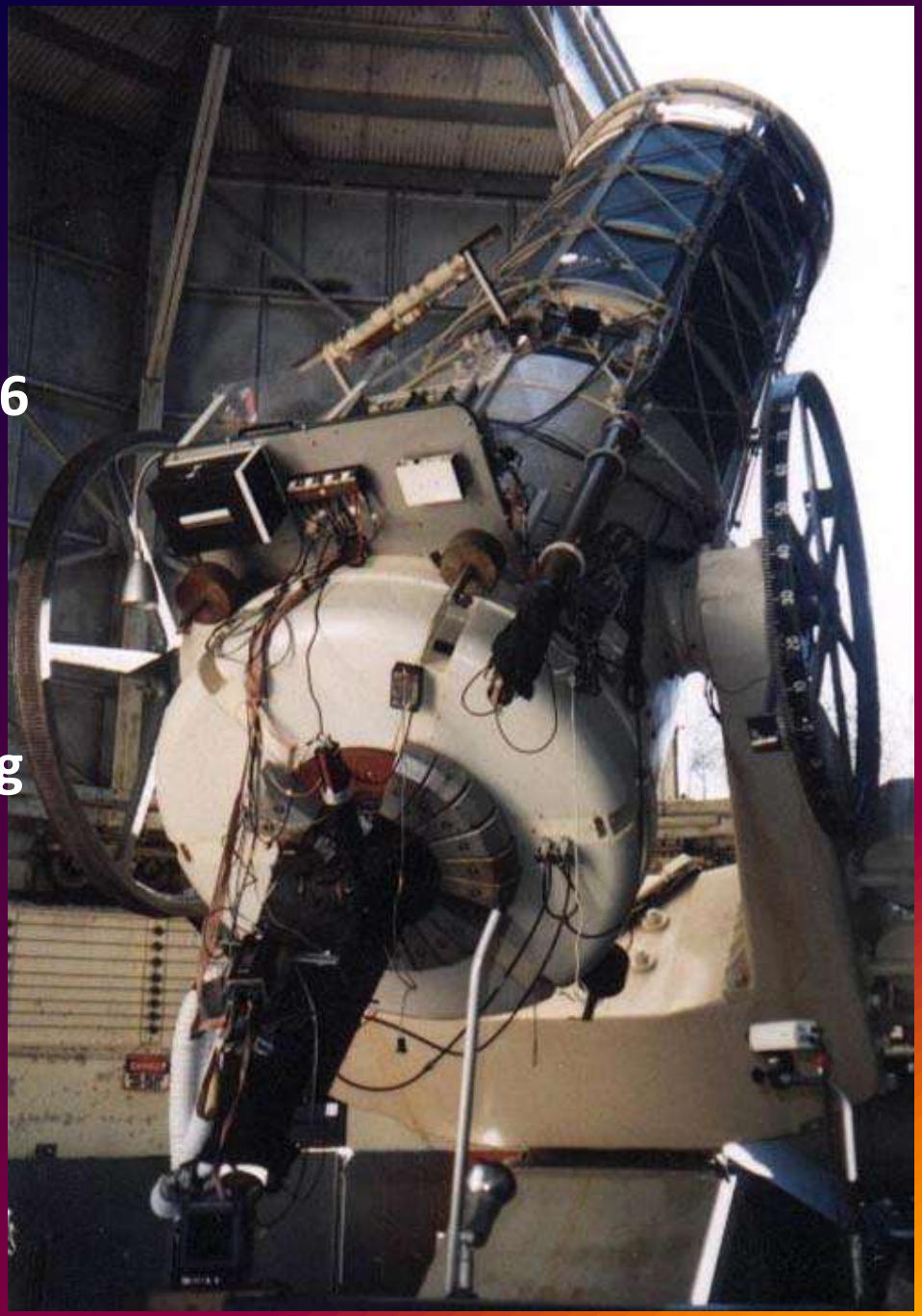
Still searching for ETI signals, among other radio observations

Optical Searches for ETIs (OSETI)

First such program was initiated at Harvard in April, 2006

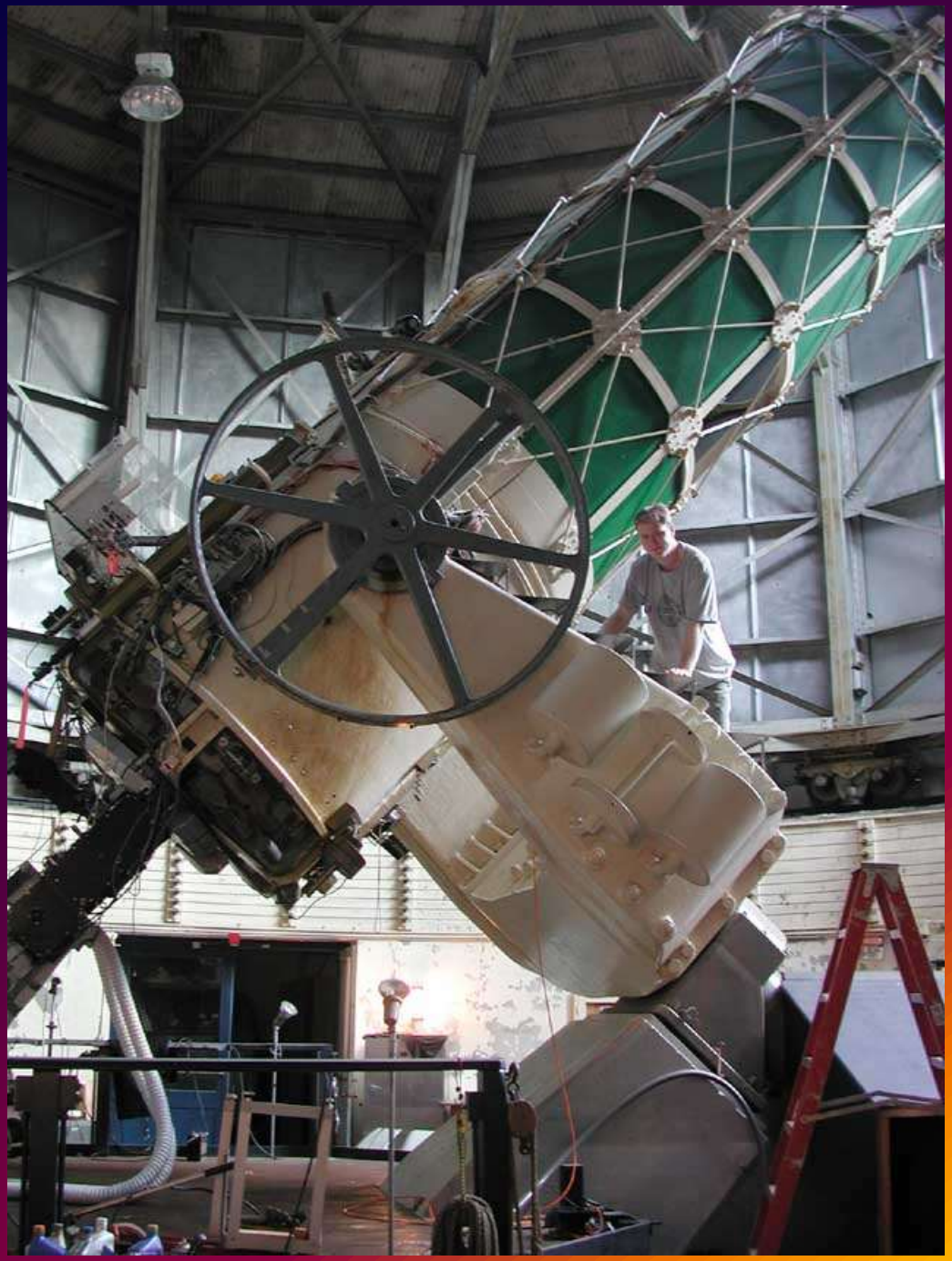
Assumption:
A civilization with our current technology or just a bit beyond would be capable of transmitting a focused signal which would be distinguishable from both astrophysical phenomena and background noise.

Horowitz et al., Harvard



Two types of optical searches:
*** pulsed laser beacon targeted search**
*** all-sky survey**

Electronics on the back end of the 72” telescope for detecting pulsed signals in two channels simultaneously



Results of Harvard's pulsed OSETI So Far:

After 27 months, we've seen 191 "events" from 160 stars (of 3,400 total stars observed), roughly 0.7 per night. These events appear to be uncorrelated with stellar magnitude; nor do they exhibit any periodicity. In fact, there is no clear evidence that they originate from light entering the telescope from the direction of the targeted star.

We are conducting tests to determine the origin of these irregular events. By "event," we mean an instance when each photodetector sees multiple photons (light pulses) within a very short time interval (roughly a nanosecond).

http://seti.harvard.edu/oseti/targeted/results.htm

Optical SETI: The All-Sky Survey

A high-intensity pulsed laser, teamed with a moderate sized telescope, forms an efficient interstellar beacon. Using only "Earth 1998" technology, we could build such a laser transmitter. To a distant observer in the direction of its slender beam, it would appear (during its brief pulse) a thousand times brighter than our sun.

http://seti.harvard.edu/oseti/index.html

A rich website to scour for tons of references:
http://www.coseti.org/opticals.htm

OSETI at UCSB

"If a class 4 civilization in Andromeda wanted to target the Milky Way and used our "intelligent targeting" scheme to maximize detection by intelligent life on planets, such as ourselves (i.e., target the stars in the Milky Way), then a simple Earth-based 3 year survey with a 1 meter telescope would detect a single class 4 civilization anywhere in Andromeda with near unity probability." – Lubin, 2016

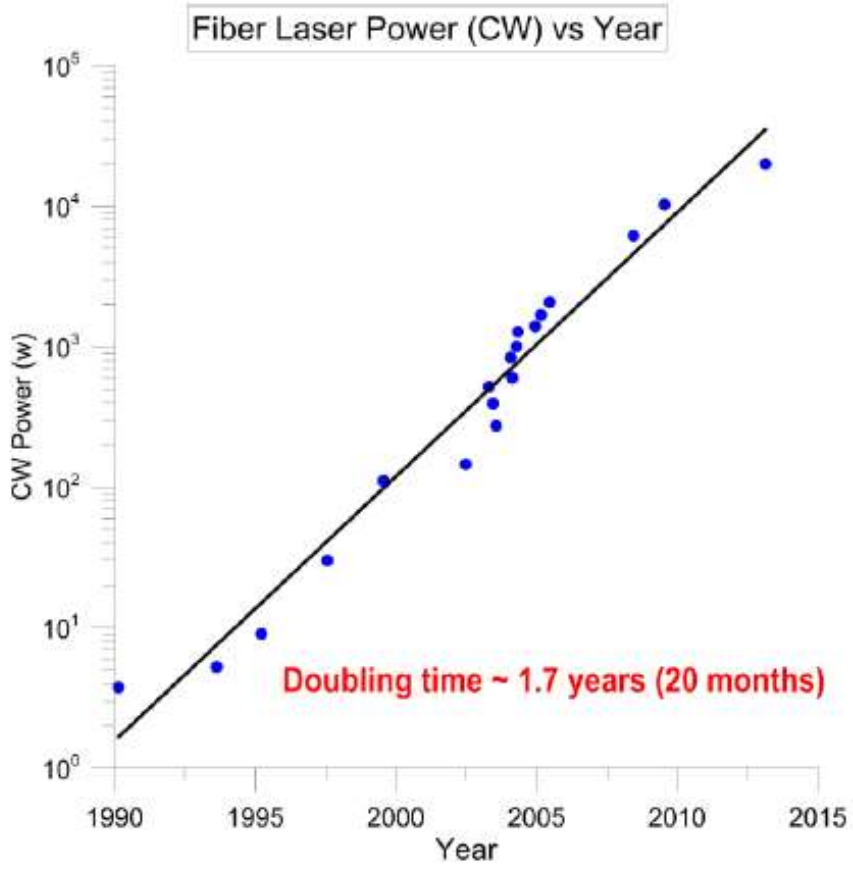
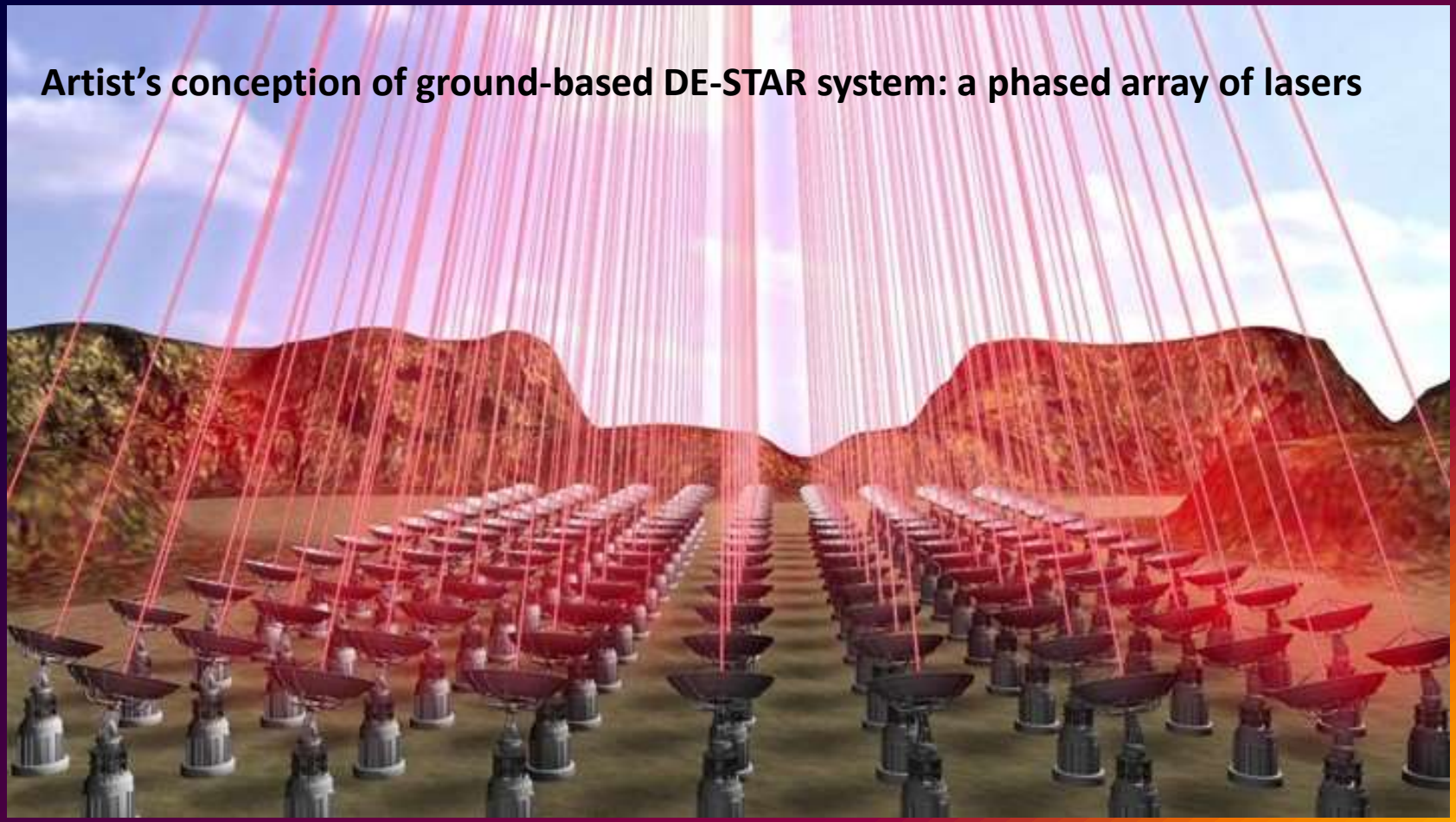


Figure 1 – Fiber laser CW output power vs year over the past 25 years based on data in the literature.

Our ability to produce power doubles every ~1.7 years. Hence we could expect that if a civilization would have developed similar technology, and wanted to communicate, we could be detecting their signals "now."

One of the enabling technologies that is relevant is the extremely dramatic progress in solid state lasers and in particular laser amplifiers that can be arrayed into larger elements. (Lubin, 2016)



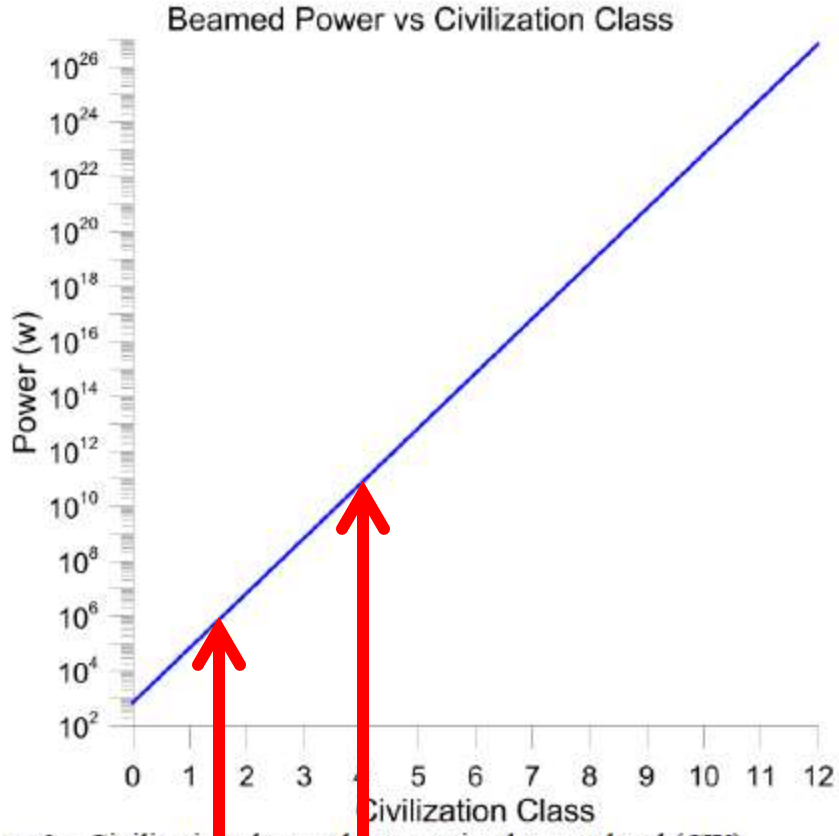


Figure 2 – Civilizatio class and aser emitted power level (CW).

We are currently at ~ Class 1.5.

Class 0: 1 m diameter optical system, transmitting 1 kW D.E.

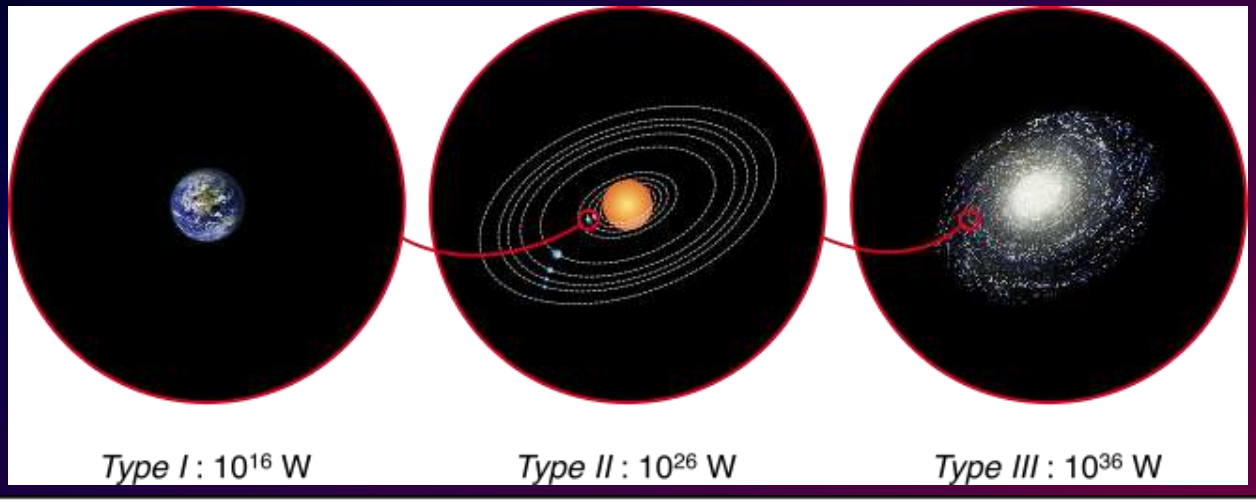
Class 4: 10 km array, transmitting 100 GW D.E.

Class 5: similar to a Kardashev Type I; can harness full power of their planet and convert to D.E. (10^{17} W)

Class 11: Can harness full power of their sun and convert it to D.E., similar to Kardashev Type II

We could rise to the level of Class 4 by the end of this century, if we choose to.

Recall from last time the Kardashev classification of ETI civilizations:



Type I	• Master of their planet • Can fully harness energy from within planet • Can control weather on surface of planet • Power order 10^{17} Watts
Type II	• Master of their solar system • Can fully harness energy from within star • Has established colonies on several celestial bodies • Power order 10^{26} Watts
Type III	• Master of their galaxy • Can fully harness energy from within all galactic stars • Has established colonies within several solar systems • Power order 10^{37} Watts

Next question: Could we see a directed energy beam from a civilization in another star system in our galaxy?
In another galaxy?
In a galaxy at high red shift?

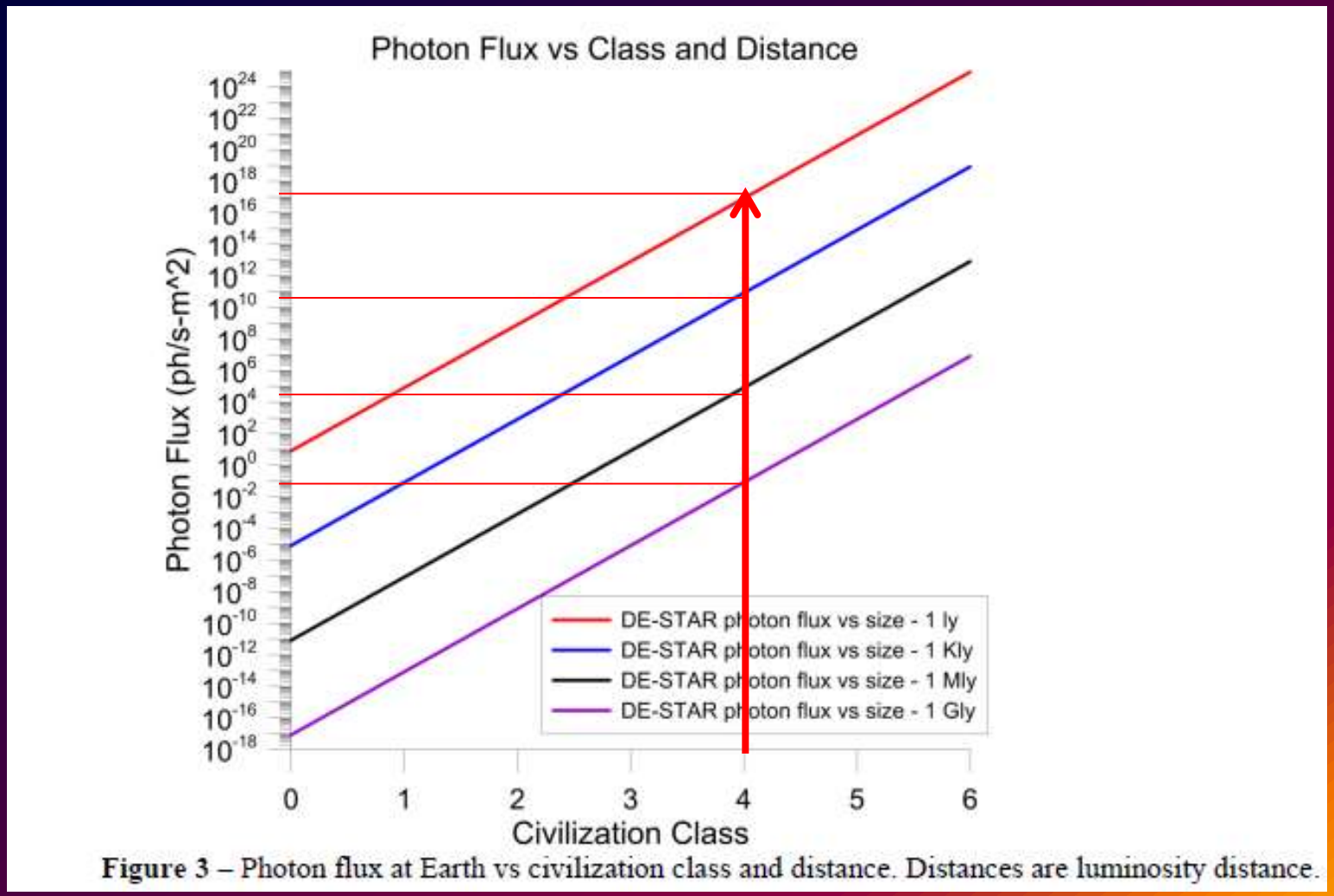


Figure 3 – Photon flux at Earth vs civilization class and distance. Distances are luminosity distance.

Other considerations:

- **Reddening and extinction by the interstellar medium**
- **Gravitational lensing of distant sources**
- **Background ‘noise’ of other stars in the field of view**
- **Scattered light from dust and gas in our galaxy**
- **Infrared background of the universe**
- **Noise in the detector**
- **Zodiacal light (Sunlight reflected off dust in the plane of the ecliptic**

May not be problems when searching for narrow-band laser light.

Other considerations: See the full paper.

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Even modest directed energy systems can be “seen” as the brightest objects in the universe within a narrow laser linewidth.

UCSB's Trillion Planet Survey

Searching M31 – the Andromeda Galaxy, our closest galactic neighbor (~2.5 Mly), using the Las Cumbres Global Observatory Telescopes and standard photometric system, with a custom image processing pipeline.