SETI Observations of Low Mass Stars at the ATA

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SETI Institute

ATA interferometer, 12 Hr/Day Every Day

Designed
For SETI

1-10 GHz

6.2 m Dishes

42, using 20 on regular basis

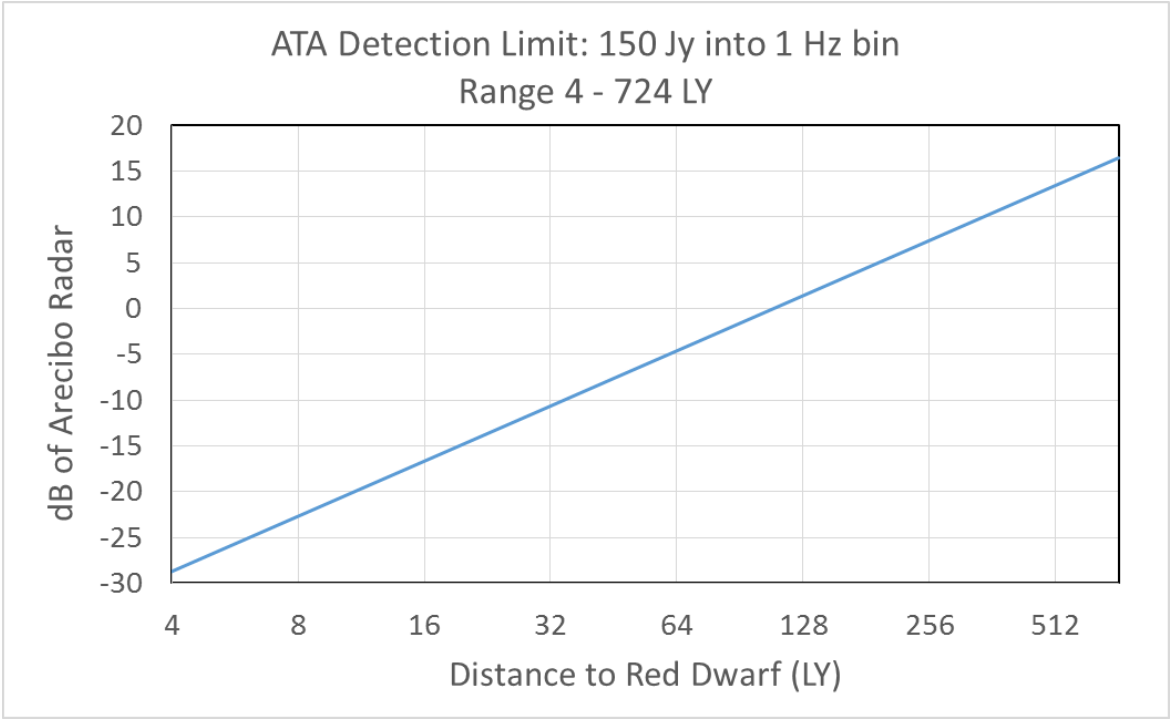
Why Red Dwarfs?

- Last longer
  - More time for life to evolve
- Majority of all stars
  - Many found nearby (4-500 LY)
- Given less attention in past SETI searches
- 16 with known rocky exoplanets in temperate (habitable) zone

Alias	RA (hr)	Dec (deg)	Spectral Type
GJ 1214	17.255	04.96	M4.5
TYC4006-01866-1	23.221	57.17	K
KIC 2626	19.624	49.92	M
KIC 2418	19.832	47.00	M
KIC 2124	19.686	49.38	K
KIC 3138	19.500	41.83	M
KIC 4427	19.674	39.27	M
GJ 180	04.897	-16.23	M
GJ 3293	04.477	-25.17	M
EPIC 201912552	11.504	07.59	M
EPIC 201367065	11.489	-01.45	M
Kepler 17 d	19.163	43.83	M
Kepler 62 e	18.881	45.35	K
Kepler 29 d, e, f	18.869	48.83	M
Kepler 28 c	19.574	47.84	M
Trappist-1	23.108	-05.04	M

ATA Red Dwarf Survey

- Red Dwarf catalog compiled from SDSS by Andrew West at Boston University (70,000 total)
- Select nearest 20,000
  - 4 – 724 Light Years
- 90 second observations
  - 0.7 Hz resolution (R = 10^9)
  - Drift rates -1 to 1 Hz/s
    - (~10 times sidereal)
  - Sensitivity 150 Jy into a 1 Hz bin
- At least 500 MHz on each target
  - All targets at some frequencies
  - All frequencies on some targets
  - Toward all frequencies on all targets



What makes SETI on ATA Unique

- There are plenty of stars to go around
- Examine full 1-10 GHz, no magic frequencies
- Interferometer: 3 stars simultaneously
  - Anticoincidence is strong RFI rejection filter
  - Beam to beam interferometric nulling reduces cross-talk even more
- Real time follow up of candidate signals
  - Don’t let signal go until
    - Source sets
    - Signal is proven to be RFI
  - Sensitive to signals that are not infinitely persistent (couple of hours)

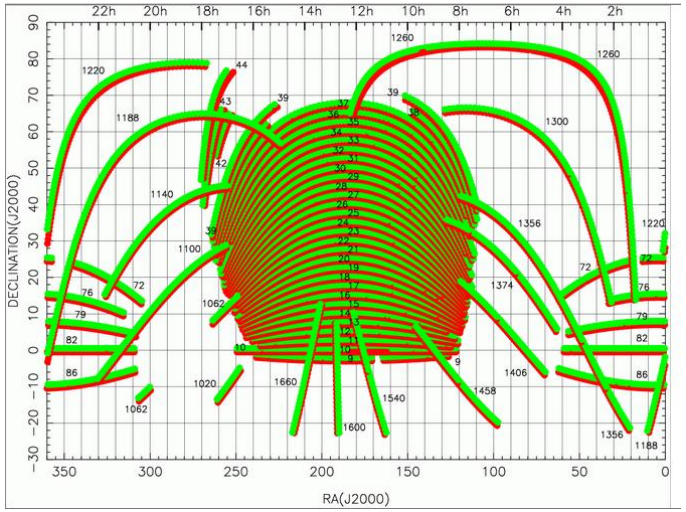
$\rightarrow$ Zero False Positives

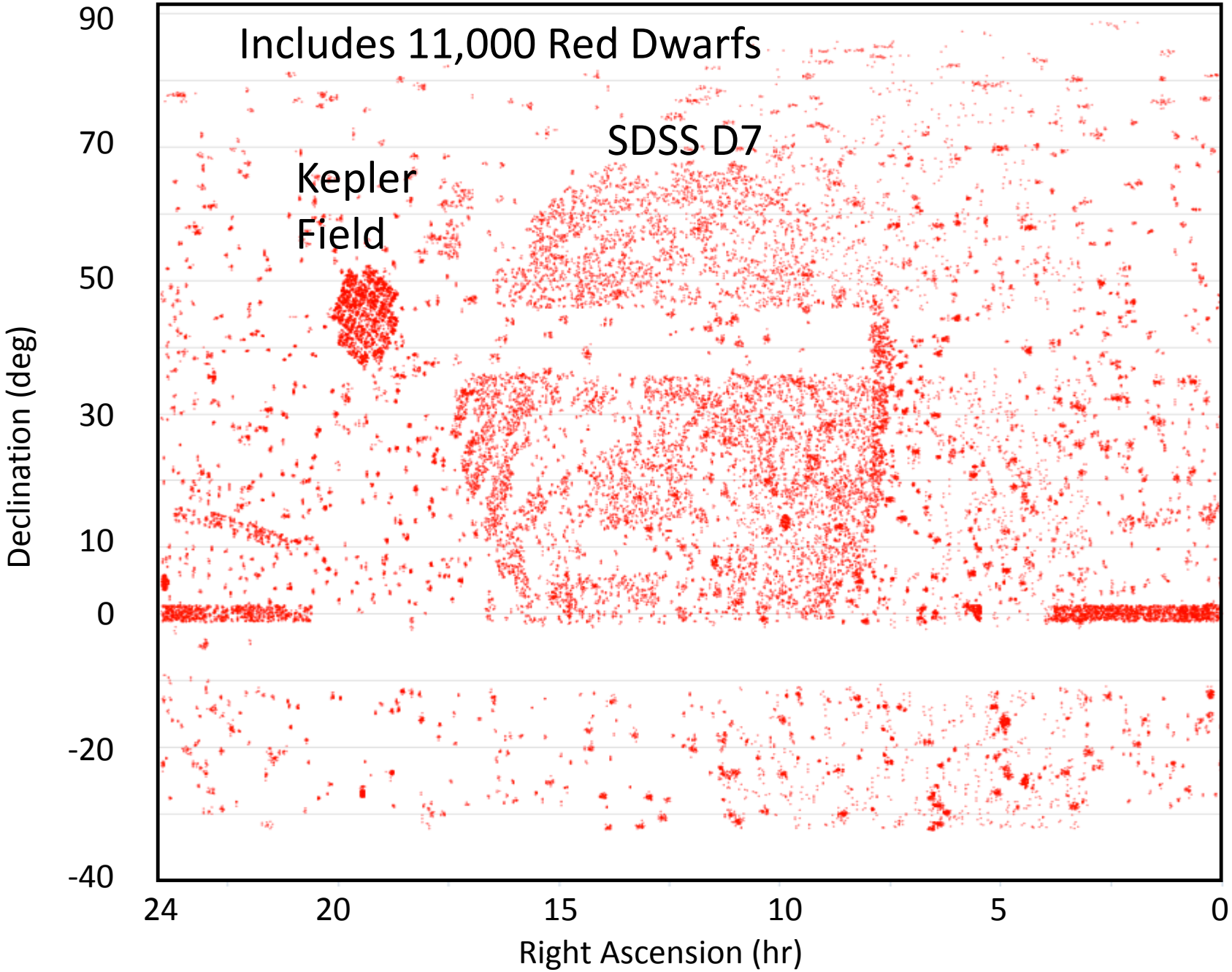
Directions of Red Dwarf Observations

70,000 Red Dwarf Catalog
Andrew West at
Boston University

Nearest 20,000
out to 500 LY

SDSS





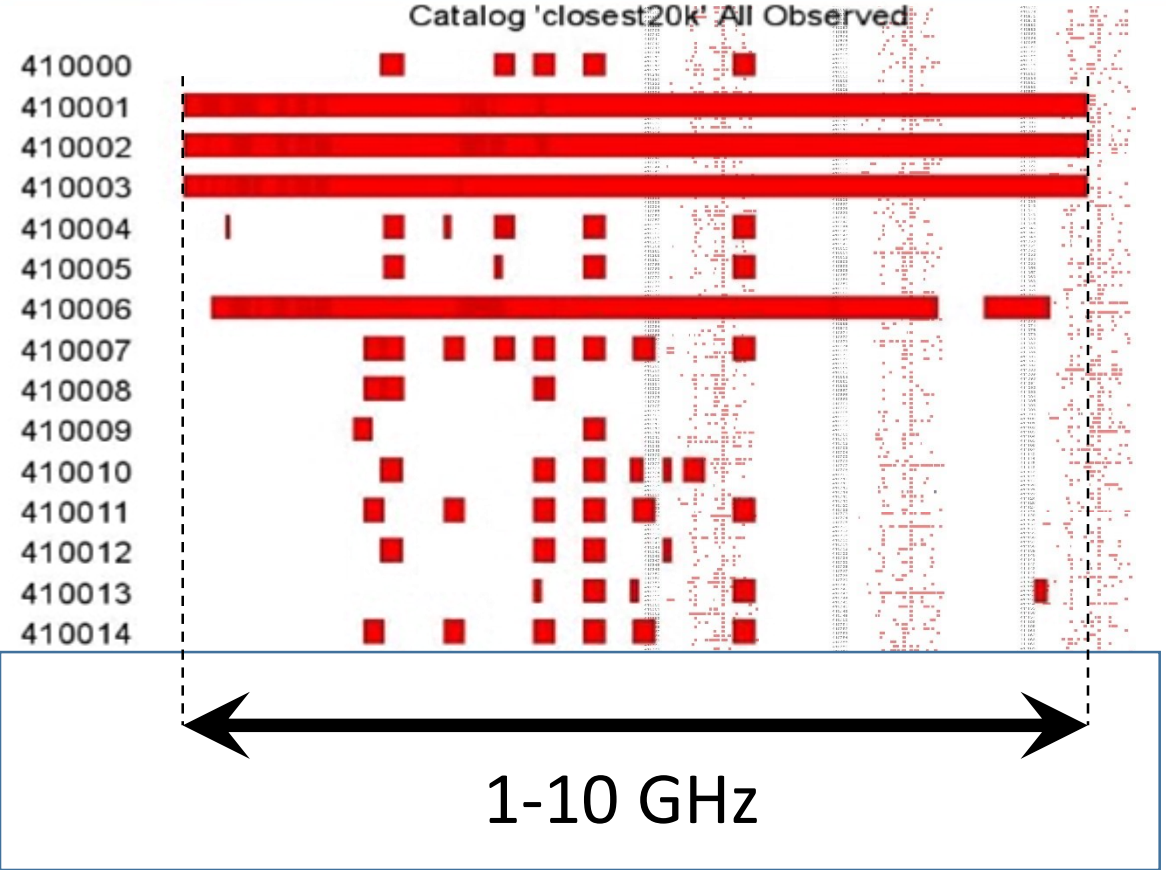
SETI Signal Searching

The Allen Telescope Array, Hat Creek Radio Observatory

Tue, 09 May 2017 04:14:02 UTC

40° 49' 03" N
121° 28' 24" W
3235 ft / 986 m

www.setiquest.info
By Jon Richards
11,000 so far

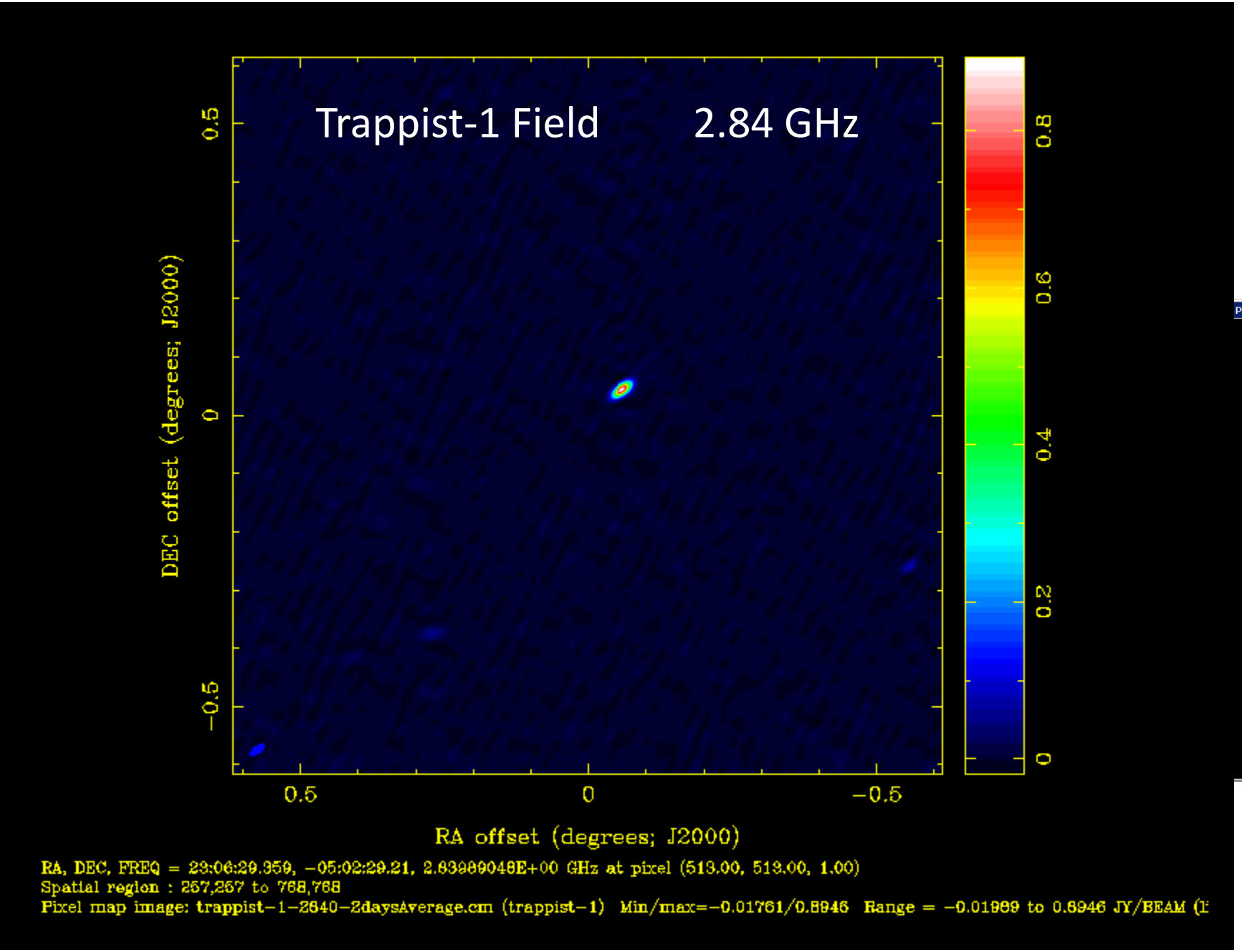


Our biggest challenge: Lens Flare?

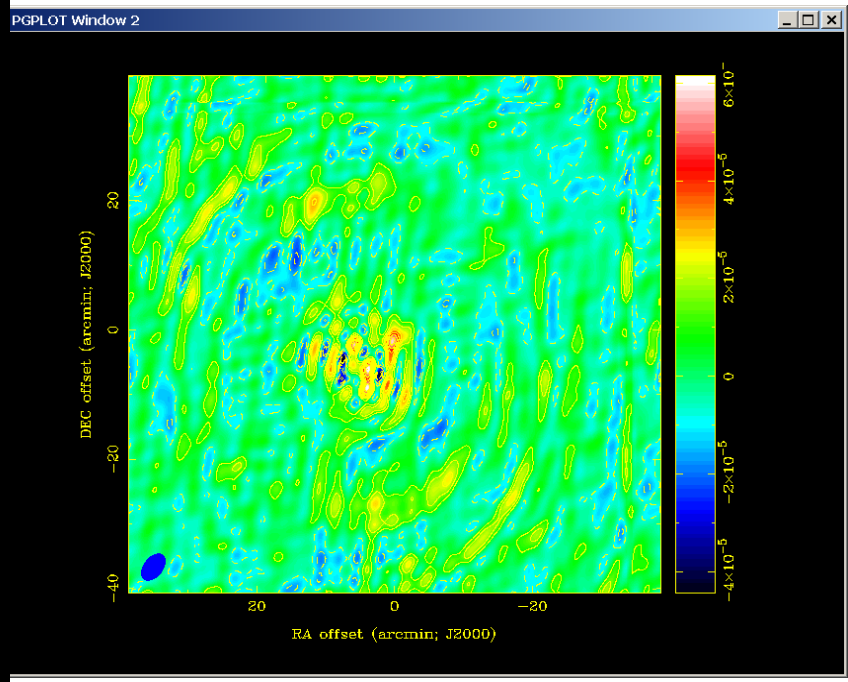
Lens flare is created when non-image forming light enters the lens and subsequently hits the camera's detector.

What is Lens Flare?

- Flare can take many forms. It is generally spread out over many pixels in the camera image.
- This can be used to identify and eliminate those same unwanted signals.

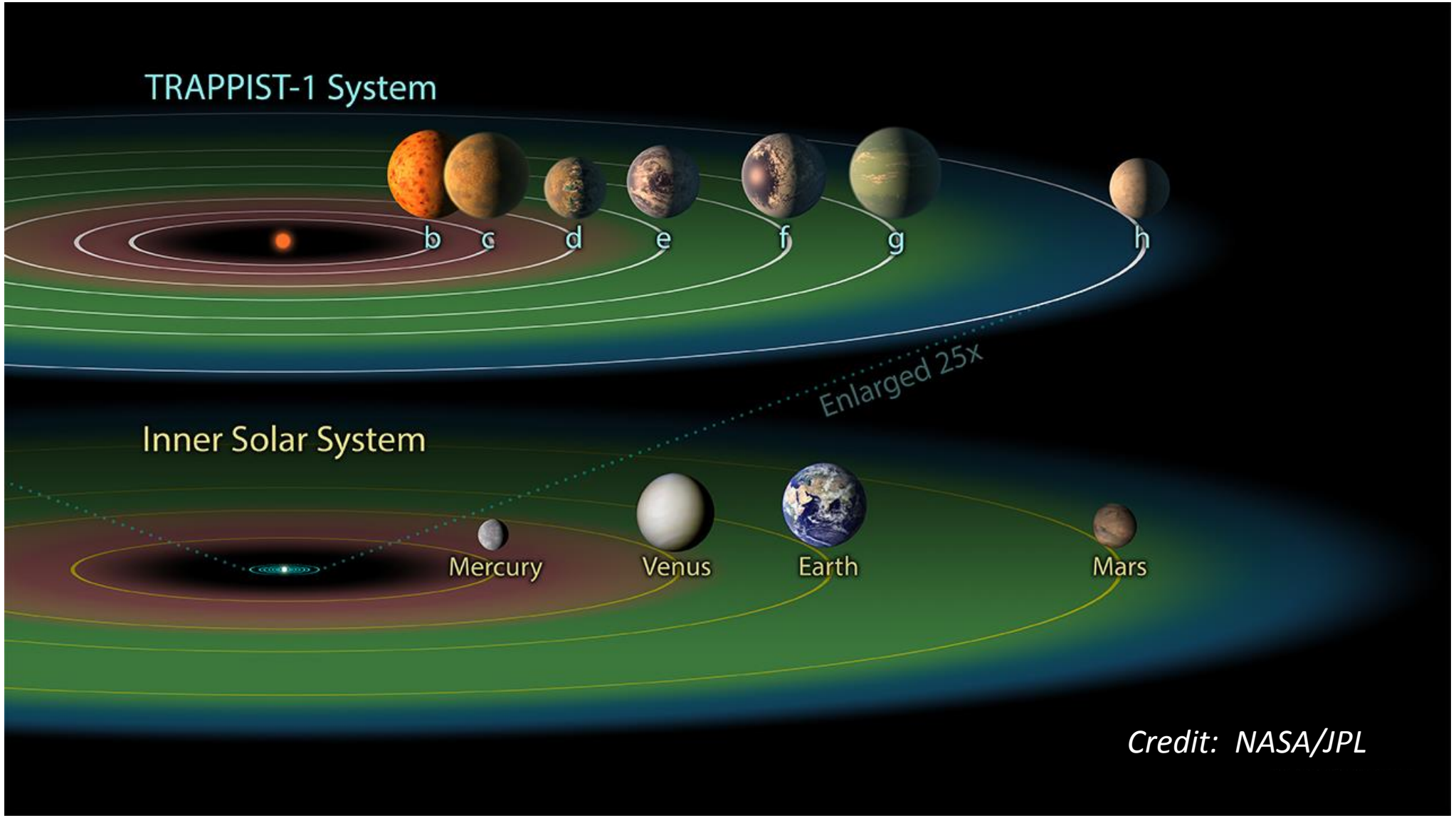


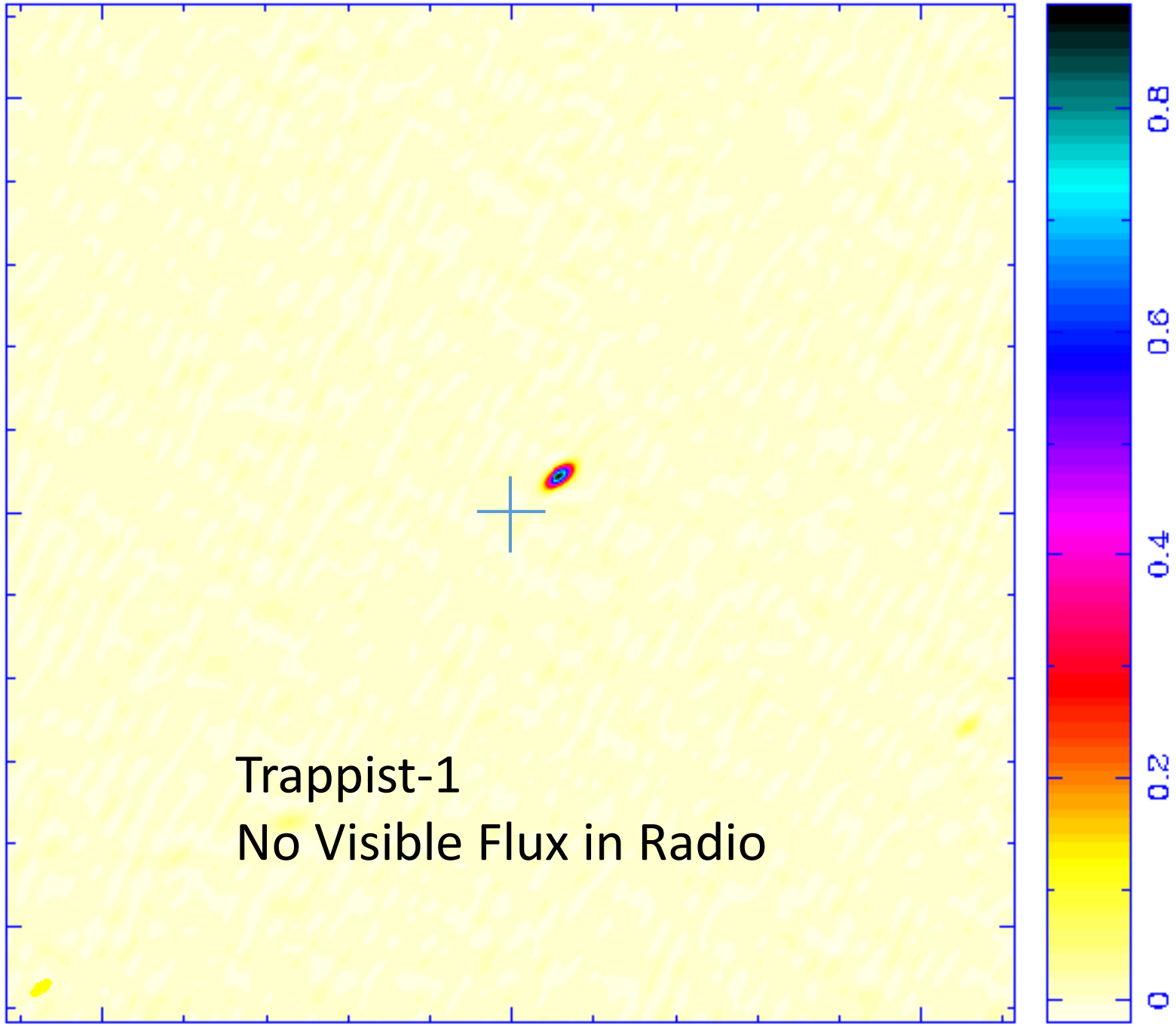
New approach uses imaging:
1 beam on
999 beams off



“Image” of interference

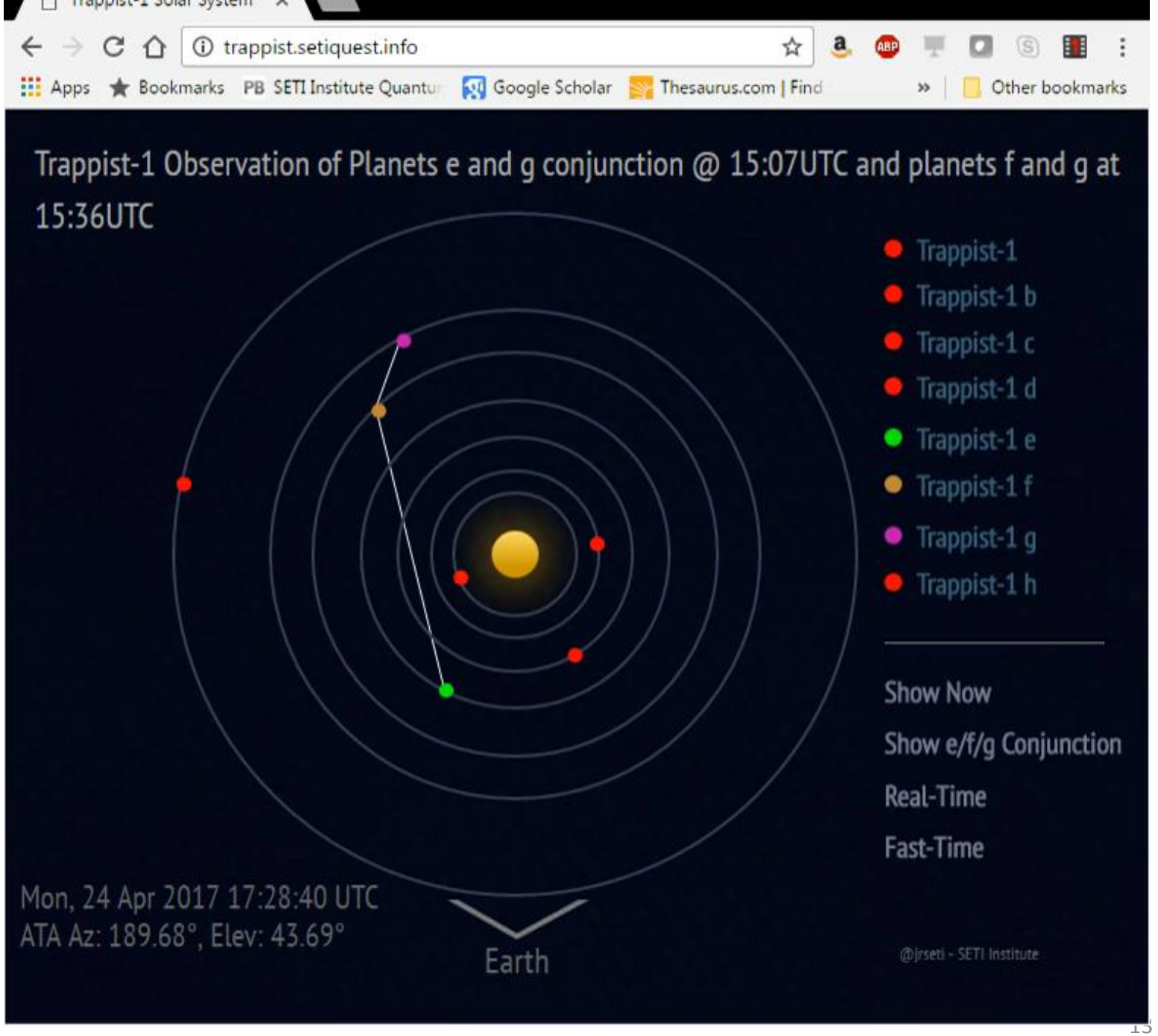
Trappist-1: The richest set of Earth-sized planets every found, 3 in HZ





Trappist-1
No Visible Flux in Radio

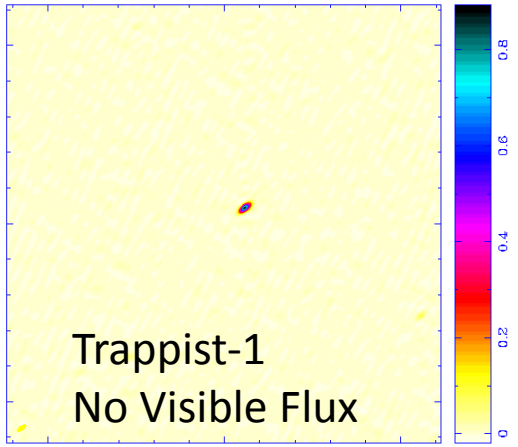
Trappist-1 Alignment Simulation



Trappist-1 Alignments / Observations

Date	Time	Event Type	Capture Backends
06-Apr-2017	4/6/17 22:00	Conjunction planets e/f	Correlator, 100 MHz beam
12-Apr-2017	4/12/17 22:01	Conjunction planets e/g followed by f/g	Correlator, 100 MHz beam
17-Apr-2017	4/17/17 21:22	Occultation planet f	Correlator only
25-Apr-2017	4/25/17 21:14	Occultation planet g	Correlator only Planned
14-May-2017	5/14/17 19:49	Occultation planet e	Correlator only Planned

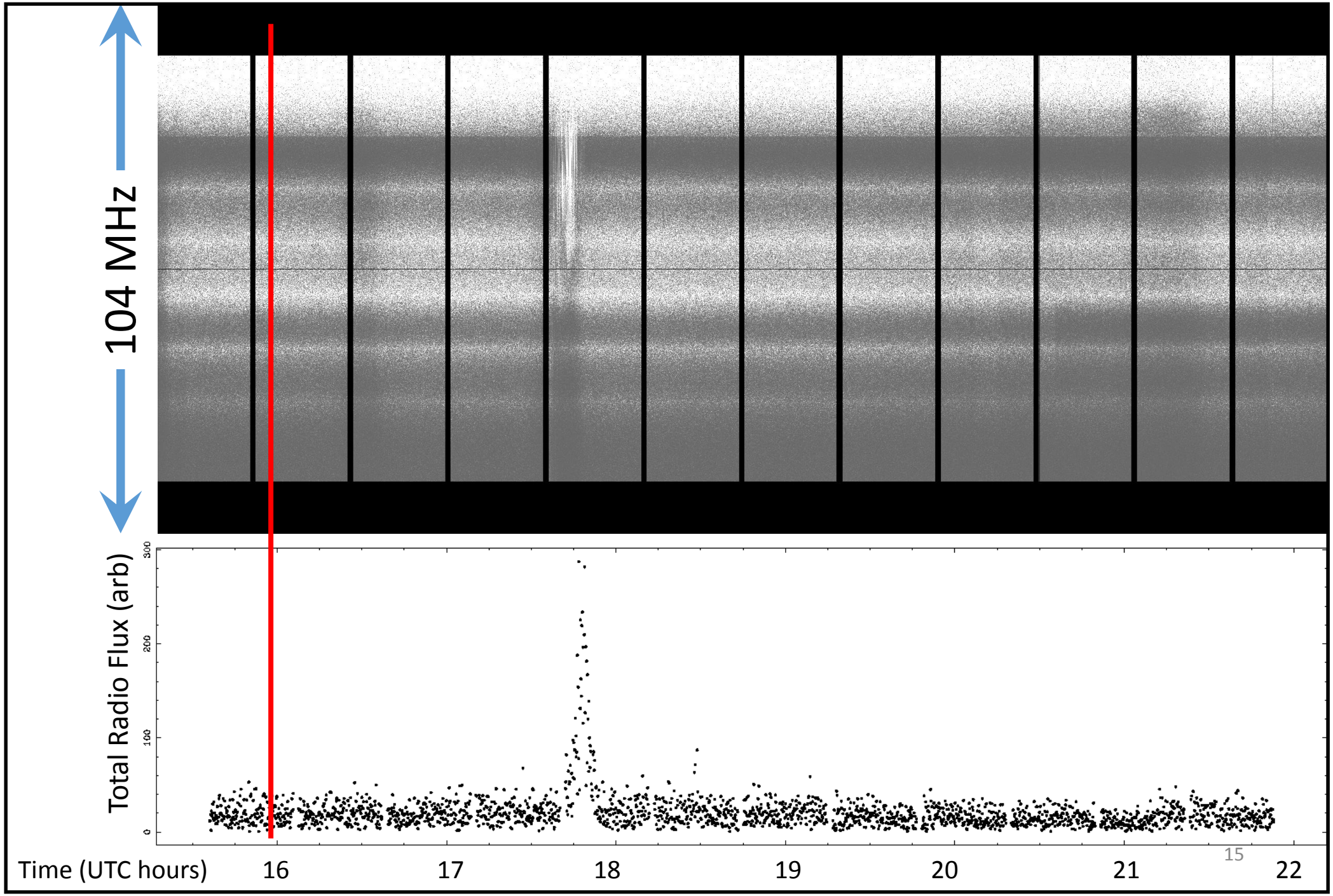
Backend – 104 MHz total	Frequency (MHz)	Field of View (FWHM)
Correlator 1	8200	0.43°
Correlator 2	2840	1.2°
Beam 1 (6.5 Hr = 5 TB)	8200	0.012°
Beam 2 (6.5 Hr = 5 TB)	2840	0.035°



Trappist-1
06-Apr-2017

8200 MHz Center
104 MHz BW

Planetary alignment at red line



ATA Observations of Red Dwarfs

- ALWAYS: Use SonATA system to look for narrowband signals 1-10 GHz
- TRANSIT/OCCULTATION: Look for peaks/dips in light curve, 2 frequencies, 100 MHz BW
  - correlator for light curve / imaging to verify position
- CONJUNCTIONS: Look for peaks in light curve, 2 frequencies, 100 MHz BW
  - correlator for light curve / imaging to verify position
  - direct beams to disk -> upload to cloud and process using ML

www.seti.org/ml4seti