AN EXPLORER'S GUIDE TO THE VLA SKY SURVEY (VLASS)

Commensal Systems: COSMIC SETI

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BERKELEY SETI RESEARCH CENTER

SETI INSTITUTE

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NRAO

NSF

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Dave MacMahon

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C OMENSAL
O PEN-
S OURCE
M ULTIMODE
I NTERFEROMETER
C LUSTER

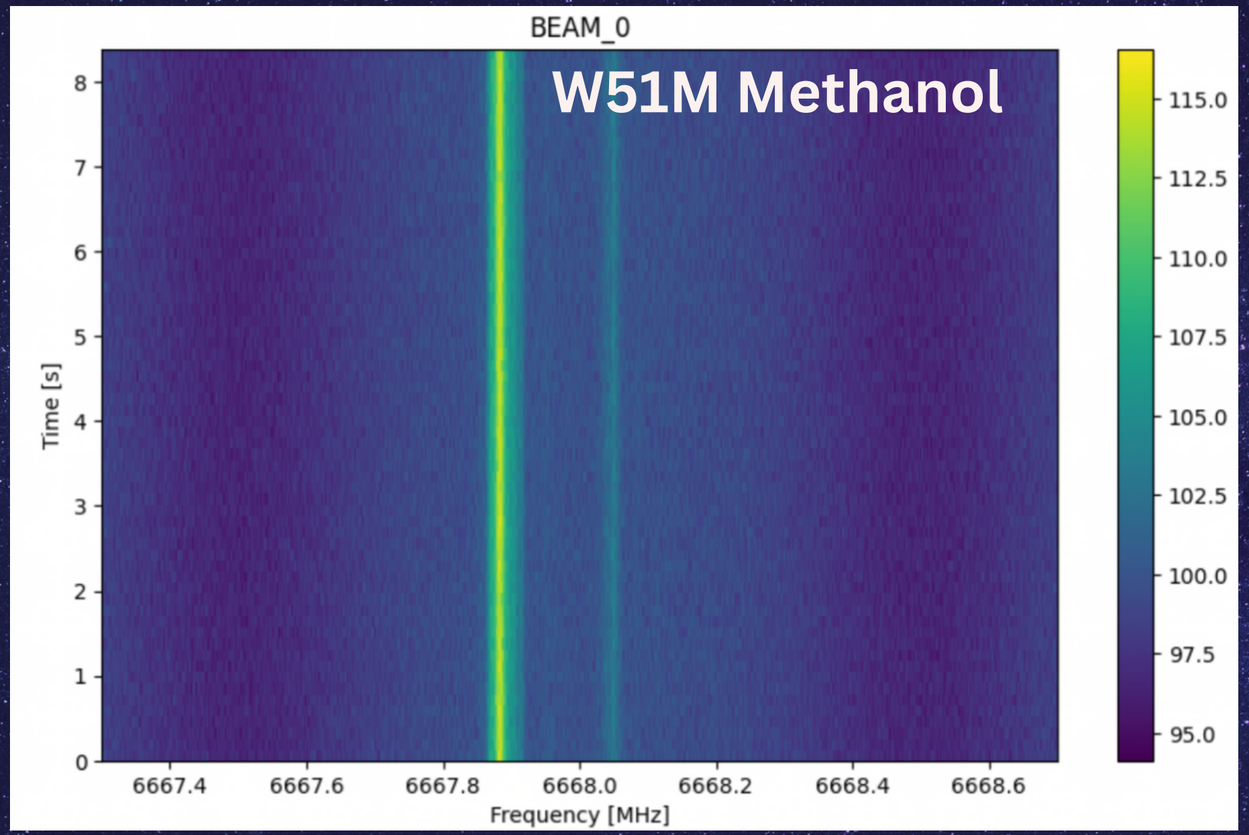
ARE WE ALONE IN THE GALAXY? IN THE UNIVERSE?

COSMIC Haystack

9 Dimensional Search:

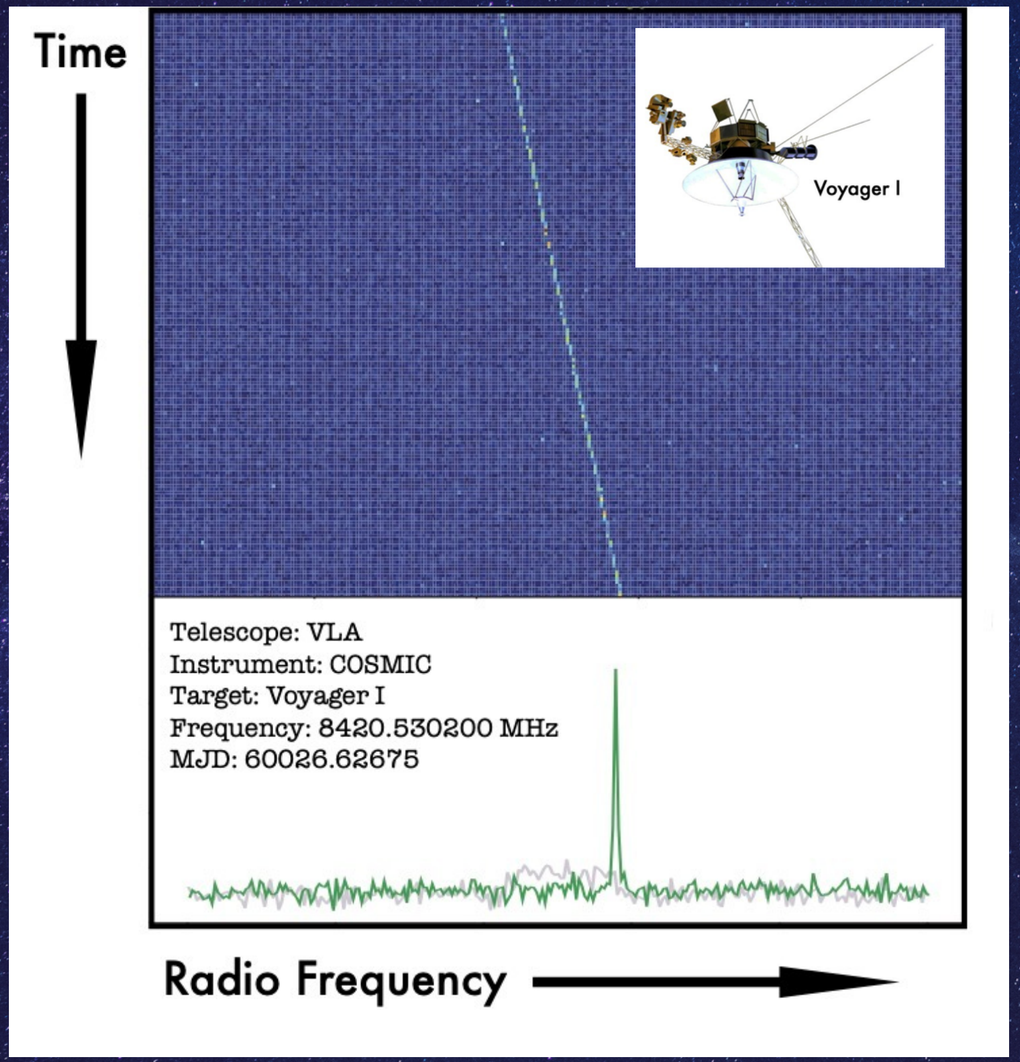
1. **Sensitivity**
2. **Frequency**
3. **Distance**
4. **Spatial in X**
5. **Spatial in Y**
6. **Transmission Bandwidth**
7. **Time / Repetition Rate**
8. **Polarization**
9. **Modulation**

THE COSMIC SEARCH

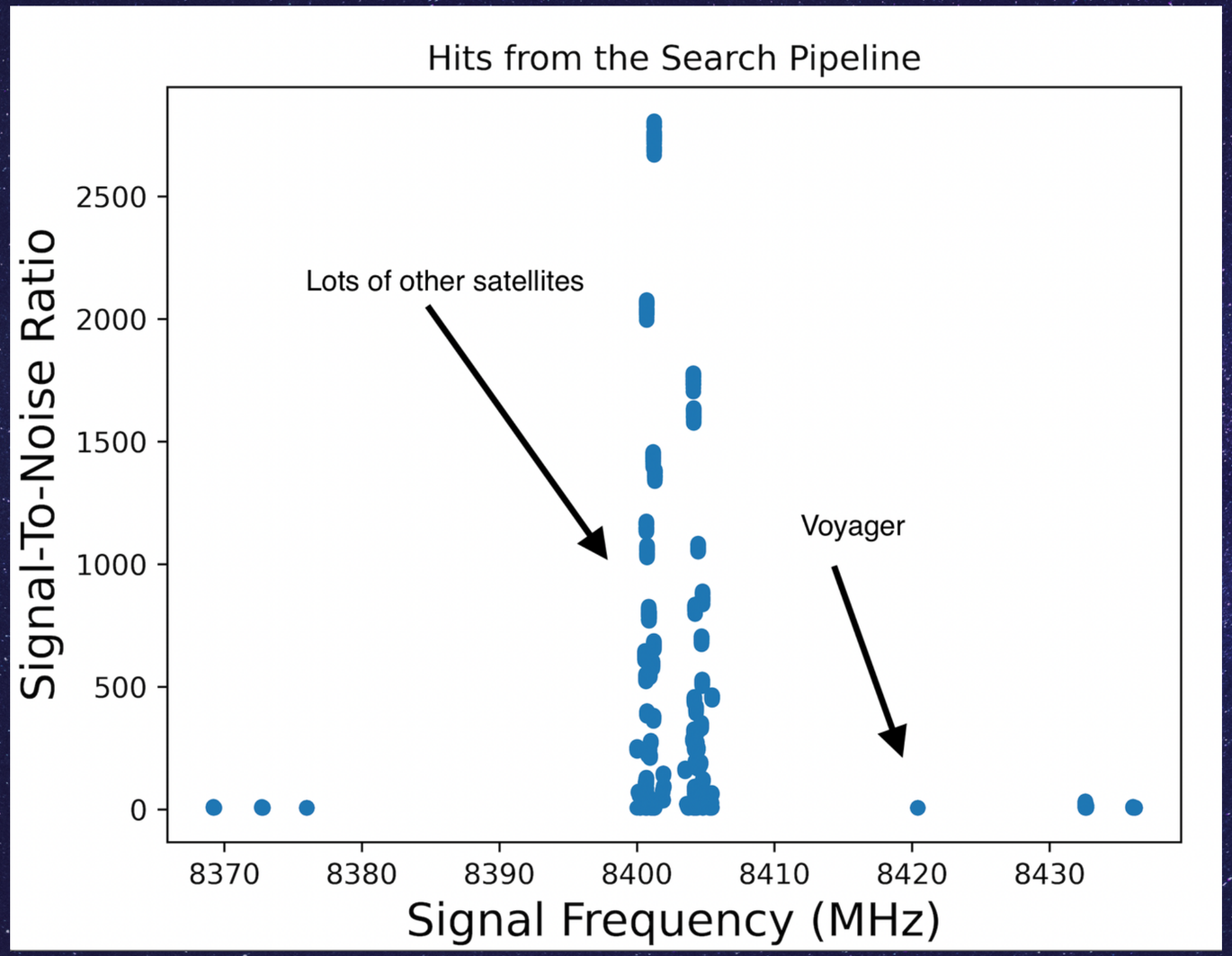


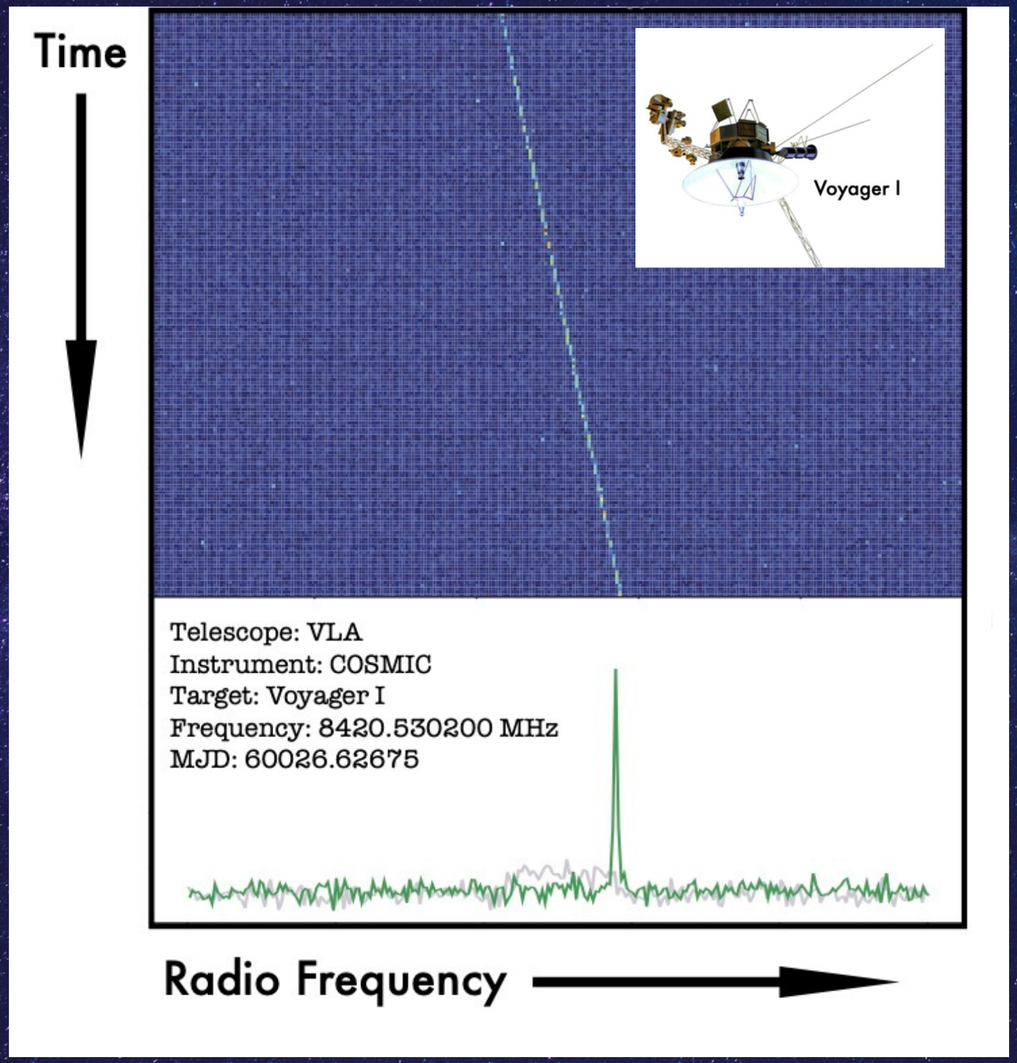
Time --->

Frequency --->



THE COSMIC SEARCH





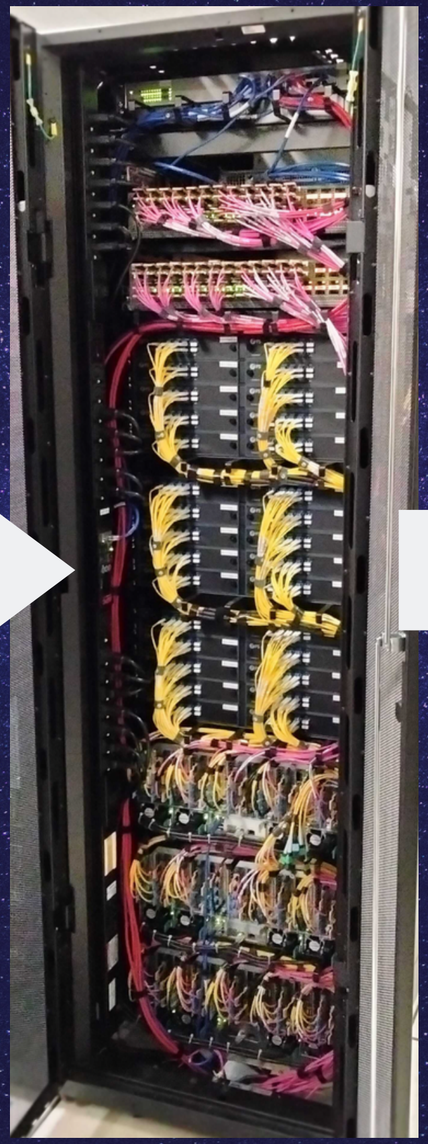
KARL G JANSKY VERY LARGE ARRAY

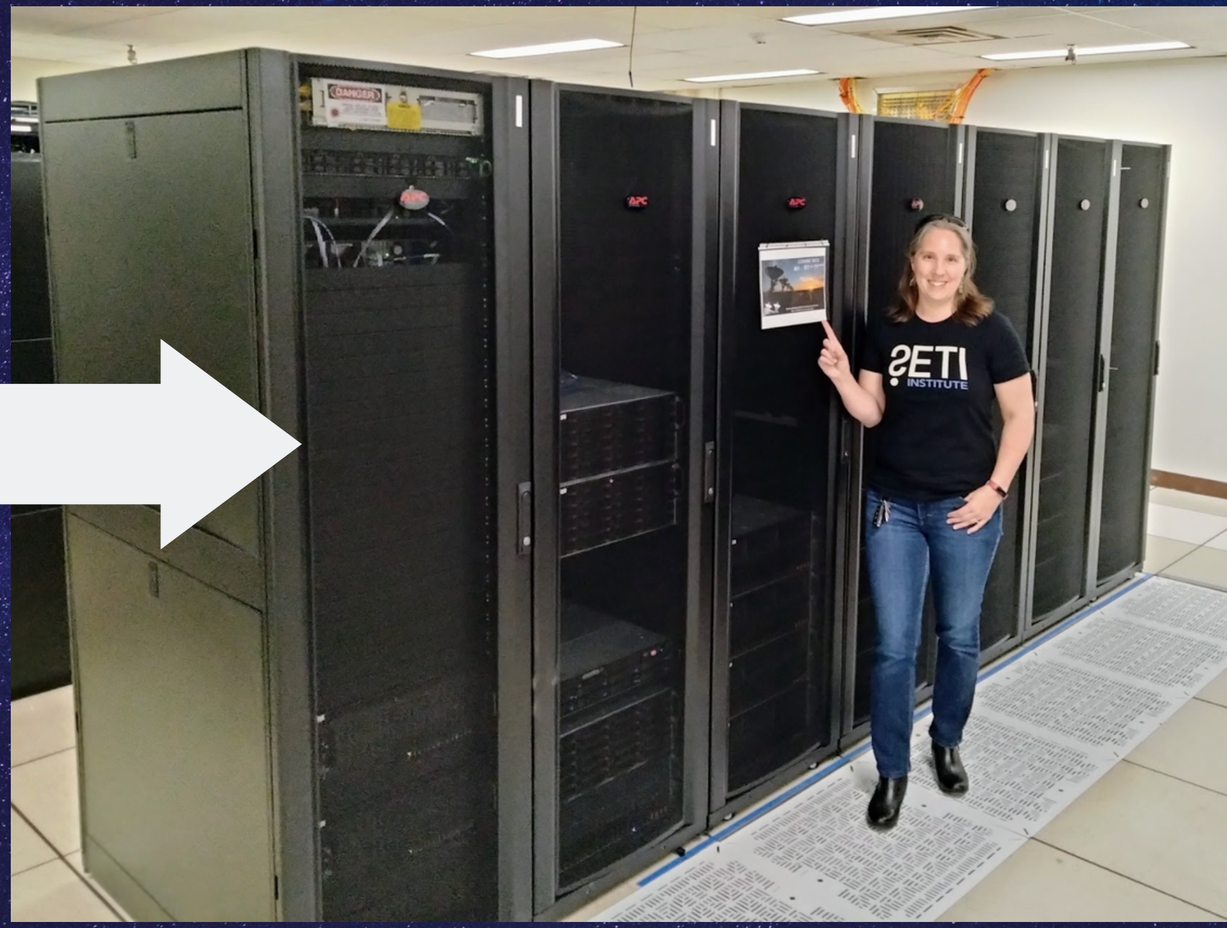
- 27 ELEMENT INTERFEROMETER
- EACH 25M (82FEET) DIAMETER
- BASELINES RANGE FROM 1-36KM DEPENDING ON CONFIGURATION
- OPERATED BY NRAO
- OBSERVES 0.23-50GHZ

Table 3.1.1: Configuration Properties

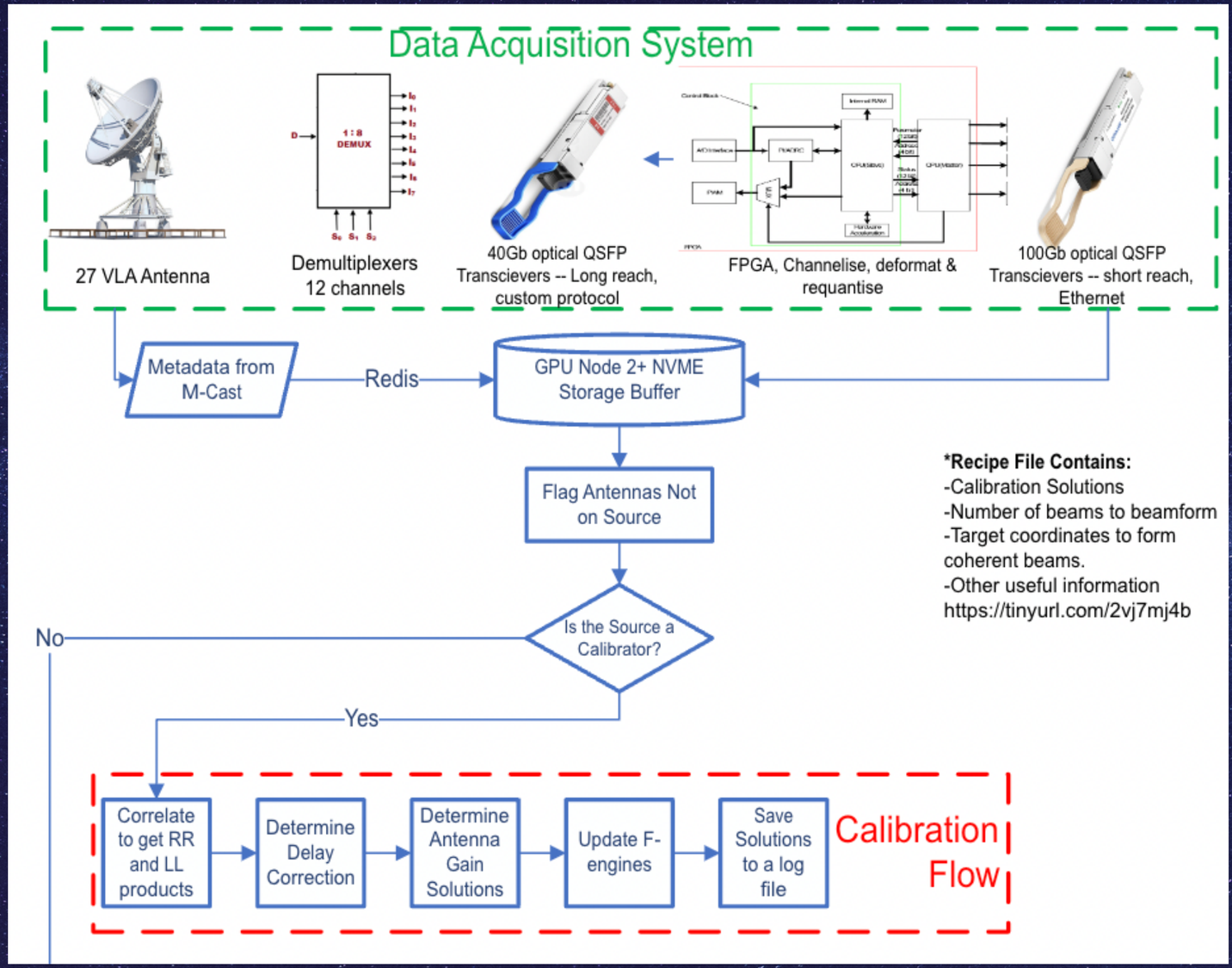
Configuration	A	B	C	D
B_{max} (km^1)	36.4	11.1	3.4	1.03
B_{min} (km^1)	0.68	0.21	0.035^5	0.035

COSMIC AT THE VLA

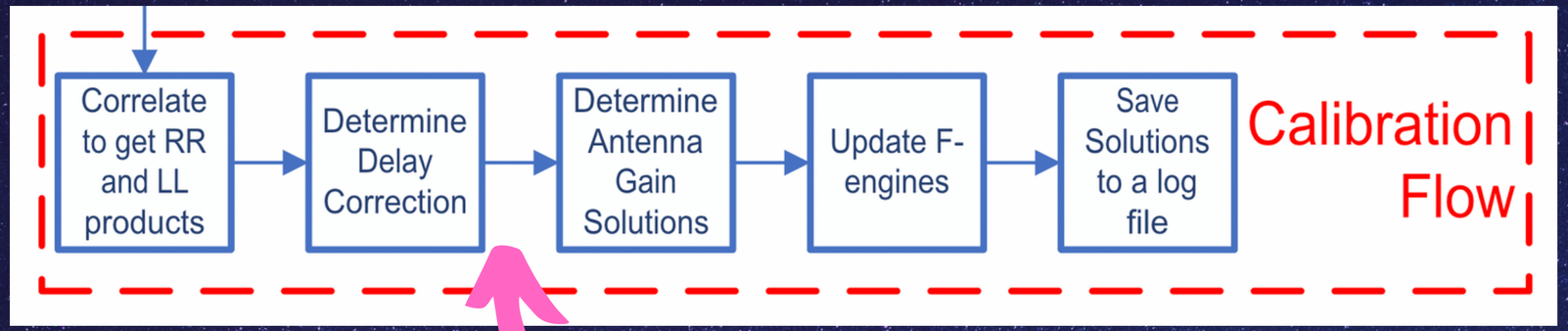




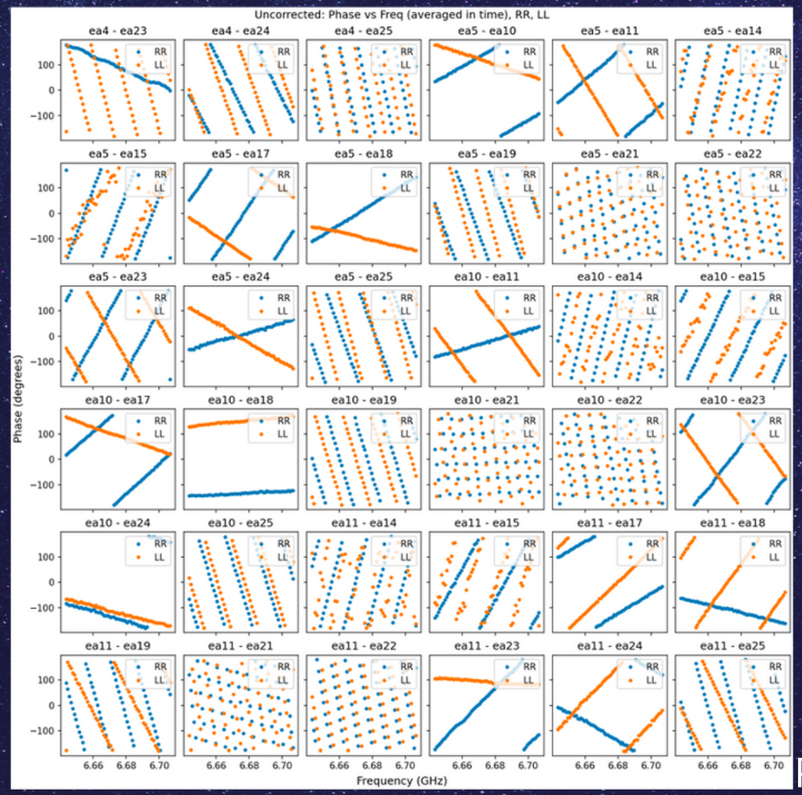
COSMIC SYSTEM DESIGN



Calibration

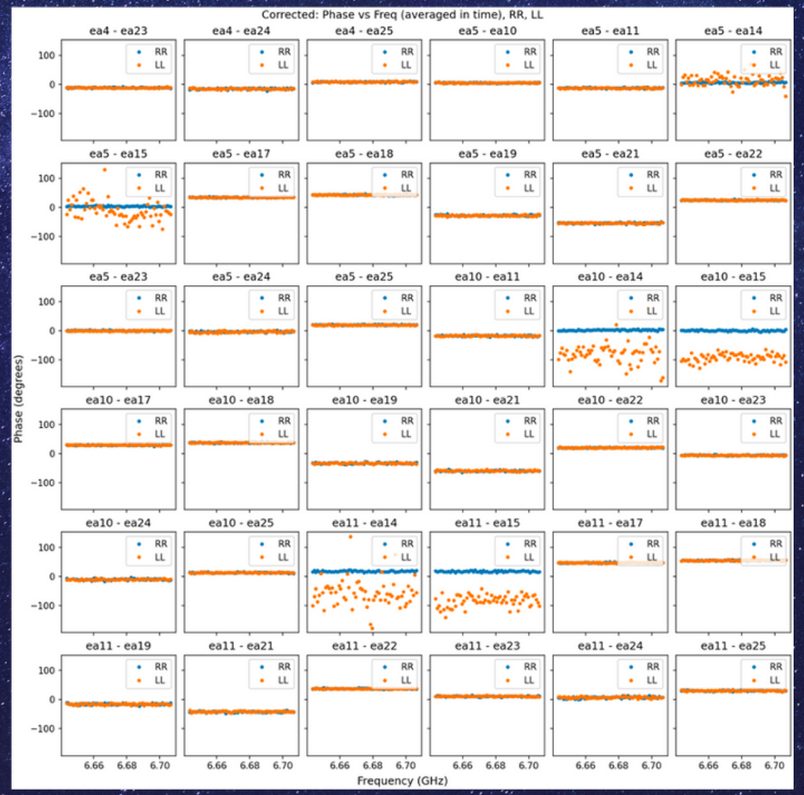


Before



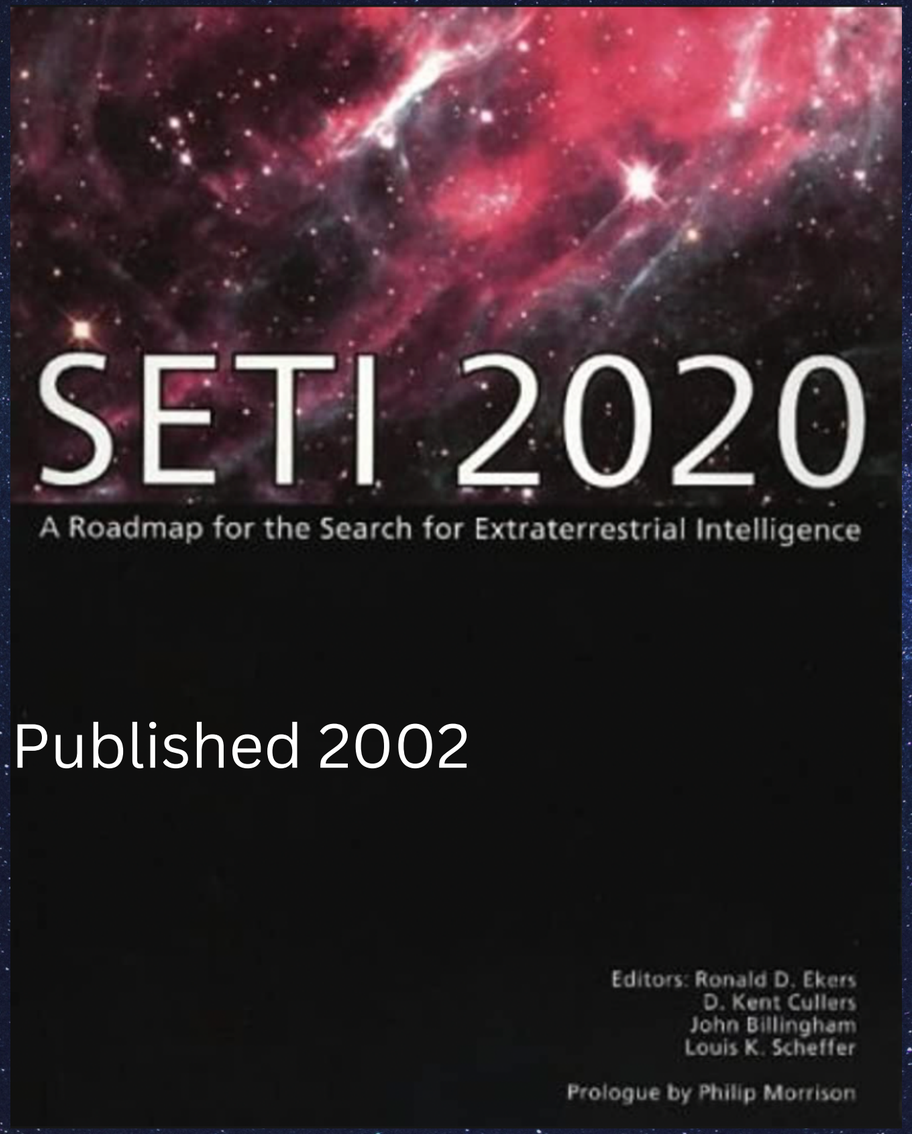
RFI flagging

After



Provided by Savin S..

SETI



Published 2002

Decision Tree – SETI 2020

many search options

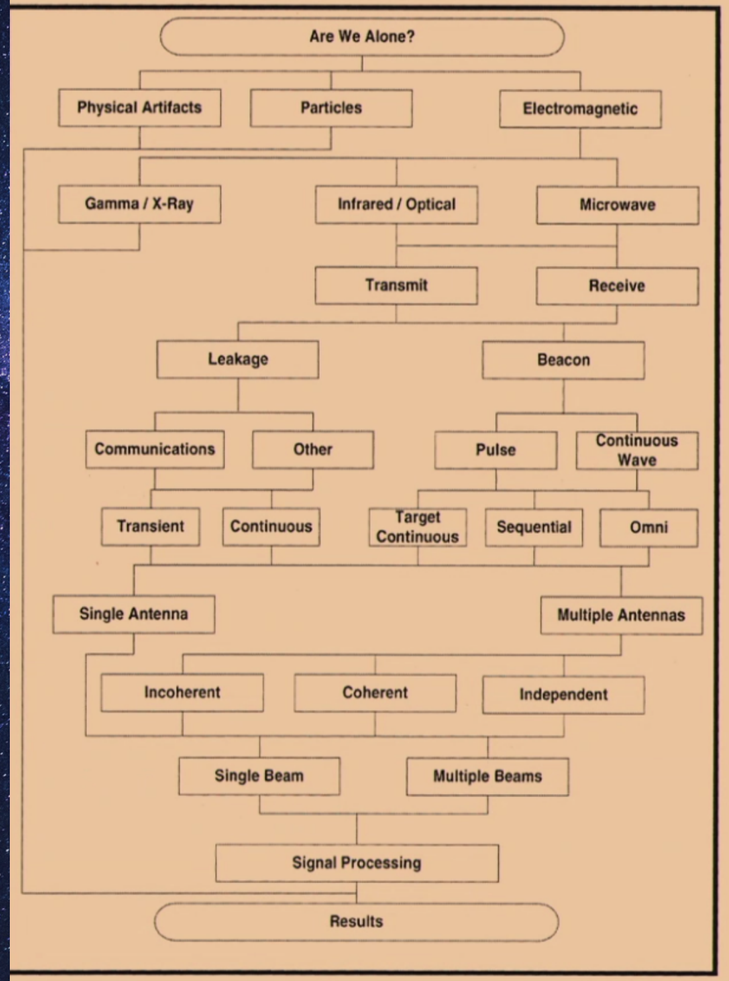
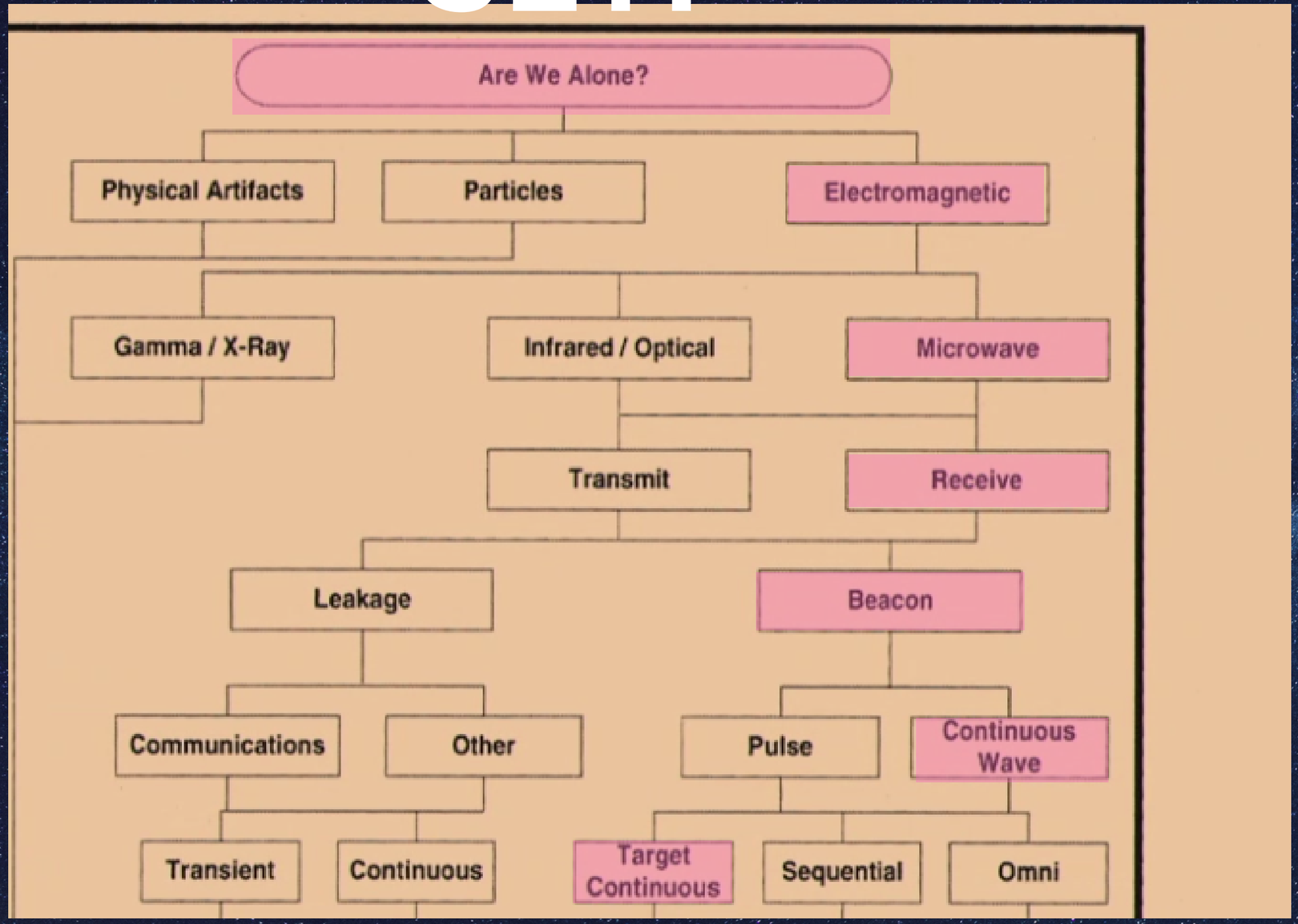


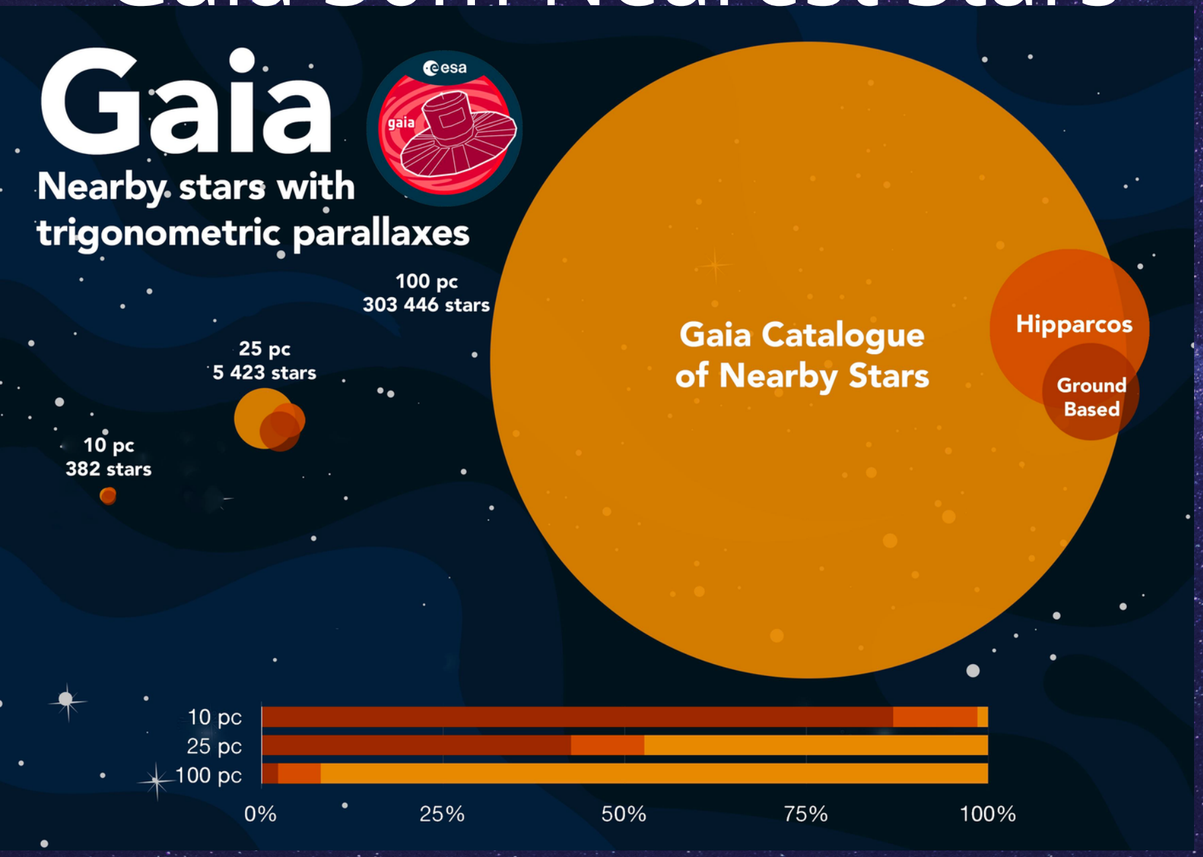
Figure 1.1: Decision Tree for SETI.

SETI


Are We Alone?
Physical Artifacts
Particles
Electromagnetic
Gamma / X-Ray
Infrared / Optical
Microwave
Transmit
Receive
Leakage
Beacon
Communications
Other
Pulse
Continuous Wave
Transient
Continuous
Target Continuous
Sequential
Omni

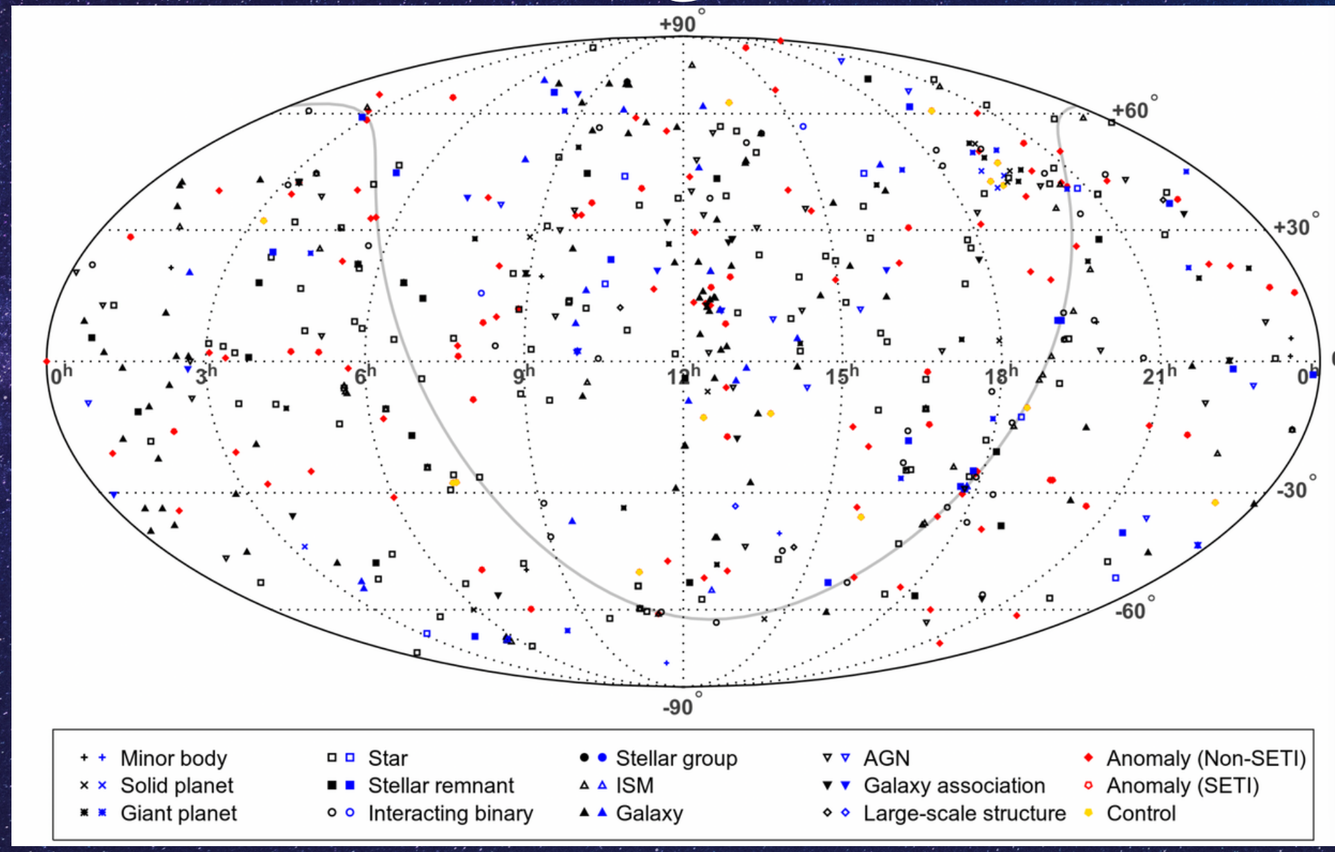
Target Selection

Gaia 30m Nearest Stars



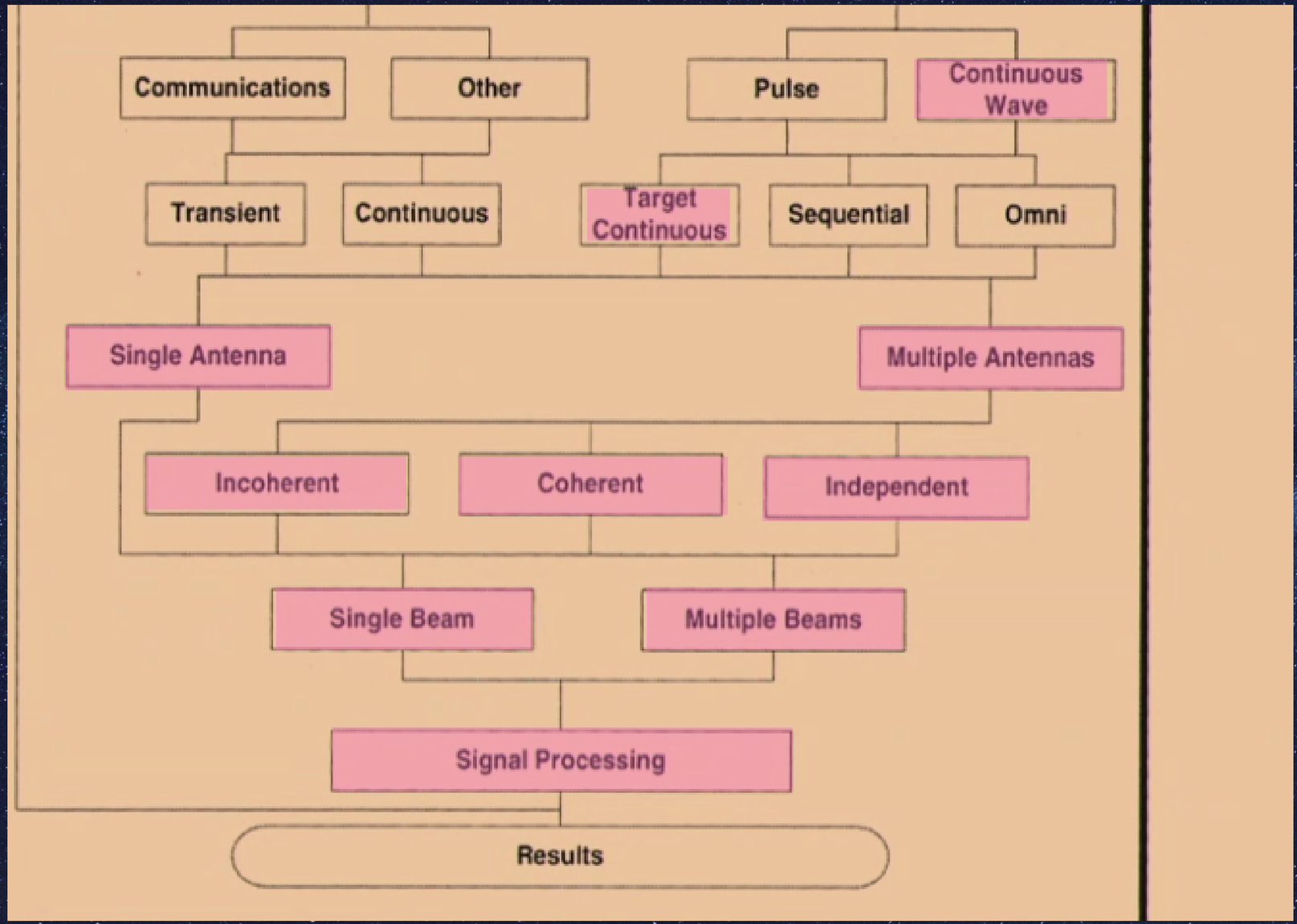
Czech et al. 2021, PASP, 133,1024

Catalog Exotica

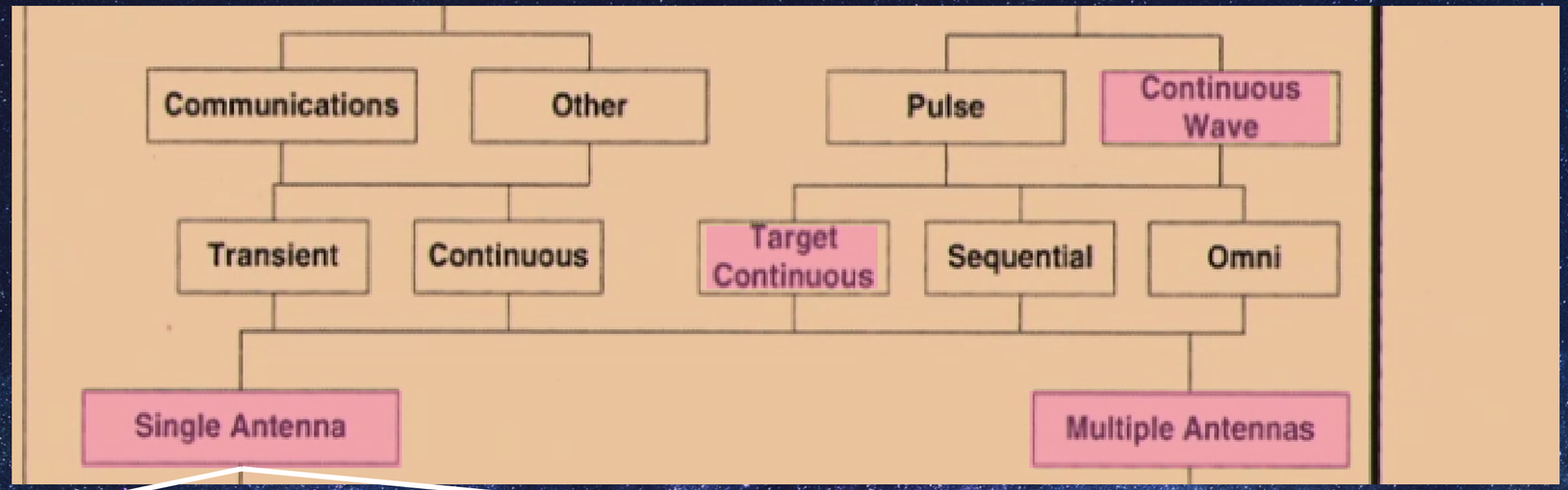


Lacki et al. 2021, ApJSS, 257:42

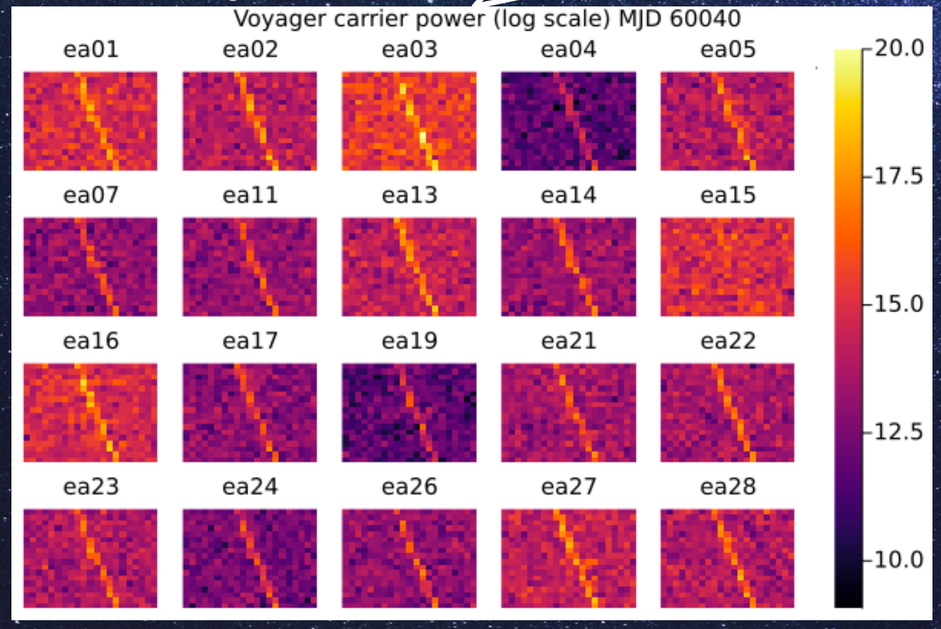
SETI


Communications
Other
Pulse
Continuous Wave
Transient
Continuous
Target Continuous
Sequential
Omni
Single Antenna
Multiple Antennas
Incoherent
Coherent
Independent
Single Beam
Multiple Beams
Signal Processing
Results

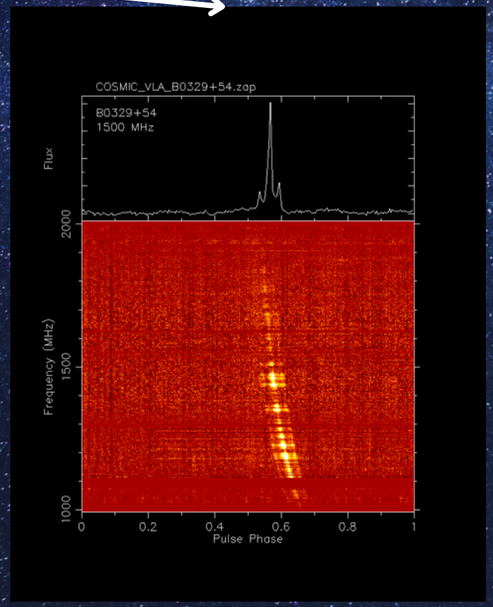
Single Antenna Tests



Provided by Dave M.

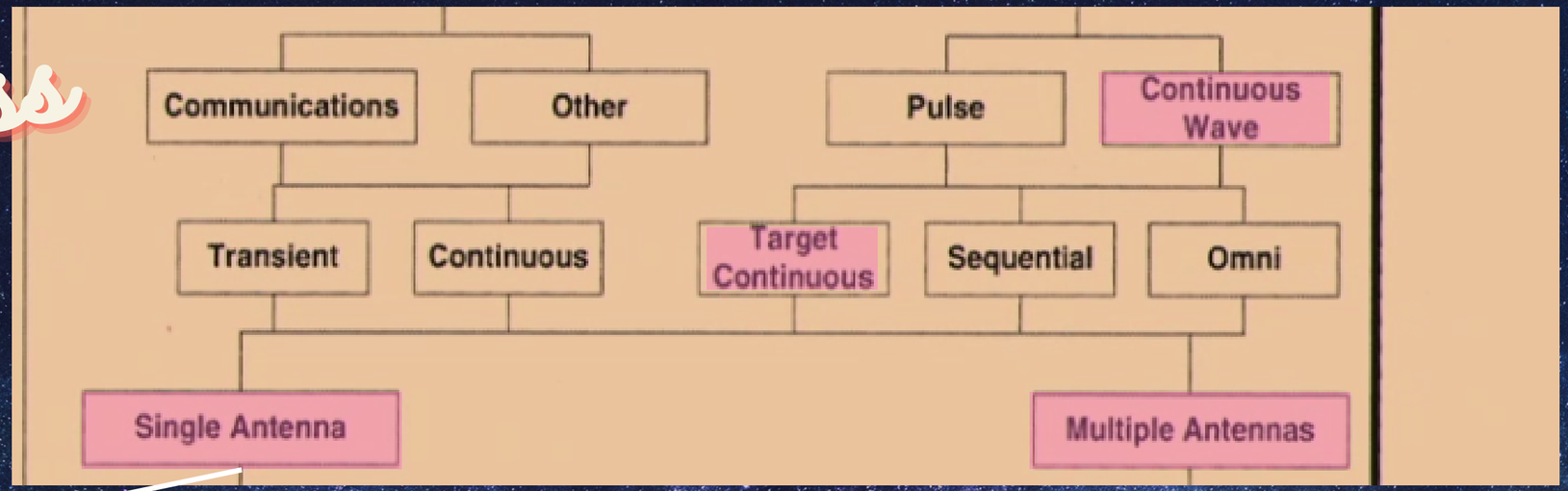


Provided by Paul D..

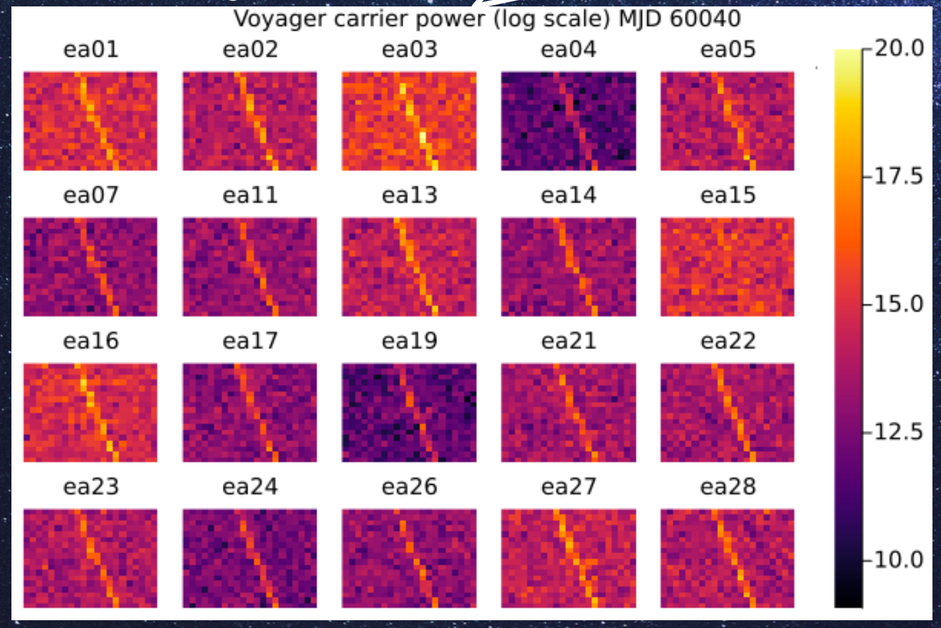


Single Antenna Tests

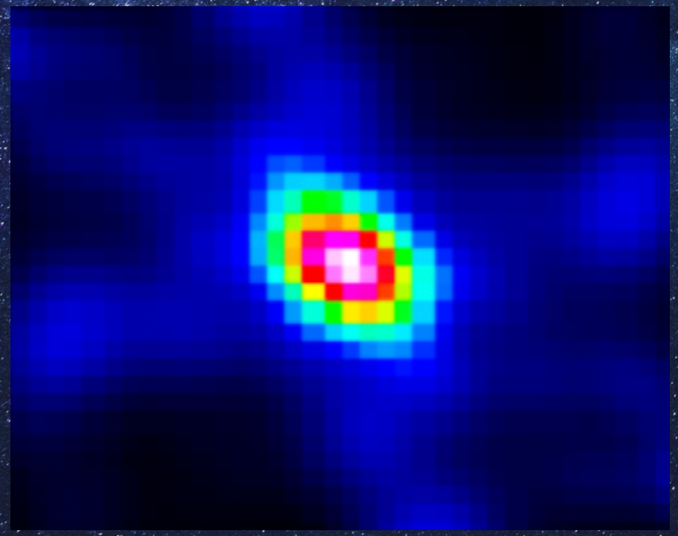
In Progress



Provided by Dave M.

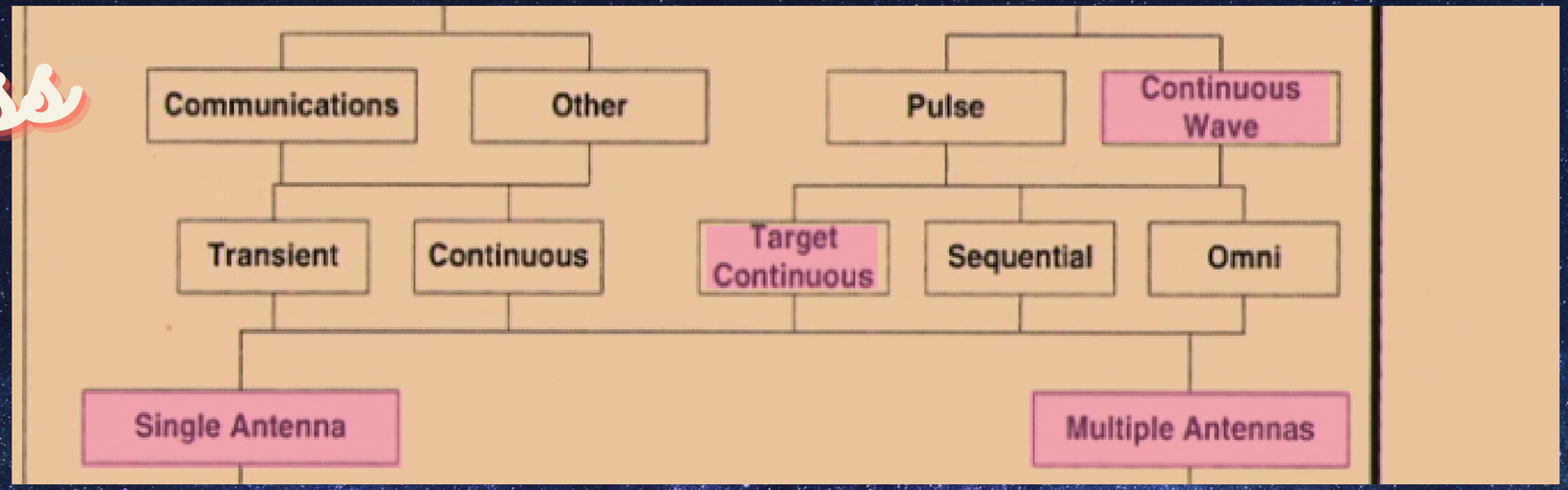


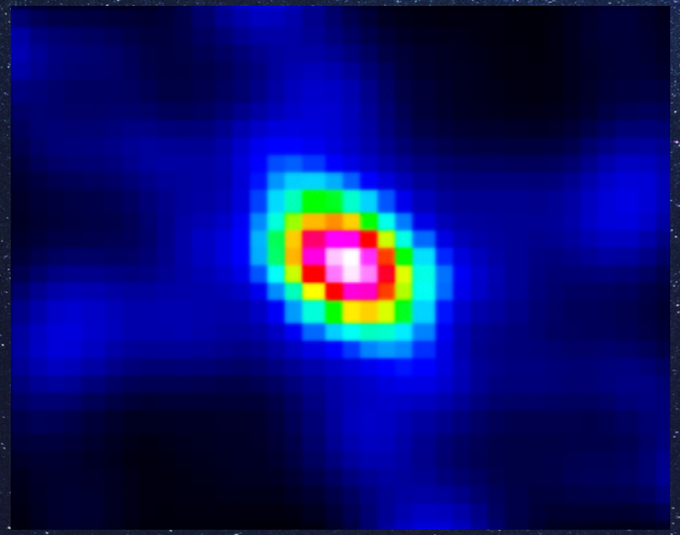
Offline Correlate

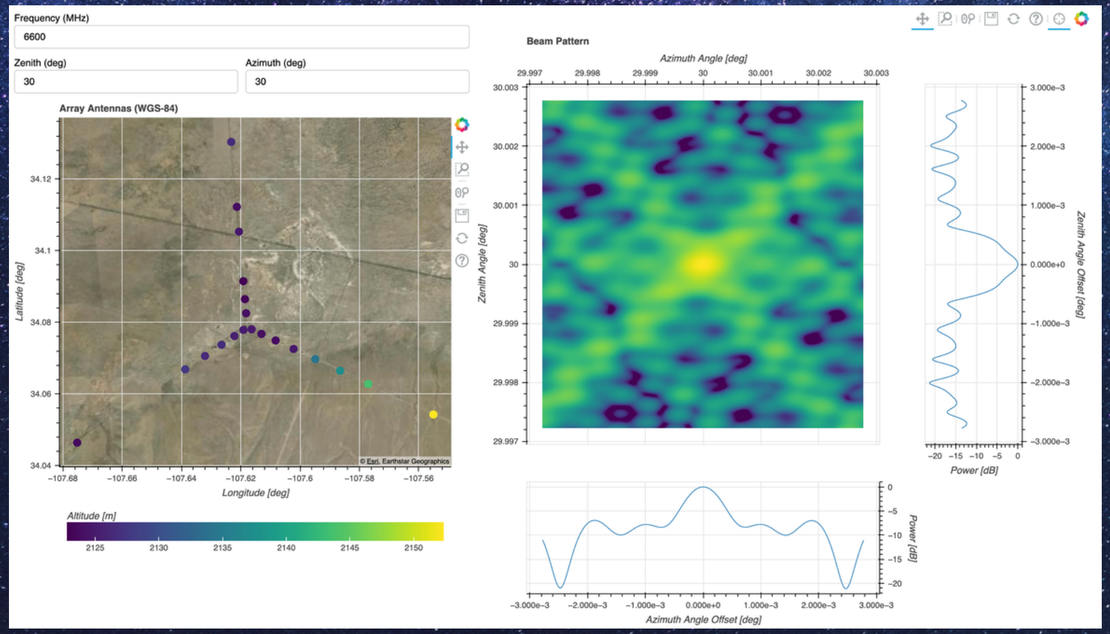


Single Antenna Tests

In Progress

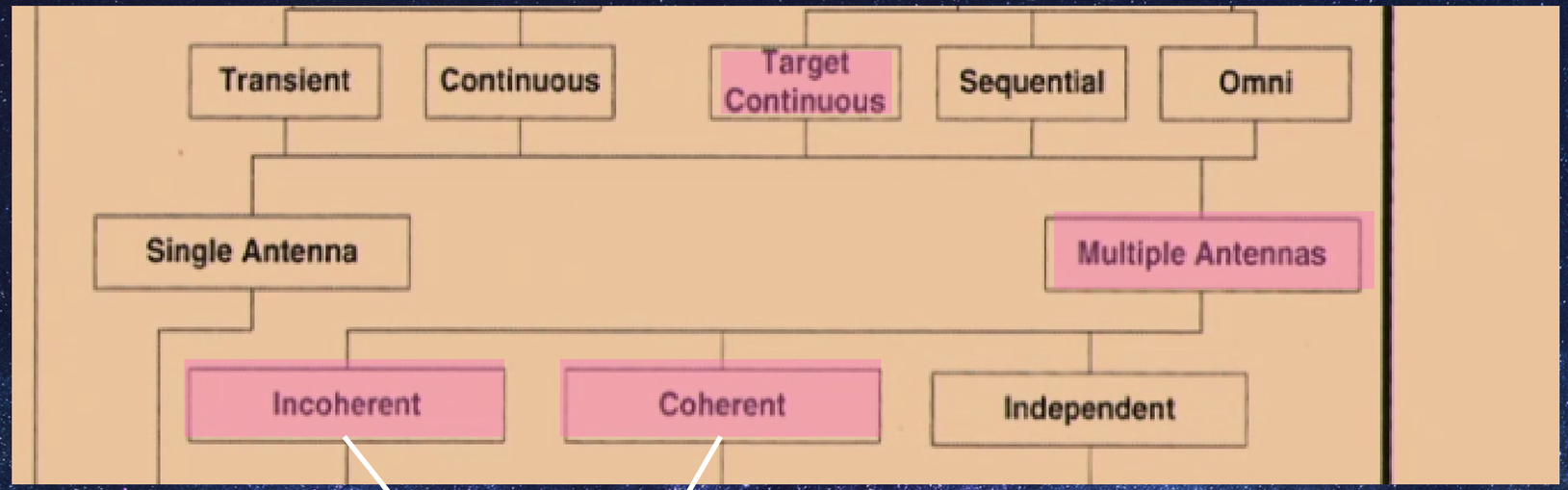






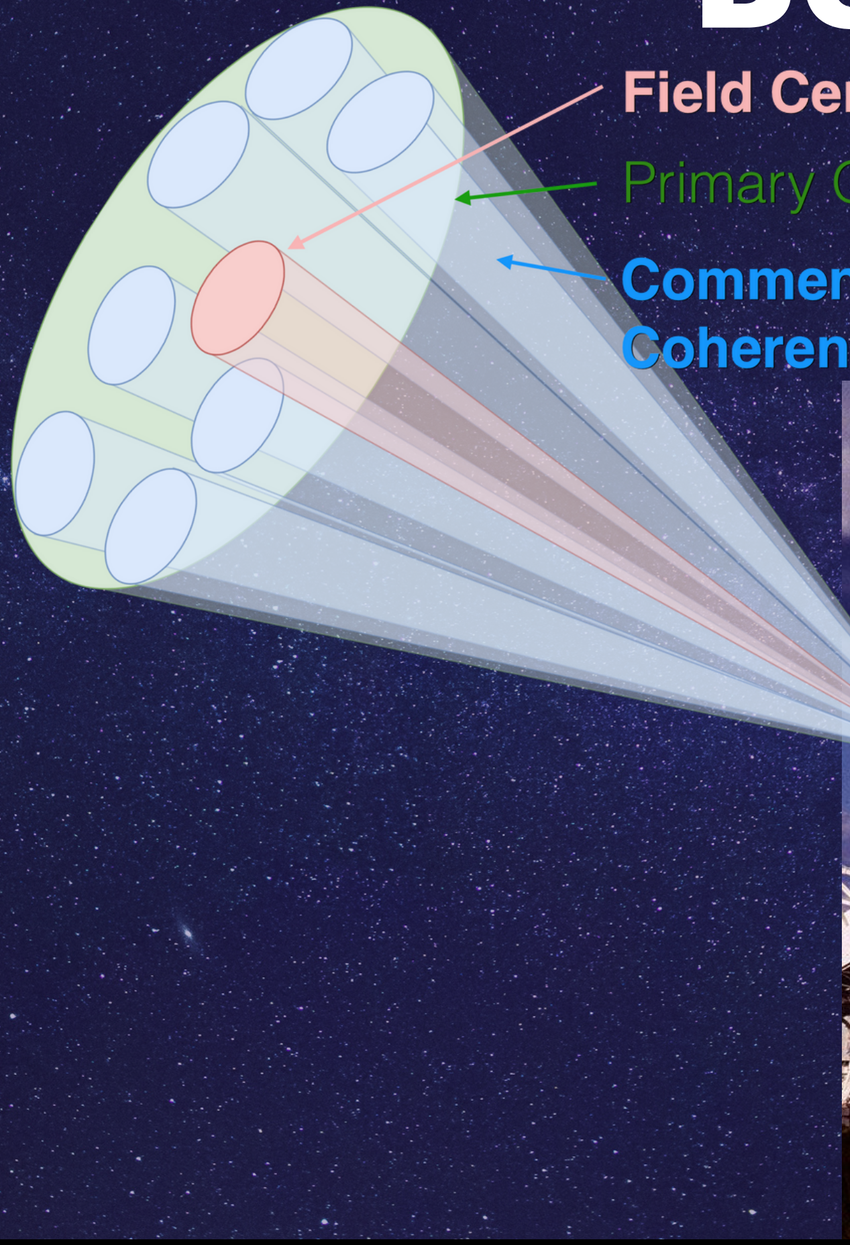
Simulated VLA beam pattern by Wael F.

Multiple Antenna Tests



Beamformed Data Products

Beamforming

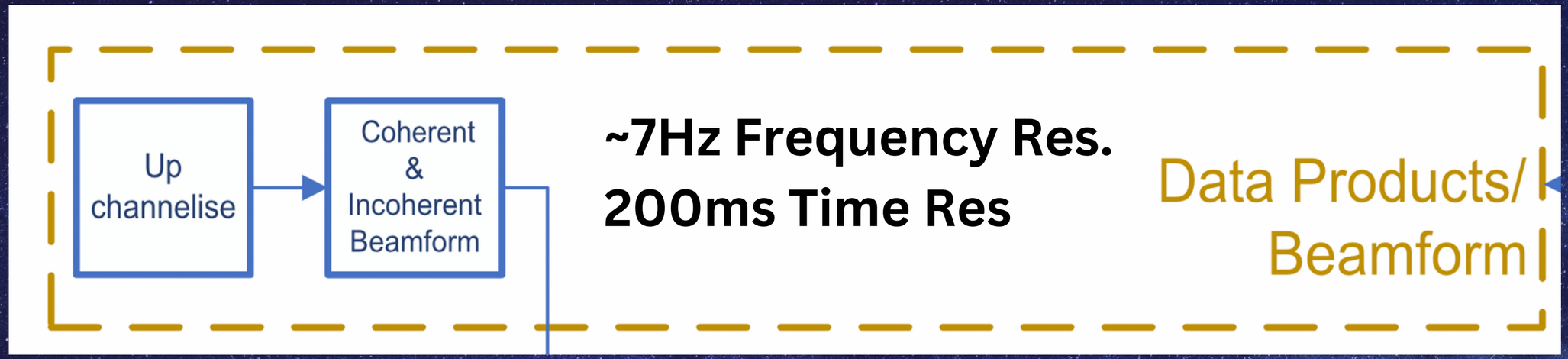


Field Center (Boresight)

Primary Observer

Commensal beams:
Coherent & Incoherent

Beamforming

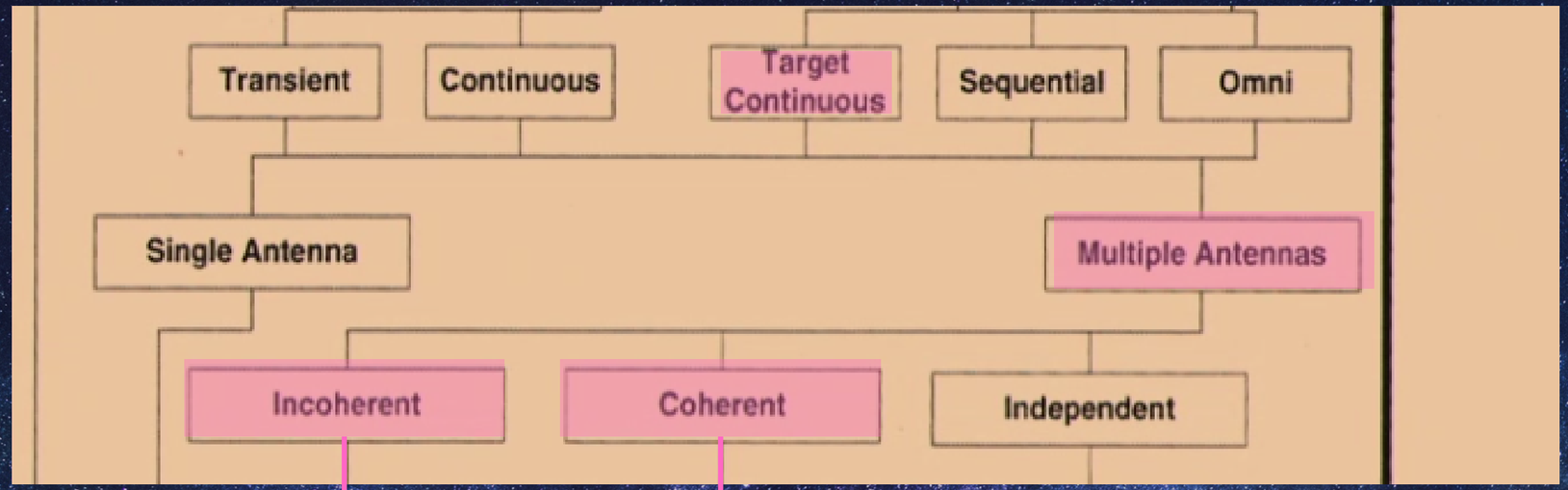


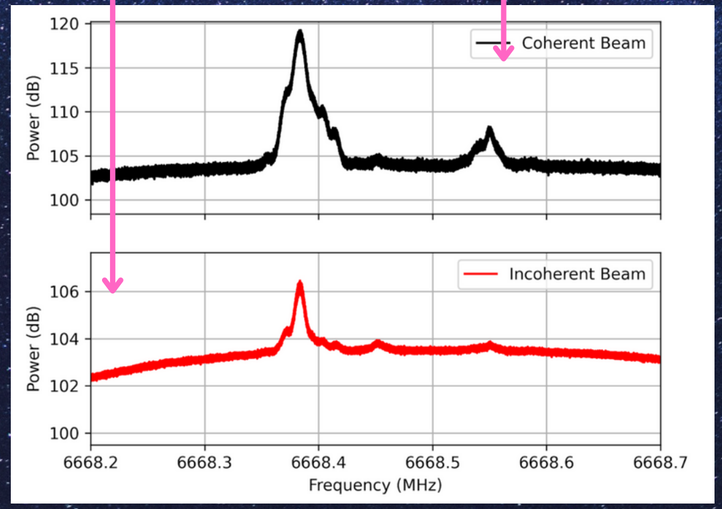
Similar developed for VLA & ATA with BLADE Beamformer

https://github.com/luigifcruz/blade

Beamformer: Luigi Cruz & Ross Donnachie

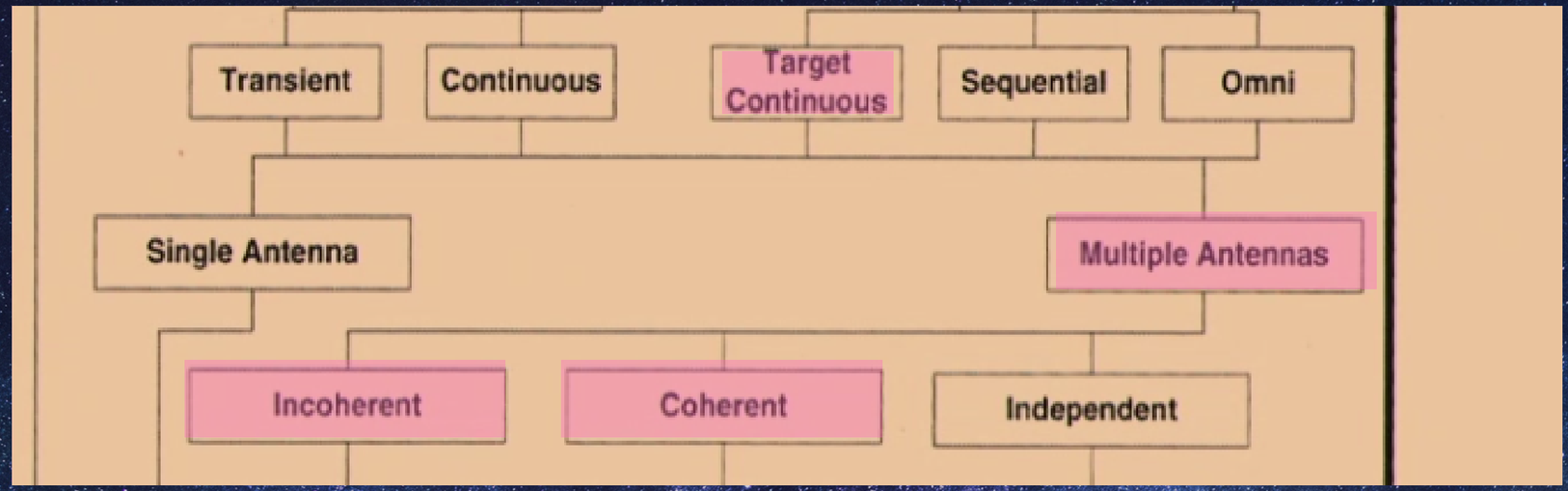
Multiple Antenna Tests

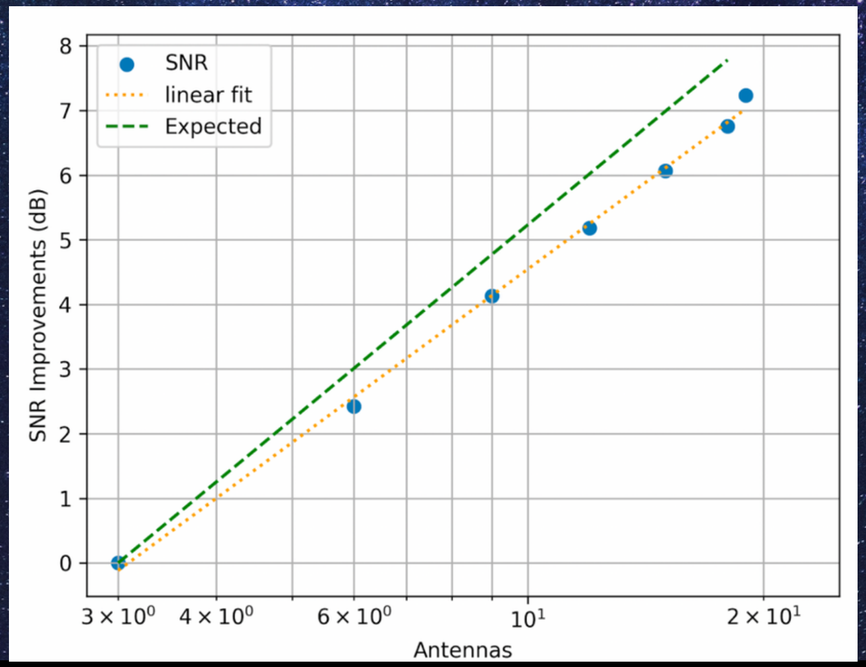




Using W51M Methanol Maser

Multiple Antenna Tests





Using W51M Methanol Maser

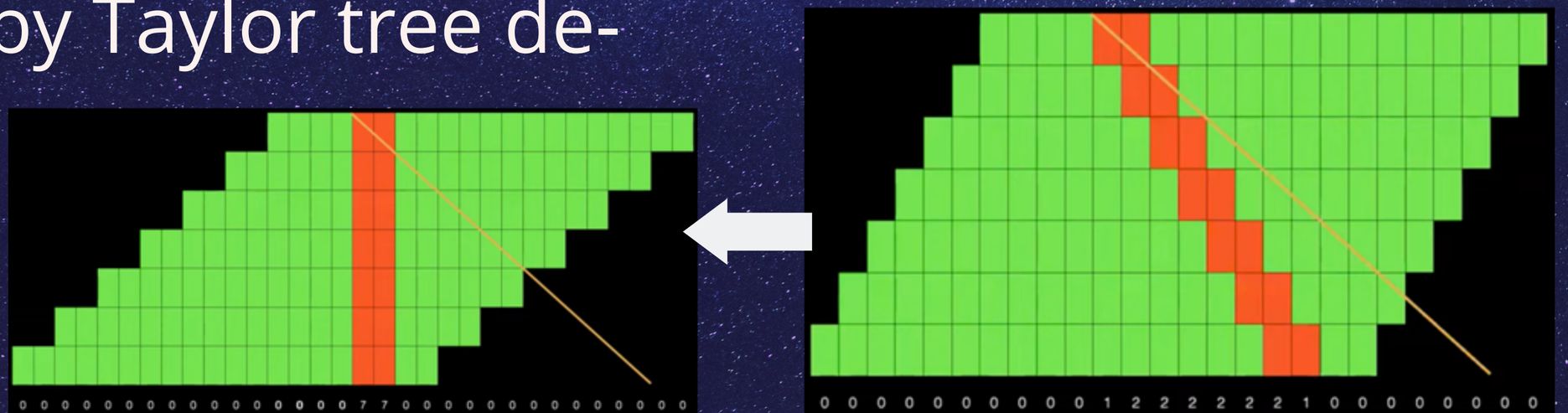
Beamformer Efficience ~80% with 19 antennas

WHAT ARE THEY DESIGNED TO DO?

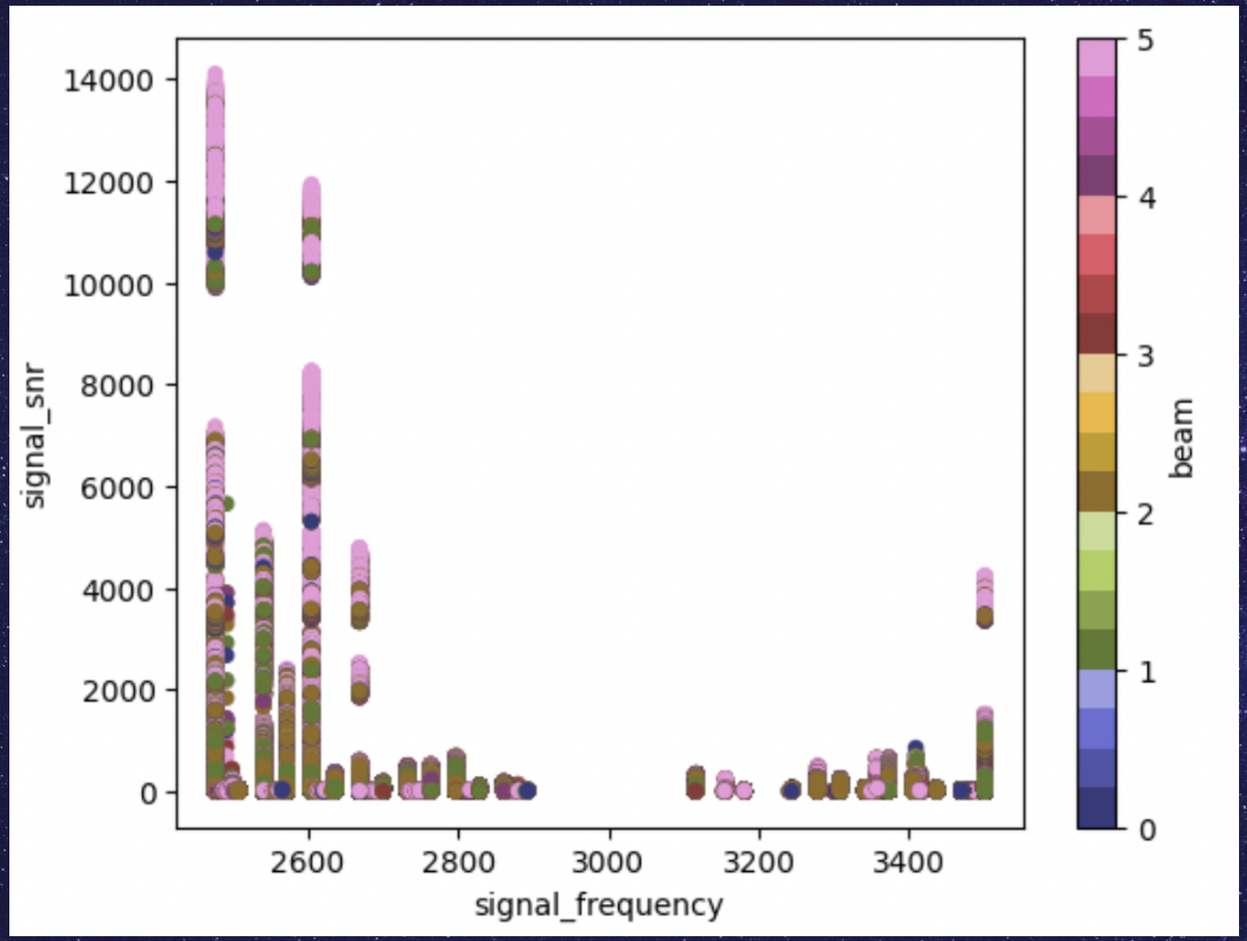
Key features of technosignatures:

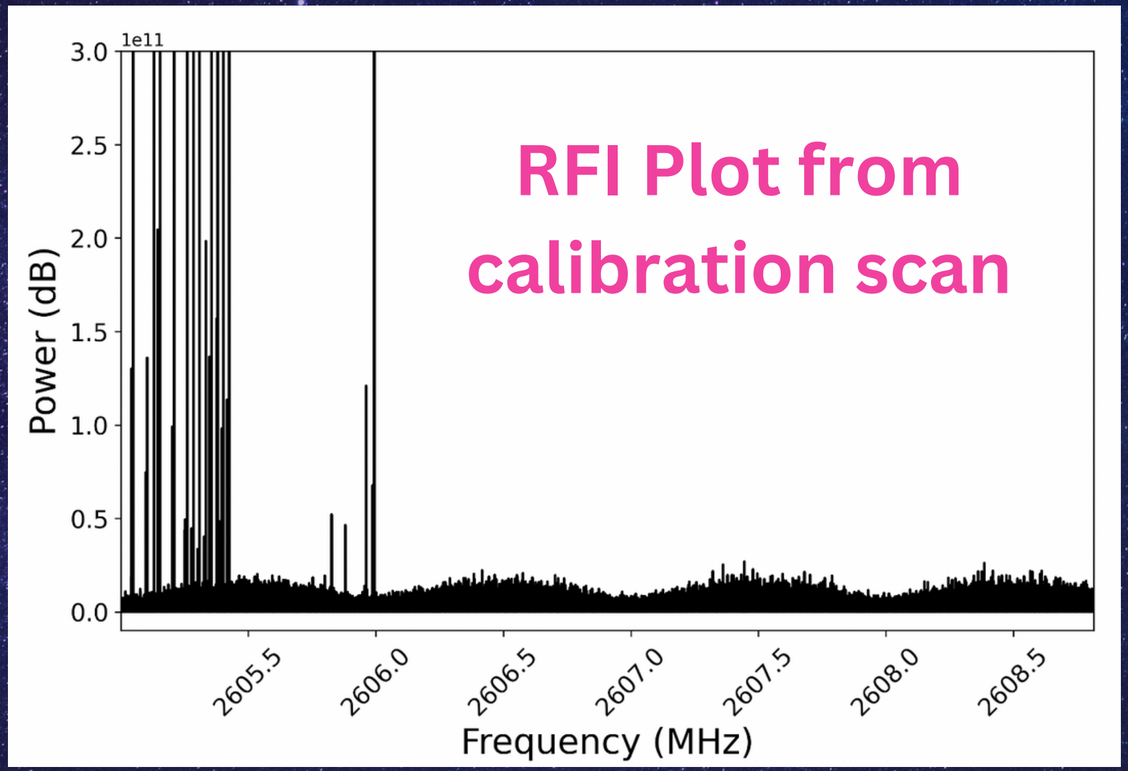
- Narrowband
- Drift

Drift solved by Taylor tree de-dispersion



First Results

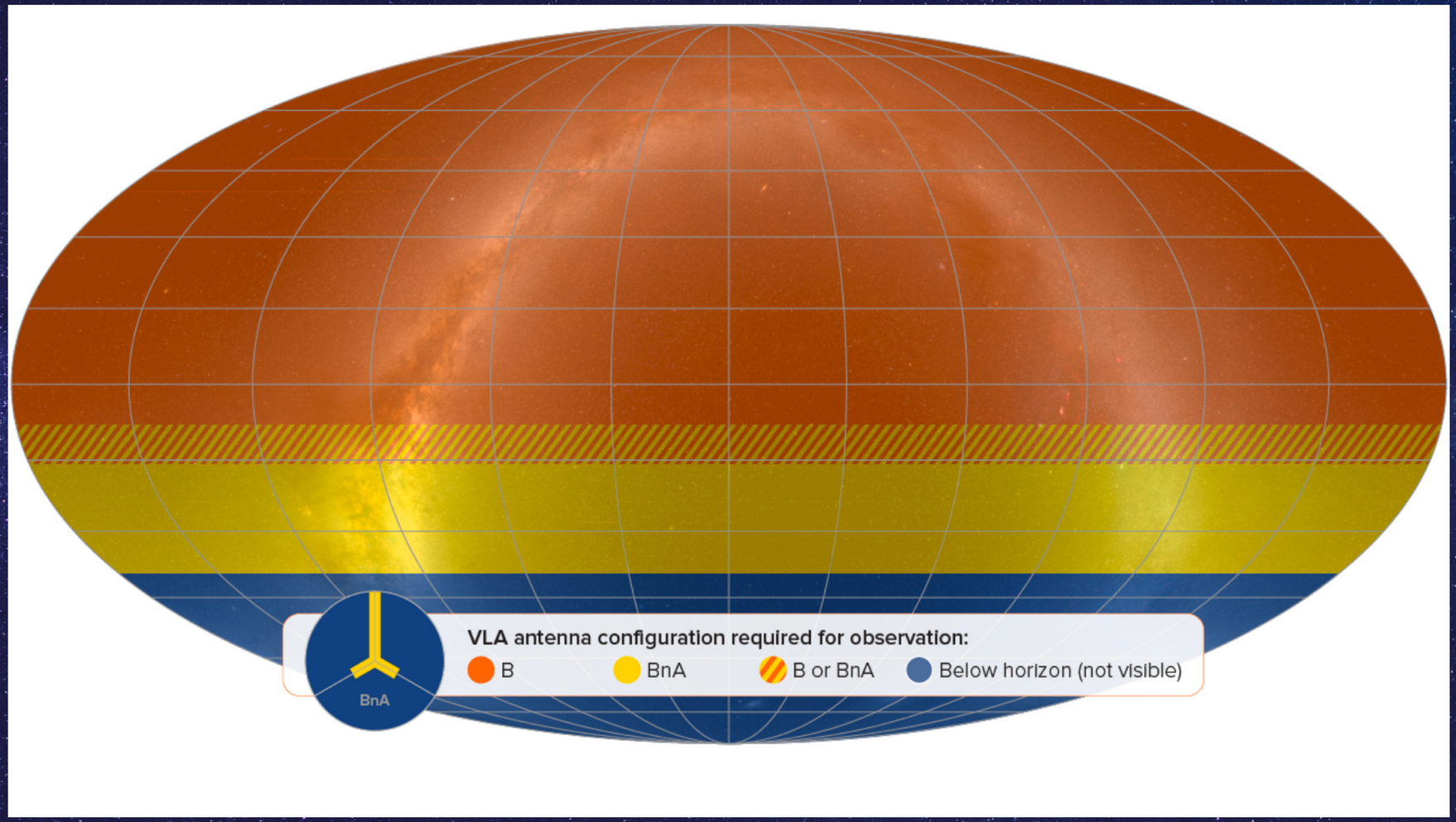




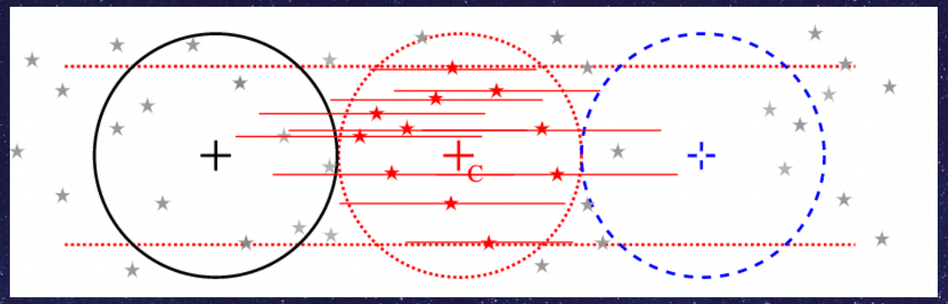
RFI Plot from calibration scan

VLA Sky Survey

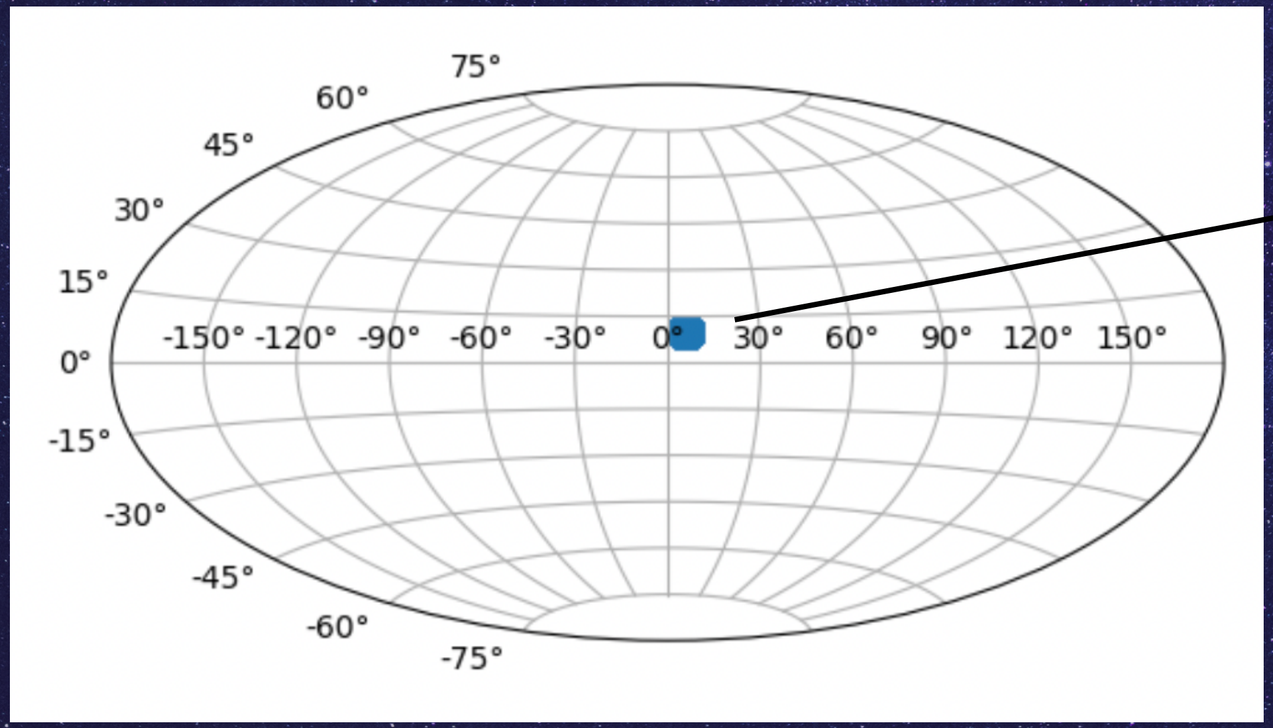
- Want to tag along with VLASS all-sky survey
- Above Dec -40
- This is a fast raster scan survey
- ~5seconds per source
- Different configurations
- Started January 2023

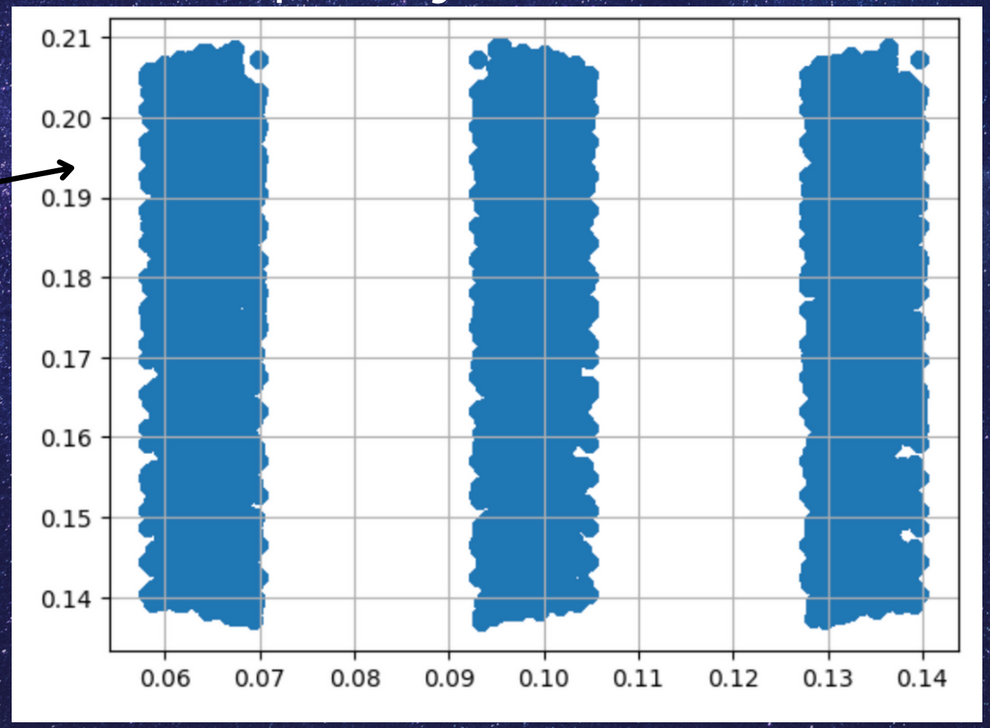


First Results



This one patch produced:
5.6 million hits
Drift rate values -4 to +4 Hz/s
Frequency 2.5 - 3.5 GHz



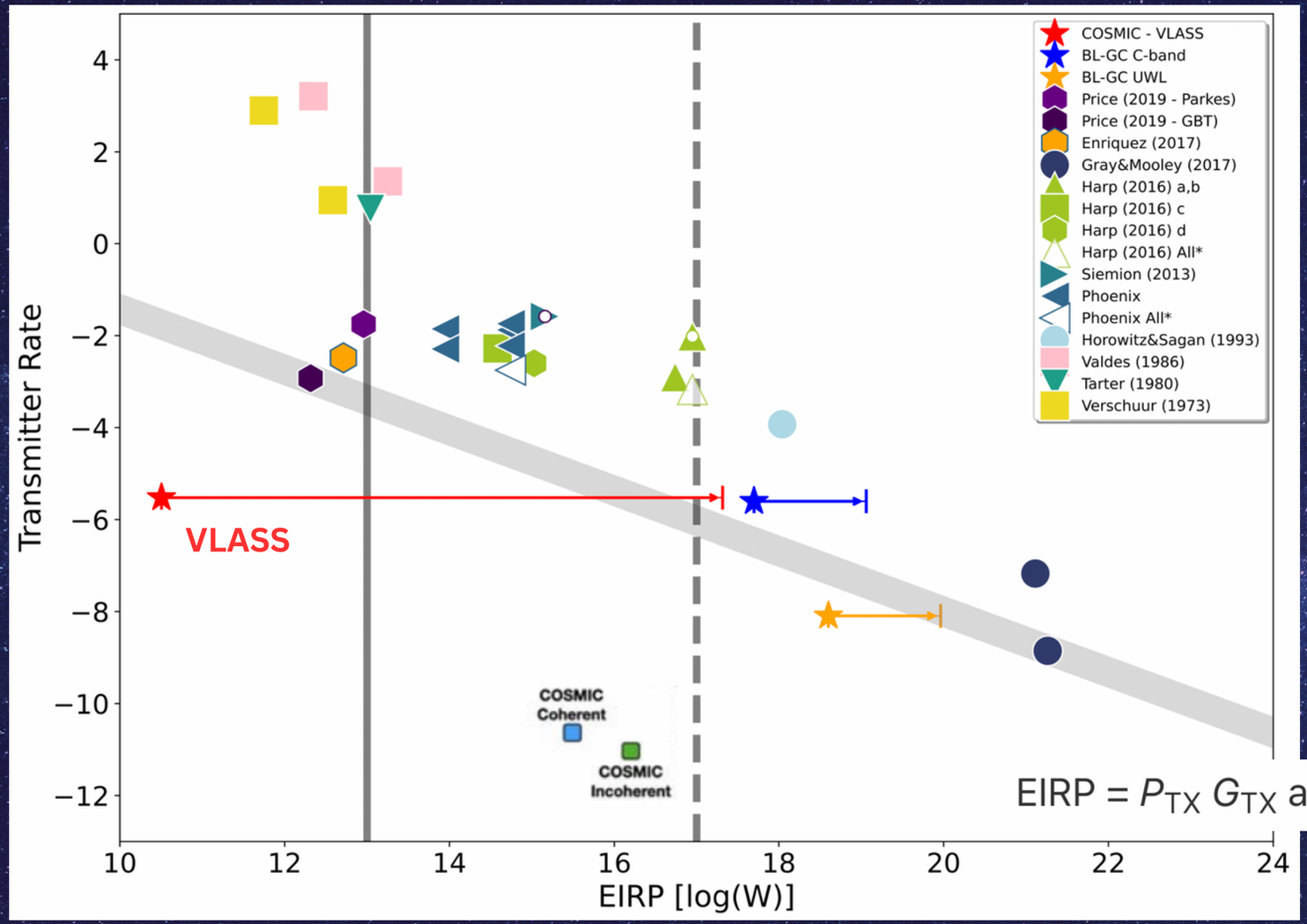


Dec ---->

RA ---->

Where we are heading

Number of Stars -->



EIRP = $P_{TX}\, G_{TX}$ and $G_{RX} = 4\pi\, A_{eAP}\, /\lambda^2$

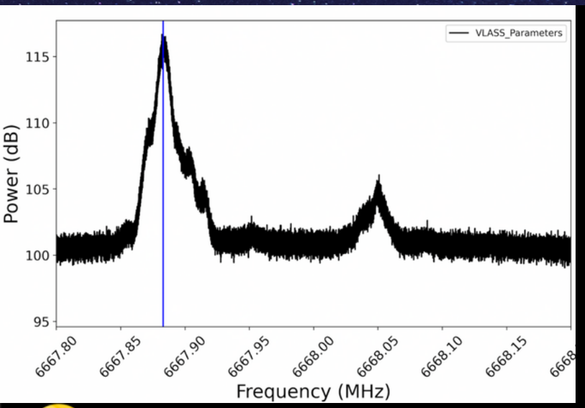
Minimum Detectable Power ----->

Opportunities

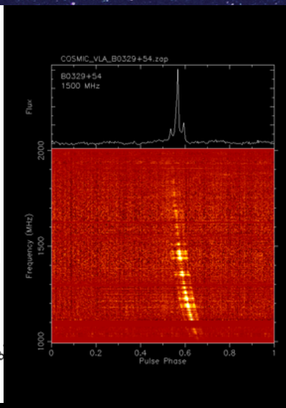
Collaborations

1. Fast Radio Bursts - RealFast
2. Axions Dark Matter
3. RFI Tracking

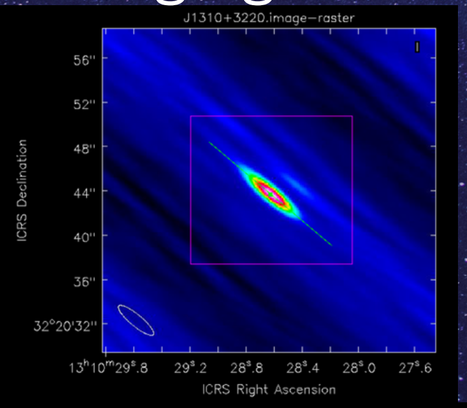
Masers



Pulsars



Imaging



Potential Future Science

1. High Time Resolution (0.1-5s)
2. High Frequency Resolution (0.2 - 10 Hz)
3. Raw Voltages
4. Full Polarisation

WANT TO KNOW MORE?

science.nrao.edu/facilities/vla/observing/cosmic-seti

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Facilities > VLA > Observing > COSMIC SETI

- Proposing
- Observing
- Data Processing
- Data Archive
- Other Info for Observers
- HelpDesk
- Science

COSMIC SETI

Overview

The **C**ommensal **O**pen **S**ource **M**ultimode **I**nterferometer **C**luster (COSMIC) system is a newly developed digital signal processing instrument deployed at the Karl G. Jansky Very Large Array (VLA), which is designed to enable Search for Extra-Terrestrial Intelligence (SETI) observations to be conducted at the VLA in parallel with "Primary User" PI-led Science observations. The COSMIC system capabilities are still under active development.

This page attempts to summarize the planned operating modes of the COSMIC system in order to highlight opportunities where PIs might be able to leverage the power of the COSMIC system for their own observations, and also to provide insight as to where conflicts may exist between PI-led science and COSMIC.

Massive Radio Array to Search for Extraterrestrial Signals from Other Civilizations

The SETI Institute, the National Radio Astronomy Observatory and the Breakthrough Listen Initiative team up for COSMIC and SETI

SETI INSTITUTE

Image Credit: VLA/NRAO

PRESS RELEASE

DATE

May 1, 2023

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SETI Institute
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Thank you

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astrochenoa@gmail.com