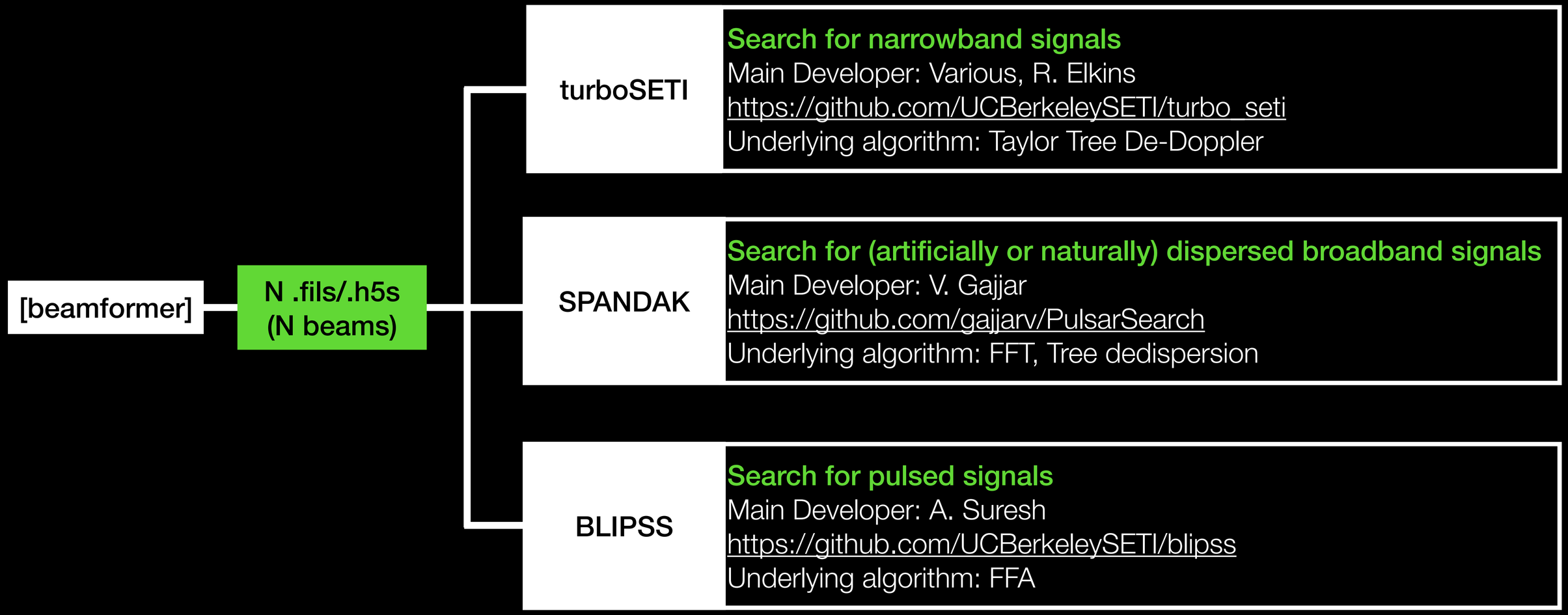
ATA SETI Science Updates

RFI Survey and 2022 SETI Programs

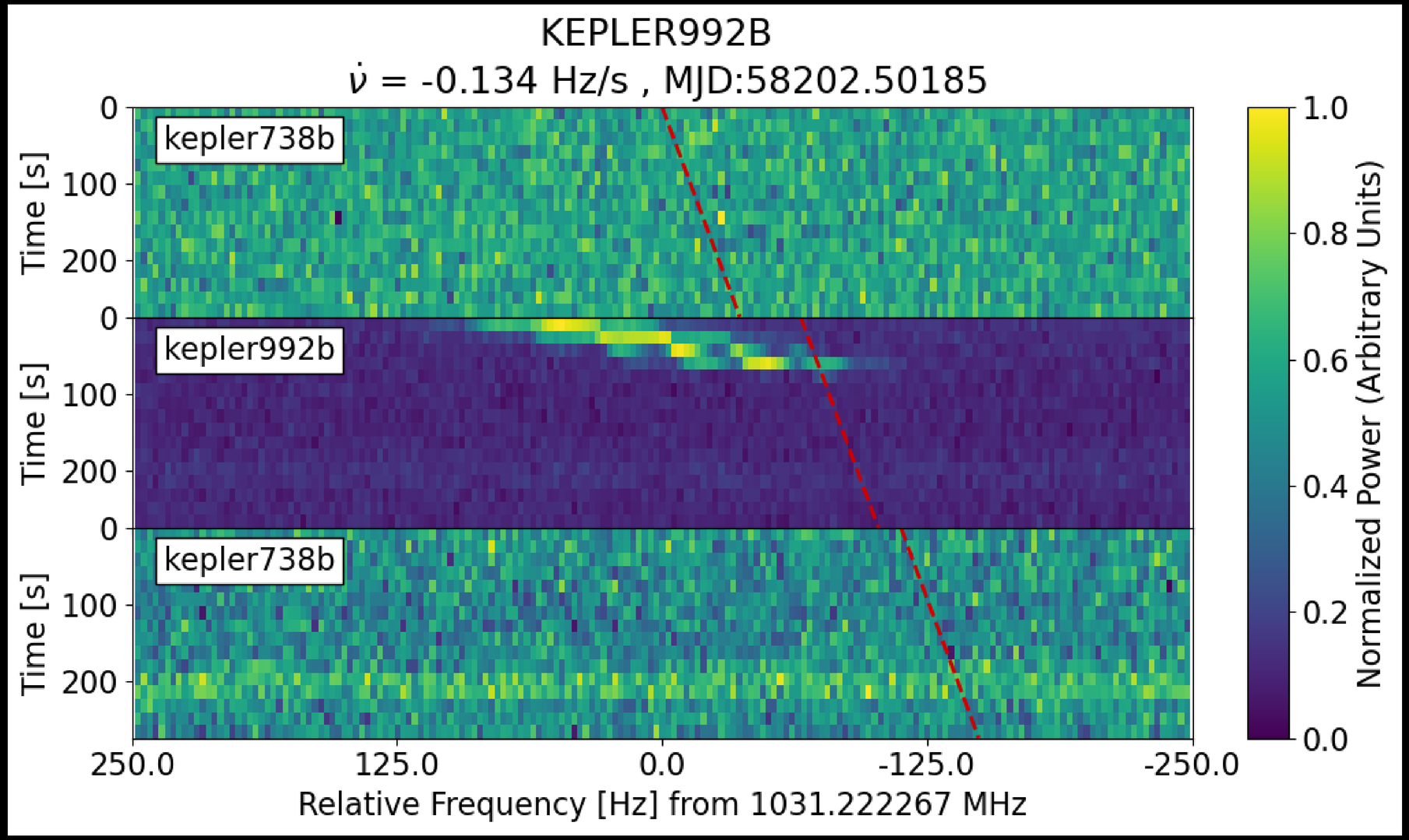
Sofia Sheikh - 02/22

Summary

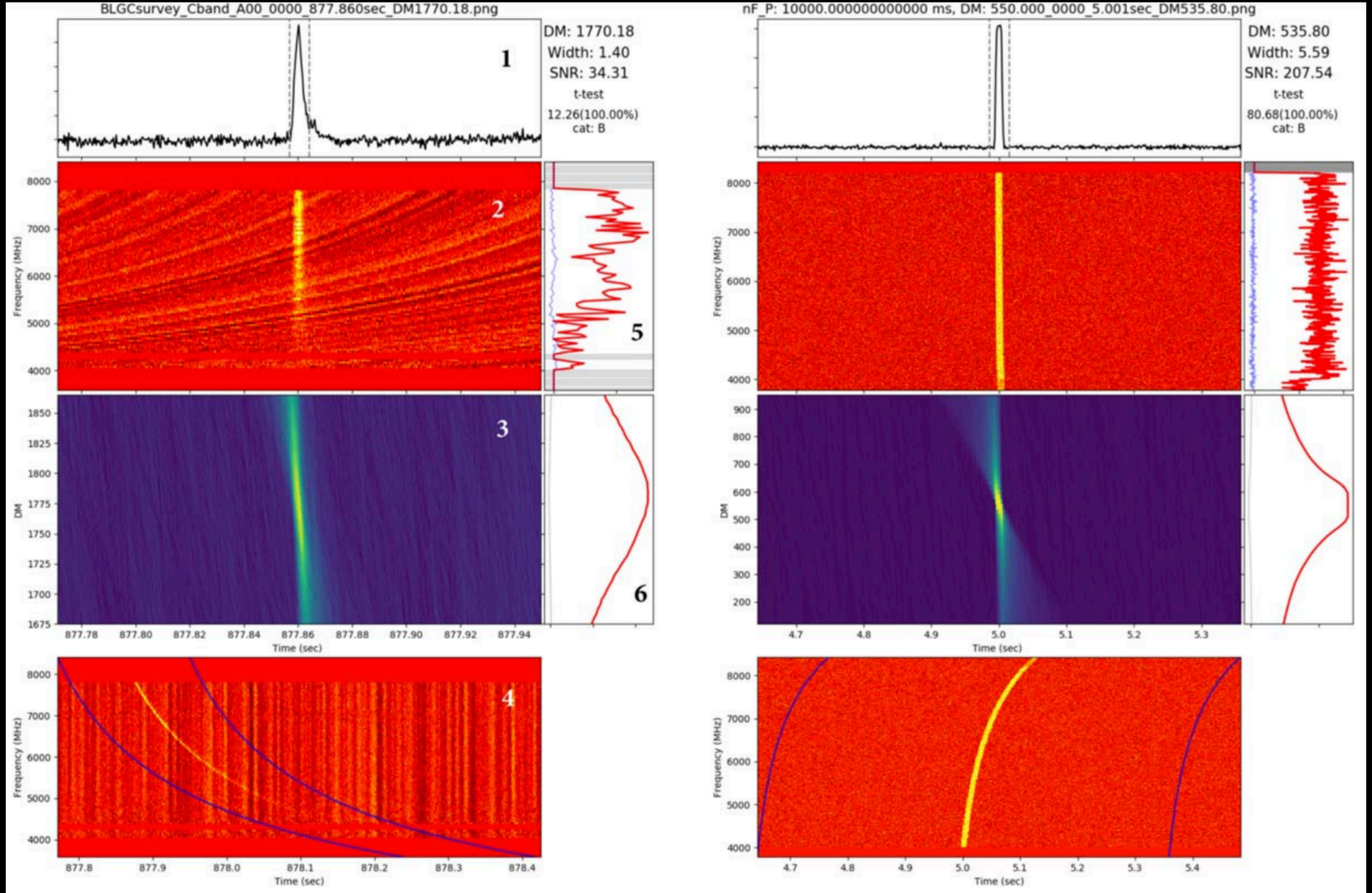
1) SETI Analysis Overview
2) RFI Survey Updates/Status
3) 2022 SETI Campaign Plans


[beamformer]
N .fils/.h5s
(N beams)
turboSETI
Search for narrowband signals
Main Developer: Various, R. Elkins
https://github.com/UCBerkeleySETI/turbo_seti
Underlying algorithm: Taylor Tree De-Doppler
SPANDAK
Search for (artificially or naturally) dispersed broadband signals
Main Developer: V. Gajjar
https://github.com/gajjarv/PulsarSearch
Underlying algorithm: FFT, Tree dedispersion
BLIPSS
Search for pulsed signals
Main Developer: A. Suresh
https://github.com/UCBerkeleySETI/blipss
Underlying algorithm: FFA

turboSETI



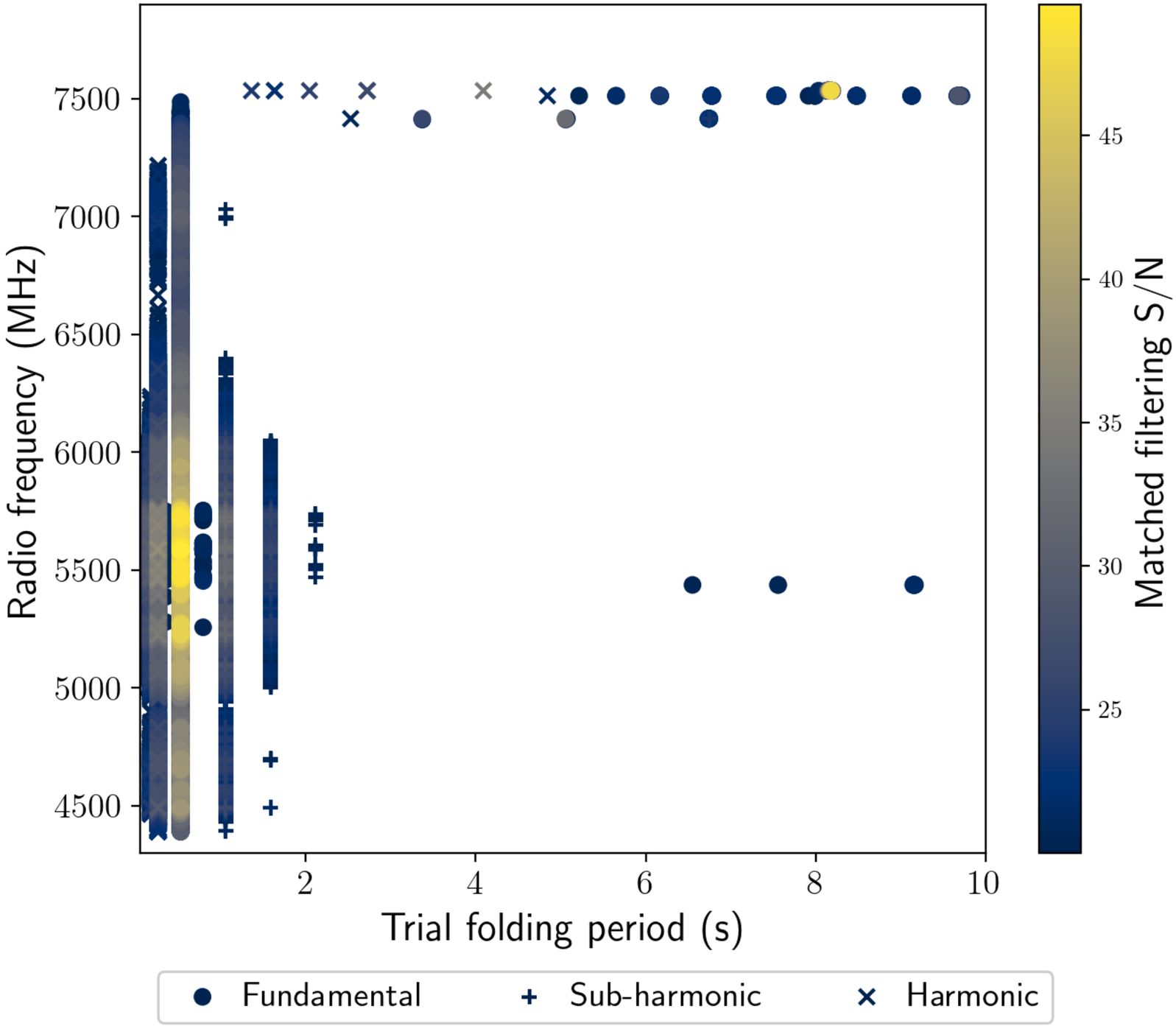
Sheikh et al. 2022 (in prep)



SPANDAK

Gajjar et al. 2021

BLIPSS



A. Suresh, unpublished

RFI Survey

Progress Overview

RFI Survey - Since the last time we met…

- Finalized observing plan
  - 16 tunings to cover ~0.4-11.1 GHz
  - Simultaneous scans with 3 old feeds / 3 new feeds
  - Sampling time of 20 ms (allow for reasonable data volume)
  - Alternate clockwise/counter-clockwise scans at 20° elevation
  - Keep individual antenna information (localize nearby RFI)

Progress Overview

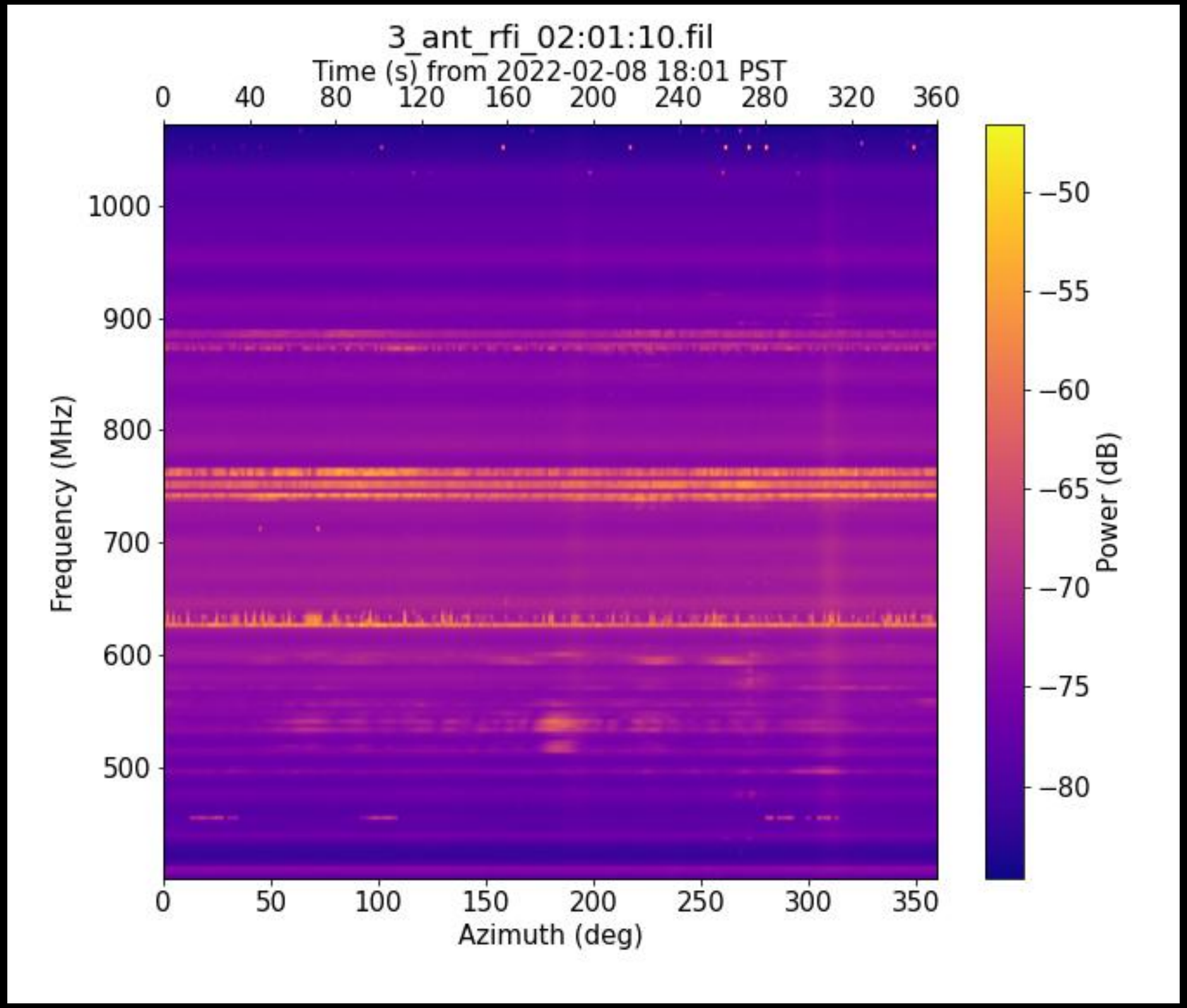
RFI Survey - Since the last time we met…

- Finalized observing plan
- Ran two test scans with snap board recording
  - 1) 3 new feeds
  - 2) 3 old feeds
  - Worked out issues with slew pattern logic, sampling time, ephem file generation etc.
  - Learned to observe via Observer’s Guide, improved guide

Progress Overview

RFI Survey - Since the last time we met…

- Finalized observing plan
- Ran two test scans with snap board recording
- Wrote visualization tools using test data for development
  - 1) Waterfall plots of single scans


3_ant_rfi_02:01:10.fil
Time (s) from 2022-02-08 18:01 PST
0
40
80
120
160
200
240
280
320
360
1000
900
800
700
600
500
Frequency (MHz)
0
50
100
150
200
250
300
350
Azimuth (deg)
−50
−55
−60
−65
−70
−75
−80
Power (dB)

Progress Overview

RFI Survey - Since the last time we met…

- Finalized observing plan
- Ran two test scans with snap board recording
- Wrote visualization tools using test data for development

  1. Waterfall plots of single scans
  2. Waterfall plots of all scans from a given observation

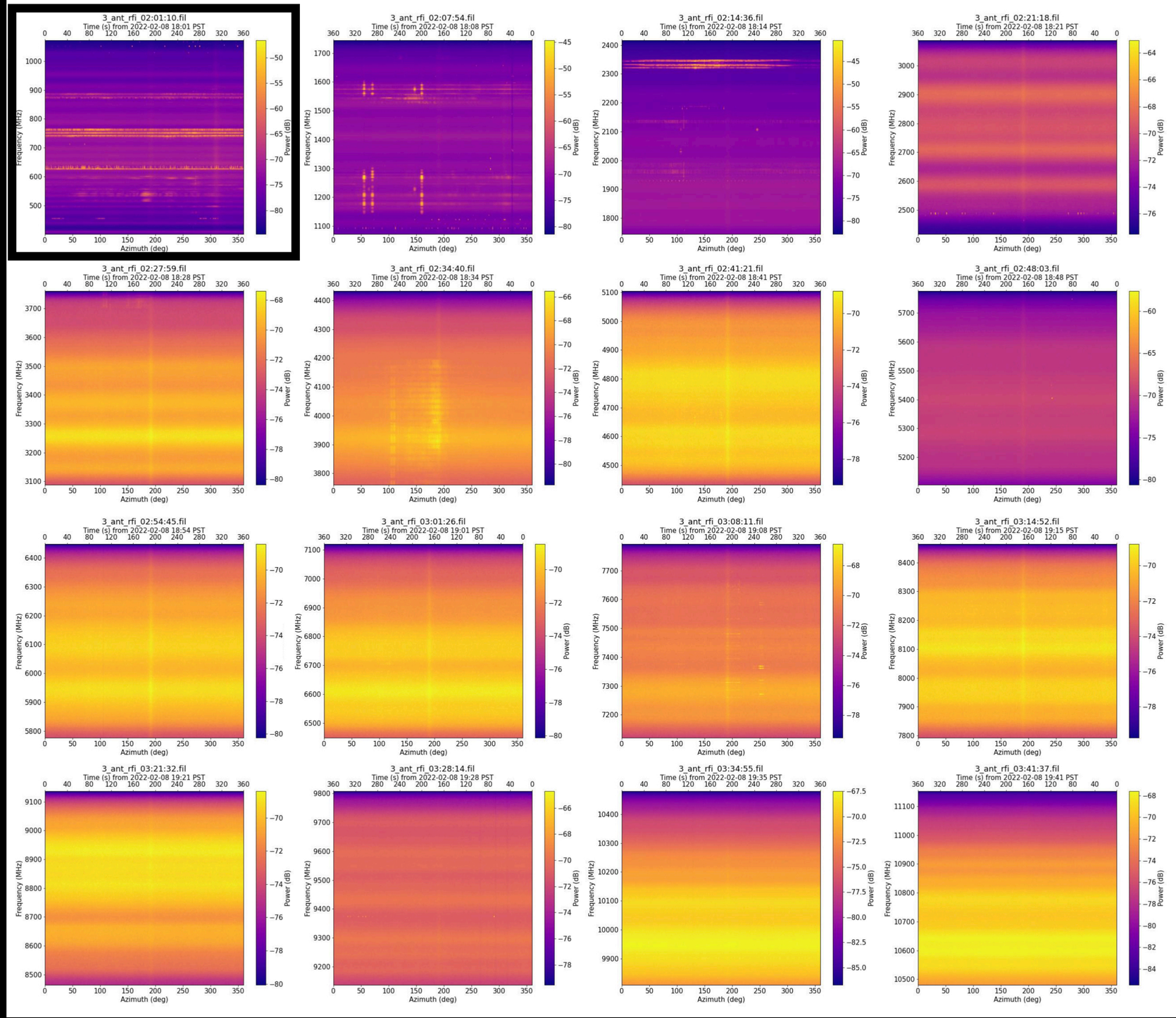
736 MHz
1408 MHz
2080 MHz
2752 MHz

3424 MHz
4096 MHz
4768 MHz
5440 MHz

Central frequency in each sub panel (left to right)

6112 MHz
6784 MHz
7456 MHz
8128 MHz

8800 MHz
9472 MHz
10144 MHz
10816 MHz



Progress Overview

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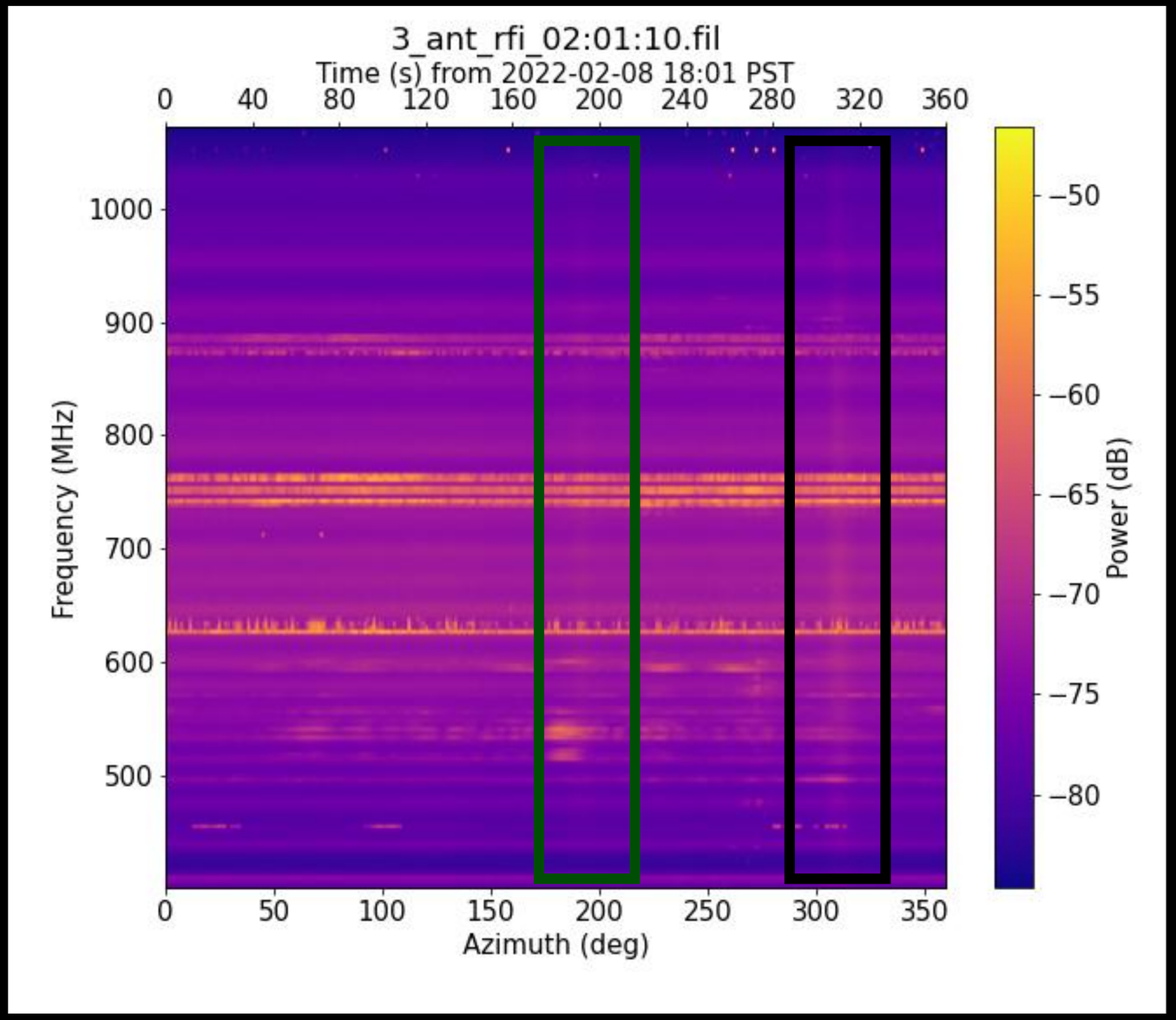
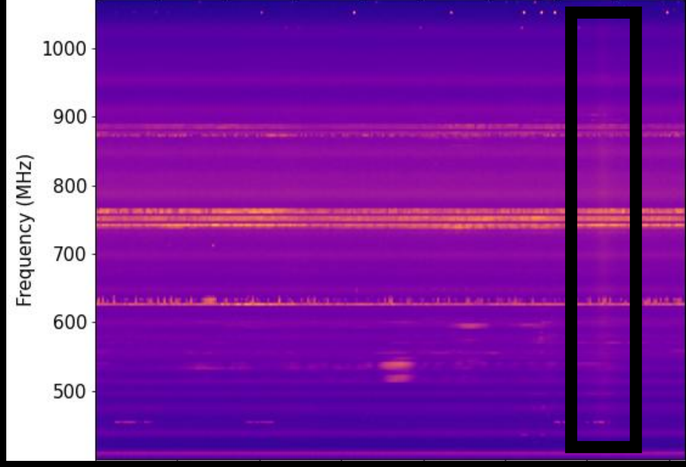
  1. Waterfall plots of single scans
  2. Waterfall plots of all scans from a given observation
  3. Utility to plot pointing direction over site map

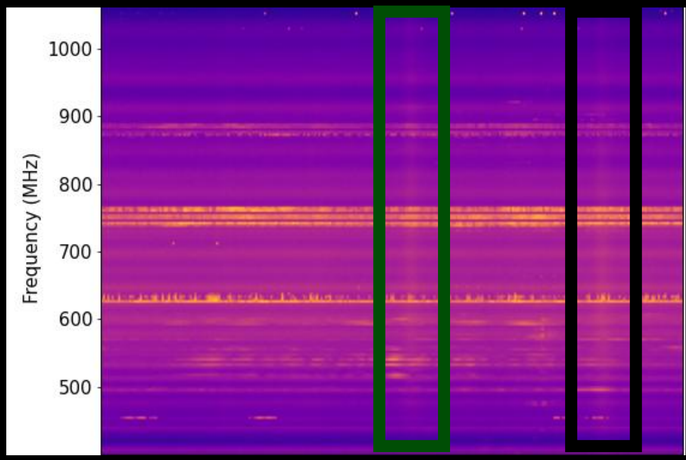
Incoherent sum of 1f, 5c, 1a



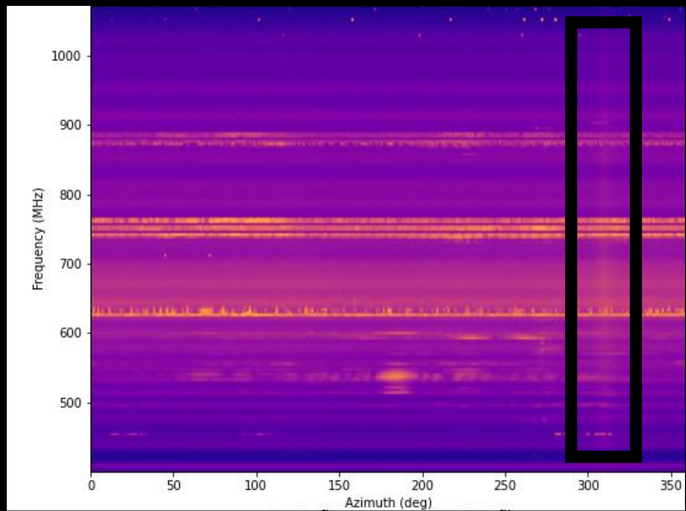
1f

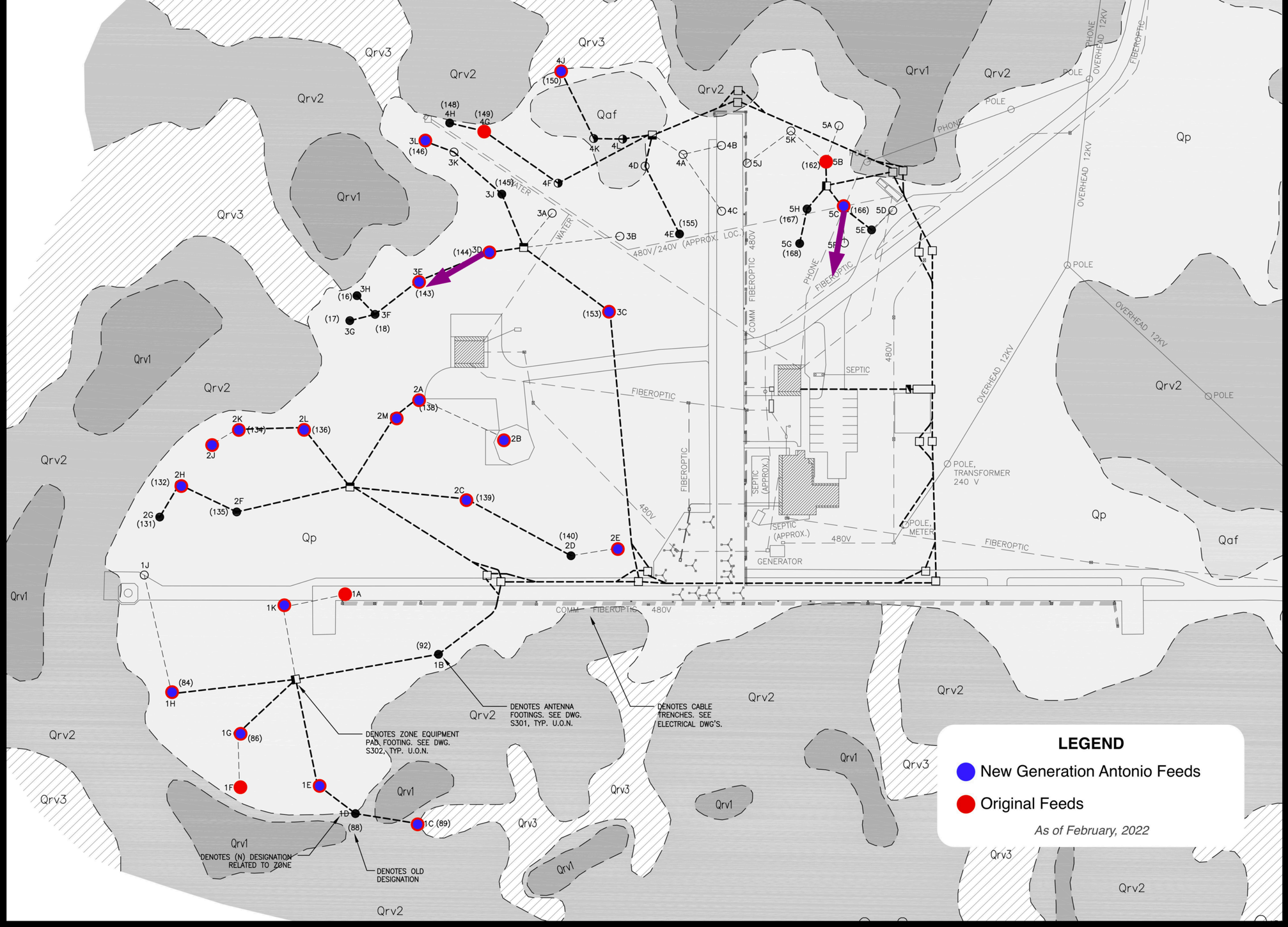


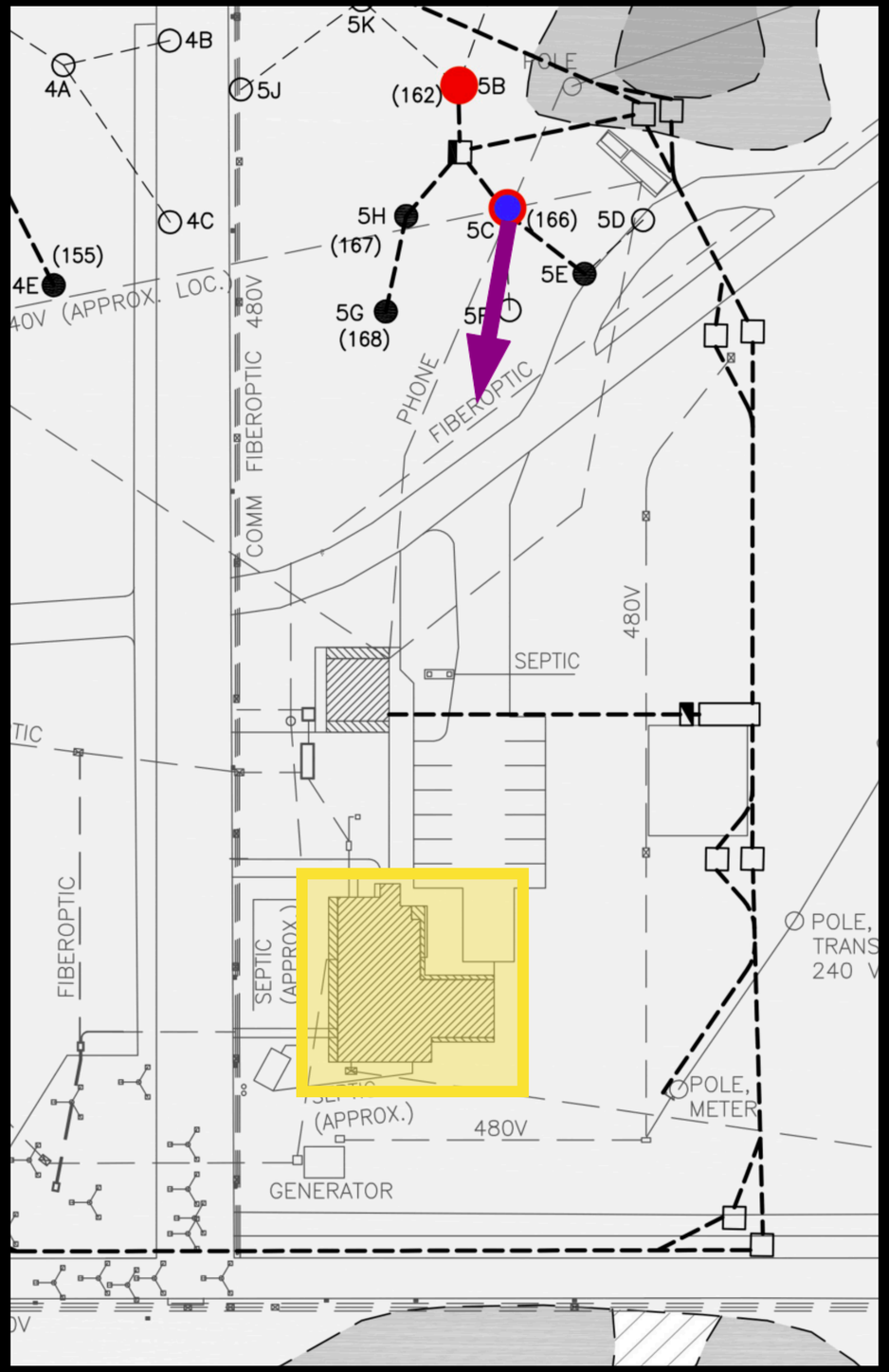
5c



1a




Qrv3
Qrv2
Qrv1
Qaf
Qp
4J
(150)
(148)
4H
(149)
4G
3L
(146)
3K
4K
4L
4F
4D
4A
4B
5J
5K
5A
(162)
5B
(145)
3J
WATER
3A
3B
4C
4E
(155)
5H
(167)
5C
(166)
5D
5E
5G
(168)
5F
(144)
3D
3E
(143)
3H
(16)
3F
(17)
3G
(18)
(153)
3C
480V/240V (APPROX. LOC.)
COMM FIBEROPTIC 480V
PHONE
FIBEROPTIC
POLE
OVERHEAD 12KV
SEPTIC
480V
2A
(138)
2M
2B
2K
(134)
2L
(136)
2J
2H
(132)
2F
(135)
2G
(131)
2C
(139)
(140)
2D
2E
FIBEROPTIC
SEPTIC (APPROX.)
POLE, TRANSFORMER 240 V
POLE, METER
GENERATOR
1J
1K
1A
(92)
1B
(84)
1H
1G
(86)
1F
1E
1D
(88)
1C (89)
COMM FIBEROPTIC 480V
DENOTES ANTENNA FOOTINGS. SEE DWG. S301, TYP. U.O.N.
DENOTES CABLE TRENCHES. SEE ELECTRICAL DWG'S.
DENOTES ZONE EQUIPMENT PAD FOOTING. SEE DWG. S302, TYP. U.O.N.
DENOTES (N) DESIGNATION RELATED TO ZONE
DENOTES OLD DESIGNATION
LEGEND
New Generation Antonio Feeds
Original Feeds
As of February, 2022


4A
4B
5J
5K
(162)
5B
POLE
4C
5H
(167)
5C
(166)
5D
5E
(155)
4E
5G
(168)
5F
480V (APPROX. LOC.)
COMM FIBEROPTIC 480V
PHONE
FIBEROPTIC
480V
SEPTIC
TIC
FIBEROPTIC
SEPTIC (APPROX.)
POLE, TRANS
240 V
POLE, METER
(APPROX.)
480V
GENERATOR

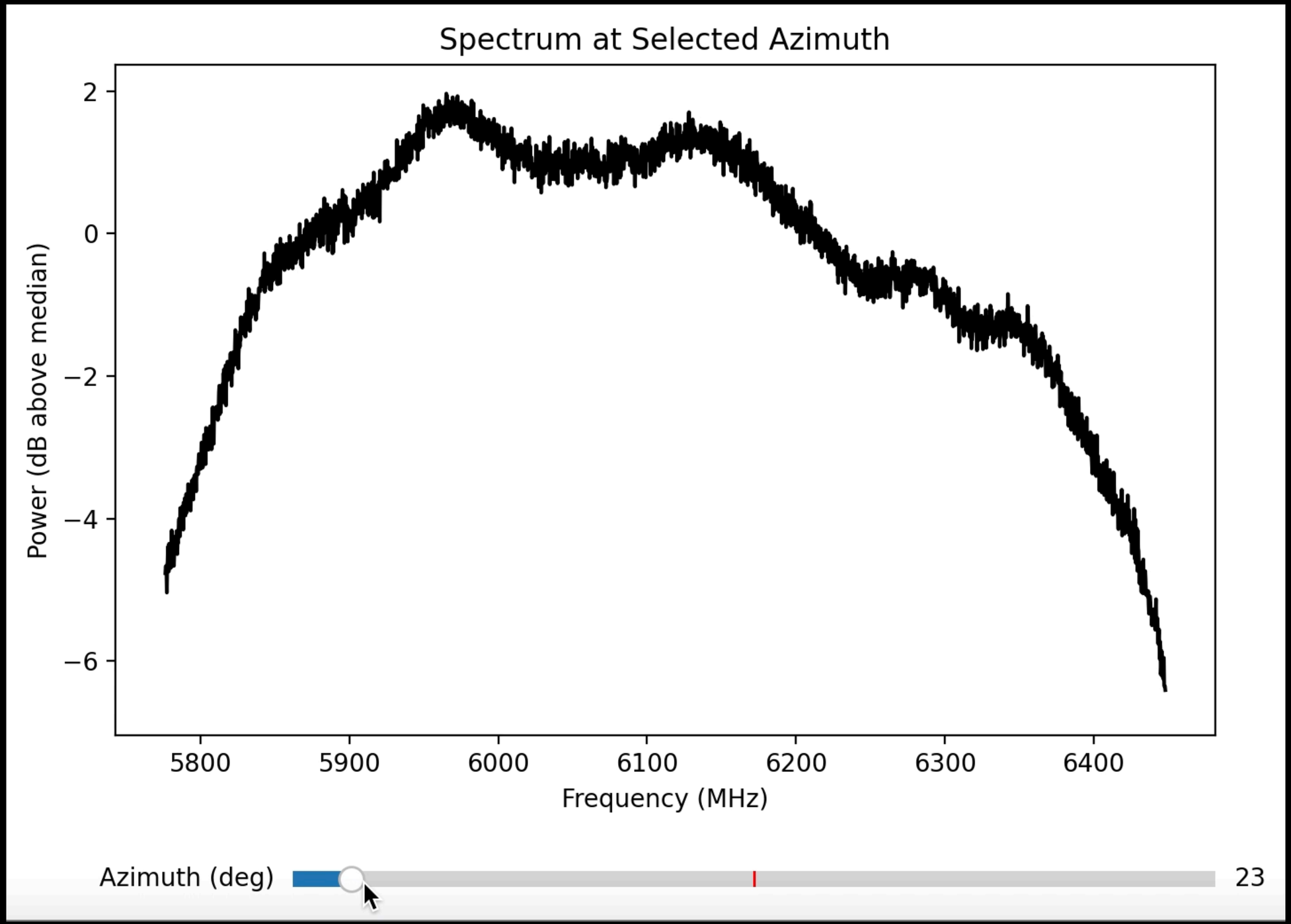
Progress Overview

RFI Survey - Since the last time we met…

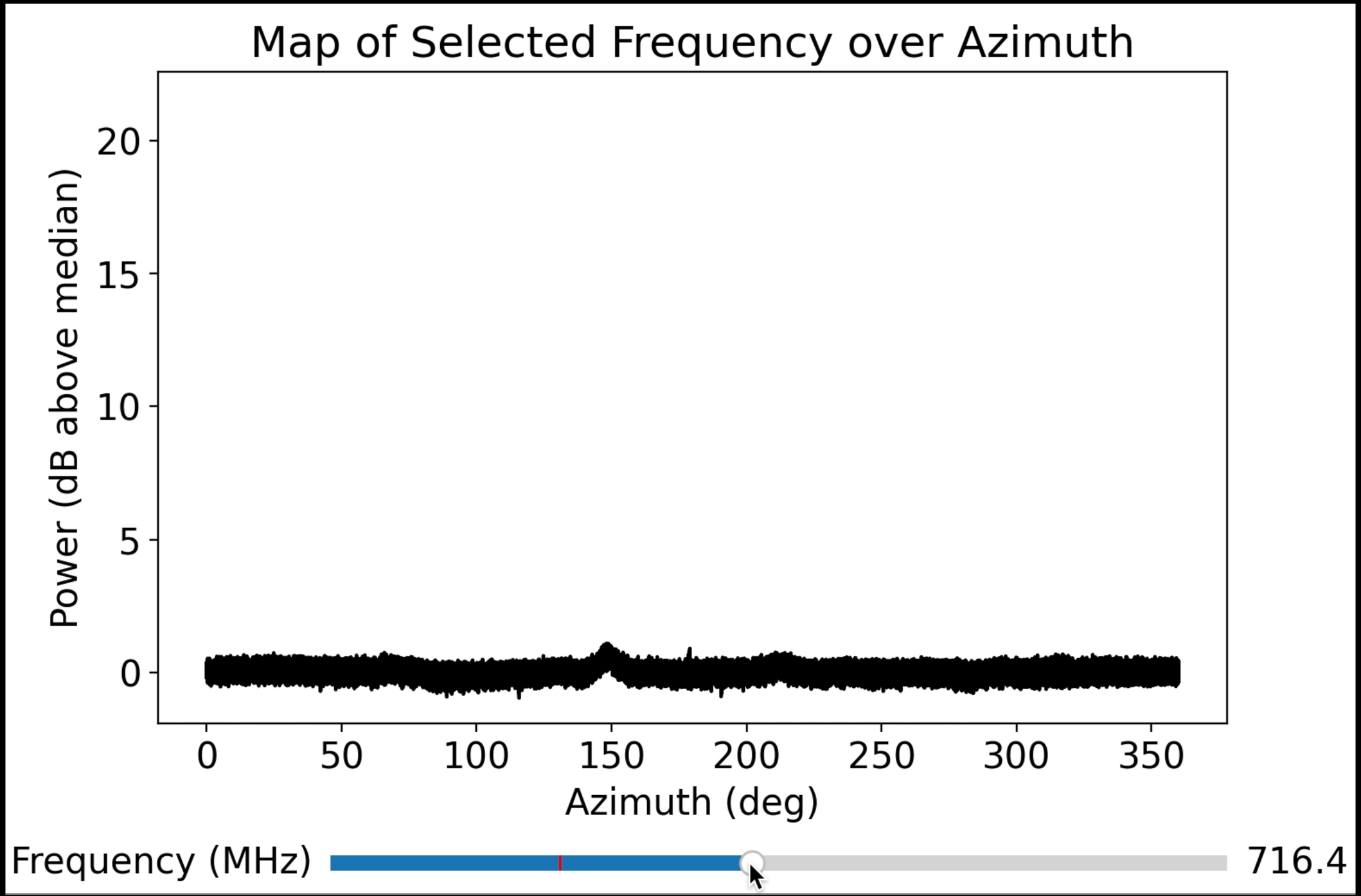
- Finalized observing plan
- Ran two test scans with snap board recording
- Wrote visualization tools using test data for development

  1. Waterfall plots of single scans
  2. Waterfall plots of all scans from a given observation
  3. Utility to plot pointing direction over a site map
  4. Interactive tools to explore single-scan spectra at a given azimuth and azimuth distribution at a given frequency

4j


Spectrum at Selected Azimuth
Power (dB above median)
2
0
−2
−4
−6
5800
5900
6000
6100
6200
6300
6400
Frequency (MHz)
Azimuth (deg)
23

4j

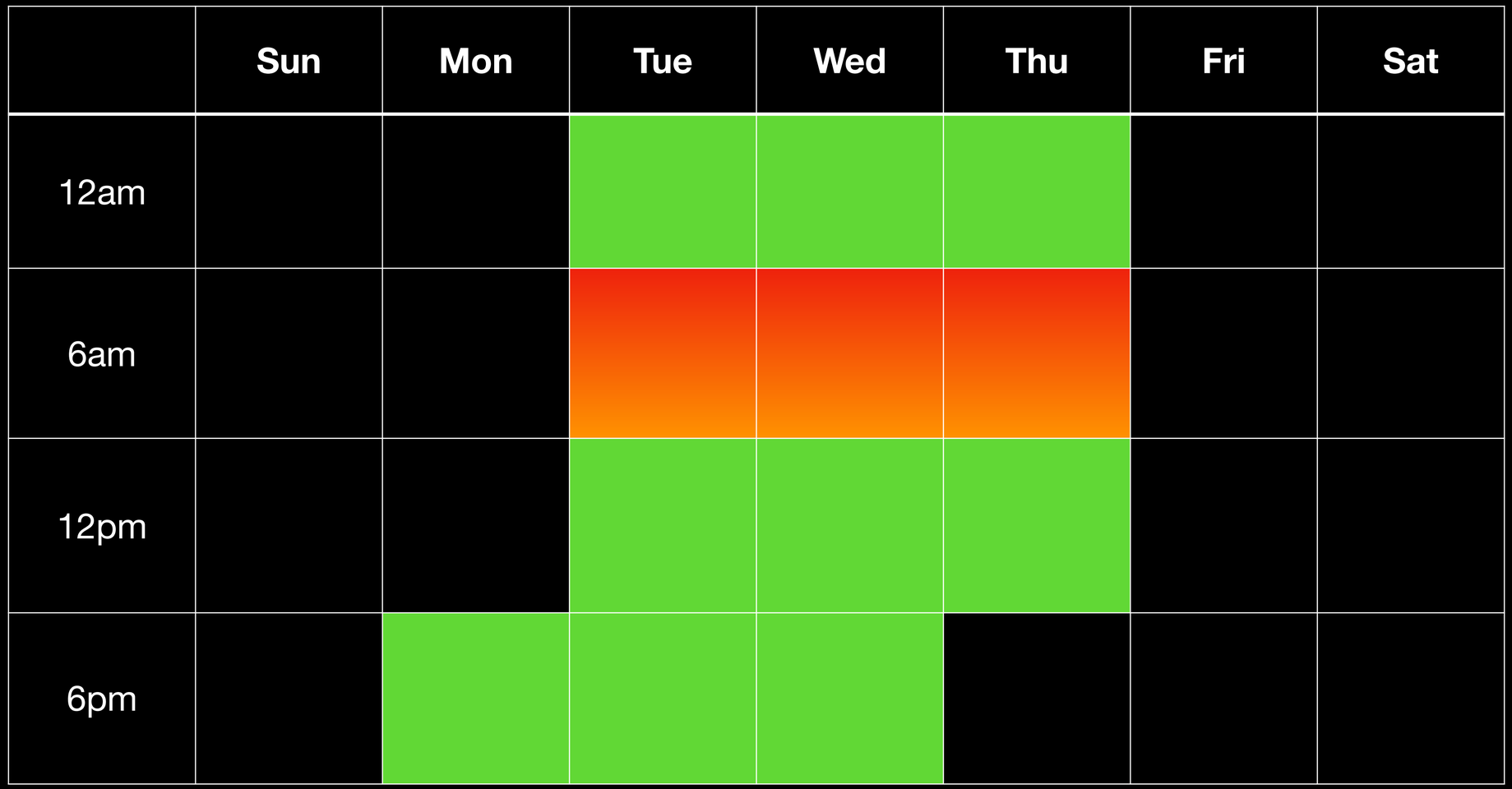

Map of Selected Frequency over Azimuth
Power (dB above median)
20
15
10
5
0
0
50
100
150
200
250
300
350
Azimuth (deg)
Frequency (MHz)
716.4

Progress Overview

RFI Survey - Since the last time we met…

- Finalized observing plan
- Ran two test scans with snap board recording
- Wrote visualization tools using test data for development
- **Began full, 28 scan RFI Survey**

Green = Completed Observations
Red/Orange = Incomplete (Failed) Observations



Observations failed because of a set_az_el() call that attempted to move the antennas, and one or more antennas did not move. Always on the 13th scan? Diagnosing with Todd - had been seen to happen intermittently in cold weather especially, but this seems more repeatable.

Next Steps

RFI Survey

- Finish 28 scan cadence (should be complete by end of next week, to fill in 6ams)
- Determine how best to reduce and save the data
  - pandas dataframe of RFI hits containing frequency, azimuth, time, day of week, antenna… then cluster/plot to look for patterns
    - How to make that dataframe? Need interference detection
      - **IQRM-APOLLO** code (written by Rajwade et al., narrowband, uses interquartile range)
      - **rfifind** function within PRESTO (written by Ransom, narrowband OR short duration broadband, takes time-freq blocks and uses a standard deviation cutoff of 4σ)

End-of-Project Goals

RFI Survey

- For any observing script, compare the antennas/dates/times/pointings to the pandas dataframe
  - Automatically warn the user if RFI-heavy parts of parameter space are included in their plan
  - Give user suggestions for mitigation
- Continue adding to the dataframe with daily/weekly RFI scans using the old feeds
  - Send an alert if RFI environment is sufficiently different from the existing data in the dataset

SETI Science Programs

SETI Science Programs

Looking Ahead: 2022

- Planned Observational SETI Campaigns

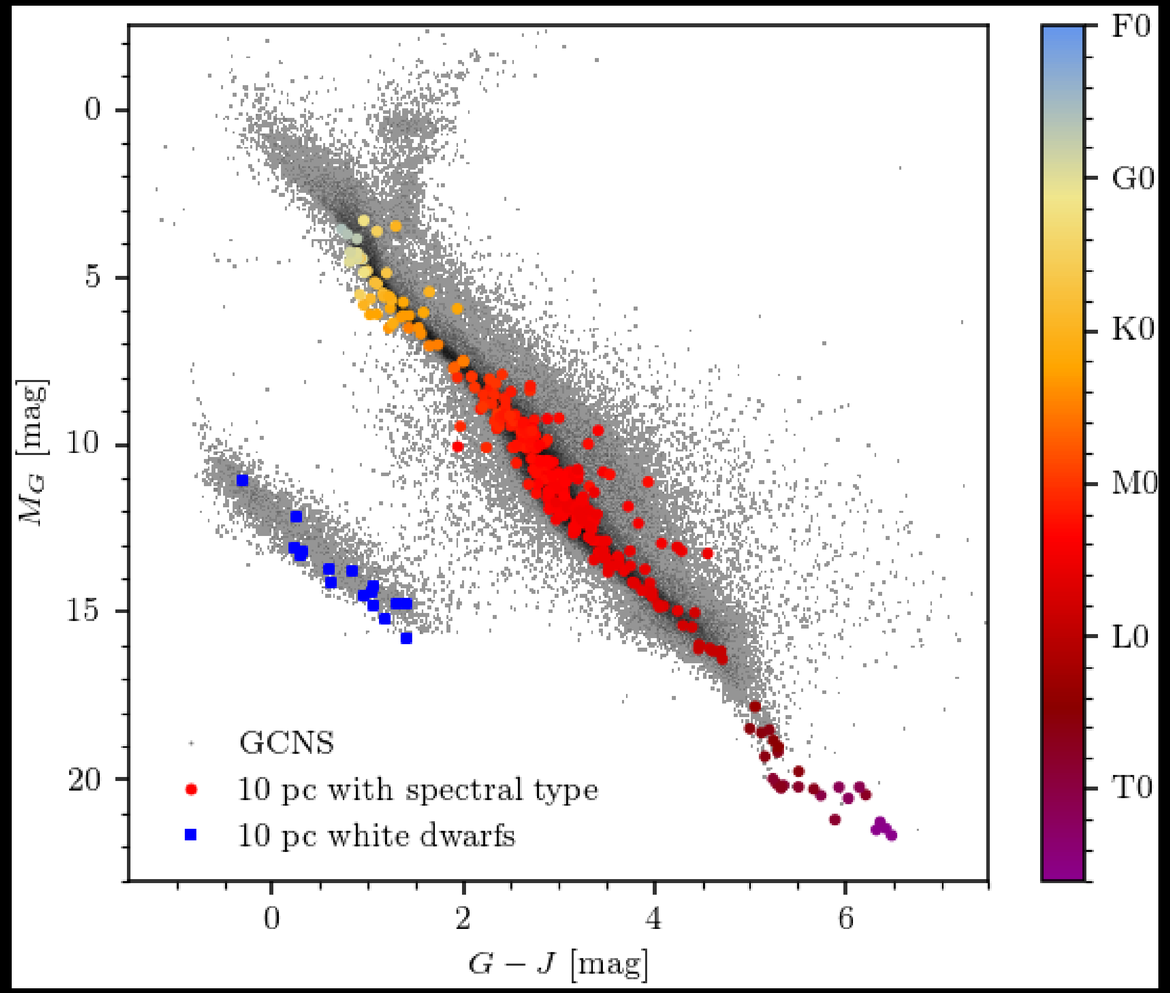
1. Nearby stars
2. Anti-solar point / Earth Transit Zone
3. Transiting Kepler planets
4. Planet-Planet Occultation events

Collaboration with PSETI

Nearby Stars

SETI Science Programs 2022

- SETI Motivation: Can see Earth-level transmitters from nearby stars, easier for ETIs to characterize Earth, best bet if tech is common (ex. node-based communication)
- Why the ATA? Nearby stars are an extremely well-founded SETI strategy, easy to plan and execute
- Target sample: 16 stars within 6.4 pc from RECONS, 2 of them with known terrestrial exoplanets in the habitable zone
- Observing strategy: beam forming with all functional antennas, across 2-10 GHz
- Status: 3 targets observed at 2.7-3.3 GHz

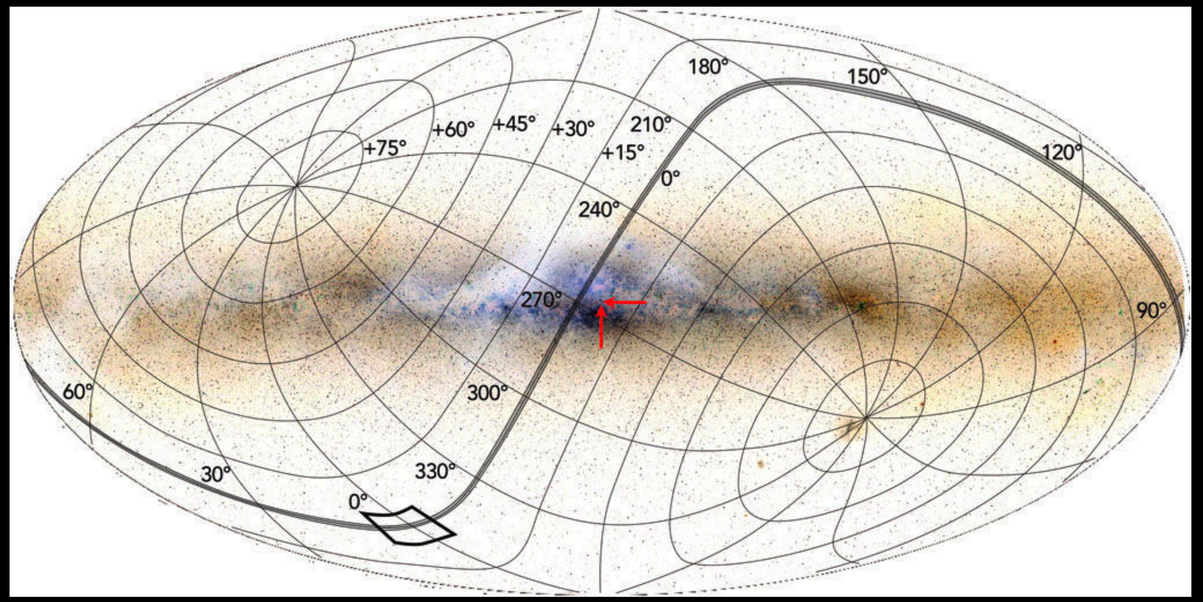


Reyle et al. 2021

Anti-Solar Point / Earth Transit Zone

SETI Science Programs 2022

- SETI Motivation: Earth would be visible during transit to these ETIs, anti-solar point is (perhaps) the most obvious Schelling Point
- Why the ATA? Need 1 year of nightly observations to tile entire ETZ at the anti-solar point
- Target sample: 365 pointings on the ecliptic
- Observing strategy: Incoherently-summed pointings, half of the antennas on, half off, freqs undetermined (but best below ~6 GHz for tiling?)
- Status: Will begin after RFI survey

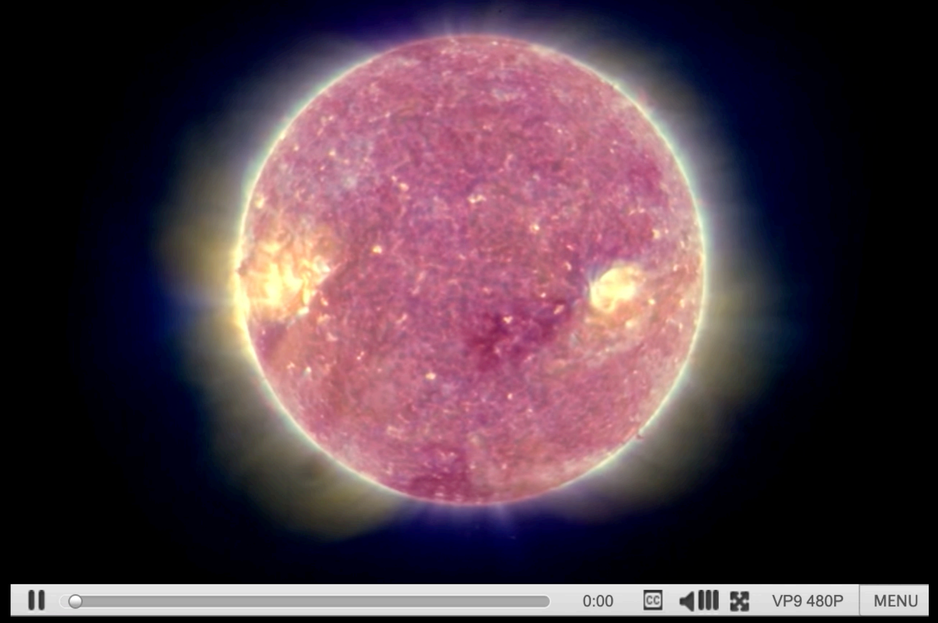


Heller and Pudritz 2016

Transiting Kepler Planets

SETI Science Programs 2022

- SETI Motivation: Mid-transit of an exoplanet is an orbital Schelling point, tidally-locked transiting planets are perfect for stellar-powered beacons on their nightside; proof-of-concept just completed by PSETI Center
- Why the ATA? Good follow up of “on-demand” timing events
- Target sample: The Kepler Field (115 sq. deg)
- Observing strategy: Incoherently-summed pointings to tile Kepler Field whenever possible, beamforming on specific systems during transit
- Status: PSETI analysis of GBT data almost complete

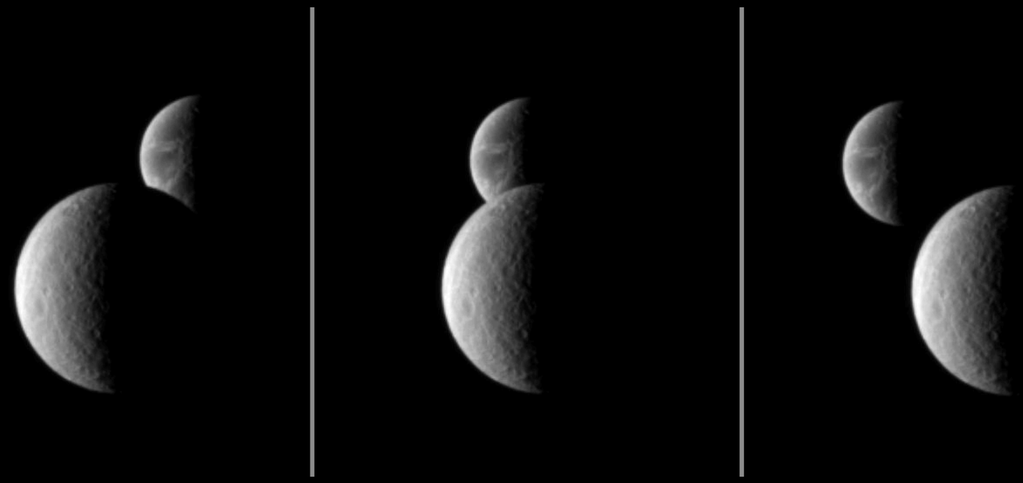


STEREO-B - Moon eclipsing Sun (2007, NASA)

Planet-Planet Occultations

SETI Science Programs 2022

- SETI Motivation: Planets in the same system sending radio transmissions (or radar) to each other could be “eavesdropped” on when they’re aligned with Earth
- Why the ATA? Good follow up of “on-demand” timing events
- Target sample: 25 systems with predictable PPOs
- Observing strategy: Beamforming on specific systems during PPO events
- Status: PPO prediction software paper soon-to-be-submitted (~1 month) by PSETI



Dione occulting Rhea (Cassini, 2009)