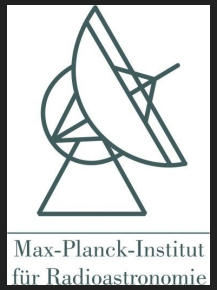
FRB searches with Effelsberg

Henning Hilmarsson - MPIfR Bonn

FRB2018: Finding and understanding FRBs
Feb 14, Melbourne

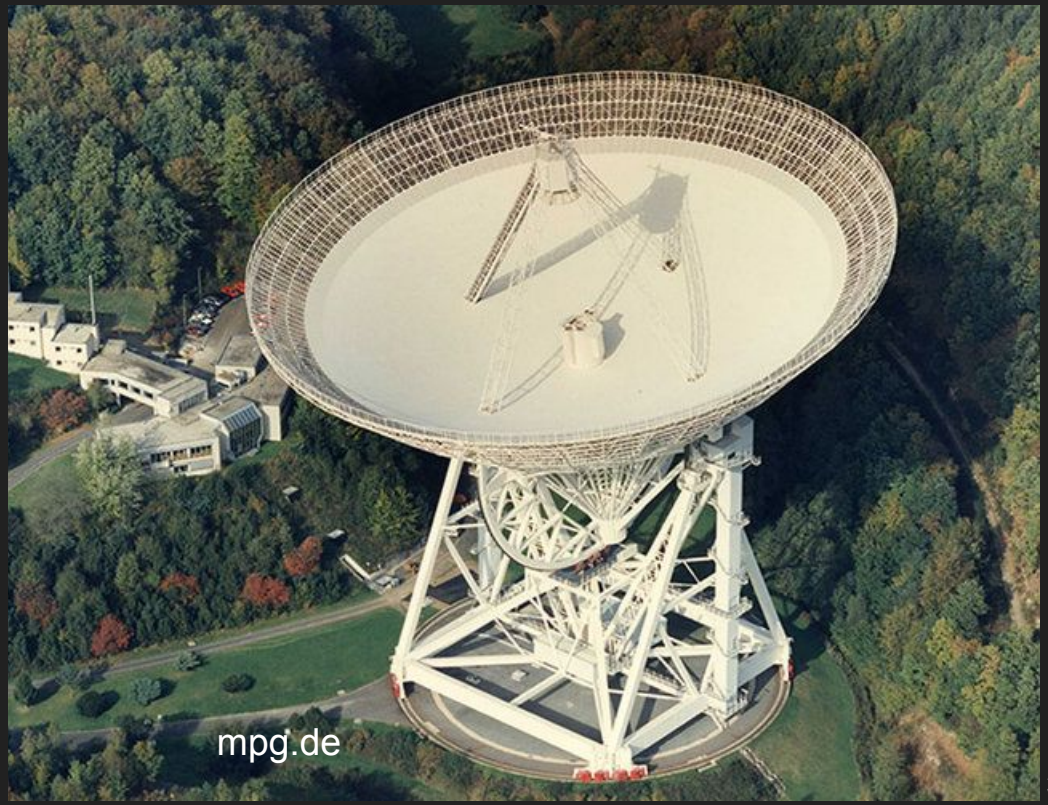


Overview

- Effelsberg
- Targeted searches
  - C+ receiver
  - LGRBs/SLSN-I
- Blind searches
  - PAF

The Effelsberg 100 m telescope

- Bad Munstereifel, Germany
- 100 m diameter
- Parabolic reflector
- Pulsars
- FRBs
- The European VLBI network



FRBs & LGRBs/SLSNe-I

- Targeted FRB search
  - Locations of known LGRBs/SLSN-I
- Motivation

Millisecond Magnetar Birth Connects FRB 121102 to Superluminous Supernovae and Long-duration Gamma-Ray Bursts

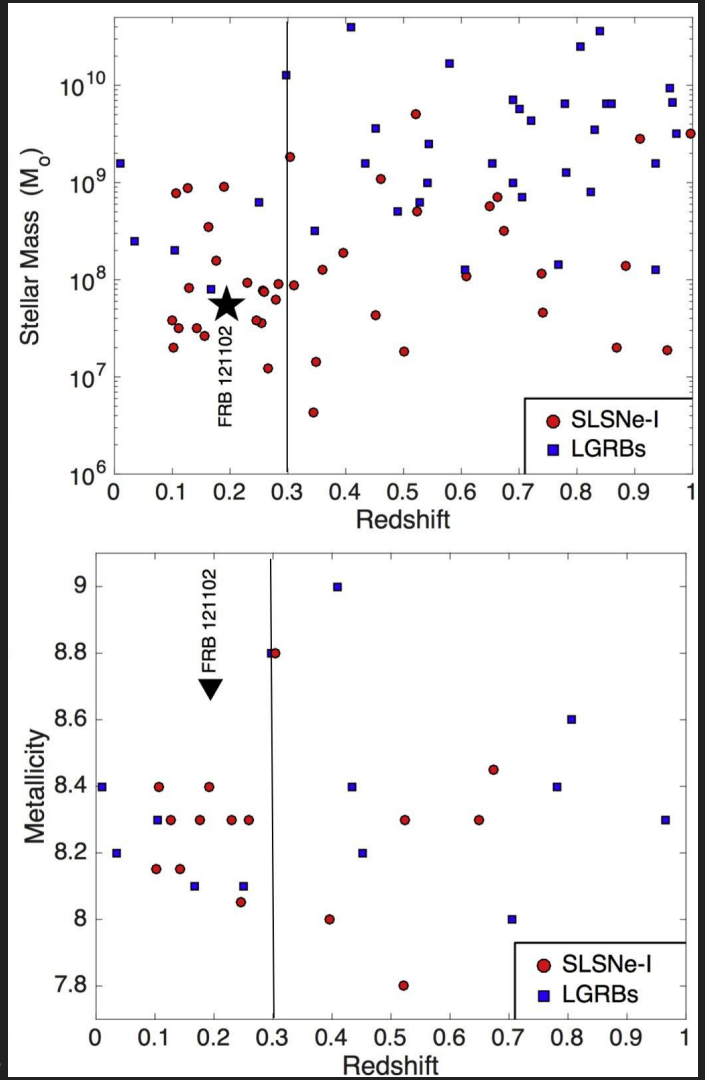
Brian D. Metzger[1], Edo Berger[2], and Ben Margalit[1]

- LGRBs
  - > 2 s
  - Core collapse of massive stars
- SLSN-I
  - H-poor
  - More luminous than SN

- Possibly powered by ms magnetars
- Low-mass/metallicity host galaxies
  - FRB121102 host galaxy

FRBs & LGRBs/SLSNe-I

- Burst mechanism
  - Release of magnetic energy
  - Similar to giant flares of Galactic magnetars
- Ejecta transparency
  - Free-free optical depth
  - Transparent after 9 yr @ 1.4 GHz, 5 yr @ 6 GHz
- Event rates
  - LGRB/SLSN-I factor of 10-100 lower than FRB rate
  - FRB repeats
  - Compatible with birth-rate of FRB producing objects



Metzger, Berger, Margalit, 2017, ApJ 841 14

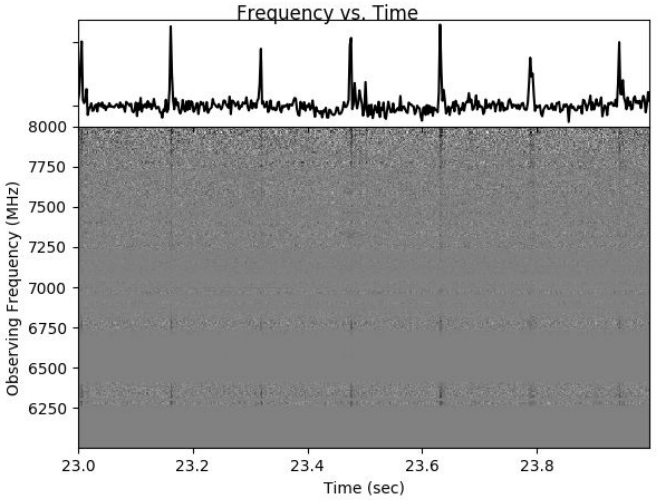
FRBs & LGRBs/SLSNe-I - Observations

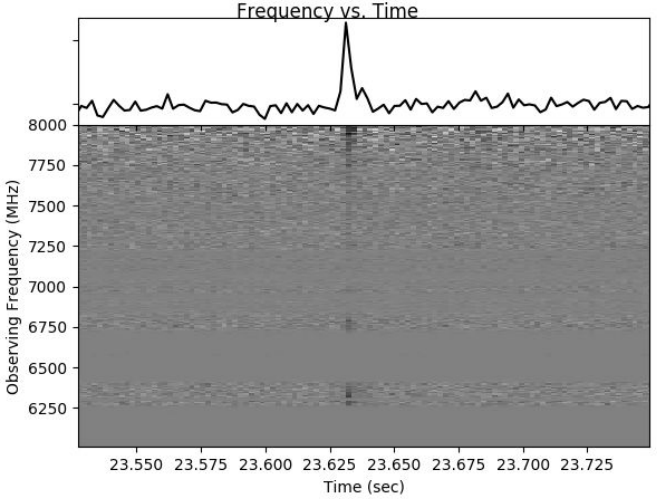
- C+ receiver at Effelsberg
  - 5.3-9.3 GHz
  - Transparent ejecta
  - Scintillation transition @ 6 GHz
  - Negligible DM smearing
- 72 hours
- 9 sources
  - > 5 years
  - $z < 0.4$
  - Outside Arecibo FOV

- Data specs
  - ROACH2 backends
  - Two 2 GHz filterbanks
  - 2048 channels/filterbank
  - ~1 Mhz channel bandwidth
  - 131 μs sample time

FRBs & LGRBs/SLSNe-I

- Obs 1
  - June 2017
  - 5 sources
  - 1 hour each
  - Single pulse search, no bursts detected
- Obs 2
  - Nov 2017
  - 7 sources
  - 2 hours each
  - 1.5 hour on repeater
  - No bursts detected
- Future obs
  - TBD





B0355+54, dedispersed at 57 pc cm-3

Phased Array Feed @ Effelsberg

Collaboration

MPIfR

CSIRO CASS

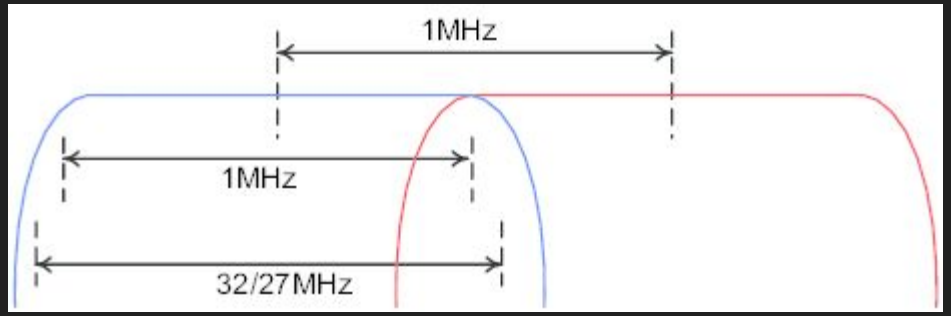
University of Manchester

Phased Array Feed @ Effelsberg

- Modified ASKAP PAF
  - Primary focus
  - Dense array of antenna elements
  - 188 element checkerboard
  - Combine output to form beams
  - 336 MHz bandwidth
  - Dual polarization
  - Three frequency bands
    - 892 MHz
    - 1308 MHz
    - 1525 MHz

PAF @ Effelsberg

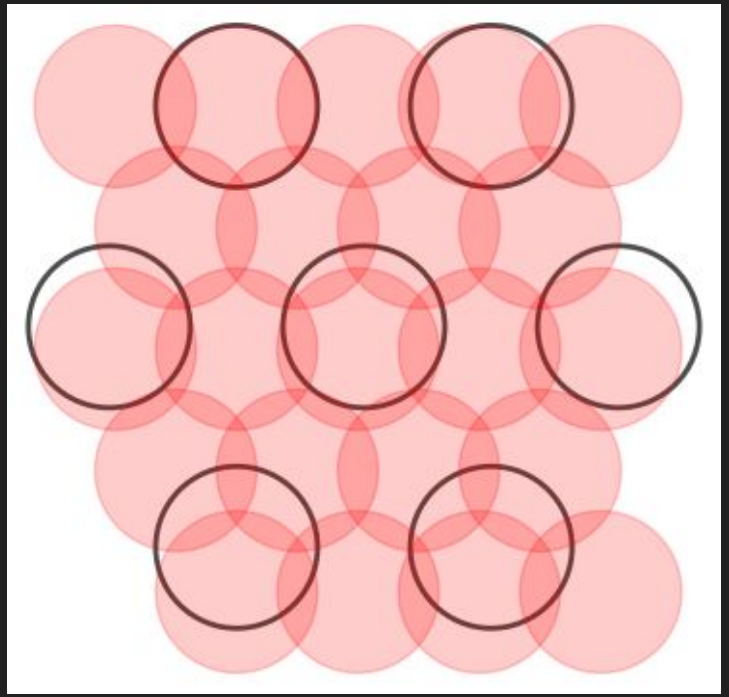
- Technical info
  - 32/27 oversampling PFB
  - Synthesis filterbank
  - 54 μs sampling (binned power)
  - 512 channels
  - Real-time Heimdall
  - Transient Buffer
  - 18 beam capability
  - Plan to scale up to 27 beams



Tuthill et al., 2012, 1067-1070. 10.1109/ICEAA.2012.6328788.

PAF @ Effelsberg

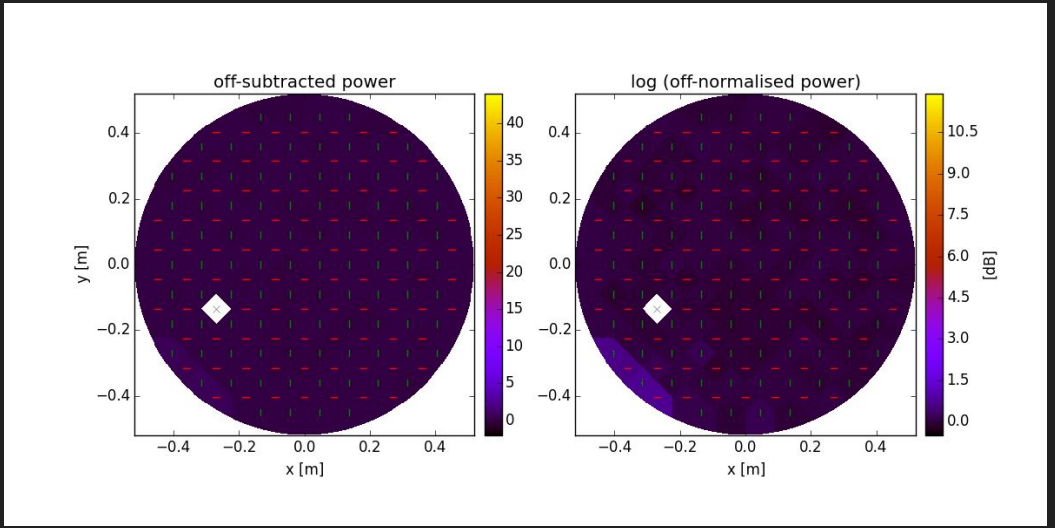
- Advantages of PAF
  - Beamforming
    - Close packed pattern for better localization
    - Spaced pattern for faster survey speeds
  - Large FOV
- Disadvantage
  - Higher Tsys



Red: PAF 22 beam close packed pattern
Black: 7 beam pattern

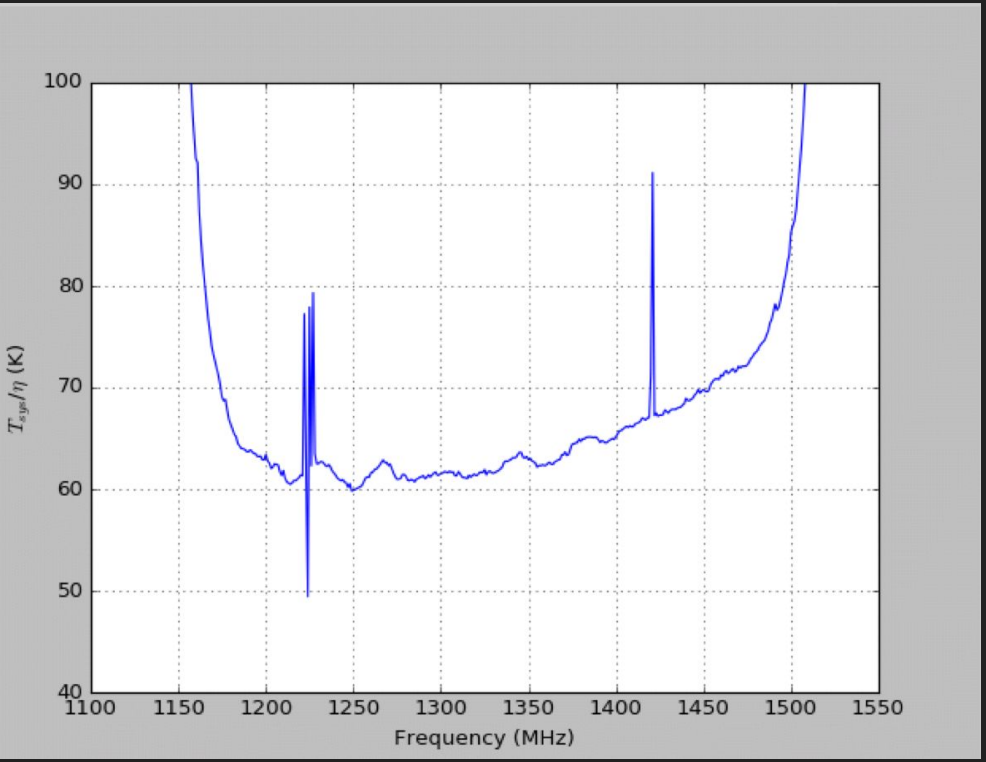
PAF observations

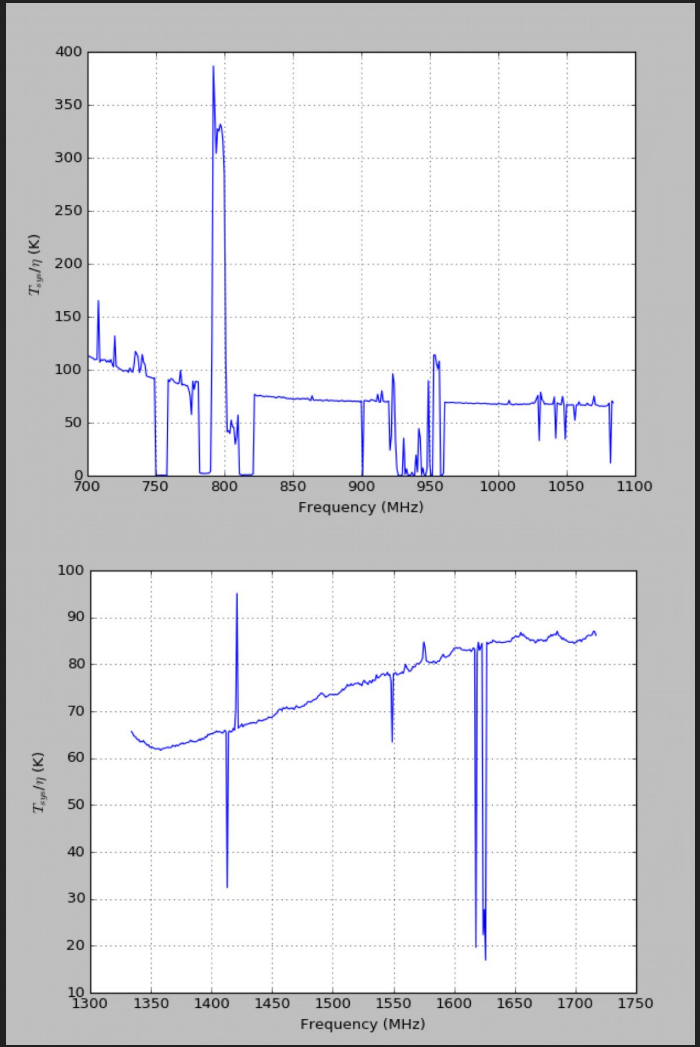
- 3 commissioning runs
  - August 2017
  - December 2017
  - January 2018
- Commissioning 1
  - Single beam pulsar observations
  - Band testing
- Commissioning 2
  - Multi-beam pulsar observations
  - Work out kinks with data transfer/data capture



Power distribution changes over the PAF as we move through an 11x11 raster scan across CasA.
Left: power, off-source power on a linear scale
Right: log(power, off-source power) in dB

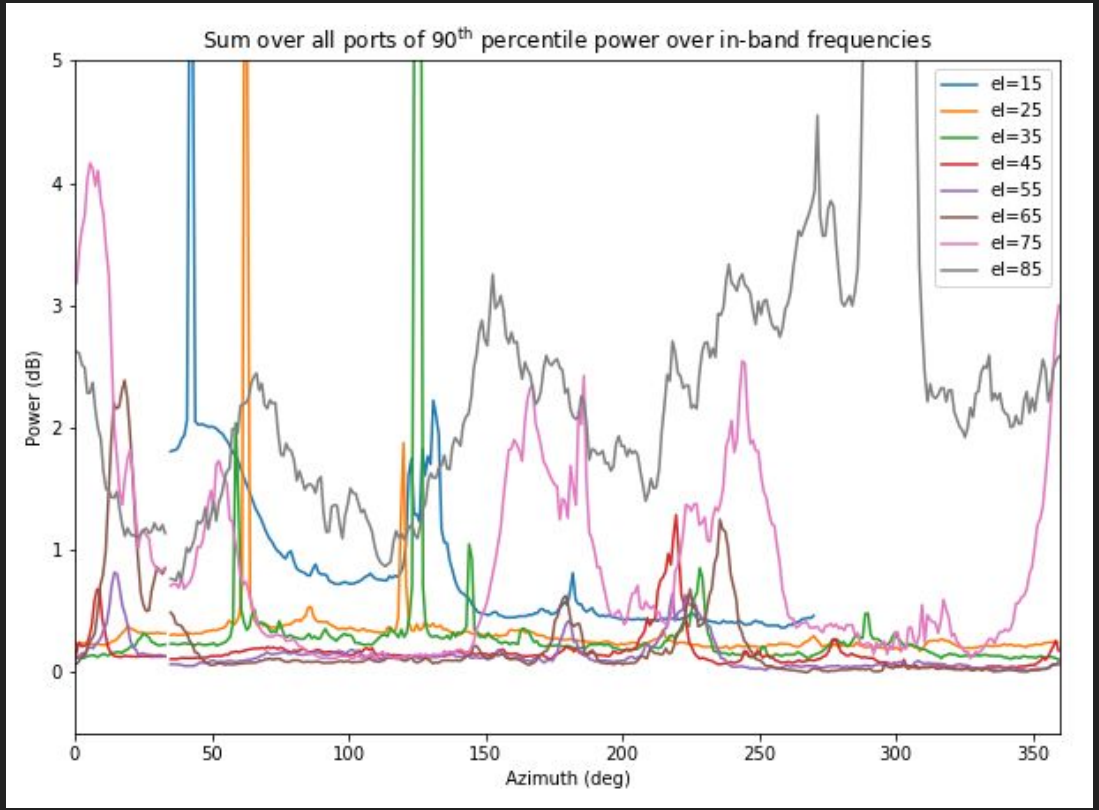
Tsys vs freq


100
90
80
70
60
50
40
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
T_{sys}/η (K)
Frequency (MHz)


400
350
300
250
200
150
100
50
0
700
750
800
850
900
950
1000
1050
1100
T_{sys}/η (K)
Frequency (MHz)
100
90
80
70
60
50
40
30
20
10
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
T_{sys}/η (K)
Frequency (MHz)

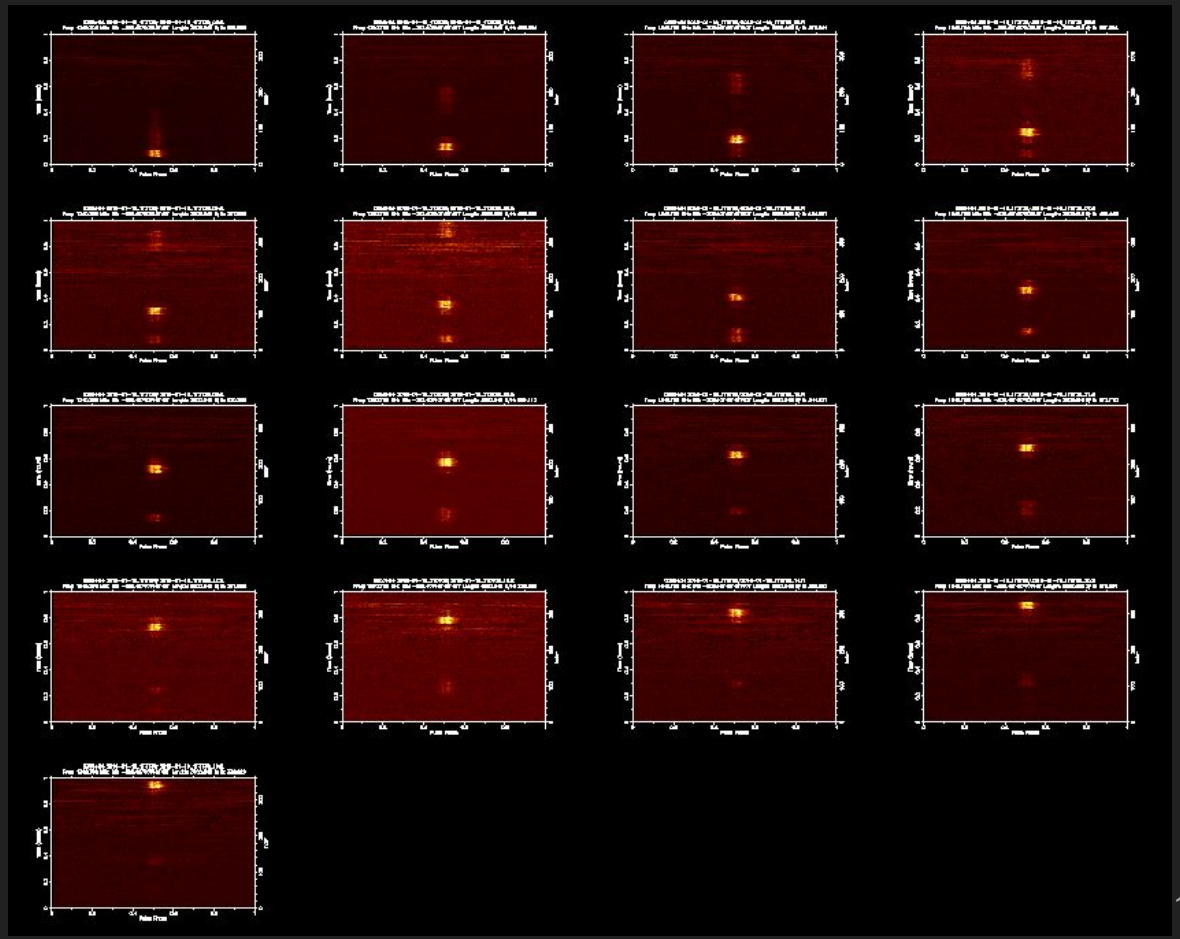
RFI vs azimuth and elevation

- 25-65° optimal elevation range



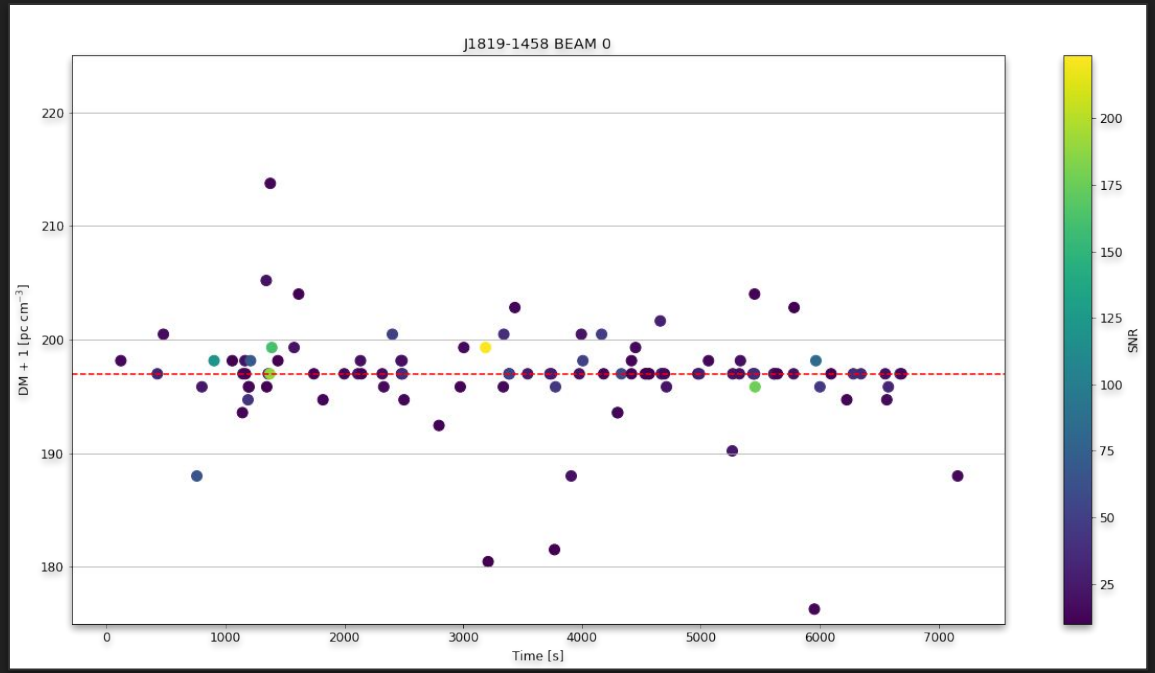
PSR J0358+5413

- Pulsar cycled through each beam
- Phase vs time
- 2 min per beam



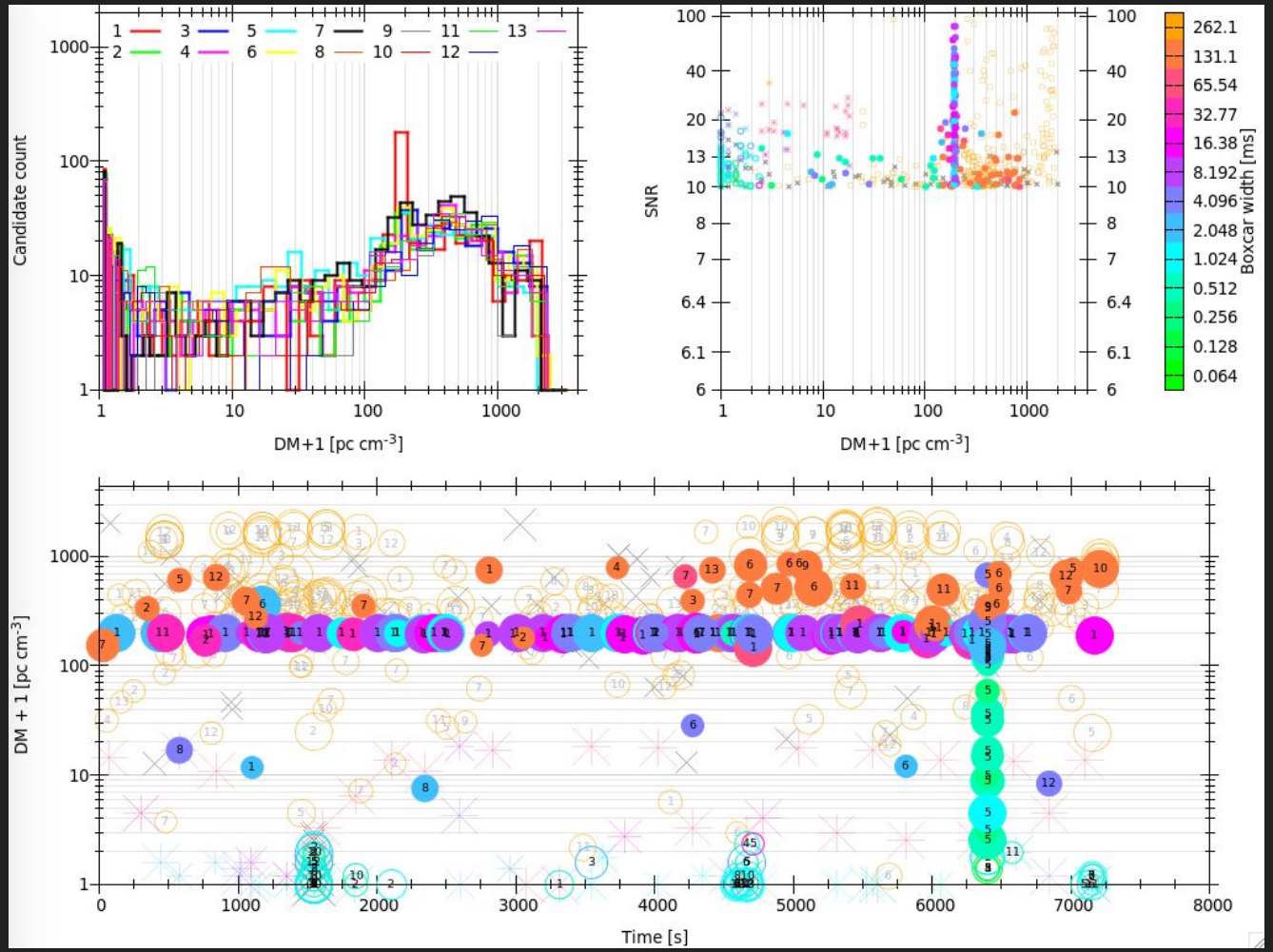
PAF observations

- Commissioning 3
  - Multi-beam FRB observations
    - FRB130729
      - 9 hrs
    - FRB110523
      - 18 hrs
    - FRB121102
      - 11 hrs
  - RRAT J1819-1458
    - P = 4.26 s
    - DM = 196 pc cm^{-3}
    - 2 hrs



J1819-1458

- 13 beams



Summary

- Known locations of LGRBs/SLSNe-I
  - CX band
  - No bursts detected yet
  - Plenty of observing time left
- PAF commissioning at Effelsberg
  - 18 beam capability
  - Pulsars
  - RRAT
    - Can detect FRBs
  - What will we do in the near future?
    - FRBs
      - Repeater observations
      - Blind FRB searches
    - Technical development

1 FRB per 22 days of obs