

Fast Radio Bursts with ASKAP

Dr. Shivani Bhandari
on behalf of CRAFT Collaboration

Research plus postdoctoral fellow
CSIRO/ATNF

MWSKY II
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The Australian SKA Pathfinder (ASKAP)

- 36 antennas, each 12m in diameter.
- Frequency coverage: 700 MHz to 1.8 GHz
- 300 MHz instantaneous bandwidth
- 36 independent beams
- 30 square degree field-of-view at 1.4 GHz
- 6 km maximum baseline

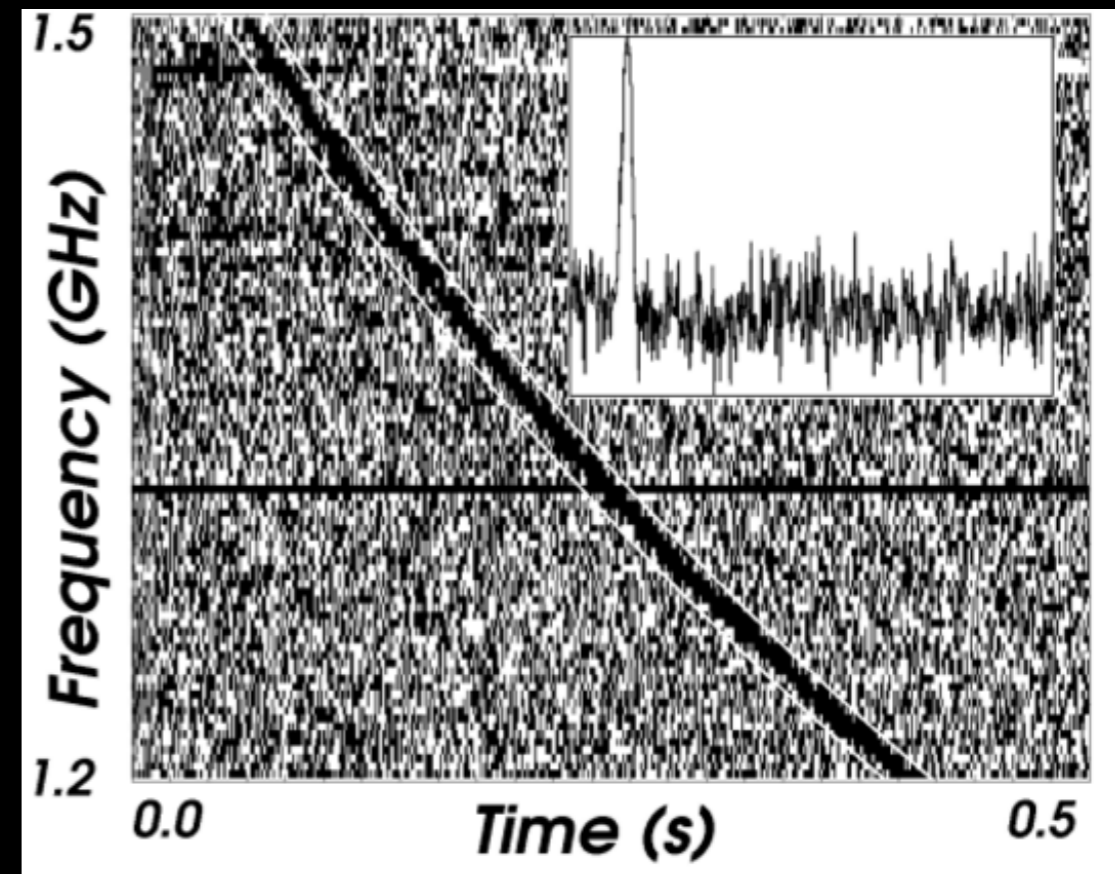


The Commensal Real-Time ASKAP Fast Transients (CRAFT)

Fast Radio Bursts

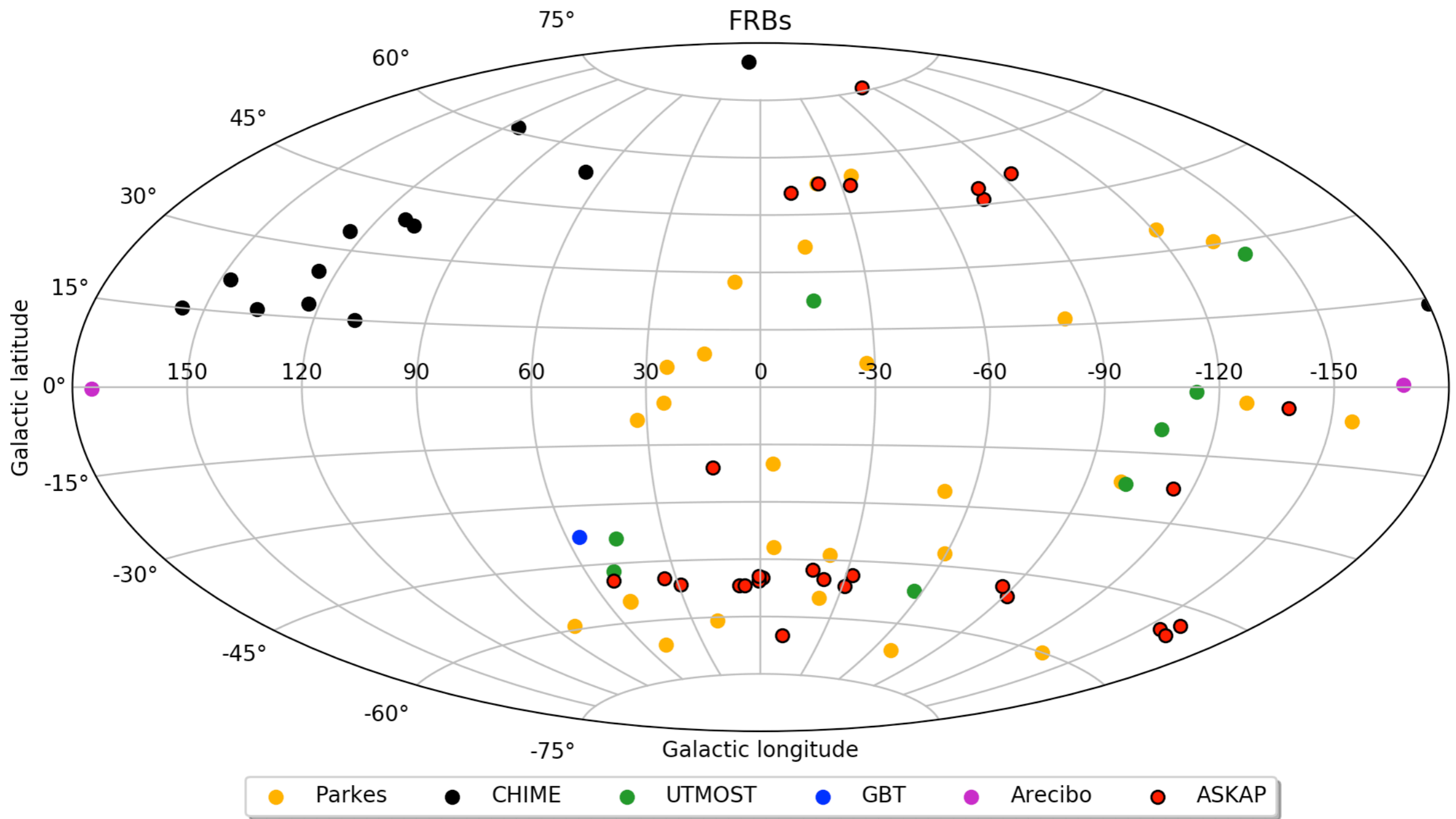
What do we know about FRBs?

- Bright (few to ~ 400 Jyms) millisecond duration pulses of coherent ($T_b > 10^{35}$ K) emission
- Observed DMs $>$ Galactic DMs
- Observed high DMs (~ 100 to 2600 pc/cc) correspond to high inferred redshifts.
- 50+ progenitor theories (frbtheorycat)



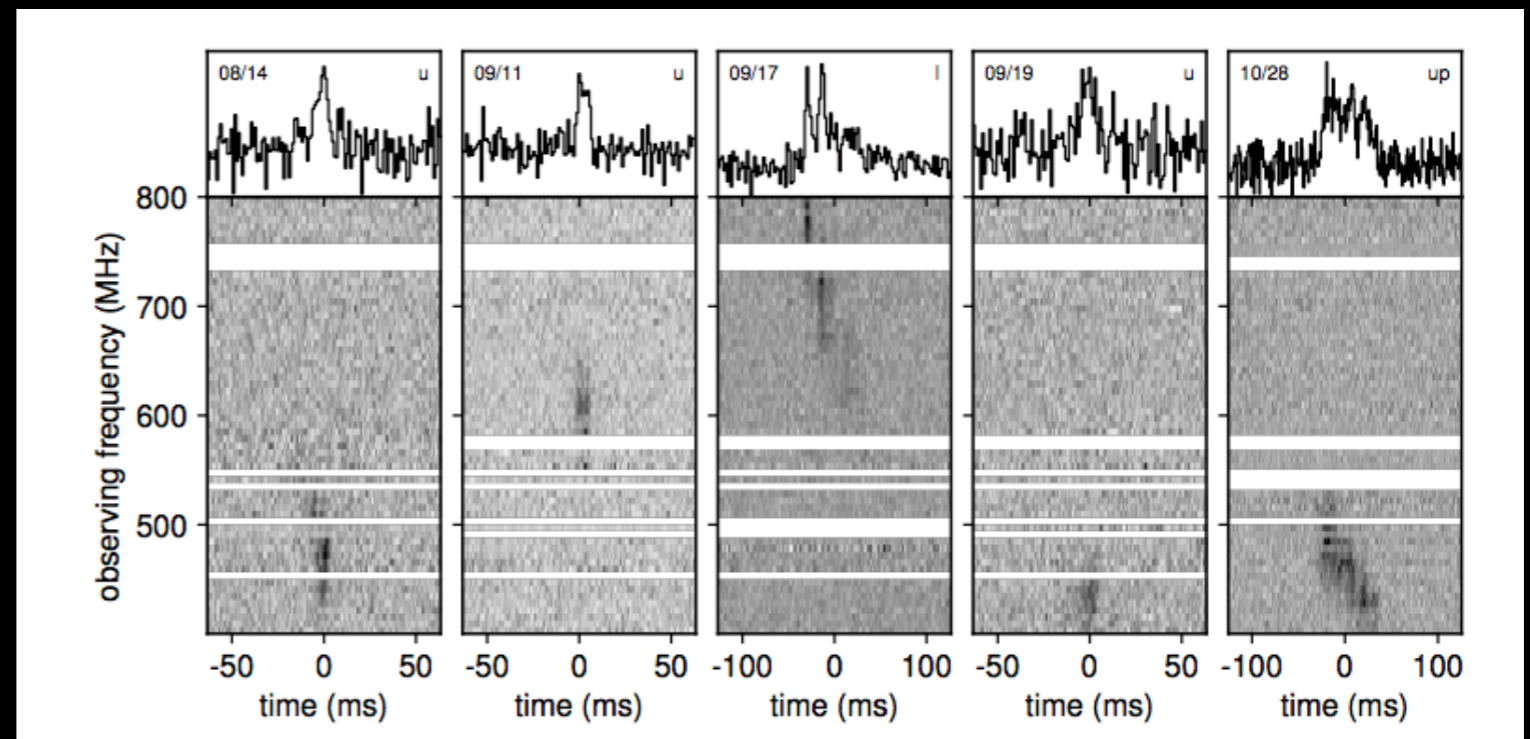
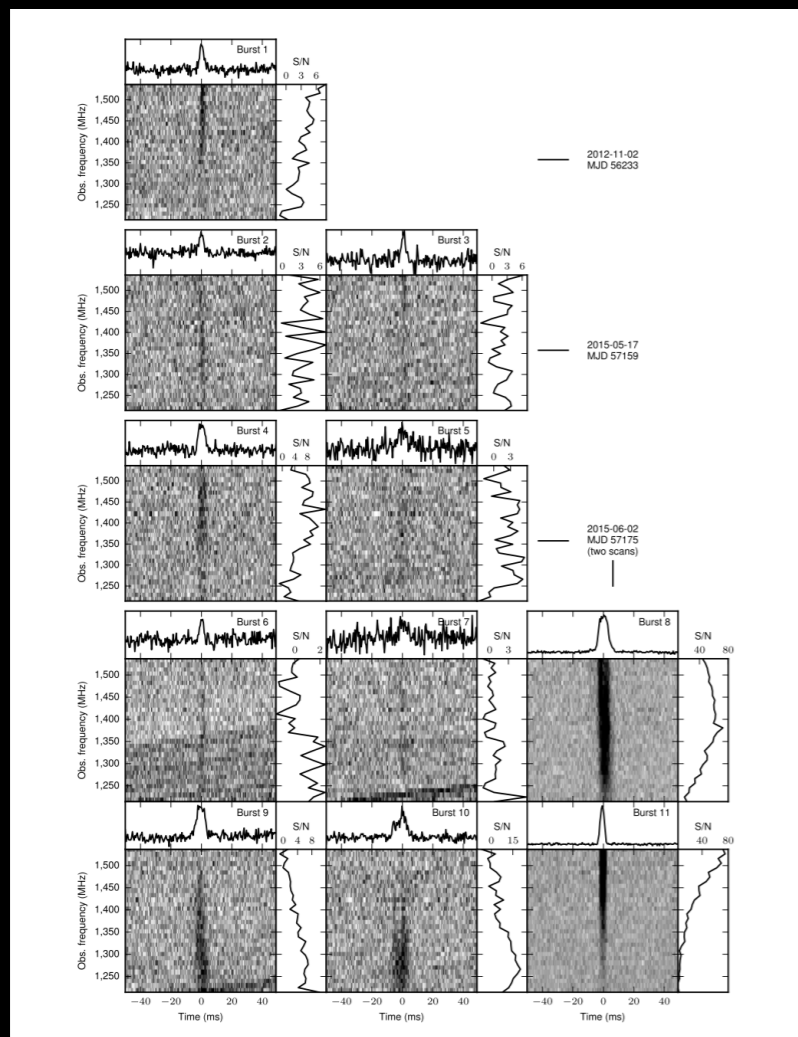
Lorimer et al, 2007

FRB Sky Distribution



80+ FRBs

The repeating FRBs



FRB 180814.J0422+73
(The CHIME collaboration)

R1: FRB 121102 (Spitler et al 2016)

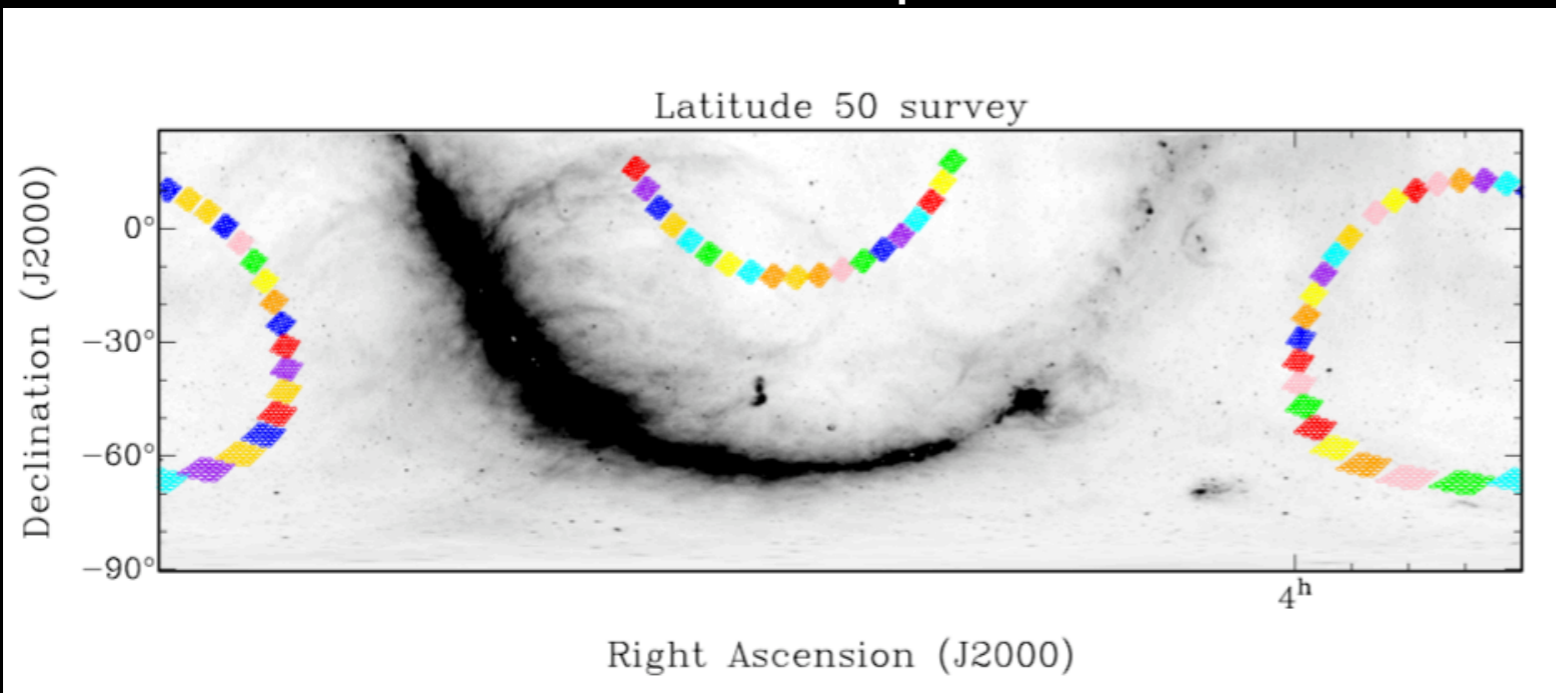
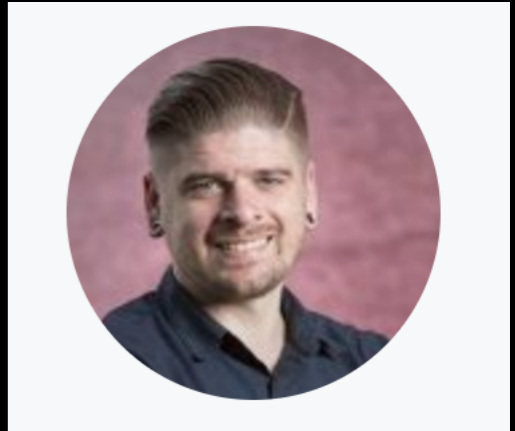
- Direct FRB localisation co-located with persistent radio source.
- Host galaxy is a dwarf (!)

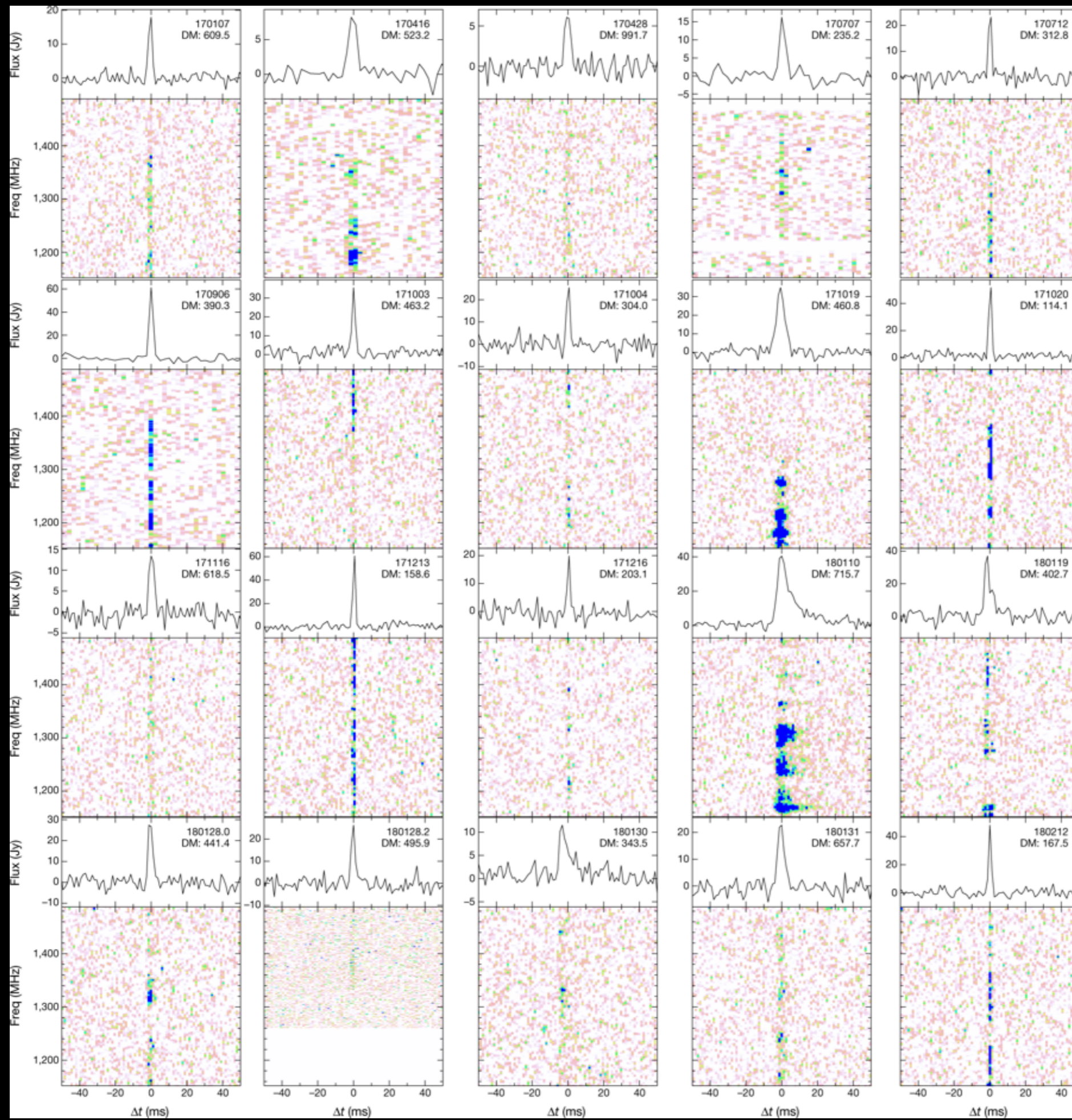
(Chatterjee et al 2017, Tendulkar et al 2017).

The latitude-50 survey

Shannon et al, 2018

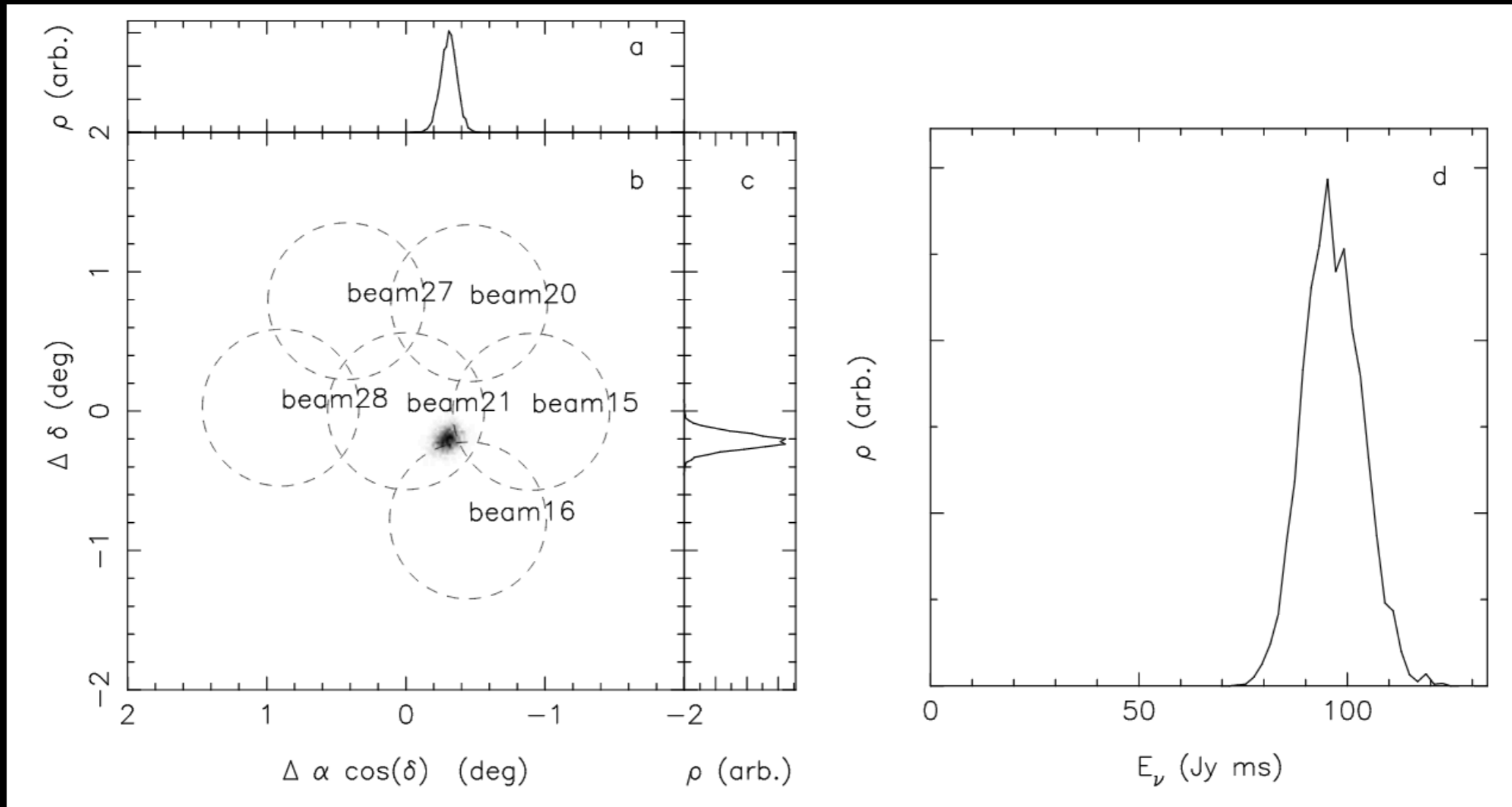
- Wide (exposure: $5.1 \times 10^5 \text{ deg}^2 \text{ hr}$) and shallow (26 Jy ms)
Fly's eye survey
- 20 FRBs detected
- Bright FRBs exist (34 - 420 Jy ms)
- Lower DM sample than detected by Parkes (114-991 pc cm^{-3})
- No evidence for repetition



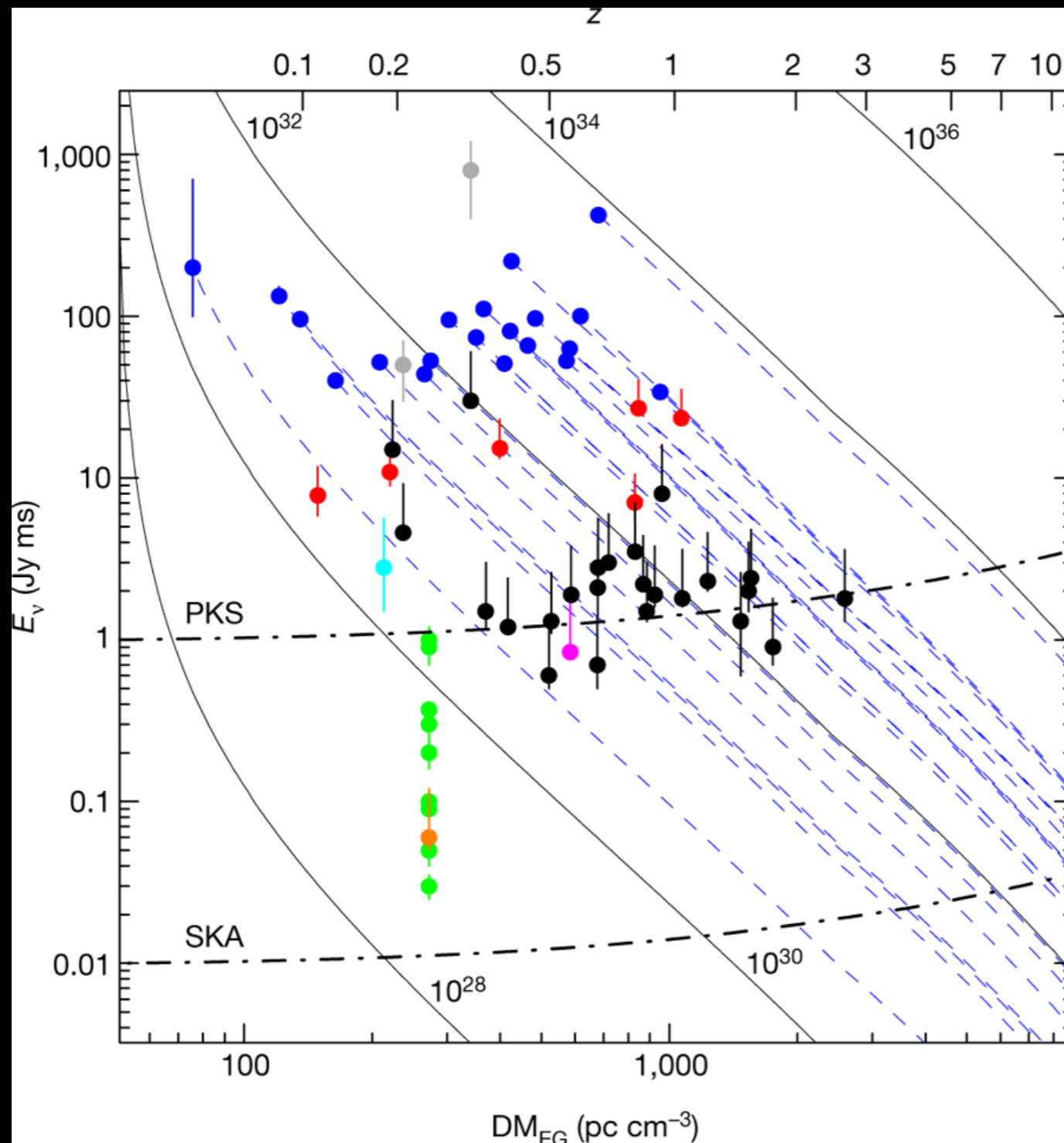


ASKAP FRB GALLERY

10' Localisations



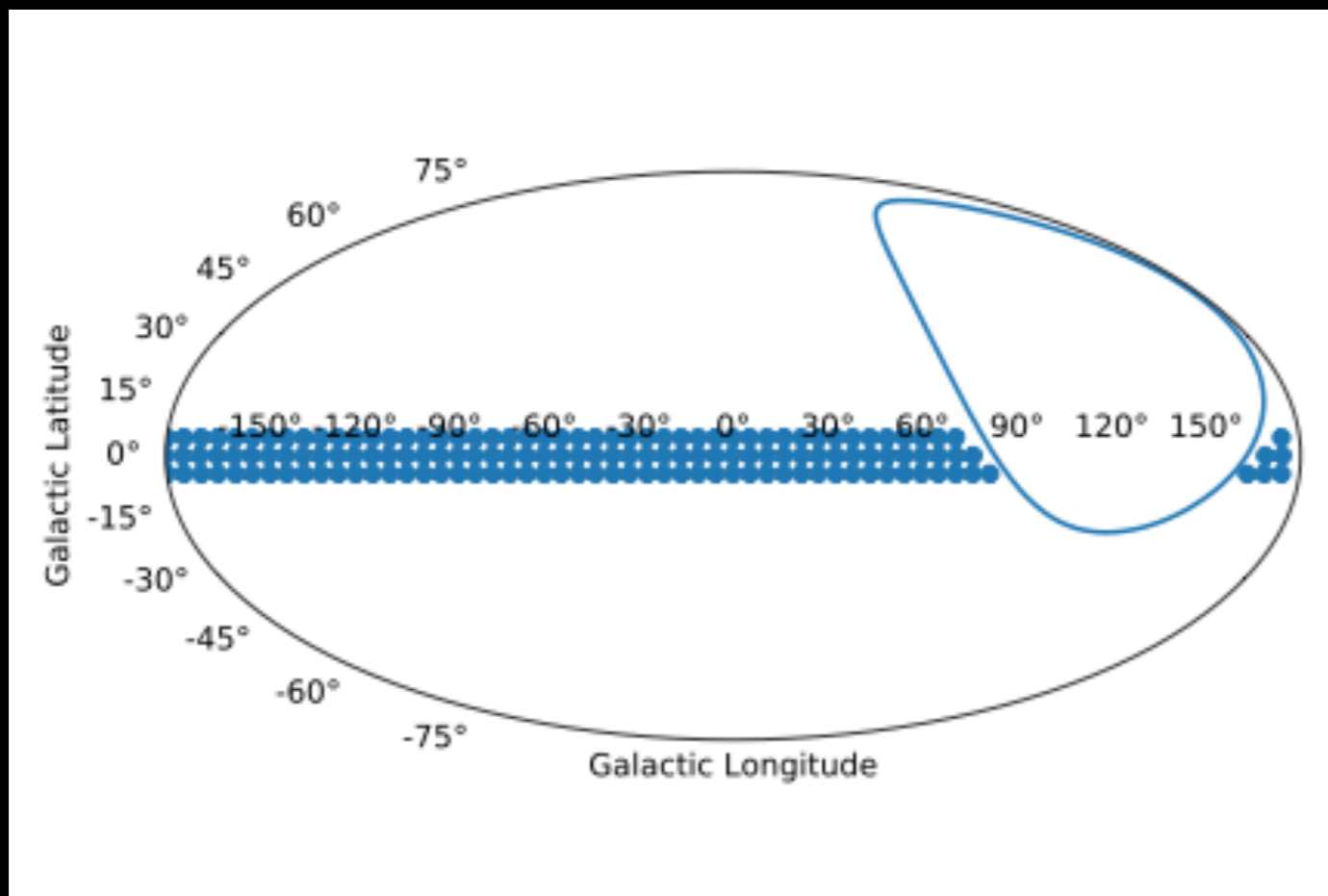
Dispersion-Brightness Relation



The high-fluence bursts are the nearby analogues to the more distant events found in the higher-sensitivity, narrower-field surveys.

Survey of the Galactic plane

Qiu et al (In press, MNRAS)

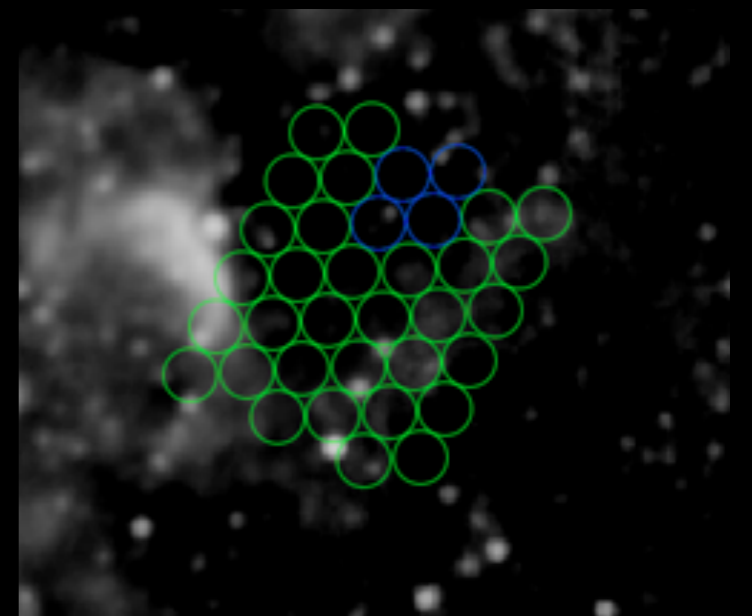
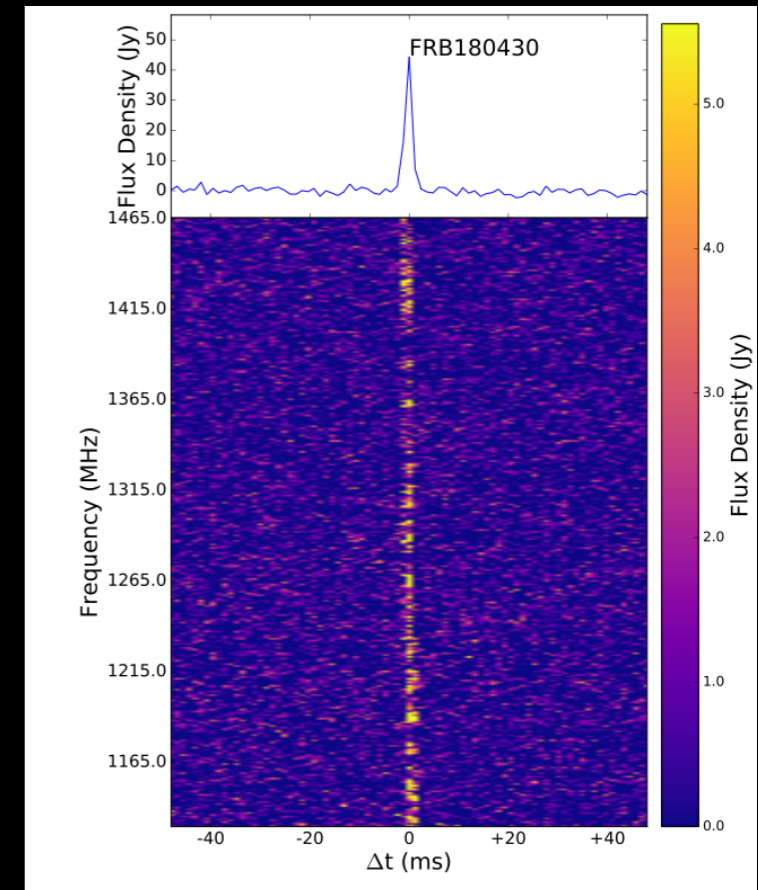


- 8 antennas, 36 beams
- Goal: To find pulsars and RRATs
- Single beam width: 0.9 deg
- 4,800 deg²
- Exposure of 10 hrs/pointing
- 160 pointings
- Total Coverage: 3.6e4 deg²h
- Discovery of FRB 180430
- No RRATs

Survey of the Galactic plane

Detection of FRB 180430

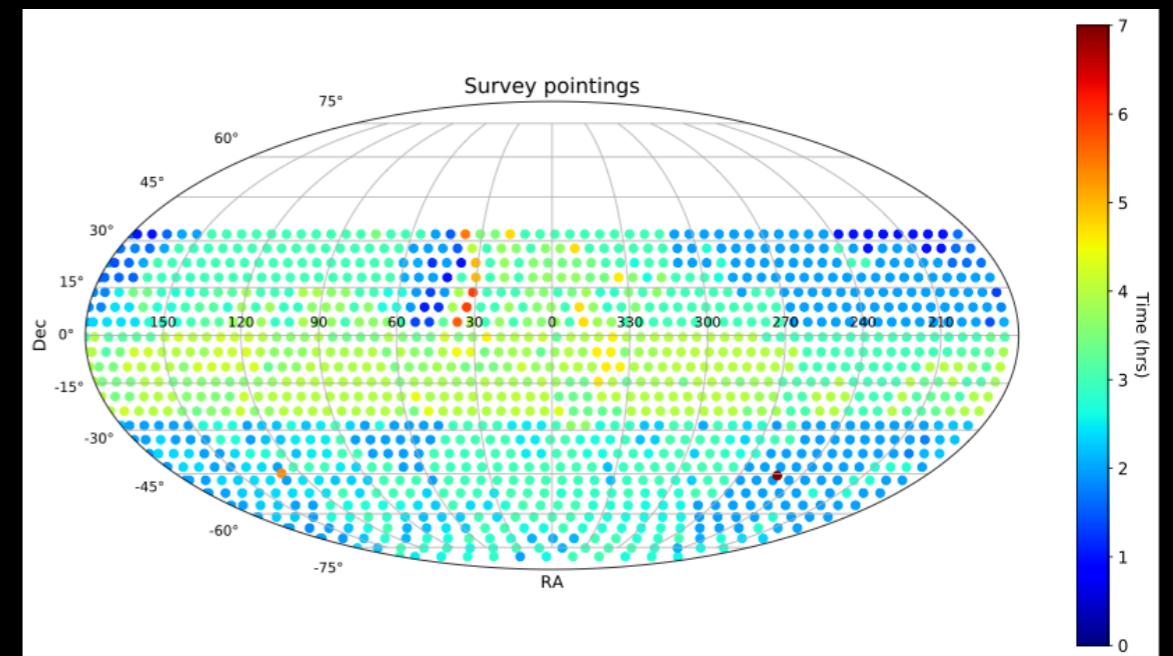
- Beam 17, S/N = 28.
- Galactic anti-centre ~ -5 deg
- DM: 264.1 pc cm^{-3}
- NE2001: 165 pc cm^{-3}
- YMW2016: 299 pc cm^{-3} at 50 kpc
- 2 pulsars within 10 deg radius, all DM ~ 100
- Repetition follow up
 - ASKAP Fly's Eye 7.2 Hrs after detection
 - 5.25 Hrs Parkes follow-up since June 5th 2018
- Periodicity Search in this observation (FFT)
 - No detection limit 0.06 Jy

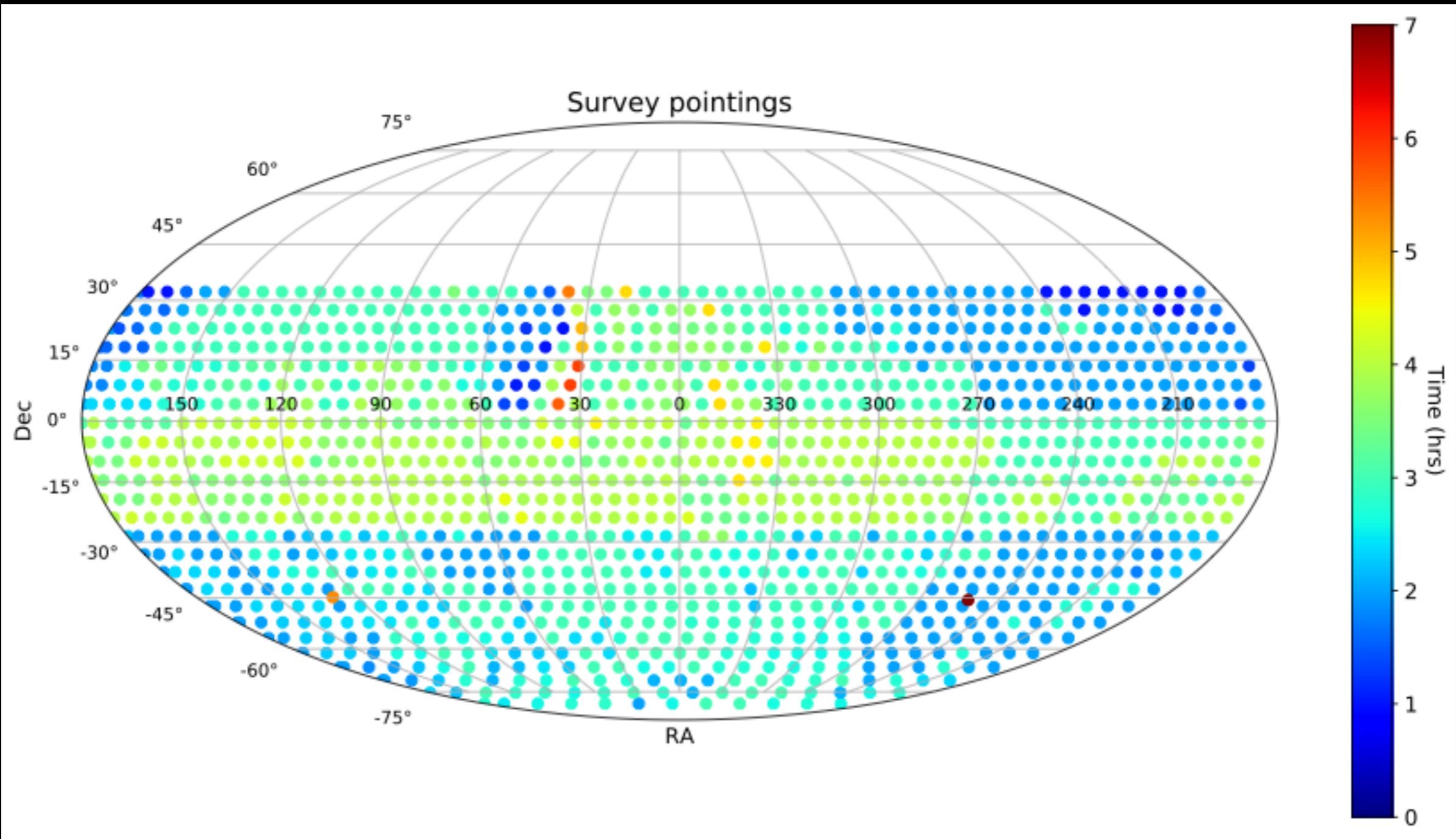


Southern sky search for repeating FRBs

Bhandari et al (In press, MNRAS)

- To search for bright and close repeating FRBs by re-observing the sky multiple times with different cadence.
- $\sim 30,000$ deg² of sky
- Exposure of 1 hr/pointing
- 1287 pointings
- 8 antennas
- 158 antenna-days

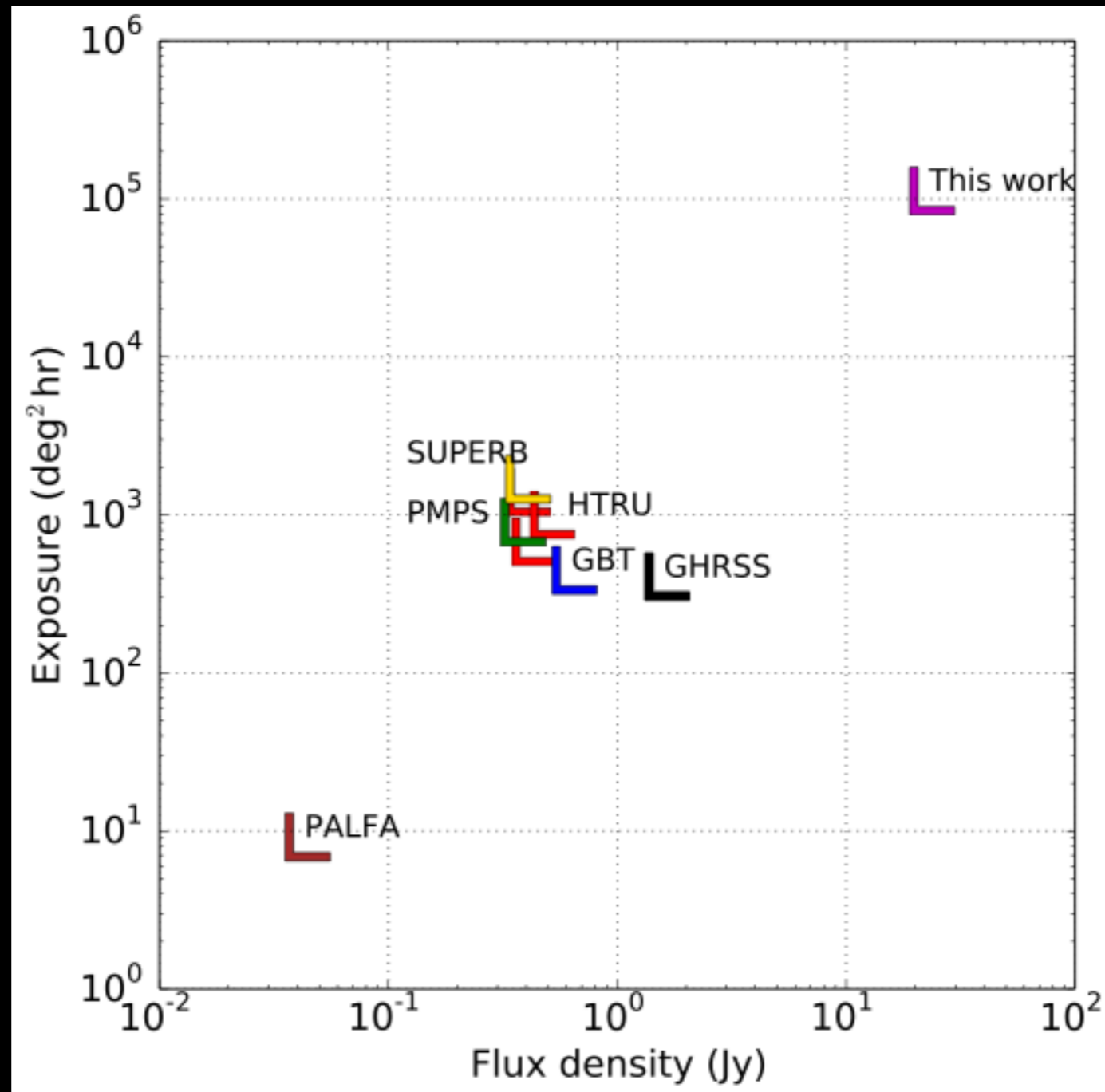




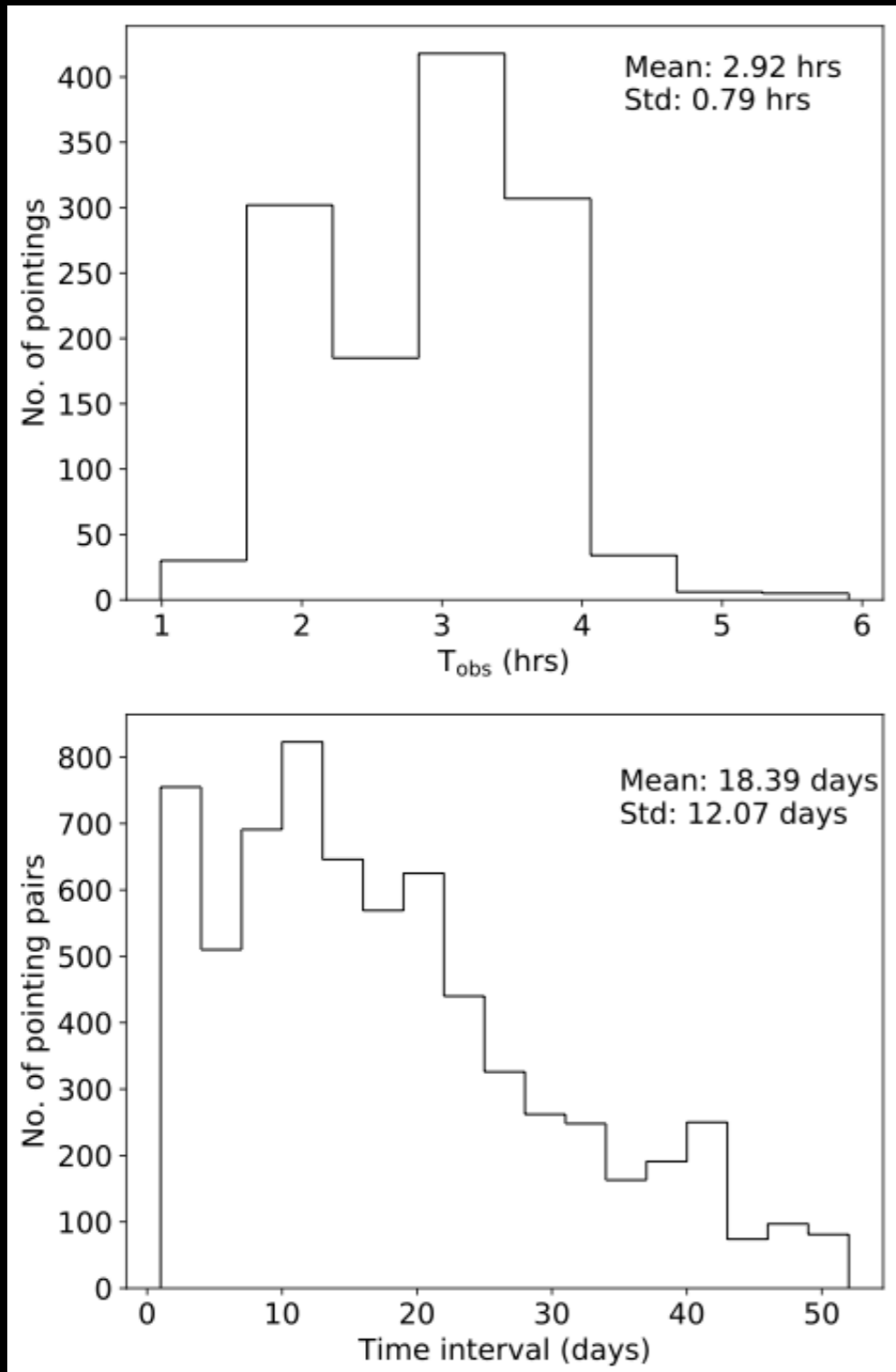
Three regions of declination
AS1: -80° to -30°
AS2: -30° to 0°
AS3: 0° to 30°

Southern sky search for repeating FRBs

The Phase Space



Southern sky search for repeating FRBs



Time spent on individual pointings

Mean ~ 3hrs

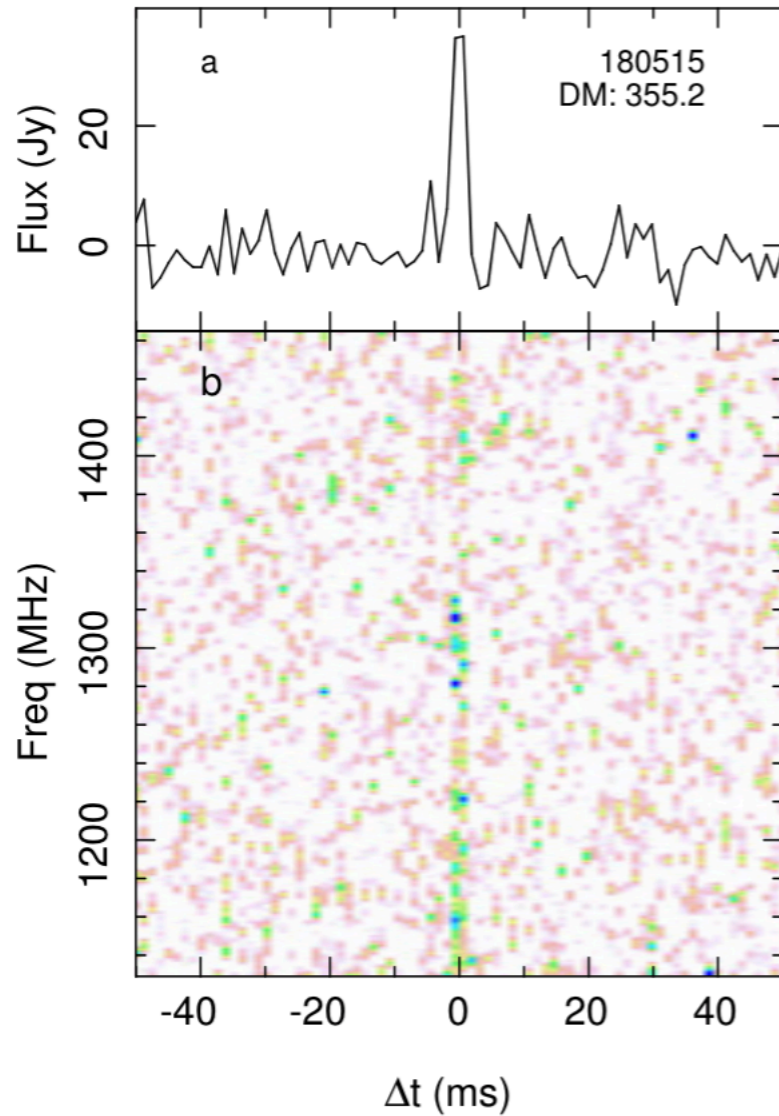
Cadence for observing the same pointing

Mean ~ 18 days

The repeating FRB 121102 is aperiodic and mostly clustered in time. It is active and dormant at times

Southern sky search for repeating FRBs

Detection of FRB180515



Measured Properties

Event time at 1.4 GHz UTC	2018-15-05 21:57:26.485
ASKAP beam	20
Beam centre (Ra, Dec) (J2000)	23:13:33.8, -42:11:51.3
FRB (Ra, Dec) (J2000)	23:13:12, -42:14:46
Localisation error	7' radius
Galactic coordinates (ℓ , b)	349.5°, -64.9°
Signal to noise ratio, (S/N)	12.1
Dispersion measure, DM (pc cm^{-3})	355.2(5)
Fitted width (ms)	1.9(4)
Scattering time (ms)	$< 0.38^{+0.10}_{-0.12}$
Measured fluence (Jy ms)	46(2)

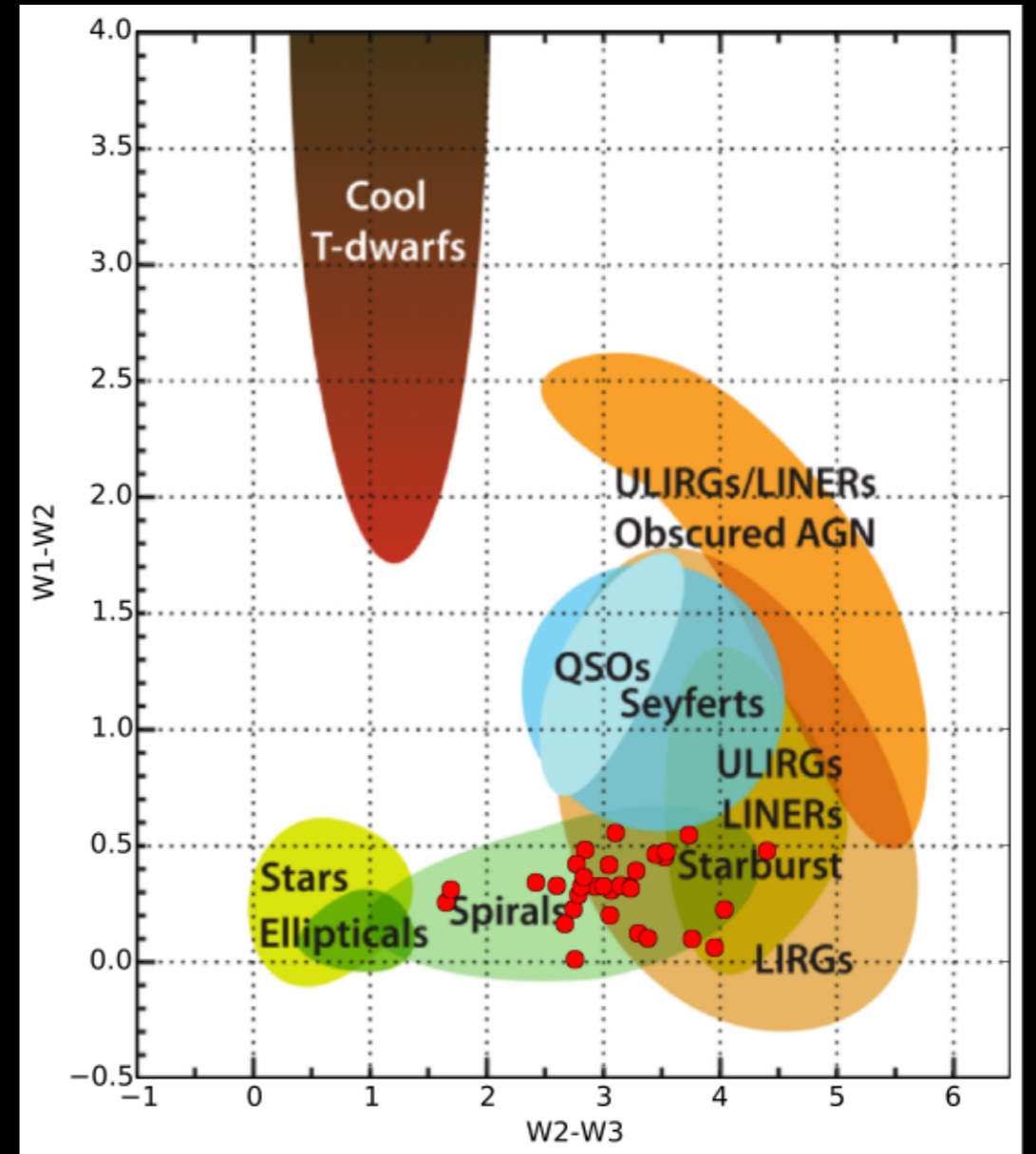
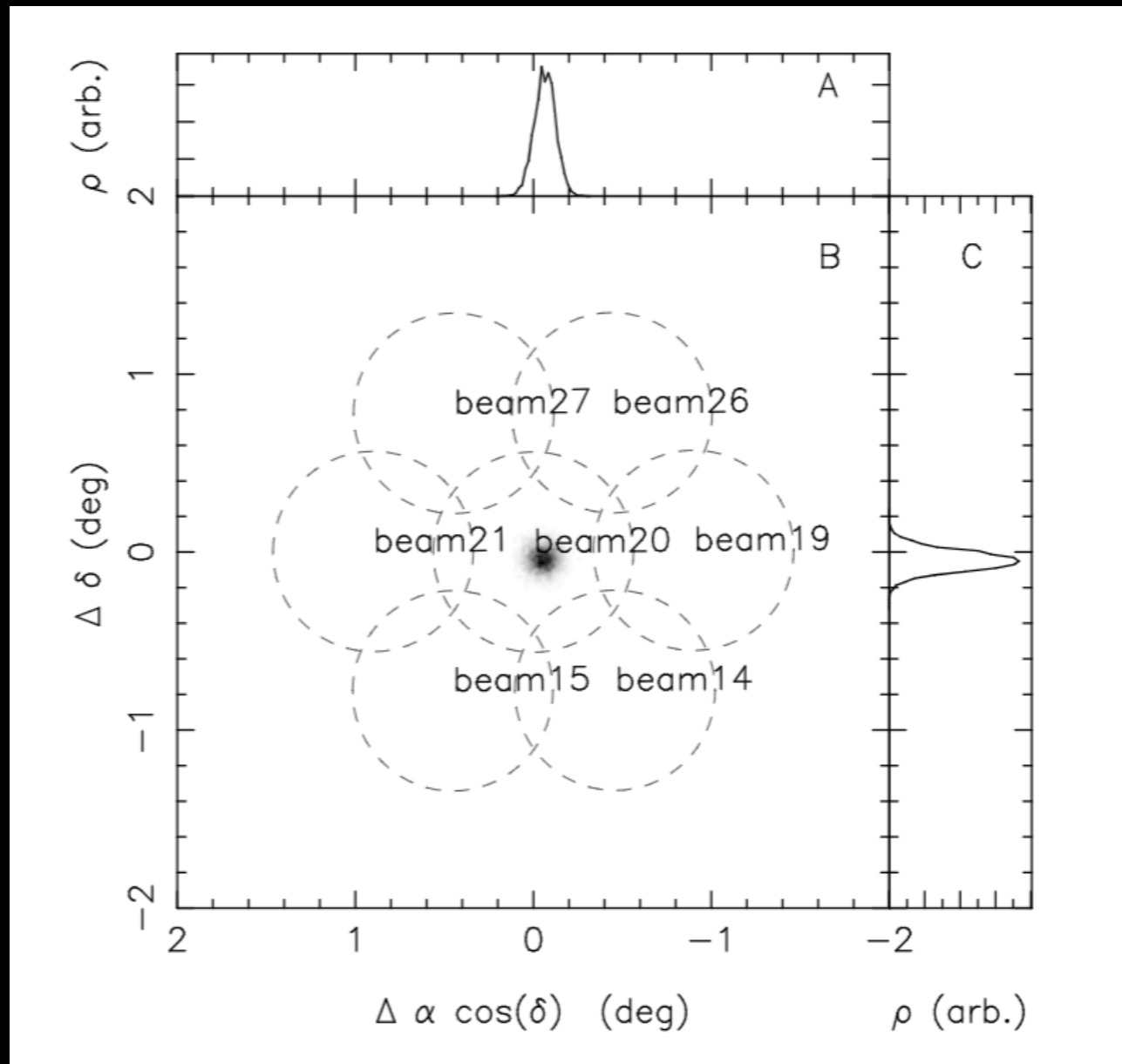
Model-dependent properties

DM _{NE2001} (pc cm^{-3})	~ 33
DM _{YWM16} (pc cm^{-3})	~ 19
Max. inferred z	0.2
Max. comoving distance (Gpc)	0.9
Max. luminosity distance (Gpc)	1.1
Max. isotropic energy (10^{33} J)	1.6

$$N_{\text{FRBs}} = 37 \times \frac{3 \text{ hrs}}{24 \text{ hrs}} \times \frac{30000 \text{ deg}^2}{41253 \text{ deg}^2} \sim 3 \text{ FRBs.}$$

Southern sky search for repeating FRBs

Detection of FRB180515



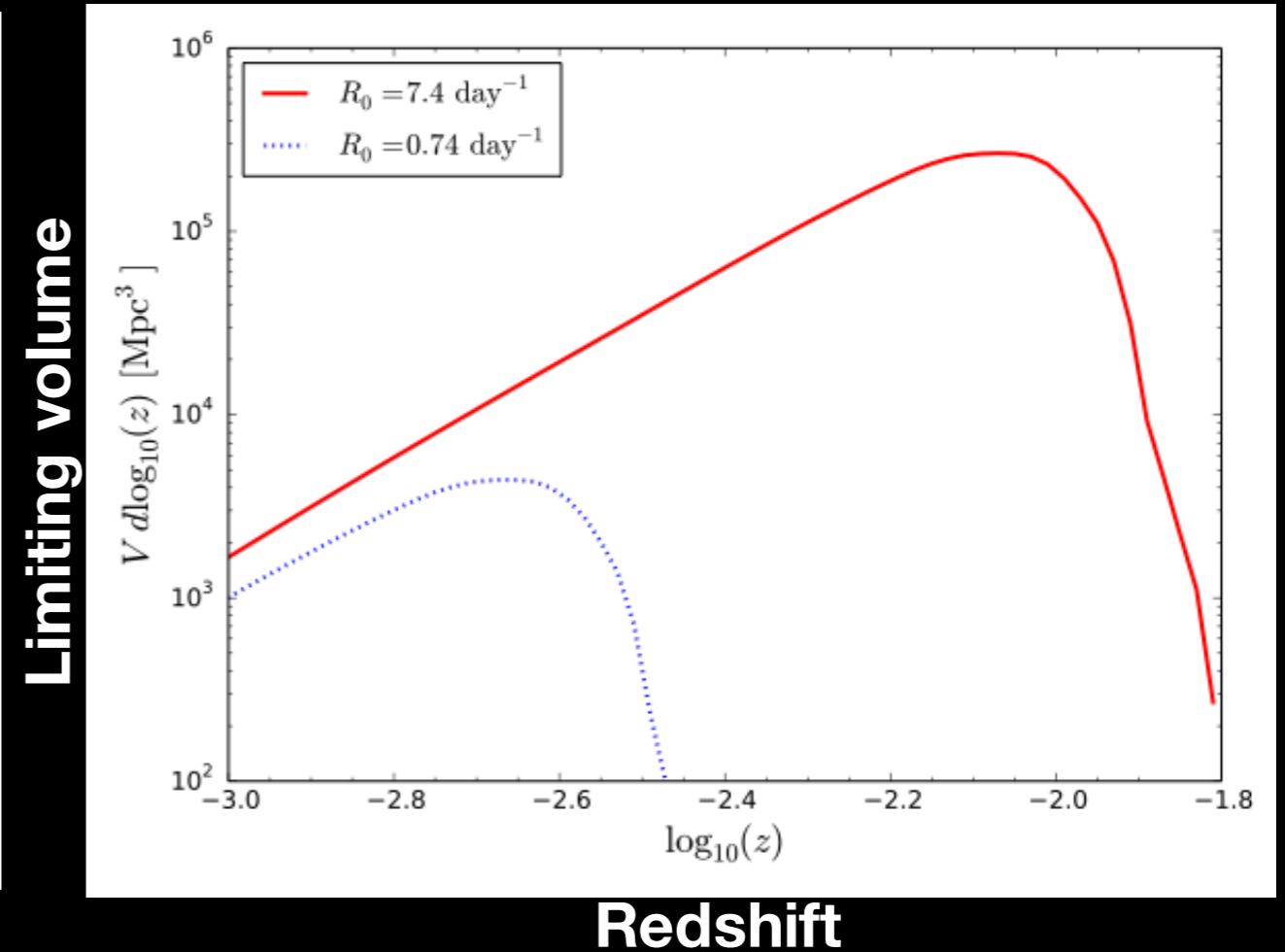
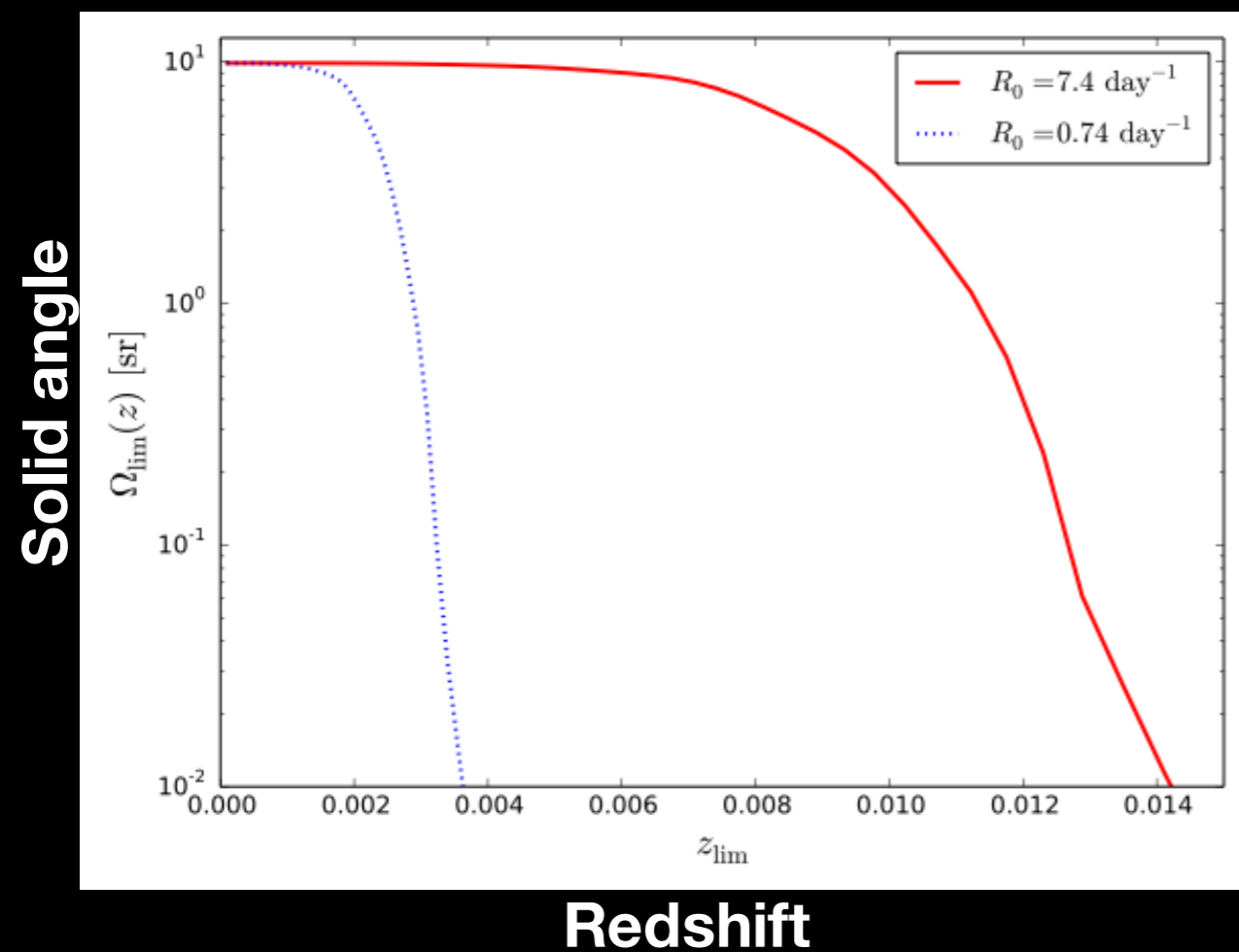
Bhandari et al (In press, MNRAS)

35 galaxies in
WISExSCOSPZ catalogue

Wright et al 2010

Southern sky search for repeating FRBs

- No repeating FRBs detected
- Exclude the presence of a repeating FRB with FRB 121102 like properties* closer than $z=0.004$, a volume of $9.4e4 \text{ Mpc}^3$ in whole surveyed sky.



* James et al, 2019

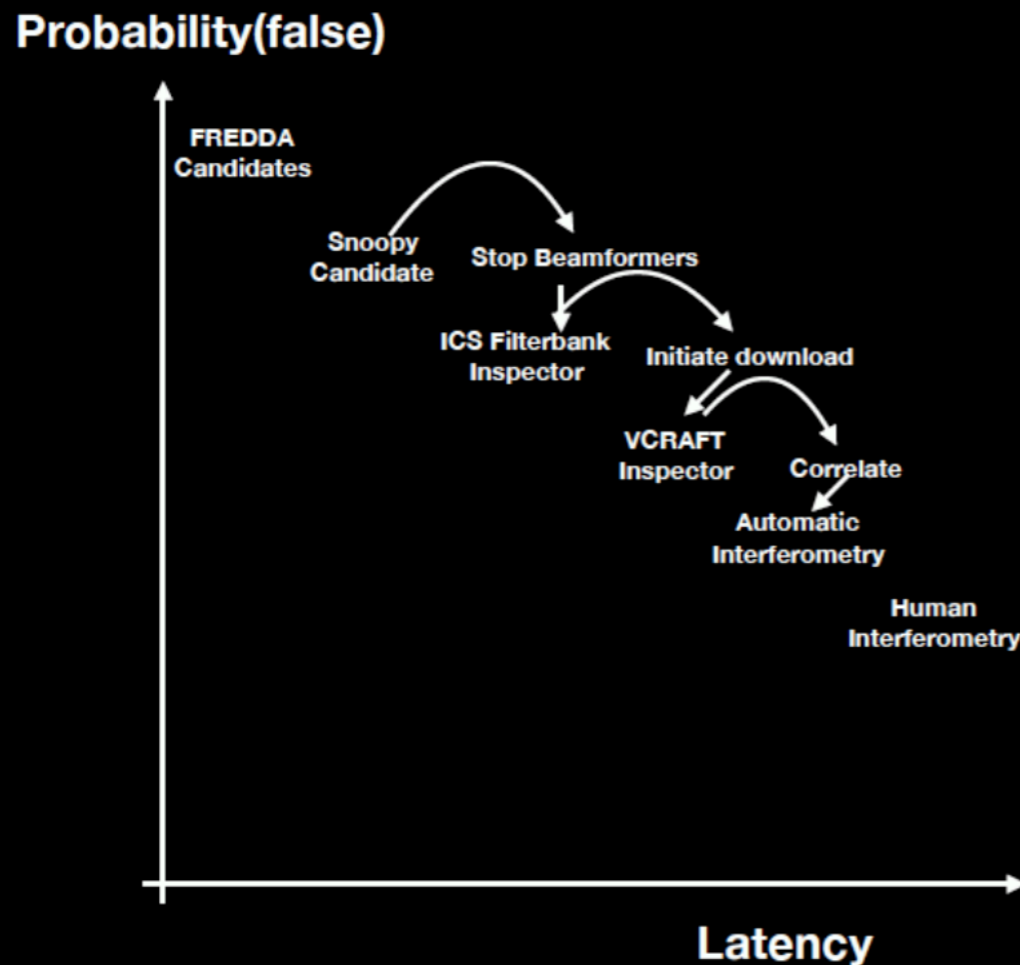
Real-time incoherent searches (ICS)



Real-time ICS

Ready to go!

- 28 antennas
- Morning: deep south pointings
- Evening: Latitude 50 pointings
- FREDDA real-time searches
- 3 seconds long voltage buffer
- Time resolution : 864 us
- Frequency resolution: 1 MHz



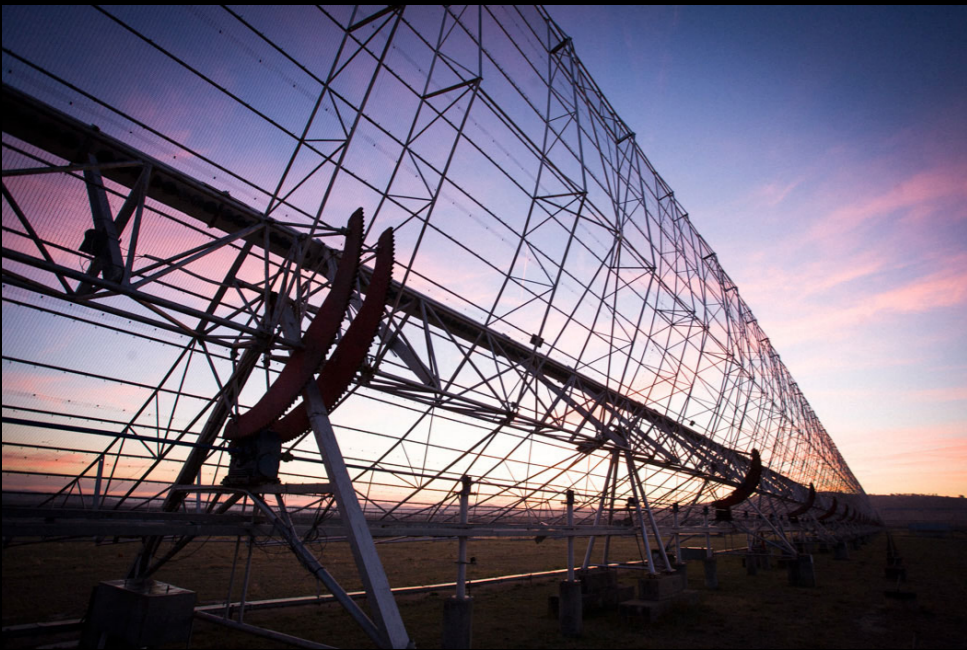
Array State	Band	Center Freq.	Zoom
ONLINE	1450MHz Filter	1320	18.5kHz

Subsystem State																																		
	1	6	12	18	24	30	36																											
SEL	/	/	/	/	/	/	/	X	X	L	/	/	/	/	/	L	/	/	X	X	X	X	/	/	/	X	/	/	L	/	X	/		
CMP	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
TRD	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
PAF	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
DRX	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
BMF	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█

	1	4	7								
TRD	█	█	█	█	█	█	█	█	█	█	█
COR	█	█	█	█	█	█	█	█	█	█	█

Legend	disconn.	IOC down	degraded	connected
	█	█	█	█
	█	lowpower	idle	loaded
	█	█	standby	online

The chase is underway !



UTMOST



PARKES



ATCA



KECK



GEMINI



VLT/MUSE

Future

Sending VO event triggers in 6-12 months

Beam position (~arcminutes localisation)



Automatic Interferometry (~arcsec localisation)



Human Interferometry (~subarcsec localisation)

Implementing coherent searches

Follow-up observations to look for prompt emissions

False positive rate: 1 event per hr

Thank you

CSIRO Space and Astronomy Science
Dr. Shivani Bhandari
Research Plus Postdoctoral Fellow
E: shivani.bhandari@csiro.au

