Microstructure revealed in FRB 170827

Presented by:

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Feb 14, 2018

SWINBURNE

CENTRE FOR ASTROPHYSICS AND SUPERCOMPUTING

Australian National University

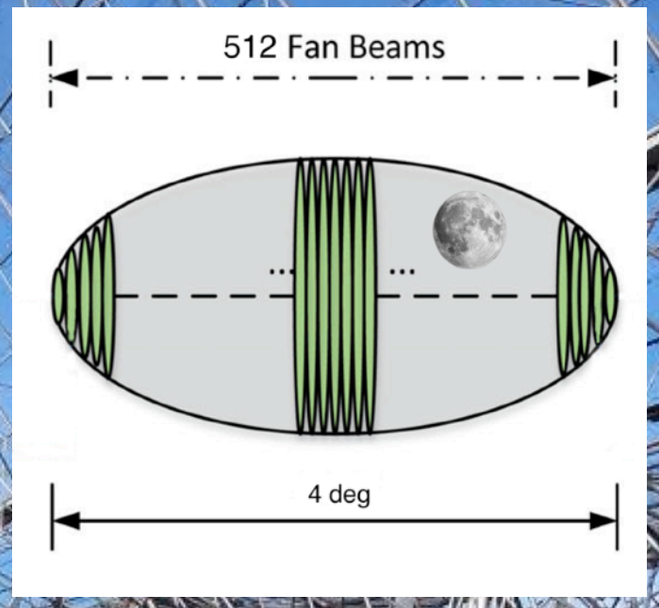
CSIRO

THE UNIVERSITY OF SYDNEY

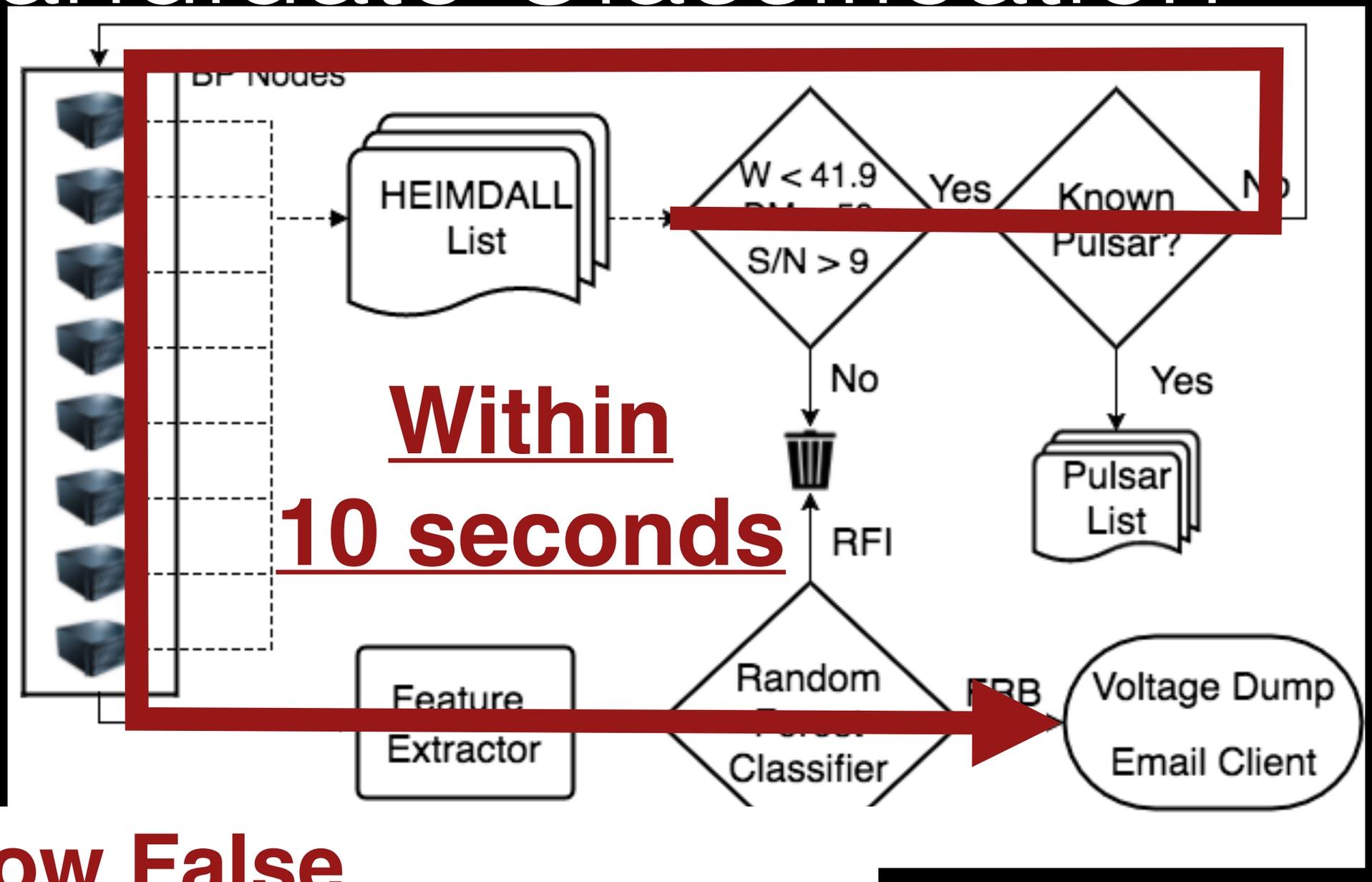
CAASTRO
ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

The Molonglo Telescope

- **Mills-Cross design (Only E-W currently functional)**
- **Collecting area: 18000 m²**
- **Field of view: 4.25x2.8 deg2**
- **45 arcsec x 1.4 degrees localisation**
- **Centre Frequency: 843 MHz**
- **Bandwidth: 31.25 MHz/320 channels**
- **Commensal science (FRB + Pulsars)**



Random Forest based Candidate Classification



Low False Candidate rate (~5/day)

Email Alert Within Seconds

UTMOST Transient Detector noreply@utmost.usyd.edu.au via swin.edu.au
to Wael, Christopher, bateman.tim, Stefan, vivekvenkris

31 Jan (13 days ago)

Transient Candidate

SNR	9.03
DM	61.57
Width	5.24 ms
Probability	0.821
Name	CAND 2018-01-30-22:18:44.7
UTC	2018-01-30-22:18:44.7

Observation

UTC START	2018-01-30-22:16:51
Beam	216
MD Offset	-0.642044444444444 degrees
RA Offset	-0.697881725475779 degrees
Total Beams	352
PID	P003
Voltage Dump	false

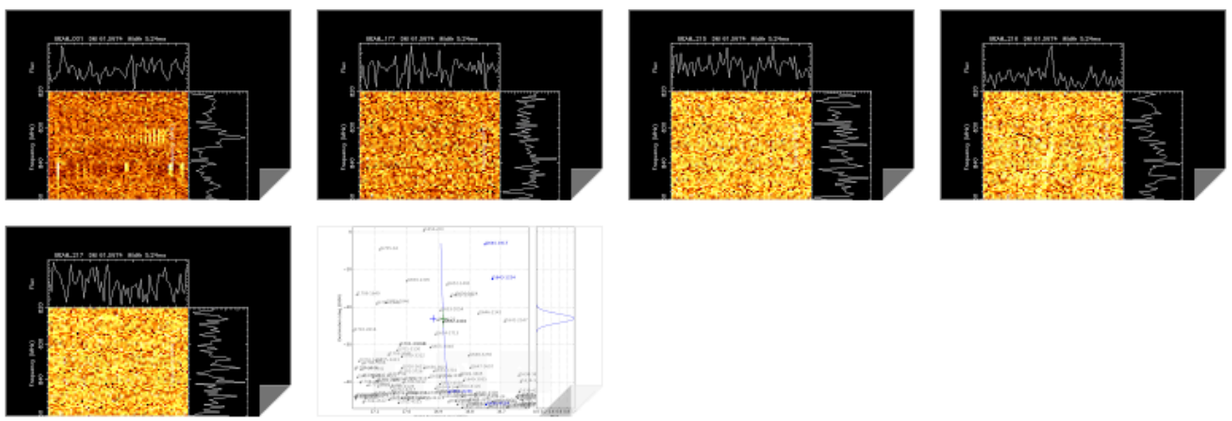
Boresight Properties

SOURCE	FRBTransit_1
LST	16:56:49.1075
DELAY TRACKING	false
BORESIGHT RA	16:56:49.1

Candidate Position Properties

RA	16:54:01.6
DEC	-23:04:31.19
GI	358.270214206
Gb	12.8638583923
NE2001 DM	180.6329

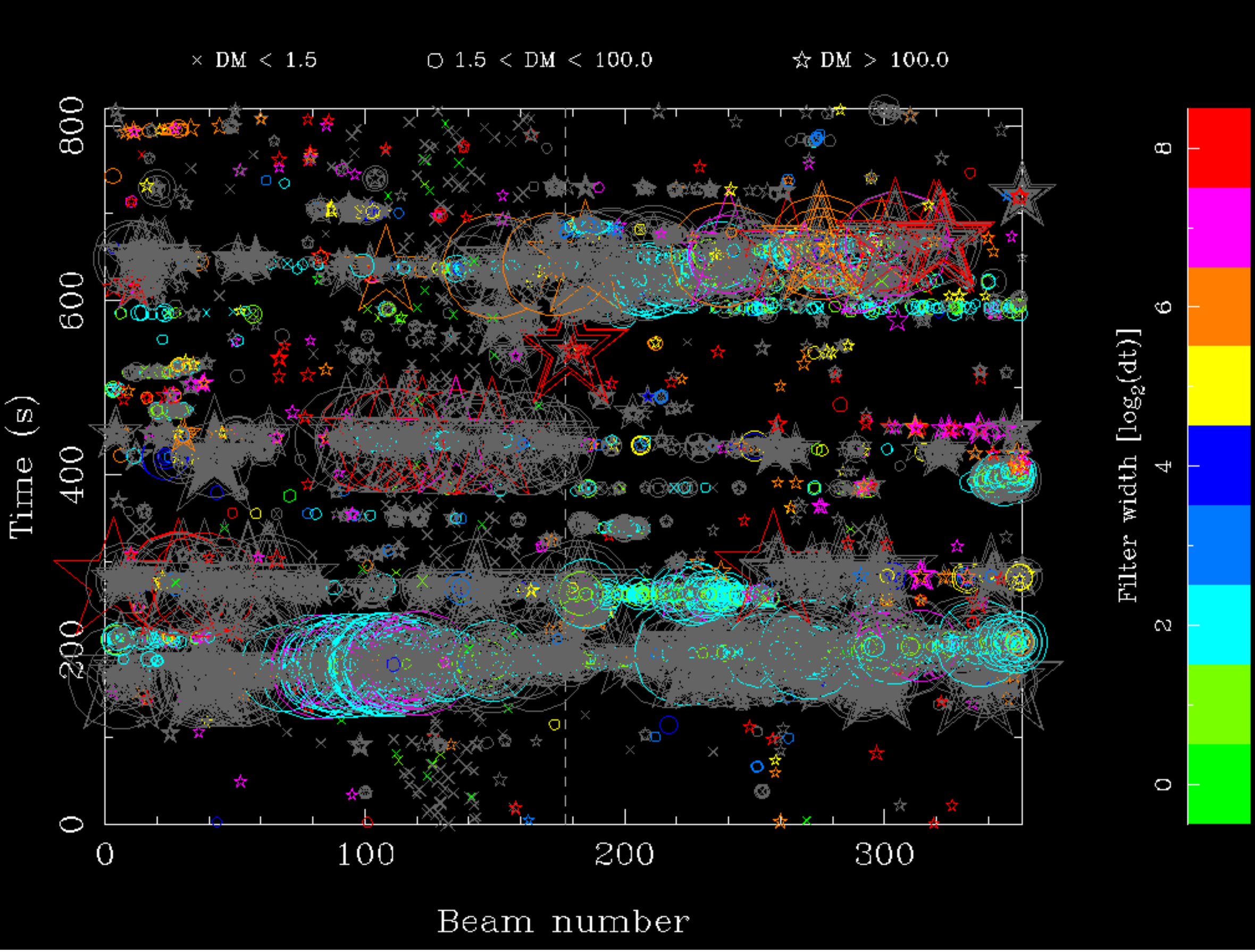
6 Attachments

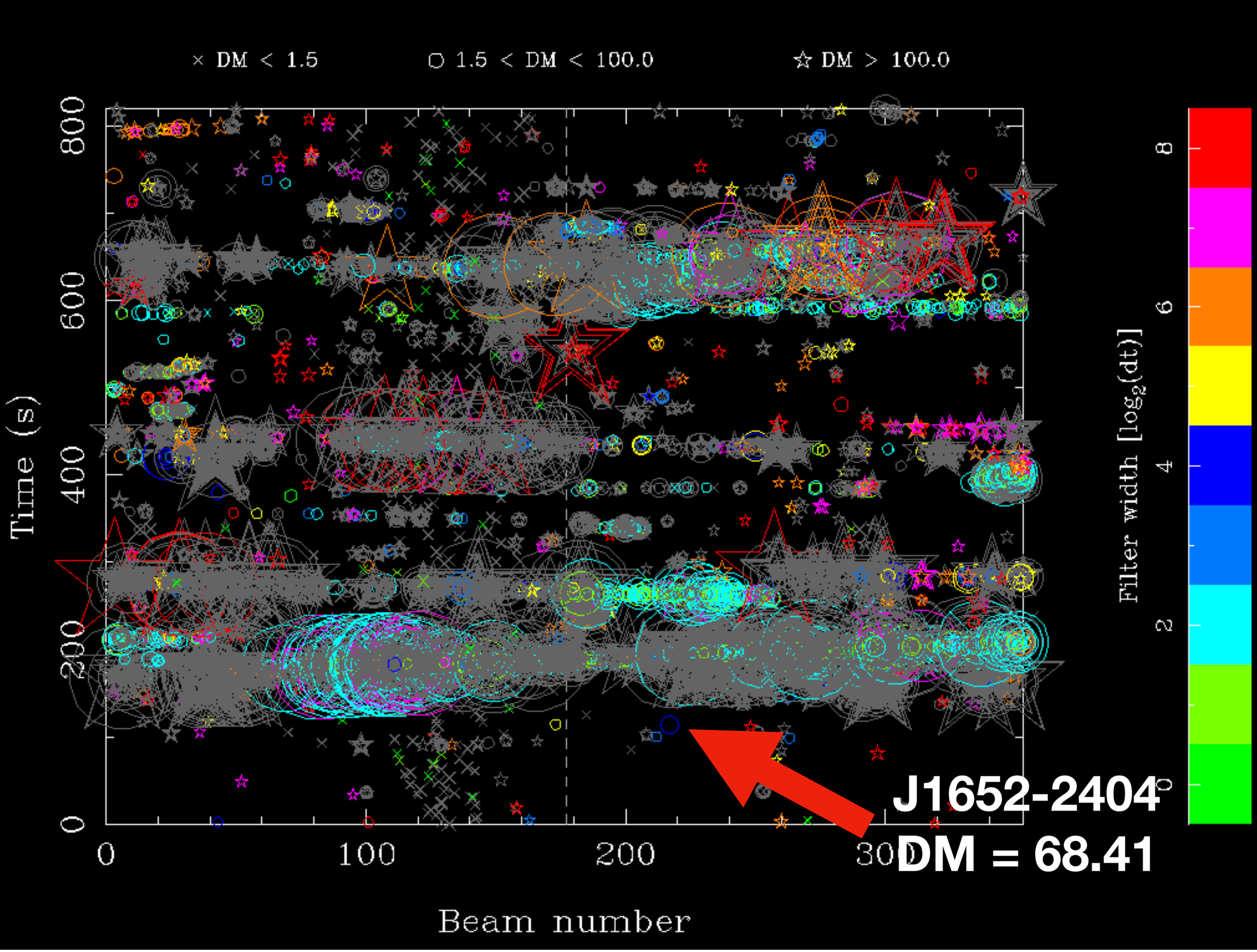


FRB Conference - Swinburne

Wael Farah

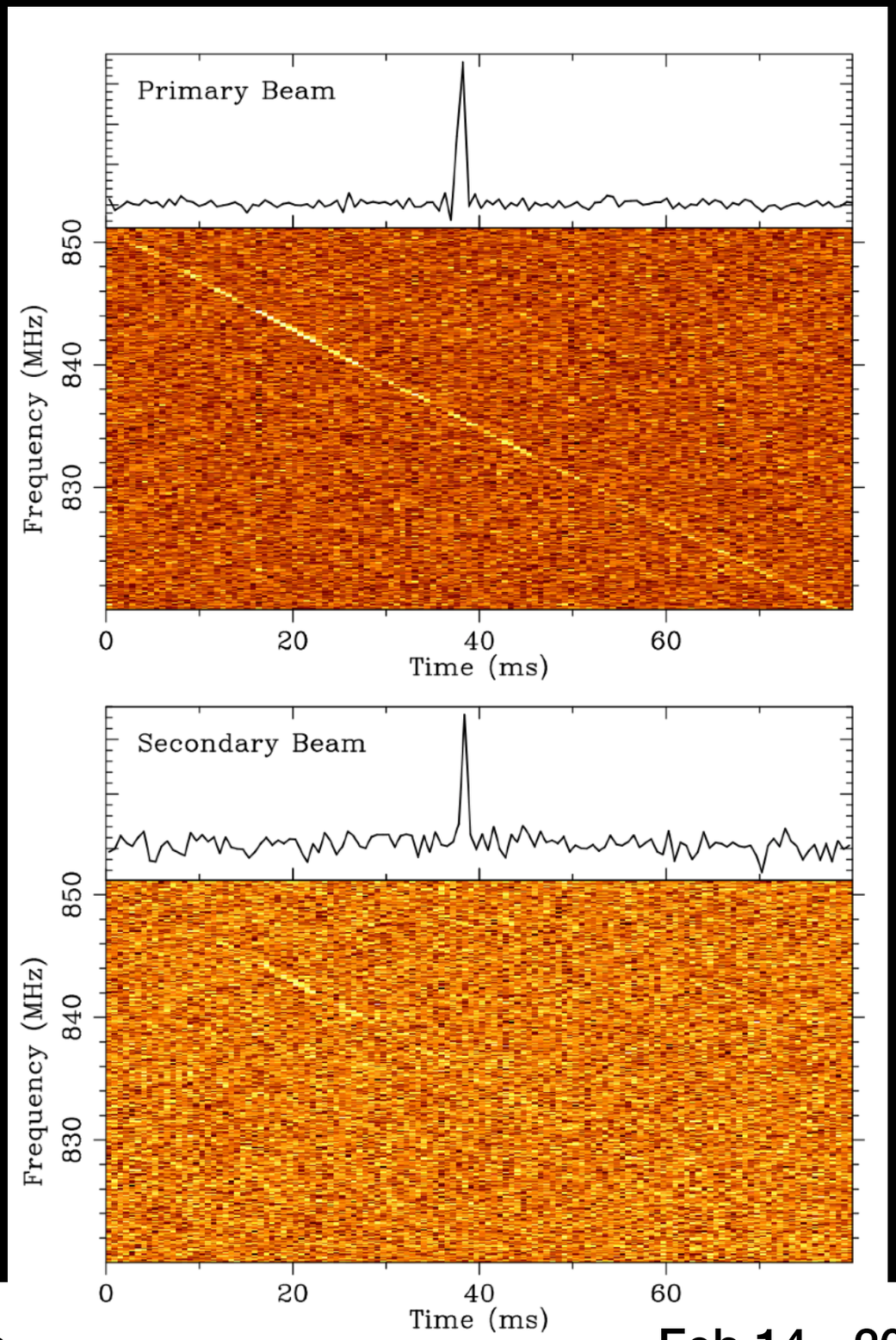
Feb 14 - 2018


× DM < 1.5
○ 1.5 < DM < 100.0
☆ DM > 100.0
Time (s)
0
200
400
600
800
0
100
200
300
Beam number
Filter width [log2(dt)]
0
2
4
6
8


× DM < 1.5
○ 1.5 < DM < 100.0
☆ DM > 100.0
Time (s)
0
200
400
600
800
0
100
200
300
Beam number
Filter width [log2(dt)]
2
4
6
8
J1652-2404
DM = 68.41

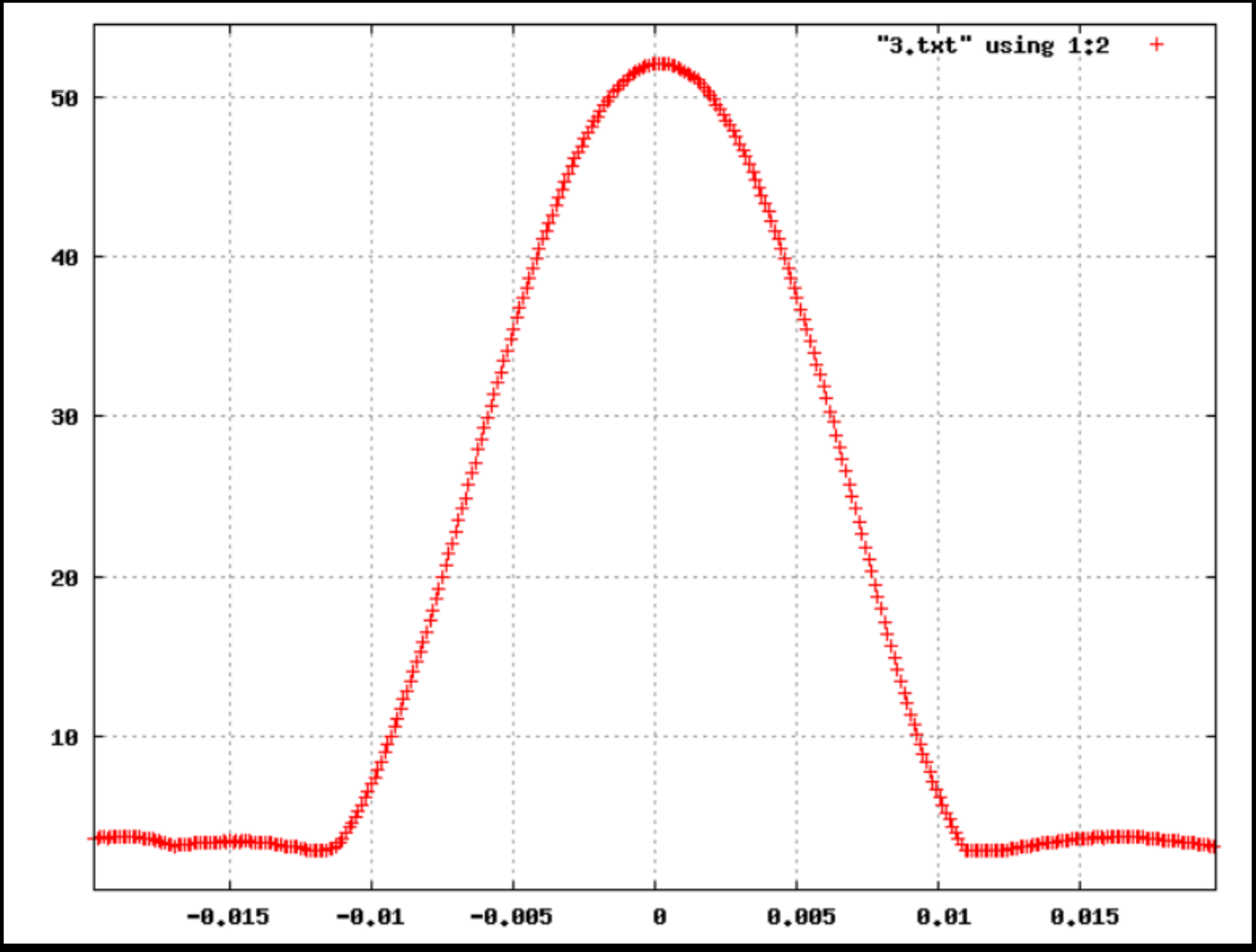
Discovery of FRB 170827

- SNR = 48 (Detection)
- DM = 176.8 (DM_Gal ~ 40)
- z ~ 0.12
- Width = 0.4 ms
- S_{peak} = 60 Jy
- Fluence = 20 Jyms

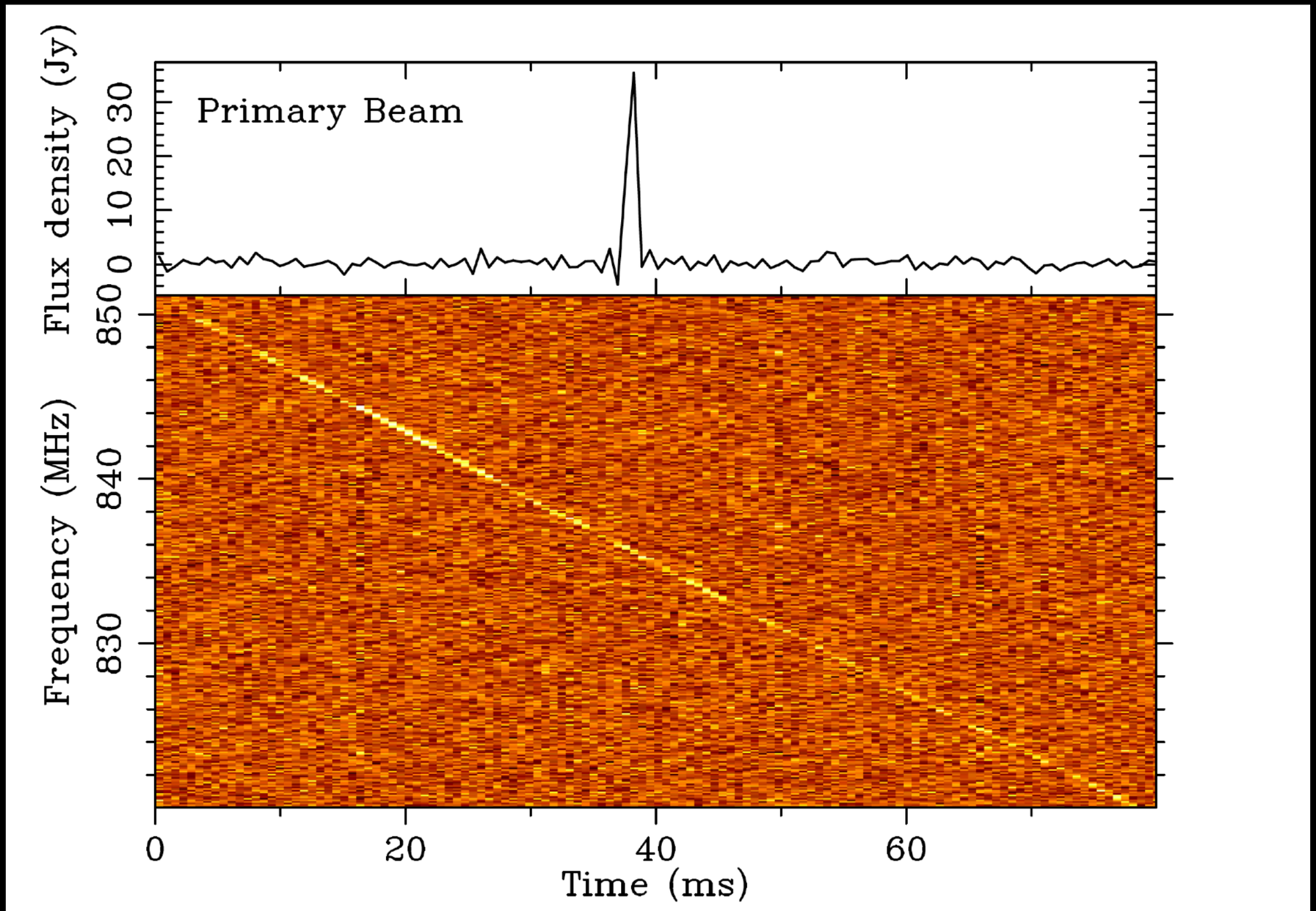


Real Time => Voltage data

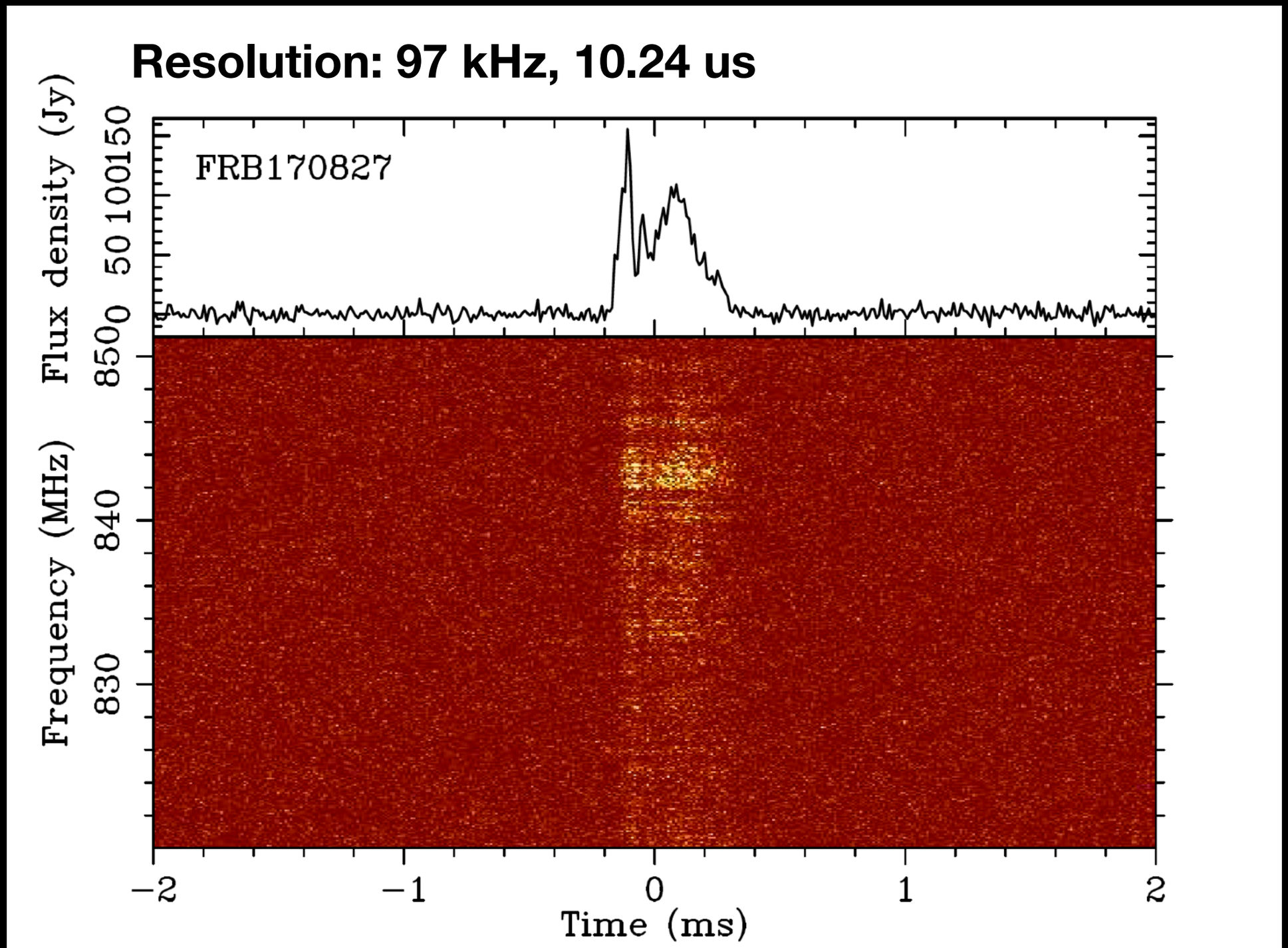
- Hyperfine fan beam layout
- Optimise event sky position



In-coherent dedispersion



Coherent dedispersion



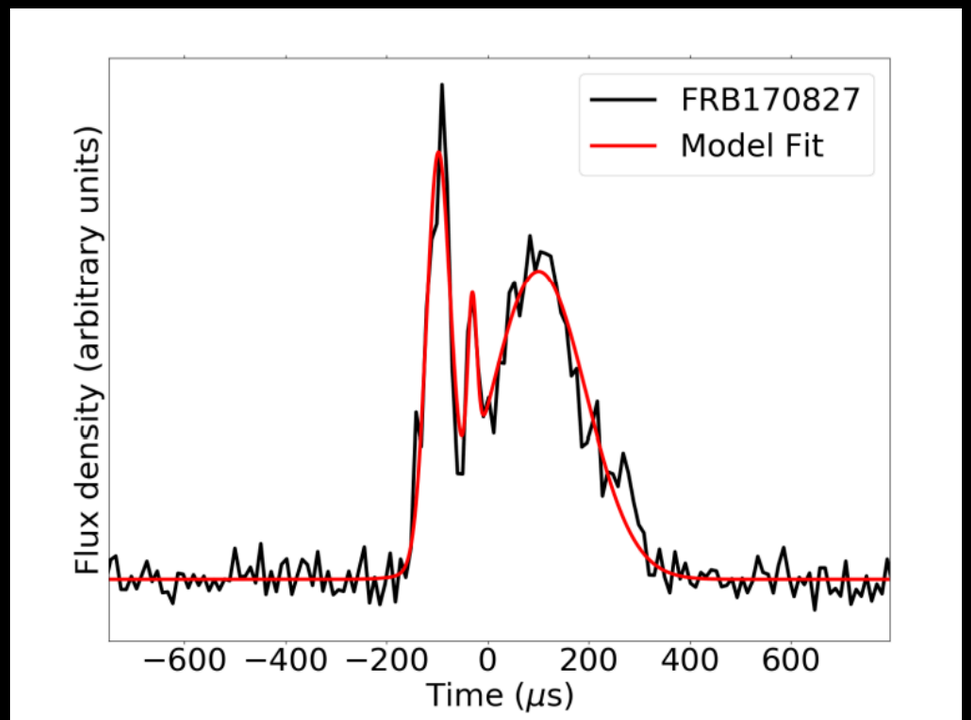
FRB Pulse Profile Fitting

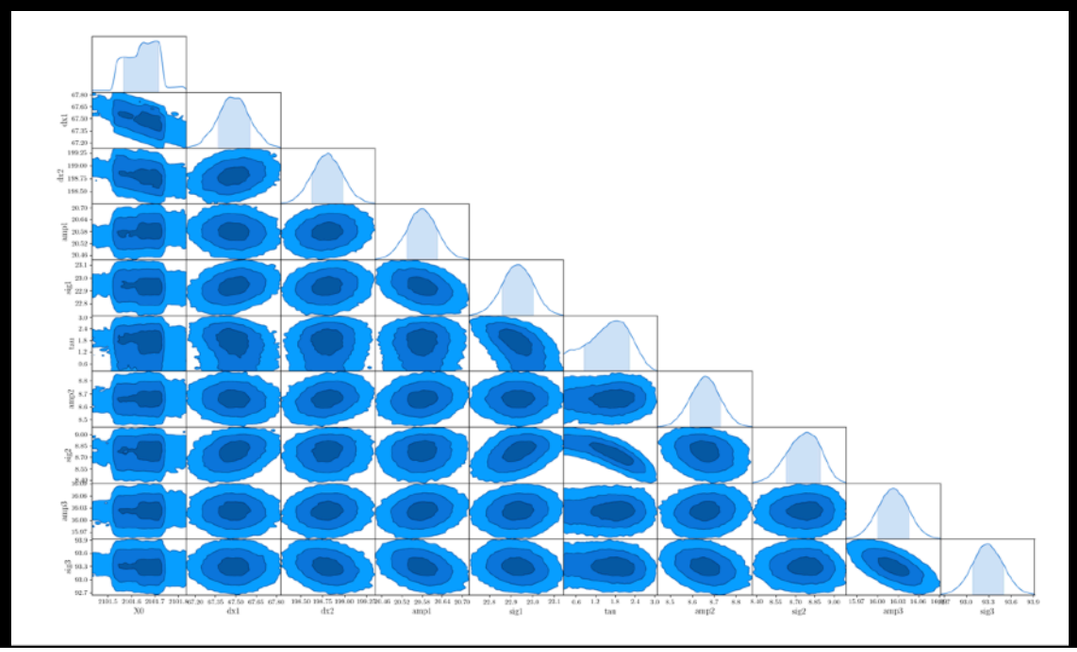
- Three temporal features
- Least square fit - MCMC

Model:

$$\mathbb{G}_i(t \mid \mathrm{A}_i, dt_i, \sigma_i, \tau) = \mathrm{A}_i \times \left[\exp\left(-\frac{(t - dt_i)^2}{2\sigma_i^2} \right) \right] * \left[\mathbb{H}(t - dt_i) \exp\left(-\frac{t - dt_i}{\tau} \right) \right]$$

$$\mathbb{G} = \mathbb{G}_1 + \mathbb{G}_2 + \mathbb{G}_3$$

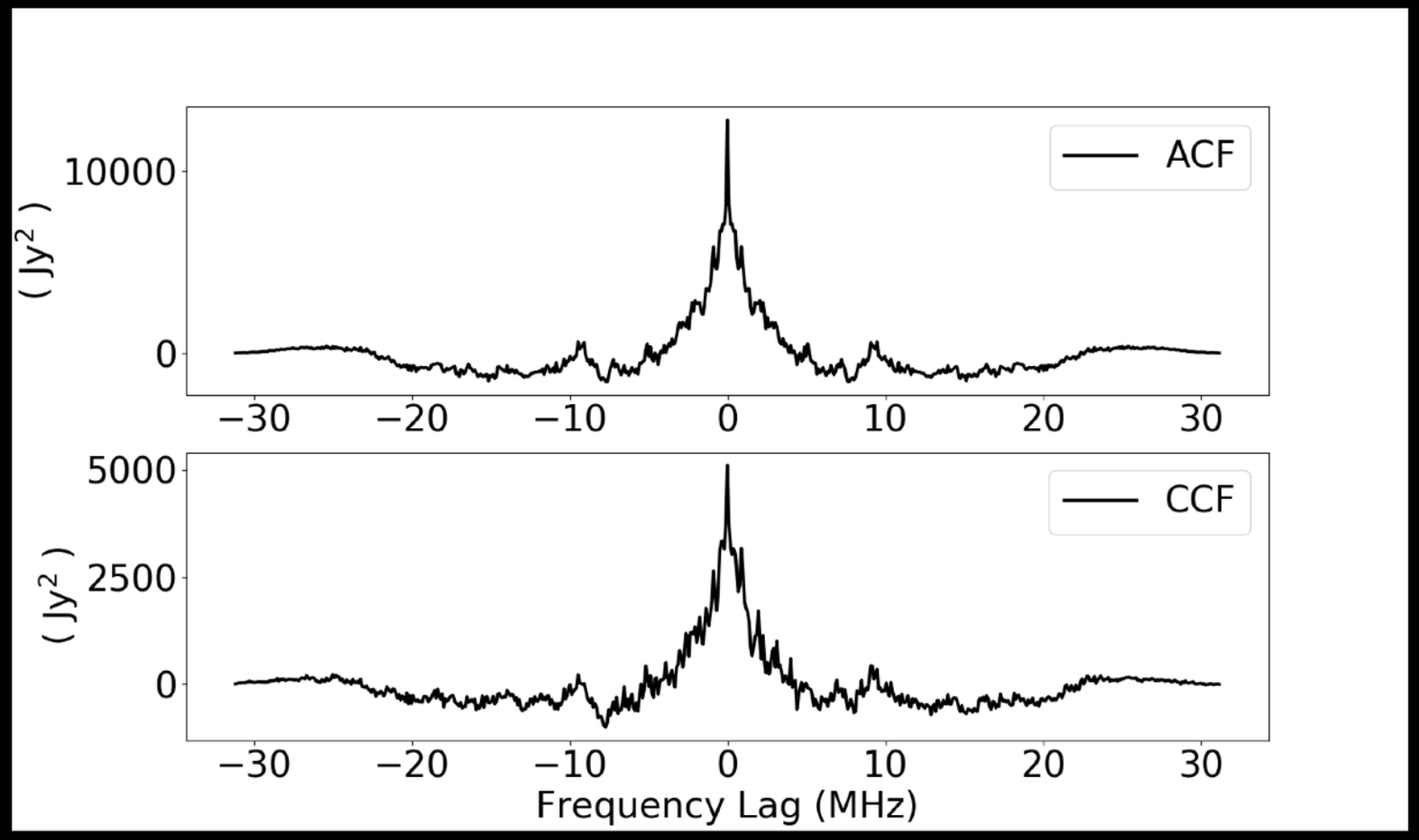




- Widths = {23, 9, 93} micro-sec
- Tau = 2 us

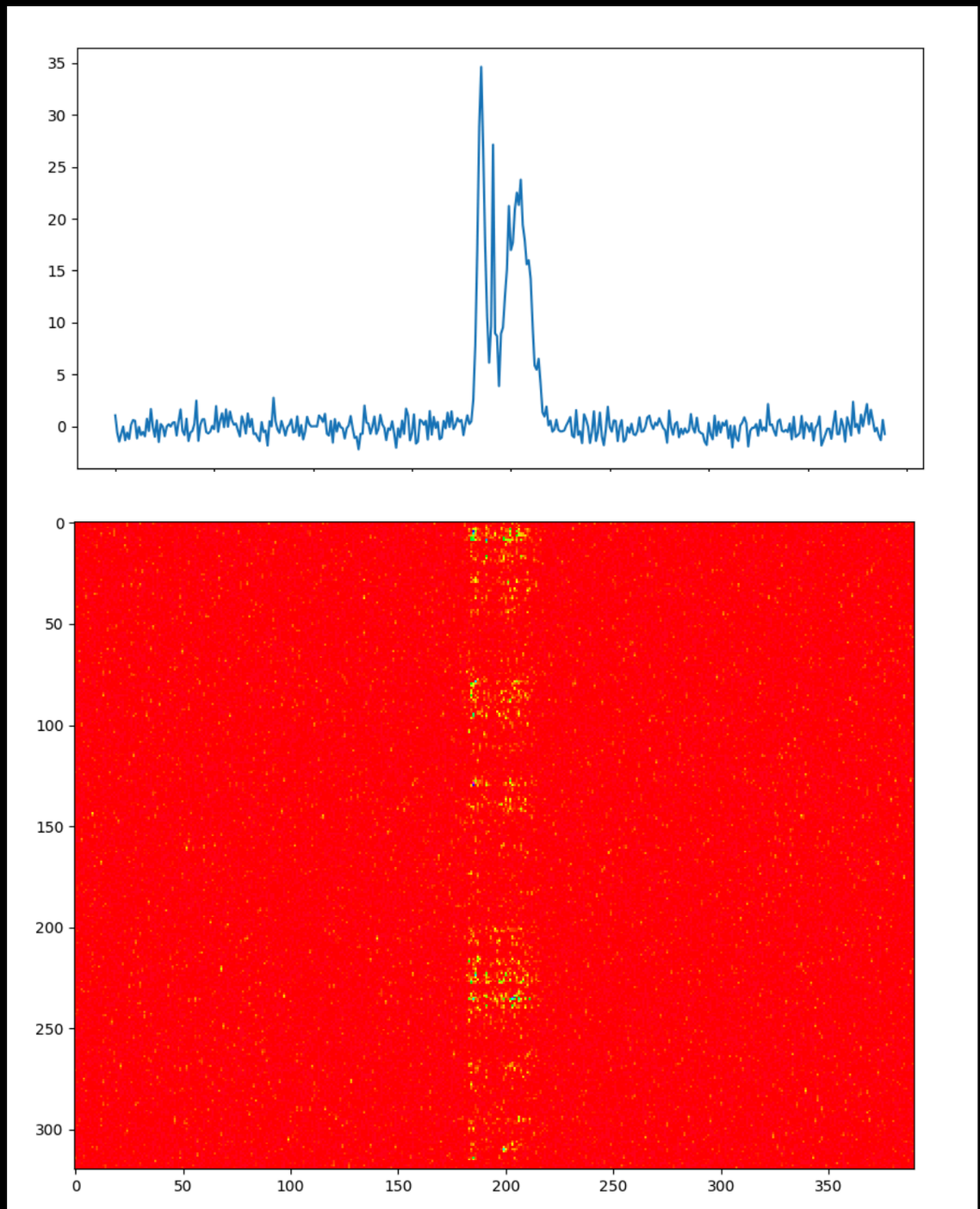
Spectral Modulation

- Spectral ACF / CCF were computed
- $\Delta\nu$ = 1.5 MHz (expected along the line of sight, NE2001)
- Another spectral modulation scale?



Can’t explain it? Simulate it!

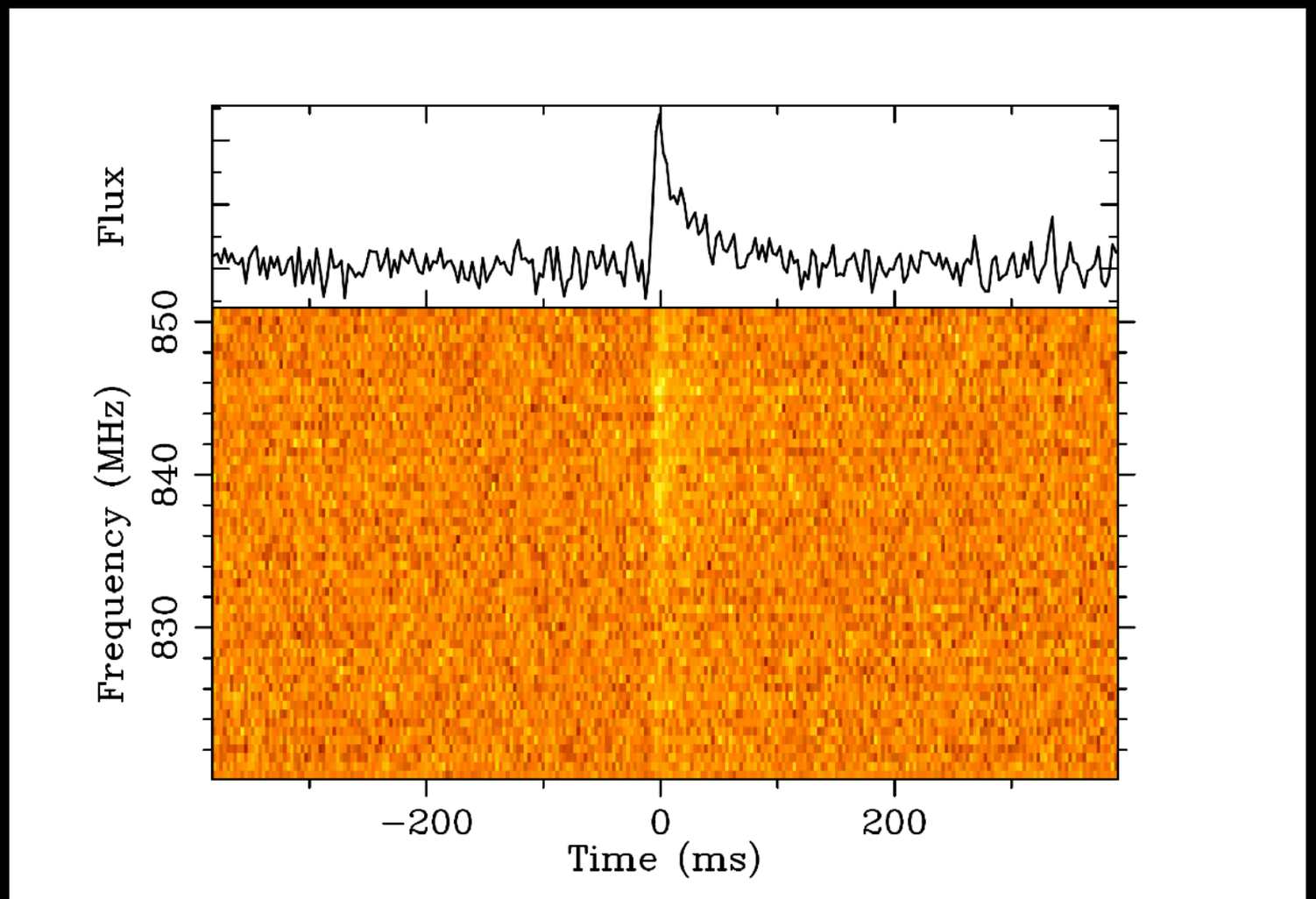
- Amplitude modulated noise model
- Complex “voltages”
- 2 scattering screens:
  - 0.1 us broadening
  - 2 us broadening
- Can replicate FRB170827 spectral/temporal structure



And another snowflake - FRB170922

22nd September 2017

- Real time detection, but no voltage trigger…
- DM = 1111 pc cm^{-3}
- DM_{MW} = 33 pc cm^{-3}
  => $z \approx 1$
- Width = 47 ms
- Fluence = 60 Jyms
- Scattering (not MW!)
  ($\tau \approx 30$ ms @ 843MHz)



Multi-wavelength Followup

- SkyMapper
- ASKAP
- Parkes
- Molonglo

Credit: ScienceWise

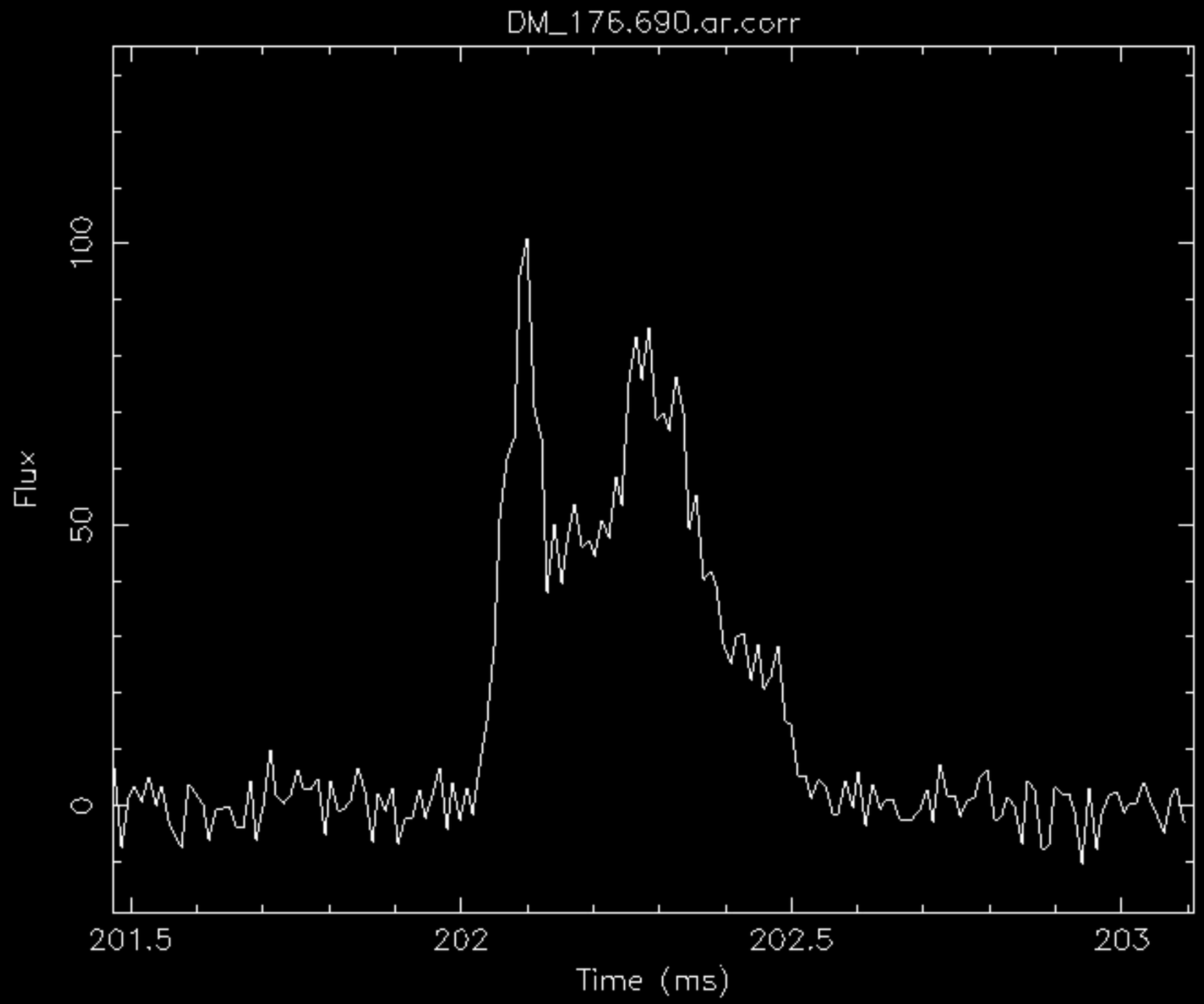
Credit: CSIRO

Credit: George `Nyima' Warr

Credit: CSIRO

Conclusions

- FRB 170827 demonstrated Molonglo's ability to dump voltages for an FRB discovered in real time
- Native resolution of telescope => remarkable microstructure
- 2 screen model: possible explanation of the seen spectral modulation
- Similarities to the repeater,
  except: it hasn't repeated yet…


DM_176.690.ar.corr
100
50
0
Flux
201.5
202
202.5
203
Time (ms)