

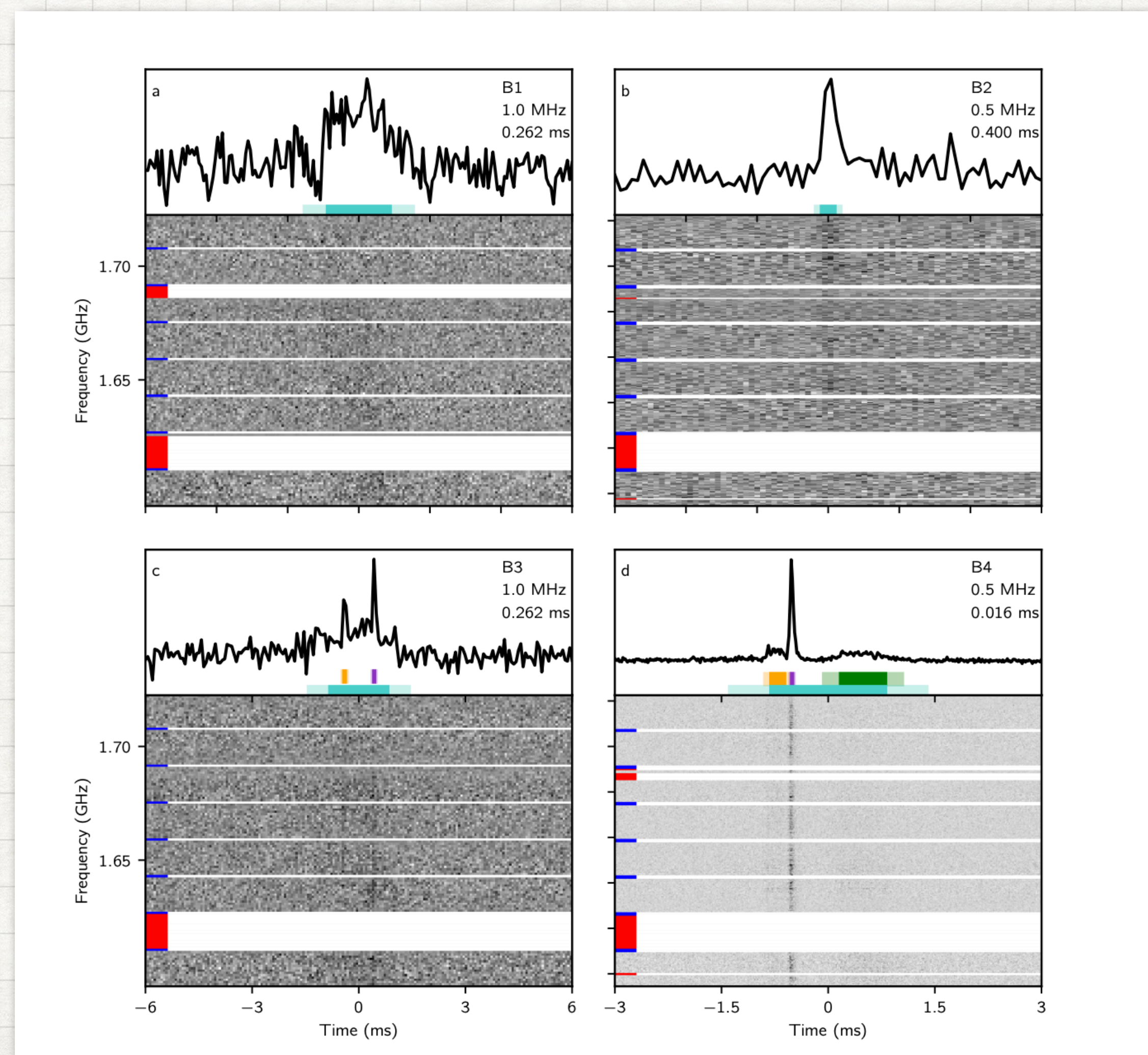
An aerial photograph of the SKA Northern Cross radio telescope array. The image shows a long, straight line of large, white, Y-shaped radio telescope structures stretching across a green and brown rural landscape. The sky is blue with scattered white clouds. The text is overlaid in white, bold, sans-serif font.

PREPPING UP FOR THE SKA FAST RADIO BURST ERA USING THE NORTHERN CROSS

Maura Pilia on behalf of the NC-FRB Team

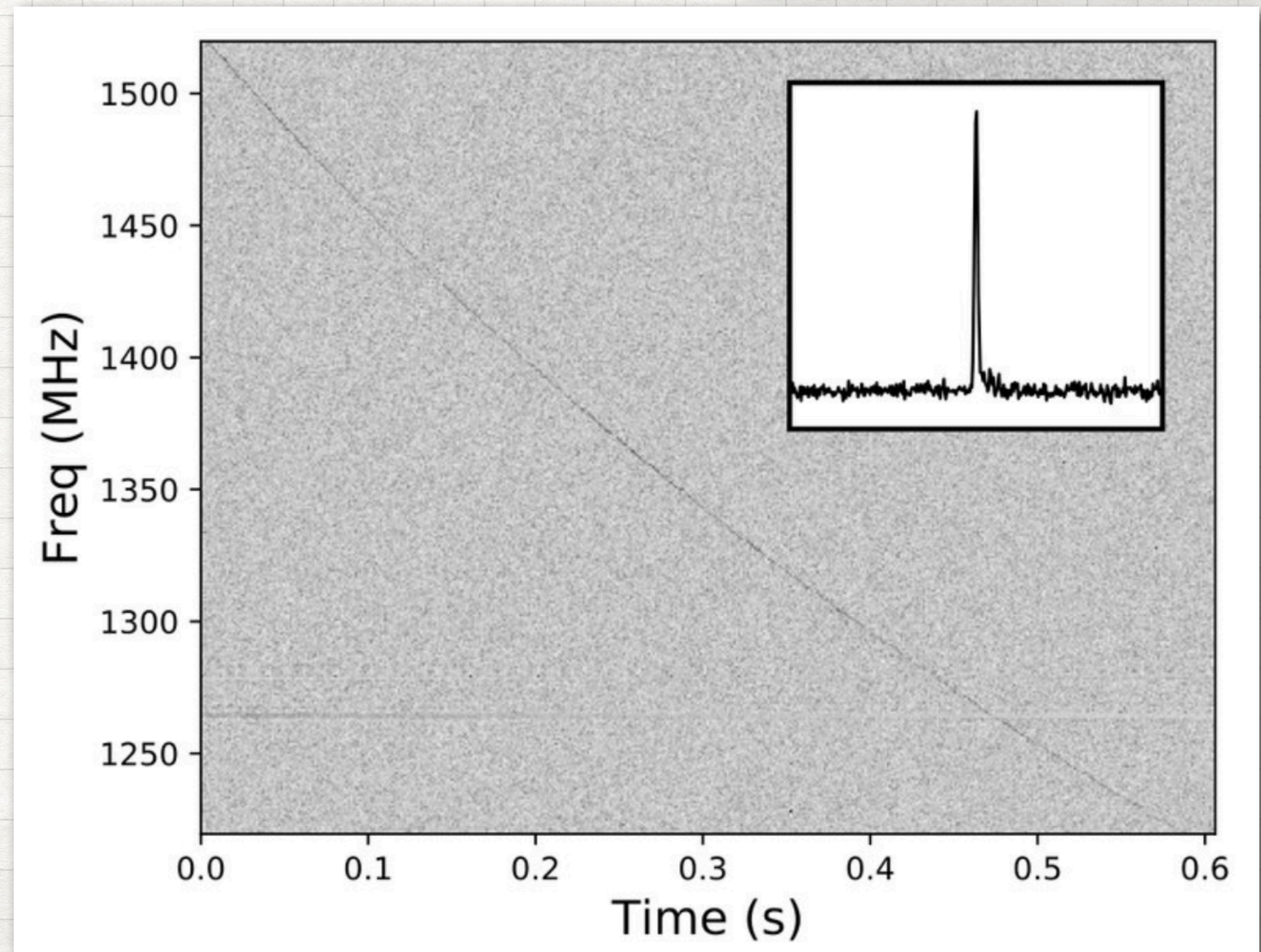
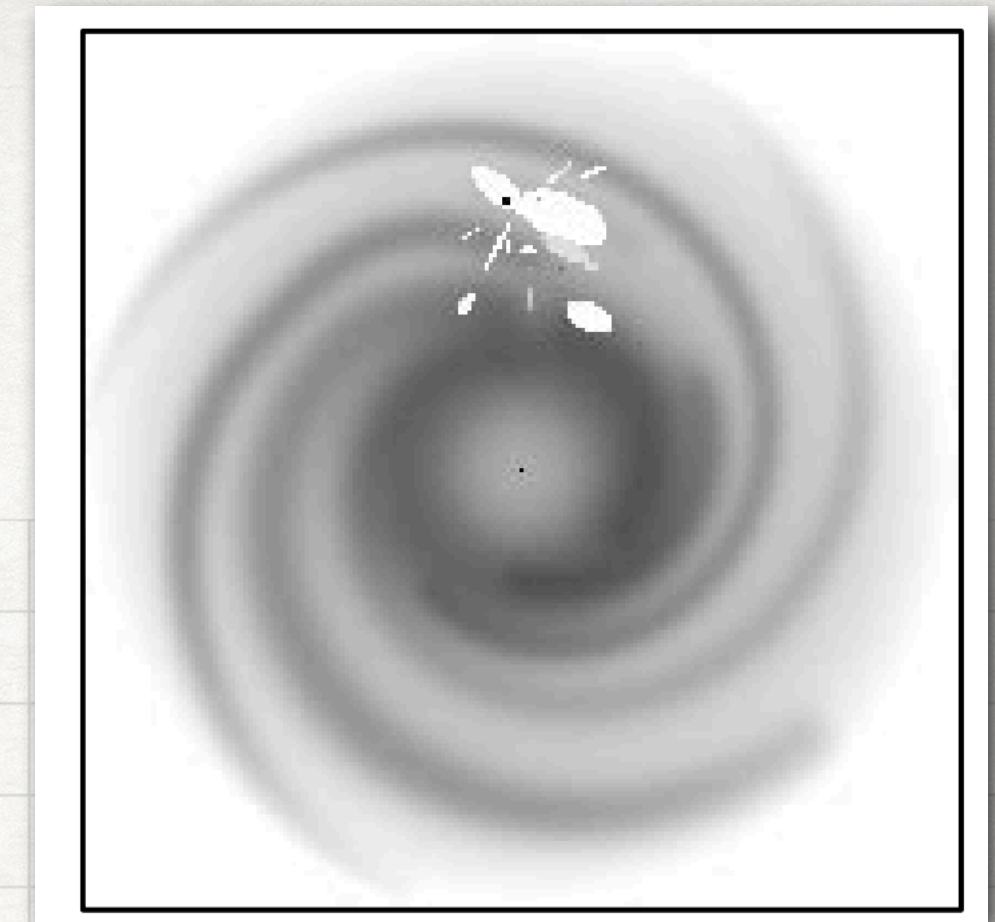
FAST RADIO BURSTS

- ~ms long Jy radio transients
- Dispersed signal -> DM > galactic
- One-offs vs repeaters
- Magnetars
- Why are FRBs so interesting?



FAST RADIO BURSTS

- ~ms long Jy radio transients
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FAST RADIO BURSTS

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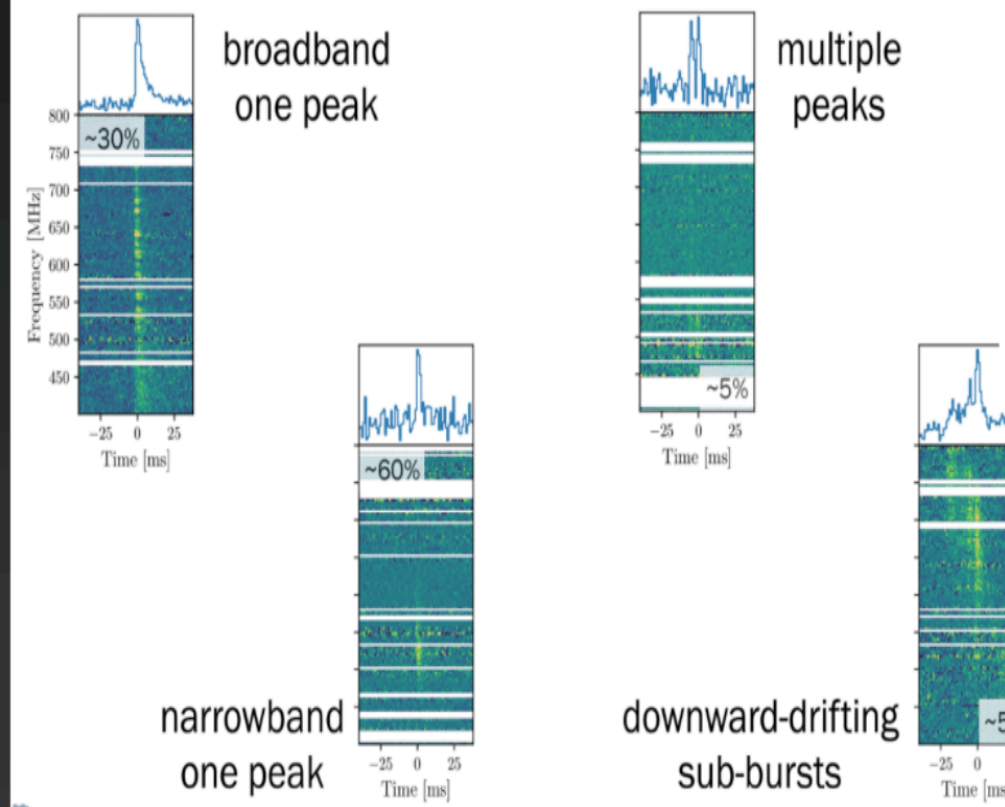
Some main conclusions from the meeting

- Do all FRBs repeat? Maybe?

Radio bursts are cheap*

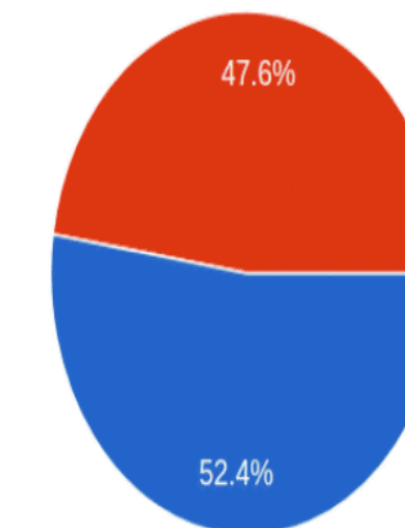
- Burst morphology

Observed fast radio burst archetypes



Do all FRBs repeat?
63 responses

PRELIMINARY

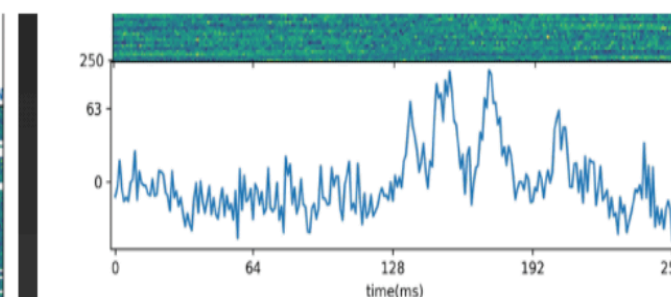


● Yes
● No

Rotationally-powered

Magnetically-powered

Accretion-powered???



S7: Tendulkar
uGMRT, Arun Naidu

* Paraphrasing Andrei Grusinov

S8: Hessels

S2: Pleunis

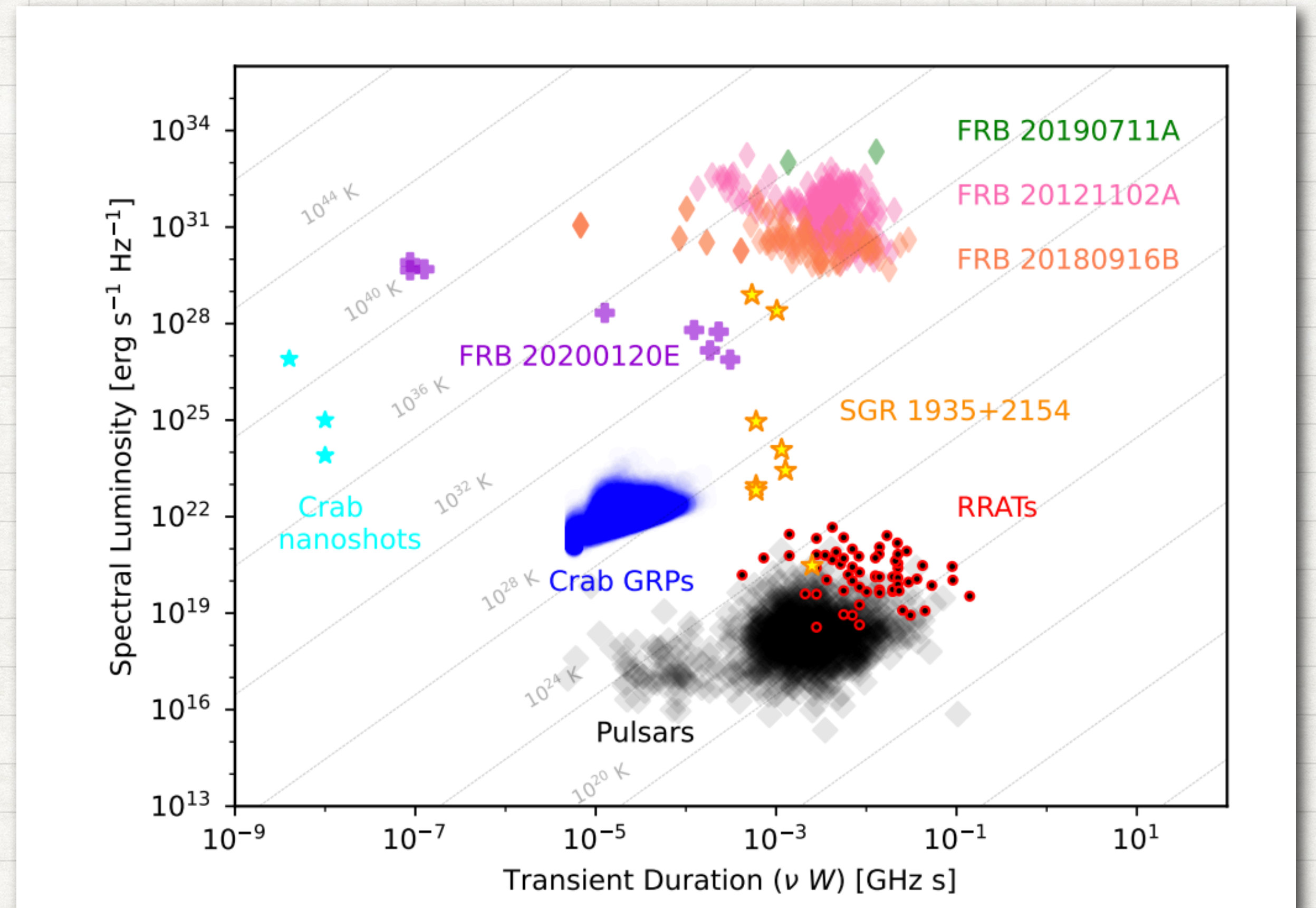
FAST RADIO BURSTS

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FAST RADIO BURSTS

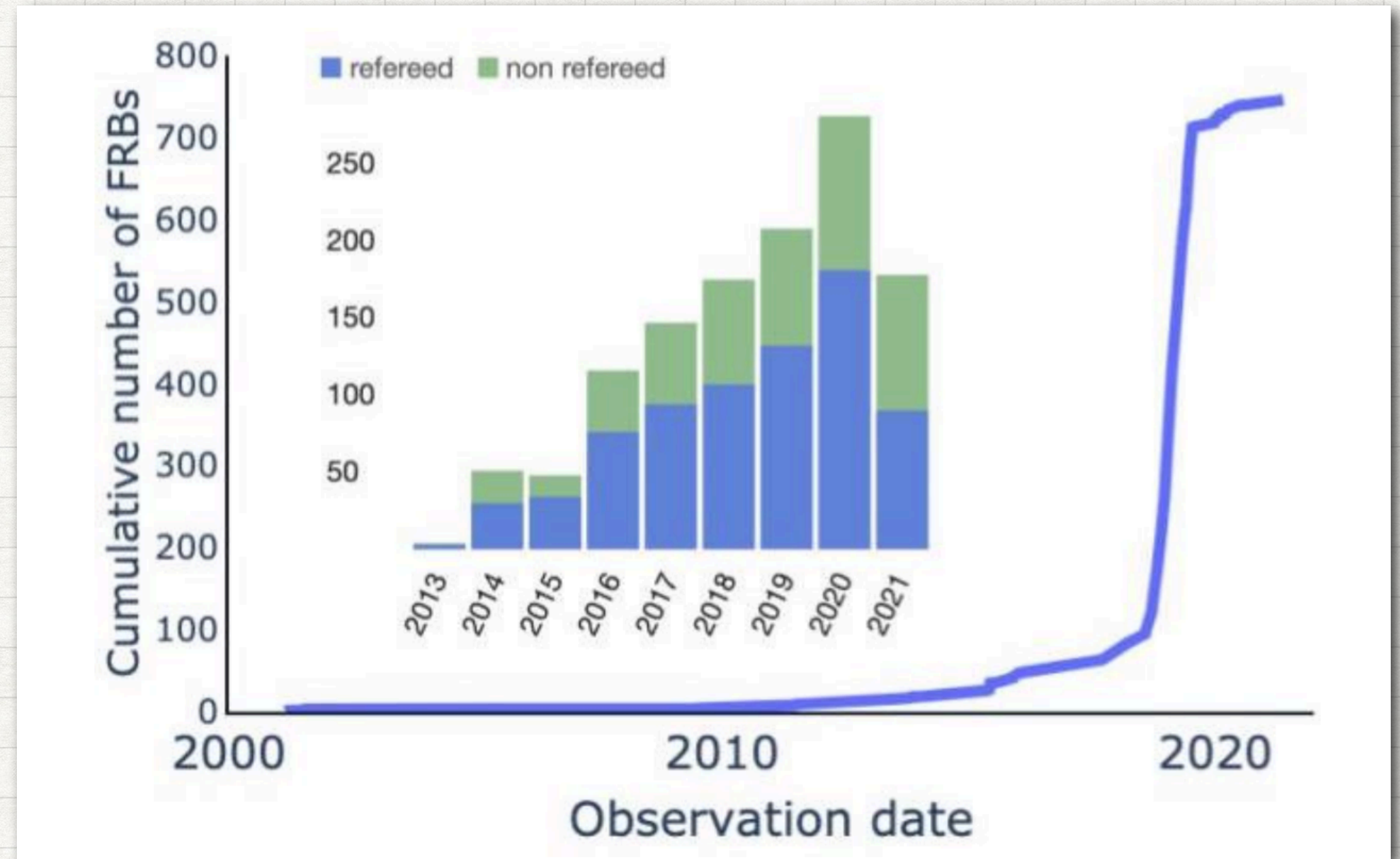
- ~ms long Jy radio transients
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- Why are FRBs so interesting?



Petroff, Hessels & Lorimer 2021

FAST RADIO BURSTS

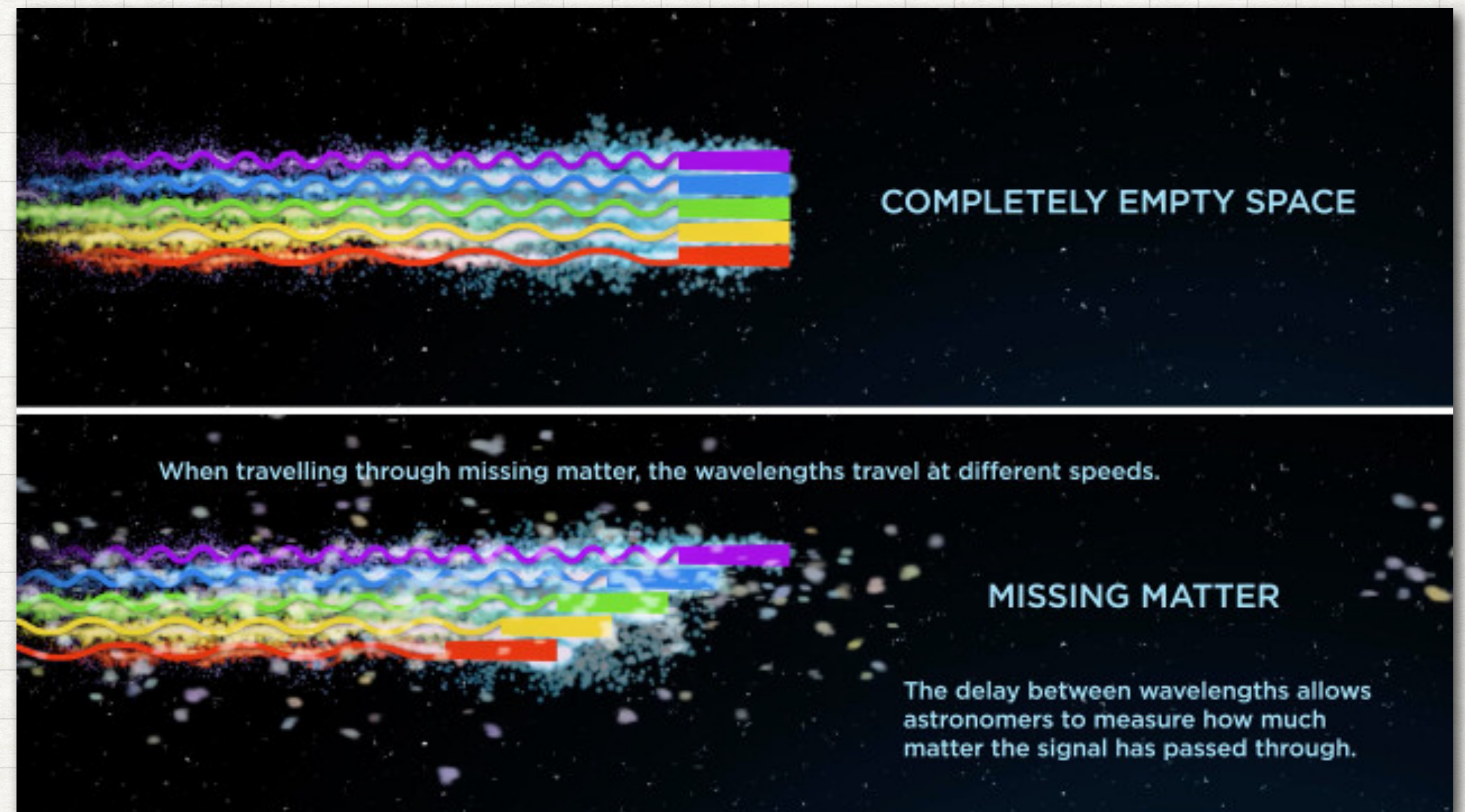
- ~ms long Jy radio transients
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- Why are FRBs so interesting?



Petroff, Hessels & Lorimer 2021

FAST RADIO BURSTS

- ~ms long Jy radio transients
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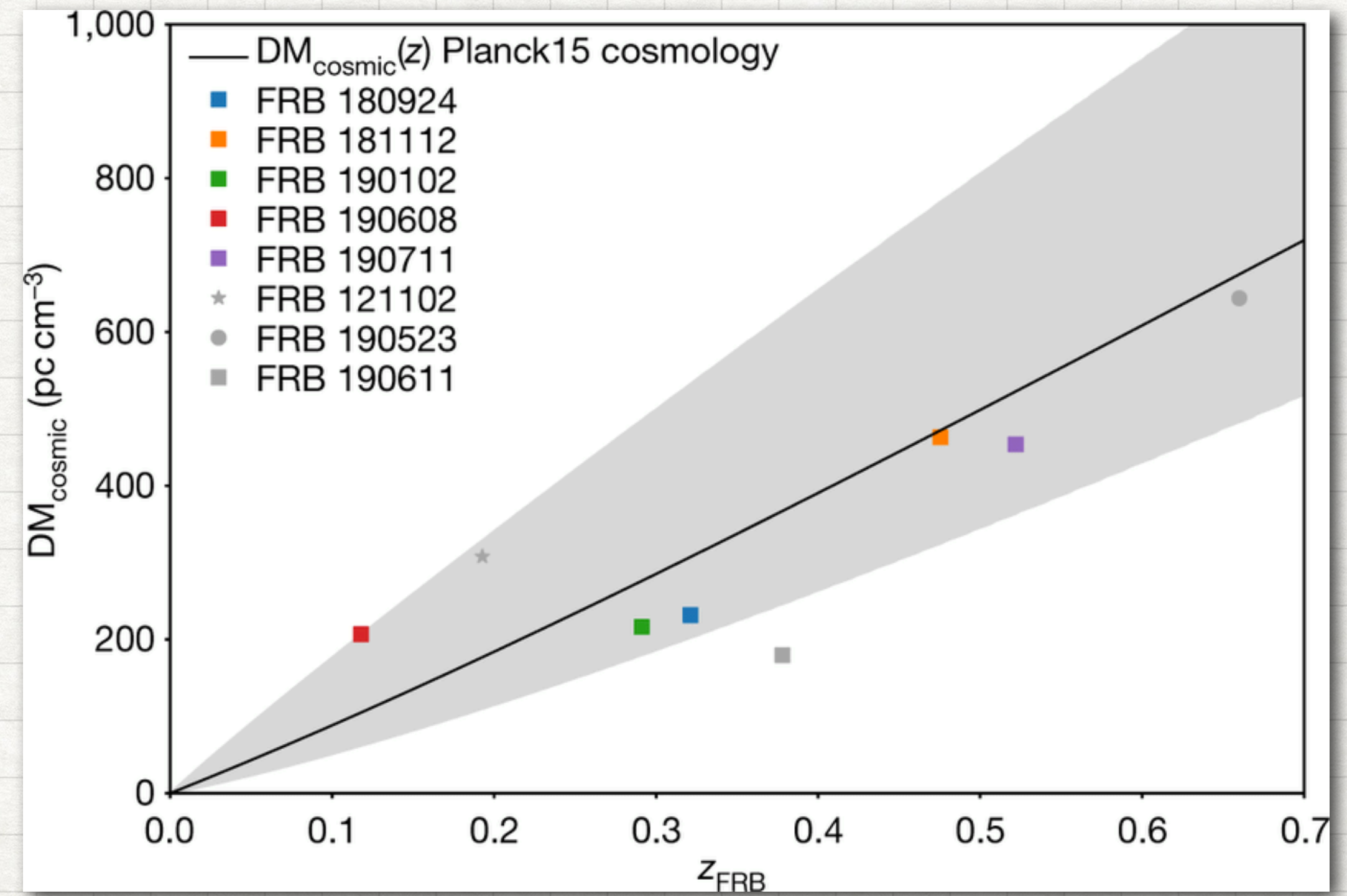
THE ROLE OF THE SKA PRECURSORS

ASKAP, MEERKAT



THE ROLE OF THE SKA PRECURSORS

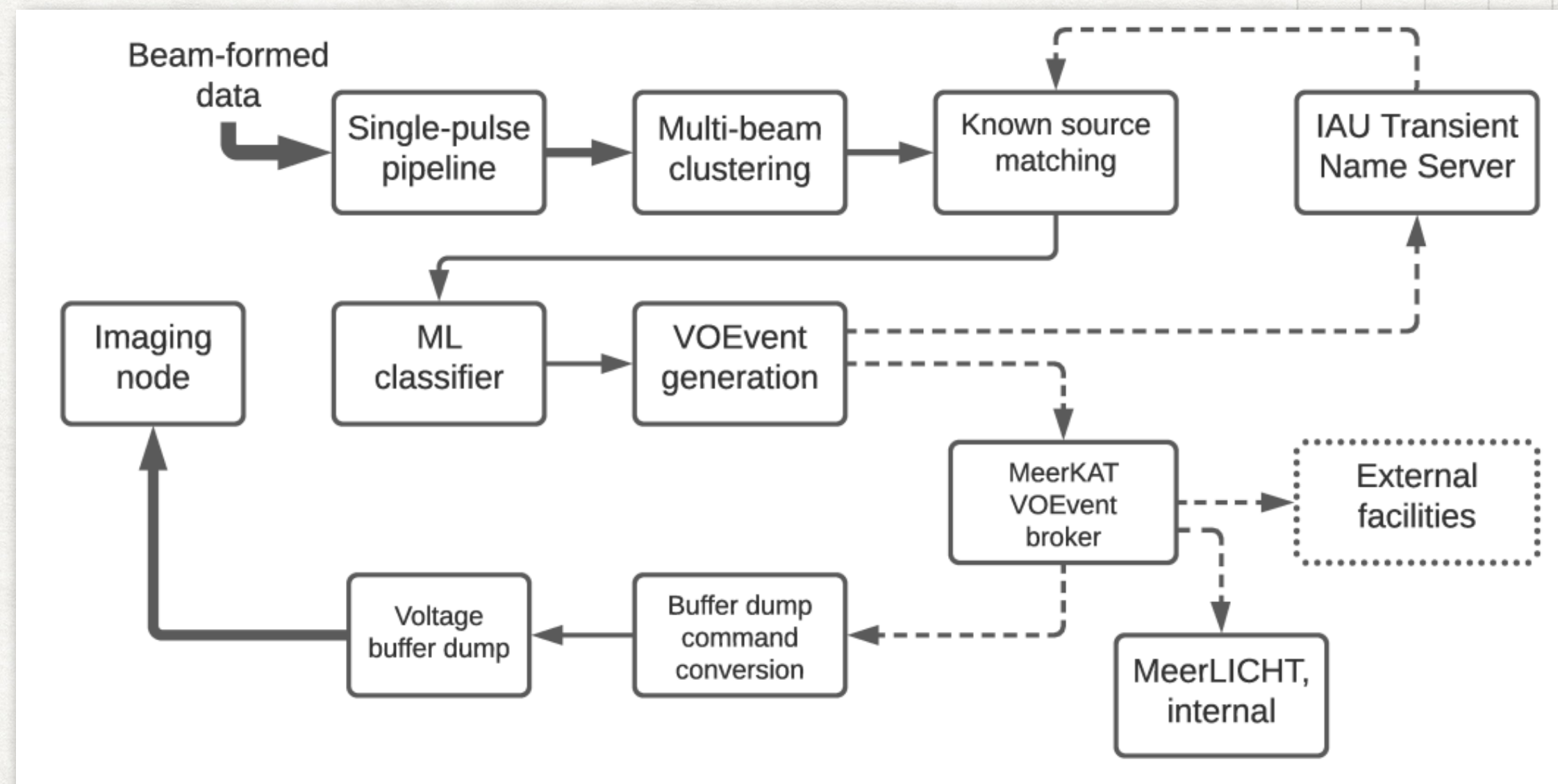
ASKAP



Macquart et al. 2020

THE ROLE OF THE SKA PRECURSORS

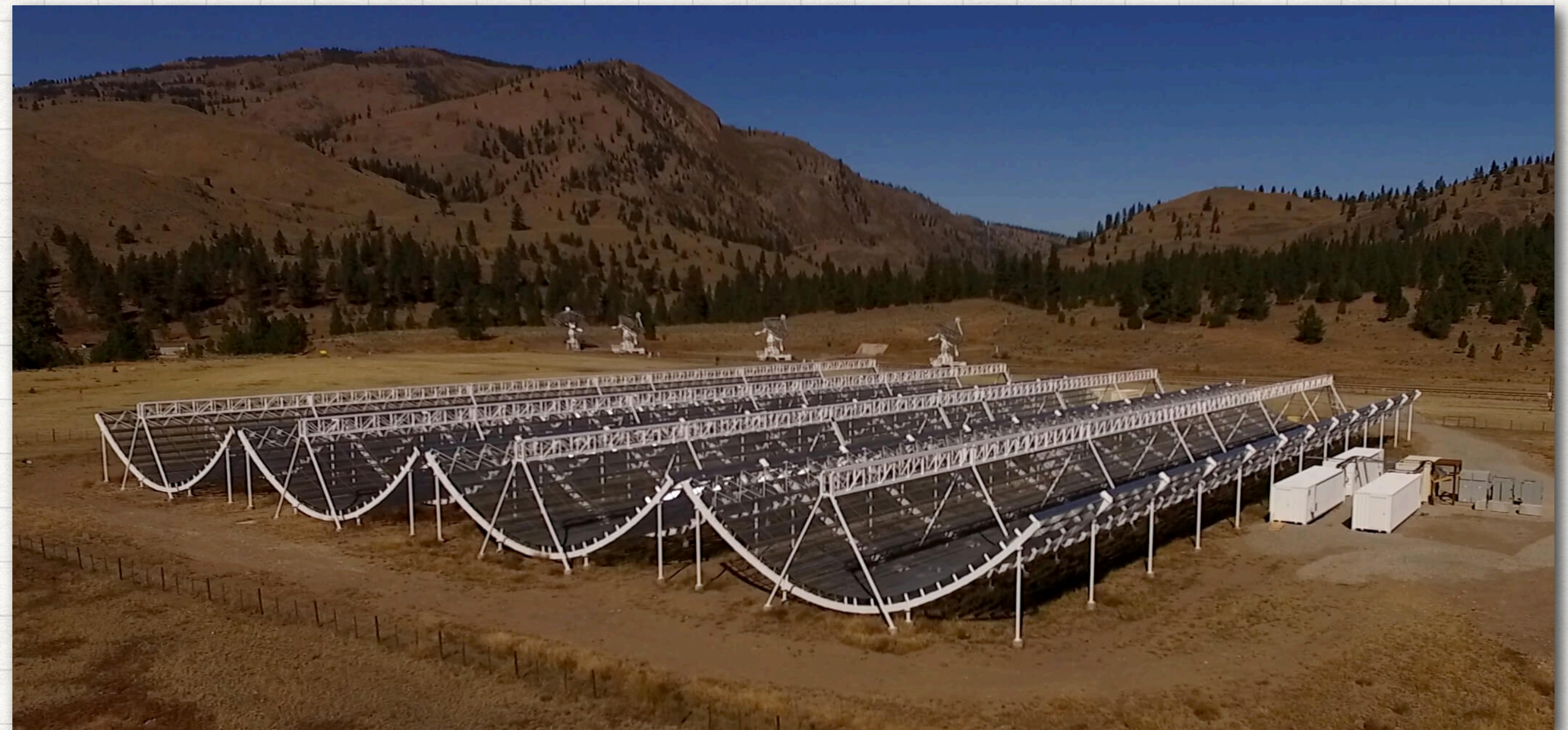
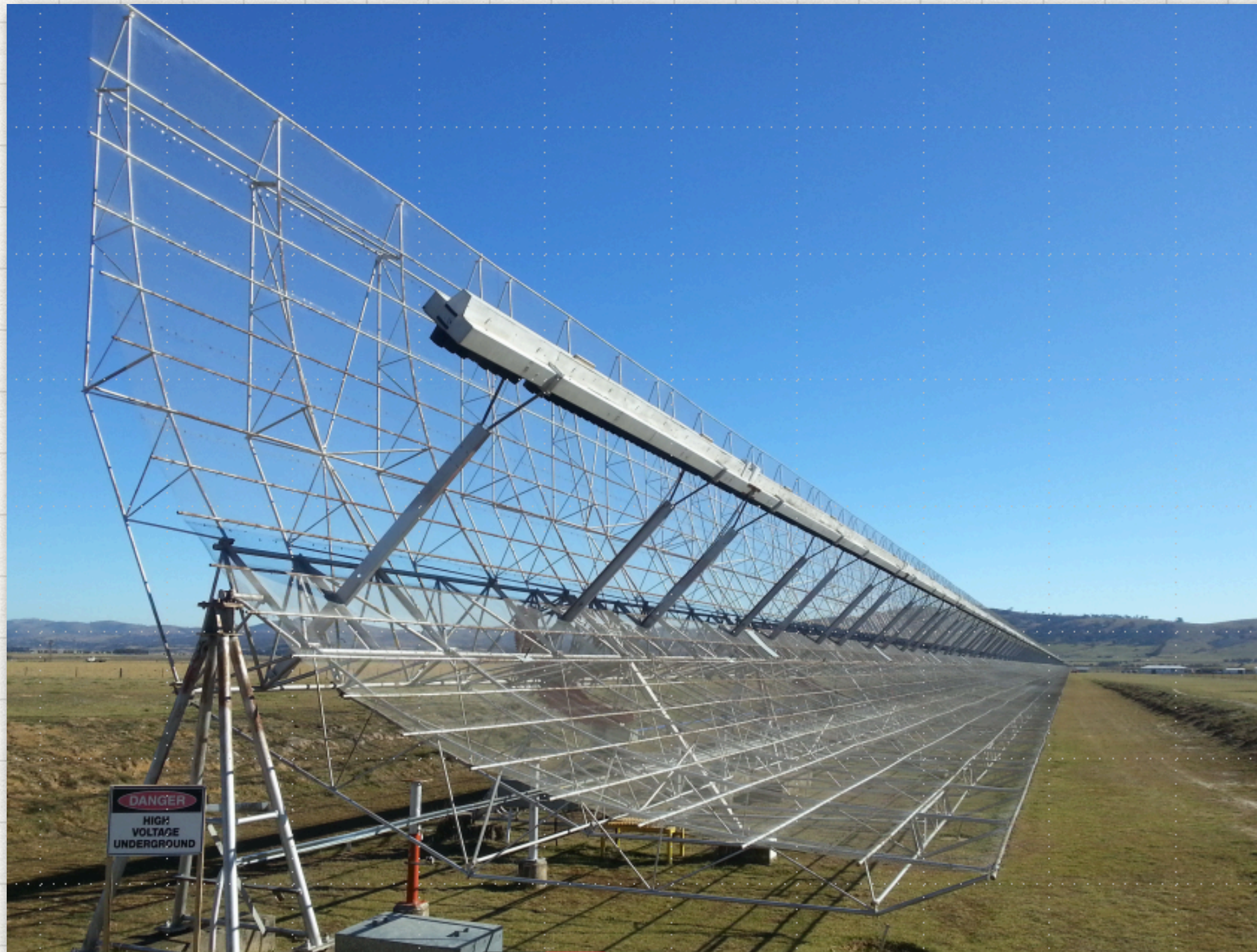
MEERKAT



Rajwade et al. 2020

FRB MACHINES

UTMOST, CHIME



THE NC-FRB PROJECT

HISTORY



THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 106:611-619, 1996 October
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THE NEW NORTHERN CROSS PULSAR SYSTEM: FOUR YEARS OF PULSE-TIMING OBSERVATIONS

N. D'AMICO,^{1,2} G. GRUEFF,^{2,3} S. MONTEBUGNOLI,² A. MACCAFERRI,² A. CATTANI,² C. BORTOLOTTI,²
L. NICASTRO,⁴ F. FAUCI,⁵ G. TOMASSETTI,² M. ROMA,² R. AMBROSINI,² AND E. RODRIGUEZ⁶

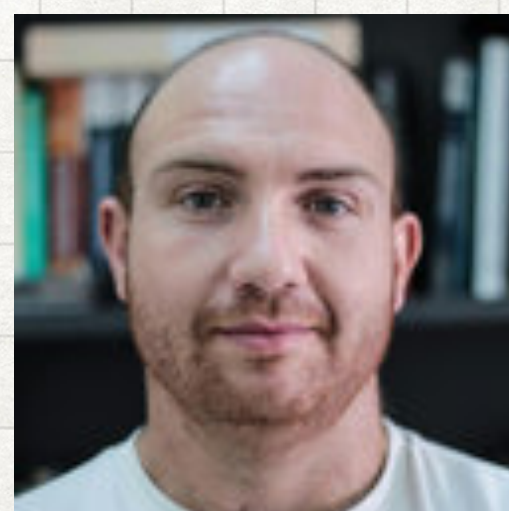
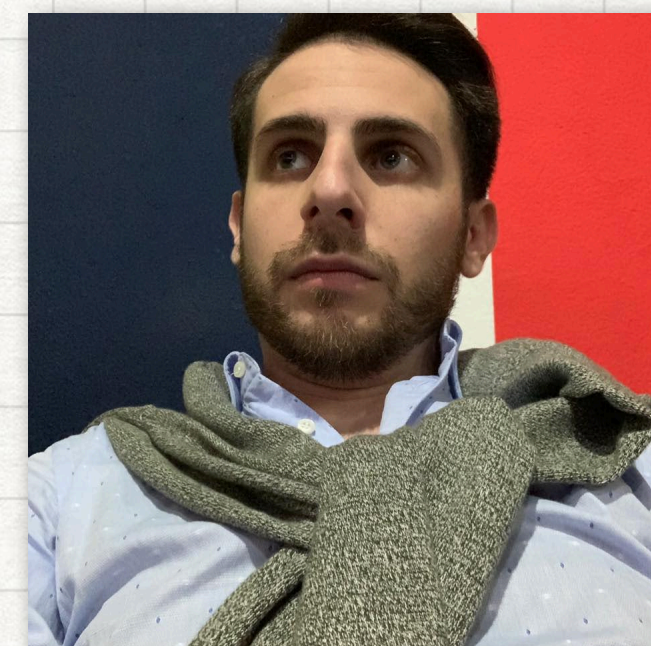
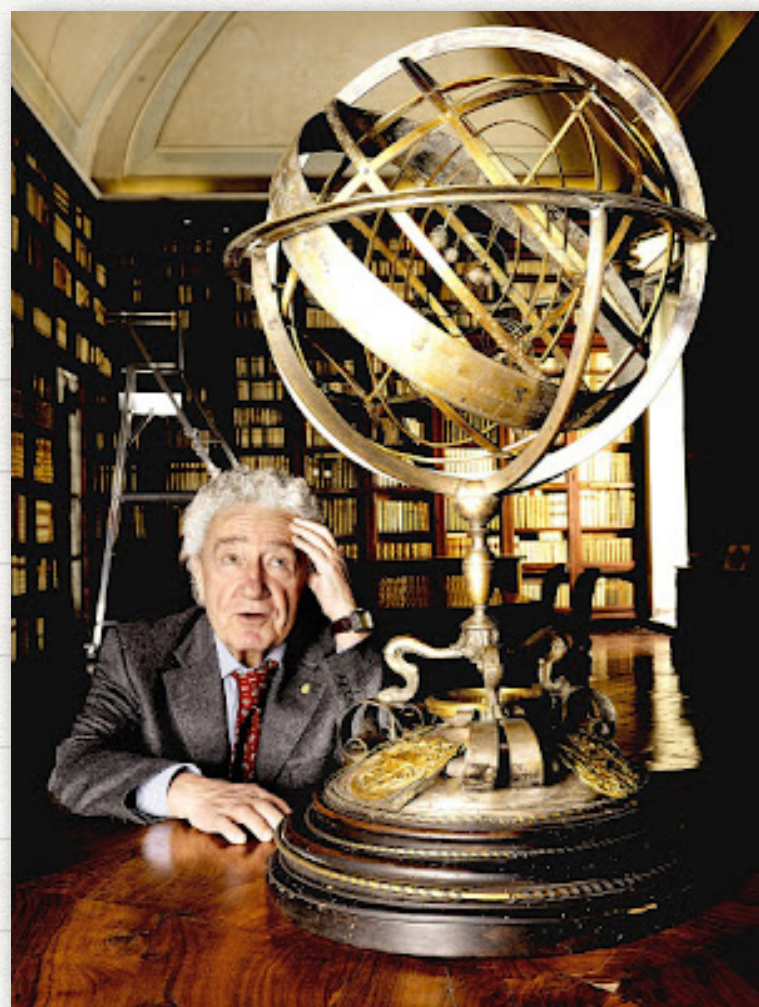
Received 1995 December 5; accepted 1996 April 3

ABSTRACT

We renewed the Northern Cross radio telescope and built a data acquisition system suitable for pulsar observations, including on-line processing equipment. In this paper we discuss the new telescope capabilities and the characteristics of the pulsar system. We also present results from a long-term timing program of a sample of radio pulsars coordinated with the *Compton Gamma Ray Observatory* mission. Pulse profiles were recorded at a center frequency of 408 MHz between 1991 April and 1995 February, yielding positions, periods, and period derivatives. A glitch in PSR J2257 + 5909 was observed.

THE NC-FRB PROJECT

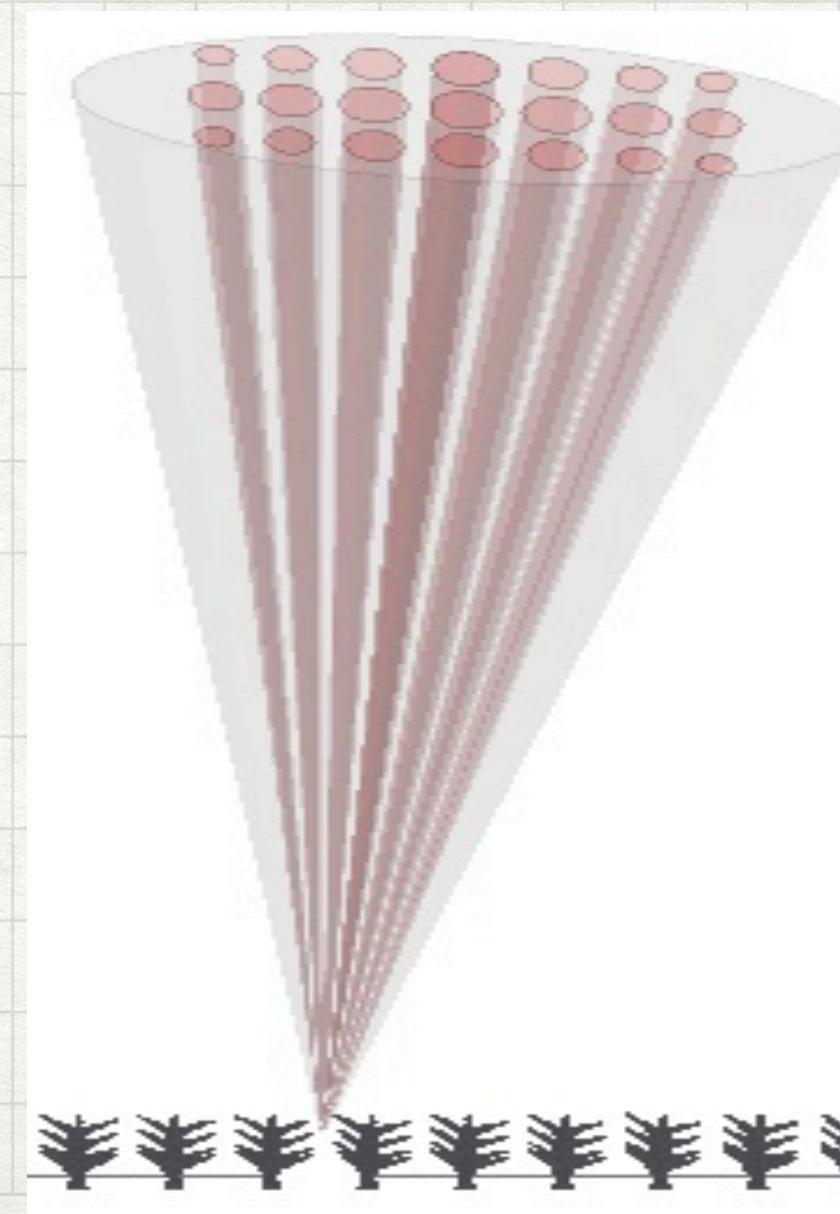
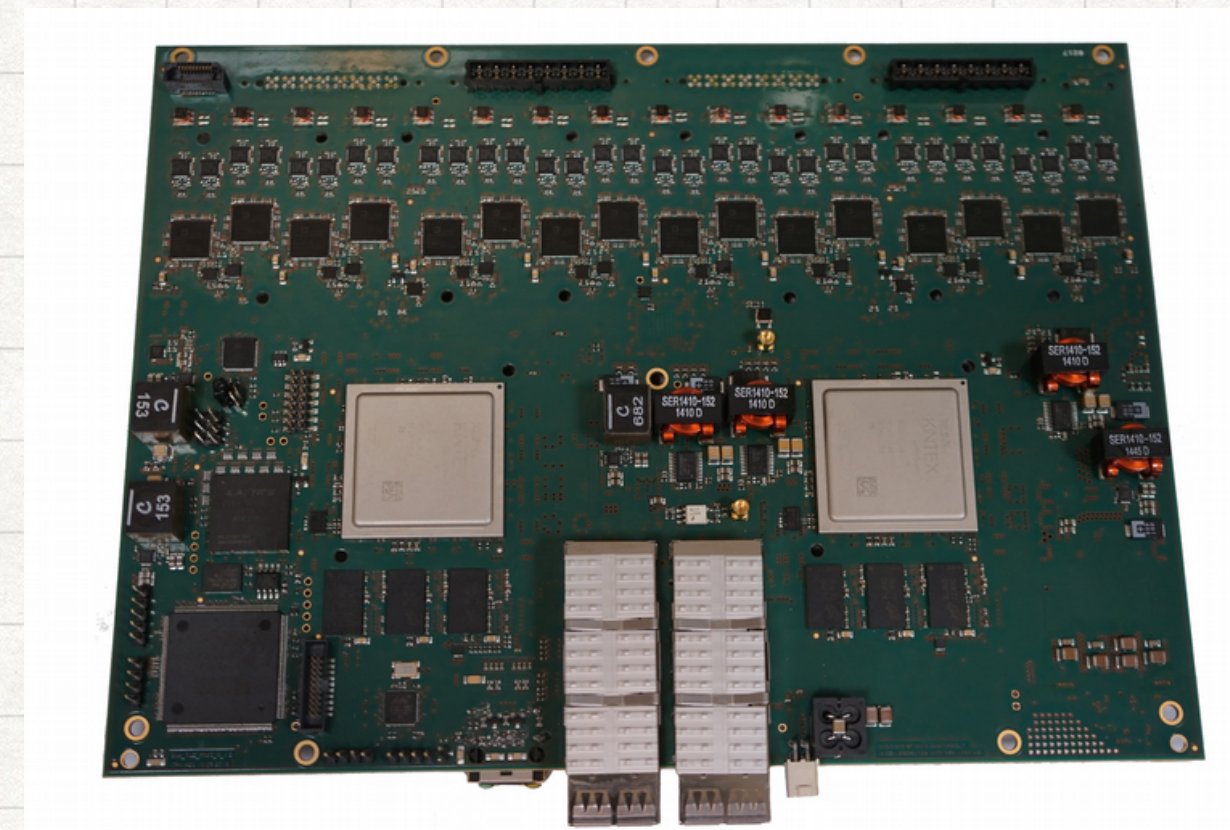
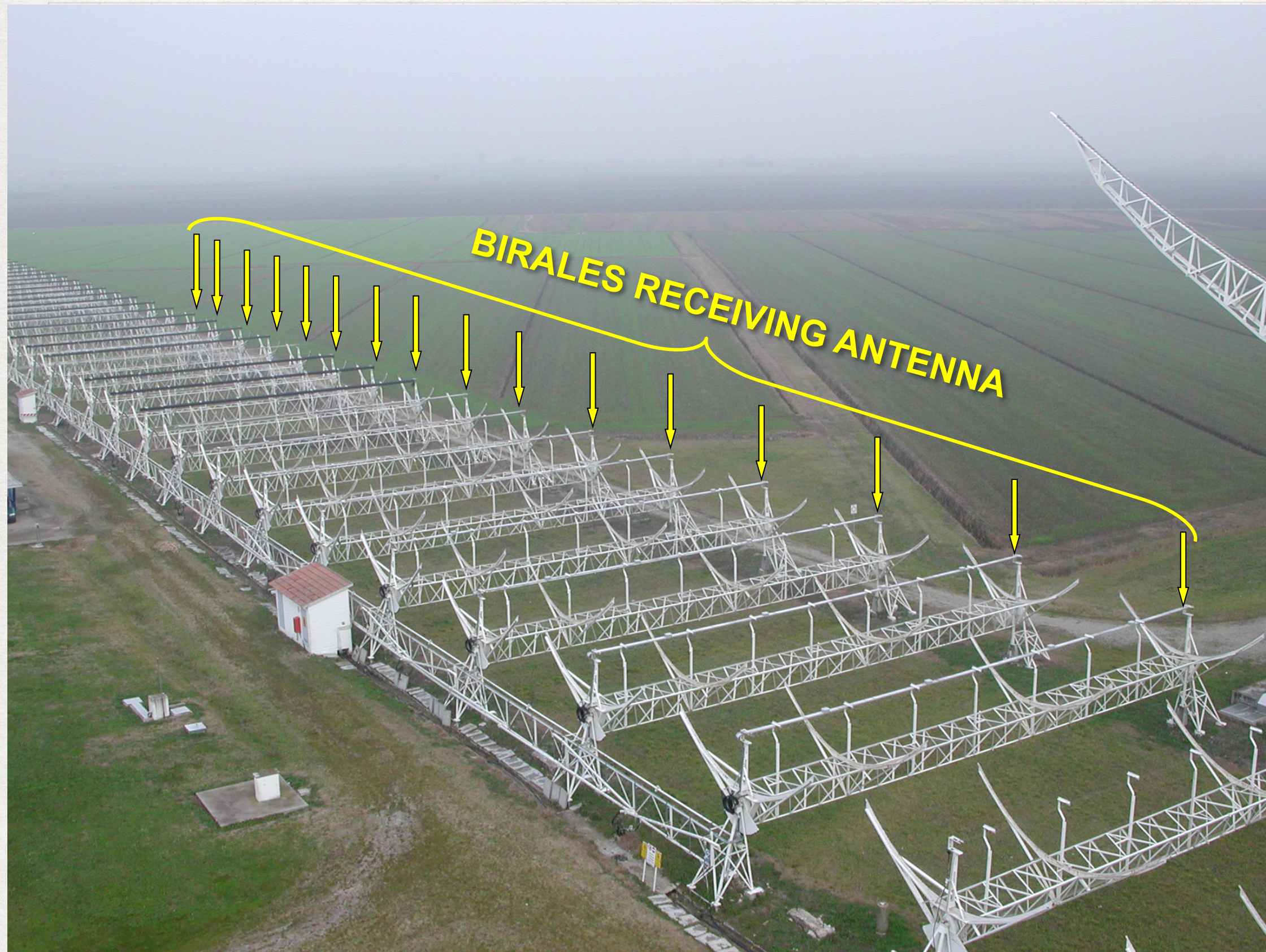
THE TEAM



- + Bortolotti, Maccaferri, Mattana, Perini, Roma, Schiaffino
- + Locatelli, Ridolfi, Dalla Casa, Michilli, Tavani, Verrecchia

THE NC-FRB PROJECT

TECHNOLOGICAL ADVANCEMENTS



N. of frequency channels	1024
Channel width	781.25 kHz
Time resolution	1.08 μ s

Multibeam beamformer

N. bits	16 complex
N. channels	384
N. beams	4
Max. time resolution	69.12 μ s
Max. throughput	355.56 Mb/s

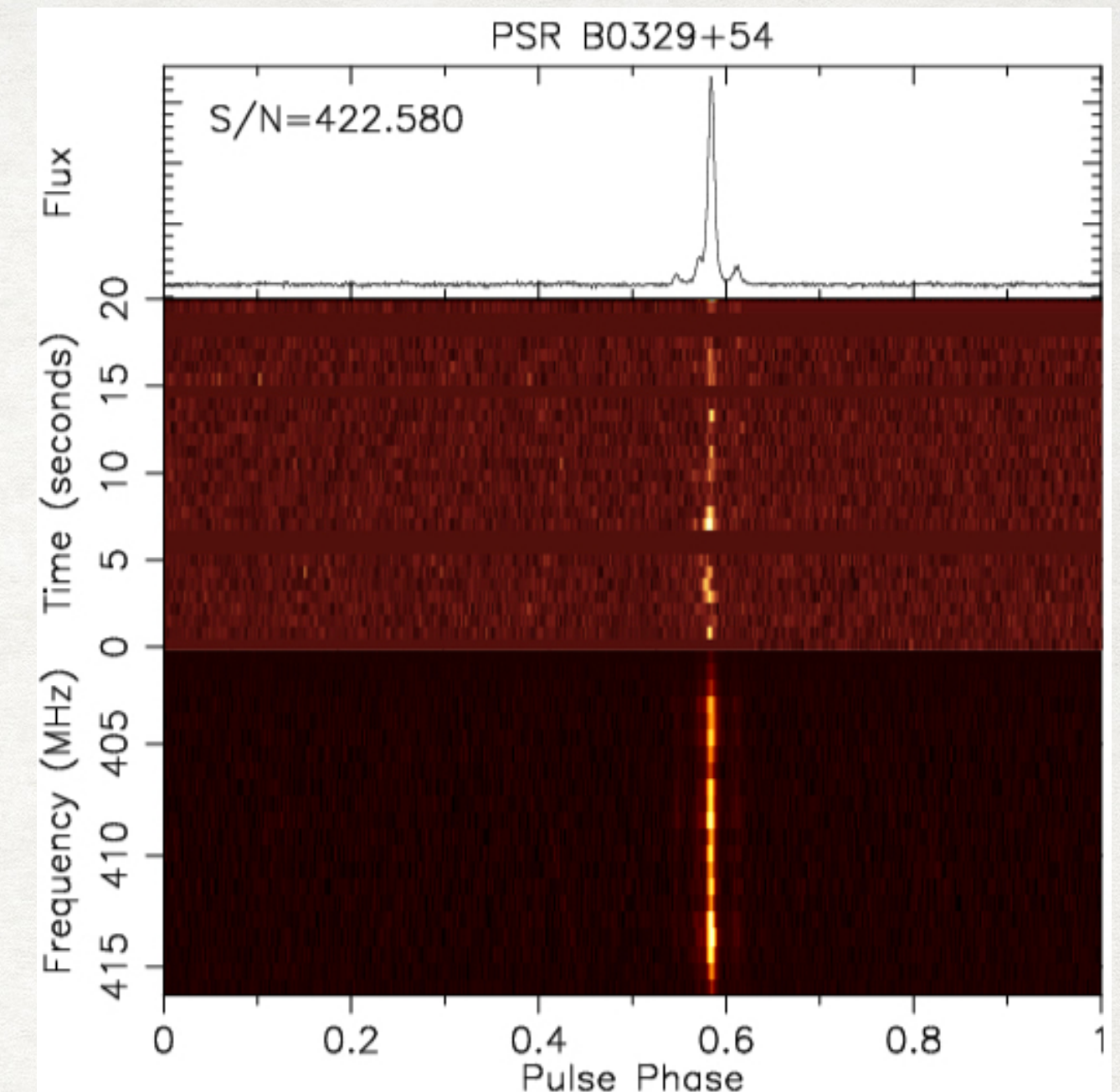
Single beam beamformer

N. bits	16 complex
N. channels	21
Throughput	311.11 Mb/s

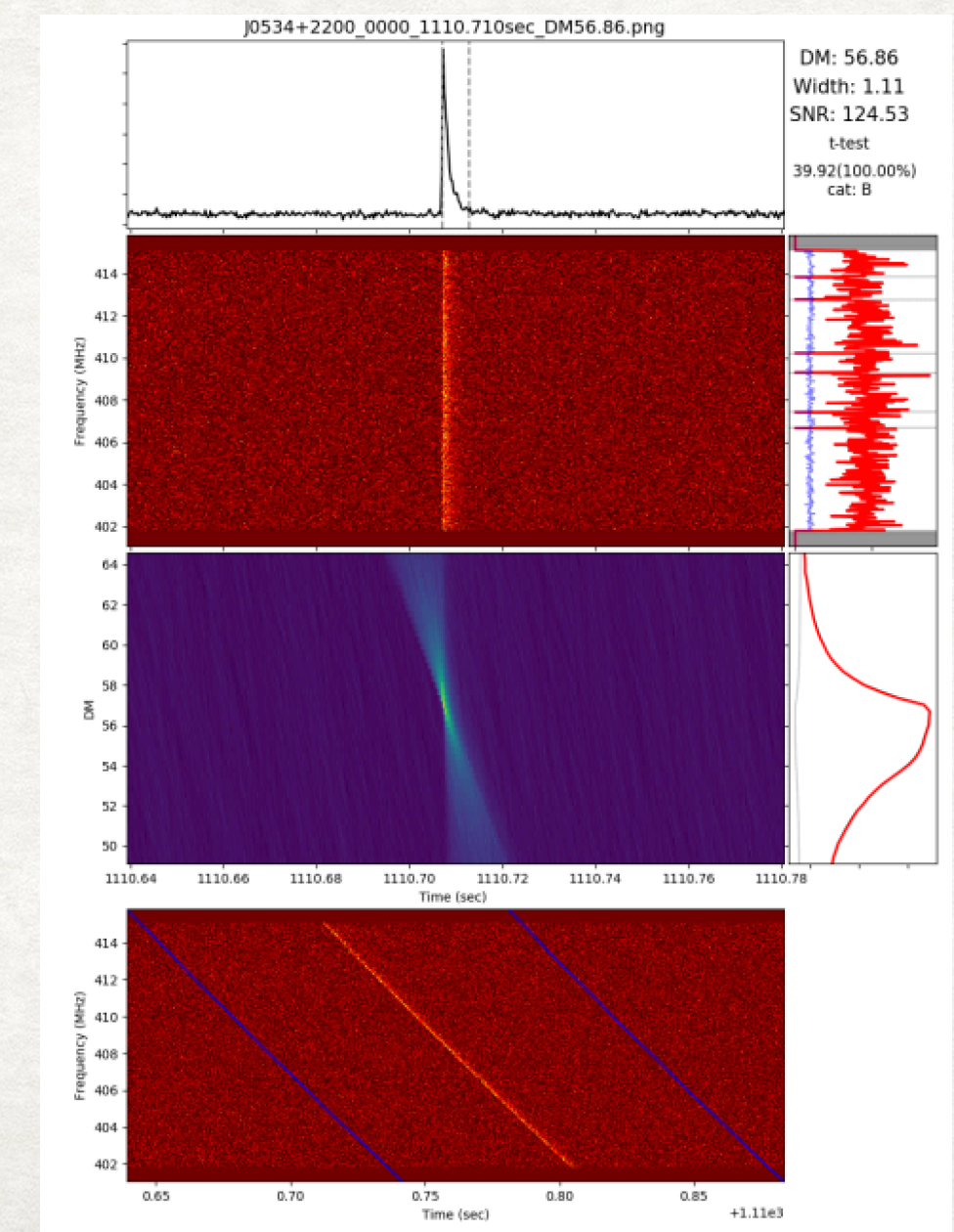
Locatelli et al. 2020

THE NC-FRB PROJECT OBSERVATIONS

- PSR B0329+54, Crab pulsar, other pulsars (system validation)
- FRB 180916 (ongoing monitoring since Jan. 2020, MWL synergy)
- FRB 20200120E (closest localised FRB)
- FRB 20201124A (close-by, very active)
- FRB 181030 (one of the closest repeaters)
- SGR 1935+2154 (active Galactic radio magnetar)



Locatelli et al. 2020



PUBLICATIONS

The Northern Cross fast radio burst project – I. Overview and pilot observations at 408 MHz

Nicola T Locatelli ✉, Gianni Bernardi, Germano Bianchi, Riccardo Chiello, Alessio Magro, Giovanni Naldi, Maura Pilia, Giuseppe Pupillo, Alessandro Ridolfi, Giancarlo Setti, Franco Vazza

Monthly Notices of the Royal Astronomical Society, Volume 494, Issue 1, May 2020, Pages 1229–1236, <https://doi.org/10.1093/mnras/staa813>

THE ASTROPHYSICAL JOURNAL LETTERS, 893:L42 (8pp), 2020 April 20
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<https://doi.org/10.3847/2041-8213/ab86b1>



Gamma-Ray and X-Ray Observations of the Periodic-repeater FRB 180916 during Active Phases

M. Tavani^{1,2}, F. Verrecchia^{3,4}, C. Casentini^{1,5}, M. Perri^{3,4}, A. Ursi¹, L. Pacciani¹, C. Pittori^{3,4}, A. Bulgarelli⁶, G. Piano¹, M. Pilia⁷, G. Bernardi^{8,9}, A. Addis⁶, L. A. Antonelli⁴, A. Argan¹, L. Baroncelli^{6,10}, P. Caraveo^{11,12}, P. W. Cattaneo¹², A. Chen¹³, E. Costa¹, G. Di Persio¹, I. Donnarumma¹⁴, Y. Evangelista¹, M. Feroci¹, A. Ferrari¹⁵, V. Fioretti⁶, F. Lazzarotto¹⁶, F. Longo¹⁷, A. Morselli⁵, F. Paoletti^{1,18}, N. Parmiggiani^{6,19}, A. Trois⁷, S. Vercellone²⁰, G. Naldi⁸, G. Pupillo⁸, G. Bianchi⁸, and S. Puccetti¹⁴

THE ASTROPHYSICAL JOURNAL LETTERS, 896:L40 (11pp), 2020 June 20
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<https://doi.org/10.3847/2041-8213/ab96c0>



The Lowest-frequency Fast Radio Bursts: Sardinia Radio Telescope Detection of the Periodic FRB 180916 at 328 MHz

M. Pilia¹, M. Burgay¹, A. Possenti^{1,2}, A. Ridolfi^{1,3}, V. Gajjar⁴, A. Corongiu¹, D. Perrodin¹, G. Bernardi^{5,6,7}, G. Naldi⁵, G. Pupillo⁵, F. Ambrosino^{8,9}, G. Bianchi⁵, A. Burtovoi^{10,11}, P. Casella¹², C. Casentini^{8,13}, M. Cecconi¹⁴, C. Ferrigno¹⁵, M. Fiori¹⁶, K. C. Gendreau¹⁷, A. Ghedina¹⁴, G. Naletto^{11,16}, L. Nicastro¹⁸, P. Ochner^{11,16}, E. Palazzi¹⁸, F. Panessa⁸, A. Papitto¹², C. Pittori^{12,19}, N. Rea^{20,21}, G. A. Rodriguez Castillo¹², V. Savchenko¹⁵, G. Setti^{5,22}, M. Tavani^{8,23}, A. Trois¹, M. Trudu^{1,2}, M. Turatto¹¹, A. Ursi⁸, F. Verrecchia^{12,19}, and L. Zampieri¹¹

Multifrequency observations of SGR J1935+2154

M Bailes, C G Bassa, G Bernardi, S Buchner, M Burgay, M Caleb, A J Cooper, G Desvignes, P J Groot, I Heywood, F Jankowski, R Karuppusamy, M Kramer, M Malenta, G Naldi, M Pilia, G Pupillo, K M Rajwade, L Spitler, M Surnis, B W Stappers ✉, A Addis, S Bloemen, M C Bezuidenhout, G Bianchi, D J Champion, W Chen, L N Driessen, M Geyer, K Gourdji, J W T Hessels, V I Kondratiev, M Klein-Wolt, E Körding, R Le Poole, K Liu, M E Lower, A G Lyne, A Magro, V McBride, M B Mickaliger, V Morello, A Parthasarathy, K Paterson, B B P Perera, D L A Pieterse, Z Pleunis, A Possenti, A Rowlinson, M Serylak, G Setti, M Tavani, R A M J Wijers, S ter Veen, V Venkatraman Krishnan, P Vreeswijk, P A Woudt

Monthly Notices of the Royal Astronomical Society, Volume 503, Issue 4, June 2021, Pages 5367–5384, <https://doi.org/10.1093/mnras/stab749>

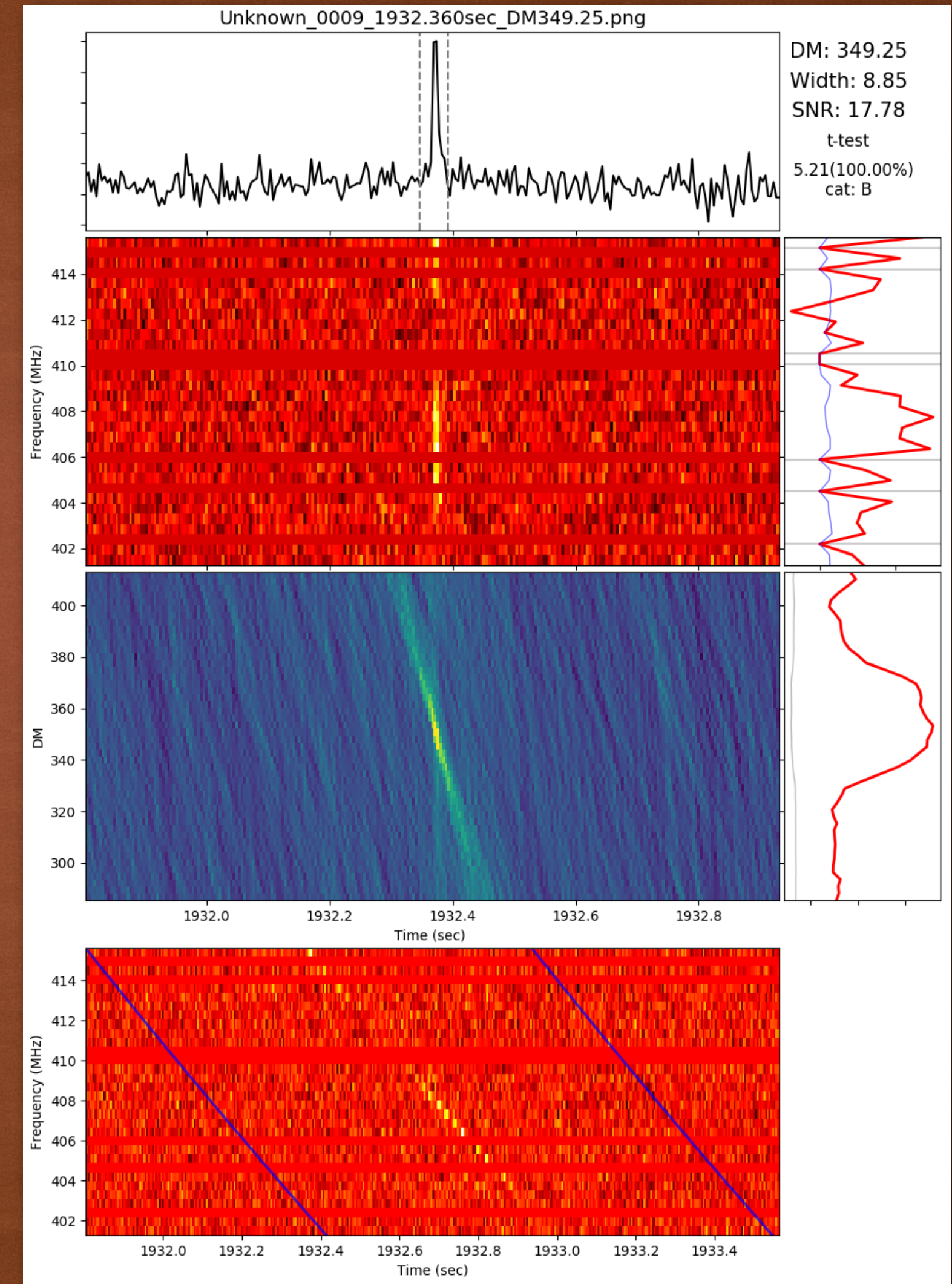
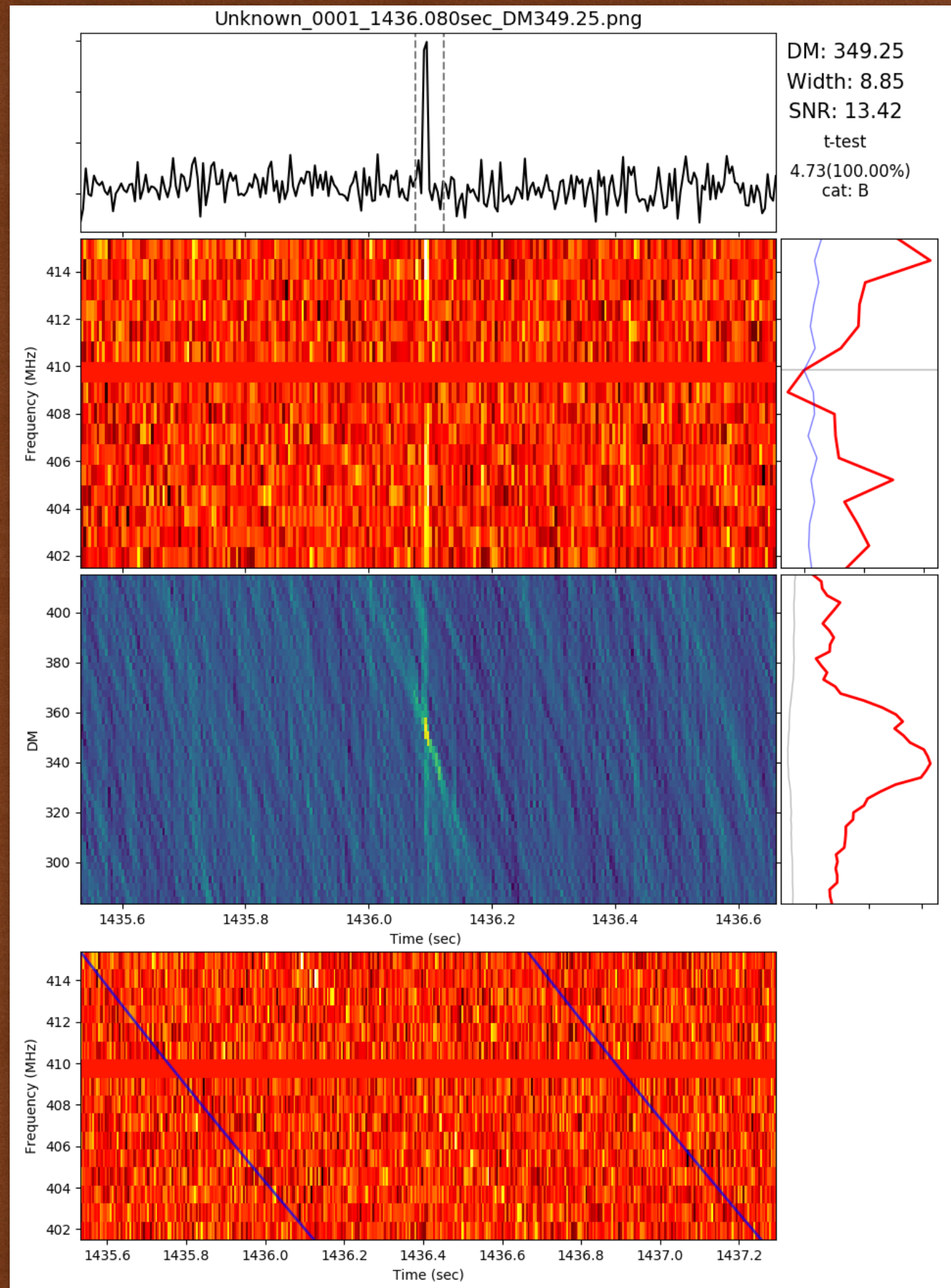
Article | Published: 18 February 2021

An X-ray burst from a magnetar enlightening the mechanism of fast radio bursts

M. Tavani ✉, C. Casentini, A. Ursi, F. Verrecchia, A. Addis, L. A. Antonelli, A. Argan, G. Barbiellini, L. Baroncelli, G. Bernardi, G. Bianchi, A. Bulgarelli, P. Caraveo, M. Cardillo, P. W. Cattaneo, A. W. Chen, E. Costa, E. Del Monte, G. Di Cocco, G. Di Persio, I. Donnarumma, Y. Evangelista, M. Feroci, A. Ferrari, V. Fioretti, F. Fuschino, M. Galli, F. Gianotti, A. Giuliani, C. Labanti, F. Lazzarotto, P. Lipari, F. Longo, F. Lucarelli, A. Magro, M. Marisaldi, S. Mereghetti, E. Morelli, A. Morselli, G. Naldi, L. Pacciani, N. Parmiggiani, F. Paoletti, A. Pellizzoni, M. Perri, F. Perotti, G. Piano, P. Picozza, M. Pilia, C. Pittori, S. Puccetti, G. Pupillo, M. Rapisarda, A. Rappoldi, A. Rubini, G. Setti, P. Soffitta, M. Trifoglio, A. Trois, S. Vercellone, V. Vittorini, P. Giommi & F. D'Amico -Show fewer authors

Nature Astronomy 5, 401–407 (2021) | [Cite this article](#)

FIRST RESULTS



WHERE ARE WE
GOING?

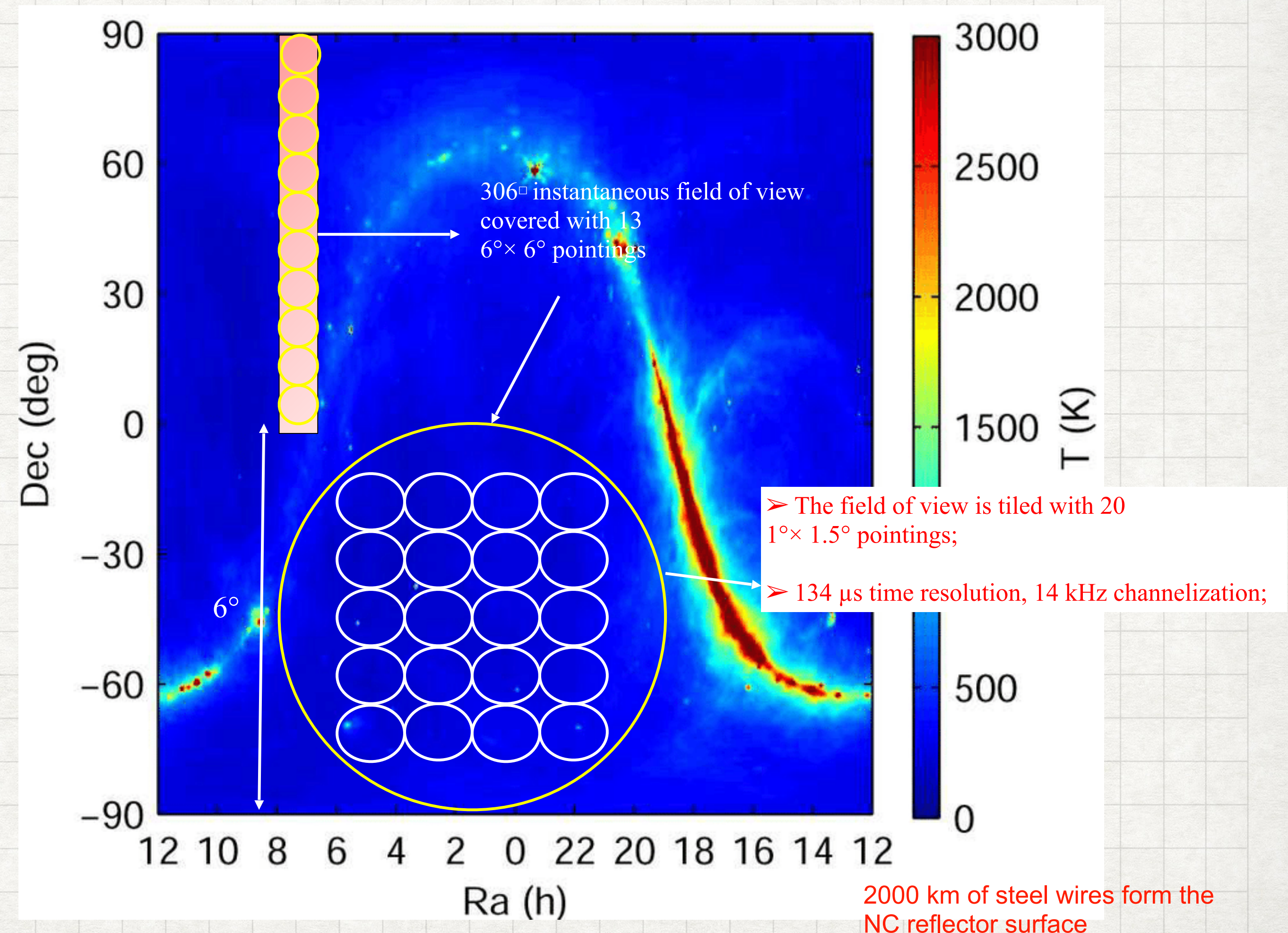
HW/SW UPGRADES

- Mid 2021: 6 -> 8 cylinders
- End 2021: 8 -> 16 cylinders
- Fall 2022: 16 -> 32 cylinders
- End 2023: 32 -> 64 cylinders



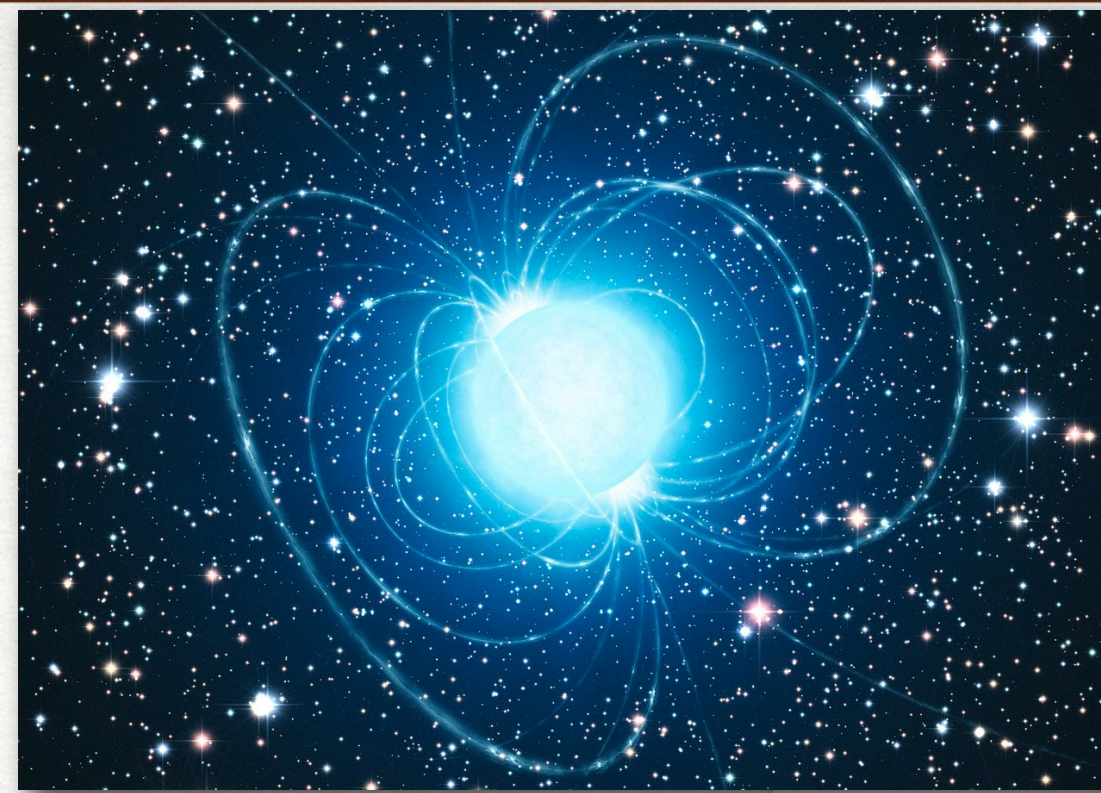
OBSERVATIONAL UPGRADES

- Monitoring of active/interesting repeaters + galactic magnetars (ongoing)
- Monitoring of nearby galaxies (starting end 2021)
- Blind survey (end 2022)
- Synergies with LOFAR (2023)



Locatelli et al. 2020

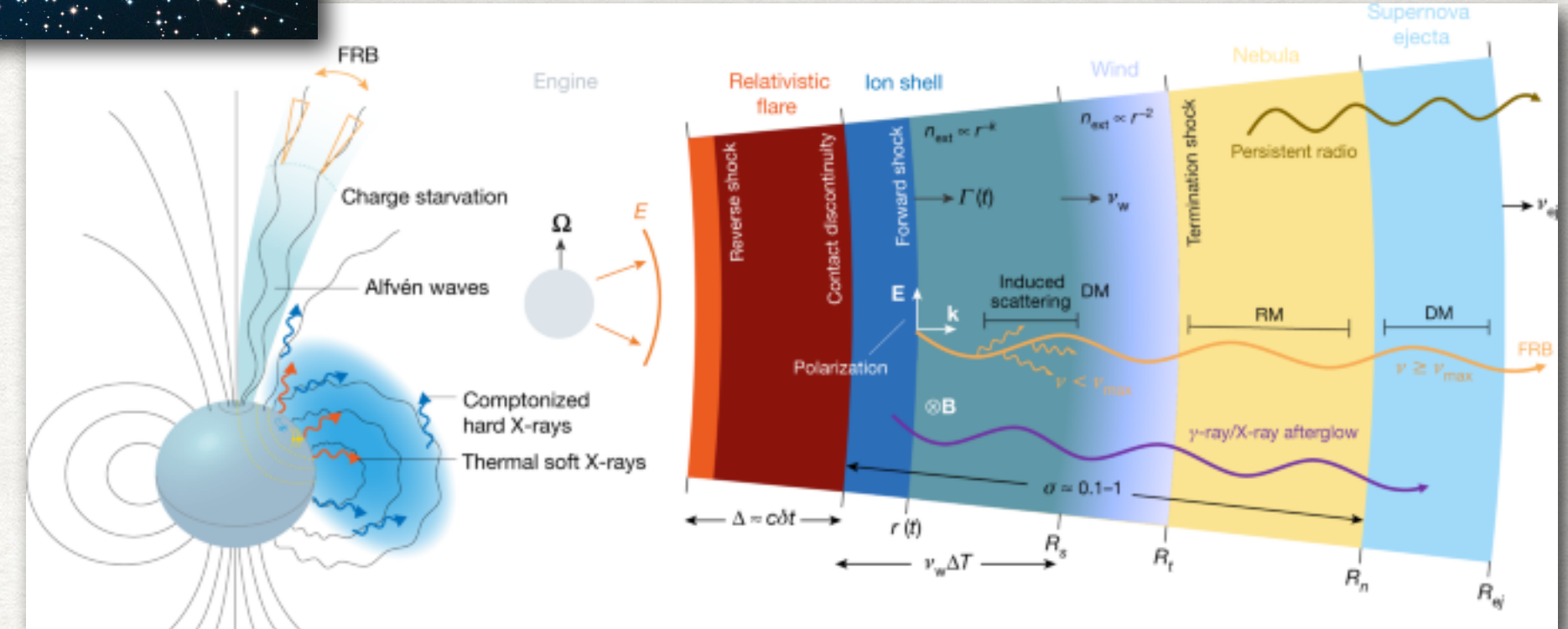
**TAKE HOME
MESSAGES**



- FRBs will be key science for the SKA

- Open questions:

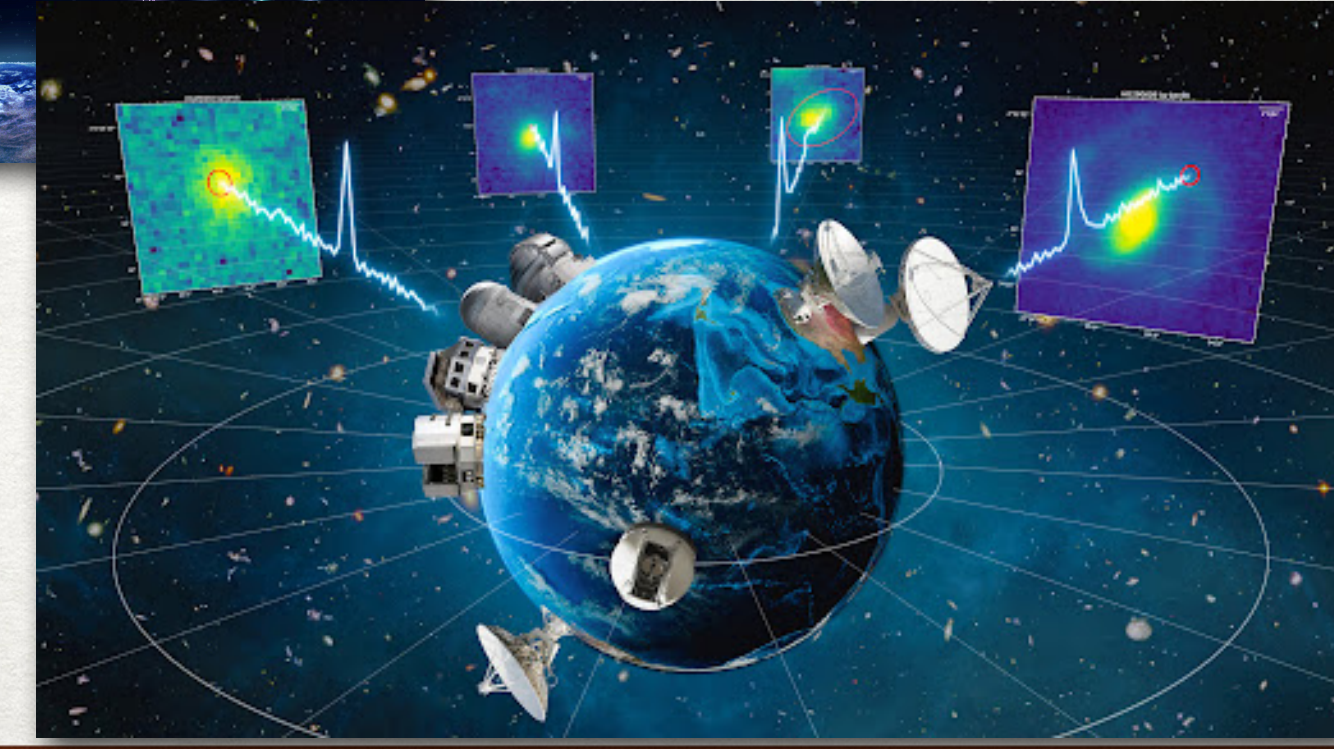
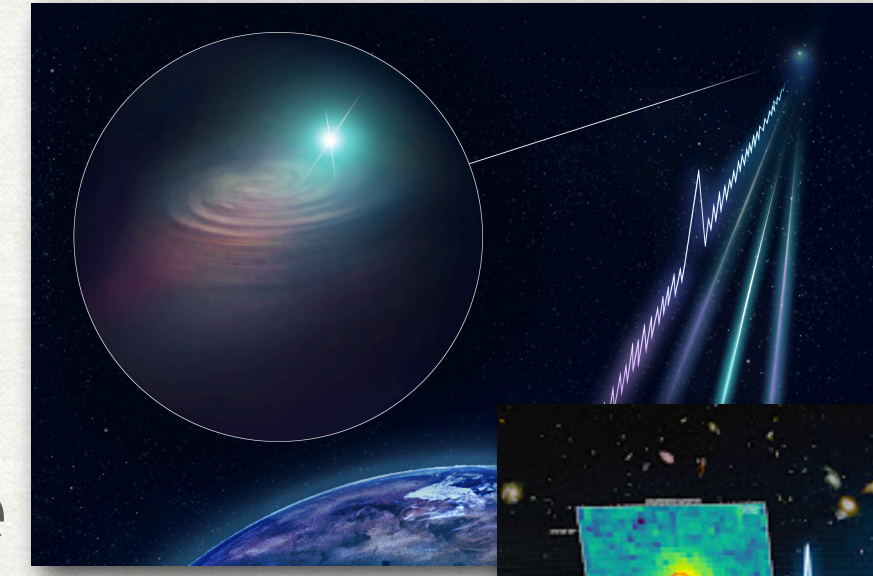
- What are FRBs?
- Are there one or multiple classes of them?



- What's the relation between the progenitor and its ambient medium?

- Key answers:

- Unique probes of matter distribution in the Universe
- Localisation of many FRBs



- The NC can be fully dedicated to FRBs with flexibility on the choice of targets or operating mode
- The NC can provide large on-sky time complementary to CHIME's
- We are building in-house technical expertise on big-data challenges
- We are building in-house scientific expertise on time domain astronomy with beam formed data

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Thank you!