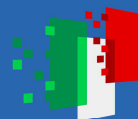




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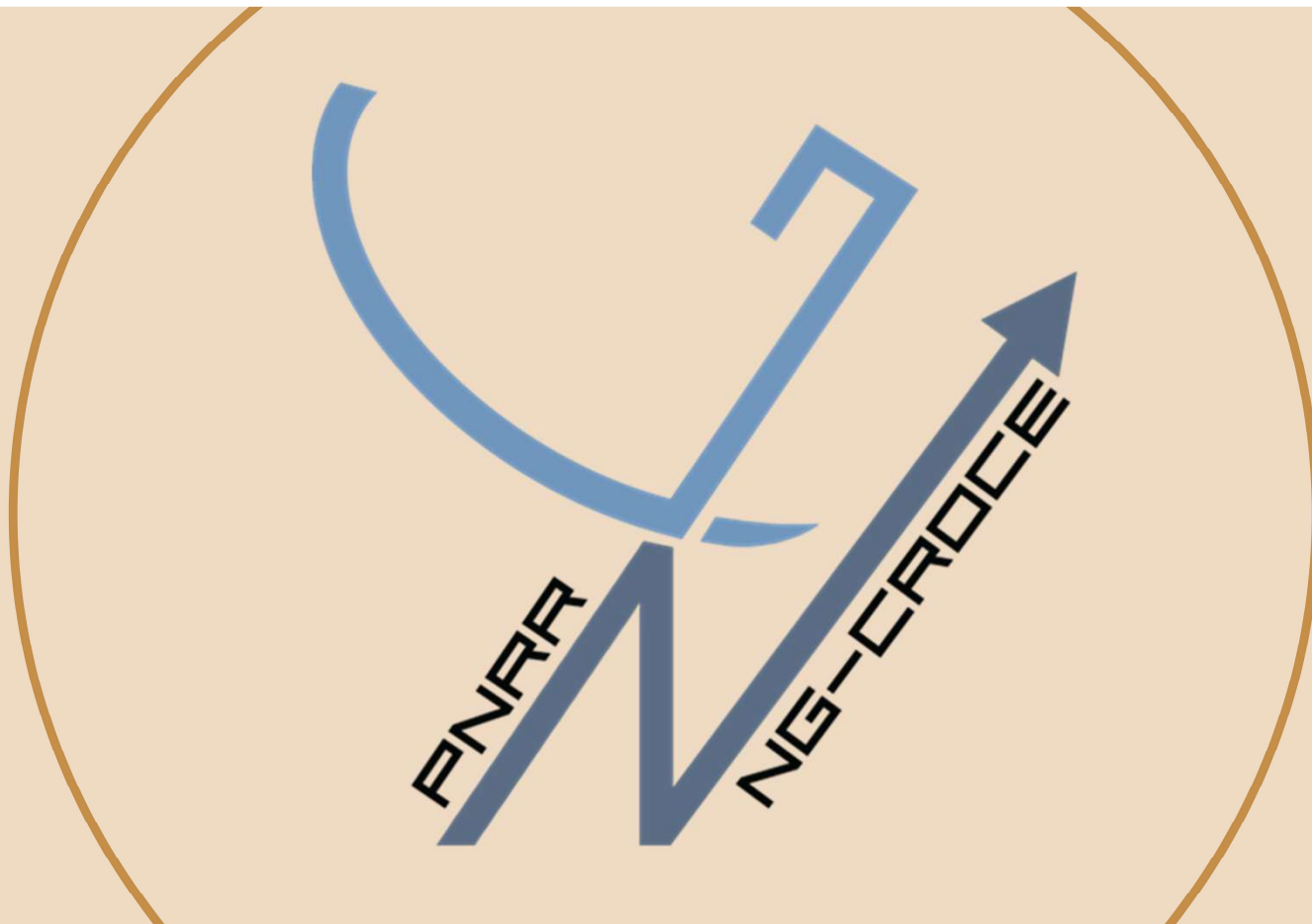
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DI ASTRONOMIA

Fast radio bursts in the 2020s: science review and the opportunity for the Northern Cross

Final Meeting

Martedì 30 Giugno – Giovedì 02 Luglio

OAC - Osservatorio Astrofisico di Arcetri





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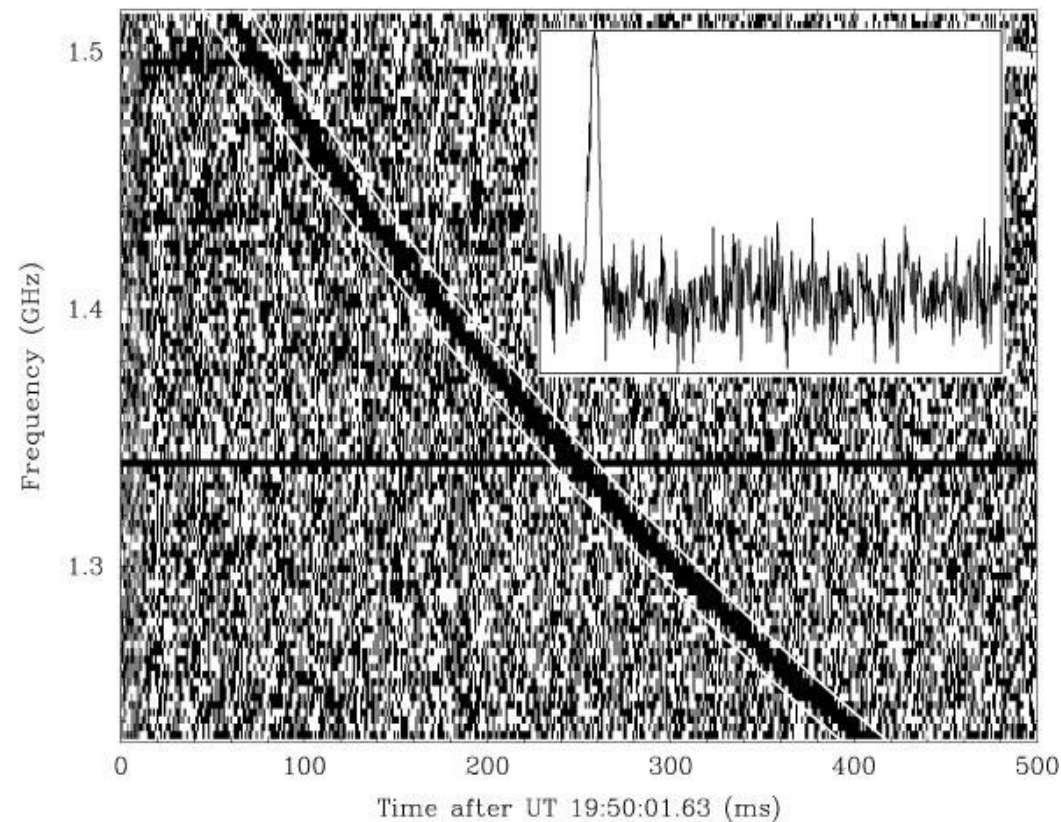
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Fast Radio Bursts in 2008



ms-long, 30 Jy @ 1.4 GHz
dispersed event “only” visible at
radio wavelengths

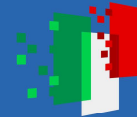
the Adam of FRBs (Lorimer et al. 2008)



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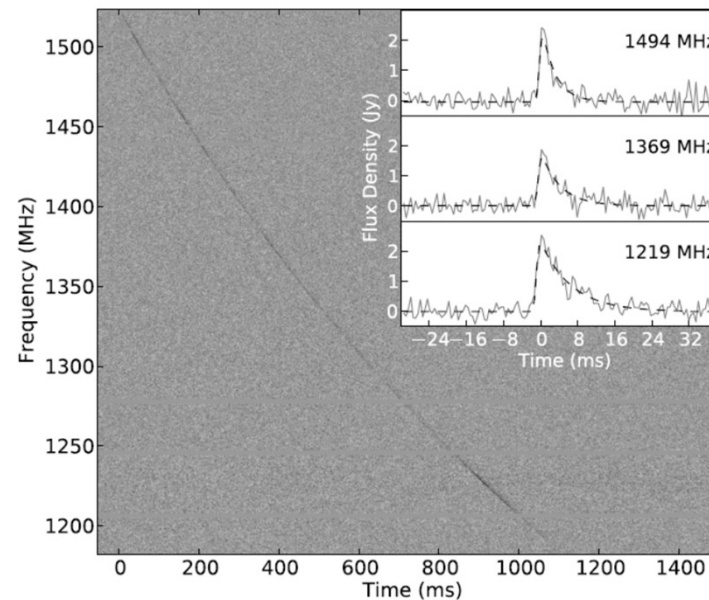
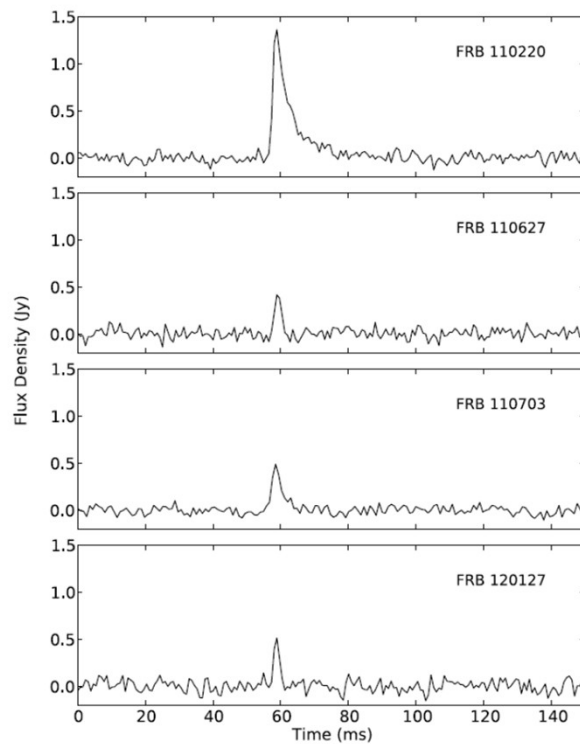


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Fast Radio Bursts in 2013: final confirmation!



Four new bursts found in a recent
Parkes pulsar survey

$550 < DM < 1100 \text{ pc cm}^{-3}$

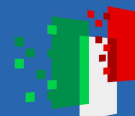
Thornton et al. (2013)



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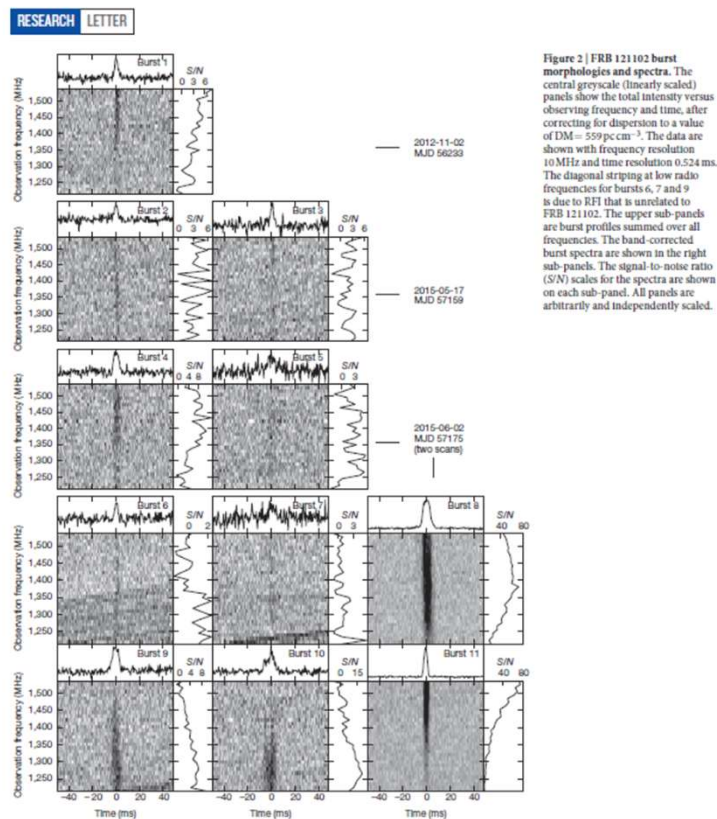
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Fast Radio Bursts in 2013: they repeat! FRB 111202



Ten new bursts found!

Now... ~1650 bursts by FAST!!!

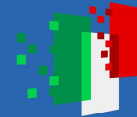
Spitler et al. (2013); Zhang et al. (2021)



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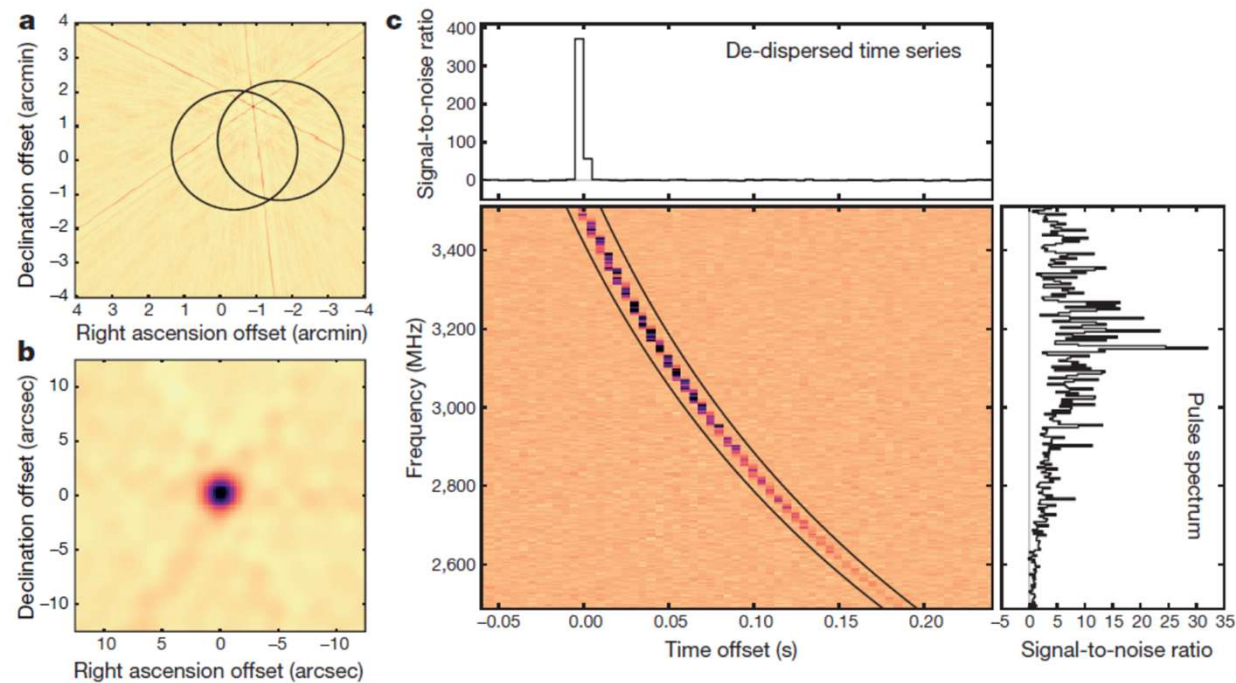


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Fast Radio Bursts in 2017: the first localization! FRB 111202



Chatterjee et al. (2017)



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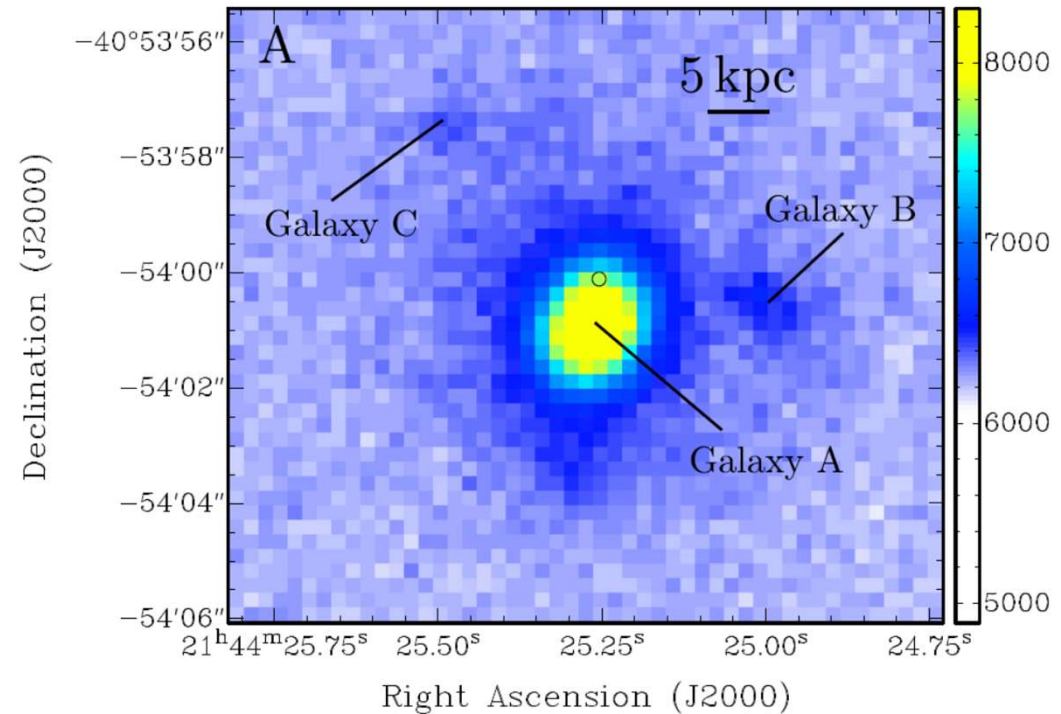
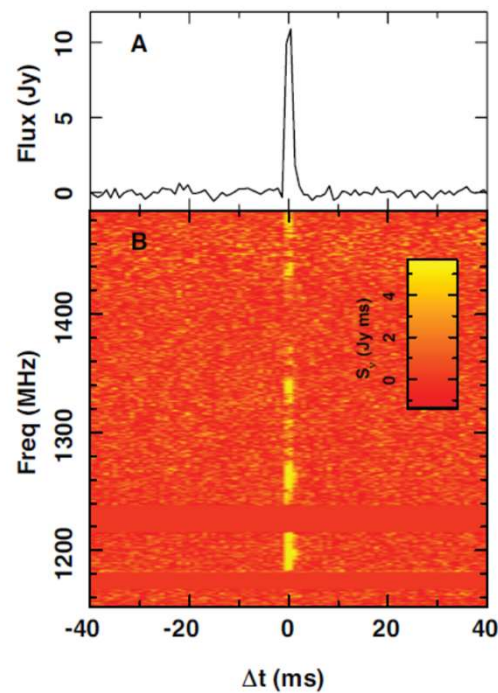
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Fast Radio Bursts in 2019: localization of the first non repeating FRB 180924



$z = 0.32$

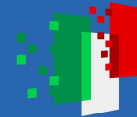
Bannister et al. (2019)



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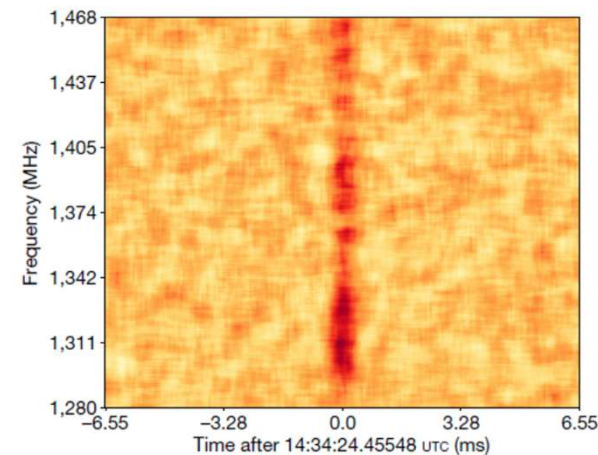
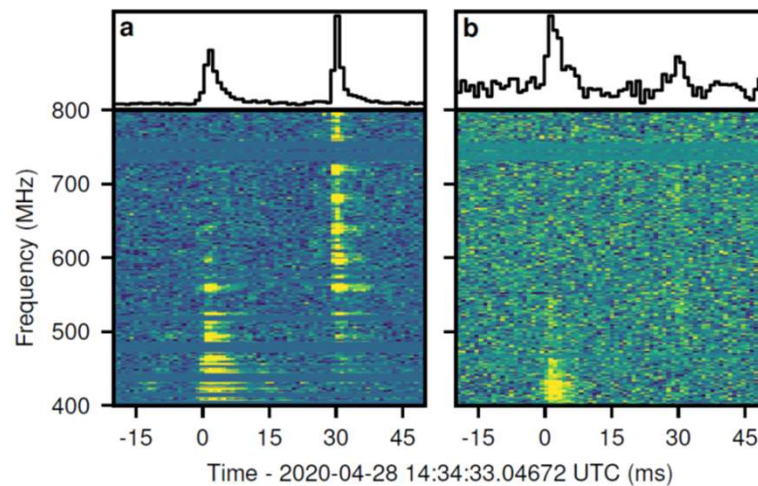


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Fast Radio Bursts in 2020: the first FRB-magnetar association

- SGR 1935+2154; $P = 3.24$ s, $B \sim 2.2 \times 10^{14}$ G;
- A forest of X-ray bursts started on April 24th 2020;
- Radio bursts detected on April 28th at 400-800 MHz and 1400 MHz with ~ 700 kJy ms and 1.5 MJy ms fluence – simultaneous to an X-ray burst;



Bochenek et al. (2020);
CHIME Collaboration
(2020)



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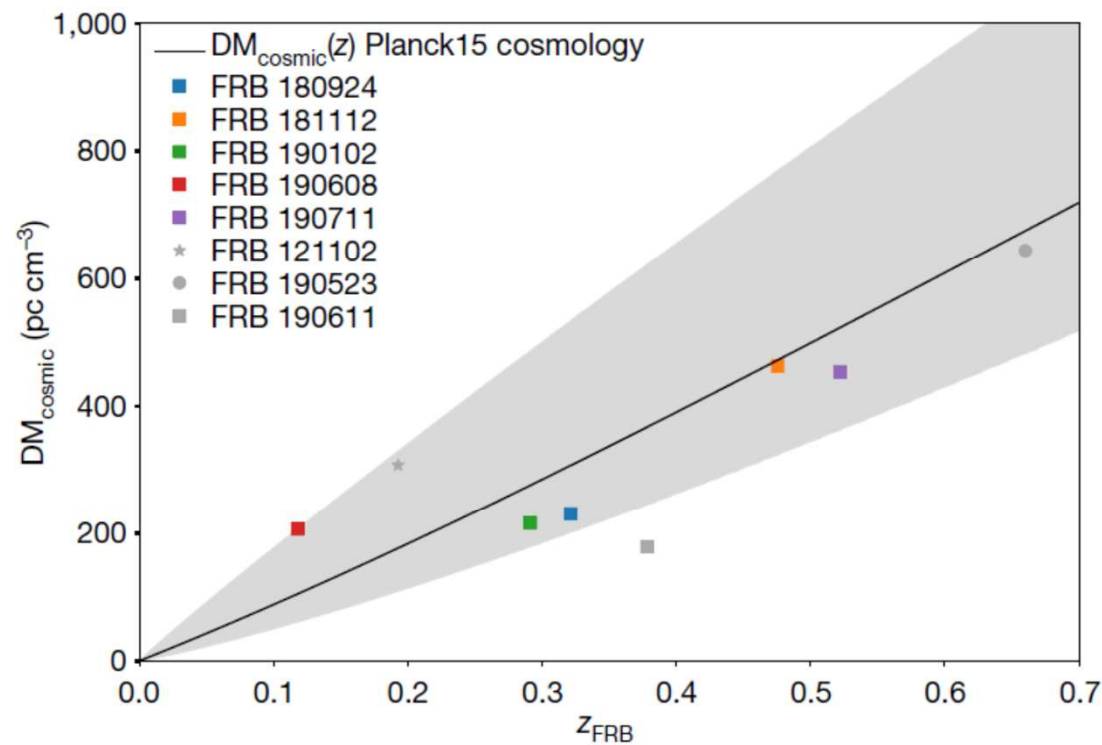


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Fast Radio Bursts in 2020: cosmology with FRBs



$$DM_{\text{FRB}}(z) = DM_{\text{MW,ISM}} + DM_{\text{MW,halo}} + DM_{\text{cosmic}}(z) + DM_{\text{host}}(z)$$

$$\langle DM_{\text{cosmic}} \rangle = \int_0^{z_{\text{FRB}}} \frac{c \bar{n}_e(z) dz}{H_0 (1+z)^2 \sqrt{\Omega_m (1+z)^3 + \Omega_\Lambda}}$$

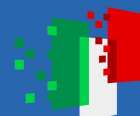
Macquart et al. (2020)



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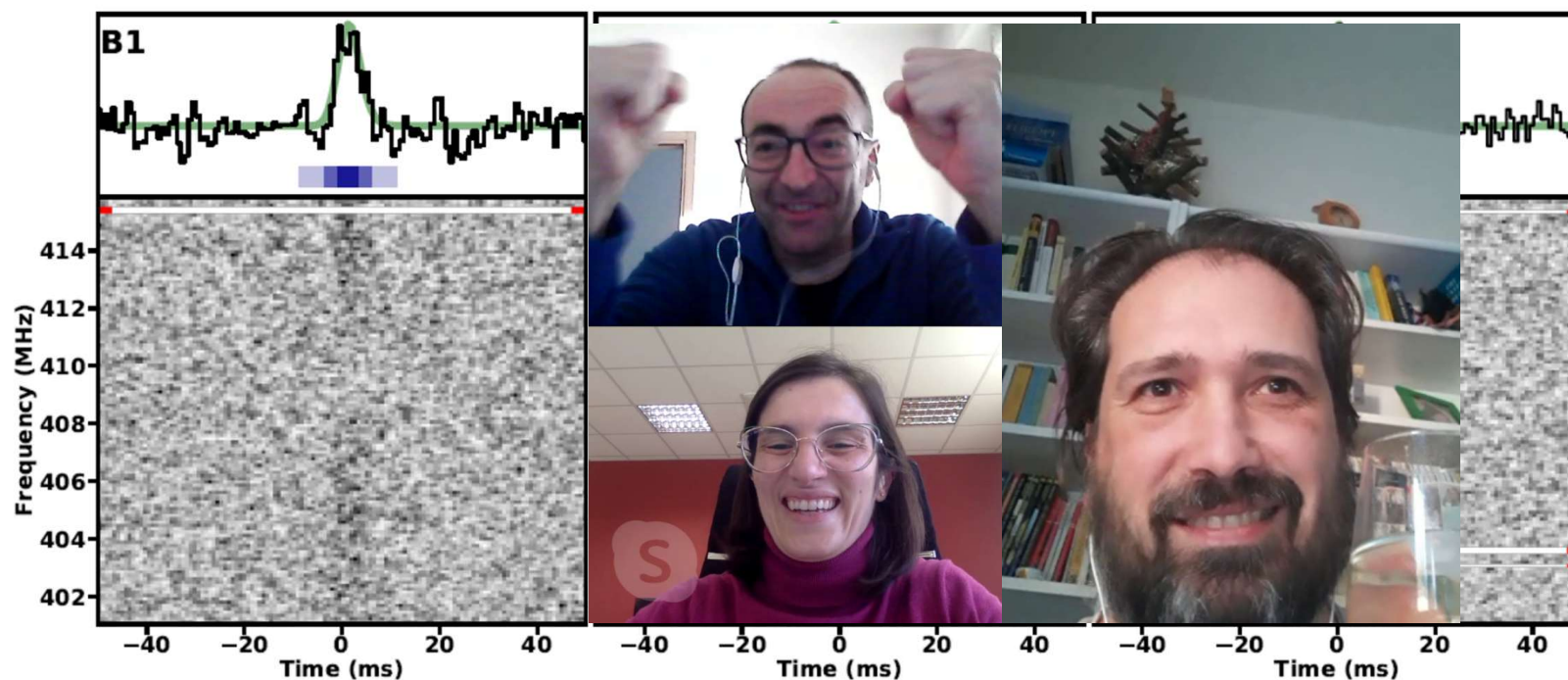


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Fast Radio Bursts in 2020: the Northern Cross joins the game

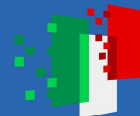




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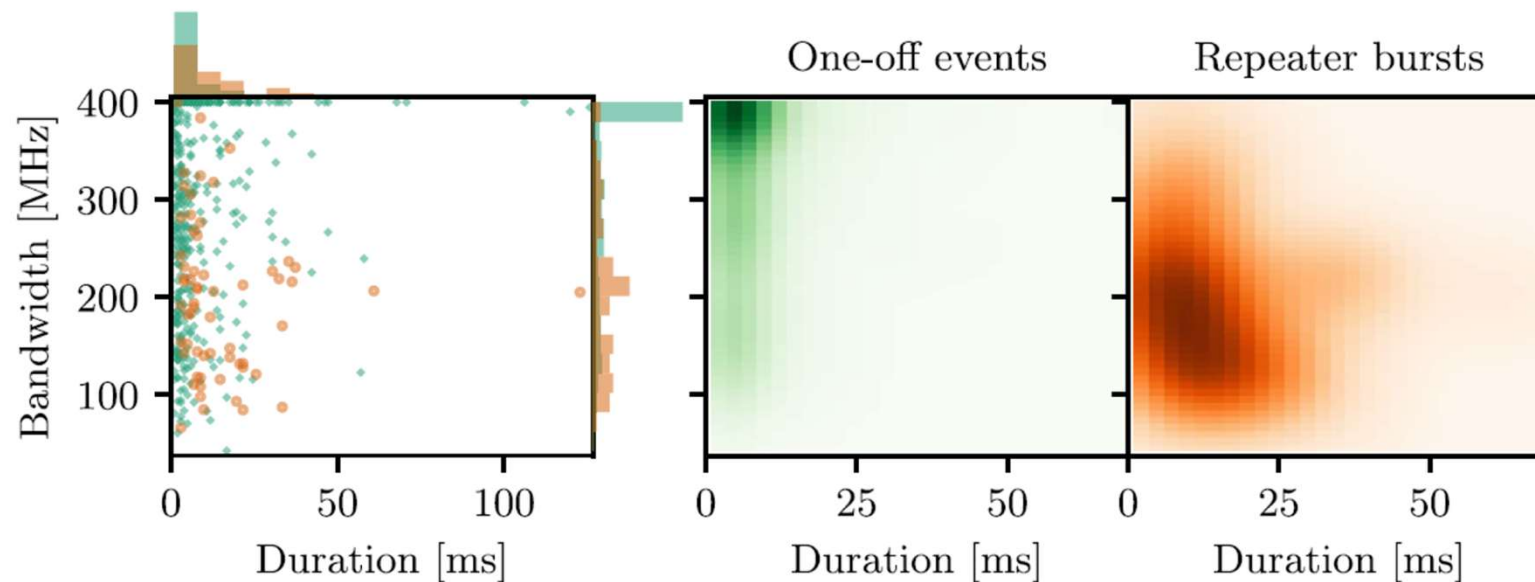


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Fast Radio Bursts in 2021: the first large catalogue



Population studies!

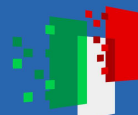
The CHIME collaboration
(2021);, Pleunis et al. (2021)



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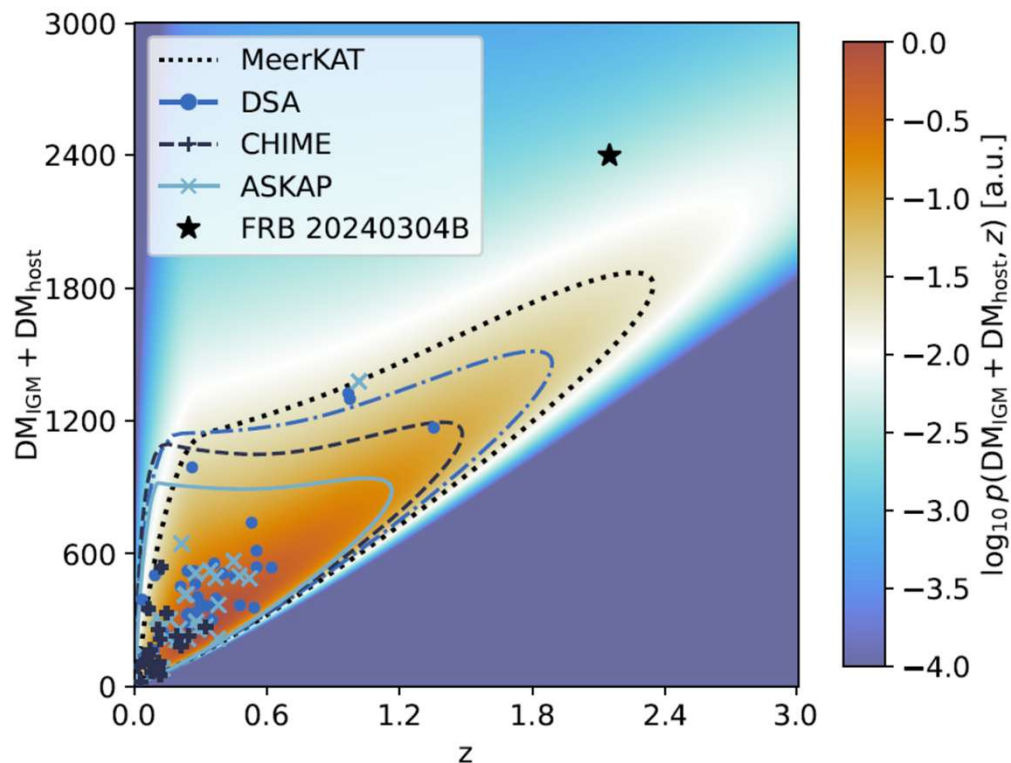
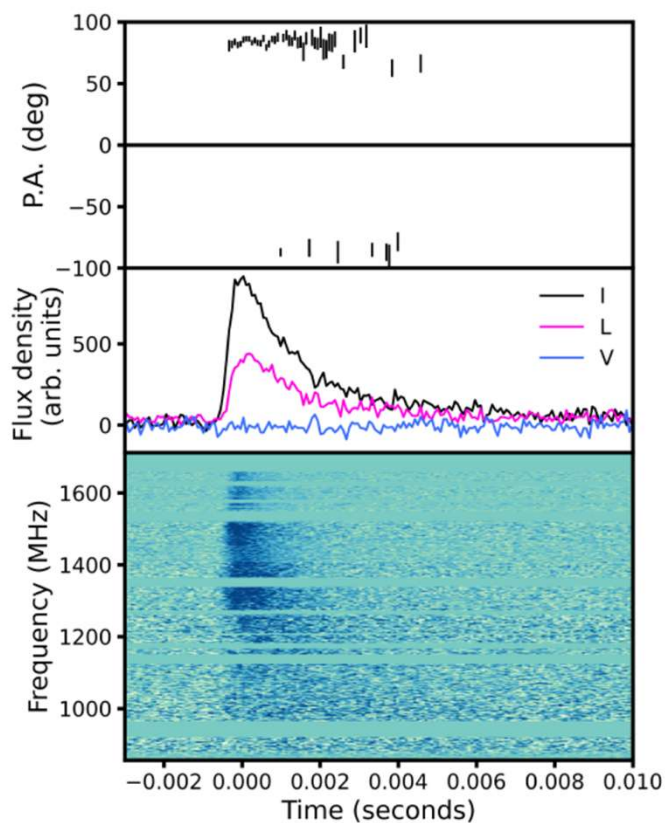


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Fast Radio Bursts in 2025/2026: an FRB @ $z = 2.148$



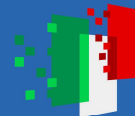
Caleb et al. (2026)



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Fast Radio Bursts in the 2020s: a paradigm shift from discovery and understanding FRBs to population studies and probes

- More numbers, leading towards 10000+ FRBs;
- Cosmological probes;
- High redshift Universe;



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Fast Radio Bursts in the 2020s: a paradigm shift from discovery and understanding FRBs to population studies and probes

- More numbers, leading towards 10000+ FRBs → collecting area, sky time



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Fast Radio Bursts in the 2020s: a paradigm shift from discovery and understanding FRBs to population studies and probes



CHIME

4 cylinders, 100m x 20m, ~8000 sqm;

400 - 800 MHz instantaneous bandwidth;

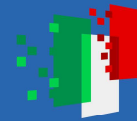
Key factor: correlates the individual elements, placing ~1000 simultaneous beams on the sky, covering ~200 square degrees



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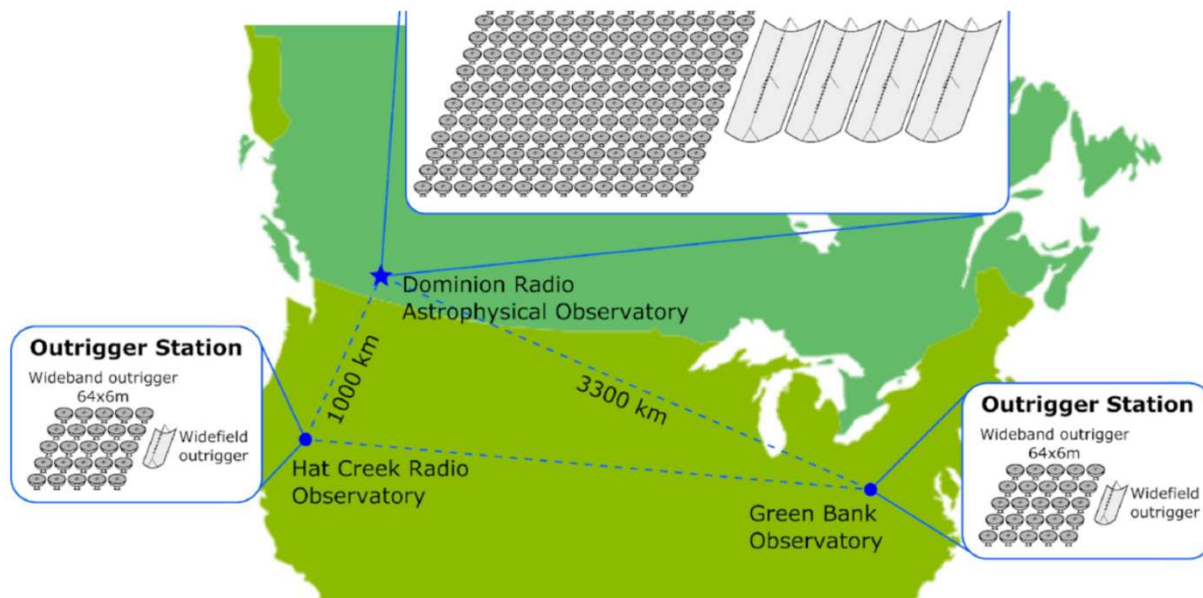
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Fast Radio Bursts in the 2020s: a paradigm shift from discovery and understanding FRBs to population studies and probes



→ collecting area, sky time

CHORD



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Fast Radio Bursts in the 2020s: a paradigm shift from discovery and understanding FRBs to population studies and probes

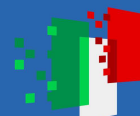
- More numbers, leading towards 10000+ FRBs;
- Cosmological probes → collecting area, sky time, localization



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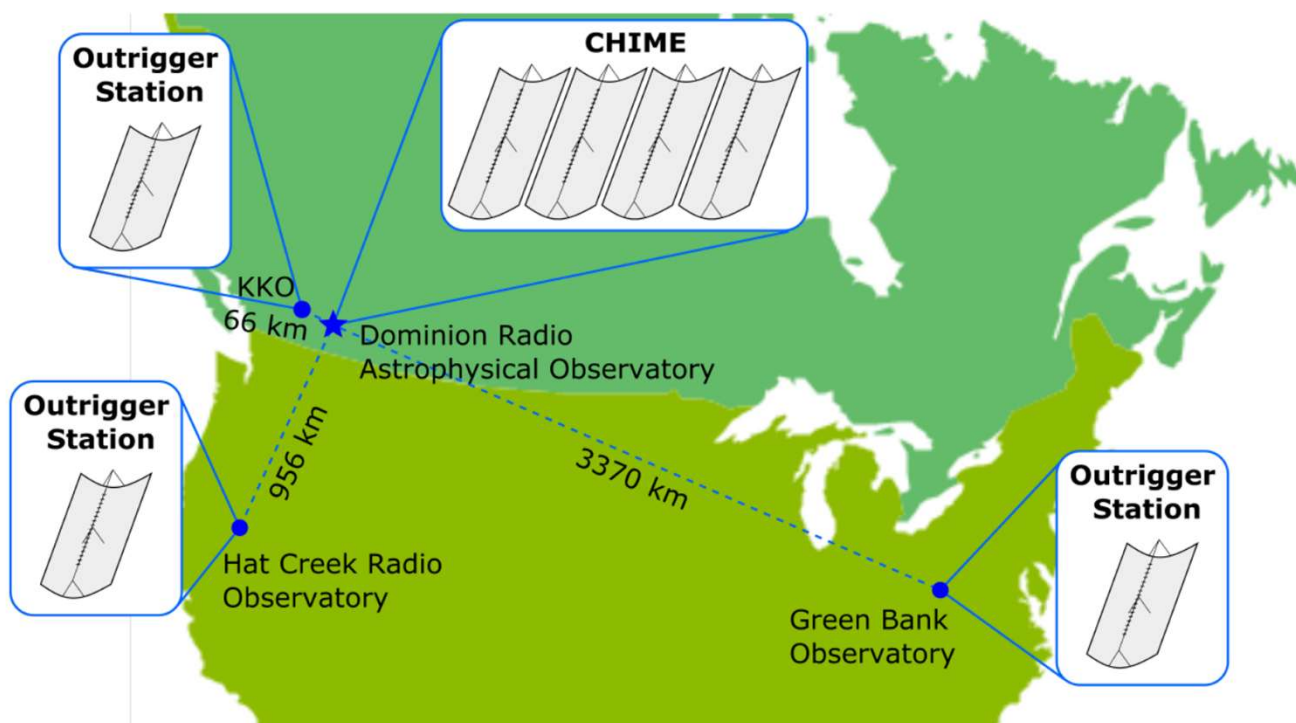


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CHIME outrigger

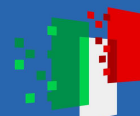
- 81 FRBs, 2 – 60 arcsec resolution, more to come...



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100+ FRB
area, sk

Parameter	Value
Number of dishes *	110
Dish diameter	4.65 m
Aperture efficiency	0.65
System temperature #	25 K
Frequency band	1280 – 1530 MHz
Number of channels	8192
FRB search sensitivity (7.5σ, 1 ms) †	< 1.7 Jy ms
Field of view	10 deg ²
Maximum baseline	2.6 km
FRB localization accuracy	± 1.5 arcsec
Survey speed	3.1 × 10 ⁴ deg ² m ⁴ K ⁻²

DSA 110



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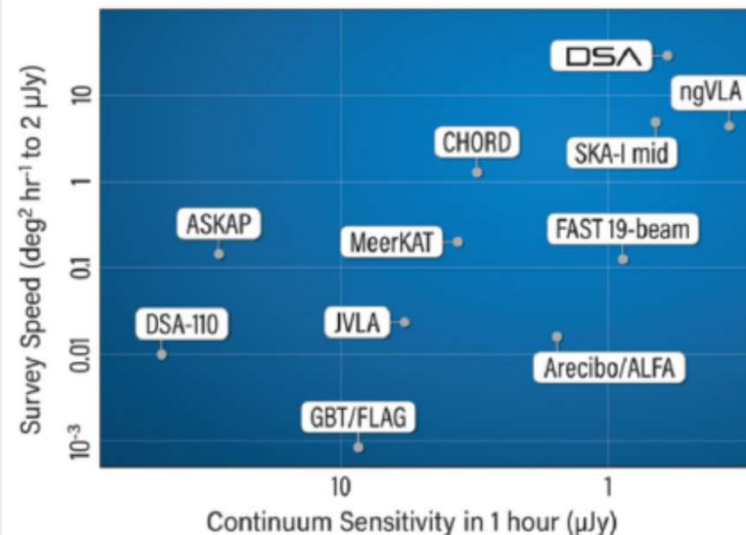


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Fast Radio Bursts in the 2020s: a paradigm shift from discovery and understanding FRBs to population studies and probes

Parameter	Value
Antennas	1650 × 6.15-m dishes
Frequency coverage	0.7 – 2.0 GHz
Primary beam FWHM	2.5° at 1.35 GHz
Synthesized beam FWHM	3.0" at 1.35 GHz
Continuum sensitivity	600 nJy in 1 hr
All-sky survey	31,000 deg ² @ 500 nJy/beam
Number of unique radio sources	> 1 billion
HI: $z < 1$ (5600 × 130 kHz)	5 million galaxies



DSA (in 2028)

100000 FRBs localized < 0.5 arcsec



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Fast Radio Bursts in the 2020s: a paradigm shift from discovery and understanding FRBs to population studies and probes

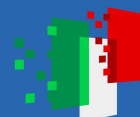
- More numbers, leading towards 10000+ FRBs;
- Cosmological probes;
- High redshift Universe (including cosmic reionization) → collecting area, sky time



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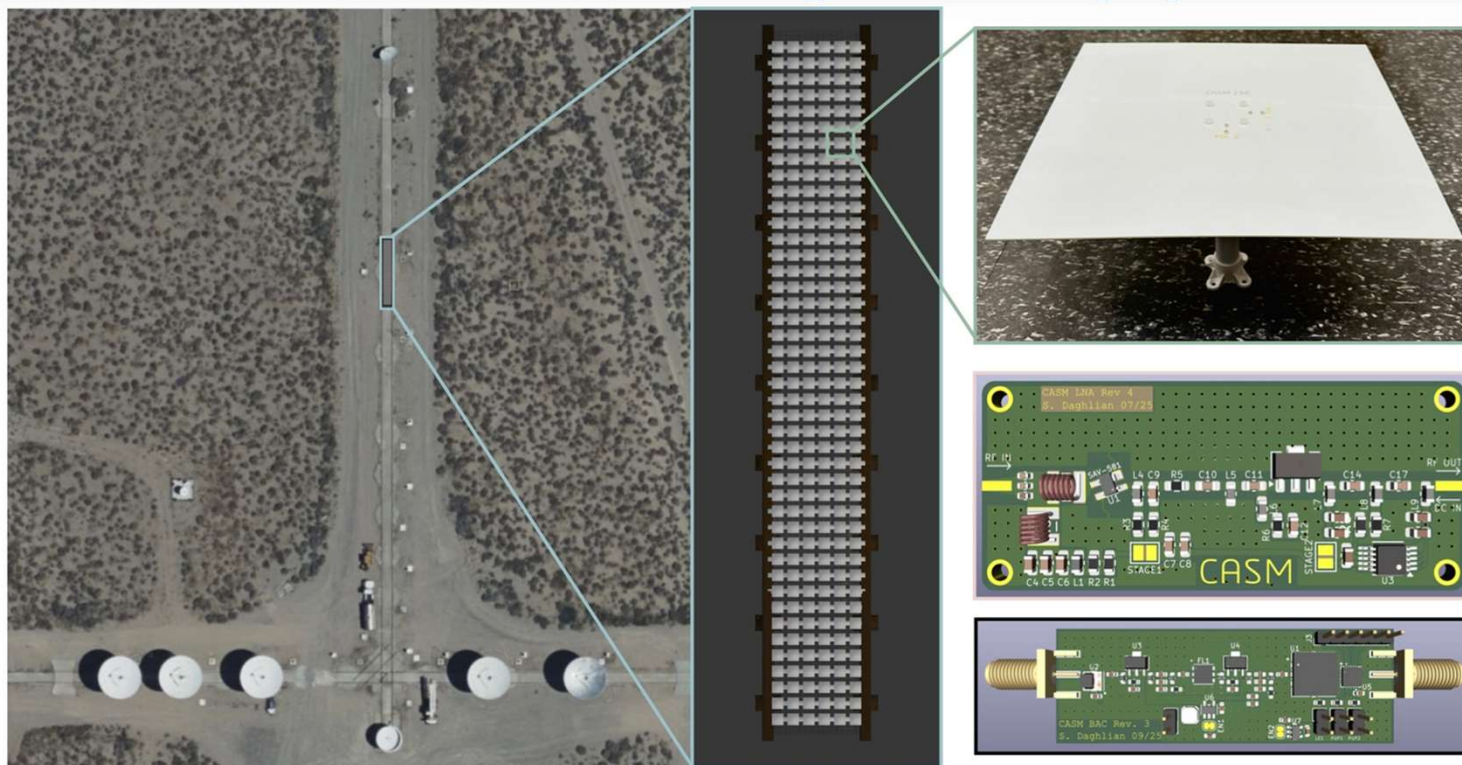


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Fast Radio Bursts in the 2020s: a paradigm shift from discovery and understanding FRBs to population studies and probes



Specifications

CASM-256 Pathfinder

- **Elements:** 256 PCB dipoles
- **Location:** Owens Valley Radio Observatory
- **Frequency:** 375-500 MHz
- **Field of View:** ~10,000 square degrees
- **Time Resolution:** ~1 ms
- **PIs:** Liam Connor and Vikram Ravi



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Fast Radio Bursts in the 2020s: the role of the NG-Croce

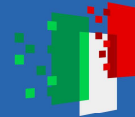
- More numbers, leading towards 10000+ FRBs → collecting area, sky time → YES
- Cosmological probes;
- High redshift Universe FRBs (including cosmic reionization) → collecting area, sky time → YES



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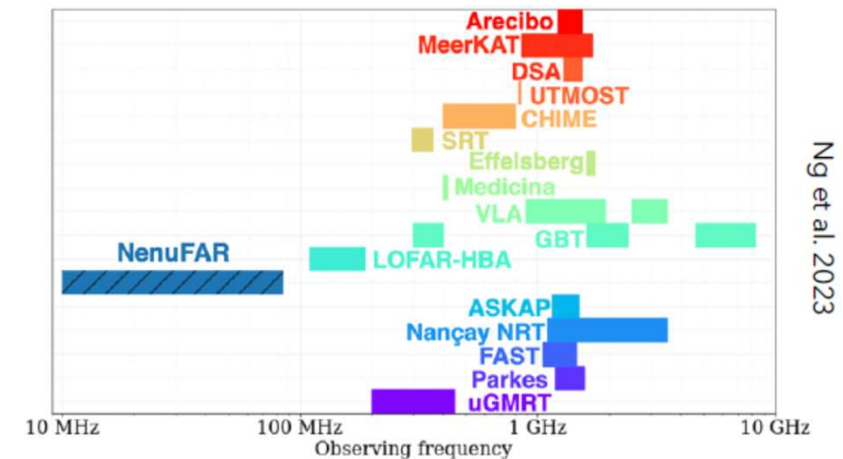


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Fast Radio Bursts in the 2020s: the role of the NG-Croce critical requirements

- More numbers, leading towards 10000+ FRBs;
- High redshift Universe FRBs (reionization);
- It would remain complementary in the SKA era.
The only European array to discover
FRBs/transients;
- They all need a fast development and a reliable
operational model



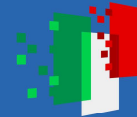
Caleb et al. (2026) @ the 2025
SKA science meeting



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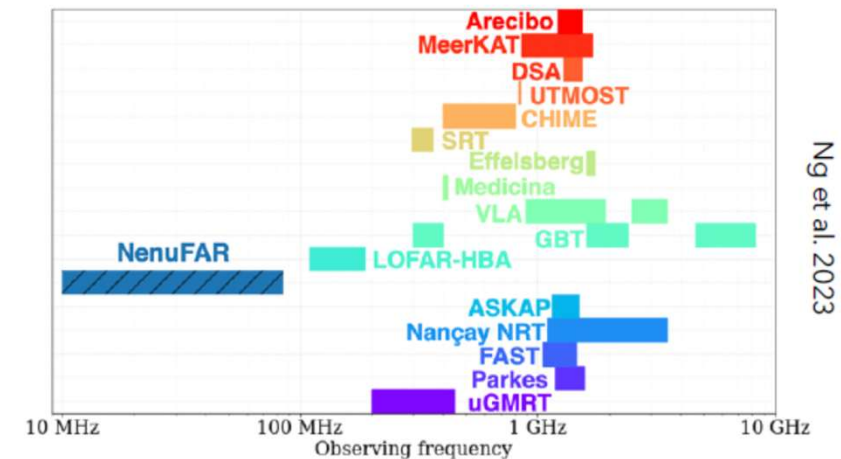
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Fast Radio Bursts in the 2020s: the role of the NG-Croce critical requirements

- More numbers, leading towards 10000+ FRBs
- High redshift Universe FRBs;
- It would remain complementary to the SKA era.
The only European array to catch FRBs/transients;
- They all need a fast development and a reliable operational model

THANK YOU



Caleb et al. (2026) @ the 2025
SKA science meeting