The curious case of ‘twin’ Fast Radio Bursts

CORTEX
(NWA.1160.18.316),
Funded by NWO

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International Centre for Radio Astronomy Research

Fast Radio Bursts (FRBs)

- Mysterious and intense bursts of radio emission
- Short-duration (< ~ tens of milliseconds)

  Lorimer et al. 2007, Thornton et al. 2013
- Extragalactic origin → useful probe of cosmology

  Chatterjee et al. 2017, Bannister et al. 2019, Macquart et al. 2020
- Only a small fraction (< 5%) are known to repeat

  – no pulsar-like periodicity
- Unknown source and emission mechanism

  – strongly magnetized neutron stars ?

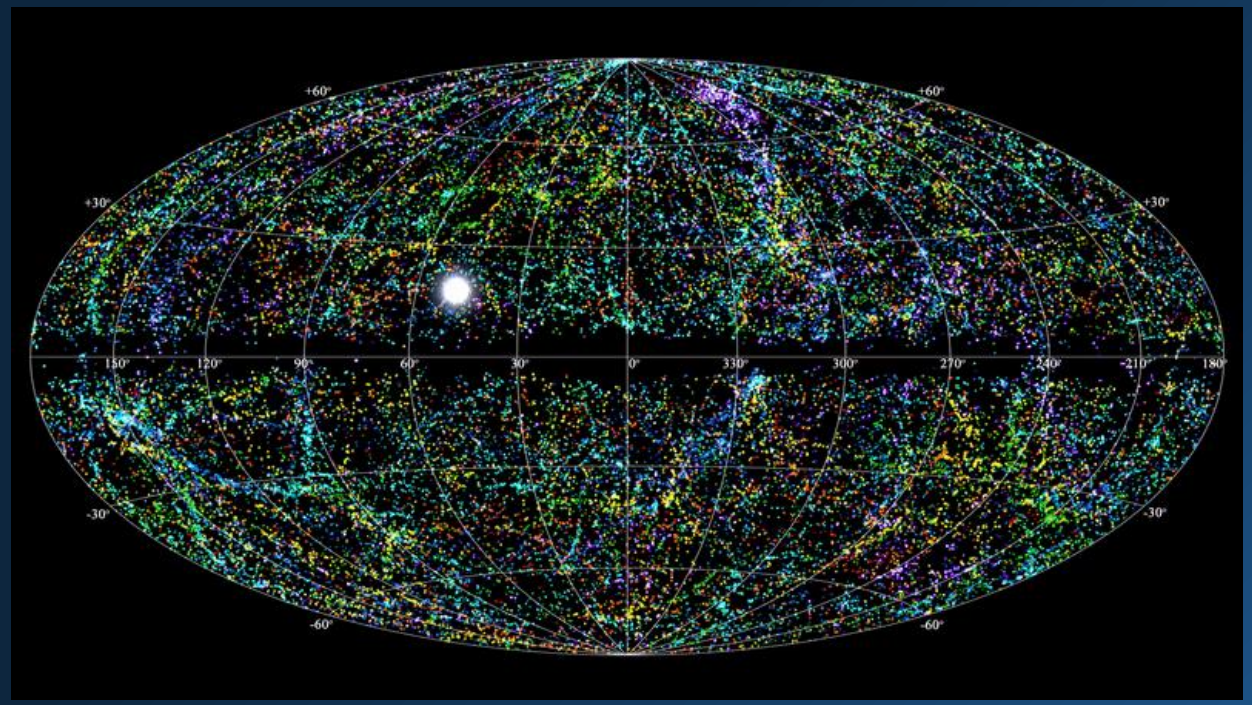

Image credit:
T. Jarrett (IPAC/Caltech)
B. Saxton (NRAO/AUI/NSF)

Shannon et al. 2018, CHIME/FRB collaboration 2021, Petroff et al. 2022

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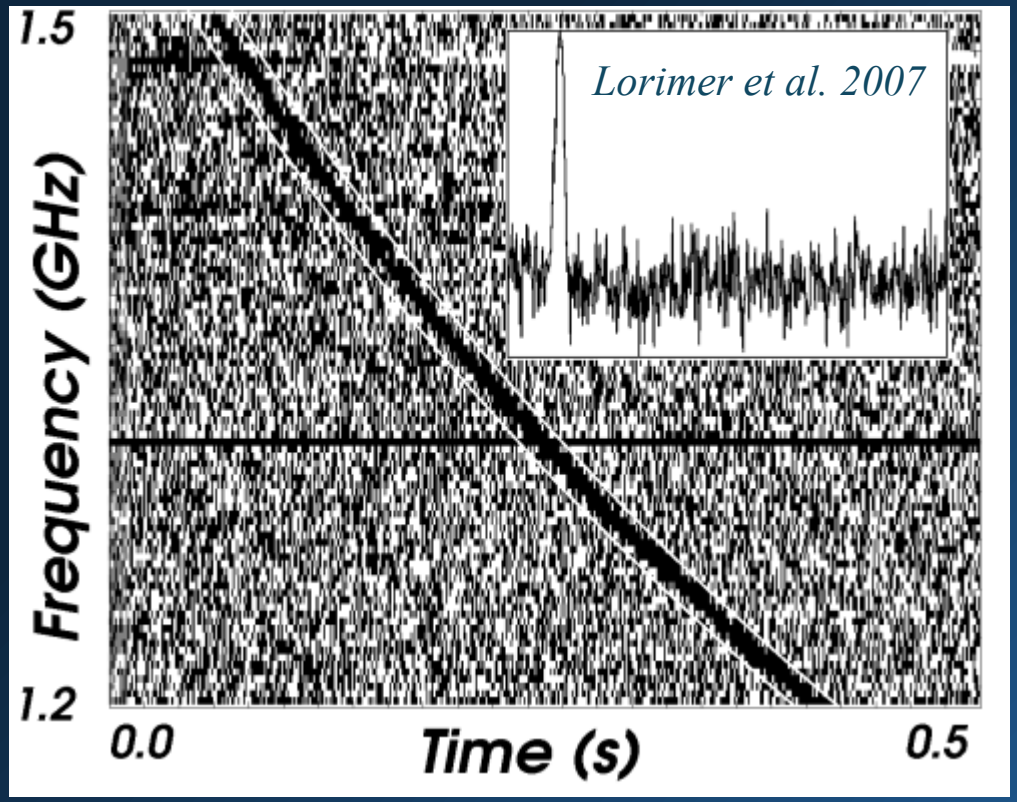
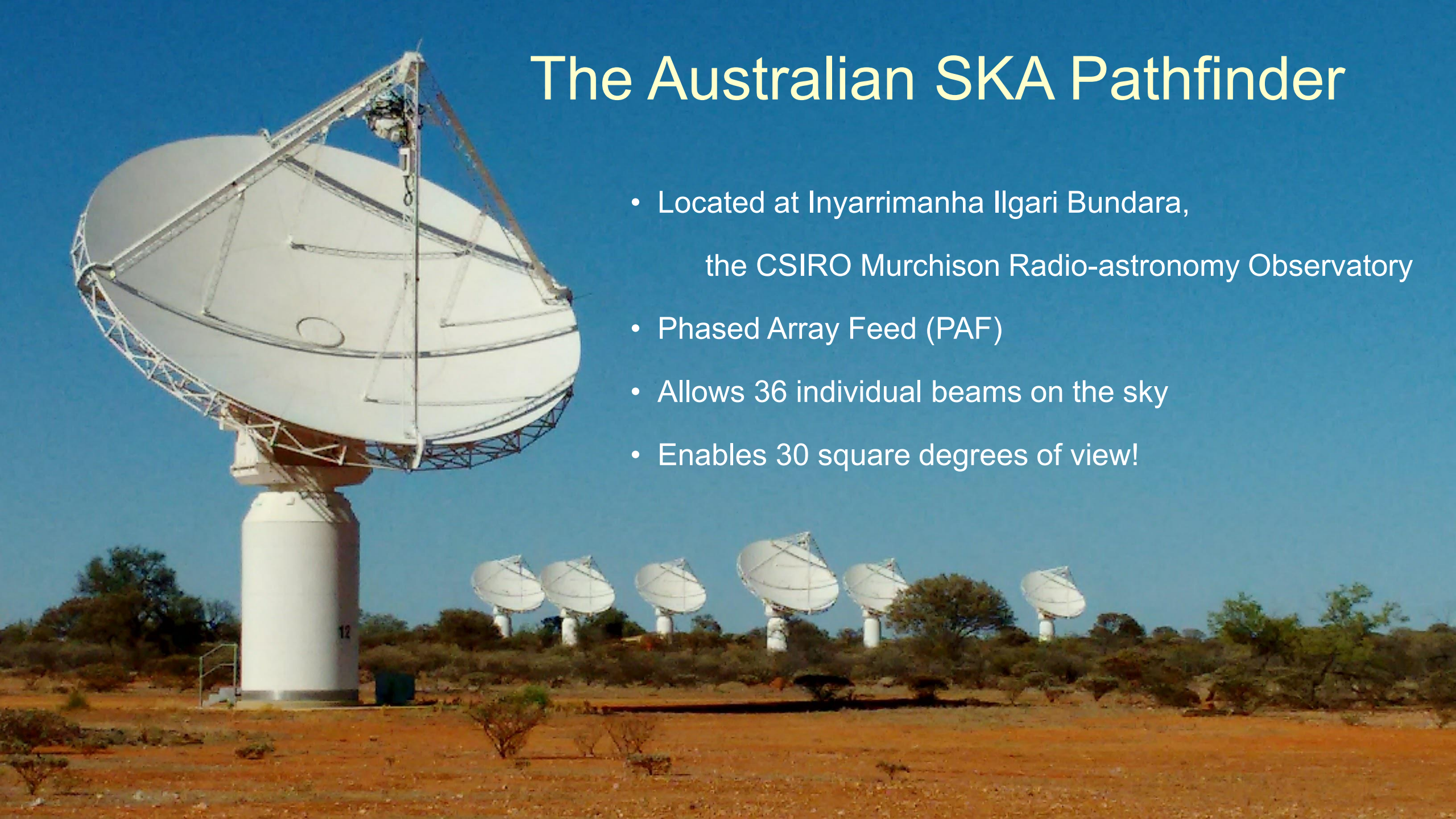


The "Lorimer Burst"
detected with the Murriyang (Parkes) radio telescope

Shannon et al. 2018, CHIME/FRB collaboration 2021, Petroff et al. 2022

The Commensal Real-time ASKAP Fast Transients survey

CRAFT team (50+ members) spans 10+ countries and 20+ institutes



The Australian SKA Pathfinder

- Located at Inyarrimanha Ilgari Bundara,

  the CSIRO Murchison Radio-astronomy Observatory
- Phased Array Feed (PAF)
- Allows 36 individual beams on the sky
- Enables 30 square degrees of view!

The CRAFT survey with ASKAP

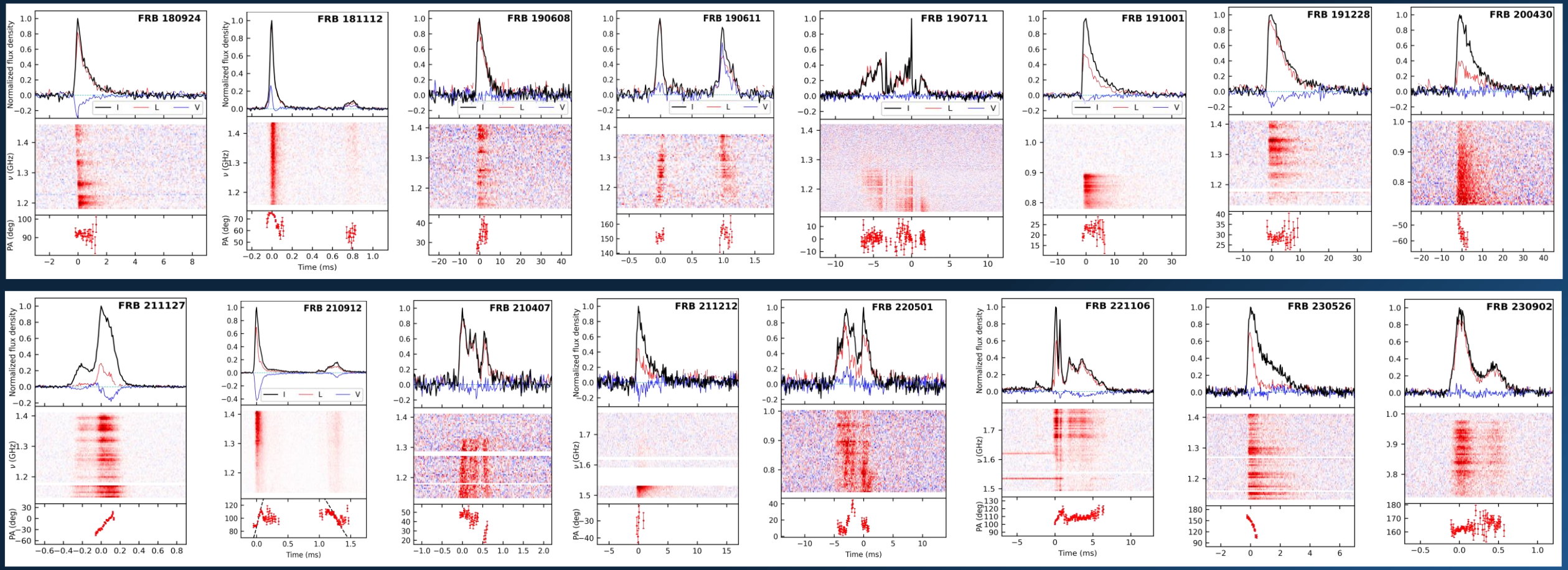
- Commensal Real-time ASKAP Fast Transient (CRAFT) Survey
  - Realtime search for dispersed radio signals
  - Detection triggers recording of raw voltage data

Bannister et al. 2017, Hotan et al. 2021
Qiu et al. 2023, Shannon et al. 2025

- CRAFT Effortless Localisation and Enhanced Burst Inspection (CELEBI) pipeline
  - Offline correlation and imaging → sub-arcsecond localization of FRBs
  - Phase coherent beamforming → full polar high time resolution output
  - Reveals FRB emission properties at time scales down to ~ 3 ns !

Scott et al. 2023

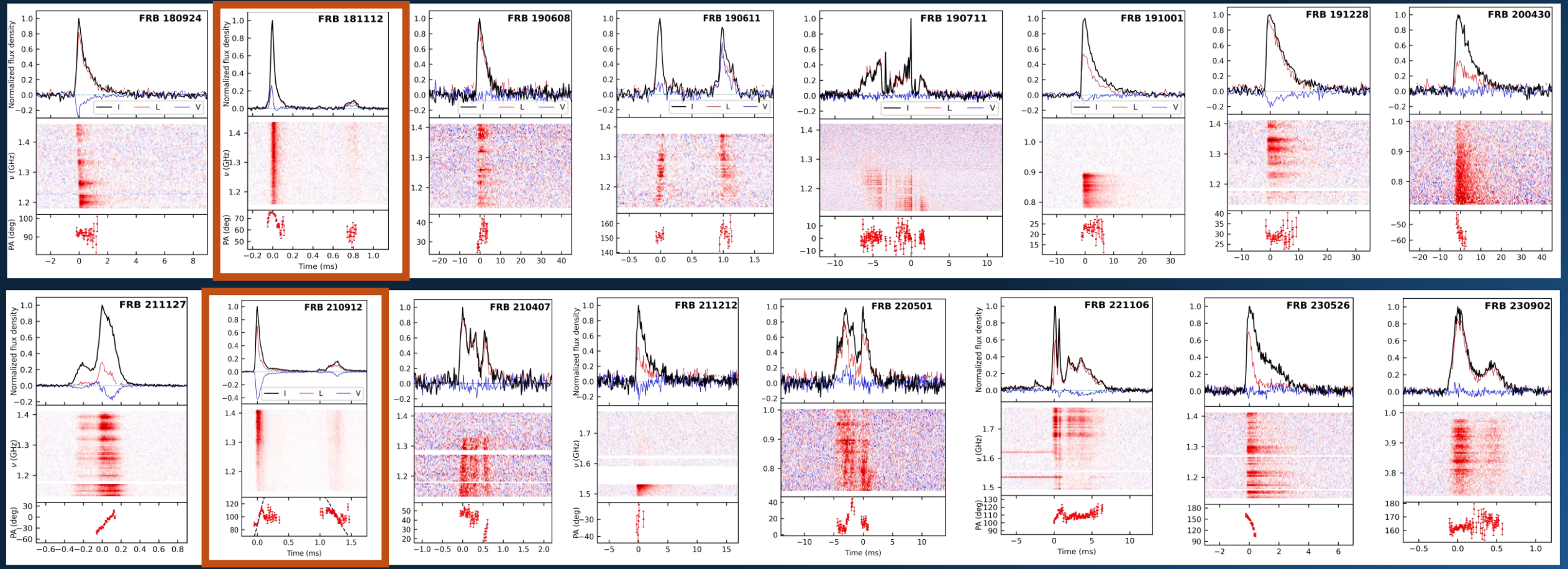
Diverse properties of Fast Radio Bursts



- Complex time-frequency structure and polarization behaviour …
- Propagation effects (scattering, scintillation)

Scott et al. 2025

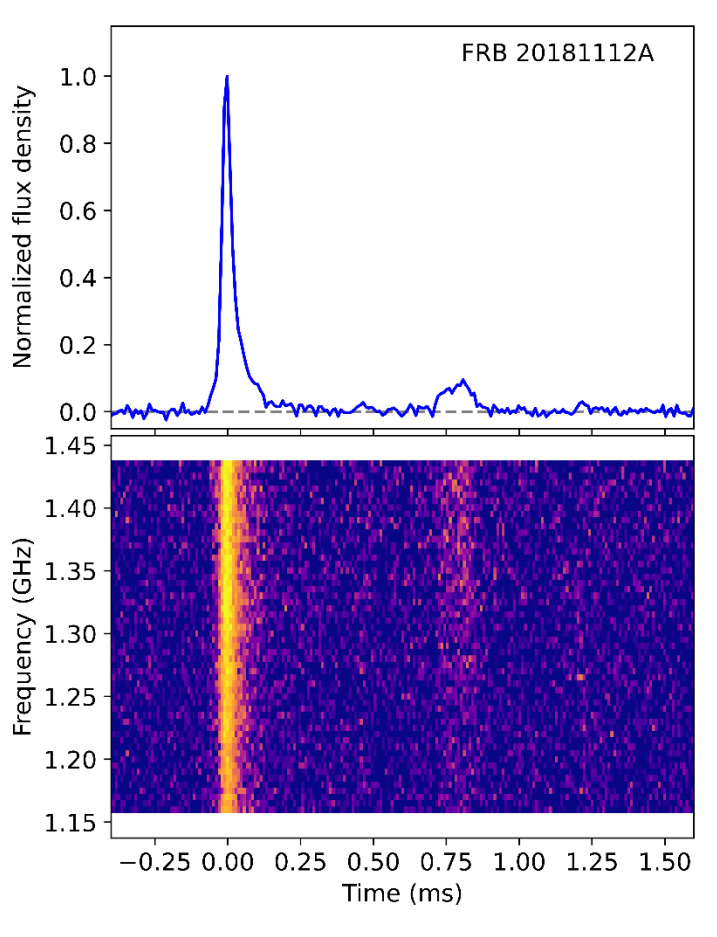
Diverse properties of Fast Radio Bursts

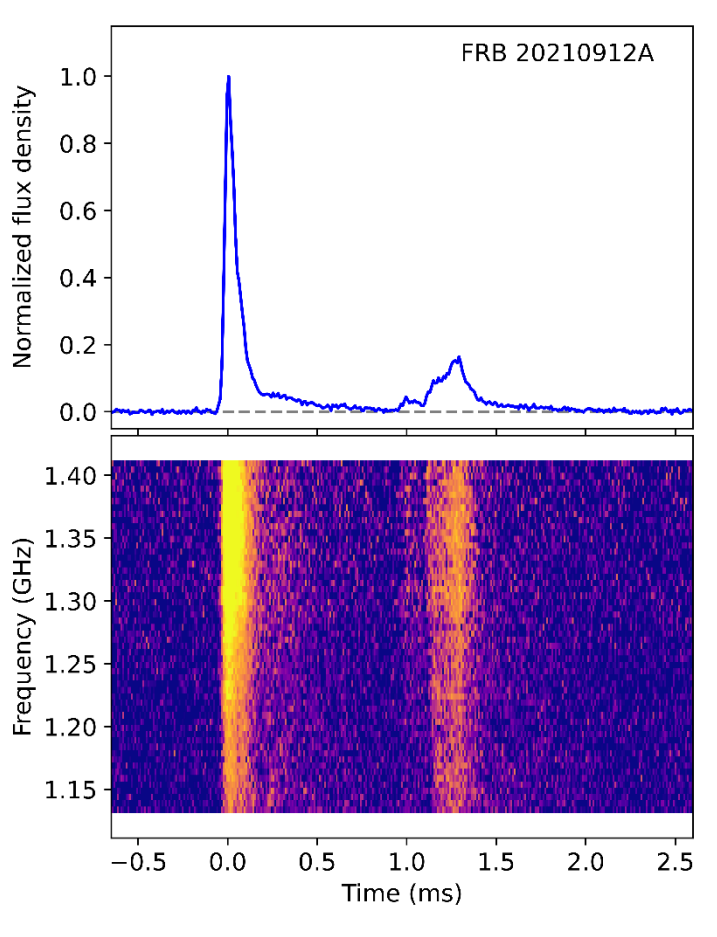


Scott et al. 2025

- Complex time-frequency structure and polarization behaviour … wait !

Twin Fast Radio Bursts !

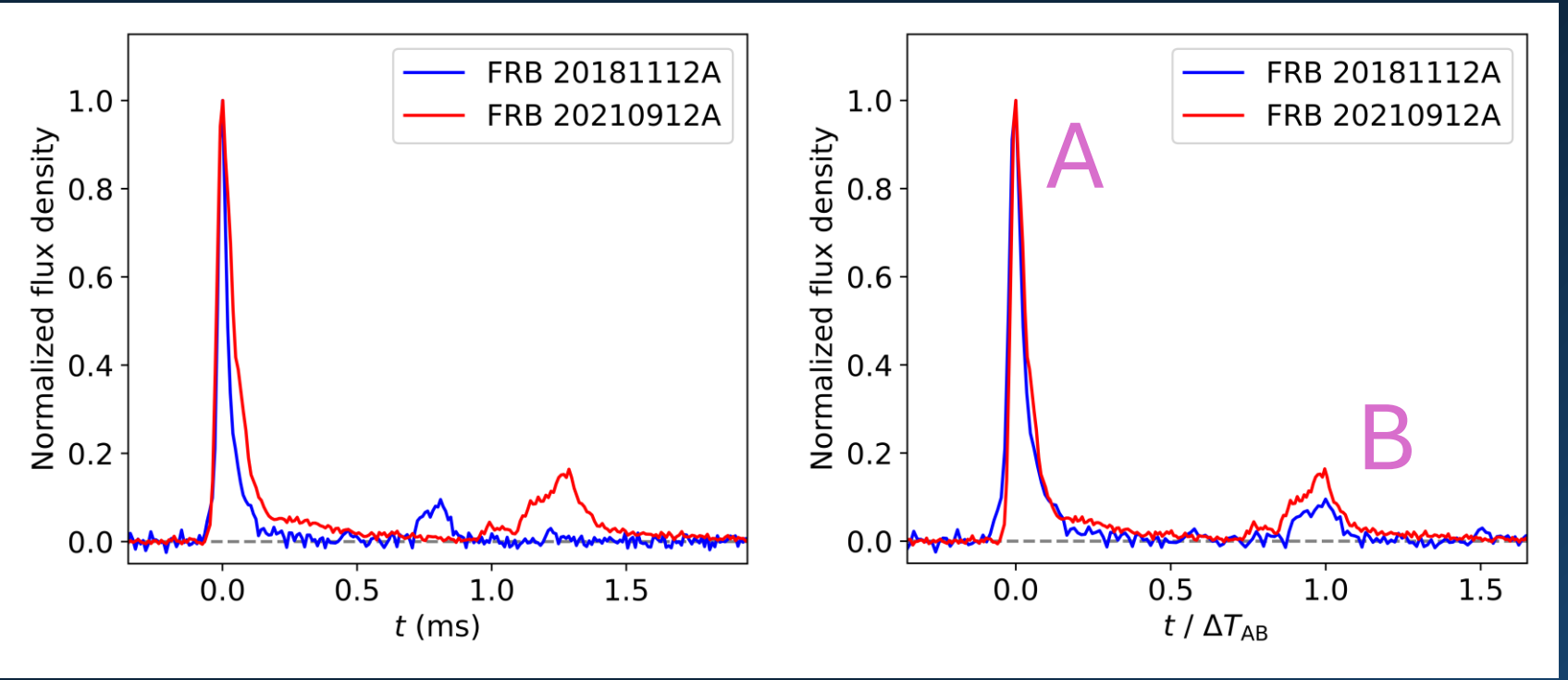




21h49m23.6s	**R. A.**	23h23m10.4s
-52d58’15.4”	**Decl.**	-30d24’19.2”
589	**DM** $(pc\ cm^{-3})$	1234
26 ± 3	**Fluence (Jy ms)**	70 ± 2
0.4755	**Redshift**	Unknown !

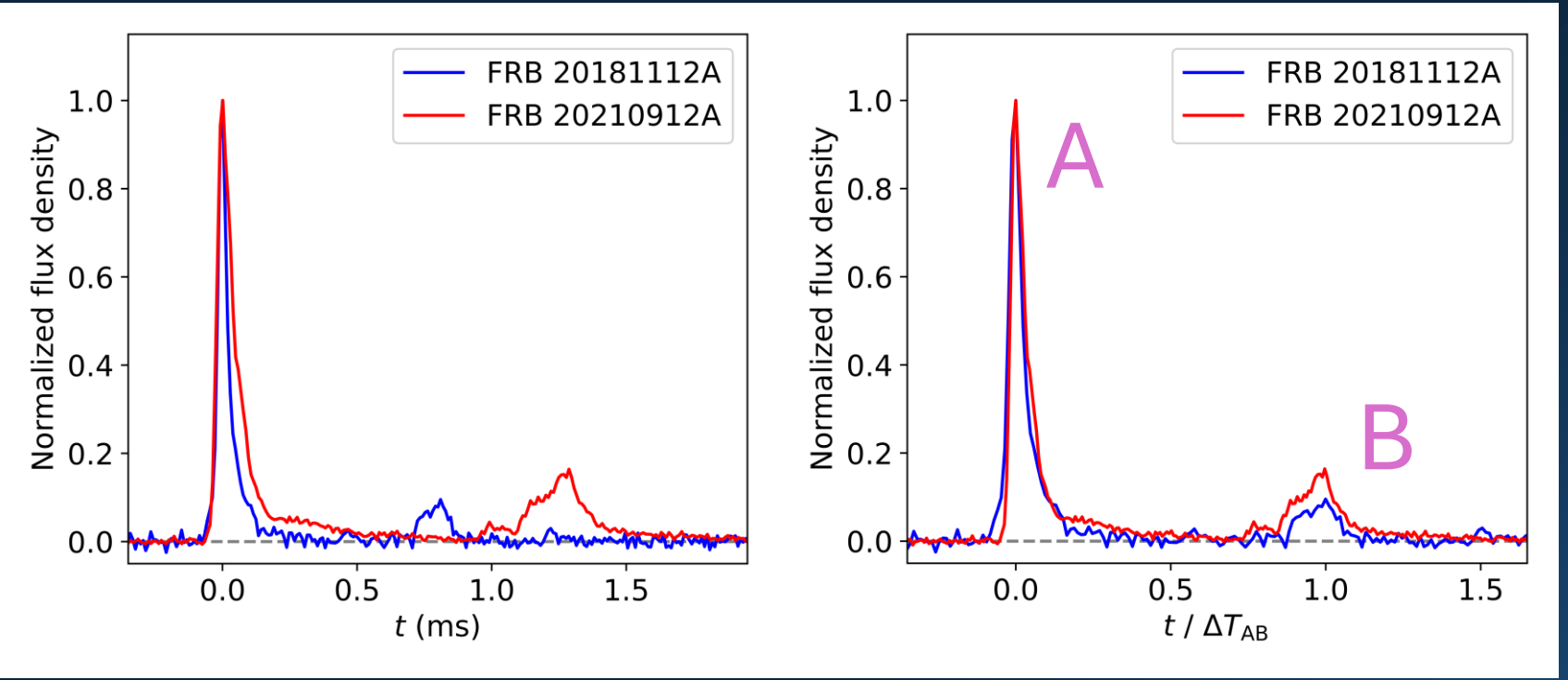
Prochaska et al. 2019, Cho et al. 2020, Marnoch et al. 2023, Bera et al. 2024

Burst profiles & emission time-scales



0.31 ± 0.02	$FWHM_A/FWHM_B$	0.32 ± 0.01
0.81 ± 0.06	**Peak separation (ΔT/ms)**	1.27 ± 0.11
(A) 0.046 ± 0.003 (B) 0.148 ± 0.007	$FWHM/\Delta T$	(A) 0.052 ± 0.005 (B) 0.16 ± 0.01

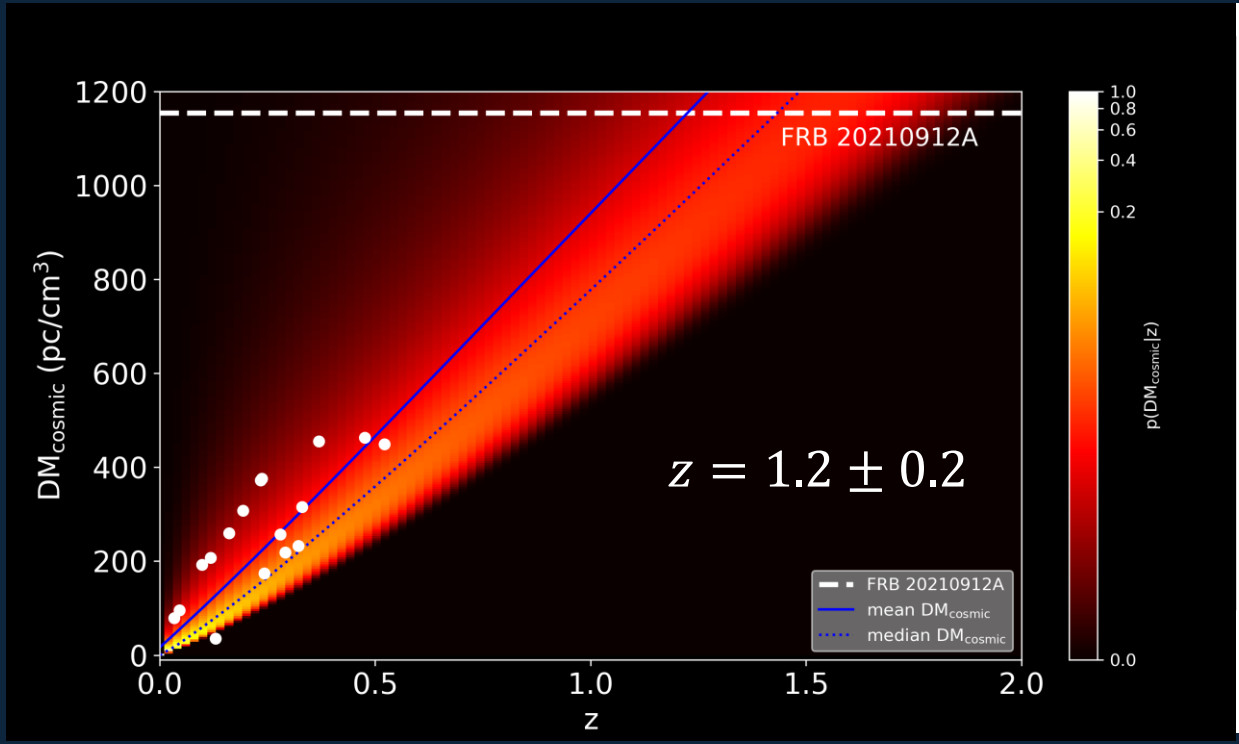
Burst profiles & emission time-scales

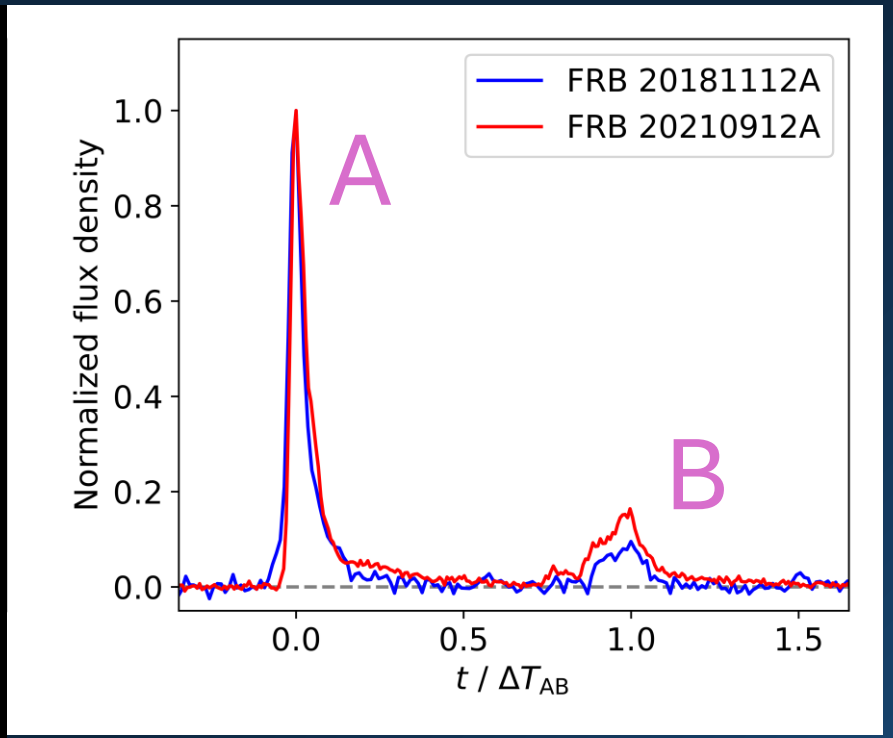


Identical rest-frame time-scales **if**

$$z(FRB\ 20210912) = 1.33\ !$$

Burst profiles & emission time-scales

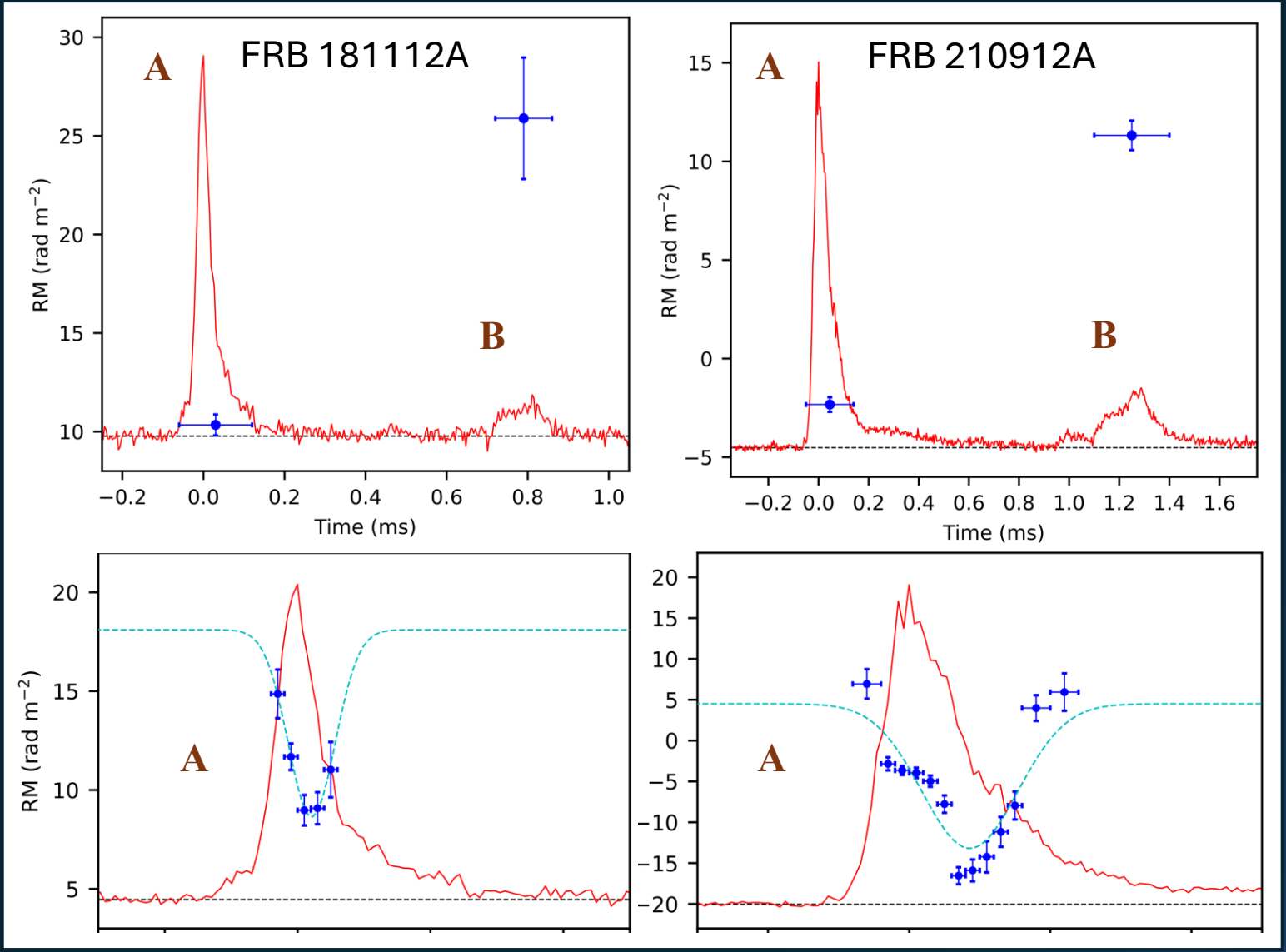




Identical rest-frame time-scales **if** $z(FRB\ 20210912) = 1.33$!

Consistent with cosmological redshift – DM relation !

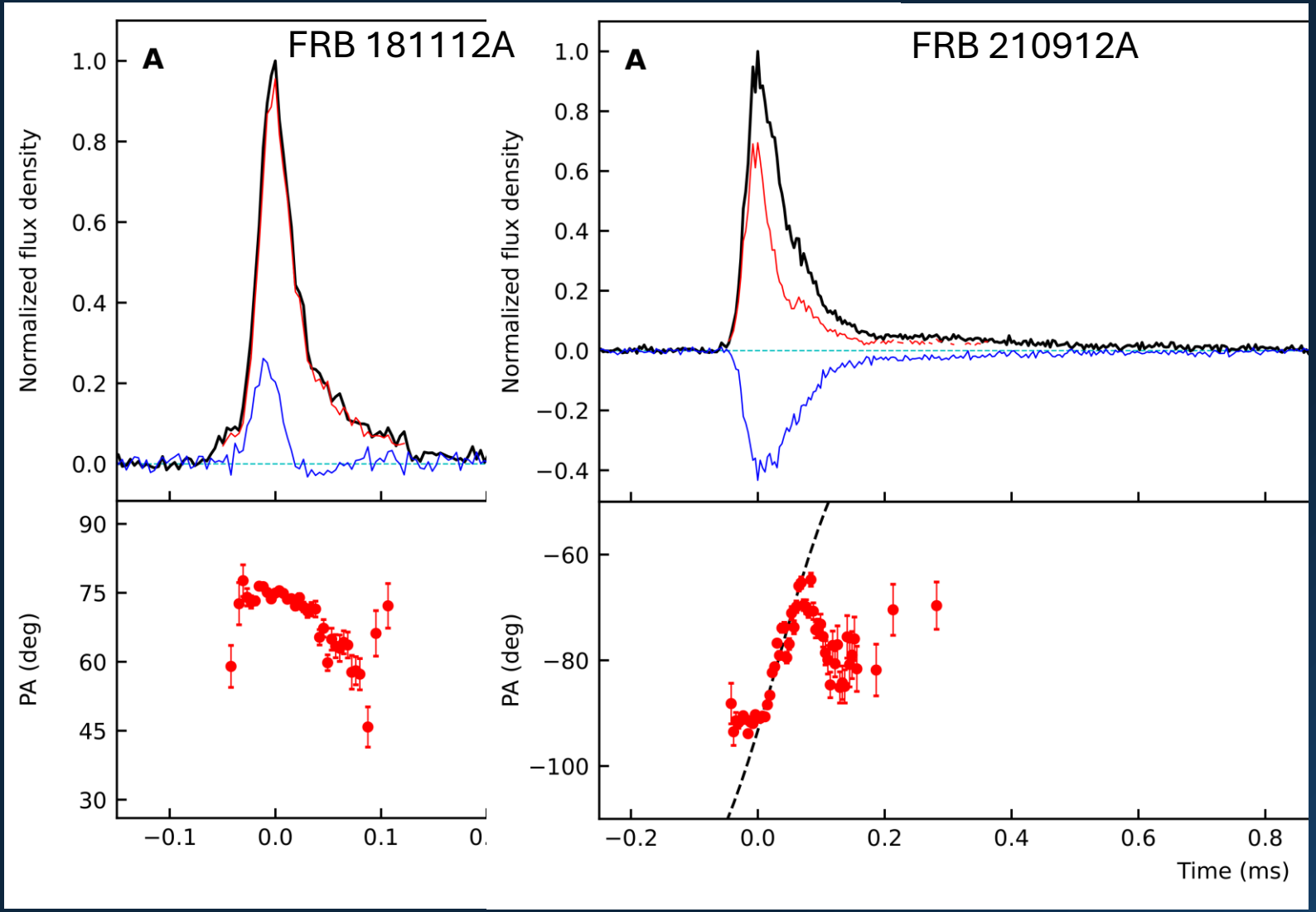
Twins, but not Identical…



- Different Rotation measure (RM) in two sub-bursts
- $\mathbf{\Delta RM_{AB}} \approx \mathbf{15}\, rad\, m^{-2}$
- Short time-scale (~ 0.01 ms) variation of RM
  - similar in both FRBs

Bera et al. 2024

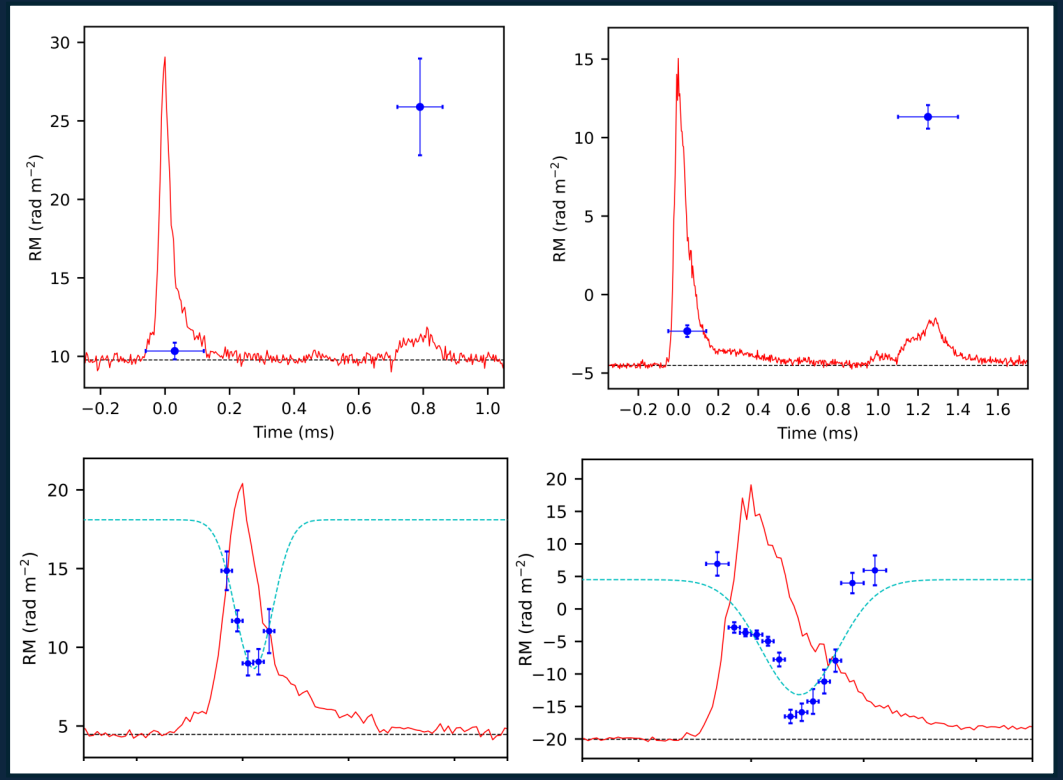
Twin FRBs – Polarization profiles

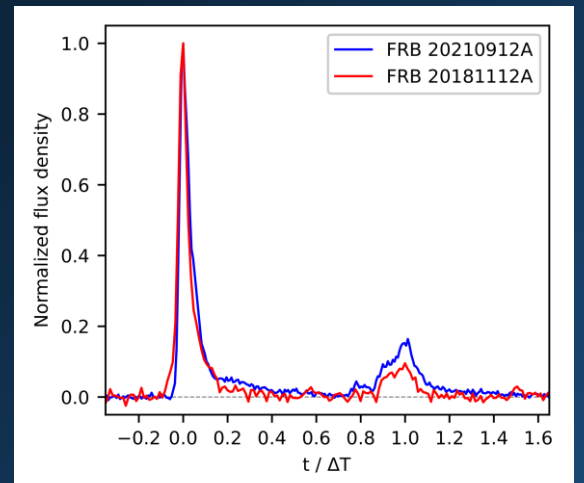


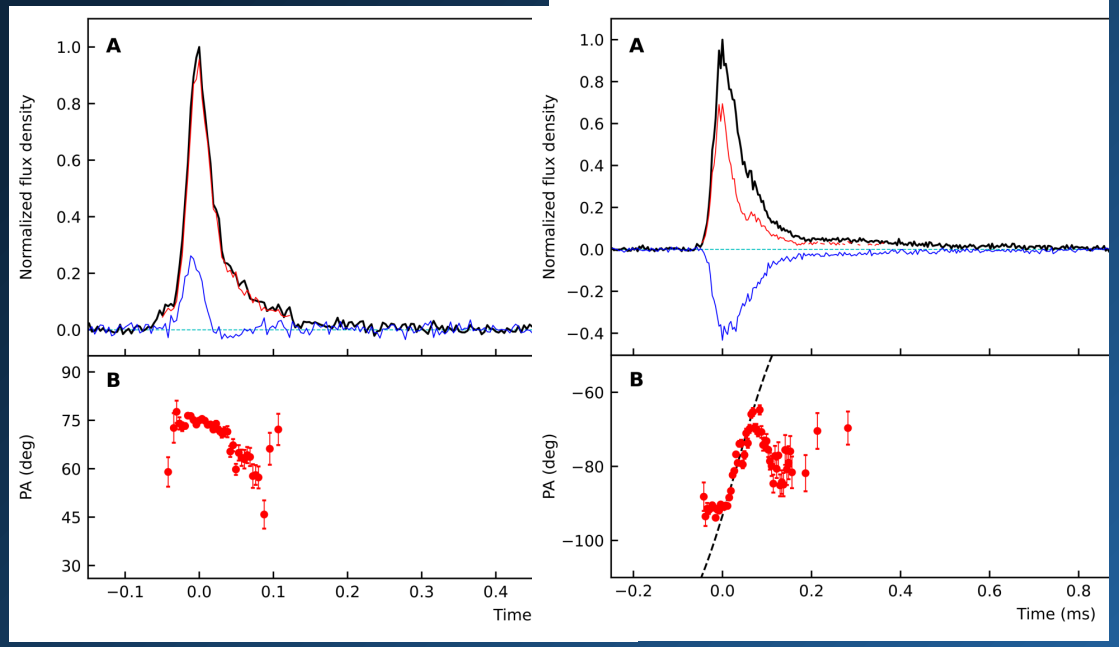
- Time varying fraction of linear and circular polarization
- Position Angle (PA) variation across primary sub-burst
- Similar in both FRBs

Bera et al. 2024

Twin FRBs – A random coincidence ?

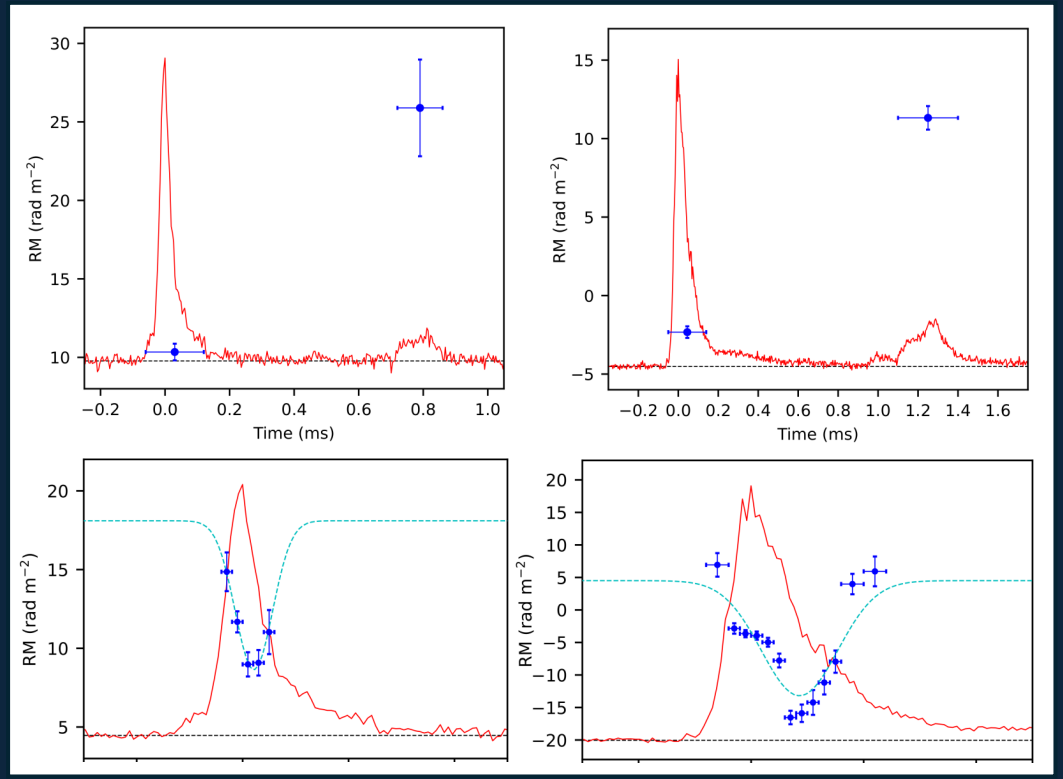


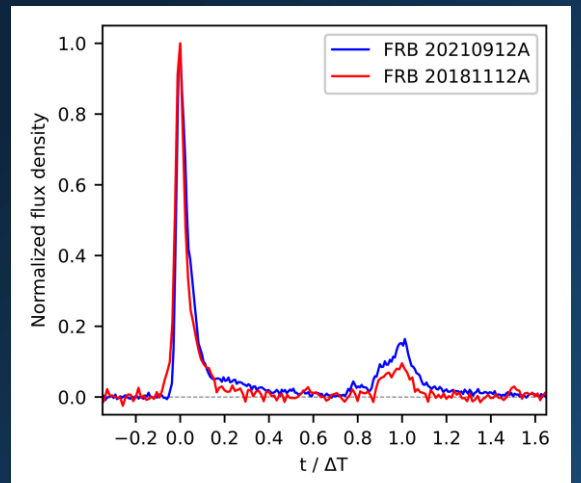


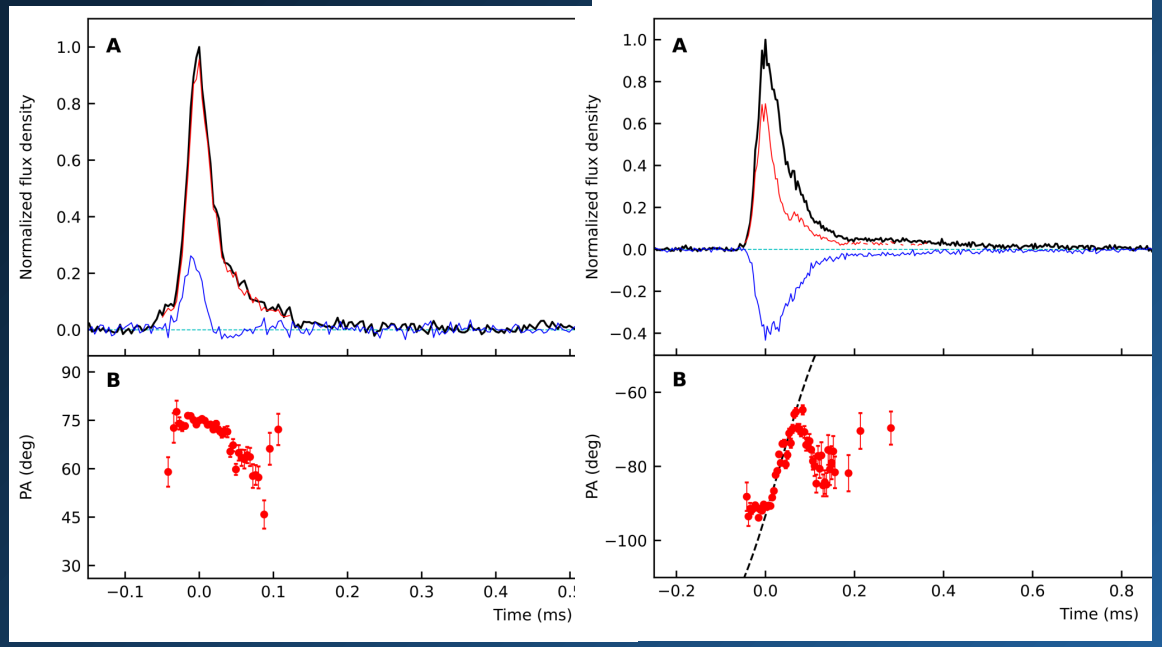


- Similarities are hard to quantify !
- Difficult to estimate probability of random coincidence

Or… similar progenitors ?

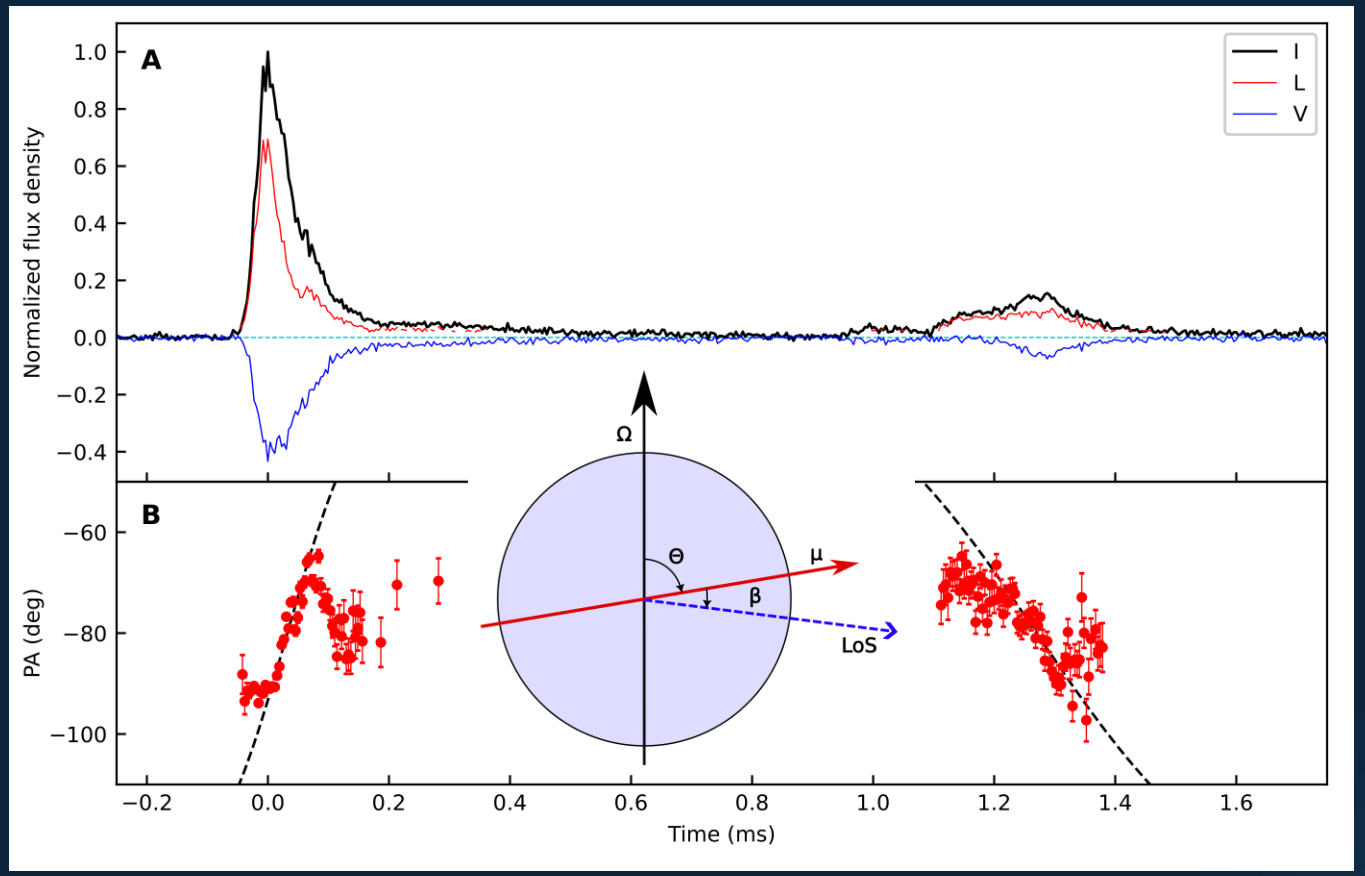






- **What could be their progenitors ?**

PA variation in FRB 210912A



- Rotating Vector Model for PA variation
  - PA traces projection of magnetic field on to the sky plane

Radhakrishnan & Cooke 1969

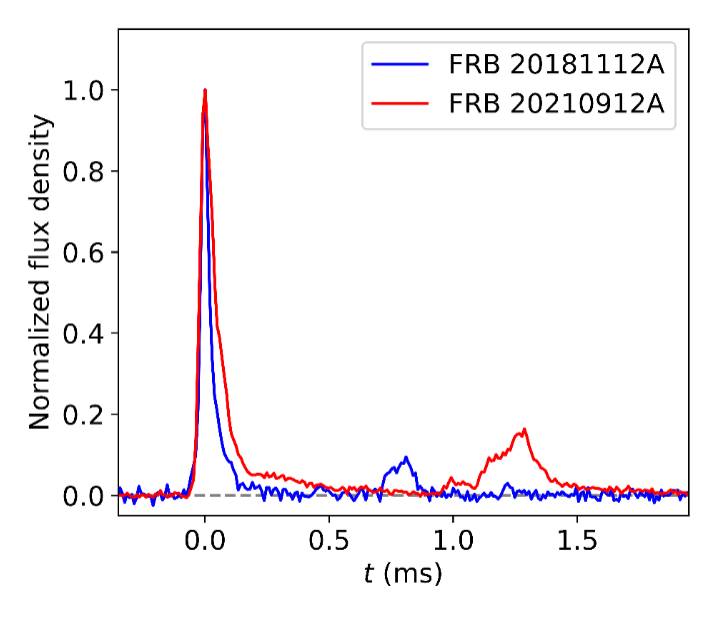
- PA variation can be broadly described by simple (dipolar) RVM with

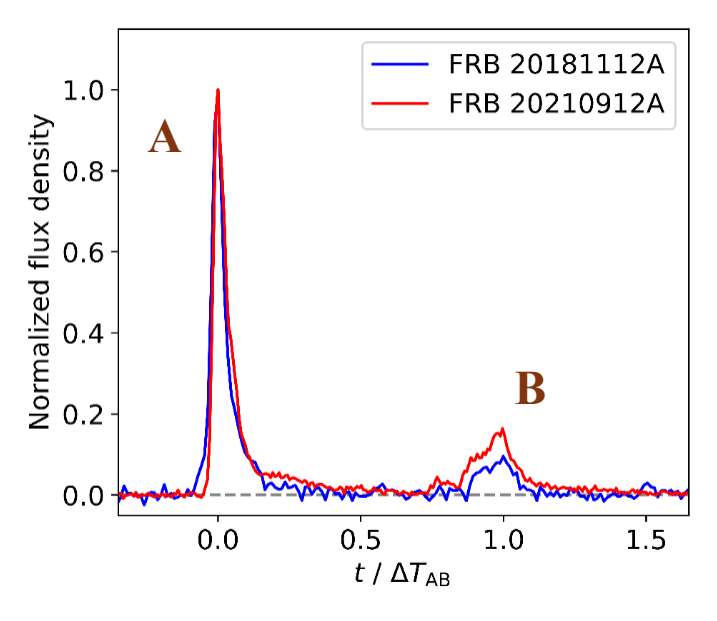
magnetic obliquity ⟶ $\Theta \approx 59°$

impact angle ⟶ $\beta \approx 17°$

Two neutron stars with rest-frame spin periods of $\approx 1.1\ ms$?

Rest frame emission time-scales ?





- **FRB 210912A**

  Host galaxy not yet found !

  z-DM relation → $z \sim 1.2 \pm 0.2$

Intrinsic time scales would be identical if

$z = 1.33$!

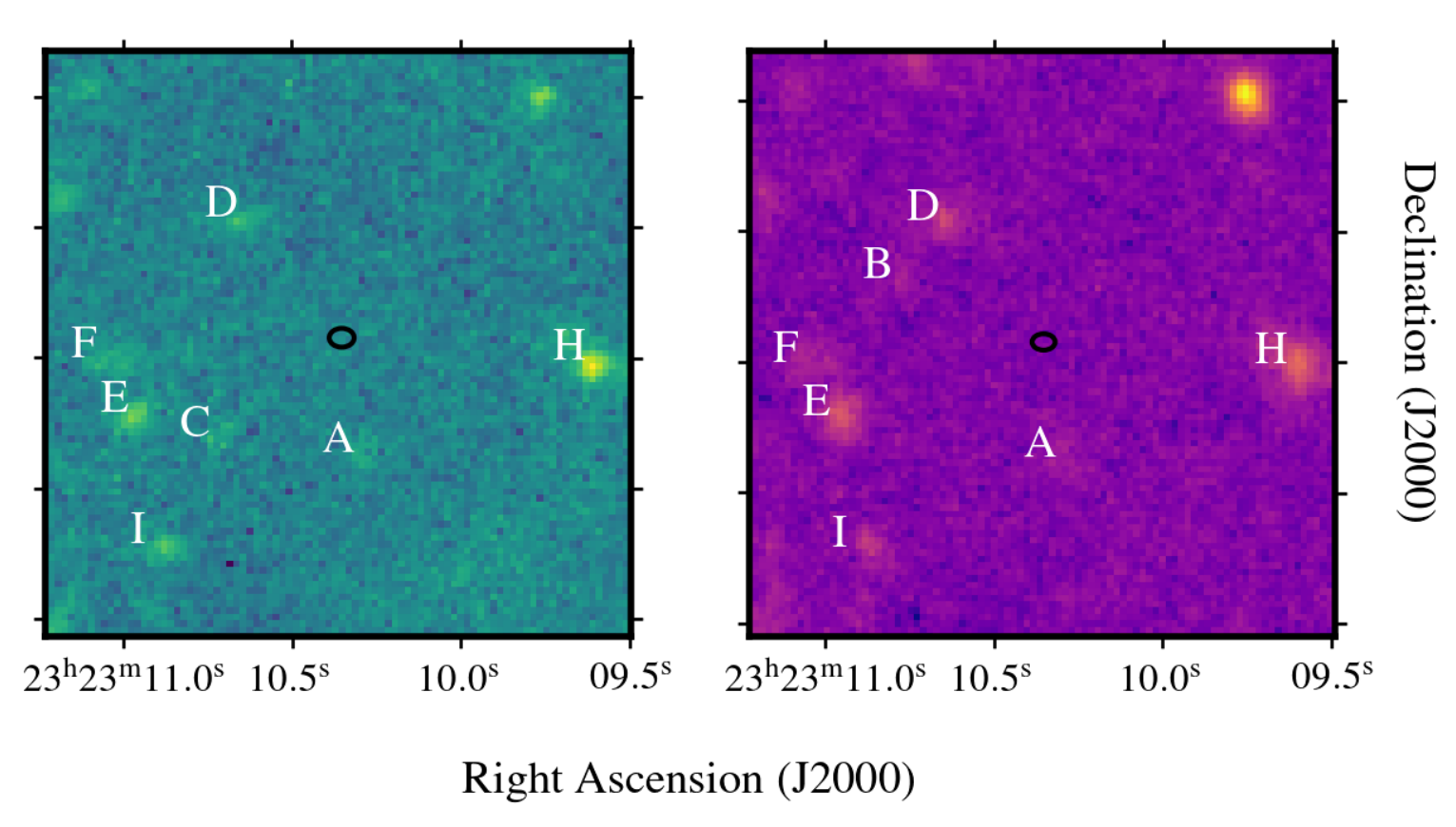
Find the host galaxy of FRB 210912A and measure its redshift !

Bera et al. 2024

Marnoch et al. 2023

Macquart et al. 2020

Finding the host galaxy…

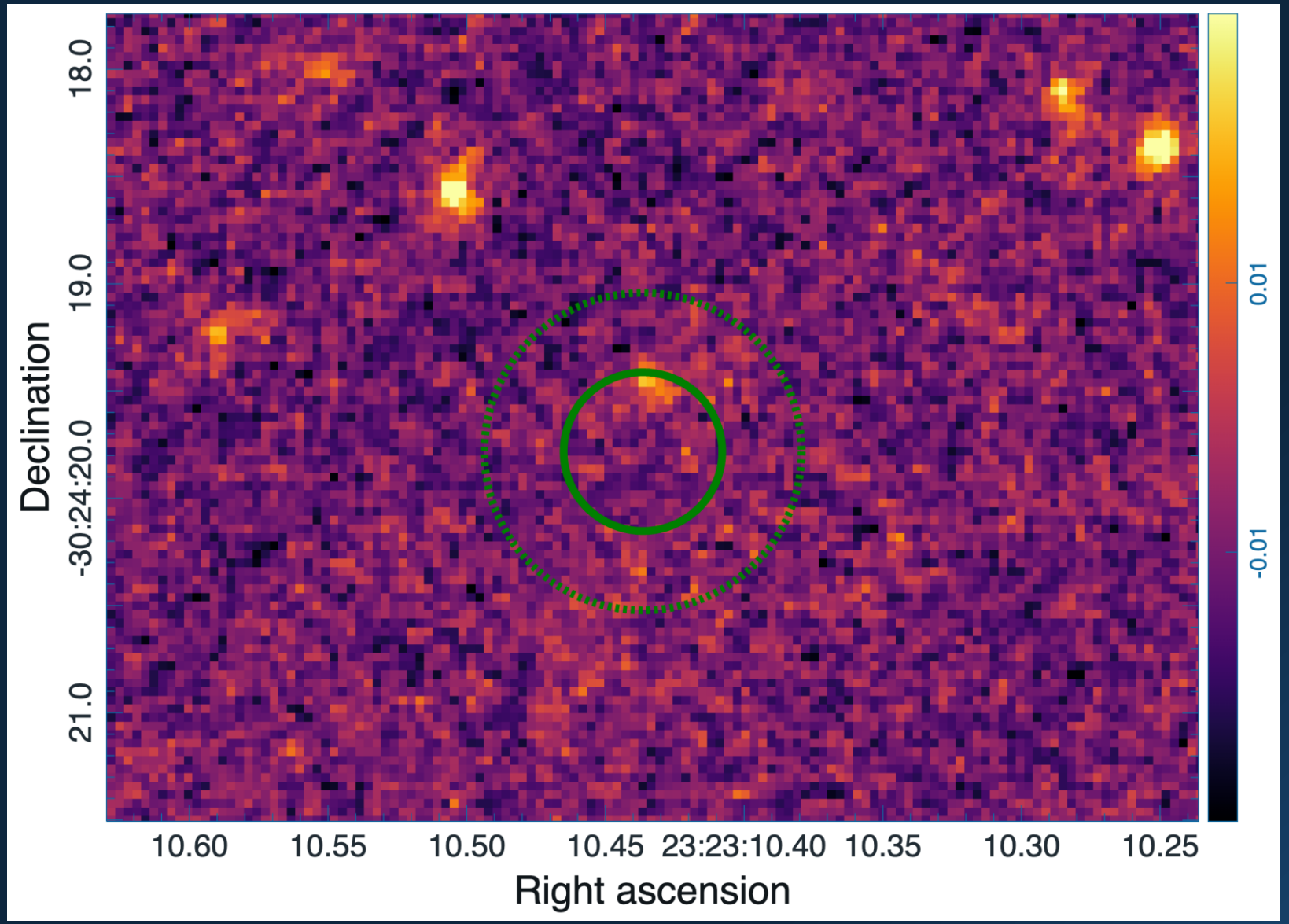


Not found in very deep VLT image

R > 26.7 and K > 24.9 (5σ limits)

Marnoch et al. 2023

JWST image



JWST NIRCAM
(F200W+F322W)

Localization

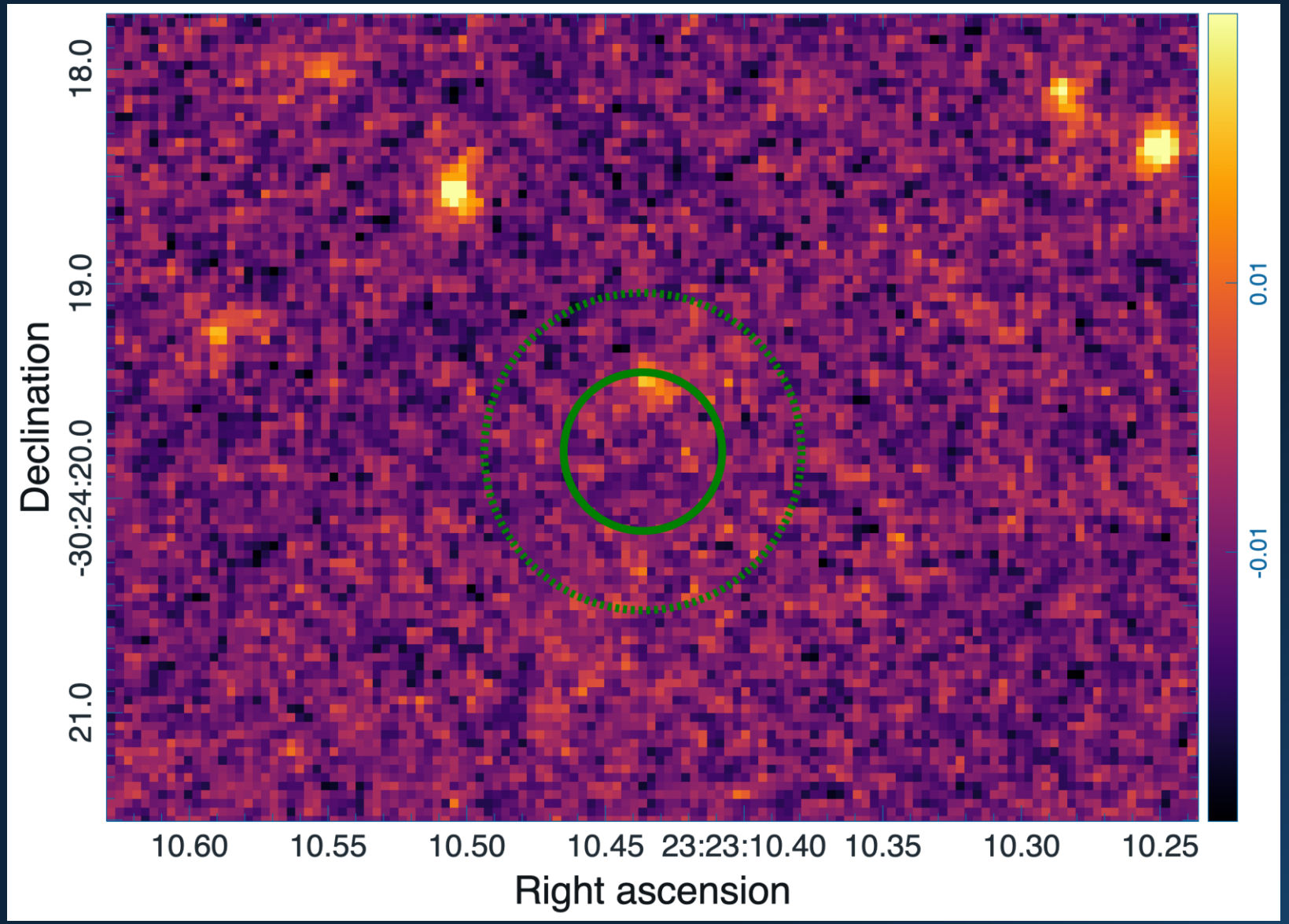
Solid → 1σ Dashed → 2σ

Faintest FRB host so far !

Waiting for spectroscopy results…

Thanks to
Adam Deller
Lalitwadee Kawinwanichakij
Themiya Nanayakkara
Karl Glazebrook

JWST image



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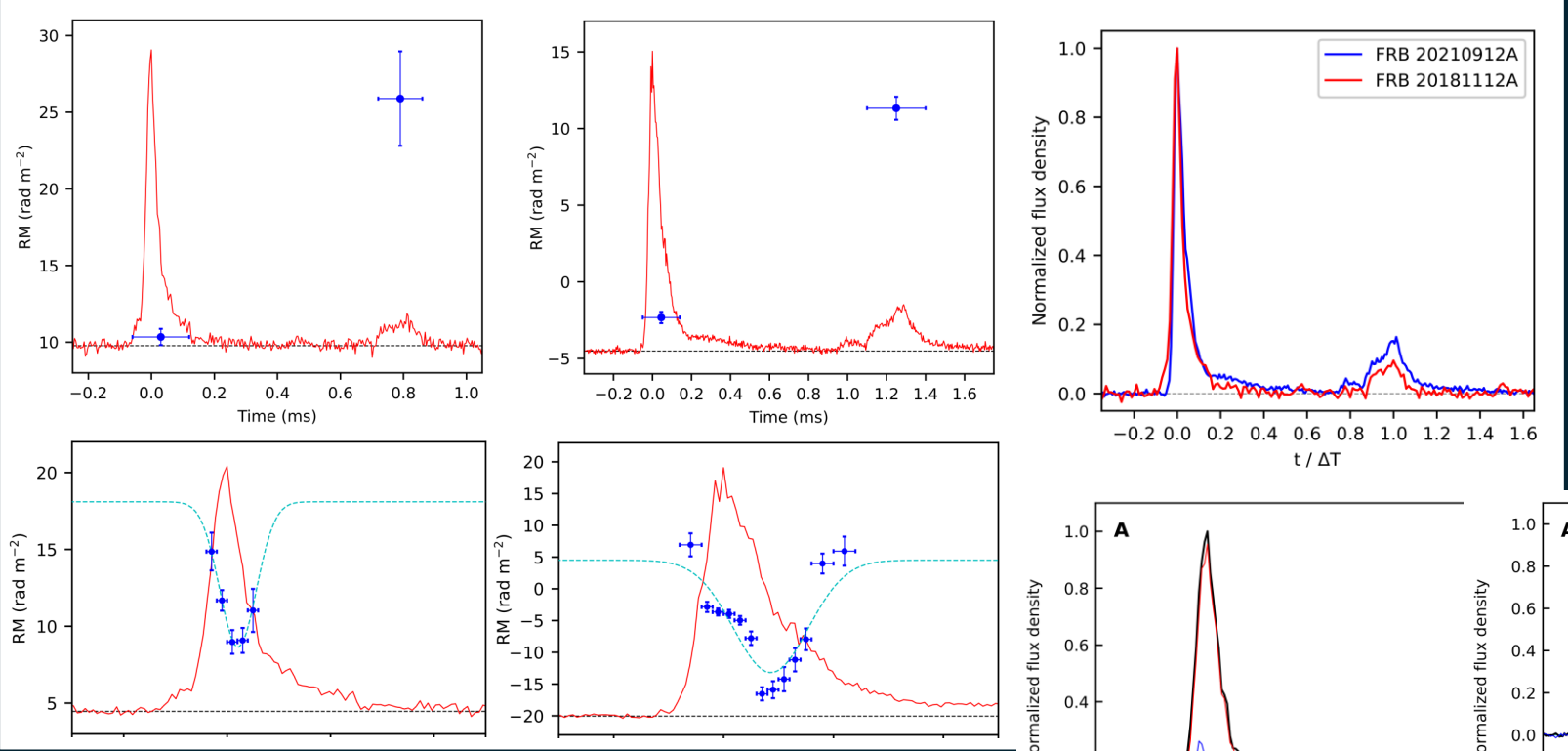
If it gives

$z = 1.33$ ... ...

Thanks to
Adam Deller
Lalitwadee Kawinwanichakij
Themiya Nanayakkara
Karl Glazebrook

Twin FRBs – 1.1 ms-period neutron stars?



- Faster than the fastest rotating known millisecond pulsar

Hessels et al. 2006

- Close to shortest possible spin period of neutron stars !

Haskell et al. 2018

- **A class of FRBs originating from fast rotating neutron stars?**

Bera et al. 2024