Propagation effects at low frequencies seen in the LOFAR long-term monitoring of the periodically active FRB 20180916B

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(Submitted)

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LOFAR family meeting
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ANTON PANNEKOEK INSTITUTE

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FRB20180916B (R3) : What we know

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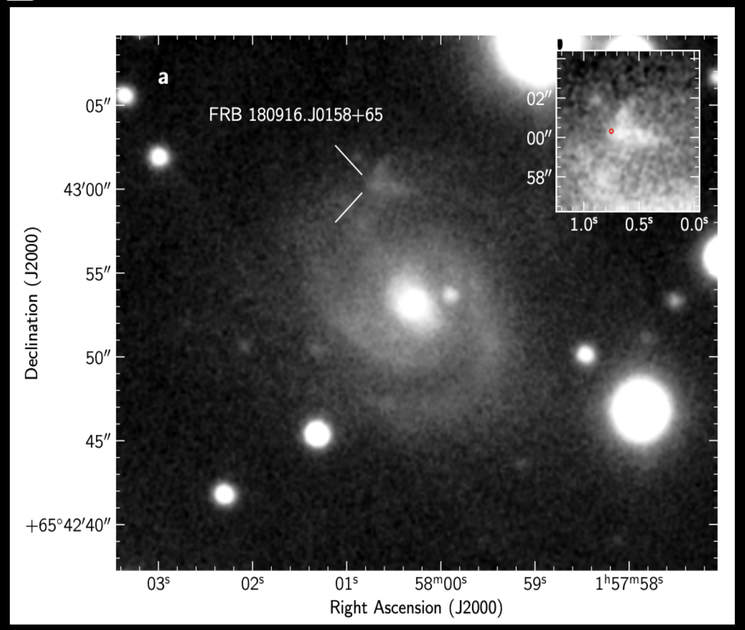
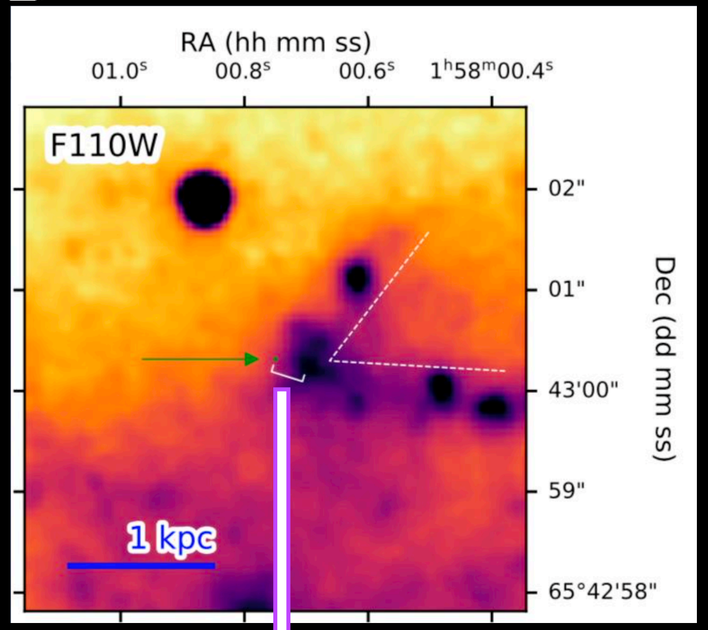
16.33 day period → rotation, precession and binary NS models

Marcote+ 2020



Milliarcsec localization to a spiral galaxy
150 Mpc away

Tendulkar+ 2021

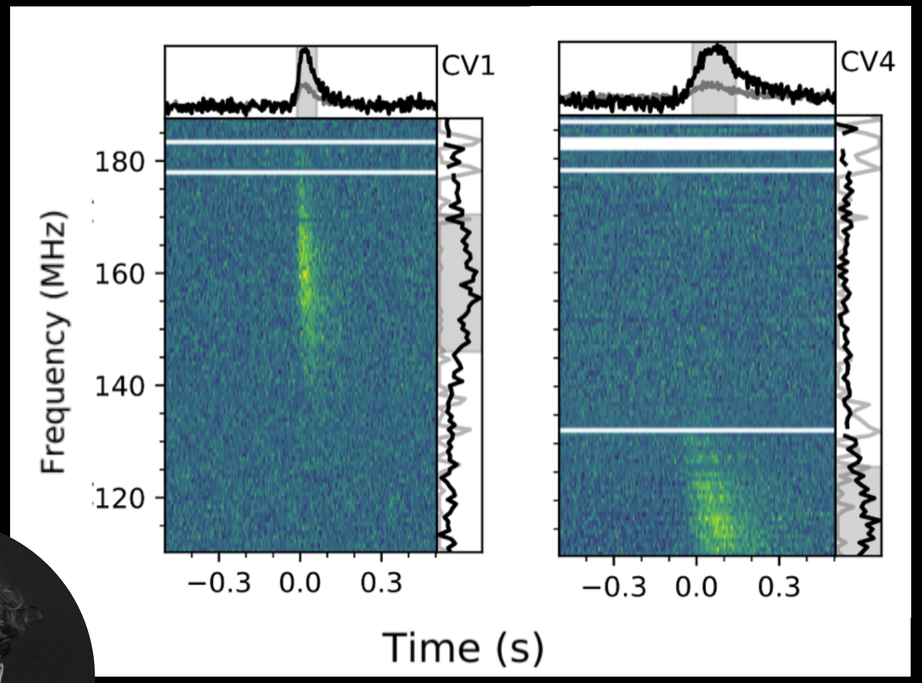


250 kpc offset from star-forming knot.
Inconsistent with ages of active magnetars

LOFAR detections of FRB20180916B (R3)

Lowest frequency FRB detection by LOFAR : 110 - 188 MHz!

Activity systematically delayed towards lower frequencies



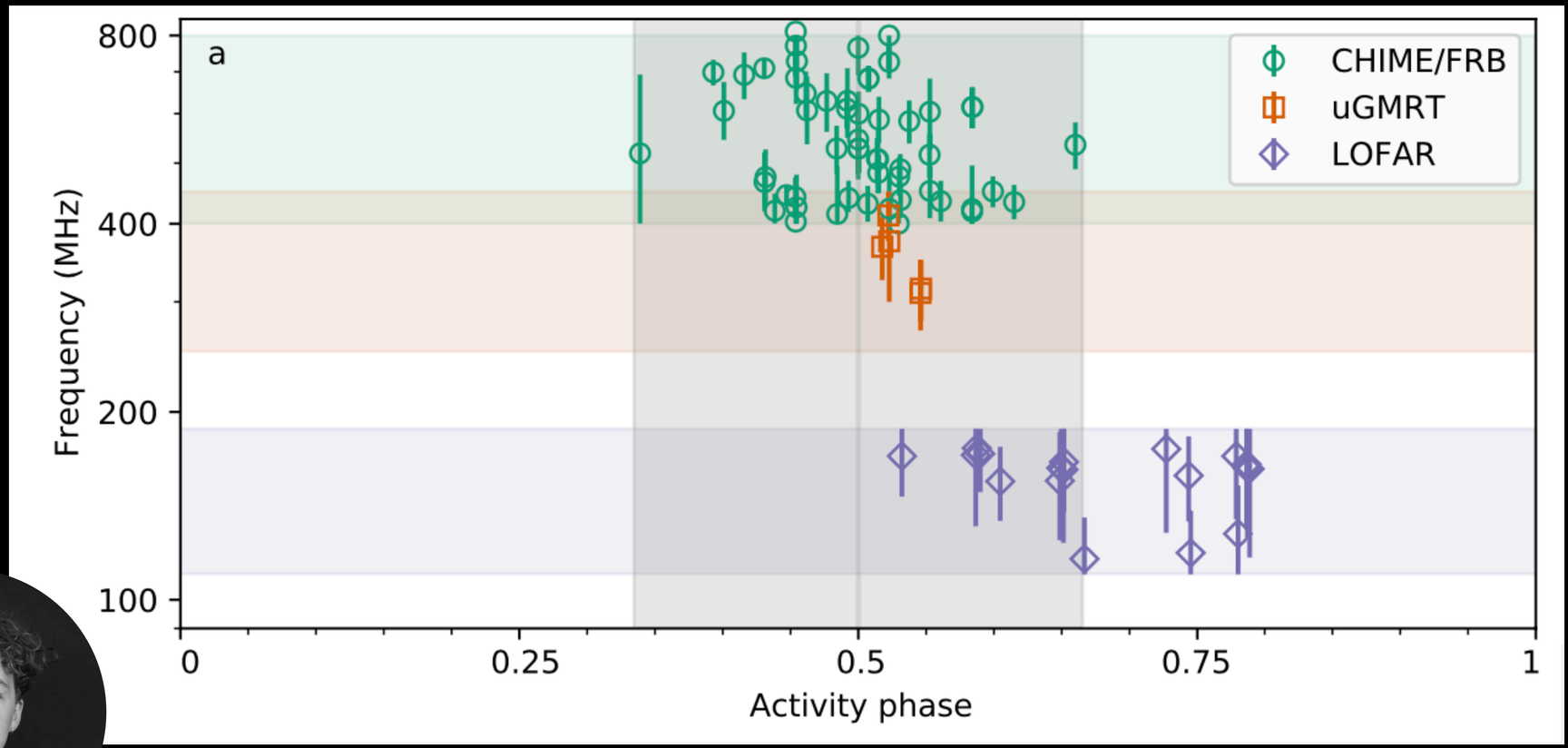
Pleunis+ 2021

See also Pastor-Marazuela+ 2021

Frequency dependent activity

Lowest frequency FRB detection by LOFAR : 110 - 188 MHz

Activity systematically delayed towards lower frequencies



Pleunis+ 2021

See also Pastor-Marazuela+ 2021

FRB20180916B (R3) : What's new

Monitoring activity at LOFAR over a 3.5 yr duration

Track burst properties :

Scattering $\propto \nu^{-4}$

Drift $\propto \nu^{-1}$

RM $\propto \nu^{-2}$

Polarization fraction

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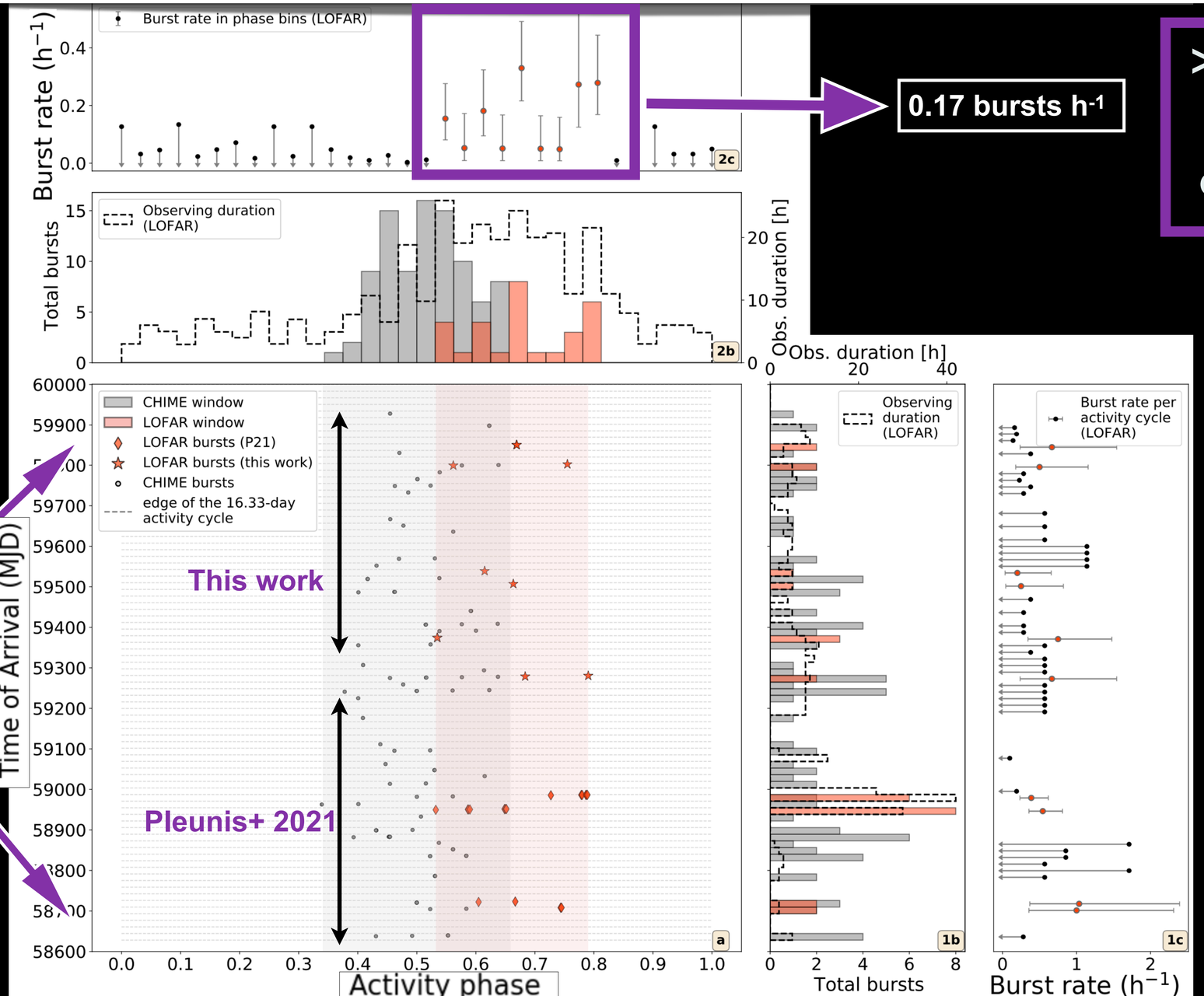
Gopinath+ (submitted)

~3.5 yr LOFAR monitoring



0.17 bursts h^{-1}

>3-sigma difference in average burst rate during active window

29 bursts @ LOFAR

Jan 2023

April 2019

Window width at LOFAR $4.3^{+0.7}_{-0.3}$ days

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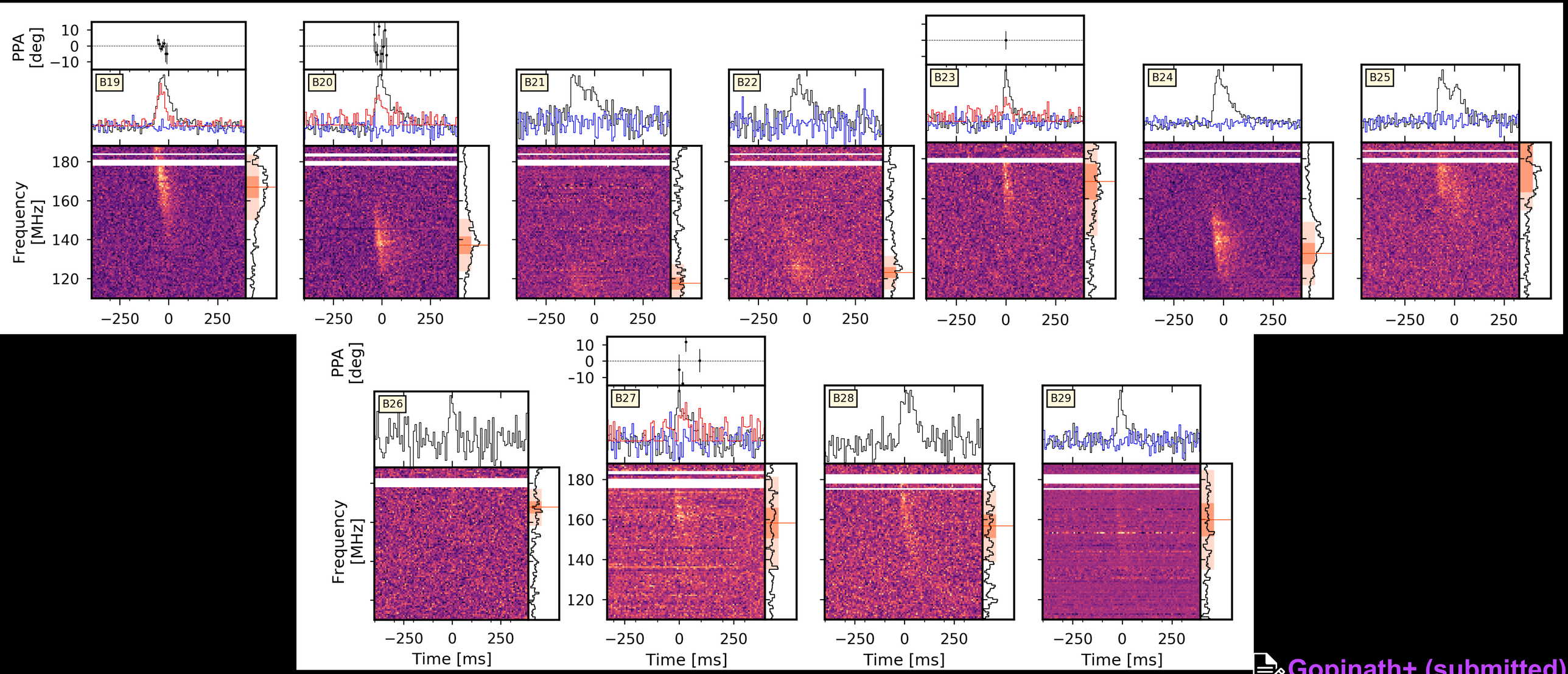
FRB20180916B (R3) : New bursts



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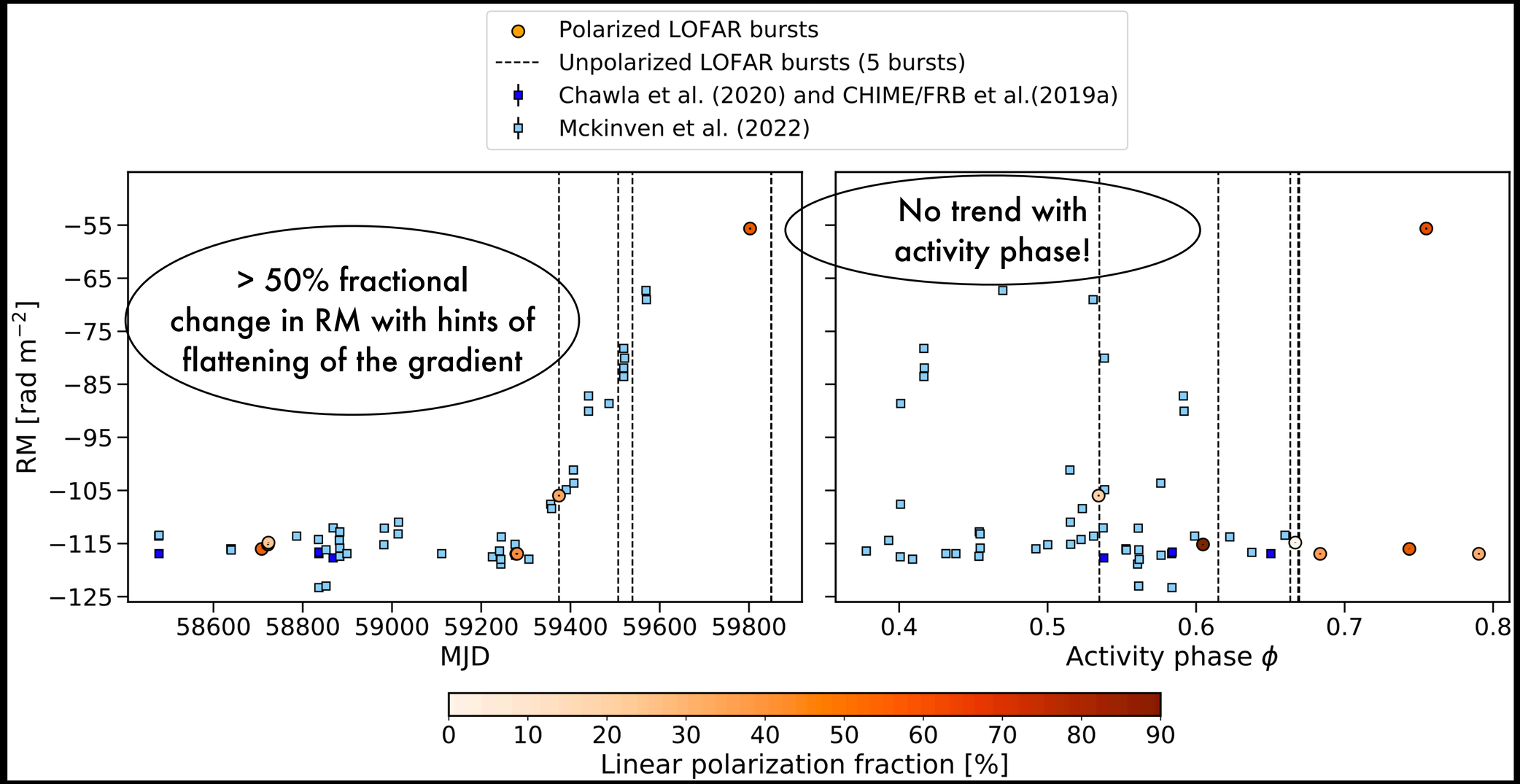
Tracing the local environment : Faraday rotation

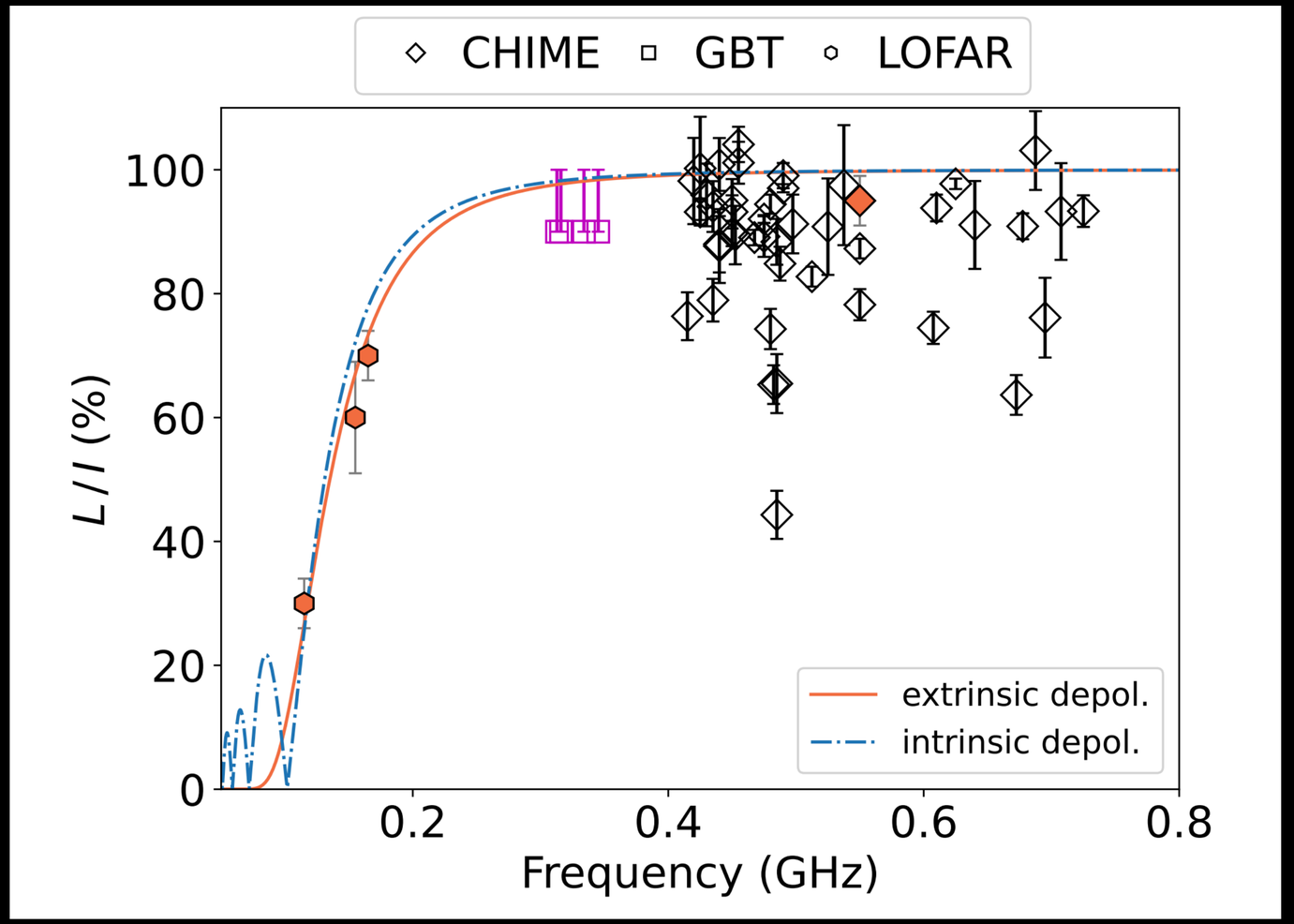
Faraday rotation traces magnetic field in the local medium



Gopinath+ (submitted)

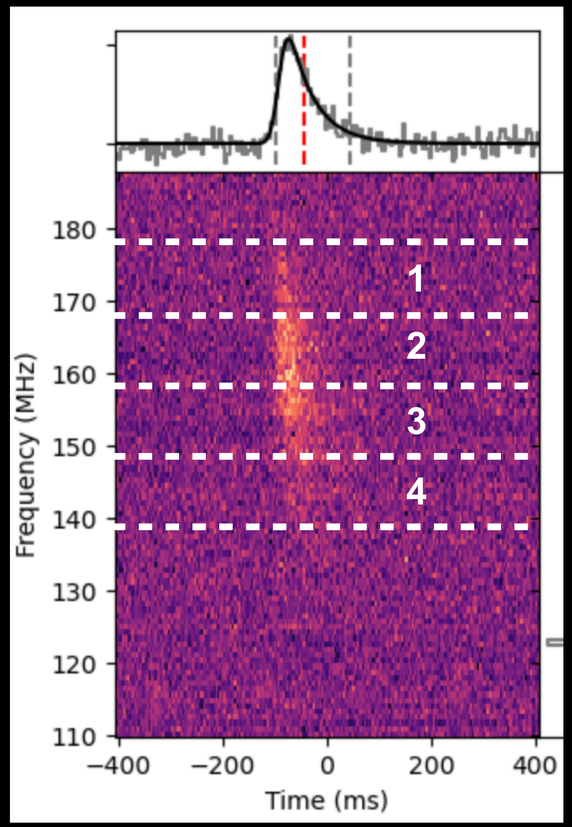
Tracing the local environment : Depolarisation

R3 bursts are ~100% linearly polarised at higher frequencies
Significant depolarisation occurs at LOFAR frequencies (Pleunis+ 2021)

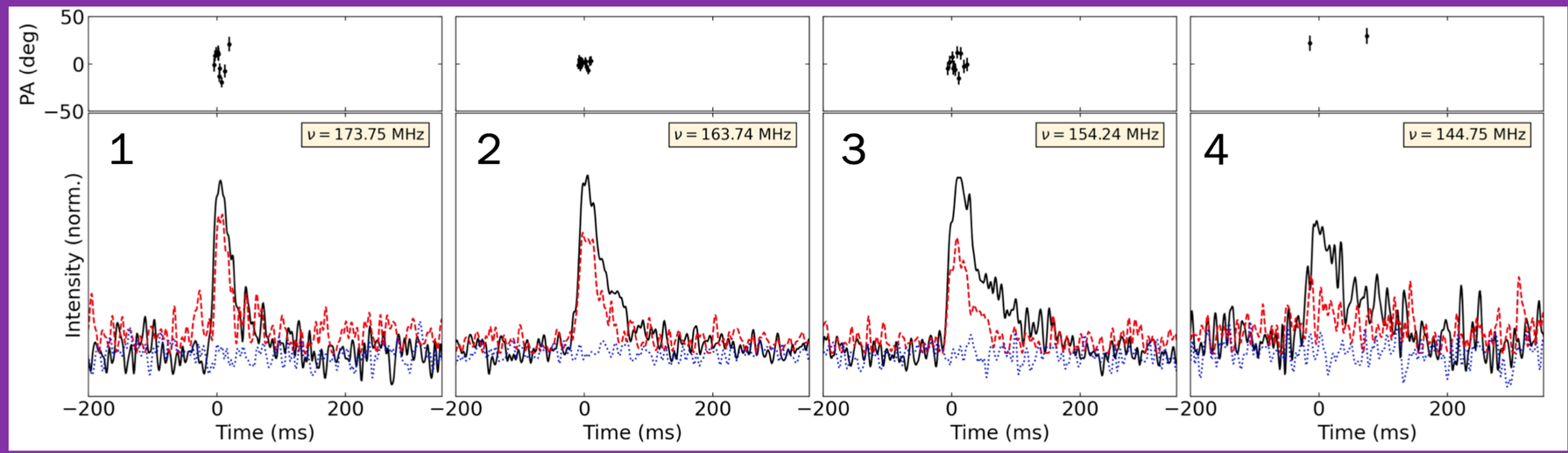


Mckinven+ (2022)

Tracing the local environment : Depolarisation



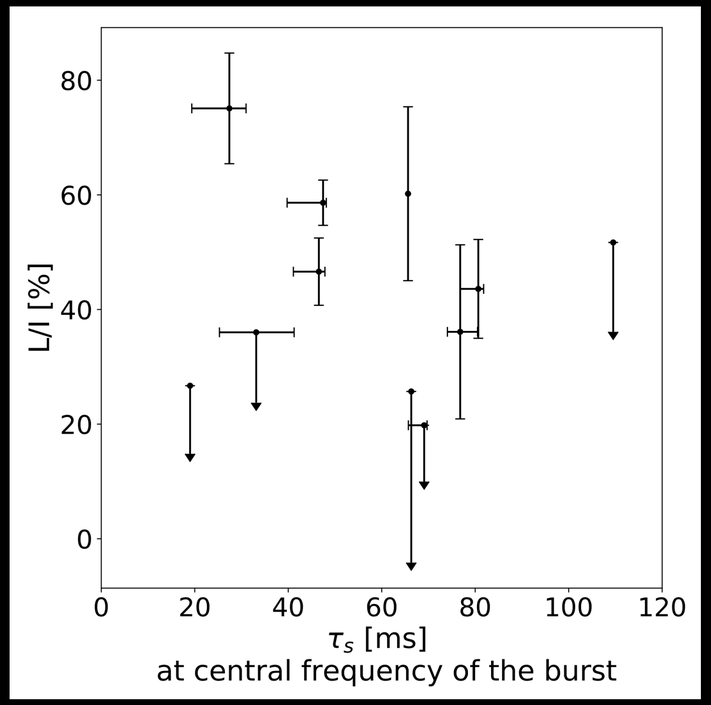
Quantifying depolarization within individual bursts
Effect of scattering?



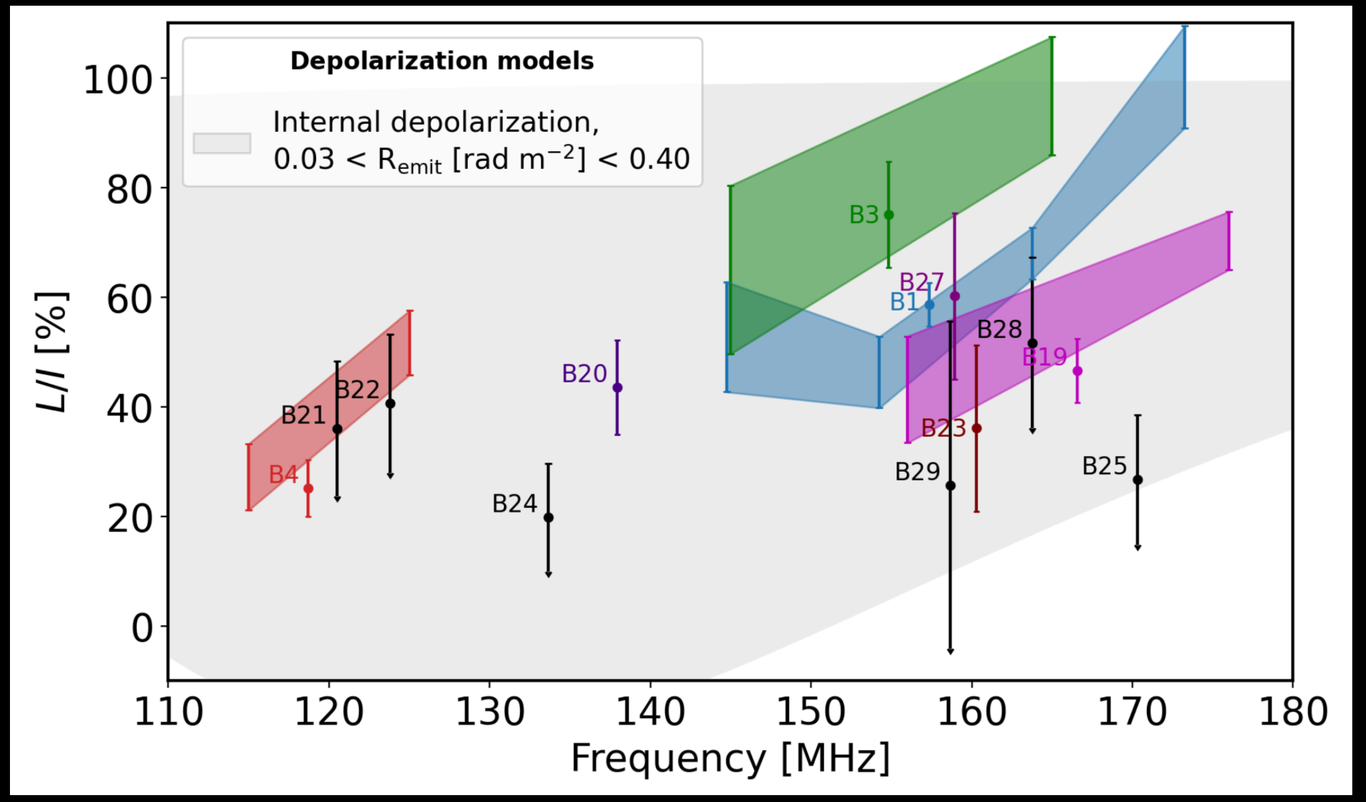
Gopinath+ (submitted)

Tracing the local environment : Depolarisation

No correlation between scattering time and polarization fraction.



Depolarization between AND within bursts.
Frequency of depolarisation varies between bursts.



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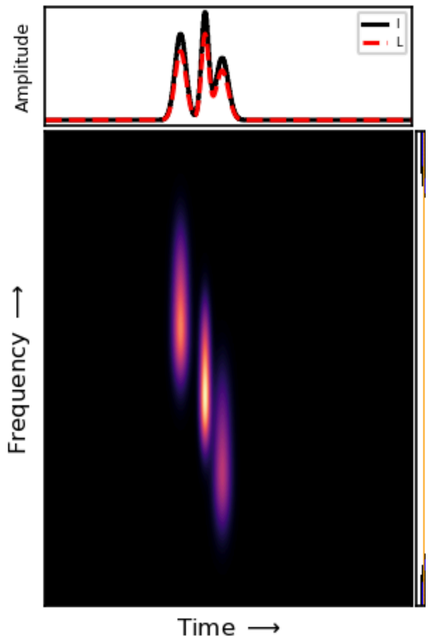
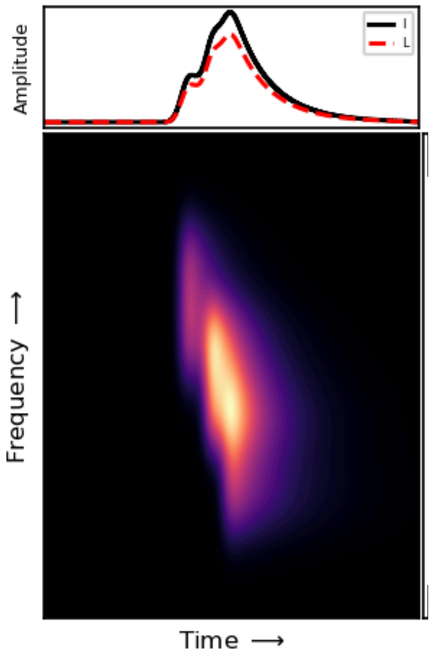
~~Propagation~~ effects : Drift & scattering

Drifting $\propto \nu^{-1}$

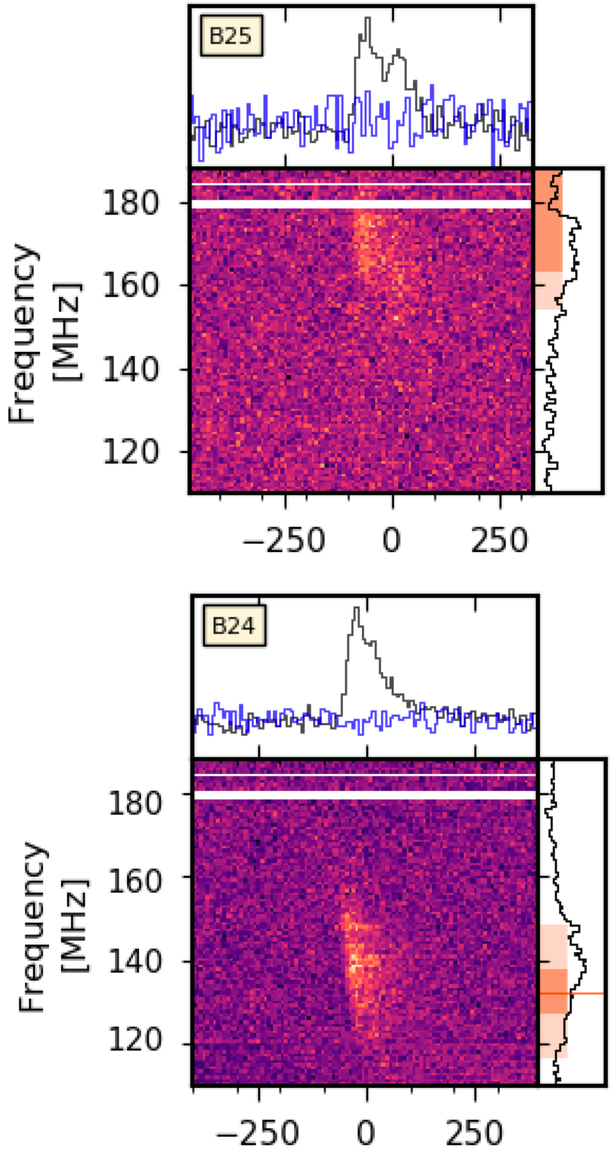


Scattering $\propto \nu^{-4}$



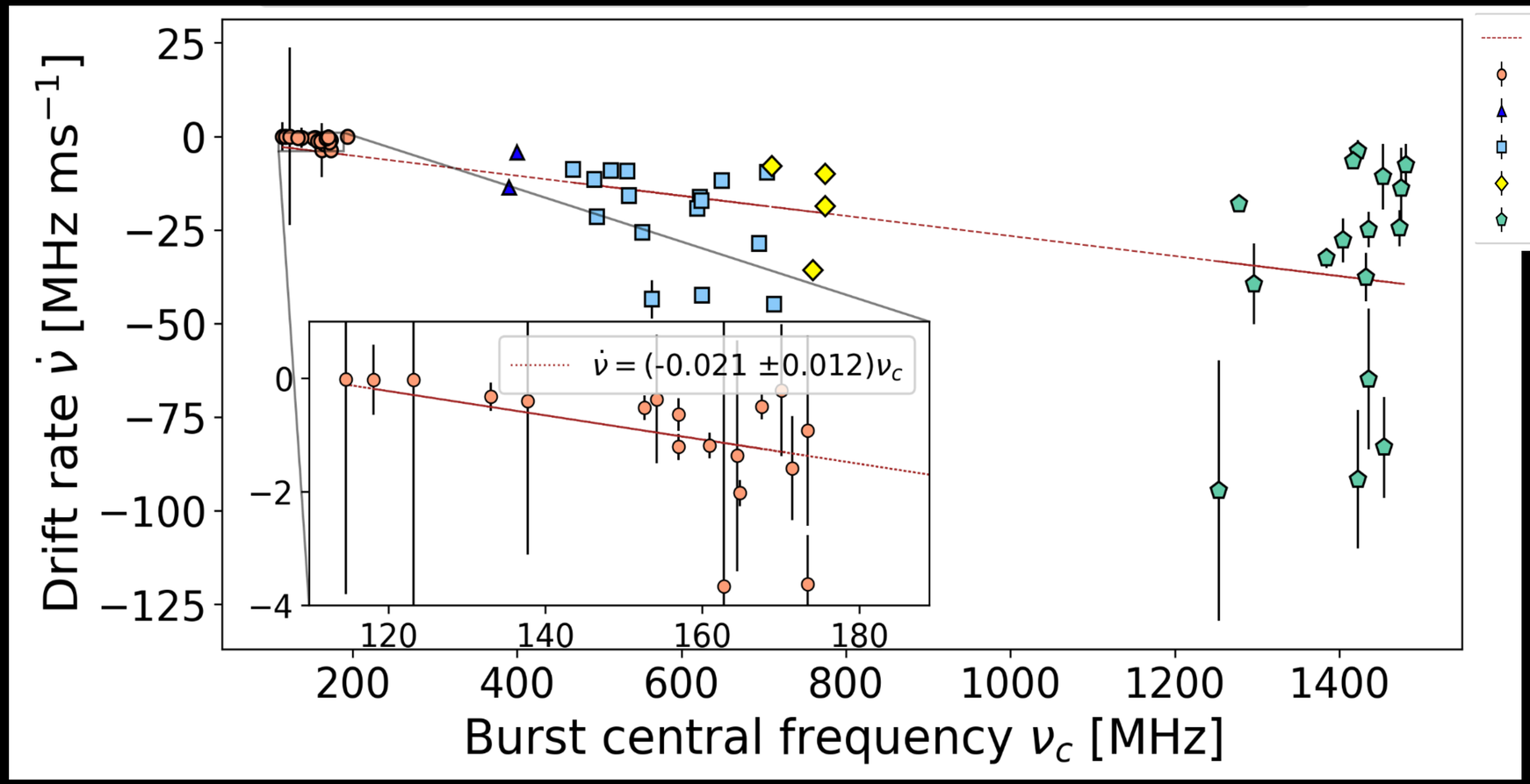
'Radius-to-frequency mapping'
- Emission frequency decreases as the emission region moves further away from the central source

Lyutikov 2020



Tracing the emission height? Drift

Sub-burst drift rate varies linearly with frequency within the LOFAR band and across 4 octaves in frequency



Linear relation seen in bursts from the other periodically active FRB 20121102A

Hessels (2019)

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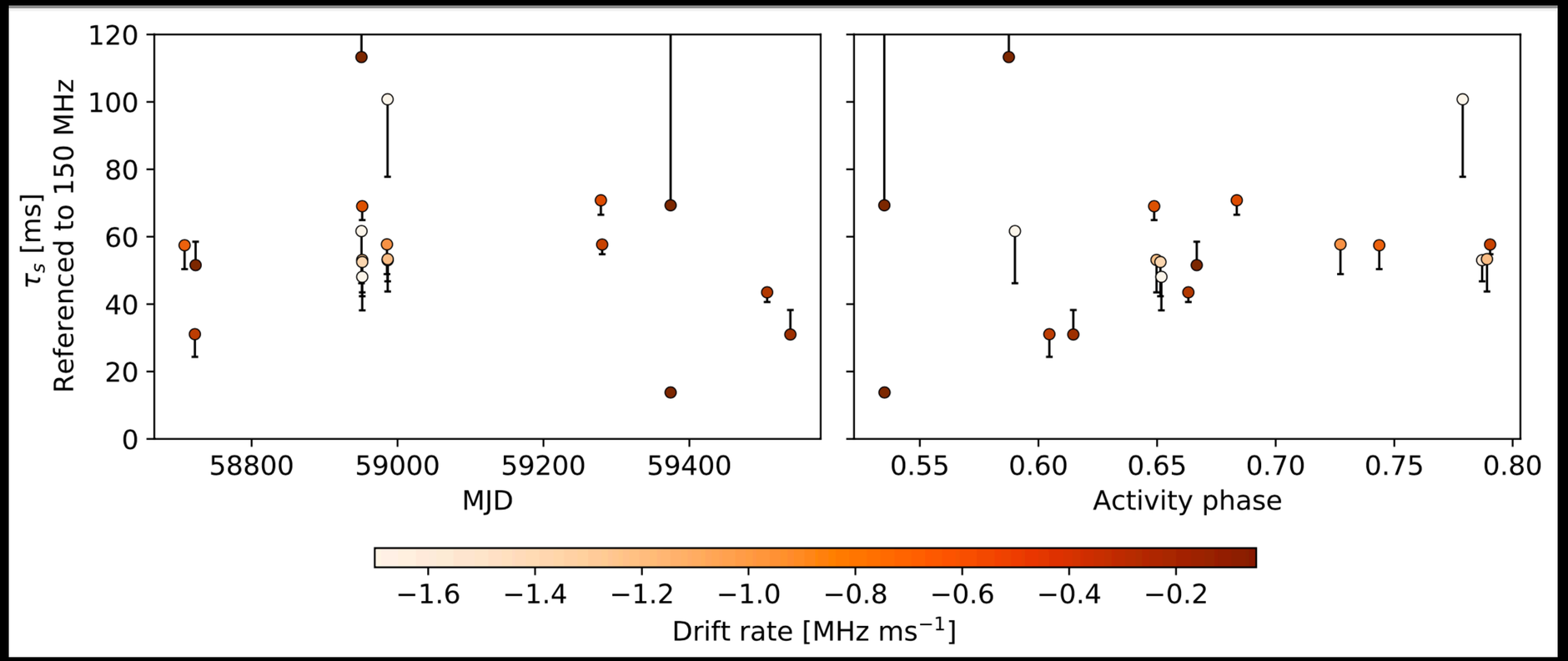
Tracing the local environment : Scattering

Scattering traces inhomogeneities in the local medium
Scattering variations of a few 10s of ms.



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FRB20180916B (R3) : What's new

- Stable activity window spanning 3.5 years of activity, with new constraints on LOFAR window.
- RM changes consistent between LOFAR (150 MHz) and CHIME/FRB (600 MHz)
- Depolarization in the LOFAR band
- Drifting consistent with linear dependence on frequency.
- Scattering variations of a few 10s of ms from local environment.

arXiv:2305.06393

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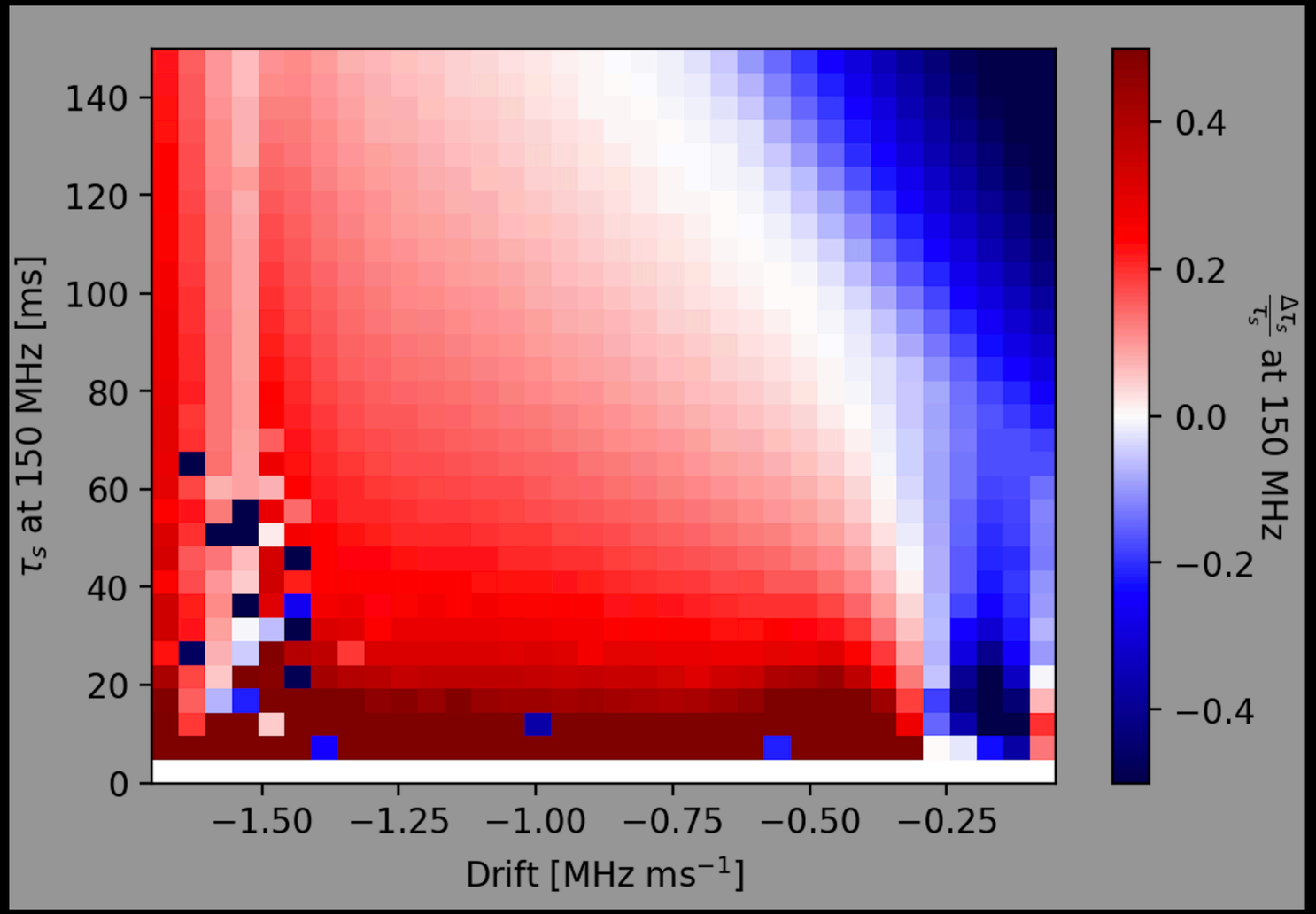

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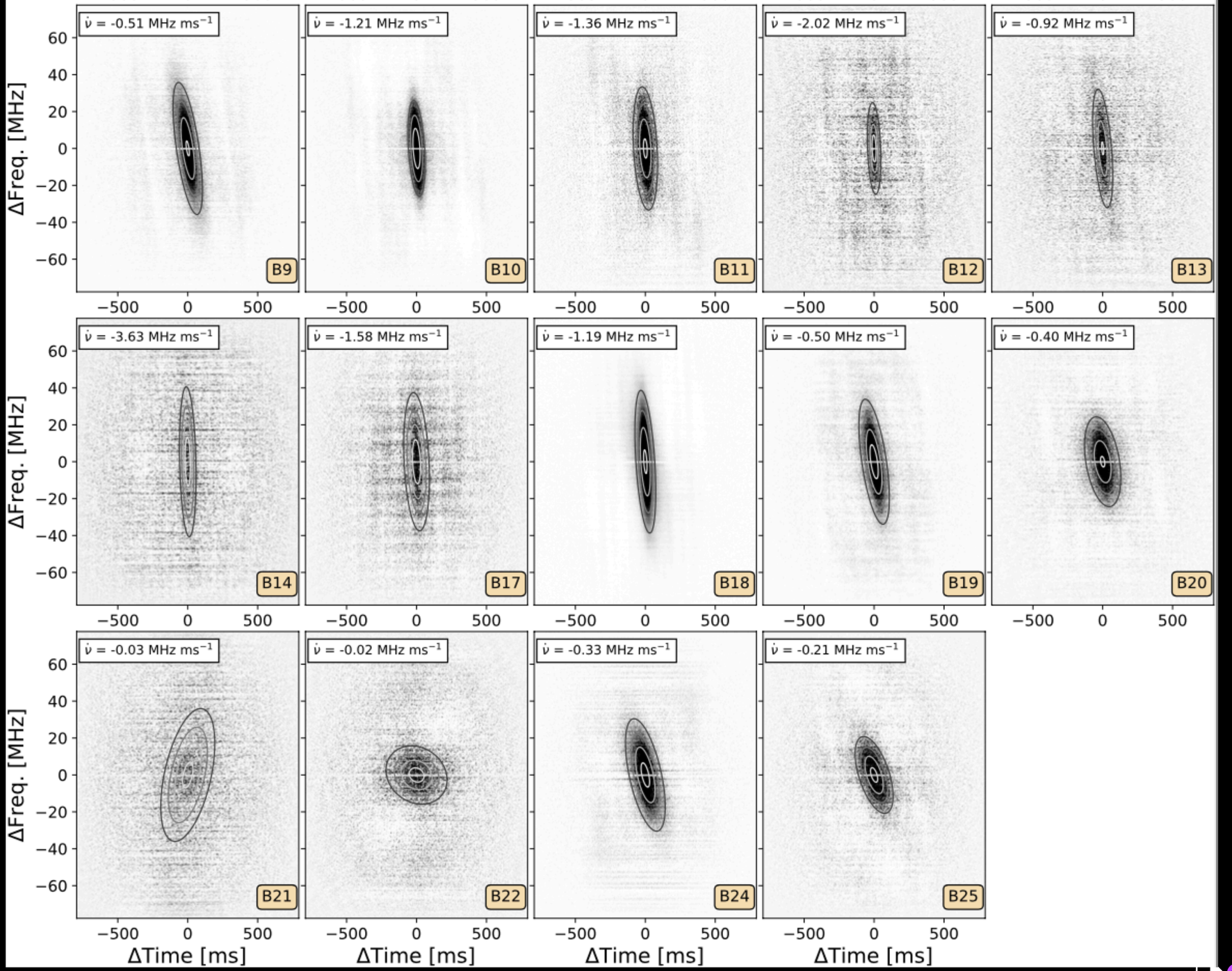

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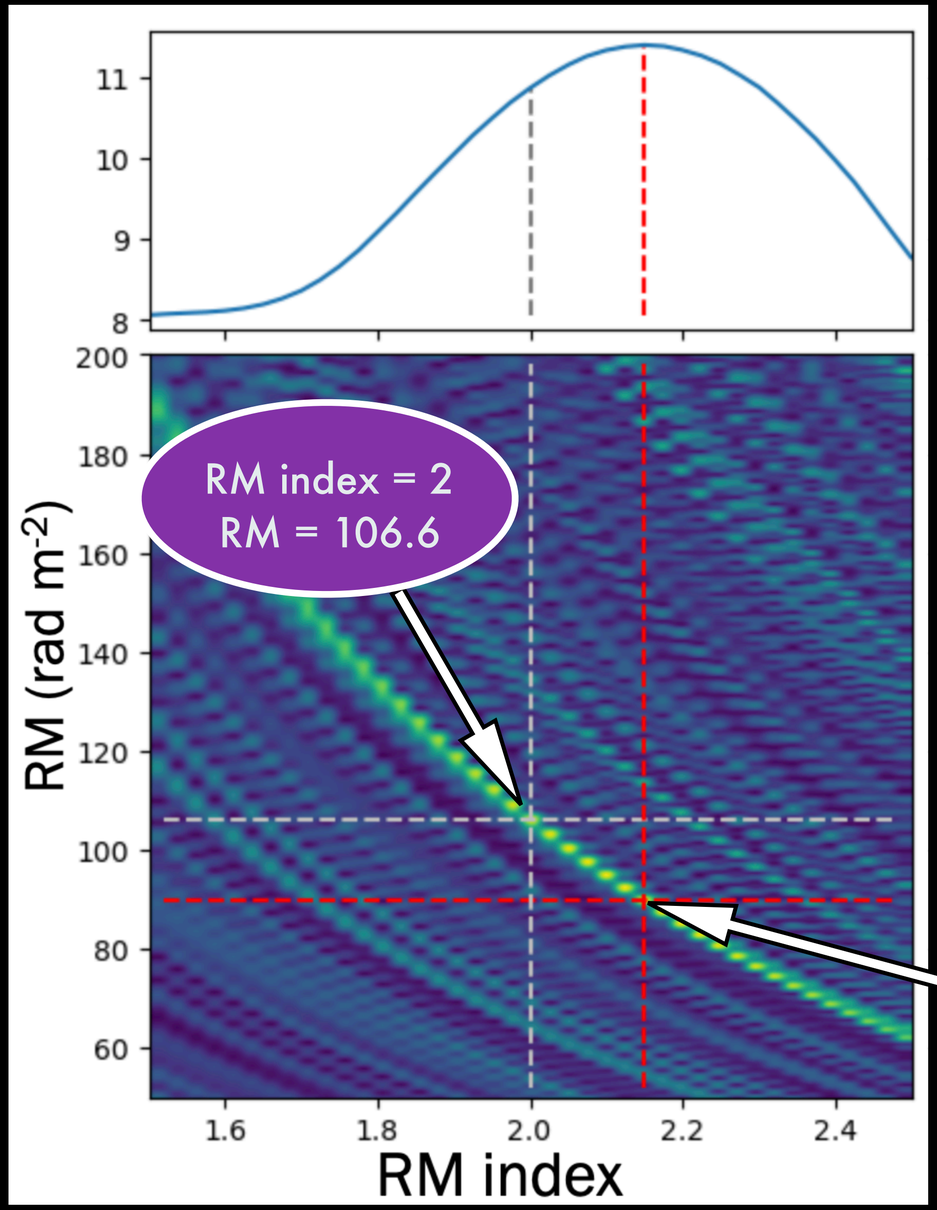
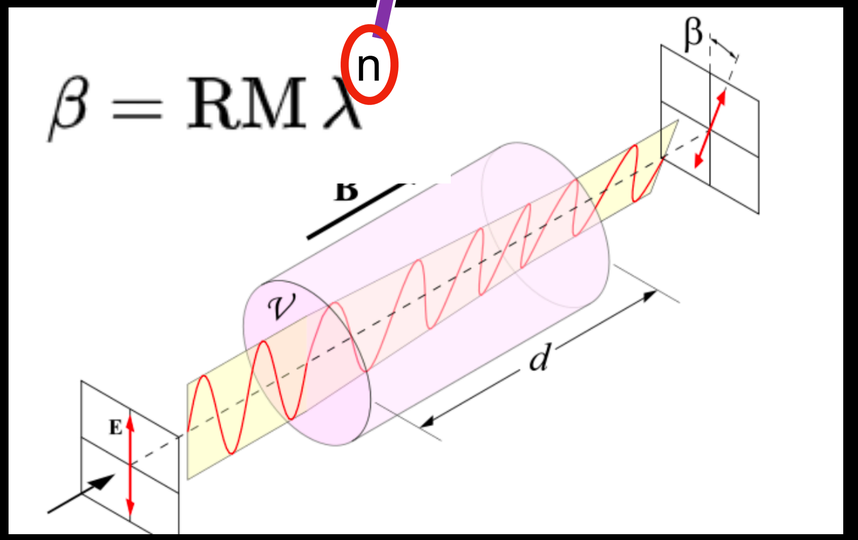
Tracing the local environment : RM index

Burst B23



"RM index"

$\beta = \mathrm{RM}\,\lambda^{n}$



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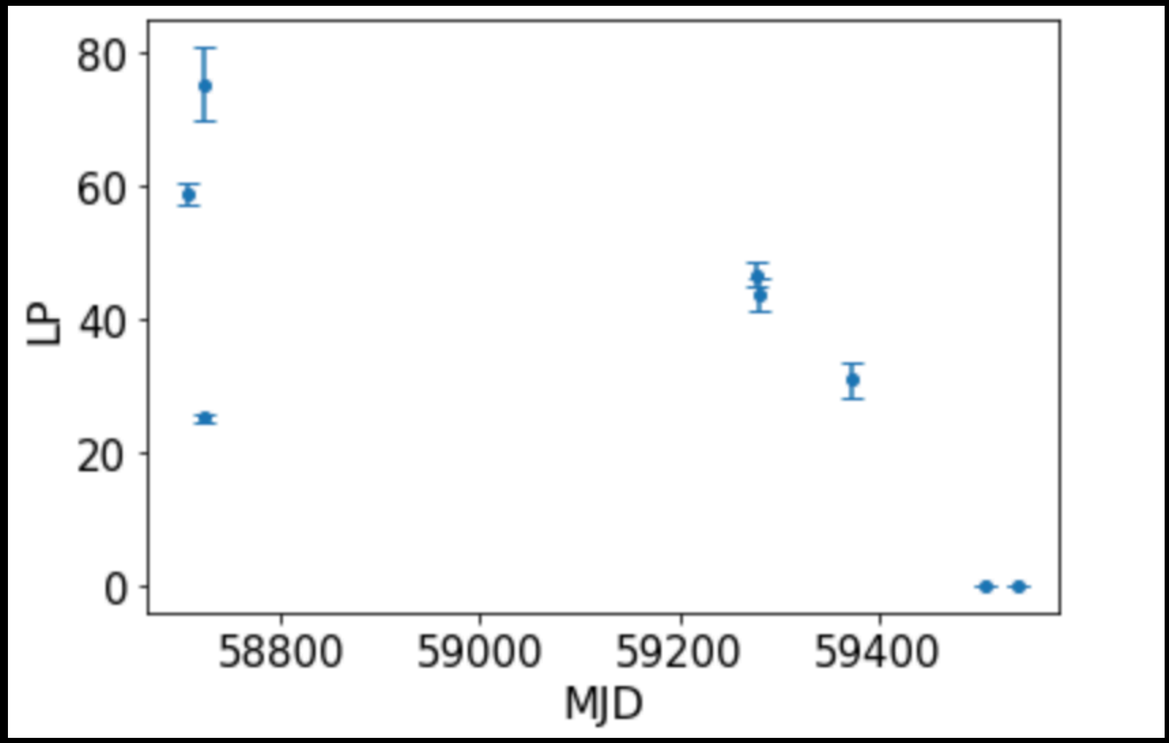

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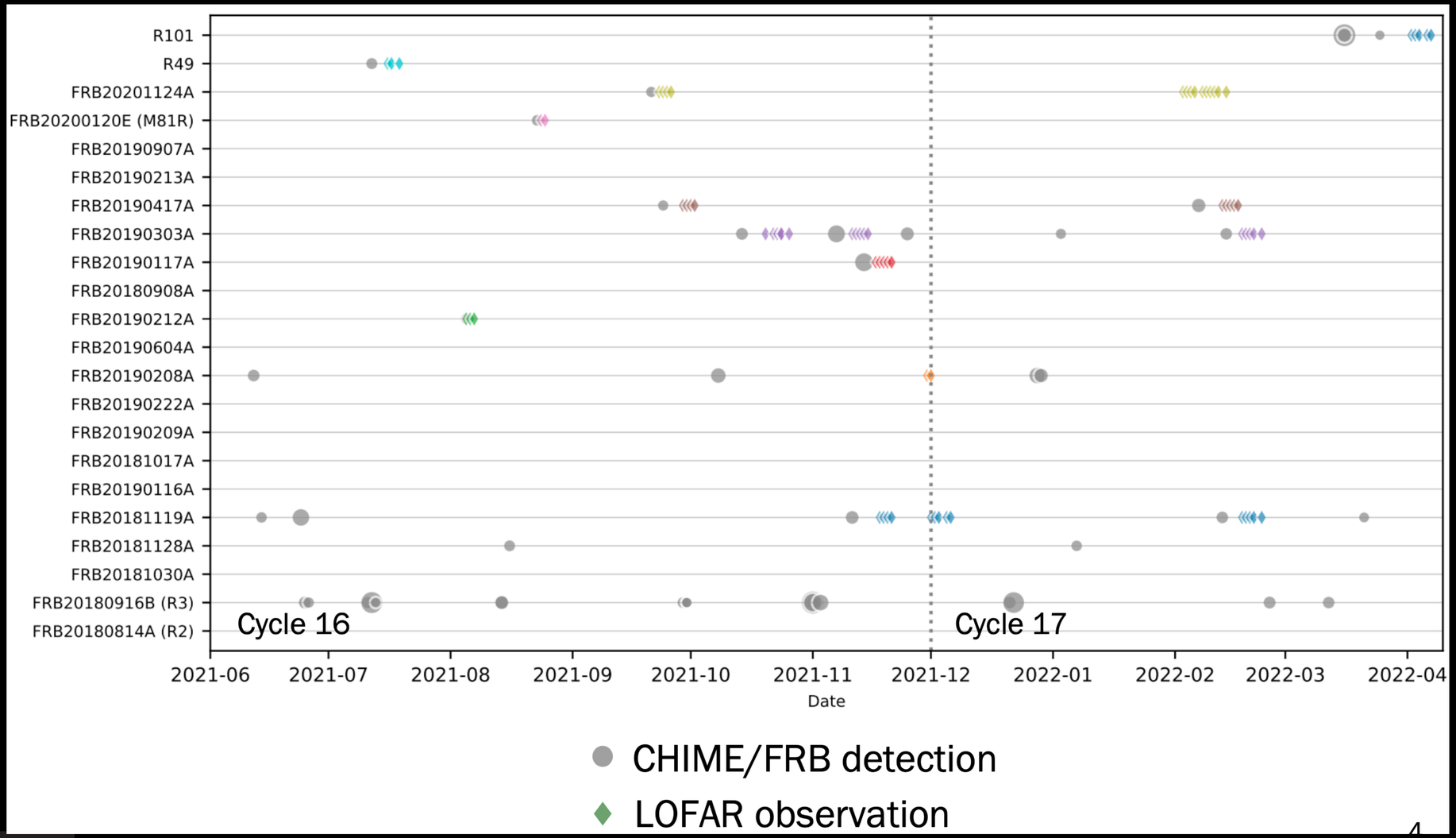
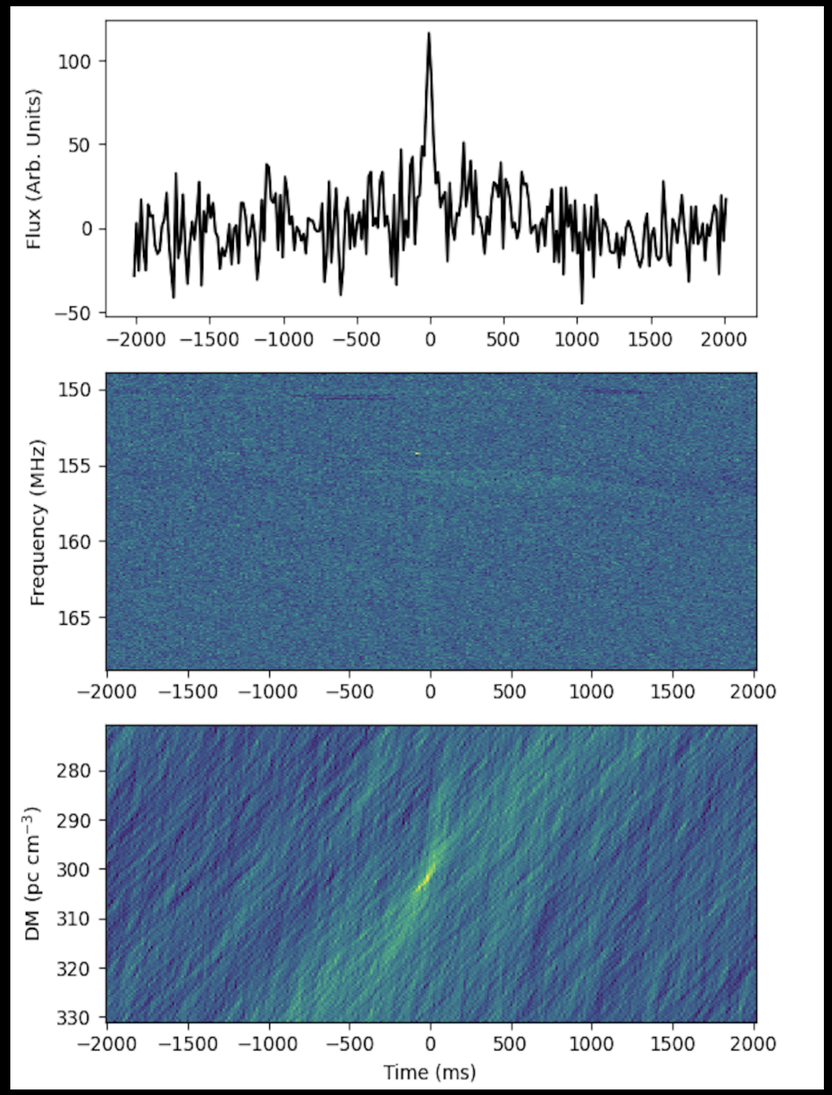
LOFAR follow-up of CHIME/FRB repeaters



FRB 20190212B (R14)



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