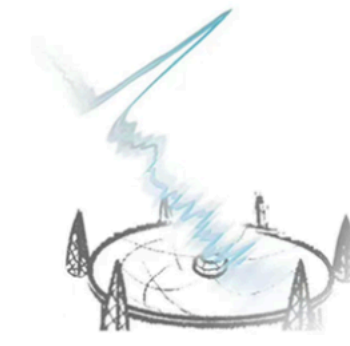




中国科学院国家天文台
NATIONAL ASTRONOMICAL OBSERVATORIES, CAS



FAST 快速射电暴优先及重大项目
FAST Fast Radio Burst (FRB) Key Science Project

Links between Pulsars, Fast Radio Bursts and Long-Period Radio Transients

Heng Xu 胥恒 (NAOC)

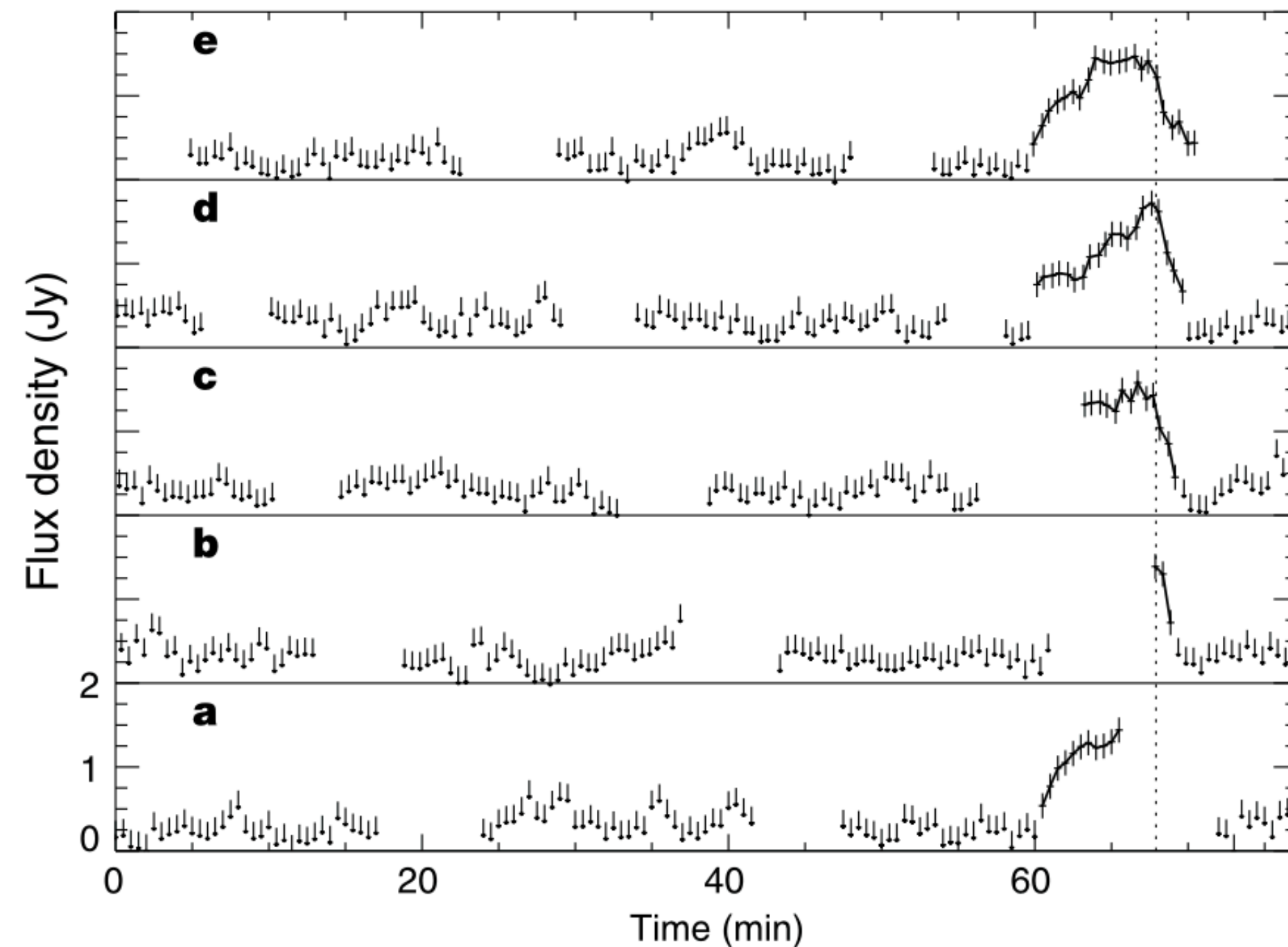
FPS15 | 2026-07-05

Collaborators: Yongkun Zhang, Dejiang Zhou, Zhenyin Zhao, Jiangwei Xu, Xiaohui Liu, Yuanpei Yang, Weiyang Wang, Fayin Wang, Shuo Cao, Yanjun Guo, Jinlin Han, Jincheng Jiang, Kejia Lee, Botao Li, Ye Li, Yunpeng Men, Jiarui Niu, Yuanhong Qu, Meng Sun, Bojan Wang, Wei Wang, Ziteng Wang, Qin Wu, Xuefeng Wu, Ziwei Wu, Renxin Xu, Zihan Xue, Bing Zhang, Cijie Zhang, Songbo Zhang, Weiwei Zhu & FAST FRB Key Science Project.



Back to ~2005

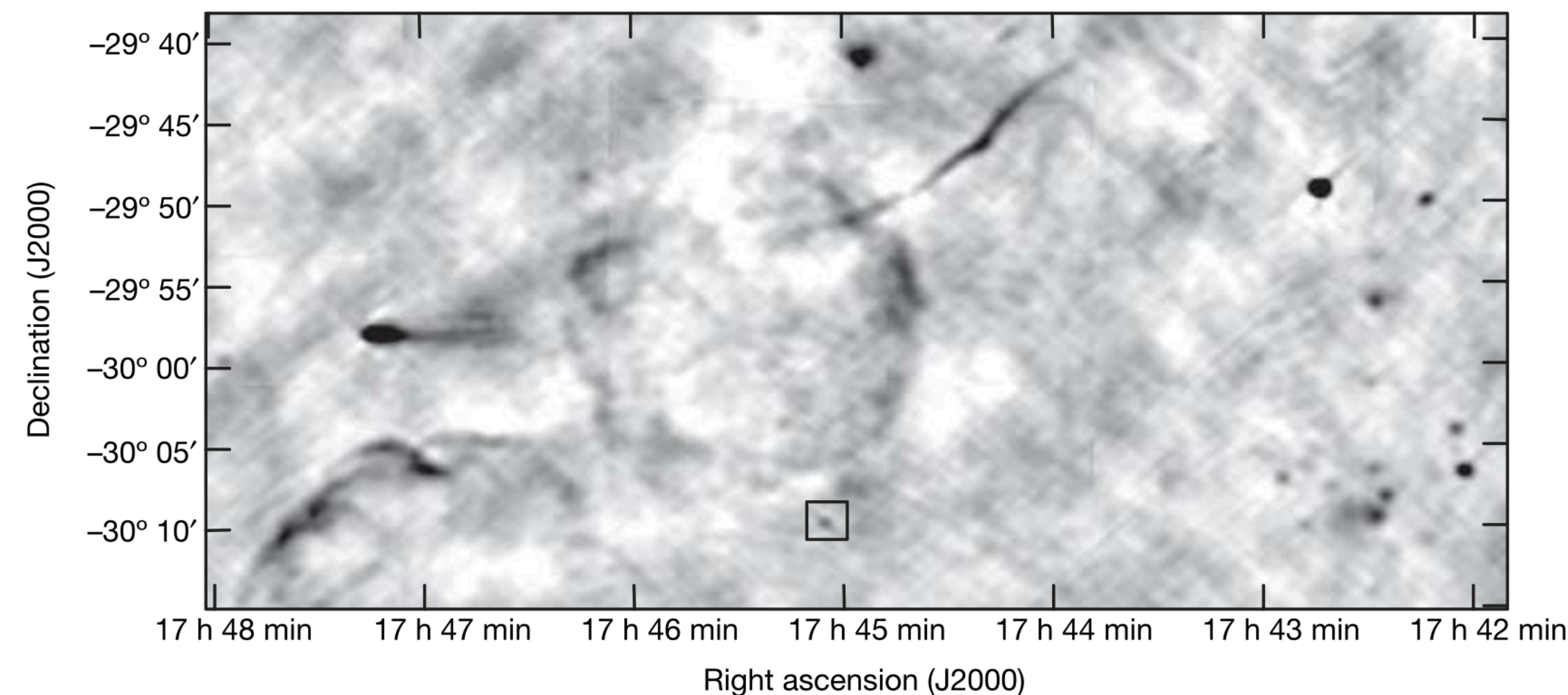
- GCRT J1745-3009: VLA wide-field monitoring program of the Galactic center (0.33 GHz)
- Bright ~ 1 Jy
- Long duration ~ 10 mins
- Long period ? ~ 77.13 mins?
- High brightness temperature $\sim 10^{12}$ K $(D/70 \text{ pc})^2$



letters to nature

A powerful bursting radio source towards the Galactic Centre

**Scott D. Hyman¹, T. Joseph W. Lazio², Namir E. Kassim², Paul S. Ray³,
Craig B. Markwardt⁴ & Farhad Yusef-Zadeh⁵**



Hyman+ 2005

A White Dwarf ?

GCRT J1745–3009 AS A TRANSIENT WHITE DWARF PULSAR

BING ZHANG¹ AND JANUSZ GIL^{1,2}

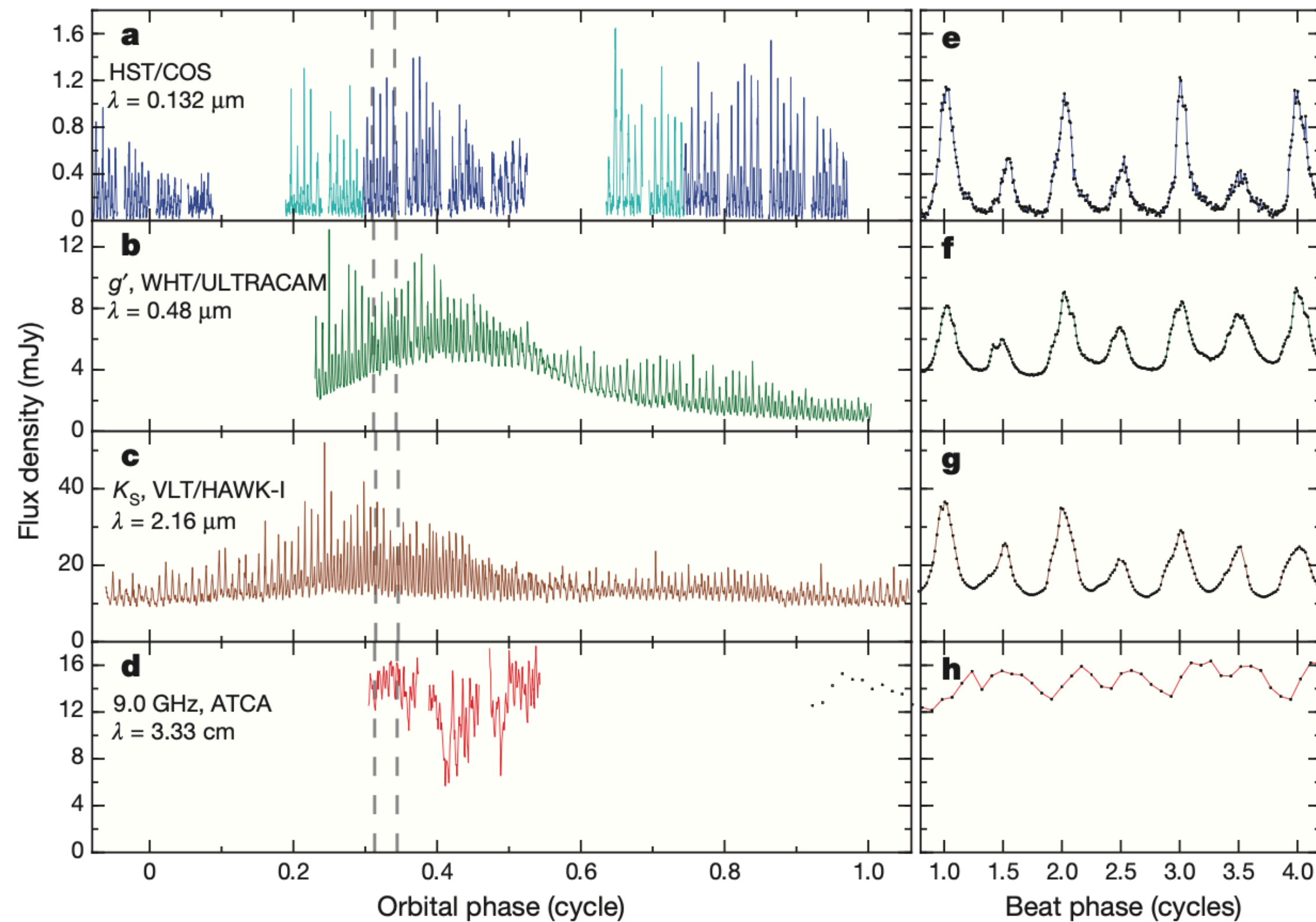
Received 2005 August 9; accepted 2005 August 25; published 2005 September 14

ABSTRACT

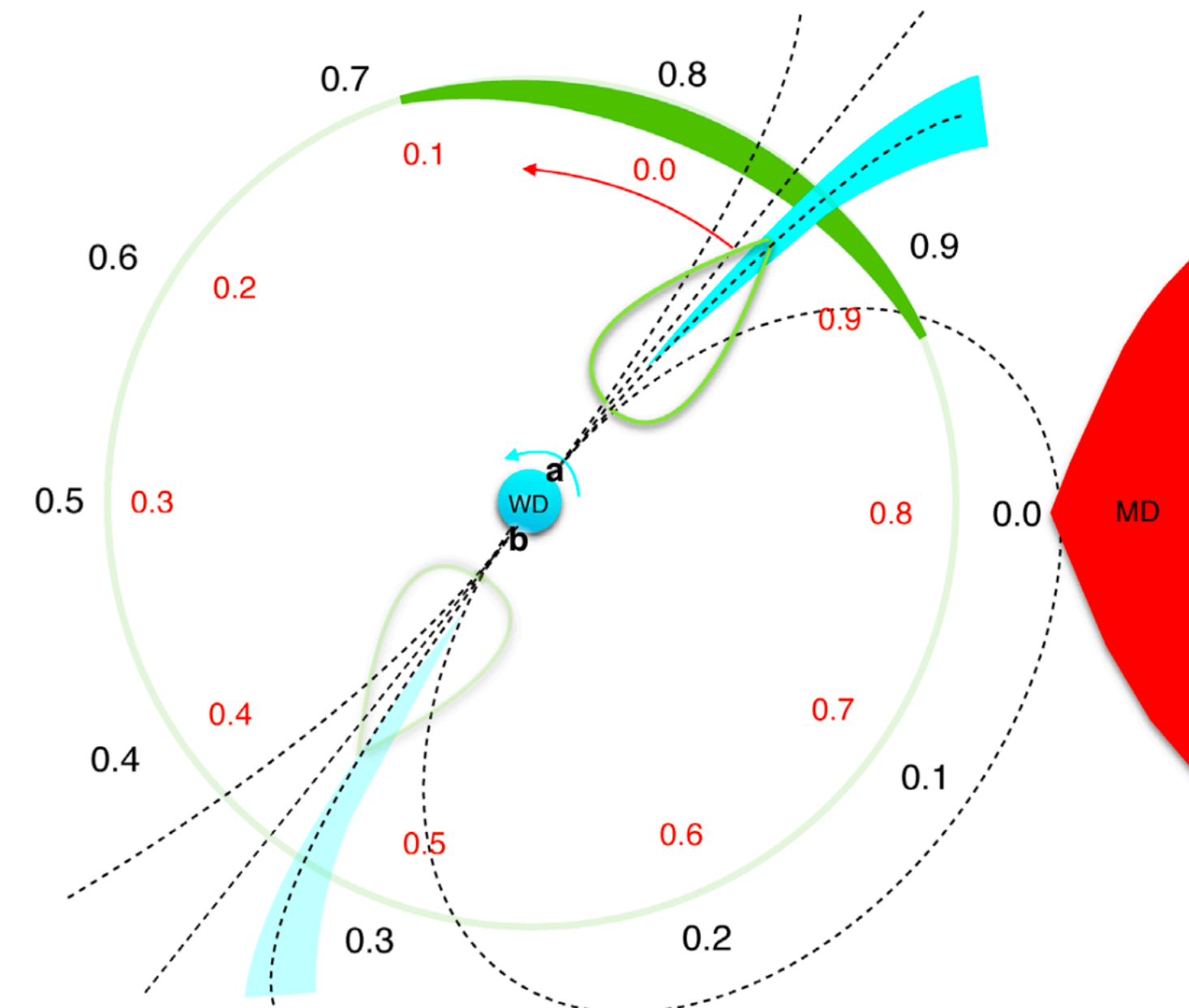
A transient radio source in the direction of the Galactic center, GCRT J1745–3009, exhibited five peculiar consecutive outbursts at 0.33 GHz with a period of 77.13 minutes and a duration of ~ 10 minutes for each outburst. It has been claimed to be the prototype of a hitherto unknown class of transient radio sources. We interpret it as a transient white dwarf pulsar with a period of 77.13 minutes. The ~ 10 minute flaring duration corresponds to the epoch in which the radio beam sweeps our line of sight. The bursting epoch corresponds to the episodes in which stronger sunspot-like magnetic fields emerge into the white dwarf polar cap region during which the pair-production condition is satisfied and the white dwarf behaves like a radio pulsar. It switches off as the pair-production condition breaks down.

A radio-pulsing white dwarf binary star

T. R. Marsh¹, B. T. Gänsicke¹, S. Hümmerich^{2,3}, F.-J. Hambsch^{2,3,4}, K. Bernhard^{2,3}, C. Lloyd⁵, E. Breed¹, E. R. Stanway¹, D. T. Steeghs¹, S. G. Parsons⁶, O. Toloza¹, M. R. Schreiber⁶, P. G. Jonker^{7,8}, J. van Roestel⁸, T. Kupfer⁹, A. F. Pala¹, V. S. Dhillon^{10,11,12}, L. K. Hardy¹⁰, S. P. Littlefair¹⁰, A. Aungwerojwit¹³, S. Arjyotha^{14‡}, D. Koester¹⁵, J. J. Bochinski¹⁶, C. A. Haswell¹⁶, P. Frank² & P. J. Wheatley¹

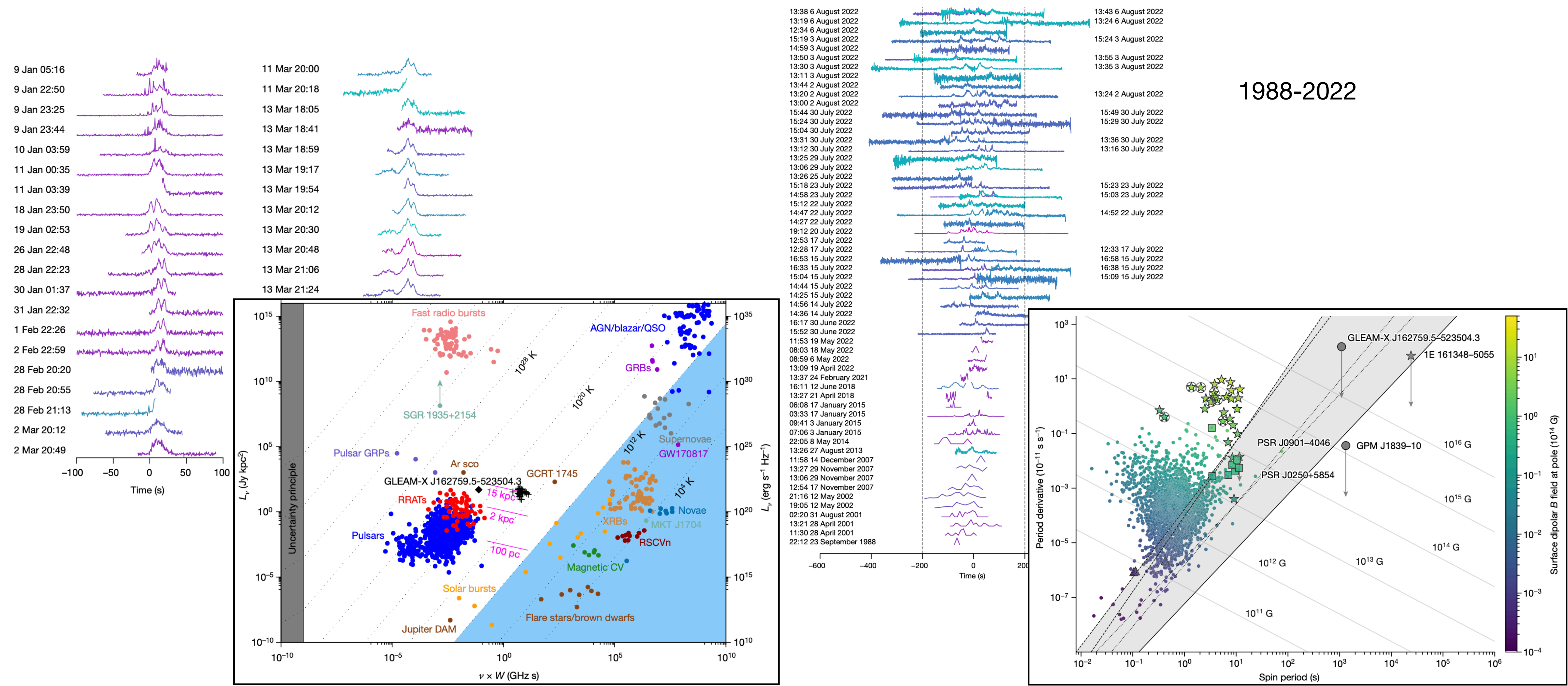


Marsh+ 2016



Potter+ 2018

Long-Period Radio Transient (LPT)

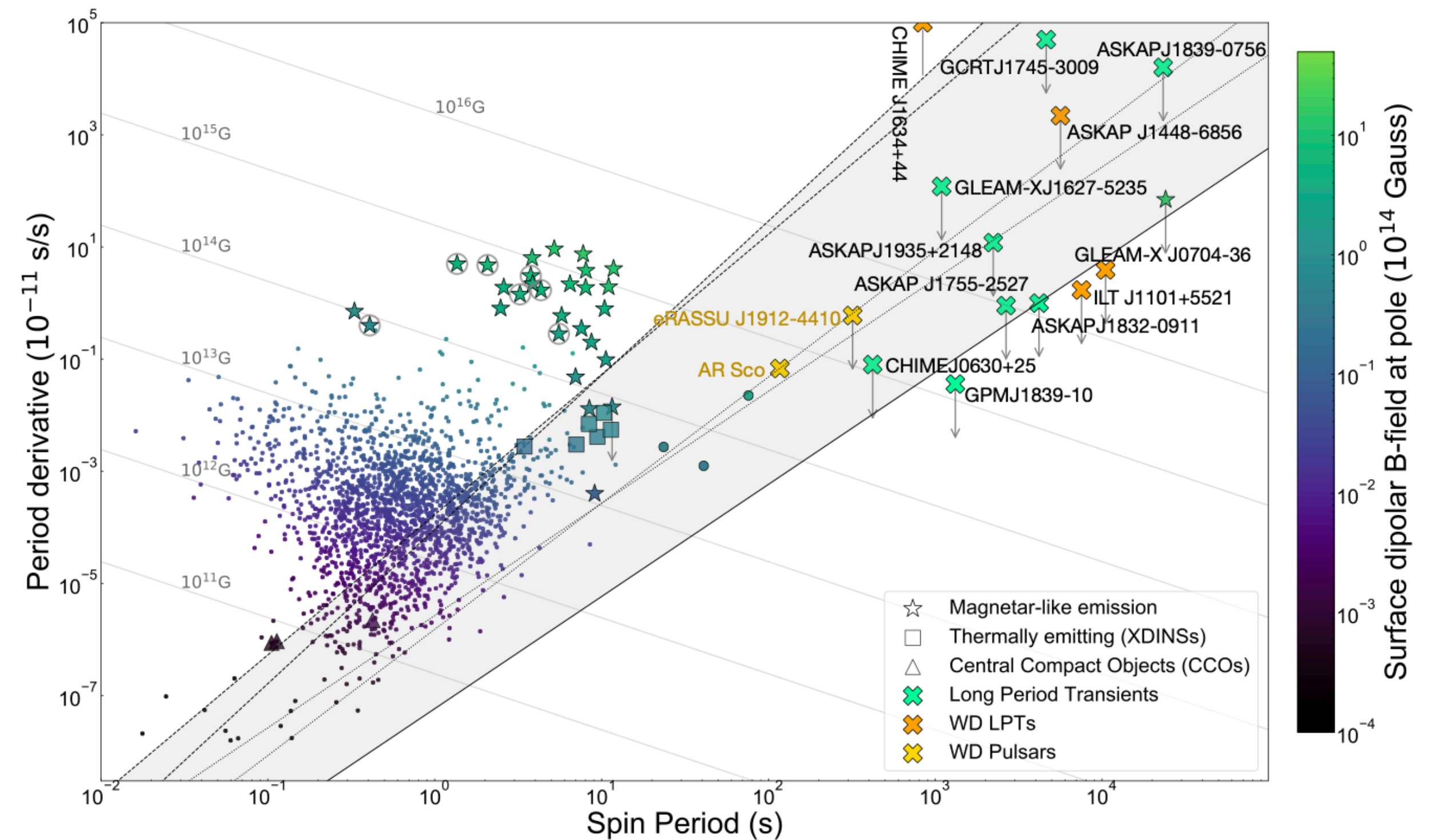
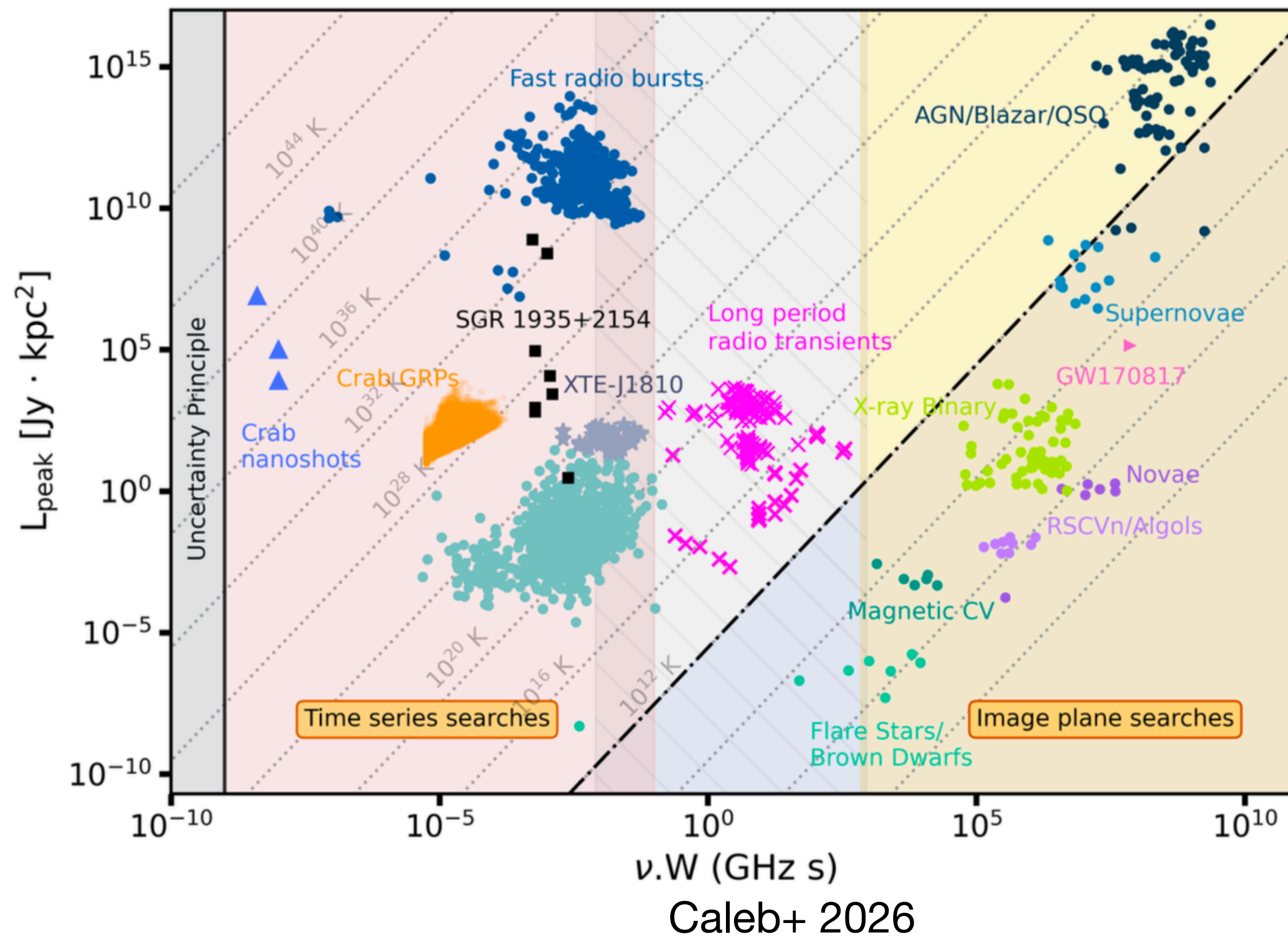


Hurley-Walker+ 2022

Hurley-Walker+ 2023

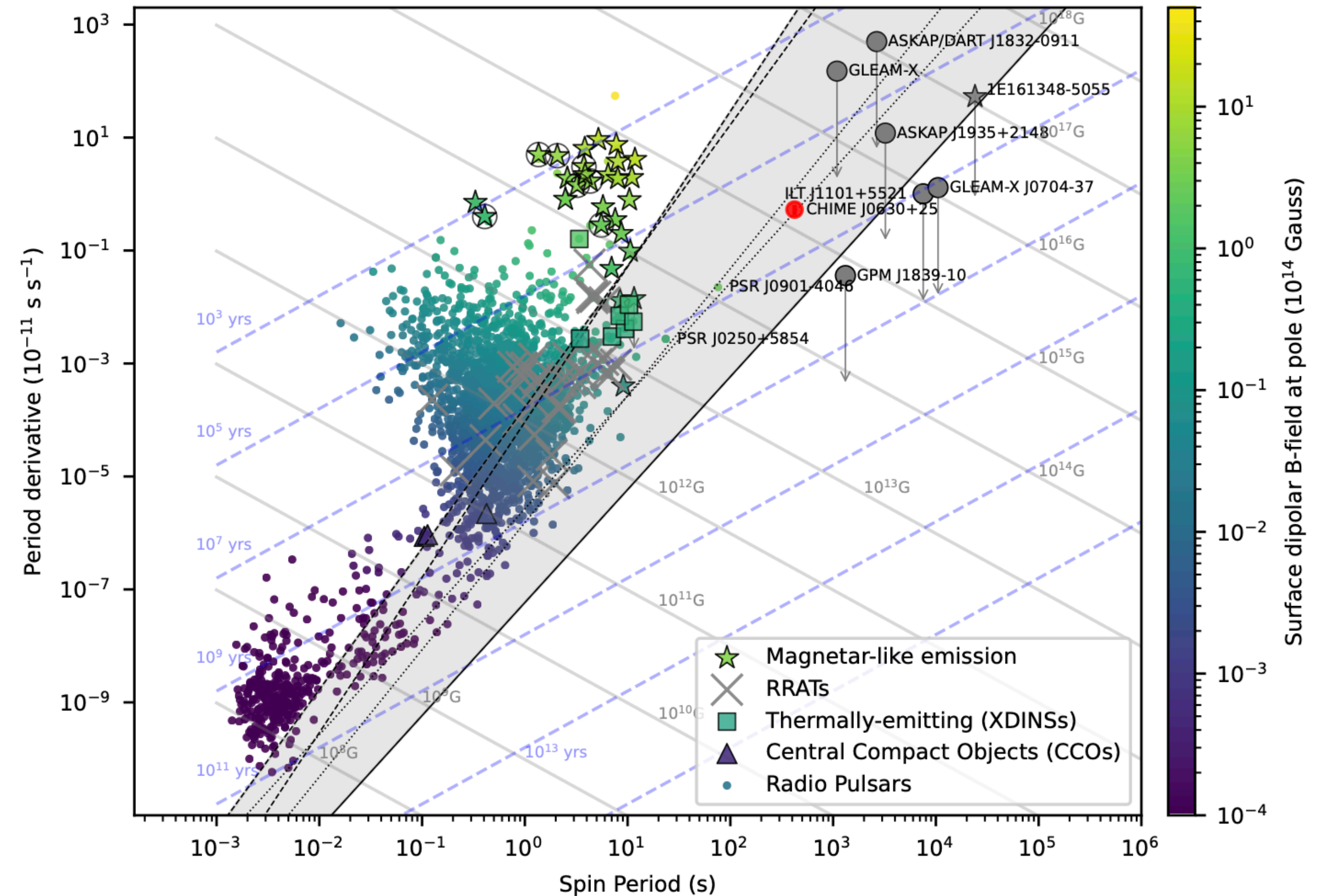
The LPT Population

- 10+ LPTs discovered (e.g., Rea+2026; Caleb+2026)
- Heterogeneous properties: polarization (e.g., Men+2025), radio, X-ray (e.g., Wang+2025)
- Two categories of models: isolated white dwarf (WD)/neutron star (NS) and WD-M dwarf binary (e.g., Zhang&Gil 2005; Katz 2022; Qu+2025; Yang+2026)
- 3 with confirmed WD binary origin



CHIME J0630+25

- Period ~ 421 s with a possible timing glitch
- Small distance ~ 100 -500 pc (DM derived)
- Low luminosity compared with other LPTs
- Low degree of polarization

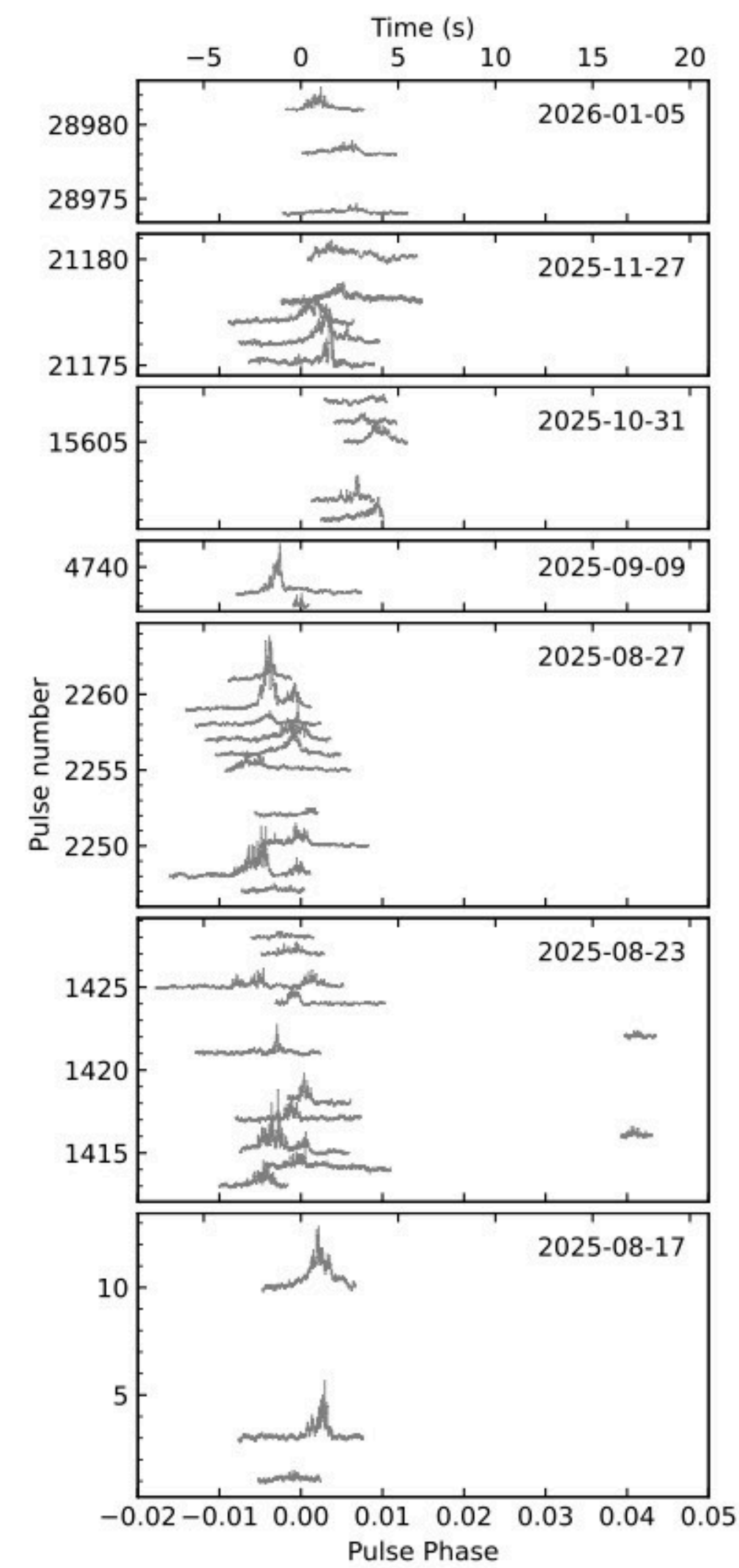


Dong+ 2025

FAST Observation

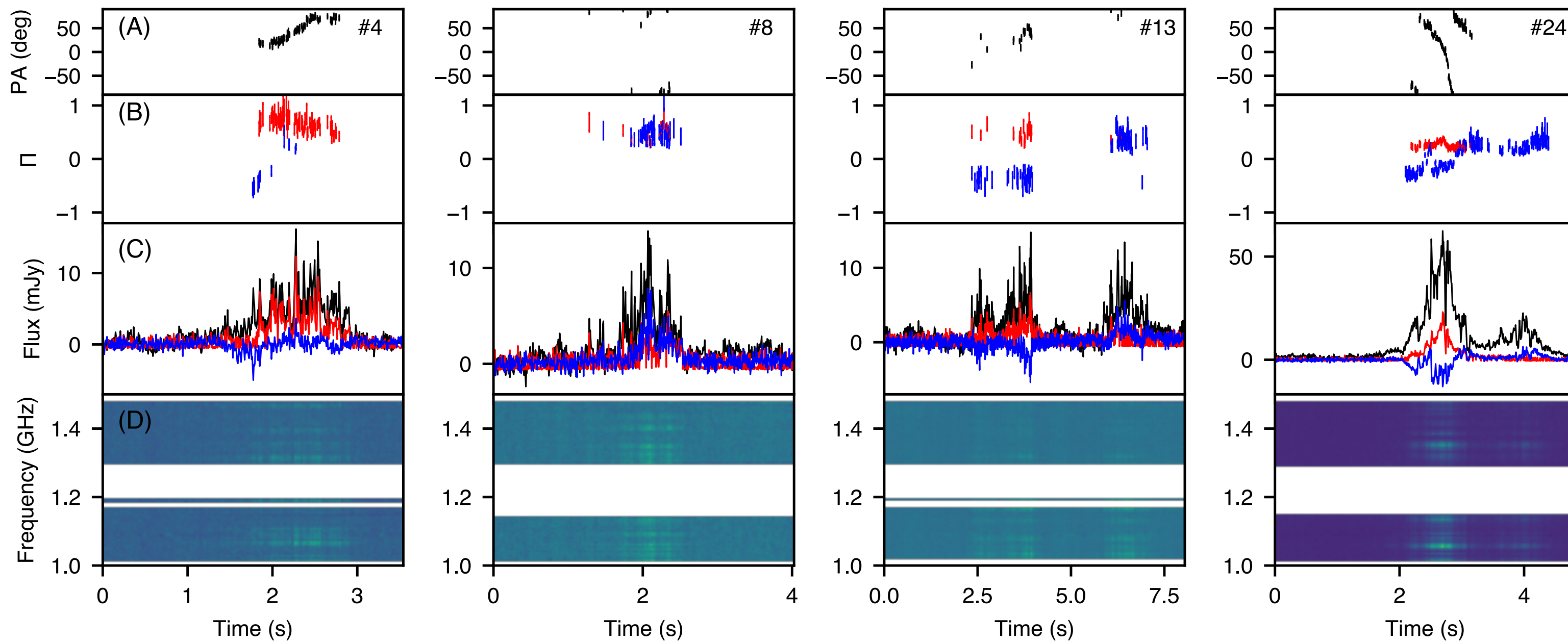
Epoch	Start Time (UTC)	Duration (min)	Npulse
1	2025-08-17T02:12:09	120	3
2	2025-08-23T22:31:00	120	12
3	2025-08-27T23:42:00	120	10
4	2025-09-09T01:29:00	30	2
5	2025-09-22T21:58:00	60	0
6	2025-10-11T19:50:00	60	0
7	2025-10-31T18:51:00	60	5
8	2025-11-27T20:03:00	60	5
9	2026-01-04T16:28:00	60	3

Submitted

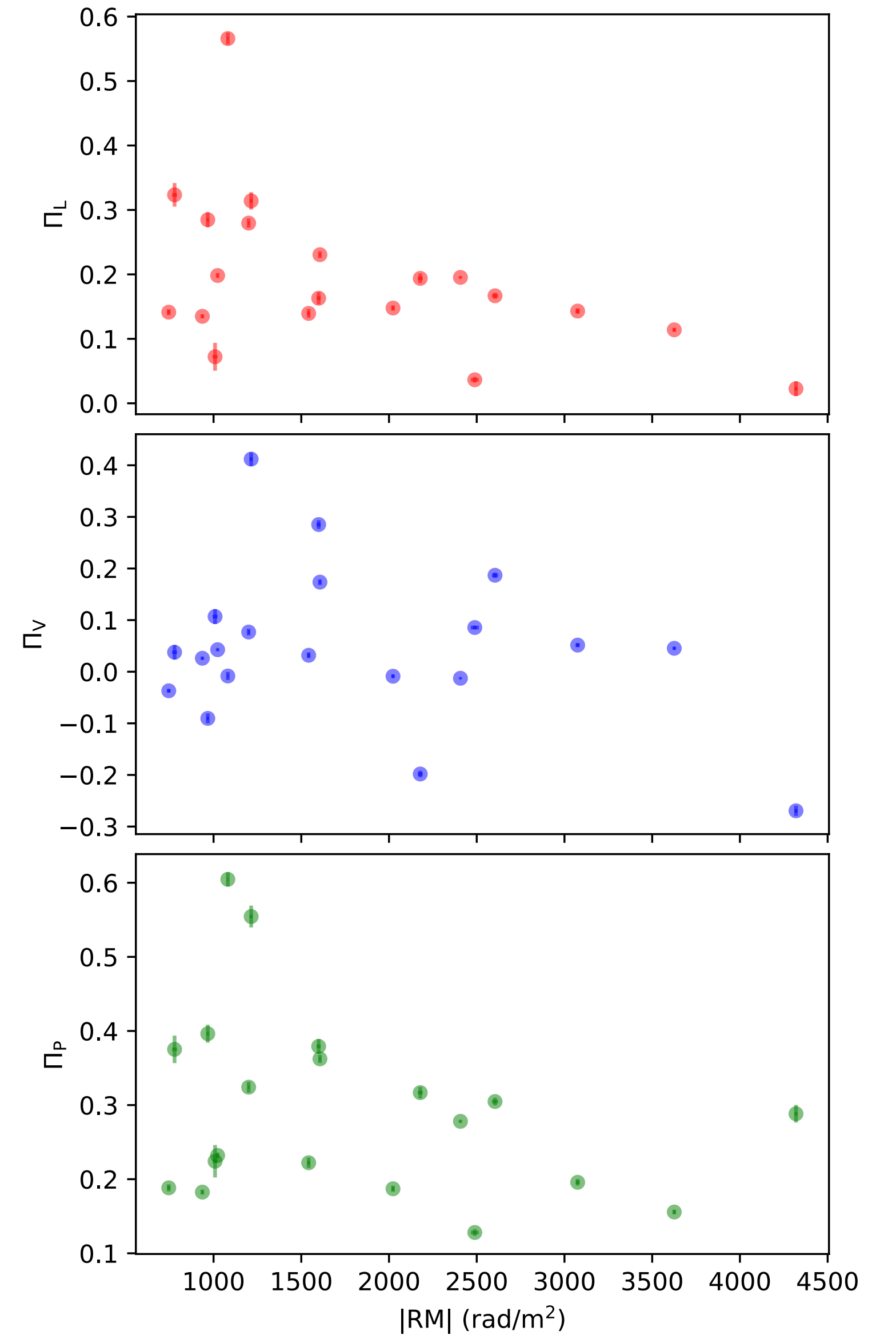


Polarization

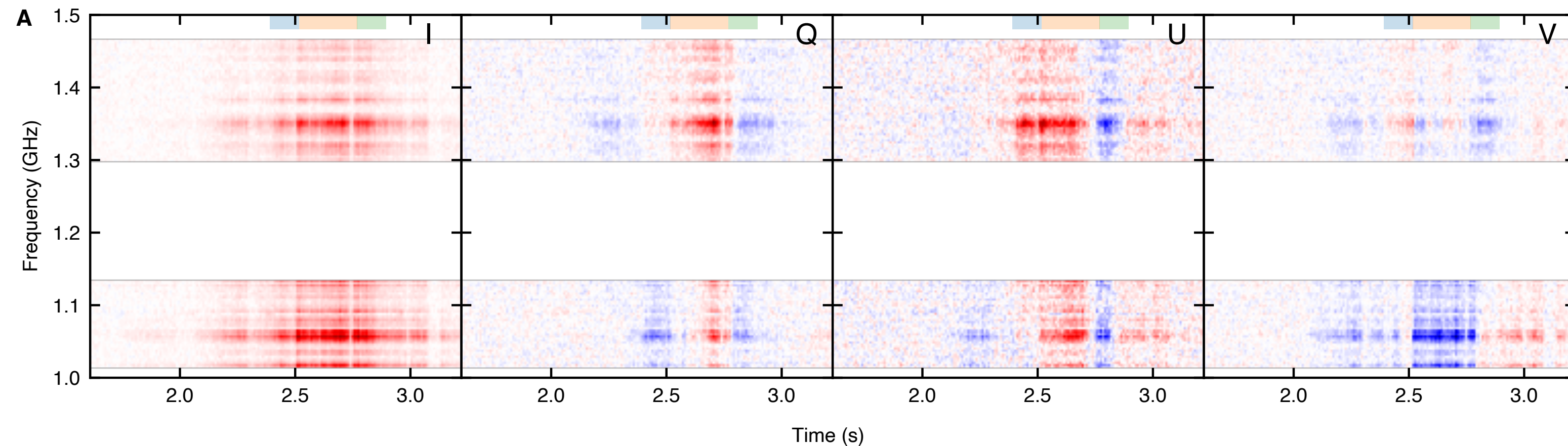
Polarization profiles



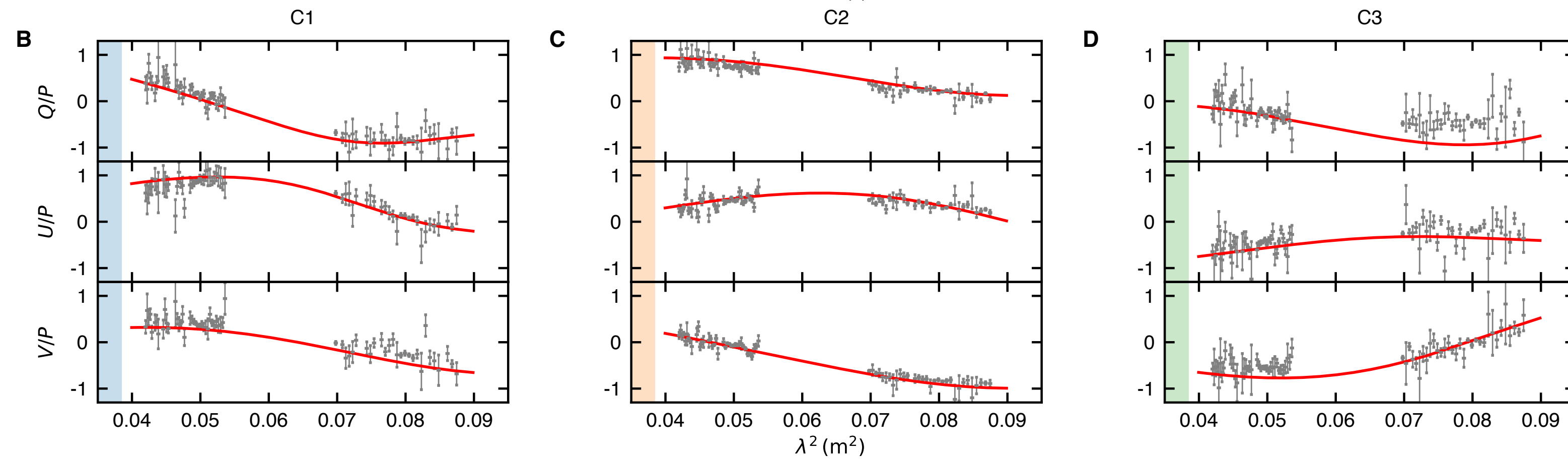
Depolarization



Linear-to-Circular Conversion



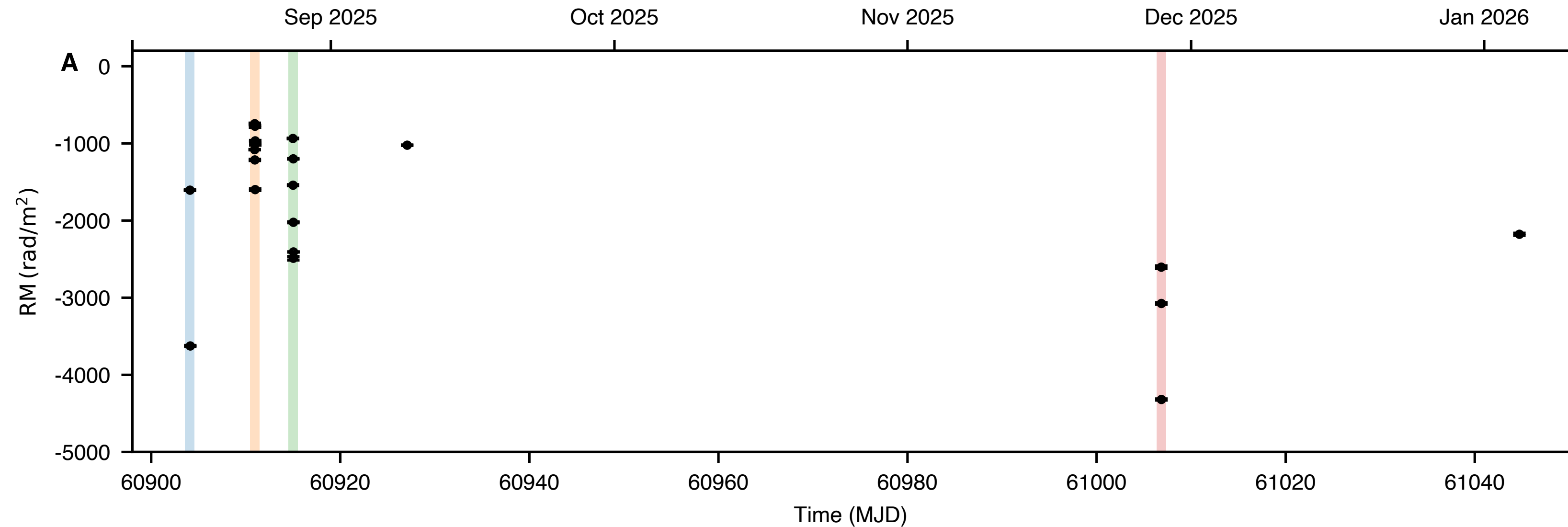
- FRB 20201124A (Xu+2022)
- PSR B1744-24A (Li+2023)
- LPT GPM J1839-10 (Men+2025)



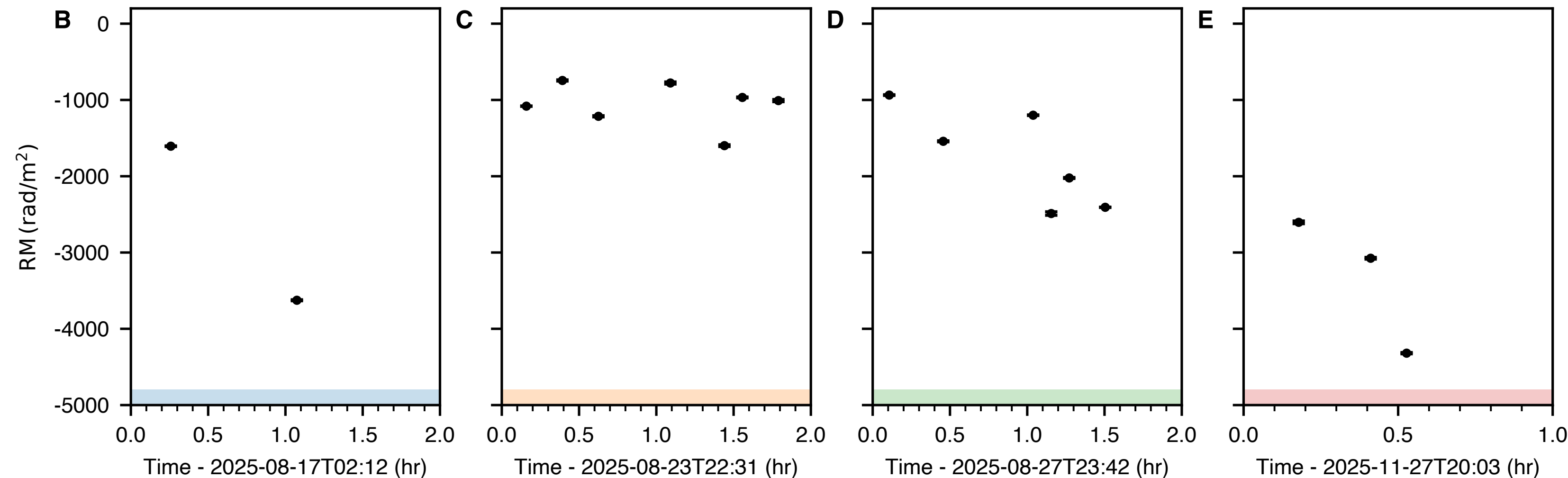
B~1 Gauss

Intense RM Variation

Maximum $|RM| \sim 4000 \text{ rad/m}^2$, RM variation $\sim 1000 \text{ rad/m}^2$ at 7 mins

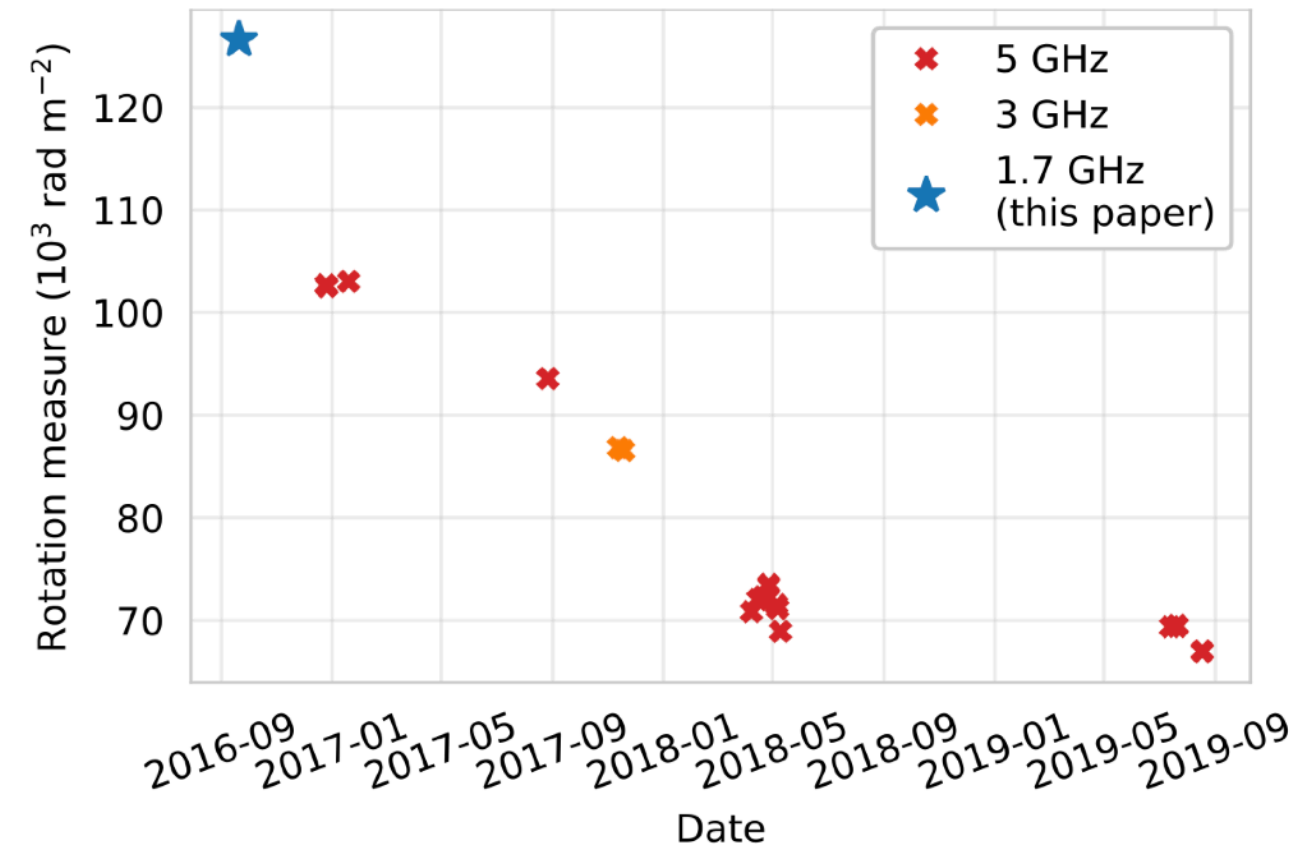


The only LPT showing RM variation!

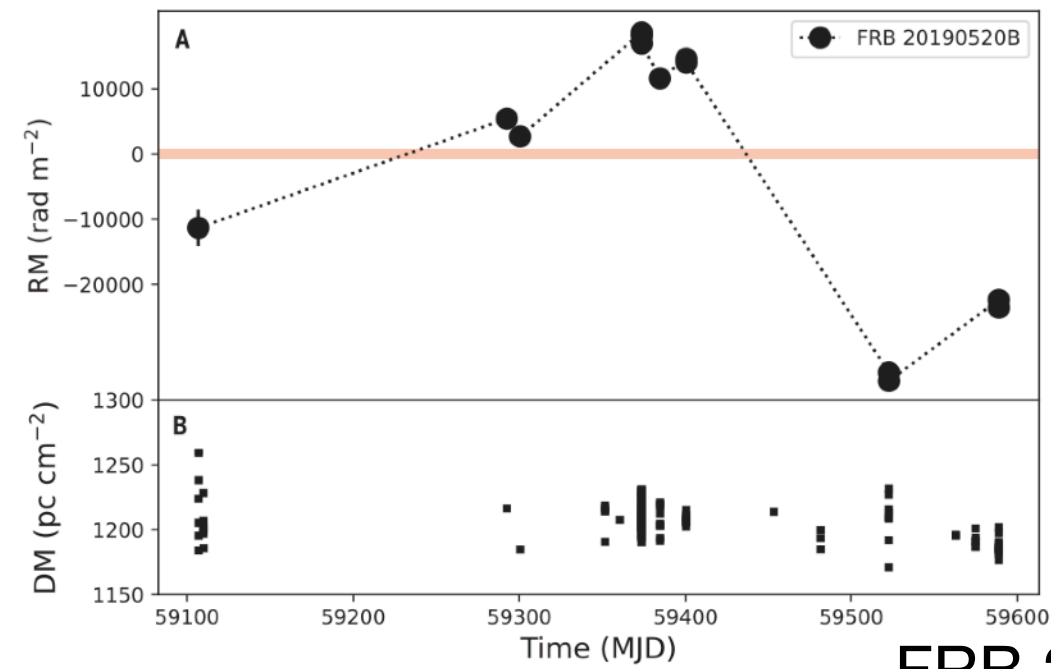


Dynamically magnetized environment!

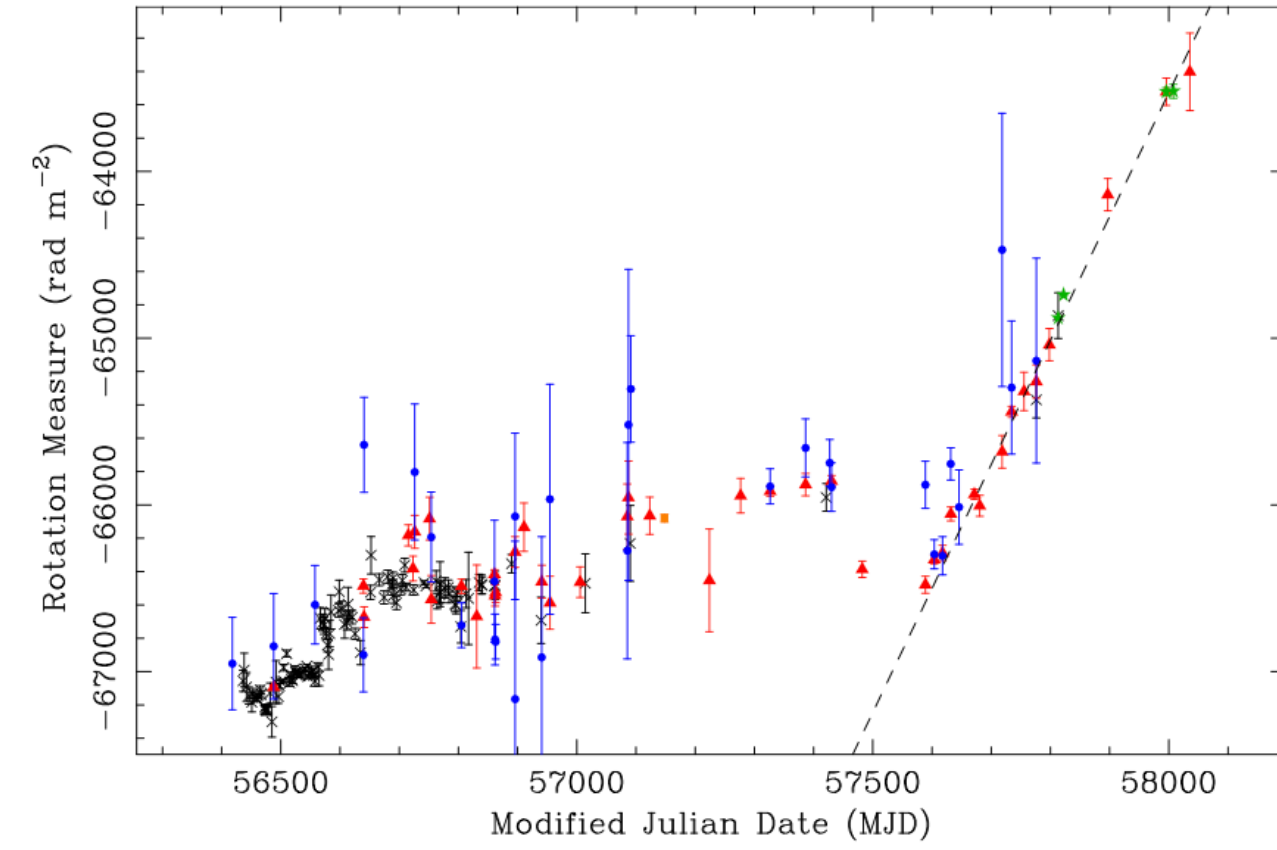
RM Variation in Repeating FRBs



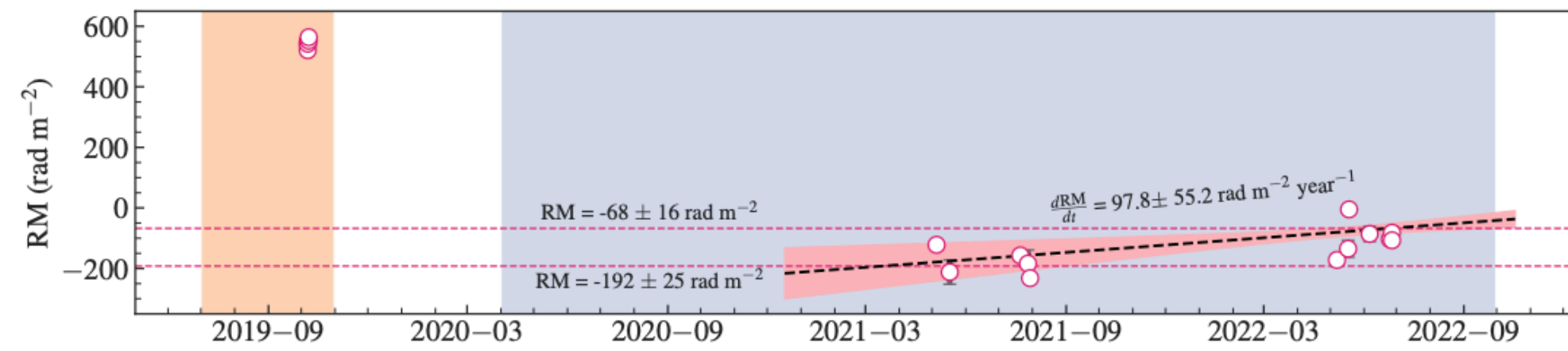
FRB 20121102A, Plavin+ 2022



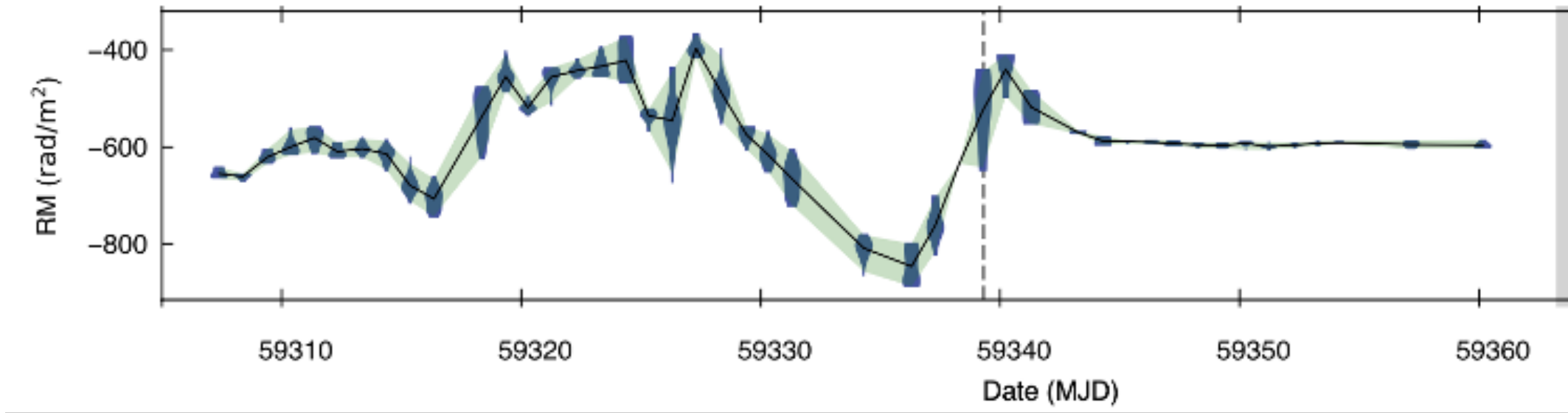
FRB 20190520B, Anna-Thomas+ 2023



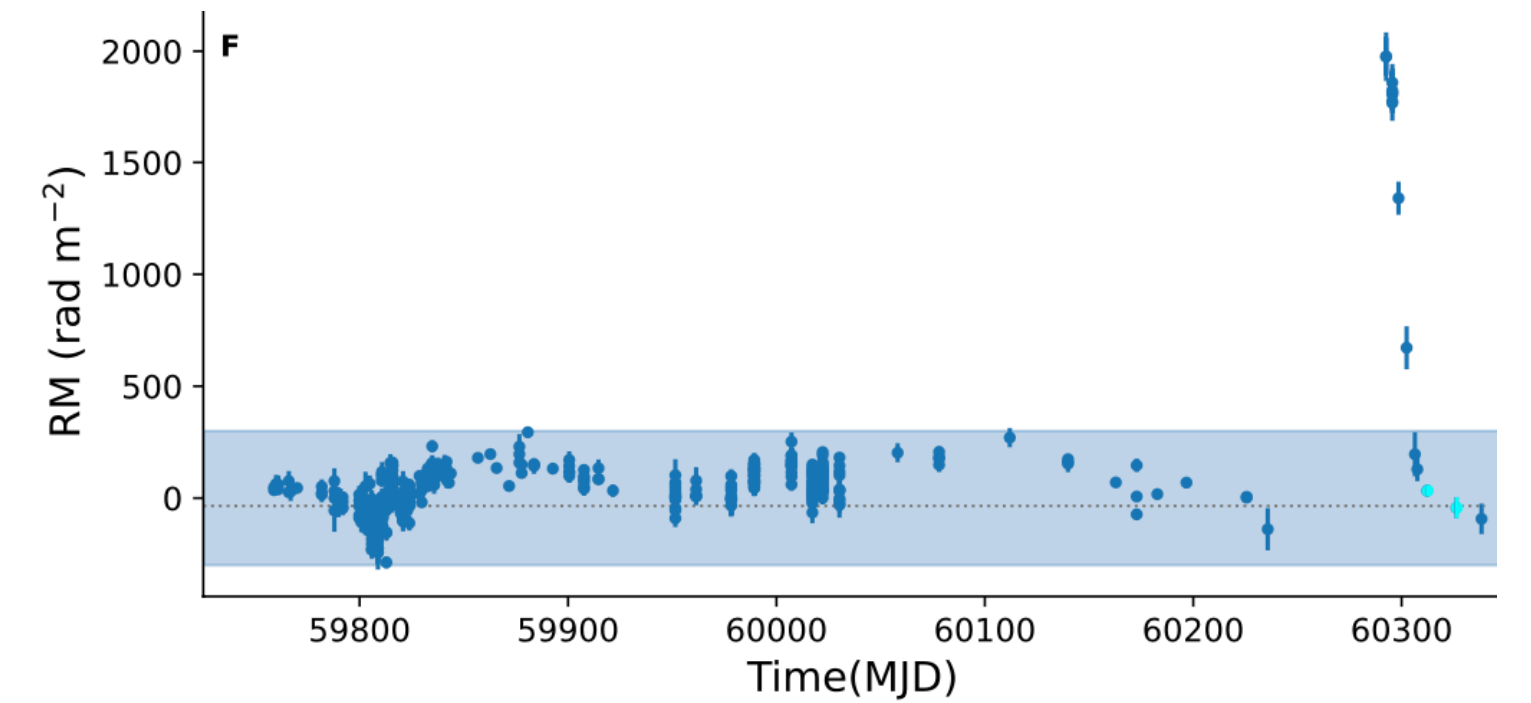
PSR J1745-2900, Hilmarsson+ 2018



FRB 20180301A, Kumar et al., 2023

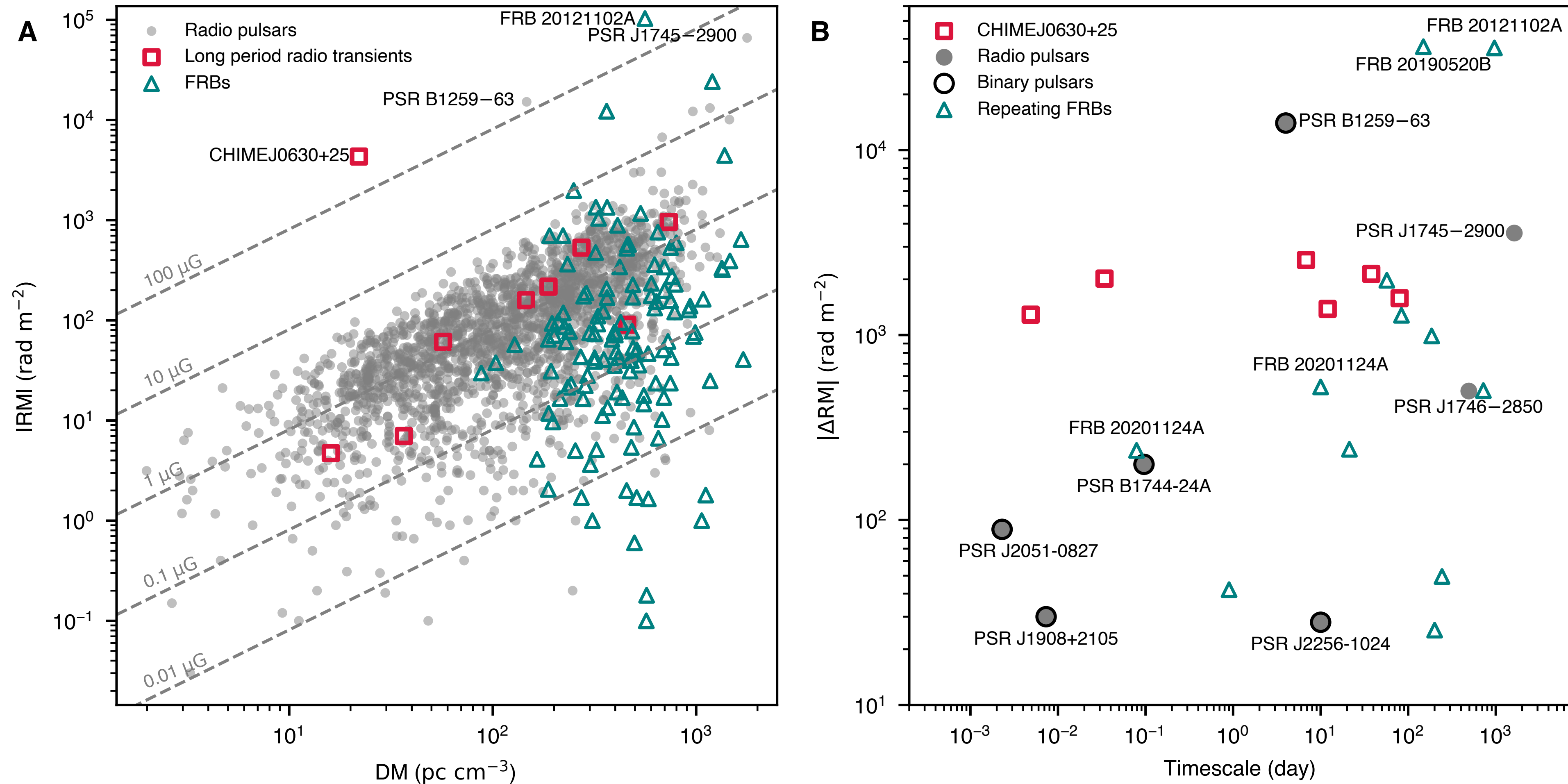


FRB 20201124A, Xu+ 2022



FRB 20220529, Li + 2025

Intense RM Variation

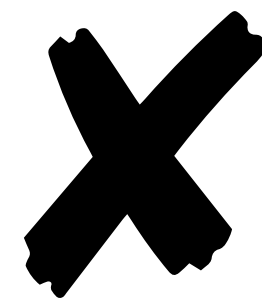
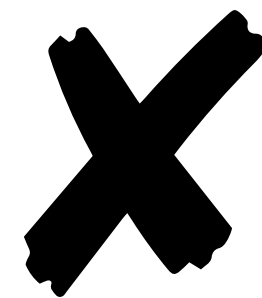
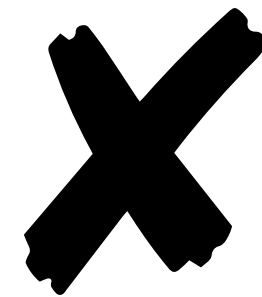


Resemble Be Star binary, black widow binary, repeating fast radio bursts

Interpretation of RM

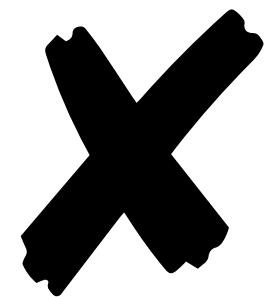
Isolated

MS star
White dwarf
Neutron star



Binary

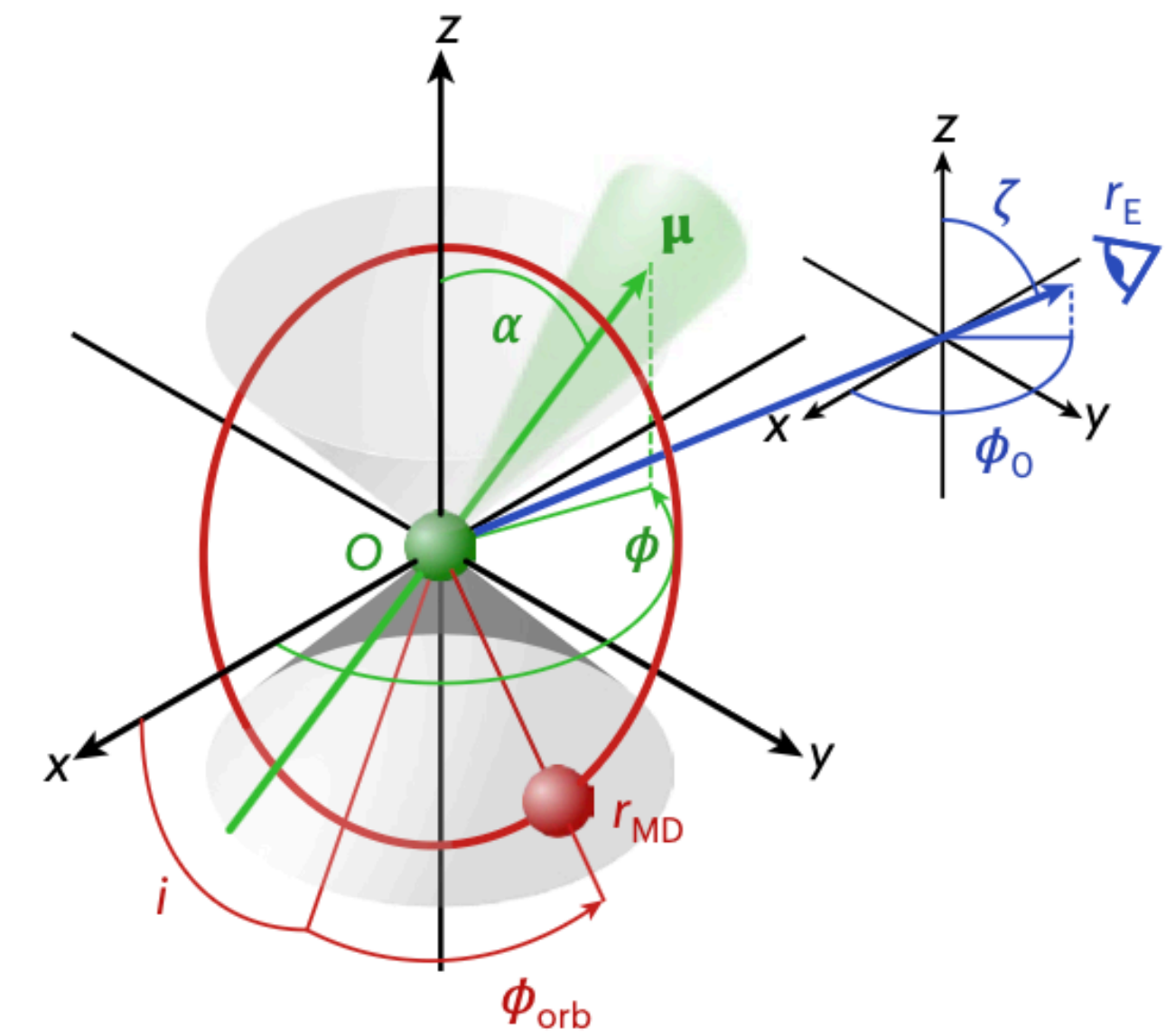
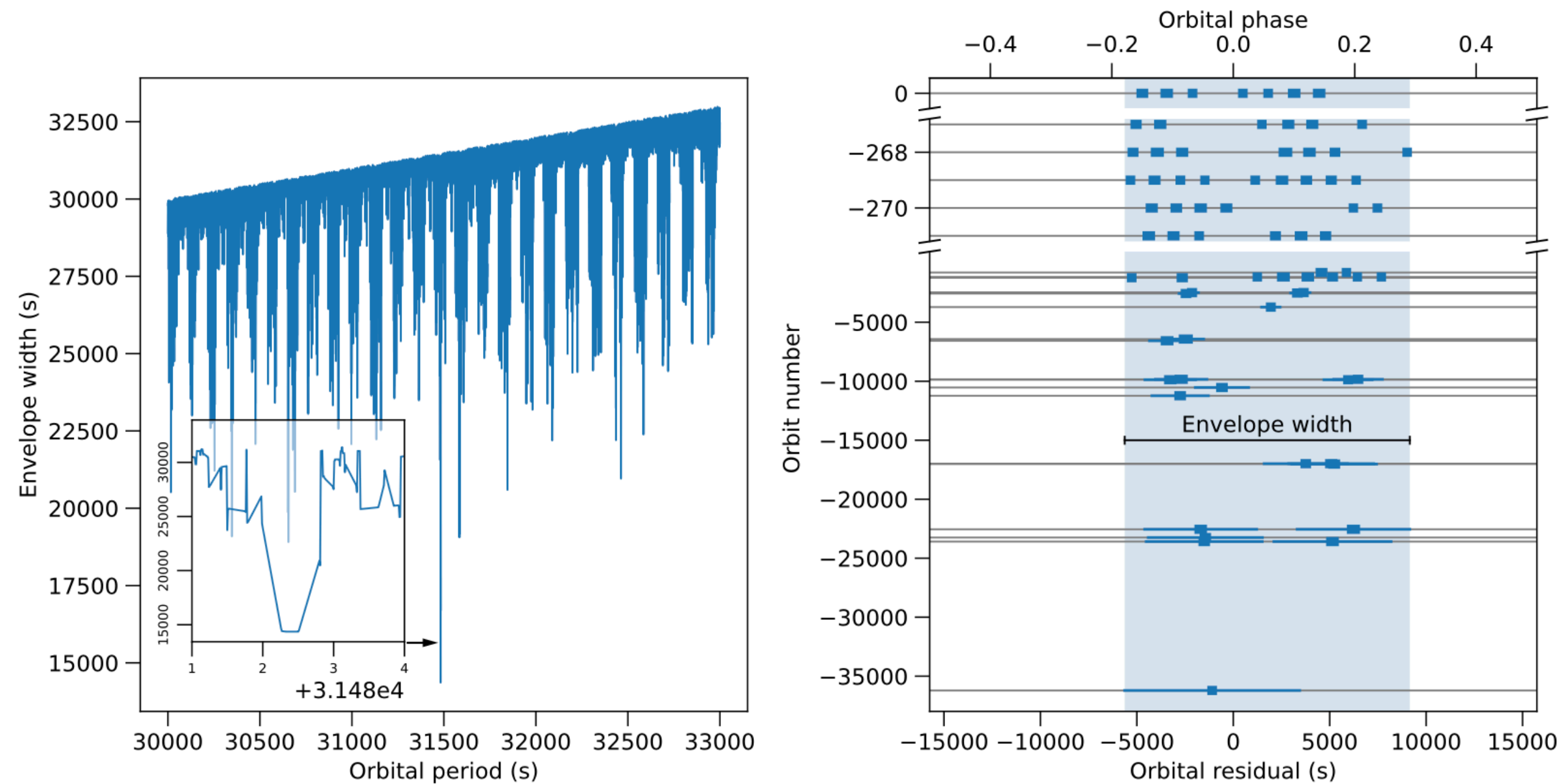
Compact object+ compact object
WD+MS star (Non-interacting)
WD+M dwarf (Interacting)
NS+MS star



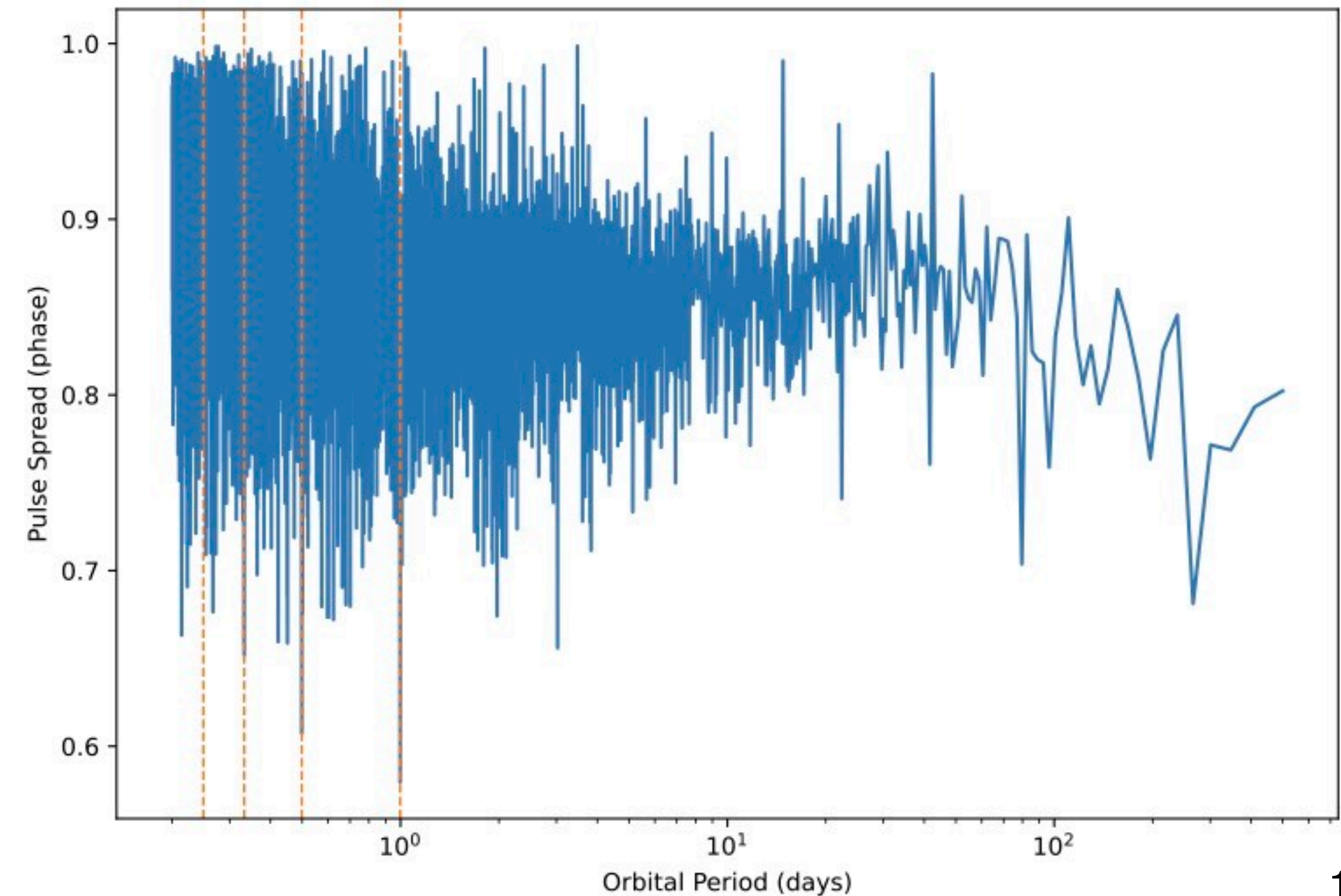
WD-M dwarf Scenario

- Standard WD-M dwarf model requires pulses appears at limited orbital phase ranges
- Disfavor!

GPM J1839-10 (Horváth+2026)

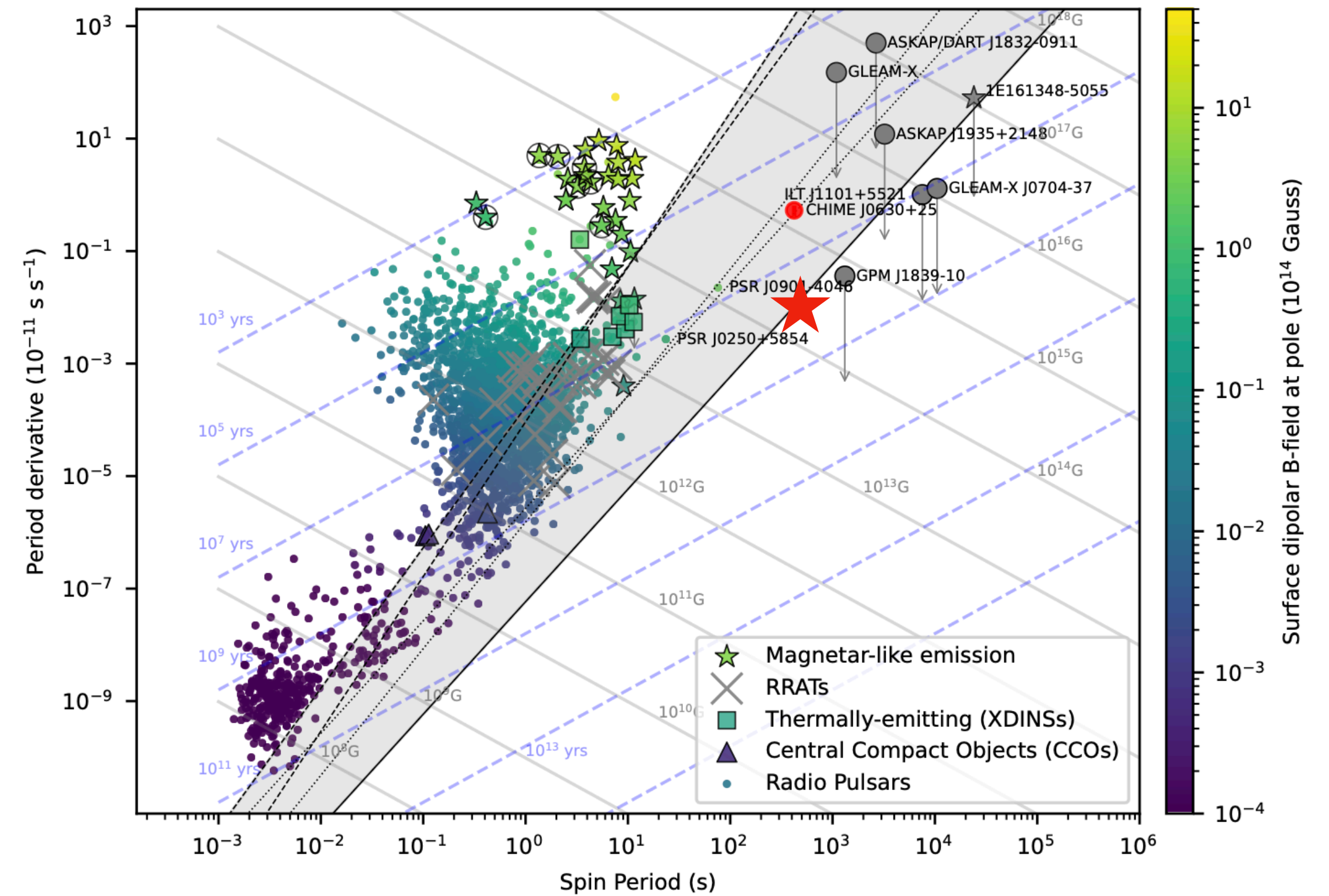
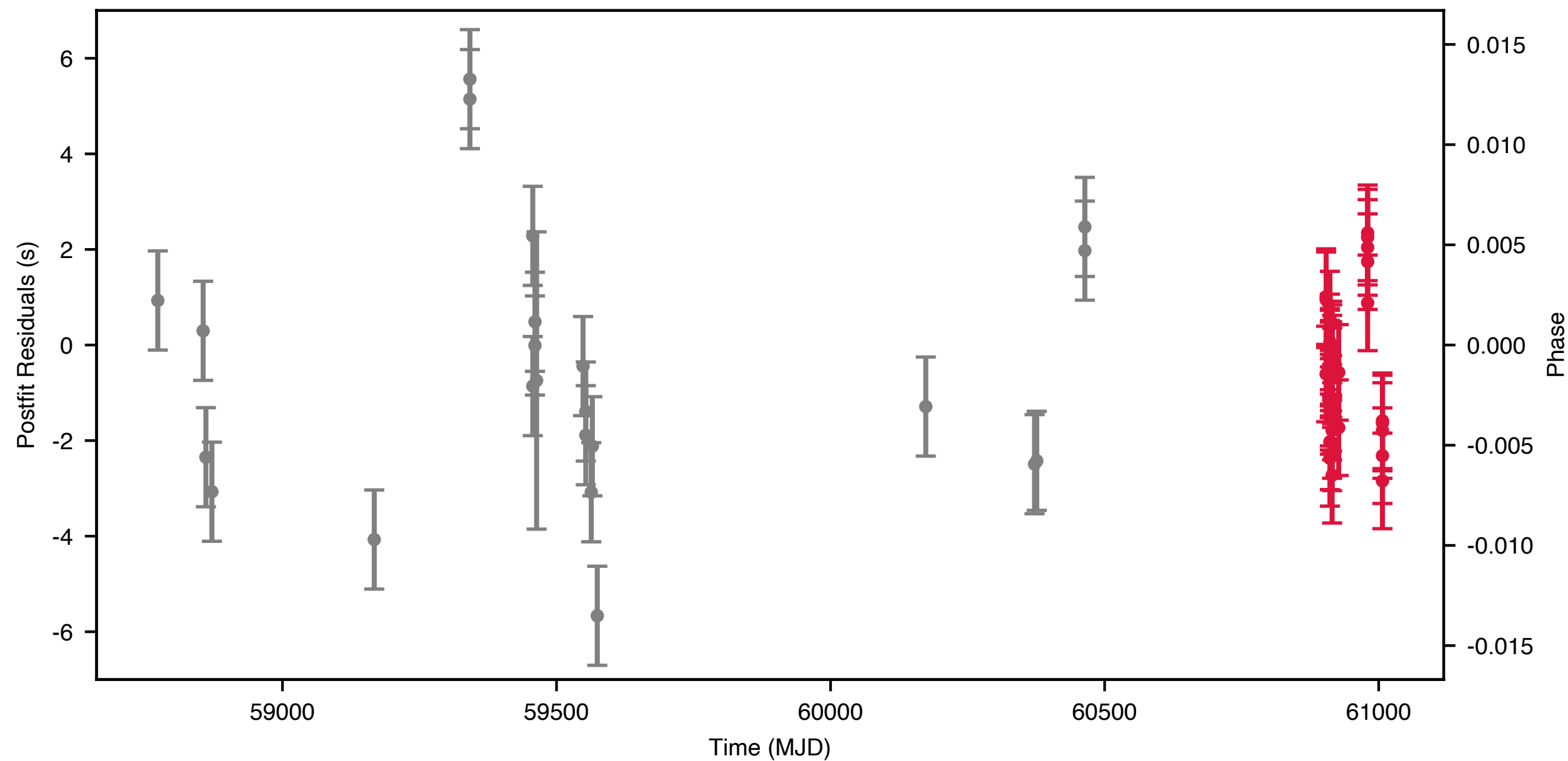


CHIME J0630+25



Timing

- Different timing solution with CHIME (Dong+2025): 419s vs 421s! not a glitch!



Dong+ 2025

NS+MS star binary scenario

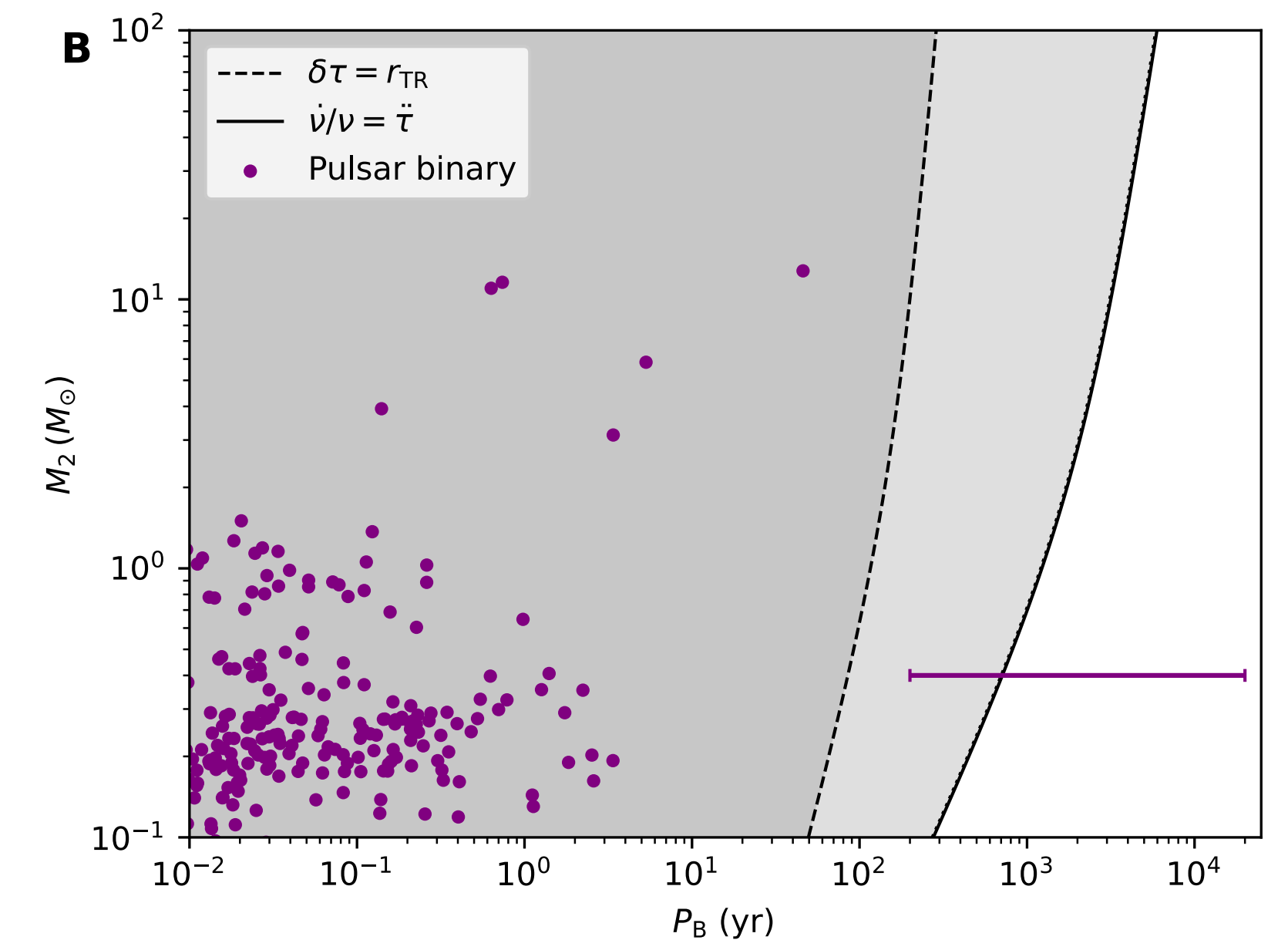
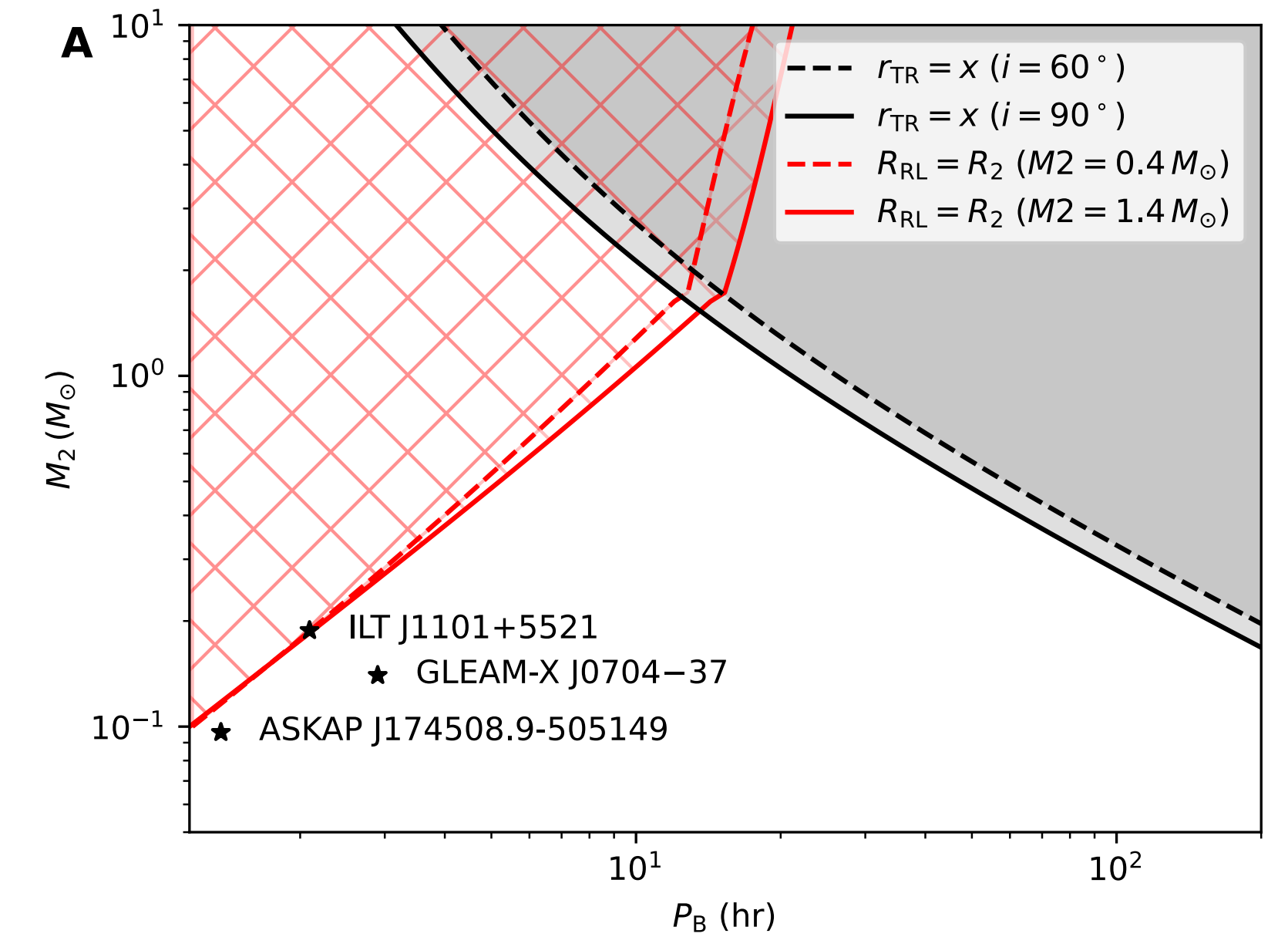
- Allowed parameter space
 - Roche lobe > MS star radius
 - Timing residuals < Orbital motion induced signals
- RM interpretation

- Small orbit

$$\begin{aligned} \text{RM}_w &= 8.1 \times 10^5 \int_{\text{LOS}} n_e \mathbf{B}_{\parallel} dl \\ &\simeq 2200 \text{ rad m}^{-2} v_{w,8}^{-1} \max\{B_p(a), B_s(a)\} \left(\frac{\dot{M}}{10^{-14} M_{\odot} \text{yr}^{-1}} \right) \left(\frac{a}{0.5 R_{\odot}} \right)^{-1} \end{aligned}$$

- Large orbit

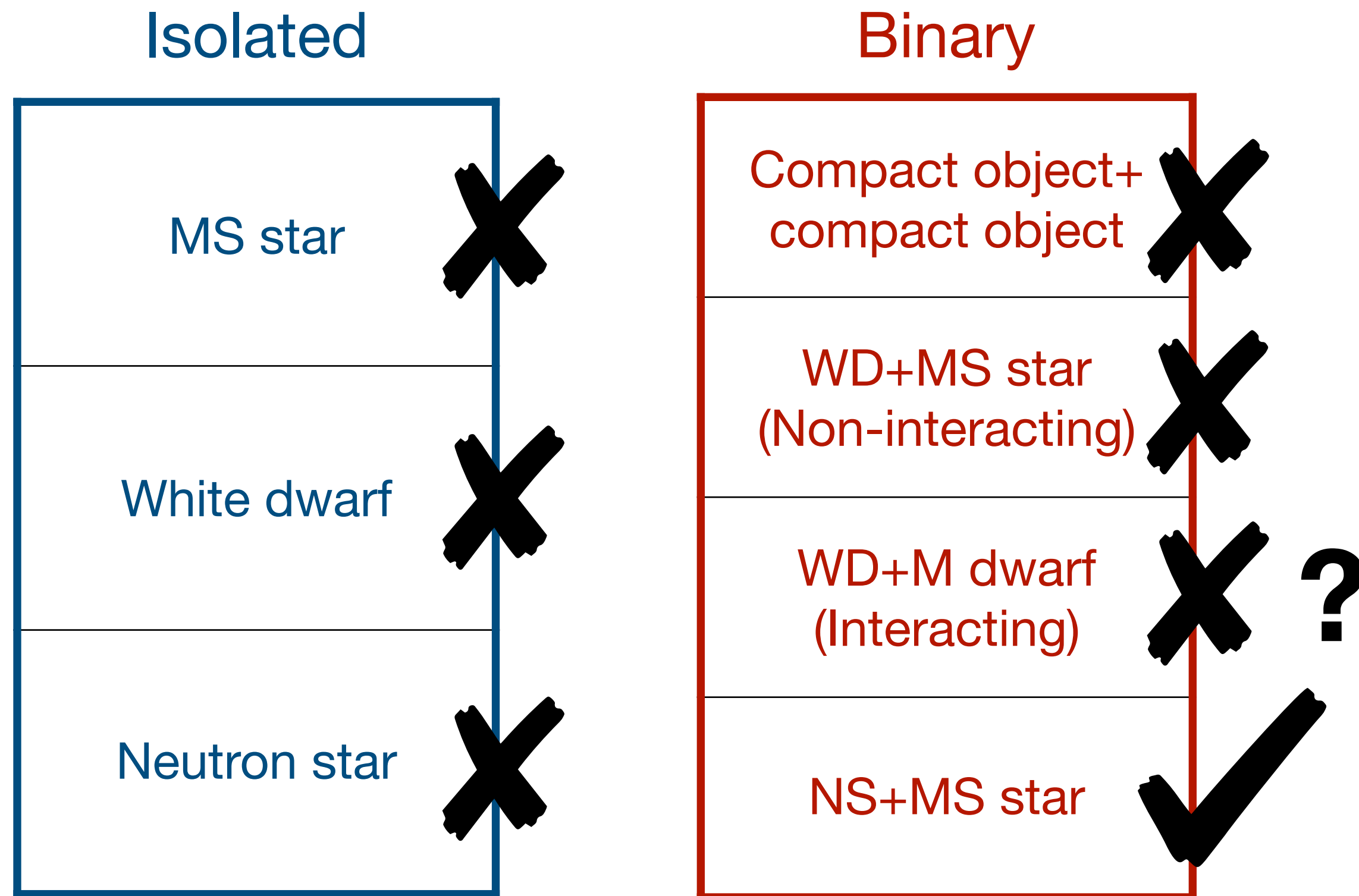
$$\begin{aligned} \text{RM}_w &\sim \frac{e^3 B n_w a}{2\pi m_e^2 c^4} \simeq 5.5 \times 10^3 \text{ rad m}^{-2} \left(\frac{B_0}{10 \text{ G}} \right) \left(\frac{R_2}{10 R_{\odot}} \right) \\ &\times \left(\frac{\dot{M}}{10^{-7} M_{\odot} \text{yr}^{-1}} \right) \left(\frac{a}{60 \text{ AU}} \right)^{-2} \left(\frac{v_w}{10^3 \text{ km s}^{-1}} \right)^{-1} \end{aligned}$$



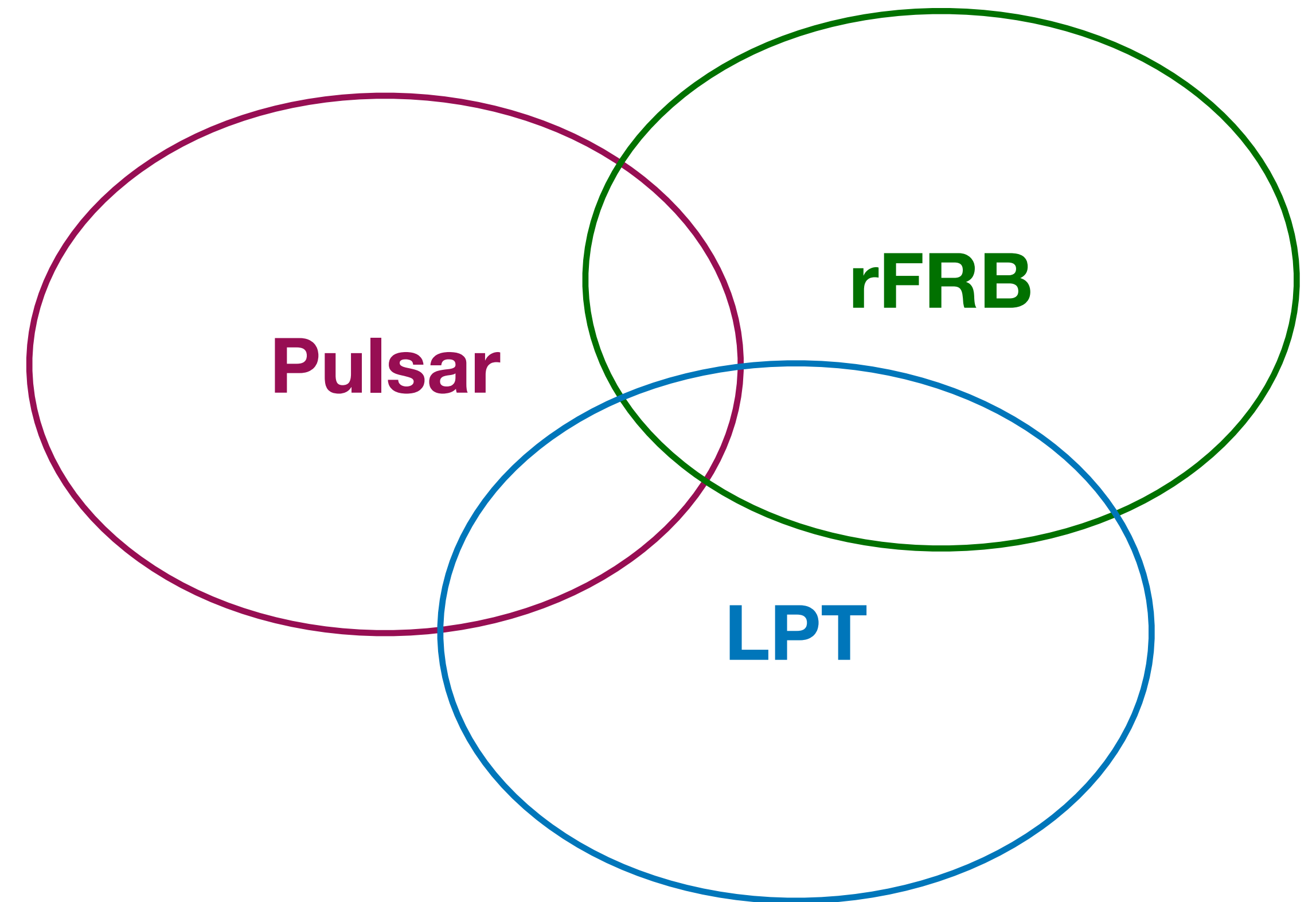
Binary parameter constraints

Summaries

- Polarization properties are similar to pulsars, FRBs
- Dynamically magnetized environment similar to some binary pulsar, rFRBs
- The radio transient sky is amazing!



Model constraint for CHIME J0630+25



Thanks for listening!