2020.09.24-25

18th Mizusawa VLBI Observatory Users Meeting

Long-term spectral variations of XTE J1810-197

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(Mizusawa VLBI Observatory, NAOJ / UTokyo)

Video credit: NASA's Goddard Space Flight Center

INTRO Radio-loud Magnetars

- 6 known so far (i
- Fast & large varia
  with time and fre
- (Generally) Flat s
- Seem to be "tran

Name	Radio detection	P (s
XTE J1810-197	2004	5.5
1E 1547.1-5408	2007	2.0
PSR J1622-4950	2010	4.3
SGR J1745-2900	2013	3.7
Swift J1818.0-1607	2020	1.3
SGR J1935+2154	2020	3.2

(Kaspi & Beloborodov 2017; Eatough+2

- X-ray/γ-ray outbursts stronger than ordinary radio pulsars' energy
- Young age, extremely strong B are estimated
- Magnetically powered star? (Duncan & Thompson 1992)
- ~30 detected

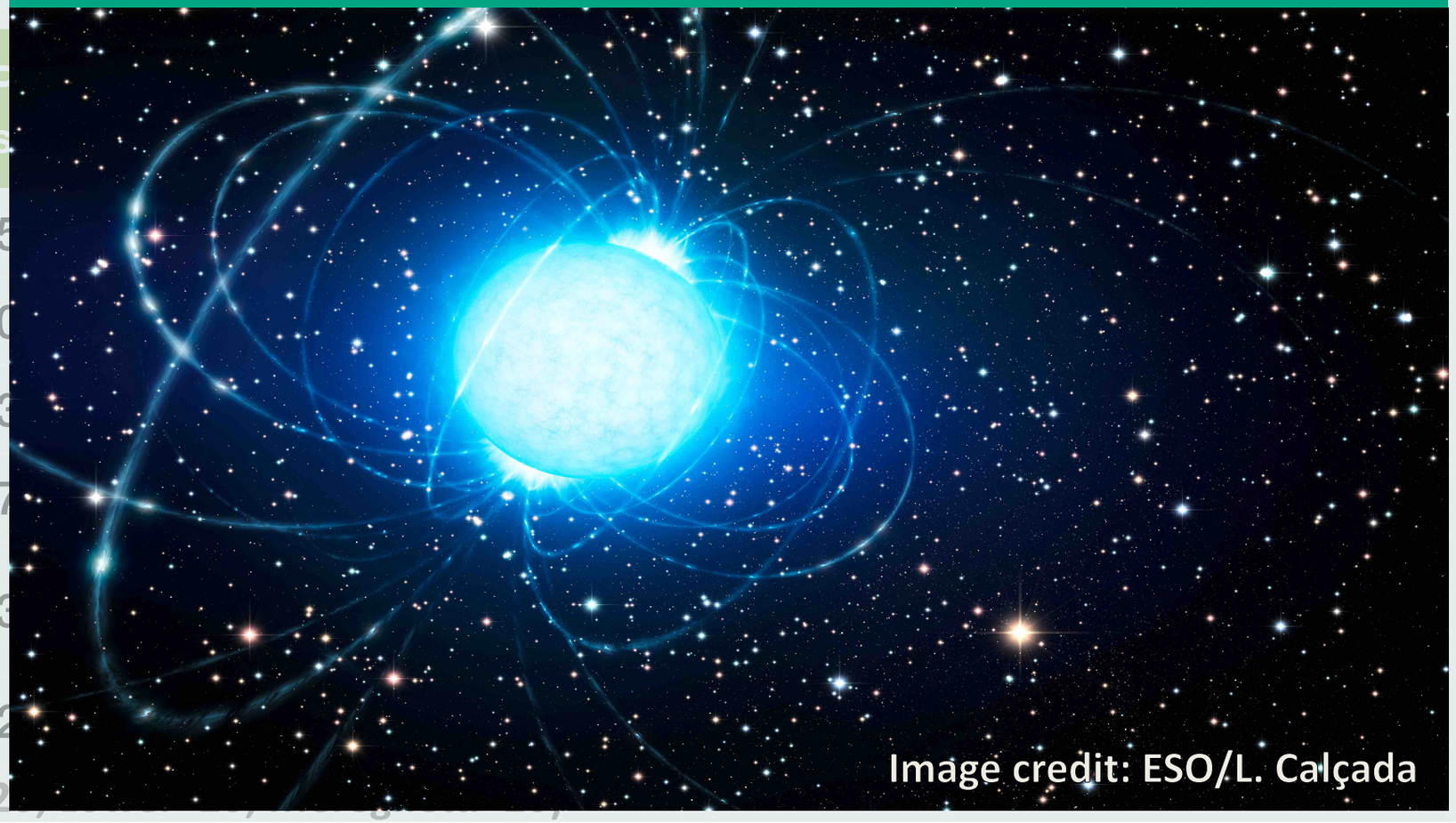


Image credit: ESO/L. Calçada

INTRO Radio-loud Magnetars

- 6 known so far (increasing!)
- Fast & large variations in profiles, intensity, polarization with time and frequency (e.g. Camilo+07, Kramer+07, Lazaridis+08)
- (Generally) Flat spectrum in radio band ($\alpha \approx -0.5$) (Camilo+07)
- Seem to be "transients" (i.e. radio-loud $\rightleftarrows$ radio-quiet)

Name	Radio detection	*P* (s)	*B* (10^{14} G)	τ_c (kyr)	*D* (kpc)
XTE J1810-197	2004	5.54	2.1	11	3.5
1E 1547.1-5408	2007	2.07	3.0	0.69	4.5
PSR J1622-4950	2010	4.33	2.7	4.0	~ 9
SGR J1745-2900	2013	3.76	2.3	4.3	8.3
Swift J1818.0-1607	2020	1.36	6.8	0.24 - 0.31	4.8 / 8.1
SGR J1935+2154	2020	3.24	2.2	3.6	4.4

FRB-like bursts! (FRB 200428)
: Fluence ≈ 1.5 MJy ms!
(Bochenek+20)

(Kaspi & Beloborodov 2017; Eatough+20; Lower+20; Mereghetti+20)

INTRO Unsolved questions

Magnetar radio emission

Relation with extreme transients

- Fast Radio burst (FRB)

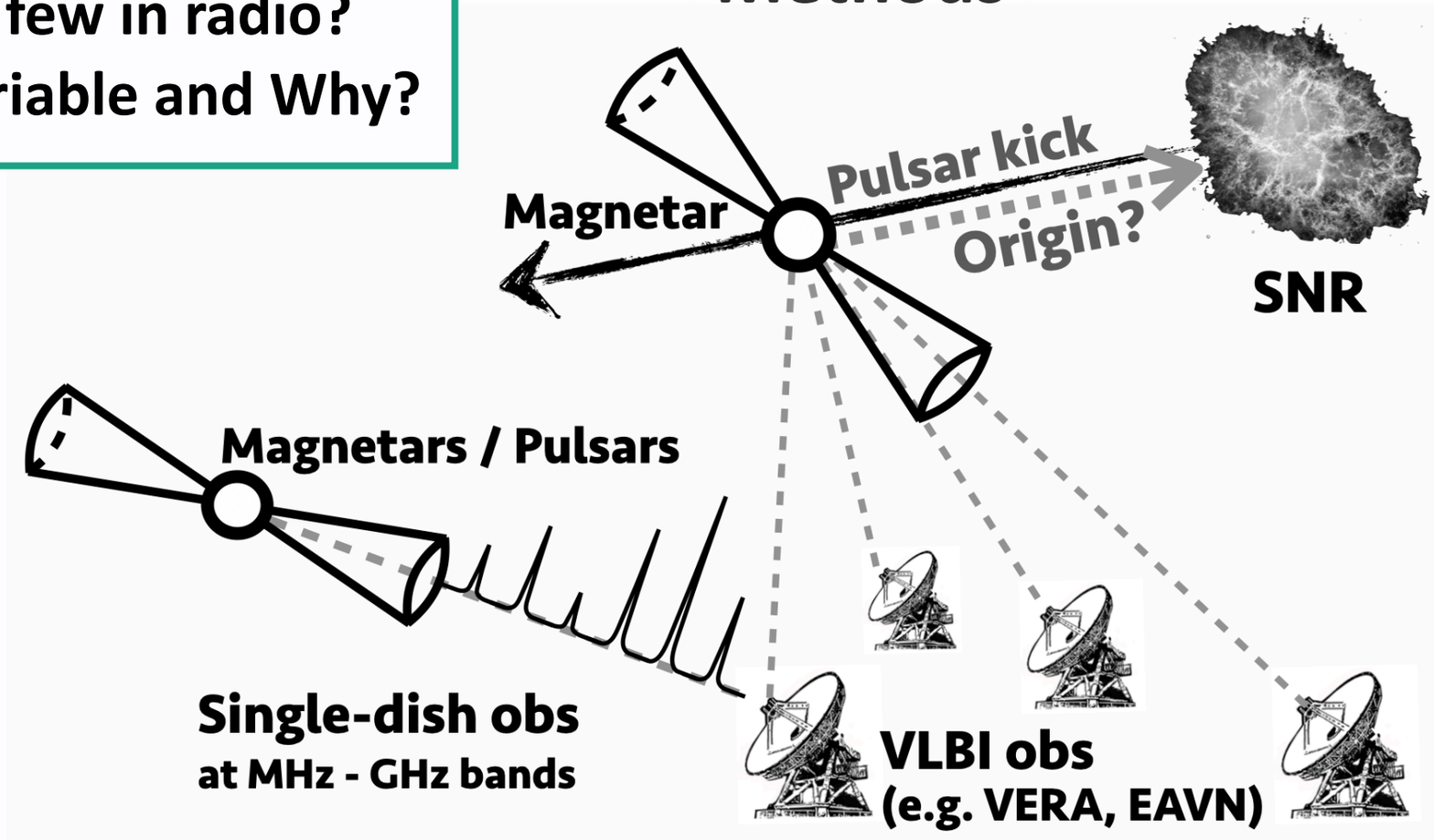
Relation with (relatively) standard radio pulsars [pulses]

- Giant radio pulses
- Young radio pulsars
- High-B radio pulsars (w/ magnetar-like emission)

Magnetars themselves

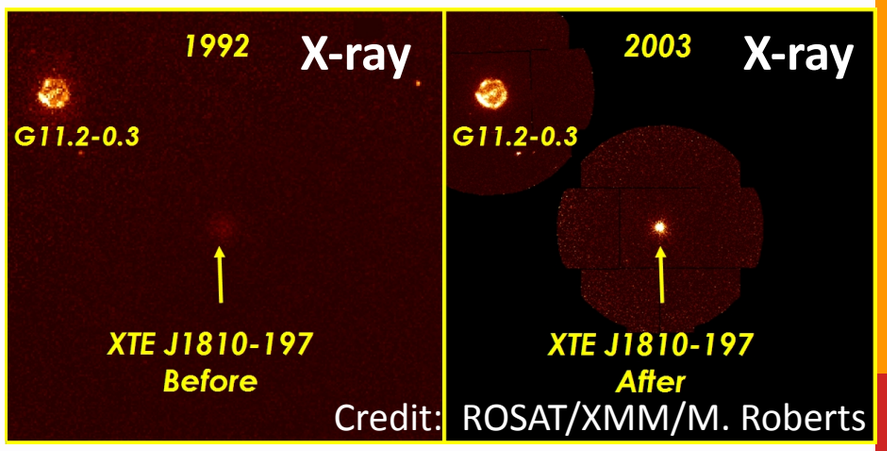
Why only a few in radio?
How much variable and Why?

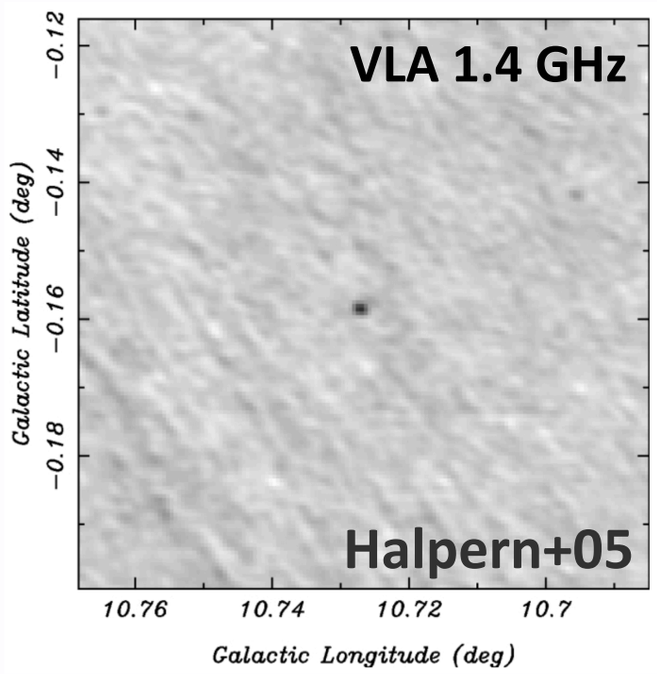
< Methods >

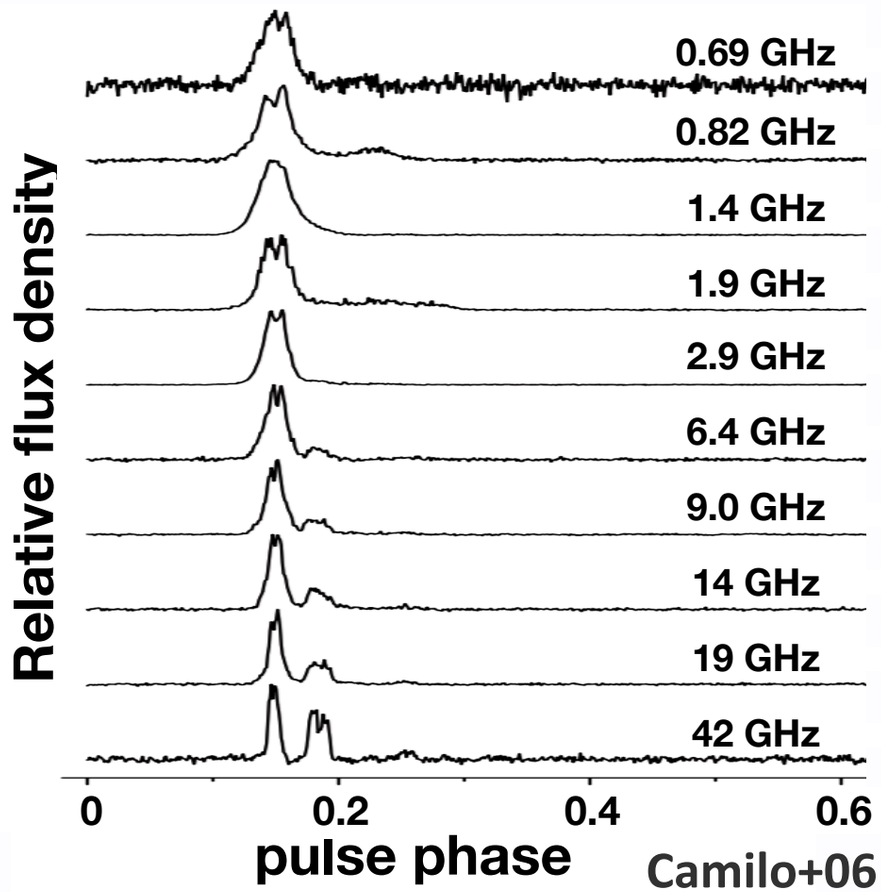


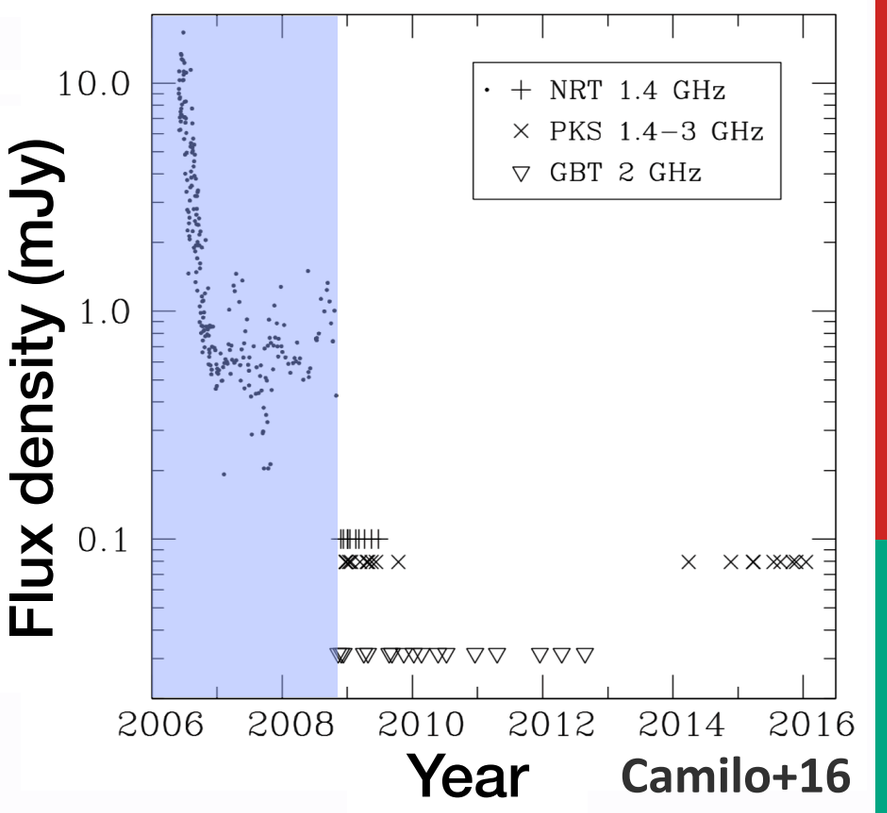
TGT XTE J1810-197 (PSR J1809-1943)

- **Brightened in 2003 (X-ray) and 2005 (Radio)**
  (Ibrahim+04, Halpern+05, Camilo+06)
- **Became radio-silent in Oct 2008 (Camilo+16)**
- **Period: 5.54 s**



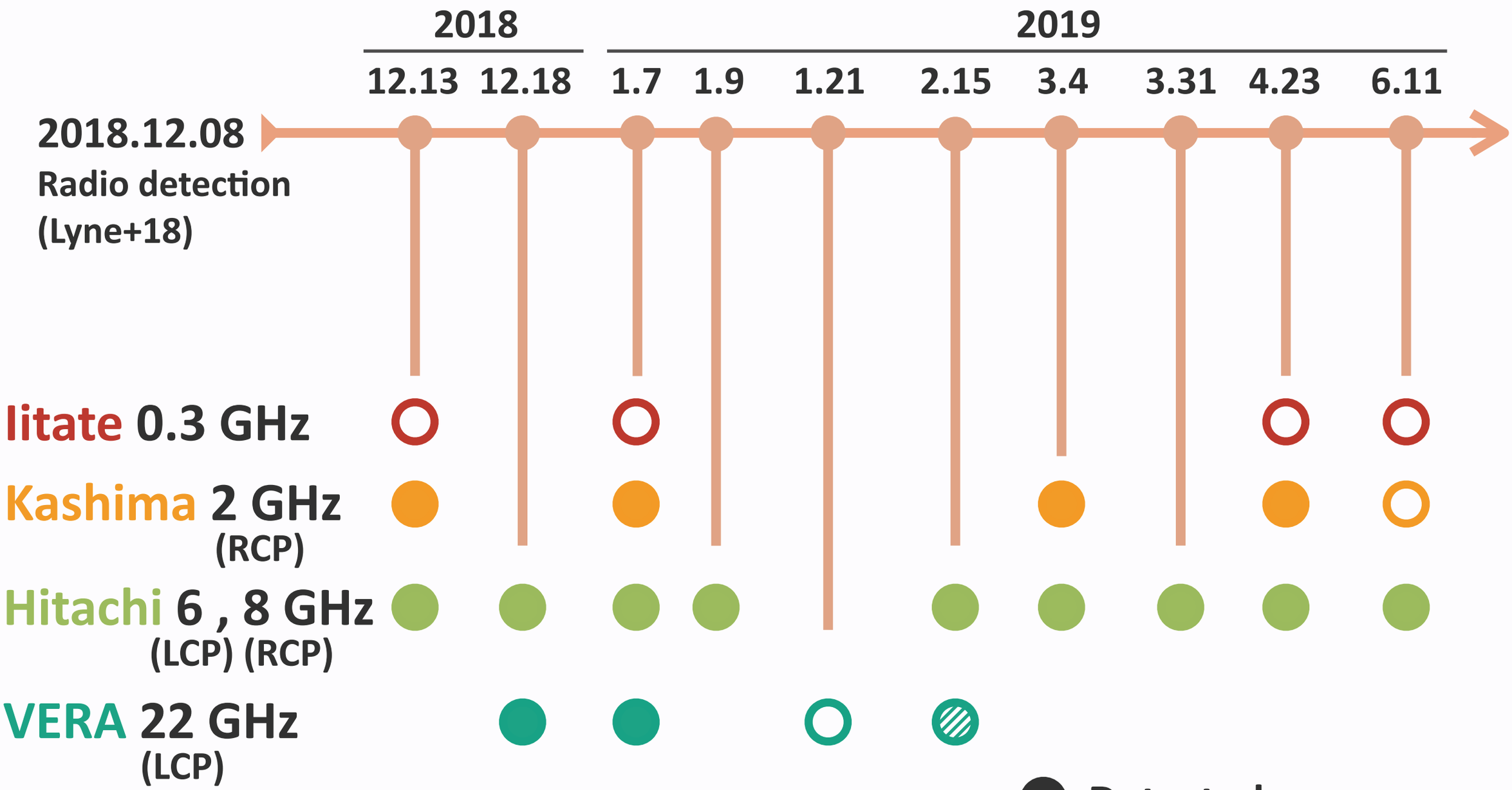






- **Re-brightened in Dec 18th 2018 (Lyne+ATel #12284)**
- **No associated SNR found (Ding+20, VLBA, obs in 2019~2020)**

Observations



We specially thank Oyama-san, Yonekura-san, Sekido-san, Takefuji-san, Misawa-san, Tsuchiya-san for those observations.

Data reduction

VERA (20 m each)


MIZ


IRK


OGA

ISG

Hitachi


32 m

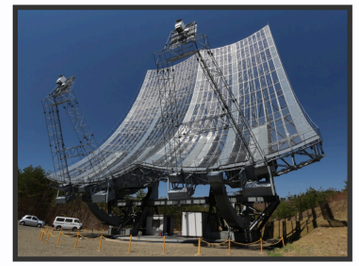
8 GHz 6 GHz

Kashima

34 m

2 GHz

Iitate

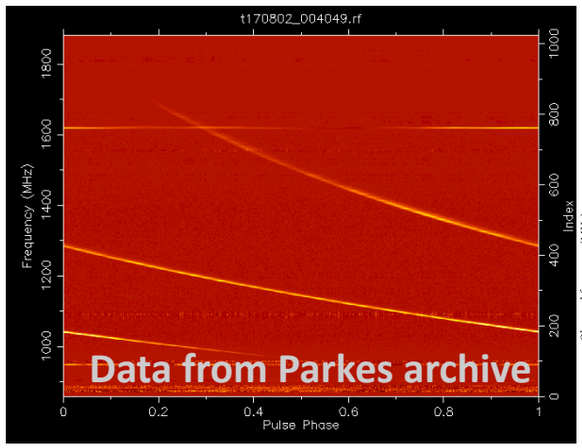

31 x 16.5 m² x 2

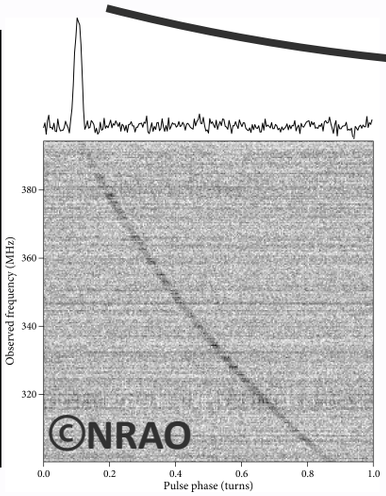
0.3 GHz

Combine together

~37 m

22 GHz





Correct dispersion delay

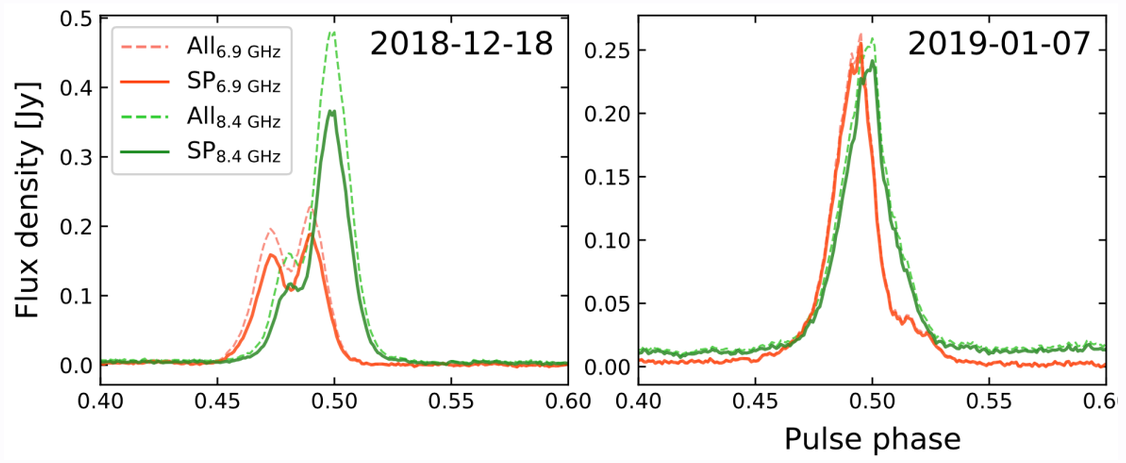
(Coherent de-dispersion)

Align time to correct time delay by different geographic locations ← **tempo2**

(pulsar-timing package, Hobbs+06)

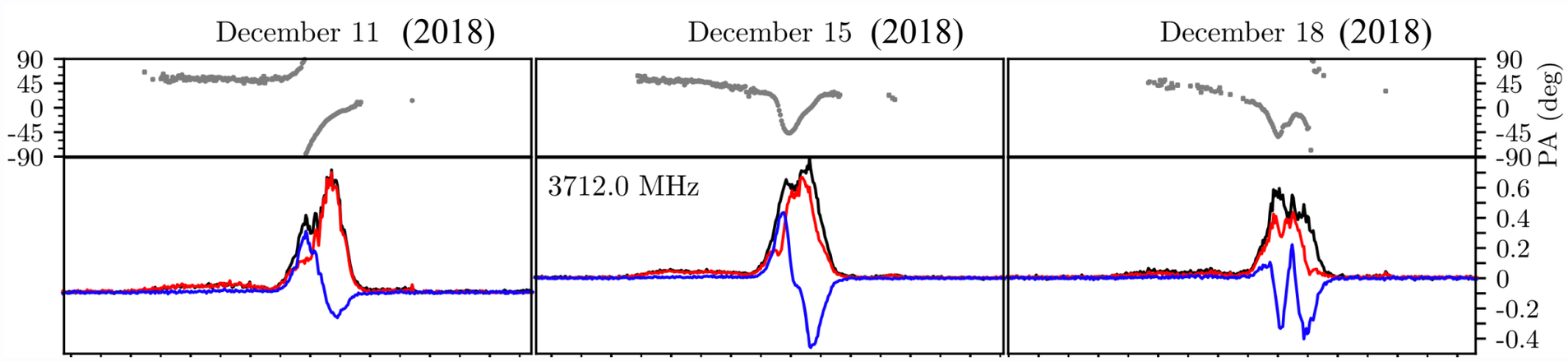
Averaging & RFI mitigation & De-trending

Results Magnetar polarization



6.9 GHz (LCP)

8.4 GHz (RCP)



Total intensity

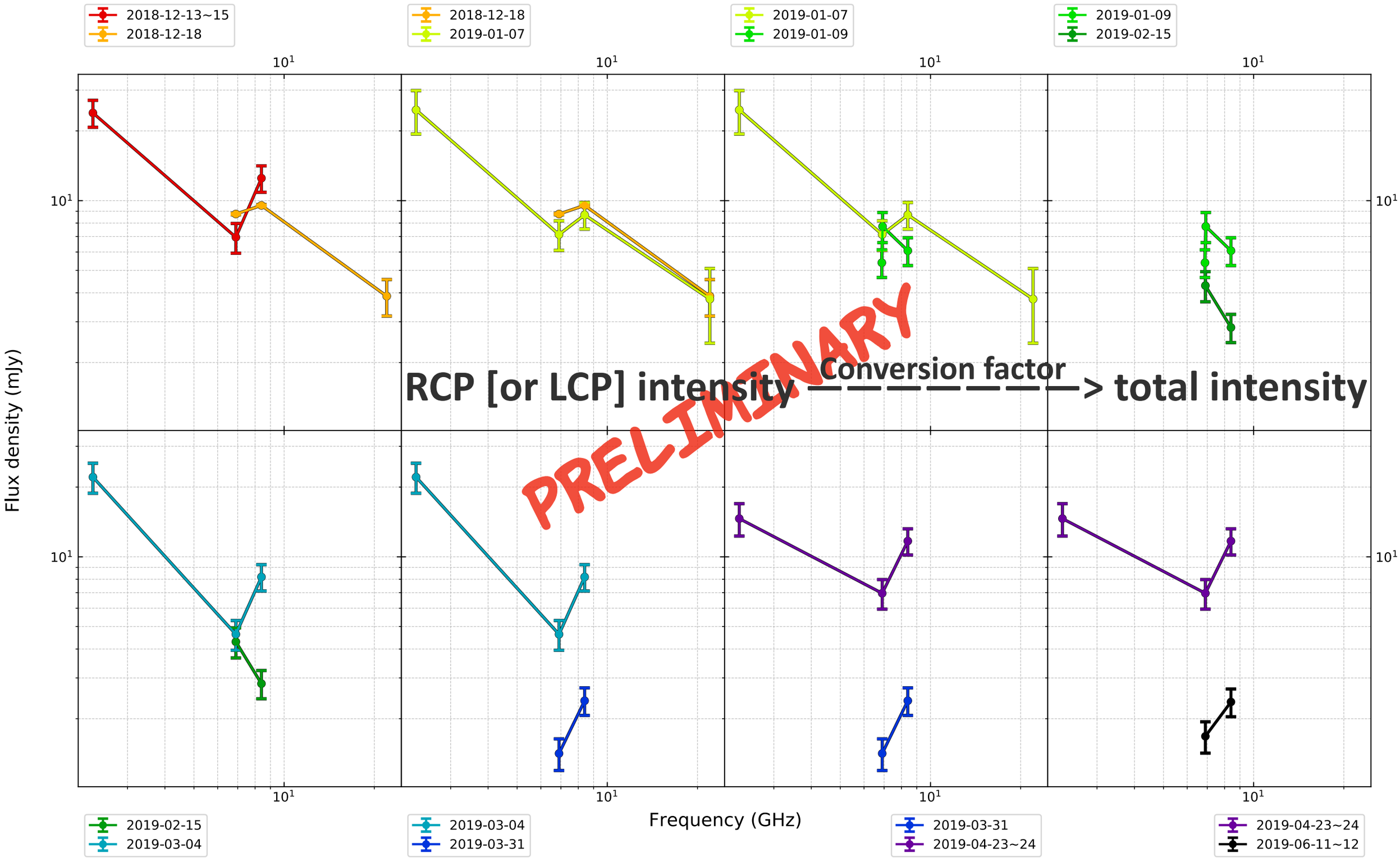
Linear pol.

Circular pol.
($V = I_L - I_R$)

Dai+19; Parkes 64-m in Australia

- Magnetar pulsations show large $|V|$ during Dec 2018 (Dai+19)
- Only RCP or only LCP may not fully reflect total intensity by multiplied by 2.
- We assume $\langle V \rangle$ during the early phase would be similar with those of ours.
- Our RCP [or LCP] intensity ——Conversion factor——> total intensity

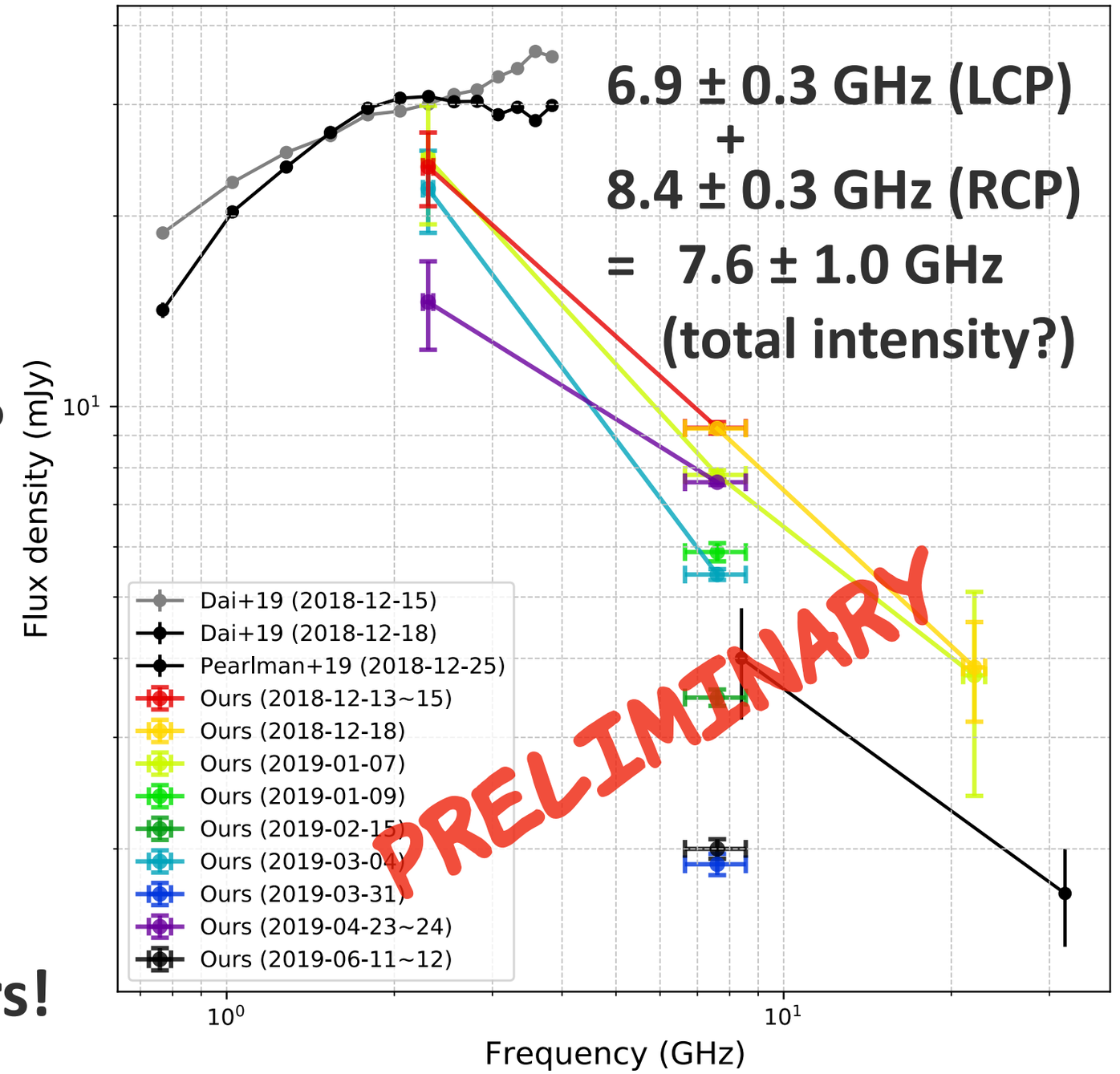
Results Long-term spectral variations



Results Long-term spectral variations

- Fast changing flux density
- Negative spectra between 2.3 ~ 22 GHz (ours)
- α ≈ +0.3 @ 0.7~4 GHz (Dai+19)
- Turn-over around 3 ~ 6 GHz?

- GHz-peaked spectra pulsars (Kijak+11)
  - It could be a connection with this reactivated emission to normal pulsars!



Wrap-up & Future works

- Magnetars would be one of the best sources among neutron stars for high-freq radio observations (-> for us!).
- We confirmed XTE J1810 has negative spectra in 2.3~22 GHz throughout our 7-months observing period.
  : turn-over between 3~8 GHz
  -> Possible link with GHz-peaked spectra pulsars.
- We emphasize the importance of full Stokes recording.
- Full Stokes information of (future) VERA obs may enable more comprehensible understanding of magnetar pulsations!
- Utilizing Piggyback search for high-ν magnetars?

Thank you for listening!