

Radio outburst of a magnetar

XTE J1810-197:

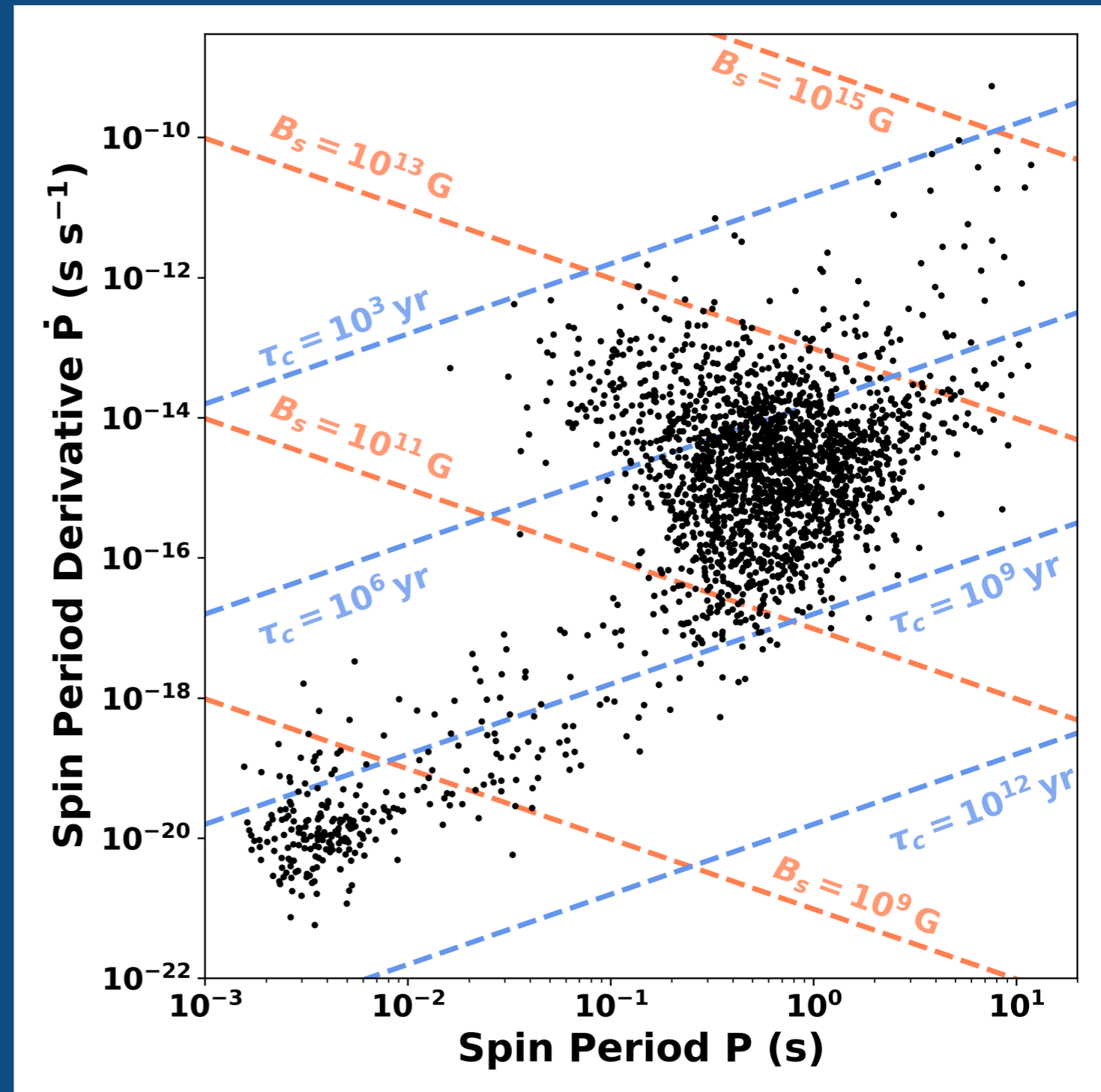
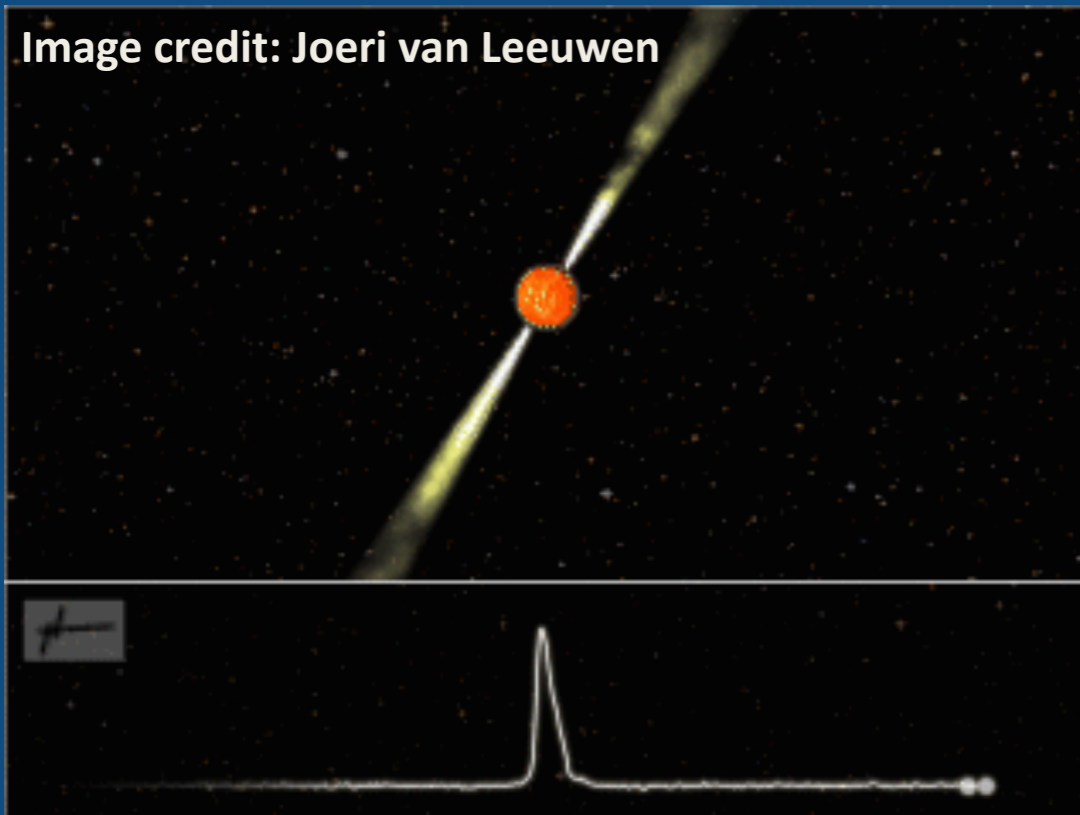
VERA observation at 22 GHz

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Pulsar | Signals from neutron stars!

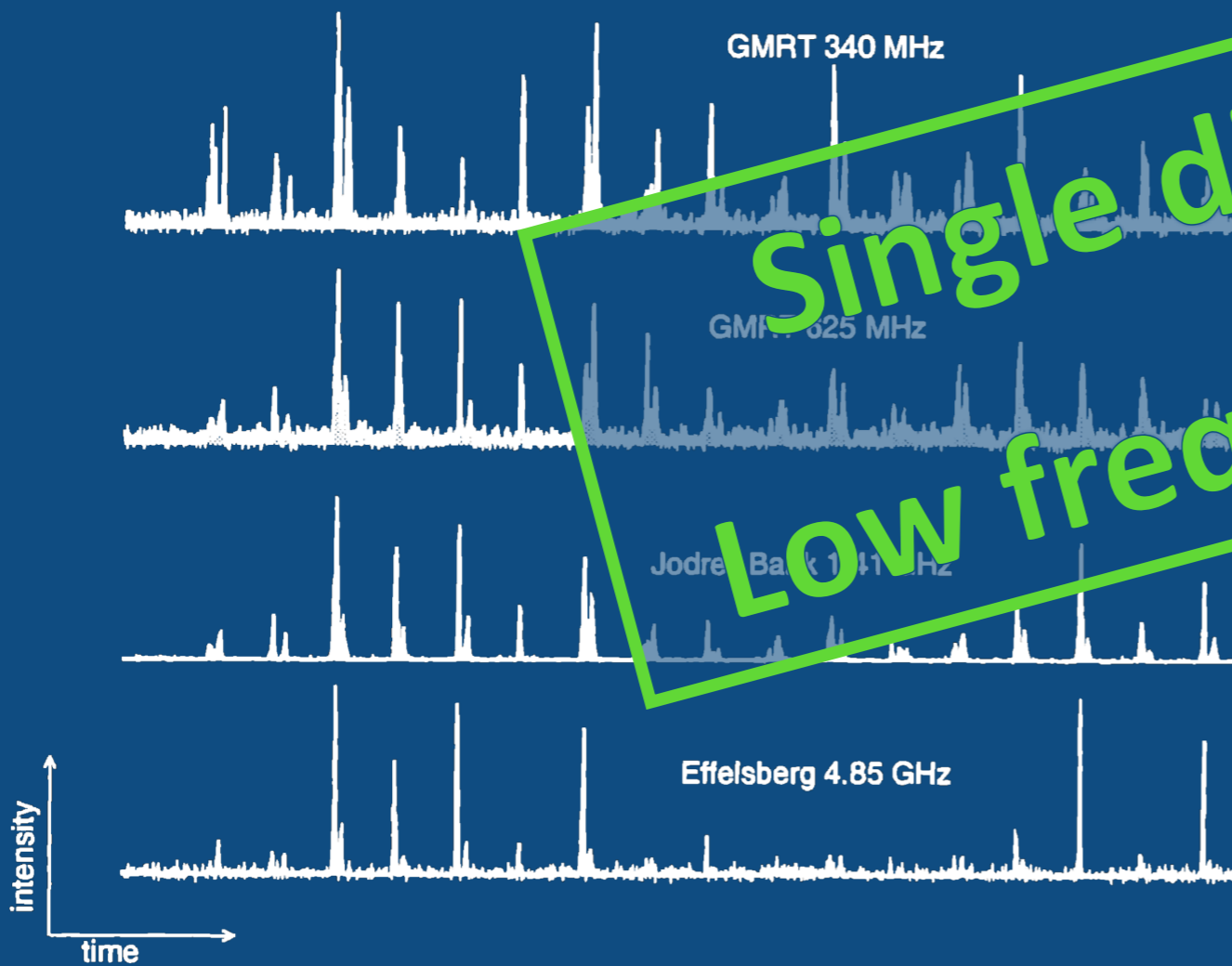
- Rapidly rotating neutron stars
- Spin parameters can infer pulsars' physical properties.
(age, magnetic field strength, spin-down luminosity, ...)



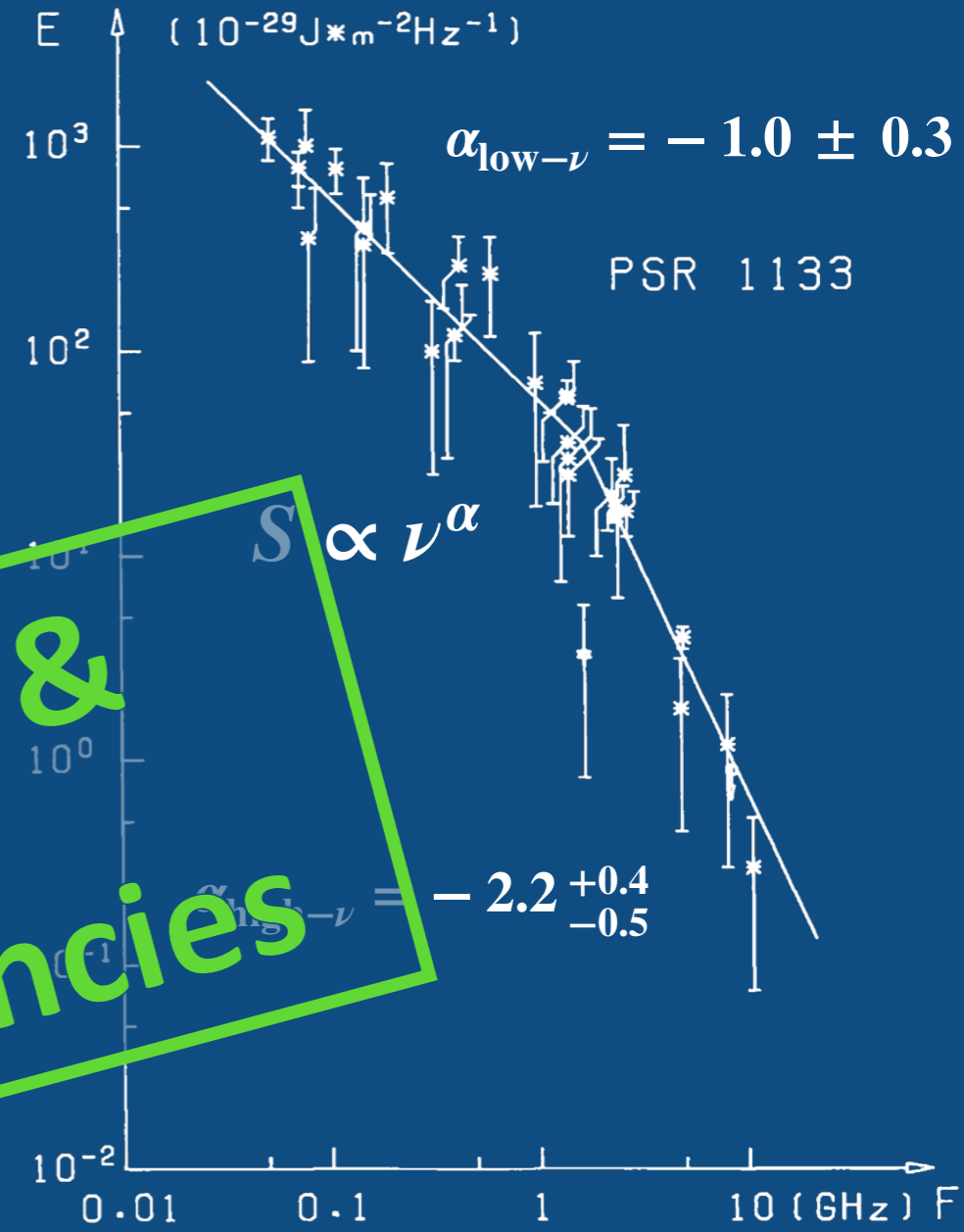
Data is from the Australia Telescope National Facility (ATNF)
Pulsar Catalog (Manchester+05)

Pulsar | Radio observations

- Generally weak
- Much weaker at high frequencies
 - Average spectral index $\langle \alpha \rangle = -1.8 \pm 0.2$ (Maron+2000)



Single dish & Low frequencies

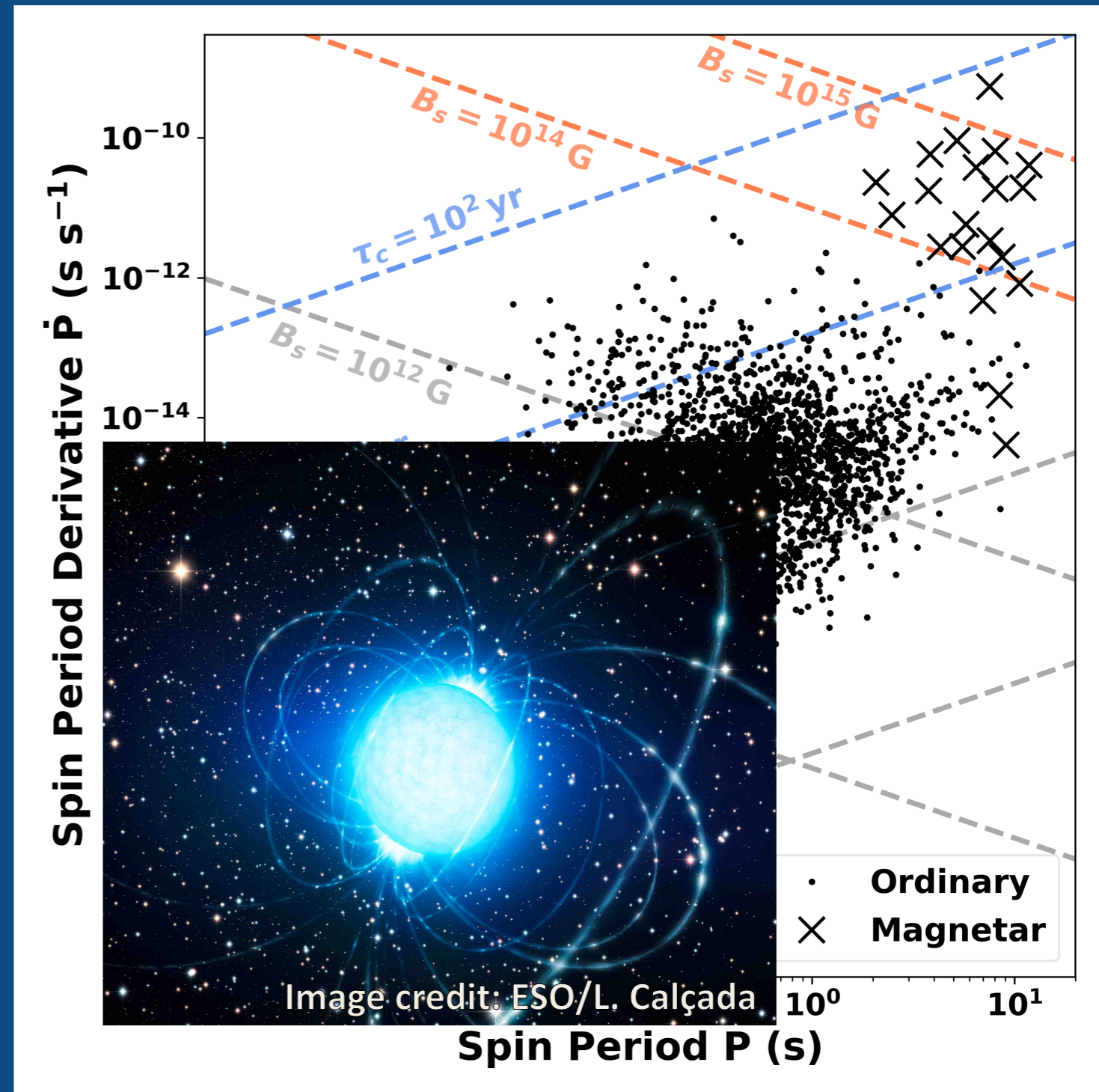


↑ Spectrum of PSR B1133+16 (Sieber 1973)

← Single pulses from PSR B1133+16 (Karastergiou+2004)

Magnetar | MAGnetic NEutron sTAR

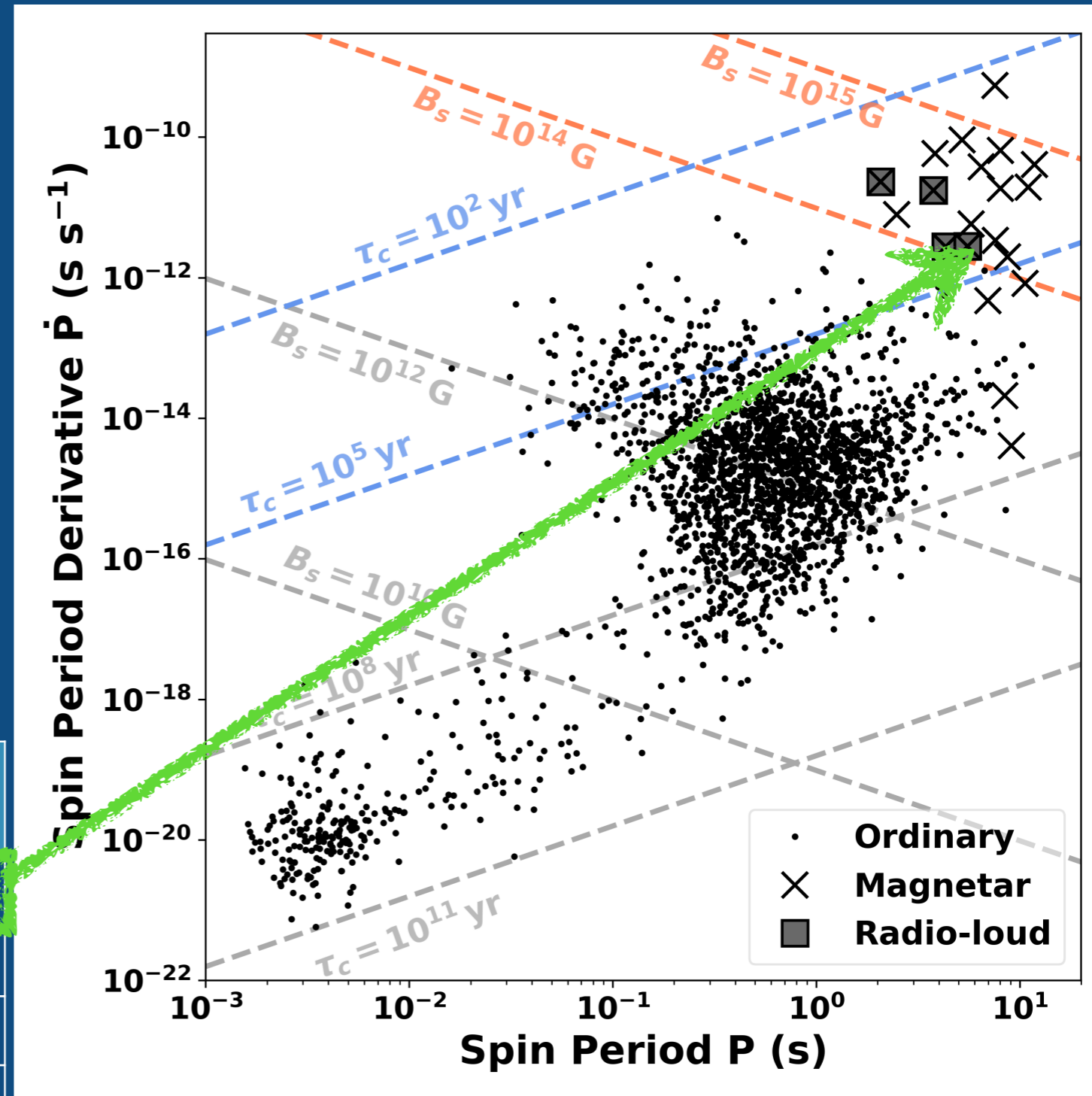
- Pulsars with intense short bursts, pulsations, outbursts in X-ray, soft γ -ray
- Slow spin & fast spin-down
 → **Ultra-strong \vec{B} (10^{14-15} G)**
 & Relatively young ages
 ($\lesssim 10000$ yrs)
- “The most powerful magnet in the Universe”



Data is from the Australia Telescope National Facility (ATNF)
 Pulsar Catalog (Manchester+05)

Magnetar | Radio-bright

- 4 sources detected in radio
- Distinct radio properties from **ordinary pulsars**
- **Strong variations** with time : profile shape, intensity, polarization (e.g. Camilo+07, Levin+12, Lynch+15)
- **Flatter** spectra ($\alpha \approx -0.5$ vs -1.8) (Camilo+07, Maron+00)



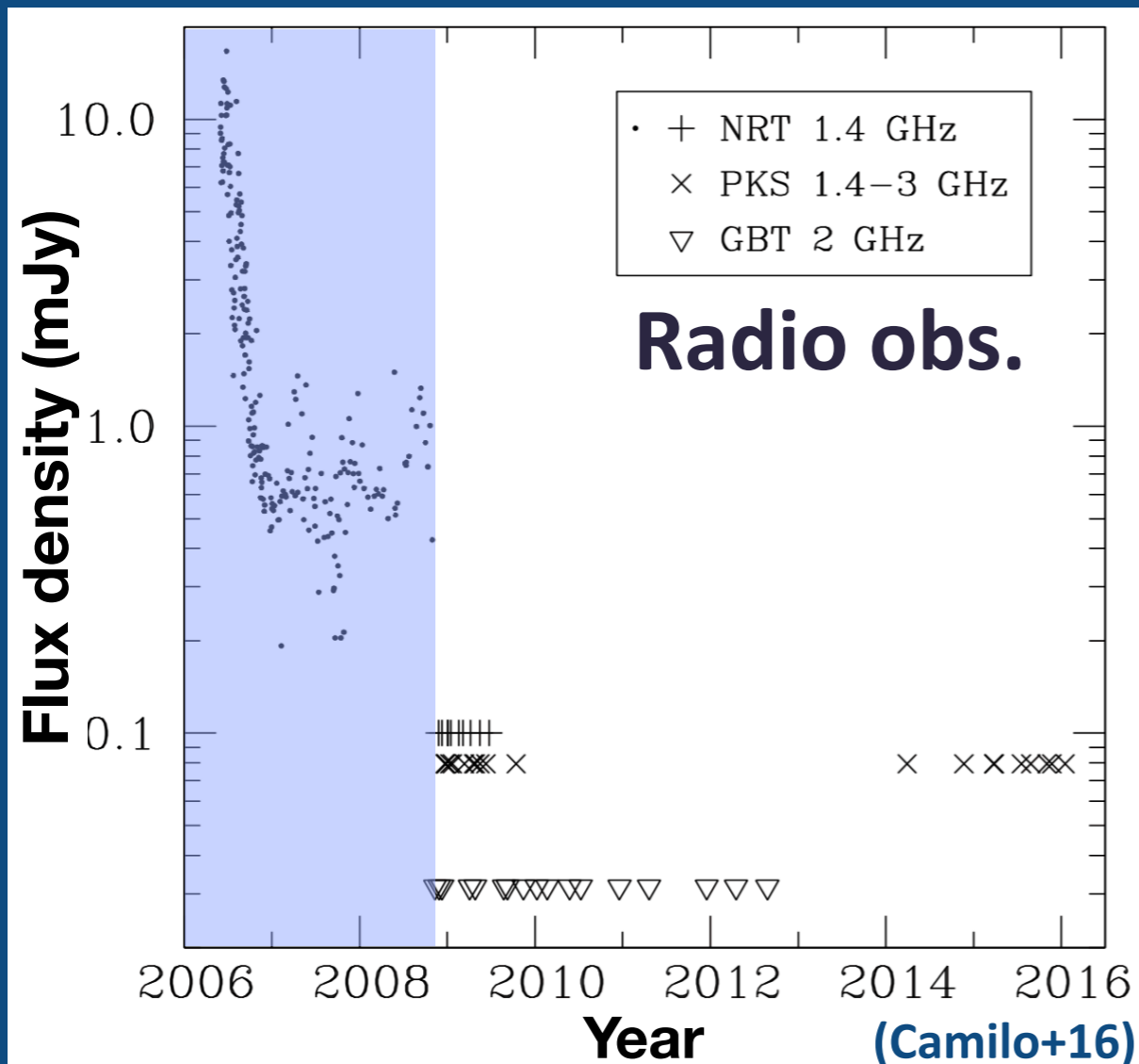
Data is from the Australia Telescope National Facility (ATNF) Pulsar Catalog (Manchester+05)

(Kaspi & Beloborodov 2017)

Name	P (s)	B (10^{14} G)	τ_c (kyr)	D (kpc)
XTE J1810-197	5.54	2.1	11	3.5
1E 1547.1-5408	2.07	3.0	0.69	4.5
PSR J1622-4950	4.33	2.7	4.0	~ 9
SGR J1745-2900	3.76	2.3	4.3	8.3

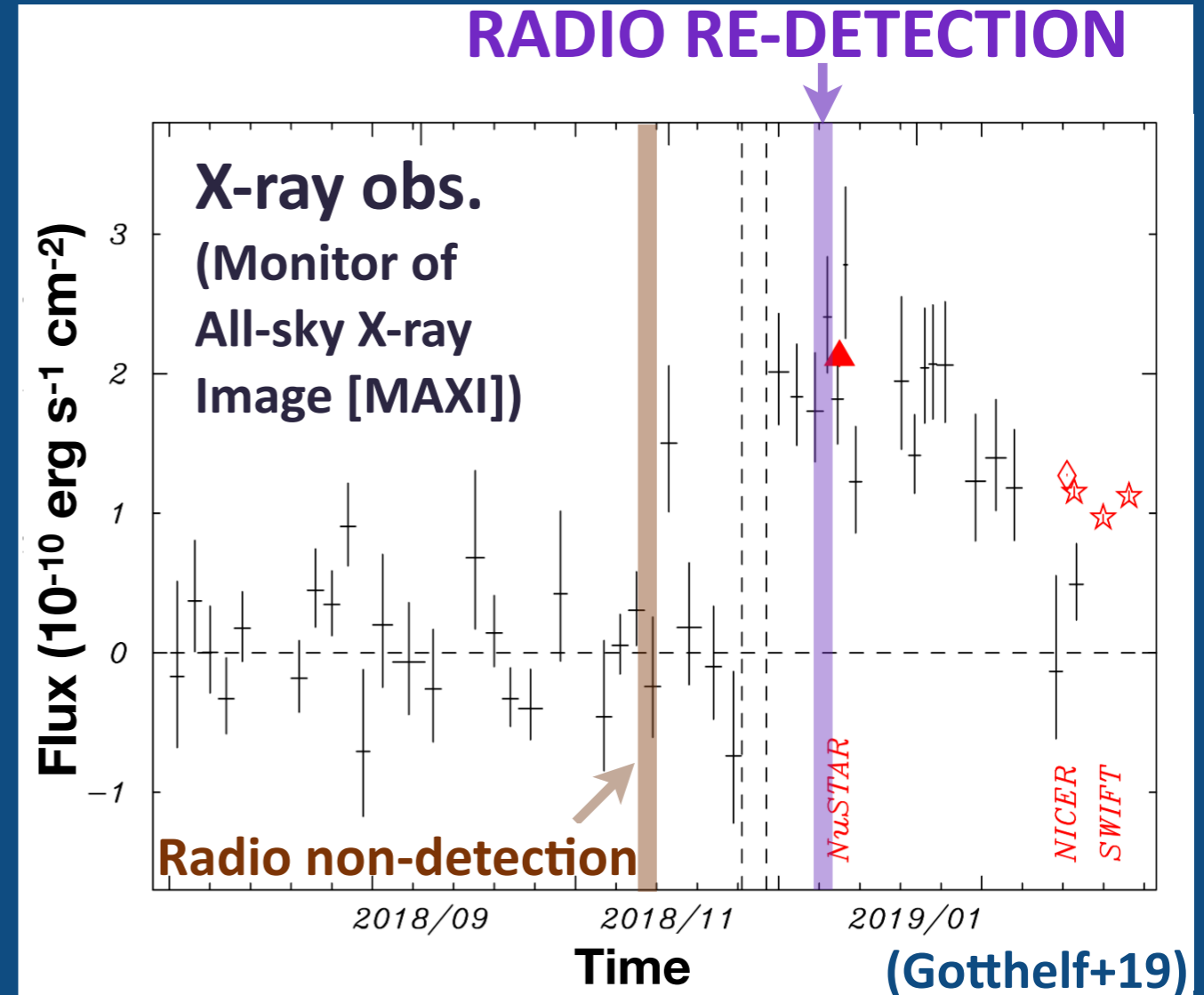
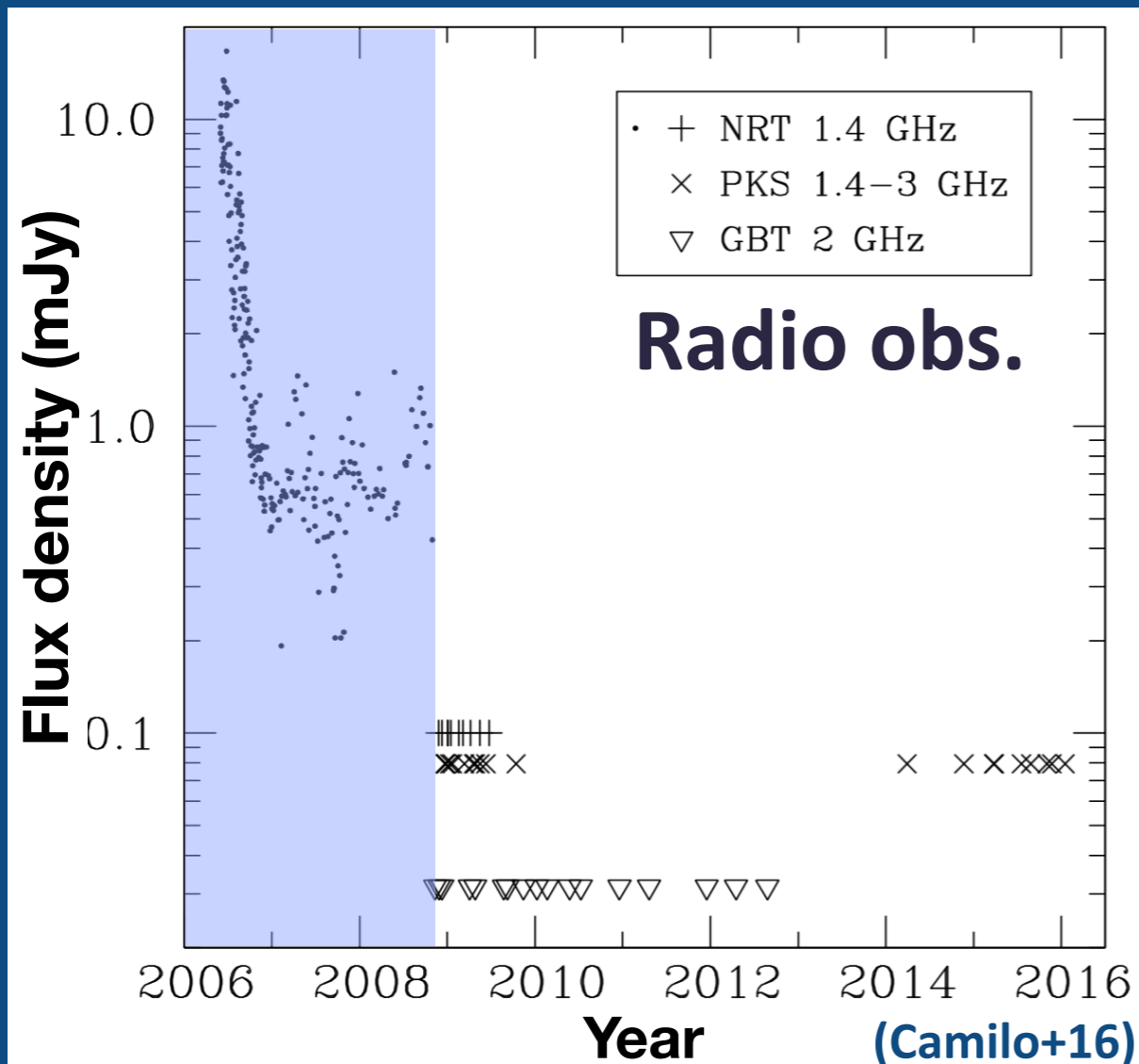
XTE J1810-197 | Discovery

- Discovered in 2003 in X-ray (Rossi X-ray Timing Explorer; Ibrahim+04)
- Detection of radio pulsations in 2006
- No detectable radio pulsations from 10 years ago (Camilo+16)



XTE J1810-197 | Re-brightened!

- No detectable radio pulsations from 10 years ago (Camilo+16)
- **Reactivated!!**
 - Strong radio flares (2018/12/08) (Lyne+ ATel #12284)
 - X-ray was also confirmed (Gotthelf+19)

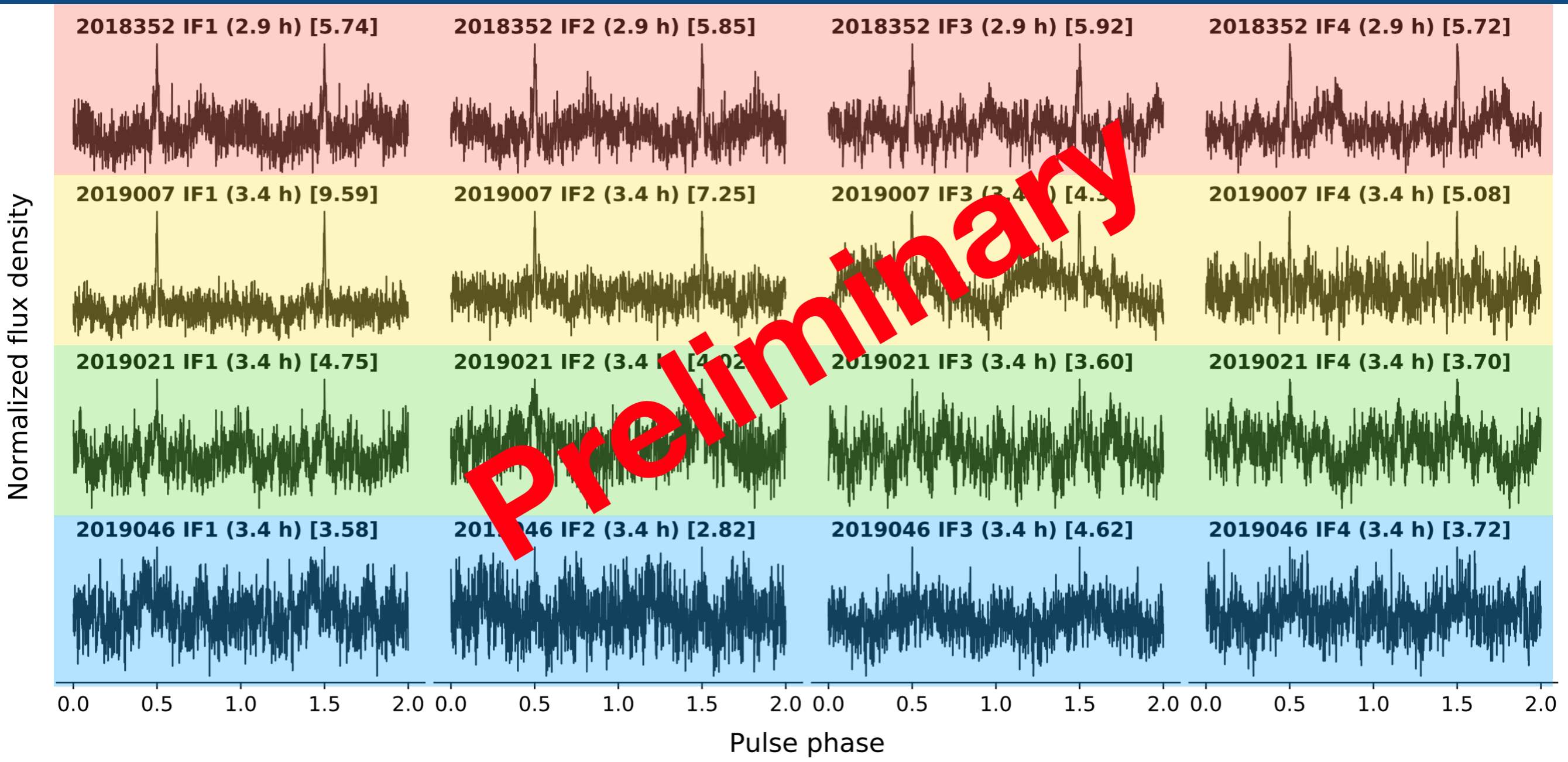


VERA observations | もっとVERA

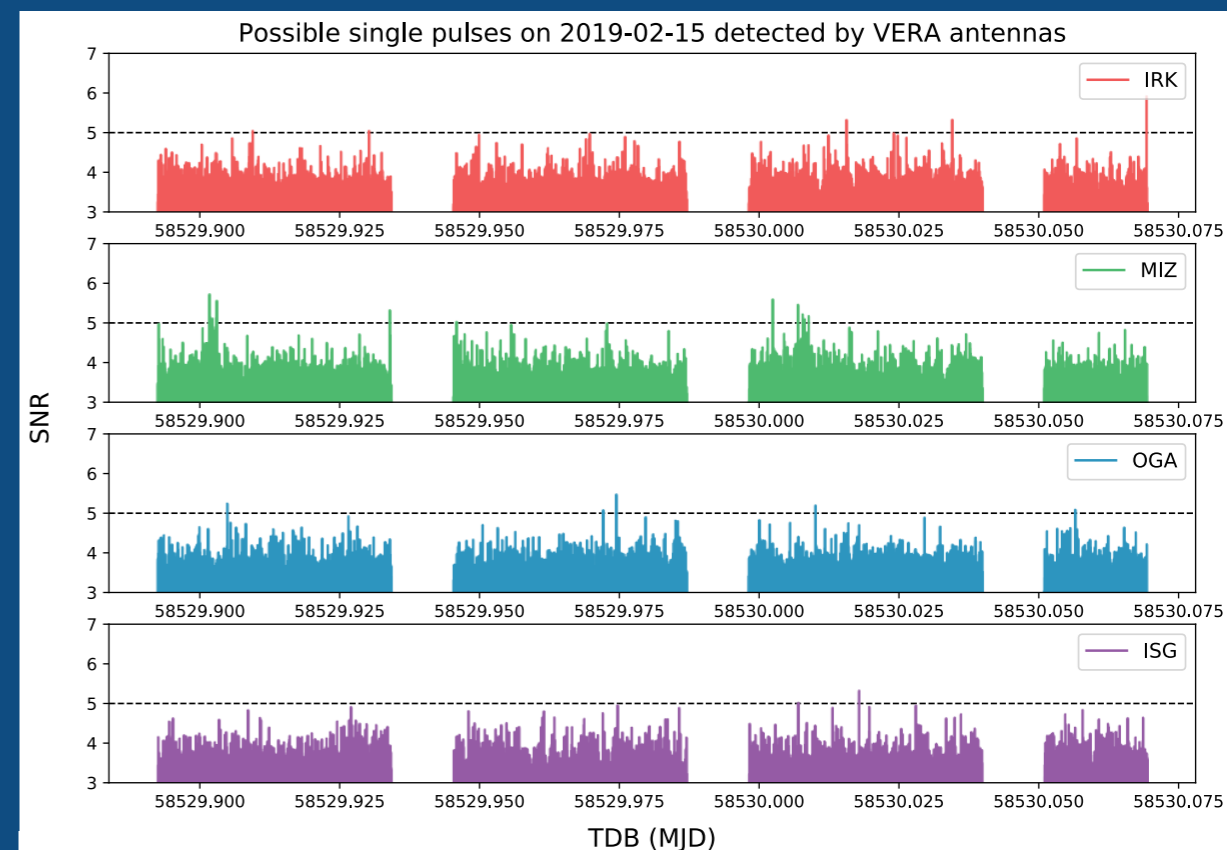
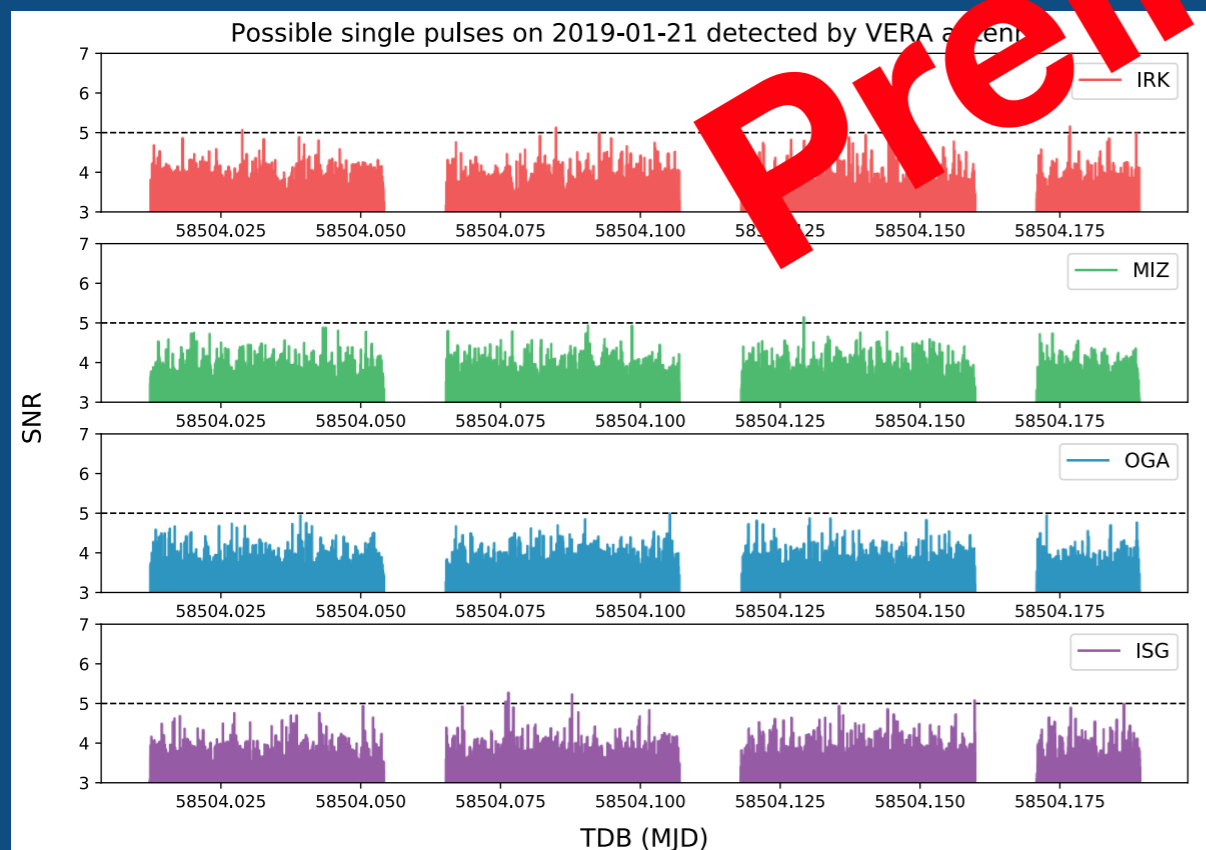
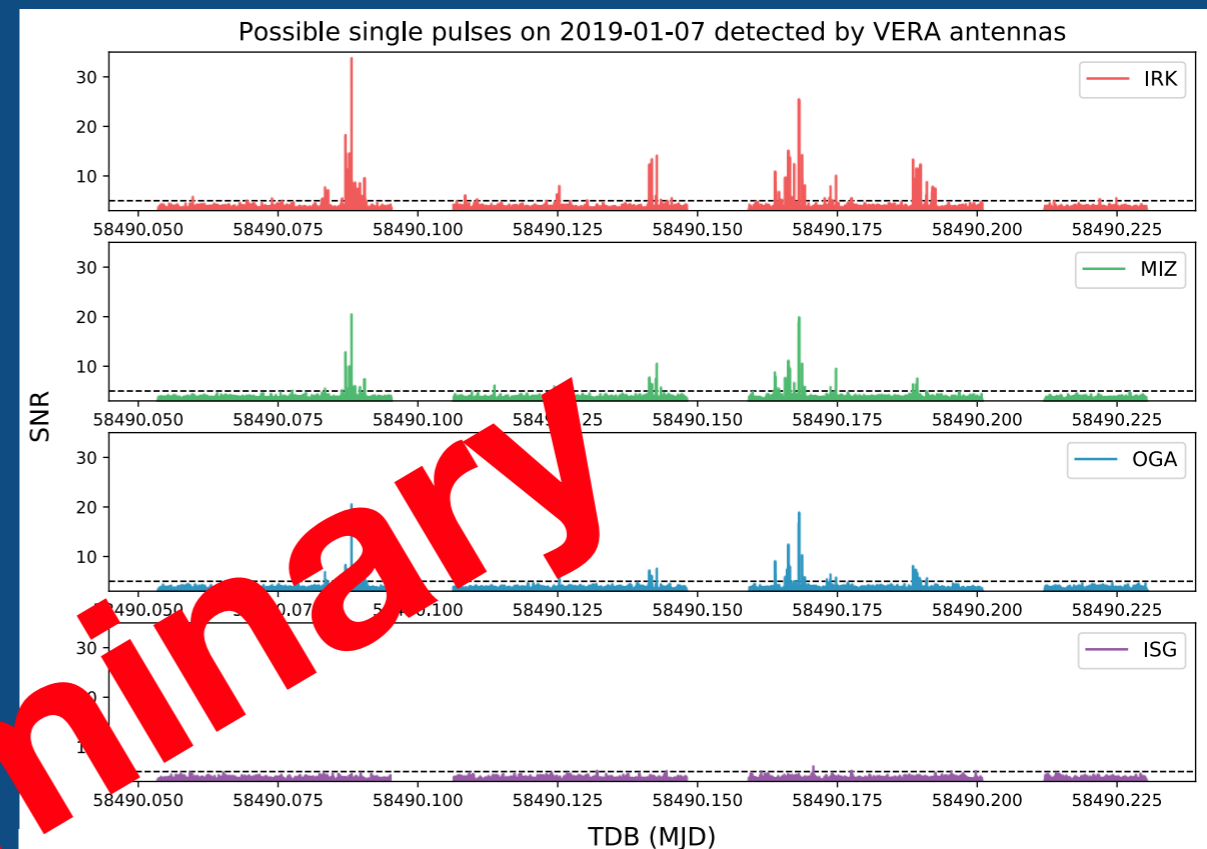
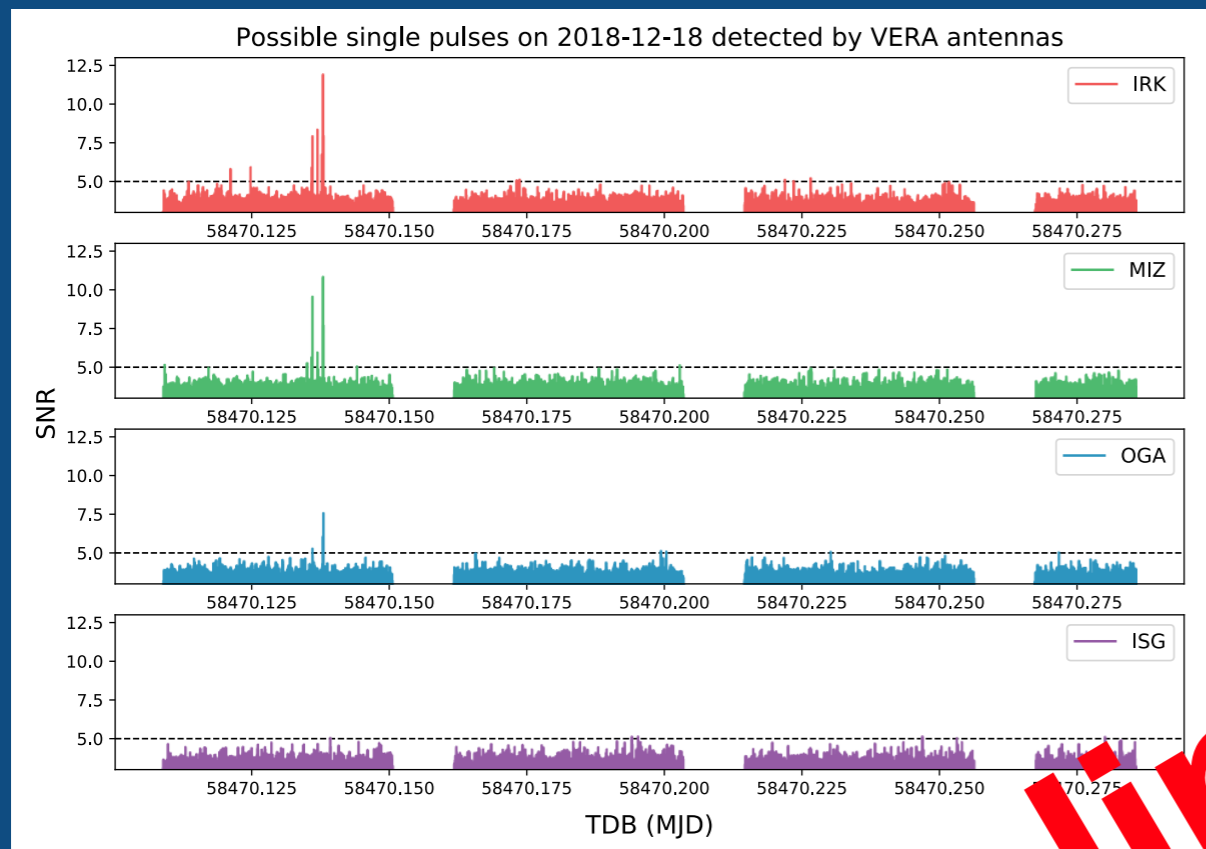
Magnetar Observation Team of VERA (PI: 赤堀さん)

- Observations of XTE J1810-197 conducted in 4 epochs
(Radio outburst obs on 2018-12-08,
Expected X-ray outburst within 2018-11-20~26)
 - 2018-12-18
 - 2019-01-07
 - 2019-01-21
 - 2019-02-21

Result | Average pulses at 22 GHz

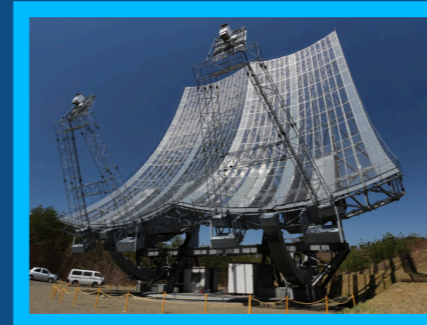


Result | Single pulses at 22 GHz



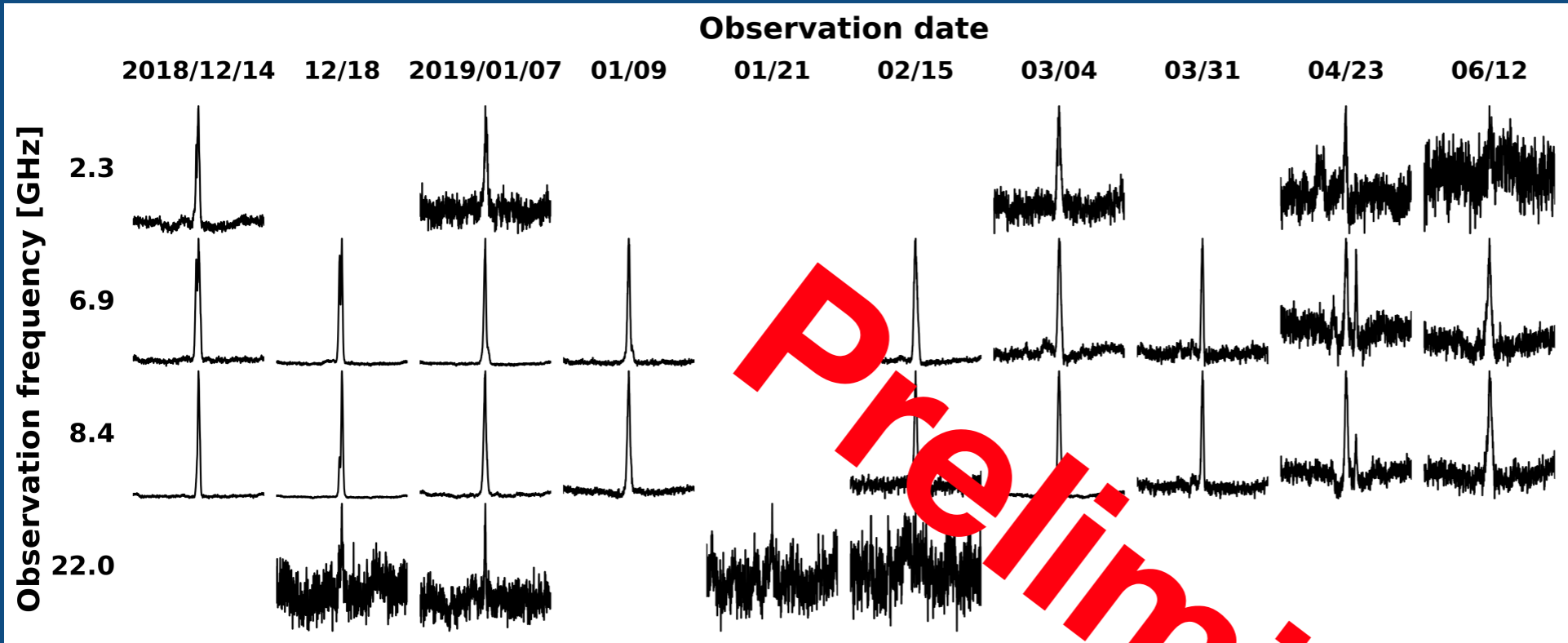
Collabo | Multi-freq, epoch obs

- VERA 20 m (4 stations) [NAOJ]
@ 22 GHz
- Hitachi 32 m [Ibaraki Univ.]
@ 6 & 8 GHz
- Kashima 34 m [NICT]
@ 2 GHz
- Iitate antenna
31 m × 16.5 m × 2
[Tohoku Univ.]
@ 325 MHz

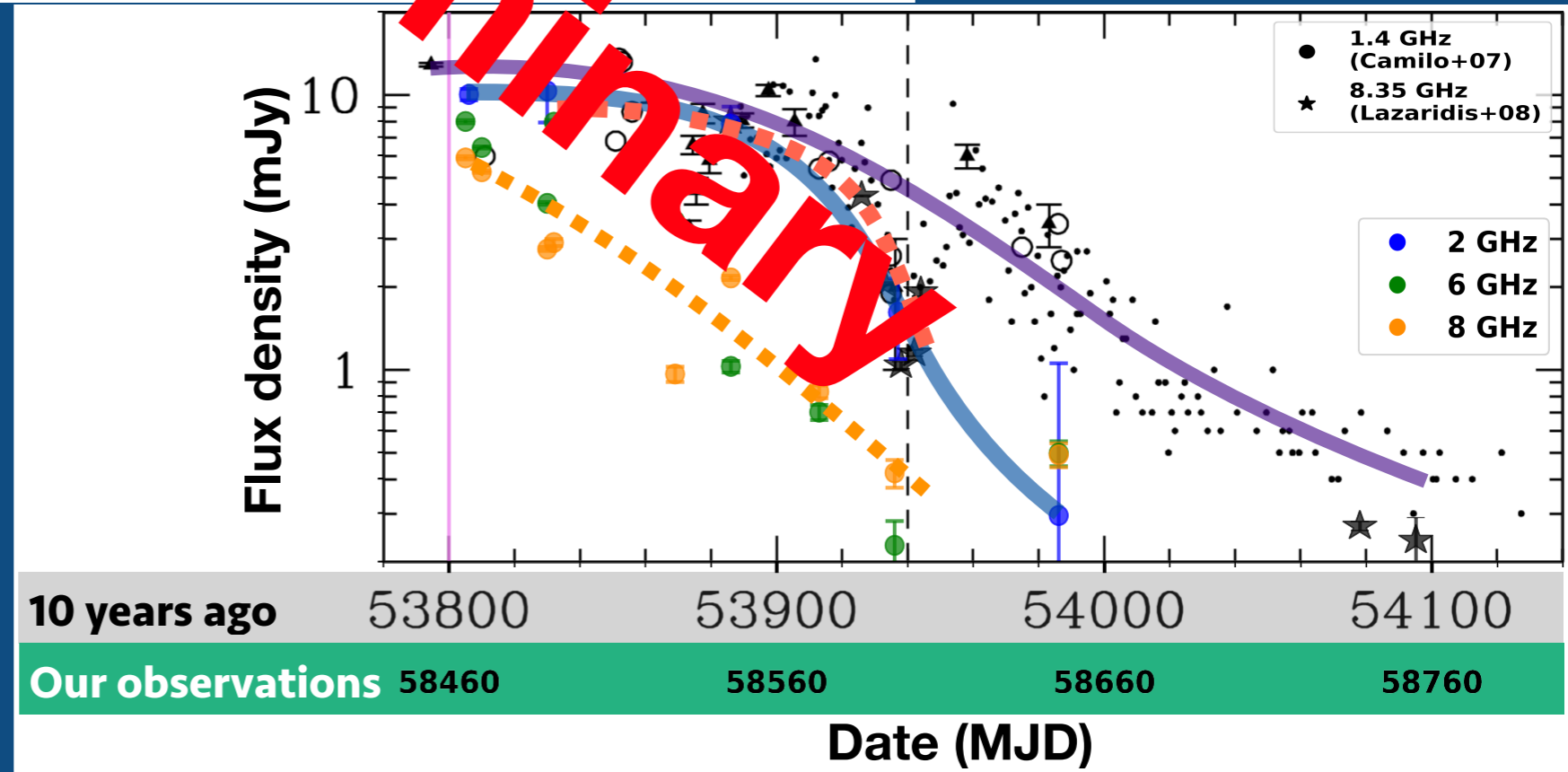


5 bands & 10 epochs

Collabo | Multi-freq, epoch obs



Preliminary

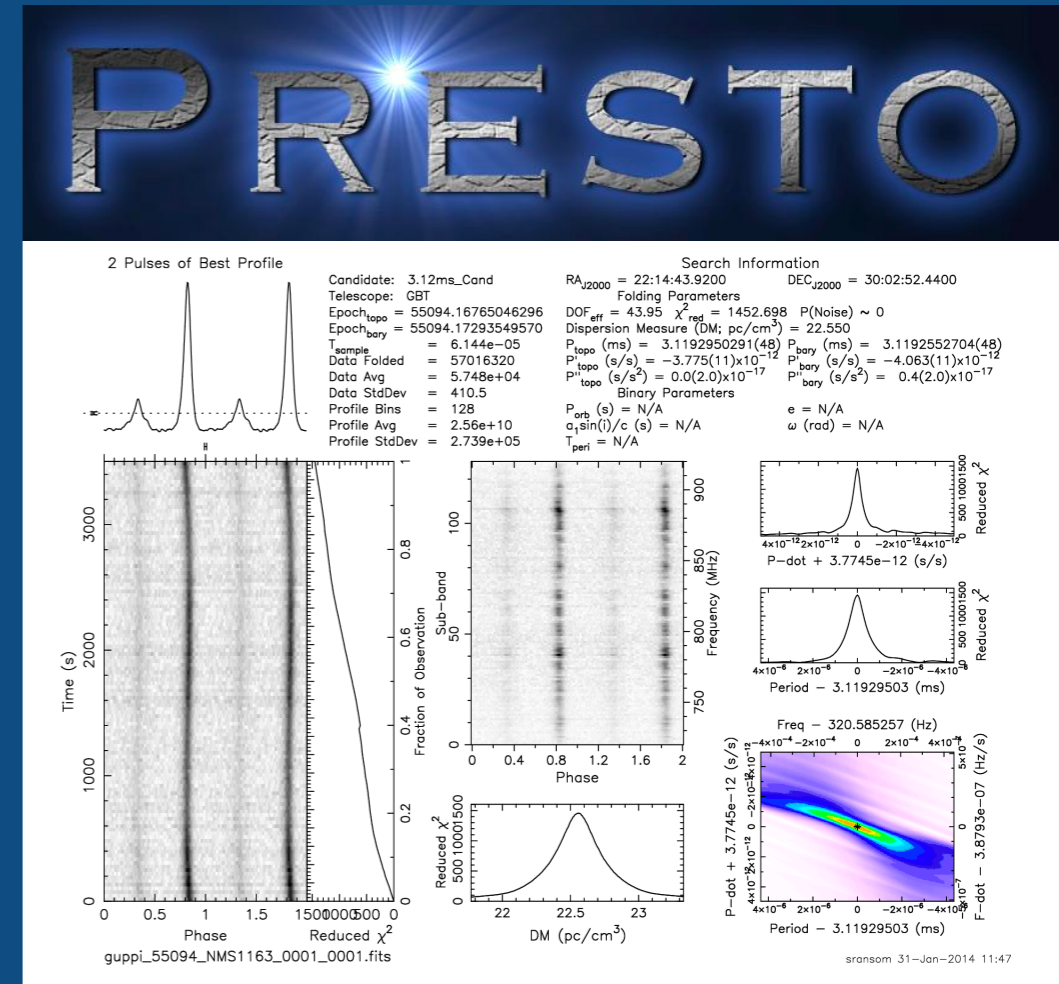


Future work | PRESTO for VERA

PRESTO [Pulsar Exploration and Search Toolkit]:

A software for pulsar search and analysis

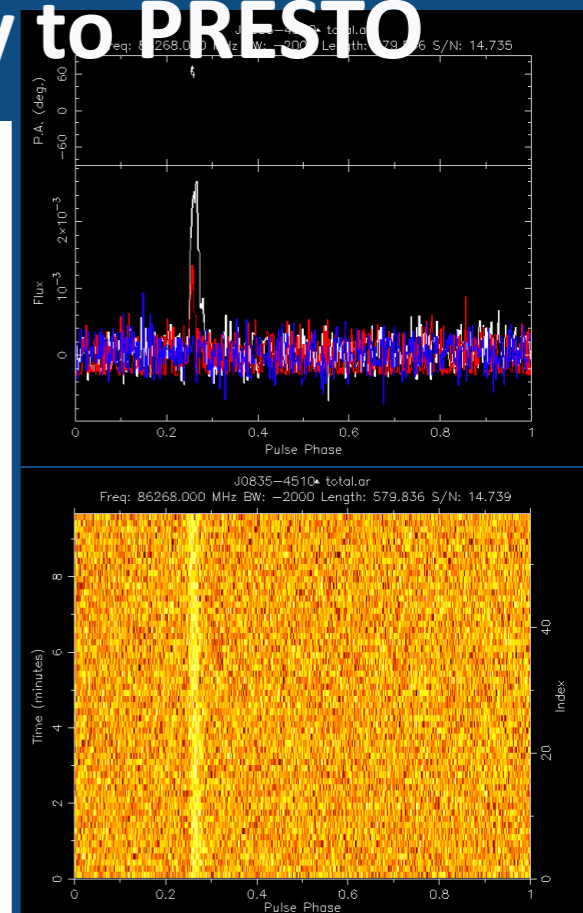
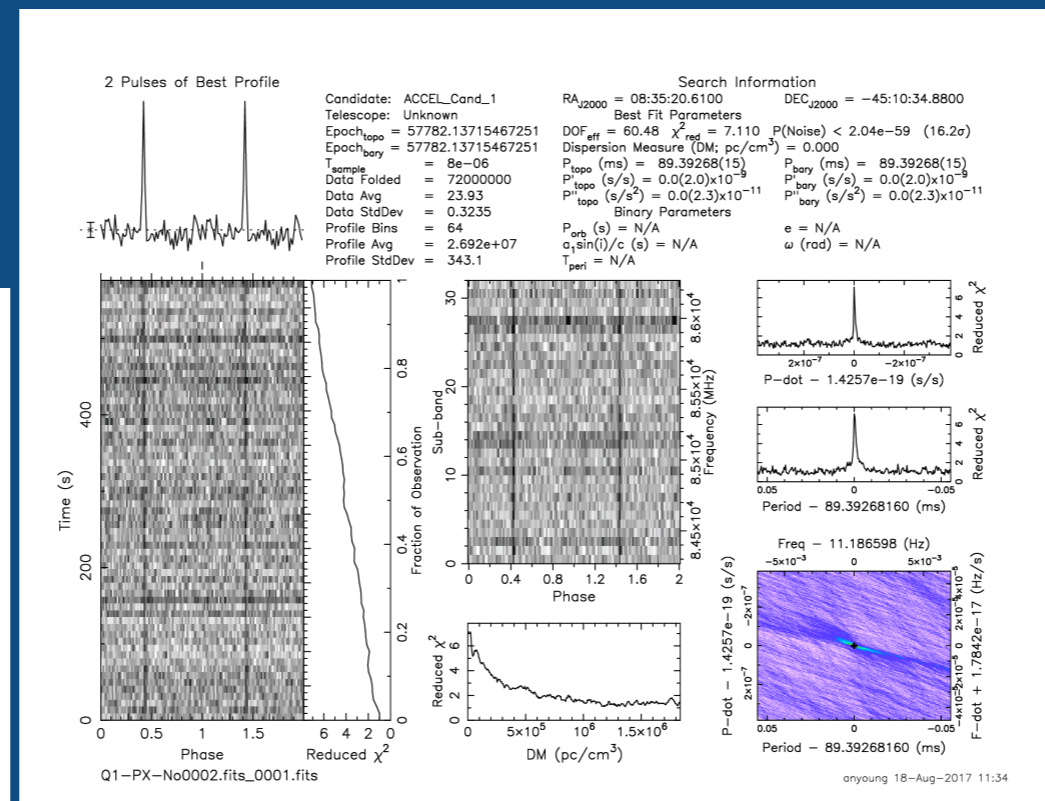
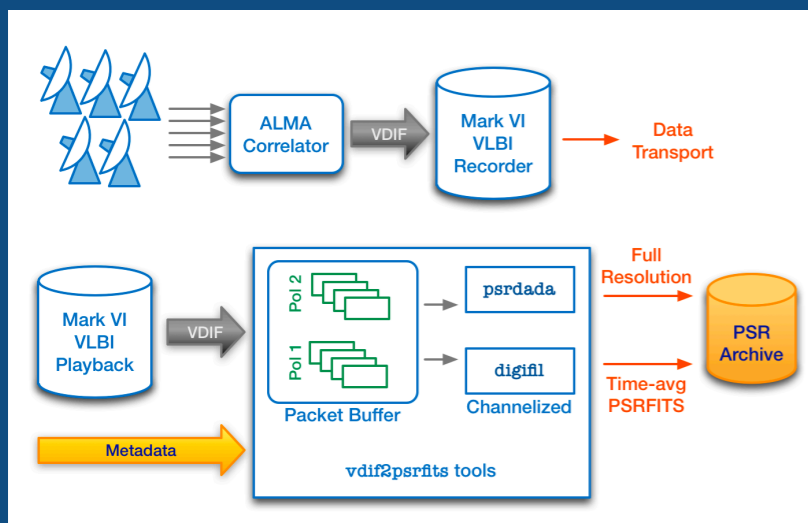
- The most commonly used software
- They requires the data in standard pulsar format (PSRFITS).
- The problem is we haven't know how to convert our data to PSRFITS.



From PRESTO official website

Future work | PRESTO for VERA

- Detection of pulsations of a pulsar by phased ALMA (Vela pulsar @ 85-101 GHz, $S_{\text{mean}, 87\text{GHz}} = 0.99 \pm 0.17$ mJy with 40 min obs.) + software for (VDIF format data of ALMA -> PSRFITS format)
- KVN has phased-resolving pipeline (Dodson+2014).
- We can test VERA phase resolving and apply to PRESTO



Liu+2019