

# The slowest pulsar

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## LOFAR Discovery of a 23.5 s Radio Pulsar

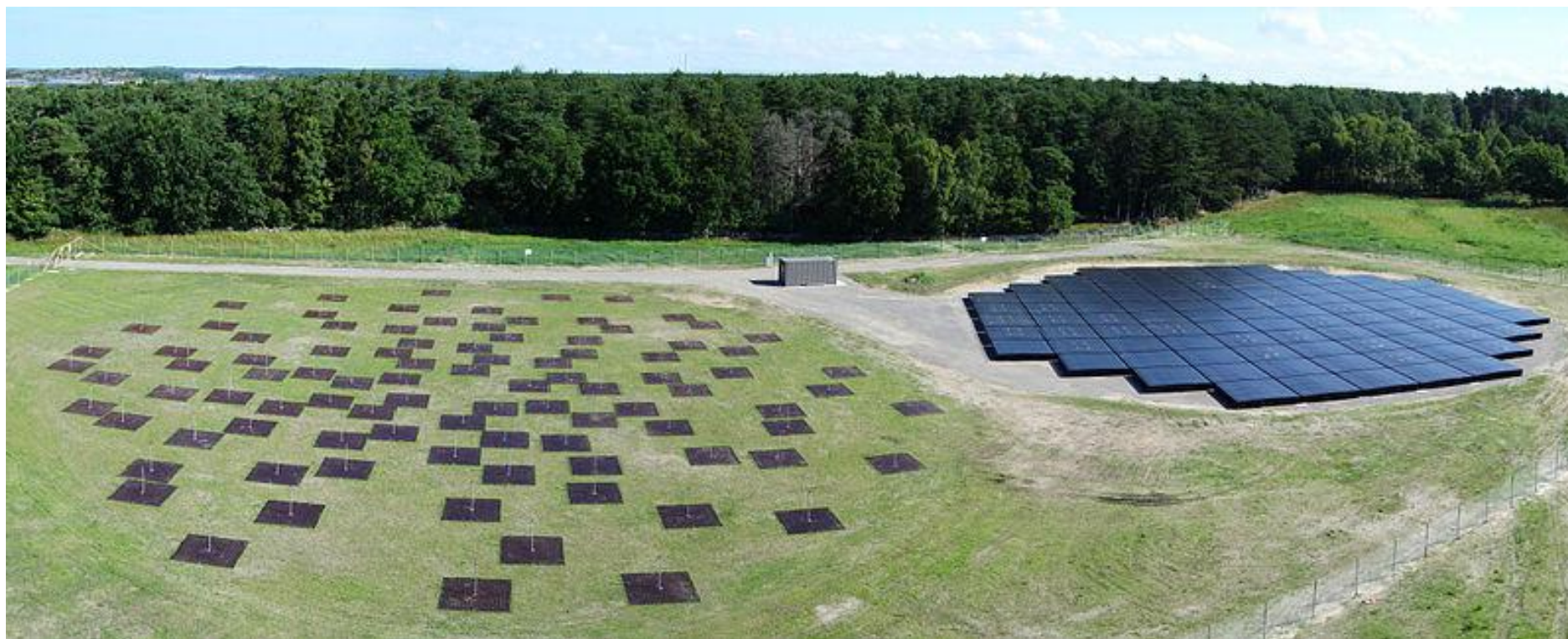
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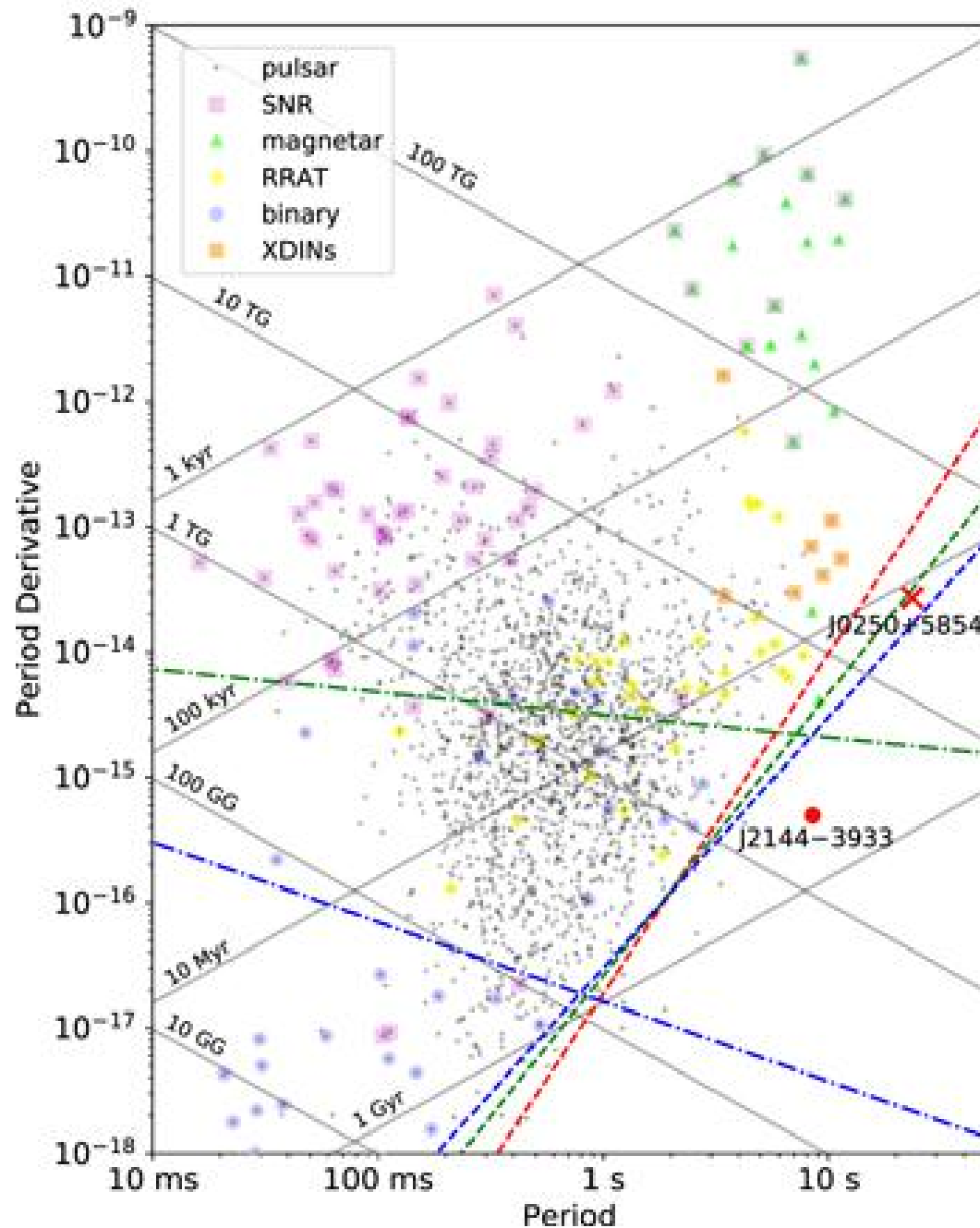
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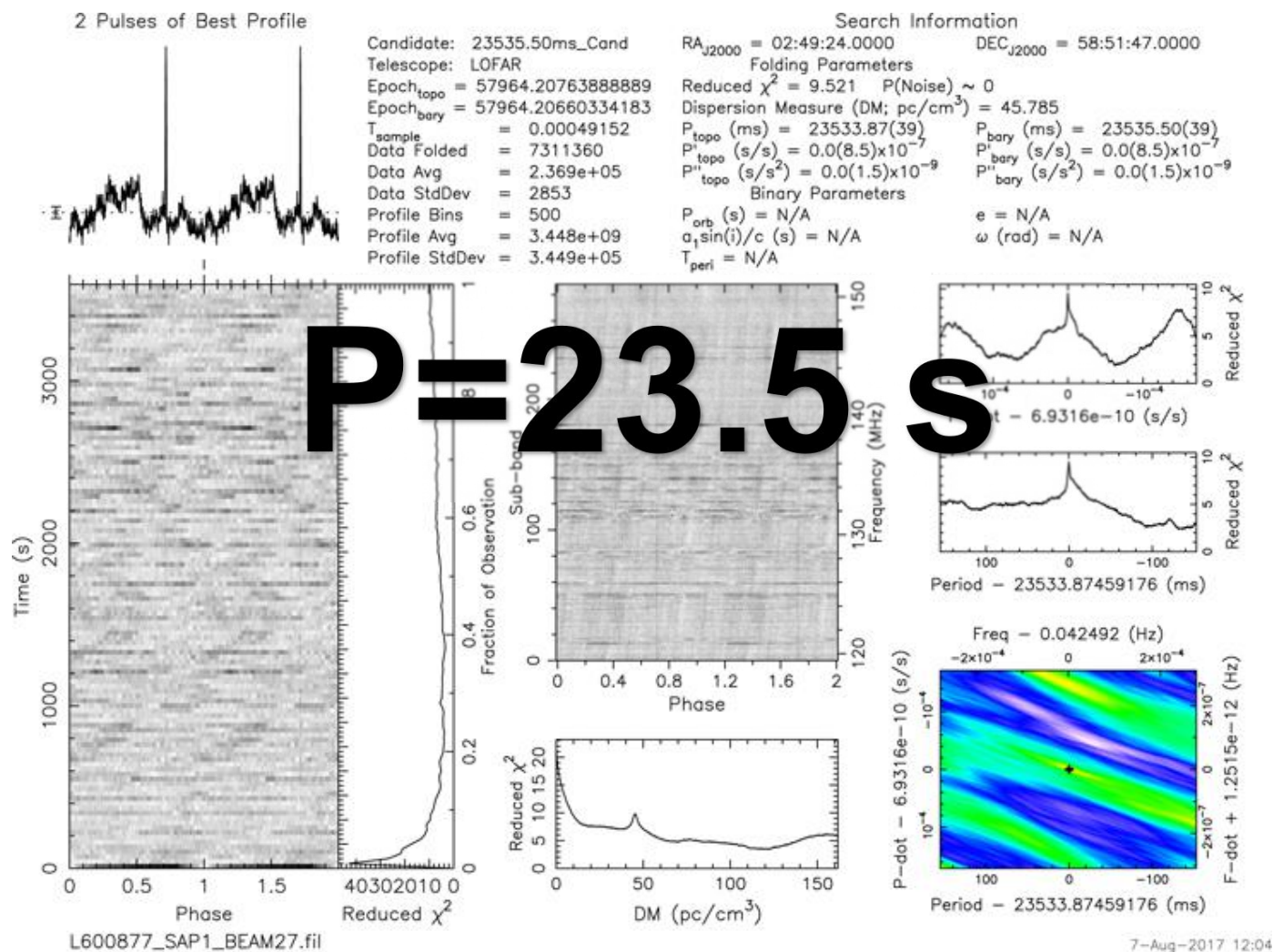
# Telescope(s)



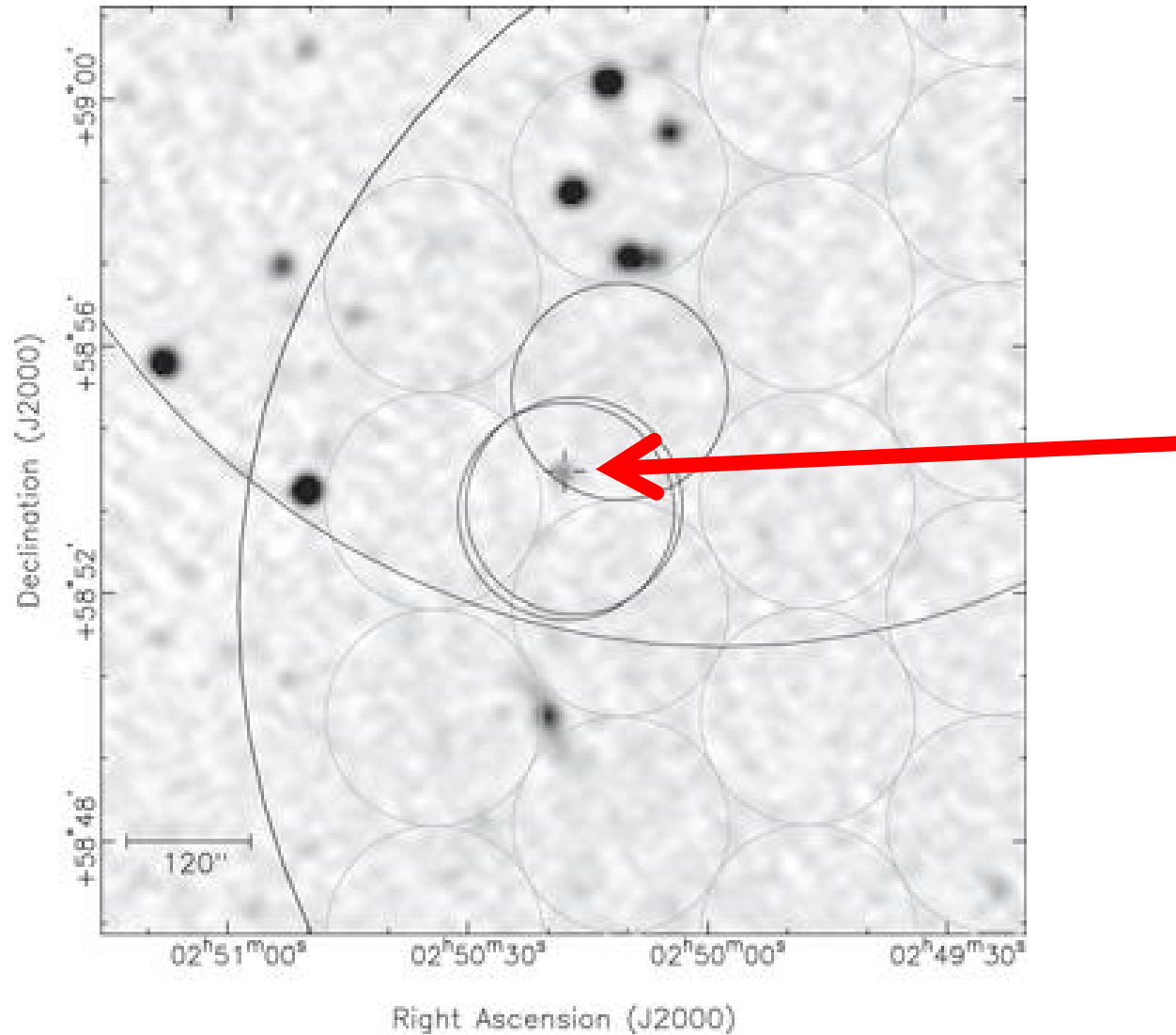


- Magnetar -> Flat spectral index, High B-field and spindown, associated with high energy sources
- XDINs -> Detected with BB radiation but really dim. This type of pulsar is expected to be the last stage of the magnetars.
- Deathline(s) -> The limits where pulsar can not emissions after cross this line acrossding to each emission model.

# Discovery



# Discovery



# Parameters

**Table 1**  
The Timing Parameters of PSR J0250+5854 Obtained from the Timing Solution Including the Prediscovery TOA from 2015 August 5

Timing Parameters	Values
R.A., $\alpha_{J2000}$	02 <sup>h</sup> 50 <sup>m</sup> 17 <sup>s</sup> .78(3)
Decl., $\delta_{J2000}$	58°54′01″.3(2)
Spin period (s)	23.535378476(1)
Spin period derivative (s s <sup>-1</sup> )	2.716(7) × 10 <sup>-14</sup>
Dispersion measure, DM (pc cm <sup>-3</sup> )	45.281(3)
Epoch of timing solution (MJD)	57973
Solar system ephemeris model	DE405
Clock correction procedure	TT(TAI)
Time units	TCB
Timing span (MJD)	57238.2-58071.9
Number of TOAs	16
Weighted post-fit residual ( $\mu$ s)	493
Reduced $\chi^2$ value	2.9
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Derived Parameters	
Galactic longitude (degree)	137.8
Galactic latitude (degree)	-0.5
DM distance (kpc)	1.6
Characteristic age (Myr)	13.7
Surface dipole magnetic field strength (G)	2.6 × 10 <sup>13</sup>
Spin-down luminosity (erg s <sup>-1</sup> )	8.2 × 10 <sup>28</sup>

**Note.** The parentheses indicate the 1 $\sigma$  uncertainty in the values. The position of the pulsar is fixed to the position obtained from LoTSS. The large reduced  $\chi^2$  value obtained is likely due to each TOA being formed from a limited number of pulses, which could certainly add some jitter compared to the formal uncertainty.

$$P = 23.5 \text{ s}$$

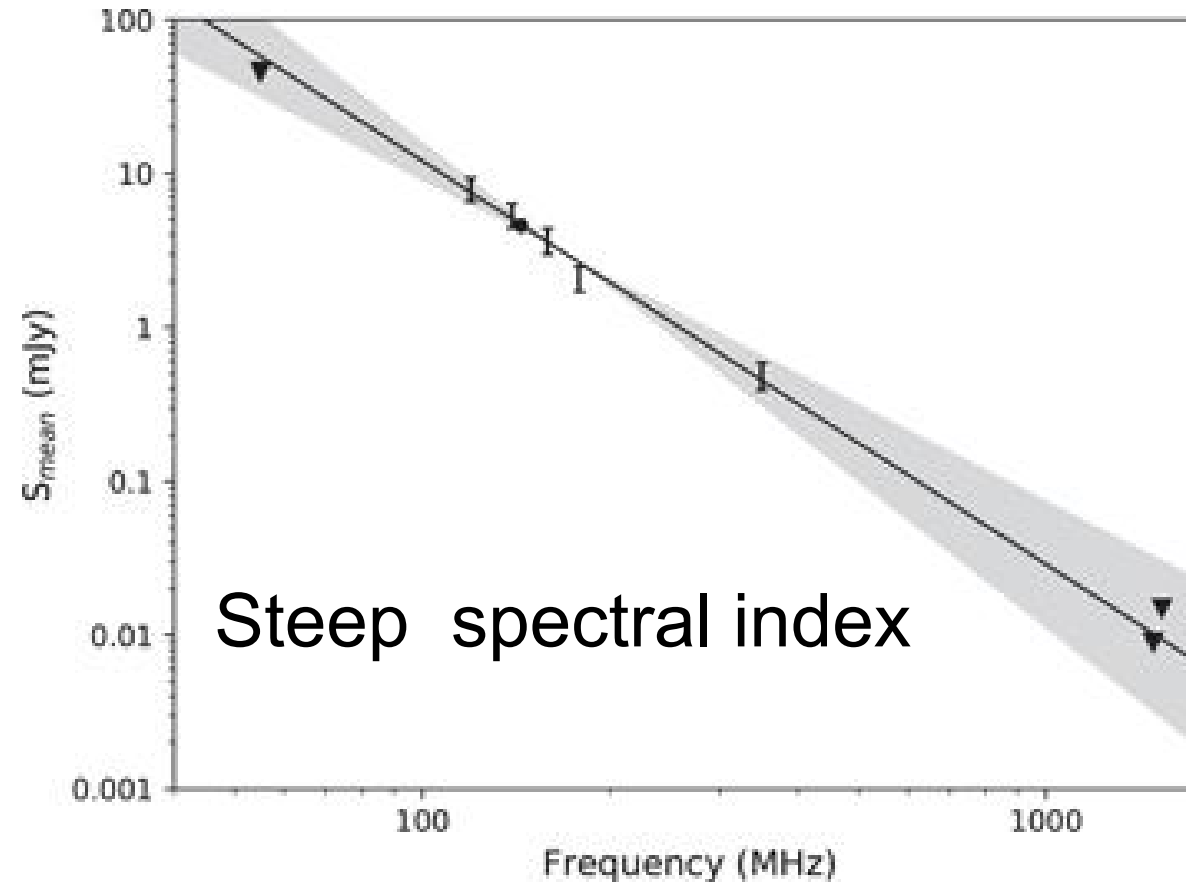
$$\dot{P} = 2.7 \times 10^{-14} \text{ s}$$

$$\text{DM} = 45.281 \text{ pc cm}^{-3}$$

$$\text{DM distance} = 1.6 \text{ kpc}$$

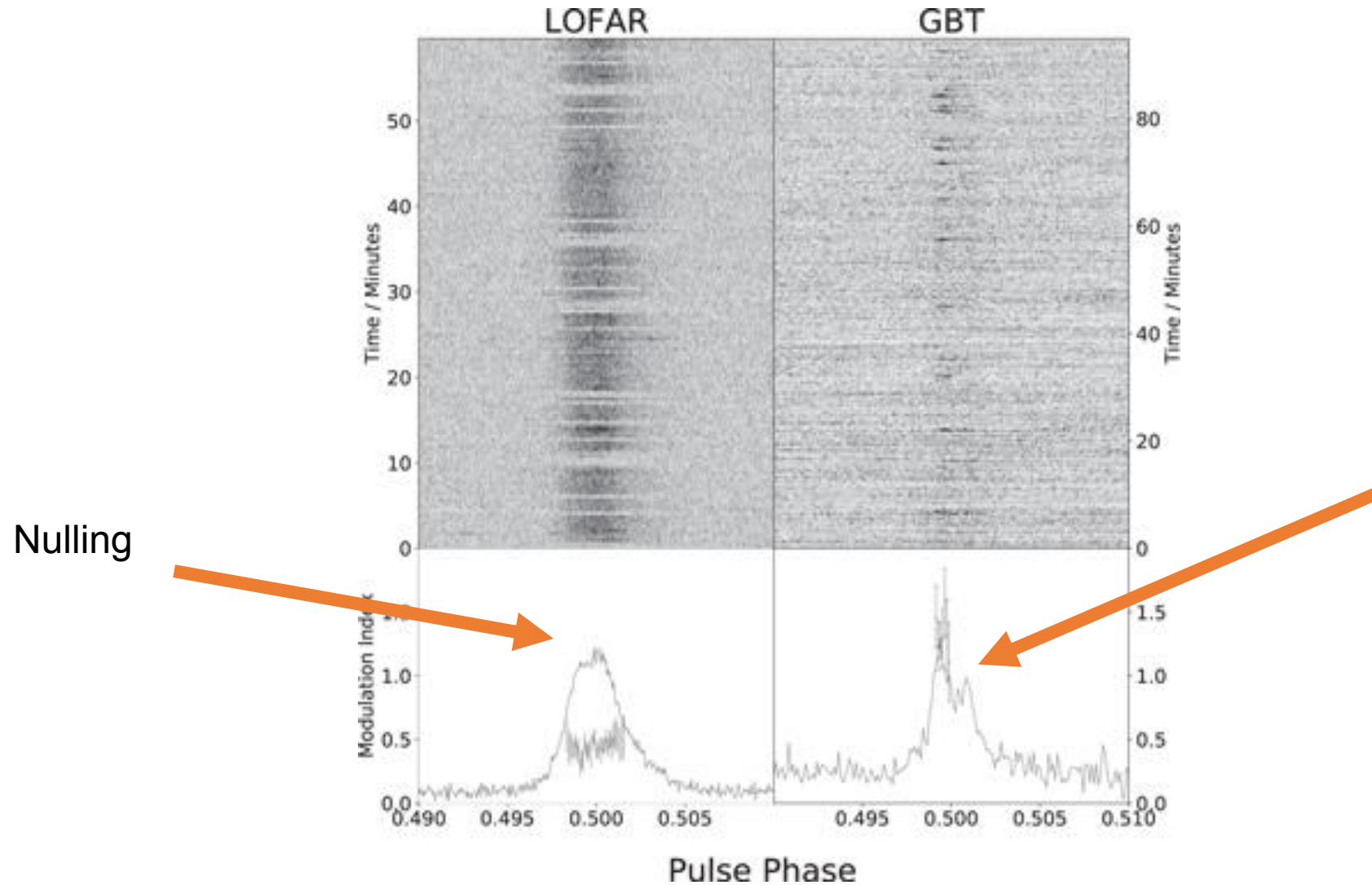
$$\text{age} = 13.7 \text{ Myr}$$

# Spectral index

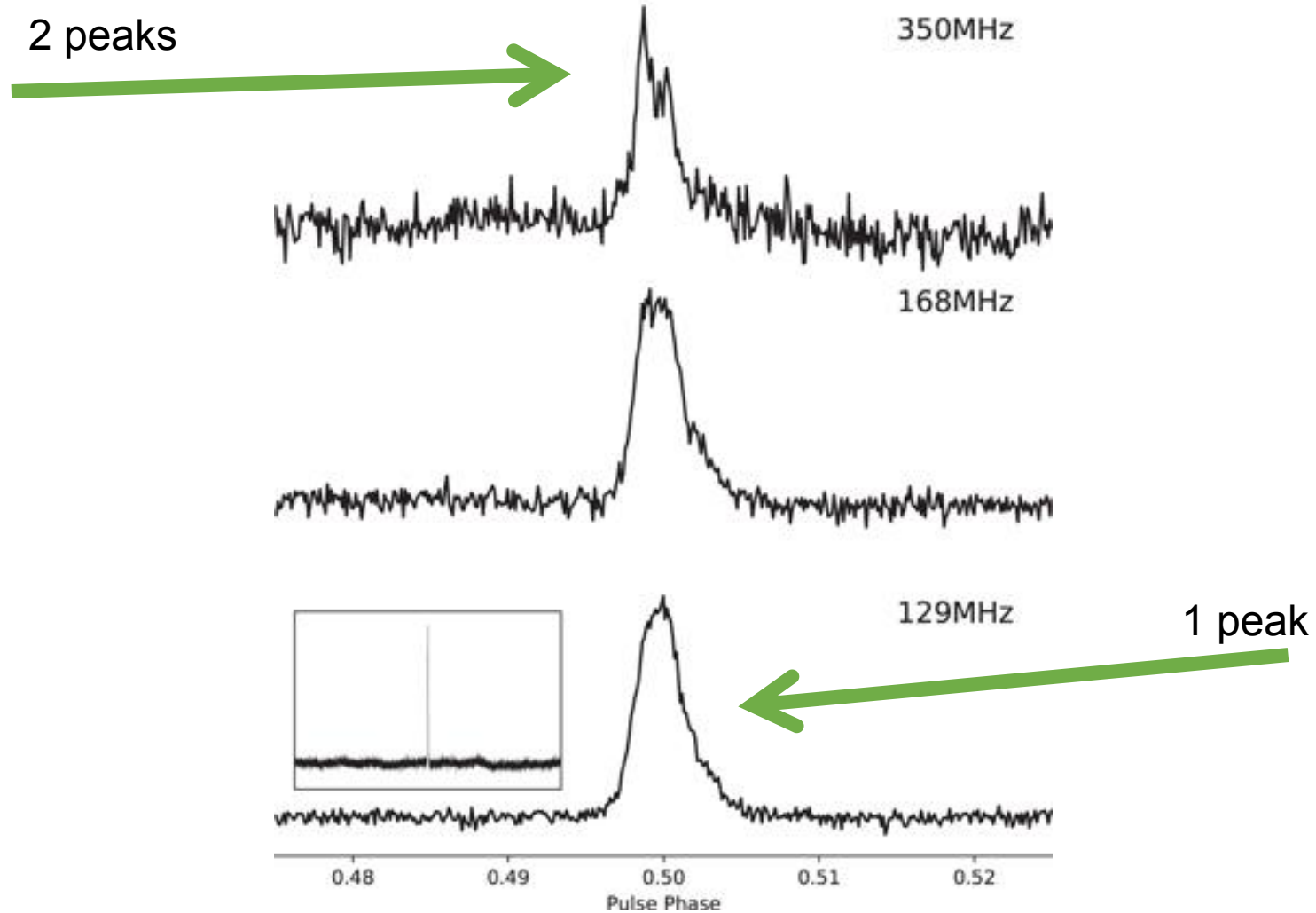




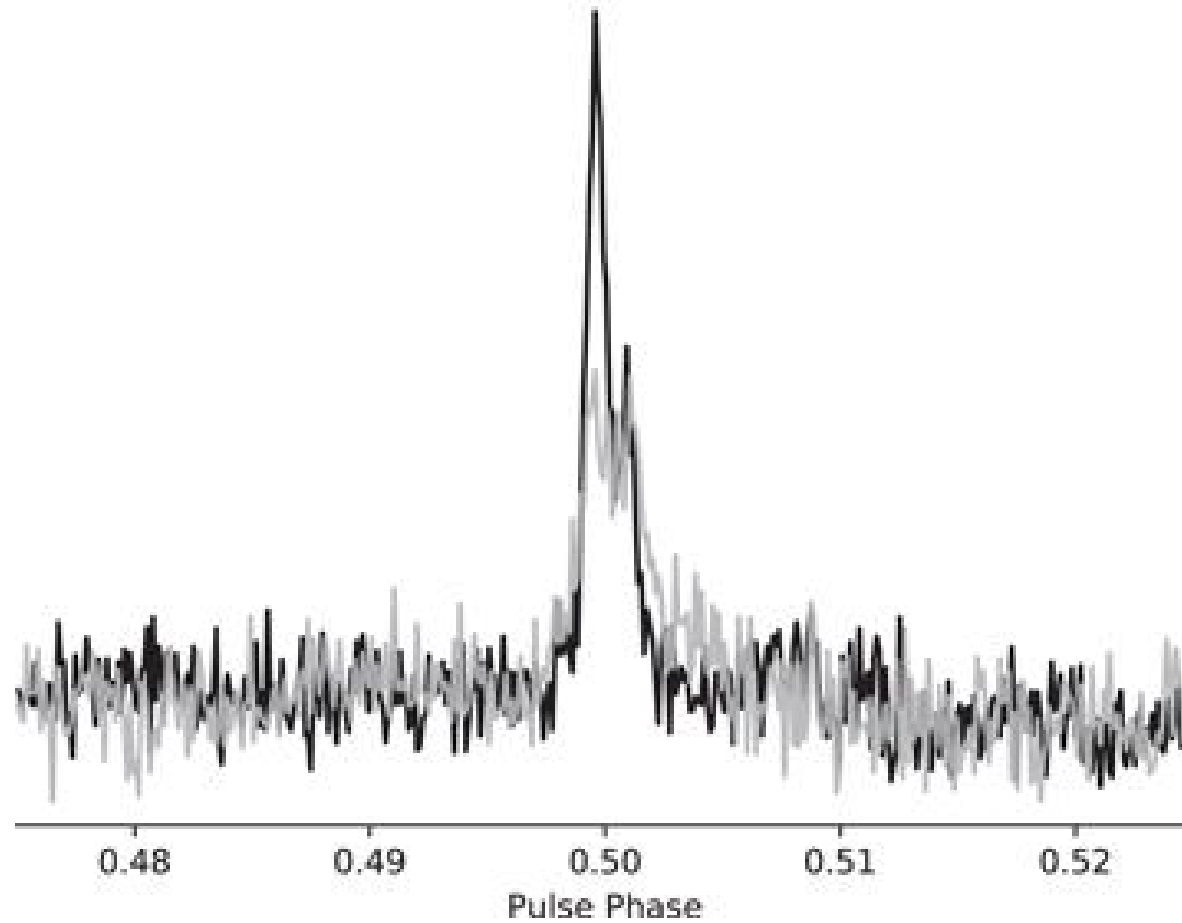
# Multifrequency observations

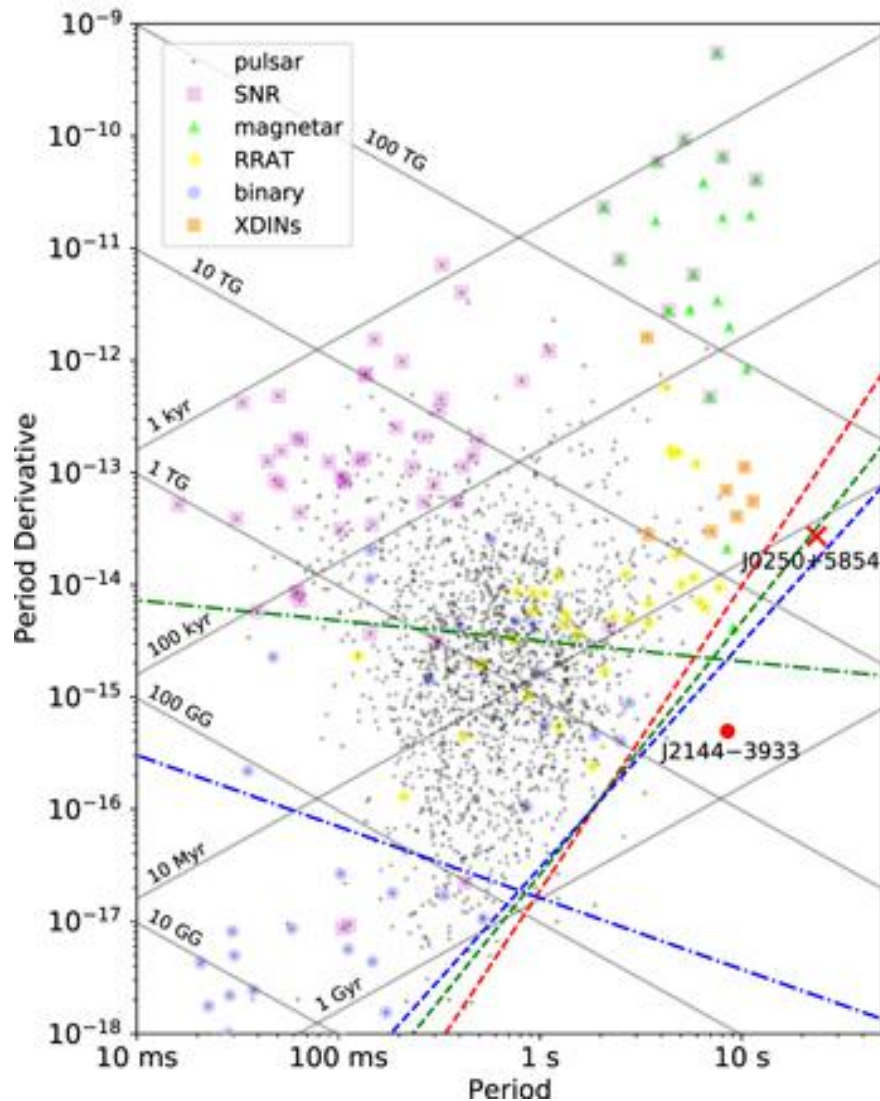


# Multifrequency observations



# Two mode pulse profiles





- Beyond (some) deathlines --> theory of pulsar emissions.
- Detected at 5th harmonics with S/N of 9 --> Detectability of long period pulsars.
- No detection in X-ray observation (but this guy is located far away from the Earth --> low x-ray flux)

# Conclusions

- A pulsar with a 23.5s period has been found.
- This pulsar shows only nulling for high frequency observations.
- Mode switching and nulling are found in low frequency observations.
- This pulsar is located beyond some deathlines indicate a new model of pulsar emissions is needed.
- The articles suggested that this pulsar might be the end of the magnetar and expected to find more pulsar in this region in P-Pdot diagram in the future.