



# Future Pulsar Symposium 11 (FPS 11)



Xiangtan University, Xiangtan

---

## Profile shifting and irregular sub-pulse drifting in PSR J0344-0901

Presenter: Habtamu Menberu Tedila (PhD Candidate)

Collaborators: **Na Wang**, **Rai Yuen**, Zhigang Wen, Wenming Yan, Jianping Yuan, X. H. Han, et al.

Xinjiang Astronomical Observatory, CAS

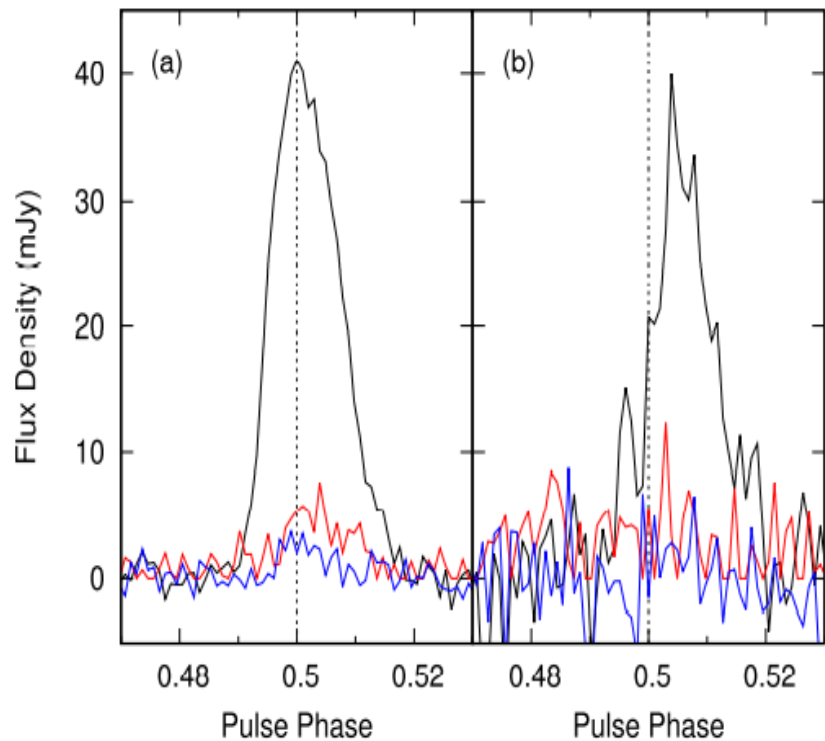
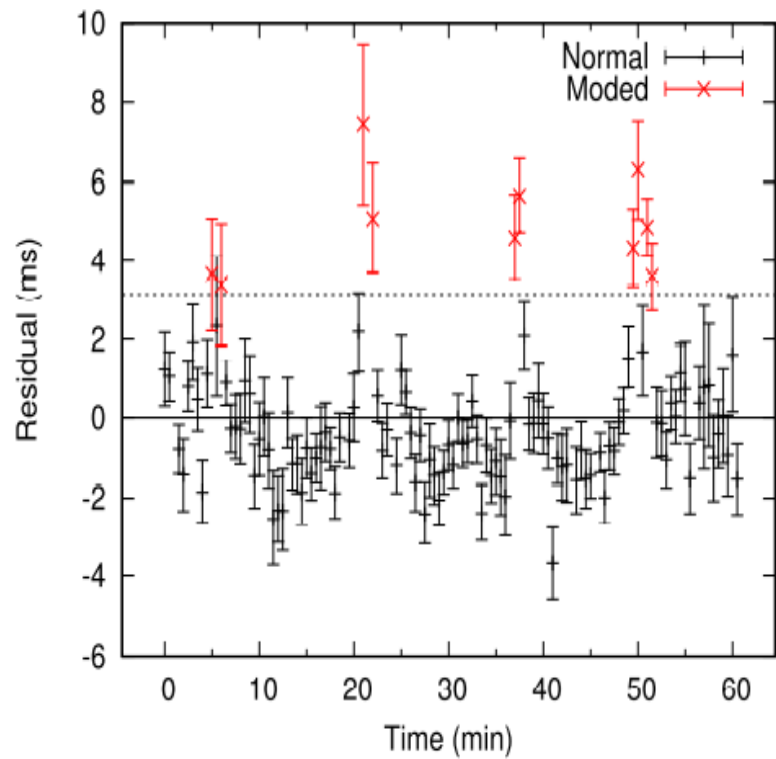
8/3/2022

# Outline

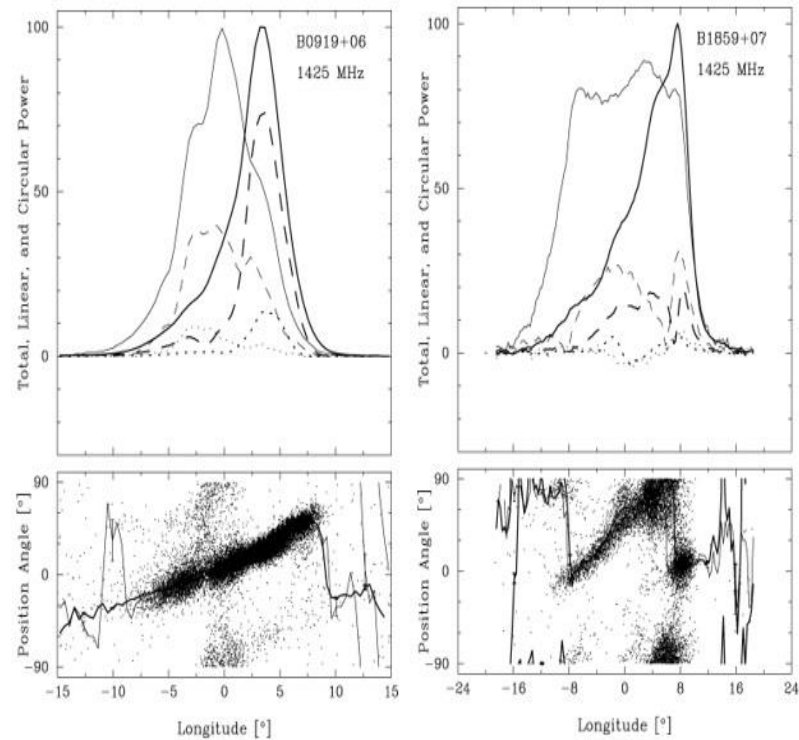
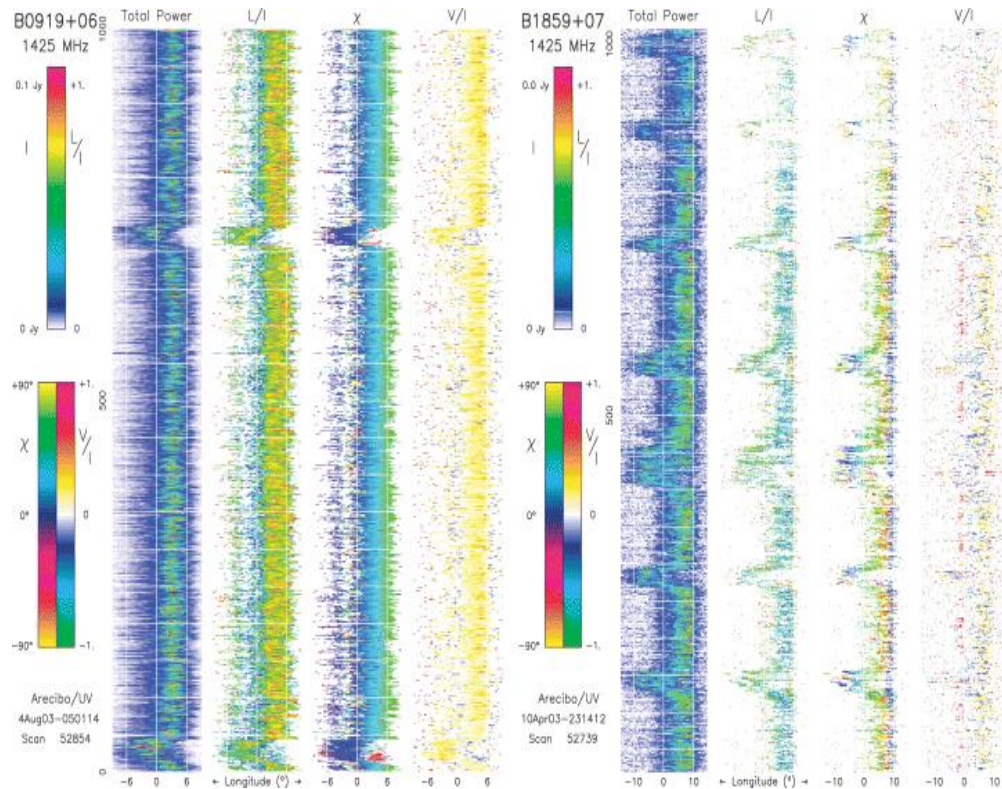
1. Introduction
2. Profile shifting
3. Subpulse drifting
4. Summary

# 1. Introduction

- PSR J0344-0901 was discovered during the pilot scans of the Commensal Radio Astronomy FAST Survey (CRAFTS; [Li et al. 2018](#)) with the UWB receiver in 2017,
- and confirmed by Parkes 64-m Radio Telescope in 2018 ([Cameron et al. 2020](#)).
- Right ascension ( $\alpha$ ): 03:44:37.471,
- Declination ( $\delta$ ): -09:01:02.66,
- Rotation period (P): 1.23 s,
- Period derivation ( $\dot{P}$ ):  $3.47 \times 10^{-15} \text{ s s}^{-1}$ ,
- Dispersion measure (DM):  $31 \text{ cm}^{-3} \text{ pc}$ ,
- Surface magnetic field ( $B_{\text{surf}}$ ):  $2.06 \times 10^{12} \text{ G}$ ,
- Characteristic age ( $\tau_c$ ): 5.58 Myr,
- Spin-down energy loss ( $\dot{E}$ ):  $7.44 \times 10^{31} \text{ erg s}^{-1}$  ([Cameron et al. 2020](#)).



Timing residuals (left-hand) and mode-changing behavior (right-hand) in PSR J0344–0901 (Cameron et al. 2020).

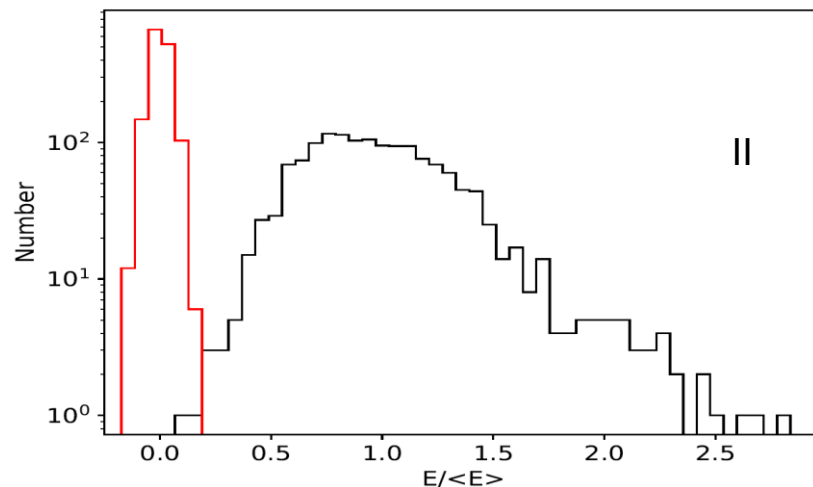
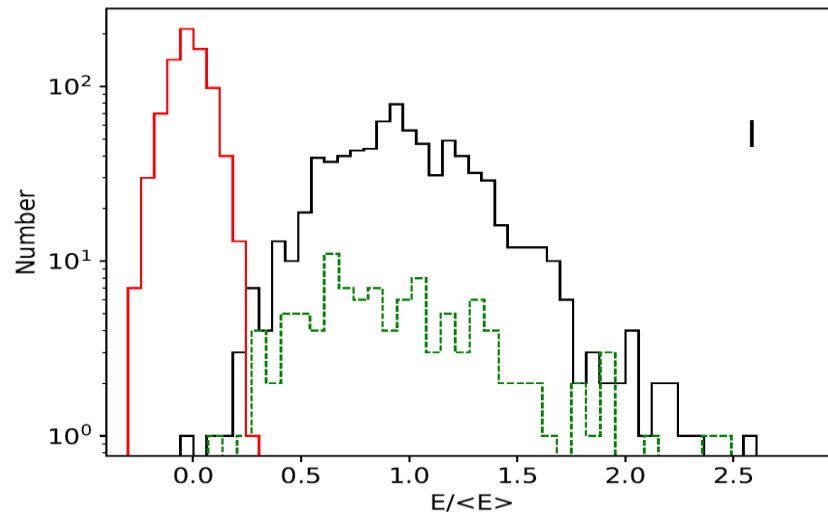


Emission shift effect in the PSR B0919+06 and B1859+07 at 1425 MHz (Rankin et al. 2006).

## 1.2 Observations and energy distribution

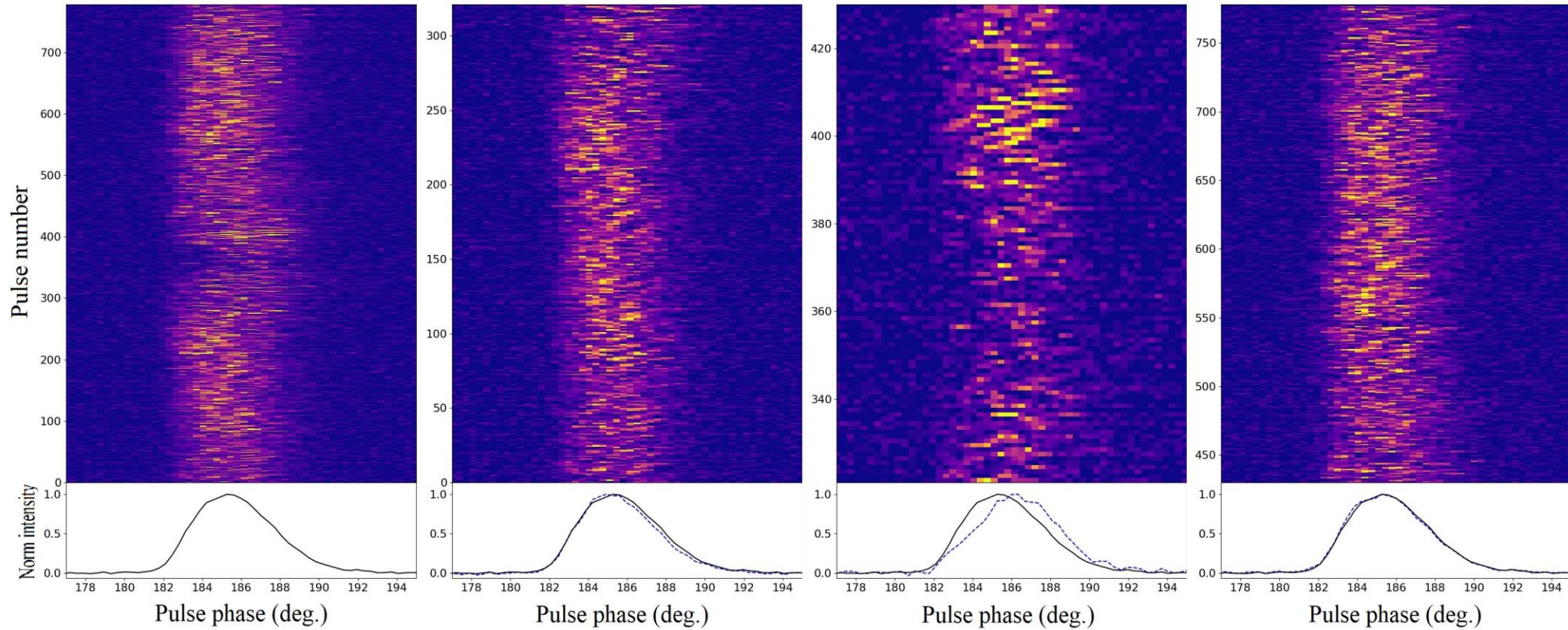
Observation	Date	MJD	Duration (s)	Pulses
I	2020-09-19	59111	900	778
II	2020-11-03	59156	1800	1469

Table 1. Telescope: **FAST**, frequency centered at 1.25 GHz, with a BW of 400 MHz, and the number of channels is 1024.



No nulling was found in this pulsar!

## 2. Profile shifting



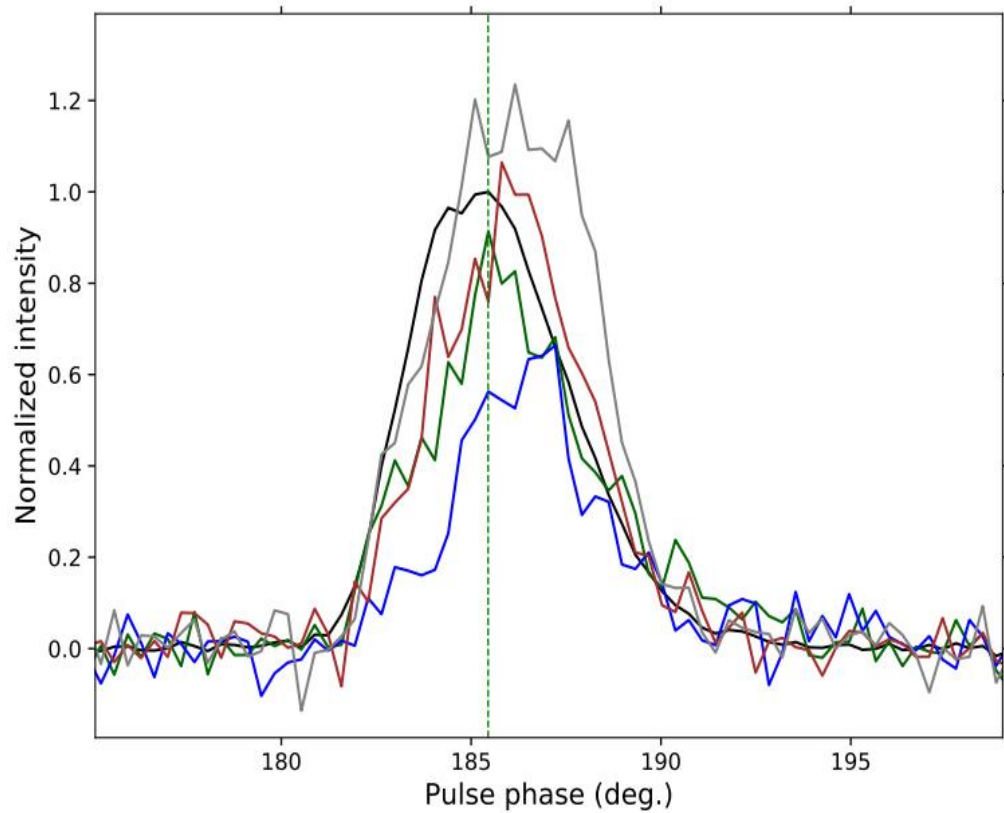
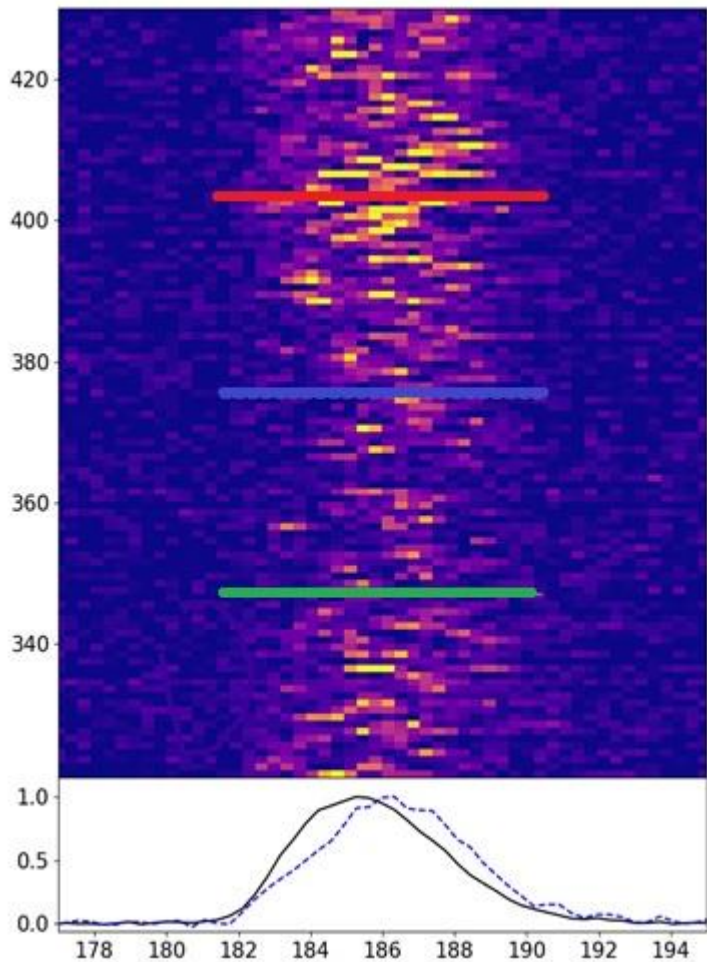
a) Overall observation

b) Before

c) During

d) After

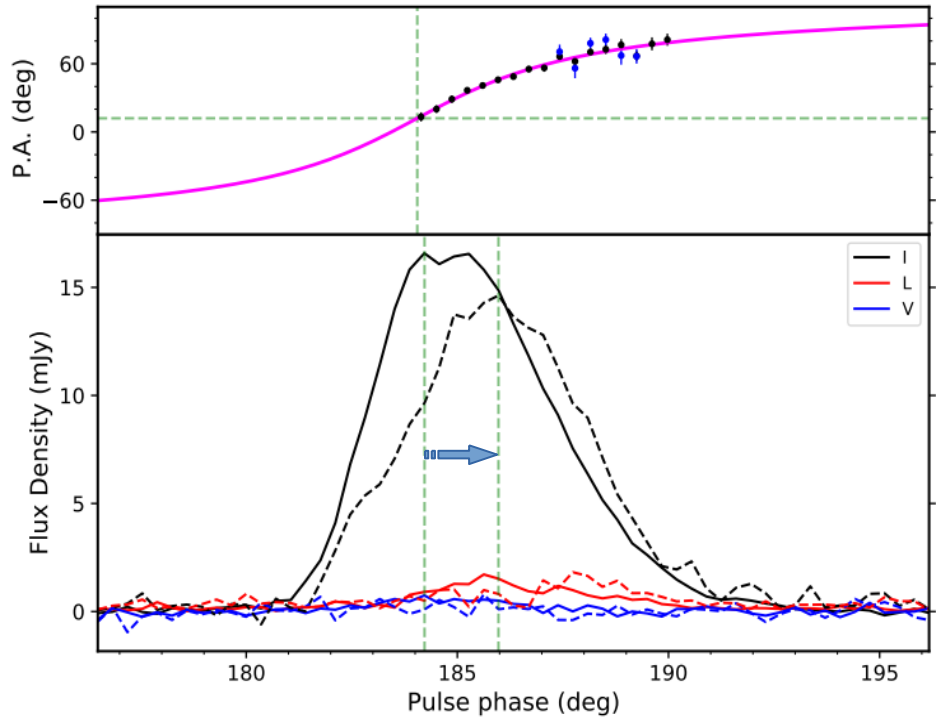
Different sequence of single pulses from observation I.



The emission evolution during the shifting event.



- The shifting between the non-shifted and shifted profile peaks to be  $\sim 2^\circ$ .
- The intensity is lower in the shifted profile by about 10%.
- The best PA fitting parameters:
  - $\alpha = 84.1^\circ$
  - $\zeta = 81.4^\circ$
  - $\psi_0 = 12.03^\circ$
  - $\phi_0 = 183.78^\circ$
- According to [Lyne and Manchester \(1988\)](#), this pulsar belongs to the “partial cone” pulsars.

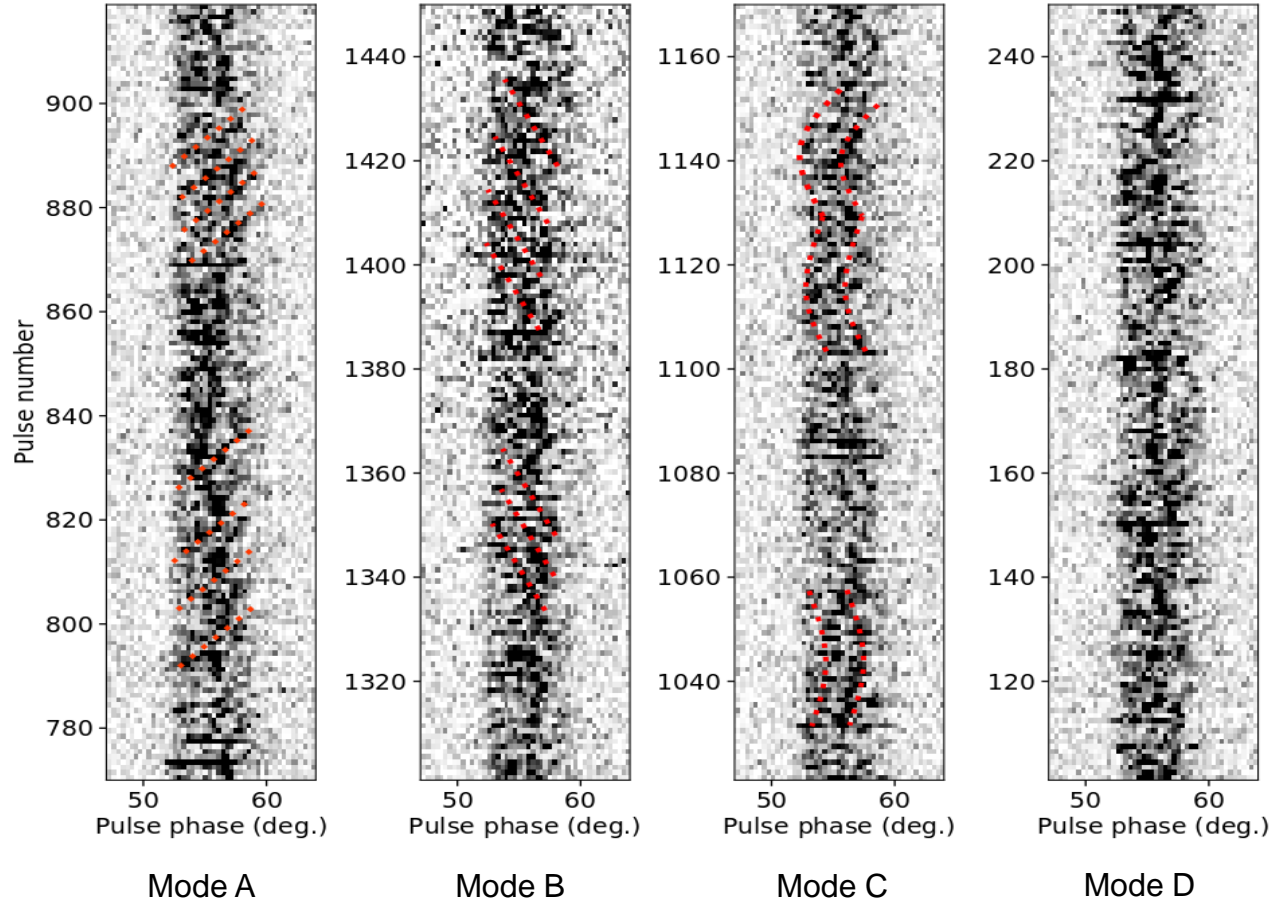


Variations in polarization across the non-shifting (solid) and shifted (dashed) profiles.

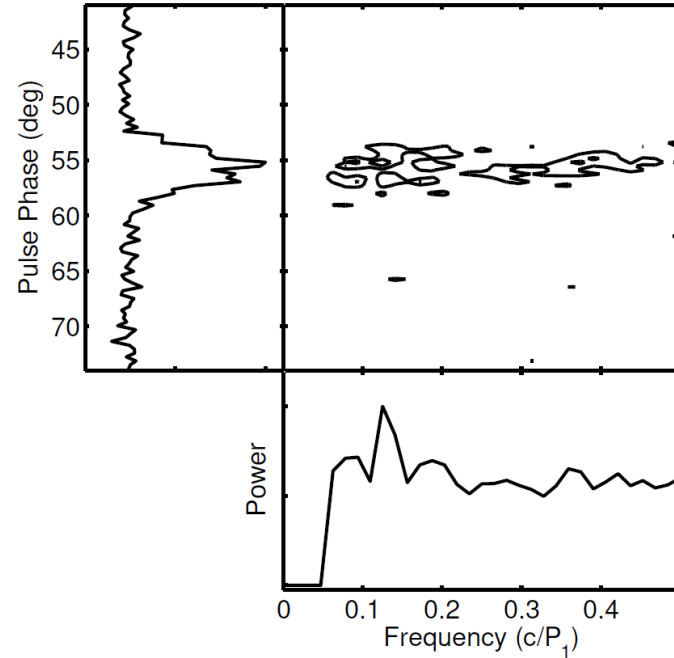
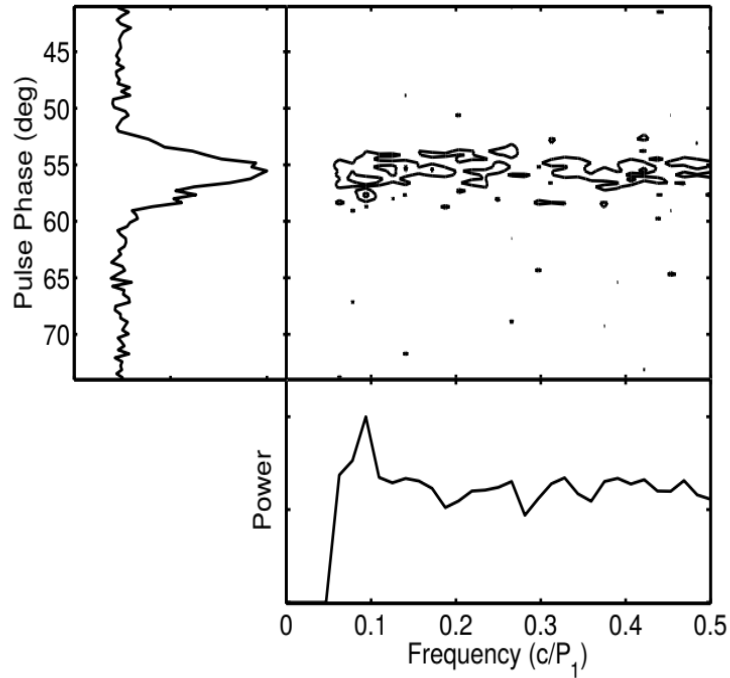
# What is the case for profile shifting in the pulsar?

- Rankin et al. (2006) argued that the events could be associated with the profile mode changing, which is due to relative aberration and retardation effects.
- Perera et al. (2015) showed that the spin-down rate of PSR B0919+06 varies quasi-periodically and can be correlated with the pulse-shape variations.
- Han et al. (2016) also observed PSR B0919+06 and they suggested that the emission events originate from gradual emission processing changes in the pulsar magnetosphere.
- Yuen & Melrose (2017) the profile shifting in PSR B0919+06 can be related to the magnetospheric state switching.
- In this work, nulling is not a case of profile shifting events, and it may be related to the systematic drifting subpulses in PSR J0344-0901.

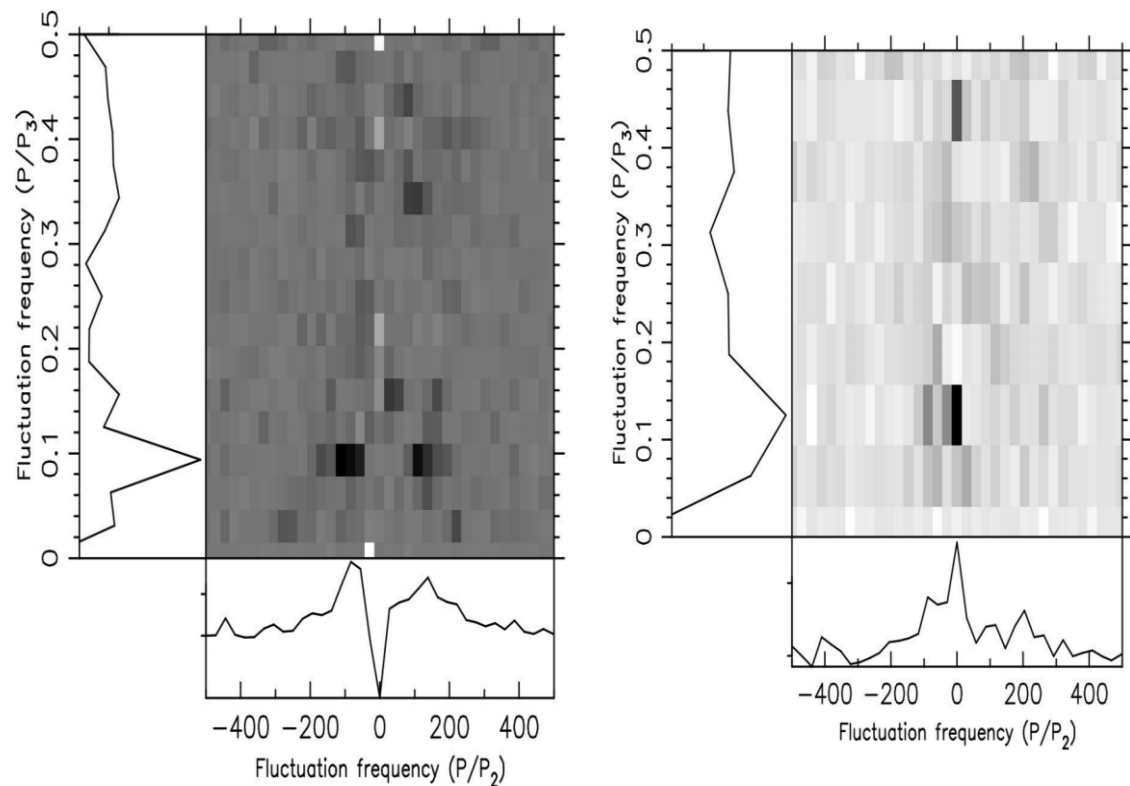
### 3. Subpulse drifting



The continuous single pulse sequence from observation II shows the subpulse drifting feature of PSR J034-0901.



The phase averaged power spectrum (PAPS) for a sequence of 50 pulses shows about 0.1  $c/P_1$  (left panel) in mode A, and for mode B, a sequence of 26 pulses shows about 0.12  $c/P_1$  (right panel).



Drift mode	No. of pulses	Occurrence (%)	$P_3$ ( $P_1$ )	$P_2$ ( $^\circ$ )
A	415	28	$10.5 \pm 0.2$	$3.3 \pm 0.1$
B	155	11	$8.3 \pm 0.4$	$-2.1 \pm 0.7$
C	90	6	$6.3 \pm 0.5$	$1.5 \pm 0.3$
D	806	55	-	-

The average Longitudinal Resolved Fluctuation spectra (LRFS) and the two-dimensional fluctuation spectrum (2DFS) for mode A (left,  $P_3 = 10.5 \pm 0.2 P_1$ ) and mode B (right,  $P_3 = 8.3 \pm 0.4 P_1$ ).

# 4. Summary

We report on two single-pulse events in PSR J0344-0901 observed at a frequency centered at 1.25 GHz using FAST.

- ✓ A rotation period of 1.23 s.
- ✓ No nulling was detected in this pulsar.
- ✓ The pulsar is estimated with an inclination angle of  $84.1^\circ$ , and an impact parameter of  $-2.7^\circ$ .
- ✓ The pulsar exhibits shifting in the profile of about  $2^\circ$  measured at the profile peak to later longitudinal phases relative to the original position.
- ✓ The event lasted for around 110 pulse periods or about 135 seconds.
- ✓ Noticeable changes in the polarization position angle have been detected during the event.
- ✓ The event is non-periodic, and it is not a frequent event in this pulsar.
- ✓ We identify four different subpulse drift modes each with unique drift features.
- ✓ Modes A and B exhibit positive and negative drifting and mode C exhibit curved drift bands, and mode D contains irregular drifting subpulses.
- ✓ The abundances are 28% for mode A, 11% for mode B, 6% for mode C, and 55% for mode D.

# Reference

1. Cameron, A. D., Li, D., Hobbs, G., et al. 2020, Monthly Notices of the Royal Astronomical Society, 495, 3515.
2. Han, J., Han, J. L., Peng, L.-X., et al. 2016, MNRAS, 456, 3413.
3. Li, D., Wang, P., Qian, L., et al. 2018, IEEE Microwave Magazine, 19, 112.
4. Lu, J. G., Peng, B., Xu, R. X., Yu, M., Dai, S., Zhu, W. W., Yu, Y.-Z., Jiang, P., Yue, Y. L., & Wang, L. 2019, Science China Physics, Mechanics & Astronomy, 62(5).
5. Lyne, A. G., & Manchester, R. N. 1988, MNRAS, 234, 477.
6. Perera, B. B. P., Stappers, B. W., Weltevrede, P., Lyne, A. G., & Bassa, C. G. 2015, MNRAS, 446, 1380.
7. Rankin, J. M., Rodriguez, C., & Wright, G. A. E. 2006, MNRAS, 370, 673.
8. Smits, J. M., Mitra, D., & Kuijpers, J. 2005, A&A, 440, 683
9. Yuen, R., & Melrose, D. B. 2017, in Journal of Physics Conference Series, Vol. 932, Journal of Physics Conference Series, 012014.
10. Wen, Z. G., Wang, N., Yuan, J. P., et al. 2016, A&A, 592, A127.

I'm looking for a Postdoc position

- Pulsar searching
- Pulsar timing

Email: [habta125@xao.ac.cn](mailto:habta125@xao.ac.cn)

**Thank You!**