

# Single pulse study of a millisecond pulsar PSR J0621+1002 using FAST

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# PSR J0621+1002

- A 28.9 ms MSP which is monitored in the European Pulsar Timing Array program for the gravitational wave detection.
- In a binary with an 8.3 days orbit period and a  $0.41M_{\odot}$  CO white dwarf companion.

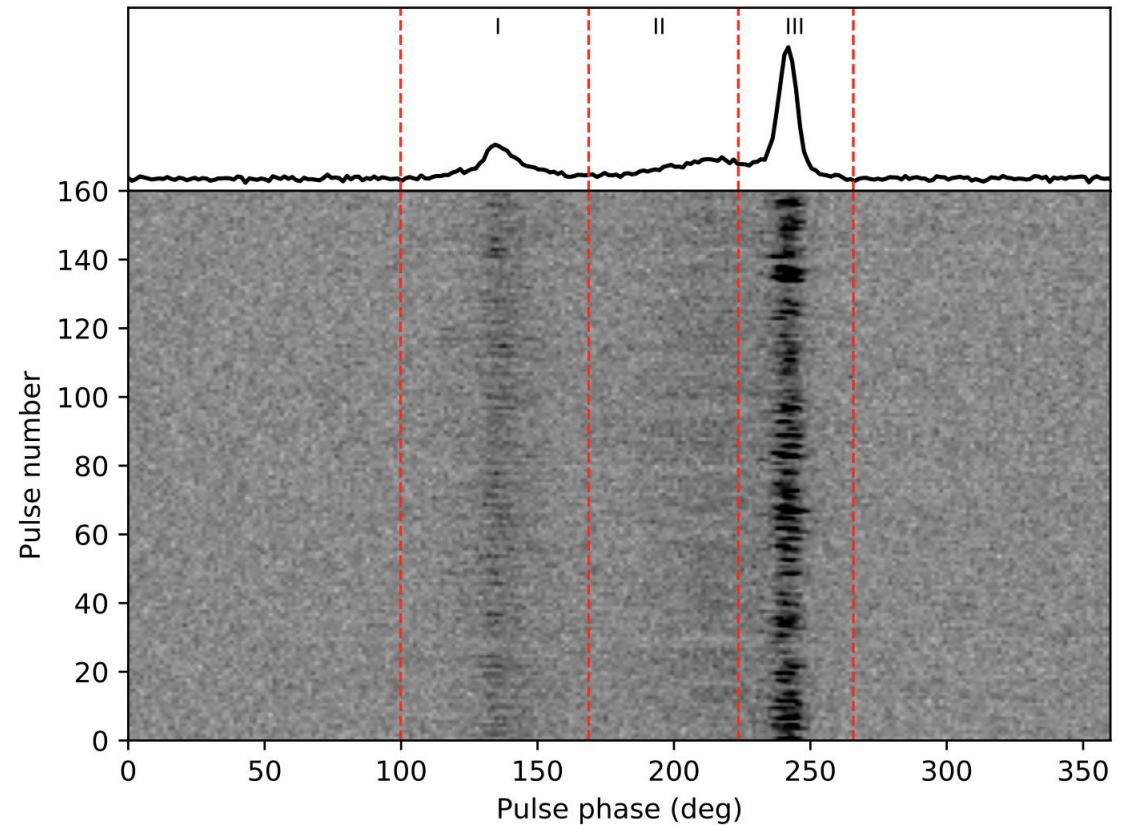
# FAST observation

- We use the central beam of the 19-beam receiver with the bandwidth 1.05–1.45 GHz to observe PSR J0621+1002 on January 14, 2020, and the data is search mode PSRFITS format.
- The number of the frequency channels is 4096 with the channel band-width 0.122 MHz and the sampling time is 49.152 $\mu$ s. The observation lasts for 27 minutes and 56768 single pulses are obtained.



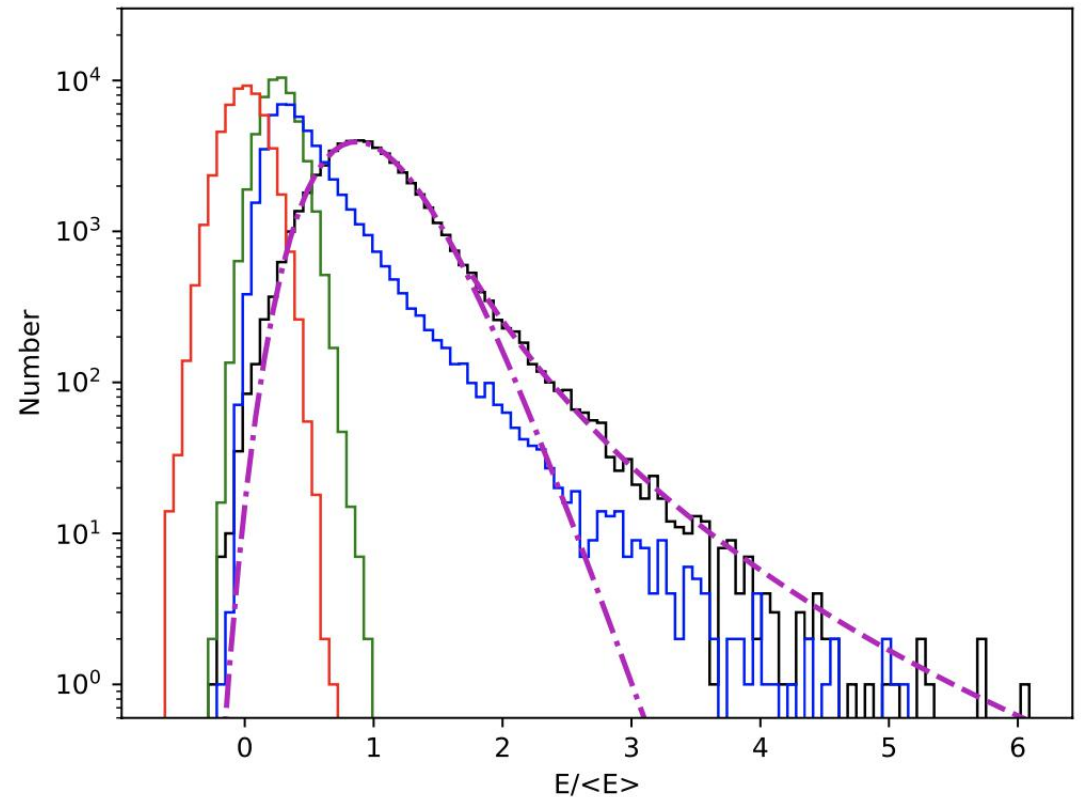
# Single pulse stack

- The average pulse profile is shown in upper panel and the pulse profile is divided into three components (labeled as I, II and III) by the four vertical red lines.
- This pulsar shows a pulse intensity modulation in both the first and the third pulse components.

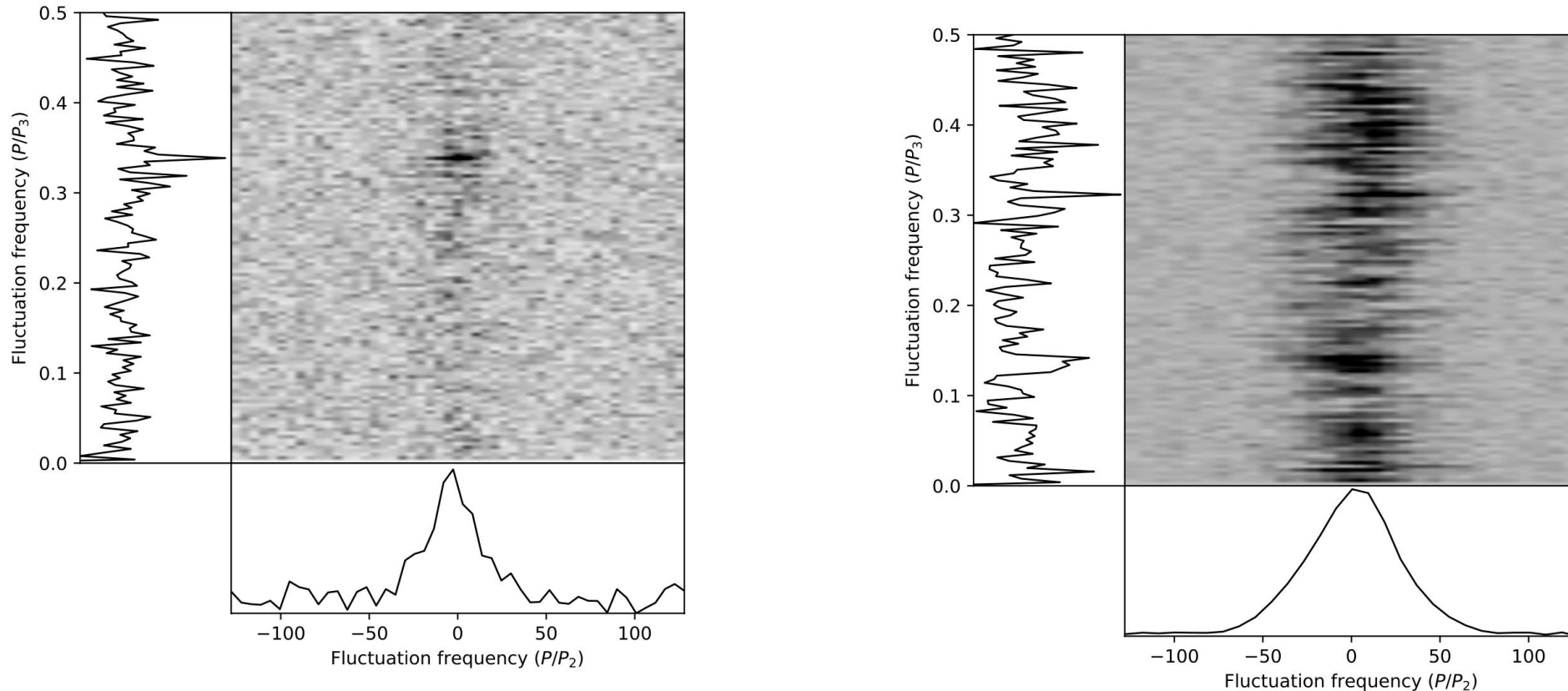


# Energy distribution

- The red, black, green and blue lines are for the energies of off-pulse window, on-pulse window, the first and the third pulse components, respectively. The energies are normalised by the mean on-pulse energy.
- The energy of the on-pulse is a log-normal distribution with a high-energy power-law tail (the magenta dashed and dash-dotted lines).

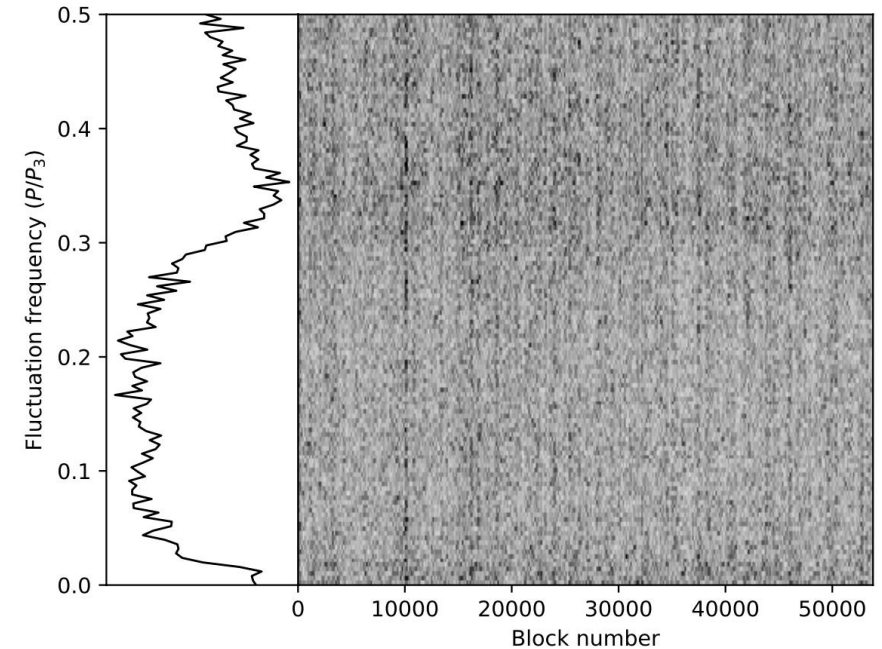
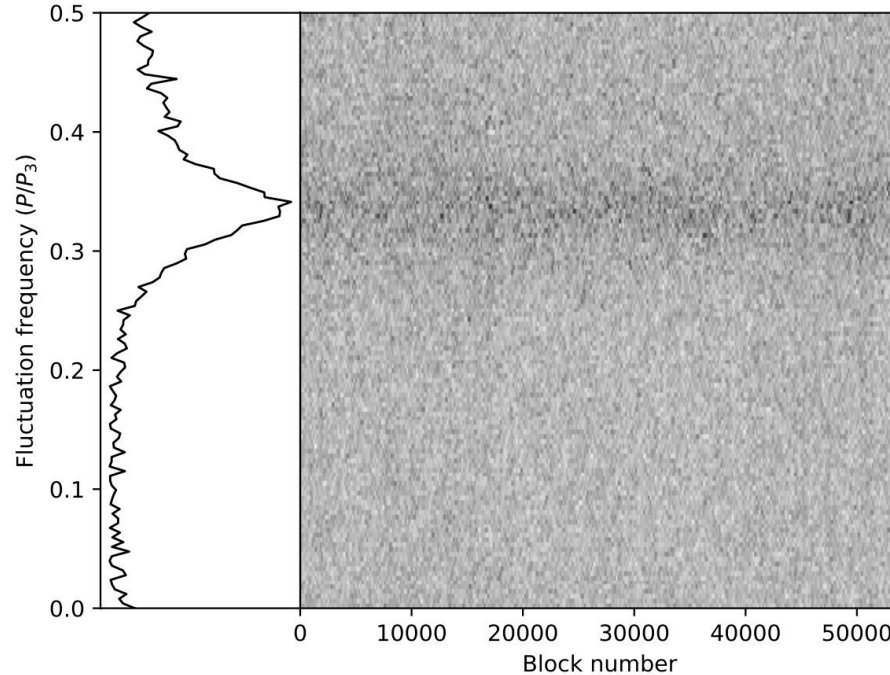


# The two-dimensional fluctuation spectrum (2DFS)



The 2DFS analysis of 256 single pulses for the first (upper left) and third (upper right) pulse components of PSR J0621+1002 with side panels showing horizontally (left) and vertically (bottom) integrated power.

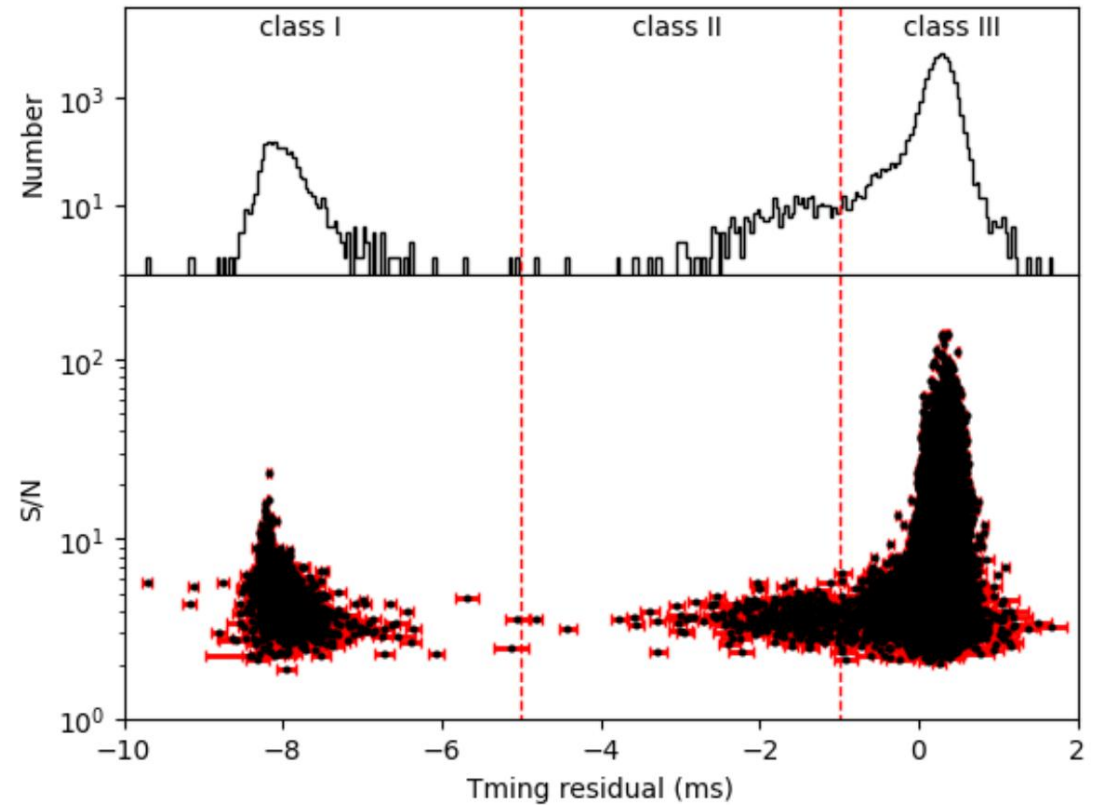
# Sliding two-dimensional fluctuation spectrum (S2DFS)



Using the S2DFS in which a 256 pulse block is selected which slides by a pulse to produce the collapsed fluctuation spectrum map, the statistics results of P3 are obtained (the left panels). The P3 of the first pulse component is centered at  $2.9 P$ , while that of the third pulse component is a bimodal distribution which is centered at  $64.0 P$  and  $2.8 P$ , respectively.

# Single pulse timing

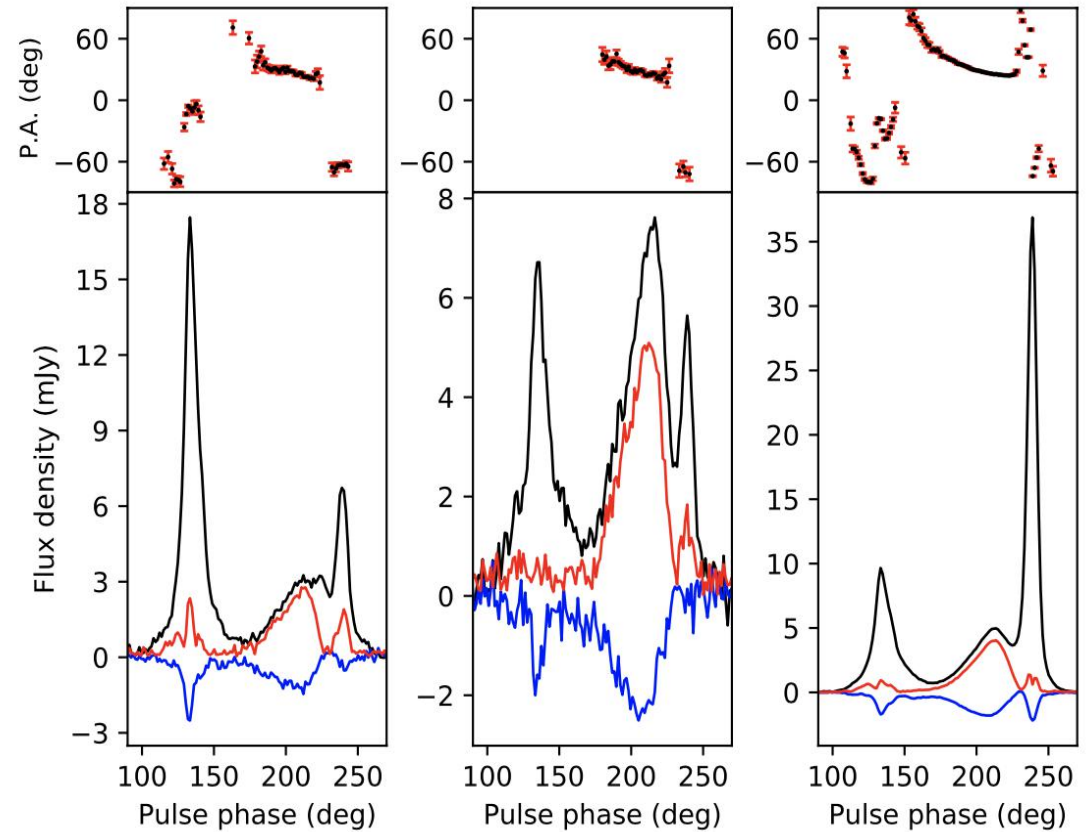
- The post-fit residuals are divided into three classes (labeled as class I, class II and class III), which suggests that the pulse jitter of this pulsar has three different modes.





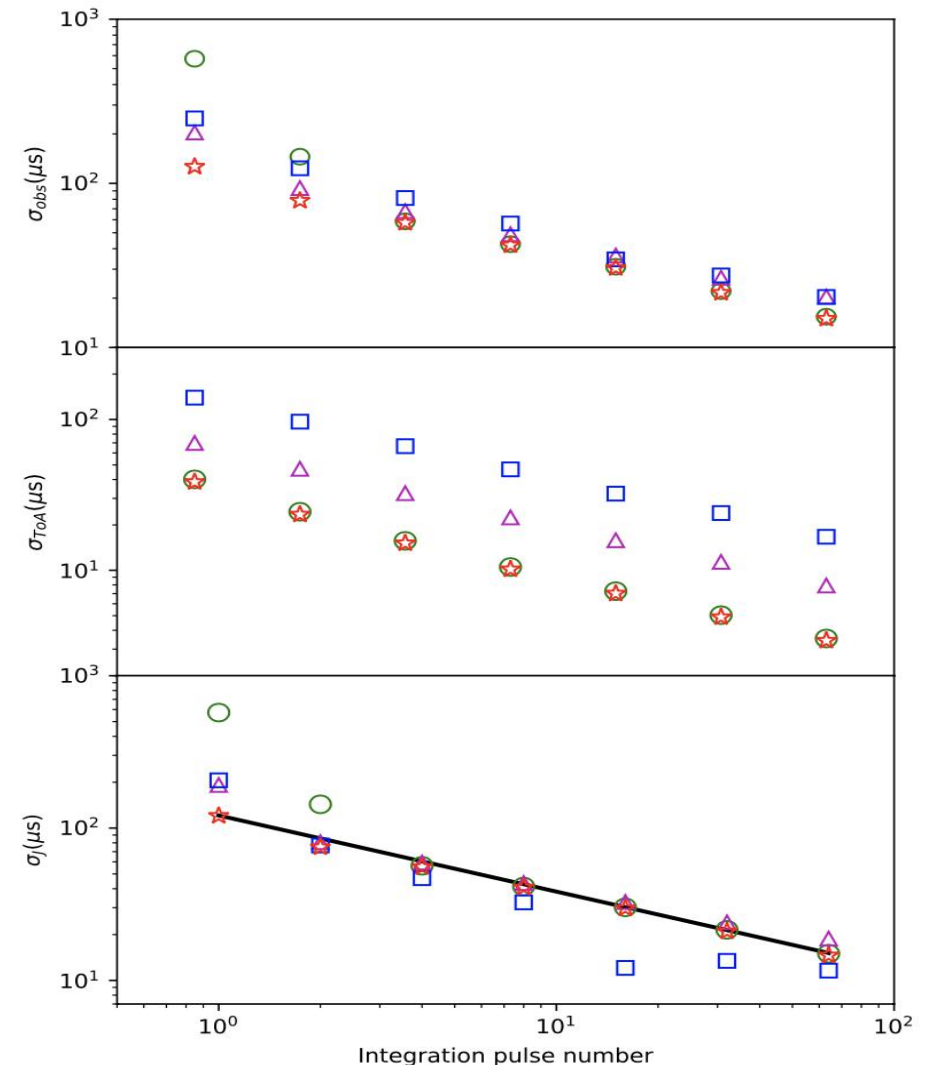
# Average profiles

- The average pulse profiles for classes I (left panel), II (middle panel) and III (right panel). The black, red and blue lines are for the total intensity, linearly polarised intensity and circularly polarised intensities, respectively. The position angles (black dots) with the error bars (red bars) of the linearly polarised emission are shown in the upper sub-panels.



# Pulse jitter

- Upper panel: the variations of residuals versus the number of pulses averaged. The circles, triangles, squares and stars are for all the single pulses, the single pulses in the class I, class II and class III, respectively.
- Middle panel: the variations of ToA uncertainty versus  $N_p$  for these four classes.
- Bottom panel: the quadrature difference ( $\sigma_J(N_p)$ ) between the observed data and ToA uncertainty for these four classes. The black line is the best fitting model for the jitter noise with the index of  $-0.50 \pm 0.01$ .



**Thanks**