XMM-Newton Timing Monitoring

Antonio Martin Carrillo

Tutor: Marcus Kirsch

July 24, 2006

Overview

- XMM-Newton
- Pulsars
- Crab pulsar
- Relative time accuracy
  - χ^2 epoch folding
- Conclusions
- Next steps

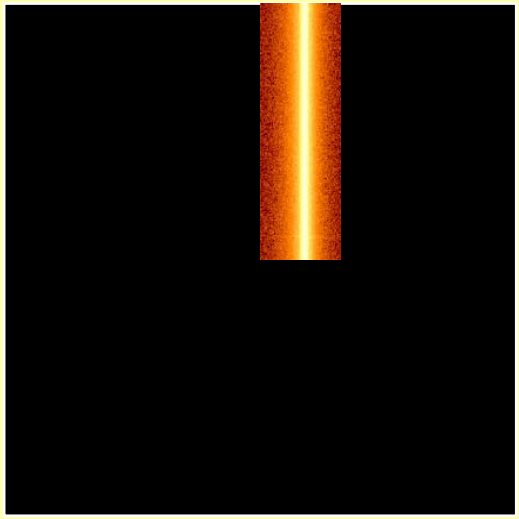
XMM-Newton

- Launched in December 1999
- 3 independent CCD cameras called EPIC (European Photon Imaging Camera)
- 2MOS and 1PN
- Several observing modes with different time resolution

XMM-Newton

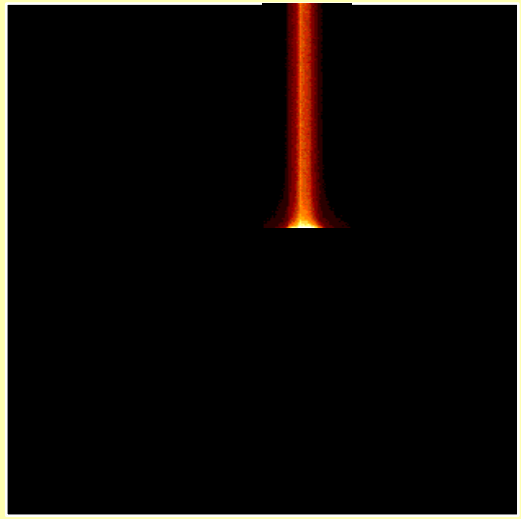
- We want to study objects with high spining velocities
- We need a camera with a really good time resolution ⟶ **EPIC PN**

Timing mode



Time Res: 0.03 ms

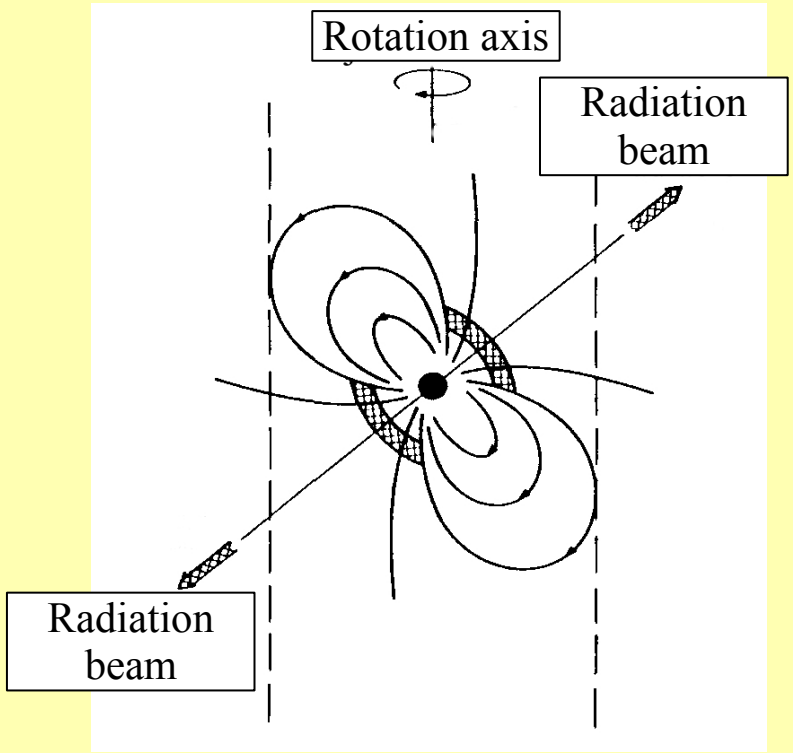
Burst mode



Time Res: 7 μs

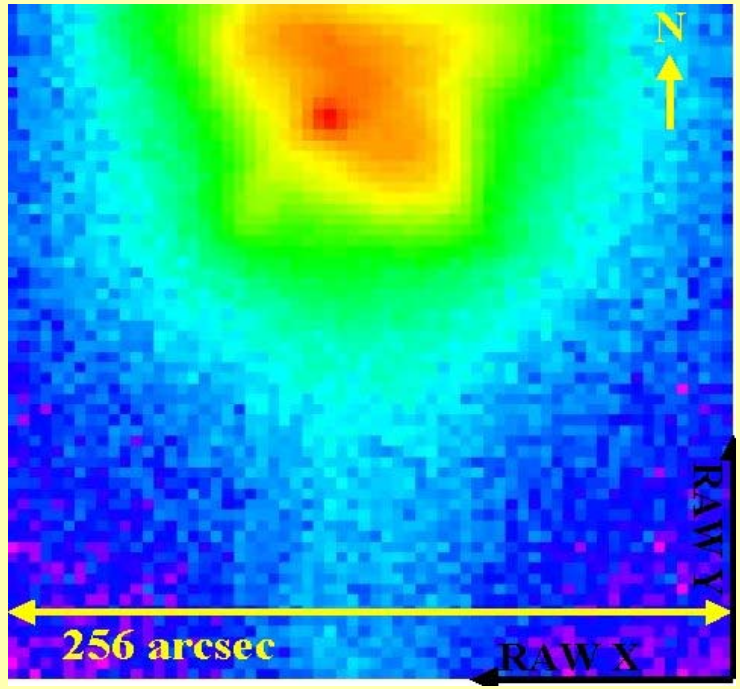
Pulsars

- Neutron stars with high spining velocities and strong magnetic fields
- Radius ~ 10 km
- Density ~ $4x10^{14}$ gcm^{-3}
- Temperature ~ 10^{10} K
- Magnetic field ~ 10^{9-12} G



Crab pulsar

- Discovered at 1968 in radio
- The most studied pulsar in every wavelength
- Very bright source with a stable pulse
- Distance: 2200 pc
- Period of 33 ms
- Two observations per year with XMM-Newton: spring and autumn



Relative time accuracy

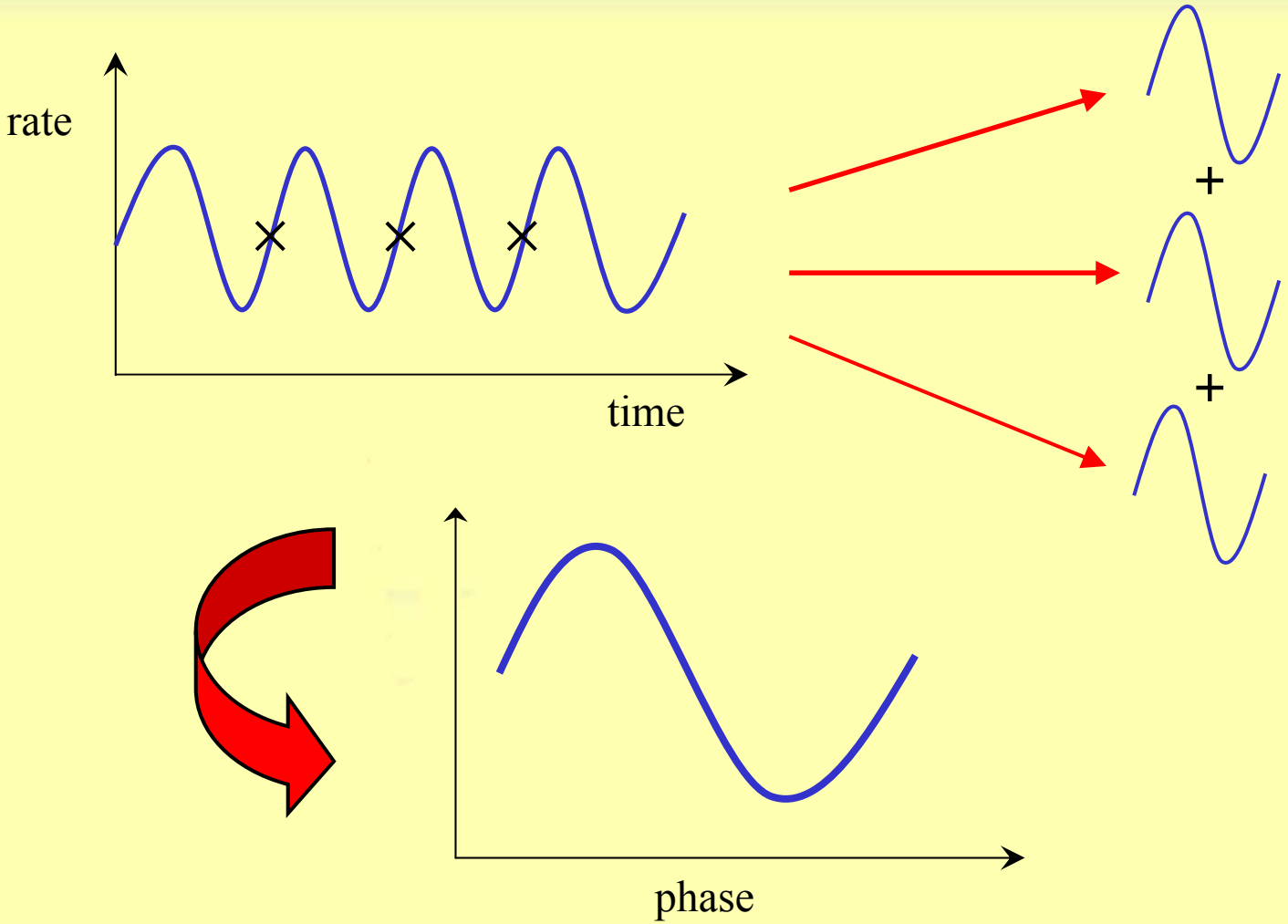
- Procedure to obtain the relative time accuracy

1. Choose the correct EPIC PN mode
2. Produce the event file
3. Do the barycentric correction
4. Extrapolate the radio data observation
5. Epoch folding to one phase
6. Search for the period in X-ray using χ^2 test
7. Obtain the χ^2 plot, the X-ray period and the $\Delta P/P$

$$\frac{\Delta P}{P} = \frac{P_R - P_X}{P_R}$$

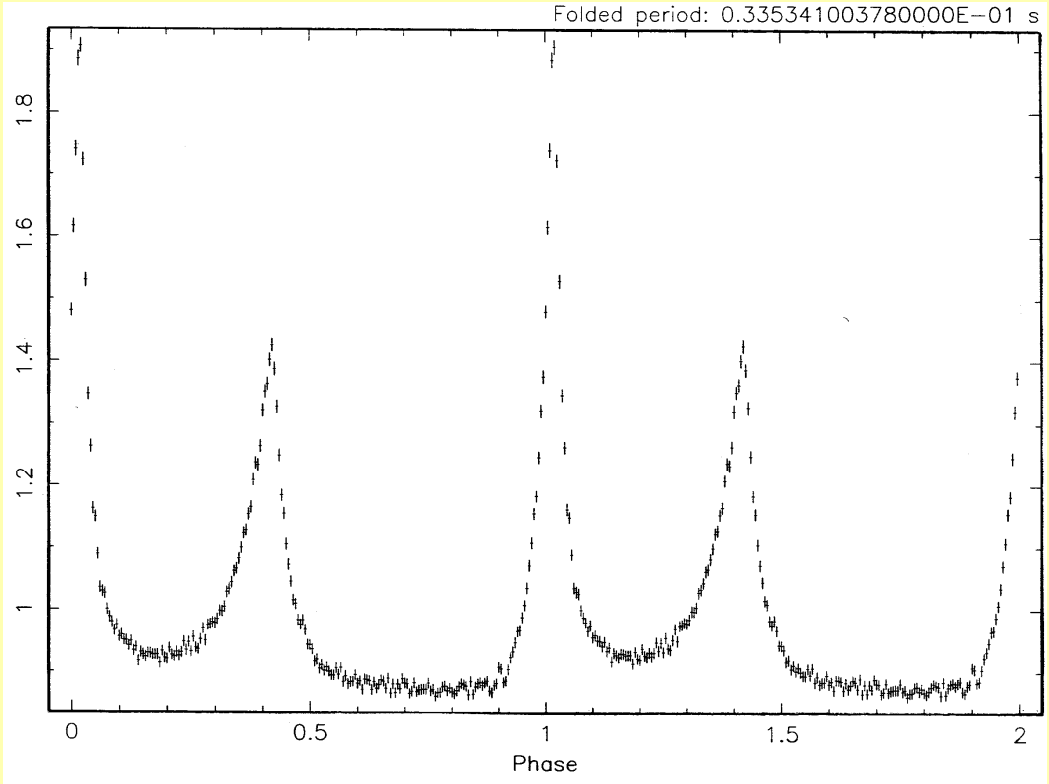
Relative error

Epoch folding



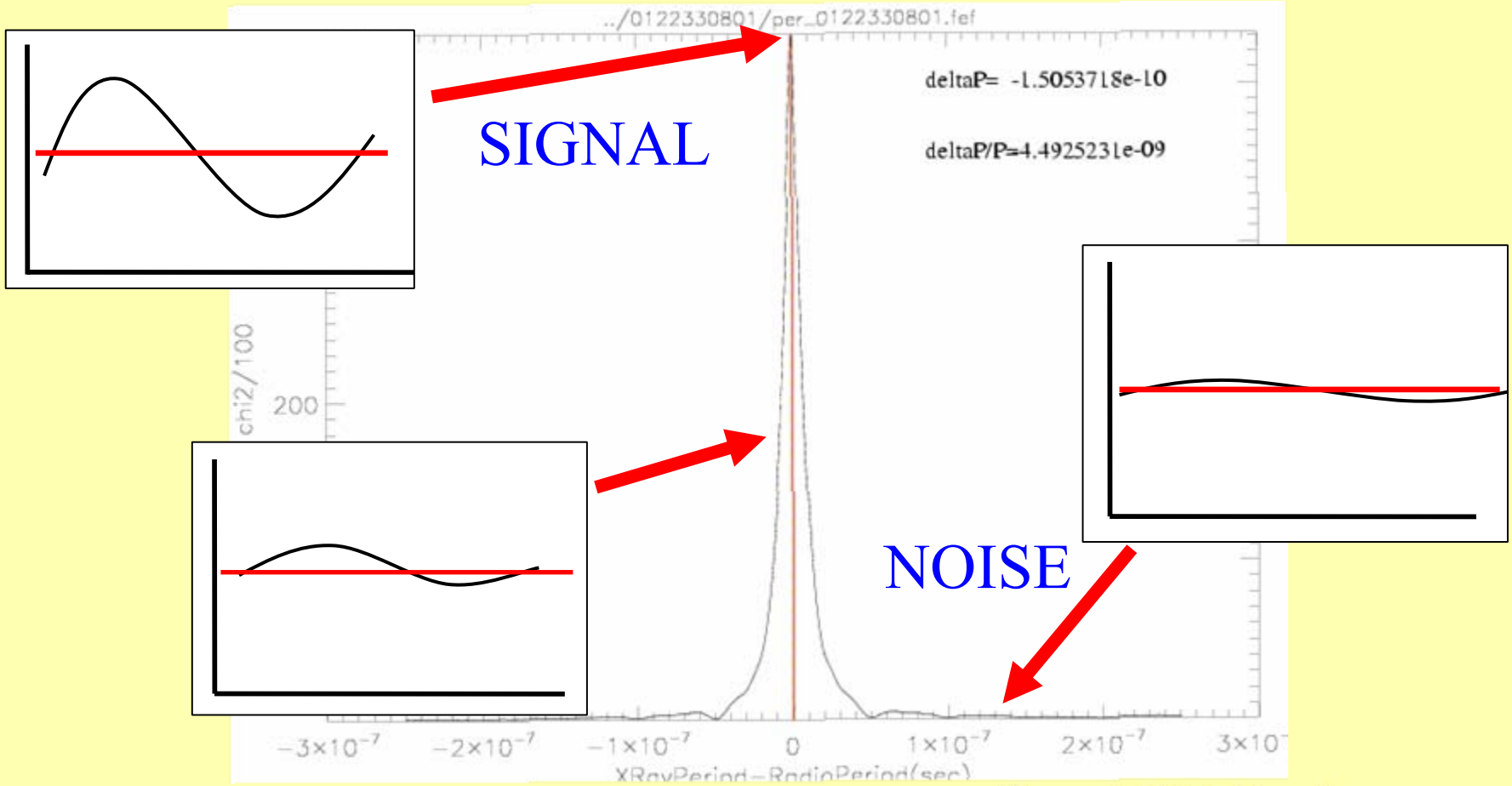
Epoch folding

- Lightcurve of the Crab
- Range between 0.5-10 keV
- Pulse profile presents two maximums



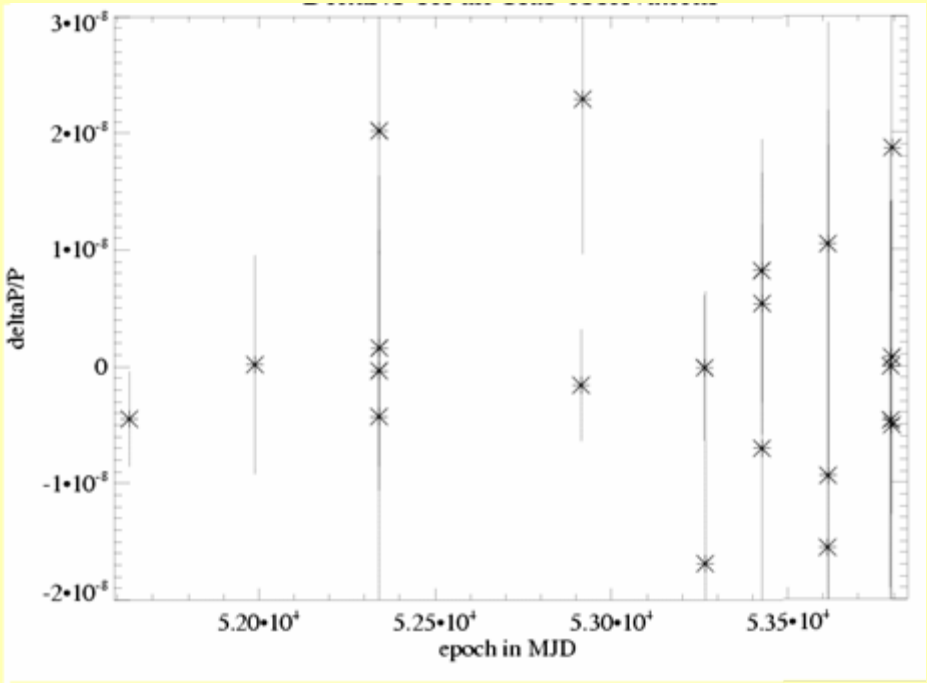
χ^2 epoch folding

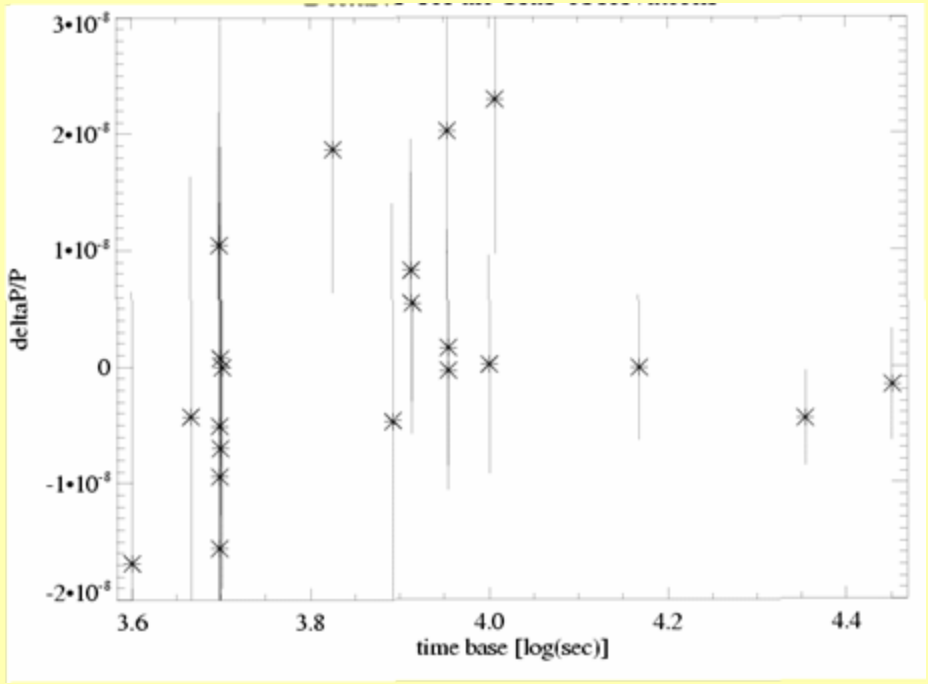
- Typical result of a χ^2 test for one observation of the Crab pulsar



Relative time accuracy using Crab

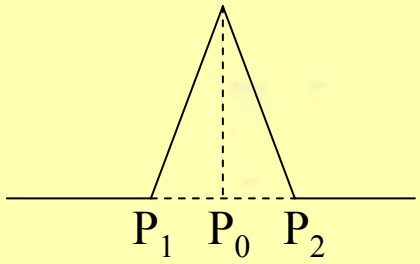
- Representation of the relative error vs epoch (left) and observational time (right)





Error approximation

- $\Delta P = P_R - P_X \rightarrow$ error of our observation
- Consider that the radio period has no error
- The ΔP comes from the error of the X-ray period
- χ^2 distribution can be approximated by a triangle



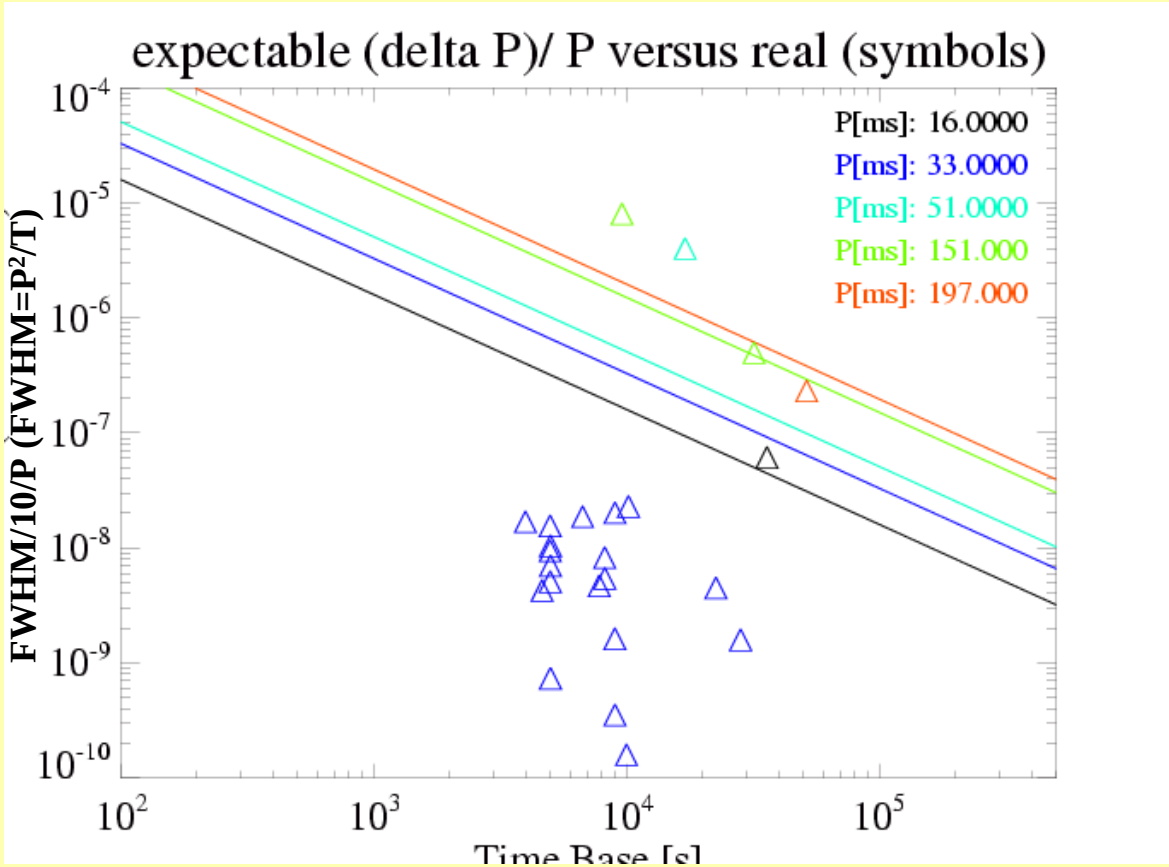
$$\left.\begin{aligned} P_1 &= \frac{TOB}{NPER+1} \\ P_2 &= \frac{TOB}{NPER-1} \end{aligned}\right\} \text{ where } NPER = \frac{TOB}{P}$$

$$FWHM \approx \frac{P_2 - P_1}{2} \Rightarrow \boxed{FWHM \approx \frac{P^2}{TOB}}$$

- Approximation: $\Delta P = \frac{FWHM}{10?}$
- Compare the real and approximated errors of the periods

Preliminary results

- Comparison of expectable relative error and real values for different pulsars



Conclusions

- The relative time accuracy for the Crab with the new observations analysed is:

$$\frac{\Delta P}{P} < 3 \times 10^{-8}$$

- As shown in the previous plots, we can say that the relative error does not depends on the Earth's orbital phase.

Next steps

- Monte Carlo simulation to produce the errors of the periods
- Calibration of the factor for the expectable errors of the periods
- Further analysis of other pulsars