XMM-EPIC TIMING MONITORING AT ESAC

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ABSTRACT

The EPIC-pn camera on board XMM-Newton provides a very high time resolution. In its Timing mode, EPIC-pn reaches a time resolution of 0.03 ms and 7 μs in the Burst mode. In order to monitor the relative timing accuracy, XMM-Newton performs two observations a year of the Crab pulsar. An automatic tool has been created to check the timing accuracy of EPIC-pn. It calculates the period of the Crab pulsar in the X-ray regime and compares it with the period obtained from radio data. Observations of pulsars PSRB0540-69, PSRB1509-58 and PSRB1055-52 have also been used in this analysis. We present first results of the timing accuracy from this analysis covering the whole XMM-Newton mission time till revolution 1000.

Key words: XMM-Newton; EPIC-pn; calibration; timing.

1. INTRODUCTION

The EPIC instruments on board XMM-Newton were succesfully launched on 1999 December 10. EPIC provides spatially resolved spectroscopy over a field of view of 30' with moderate energy resolution. The EPIC-pn camera is equipped with a p-n-junction CCD that has been specially developed for XMM-Newton. EPIC-pn can be operated in different readout modes, four imaging modes and two fast readout modes (Timing and Burst modes). We concentrate here on the timing capabilities of the EPIC-pn camera. For a detailed description of EPIC-pn see Kirsch et al. 2001, Kuster et al. 2001, Ehle et al. 2005.

2. TIMING MONITORING

The relative timing accuracy is monitored by calculating the X-ray period P_X of a pulsar and comparing it with the period P_R obtained at radio frequencies. The relative error gives the timing accuracy (Eq.1)

$$\frac{\Delta P}{P} = \frac{P_R - P_X}{P_R} \qquad (1)$$

XMM-Newton performs one observation of the Crab in autumn and one in spring, at different position angles, in order to monitor the timing accuracy. The relative timing accuracy has also been checked with XMM-Newton observations of pulsars PSRB0540-69, PSRB1509-58 and PSRB1055-52.

3. OBSERVATIONS AND PROCESSING OF DATA

This analysis was performed using Crab observations made in revolutions 0056, 0411, 0698 and 0700 in Timing mode, and 0411, 0234, 0874 and 0955 in Burst mode. PSRB0540-69 was observed in revolution 0085 (Timing mode), PSRB1509-58 in revolution 0137 (Timing mode) and PSRB1055-52 in revolution 0187 (Timing mode). Data was analysed using the SAS version 6.5.0. A barycentric correction of photon arrival times was performed using the SAS task *barycen*.

4. PERIOD DETERMINATION

4.1. Radio period of pulsars

Radio data for the Crab pulsar was obtained from the Jodrell Bank Observatory (University of Manchester) where one observation of the Crab is performed every month (Lyne et al. 2001). For the other pulsars data was obtained from the Princeton pulsar database (Taylor et al. 1993). The radio period for the epoch of the X-ray observation is obtained by a linear interpolation in the case of the Crab pulsar, and by extrapolating the data for the other pulsars using $\dot{P}$ and $\ddot{P}$.

4.2. X-ray period of pulsars

The X-ray period is obtained by folding the light curve of the pulsar over a range of test periods, using as a first trial the radio period. For each observation a χ^2 maximization test is performed. Fig. 1 shows the resulting χ^2 distributions for the four pulsars. The FWHM of these

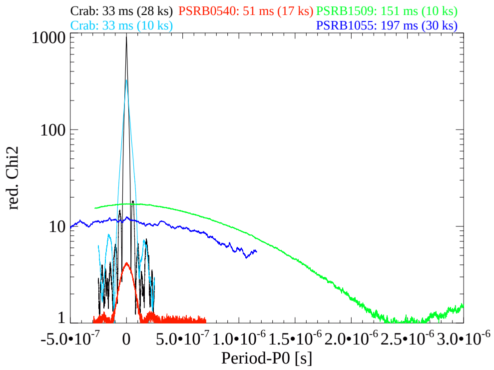

Figure 1. Different χ^2 distributions for the different pulsars used

χ^2 distributions, approximating it by an isosceles triangle, is $FWHM \simeq \frac{P^2}{T}$, where P is the period and T the time span. We calculated the FWHM for all four pulsars and compared them with the expected values, and those values agree.

5. RESULTS

The relative timing accuracy obtained for the Crab is $\frac{\Delta P}{P} < 3x10^{-8}$. This can be seen in Fig. 2. In order to improve statistics and to create additional data points, we merged all obervations from revolutions $0411, 0700$ and 0955 and analysed those as separate data files. Table 1

Table 1. Relative timing accuracy obtained for all pulsars

	$\frac{\Delta P}{P}$
Crab (all obs.)	$<3x10^{-8}$
PSRB0540-69	$-4.0x10^{-6}$
PSRB1055-52	$2.3x10^{-7}$
PSRB1509-58	$-1.4x10^{-5}$

and Fig. 3 show the relative timing accuracy obtained for all four pulsars.

The relative timing accuracy obtained for pulsars PSRB0540-69 and PSRB1509-58 is worse than expected.

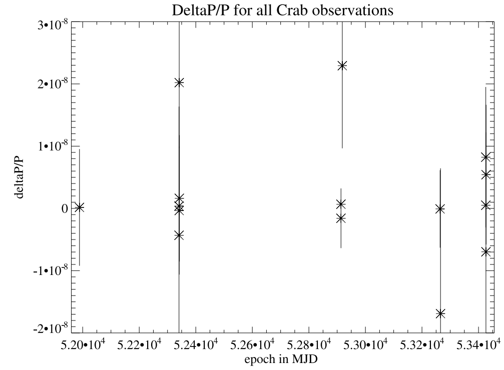

Figure 2. $\frac{\Delta P}{P}$ vs. epoch for all Crab observations. Allows to check the relative timing accuracy along the mission

Future observations of those pulsars are planned, in parallel with RXTE and radio observations, in order to verify the relative timing accuracy.

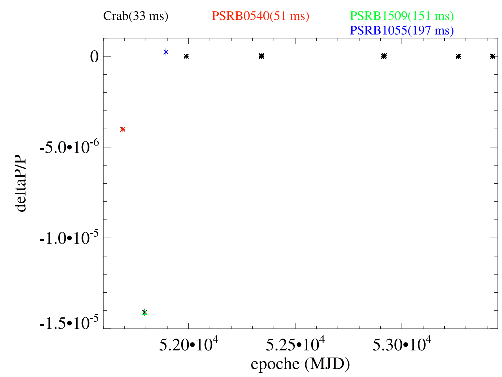

Figure 3. $\frac{\Delta P}{P}$ vs. epoch for all four pulsars

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