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PULSAR STUDIES WITH GRO-COMPTEL

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Summary. Pulsar measurements performed by the experiment COMPTEL, aboard the Compton Gamma Ray Observatory, are described. The main results refer to the Crab and Vela pulsars whose pulse shape characteristics are given in some detail and light curves are compared with those above 50 MeV, as observed by the COS-B satellite. No other gamma-ray pulsars have been detected to date by COMPTEL, the upper limit on the pulsed signal from Geminga being compatible with indications by other experiments.

1. The Crab pulsar.

The Crab pulsar has been observed by COMPTEL 4 times during 1991, for a total of 46 days, at different viewing angles with respect to the experiment pointing axis. Details of observations #0 ("validation period", April 28th - May 7th 1991), #1.0 (May 16th - 30th 1991) and #2.1 (June 8th - 13th 1991) are given in Bennett et al. (1992); a further observation (#15), not included in the above mentioned paper, started Nov. 29th and ended Dec. 11th 1991. We present in this paper the results of the analysis of the data of the 4 observations of 1991 using an improved selection of the detected gamma-ray events.

The Crab ephemeris, derived from contemporaneous radio observations of pulsars (Lyne et al., 1992; Arzoumanian et al., 1992), planned well before the GRO launch (Buccheri et al., 1987), have been used to fold the selected photon arrival times, after their transformation to the Solar System Barycenter. Fig. 1 shows the obtained light curves in the energy range from 1 to 10 MeV (where the signal-to-noise is optimal) for each of the 4 observations mentioned above.

A statistical analysis to detect variability of the shape of the pulsed signal has been performed. Using an a priori definition of the "pulsed" duty cycle (20 out of the 33 histogram bins), the "pulsed" and the "unpulsed" fraction of the detected photons were independently normalized for each pair of observations and a statistical comparison was performed by using a 20-dof χ^2 over the "pulsed" phase interval. As a result of the analysis, no statistically significant differences between the four observations have been found, in spite of their different visual appearance, due to the large combined uncertainty in the difference between corresponding bins of different phase histograms.

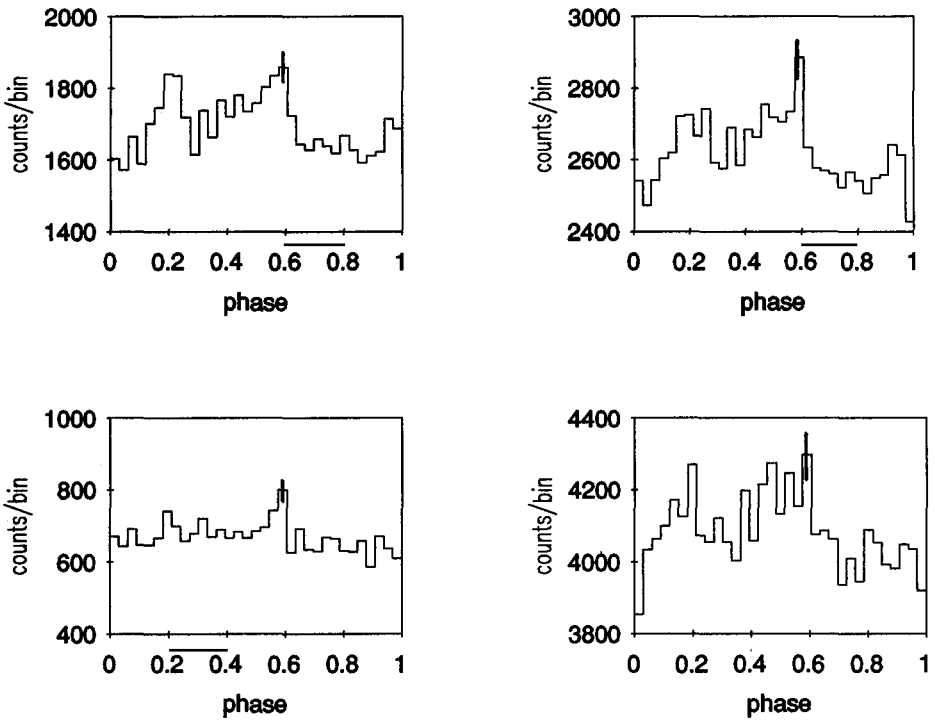

***Fig. 1** - Crab light curves (1 to 10 MeV) obtained in GRO observations 0 (upper left), 1.0 (upper right), 2.1 (lower left) and 15 (lower right).*

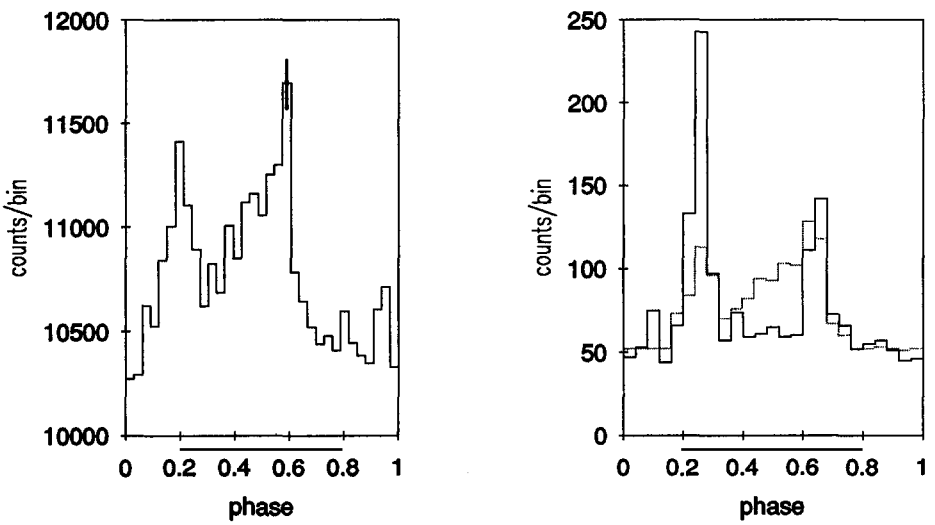

***Fig. 2** - Left: integrated Crab light curve (1 to 10 MeV). Right: the same light curve compared, after independent normalization of the pulsed signal and the flat unpulsed background, with the COS-B light curve (continuous line) above 50 MeV.*

The 1 - 10 MeV Crab light curve integrated over the 4 observations is shown in fig. 2 (left); as expected from measurements in similar energy ranges (see for example Agrinier et al., 1990), the shape of the pulsed emission is characterized by two main peaks at about 0.4 phase distance with an important bridge of emission between them. It is important to notice that this bridge is marginal above 50 MeV (Clear et al., 1987). A statistical comparison of the COMPTEL and COS-B light curves as the one described above, shows that the difference in shape (independently from the absolute intensity of the signal) is highly significant (fig. 2, right side) due both to a much higher prominence of the first peak at COS-B energies and to the important presence of the bridge of emission between the two peaks at COMPTEL energies.

2. The Vela pulsar.

Fig. 3 (left) shows the light curve of the Vela pulsar in the energy range 10 to 30 MeV (where the signal is more pronounced), integrated over the 4 COMPTEL observations #0, #6, #8 and #14, for a total observing time of about 46 days, between May and November 1991. The canonical shape of two main pulses separated by 0.4 in phase is observed as it is at higher energies (Grenier et al., 1988). The detail far exceeds any earlier results in the same energy range (Tumer et al., 1984).

Fig. 3 (right) shows the comparison with the COS-B light curve above 50 MeV. In contrast with the Crab case, for the Vela pulsar the main difference between the two shapes is the absence of emission between the two main pulses. However, due perhaps to the low signal-to-noise ratio, the statistical significance of the difference in shape between the COMPTEL and COS-B light curves, after normalization, is only at the 2σ level. The apparent phase difference of peak 2 could be an artifact and will be investigated in subsequent detailed analysis. Likewise no interpulse emission may be quantified at this stage.

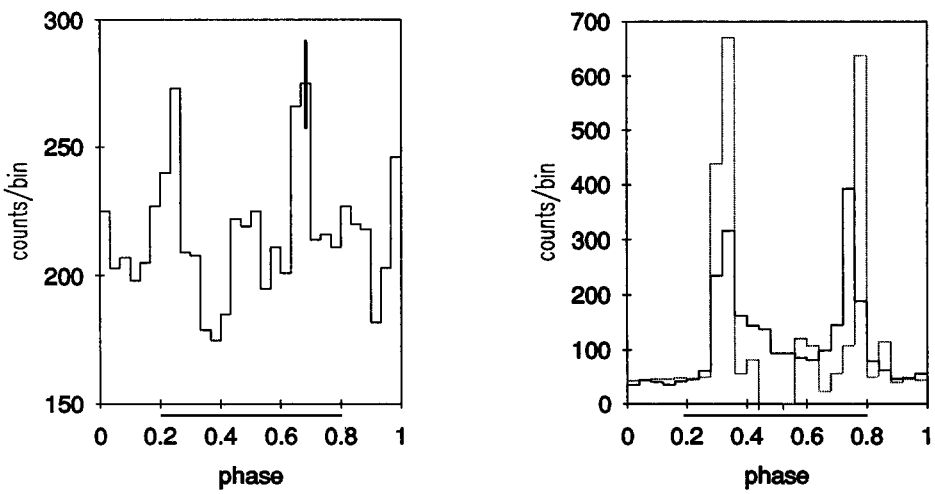

***Fig. 3** - Left: Vela integrated light curve (10 to 30 MeV) relative to GRO observations 0, 6, 8 and 14. Right: the same light curve compared, after independent normalization of the pulsed signal and the flat unpulsed background, with the COS-B light curve (continuous line) above 50 MeV.*

3. Observation of other pulsars.

Using the pulsar ephemerides derived from radio observations simultaneously with GRO, the COMPTEL data for a sample of other radio pulsars have been searched for pulsed gamma-ray emission between 1 and 30 MeV. No signals have been detected to date. In particular, no significant signal was detected from PSR1706-44 (detected by EGRET above 500 MeV) and PSR1509-58 (detected at lower energies by BATSE and OSSE).

Among RADIO pulsars not detected by other GRO experiments, no signal was sofar detected in the COMPTEL data of PSR0740-28, PSR0959-54, PSR1046-58, PSR1610-50, PSR1643-43, PSR1727-33, PSR1758-24, PSR1800-21, PSR1821-24, PSR1823-13, PSR1830-08, PSR1929+10, PSR1951+32. Furthermore, no signal, either steady, or pulsed, has been observed from the Geminga pulsar (detected by EGRET), the upper limit being compatible with the possible detection at 150-400 KeV by FIGARO (Scarsi, private communication) and with the upper limits reported by GRANAT-SIGMA.

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