



Search for correlation between giant radio pulses and hard X-ray pulses from the Crab pulsar

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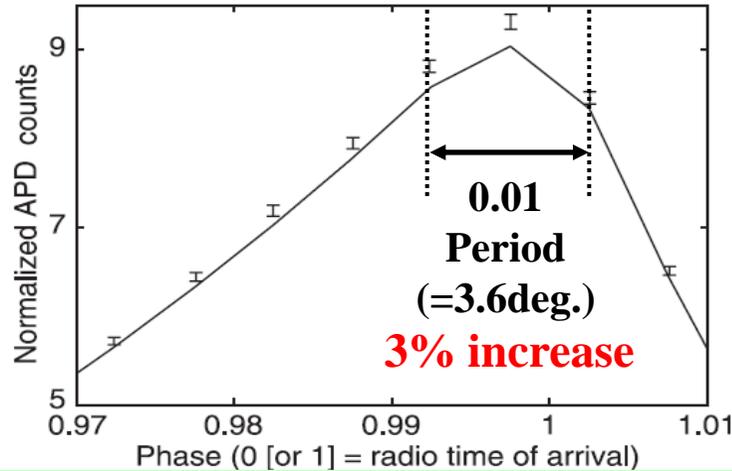
Abstract

We made simultaneous observations of radio (Kashima 34m and Usuda 64m dishes in Japan, 1.4GHz) and hard X-ray (Suzaku satellite, 15-75keV) pulses from the Crab pulsar for total 12.7 hours on three occasions in 2010-2011.

Based on these datasets we have searched a correlation between giant radio pulses (GRPs) and X-ray pulses, and found that peak X-ray flux concurrent with main phase GRPs showed a statistically marginal increase by 21.5 ± 8.0 percent (2.7 sigma significance) over the average X-ray flux when radio pulses were normal.

We will discuss physical implications of this correlation, if it is proved to be real.

Previous correlation studies



I → simultaneous with GRPs
— → not simultaneous with GRPs

[Shearer+ , Science, **301**, 493 (2003)]

Energy band	Flux variation concurrent with GRPs	Satellite/Telescope	Reference
Optical (600-750nm)	Enhanced by 3%	William Herschel Telescope	Shearer+ (2003)
Soft X-ray (1.5-4.5keV)	<200%	Chandra/HRC-S	Bilous+ (2012)
Hard X-ray (15-75keV)	This work.	Suzaku/HXD	This work.
Soft γ -ray (50-220keV)	<250%	CGRO/OSSE	Lundgren+ (1995)
γ -ray (0.1-5GeV)	<400%	Fermi/LAT	Bilous+ (2011)
VHE γ -ray (>150GeV)	<500-1000%	VERITAS	Aliu+ (2012)

Our observations of the Crab pulsar

©Radio observations (1.4GHz):

The **Kashima 34m parabola** and the **Usuda 64m parabola**

©Hard X-ray observations (15-75keV):

The **Suzaku HXD**

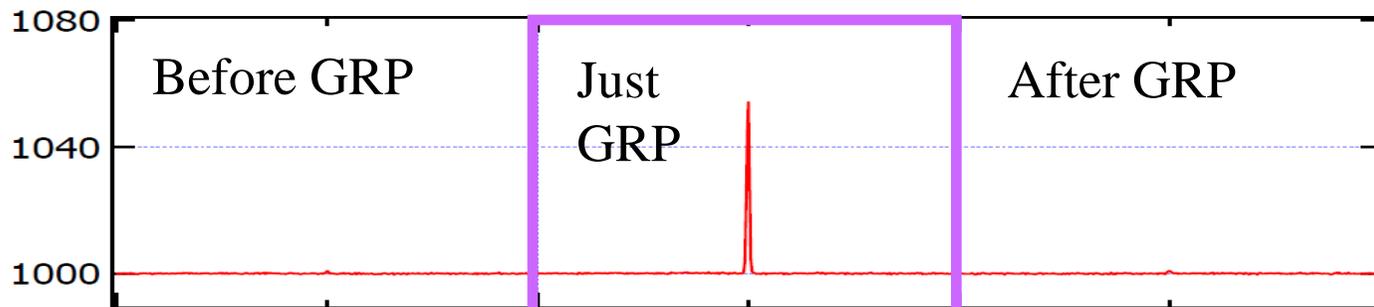
Date	6 Apr, 2010	22 Mar, 2011	1-2 Sep, 2011
Observing time [min.]	313	178	271
# of normal pulses	558118	317311	483044
# of GRPs ($S/N \geq 5$) (The ratio to all pulses)	4090 (0.73%)	2568 (0.81%)	6487 (1.34%)

We compared flux densities of hard X-ray pulses coincident with **GRPs occurring at the phase of the main pulse** with those not coincident with GRPs.

Result

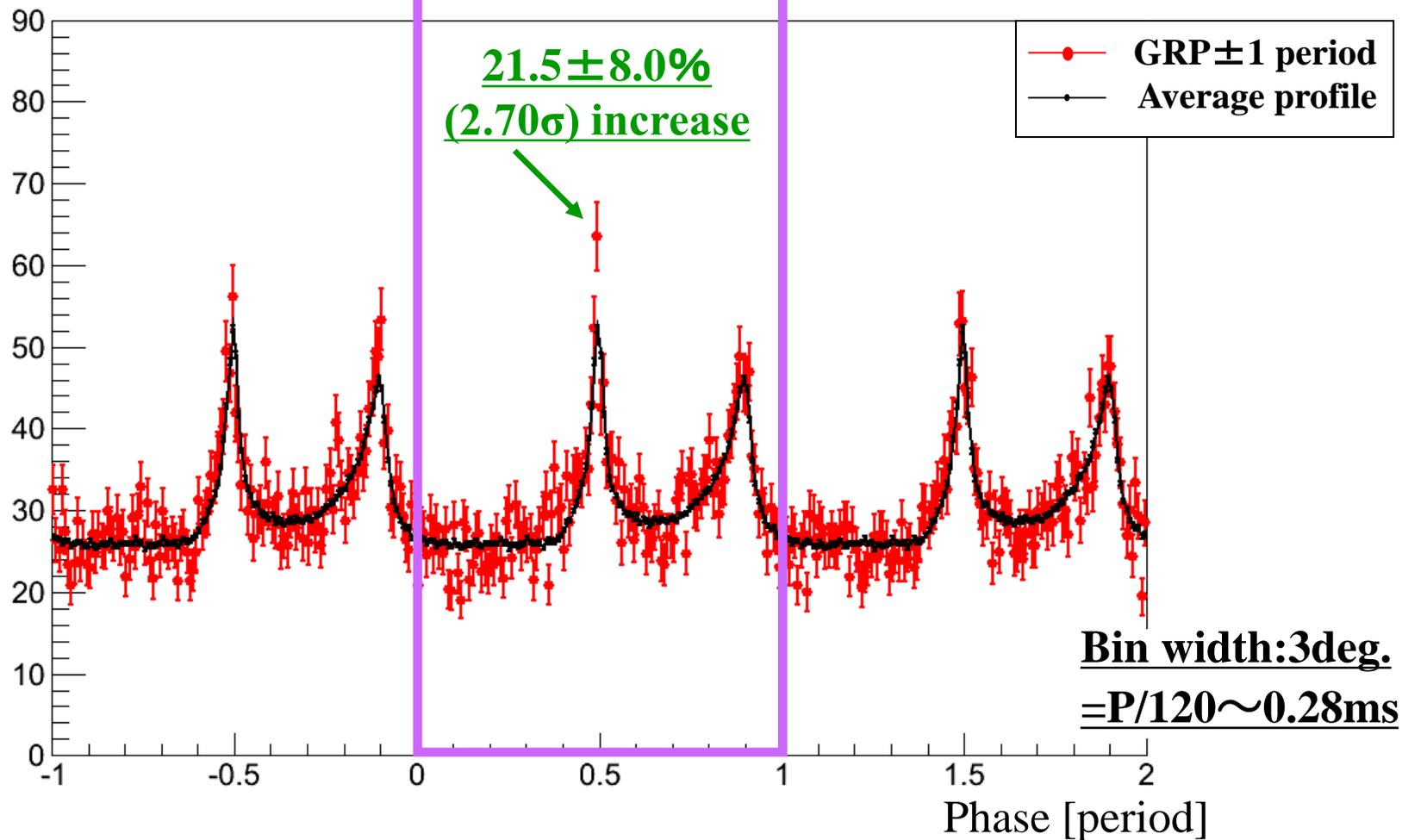
Radio

intensity
(arbitrary scale)



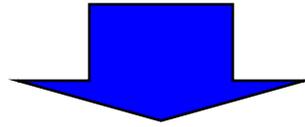
Hard X-ray

photon counts
(arbitrary scale)



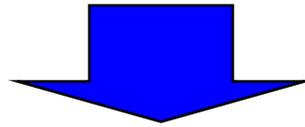
Implications for the GRP emission (I)

Possible correlation is found between hard X-rays and GRPs.



This may indicate **an increase of plasma density in the pulsar magnetosphere** at GRP time.

The hard X-ray flux increases only at the peak of those pulses.



Hard X-ray emission region is **“partially”** affected by the mechanism that causes GRPs.

Implications for the GRP emission (II)

Spectral hardening at the time of GRPs?

Flux increase [%]

$$= (F_{\text{peak}} - F_{\text{average}}) / F_{\text{average}}$$

●: **Optical**

→ $\sim 3\%$ increase [Shearer+ (2003)]

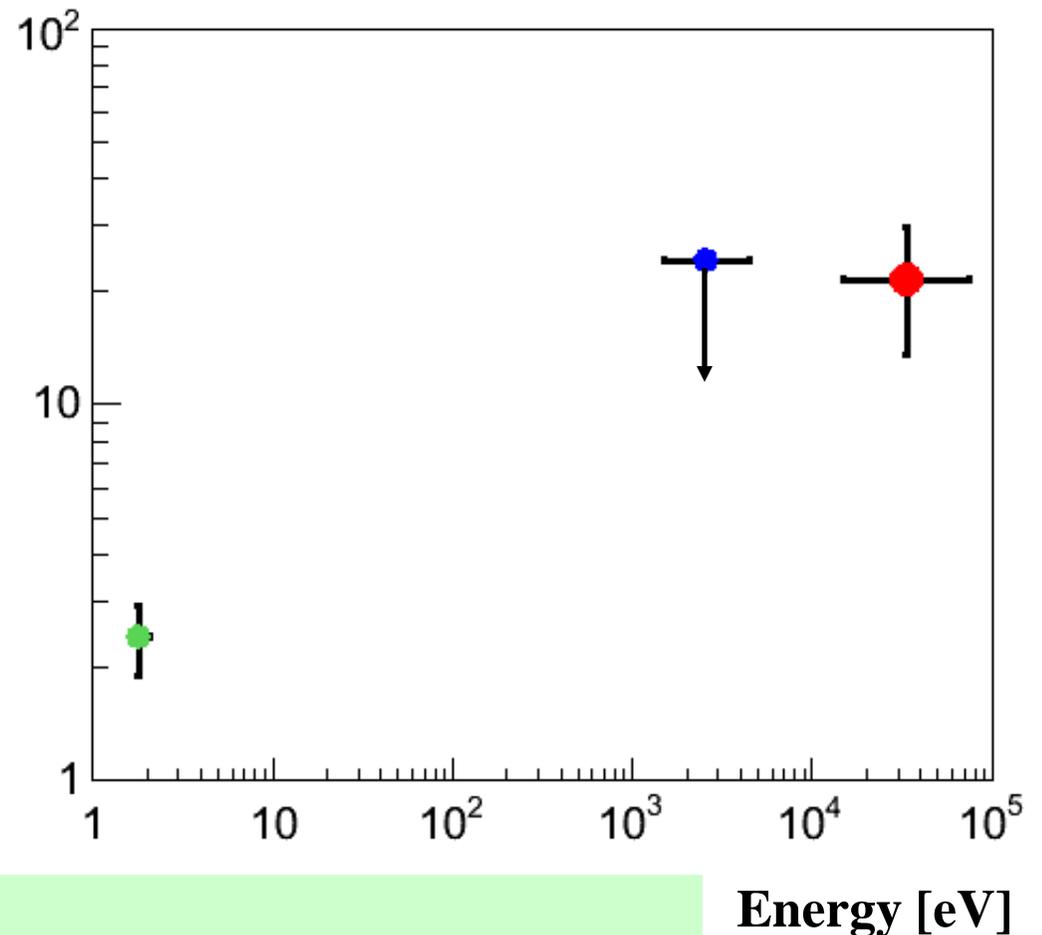
●: **Soft X-ray**

→ $\sim 24\%$ upper limit

[estimated from Bilous+ (2012)]

●: **Hard X-ray**

→ $21.5 \pm 8.0\%$ increase [Our data]



Summary

- Making simultaneous radio and hard X-ray observations, we found possible **increase ($21.5 \pm 8.0\%$, 2.70σ) of hard X-ray flux coincident with GRPs.**
- We are planning to make further observations in order to improve statistics.