Proceedings of the 30th International Cosmic Ray Conference
Rogelio Caballero, Juan Carlos D'Olivo, Gustavo Medina-Tanco,
Lukas Nellen, Federico A. Sánchez, José F. Valdés-Galicia (eds.)
Universidad Nacional Autónoma de México,
Mexico City, Mexico, 2008

Vol. 2 (OG part 1), pages 703–706

30TH INTERNATIONAL COSMIC RAY CONFERENCE

Report on TeV γ-Ray Observations of PSR B1259−63/SS2883 near the 2007 Periastron with the H.E.S.S. Stereoscopic System of Cherenkov Telescopes

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Abstract: PSR B1259−63 / SS 2883 is a binary system consisting of a 48 ms radio pulsar orbiting a Be star with a period of 3.4 y in a highly eccentric orbit (e = 0.87). The system was first detected in TeV γ-rays by H.E.S.S. around the last periastron passage in March 2004. These observations established PSR B1259−63 / SS 2883 as the first variable galactic source in the very high energy (VHE) regime. A lightcurve for the system, covering mainly the post periastron part, could be deduced, clearly showing a variable flux in VHE photons. New data have been taken this year from April to June with the system approaching its next periastron (July 27, 2007). The status and outcome so far of the corresponding campaign will be discussed.

Introduction

The binary system PSR B1259−63 / SS 2883 was first observed in TeV γ-rays during its periastron passage between February and June 2004 [1], establishing it as the first variable galactic TeV γ-ray source (see Fig. 1). The corresponding data showed a clear pointlike signal with a statistical significance of 13 standard deviations at the position of PSR B1259−63. A time averaged spectrum as well as a lightcurve for the integrated flux above 380 GeV from this object could be extracted (see Fig. 2 & 3). Moreover, it was the first time in the history of TeV γ-ray astronomy where two sources have been discovered within the same field of view as this campaign lead to the serendipitous discovery of HESS J1303-631 [2] (see Fig. 1).
The peculiar shape of the PSR B1259−63 lightcurve has been object of various model descriptions trying to explain the underlying physical processes causing the VHE emission. Mechanisms like Inverse Compton (IC) scattering of ultrarelativistic electrons on the stellar photons or hadronic scenarios (e.g. $pp \rightarrow \pi^0 \rightarrow \gamma\gamma$) have been suggested as possible origins of TeV photons in the interactions of the pulsar wind with the stellar outflow and radiation field of the companion Be star (e.g. [3]). Some of them take into account the influence of the dense stellar disc that might play a crucial role in the generation mechanism of VHE γ-rays (see [4]). In order to constrain the various parameters used in the model predictions as well as to be able to discriminate between the models in question, data for the up to now unknown pre-periastron (lightcurve) part of PSR B1259−63 are needed.
As the next periastron takes place on July 27, 2007, a campaign of 60 h of intended exposure during the pre-periastron phase from April to July 2007 has been started.

The H.E.S.S. PSR B1259−63 2007 Campaign

Figure 4 shows the H.E.S.S. visibility windows of PSR B1259−63 in 2007 for zenith angles below 45° together with data from 2004 with respect to periastron. The numbers underneath each observa-

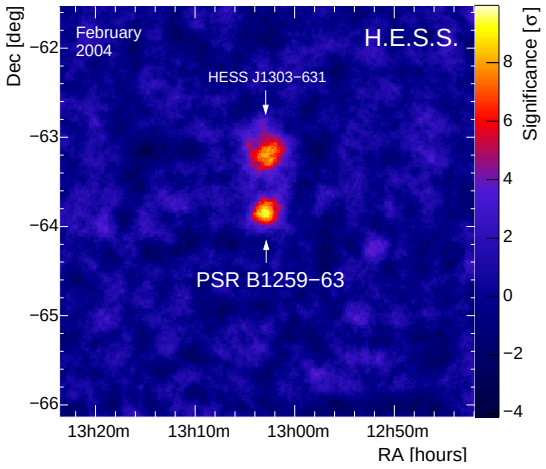

Figure 1: *Significance skymap of the PSR B1259−63 field of view as seen in February 2004. The unidentified γ-ray source HESS J1303−631 is located 0.6° to the north of the source.*

tion slot indicate the amount of intended exposure time for this month. Observations will cover the pre-periastron orbital phase until 14 days prior to the periastron passage. Green boxes refer to time windows where data taking already has been accomplished. The overall exposure time of roughly 60 h was chosen to match the dataset from 2004, in terms of good quality data, in order to have a comparable amount of data for the pre-periastron part of the lightcurve.
So far, data from April to June with an overall livetime of 33 h have been taken (see Tab. 1). The livetime for the overall 2004 dataset was $\sim$ 45 h.

Period 2007	τ [h]	S [σ]	Calibration Status
April	5.3	1.0	final
May	14.6	3.2	final
June	13.2	6.4	preliminary

Table 1: *PSR B1259−63 April-June 2007: Livetime τ, Significance S for a preliminary point source analysis. The June data has been calibrated preliminarily on site in Namibia.*

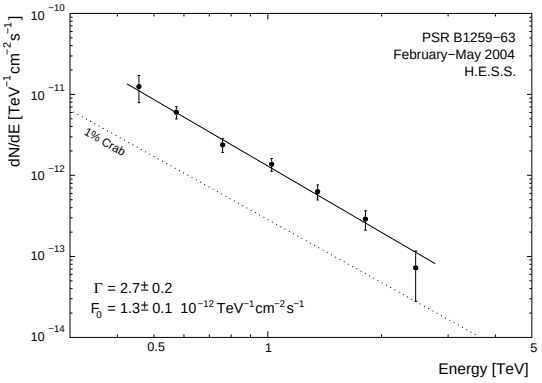

Figure 2: *Energy spectrum dN/dE of γ-rays from PSR B1259−63 determined from the H.E.S.S. 2004 data. The solid line indicates the power-law fit $F(E) = F_0 E^{-\Gamma}$.*

A preliminary standard point source analysis of these data has been carried out (for details on the H.E.S.S. analysis chain see [1]). The significance for a γ-ray excess from the source in April and May is 1.0 and 3.2 standard deviations respectively, showing no strong detection for these months. However, when analyzing data from June on site, using a preliminary on site calibration, a clear signal with a significance of 6.4σ can be seen from PSR B1259−63 (see Tab. 1).

Multi Wavelength Coverage

In order to also have Multi Wavelength (MWL) data available coincident with the TeV data provided by H.E.S.S. a cooperation with the *SUZAKU* [5] satellite project has been established. Corresponding observation schedules have been optimized for a maximum MWL coverage. *SUZAKU* will observe PSR B1259−63 from July to September 2007 in eight pointings of 20 ks duration each. Four pointings will take place in July coincident with the H.E.S.S observations covering the assumed first entrance of the pulsar into the dense circumstellar disc. This interesting phase of the system's orbit is therefore covered in the keV and TeV energy bands.

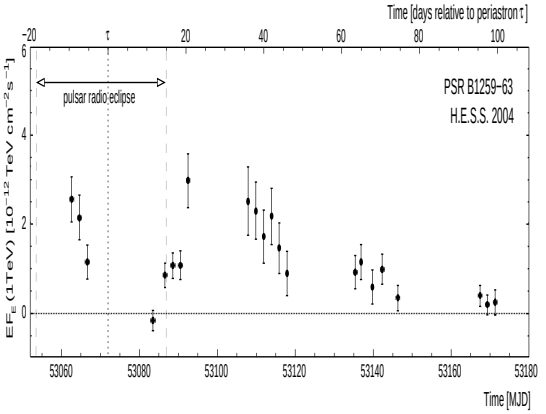

Figure 3: *The PSR B1259−63 lightcurve around periastron in 2004. The vertical dashed black line indicates the position of the periastron. The data clearly indicate a variable flux.*

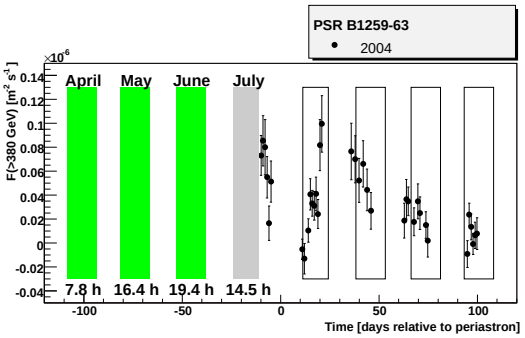

Figure 4: *The PSR B1259−63 observation windows in 2007 for zenith angles $< 45°$ with respect to the system's time relative to periastron. Green boxes indicate that data taking has already been accomplished during the corresponding month. The empty boxes are the 2007 observation windows mirrored with respect to periastron, overlayed with the 2004 data for comparison.*

Summary & Outlook

PSR B1259−63 is currently re-observed by the H.E.S.S. Cherenkov Telescope System in Namibia in a 60 h exposure campaign lasting from April to July 2007. 33 h of livetime data have already been taken during the April to June period. A preliminary point source analysis yields no significant excess from the system for April and May. The preliminarily calibrated June data (on site calibration) however shows a clear signal at 6.4σ.
The campaign is carried on in July with a planned exposure of 14.5 h coinciding with 4 pointings on the target done by the X-ray satellite *SUZAKU* covering the crucial first disc crossing of the pulsar.
Further isolated post-periastron H.E.S.S. observations are planned during August when *SUZAKU* as well as *Chandra* will observe this unique HE & VHE accelerator.

References

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