Hunting for GeV emission from the binary HESSJ0632+057

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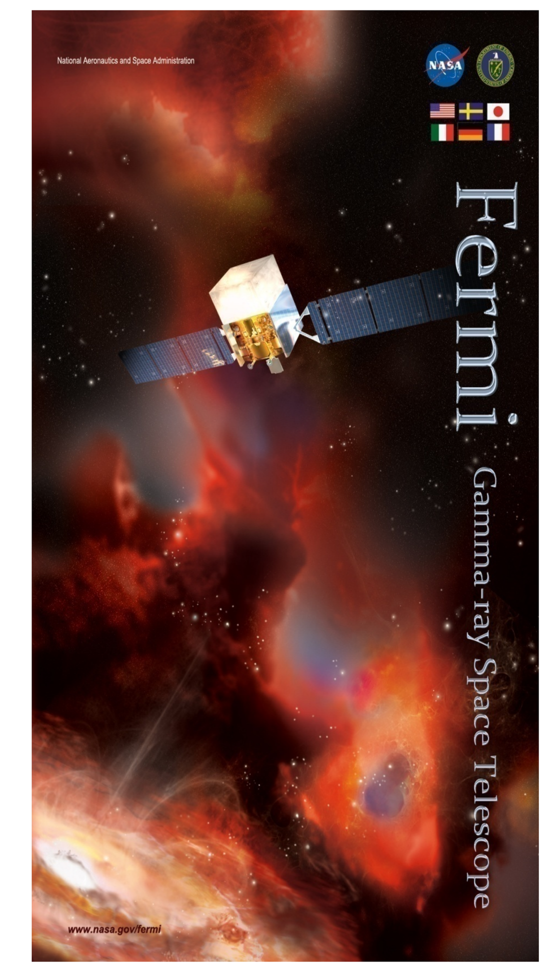
on behalf of the Fermi Large Area Telescope Collaboration



ABSTRACT

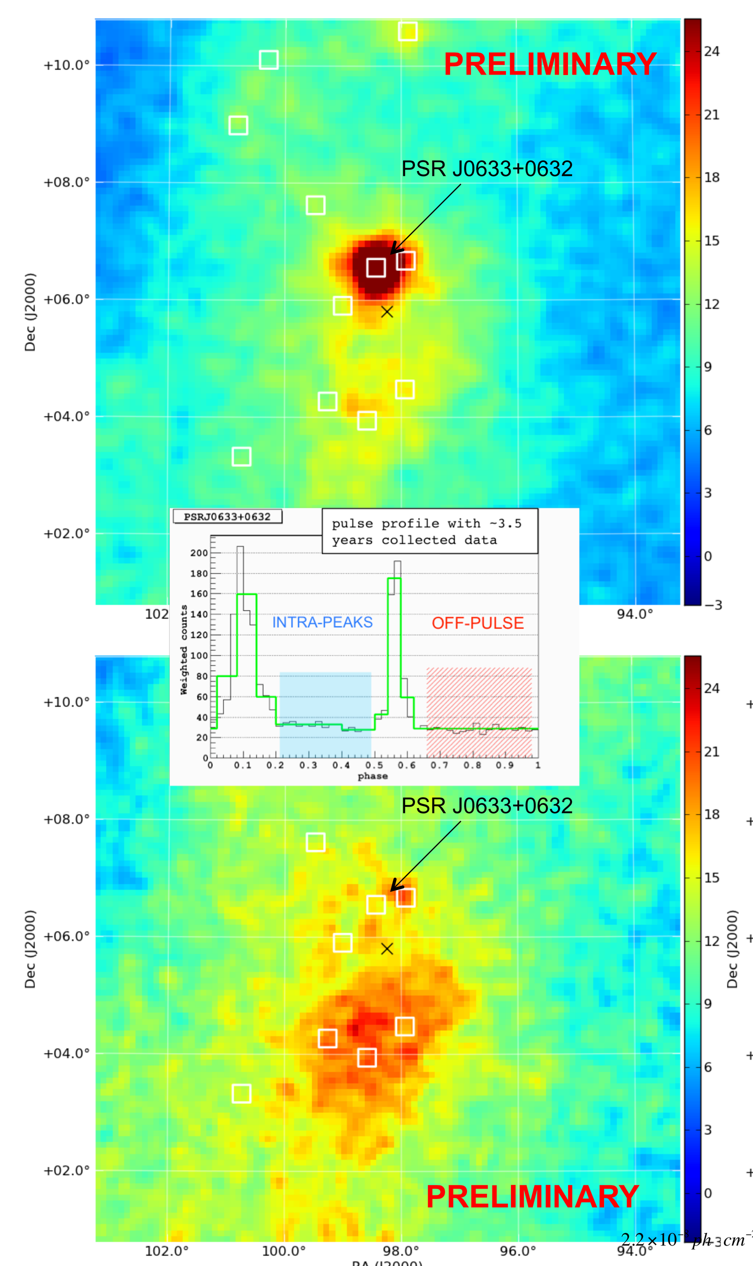
In the last decade Cherenkov telescopes on the ground and space-based gamma-ray instruments have identified a new sub-class of high mass X-ray binaries (HMXB), whose emission is dominated by gamma rays. To date only six of these systems have been definitively identified. However at GeV energies there is still one, HESS J0632+057 that has no reported detection with the Fermi LAT. A deep search for gamma ray emission of HESS J0632+057 has been performed using more than 3.5 years of Fermi-LAT data. We present the results of this search in the context of the other known gamma-ray binary systems.

What is HESS J0632+057?

The population of γ-ray binaries comprises of a handful of high mass X-ray binaries that have been detected at high (0.1-100 GeV) or very high (>100 GeV) energies with the peak of their emission lies within the γ-ray band [1]. In the majority of these systems the nature of the compact object is unknown and consequently the origin of the high energy emission is still not clear.

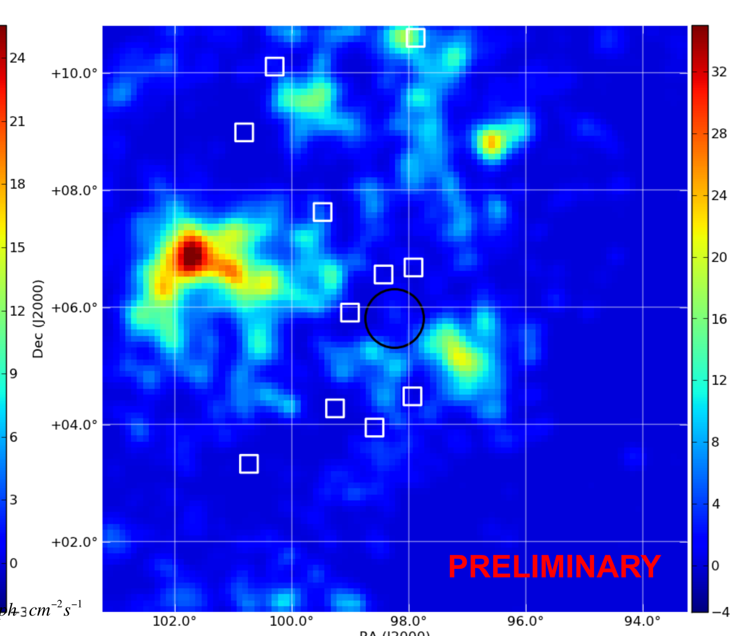
In 2007 the H.E.S.S. collaboration reported the discovery of a new TeV point-source lying in the Galactic Plane, HESS J0632+057 [2]. Within the H.E.S.S. error circle was a massive emission-line star, MWC 148, of spectral type B0pe which pointed to the possible binary nature of the object.

Subsequent multi-wavelength follow up identified a periodicity in the X-ray and γ-ray at 321 +/- 5 days [3,4] confirming the binary nature of this object and adding a new member to the class of γ-ray binaries; see figures below. Recently reported observations from the MAGIC team reported the first detection of γ-ray emission in the 136-400 GeV range [5].



In the neighbouring figures white squares indicate the location of 2FGL catalog sources and the black cross indicates the known position of HESS J0632 +057.

Top left: Smoothed LAT counts map above 100 MeV of the region centred on the location of HESS J0632+057.
Middle left: The phase folded light curve of PSR J0633+0632.
Bottom left: The smoothed LAT counts map of the region after subtracting the pulsed emission of PSR J0633+0632. This map is rescaled to have equivalent exposure to the top counts map.
Bottom right: The residual TS map having fit the LAT data with a model comprising only of 2FGL catalog sources together with a Galactic Diffuse and isotropic diffuse component.

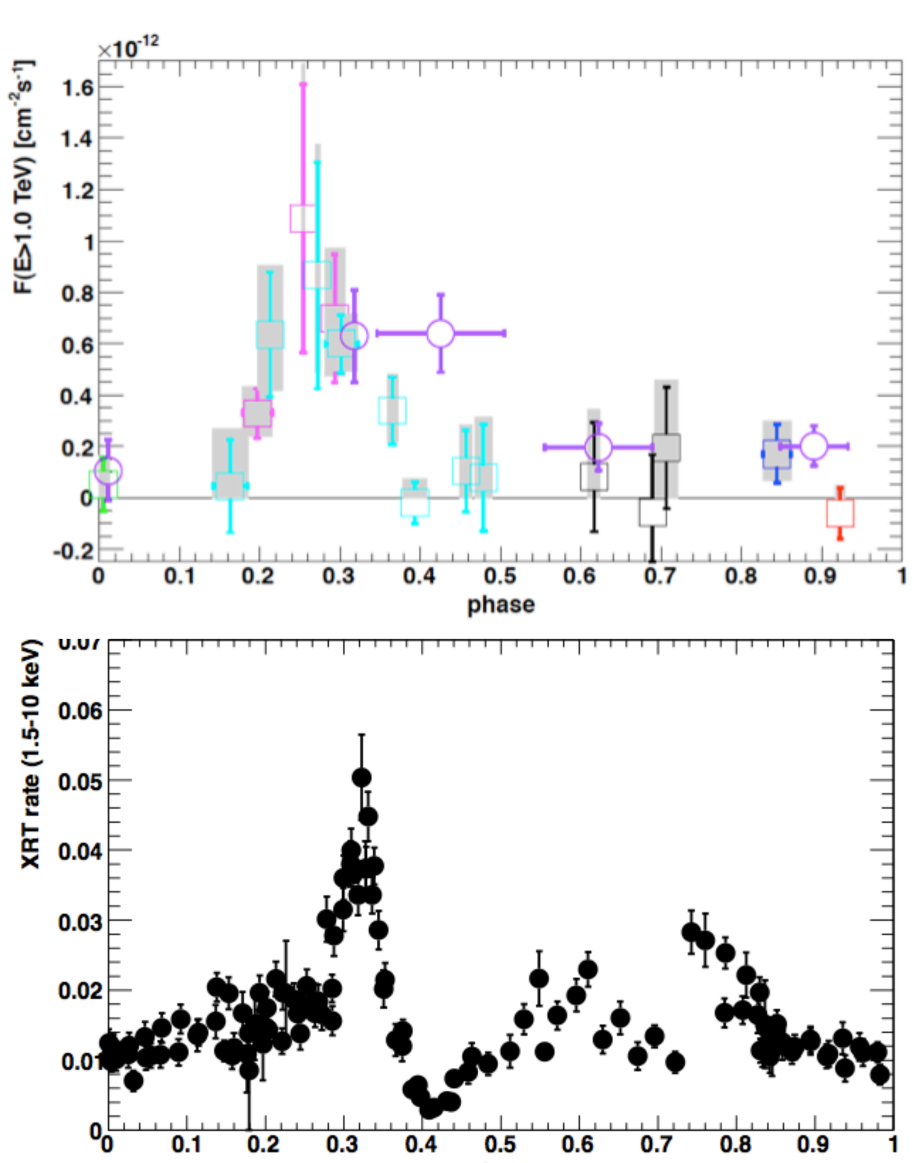


The GeV environment: First look at the LAT data

In searching for emission from HESS J0632+057 at GeV energies we examined ~3.5 years of Fermi LAT data at energies >100 MeV. The analysis is challenging due to the location of the source in an area of high Galactic diffuse emission and the nearby proximity of a bright γ-ray pulsar, PSR J0633+0632. This is indicated in the smoothed LAT counts map shown to the top left.

To improve the situation we apply the 'pulsar gating' procedure of only selecting events which occur outside of the two peaks of PSR J0633+0632. Using only events from the intra-peak and off-peak regions can be seen to drastically reduce the pulsar emission in the region.

Fitting the 'pulsar gated' events with a model based upon the 2FGL catalog [6] and the Galactic and isotropic diffuse models indicates that there are a number excesses in the TS map which are not accounted for.



Top: The TeV phase folded light curve for HESS J0632+057 from H.E.S.S. (circles; 2004 & 2010) and VERITAS (squares; 2006 to 2011). [4]

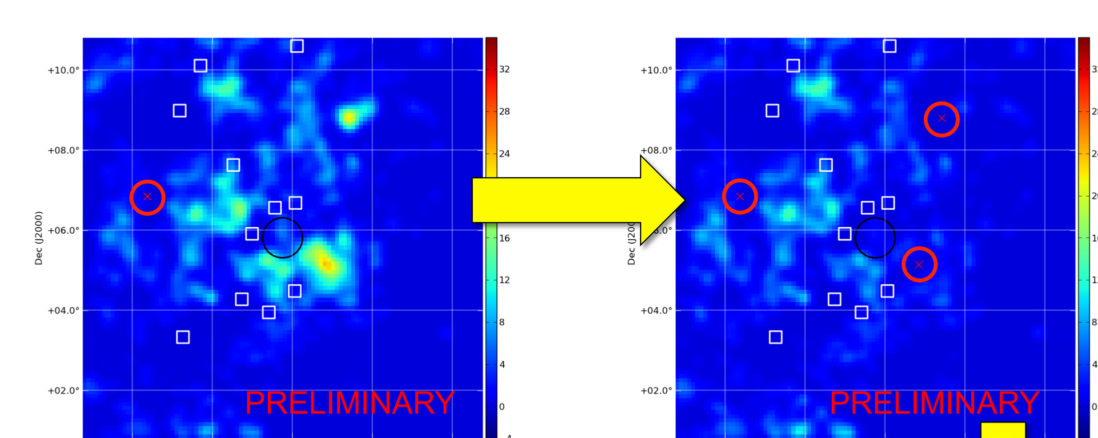
Bottom: The Swift-XRT 1.5-10 keV phase folded light curve [4].

Modelling the local source environment: An iterative search

To reduce the residuals shown in the above TS map the source model of the region has to be improved. If residuals are found at or near the position of known 2FGL sources then they are re-localized and their flux normalizations allowed to vary when fitting the data. Additional residuals must be accommodated by adding new sources to the model; this is performed in an iterative fashion to minimise the number of new sources added to the model. The addition of 4 new sources reduces the residuals in the >100 MeV TS map to be below ~3σ.

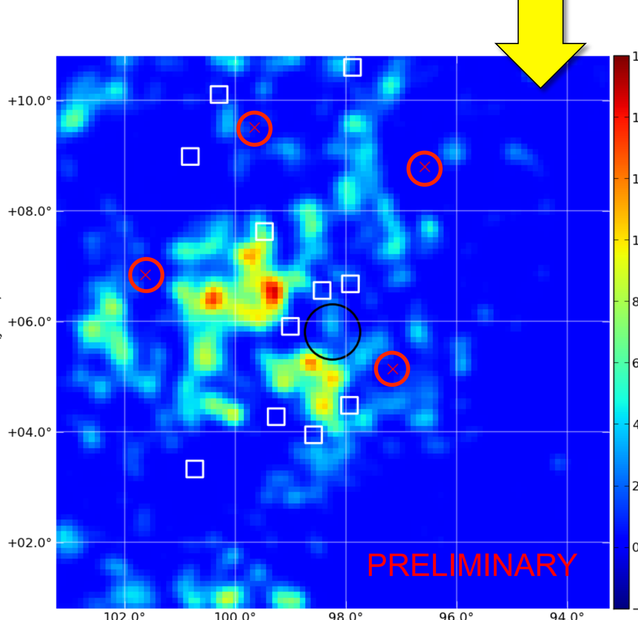
No detection of GeV emission!

There is no significant detection of HESS J0632+057 at GeV energies when using 3.5 years of Fermi LAT data. A search for emission over eight orbital phase bins also does not yield a detection. As a consequence HESS J0632+057 remains the only known γ-ray binary to not be detected by the LAT. For the energy range 0.1-100 we infer a 95% confidence flux upper limit for the source of 2.2×10^{-8} ph cm^{-2} s^{-1}.



In the neighbouring figures white squares indicate the location of 2FGL catalog sources, the black circle indicates the known position of HESS J0632 +057 and the red circles with crosses indicate new non-2FGL sources incorporated into the model.

The series of figures shows examples of iteratively improving the model of the region with 1 new non-2FGL source, followed by 3 new sources and finally the addition of a 4th new source reduces any residuals to have a TS < 16.



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The γ-ray binary population

	LS I +61 303	LS 5039	PSR B1259-63	1FGL J1018.6-5856	HESS J0632+057	Cyg X-3
Orbital Period	26.5 days	3.9 days	3.4 years	16.6 days	321 days	4.8 hrs
Compact object	?	?	pulsar	?	?	BH?
Distance (kpc)	1.9	2.5	2.3	5.4	1.5	~7
GeV	✔	✔	✔	✔	✗	✔
TeV	✔	✔	✔	✗?	✔	✗

[1] Hill, A.B, Dubois, R. & Torres D.F., Proceedings of the 1st Session of the Sant Cugat Forum of Astrophysics. Nanda Rea & Diego F. Torres (Editors), 2011, Springer, ISSN: 1570-6591. ISBN 978-3-642-17250-2, arXiv: 1008.4762

[2] Aharonian, F. A., Akhperjanian, A. G., Bazer-Bachi, A. R., et al. 2007, A&A, 469, L1

[3] Bongiorno et al. 2011, ApJ, 737, 11

[4] Maier G., 2011, ICRC, 7, 78, arXiv: 1111.2155

[5] Aleksić, J, 2012, ApJ, 754, 10

[6] Nolan et al., 2012, ApJS, 199, 31