Fermi-LAT observations of PSR J1836+5925

A. Belfiore[1,2], P. M. Saz Parkinson[3], Y. Kanai[4], A. De Luca[2,5]
on behalf of the Fermi Large Area Telescope Collaboration

[1]Dipartimento di Fisica Nucleare e Teorica, University of Pavia, 27100 Pavia, Italy [2]INAF-Istituto di Astrofisica Spaziale e Fisica Cosmica, I-20133 Milano, Italy [3]Santa Cruz Institute for Particle Physics, Department of Physics and Department of Astronomy and Astrophysics, University of California at Santa Cruz, Santa Cruz, CA 95064 [4]Department of Physics, Tokyo Institute of Technology, Meguro City, Tokyo 152-8551, Japan [5]IUSS - Istituto Universitario di Studi Superiori, 27100 Pavia, Italy

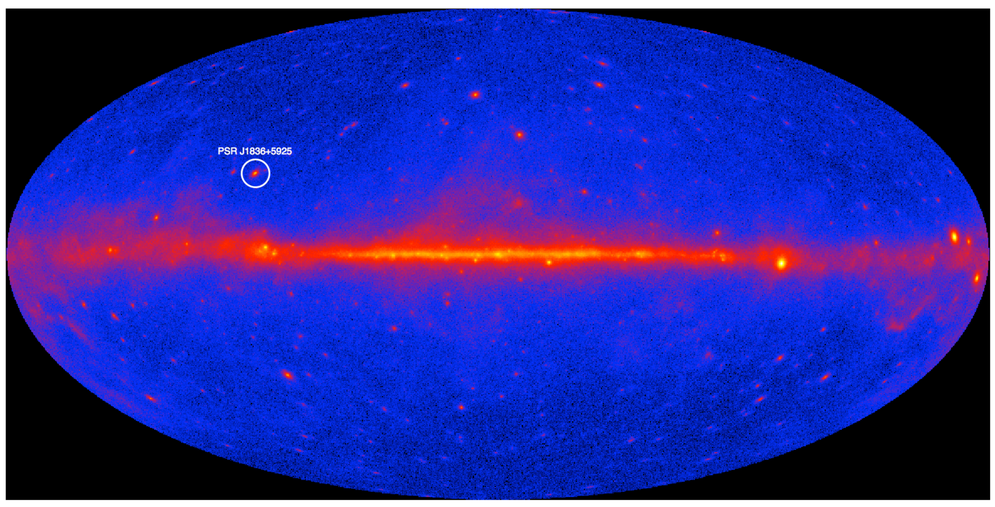
Summary: We present the key timing and spectral results on the long sought-after pulsar powering 3EG J1835+5918, formerly the brightest of the EGRET unidentified sources off the plane.

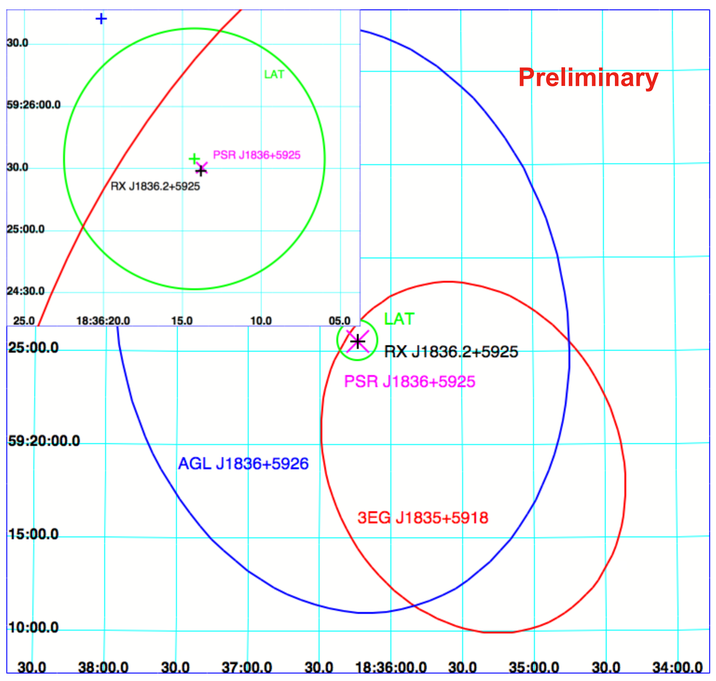
Abstract

Blind search analysis of Fermi LAT data has proved the bright EGRET source 3EG J1835+5918 to be a pulsar. PSR J1836+5925 is characterized by a strong baseline emission and a large characteristic age, the lack of a radio counterpart and a position out of the galactic plane. Variability and extension are discussed. We present the results of our phase-resolved spectral analysis. There is no evidence that the unpulsed component is due to a pulsar wind nebula (PWN). The spectrum obtained observing with XMM Newton the X-ray counterpart confirms it is a Geminga-like nearby neutron star.

Introduction

3EG J1835+5918, a very bright unidentified EGRET source (Nolan et al. 1996), was an early target for the Fermi Large Area Telescope. Its nature was elusive: past claims of variability and its position out of the galactic plane suggested it could be a blazar; a lack of a radio counterpart and a possible association with the ROSAT source RX J1836.2+5925 (Mirabal et al. 2000) indicated it could be a pulsar (Halpern et al. 2002). Blind search analysis of Fermi LAT data found a pulsation with P=173ms confirming the second hypothesis (Abdo et al. 2009). Timing analysis provides a large characteristic age of 1.8Myr and a spindown luminosity of 1.1e34erg/s. Timing localization leaves no doubt about the association of PSR J1836+5925 with RX J1836.2+5925. The folded light curve shows a strong off-peak emission, whose nature is probably magnetospheric, lacking any other evidence for a bright PWN.





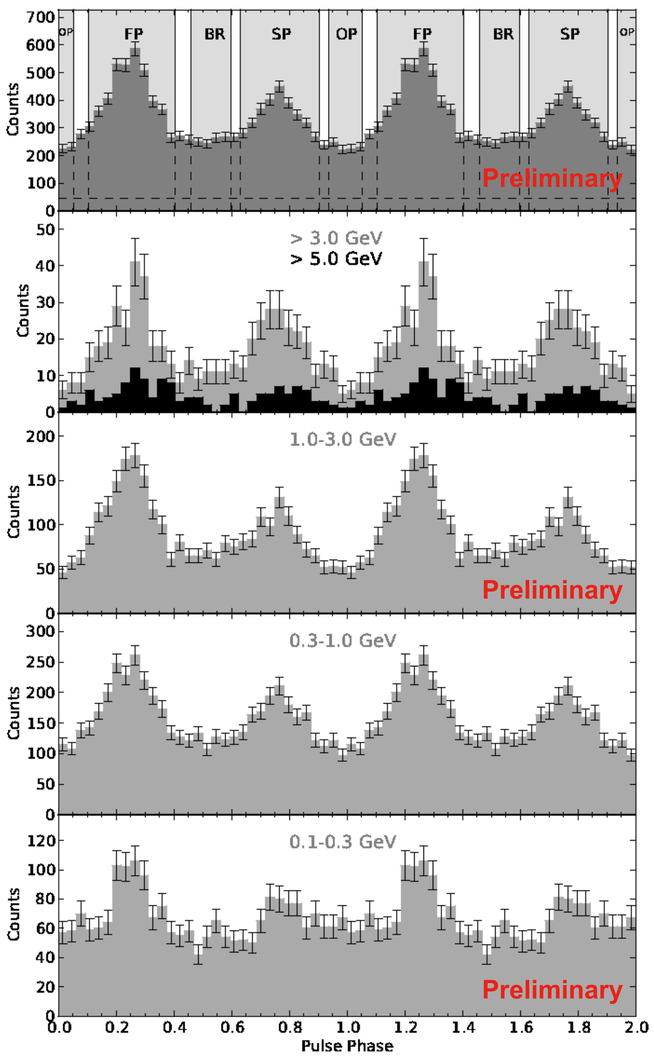
Above. *Error boxes provided by EGRET (red), AGILE (blue), Fermi-LAT using pointlike (green), Fermi-LAT from timing (magenta), and the ROSAT source RX J1836.2+5925 (black)*
Right. *The folded light curve in various energy bands. In the top plot, from 0.1GeV up, 4 phase regions are highlighted, while the dashed horizontal line represents the background.*

F0=5.7716Hz
F1=-5.0e-14Hz/s
τ=1.8Myr

RA=18:36:13.7
DEC=+59:25:30
Ė=1.1e34erg/s

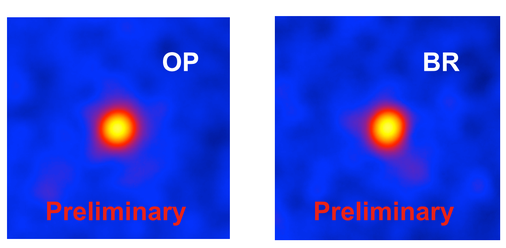
Timing and Localization

Analysis of the early LAT pointed observations of 3EG J1835+5918, provided a first timing solution for PSR J1836+5925. This analysis has now been refined, extending the dataset to the first 11 months of Fermi LAT operations, from 06/30/08 to 06/30/09. The best-fit position lies 0.35 arcsec away from RX J1836.2+5925, well within the error boxes.

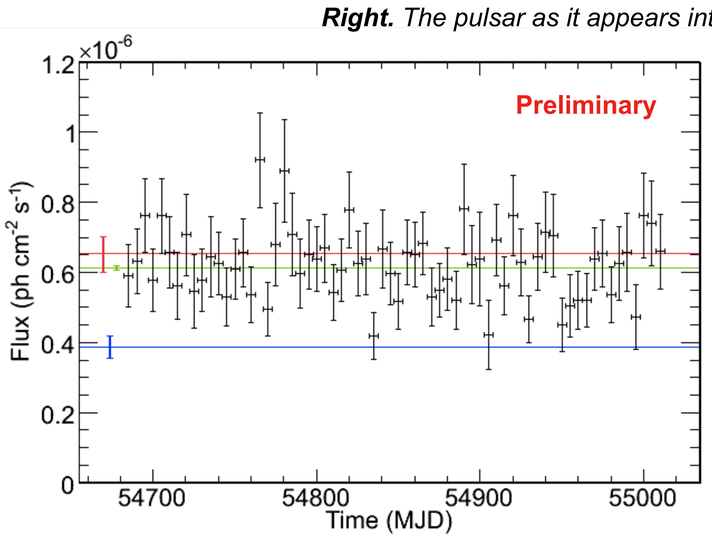


Extension

The folded light curve of PSR J1836+5925 is well fit by a constant plus 2 gaussians, corresponding to the peaks, centered at phase 0.25 and 0.74. The pulsar shines brightly even out of the peaks, hampering any efforts to detect extended emission. A systematic study of Fermi LAT sources in this respect confirmed that there is no significant hint of extension (see the poster by J.Lande).



Right. *The pulsar as it appears int the off-peak (OP) and in the bridge (BR)*

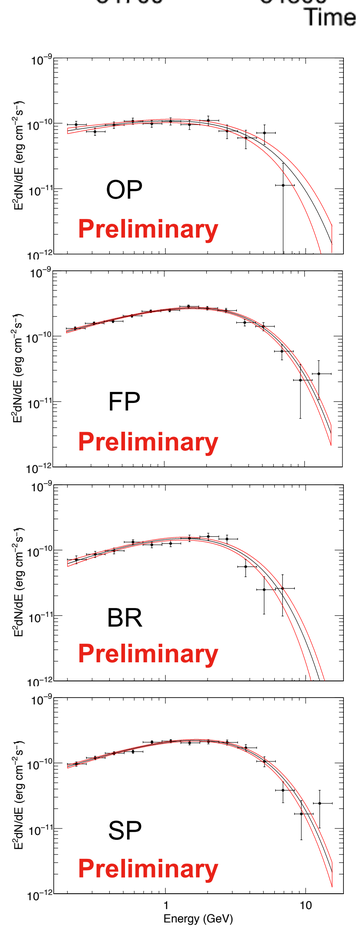


Variability

AGILE detected 3EG J1835+5918 at a flux much lower than EGRET, and confirmed previous claims of variability (Bulgarelli et al. 2008). We have tested the steadiness of the flux on the same 5 days timescale. A statistical analysis of the long term light curve obtained from spectral fitting, disentangling the contribution from other nearby sources, shows no evidence for variability. The average flux is consistent with the EGRET results.

We searched for variability also in the pulse profile shape. First the dataset was divided into slices with equal counts. Then we took each pair of them and compared them against the null hypothesis that the two slices are drawn from the same population. We performed two kinds of non parametric tests: chi2 and Kolmogorov-Smirnov. The tests have been repeated dividing the dataset into 2, 4, 8, 16, and 32 slices. No evidence of variability has ever been found.

Left. *Long term Fermi light curve. Superimposed is the average flux as measured by EGRET (red), AGILE (blu), and Fermi (green)*

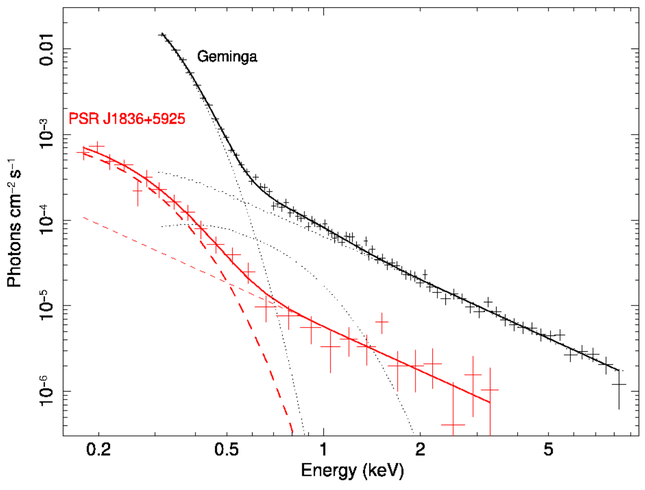


Spectral Analysis

We used photons above 200 MeV from 08/04/08 to 06/30/09, within a ROI of 15 deg around PSR J1835+5925. The standard zenith cut at 105 deg have been applied to avoid atmospheric gammas. Diffuse models are gll_iem_v02 and isotropic_iem_v02 for galactic and extragalactic contribution respectively. Sources in the ROI are fit with a simple power law, while for the pulsar we used a power law with an exponential cutoff.

Next, we studied the energy spectrum in 4 phase regions: off-peak (OP), first peak (FP), bridge (BR), and second peak (SP). The spectral parameters for the pulsar were free while those of the other sources were fixed. The results are shown in the figure (***Left***) and reported in the table (***Below***). The similarity of the spectral shapes, in and out of the peaks, is suggestive of a pulsar rather than a PWN.

	OP φ=0.995 ±0.058	FP φ=0.255 ±0.150	BR φ=0.528 ±0.069	SP φ=0.768 ±0.136
photon index	1.59±0.11	1.31±0.05	1.17±0.11	1.24±0.05
cutoff energy GeV	2.65±0.57	2.31±0.17	1.64±0.23	2.18±0.18
photon flux e-07ph·cm⁻²·s⁻¹	4.87±0.38	8.32±0.24	4.47±0.28	6.44±0.22



X-ray Observations

XMM-Newton observed RX J1836.2+5925 on 05/18/08 and 06/25/08 for a total exposure of 24.4 ks (EPIC/pn) and 30.7 ks (EPIC/MOS) in Full Frame Mode. Spectral fits to the data exclude a simple black-body model, preferring a simple power law, or even better a combination of the two. In both cases the fit strongly constrains the Nh (<2e19 and <2.7e20 cm^{-2} respectively), implying the proximity of the source. The plot (***Above***) shows also the strong similarity with the spectrum of Geminga.

Conclusion

Blind search analysis of Fermi LAT data proved that 3EG J1835+5918 is powered by a pulsar. Localization obtained from timing confirms RX J1836.2+5925 as its X-ray counterpart. The pulse profile has 2 peaks separated by ~0.5 in phase, with a strong emission in the off'peak interval. The spectral characteristics of this emission, along with the lack of extension, suggests a magnetospheric origin, rather than a PWN. The strong brightness despite the low spindown power and the X-ray spectrum constrain the distance to less than 800 pc. This, along with the large characteristic age, explains the location of this pulsar far out of the Galactic plane.

References

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