GeV Gamma-ray Emission Coinciding with HESS J1832-085

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Abstract

Recent studies (Maxted et al. 2019) of the Galactic supernova remnant (SNR) G23.11+0.18 in radio wavelengths revealed that the radio emission of the SNR was spatially coincident with a TeV gamma-ray source, HESS J1832–085. A dip in molecular gas at a velocity of ~85 km/s and molecular gas clumps at a neighbouring velocity towards HESS J1832–085 hints to the possibility of hadronic gamma-ray production mechanism in the northern parts of the SNR. We analysed 10-years of gamma-ray data taken by Fermi-LAT in the energy range of 0.2 - 300 GeV to look for possible spatial correlations between GeV and TeV gamma rays, as well as any overlaps between the radio and gamma-ray emissions within the close neighbourhood of G23.11+0.18. Here, we report about the detection of the excess GeV gamma-ray emission partially coinciding with both G23.11+0.18 and HESS J1832–085 in the northern region of the SNR.

Introduction

SNRs are the primary candidates for Galactic cosmic ray (CR) acceleration up to PeV energies. G23.11+0.18 was detected in radio continuum using the data of Murchison Widefield Array (MWA), a low-frequency pre-cursor to the Square Kilometer Array (SKA) by Maxted et al. (2019). Its central location is found to be at RA (J2000), Dec (J2000): (278.12, -8.65) deg with a radius of 700 ± 50 arcsec. The point source found within the shell of G23.11+0.18 (at RA (J2000), Dec (J2000): (278.12, -8.65) deg) was found not to be related to the SNR.

The lack of strong non-thermal X-rays favours a middle-age (~10^4 yr) for G23.11+0.18 and it indicates that electrons with energies higher than 1 TeV are missing in the region. Its distance was estimated to be ~4.6 kpc from CO(1-0) observations.

The spatially coinciding TeV gamma-ray source, HESSJ1834–087, was detected in H.E.S.S. Galactic Plane Survey (Abdalla et al. 2018) but it was not reported in the 4th Fermi-LAT point-source catalog (4FGL - Ajello et al. 2020). The other sources detected in gamma-rays that are inside the SNR or in its close vicinity are 4FGL J1832.4-0847 (~0.285 deg away), the composite PWN/SNR W 41 (HESSJ1834–087 / 4FGL J1834.5–0846e) and the SNR G22.7-0.2 (HESS J1832–093 / 4FGL1832.9-0913).

Analysis:

— Using fermitools & fermipy (Woods et al. 2017) packages.

Event Selection:

— Data from 01/09/2008 to 06/11/2020
— Energy range: 1 - 300 GeV (for spatial maps); 0.2 - 300 GeV (for spectral analysis)
— Fermi-LAT Pass 8 `Source' class & front+back type events
— Events coming from zenith angles smaller than 90 deg
— Events taken from a circular region of interest (ROI) with a radius of 15 deg centred at the radio location of G23.11+0.18.

Background Model:

— Galactic diffuse sources (gll_iem_v7.fits) and isotropic sources (iso_P8R3_SOURCE_V2_v1.txt)
— All point-like and extended sources from the 4FGL catalog located within a 10 deg x 10 deg region centred at the ROI centre
— Freed normalisation parameters of sources that are within 3 deg of ROI centre
— Freed all parameters of the diffuse Galactic emission and the isotropic component
— All sources with TS > 10 are set free and all sources with TS < 10 are fixed
— Instrument response function: P8R3_SOURCE_V2

Preliminary Results

New GeV Sources within the Analysis Region:

— Included W41 into the gamma-ray background model as an extended source using a Radial Gaussian template. G23.11+0.18 is not included into the background model.
— Using the find_sources script of fermipy and detected a new point source within W41, which was named as PS J1834.5-0841.
—The gamma-ray emission distribution of PS J1834.5-0841 is shown in the TS map (left panel of Figure 1), where it was not included into the background model. After including this source into the background model, we obtained the TS map shown in the middle panel of Figure 1.
—To analyse the excess gamma-ray emission related to G23.11+0.18, we added a new point source PS J1834.7+0830 with a power-law (PL) type spectrum and found its best-fit location.

Positions & Significances of PS J1834.5-0841& PS J1834.7+0830:

— PS J1834.5-0841: RA(J2000) = (278.61 ± 0.05) deg, Decl.(J2000) = (-8.697 ± 0.05) deg ; Significance: ~6 sigma (1 - 300 GeV) & ~12 sigma (0.2 - 300 GeV)
— PS J1834.7+0830: RA(J2000) = (278.216 ± 0.05) deg, Decl.(J2000) = (-8.514 ± 0.05) deg ; Significance: 4.6 sigma (1 - 300 GeV) & ~5 sigma (0.2 - 300 GeV)

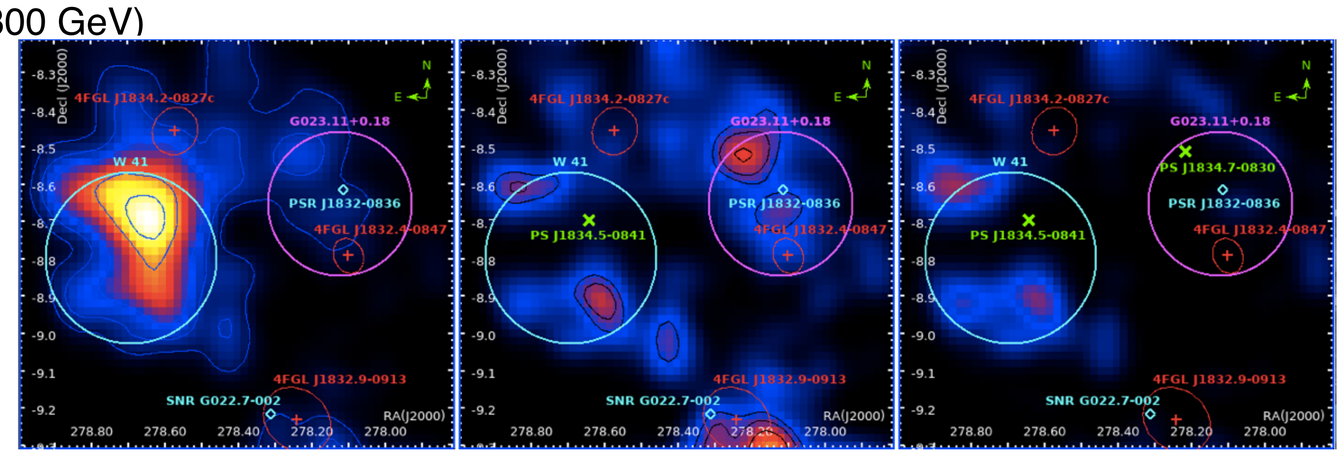

Figure 1: *Fermi-LAT TS maps in the energy range of 1-300 GeV. 4FGL catalog source positions and error ellipses are shown in red colours. The cyan and magenta circles represent the SNRs W41 and G23.11+0.18 (from Maxted et al. 2019). The other sources in the analysis region are shown with cyan diamonds. The new GeV sources are indicated with green crosses. Left Panel: Both PS J1834.5-0841 & PS J1834.7+0830 are not included in the gamma-ray background model. The blue TS contours are: 4, 9, 16, 36, 49. Middle Panel: Only PS J1834.5-0841 included in the gamma-ray background model. The black TS contours are: 7, 9, 12. Right Panel: Both PS J1834.5-0841 & PS J1834.7+0830 are included in the gamma-ray background model.*

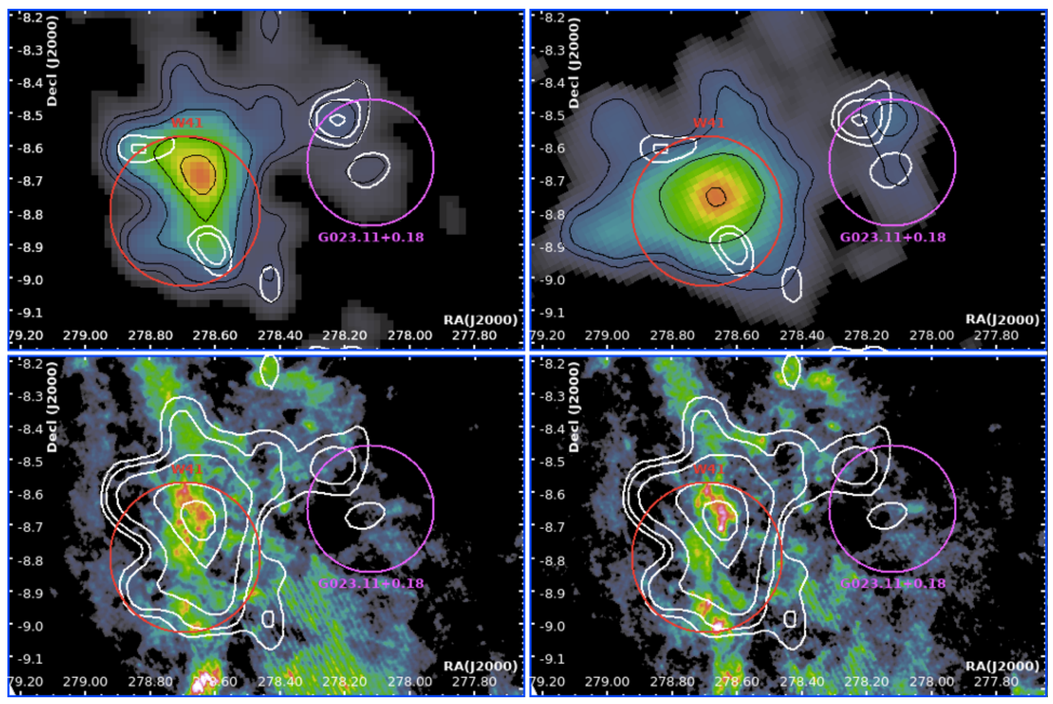

Figure 2: *Multi-wavelength view of the analysis region. Upper-left Panel: Fermi-LAT gamma-ray TS map of the analysis region (as Figure 1 left panel). Upper-right Panel: H.E.S.S. gamma-ray significance map of the analysis region (Abdalla et al. 2018). Bottom-left Panel: ^{12}CO data (FUGIN) of the analysis region (Maxted et al. 2019). Bottom-right Panel: ^{13}CO data (FUGIN) of the analysis region (Maxted et al. 2019).*

Spectral Analysis Results:

PS J1834.5-0841 (PL type spectrum):

— Spectral index = 2.35 ± 0.06
— Photon flux = (2.28 ± 0.26) × 10^{-8} photons cm^{-2} s^{-1}
— Energy flux = (1.61 ± 0.15) × 10^{-6} MeV cm^{-2} s^{-1}

PS J1834.7+0830 (PL type spectrum):

— Spectral index = 2.27 ± 0.12
— Photon flux = (0.73 ± 0.23) × 10^{-8} photons cm^{-2} s^{-1}
— Energy flux = (0.59 ± 0.13) × 10^{-6} MeV cm^{-2} s^{-1}

References

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