Mapping the TeV PWN candidate source HESS J1857+026 down to Fermi-LAT energies with the MAGIC telescopes

V. Stamatescu, J. Krause, S. Klepser, R. Gozzini, D. Paneque et al.

Citation: [AIP Conf. Proc.](#) **1505**, 345 (2012); doi: 10.1063/1.4772268

View online: <http://dx.doi.org/10.1063/1.4772268>

View Table of Contents: <http://proceedings.aip.org/dbt/dbt.jsp?KEY=APCPCS&Volume=1505&Issue=1>

Published by the [American Institute of Physics](#).

Additional information on AIP Conf. Proc.

Journal Homepage: <http://proceedings.aip.org/>

Journal Information: http://proceedings.aip.org/about/about_the_proceedings

Top downloads: http://proceedings.aip.org/dbt/most_downloaded.jsp?KEY=APCPCS

Information for Authors: http://proceedings.aip.org/authors/information_for_authors

ADVERTISEMENT

Submit Now

Explore AIP's new open-access journal

- Article-level metrics now available
- Join the conversation! Rate & comment on articles

Mapping the TeV PWN candidate source HESS J1857+026 down to Fermi-LAT energies with the MAGIC telescopes

V. Stamatescu*, J. Krause†, S. Klepser*,**, R. Gozzini** and D. Paneque†
for the MAGIC Collaboration

**IFAE, Edifici Cn., Campus UAB, Bellaterra, Spain*

†*Max-Planck-Institut für Physik, München, Germany*

***Deutsches Elektronen-Synchrotron (DESY), Zeuthen, Germany*

Abstract. HESS J1857+026 is an extended TeV gamma-ray source that was discovered by H.E.S.S. close to the Galactic plane. Given its spatial coincidence with the young energetic pulsar PSR J1856+0245, the source represents a pulsar wind nebula (PWN) candidate. The source has now also been detected and analyzed using Fermi-LAT data. HESS J1857+026 was observed by MAGIC in 2010, yielding 29 hours of good quality stereoscopic data that resulted in a highly significant detection. We present an updated energy spectrum that ranges from 100 GeV to 10 TeV, together with a detailed analysis of the source morphology, which uses skymaps for two different energy regimes. We outline the evidence for the possible PWN nature of the source based on the spectral and morphological information obtained with MAGIC together with existing multi-wavelength data.

Keywords: gamma-rays: observations, pulsar wind nebulae

PACS: 95.30.Cq, 95.85.Pw, 97.60.Gb

MULTI-WAVELENGTH PICTURE

HESS J1857+026 was discovered by HESS, during its survey of the inner Galaxy, as a VHE source without clear counterparts [1]. The source was slightly extended: $(0.11 \pm 0.08)^\circ \times (0.08 \pm 0.03)^\circ$, and showed a significant Northern tail-like structure. The spectrum, which ranged from 800 GeV up to 45 TeV (see Fig. 1), was compatible with a power law of spectral index 2.39 ± 0.08 . The source detection was confirmed by VERITAS [2].

Subsequently, an energetic Vela-like pulsar, PSR J1856+0245, was discovered in the vicinity of HESS J1857+026 (see Fig. 2), with a spin period of 81 ms, and characteristic age of 21 kyr [3]. By coupling the pulsar dispersion measure (DM) of $622 \pm 2 \text{ cm}^{-3}\text{pc}$ together with the NE2001 model for the Galactic distribution of free electrons [4], a distance estimate of $\sim 9 \text{ kpc}$ was obtained. The uncertainty on this distance is not well determined, and this estimate may vary by up to a factor of 2 – 3 [3].

At GeV energies, no significant pulsation from the pulsar has been detected, based on 3 years of Fermi-LAT data [7]. By assuming a point-like source model in their analysis, the authors of that paper extracted a spectrum that is included on the SED shown in Fig. 1.

Leptonic and hadronic models, which attribute the TeV emission to a PWN that is powered by PSR J1856+0245, were then fitted to the data from Fermi-LAT, H.E.S.S.

FIGURE 1. Spectral energy distributions of HESS J1857+026 measured by MAGIC (this work), H.E.S.S. [1] and Fermi-LAT [5, 6, 7]. The MAGIC data are unfolded to correct for migration and energy biasing effects [8], therefore the errors are not independent of one another.

and MAGIC, together with an X-ray synchrotron emission upper limit derived from Chandra data, which suggests a low magnetic field in the case of a leptonic scenario.

ANALYSIS WITH MAGIC

MAGIC is a system of two Imaging Atmospheric Cherenkov Telescopes (IACTs) located on the Canary Island of La Palma, which has been operating in stereoscopic mode since autumn 2009. Prior to this, MAGIC comprised a single IACT that began operating in 2004. MAGIC achieves a low trigger threshold of 50 – 60 GeV, while its sensitivity for point-like sources in 50 h is 0.8 Crab units (C.U.) above 290 GeV [9].

We observed HESS J1857+026 during July-October 2010, taking 29 hours of data in wobble mode, for zenith angles between 25° – 36°. The results presented here were obtained using the analysis developed for extended sources described in Klepser et al. [10], coupled with the so-called image ‘sum-cleaning’ algorithm [11], in order to optimize the analysis of this source at lower energies, close to 100 GeV.

SPECTRAL AND MORPHOLOGY RESULTS

The MAGIC spectrum, the SED of which is shown in Fig. 2, is well described by a power law of the form $dN/dE = N_0(E/1\text{TeV})^{-\Gamma}$ with index $\Gamma = 2.24 \pm 0.07_{\text{stat}} \pm 0.15_{\text{sys}}$ and differential flux at 1 TeV of $N_0 = (4.85 \pm 0.40_{\text{stat}} \pm 1.5_{\text{sys}}) \times 10^{12} (\text{TeV cm}^2 \text{ s})^{-1}$. By fitting a symmetric 2D Gaussian function to the 0.3 – 1 TeV gamma-ray flux map (Fig. 2 left) we obtain the position and, after accounting for the instrumental point spread

FIGURE 2. MAGIC gamma-ray flux map in arbitrary units (a.u.) for events with $300 \text{ GeV} < E_{\text{est}} < 1 \text{ TeV}$ (left) and $E_{\text{est}} > 1 \text{ TeV}$ (right). Based on MC, the median energies of these maps are around 480 GeV and 1.7 TeV, respectively. The gamma-ray flux in arbitrary units is calculated as the number of smeared excess events in units of the background flux within 0.1° . Overlaid are TS value contours in steps of 1, starting at 3. They roughly correspond to Gaussian significances. Also shown in the bottom-left corner is the instrumental point spread function (PSF) after the applied smearing. The H.E.S.S. source HESS J1858+20 is not discussed, given the relatively low MAGIC exposure at this angular distance to the pointing positions. The Fermi-LAT source position is that determined in [7].

function (PSF) and applied smearing, the intrinsic extension of the source. The RA and DEC are $(18.954 \pm 0.02_{\text{stat}} \pm 0.02_{\text{sys}})^\circ$ h and $(2.70 \pm 0.02_{\text{stat}} \pm 0.03_{\text{sys}})^\circ$, respectively, which agree well with the H.E.S.S. centroid position. The intrinsic source extension at these energies is found to be $0.21 \pm 0.02_{\text{stat}} \pm 0.15_{\text{sys}}$, which is larger than the average H.E.S.S. extension in their respective energy range. At energies above 1 TeV we also detect a significant Northern tail-like feature.

A PWN CANDIDATE SOURCE

The combined SED in Fig. 1 exhibits a relatively strong turnover at energies close to 100 GeV. This may be attributed to the Inverse Compton (IC) peak expected from a leptonic scenario, although Rosseau et al. [7] showed that the SED could also be modeled in terms of gamma-ray emission given by hadronic interactions.

It is also worth considering whether the PWN scenario can adequately explain the source morphology observed with HESS, MAGIC and Fermi-LAT. Interestingly, while we find that the source is significantly extended with respect to our PSF in the energy range of 300 GeV to 1 TeV, no significant extension was detected using Fermi-LAT data for energies above 10 GeV. We are investigating whether the source is more compact at the highest energies ($> 1 \text{ TeV}$), as this would provide morphological evidence in favor of a leptonic PWN scenario, in which lower energy electrons have longer mean free paths and can diffuse further away from the pulsar. Our preliminary results suggest

that this is only the case if we consider the high-energy Northern tail-like feature as a separate source or component.

Concluding, MAGIC has observed the TeV PWN candidate source HESS J1857+026, thus bridging the gap in energy between the measurements made with H.E.S.S. and Fermi-LAT. The full nature of this gamma-ray emission region remains a mystery, and further study together with more multi-wavelength data may be necessary in order to gain a deeper understanding of the source.

ACKNOWLEDGMENTS

We would like to thank the Instituto de Astrofísica de Canarias for the excellent working conditions at the Observatorio del Roque de los Muchachos in La Palma. The support of the German BMBF and MPG, the Italian INFN, the Swiss National Fund SNF, and the Spanish MICINN is gratefully acknowledged. This work was also supported by the CPAN CSD2007-00042 and MultiDark CSD2009-00064 projects of the Spanish Consolider-Ingenio 2010 programme, by grant DO02-353 of the Bulgarian NSF, by grant 127740 of the Academy of Finland, by the DFG Cluster of Excellence “Origin and Structure of the Universe”, by the DFG Collaborative Research Centers SFB823/C4 and SFB876/C3, and by the Polish MNiSzW grant 745/N-HESS-MAGIC/2010/0.

REFERENCES

1. Aharonian, F. et al., *A&A*, 2008, 477(353)
2. Ong, R.A. et al., *Proc. 31st ICRC 2009* (arXiv:0912.5355)
3. Hessels, J.W. et al., *ApJ*, 2008, 682(L41)
4. Cordes, J. M., & Lazio, T. J. W. 2002, preprint (arXiv:astro-ph/0207156)
5. Neronov A., & Semikoz, D. 2010, arXiv:1011.0210v1
6. Paneque, D. et al., *Sources in the Fermi Sky Above 10 GeV*, Rome, 2011
7. Rousseau R. et al. *A&A* 2012, DOI: 10.1051/0004-6361/201118685
8. J. Albert et al., *Nucl. Instr. Meth. A*, 2007, 583, 494
9. Aleksić J. et al, *Astropart. Phys.*, 2012, 35, 435
10. Klepser, S., Krause, J., & Michele, D., et al *Proc. 32nd ICRC 2011* (arXiv:1109.6448v1)
11. Lombardi S., Berger K., Colin P., et al., *Proc. 32nd ICRC 2011* (arXiv:1109.6195)