HESS J1641-463, a very hard spectrum TeV gamma-ray source in the Galactic plane

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Conclusions

HESS J1641-463 is a unique VHE source, with one of the hardest gamma-ray spectra ever found at these energies. Scenarios where protons are accelerated up to hundreds of TeV at either SNR G338.5+0.1 or G338.3−0.0, and then interact with local gas or nearby massive MCs are the most compelling ones. If this is the case, then J1641−463 may be representing a source class contributing to the Galactic cosmic-ray flux around the knee.

Introduction

HESS J1641-463 is a unique source discovered by the H.E.S.S. telescope array in the multi-TeV domain [1]. With one of the hardest spectra observed in VHE gamma-rays extending at least to 20 TeV, and a positionally coincidence with the supernova remnant SNR G338.5+0.1 and a massive molecular cloud, the source constitutes an interesting case to study particle acceleration in the Galaxy.

Emission models

Measured spectrum is compared with predictions from p-p collision and inverse Compton models

P-P collisions

- Parametrization of Kelner et al [2], proton spectrum with Γ= -2.1
- Lower limit on particle cutoff energy 0.1 PeV (99% CL).
- Harder than the young SNR RXJ1713-4936 at energies above a few TeV
- Either SNR G338.5+0.1 interacting with ambient gas (if young SNR), or protons reaching from the young SNR G338.3-0.0

Electron IC off CMB photons

- Inverse Compton scattering off CMB photons
- The 99% CL lower limit on the particle cutoff energy is 700 TeV
- Electrons accelerated either in SNR G338.5+0.1 or in the young pulsar PSR J1640-4631
- Extremely difficult to accelerate electrons in SNRs

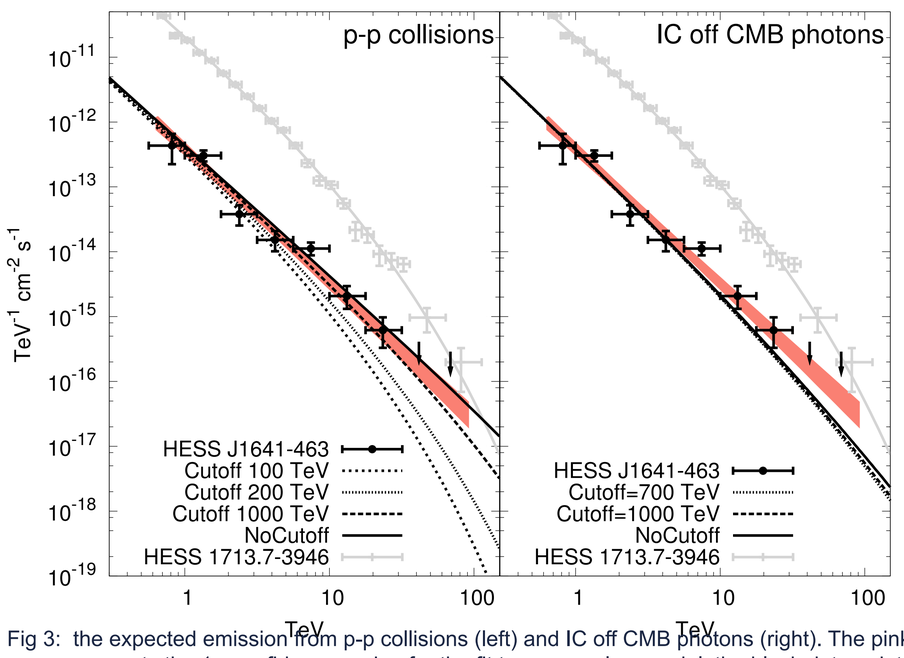


Fig 3: the expected emission from p-p collisions (left) and IC off CMB photons (right). The pink area represents the 1σ confidence region for the fit to a power law model, the black data points the H.E.S.S. measured photon flux, the arrows the 95% CL upper limits on the flux level, and the black curves the expected emission from the models. For comparison, the gray data points and curve represent the archival data of SNR RX J1713.7−3946. Figure from [1].

References

[1] Abramowski, A., et al. 2014, ApJL, 794, L1
[2] Kelner, S. R., Aharonian, F. A., & Bugayov, V. V. 2006, PhRvD, 74, 034018
[3] Lemoine-Goumard,M., et al. 2014, ApJL, 794, L16

H.E.S.S. analysis

Dataset

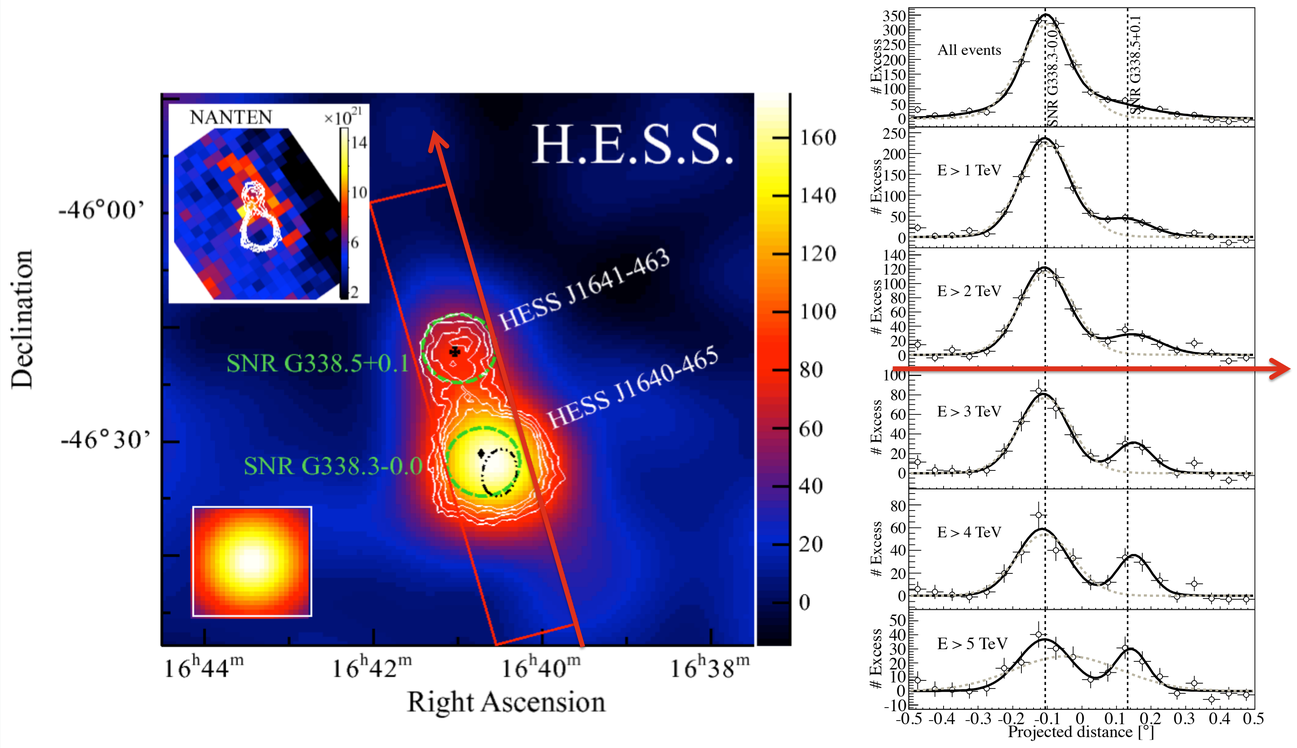
- 72 hours of taken with H.E.S.S. between 2004 and 2011

Technique

- Hillas parameters technique
- Energy dependent analysis, hard cuts to reduce source confusion with nearby, brighter source HESS J1640-464

Results

- Source confusion vanishing with increasing energies
- 8.5 σ detection at E > 4 TeV
- Differential spectrum fitted with power law with index $\Gamma = 2.07\ 0.11_{stat} \pm 0.20_{sys}$
- 1.8% of the Crab Nebula flux for E > 1 TeV



Map of excess events with energies E> 4 TeV for the region around J1641− 463 smoothed with the instrument. The white contours indicate the significance of the emission at the 5, 6, 7 and 8σ level. The dash-dotted black ellipse the 95% confidence error position of 1FHL J1640.5− 4634, and the red box indicates the area for the extraction of the profiles shown in the panel on the right. The upper left inset shows a map of the distribution of the column density of molecular hydrogen in units of cm^{-2} , estimated from the NANTEN CO(1− 0) data, together with the H.E.S.S. significance contours. Figure from [1].

Distribution of VHE g -ray excess profiles and Gaussian fits for the red rectangular slice shown in the left panel (read arrow in both figures shows the direction and sense). Vertical lines show the position of the SNR 338.3− 0.0 and G338.5+0.1. Fits using a single and a double Gaussian function are shown in dashed and solid lines, respectively. The double-Gaussian model being favored at the 3.6 − 4.3σ levels. Figure from [1].

Multiwavelength counterparts

Radio band

- Within the bounds of SNR G338.5+0.1, age estimate 1.1 to 17 kyr,
- Close to young energetic SNR G338.3-0.0
- Molecular gas at ~ 11 kpc, source region density of 100 cm^{-3} and 2.4×10^5 $M_\odot$

X-rays

- No obvious counterpart found in Chandra or XMM-Newton archival data [1].

HE gamma-rays

- Fermi-LAT detects a source in the position of HESS J1641-463 [3].
- Relatively soft spectrum with Γ= 2.47 ± 0.05 ± 0.06.
- The connection the hard H.E.S.S. spectrum remains unclear: two different mechanisms, or overlap sources?

Acknowledgements

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