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H.E.S.S. Galactic Plane Survey unveils a Milagro Hotspot

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Abstract: We report here on a new VHE source, HESS J1908+063, disovered during the extended H.E.S.S. survey of the Galactic plane and which coincides with the recently reported MILAGRO unidentified source MGRO J1908+06. The position, extension and spectrum measurements of the HESS source are presented and compared to those of MGRO J1908+06. Possible counterparts at other wavelenghts are discussed. For the first time one of the low-lattitude MILAGRO sources is confirmed.

Introduction

H.E.S.S. observations of the inner Galactic plane in the [$270°$, $30°$] longitude range have revealed more than two dozens of new VHE sources, consisting of shell-type SNRs, pulsar wind nebulae, X-ray binary systems, a putative young star cluster, etc, and yet unidentified objects (see e.g. [1] and [2] in these proceedings for a summary).

The extended H.E.S.S. survey in the [$30°$-$60°$] longitude range performed between 2005 and 2007 overlaps with regions covered by the MILAGRO sky survey at longitudes greater than $30°$. The latter experiment has recently reported [3] three low-latitude sources including, MGRO J1908+06, detected after seven years of operation (2358 days of data) at 8.3σ (pre-trials) confidence level. MGRO J1908+06, of which the extension remains unknown but bounded to a maximum diameter of 2.6°, is located near the galactic longitude $\sim 40°$ and hence is covered by the H.E.S.S. galactic plane survey.

A new H.E.S.S. source, HESS J1908+063, which coincides with MGRO J1908+06, is presented here. Its position, size and spectrum are measured and compared to the MILAGRO source. Possible counterparts at other wavelengths are discussed in the light of the H.E.S.S. measurements.

Observations, Analysis & Results

Results presented in this section should be considered as preliminary.

Observations around HESS J1908+063 were first performed during June 2005 and then from May to September 2006 as part of the extension of the Galactic plane survey in the range of galactic longitude and latitude of $30° < \mathrm{l} < 60°$ and $-3° < \mathrm{b} < 3°$, respectively. Followup observations were made during May and June 2007. In the available data-set the source is offset from the field of view center, at different angular distances with an average offset of 1.4°. Observations for which the source is offset by more than 2.5° were not considered for the analysis. The total dead-time corrected and quality selected data-set amounts to 14.9 hours with the zenith angle ranging from 30 to 46° and with a mean energy threshold of $\sim$300 GeV.

After calibration, the standard H.E.S.S. event reconstruction scheme was applied to the data [4]. In order to reject the background of cosmic-ray showers, γ-ray like events were selected using cuts on image shape scaled with their expected values obtained from Monte Carlo simulations. As described in [5], two different sets of cuts, depending on the image size, were applied. Cuts optimized for a hard spectrum and a weak source with a rather

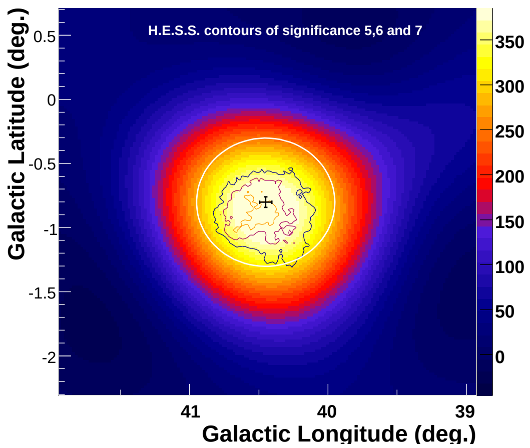

Figure 1: Smoothed excess map ($\sigma = 0.5°$) of the $1.5° \times 1.5°$ field of view around the position of HESS J1908+063. The contours show the pre-trials significance levels for 5, 6 and 7σ, while the white circle shows the $0.5°$ integration radius used for the spectrum derivation.

tight cut on the image size of 200 p.e. (photoelectrons), which achieve a maximum signal-to-noise ratio, were applied to study the morphology of the source, while for the spectral analysis, the image size cut is loosened to 80 p.e. in order to cover the maximum energy range. The background estimation (described in [6]) for each position in the two-dimensional sky map is computed from a ring with an (apriori) increased radius of $1.0°$, as compared to the standard radius of $0.5°$, in order to deal with the large source diameter. This radius yields four times a larger area for the background estimation than the considered on-source region. Also events coming from known sources were excluded to avoid contamination of the background. For the spectrum analysis, the background is evaluated from positions in the field of view with the same radius and same offset from the pointing direction as the source region.

Fig. 1 shows the Gaussian-smoothed excess map for a size cut on the images above 200 p.e. The colored contours indicate the H.E.S.S. pre-trials significance contour levels for 5,6 and 7 σ. HESS J1908+063 was discovered first as a hot-spot within the standard survey analysis scheme [1] and was subsequently confirmed at 7.7 σ (pre-trials). A conservative estimate of the trials yields a post-trials significance of 5.7 σ.

To evaluate the extension and the position of the source, the sky-map was fitted to a simple symmetrical two-dimensional Gaussian function, convolved with the instrument PSF (point spread function). The best-fit position lies at $l = 40.45° \pm 0.06°_{stat} \pm 0.06°_{sys}$ and $b = -0.80° \pm 0.05°_{sta} \pm 0.06°_{sys}$, while the intrinsic extension derived is $\sigma_{src} = (0.21° + 0.07°_{sta} - 0.05°_{sta})$. As the shape of the source seems to depart from a symmetrical Gaussian, these values should be taken as first approximations.

The differential energy spectrum was computed within an integration radius of $0.5°$ (corresponding to the FWHM of the source size and shown as a white circle in Fig. 1) centred on the best-fit position by means of a forward-folding maximum likelihood fit [7]. The spectrum is well fitted with a simple power-law function (Fig. 2) with a hard photon index of $2.08 \pm 0.10_{\rm stat} \pm 0.2_{\rm sys}$ and a differential flux at 1 TeV of $(3.23 \pm 0.45_{\rm stat} \pm 0.65_{\rm sys}) \times 10^{-12}$ cm^{-2} s^{-1}. The integrated flux

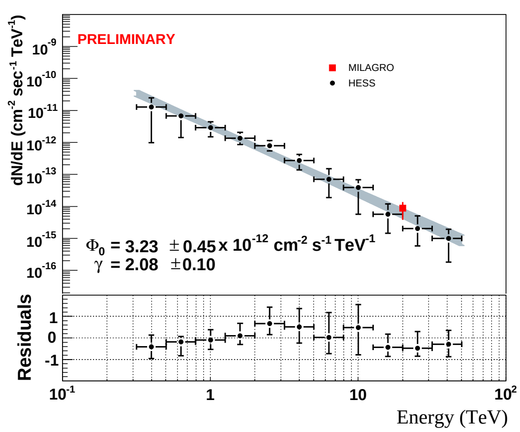

Figure 2: Differential energy spectrum measured above 300 GeV for HESS J1908+063. The shaded area shows the 1 σ confidence region for the fit parameters. The differential flux of MGRO J1908+06 at 20 TeV is shown in red. Fit residuals are given in the bottom panel.

above 1 TeV corresponds to 14% of the Crab Nebula flux above that energy.

Comparison with MGRO1908+06 & Search for Counterparts

Fig. 3 shows the $1.5° \times 1.5°$ field of view around the position of HESS J1908+063 together with sources at other wavelengths including MGRO J1908+06. The latter source was discovered by the MILAGRO collaboration [3] after seven years of operation (2358 days of data) at the galactic longitude and latitude of $l = (40.4° \pm 0.1°_{\rm stat} \pm 0.3°_{\rm sys})$ and $b = (-1.0° \pm 0.1°_{\rm stat} \pm 0.3°_{\rm sys})$, respectively. The differential flux, at the median energy of 20 TeV, and assuming a spectral index of -2.3, is at a level of $(8.8\pm2.4_{\rm stat}\pm2.6_{sys})\times10^{-15}$ $\rm TeV^{-1}cm^{-1}s^{-1}$. MGRO J1908+06 is reported to be both compatible with a point or extended source up to a diameter of 2.6°.

As clearly seen on Fig. 3, the positions of the two VHE sources are fully compatible within errors. There is also a quite good agreement between the differential flux at 20 TeV of MGRO J1908+06 and the spectrum measured by HESS as shown on Fig. 2. Given the larger integration radius of $1.3°$ for the MILAGRO source as compared to the $0.5°$ radius for HESS J1908+063, the flux agreement implies the absence of any other significant emission to the MILAGRO flux: the two sources can consequently be identified to each other.

The better determination of the position of HESS J1908+063 and the measurement of its size and spectrum allow to search for counterparts with stronger constraints.

At radio wavelengths, SNR G40.5-0.5 [8] at an estimated distance of 5.3 kpc overlaps with HESS J1908+063. At EGRET energies, 3EG J1903+0550, shown in green contours, lies close to the SNR and has been suggested as possibly associated with it [9]. However G40.5-0.5 is not in exact coincidence with HESS J1908+063 position and 3EG J1903+0550 is only marginally overlapping with the latter. HEGRA observations of this region of the sky [10] yielded an upper limit at 0.7 TeV at the SNR position of 4.8% of the Crab Nebula flux. As this limit only applies for a point-like source it is not in contradiction with the measurements reported here.

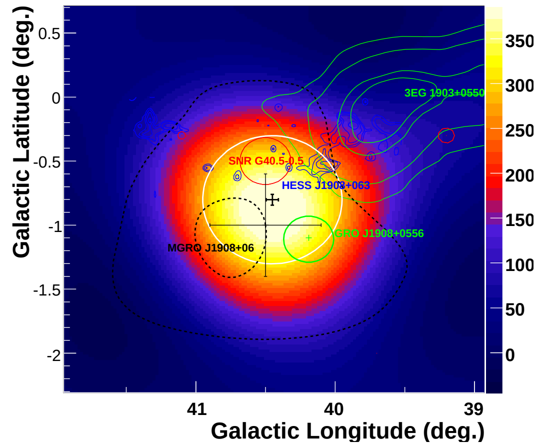

Figure 3: Multi-wavelength view of the $1.5° \times 1.5°$ field of view around the position of HESS J1908+063. The dotted black line shows the MILAGRO significance contours for 5 (inner) and 8σ (outer contour). The position of the EGRET GeV source GRO J1908+0556 is marked with a green cross as well as the 1σ error in the position. The 3EG 1903+0550 contours corresponding to 99, 95, 68 and 50% confidence levels are shown in green. The red circle marks the size and position of the radio-bright SNR G040.5-00.5. Contours in blue show the ^{13}CO molecular cloud in the velocity range between (45,65) km/s.

If the SNR is associated with the VHE source, the fact that the 22 arc-min size of the shell is smaller than the FWHM of HESS J1908+063 would contrast to previously discovered HESS sources identified with shell-type VHE emitters, such as RX J1713.7-3946 [11] or RCW 86 reported at this conference [12]. The contribution of nearby unresolved sources or interactions of accelerated cosmic rays with molecular matter in the vicinity of the source could explain a larger size. However, for the latter case, the position of the nearby ^{12}CO cloud [13] or alternatively the ^{13}CO contours (shown in blue on Fig. 3) do not favour this scenario.

An analysis of the highest energy photons (>1 GeV) observed by EGRET [14, 15] from this region shows a nearby and yet unidentified source, GRO J1908+0556/GEV J1907+0557. The positions of the two GeV derivations are compatible within errors. GRO J1908+0556, shown as a green circle on Fig. 3, lies within a distance of less than two times the EGRET 68% position measurement error to HESS J1908+063. A simple extrapolation of the H.E.S.S. spectrum to lower energies leads to a lower flux than that reported for the EGRET source ($6.33 \times 10^{-8}\ \mathrm{cm}^{-1}\mathrm{s}^{-1}$). However given the large PSF of EGRET even at GeV energies, other unresolved sources can contribute to the flux measurement of GRO J1908+0556. The association of the HESS and MILAGRO sources to the GeV source is then likely, although a coincidence by chance is not excluded.

Summary

In summary, a new source, HESS J1908+063 is reported above 300 GeV at the level of 14% of the Crab Nebula flux and a post-trials significance of 5.7 σ. The H.E.S.S. source is extended, with a FWHM size of 0.5°, and shows a hard spectrum with an index of 2.08±0.10. This detection confirms for the first time one of the low-latitude sources reported by the MILAGRO collaboration, MGRO 1908+062. A connection to the EGRET GeV source GRO J1908+0556/GEV J1907+0557 at lower energies remains possible. The association with SNR G40.5-0.5 is not excluded but the larger size of the TeV emission should then find an explanation in terms of either contribution of unresolved sources or interactions of ultra-relativistic particles with molecular matter in the vicinity of the SNR. Deeper observations of this region with Cherenkov telescopes and GLAST data would help the interpretation of the detected VHE emission.

Acknowledgments

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References

[1] F.A. Aharonian et al. (H.E.S.S. Collaboration). *ApJ*, 636:777–797, January 2006.
[2] S. Hoppe for the H.E.S.S. Collaboration. In *30th ICRC, Merida, Mexico*, 2007.
[3] A.A. Abdo et al. *astro-ph/0611691*, 2006.
[4] F.A. Aharonian et al. (H.E.S.S. Collaboration). *A&A*, 457:899–915, 2006.
[5] F.A. Aharonian et al. (H.E.S.S. Collaboration). *A&A*, 456:245–251, 2006.
[6] J.A.. Hinton et al. In *Cherenkov 2005, Palaiseau*, 2005.
[7] F. Piron et al. *A&A*, 374:895, 2001.
[8] D.A. Green et al. *A Catalogue of Galactic Supernova Remnants*, 2006.
[9] S. J. Sturner and C. D. Dermer. *A&A*, 293:L17–L20, January 1995.
[10] F.A. Aharonian et al.(HEGRA Collaboration). *A&A*, 439:635, 2005.
[11] F.A. Aharonian et al. (H.E.S.S. Collaboration). *Nature*, 432:75–77, November 2004.
[12] S. Hoppe & M. Lemoine-Goumard for the H.E.S.S. Collaboration. In *30th ICRC, Merida, Mexico*, 2007.
[13] J. Yang et al. *A&A*, 6:210, 2006.
[14] O.. Reimer et al. In *25th ICRC, Durban, South Africa*, page 97, 1997.
[15] R. C. Lamb and D. J. Macomb. *ApJ*, 488:872, 1997.