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Observations of VHE Gamma Radiation from HESS J 1813-178 with the MAGIC Telescope

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Recently, gamma radiation above a few hundred GeV has been detected from eight new sources in the Galactic Plane by the HESS collaboration [1]. The source HESS J 1813-178 (HESS1813) has caused particular interest as its nature was unknown. Subsequent radio observations imply an association with the SNR G12.82-0.02 [2]. The source has also been detected by the INTEGRAL and ASCA satellites [3, 4]. At La Palma this source culminates at a zenith angle (ZA) of about 47°. MAGIC has observed the source up to 52° ZA, for 20 hours in June and July 2005. The large zenith angle observations lead to a good sensitivity for energies in the TeV range. The observation confirms the VHE gamma emission from HESS J 1813-178. A preliminary flux determination yields a flux above 300 GeV of about 6% of the Crab flux with a rather hard spectrum.

1. Introduction

In the galactic plane scan performed in 2004 by HESS [1], eight new sources have been detected. One of the newly detected gamma-ray sources is HESS J 1813-178 (HESS1813). Initially it was assumed to be a “dark particle accelerator” as no counter parts at other wavelengths had been identified.

Since the original discovery, HESS1813 has been associated with the SNR G12.82-0.02 [3, 4, 2]. Figure 1 shows a VLA 20 cm image of the region around G12.82-0.02 [2]. The location of HESS1813 is indicated as the smaller circle. The chance probability for spatial coincidences with a SNR in this region is non-negligible (6%) [1].

(RA, dec), epoch J2000.0	$(18^h 13^m 23^s, -17°56')$
heliocentric distance	≥ 4 kpc (1 deg = 70 pc)
shell diameter	0.03 deg
observation zenith angle at La Palma	$47° \leq$ ZA $\leq 52°$

Table 1. Observational parameters of SNR G12.82-0.02.

HESS J1813-178 has been found to be nearly point like. A brightness distribution $\rho = exp(-r^2/\sigma^2)$ with a size $\sigma = 3'$ has been reported [1]. The source lies at 10 arc min distance from the center of the radio source W 33. W 33 has an extension of at least 15 arc min, with a compact radio core (G12.8-0.2) that is 1 arc min across [5]. This patch in the sky is highly obscured and has indications of being a recent star formation region [6].

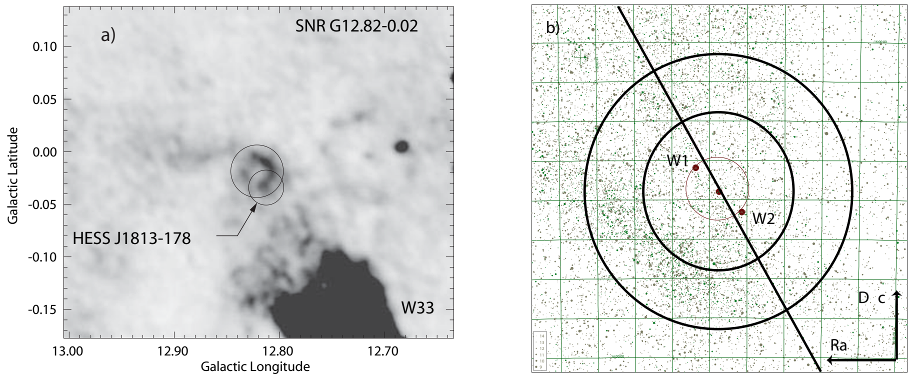

Figure 1. *(a) VLA 20 cm image of SNR G12.82-0.02 (indicated by the larger circle). The bright nearby HII region W33 can be seen at the lower right [2]. (b) The star field around HESS1813. Stars up to a magnitude of 14 are shown. The two big circles correspond to distances of 1° and 1.75° from HESS1813, respectively. The wobble positions W1 and W2 are given by the full circles. The x axis is pointing to the direction of decreasing RA, the y axis into the direction of increasing declination. The grid spacing in declination is 0.5 degree.*

2. Observations

The Major Atmospheric Imaging Cherenkov telescope (MAGIC [7, 8]) is currently the largest single dish Imaging Air Cherenkov Telescope (IACT). Located on the Canary Island La Palma ($28.8\,°$N, 17.8°W, 2200m a.s.l), the telescope has a 17m diameter tessellated parabolic mirror, supported by a light weight carbon fiber frame. It is equipped with a high efficiency 576-pixel $3.5\,°$ FOV photomultiplier camera. The analogue signals are transported via optical fibers to the trigger electronics and are read out by a 300 MSamples/s FADC system.

In La Palma HESS1813 culminates at about $47°$ ZA. The large ZA implies a higher energy threshold for MAGIC, of about 300 GeV, but it also provides a larger effective collection area [9]. This makes sensitive measurements in the multi-TeV energy regime possible.

The sky region around HESS1813 has a relatively high and non-uniform level of light of the night sky, see figure 1b). Within a distance of $1°$ from HESS1813 there are no stars brighter than mag = 8. In the region south west of the source the star field is brighter. This together with the large ZA requires either observations in the false-source tracking (wobble) mode [10] or to take dedicated OFF data. The sky directions (W1, W2) to be tracked in the wobble mode are chosen such that in the camera the sky field relative to the source position (HESS1813) is similar for both wobble positions, see figure 1b). The source direction is $0.4\,°$ offset from the camera center. During wobble mode data taking, 50% of the data is taken at W1 and 50% at W2, switching (wobbling) between the 2 directions every 30 minutes.

3. Data Analysis

HESS1813 was observed for a total of about 20 hours in June-July 2005 in the so called wobble mode (ZA $\leq 52°$). In total, about 15 million triggers have been recorded. Image cleaning tail cuts have been applied: Pixels are only considered to be part of the image if their reconstructed charge signal is larger than 10 photo electrons (core pixels) or larger than 5 photo electrons (boundary pixel) and they are neighbors of a core pixel. After filter cuts about 10 million events remained. These data were processed for the γ/hadron separation.

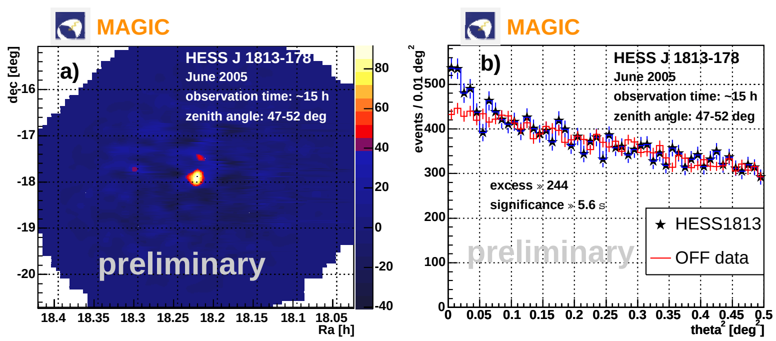

Figure 2. *(a) Sky map of candidate gamma-ray excess events in the directions of HESS1813. (b) Distributions of* θ^2 *values for the source and anti-source, see text, for SIZE* ≥ 300 *photo electrons (corresponding to about 300 GeV) and a hadronness*< 0.15.

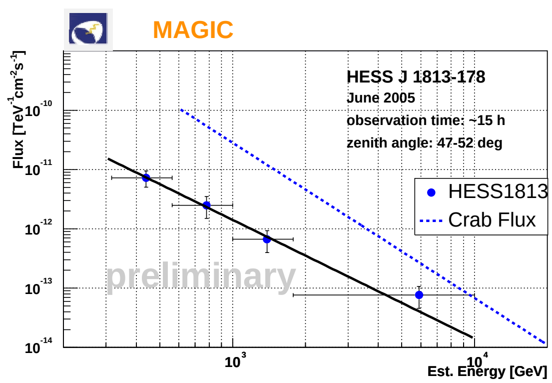

Figure 3. *Reconstructed VHE gamma-ray spectrum of HESS1813. The spectral index is* -2.0 ± 0.8 *and the integral flux above 315 GeV is about 6% of the Crab nebula (statistical errors only). The upper curve shows the spectrum of the Crab nebula as measured by MAGIC [14].*

We performed this analysis similar to the one described in [11]. We used the Random Forest method [12] for the gamma hadron separation and the energy estimation. Every event is assigned an energy value and a parameter called hadronness $\in [0; 1]$ which is a measure for the probability to be a background event.

To train the Random Forest algorithm, high ZA (50° ZA) Monte Carlo (MC) gamma showers were generated with energies between 200 GeV and 30 TeV. The spectral index of the generated differential spectrum is -2.6, conforming with the energy spectrum of the Crab nebula. The MC sample was divided into two sub-samples. The algorithm was trained with one sub-sample of the MC gammas and a sub-sample of the wobble data which contains mainly background events with a negligible contamination with gammas. Subsequently, the algorithm was tested using the remaining samples of MC and wobble data. As training parameters we used the image parameters SIZE, WIDTH, LENGTH, CONC, and M3Long [13].

In order to develop and verify the analysis at high zenith angles, Crab data in the interesting ZA range around 50° have been taken in January 2005. From that sample, we determined the energy spectrum and found it to be consistent with existing other measurements, see figure 3, upper curve.

For each event the sky position is determined by using the so-called DISP-method [10, 16]. Figure 2a) shows the sky map of gamma-ray candidate excess events from the direction of HESS1813 with a lower SIZE cut of 300 photo electrons and a hadronness < 0.15. The size cut corresponds to an energy threshold of about 300 GeV. Figure 2b) shows the distribution of the squared angular distance, θ^2, between the reconstructed shower direction and the nominal object position. The observed excess in the direction of HESS1813 is compatible within errors with the measurement of HESS [1]. It is also compatible with a point source like emission.

Figure 3 shows the reconstructed VHE gamma-ray spectrum of HESS1813. No unfolding with the energy resolution of the detector has been applied yet. The spectral index $(\mathrm{d}N/(\mathrm{d}E\mathrm{d}A\mathrm{d}t) \sim E^{\Gamma})$ was found to be $\Gamma = -2.0 \pm 0.8$ and the integral flux above 315 GeV corresponds to about 6% of the Crab nebula (statistical errors only). The results are still preliminary; the final analysis will be presented elsewhere.

4. Conclusions

The detection of HESS J 1813-178 using the MAGIC Telescope confirms a new VHE gamma-ray source in the Galactic Plane. A reasonably large data set was collected from observations at large zenith angles to infer the spectrum of this source up to energies of about 6 TeV. Between 300 GeV and 6 TeV the differential energy spectrum can be fitted with a power law of slope $\Gamma = -2.0 \pm 0.8$. The data can be used to cross-calibrate the HESS and MAGIC IACTs, and show satisfactory agreement.

Observations in the radio, X-ray and gamma-ray band imply a connection between HESS J 1813-178 and the SNR G12.82-0.02 [2, 3, 4]. Generally, hard gamma-ray spectra are expected from SNRs due to Fermi acceleration of cosmic rays [15]. The hard spectrum determined for HESS J 1813-178 may be a further hint for its association with the SNR G12.82-0.02.

Surveying the inventory of galactic VHE gamma ray sources puts models for the origin of cosmic rays into a new perspective. In particular, modeling the source distribution for propagation models that predict the Galactic diffuse emission will provide added value to these observations in the GLAST era.

Acknowledgements

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