Observation of VHE Gamma Radiation from Galactic Sources with the MAGIC Telescope

MAGIC Major Atmospheric Gamma Imaging Cerenkov Telescope

bmb+f - Förderschwerpunkt Astroteilchenphysik Großgeräte der physikalischen Grundlagenforschung

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During its first year of operation the MAGIC telescope [1] has observed, besides other sources, four galactic sources of VHE gamma radiation: the Crab nebula, the Galactic Center and two of the recently discovered sources HESS J 1813-17.8 and HESS J 1834-8.7 [2]. The steady flux of the Crab nebula provides a good reference to validate the analysis techniques, especially the spectral and spatial source reconstruction. The Galactic Center is a very interesting source as the acceleration mechanism of the VHE gamma radiation is still unknown and because the experimental results reported by CANGAROO and HESS are controversial. A few months after the initial discovery of HESS J 1813-17.8 and HESS J 1834-8.7 by the HESS experiment the VHE gamma-ray emission from these sources could be confirmed with the MAGIC telescope. Both sources spatially coincide with supernova remnants and allow to study the role of SNRs for the cosmic ray acceleration.

HESS J 1813-17.8:

HESS J 1813-178 (HESS1813) was initially assumed to be a "dark particle accelerator" as no counter parts at other wavelengths had been identified [2]. After the original discovery, HESS1813 has been associated with the SNR G12.82-0.02 [5,13,14].

Fig.2 shows the sky map of gamma-ray candidate excess events from the direction of HESS1813 with an energy threshold of 1 TeV. The most probable source position is (Ra,Dec)=(18h13^{m}25^s, -17°51'). The systematic pointing uncertainty of this observation of ~3' will in future be significantly reduced using the MAGIC starguider.

Fig.1 shows the reconstructed VHE gamma-ray spectrum of HESS1813 (significance 10.6σ). The spectral points are unfolded with the energy resolution of the detector. A fit to a power-law results in (preliminary):

$$\frac{dN_g}{dE_g dA dt} = \frac{(3.3 \pm 0.5)\ 10^{-12}}{cm^2\ s\ TeV} \left[\frac{E}{TeV}\right]^{-2.15 \pm 0.20}$$

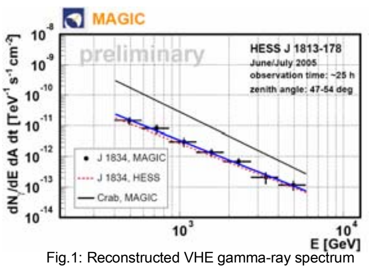


Fig.1: Reconstructed VHE gamma-ray spectrum

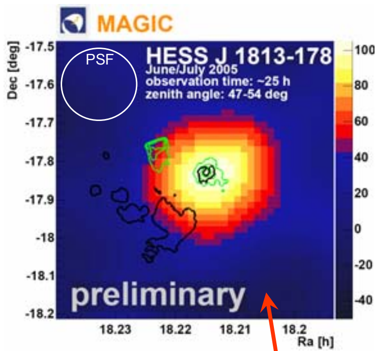


Fig.2: Sky map of VHE gamma ray excess events density. Black contours: 20 cm VLA radio data from [2], green contours: ASCA data from [3].

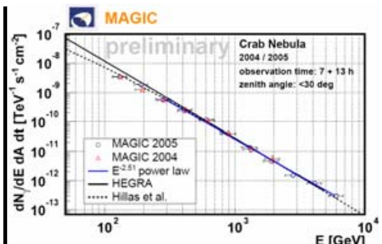


Fig.3: Reconstructed VHE gamma-ray spectrum

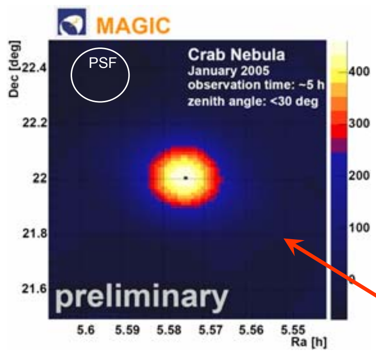


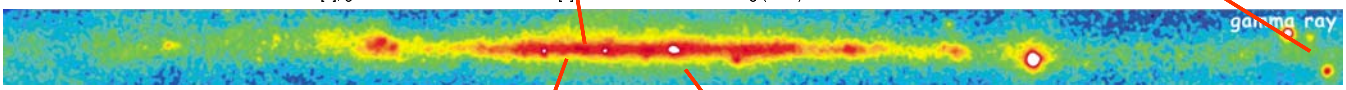
Fig.4: Sky map of VHE gamma ray excess events density, 250 GeV energy threshold. Point spread: 0.09 deg (2D σ).

The Crab Nebula:

The Crab nebula was the first source detected at TeV energies employing the IACT technique [10]. Its strong and stable gamma-ray emission makes it a standard candle in VHE astronomy. The Crab nebula has been extensively observed over a wide range of wavelengths up to nearly 100 TeV [6]. Nevertheless, various new physics results are expected in the VHE domain, e.g. the spectrum showing the IC peak close to 100 GeV or the verification of true flux stability down to the percent level.

A total number of 20 hours of data taken in 2004 and 2005 have been included in this analysis [11]. For the gamma/hadron separation and energy estimation, so-called Random Forest methods have been applied [12]. The analysis yields a signal of 20.4 $s/\sqrt{h}$. A fit with a power-law to the spectral points yields (preliminary):

$$\frac{dN_g}{dE_g dA dt} = \frac{(1.50 \pm 0.18)\ 10^{-3}}{cm^2\ s\ TeV} \left[\frac{E}{GeV}\right]^{-2.58 \pm 0.16}$$



HESS J 1834-08.7:

HESS J 1834-8.7 (HESS1834) is spatially coincident with SNR G23.3-0.3 (W41), a shell-type SNR of diameter 27 arc min [3]. Fig. 5 shows the sky map of gamma-ray candidate excess events from the direction of HESS1834 with an energy threshold of 500 GeV (6.8σ significance). The most probable source position is (Ra,Dec)=(18h 34^{m}38^s, -8°48'). The systematic pointing uncertainty of this observation of ~3' will in future be significantly reduced using the MAGIC starguider. The source is extended beyond the MAGIC PSF. It is interesting to study whether the VHE gammas are accelerated in the SNR shell or in the interior of the SNR, maybe by a compact object.

Fig.6 shows the reconstructed VHE gamma-ray spectrum of HESS 1834. The spectral points are not yet unfolded with the energy resolution of the detector. A fit to a power-law results in (preliminary):

$$\frac{dN_g}{dE_g dA dt} = \frac{(3.1 \pm 0.5)\ 10^{-12}}{cm^2\ s\ TeV} \left[\frac{E}{TeV}\right]^{-2.4 \pm 0.3}$$

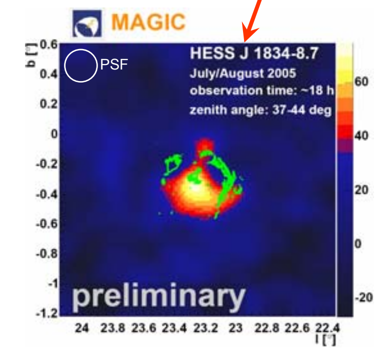


Fig.5: Sky map of VHE gamma ray excess density. Green contours: 20 cm VLA radio data from [3].

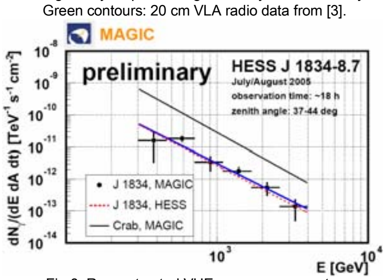


Fig.6: Reconstructed VHE gamma-ray spectrum

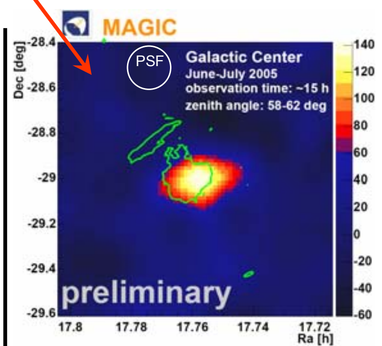


Fig.7: Sky map of VHE gamma ray excess density. Green contours: 20 cm VLA radio data from [4].

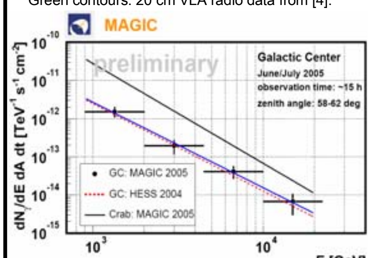


Fig.8: Reconstructed VHE gamma-ray spectrum

The Galactic Center:

First detections of the Galactic Center (GC) were made by the Cangaroo, Whipple and HESS collaborations [7-9]. The measured fluxes exhibit significant differences.

Fig. 7 shows the sky map of gamma-ray candidate excess events from the direction of the GC with an energy threshold of 1 TeV (6.3σ significance). The most probable source position is (Ra,Dec)=(17h 45^{m}20^s, -29°2'). The systematic pointing uncertainty of this observation of about 3' will in future be significantly reduced using the MAGIC starguider. The VHE gamma source location is consistent with the compact radio source SgrA*, still SNR SgrA East cannot be excluded.

Fig.8 shows the reconstructed VHE gamma-ray spectrum of the GC; it is consistent with the HESS measurements. The spectral points are unfolded with the energy resolution of the detector. A fit to a power-law results in (preliminary):

$$\frac{dN_g}{dE_g dA dt} = \frac{(2.7 \pm 0.9)\ 10^{-12}}{cm^2\ s\ TeV} \left[\frac{E}{TeV}\right]^{-2.2 \pm 0.3}$$

References:

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