

Results of Low Redshift AGN Observations with the HEGRA IACT System and Detection of 1ES1426+428 and 1ES1959+650

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Abstract

A search for TeV gamma-rays from a sample of nearby AGN (without Mrk-421 and Mrk-501) has been performed by the HEGRA Collaboration using the stereoscopic system of five Imaging Atmospheric Cherenkov Telescopes (IACTs) on the Canary Island La Palma. Here we present the results of approx. 650 hours of observation carried out from September 1997 to July 2001. The sample contains 35 AGN with redshifts up to $z=0.2$. The object 1ES1426 ($z=0.129$) was clearly detected at TeV-Energies, the object 1ES1959 exhibits strong indications for TeV emission at least in an active state. For the other objects we present upper limits on the TeV gamma-ray flux.

HEGRA AGN sample (without Mrk-421 and Mrk-501)

Object	z	Obs. time (h)	E_{thr} (TeV)	$E_{99\%}^{90\%}$ (Crab units)	Object	z	Obs. time (h)	E_{thr} (TeV)	$E_{99\%}^{90\%}$ (Crab units)
NGC0315	0.017	15.1	0.77	0.07	3C-197	0.128	16.3	0.80	0.05
NGC1275	0.018	92.2	0.69	0.02	1ES1426	0.129	36	0.79	0.05
1H1720	0.018	7.4	0.69	0.09	PG1219	0.130	4.1	0.69	0.16
HB89-2301	0.027	18.6	0.81	0.08	1ES1212	0.136	3.1	0.92	0.15
3C-120	0.033	25.7	0.79	0.05	1ES0229	0.140	3.4	0.78	0.18
UGC01651	0.037	15.3	0.66	0.05	MS1019	0.141	18.1	0.78	0.06
UGC03927	0.041	7.1	1.01	0.07	1ES1255	0.141	5.0	1.04	0.05
1ES2344	0.044	62.4	0.84	0.05	1ES0223	0.147	12.9	0.86	0.10
1ES1959	0.048	12.1	1.11	0.05	PG1408	0.151	19.1	1.15	0.04
4C3711	0.055	8.1	0.68	0.08	3C-273	0.158	13.2	1.09	0.10
6IZw187	0.059	17.3	0.78	0.06	1ES1440	0.162	12.7	0.75	0.06
1ES2321	0.059	36.5	0.72	0.04	BL0829	0.180	24.3	0.88	0.08
4C3104	0.060	3.4	0.65	0.09	1ES0927	0.188	14.0	0.78	0.05
BL-Lac	0.069	21.7	0.86	0.07	MS0317	0.190	2.7	0.67	0.13
1ES1741	0.083	10.6	0.80	0.09	HB89-2254	0.190	20.3	0.75	0.07
1ES1118	0.124	4.0	0.84	0.10	BL1011	0.200	2.7	0.86	0.07
1ES0145	0.125	5.3	0.78	0.07	1ES0120	0.272	18.1	0.75	0.03
EX00706	0.125	34.3	1.01	0.04					

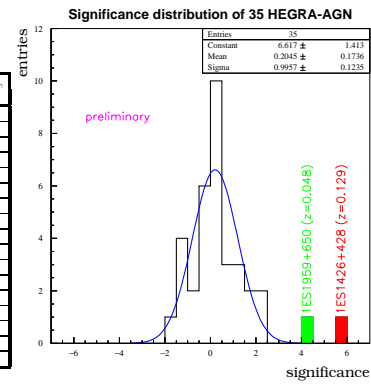


Figure 1. Distribution of significances for the excess in the signal region of all 35 objects from the HEGRA AGN sample. All significances have been computed with cuts optimized for pointlike emission ($m_{scw} \leq 1.1$, $\Delta\theta^2 \leq 0.012$). The curve was fitted excluding 1ES1426+428 and 1ES1959+650 and corresponds to the background expectation. Only 1ES1426+428 and 1ES1959+650 show clear evidence for a signal.

1ES1426+428 (z = 0.129)

Data analysis: 1999 and 2000 data after quality cuts: 36 hours. The data was taken in the so-called wobble mode [1]. Energy threshold E_{thr} approx. 700 GeV. The cuts were optimized for pointlike sources with Crab Nebula data.

Figure 2. The number of events versus the squared angular distance $\Delta\theta^2$ to the source position is shown: black points: data, broken blue histogram: background, blue line: mean background, vertical green line: signal region. A clear excess for $\Delta\theta^2 < 0.012$ is visible, corresponding to 5.7σ .

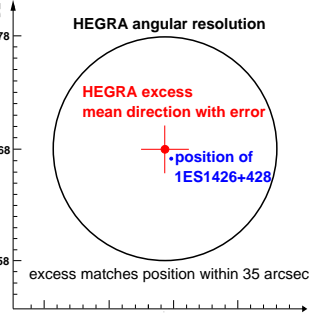
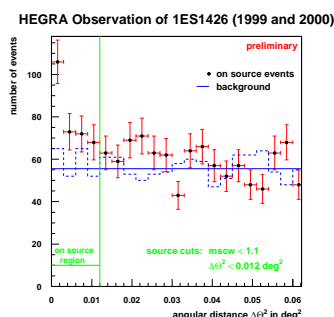


Figure 3. Mean direction with errors of the HEGRA excess (red), position of 1ES1426 (blue), HEGRA angular resolution (black circle). The HEGRA measurement matches the position of 1ES1426 by approx. 35 arcseconds, clearly within the errors.

The BL-Lac 1ES1426+428 ($z=0.129$) has been detected with approx. 5.7σ (1999+2000). This is the BL-Lac at largest distance observed so far in the TeV energy range. The mean direction of the excess matches the source position within 35 arcsec.

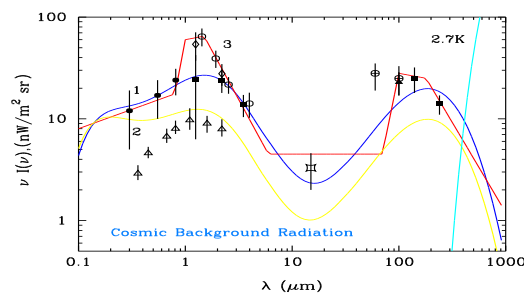


Figure 4. Spectral energy distribution of the cosmic background radiation (CBR). Measurements and models. 1 (blue): LCDM model of Primack [2] rescaled (factor 2) and sub-micron part suppressed in order to get better agreement with the HST data (agrees with revised calculations of Primack) 2 (yellow): LCDM model (without any scaling) 3 (red): Eye fit

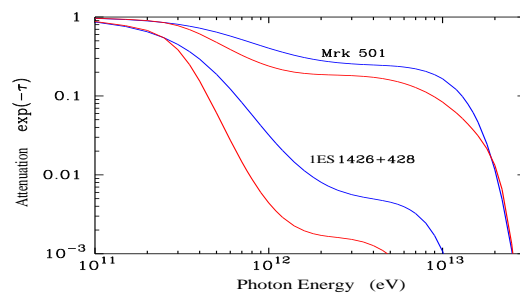


Figure 5. Attenuation of the γ -flux due to the interaction with the CBR through the process $\gamma_{TeV} + \gamma_{IR} \rightarrow e^+e^-$, for Mrk-501 ($z = 0.03$) and 1ES1426+428 ($z = 0.129$) for models 1 and 3 of Figure 4. The optical depth τ is for 1ES1426+428 already at 1 TeV very large ($\tau = 3.3$ for model 1).

The HEGRA preliminary spectral analysis shows a good agreement between the X-ray and gamma-ray spectra (within the one zone SSC model) taking into account significant intergalactic $\gamma\gamma$ absorption, and favors rather high near infrared fluxes at the level of 20 nW/m² sr at 1 micron.

1ES1959+650 (z = 0.048)

A preliminary analysis of the HEGRA data shows evidence (4σ) for an excess of TeV γ -ray emission from 1ES1959. The analysis is still in progress.

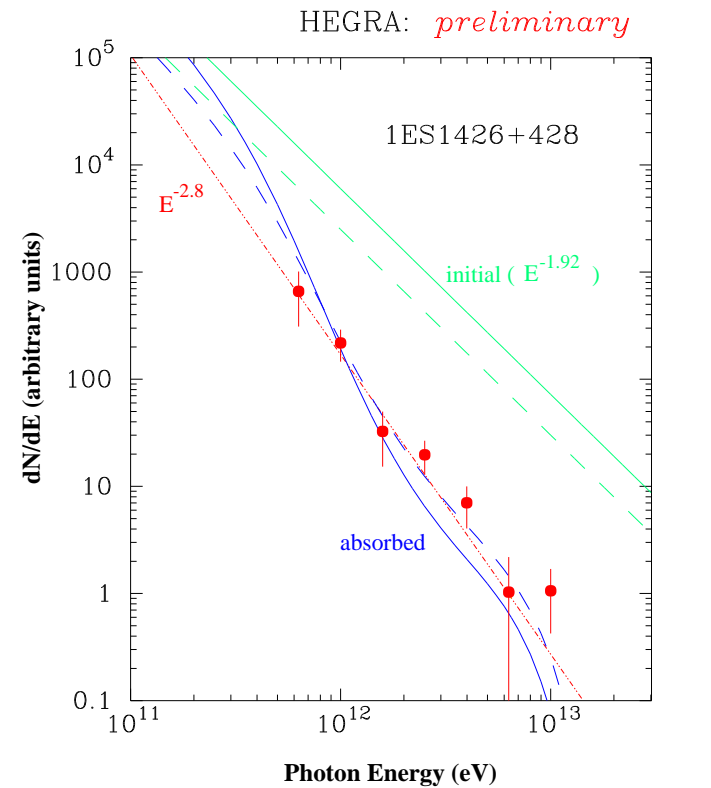


Figure 6. The differential energy spectrum of 1ES1426+428 (149 events):
red points: HEGRA data with error bars
dotted red line: power law fit of the HEGRA data with $E^{-2.8}$.
green: initial (source) spectra assumed to coincide with the X-ray spectrum (power-law with spectral index -1.92)
blue: after absorption (normalized to the data at 1TeV)
solid lines (green, blue): calculated for diffuse background model 1 in Fig. 4, (Hubble constant $H_0 = 60$ km/s Mpc)
dashed lines (green, blue): calculated for a value of CBR-flux/ H_0 decreased by 30%

References:

- [1] F. Aharonian et al. (the HEGRA Collaboration), 1997, A & A, 327, L5 – L8
- [2] J.S. Bullock et al. Astropar. Phys. 1999, vol. 11, 111

The support of the German Ministry for Research and Education BMBF and the Spanish Research Council CYCIT is gratefully acknowledged. We thank the Instituto de Astrofísica de Canarias IAC for the use of the HEGRA site at the ORM and for the excellent working conditions at La Palma.