First Results from Southern Hemisphere AGN Observations Obtained with the H·E·S·S· VHE Gamma-ray Telescopes

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Abstract

The first and second telescopes of the H·E·S·S· stereoscopic system are operating since June 2002 and February 2003, respectively. We will present the first results from a number of southern AGN observed using the first two H·E·S·S· telescopes, which already yield a significant sensitivity in mono-telescope mode, with a threshold for detection below that of other Imaging Atmospheric Cherenkov Telescopes. In this paper we report in particular on the first detection of an AGN by H·E·S·S·: the BL Lac object PKS 2155-304 was seen during July and October 2002 at a total significance level of 11.9 standard deviations (s.d.).

1. Introduction

The BL Lac object PKS 2155-304 is one of the brightest nearby blazars ($z = 0.116$) in the optical to X-ray range, and is a highly variable source. Numerous multi-wavelength observations (see e.g. [3]) have clearly shown the synchrotron nature of its emission which extends up to hard X-rays (e.g., see results from BeppoSax [2]). As its peak synchrotron frequency lies at UV/soft X-rays, PKS 2155-304 is classified as a High frequency-peaked BL Lac object or HBL [4].

PKS 2155-304 was first seen in the GeV γ-ray range by the EGRET detector [10] aboard the satellite C-GRO, exhibiting a hard spectrum with a differential index of 1.71 ± 0.24. It was thereby considered as a strong potential TeV source, despite its redshift for which estimations of the Extragalactic Background Light (EBL) absorption effects are significant. Chadwick *et al.* [1] reported its first detection in the TeV range with the Mark 6 telescope at Narrabri (Australia) at a level of 6.8 s.d. and a flux above 300 GeV of $4.2 \pm 2.1 \times 10^{-11}$ cm^{-2} s^{-1}.

We report here on observations made during July and October 2002 on PKS 2155-304 by the first H·E·S·S· atmospheric Cherenkov telescope operating at a threshold energy of $\sim$ 150 GeV. Its Davies-Cotton reflector has a focal length of 15 metres and an f/d of 1.2. It is made up of 380 60 cm diameter mirror facets, giving an effective reflecting area of 107 m^2. The camera is equipped with 960 PMs with a pixel size of 0.16° for a full field of view of $\sim$ 5° (see [6,11]). The

pp. 1–4

data-set and the analysis technique are presented in the next section. The results and detected signal are then given, and we conclude with a short discussion.

2. Data-set and Analysis

Observations of PKS 2155-304 started shortly after the first H·E·S·S· telescope became operational in June 2002. The data-set used here consists of 7 pairs of ON−OFF observation runs (ON being at the source position, and OFF at a control region displaced in Right Ascension) taken during four nights from July 15^{th} to 18^{th}, 2002, and 15 pairs taken from September 29^{th} to October 10^{th}, 2002, for an ON live-time of 2.18 and 4.7 hours, respectively.

Raw data, consisting of images of cosmic-ray showers, muons, and candidate γ-rays are first processed through a calibration chain, including pedestal subtraction, ADC-to-photoelectron (p.e.) gain scaling, flat-fielding, bad-channel filtering and image-cleaning (see [7]). Image shape and orientation parameters, obtained after a simple moments analysis [5] are then used to discriminate against the cosmic-ray background. The parameters retained for this discrimination are the length (L), width (W), distance (D), the ratio of the length to the charge in the image (LoverS or L/S), and the pointing angle, α — which is the angle at the image barycentre between the actual source position and the reconstructed image axis of the γ-ray candidate.

The cut values given in Table 1 were determined through an optimisation procedure where a simulated γ-ray spectrum with a differential index of -2.8 was tested against real background events (available from OFF-source runs). Simulated γ-ray images were obtained through full Monte Carlo simulations of showers in the atmosphere, and of the telescope response (see [9]).

The γ-ray efficiency and the overall background rejection factor obtained using the above cuts are respectively $\epsilon_\gamma = 25\%$ and $R_h \approx 4400$ with a corresponding quality factor $QF = \epsilon_\gamma \times \sqrt{R_h}$ of 16. Observations of the Crab, with cuts adapted to its low elevation transit, yield a rate of 3.6 γ min^{-1} and a significance per hour of 9.3 ([8]).

3. Results

Fig. 1 shows the pointing angle α-plots of ON and OFF-source cumulated data after selection cuts for the July and October 2002 data-sets. Excesses of 404

Table 1. Cut values: L, W and D are in mrad, L/S in mrad/p.e. and α in degrees.

Parameter	L	W	D	L/S	α
Upper cut	5.8	1.42	17	0.017	8°

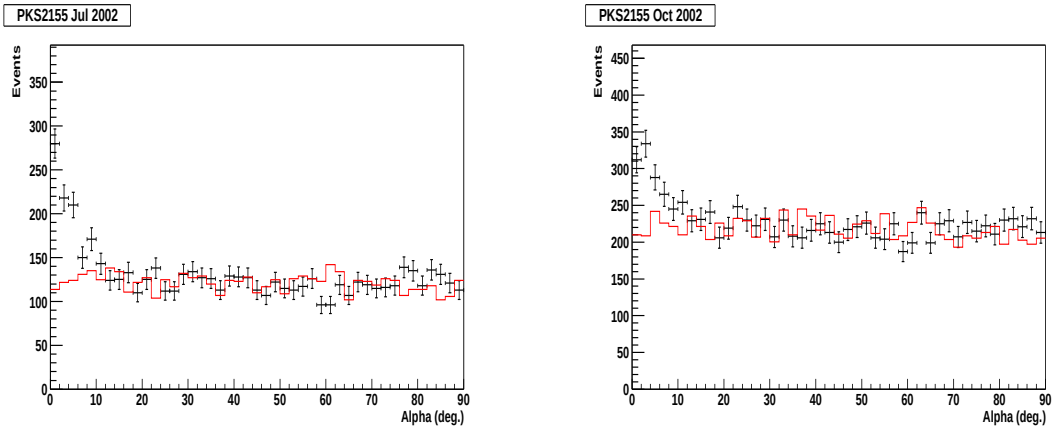

Fig. 1. The pointing angle α-plot of PKS 2155-304 observations for July (left panel) and October (right panel) 2002. The OFF-source distributions have been normalised to the control region between 30° and 90°.

Table 2. Live-time, number of ON and OFF events within the cuts, excess, rate and the significance for July and October 2002.

PKS2155	Ton	Non	Noff	Excess	γ min^{-1}	Significance
Jul 2002	2.2h	1029	625	404	3.1	9.9
Oct 2002	4.7h	1444	1107	337	1.2	6.6

and 337 events, corresponding to γ-ray rates of 3.1 and 1.2 γ min^{-1}, are observed at significance levels of 9.9 and 6.6 s.d, respectively for the two periods. Hence the TeV flux of PKS 2155-304, as measured by H·E·S·S·, decreased significantly over a period of about three months.

4. Discussion and Conclusion

Observations of PKS 2155-304 by the first H·E·S·S· telescope show a clear signal during July and October 2002, with a total significance of 11.9 s.d., and mark definitely this source into the still-short list of confirmed extragalactic TeV sources, together with Mkn 421 (z=0.031), Mkn 501 (z=0.034), 1ES1959+650 (z=0.048) and 1ES1426+428 (z=0.129).

Comparisons of the detected rates during July, 3.1 γ min^{-1}, and October 2002, 1.2 γ min^{-1}, show a clear dimming of PKS 2155-304 (by a factor ~ 3) in the latter period. Although the comparison of the weekly averaged X-ray count-rates for the two periods, as monitored by the *All Sky Monitor* on board the satellite RXTE, shows a slightly brighter source in July 2002, it has not been possible to make quantitative correlations between the X-rays and γ-rays due to the very

Table 3. Other extragalactic sources observed by H·E·S·S·

Source	Redshift	ExposureTime	Type
PKS0548-322	0.069	8	BL Lac
1ES1101-232	0.186	6	BL Lac
Mkn 421	0.031	1.6	BL Lac
M87	0.00436	24	NLRG
PKS2005-489	0.071	11	BL Lac

faint flux of the former.

This source, at an intermediate redshift (close to that of 1ES1426+428) in the growing catalogue of extragalactic TeV γ-ray sources, should provide further information on the link between the intrinsic spectrum of AGN sources and their absorption by the intervening EBL. The H·E·S·S· instrument is well-placed to measure such behaviour, as its low threshold can allow spectral information to be found in the energy region where absorption is almost negligible, while still being sensitive up to the highest γ-ray energies. An indication of the spectral behaviour, as compared to H·E·S·S· observations on the Crab Nebula, will be presented at the conference as well as results of observations on a number of other AGN which are listed in Table 3.

5. References

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