TeV Observations of Selected GeV Sources with the HEGRA IACT-System

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Abstract

Results from a search for TeV γ-ray emission from the vicinity of five X-ray-studied GeV sources is presented. A number of possible X-ray counterparts have been suggested based on ASCA and ROSAT observations (e.g. the SNR CTA 1, and X-ray binary LS I+61°303). Our search has yielded no convincing evidence for TeV emission at these GeV source positions and also a number possible counterparts. Preliminary upper limits in the range ~1% to 10% of the Crab flux have been estimated above various energy thresholds 0.7 to 1.3 TeV.

1. Introduction & Data Analysis

A number of EGRET sources visible above 1 GeV [8,10] were earlier studied in X-rays with ASCA [12], revealing possible counterparts. The large field of view (FoV) of the HEGRA IACT-System (Imaging Atmospheric Čerenkov Telescope System, see [11]) allows good coverage of many GeV sources even if they were not the original targets of observation. We have selected five of these GeV sources for further analysis:

GeV J0008+7304: This source could be associated with the nearby ($\sim 0.2^\circ$ distant) supernova remnant CTA 1 (radio shell $100'$ diameter) and may contain a radio quiet pulsar [3]. This pulsar may power the extended, centre-filled non-thermal X-ray emission from CTA 1. Our observations were centred on the ROSAT point source RX J0007.0+7302 [15]. Previous TeV observations by the CAT [7] and Whipple [5] collaborations give upper limits for CTA 1.

GeV J0241+6102: The GeV contours are quite consistent with the unusual X-ray binary LS I+61°303 [4]. An association with the COS B source 2CG135+01 in the past has led to various γ-ray production models for LS I+61°303. Our observations were centred on 2CG135+01.

GeV J1907+0557: This GeV source is located $\sim 2^\circ$ from the microquasar SS-433. ASCA studies reveal a weak source possibly comprised of two pointlike components within the GeV 95% contour. Our observations were taken from the HEGRA SS-433 archive.

GeV J2026+4124: ASCA studies reveal a single point source within the 95%

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contour. This GeV source is $\sim 1^\circ$ from Cyg X-3.
GeV J2035+4214: Two pointlike (possibly non-thermal, labelled Src1 & Src2) and one marginally extended (thermal, Src3) ASCA sources are seen within the GeV 68% contour. HEGRA observations of these latter two GeV sources come from the extensive archive on Cyg X-3 and TeV J2032+4130 [14].

In these analyses we employ the *mean-scaled-width* $\bar{w} < 1.1$ [2] cut as a means to reject the cosmic-ray background, and also a cut in the angular separation θ between reconstructed (employing the so-called 'algorithm 3' [6]) and assumed arrival directions for each event. A point-source search utilises a $\theta_{\rm cut} < 0.12^\circ$ cut. Extended sources with radius $\sigma_{\rm src}$ utilise a cut $\theta_{\rm cut} < \sqrt{\sigma_{\rm src}^2 + 0.12^2}^\circ$. A minimum of three telescope images per event $n_{\rm tel} \geq 3$ are demanded in calculating $\bar{w}$ and θ. The cosmic-ray background is estimated using the so-called *template* model [1,13]. Quite consistent results are also obtained using independent (e.g. so-called *displaced*) background models.

Table 1. Numerical results for various GeV sources and other positions of interest. The values s and b are respectively the source counts and background estimate from the template model.

Source	Obs. time [h]	$^a E_{\rm th}$ [TeV]	$\theta_{\rm cut}$ [deg]	s	b	α^b	S^c [σ]	$^d\phi^{99\%}$
		— GeV J0008+7304 —						
GeVJ0008+7304	26.0	1.3	0.120	72	615	0.114	**+0.2**	**0.74**
RXJ0007.0+7302	26.0	1.3	0.120	70	598	0.114	**+0.2**	**0.73**
CTA 1^e	26.0	1.3	0.195	181	1618	0.114	**−0.2**	**1.09**
		— GeV J0241+6102 —						
GeVJ0241+6102	28.8	0.8	0.120	55	338	0.130	**+1.5**	**1.74**
LS I+61°303	28.8	0.8	0.120	59	380	0.130	**+1.3**	**1.50**
		— GeV J1907+0557 —						
GeVJ1907+0557	114.1	0.7	0.120	183	1019	0.164	**+1.1**	**0.66**
AXJ1907.4+0549	114.1	0.7	0.120	187	1101	0.164	**+0.4**	**0.62**
		— GeV J2026+4124 —						
GeVJ2026+4124	275.0	0.7	0.120	541	3429	0.168	**−1.3**	**0.29**
AXJ2027.6+4116	275.0	0.7	0.120	771	4497	0.168	**+0.6**	**0.42**
		— GeV J2035+4214 —						
GeVJ2035+4214	275.0	0.7	0.120	784	4457	0.168	**+1.2**	**0.45**
AXJ2036.0+4218(Src1)	275.0	0.7	0.120	620	4005	0.168	**−1.8**	**0.22**
AXJ2035.4+4222(Src2)	275.0	0.7	0.120	663	4083	0.168	**−0.7**	**0.27**
AXJ2035.9+4229(Src3)	275.0	0.7	0.120	584	3626	0.168	**−0.9**	**0.28**

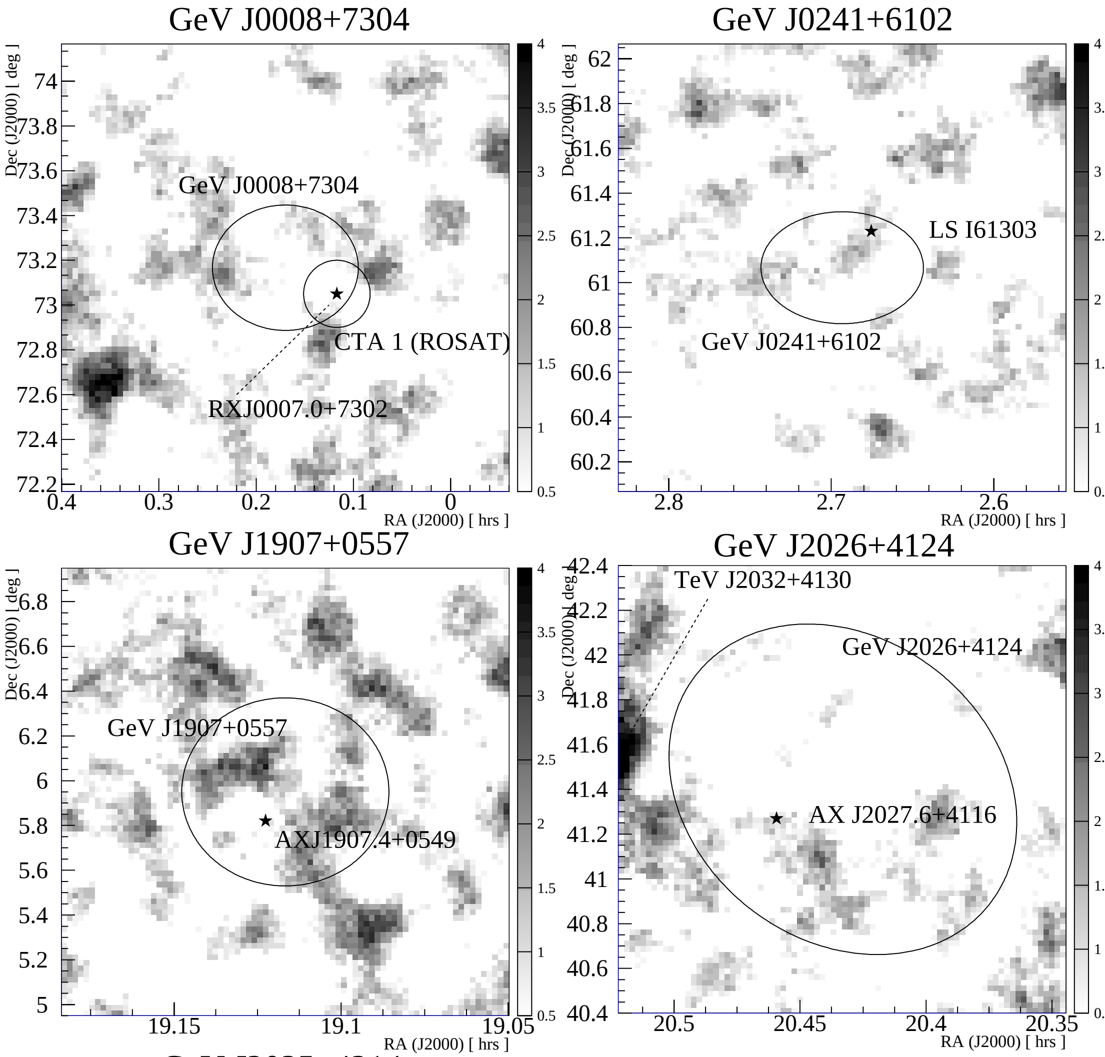
a. Estimated γ-ray threshold energy for mean zenith $\bar{z}$: $E = 0.5\cos(\bar{z})^{-2.5}$.

b. Normalisation factor for the background b.

c. Statistical significance using Eq. 17 of [9].

d. $\phi_{ph}^{99\%}$ =99% upper limit $E > E_{\rm th}$ [$\times 10^{-12}$ ph cm^{-2}s^{-1}]

e. For CTA 1, a radius $\sigma_{\rm src} = 0.153^\circ$ is used (the inner region for ROSAT spectral analysis [15]).



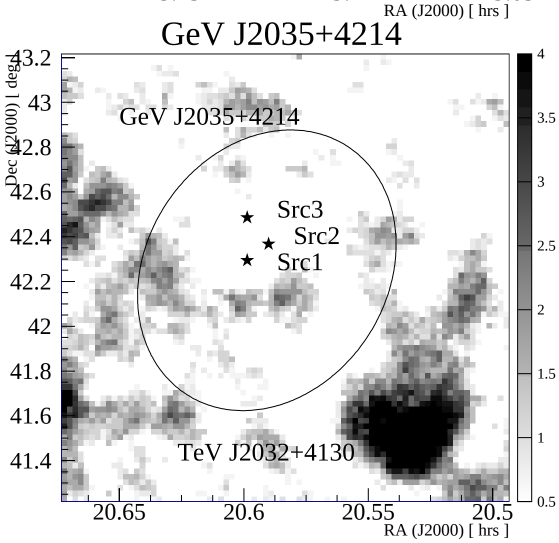


Fig. 1. Preliminary 2D skymaps of excess significance S (only $S \geq 0.5\sigma$ are shown) for $2^\circ \times 2^\circ$ FoV centred on the GeV sources (99% ellipse given). Events are integrated in a circle of radius $\theta_{\rm cut} < 0.12^\circ$ centered at positions over an $0.025^\circ \times 0.025^\circ$ grid. Other positions of interest according to the text are shown. In the GeV J2026+4124 and GeV J2035+4214 skymaps, the unidentified TeV source TeV J2032+4130 is clearly seen, somewhat 'clipped' since a maximum $S = +4\sigma$ is set.

2. Results & Discussion

As *a-priori* targets, we have chosen the ASCA sources identified by [12], some pre-identified objects (e.g. CTA 1, LS I+61°303 etc.), and also a point source centred on each GeV source (SIMBAD coordinates). Numerical results are presented in Table 1. and 2D skymaps of excess significances are given in Fig 1. For all of our *a-priori*-chosen positions, no convincing evidence for TeV emission was found. Upper limits at the 99% confidence level were estimated for each position using the expected Crab event rate from Monte Carlo simulations scaled according to an estimate of the γ-ray acceptance in the FoV. These preliminary upper limits are in the range 1% to 10% of the Crab flux at various energy thresholds ($E_{\rm th} \sim$ 0.7 to 1.3 TeV, based on the mean zenith angle of events). Further discussion and comparison with models will be presented at the conference.

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