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Observation of HESS J1303−631 with the CANGAROO−III telescopes

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Abstract: HESS J1303−631 is one of the unidentified TeV gamma-ray sources which H.E.S.S. group discovered as a diffuse source. We observed HESS J1303−631 between February and May in 2006 with the CANGAROO−III imaging atmospheric Cherenkov telescope system. After considering the weather conditions, the total live time was about 34 hours. Here we report our preliminary results of HESS J1303−631 observation.

Introduction

HESS J1303−631 was serendipitously discovered by H.E.S.S group in a dataset of the binary system PSR B1259-63/SS 2883 as an unidentified TeV gamma-ray source. The details of HESS J1303−631 were reported in Beilicke *et al.* (2005) [4] and Aharonian *et al.* (2005a)[2] as follows: HESS J1303−631 was found $0.^\circ6$ north of the binary system PSR B1259−63/SS 2883, which was also discovered at TeV energies by H.E.S.S group [3]. Detected gamma-ray region around HESS J1303−631 is extended with a width of an assumed Gaussian emission of $\sigma = 0.^\circ16 \pm 0.^\circ02$. The energy spectrum is a power-law with a photon index of $\Gamma = 2.44 \pm 0.05_{\rm stat} \pm 0.2_{\rm syst}$. The integral flux above $380\,\mathrm{GeV}$ was found to remain on a constant level of $17 \pm 3\%$

Crab flux during the H.E.S.S. observations period between February and March 2004. In X-ray range, HESS J1303−631 was observed with the Chandra X-ray observatory and the Swift X-ray Telescope. However no X-ray counterpart was found [13] [10]. Following the H.E.S.S. result, we have observed HESS J1303−631 with the CANGAROO−III telescopes. Here we report the preliminary result of CANGAROO−III observations.

Observations

Observations of HESS J1303−631 were carried out between February and May in 2006 with the CANGAROO−III imaging atmospheric Cherenkov telescope system in Woomera, South Australia (136°47'E, 31°06'S, 160 m a.s.l.). The telescopes use altitude-azimuth mounts. Each reflector has a parabolic shape with the diameter of 10 m and the focal length of 8 m. It consists of 114 identical spherical mirror facets with a 80 cm diameter [8]. The imaging camera at the focal plane of the telescope consists of 427 photo-multiplier tubes (PMTs) of 0.°17 size and a total field of view of about 4° [7]. These observations were done using three (T2,T3 and T4) of the four telescopes. The telescopes are located at the west(T2), south(T3) and north(T4) corners of a diamond with sides of about 100 m. Data were recorded for each telescope, when more than four PMT signals exceeded 7.6 photoelectrons (p.e.) in any two telescopes. The details of the global trigger system were given elsewhere [9] [12] and the details of the CANGAROO−III were described in Mori *et al.* (2007)[11].

The position of HESS J1303−631 is Right Ascension(R.A.) 195.°751 and declination −63.°199 [2]. In order to avoid TeV gamma-ray source of PSR B1259−63 within the background region, the data were taken in the R.A. wobble mode, where the source direction was shifted by $\pm 0.°5$ in Right Ascension from the center of the camera alternatively every twenty minutes. It was observed near its culmination at zenith angle of 32° and the mean zenith angle of the observations was 36.°6. A typical trigger rate of the three-fold coincidence was ∼12 Hz.

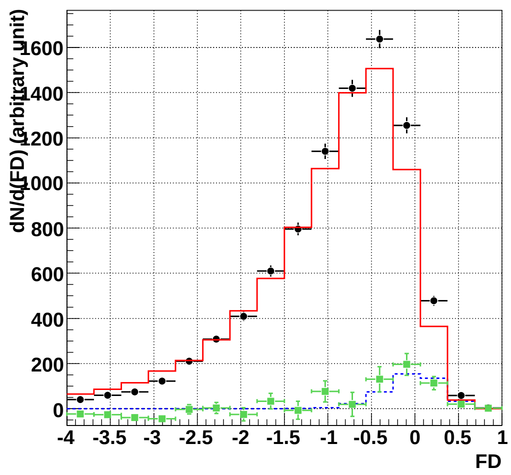

Figure 1: Preliminary Fisher Discriminant (FD) distributions for HESS J1303−631. The closed circle and square are those for on-source events and the background subtracted gamma-ray candidate events. Solid and dotted histogram are the best-fit FD distributions for background events and for MC gamma-ray events.

Analysis

The analysis procedures were described in Enomoto *et al.* (2006a) [5]. We calibrated the relative gain and the timing for each PMT using the LED data. After these calibrations, we selected the events of which timing of hit PMTs concentrate within ±30 nsec of the average shower timing to reject the accidental hit due to night sky background. Since some accidental hits were still survived from this timing cut and deforms imaging parameters, a "cluster" cut was applied to remove PMTs, retaining only PMTs exceeding ∼ 5 p.e. and having more than 5 adjacent hits. After these selections, the shower rate of the three-fold coincidence was ∼ 7 Hz. The effects such as clouds or dew were obviously reflected on the shower rate, hence the observation period affected by such bad weather conditions were perfectly removed using the shower rates. In this analysis, eventually the periods of which shower rate was less than 5 Hz were not used. Considering the DAQ dead-time, total live time of the three-fold coincidence data was 34.3 hours.

At first, *Hillas parameters* [1], "Width", "Length" and "Distance" were calculated for the events selected by the previous noise reductions. The arrival directions were reconstructed using the intersection of the image axes of the three telescopes. The intersection point was determined by minimizing the sum of squared widths of the three images seen from the assumed position with a constraint on the distances between image's center of gravity and assumed intersection point considering the $Length/Width$ ratio. We rejected events with any hits in the outermost layer of the cameras (edge cut) in order to avoid deformation of the image. In this analysis, we allowed less energetic hit pixels on the "edge" layer if their pulse heights were less than that of brightest 15 pixels.

After event reconstruction, we applied the Fisher Discriminant (FD) method [14], used a linear combination of image parameter set of $\vec{P} = (W2, W3, W4, L2, L3, L4)$, where $W2, W3, W4, L2, L3, L4$ are energy corrected "Widths" and "Lengths" for the T2, T3, and T4. The details of the application of the FD method to our analysis were described in Enomoto *et al.* (2006b) [6] and this analysis method was checked using Crab nebula data taken in 2005.

For obtaining the FD distribution of gamma rays, the Monte Carlo simulation was carried out using the GEANT 3.21. In this simulation, atmospheric and detector conditions were included. Efficiencies of the light collection (reflectivity of mirrors, quantum efficiencies) of PMTs were estimated from a muon ring analysis [5]. The gamma-ray showers were simulated in the energy range from 500 GeV to 60 TeV with the initial differential power of -2.44 and were assumed to come from extended region with a single Gaussian of σ=0.$^\circ$16. These parameters were referred to the H.E.S.S. result [2]. These gamma-ray showers were simulated using the same variation of zenith angle as the actual observations.

For the background, we selected a ring regions around the source positions 0.2 $< \theta^2[\mathrm{degree}^2] <$ 0.5, where θ is the angular distance from the source position.

Results

The FD distributions for HESS J1303$-$631 are shown in Fig. 1. The background subtracted gamma-ray candidate events (closed square) is well fitted by the best-fit FD distributions for MC gamma-ray events (dotted histogram). Figure 2 shows the preliminary θ^2 distribution by fitting the FD distribution. Figure 3 shows the smoothed morphology of gamma ray candidates from HESS J1303$-$631. The excess events were estimated by the FD methods in each sky bin of a 0.$^\circ$2 $\times$ 0.$^\circ$2 square. The dashed circle of 0.$^\circ$23 is the point spread function. Excess events from the direction of HESS J1303$-$631 are clearly seen, and it seems to be extended compared with point spread function.

These results are roughly consistent with H.E.S.S. results.

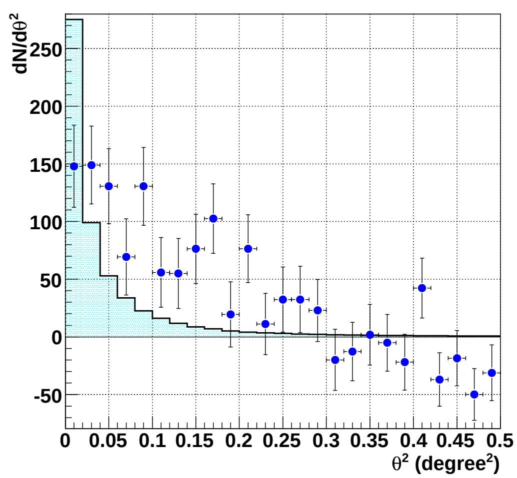

Figure 2: Preliminary θ^2 distributions for HESS J1303$-$631 using the FD method with fitted FD distribution. The closed circle is those for on-source events. The hatched histogram shows point spread function normalized to give the same number of ON-source events in $\theta^2 < 0.06$.

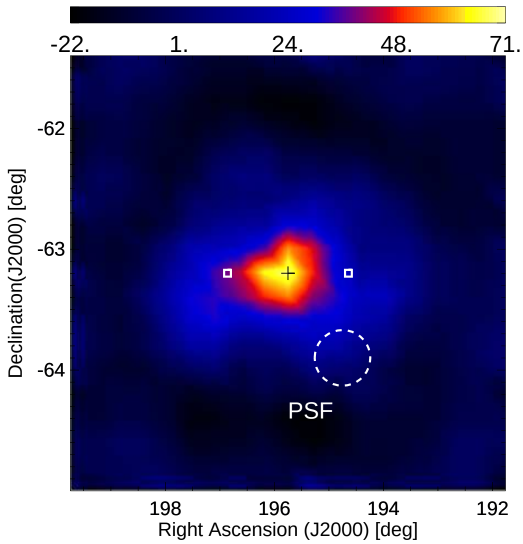

Figure 3: Preliminary smoothed morphology of gamma ray candidates from HESS J1303−631. The dashed circle of 0.°23 is the point spread function. The empty squares indicate the tracking positions.

Conclusions

We have observed HESS J1303−631 between February and May in 2006 with the CANGAROO−III telescopes, and successfully detected diffuse gamma-ray signals from the direction of HESS J1303−631.

Acknowledgments

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