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Observation of VHE gamma rays from HESS J1804-216 with CANGAROO-III Telescopes

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Abstract: The H.E.S.S. collaboration has reported the detection of the gamma-ray emission from eight new sources located in the Galactic Plane. HESS J1804-216 is one of the brightest, and its size and photon index suggest it as one of the largest and softest sources. We observed HESS J1804-216 with CANGAROO-III telescopes from May to July in 2006. We detected gamma-ray signals with $\sim 10\sigma$ level during an effective exposure of 74.8 hours. The differential flux and emission size are consistent with that of H.E.S.S..

Introduction

In the Galactic Plane scan performed by the H.E.S.S. Cherenkov array in 2004 with a flux sensitivity of 3% Crab units for gamma-rays above 200 GeV, eight sources were discovered [1]. HESS J1804-216 is one of the brightest and softest of them, the flux is about 24% Crab units above 200 GeV with the photon index of 2.72 ± 0.06. The size of 22 arc minutes is one of the widest extended sources. The H.E.S.S. collaboration proposed two possible counter parts, young Vela-like pulsar B1800-21 and the SNR G8.7-0.1, however it does not perfectly coincide with them. Recently, the discovery of new supernova remnant, G8.31-0.09, with radio observation was reported[2],which

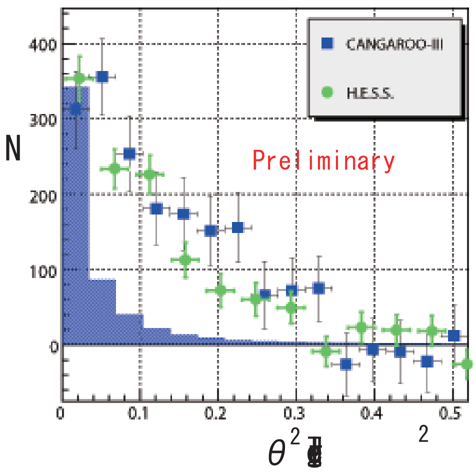

Figure 1: Distibution of squared angular distances θ^2. The blue plot is obtained by CANGAROO-III. The green plot is obtained by H.E.S.S. group[1]. The blue hatched histogram represents our point spread function.

located within its error circle of H.E.S.S., but with smaller size. Suzaku deep observations discovered new two X-ray sources, Suzaku J1804-2142(Src1) and Suzaku J1804-2140(Src2), centered on the HESS J1804-216[3]. SWIFT found three faint X-ray sources in the region of HESS J1804-216, one of them is near the center of HESS J1804-216, and its position coincides with Suzaku src2 [4]. However these sources don't morphologically match to the HESS source, therefore the origin is still unknown. Here, we present observations of HESS J1804-216 with CANGAROO-III telescope, and we briefly discuss the result with other wavelength observation.

Observation and analysis method

We observed HESS J1804-216 from May to July in 2006. This observation was done using the so-called wobble mode in which pointing position of each telescope was shifted in declination ± 0.5 degree from the center of HESS J1804-216. The mean zenith angle of the observation was 21 degree and the total observation time was about 90 hr. We used the 3-fold coincidence data which zenith angle was less than 40 degree. For eliminating the night sky background photons and selecting shower images, each pixel is required to have a signal larger than 5 p.e. with an arrival time within ± 30 nsec around the average shower timing. Images containing at least five adjacent pixels which pass the above requirements are selected. After these procedure, we require that none of the brightest 15 pixels of each image should be in the outermost layer of the cameras in order to avoid the deformation of the image due to the edge effect. Taking into account the DAQ dead-time, the effective live time is calculated to be 74.8hr. After the event reconstruction, the Fisher Discriminant method was applied for the gamma/hadron separation. We use the size-corrected $width$ and $length$ for each telescope as parameters. The background level was estimated using all events in a ring around the source position which is chosen so that θ^2 is between $0.3°$ and $0.5°$, where θ is the angular distance from the source position. The details of the application of the Fisher Discriminant method to our analysis are explained in Enomoto et al.[5]. The primary gamma-ray energy is estimated from the number of detected photo-electrons based on Monte Carlo simulation. This relation depends on the zenith angle of the observations, therefore, the simulations include the the same variation of the zenith angle as the actual observations. The Monte Carlo simulation was carried out assuming a single power-law spectrum, $dF/dE \propto E^{-\Gamma}$, with an index of $\Gamma = 2.7$, as determined for HESS J1804-216 by the H.E.S.S. group[1].

Result

After the data analysis described in previous section, the preliminary θ^2 distribution (the square of the angular difference between the reconstructed arrival direction and the source position) is obtained by fitting the FD distribution for the on-source data with those for Monte-Carlo gamma-rays and control background data. It is shown in Figure 1. The blue points are obtained by this work, the green points are obtained by H.E.S.S. group[1]. The blue hatched histogram derived from the Monte-Carlo simulation of a point like

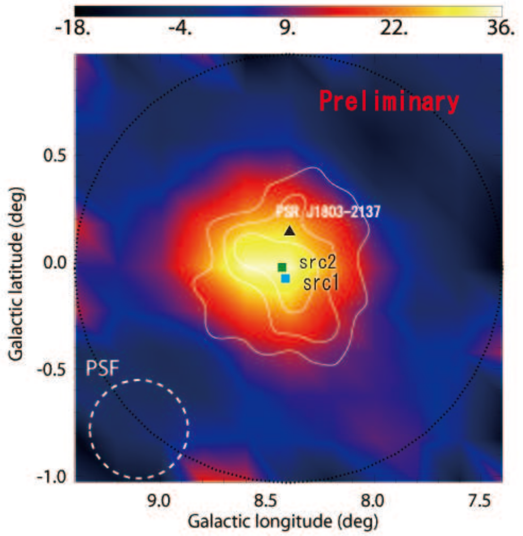

Figure 2: Morphology of TeV emission. The contour represents H.E.S.S. result[1]. The black triangle indicates the position of PSR J1803-2137[7]. The blue square and green square indicates the positions of Suzaku src1 and Suzaku src2, respectively[3]. Our PSF[6] of 0.23 degree radius circle is also shown in the bottom of the panel.

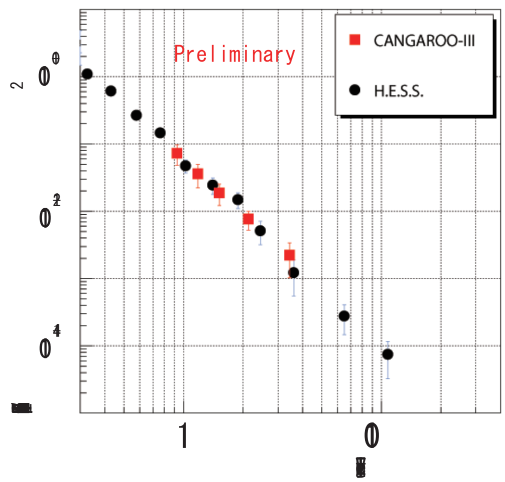

Figure 3: Differential energy spectrum. The red square is obtained by CANGAROO-III. The black circle is obtained by H.E.S.S. group[1].

source. We detected gamma-ray signals of $\sim 10\sigma$ level.

Figure 2 shows the sky map of gamma-ray candidates from the direction of HESS J1804-216. It is extended from our PSF (0.23°)[6].

For the spectral analysis, a sky region of the maximum angular distance of $\theta^2 = 0.13$ deg^2 around the excess center was integrated. Figure 3 shows obtained gamma-ray spectrum together with the result of H.E.S.S.. A simple power law spectrum is well fitted to the measured spectrum, the photon index is obtained to be $\Gamma = 2.7 \pm 0.4$. The flux is consistent within statistical errors with the measurement of H.E.S.S. made two year earlier.

Discussion and conclusion

The results of the independent observations of the H.E.S.S. and CANGAROO-III telescopes shows HESS J1804-216 is a quite extended. It rejects the possibility that HESS J1804-216 is an Active Galactic Nucleus. The major candidates seem to be SNR or PWN.

Figure 4 shows the multiwavelength spectrum of the sources which located within the region of HESS J1804-216, G8.31-0.09; observed by VLA[2], and Suzaku src1 and src2 [3]. The remarkable point of this figure is the large ratio of TeV gamma-ray to hard X-ray fluxes. Such a large ratio of the gamma-ray energy flux to the X-ray flux could occur in old supernova remnants (age of $\sim 10^5$ yr), where the electrons have already lost most of the energy, and only nucleonic cosmic rays are left over[8].

On the other hand, PWN is also possible other origin of the TeV emission. In fact, the PWN G18.0-0.7 around the Vela-like pulsar B1824-13 which likely associated with HESS J1825-137 has a large ratio of TeV gamma-ray to X-ray fluxes ~ 3.4 [9]. The TeV emission detected with HESS spatially covers a much larger area than the X-ray emission from G18.0-0.7. However, both the TeV and X-ray emission have similarly asymmetric shapes, and they are offset in the same direction with the respect to the pulsar position. A similar picture is observed around the Vela pulsar [10]. These phenomena can be explained by the ”crushed PWN”

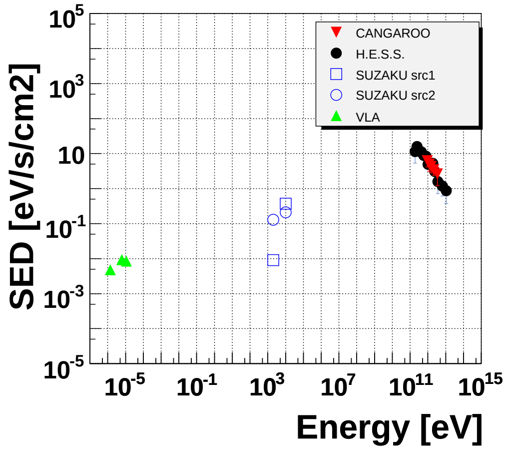

Figure 4: Spectral energy distribution. The references of data are given in the text.

hypothesis [11]. On a time scale $\sim 10^4$ yr, the reverse SNR shock front toward the center of the remnant, where it crushed the PWN, and asymmetries in the surrounding interstellar medium gives arise to asymmetries in the position of the PWN relative to the pulsar and explosion site. Recently, the X-ray emission from the young Vela-like pulsar B1800-21 and its synchrotron nebula was detected [12][13]. Its asymmetric PWN component extended toward HESS J1804-216, but the sensitivity of the Chandra observation was not enough to detect the PWN emission on a larger spatial scale. It could be detected in a deep XMM-Newton's exposure.

In conclusion, the observation of HESS J1804-216 with the CANGAROO-III telescopes confirms a very high-energy extended gamma-ray source in the Galactic Plane. The differential energy spectrum can be fitted with a power law, $\Gamma = 2.7 \pm 0.4$. The results of the independent observations of the H.E.S.S. and CANGAROO-III telescopes are in agreement within errors concerning the level of flux, the spectral shape, and the extension of the source. Recently, new detections around HESS J1804-216 in the multiwavelength have been reported, however the origin of this source is still unknown. Deeper observation in the radio and X-ray band will be needed to confirm this nature, and the GLAST observation may give us new information about it.

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