PROCEEDINGS OF SCIENCE

Study of the HAWC counterpart of LHAASO J1849-0003 and its surroundings at TeV energies

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LHAASO J1849-0003 is one of the twelve gamma-ray sources that can emit photons above 100 TeV reported by LHAASO in 2021. It is spatially coincident with HESS J1849-000, which may be powered by PSR J1849-0001. The High Altitude Water Cherenkov (HAWC) observatory has also observed a possible counterpart source named eHWC J1850+001 above 56 TeV. In this work, we use the most up-to-date HAWC dataset with 2398 days of data to perform dedicated multi-source modeling of the region around eHWC J1850+001. We present the spectrum and morphology of eHWC J1850+001 and other nearby sources identified during a systematic source search. We anticipate the HAWC observational results to determine a potential connection between HESS J1849-000 and LHAASO J1849-0003, providing a more complete TeV spectral study of this energetic source.

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1. Introduction

The High Altitude Water Cherenkov (HAWC) γ-ray observatory published the energy-HAWC catalog (eHWC) including γ-ray sources significant above 56 TeV [1]. One of them, eHWC J1850+001, has been reported near HESS J1849-000 with significant flux points in the energy range of 0.2 – 50 TeV [2]. Moreover, the Large High Altitude Air Shower Observatory (LHAASO) reported LHAASO J1849-0003 as one of the γ-ray sources emitting above 100 TeV, possibly having the same origin as HESS J1849-000 and eHWC J1850+001 [3]. Its maximum photon energy is calculated to be 340 TeV. The LHAASO collaboration recently reported 1LHAASO J1848-0001u in their first catalog, perhaps the same origin as their previous observation of LHAASO J1849-0003 [4].

Because of their spatial coincidence, a possible origin of those TeV γ-ray sources is PSR J1849-0001. The spin-down power and age of PSR J1849-0001 are 9.8×10^{36} erg/s and 43.1 kyr, respectively [5]. The existence of the PWN G32.6+0.5 embedding PSR J1849-0001 has been confirmed in a X-ray observation, and TeV γ-ray observation with H.E.S.S. [2, 6, 7]. There is no reported GeV γ-ray source by Fermi-LAT near those TeV sources [8].

2. HAWC gamma-ray observatory

The HAWC γ-ray observatory is a particle sampling array of 300 water Cherenkov detectors primarily intended for TeV γ-ray source observation [9]. Its location is the Sierra Negra, Mexico, at a high altitude of 4100 m, which is suitable for observing the northern sky (declination from $-26°$ to $+64°$). More details can be found in [9–11].

3. HAWC analysis

In this work, we carefully analyze the region around eHWC J1850+001 near the galactic equator. We used HAWC data, including 2398 days observations and a neural network energy estimator [10]. The analysis bin includes photons with estimated energy greater than 1 TeV. We define a rectangular region of interest (ROI) around the galactic longitude $30° < l < 34.5°$ and latitude $-3° < b < 3°$.

We systematically resolve sources in the ROI by adopting the method developed by the Fermi-LAT collaboration [12]. The procedure first fits a diffusive background emission (DBE), including unresolved sources and the galactic diffuse emission. The morphological model of DBE is taken as the Gaussian with a width of 1° along the galactic equator. The spectrum of DBE follows a power-law function with a fixed index of -2.75 adopted from the previous HAWC galactic source searches [13].

We iteratively add a point source at the location of a hotspot in the residuals until no significant test statistic (TS) improvement. We iteratively change the point source to an extended source with a Gaussian morphological model to test if the detected sources have an extension. We found three extended sources following this process, as shown in Figure 1. Finally, we test other morphological (diffusion [14]) and spectral (log parabola, cutoff powerlaw) models for the sources found to be extended. The best model for the source of interest, HAWC J1849+0001, is a diffusion model for the morphology and a log parabola spectrum.

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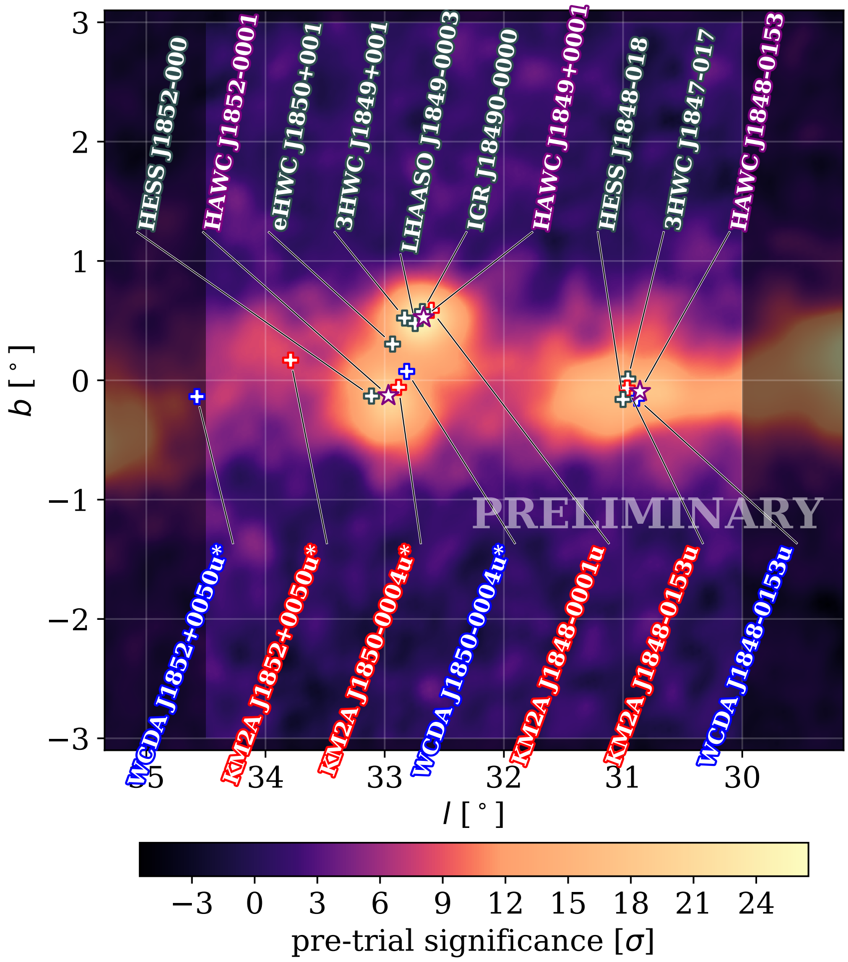

Figure 1: HAWC pre-trial significance map with an spectral index of -2.7 using data within 1 TeV – 316 TeV. The black labels are taken from TeVCat, and the purple labels are the three sources found from this work. 1LHAASO sources are denoted as WCDA (blue) and KM2A (red) by their independent measurement of positions.

4. Discussion

Figure 1 shows previously observed TeV γ-ray sources, represented by green crosses. The three sources that we detected (HAWC J1848-0153, HAWC J1849+0001, HAWC J1852-0001), denoted by purple star markers, are coincident with the three sources resolved both by H.E.S.S. and LHAASO, as shown in Table 1. The position of HAWC J1849+0001 is close to the positions of HESS J1849-000 (denoted as IGR J18490-0000 in TeVCat [15]), LHAASO J1849-0003 and 1LHAASO J1848-0001u [2–4]. Those sources are found to be extended sources. Note that 1LHAASO J1848-0001u was observed only in the KM2A data.

The angular distances (0.067°, 0.087°, 0.030°) of the possible counterparts (HESS J1849-000, 1LHAASO J1848-0001u, PSR J1849-0001) from HAWC J1849+0001 are smaller than 0.1°, the

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Table 1: TeV γ-ray sources from this work and their possible H.E.S.S. and LHAASO counterparts [2–4]. The best-fit positions are denoted in parentheses as right ascension and declination.

HAWC (This work)	H.E.S.S.	LHAASO
HAWC J1848-0153 (282.02°, −1.85°)	HESS J1848-018 (282.12°, −1.89°)	1LHAASO J1848-0153u (WCDA, KM2A) (282.06°, −1.89°), (282.02°, −1.78°)
HAWC J1849+0001 (282.27°, 0.01°)	HESS J1849-000 (282.24°, −0.04°)	LHAASO J1849-0003, (282.35°, −0.05°) 1LHAASO J1848-0001u (KM2A) (282.19°, −0.02°)
HAWC J1852-0001 (283.00°, −0.04°)	HESS J1852-000 (283.06°, 0.10°)	1LHAASO J1850-0004u (WCDA, KM2A) (282.74°, −0.07°), (282.89°, −0.07°)

best angular resolution of HAWC. Therefore, the three TeV gamma-ray sources from the different observatories are likely to have the same origin and to be associated with the PWN of PSR J1849-0001, producing TeV γ-ray through a leptonic process.

5. Conclusion

We report on the observation of HAWC J1849+0001 obtained by the multi-source fitting. HAWC J1849+0001 is found as log parabola spectrum and diffusion morphology. The best-fit position and flux points of HAWC J1849+0001 agree well with HESS J1849-000 and 1LHAASO J1848-0001u.

According to the positional association, it is likely that HAWC J1849+0001 and its TeV counterparts have a leptonic origin powered by PSR J1849-0001 embedded in the PWN G32.6+0.5. PSR J1849-0001 and its PWN have been observed only in X-ray and TeV gamma-ray. Using the multi-wavelength data may be possible to fit a leptonic emission model through synchrotron and inverse Compton scattering. The future prospects of this work are to test the PWN scenario and obtain a leptonic spectrum.

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