Form 8

Research Result Report
ICRR Inter-University Research Program 2024

Research Subject: Study of high-energy cosmic rays at a high altitude in Tibet, China
Principal Investigator: Ding Chen, Professor, National Astronomical Observatories of China, CAS, (China)
Participating Researchers:
Summary of Research Result :

1. Tibet AS + MD experiment

The Tibet Air shower array + Muon Detector array (AS+MD) experiment, which aims to develop gamma-ray astronomy in the 100 TeV region (10-1000 TeV), has been active. In FY2024, we continued to study 100 TeV gamma-ray sources.

We published the first detection of 23 diffuse gamma rays (>398 TeV) along the Galactic plane (<±10 degrees in Galactic latitude) in 2021 with a hybrid experiment of the surface air shower array and the underground muon detectors. There was no overlap between the direction circles with 0.5 degrees radius centered at the 23 events and the objects in the TeVcat catalogue as of 2021. However, some of the 43 sub-PeV gamma-ray emitting sources in the newly published 1LHAASO catalog as of 2023 and the Cygnus region were not masked, so we estimated their flux upper limits. (Figure 1: ApJ 977: L3, (2024)). We found that their contribution is subdominant to the sub-PeV Galactic diffuse gamma rays observed in the Tibet ASγ experiment. Figure 1 also shows that the contribution from unresolved sources of electron origin is also subdominant. Therefore, the most natural interpretation of the sub-PeV gamma rays along the Galactic plane observed in the Tibet ASγ experiment is that they originate from neutral pions produced by collisions of PeV cosmic rays stored in the Galactic cosmic-ray pool with the interstellar medium.

How much extent to which cosmic gamma rays and nuclear cosmic rays can be distinguished using only information from the surface air shower array in the Tibet ASγ experiment was investigated based on Monte Carlo simulations of gamma rays and cosmic rays from the Crab Nebula. The significance was improved by a factor of 1.3 to 1.8 using the Convolutional Neural Network method, from 10 TeV to 100 TeV. (Figure 2: Mach. Learn. Sci. Technol., 5:025016 (pp. 1–4) (2024).

2. Tibet AS + YAC experiment

The Tibet AS + YAC (Tibet air shower core detector array) experiment, which aims to observe the energy spectrum of each particle component in the knee region cosmic rays, is being promoted. The Tibet air shower core detector array (YAC-II), which consists of 124 air shower core detectors [burst detectors], is installed near the center of the Tibet Air Shower Observatory. In FY2014, electronics and data acquisition software were implemented, and YAC-II, which focuses on proton discrimination in cosmic rays in the Knee energy region, started data acquisition. In FY2023, software tools for analysis were actively developed using Monte Carlo simulations.

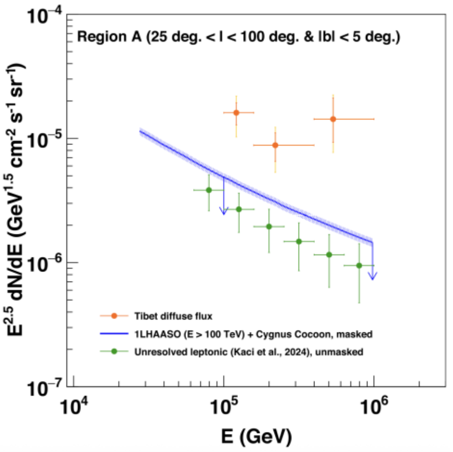

Fig.1 Inner-Galactic diffuse gamma-ray energy spectrum (red dots) observed by the Tibet ASγ experiment compared with the estimated flux upper limit from the Cygnus Region + new sources (>100 TeV) in 1LHASSO not masked by the Tibet ASγ experiment (solid blue curve). Green dots are the predicted from unresolved electron sources.

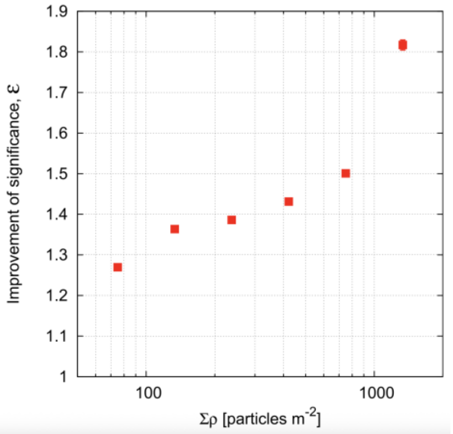

Fig.2 Improvement factor in the discrimination between gamma rays from the Crab Nebula and cosmic rays, as a function of energy ranging from 10 TeV (leftmost point) to 100 TeV (rightmost point), based on Monte Carlo simulations assuming the surface air shower array of the Tibet ASγ experiment. The Convolutional Neural Network method was employed for discrimination.

3. International Conferences

10 presentations at ISVHECRI2024, TeVPA2024, COSPAR2024 and others.

4. Publications

[1] S. Kato et al., ApJ, 977: L3(8pp), (2024).

[2] S. Okukawa et al., Mach. Learn. Sci. Technol., 5: 025016 (pp1-4), (2024).