Form 8

Research Result Report
ICRR Inter-University Research Program 2022

Research Subject: Study of high-energy cosmic rays at a high altitude in Tibet, China

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Participating Researchers:

Summary of Research Result :

1. Tibet AS + MD experiment

The Tibet-AS+MD experiment (Tibet Air shower array + Muon Detector array experiment), which aims to develop gamma-ray astronomy in the 100 TeV region (10-1000 TeV), has been actively done. In FY2022, we continued to develop a new software tool for data analysis. We focused on HESS J1843-033 as a gamma-ray source, which is a very high-energy gamma-ray source whose origin is still unknown. A gamma-ray source with an extension of 0°.34 ± 0°.12 was successfully detected above 25 TeV at (α, δ) = (281°.09 ± 0°.10, -3°.76 ± 0°.09) near HESS J1843-33. The statistical significance is 6.2σ and the source is named TASG J1844-038. The position of TASG J1844-038 is consistent with the positions of HESS J1843-033, eHWC J1842-035 and LHAASO J1843-0338. At 25 TeV < E < 130 TeV the measured gamma-ray energy spectrum is described by $dN/dE = (9.70\pm1.89) \times 10\text{-}16 \times (E/40\ \mathrm{TeV})^{-(3.26\pm0.30)}\ \mathrm{TeV}^{-1}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$ (Figure 1).Fitting our results with the combined spectra of HESS J1843-033 and LHAASO J1843-0338 suggests the presence of a cutoff at 49.5±9.0 TeV for TASG J1844-038. The correlation between TASG J1844-038 and nearby SNR G28.6-0.1 and PSR J1844-0346 is discussed in detail for the first time (ApJ, 932:120, pp1-8 (2022)).

Kurashige et al. performed a Monte Carlo simulation assuming the air shower array and the underground muon detector to estimate their sensitivity with respect to the energy spectrum of primary cosmic ray protons in the 40-630 TeV range. The results show that protons can be selected with 90% purity. The survival ratio of protons including model dependence is 14.2%-19.1% at about 35 TeV and 3.7%-7.4% at about

450 TeV. Systematic errors in the proton flux from hadronic-interaction and cosmic-ray composition models are estimated to be less than ±37%. With a significantly larger effective area than satellite experiments as well as high proton selection capability, the Tibet AS+MD experiment is able to observe the cosmic ray proton spectrum with high statistical accuracy over the energy range from tens to hundreds of TeV (Figure 2: PTEP 2022:093F01, pp1-15 (2022)).

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 FY2022, software tools for analysis were actively developed using Monte Carlo simulations.

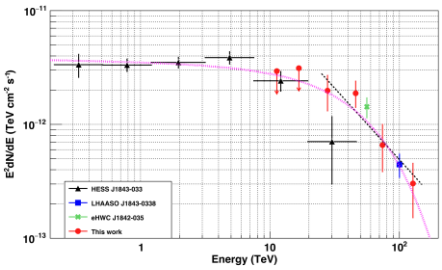

Fig.1 Gamma-ray energy spectrum from TASG J1844-038 observed by the Tibet AS+MD experiment (red circles: This work).

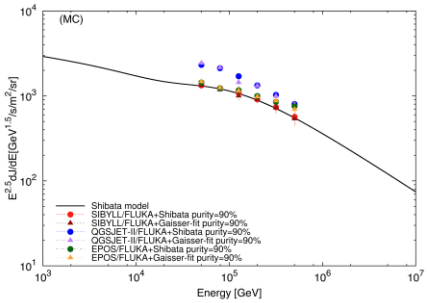

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Fig. 2 Predicted cosmic-ray proton energy spectra obtained from a Monte Carlo simulation of the Tibet AS+MD experiment, assuming two primary cosmic-ray composition models and three hadron interaction models.

3. International Conferences

13 presentations at ISVHECRI2022 and others.

4. Publications

[1] M. Amenomori et al., ApJ, 932:120, pp1-8 (2022).

[2] D. Kurashige et al., Prog. Theor. Exp. Phys. 2022:093F01, pp1-15 (2022).