

## Research Report

### ICRR Inter-University Research Program 2021

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

Principal Investigator: Ding Chen, Professor, National Observatories of China, CAS, (China)

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 FY2020, we continued to develop a new software tool for data analysis. For the first time in the world, we succeeded in observing sub-PeV galactic diffuse gamma-rays. Surprisingly, the 23 events above 400 TeV along the galactic disk come apart from any known TeV sources and are not accompanied by gamma-ray events above 10 TeV. They are orphan events in space and energy (see Figures 1). They are interpreted as gamma-ray events from  $\pi^0$  decay produced by PeV cosmic rays interacting with the interstellar matter. This is the first experimental evidence for sub-PeV gamma rays of cosmic ray origin, as gamma rays from inverse Compton scatterings of PeV electrons with the photon field would point back to an energetic source due to synchrotron radiation energy loss of PeV electrons. This is also the first experimental evidence for existence of PeVatrons in our galaxy. The result is available in PRL, <https://doi.org/10.1103/PhysRevLett.126.141101>. The paper was selected as Editors' Suggestion & VIEWPOINT which is given to 0.5 % of all the yearly APS publications. In addition, the result was press-conferenced at IHEP, China and other institutes as well as at APS.

We detect gamma-rays in the Cygnus OB1 and OB1 regions, as shown in Fig. 2. The result is available in PRL, <https://doi.org/10.1103/PhysRevLett.127.031102>.

#### 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 FY2013, 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 FY2020, software tools for analysis were actively developed using Monte Carlo simulations.

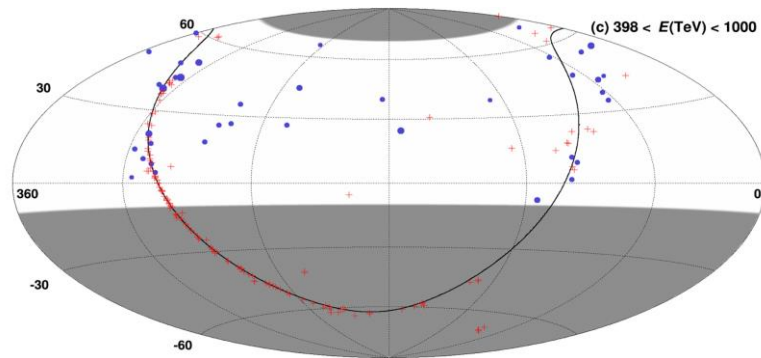


Fig. 1 Directional distribution (equatorial coordinates) of incoming gamma rays above 400 TeV (blue points) observed by the hybrid experiment of the Tibet air shower array and the underground muon detectors. Solid curve indicates the galactic plane, while the red crosses show the known TeV sources.

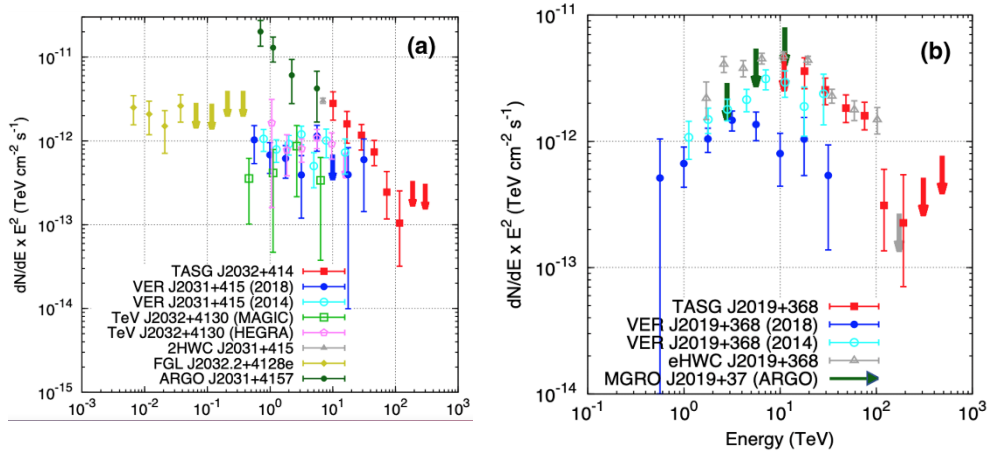


Fig. 2 Energy distributions of gamma rays observed by the hybrid experiment of the Tibet air shower array and the underground muon detectors (red points) for (a): Cygnus OB2 and for (b): Cygnus OB1, respectively.

### 3. International Conferences

10 presentations at ICRC2021 and others

No.

