

## 【Grant-in-Aid for Scientific Research (S)】

### Broad Section B



**Title of Project :** Study of origins and propagation of very high energy cosmic rays with detailed measurements in the wide energy range

OGIO, Shoichi

(Osaka City University, Graduate School of Science, Professor)

Research Project Number : 19H05607 Researcher Number : 20242258

Keyword : cosmic rays, chemical composition, origins of cosmic rays, the Galaxy, inter-galactic space, astrophysics

#### 【Purpose and Background of the Research】

The Telescope Array (TA) experiment in Utah, USA continues observations of very high-energy cosmic rays from 2008. The TA collaboration reported the cosmic ray energy spectrum in the wide energy range from 2 PeV to above  $10^{20}$  eV. The energy spectrum has complicated structures showing several kinks and dips rather than a simple power law. The galactic and extra-galactic components coexist in the lower energy range than  $10^{18}$  eV, and the spectrum of the extra-galactic component has convolved information of source spectra, the redshift evolution of sources, integration of energy losses during propagations and the shielding by the galactic magnetic field. In contrast, the spectrum of the galactic component has a convolution of the physics processes limiting the accelerated energy at galactic sources and the confinement of cosmic rays in the Galaxy.

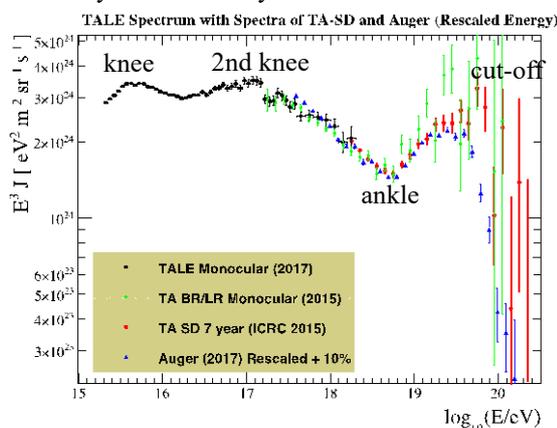


Figure 1: Cosmic ray energy spectrum plotted along with measurements by TA and by TALE, also shown is the Auger spectrum.

In order to unfold and resolve the convolved information in the galactic and the extra-galactic spectra, precise measurement for the chemical composition is essentially needed as well as a precisely measured energy spectrum.

#### 【Research Methods】

The TA experiment consists of the surface detector (SD) array of 700 km<sup>2</sup> coverage and 38 fluorescence detectors (FDs), and it continues operations from 2008 by an international collaboration of 35 institutes from six countries, such as Japan, USA, Korea, Russia, Belgium and Czech. In 2012, we started TA Low energy Extension (TALE) experiment additionally installing ten FDs pointing higher elevation, i.e., observing lower energy. In 2018, we constructed the TALE SD array with installing 80 SDs with

400 m spacing covering 30 km<sup>2</sup> at the bottom of the observation volume by the TALE FDs, and we developed the hybrid observation system for the SD array to be operated with FD-to-SD cross-trigger.

In this project, we will additionally install the other 50 SDs with 200 m spacing to make the hybrid threshold energy down to lower, to  $10^{15}$  eV.

#### 【Expected Research Achievements and Scientific Significance】

This is the world first experiment to cover the knee region and the very wide energy region from  $10^{15}$  to  $10^{20}$  eV with the FD-SD hybrid technique. We expect a precise composition measurement for galactic cosmic rays and to obtain precise data for studies of the galactic magnetic field, the galactic wind, the galactic halo, the cosmological evolution of the extragalactic cosmic ray origins.

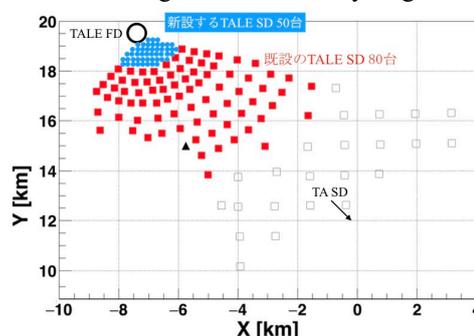


Figure 2: The layout of TALE and infill SDs

#### 【Publications Relevant to the Project】

R. U. Abbasi, et al., Ap. J., 865, 1(2018)  
R. U. Abbasi, et al., Ap. J., 858, 76(2018)

#### 【Term of Project】 FY2019-2023

#### 【Budget Allocation】 155,700 Thousand Yen

#### 【Homepage Address and Other Contact Information】

<http://www.telescopearray.org>  
<http://www-ta.icrr.u-tokyo.ac.jp>  
<http://www.cosmicray-ocu.jp>