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

Broad Section B

Title of Project： Long-term observations to study the origins of Galactic Cosmic Rays and search for Dark Matter with CALET

TORII, Shoji
(Waseda University, Faculty of Science and Engineering, Professor Emeritus)

Research Project Number：19H05608　Researcher Number：90167536
Keyword：high-energy cosmic ray, Galactic cosmic ray, nearby sources, dark matter, International Space Station

【Purpose and Background of the Research】

We are carrying out a precise measurement of cosmic rays in space with the CALET detector onboard the Japanese Experiment Module “KIBO” on the Inter- national Space Station. Launched in August, 2015, CALET (Fig.1) is a detector composed of a very thick (30 radiation lengths) calorimeter uniquely capable of containing and imaging high-energy cosmic-ray showers to enable observations of electrons up to the TeV region. CALET is also capable of measuring the charge of incident particles in the range of Z=1-40, and the spectra of the major primary heavy nuclei in the energy range from several tens of GeV to 1 PeV.

With this novel detector, we are achieving a high- precision measurement of the cosmic rays, at energies at which the observations have not yet successfully been accomplished. CALET addresses unresolved problems concerning the acceleration and propagation mechanisms of the Galactic cosmic rays and performs a new search for dark matter--one of the greatest puzzles in astrophysics.

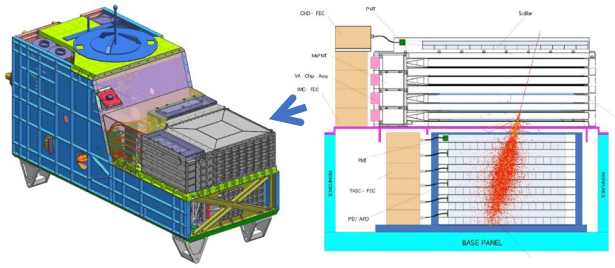

Figure 1: CALET overview (left) and side view of the calorimeter with a superimposed 1TeV electron shower simulation (right).

【Research Methods】

We set up the Waseda CALET Operations Center (WCOC) where the mission operations and data analysis are carried out by receiving the observed data from the Tsukuba Space Center at JAXA, transferred from the ISS. The raw data sent instantly are used for real-time monitoring, and the full analysis is performed on the data received at a frequency of once per one hour after correcting for data loss during transmission by the relay satellites. After calibrations and revisions of the data at the WCOC, the data volume is provided to the inter- national collaboration teams in Japan, Italy, and the US for independent scientific analysis. We also perform a quick analysis by using the raw data for transient astrophysical phenomena, i.e. gravitational wave events and gamma-ray bursts etc., to report the observations quickly to the science communities.

Scientific achievements are presented at international and domestic conferences as soon as possible, and important results are submitted to high-impact journals and made public on the collaboration Web pages.

【Expected Research Achievements and Scientific Significance】

Direct observations of cosmic rays made great strides in the 2000’s, bringing us a “standard model” of the acceleration and propagation mechanism of the Galactic cosmic rays. We will verify key concepts of the model for both electrons (leptons) and nuclei (hadrons) including their acceleration in supernova remnants and diffusive propagation through the Galaxy.

We will attempt to detect the acceleration limit expected in the 100 TeV region for the nuclear component, and search for nearby sources of electrons in the TeV region. Even if these searches are not successful, valuable limits to the source and acceleration components of the model will certainly be obtained. For the propagation model, we will measure precisely the fluxes of heavy nuclei up to nickel (Z=28) and the secondary to primary ratio, i.e. the boron/carbon ratio etc., over a wide energy range.

Moreover, we will perform a search for dark matter with a mass in the TeV range by looking for structures in the electron + positron energy spectrum.

【Publications Relevant to the Project】

・ “Extended Measurements of Cosmic-ray Electron and Positron Spectrum from 11 GeV to 4.8 TeV with the Calorimetric Electron Telescope on the International Space Station”, Y.Asaoka, S.Torii, *et al.* (CALET collabo -ration), Phys. Rev. Lett. 120, 261102 (7pp) (2018).

・ “Direct Measurement of the Cosmic-Ray Proton Spectrum from 50 GeV to 10 TeV with the Calorimetric Electron Telescope on the International Space Station", Y.Asaoka, P.S.Morrocchesi, S.Torii, *et al.* (CALET collaboration), Phys. Rev. Lett. 122, 181102 (2019).

【Term of Project】FY2019-2023

【Budget Allocation】154,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://calet.jp
torii.shoji@waseda.jp