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On-orbit operations and offline data processing of CALET onboard the ISS

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ABSTRACT

The CALorimetric Electron Telescope (CALET), launched for installation on the International Space Station (ISS) in August, 2015, has been accumulating scientific data since October, 2015. CALET is intended to perform long-duration observations of high-energy cosmic rays onboard the ISS. CALET directly measures the cosmic-ray electron spectrum in the energy range of 1 GeV to 20 TeV with a 2% energy resolution above 30 GeV. In addition, the instrument can measure the spectrum of gamma rays well into the TeV range, and the spectra of protons and nuclei up to a PeV.

In order to operate the CALET onboard ISS, JAXA Ground Support Equipment (JAXA-GSE) and the Waseda CALET Operations Center (WCOC) have been established at JAXA and Waseda University, respectively. Scientific operations using CALET are planned at WCOC, taking into account orbital variations of geomagnetic rigidity cutoff. Scheduled command sequences are used to control the CALET observation modes on orbit. Calibration data acquisition by, for example, recording pedestal and penetrating particle events, a low-energy electron trigger mode operating at high geomagnetic latitude, a low-energy gamma-ray trigger mode operating at low geomagnetic latitude, and an ultra heavy trigger mode, are scheduled around the ISS orbit while maintaining maximum exposure to high-energy electrons and other high-energy shower events by always having the high-energy trigger mode active. The WCOC also prepares and distributes CALET flight data to collaborators in Italy and the United States.

As of August 31, 2017, the total observation time is 689 days with a live time fraction of the total time of $\sim$84%. Nearly 450 million events are collected with a high-energy ($E > 10$ GeV) trigger. In addition, calibration data acquisition and low-energy trigger modes, as well as an ultra-heavy trigger mode, are consistently scheduled around the ISS orbit. By combining all operation modes with the excellent-quality on-orbit data collected thus far, it is expected that a five-year observation period will provide a wealth of new and interesting results.

1. Introduction

The CALorimetric Electron Telescope (CALET) [1], launched for installation on the International Space Station (ISS) in August, 2015, has been accumulating scientific data since October, 2015. CALET is primarily intended to discover nearby cosmic-ray accelerators and search for dark matter by precisely measuring all-electron (electron + positron) and gamma-ray spectra in a wide energy range from 1 GeV to 20 TeV. CALET includes a high-performance particle detector equipped with a thick large-area calorimeter. Onboard the ISS, CALET has been performing long-term observations for two years and is expected be operational for three or more additional years. A schematic overview of the CALET instrument is presented in the left-hand panel of Fig. 1.

CALET features a very thick calorimeter that incorporates imaging and total absorption calorimeters (see the right-hand panel of Fig. 1). A calorimeter of 30 radiation-length thickness completely absorbs the electron shower energy in the TeV energy range and identifies electrons from the overwhelming flux of protons using the difference in shower development in the fully active fine-sampling and thick calorimeter. Long-term observation using the large-area detector is provided by observation onboard the ISS. By combining all of these features, it becomes possible for the first time to precisely measure the all-electron spectrum up to 20 TeV. The main components of cosmic rays, such as protons, heliums, and heavier nuclei, can be measured past PeV. Including electrons and gamma rays, the ability to perform unique observations by extending the previous limits of direct measurements is expected.

In this paper, we mainly describe the operations and offline data processing of the main calorimeter. Details of processing CGBM data (after creating Level-1 data: see Section 4) are presented elsewhere [3,4].

2. The CALET detector system

2.1. Detector components

The CALET detector (see the right-hand panel of Fig. 1) consists of a Charge Detector (CHD), which identifies the charge of the incident particle [5,6], an IMaging Calorimeter (IMC), which reconstructs the track of the incident particle and finely images the initial shower development, and a Total AbSorption Calorime-