Abstract

The Cosmic-ray elemental spectra are important to understand the origin and acceleration mechanism of high-energy cosmic rays. The Cosmic Rays Energetics And Mass (CREAM) experiment [1] on the International Space Station (ISS) plans to measure nuclear and electron energy spectra precisely. The separation of electrons from protons is crucial because the proton flux is about 1000 times higher than that of electrons in the energy range 300 GeV – 800 GeV. The Top Counting Detector (TCD) and Bottom Counting Detector (BCD) are designed to optimize e/p separation. The TCD and BCD each consists of a plastic scintillator and an average of 400 photo-diodes, respectively. The TCD and BCD are located immediately above and below the calorimeter, respectively. This detector configuration provides a separation by using the different shapes of electromagnetic and hadronic showers. We have characterized the performance of the TCD/BCD in several different ways. The signal-to-noise ratio of the detector cell components was measured by using a 39Sr radioactive source and a high-energy beam at CERN. The temperature dependence of the detector cell component, from -40 °C to 70 °C, and the robustness of the TCD/BCD module were confirmed using thermal and vacuum chambers. We present the TCD/BCD design considerations and a summary of the measured performance of the TCD/BCD modules.

I. Introduction

The CREAM for the ISS (CREAM-ISS) instrument comprises a Silicon Charged Detectors, a carbon target, a tungsten/scintillator sampling calorimeter, a Top Counting Detector, a Bottom Counting Detector, and a Boronated Scintillator Detector.

The ISS-CREAM experiment [2] is planned to be installed on the ISS in 2014.

The TCD/BCD are designed to optimize e/p separation by using the different shapes of electromagnetic and hadronic showers.

Goals of TCD/BCD

Electron/proton separation for electron and gamma-ray physics

Provide redundant trigger for CREAM Calorimeter

Provide an MIP (Minimum Ionizing Particle) trigger for calibration

II. Design of TCD/BCD

TCD/BCD consist of a polystyrene/liquid plastic scintillator (EJ-200) and an array of 400 photo-diodes.

The photo-diodes were developed by Kyungpook National University.

- 650 μm thickness, n-type silicon wafers
- Operating voltage: -265 V
- TCD: 900 × 535 × 300 mm
- BCD: 960 × 651 × 33 mm

Dimension

- TCD: 900 × 535 × 300 mm
- BCD: 960 × 651 × 33 mm
- Mass
- TCD: 12 kg
- BCD: 16 kg

III. Radioactive Source Test

- Use 39Sr radioactive source for measuring the signal to noise ratio (SNR)

Setting values

- Biasing voltage for PMT: -700 V
- AMP setting: shaping time 3 μs, coarse gain 50, fine gain 0.5
- PD: -190 V
- The measured SNR = 13.0

SNR = (MPV, of signal - mean of pedestal) / sigma of pedestal

IV. Thermal/Vacuum test of the detector cell components

- Survival temperature: -40 °C to 70 °C
- The pedestal was measured during a full thermal cycle
- Setting value
- Thermal cycles: 11 hour period
- Biasing voltage for PD: -120 V
- Carried out a calibration test, to find the e RMS value that corresponds to one ADC count
- one ADC = RMS of 2063 e−

The value of e RMS reliably tracked the temperature change

V. CERN Beam Test

- The performance of the TCD/BCD prototypes was measured using electron, muon, and pion beam at CERN

Prototype TCD/BCD

- consist of 32 PD and a plastic scintillator

Using an all-purposes muon

50000 signal events

Prototype TCD/BCD

- The measured SNR was 7.1 on average

Since the SNR needs to exceed 5 for MIP identification, the prototype TCD/BCD showed good performance for MIP identification

VI. Conclusion

- We fabricated the PD’s for the TCD/BCD and attached them to the plastic scintillators.
- The TCD/BCD will measure the high-energy cosmic-electron by providing e/p separation for ISS-CREAM.
- The SNR of the detector cell component was measured to be 13.0 with a 39Sr radioactive source.
- The characteristics of the detector cell components were measured before/after thermal and vacuum tests.
- The value of the e RMS tracked well with temperature change.
- The leakage current value before/after the vacuum test did not change.
- The TCD/BCD can provide a MIP trigger for detector calibration.

VII. References