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Progress on Ultra-Heavy Cosmic-Ray Analysis with CALET on the International Space Station

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Abstract

The Calorimetric Electron Telescope (CALET), launched to the International Space Station in August 2015 and continuously operating since, measures cosmic-ray (CR) electrons, positrons, and relativistic gamma rays, with an emphasis on measuring nuclei with rigidity from 100 GV to 10 TeV. CALET utilizes a mass calorimetric charge detector to measure CR nuclei from 160 to 2000 TeV. In order to maximize the acceptance of the ultra-heavy (UH) CR showers, CALET utilizes a special high rigidity cut (100 GV < R ≤ 2000 GV) which is triggered with a minimum ionizing particle (MIP) signal and does not require passage through the 27 radiation length deep Total Absorption Calorimeter (TASC). This provides a 5 to 10 increase in geometric factor allowing CALET to collect in 5 years a UHCR dataset with statistics comparable to those from the first flight of the balloon-borne SuperKamiokande detector. However, the first year of the UH analysis shows a small abundance of even nuclei and the need for further improvements in the UH trigger analysis. The CALET calorimeter is comprised of three detector systems: the Cherenkov, the Imaging calorimeter, and the Total Absorption Calorimeter (TASC). The Cherenkov detector, which is 156.5 mm tall and 70 mm thick, is divided into 14 layers of plastic scintillator (PWO) which gives a determination of particle energy. In the Imaging calorimeter, which is 450 mm long, each paddle is 32 mm wide by 10 mm thick by 450 mm long. Provides the particle charge identification. The Total Absorption Calorimeter (TASC) is made of 5 x 6 m of lead and 16 lead tungstate (PWO) scintillator logs which gives a determination of particle energy. In this analysis cuts are done for:

- minimum total deposited TASC energy
- minimum TASC first and second layer energy
- charge consistency between CHD and ≤ 2% accuracy

UH CR data collected with CALET on the International Space Station

Figure 1: CALET instrument package detailing location of various CALET subsystems.

Figure 2: Solar System (SS) and Galactic cosmic-ray (GCR) relative abundances at 2 GeV/nuc. GCR data is smoothed by (1.2 - 2) GeV/nuc. 

Figure 3(a): Histogram of MIP charge assignments in the CALET calorimeter for charged cosmic-ray nuclei. 
Figure 3(b): TASC analysis histogram with multiple-Gaussian fit with integer charge means shown in Fig. 5a. By comparison with the histogram of multi-Gaussian fits, you can see that there is an improved resolution of higher charge peaks.

Figure 4: A charge histogram showing which each successive cut on the TASC data-set does step-by-step from a charge consistency cut that requires both the CHD and TASC energy cuts down to the final UH trigger energy cut.

Figure 5: Comparison of the relative abundances of the angular-resolution peak with SuperKGRS and ACU-CHD for iron from 222 to 1017. Errors here are statistically.

Conclusions

Preliminary abundances from CALET UH-trigger and TASC UHCR analyses continue to agree with previous CALET results and other instrument measurements. CALET continues to operate excellent data from the International Space Station, and it is expected to continue operating for several more years. This further data collection will continue to improve the CALET dataset and contribute to the total UHCR data set, and complement the measurements made by other balloon and space-borne instruments.

References


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