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ISS-CREAM detector performance and tracking algorithms

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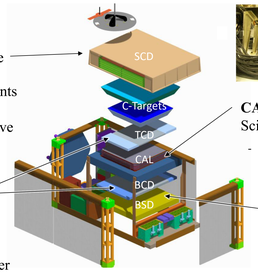
The ISS-CREAM experiment grew out of a balloon-borne instrument, CREAM, which measures the fluxes of elements between protons and iron in an energy region almost up to the knee.

1. ISS-CREAM instrument



Carbon Targets (0.5 λ_{int}) induce hadronic interactions

4 layer **S**ilicon **C**harge **D**etector
- Charge measurements
- 2.12 cm^2 pixels
- 79 cm x 79 cm active detector area

CALorimeter (20 layers W + Scintillating Fibers, 1.0 λ_{int})
- Provides energy, tracking, and trigger

Top & **B**ottom **C**ounting **D**etectors
- Segmented for e/p separation
- Independent Trigger
- Scintillator viewed by photodiode array

Boronated **S**cintillator **D**etector
- Alternative energy measurement

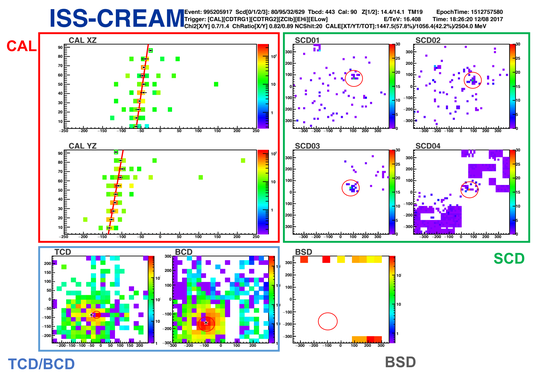
Adapted from E.S. Seo

ISS operations from 8/22/2017 to 2/12/2019

CAL provides XZ/YZ tracking with 50 fiber bundles/layer.

2. Event display

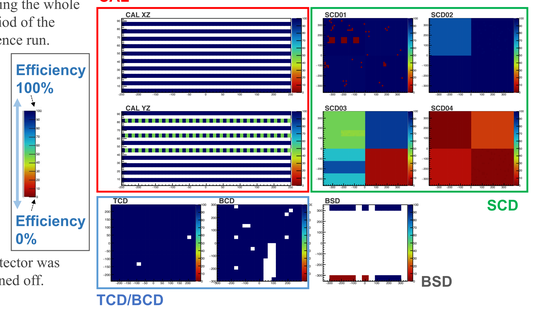
Event display enables simultaneous viewing of all detector responses.
Shown: Typical high energy event. Charge: Si (Z=14)



3. Detection efficiencies of each detector during the observations

Efficiencies of each detector operated in science run are shown.

Detector worked during the whole period of the science run.

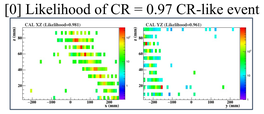


Detector was turned off.

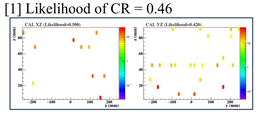
Half of the channels in 3 layers of the CAL have a 50% efficiency. The top two layers of the SCD look almost fine, but the bottom two SCD layers have low efficiency. In particular, SCD4 is extremely noisy and was turned off for much of the flight. BCD has a dead region.

5. Detector performance of the CAL

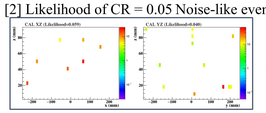
[0] Likelihood of CR = 0.97 CR-like event



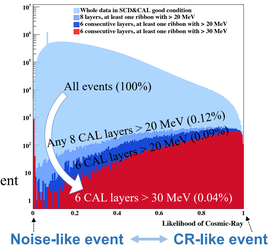
[1] Likelihood of CR = 0.46



[2] Likelihood of CR = 0.05 Noise-like event



Track independent CR identification using machine learning (TensorFlow). Validated by hand scanning.



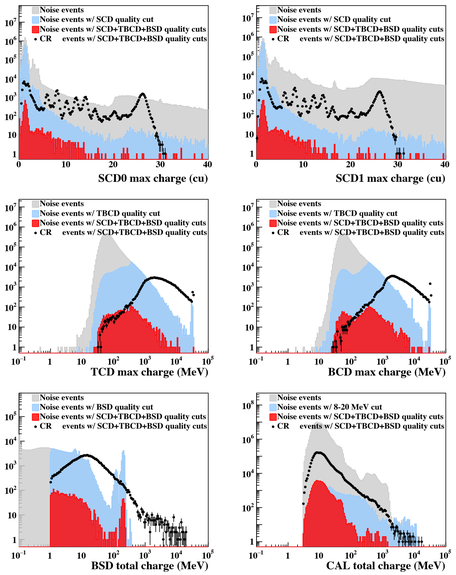
Noise-like event ⟷ CR-like event

0.04~0.12% of triggered events have useful hit information in CAL.

- **Detail of machine learning → ICRC Poster 476 by Monong Yu**
- **Energy calibration by using BSD → ICRC Poster 866 by Yu Chen**

4. Detector noise characterization

The background detector noise characterization was investigated by using 0.5 Hz periodic trigger that has identical acquisition process to event data.



Above figures show that the combined quality cuts of SCD, T/BCD and BSD worked well to prevent the contamination by noise events. The reason that CAL quality cut isn't applied is described in Section 5.

6. Tracking algorithms (22)

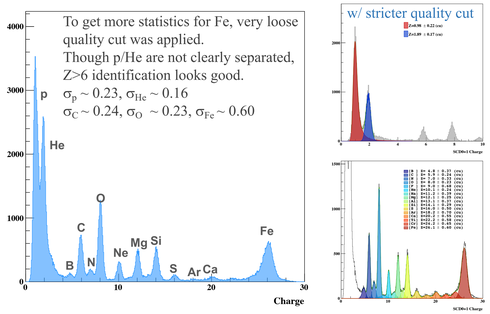
The following two are picked up from 22 different tracking algorithms.

CAL-based tracking: standard tracking: track was reconstructed by using energy-weighted CAL hits, then SCD charge is searched within a 70mm radius of the extrapolated point. For most events, CAL tracking failed because more than 99.9% events don't have useful hit information in the CAL.

SCD/CAL/TCD-based tracking : new tracking using 2 layers of SCD, TCD and CAL hits was developed and used for the flux calculation. Even if CAL is missing data, the tracking was reconstructed by using three points from the other detectors.

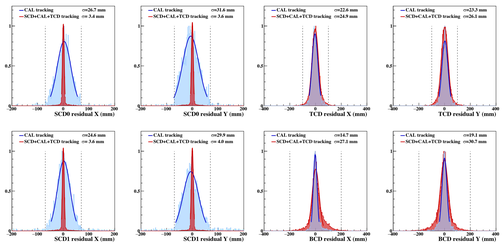
7. Detector performance of the SCD and T/BCD

- **SCD charge resolution**



- **Position resolution**

SCD position resolution TCD/BCD position resolution



Position resolution of each detector was calculated by using Z>6 events whose track has more than 6 layer hits in CAL.

- **Flux calculation→ ICRC Poster 696 by Scott L. Nutter**

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