The EPI-Lo Concept Instrument Response to Incident Electrons, Modeled Using EGS4

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Abstract

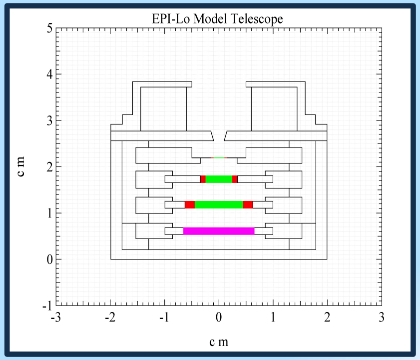
The majority of energetic particles in space (>~50 keV) are protons and electrons. Incident electrons can affect on-board electronics, cause spacecraft charging, as well as other affecting instruments on a spacecraft. The improved EPI-Lo instrument is designed to measure incident charged particles and features stacked solid-state detectors (SSD's) with ring anticoincidence. Preliminary instrument response to initial modeling of incident electrons has been modeled using EGS4 Monte Carlo software.

Charged Particle Sources

Charged particles event come from several different areas in space. Solar Energetic Particles (SEP), Galactic Cosmic Rays (GCR), and Corotating Interaction Regions (CIR), are a few of these sources.[1] The improved EPI-Lo instrument can effectively measure up to 2 MeV electrons. Typically SEP's provide electrons and other charged particles with energies in this range. Thus the particles that this instrument would measure are gradual and impulsive events that have come from Coronal Mass Ejections or solar flares.[1]

Monte Carlo Modeling

Monte Carlo software packages use a random number generator to simulate charged particle events. EGS4 was developed by the SLAC group and serves as an open source Monte Carlo package. The EGS4 software models electron, positron, and photon interactions in materials using the physics of particle scattering, energy loss in various materials etc. Compton scattering, Moeller scattering, Bhabha scattering, pair annihilation, and the Bethe-Bloch formula for energy loss in materials are some of the important features that the EGS4 Monte Carlo incorporates.[2]



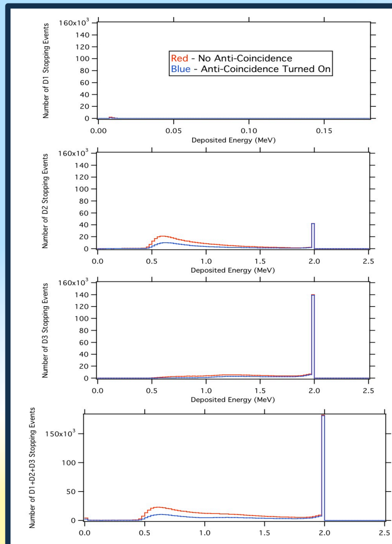
The EPI-Lo Instrument

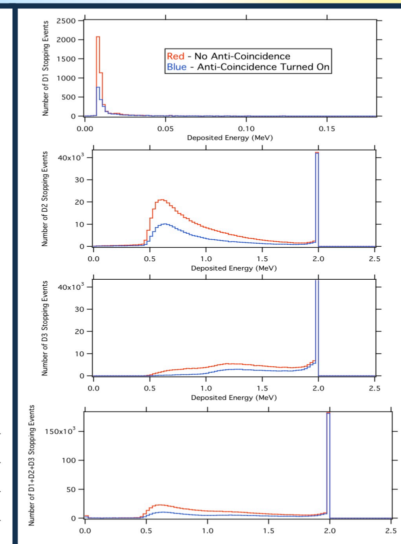
The improved EPI-Lo instrument shown above features three Solid-State Detectors (SSD's) of 30 micron thickness and 1500 micron thickness respectively. (Green) These detectors increase in active radius moving down the stack. This increase in radial size is to keep the half-viewing angle of 20°, defined by the collimator, consistent throughout the stack. An active ring has been placed around each detector of size equal to the active area of the detector. (Red) Along with the rings, a fourth detector of 1500 microns is added at the bottom to complete the anti-coincidence system. (Pink)

References

[1] D. Reames, *Particle Acceleration at the Sun and in the Heliosphere,*(NASA/ Goddard Space Flight Center, 1999)

[2] W. Nelson, H. Hirayama, D. Rogers, *EGS4 Code System,* (Standford University, 1985)





EPI-Lo Instrument Response

The above plots represent the instrument response to a 2 MeV mono-energetic beam of normal incidence. The left figure shows the count rate on one single scale. The right figure has varying scale sizes to show the effect of the ring anti-coincidence. Most if the stopping events occur in D3 with the 2 MeV beam as seen in the lower most graph. The tails shown before the large count spike near 2 MeV are events that registered as valid, in-geometry stopping events, but have the incomplete energy due to scatter and other effects. When the ring anti-coincidence is turned on there is a reduction in the number of invalid events by about 50%.

Future Work

The improved EPI-Lo instrument requires further modeling in order to get a complete understanding of the instrument performance.

- Mono-energetic beams of normal incidence will be tested over a range of incident energy starting at 40 keV up to 2 MeV.
- Omni-directional beams must be tested to evaluate the efficiency of the anti-coincidence system to reject out-of-geometry events.
- Lastly, detector noise must be added to provide a realistic response.