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Measuring Energetic Particles in Harsh Environments

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Abstract

Measuring energetic ions and electrons in the presence of high foreground rates (10^5 s^{-1}) and intense penetrating background radiation (> 1 MeV electrons; >10 MeV ions) has been a challenging task for characterizing the radiation belts in planetary magnetospheres. The effects of high foreground rates and penetrating radiation are the two critical issues that have to be mitigated in order to make successful measurements.

Here we describe the basic principles of an energetic particle spectrometer that can be operated in the harsh radiation environments of Earth's and Jupiter's radiation belts. We discuss some of the design issues that have to be kept in mind for, particularly the Jovian environment, where for example the 1.5 MeV electron fluxes can be around 10^8 (cm^{-2} s^{-1}) (Europa's orbit).

The spectrometer uses a three-parameter time-of-flight (TOF) and energy measurement to resolve H^+, He^+, O^+ and S^+ in the ~10 (45 for O and S) keV – 1 MeV range. TOF is obtained by recording the electrons that are produced when the ion penetrates a start and a stop foil. A solid state detector (SSD) records the energy of the ion required for the mass determination. In addition to shielding, in order to minimize background valid events are selected by requiring that the start, stop and the SSD pulse all coincide within a valid event window ("double coincidence"). A single-parameter (energy only) measurement obtains ions in the 10 keV – 10MeV range and electrons in the 25 keV – 1 MeV range. The spectrometer has a 160x12 deg field of view, subdivided into 6 angular sectors for both ion and electron measurements.

Several versions of the energetic particle spectrometer have been or will be flown in the radiation belts of Earth and Jupiter:

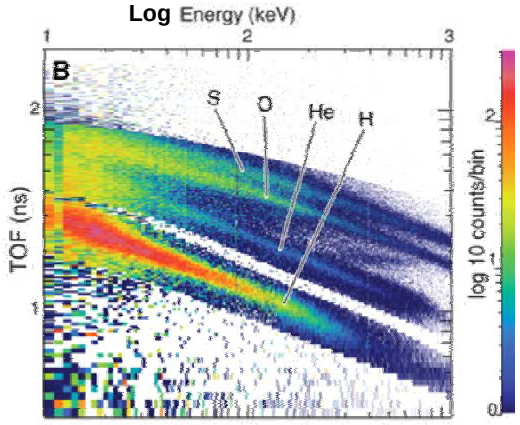

Figure 1. As New Horizons flew through the Jovian magnetotail, PEPSSI resolved all the major species with a high signal to noise ratio.

- The Pluto Energetic Particle Spectrometer Science Investigation (**PEPSSI**) on board the New Horizons mission en route Pluto, flew through the Jovian magnetotail at 39-2600 R_J in 2007 demonstrating that all the major species (H, He, O, S) could be resolved from about 45 keV up to 1 MeV.
- The Jupiter Energetic Particle Detector Instrument (**JEDI**) is being developed to fly on the Juno mission to Jupiter.
- The Radiation Belt Storm Probes Ion Composition Experiment (**RBSPICE**) has been designed to fly on the Radiation Belt Storm Probes (RBSP) mission.
- The Energetic Ions Spectrometer (**EIS**) will fly on the Magnetospheric Multi-Scale (**MMS**) mission.