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The Compact Electron Proton Spectrometer - Space Weather Nowcasting with a CdTe Timepix2 Based Instrument

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Space weather poses significant hazards for space travelers beyond low Earth orbit, particularly during large solar energetic particle events (SEPs), which can result in acute radiation exposures, especially during lightly shielded activities such as extravehicular activities (EVAs).

There has been great progress in recent years in the development of 'nowcasting'models that provide early warning of space weather events after they have started at the sun and predictions of peak fluxes based primarily on measurements of energetic electrons for early warning and energetic protons for flux and dose prediction. However current instrumentation to support this is large and primarily based on satellites. As exploration expands beyond initial lunar missions and existing instrumentation situated along the Sun-Earth line, it becomes increasingly important for crew to carry these detection and forecasting capabilities with them. Thus there is a need for a highly reliable compact instrument aimed at the measurement of electron and proton fluxes in the energy ranges relevant to solar energetic particle events.

Following an initial selection process, we chose the Timepix2 ASIC coupled with a 1 mm CdTe sensor. This decision builds upon our heritage with Timepix-based instrumentation developed for numerous human and scientific spaceflight missions, including the International Space Station, Artemis I–III, Polaris Dawn, Fram2, Biosentinel, LEIA, Astrobotic Peregrine, and Beresheet II.

We discuss the rationale behind selecting Timepix2, emphasizing its capability to provide track-like data at exceptionally high particle fluxes characteristic of Carrington-class storms. The pixelated ASIC offers exceptional electron-proton separation capability, and the high stopping power of the CdTe sensor further enhances both particle discrimination and electron spectroscopy. All these capabilities have been demonstrated through beamline testing, which is detailed herein.

Subsequently the system with significant funding from the NASA Development of Lunar Instrumentation Program and the Mars Campaign Office Radworks program has been developed into a compact high reliability prototype. We also discuss some of the unique challenges in incorporating this technology into a very high reliability system especially with regards to very limited radiation tolerant processing and data rate capability.

Finally we discuss future developments of this system including possible spaceflight demonstrations and future applications of this technology.

Workshop topics

Applications

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