CEPS – A Compact Electron-Proton Spectrometer

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Technology Taxonomy Area (TX): **6** Human Health, Life Support and Habitation Systems, 7 Exploration Destination Systems, 8 Sensors and Instruments

TRL: Start 2 / Current 4

FY22 IRAD PROJECT OVERVIEW

Small mass/power sensors are needed for autonomous Moon surface ops that provide alerts to impending adverse space weather conditions. In order to use current operational forecasting tools, a sensor capable of measuring both high-energy electrons and protons is needed. By combining high-TRL Timepix technology with a CdTe layer, this project leverages known technology to fill a critical gap for surface operations. The proposed work will bring ability to provide warnings to crews to shelter with a device that can easily be carried on the Lunar and Martian surfaces.

Quantity	Fidelity	Significance	TRL	TRL Validation
Electron Spectra	5 differential bins 200 keV – 1.5 MeV at 1 min cadence	Electron spectra used for SEP event nowcasting models	4	Measurement with relevant electrons, Monte Carlo Modelling
Proton Spectra	5 differential bins 10 MeV – 150 MeV/1 min cadence	Proton spectra used SEP nowcasting models and to predict dose in habitable volumes	4	Measurement with relevant protons, Monte Carlo Modelling
High Count Rate Performance	At least 1e^8 hits/cm^2.s above 5 keV (electron/proton/x-ray)	CEPS maintains performance through large events	4	High count rate testing with ions
Field of View	45 degree/1.84 sr	Wide FOV samples particles over a variety of pitch angles.	4	N/A

INNOVATION

This project is innovative in two ways: (1) leverages roughly a decade of measurements with Timepix detectors on ISS, and; (2) leverages recent advances in CdTe materials development.

OUTCOME

In Year1 (FY22), the project successfully completed four key elements as proof-of-concept:

- Calibration and source testing at JSC
- Tests of electron/proton detection capability at Chicago Proton therapy Center (proton exposure) and Idaho Accelerator Center (electron exposure)
- Radiation hardness testing at Los Alamos National Lab
- Thermal vac testing at JSC

INFUSION SPACE / EARTH

In Year1 (FY22), CEPS was partially incorporated into the AES/Radworks program to investigate heritage Timepix electronics design changes to ensure radiation hardness. AES PM was given out briefing on CEPS IRAD progress.

PARTNERSHIPS / COLLABORATIONS

Collaborations in year one involved Los Alamos National Lab (LANL) and the University of Houston. Both provided expertise in Timepix technology.

FUTURE WORK

FY23 (Year 2 IRAD): (1) Prove out concurrent detection of electrons and protons; (2) Prove out detector response functions. Expect to increase to TRL 5.

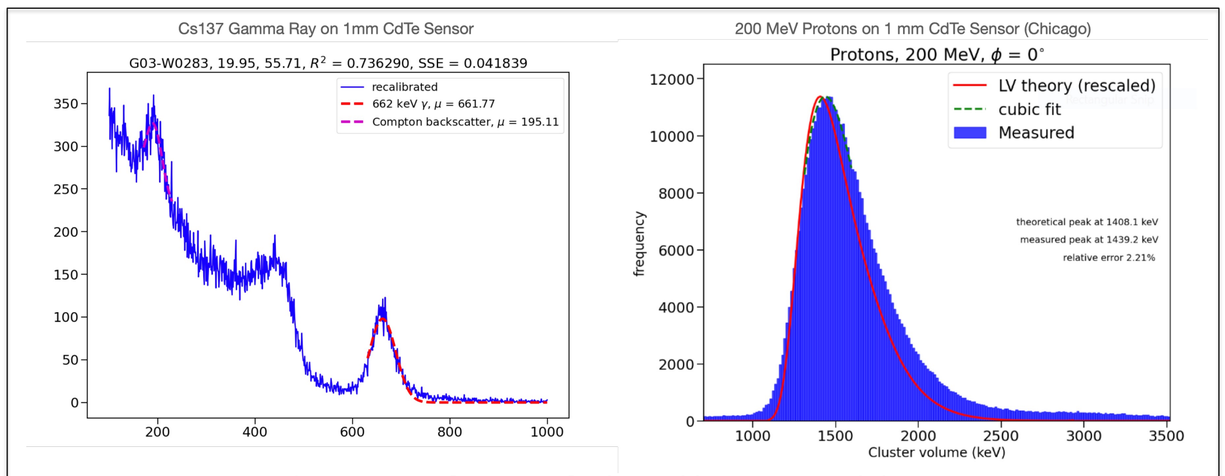

Figure 1: *Verification of CdTe Calibration Capability*

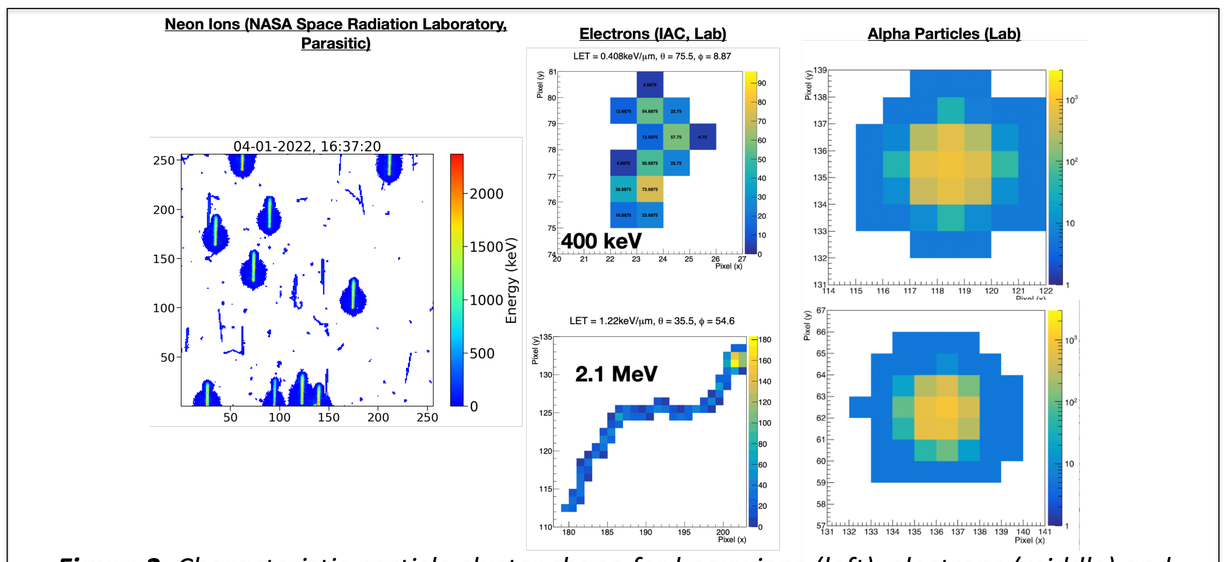

Figure 2: *Characteristic particle cluster shape for heavy ions (left), electrons (middle) and alpha particles (right). Demonstrates shape is consistent with heritage silicon-based Timepix detection technology.*

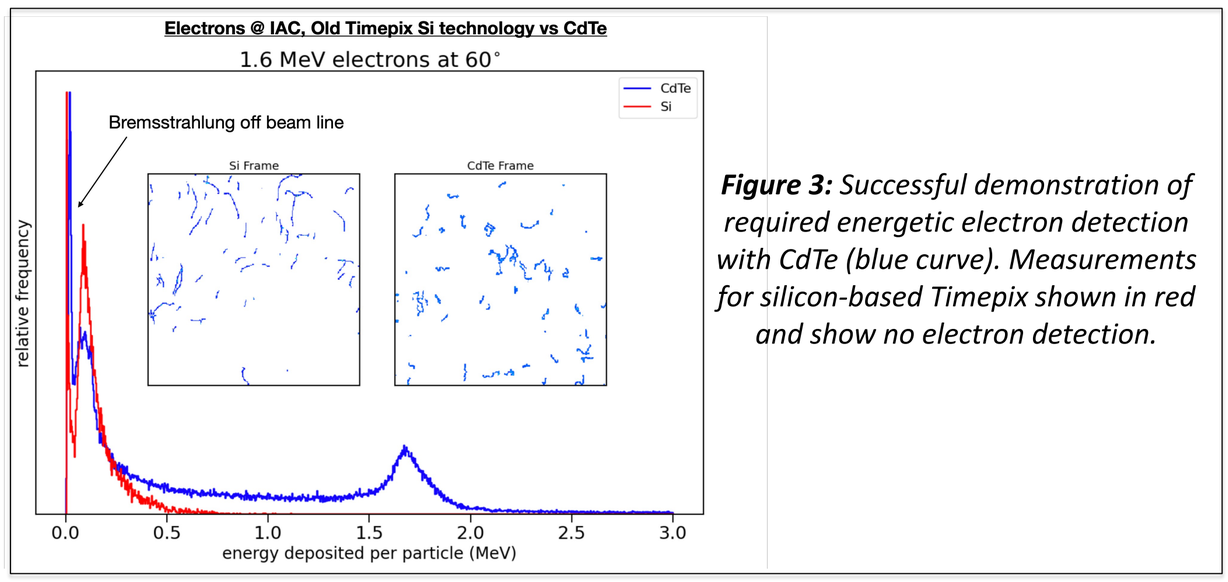

Figure 3: *Successful demonstration of required energetic electron detection with CdTe (blue curve). Measurements for silicon-based Timepix shown in red and show no electron detection.*

Figure 4: *Radiation hardness testing setup and results (bottom plot). Results show calibration shifts with increasing cumulative dose to sensor. Can be corrected for but will be investigated further in FY23.*