The Design and Testing of a Gamma-Neutron Spectrometer for the HELEN Project

Everett Cavanaugh¹, Christopher Helmerich¹, Sean Widmier², Jered Hunn¹

Overview

HELEN is a high-altitude ballooning payload network that is designed for multiple in-situ measurements of Terrestrial Gamma-ray Flashes (TGFs). The primary science instrument of HELEN is a gamma-neutron spectrometer: an instrument capable of detecting and discriminating between photons and neutrons. The instrument and supporting hardware were designed and assembled in-house, while testing was performed in collaboration with the United States Army Radiation Standards Laboratory.

Instrumentation

1. Scintillator
   Radiation interacts with the scintillator crystal and creates a pulse of visible light. The amount of light is proportional to the energy of the particle.

2. Signal Processing
   Light produced by the scintillator is absorbed by a photocathode in the Photomultiplier Tube (PMT), which results in a current pulse. The current pulse is transformed into a voltage pulse using a transimpedance amplifier within the PMT socket.

3. FPGA
   The Field Programmable Gate Array (FPGA) measures the voltage pulse using an ADC. It then finds the peak energy, tail energy, and time stamp of the pulse. Finally, the data is saved to a microSD card.

Testing Data

- CLYC Pulse Shape Discrimination Scatter Plot: Moderated Californium 175ns Peak to Tail Delay
- LYSO Pulse Shape Discrimination Scatter Plot: Moderated Californium 175ns Peak to Tail Delay

Pulse Shape Discrimination Algorithm

\[ Q_{factor} = \frac{V_{tail}}{V_{peak}} \]

Conclusions

As a result of the tests with the US Army Radiation Standards Laboratory, we are equipping HELEN with CLYC scintillators that allow for gamma-neutron detection and discrimination. HELEN will attempt to use this detector to investigate photonuclear reactions outside of a TGF beam in the coming months.

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