We are building and testing a gamma-ray detector for two CubeSats that will take multipoint measurements of the beam profile of terrestrial gamma-ray flashes.

**Abstract**

Terrestrial Gamma-Ray Analysis and Detection (TRYAD) is a collaborative project between the University of Alabama in Huntsville, NASA, and MSFC to detect and measure terrestrial gamma-ray flashes (TGFs). TGFs are short bursts of gamma-radiation in the upper atmosphere thought to be associated with bremsstrahlung radiation originating from electrons accelerated in thunderstorms. The two CubeSats will be deployed into low-Earth orbit, flying in tandem, and take multipoint measurements of the TGF beams to shed light into their production mechanisms. The primary role of the TRYAD I-SIP is to create a science instrument package (SIP) that will act as the gamma-ray detector of the CubeSats and design the Data Acquisition (DAQ) board that powers and reads data from the SIP. Recent work has focused on testing and assembling the first SIP to prepare for a launch planned for 2023.

**Terrestrial Gamma-Ray Flashes**

Terrestrial gamma-ray flashes are brief, sub-millisecond intense pulses (up to 40 MeV) of gamma rays believed to be produced when a relativistic electron or cosmic ray enters a strong electric field associated with thunderstorms.

**TFG Production**

The electron is then accelerated, and interacts with atoms in the atmosphere, knocking off electrons on these atoms. This process continues and produces a cascade of electrons which interact with the electric field in atoms, causing bremsstrahlung emission. The cascading of electrons that produce this is called relativistic runaway electron avalanche (REEA).

**GPF Production Mechanisms**

Though REEA is thought to be produced as a result of bremsstrahlung emission caused by REEA, the production mechanism of the accelerating electrons is not known. TRYAD will be investigating two competing theories that explain the TGF production mechanism: the Lightning Leader model (Celestin 2012) and the Relativistic Feedback Discharge (RFD) model (Dwyer 2012). The Lightning Leader model describes the electron as a voltage impulse that is accelerated by a TGF is generated by lightning steps leading a creating wide beam profile, while the RFD model hypothesizes that the electric field of the lightning itself accelerates the electron, thus producing a narrow beam profile. Therefore, TRYAD will take multipoint measurements of the beam profiles.

**Silicon Photomultipliers (SiPMs)**

SiPMs are well suited for this application due to their high sensitivity to light and their ability to detect very low light levels. The SiPMs will be selected based on the science instrument's performance, and some SiPMs have been selected for the final design. More research is needed to determine the optimal SiPMs for the mission.

**Progress**

The goal of UA’s TRYAD team for the summer of 2021 was to fully assemble and test the science instrument package (SIP) so that we could have one of two detectors finished for launch. While we do not yet have a finished SIP, the steps we have taken towards completing this goal are as follows:

- Developed an updated procedure for building the SIP.
- Ensured inventory and documented each component needed for flight assembly.
- Developed an updated procedure for fabricating the casing gasket and then successfully created multiple gaskets to help with light tightness of the SIP.
- Tested base A of the SIPs in a dark box and using an LED bulb to verify that the lighttightness of the SIP is good.
- Assembled the SIP completely with flight components to test with a radioactive source.

**Results & Future Work**

Testing the fully completed SIP with a radioactive source revealed that only base A of the SIPs are working, so further testing of base B is required. When connected to the oscilloscope, a signal can be shown, but a spectrum of light has not yet been acquired due to difficulties with the CAEN MC2 software. Future tests will focus on testing base B as it is necessary and becoming familiar with the CAEN MC2 software.

**Acknowledgements**

This work was supported by funding from NSF REU grant AGS-1519880 for the University of Alabama in Huntsville. This research was conducted as part of the RFP’s Summer Research program. We are grateful to our mentorship and guidance throughout the work, especially to Dr. Peter Jener and Dr. Michael Briggs, two of the best mentors we have ever had. Finally, we would like to thank Michael Briggs for his mentorship and guidance throughout the work, and Dr. Peter Jener for his dedication and guidance throughout the project.

Alexis Lupo
alupo@miners.utep.edu
Check out my website.