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Building Gamma-Ray Detectors for Two CubeSats

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Project Title: Building Gamma-Ray Detectors for Two CubeSats

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Project Description

Terrestrial Gamma-ray Flashes (TGFs) are very brief (sub-ms) and extremely intense pulses of gamma-rays associated with thunderstorms and generally observed by space based instruments. Electrons are accelerated to high energies by electric fields within thunderstorms. When these electrons encounter the strong electric fields of atomic nuclei, their paths are bent and they emit gamma rays, in the process known as bremmstrahlung.

The Terrestrial RaYs Analysis and Detection (TRYAD) Cubesat project is designed to distinguish between the two leading theories for the origin of Terrestrial Gamma-ray Flashes (TGFs). One theory for TGFs is that the electron acceleration takes place in large-scale fields in thunderstorms. Another idea is that the acceleration takes place in the intense fields at the tips of lightning leaders. For the large-scale theory, the acceleration would tend to be parallel so that the TGF beams would typically be narrow. The electric field of a lightning tip diverges from a point, and thus would naturally produce a broad beam. TRYAD consists of a pair of 12U CubeSats and is a collaboration between UAH, Auburn University and NASA/GSFC, with UAH and Auburn funded by the National Science Foundation. UAH is responsible for the gamma-ray detectors, GSFC is contributing electronics designs and Auburn is responsible for the CubeSats.

We are developing TRYAD for a novel NSF funded CubeSat mission that will enable unique measurements of TGFs. Our methods require multiple CubeSats to be flown in low Earth orbit at controlled distances of a few tens of kilometers. This will allow us to make simultaneous measurements of a TGF across the beam profile which has never been accomplished in a controlled manner. This is the most direct way to constrain models of TGF production.

TRYAD development has been underway for several years. In Summer 2018 a student team successfully tested all components of the detector. During the 2018-2019 academic year, we made several changes to the design to mitigate issues that came up in the practical assembly and operation of the detector. In the 2019-2020 academic year we are assembling the Engineering Unit detector and will conduct vibration, vacuum and thermal testing. Based on experience, we expect that problems will be discovered in testing, and that a modest redesign will be necessary.

The goal for the summer of 2020 is to remedy any problems discovered in the final testing, followed by assembly and testing of the two flight detectors. The detectors will be characterized, both in electrical and gamma-ray performance. Gamma-ray spectra will be recorded to measure the detector efficiency and high rate performance, using both LEDs and weak radiation sources.

Student Duties, Contributions, and Outcomes

The student will assemble and test the actual detectors that will fly in low Earth orbit. They will characterize the detector response and develop a data analysis methodology. They will also develop a fault analysis scheme in case something is not working correctly once the instrument has launched.

During the Summer of 2020 we may be able to deliver the flight detectors to Auburn University. One or more students may need to visit Auburn several times for one to several days each trip to support testing activities. At the end of the Summer the student team will attend and make a presentation at progress review at Auburn.

The student will learn physics laboratory procedures, space hardware development procedures, analysis of test results, documentation writing, and team work. They will learn about the science of terrestrial gamma-ray flashes. The student will have the opportunity to give a presentations to the UAH/MSFC gamma-ray research group, and also at the progress review at Auburn. They will have the opportunity to present a poster at the American Geophysical Union Fall Meeting or at a SmallSat conference.

Student Selection Criteria

Students who are or have worked on TRYAD were either Summer interns or will soon graduate, so additions to the TRYAD team are needed.

The student is required to be studying Physics, Mechanical, Aerospace or Electrical Engineering. The student is required to have sophomore rank; junior rank or higher is preferred. Due to export control regulations on space hardware, the student is required to be a US Citizen or Permanent Resident.

Faculty/Research Staff Mentorship

The mentor and adjunct mentor have a weekly meeting with the student team to review progress and plan the following weeks activities. Additional group or individual meetings will be held with either the mentor or adjunct mentor prior to tests, or to discuss test results. For the first three weeks, two additional meetings per week will be held to discuss previous work on TRYAD, laboratory and radiation safety, TGF science, development practices for space projects, gamma-ray detectors, etc.

The Adjunct Mentor will be present if the Mentor should be away for more than a few days. If neither is available, the student shall not conduct lab work and will instead analyze data or perform other tasks. The student will be able to interact with other members of the Huntsville gamma-ray group (MSFC & UAH) and to attend research presentations and informal discussions of the research group.