High Energy Lightning Emission Network for Multi-Point Observations of TGFs from Balloons

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Overview
Terrestrial Gamma-ray Flashes (TGFs) are bursts of radiation produced by thunderstorms. Several models have been proposed to describe TGFs, but more observational data would help verify certain models. The High Energy Lightning Emission Network (HELEN) seeks to make multi-point, in-situ measurements of a TGF with a network of balloon-borne gamma-neutron spectrometers and electric field meters.

Simulations
A simulation of TGF propagation was written in MATLAB to determine the necessary timing resolution to accurately locate a TGF. Location determination will be done through a process called multilateration, which depends on the time difference of arrival of the event at each payload location. The simulation can compare the location errors for different resolutions of the time differences and for different payload location configurations. A tetrahedral network configuration was found to be the most accurate.

Mission

Objectives
Verify pre-existing models of TGF formation
Calculate the location of TGFs
Determine the bounds on the TGF cone of emission
Correlate the photon flux and energy spectrum of the TGF with the measured electric field strength of the thunderstorm
Correlate the location of TGFs with the location of lightning
Determine the neutron flux due to TGFs

Conclusions
The High Energy Lightning Emission Network (HELEN) is prepared for its first thunderstorm campaign. The thunderstorm season in Huntsville, Alabama lasts from March through August. HELEN aims to conduct a thunderstorm flight campaign consisting of 10-15 full mission flights during that period. We intend to have the results from the first thunderstorm campaign ready for publication by Winter 2020.

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Instrumentation

Radiation Detection Payload

- Incoming high-energy particle
- Scintillator emits light when struck by high-energy particle
- PhotoMultiplier Tube (PMT) converts light from scintillator into electrons, producing an output current
- ADC converts the analog voltage signal into digital voltage values
- PGA reads ADC and performs energy determination and particle discrimination calculations
- FPGA reads ADC and performs energy determination and particle discrimination calculations

- Motor spins the metal spheres about the sphere rotation axis
- Conductive aluminum spheres accumulate charges in the thunderstorm electric field
- Wind vanes provide rotation about balloon line axis

Electric Field Meter
- Custom PCB records voltage differences between spinning spheres, acceleration data, gyroscopic data, and magnetometer data
- Custom PCB records voltage differences between spinning spheres, acceleration data, gyroscopic data, and magnetometer data
- Wind vanes provide rotation about balloon line axis

- 1600g Latex Balloon
- Parachute
- Radiation Detection Payload
- Electric Field Meter

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