

Relationship between lightning & TGFs

Satellite studied for this purpose – Firefly

Firefly – (manufactured by NASA/GFSC, USRA & Siena College)

A **terrestrial gamma-ray flash (TGF)** is a burst of gamma rays produced in Earth's atmosphere. TGFs have been recorded to last 0.2 to 3.5 milliseconds, and have energies of up to 20 million electron volts. It is speculated that TGFs are caused by intense electric fields (beams of very energetic e^- s are accelerated in these fields) produced above or inside thunderstorms.

Objective of the missions

- 1) Which types of lightning produce these e^- beams and associated TGFs?
- 2) Occurrence rate of TGFs & their dependence on TGF size
- 3) How bright do TGFs get?
- 4) What is detailed timing of gamma, e^- , optical & VLF signatures?
- 5) What is the energy spectrum & flux of energetic e^- s generated in association with TGFs?
- 6) To what extent are TGFs associated with luminous events (TLEs) such as sprites, elves etc.?

What measurements should we take to fulfill the objective?

- 1) e^- s in MeV range generated over the thunderstorms
- 2) Associated gamma & X rays generated as bremsstrahlung in the thunderstorm e^- avalanche process & their precise timing
- 3) Associated optical & VLF radiowave lightning discharge signatures for every single TGF observed by Firefly
- 4) Intense fluxes during the initial portion of TGF

Electron avalanche is a process in which a no. of free e^- s in a transmission medium are subjected to strong acceleration by an electric field & subsequently collides with other atoms of the medium thereby ionizing them. This releases additional e^- s which accelerates & collides with further atoms, releasing more electrons & the chain continues.

Mass	4 kg
Power	3 W
Altitude	500km
Inclination	40.5 deg.

Orbit	Near circular
Life	Planned 3 months but lasted 12 months

Instruments:

- 1) Energy sensitive radiation detector
- 2) Electronics to process detector signals produced by the detector such as pulse sorter
- 3) Associated amplifiers and data readout devices to generate, display and store the spectrum

Detectors used:

- 1) Gamma ray detector
 - a) Photons: 100KeV to 10MeV –tell us about Gamma ray energy & time of arrival
 - b) Electrons: 100KeV to 2MeV – energetic e^- energy & time of arrival
 - c) Count rates up to 100000/s – Background Spectra
- 2) VLF receiver- measures till + - 20 mV, sample rate of 40ksample/s at 16 bit – ELF/VLF electric field waveforms
- 3) OLD – 98% of all lightning optical power, Sample rate of 100ksample/s at 16 bit – optical power waveform, some localization

Requirements imposed on detectors:

- 1) Measure gamma rays, electrons & lightning signatures with accurate relative timing (1micro sec.) & absolute timing to UTC of better than 1 millisecond
- 2) Discriminate e^- counts from gamma ray counts
- 3) Use of VLF and optical signatures to discriminate weak TGFs from statistical fluctuations
- 4) Fast detection up to 100MHz
- 5) Overflights of ground based receivers for lightning characterization