

DEPARTMENT OF PHYSICS & ASTRONOMY
COLLOQUIUM

JOHN BELZ
UNIVERSITY OF UTAH

**Observing the Origins of Terrestrial
Gamma-Ray Flashes**

Abstract

Terrestrial Gamma-ray Flashes (TGFs) -- high-fluence bursts of gamma radiation originating in the Earth's atmosphere -- were discovered by Earth-orbiting satellites in 1992. They were eventually associated with lightning storms. Although observations of TGFs now number in the thousands, their precise explanation is unknown due to the great distance and small solid angle through which they are typically detected.

The Telescope Array Surface Detector (TASD) is a 700 square kilometer cosmic ray observatory in the western desert of Utah, U.S.A. It is designed to record the "footprint" of extensive air showers of elementary particles produced by the interaction of the highest-energy cosmic rays with the Earth's atmosphere. In 2013, anomalous events were observed in which the TASD recorded multiple air showers within less than a millisecond. These events were associated with lightning, and subsequent measurements and simulation studies demonstrated that they were the downward-directed counterpart of the TGF phenomenon.

In this talk, I will present new TGF observations from the TASD coupled with a broadband interferometer and fast field-change antenna. These observations for the first time link the downward TGFs at the sub-microsecond level with high-current processes early in the lightning breakdown. This Utah-based discovery helps explain the origin of TGFs, while at the same time constraining models of the lightning initiation process.

FRIDAY, SEPTEMBER 13TH
JFB 101
2PM

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