



## **In-situ Observations of Gamma-ray Production in Thunderstorms**

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The majority of the reported observations of energetic radiation from thunderstorms have come from either ground-based or satellite-based measurements. In order to better understand the physical conditions necessary for the production of fast electrons and gamma-rays, measurements are needed near the production regions inside or above the thunderstorm. Three different measurements are of particular interest. First, gamma-rays produced by the quasi-static electric-field may provide details about the physics of runaway electrons that would be difficult to determine from measurements of transient phenomena, such as lightning and terrestrial gamma-ray flashes (TGFs). Second, what process inside the thunderstorm is responsible for TGFs? Recent ground-based studies have pointed to the upward negative leader in inter-cloud lightning as a possible source. Finally, the initiation of lightning appears to be a problem in light of the relatively weak (about 10% of the classical breakdown threshold) electric fields observed inside thunderstorms. Since these field strengths are adequate for runaway electrons, they have been proposed as a possible source for the initial breakdown in lightning. In this paper, we will present observations from balloon-borne gamma-ray detectors and electric-field sensors, as well as ground based instruments like the lightning mapping array (LMA) in effort to examine these areas of interest.