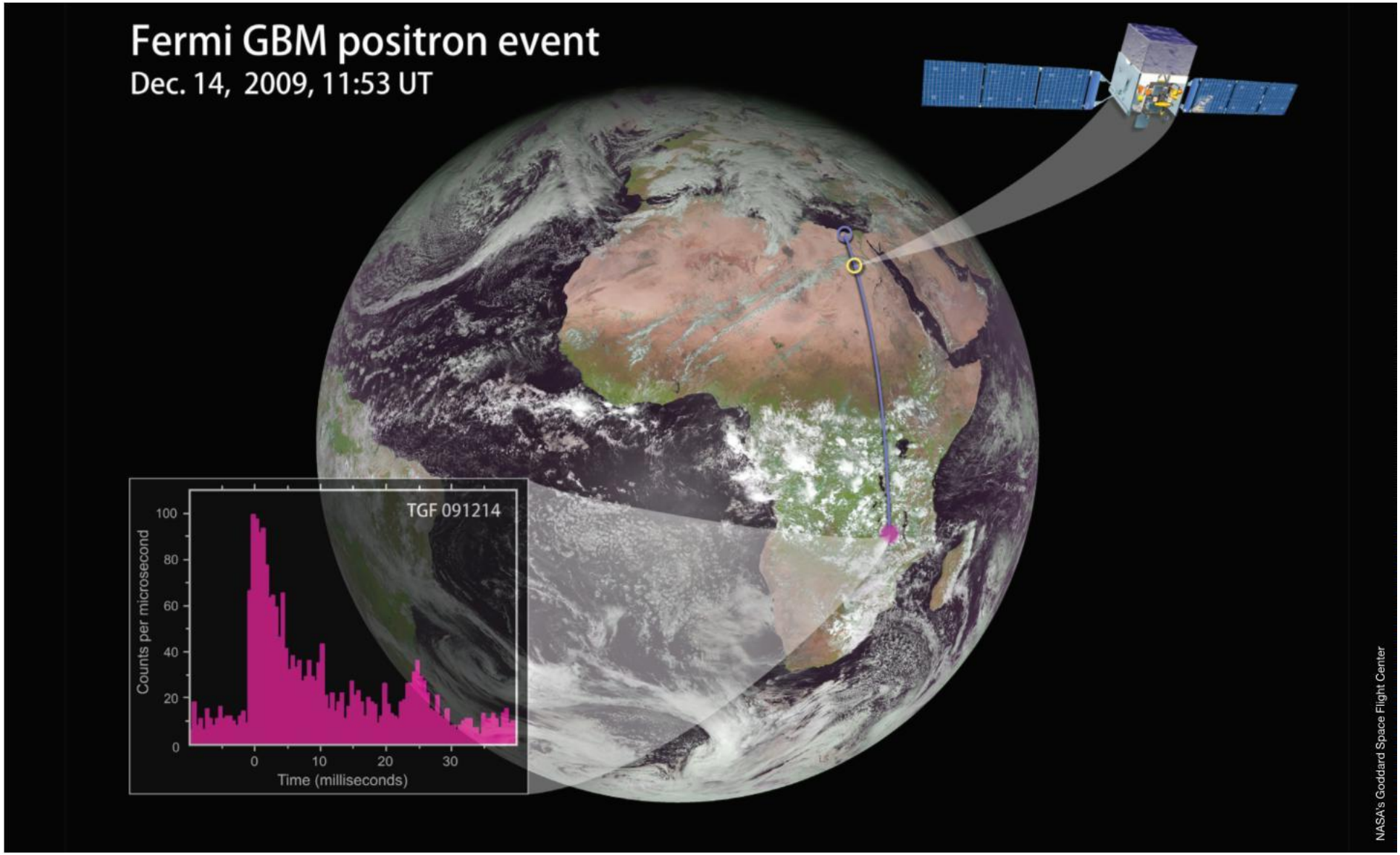
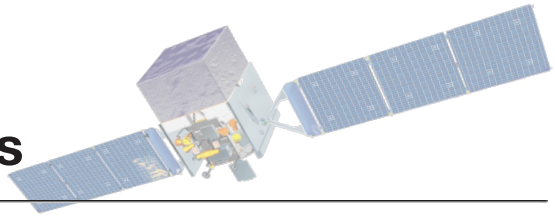
National Aeronautics and Space Administration



Terrestrial Gamma-ray Solar Flashes. For more information visit http://fermi.gsfc.nasa.gov/

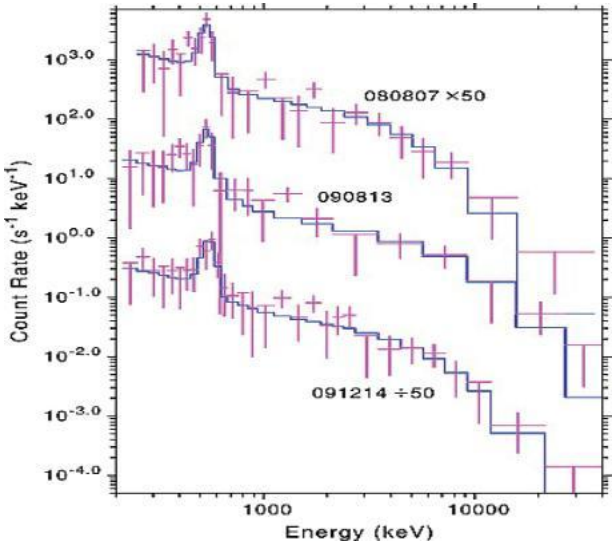
Terrestrial Gamma-ray Solar Flashes



Terrestrial Gamma-ray Flashes seen by Fermi spark surprise

Discovered in 1994 by the Compton Gamma-Ray Observatory, Terrestrial Gamma-ray Flashes (TGFs) are intense sub-millisecond bursts of MeV gamma rays produced in active thunderstorm regions and temporally associated with lightning events. They have been detected by RHESSI, AGILE, as well as Fermi LAT and GBM.

While TGF gamma-rays have not been well-imaged, many TGFs are coincident with a lightning event near the sub-satellite point, suggesting that TGFs are associated with lightning processes. Detailed RF imaging of several events suggests that the source of the gamma rays is ~10-15 km in altitude, within the thundercloud and deep in the atmosphere. Recently the GBM has detected the signature of antimatter produced in these intense gamma ray flashes, a phenomenon never before seen.



How Thunderstorms Launch Particle Beams Into Space

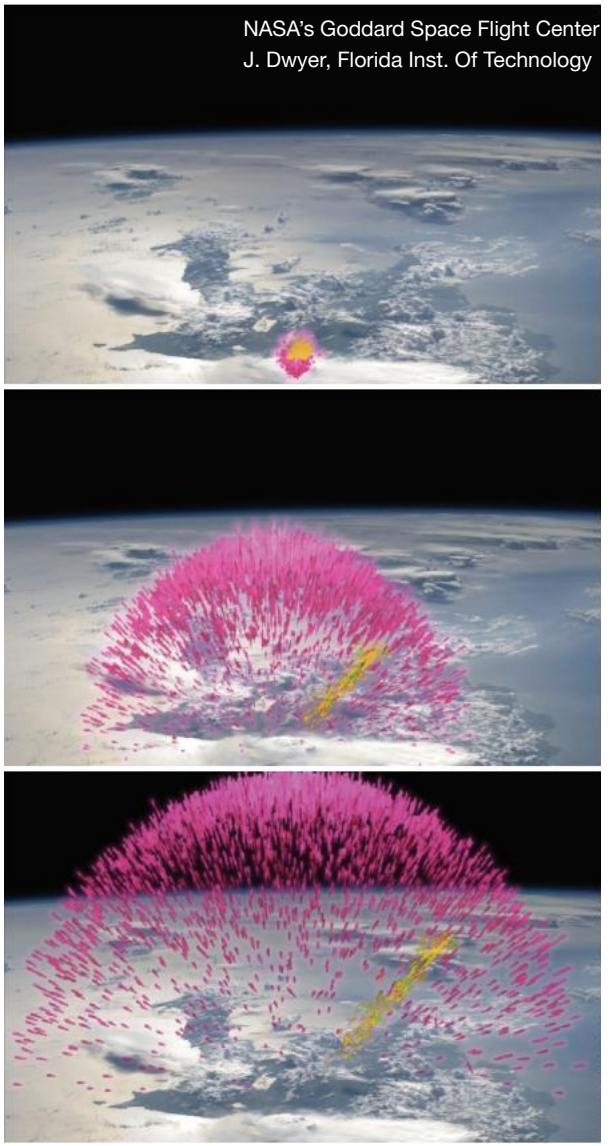
Electric fields (>100 kV/m) within thunderclouds can create an upward-moving avalanche of relativistic electrons. Deflection of these electrons by air molecules causes the emission of bremsstrahlung gamma-rays. While many of these Compton-scatter off electrons in the molecules to eject relativistic electrons, others pass close enough to the nuclei of atoms in the air to pair-produce, becoming a relativistic electron/positron pair. These high energy particles then escape into space, spiraling along the Earth's magnetic field lines where they can be intercepted by spacecraft.

Finding Antimatter with the GBM

When the spacecraft intercepts a TGF positron beam, the positrons annihilate with electrons in the spacecraft and detectors, producing a gamma-ray pair with energy equal to the rest mass of the electron (511 keV). GBM detects gamma-rays in the 10 keV to 40 MeV range, which puts the 511-keV electron-positron annihilation line well within its range of sensitivity. This antimatter beam is therefore detected as a spike in gamma rays at that specific energy.

RIGHT: A set of snapshots of a model TGF forming at an altitude of 15 km (9.3 mi). The frames show the extent of the TGF at 0.2, 1.4 and 1.98 milliseconds after the trigger time.

LEFT: GBM spectra (magenta crosses) for three different TGFs showing the characteristic 511 keV line produced by positron annihilation (modeled in blue).



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