On the highest photon energy of Terrestrial Gamma-ray Flashes

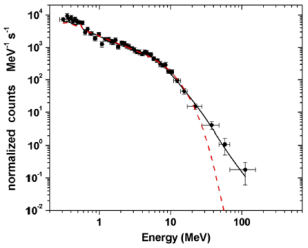
M. Marisaldi[1,2*], F. Fuschino[1], M. Tavani[1], S. Dietrich[3], C. Price[4], A. Argan[1], C. Labanti[1], M. Galli[5], F. Longo[6], E. Del Monte[1], G. Barbiellini[6], A. Giuliani[1], A. Bulgarelli[1], F. Gianotti[1], M. Trifoglio[1], A. Trois[1], C. Pittori[7,1], F. Verrecchia[7,1], P. Giommi[7],

[1] INAF - National Institute for Astrophysics, Italy; [2]Birkeland Centre for Space Science, University of Bergen, Norway; [3]CNR ISAC Roma, Italy; [4]Department of Geophysics and Planetary Science, Tel Aviv University, Israel; [5]ENEA Bologna, Italy; [6]Physics Department, Univ. of Trieste and INFN Trieste, Italy; [7]ASI Science Data Center, Italy; * Martino Marisaldi, e-mail: marisaldi@iasfbo.inaf.it

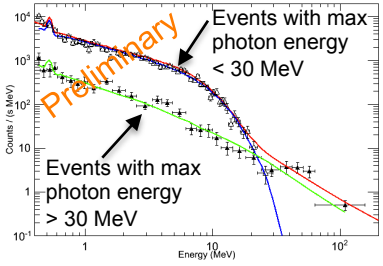
TGFs are known to include photons of energy up to several tens of MeV. Results by the mini-calorimeter (MCAL) of the AGILE satellite have shown that the cumulative spectrum of TGFs is significantly above background up to about 100 MeV and that the spectral shape deviates from a cutoff power law at high energy suggesting a production mechanism different from canonical Relativistic Runaway Electron Avalanche (RREA). Subsequent analysis of AGILE data have shown that about 15% of TGFs exhibit photon energies above 30 MeV. From the theoretical point of view, it has been shown that a production model based on electron acceleration in strong electric fields at lightning leader tips may account for the high energies observed by AGILE. In this presentation we review the detection of high-energy photons in AGILE TGFs. Possible sources of error such as energy calibration, background and cosmic rays contamination are discussed as well.

1. AGILE observations

- 15% of AGILE TGFs include photons with energy > 30 MeV.
- Below 30 MeV the background-subtracted TGF cumulative spectrum is well described by a cutoff power law, in agreement with RHESSI results (see poster Z216 and Marisaldi et al., JGR (2014), DOI: 10.1002/2013JA019301)
- Cumulative spectrum of TGFs with photons above 30 MeV is well fitted by a broken power law.
- Counts above 30 MeV are well significant above background.

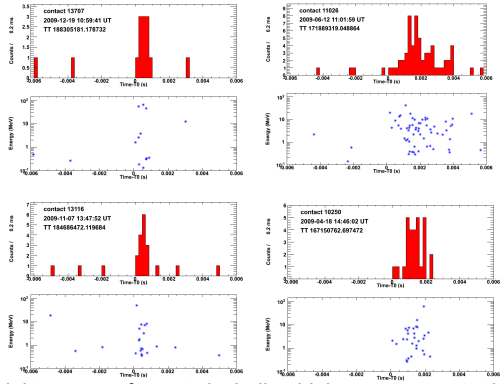


Significant detection up to ~100 MeV (Tavani et al., PRL, 2011)

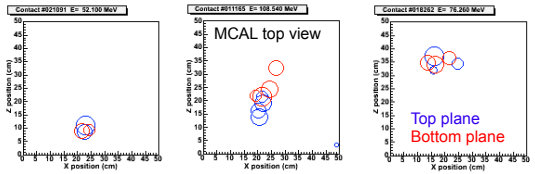


Marisaldi et al., in preparation

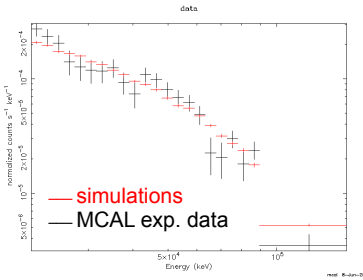
2. Events topology



- Light curves of events including high-energy counts do not appear to be peculiar with respect to low-energy TGFs.
- Cosmic-ray showers are inhibited by anti-coincidence shield (5.4μs veto time window).
- Spurious counts due to the effects of large energy deposits on the MCAL front-end electronics, which may mimic a fast transient, are suppressed by a dedicated baseline restorer.
- High energy counts are clustered in the detector plane (which has a coarse 2D position resolution): not compatible with pile-up of low energy events.



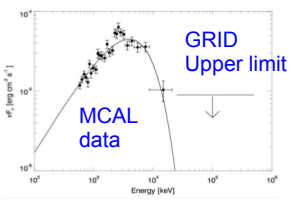
3. Energy calibration



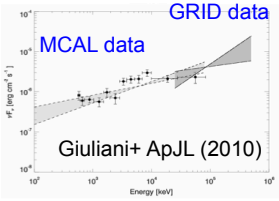
MCAL calibration data checked against simulations by INFN Pavia (P.W. Cattaneo and A. Rappoldi) up to ~80 MeV for ground test beam with high-energy photons at the INFN DAΦNE Beam Test Facility (BTF), Frascati, Italy.

MCAL calibration checked up to ~80 MeV with cosmic gamma-ray burst GRB 090510.

GRB Prompt phase



GRB Extended emission



Work in progress:

- Is there a bias due to selection criteria?
- What is the satellite orientation for these events?
- What are the meteorological conditions (lightning / cloud coverage) for these events?
- How does it fit with production models?