Two TGF populations Detected by AGILE?

Martino Marisaldi (INAF-IASF Bologna)
F. Fuschino, M. Tavani, C. Labanti, A. Argan (INAF)
S. Dietrich, M. Formenton (CNR ISAC)

10th AGILE Workshop “Lightning, TGFs and meteorology”
ESRIN Frascati, April 18 2012
TGF Cumulative spectrum

110 TGFs 1806 photons 142 $\gamma$ E > 10 MeV 26 $\gamma$ E > 20 MeV


M. Marisaldi

Frascati, 18/04/2012
Operating TGF detectors

Effective Area vs. Energy

Data from: Smith et al. (2002), Meegan et al. (2009), Labanti et al. (2009), Tavani et al. (2009)
Cumulative spectrum

302 class A TGFs detected in the period Mar. 2009 – Nov. 2011
Model fit is cutoff powerlaw (low energy) + powerlaw (high energy)
High energy TGFs

contact 13707
2009-12-19 10:59:41 UT
TT 188305181.178732

contact 11026
2009-06-12 11:01:59 UT
TT 171889319.048864

contact 13116
2009-11-07 13:47:52 UT
TT 184686472.119684

contact 10250
2009-04-18 14:46:02 UT
TT 167150762.697472
Low energy population cumulative spectrum

259 low energy TGFs (max energy < 30 MeV).
Normalized to total duration 277 ms

Data + cutoff powerlaw model

$E_{\text{cut}} = (5.1 \pm 0.3) \text{ MeV}$
Cumulative spectrum: two different populations!

HE and LE samples are normalized to the complete sample duration (330 ms)
All spectra are background-subtracted

- **43 high energy TGFs** (max energy > 30 MeV)
- **259 low energy TGFs** (max energy < 30 MeV)

All data is fit using a **broken powerlaw model** for high energy and a **cutoff powerlaw model** for low energy.
Low and high energy populations power spectral density $E^2 f(E)$

Low energy population

High energy population

M. Marisaldi

Frascati, 18/04/2012
HE vs LE populations

Normalized parameter distributions

- Burst duration distribution
- Total number of events distribution
- Peak flux distribution
- Average energy distribution

M. Marisaldi

Frascati, 18/04/2012
HE vs LE events: Geographical distribution

No clear geographical pattern as for low energy TGFs
HE vs LE events: local time

No clear pattern: statistics too low
HE events topology:
Can HE events be due to pile-up of many low energy events?

MCAL position reconstruction capabilities
Spatial clustering in MCAL allows to exclude high-energy events being due to pile-up of low energy photons

M. Marisaldi

Frascati, 18/04/2012
AGILE on-ground calibration performed at INFN Beam Test Facility, Frascati, with Bremmstrahlung $\gamma$-rays by 460 MeV e$^-$ on Si target

M. Marisaldi

Frascati, 18/04/2012
MCAL high energy calibration

In flight
GRB 090510


M. Marisaldi

Frascati, 18/04/2012
HE events: the lightning connection

GLN network: global coverage but inhomogeneous efficiency.

No one-to-one correlations.

200km side box, ±5 min from TGF: 5/6 correlations above S.E. Asia. 18% global.

M. Marisaldi
Benchmark: low-energy TGF lightning connection

201 AGILE low-energy TGFs, same algorithm

Central America:
66% match.
Non compliant with HE sample
5.9 expected, 1 observed

Africa:
10% match.
Compliant with HE sample non detection

South East Asia:
81% match.
Compliant with HE sample

Different lightning mechanisms at play? Results non conclusive yet.
Need for more efficient networks and one-to-one correlations.

M. Marisaldi

Frascati, 18/04/2012
Conclusion

• Evidence for two distinct populations in the AGILE TGF sample
• The low-energy population (90% of events, $E_{MAX} < 30\text{MeV}$) match standard TGF phenomenology: cutoff powerlaw spectrum, longitude and local time follow lightning distributions
• The high-energy population (10% of events, $E_{MAX} > 30\text{MeV}$):
  • Power law spectrum up to 100 MeV and above
  • Statistics is too low for a clear geographical and local time pattern, but many events above the oceans
• HE events are spatially clustered: not a pile-up effect
• High confidence on MCAL response at high energy
• Correlation to lightning detected on ground is not conclusive yet
THANK YOU!

Credit: Alan Stonebraker

M. Marisaldi

IASF Bologna

Frascati, 18/04/2012