# Properties of AGILE Terrestrial Gamma-ray Flashes

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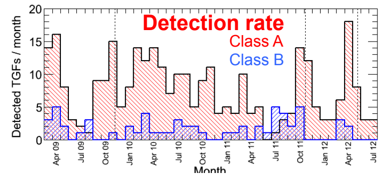
**We present the characteristics of 369 Terrestrial Gamma-ray Flashes (TGFs) detected by the AGILE satellite in the latitude belt +/- 2.5° in the period March 2009 - July 2012 (Marisaldi et al., to be submitted to JGR).**

1. **Event selection is a two-steps strategy consisting in an onboard trigger logic acting on millisecond time scales followed by a ground selection algorithm based on spectral hardness and simple topology rules. Here we focus on low energy TGFs ($E_{MAX}$ ≤ 30 MeV). The high-energy population has different characteristics and will be studied later.**
2. **Dead time induced by the AGILE anticoincidence shield has important effects and is a key factor to understand AGILE TGF properties.**
3. **An overall good consistency between the AGILE and RHESSI samples concerning longitude distribution and local time is evident. The AGILE duration distribution has a median value 2.3 times larger than that observed by *Fermi*. This can be explained in terms of dead time suppression of short events.**
4. **The correlation with WWLLN sferics shows a statistically evident correlation between AGILE TGFs and lightning activity within 600 km from the satellite footprint, although no sferics simultaneous to TGFs were observed. This can be explained by the larger average duration of the AGILE TGF sample.**


## 1. Trigger algorithm and data selection

**Data pre-scan:**
A data pre-scan to identify clusters with ≥6 counts/ms is performed independently from the trigger. Then, a cluster is identified as a TGF according to:




**Class A: (triggered low energy TGFs) 308 events**

1. onboard trigger on short time scales
2. ≥10 counts
3. HR = (n. counts > 1.4 MeV) / (n. counts < 1.4 MeV) ≥ 0.5
4. Topology: at least 1 count in each of the 4 MCAL quadrants
5. Maximum energy ≤ 30 MeV

**Class B: (untriggered low energy TGFs) 61 events**
All criteria for class A but 1.

**Results: 0.3 (A+B) TGFs / day**

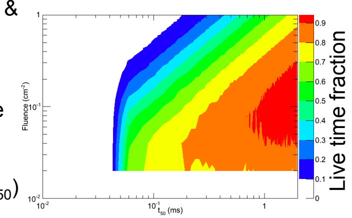
## 2. Dead time estimate

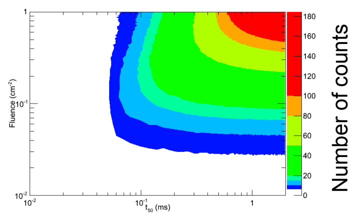
**Method:**

- MC simulations propagating a TGF spectrum as the best fit of Dwyer & Smith, GRL 32, L22804 (2005) through the AGILE mass model.
- Assume a TGF Gaussian time profile and apply anti-coincidence 5.4μs veto signal (paralizable).
- Extract live time and number of detected counts in the (fluence, $t_{50}$) parameter space.

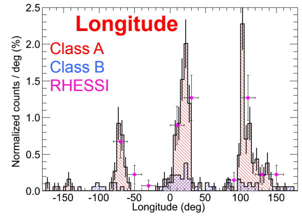
**Results:**

- TGFs with duration ~100μs or less cannot be detected by MCAL.
- Minimum fluence at threshold is ~0.05 $cm^{-2}$.
- Fluences above ~0.1 $cm^{-2}$ yield a significant dead time fraction.

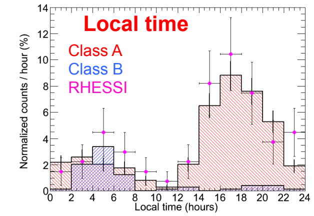


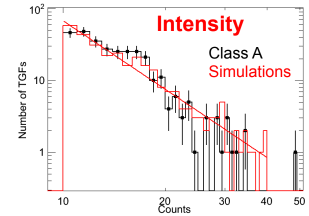

## 3. TGF properties



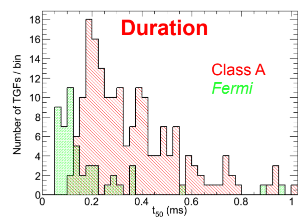

**Longitude** distribution peaks on continental masses, compliant with RHESSI.




**Local time** distribution peaks on late afternoon, compliant with RHESSI. Class B events peak on early morning because more photon-by-photon data are available there due to noise triggers (selection effect).



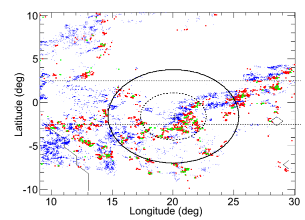

**Intensity** distribution can be fit with a power law with index -3.3±0.2, different from the value -2.3±0.2 suggested by Østgaard et al., JGR 117, A03327 (2012). However, when dead time is accounted for, a good agreement is obtained.

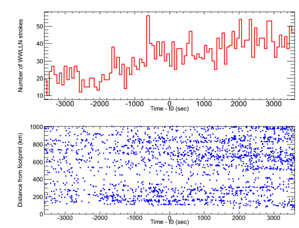


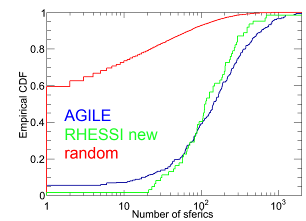

**Duration** ($t_{50}$) distribution has a median of 260 μs and a mean value of 400 μs. The median value is a factor 2.3 that of *Fermi* GBM (Fishman et al., JGR 116, A07304, 2011). The discrepancy can be ascribed to suppression of short TGFs by anticoincidence-induced dead time (see Section 2).

## 4. Correlation with WWLLN sferics

**Results 1**: no simultaneous (within 200 μs) sferics were found. This is compatible with the larger average TGF duration in the frame of the TGF / electron radio pulse correlation (Connaughton et al., JGR 2013 in press; Dwyer & Cummer JGR 2013 in press).






**Method (statistical approach):**

- For each TGF extracted the number of sferics within ± 10 minutes from the TGF time and <600 km from the satellite footprint. This observable ($N_{600}$) is a good proxy of lightning activity at the TGF time / region.
- Compare distribution with randomly extracted dataset and with new RHESSI TGFs (Gjesteland et al., GRL 39, L05102, 2012; and T. Gjesteland private communication).

**Results 2:**

- AGILE and new RHESSI TGFs are compatible with the same parent distribution by Kolmogorov Smirnov test.
- AGILE is not compatible with a random dataset.