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Implications for Terrestrial Gamma-ray Flashes spectrum, flux and fine time structure at source based on the high-energy events observed by AGILE

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The detection of counts with energy as large as 100 MeV in the Terrestrial Gamma-ray Flashes (TGFs) detected by the AGILE satellite has puzzled the community for several years. We addressed this issue by using a TGF dataset selected based only on the simultaneous association to lightning detected by the World Wide Lightning Location Network (WWLLN). This dataset indeed confirms the observation of counts with measured energy up to about 100 MeV, but at the same time points out the relevance of the contribution of dead-time and pile-up to these measurements. In order to quantitatively assess this contribution we developed a semi-analytical model of the AGILE-MCAL front-end electronics, based on PSpice simulations of the actual circuitry. Given the complexity of the model, it is not possible to correct a single TGF measurement back to its 'true' incoming flux. However, it is possible to use a forward-folding approach to identify most likely scenarios compatible with the measurements. We show that observations are compatible with a standard RREA TGF spectrum, although the possibility of a harder spectrum is not ruled out. However, in case of a RREA spectrum, an unusually large flux is required if we assume that photons are uniformly distributed in time within the overall TGF time profile. This flux requirement can be reconciled with current expectations if we assume that photons are emitted at source in bursts of microsecond duration. Observations and modeling therefore point towards a production scenario where several microbursts of radiation are produced at source and overlap at satellite altitude to produce the finally observed TGF time profile.