Signs of magnetic acceleration and multi-zone emission in GRB080825C

Elena Moretti & Magnus Axelsson
On behalf of the Fermi-LAT collaboration
The LAT and GBM on Fermi

The GBM detects \(~250\) GRBs/year

\(~18\%\) short

\(~50\%\) in the LAT FoV

The LAT detects \(~10\) GRBs/year

NaI: 8 keV - 1 MeV
BGO: 200 keV - 40 MeV
LAT: 30 MeV - 300 GeV

"Typical" Prompt GRB Spectrum
The Idea

- The LAT GRB catalog (Ackermann et al. 2013) shows that the most fluent GRBs deviate from a Band only spectral modelling.
- Do all bursts deviate from the Band function?
- Are we limited by the statistic to detect this deviation in the less fluent bursts?
- Can we investigate deviations with lower significance of the extra-components?
GRB 080825C is a moderately weak burst that did not show any deviation $>4\sigma$ from the Band function in Abdo et al. 2009.

We add the LLE (LAT Low Energy) events to model the gaping region between GBM and LAT from 30 to 100 MeV.

Data used: NaI 9 & 10 and BGO 0 & 1 (same as in Abdo et al. 2009); LLE (P7), P7REP_transient (new datasets).

We use the same time bins as in Abdo et al. 2009.

We lower the significance threshold, and investigate extra components above $3\sigma$. 
An extra component is found with $3.5\sigma$ significance in the first and fourth time bins.

Moretti, Axelsson 2015 subm. MNRAS
Bin IV

An extra component is found with 3.5σ significance in the first and fourth time bins.

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Results

- An extra component is found with 3.5σ significance in the first and fourth time bins.
- It is not significant in the time bins between, but the recovered parameters follow the same relation throughout the burst.
- The simplest model consistent throughout the burst is Band+BB.
- The first peak can not be modelled with a BB as it is wider.
- The second peak is likely wider than a BB peak, but if modelled with a Band function the parameters can not be fully constrained.
The energy of the Band peak has a typical hard-to-soft evolution.

The energy of the second peak (BB) increases linearly with time and reaches almost 16 MeV (similar to 110721).

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Interpretation (1)

Assuming that at least one component is related with the photosphere, there are two scenarios:

(1) One zone emission at the photospheric radius:

✗ Double-peaked spectra can be produced by subphotospheric emission, but the evolution of the second peak does not match predictions (Keren & Levinson 2014).

✔ If there is no subphotospheric dissipation, the temperature of the BB component is too high for photospheric emission. Possibly inverse Compton component from thermal/MeV photons scattering on accelerated electrons? (Pe’er et al. 2006, Vurm et al. 2014).

⇒ Not a likely scenario!
Interpretation (2)

2) Multi-zone emission:

✔ The Band is the photospheric emission:
  • thermal acceleration;
  • the BB component could be from synchrotron (internal shocks) or inverse Compton (Beloborodov et al. 2014; unlikely given the peak energy and the temporal behaviour).

✔ The BB is the photospheric emission:
  • acceleration from magnetic reconnection (kT too high for thermal acceleration; Bégué & Pe'er 2015);
  • the Band component could be synchrotron emission from electrons accelerated via reconnection (as the ICMART scenario of Gao & Zhang 2015).

➔ Most likely scenario if BB is photospheric!
**Conclusions**

- Evidence for a second peak at energies above the previously reported Band component, present at the level of 3.5σ.

- The peak energy of the extra/component increases throughout the emission episode, from a few hundred keV to several MeV.

- The results point to a 2 zone emission model disfavouring a single radius origin of the emission.

- The high energy of the second peak points to magnetic dissipation in the photospheric emission scenario.
Thank you
**Tests**

- We checked we had the same results with and without LAT>100 MeV data.
- We tested different spectral models but the simplest and consistent throughout the whole burst is Band+BB.
- We checked the width of the second peak by fitting the IV time bin with 2 Band functions. The peak is wider than a BB peak, but the second Band could not be fully constrained (alpha had to be fixed).
- We check the effect of a systematic error on the effective area, but it resulted in a marginal change of the significance of the extra-component.
- Effects on the GBM energy dispersion and calibration are likely below the statistical errors (from communications with GBM team).