Fermi-LAT Observations of Gamma-ray Bursts

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Fermi-LAT has provided a unique new dataset of high energy observations of Gamma-ray Bursts, which has led to many recent theoretical advancements and challenges. We present an overview of the first 3 years of observations in the 100 MeV - 300 GeV LAT bandpass including the detection of ~30 GRBs and limits on those not detected but within the LAT field-of-view.

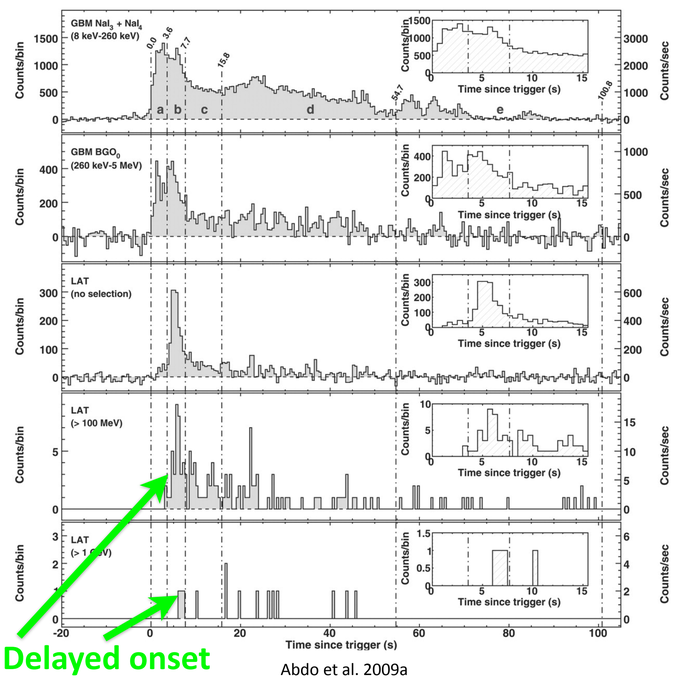
Several new features are common in the temporal and spectral behavior of these bursts including a delayed onset compared to the keV-MeV emission, an additional power-law component in the high-energy spectrum, and an extended emission lasting significantly longer than the lower-energy (keV) prompt emission possibly associated with the broadband afterglow.

LAT GRB Sample

30 LAT detected bursts in 3 years of observations (of 370 GBM triggers in LAT field of view - see posters #149.09 & 149.12)

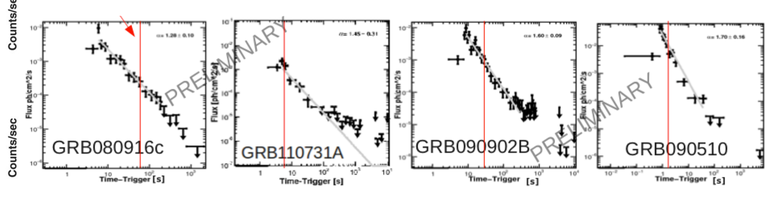
- 25 long ($T_{90,GBM}$>2 s), 5 short ($T_{90,GBM}$<2 s)
- 22 detected in likelihood analysis (E>100 MeV), 23 detected in LAT Low Energy technique (see poster #442.08), 2 seen off-axis (calorimeter only), 2 sub-threshold
- 10 with temporally extended emission
- 5 with additional spectral power-law
- 12 with delayed onset compared to GBM
- 9 with redshifts
- 4 with exceptionally bright LAT emission (GRBs 080916C, 090510, 090902B, 090926A)

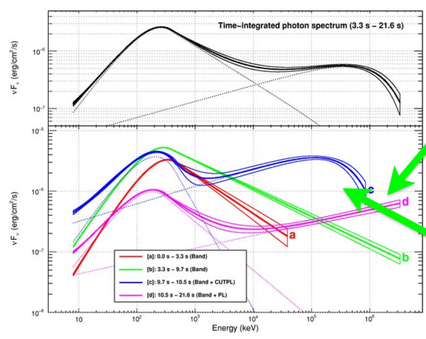
New Features of LAT GRBs



Abdo et al. 2009a

Temporally Extended Emission

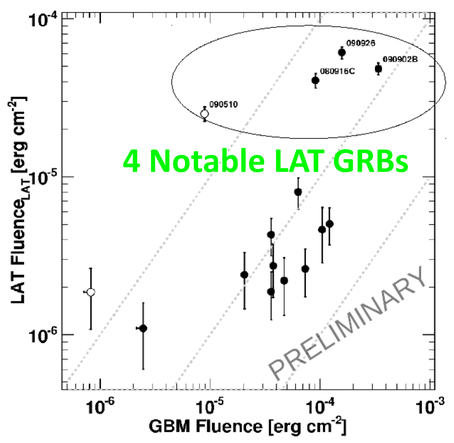


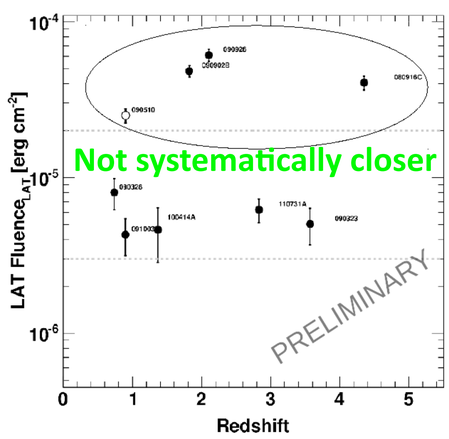


Extra Spectral Power Law with cutoff (in at least one case)

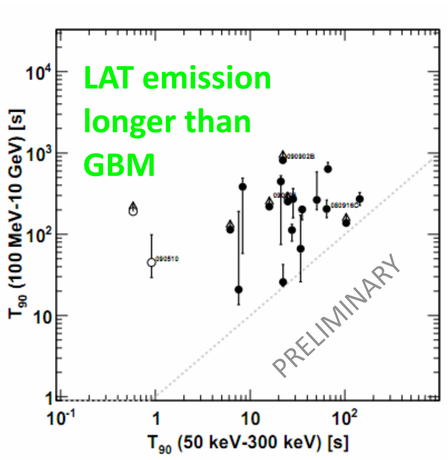
Ackermann et al. 2011

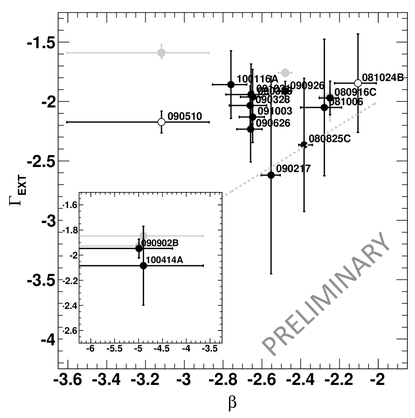
First LAT GRB Catalog



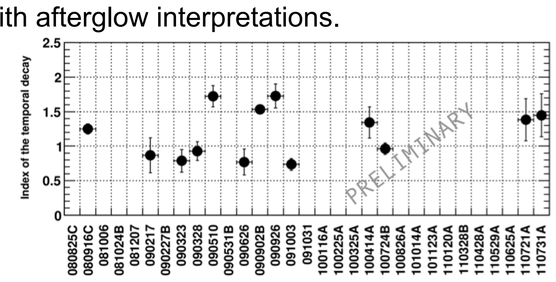


First systematic study of high energy (E>20MeV) GRB properties. The catalog will include tabulated data describing general GRB parameters (duration, average flux, peak flux, time of the peak flux, fluence), High-energy extended-emission parameters (temporal decay slope, spectral evolution, start/end time), Prompt emission parameters (delayed onset of the LAT emission, spectral evolution & components). Includes discussions on the unique properties of individual bursts (extra spectral components, HE spectral cut-offs, analysis caveats), and details on the tools and methods involved in the analysis.
To be submitted Spring 2012

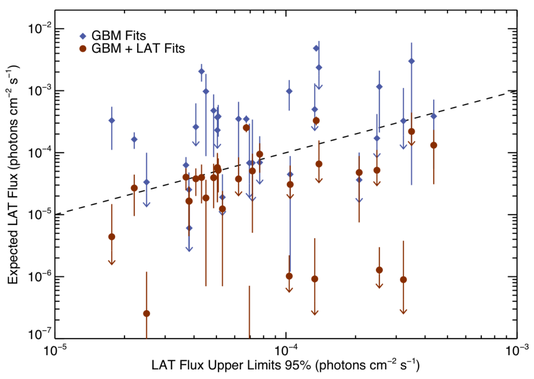




Extended emission linked to broadband afterglows (Kumar & Barniol Durran 2010, Ghisellini et al. 2010, Zhang et al. 2011). Spectral indices of prompt emission (β) not correlated with extended emission (Γ_{EXT}). Temporal indices consistent with afterglow interpretations.



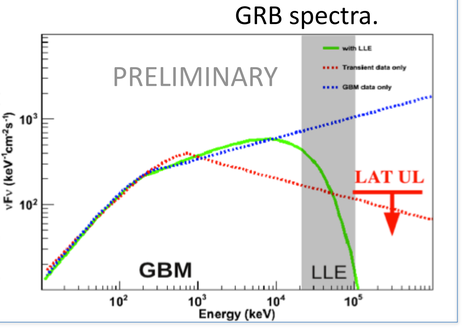
LAT Non-Detections



Ackermann et al. 2012

Fewer GRBs are detected by the LAT than would be expected by extrapolating GBM spectra. A systematic study (Ackermann et al. 2012) examines this question revealing the need for high-energy cutoffs in GRB spectra.

The LLE data selection technique (poster #442.08) is revealing additional spectral cutoffs not detectable with GBM alone or standard LAT analysis. Cutoffs, if due to opacity attenuation, can be used to set limits on bulk Lorentz factors.



Conclusions

Together *Fermi*-LAT and GBM observations of GRBs have allowed us to characterize a large sample from keV-GeV energies, revealing new temporal and spectral components, and explore the relationship between the low and high energy components. Although the LAT GRB detection rate is low, each burst provides clues to the origin of the new components and emission mechanisms. Individual GRBs have shown variation to the above picture, including a lack of one of the above components, and thermal components in addition to or instead of Band function (Ryde et al. 2010). LAT GRBs have also been used to constrain quantum gravity models via Lorentz Invariance Violation (Abdo et al. 2009b), and the opacity of the Universe to high-energy gamma-rays (Abdo et al. 2010).

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