THE SYNERGY BETWEEN THE LAT AND GBM IN GLAST'S STUDY OF GAMMA-RAY BURSTS

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Abstract

Gamma-ray burst studies by GLAST will be enhanced by the synergy between the Large Area Telescope (LAT; 20 MeV to >300 GeV) and the GLAST Burst Monitor (GBM; 10 keV to 25 MeV). Between the two detectors GLAST may observe burst spectra covering 7 energy decades; the GBM's field-of-view (FOV) covers totally the LAT's large FOV. Using semi-analytic calculations I characterize the bursts to which each instrument will be sensitive. The thresholds of both instruments are at approximately the same $\nu f_\nu \propto E^2N(E)$ values, i.e., the thresholds can be connected by an E^{-2} spectrum. Therefore simultaneous detections by both instruments will be biased towards spectral components flatter than E^{-2}.

GLAST Burst Overview

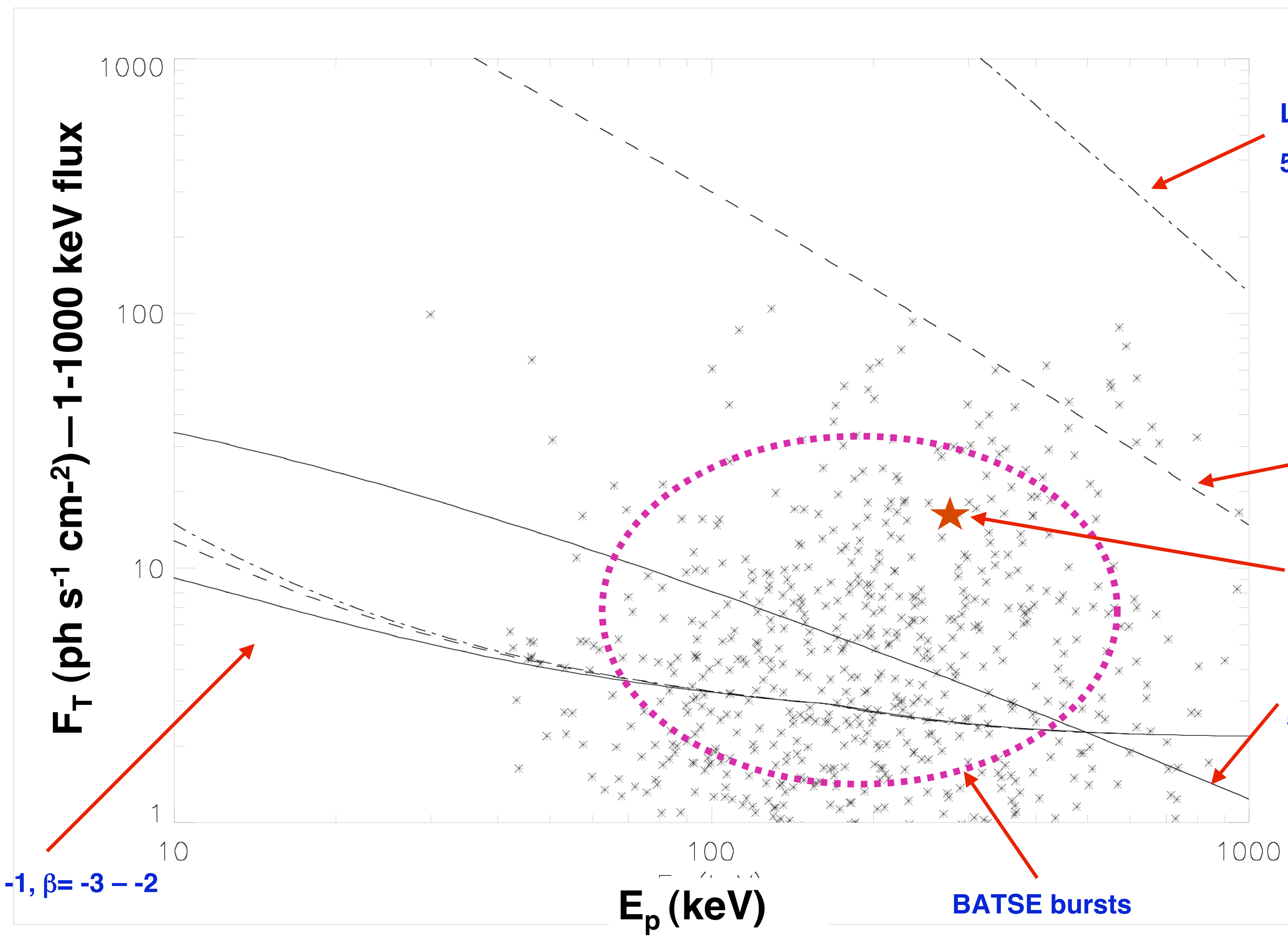
- The Large Area Telescope (LAT) will have an energy range <20 MeV to >300 GeV, effective area of >8000 cm^2, angular resolution <3.5º @ 100 MeV, <0.15º @ >10 GeV, field of view of >2 sr, and deadtime <100μs

- The GLAST Burst Monitor (GBM):
  - 12 NaI detectors— <10 keV to 1 MeV. Used for onboard trigger, onboard and ground localization, spectroscopy
  - 2 BGO detectors— 150 keV to 25 MeV. Used for spectroscopy.

- Both GBM and LAT will have onboard burst detection and localization software.
- GBM will alert LAT that a burst is in progress.
- Spacecraft will send burst alert and location to afterglow community within 7s via TDRSS and GCN (subscribe to GCN!).
- Spacecraft may repoint autonomously to observe burst location for 5 hours.
- Burst searches of downlinked LAT and GBM data.
- Locations will be refined on the ground.
- GBM and LAT burst catalogs through GSSC website (http://glast.gsfc.nasa.gov/ssc/).
- All GBM science and LAT summary data released during 1st year, LAT count data public beginning with the 2nd year.

Modeling Assumptions

- Single component in both GBM and LAT bands
- Spectrum is 'Band Function,' a smoothly broken power law:
  - Low energy power law, E^α; typically $\alpha \sim -1$
  - High energy power law, E^β; typically $\beta < -2$
  - E_p is energy of peak of $E^2N(E) \propto \nu f_\nu$
  - The spectrum is normalized by F_T, the 1-1000 keV flux
- Expectations (spectrum, burst rate) for GBM are based on BATSE (similar energy band)
- EGRET observations and theory suggest additional ~1 GeV temporal and spectral components
- Preliminary 'direct' GBM response used, i.e., no scattering off spacecraft or atmosphere
- Current 'DC2' LAT response used



GLAST in the F_T-E_p Plane

The F_T-E_p plane is useful for comparing the burst sensitivity of different detectors.

- F_T is the 1-1000 keV flux, the normalization of the spectrum
- E_p is the peak of the spectrum

Note that the value of F_T at E_p is NOT the detector's sensitivity as a function of energy! It is the sensitivity as a function of the spectral parameters.

GBM detects bursts with a rate trigger:
- Continuously bin count rate in ΔE and Δt
- Require a >4.5σ increase in number of counts in bins from 2 NaI detectors
- Threshold value of peak F_T for given spectral indices α and β, and E_p
- Since detectability is in terms of spectrum's parameters, detectors with different energy dependencies can be compared.
- Plot shows GBM's threshold F_T in terms of E_p, holding α and β fixed, for Δt=1 s.

Assume 5 LAT photons are detected in Δt=1 s. Holding α and β fixed, the relationship between E_p and F_T is plotted above.

E_p and F_T are plotted for a sample of BATSE bursts.

Conclusions

- GBM will be less sensitive than BATSE (expected based on detector size). Note that the GBM sensitivity to long duration bursts will be increased by the rate trigger accumulating counts over timescales longer than Δt=1 s (BATSE's maximum).
- The GBM and LAT are well matched for bursts with β=-2, i.e., constant $\nu f_\nu \propto E^2N(E)$.
- LAT bursts with β<-2.5 will be brighter than most of the bursts that BATSE observed, and therefore rare
- Thus there will be a bias towards LAT bursts with β=-2

Caveat: Additional spectral and temporal components are expected in LAT energy band

Acknowledgements

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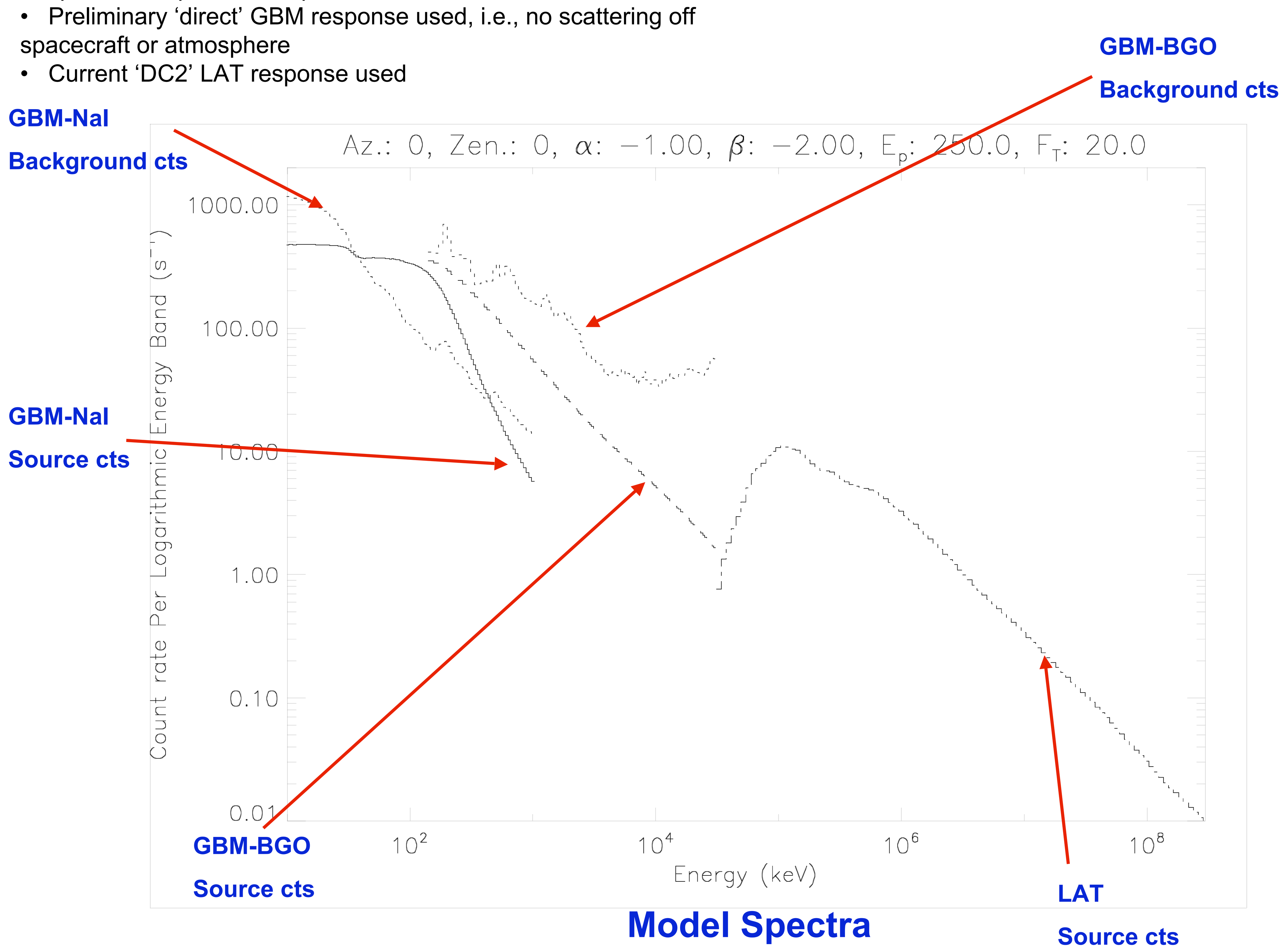

Model Spectra

- Burst spectrum is folded through the response of NaI (solid), BGO (dashed) and LAT (dot-dashed).
- GBM NaI and BGO backgrounds (dotted) estimated from BATSE backgrounds; there are essentially no background LAT counts during the burst.
- Spectra from single NaI and BGO detectors shown; a number of detectors of each type will observe burst.
- The spectrum is marked on the F_T-E_p plot.
- Note 7 energy decades are covered!

Scientific Questions that Can Be Addressed

Spectral-temporal components—characterization, origin
⇒ Need both GBM and LAT time resolved spectra

Intrinsic spectral cutoffs—probe of particle acceleration
⇒ Need GBM to constrain intrinsic spectrum

Extrinsic spectral cutoffs—absorption by intervening photon fields (work by Dwek, Stecker, Kashlinsky)
⇒ Need GBM to constrain intrinsic spectrum

Quantum gravity—predictions of $c_{light}(E)$ can be tested by searching for energy-dependent lags (see Scargle et al. 2007)
⇒ Need broad energy band and high time resolution lightcurves

Redshift indicators—relations between burst properties turn bursts into standard candles (e.g., Firmani et al. 2006)
⇒ Need GBM spectra and lightcurves, and burst redshifts

Burst locations—afterglows, host galaxies, redshifts
⇒ But will we have enough redshifts? Swift will observe ~1/6 of GLAST bursts.