GLAST Observations of Gamma-Ray Bursts

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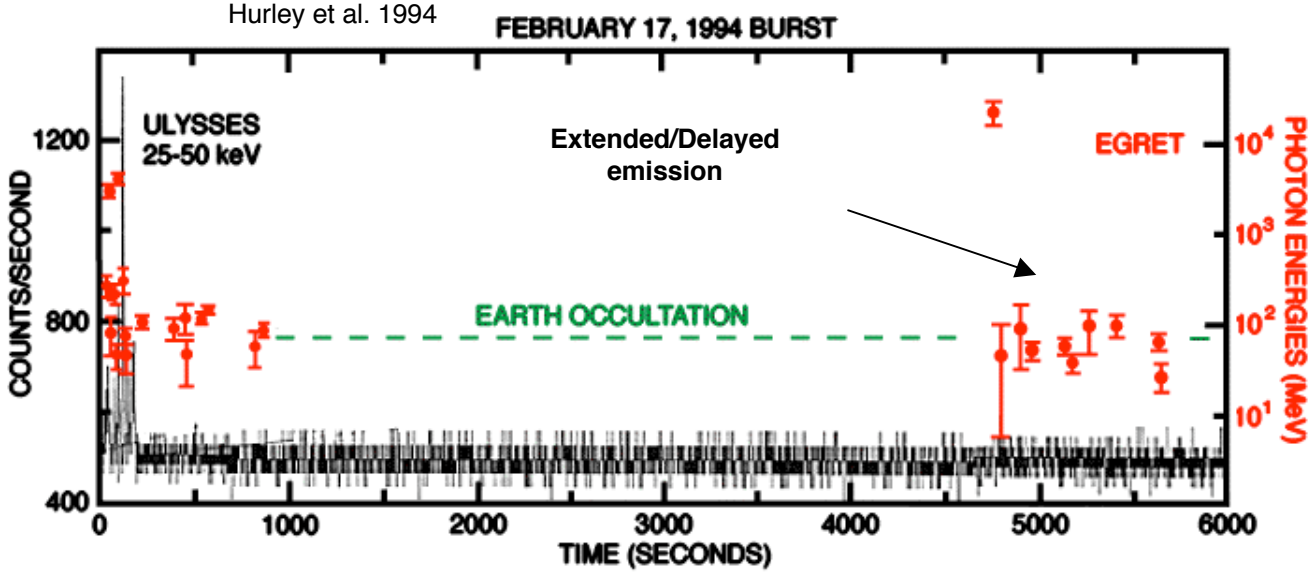
Outline

- What has been seen
- What is expected
- What GLAST might observe

What Has Been Seen

- Bursts are usually observed in the 15-1000 keV band (BATSE, Swift→GBM) with differing lightcurves, spectra.
- EGRET found ~GeV emission:
  - Extrapolation of low energy
  - Additional component
  - Afterglow
- Higher energy emission reported but not confirmed

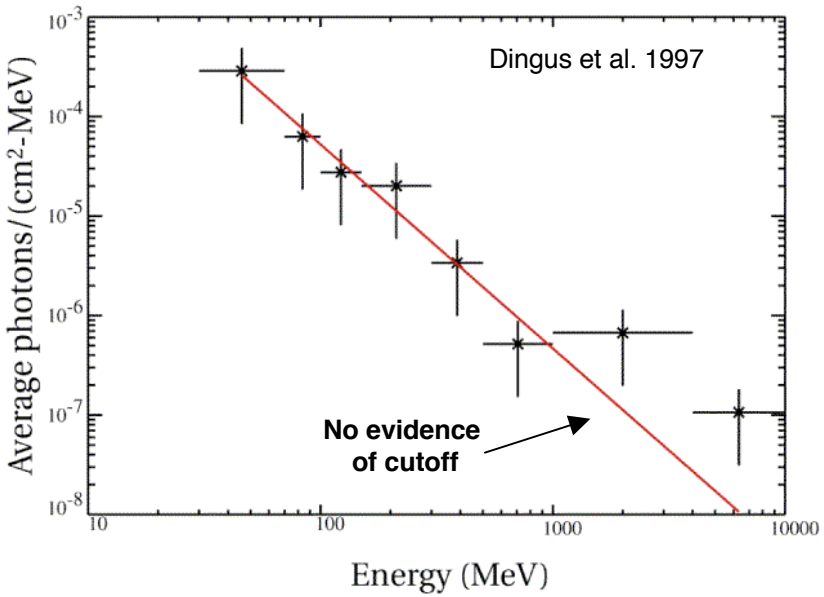
Hurley et al. 1994



Power Law Spectra, But…

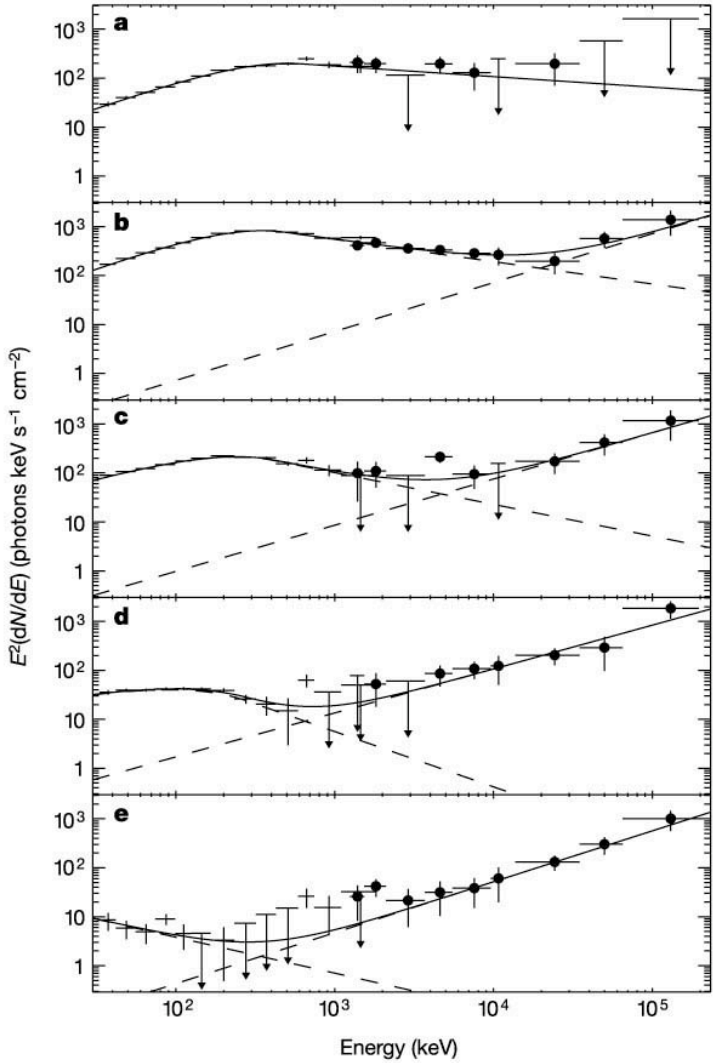
- EGRET spectra are consistent with power law with β=-2. But…
- This is probably a selection effect (steeper spectra not detectable)
- A break is expected:
  - Finite energy—β=-2 has infinite energy
  - Absorption resulting from Extragalactic Background Light (EBL)—function of redshift

Composite spectrum of 5 EGRET Bursts



Multiple Spectral Components

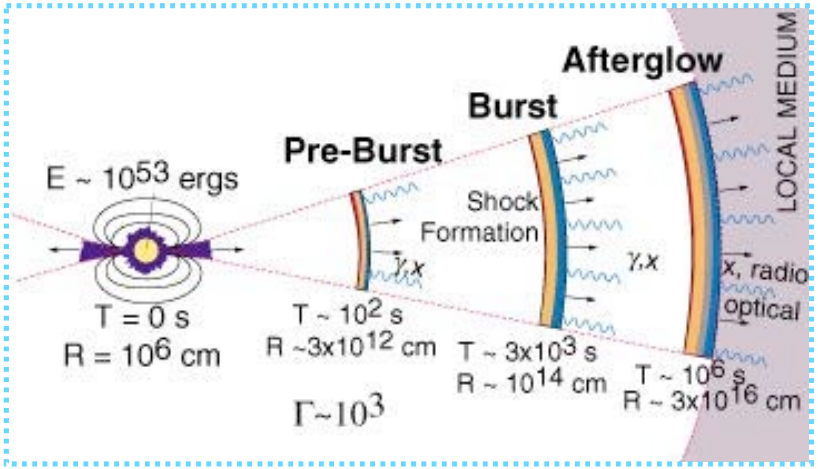
- Temporal-spectral evolution of GRB 941017 showed two components with different temporal and spectral behavior.



Gonzalez et al. (2003)

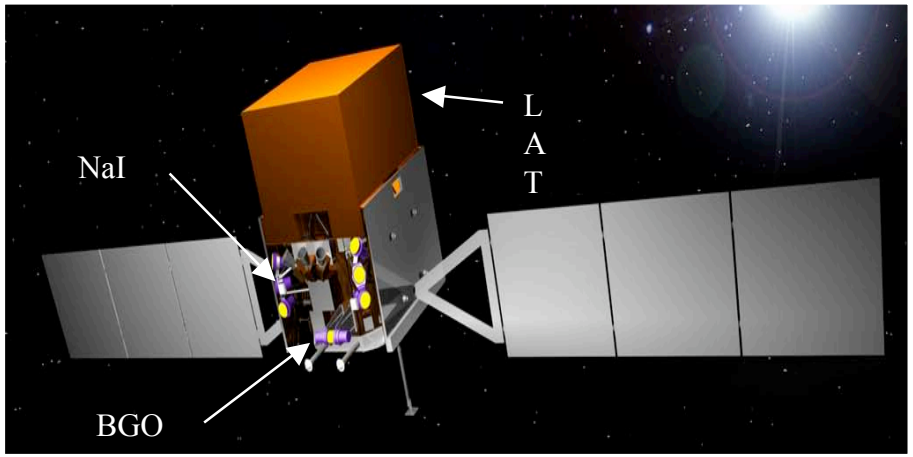
What is Expected

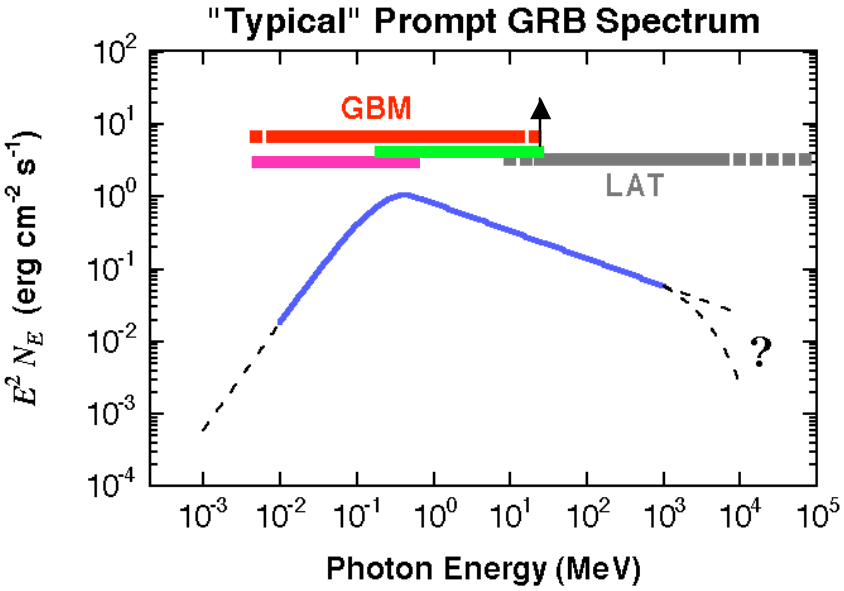
- Temporal-spatial model of burst emission has many potential emitting regions
  - External shock
  - Internal shock
  - Forward and reverse shocks in both region types
- Many emission mechanisms
  - Synchrotron, by both electrons and protons
  - Inverse Compton, by both electrons and protons
- Therefore, expect multiple emission components, many in the ~GeV band.



What GLAST Might Observe

- LAT— <20 MeV to >300 GeV. Will have both onboard and ground burst triggers.
- 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.
- Total of >7 energy decades!





Burst Operations

- 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 on GSSC website (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.

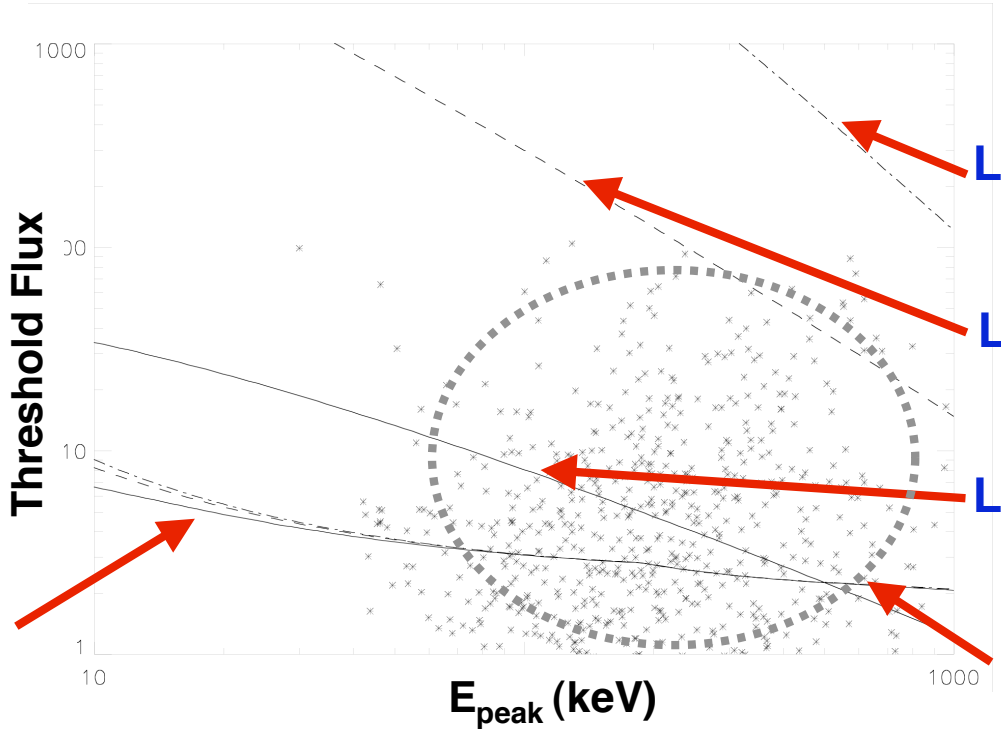
Detector Sensitivity

- If the ~GeV emission is extrapolation of 10-1000 keV emission then:
  - GBM should detect bursts with detected LAT emission
  - Bias towards LAT bursts with $\beta = -2$

Δt=1s

5 LAT counts for detection

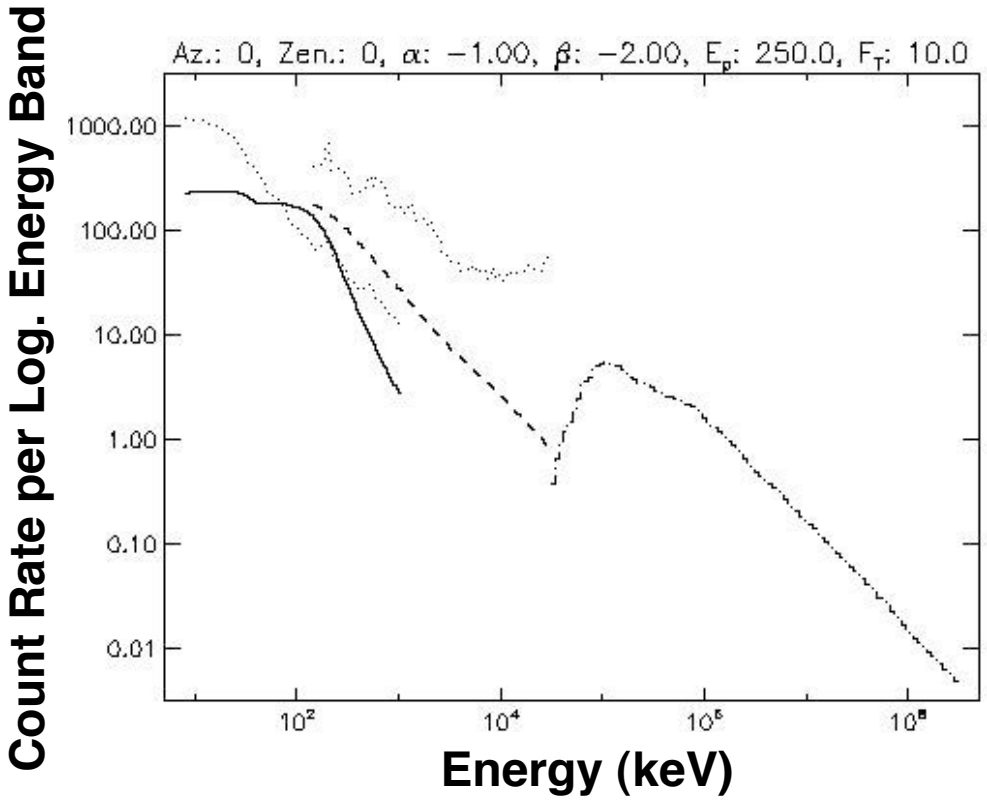
Threshold flux integrated over 1-1000 keV



GBM $\alpha = -1$, $\beta = -3 - -2$

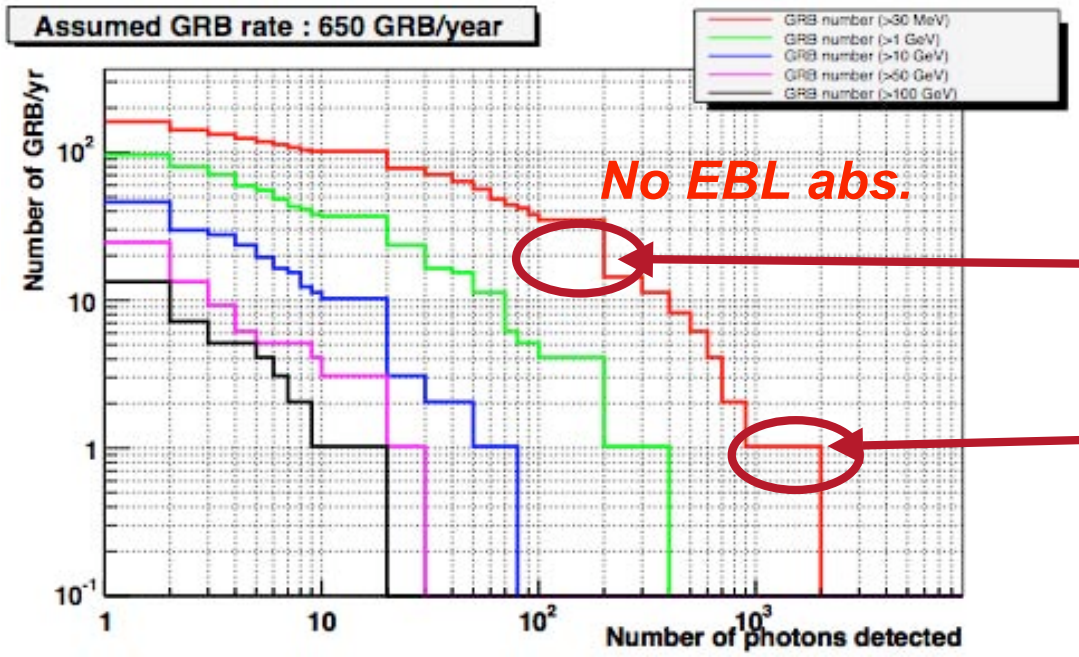
Burst Spectra

- **Joint fits will be possible with XSPEC after the counts from each detector are binned.**



Expected Detection Rate

- Based on BATSE detection rate, the GBM should detect ~200 bursts per year.
- The LAT detection rate depends on the relatively unknown ~GeV emission. Using BATSE data and extrapolating to LAT band, estimate LAT rates.



A few bursts per month with 100 counts

~1 burst per year with 1000 counts

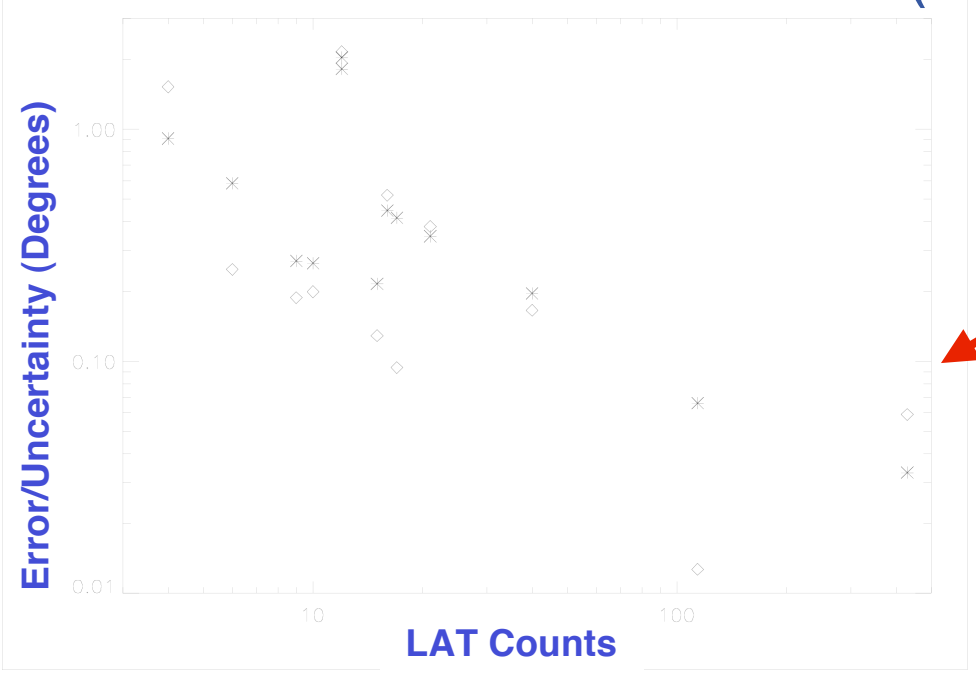
Burst Localization

- GBM—dependent on burst strength
  - Statistical:
    - [15°, 9°, 1.5°] for [threshold, brightest 40%, brightest 5%]
  - Systematic:
    - Onboard: ~10°
    - On ground: 1-2°
- LAT—depends on number of detected counts (& spectrum)

DC2 Simulations

♦—difference between 'true' and calculated positions

x—calculated uncertainty



Scientific Questions

- Spectral-temporal components—characterization, origin
- Intrinsic spectral cutoffs—probe of particle acceleration
- Extrinsic spectral cutoffs—absorption by intervening photon fields (low-mid z OUV—Dwek, Stecker, high z Pop III—Kashlinsky)
- Quantum gravity—predictions of $c_{light}(E)$ can be tested by searching for energy-dependent lags
  - See Scargle et al. (2007)—astro-ph/0610571
- Redshift indicators—relations between burst properties turn bursts into standard candles
  - E.g., Firmani et al. (2006, MNRAS, 370, 185)
- Burst locations—afterglows, host galaxies, redshifts
  - But will we have enough redshifts? Swift will observe ~1/6 of GLAST bursts.