Analyzing GRB Spectra

David Band

(GLAST SSC—GSFC/UMBC)

Special Case—Gamma-Ray Bursts

- Bursts are (relatively) short—10's of seconds—although emission up to an ~hour was seen in one burst
- Within PSF length of the burst position no non-burst LAT photons are expected on a minute timescale
- The pointing will not change significantly during the burst (~4° per minute)

∴ Treat all photons within 1-2 PSF lengths as burst photons

- Many burst photons—bin in time and energy, fit spectra (e.g., with XSPEC)
- Few burst photons—fit spectra using likelihoods; energy is the only observable

[Operationally, the GBM will detect and crudely localize bursts. LAT GeV photons will localize bursts to ~0.1°. GLAST may point at a burst's location for ~5 hrs.]

Binned LAT Spectral Analysis

- Extract LAT photons from region around burst
- Bin these LAT photons in energy (⇒count spectra) and time (⇒series of count spectra)
  - Time binning:
    - User selected
    - Constant Δt
    - Constant S/N
    - Bayesian Blocks
  - Binning tool will operate on LAT, GBM and Swift counts
  - Result is PHA-II readable by XSPEC ⇒ defining RMF-II format
- Tool is called evtbin

Binned LAT Spectral Analysis, cont.

- Collapse instrument response (many observables) to DRM (one observable—apparent energy)
  - Format is RMF readable by XSPEC
  - May need series of DRMs for long burst
- Tool is called rspgen

- Fit resulting spectra with XSPEC
  - Provide scripts for fitting series of spectra
  - Working with XSPEC team in defining standard fitting output

- Note that XSPEC can minimize either χ^2 or the Cash statistic, based on the number of counts in a spectrum

Binned GBM Spectral Analysis

- The basic GBM burst data are 'timed tagged events.' Therefore GBM binned spectral analysis is nearly the same as for the LAT.
- The counts are already from a region around the burst
- Counts are binned in time and energy using evtbin
- The GBM team will provide DRMs for the burst. In addition, new DRMs can be calculated with DRMGen.
- Backgrounds are required. The GBM team will provide background spectra (PHA-II format). A tool will be provided to calculate new backgrounds.

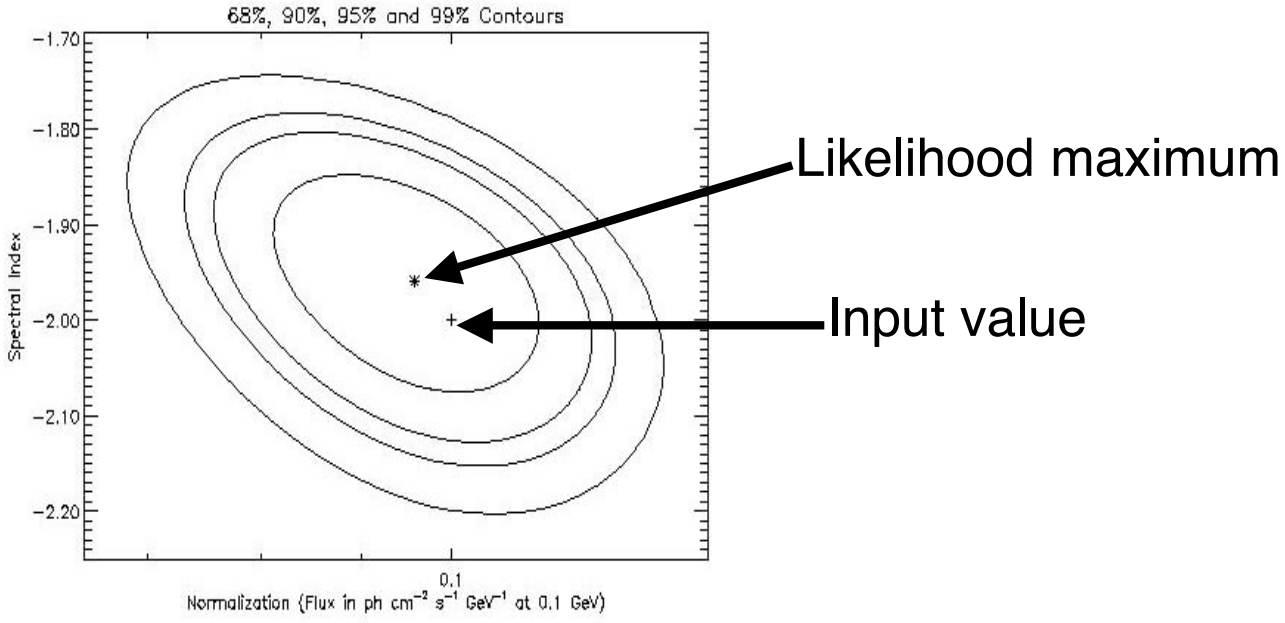
Joint Fits

- Because both the LAT and GBM data are both fit by XSPEC, joint fits are possible!
- Because event lists are binned, the time binning can be the same.
- Joint fits with the data from other missions (e.g., Swift) are also possible.

Unbinned Spectral Analysis

- For a very small number of counts, a likelihood analysis of counts unbinned in energy may extract more information.
- The Likelihood code discussed by Jim is flexible enough to fit data in only one dimension.
- Note that XSPEC fits to the GBM data could be priors for a likelihood analysis.

115 counts in an E^{-2} power law spectrum



Additional Burst Tools

- We will provide graphical tools to look at the burst data
- We will provide a tool kit to analyze binned and unbinned lightcurves, e.g.,
  - Bayesian Blocks
  - FFTs
  - Wavelets
- A temporal-spectral fitting tool is also being developed. This tool will be able to fit physical models to the LAT data

What is NOT Included

The SAE will not include:

- **Burst detection software**
  - The instruments will have burst triggers
  - The instrument teams will look for additional bursts as part of the ground processing
- **Burst localization software**
  - The GBM and LAT will localize bursts onboard; these localizations will be downlinked through TDRSS and distributed as GCN Notices.
  - A burst processor provided by the GBM team will localize bursts autonomously using data transmitted through TDRSS; the resulting localization will be distributed as a GCN Notice.
  - The instrument teams will localize (and analyze) bursts as part of the ground processing; the results will be distributed as GCN Circulars.