Towards the First *Fermi*-LAT GRB Catalog

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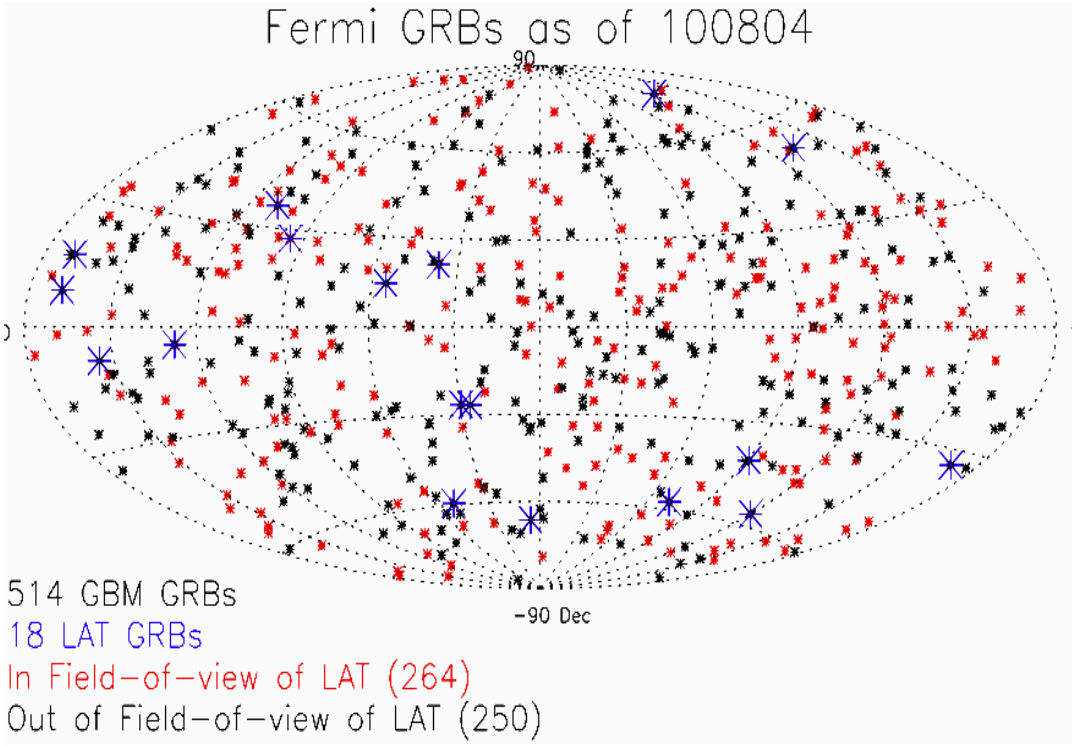
on behalf of the *Fermi*-LAT collaboration

GRBs Detected by the *Fermi*-LAT

- About half of GBM bursts are in the LAT's Field of View (FOV).
- About 7% of the in-FOV bursts are significantly detected by the LAT.
- The properties of these bursts will be described in the forthcoming *First Fermi-LAT GRB Catalog*.
- Will include 20 LAT-detected bursts as of 100903 (with GCN Circulars) + not-yet-announced recent detections.



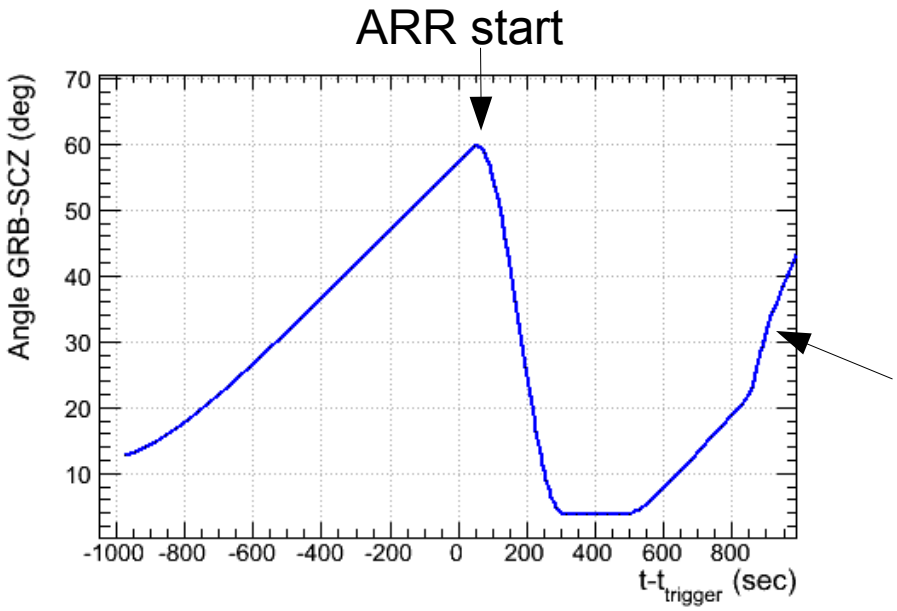
- http://fermi.gsfc.nasa.gov/ssc/observations/types/grbs/grb_table/

The *Fermi*-LAT GRB Catalog

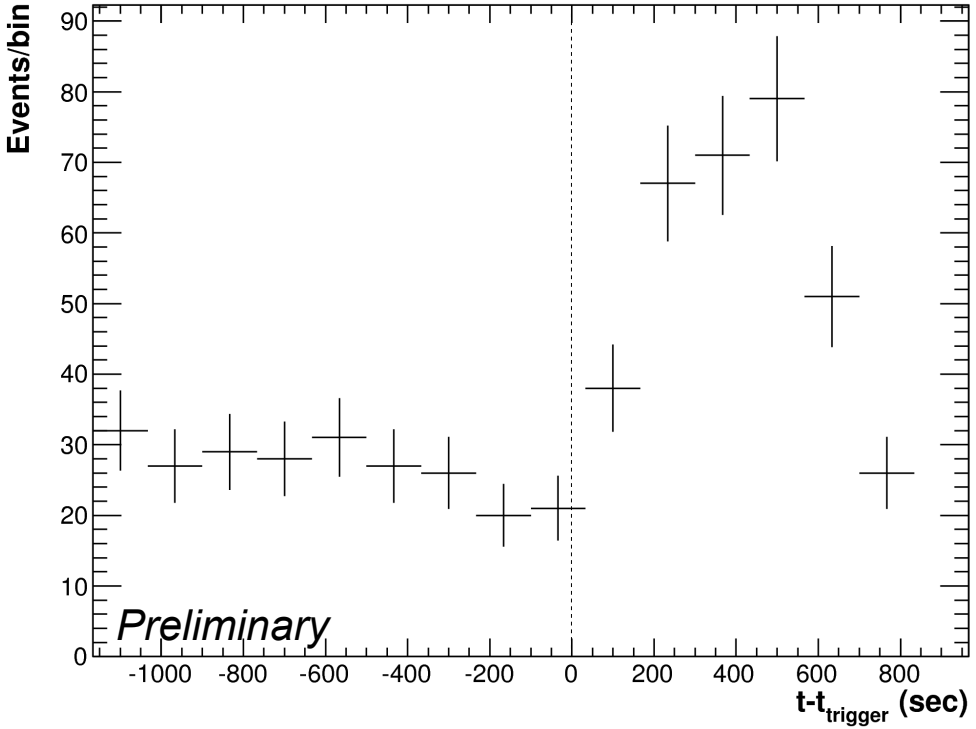
- First systematic study of GRB properties at high (E>50MeV) energies.
- Covers bursts starting August 2008 – ~present (2+ yrs).
- Will include tabulated data describing important GRB parameters
  - Usual GRB properties:
    - Duration, average flux, peak flux, time of the peak flux, fluence
  - HE Extended 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).
- Includes details on the tools and methods involved in the analysis.
- I will first give some details on the analysis improvements involved in the LAT GRB-catalog project and then present some preliminary results.

Backgrounds & ARRs

- Autonomous Repoint Requests (ARRs) typically cause large fluctuations in the off-axis angles of GRBs, complicating analyses:
  - Pre-fit backgrounds become invalid
  - Large exposure variations have to be properly taken into account → can't fit lightcurves in detected-count space.



GRB090323 Lightcurve -- E>50MeV, ROI=20deg

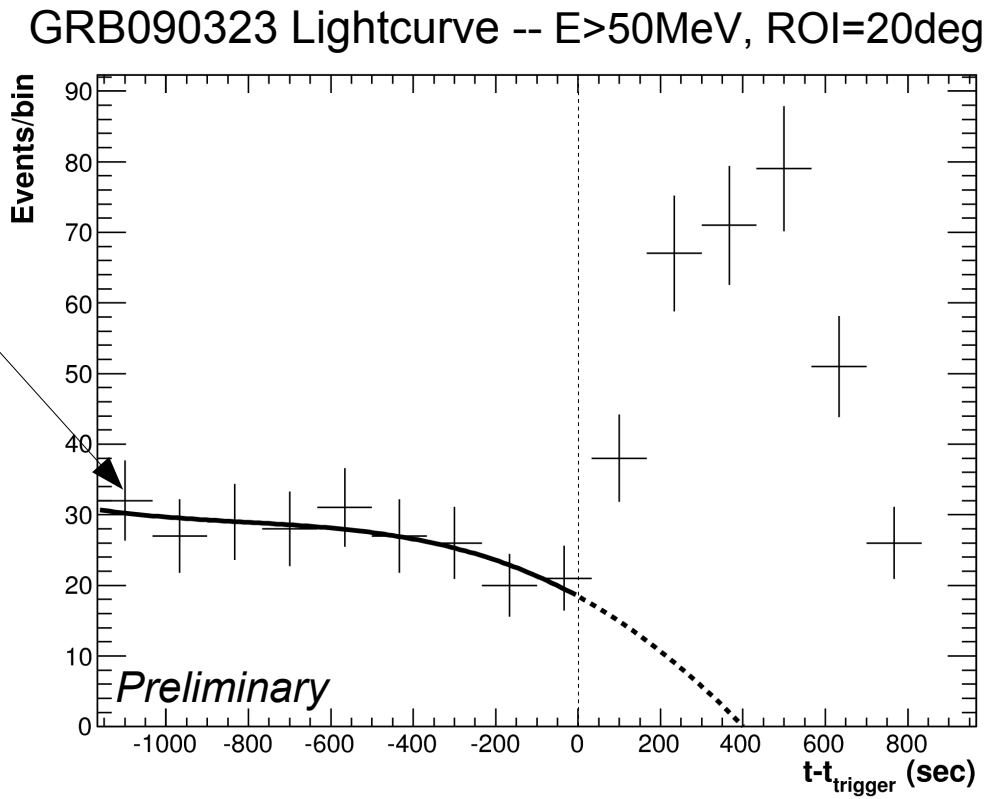


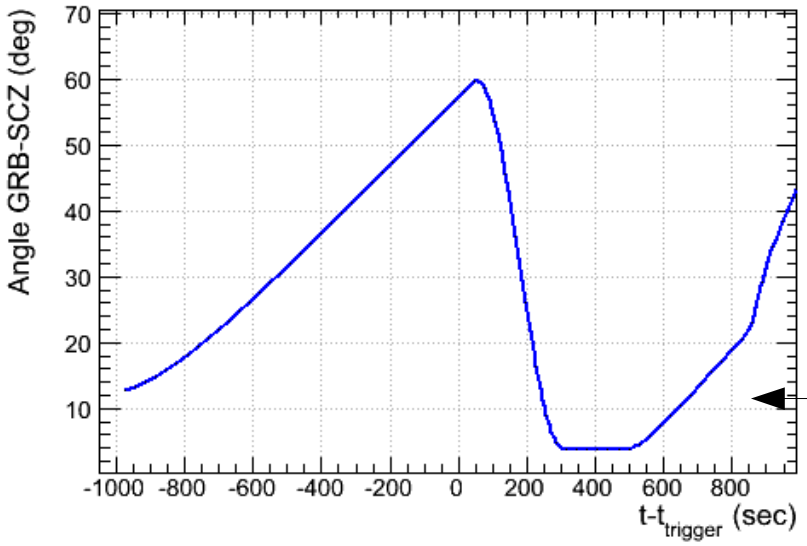
Angle between GRB090323 and the LAT's Boresight

Background Estimation & ARRs

- A common method for estimating the background is by
  - fitting the background before and after the burst and interpolating or by
  - fitting the background before the burst and extrapolating.

✗ Does not work if an ARR causes rapid off-axis angle variations in the fit or burst intervals.

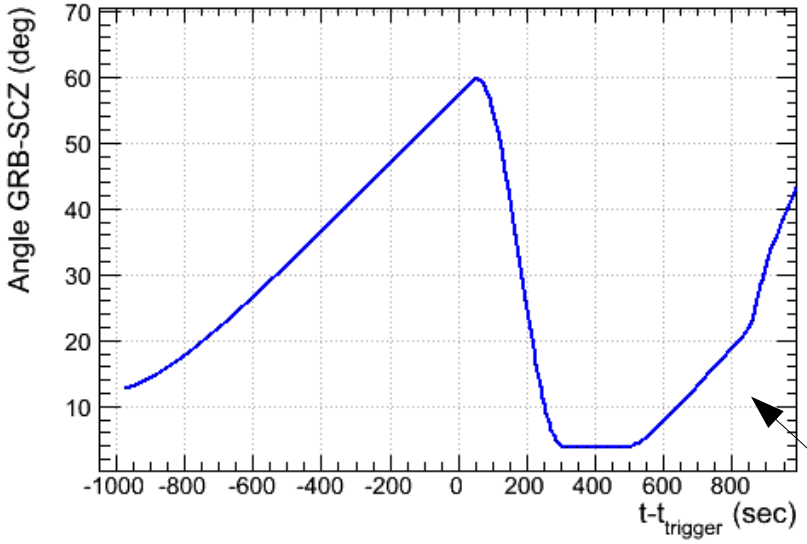




Angle between GRB090323 and the LAT's Boresight

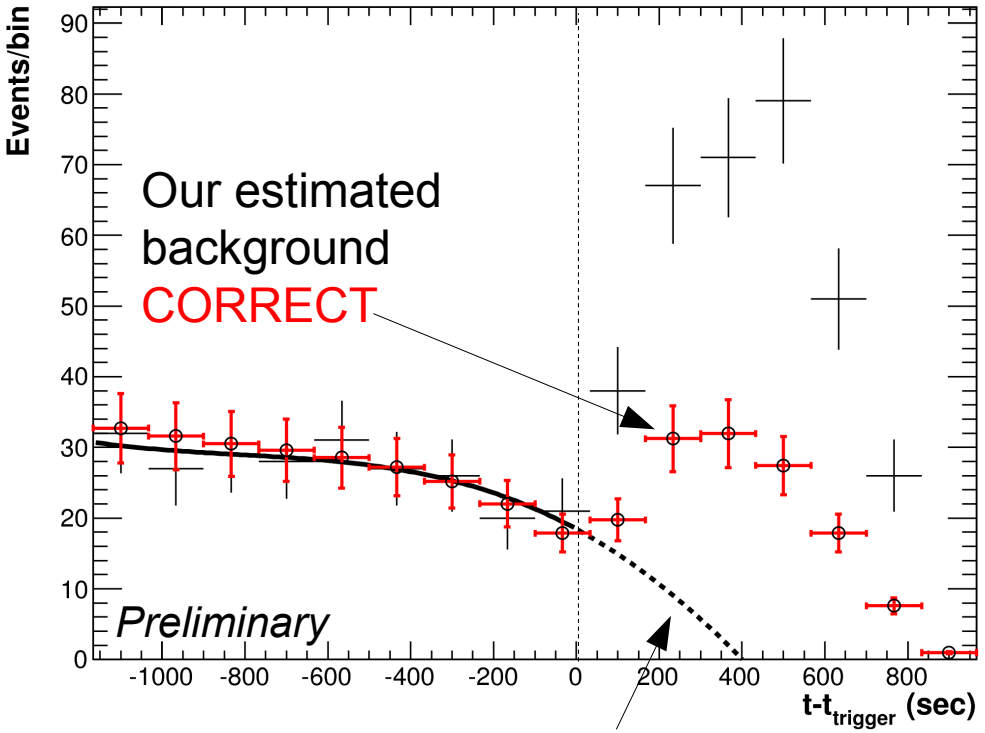
Background Estimation & ARRs

- We have developed a background-estimation tool that uses a model of the LAT backgrounds (described in Fermi's GRB080825c paper).
- ✔ ~10-15% accuracy. Works for any observational conditions.
- ✔ Extensively used in the catalog's analyses: maximum likelihoods, duration estimates, event probabilities.



Angle between GRB090323 and the LAT's Boresight

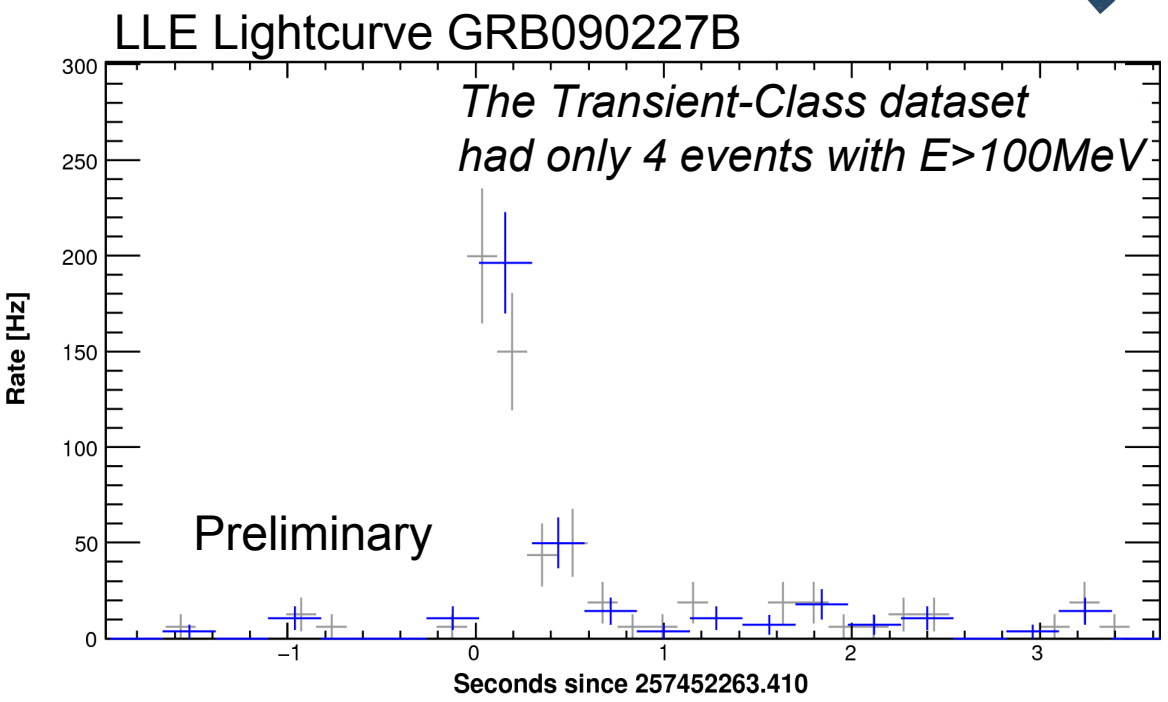
GRB090323 Lightcurve -- E>50MeV, ROI=20deg



Prefit background WRONG

LAT Low Energy (LLE) Data Class

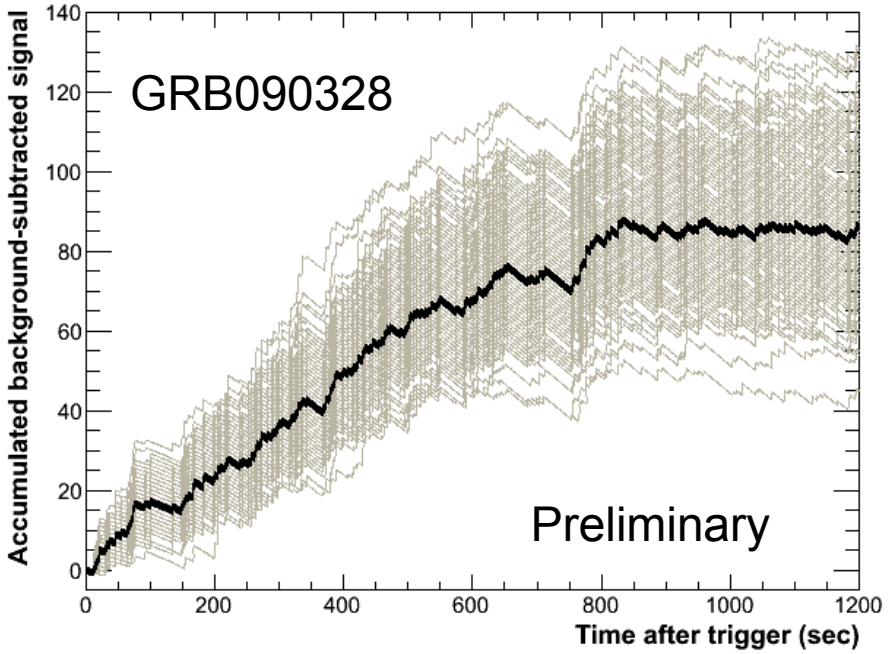
- Some bursts are too weak, too soft, or at a too high off-axis angle (i.e. θ>70°) to be significantly detected using our standard data selection ("Transient" data class).
- Our new LLE data class corresponds to a relaxed data-selection criteria, and
- provides a significantly higher effective area at low (tens of MeV) energies and at larger off-axis angles.



- We are using the LLE class for the GRB catalog:
  - ✔ Allowed us to detect more GRBs including GRB 081215A, 090227B, 091031, 100225A and 100707A (90° off-axis).
  - ✔ Provided the necessary statistics to study the temporal characteristics of the faintest LAT GRBs.

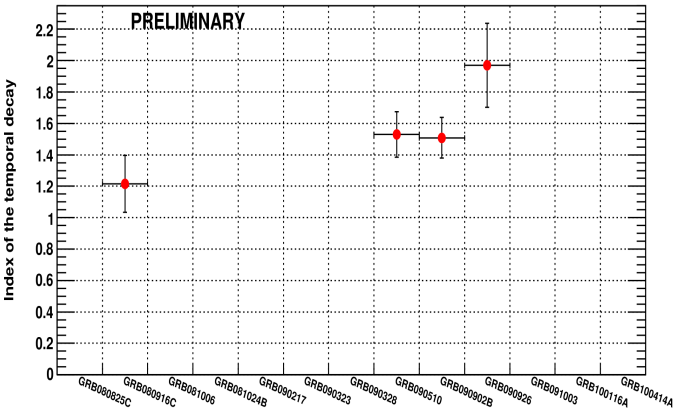
Duration Estimation

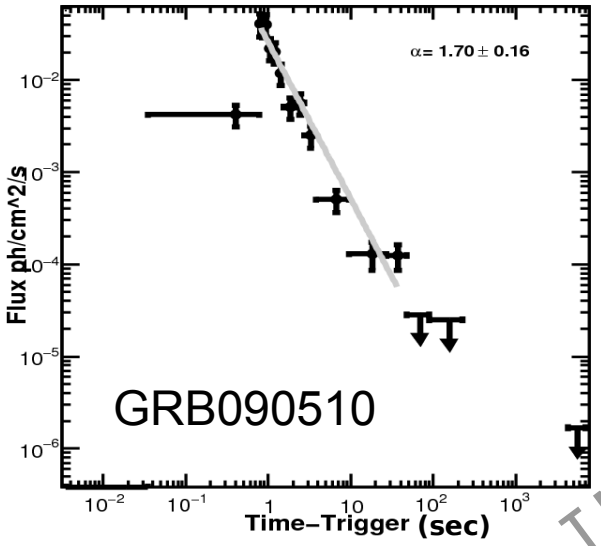
- GRB T90s are calculated based on the time development of the cumulative background-subtracted lightcurve.
- In low statistics lightcurves (as in the LAT) → individual fluctuations can introduce uncertainties in the choice of the plateau and can also "drive" the final T05/T95.
- To characterize these fluctuations we perform duration estimations on simulated lightcurves that are statistically compatible with the actual detected lightcurve.
- The final result comes from the median and +-1σ quantiles of the simulated T05/T95/T90 distributions.
- *Method under development and verification.*
- Improvements include removing the effects of variable exposure observations.

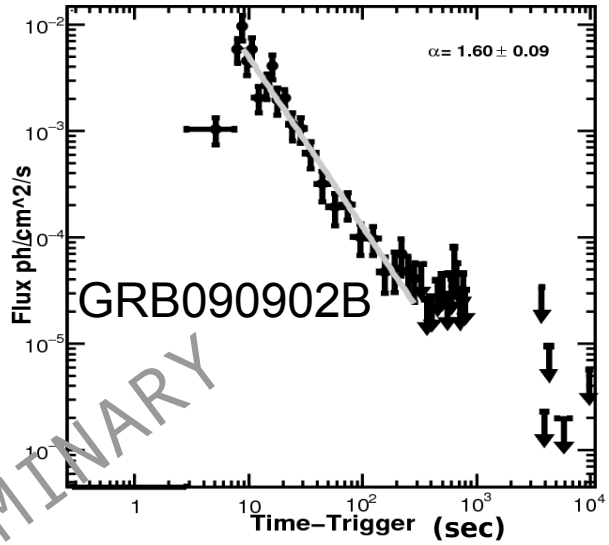


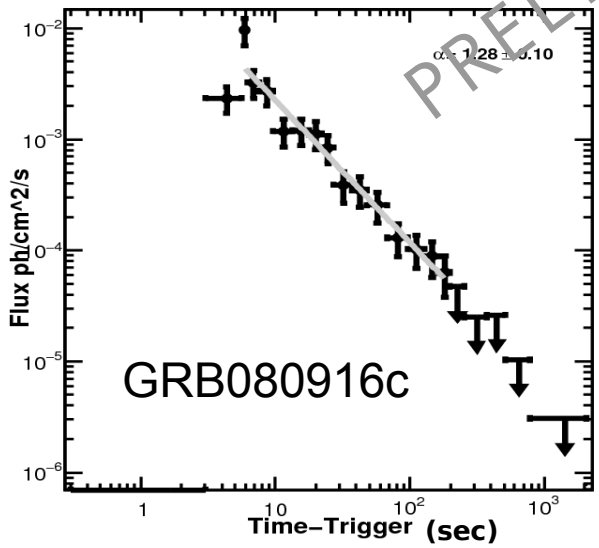
Extended Emission

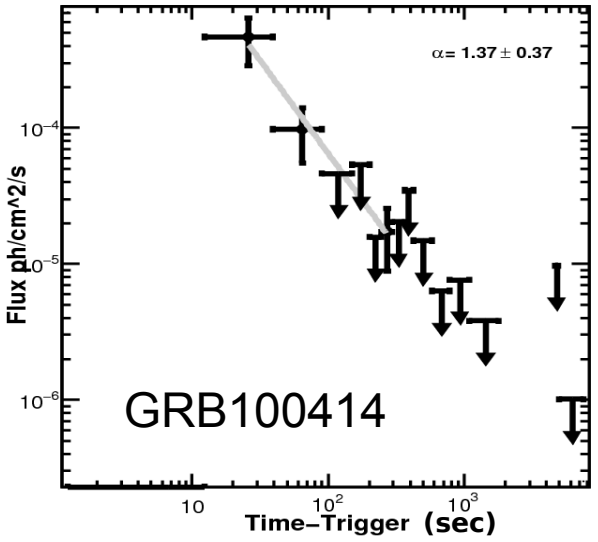
- Observed in several LAT-detected GRBs.
- Flux decays as a power law in time.
  - Typically the decay can be described by a single index: ~-1.5
  - Sometimes “breaks” are observed (under investigation).







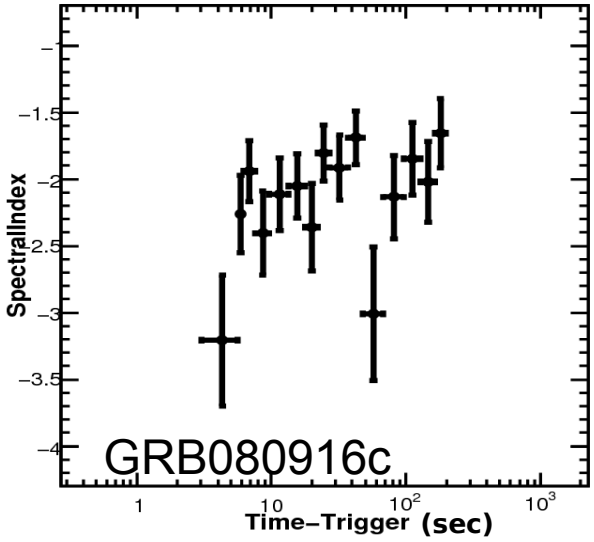


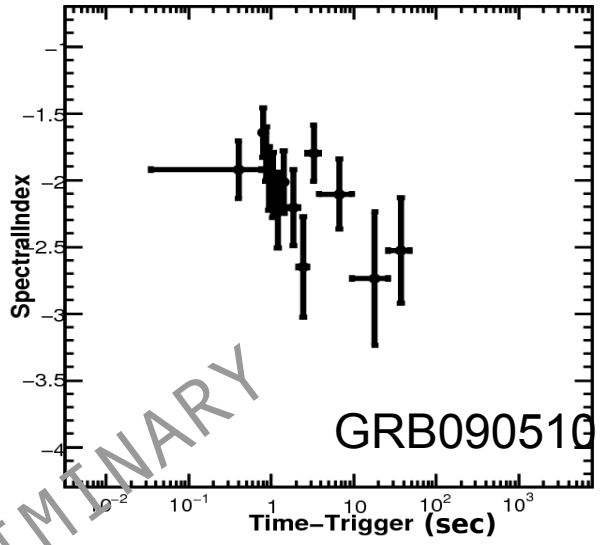


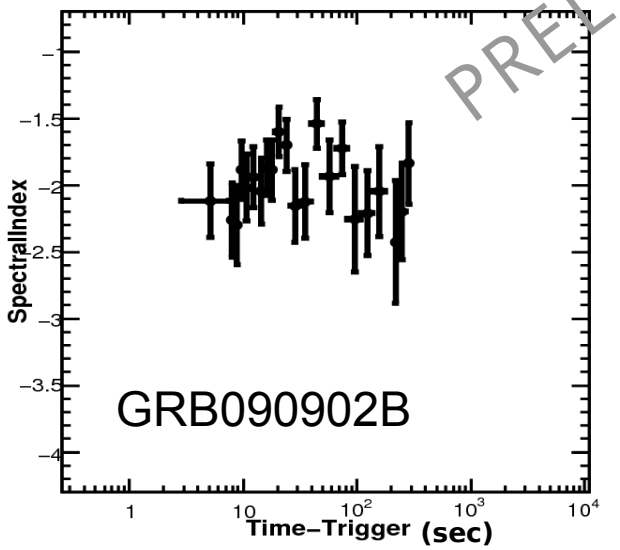
PRELIMINARY

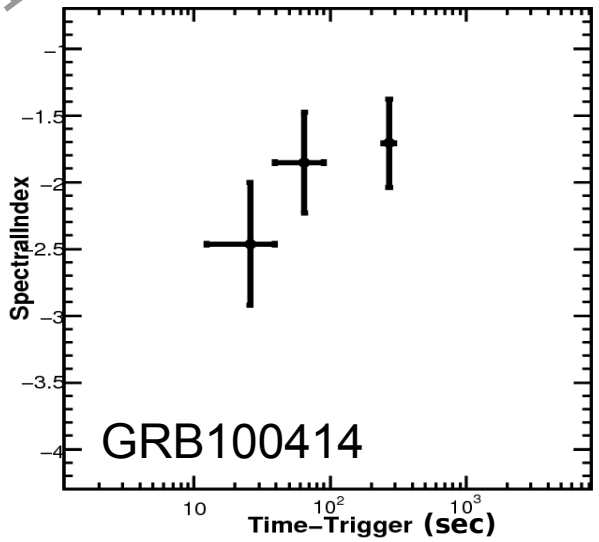
Extended Emission - Spectra

- No obvious spectral-evolution pattern observed.
- Spectral index typically around -2



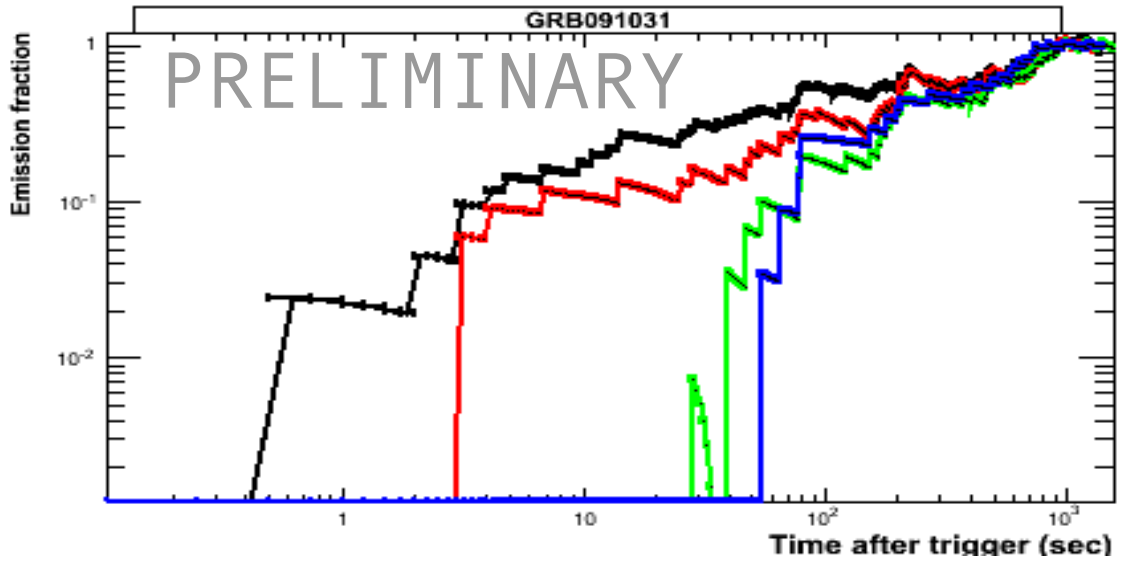


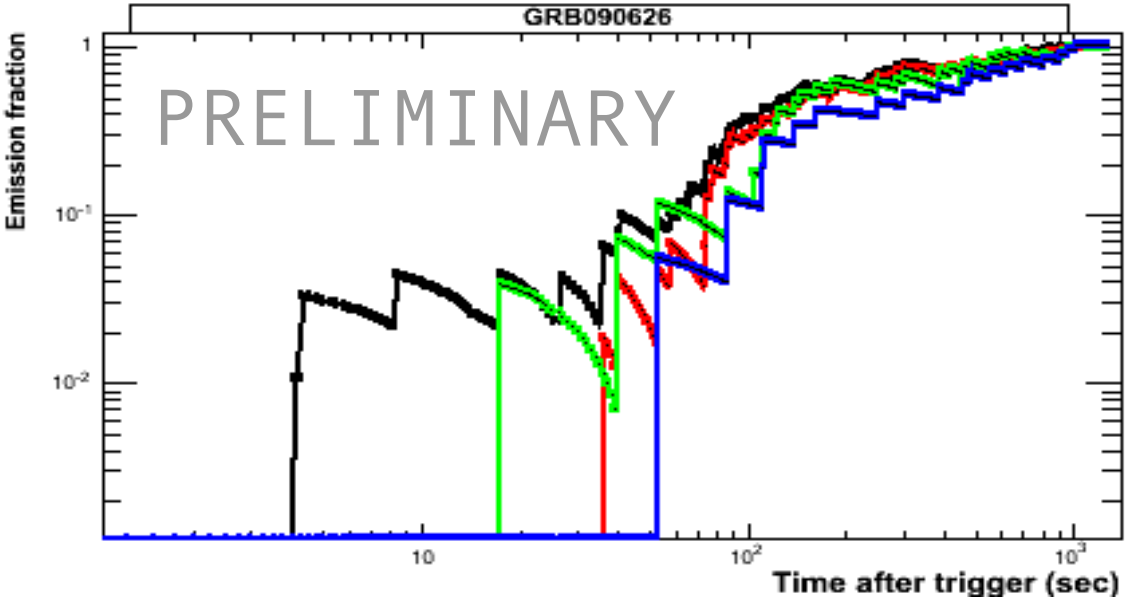




Delayed onset

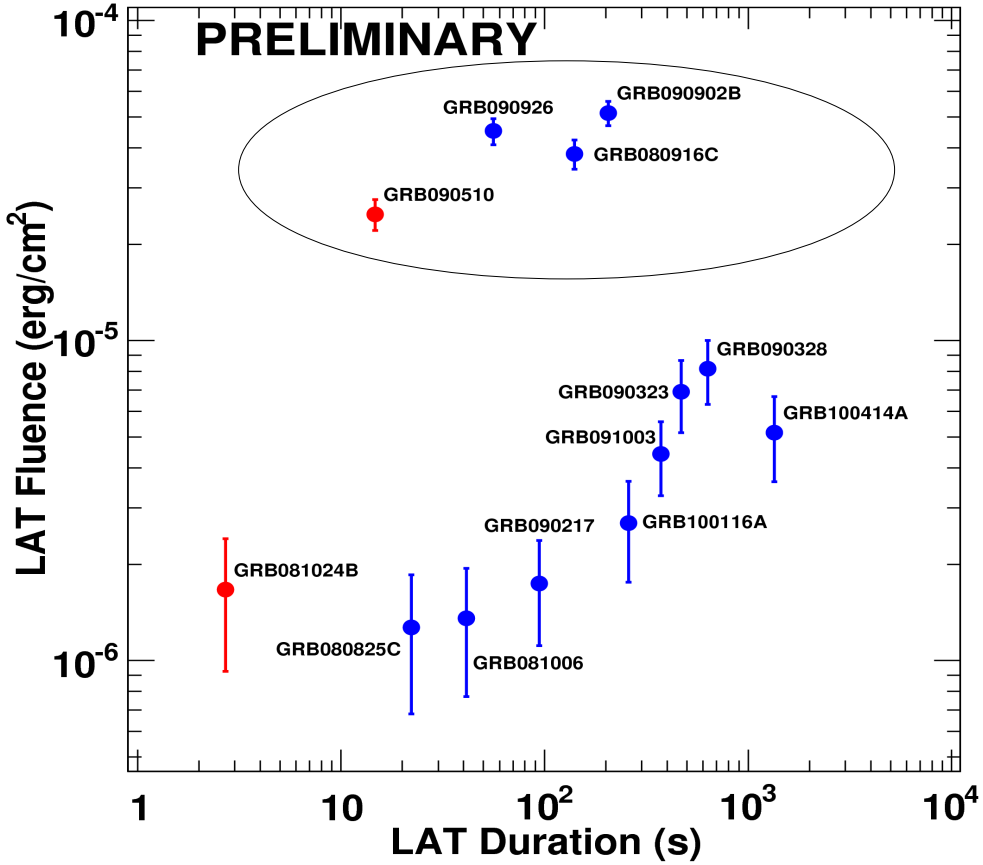
- LAT-detected GRB emission (at E>50MeV) starts delayed in time with respect to the lower-energy GBM-detected emissions (E>8keV).
- The effect is clearly evident when looking at cumulative lightcurves constructed using different minimum-energy cuts
  - E>50MeV, E>100MeV, E>200MeV, E>400MeV
  - The higher the energy, the more delayed the emission is.

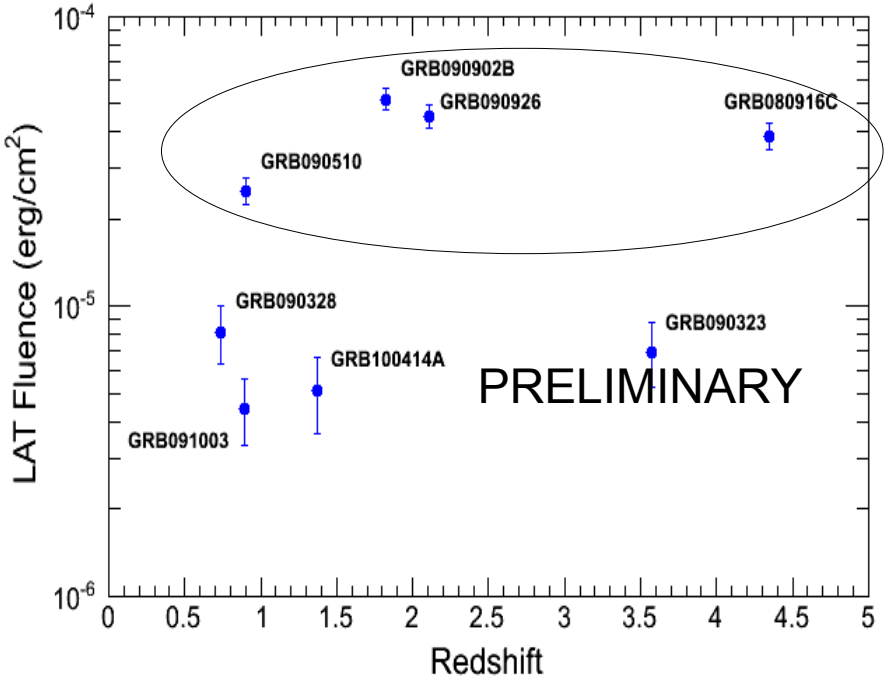




Energetics

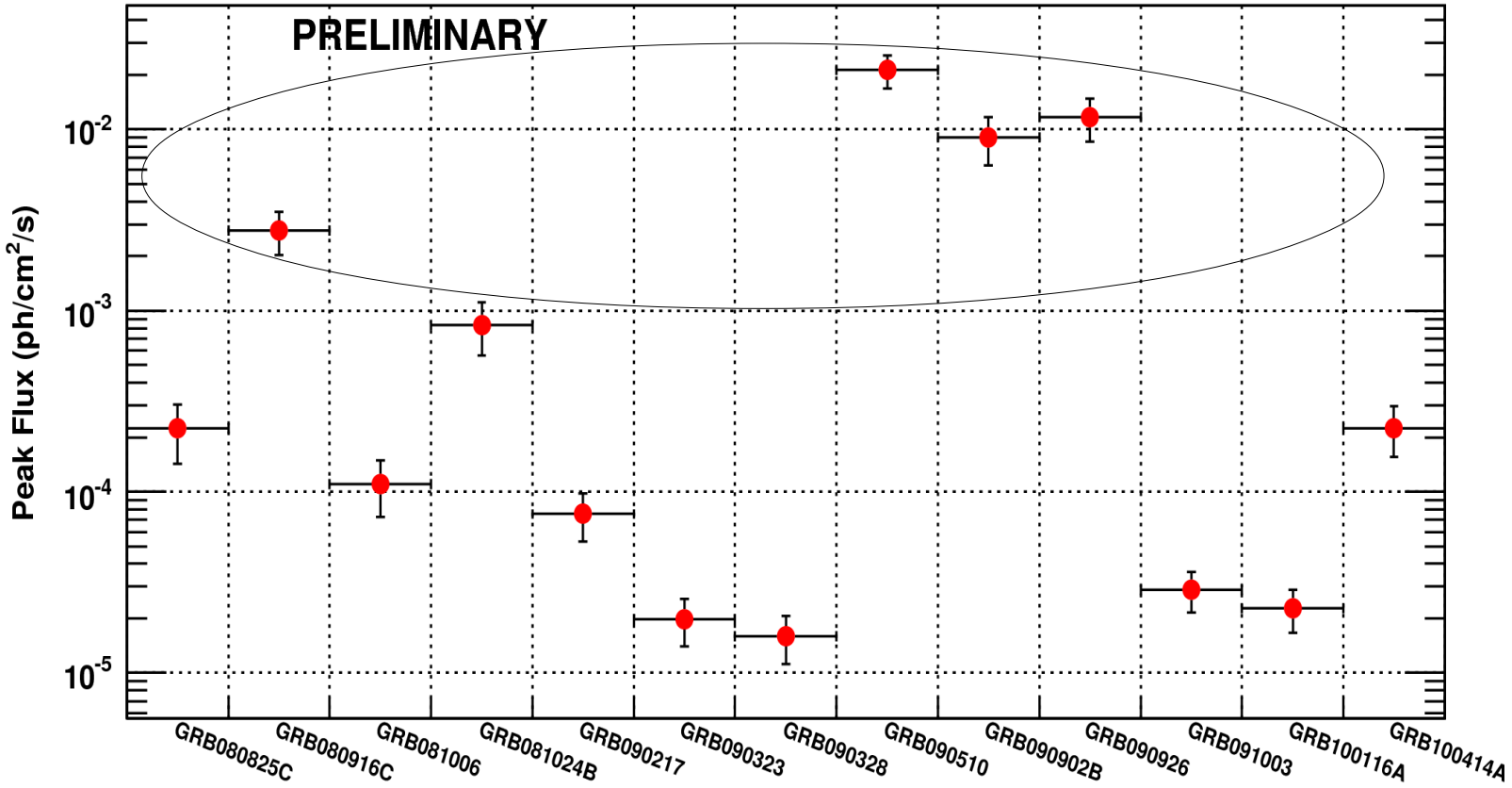
- Looking at a fluence-duration scatter plot, a set of 4 hyper-energetic bursts emerges (left to right: GRB 090510, 090926, 080916C, 090902B)
- These bursts are not systematically closer to us.





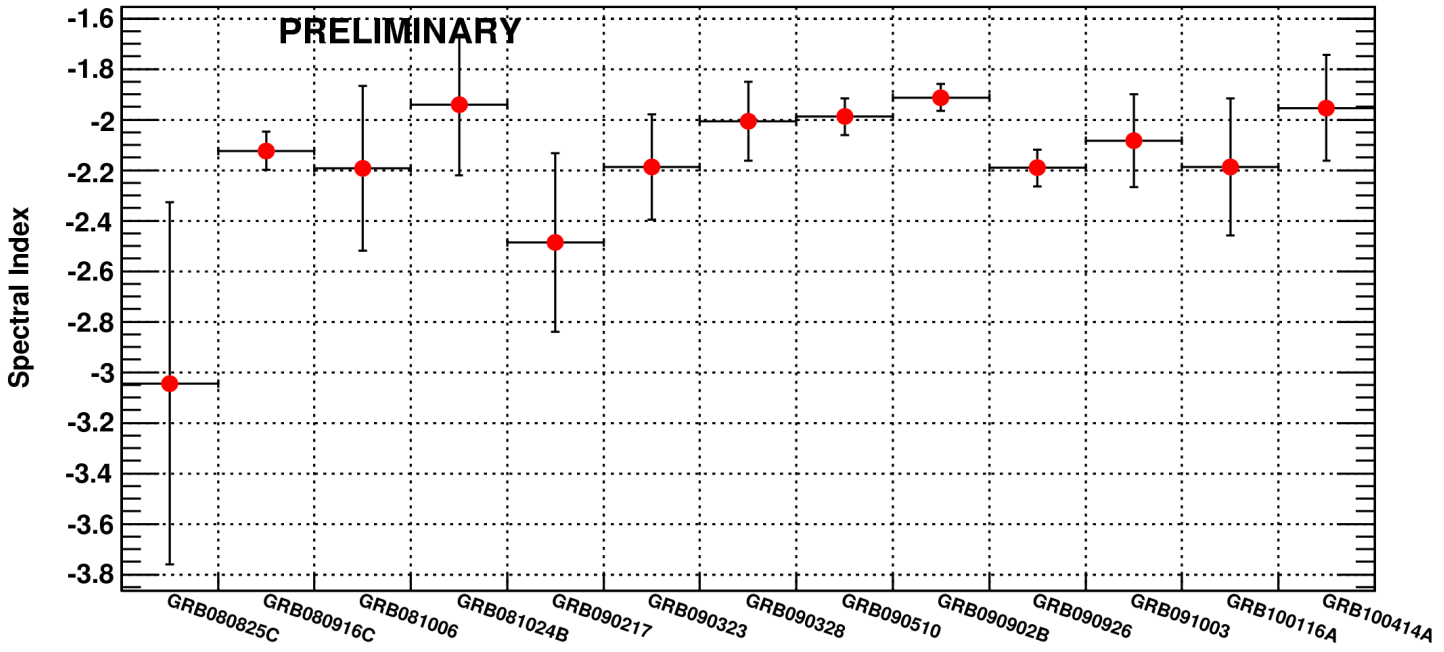
Energetics – Peak Flux

- These 4 hyper-energetic bursts also have the highest peak fluxes.
- Studies are under way to find more ways that these bursts are different than the rest of the LAT-detected sample.



LAT Spectral Studies

- A power-law fit of the LAT emission reveals that the LAT bursts have a remarkably similar spectral index ~ -2.1
- The catalog will include details on the spectral properties of LAT-detected GRBs: identification of spectral components, their evolution, etc.



Conclusion

- A comprehensive analysis of the GRBs detected by the LAT in the first ~two years of operations is under way and will be published soon.
- The catalog will be a valuable tool for future theoretical research and a useful informational resource for scientists who wish to analyze LAT GRB data.
- Our first preliminary analyses reveal interesting patterns and emergent groups among the LAT-detected GRBs.

THANK YOU

LAT T90 vs GBM T90