

Observational Properties of GRB Prompt Emission

Neil Gehrels

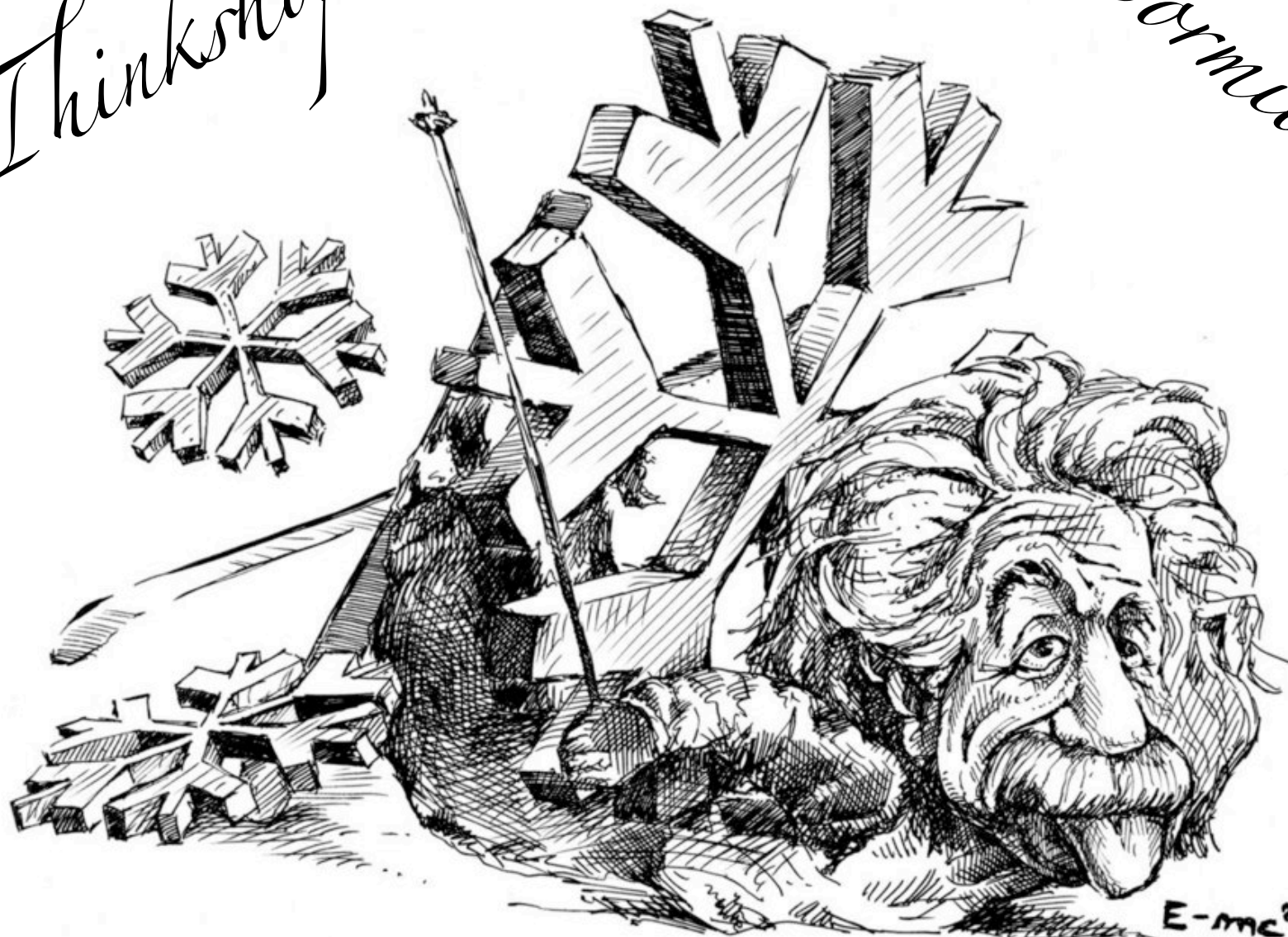
NASA-GSFC

January 20, 2014

Bormio Thinkshop

Thinkshop

Barmia

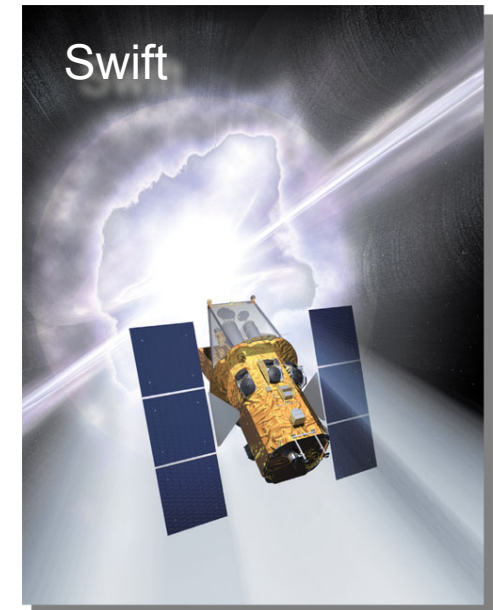


$E=mc^2$

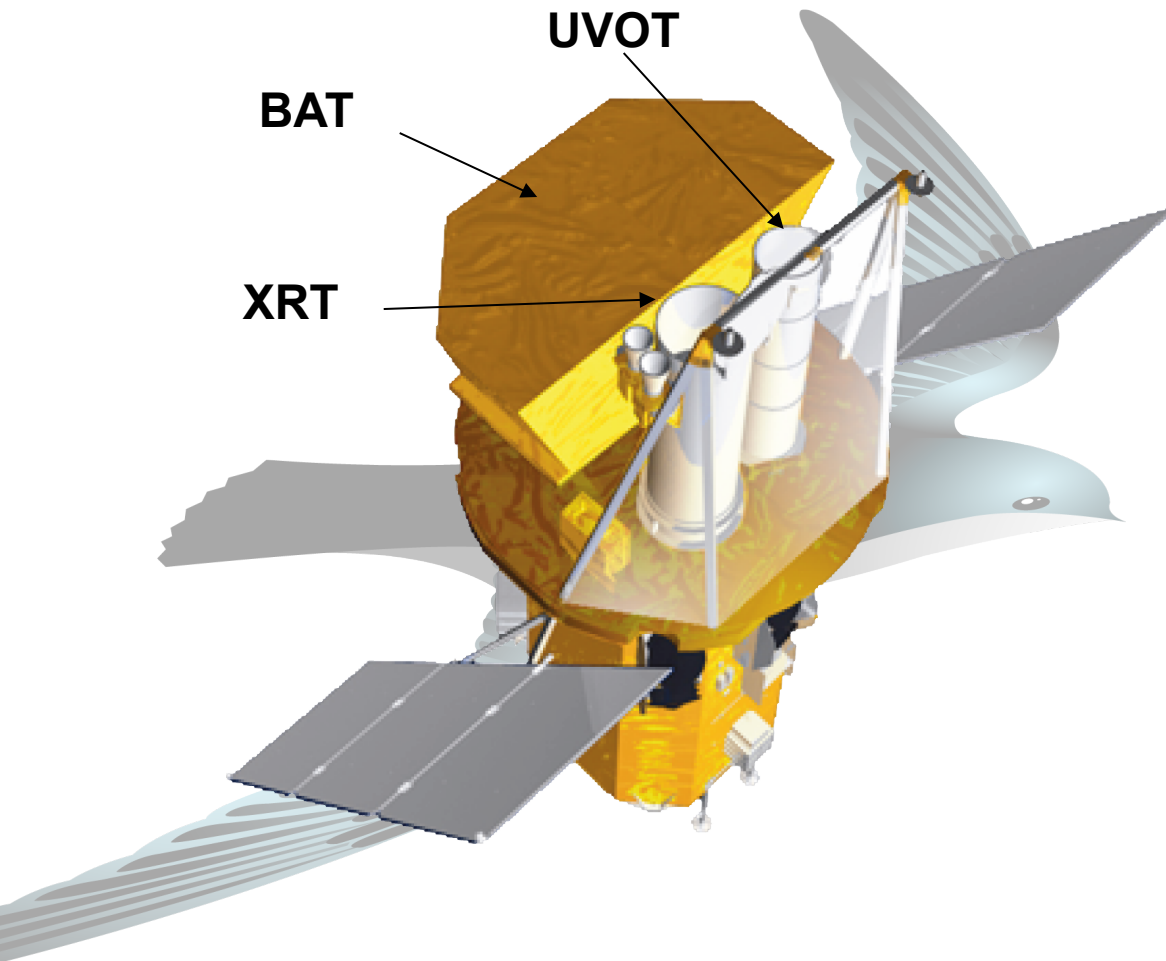
Wini 2011

GRB Prompt Emission

- **Duration**
- **Variability**
- **Spectra**
- **Interesting Issues**
- **Future Considerations**



Swift Mission

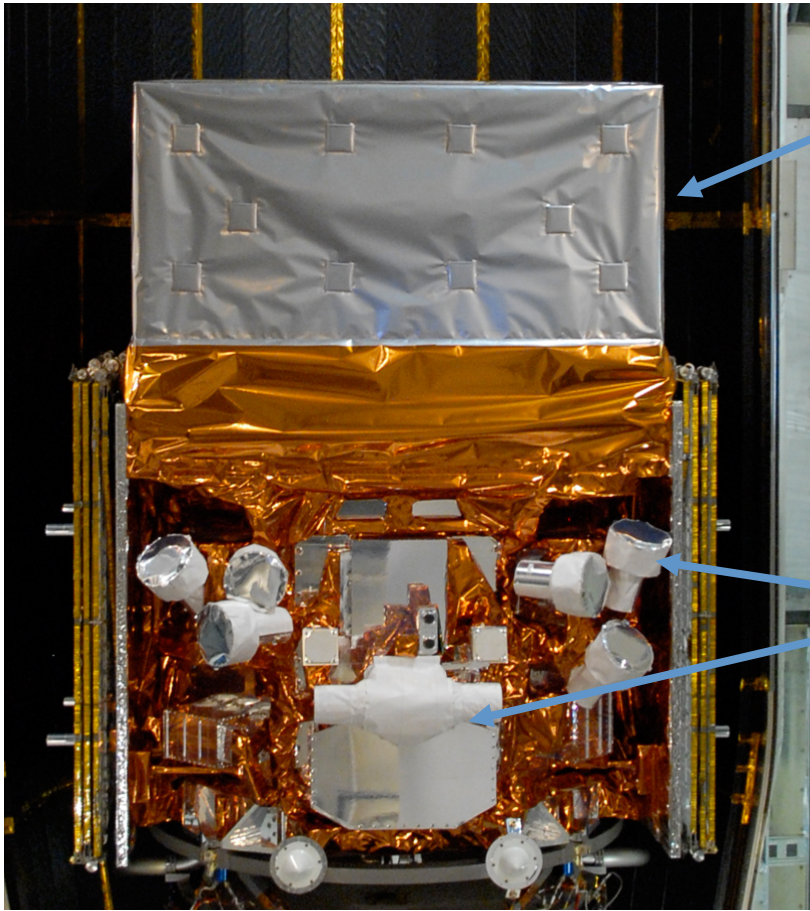


Launch November 20, 2004



- 3 instruments
- Rapid slewing spacecraft
- **BAT instrument**
 - 32,000 CZT detectors
 - 15 – 150 (300) keV
 - 1.4 sr FoV
 - ~100 GRBs per year
 - most sensitive GRB instrument flown

Fermi Mission



Large Area Telescope (LAT):

- 20 MeV - >300 GeV
- 2.4 sr FoV
- ~18 GRBs per year

Atwood+ 2009

Gamma-ray Burst Monitor (GBM)

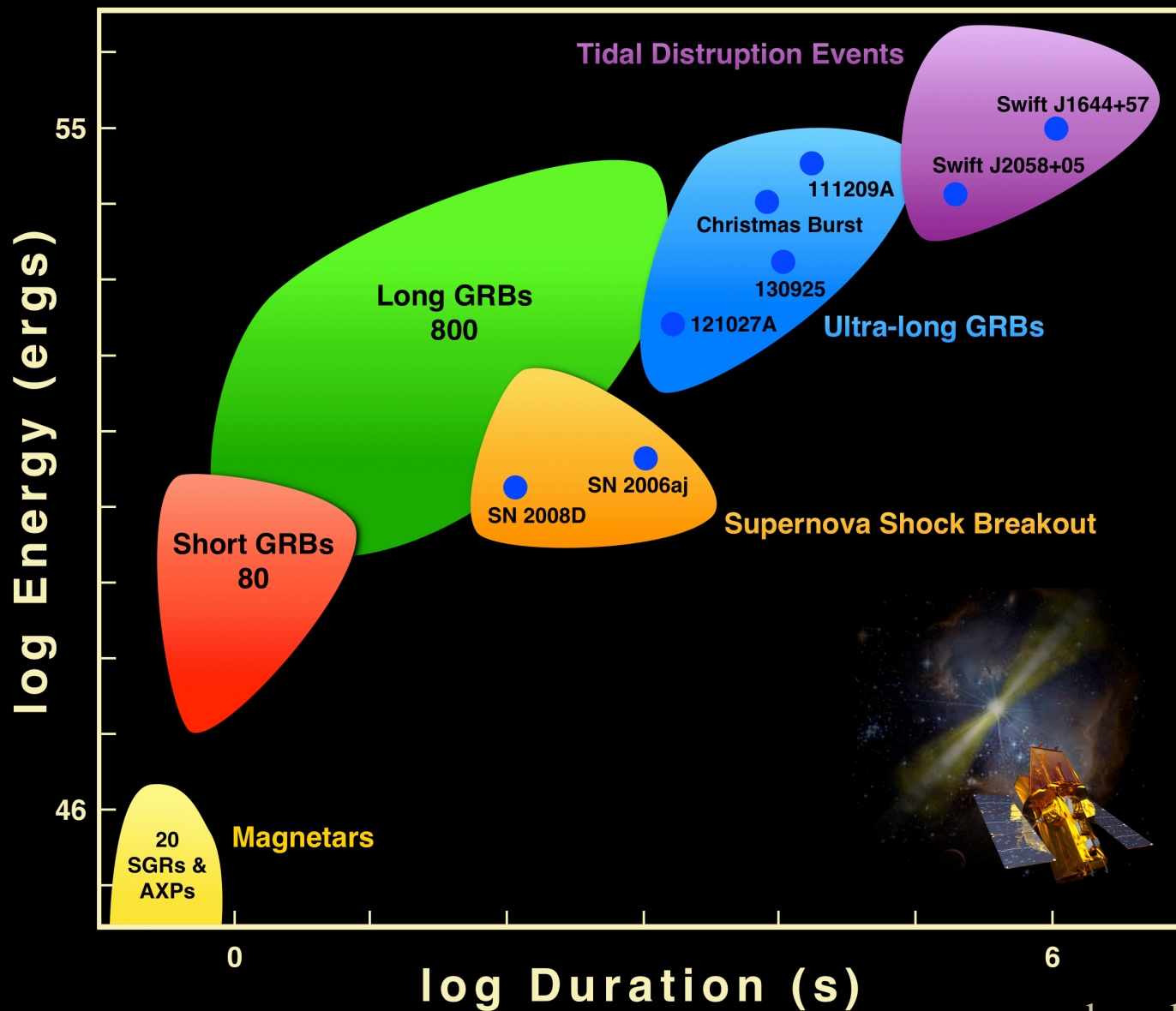
- 8 keV - 40 MeV
- 8 sr FoV
- ~300 GRBs per year

Meegan+ 2009

Launch June 11, 2008



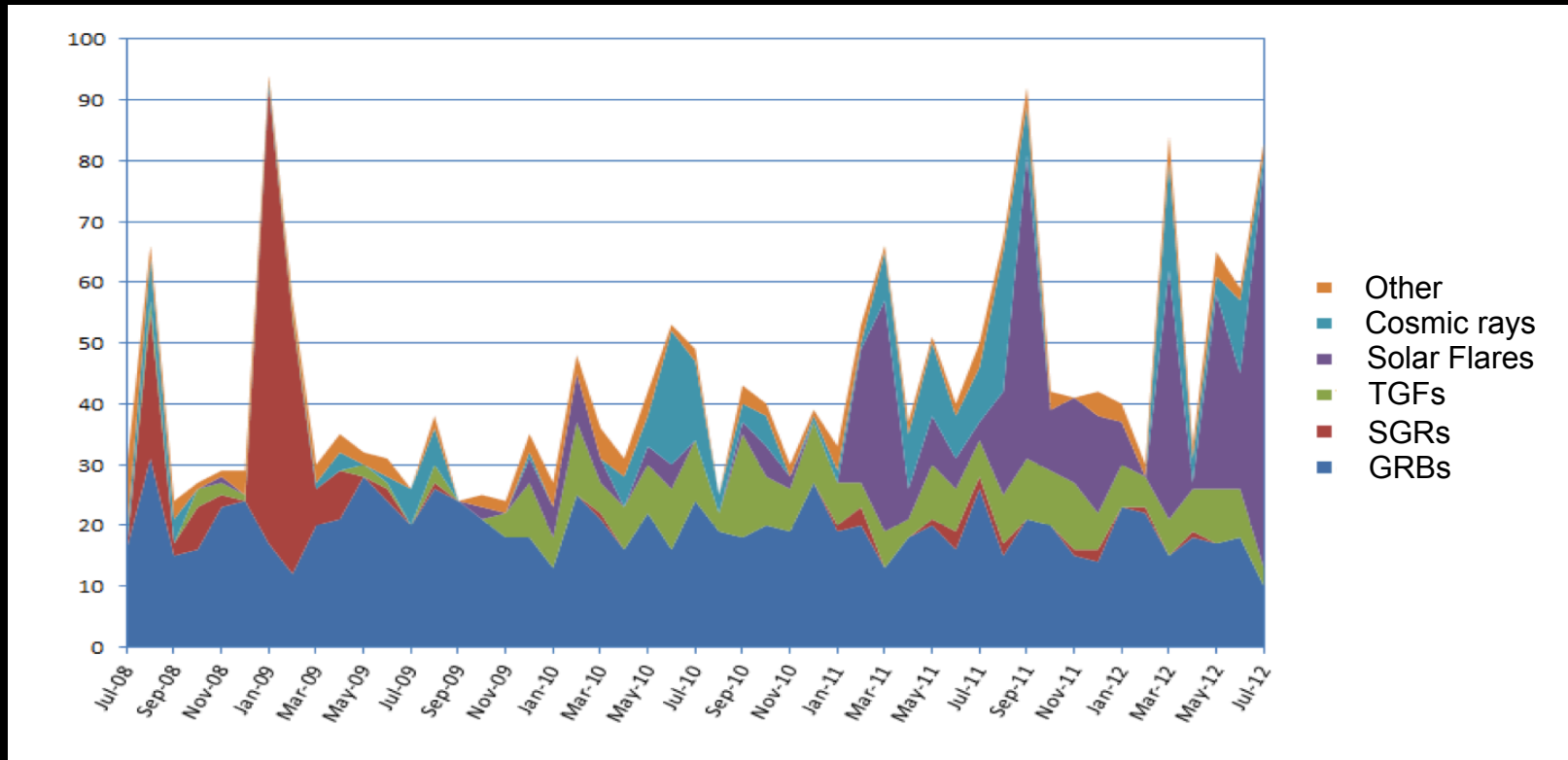
Swift



based on Levan+ 13

Fermi

GBM is most prolific detector of GRBs, SGRs and TGFs



LAT GRB rate is increasing:

- 18 GRBs 2010-11, 37 GRBs 2012-13
- Pass 8 analysis software in 2015 will increase rate even more

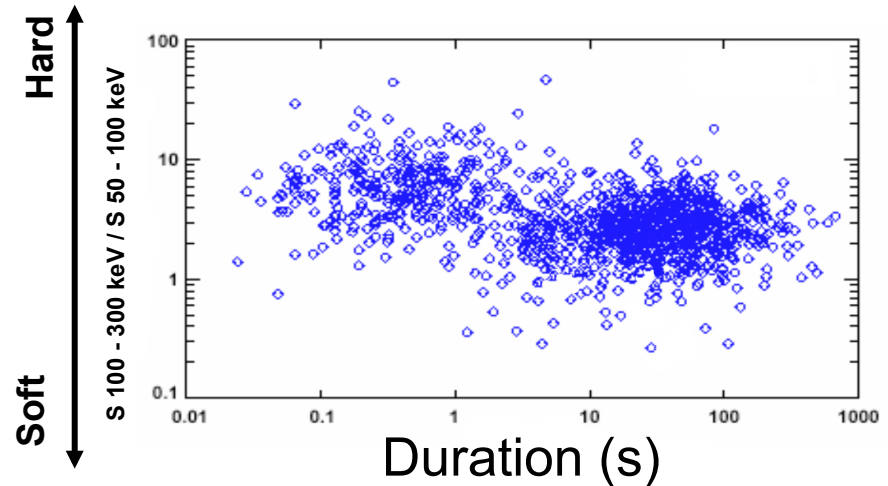
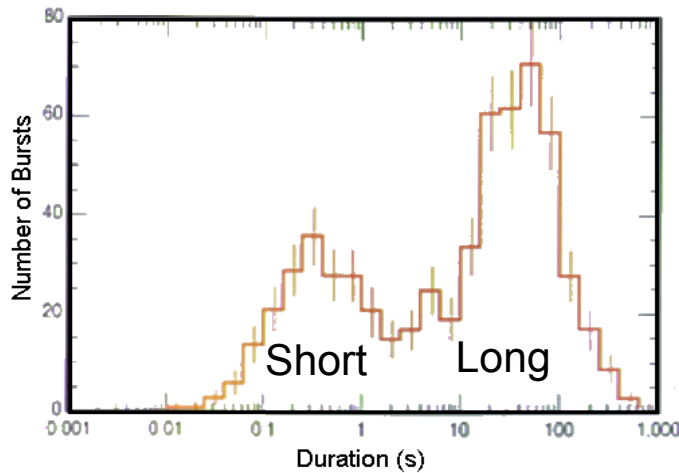
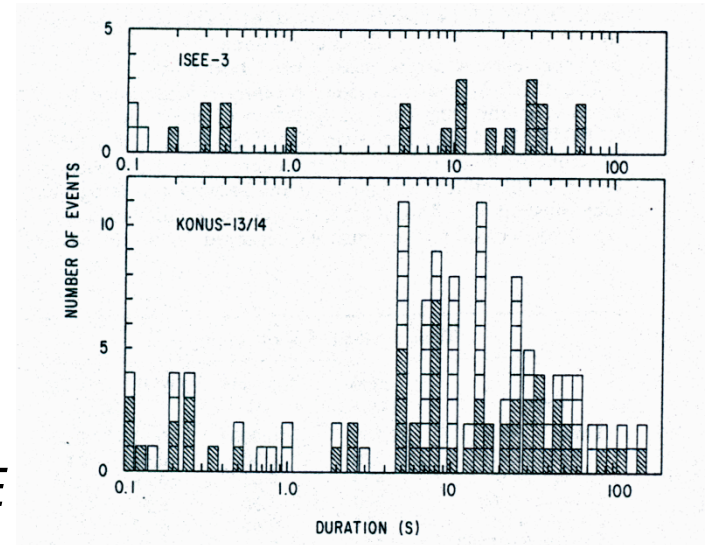
Durations @ Variability

A Brief History of Time

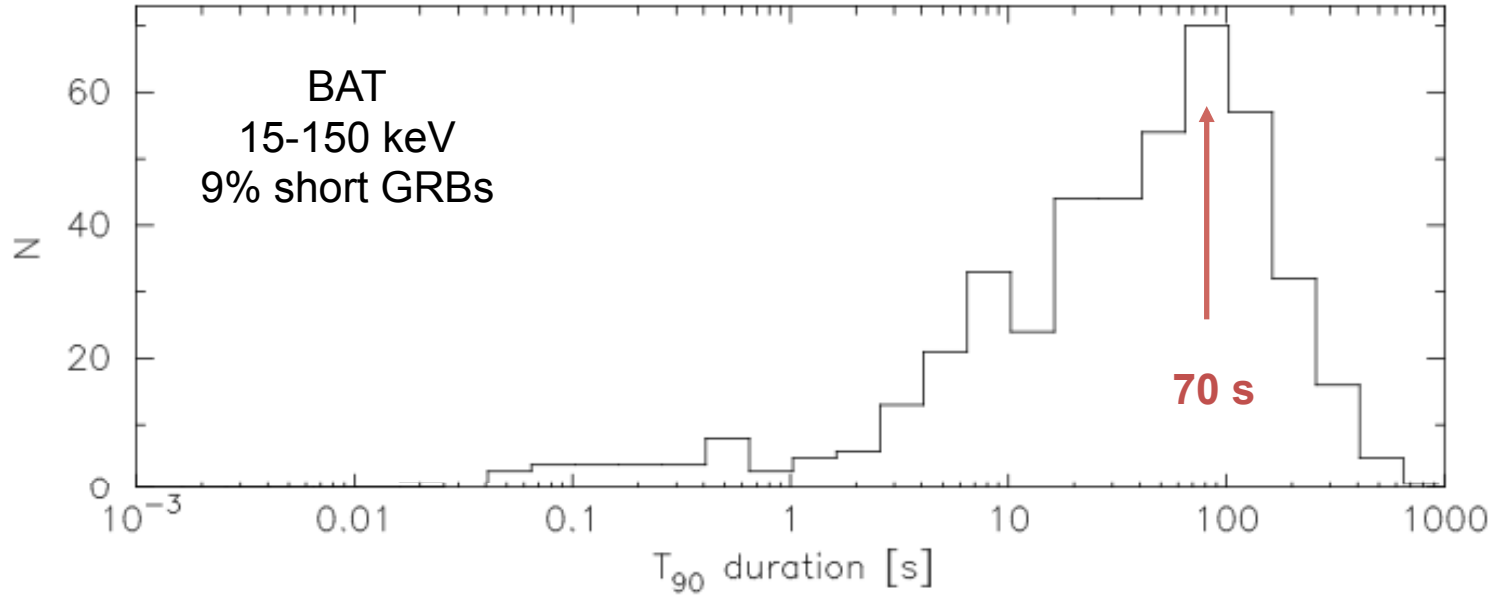
First hints of 2 duration groups:
Cline & Desai 74; Mazets 81

Two groups seen in *ISEE-3* & *Konus* data
Norris+ 84

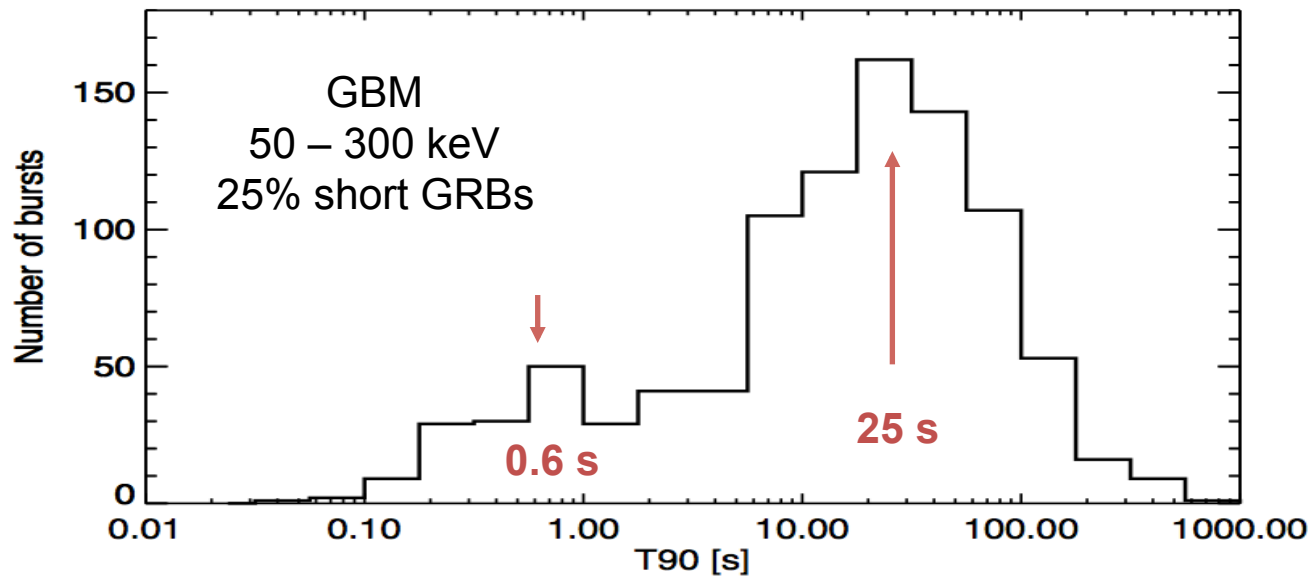
Proof of 2 classes with large statistics from *BATSE*
Kouveliotou+ 93



BAT vs GBM Durations

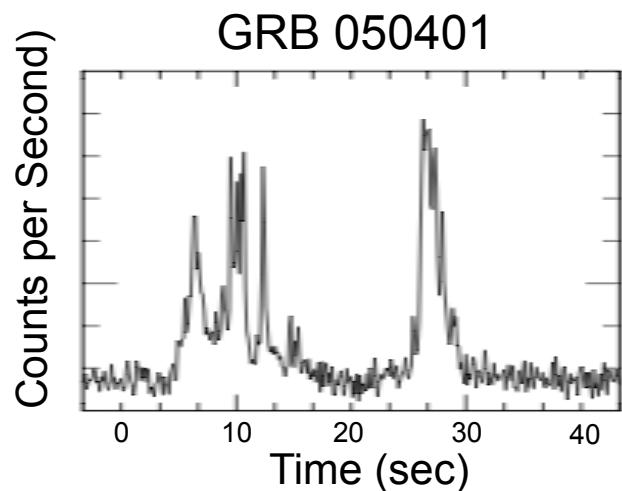


Sakamoto+ 10

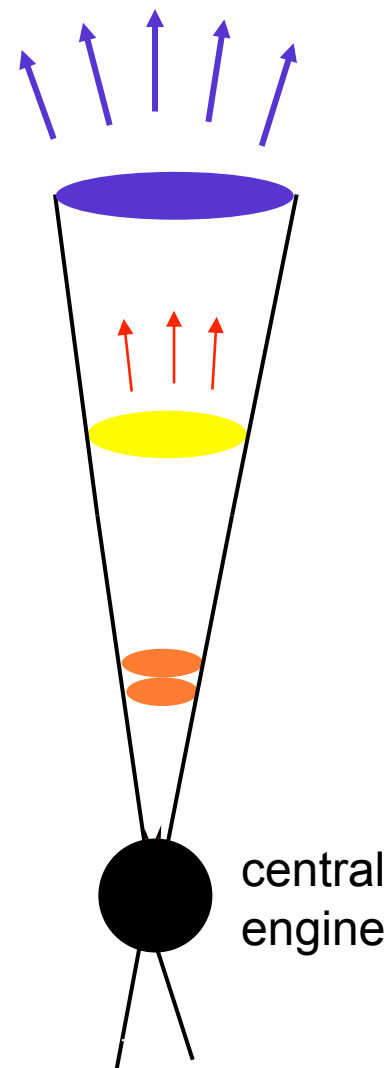
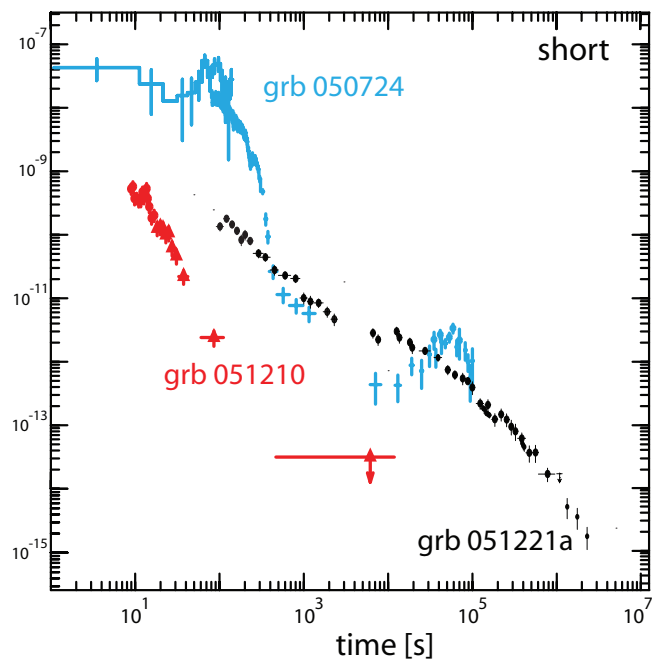
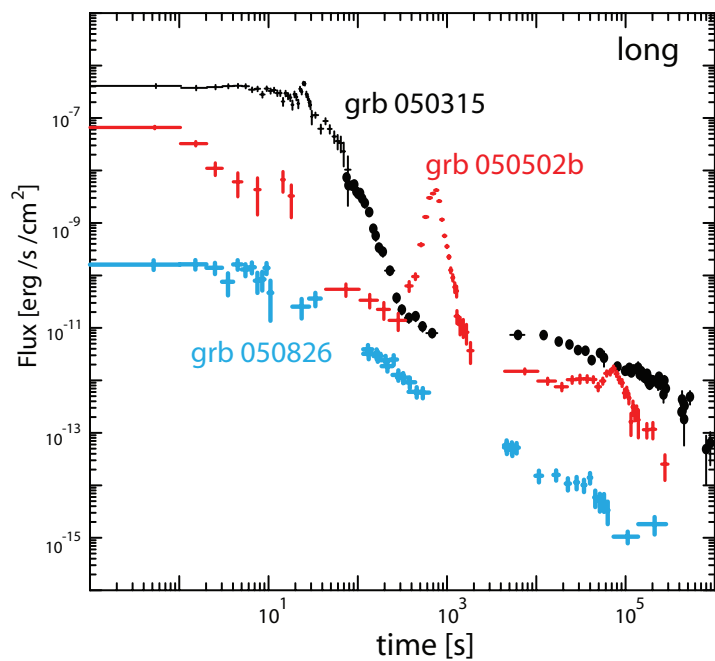
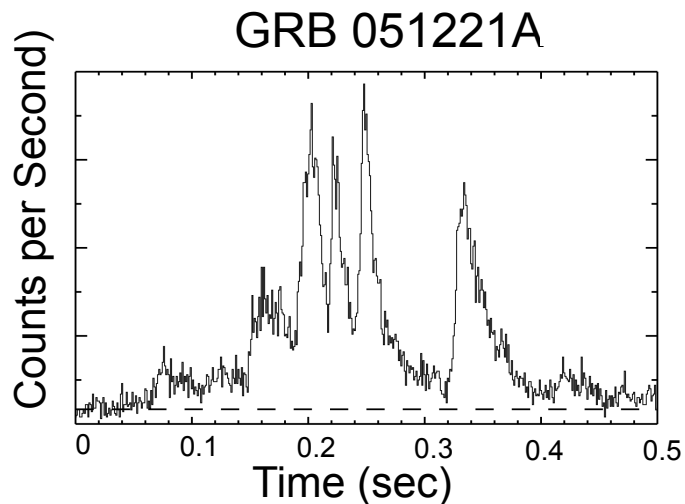


Kienlin+ 14

Long



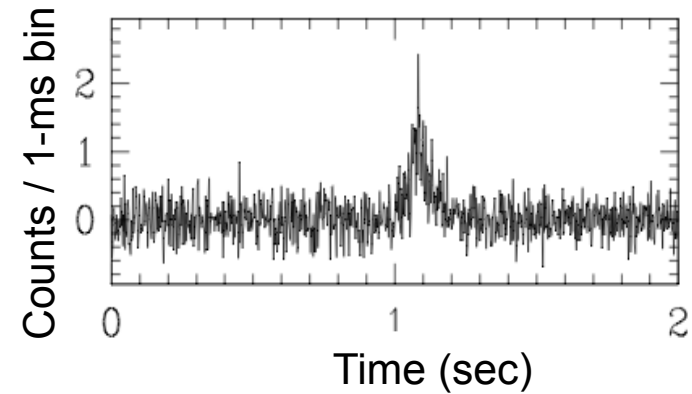
Short



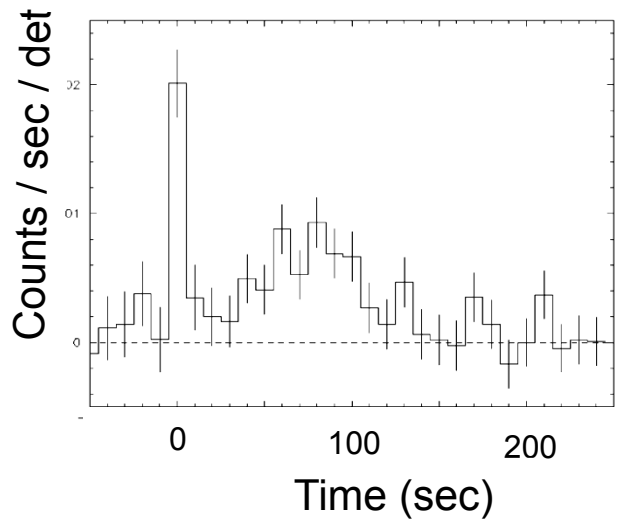
Gehrels, Ramirez-Ruiz
Fox 09

Short GRB Lightcurves

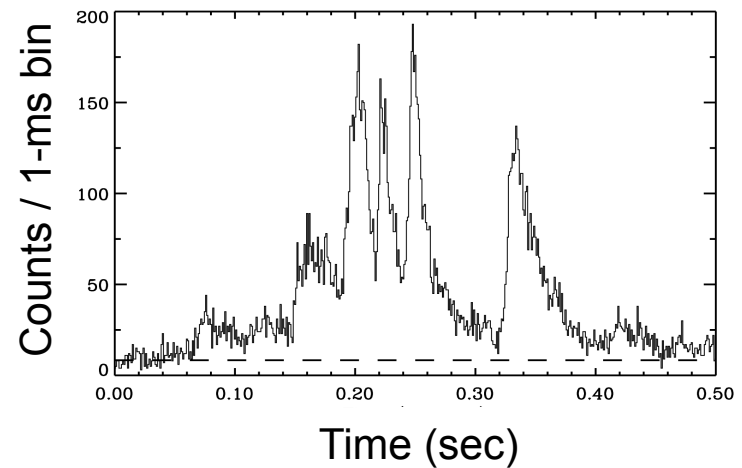
Single Spike - 15%
GRB 090621B



Extended Emission - 25%
GRB 050724



Complex - 25%
GRB 051221A



GRB 060614 $z=0.125$

$T_{90} = 103$ s

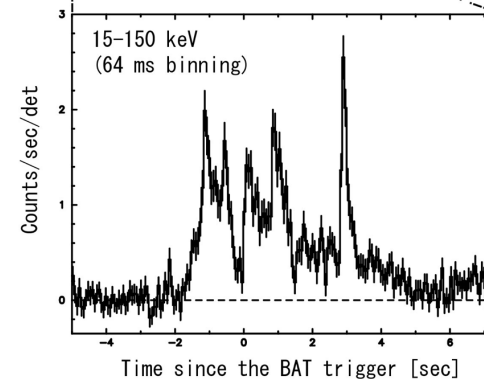
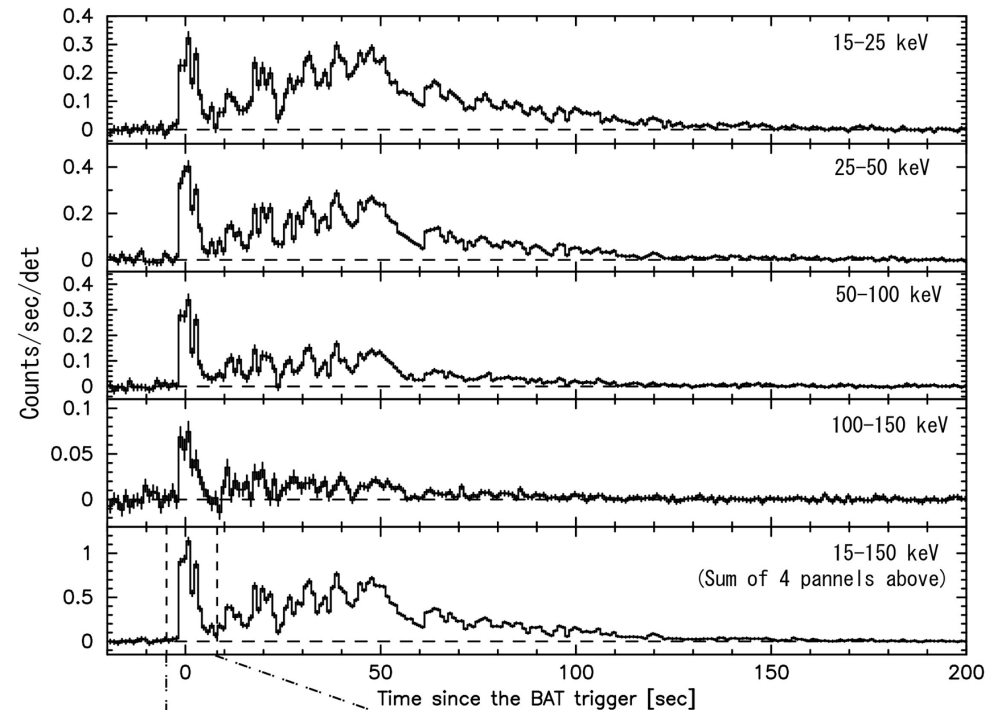
Could it be in "short"?

- Hard short episode followed by softer extended emission
- Short "lag"

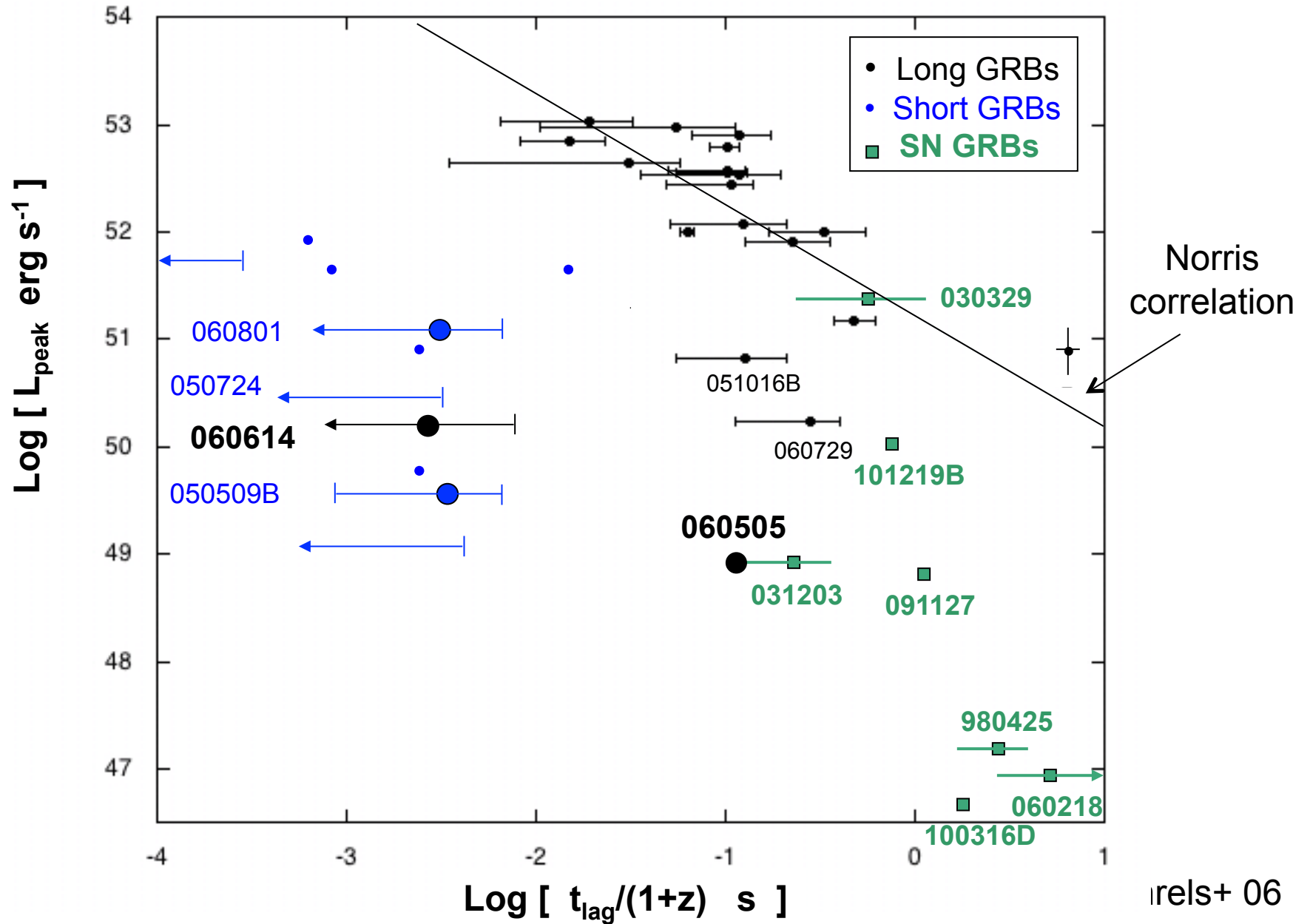
However:

- 5 s duration of hard episode
- Brighter & more variable extended emission than others

BAT Lightcurves



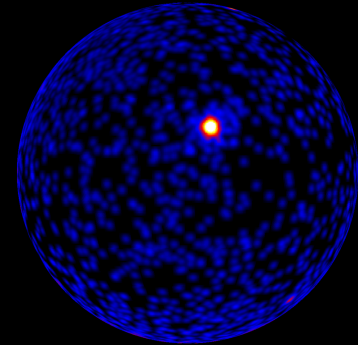
Lag – Peak Luminosity Relation



3 January 2014 | \$10

Science

Record-Setting
Gamma-Ray Burst



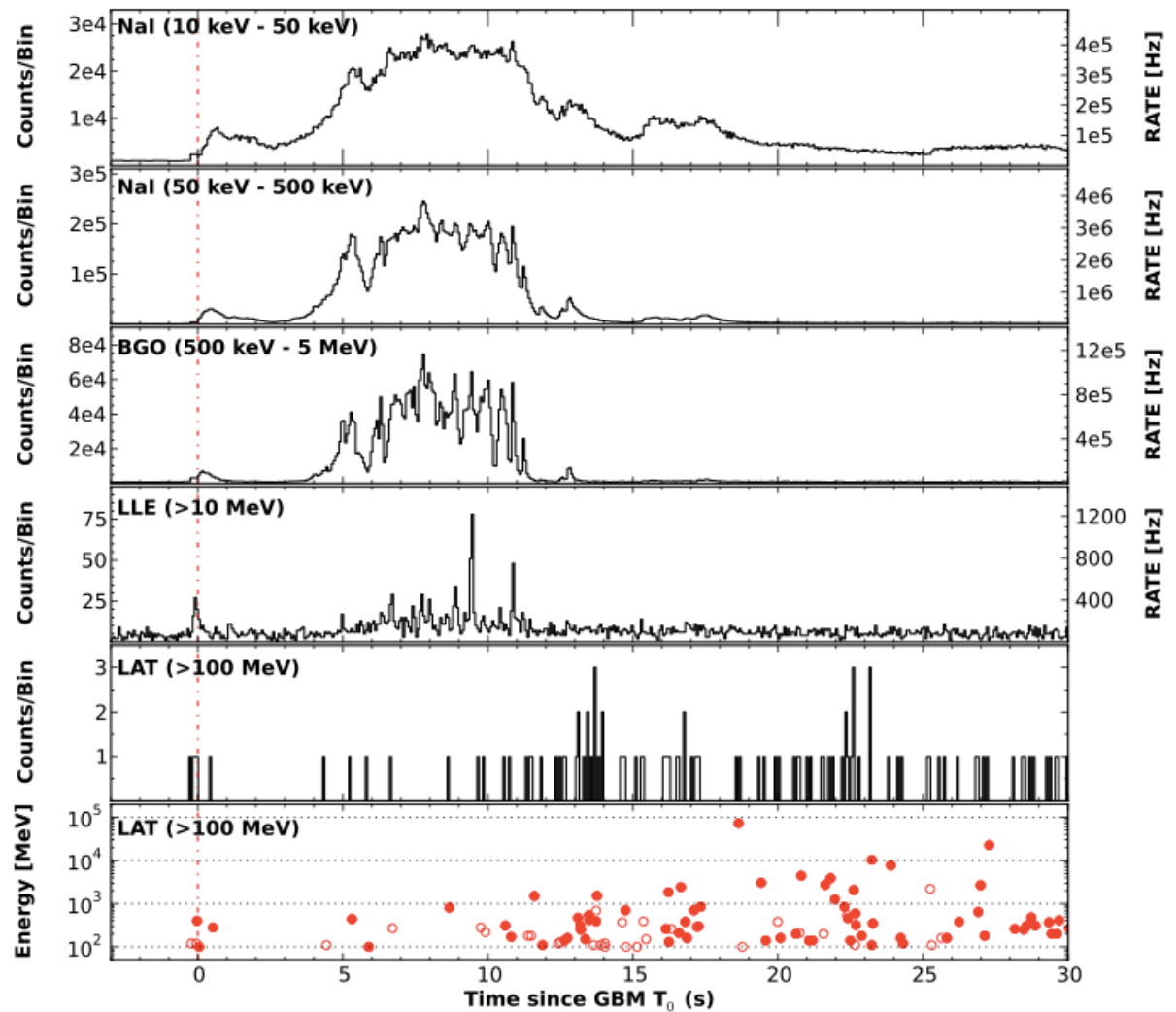
 AAAS

High Energy Gamma Ray Emission

GRB 130427A

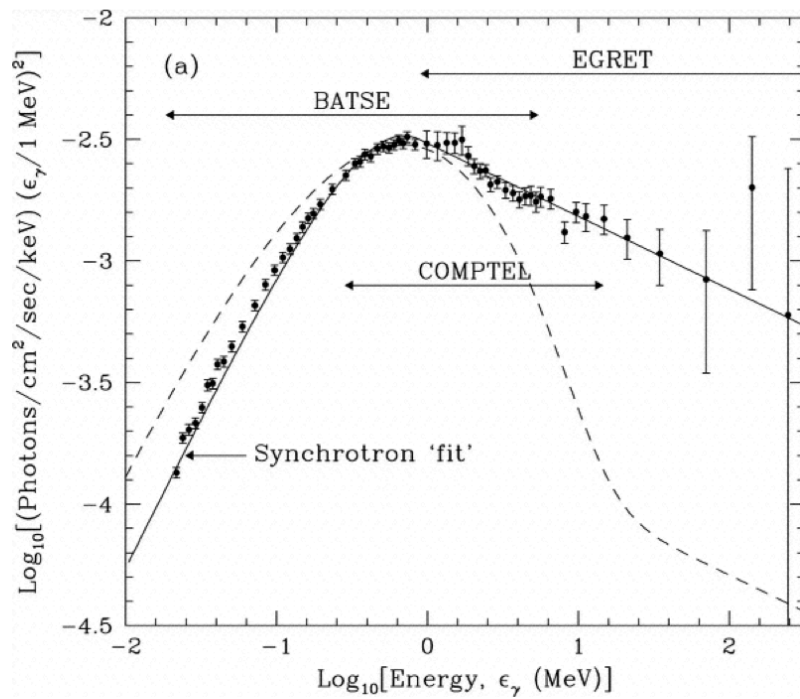
Relative to keV / MeV,
>100 MeV emission is

- delayed in initiation
- extended in time

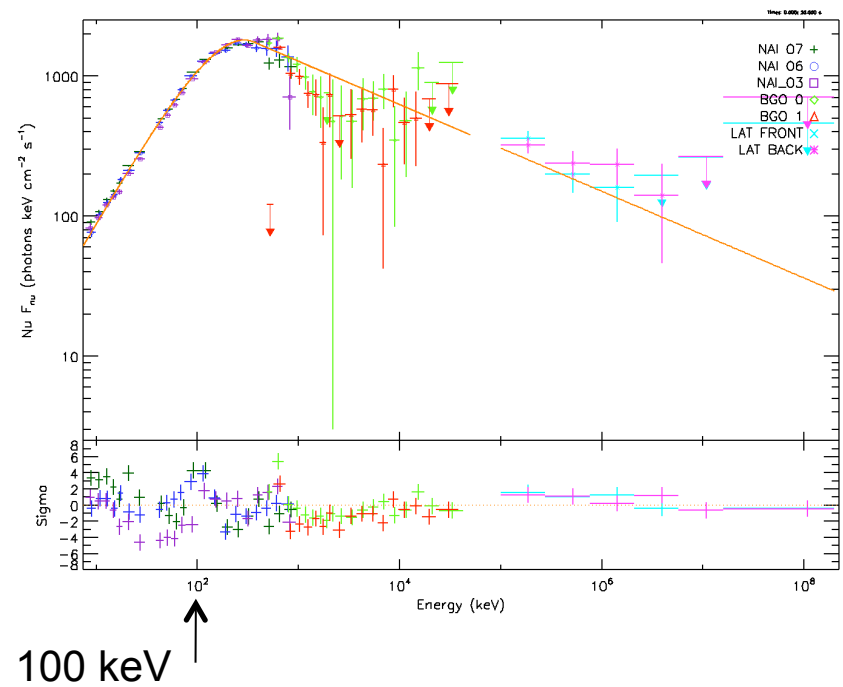


Spectra

Band Function Spectral Shapes



Baring & Braby 04

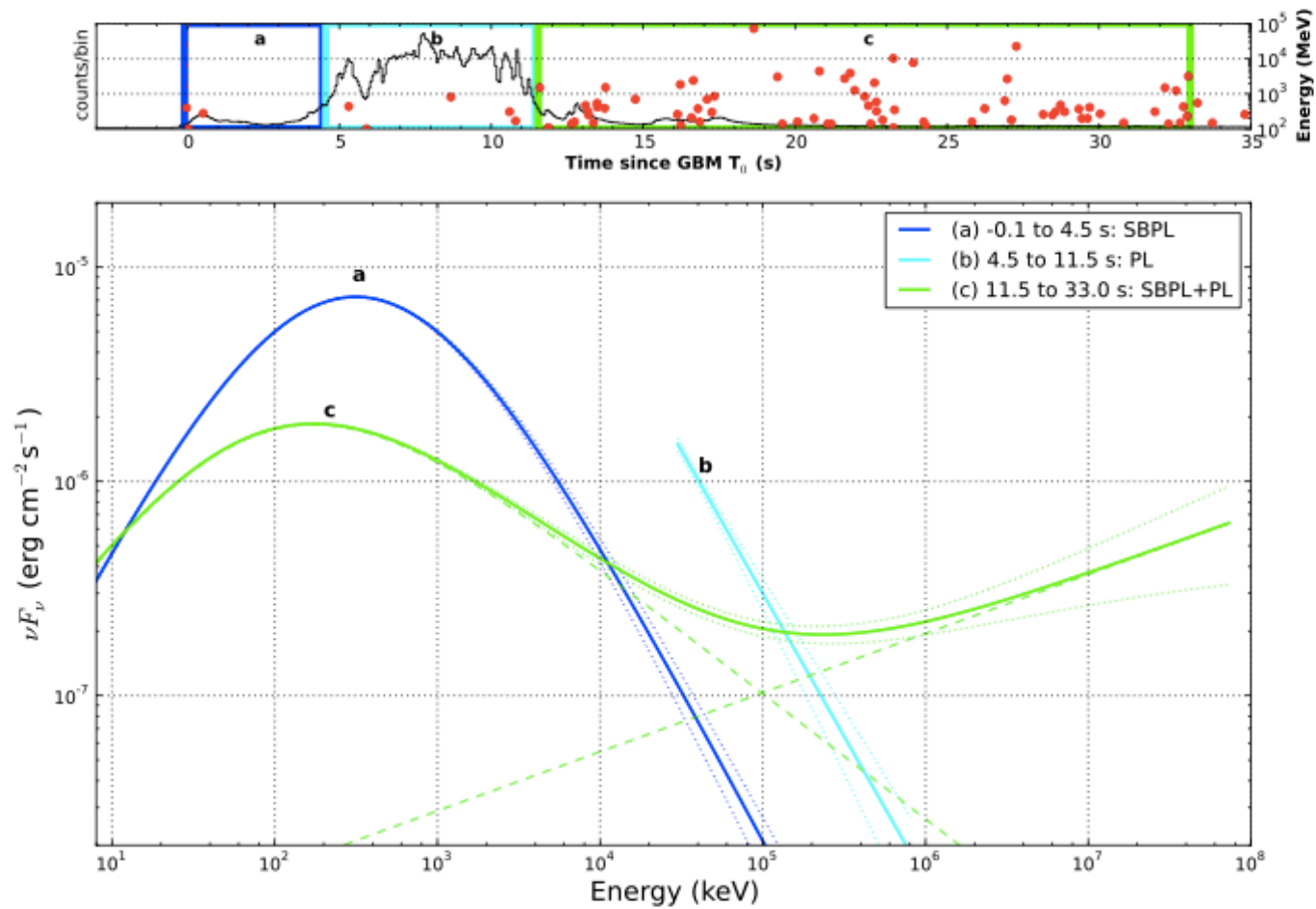


Guiriec+ 12

Changing Spectral Components

GRB 130427A

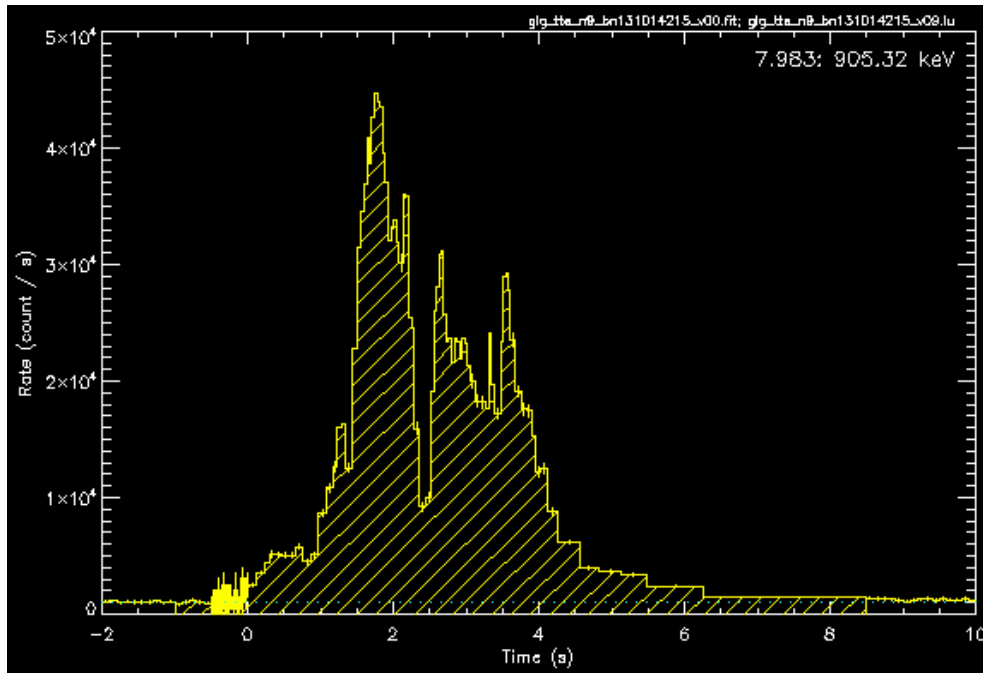
$z=0.34$ $T_{90}=162\text{s}$



Blackbody Component

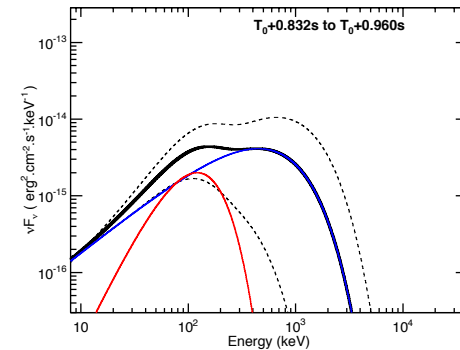
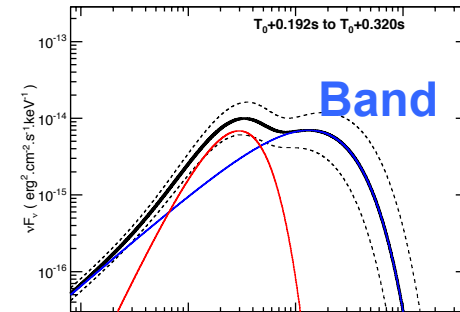
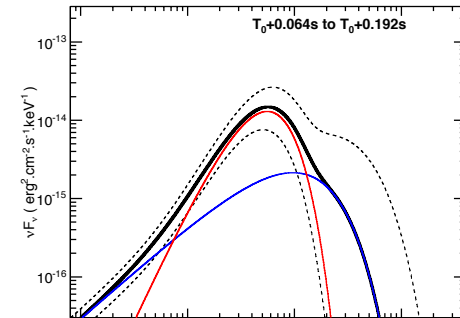
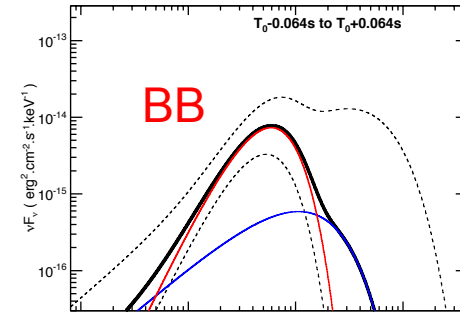
GRB 131014A

$T_{90} = 3\text{s}$



The spectrum is dominated by BB emission early

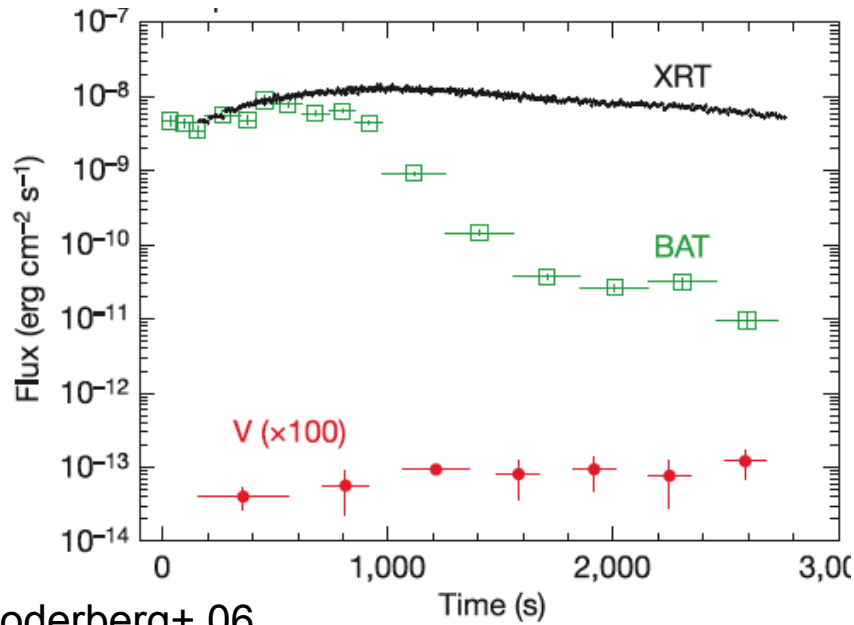
Guiriec +14



Interesting

Questions

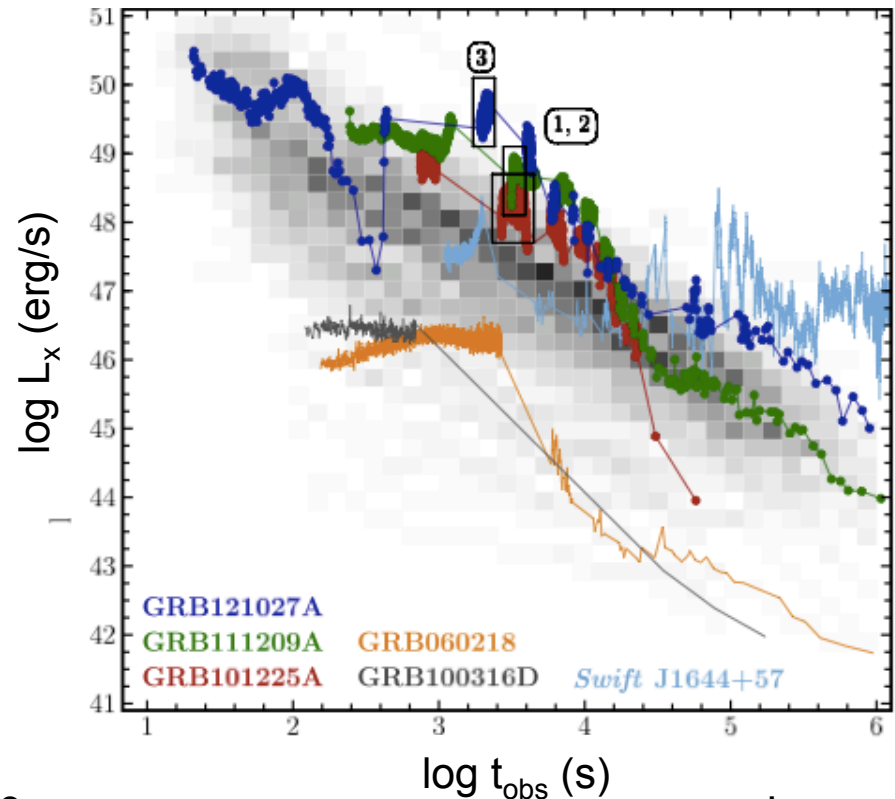
Underluminous Superlong GRB 060218



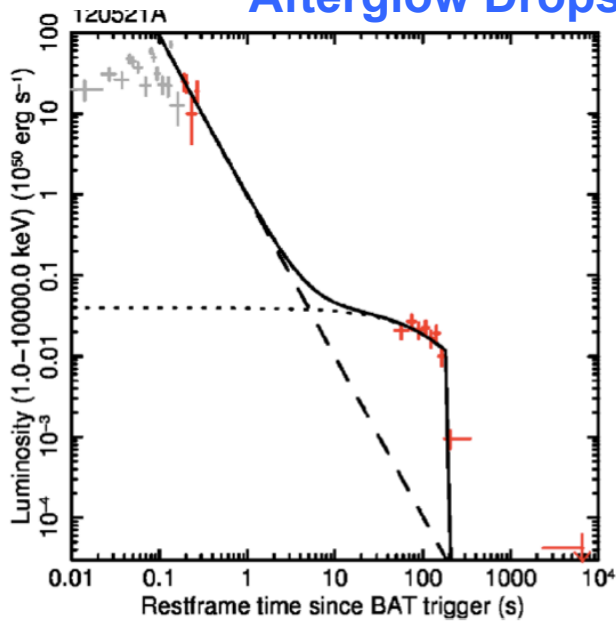
Soderberg+ 06

Are Magnetar Engines Part of the GRB Family?

Ultralong GRBs



Afterglow Drops

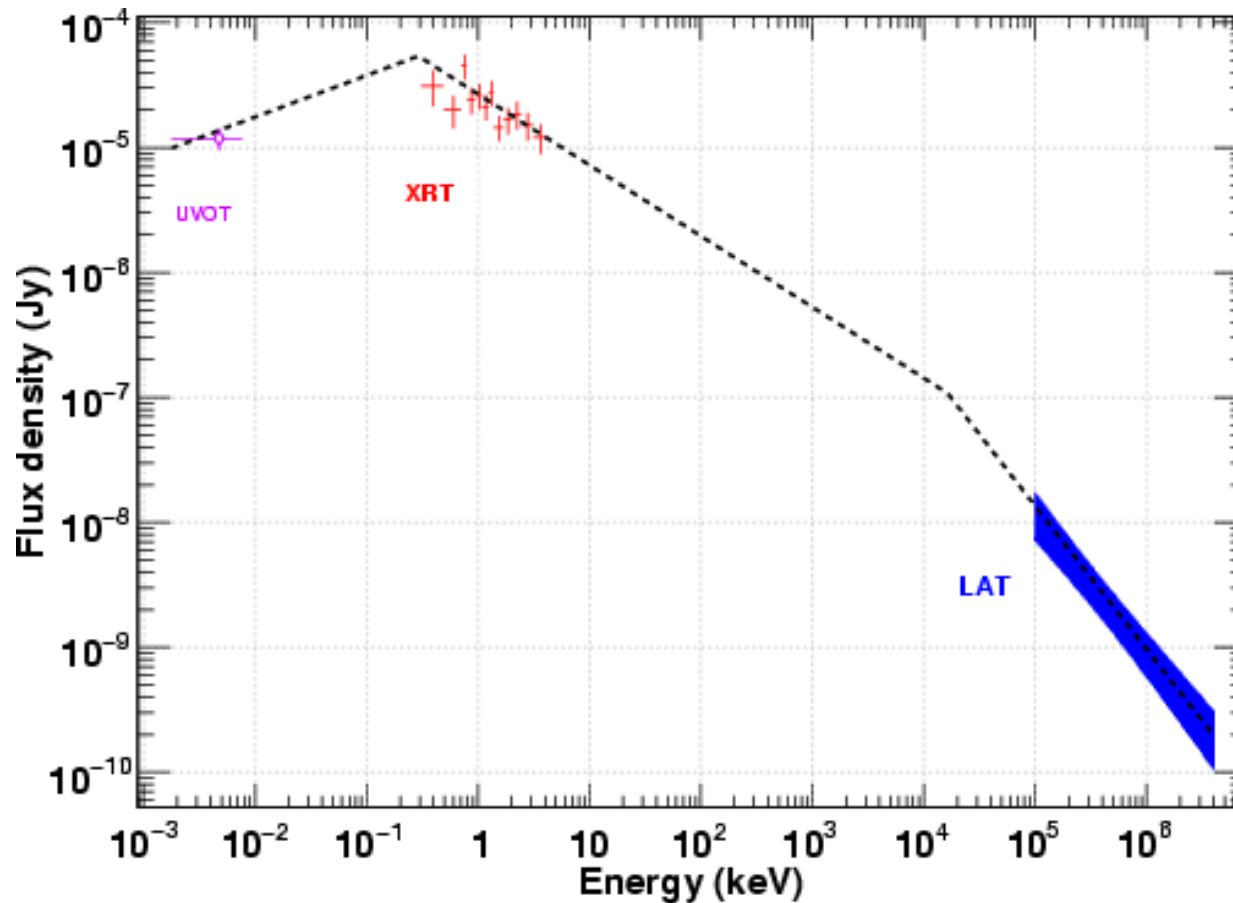


Rowlson+ 13

Levan+ 14

Is LAT High Energy GRB Emission Prompt or Afterglow?

GRB 090510 - detected by BAT & LAT

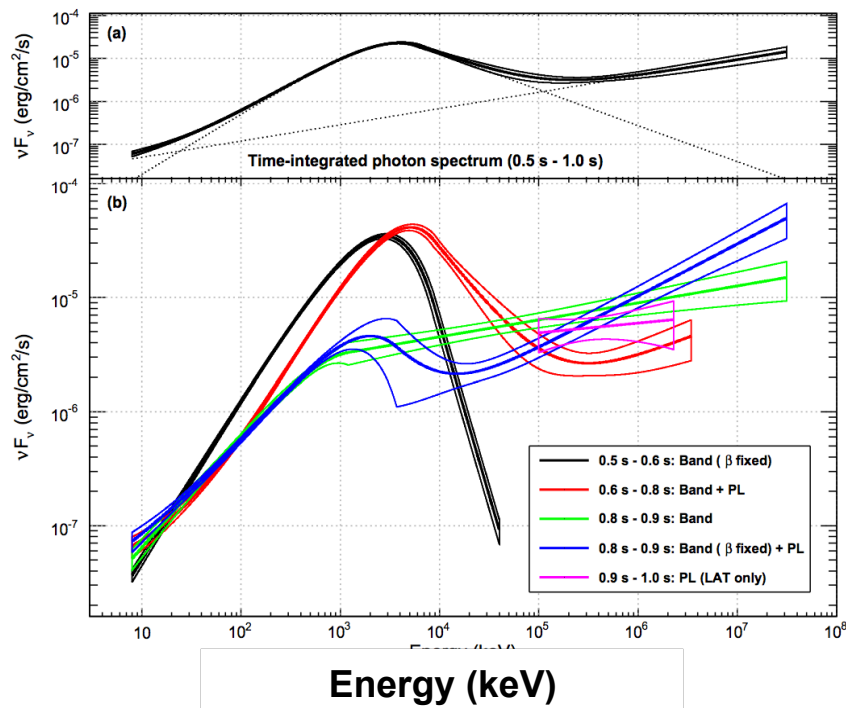


LAT data 0.38 - 200s

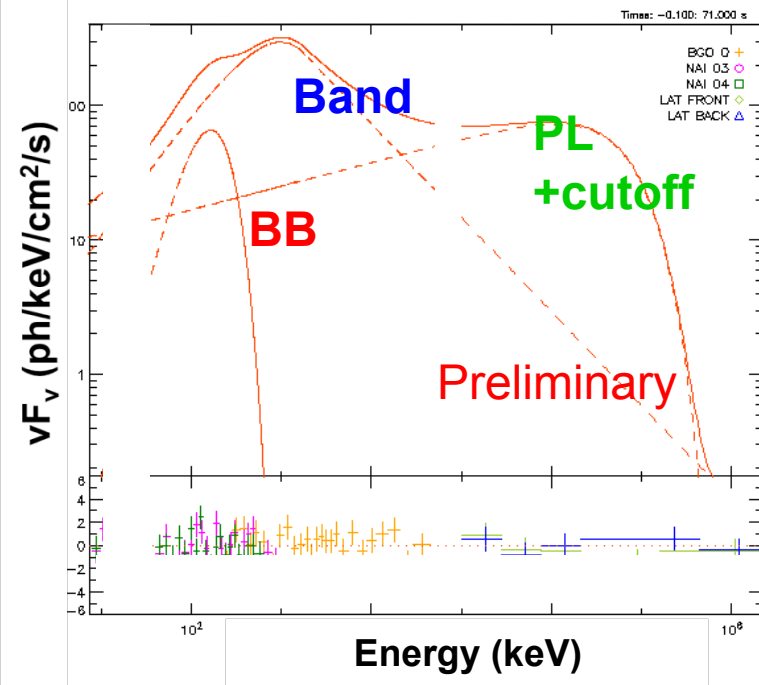
De Pasquale+ 09

What is the Origin of the GBM+LAT Spectral Components?

GRB 090510



GRB 080916C



Future Considerations

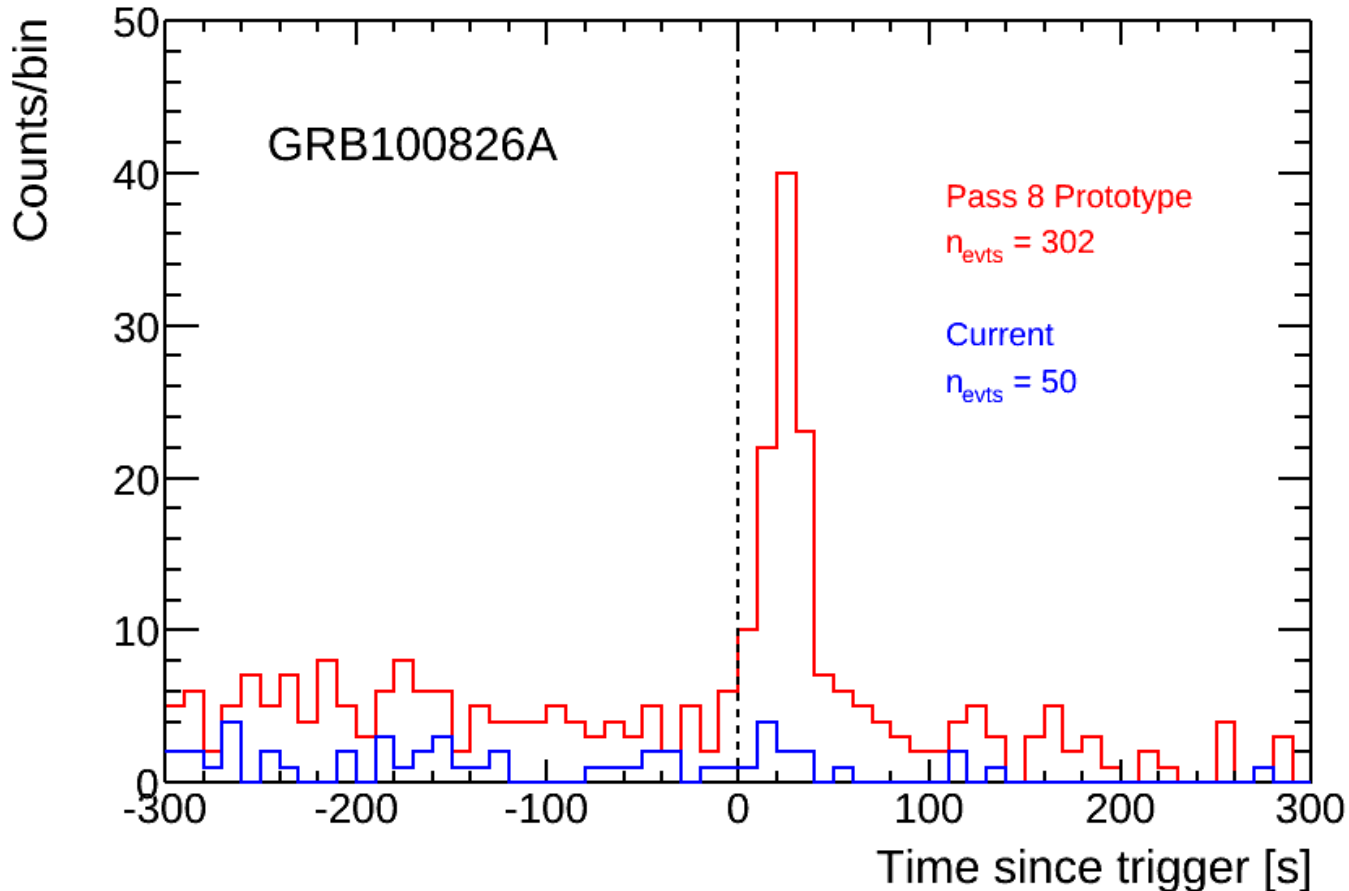
LAT Pass 8 Event Analysis

New software for:

- event reconstruction
- detector simulation

Improvements:

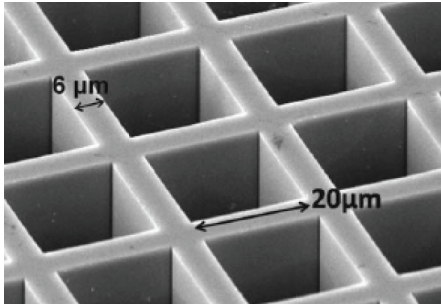
- increased effective area (much better <100 MeV)
- increased FoV
- better understanding of systematics
- better point-spread-function (especially >100 GeV)



LAT team

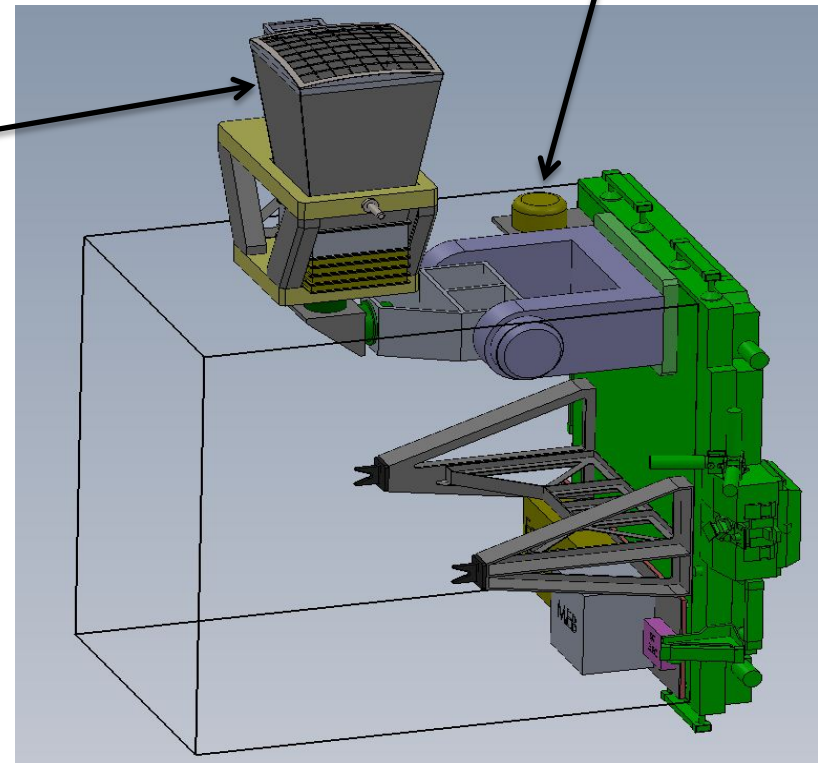
ISS-Lobster

microchannel plate



ISS - ELC attach point

γ -ray detector



$30^\circ \times 30^\circ$ FOV (0.3 sr)
0.3 – 6 keV
sensitivity is 10X better than BAT