Observational Properties of GRB Prompt Emission

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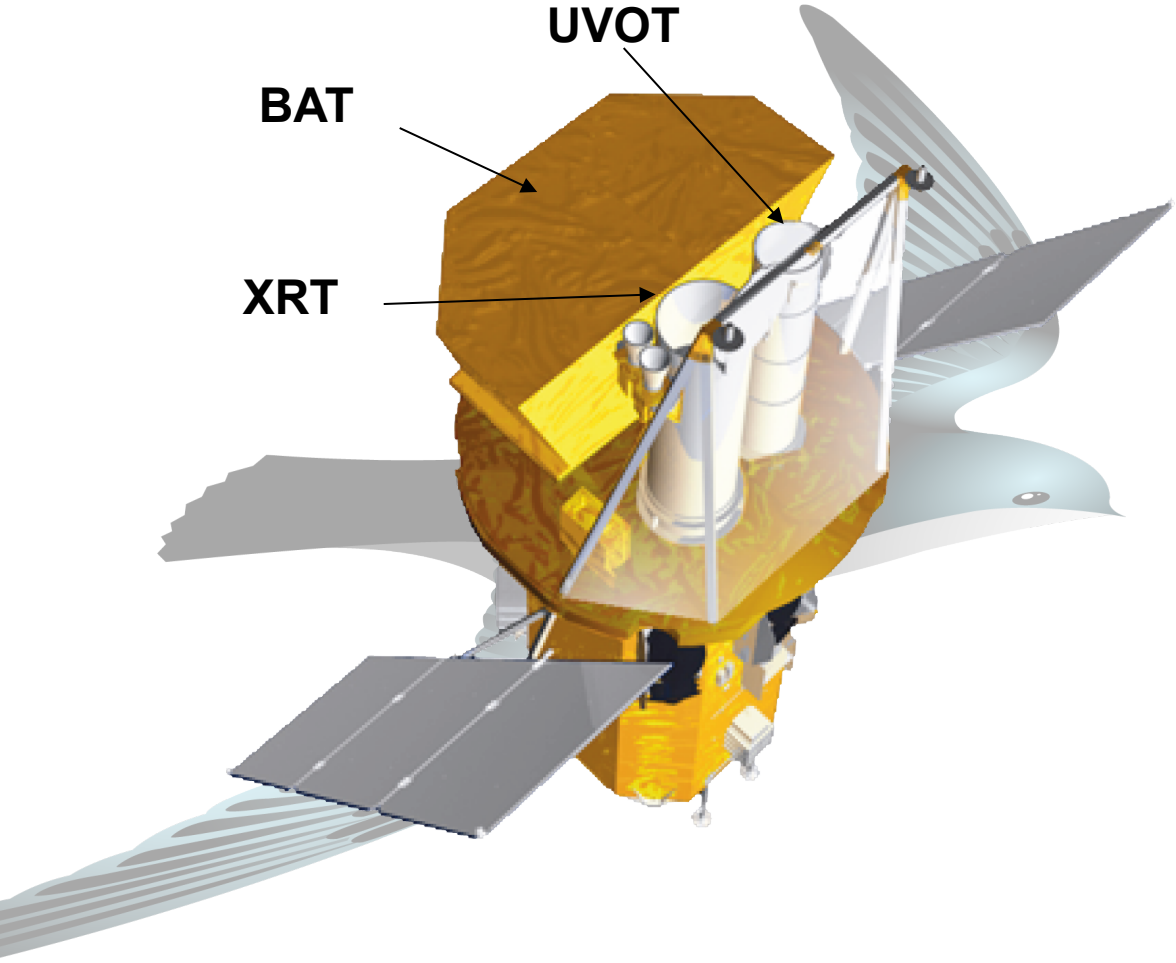
Bormio Thinkshop

Thinkshop Bormio

GRB Prompt Emission

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

Swift Mission

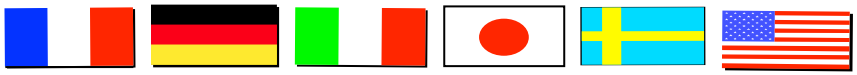


Launch November 20, 2004

- 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

Launch June 11, 2008



Large Area Telescope (LAT):

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

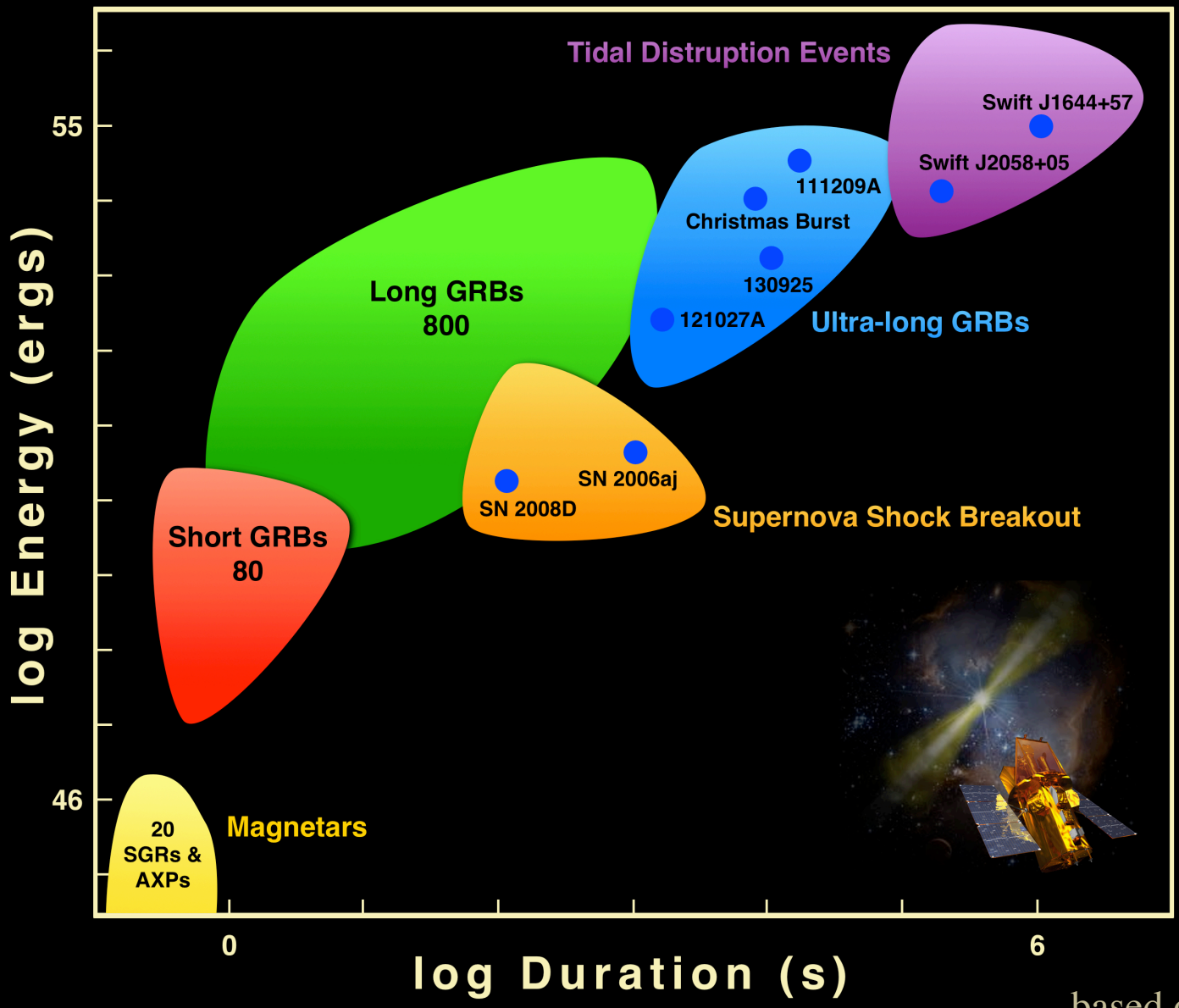
Atwood+ 2009

Gamma-ray Burst Monitor (GBM)

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

Meegan+ 2009

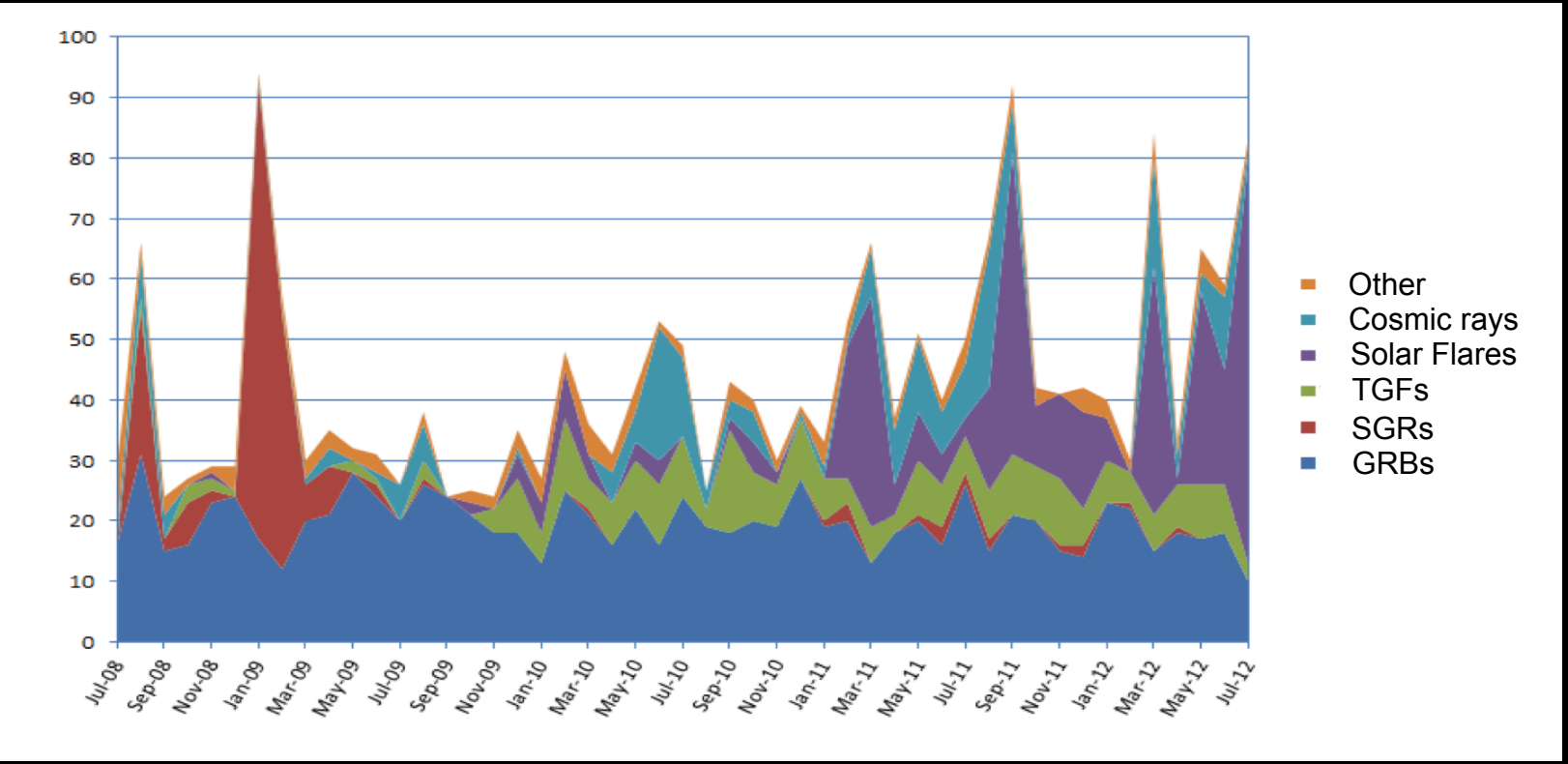
Swift



based on Levan+ 13

Fermi

GBM is most prolific detector of GRBs, SGRs and TGFs



LAT GRB rate is increasing:

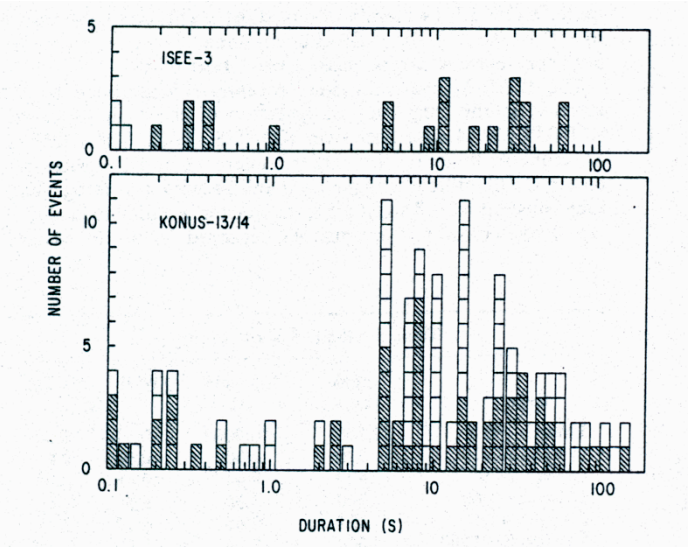
- 18 GRBs 2010-11, 37 GRBs 2012-13
- Pass 8 analysis software in 2015 will increase rate even move

Durations & Variability

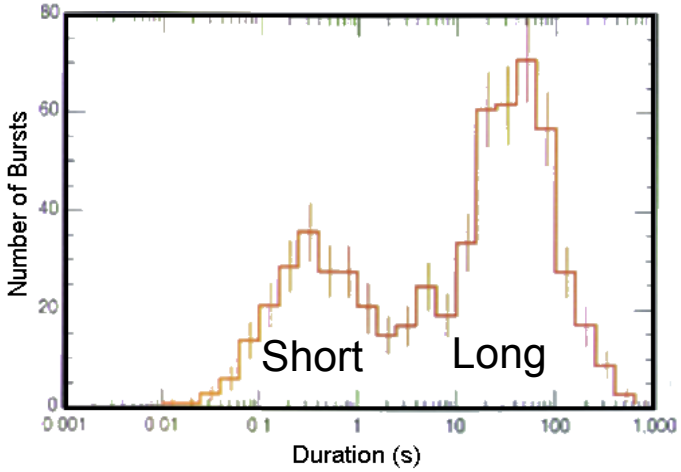
A Brief History of Time

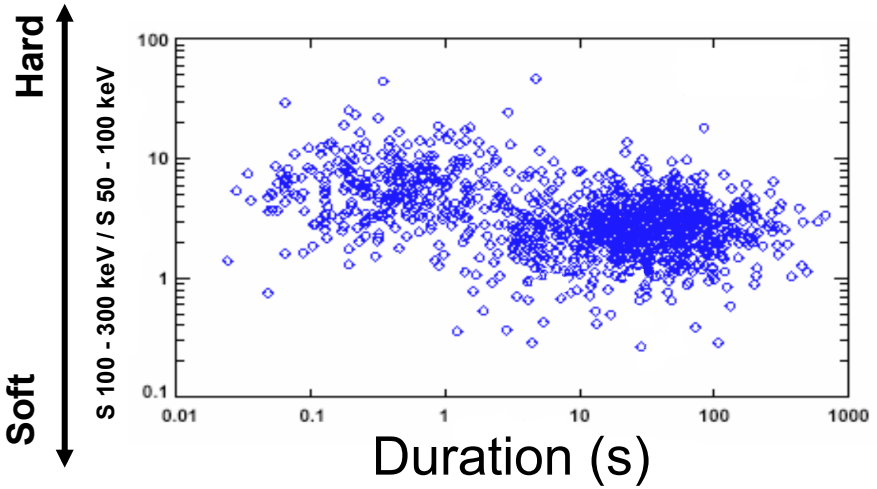
First hints of 2 duration groups:
Cline & Desai 74; Mazets 81

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

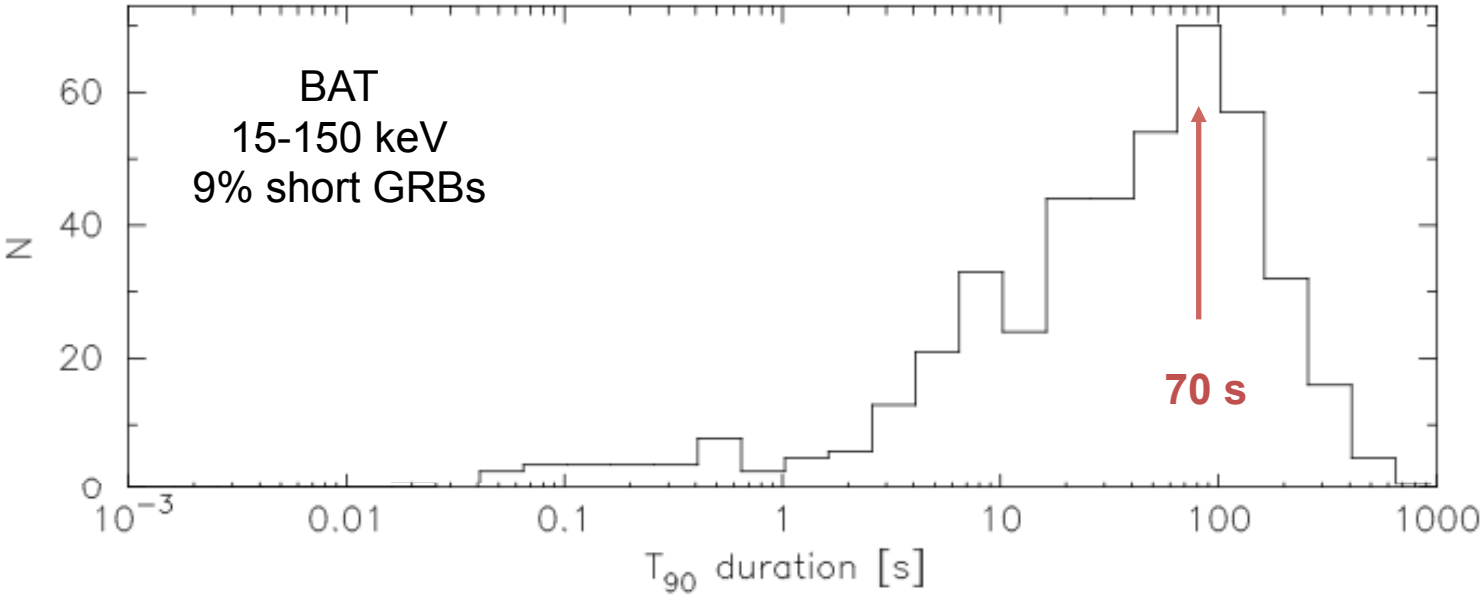


Proof of 2 classes with large statistics from *BATSE*
Kouveliotou+ 93

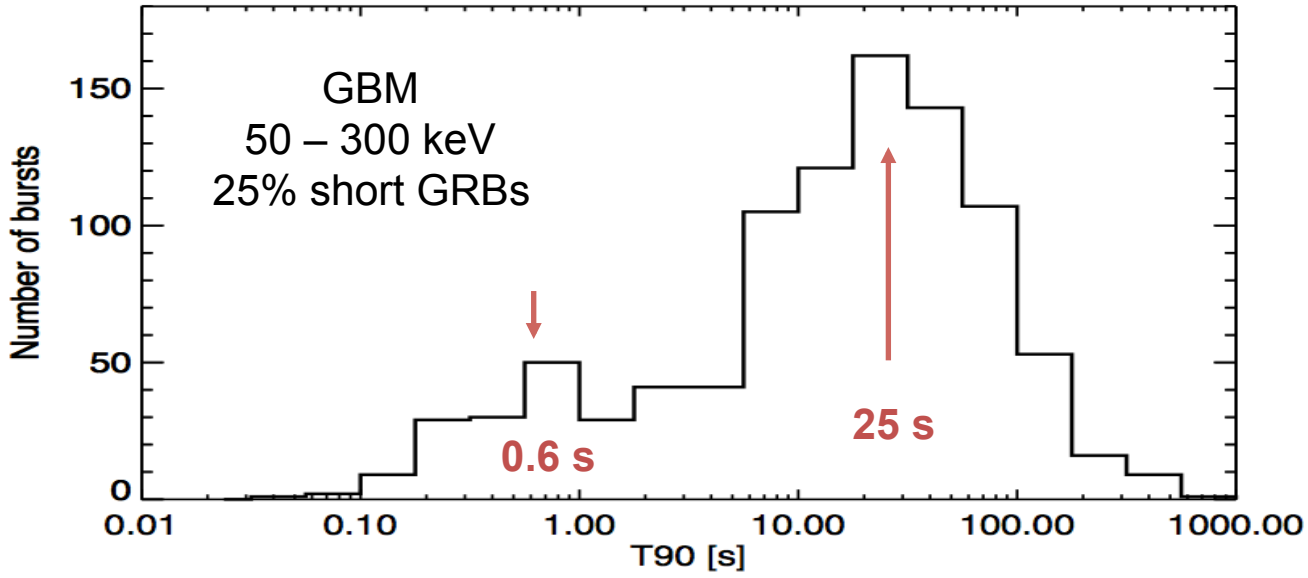




BAT vs GBM Durations

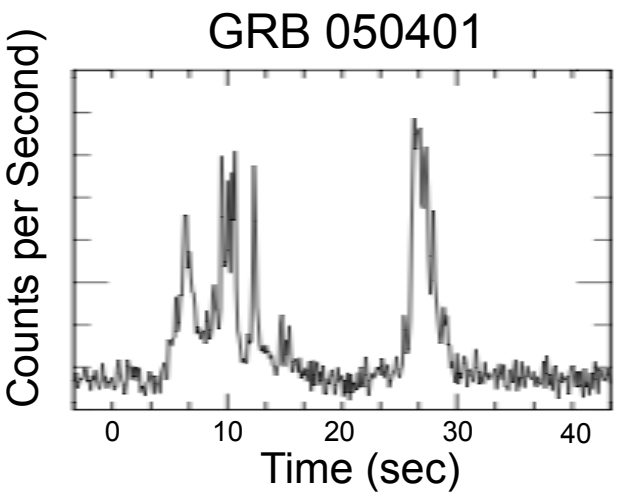


Sakamoto+ 10

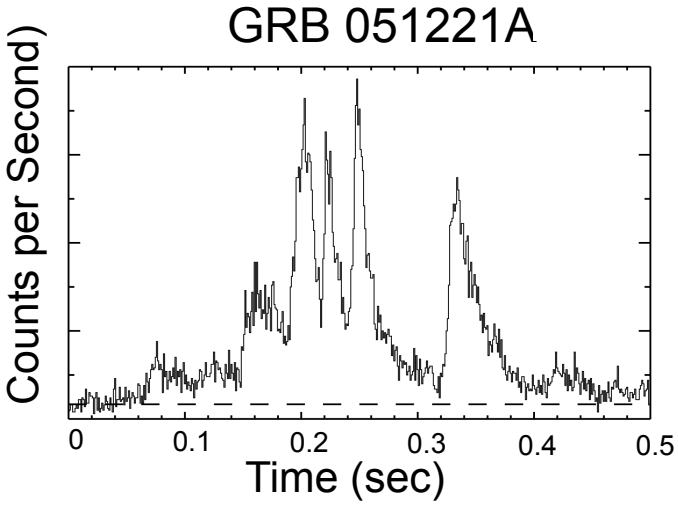


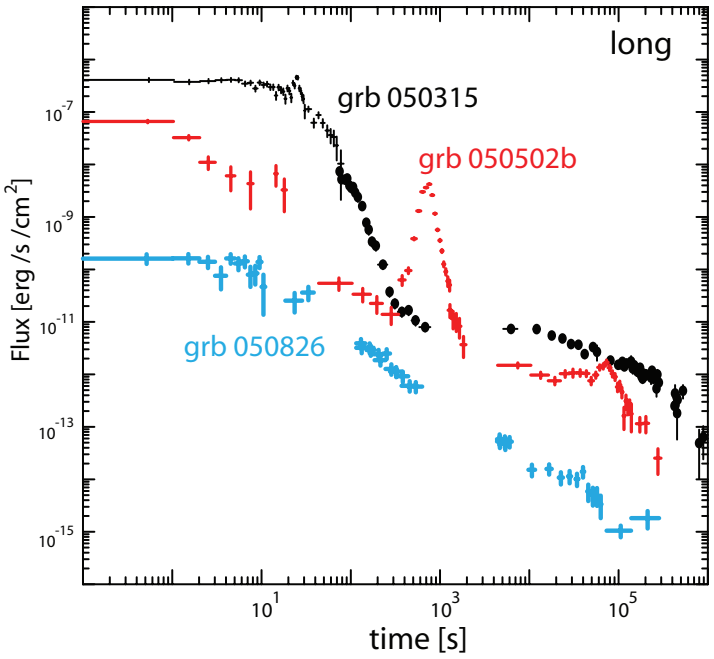
Kienlin+ 14

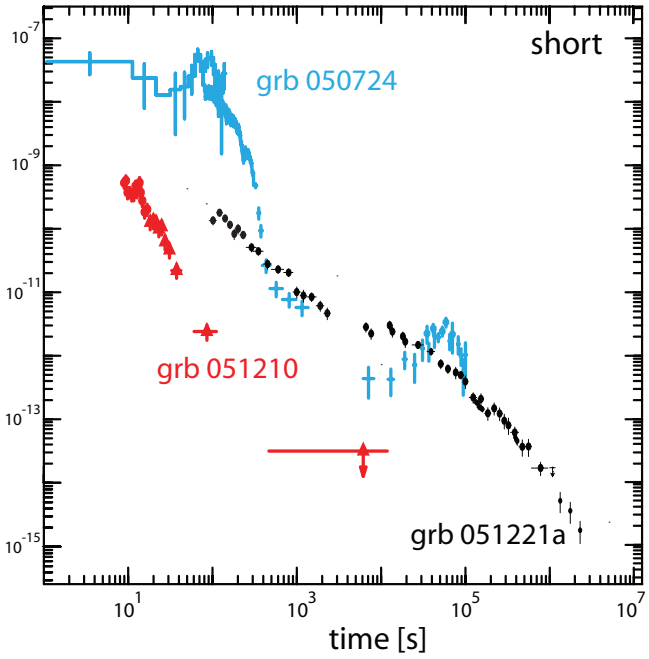
Long

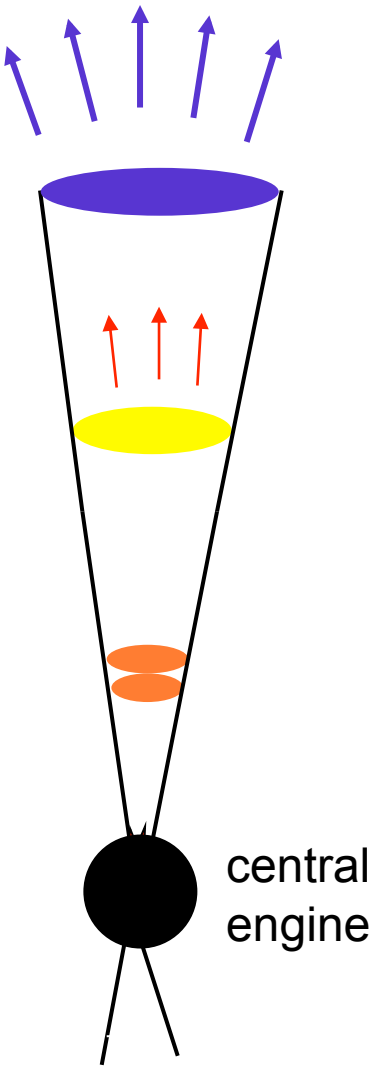


Short





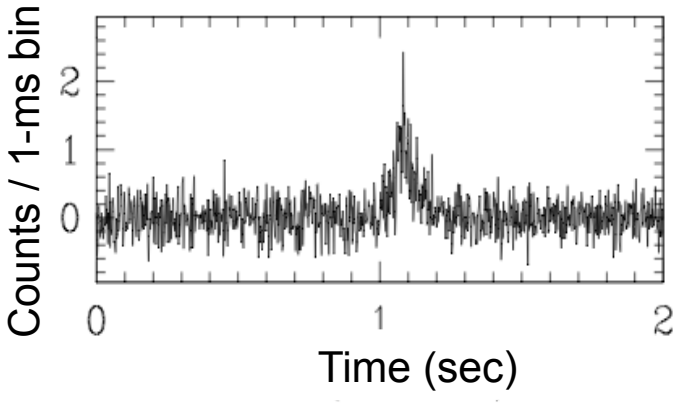




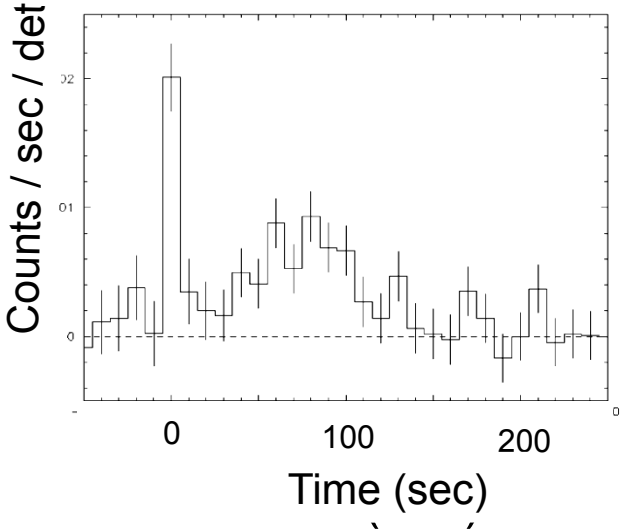
Gehrels, Ramirez-Ruiz
Fox 09

Short GRB Lightcurves

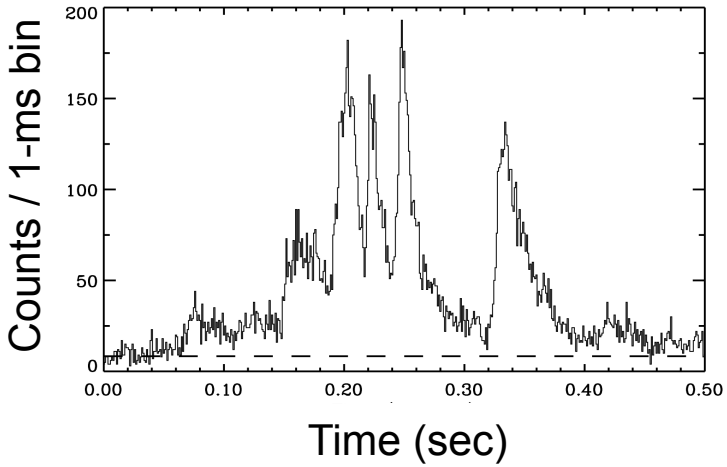
Single Spike - 15%
GRB 090621B



Extended Emission - 25%
GRB 050724



Complex - 25%
GRB 051221A



GRB 060614 z=0.125

T_{90} = 103 s

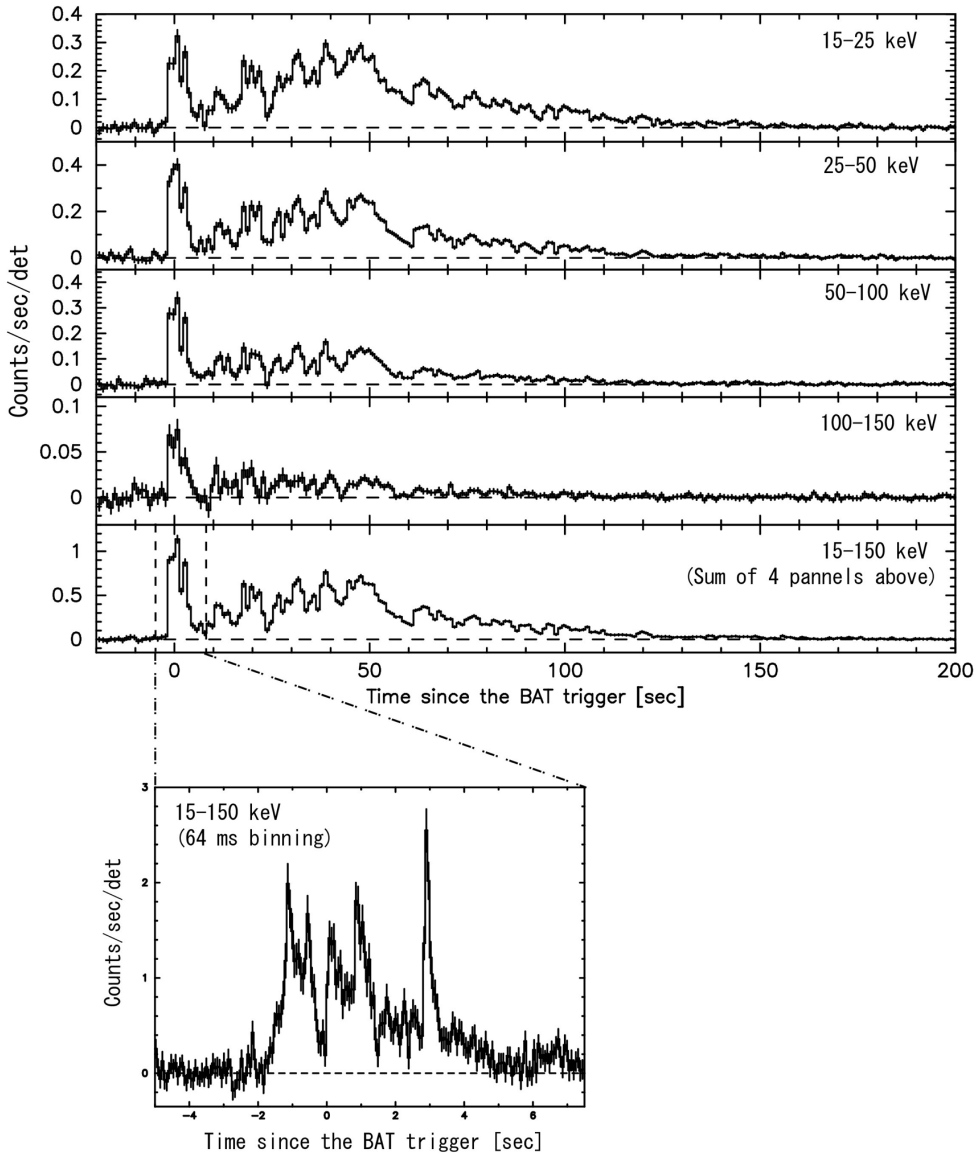
Could it be in "short"?

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

However:

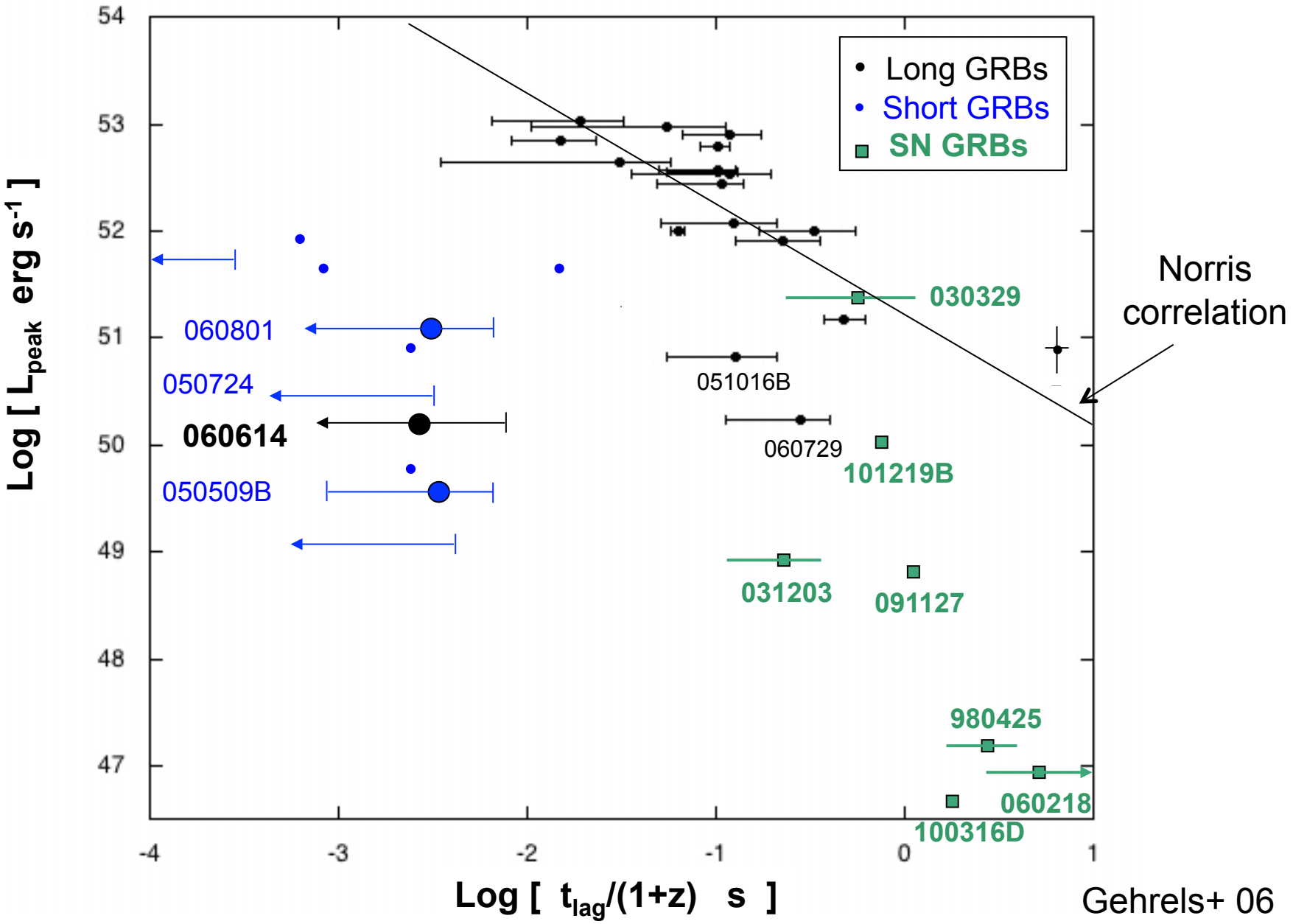
- 5 s duration of hard episode
- Brighter & more variable extended emission than others

BAT Lightcurves



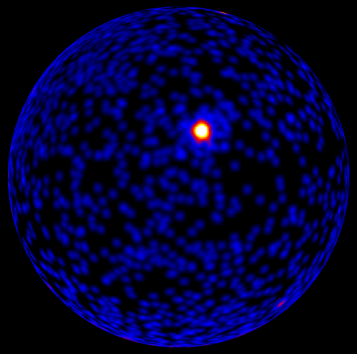
Gehrels+ 06

Lag – Peak Luminosity Relation



Gehrels+ 06


Science
3 January 2014 | S10
Record-Setting
Gamma-Ray Burst
AAAS

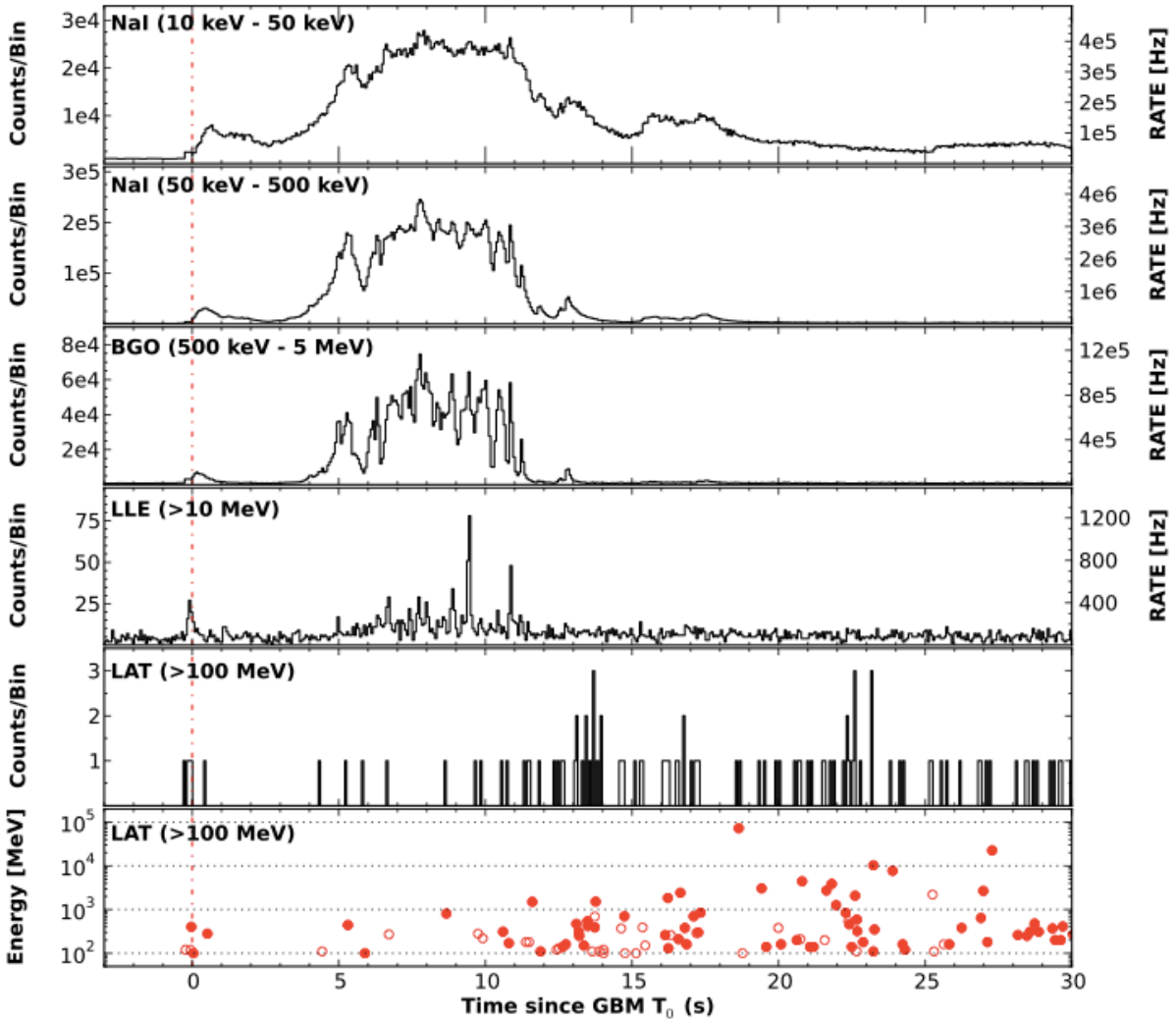


High Energy Gamma Ray Emission

GRB 130427A

Relative to keV / MeV, >100 MeV emission is

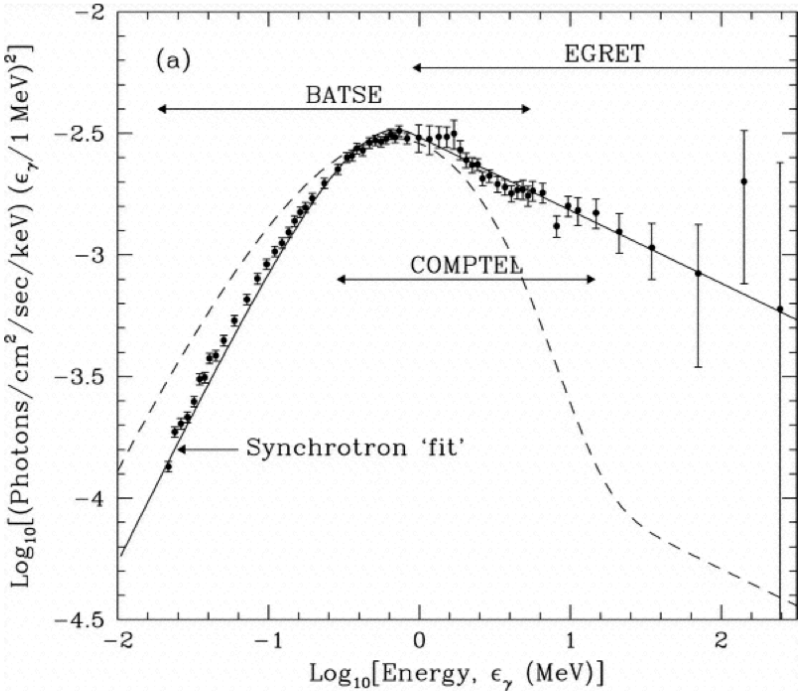
- delayed in initiation
- extended in time



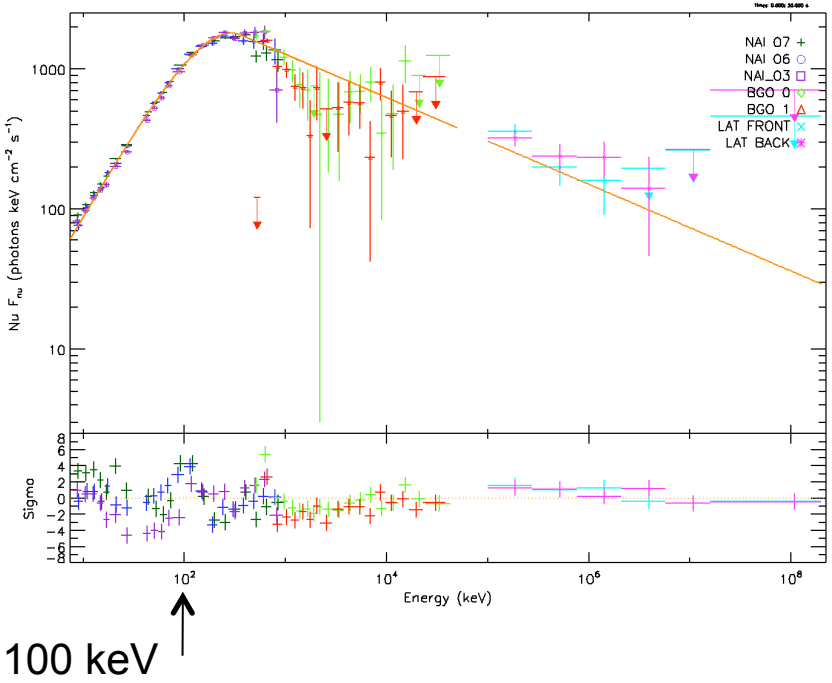
Ackermann+ 13

Spectra

Band Function Spectral Shapes



Baring & Braby 04

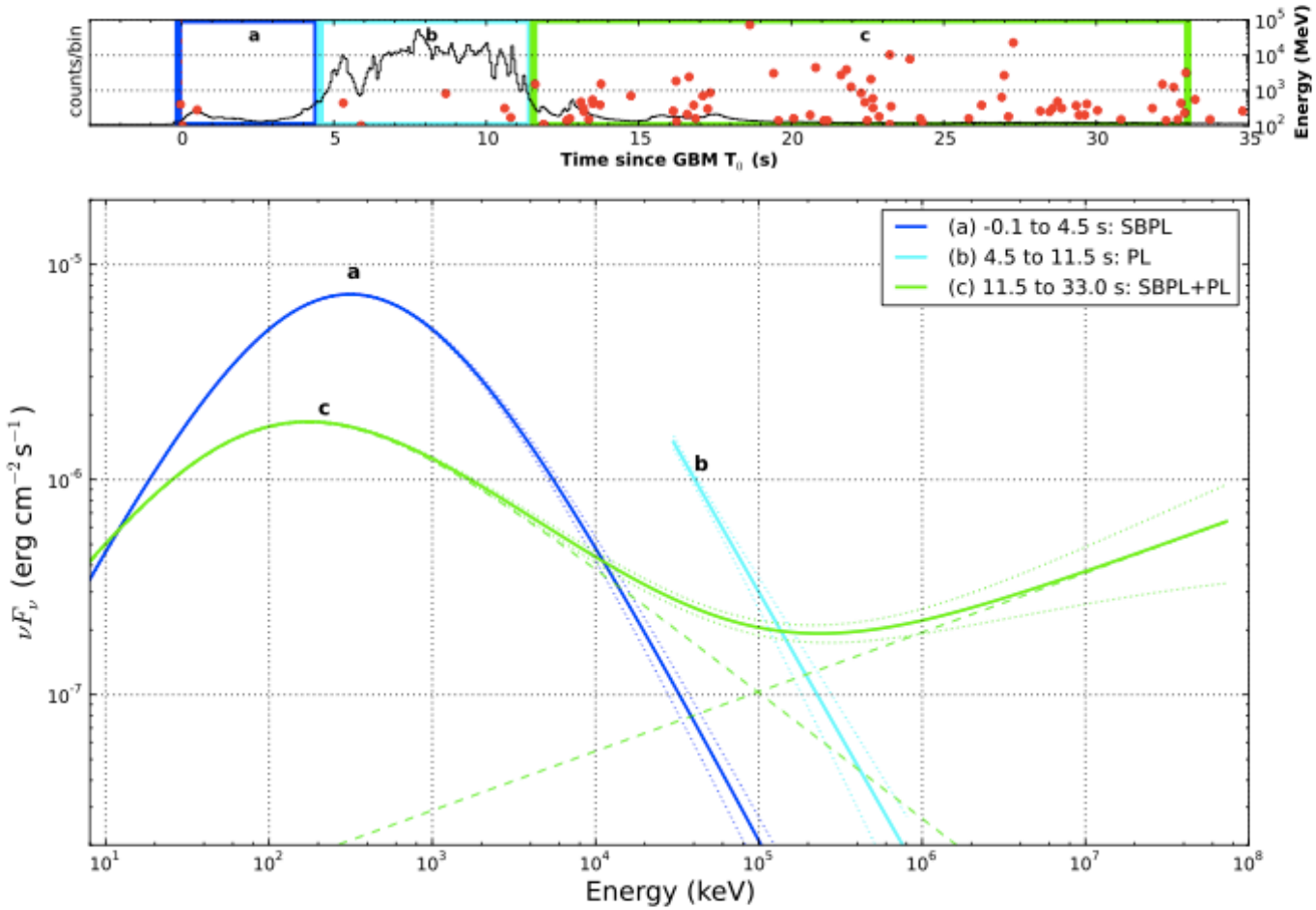


Guiriec+ 12

Changing Spectral Components

GRB 130427A

z=0.34 T90=162s

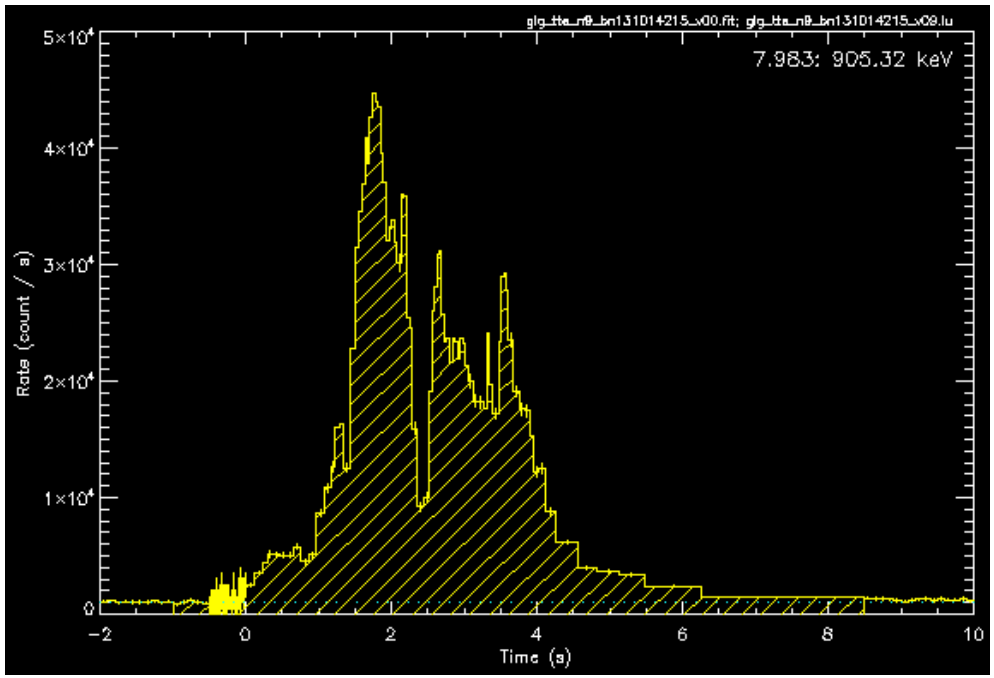


Ackermann+ 13

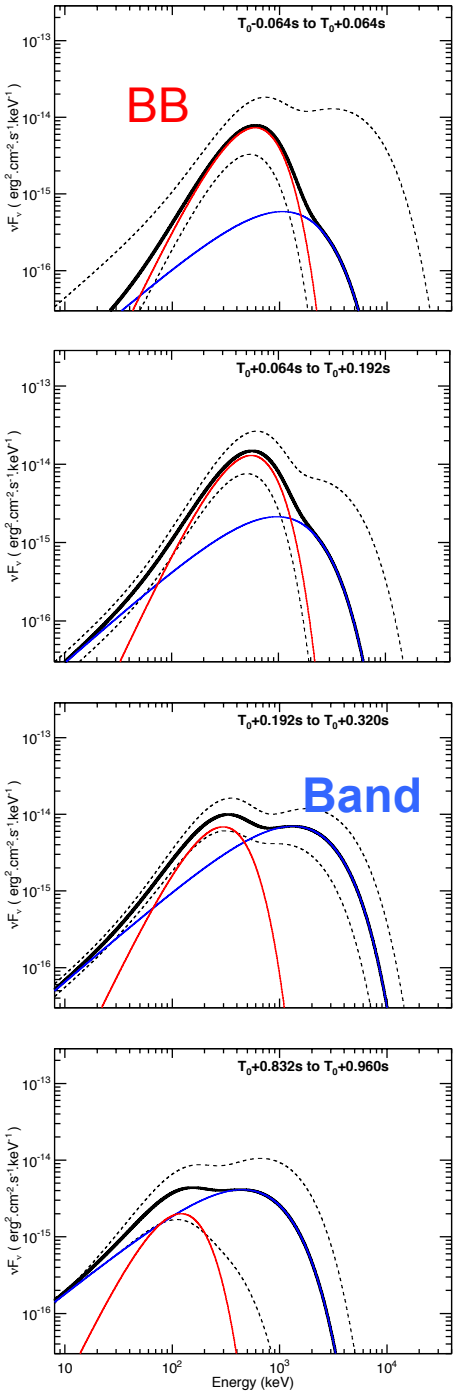
Blackbody Component

GRB 131014A

T90 = 3s



The spectrum is dominated by BB emission early

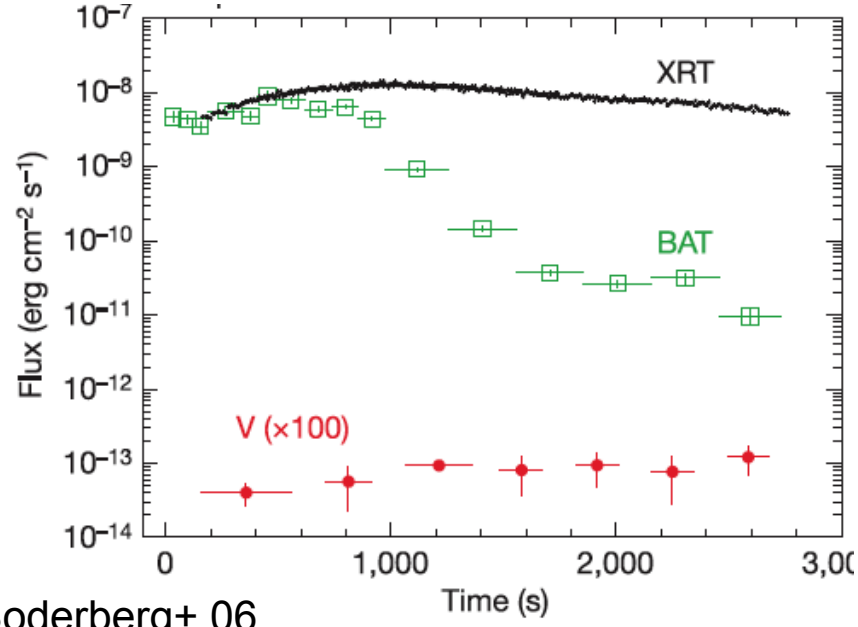


Guiriec +14

Interesting Questions

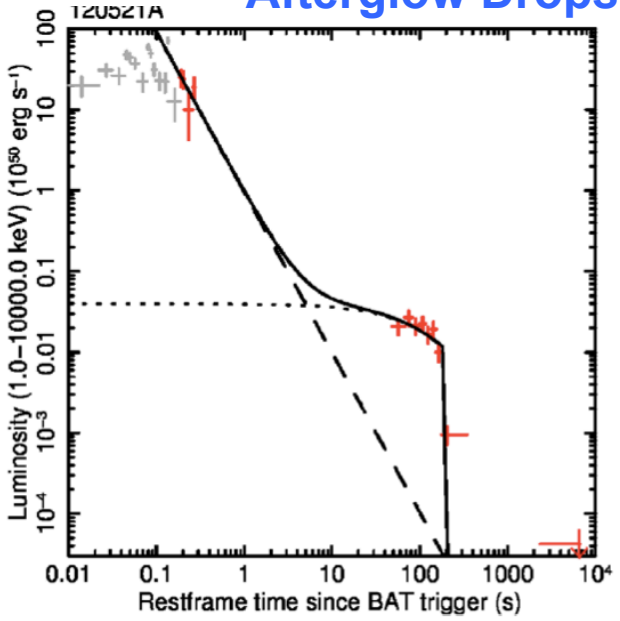
Are Magnetar Engines Part of the GRB Family?

Underlumious Superlong GRB 060218



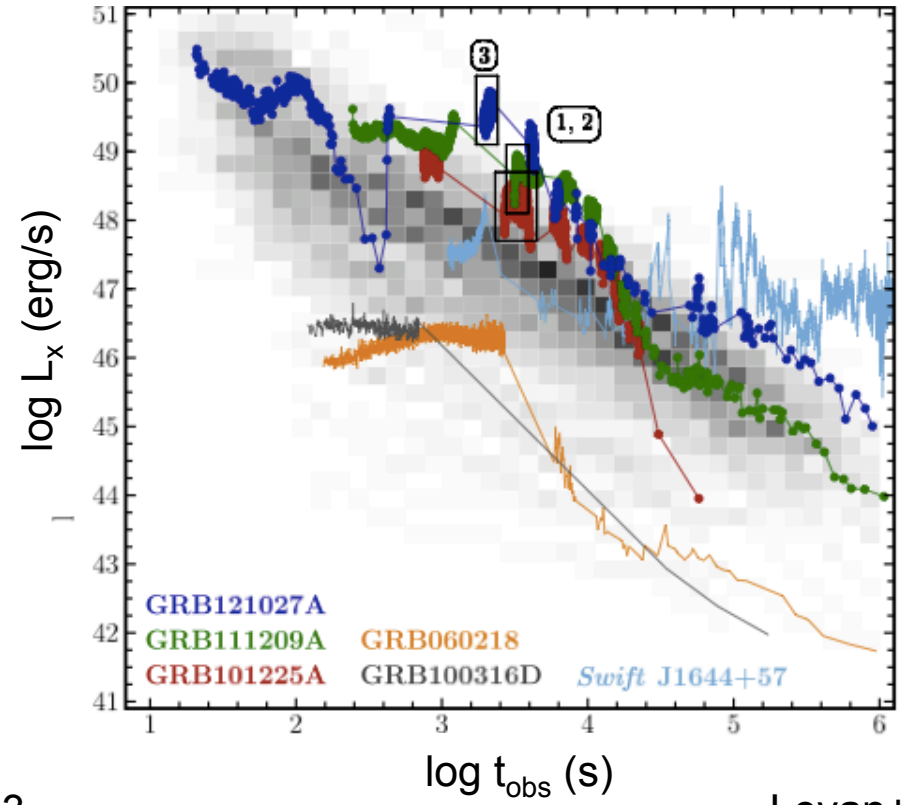
Soderberg+ 06

Afterglow Drops



Rowlson+ 13

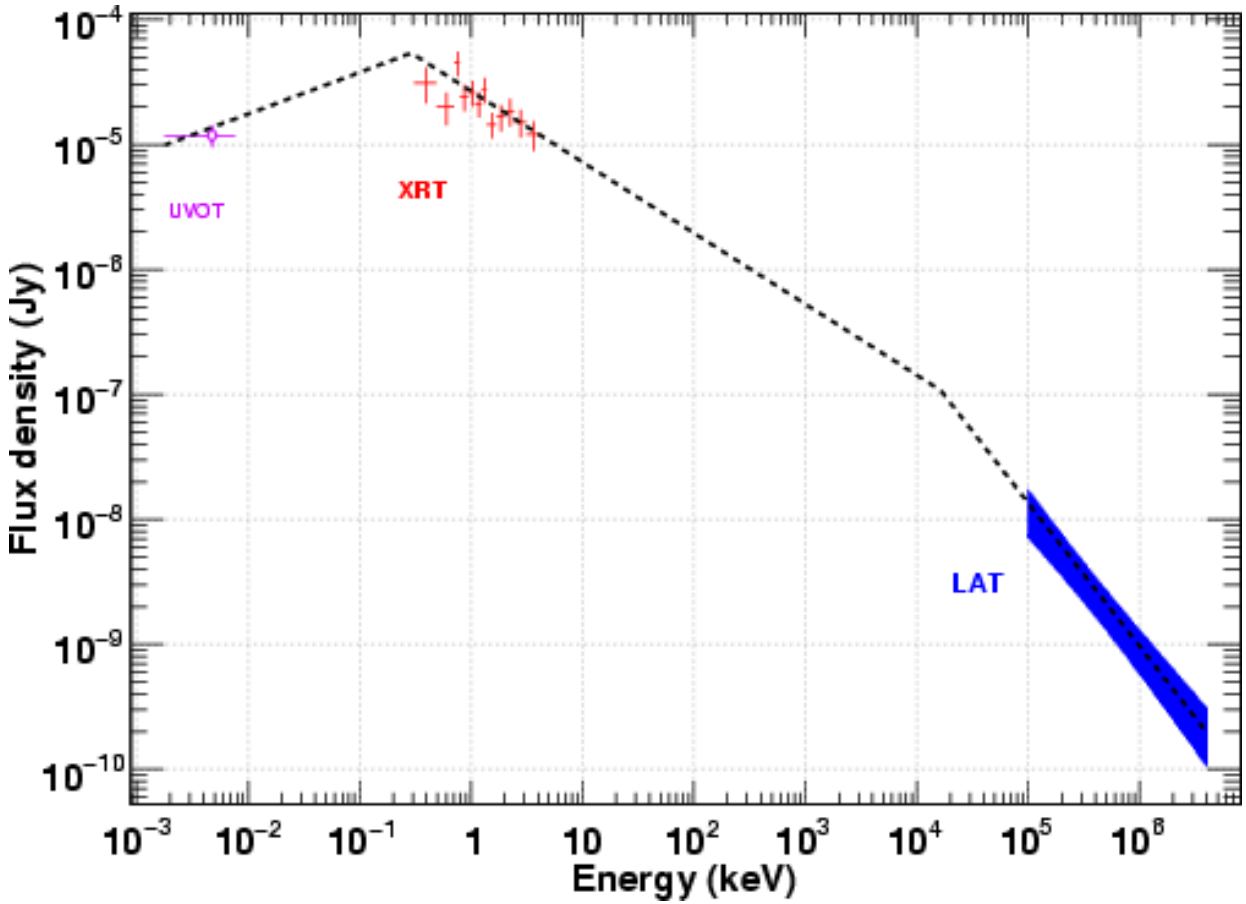
Ultrlong GRBs



Levan+ 14

Is LAT High Energy GRB Emission Prompt or Afterglow?

GRB 090510 - detected by BAT & LAT

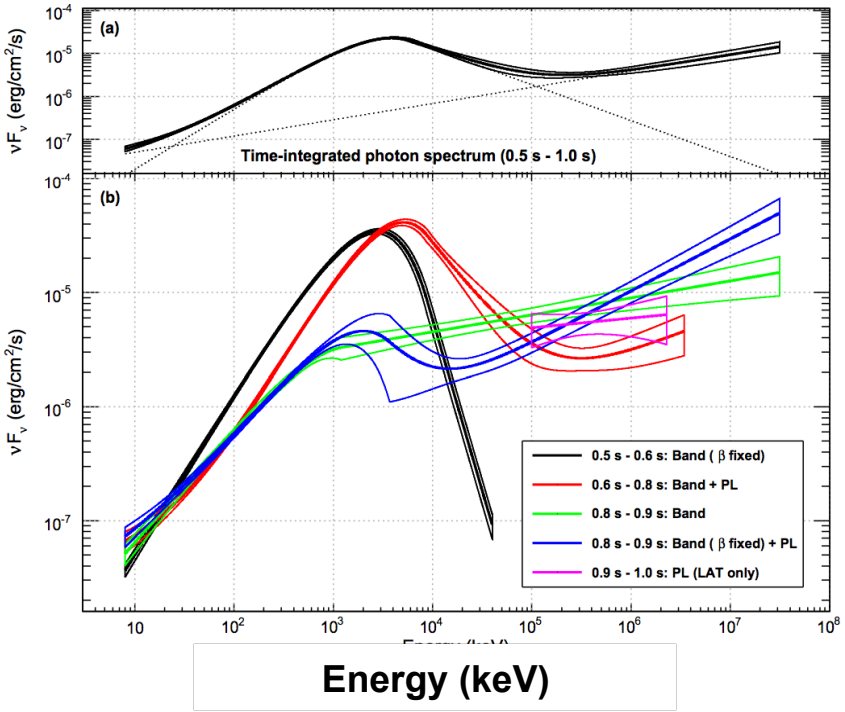


LAT data 0.38 - 200s

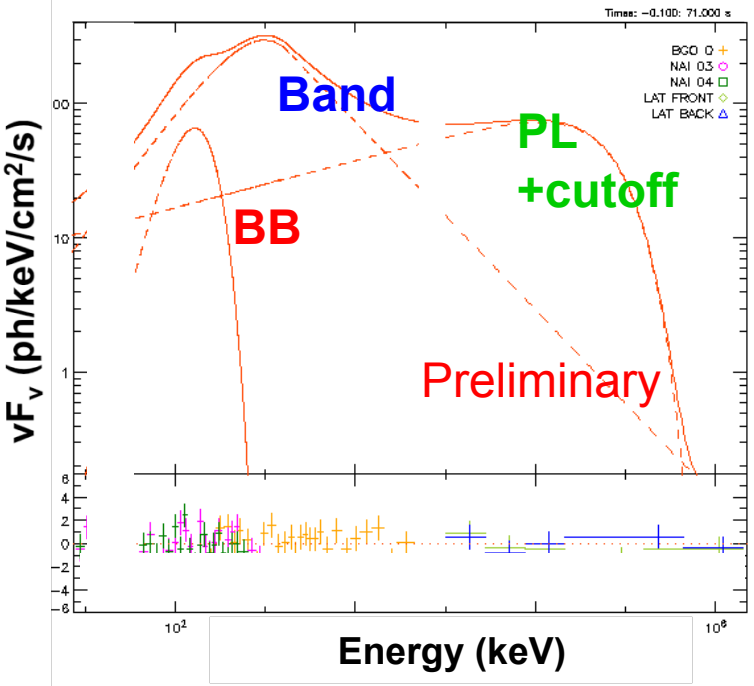
De Pasquale+ 09

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

GRB 090510



GRB 080916C

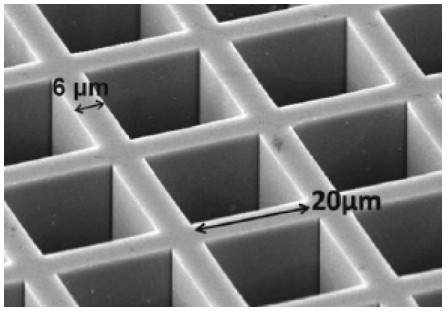


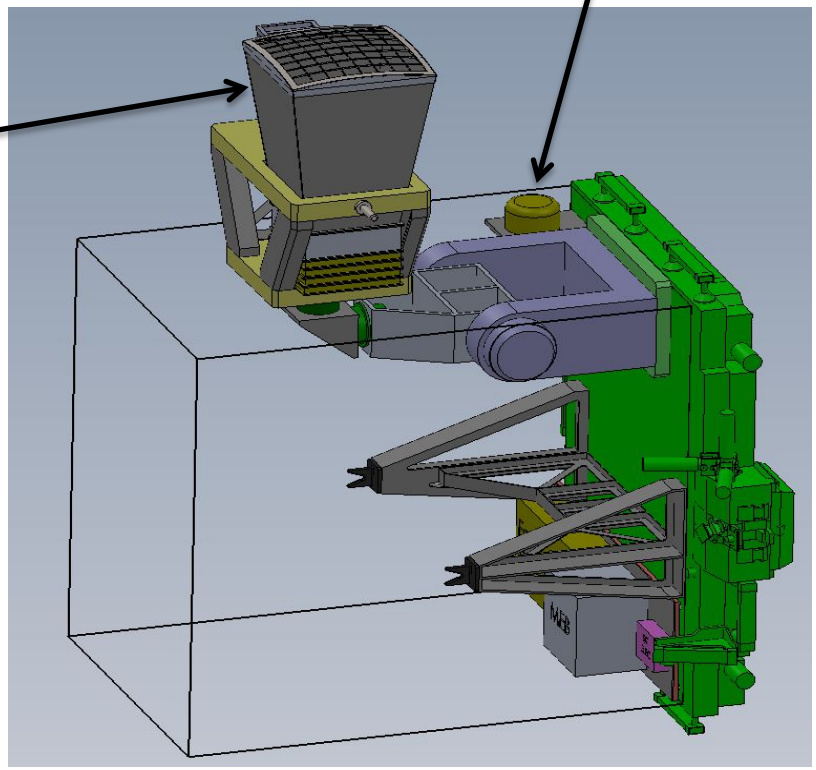
Future Considerations

ISS-Lobster

γ-ray detector

microchannel plate





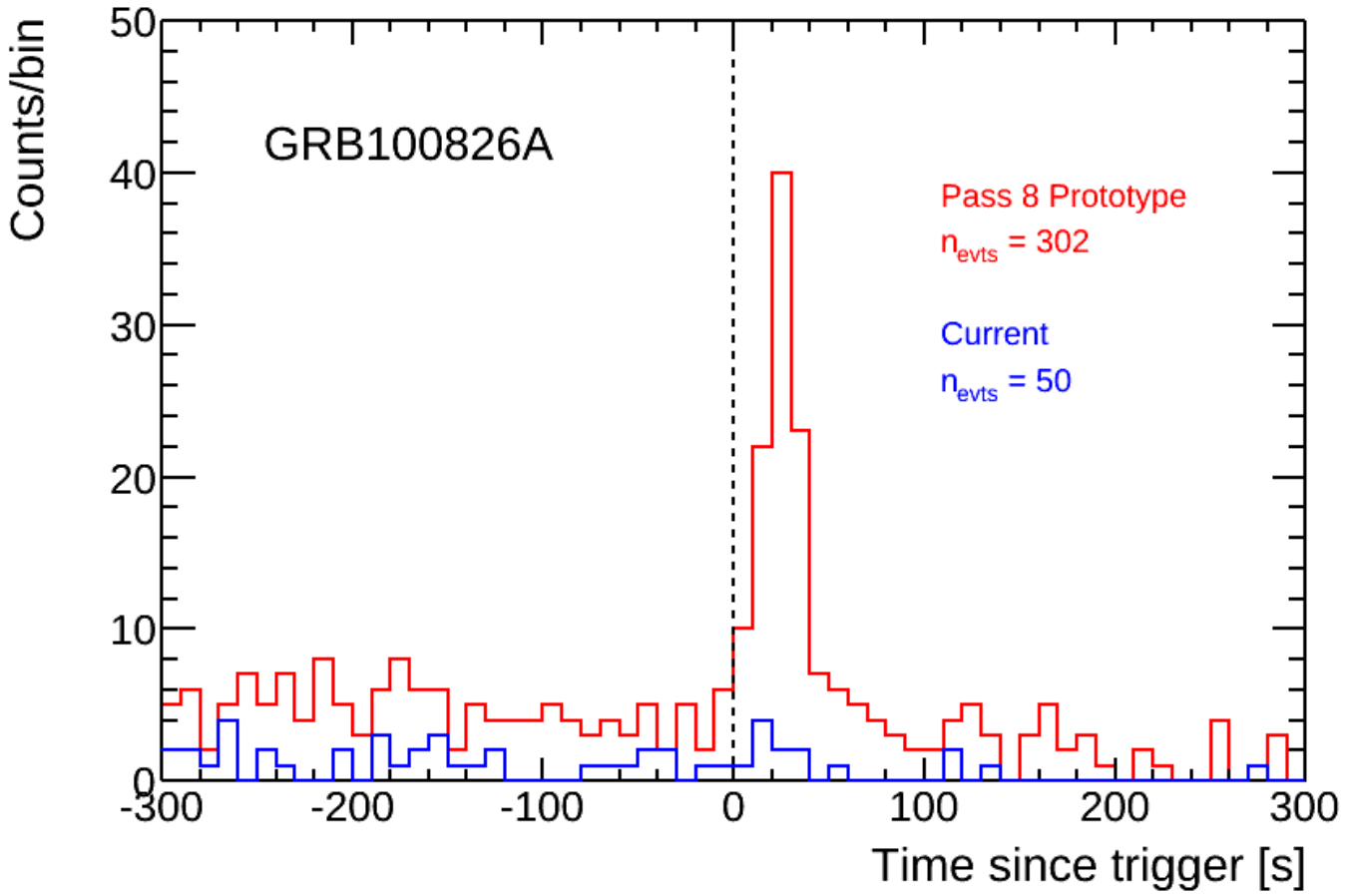
ISS - ELC attach point

30° x 30° FOV (0.3 sr)
0.3 – 6 keV
sensitivity is 10X better than BAT

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