Bright High-Energy GRBs detected with Fermi GBM

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On behalf of the Fermi GBM and LAT Collaborations

Project Collaborators:

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Artist's impression of a gamma-ray burst - Credit: ESO/A. Roquette

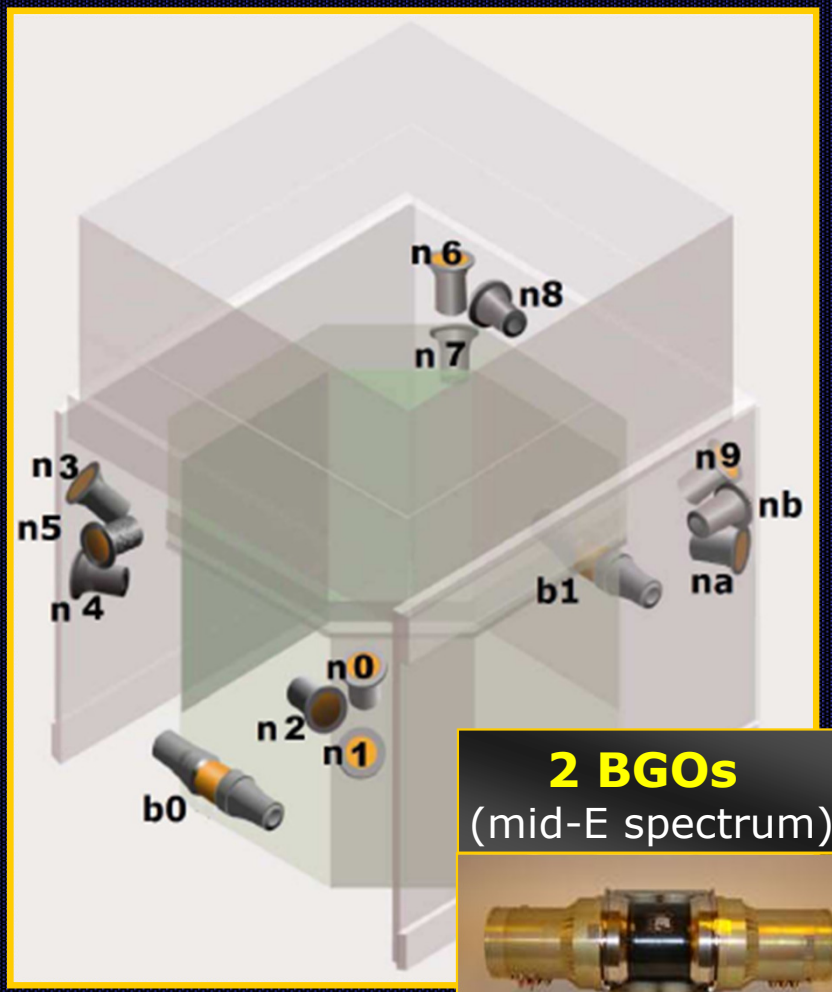
Main ideas

- Extension of the analysis presented in "First-year Results of Broadband Spectroscopy of the Brightest Fermi-GBM Gamma-Ray Bursts" (Bissaldi et al., 2011, ApJ 733, 97B)

- "BGO bright" bursts
  - Selection criteria

1. Detection of more than **80 counts/s** over background in the raw counts of at least one BGO detector over its full energy range (**250 keV–40 MeV**)

2. Detection of more than **4 sigma** over background of the maximum or "peak" count rate (PCR) of the TTE lightcurves on various timescales (64ms, 128ms, 256ms and 512ms) in the **500-1000 keV** energy band



BGO bright bursts sample

- Previous analysis: 52 bursts (year 1)

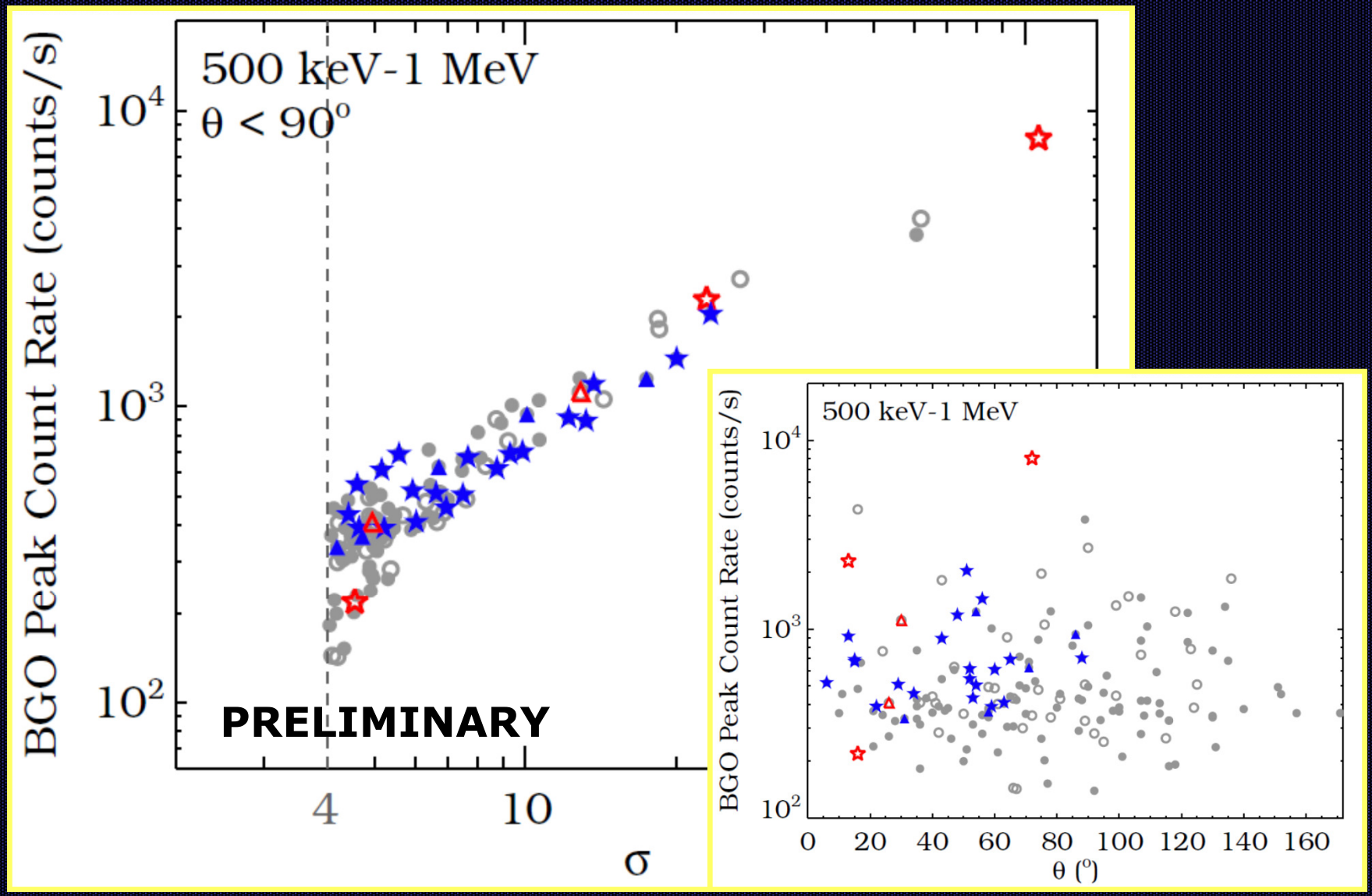
➔ Current analysis: **178 bursts (years 1-4, 2008-2012)**

- **39 short, 139 long** **~1/4 short**
- **95 in the LAT FoV** **~1/2 in LAT FoV**
- **Excluded 3 long bursts** which are among the 35 GRBs of the official LAT catalog (The Fermi LAT Collaboration, 2012, in prep)
  - **NOT** matching our criterion n.2 (4 sigma)
  - 27 long, 5 short

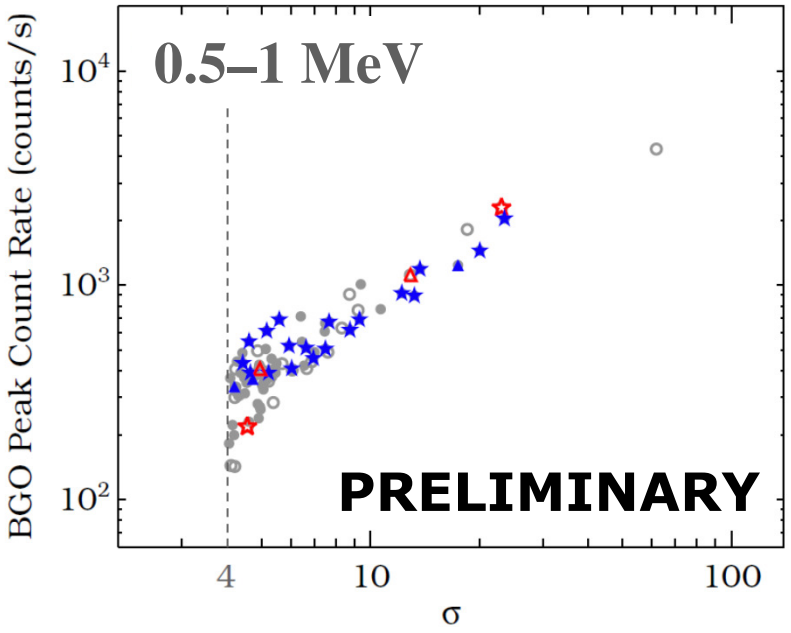
➔ **Can we confirm earlier results of BGO predictability for LAT bursts?**

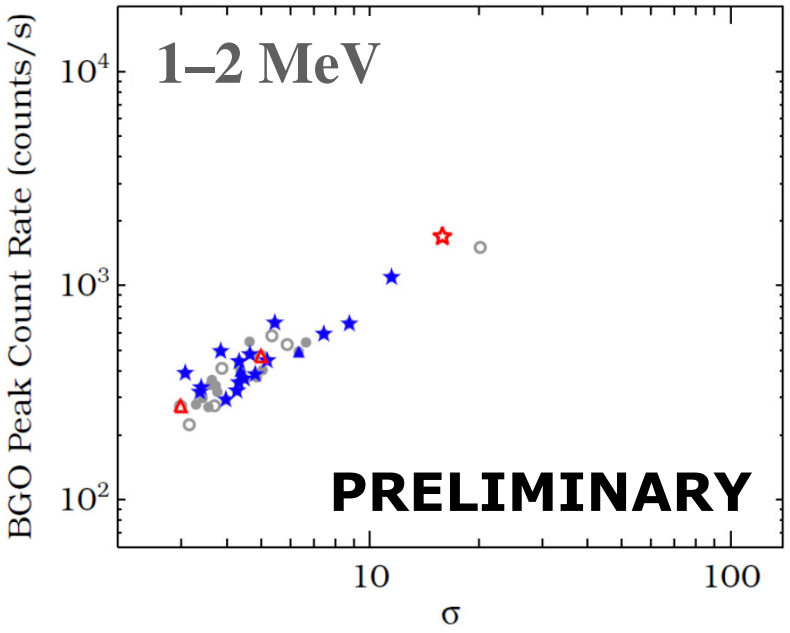
Peak Count Rate analysis

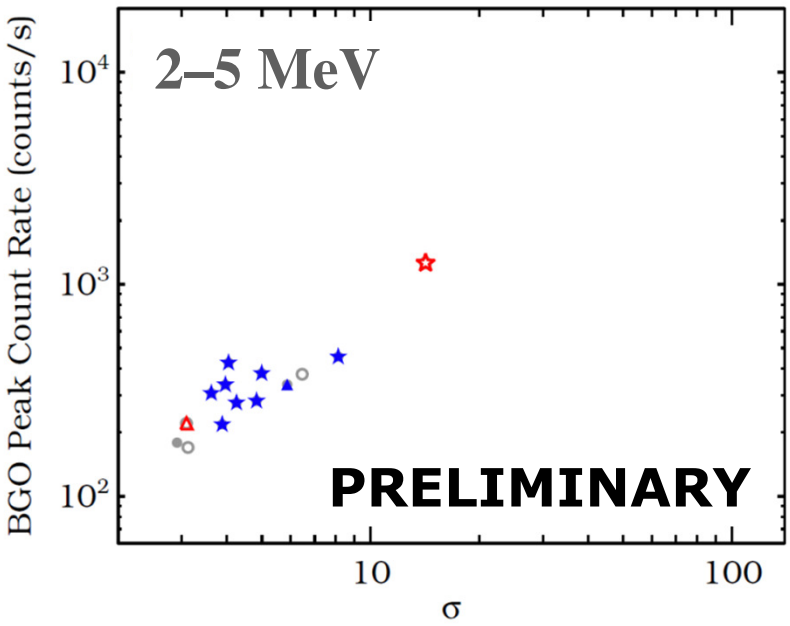
- **Peak Count Rate (PCR) vs. Sigma in BGO**

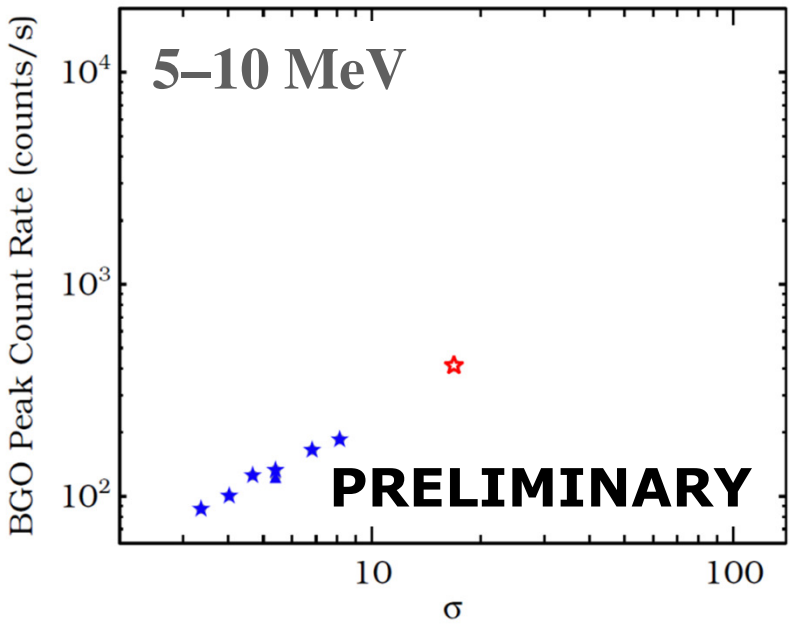


PCR analysis at higher energies



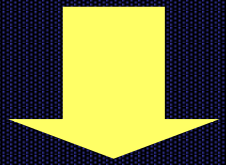






Analysis of systematics

- Systematics: "Human-in-the-loop" and instrumental



- Analysis T90 calculated in counts space in each energy band
  - Using a "calibration sample" of 4 long and 4 short GRBs
    - 2 "Strong" (8 keV-10MeV)
    - 4 "Medium" (8keV-2MeV)
    - 2 "Weak" (8 keV-1MeV)
  - Changing selections
    - Background, interval, binning
- Results:

Long GRBs	
Energy band	Syst. error
8–140 keV	10%
140–1000 keV	20%
1 - 2 MeV	30%
2 - 10 MeV	60%

Short GRBs	
Energy band	Syst. error
8–70 keV	30%
70–1000 keV	20%
1–2 MeV	30%
2–10 MeV	60%

Analysis of systematics

- Systematics: "Human-in-the-loop" and instrumental

- Compared with T_{90} results calculated in photon space from 8 keV to 1 MeV using RMfit with NaI only data

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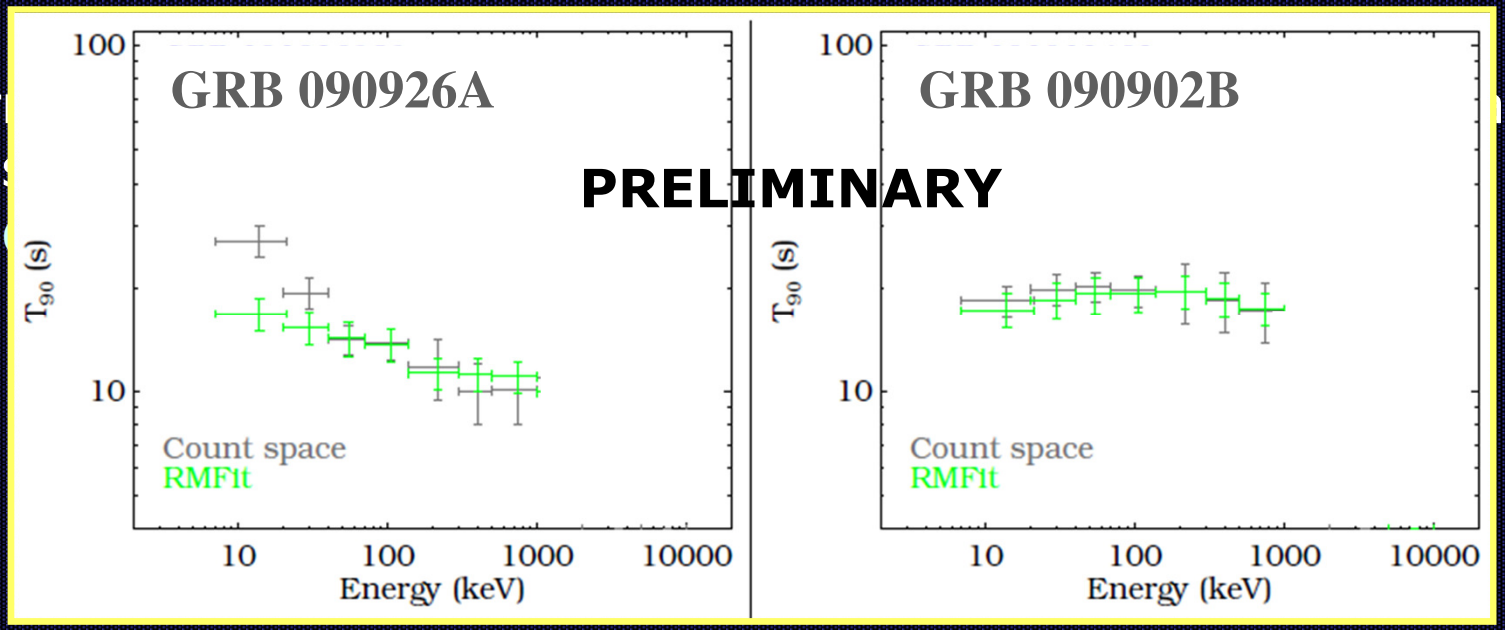
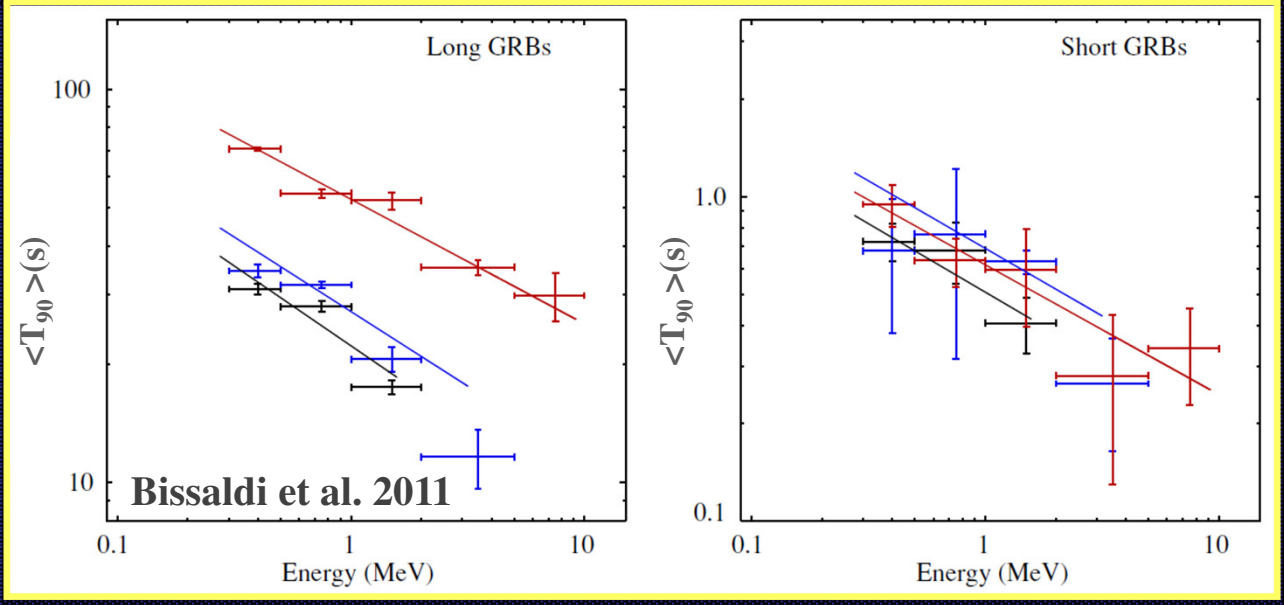


Evolution of duration with energy

- **Previous analysis results:**

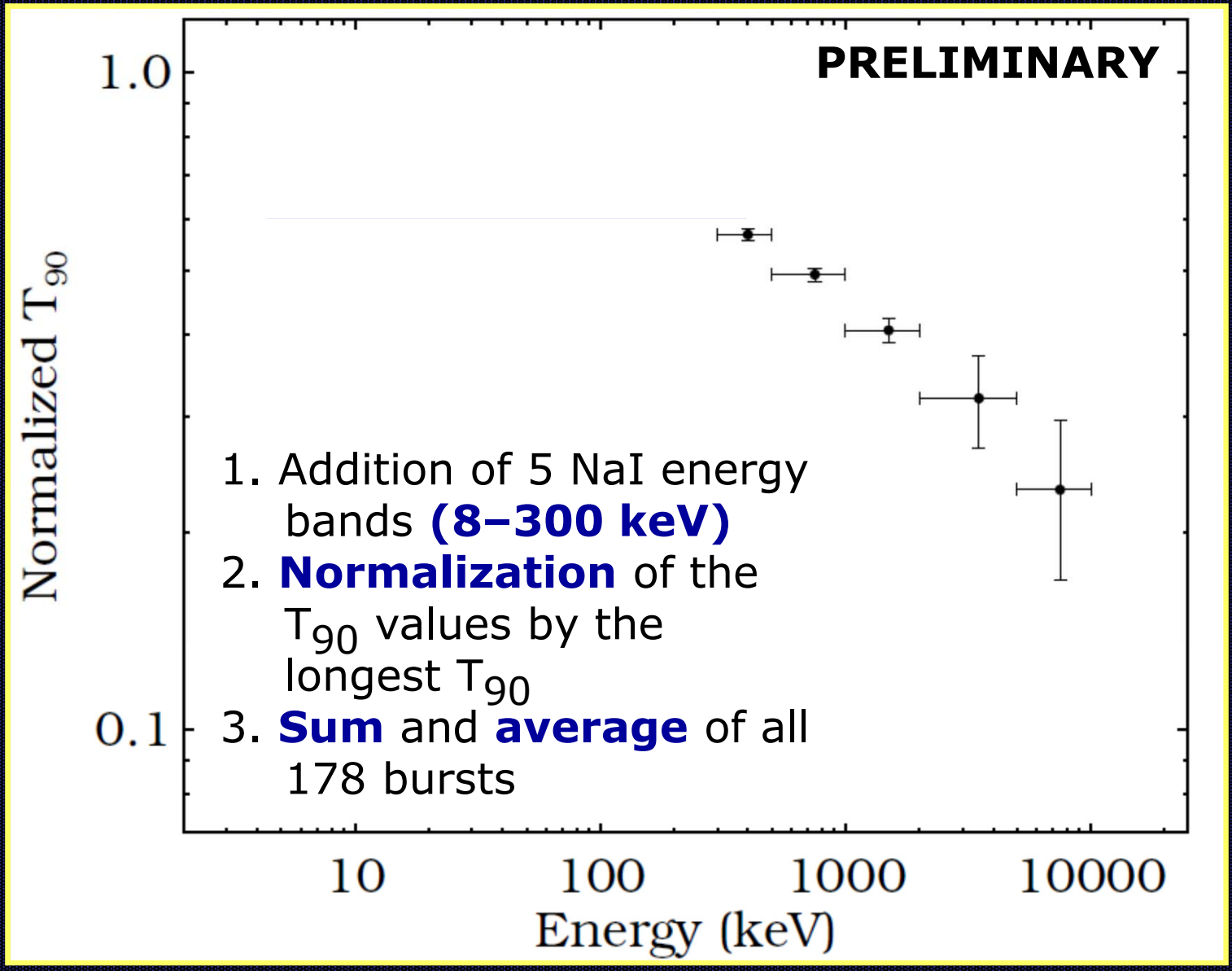
Energy Range	$\langle\alpha_{90}\rangle$	
	L	S
300 keV–2 MeV	-0.41 ± 0.04	-0.42 ± 0.17
300 keV–5 MeV	-0.38 ± 0.04	-0.42 ± 0.17
300 keV–10 MeV	-0.32 ± 0.02	-0.40 ± 0.12



- **52 bright** GBM year 1 GRBs
- **Five** energy channels [0.3-10 MeV]
- Divided long from short GRBs
- Simple PL fit

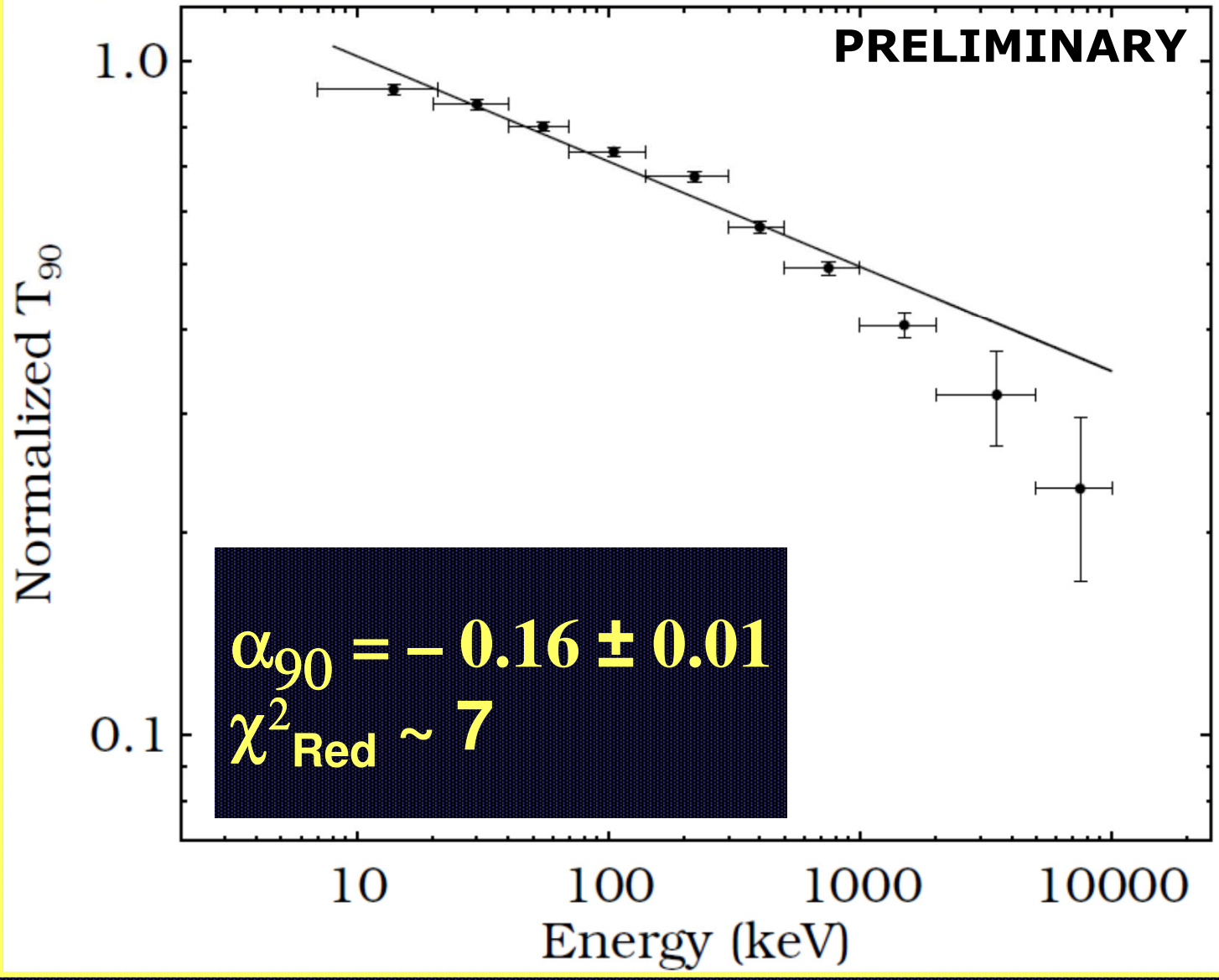
Evolution of duration with energy

- **New extended analysis:**



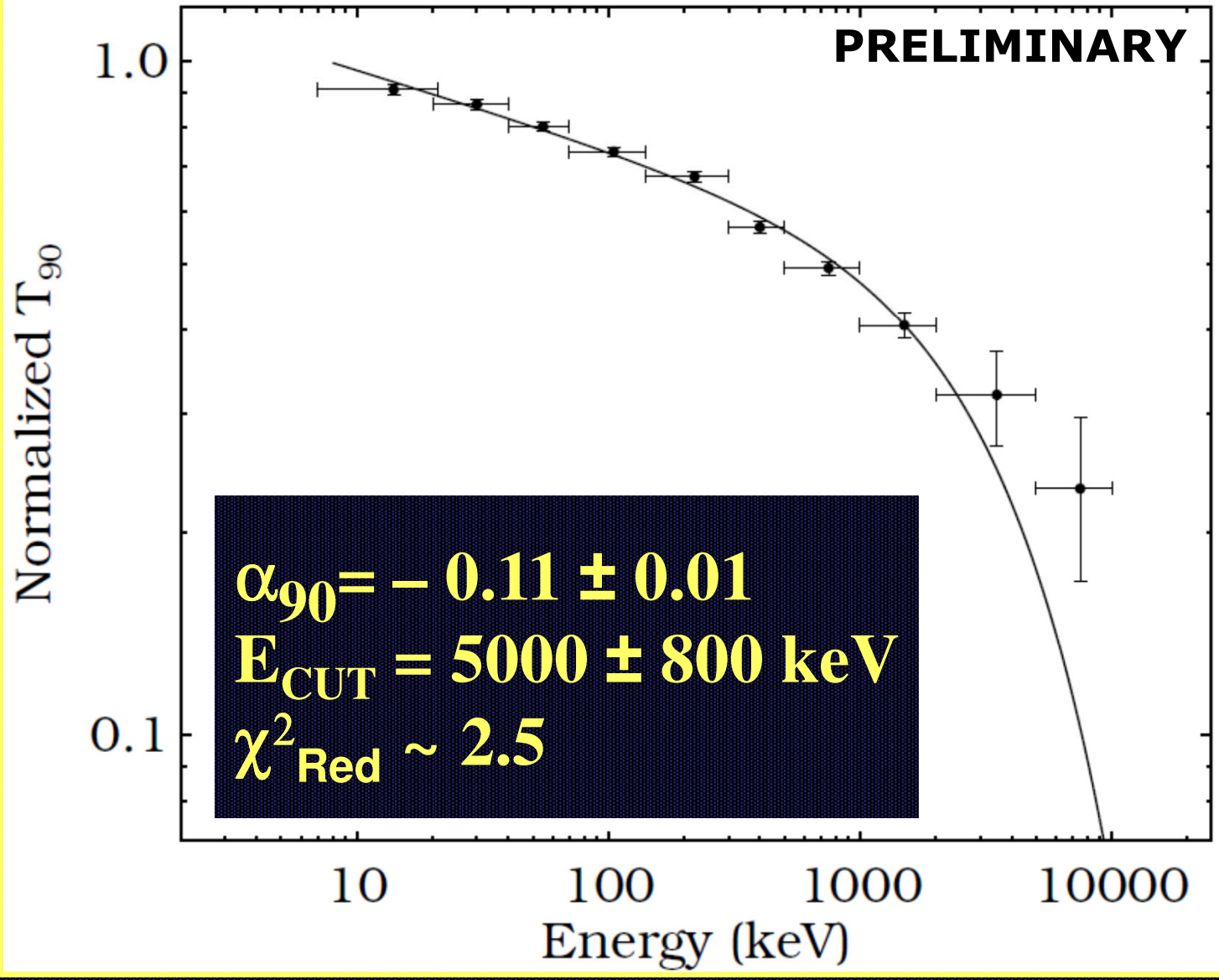
Evolution of duration with energy

Simple PL fit



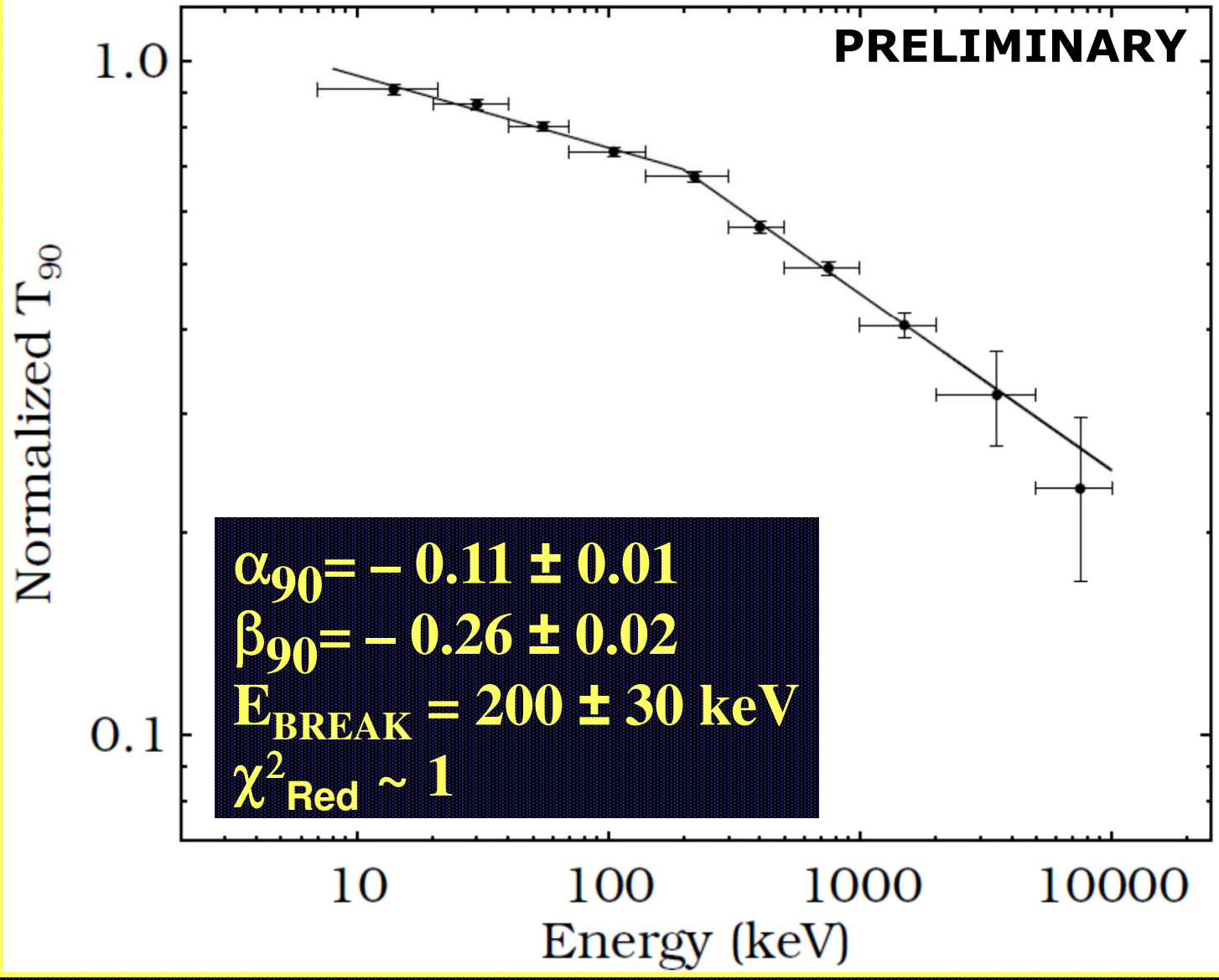
Evolution of duration with energy

PL with exp cutoff fit



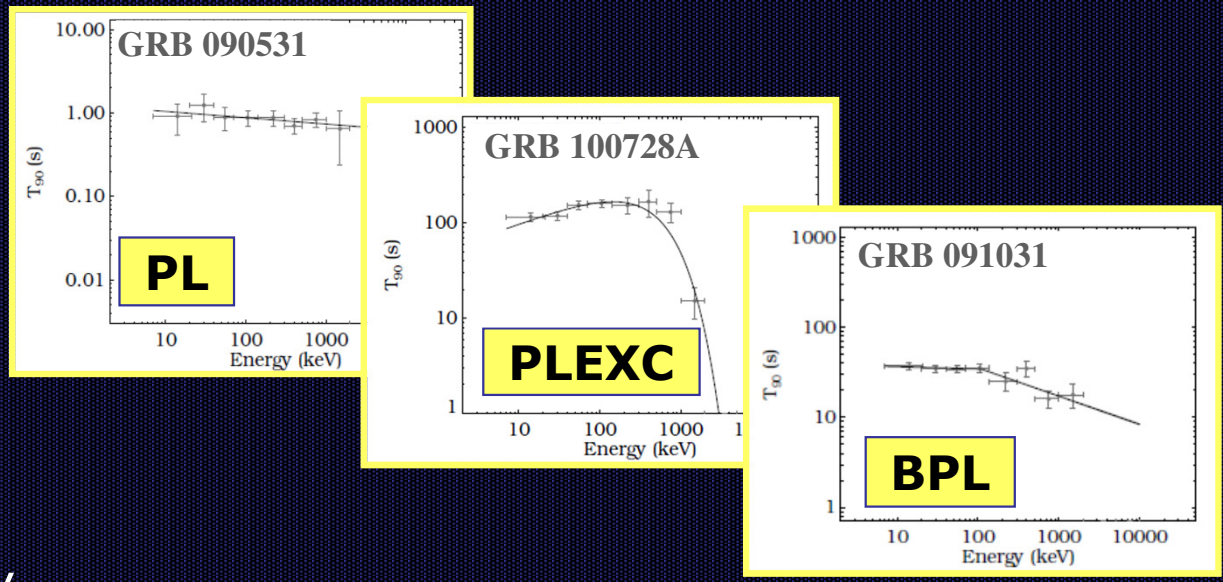
Evolution of duration with energy

Broken PL fit

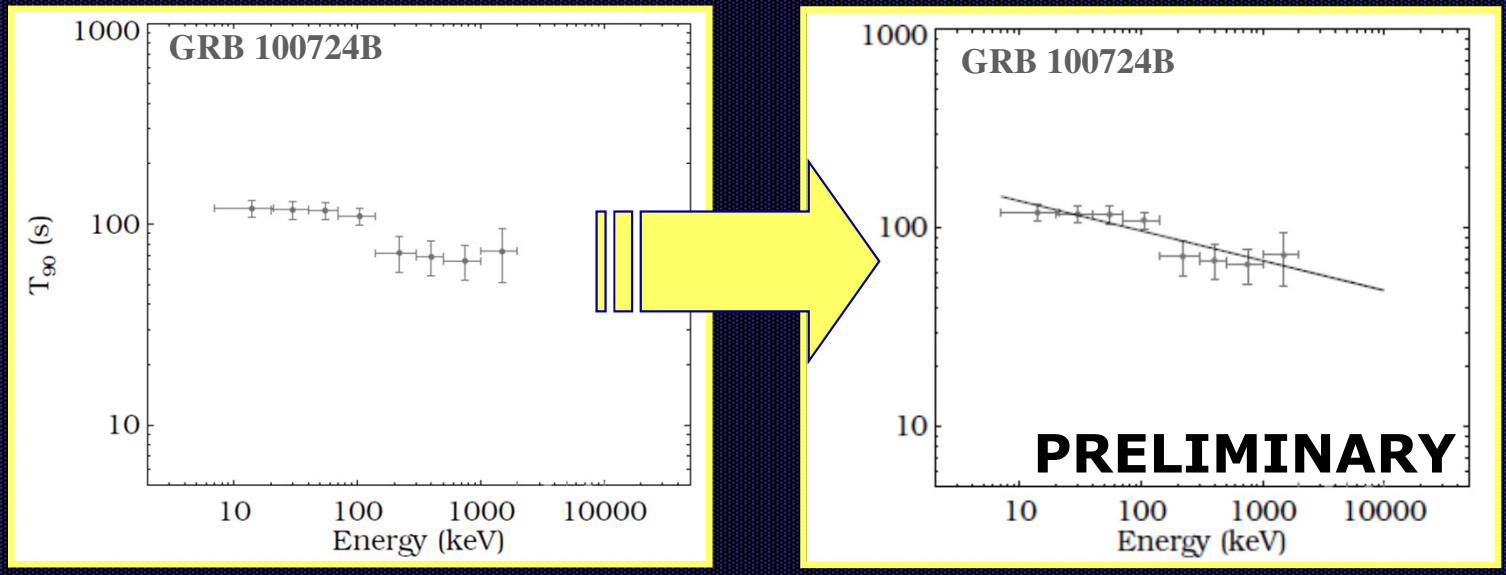


Evolution of duration with energy

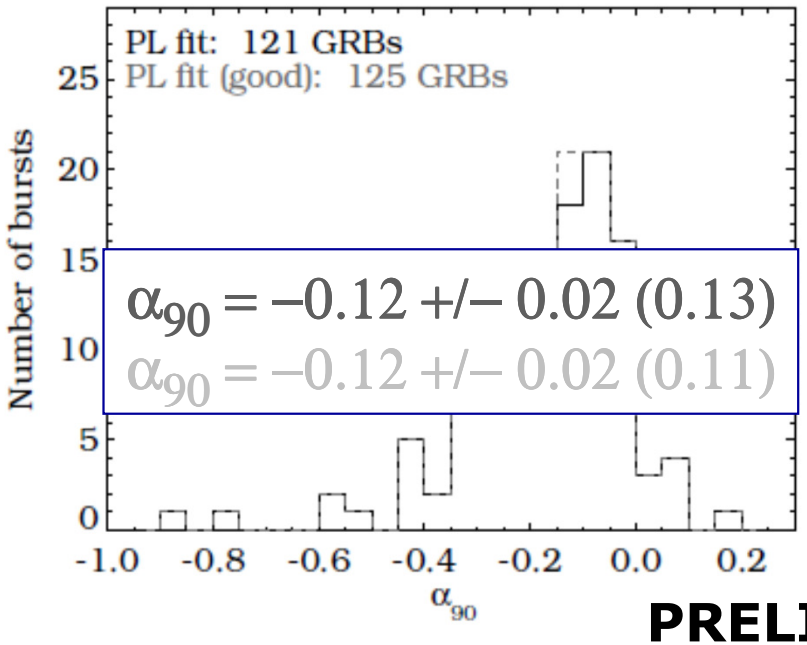
- Best fit results for **individual burst analysis** of the 178 GRBs
  - PL fit: 121 bursts
  - PLEXC fit: 41 bursts
  - BPL fit: 16 bursts



- **Trends** of T_{90} vs. energy
  - E.g. Steps!

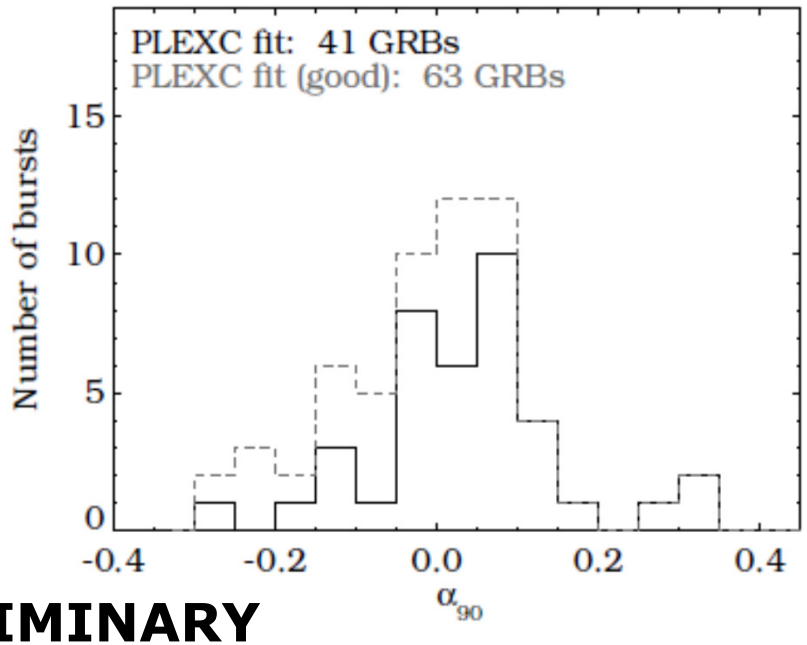


Distribution of parameters

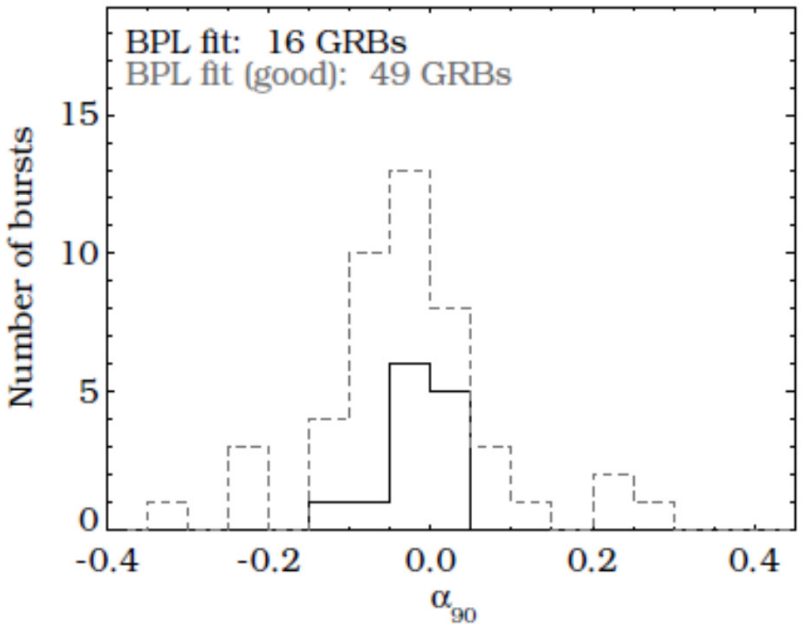


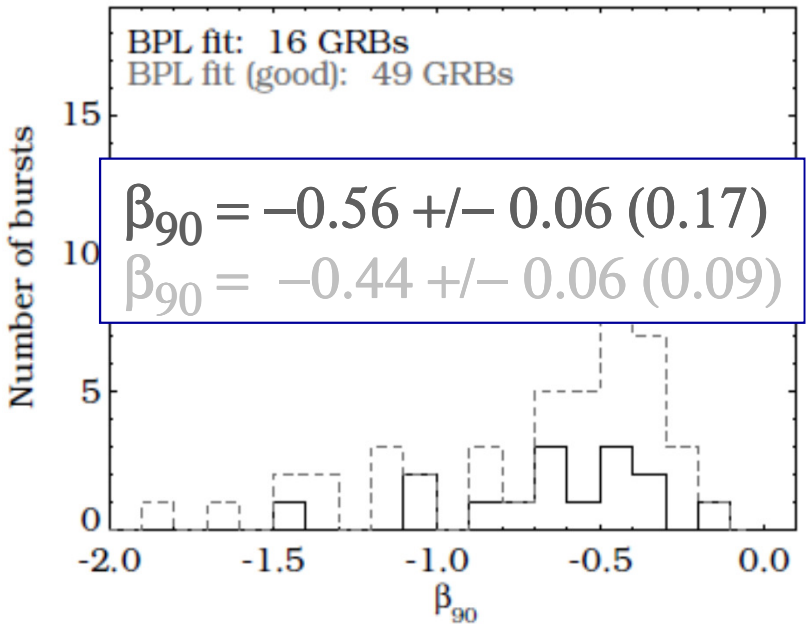
$\alpha_{90} = -0.12 +/- 0.02 (0.13)$

$\alpha_{90} = -0.12 +/- 0.02 (0.11)$



PRELIMINARY

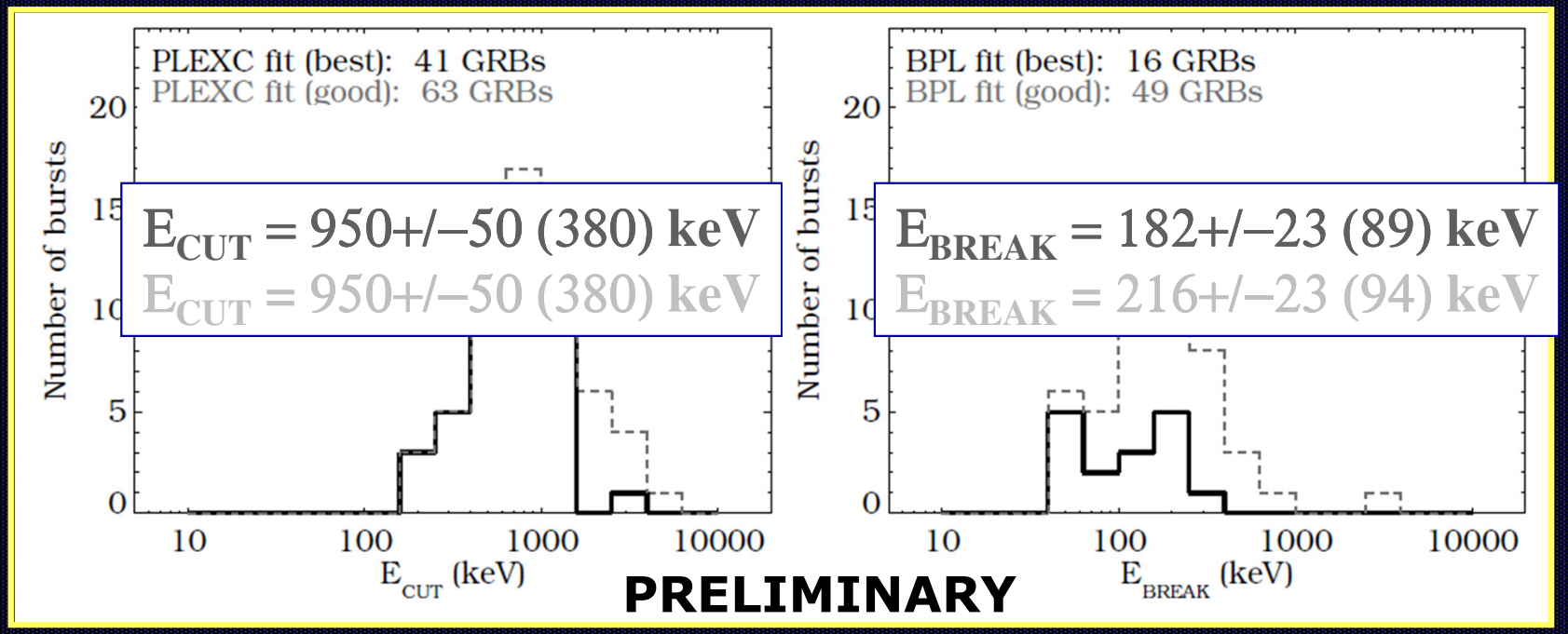




$\beta_{90} = -0.56 +/- 0.06 (0.17)$

$\beta_{90} = -0.44 +/- 0.06 (0.09)$

Distribution of parameters

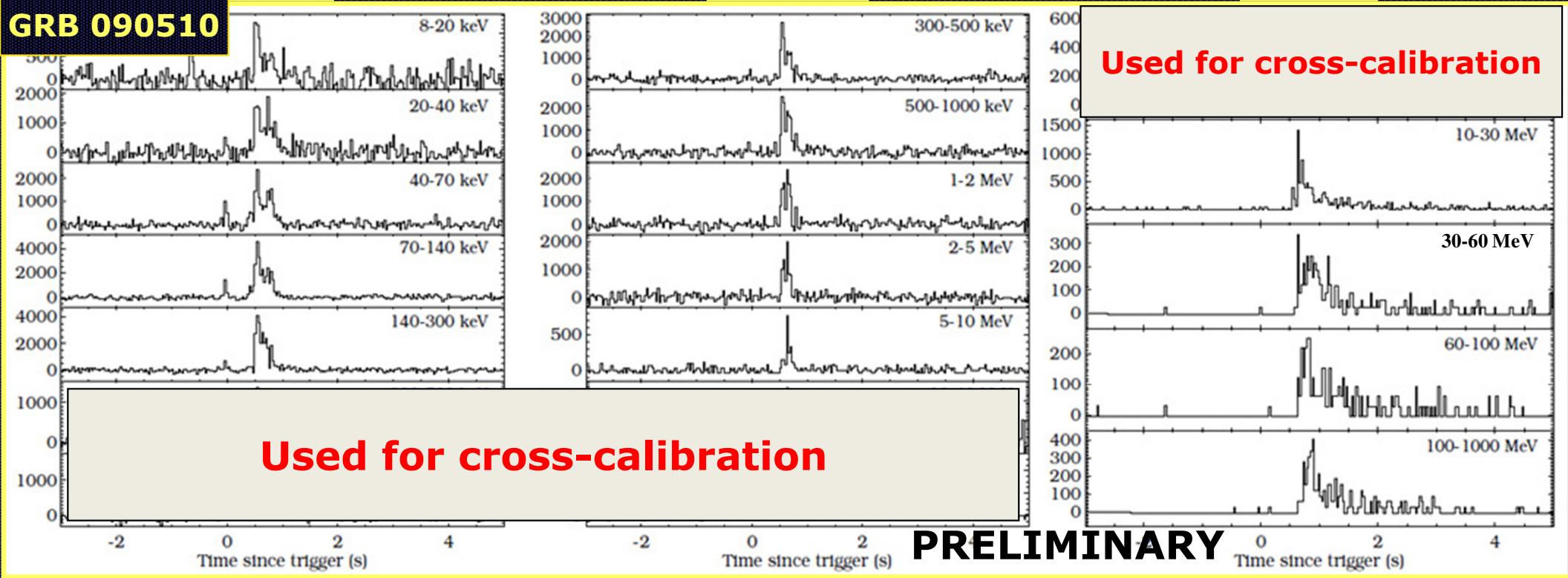


➔Can we relate these "temporal" properties with the spectral properties of each burst? Work in progress!

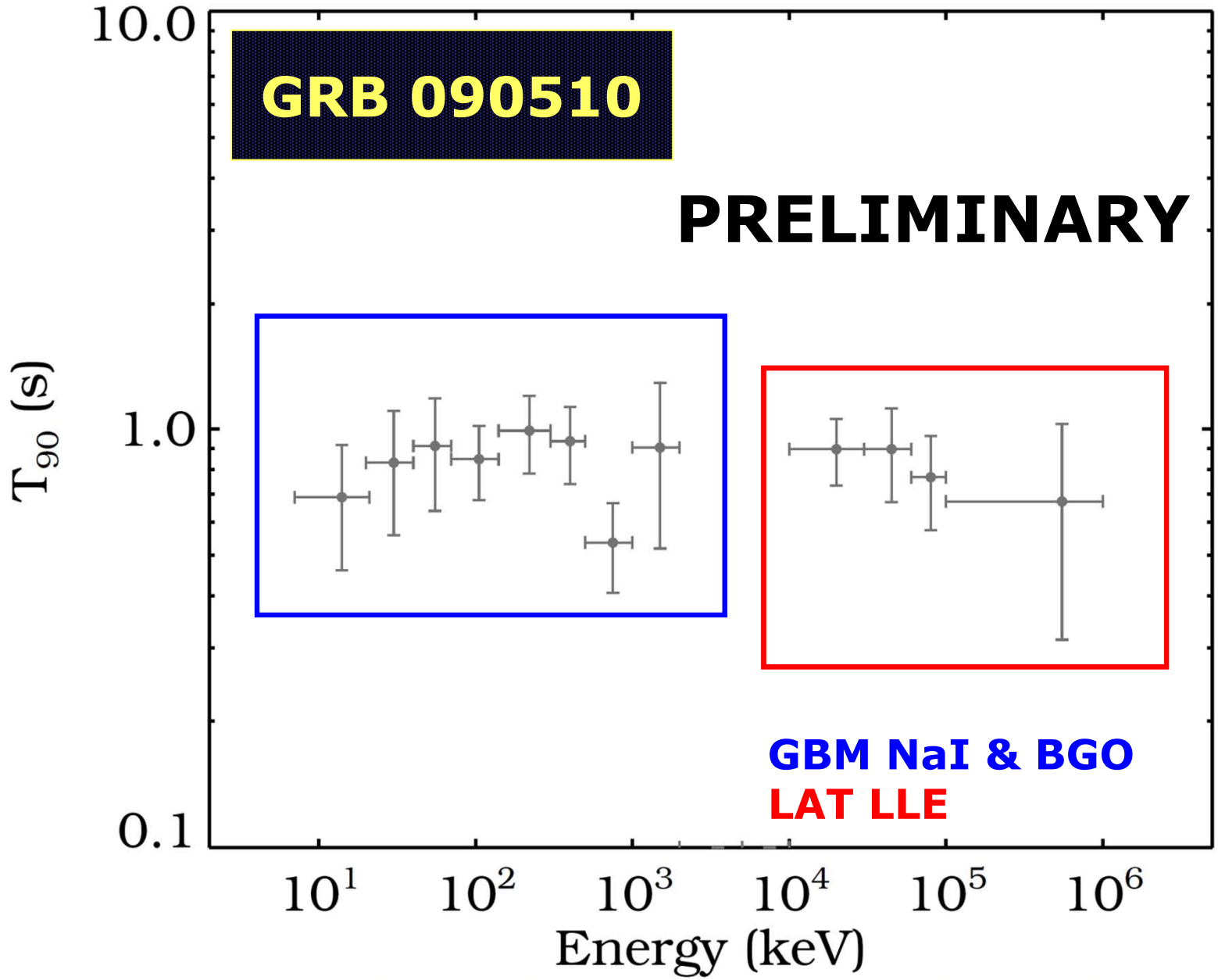
Adding LLE data to the analysis

- For the strongest bursts, analysis of LLE data from LAT measurements
  - Sample of **22 GRBs with LLE data** available
- Analysis from **10 MeV to 1 GeV** (4 new energy intervals!)
  - Cross-calibration NaI-BGO in the 300 keV-1 MeV band
  - Cross-calibration BGO-LLE in the 1-10 MeV band

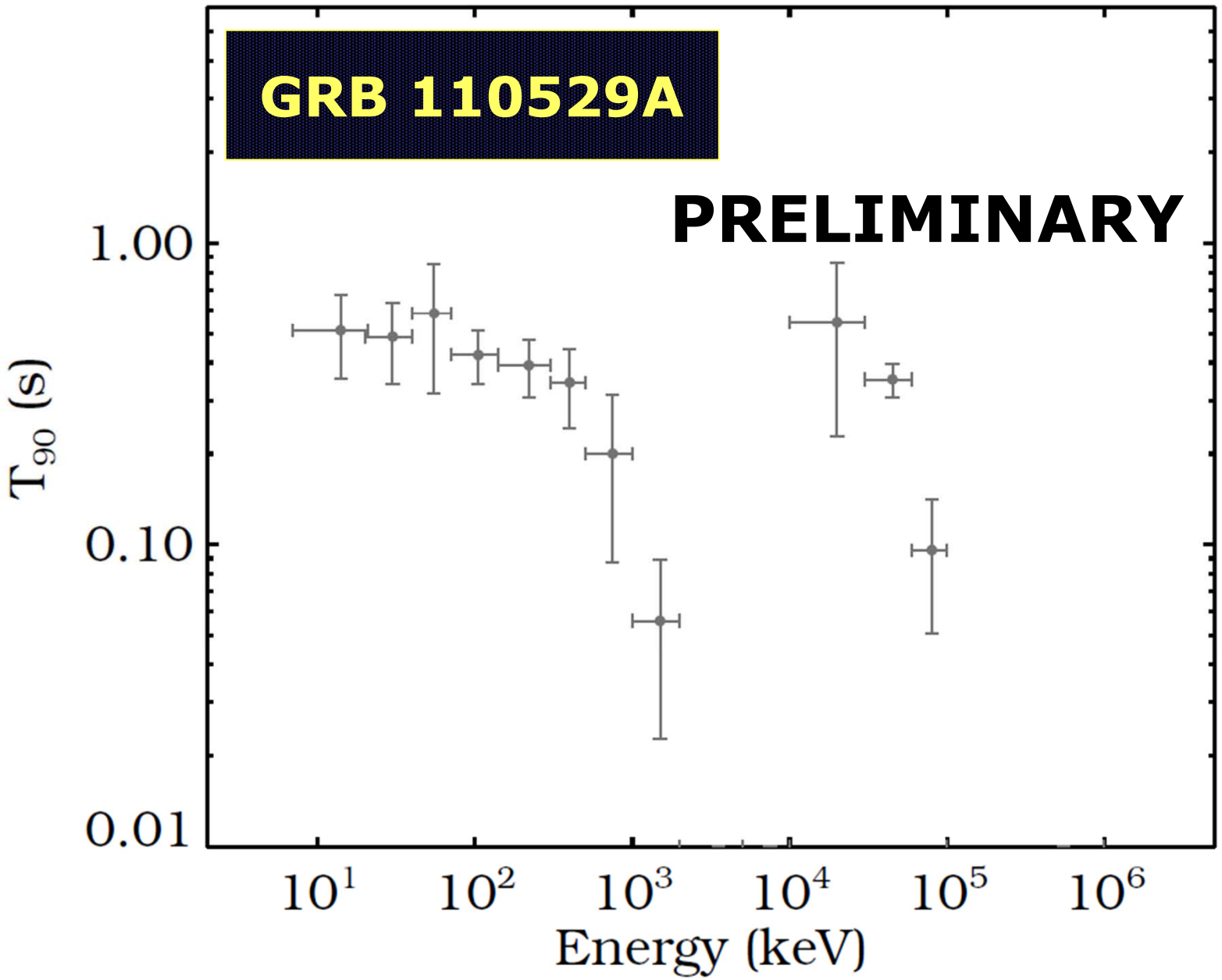
GRB 090510



Adding LLE data to the analysis



Adding LLE data to the analysis



Conclusion

- Analysis of a big sample of 4 years of data (178 GRBs!)
- 3 functional forms for T_{90} vs. energy
  - GBM data follow a **relatively flat** index (~ -0.1 vs. -0.3)
- Inclusion of 10 MeV-1 GeV data
  - Possible break and/or continuation in the LAT-LLE domain
- Interpretation of results
  - Different component or systematic effect?
  - ➔ Investigation of systematics still ongoing
- Outlook
  - Extension of the analysis at energies >1 GeV (LAT-transient data)