Gamma-ray bursts prompt emission spectra at high energies

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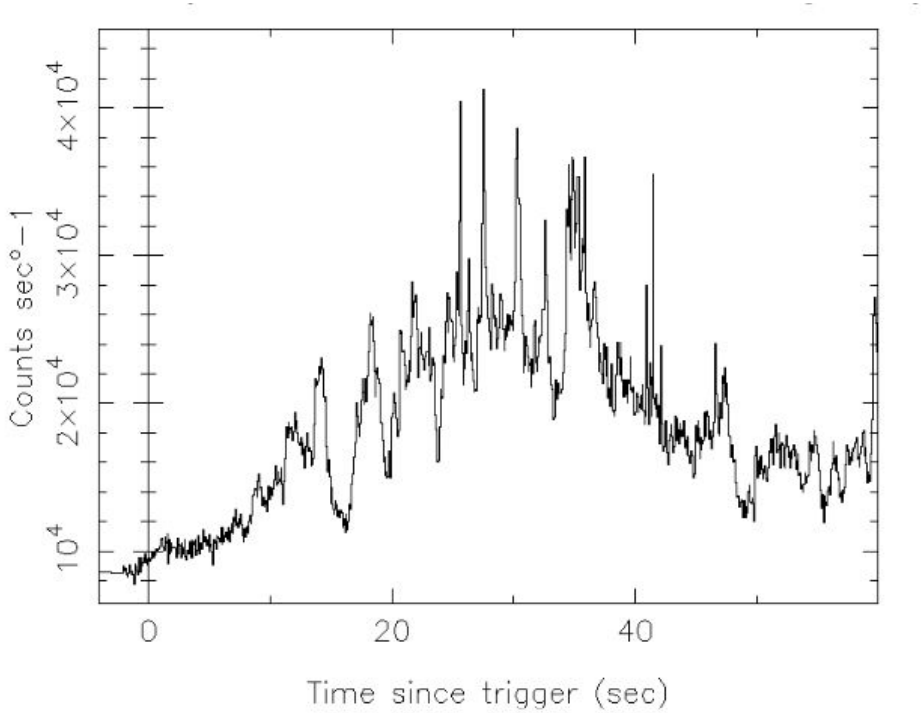
Prompt emission of Gamma-ray Bursts (GRBs)

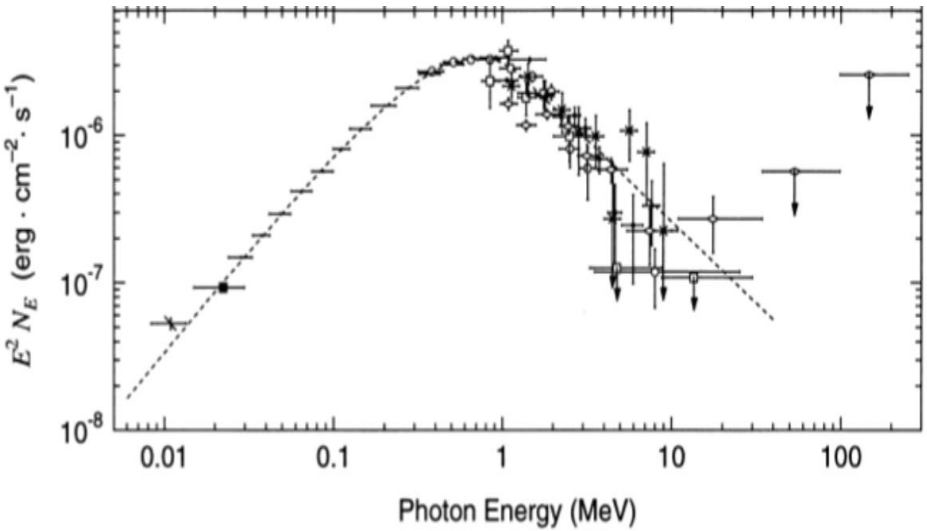


Sari and Piran, 1997

- Burst of MeV photons which lasts from seconds to minutes
- High E_{iso} $\sim 10^{50} - 10^{54}\,\mathrm{erg}$
- High variability (0.01 -1 s)

See Gor Oganesyan's talk

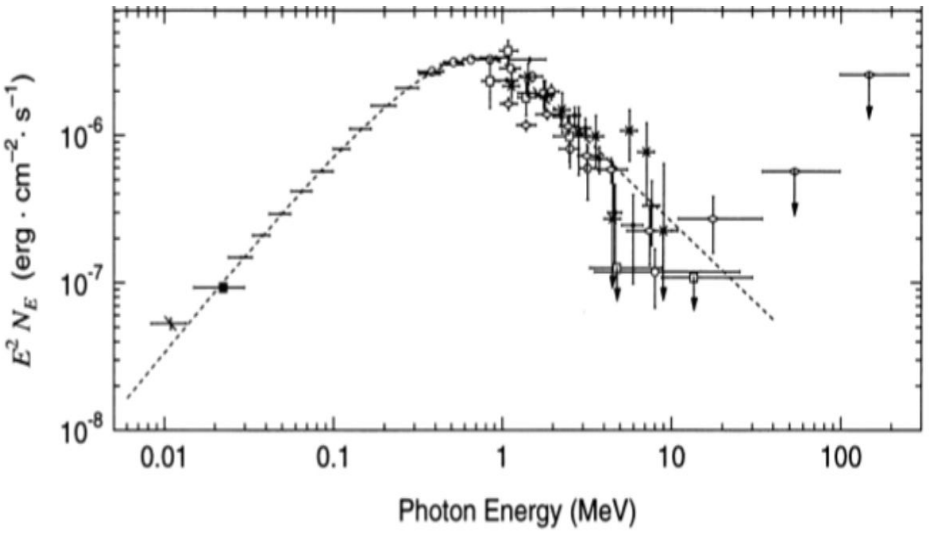
Prompt emission of Gamma-ray Bursts (GRBs)



Briggs et al. 1999

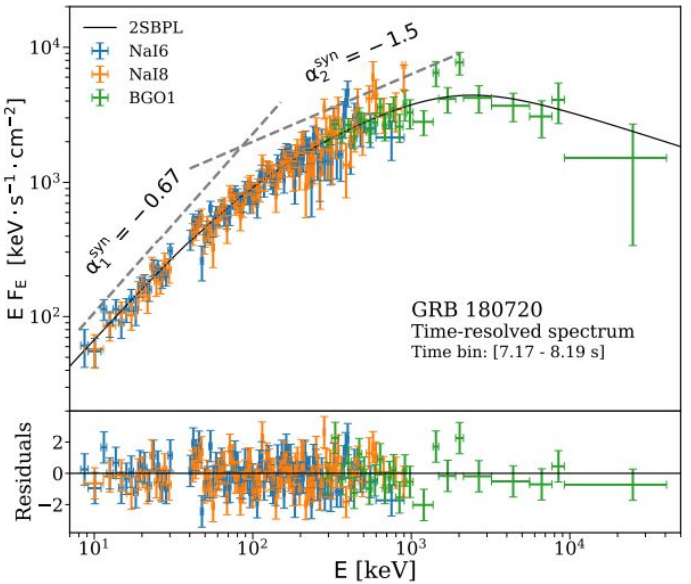
- Broad spectrum of non-thermal origin
- Peak energy in the range 100 keV - 1 MeV
- Two power-laws smoothly connected

Prompt emission of Gamma-ray Bursts (GRBs)



Briggs et al. 1999

Ravasio et al 2018

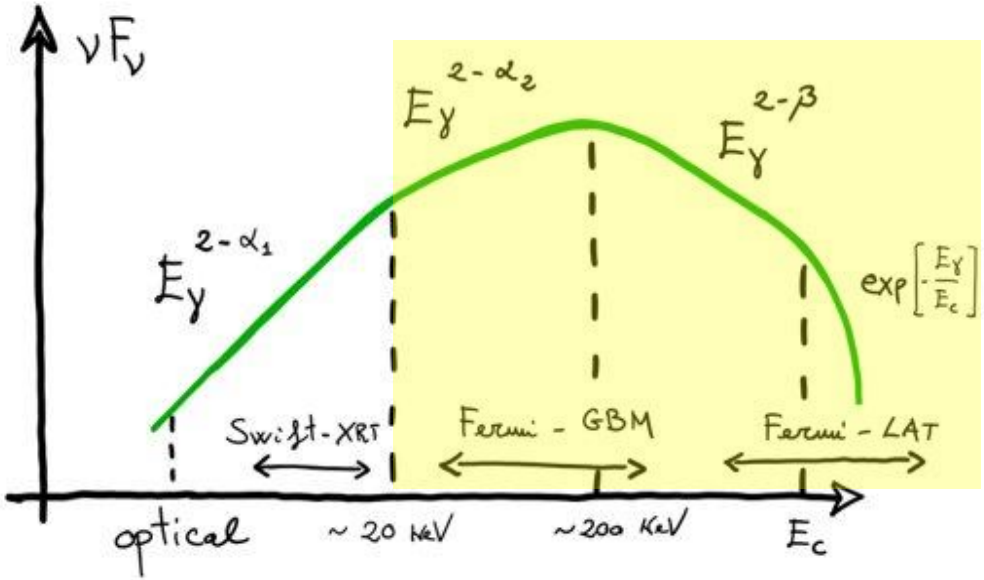


Extension of prompt spectrum to X-rays

See Gor Oganesyan's talk

Low energy breaks empirically consistent with Synchrotron

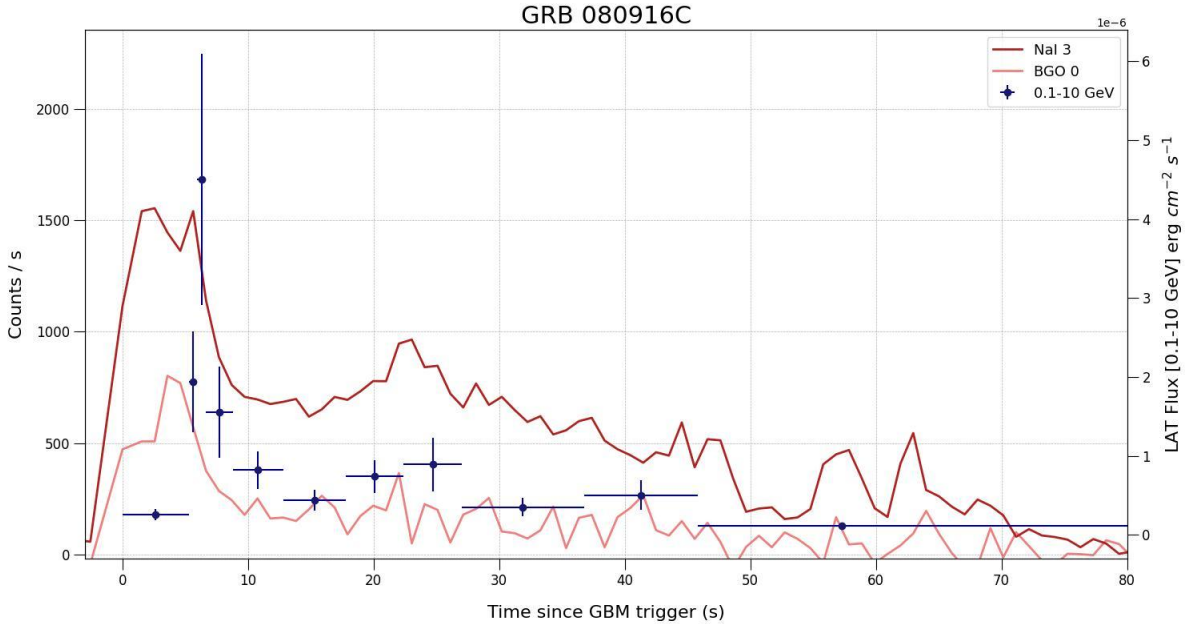
Prompt spectrum at higher energies (GeV)



Fermi/GBM:
8 keV - 40 MeV

Fermi/LAT and **Fermi/LAT-LLE:**
30 MeV to > 300 GeV

Early high energy (HE) emission in GRBs

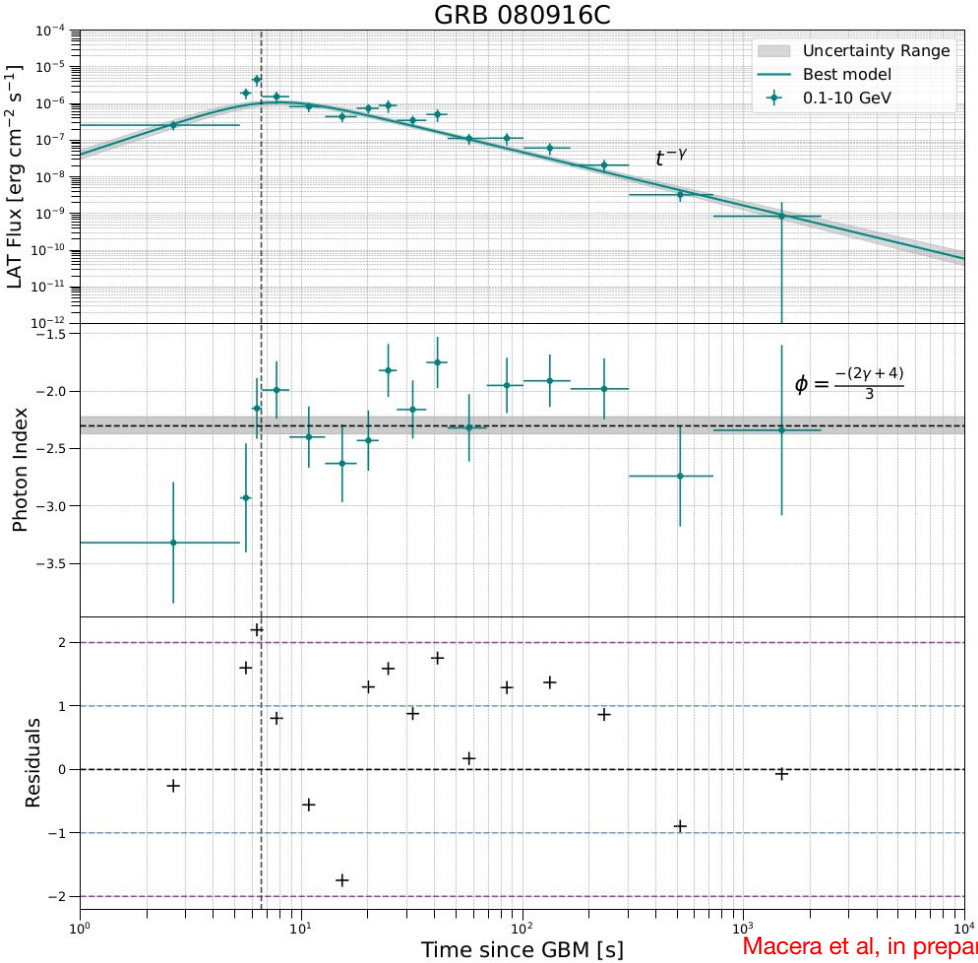


Fermi/GBM + Fermi/LAT lightcurves

- High energy emission is delayed
  [Tajima et al. 2009 for GRB080916C**]**
  [Abdo et al. 2009 for GRB090902B**]**
- For some GRBs early GeV emission follows variability of prompt
  [Zhang et al. 2011]
- Early Afterglow or Prompt origin?
  Ghisellini et al. 2009, Kumar & Barniol Duran, 2009
  Maxham et al. 2011
- Prompt second component?

For a complete review see: **Nava, 2018** and the references therein

Early high energy (HE) emission in GRBs



Temporal analysis

→ Does the emission follow the afterglow LC time-evolution?

Spectral analysis needed

Macera et al, in preparation

Sample selection

- At least three significant temporal bins (>5 σ detection) simultaneous with Fermi/GBM
- GRBs with and without redshift up to year 2023
- At least 20 photons within 10° of region of interest around the GRB location

- One significant temporal bin (>5 σ detection) simultaneous with Fermi/GBM
- GRBs with and without redshift up to year 2023
- At least 20 photons within 10° of region of interest around the GRB location

Sample 1

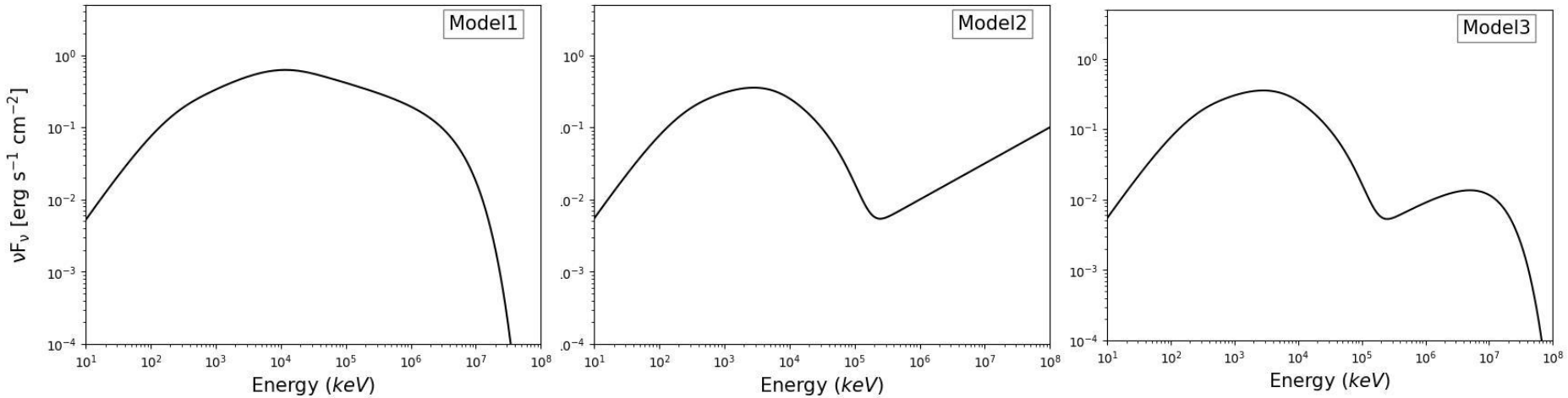
Time resolved spectral analysis of 14 GRBs

Sample 2

Spectral analysis of 21 GRBs

Total of 35 GRBs and 89 spectra analysed in the energy range 8 keV - 10 GeV

Spectral analysis: three physical models



- Extend energy band to Fermi-LAT energy range

  → <u>total energy range covered: 8 keV - 10 GeV</u>

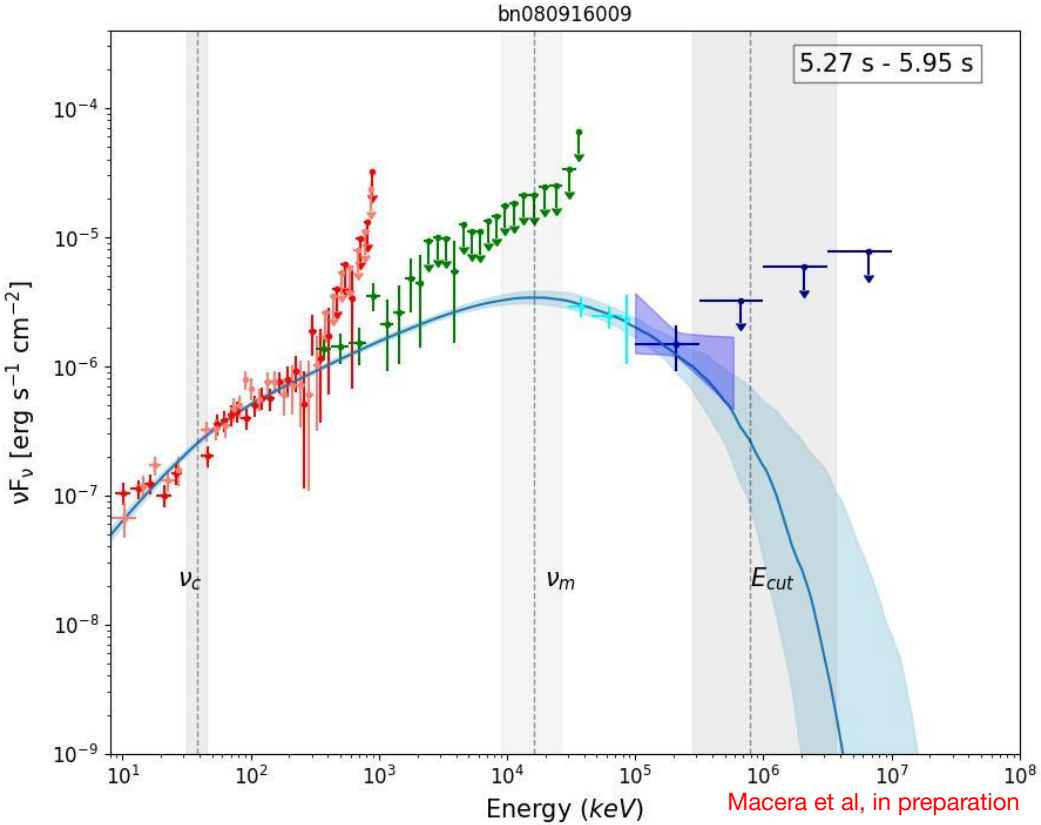
- Use a physical model for the prompt emission

  → <u>joint spectral analysis of prompt spectra with synchrotron models</u>

Results of the spectral analysis

Pure synchrotron spectra:

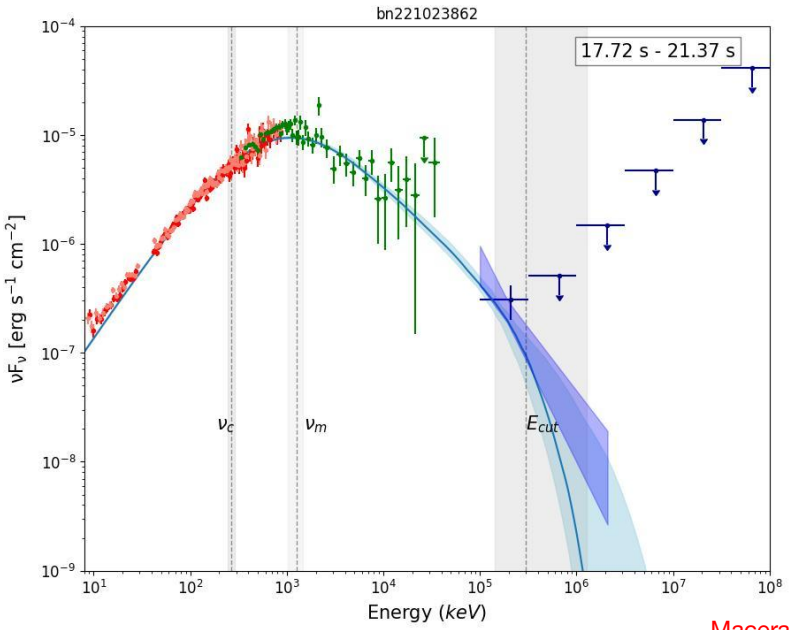
GRB 080916C

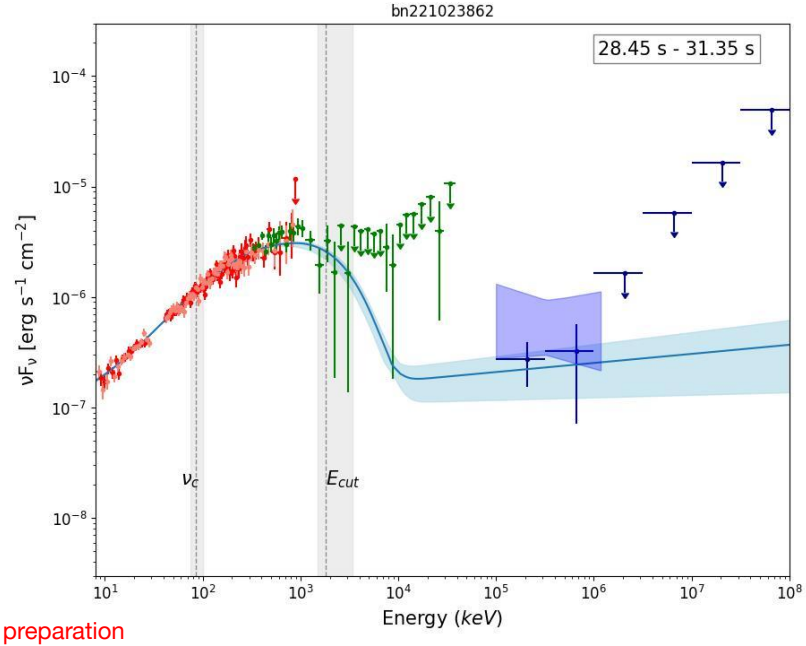


Macera et al, in preparation

Results of the spectral analysis

Synchrotron + power-law: GRB221023A

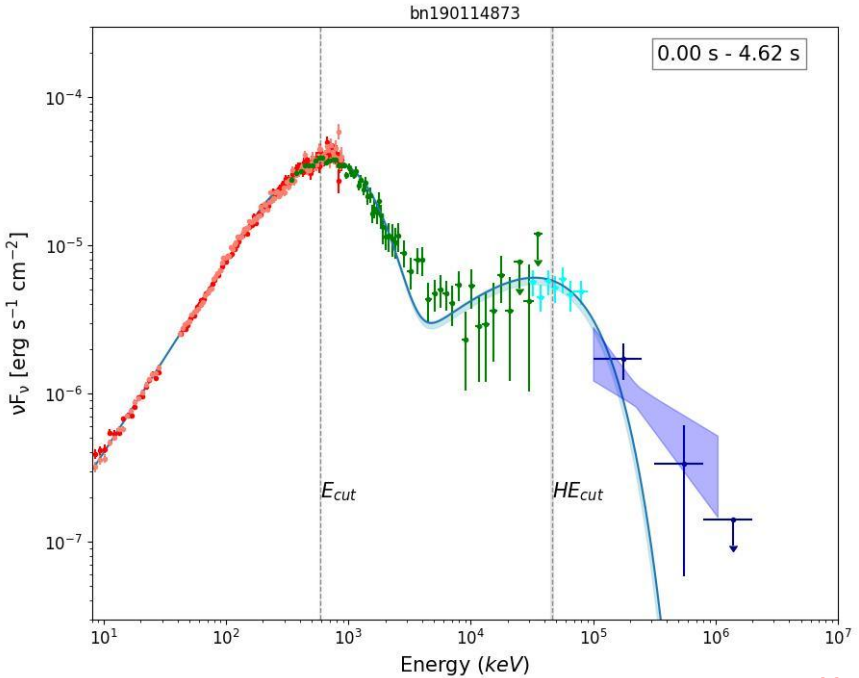


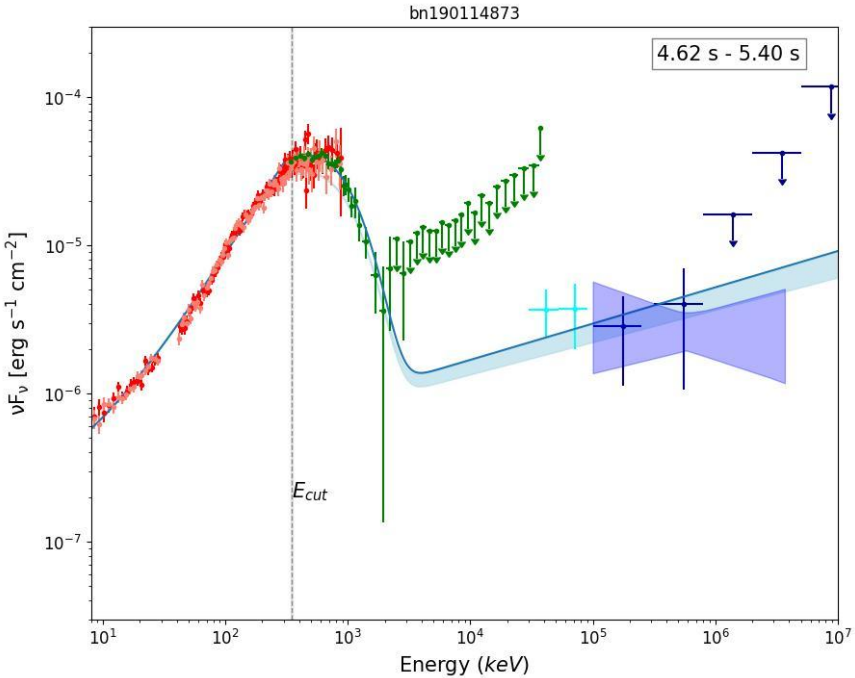


Macera et al, in preparation

Results of the spectral analysis

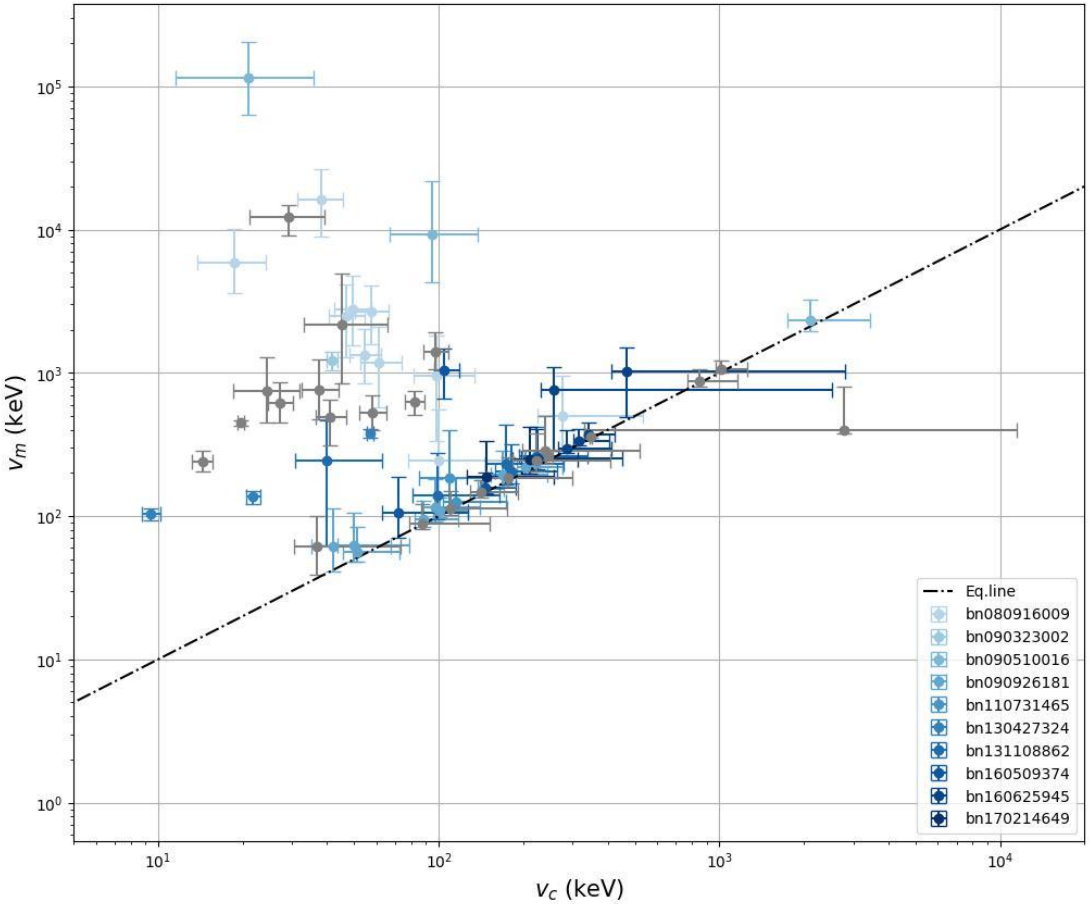
Synchrotron + cutoff power-law: GRB 190114C



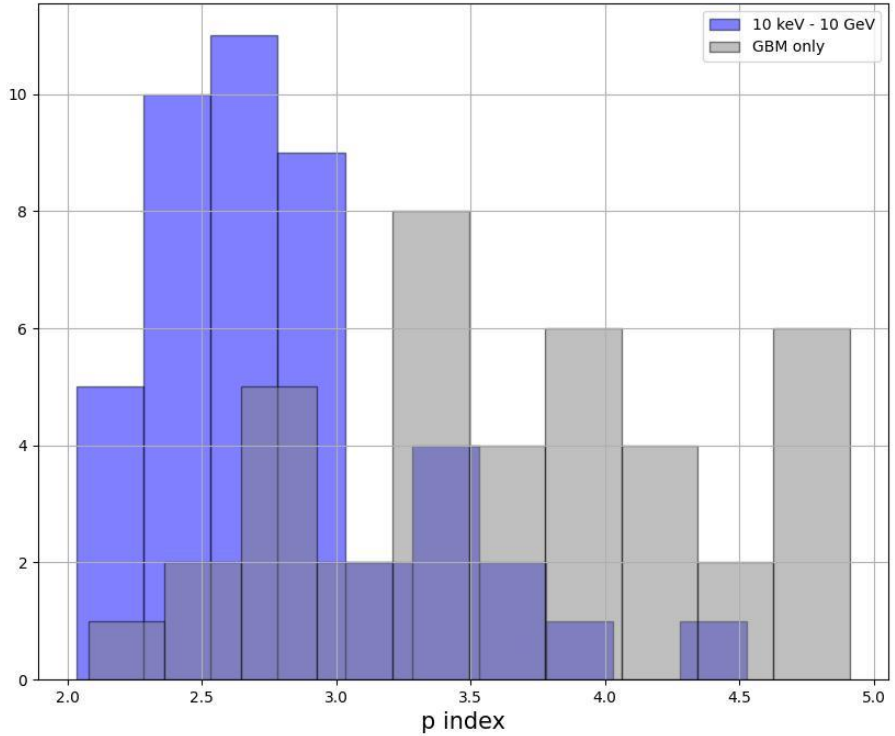


Macera et al, in preparation

Parameter space of synchrotron

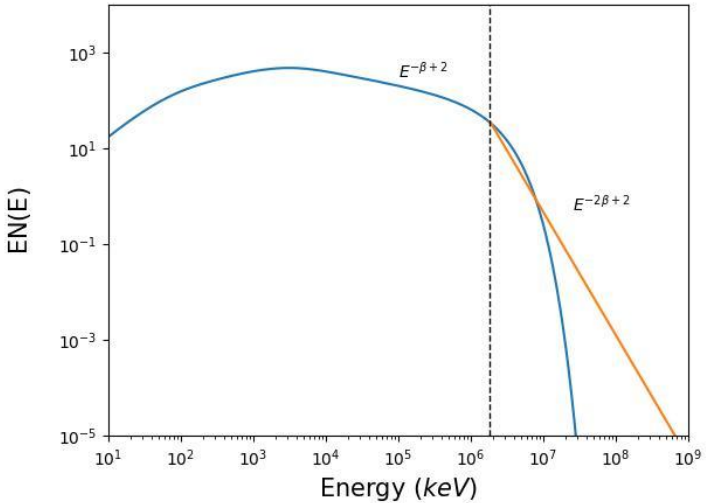


Constraints on the acceleration mechanisms

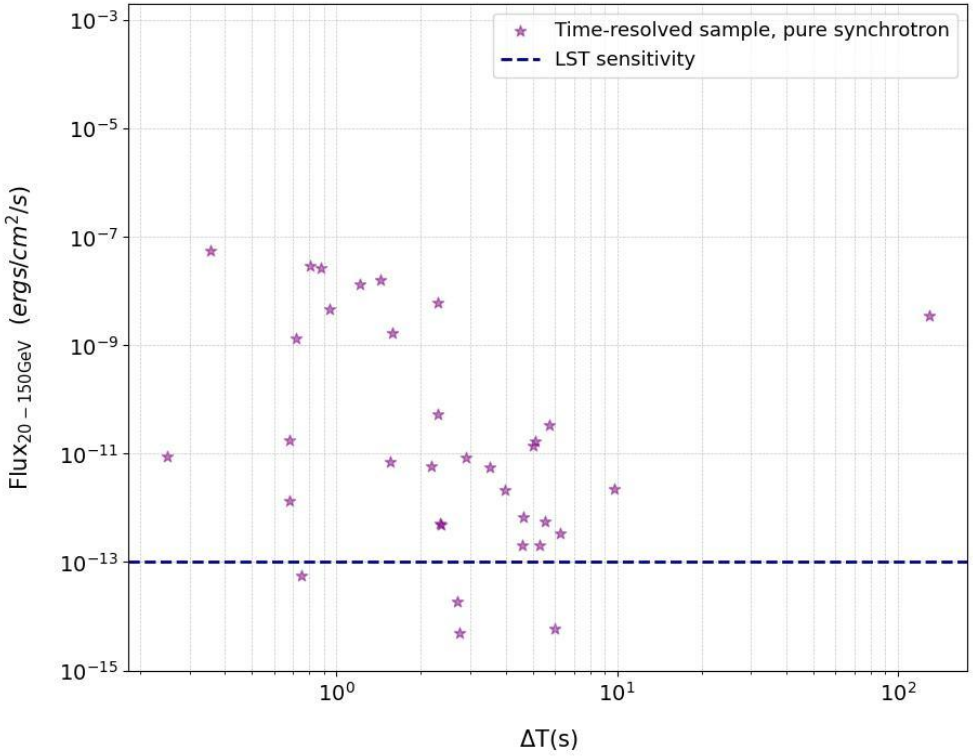


Better p-index constraints with Fermi/GBM + Fermi/LAT and LLE data, but better data at HE needed

Flux extrapolation to very-high energies (> 20 GeV)



Large Sized Telescope energy range: 20 - 150 GeV



Conclusions

- The majority of spectra are consistent with synchrotron origin
- In the majority of cases early GeV emission is dominated by Synchrotron radiation → Broad synchrotron covering the energy range 8 keV - 10 GeV
- Second power law component very rare and with unclear origin -> better data needed in the GeV-TeV energy range (LST)
- HE data allow to probe synchrotron model over 7 order of magnitude and to have better constraints for the acceleration mechanism