Physical Origin of GeV emission in the early phase from GRB 170405A: *clue from emission onsets with multi-wavelength observations*

Makoto Arimoto (Kanazawa University),

Katsuaki Asano (ICRR/Univ. of Tokyo)

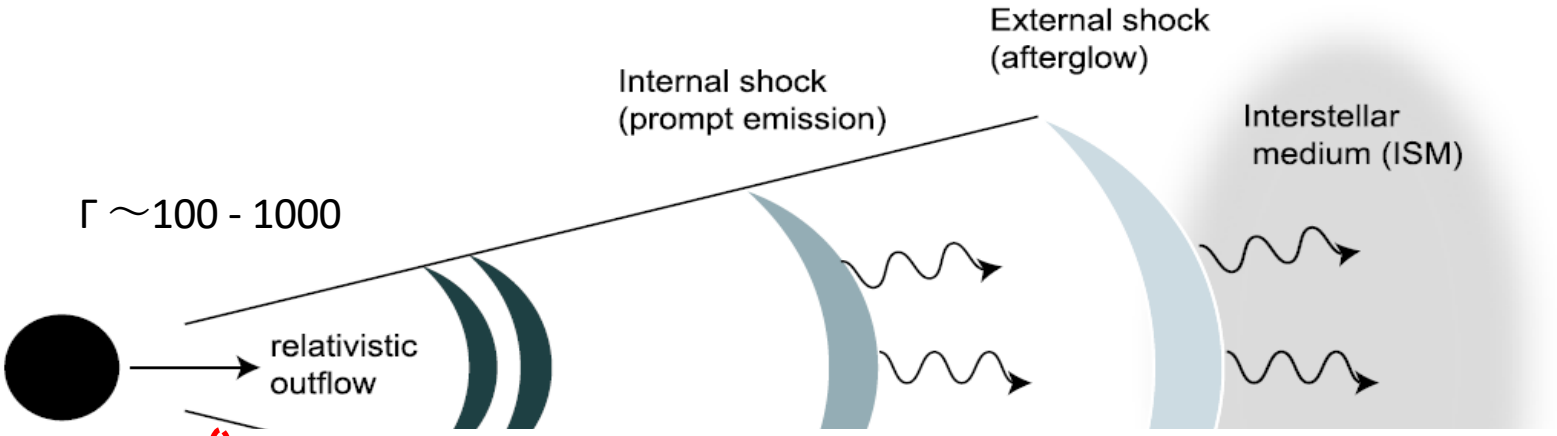
on behalf of the Fermi-LAT collaboration

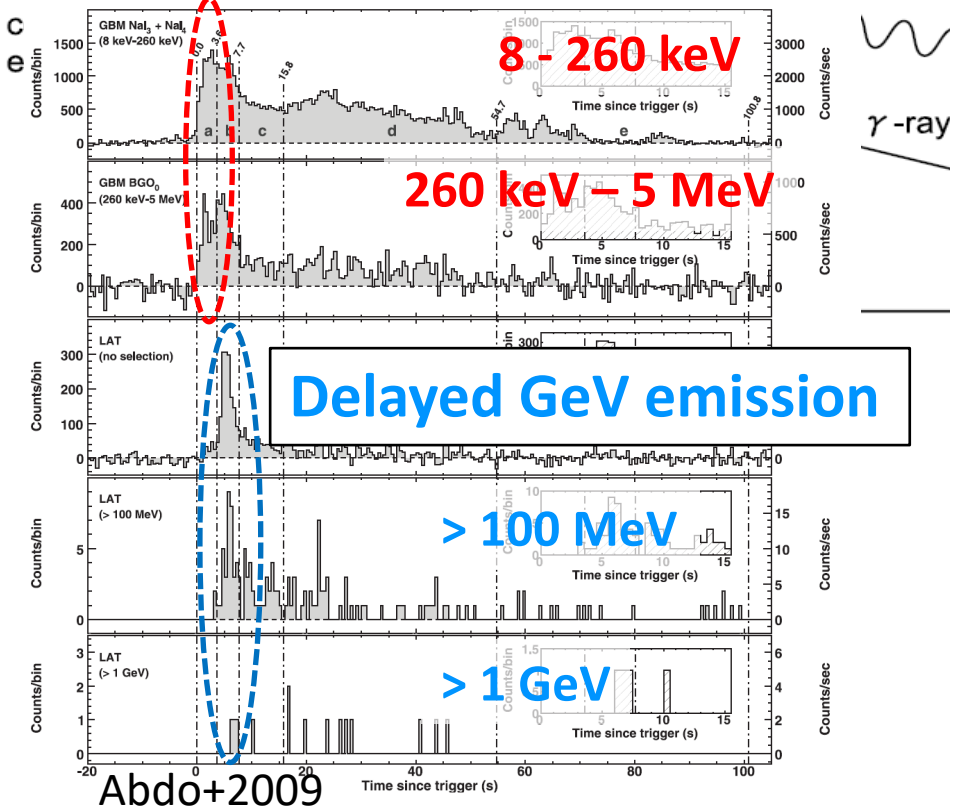
17th, October 2018

Outline

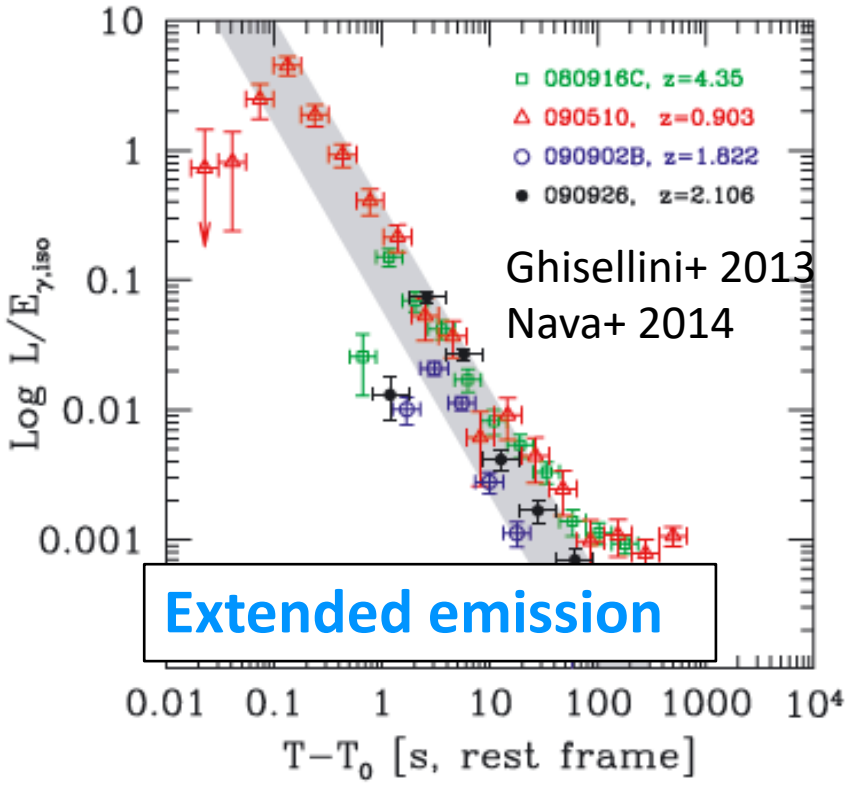
- Introduction: GeV emission from GRBs
  - ✓ Delayed emission
  - ✓ Extended emission
- GRB 170405A
  - ✓ Lightcurve
  - ✓ Spectrum
- Discussion
  - Bulk Lorentz factor
  - Synchrotron emission from the forward shock ?
- Summary

Anatomy of Gamma-ray bursts





Abdo+2009

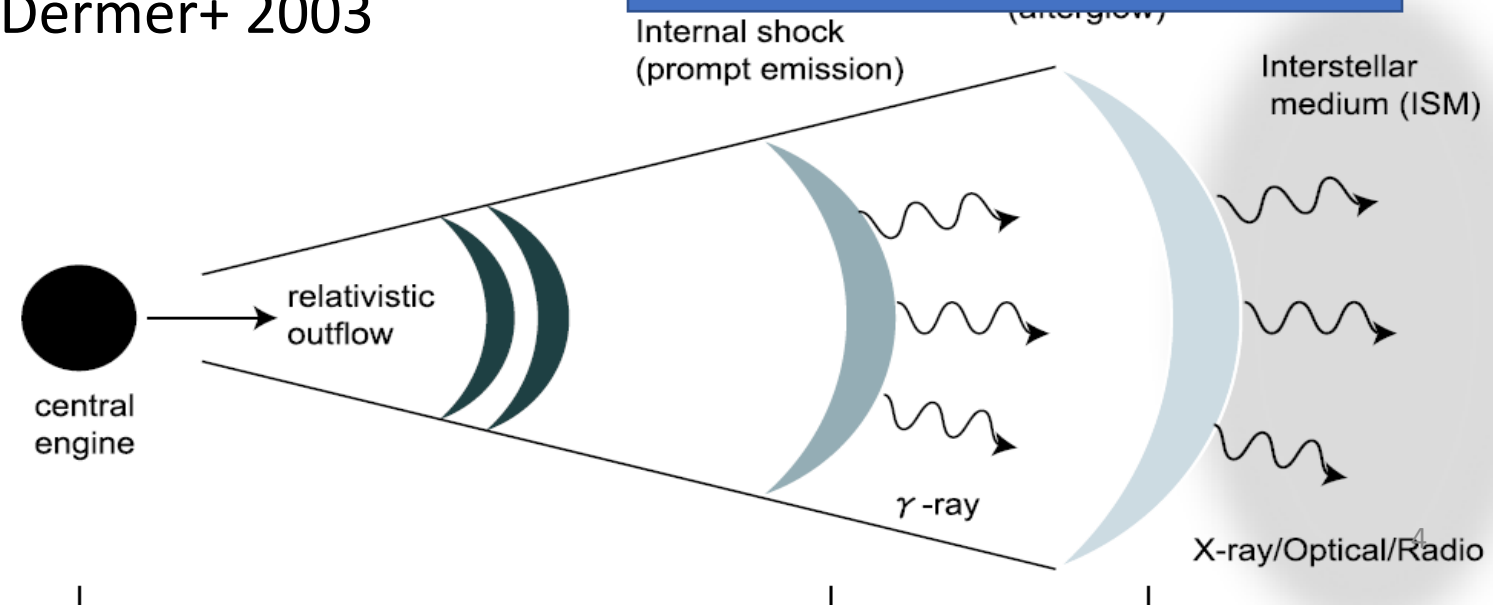


Ghisellini+ 2013
Nava+ 2014

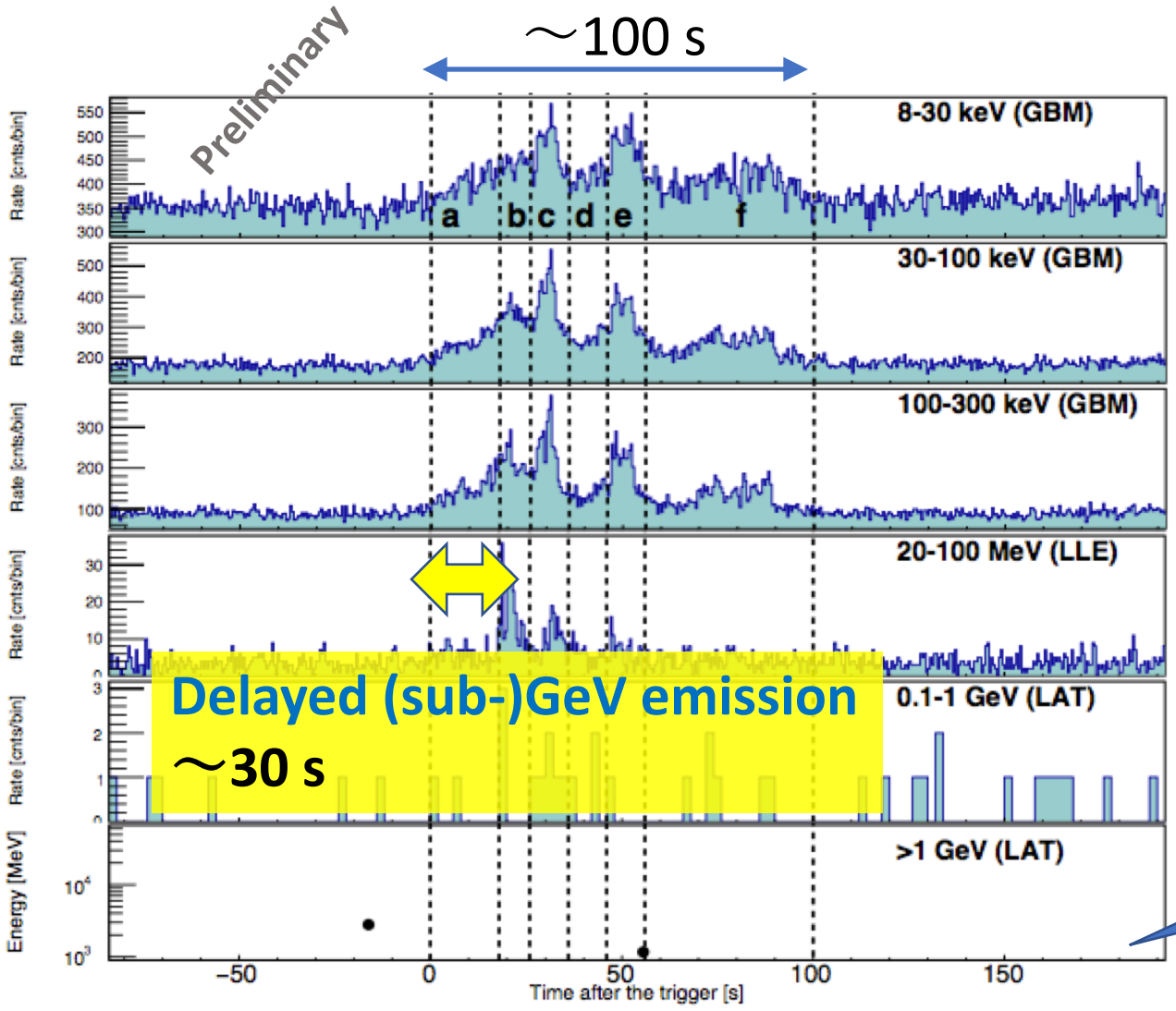
What causes the GeV emission ?

- Synchrotron emission in the forward shock ?
  - ✓ Ghisellini+2010, Kumar+2010
- Inverse Compton (IC) emission in the internal shock ?
  - ✓ Razzaque+ 2004
- IC emission in the reverse sh
  - ✓ Granot & Guetta 2003
- Hadronic emission ?
  - ✓ Dermer+ 2003

can easily explain both
- *the delayed emission*
- *the extended emission*



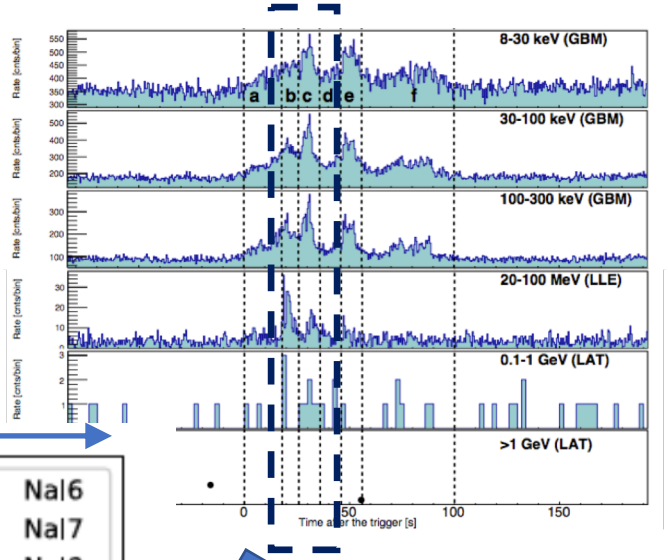
GRB 170405A: Prompt emission

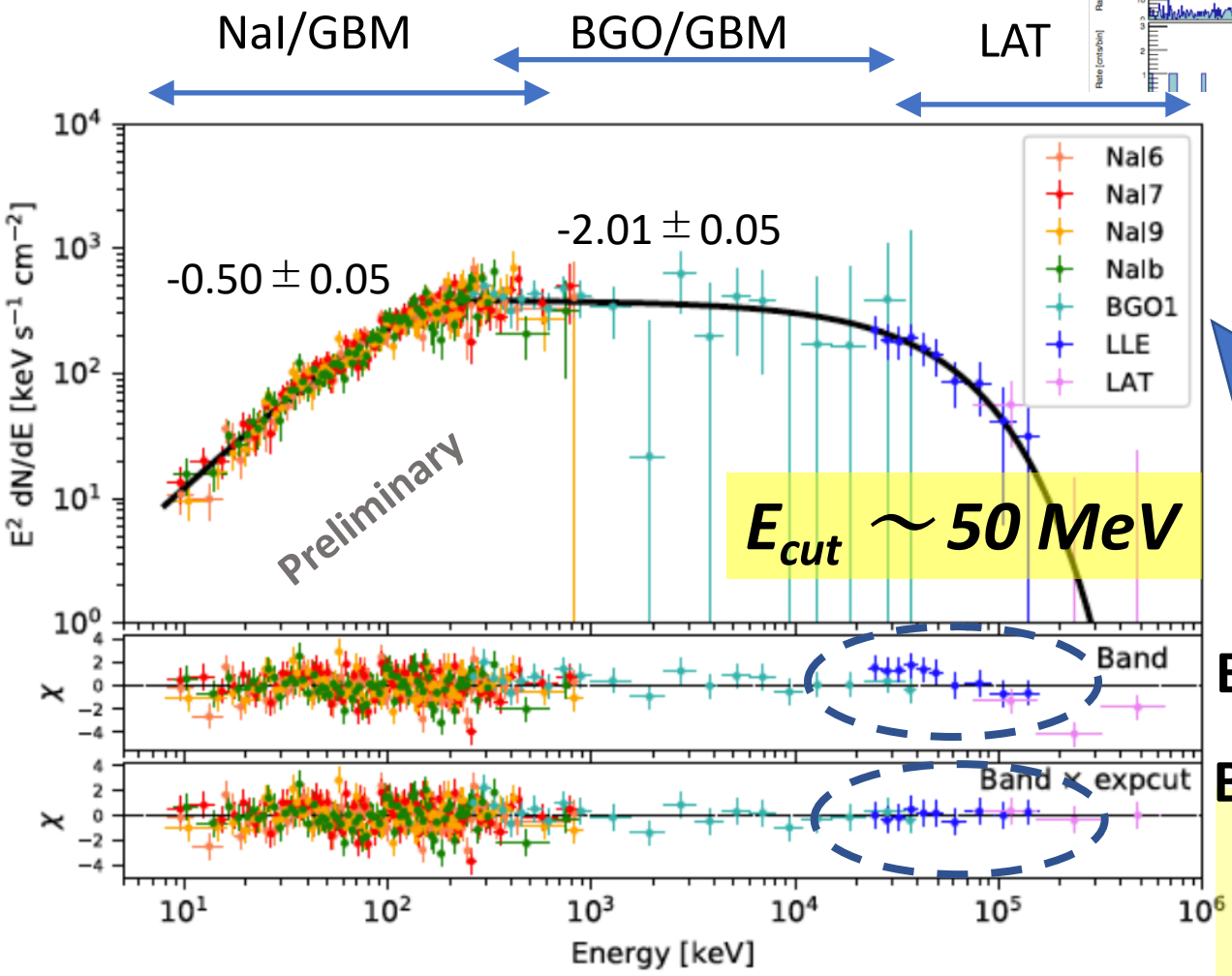


- Simultaneous detection w/ Swift
- z = 3.51 (GCN #20990)

Few GeV photons (> 1 GeV)

Spectrum





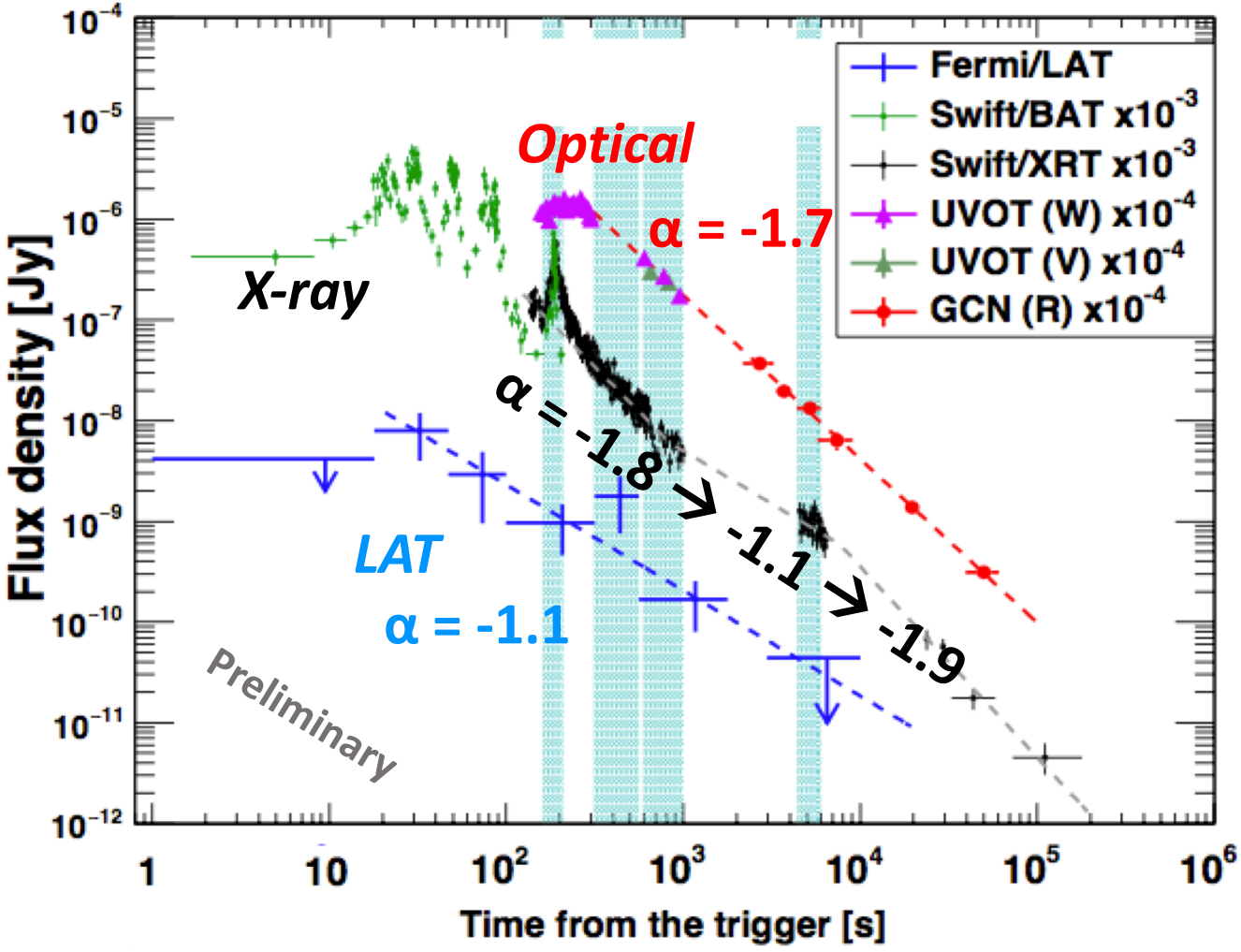
Band

Band x expcut

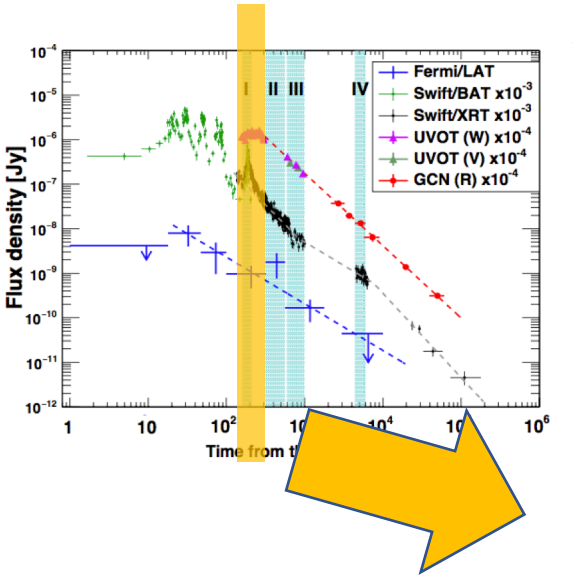
$\Delta PG_{stat} \sim 40$

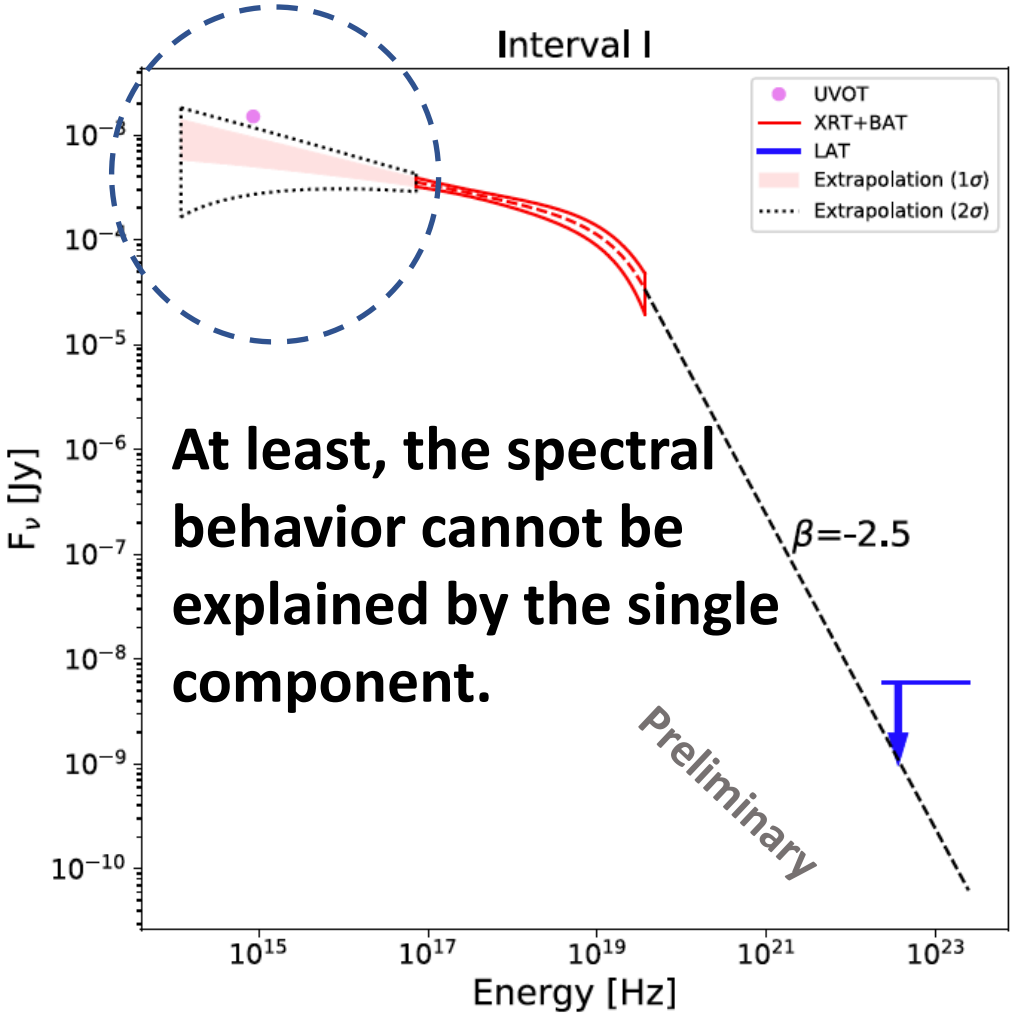
→ **>4 σ**

Extended emission/Afterglow



Spectral Energy Distribution





Bulk Lorentz factor from *opacity*

From the pair production opacity

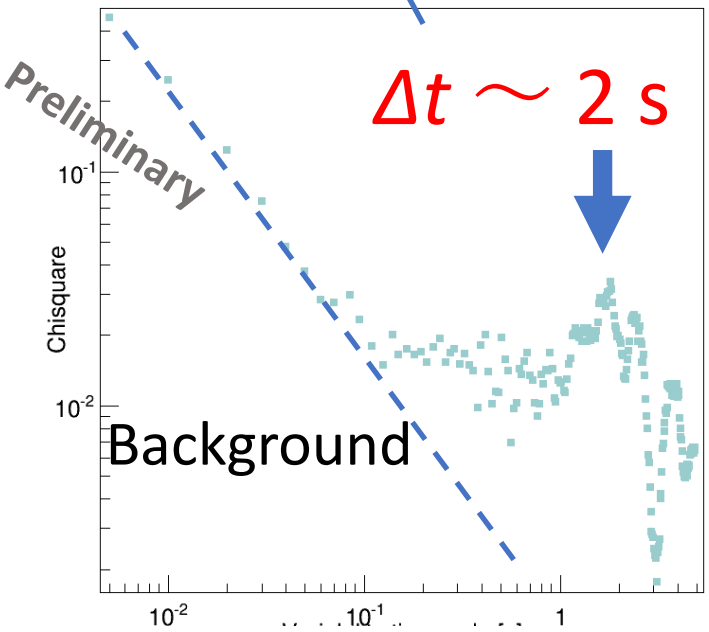
Ackermann+2011

$$\Gamma \sim \left[\sigma_T \left(\frac{d_L}{c\Delta t} \right)^2 E_{piv} f(\lambda) F(\lambda) (1+z)^{-2\lambda-2} \left(\frac{E_{cut} E_{piv}}{m_e^2 c^4} \right)^{-\lambda-1} \right]^{1/(2-2\lambda)}$$

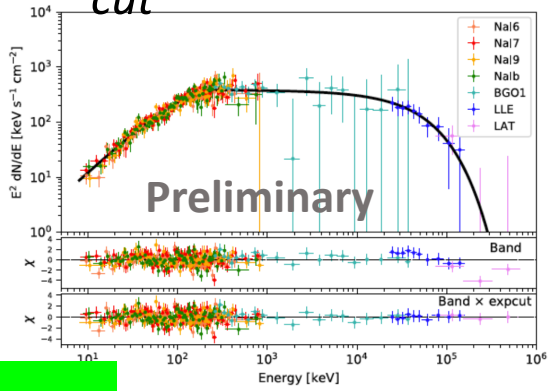
~ 1

Flux

Photon index



$E_{cut} \sim 50$ MeV



$\Gamma \sim 370$

Optical onset from the forward shock scenario

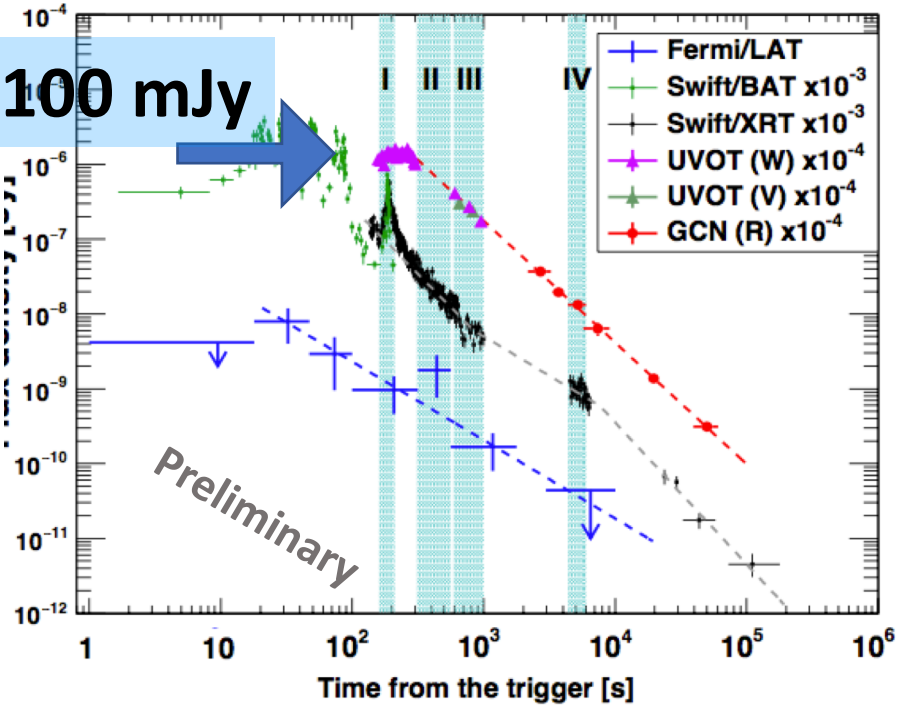
$$t_{onset} = \left[\frac{3E_{FS}(1+z)^3}{32\pi n_{ISM} m_p c^5 \Gamma^8}\right]^{1/3}$$

- E_{FS} = 3 x 10^{54} η^{-1} erg
- n_{ISM} = 1 cm^{-3}
- z = 3.51

If $\Gamma \sim 370$, t_{onset} **~200 s.**

~200 s

~100 mJy



- Optical flux @ 200 s (Sari+98)

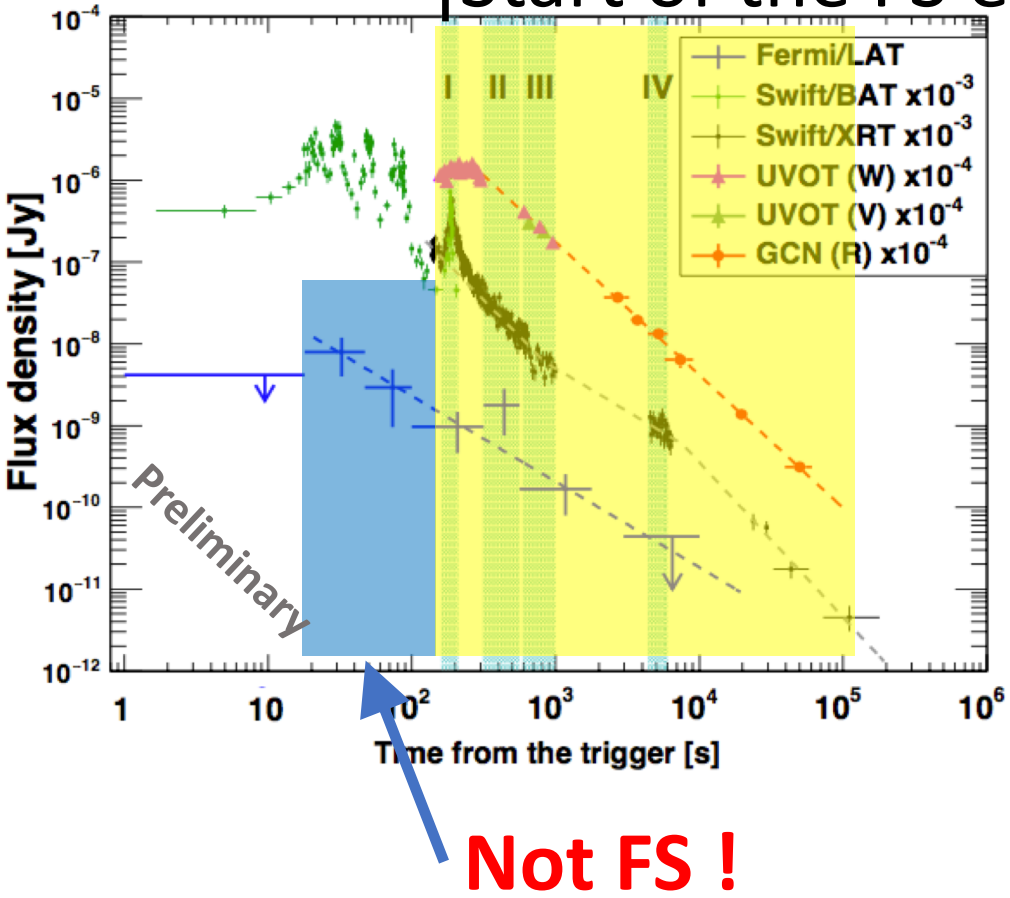
$F_\nu \sim$ 50 mJy for adiabatic jet with $\varepsilon_e = \varepsilon_B = 0.01$

→ *Optical emission originates from the forward shock*

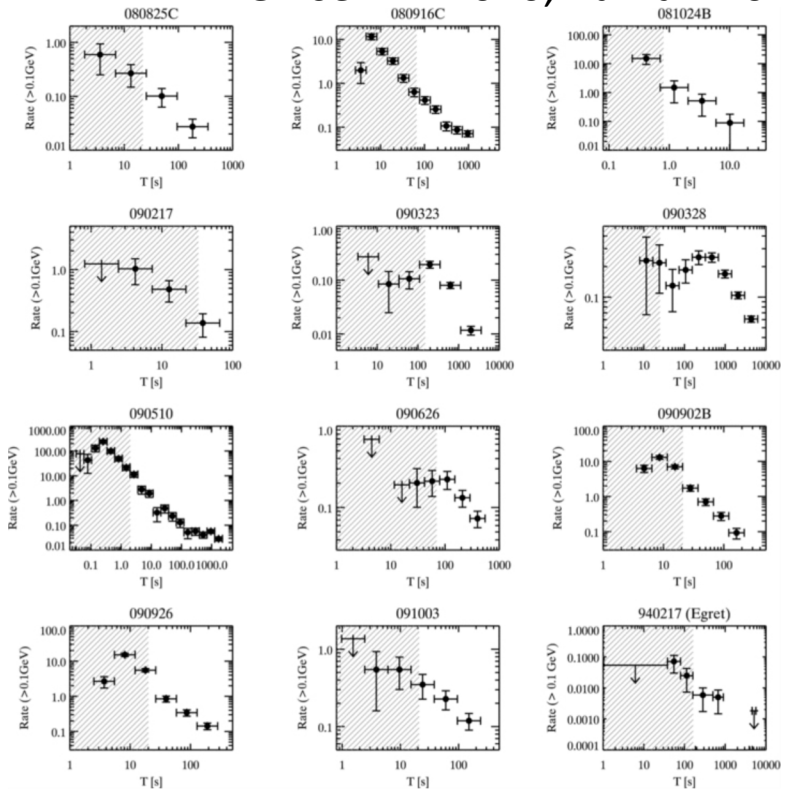
Physical Origin

~200 s

Start of the FS emission



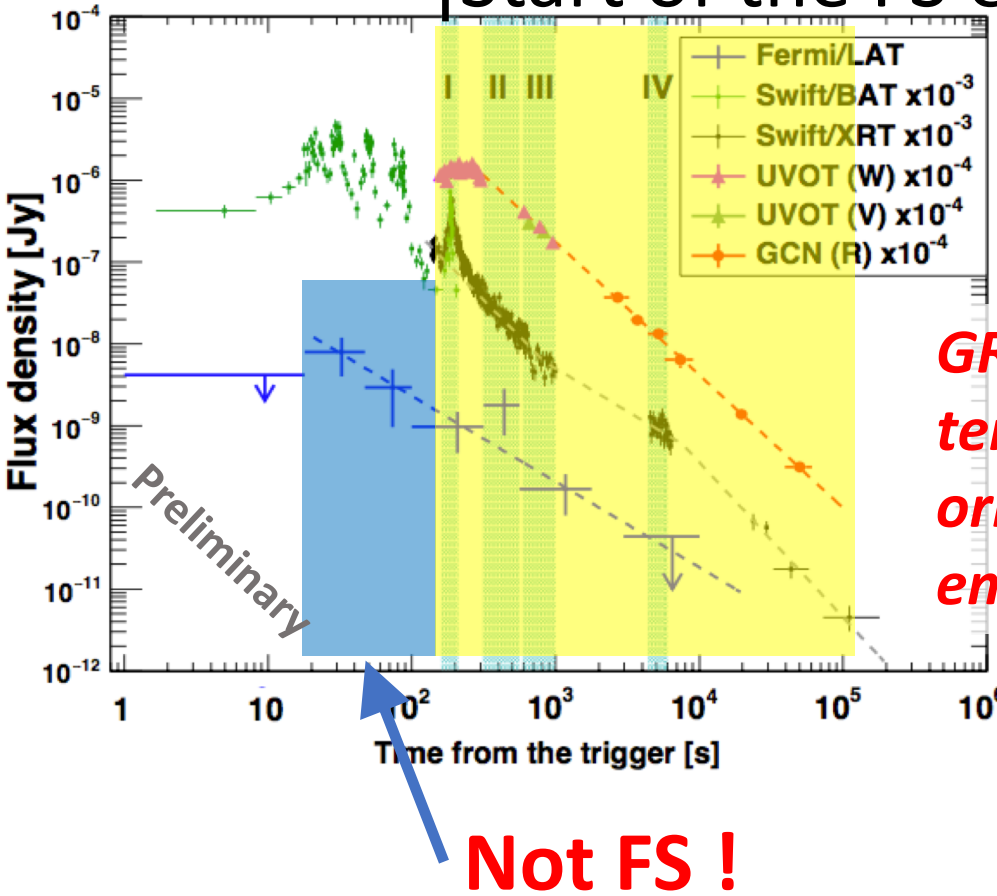
Ghisellini+2010, Kumar+2010



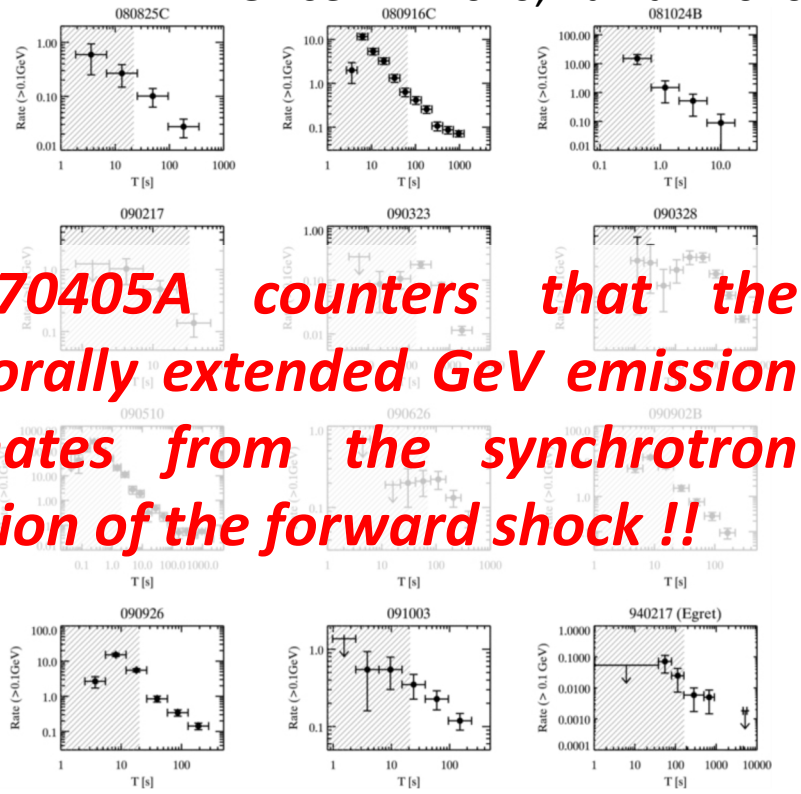
Physical Origin

~200 s

Start of the FS emission



Ghisellini+2010, Kumar+2010



GRB170405A counters that the temporally extended GeV emission originates from the synchrotron emission of the forward shock !!

Summary

- Optical-X-ray-GeV observation for GRB170405A shows
  - ✓Different time onsets in the optical and GeV bands
  - ✓High-energy cutoff appears in the prompt phase
  - ✓Γ_{max} is ～370, which can reasonably explain the ***optical*** onset, which is caused by the external forward shock
  - ✓***Delayed GeV emission is not likely to be the external forward shock***

- *Multi-wavelength observatio*n is a key to understanding the emission mechanism of GeV emission
  - ✓After Fermi10, we need to be more active for multi-wavelength campaign.