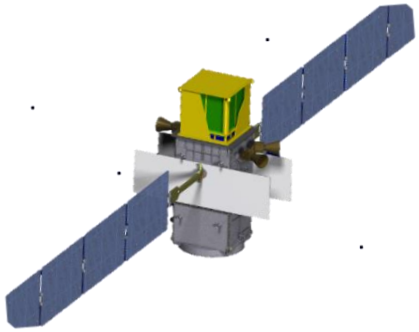
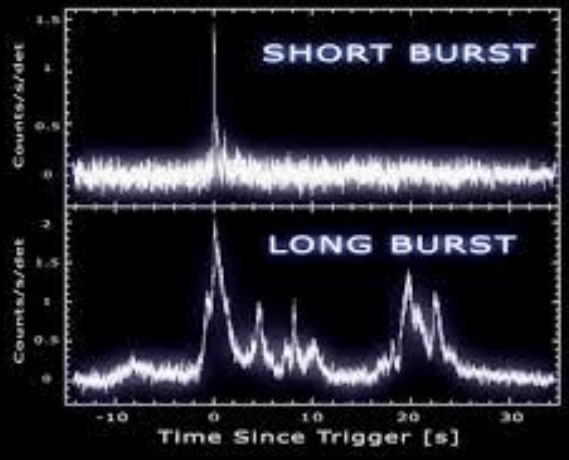
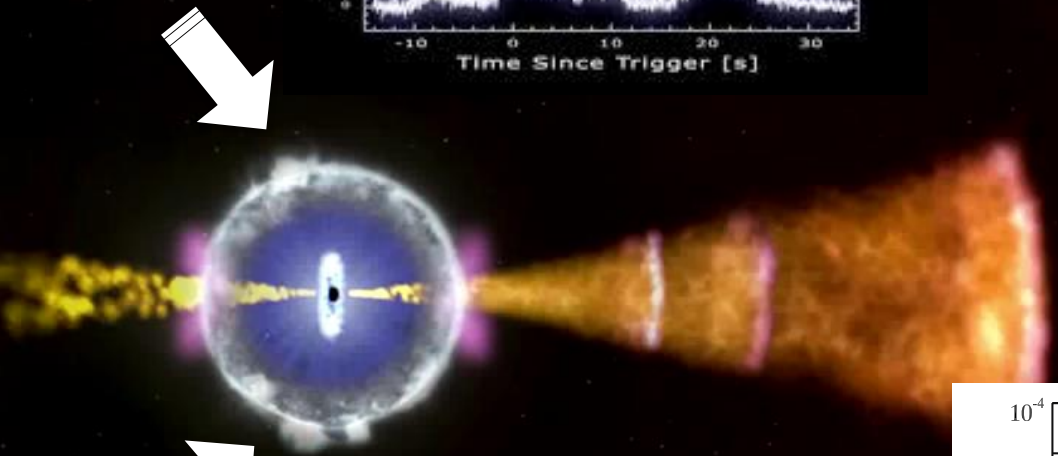


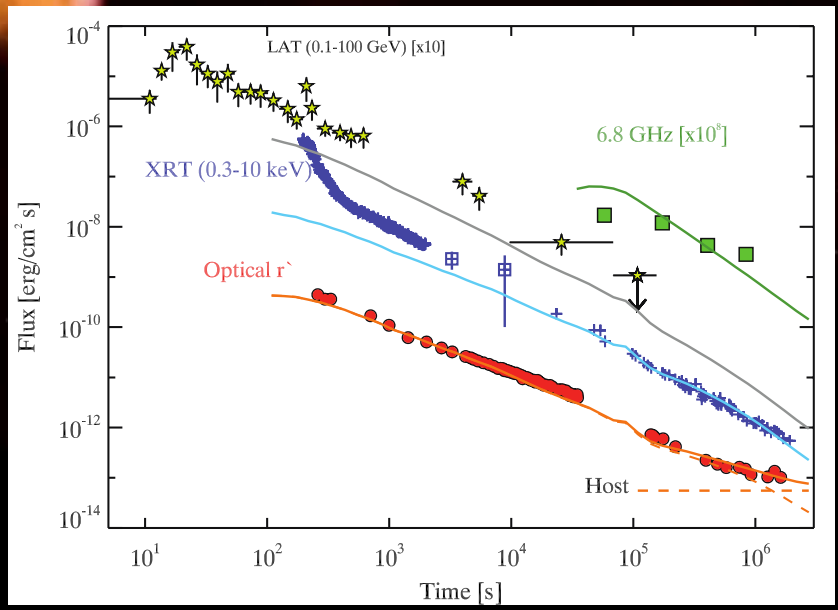
Gamma Ray Bursts with e-Astrogam

Giancarlo Ghirlanda
INAF-Osservatorio Astronomico di Brera

1. keV-MeV → MeV-GeV emission in GRBs
2. Measuring jet dynamics
3. Polarization
4. Conclusions → towards e-Astrogam

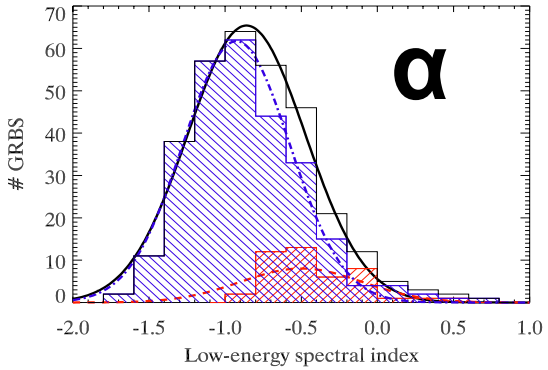

SHORT BURST
LONG BURST
Counts/s/det
Time Since Trigger [s]

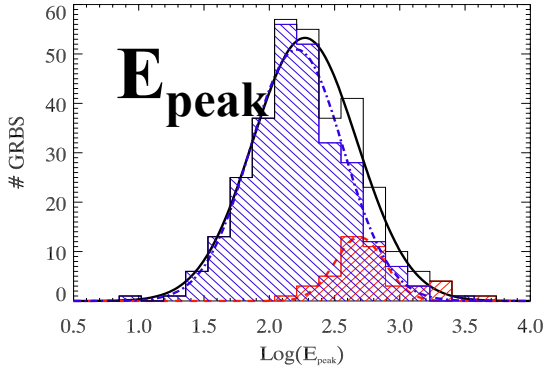


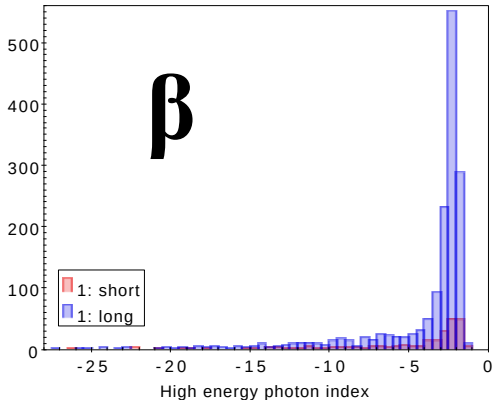

LAT (0.1-100 GeV) [x10]
6.8 GHz [x10⁸]
XRT (0.3-10 keV)
Optical r`
Host
Flux [erg/cm² s]
Time [s]

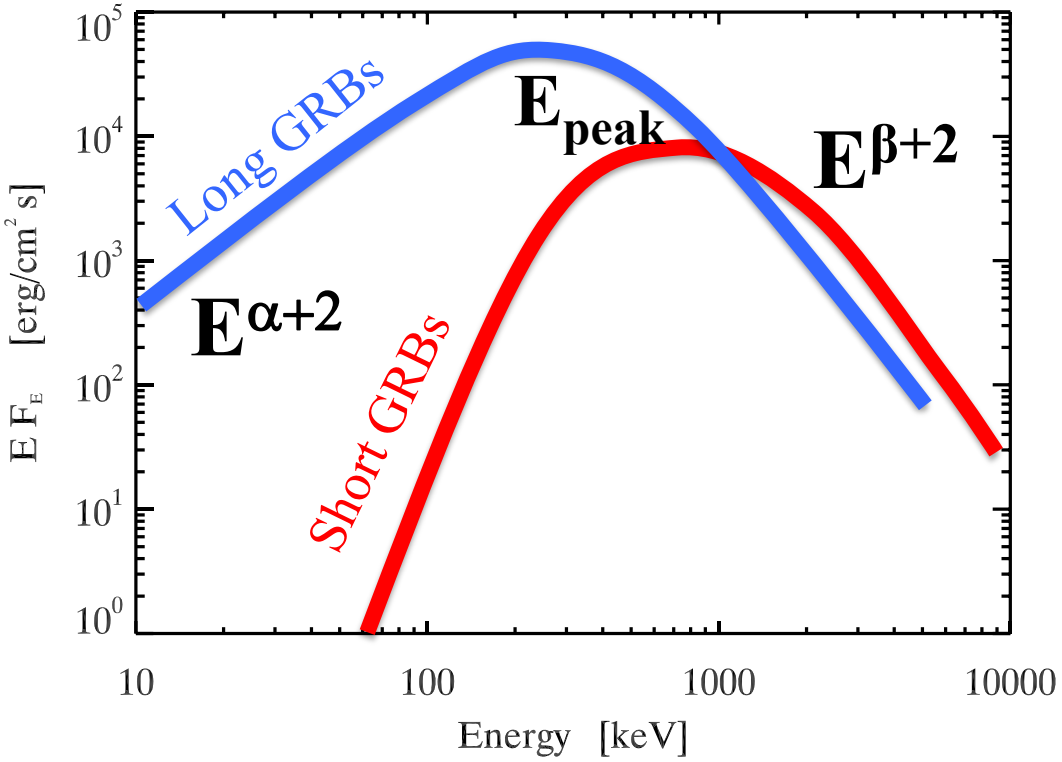
MeV emission of GRBs

BATSE-CGRO [Band+1998;Preece+2000; GG+2003], **BeppoSAX** [Frontera+2006]; **Fermi** [Goldstein+2010; GG+2011; Nava+2011]; **Integral** [Vianello 2008]; **Swift** [Sakamoto 2013]

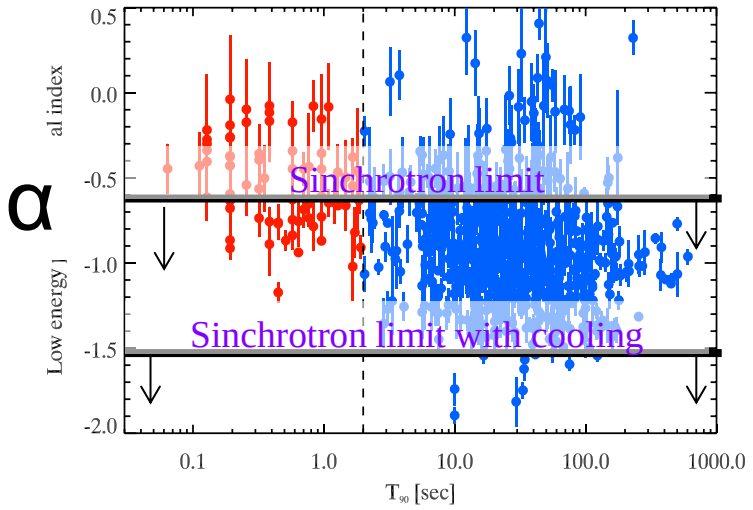


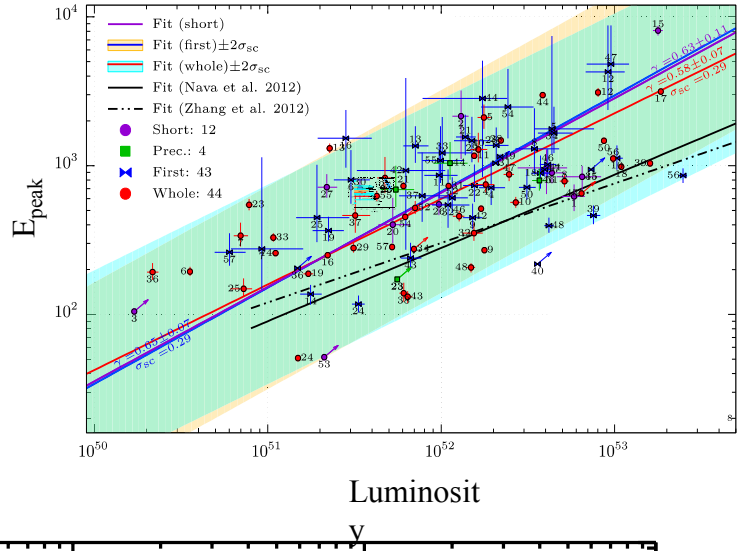






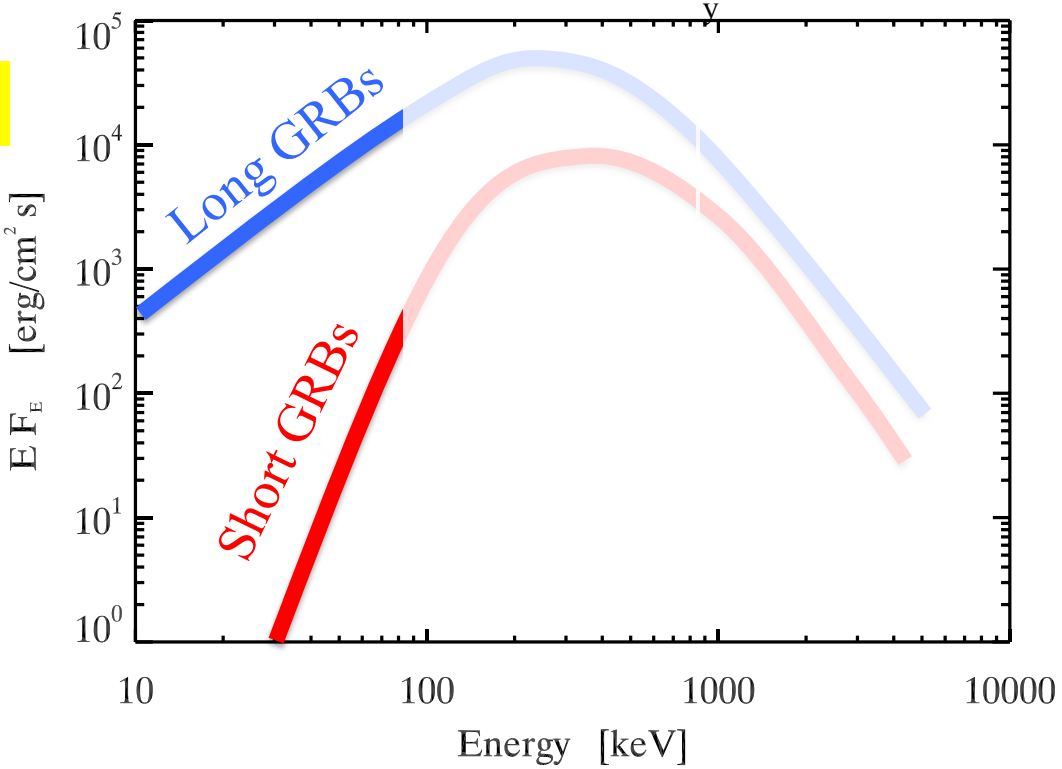
MeV emission of GRBs





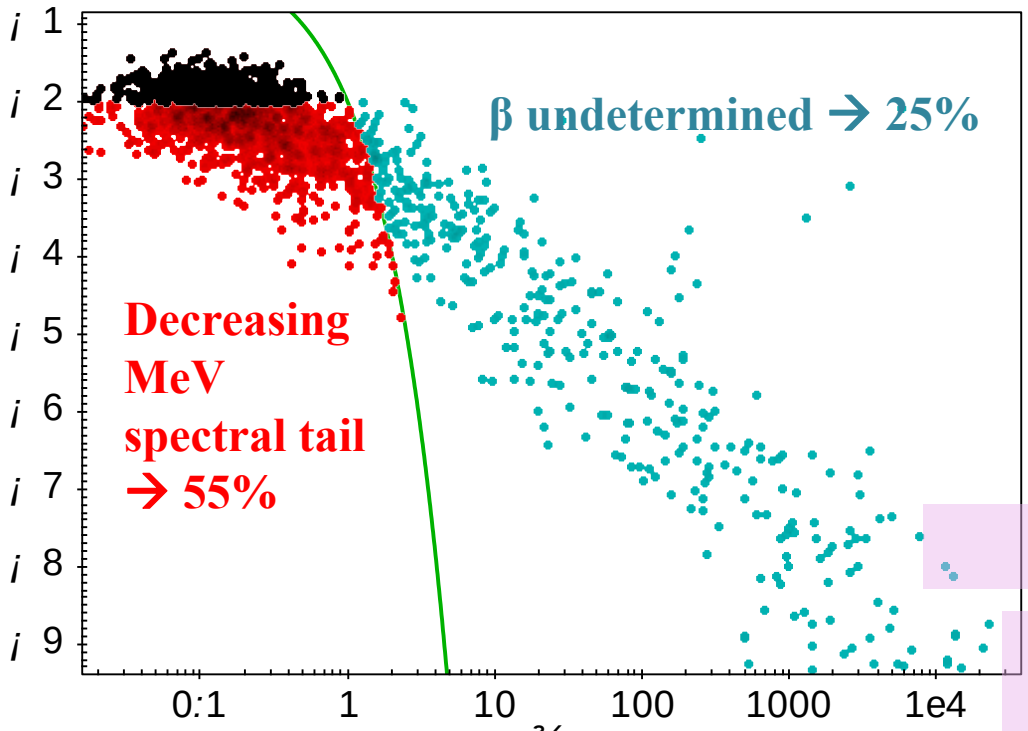
Radiation process?

- Need more realistic synchrtron/IC model for prompt
- Need also thermal component?



MeV emission of GRBs

β > -2 (no peak) → 20%

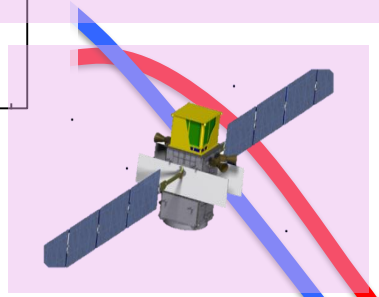


Powerlaw vs Exp cutoff?

Time evolution?

- Different emission mechanisms?
- Internal absorption?
- Contamination by higher energy component?

ASTROGAM

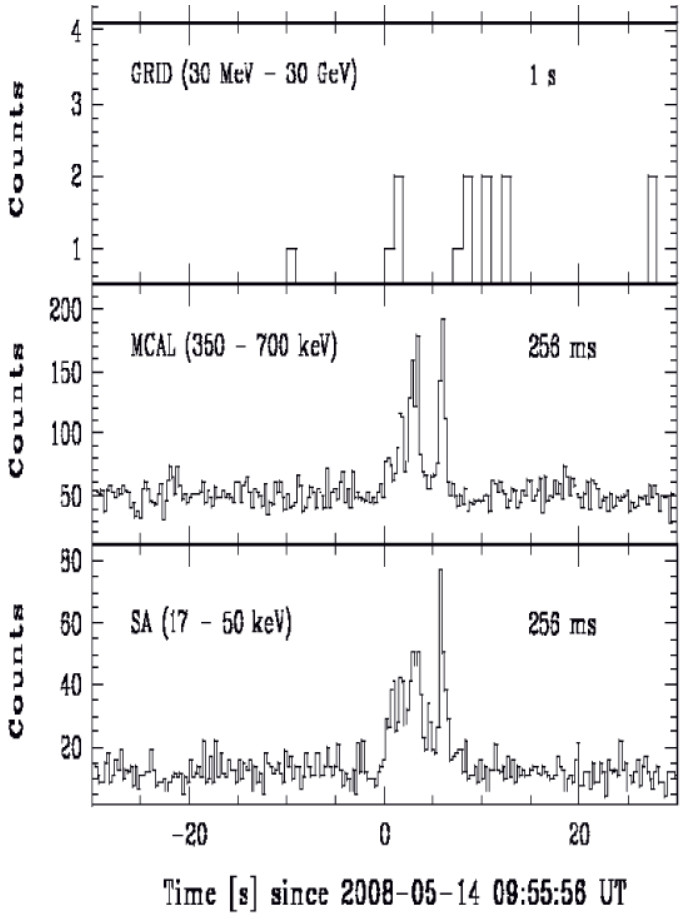


GeV emission of GRBs

EGRET (e.g. GRB 941017 – Gonzales+2004)

AGILE

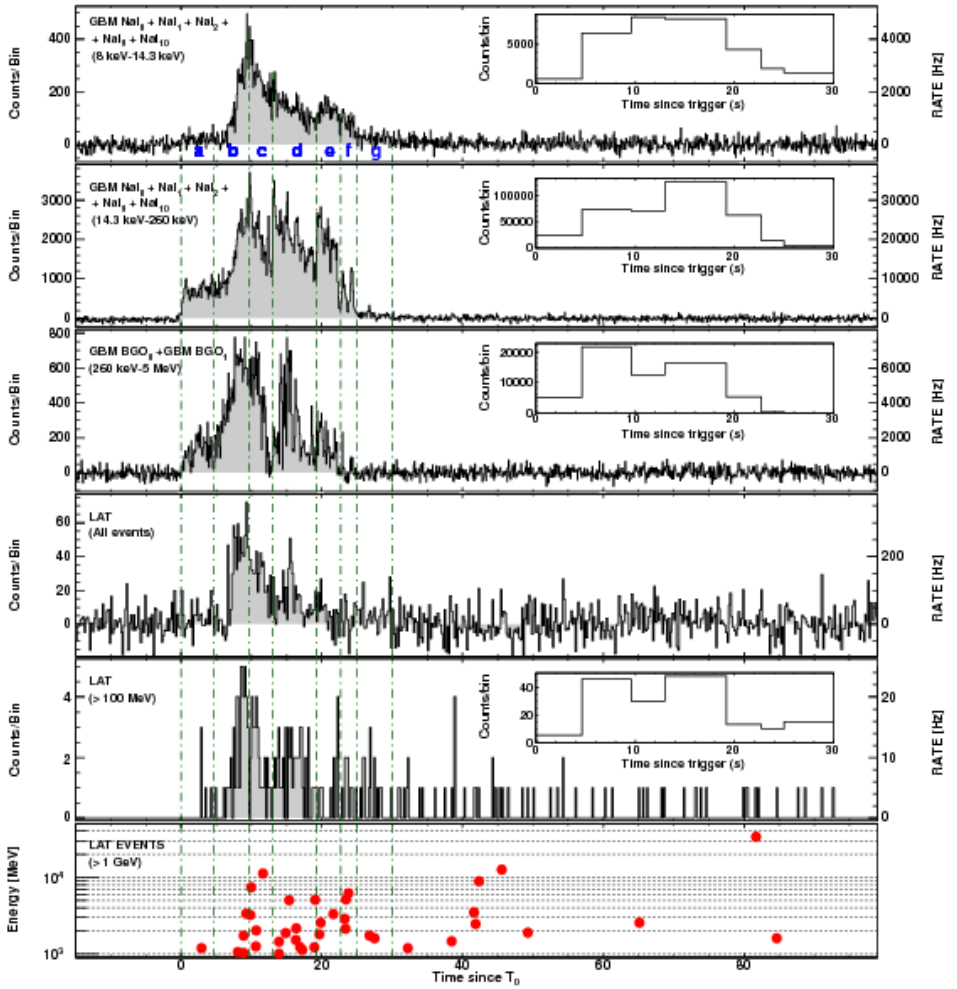
GRB 080514 Giuliani+2008



090401B [Moretti+2009], 090510 [Giuliani+2009], 100724B [Del Monte+2011], 130327B [Longo+2013], 130427A [Verrecchia+ 2013], 131108A [Giuliani+2013], 15479 [Giuliani+2015]

Fermi

GRB 090902 Abdo+2009

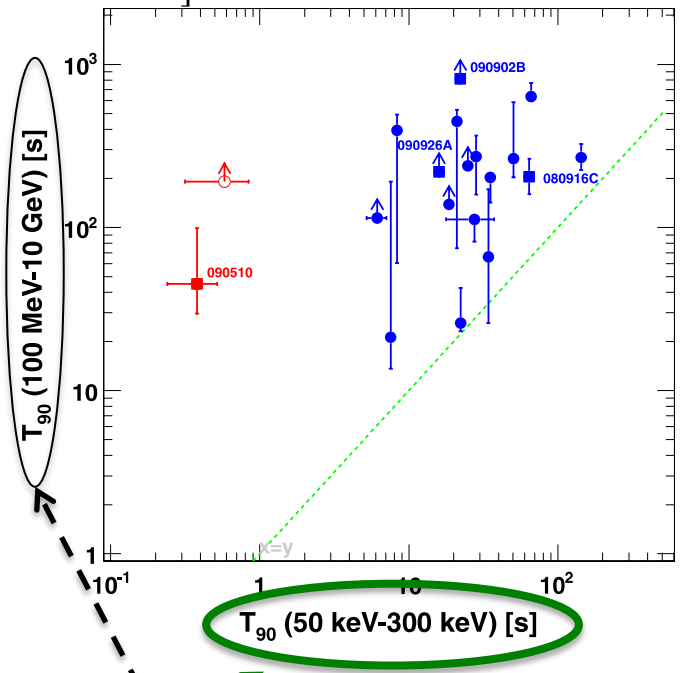


Statistics: ~ 10 yr^{-1} above 100 MeV [e.g. Ackermann+2013]

GeV emission: (I) Duration & Delay

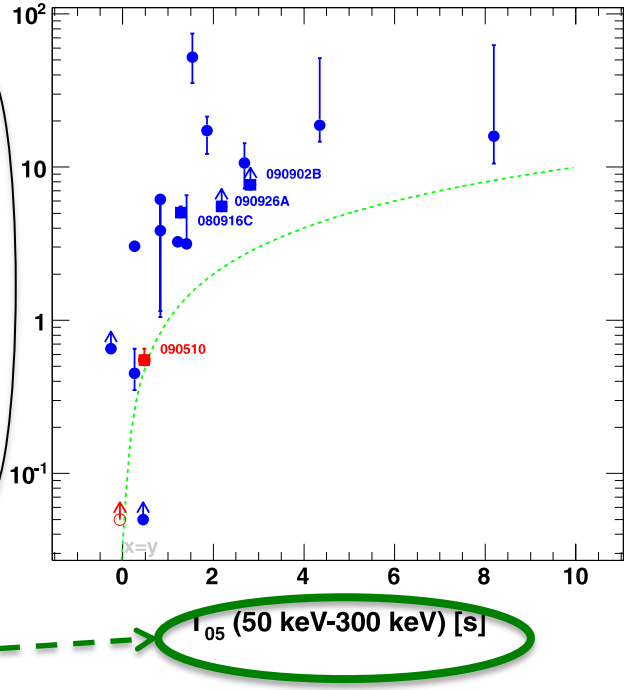
[in individual GRBs detected by Agile and Fermi, e.g. Giuliani+2009, Abdo+2010, Ghisellini+2011; and globally in Fermi LAT catalog: Ackermann+2013]

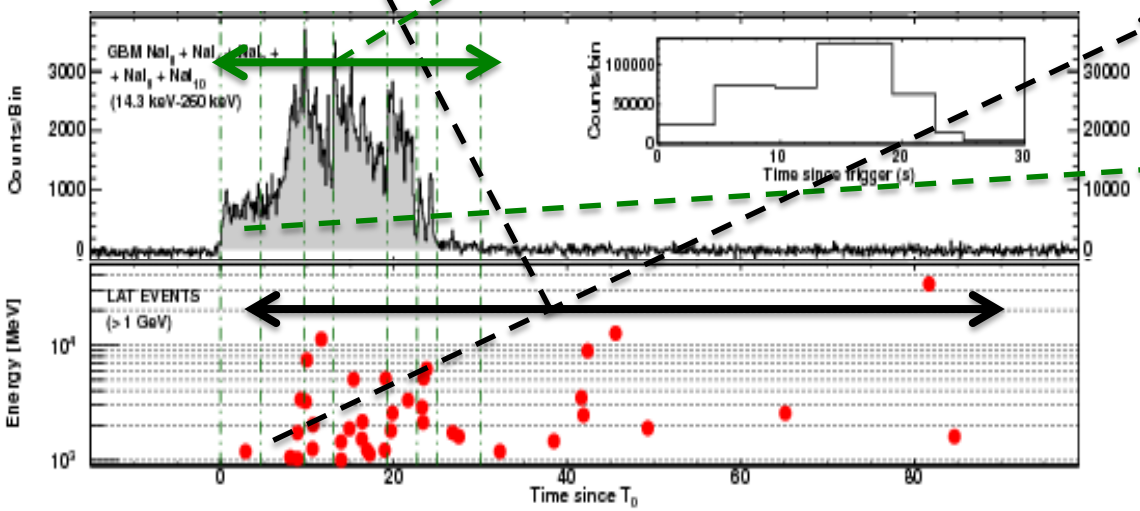
> GeV emission lasts longer than MeV component



Ackermann+2013

Start time of GeV emission



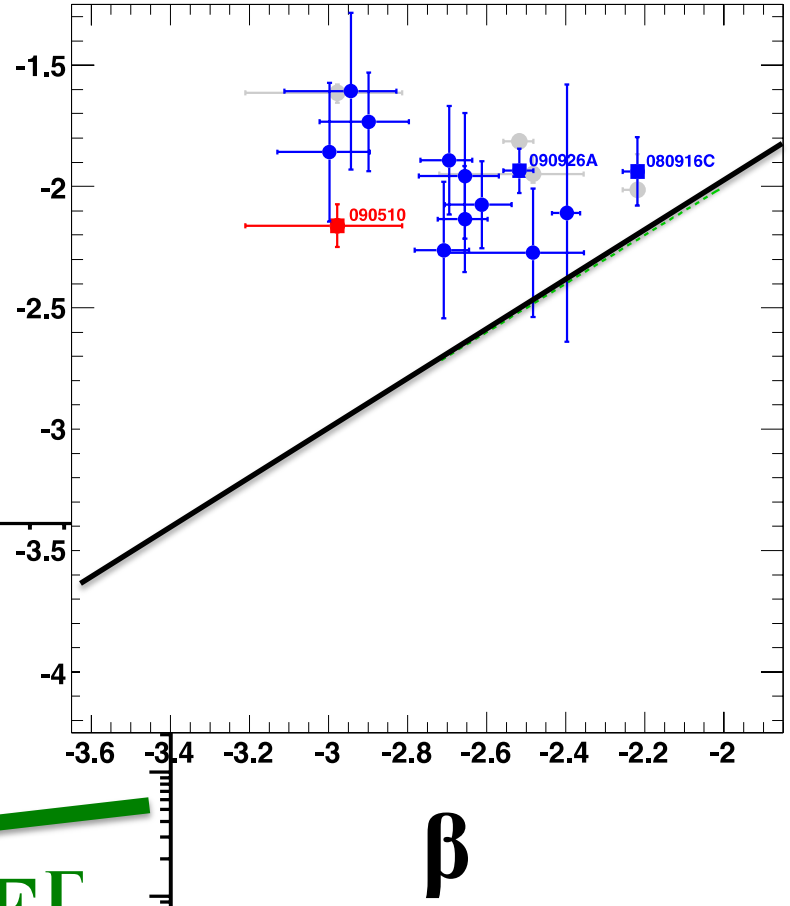


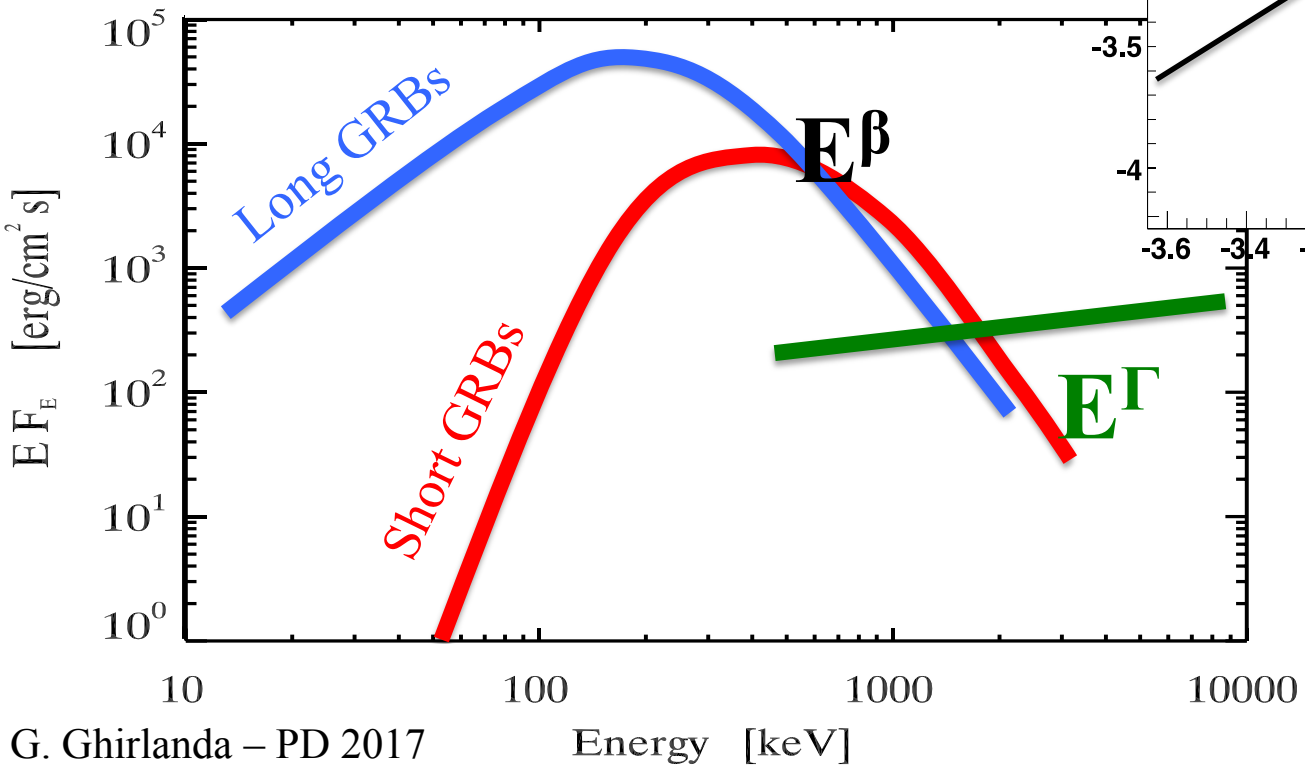
> GeV emission start time is delayed wrt < MeV

GeV emission: (III) Spectrum

GeV component is spectrally harder than the tail of the MeV

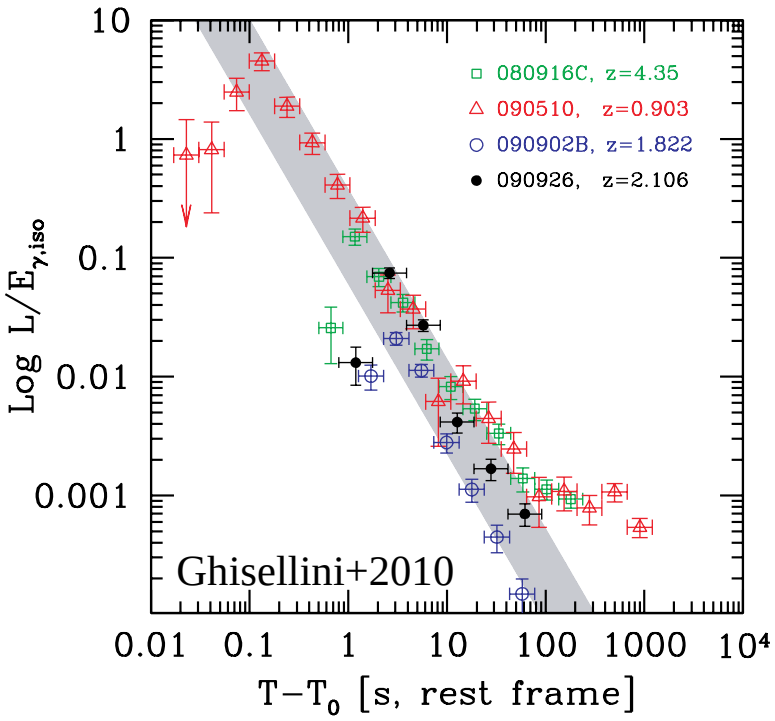
GeV component delayed wrt MeV





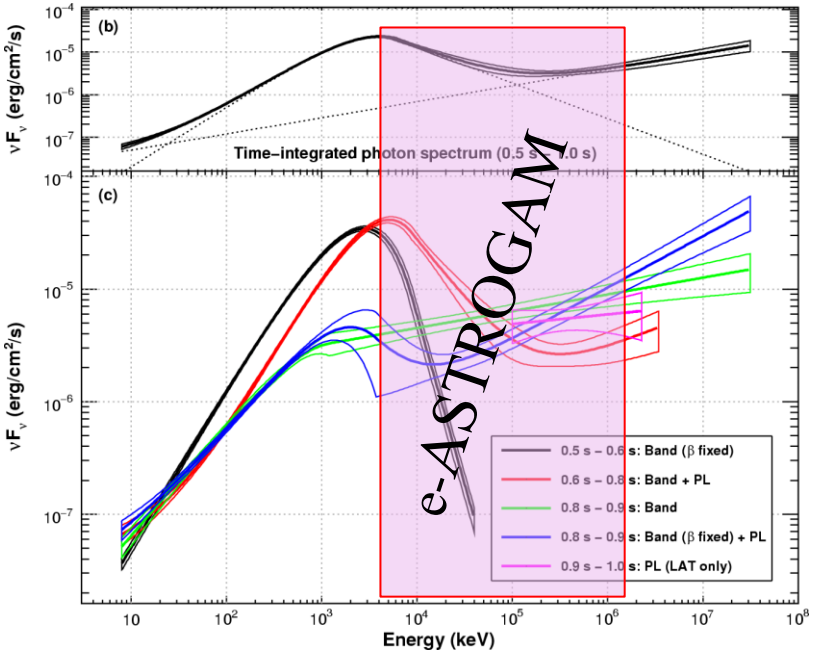
GeV emission origin

> GeV flux decays ~ $t^{-1.5}$



+

Spectral diversity of GeV wrt to MeV



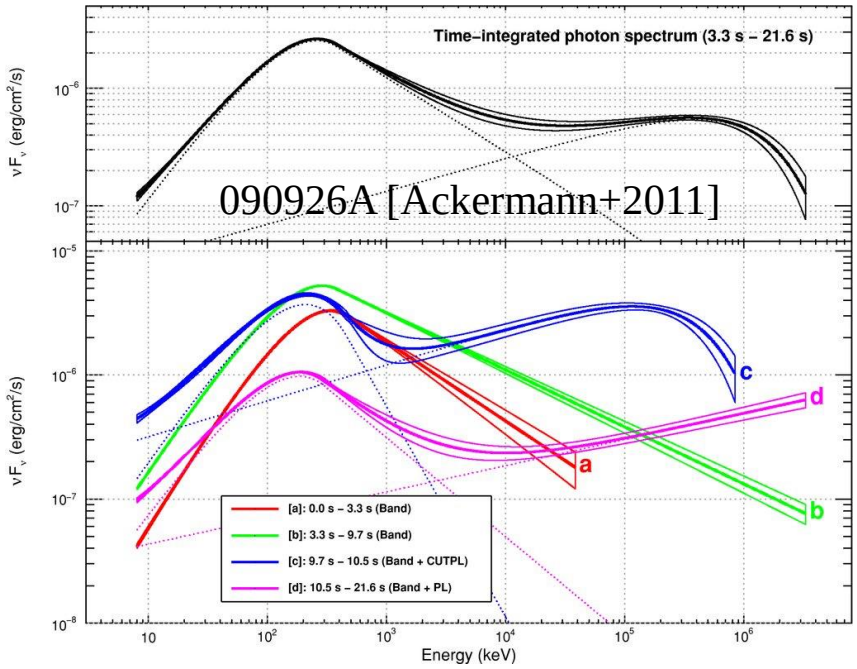
External origin → SYNCH. [Kumar+2009; Ghisellini+2010]

External origin → IC [Beloborodov+2014]

Internal origin [e.g. Toma+2011]

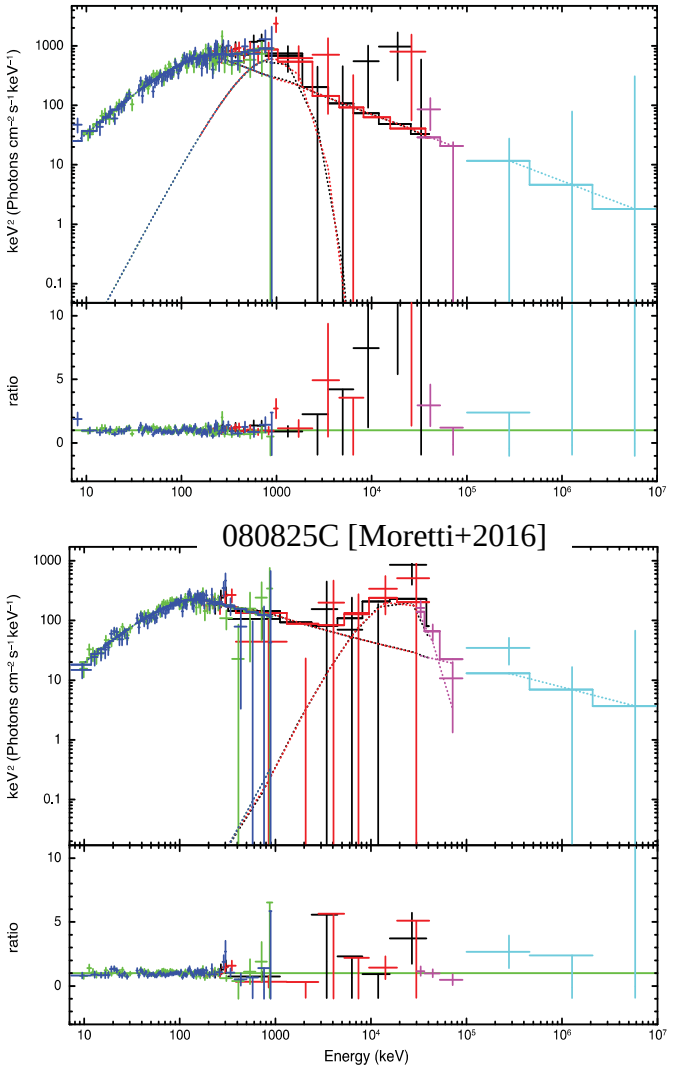
GeV emission

Transient spectral break (or cutoff?) @ 1.4 GeV



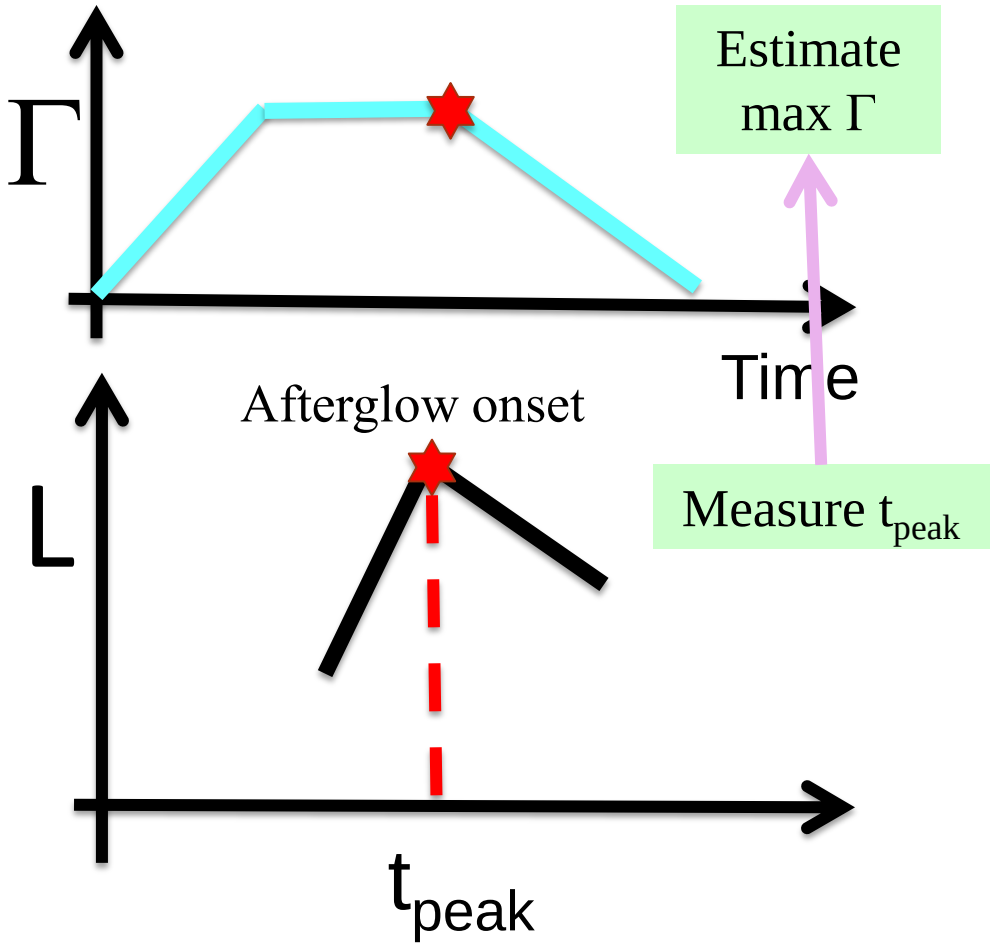
- Intrinsic apsorption
- Emission mechanism (IC in KN regime)

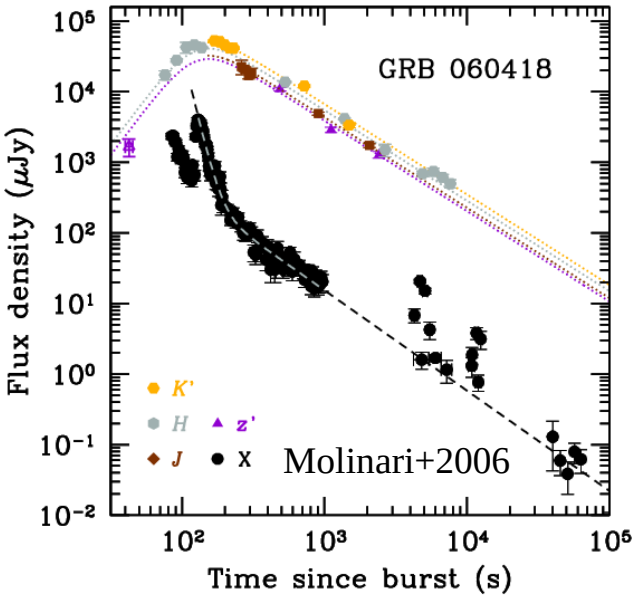
Additional peaked MeV component

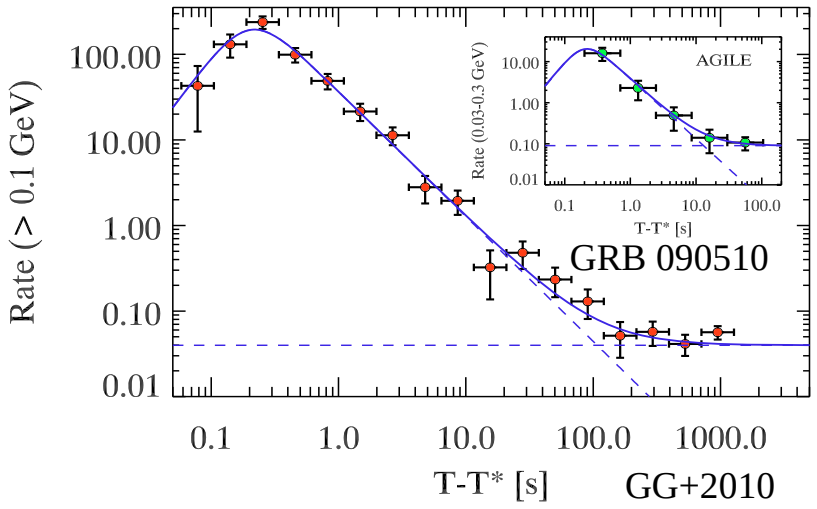


GRBs are relativistic

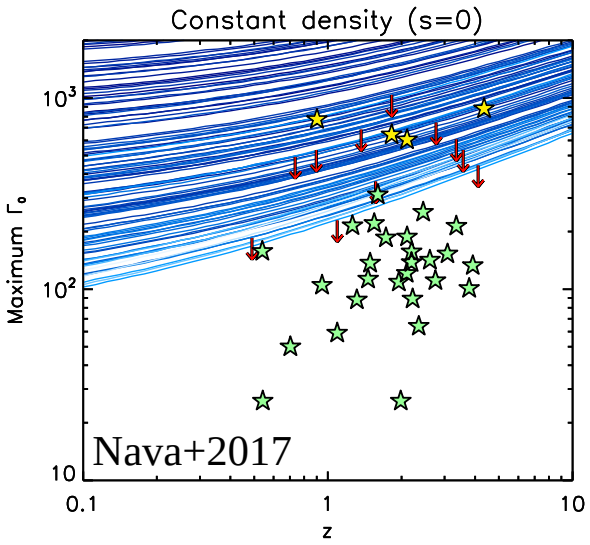
[Sari&Piran 1999; … Molinari+2006; GG+2010; Liang+2010; Longo+2012; Nava+2016]



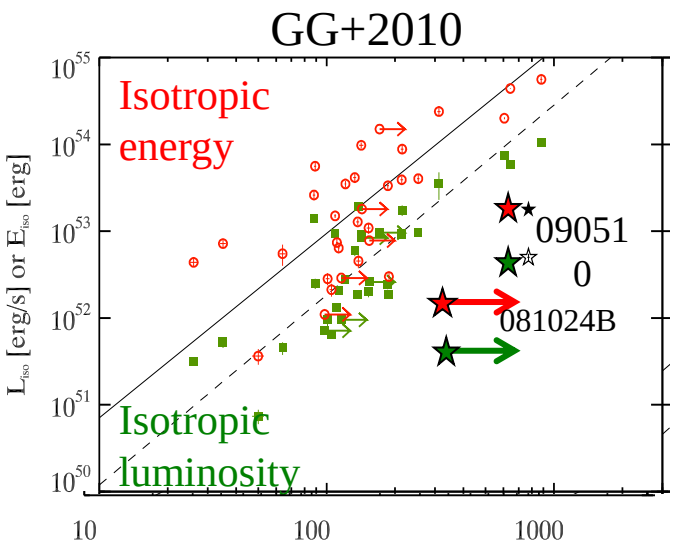




Bulk Lorentz factor

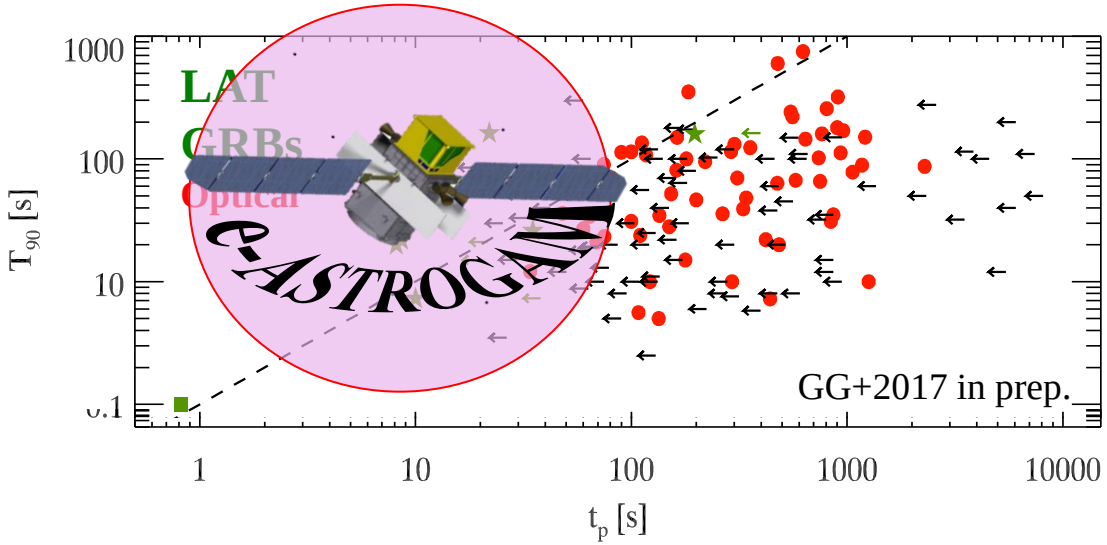


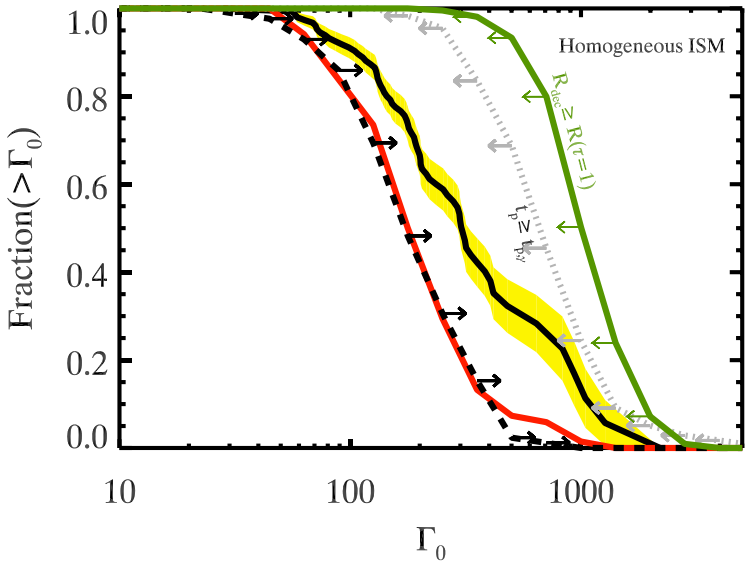
Bulk Lorentz factor and Jet opening angle could be related [e.g. McKinney 2009] [GG+2011] $\vartheta^2\Gamma$=const



Estimate of Γ_0 from the peak of the afterglow

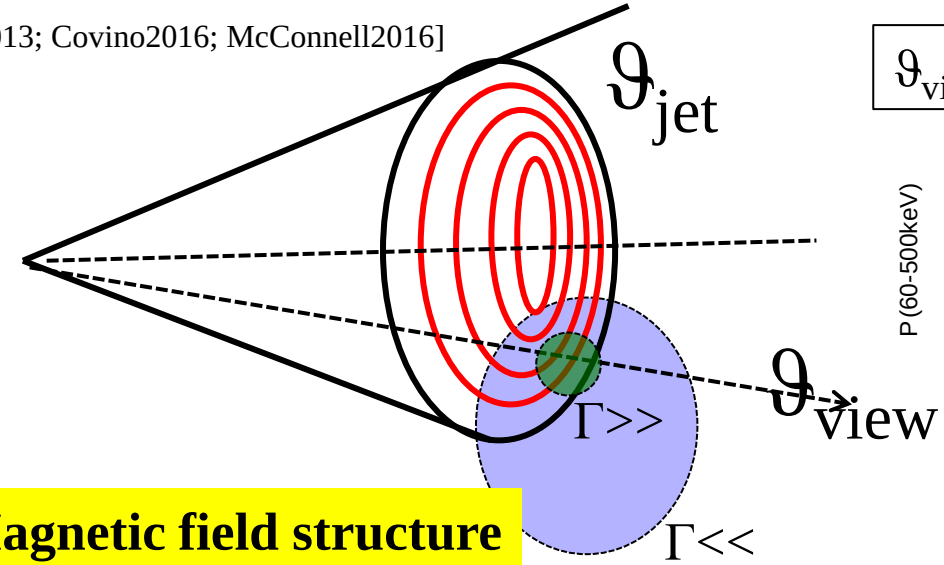
$$\frac{t_{peak}}{1+z} \sim t_{dec} \sim \left(\frac{3E_{k,iso}}{32\pi n m_p c^5 \Gamma_0^8}\right)^{1/3}$$

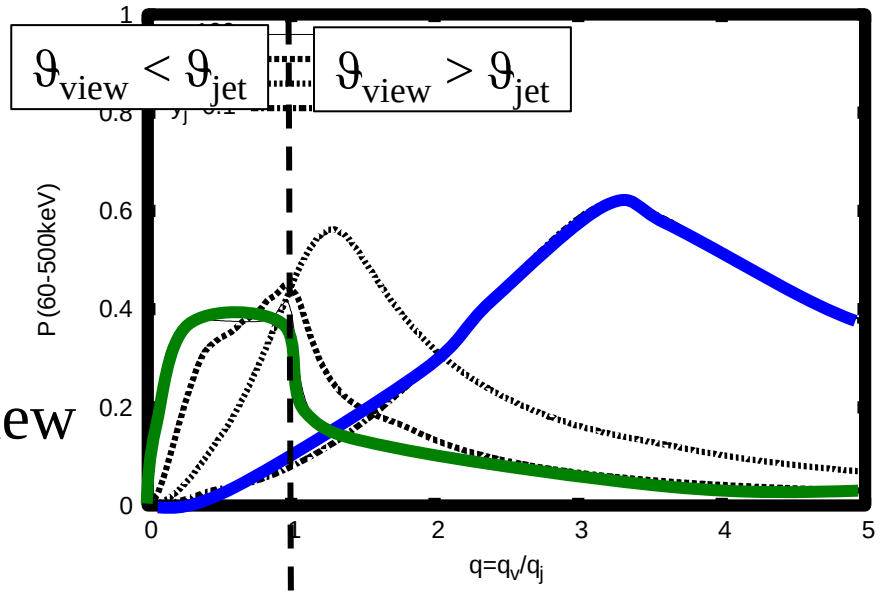




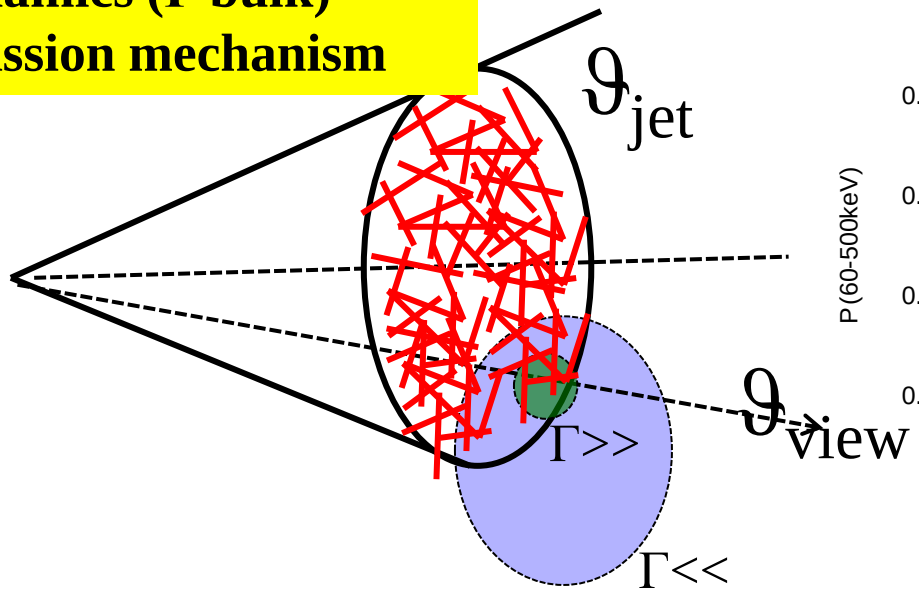
Polarization

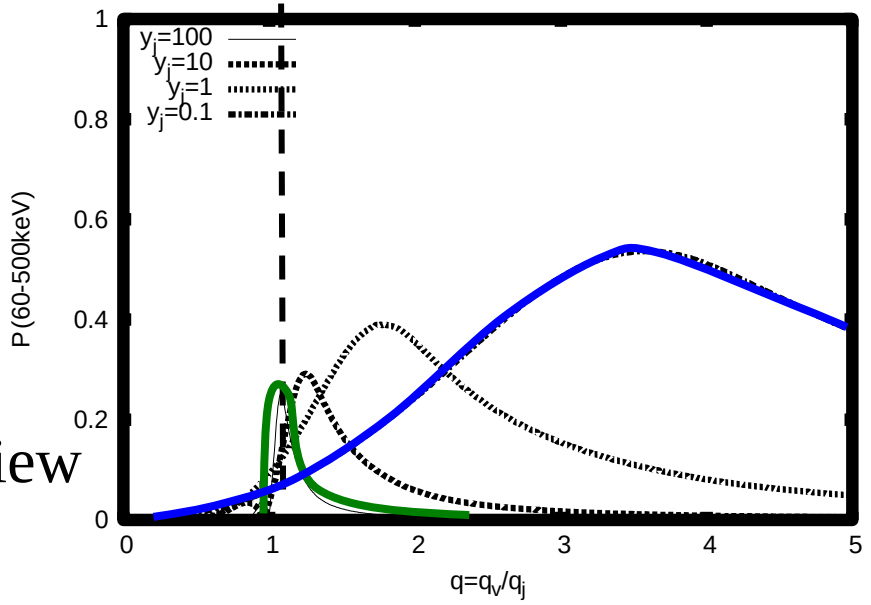
[Toma2013; Covino2016; McConnell2016]





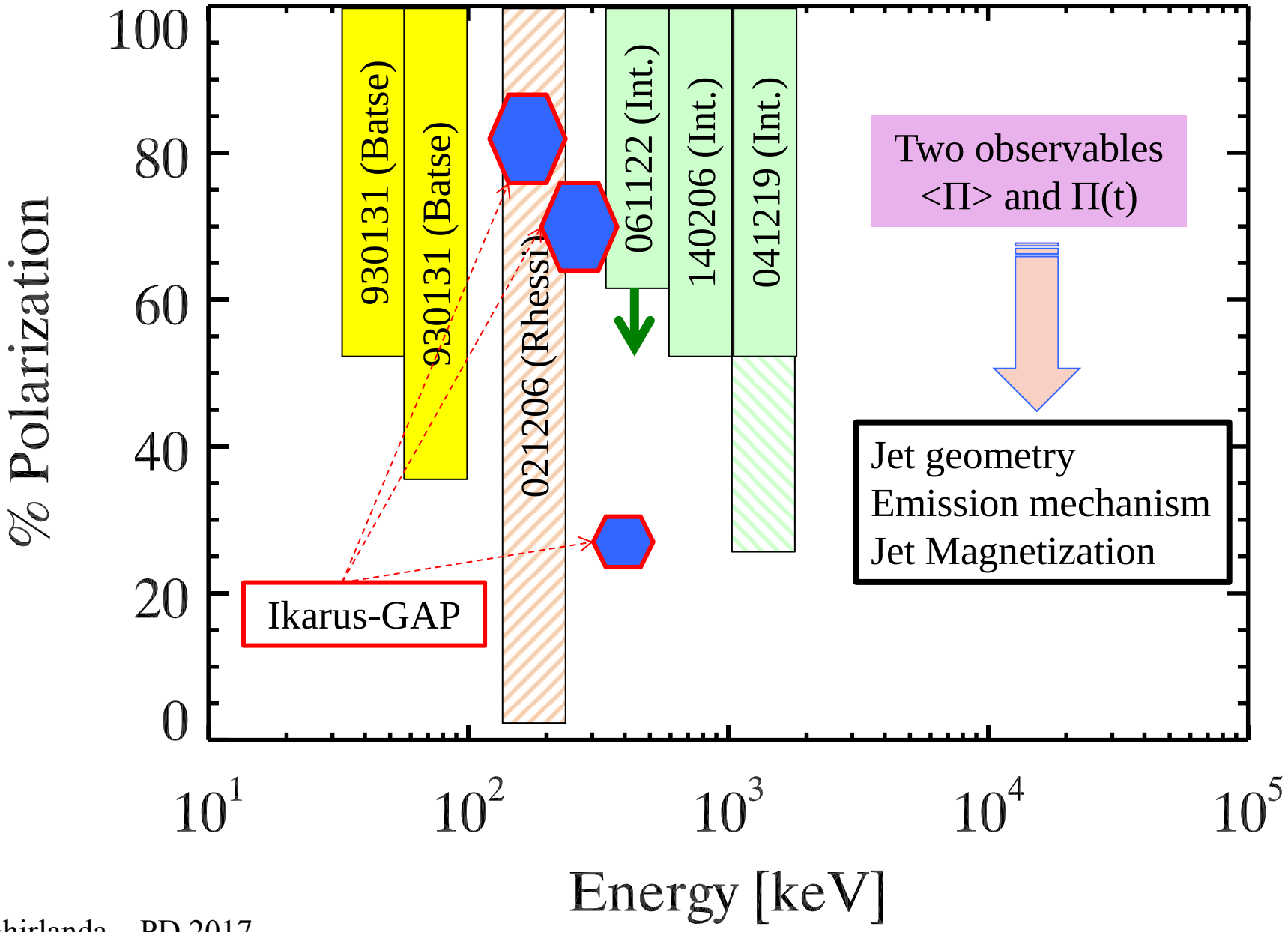
1. **Magnetic field structure**
2. **Geometry (ϑ_{jet} ; ϑ_{view})**
3. **Dynamics (Γ bulk)**
4. **Emission mechanism**



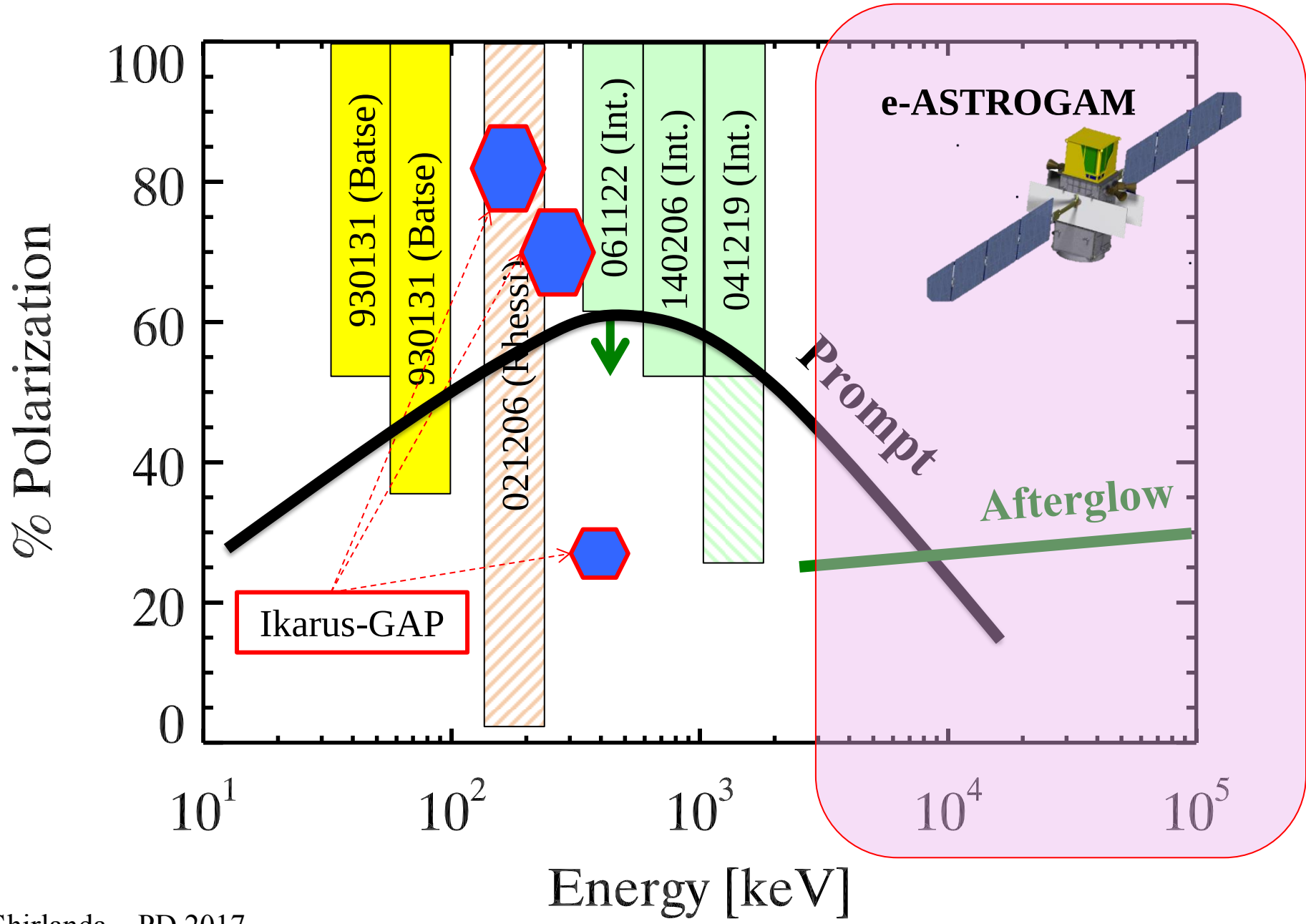


Polarization

Coburn+2003; Rutledge+2004; Wigger+2004; McGlynn+2007; Gotz+2013, 14; Yonetoku+2011, 12; Rao+2016

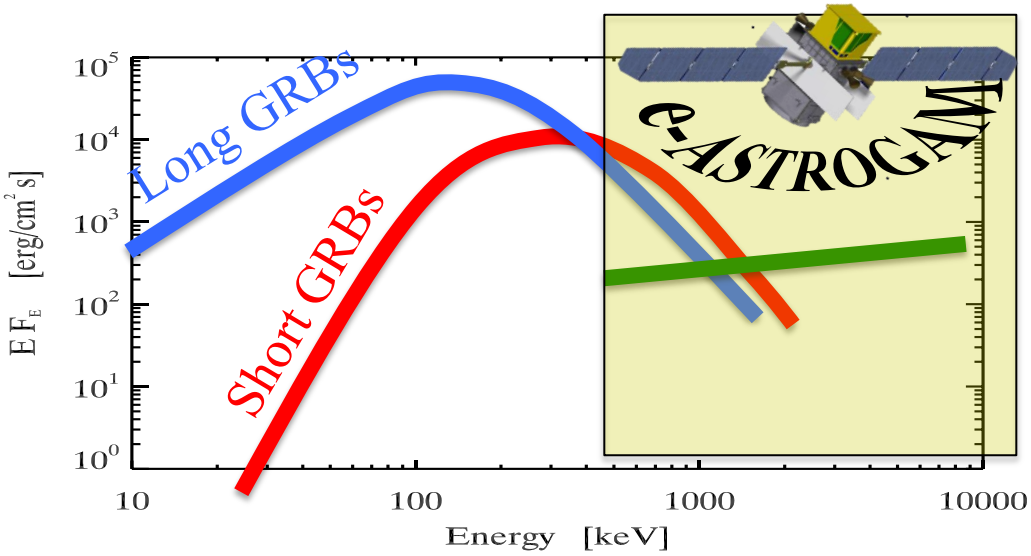


Polarization



CONCLUSIONS

Question	Key obs → e-ASTROGAM	How?(suggestions) → simulations
Origin of prompt emission	• Spectra (1MeV – 3GeV) ✓ Energy resolution ✓ Temporal resolution • Sensitivity (hundreds yr^{-1}) • Polarization	GRB detection rates (short and long)
Origin of GeV emission		Properties of detected population (prompt + afterglow)
Role of magnetic field Geometry (ϑ_{jet} ;ϑ_{view})		Include viewing angle effects (relevant for some polarization mechanisms)
Jet acceleration (Γ)		Population – extend earliest onset



High sensitivity
Spectral resolution
Polarization

Thank you

G. Ghirlanda – PD 2017