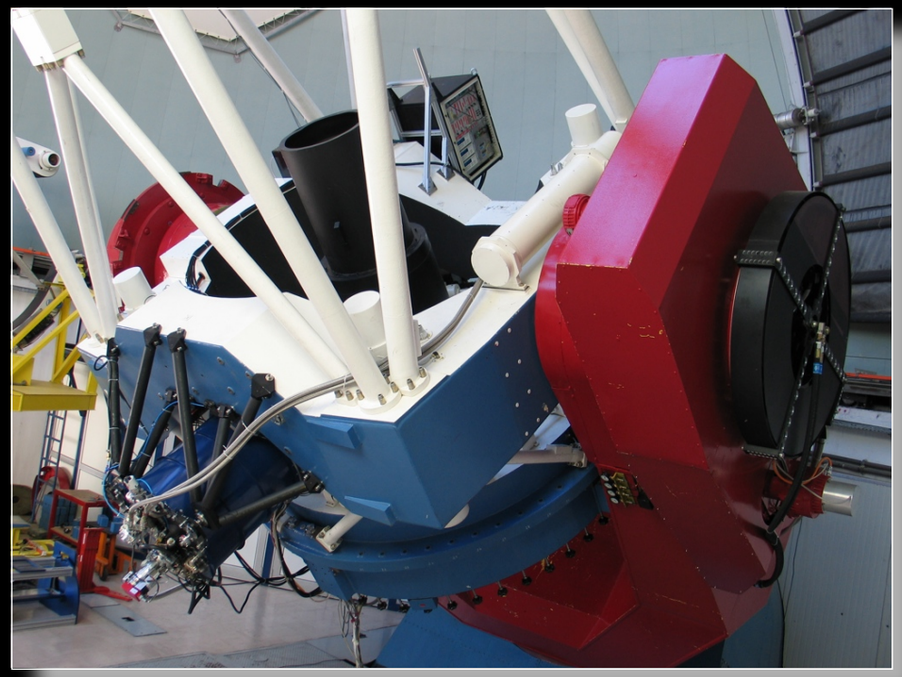
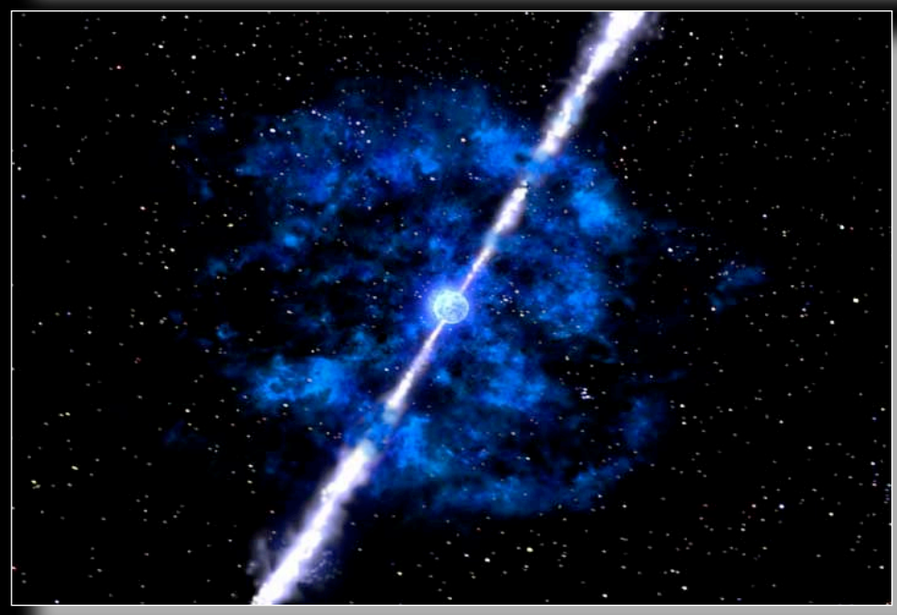
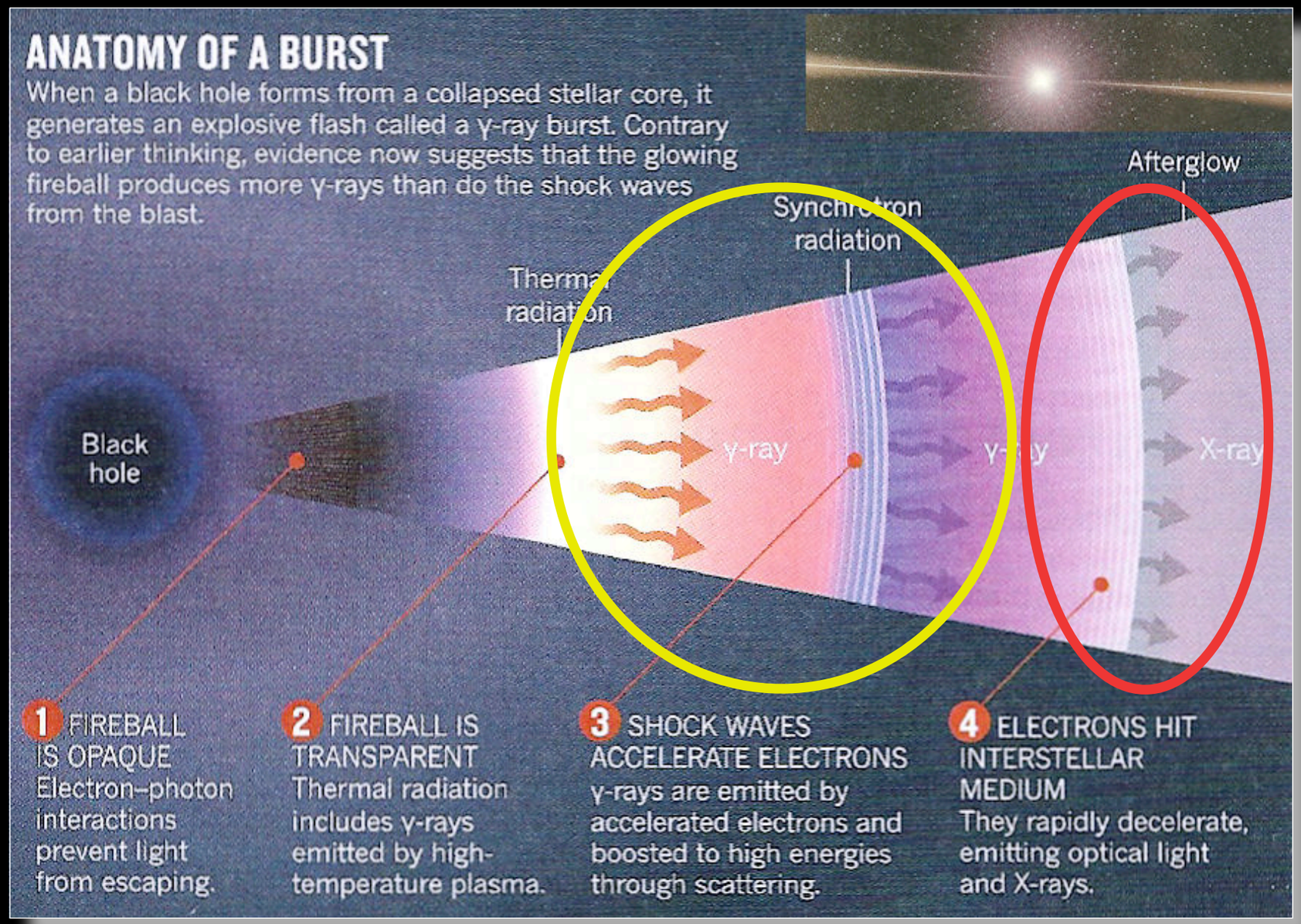
Fermi, GROND and GRBs

Arne Rau
(MPE Garching)



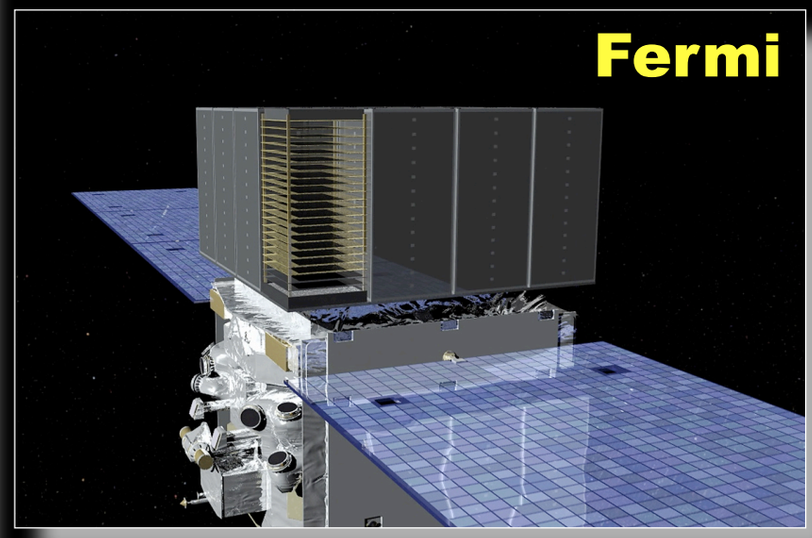


Gamma-ray Bursts



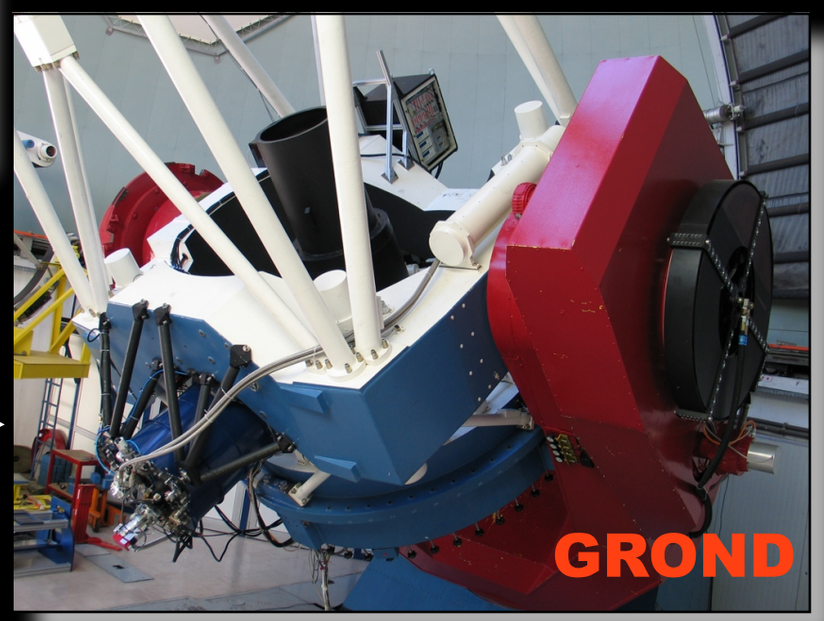
Prompt Emission probes:

- **central engine**
- **jet physics**



Afterglow probes:

- **central engine**
- **jet physics**
- **progenitor environment**
- **(host environment)**



The Fermi γ-ray Observatory

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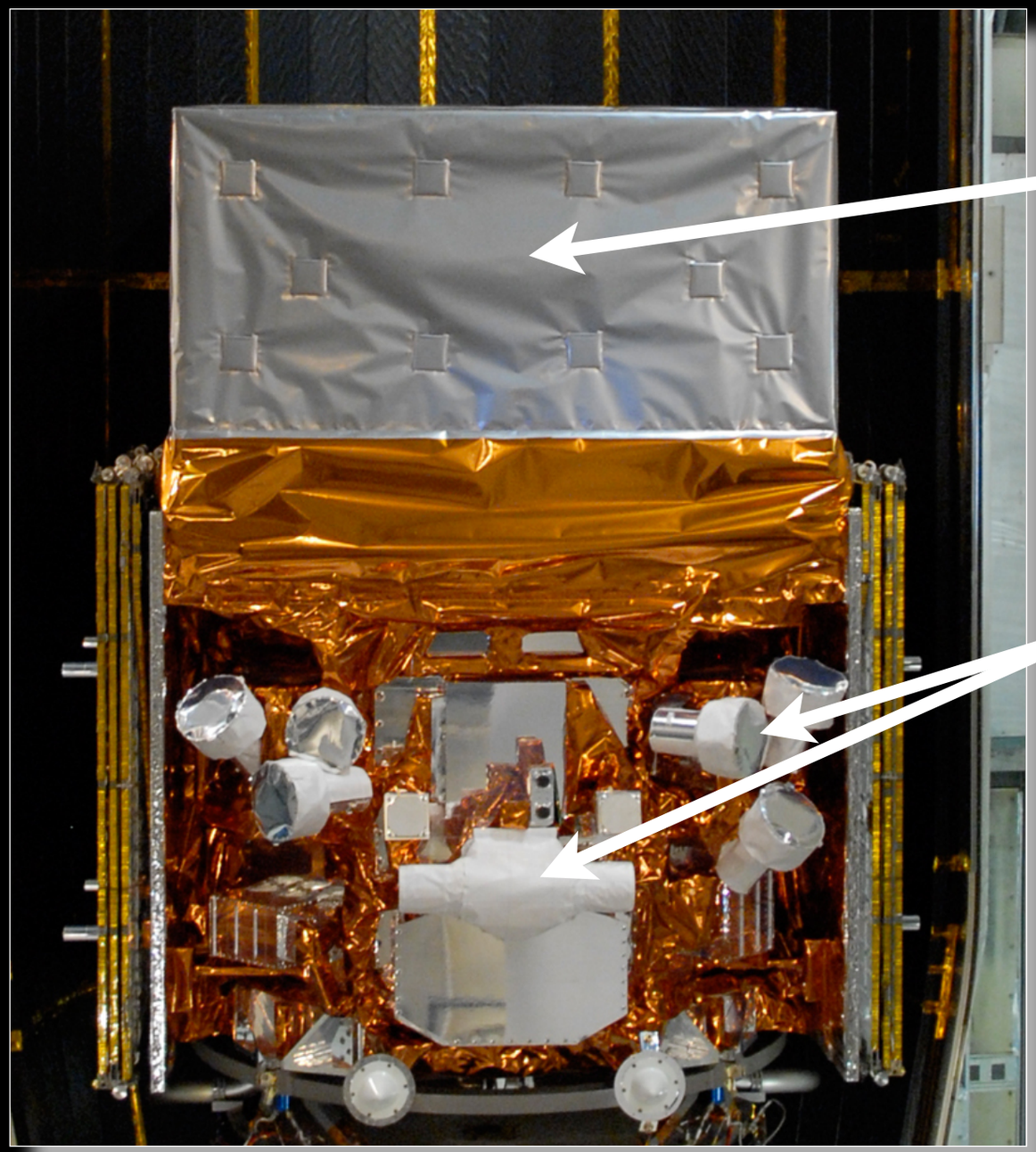
Large Area Telescope (LAT)

- **20 MeV - >300 GeV**
- **instant 20% of the sky (survey mode)**
- **all sky for ~30min every 3hr**

The Fermi γ-ray Observatory



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- **8 keV - 40 MeV**
- **whole un-occulted sky at any time**

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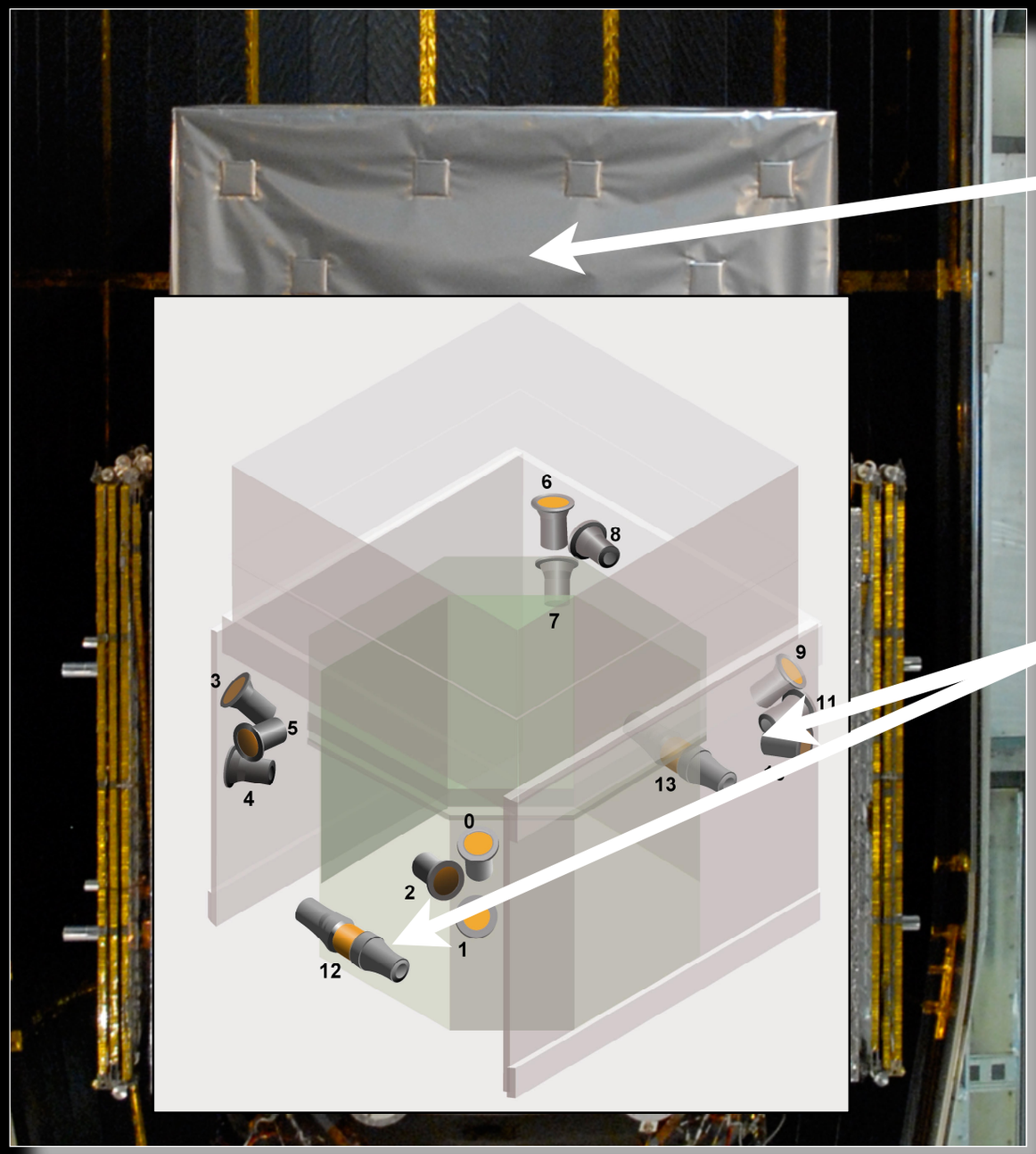

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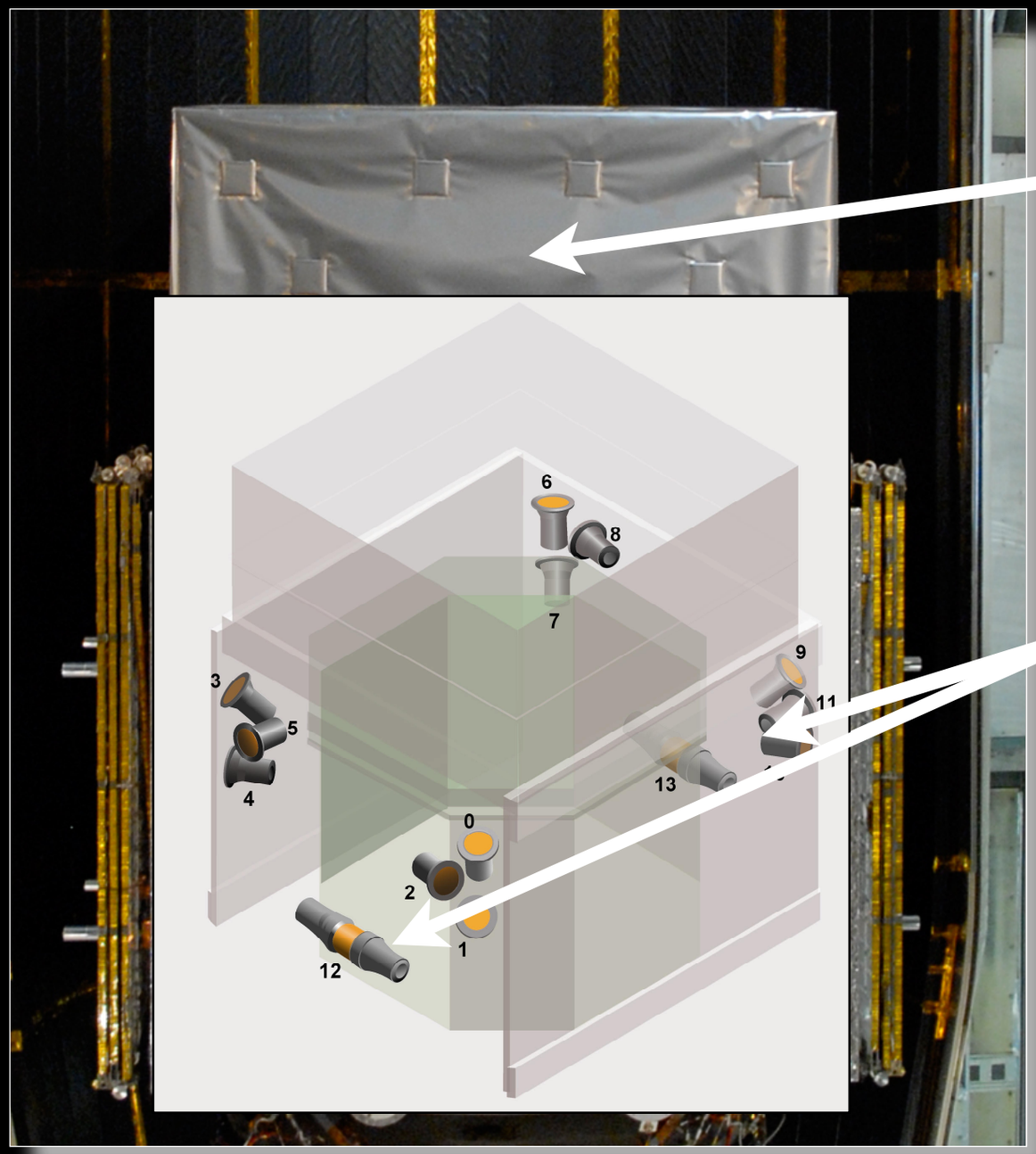

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Together

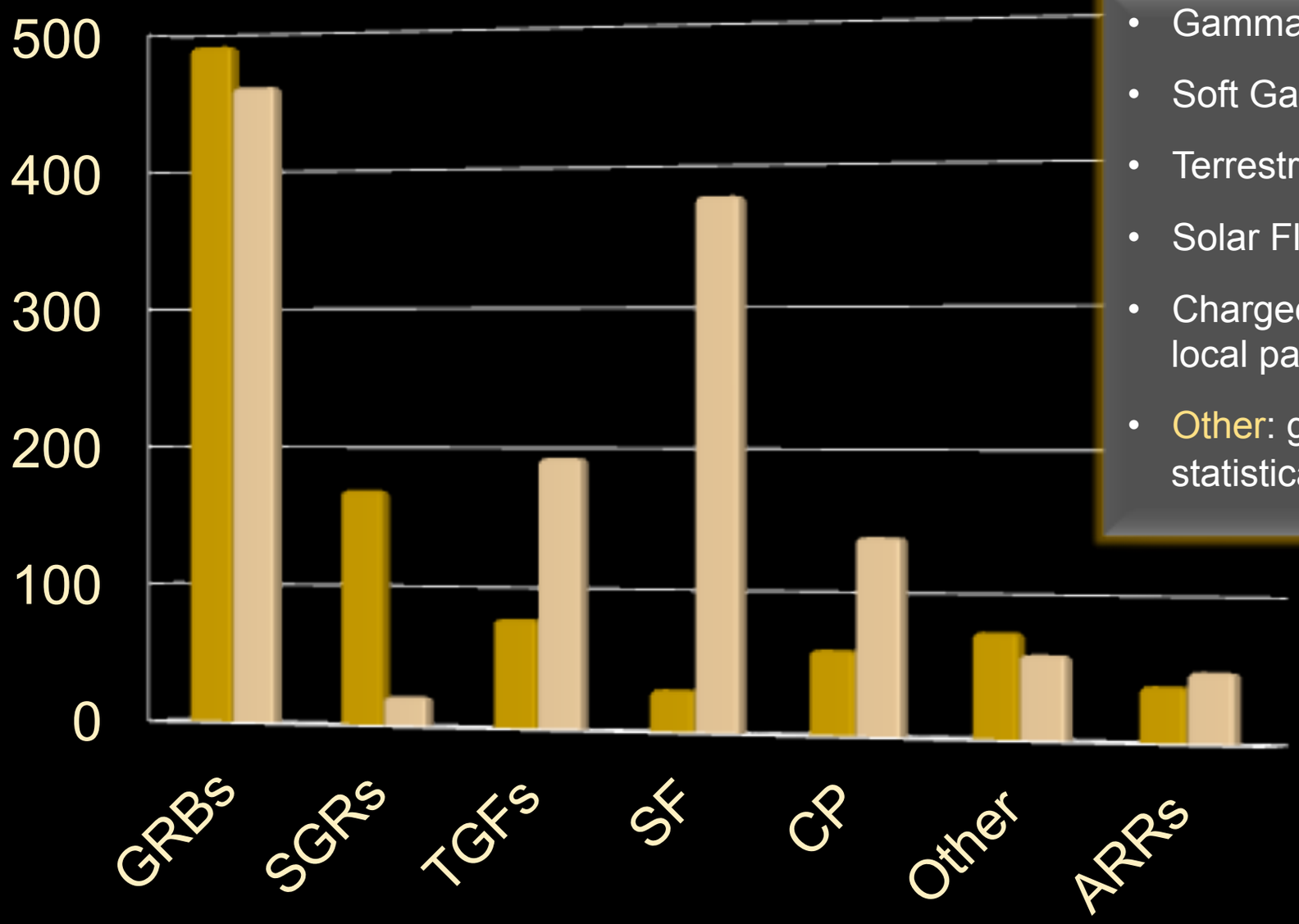
- **7 decades in energy**
- **huge discovery potential (not only for GRBs)**

GBM Triggered Sources

Fermi launch: 2008 June 11

GBM Trigger enabling: 2008 July 12

⇨ short transients detected by on-board trigger algorithm



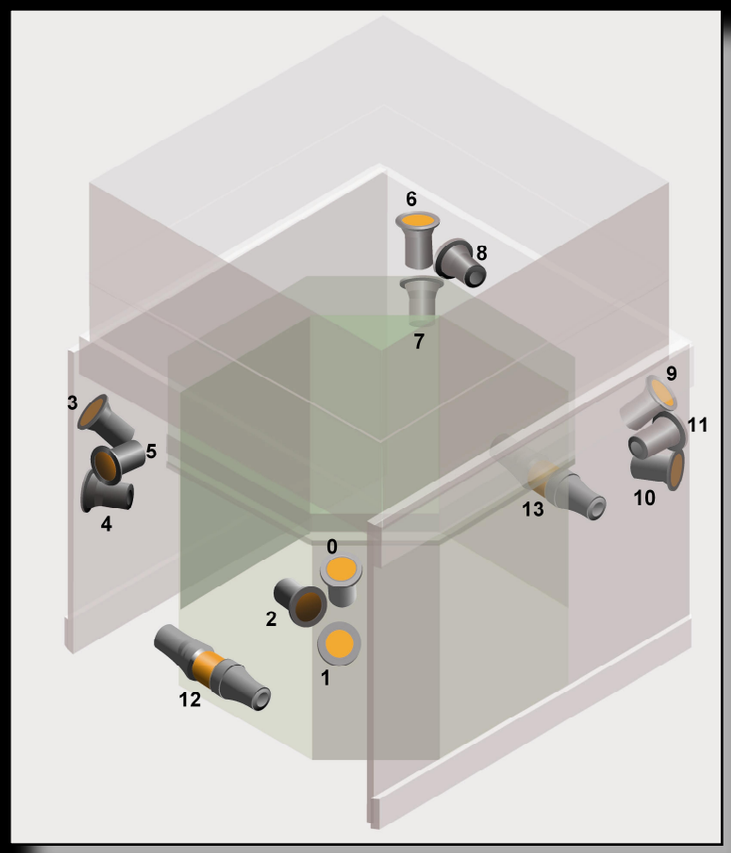
- Gamma-Ray Bursts (GRBs)
- Soft Gamma Repeaters (SGRs)
- Terrestrial Gamma Flashes (TGFs)
- Solar Flares (SFs)
- Charged Particle (CP): Cosmic Rays, local particles, distant particles, SAA entry
- Other: galactic source, accidental statistical fluctuations, too weak to classify

	GRBs	SGRs	TGFs	SF	CP	Other	ARRs
Year 1 & 2	492	170	79	31	61	75	40
Year 3 & 4	462	22	194	379	140	60	50

2008 July 12 - 2010 July 11

2010 July 12 - 2012 July 11

GBM: Localization



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- **larger FoV then Swift**
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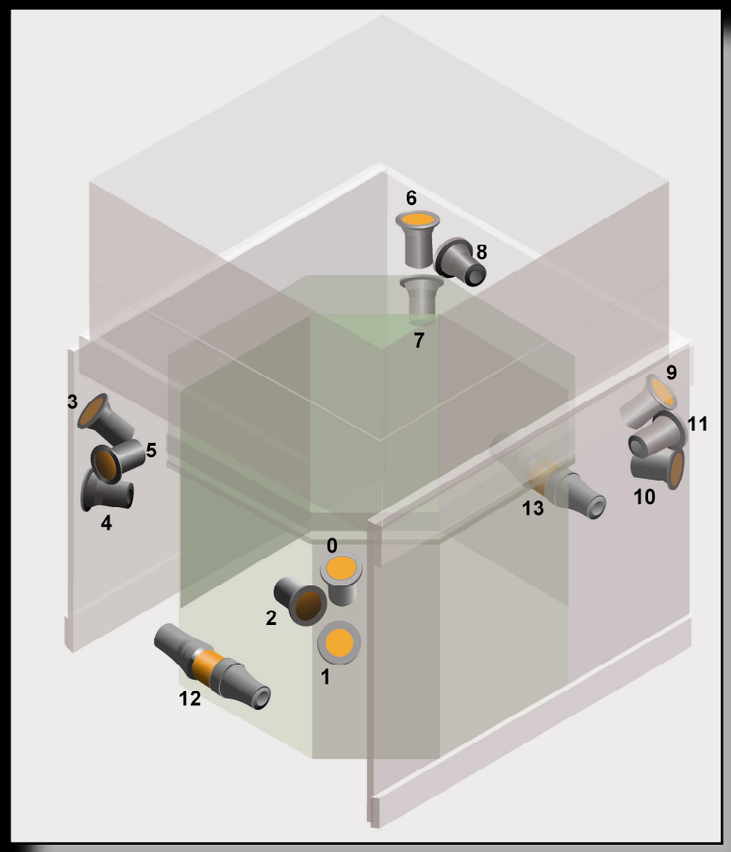

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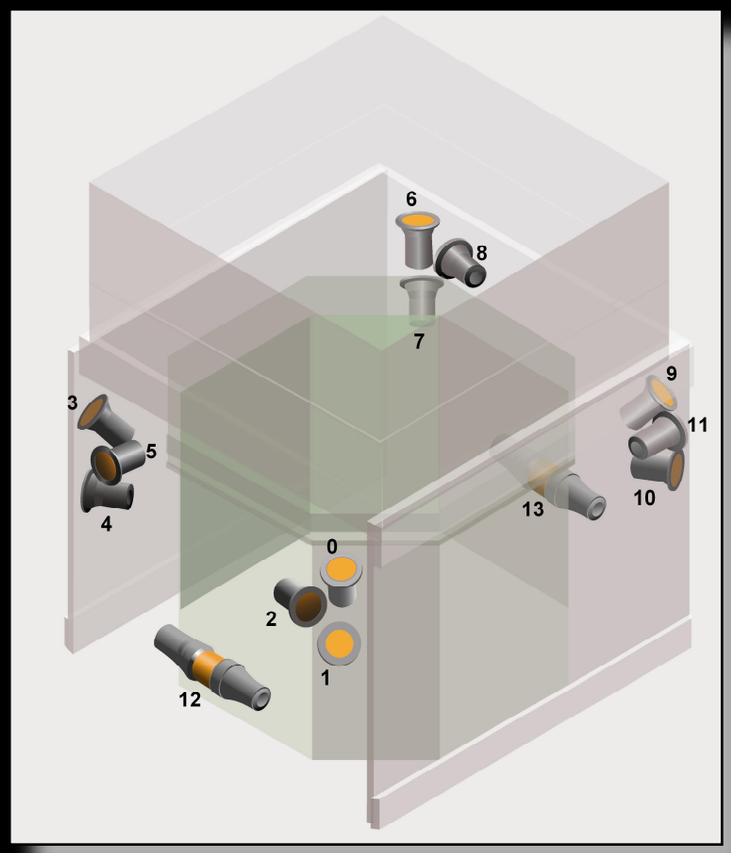

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- **statistical:**

  $\sigma_{stat} \geq 1^{o}$

- **systematical:**

  (vs Swift, INTEGRAL, IPN, or OT positions)

  $\sigma_{core} \sim 3^{o}$ **(~85%)**

  $\sigma_{tail} \sim 12^{o}$

- **under investigation by the GBM team**

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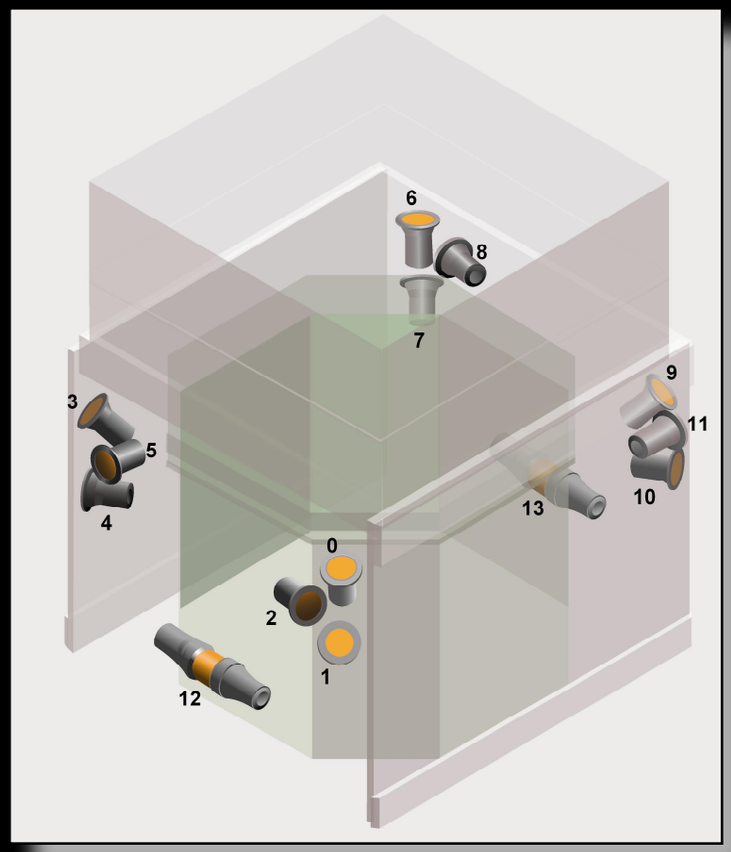

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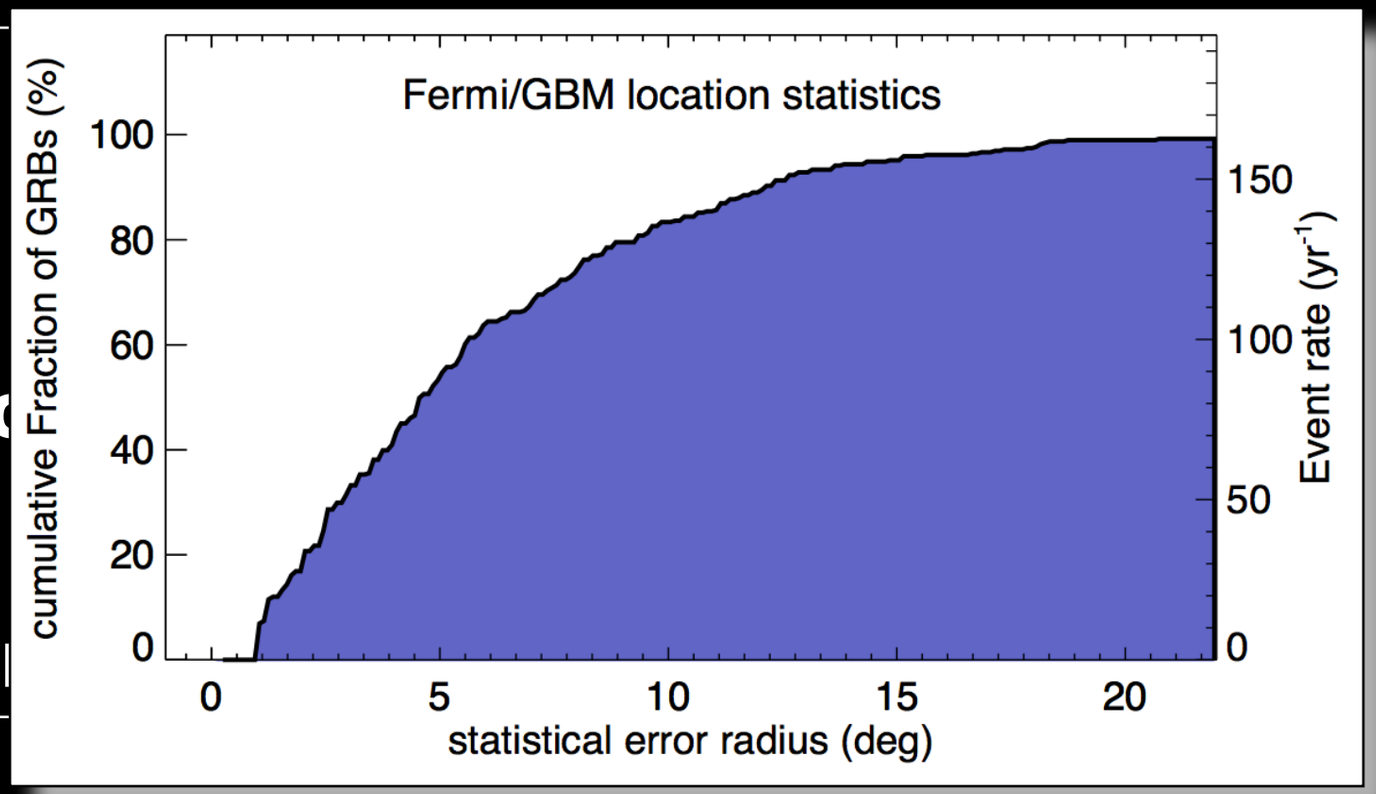

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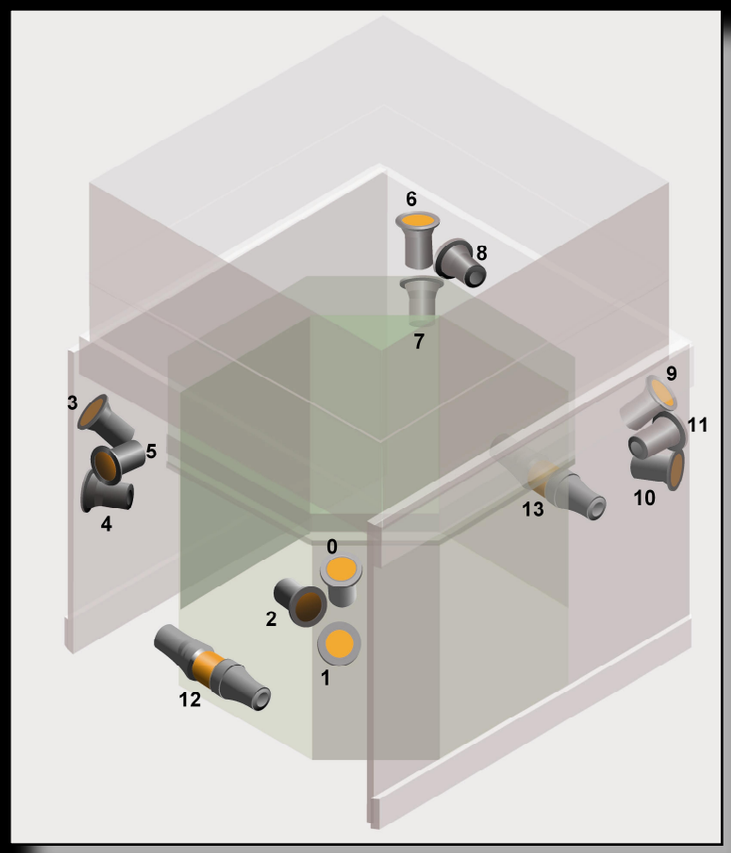

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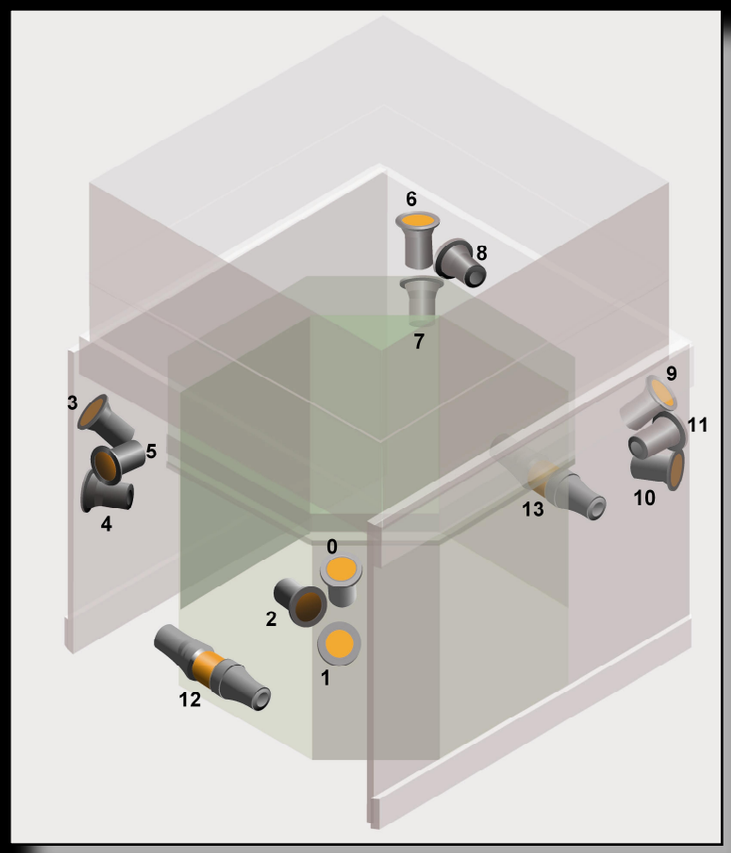

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Needs:

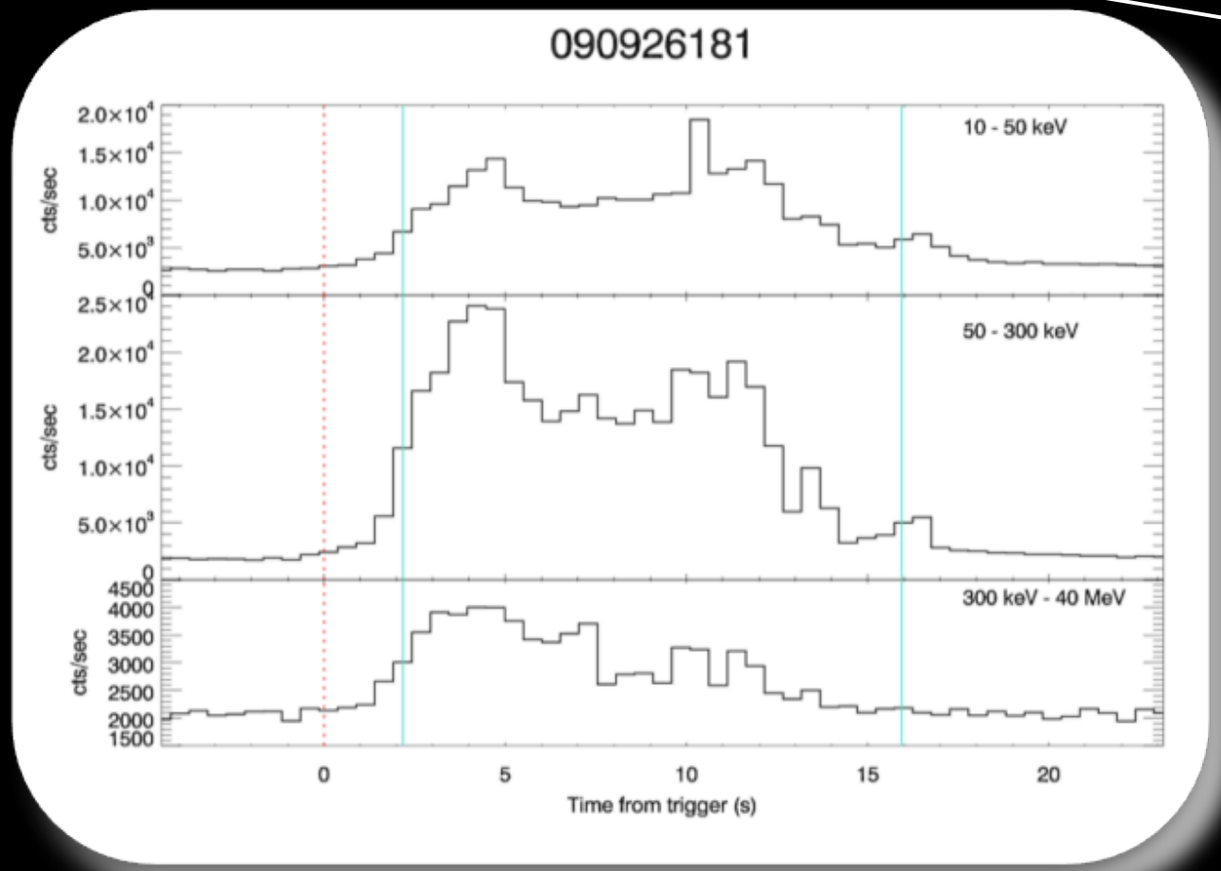
- **LAT, IPN, or ground-based wide-field surveys (e.g., PTF)**

GRB Catalog

Year 1 & 2 Catalog:
Paciesas, W.S. et al. 2012 ApJS 199, 18

Year 3 & 4 Catalog:
von Kienlin, A. et al. → in preparation

- Locations
  - RA, DEC
- Durations
  - (T_{50}, T_{90}) in 50–300 keV
- Peak flux (ph/cm^{2}s)
  - 64 ms, 256 ms, 1024 ms
  - 50 – 300 keV, 10 – 1000 keV
- Fluence (erg/cm^2)
  - 50 – 300 keV, 10 – 1000 keV
- Light curves ⇨



http://gammaray.nsstc.nasa.gov/gbm/science/grbs/month_listings/ (2008 07 – 2010 07)

- Catalog results are accessible on-line through FSSC ⇨

http://heasarc.gsfc.nasa.gov/W3Browse/fermi/fermigbrst.html

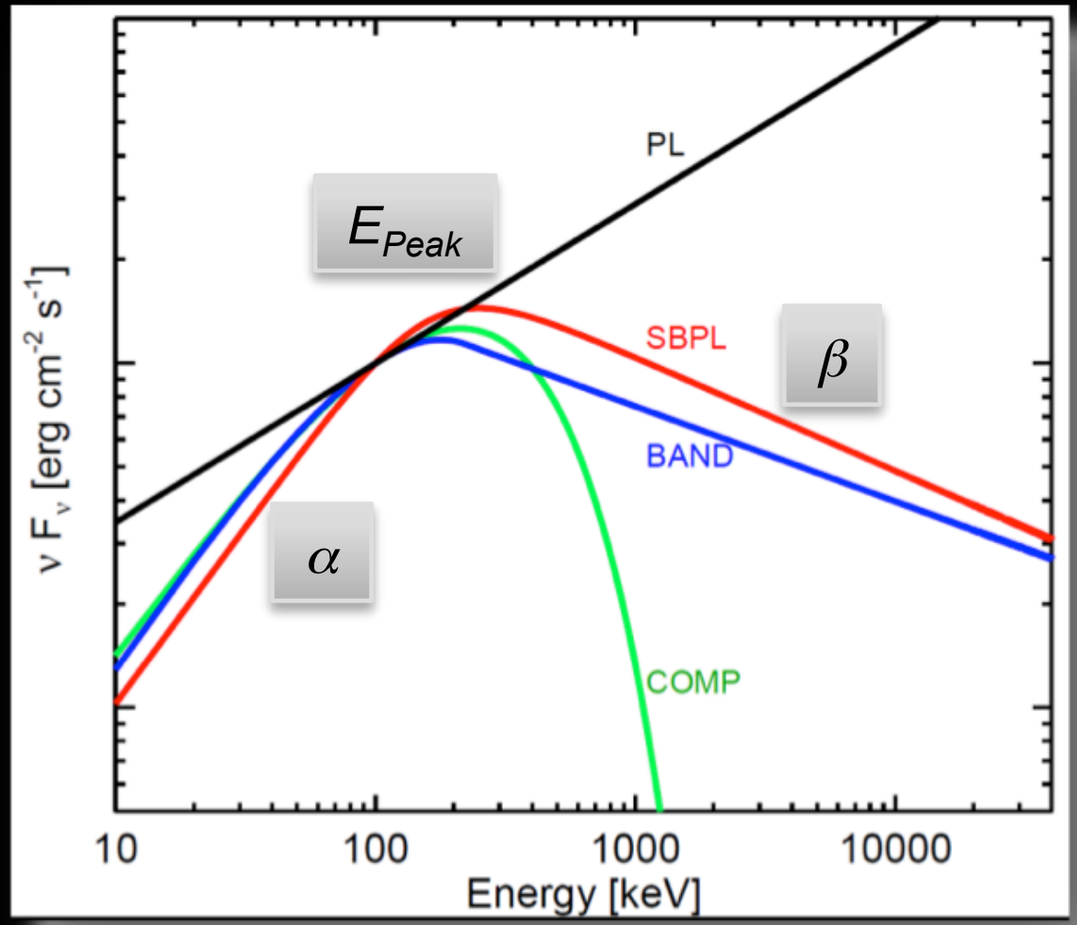
GBM GRB Spectral catalogs

- The “Peak Flux and Fluence” Spectral Catalog:
  - Two Spectra from all but the weakest GRBs:
    - 1.024 s Peak Flux Spectrum ⇨ Long GRB
    - 64 ms Peak Flux Spectrum ⇨ Short GRB
    - > 3.5 sigma integrated Fluence Spectrum
    - Year 1 & 2: 487 GRBs, ~3800 spectra
    - Year 3 & 4: ~450 GRBs, ~3600 spectra
  - BATSE Heritage: Mallozzi et al. 1995; Goldstein et al. 2012

Year 1 & 2 Spectral Catalog:
Goldstein, A. et al. 2012 ApJS 199, 19

Year 3 & 4 Spectral Catalog:
Gruber, D. et al. → in preparation

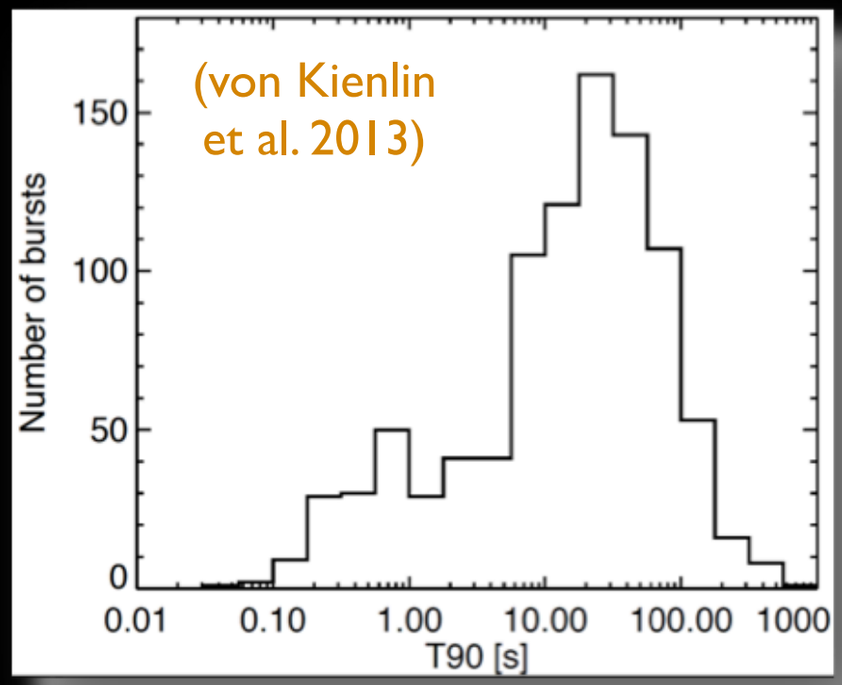
- Four Spectral Models Fit to each spectrum:
  - Power Law: A & α
  - Exponentially-attenuated Power Law (“Comptonized”): A, α & E_{peak}
  - Band function: A, α, β & E_{peak}
  - Smoothly-Broken Power Law: A, α, β, Δ & E_{break}
    - For current analysis Δ fixed to 0.3 !
- Catalog results are accessible on-line through FSSC



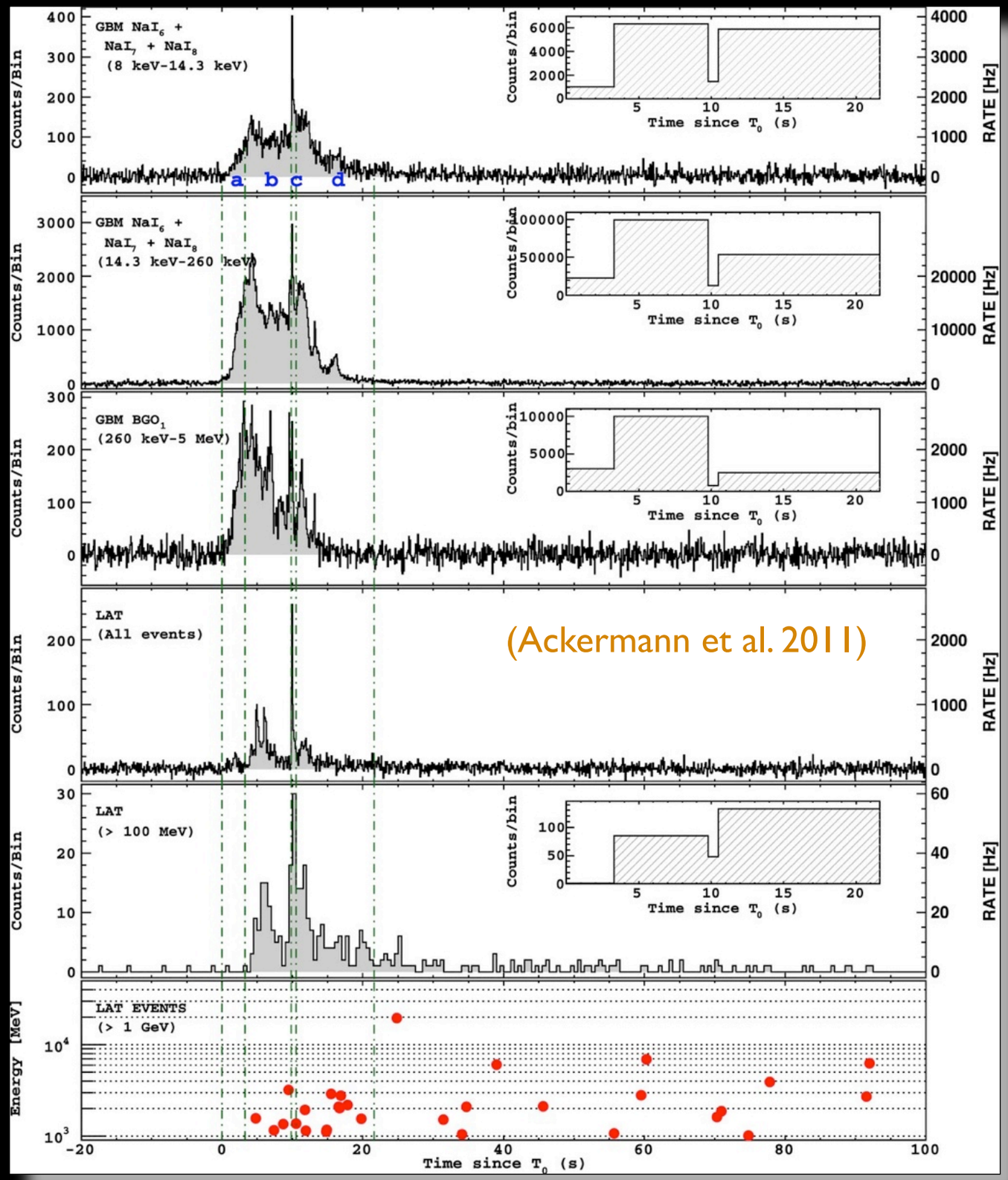
Fermi: Hightlights I

Lightcurves:

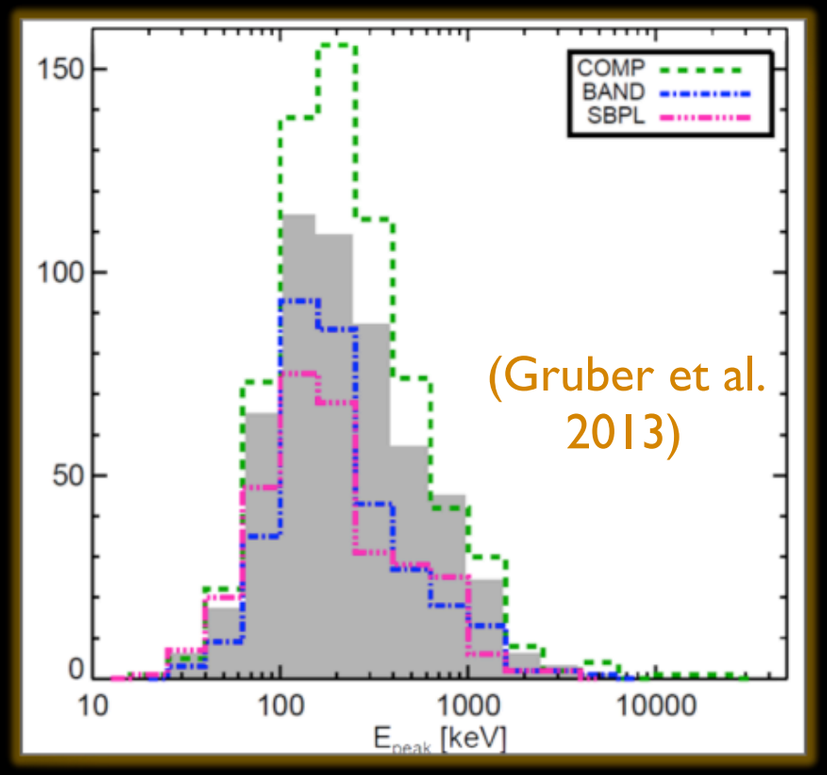
- **known bimodal distribution**



- **onset of high energy emission lags**
- **soft to hard to soft evolution**
- **persistent high energy emission (afterglow?)**



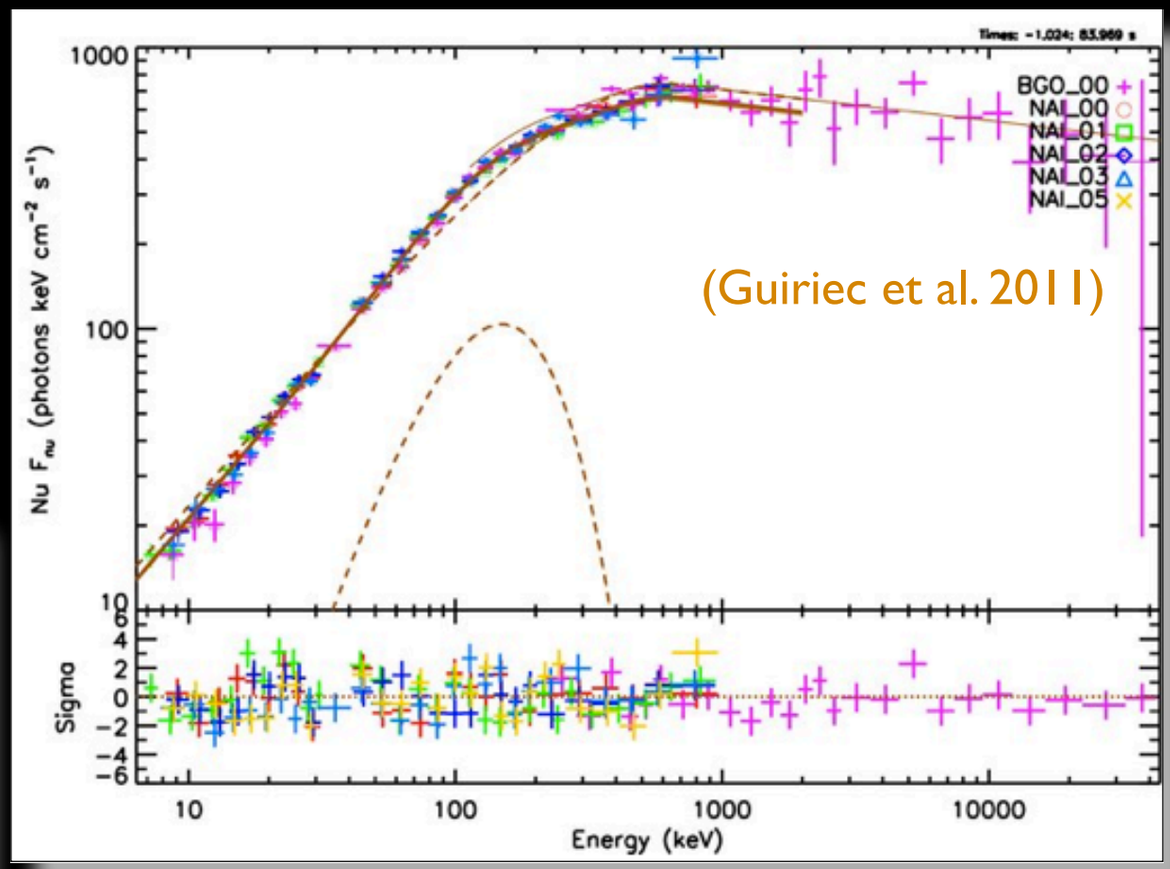
Fermi: Hightlights II



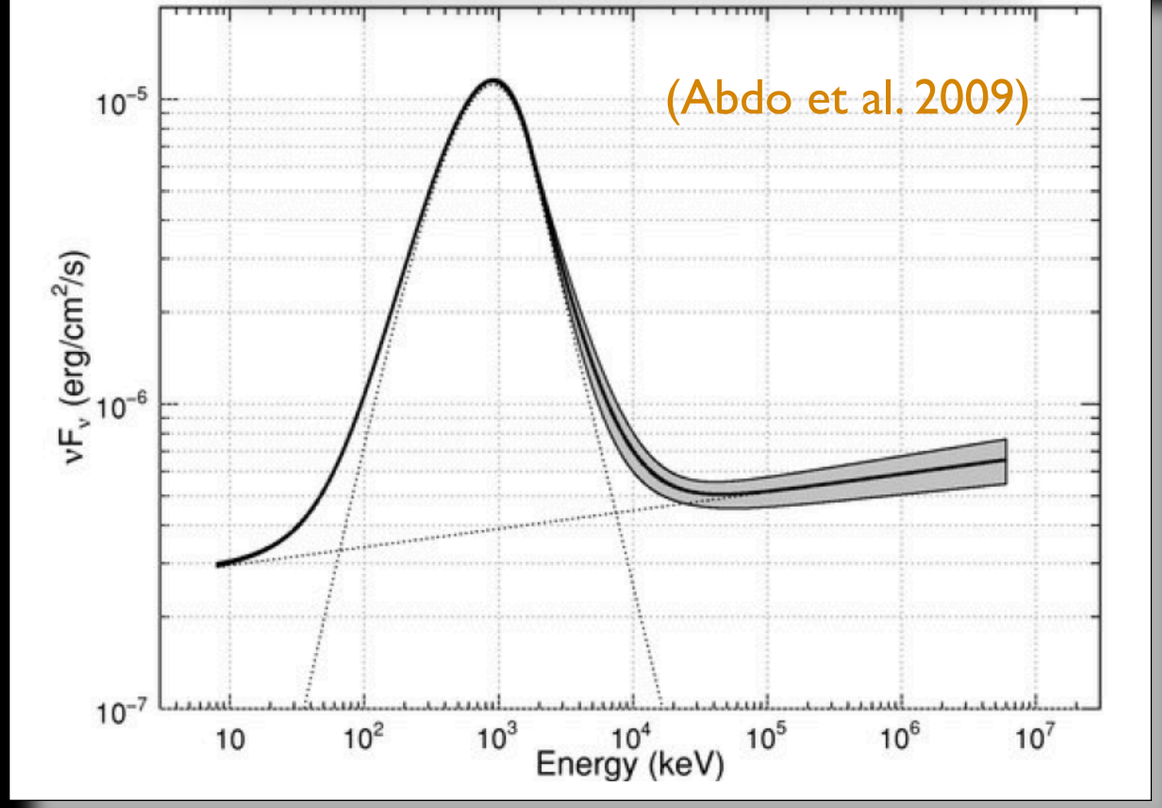
(Gruber et al. 2013)

Spectra:

- **no surprises with E_{peak}**



(Guiriec et al. 2011)

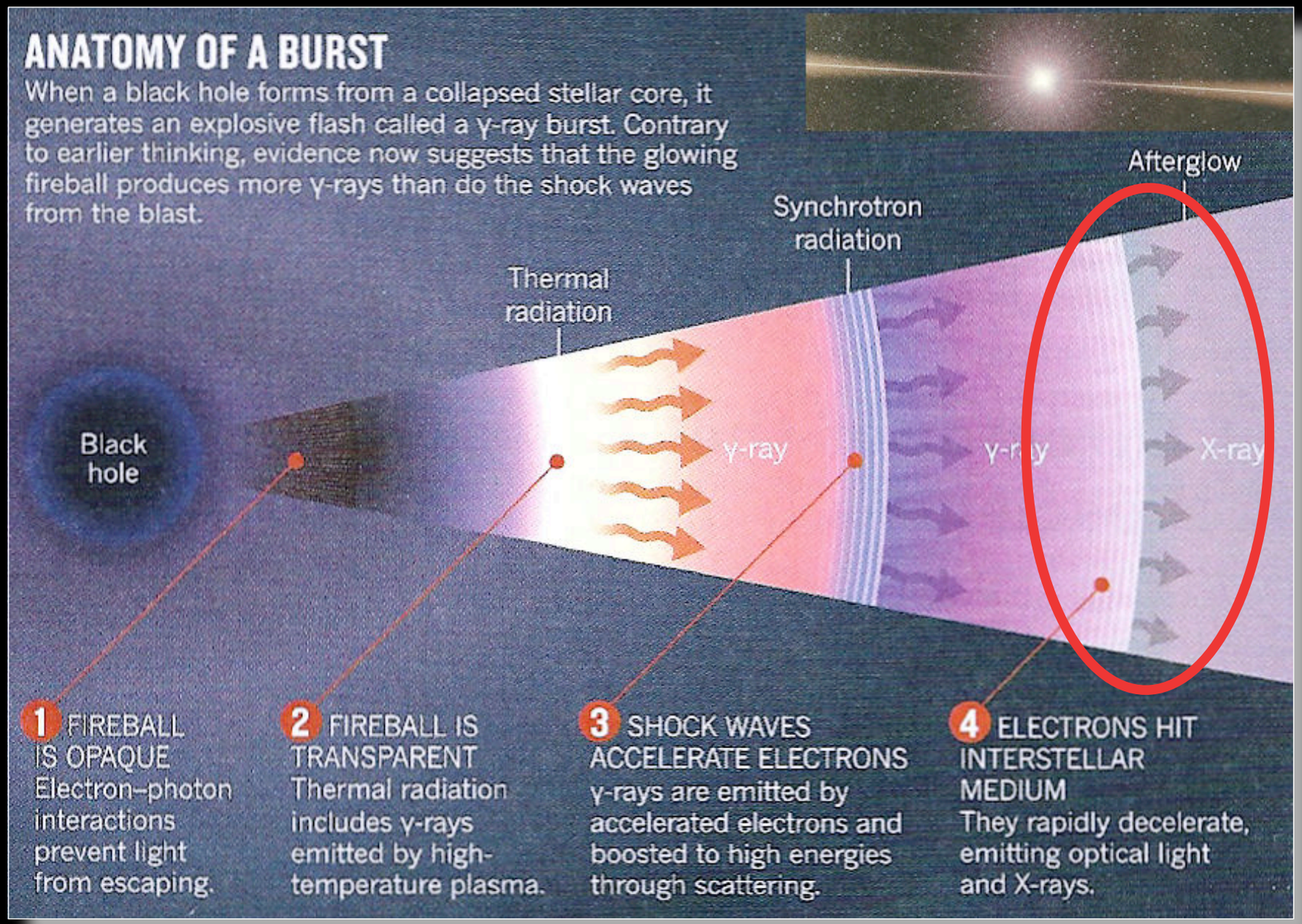


(Abdo et al. 2009)

Not just Band function:

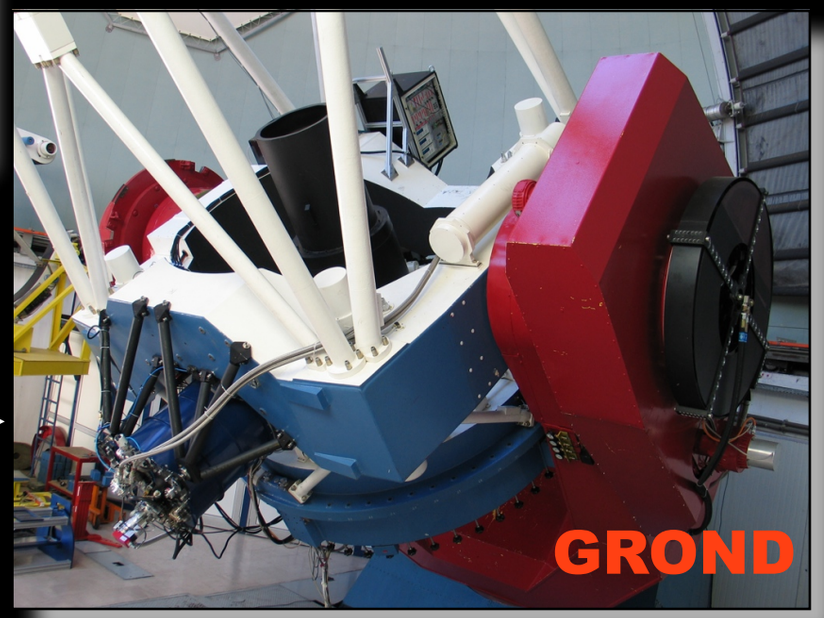
- **thermal component (?)**
- **additional high (and low) energy component**

Gamma-ray Bursts



Afterglow probes:

- **central engine**
- **jet physics**
- **progenitor environment**
- **(host environment)**



The Gamma-Ray burst Optical Near-infrared Detector (GROND)

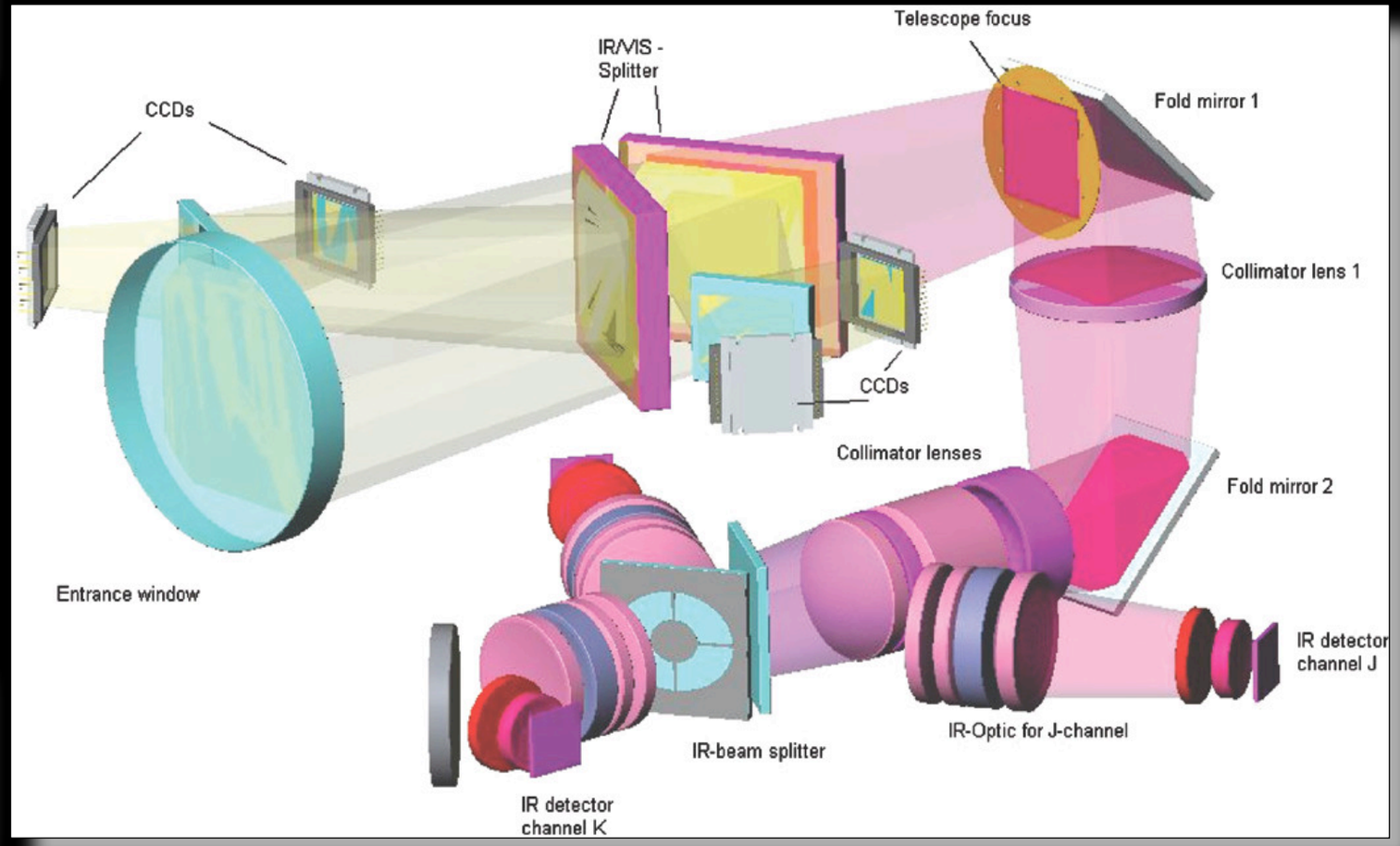
Telescope

- **2.2m MPG/ESO telescope in La Silla (Chile)**
- **permanently mounted**
- **first light 2007**
- **PI Jochen Greiner (MPE)**

Instrument

- **7-bands simultaneously**
- **g', r', i', z', J, H, K**
- **4000-25000 Angstroem**
- **5.4 x 5.4 amin in optical**
- **10 x 10 amin in near-IR**
- **in 8 min**

g'	r'	i'	z'	J	H	K
23.0	23.0	22.5	22.2	20.6	20.1	19.4



GROND: Operation (GRBs)

Always alert:

- **operated in Target of Opportunity (Rapid Response) Mode**
- **direct link to GCN**
- **on target as short as 2min post-trigger, 4-5min typical for night bursts**
- **observe every visible burst, as long as possible (completeness)**

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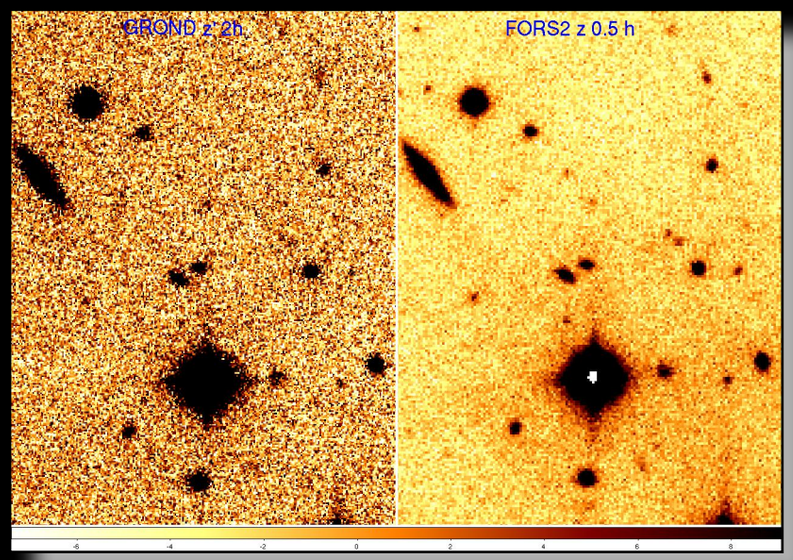
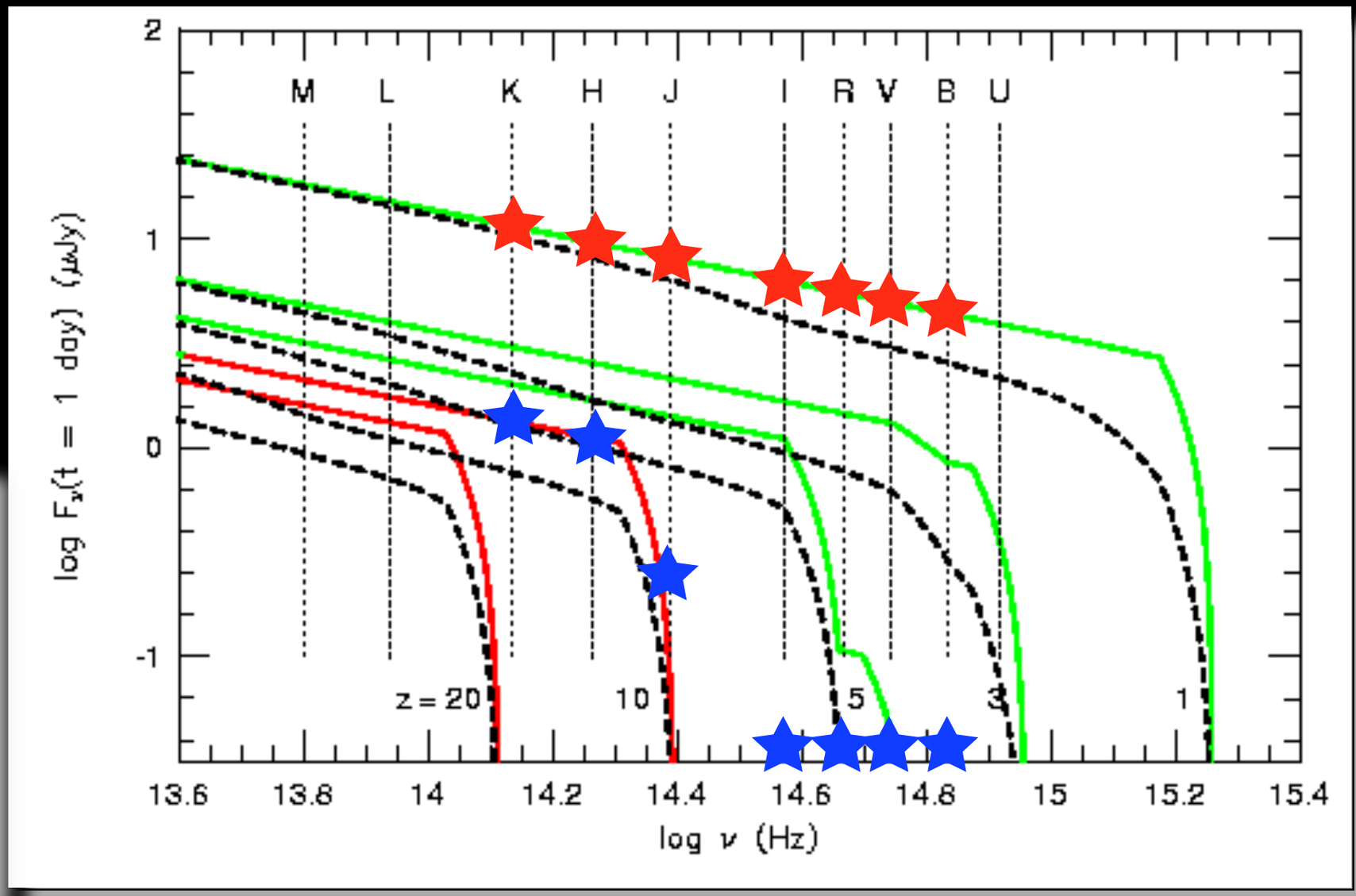
Products

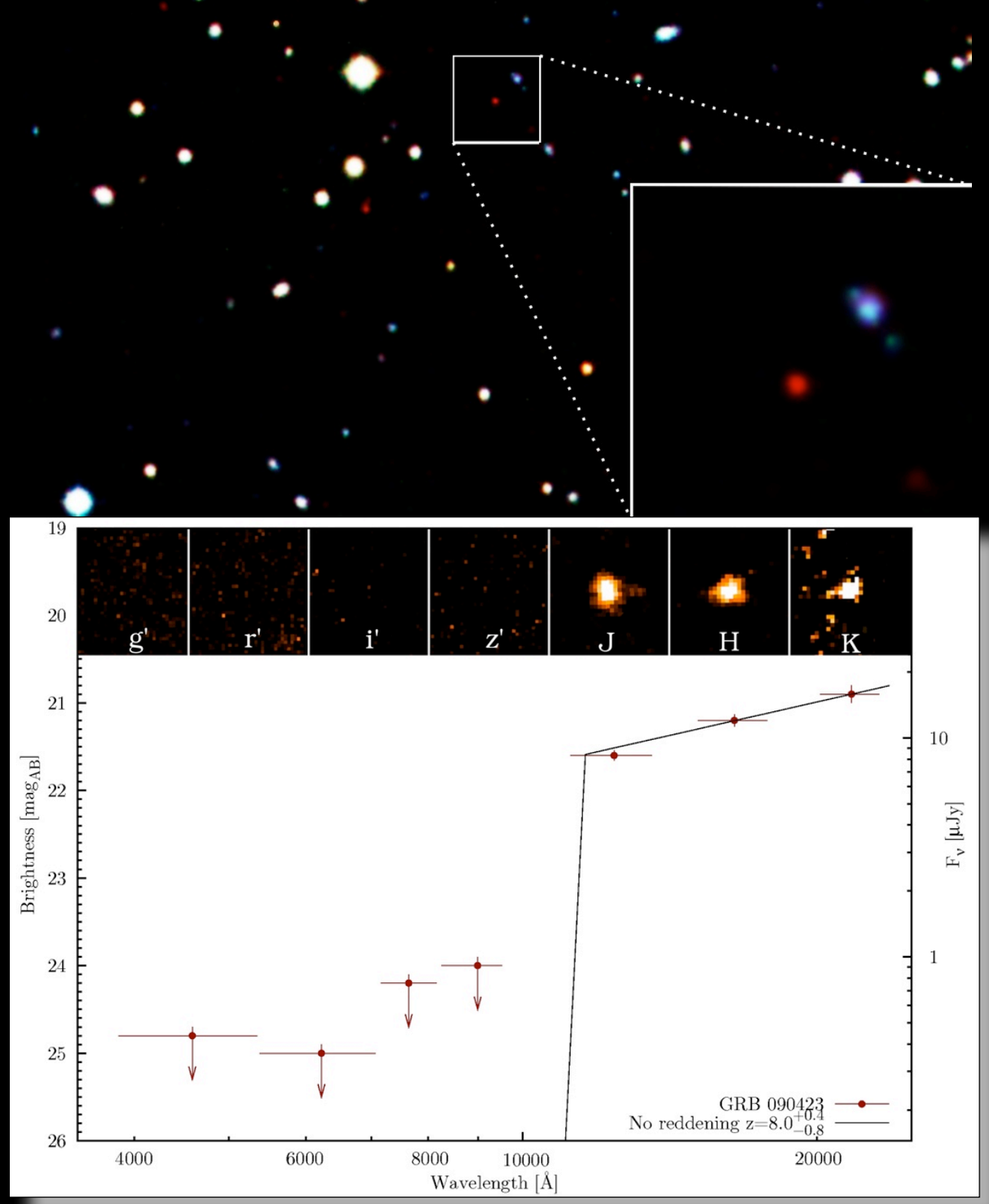
- **SEDs**
- **photo-z**
- **light curves**
- **within ~15min**

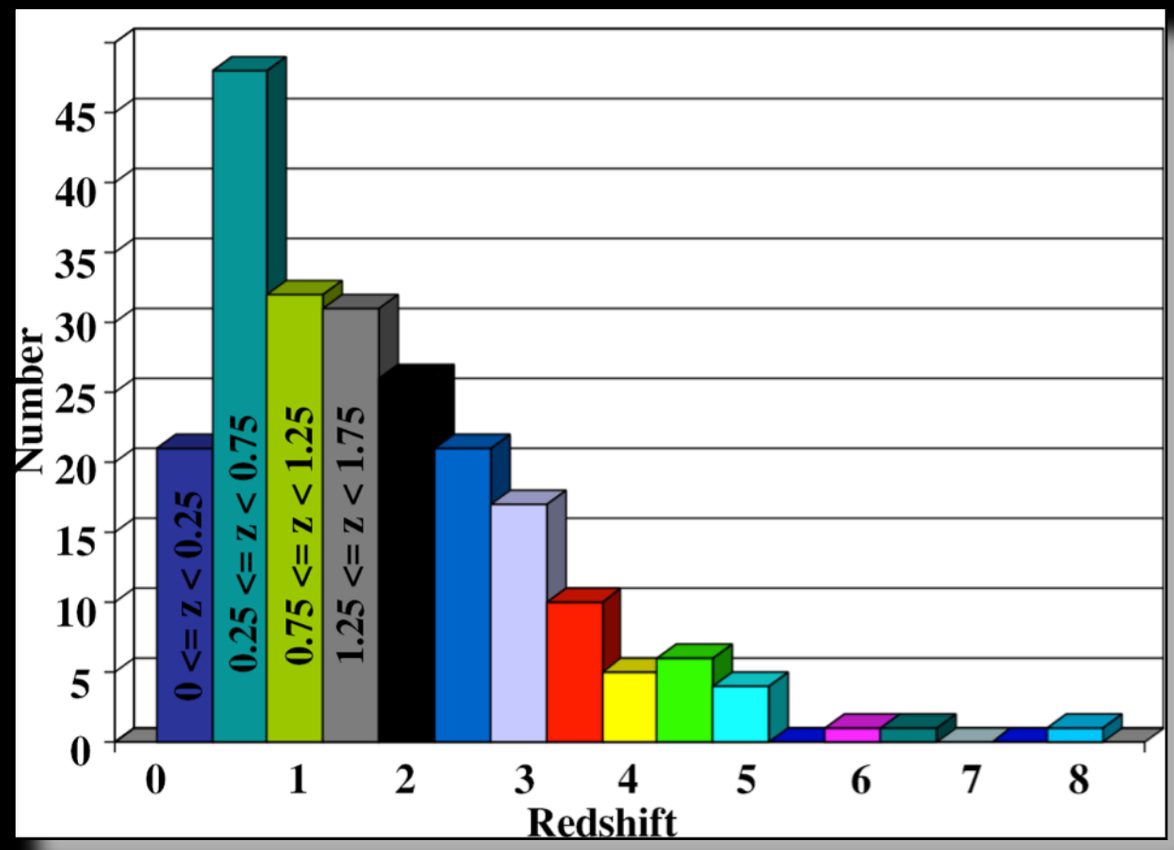




GROND: Photometric Redshifts

GRB 090423





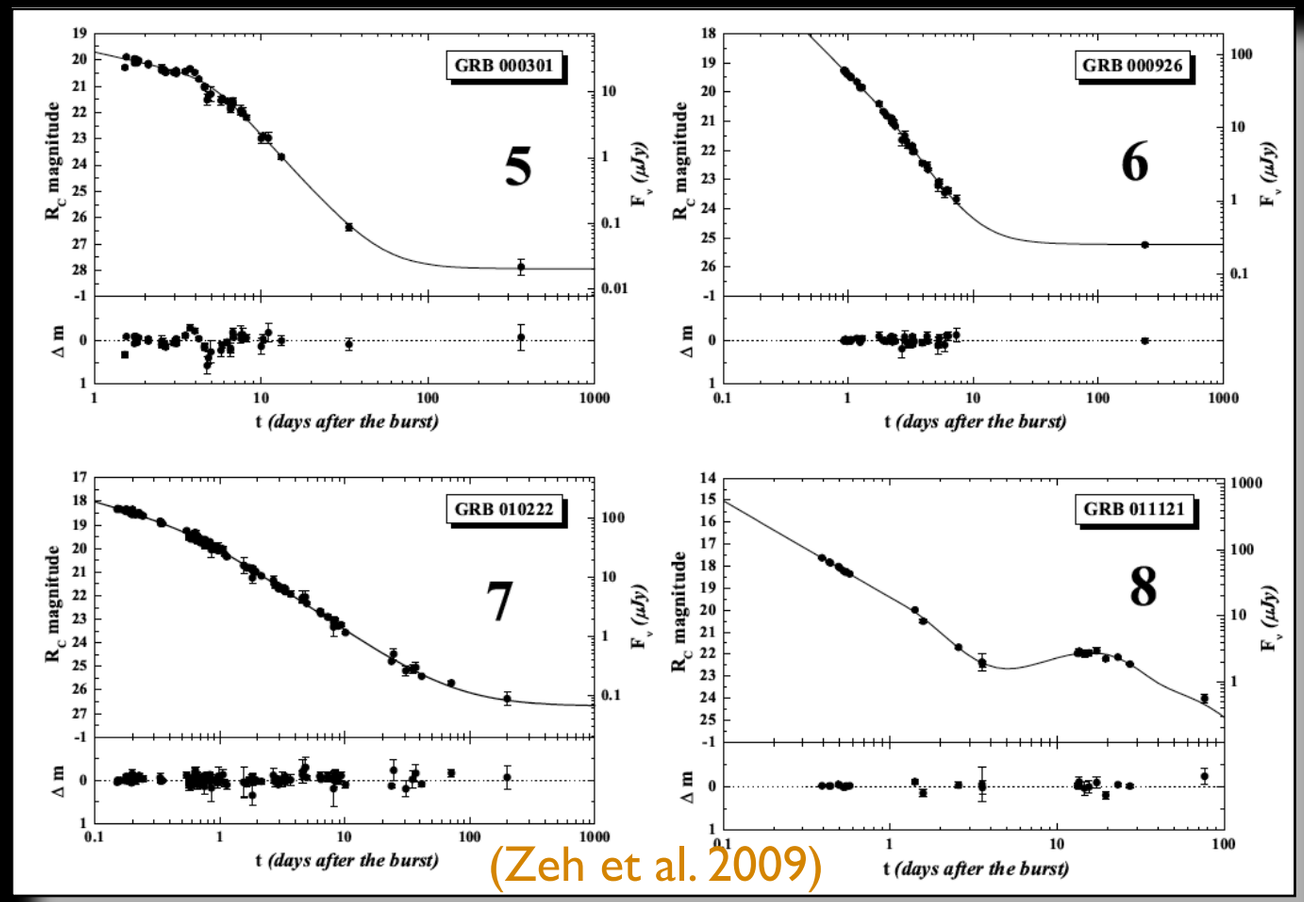
Establishing records:

- **080913 at z=6.7**
- **090423 at z=8.2**
- **090429B at z~9.4**

GROND: Lightcurves

Not a simple broken powerlaw

- **multiple jets**
- **flares**
- **jumps**
- **chromaticity**



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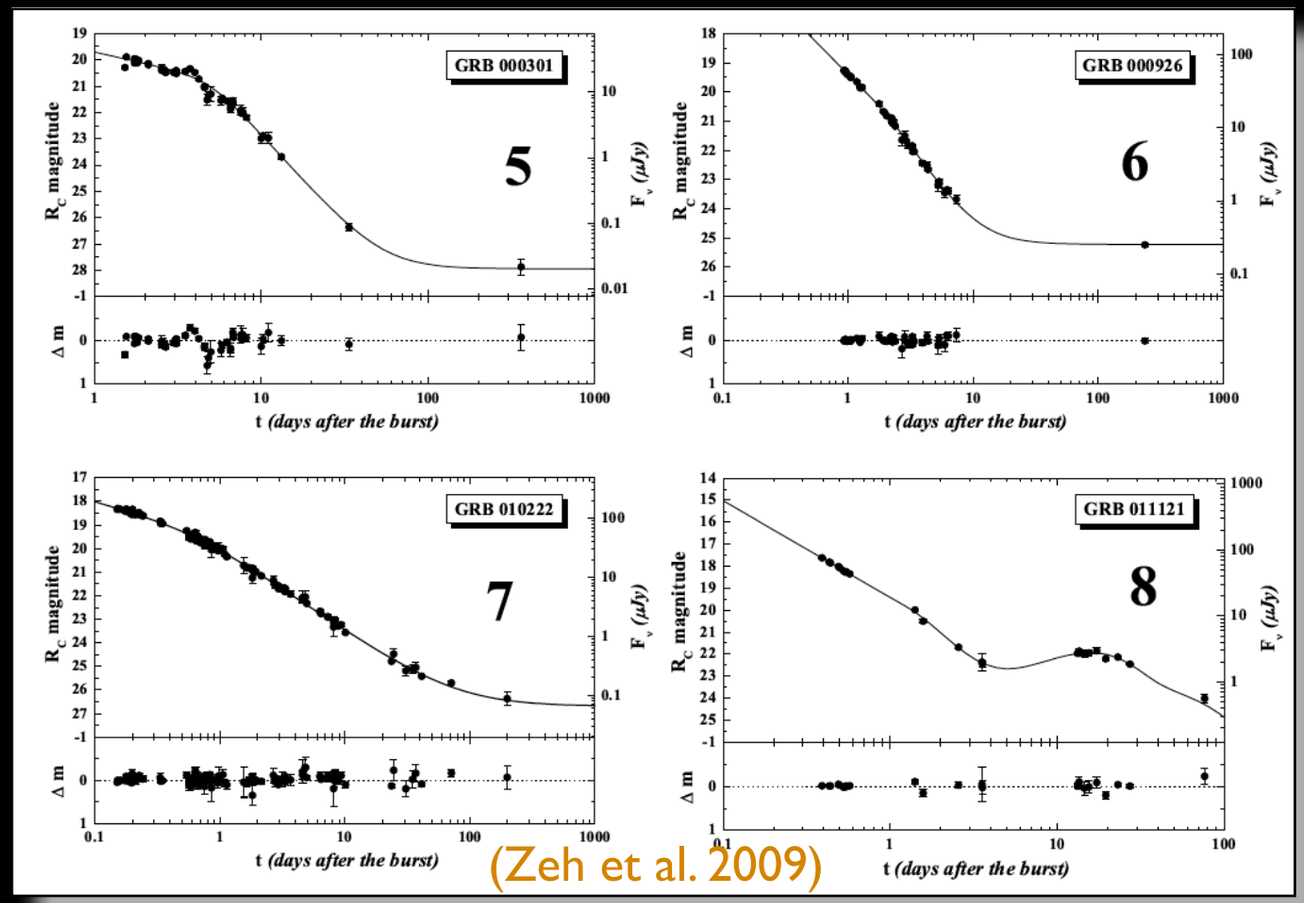

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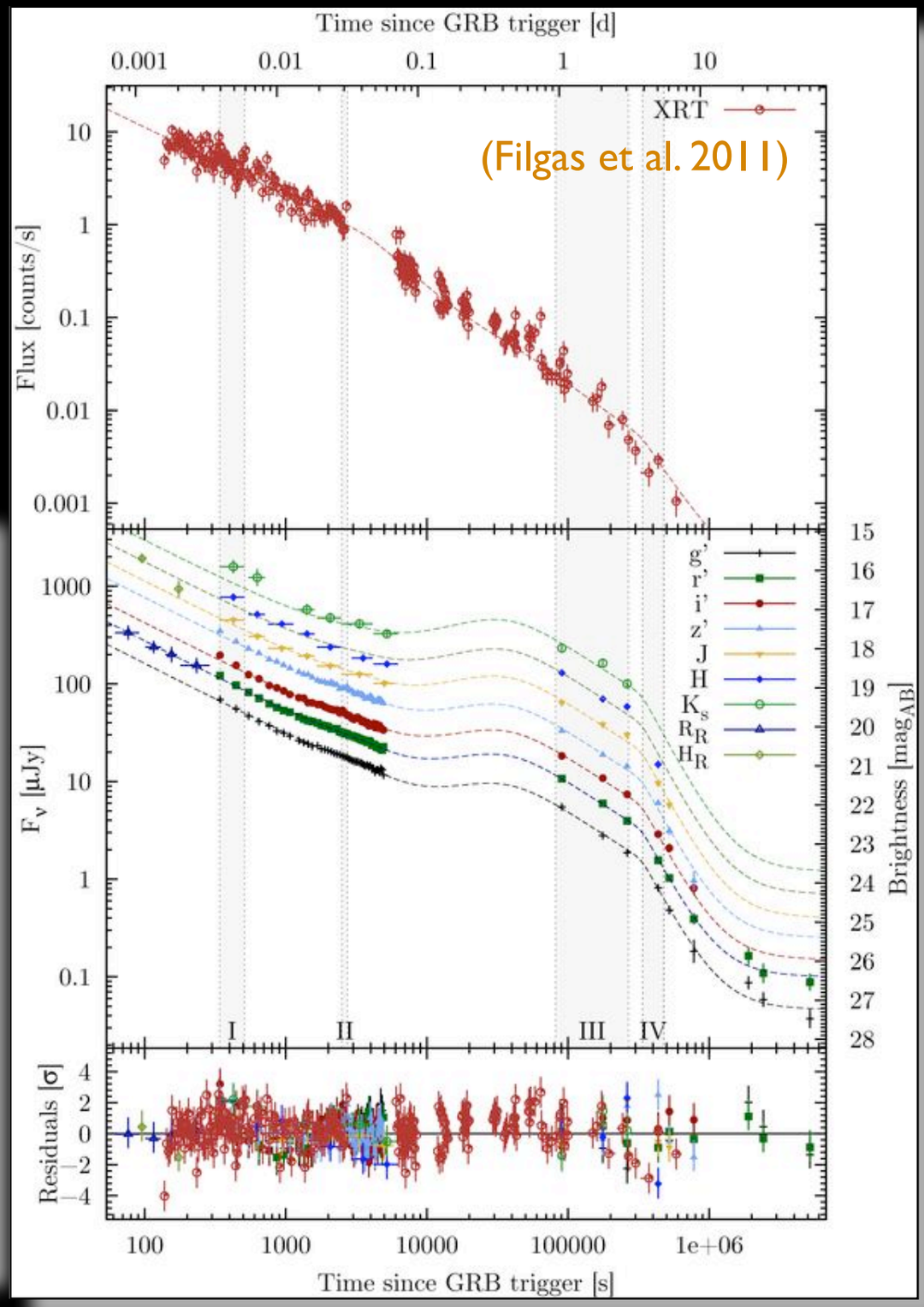

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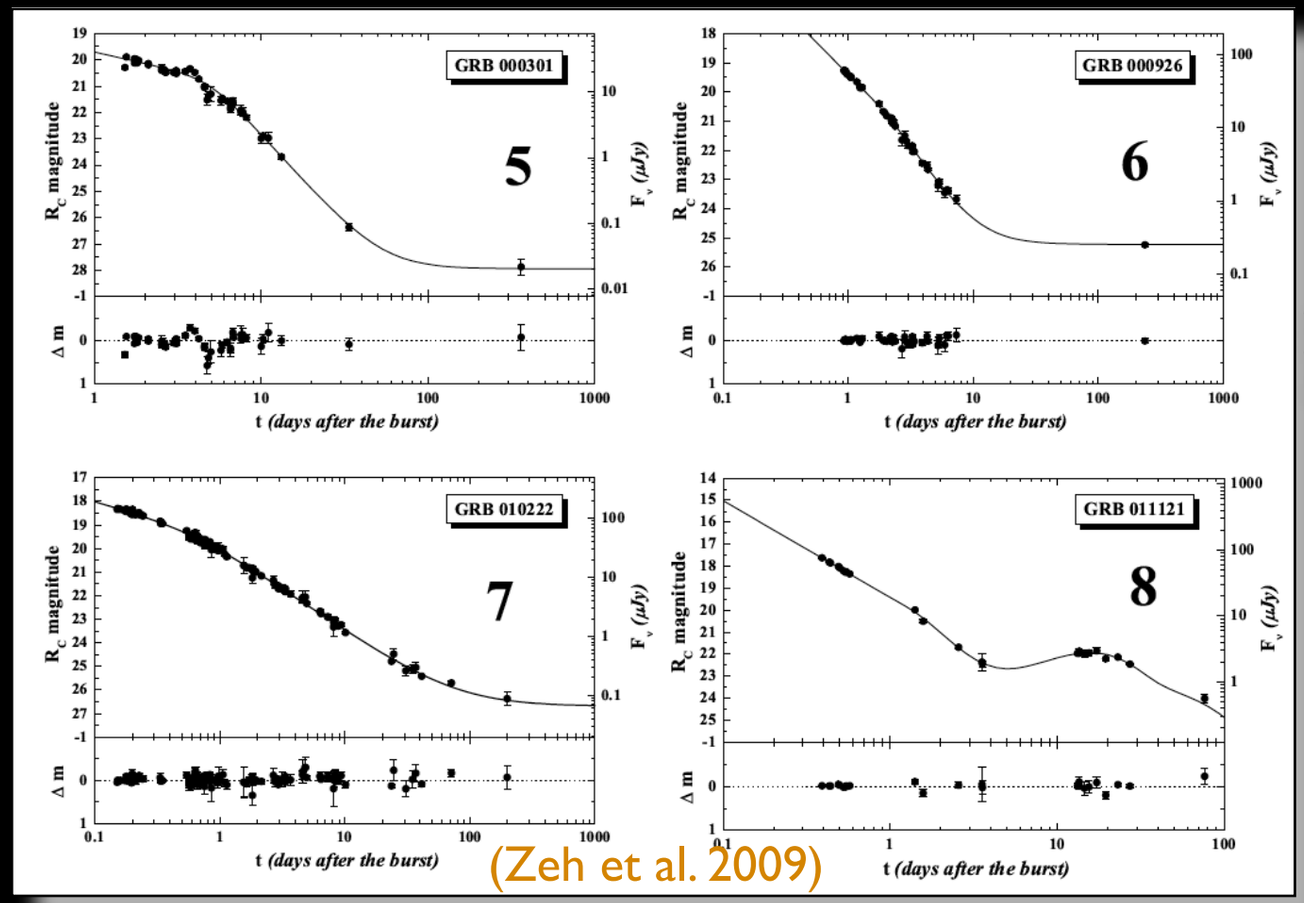

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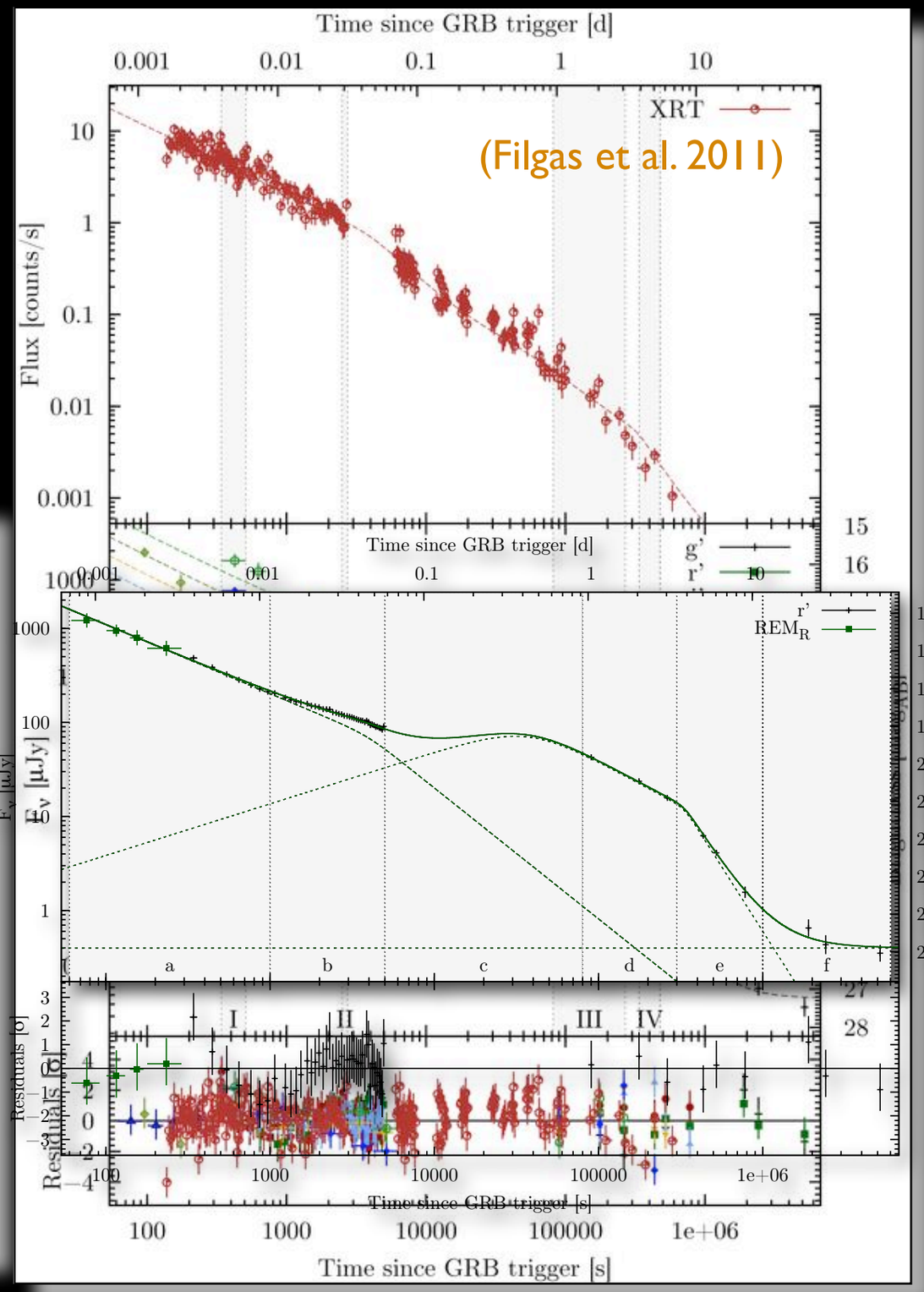

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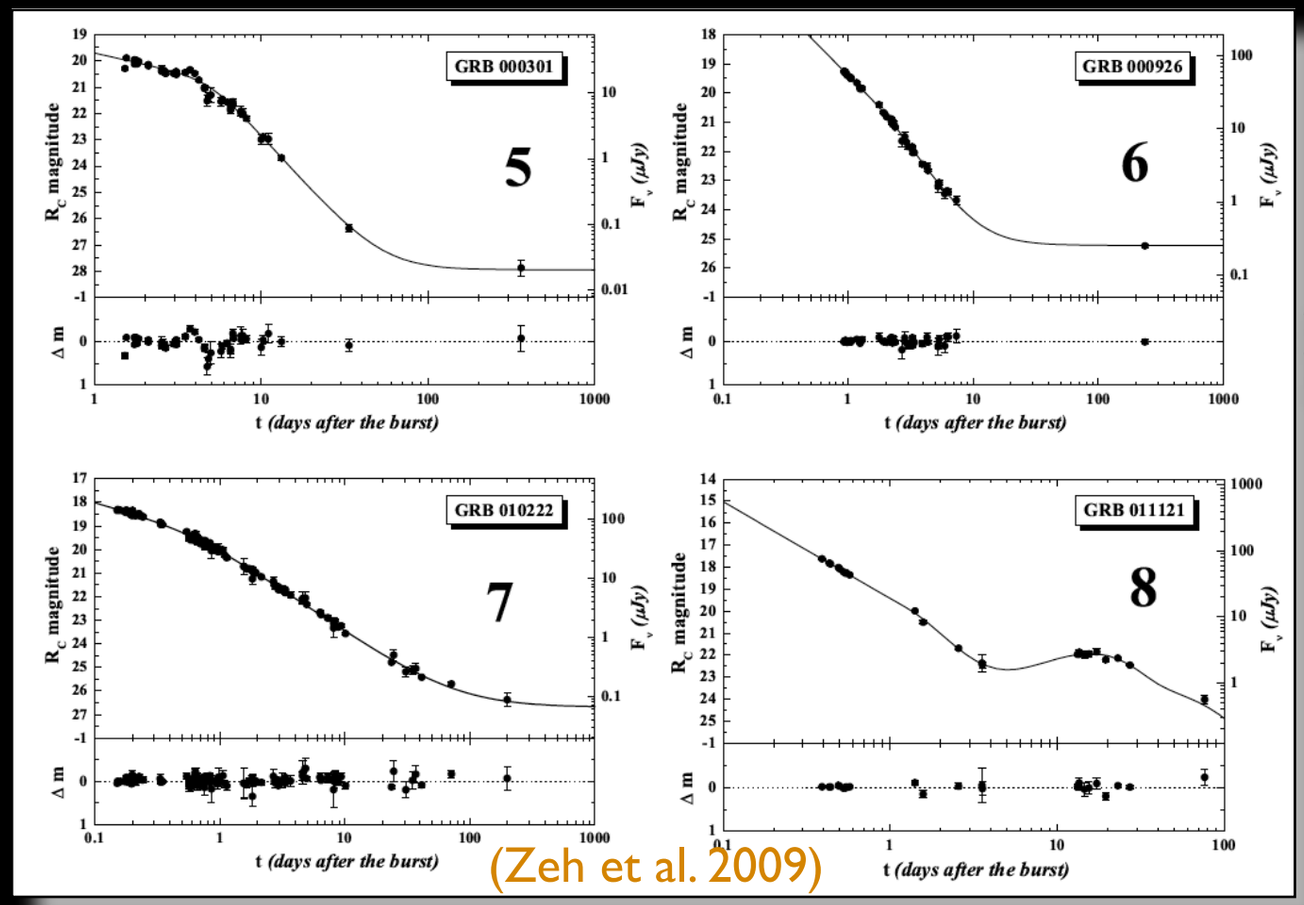

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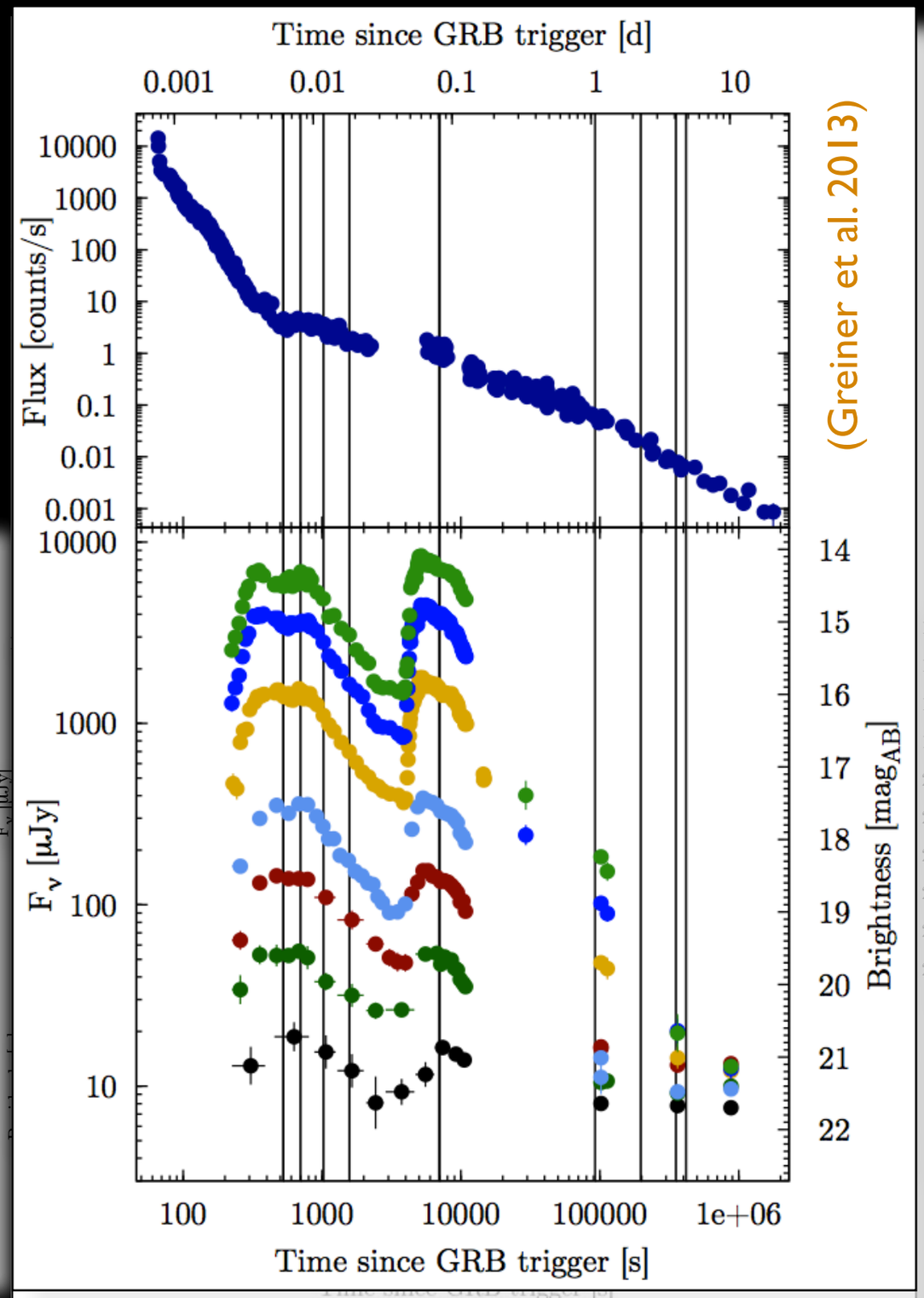

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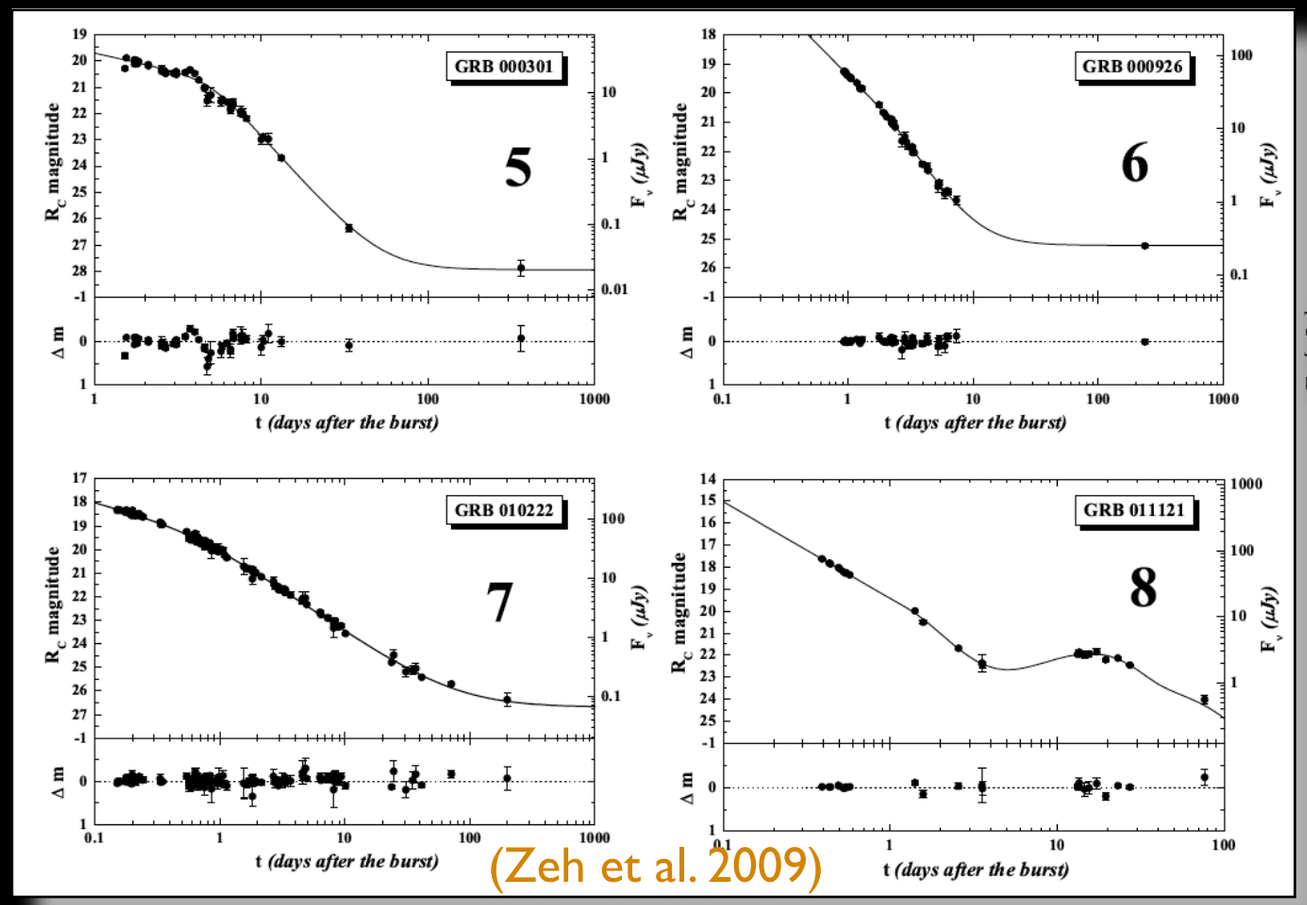

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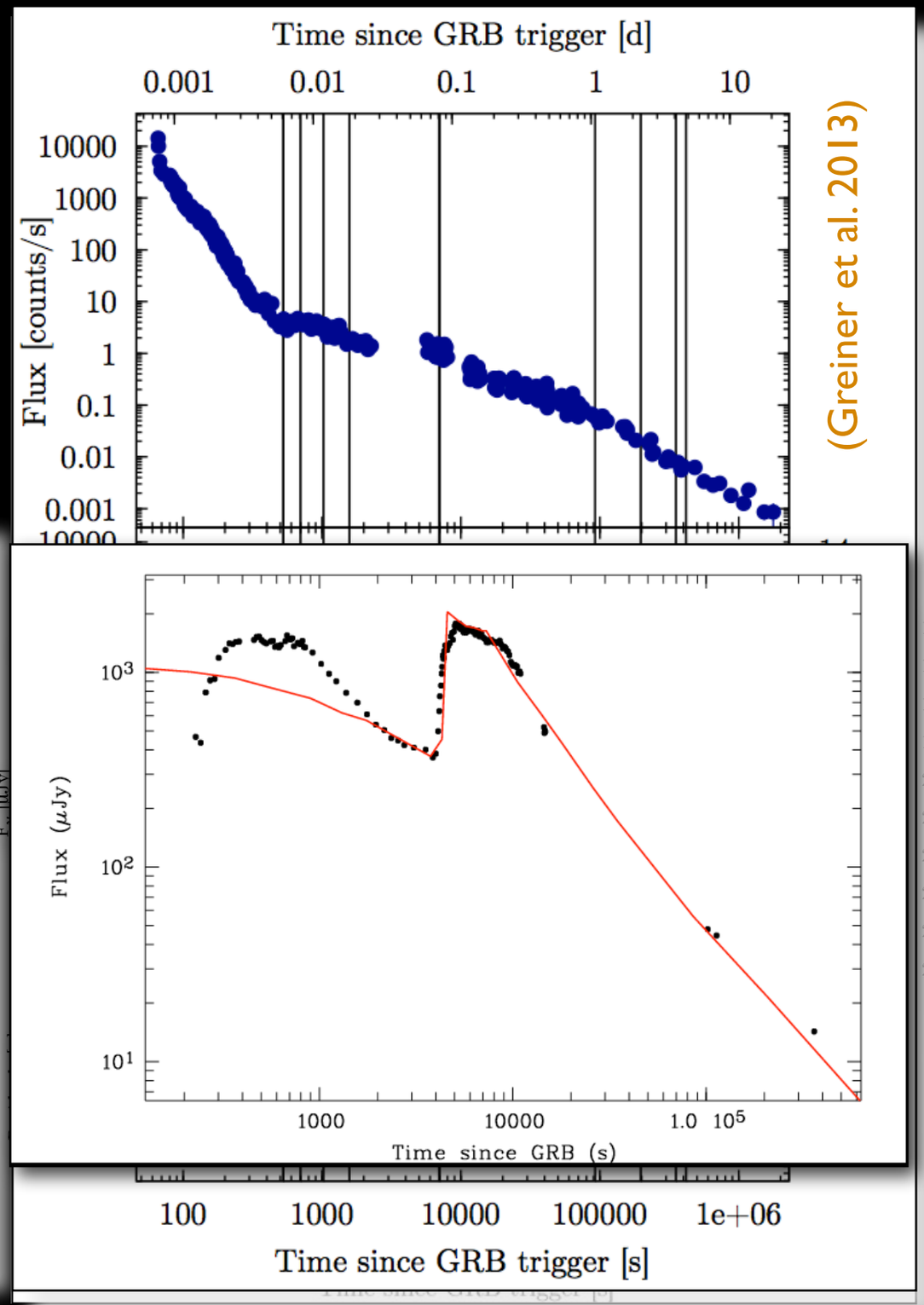
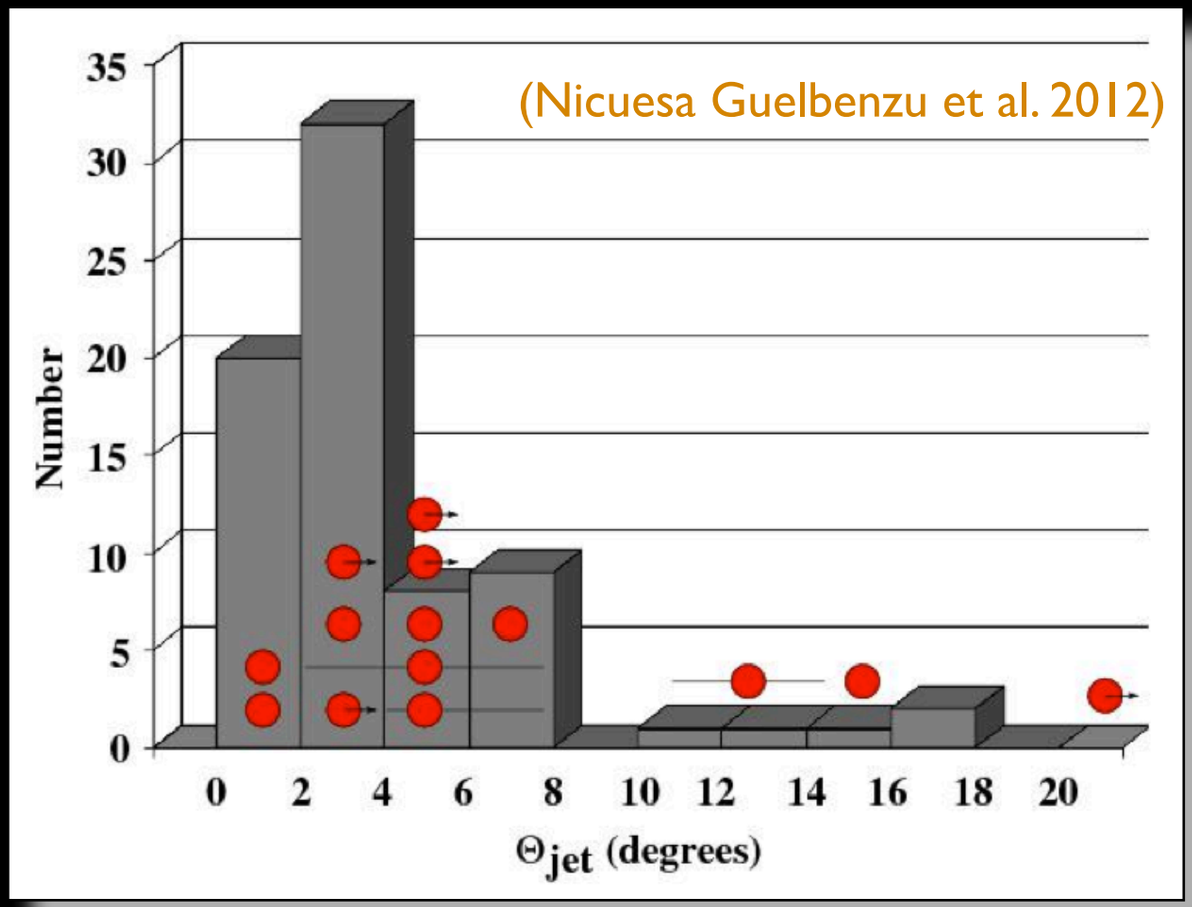


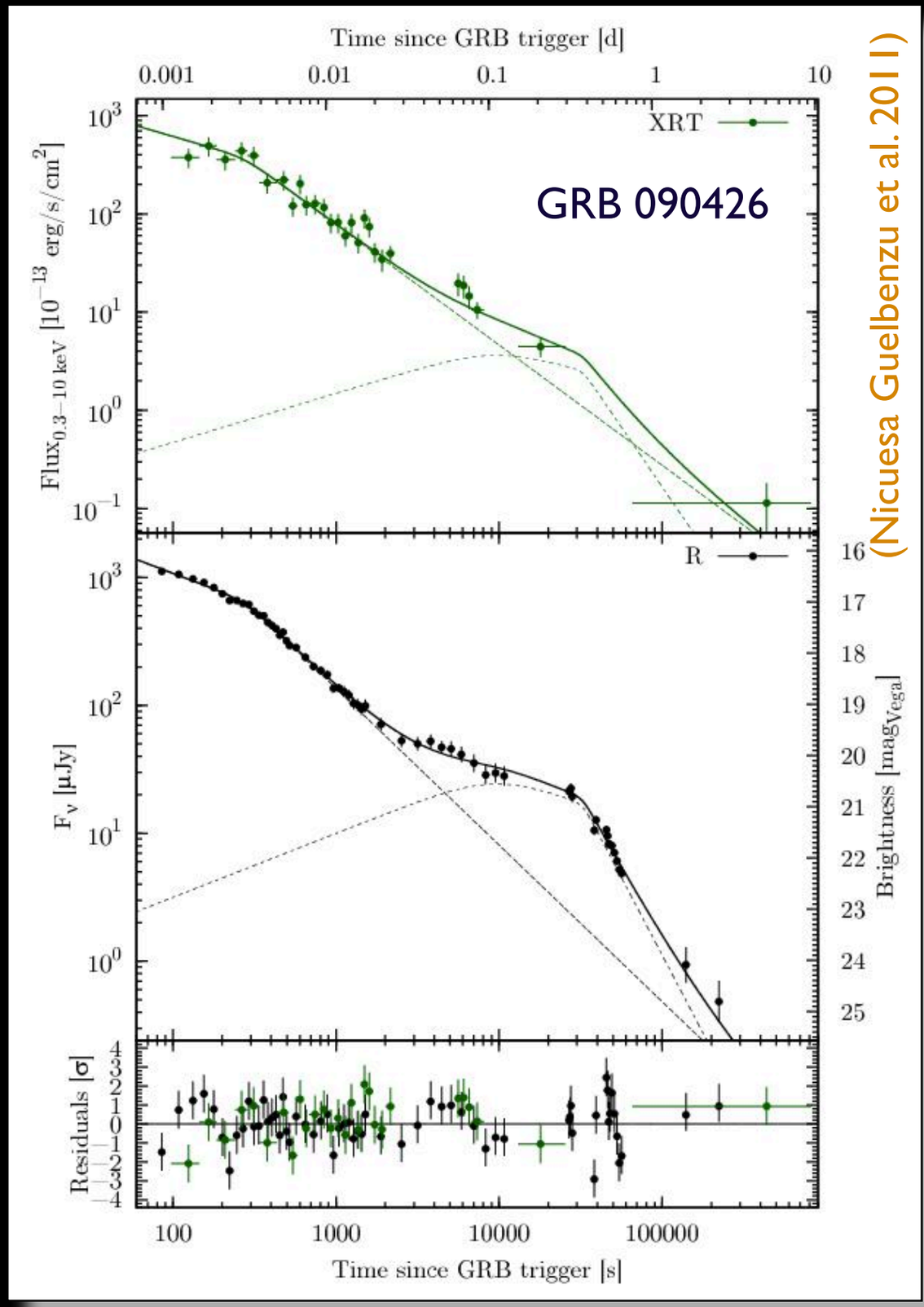
(Greiner et al. 2013)

GROND: Short Bursts

- **detailed lightcruves**
- **jet breaks**
- **classification (090426 (z=2.6) short but likely collapsar)**
- **jet opening angles larger?**



(Nicuesa Guelbenzu et al. 2012)

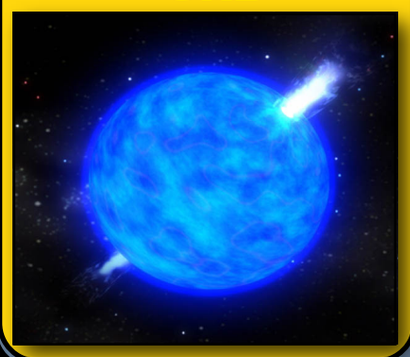


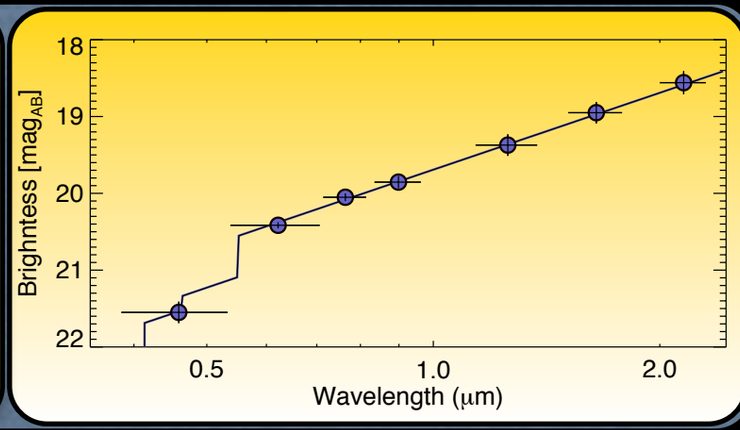
(Nicuesa Guelbenzu et al. 2011)

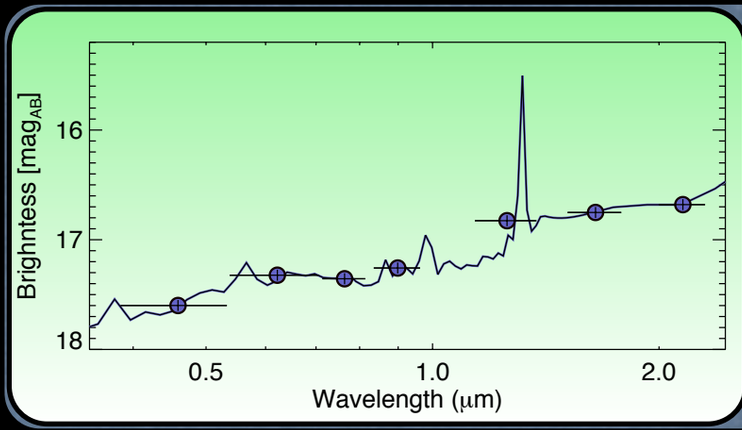
Source Typing with SEDs from GROND

(Arne Rau 2012)

GRB

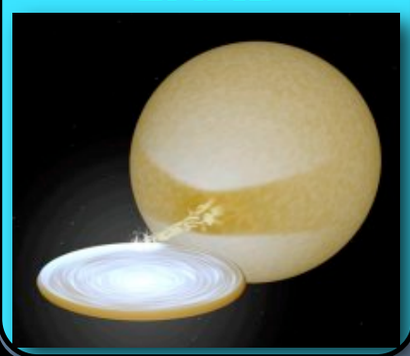


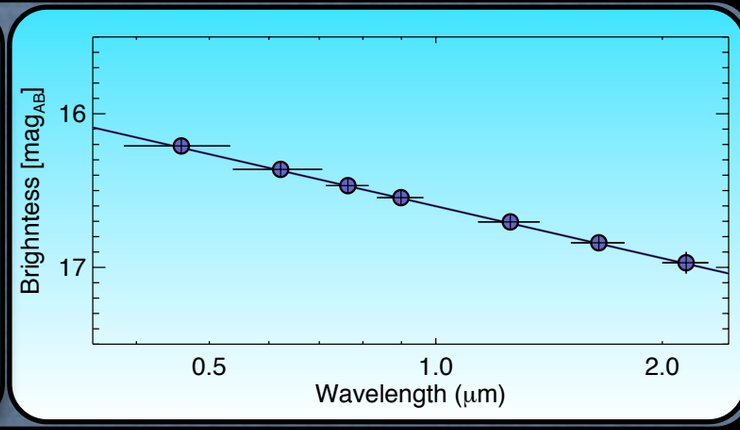


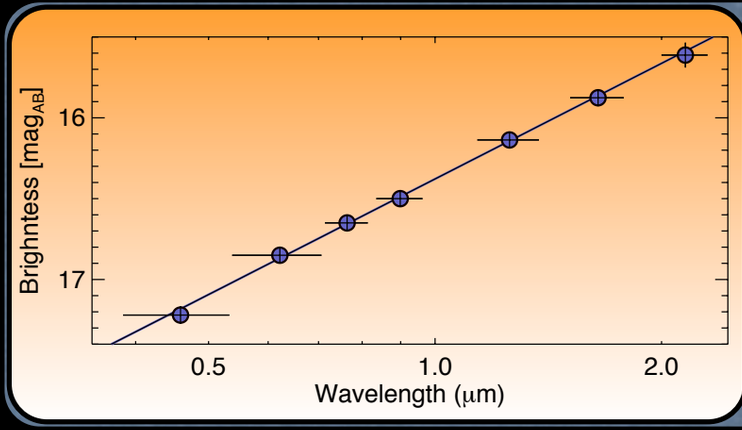


AGN

LMXB

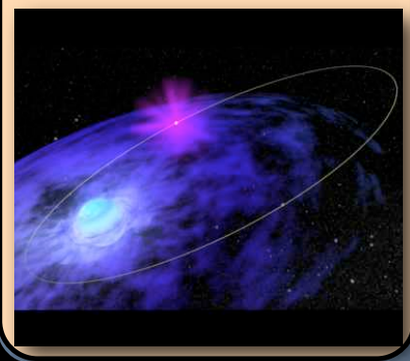


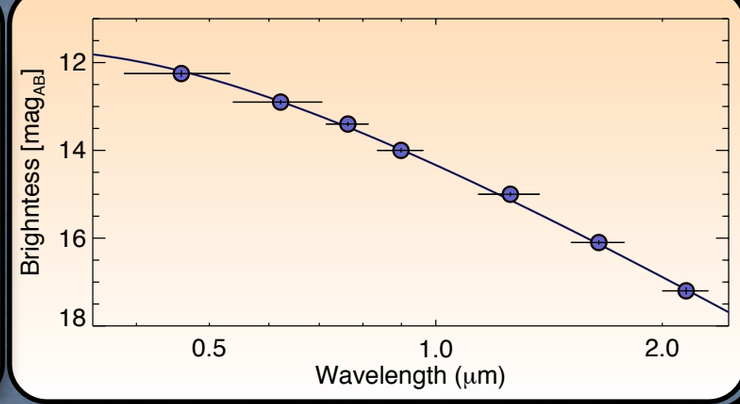


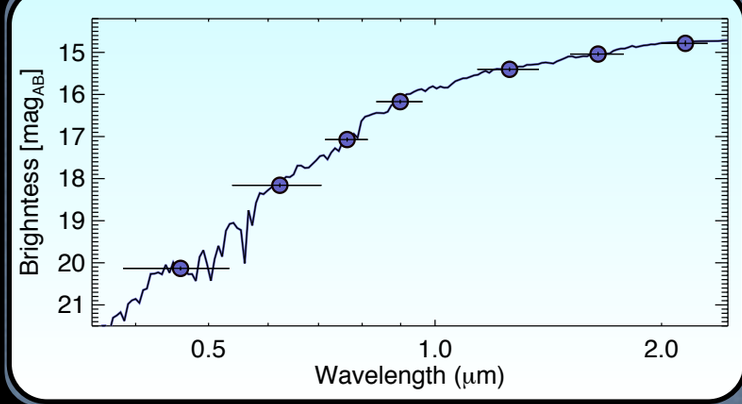


Blazar

HMXB

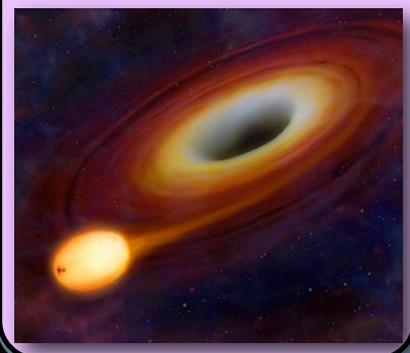


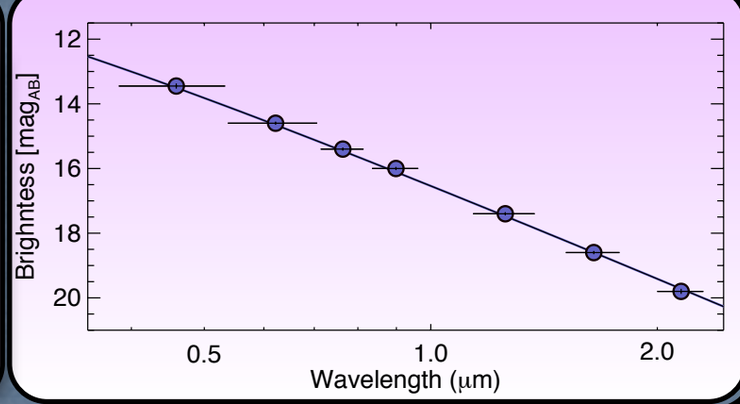


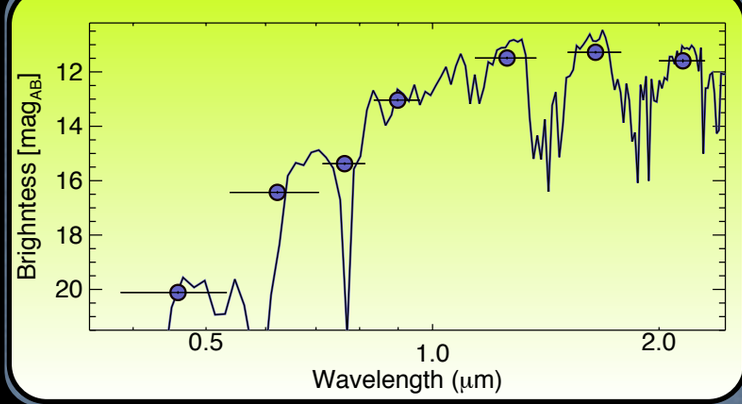


Galaxy Cluster

Tidal Dis. Flare

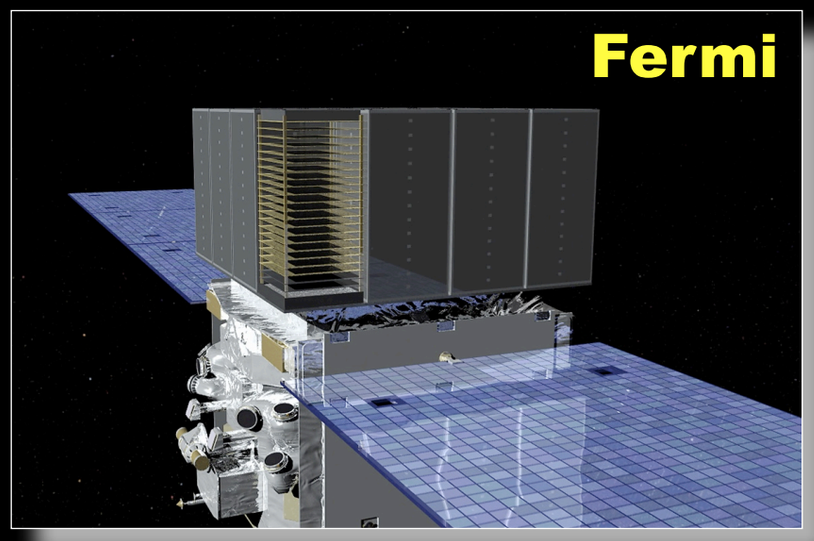






Flare Star

Summary



- GBM: ~250 bursts per year
- LAT: ~5 burst per year
- excellent spectroscopic capability (revealed new components)
- (systematics of) localization to be improved
- many non-GRB sources (TGFs, SGRs, Sun)

- simultaneous optical-near-IR imaging
- observes every visible bursts from La Silla
- complete sample of ~60 GRBs within 4hrs
- lightcurves not as simple (achromatic) as thougt
- many non-GRB sources (XRBinaries, Blazars, Planets, Galaxie Clusters, etc)