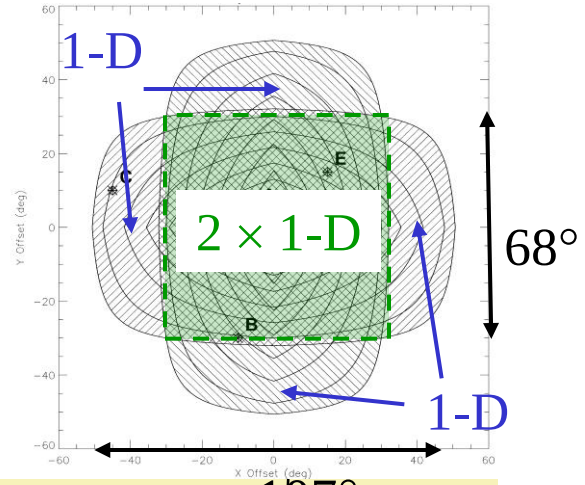
Observation of Gamma Ray Bursts with AGILE

E. Del Monte
on behalf of the AGILE team

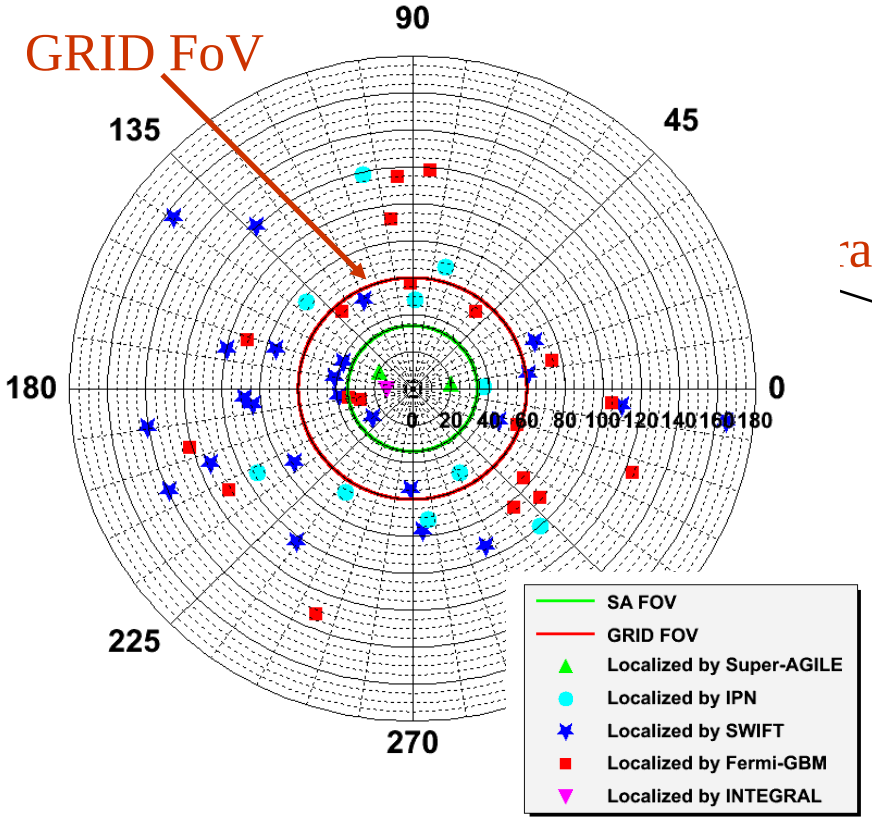
Two co-aligned imagers and quasi all-sky sensitive scintilla

The AGILE payload is composed of two imaging instruments:



SuperAGILE

GRID FoV



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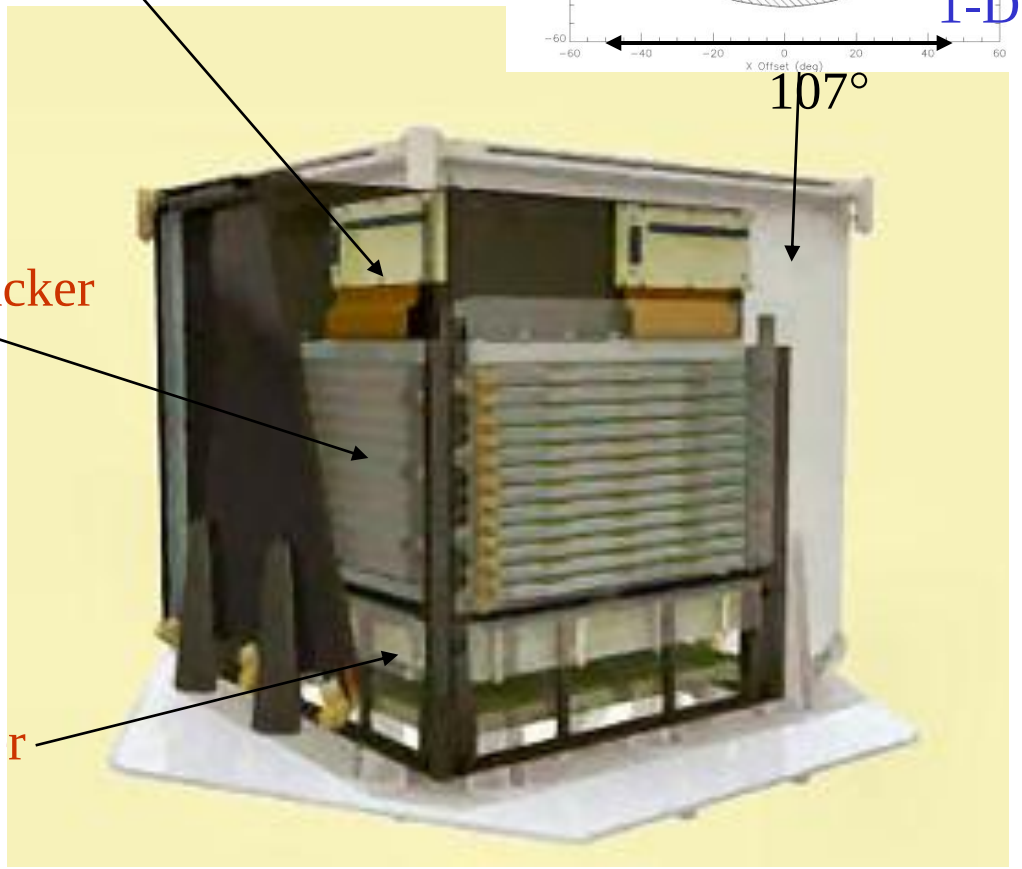


The census of the GRBs observed by AGILE: pointing mode (July 2007 – October 2009)

Hard X-rays:

- 29 GRBs localized by SuperAGILE (18 in 2×1-D and 11 in 1-D) => ~1 GRBs/month;
- 3 arcmin radius uncertainty on the localization and minimum detected fluence of $\sim 5 \times 10^{-7}$ erg cm^{-2}
- ~1 GRB/week detected by MCAL and 1 – 2 GRBs/month detected by SuperAGILE outside the FoV;

Gamma rays:

- Three firm detections: GRB 080514B, GRB 090401B and GRB 090510;
- Two less significant detections: GRB 080721 and GRB 081001;

What changes in spinning mode (since November 2009)?

Hard X-rays:

- a strong background modulation is introduced in SuperAGILE by the spinning mode;
- an FFT-based algorithm is introduced in our trigger to reduce the modulation;
- we expect a decrease in the SuperAGILE localization rate down to ~0.3 – 0.5 GRBs/month;
- the MCAL capabilities are marginally affected by the spinning due to the modulation introduced by the Anticoincidence shielding thus no significant variation is expected;

Gamma rays:

- more Sky is sensed by in gamma rays but the GRBs “transit” in the field of view.

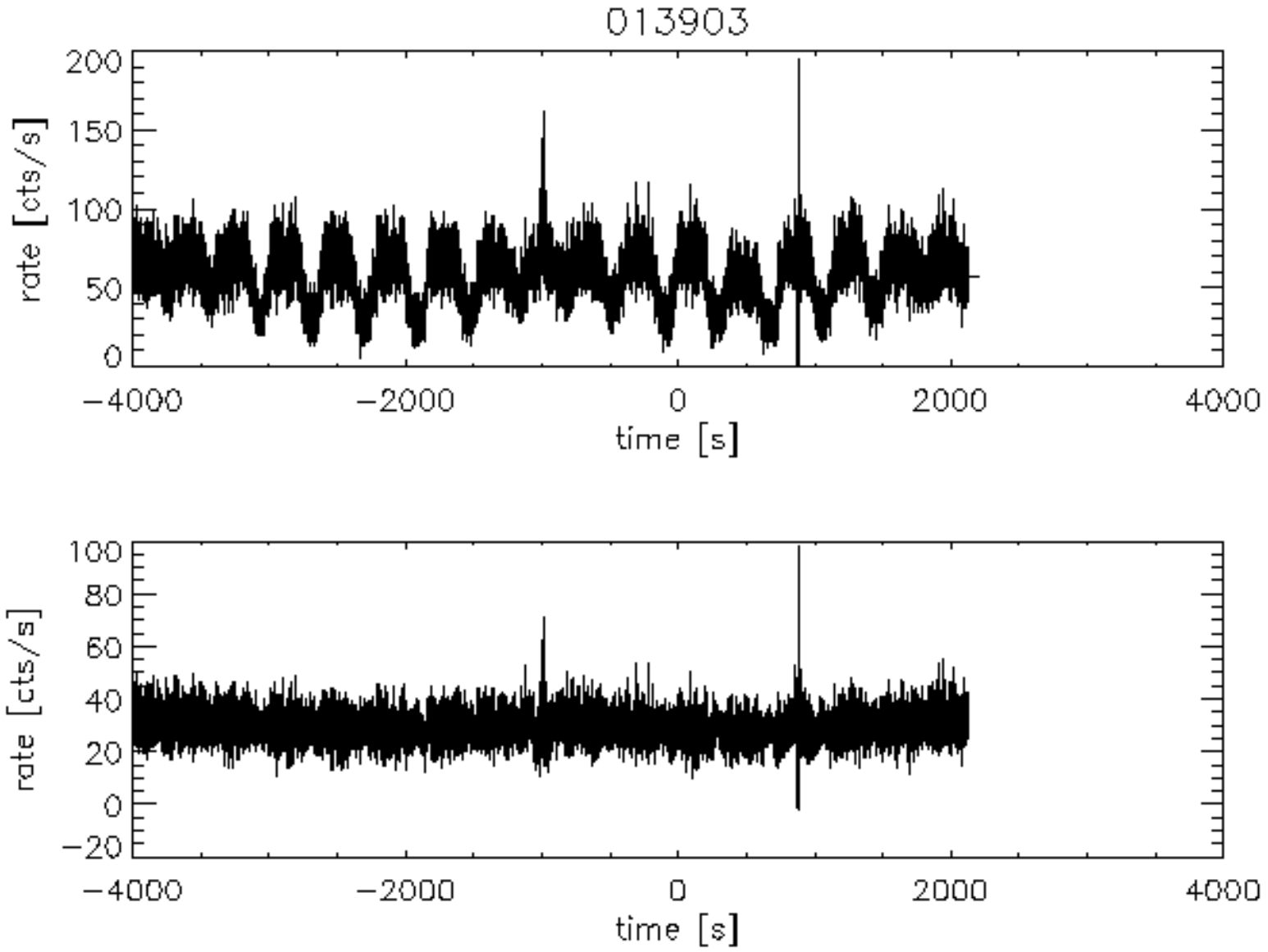
A correction algorithm for SuperAGILE based on the FFT

- the background modulation due to the spinning is subtracted from the lightcurve:

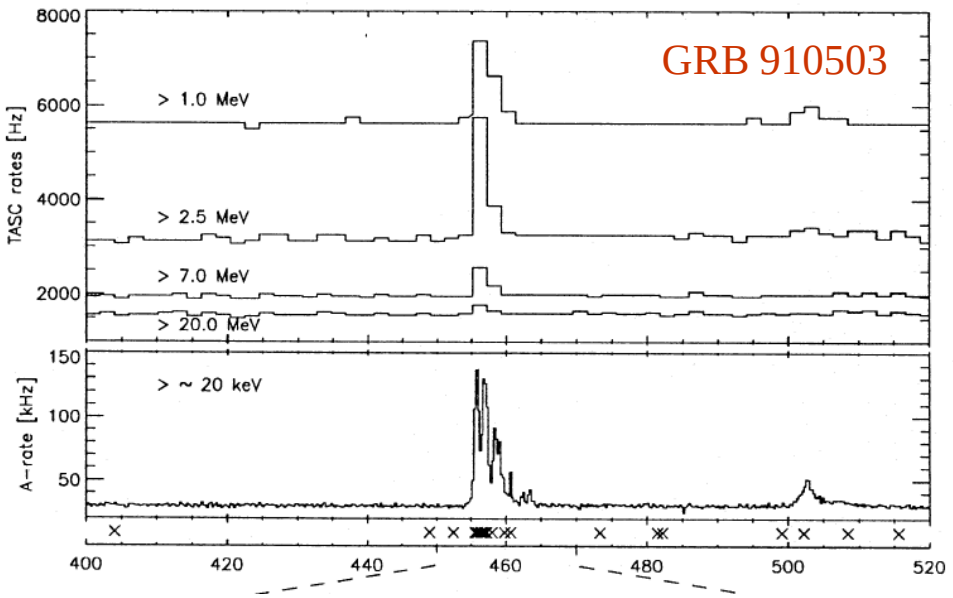
1. the FFT of the lightcurve is calculated;
2. the low frequencies (0.001 – 0.01 Hz) are reduced with a dedicated filter;
3. the reverse-FFT is calculated to obtain back the lightcurve (now frequency filtered);

- the filter is tuned to previous detections in order to avoid the suppression of the GRB signal in the lightcurve.

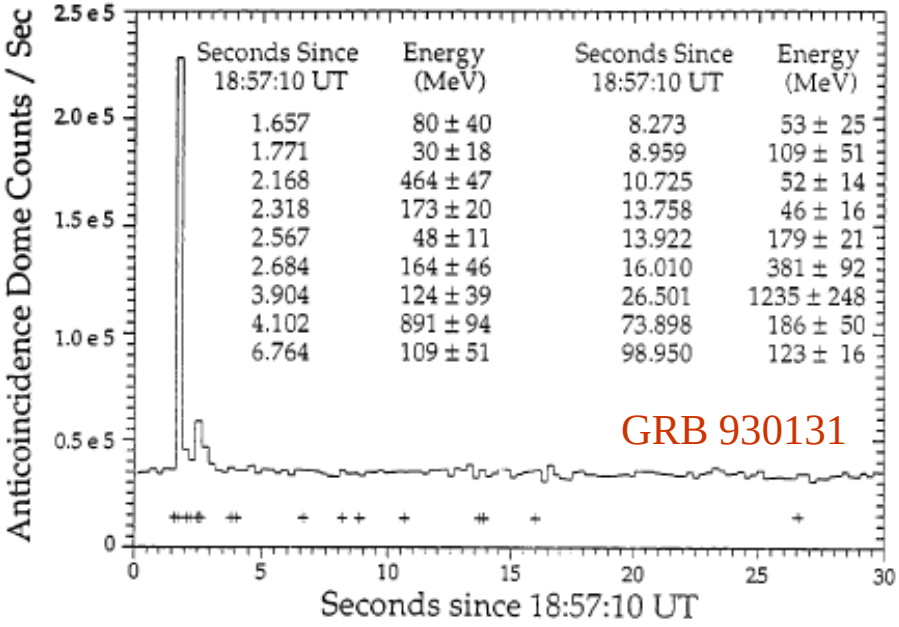
GRB 100102A triggered outside the field of view



The EGRET heritage



Schneid et al., 1992, A&A



Sommer et al., 1994, ApJ

Five GRBs coincident in time with BATSE triggers were detected by EGRET above 100 MeV;

They showed both simultaneous and extended emission of gamma rays, until a few hundreds of seconds after trigger (with GRB 940217 until more than 5000 s);

In some GRBs (e. g. GRB 930131) the spectrum in 1 MeV – 1 GeV is modeled by the same powerlaw, others (e. g. GRB 941017) show additional components;

The afterglow emission was not yet discovered, thus the redshift was not known.

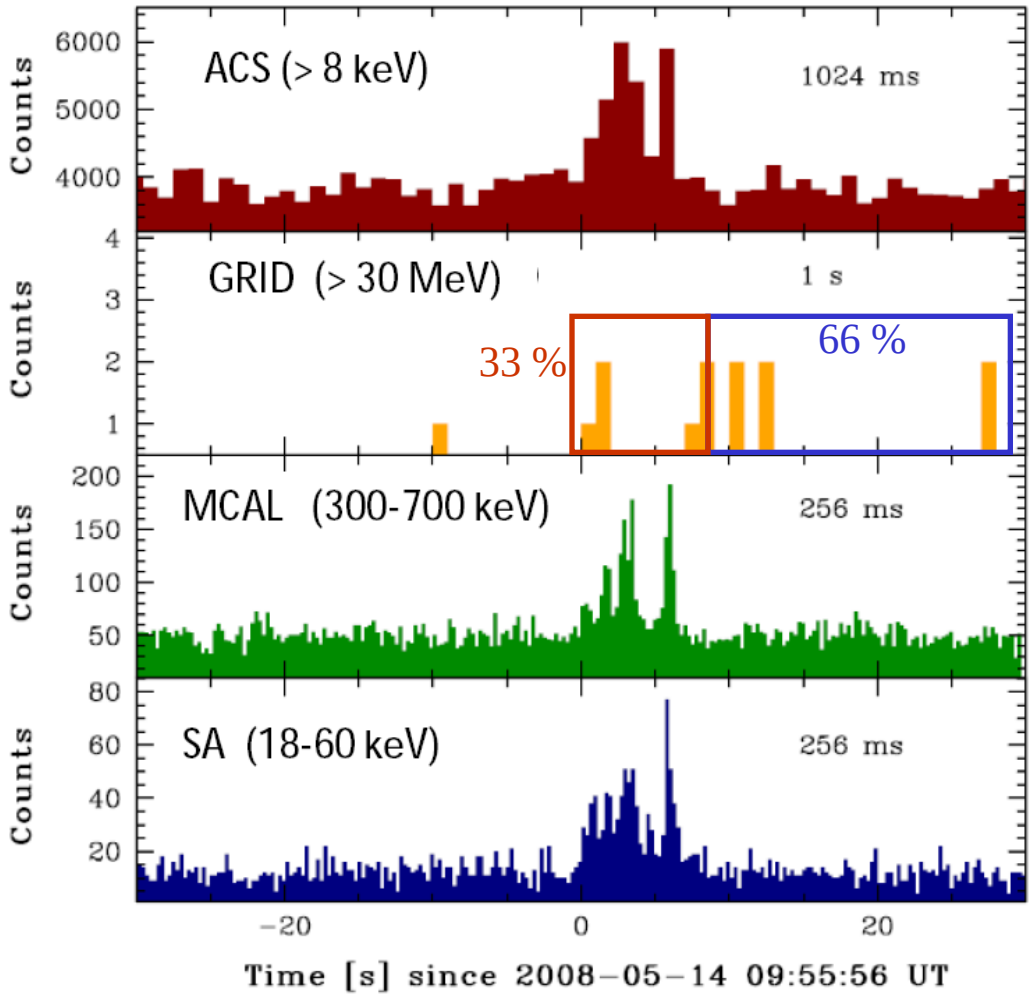
Distinctive features of the AGILE GRBs

- GRB 080514B: long GRB, with extended emission of gamma rays and single Band spectrum (20 keV – 50 MeV);

- GRB 090510: short GRB with delayed emission and spectral evolution;

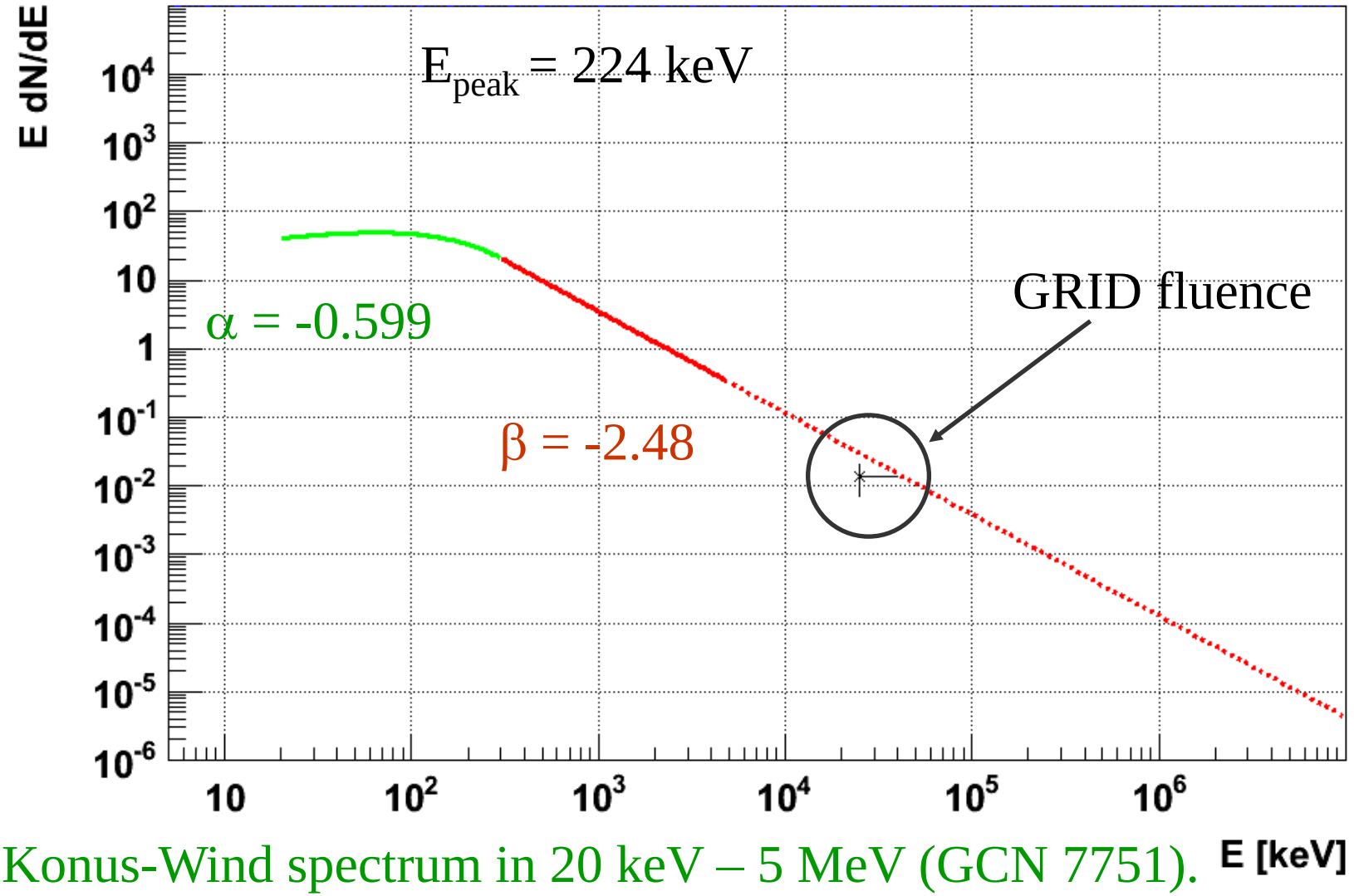
- GRB 090401B: long GRB with multiple peak structure, simultaneous and extended emission of gamma rays;

Temporal properties of GRB 080514B



GRB 080514B (Giuliani et al., 2008, A&A) is the first gamma ray bright GRB after EGRET and it is also associated to an afterglow and a photometric redshift measure of 1.8 (A. Rossi et al., 2008, A&A).

A single model for the whole spectrum of GRB 080514B



Konus-Wind spectrum in 20 keV – 5 MeV (GCN 7751).

The same Band model fits the spectrum from 20 keV up to 50 MeV.

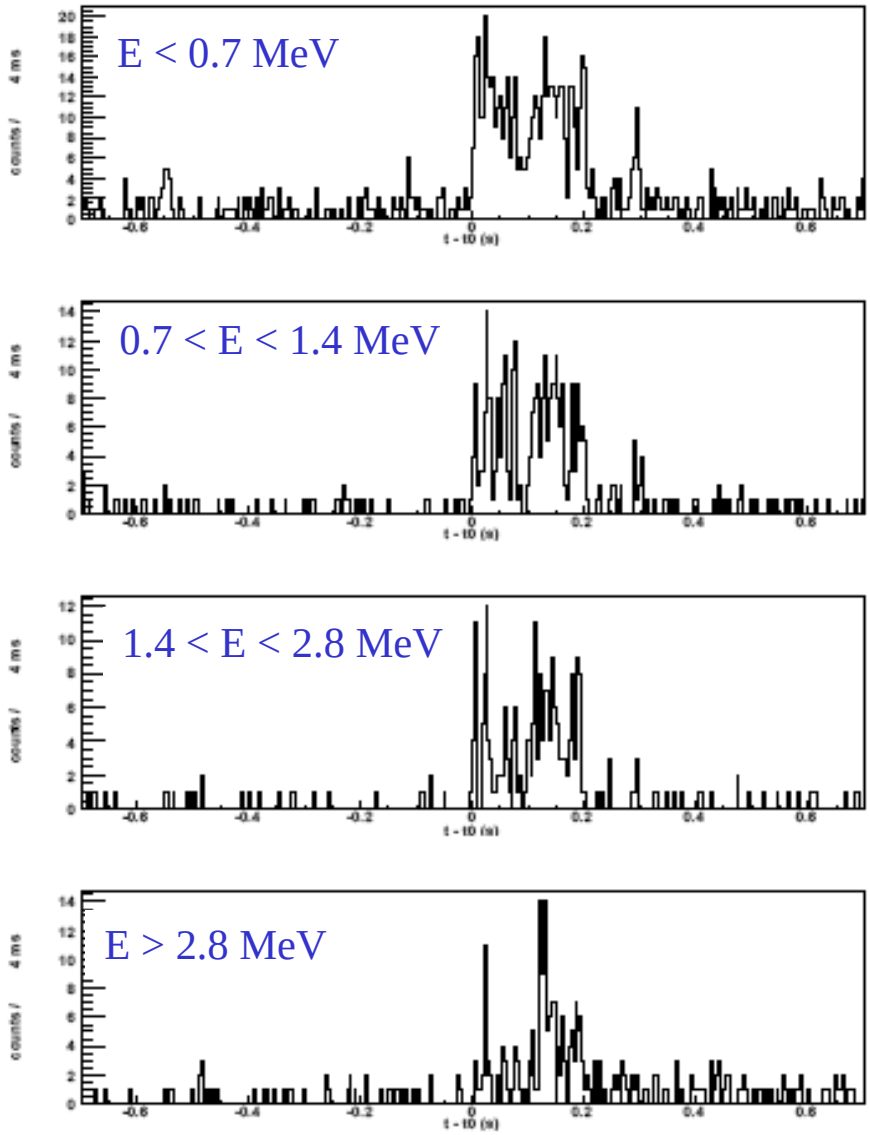
Distinctive features of the AGILE GRBs

- GRB 080514B: long GRB, with extended emission of gamma rays and single Band spectrum (20 keV – 50 MeV);

- GRB 090510: short GRB with delayed emission and spectral evolution;

- GRB 090401B: long GRB with multiple peak structure, simultaneous and extended emission of gamma rays;

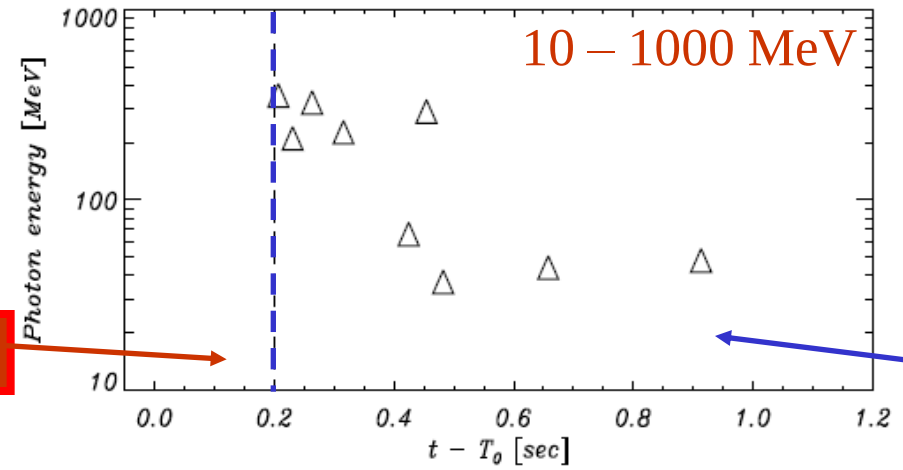
Short GRB 090510: the prompt emission in the MeV band



Lightcurves of the MCAL with 4 ms bin size.

The second peak is harder than the first one.

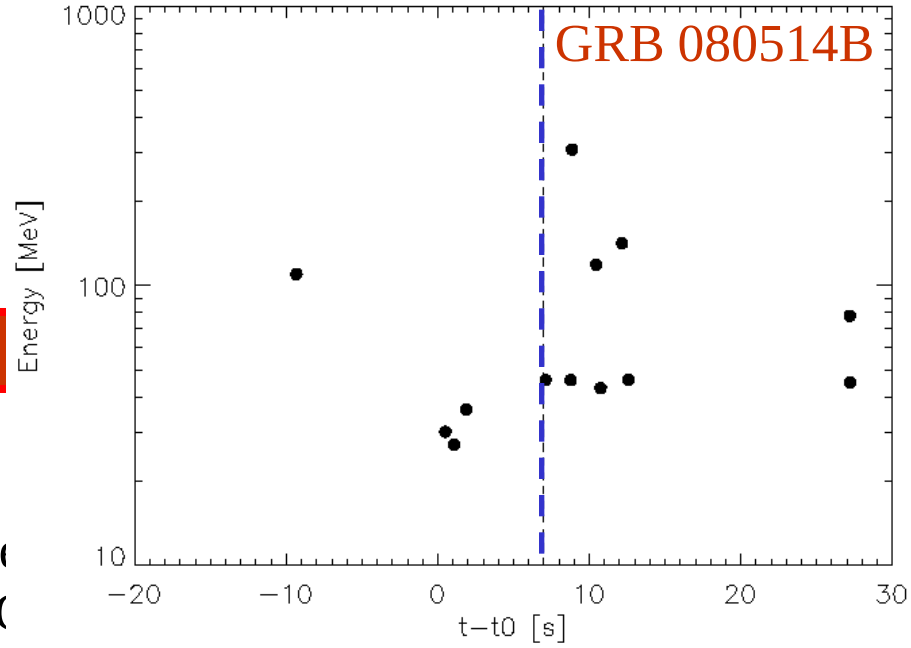
GRB 090510: the delayed emission



Giuliani et al. 2009, ApJ, L84 – L88

prompt emission interval

delayed emission interval

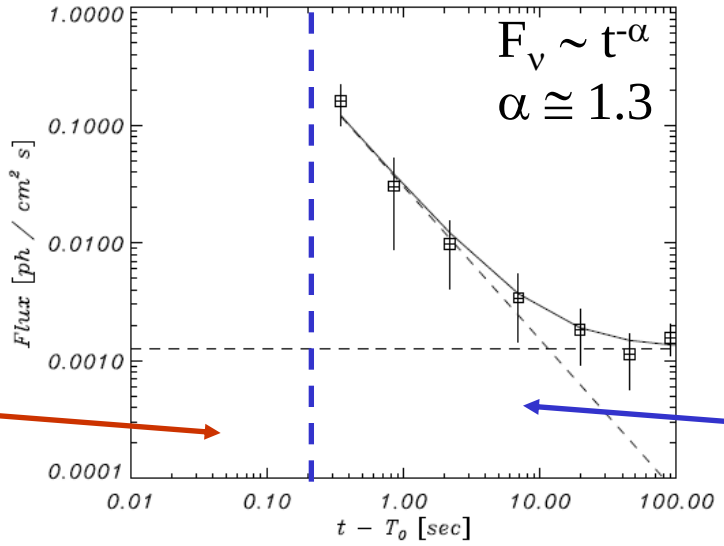


prompt emission interval

delayed emission interval

GRB 090510 has b tected also by Fermi/LAT (GCN 9334) and A GCN 9353).

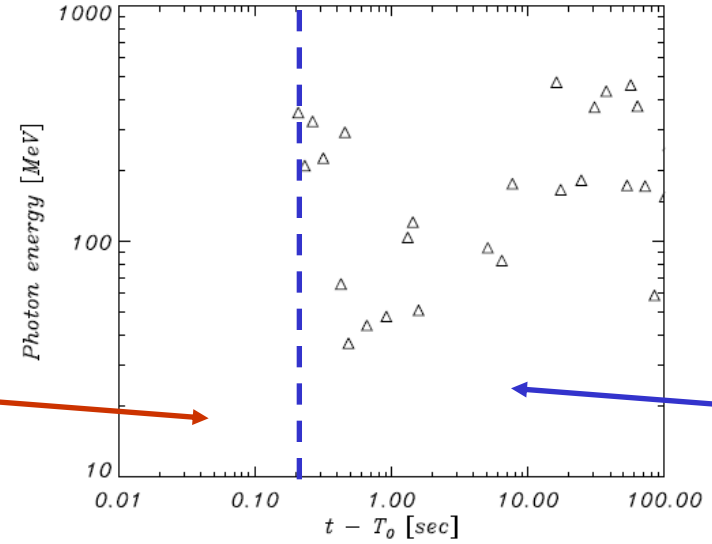
GRB 090510: the delayed emission



Giuliani et al. 2009, ApJ L84 – L88

prompt emission interval

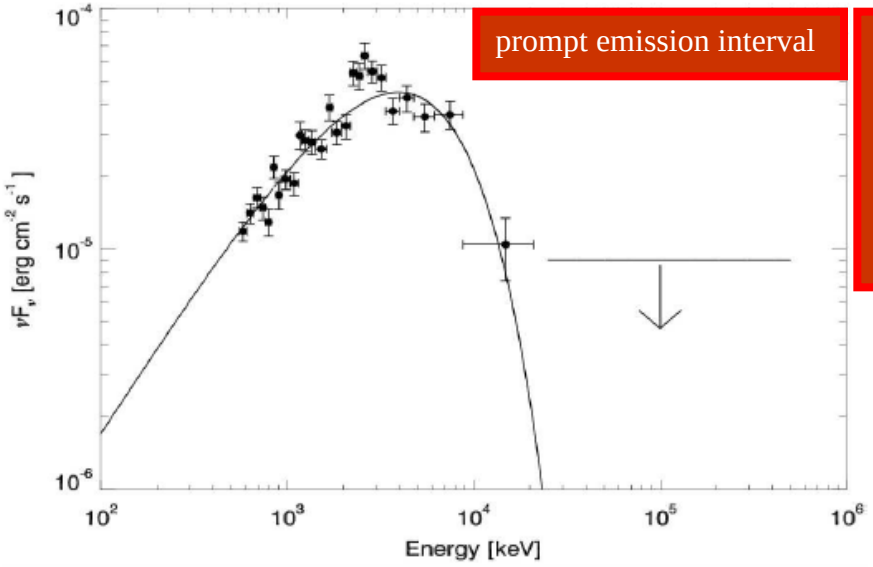
delayed emission interval



prompt emission interval

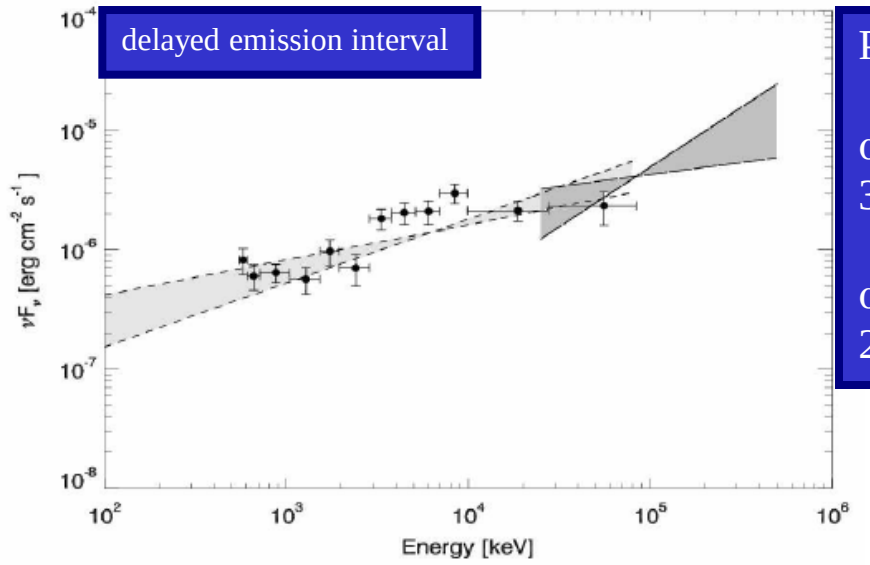
delayed emission interval

GRB 090510: spectral evolution in a short GRB



Powerlaw with cutoff

$\alpha_1 = 0.6 \pm 0.3$
Ec = 2.8 ± 0.9 MeV
1.8×10^{-5} erg/cm^2 (0.5 – 10 MeV)



Powerlaw without cutoff

$\alpha_2 = 1.6 \pm 0.1$
3.1×10^{-6} erg/cm^2 (0.5 – 10 MeV)

$\alpha_3 = 1.4 \pm 0.4$
2.9×10^{-5} erg/cm^2 (25 – 500 MeV)

Distinctive features of the AGILE GRBs

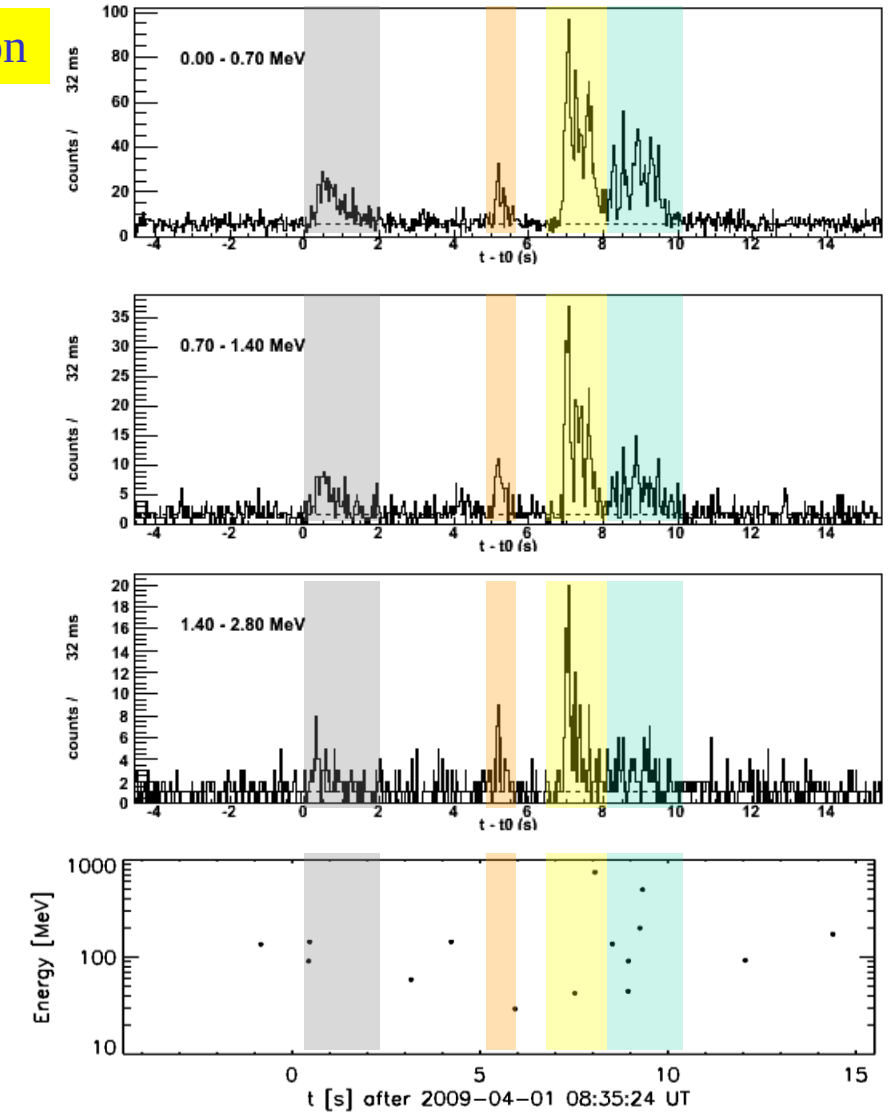
- GRB 080514B: long GRB, with extended emission of gamma rays and single Band spectrum (20 keV – 50 MeV);

- GRB 090510: short GRB with delayed emission and spectral evolution;

- GRB 090401B: long GRB with multiple peak structure, simultaneous and extended emission of gamma rays;

GRB 090401B: prompt emission at MeV energy

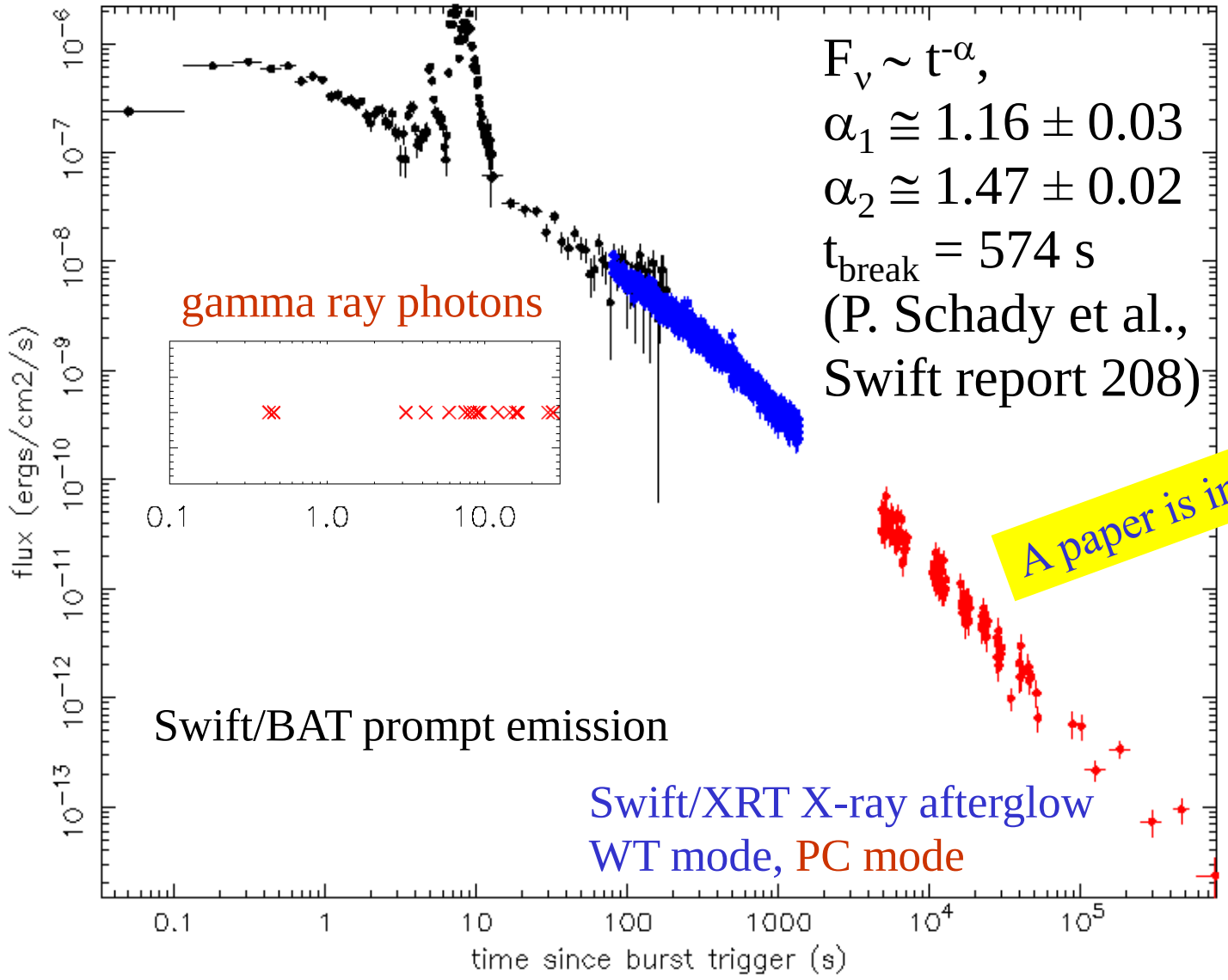
A paper is in preparation



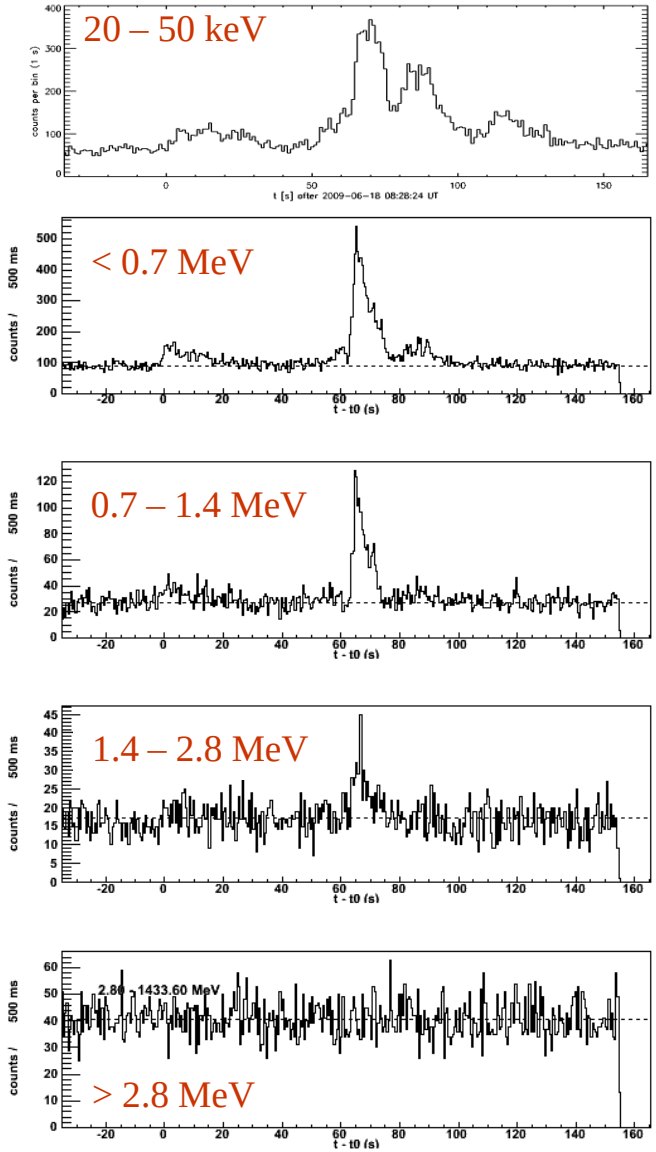
68 % of the gamma ray photons are emitted during prompt;

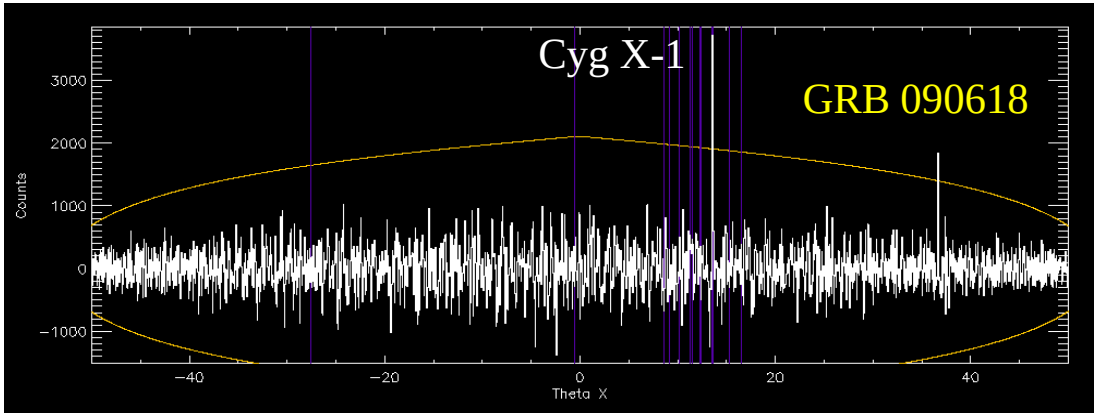
32 % of the gamma ray photons are in the extended emission

GRB 090401B: afterglow emission



The interesting case of GRB 090618





GRB 090618 compared with Cyg X-1 in the orbital image of SuperAGILE (20 – 50 keV, 3 ks exposure).

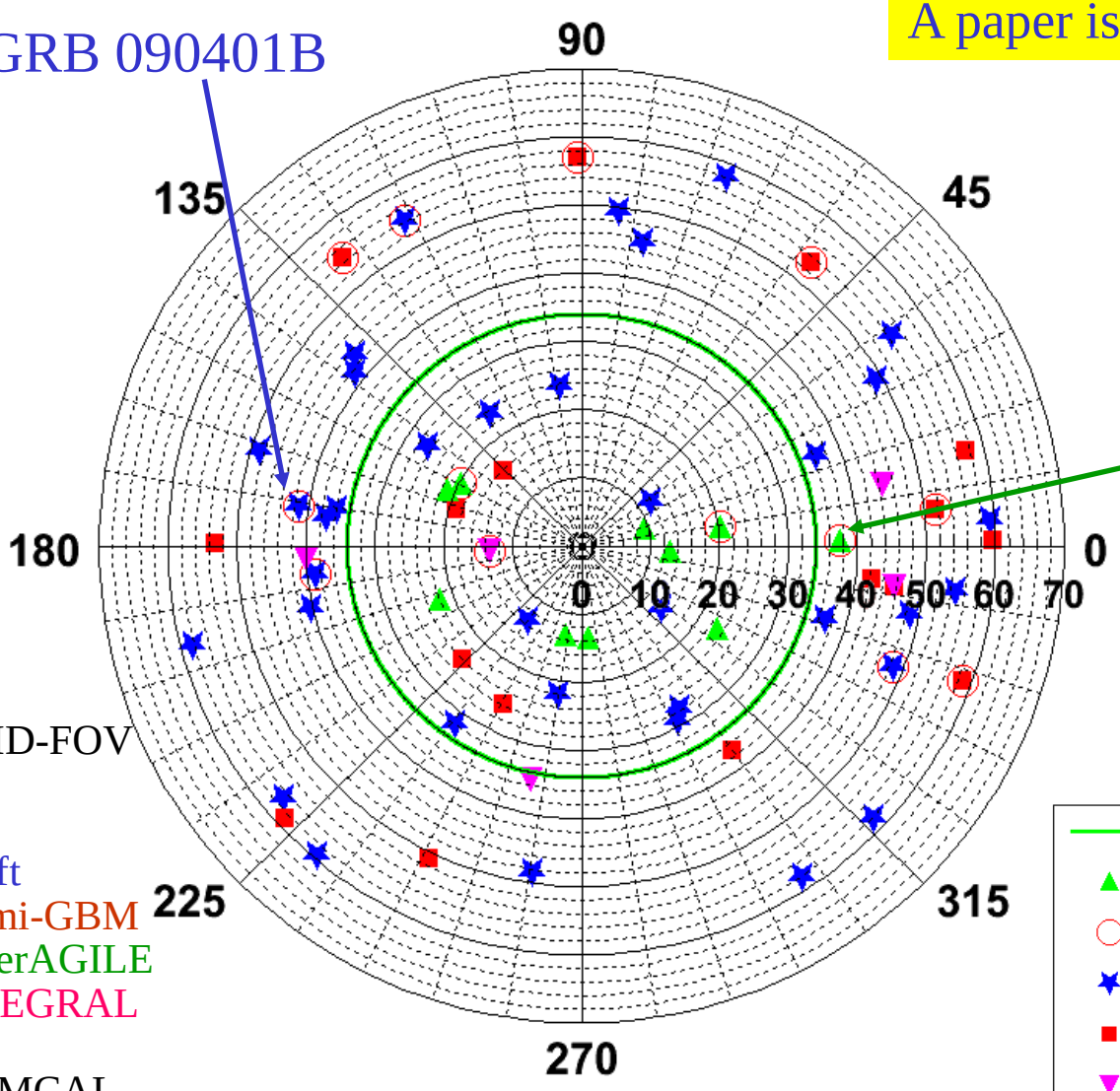
Despite the remarkable value of E_{peak} = 186 keV (GCN 9553) and a rescaled peak flux of 8.3×10^{-6} erg/cm^2/s (in 50 – 300 keV), this GRB is not detected in the gamma ray band. Notice that z=0.54

Upper limits in gamma rays: the sample

A paper is almost finished

GRB 090401B

GRB 080514B



68 GRBs in the GRID-FOV until 17 April 2009:

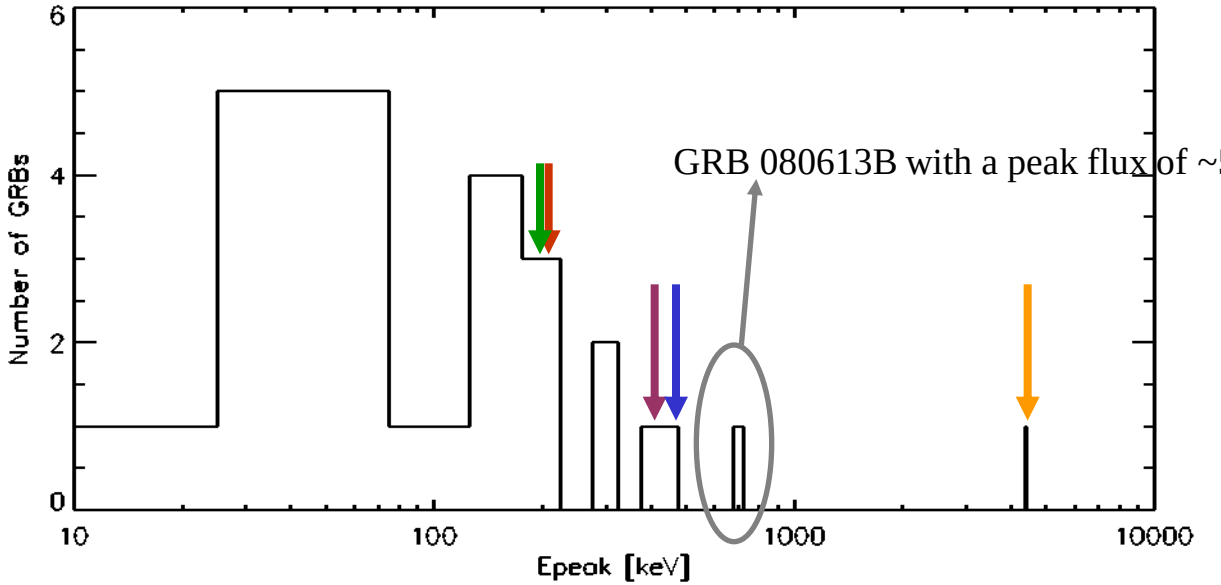
36 localized by Swift
17 localized by Fermi-GBM
10 localized by SuperAGILE
5 localized by INTEGRAL

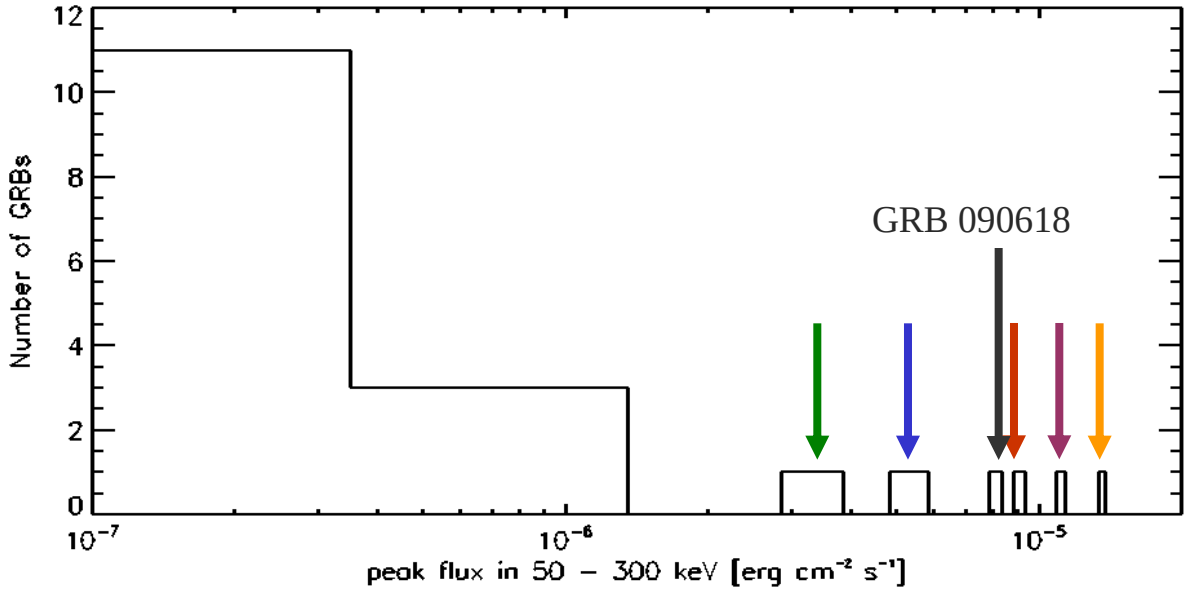
13 also detected by MCAL

Upper limits in gamma rays: the results

- We estimated the upper limit of the 69 GRBs localized in the GRID FoV in July 2007 – April 2009;
- the background is estimated inside the GRID PSF before trigger and for 10 times the burst duration;
- 40 GRBs have spectral information (from Konus-Wind, Suzaku/WAM and Fermi/GBM), that is used to convert counts into flux;
- the corresponding 3 sigma upper limit ranges in 0.015 - 0.04 ph cm^{-2} s^{-1}

Population studies and the gamma ray emission





29 GRBs are found in the GRID FoV with spectral parameters by Konus-Wind, Suzaku/WAM or Fermi/ GBM.

GRB 080514B, GRB 090401B and GRB 090510 are firmly detected by GRID;

GRB 080721 and GRB 081001 have smaller significance in GRID;

The not ubiquitous GeV emission

- Only a small subsample of GRBs emits in gamma rays:

  AGILE/GRID detected 5 GRBs in 2.8 years;
  Fermi/LAT detected 17 GRBs in 1.9 years;
  the rate is ~9 events per year (consistent with Band et al. 2009);

- The impact of the lack of GeV emission on the currently accepted models of the GRB prompt emission is being investigated;

- Up to now no signature is found in the X-ray afterglow of the gamma ray emitting GRBs but the sample is still small;

- In particular, no gamma rays are detected by AGILE simultaneously with flares in the afterglow.

The extended emission

- The extended emission of gamma rays is a common feature of the GRBs (both long and short) detected in this energy band;

- For some events the fluence emitted in gamma rays follows the same Band model of the keV – MeV emission, while up to now only GRB 090510 shows a spectral evolution;

- The gamma ray emission of GRB 090510 is debated: prompt or afterglow? (see e.g. Ghirlanda, Ghisellini and Nava 2009);

- Following Fan 2009, the gamma rays may be delayed because the early outflow has Lorentz factor smaller (baryon pollution) than the late emission;

Conclusions and future perspectives

- the gamma ray emission is not a common feature of GRBs;
- it is concentrated in the prompt phase…
- … but it is often extended well after the end of the prompt emission;
- some GRBs have a single spectrum (keV – GeV), while others (e. g. GRB 090510) show spectral evolution;
- the afterglow of gamma ray emitting GRBs is not peculiar and no gamma rays are detected simultaneously with flares in the afterglow;
- the presence of gamma rays in the prompt emission correlates pretty well with the flux in the 50 – 300 keV energy band;
- typical AGILE upper limits for GRBs are 0.015 – 0.04 ph/cm^2.