The observation of GRBs with AGILE and the interesting cases of GRB 090618 and GRB 100724B

E. Del Monte
on behalf of the AGILE team

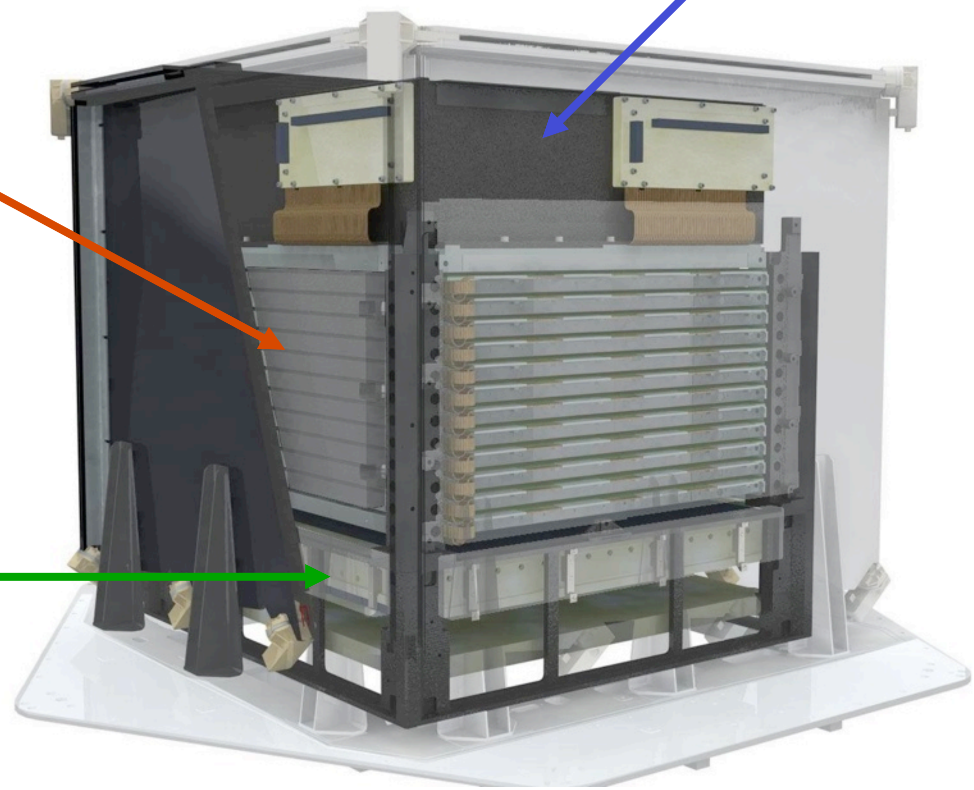
Outline

1. Status of the observation of GRBs with AGILE;
2. Highlights of observed GRBs;
3. AGILE observation of GRB 100724B;
4. The peculiar GRB 090618.

Two co-aligned imagers and a quasi all-sky sensitive scintillator

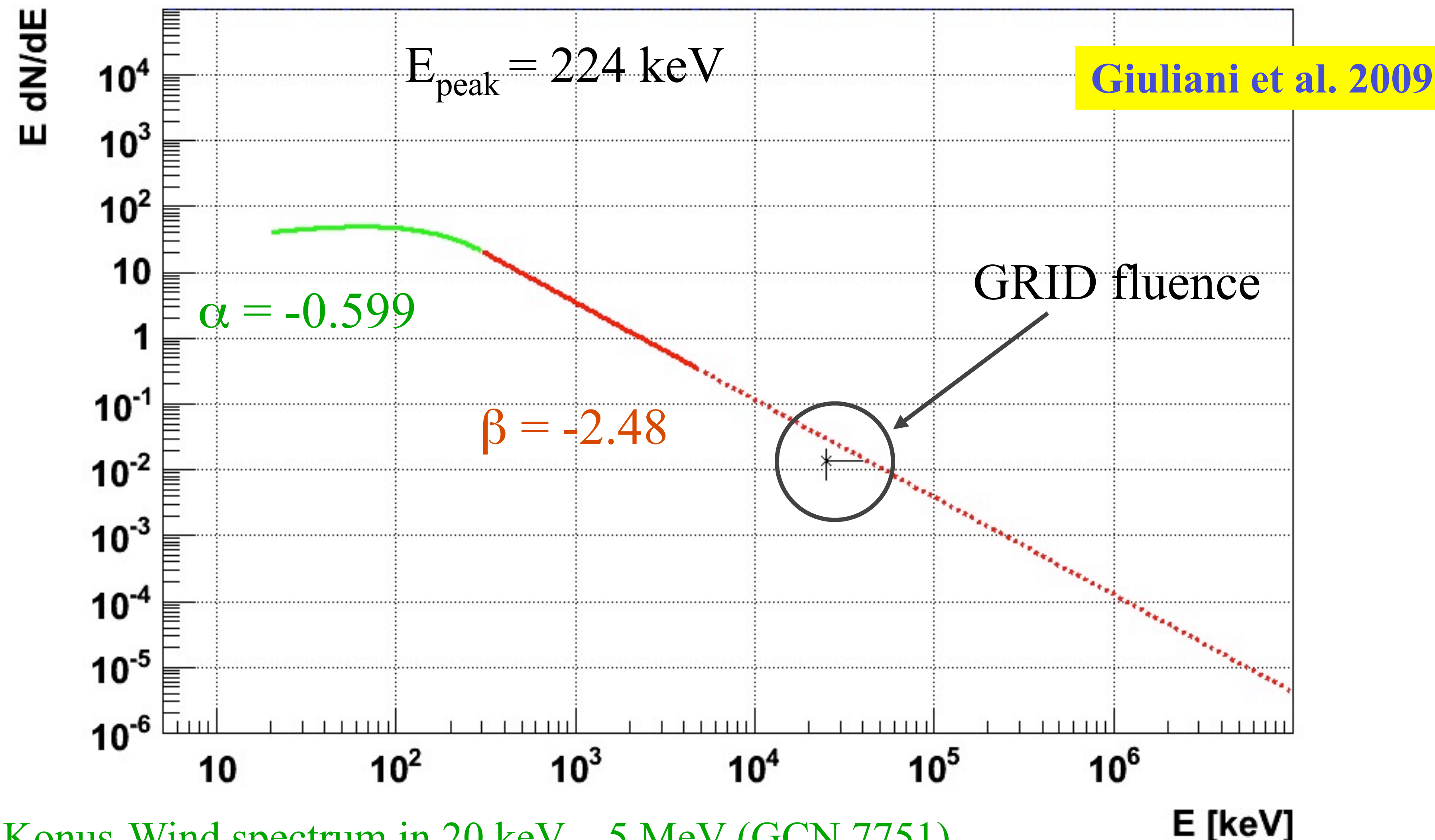
SuperAGILE
Coded aperture
18 – 60 keV
~1 sr FoV

Gamma Ray Imaging Detector
Silicon tracking detector
30 MeV – 50 GeV
~2.5 sr FoV



Minicalorimeter
non imaging scintillator
0.3 – 200 MeV
almost all-Sky FoV

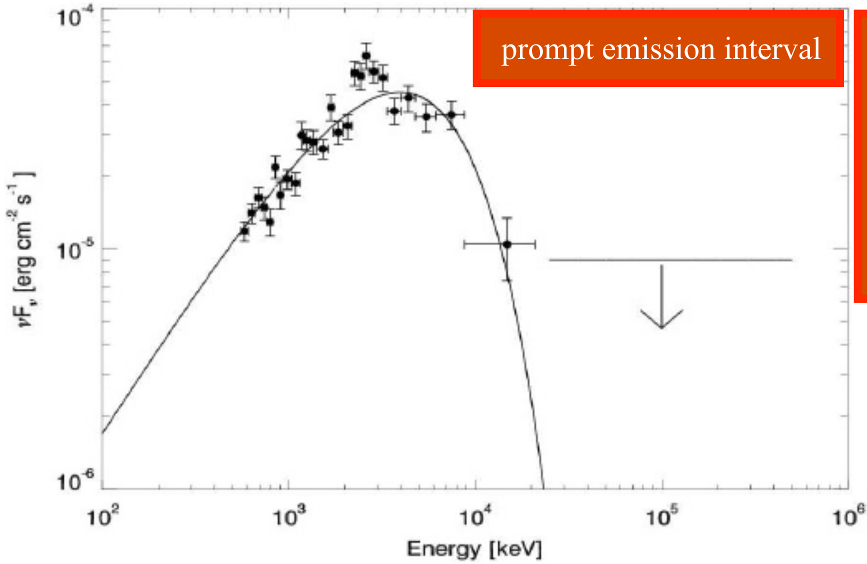
A single model for the whole spectrum of GRB 080514B



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

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

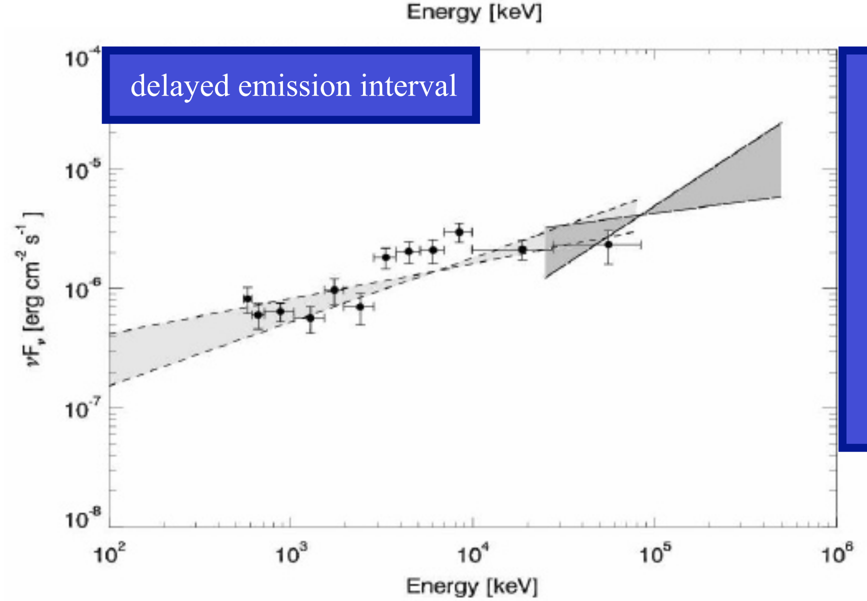
GRB 090510: spectral evolution in a short GRB



Powerlaw with cutoff

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

Giuliani et al. 2010

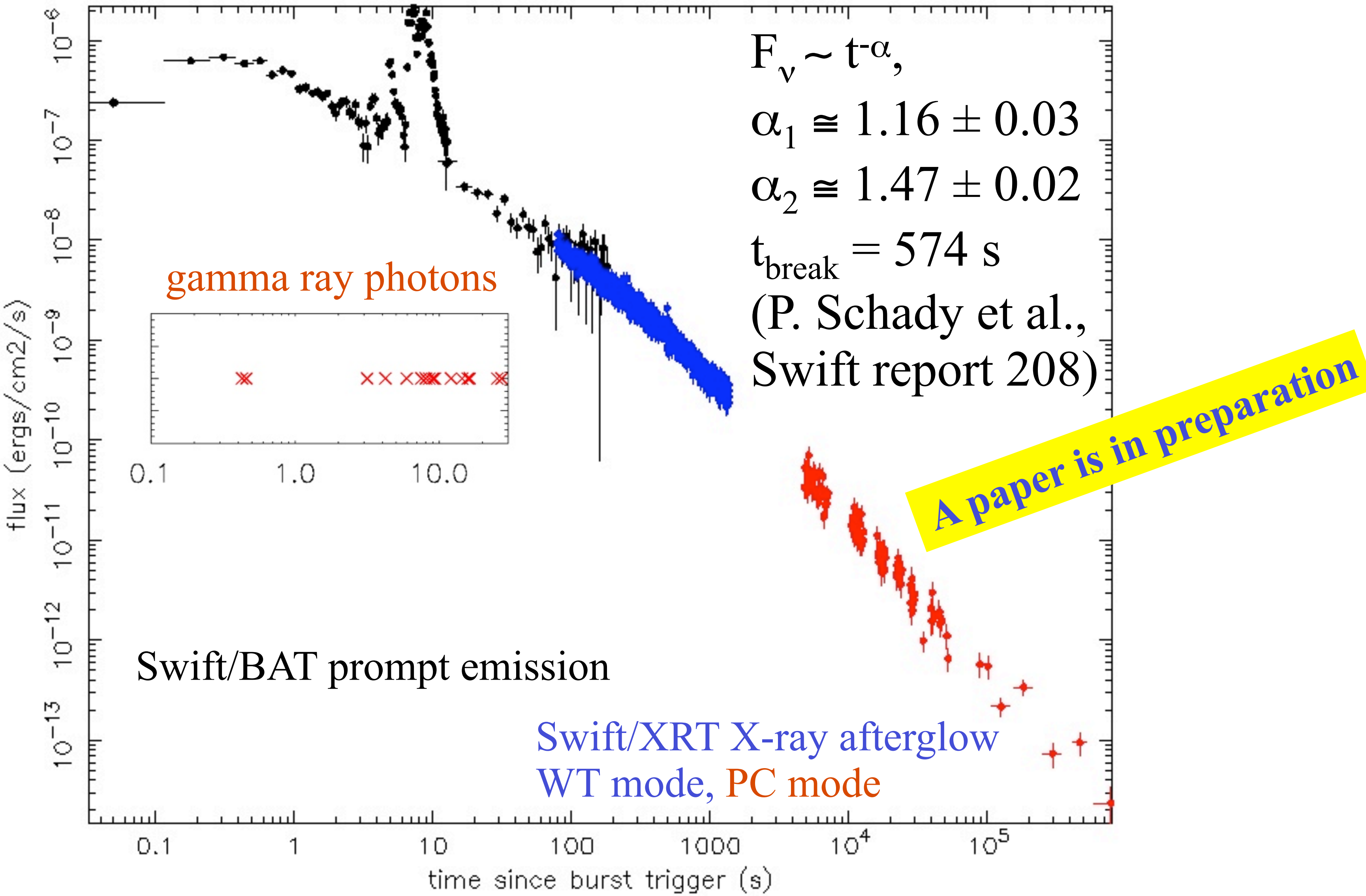


Powerlaw without cutoff

$\alpha_2 = 1.6 \pm 0.1$
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)

GRB 090401B: afterglow emission



Upper limits in gamma-rays: results and expected flux

$\sim 10^{-7}$ erg/cm^2/s

Band function model

GRB	UL ($\times 10^{-3}$) cts/(s cm^2)	Expected ($\times 10^{-3}$) cts/(s cm^2)
071010B	1.06	$0.03^{+0.06}_{-0.03}$
080721	7.86	$2.81^{+8.33}_{-2.25}$
080723B	0.95	$0.66^{+0.97}_{-0.58}$
090222	5.65	$0.04^{+1.35}_{-0.04}$
090618	1.12	$0.32^{+0.35}_{-0.16}$
090620	2.00	$0.24^{+0.11}_{-0.13}$
090709	0.75	$0.18^{+0.67}_{-0.10}$
090904B	0.53	$0.62^{+0.46}_{-0.51}$
091010	2.51	$0.04^{+0.6}_{-0.01}$
070724B	0.78	$0.11^{+0.6}_{-0.05}$
070824	21.84	$1.28^{+3.4}_{-0.46}$
080413A	1.08	$0.08^{+0.18}_{-0.06}$
080413B	2.11	$0.04^{+0.32}_{-0.02}$
080613B	0.75	$0.64^{+0.21}_{-0.55}$
080714	3.37	$0.07^{+0.27}_{-0.06}$
080916A	2.92	$0.01^{+0.23}_{-0.01}$
081001	5.38	$0.45^{+2.11}_{-0.19}$
081130B	3.33	$0.09^{+0.32}_{-0.05}$
081203A	1.40	$0.10^{+3.75}_{-0.002}$
081224	2.92	$1.44^{+3.48}_{-0.49}$
090319	0.52	$0.02^{+0.25}_{-0.006}$
090326	3.75	$0.02^{+0.16}_{-0.01}$
090410	0.80	$0.06^{+0.33}_{-0.03}$
090418B	0.75	$0.12^{+0.11}_{-0.06}$
090516	1.61	$0.04^{+0.19}_{-0.03}$
090516B	0.87	$0.13^{+0.36}_{-0.05}$
090715B	0.10	$0.04^{+0.04}_{-0.04}$

Longo et al., in preparation

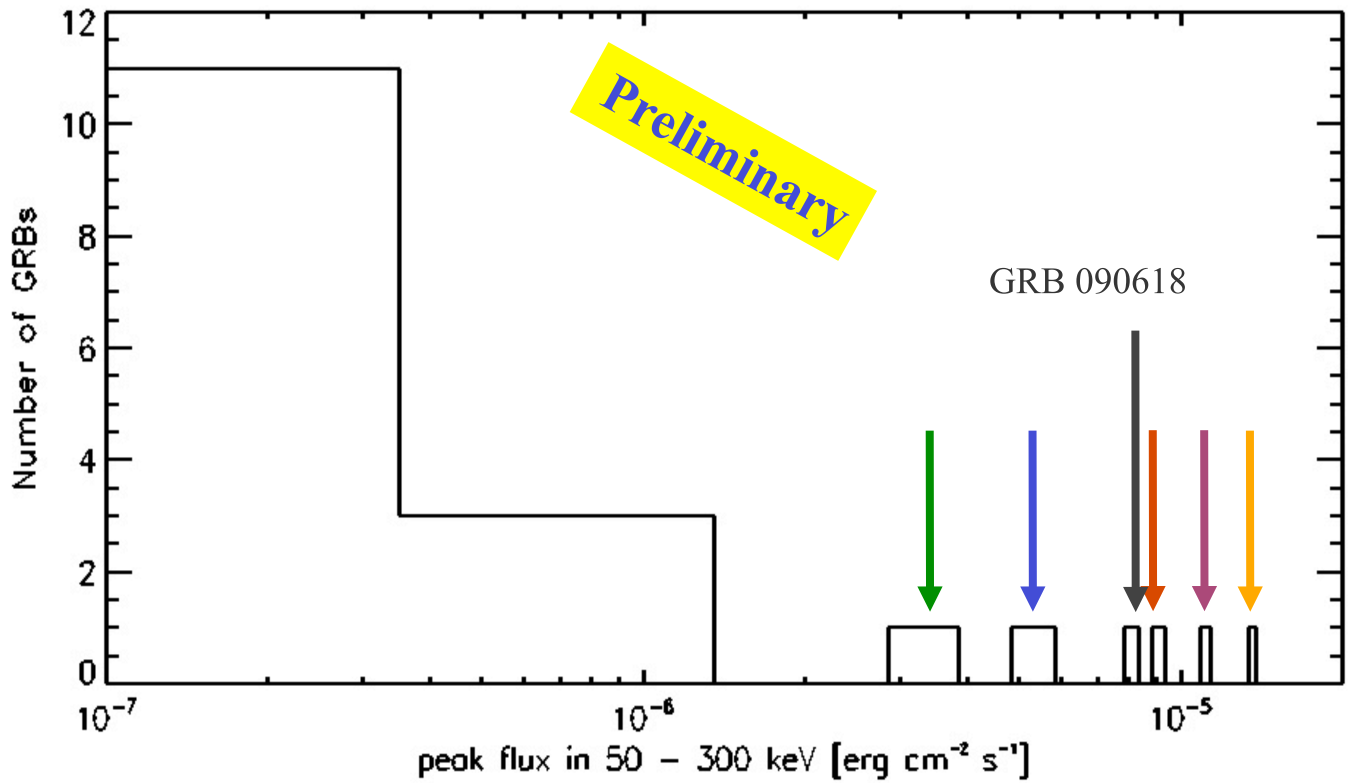
Exponential cutoff + BATSE average Band function model ($-2.58 < \beta < -2.19$).

Expected flux derived from the available spectral info and compared with upper limits.

Sample of 68 GRBs in the AGILE/GRID field of view (between 2007 and 2009) localized by Swift, Fermi/GBM, SuperAGILE and INTEGRAL.

No gamma ray afterglow is detected 3600 s after trigger.

Emerging correlation between hard X-rays and GeV

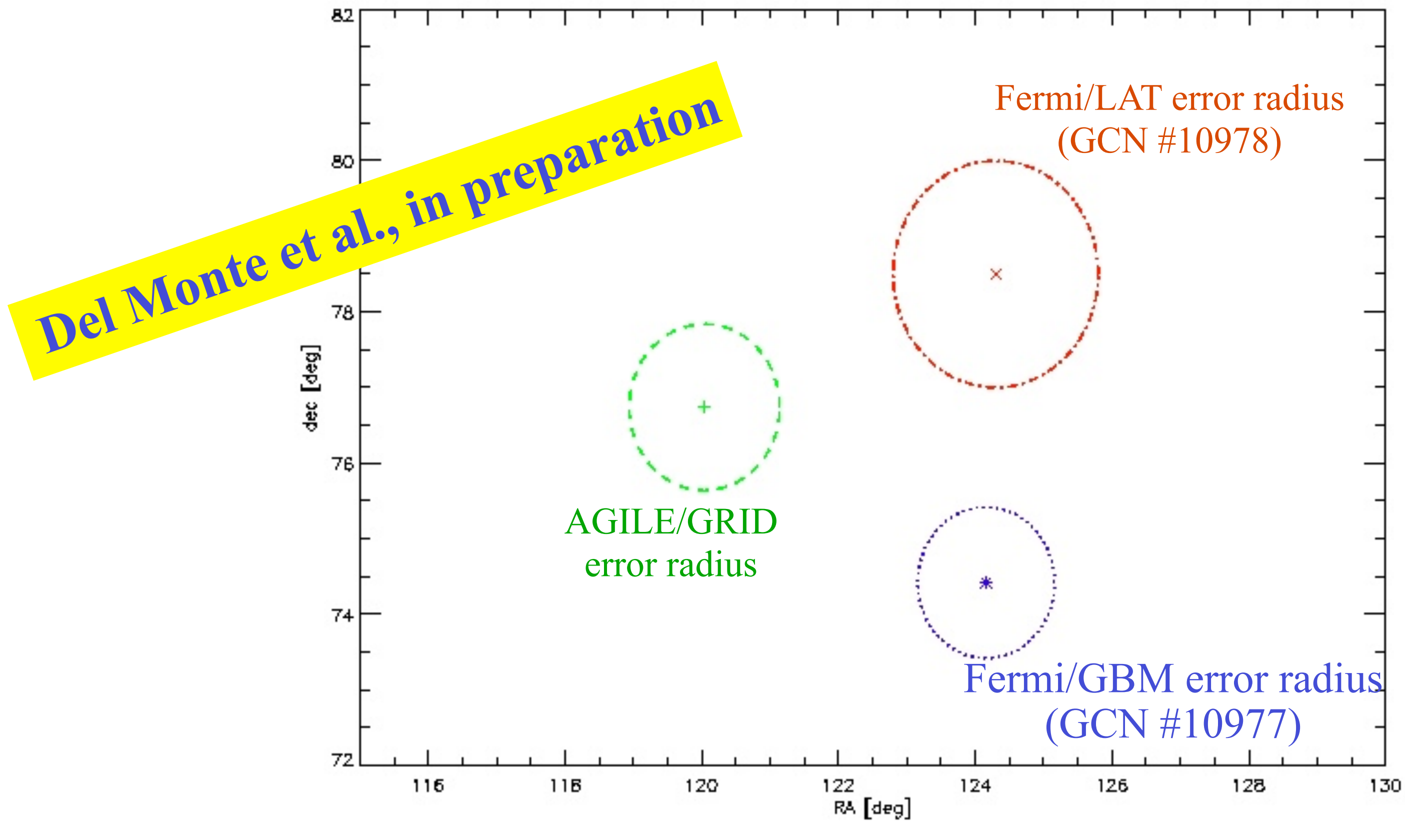


From a preliminary analysis of 29 GRBs in the AGILE/GRID FoV with spectral parameters measured by Konus-Wind, Suzaku/WAM or Fermi/ GBM.

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

GRB 080721 and GRB 081001 have smaller significance in GRID;

Discovery of GRB 100724B



The GRB could not be immediately observed by Swift due to Sun constraints.
On 2 August 2010 Swift observed two fields in the LAT error region but did not localise any afterglow. No more follow-up observations are available thus GRB 100724B lacks both afterglow and redshift.

GRB 100724B: simultaneous onset of GeV and MeV

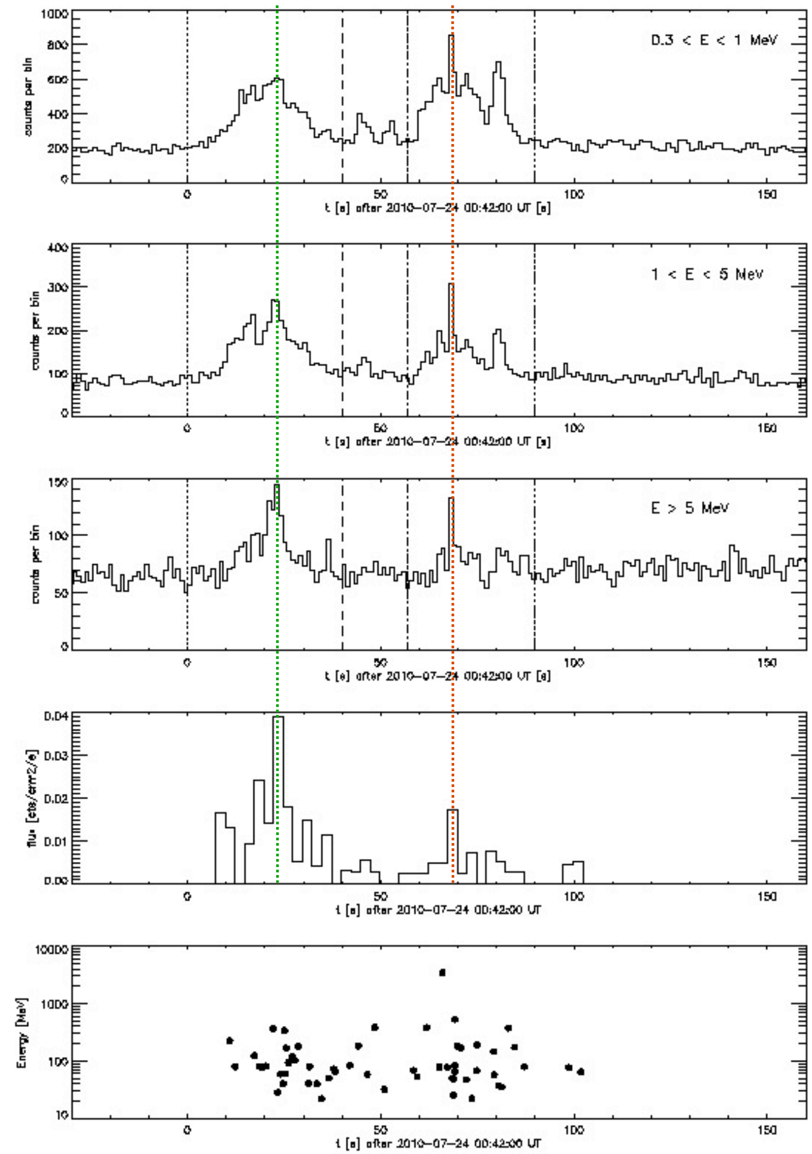
No time lag is found between the MeV and GeV emission. The two main bumps in the lightcurve show a remarkably similar shape at MeV and GeV.

Del Monte et al., in preparation

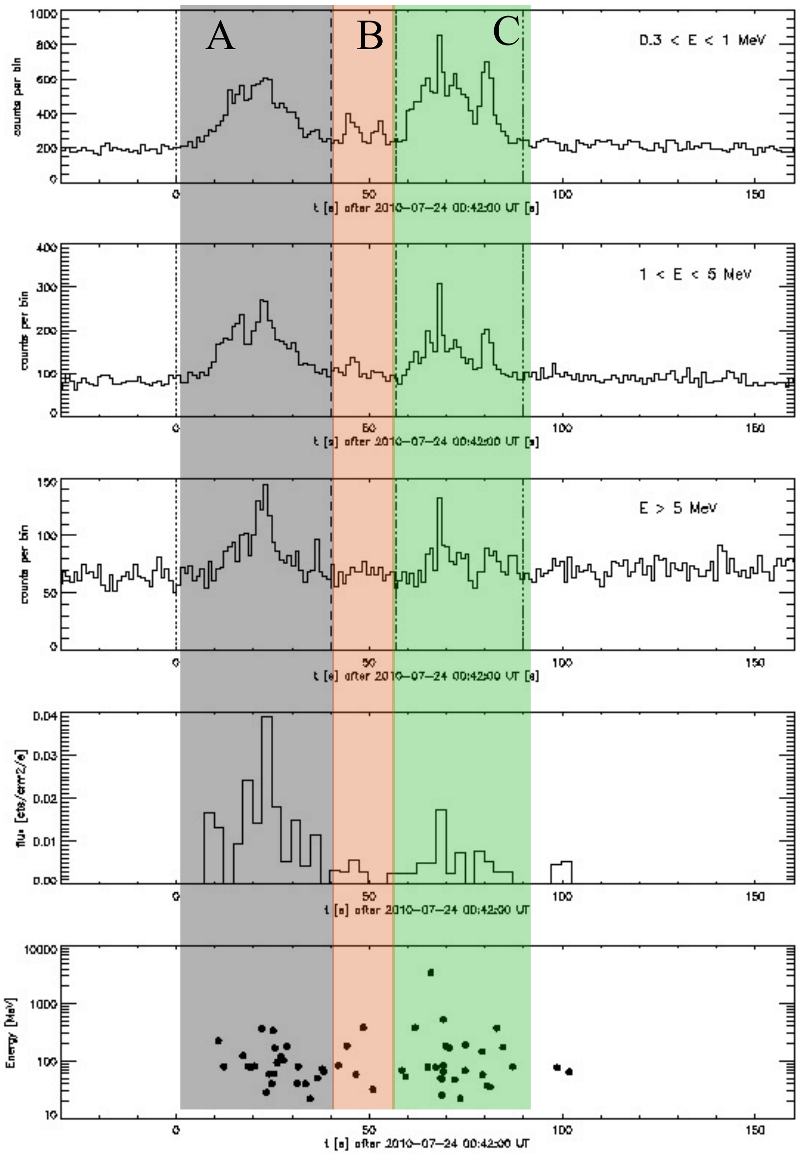
Due to the spinning operative mode, GRB 100724B remained within the AGILE/GRID FoV between $t_0 + 6$ s and $t_0 + 125$ s.

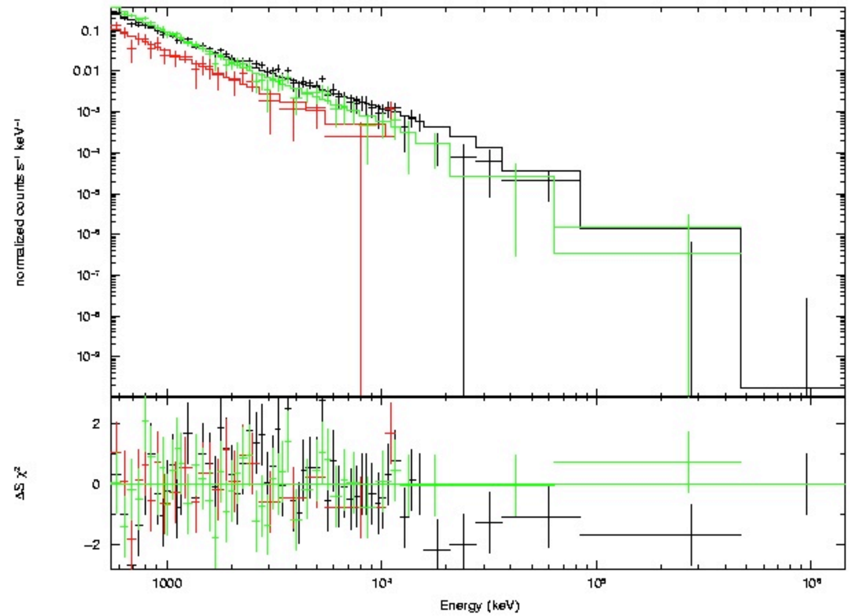
The GRB is not detected during the next “transit” in the FoV ($t_0 + 410$ s , $t_0 + 529$ s).

SuperAGILE was not collecting data for telemetry sharing reasons.



GRB 100724B: spectral evolution





Del Monte et al., in preparation

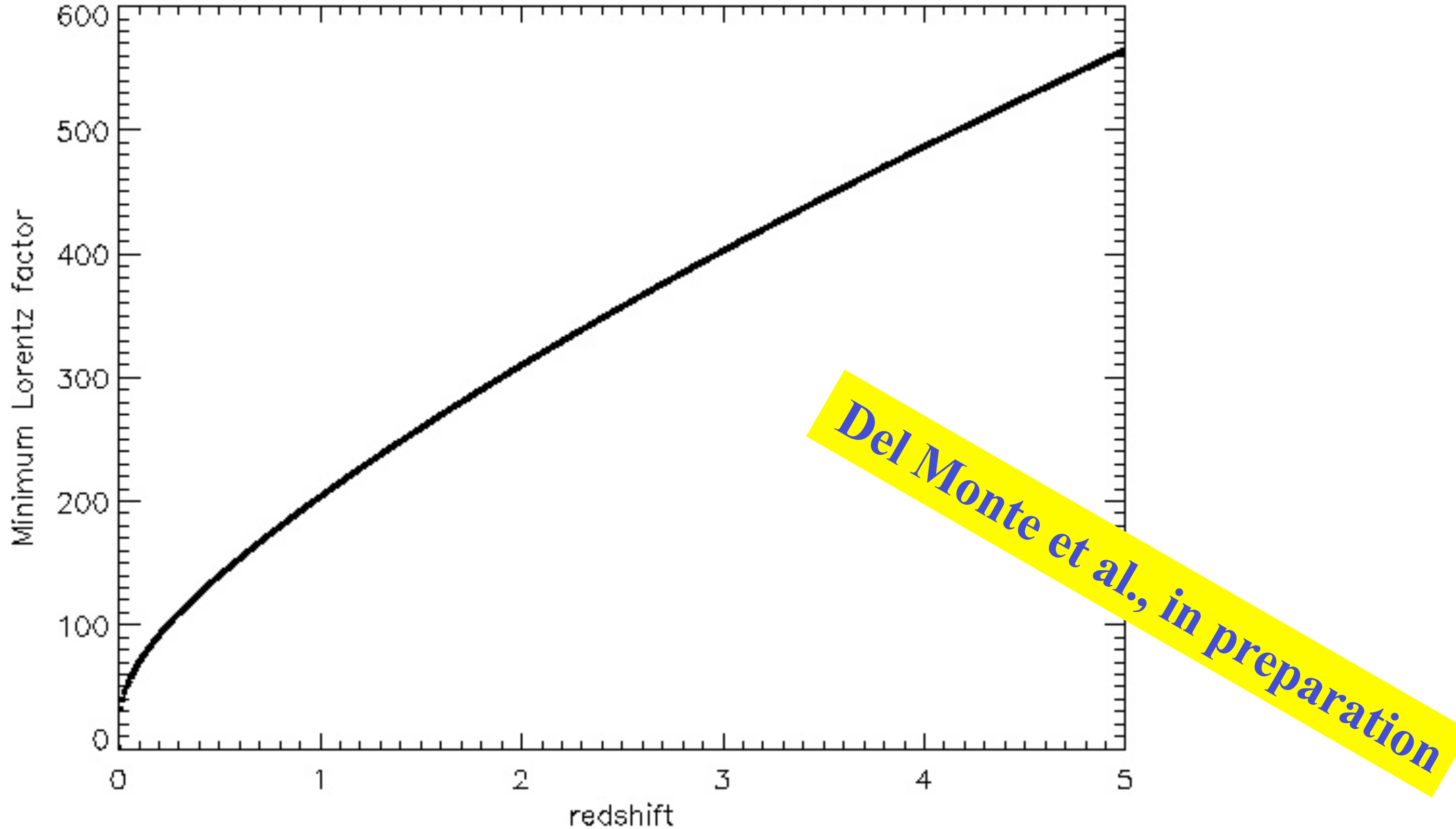
A: t_0 , t_0 + 40 s; photon index=2.01 ± 0.04

B: t_0 + 40 s , t_0 + 57 s; photon index=2.19 (+0.26,-0.19)

C: t_0 + 57 s , t_0 + 90 s; photon index=2.35 (+0.08,-0.07)

A variation at 4.2σ is found in the spectral indices.

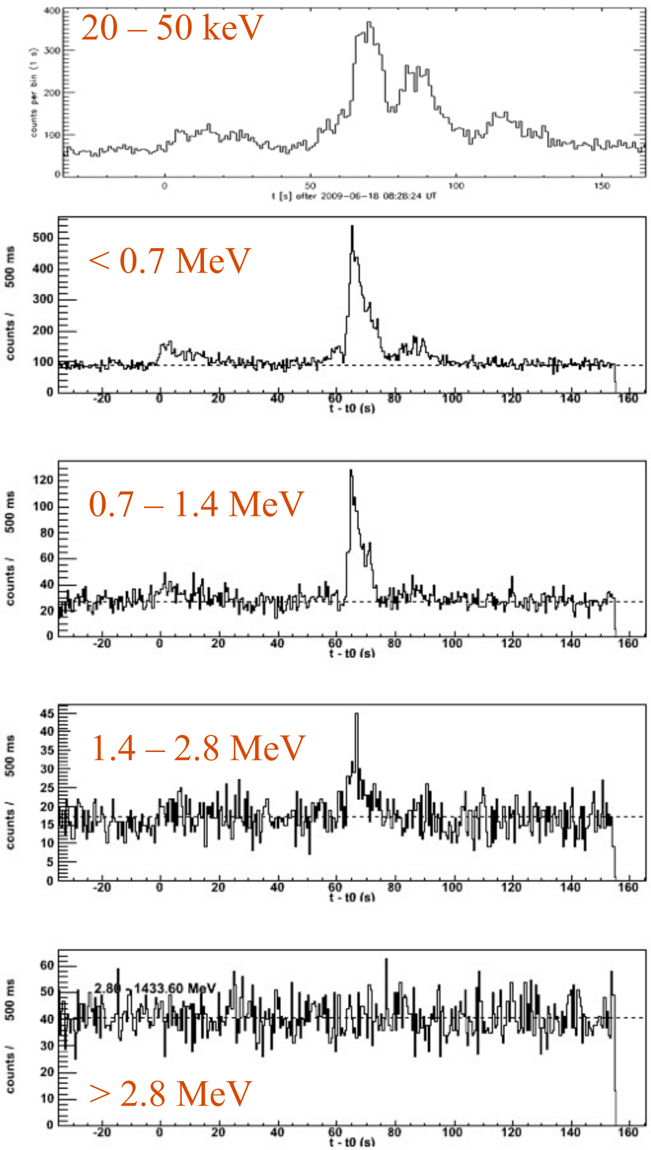
GRB 100724B: minimum bulk Lorentz factor

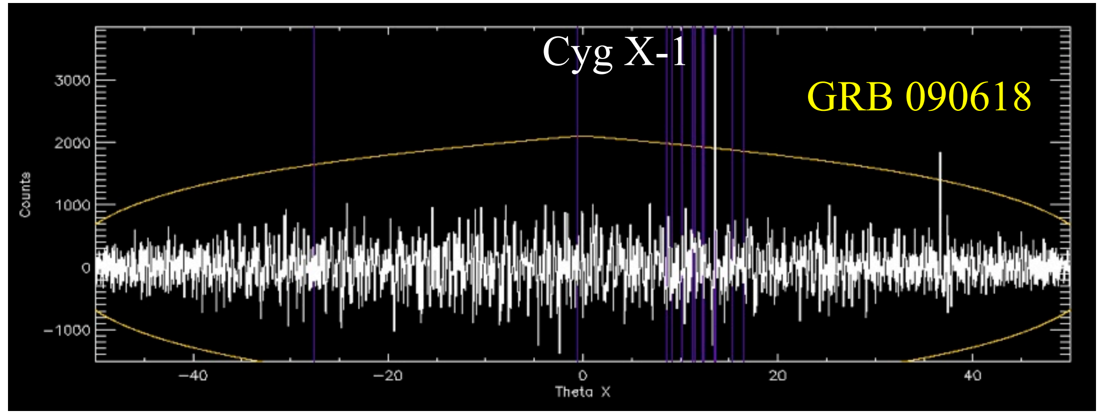


Following the method reported in the Supporting Online Material of the paper about GRB 080916C (Abdo et al 2009, Science, 323, 1688), $\Gamma_{min} = \Gamma_{min}(z, \Delta t, E_{max}, \beta)$.

The estimated Lorentz factor is similar to other GeV-bright GRBs (e. g. GRB 080916C, GRB 090902B and GRB 090510).

Why care about GRB 090618?





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

GRB 090618 is a bright event characterised by a fluence of 2.7×10^{-4} erg/cm^2 (in 8 – 1000 keV, GCN 9535) and a steep spectrum with $\beta \sim -3$ and $E_{peak} \sim 200$ keV (GCN 9524, 9535, 9553). GRB 090618 is not detected in the gamma ray band (GCN 9524). The measured redshift is 0.54 (GCN 9518).

Preliminary summary from the AGILE GRBs

Preliminary summary from the AGILE GRBs

Only a small subsample of GRBs emits in gamma rays: the overall detection rate (AGILE + Fermi) is ~10 events per year (consistent with the expectations of Band et al. 2009);

Preliminary summary from the AGILE GRBs

Only a small subsample of GRBs emits in gamma rays: the overall detection rate (AGILE + Fermi) is ~10 events per year (consistent with the expectations of Band et al. 2009);

GeV emitting are also bright GRBs (~10^{-5} erg/cm^2 at keV – MeV). Both long (GRB 080514B, GRB 0904041B, GRB 100724B) and short (GRB 090510) are detected. A correlation between the hard X-ray peak flux and the GeV emission is emerging;

Preliminary summary from the AGILE GRBs

Only a small subsample of GRBs emits in gamma rays: the overall detection rate (AGILE + Fermi) is ~10 events per year (consistent with the expectations of Band et al. 2009);

GeV emitting are also bright GRBs (~10^{-5} erg/cm^2 at keV – MeV). Both long (GRB 080514B, GRB 0904041B, GRB 100724B) and short (GRB 090510) are detected. A correlation between the hard X-ray peak flux and the GeV emission is emerging;

The GeV emission is concentrated in the prompt phase but see also Ghisellini, Ghirlanda, Nava and Celotti 2010. A delayed onset and a longer duration compared to hard X-rays are frequent;

Preliminary summary from the AGILE GRBs

Only a small subsample of GRBs emits in gamma rays: the overall detection rate (AGILE + Fermi) is ~10 events per year (consistent with the expectations of Band et al. 2009);

GeV emitting are also bright GRBs (~10^{-5} erg/cm^2 at keV – MeV). Both long (GRB 080514B, GRB 0904041B, GRB 100724B) and short (GRB 090510) are detected. A correlation between the hard X-ray peak flux and the GeV emission is emerging;

The GeV emission is concentrated in the prompt phase but see also Ghisellini, Ghirlanda, Nava and Celotti 2010. A delayed onset and a longer duration compared to hard X-rays are frequent;

Some events have a single spectrum (e. g. GRB 080514B, Giuliani et al. 2009) other have two spectral components (e. g. GRB 090510, Giuliani et al. 2010, Ackermann et al. 2010;
GRB 090902B <50 keV and >100 MeV, Abdo et al. 2009);

Preliminary summary from the AGILE GRBs

Only a small subsample of GRBs emits in gamma rays: the overall detection rate (AGILE + Fermi) is ~10 events per year (consistent with the expectations of Band et al. 2009);

GeV emitting are also bright GRBs (~10^{-5} erg/cm^2 at keV – MeV). Both long (GRB 080514B, GRB 0904041B, GRB 100724B) and short (GRB 090510) are detected. A correlation between the hard X-ray peak flux and the GeV emission is emerging;

The GeV emission is concentrated in the prompt phase but see also Ghisellini, Ghirlanda, Nava and Celotti 2010. A delayed onset and a longer duration compared to hard X-rays are frequent;

Some events have a single spectrum (e. g. GRB 080514B, Giuliani et al. 2009) other have two spectral components (e. g. GRB 090510, Giuliani et al. 2010, Ackermann et al. 2010;
GRB 090902B <50 keV and >100 MeV, Abdo et al. 2009);

Up to now no signature seems to be found in the X-ray and optical afterglow of the GeV emitting GRBs but see also Swenson et al. 2010;

Preliminary summary from the AGILE GRBs

Only a small subsample of GRBs emits in gamma rays: the overall detection rate (AGILE + Fermi) is ~10 events per year (consistent with the expectations of Band et al. 2009);

GeV emitting are also bright GRBs (~10^{-5} erg/cm^2 at keV – MeV). Both long (GRB 080514B, GRB 0904041B, GRB 100724B) and short (GRB 090510) are detected. A correlation between the hard X-ray peak flux and the GeV emission is emerging;

The GeV emission is concentrated in the prompt phase but see also Ghisellini, Ghirlanda, Nava and Celotti 2010. A delayed onset and a longer duration compared to hard X-rays are frequent;

Some events have a single spectrum (e. g. GRB 080514B, Giuliani et al. 2009) other have two spectral components (e. g. GRB 090510, Giuliani et al. 2010, Ackermann et al. 2010; GRB 090902B <50 keV and >100 MeV, Abdo et al. 2009);

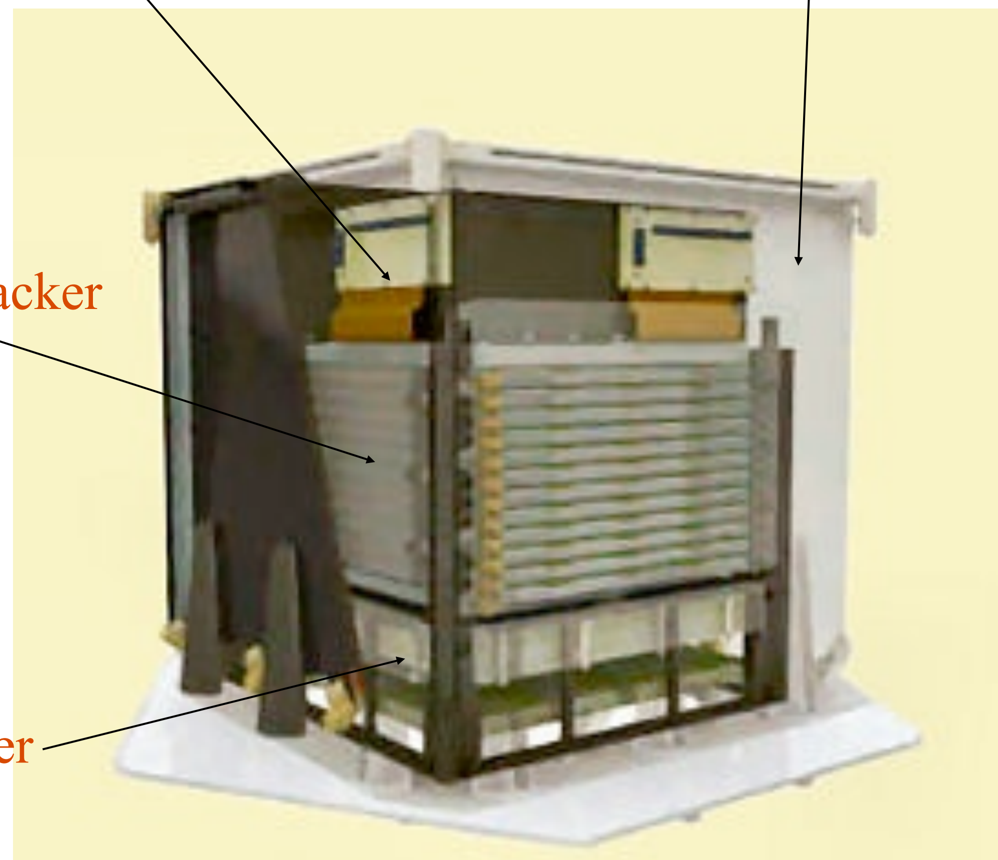
Up to now no signature seems to be found in the X-ray and optical afterglow of the GeV emitting GRBs but see also Swenson et al. 2010;

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

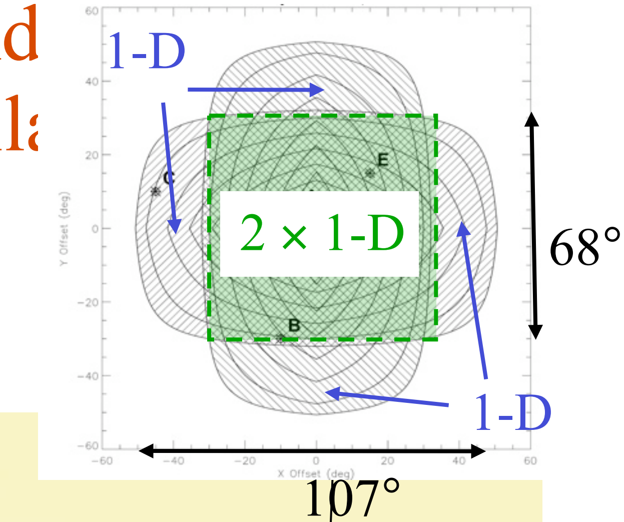
Two co-aligned imagers and a quasi all-sky sensitive scintillator

Gamma Ray Imaging Detector (Silicon Tracker & Mini-calorimeter):

SuperAGILE:

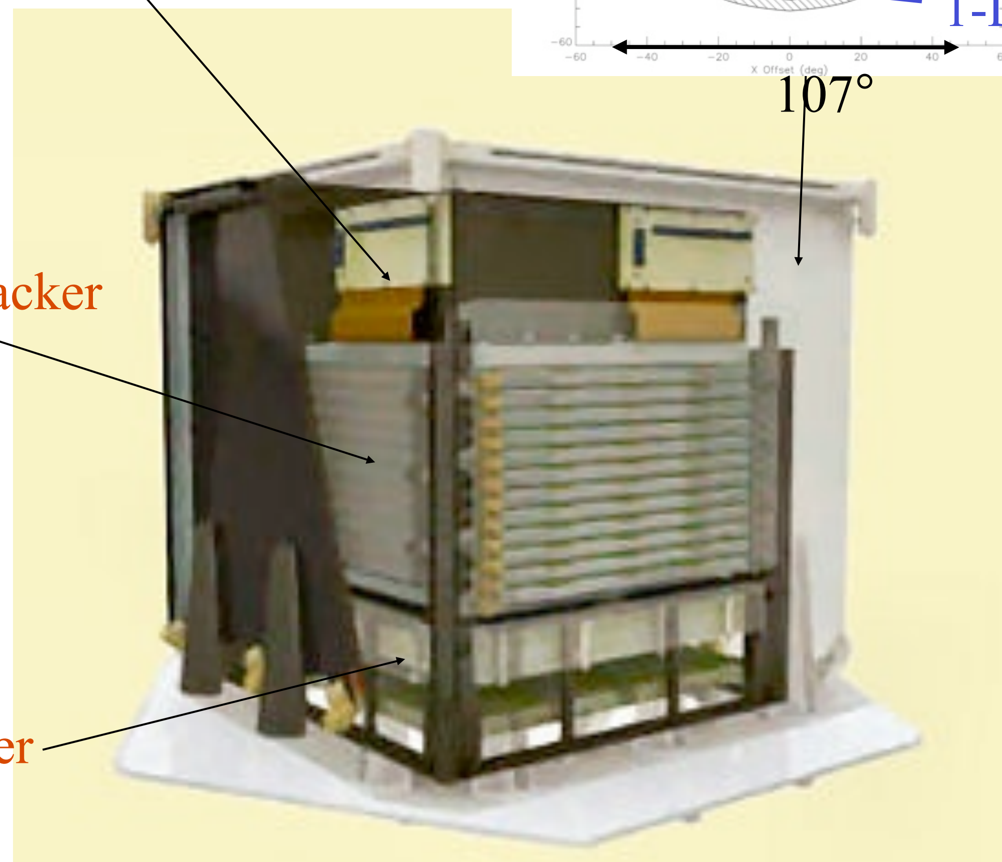


Two co-aligned imagers and quasi all-sky sensitive scintill

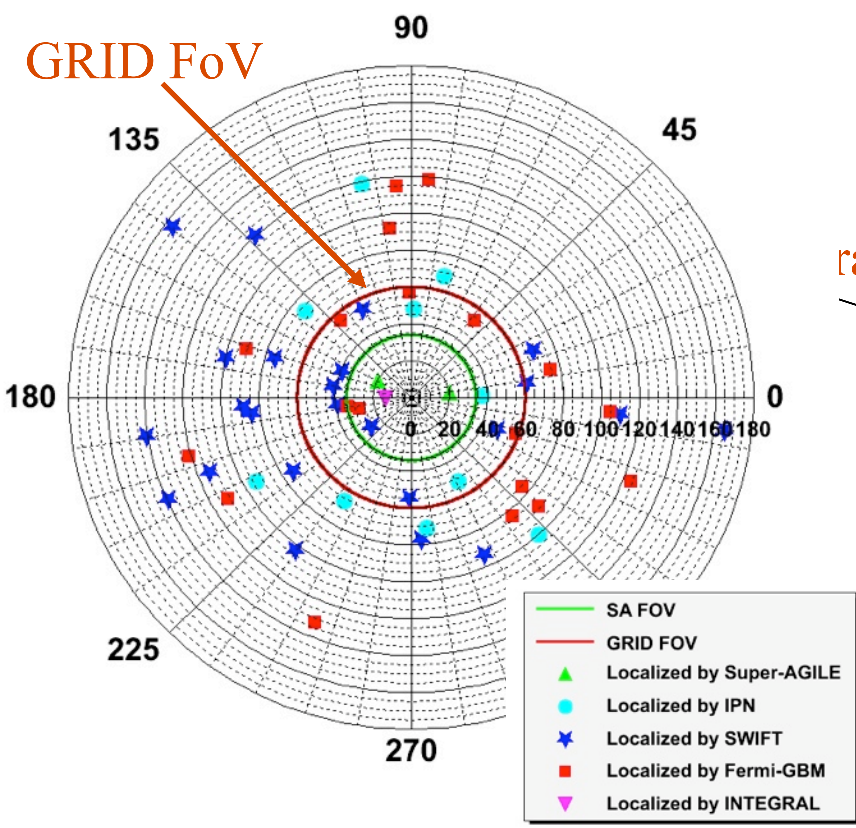


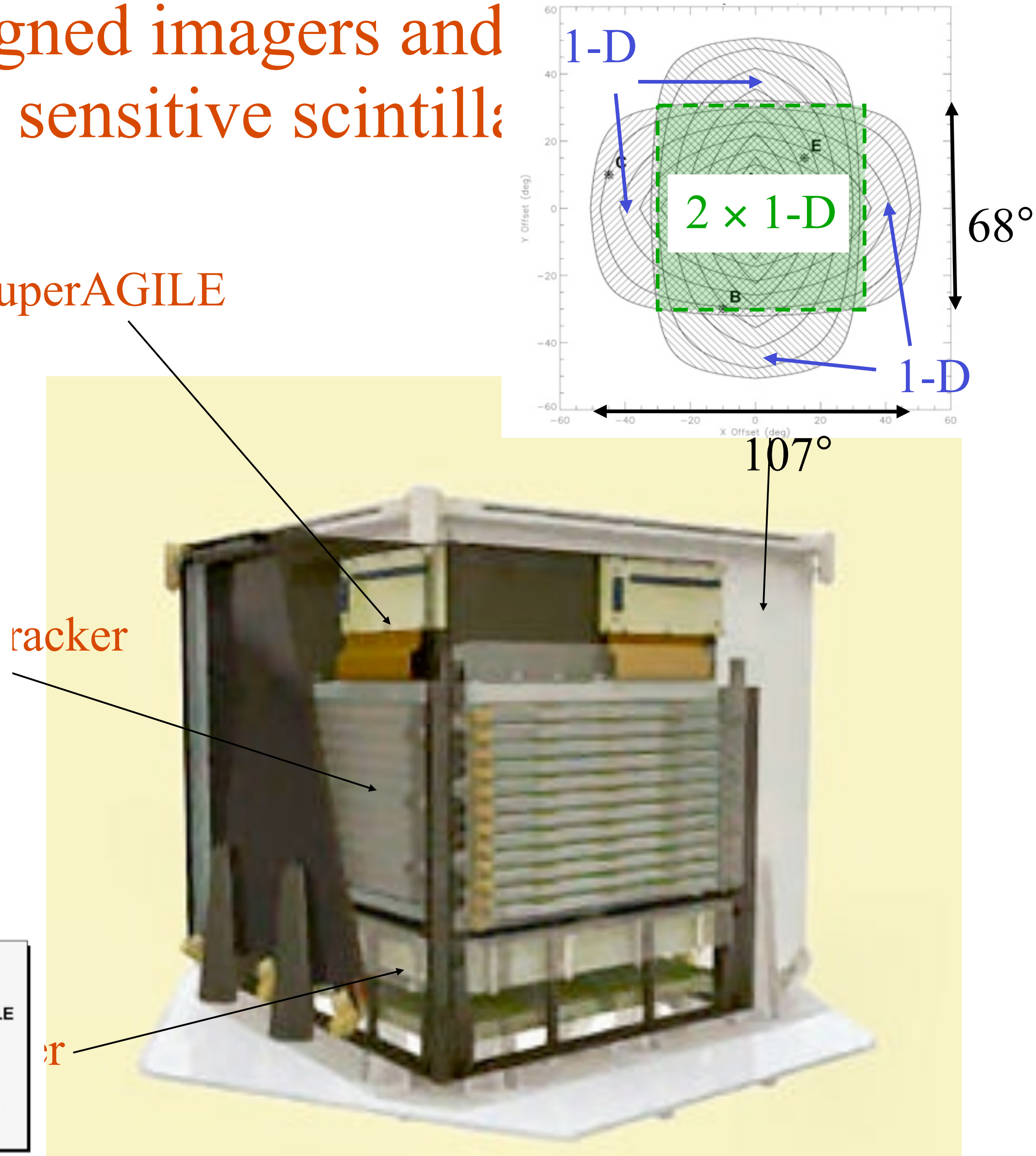
Gamma Ray Imaging Detector (Silicon Tracker & Mini-calorimeter):

SuperAGILE:



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





The census of the GRBs observed by AGILE

The census of the GRBs observed by AGILE

Hard X-rays:

• SuperAGILE localized ~1 GRBs/month in pointing operative mode, expected to decrease to 0.3 – 0.5 GRB/month in spinning mode;

• 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 (negligibly affected by the spinning mode) and 1 – 2 GRBs/month detected by SuperAGILE outside the FoV. SuperAGILE and MCAL are active members of the IPN;

The census of the GRBs observed by AGILE

Hard X-rays:

• SuperAGILE localized ~1 GRBs/month in pointing operative mode, expected to decrease to 0.3 – 0.5 GRB/month in spinning mode;

• 3 arcmin radius uncertainty on the localization and minimum detected fluence of $\sim 5\times10^{-7}$ erg cm^{-2}

• ~1 GRB/week detected by MCAL (negligibly affected by the spinning mode) and 1 – 2 GRBs/month detected by SuperAGILE outside the FoV. SuperAGILE and MCAL are active members of the IPN;

Gamma rays:

• Four firm detections: GRB 080514B, GRB 090401B, GRB 090510 and GRB 100724B;

• Two less significant detections: GRB 080721 and GRB 081001;

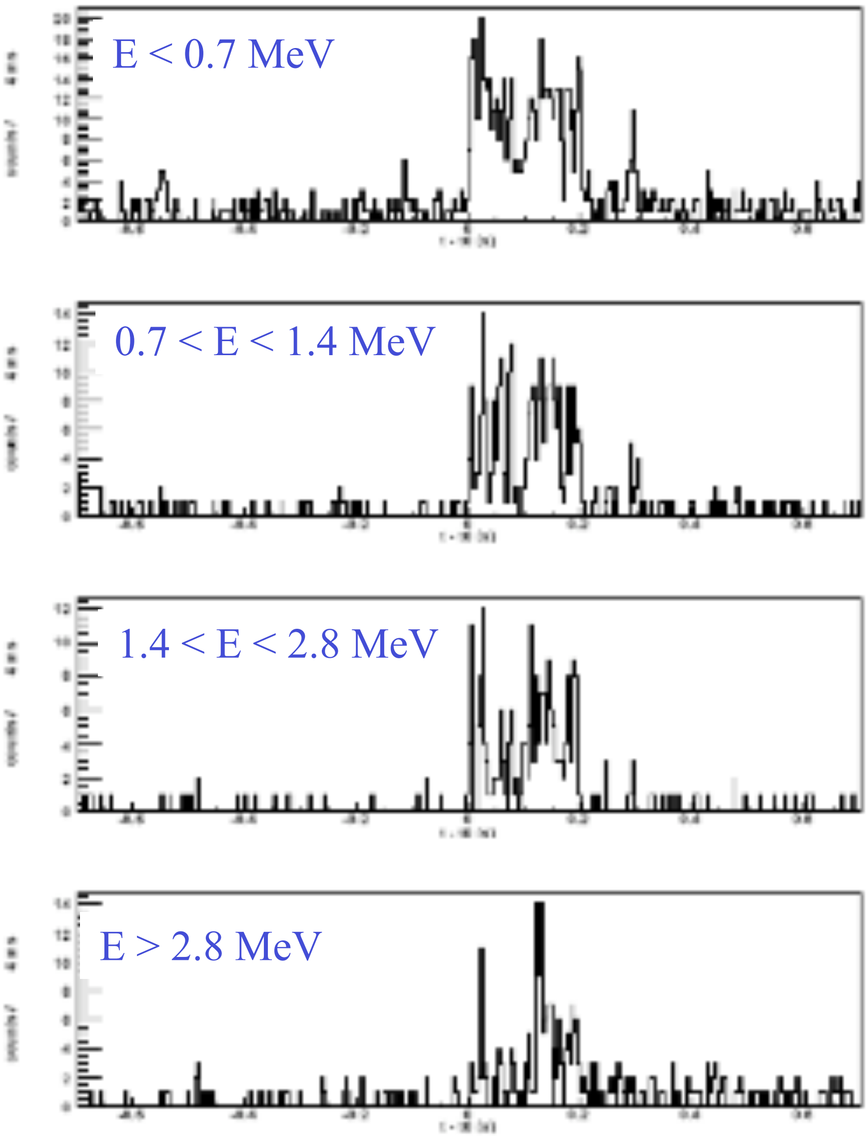
Distinctive features of the AGILE GRBs

- 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;

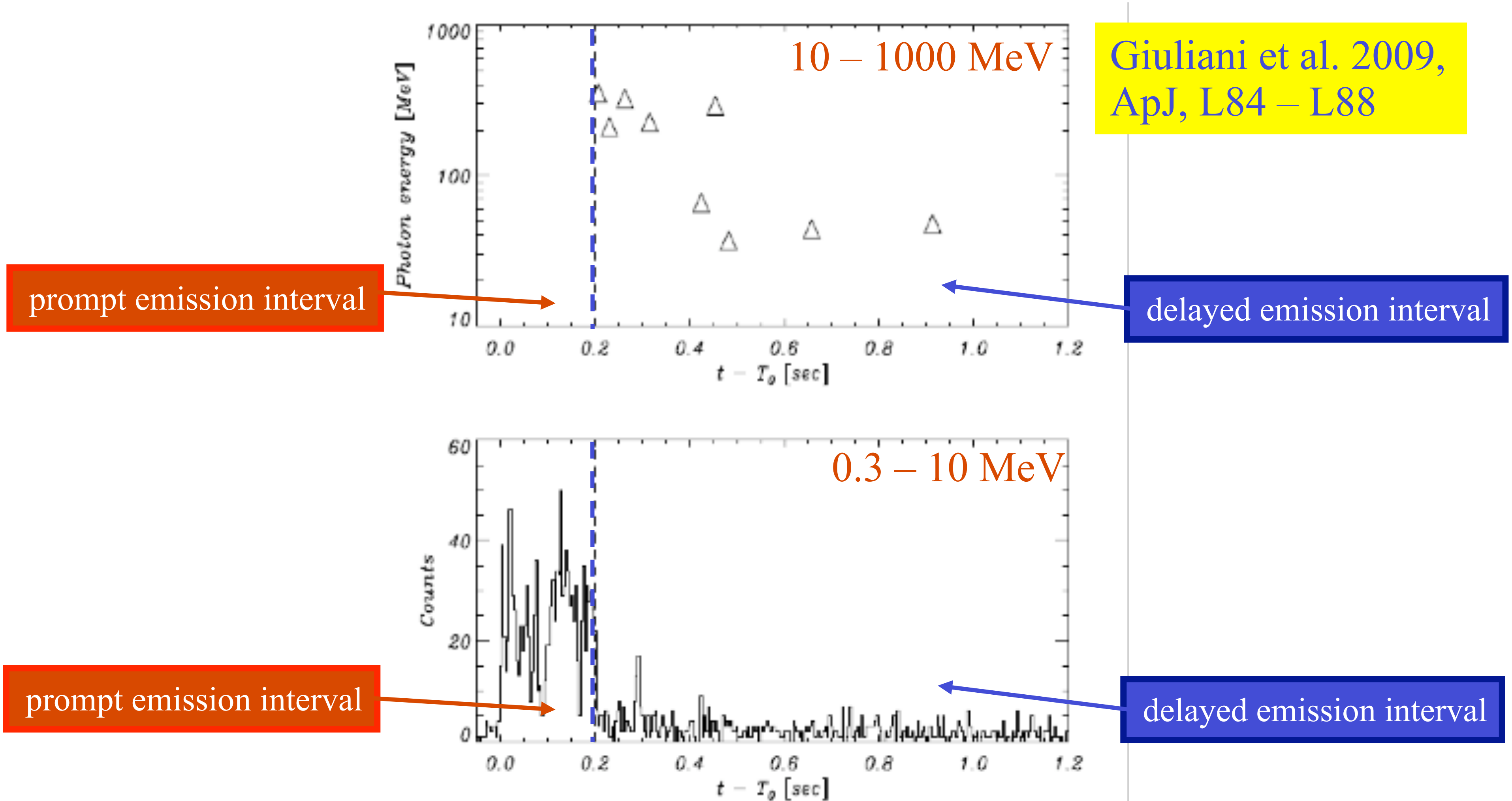
Short GRB 090510: the prompt emission in the MeV band



Lightcurves of the MCAL with 4 ms bin size.

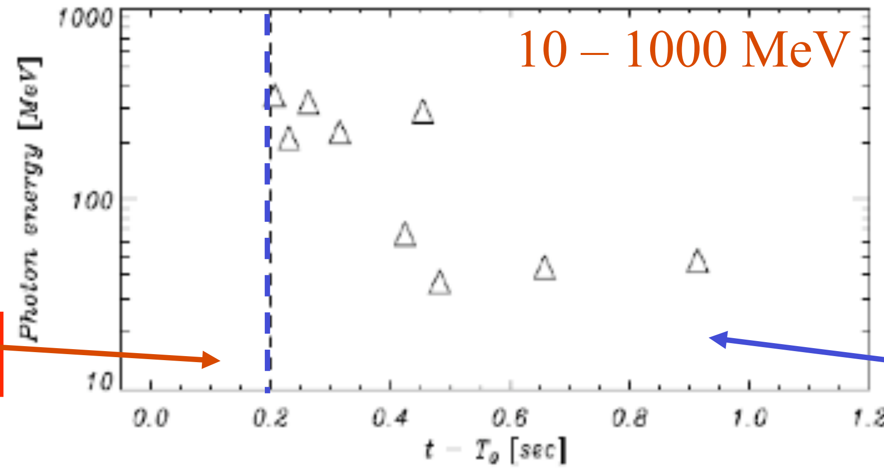
The second peak is harder than the first one.

GRB 090510: the delayed emission



GRB 090510 has been localized by Swift (GCN 9331) and detected also by Fermi/LAT (GCN 9334) and AGILE (GCN 9343). The redshift is 0.903 (GCN 9353).

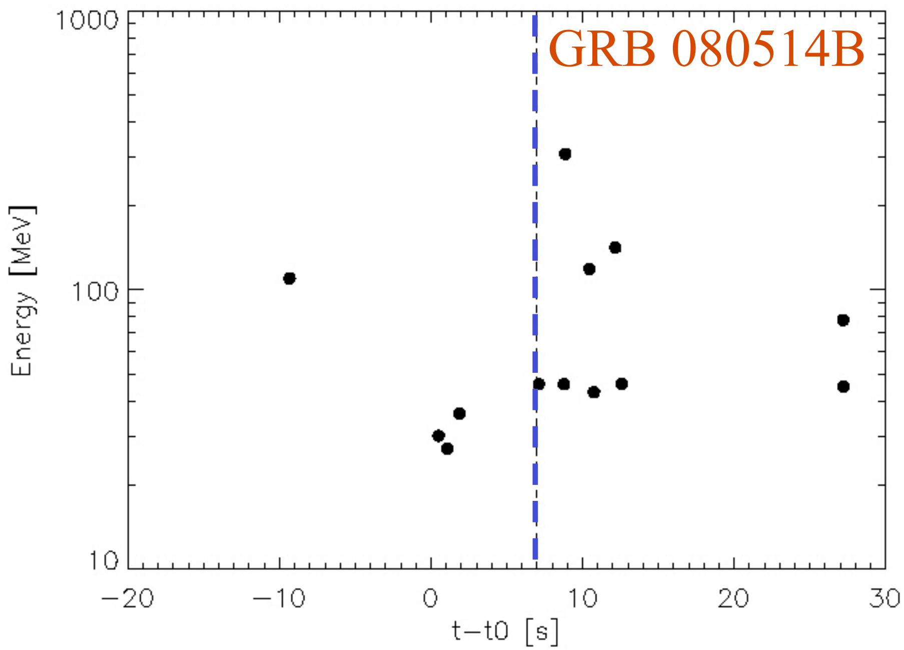
GRB 090510: the delayed emission



Giuliani et al. 2009, ApJ, L84 – L88

prompt emission interval

delayed emission interval



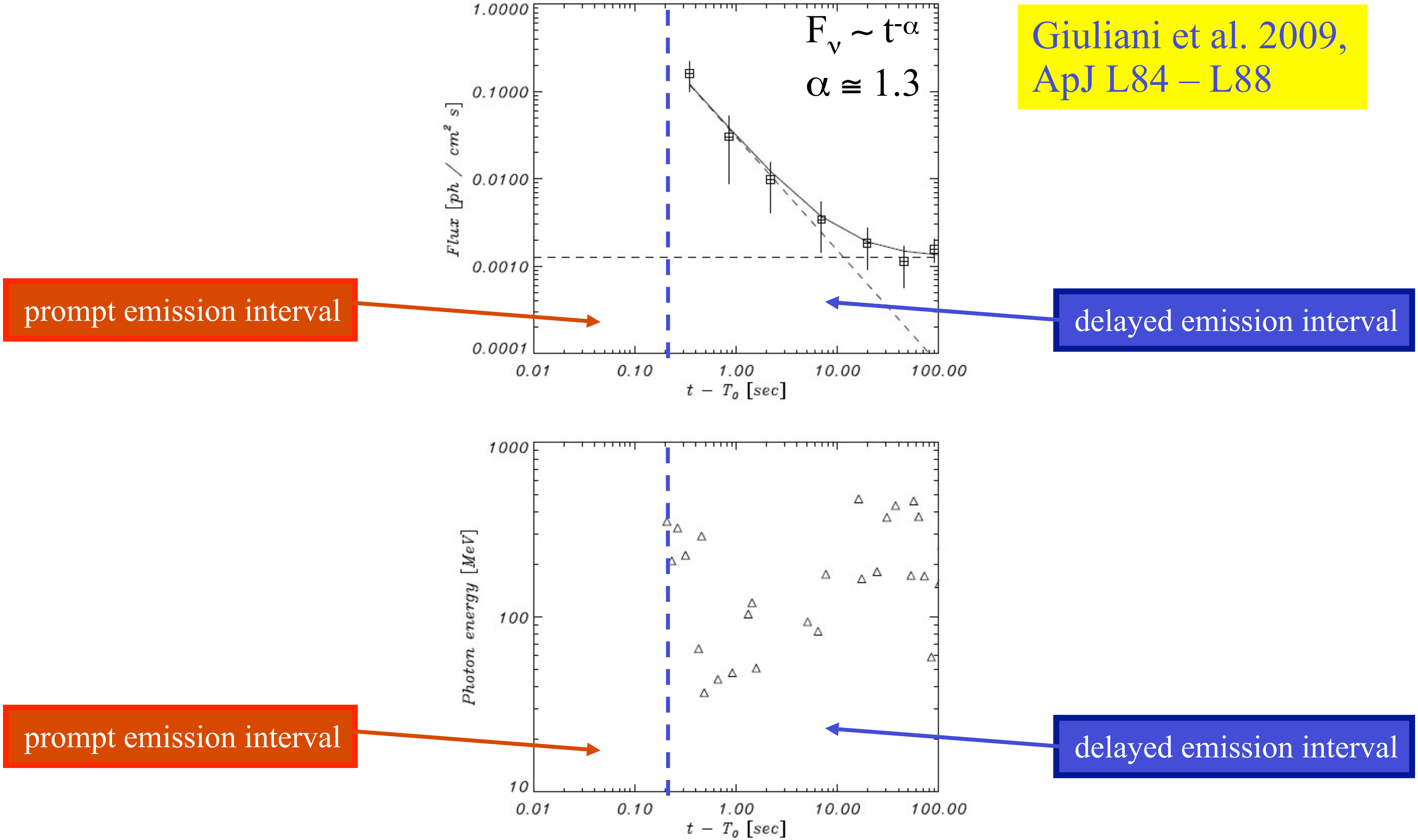
prompt emission interval

delayed emission interval

GRB 090510 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



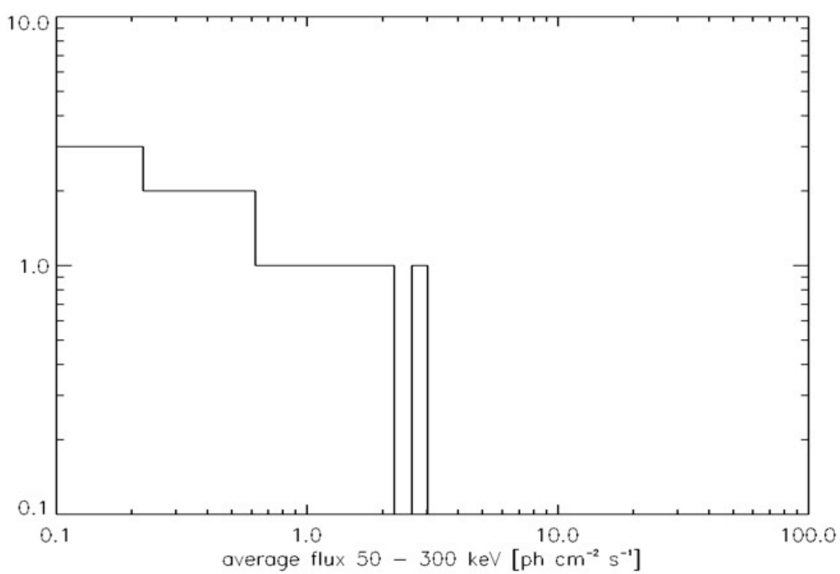
Distinctive features of the AGILE GRBs

- 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;

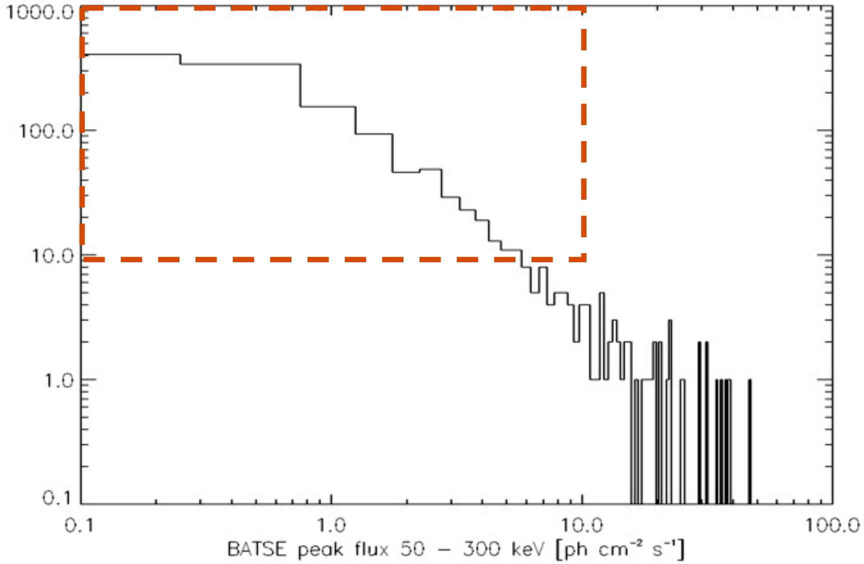
- GRB 090401B: long GRB with multiple peak structure, simultaneous and extended emission of gamma rays;

Log N – Log S of SuperAGILE and BATSE

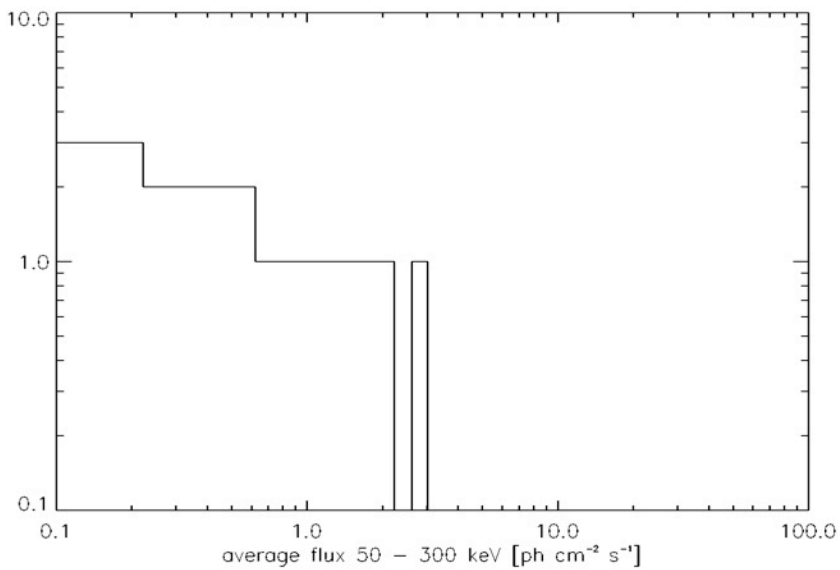


Log N – Log S of the GRBs localized by SuperAGILE (with spectra by Konus-Wind and GBM), rescaled to the BATSE energy band (50 – 300 keV).

Log N – Log S of SuperAGILE and BATSE

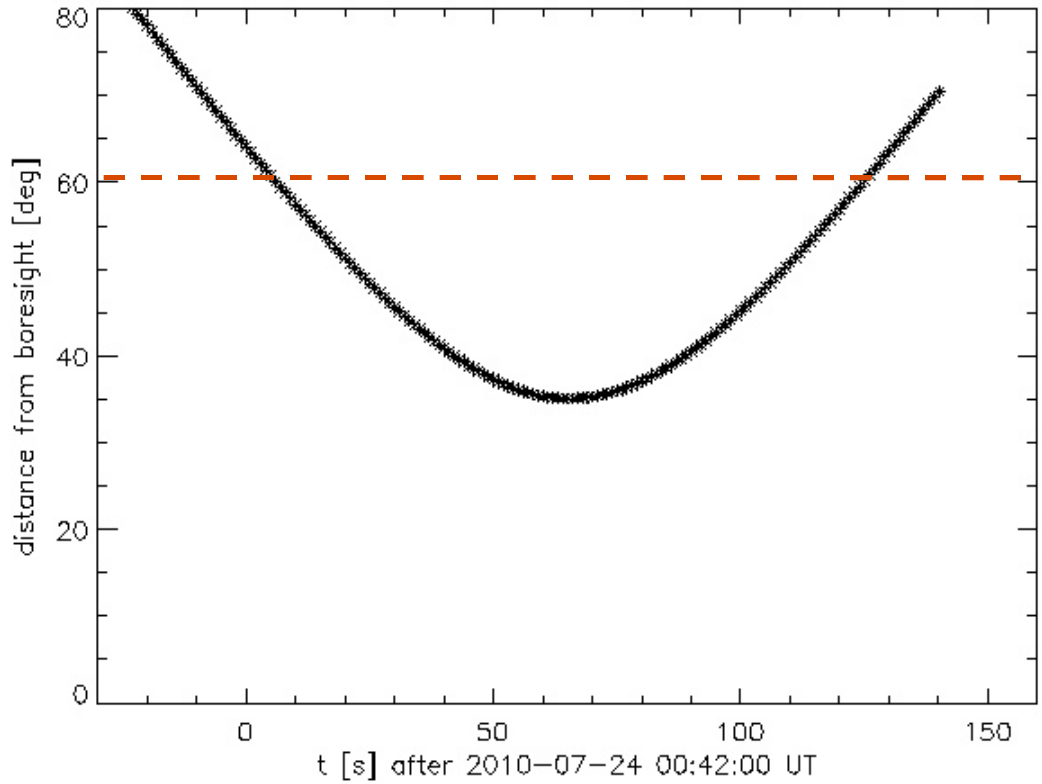


Log N – Log S from the Fourth BATSE Catalogue (Paciesas et al. 1999) in 50 – 300 keV.



Log N – Log S of the GRBs localized by SuperAGILE (with spectra by Konus-Wind and GBM), rescaled to the BATSE energy band (50 – 300 keV).

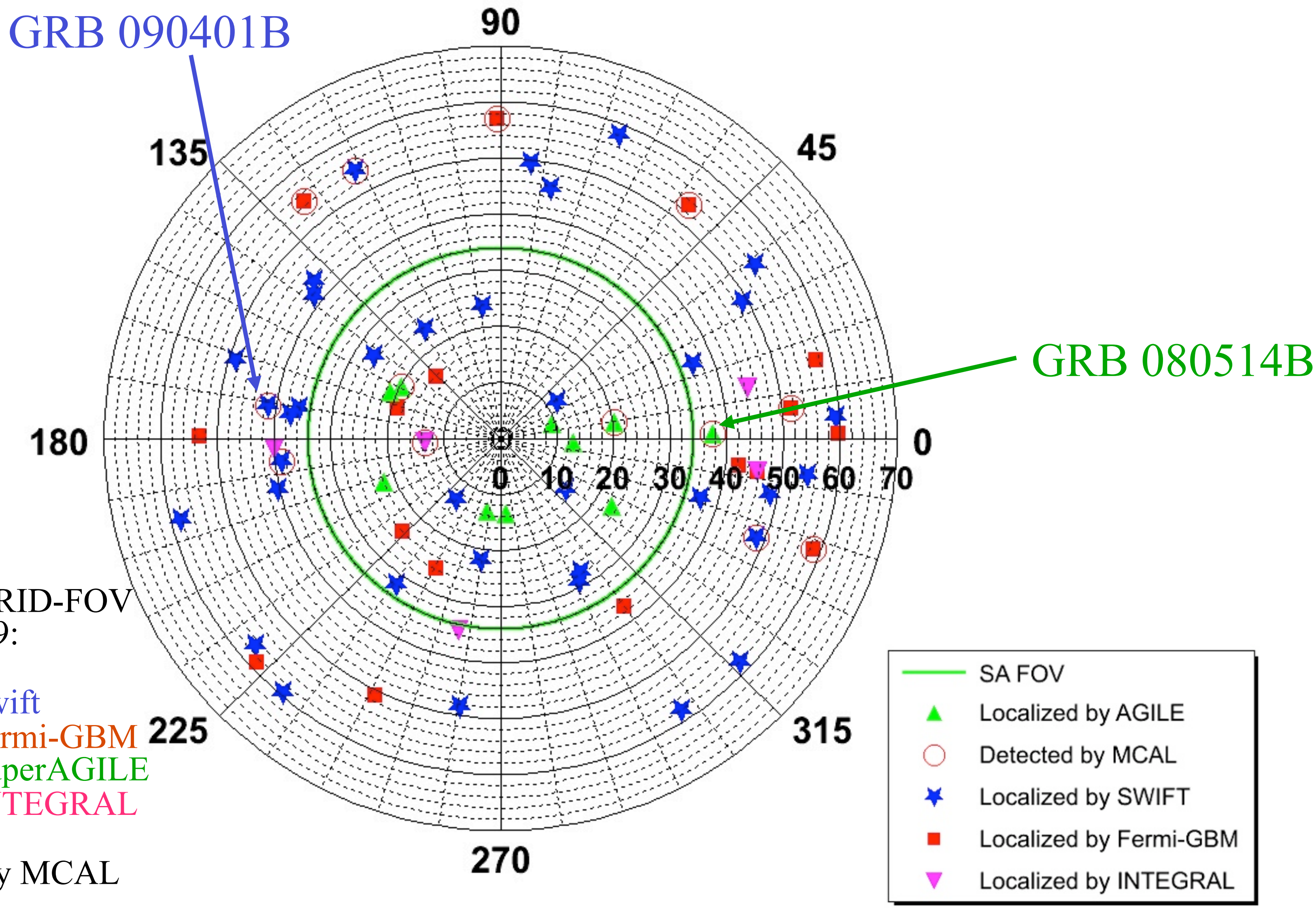
“Transit” of GRB 100724B in the GRID field of view



The algorithms used to observe GRBs and calculate upper limits in GRID have been corrected:

1. A region of 15 deg remains on average 120 s (1/3 of the time) within the GRID field of view;
2. The background is calculated on 6 “transits” (720 s);
3. The exposure for background average is now 10800 s (vs 2000 s), obtained from 5 intervals of 2160 s (30 “transits”) to reduce the SAA impact;

Upper limits in gamma rays: the sample



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

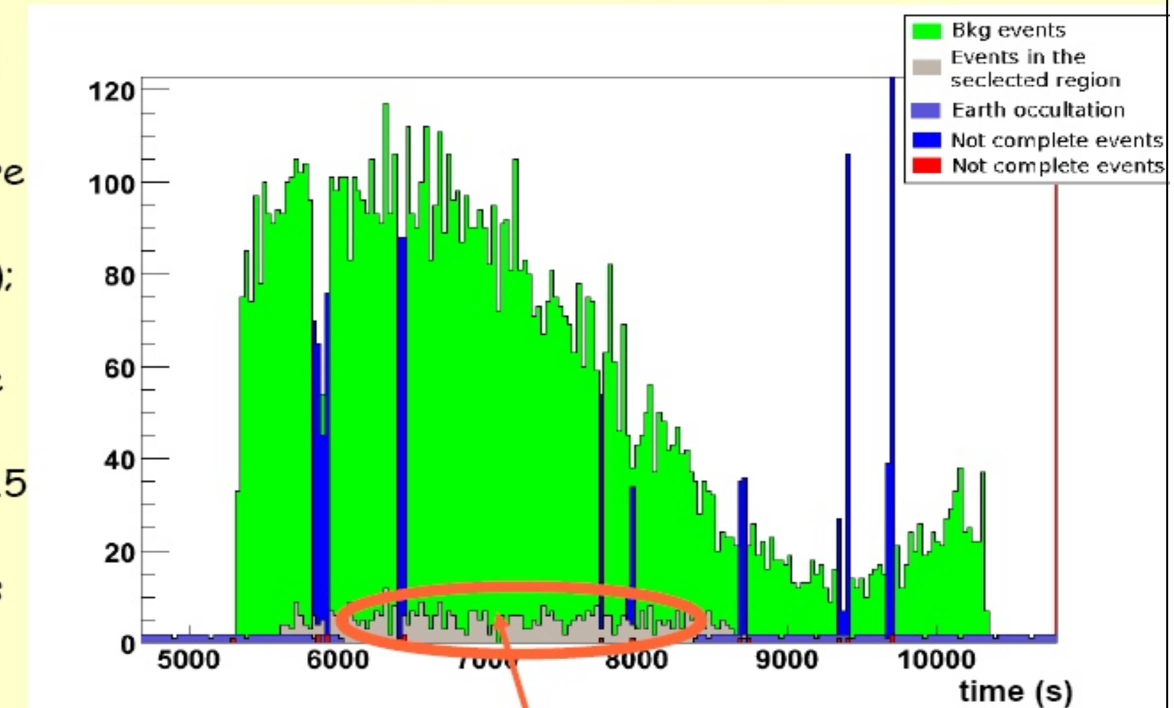
Upper limits in gamma rays: preliminary results

- We estimated the upper limit of the 68 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 is ~0.03 ph cm^{-2} s^{-1} (=> (1 – 5) × 10^{-7} erg/cm^2/s);
- a paper by F. Longo et al. is almost finished.

Background Sampling

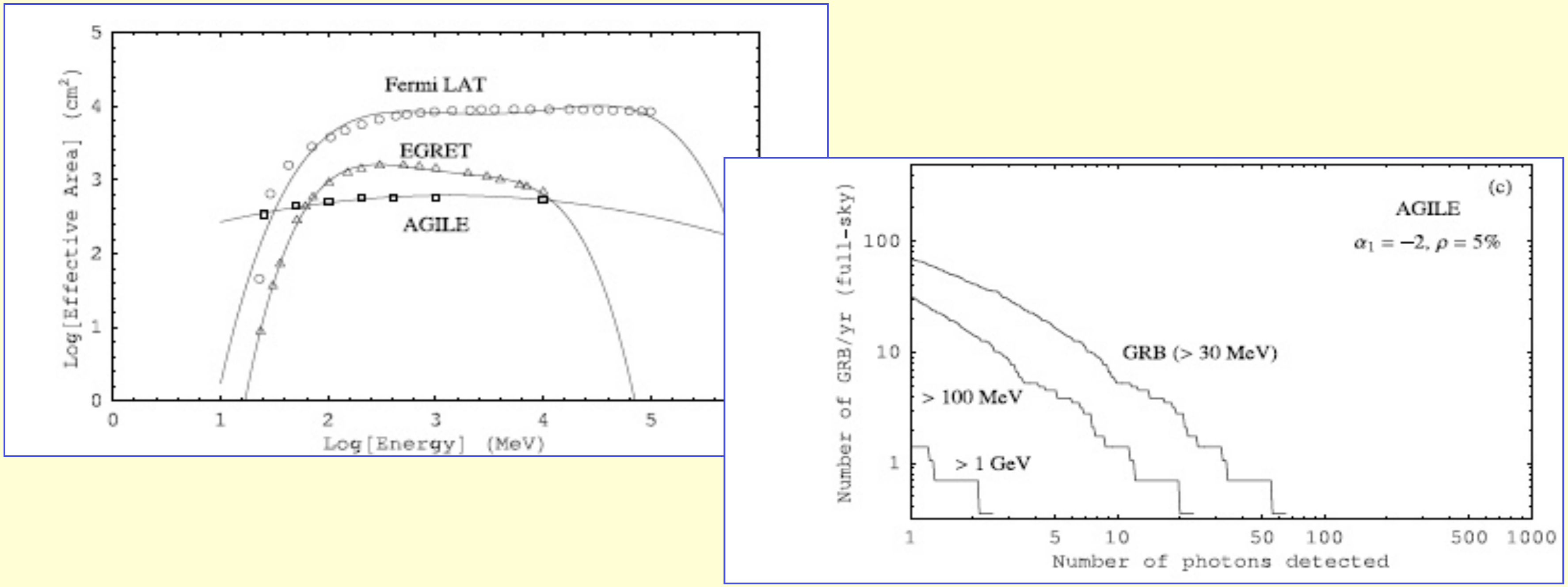
To extract the background we want to look:

- into a region where there is no signal (before the trigger);
- into the same spatial region as the one where we extract the signal: 15 deg;
- when this region is not occulted by earth;
- when the data taken by AGILE are complete with all information.



The modulation in the all bkg event distribution is no longer present in the selected region events.

Estimated rate of GRBs detected by AGILE



AGILE FoV = 1/5 of the sky

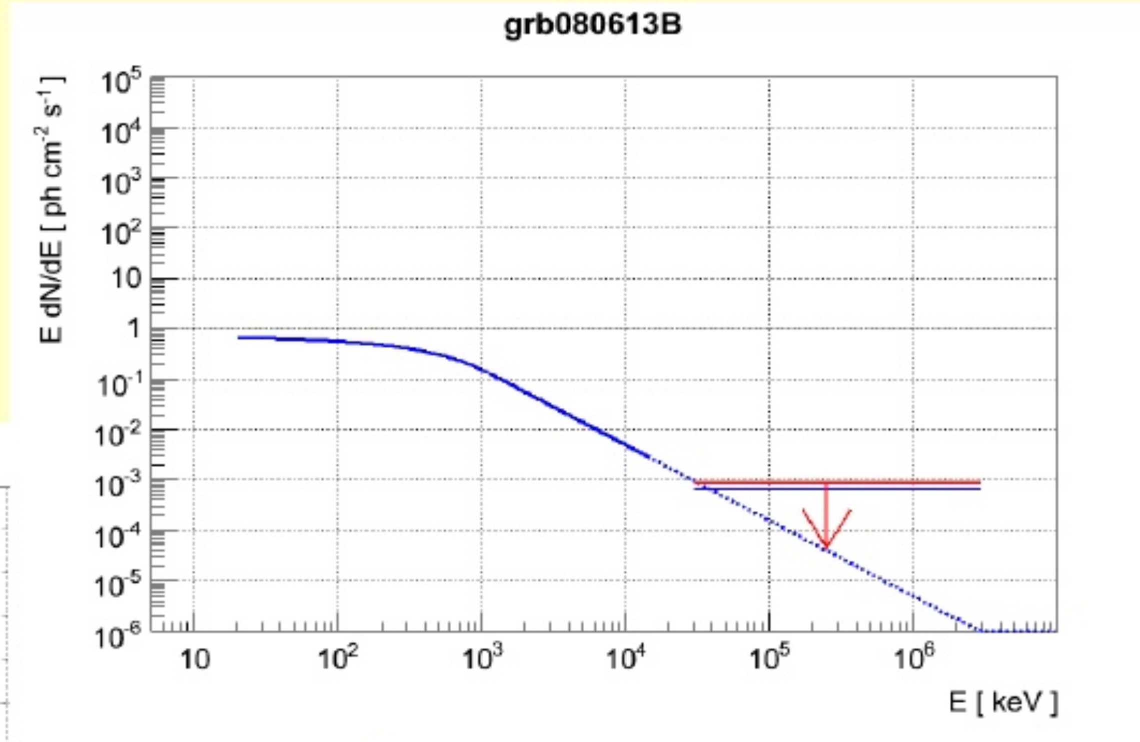
AGILE effective area = 400 cm^2

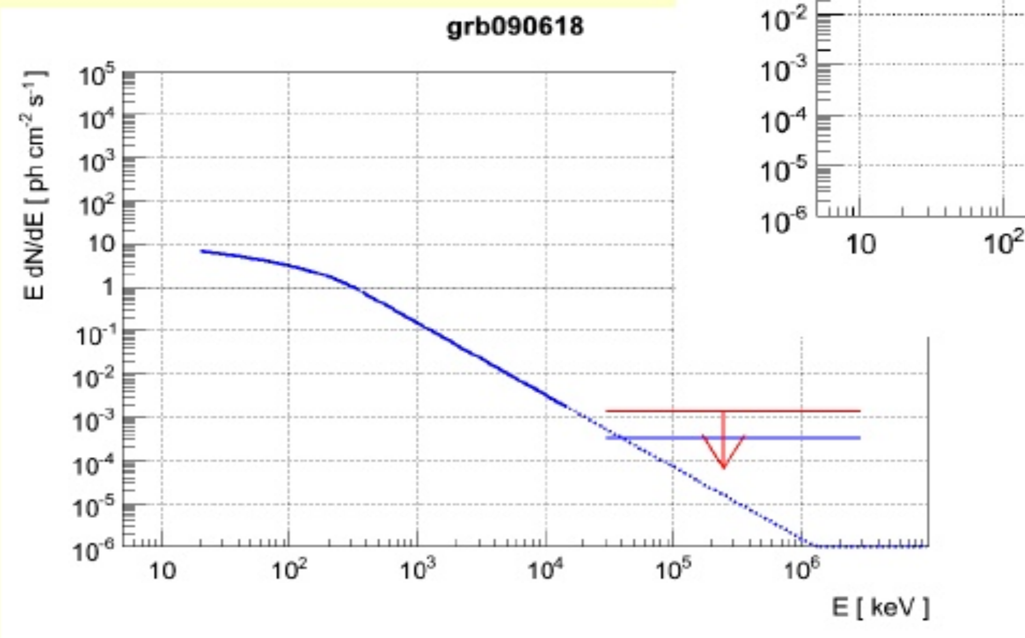
Estimated full sky rate by Le and Dermer (2009)

Rate = ~ 10 GRB full sky / yr

Upper limits in gamma rays: time integrated spectra

Temporal integrated spectra with spectral parameters from Konus-Wind or WAM or BAT or GBM.





What changes in spinning mode (since November 2009)?

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;
- MCAL is marginally affected by the spinning (via the background modulation introduced by the Anticoincidence) thus no significant variation is found;

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;

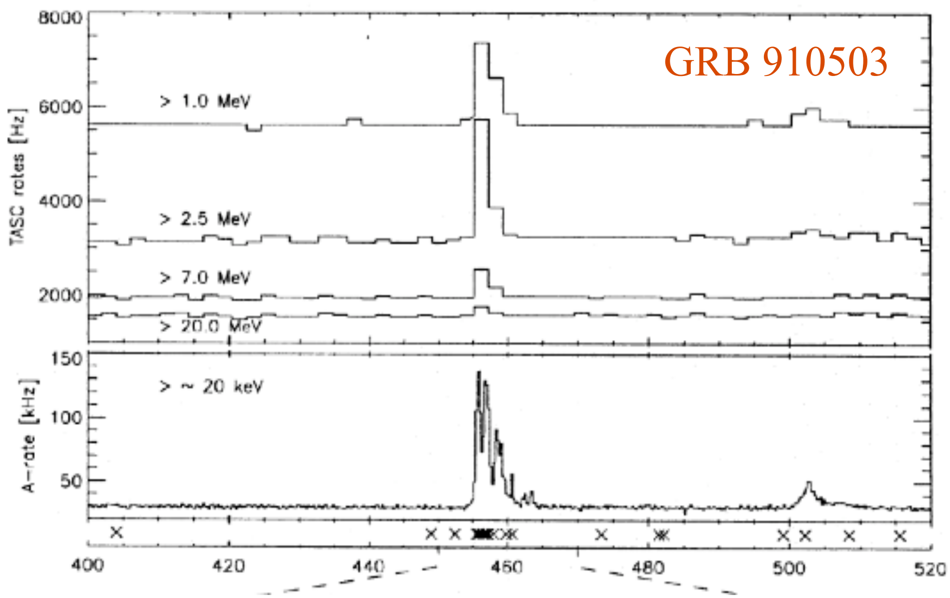
• we expect a decrease in the SuperAGILE localization rate down to ~0.3 – 0.5 GRBs/month;

• MCAL is marginally affected by the spinning (via the background modulation introduced by the Anticoincidence) thus no significant variation is found;

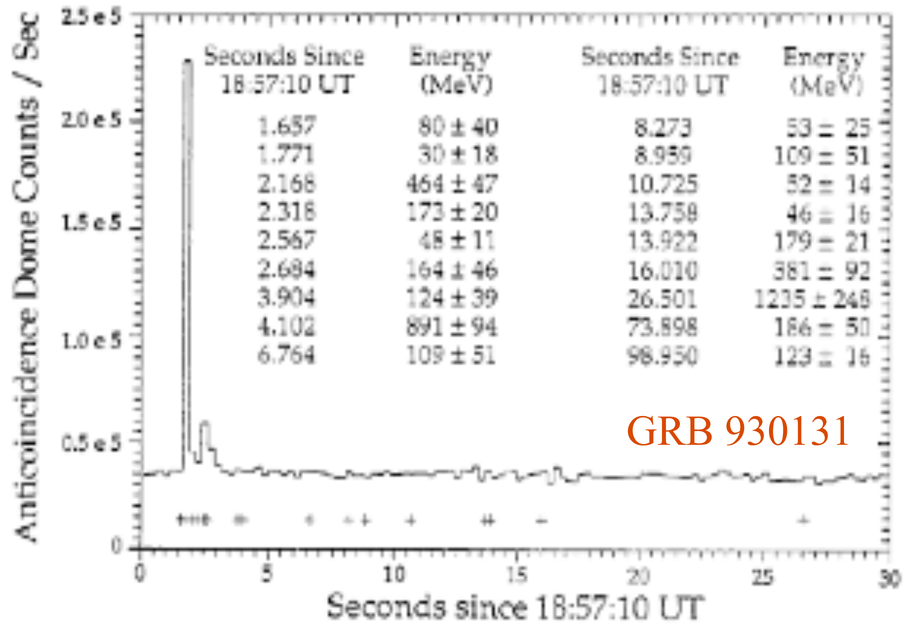
Gamma rays:

• more Sky (~70 %) is observed by the GRID in gamma rays but the GRBs “transit” in 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.

Discovery of GRB 100724B

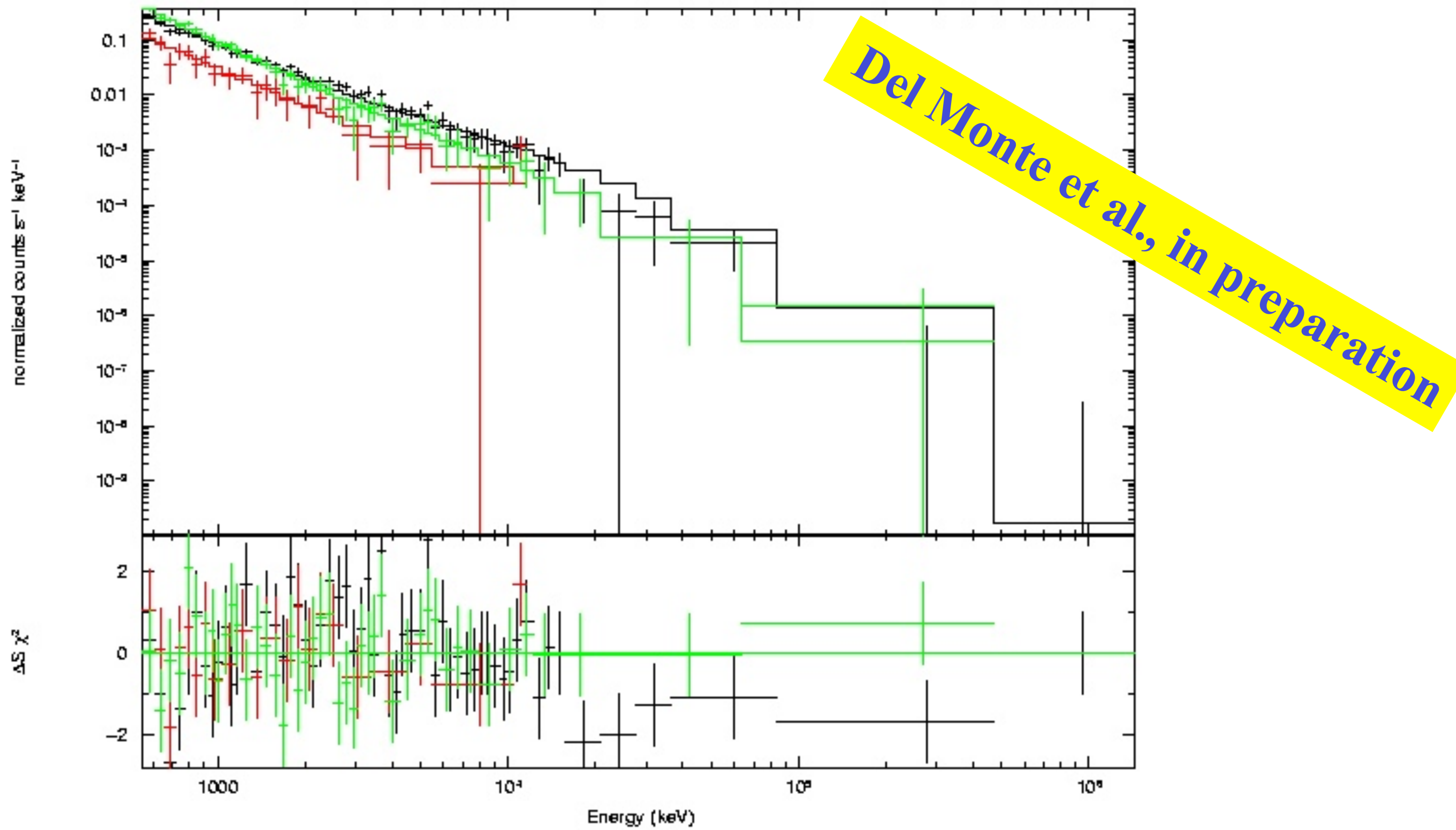
GRB 100724B was localized by Fermi/GBM (RA = 124.16°, dec = 74.42°, GCN 10977) with an uncertainty of 1.0° (statistic), 2 – 3° (systematic) and Fermi/LAT (RA = 120.04°, dec = 76.74°, GCN 10978) with an error box of 1.1°.

GRB 100724B triggered [illegible] AGILE/MCAL on 2010-07-24 00:42:00 UT. (GCN 10994) and was detec[illegible] the AGILE/GRID (GCN 10996) at a position (RA = 124.3°, dec = 78.[illegible] [illegible]onsistent with LAT and GBM with an error radius of 1.5° at 95 % confide[illegible]vel.

The GRB could not be observed by Swift due t[illegible] constraints. On 2 August 2010 Swift observed two fields in th[illegible]T error region but did not localise any afterglow. No more follow-up observations are available thus GRB 100724B lacks both afterglow and redshift.

Immagine delle localizzazioni di questo GRB!!!

GRB 100724B: MCAL spectral evolution



Interval A: photon index = 2.01 ± 0.04

Interval B: photon index = 2.19 (+0.26,-0.19)

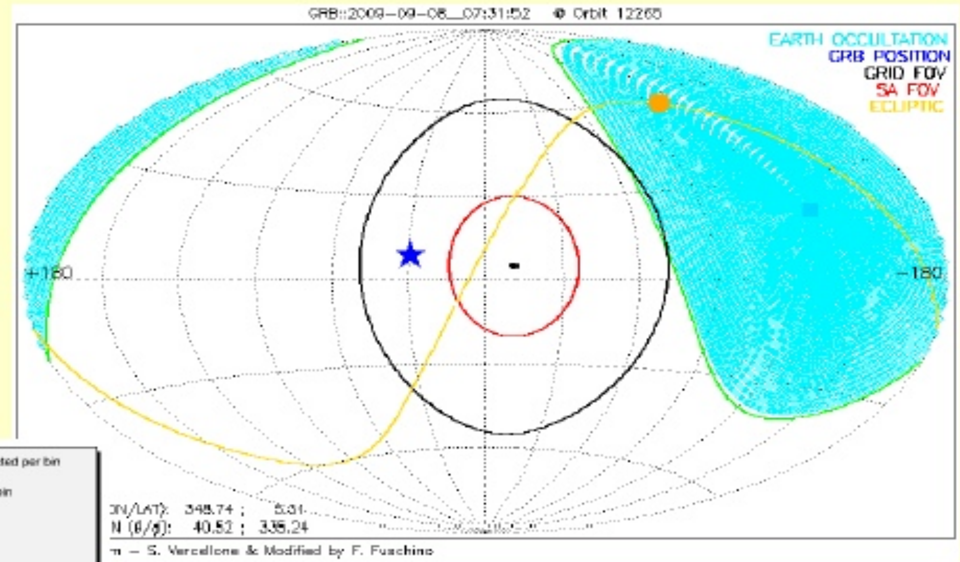
Interval C: photon index = 2.35 (+0.08,-0.07).

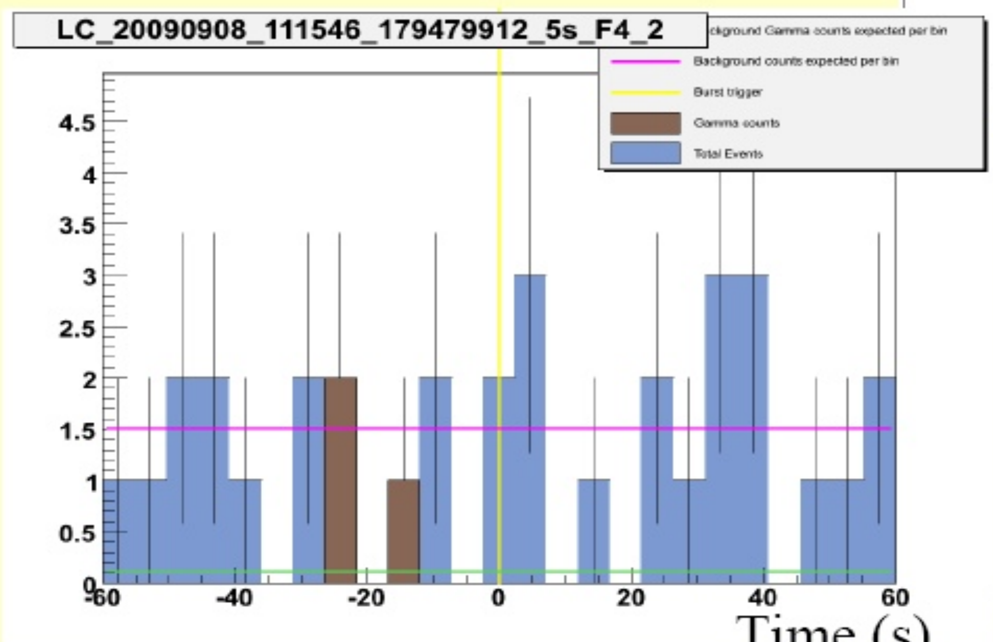
A variation at 4.2σ is found in the spectral indices

Upper limits in gamma rays: selected sample

36 localized by SWIFT
17 localized by Fermi-GBM
10 localized by SuperAGILE
5 localized by INTEGRAL
10 detected by MCAL

30 GRBs with spectral informations





Upper limits in gamma rays: search for afterglows

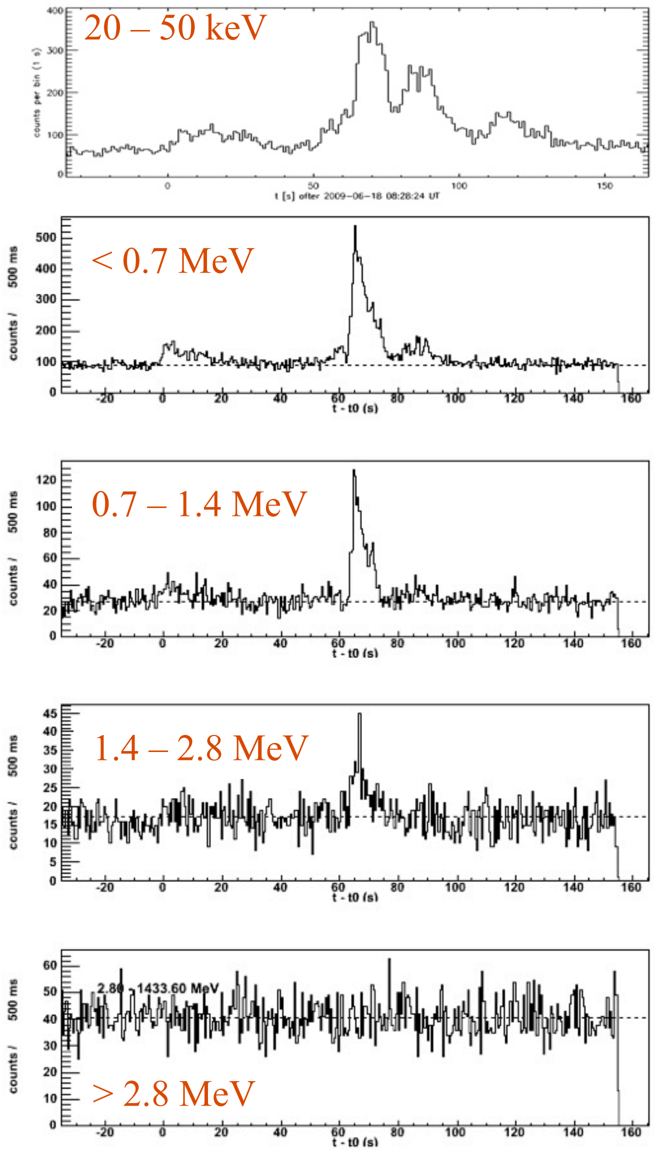
GRB	$\sqrt{TS}$	Flux upper limit (photons cm^{-2} s^{-1})
070724B	1.17	3.15e-06
071021	0.80	6.68e-06
071104	1.24	2.05e-06
080210	1.14	2.67e-06
080524	0.39	1.30e-06
080613A	0.40	9.86e-07
080625	0.25	6.86e-07
080714	1.60	3.25e-06
080721	1.07	4.23e-06
080723B	0.96	2.40e-06
080727C	1.63	5.03e-06
080828	0.24	5.34e-07
080915B	2.28	1.18e-05
081001	0.78	2.48e-06
081102	0.94	1.23e-05
081119	0.56	1.86e-06
090108	1.89	5.57e-06
090131	0.48	4.23e-06
090219	0.61	2.16e-06
090324	0.60	1.25e-06
090410	1.02	6.03e-06
090516	1.45	3.10e-06
090516B	0.90	2.81e-06
090618	1.53	4.17e-06
090904B	0.65	2.11e-06
091010	0.093	2.91e-07

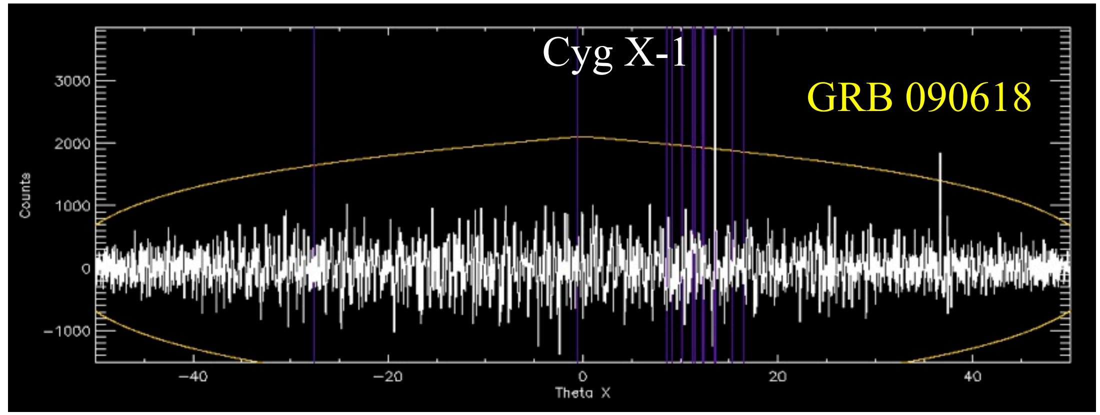
Multi Source Likelihood analysis of Gamma-ray events from GRB afterglows in progress (from 100 s until 3700 s after the trigger) .

Peculiarities of GRB 100724B

- simultaneous onset of keV – MeV – GeV emission;
- important hard-to-soft spectral evolution;
- minimum Lorentz factor similar to GeV-bright GRBs;
- lack of afterglow and redshift (too bad!);

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. The redshift is 0.54

Conclusions as questions

Conclusions as questions

- Do only the brightest events emit gamma rays? (top 5 % fluence, $\sim 10^{-5}$ erg/cm^2)

Conclusions as questions

- Do only the brightest events emit gamma rays? (top 5 % fluence, ~10^{-5} erg/cm^2)

- Is the Lorentz factor really larger in GeV emitting GRBs? (Γ~1000 in GRB 080916C, GRB 090902B and GRB 090510);

Conclusions as questions

- Do only the brightest events emit gamma rays? (top 5 % fluence, $\sim 10^{-5}$ erg/cm^2)

- Is the Lorentz factor really larger in GeV emitting GRBs? ($\Gamma \sim 1000$ in GRB 080916C, GRB 090902B and GRB 090510);

- Are the gamma rays emitted in the prompt or in the afterglow? (Ghisellini, Ghirlanda, Nava and Celotti 2010; GRB 940217, Hurley et al. 1994);

Conclusions as questions

- Do only the brightest events emit gamma rays? (top 5 % fluence, ~10^{-5} erg/cm^2)

- Is the Lorentz factor really larger in GeV emitting GRBs? (Γ~1000 in GRB 080916C, GRB 090902B and GRB 090510);

- Are the gamma rays emitted in the prompt or in the afterglow? (Ghisellini, Ghirlanda, Nava and Celotti 2010; GRB 940217, Hurley et al. 1994);

- Is the GeV emission always temporally extended? And when is its onset delayed?

Conclusions as questions

- Do only the brightest events emit gamma rays? (top 5 % fluence, ~10^{-5} erg/cm^2)

- Is the Lorentz factor really larger in GeV emitting GRBs? (Γ~1000 in GRB 080916C, GRB 090902B and GRB 090510);

- Are the gamma rays emitted in the prompt or in the afterglow? (Ghisellini, Ghirlanda, Nava and Celotti 2010; GRB 940217, Hurley et al. 1994);

- Is the GeV emission always temporally extended? And when is its onset delayed?

- A single spectrum or two components? (GRB 080514B, Giuliani et al. 2009, GRB 090510, Giuliani et al. 2010, Ackermann et al. 2010; GRB 090902B <50 keV and >100 MeV, Abdo et al. 2009);

Conclusions as questions

• Do only the brightest events emit gamma rays? (top 5 % fluence, $\sim 10^{-5}$ erg/cm^2)

• Is the Lorentz factor really larger in GeV emitting GRBs? ($\Gamma \sim 1000$ in GRB 080916C, GRB 090902B and GRB 090510);

• Are the gamma rays emitted in the prompt or in the afterglow? (Ghisellini, Ghirlanda, Nava and Celotti 2010; GRB 940217, Hurley et al. 1994);

• Is the GeV emission always temporally extended? And when is its onset delayed?

• A single spectrum or two components? (GRB 080514B, Giuliani et al. 2009, GRB 090510, Giuliani et al. 2010, Ackermann et al. 2010; GRB 090902B <50 keV and >100 MeV, Abdo et al. 2009);

• Which are the emission mechanisms capable to produce GeV photons? (Synchrotron e. g. Ghisellini, Ghirlanda, Nava and Celotti 2010, Synchrotron Self Compton e. g. Corsi, Guetta and Piro 2009, External Inverse Compon e. g. Zou, Fan and Piran 2008).

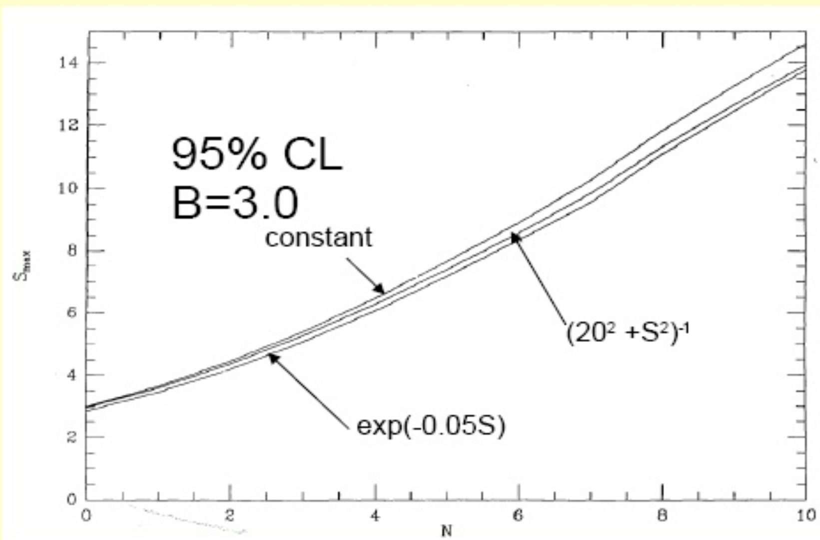
UL computation method

The Helene Method

We know the mean value of background counts, but not the background counts expected in the signal region (B), nor the number of signal counts (S). We suppose that the probability distribution of S is constant from 0 to ∞.

From Bayes's theorem: $f_{N,B}(S) \propto p(S) P_S(N)$

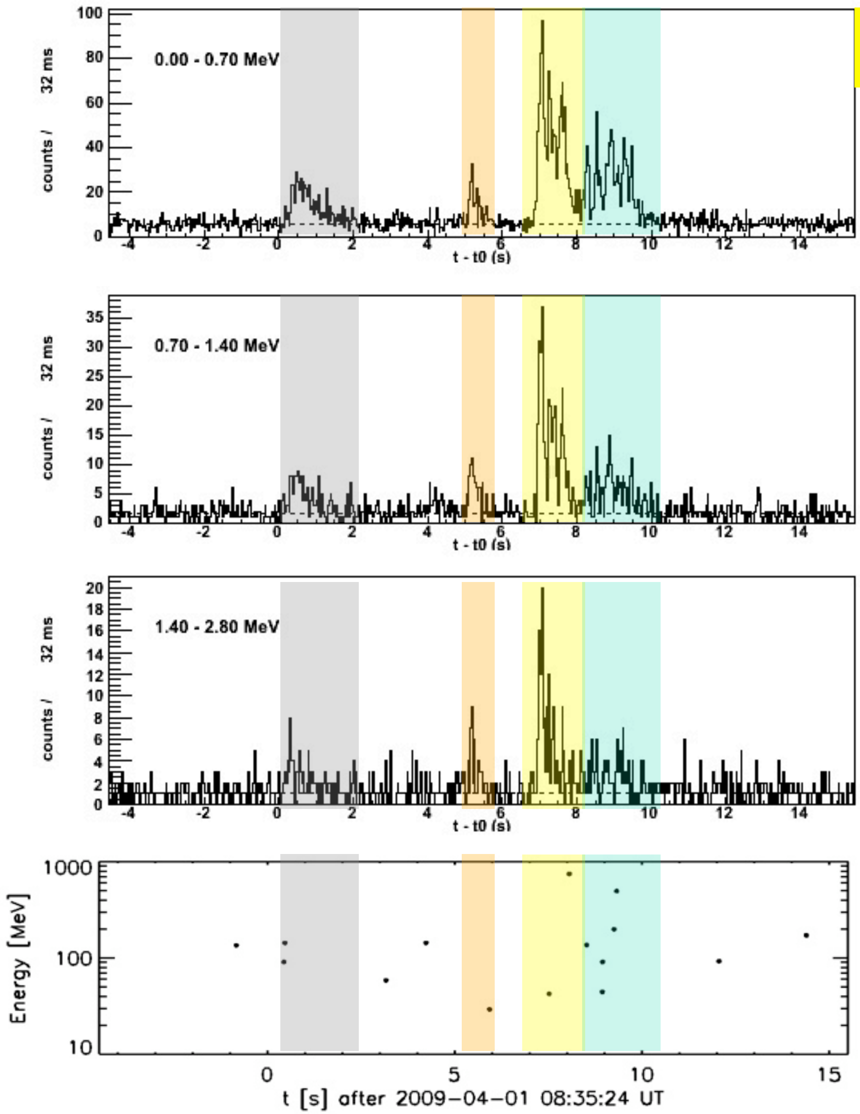
The posterior probability distribution ($f_{N,B}(S)$) for a conditional distribution function ($P_S(N)$) that is a Poisson distribution with a constant a prior ($p(S)$) is:



$$f_{N,B}(S) = C \frac{e^{-(S+B)}(S+B)^N}{N!}$$

The UL on S does not change if priors with a decreasing probability for high S counts are used.

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