High Redshift Gamma-Ray Bursts observed by GLAST

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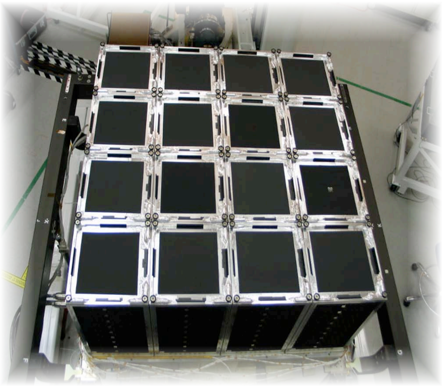
on behalf of the GLAST LAT GRB Science Group and of the GLAST LAT collaboration

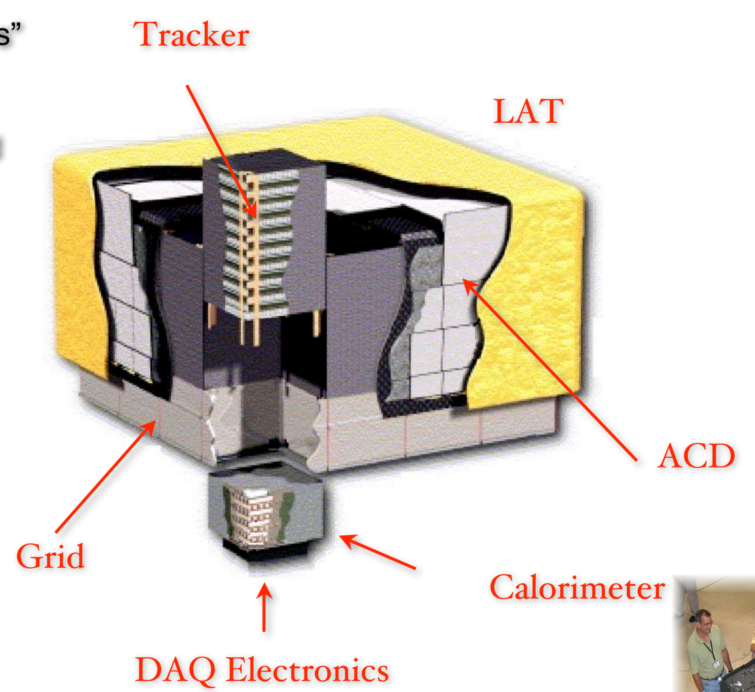
Abstract

The Gamma-ray Large Area Space Telescope (GLAST) is the next generation satellite for high energy astronomy. It will be launched in 2007 and it will cover the energy range from 10 keV to 300 GeV. Inspiring our self to the huge explosion observed the 4th September of 2005 by the mission Swift, we use the full simulation chain developed by the GLAST collaboration to simulate an high-redshift Gamma-Ray Burst, combining all the information available in literature on GRB 050904 with some assumptions, especially for the high energy emission. Our simulation takes care both of the effect of the cosmological expansion on the spectra and on the light curve, as well as the absorption of radiation by photon-photon interaction with the Extragalactic Background Light (EBL).

The Heart of GLAST: Large Area Telescope

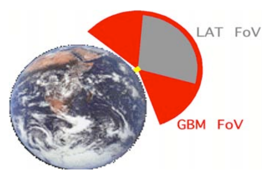
LAT: array of 16 identical "towers" Each tower with a tracker, a calorimeter and a DAQ. Surrounded by finely segmented ACD

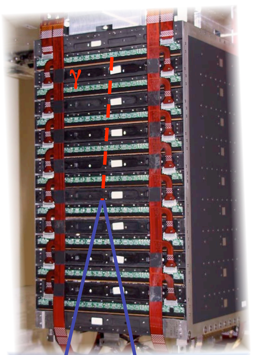




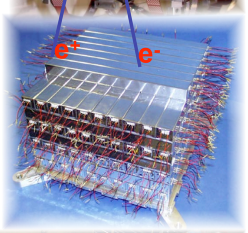
The GLAST mission:

Launch Vehicle :	**Delta II – 2920-10H**
Launch Location:	**Kennedy Space Center**
Orbit Altitude:	**565 Km**
Orbit Inclination:	**28.5 degrees**
Orbit Period:	**95 Minutes**
Launch Date:	**Late 2007**





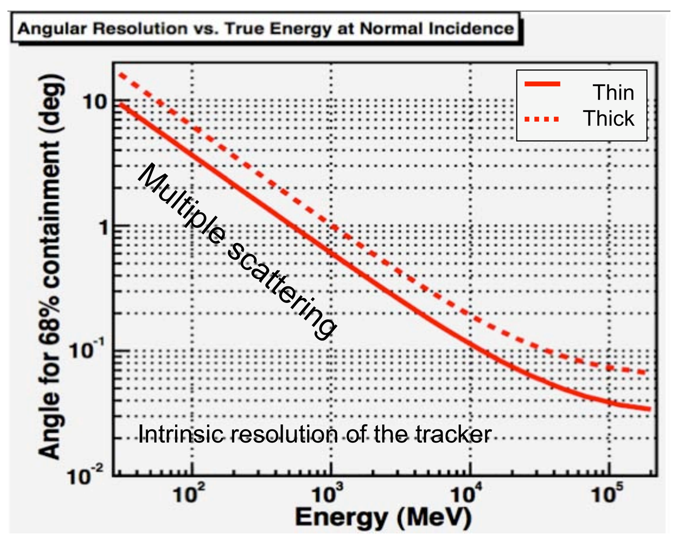
Tracker/Converter (TKR):
- ✓ Silicon strip detectors (single sided, each layer is rotated by 90 degrees with respect to the previous one).
- ✓ W conversion foils.
- ✓ ~80 m² of silicon (total).
- ✓ ~10^6 electronics chans.
- ✓ High precision tracking, small dead time.

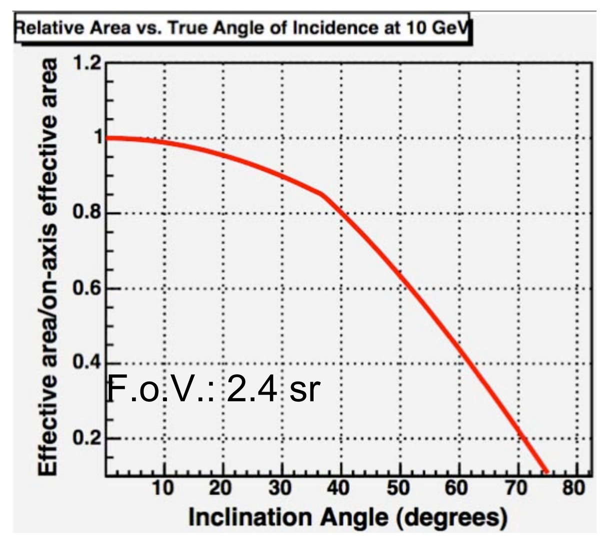


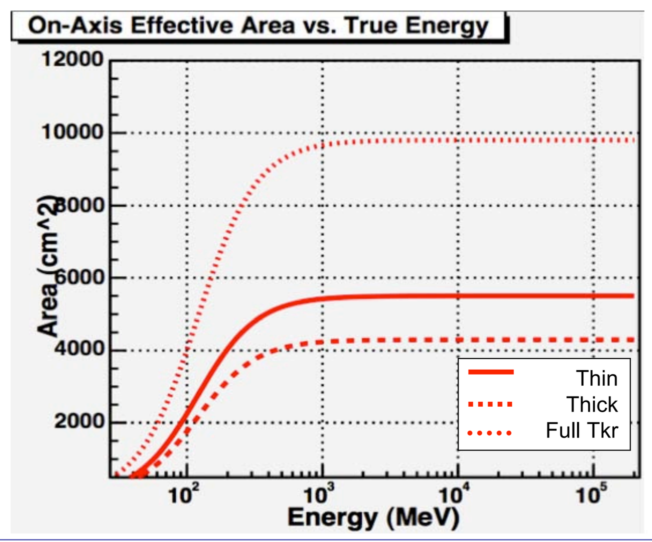
Calorimeter (CAL):
- ✓1536 CsI crystals.
- ✓ 8.5 radiation lengths.
- ✓ Hodoscopic.
- ✓ Shower profile (leakage correction)

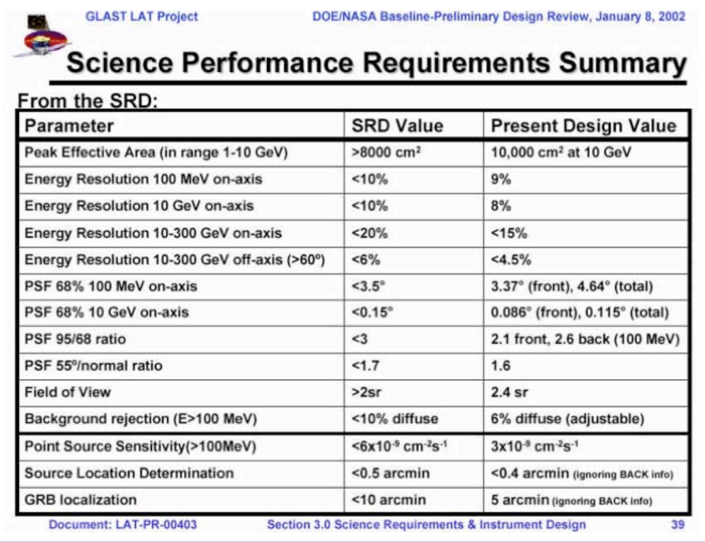
Anti-Coincidence (ACD):
- ✓ Segmented (89 tiles).
- ✓ Self-veto @ high energy limited.
- ✓ 0.9997 detection efficiency (overall).

GLAST/LAT scientific performance







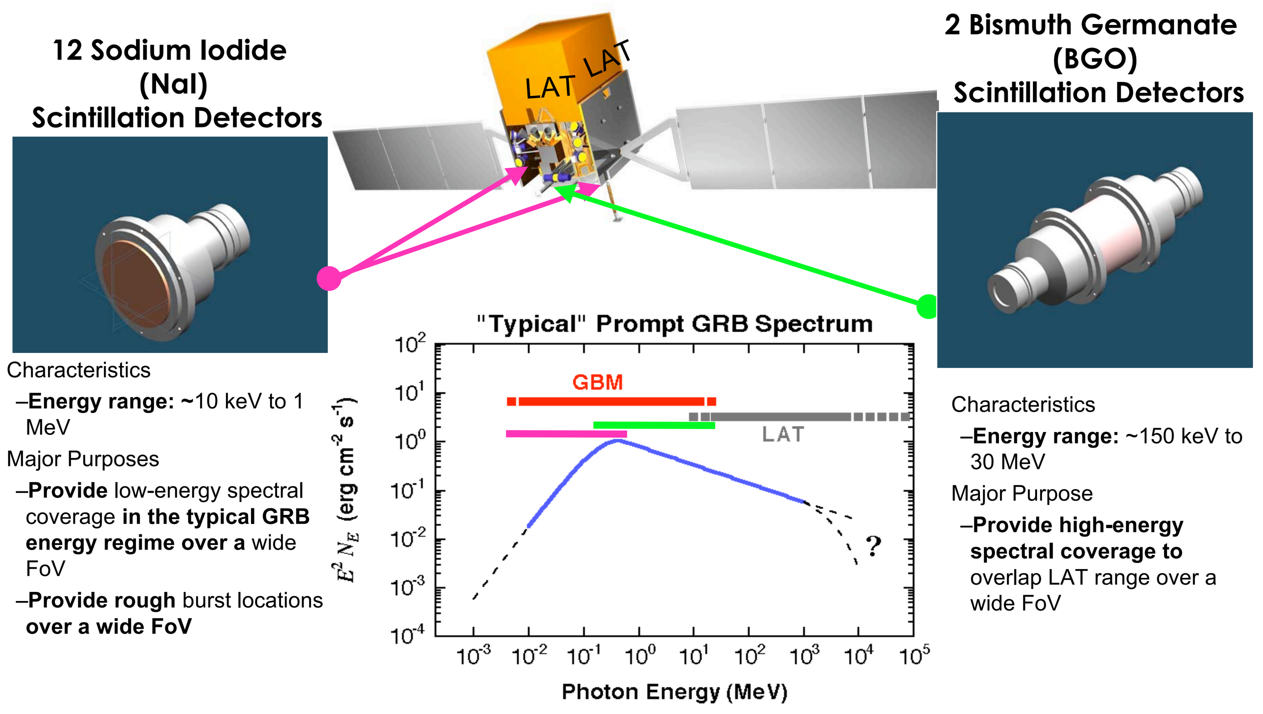


Science Performance Requirements Summary

From the SRD:

Parameter	SRD Value	Present Design Value
Peak Effective Area (in range 1-10 GeV)	>8000 cm²	10,000 cm² at 10 GeV
Energy Resolution 100 MeV on-axis	<10%	9%
Energy Resolution 10 GeV on-axis	<10%	8%
Energy Resolution 10-300 GeV on-axis	<20%	<15%
Energy Resolution 10-300 GeV off-axis (>60°)	<6%	<4.5%
PSF 68% 100 MeV on-axis	<3.5°	3.37° (front), 4.64° (total)
PSF 68% 10 GeV on-axis	<0.15°	0.086° (front), 0.115° (total)
PSF 95/68 ratio	<3	2.1 front, 2.6 back (100 MeV)
PSF 55°/normal ratio	<1.7	1.6
Field of View	>2sr	2.4 sr
Background rejection (E>100 MeV)	<10% diffuse	6% diffuse (adjustable)
Point Source Sensitivity(>100MeV)	$<6\times10^{-9}$ cm^{-2}s^{-1}	3×10^{-9} cm^{-2}s^{-1}
Source Location Determination	<0.5 arcmin	<0.4 arcmin (ignoring BACK info)
GRB localization	<10 arcmin	5 arcmin (ignoring BACK info)

Hunting GRBs: the GLAST Burst Monitor



Swift on 2005 September 4 at 01:51:44 UT detected "a huge explosion in the early Universe", *Cusmano et al., astro-ph/0509737*

Redshift: 6.3

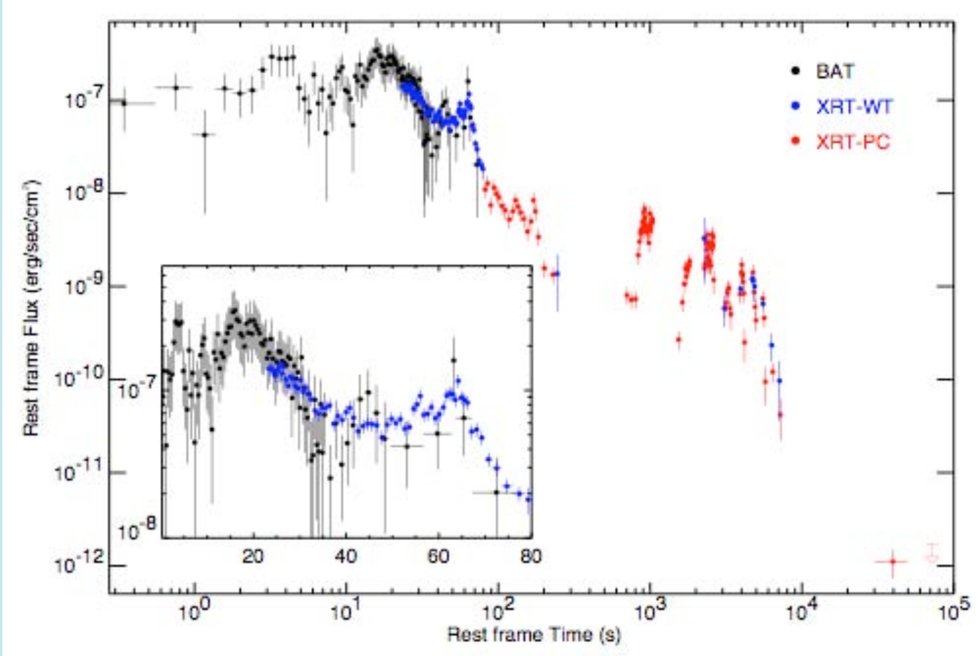
BAT Fluence: 5.4×10^{-6} erg/s

Duration (BAT)/(1+z) ~ 60 s

E_{peak} > 150 keV (1+z) ~ 1 MeV

3-4 main peaks in the BAT light curve

Low energy spectral index ~ 1.2



GRB simulation:

A. Spectrum: parameterized with a 'Band' model *(Band et al. 1993)*

B. Light curve: universal pulse shape *(Norris et al. 1996)*

C. Pulse width: depends on the energy as W(e)~$e^{-0.4}$

D. Parameters are sampled from the **observed BATSE distributions** *(Preece et al. 2000)*

E. The fluence is normalized in the BATSE energy range.

The flux is extrapolated at LAT energies: photons are sampled from the N(e,t)

Simulation strategy:

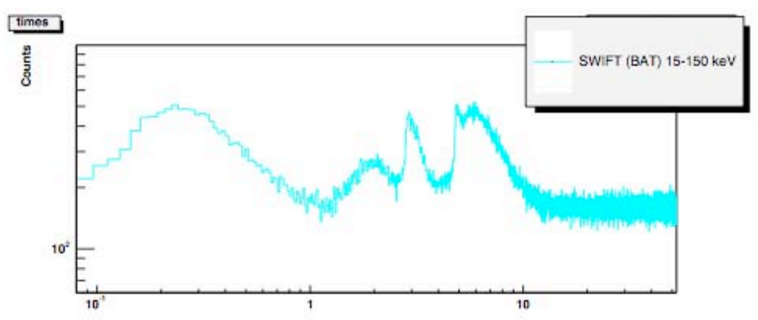
From the observation the fluences the durations and the low energy spectral index are known.

From the BAT specs, an upper limit for the E_p is provided. For GRB, typically, the high energy spectral index is around 2.25

Two identical GRBs are simulated:
One at 'GRB rest frame' (z~0)
One with z = 6.3

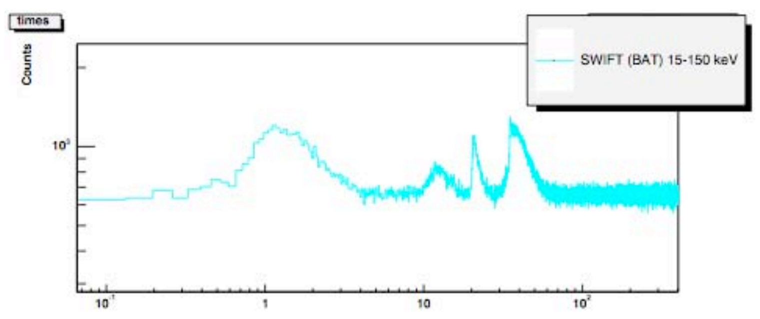
Dependence on redshift:
- Shift of the spectrum at low energy
- "Stretch" of Light curve
- **EBL absorption** due to the interaction of high energy photons with the Extragalactic Background Light *(Primack et al. 2005)*

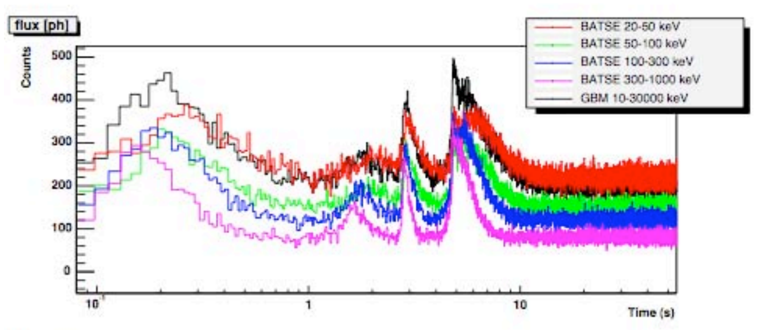
GRB Frame (z~0) | Earth Frame (z~6.3)



Simple simulation of the SWIFT/BAT signal:

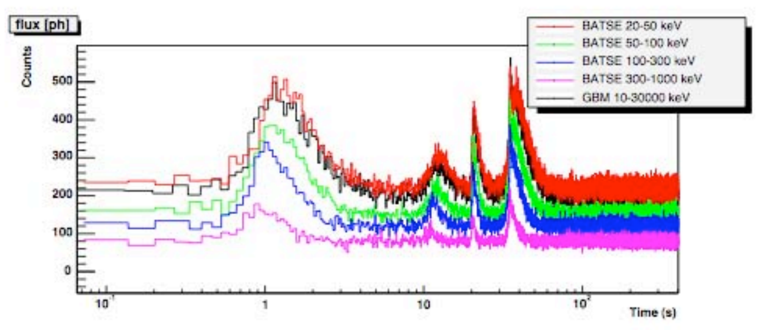
Assuming an effective area 2000 cm² and a background 1000 counts/s

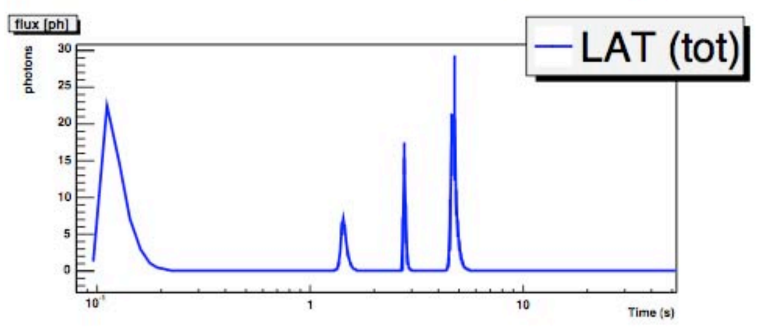




Simple simulation of the CGRO/BATSE and of the GLAST/GBM signal. The effective area of BATSE is 2000 cm² with different backgrounds in different channels.

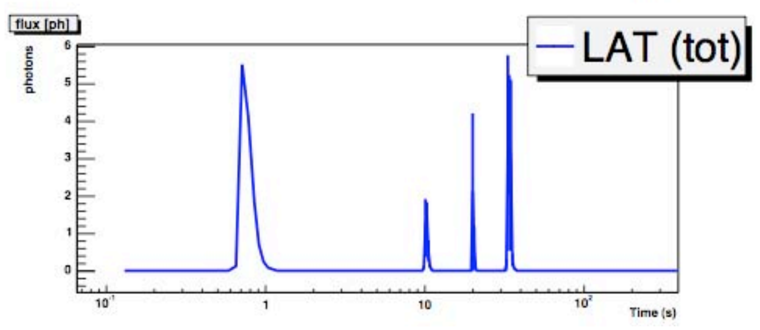
For GBM is assumed an effective area of 750 cm² and a Background of 200 counts per bin.

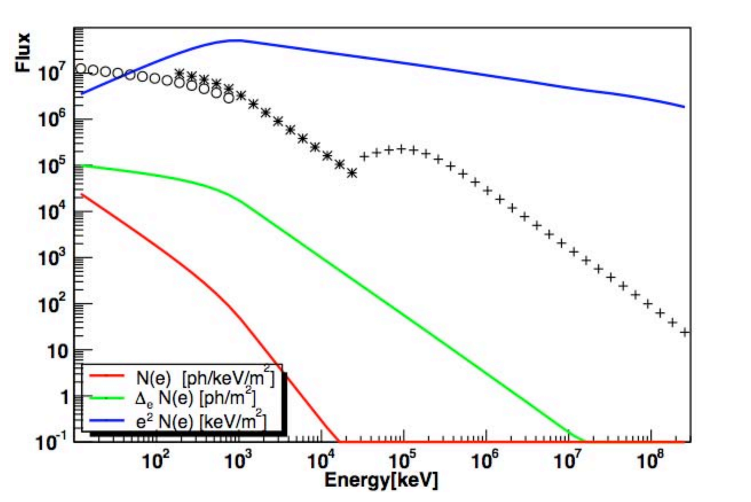




Analytical light curve a LAT energies

Pulses are narrower at higher energies, and peak before!





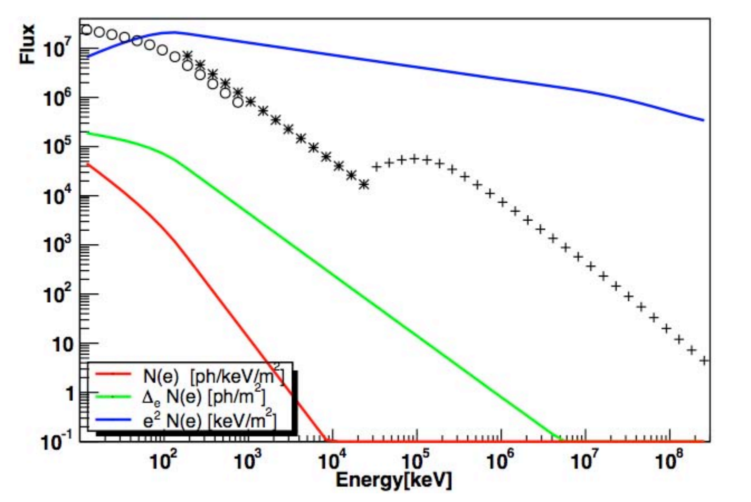
Analytical integrated spectrum

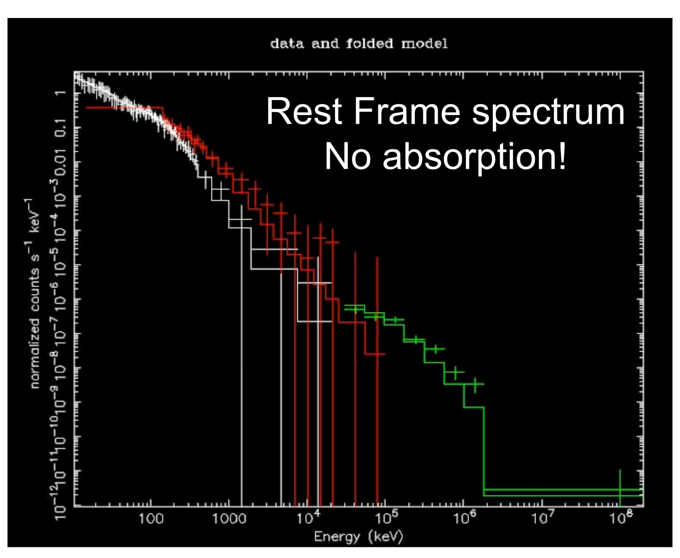
N(e), Δ_e N(e), e²N(e)

The expectation for GBM, and LAT detectors are also plots with symbols.

The effect of the cosmological expansions are evident!

No EBL absorption is included here!





Complete simulation

LAT: **each photon** is folded with the IRF

(Aeff, Edisp, PSF)

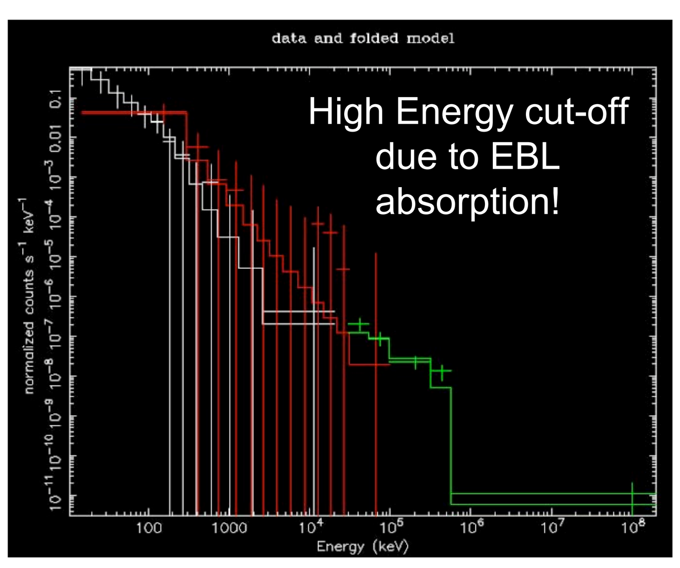
EBL absorption is included

Simulated LAT "FITS" files are obtained

GBM: A series of fluxes is folded with the IRF for each GBM detectors

Simulated GBM "FITS" files are obtained

The set of files are combined and a spectral analysis is performed, **as with real data** !



Conclusions:

Test of the full simulation chain: from the simulation of astronomical flux to the analysis of data.

Redshift dependence include in the GRB model

EBL absorption provided by Luis C. Ryes & Julie McEnery available to GRB models!

GLAST will be able to see High Redshift objects!

GRB050904 was faint and only few photons are detectable by the LAT.

GBM constrain the spectral index at high energy and LAT data can be used to study the cutoff!

Refinement on the simulation will include:

Better representation of SWIFT bursts.

Better representation of the analytical IRF for simple estimations.

Analysis tools for studying the high energy cut-off in case of few photons.