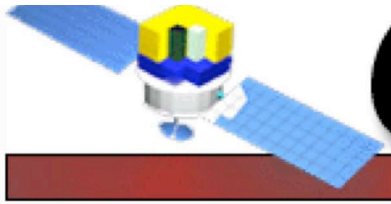
GLAST, LAT and GRBs

Gamma-Ray Bursts in the Swift Er
29 Nov. - 2 Dec., Washington DC

Nicola Omodei,
on behalf of the LAT GRB
science working group



GLAST

The Gamma Ray Large Area Space Telescope

GLAST LAT Science Group: Gamma-Ray Bursts

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Steve Ritz
Felix Ryde
Jeff Scargle
Gloria Spandre
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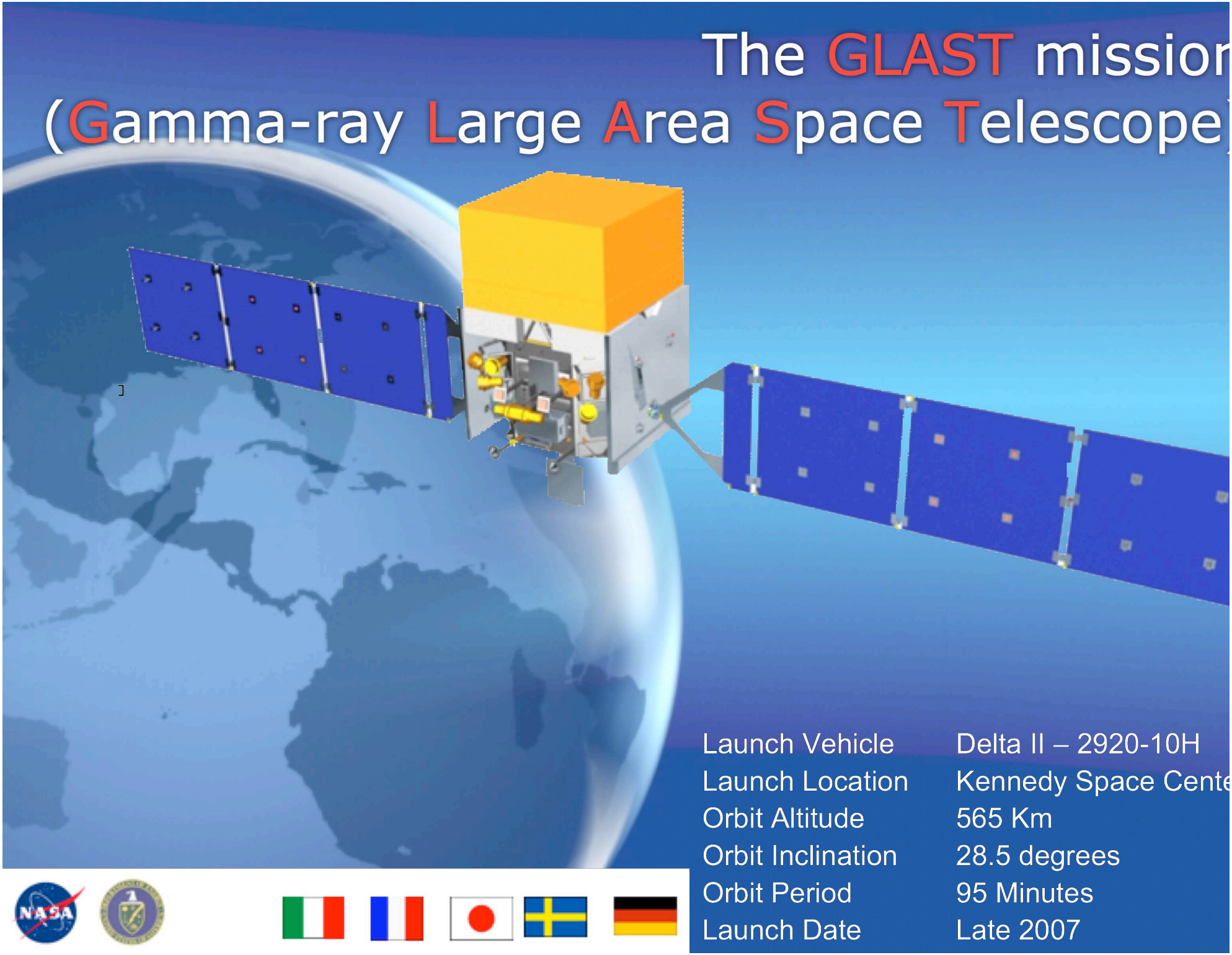
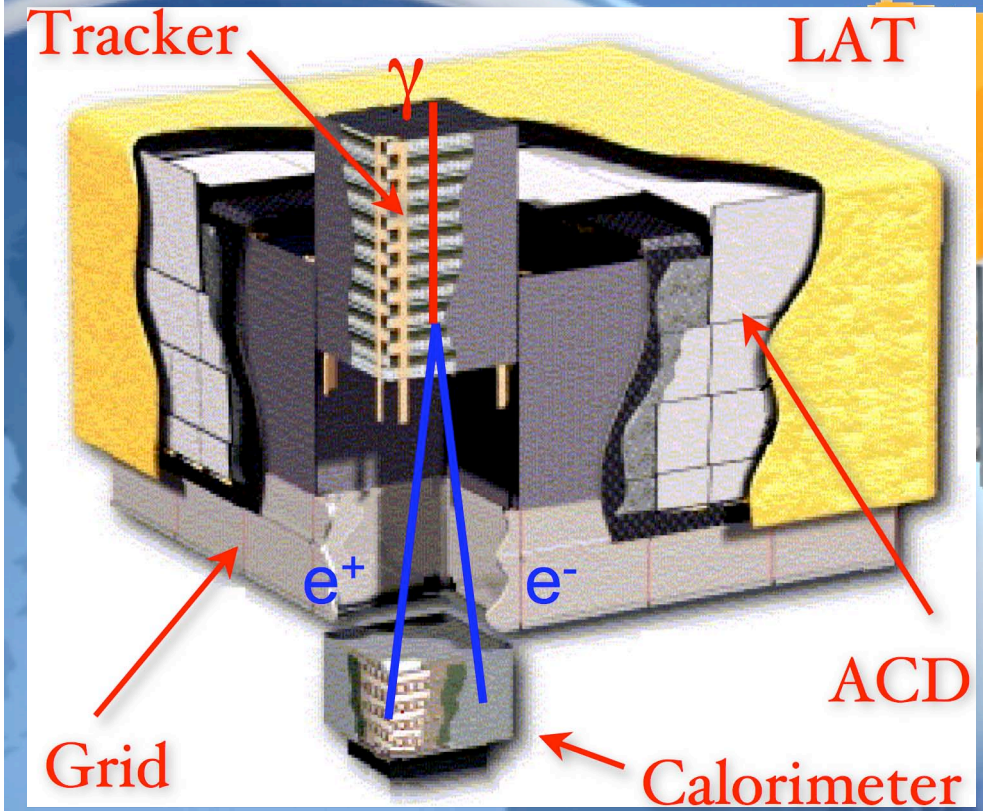

The GLAST mission
(Gamma-ray Large Area Space Telescope)
Launch Vehicle
Delta II – 2920-10H
Launch Location
Kennedy Space Cente
Orbit Altitude
565 Km
Orbit Inclination
28.5 degrees
Orbit Period
95 Minutes
Launch Date
Late 2007

The GLAST mission
(Gamma-ray Large Area Space Telescope)



Large Area Telescope:
Energy Range: **20 MeV - >300GeV**

Array of *16 identical "towers"*
Each tower:

- **Tracker** *(W conversion foils + SSD for tracking particles)*
- ***Calorimeter*** *(8.5 r.l., hodoscopic)*

Surrounded by finely segmented ACD

Launch Vehicle	Delta II – 2920-10H
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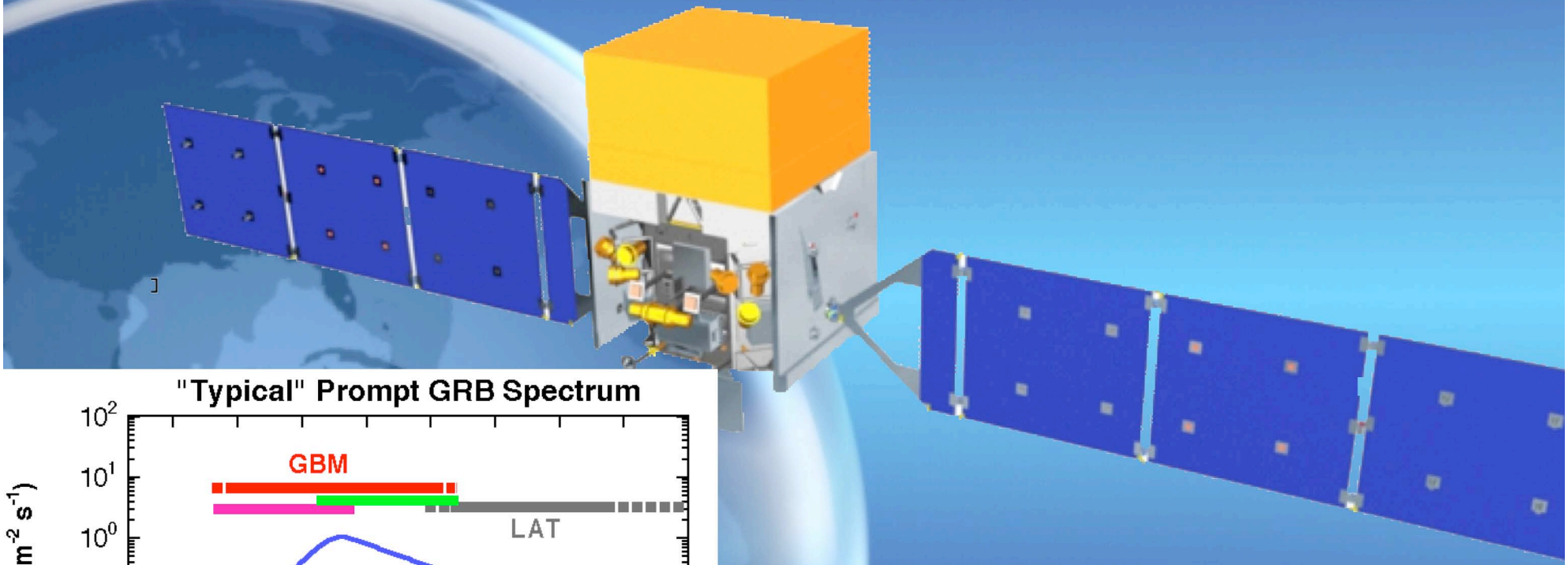

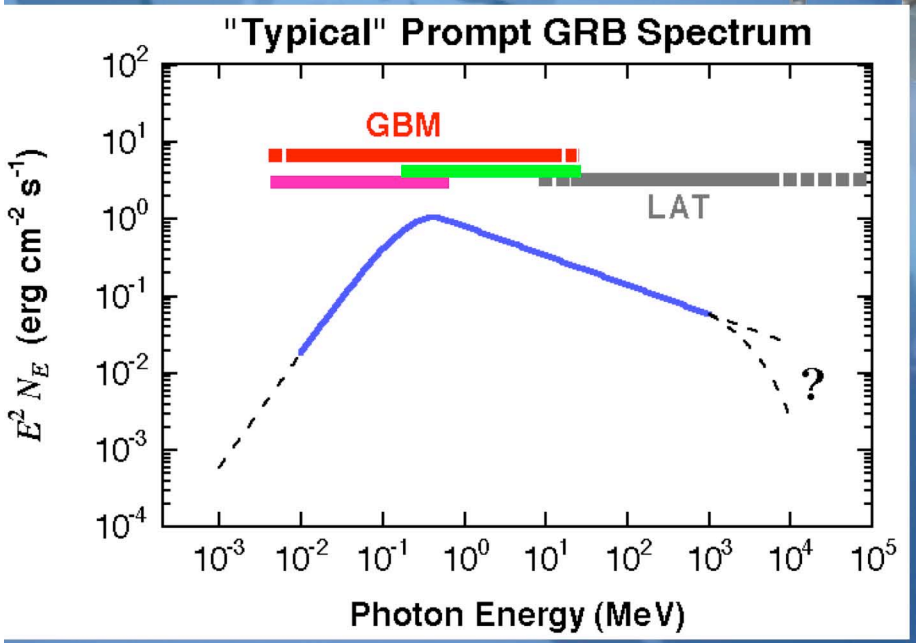

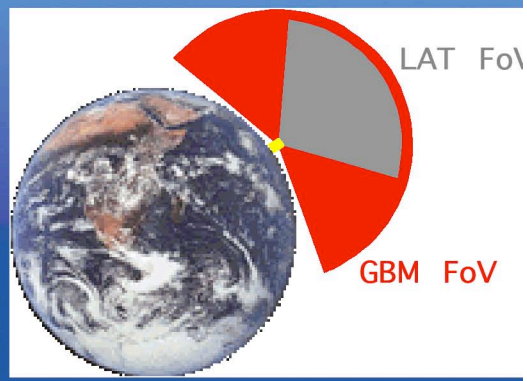

See also posters: 12.15 and 12.2

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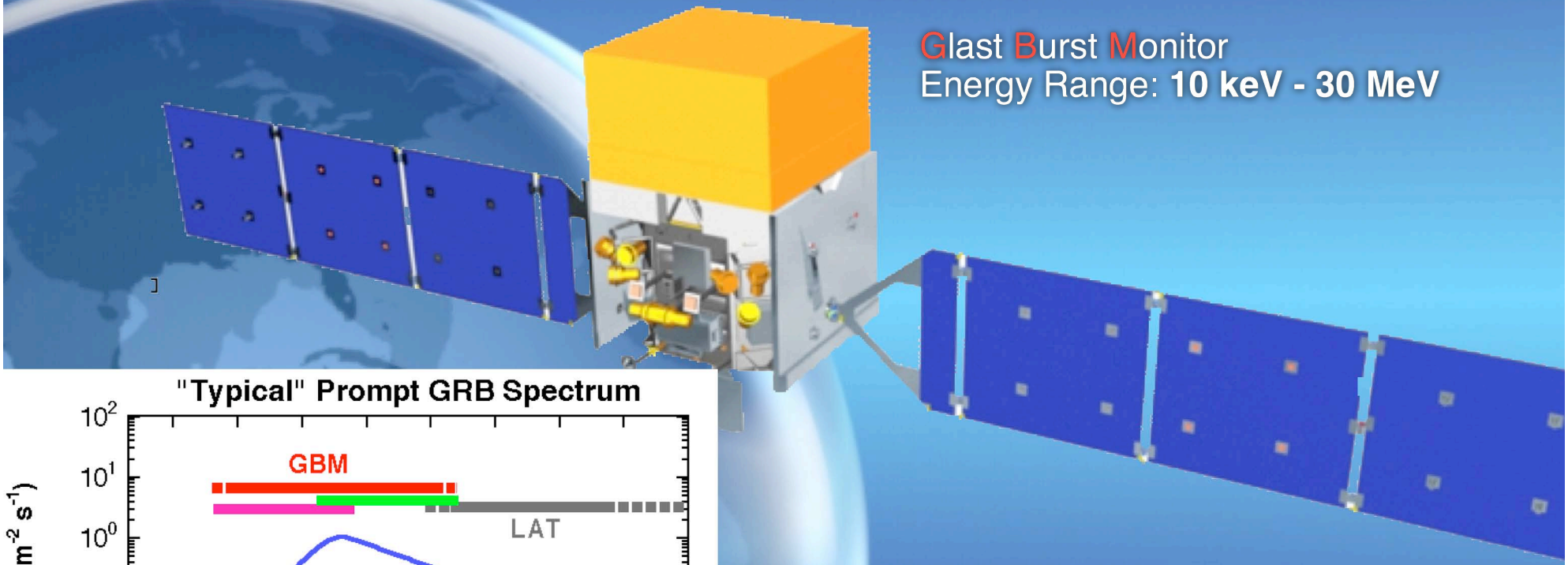
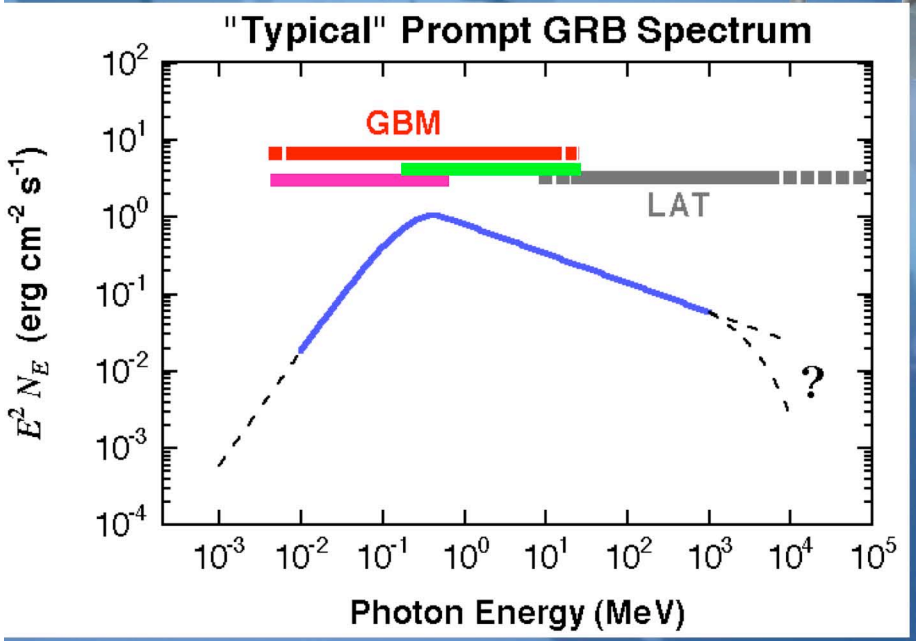
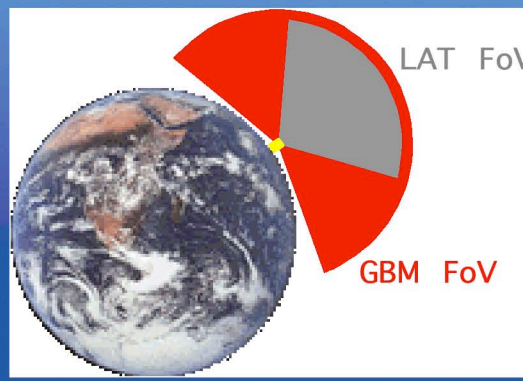


Glast Burst Monitor
Energy Range: **10 keV - 30 MeV**





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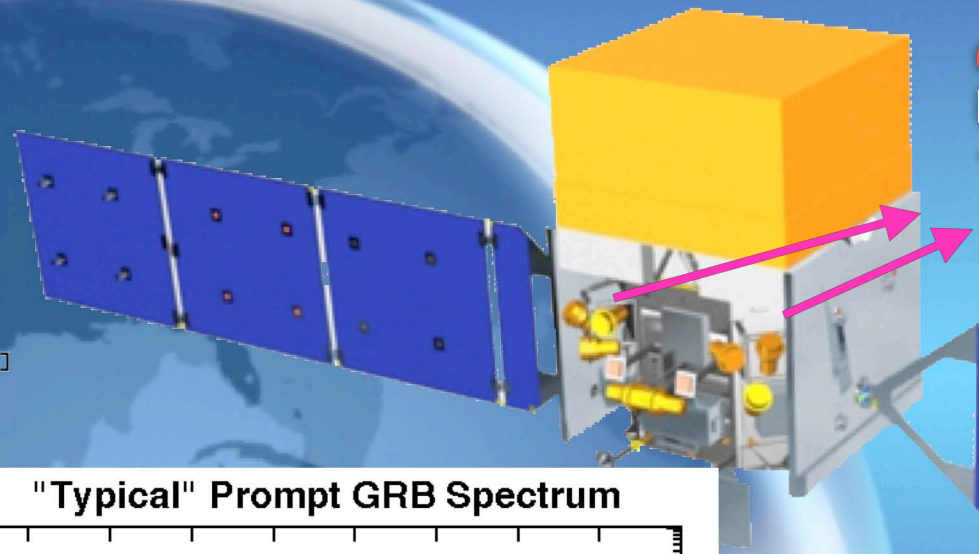
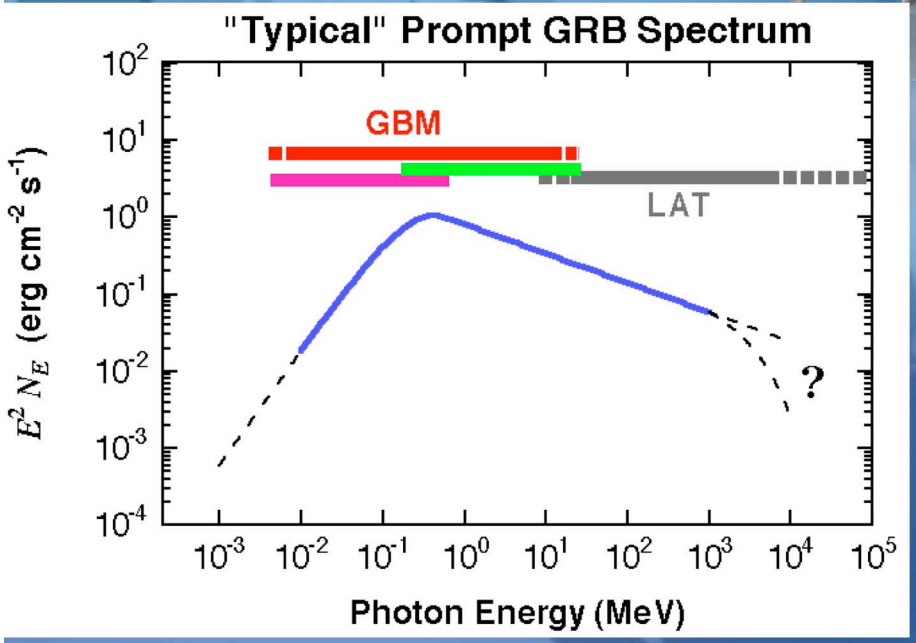
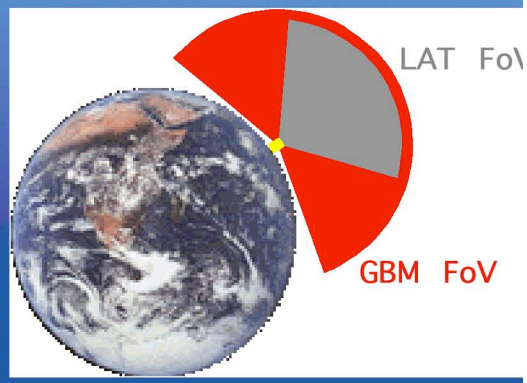


Glast Burst Monitor
Energy Range: **10 keV - 30 MeV**

- 12 Sodium Iodide (NaI) Scintillation detectors
  - Burst trigger
  - Coverage of the typical GRB spectrum **(10 keV 1 MeV)**





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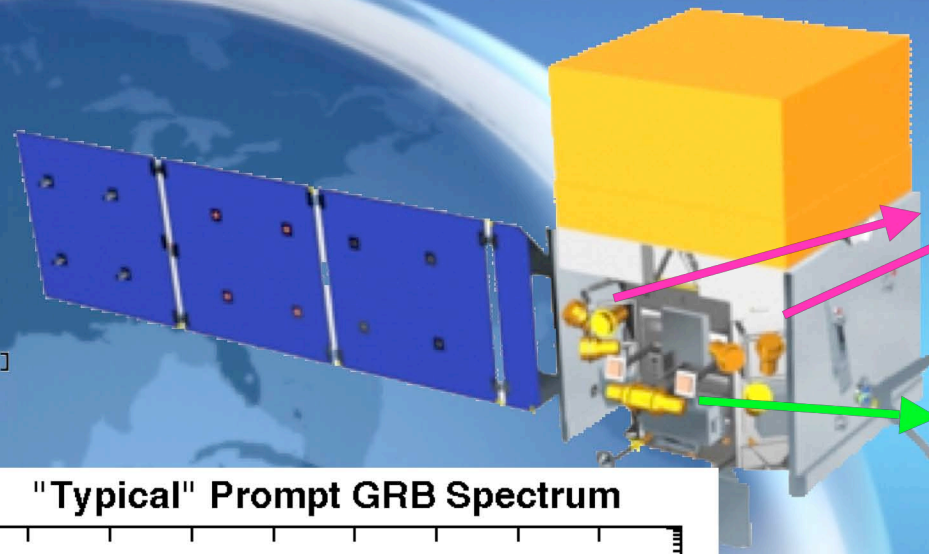
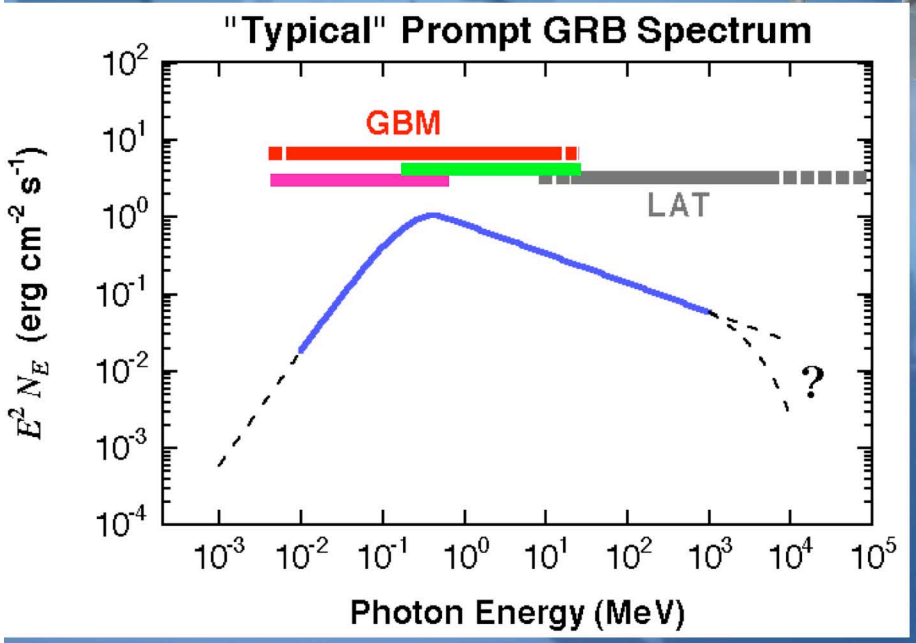


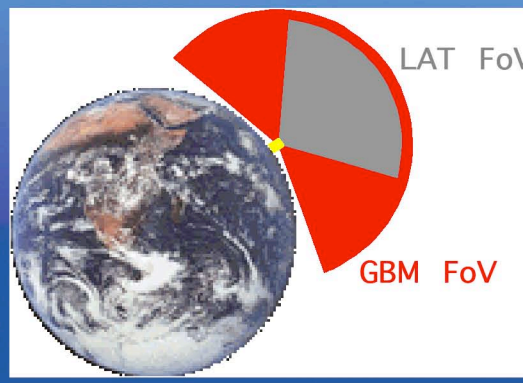
Glast Burst Monitor
Energy Range: **10 keV - 30 MeV**

- 12 Sodium Iodide (NaI) Scintillation detectors
  - Burst trigger
  - Coverage of the typical GRB spectrum
    (10 keV 1 MeV)

2 Bismunth Germanate (BGO) Scintillation detectors

- Spectral overlap with the LAT
  (150 keV-30 MeV)





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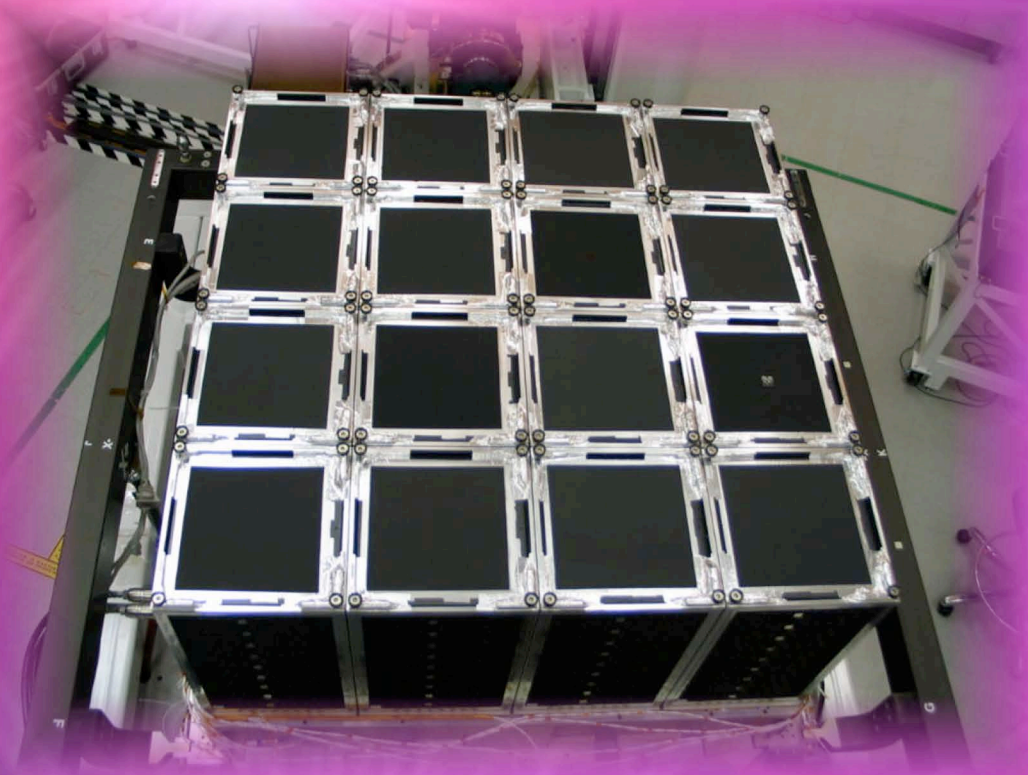
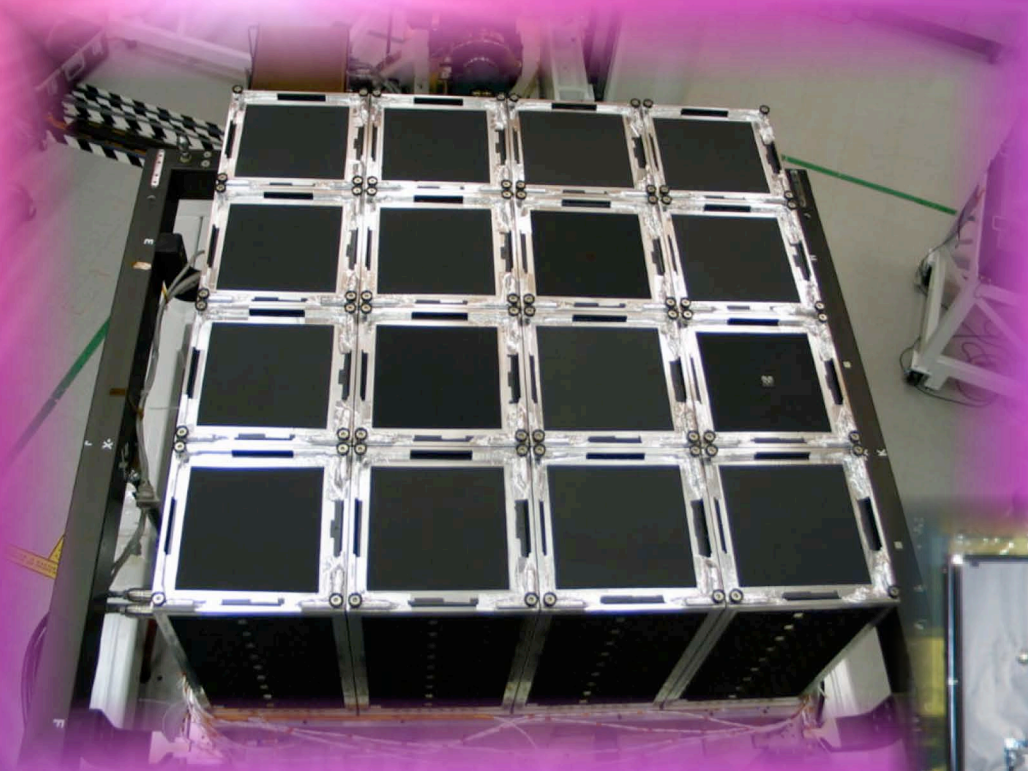
LAT status



Current status:

✓ All the 16 towers (Tracker + Calorimeter + Electronics) integrated in the flight grid.

LAT status



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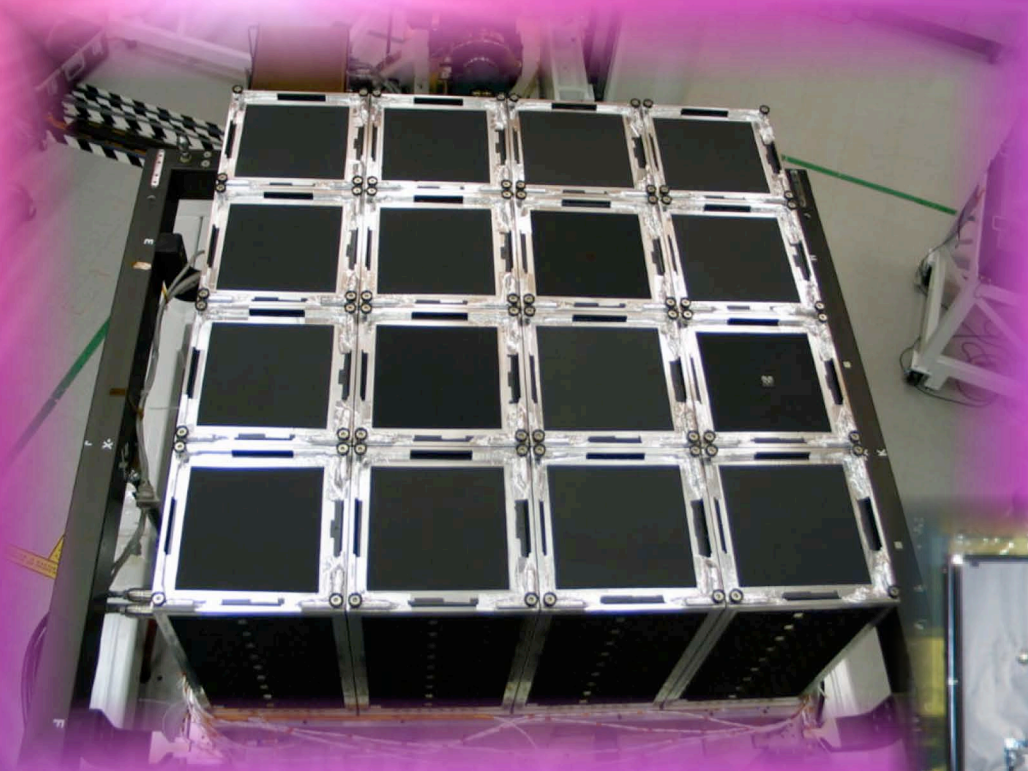
✓ ACD integrated with the rest of the instrument.

LAT status



Current status:

✓ All the 16 towers (Tracker + Calorimeter + Electronics) integrated in the flight grid.

✓ ACD integrated with the rest of the instrument.

Coming soon:

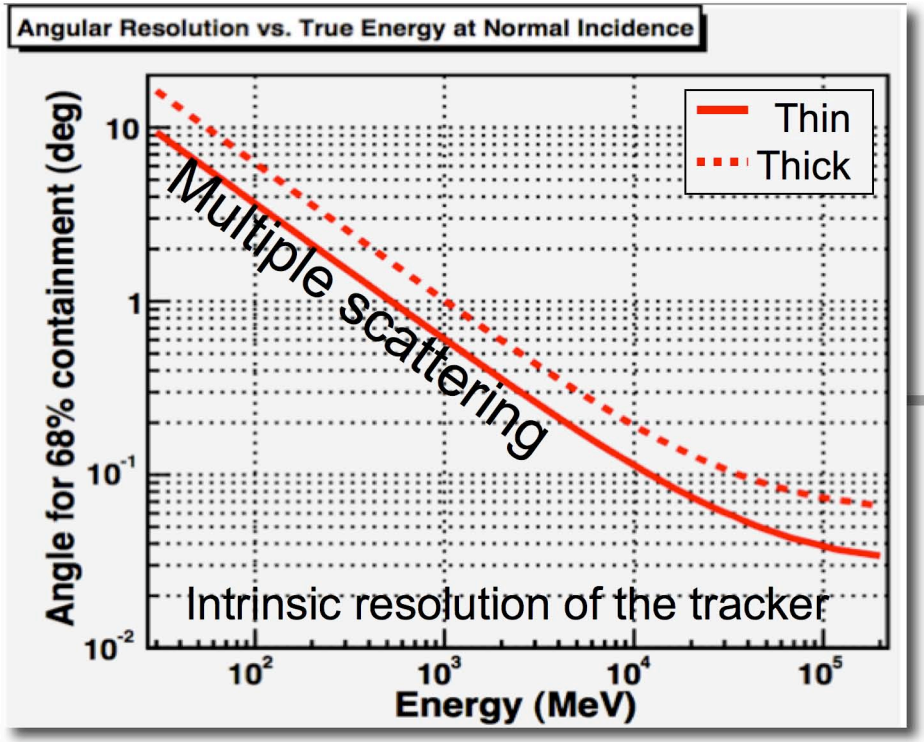
✓ Beam test of the calibration unit (2 spare TKR modules + 4 spare CAL modules).

✓ LAT environmental tests.

✓ Integration with the spacecraft.

✓ Launch.

GLAST/LAT performance



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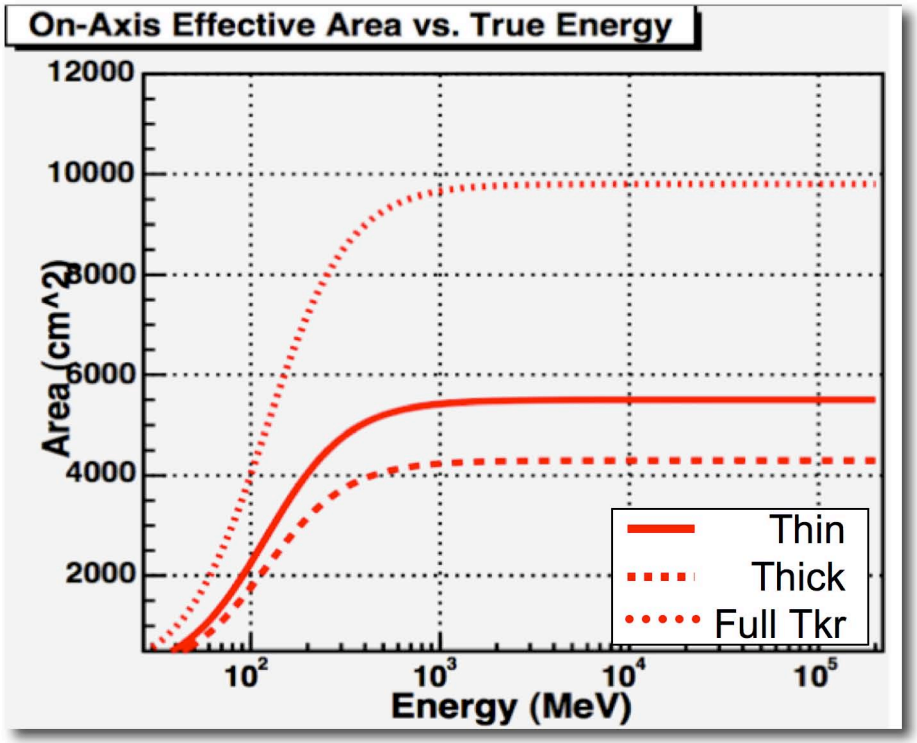
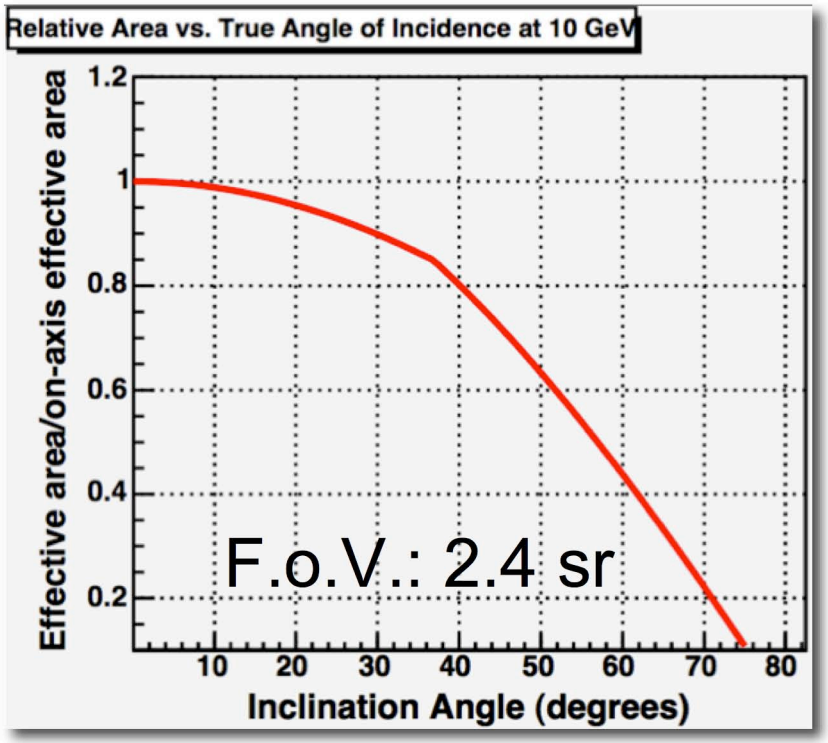
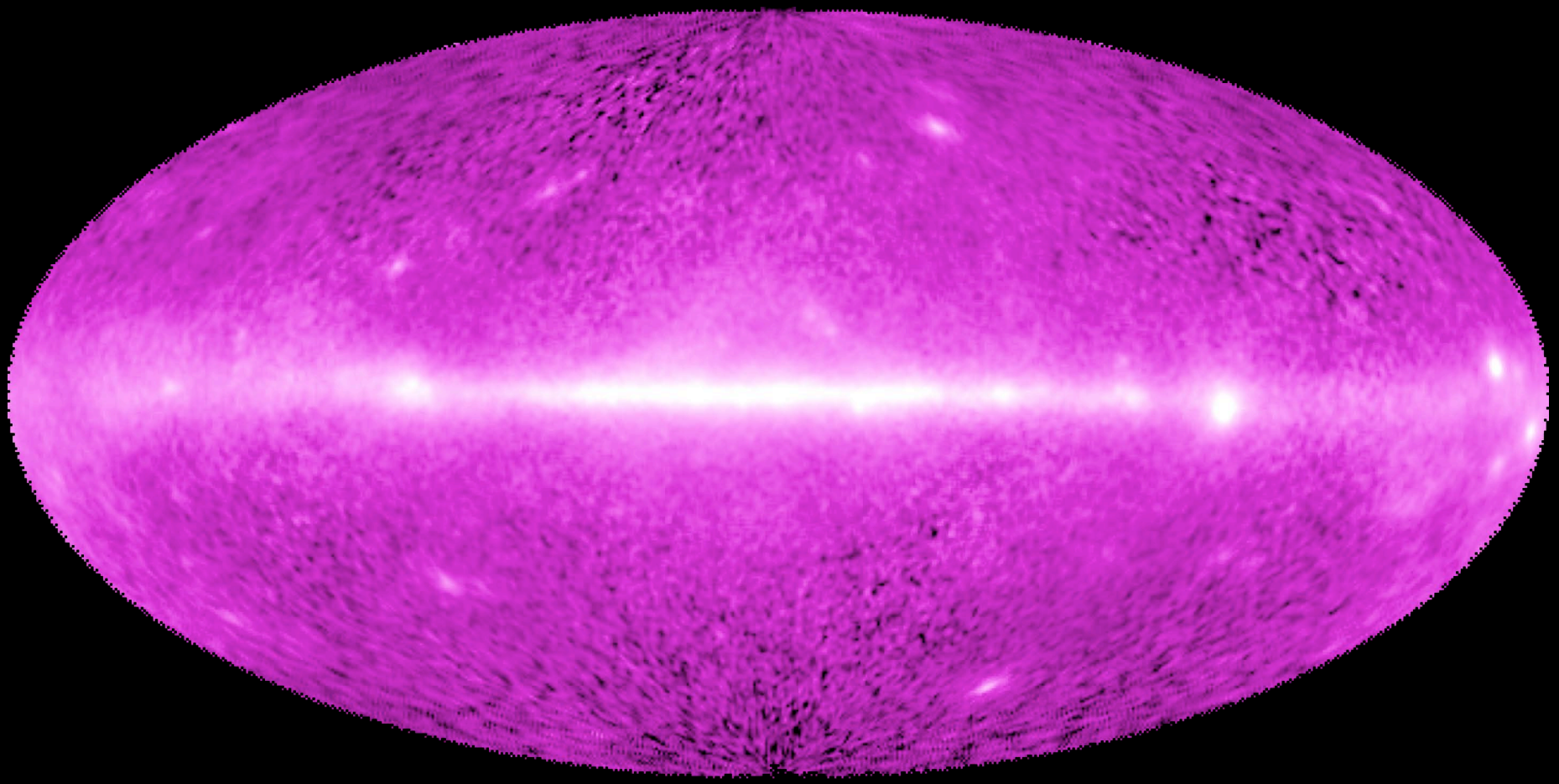
Energy Resolution: ~10% (~5% off-axis)
PSF (68%) at 100 MeV ~ 5°
PSF (68%) at 10 GeV ~ 0.1°
Field Of View: 2.4 sr
Point Source sens. (>100 MeV): 3×10^{-9} cm^{-2} s^{-1}





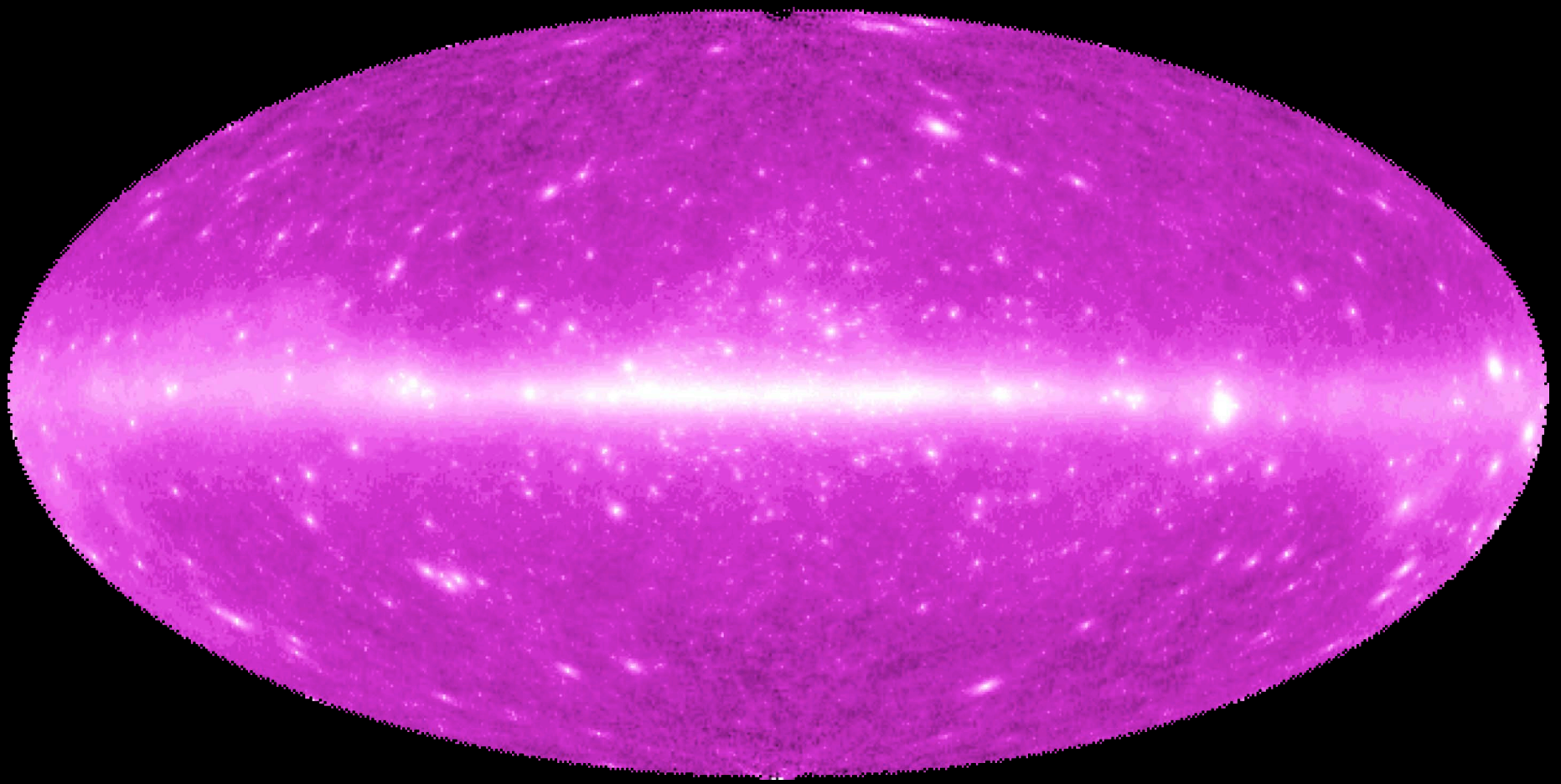
The GLAST science

The GLAST science



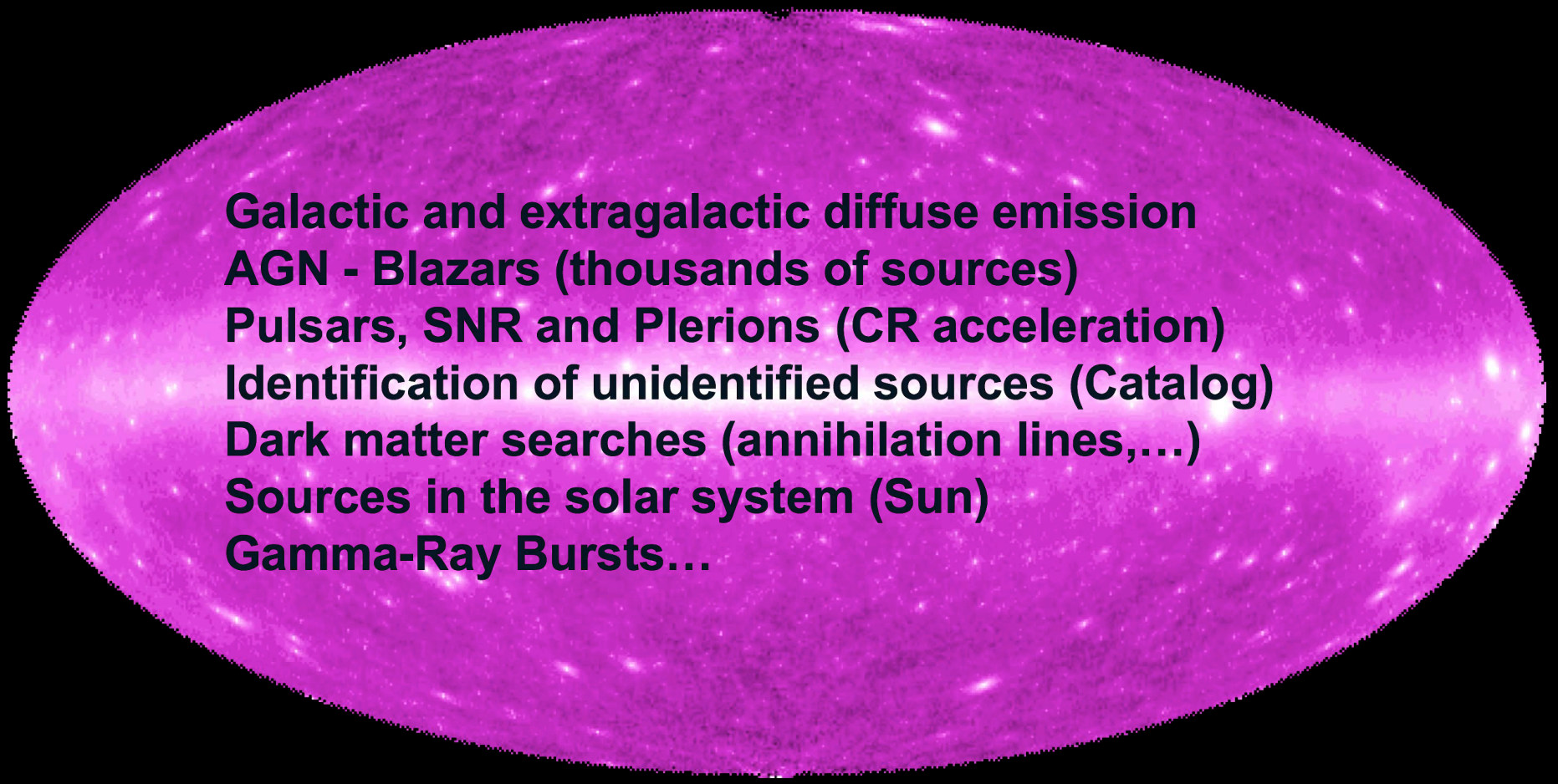
EGRET (>100 MeV)

The GLAST science



GLAST Simulated (>100 MeV)

The GLAST science



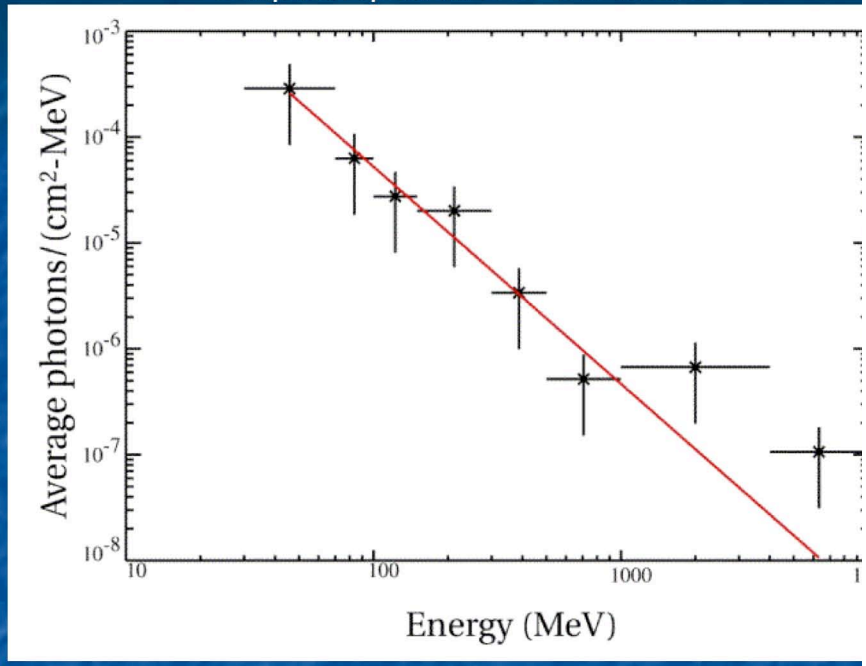
Galactic and extragalactic diffuse emission
AGN - Blazars (thousands of sources)
Pulsars, SNR and Plerions (CR acceleration)
Identification of unidentified sources (Catalog)
Dark matter searches (annihilation lines,…)
Sources in the solar system (Sun)
Gamma-Ray Bursts…

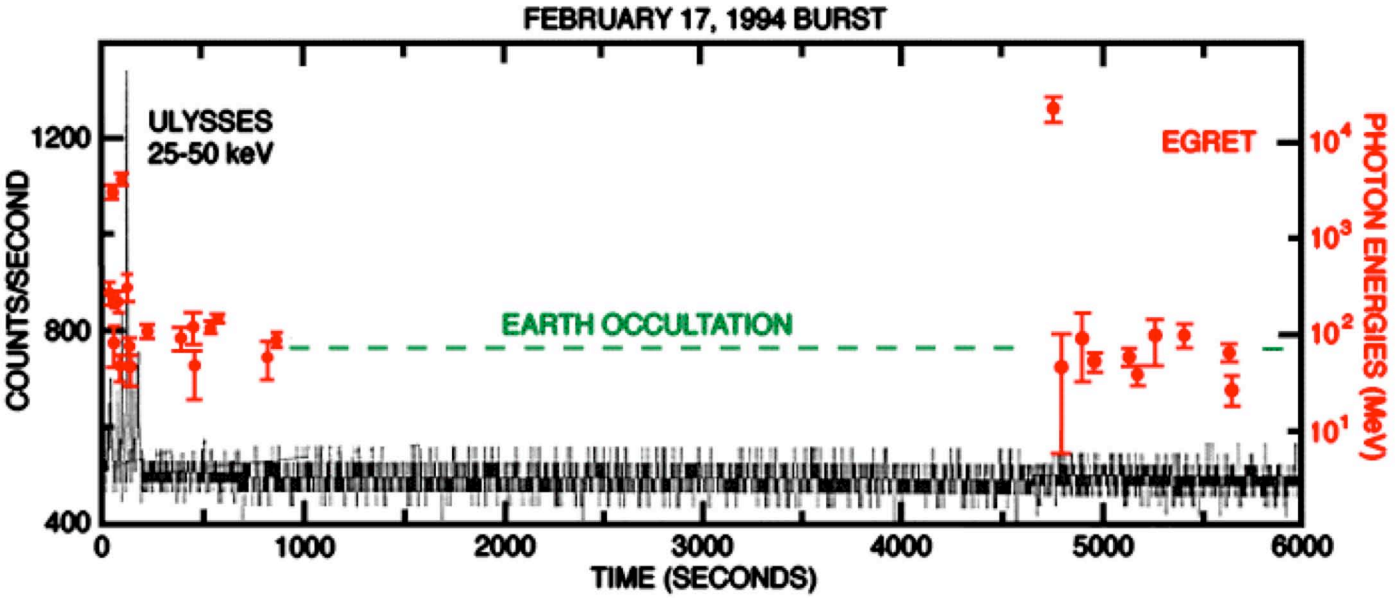
GLAST Simulated (>100 MeV)

Gamma-Ray Bursts at High Energy

- Little is known about GRB emission in the >50 MeV energy regime
- EGRET detected few high-energy bursts
  - Prompt GeV emission with no high-energy cutoff (combined with rapid variability) implies highly relativistic bulk motion at source: $\Gamma > 10^2 - 10^3$
  - Observed an high energy spectra component (Gonzàlez et al. 2003) (POSTER 11.5)
- GLAST, compared to EGRET, will have:
  - Wider FoV
  - Short deadtime (~25 μs)
  - Repoint

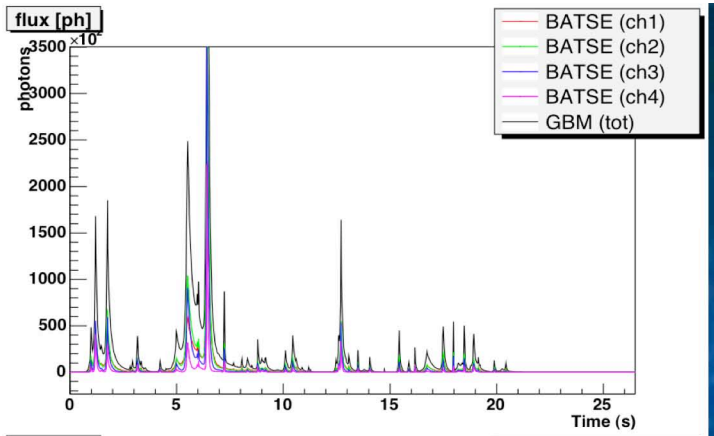
Composite spectrum of 5 EGRET Bursts

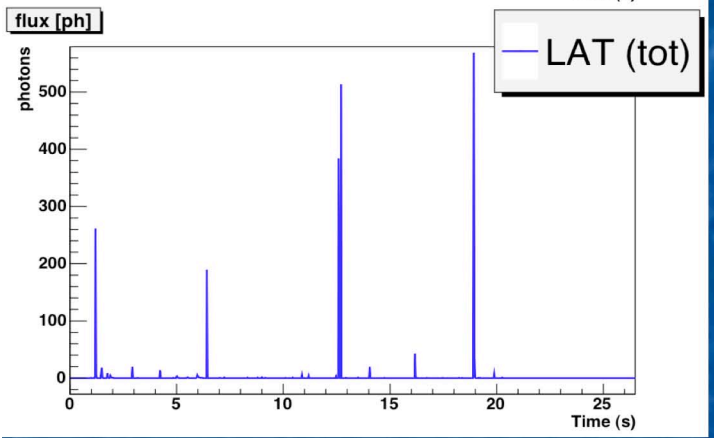




•Extended or delayed GeV emission may require more than one emission mechanism, and remains one of the unsolved problems.

GLAST/GRB Simulations





Phenomenological approach

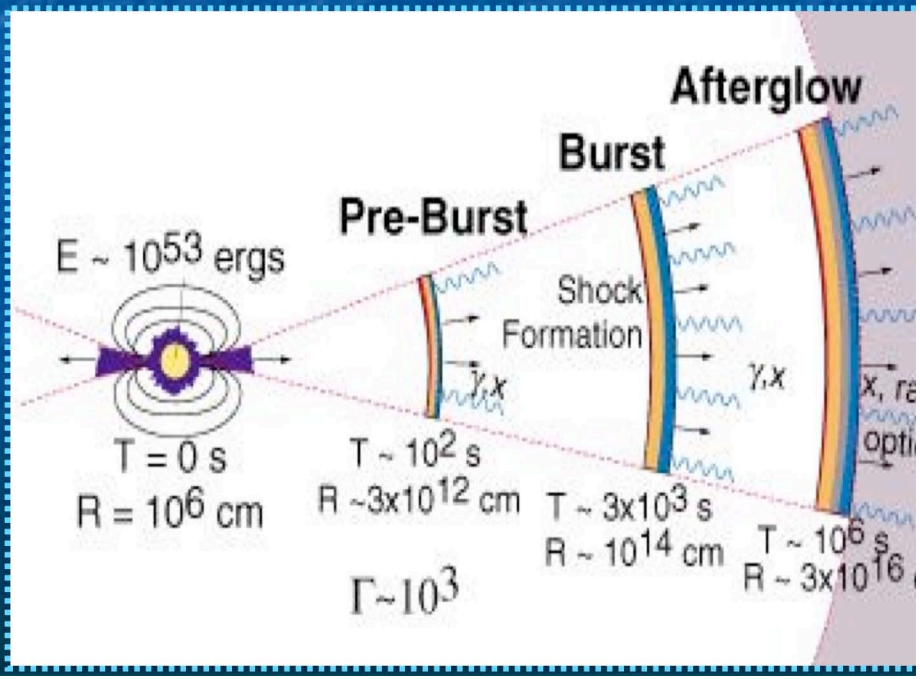
Parameters from observed distributions (BATSE)
Different GRB light curves can be obtained.
Fluxes are normalized to the BATSE observed fluence distribution (BATSE catalogue)
LAT flux is obtained extrapolating the BATSE flux at LAT energies.

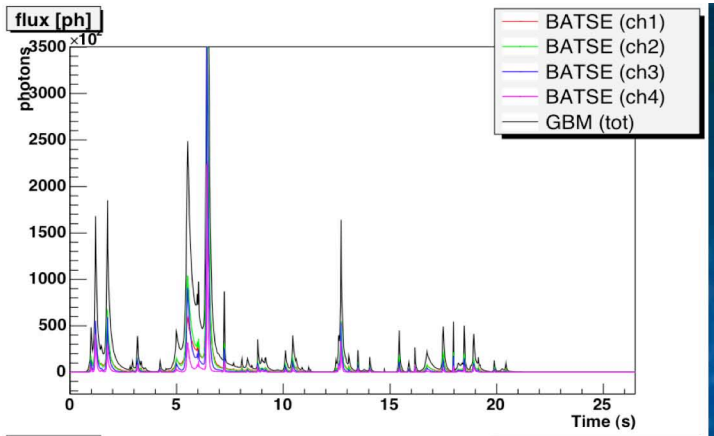
Physical approach

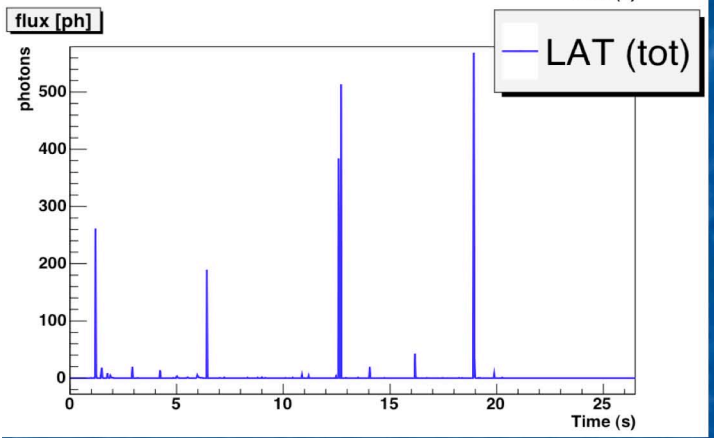
Fireball model (Piran,1999)
Shells emitted with relativistic Lorentz factors
Internal shocks (variability naturally explained)
Acceleration of electrons between with a power law initial distribution, between γ_{min} and γ_{max}
Non-thermal emission (Synchrotron and Inverse Compton) from relativistic electrons

Other model can be accommodated in our simulators

Hybrid thermal + power law model (Felix Ryde & Mlan Battelino)







GLAST/GRB Simulations

Phenomenological approach

Parameters from observed distributions (BATSE)
Different GRB light curves can be obtained.
Fluxes are normalized to the BATSE observed fluence distribution (BATSE catalogue)
LAT flux is obtained extrapolating the BATSE flux at LAT energies.

LAT photons are extracted from the predicted flux and processed by the GLAST/LAT Software
[Full Montecarlo or parameterized (fast) Sim]

Flux in the **GBM** energy range fed the GBM simulator and GBM signal is obtained

Physical approach

Fireball model (Piran,1999)
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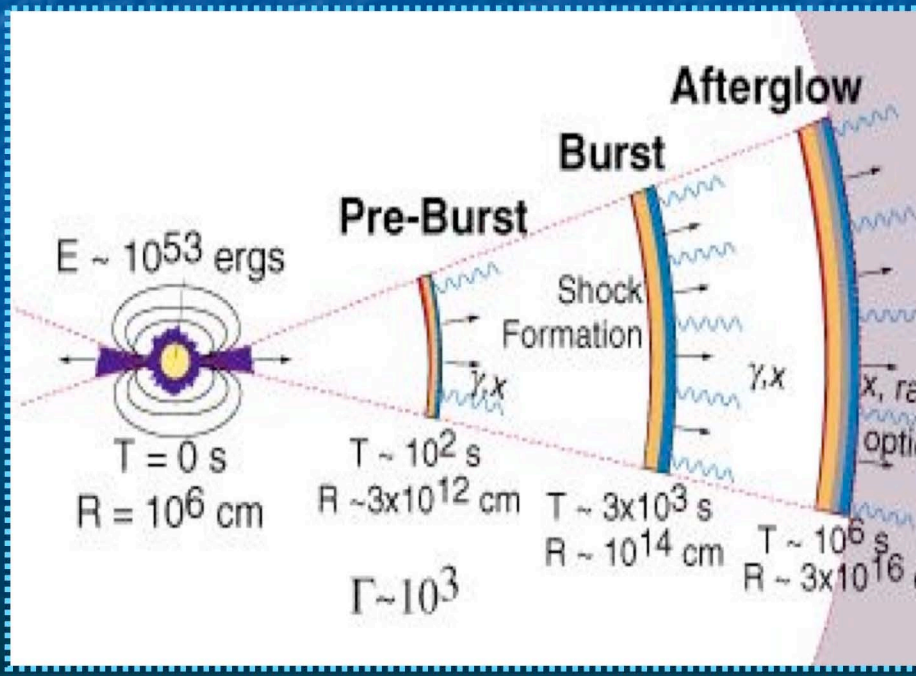
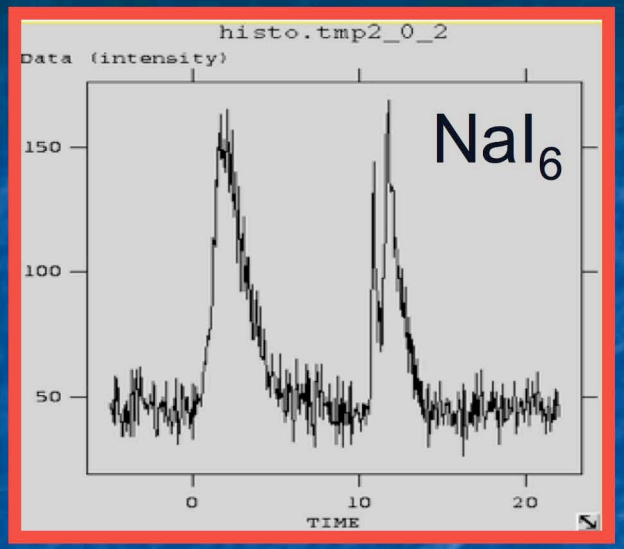
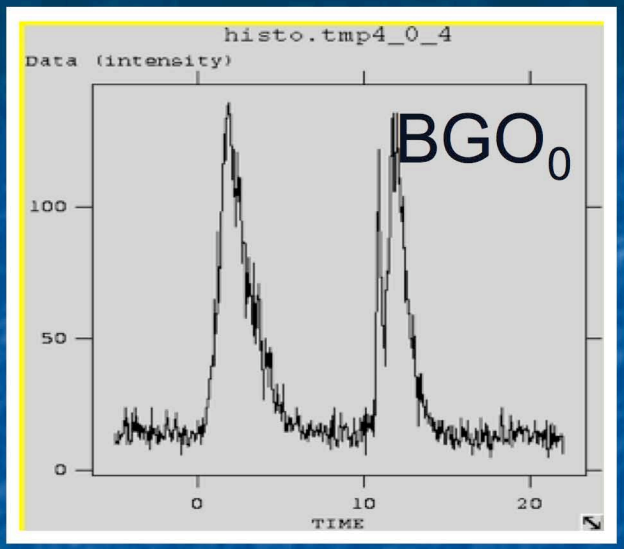
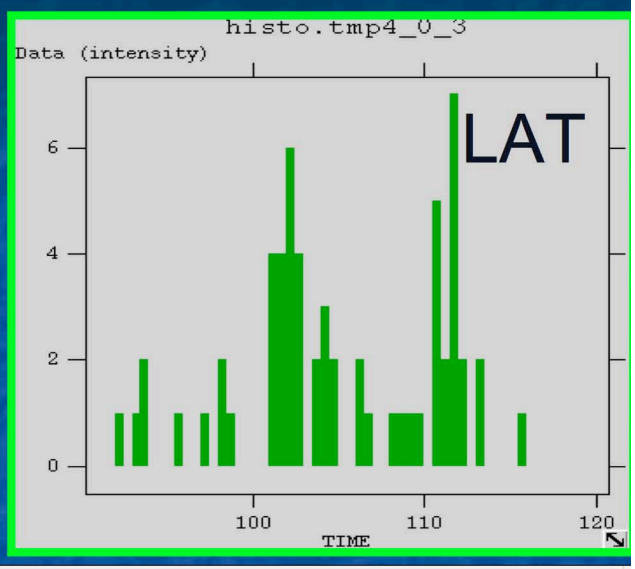


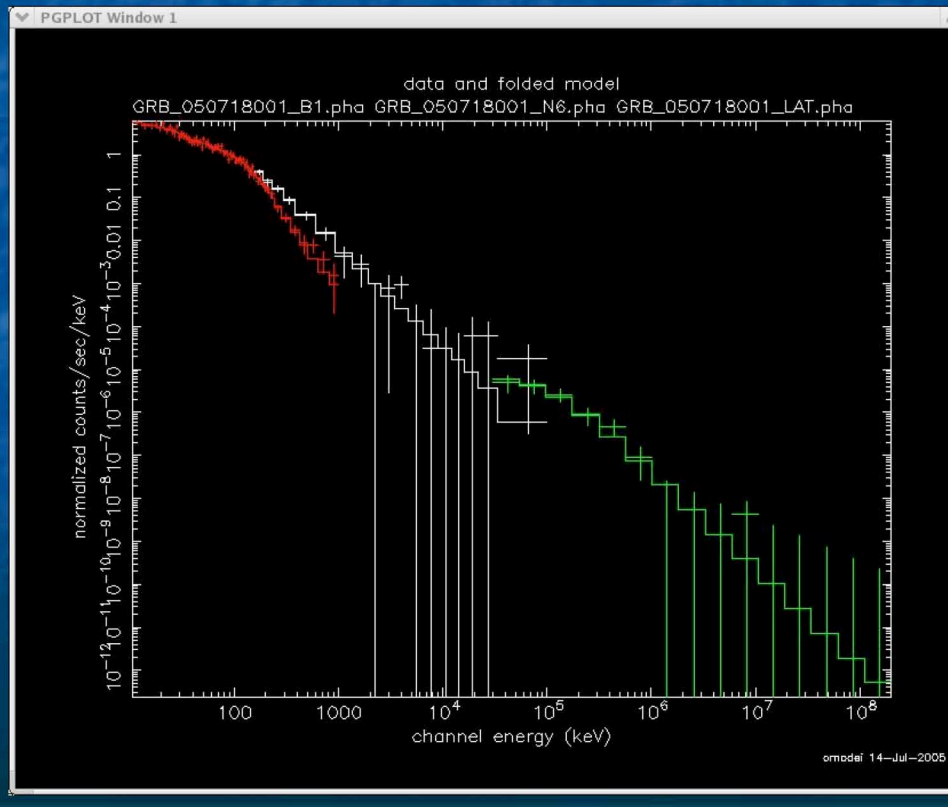
GBM+LAT simulation







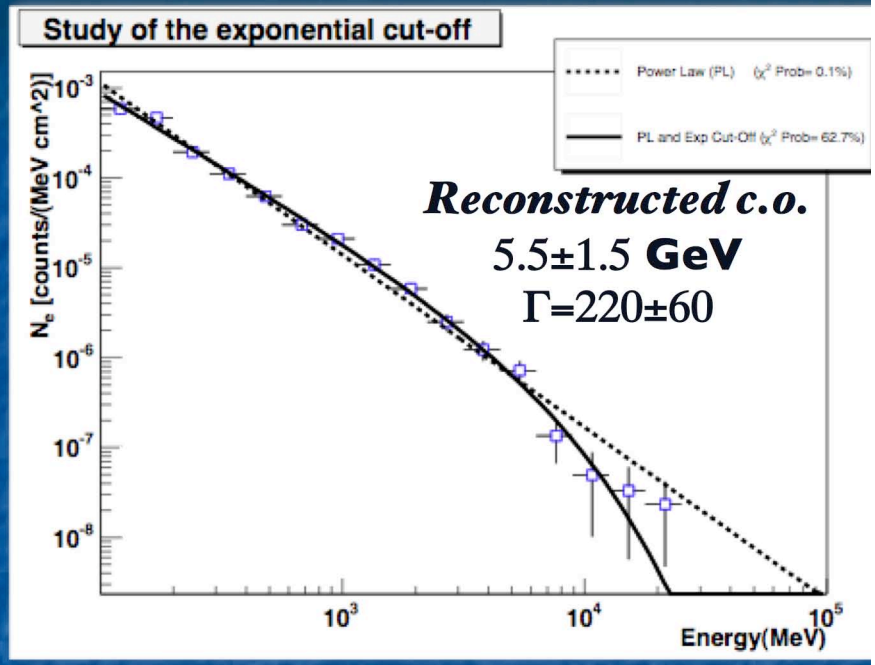
- Simulated signal for all the GLAST detectors (LAT + 12 NaI + 2 BGO)
- Response matrices are computed
- *Prompt GRB LAT observations are ~ BACKGROUND FREE =>No "background" files for XSPEC*
- *Prompt GRB GBM observations are BACKGROUND DOMINATED => Background file for XSPEC*
- *Joint spectral analysis! (7 decades in energies !!!)*
- Possibility to have an extra component.
- Possibility to add a time lag due to QG effect (POSTER 12.13)
- Possibility to add the EBL absorption to simulate high redshift bursts (POSTER 13.9)



Gamma Ray Bursts Spectral Studies

High energy cutoff

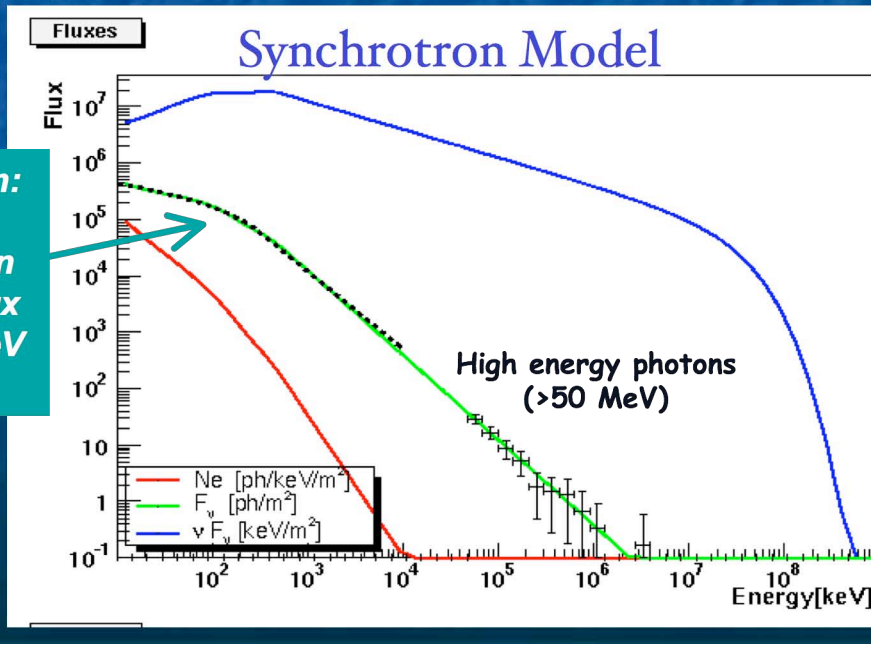
- GLAST/LAT will be able to study the high energy spectrum of GRB, recognizing the cut-off up to energy above 10 GeV for single bursts.
- Information on the Lorentz Factor of the expanding shells (synchrotron emission from accelerated electrons)
- Cosmological cut-off: EBL absorption



Self Synchrotron Compton

- GLAST/LAT detector will have the requirements for detecting the high energy component and to localize the SSC peak of the vFv spectrum
- The Inverse Compton component does not affect the BATSE energy range !
- Important for understanding the Energy reservoir!

Band Function: "best" representation of the GRB flux between 20 keV and 1 MeV



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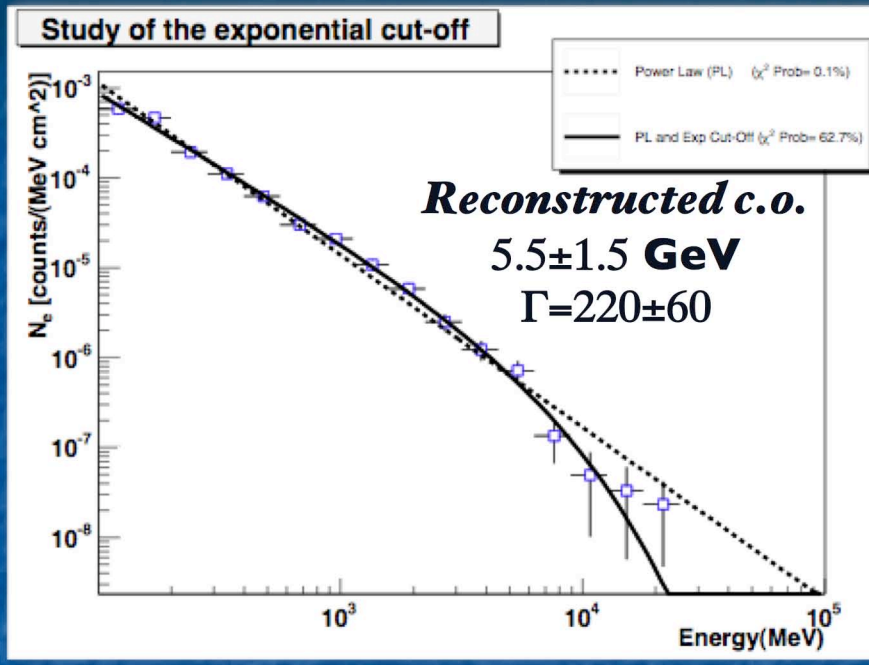

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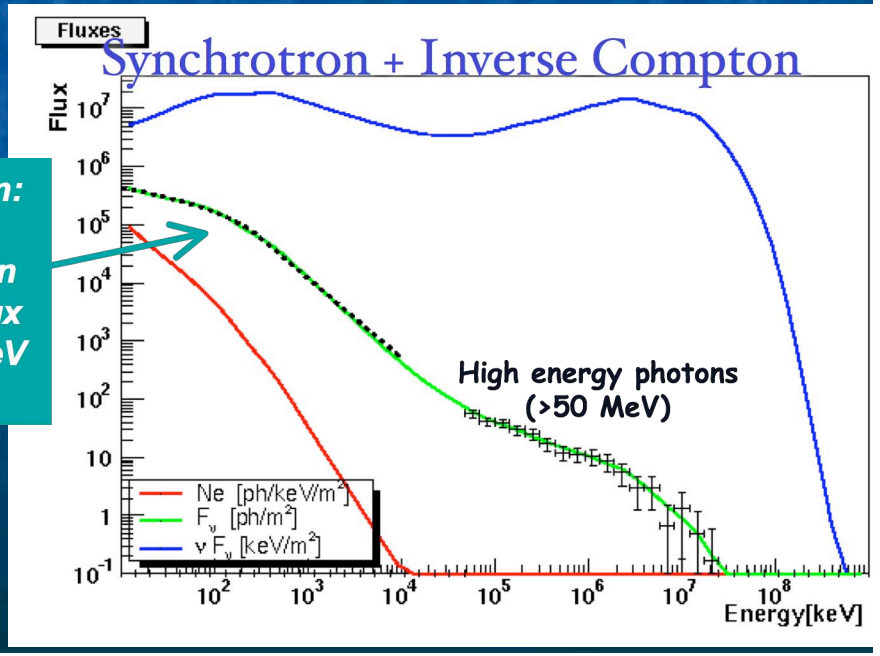
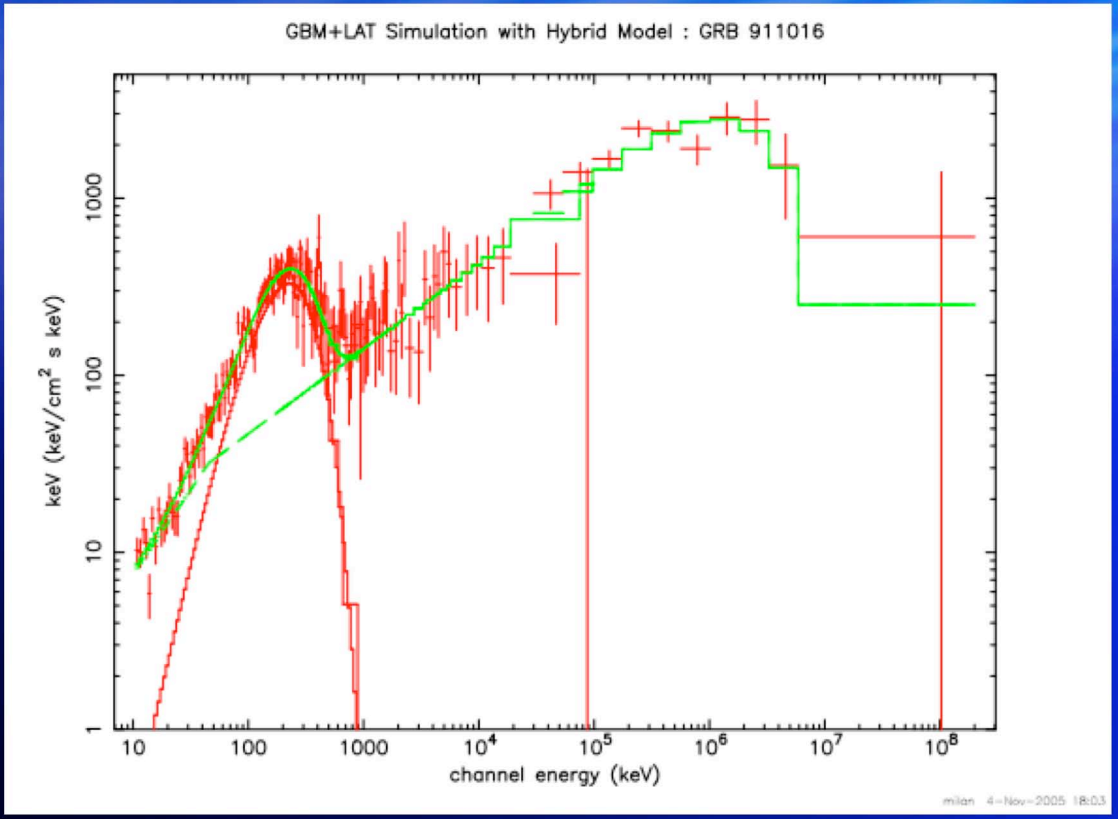


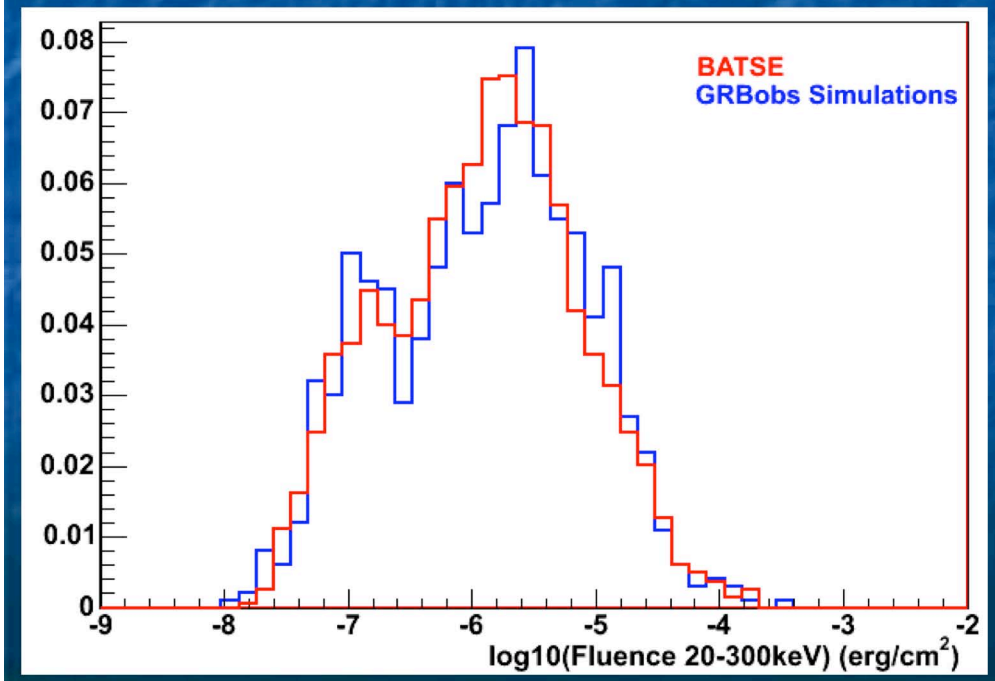
GRB Spectrum with a Hybrid Model

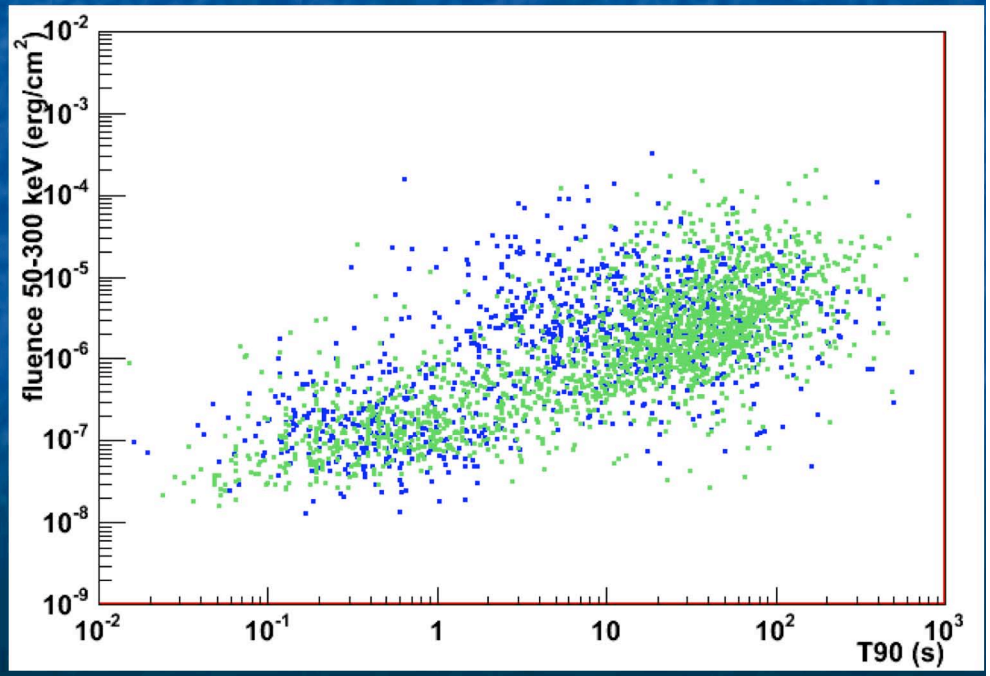
- Simulation (NaI+BGO+LAT) of a hybrid model consisting of a thermal, photospheric component (~100 keV) and a non-thermal synchrotron shock component with a high-energy cut-off. BATSE burst GRB 911016 used as calibration. (POSTER 3.52)



Studying the LAT sensitivity

- From BATSE catalog:
  - 650 bursts per year per 4 π
  - Duration, Fluence, peak energy, spectral indexes (sampled from the observed distributions).
  - Simulation of **one year** of data taking.
  - Orbital motion of the satellite is considered (bursts inclination).





GRB LAT sensitivity

No cosmological absorption included.

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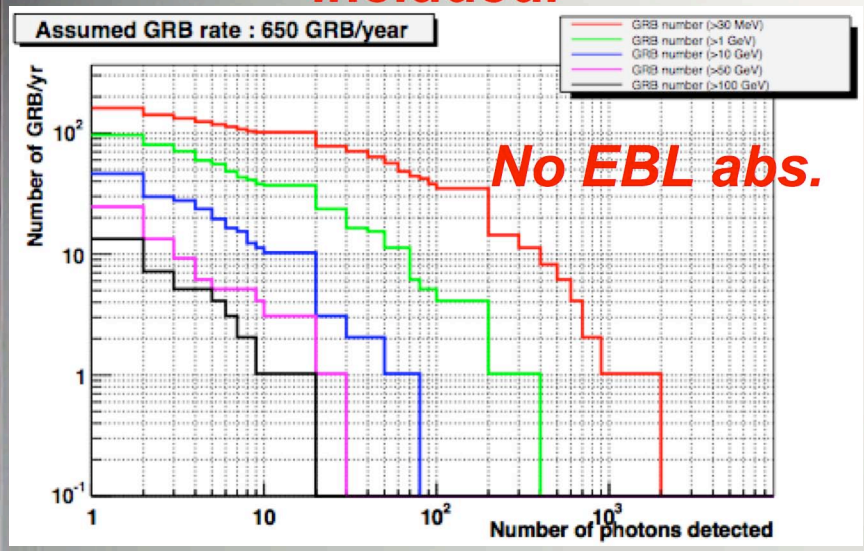

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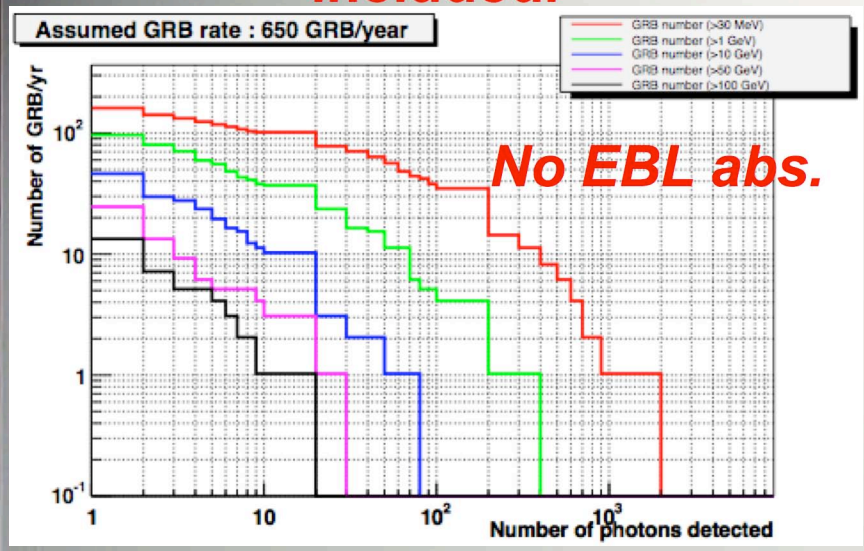

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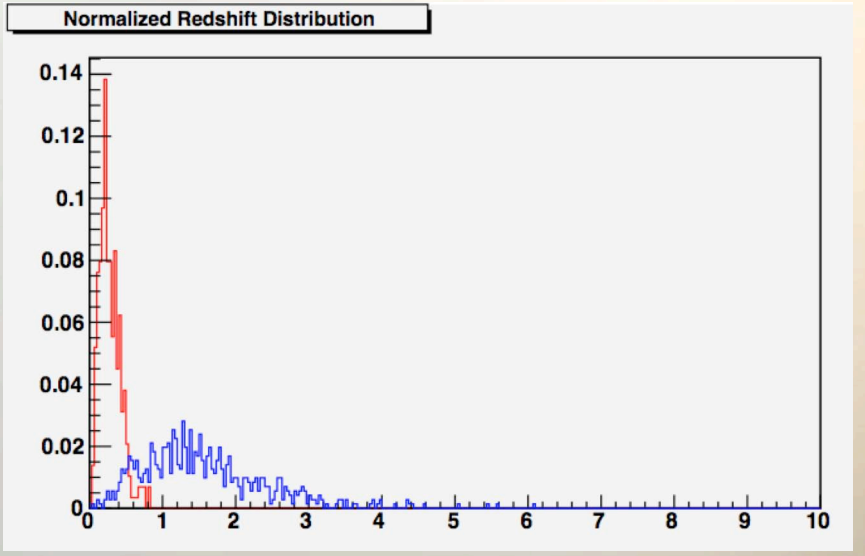
SFR *(Madau & Porciani)*

Short bursts redshift distribution:

NS-NS merges, peaked at low redshift (~0.2) ~ *(Guetta and Piran, 2005)*



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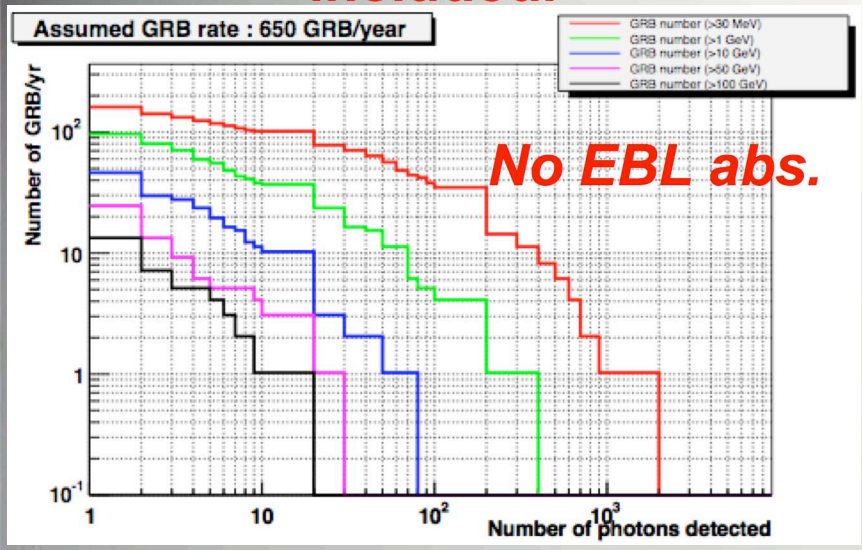

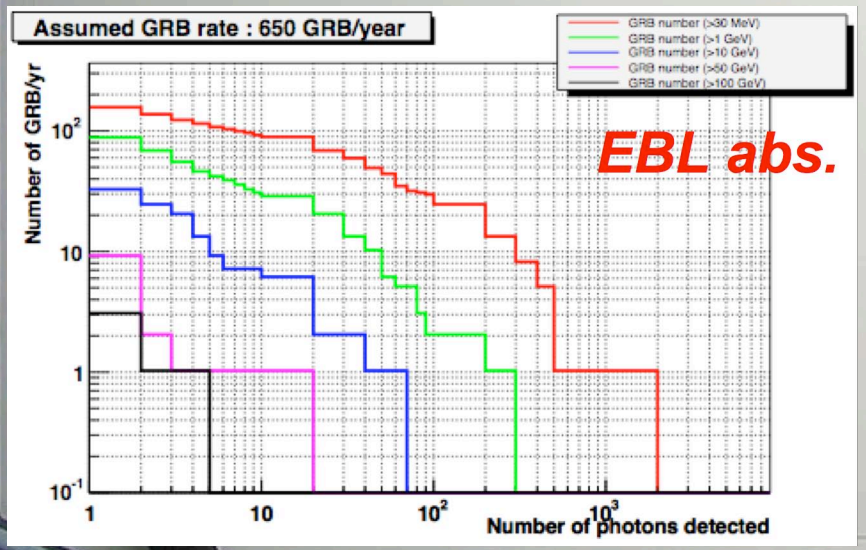

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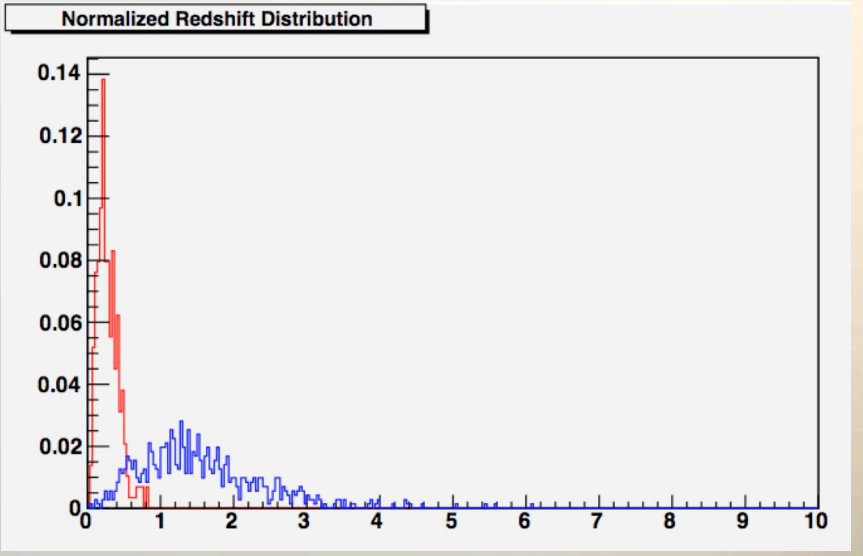

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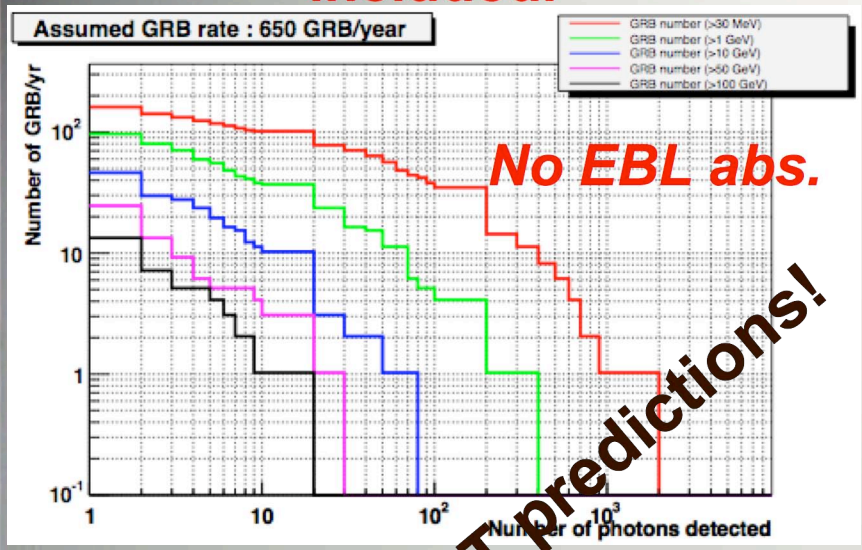

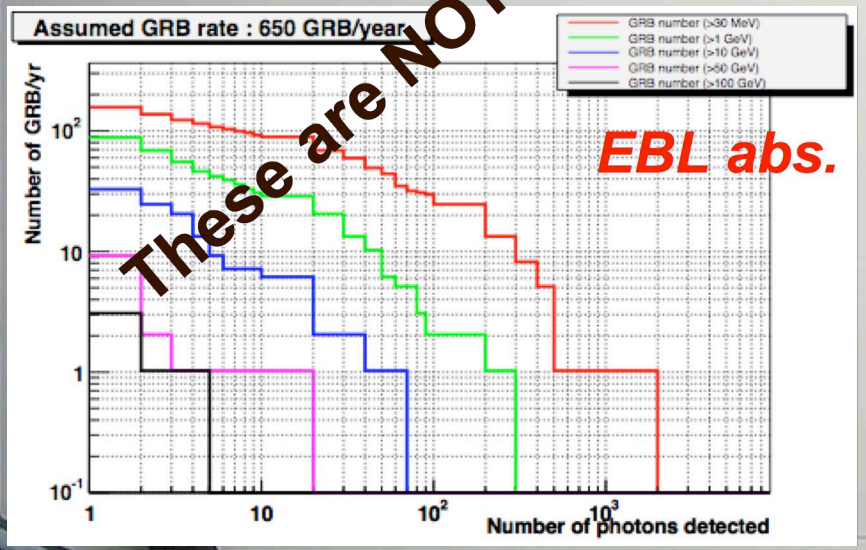

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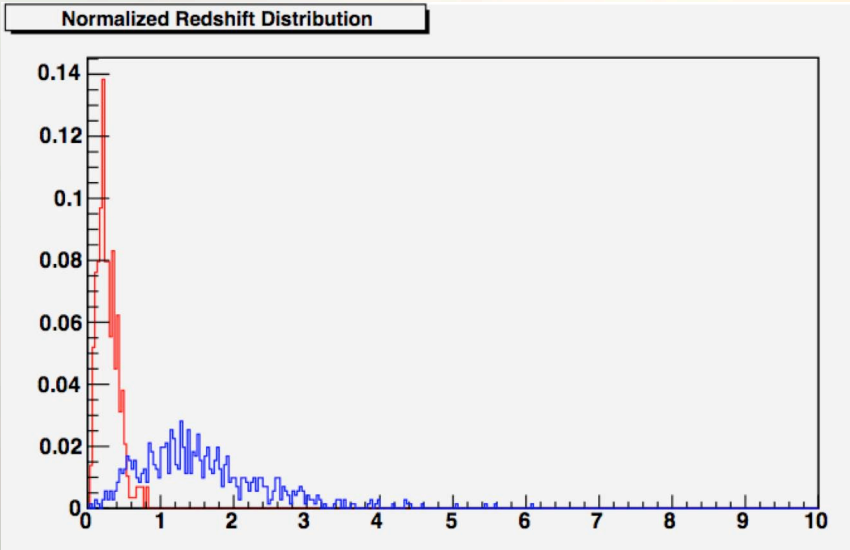


GLAST & GRB

- Operational modes
  - Sky survey (full coverage every 3 hours)
  - Pointing mode
- GBM and LAT will both have triggers!
  - GBM will detect ~ 200 burst per year
  - >60 burst per year within the FoV of the LAT detector
  - Alert to GCN ~ 10 seconds
  - GBM < 15° initially, update <5°
  - LAT > ~10 arcmin depending on burst
- Downlink and communications
  - Bursts alerts sent on ground in near real-time (TDRSS)
  - TDRSS: full science data downlink (~ 8 times day)
- Autonomous repoint
  - In case of intense bursts GLAST can repoint t keep the burst in the LAT FoV. Dwell time: initially 5 hr (adjustable)

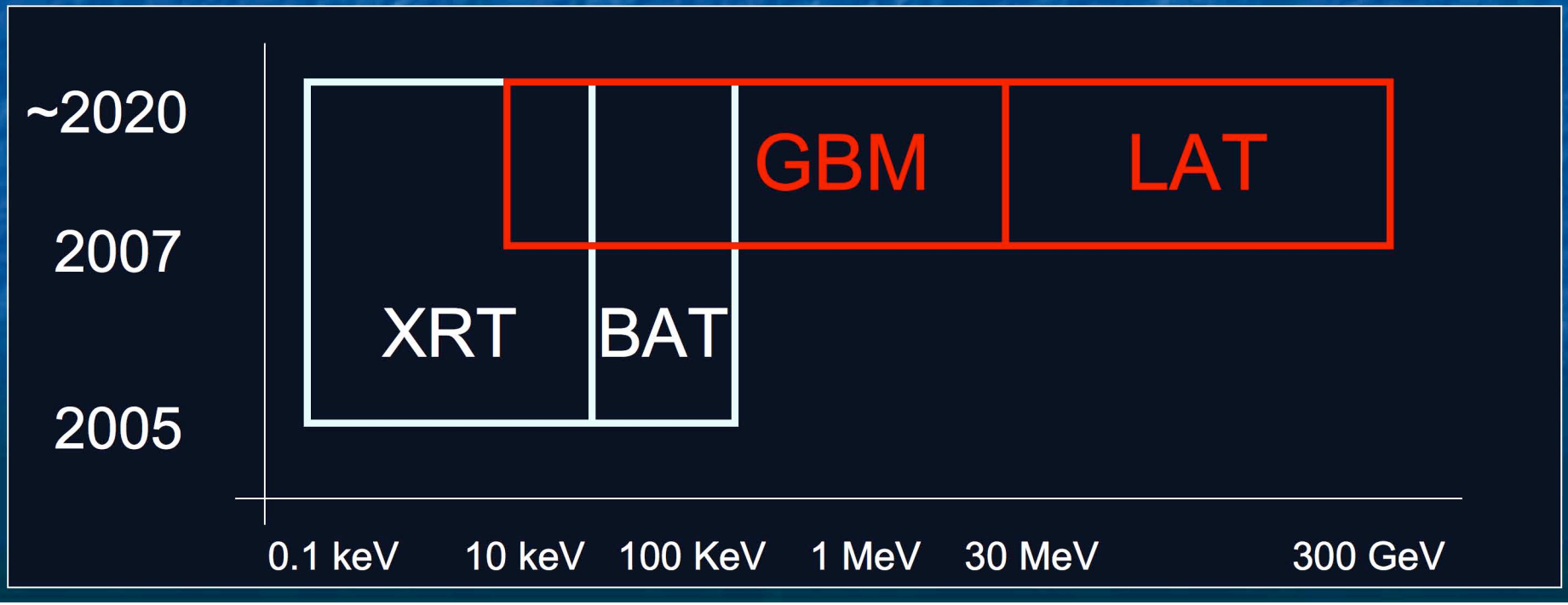
GCN

Users community

GLAST mission details: see the poster by J. McEnery and S. Ritz (11.7)

GLAST and SWIFT era

- GLAST can provide alerts to GRBs that Swift can point for follow on observations.
  - Precise measurements of the position will be given by Swift!
- GLAST will frequently scan the position of the bursts hours after the Swift alerts, monitoring for High energy emission.
- In these cases, we will have a broad spectral coverage of the GRB spectrum (from 0.1 keV to hundreds of GeV > 9 decades!!).
- Swift is seeing 100 bursts per yr: ~ 20/yr will be in the LAT FoV

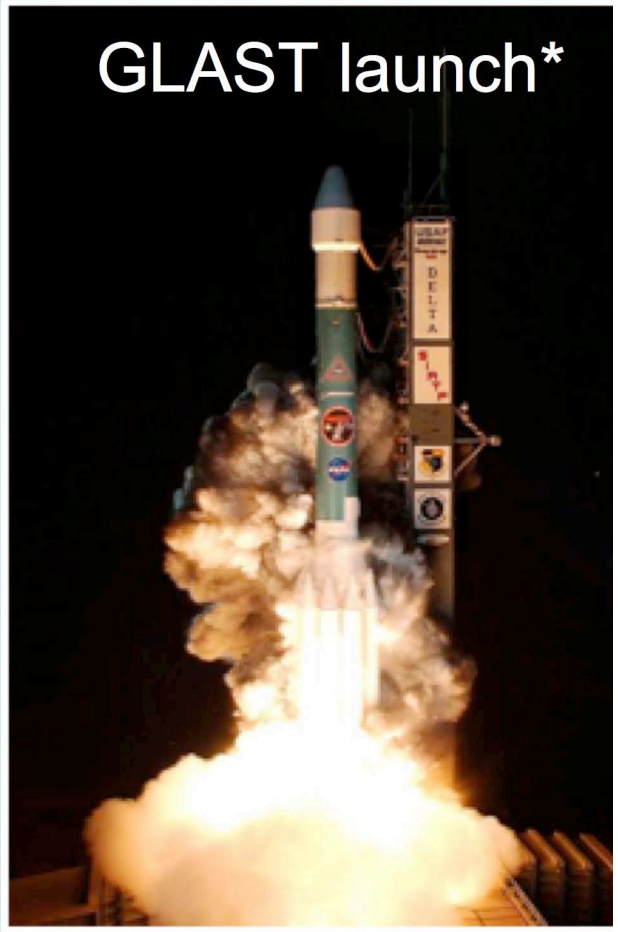


Conclusions

- GLAST will open a new window on the gamma-ray sky, exploring an uncovered region of the electromagnetic spectrum, with big impact on science!
- The flight hardware is close to being integrated with the SC!

- GLAST - GBM will detect ~200 bursts per year, > 60 suitable for LAT observations.
- GLAST - LAT will independently detect bursts
- GLAST will provide burst alerts rapidly (~ 10 seconds)
- Burst position is provided by both the GBM (~5°) and LAT (1°-0.1°) in few seconds and sent to ground for afterglows follow-up.
- GLAST can be repointed autonomously.
- Spectral resolution typically 10% important for spectral studies (high energy cut-offs, inverse Compton peaks).
- Joined LAT and GBM observations will study the relationship between GeV emission and keV-MeV
- The large lever-arm is a key point for investigating fundamental questions like the breaking of the Lorentz Invariance due to Quantum Gravity effect.
- Partnership between Swift and GLAST would open a new era for the gamma-ray astronomy!

GLAST launch*



*Simulated data