GRB observations with GLAST and TeV observatories

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Abstract

The Gamma-Ray Large Area Space Telescope (GLAST) is scheduled to be launched in 2007, with the capability of observing GRBs from 10 keV to more than 300 GeV. Since the spectral and temporal properties of GRBs above a few GeV are still almost unknown, extending these detections to higher energies would have a large impact on our knowledge of the particle acceleration and emission processes occuring within these sources. It would also allow their use as probes of the distant Universe and to study its transparency to high-energy gamma-rays. In this work we review the requirements for a good coordination of GLAST with ground-based telescopes operating above a few tens of GeV, and examine the potential of such simultaneous observations in terms of expected rates of alerts and sensitivity.

GRBs and GLAST

GeV burst observations are important: closer to underlying GRB engine energy scale and observable to high redshift. Little is known about the high-energy behavior of bursts. The few results from EGRET are tantalizing, making GLAST observations even more important:

- **observations of the prompt phase from 8 keV to >300 GeV (>7 decades in energy!)**
- **GBM will detect ~200 GRB/year, with ~60 of these within the canonical LAT FoV.**
- **autonomous repoint capability will allow high-energy afterglow studies**
- **GRB locations determined onboard by either the GBM (several degrees) or the LAT (sub degree), depending on burst properties, are sent in near real time to GCN.**

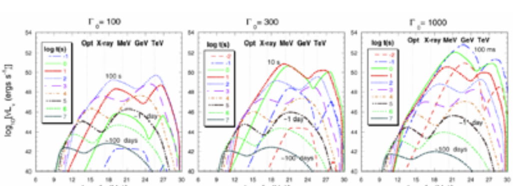
Scientific Motivations

High Energy GRB detections and upper limits.

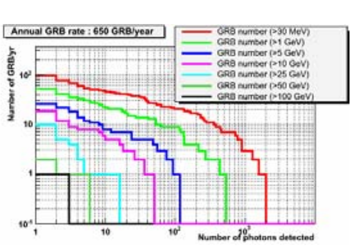
- **EGRET detection of GeV prompt and delayed emission from 940217 (Hurley et al. 1994)**
- **Evidence for a second component from BATSE + EGRET/TASC analysis (Gonzales et al. 2003)**
- **GRB 970417a detection above 600 GeV by MILAGRITO during BATSE T90 (Atkins et al. 2003)**
- **Upper limits on 100 GeV prompt emission from GRB 050713a by MAGIC (Albert et al. 2006)**
- **Upper limits on several GRB both by MAGIC and MILAGRO**

High Energy GRB models.

- **GeV-TeV photons can estimate the bulk Lorentz factor (Baring 2006)**
- **Different production mechanisms could be tested with GeV-TeV observation (e.g. Zhang and Meszaros 2001)**
- **Different time evolution for internal and external shocks.**
- **GeV observations could test particle acceleration mechanisms.**
- **Several mechanism predict gamma-ray emission for X-ray flares in the early afterglow phase.**



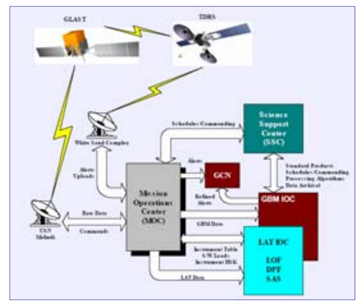
The spectral evolution of a GRB produced by the shock created when a blast wave of different initial bulk Lorentz factors Γ interacts with an external medium (Dermer & Chiang 1999). As in active galactic nuclei, two peaks are expected with the lower energy due to synchrotron emission and the higher energy due to inverse Compton scattering.



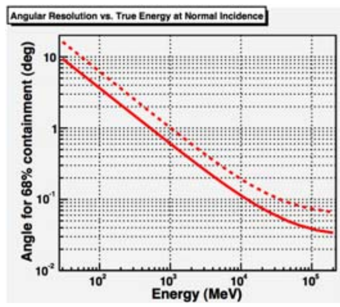
Expected GRB detected counts above a certain energy by the LAT. (Omodei et al. 2007)

GRB alerts and localization

- **GLAST will rapidly send (<7 s) burst alerts and positions to GCN through TDRSS**
- **A coordination with SWIFT is foreseen. Joint observations of bursts by both Swift and GLAST will be extremely valuable as the two missions provide fundamentally different, but complementary, observations of GRB.**
  Assuming a Swift GRB detection rate of 100 GRB/year, if the GLAST and Swift pointing directions are uncorrelated, then we expect ~20 Swift-detected GRBs/year to occur within the LAT FoV. Swift could repoint to GBM detected bursts.



Overview of the GLAST ground segnment



68% containment of the PSF for conversions in the THIN (solid line) and THICK (dashed line) sections vs true photon energy at near-normal incidence

- **Burst position will be provided by the LAT (0.1°- 1°) and/or the GBM (~15° on board - ~5° onground)**
- **The LAT will be very good at localization: a few high-energy photons (or even 1 single photon > 10 GeV) will be enough for ground based searches.**

Synergy with TeV telescopes

Sky Coverage

- **GBM/LAT FoV will be 9.5 and 2.4 sr respectively. GLAST will cover the entire sky in 3h**
- **The Extensive Air Showers (EAS) Arrays (MILAGRO and ARGO) have a high duty cycle (~100%) and large FoV (~20%). The GBM location will be enough for GRB emission searches.**
- **Imaging Atmospheric Cherenkov Telescopes (IACTs: CANGAROO, HESS, MAGIC, VERITAS, STACEE) observe during clear and moonless nights: they have low duty cycles (~10%) and ~5° FoV. (but can slew to any location within 30 s – few minutes and access ~20% of the sky). They need GRB position accuracy around 1° (LAT only).**

Sensitivity of TeV telescopes

- **An energy threshold ~ 50 - 100 GeV (<30 GeV for next generation IACT – MAGIC II and HESS II) defined as the gamma-ray count rate peak energy. Sub 100 GeV gamma-rays will be detected with optimal analysis and cut optimization.**
- **Observations with sensitivity of 10^{-9} – 10^{-11} erg cm^{-2} s^{-1} for the afterglow phase (~30 s few hours after trigger time)**
- **All instruments have energy resolution around 5%-20% at ~100 GeV.**

EXPECTED RATES of ALERTS

GBM and LAT detection rates

- **GBM will detect ~ 200 GRB/yr**
- **A phenomenological approach was used to estrapolate BATSE results to LAT energies, including EBL attenuation. This approach gave an estimate of 70 GRB/yr with > 10 counts above 50 MeV. Few GRB/yr will be detected with few photons above 50 GeV.**
- **Including the IC component this detection rate increases.**

GRB observation rates at TeV energies

- **An estimate of the number could be derived roughly as:**
  (number of alerts*duty cycle*sky coverage)

- **For the prompt emission phase:**
  - **EAS: 200 * 1.0 * 0.2 ~ 40 GRB/yr (10 LAT alerts)**
  - **IACT: 70 * 0.1 * 0.2 ~ 1/yr**

- **For the afterglow phase few LAT GRB/yr could be followed by IACT.**