The GLAST Burst Monitor

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Abstract. The Gamma Ray Large Area Space Telescope (GLAST) mission is a follow-up to the successful EGRET experiment onboard the Compton Gamma Ray Observatory (CGRO). It will provide a high-sensitivity survey of the sky in high-energy γ-rays, and will perform detailed observations of persistent and transient sources. There are two experiments onboard the GLAST - the Large Area Telescope (LAT) and the GLAST Burst Monitor (GBM).

The primary mission of the GBM instrument is to support the LAT in observing γ-ray bursts (GRBs) by providing low-energy measurements with high time resolution and rapid burst locations over a large field-of-view ($\geq$ 8 sr). The GBM will complement the LAT measurements by observing GRBs in the energy range 10 keV to 30 MeV, the region of the spectral turnover in most GRBs. An important objective of the GBM is to compute the locations of GRB sources on-board the spacecraft and quickly communicate them to the LAT and to the ground to allow rapid follow-up observations. This information may be used to re-point the LAT towards particularly interesting burst sources that occurred outside its field-of-view.

The GBM consists of 14 uncollimated scintillation detectors coupled to phototubes to measure γ-ray energies and time profiles. Two types of detectors are used to obtain spectral information over a wide energy range: 12 NaI($T\ell$) detectors (10 keV to 1 MeV), and 2 BGO detectors (150 keV to 30 MeV). The detectors are distributed around the GLAST spacecraft to provide a large, unobstructed field of view. The 12 NaI($T\ell$) detectors are mounted with different orientations for use in locating GRB sources.

INTRODUCTION

Gamma Ray Bursts (GRBs), are unique in the sense that they release most of their energy as photons with energies in the range 30 keV to a few MeV [1]. Observations of GRB after-glows in the optical wavelengths have revealed the cosmic origin of these enigmatic explosions. The redshifts of about 35 GRB counterparts are now measured, confirming their enormous energy scale [2, 3, 4]. Models of the prompt emission powering these energetic events remain highly speculative. However, the optical afterglow observations of the recent GRB030329 have led to the conclusion that its origin is linked to a supernova explosion (SN2003dh), providing tantalizing observational clues pointing to supernovae (SNe) as a mechanism (through core collapse) for producing GRBs [5, 6, 7, 8, 9]. There are several emission models such as the relativistic shock model

[10] in which the prompt & afterglow emissions correspond to synchrotron radiation from shock accelerated electrons. In order to discriminate between various models for the prompt γ-ray emission more observational parameters are needed.

GRB energy spectra have been measured from ~ 2 keV [11] to 18 GeV [12] with no evidence for spectral cut-off at high energies in many bursts. It is interesting to note that the GeV photons are delayed by as much as 1.5 hr with respect to the GRB trigger in GRB940217 [12]. There are bursts showing a distinct higher energy component (*e.g*. GRB941017 [13]) which could be related to relativistic electrons either through synchrotron emission or their interaction with the surrounding cloud. Similarly, there are a significant number of *X-ray rich* GRBs as well as *X-ray flashes* [14]. Even very high energy emission, in the range of GeV-TeV, is expected theoretically from inverse Compton scattering of electrons in external shocks [15] as well as from internal shocks in the prompt phase [16]. Hence there is an obvious need to study the GRB spectra over an extended energy range in order to understand the emission mechanisms.

The primary objective of the Glast Burst Monitor (GBM) instrument is to support the Large Area Telescope (LAT) in observing GRBs by providing low-energy measurements with high time resolution and by providing rapid burst locations over a large field-of-view (≥ 8 sr). The GBM will complement the LAT (energy range: 10 MeV to > 100 GeV) measurements by observing GRBs in the energy range 10 keV to 30 MeV, the region of the prominent spectral turnover of most GRBs. Another important objective of GBM is to compute the locations of GRB sources on-board the spacecraft and quickly communicate them to the LAT and to the ground to allow rapid follow-up observations. This information may be used to re-point the spacecraft towards particularly interesting bursts that occurred outside the LAT field of view.

THE ROLE OF GBM

The goal of the GBM, which is functionally similar to its predecessor BATSE, is to enhance the science return of the GLAST mission in the study of γ-ray bursts by providing low energy context measurements with high time resolution (2 μs). The LAT will provide ground-breaking new GRB observations while the GBM will enable to evaluate them in the context of prior observations & current knowledge.

FUNCTIONAL HIGHLIGHTS OF GBM

- GBM will provide spectra of bursts from 10 keV to 30 MeV, extending the LAT high energy (10 MeV to > 100 GeV) measurements with 2 more familiar energy domains.
- GBM will provide a wide sky coverage ($\sim$ 8 sr) and will generate a GRB trigger and locations enabling autonomous re-pointing for interesting bright bursts outside the LAT field-of-view for high energy afterglow studies.
- GBM with the LAT will provide an energy range spanning > 8 decades (10 keV to > 100 GeV) for the first time.

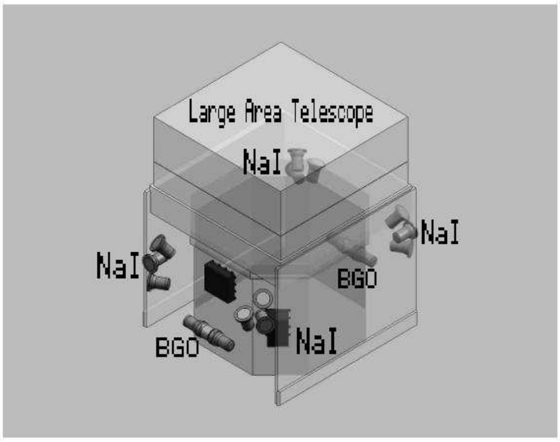

FIGURE 1. Placement of 12 NaI($T\ell$) and 2 BGO detectors onboard the satellite with respect to LAT, shown as the large structure above the spacecraft structure.

- GBM will provide rapid GRB locations for ground or space based quick follow-up observations and for further improvements in localization using the Swift or the inter-planetary network (IPN).

GBM DETECTOR DESIGN STRATEGY

GBM uses two types of uncollimated detectors: *viz.* NaI($T\ell$) to cover the energy range 10 keV to 1 MeV and BGO to cover 150 keV to 30 MeV. Each of the 12 NaI($T\ell$) detectors, having a thin Beryllium entrance window is $5''$ diameter and $0.5''$ thick; it is viewed by a $5''$ phototube. Each of the two BGO detectors consists of a $5''$ diameter and a $5''$ thick BGO crystal viewed by two $5''$ phototubes. The performance goals of these detectors are summarized in table 1. The 12 NaI($T\ell$) detectors and 2 BGO detectors are placed as shown in Figure 1 with respect to the LAT.

PROSPECTS OF GBM ON THE GLAST MISSION

GRB Spectra: GBM has a very high time resolution (2 μs) and hence will provide time resolved spectra of GRBs in the energy range 10 keV - 30 MeV. This provides a unique advantage of studying the relation between the GRB spectra in keV - MeV - GeV energies. It will also enable us to explore whether those GRBs detected by the LAT form a separate class of bursts. Time resolved spectra will also allow us to study the temporal behavior & distribution of spectral parameters. Due to the large energy range available (10 keV to $>$ 100 GeV) one can detect likely energy cut-offs in GRB spectra.

TABLE 1. GBM detector design capabilities

Parameter	Requirement	Goal	Current Capability
Energy Range	10 keV - 25 MeV	5 keV - 30 MeV	10 keV - 30 MeV
Energy Resolution	$< 23.5\%$ $FWHM$	<7%	$\sim 12\%$ $FWHM$ 511 keV
On-board GRB locations	Within 2 s	15° within 1 s	$<$ 15° within 1.8 s
Rapid ground GRB locations	5° accuracy (1 σ radius) within 5 s	3° within 1 s	TBD by analysis (scattering influenced)
Final GRB locations	3° accuracy (1 σ radius) within 1 day	No stated goal	TBD by analysis (scattering influenced)
GRB sensitivity (on ground)	0.5 photons cm^{-2} s^{-1} (peak flux 50-300 keV)	0.3 photons cm^{-2} s^{-1} (peak flux 50-300 keV)	0.35 photons cm^{-2} s^{-1} (peak flux 50-300 keV)
Field of View	8 sr	10 sr	$\sim$ 8.8 sr
Dead-time	$< 10\mu s/count$	$< 3\mu s/count$	$\sim 2.5\mu s/count$

GRB Light-curves: The GBM can measure energy & time resolved light-curves to enable us to study possible spectral & temporal lags. It provides 8 channel spectra every 64 ms as well as 128 channel spectra every 2.048 s during a burst, for each type of detector. The time tagged event data (TTE) with a time resolution of 2 μs is available for $>$ 300 s at a peak counting rate of 350 kHz during a burst. The TTE events too have a spectral resolution of 128 channels.

GRB Triggers: One would expect $\sim$150 GRB triggers/year of which $\sim$50-100 are expected to be observed by the LAT. Prior location provided by the GBM will enable the LAT to detect weaker GRBs by limiting the search area, thus increasing its sensitivity to GRBs.

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