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Expected Performance of the GLAST Burst Monitor

Charles Meegan*, Narayana Bhat†, Michael Briggs†, Valerie Connaughton†, Roland Diehl**, Gerald Fishman*, Jochen Greiner**, Andreas von Kienlin**, R. Marc Kippen‡, Chryssa Kouveliotou*, Giselher Lichti**, William Paciesas†, Robert Preece†, Helmut Steinle** and Colleen Wilson-Hodge*

**NASA/Marshall Space Flight Center, Huntsville, AL*
†University of Alabama Huntsville, Huntsville, AL
***Max Planck Institute for Extraterrestrial Physics, Garching, Germany*
‡Los Alamos National Laboratory, Los Alamos, NM

Abstract. The GLAST Burst Monitor (GBM) will enhance LAT observations of GRBs by extending the spectral coverage from the LAT threshold down to ~ 8 keV, and will provide a trigger for re-orienting the spacecraft to observe delayed emission from selected bursts outside the LAT field of view. GBM consists of twelve NaI scintillation detectors operating in the 8 keV to 1 MeV energy range and two BGO scintillation detectors operating in the 150 keV to 30 MeV energy range. Detector resolution, effective area, and angular response have been determined by calibrations. Analyses indicate that the on-board burst threshold will be ~ 0.7 photons $cm^{-2}s^{-1}$ and the on-board burst localization accuracy will typically be better than 8°.

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INTRODUCTION

The Gamma Ray Large Area Space Telescope (GLAST) observatory, scheduled for launch in the spring of 2008, comprises the Large Area Telescope (LAT) and the GLAST Burst Monitor (GBM). The Burst Monitor will enhance gamma-ray burst observations of the main telescope by extending spectral coverage downward into the range of spectral breaks studied in detail by current databases. Furthermore, it will provide a trigger for re-orienting the spacecraft to observe delayed emission from bursts outside the LAT field of view. GBM consists of twelve NaI and two BGO scintillation detectors operating in the 10 keV to 30 MeV range and covering the entire unocculted sky.

DETECTORS

Twelve sodium iodide (NaI) detectors cover the energy range of 10 keV to 1 MeV. They are 12.7 cm (5") in diameter and 1.27 cm (0.5") in thickness, with a Beryllium entrance window. In addition to covering the low energy range for burst spectra, the NaI detectors are used to obtain burst locations.

Two bismuth germanate (BGO) detectors cover the energy range of 150 keV to 30 MeV, overlapping the NaI energy range and extend to the lower limit of the LAT energy range. The BGO detectors are 12.7 cm (5") in diameter and 12.7 cm (5") in thickness and viewed by two photomultiplier tubes for better light collection and for redundancy.

The detectors were calibrated using laboratory radioactive sources. The energy resolution is shown as a function of energy in figure 1. The GBM requirement for 23% (FWHM) resolution between 100 keV and 1 MeV is easily met.

The effective area is shown as a function of energy in figure 2. For the NaI detectors, this is the area for normal incidence (geometric area of 126 cm^2). For the BGO detectors, it is the area for incidence perpendicular to the detector axis (geometric area of 161 cm^2). Summing the NaI detectors illuminated by a burst will typically yield an effective area about a factor of three above the plotted curve.

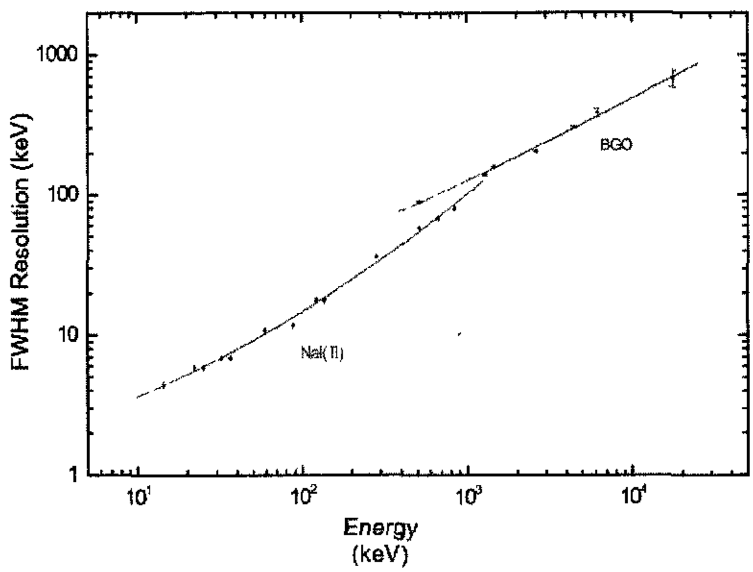

FIGURE 1. Detector resolution (FWHM) for NaI and BGO detectors as a function of energy.

DATA TYPES

GBM will at all times transmit two types of histograms of spectra from each of the detectors. The CTIME data type emphasizes temporal resolution, while the CSPEC data type emphasizes spectral resolution. The temporal resolution and energy channel boundaries of both CTIME and CSPEC are under software control. Time-tagged event data are transmitted for a limited time during bursts, as described in the next section. Table 1 summarizes the nominal characteristics of the data types.

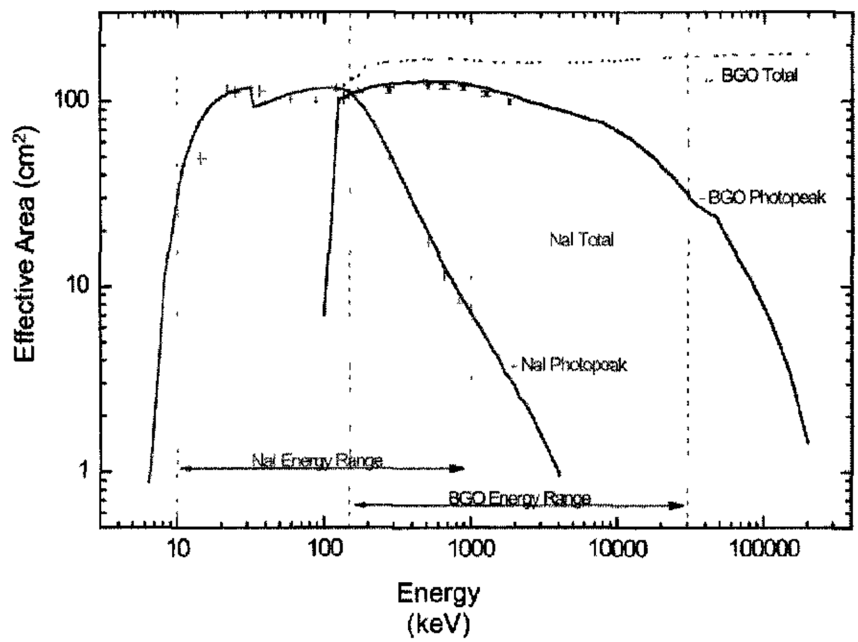

FIGURE 2. Effective area as a function of energy for a single NaI and a single BGO detector.

BURST TRIGGERING

GBM flight software will implement a burst trigger that will initiate an increase in data transmission. A trigger occurs if the count rates in two or more of the NaI detectors exceeds a specified statistical significance above the background rate. The required significance is separately adjustable for five different time scales (16 ms, 64 ms, 256 ms, 1.024 s, and 4.096 s) in up to five adjustable energy ranges.

When a burst trigger occurs, GBM begins transmitting time-tagged event data for 300 seconds. A ring buffer of 524,288 (2^{19}) pre-trigger time-tagged events is also transmitted. On-board software also computes the direction to the event, the classification likelihood (GRB, solar flare, particle precipitation, etc.), and peak flux and fluence estimates. These parameters are sent to the LAT and to the ground in near-real time. Particularly intense bursts will initiate a re-pointing of the observatory to place the burst in the LAT field of view. Trigger information will be distributed to ground-based observers via the GCN.

The predicted rate of GRB triggers is 200 per year. The total GBM data rate will depend on the trigger rate but is expected to be approximately 1.3 Gigabits per day.

TABLE 1. GBM Data Types

Name	Purpose	Temporal Resolution	Spectral Resolution
CSPEC	Continuous high spectral resolution	Nominal: 8.192 s; During Bursts: 2.048 s; Adjustable Range: 1.024 - 32.768 s	128 energy channels (adjustable boundaries)
CTIME	Continuous high time resolution	Nominal: 0.256 s; During Bursts: 0.064 s; Adjustable Range: 0.064 - 1.024 s	8 energy channels (adjustable boundaries)
TTE	Time-tagged events during bursts	2 μs time tags; 300 s after trigger; 512k events before trigger	128 energy channels (adjustable boundaries)

TABLE 2. Expected GBM Performance

Parameter	Expected or Measured Performance
Energy range	~8 keV - 30 MeV (measured)
Energy resolution	15% FWHM at 0.1 MeV (measured) 8% FWHM at 1.0 MeV (measured)
On-board GRB locations	$< 15°$ for any pointing $< 8°$ for S/C zenith angle $< 60°$
GRB sensitivity (5σ, on ground)	0.47 photons $cm^{-2}s^{-1}$ (peak flux, 1 s, 50-300 keV)
GRB on-board trigger sensitivity	0.71 photons $cm^{-2}s^{-1}$ (peak flux, 1 s, 50-300 keV)
Field of view	9.0 steradians

SYSTEM PERFORMANCE

Table 2 summarizes the expected performance of the GLAST Burst Monitor. The energy resolution was measured using radioactive sources. Trigger sensitivity and location accuracy were determined by simulation.

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