GLAST Burst Monitor

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The mission of the GLAST Burst Monitor (GBM) is to enhance the science return of the Gamma Ray Large Area Space Telescope (GLAST) mission in the study of gamma-ray bursts. The GBM will detect bursts over a large solid angle and will continually measure the spectra of bursts over a wide energy band and with high temporal resolution. It will also determine the directions to the bursts to allow optional repointing of the observatory.
GBM Management and Science Team

- Principal Investigator - Dr. Charles Meegan, MSFC
- Co-Principal Investigator - Dr. Giselher Lichti, MPE
- Project Manager - Stephen Elrod, MSFC
- Systems Engineer - Fred Berry, MSFC
- Co-Investigators (MSFC) - Dr. Jerry Fishman, Dr. Chryssa Kouveliotou
- Co-Investigators (MPE) - Dr. Robert Georgii, Dr. Andreas von Keinlin, Dr. Roland Diehl, Dr. Volker Schönfelder
- Co-Investigators (UAH) - Dr. William Paciesas, Dr. Geoff Pendleton, Dr. Robert Preece, Dr. Marc Kippen, Dr. Michael Briggs
## GBM Near Term Schedule

### GBM Program Milestones

- **Gamma-Ray Burst Monitor (GBM) Development**
- **Science Support for GBM Lifecycle**
- **Burst Monitor Instrument Management**
- **Instrument Systems Engineering**
- **Mission Assurance & Safety**
- **Flight Instrument**
- **Engineering Model (Deleted)**
- **Mechanical/Thermal Subsystem**
- **Instrument Harness Development**
- **Instrument Power Distributor**

### Timeline

**2001**
- Oct: GLAST SRR - GBM Lite' SRR
- Nov: 2/1 GBM Delta MSFC SRR

**2002**
- Oct: GLAST Mission PDR - GBM Lite' PDR
- Nov: 8/1 GBM NAR

### Key Dates
- **09/27-28/2000**

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**GLAST SRR**
GBM Functional Block Diagram

Data Processing Unit (DPU)

Science data
Cmd/Resp
PPS
Ancillary Data
Power

Spacecraft Interface

HVPS
LVPS

NaI
PMT
BGO
PMT

Command

Power

Command

NaI
PMT

1 of 12

1 of 2


GLAST SRR
GBM Detector Concept Drawings

BGO Detector

NaI Detector
<table>
<thead>
<tr>
<th>Component</th>
<th>M[kg]</th>
<th>Number</th>
<th>M[kg]</th>
<th>%</th>
<th>kg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crystal mass:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BGO</td>
<td>11.47</td>
<td>2</td>
<td>22.9</td>
<td>1%</td>
<td>0.2</td>
</tr>
<tr>
<td>NaI</td>
<td>0.59</td>
<td>12</td>
<td>7.1</td>
<td>1%</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Al-Housing for 1 detector:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BGO</td>
<td>0.28</td>
<td>2</td>
<td>0.6</td>
<td>5%</td>
<td>0.0</td>
</tr>
<tr>
<td>NaI</td>
<td>0.03</td>
<td>12</td>
<td>0.4</td>
<td>5%</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>PMT (incl. Housing + Bleeder string):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M[kg]</td>
<td>0.86</td>
<td>16</td>
<td>13.8</td>
<td>15%</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Mounting Flanges</strong></td>
<td>M[kg]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.065</td>
<td>16</td>
<td>1.0</td>
<td>100%</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>DPU:</strong></td>
<td>M[kg]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>2.0</td>
<td>100%</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>HVPS:</strong></td>
<td>M[kg]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.35</td>
<td>1</td>
<td>3.4</td>
<td>10%</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>LVPS:</strong></td>
<td>M[kg]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.27</td>
<td>2</td>
<td>4.5</td>
<td>10%</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Thermal Hardware:</strong></td>
<td>M[kg]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Heater, radiator)</td>
<td>0.13</td>
<td>16</td>
<td>2.1</td>
<td>50%</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Contingency</strong></td>
<td>M[kg]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.3</td>
<td></td>
<td>7.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total with Contingency.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>57.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allocation</td>
<td>70.0</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Margin</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Power Estimate for GBM

## Contingency Power Estimate

<table>
<thead>
<tr>
<th>Component</th>
<th>Watts</th>
<th>Number</th>
<th>Total Watts</th>
<th>%</th>
<th>Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PMT (incl. Bleeder string &amp; Preamp):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaI</td>
<td>0.3</td>
<td>12</td>
<td>3.6</td>
<td>25%</td>
<td>0.9</td>
</tr>
<tr>
<td>BGO</td>
<td>0.6</td>
<td>2</td>
<td>1.2</td>
<td>25%</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>DPU:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1</td>
<td>10.0</td>
<td>100%</td>
<td>10.0</td>
</tr>
<tr>
<td><strong>HVPS:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1</td>
<td>5.0</td>
<td>25%</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>LVPS:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>4.0</td>
<td>25%</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Thermal Hardware:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Heater, radiator)</td>
<td>0.2</td>
<td>16</td>
<td>3.2</td>
<td>100%</td>
<td>3.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>27.0</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contingency</strong></td>
<td>16.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total with Contingency.</strong></td>
<td>43.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Allocation</strong></td>
<td>50.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Margin</strong></td>
<td>6.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• GBM is using a standard MSFC Requirements, Verification and Compliance (RVC) database.

• Each requirement is numbered and categorized.

• Verification method and description captured on same page.

• Compliance data either referenced or stored electronically in database.

• Non-conformances summarized and referenced in database, and dispositioned by the GBM configuration control board.
GBM Sample Verification Sheet

## GBM System Level Performance Requirements

<table>
<thead>
<tr>
<th>Title</th>
<th>Requirement</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Resolution</td>
<td>20% FWHM at 511 keV</td>
<td></td>
</tr>
<tr>
<td>On-board Burst Locations</td>
<td>20 degrees within 2 s</td>
<td>10 degrees within 1 s</td>
</tr>
<tr>
<td>Ground Burst Locations</td>
<td>5 degrees computed in 5 s</td>
<td>3 degrees computed in 1 s</td>
</tr>
<tr>
<td>Final Burst Locations</td>
<td>3 degrees computed in 1 day</td>
<td></td>
</tr>
<tr>
<td>Sensitivity (5σ)</td>
<td>0.5 photons cm⁻²s⁻¹</td>
<td>0.3 photons cm⁻²s⁻¹</td>
</tr>
<tr>
<td>Field of View</td>
<td>8 steradians</td>
<td>10 steradians</td>
</tr>
</tbody>
</table>
Effects of Requirements on Design

Science Requirements
- Large Energy Range
- Adequate Sensitivity
- Coarse Location
- Wide FOV
- Good Timing
- Burst Alerts
- Mass & Volume Constraints

Design Impacts
- NaI & BGO Detectors
  - Number & Size of Detectors
- Number & Placement of NaI Detectors
- DPU speed
- Data Types
- Telemetry Requirements
GBM Detector Mounting

**NaI detectors:**

The direction to any point in the sky within 120 degrees (TBC) of the +Z axis shall be <80 degrees (TBC) from the normal vectors of at least 3 unobstructed non-collinear NaI detectors, with 95% probability. The goal is 4 unobstructed non-collinear detectors with 100% probability. Solar panels are not considered to be an obstruction.

The angle between the normals of any two NaI detectors shall be >25 degrees (TBC).

**BGO Detectors:**

At least one unobstructed BGO detector must be visible from any point in the sky within 150 degrees (TBC) of the +Z axis, with 95% probability. The goal is 100% probability over all directions. Solar panels are not considered to be an obstruction.

The axis of symmetry of the BGO detectors should be perpendicular to the Z axis.
<table>
<thead>
<tr>
<th>Title</th>
<th>Requirement</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Area for Locations</td>
<td>&gt;110 cm² at 122 keV, on axis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;90 cm², 40 to 400 keV, on axis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;45% of on axis at 60 degrees</td>
<td></td>
</tr>
<tr>
<td>Effective Area for Spectra – low E</td>
<td>&gt;100 cm² at 14 kev, on axis</td>
<td>&gt; 50 cm² at 6 keV, on axis</td>
</tr>
<tr>
<td></td>
<td>&gt;40 cm² at 14 keV, up to 60°</td>
<td>&gt; 15 cm² at 6 keV, up to 60°</td>
</tr>
<tr>
<td>Effective Area for Spectra – high E</td>
<td>&gt;80 cm², at 1.8 Mev, up to 90°</td>
<td></td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>&lt;35 % FWHM at 14 keV</td>
<td>&lt; 22% HWHM at 6 keV</td>
</tr>
<tr>
<td></td>
<td>&lt;20 % FWHM at 60 keV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;11 % FWHM at 662 keV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;7 % FWHM at 1.8 MeV</td>
<td></td>
</tr>
<tr>
<td>Gain Stability</td>
<td>2% over 1.5 hours</td>
<td></td>
</tr>
</tbody>
</table>
## GBM DPU Performance Requirements

<table>
<thead>
<tr>
<th>Title</th>
<th>Requirement</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Rate performance</td>
<td>$10^5$ cps per detector, $6 \times 10^5$ cps total</td>
<td></td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>200:1</td>
<td>300:1</td>
</tr>
<tr>
<td>Linearity</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>Automatic Gain Control</td>
<td>Monitor 511 keV line and adjust HV</td>
<td></td>
</tr>
<tr>
<td>Burst Trigger</td>
<td>16 ms integrations</td>
<td></td>
</tr>
<tr>
<td>CTIME data</td>
<td>8 channels, 0.512 s</td>
<td>Adjustable to 0.128 s</td>
</tr>
<tr>
<td>CSPEC data</td>
<td>128 channels, 8.192 s</td>
<td>Adj. to 2.048 s</td>
</tr>
<tr>
<td>TTE data</td>
<td>250,000 events pre-trigger</td>
<td>500,000 events pre-trigger</td>
</tr>
<tr>
<td>Housekeeping data</td>
<td></td>
<td>Deadtime counters</td>
</tr>
</tbody>
</table>
GBM Requirements Issues

- System linearity and stability need further study
- **DPU redundancy/cost trades**
- **DPU/Spacecraft Interface**
  - Small increase in telemetry buffer can achieve goal of science enhancement
  - Max Spacecraft Bus Rate affects TTE Buffer
- **Trigger alerts need to be coordinated with LAT team**
- **Requirements levied on GLAST project**
  - Observatory mass model
  - Spacecraft simulator
  - TBD spacecraft level radioactive source calibration
- **Detector Mounting** – Thermal, FOV, Mechanical
GBM Ground Support System (pre-launch)

- **Purpose**
  - System test & calibration
  - S/C integration & test

- **Functions**
  - Receive & store data
  - Monitor detector rates, housekeeping, status
  - Display & analyze detector spectra
  - Generate & transmit instrument commands
  - Simulate detector response

- **Capabilities**
  - Process/store >95% of real-time packets
  - Transportability
  - Critical custom components redundant
  - DPU interface
  - GLAST S/C interface
    - S/C simulator required
GBM Ground Support System (post-launch)

Instrument Operations Center

• **Purpose**
  – Instrument operations
  – Data archival
  – Primary data analysis

• **Functions**
  – Process data, level 1 → 2
  – Maintain flight S/W
  – Monitor detector calibration
  – Monitor detector rates, housekeeping, status
  – Locate GRBs
  – Deconvolve GRB spectra
  • Mass Model required

• **Functions (continued)**
  – Generate/transmit instrument commands
  – Compute GRB peak flux, fluence, duration
  – Produce and deliver high-level data
  – Interface to GLAST MOC/SSC
  – Autonomous GRB location software for MOC