GLAST Mission: Status and Science Opportunities

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Outline

• GLAST: An International Science Mission
  – Large Area Telescope (LAT)
  – GLAST Burst Monitor (GBM)

• mission operations plan

• highlights of science opportunities

• schedule highlights

LAT: 20 MeV → 300 GeV
GBM: 10 keV → 25 MeV

Launch: February 2007
GLAST is an International Mission

NASA - DoE Partnership on LAT
LAT is being built by an international team
  - Stanford University (SLAC & HEPL, Physics)
  - Goddard Space Flight Center
  - Naval Research Laboratory
  - University of California, Santa Cruz
  - University of Washington
  - Ohio State University
  - CEA/Saclay & IN2P3 (France)
  - ASI & INFN (Italy)
  - Hiroshima University, ISAS, RIKEN (Japan)
  - Royal Inst. of Technology & Stockholm Univ. (Sweden)

GBM is being built by US and Germany
  - MPE, Garching (Germany)
  - Marshall Space Flight Center

Spacecraft and integration - Spectrum Astro

Mission Management: NASA/GSFC

Flags:
- Sweden
- Italy
- France
- Germany
- USA
- Japan

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Overview of LAT

- **Precision Si-strip Tracker (TKR)**
  18 XY tracking planes. Single-sided silicon strip detectors (228 µm pitch)
  Measure the photon direction; gamma ID.

- **Hodoscopic CsI Calorimeter (CAL)**
  Array of 1536 CsI(Tl) crystals in 8 layers. Measure the photon energy; image the shower.

- **Segmented Anticoincidence Detector (ACD)**
  89 plastic scintillator tiles. Reject background of charged cosmic rays; segmentation removes self-veto effects at high energy.

- **Electronics System**
  Includes flexible, robust hardware trigger and software filters.

**Systems work together to identify and measure the flux of cosmic gamma rays with energy 20 MeV - >300 GeV.**
LAT Status Summary

- Work by many people across institutions/countries:
  - Subsystems completing testing their engineering model hardware; starting flight production and testing now
  - Software tools shaping up well.
    First data challenge complete Feb 2004.
GLAST LAT High Energy Capabilities

- **Huge FOV** (~20% of sky)
- **Broadband** (4 decades in energy, including unexplored region > 10 GeV)
- **Unprecedented PSF** for gamma rays (factor > 3 better than EGRET for E>1 GeV)
- **Large effective area** (9x larger than EGRET @ 1 GeV)
- **much smaller deadtime per event** (25 μsec → factor 4,000 better than EGRET)
- **No expendables** → long mission without degradation (min. 5 years)

**Light Gathering Power:** $A_{\text{eff}} \cdot \Delta \Omega$ Product

- **EGRET:** 500-600 cm$^2$-str
- **GLAST:** 24000 cm$^2$-str

- **700K Photons**
- **Est. ~ 150M Photons**
High energy source sensitivity: all-sky scan mode

EGRET Fluxes
- GRB940217 (100sec)
- PKS 1622-287 flare
- 3C279 flare
- Vela Pulsar

During the all-sky survey, GLAST will have sufficient sensitivity after O(1) day to detect (5σ) the weakest EGRET sources.

*zenith-pointed*
**GBM Detector**

**Bismuth Germanate (BGO) Scintillation Detector**

**Major Purpose**
- Provide high-energy spectral coverage (150 keV – 25 MeV) to overlap LAT range over a wide FoV
Roles of the GBM

- provides spectra for bursts from 10 keV to 25 MeV, connecting frontier LAT high-energy measurements with more familiar energy domain:

  Simulated GBM and LAT response to time-integrated flux from bright GRB 940217
  Spectral model parameters from CGRO wide-band fit
  1 NaI (14º) and 1 BGO (30º)

- provides wide sky coverage (8 sr) -- enables autonomous repoint requests for exceptionally bright bursts that occur outside LAT FOV for high-energy afterglow studies (an important question from EGRET);

- GLAST observatory provides burst alerts to the ground.
GLAST Science Menu

• Systems with supermassive black holes & relativistic jets
• Gamma-ray bursts (GRBs)
• Pulsars
• Solar physics
• Origin of Cosmic Rays
• Probing the era of galaxy formation
• Solving the mystery of the high-energy unidentified sources
• Discovery! Particle Dark Matter? Other relics from the Big Bang? Testing Lorentz invariance. New source classes

GLAST draws the interest of both the High Energy Particle Physics and High Energy Astrophysics communities.
Features of the Gamma-Ray Sky

- diffuse extra-galactic background (flux $\sim 1.5 \times 10^{-5}$ cm$^{-2}$s$^{-1}$sr$^{-1}$)
- galactic diffuse (flux $\sim$O(100) times larger)
- high latitude (extra-galactic) point sources (typical flux from EGRET sources O($10^{-7}$ - $10^{-6}$) cm$^{-2}$s$^{-1}$)
- galactic sources (pulsars, un-ID’d)

EGRET all-sky survey (E$>$100 MeV)

An essential characteristic: **VARIABILITY** in time!

wide field of view, and the ability to repoint, important for study of transients.

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GLAST Survey: ~10,000 sources (2 years)
Anticenter Region
AGN, the EBL, and Cosmology

IF AGN spectra can be understood well enough, they may provide a means to probe the era of galaxy formation:
(Stecker, De Jager & Salamon; Madau & Phinney; Macminn & Primack)

Pair creation attenuates flux. For flux of $\gamma$-rays with energy, $E$, this cross-section is maximized when the partner, $\epsilon$, is

$$\frac{\epsilon \text{TeV}}{E \text{eV}}$$

This corresponds to a partner photon energy sensitive to time of galaxy formation.

- No significant attenuation below 10 GeV
- Opaque

GLAST Can Probe the Optical-UV EBL

- GLAST will see thousands of blazars - instead of peculiarities of individual sources, look for systematic effects vs redshift.
- key energy range for cosmological distances (TeV-IR attenuation more local due to opacity).

Effect is model-dependent (this is good):

**Caveats**
- How many blazars have intrinsic roll-offs in this energy range (10-100 GeV)? (An important question by itself for GLAST!) Power of statistics is the key.
- Must measure the redshifts for a large sample of these blazars!
Gamma-Ray Bursts

GRBs are now confirmed to be at cosmological distances. The question persists: What are they??

EGRET detected very high energy emission associated with bursts, including a 20 GeV photon ~75 minutes after the start of a burst:

Hurley et al., 1994

Future Prospects: GLAST will provide definitive information about the high energy behavior of bursts: LAT and GBM together will measure emission over >7 decades of energy.
recent analysis by Gonzalez, et al.

Compare data from EGRET and BATSE: Distinct high-energy component has different time behavior!

What is the high-energy break and total luminosity?

Need GLAST data!
Particle physics models with SUSY could also solve the dark matter problem. If correct, these new particle interactions could produce an observable flux of gamma rays.

\[ \chi \rightarrow \gamma \gamma \text{ or } Z\gamma \text{ “lines”?} \]

Observations of the galactic center are intriguing:

- EGRET detected a gamma-ray source near the galactic center, with a small excess GeV flux.
- Hints of a TeV galactic center source from Whipple [K. Kosack et al., astro-ph/0403422]

Contributions to extragalactic diffuse flux from dark matter haloes also possibly observable. [Ullio et al, astro-ph/0207125]

Just an example of what might be waiting for us to find!
**GLAST Master Schedule**

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<th>GBM Instrument</th>
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<th>Ground System</th>
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<td>Observatory I&amp;T starts: December 2005</td>
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<td>First flight hardware deliveries to SLAC for I&amp;T: late summer 2004</td>
<td>GBM I&amp;T starts: September 2004</td>
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<td>latent test: July 2005</td>
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