Abstract

Because gamma-ray astrophysics depends in many ways on multiwavelength studies, the Gamma-ray Large Area Space Telescope (GLAST) Large Area Telescope (LAT) Collaboration is carrying out multiwavelength planning in preparation for the scheduled 2007 launch of the observatory. Many of these multiwavelength activities complement some other areas of high-energy astrophysics. We identify the spectral bands that might be particularly important towards understanding the nature of gamma-ray sources. Some of the high-priority needs include: (1) simultaneous broad-spectrum blazar flare measurements; (2) characterization of gamma-ray transients, including gamma-ray bursts; (3) X-ray timing of radio-quiet pulsars; (4) broad-spectrum variability studies of sources such as microquasars; (5) X-ray and TeV counterpart searches for unidentified gamma-ray sources. The LAT team welcomes cooperative efforts from observers at all wavelengths.

The LAT is an international project with U.S. support from NASA and the Department of Energy.

Multiwavelength Observations - Important for GLAST

Some Motivations for Multiwavelength Observations

- Source identification and population studies
- Intensive exploration of the brightest and most variable sources that will allow deep study of the source physics
- Rapid follow-up on transients (e.g. GRBs, blazar flares)

GLAST mission is designed to support rapid notification for follow-up studies.

Probing Extragalactic Background Light (EBL) with Blazars

- The EBL contains unique information about the epochs of formation and the evolution of galaxies and its role in the environment of the universe today.
- Shorter EBL wavelengths require source modeling that includes interstellar and intergalactic absorption.
- Alternative approach: nucleosynthesis of EBL photons from high-energy spectra of cosmological objects with $>10^8$ eV, maximum energy $E_{\gamma}$ (10MeV, 1Gev).

Deciphering the Workings of Relativistic Jets

- AGNs and gamma-ray bursts represent powerful jet sources, whose understanding depends on multiwavelength studies.
- Time variability on both short and long timescales is an important diagnostic for the physical processes.
- The gamma rays help link the accretion processes near the central engine to the jet outflow.
- Understanding the emission process is a first step towards determining how these jet sources interact with their environment.

Identifying New Source Classes

- Over half of the sources in the first EGRET catalog remain unidentified, largely because the error boxes were too large for identifying a unique counterpart in deep surveys.
- Potential new source classes include starburst galaxies, radio galaxies, clusters of galaxies, pulsars, nebulae, and microquasars (please see poster 10.95).
- The major increases in sensitivity and better angular resolution of GLAST LAT will reduce the size of the error boxes, leading to more compact error boxes, sub-arcmin in many cases.
- Finding new source classes is an important part of the discovery potential of the LAT.

Exploring the Extreme Environments of Pulsars

- Pulsars – rotating neutron stars – are sites of interactions in extreme gravitational, electric, and magnetic fields.
- One key to modeling these extreme conditions is having accurate, simultaneous timing data for many pulsars, not limited to the 200 best-prioritized objects.
- Although most timing information comes from radio searches, some X-ray pulsars provide timing data as well as light curves and energy spectra to compare with the gamma-ray data.

Summary

The GLAST Large Area Telescope will be optimized by coordinated multiwavelength observations and analysis. GLAST welcomes cooperative efforts from observers at all wavelengths. See http://glast.gsfc.nasa.gov/science/multi/

To be added to the Gamma-Ray Multiwavelength Information mailing list, please contact Dave Thompson (djt@egret.gsfc.nasa.gov). The GLAST Guest Investigator Program will support correlative observations and analysis. See http://glast.gsfc.nasa.gov/osc/proposals/ and Poster 18.06

GLAST Large Area Telescope High-Energy Multiwavelength Planning

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Planck Approach

The GLAST LAT Collaboration invites cooperative efforts from observers at all wavelengths to help optimize the mission’s performance. The GLAST Large Area Telescope Coordination Group (GLAMCOG), working with the GLAST Burst Monitor and GLAST Project science teams, will assist planning.

Some of the known multiwavelength needs are described in this poster, along with the steps being taken to meet those needs. This work is preliminary and does not represent the full range of multiwavelength activities that will be investigated.

Summary

- A significant sample of blazar broad spectra as a function of redshift is needed in order to separate intrinsic spectral features and time variability from EBL absorption effects.
- The LAT results complement those of the TeV telescopes like H.E.S.S. that measure lower-redshift objects.

Probing Extragalactic Background Light (EBL) with Blazars

- The GLAST Guest Investigator Program will support correlative observations and analysis. See http://glast.gsfc.nasa.gov/science/multi/

Multiwavelength Needs and Planning

### Diffuse Multiwavelength Measurement VS Z Incremental Background Light to Z ~ 5.5

<table>
<thead>
<tr>
<th>Science Objective</th>
<th>GLAST Provides</th>
<th>Multiwavelength Requirements</th>
<th>Multiwavelength Planning Activities</th>
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<tbody>
<tr>
<td>- Differentiation measurement (e.g.)</td>
<td>EBL spectra in bands where</td>
<td>- Broadband contemporaneous/ simultaneous spectral measurements (radio, optical, X-ray, Gamma, TeV) of blazar spectra</td>
<td>Participate with and encourage programs to expand blazar catalogs and measure broadband spectra.</td>
</tr>
<tr>
<td>- Origin of particle acceleration and emission mechanisms in</td>
<td>All-sky monitoring coverage of blazar flares and Gamma Ray Bursts (GRB)</td>
<td>- Participate with and encourage programs to expand blazar catalogs and measure broadband spectra.</td>
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<tr>
<td>- Search out and understand new classes of gamma-ray sources</td>
<td>Large number of source detections; Relatively uniform sky coverage; Good positions, energy spectra, time histories</td>
<td>- Participate with and encourage programs to expand blazar catalogs and measure broadband spectra.</td>
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<tr>
<td>- Understand particle acceleration and emission mechanisms in</td>
<td>Spectra and light curves resulting from particle interactions of the most energetic particles</td>
<td>- Identify facilities and plan proposal strategies for obtaining observing time needed to identify gamma-ray sources at other wavelengths; Cooperate with existing and planned monitoring surveys; Prepare for use of the many available astronomical catalogs.</td>
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</table>

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### Exploiting the Extreme Environments of Pulsars

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### Strategies for Identifying Individual Gamma-ray Sources

- Top Down Approach
  - Search LAT error boxes for X-ray or TeV counterparts with nonthermal, hard spectra, then use the softer error boxes to the corresponding optical and radio sources.
  - Suzaku and Swift (shown here) are X-ray resources that offer good possibilities.
- Search for Correlated Variability
  - Correlated variability between gamma-rays and radio/optical/soft X-rays will provide one of the most distinctive signatures for source identification. Pan-STARRS (shown in the photo) is one optical facility, well-matched to be added to the LAT for correlated studies. Radio monitoring of blazars (e.g. VLA/40m, ATCA) can also help cement counterpart identifications.

### Pulsar Timing and Searches

- Most pulsar timing information comes from radio observations.
- The RXTE timing capability is a principal source of X-ray pulsar timing information that can be used by GLAST.
- After launch, unidentified LAT sources will provide targets for deep X-ray pulsar searches, possibly with Chandra or XMM.