GLAST Large Area Telescope High-Energy Multiwavelength Planning

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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 emphasize 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)**

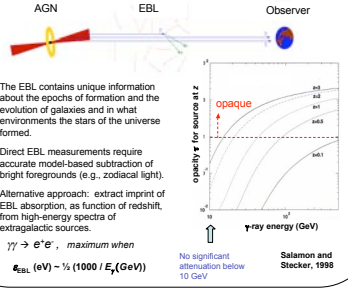
GLAST mission is designed to support rapid notification for follow-up

Planning Approach

The GLAST LAT Collaboration invites cooperative efforts from observers at all wavelengths to help optimize the science return from the mission. The GLAST LAT Multiwavelength 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.

Probing Extragalactic Background Light (EBL) with Blazars

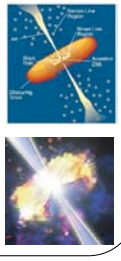


- The EBL contains unique information about the epochs of formation and the evolution of galaxies and in what environments the stars of the universe formed.
- Direct EBL measurements require accurate model-based subtraction of bright foregrounds (e.g., zodiacal light).
- Alternative approach: extract imprint of EBL absorption, as function of redshift, from high-energy spectra of extragalactic sources.

$\gamma\gamma \rightarrow e^+e^-$, *maximum when*

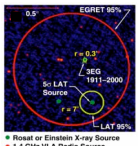
ε_{EBL} (eV) ~ ½ (1000 / E_γ(GeV))

Deciphering the Workings of Relativistic Jets



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

Identifying New Source Classes

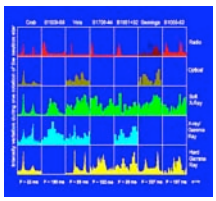


Comparison of EGRET and LAT error boxes.

- Over half the sources in the third EGRET catalog remain unidentified, largely because the error boxes were too large for identifying a unique counterpart in deep searches.
- **Potential new source classes include starburst galaxies, radio galaxies, clusters of galaxies, pulsar wind nebulae, and microquasars** (please see poster 18.56).
- The major increase in sensitivity and better angular resolution of GLAST LAT (especially at higher energies) will produce much smaller 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, absolute timing data for many pulsars. Another is measuring the pulsar properties at other wavelengths.
- Although most timing information comes from the radio band, some X-ray pulsars provide timing data as well as light curves and energy spectra to compare with the gamma-ray data.



Multiwavelength light curves of gamma-ray pulsars (Thompson, 2004). Their diversity shows the need for a larger sample with better detail, including phase-resolved spectra at all wavelengths.

Please also see poster 18.02

SUMMARY OF SOME MULTIWAVELENGTH NEEDS AND PLANNING

Science Objective	GLAST Provides	Multiwavelength Requirements	Multiwavelength Planning Activities
Differential measurement (vs Z) of extragalactic background light to Z ~5.5	Measurement of blazar spectra in band where cutoffs are expected from $\gamma + \gamma_{ebl} \rightarrow e^+ + e^-$	Broadband contemporaneous/ simultaneous spectral measurements (radio, optical, X-ray, TeV) of blazar spectra.	Participate with and encourage programs to expand blazar catalogs and measure broadband spectra.
Resolve origin of particle acceleration and emission mechanisms in systems with relativistic jets, supermassive black holes.	All-sky monitoring coverage of blazar flares and Gamma Ray Bursts (GRB)	Broadband contemporaneous/ simultaneous spectral measurements (radio, optical, X-ray, TeV) of GRB	Cooperate with and expand existing multiwavelength blazar and GRB campaigns (e.g. WEBT, ENIGMA, GTN, Swift) to have the broadest possible coverage during the mission
Search out and understand new classes of gamma-ray sources	Large number of source detections; Relatively uniform sky coverage; Good positions, energy spectra, time histories	Counterpart searches at all other wavelengths, plus particle detections; Population studies; Correlated variability; Multi-Messenger modeling; Contemporary, complete astronomical catalogs	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
Understand particle acceleration and emission mechanisms in extreme environments of rotating neutron stars	Spectra and light curves resulting from primary interactions of the most energetic particles	Contemporaneous radio and X-ray pulsar timing observations	Select pulsar candidates for radio timing; work with radio astronomers to monitor timing of selected pulsars; plan proposals for X-ray pulsar observations

Larger Sample of Well-Measured Blazar Spectra

- **A significant sample of blazar broadband 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.**

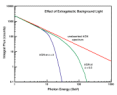
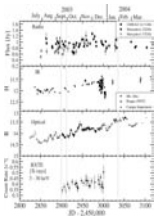


Image: H.E.S.S. Collaboration

Please see poster 18.09 for additional information about GLAST and TeV observations. See abstract 7.29 for an example of optical/radio catalog expansion.

Coordinated Multiwavelength Campaigns



- Left: Multiwavelength campaign on blazar 3C66A conducted by the Whole Earth Blazar Telescope (WEBT), Böttcher et al. 2005.
- **The GLAST LAT team will be an active participant in such campaigns. Because LAT will serve as an all-sky monitor, it will be an important trigger for coordinated efforts.**

The Global Telescope Network (http://gtn.sonoma.edu/public) is another example of an existing program for blazar monitoring and gamma ray burst follow-up.

Strategies for Identifying Individual Gamma-ray Sources – two possibilities

▶"Top Down" Approach

Search LAT error boxes for X-ray or TeV counterparts with nonthermal, hard spectra, then use the smaller error boxes to find corresponding optical and radio sources. **Suzaku and Swift (shown here) are X-ray resources that offer good possibilities.** Please see poster 18.62 for additional details

Image: JAXA/NASA

▶Search for Correlated Variability

Correlated variability between gamma-rays and radio/IR/optical/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 the LAT for correlated studies.** Radio monitoring of blazars (e.g. OVRO-40m, ATA) can also help cement counterpart identifications.

Image: /NASA

Image: K. Wood

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.**

RXTE Image: NASA

Image: CSIRO

SUMMARY

The GLAST Large Area Telescope science 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/ssc/proposals/ and Poster 18.06