GLAST Large Area Telescope Multiwavelength Opportunities

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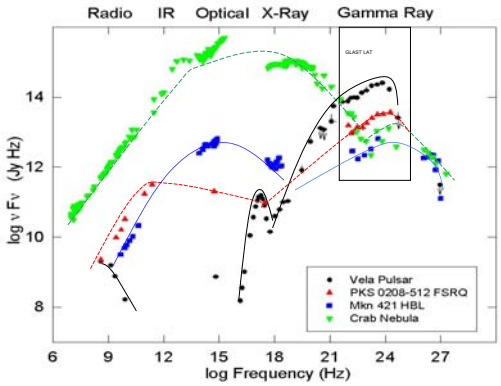
on behalf of the GLAST LAT Multiwavelength Coordination Group

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.



Gamma-ray sources are nonthermal, multiwavelength objects. Spectral Energy Distributions for some known gamma-ray sources are illustrated here.

Some General Invitations from the LAT Team

Learn about the LAT capabilities http://www-glast.slac.stanford.edu/software/IS/glast_lat_performance.htm

Propose for the GLAST Guest Investigator Program http://glast.gsfc.nasa.gov/ssc/proposals/

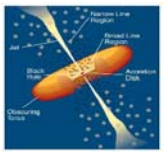
Sign up for the Gamma-Ray multiwavelength Information mailing list - e-mail to Dave Thompson (djt@egret.gsfc.nasa.gov).

ACTIVE GALACTIC NUCLEI

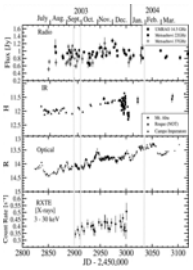
Particularly blazars, but also radio galaxies, starburst galaxies and luminous IR galaxies

Scientific Goals:

Decipher 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. Right: Multiwavelength campaign on blazar 3C66A conducted by the Whole Earth Blazar Telescope (WEBT), Böttcher et al. 2005.
- 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.

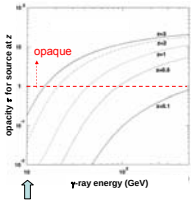


Probe Extragalactic Background Light (EBL) with Blazars

- 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.

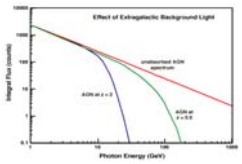
$\gamma\gamma \rightarrow e^+e^-$, *maximum when*

ε_{EBL} (eV) ~ ½ (1000 / E_γ(GeV))



No significant attenuation below 10 GeV

Salamon and Stecker, 1998



The opacity due to absorption on the EBL (left) produces steepening in AGN spectra (right).

Multiwavelength Opportunities

Before Launch:

Expand the list of known blazars by redshift, polarization, and variability measurements on candidate objects at other wavelengths. Example: Sowards-Emmerd et al. The LAT is likely to detect more blazars than are currently cataloged.

Join the Global Telescope Network (**http://gtn.sonoma.edu/public**) or WEBT in preparation for MW campaigns.

During Year One (when most LAT data will not be public)

LAT will announce strong flares of sources. Join multiwavelength campaigns on these sources. Use these announcements as Target of Opportunity triggers for other telescopes. Correlative observations make cooperative efforts attractive for all of us. A LAT contact will be identified for each flare announced.

Preliminary LAT results, including a list of sources, will be released during the first year. Use these results to propose for Guest Investigator data and support during later years. If relevant data already exist, contact the LAT team for possible joint publication.

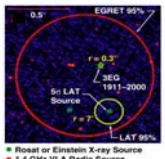
During Later Years

Join planned MW campaigns on specific sources.

Join TOO campaigns for flaring sources.

Analyze archival data or cooperate with LAT team members on joint publications.

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**
- 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.

Strategies for Identifying Individual Gamma-ray Sources – three 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.**

Image: JAXA/NASA

Image: /NASA

►"Bottom Up" Approach

Search LAT error boxes for radio counterparts with flat spectra, then follow up with redshift and polarization measurements in the optical to identify potential blazars. The VLA (shown here) VIPS program is one program studying candidate blazars at present.

Image: NRAO

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: K. Wood

Multiwavelength Opportunities

First Year: A preliminary list of LAT source detections will be released mid-year. Propose for observations that would aid identification. Cooperate with the LAT team to construct Spectral Energy Distributions and source models.

Later Years: Use the LAT catalogs as a guide to MW observations that can first identify then analyze new source classes.

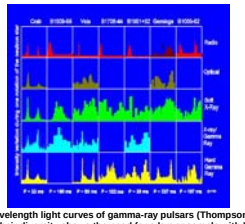
Pulsars and other Galactic Sources

Rotation-powered pulsars and microquasars are known gamma-ray sources with periodic emission

Scientific Goals:

Explore the Extreme Environments of Pulsars and other compact objects.

- ► 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.
- ► Microquasars are binary sources with jets. The relationship of emission at various wavelengths is a powerful tool for determining the energy-release processes.



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.

Pulsar Timing

- ► 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.**

RXTE Image: NASA

Image: CSIRO

Multiwavelength Opportunities

During the First Year: combine your timing information on pulsars or phase-resolved spectra of microquasars with the LAT team gamma-ray analysis.

Later Years: Use the LAT catalogs as a guide to MW observations that can first identify and then analyze new pulsars and microquasars.