Multiwavelength Opportunities and Challenges in the Era of Public *Fermi* Data

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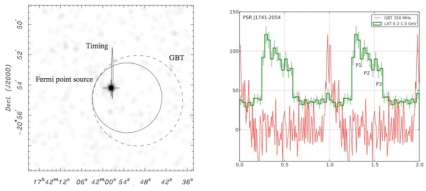
Summary: Multiwavelength studies maximize the scientific return from gamma-ray observations. This poster offers some practical suggestions about making use of *Fermi* LAT data for multiwavelength research.

Abstract

The gamma-ray survey of the sky by the *Fermi Gamma-ray Space Telescope* offers both opportunities and challenges for multiwavelength and multi-messenger studies. Gamma-ray bursts, pulsars, binary sources, flaring Active Galactic Nuclei, and Galactic transient sources are all phenomena that can best be studied with a wide variety of instruments simultaneously or contemporaneously. Identification of newly-discovered gamma-ray sources is largely a multiwavelength effort. From the gamma-ray side, a principal challenge is the latency from the time of an astrophysical event to the recognition of this event in the data. Obtaining quick and complete multiwavelength coverage of gamma-ray sources can be difficult both in terms of logistics and in terms of generating scientific interest. The *Fermi* LAT team continues to welcome cooperative efforts aimed at maximizing the scientific return from the mission through multiwavelength studies.

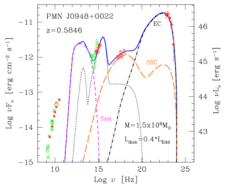
Opportunities

During its first year, the *Fermi* Large Area Telescope has excelled in producing scientific results using multiwavelength approaches. Some examples:



PSR J1741-2054 - radio pulsar found from gamma-ray timing (Camilo et al 2009)

***Fermi* LAT point source -> LAT timing discovered gamma-ray pulsations -> Swift X-ray source gave better position -> Radio telescopes found the radio pulsar**



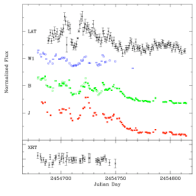
PMN J0948+0022 - A new source type

A Spectral Energy Distribution using simultaneous data provides evidence that this narrow-line Seyfert 1 is similar to the gamma-ray blazars.

Work led by Luigi Foschini

Correlated Variability of 3C454.3 as a Tool for Understanding Jet Physics

Bonning et al. (2009) used the public LAT light curve to compare with simultaneous multiwavelength observations.



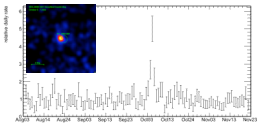
Enabling Technologies

Three developments in recent years have made such multiwavelength efforts feasible:

1. **Communication - The ubiquity of network connectivity has allowed rapid exchange of data and ideas.**
2. **Facilities - Much of the electromagnetic spectrum (and several multi-messenger fields) is now covered by ground-based and space-based observatories.**
3. **Consolidated Information Centers - Resources like ADS, NED, Simbad, ASDC, HEASARC, and others facilitate rapid discoveries of existing coverage of sources.**

Challenges

Challenge #1 - Time-Criticality of Response



3EG J0903-3531

Although gamma-ray bursts can be detected by *Fermi* LAT on-board software, ground processing is required for less intense time-variable sources. Known and newly-discovered sources can flare on time scales of days. See the talk by Elizabeth Hays for some examples.

Determining that something "interesting" has happened can take time. Approximately half a day is required for collection, transmission, processing and automated analysis of the LAT data. Only after this time can multiwavelength coverage be investigated.

What is the LAT team doing to meet this challenge?

The LAT Flare Advocates (see poster by Ciprini and Gasparrini) review data daily and put out ATels for "breaking news." The LAT team has sent out more than 40 ATels.

This group also generates the *Fermi* Blog,with weekly updates about the high-energy gamma-ray sky: http://fermisky.blogspot.com/

Public light curves for bright sources are generated automatically. 41 sources are now being tracked, and new ones are being added regularly. That work will continue. See http://fermi.gsfc.nasa.gov/ssc/data/access/lat/msl_lc/

All these exercises are advertisements of multiwavelength opportunities for the community.

Challenge #2 - Finding Enough Multiwavelength Coverage

The LAT is an all-sky monitor. Most forms of MW coverage require narrow-field instruments, limiting the number of sources that can be studied. Two approaches are being used by MW observers:

Monitoring Program Examples:

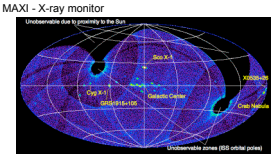
Radio AGN studies

(see http://pulsar.sternwarte.uni-erlangen.de/radiogamma/)

Optical/IR programs

All-sky Detector Examples:

MAXI - X-ray monitor



Long-wavelength: Planck and Herschel are now in orbit, and WISE is at Vandenburg for a December launch

Challenge #3 - Deciding When to Work with the LAT Team

Some important caveats (see http://fermi.gsfc.nasa.gov/ssc/data/analysis/LAT_caveats.html for more details):

- **The diffuse Galactic emission is bright and highly structured. The diffuse model supplied by the LAT team has recently been updated and is likely to continue to evolve. Separating weaker sources from the diffuse Galactic emission is non-trivial.**
- **The LAT Instrument Response Functions (IRFs) have significant uncertainties at energies near 100 MeV and a non-negligible charged particle background at energies above 10 GeV. Improvements in the IRFs are expected but are not imminent.**

Some Suggestions:

- **If you are searching for a source that is not in the LAT catalog, then it is probably weak enough that a simple analysis will not be adequate.**
- **If you need a detailed energy spectrum or are looking for particular spectral features, especially at very low or very high energies, the LAT team has experience with non-standard analysis.**
- **If you are trying to analyze the Galactic Center region, you are strongly advised not to go it alone!**
- **If you are interested in the most complete multiwavelength coverage, consider contacting the LAT team. We have many cooperating groups across the spectrum who may be interested in working with you (even if you don't include the LAT team).**

The *Fermi* Large Area Telescope team welcomes cooperative multiwavelength efforts of all kinds.