Outline

• Introduction - the Fermi Gamma-ray Space Telescope
• Characteristics that provide versatility
  • Instruments
  • Operations
• Time Domain Gamma-ray Astronomy
The Fermi Gamma-ray Space Telescope
Prior to Fairing Installation
The Observatory

**Spacecraft Partner:** General Dynamics

**Large Area Telescope (LAT)**
- 20 MeV - >300 GeV

**Gamma-ray Burst Monitor (GBM)**
- NaI and BGO Detectors
  - 8 keV - 40 MeV

**KEY FEATURES**
- **Huge field of view**
  - LAT: 2.4 sr; 20% of the sky at any instant;
  - GBM: whole unocculted sky at any time.
- **Broad energy range.**
  - Total of >7 energy decades!
- **Every photon can be time-tagged.**
  - 1 microsecond accuracy
Survey Mode - Default

- Rock north for one orbit and south for the next.
- Keep LAT Field of View away from the bright Earth limb.
- Covers the full sky every 3 hours.
GRB090902B - Autonomous repoint

- LAT pointing in celestial coordinates from -120 s to 2000 s
  - Red cross = GRB 090902B
  - Dark region = occulted by Earth; Yellow disk = Sun
  - Blue line = LAT FoV
  - White lines = 20° (Earth avoidance angle) / 50° above horizon
  - White points = LAT events
Other Fermi Pointing Modes

1. Target of Opportunity - On short notice, the observatory can be pointed at any direction in the sky. In this mode, many parts of the sky receive no coverage.

2. Planned Pointing - With advance planning, some survey mode observations can be done during times when the target is occulted.
Time Domain Gamma-ray Astronomy
with Fermi

Because all the Fermi gamma-ray data are made public immediately, these sample results come from independent investigations, cooperative efforts, or the instrument teams.
Variability on Very Short Time Scales

FWHM of the sharp peak of this ms pulsar is $23 \pm 11$ microseconds. Guillemot et al. 2012

GBM measured both flux and spectral variation for this Gamma-Ray Burst on a time scale of 10 milliseconds. Guiriec et al. 2010
Variability on Short Time Scales

GRB 091024 showed emission extending for minutes. Gruber et al. 2011

When in an active gamma-ray state, the microquasar system Cygnus X-3 shows variability with a period of 4.8 hours. Abdo et al. 2009
Variability on Intermediate Time Scales

Soft Gamma Repeater J0501+4516 produced 29 bursts in an episode lasting 13 days. Lin et al. 2011

The symbiotic binary system V407 Cyg gamma-ray outburst extended for 2 weeks. Abdo et al. 2010
Variability on Longer Time Scales

The PSR B1259-63 binary system showed activity around the 2010 periastron lasting for months. Tam et al. 2011

AGN PKS 1424-418 had two bright flares in 2 1/2 years. Longo et al. 2011
Time scales beyond what Fermi can measure

For steady sources, longer exposures produce more detailed (and sometimes unexpected) results
In addition to nearly 500 sources at these energies (see poster 149.20), the sky shows large-scale features like the previously reported “Fermi bubbles” (Su, Slatyer, Finkbeiner, 2010).
What is Not Seen Can Also Be Important

Some clusters of galaxies were predicted to be gamma-ray sources. None are seen in the Second LAT Catalog, indicating that the predictions were too optimistic.

Dwarf spheroidal galaxies are thought to be largely composed of dark matter. If dark matter consists of some types of Weakly Interacting Massive Particles (WIMPs), such galaxies would be gamma-ray sources visible to Fermi LAT. Their absence puts constraints on dark matter models.
Fermi LAT Constraints on Dark Matter

Upper limits, $\bar{b}b$ channel

Ackermann et al. 2011

WIMP cross section [cm$^3$/s]

WIMP mass [GeV]

Thermal limit
Support for Multiwavelength Observations

The Fermi mission recognizes the importance of multiwavelength observations for Fermi science (see the statement of the Fermi Users’ Group). Fermi’s support of multiwavelength observations is coordinated through the Multiwavelength Observations webpage. Among other efforts, Fermi sponsors the Global Telescope Network, as well as many observational programs that provide multiwavelength observations to support Fermi science.

Please report multiwavelength observations that are relevant to Fermi on this webform. You may indicate that this information is proprietary. Non-proprietary information reported through this webform can be seen here. This information will help us plan the Fermi observing timeline.

In addition, when evaluating the impact of a TOO, we review the scheduled or ongoing multiwavelength observations that have been reported to the FSSC. If planned observations would be impacted, the project requires a higher level of urgency before implementing a TOO, but we can only conduct trade studies against known campaigns. Alternately, if a TOO is undertaken, we will inform observers who have reported their planned campaigns so that they can re-evaluate their plans.

Multiwavelength Support

The FSSC provides a number of services that support multiwavelength observations:

- Timelines — Fermi's planned observations are posted. These timelines and the associated tools are available to assist observers in determining when a source will be observed.
- Source Detectability Tools — The proposal preparation tools can also be used to estimate the detectability by Fermi of candidates for multiwavelength campaigns.
- Multimission Analysis — The Fermi Science Tools are an extension of the HEADAS analysis system and use FITS files, facilitating joint analysis of Fermi data with that of other missions or telescopes.
The Fermi Cycle-5 amendment to the 2011 ROSES NRA was released on October 31, 2011. Proposals to participate in the Cycle-5 program are due on January 20, 2012.

Fermi PIs can propose to:

- Analyze GBM or LAT event data from the beginning of science operations.
- Analyze higher level data released by the LAT: lightcurves of bright or transient sources; and a point source catalog.
- Carry out pointed LAT observations. However, proposers should be aware that very strong science justifications will be required in view of the probable low additional scientific benefit of such observations see the Fermi Users' Group (FUG) analysis at http://fermi.gsfc.nasa.gov/ssc/proposals/pointing_analysis/. Pointed observations will follow the same open data policy as sky survey data, i.e., they will become public immediately.
- Support correlated observations of gamma-ray sources at other wavelengths that are directly relevant to Fermi.
- Perform theoretical studies of gamma-ray sources.
- Obtain observing time on the NRAO and NOAO facilities or on the Suzaku satellite in support of Fermi-related science.

http://fermi.gsfc.nasa.gov/ssc/proposals/
The flexibility and versatility of the Fermi instruments and operations have produced a wide range of results, including time domain studies on many time scales and continual improvements in both exposure depth and energy range for steady sources.

Multiwavelength and theoretical studies are essential to make the best scientific use of the Fermi observations. The Guest Investigator program supports such work.

The Fermi Web site is http://www.nasa.gov/fermi

All the Fermi gamma-ray data are public immediately. Join the fun!