The Fermi Observatory

Large Area Telescope (LAT)

- Large field of view (>2.4 sr)
- Entire sky every 3 hrs (every 2 orbits)
- Broad energy range (20 MeV - >300 GeV)

Gamma-ray Burst Monitor (GBM)

- Views entire unocculted sky
- NaI: 8 keV - 1 MeV
- BGO: 150 keV - 40 MeV
Fermi discoveries cover a broad range of astrophysics

- Gamma Ray Bursts
- Blazars
- Radio Galaxies
- Starburst Galaxies
- Globular Clusters
- LMC & SMC
- Fermi Bubbles
- Novae
- Supernova Remnants & Pulsar Wind Nebulae
- Pulsars: isolated, binaries, & MSPs
- Sun: flares & Cosmic Ray interactions
- Terrestrial γ-ray Flashes
- Unidentified Sources

Neutrino Counterpart searches

Gravitational Wave Counterparts

Cosmic Rays

- e^+ e^- spectrum

3FHL
3FGL
Fermi users make Fermi Science great

- The GI program is the heart of Fermi science
  - Funds all aspects of science investigation: analysis, correlated studies, theory, and multiwavelength data collection
  - Fermi is the only mission program dedicated to high-energy gamma-ray data analysis
- Fermi science is increasing with time
  - New topics and questions, new discoveries, new multiwavelength and multimessenger facilities and capabilities
- Fermi support grows with the users
  - New data products
  - New analysis tools
  - New catalogs
  - New partners
Fermi Transient Searches

LAT Transient Factor (LTF)
Likelihood Around GBM/BAT triggers
seconds to orbits
LAT Team - Results in GCNs
Triggered + Blind Search

LAT Burst Advocate Tool
Likelihood Around GBM/BAT triggers
100 s, 1000 s
LAT Team - Results in GCNs

LAT Automated Science Processing (ASP) + Flare Advocates
Likelihood
6 & 24 hour ATels, FAV catalogs
http://fermi.gsfc.nasa.gov/ssc/data/access/lat/FAVA/

Fermi All-sky Variability Analysis (FAVA)
Counts Map Aperture Photometry
3 day (coming soon), 1 week
ATels, FAV catalogs
http://fermi.gsfc.nasa.gov/ssc/data/access/lat/FAVA/

LAT Catalogs
Likelihood, associations
FGL, FHL, LAC, FLE, PSR
http://fermi.gsfc.nasa.gov/ssc/data/access/

GBM Targeted Search
ground search
ms - s
Temporal/Spatial Input

GBM Untargeted Search
ground search
ms - s
GCN Notices

GBM Onboard Triggers
rate triggers
16 ms - minutes
GCN Notices

Pulsars
Solar Flares
All Sky Cadence
Terrestrial γ-ray Flashes
GRBs
Magnetar Flares

Novae
Blazar Flares
Crab Flares

γ-ray Binaries

Not to scale
Recent Data and Catalog Releases

- **Large Area Telescope**
  - *8-year LAT catalog (4FGL)* – February 2019
  - Interstellar emission model update – March 2019
  - *2nd LAT GRB Catalog* – July 2019
  - *10-year LAT catalog (4FGL-DR2)* update to 4FGL – May 2020
  - Coming soon! 10-year AGN catalog and Solar Flare catalog

- **Gamma-ray Burst Monitor**
  - *4th GBM GRB Catalog* – April 2020
  - [Custom pulsation search](#) – March 2020
  - [GBM Data Tools](#) release – March 2020
Observatory Status: Excellent

• Operations continue to be extremely stable and reliable.
  • Both instruments exceed performance at time of launch.
• No consumables; no expected instrument limitations
  • The orbit can be maintained until the 2030s.
• Observations conducted in traditional all-sky survey and modified sky survey since 2019 to accommodate one solar array panel that no longer rotates.

Traditional survey = all-sky every 3 hours
Sine-modified survey = 85% sky every 1.5 hours,
  all-sky within a week

Exposure more limited toward Sun, but available at off-axis angles.
The Future of Fermi Science

• The future of Fermi is bright!
• Users can build on the strong foundation of data, catalogs, and analysis tools and techniques to dig deeper into the high-energy Universe and to catch new events as they happen.
• We welcome your ideas for programs aiming to make new discoveries and meet new needs for time domain and multi-messenger science
• Got a question? We’re here to help!

Liz Hays, Fermi Project Scientist
Judy Racusin, Fermi Deputy Project Scientist
Chris Shrader, Fermi Science Support Center Lead
Fermi Help Desk
Extras
Fermi Mission Elements

Fermi Spacecraft

Large Area Telescope & GBM

Mission Operations Center (MOC)

GLAST Science Support Center

LAT Instrument Science Operations Center

GBM Instrument Operations Center

HEASARC GSFC

GRB Coordinates Network

GPS

DELTA 7920H

TDRSS SN S & Ku

White Sands
Fermi Mission Organization

Fermi Project
PS: Liz Hays
Deputy PS: Judy Racusin
MW Coordinator: Dave Thompson

Mission Operations Center
Mission Manager: Beth Pumphrey

Science Support Center
Lead: Chris Shrader

GBM Instrument Team
PI: Colleen Wilson-Hodge
    (MSFC)

LAT Instrument Team
PI: Peter Michelson
    (Stanford)
Currently Available Data Products

The Fermi data released to the scientific community is governed by the data policy. The released instrument data for the GBM, along with LAT source lists, can be accessed through the Browse interface specific to Fermi. LAT photon data can be accessed through the LAT data server.

The FITS files can also be downloaded from the Fermi FTP site. The file version number is the 'xx' in the characters before the extension in each filename; you should keep track of the version numbers of files you analyze since the instrument teams may update them.

Note that the LAT and GBM data are accompanied by caveats about their use.

- LAT Photon and Extended Data
  - LAT Data Server (updated with P8R3 data 26-Nov-2018)
  - LAT Low-Energy (LLE) Data (Browse table)
  - Products available on the FTP Site (current processing version of the data):
    - Weekly Photon Files
    - Weekly Spacecraft Files
    - Mission Long Spacecraft File
    - Weekly 1-second Spacecraft Files
    - Filtered Weekly Photon Files with Diffuse Response Columns
  - Previous processing versions available on the FTP site
    - Pass 8 (P8R2) Weekly Files
    - Pass 7 (V6d) Weekly Files
    - Pass 6 (V11) Weekly Files
    - Pass 6 (V3) Weekly Files
  - ASCC data server (external)

- LAT catalogs and associated products (high-level products only)
  - LAT Source Catalog
    - LAT 8-year Source Catalog (4FGL)
    - Preliminary LAT 8-year Source List (FL8Y)
    - LAT 4-year Source Catalog (3FGL)
    - LAT 2-year Source Catalog (2FGL)
    - LAT 1-year Source Catalog (1FGL)
    - LAT 3-month Bright Source List (0FGL)
GBM Data Tools

Python interface to GBM analysis provides a leap for community GBM data analysis and supports multi-instrument analysis.

https://fermi.gsfc.nasa.gov/ssc/data/analysis/gbm/

Fermipy

• Python framework developed for the Fermitools
• Interfaces to plotting and diagnostic tools
• Pipeline-building tools
• Jupyter Notebook tutorials for baseline LAT data analysis procedures
• Publicly available on github
Fermi observational efficiency undiminished with one stationary solar array

New sine-modified profile used ~34% of the time in place of traditional sky survey.

- No impact to GBM
- No reduction in LAT instantaneous sky coverage
- LAT survey is less uniform on short time scales, but cadence for ~85% of the sky is 1.5 hrs instead of 3 hrs

All-sky coverage reached in ~1 week for sine-modified profile observations

Sun is not observable during sine-modified survey but is during two-sided rocking.
Post-solar array anomaly observing profiles

- Two-sided rocking, symmetric $+50/-50$ or asymmetric $\pm 50/\pm 60$, for $|\beta| < 24$
  - Two orbit period: south for one orbit and north for the next
  - $\pm 50$ ($\beta \leq 14$): 44.2% of the time
  - $\pm 50/\pm 60$ ($14 < \beta \leq 24$): 21.3% of the time
  - Shorter time to achieve full-sky coverage and allows solar observations

- Sine-modified profile with $50^\circ$ amplitude for $|\beta| > 24$
  - One orbit period, sine function with amplitude $50^\circ$, phased so that zero crossing is at orbit 6 am and 6 pm. Constant $50^\circ$ during orbit night.
  - In use 34.5% of the time
  - Takes up to a week to expose full sky during these intervals.

- Documented on the FSSC web site: https://fermi.gsfc.nasa.gov/ssc/observations/types/post_anomaly/
Modified Fermi Survey: Sky Coverage at 1 GeV

- Fraction of sky exposed more than 50% of mean
  - 50/50 rocking:
    - 1 orbit: 62.5%
    - 1 day: 100%
  - Sine-modified:
    - 1 orbit: 85.3%
    - 1 day: 87.6%

- Modified sine has “holes” in coverage toward the Sun and anti-Sun directions, but observes the other ~85% of the sky with a cadence of 90 mins (i.e., double that of normal sky survey).