

Fermi

Gamma-ray Space Telescope

# Fermi Proposer Workshop

## Mission Overview

Jan. 24, 2023

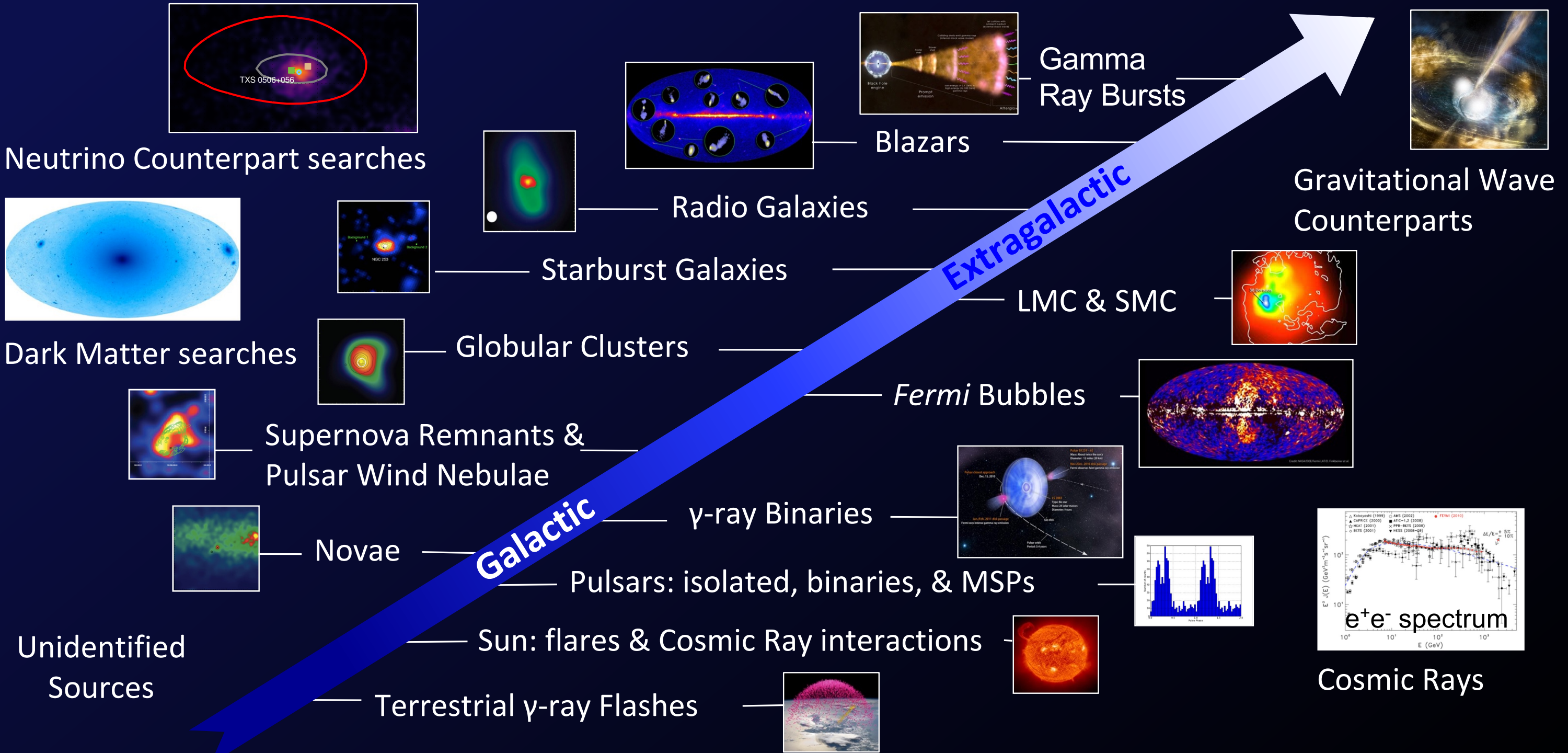
Liz Hays

Fermi Project Scientist

Judy Racusin

Fermi Deputy Project Scientist

# Fermi discoveries cover a broad range of astrophysics



# *Fermi* Users Make *Fermi* Science Excellent

- 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 increases with time
  - New topics and questions, new discoveries, new synergies with multiwavelength and multimessenger facilities and capabilities
- *Fermi* support grows with the users
  - Continued updates to data products, analysis tools, catalogs, and joint observation opportunities

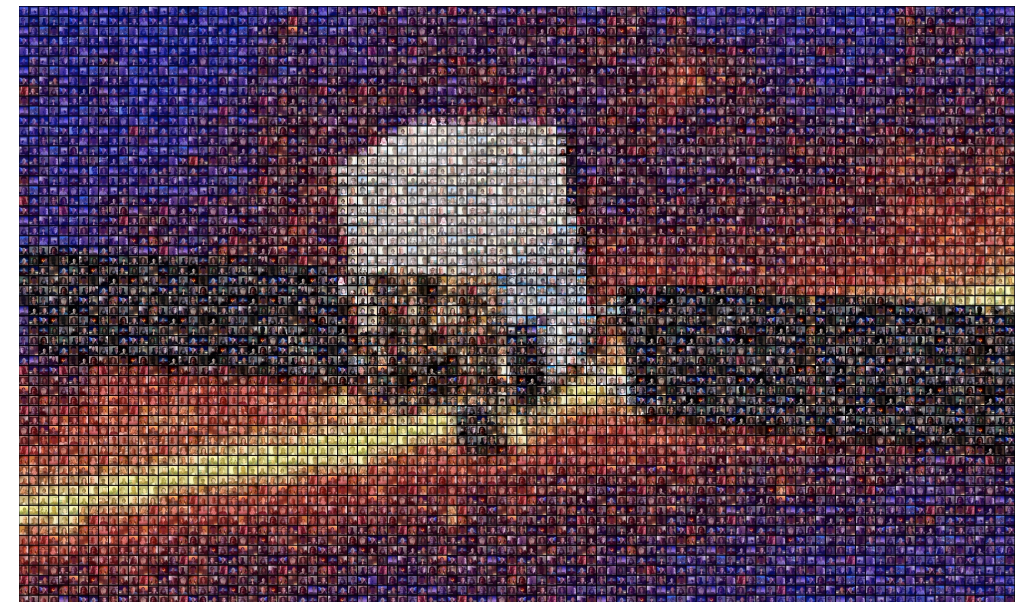
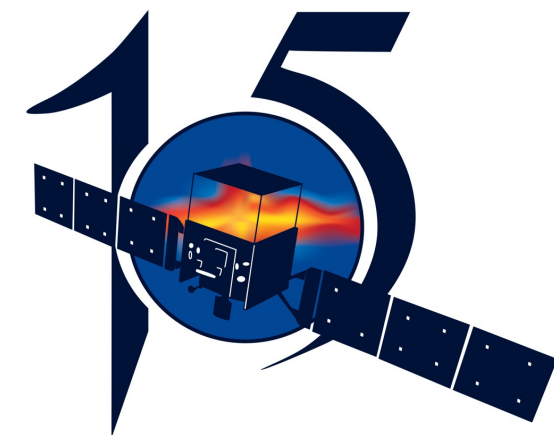


Photo mosaic of attendees of the 9<sup>th</sup> International Fermi Symposium



# 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)

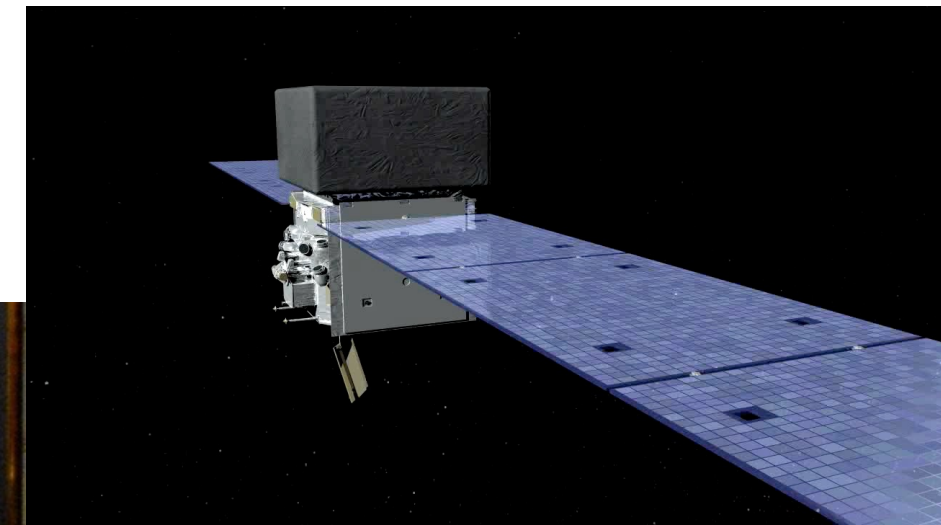


## Gamma-ray Burst Monitor (GBM)

Views entire  
unocculted sky

NaI: 8 keV - 1 MeV

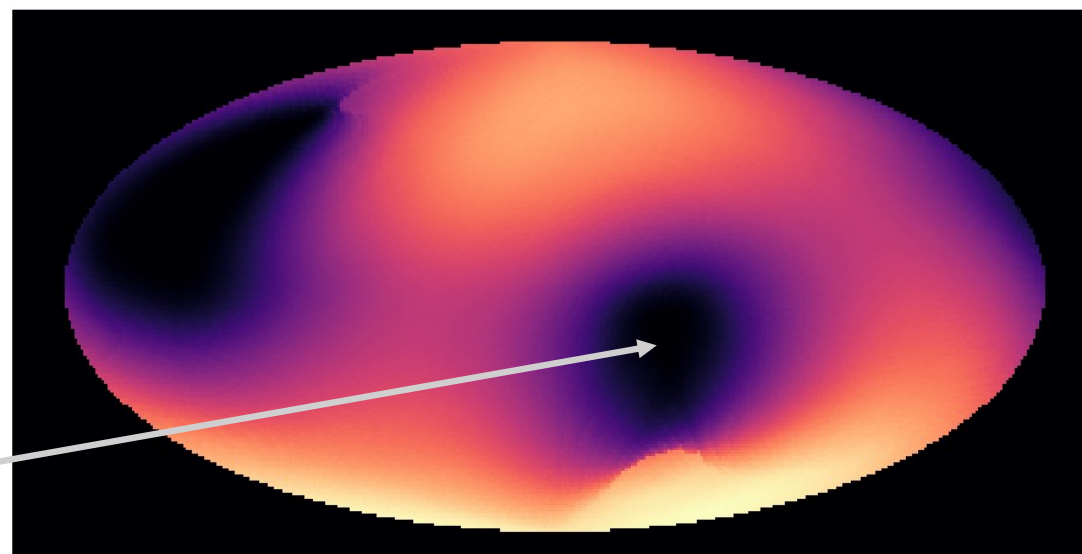
BGO: 150 keV - 40  
MeV



# Observatory Status: Excellent

- Operations stable and reliable.
  - Both instruments exceed original flight performance due to software and configuration improvements.
- No consumables; no expected instrument limitations
  - Orbit and current communications can be maintained into the 2030s.
- Survey modes provide LAT **all-sky coverage in 3 hours or 85% of the sky every 1.5 hours** reaching all-sky coverage in approximately 1 week during sine-modified survey intervals.

LAT exposure more limited toward Sun in sine-modified survey but is available at off-axis angles. A number of solar flares have been detected in the current solar cycle.

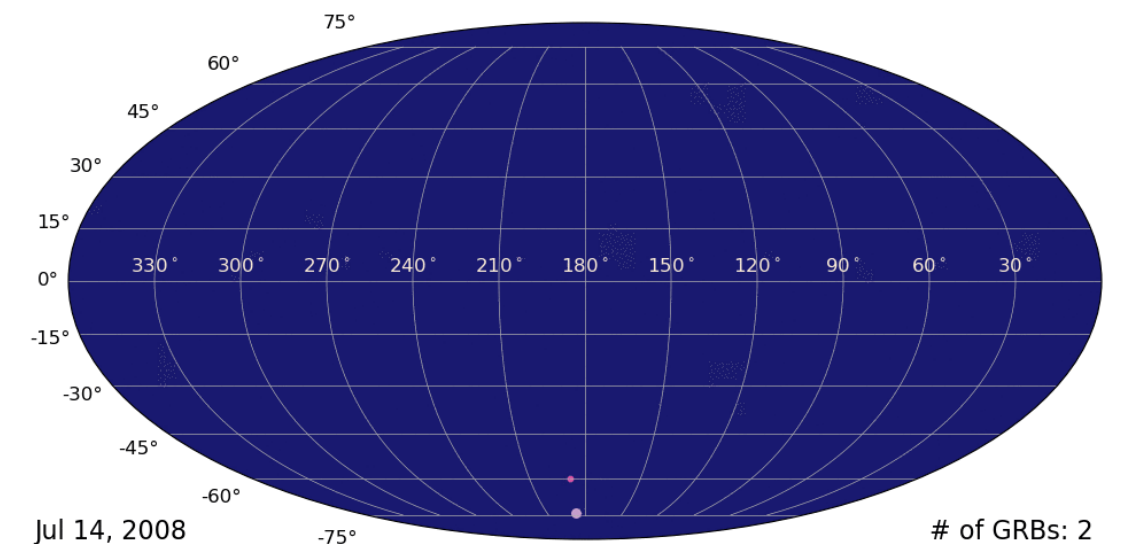
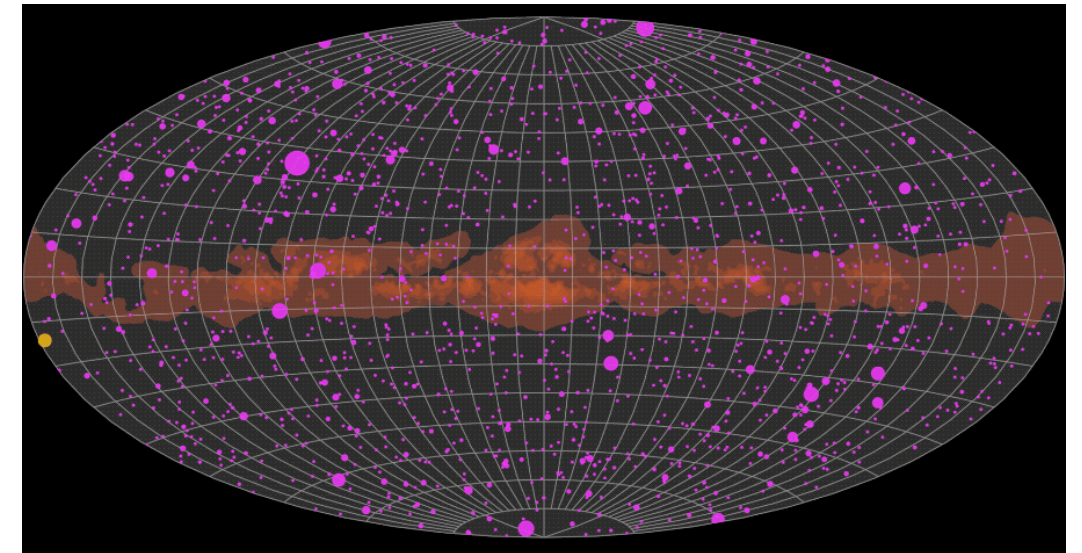
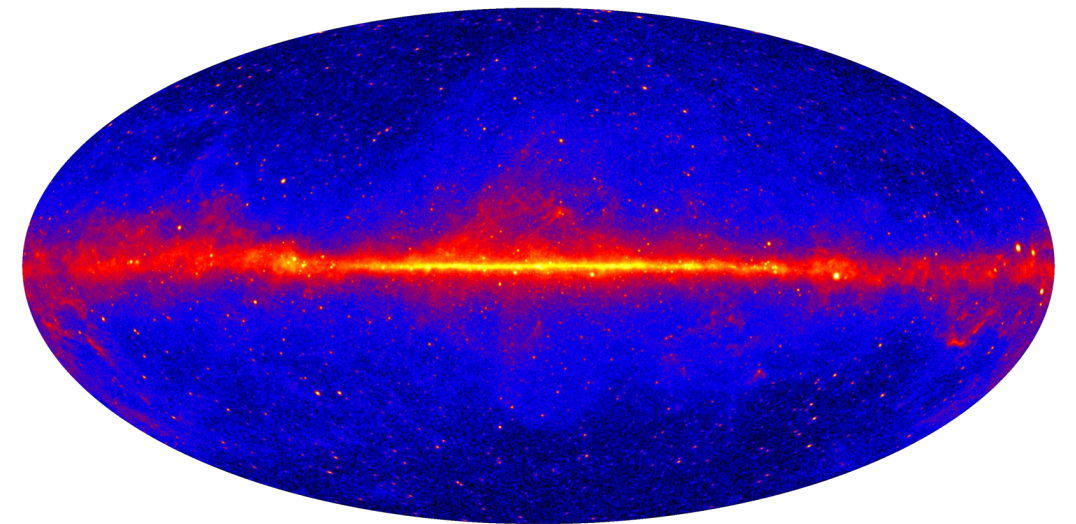


Sine-modified Survey Exposure Map (2 orbits)

# Data and Catalog Highlights

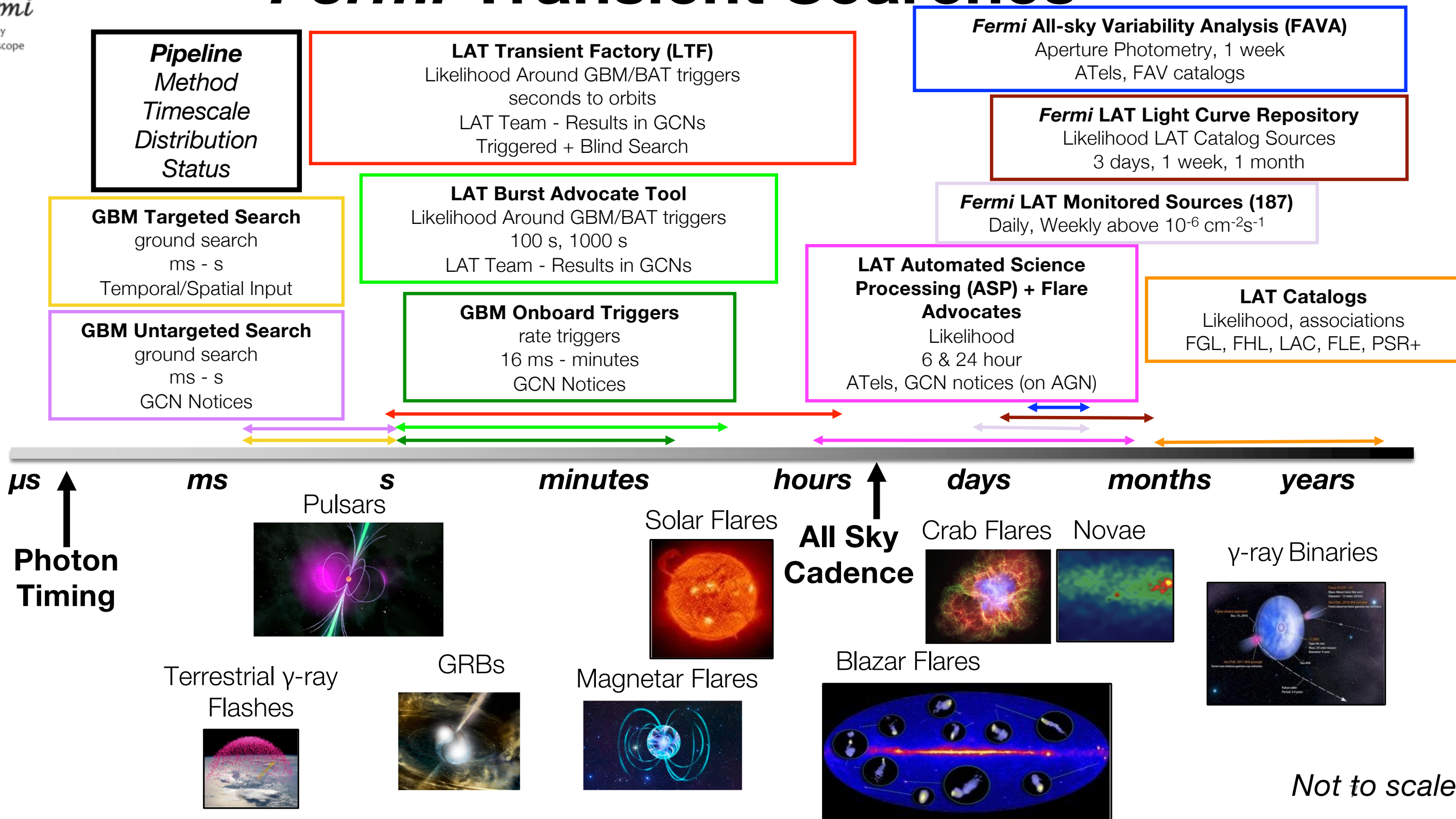
- Large Area Telescope
  - [14-year LAT catalog \(4FGL-DR4\)](#)
  - [12-year LAT AGN Catalog \(4LAC-DR3\)](#)
  - [10-year AGN Catalog \(4LAC-DR2\)](#)
  - [LAT Third Catalog of Gamma-ray Pulsars \(3PC\)](#)
    - [Individual timing models, pulse profiles and SED available for many pulsars](#)
  - [Solar Flare catalog \(FLSF\)](#)
  - [LAT Light Curve Repository](#)
- Gamma-ray Burst Monitor
  - GBM [Trigger Catalog](#), [Burst Catalog](#), and [Daily Data](#)
  - [GBM Data Tools](#)
  - [4<sup>th</sup> GBM GRB Catalog](#)
  - [Accreting Pulsars and Custom Pulsation Search](#)
  - [Earth Occultation Light Curves](#)

More at the [FSSC Data Products](#) page



# Fermi Transient Searches

Transients Timescale Pipelines



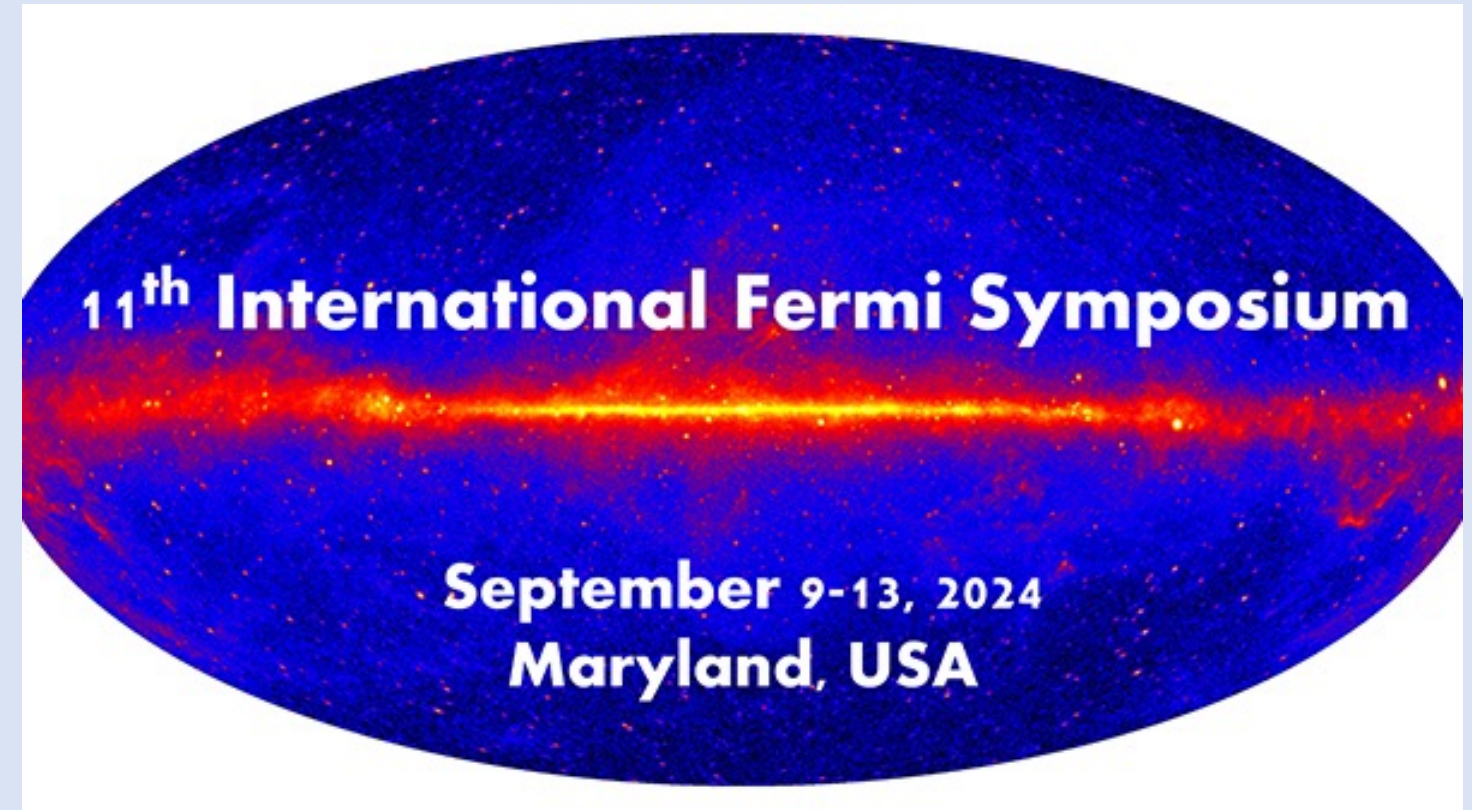
# Upcoming Events

Now accepting applications for the Fermi Summer School  
May 28 – June 7, 2024



<https://fermi.gsfc.nasa.gov/science/mtgs/summerschool/2024/>

Next Symposium scheduled for Fall 2024 in DC Area



<https://fermi.gsfc.nasa.gov/science/mtgs/symposia/eleventh/>





# The future is bright – we hope you will add to it!

- Opportunities with Fermi continue to grow
  - Observatory and instruments in excellent health
  - Opportunities for new discoveries across wide range of Fermi science
  - Data, catalogs, and analysis tools and techniques available to dig deeper into the high-energy Universe and discover new events when they happen.
- Got a question? We're here to help!

[Liz Hays](#), Fermi Project Scientist

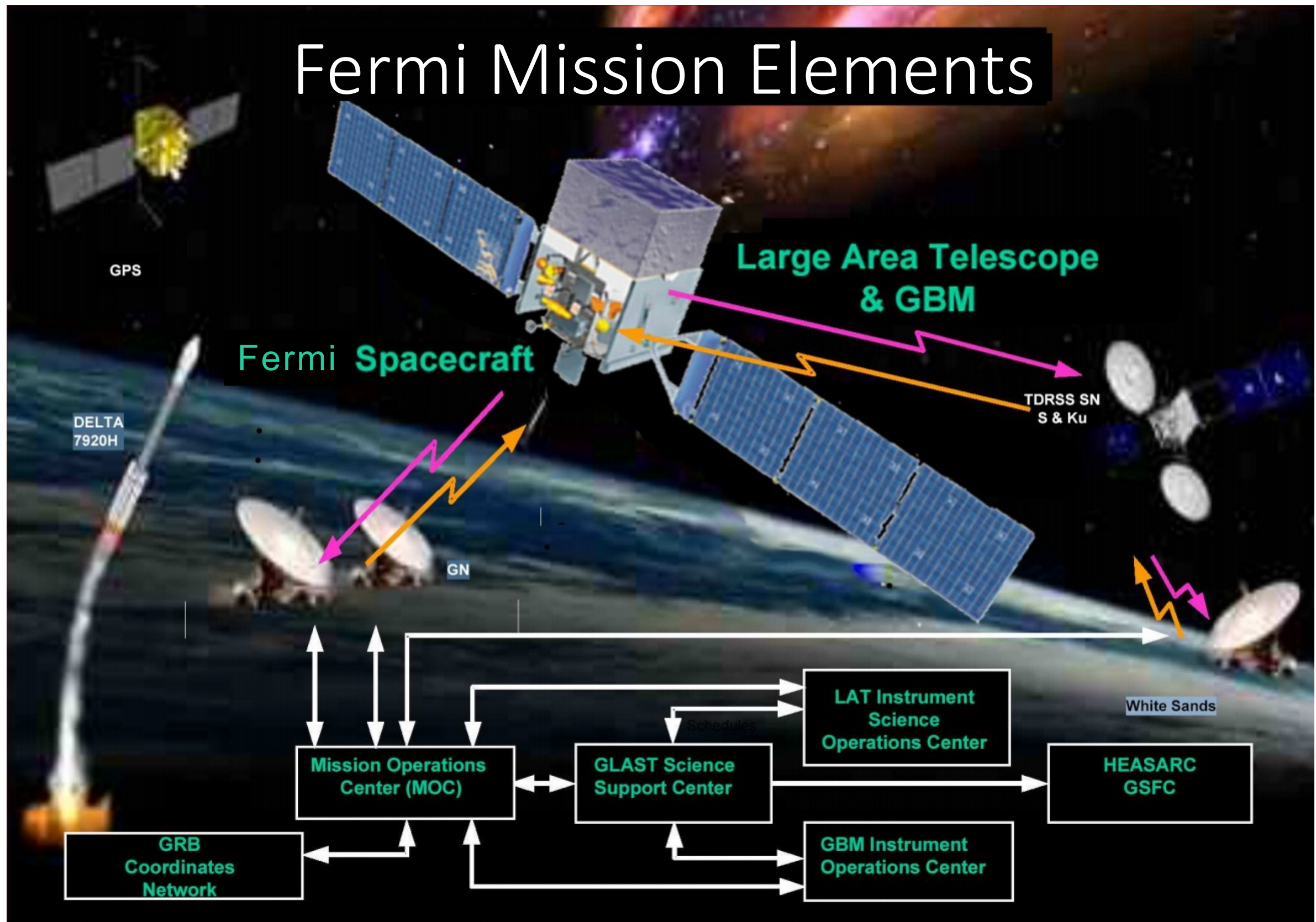
[Judy Racusin](#), Fermi Deputy Project Scientist

[Chris Shrader](#), Fermi Science Support Center Lead

[Fermi Help Desk](#) [fermihelp@milkyway.gsfc.nasa.gov](mailto:fermihelp@milkyway.gsfc.nasa.gov)

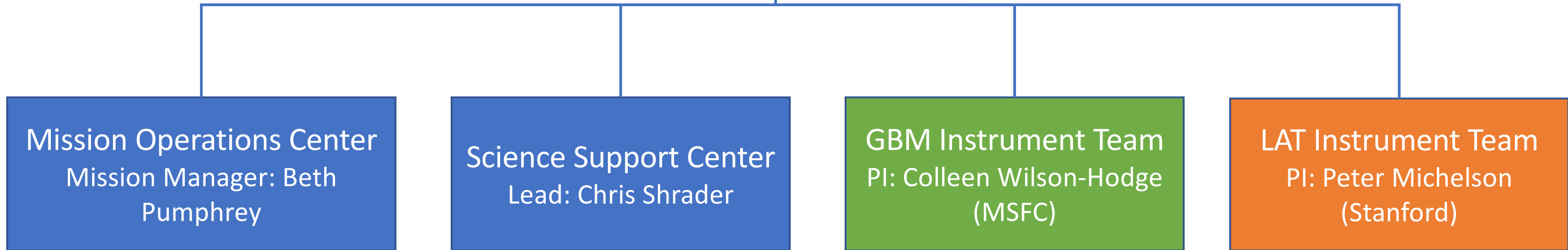


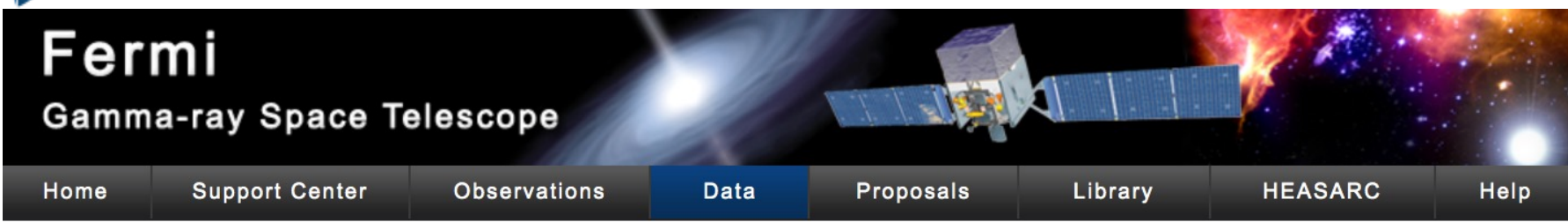
# Fermi Mission Elements





# Fermi Mission Organization





- Data**
- ▶ [Data Policy](#)
  - ▶ [Data Access](#)
    - + [LAT Data](#)
    - + [LAT Catalog](#)
    - + [LAT Data Queries](#)
    - + [LAT Query Results](#)
    - + [LAT Weekly Files](#)
    - + [GBM Data](#)
  - ▶ [Data Analysis](#)
  - ▶ [Caveats](#)
  - ▶ [Newsletters](#)
  - ▶ [FAQ](#)

## 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.

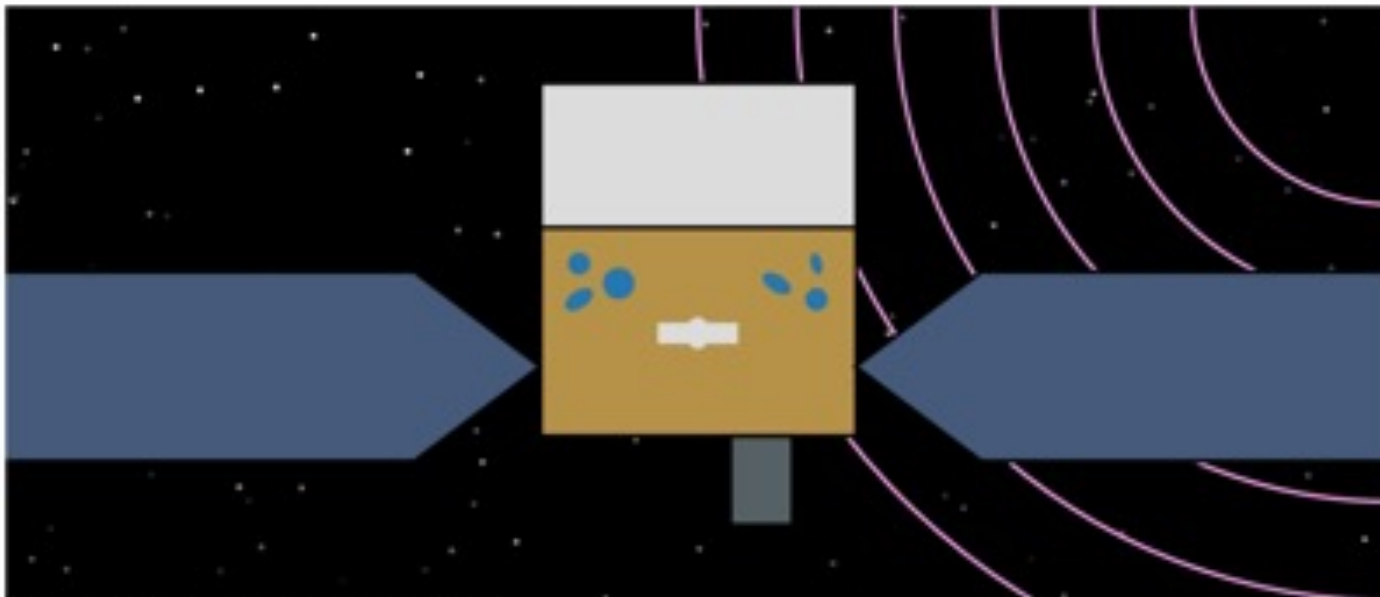
Note that the LAT and GBM data are accompanied by [caveats](#) about their use.

- 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 7 \(V6\) Weekly Files](#)
    - [Pass 6 \(V11\) Weekly Files](#)
    - [Pass 6 \(V3\) Weekly Files](#)
  - [ASDC 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 \(0FGL\)](#)

- Aperture Photometry Light Curves
  - [Aperture Photometry Light Curves for LAT 4-year Catalog Sources](#) (Updated Weekly)
  - [Flaring Sources in the LAT 4-year Aperture Photometry Light Curves](#) (Updated Weekly)
  - [Aperture Photometry Light Curves for the LAT 2-year Source Catalog](#)
  - [Flaring Sources in the LAT 2-year Aperture Photometry Lightcurves](#)
- LAT High Energy Source Catalog
  - [LAT Third High Energy Source Catalog \(3FHL\)](#)
  - [LAT Second High-Energy Source Catalog \(2FHL\)](#)
  - [LAT First High-Energy Source Catalog \(1FHL\)](#)
- [LAT Monitored Source List Light Curves](#)
- [LAT GRB Catalog](#)
- [Extended Sources in the Galactic Plane \(FGES\)](#)
- [Second Fermi All-sky Variability Analysis Catalog \(2FAV\)](#)
- [1st Fermi-LAT SNR Catalog](#)
- [LAT 3-year Catalog of Gamma-ray Pulsars](#)
- Other useful LAT related products
  - [List of LAT GRBs announced via GCN notices](#) (external)
  - [List of LAT Sources announced via ATels](#)
  - [LAT List of Detected Gamma-Ray Pulsars](#) (updated frequently)
  - [LAT Pulsar Ephemerides from Publications](#)
  - [LAT Background Models](#)
  - [List of time gaps in LAT data](#)
- GBM Data
  - [GBM Trigger Catalog](#) (Browse table)
  - [GBM Burst Catalog](#) (Browse table)
  - [GBM Daily Data](#) (Browse table)
  - [GBM Continuous Data](#) (FTP archive)
  - [GBM Terrestrial Gamma-ray Flashes \(TGF\) Catalog](#)
  - [Untriggered GBM Short GRB Candidates](#) (external)
  - [GBM Earth Occultation Light Curves](#) (external)
  - [GBM Pulsar Spin Histories](#) (external)
  - [List of GBM GRBs announced via GCN notices](#) (external)
- Additional Data
  - [Predicted Spacecraft Pointing \(FT2\) Files](#)
  - [Multiwavelength Programs Supporting Fermi](#)
  - [Fermi Solar Flare Observations](#)

# GBM Data Tools

## Welcome to the Fermi GBM Data Tools documentation!



*Hello, I'm Fermi. Pleased to meet you!*

The Fermi GBM Data Tools is an Application Programming Interface (API) for GBM data. The fundamental purpose of the Data Tools is to allow general users to incorporate GBM analysis into their scripts and workflows without having to sweat very many details. To this end, the Data Tools have a fairly high-level API layer allowing a user to read, reduce, and visualize GBM data with only a few lines of code. For expert users, and users who want fine control over various aspects of their analysis, the Data Tools exposes a lower-level API layer, which can also be used to generalize the GBM Data Tools to data from other like instruments.

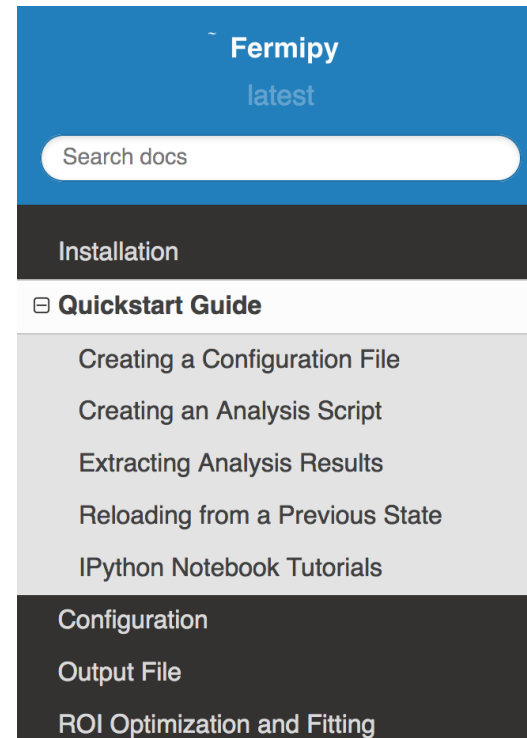
Python interface to GBM analysis provides a leap for community GBM data analysis and supports multi-instrument analysis.

New video tutorial!  
[https://fermi.gsfc.nasa.gov/aas237/tutorial\\_videos.html](https://fermi.gsfc.nasa.gov/aas237/tutorial_videos.html)

<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



Fermipy latest

Search docs

Installation

- Quickstart Guide
  - Creating a Configuration File
  - Creating an Analysis Script
  - Extracting Analysis Results
  - Reloading from a Previous State
  - IPython Notebook Tutorials
- Configuration
- Output File
- ROI Optimization and Fitting

[Docs](#) » [Quickstart Guide](#)

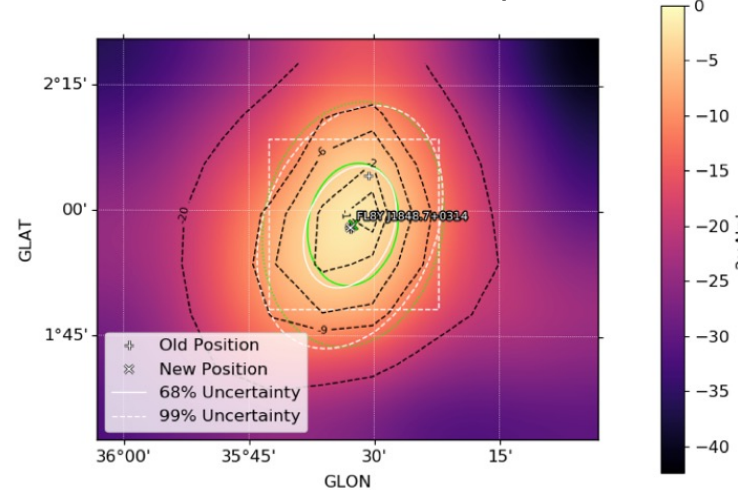
[Edit on GitHub](#)

## Quickstart Guide

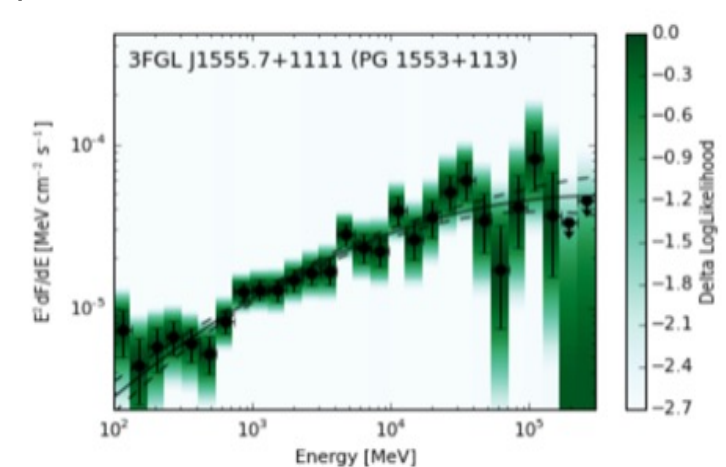
This page walks through the steps to setup and perform a basic spectral analysis of a source. For additional fermipy tutorials see the [IPython Notebook Tutorials](#). To more easily follow along with this example a directory containing pre-generated input files (FT1, source maps, etc.) is available from the following link:

```
$ curl -OL https://raw.githubusercontent.com/fermiPy/
$ tar xzf mkn421.tar.gz
$ cd mkn421
```

Source Localization Map



Spectral Fit

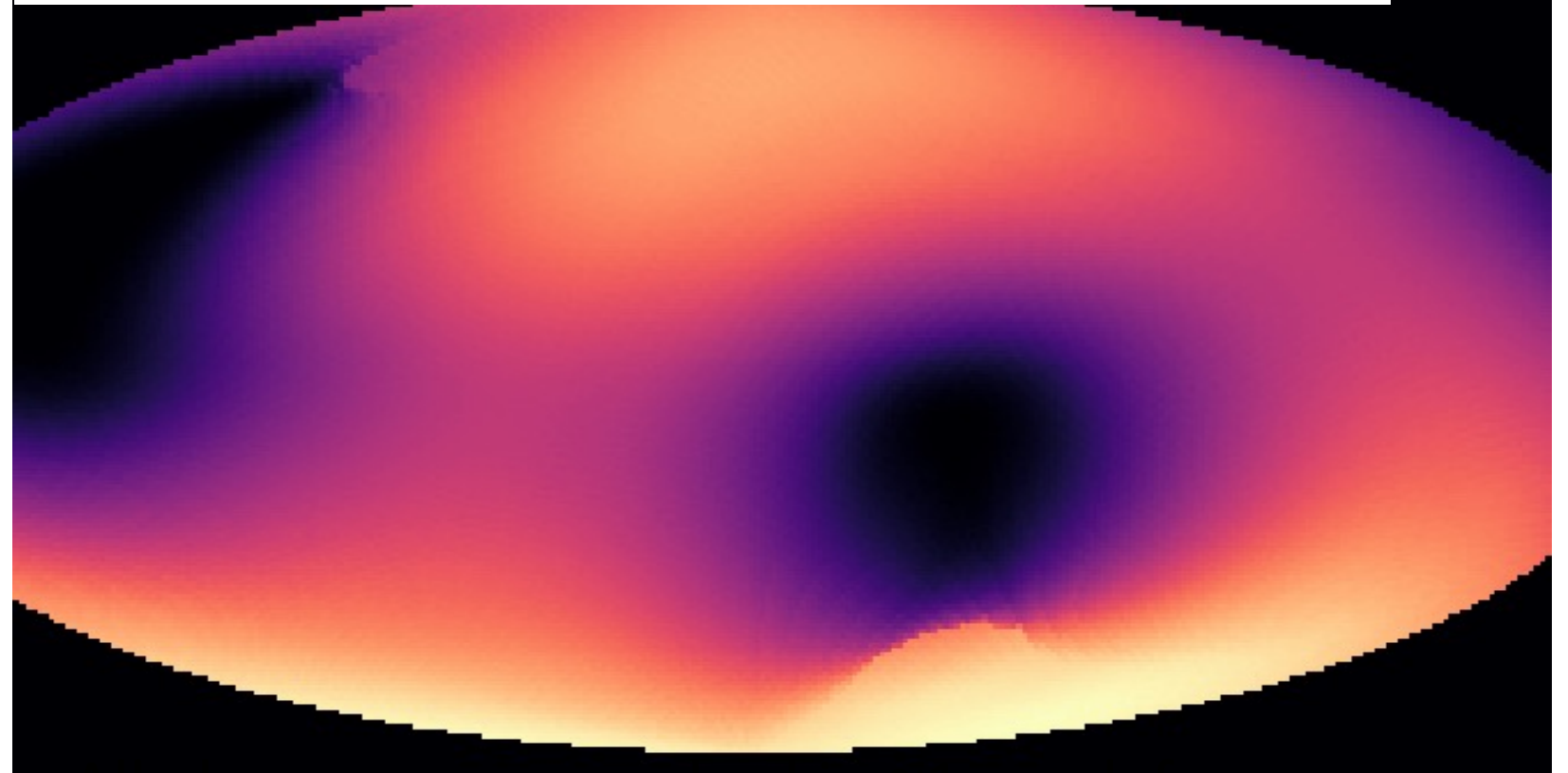


# Fermi observational efficiency undiminished with one stationary solar array

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

2 orbit (3 hour) exposure for sine-modified profile



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

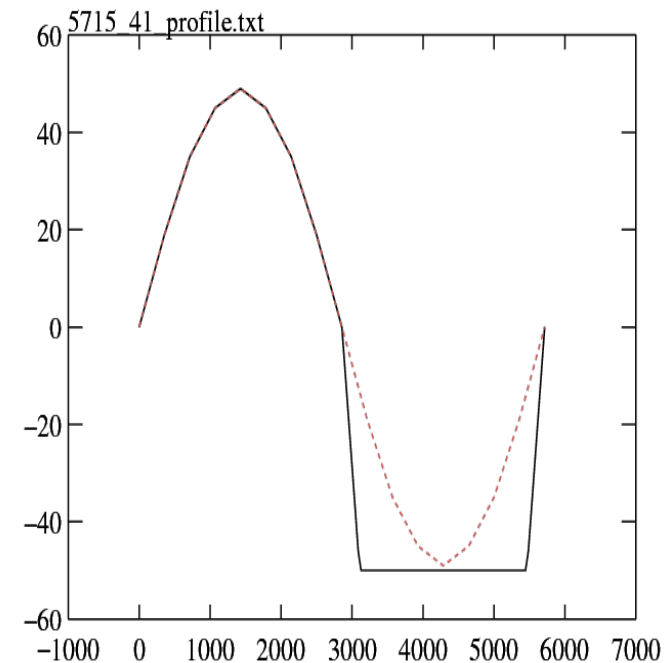
Sun is not observable during sine-modified survey but **is** during two-sided rocking.



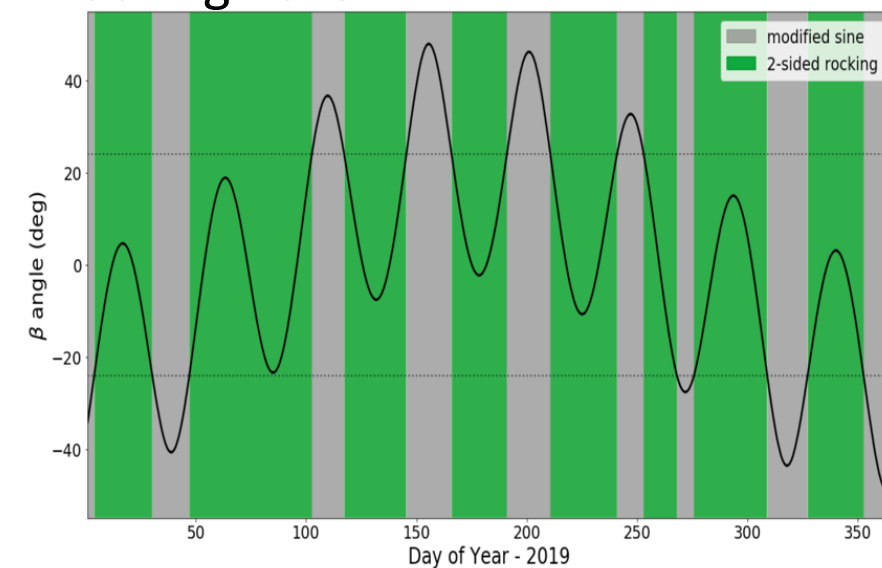
# Post-solar array anomaly observing profiles

- Two-sided rocking, symmetric  $+50/-50$  or asymmetric  $\pm 50/\mp 60$ , 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
  - $\pm 50/\mp 60$  ( $14 < \beta \leq 24$ ): 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/](https://fermi.gsfc.nasa.gov/ssc/observations/types/post_anomaly/)

Sine-modified profile



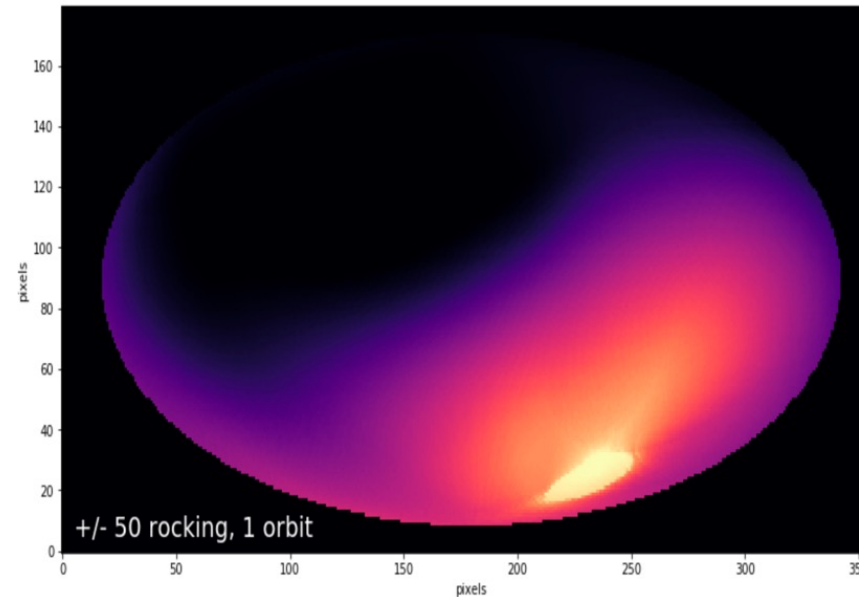
Angle between the orbit plane and the Sun during 2019.



# 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).

Traditional +/-50 rocking profile



Sine-modified profile

