Fermi Proposer Workshop

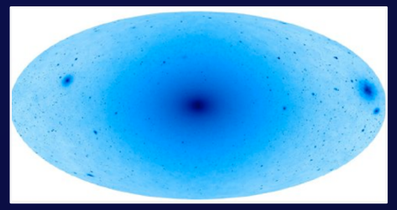
Mission Overview

Jan. 28, 2022

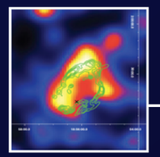
E. Hays and J. Racusin

Fermi discoveries cover a broad range of astrophysics

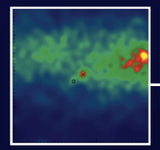
Neutrino Counterpart searches



Dark Matter searches

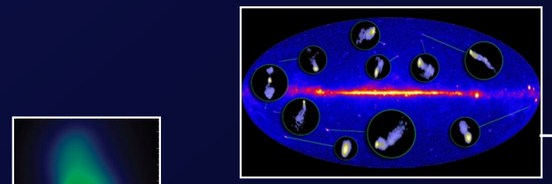


Supernova Remnants &
Pulsar Wind Nebulae

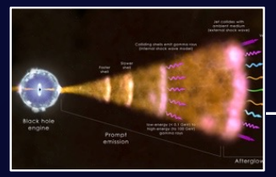


Novae

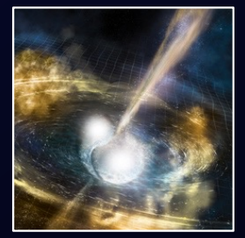
Unidentified
Sources



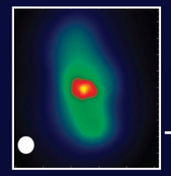
Blazars



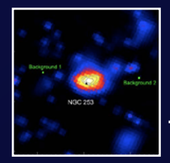
Gamma
Ray Bursts



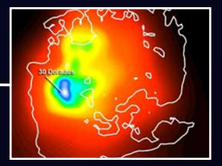
Gravitational Wave
Counterparts



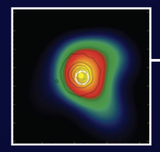
Radio Galaxies



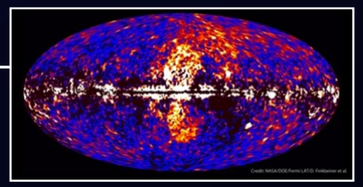
Starburst Galaxies



LMC & SMC

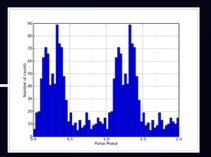


Globular Clusters

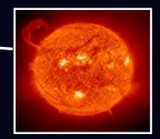


Fermi Bubbles

γ-ray Binaries

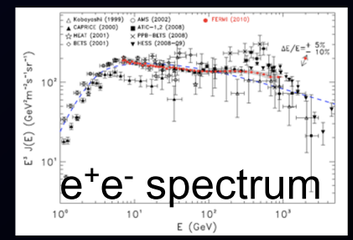


Pulsars: isolated, binaries, & MSPs



Sun: flares & Cosmic Ray interactions

Terrestrial γ-ray Flashes



Cosmic Rays

Extragalactic

Galactic

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 increasing 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

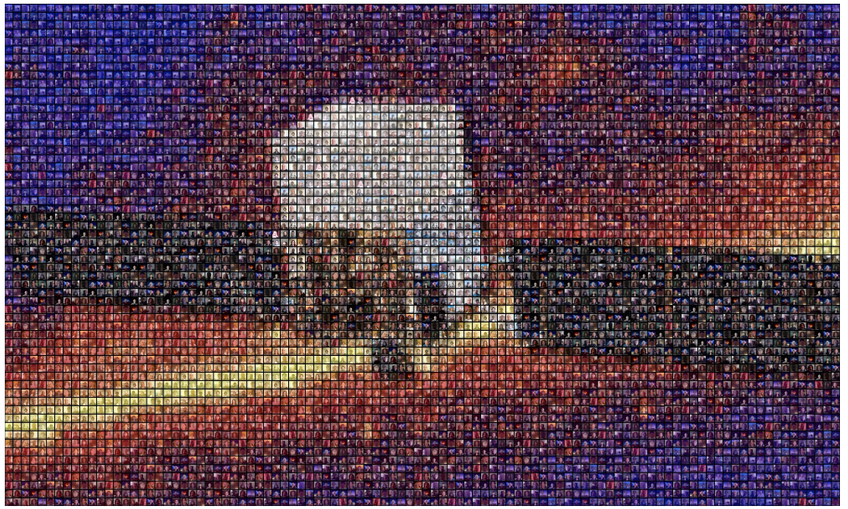
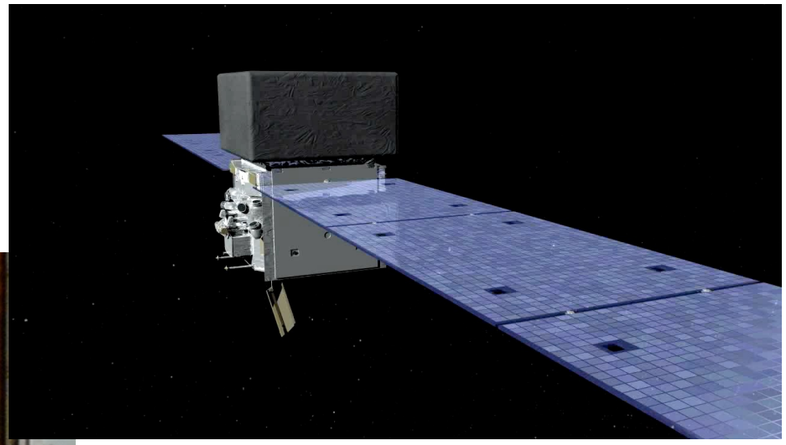
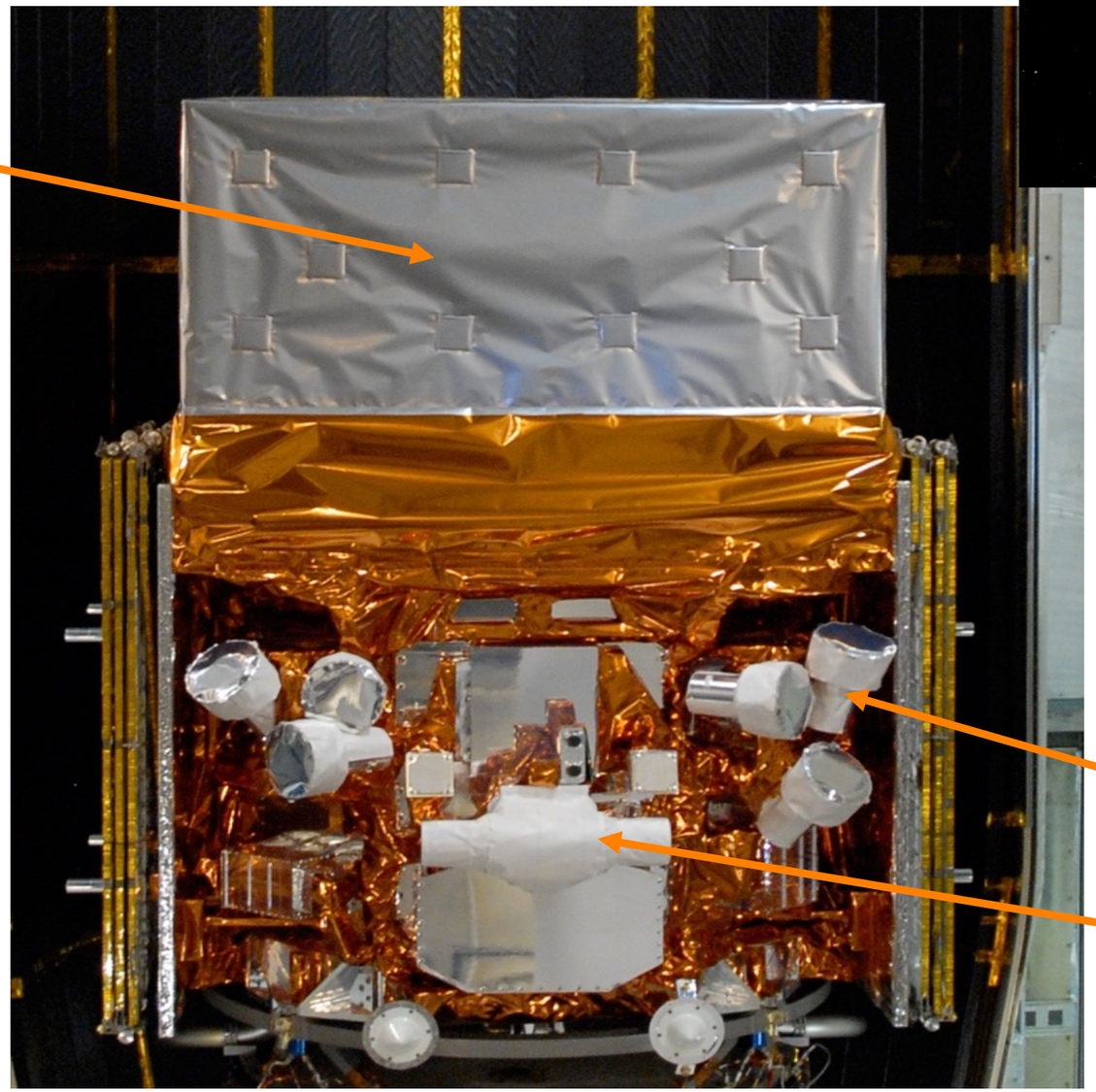


Photo mosaic from the
9th International Fermi Symposium
April 2021

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

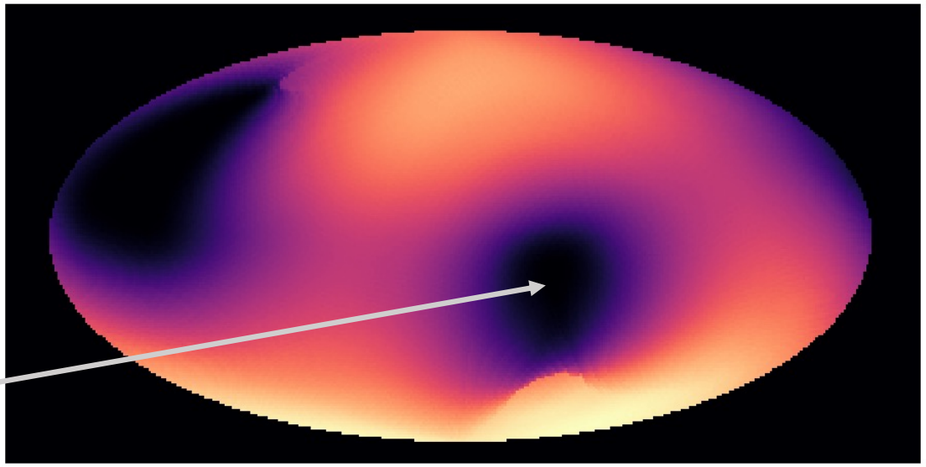
BGO: 150 keV - 40 MeV

Information on instruments and performance at https://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone/

Observatory Status: Excellent

- Operations continue to be stable and reliable.
  - Both instruments significantly exceed original performance due to software and configuration improvements.
- No consumables; no expected instrument limitations
  - The orbit can be maintained into the 2030s.
- Survey modes provide all-sky coverage in 3 hours or 85% of the sky every 1.5 hours reaching all-sky coverage in approximately 1 week

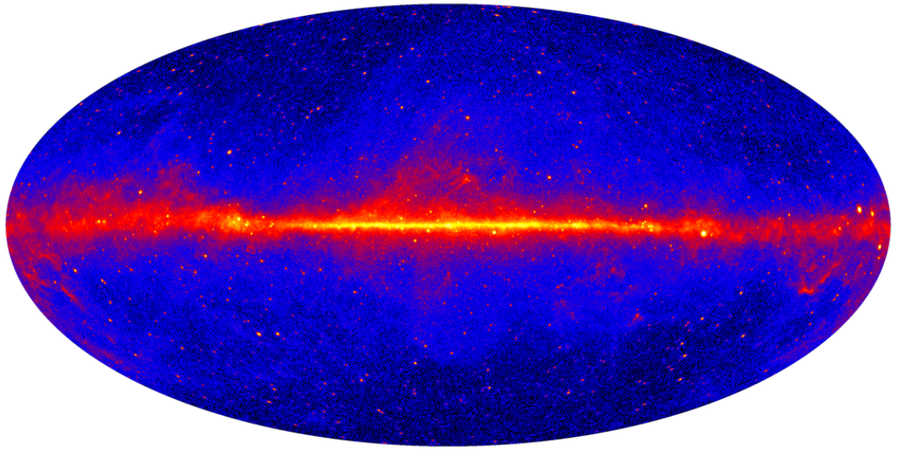
LAT exposure more limited toward Sun in sine-modified survey but is available at off-axis angles. Several solar flares have been detected in the new solar cycle.

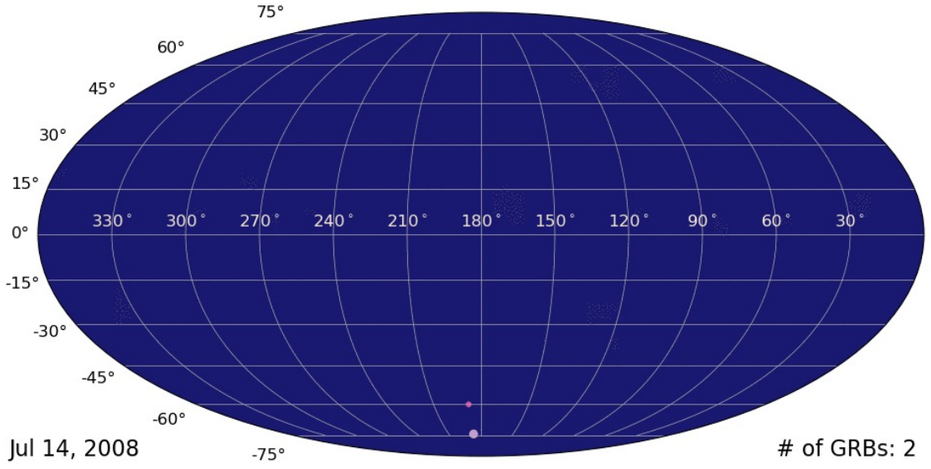


Sine-modified Survey Exposure Map (2 orbits)

Data and Catalog Highlights

- Large Area Telescope
  - **12-year LAT catalog (4FGL-DR3) – out today! See next slide.**
  - Solar Flare catalog (FLSF)
  - 10-year AGN Catalog (4LAC-DR2)
  - List of LAT Detected Pulsars
  - Updated spacecraft position and history files in 2021
    - Spacecraft velocity vectors added to support precision timing analysis
    - Updated calculation of spacecraft geodetic coordinates and updated International Geomagnetic Reference Field Model
- Gamma-ray Burst Monitor
  - GBM Data Tools
  - 4th GBM GRB Catalog
  - Custom pulsation search

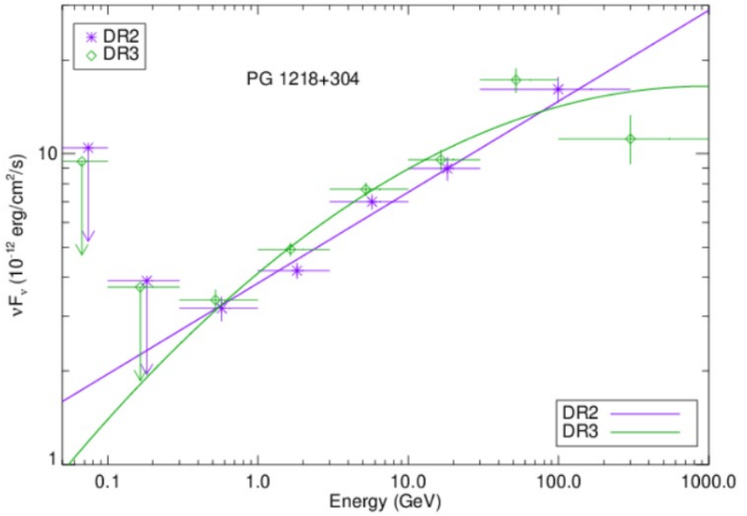




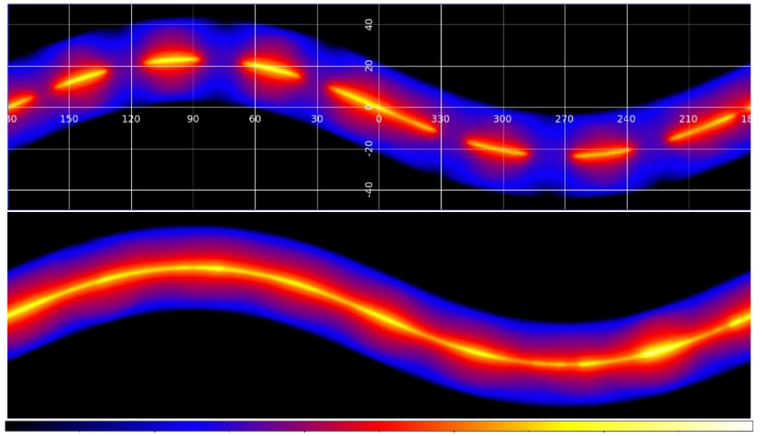
3rd Incremental Release of the 4th LAT Catalog

4FGL-DR3

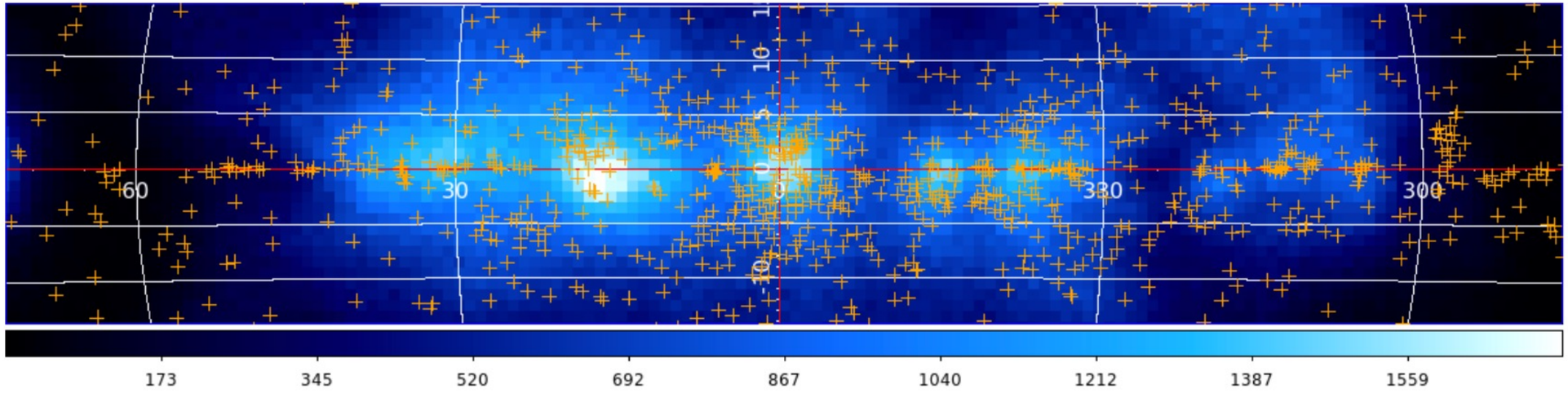
- 12 years of data
- 50 MeV to 1 TeV
- 6658 sources (from 5787 in 10-yr catalog)
- New sources in almost all of 24 class designations



Spectral comparison for PG 1218+304



Background model includes inverse Compton from the Sun



Positions of unassociated sources around the Galactic Center

Fermi Transient Searches

New!
See the following presention.

Pipeline
Method
Timescale
Distribution
Status

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

***Fermi* All-sky Variability Analysis (FAVA)**
Aperture Photometry, 1 week
ATels, FAV catalogs

***Fermi* LAT Light Curve Repository**
Likelihood LAT Catalog Sources
3 days, Weekly

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

***Fermi* LAT Monitored Sources**
Daily, Weekly above 10^{-6} cm^{-2}s^{-1}

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

LAT Automated Science Processing (ASP) + Flare Advocates
Likelihood
6 & 24 hour
ATels, GCN notices (on AGN)

LAT Catalogs
Likelihood, associations
FGL, FHL, LAC, FLE, PSR

Pipelines

Timescale

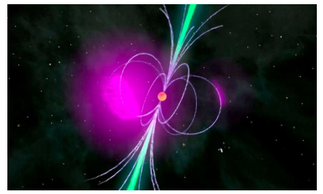
Transients

μs ***ms*** ***s*** ***minutes*** ***hours*** ***days*** ***months*** ***years***

Photon Timing

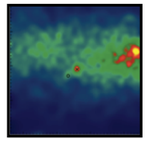
All Sky Cadence

Pulsars

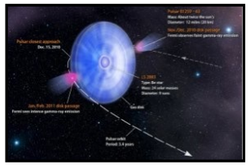


Solar Flares

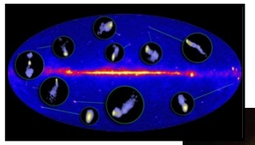
Novae



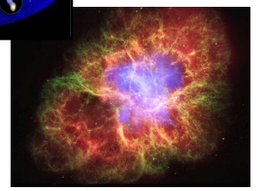
γ-ray Binaries



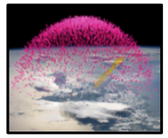
Blazar Flares



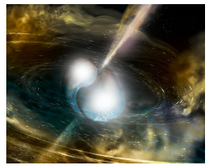
Crab Flares



Terrestrial γ-ray Flashes



GRBs



Magnetar Flares

Not to scale

The Future of Fermi Science

- The future of Fermi is bright!
  - Observatory and instruments in excellent health
  - Opportunities for new discoveries in time domain and multi-messenger astrophysics
  - Data, catalogs, and analysis tools and techniques available to dig deeper into the high-energy Universe and to catch 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