



Fermi

Gamma-ray Space Telescope



## Large Area Telescope (LAT) Update

**Peter Michelson**



## The LAT is working well

- LAT has 98.8% uptime for the science mission
- 867 billion triggers on the LAT
  - **4.19 billion LAT events available at the FSSC**
    - **1.59 billion source photons available at the FSSC**

## LAT Performance

- LAT trigger rate starting to show a small decrease (~1%), as expected as 11-year Solar cycle approaches new solar maximum
  - **Checking LAT sub-system performance just in case the decrease is an instrumental issue**
    - **Regular calibrations of the TKR, CAL, ACD sub-systems show no unexpected trends**

## SLAC Level 1 processing & reprocessing, and MC production

- Required effort effectively shared by extended core team from LAT Collaboration and FSSC



- **Post-pandemic, the LAT collaboration is doing well!**
  - **1<sup>st</sup> hybrid collaboration meeting: INFN Pisa, Sept 5-9, 2022**

# Fermi Mentoring Program (MP)



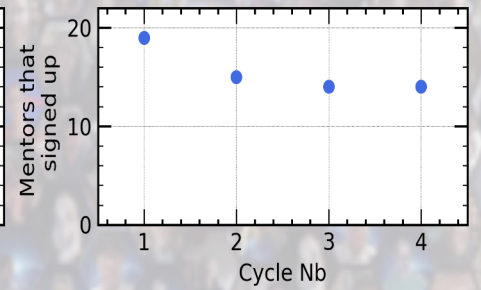
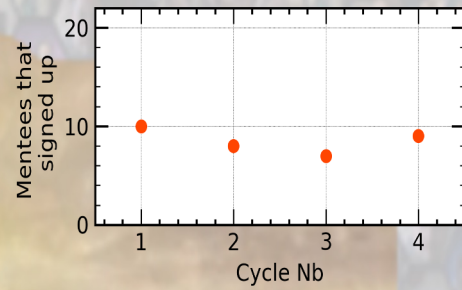
Started in spring 2021. Each cycle lasts 6 months. We have now successfully launched the 4<sup>th</sup> cycle

## Fermi MP components

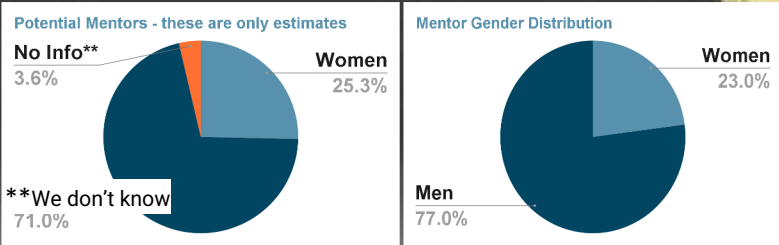
- Mentees:** Graduate students within the LAT and GBM collaborations.
- Mentors:** LAT/GBM PhD-holders. They do not supersede or interfere with the role of the research advisor, but rather serve as an additional resource.
- MP Committee:** Volunteer-based group responsible for overseeing the MP. In charge of mentor-mentee **matching and training**. Mediates in case of misunderstandings.

## Statistics

In the first 3 cycles of the *Fermi* MP, **56** people, between mentors and mentees, have met for a total of **89** hours of mentoring sessions that can be seen as **178** “people hours” of mentoring time.

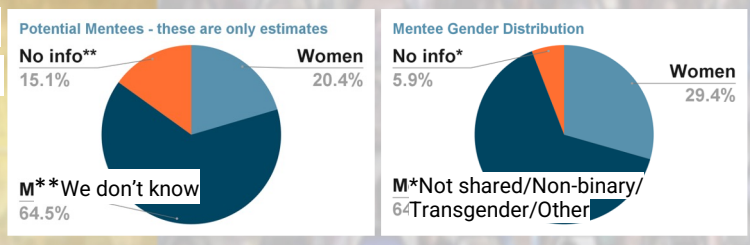


## Mentors



**Gender distribution of mentors/mentees reflects the distribution in our collaborations**

## Mentees

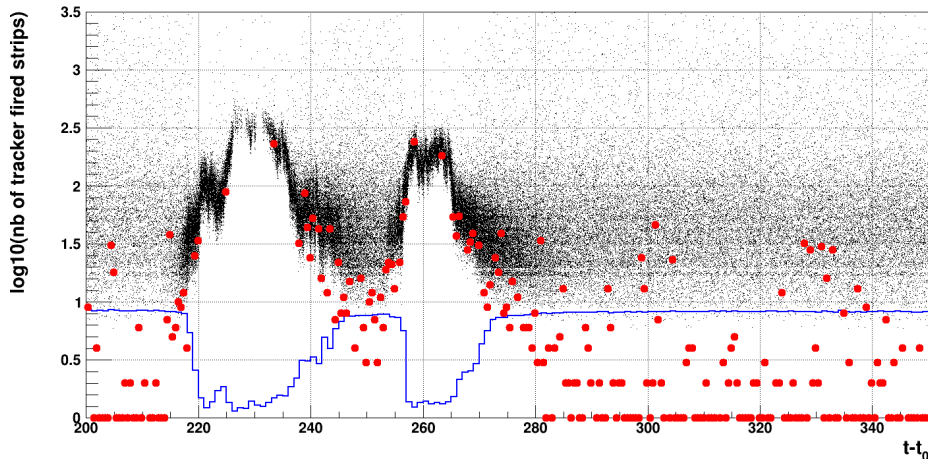




# Effect of the high flux on LAT data

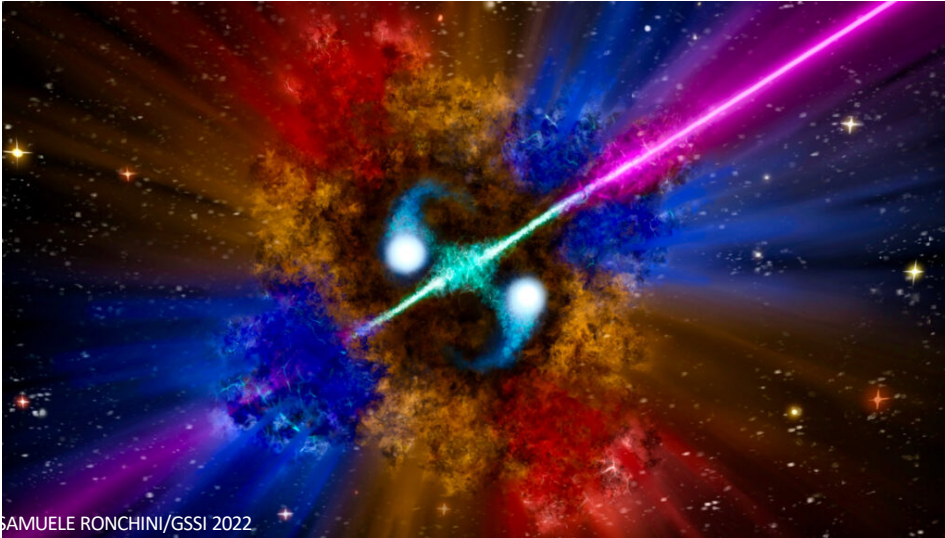


- The high rate of MeV photons caused pile-up in the LAT
  - [A page has been set up at the FSSC explaining all the details](#)
- Standard IRFs are not good representation of the instrument during the affected time intervals
  - The LAT team is working on recovering the affected time intervals.

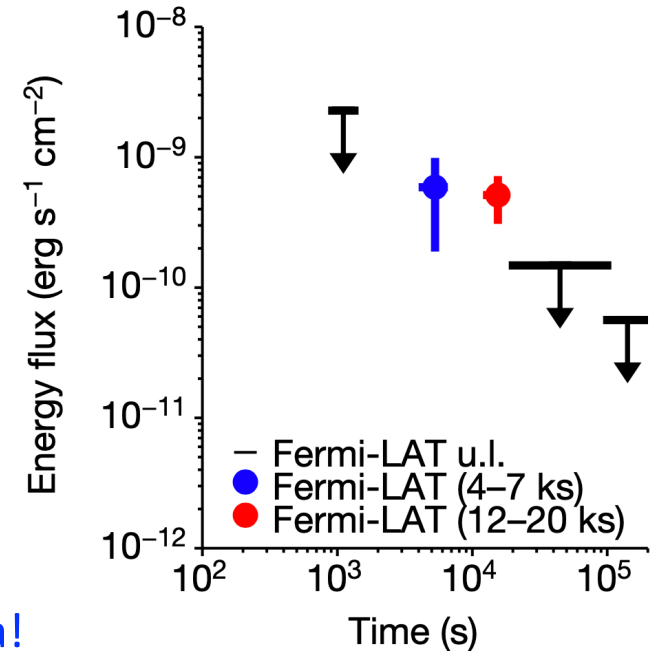


Number of tracker fired strips in the recorded events with at least one track that passes the gamma-ray main trigger and on-board filter as a function of time since the GBM trigger (**black dots**). The **red dots** correspond to the events triggered with a 2Hz cadence to monitor the noise in the instrument. The **blue histogram** shows the livetime recorded in the 1sec spacecraft file.

# First evidence of a new class of GRB?



- GRB 211211A: a long GRB associated with a kilonova!
  - Observation of optical-infrared kilonova provides evidence that this GRB is associated with a compact object binary merger
    - J. Rastinejad, et al, Nature **612**, (2022)
    - E. Troja, et al, Nature **612** (2022)
    - J. Yang, et al, Nature **612**, (2022)
  - Synergy between Fermi and GW detectors:
    - GW signal associated to long GRB and kilonova would be unambiguous proof of this new class of events



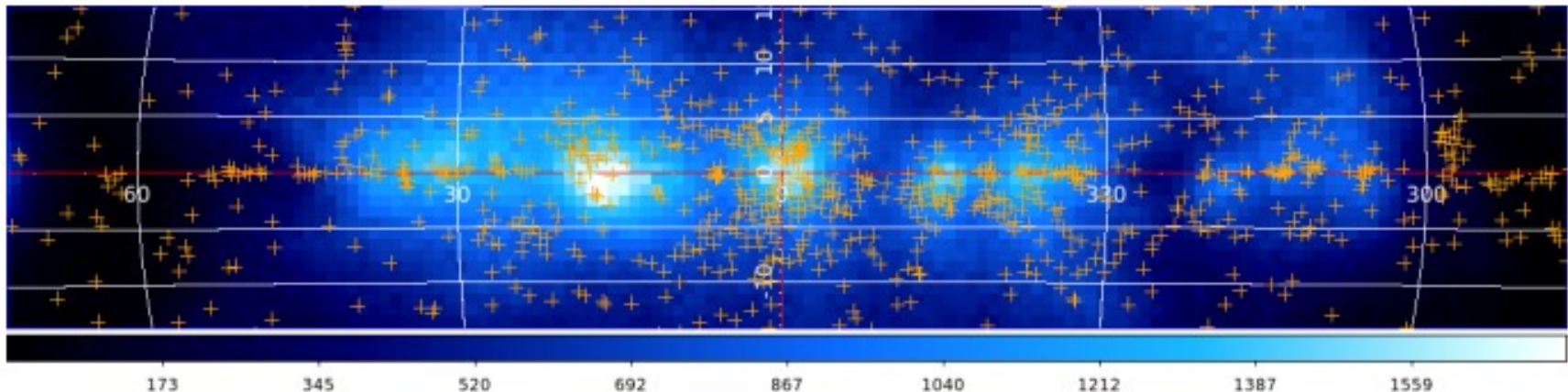
LAT detected a delayed signal up to GeV energies  
 (A. Mei et al. Nature **612**, 236-239, December 2022)

# 4FGL-DR4 in preparation



- Fairly rapid catalog updates!
  - 4FGL (8 years) 5064 sources, ApJS 247, 1, 33 (2020)
  - 4FGL-DR2 (10 years) 5787 sources; list posted 12/2020
  - 4FGL-DR3 (12 years) 6,658 sources, ApJS 263, 2, 24 (Dec 2022)
- Well established procedure now.
- Energy Range: 50 MeV – 1 TeV
- DR4 in preparation (14 years) same methodology and diffuse model as 4FGL (DR3), but with more data.

Figure from 4FGL-DR3



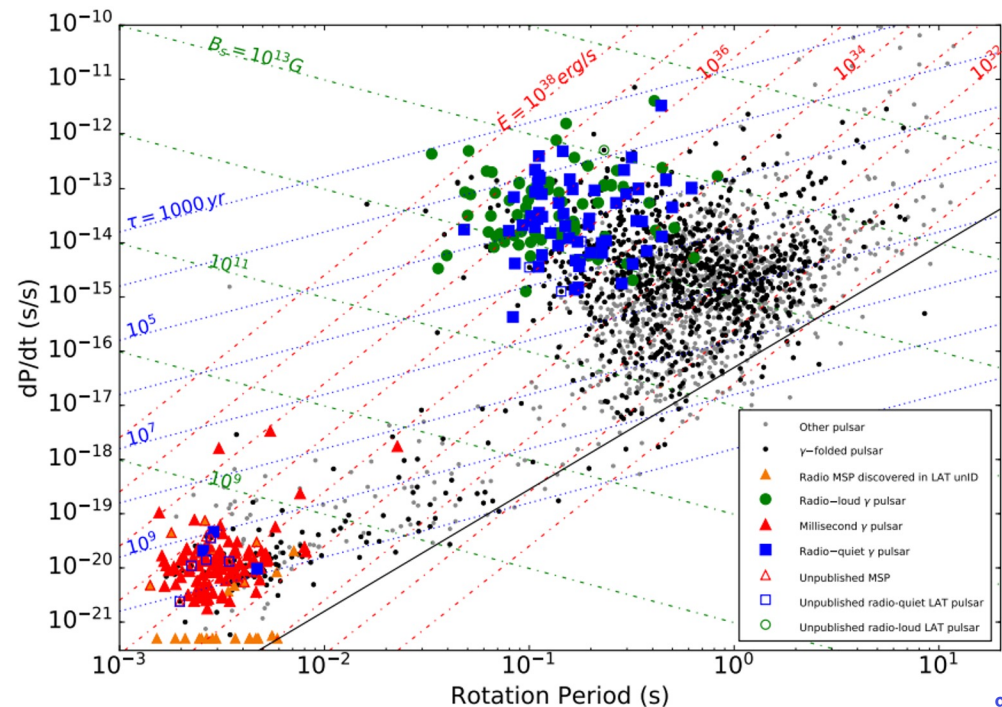
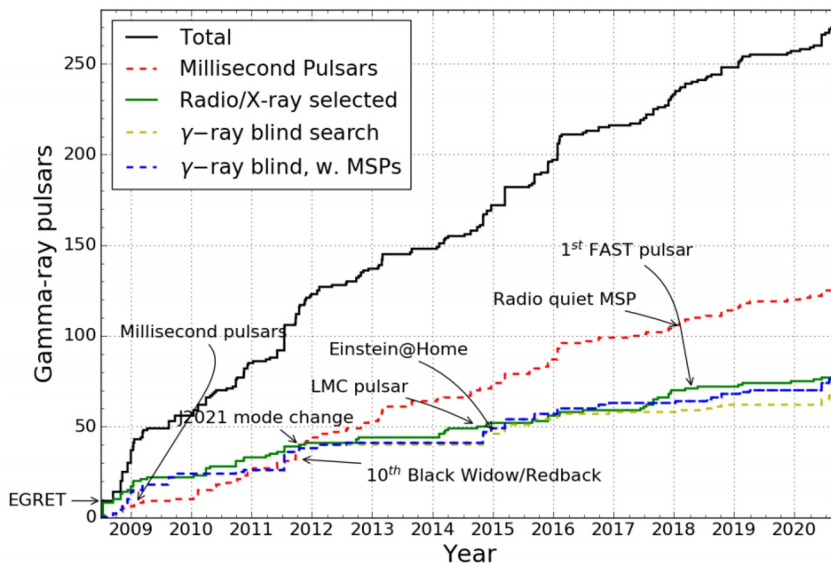
**Figure 19.** Positions of unassociated sources (crosses) around the Galactic Center. The background is a count map of 83-228 MeV "patch" photons simulated over 12 years.



# 3<sup>rd</sup> Pulsar Catalog (3PC)



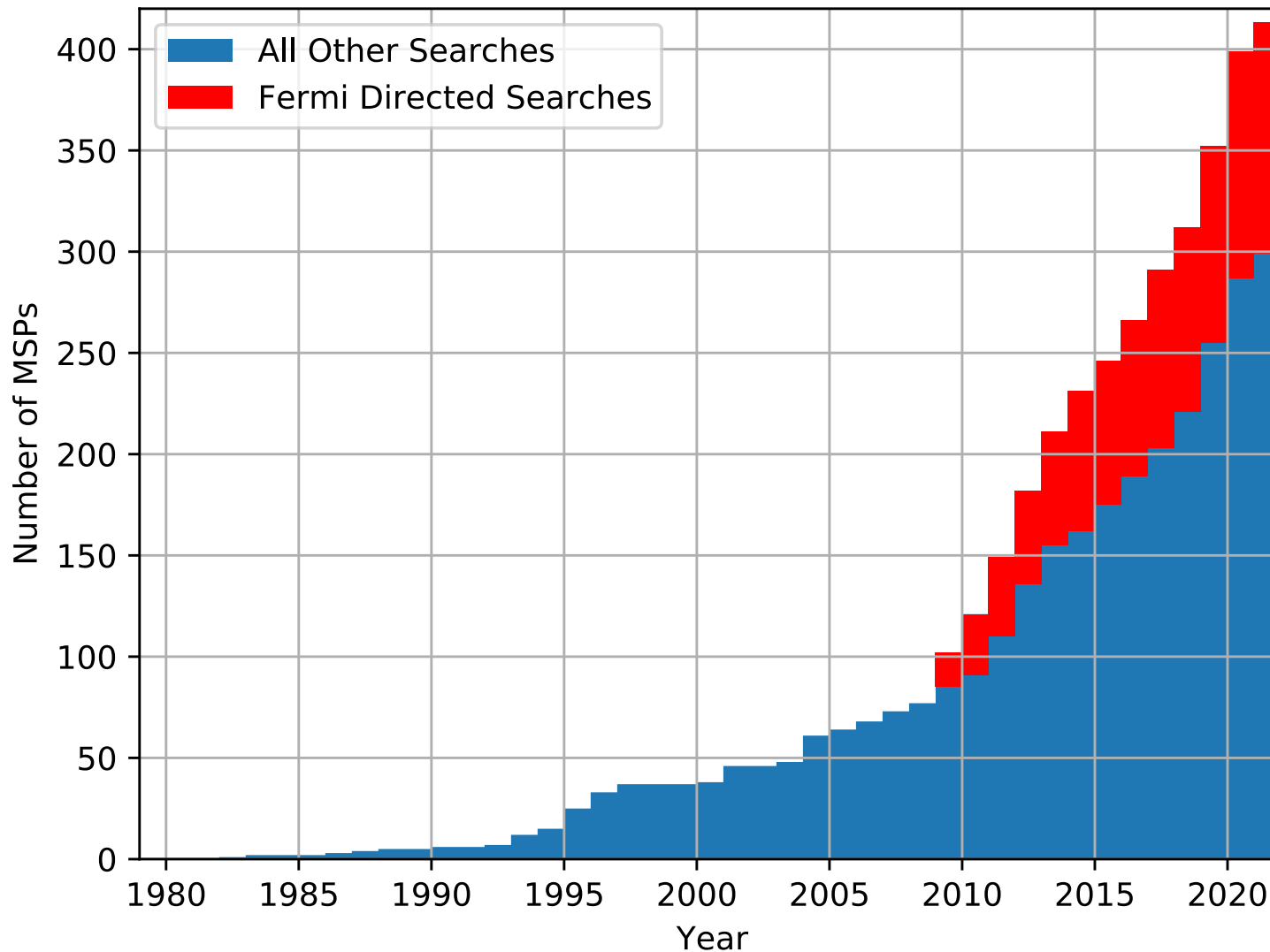
- 286 gamma-ray pulsars (150 young + 136 MSPs), c.f. 2PC (132)
- Included in catalog:
  - Ephemerides (up to MJD 58,000, longer as possible)
  - Use 4FGL-DR2 spectra
  - Updated distances
  - Pulsar light curves with classifications
  - Updated radio fluxes / upper limits
- Current main activities: **paper draft complete**; now being reviewed by collaboration
- Submission likely early next year.



# Radio pulsar discoveries and Fermi

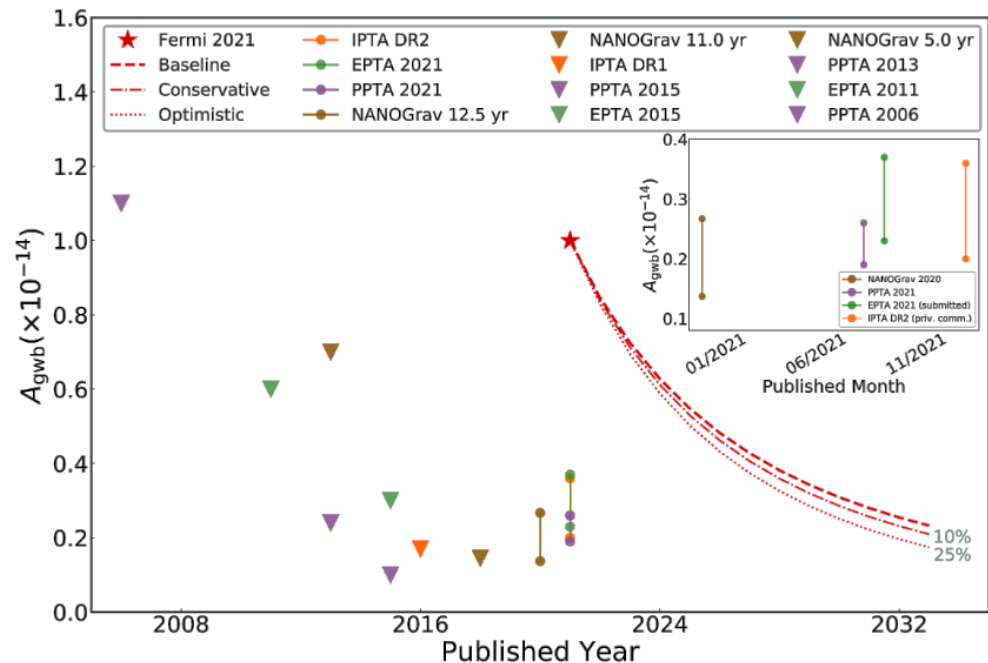


Cumulative Number of Known Field MSPs





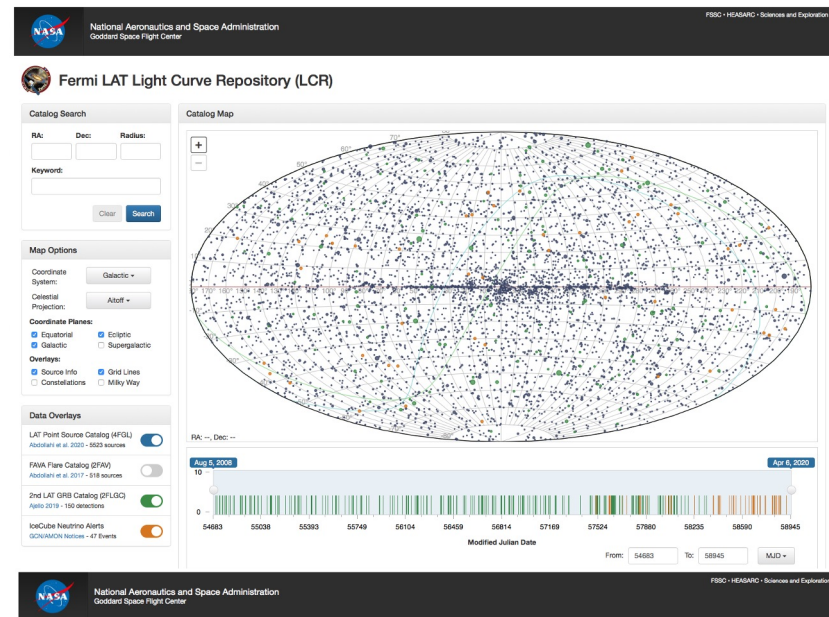
- 114 MSPs in Fermi-LAT sample.
  - Select the “best” according to sensitivity and brightness.
- Perform ensemble analysis to search for a nHz GWB expected to be generated by binary SMBHs.
- Limit is competitive with current radio results (factor of <5) and scales favorably with time.
  - In ten years will reach level of possible GWB signal pulsar timing arrays have detected.
- Already opened up study of individual pulsars and compare intrinsic noise results to radio.
- **Published: *Science* 376, 6592, 521-523 (2022)**





- Proposed as part of 2019 Senior Review
  - Establish and maintain a library of  $\gamma$ -ray source light curves (and spectra) on 3-day, 1-week, and 1-month time scales.
  - Constantly updated with new data.
  - Hosts both published variability results (like 4FGL, 1FLT) and results from a dedicated likelihood analysis.
- Now publicly released

<https://fermi.gsfc.nasa.gov/ssc/data/access/lat/LightCurveRepository/>



National Aeronautics and Space Administration  
Goddard Space Flight Center

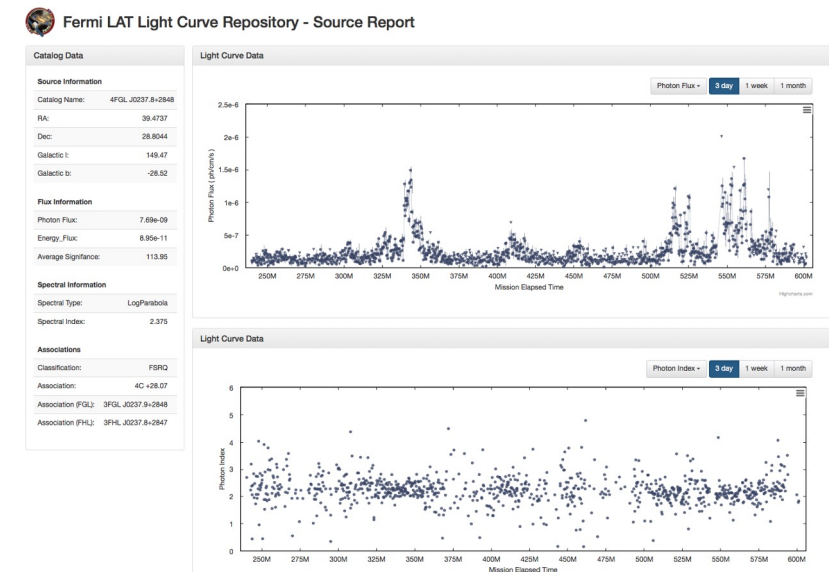
Fermi LAT Light Curve Repository (LCR)

Catalog Search  
RA: Dec: Radius: Keyword: Clear Search

Map Options  
Coordinate System: Galactic Altoff  
Coordinate Planes: Equatorial Galactic Ecliptic Supergalactic  
Overlays: Source Info Grid Lines Constellations Milky Way

Data Overlays  
LAT Point Source Catalog (4FGL) Abdo et al. 2010 - 5023 sources  
FARA Flare Catalog (FAV) Abdo et al. 2017 - 918 sources  
2nd LAT GRB Catalog (2LGRB) Ajello 2019 - 150 detections  
IceCube Neutrino Alerts ICD#1403180000 - 47 Events

Catalog Map  
RA: Dec: Modified Julian Date  
From: 54883 To: 58945 MJD



National Aeronautics and Space Administration  
Goddard Space Flight Center

Fermi LAT Light Curve Repository - Source Report

Catalog Data  
Source Information  
Catalog Name: 4FGL J0237.8+2848  
RA: 39.4737  
Dec: 28.8044  
Galactic l: 149.47  
Galactic b: -28.52  
Flux Information  
Photon Flux: 7.68e-09  
Energy Flux: 8.85e-11  
Average Significance: 113.95  
Spectral Information  
Spectral Type: LogParabola  
Spectral Index: 2.375  
Associations  
Classification: FSRQ  
Association: 4C +28.07  
Association (FGL): 3FGL J0237.8+2848  
Association (PHL): 3FHL J0237.8+2847

Light Curve Data  
Photon Flux (photons) vs Mission Elapsed Time  
Photon Flux: 3 day 1 week 1 month

Light Curve Data  
Photon Index vs Mission Elapsed Time  
Photon Index: 3 day 1 week 1 month

# Fermipy workshop



- 17-19 January 2023
  - In person (SLAC, Menlo Park, CA) or ZOOM
  - 20 participants so far,
  - FREE: no fee
- Organized around fermipy development and future maintenance
  - continuous support of the community
- Register at:
  - [https://fermipy.github.io/Workshop\\_2023/](https://fermipy.github.io/Workshop_2023/)

## Workshop\_2023

### Fermipy and Fermitools Workshop, 2023



#### Workshop description

A three day workshop to organize Fermi-LAT collaboration and community development and maintenance of public tools to analysis Fermi LAT data, focusing in particular on the "Fermipy" software package.

#### Workshop details

When: January 17, 18, 19 2023.

Where: SLAC National Lab. Palo Alto, CA

Who: We are planning for up to 30 attendees in person, as well as some remote attendees. In addition to LAT members, we invite and welcome community participation, especially from active Fermi Users Group members.

Financials: We are hoping to avoid any registration costs, or to keep them minimal.

Registration form: [link](#)

Survey for participants: [link](#)

#### Stanford Guest House Reservation

We have reserved a block of 20 rooms at the Stanford Guest House, located at SLAC. You can use the code "FERMI" to book or use the [this link](#)

The hold will expire on 12/2/22!

#### Topics covered

1. Fermipy organization, packaging, testing, distribution
2. Interdependencies between Fermipy and FSSC managed Fermitools
3. Outstanding Fermipy and Fermitools feature requests and development work
4. Underused aspects of Fermipy
5. Cross-mission data analysis, 3ML.

#### Agenda is here

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- **BACKUP SLIDES**