Fermi Proposer Workshop

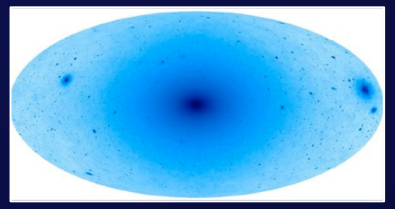
Mission Overview

Jan. 24, 2023

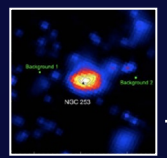
J. Racusin and E. Hays

Fermi discoveries cover a broad range of astrophysics

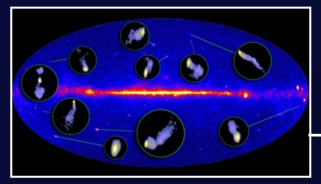
Neutrino Counterpart searches



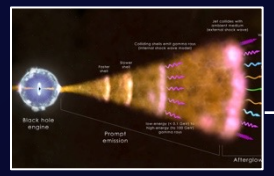
Dark Matter searches



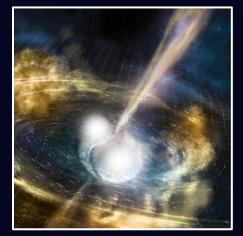
Radio Galaxies



Blazars

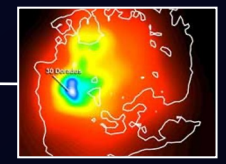


Gamma Ray Bursts

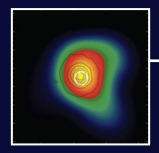


Gravitational Wave Counterparts

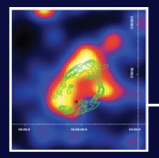
Starburst Galaxies



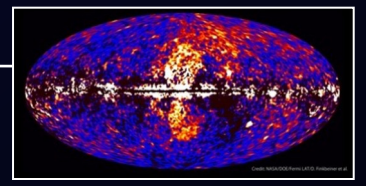
LMC & SMC



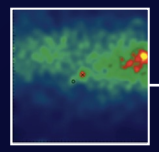
Globular Clusters



Fermi Bubbles

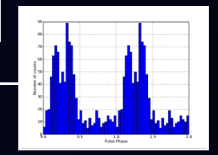


Supernova Remnants & Pulsar Wind Nebulae



γ-ray Binaries

Novae

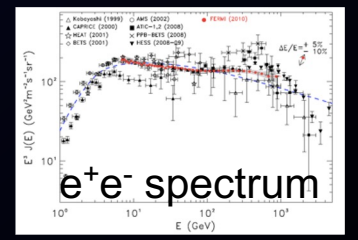


Pulsars: isolated, binaries, & MSPs

Sun: flares & Cosmic Ray interactions

Terrestrial γ-ray Flashes

Unidentified Sources



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

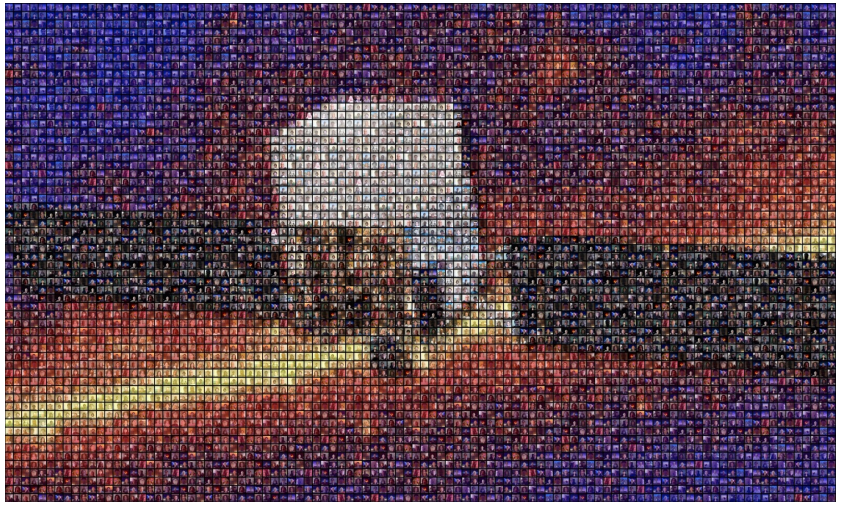
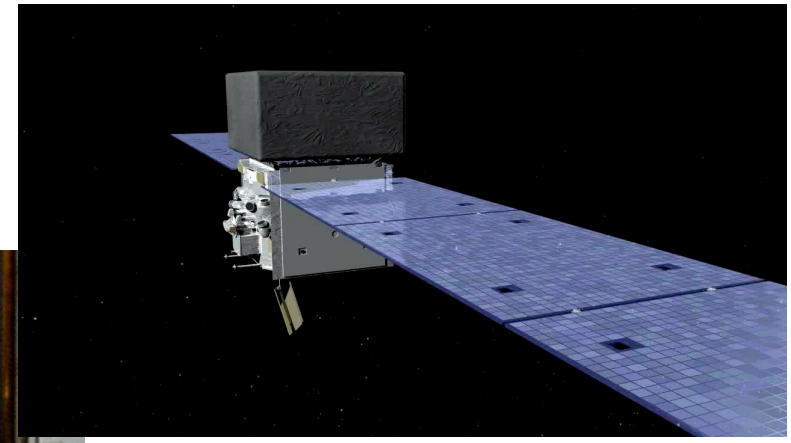


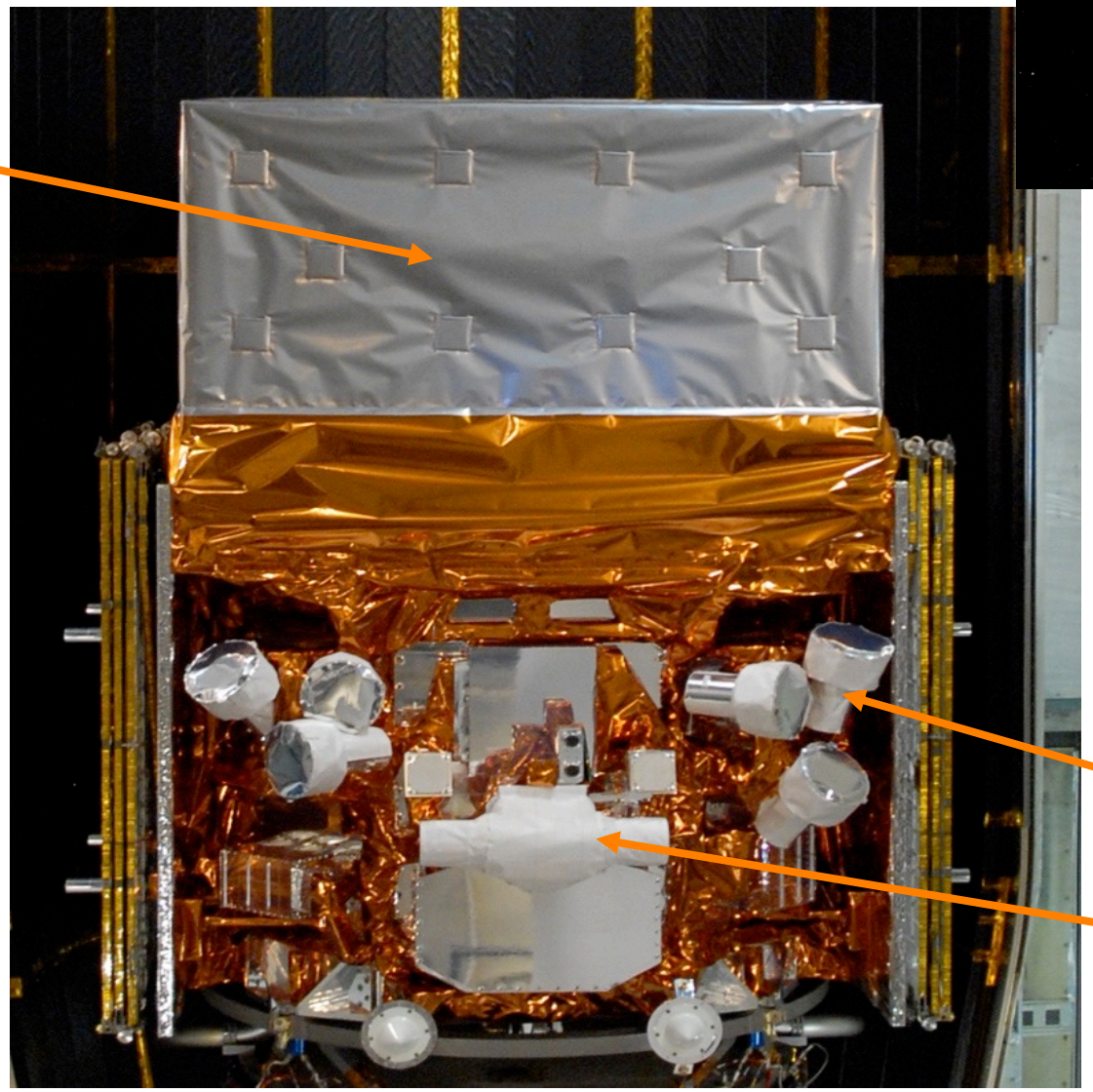
Photo mosaic from the 9th International Fermi Symposium April 2021

Photo from the 10th International Fermi Symposium in South Africa in October 2022

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

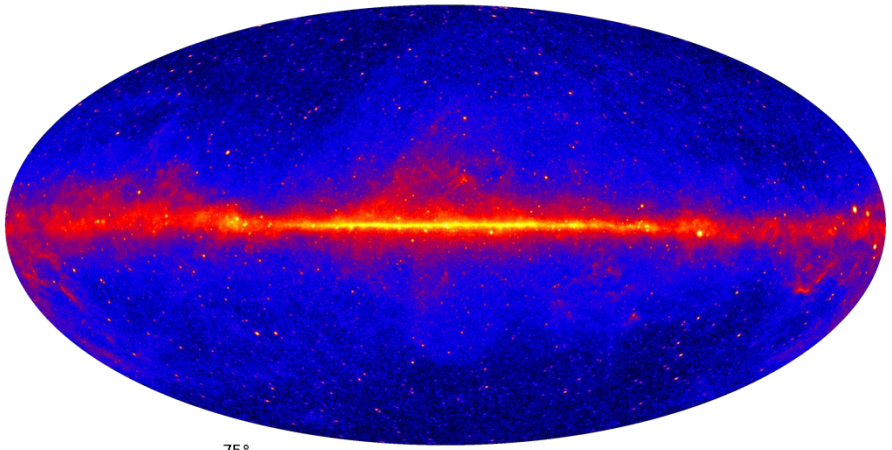
Information on instruments and performance at https://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone/

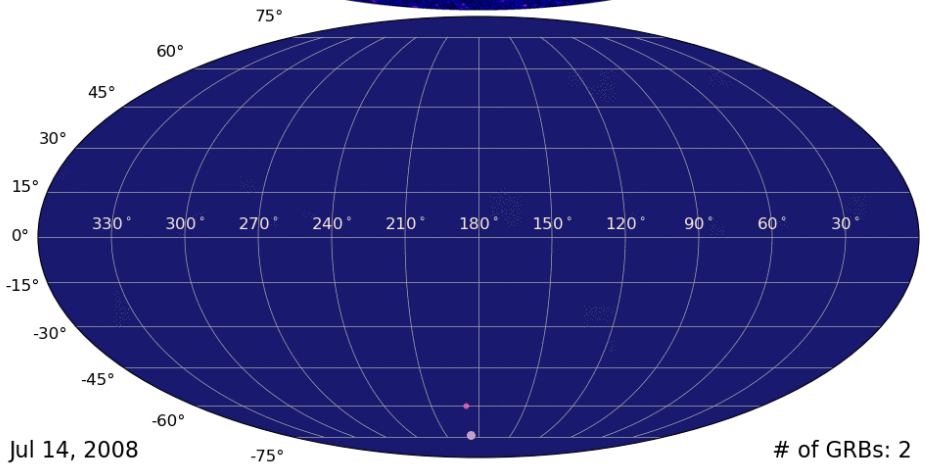
Observatory Status: Excellent

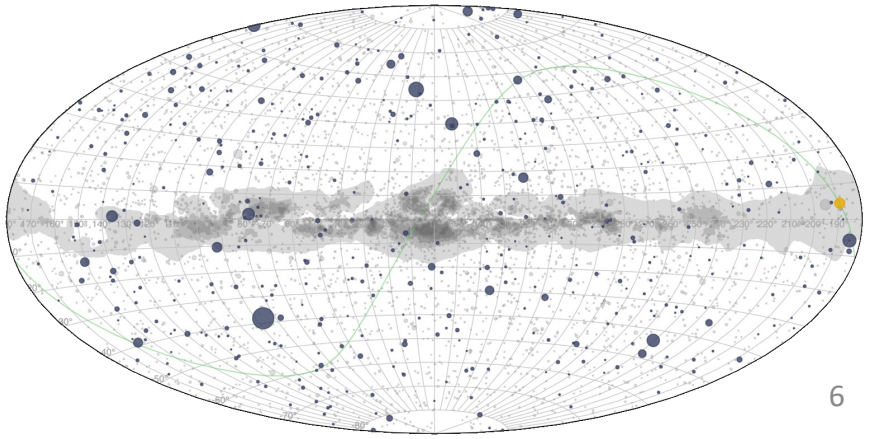
- Operations continue to be stable and reliable.
  - Both instruments significantly exceed original performance due to software and configuration improvements.
- No consumables; no expected instrument limitations
  - The orbit can be maintained into the 2030s
- Orbit Raising:
  - Study underway to use propulsion system to return orbit altitude to ~560 km (similar to value at launch) – moves above busy altitude requiring frequent maneuver planning due to potential conjunctions
  - Activities planned to avoid LVK O4 run
- 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
- SAA boundary reductions: updated by LAT in January 2022; in study by GBM. Small increase in time that instruments are collecting data and active for GRB triggers.

Data and Catalog Highlights

- Large Area Telescope
  - **LAT Light Curve Repository (LCR)**
  - **12-year LAT catalog (4FGL-DR3)**
  - 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



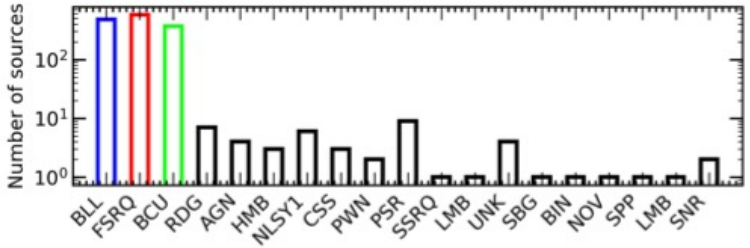


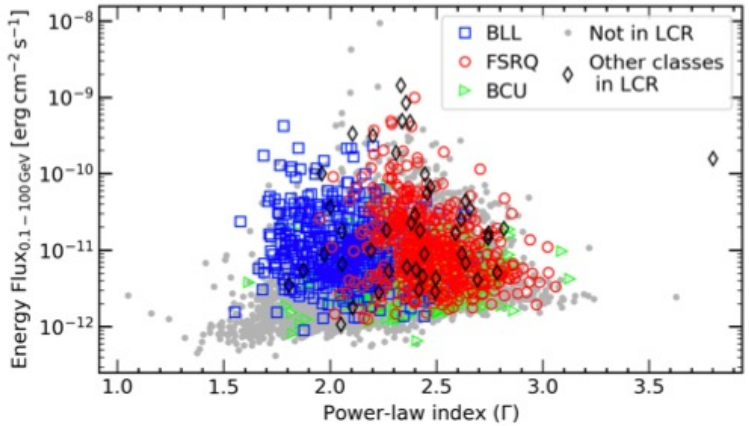


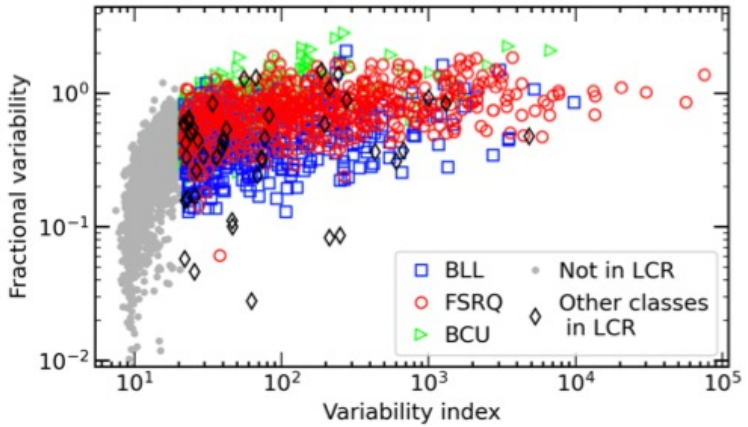
LAT Light Curve Repository (LCR)

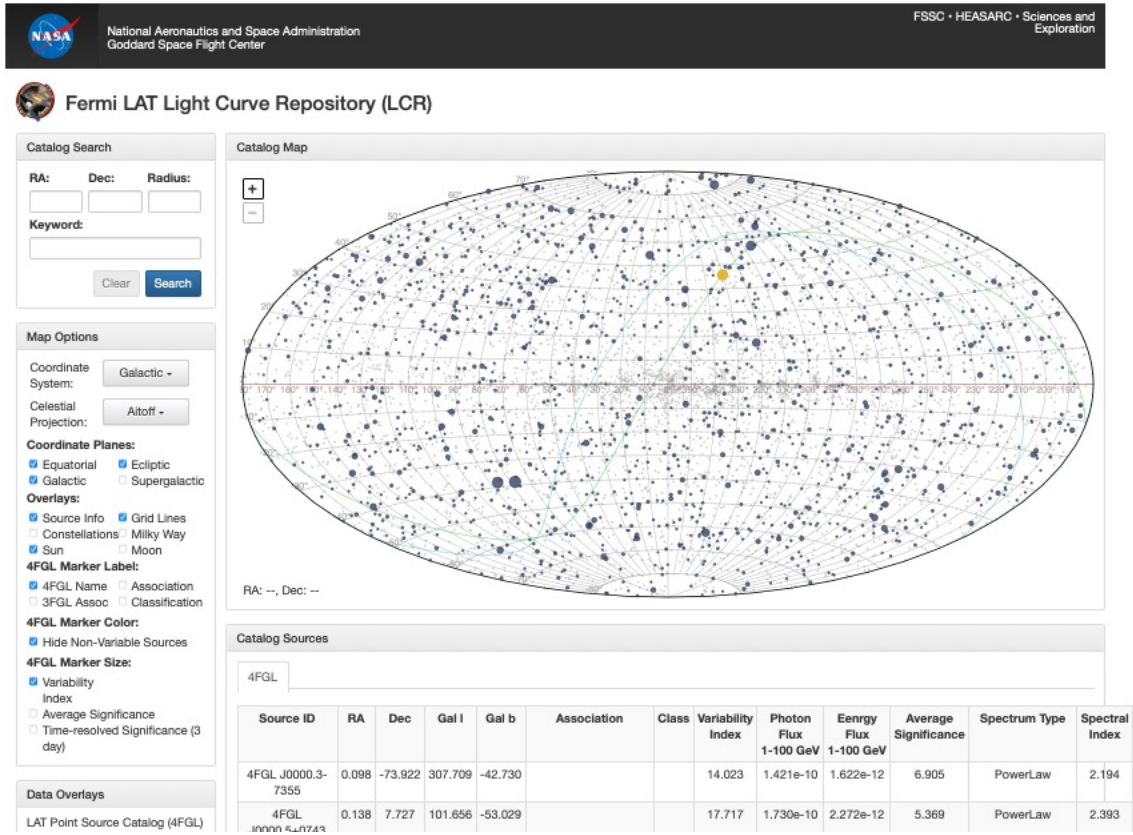
Publication-quality light curves

- binned on timescales of 3 days, 7 days, and 30 days
- 1525 sources deemed variable in the 4FGL-DR2









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

LAT Collaboration et al., submitted ApJS, ArXiv:2301.01607

Fermi Transient Searches

Transients Timescale Pipelines

Pipeline
Method
Timescale
Distribution
Status

LAT Transient Factory (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 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

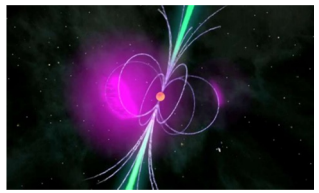
GBM Untargeted Search
ground search
ms - s
GCN Notices

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

Photon Timing

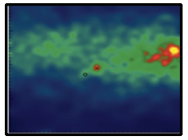
All Sky Cadence

Pulsars

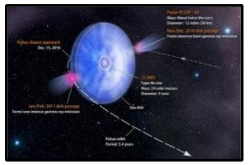


Solar Flares

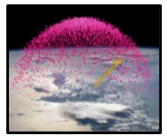
Novae



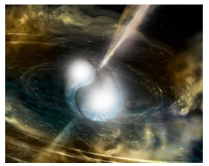
γ-ray Binaries



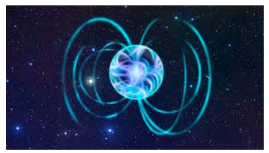
Terrestrial γ-ray Flashes



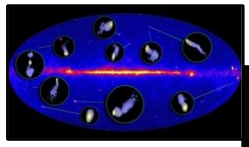
GRBs



Magnetar Flares



Blazar Flares



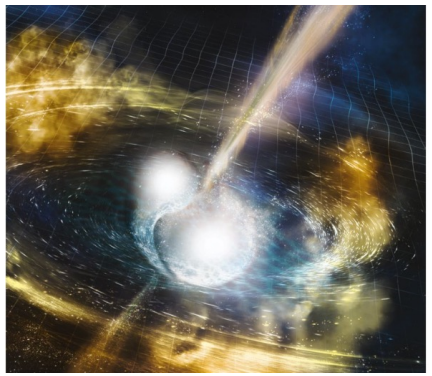
Crab Flares

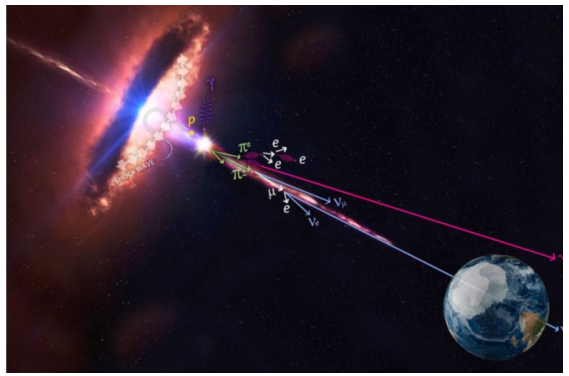
Not to scale

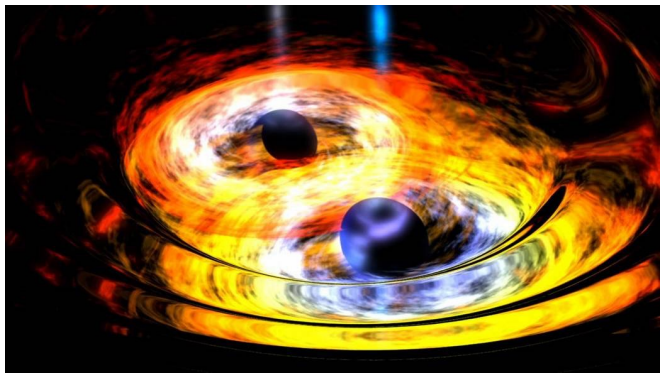
Senior Review Mission Extension

- Mission science objectives leverage Fermi's unique roles in multimessenger and time-domain astrophysics
  - **Exploring multi-messenger sources** – sources of both gravitational waves and neutrinos, and with Fermi as a gamma-ray pulsar timing array to detect low frequency GW
  - **Capitalizing on big surveys** from radio to optical and beyond
  - **Modeling the high energy universe** to probe the workings of AGN, GRBs and PeVatrons
- Mission Extension covers FY23 - FY25 with guidelines for FY26 - FY27 subject to the next Senior Review in 2025.
- Fermi capabilities are key for making new discoveries within the Astro2020 Decadal Survey theme of *New Messengers and New Physics*

Rest of Missions Panel Report link
APAC Subcommittee Report link







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!

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Judy Racusin, Fermi Deputy Project Scientist

Chris Shrader, Fermi Science Support Center Lead

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