



Fermi
Gamma-ray Space Telescope



Fermi

Gamma-ray Space Telescope

**Mission Status Update
November 29, 2023**

E. Hays, J. Racusin

Updates from the Project

The mission continues to be operationally healthy, scientifically productive, and engaged with the community and the public.

- **Mission Status and Plans**
 - **Observatory operations**
 - **Science support activities**
 - **Social media, press and outreach**
 - **Response to TDAMM priorities**

Fermi Mission Overview

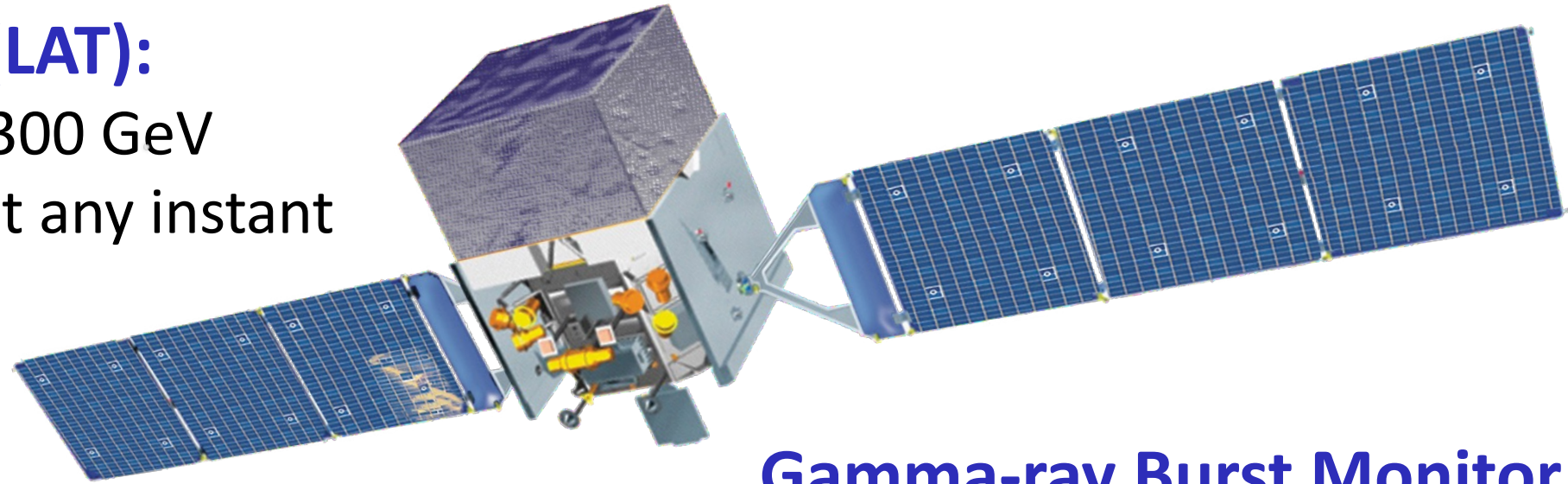
Probe class mission to study the extreme high-energy Universe

Large Area Telescope (LAT):

20 MeV to more than 300 GeV

Views 20% of the sky at any instant

Entire sky in ~3 hrs



International and interagency collaboration between NASA and DOE in the US and agencies in France, Germany, Italy, Japan and Sweden

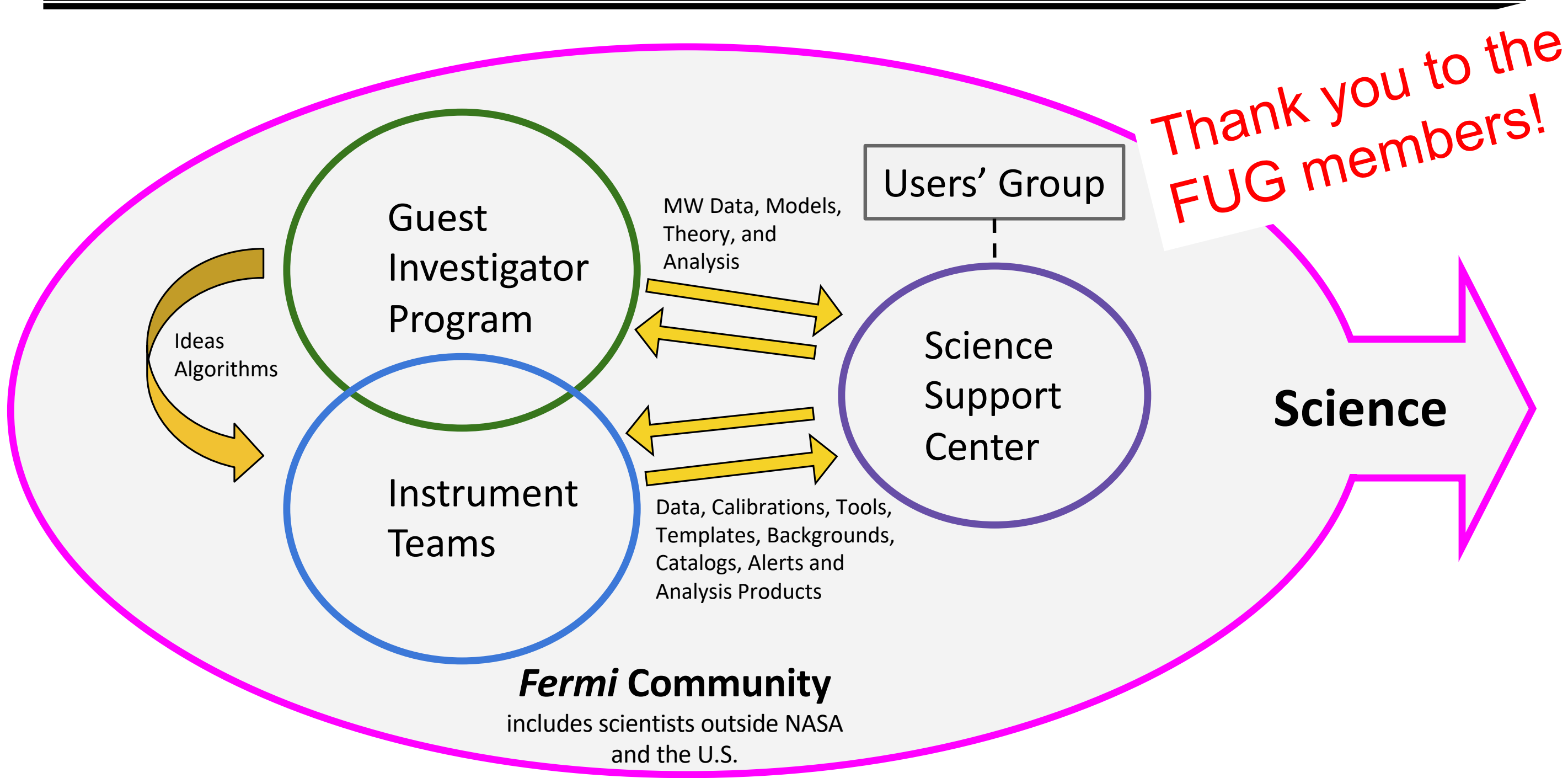
Gamma-ray Burst Monitor (GBM):

8 keV to 40 MeV

Views unocculted sky

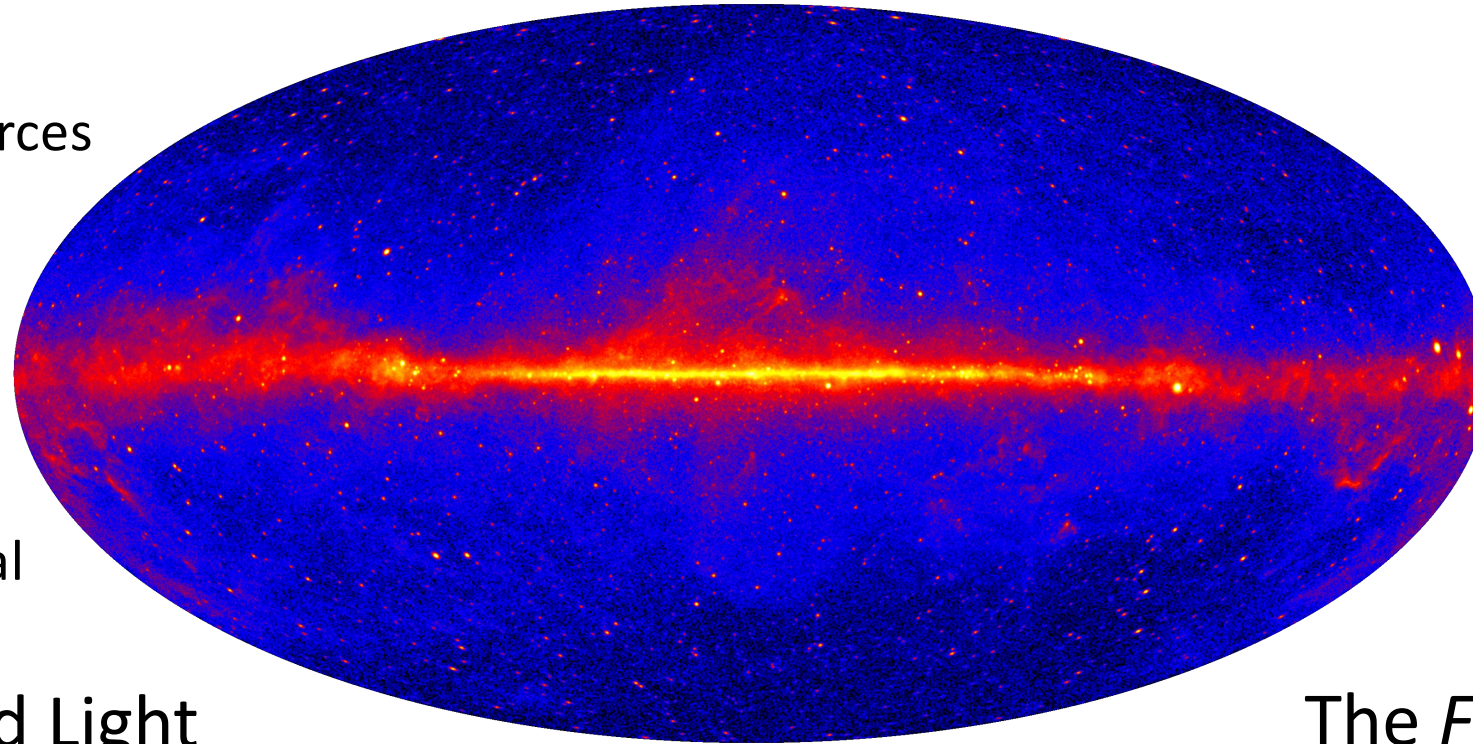
- Community involvement is central to the mission
 - Guest Investigator program supports NASA-funded *Fermi* science
 - Data available publicly immediately after processing
- Science operations rely on integrated effort from instruments (LAT: SLAC/Stanford/NRL/ GSFC; GBM: MSFC/UAH), *Fermi* Science Support Center (FSSC; GSFC), and Flight Operations Team (FOT; GSFC)

Fermi Community Organization



Unveiling the sky

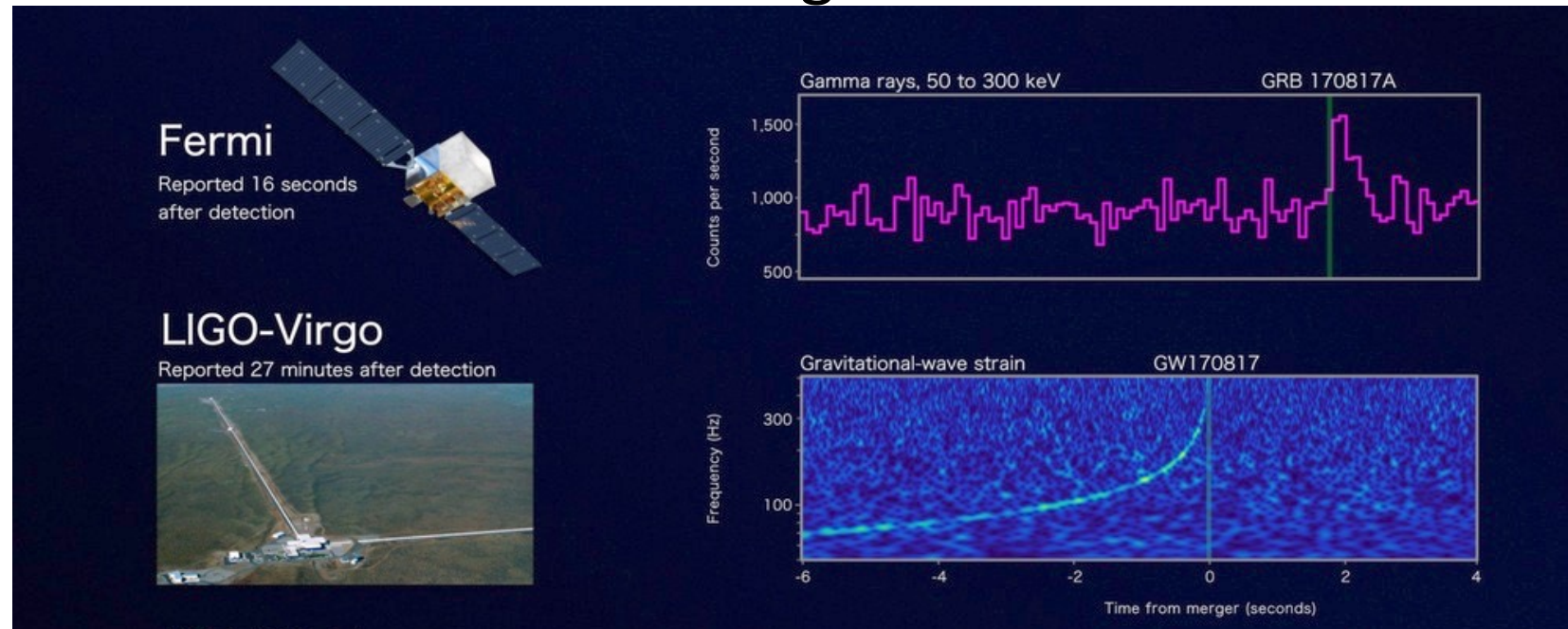
- >20x gamma-ray catalog sources
 - New source classes
 - New large-scale features
- >6000 transients
 - Gamma-ray bursts, magnetars, novae, solar flares and terrestrial gamma-ray flashes



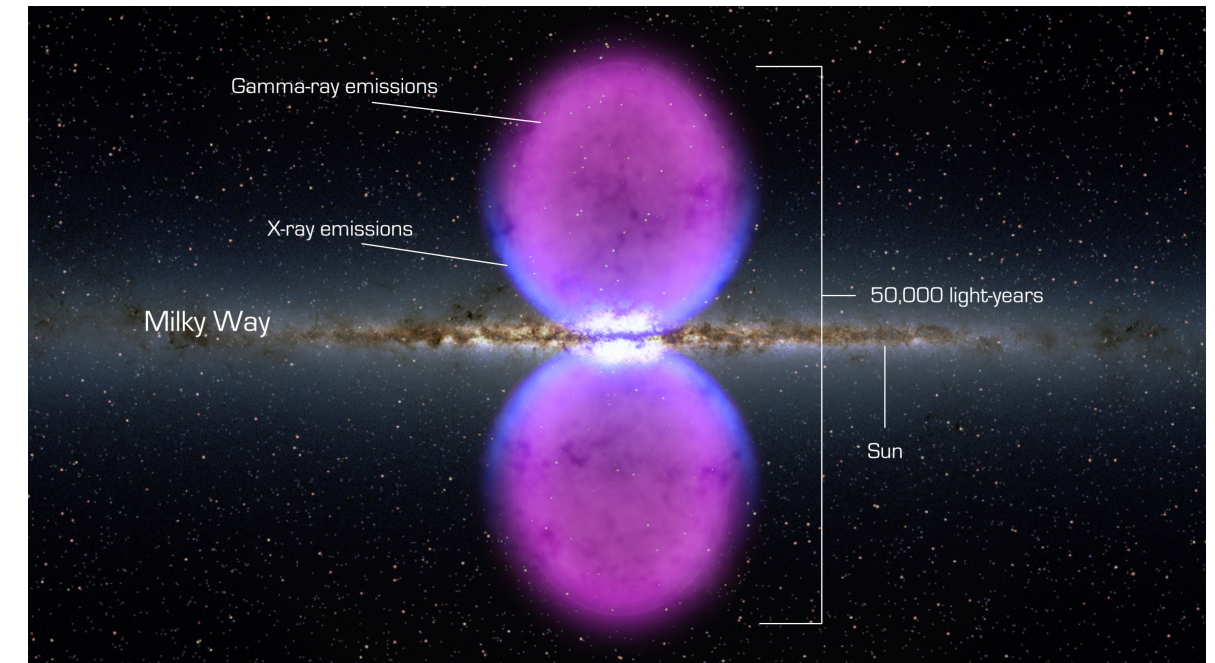
Enabling Discovery

- Immediate availability of photon data
- Automated public alerts
- Open access to analyzed source characteristics
- Continued development of public data products

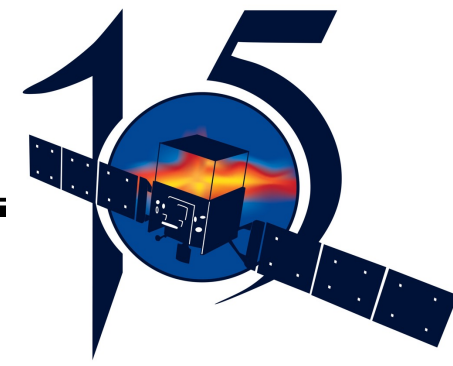
Gravitational Waves and Light



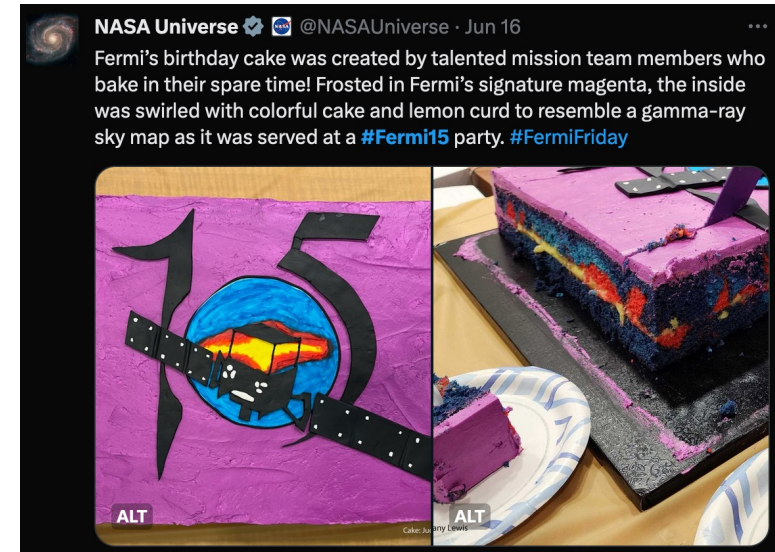
The *Fermi* Bubbles



Fermi@15 Campaign



- **Celebration of 15 years of Fermi on orbit starting with the launch anniversary on June 11, 2023**
- **Social Media**
 - Count up leading to launch anniversary of Fermi's greatest discoveries
 - Fermi received birthday greetings from SLAC, INFN, UC Santa Cruz and more as well as from space friends like Hubble, Voyager, and the Curiosity Rover.
 - Twitter Spaces live event about the BOAT GRB
 - Videos with memories of launch, greatest discoveries, and future prospects
 - Fermi@15 Intern (Jenna Ahart) - refresh of Fermi Fridays
- **Fermi 15th eBook**
 - Written by Fermi intern/contractor Hannah Richter
 - Web feature for release in January written by Jenna Ahart



Social Impact	Twitter	Facebook
Tweets/Posts	62	22
Impressions	2.8M	510k
Engagement	38k	17k

Observatory Highlights

- **Spacecraft and instrument performance is excellent at 15 years**
 - No consumables or rapid degradation of spacecraft or instrument components
 - One solar array drive no longer rotates; modified survey strategy maintains power margin while avoiding loss of observational efficiency
 - Gradual degradation in instrument components is compensated by calibration
- **Orbit outlook**
 - Lifetime of orbit extends into the mid-2030s
 - Studying orbit adjustment to lower planning frequency for collision avoidance maneuvers
 - Frequency of maneuver planning for collision avoidance has increased due to increasing number of objects for this orbit
 - Have not had to execute a maneuver since 2012, but planning impacts operations even when the maneuver is waived
 - Onboard activities could resume during for break LIGO/Virgo/KAGRA O4 gravitational wave run
- **Communications outlook**
 - Near-term: outages of TDRS Demand Access Service cause a loss of real-time notices for GRBs and other transients. Ground-generated notices are not available for several hours.
 - Storm damage to Guam station caused total DAS outage for ~2 weeks; ongoing gaps in DAS coverage require continued manual scheduling until full service is restored
 - Long-term: *Fermi* uses TDRS for all commanding, data, and real-time alerts – phase out planned in 2030s

Observatory Operations Update

- **Spacecraft**
 - **Normal operations. No current areas of concern.**
- **Observations**
 - **Observation strategy unchanged -- mix of traditional, asymmetric, and sine-modified survey. Pointed observations have been discontinued since 2018.**
 - **Ongoing absence of TDRSS Guam station requires additional communication passes to fill gaps in coverage for real time alerts**
- **FOT/engineering highlights**
 - **Mission operations systems transitioned to Redhat 8**
 - **Refresh of backup MOC underway**
 - **LAT misconfiguration found and recovered on July 18 – 1.75 hrs data not collected**
 - **Flight dynamics software tools updated and tested for operational use**
 - **Provided recovery capability during MOC computer failure in August**
 - **Flight software patch developed and implemented for use of propulsion system**
 - **Reduce onboard response time for disabling a malfunctioning thruster**
 - **Support for tests of GBM SAA boundary reductions**
 - **Orbit adjustment study made significant progress but is not complete yet (separate slide)**

Orbital Adjustment Status

- **Most engineering and procedural questions addressed over the past year**
 - **Simulation effort produced improvements in software and configuration for using the propulsion system and in the maneuver procedure**
 - **Rehearsal in January confirmed power estimation model and expectations for continued data acquisition while the observatory is in the maneuver attitude**
 - **Data collection will not need to be interrupted by future maneuvers**
 - **Disruptions to the observatory preferentially avoided during LVK O4 operations**
- **To be done**
 - **Thermal study still being completed**
 - **Initial orbital adjustment approach will be reevaluated**
 - **Account for engineering input gathered**
 - **Consider latest congestion predictions**

FSSC Personnel and Plans

- **Chris Shrader planning to retire**
 - **Many thanks to Chris for his long and valued service to Fermi and to gamma-ray astrophysics!**
- **FSSC Lead Scientist hire in progress**
 - **Ad closed Nov. 19 and applications are under review**
- **Fermi initiative approved to expand support for community software development efforts**
 - **Software developer hire in progress**
 - **Scientist hire to support community software engagement planned for early 2024**

Meetings and Events

- **Past event highlights**
 - **AAS 241 Event booth – 1st in person since 2020**
 - **11th Fermi Summer School held from May 29 – June 9, 2023**
 - **15th launch anniversary on June 11, 2023!**
 - **Project presented to NASA APAC in June 2023**
- **Upcoming**
 - **AAS 243 in New Orleans, Louisiana, Jan. 7 – 11, 2024.**
 - **Fermi SSC will host a booth jointly with Swift, NuSTAR and XRISM**
 - **GI proposers' workshop for Cycle 17, Jan. 24, 2024, 2 – 3:30 pm EST**
 - **Fermi Transient Analysis Virtual Workshop TBD**
 - **Sign up to help organize by contacting Judy and Liz**
 - **11th Fermi Symposium Fall 2024 in the DC area**

Refereed publications that present analysis of Fermi data, refer to Fermi results, make predictions for Fermi results, or present technical aspects of the Fermi mission, instruments and data.

July – September 2023: 102 papers

October 2018 – September 2023: 2397 papers

Selected Highlights from Q3 2023

- Multiple papers on GRB 221009A (Brightest of all time GRB)
- Neutrino correlations with gamma-ray blazars
- Analysis of Jupiter in gamma rays
- PeVatrons

Fermi Press Highlights

- [NASA Fermi Mission Nets 300 Gamma-ray Pulsars...and Counting – Nov 2023](#)
- [NASA Looks Back at 50 Years of Gamma-ray Burst Science – June 2023](#)
- [NASA Missions Study What May Be a 1-In-10,000-Year Gamma-ray Burst – March 2023](#)
- [NASA’s Fermi Captures Dynamic Gamma-Ray Sky in New Animation – March 2023](#)
- [NASA’s Fermi detects first gamma-ray eclipses from ‘spider’ star systems – January 2023](#)
- [NASA Missions probe game-changing cosmic explosion – December 2022](#)
- [NASA’s Swift, Fermi Missions detect cosmic blast – October 2022](#)
- [NASA’s Fermi Confirms Star Wreck as Source of Extreme Cosmic Particles – August 2022](#)



Got an exciting Fermi result? Let us know!
Contact Judy or Liz.

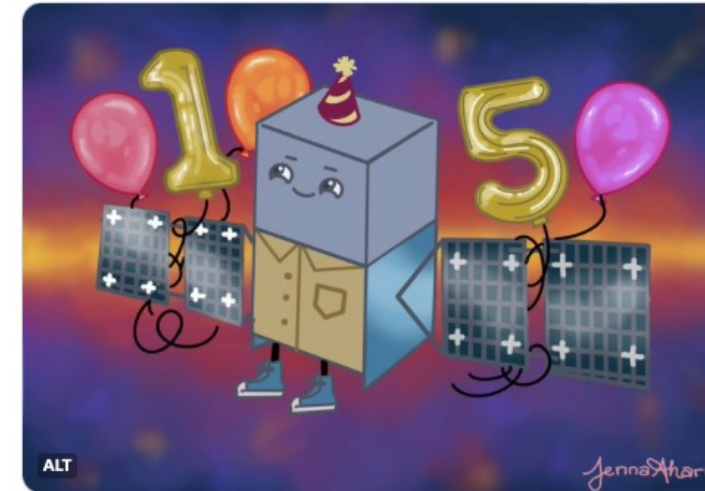
Credits: A. Simonnet (Sonoma State Univ.) and NASA’s Goddard Space Flight Center

Outreach and Social Media

- @NASAUniverse on X (formerly Twitter) & Facebook
- Social media posts using #FermiFriday content, special days, interesting results, promoting press releases, and #FermiPeople
- Mission milestones like the Fermi@15 campaign celebrating 15 years on orbit #Fermi15
- Supported a Twitter Spaces live event as part of 50 years of GRBs outreach
- Suggestions for future social media content are welcome
 - Contact Judith.racusin@nasa.gov or @jracusin on Slack

NASA Universe @NASAUniverse

#OTD in 2008, @NASA's Fermi Gamma-ray Space Telescope launched to view the universe with its gamma-ray eyes. Follow along this week as we celebrate Fermi and the incredible contributions it has made so far to gamma-ray science! #Fermi15



1:37 PM · Jun 11, 2023 · 78.9K Views

NASA Universe @NASAUniverse

Fermi's birthday cake was created by talented mission team members who bake in their spare time! Frosted in Fermi's signature magenta, the inside was swirled with colorful cake and lemon curd to resemble a gamma-ray sky map as it was served at a #Fermi15 party. #FermiFriday



12:15 PM · Jun 16, 2023 · 16K Views

NASA Universe @NASAUniverse

Meet Luca Baldini! After years working on our Fermi telescope, Luca joined the IXPE team in 2016 to help develop NASA's newest eye on the X-ray sky. Besides hardware and software development, the Italian experimentalist also has a passion for guitars: go.nasa.gov/3XT433B



12:45 PM · Jul 14, 2023 · 17.2K Views

MAGIC telescopes @MAGICtelescopes · Jun 16

Happy birthday Fermi @NASAUniverse! Last Sunday the Fermi satellite turned 15 years old! We hope for lots of new discoveries in many years to come!

#fermisatellite #nasa #satellite #theMAGICcollaboration #astronomy #astrophysics #science #gammarays



Fermi IDEA Highlights

- **Challenges include serving international and widely distributed teams and community**
- **Inclusive practices to support training, development and collaborative science include**
 - **LAT and GBM mentoring program provides mentorship outside of science advising**
 - Professional training provided at start and feedback gathered during and at completion of each 1-year cycle (previously 6 months)
 - Matching considers mentee preferences related to background, language, geographical locations+
 - 46 mentor/mentee pairs since Spring 2021
 - **LAT Collaboration leadership model uses rotational coordinator roles for science analysis leads and science working groups to bring diverse perspectives to decisions and policies**
 - Roles are frequently filled by early- to mid-career scientists
 - Enables feedback channels through regular coordinator, science group and collaboration meetings along with direct solicitations from leadership and PI on policy updates
 - Ombuds program provides additional path for dispute resolution external to leadership chain
 - **Fermi Summer School introduces gamma-ray analysis to graduate students and postdocs from a variety of backgrounds**
 - >250 students from ~20 countries (6 continents) in 11 years (+ ~60 participants in 2021 virtual workshop)
 - Imposter syndrome workshop included since 2022 with strong positive response from participants
 - Anonymous feedback collected annually by organizers

Fermi Gamma-ray Summer School

10-day workshop on gamma-ray science, analysis and instrumental techniques hosted at the University of Delaware.

Lectures and hands-on tutorials for graduate students and postdoctoral researchers.

Held annually since 2011 (1 cancelled, 1 virtual year for COVID-19.)



Registration opening in December for next year!
Dates: May 28 – June 27, 2024



Key *Fermi* Capabilities for TDAMM

- **Unique and highly dynamic energy range**
 - **8 keV - >300 GeV provides triggers and observations for a wide variety of energetic astrophysical events**
- **Sensitivity reaches beyond outliers in many transient and variable source classes**
- **All-sky survey provides both instantaneous access and history**
 - **Real-time or near real-time observation data of events anywhere in the sky**
 - **GBM within 1.5 hrs**
 - **LAT within ~ 3 hrs (typical time to cover 80% of GW event region 1000 sec)**
 - **Archival searches from ms to years available for 15 years and counting**
- **Real-time monitoring and automated communications**
- **Data available immediately after processing**
 - **Catalogs + public data products provide insight and context for multiwavelength and multimessenger studies**
 - **Team-operated science pipelines generate added alerts and information**
- **Partnerships among science support center, instrument teams, MW/MMA observational facilities and community enable innovations in analysis and tools**

Fermi Transient Searches 2008-2009

Transients Timescale Pipelines

Pipeline
Method
Timescale
Distribution
Status

GBM Onboard Triggers
rate triggers
16 ms - minutes
GCN Notices

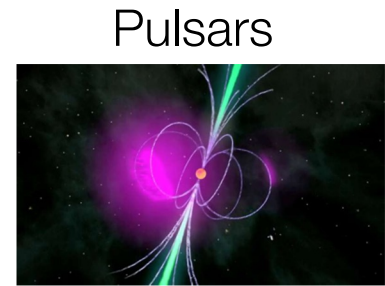
LAT Automated Science Processing (ASP) + Flare Advocates
Likelihood
6 & 24 hour
ATels

Fermi LAT Monitored Sources (21)
Daily, Weekly above $10^{-6} \text{ cm}^{-2}\text{s}^{-1}$

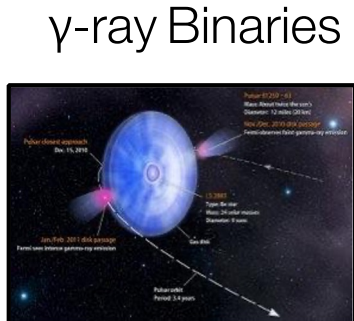
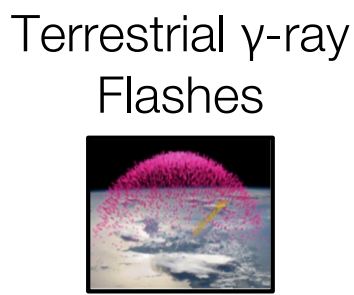
LAT Catalogs
Likelihood, associations
FGL



Photon Timing



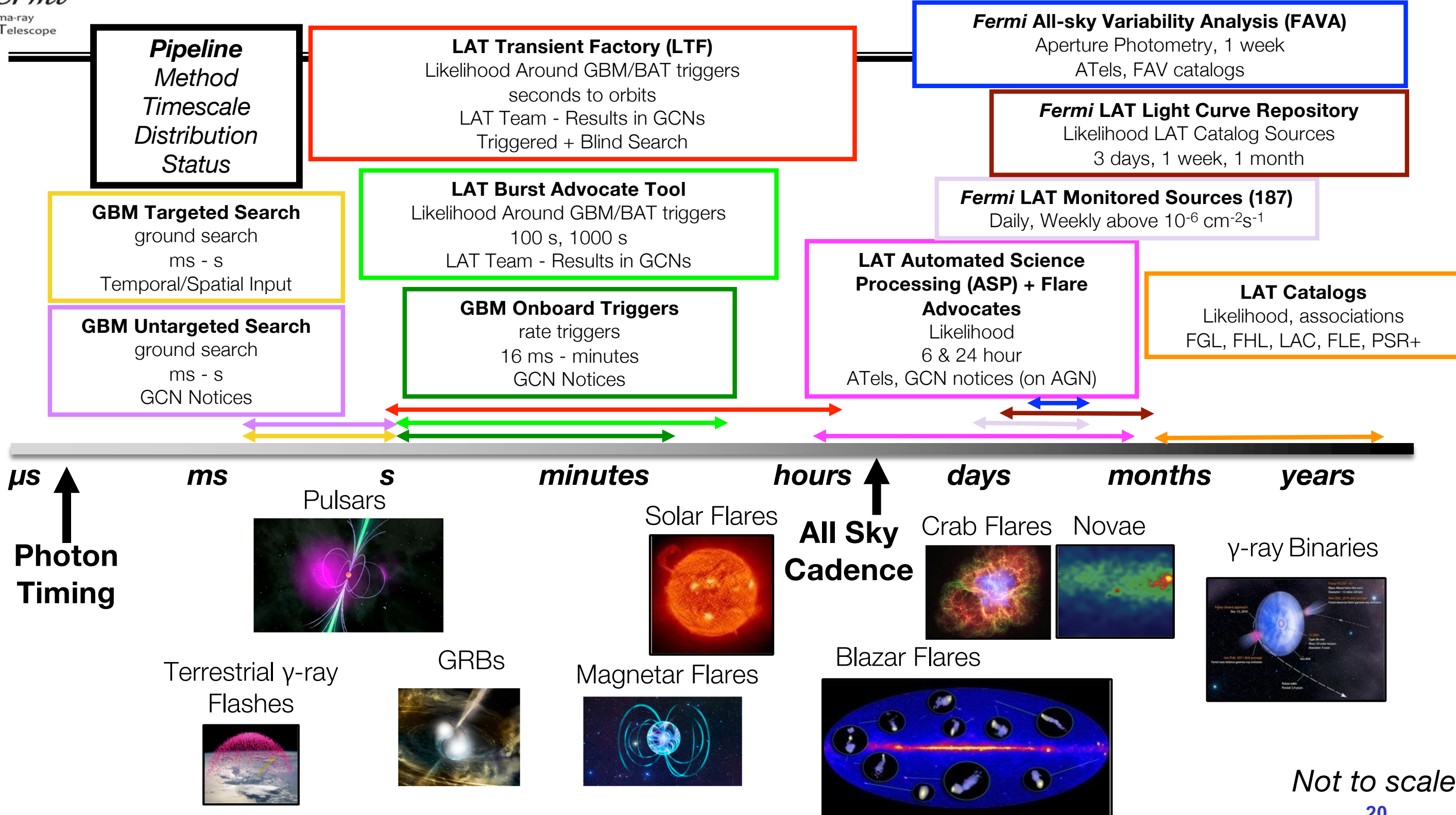
All Sky Cadence



Not to scale

Fermi Transient Searches

Transients Timescale Pipelines



Not to scale

Mission Responses to TDAMM Priorities

- **Observational responses**
 - **Continue to provide high efficiency survey of the sky – maximize probability of coincident observations of neutrino and gravitational wave events**
 - **Minimize down time for instruments**
 - **Reduced region where LAT pauses data acquisition for the South Atlantic Anomaly**
 - **Limiting calibration and engineering activities during LIGO/Virgo/KAGRA O4 run**
 - **Adjusted collision avoidance maneuver process to avoid interruption of science data taking**
 - **Maintain high efficiency for receiving real-time alerts containing onboard GRB locations**
 - **Exploratory tests to lower onboard GBM trigger threshold in planning**

Mission Responses to TDAMM Priorities

- **Added emphasis on enabling community multiwavelength and multimessenger activities**
 - **Dedicated analysis pipelines and public communications of results**
 - **Updates to use new GCN system for communicating transient events**
 - **Targeted search developed for gravitational wave counterpart searches is general and can be used for other astrophysical events**
 - **Enhancement of subthreshold searches of GBM data for external events**
 - **Additional automation streamlines search and notification process**
 - **Joint activities provide improved localization and enhance sensitivity of searches**
 - **New public data products support multimessenger and time-domain activities**
 - **LAT light curve repository provides updated, high-quality, mission-length light curves for ~1500 variable sources – expanding to include time series analysis**
 - **Third pulsar catalog will provide timing and spectral characterizations over 14 years for >280 pulsars**
 - **Summary tables of LAT observations of GW events released during O4**

Food for thought today

- **Fermi has**
 - **capabilities and synergies with a large range of observatories and facilities**
 - **Strong mission outlook and no planned successor**
 - **Pushed boundaries on open data and software and collaborated with a highly-engaged user community in innovative ways**
- **What opportunities are there to grow use of Fermi data?**
- **What are barriers to use of the data?**
- **What are barriers to new uses and new users?**

Concluding update from the Project

The mission continues to be operationally healthy, scientifically productive, and engaged with the community and the public.

- **Observatory operations**
 - **Maintenance and issue support activities supplemented by long-term efforts to make future operations reliable and sustainable**
 - **Orbit adjustment under evaluation. Stay tuned.**
- **Science support activities**
 - **Updates and refresh activities recently completed or underway.**
 - **New personnel will help strengthen strategic areas for community support**
 - **Community science output remains prolific and high impact**
- **Social media, press and outreach continue to make results available to the public**
- **Response to TDAMM priorities**
 - **The mission has accomplished much and has lots more to do to keep ahead of the needs of new facilities and scientific developments.**

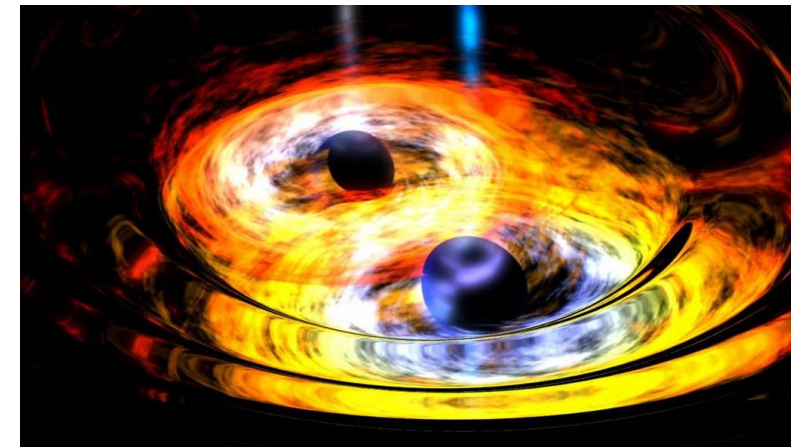
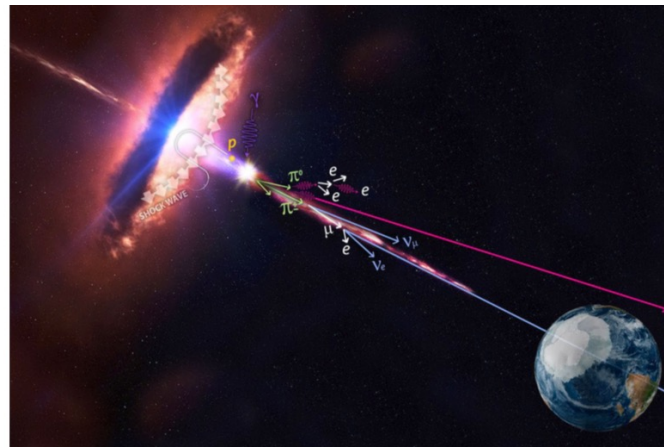
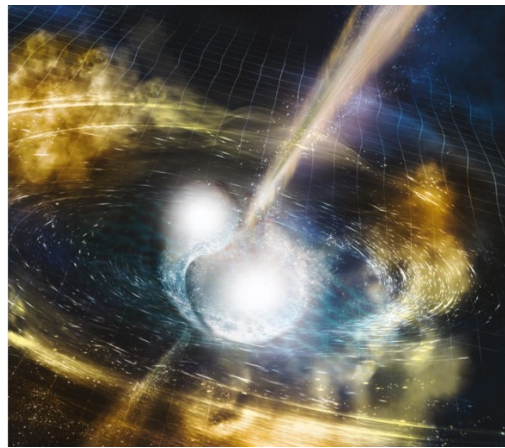
Senior Review Discussion Notes

Senior Review Discussion

- **Our timeline**
 - **Strategic community discussions -- Now – Summer 2024**
 - **FUG**
 - **Instrument teams**
 - **Fermi user community**
 - **Select key themes and initiatives – Summer 2024**
 - **Call for Senior Review proposals - early Fall 2024 (TBD)**
 - **Collect community input through the 11th Fermi Symposium – early Fall 2024**
 - **Proposal writing – Fall 2024**
 - **Proposal draft reviews – ~Nov. 2024 /early Jan. 2025**
 - **Proposal submission -- late Jan./early Feb. 2025 (TBD)**

From Senior Review 2022

- **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**
- **Fermi capabilities are key for making new discoveries within the Astro2020 Decadal Survey theme of *New Messengers and New Physics***



Progress on SR 2022 Technical Initiatives

Technical Initiative	Group	Status
II.1.1 Updating transient alert technology (KAFKA via GCN)	GBM, LAT	In progress
II.1.1 Automation of the targeted search	GBM	Done
II.1.1 Onboard threshold reduction tests	GBM	In progress
II.1.2/II.2.2 Improvement of the Light Curve Repository (LCR)	LAT	In progress
II.1.2 LAT data server improvements	FSSC	Mostly done
II.1.2 Efficiency improvements in transient source monitoring	LAT FA	In progress
II.1.3 The LAT Pulsar Portal	LAT 3PC	Stage I done
II.2.1 GBM Targeted Search Automation for FRBs	GBM	Done
II.3.1 Support connection of VHE tools to fermitools and fermipy.	LAT, FSSC	In progress

Progress on SR 2022 Science Initiatives

Senior Review 2022: Fermi Mission is extended!

- The panel report recognized Fermi's critical role in astrophysics and its strong support of the user community.
 - “Fermi provides unique access to the gamma-ray portion of the electromagnetic spectrum and the largest simultaneous field-of-view of any space telescope. Its data give us a time-domain view of the entire gamma-ray sky and are a crucial asset for gravitational-wave and multi-messenger astrophysics.”
 - “Strong synergies with other surveys, in particular new surveys that represent new technical capabilities, has and will continue to be a significant strength of the Fermi mission.”
 - “The usability of Fermi data and user support for data analysis are strong.”
- Mission Extension covers FY23 - FY25 with guidelines for FY26 - FY27 subject to the next Senior Review in 2025.
- [Rest of Missions Panel Report link](#)
- [APAC Subcommittee Report link](#)

Thank you for your help and support!