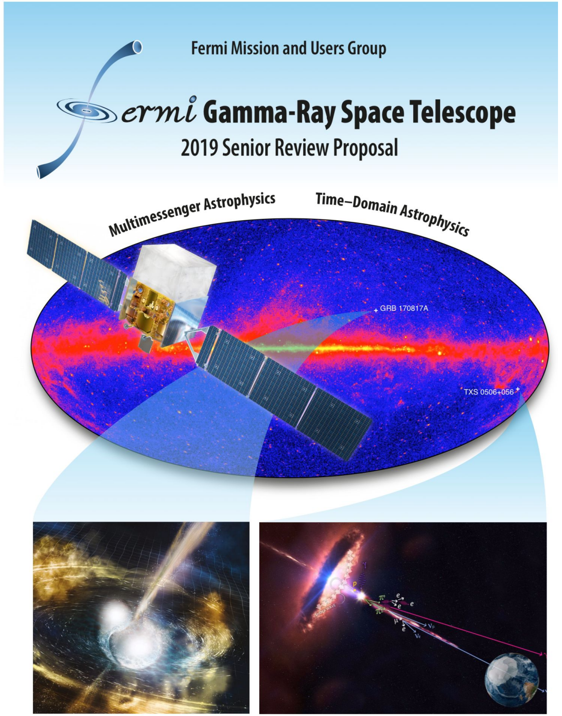
2019 Fermi Senior Review Report and Implementation Plan



Judy Racusin
(Fermi Deputy Project Scientist)

Fermi Users Group Meeting - Oct 3, 2019

NASA Astrophysics Senior Review

- “The purpose of the review is to assist NASA in maximizing the scientific productivity and operating efficiency of the Astrophysics Division mission portfolio within the available funding.”
- Process to evaluate all operating missions in extended phase for continued funding
- Review every 2-3 years (hopefully switching to 3 year cadence going forward)
- 2019 Missions
    - Main panel - Swift, Fermi, NuSTAR, NICER, TESS, XMM-Newton (US funded portion)
    - Separate panels - Chandra, Hubble
- Consequences
    - future funding profile for next review period (FY20-22), and notional for following period (FY 23-24)
    - someday will determine end of mission (and deorbit)

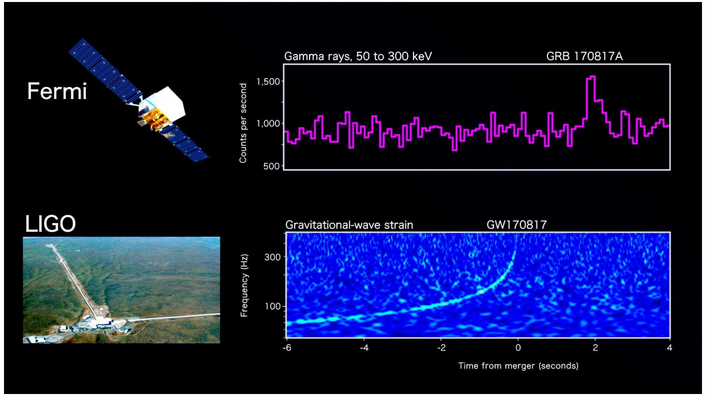
Proposal Components

- **Scientific merit**, including that of the project itself, and its **unique capabilities** and relevance to the stated Astrophysics research objectives and focus areas as part of the overall Astrophysics mission portfolio. Missions having a comprehensive and extensive GO/**GI program** should be prepared to discuss the relative merits and scientific productivity of these programs compared to alternate sources of research funding within the Astrophysics Division Research & Analysis portfolio;
- **Promise of future impact and productivity** (due to uniqueness of capabilities, wavelength coverage, etc.) (again, missions with GO/GI programs should be prepared to discuss the promise of those programs);
- **Progress made toward achieving the PMOs** identified in the 2016 Senior Review proposal (for missions that were subject to the 2016 SR);
- **Impact of past scientific results** as evidenced by publications, citations, press releases, etc., and how that ties into future promise;
- Broad **accessibility, usability, and utility of the data**, both as a unique mission and as a member of the Astrophysics mission portfolio, focusing on the cost efficiency, technology development, data collection, archiving, and distribution;
- **Spacecraft and instrument health and safety**;
- **Level and quality of observatory stewardship** (e.g.,maximizing the scientific return while minimizing the ongoing costs);
- In the context of the expected lifetime of the mission, the project's **plans to prepare for the future** by providing the **training, mentoring and leadership opportunities** that will expand the skills of its staff, as well as foster the next generation of mission leaders; and
- **Effectiveness of communications and communications plans**, including communication with the science community and the general public.

Prioritized Mission Objectives (Science Themes)

Gravitational Wave Counterparts

- GBM detected GRB 170817A 1.7 seconds after GW170817 binary neutron star merger
- Enormous follow-up campaign revealed blue and red kilonova, off-axis afterglow
- Event demonstrated
  - proof that short duration GRBs come from binary neutron star mergers
  - speed of gravity = speed of light to 10^{-15}
  - jet structure in GRBs
  - heavy element nucleosynthesis
  - constraints on Hubble constant

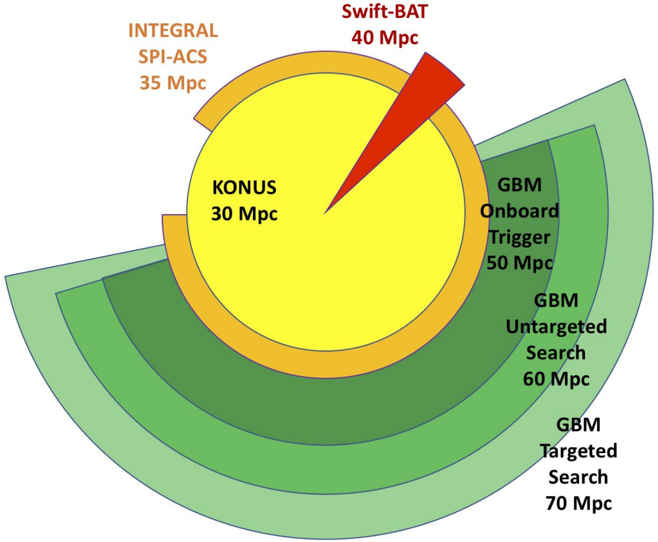


- Need more BNS mergers (also NS-BH?)
- GWs are stronger along the jet axis, boosting joint GW-GRB probability given geometry alone
- Worth searching in LAT too, but lower probability of detection

Gravitational Wave Counterparts

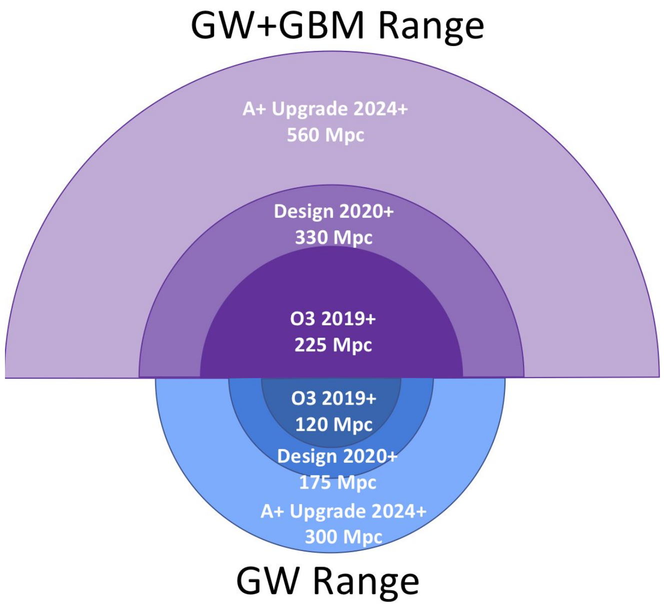
- GBM is the most prolific detector of sGRBs
  - 70% instantaneous field of view
  - sensitivity
  - sub-threshold ground pipelines only increase this capability (uses hourly CTTE)
    - Untargeted Search - blind search for rate increases, improved background modeling, triggering, relative to onboard triggers
    - Targeted Search - given temporal and (optionally spatial) seed, performs coherent search of all detectors
  - Plan to reduce onboard trigger threshold to reduce latency of lower significant events

GRB 170817A Detectability



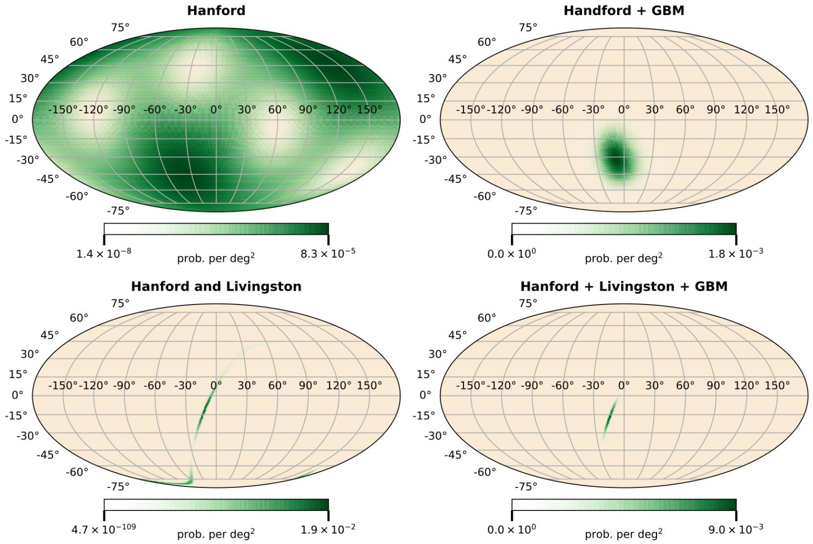
Gravitational Wave Counterparts

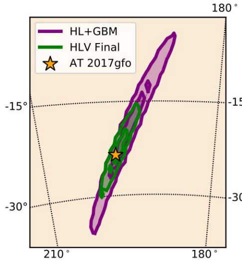
- Coincident GRB provides more than astrophysics, but also joint localization and detection, increasing capability
- GRB provides trigger time and rough sky localization, allows GW search window to be smaller, and therefore more sensitive given trials



Gravitational Wave Counterparts

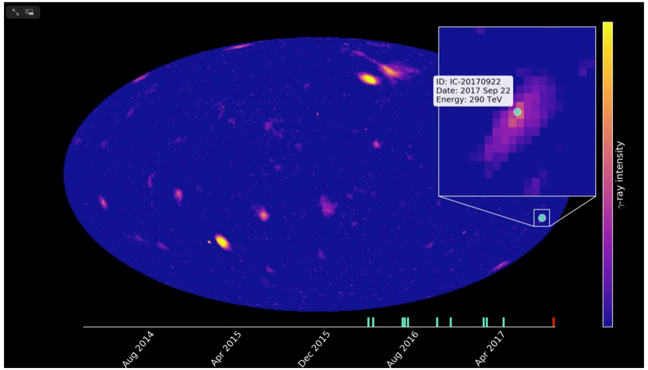
- GRB localization acts as an additional interferometer in GW network for localization
  - Especially important for 1 or 2 interferometer localizations
  - GBM localization provided within seconds of detection
- Joint localizations with LIGO are going to be provided automatically in O3

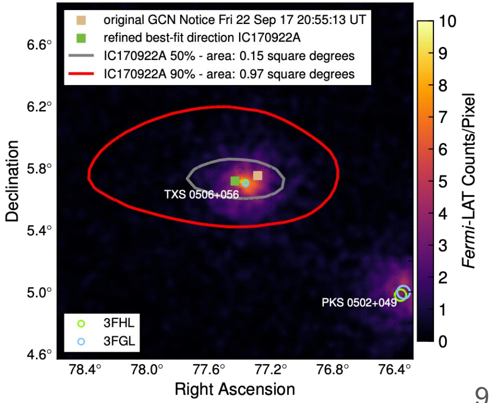




Neutrino Counterparts

- LAT all-sky monitoring, provided ~3σ association of high-energy neutrino with TXS 0506+056
- Follow-up campaign led to detection in X-ray (Swift), VHE (MAGIC), radio, etc.
- Implies some blazar jets have hadronic component, which makes them a source of extragalactic cosmic rays
- LAT is uniquely capable for these measurements because of long-term monitoring of thousands of blazars





γ-ray Source Light Curve Library

- General purpose repository for LAT transients and variable sources hosting at FSSC
- Timescales - days, weeks, months
  - allows high-fluence or high-flux intervals to be found more easily
- Monthly transient list
  - source locations, position uncertainties, detection significances, fluxes, fluences, spectral indices, and possible MW/MM associations

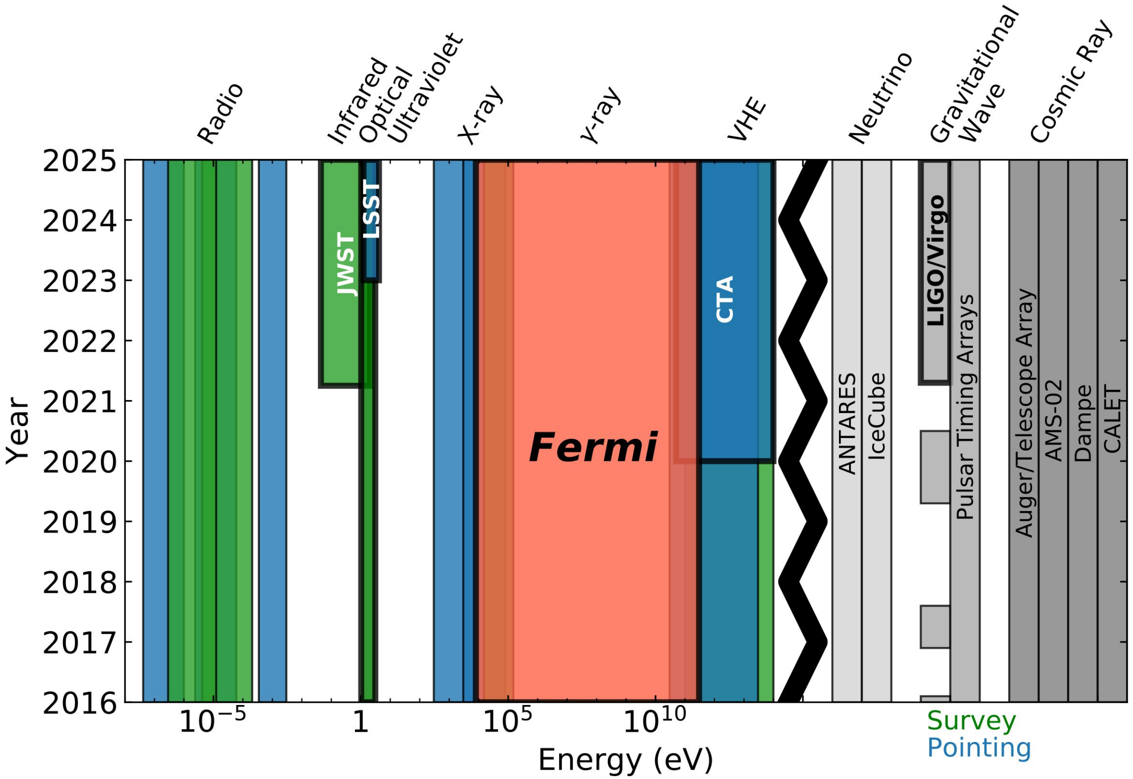
Multimessenger PMO Goals

Over the next five years the **multimessenger astrophysics PMO** with *Fermi* will:

- Disentangle emission structure, dynamics and viewing geometry of neutron star-neutron star mergers with detections of additional sGRB-GW counterparts;
- Use sGRB-GW time delays as probes of cosmology, fundamental physics, and neutron star physics;
- Resolve emission mechanisms in blazars by finding γ-ray flares in coincidence with ultra-high-energy neutrinos detected by IceCube.

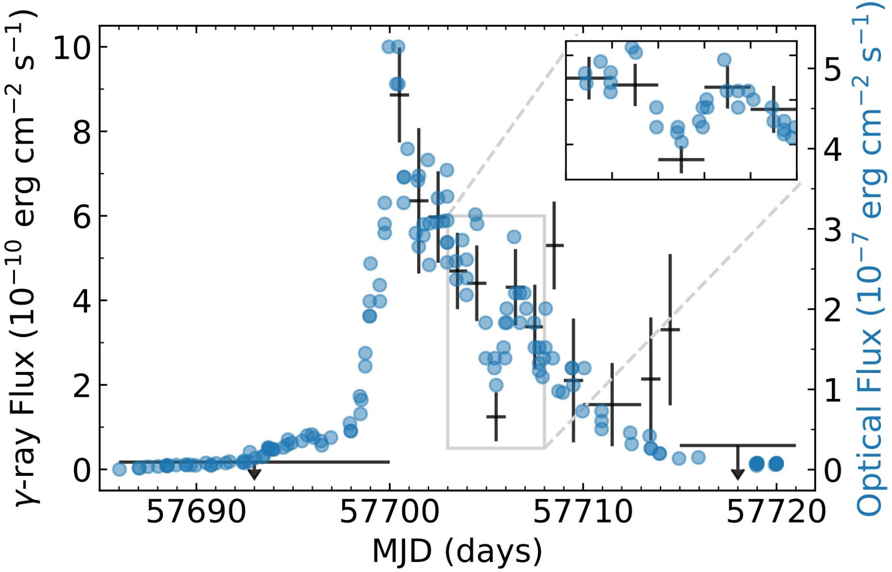
Time-Domain Astrophysics

- Fermi is uniquely capable in viewing the entire gamma-ray sky
- New facilities have recently come online or will in the next few years providing new opportunities for joint science

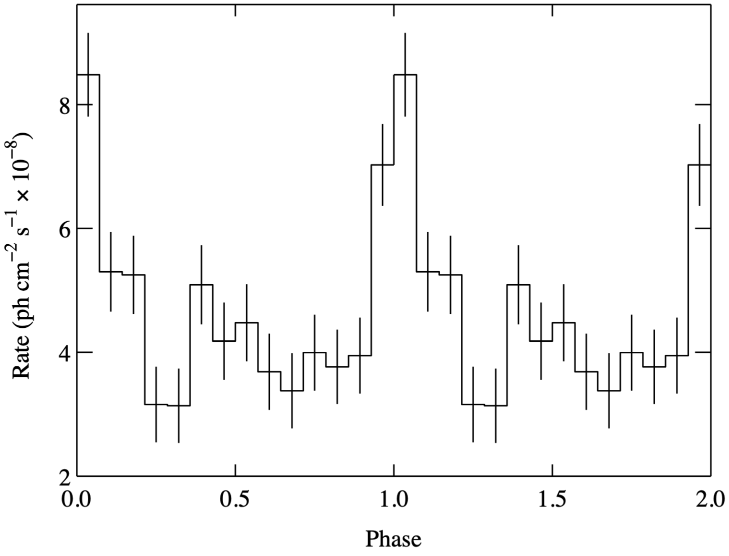


Particle Acceleration in Galactic Binaries

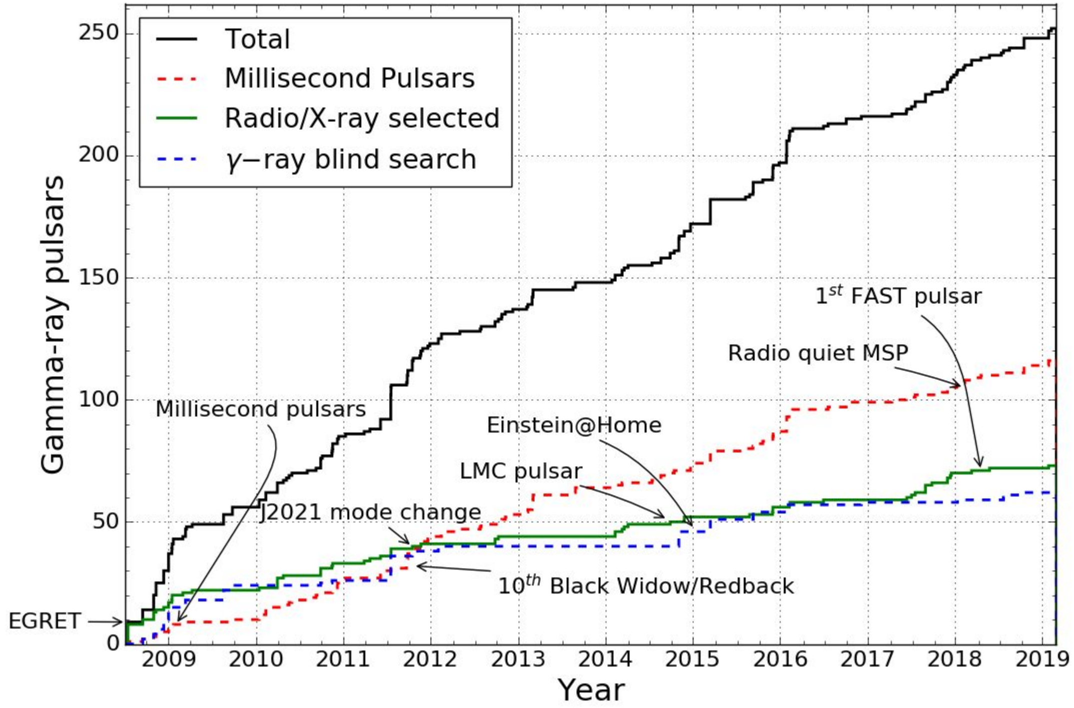
Gamma-ray Novae



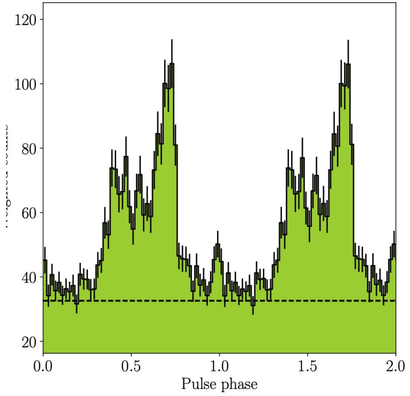
New Galactic Binary



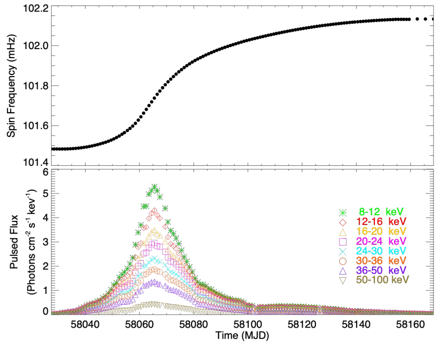
Pulsar Discoveries and Applications



Blind-search pulsars

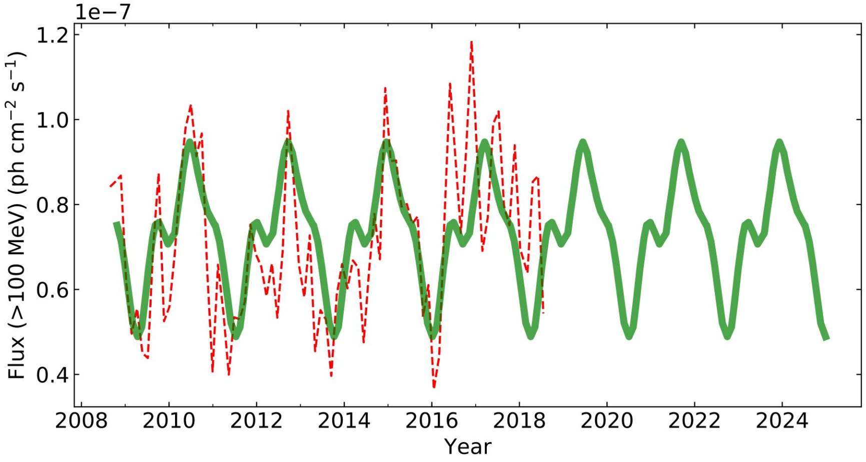


Super-Eddington Pulsar (GBM)



~Periodicity in AGN

- PG 1553+113 appears to be continuing its quasi-periodic 2.2-year cycle with >99% significance
- Additional candidate systems
- Binary systems or jet instabilities
- Need more cycles



Time-Domain PMO Goals

Over the next five years, the **time-domain astrophysics PMO** with *Fermi* will:

- Resolve the physical processes at work in super-Eddington γ-ray novae and other Galactic binaries by measuring light curves of bright novae simultaneously with observations at other wavelengths and extending the observations of long-period binaries;
- Explore and interpret the growing diversity of γ-ray pulsar systems with continued observations and extensive modeling of their temporal and spectral characteristics, as well as adding new millisecond pulsars to pulsar timing arrays;
- Identify new temporal behavior only measurable with long baselines, such as binary supermassive black holes.

Multiwavelength Synergies

- VHE - Many results from follow-up to/from IACTs (MAGIC, H.E.S.S., VERITAS), HAWC
  - CTA is coming soon
  - GRB 190114C/180720B are a nice recent demonstrations
- X-ray
  - NICER/NuSTAR
  - XIPE polarizations coming soon
- Optical surveys
  - Pan-STARRS, GOTO, Evryscope, ZTF, ATLAS
  - LSST coming soon
- Radio
  - VLBA (e.g. MOJAVE)
  - FAST, LOFAR, MeerKAT, MWA, SKA
  - Event Horizon Telescope, VLASS

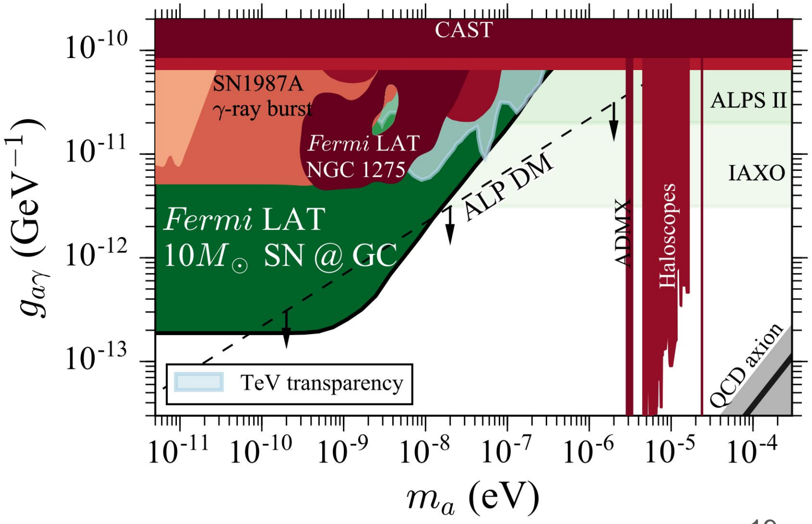
Multiwavelength PMO Goals

Initiatives as part of the **time-domain astrophysics PMO** over the next five years will support **multiwavelength synergy studies** with *Fermi*:

- Increase prompt alerts for TeV observations of events (e.g., GRBs, AGN flares) that probe the EBL by implementing a spatial/temporal clustering search for >10 GeV γ rays, for systematic;
- Constrain accreting pulsar geometries via simultaneous timing and spectroscopy in cooperation with *NICER* and *NuSTAR*;
- Transform the exploration of optical/γ-ray transients with the opportunities provided by new large optical surveys (e.g., ZTF, LSST);
- Enhance pulsar timing array gravitational wave searches and knowledge of neutron star physics by expanding the number and the variety of γ-ray pulsars in cooperation with the FAST and SKA pathfinder radio telescopes.

Low Probability/High Reward

- Fermi needs to keep flying, especially in case of:
  - Giant Magnetar Flares
  - Axion/ALPs from Galactic supernova
  - UHECRs



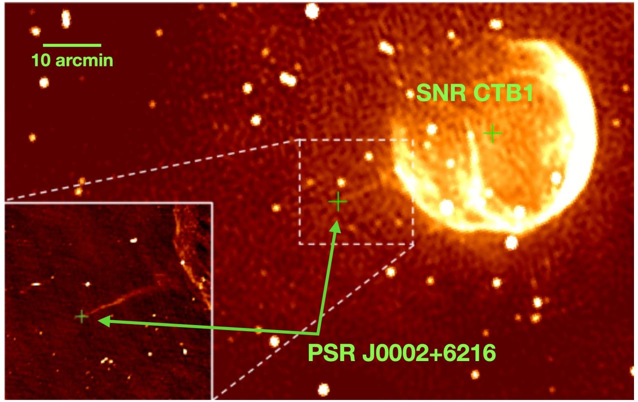
Achievements/Status of 2016 Goals

Table 1: **Scientific and Technical PMOs and Goals listed in the 2016 Senior Review proposal**

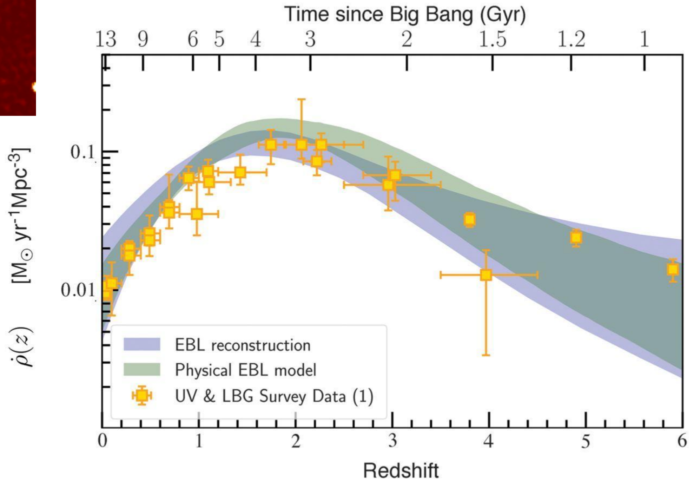
PMO/Goal in 2016 Proposal	Status
PMO: Multiwavelength/Multimessenger	
Identify potential electromagnetic counterparts of Advanced LIGO/Virgo gravitational wave events.	Complete First counterpart discovered! See **Fig. 1**
Enhance the detection capability of the stochastic gravitational wave background by adding pulsars to the International Pulsar Timing Array.	Complete More pulsars discovered; see **Fig. 9**
Evaluate correlations between γ-ray sources and neutrinos.	Complete First correlation found; see **Fig. 2**
Expand observations of AGN, variable pulsar sources, GRBs, and new transients with new facilities.	Complete See, e.g., **Fig. 11**
PMO: Time domain astronomy	
Determine the variable particle acceleration/interaction of long-period γ-ray binaries.	Complete Example: PSR B1259−63 results [28]
Measure variability in mode-changing and transitional pulsars on times <1 day to ascertain alterations in accretion or magnetic field configurations.	Complete Transitional pulsar study published [85]
Use any detections of a magnetar giant flare to study neutron star interiors and environments; these could be the origin of Fast Radio Bursts.	Pending Still waiting for the next giant magnetar flare
Substantiate the periodic nature of AGN such as PG 1553+113, testing the binary supermassive black hole interpretation.	Complete Example: **Fig. 10**
PMO: Dark matter searches	
Probe WIMP masses as great as 350 GeV using LAT observations of dSph galaxies.	In Progress See **Sec. III.2.4**
Determine the origin of the Galactic Center GeV excess in the context of the dSph studies, by reducing systematics due to diffuse emission modeling and uncertainties in the point source populations there.	In Progress Subject of several papers suggesting point source origin. See, e.g., [86]
PMO: Particle astrophysics:	
Test models, including magnetic reconnection, in a variety of variable sources.	Complete Example: AGN jet reconnection; see [87]
Explore formation mechanisms for supermassive black holes by detecting new MeV blazars below 100 MeV.	Complete New MeV blazars discovered; see [54]
Resolve spatial and spectral variations of bright LAT SNRs to diagnose in situ acceleration/propagation/interaction of cosmic rays.	Complete Example: SNR G326.3−1.8 [88]
Probe multiple emission components from Eta Carinae and other binaries by extending spectral measurements above 30 GeV.	Complete Eta Car results extended [89]
PMO: Studies of transient sources	
Reduce latency from photon detection through public release by 2−3 hours.	Complete Achieved by adding downlink contacts
Implement new pipelines for transient source searches on various timescales.	Complete Example: FAVA improvements [90]
Halve the time to disseminate transient source detections and for implementing short-term (days) TOO requests.	Complete Achieved by adding downlink contacts
PMO: Long time baseline studies	
Produce a model for residual Earth limb emission to extend analyses <100 MeV.	Complete Found workaround with PSF event types
Develop a higher fidelity Galactic diffuse emission model with Pass 8.	Complete Used for 4FGL [91]
Develop new source catalogs for long time baseline observations.	Complete Examples: 3FHL [92], 1FLE [93], 4FGL [91]
Reduce the systematic uncertainties by updating the instrument response functions for Pass 8 based on in-flight data.	In Progress New data release P8R3 [94] has reduced CR leakage; in-flight IRFs in test

Scientific Achievements

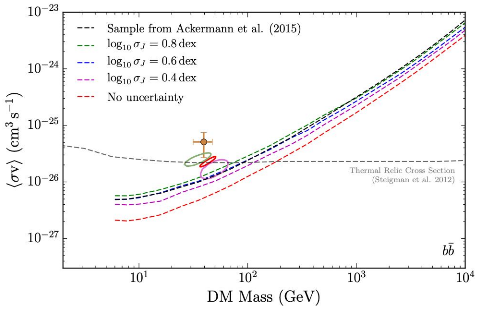
Proper Motion of PSR J0002+6216A

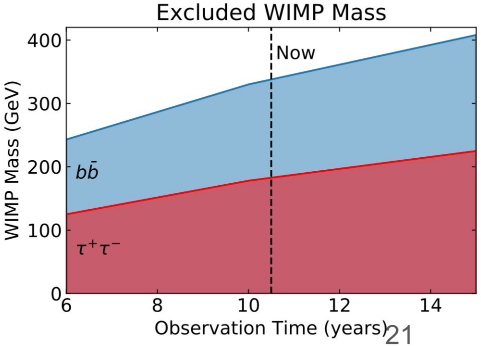


Star Formation History from EBL Measurement



Dark Matter Limits from dSphs





Technical Achievements

- LAT
  - P8R3 - removed residual backgrounds
  - Fermipy - python wrapper with analysis aids for LAT analysis
- GBM
  - RoboBA - automated burst advocate tasks
  - GSpec - new python/XSPEC analysis tool

Communications

Table 2: **Science Communication Reach**

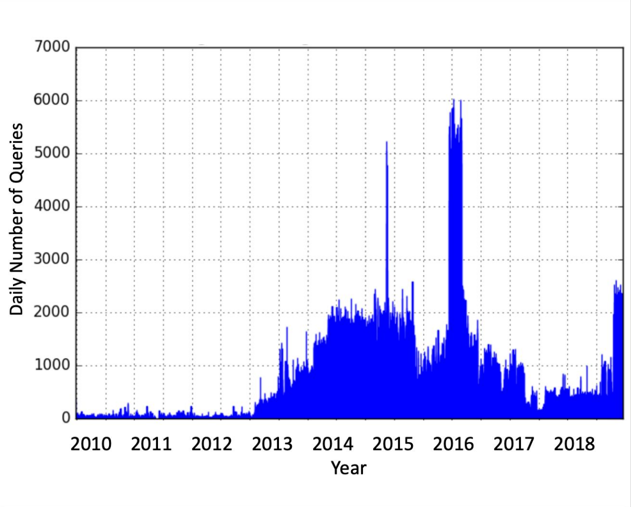
***Fermi* Science Communications Product**	**Interactions**
NASA/NSF Gravitational Wave Press Reach	>5.4M Views*
NASA/NSF Neutrino Press Reach	>2.9M Views*
Fermi Science Visualization Studio	>2M Views (2018)
Fermi Birthday Video	>230k Views
Fermi Constellations	>30k Views
Science Playoff	10k Votes
Twitter (@NASAFermi)	62k Followers
Facebook (@NASAFermi)	27.7k Followers

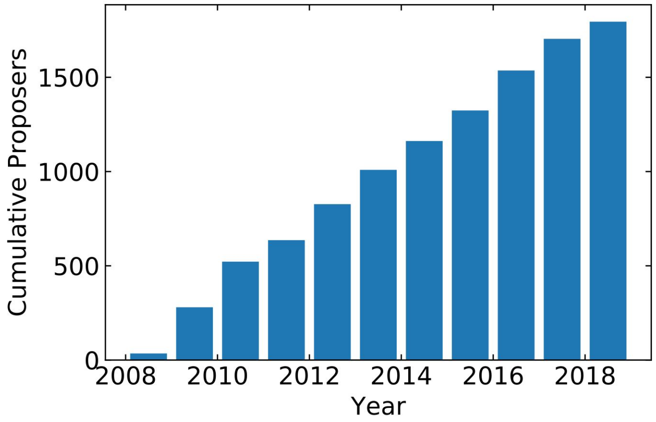
*NASA Social Media interactions only, does not include television audiences or partner content

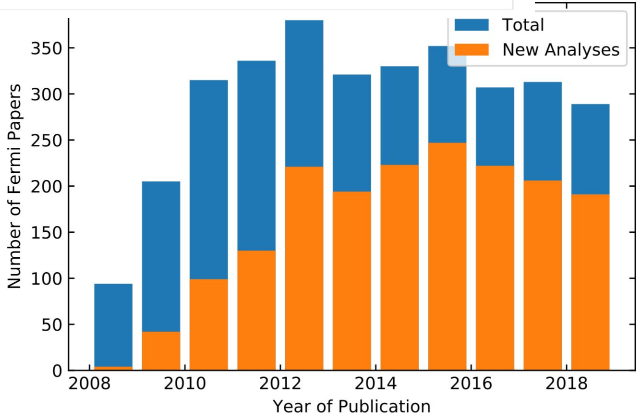
Technical Status of Teams and Observatory

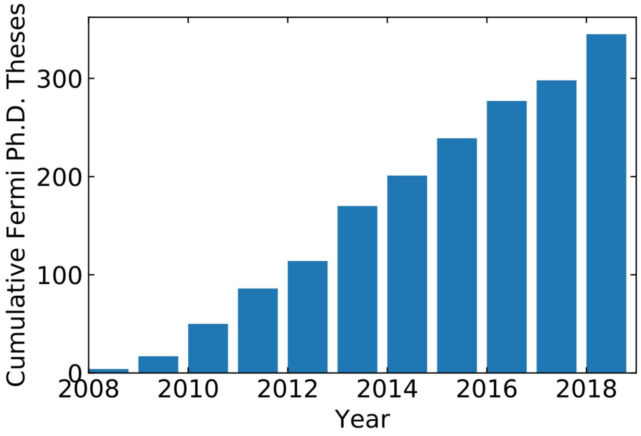
- Mostly Covered by Liz’s talk - everything is going well!
- DOE-NASA LAT science operations realignment in 2018
- Entirely new flight operations team in 2018 (due to contract changes)
- Solar Array Drive Assembly anomaly and minimal impact on observing profile

Metrics


Daily Number of Queries
7000
6000
5000
4000
3000
2000
1000
0
2010 2011 2012 2013 2014 2015 2016 2017 2018
Year


Cumulative Proposers
1500
1000
500
0
2008 2010 2012 2014 2016 2018
Year


Total
New Analyses
Number of Fermi Papers
350
300
250
200
150
100
50
0
2008 2010 2012 2014 2016 2018
Year of Publication


Cumulative Fermi Ph.D. Theses
300
200
100
0
2008 2010 2012 2014 2016 2018
Year

Panel Report

"The Panel finds no scientific reason to discontinue or substantially reduce the funding or scope of any of the six missions under review."

"We strongly encourage NASA to continue operation of all of these missions and to fund them at a level similar to or higher than their baseline budget requests."

"The complementarity of these missions makes the overall capability of the portfolio more than the sum of its parts, especially with regard to emerging opportunities in time-domain and multi-messenger astrophysics."

"Fermi comprises the next tier because of its full-sky coverage and its unique access to the gamma-ray spectral range, both of which are enormous assets for multi-messenger time-domain astrophysics."

Ranking of Missions

Level	Missions
Tier 1	Hubble, Chandra
Tier 2	TESS, Swift
Tier 3	Fermi
Tier 4	NICER, NuSTAR, XMM-Newton

	Scientific Merit	Relevance and Responsiveness	Technical Capability and Cost Reasonableness	
Mission	**Criterion A**	**Criterion B**	**Criterion C**	**Overall Score**
TESS	E	E	E/VG	E
Swift	E/VG	E	E	E
Fermi	E/VG	E/VG	VG	E/VG
NICER	VG	E/VG	E/VG	E/VG
NuSTAR	E/VG	VG	E/VG	E/VG
XMM-Newton	VG	E/VG	E/VG	E/VG

PANEL:

Dr. Alison Coil, University of California San Diego
Dr. Megan Donahue, Michigan State University
Dr. Jonathan Fortney, University of California Santa Cruz
Dr. Mark McConnell, University of New Hampshire / Southwest Research Institute
Dr. John O'Meara, Keck Observatory
Dr. Mike Nowak, Washington University in St. Louis
Dr. Rebecca Oppenheimer, American Museum of Natural History
Dr. David Weinberg, The Ohio State University **- Chair**

Fermi's Multimessenger Role

"Swift and Fermi provide continuous monitoring of the transient high-energy sky, discovering the electromagnetic counterparts to ultra-high-energy neutrino and gravitational wave events, which can be spectroscopically monitored by other missions as they fade."

"Fermi provides unique access to the gamma-ray spectrum, and the largest simultaneous field of view of any space telescope. It provides a time-domain view of the entire gamma-ray sky and is another crucial asset for gravitational wave and multi-messenger astrophysics."

"The roles of Fermi and Swift in providing early data on the GW170817 binary neutron star merger and the TXS 0506+056 blazar outburst associated with an IceCube neutrino event are two of the highlights of the field of multi-messenger astrophysics to date, and harbingers of the opportunities ahead."

"The Swift Burst Alert Telescope (BAT) and the Fermi Gamma Ray Burst Monitor (GBM) are the two instruments that can potentially detect gamma-ray transients shorter than a few seconds that are associated with compact object mergers. The GBM instantaneously observes about half of the sky, and it localizes detected sources with an accuracy of a few degrees. ... A Fermi GBM detection provides localization considerably better than typical LIGO/VIRGO error boxes but large enough to require further scanning. The GBM observes the full sky every orbit, and the Fermi Large Area Telescope (LAT) observes the full sky every two orbits, so either could provide an early detection and few degree localization if the event produces sufficiently bright gamma-ray emission."

"The Fermi LAT will automatically provide a gamma-ray light curve (or upper limits) for any gravitational wave transient as it scans the sky every two orbits."

"Fermi and Swift data effectively increase the search volume for gravitational wave events associated with gamma-ray transients, since the signal-to-noise threshold for the gravitational-wave detection can be lowered at the locations and times of these transients."

Training for the Future

The Call for Proposals for the 2019 Senior Review asked proposals to address: “In the context of the expected lifetime of the mission, the project’s plans to prepare for the future by providing the training, mentoring and leadership opportunities that will expand the skills of its staff, as well as foster the next generation of mission leaders.”

This review was the first Senior Review to include such a request, and the responses to it ranged in quality and were generally below the panel’s expectations. For the 2022 Senior Review, the panel suggests that NASA call out as distinct elements of a desired response:

1. The project’s succession planning and the elimination of single points of failure for the leadership and support of their own mission;
2. The ways that the project provides opportunities for and mentoring of the next generation of mission leaders and mission scientists; and
3. The project’s strategies for broadening its community of users and training a diverse community of astronomers to make effective use of space-based astrophysics data.

We consider all three of these elements to be implicit in the language of the Call for Proposals, but most missions addressed primarily the third item and to a lesser degree the second.

Examples of effective strategies described to the Rest-of-Missions Panel include: (a) the Fermi mission’s encouragement of postdocs to lead scientific working groups as a way to build experience in collaboration leadership, ...

Budget Guidance

The Fermi proposal listed (relatively minor) reductions to their operating budget in their “recommended” budget, though they described this budget as “under-guide.” The panel concurs that these operating efficiencies should have only minor impact on science return and are appropriate given the stage of the Fermi mission. We recommend adopting this budget as the Fermi baseline and including the enhanced GI funding requested in the in-guide budget if APD finances allow.

If further cuts are needed, the second course of action is to seek further savings in Fermi operations, since this mission has been operating for over a decade and still has an expensive operations budget. These savings would come at a cost in science capability; retaining capabilities that support gravitational wave and multi-messenger astrophysics are the highest priority.

Criteria A: Scientific Merit

The unique features of the Fermi gamma-ray mission, including its sky coverage and huge energy span (8 decades in photon energies), have allowed it to continue its scientific productivity of past years and be at the forefront of some of the most exciting astronomical discoveries of the last few years. In particular, these capabilities allowed the GBM to detect the short-duration gamma-ray burst (GRB 170817A) 1.7 seconds after the LIGO detection of gravitational waves from the merger of two neutron stars (GW170817), and the LAT to identify the blazar TXS 0506+056 as the source of an ultra high-energy neutrino identified by the South Pole IceCube neutrino experiment. The future monitoring of the gamma ray sky will continue to yield new discoveries of this type; as the LIGO, VIRGO, and the Japanese Kamioka gravitational wave observatories improve their sensitivities, other gravitational observatories are built, and as existing neutrino and high-energy cosmic ray observatories continue and upgrade their own operations. All of these multi-messenger observations benefit from knowing what the gamma-ray sky is doing as none of them localize individual events very well on their own. Gravitational wave events will occur within the Fermi coverage, including possibly neutron star-black hole mergers and short gamma-ray bursts associated with neutron star mergers, regardless of expectations of whether or not such events will emit electromagnetic radiation. These observations and the other scientific efforts of Fermi (e.g. surveys of pulsars, binary supermassive black hole searches) test and expand our understanding of fundamental physics, general relativity, and the physical processes (relativistic particle acceleration, relativistic magneto-hydrodynamics) associated with extreme objects and events.

Criteria A: Scientific Merit (continued)

As part of the NASA portfolio, Fermi is the only mission that covers the MeV-GeV range and is the most prolific gamma-ray burst detector. The team proposes to improve and speed up its identification of fainter, less significant GBM events, which will improve its utility in identifying, confirming, studying, and localizing gamma-ray counterparts to gravitational-wave events. The LAT all-sky catalog now includes over 5000 sources, and they propose a light curve tool to allow astronomers to extract a decade of temporal behavior for gamma ray sources. One example of the synergy between operating missions in the current NASA portfolio comes from the discovery of the first ultraluminous X-ray pulsar, SWIFT J0243.6+6124. The complete characterization of this system required data from Fermi/GBM, Swift/BAT, NICER, NuSTAR, and Gaia.

Fermi's data and user support for data analysis have been improved over the history of the mission. The 2015 major update to the LAT processing (Pass 8) went well except for one event-classification aspect (some cosmic rays were misidentified as gamma rays), for which a repair was subsequently developed. Suitably reprocessed data were released in Nov 2018, and any current data are processed with the updated version. The mission provides python-based analysis tools (GSPEC, Fermipy) in addition to the Fermi Science Tools. All data are made public immediately after processing; the data are available within a day and usually sooner.

One recent example of the use of the data archive was the estimate of Hubble's constant (H0) based on redshift-independent distances estimated from the gamma-ray attenuation of 700 blazars.

Criteria B: Relevance and Reponsiveness

Fermi is highly relevant to the objectives and focus areas of the SMD Science plan. It was the top-ranked medium-scale mission in the 2001 Decadal Survey. Current Fermi science addresses two of the three priority science objectives identified in the 2010 Decadal survey: (1) "searching for the first stars, galaxies, and black holes" by discovering GRBs, and (2) "advancing understanding of the fundamental physics of the universe" by enabling our study of astrophysical jets, sources of relativistic particles, and endpoints of stellar evolution. Fermi addresses the primary goal of the 2018 SMD science plan to understand the universe. Indeed, the 2013 Astrophysics Roadmap recognizes the Fermi mission for its studies of supermassive black holes and pulsars. The detection and characterization of the "Fermi bubbles" in our own Milky Way captures the history of energetic behavior, and possible influence (feedback) into the halo gas its environment by the supermassive black hole in the center of our own Galaxy.

Table 1 of the Fermi proposal documented considerable progress against their 2016 Senior Review goals. Progress was reported for all of the stated goals. The dark matter searches and papers are still in progress, as is work on the Pass 8 instrument responses.

The RoM panel commends the Fermi team on a successful transition after the reduction of the Department of Energy funding, and the relocation/reorganization of the LAT instrument support from Stanford to Goddard Space Flight Center. Furthermore, the GSFC Flight Operations Team has successfully emerged from a change in contract.

Criteria C: Technical Capability and Cost Reasonableness

Fermi is in good health. The LAT and GBM are healthy, with no signs of degradation in performance. It did experience a failure of one of the Solar Array Drives, which prevents one of the solar arrays, still functional, from moving. This failure did not affect the observing efficiency, but one worry is that the one remaining drive could fail and leave the observatory in a severely compromised state. Two modes of observing - the traditional mode, where the LAT is pointed 50 degrees above the orbital plane for one orbit and 50 degrees below for the next one, and sinusoidal mode, where the the position rocks slightly, to keep the x-side of the spacecraft (with the solar array) pointed at the Sun - are now used. Furthermore, it is possible that if the 2nd SADA failed this two-mode approach could be adapted to minimize science impact.

The high cost of data processing and pipelines was striking to the review panel, and the cost appears to be coming from the number of FTEs working around the clock. Reduction of the human effort required in meeting the expectations of low-latency data, especially LAT data, would seem like a natural line of approach for finding further cost efficiencies in future years.

Recommendation: A NASA operations review of Fermi, including its data processing pipelines software and management, should be conducted to explore possible efficiencies and automation for monitoring the pipeline and instrument status. This review should assess when low-latency response to new data is essential to the scientific value of the extended mission (e.g., to aid in localization of gravitational wave events) and when it is desirable but not essential.

The Fermi team is doing a good job in mentoring and developing the future leaders of astronomy. The review panel commends their 8 years of hosting a summer school for graduate students to work on Fermi data, and their policies for supporting early-career team members to take scientific leadership positions for the working groups on the team.

Overall Assessment

Fermi remains unique as a true all-sky monitor, operating in an important energy band that is not adequately covered by other missions. It undoubtedly will continue to play an important role in both multi-messenger and time domain astronomy. Additionally, it has unique synergies with other instruments not replicated in the remainder of the NASA portfolio. The Fermi mission continues to provide a steady stream of important scientific results. Its synergy with LIGO/VIRGO and IceCube should not be underestimated. It also plays an important complementary role for ground-based atmospheric Cerenkov instruments, such as Veritas, MAGIC, and the upcoming CTA. Because it surveys the sky several times per day, it provides a data archive that will continue to be useful for a wide range of multi-wavelength and multi-messenger studies. Although there are some concerns about the health of the spacecraft (namely, the remaining SADA), the overall mission remains healthy. The Fermi team is taking steps towards broadening the usability of the instrument, e.g., via creating an improved pipeline for generating AGN light curves, and making it easier for users to generate data products. The panel recommends that further economies be pursued.

The proposed over-guide augmentation to the GI program and augmentation towards the development of software tools both seem reasonable, and should be funded as budget and balance allows.

HQ Response

The report of the Senior Review Subcommittee emphasizes that the eight missions in the Senior Review “constitute a portfolio of extraordinary power,” and noted that “the complementary nature of these missions makes the overall capability of the portfolio more than the sum of its parts.” The Subcommittee also found that the missions “present an appropriate balance between the broadly capable Great Observatories and the smaller scale missions that have unique capabilities in particular domains.” The report of the Senior Review Subcommittee contains recommendations that NASA continue to operate and support all eight of these missions

Fermi Gamma-ray Space Telescope
The Fermi mission extension is approved with the reduced funding that was proposed by the Project. The Fermi mission will be invited to the 2022 Astrophysics Senior Review.

https://smd-prod.s3.amazonaws.com/science-red/s3fs-public/atoms/files/NASA_Response_SR2019_Final.pdf

Fermi Implementation Plan

- The Project is preparing a white paper review of operations and efficiencies to address panel recommendations
  - In short, operations are extremely efficient and routine tasks are already highly autonomous in the interest of maximizing science output and reducing latency and errors introduced by manual activities.
- GI Program budget will be augmented by $0.5M for Cycle 13
  - Are there any recommendations from the FUG on how to put this augmentation to best use? A straightforward option is to fund more proposals. May also be interesting to consider options that target additional growth of the science program in new areas. Ideas welcome!

Fermi Implementation Plan

- Science Team Implementation
  - LAT
    - Light Curve Repository useful for neutrino flare correlation and other time-domain sources
  - GBM
    - Explore reducing onboard trigger sensitivity
    - Joint GBM-LIGO localizations (already implemented)

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TITLE:   GCN CIRCULAR
NUMBER:  25406
SUBJECT: Fermi GBM-190816: A subthreshold GRB candidate potentially associated
                with a subthreshold LIGO/Virgo compact binary merger candidate
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