
Fermi Gamma-ray Space Telescope

# 2022 Fermi Senior Review

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*Fermi Users Group Meeting, September 28, 2021*

# NASA Senior Review Process

- **"NASA's Science Mission Directorate (SMD) periodically conducts independent, comparative reviews of its operating missions. NASA uses the findings from these reviews to define an implementation strategy and give programmatic direction to the missions and projects concerned for the next five fiscal years."**
  - **https://science.nasa.gov/astrophysics/2019-senior-review-operating-missions**
- **Determines the continuation and future funding of missions through evaluation of scientific merit, relevance and responsiveness to the division's strategic goals, and technical capability and cost reasonableness**
- **Conducted every 3 years (every 2 before 2016)**
  - **Fermi participated in 2012, 2014, 2016, 2019, 2022**
  - **Other missions evaluated in the 2022 Senior Review are Chandra, Hubble, SOFIA, NICER, NuSTAR, Swift, TESS, and XMM-Newton**
  - **In 2019 Fermi was ranked third following TESS and Swift**

- **All Fermi SR Content: https://confluence.slac.stanford.edu/display/FSR/Fermi+Senior+Review+2022**
  - **All drafts will be posted here, if you don't have an account, ask Judy**

# Participation

- **Core Writing Group**
  - Seth Digel, Dave Thompson, Peter Veres, Liz Hays, Judy Racusin
- **LAT Team**
  - SR focused sessions at last 2 collaboration meetings organized around partner facilities and subtopics
- **GBM Team**
  - 2 recent SR meetings
- **Fermi Users Group**
  - https://fermi.gsfc.nasa.gov/ssc/library/fug/

# Proposal Schedule

- **Proposal Outline: August 1**
- **Draft Call for Proposals: August 5**
- **LAT Collaboration Meeting: August 30 - September 3**
- **GBM Senior Review Discussion: September 7**
- **First draft of SR proposal: September 15**
- Additional Drafts: September-November
- Internal review by LAT, GBM, FUG: October-November
- Final Call for Proposals: October 1
- Goddard Red Team Review: November 15
- SR Proposals Due: February 1, 2022
- Senior Review panel meets: April 2022
- Panel Report: May 2022
- HQ Response to Panel Report: May-June 2022

# Outline of the Proposal


**I Executive Summary** *(1 page)*

**II Science and Science Implementation: Prioritized Mission Objectives**
- II.1 Exploring Populations of Multimessenger Sources *(5 pages)*
  - II.1.1 Multimessenger Approaches to Mergers
  - II.1.2 Multimessenger Approaches to Relativistic Outflows in Blazars
  - II.1.3 Pulsar Timing Constraints on the Gravitational Wave Background
- II.2 Capitalizing on The Era of Big Surveys *(5 pages)*
  - II.2.1 Extreme Physics of Magnetars
  - II.2.2 New AGN Time Domain Activity
  - II.2.3 Transitions of Millisecond Pulsars
  - II.2.4 Shock Acceleration by Novae
  - II.2.5 Low Probability-High Reward Science
- II.3 Modeling the High-Energy Universe *(4 pages)*
  - II.3.1 Probes of Acceleration: AGN Variability
  - II.3.2 A New Population of VHE GRBs
  - II.3.3 Galactic Flaring Sources in the TeV

**III Science and Science Implementation: Scientific and Technical Achievements**
- III.1 Status of Goals in the 2019 Proposal
- III.2 Other Scientific Achievements
- III.3 Other Technical Achievements
- III.4 Guest Investigator Program
- III.5 Relevance to NASA
- III.6 Science Impact and Communications
- III.7 Responsiveness to the 2019 Senior Review Findings

**IV Technical, Management & Budget**
- IV.1 Observatory Operations
  - IV.1.1 Flight Operations Team
  - IV.1.2 Spacecraft Engineering
- IV.2 Science Operations
  - IV.2.1 LAT Instrument
  - IV.2.2 GBM Instrument
  - IV.2.3 *Fermi* Science Support Center
  - IV.2.4 Data Processing and Products
  - IV.2.5 User Support
  - IV.2.6 Rebaselining *Fermi* LAT Science Operations
- IV.3 Training for the Future
- IV.4 Budget Narrative

**Appendices**

**A References**

**B Acronym List**

**C Online Bibliography**

**D Budget**

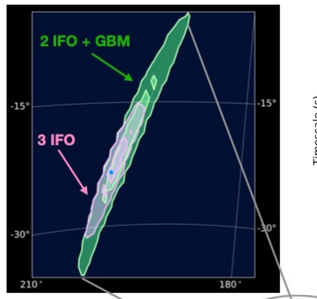
# Themes / Prioritized Mission Objectives

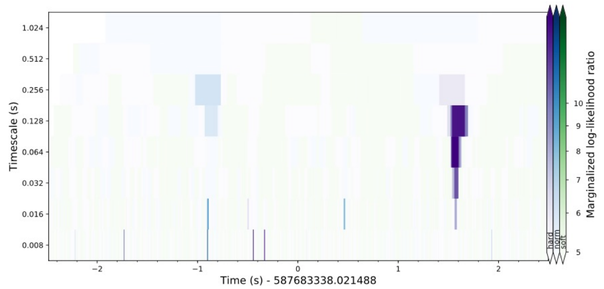
- **Exploring Populations of Multimessenger Sources**
  - Multimessenger Approaches to Mergers
  - Multimessenger Approaches to Relativistic Outflows in Blazars
  - Pulsar Timing Constraints on the Gravitational Wave Background
- **Capitalizing on The Era of Big Surveys**
  - Extreme Physics of Magnetars
  - New Flares from Known AGN
  - Transitions of Millisecond Pulsars
  - Shock Acceleration by Novae
  - Low-Probability High-Reward Science
- **Modeling the High-Energy Universe**
  - Probes of Acceleration AGN Variability
  - A New Population of VHE GRBs
  - Galactic Flaring Sources in the TeV

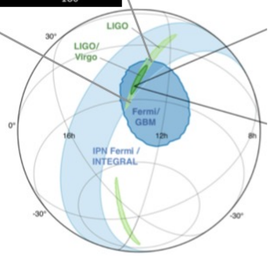
# Exploring Populations of Multimessenger Sources

## Multimessenger Approaches to Mergers

- Joint localizations
- Sub-threshold searches
- Improvements to alert dissemination



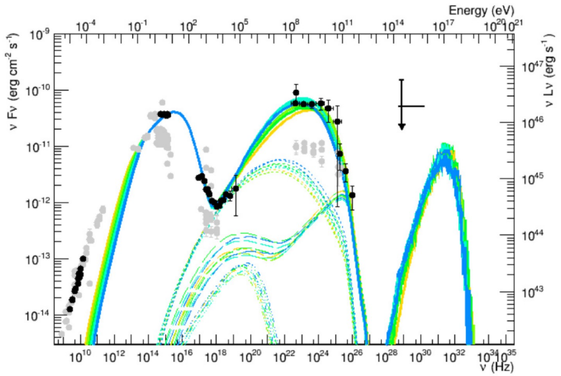




Annual number of detections [cd]

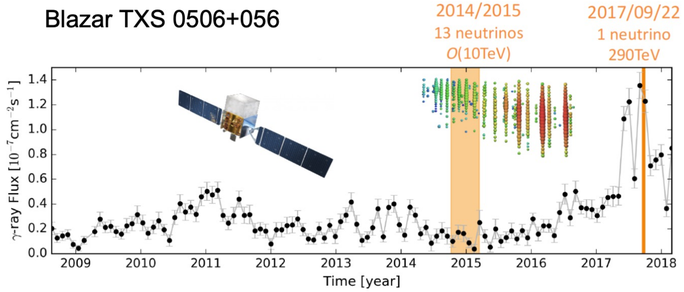
| | BNS | NSBH | BBH |
|---|---|---|---|
| O3 | $5^{+14}_{-5}$ | $13^{+15}_{-9}$ | $24^{+18}_{-12}$ |
| O4 | $34^{+78}_{-25}$ | $72^{+75}_{-38}$ | $106^{+65}_{-42}$ |
| O5 | $190^{+410}_{-130}$ | $360^{+360}_{-180}$ | $480^{+280}_{-180}$ |

arXiv:2108.07277

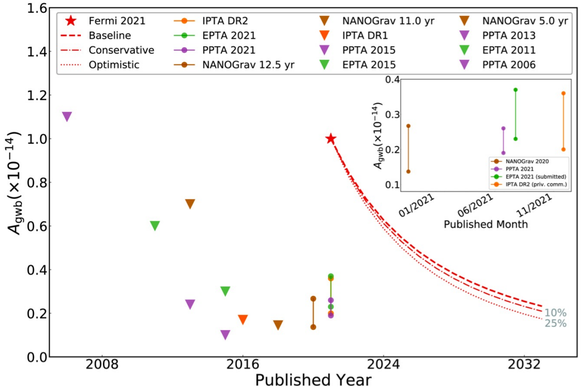
## Multimessenger Approaches to Relativistic Outflows in Blazars




- Long term blazar monitoring, coincident neutrino searches




## Pulsar Timing Constraints on the Gravitational Wave Background

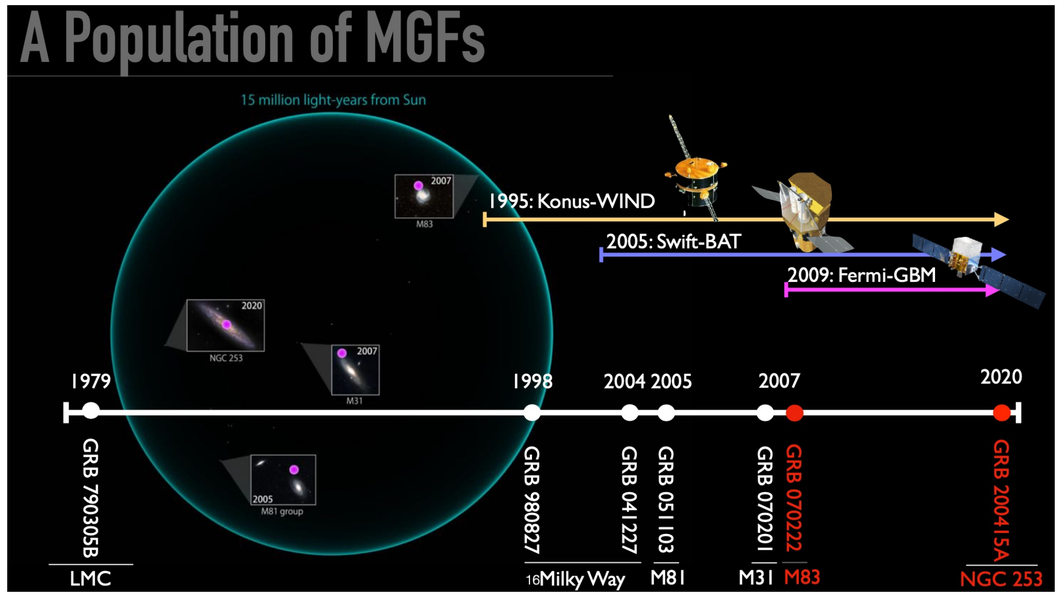



- Fermi contributed MSPs to PTAs
- Fermi as an independent PTA, limits ~comparable

# Capitalizing on The Era of Big Surveys

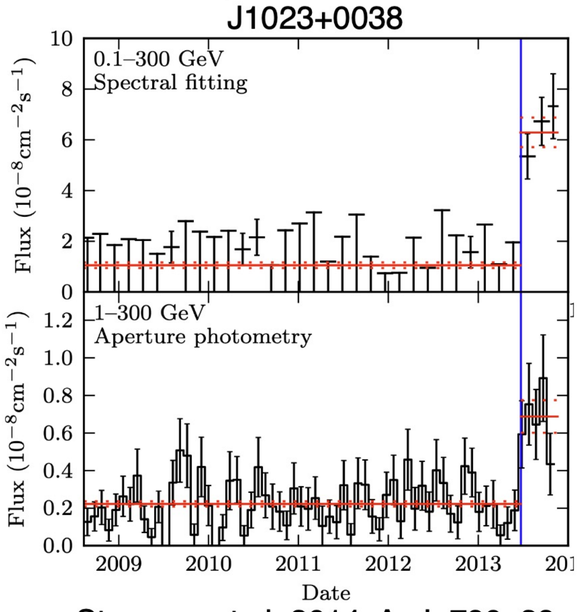
## Extreme Physics of Magnetars

- Giant Flares (Galactic/Extragalactic)
- FRB-SGR Connection
- Other transient behavior

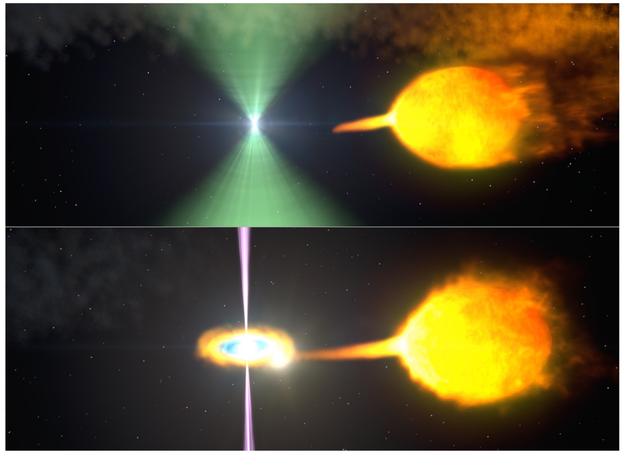



## Transitions of Millisecond Pulsars

- MSPs that transition between rotationally powered and accretion powered" states
- MW observations in era of surveys
- Unique view of systems at the end of the MSP "recycling" process



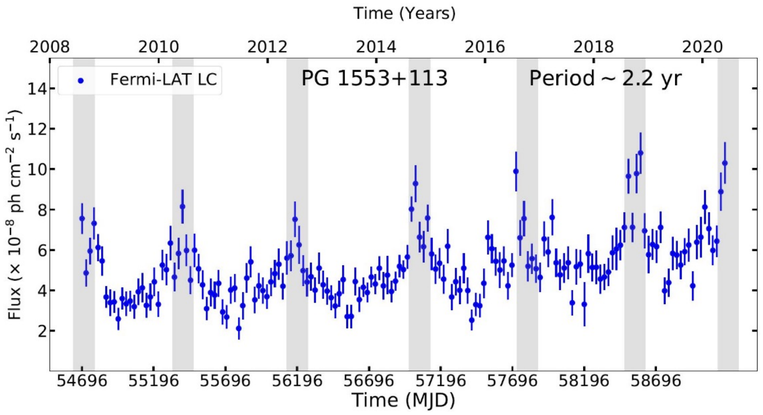

Stappers et al. 2014, ApJ, 790, 39

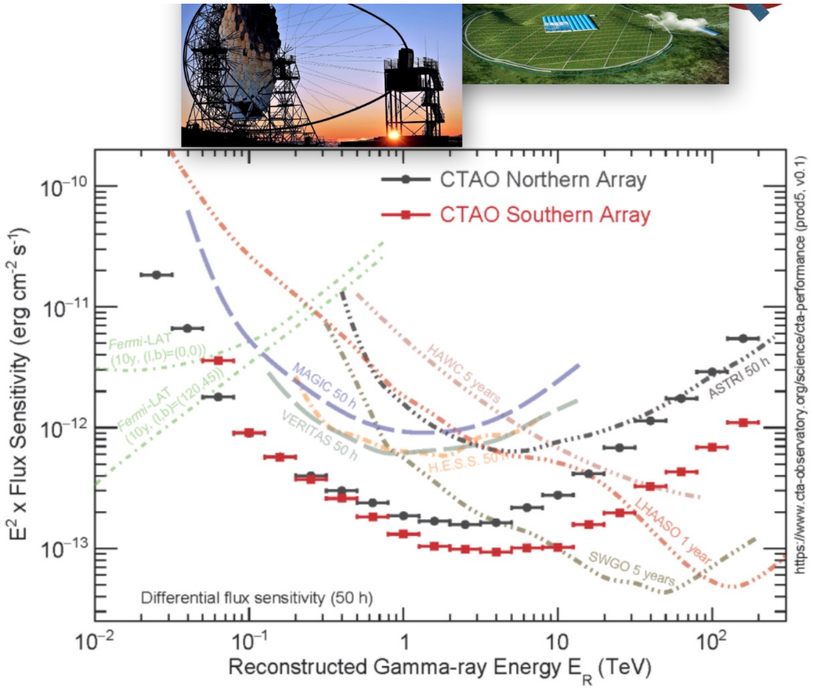


# Modeling the High-Energy Universe

## Probes of Acceleration AGN Variability

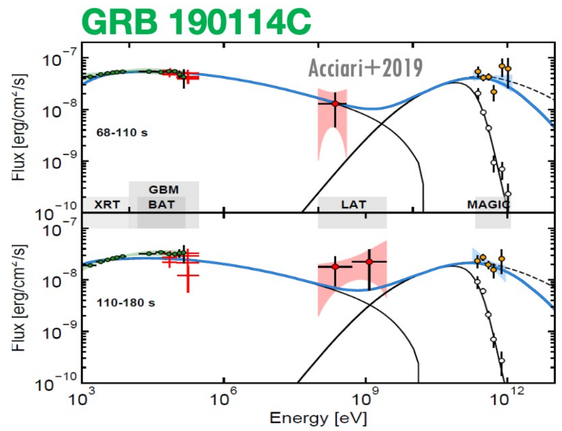
- Periodicity searches
- AGN Flares with IACTs (especially CTA), HAWC, EAS
- Lepto or lepto-hadronic emission mechanisms
- Probes of Lorentz invariance violation, Axion-like particles, EBL




## VHE GRBs

- 6 GRBs seen in VHE
- Need GBM as a trigger
- Need both GBM/LAT for modeling broadband SEDs, VHE important for SSC vs IC vs Sync

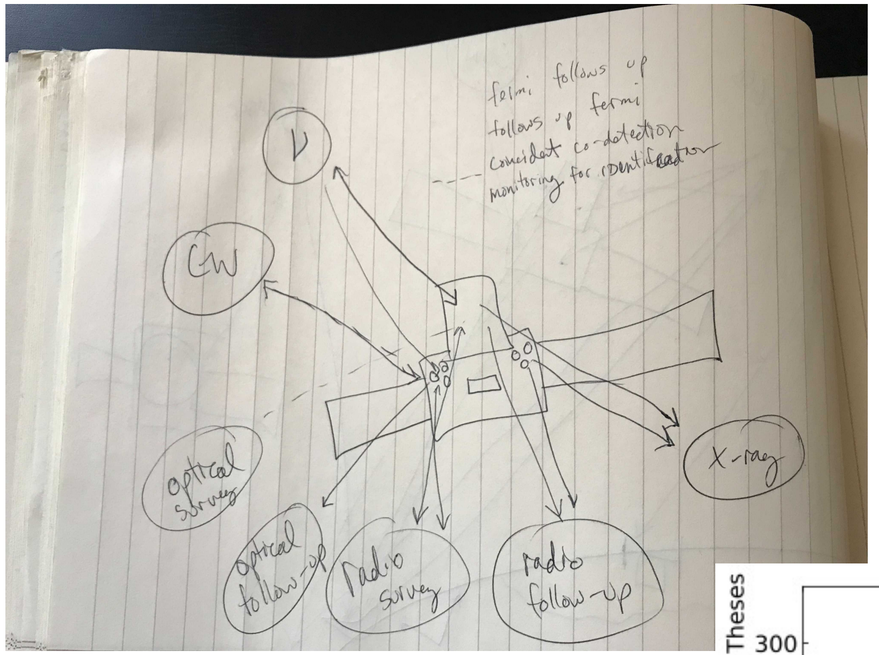


# Potential Technical Initiatives

- **LAT**
  - New Data Server Capabilities
    - expanded filtering for transient analysis (e.g. all-sky, 1 second spacecraft)
  - Exploring how to support some phased and weighted data for pulsar analyses
  - Building Upon the Light Curve repository (new features/datasets)
  - LAT SAA Definition
- **GBM**
  - New alert formats/distribution methods (e.g. TACH, SCIMMA)
  - Enable subthreshold onboard trigger? – mentioned in 2019 SR
  - GBM revising SAA definition
  - Improving response generator and atmospheric scattering, GBM data tools

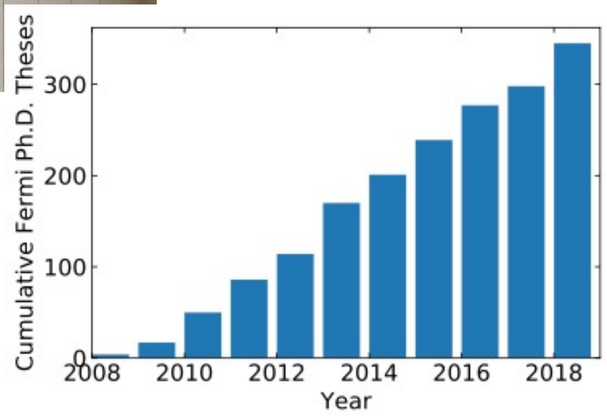
# Other Potential Figures

## Fermi Connectivity

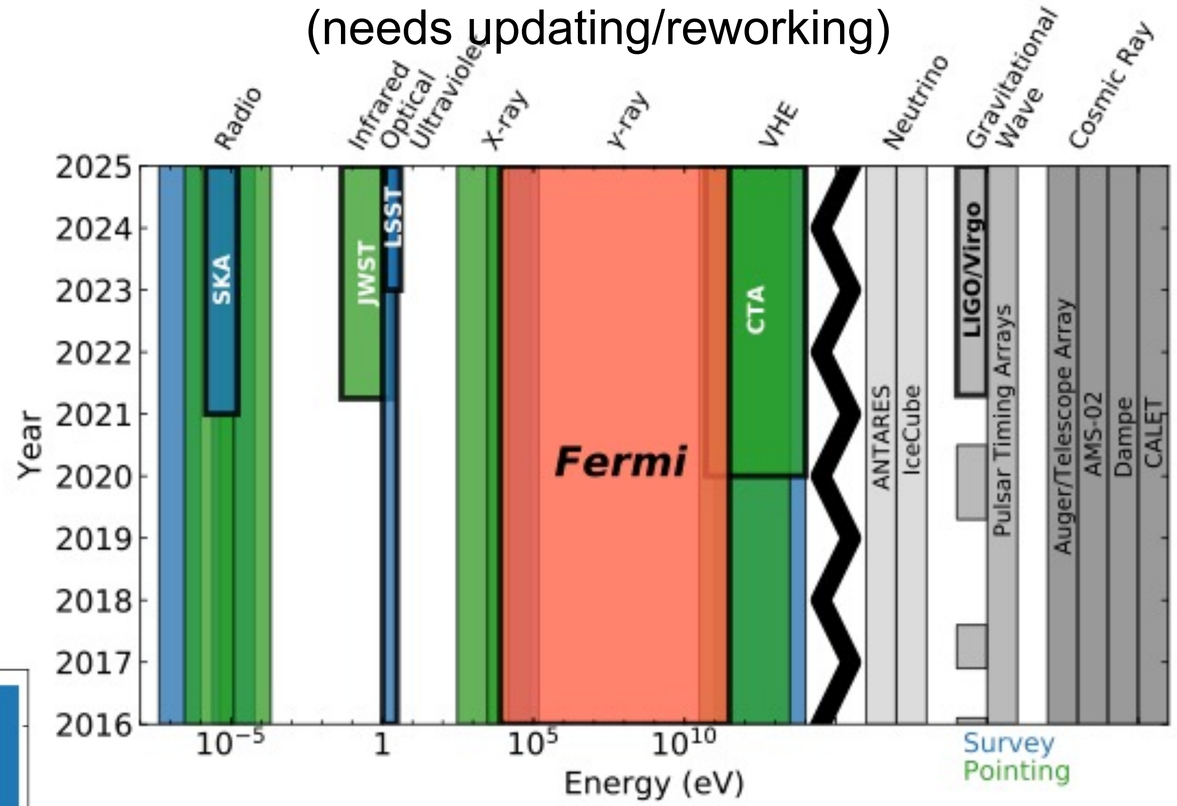



**Publication Metrics**
**GI Program Metrics**

## PhDs




## MW/MM Landscape
(needs updating/reworking)



# What we need from the FUG?

- Help with the case for GI program
- Importance of Fermi science in next 3-5 years
- Feedback on themes/structures now
- Review for new emphasis on diversity and inclusion efforts
- Read drafts of proposal in next couple of months and provide feedback
  - Release versions
  - Confluence pages for feedback