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# Fermi

Gamma-ray Space Telescope

**Data Analysis Workshop  
14 March 2010**

**Mission Overview**

**Elizabeth Hays on behalf of  
the Fermi mission team**

## Fermi instruments



### Large Area Telescope (LAT):

- 20 MeV - >300 GeV (including unexplored region 10-100 GeV)
- 2.4 sr FoV (scans entire sky every ~3hrs)

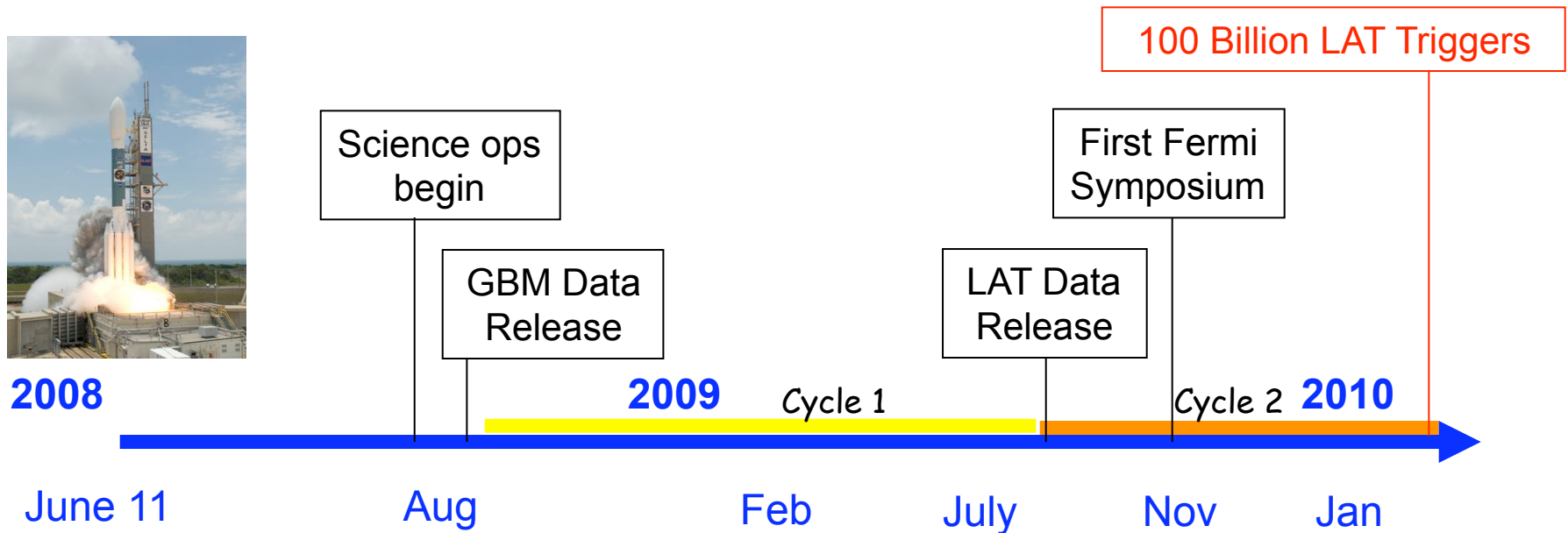
### Gamma-ray Burst Monitor (GBM)

- 8 keV - 40 MeV
- views entire unocculted sky

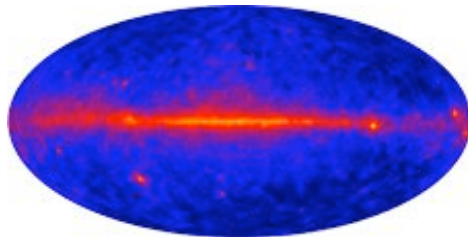
- **Large leap in all key capabilities, transforming our knowledge of the gamma-ray universe. Great discovery potential.**

# Mission Milestones

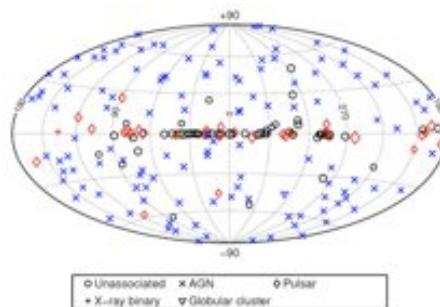
- Operations continue to be very smooth, thanks to an outstanding Flight Ops Team and great cooperation across the mission.



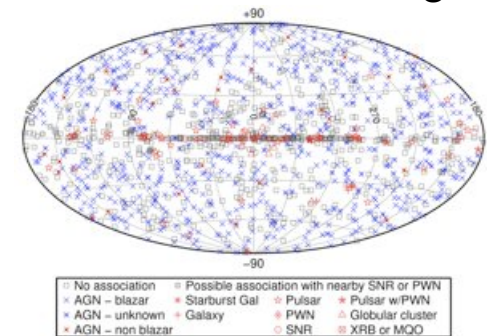
First Light



Bright Source List



First LAT Catalog

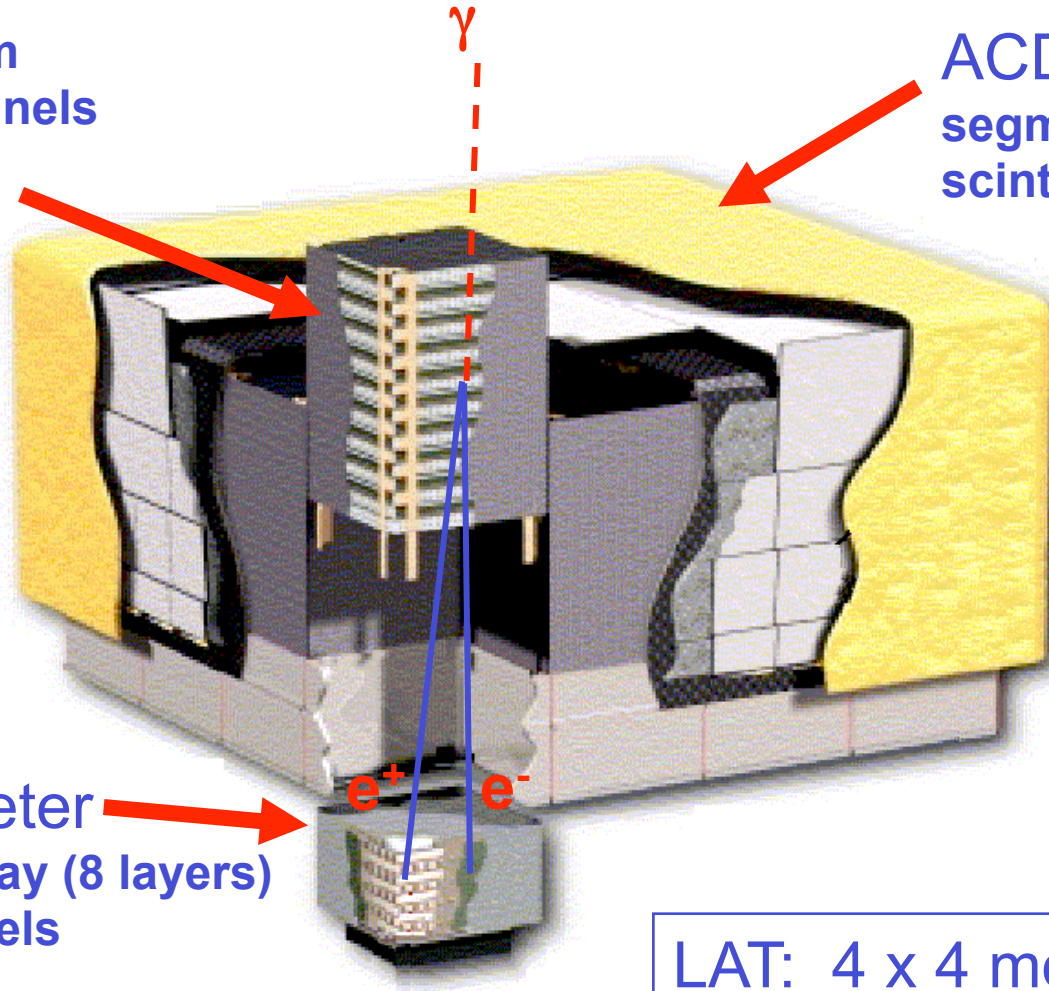


# The Large Area Telescope

## Si Tracker

pitch = 228  $\mu\text{m}$   
 $8.8 \times 10^5$  channels  
18 planes

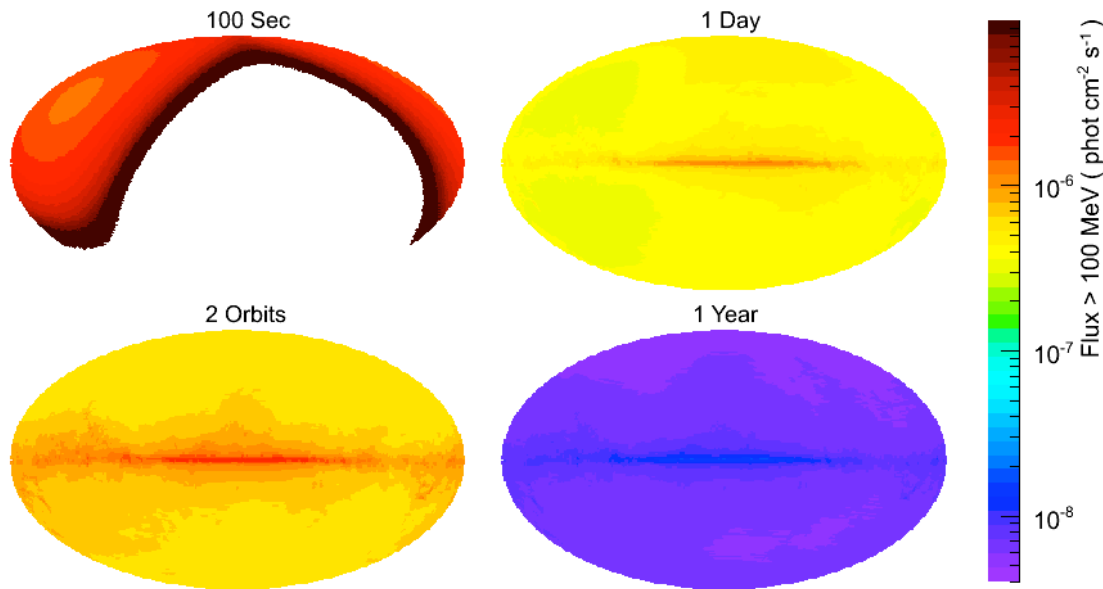
ACD  
segmented  
scintillator tiles



CsI Calorimeter  
hodoscopic array (8 layers)  
 $6.1 \times 10^3$  channels

LAT: 4 x 4 modular array  
3000 kg, 650 W  
20 MeV – 300 GeV

# Operations and observing modes



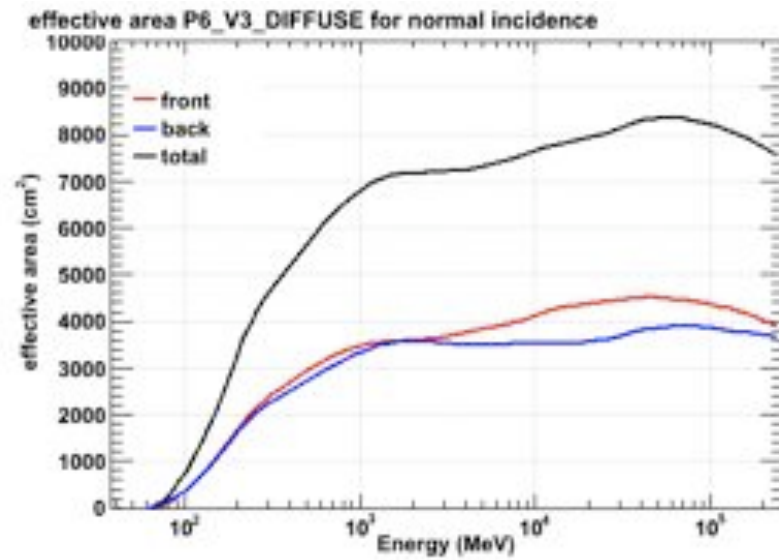
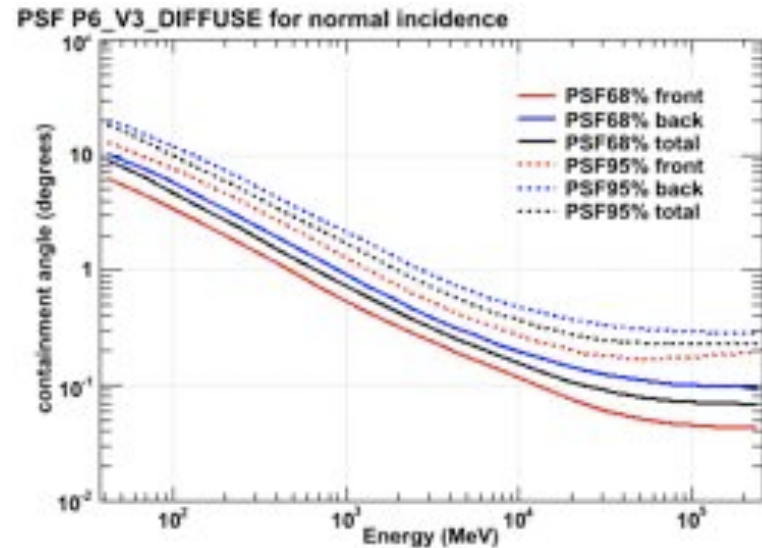
**LAT sensitivity on 4 different timescales:**

**100 s, 2 orbits (2x96 mins), 1 day and 1 year**

- **Almost all observations in survey mode - the LAT observes the entire sky every two orbits (~3 hours), each point on the sky receives ~30 mins exposure during this time.**
  - **35 deg rocking angle to September 2, 50 deg after**
- **39 ARRAs as of March 10 2010**
  - **5 hour pointed mode observations in response to bright GBM detected GRB**
- **LAT Calibrations (13 hours), Engineering (5 days)**
  - **Very high ontime!**

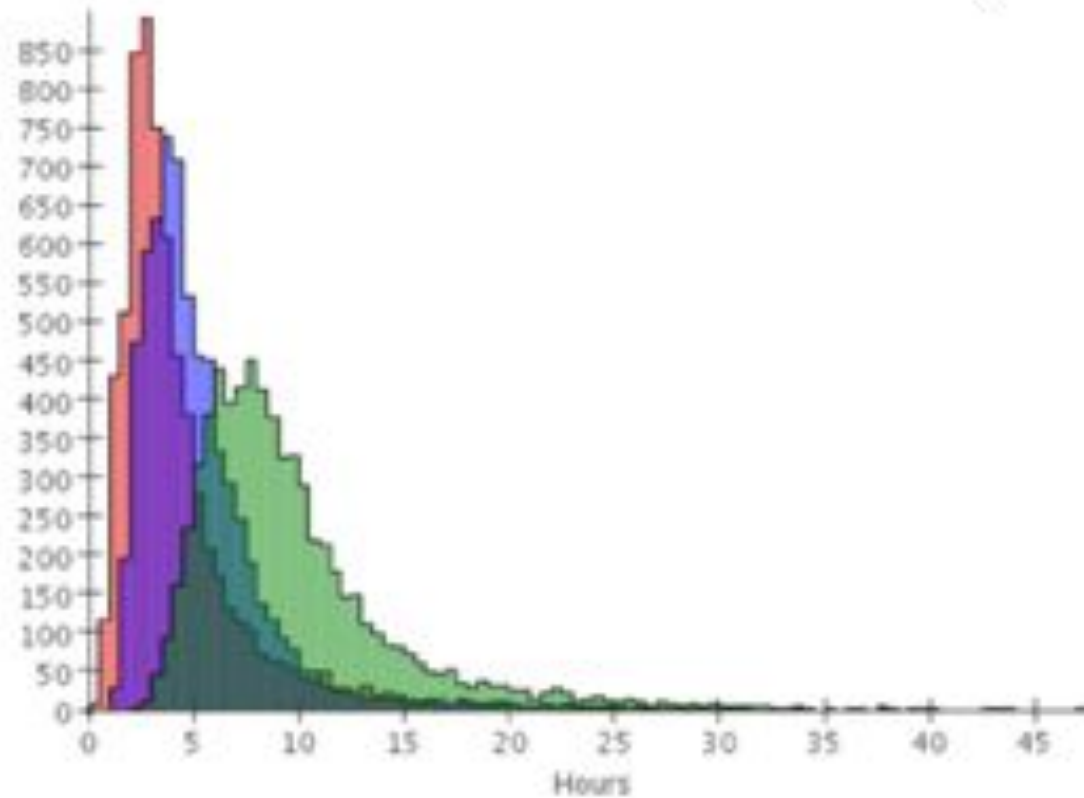
# LAT Performance

- **Current response functions:**  
**Pass 6 V3**
  - updated post-launch to include on-orbit, rate-dependent inefficiency
- **Point spread function**
  - **Very energy dependent**
  - **Little variation over FOV**
- **Effective Area**
  - **Peak >8000 cm<sup>2</sup> on-axis**
  - **Increases rapidly above 100 MeV**
  - **Plateaus above ~1 GeV**
- **Energy dispersion**
  - **E/E < 0.15 (68% containment)**
  - **Small compared to energy range**



<[http://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone/Cicerone\\_LAT\\_IRFs/](http://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone/Cicerone_LAT_IRFs/)>

# LAT Data Latency

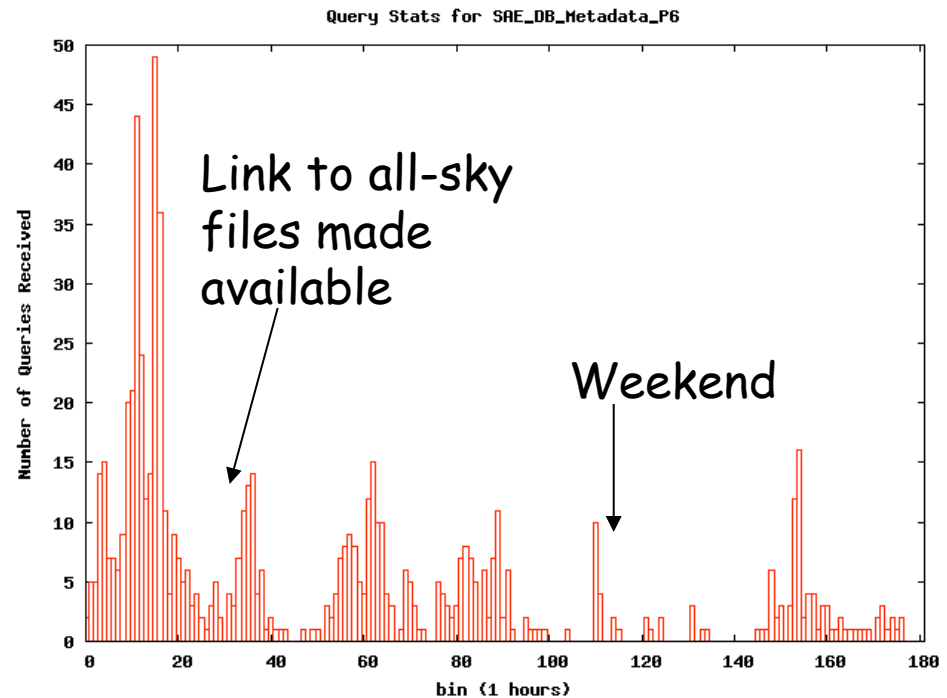


- **Typical turnaround is less than 10 hours (time to get data off spacecraft, processed and back to FSSC)**

# Data Releases

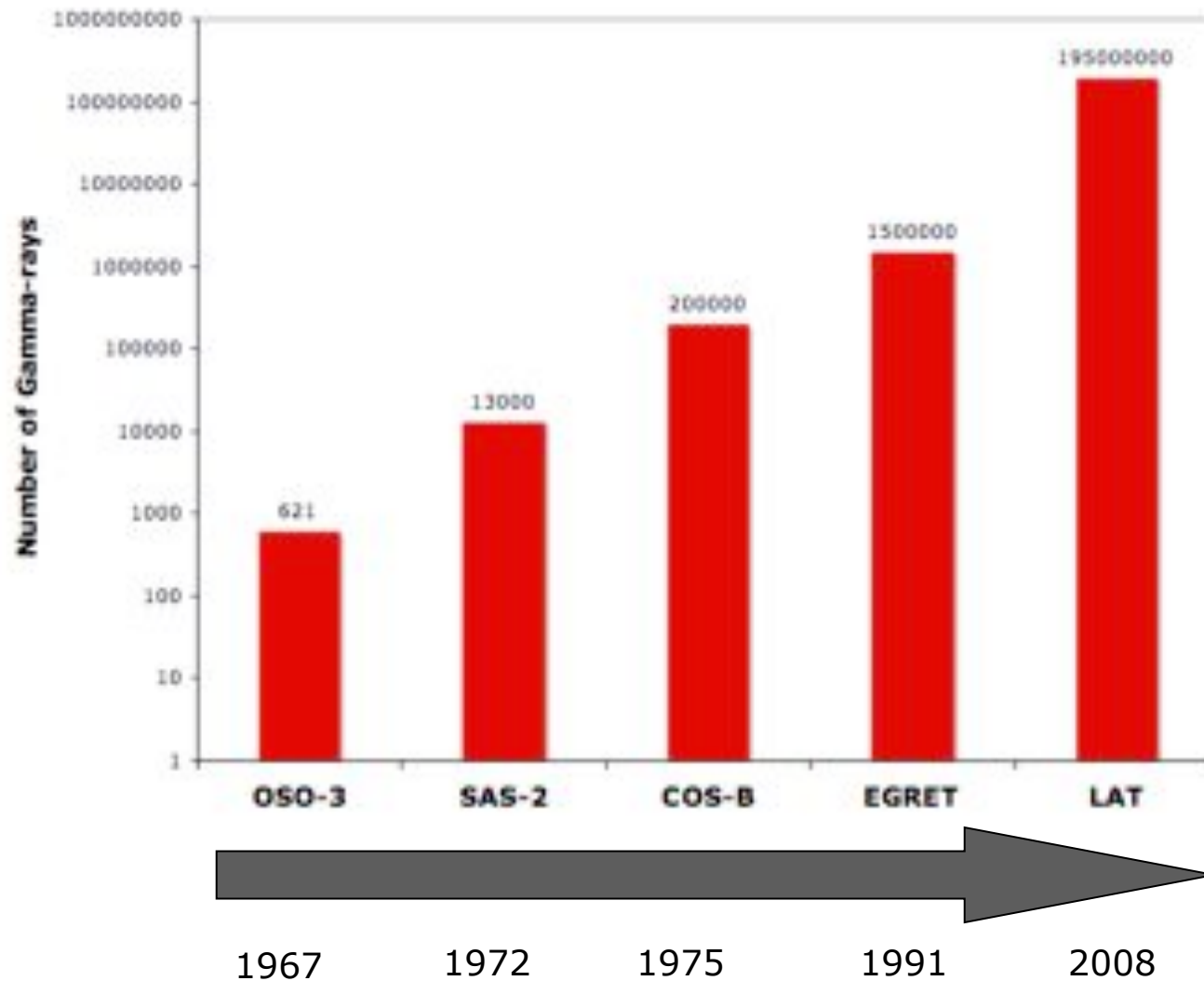
- **Beginning of science operations: GBM data + LAT high level data from start of science operations**
- **Feb 6, 2009: LAT bright source list, first LAT analysis software release**
- **Aug 25, 2009: low level LAT data, second LAT analysis software release**

- **~400 queries in first day, many requesting the entire dataset.**
- **Made link to weekly all-sky files more obvious (so number of queries dropped)**



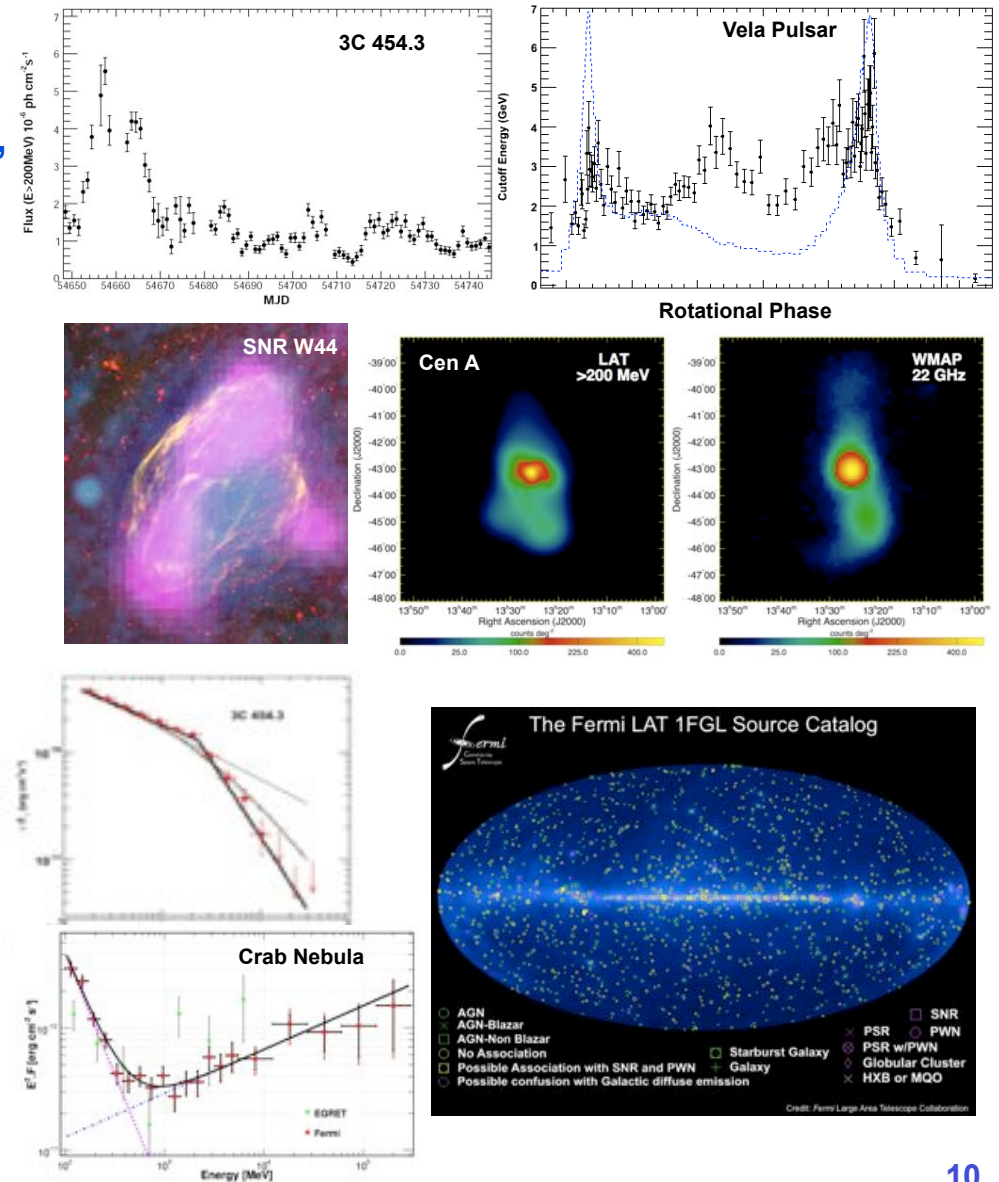


# How many gammas?



# LAT Science - Very Broad!

- **Transients and Variability**
  - >14 LAT GRBs, flaring AGN, X-ray binaries and microquasars, unidentified flares
  - Still waiting for solar flares
- **Pulsars**
  - Discovery, timing, phase profile and spectral studies
- **Imaging**
  - Resolving large supernova remnants and nearby galaxies
- **Catalogs**
  - Identifying LAT sources through spatial, spectral and timing features
  - Characterizing gamma-ray populations
- **Diffuse emission and cosmic rays**
- **Dark matter and new physics searches**



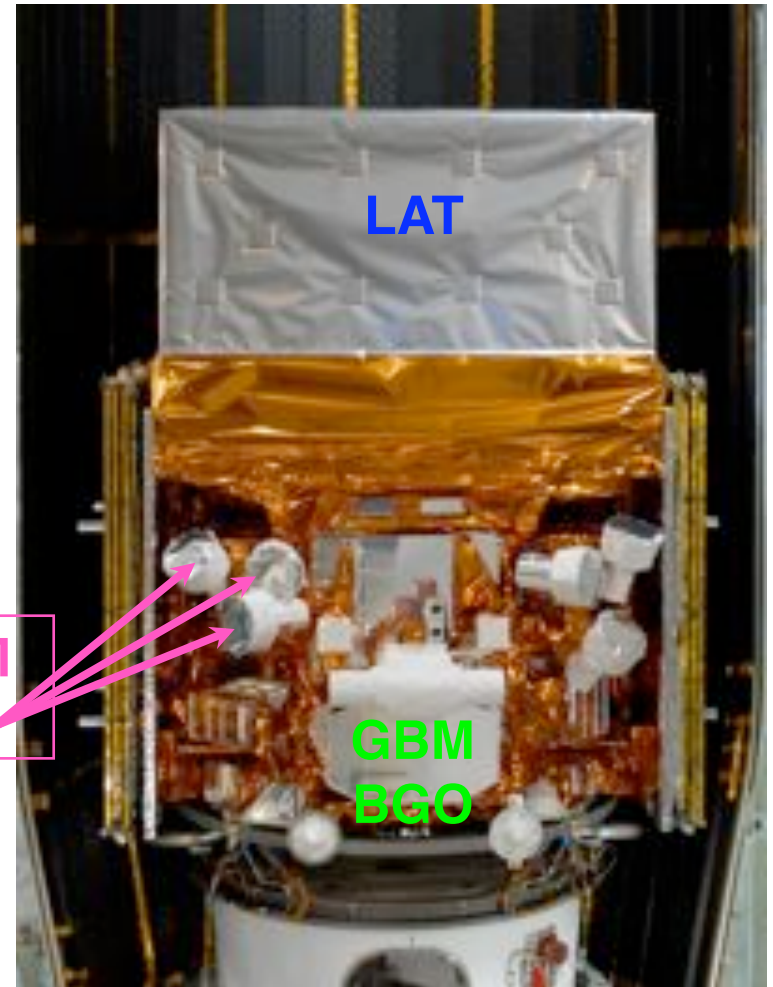
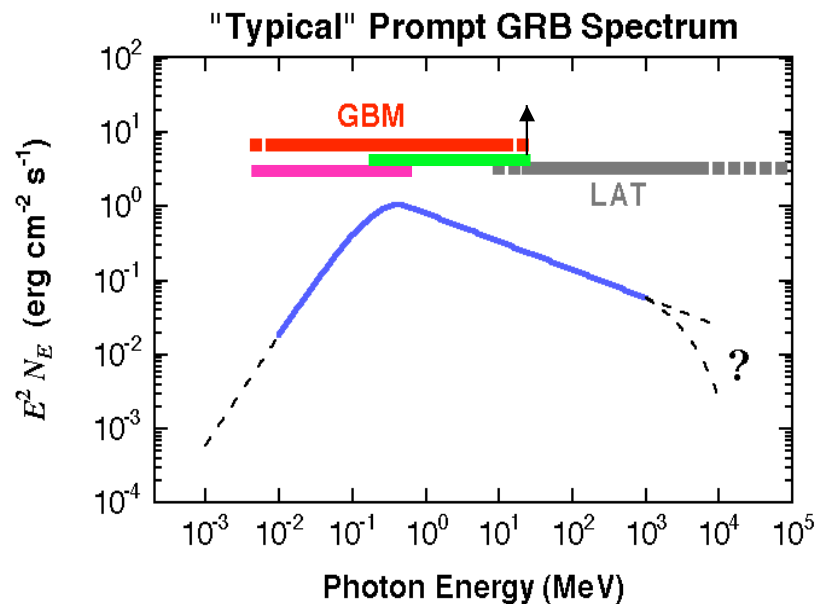
# Gamma-ray Burst Monitor

**Fermi GBM views entire unocculted sky**

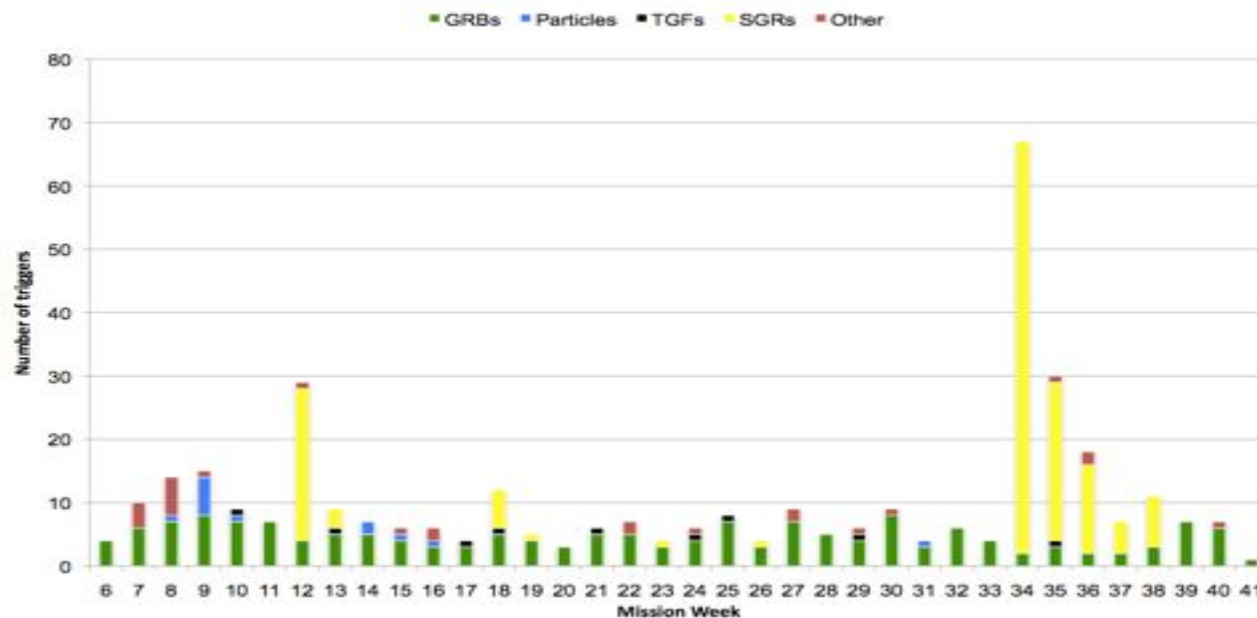
**NaI: 8 keV - 1 MeV**

**BGO: 200 keV - 40 MeV**

- Fermi GBM + LAT covers >7 decades in energy (8 keV to > 300 GeV)
- Both LAT and GBM can independently trigger



## GBM triggers by week



USA (MSFC, UAH,  
LANL) and  
Germany (MPE)

PI - Bill Paciesas (UAH)

Co-PI - Jochen Greiner  
(MPE)

- Since July 2008, GBM has detected over 400 GRB (250/year c.f. 200/year predicted)
  - Benefited from flexible onboard triggering algorithms
- Also 4 SGRs, >10 terrestrial gamma-ray flashes, 2 solar flares.
- Fall 2009 flight software updates improve reliability of autonomous repoint requests (more reliably points LAT to only bright GRB)

# GBM - not just transients

GBM Pulsar Project

http://gammaray.nsstc.nasa.gov/gbm/science/pulsars

Most Visited | Getting Started | Latest Headlines

**GBM Pulsars**

Source Name	l <sub>ii</sub> (deg)	b <sub>ii</sub> (deg)
<a href="#">GX 1+4</a>	1.94	4.79
<a href="#">Her X-1</a>	58.20	37.50
<a href="#">Cep X-4</a>	99.01	3.31
<a href="#">EXO 2030+375</a>	77.15	-1.24
<a href="#">V 0332+53</a>	146.05	-2.19
<a href="#">A 0535+26</a>	181.50	-2.64
<a href="#">MXB 0656-072</a>	220.20	-1.76
<a href="#">Vela X-1</a>	263.06	3.90
<a href="#">Swift J0513.4-6547</a>	275.99	-34.55
<a href="#">GRO J1008-57</a>	283.00	-1.80
<a href="#">A 1118-615</a>	292.50	-0.90
<a href="#">Cen X-3</a>	292.10	0.30
<a href="#">GX 301-2</a>	300.10	-0.04
<a href="#">4U 1626-67</a>	321.79	-13.09
<a href="#">4U 1538-52</a>	327.42	2.16
<a href="#">OAO 1657-415</a>	344.40	0.31

**GBM Accreting Pulsar Histories**

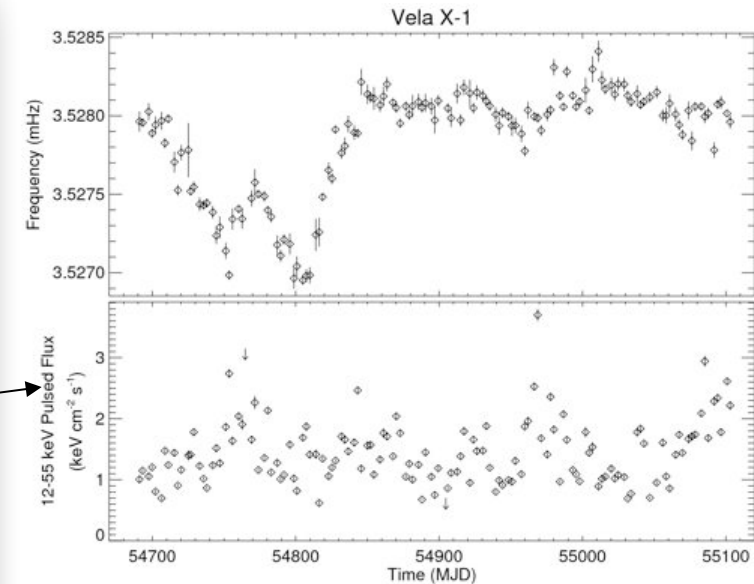
For each source we plot the history of pulse frequency and pulsed flux measured using the Fermi Gamma-Ray Burst Monitor (GBM) NaI detectors. For these measurements we use the CTIME data which normally has 0.256 s time bins, and eight energy channels. Our analysis normally uses channels 1 (12-25 keV) and 2 (25-55 keV). The integration intervals used varies from source to source, ranging from one to four days. For eclipsing systems each egress to ingress interval is divide into an integral number of equal parts, with no measurement made during the eclipse. The measured frequencies are barycentered. For sources where the binary orbit is known the frequencies are corrected for the binary motion. The R.M.S. pulsed flux is given in the energy band that the pulse search was made. This usually includes only the first and second harmonics. These results are preliminary. Please contact [Mark Finger](#) for further information.

Please return to [GBM Science](#) or the [GLAST Burst Monitor](#) or the [Gamma Ray Astrophysics Home Page](#).

Modification date: 06 Jul, 2009

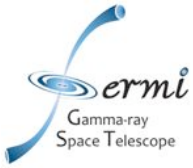
Author [Valerie Connaughton](#)

http://gammaray.nsstc.nasa.gov/gbm/science/pulsars/lightcurves/velax1\_fig1.png



GBM team have made non-GRB high level data/results available.

Available on the FSSC website



# Conclusions

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- **Fermi observatory and instruments are operating very well**
- **Extremely broad science capabilities and many opportunities to contribute**
- **Variety of public data products available**
- **Lots of great science to come!**

[\*\*<fermi.gsfc.nasa.gov>\*\*](http://fermi.gsfc.nasa.gov)