Fermi
Gamma-ray
Space Telescope

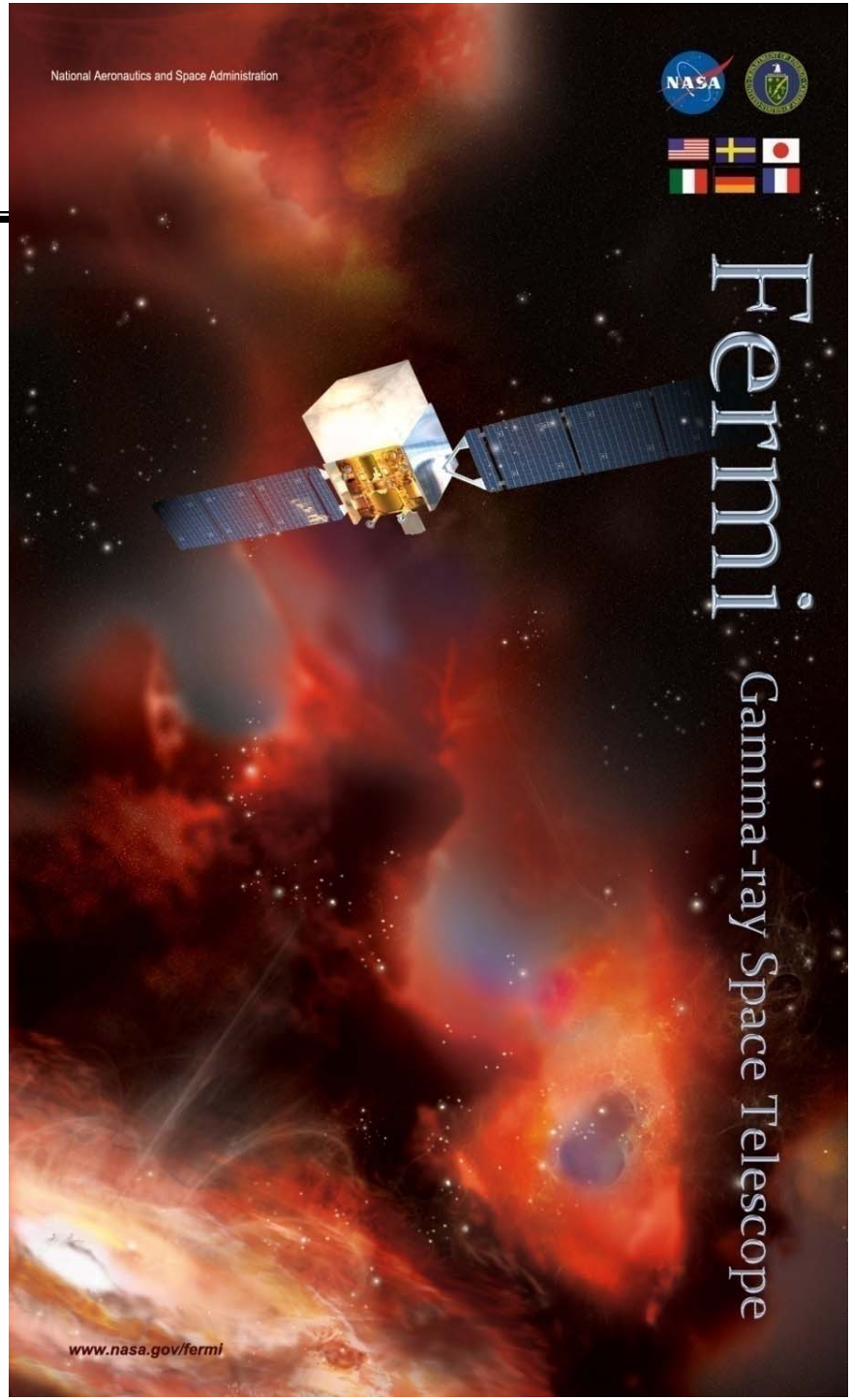
Fermi

The Gamma-ray Large Area Space Telescope

Mission Status

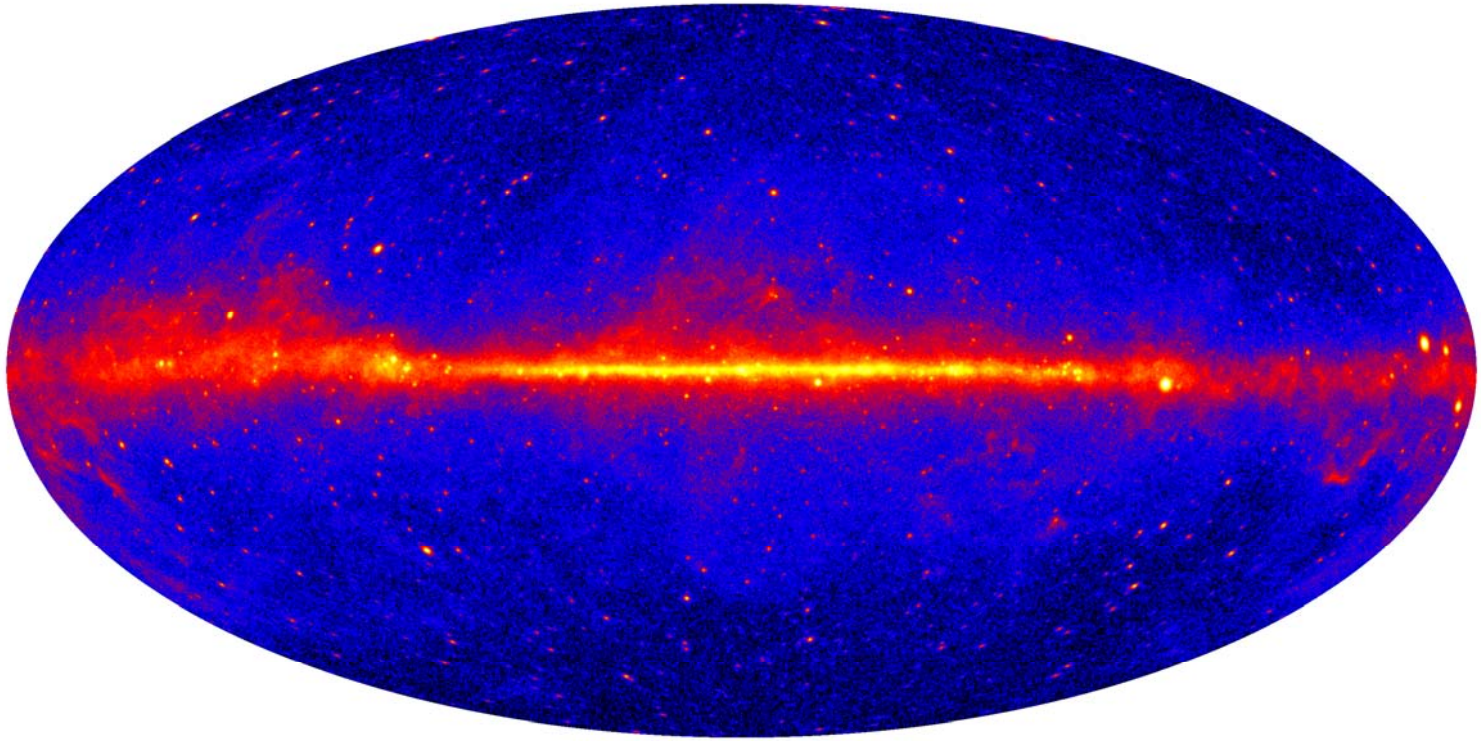
Julie McEnery
On behalf of the Fermi mission team

see *http://fermi.gsfc.nasa.gov* and links therein



Fermi Status

- **Observatory is operating smoothly**
  - **instruments and spacecraft operate as designed, no degradation in science performance since launch**



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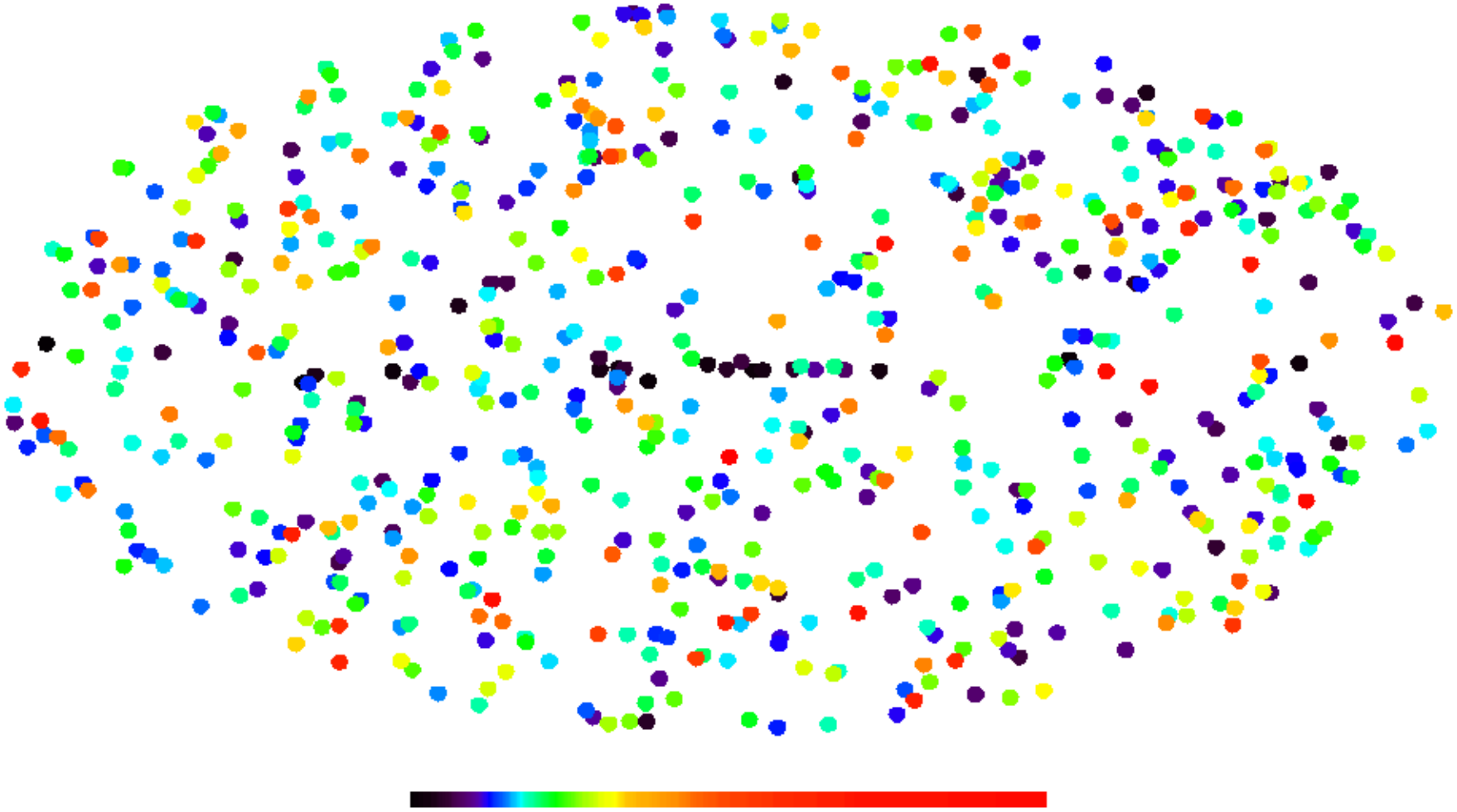

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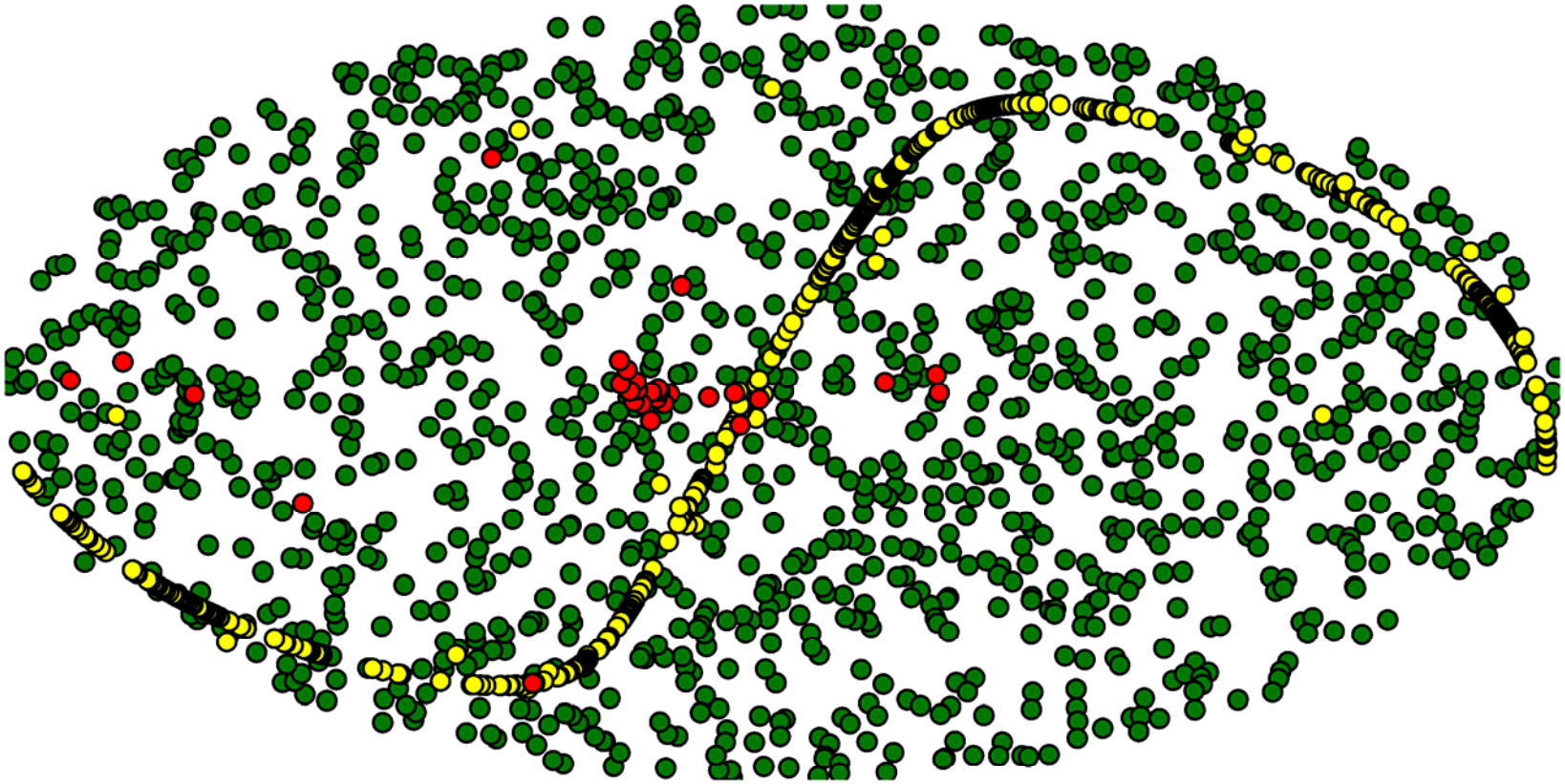
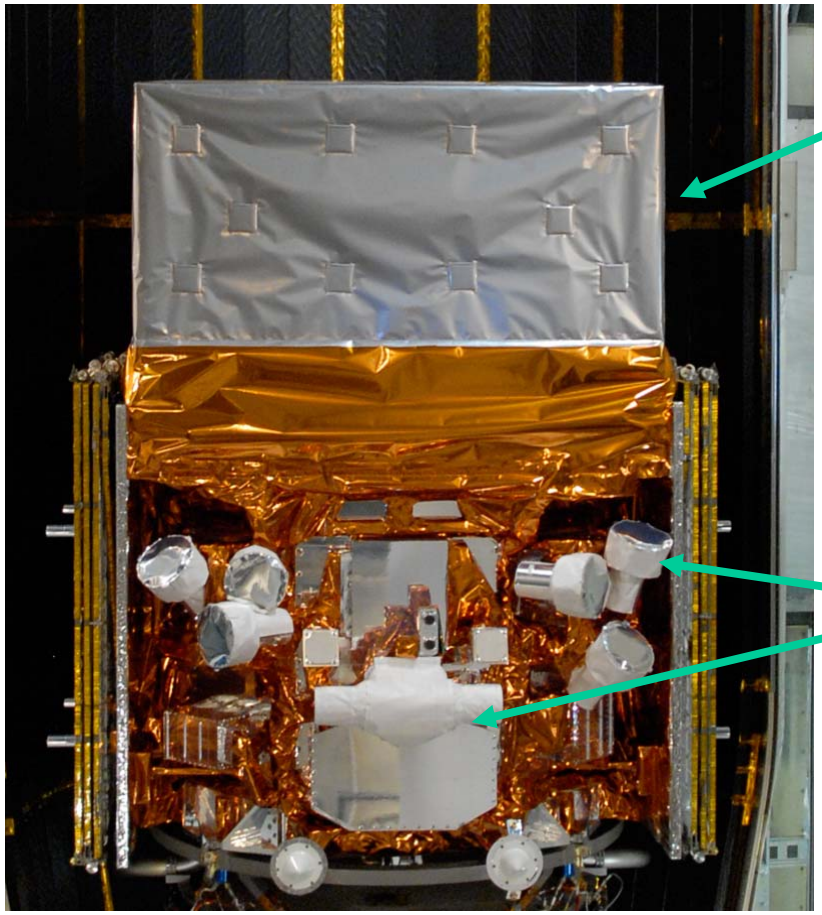


Fermi instruments



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.**

Gamma-ray Burst Monitor

- **Designed to complement high energy LAT GRB observations (GBM does much more than this!)**
  - **Provide rapid localization to allow autonomous repoint to bring GRB to center of LAT FoV**
  - **Detect all bright bursts in unocculted sky (i.e. anywhere not blocked by the Earth)**
  - **Extend sensitivity to high energies for spectral overlap with LAT**
    - **High energy sensitivity provides a boost for detection of short hard bursts relative to other current and previous GRB detectors**
  - **Recently transitioned to continuous Time Tagged Event data (TTE), preliminary tests indicate that this will increase the rate of short GRB to ~80/year (via a ground search)**
- **Summary:**
  - **GBM detects a large number of bright bursts, with a relatively rich fraction of short hard bursts.**

LAT

- Currently serving P7REP data
  - This has improved calorimeter calibrations relative to P7
    - Better angular resolution at high energies
    - Small shift in the energy scale
  - Updated galactic and isotropic diffuse models

- Third point source catalog (3FGL)
  - Based on 4 years of data and P7REP
  - Source list will be released within a few months
  - 3rd AGN catalog also in the works

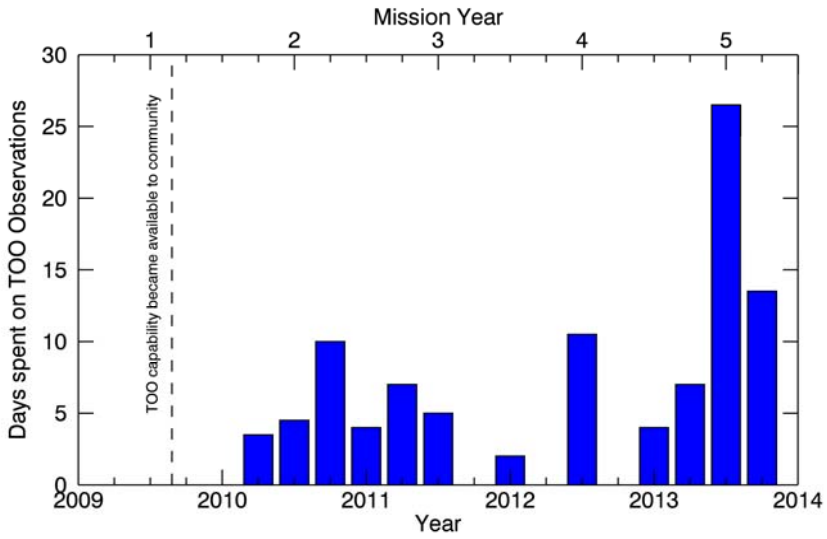
Observatory Observations

- **In Galactic Center-Biased Sky Survey since early December**
  - **Each orbit contains a mix of pointed mode and survey (fixed rocking angle).**
  - **Need to be careful with zenith and rocking angle selections.**

- **Target of Opportunity requests are increasing**
  - **Requests go straight to FSSC/Project**

http://fermi.gsfc.nasa.gov/ssc/observations/too/

If you are planning to request a ToO, please submit the form early – we will work with you to evaluate the observation options.



Observatory cont.

- **Cycle 7 GI program**
  - **224 proposals**
  - **Review in late April**
  - **Funding starts in October**

- **Senior Review Proposal**
  - **Covers period 2015-2018**
  - **Proposed for mission extension and augmentation of GI program budget (so your success in the GI program may depend on our success in the senior review…)**

How to work with us

- **Pick your favorite LAT or GBM team member and talk about what you would like to do**
  - **If you don't know who to contact send a note to Dave Thompson (david.j.thompson@nasa.gov) . He is the MW coordinator for LAT and GBM teams.**
  - **The LAT team member(s) will handle all interactions with the LAT science groups and publication board.**
    - **The intent of LAT team policies is to maintain our identity as a group that works and publishes together, and to maintain a consistently high standard for papers/analysis.**

- **An MOU can cover cases where you would like access to internal information to guide observations (e.g. high energy source list, or flaring source announcements) that are not necessarily tied to a specific analysis or papers**

LAT Papers

- **For the LAT team, any paper that presents a new analysis of LAT data and has LAT authors is a LAT paper.**
  - **Cat 1 paper – major LAT result, authorship open to all LAT members, LAT author list block ordered alphabetically, 2 internal reviewers**
  - **Cat 2 paper – LAT authorship open only to those who directly participated in the paper, LAT author list block ordered at the discretion of the authors, 1 internal reviewer**
  - **Determination of whether a paper is cat 1 or 2 is by the science group leads (but they usually go with the recommendation of the authors)**
  - **LAT publication board approval needed before paper is submitted**

Questions?

Science case for GC observation: Pulsars

- **Pulsar science is a major Fermi success story!**
  - **Many pulsars of many types discovered**
  - **Significant boost in our understanding of these objects**
- **Marked increase in sensitivity for pulsed searches near the Galactic center where the population of pulsars should be very large**
  - **Very high probability to detect new gamma-ray pulsars**
- **In the close vicinity of SgrA*, pulsation searches would have to account for accelerations due to orbital variability, orbital periods as short as 300 days could be found with a year-long observation**
  - **Possible probe of strong field gravity (if we are lucky enough to find a pulsar close to SgrA***
- **Most young pulsars do not have stable timing for longer than a year or so**
  - **Optimum observation duration for pulsar search is 1 year**

Science Case for a GC Observation: G2 passage

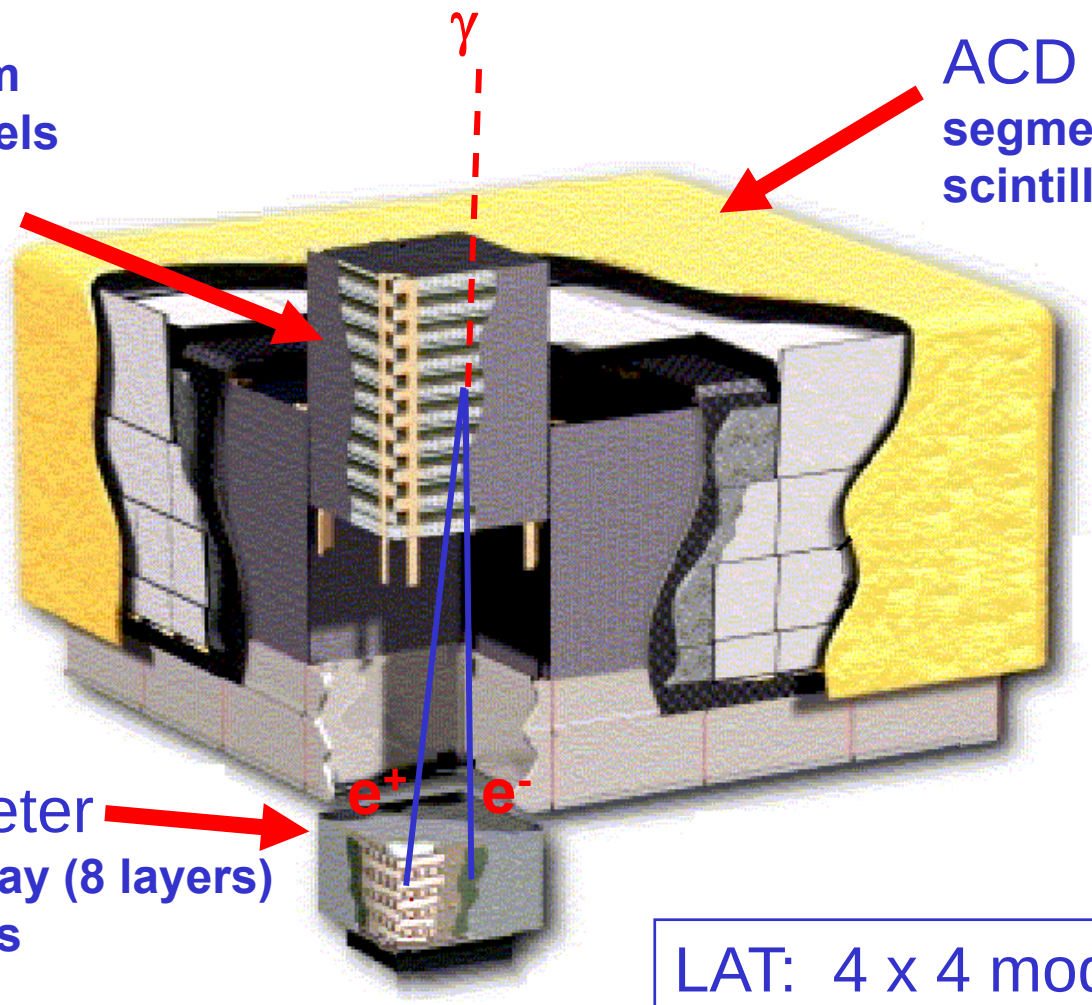
- A gas/dust cloud is approaching SgrA* in highly eccentric orbit
  - Pericenter is only 36 light hours (or ~3100 Schwarchild radii)
  - Accretion flow near SgrA* may become dominated by this cloud
    - As the cloud breaks up and fragments feed into the central accretion flow, there may be giant radiation flares
  - Duty cycle of high energy activity may be increased (i.e. more IR/X-ray flares), gamma-ray observations can test models of flare emission
  - Lots of other observatories are pointing towards the galactic center – significant chance for serendipitous discoveries
- GC is close to pericenter now – Fermi observation at GC is most useful ASAP

Gamma-ray Burst Monitor

- >9.5sr FoV (~ entire unocculted sky)
- 250 GRB/year (triggered onboard)
- 8 keV - 40 MeV (broader energy range than BATSE)
  - Overlap with LAT energy range (connects LAT observations with "traditional" GRB range)
  - Extension to high energies improved sensitivity to short hard bursts
- Localization of GRB by GBM
  - <15 degrees initially (calculated onboard within 2 s), designed to provide repoint location for LAT afterglow observations
  - Refinements with ground analysis within ~15-30 mins of GRB trigger
- Onboard GRB trigger
  - More flexible trigger algorithm compared with BATSE -> improved sensitivity to very short GRB and to long soft GRB.
  - Onboard trigger classifications (solar flare, particle event, GRB etc)
  - Provides repoint recommendation to allow high energy afterglow observations with the LAT
  - Provide rapid alert to GRB afterglow observers (via GCN)

The Large Area Telescope

Si Tracker
pitch = 228 μm
8.8 10^5 channels
18 planes

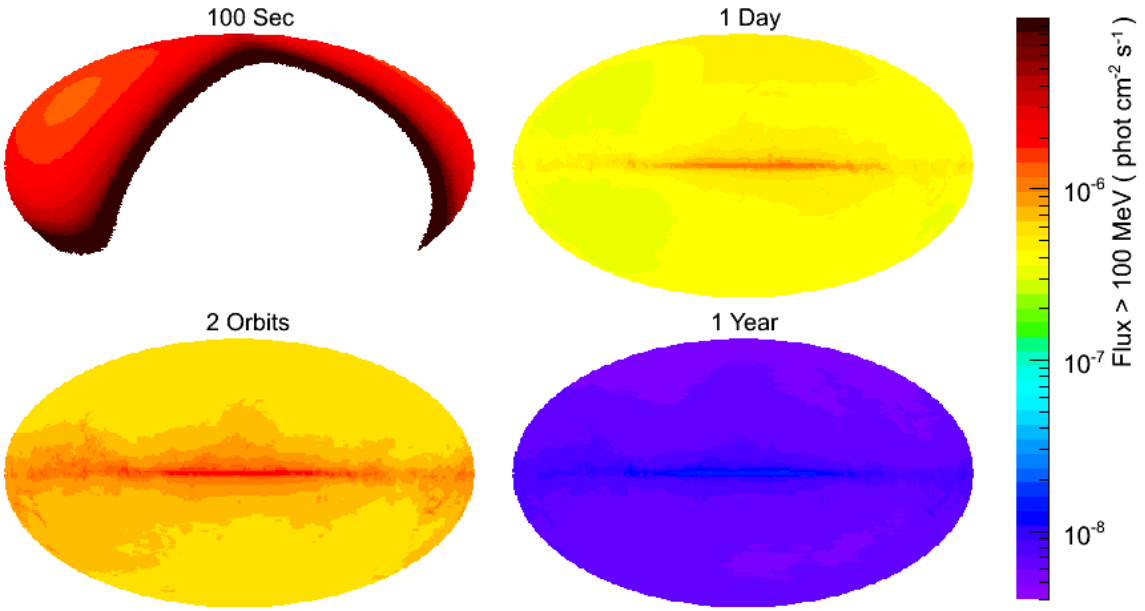


ACD
segmented scintillator tiles

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

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

All Sky Coverage

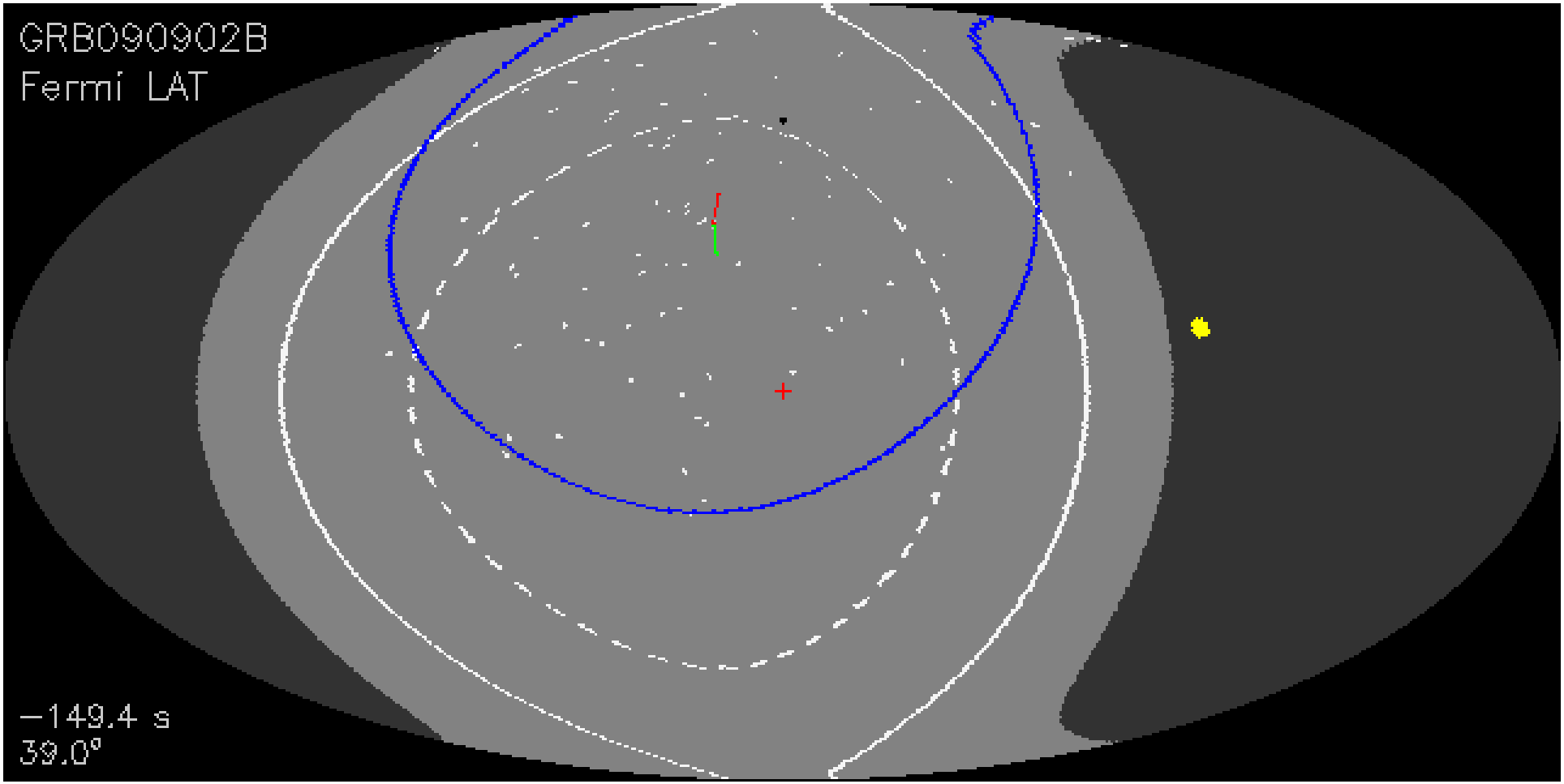


LAT sensitivity on 4 different timescales: 100 s, 1 orbit (96 mins), 1 day and 1 year

- **In survey mode, the LAT observes the entire sky every two orbits (~3 hours).**
- **Multiwavelength/multimessenger observations in coordination with the LAT are limited only by the ability to coordinate to other observations in other wavebands.**
- **Can also perform pointed observations of particularly interesting regions of the sky.**

GRB090902B - Autonomous repoint

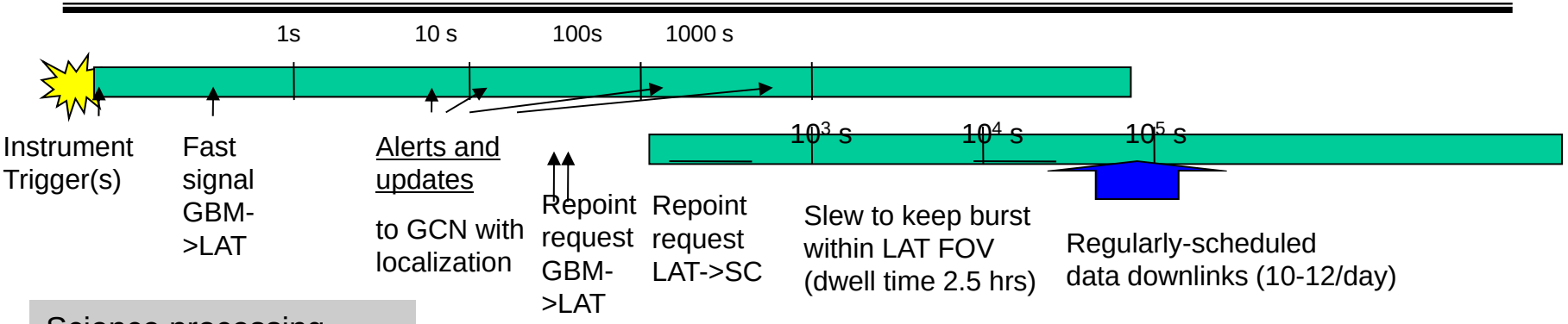
- **LAT pointing in celestial coordinates from -120 s to 2000 s**
  - **Dark region = occulted by Earth (□z>113°)**
  - **Blue line = LAT FoV (±66°), White points = LAT events**



Spacecraft performance

- **Pointing knowledge**
  - **<10 arcseconds, using 2 star trackers (a third is available as a spare)**
- **Absolute Timing**
  - **Better than 300 ns, using GPS and oscillators**
- **Orbit location (knowing where we are)**
  - **~<10m using GPS**
- **Observing modes**
  - **Survey**
    - **view entire sky every 2 orbits, efficient as the Earth does not enter the LAT FoV.**
  - **Inertially pointed**
    - **Scheduled - planned observation at an interesting location**
    - **Autonomous - to automatically put or keep a GRB location within the FoV of the LAT**
  - **Slew requirement of 75 deg in 10 mins, but can reach max slew rates of 0.3 deg/s**

Alerts and Data Flow



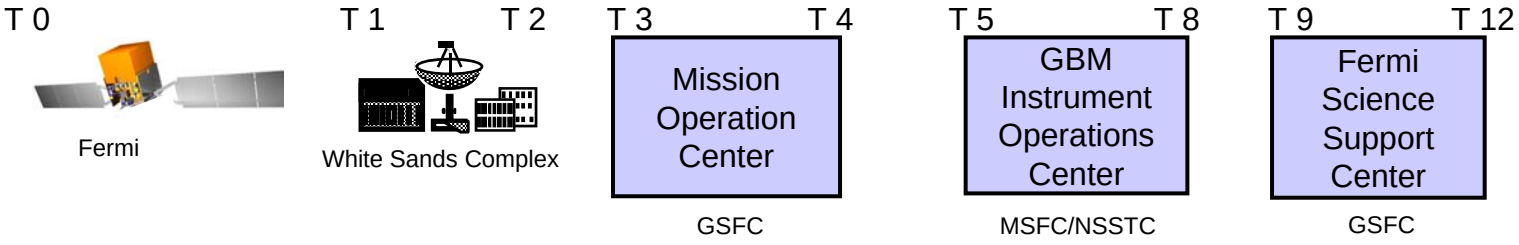
Science processing parameters reviewed by Users Committee

Planned repoint frequency (adjustable):
- bursts starting within LAT FOV ~2/month
- bursts starting outside LAT FOV ~2/year

- Onboard processing (both LAT and GBM) - GCN alerts: location, intensity (cnts), hardness ratio, trigger classification (GRB, solar flare etc)
- GBM Prompt ground processing (10-30 mins): updated location, lightcurve
- LAT ground processing (5-12 hours): updated location, high energy spectrum, flux (or upper limit), afterglow search results
- Final ground processing (24-48 hours): GBM model fit (spectral parameters, flux, fluence), joint LAT-GBM model fit, raw GBM data available. Year 2 and beyond - LAT count data available.

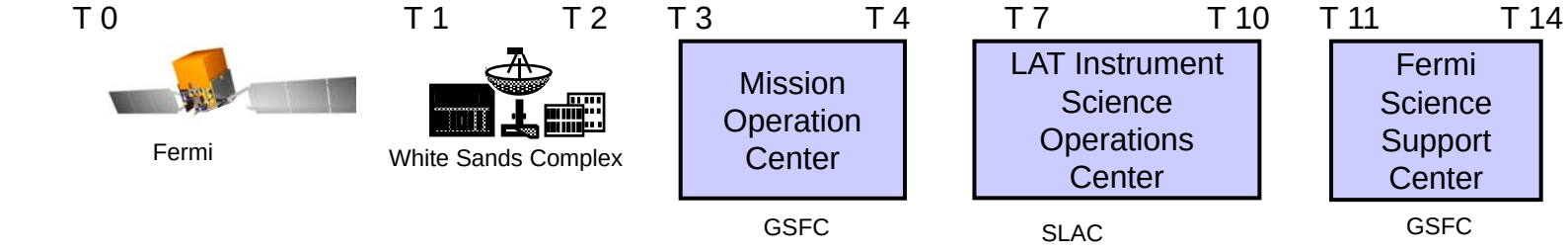
Data Latency

GBM DATA PATH



= 474m
= 7h54m

LAT DATA PATH



= 554m
= 9h14m

Data sit on SSR

4.3Mbps

Level 0 processing

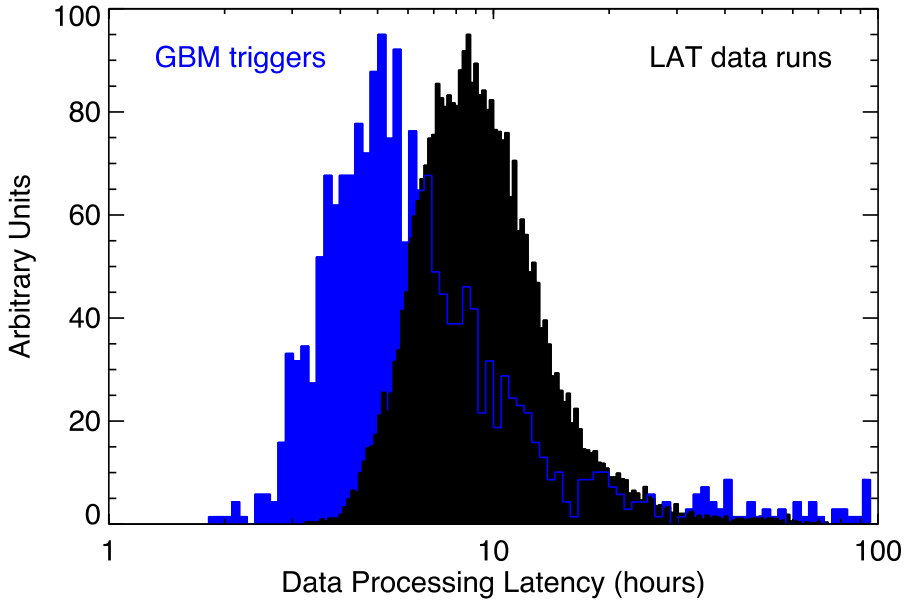
Sometimes achieve higher bandwidth

Nominal case, assuming no manual intervention or new calibrations.

Data ingest, conservative estimate

Data Availability

No proprietary gamma-ray data - Everyone gets access to the data at the same time



Latency requirement is 72 hours, typical latency is much less ~<10 hours

- All data and software release milestones met at or ahead of schedule
- LAT and GBM instrument teams generate additional high level data (lightcurves, transient alerts, pulsar timing solutions etc) which are served to the community by the FSSC

The Future

- No consumables, orbit is good until at least 2050
  - Mission will likely be able to continue as long as there is funding
- No degradation in science performance of instruments
  - Improvements in LAT reconstruction and event selections tuned to specific science studies have resulted in improvements in performance since launch
  - Operational improvements in GBM (now collecting event-based data), provide enhanced capability
- Fermi was proposed as a 10-year mission (5 year requirement, 10 year goal)
  - Planned mission continues to at least 2018 (subject to successful senior review)

Fermi Users Group Members

- Erin Bonning
- Fernando Camilo
- Wei Cui
- Doug Finkbeiner
- Dale Frail (Chair)
- Dieter Hartmann
- Jamie Holder
- Buell Januzzi
- Savvas Kousiappas
- Don Kniffen
- Anna Watts

Plus

- Neil Gehrels
- Ilana Harrus
- Julie McEnery
- Bill Paciesas
- Peter Michelson
- Steve Ritz
- Chris Shrader
- Dave Thompson
- Kathy Turner
- Lynn Cominsky

http://fermi.gsfc.nasa.gov/ssc/resources/guc/

The Large Area Telescope

Fermi Science Support Center (FSSC)

- **Supports guest investigator program (Cycle 3 deadline Feb 4)**
- **Provides training workshops**
- **Provides data, software, documentation, workbooks to community**
- **Archives to HEASARC**
- **Joint software development with Instrument Teams, utilizing HEA standards**
- **Located at Goddard**

  see http://fermi.gsfc.nasa.gov/ssc/

  and help desk

  http://fermi.gsfc.nasa.gov/ssc/help/

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)