Fermi

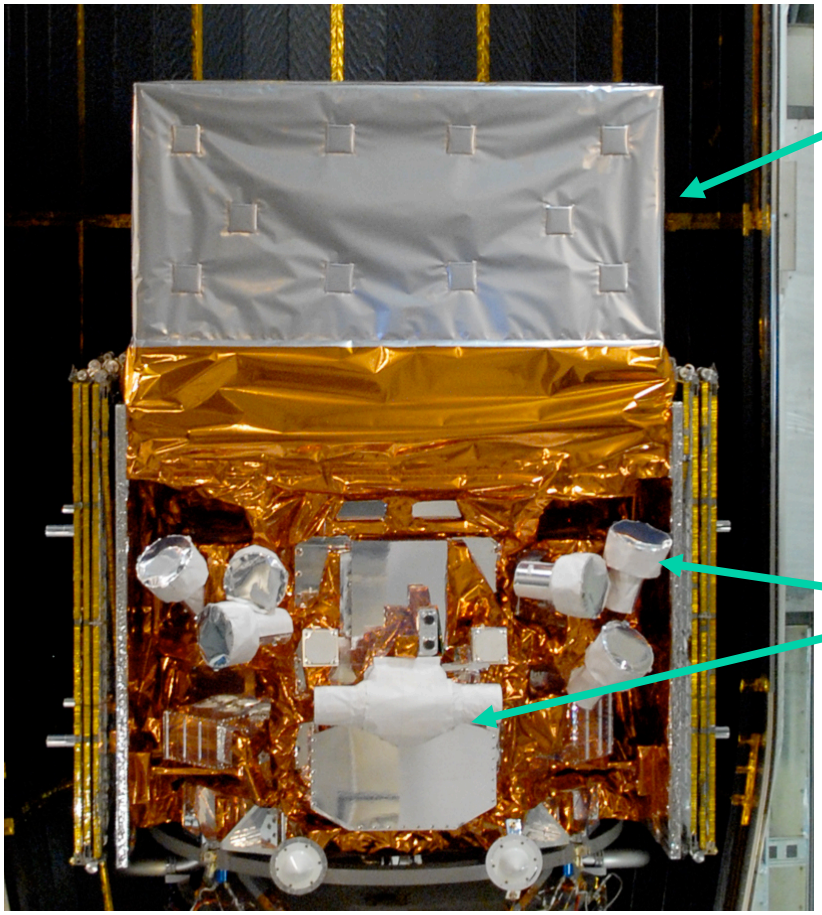
The Gamma-ray Large Area Space Telescope

Mission Status

Julie McEnery
On behalf of the Fermi mission team

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

Fermi 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.**

Broad Science Menu

- How do super massive black holes in Active Galactic Nuclei create powerful jets of material moving at nearly light speed? What are the jets made of?
- What are the mechanisms that produce Gamma-Ray Burst (GRB) explosions? What is the energy budget?
- What is the origin of the cosmic rays that pervade the galaxy?
- How does the Sun generate high-energy gamma-rays in flares?
- How has the amount of starlight in the Universe changed over cosmic time?
- What are the unidentified gamma-ray sources found by EGRET?
- What is the mysterious dark matter?

Launch! June 11, 2008

- Launch from Cape Canaveral Air Station 11 June 2008 at 12:05PM EDT
- Circular orbit, 565 km altitude (96 min period), 25.6 deg inclination.

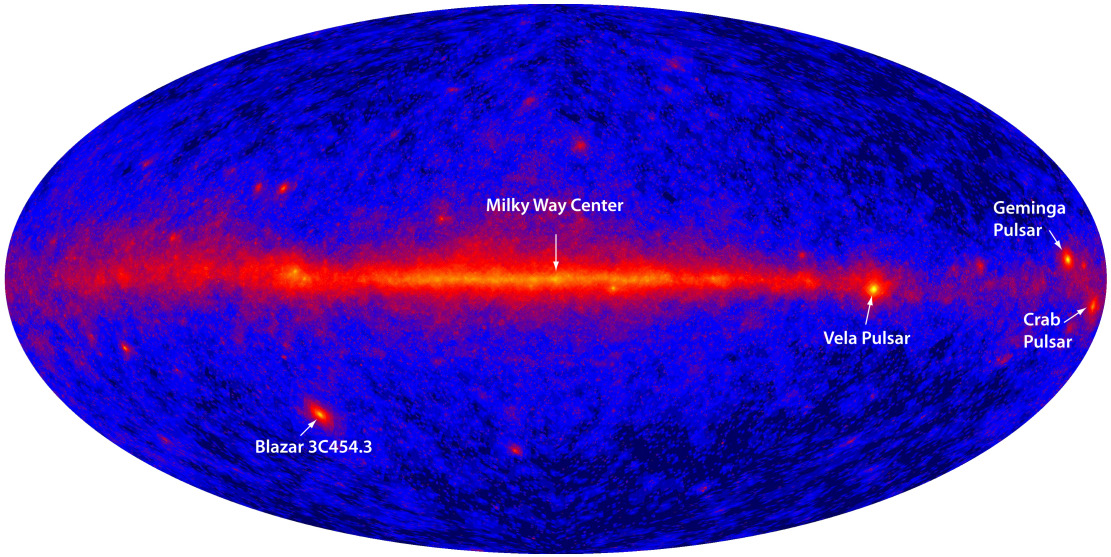
Launch Day at GSFC

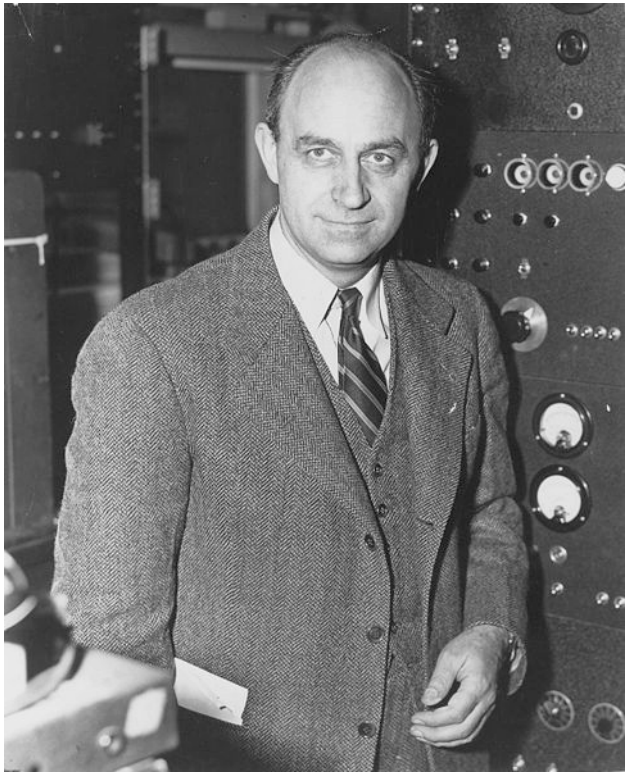
Launch Day in Florida

A few weeks later - instrument commissioning

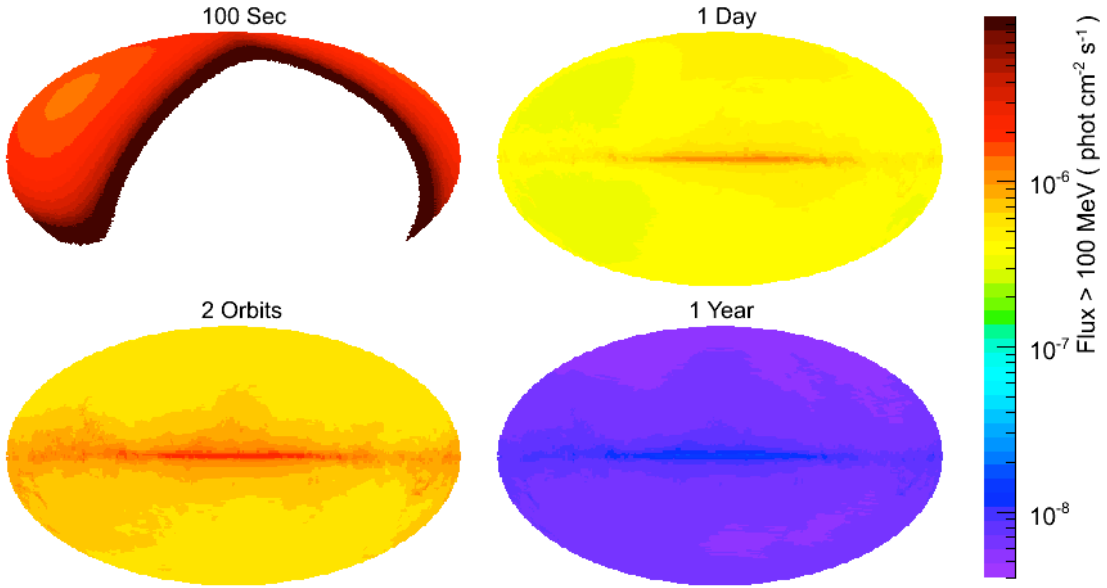
First light and Observatory Renaming

- **GLAST becomes Fermi Gamma-ray Space Telescope**





Operations and observing modes



LAT sensitivity on 4 different timescales: 100 s, 1 orbit (96 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 Sept 2, 50 deg thereafter.**
- **30 ARRs**
  - **5 hour pointed mode observations in response to bright GBM detected GRB**
- **LAT Calibrations (13 hours), Engineering (5 days)**
  - **Very high ontime!**

LAT Collaboration

- France
  - CNRS/IN2P3, CEA/Saclay
- Italy
  - INFN, ASI, INAF
- Japan
  - Hiroshima University
  - ISAS/JAXA
  - RIKEN
  - Tokyo Institute of Technology
- Sweden
  - Royal Institute of Technology (KTH)
  - Stockholm University
- United States
  - Stanford University (SLAC and HEPL/Physics)
  - University of California, Santa Cruz - Santa Cruz Institute for Particle Physics
  - Goddard Space Flight Center
  - Naval Research Laboratory
  - Sonoma State University
  - The Ohio State University
  - University of Washington

PI: Peter Michelson
(Stanford)

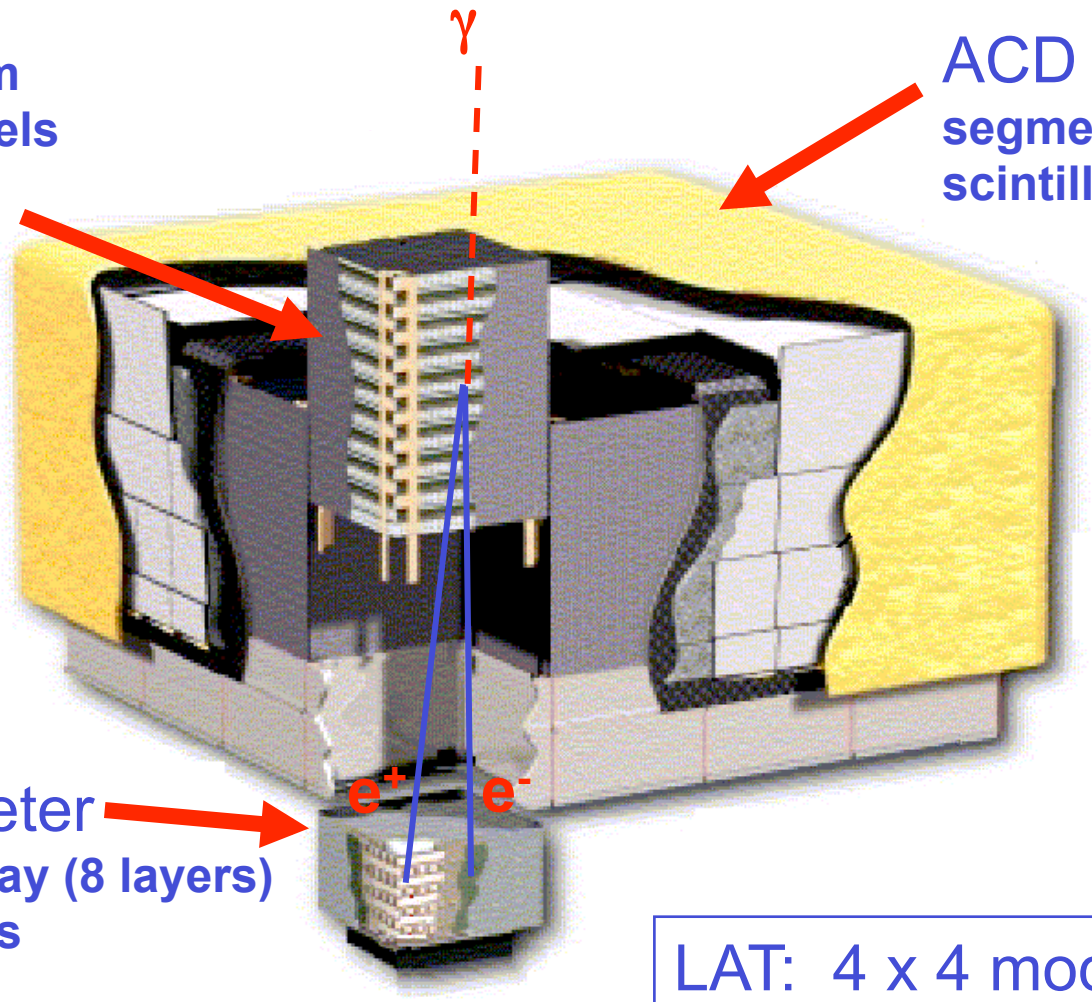
~400 Scientific Members (including 96 Affiliated Scientists, plus 68 Postdocs and 105 Students)

Cooperation between NASA and DOE, with key international contributions from France, Italy, Japan and Sweden.

Project managed at SLAC.

The Large Area Telescope

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

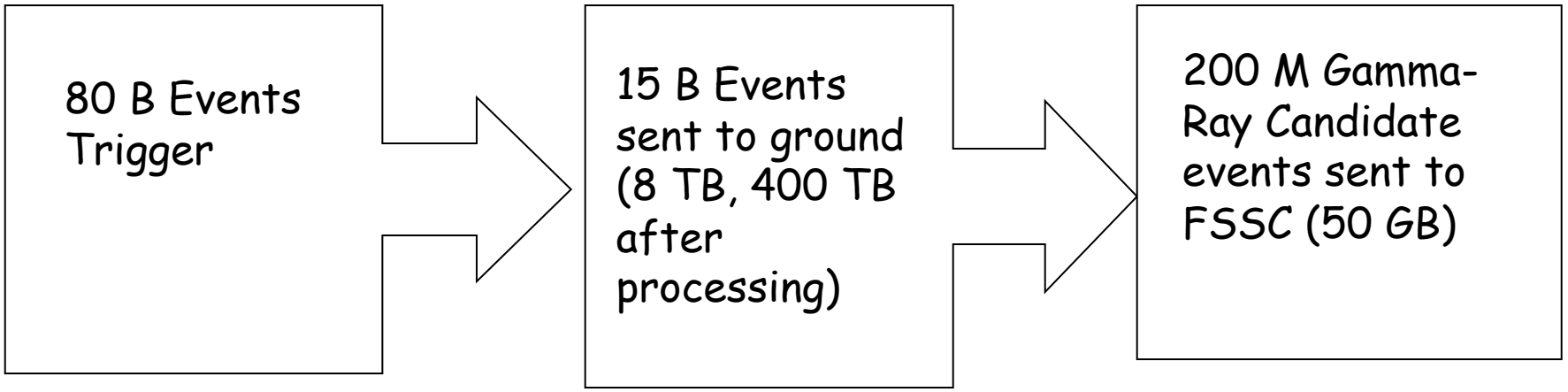


ACD
segmented scintillator tiles

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

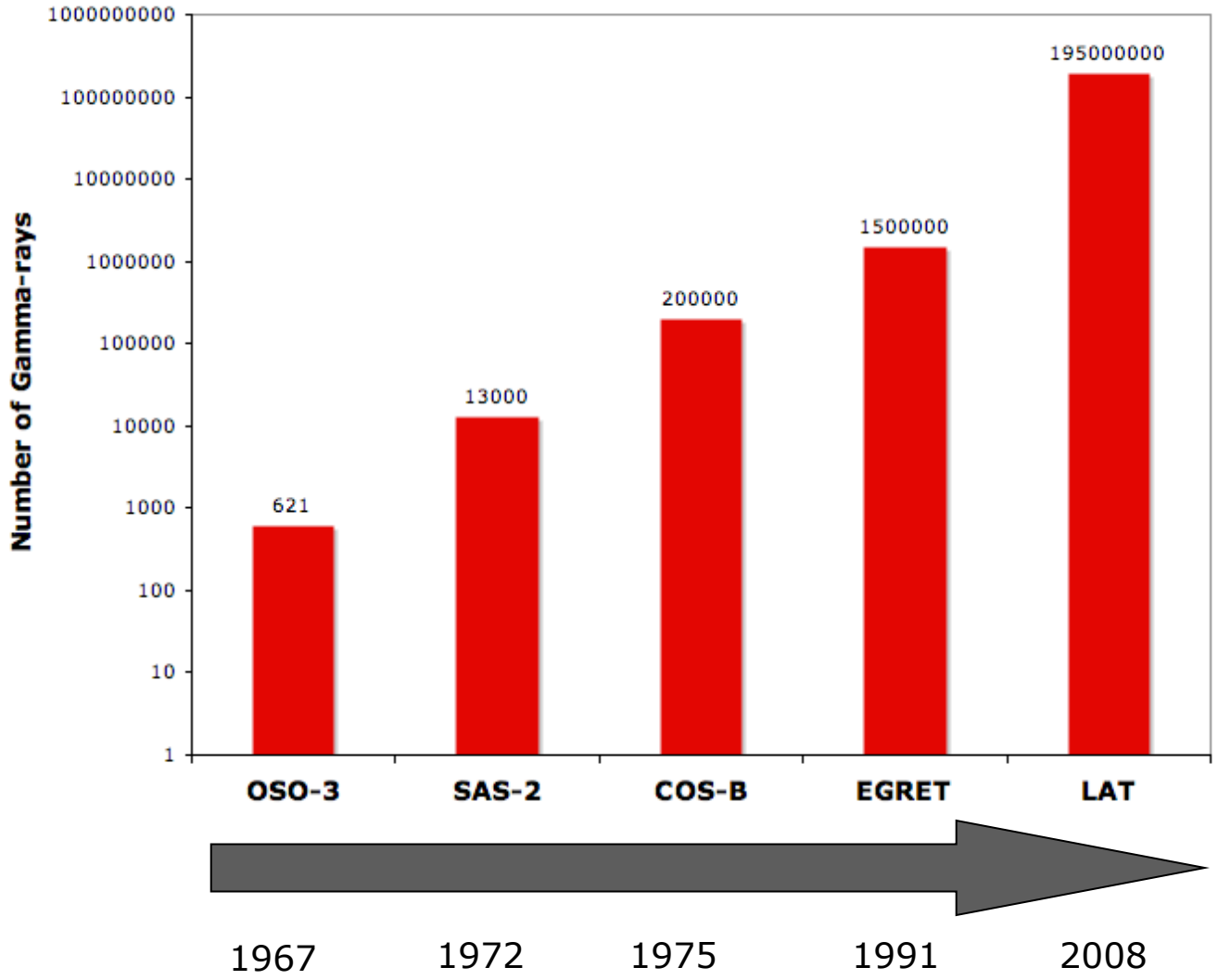
LAT: 4 x 4 modular array
3000 kg, 650 W
20 MeV – 300 GeV

LAT Data Collection and processing

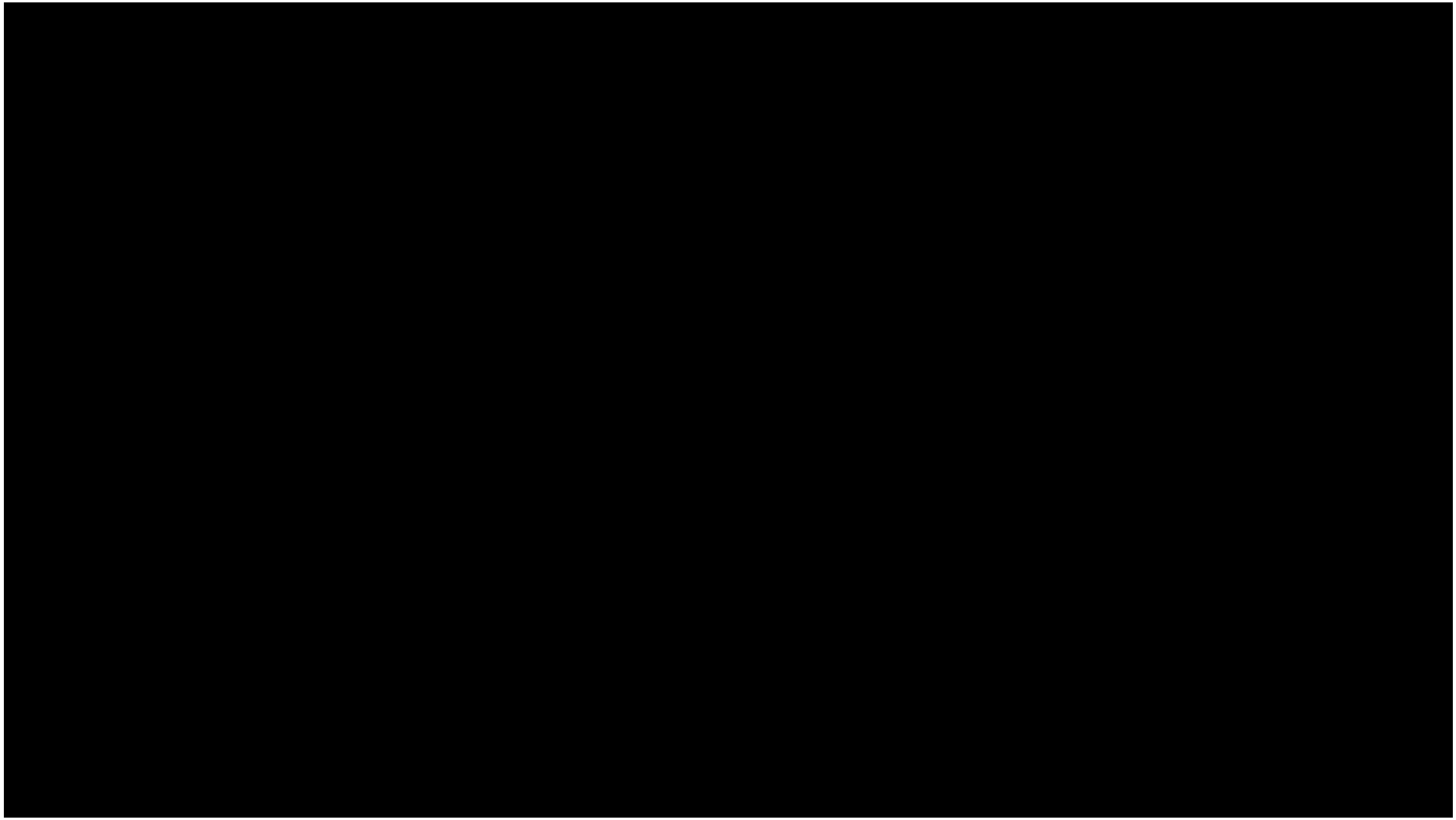


- **160 cpu years worth of processing over 16 months**

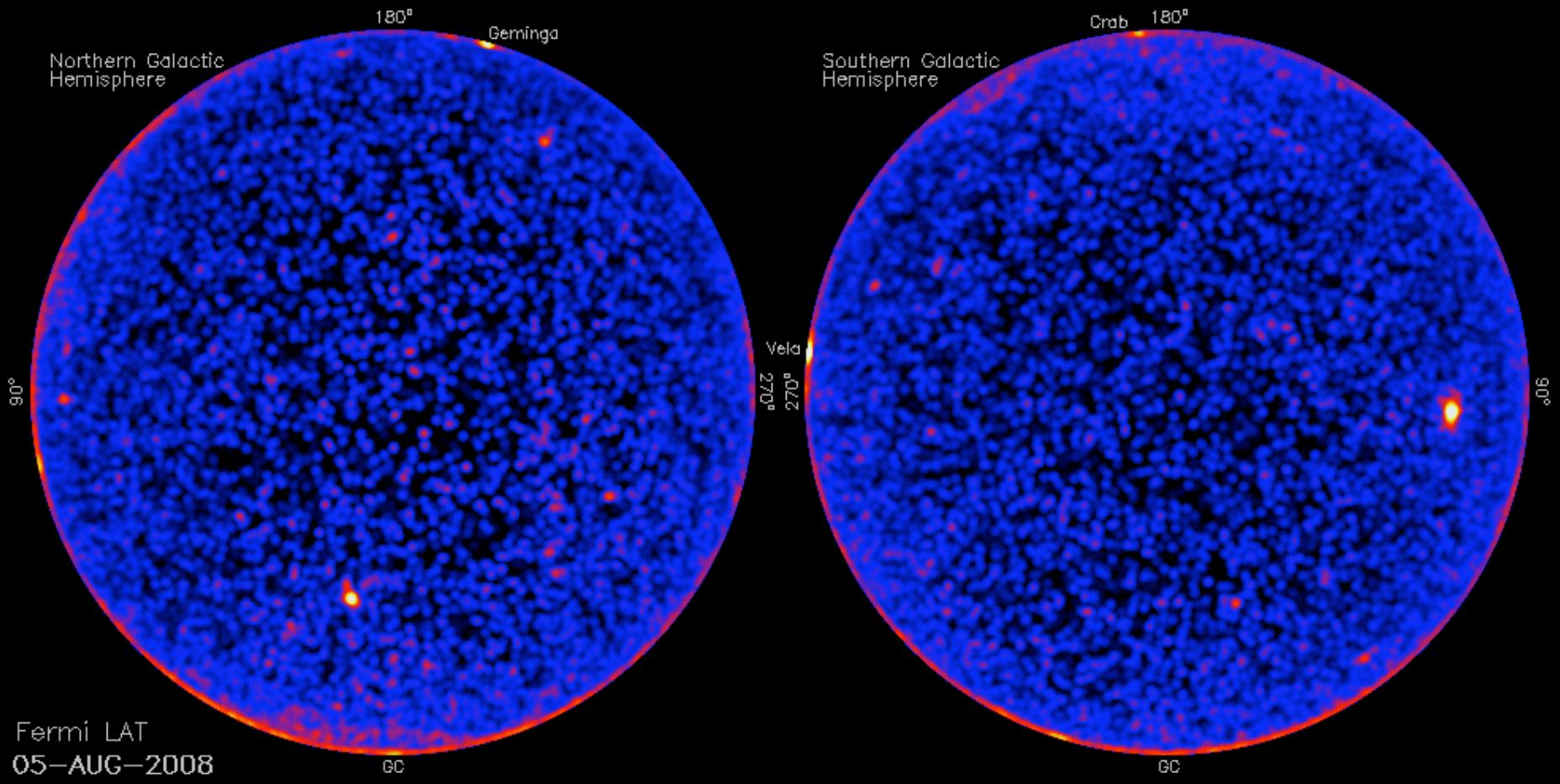
How many gammas?



The Fermi LAT Sky



The Variable Gamma-ray Sky



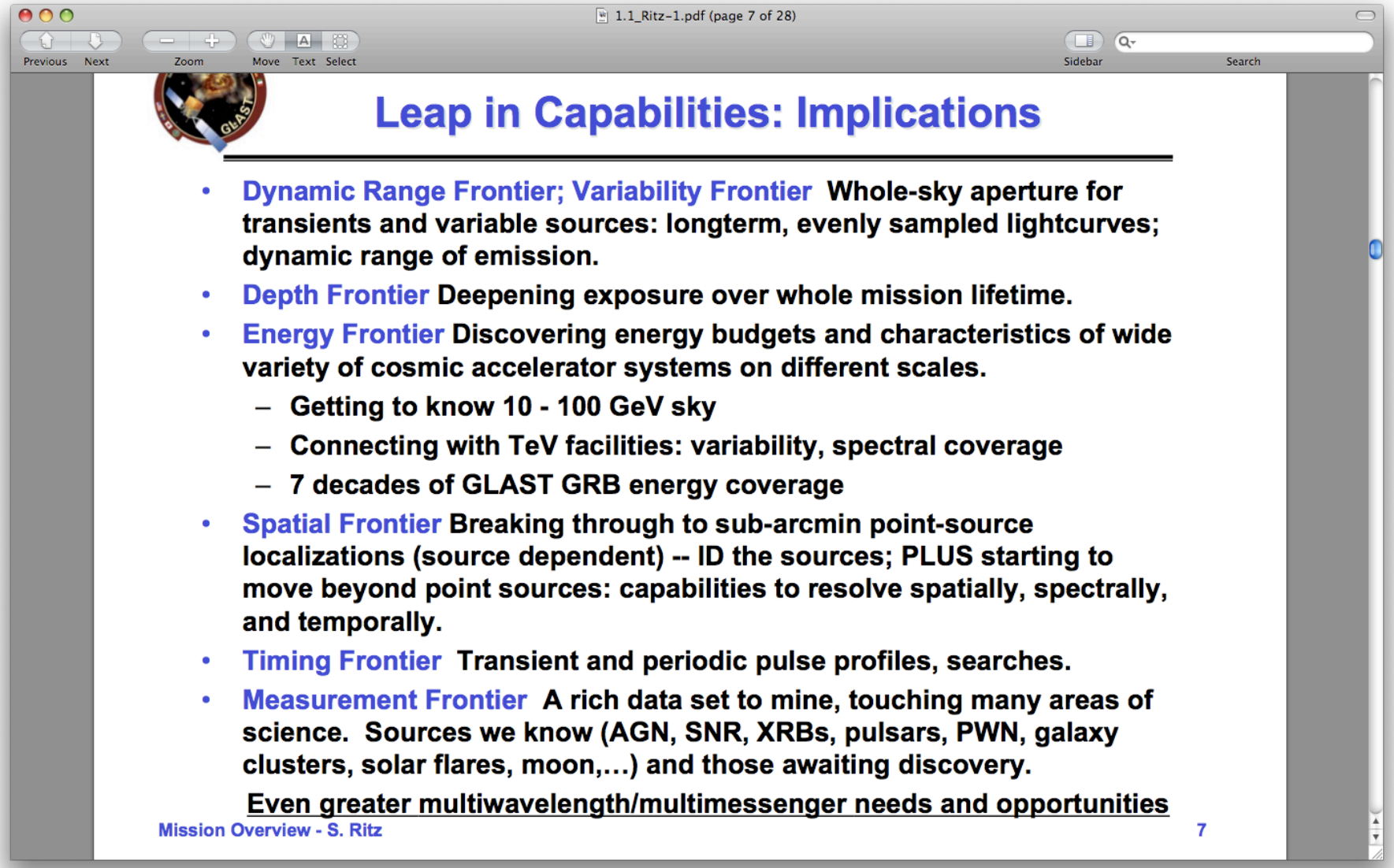
LAT High Level data releases

The LAT team releases flux/ spectra as a function of time for all sources in a pre-defined list + flaring sources during flares.

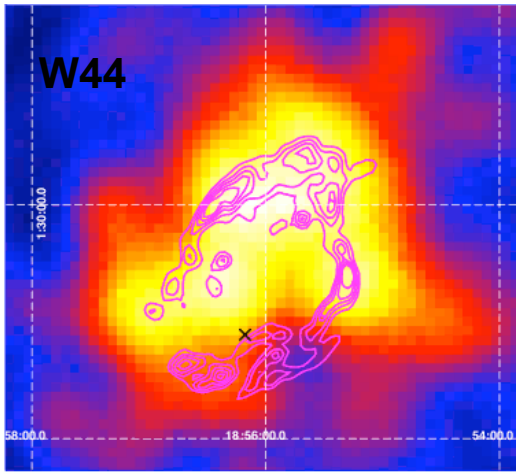
- **Modified data release after ~6months:**
  - **Lowered flux threshold to release information on flaring sources by factor of 2.**
  - **Provided information continuously (not just during flares).**
  - **started with 23 sources, now have >40**
- **http://fermisky.blogspot.com**

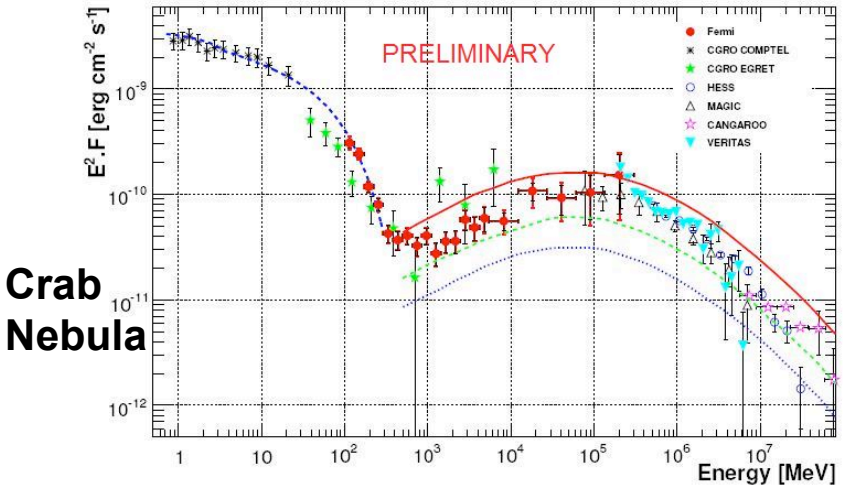
Source Type	Source Name	EGRET Name	Average or Min. Flux (10^{-8} Y $cm^{-2}s^{-1}$)	Galactic Lattitude	Redshift	TeV Source
Blazar	0208-512	3EGJ0210-5055	85.5 ± 4.5	-61.9	1.003	
	0235+164	3EGJ0237+1635	65.1 ± 8.8	-39.1	0.94	
	PKS 0528+134	3EGJ0530+1323	93.5 ± 3.6	-11.1	2.060	
	PKS 0716+714	3EGJ0721+7120	17.8 ± 2.0	28	0.3	
	0827+243	3EGJ0829+2413	24.9 ± 3.9	31.7	0.939	
	OJ 287	3EGJ0853+1941	10.6 ± 3.0	35.8	0.306	
	Mrk 421	3EGJ1104+3809	13.9 ± 1.8	65.0	0.031	Yes
	W Com 1219+285	3EGJ1222+2841	11.5 ± 1.8	83.5	0.102	
	3C 273	3EGJ1229+0210	15.4 ± 1.8	64.5	0.158	
	3C 279	3EGJ1255-0549	74.2 ± 2.8	57.0	0.538	
	1406-076	3EGJ1409-0745	27.4 ± 2.8	50.3	1.494	
	H 1426+428	NA		64.9	0.129	Yes
	1510-089	3EGJ1512-0849	18.0 ± 3.8	40.1	0.36	
	PKS 1622-297	3EGJ1625-2955	47.4 ± 3.7	13.4	0.815	
	1633+383	3EGJ1635+3813	58.4 ± 5.2	42.3	1.814	
	Mrk 501	NA		38.9	0.033	Yes
	1730-130 NRAO 530	3EGJ1733-1313	36.1 ± 3.4	10.6	0.902	
	1ES 1959+650	NA		17.7	0.048	Yes
	PKS 2155-304	3EG2158-3023	13.2 ± 3.2	-52.2	0.116	Yes
	BL_Lacertae (2200+420)	3EGJ2202+4217	39.9 ± 11.6	-10.4	0.069	Yes
	3C 454.3	3EGJ2254+1601	53.7 ± 4.0	-38.3	0.859	
	1ES 2344+514	NA		-9.9	0.044	Yes
HMXB	LSI+61 303 2CG135+01	3EGJ0241+6103	69.3 ± 6.1	1.0		Yes

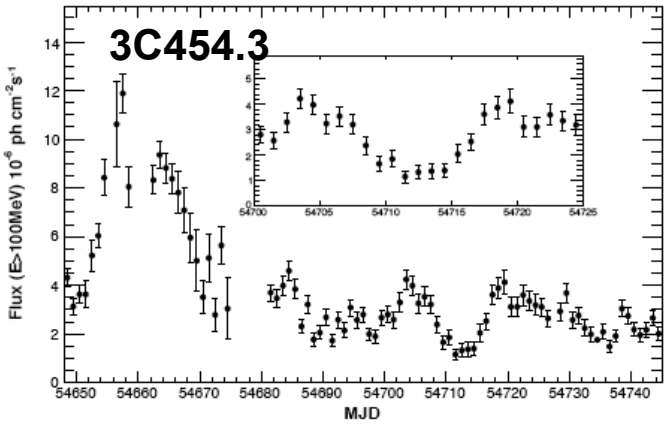
From pre-Launch GLAST Symposium

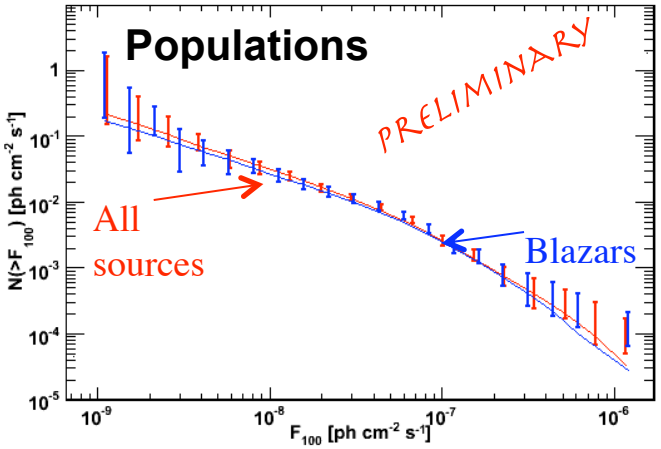


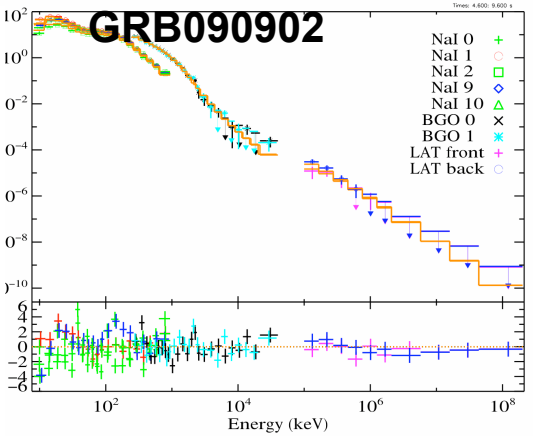
Breaking new ground!



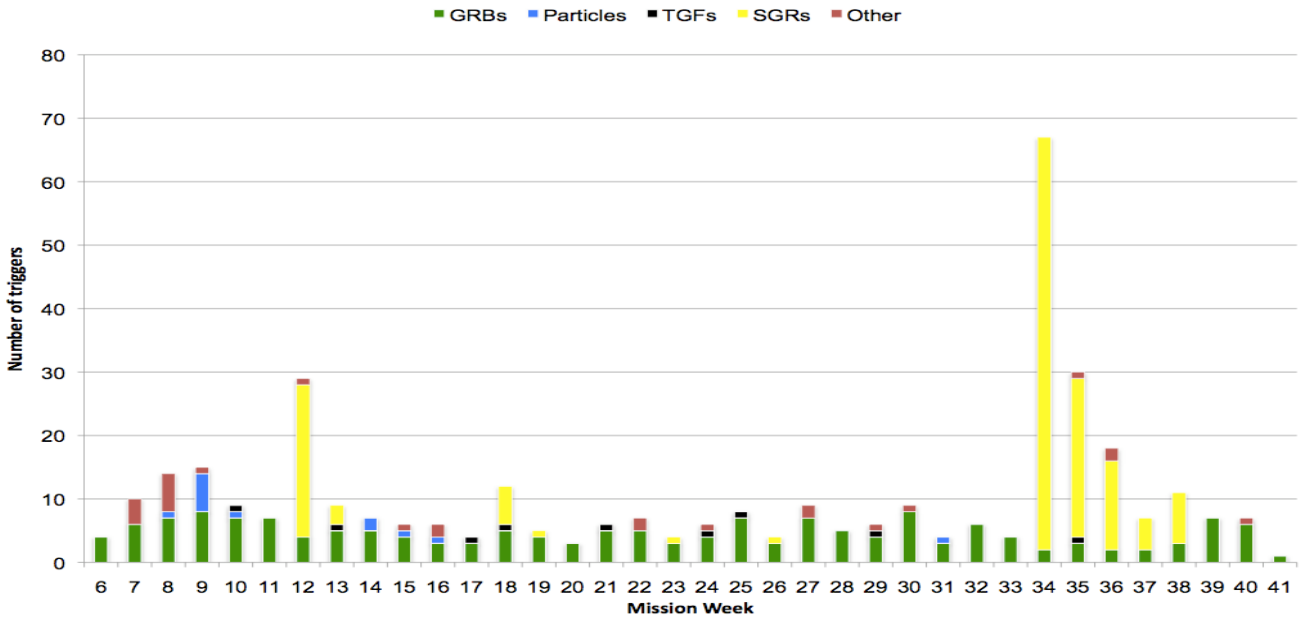








Gamma-ray Burst Monitor



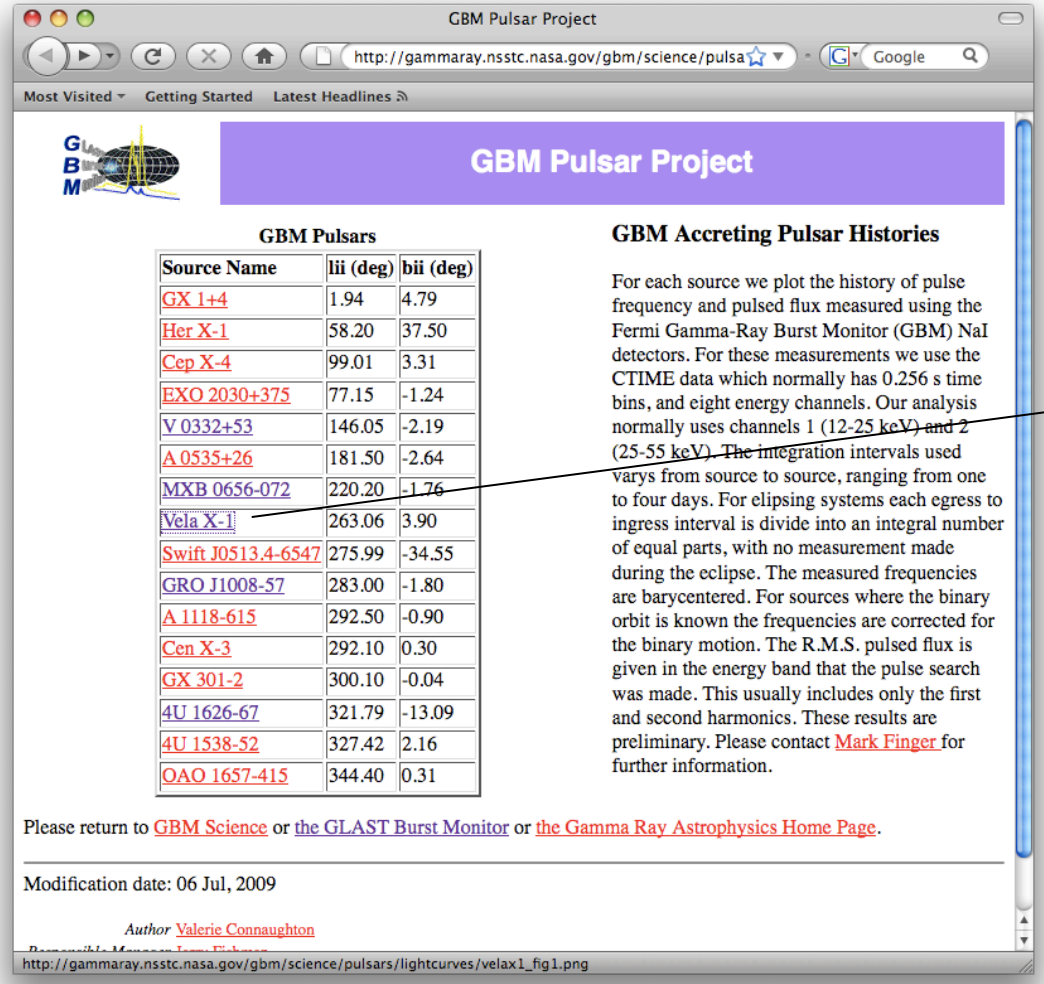
USA (MSFC, UAH, LANL) and Germany (MPE)

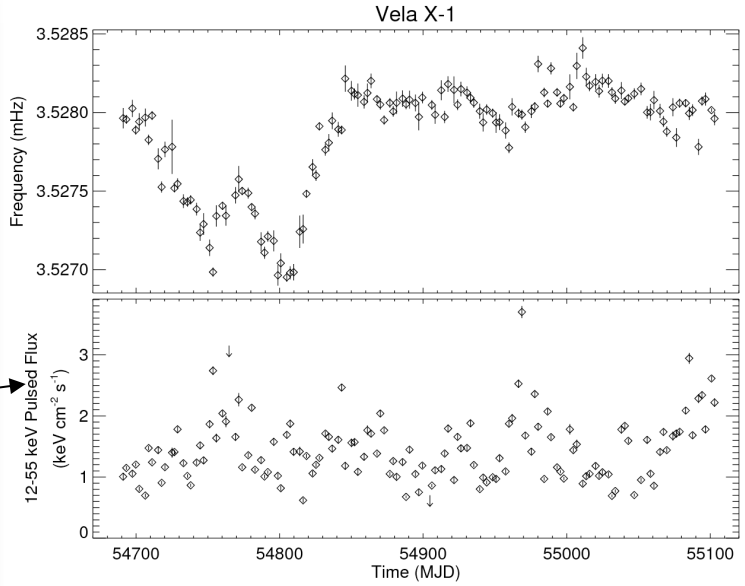
PI- Bill Paciesas (UAH)

Co-PI- Jochen Greiner (MPE)

- **Since July 2008, GBM has detected over 260 GRB (250/year c.f. 200/ year predicted)**
  - **Benefited from flexible onboard triggering algorithms**
- **Also has seen 4 SGRs, >10 TGFs and 2 solar flares.**
- **Recent flight software updates to improve reliability of autonomous repoint requests (to more reliably slew only to bright GRB)**

GBM - not just transients

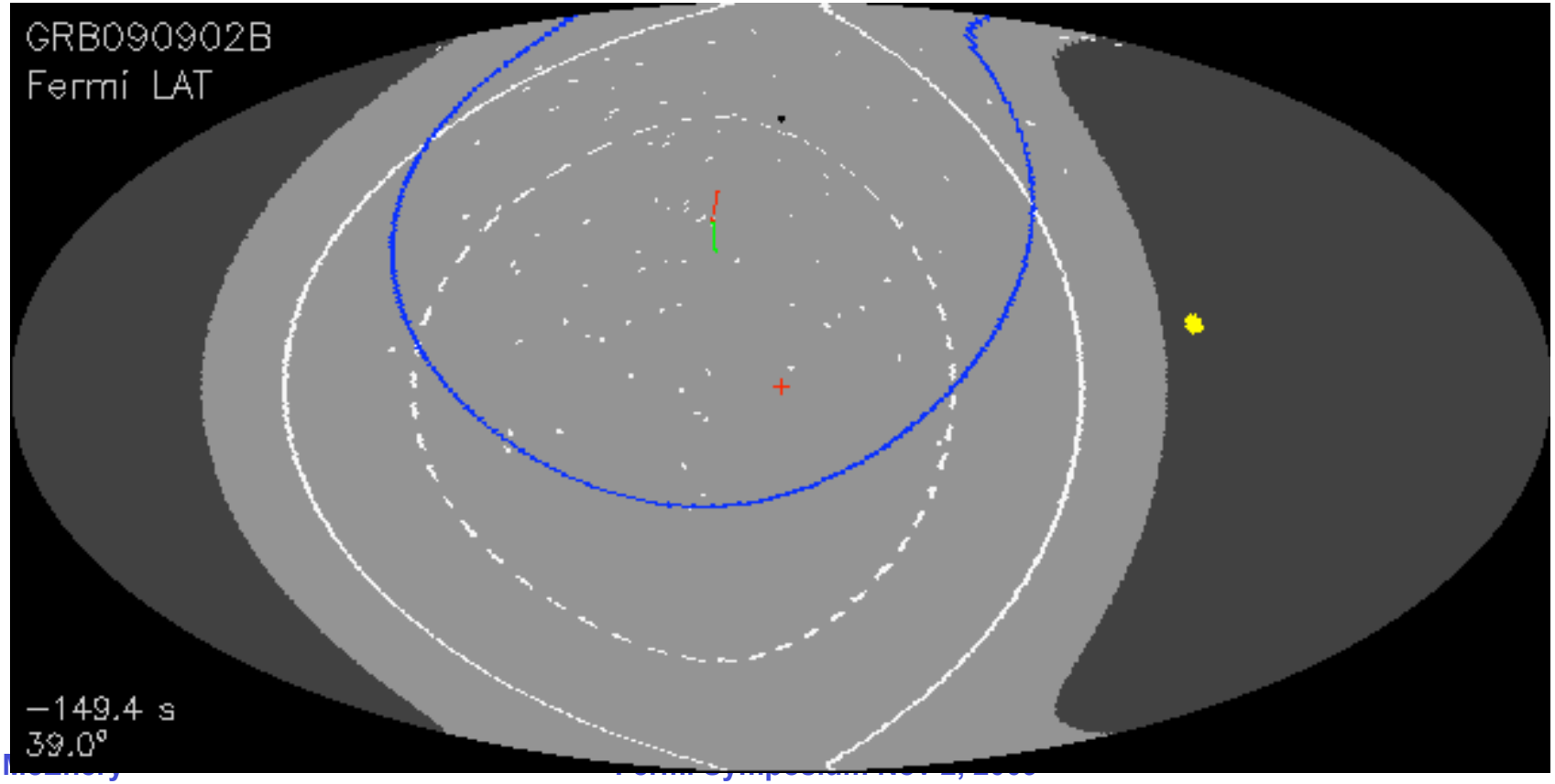




GBM team have made non-GRB high level data/ results available.

Two instruments together - Autonomous repoints

- **LAT pointing in celestial coordinates from -120 s to 2000 s**
  - **Red cross = GRB 090902B**
  - **Dark region = occulted by Earth**
  - **Blue line = LAT FoV (±66°)**
  - **White points = LAT events (no cut on zenith angle)**



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/

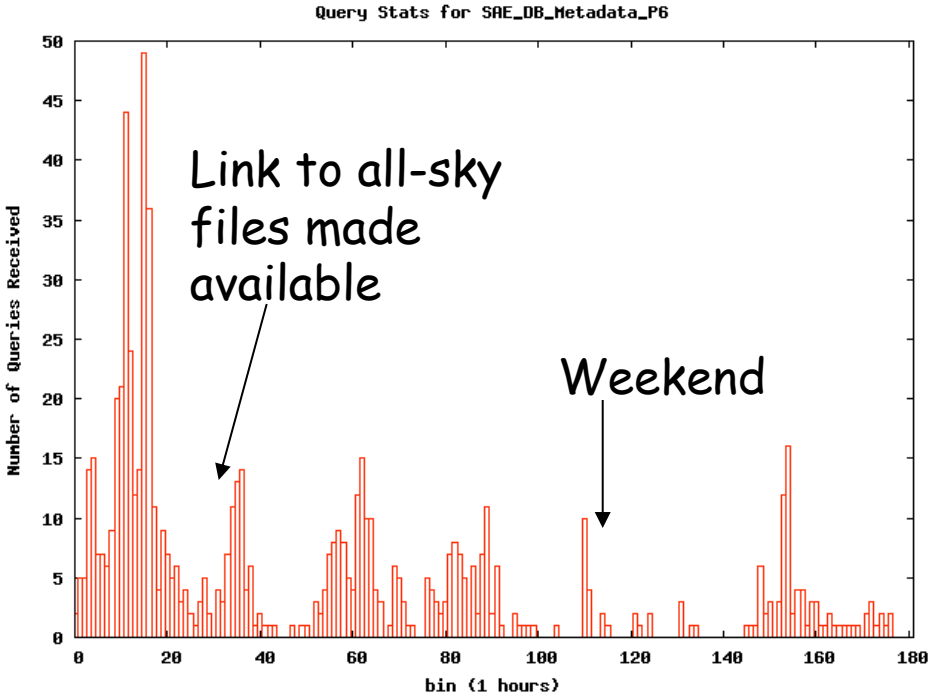
  and help desk

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

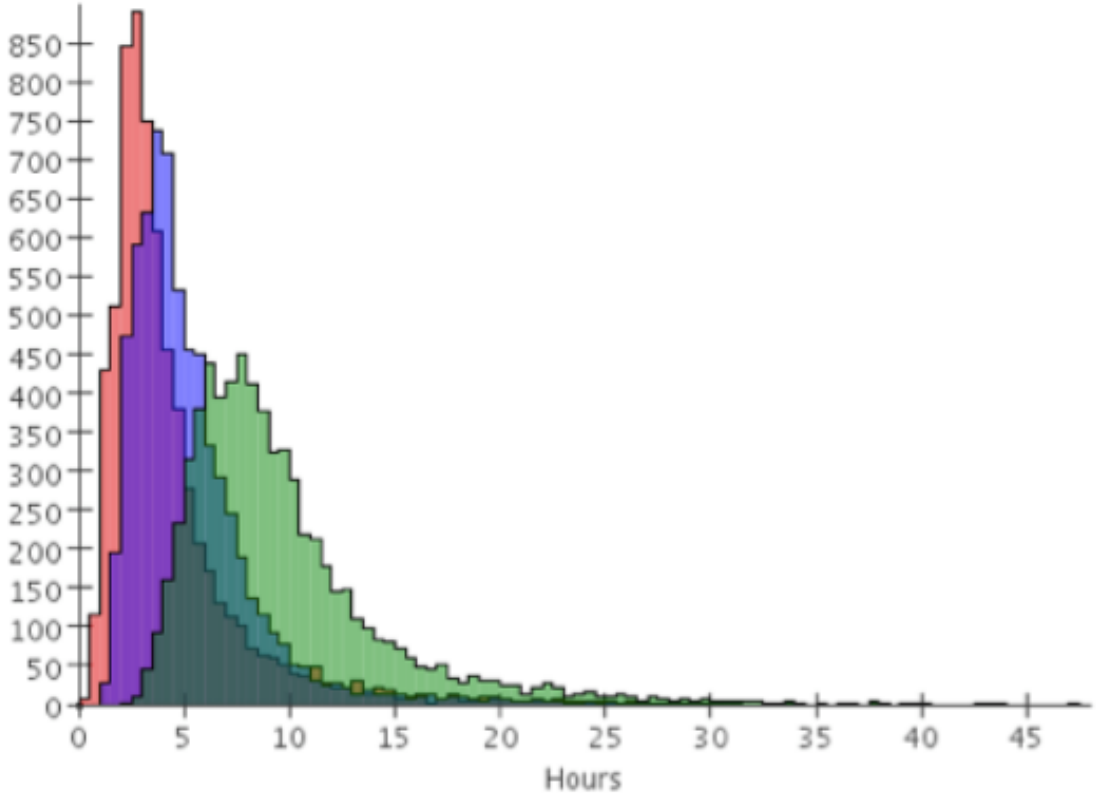
Data Releases

- **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)**



LAT Data Latency



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

Data analysis support and workshops

- The FSSC is holding a sequence of regional data analysis workshops
- First workshop on Oct 1 at GSFC
- 1-day, focus on hands-on activities
- ~<25 participants
  - Larger group limits 1-on-1 interactions
- Future workshops
  - Venues chosen based on community feedback
  - May try internet conferencing analysis workshops

- Please drop by the FSSC station for help with analysis topics, software installation and data access.

Fermi Users Group Members

- Alan Marscher (Chair)
- Matthew Baring
- Pat Slane
- Buell Januzzi
- Don Kniffen
- Henric Krawczynski
- Jamie Holder
- Wei Cui
- Scott Ransom
- Jim Ulvestad
- Alicia Soderberg

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/

Conclusions

- The LAT and GBM are both working well
- First LAT GeV catalog contains over 1000 gamma-ray sources!
  - New classes of gamma-ray sources (millisecond pulsars, gamma-ray binaries, globular clusters, starburst galaxies…)
    - field of gamma-ray astrophysics is rapidly expanding
- GBM is detecting many kinds of MeV transients
  - >300 GRB/year, 4 SGRs, >10 TGFs and 2 solar flares.
- Science returns in solar system studies, Galactic astrophysics, extragalactic astrophysics, cosmic-ray physics and fundamental physics.
- The full data release since Aug 25, software to assist with data analysis is also available.
  - http://fermi.gsfc.nasa.gov/ssc
- Lots more science to come…