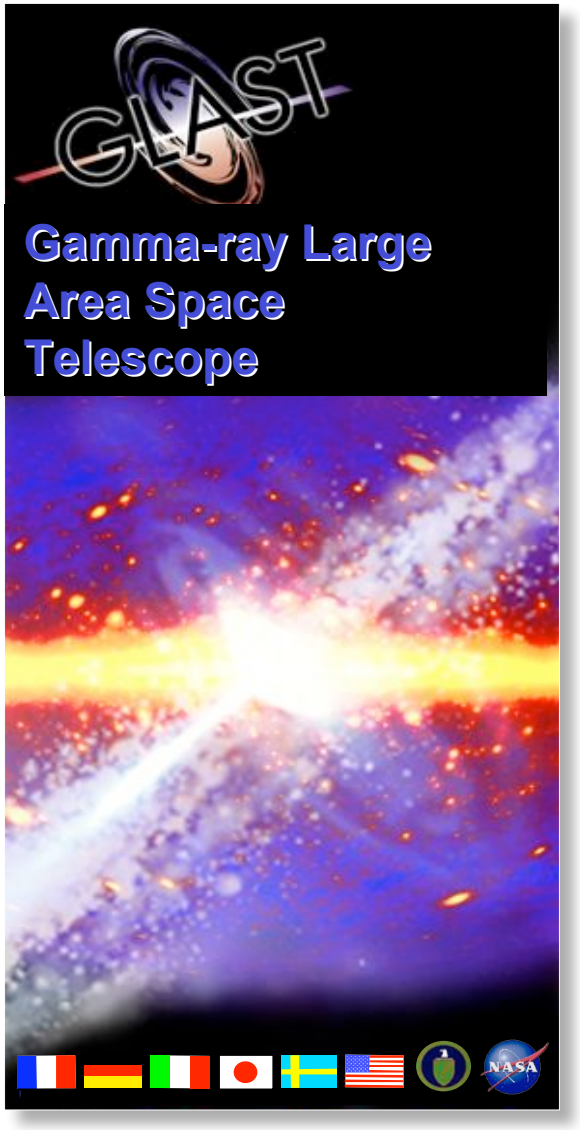


GLAST

The Gamma-ray Large Area Space Telescope

Mission Overview and Opportunities
HEAD Meeting, San Francisco
7 October 2006

S. Ritz
GLAST Project Scientist

for the GLAST Mission Team

Session Agenda

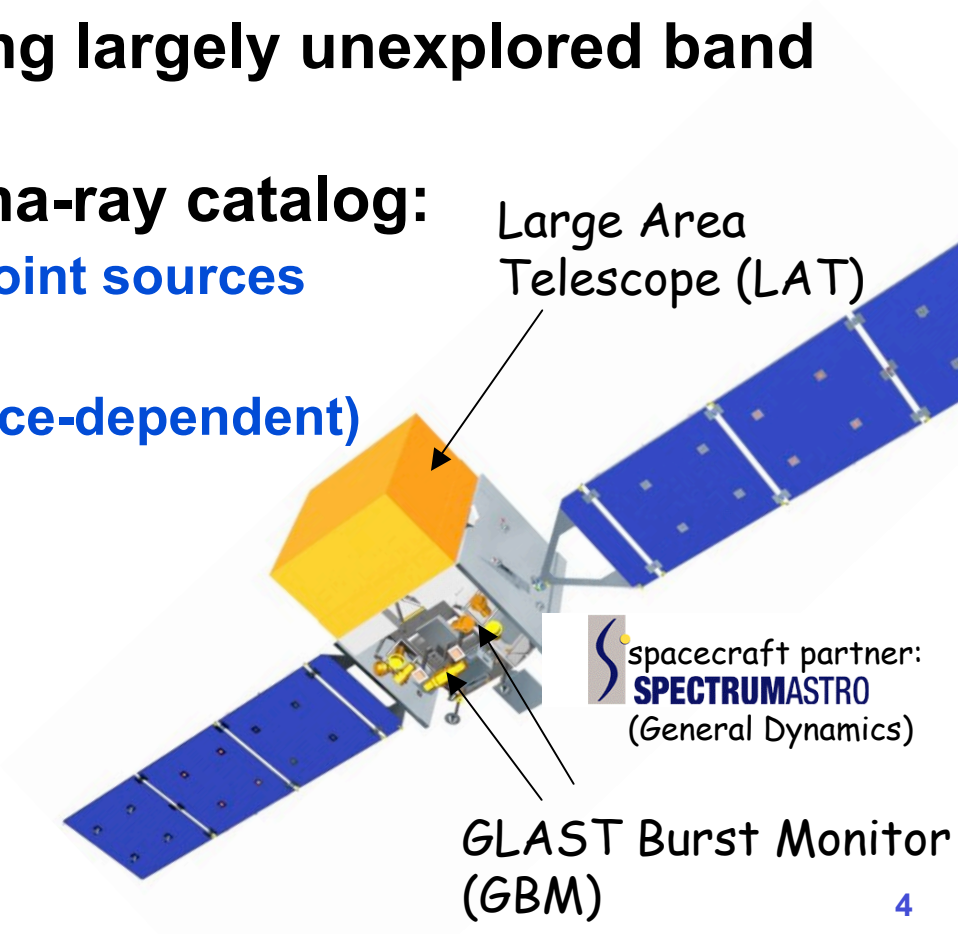
- ❑ Mission Overview and Opportunities - S. Ritz
- ❑ GLAST and AGN - M. Begelman
- ❑ GLAST and SNR - B. Gaensler
- ❑ GLAST and GRB - P. Meszaros

Topics

- Context, Mission Elements
- Instruments (LAT & GBM)
  - capabilities, status
- Schedule
- Operations phases, data
- Guest Investigator Opportunities
- GLAST Science Support Center (GSSC)
- GLAST Users Committee (GUC), Science Working Group (SWG)
- Education/Public Outreach
- The First International GLAST Symposium
- Summary

GLAST Key Features

- **Huge field of view**
  - **LAT: 20% of the sky at any instant; in sky survey mode, expose all parts of sky for ~30 minutes every 3 hours. GBM: whole unocculted sky at any time.**
- **Huge energy range, including largely unexplored band 10 GeV - 100 GeV**
- **Will transform the HE gamma-ray catalog:**
  - **by > order of magnitude in # point sources**
  - **spatially extended sources**
  - **sub-arcmin localizations (source-dependent)**



<u>Two GLAST instruments</u>:

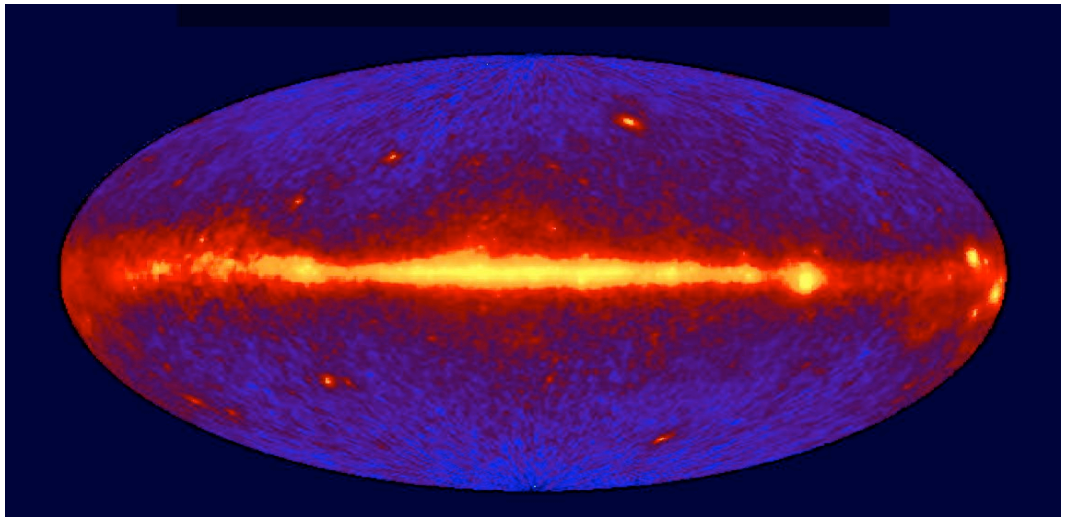
LAT: 20 MeV – >300 GeV

GBM: 10 keV – 25 MeV

Launch: 2007

5-year mission (10-year goal)

Features of the gamma-ray sky



EGRET all-sky survey (galactic coordinates) E>100 MeV

diffuse extra-galactic background
(flux ~ 1.5×10^{-5} $cm^{-2}s^{-1}sr^{-1}$)

galactic diffuse (flux ~O(100) times larger)

high latitude (extra-galactic) point sources (typical flux from EGRET sources O(10^{-7} - 10^{-6}) $cm^{-2}s^{-1}$

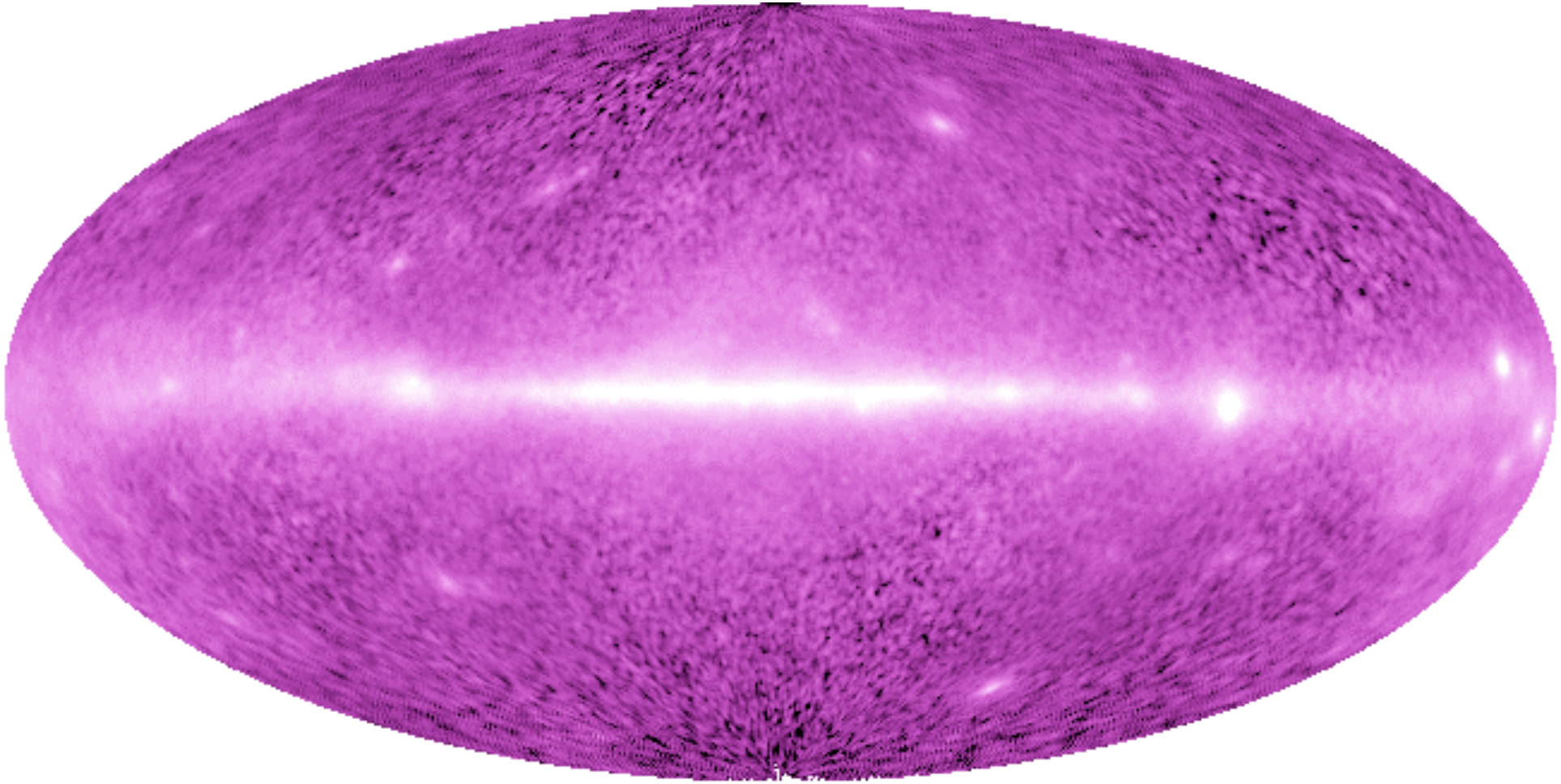
galactic sources (pulsars, un-ID'd)

An essential characteristic: VARIABILITY in time!

Field of view important for study of transients.

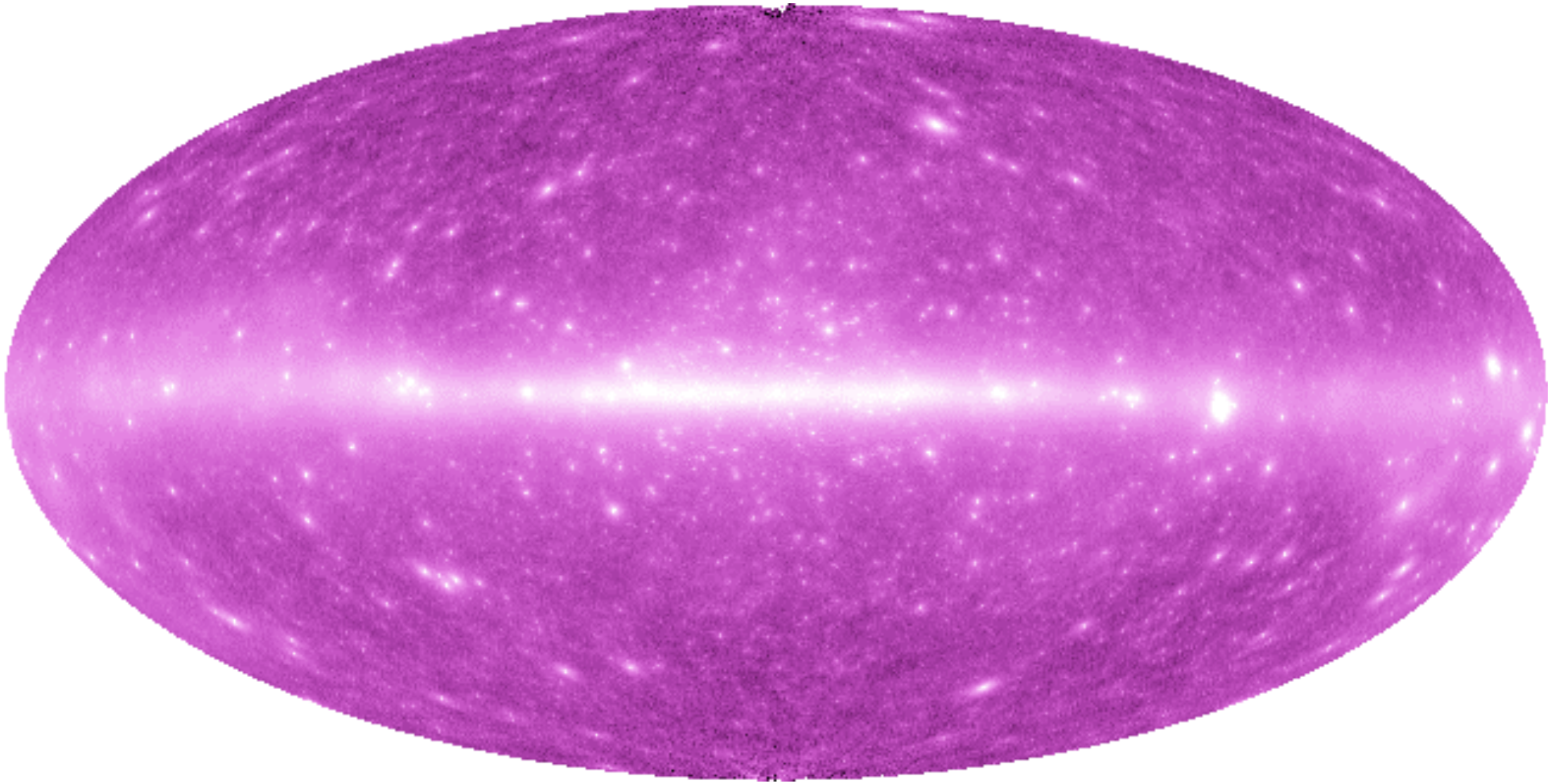
In sky survey mode, GLAST will cover the entire sky every 3 hours, with each region viewed for ~30 minutes.

EGRET all years



E>100 MeV

GLAST 1 Year

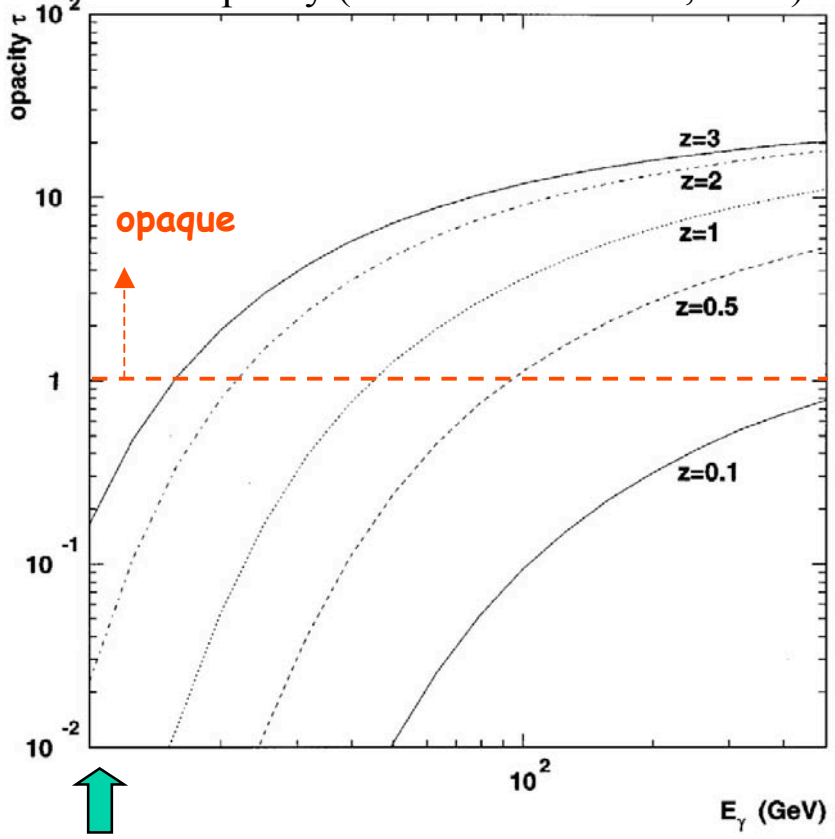


E>100 MeV

An Important Energy Band

Photons with E>10 GeV are attenuated by the diffuse field of UV-Optical-IR extragalactic background light (EBL)

Opacity (Salamon & Stecker, 1998)



No significant attenuation below ~10 GeV.

only $e^{-\tau}$ of the original source flux reaches us

EBL over cosmological distances is probed by gammas in the 10-100 GeV range. Important science for GLAST!

In contrast, the TeV-IR attenuation results in a flux that may be limited to more local (or much brighter) sources.

A dominant factor in EBL models is the time of galaxy formation -- attenuation measurements can help distinguish models.

GLAST Science

GLAST will have a very broad menu that includes:

- Systems with supermassive black holes (Active Galactic Nuclei)
- Gamma-ray bursts (GRBs)
- Pulsars
- Solar physics
- Origin of Cosmic Rays
- Probing the era of galaxy formation, optical-UV background light
- Solving the mystery of the high-energy unidentified sources
- Discovery! New source classes. Particle Dark Matter? Other relics from the Big Bang? Testing Lorentz invariance.

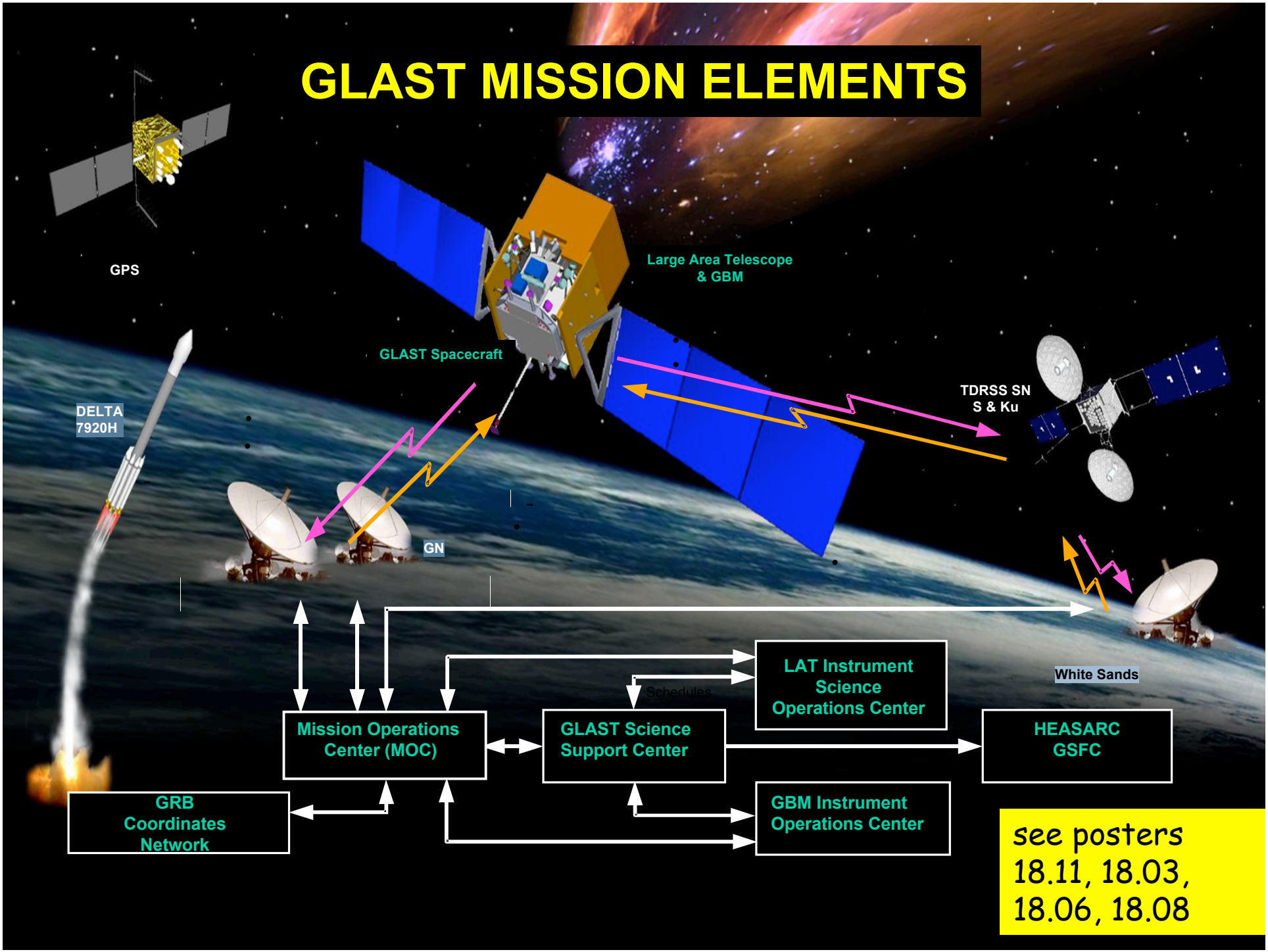
see posters 18.02, 18.07, 18.09

Huge increment in capabilities.

See *http://glast.gsfc.nasa.gov/science/multi/*

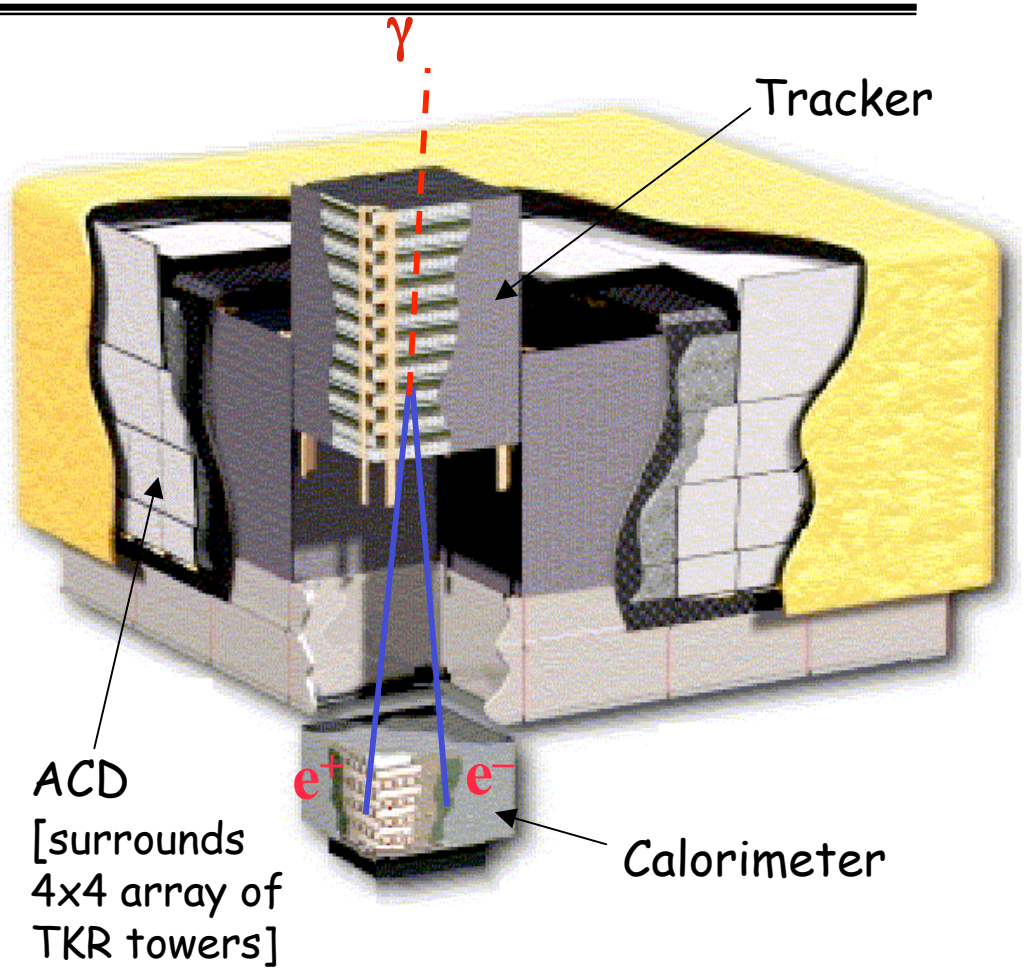
for MW campaigners information, coordination.

GLAST draws the interest of both the High Energy Particle Physics and High Energy Astrophysics communities.


GLAST MISSION ELEMENTS
GPS
Large Area Telescope
& GBM
GLAST Spacecraft
TDRSS SN
S & Ku
DELTA
7920H
GN
White Sands
LAT Instrument
Science
Operations Center
Schedules
Mission Operations
Center (MOC)
GLAST Science
Support Center
HEASARC
GSFC
GRB
Coordinates
Network
GBM Instrument
Operations Center
see posters
18.11, 18.03,
18.06, 18.08

Overview of LAT

- Precision Si-strip Tracker (TKR)
  18 XY tracking planes. Single-sided silicon strip detectors (228 μm pitch)
  Measure the photon direction; gamma ID.
- Hodoscopic CsI Calorimeter(CAL)
  Array of 1536 CsI(Tl) crystals in 8 layers.
  Measure the photon energy; image the shower.
- Segmented Anticoincidence Detector (ACD) 89 plastic scintillator tiles.
  Reject background of charged cosmic rays; segmentation removes self-veto effects at high energy.
- Electronics System Includes flexible, robust hardware trigger and software filters.



Systems work together to identify and measure the flux of cosmic gamma rays with energy 20 MeV - >300 GeV.

GLAST LAT Collaboration

United States

- University of California at Santa Cruz - Santa Cruz Institute of Particle Physics
- Goddard Space Flight Center – Laboratory for High Energy Astrophysics
- Naval Research Laboratory
- Ohio State University
- Sonoma State University
- Stanford University (SLAC and HEPL/Physics)
- University of Washington
- Washington University, St. Louis

France

- IN2P3, CEA/Saclay

Italy

- INFN, ASI

Japanese GLAST Collaboration

- Hiroshima University
- ISAS, RIKEN

Swedish GLAST Collaboration

- Royal Institute of Technology (KTH)
- Stockholm University

PI: Peter Michelson (Stanford & SLAC)

~230 Members (including ~84 Affiliated Scientists, plus 24 Postdocs, and 36 Graduate Students)

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

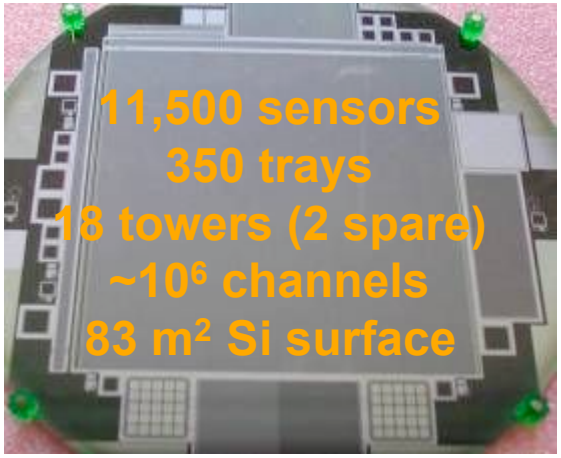
Managed at Stanford Linear Accelerator Center (SLAC).

LAT Status

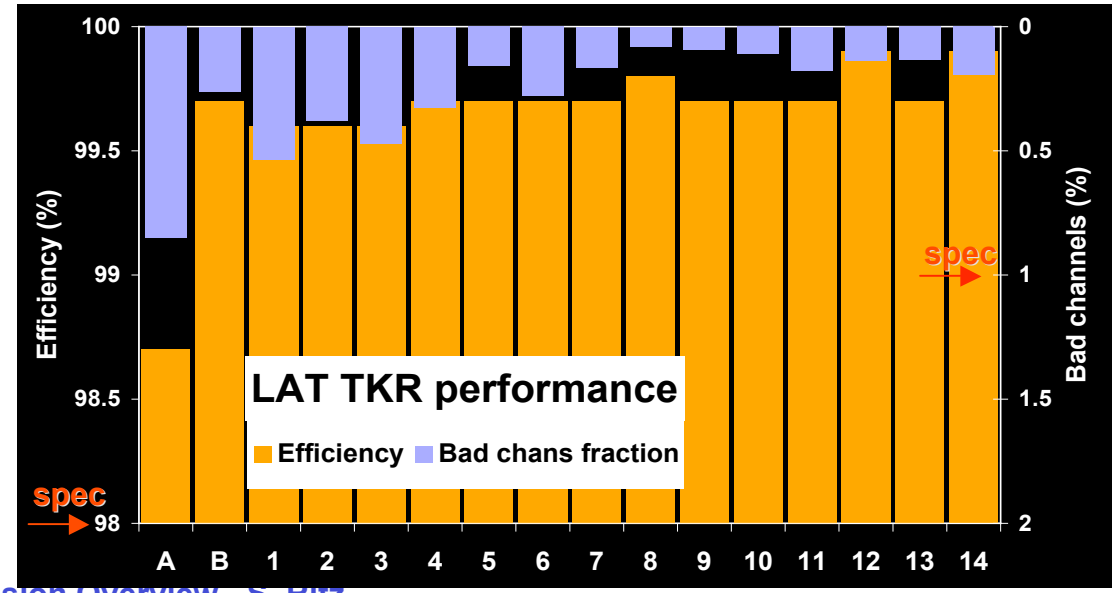
- **LAT environmental testing at NRL complete. Shipped to General Dynamics/Spectrum Astro. Integration onto observatory in October.**
- **Beam test of Calibration Unit (flight spare components) recently completed at CERN.**
- **Pending flight software updates scheduled for bug fixes and to implement onboard science (GRB) algorithms.**

see posters 18.04, 18.07

LAT Silicon Tracker

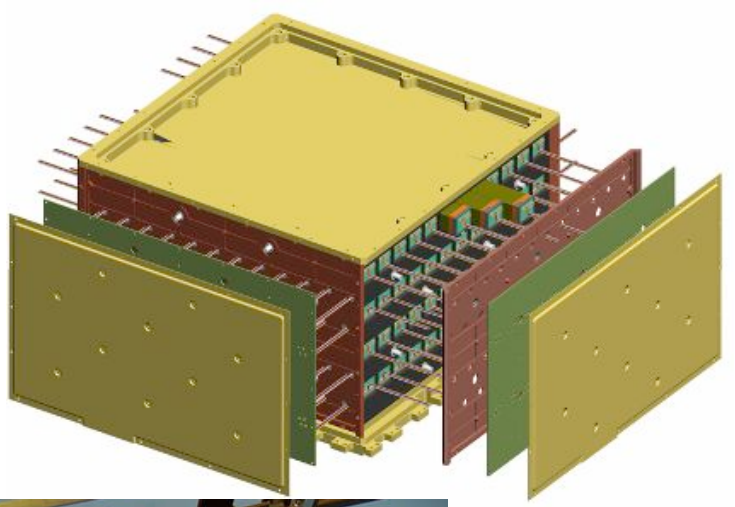


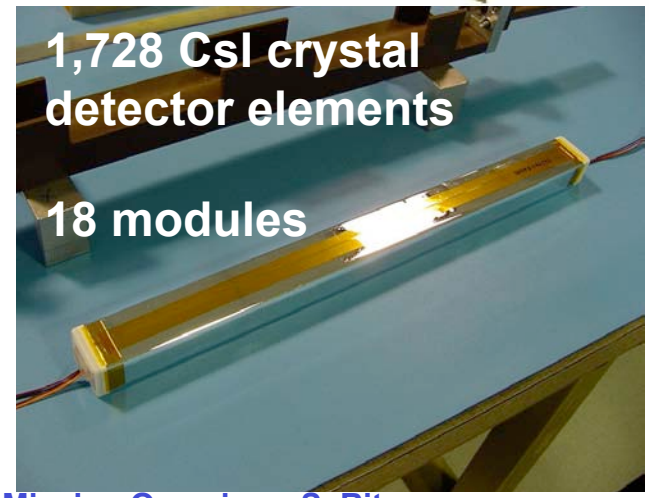
Team effort involving physicists and engineers from Italy (INFN & ASI), the United States, and Japan

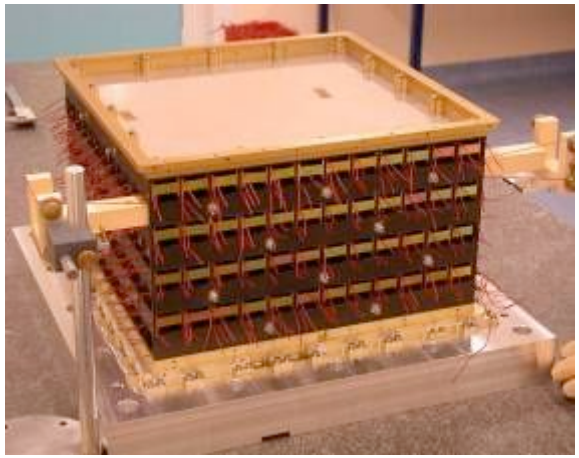


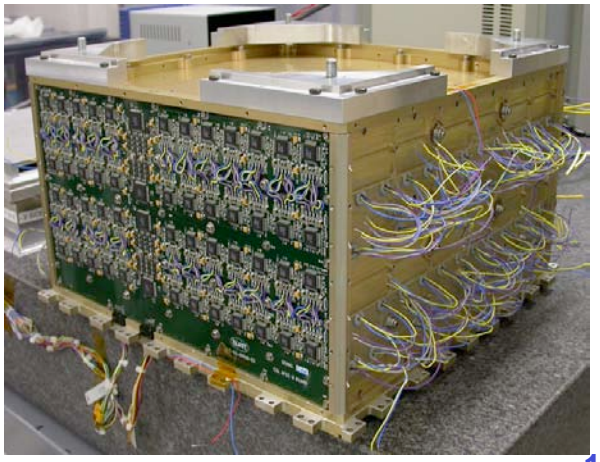
LAT Calorimeter

Team effort involving physicists and engineers from the United States, France (IN2P3 & CEA), and Sweden





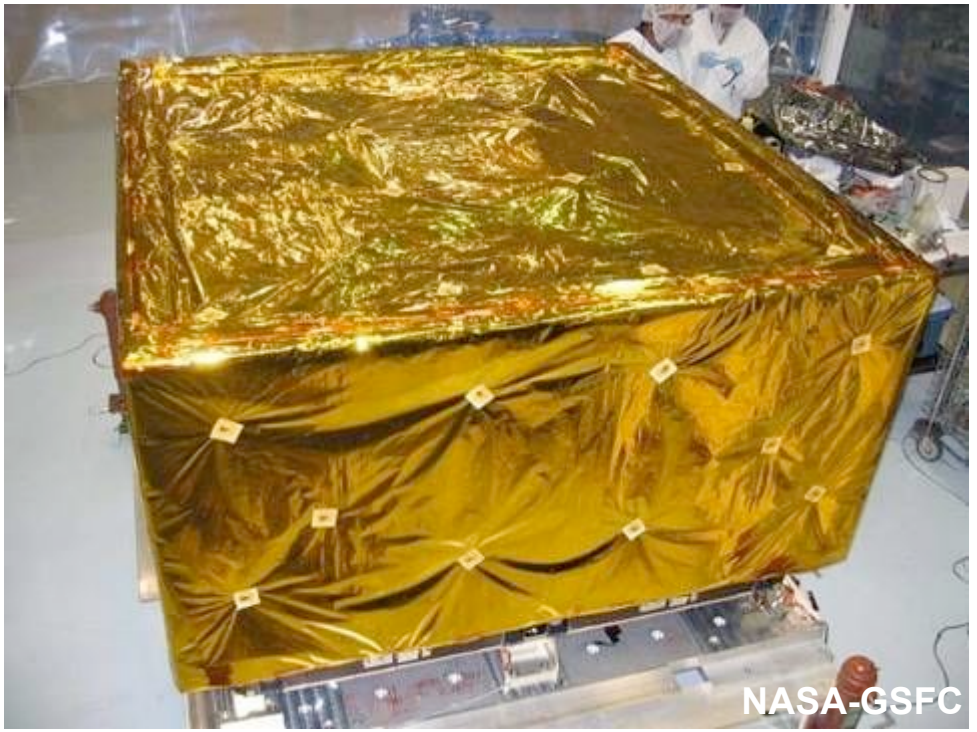




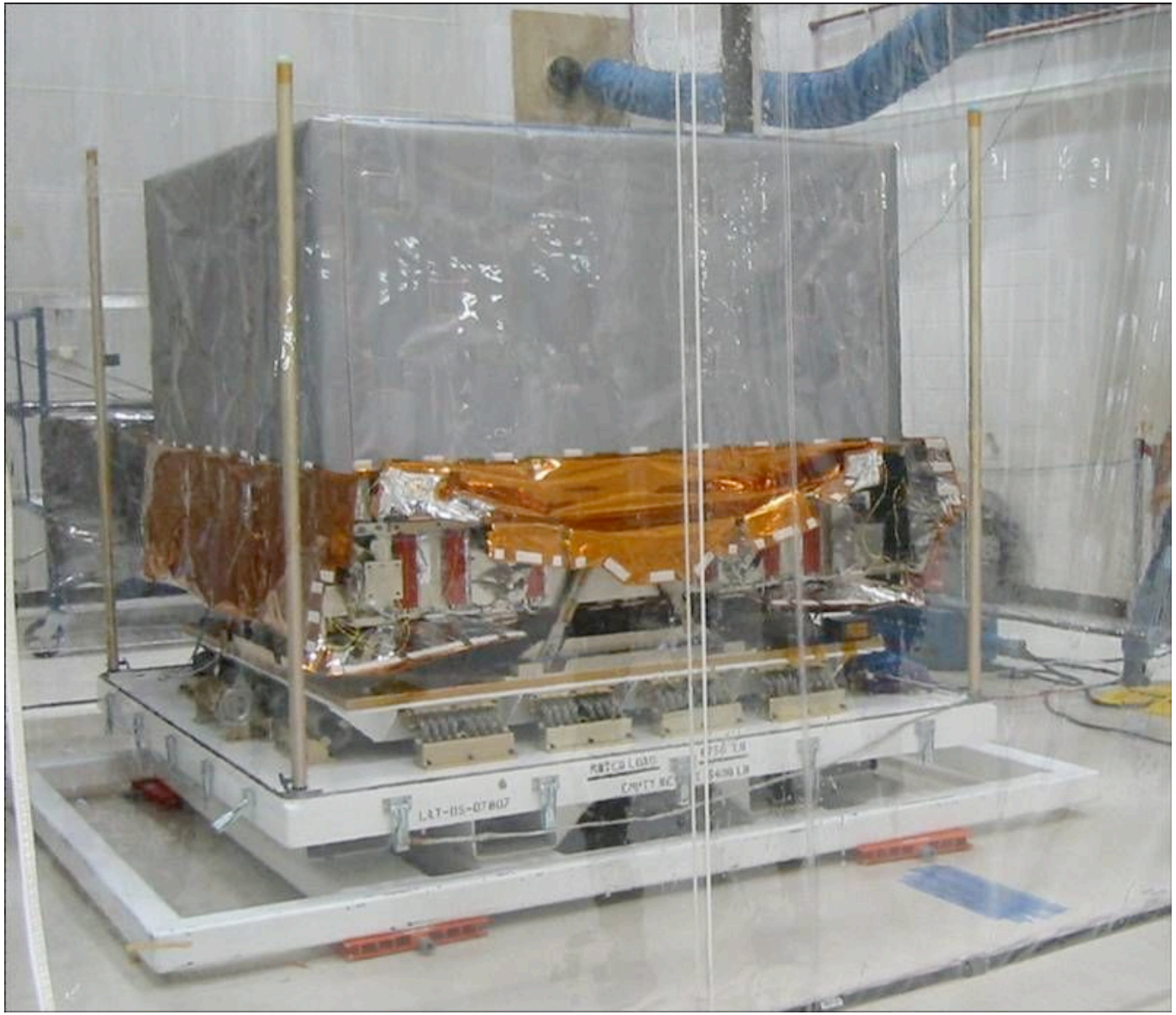
LAT Anti-Coincidence Detector

Team effort involving physicists and engineers from Goddard Space Flight Center, SLAC, and Fermi Lab

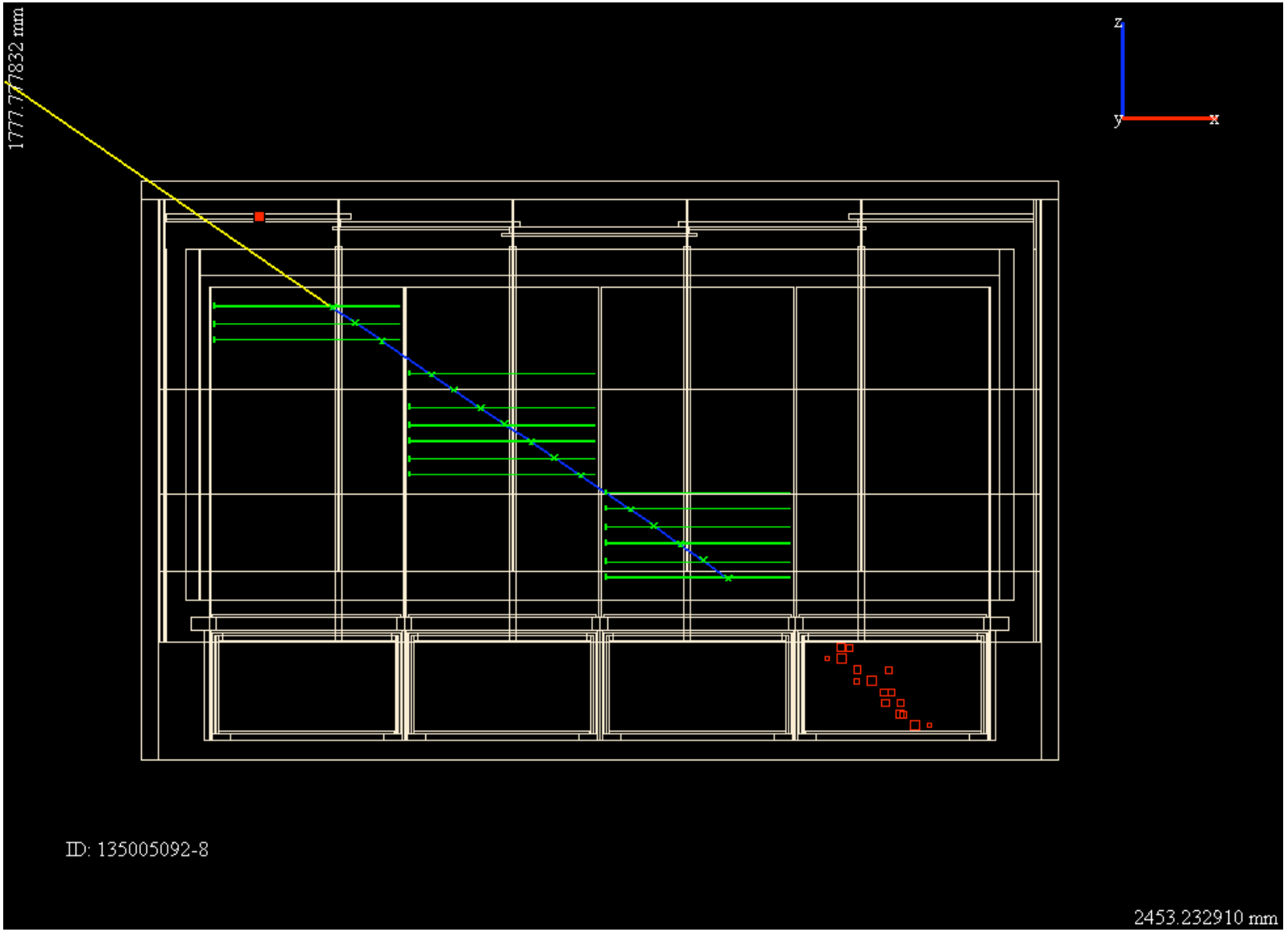
ACD before installation of Micrometeoroid Shield

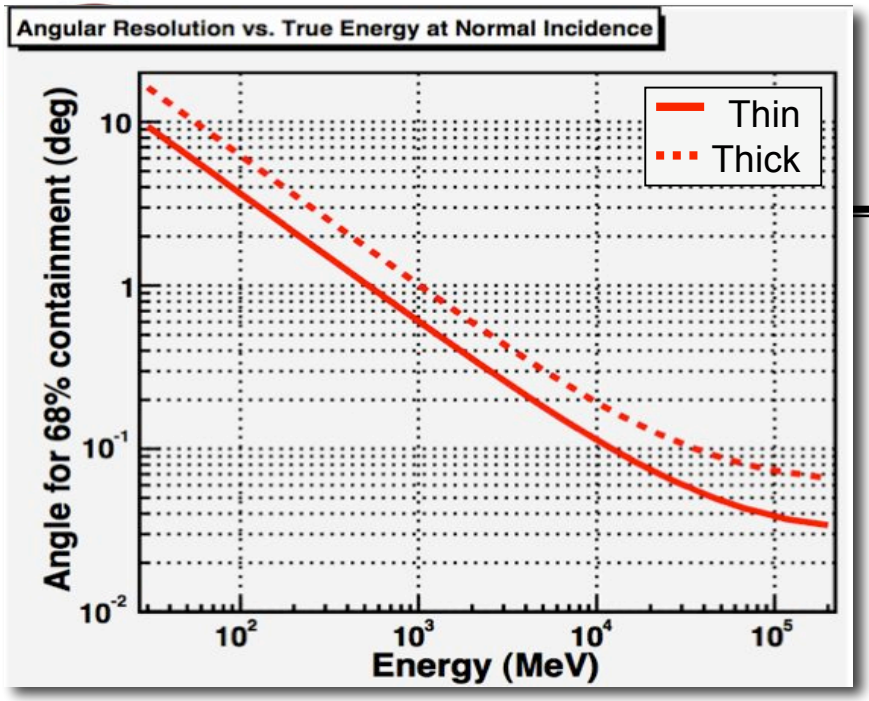


ACD with Micrometeoroid Shield and Multi-Layer Insulation (but without Germanium Kapton outer layer)



16 Towers with ACD

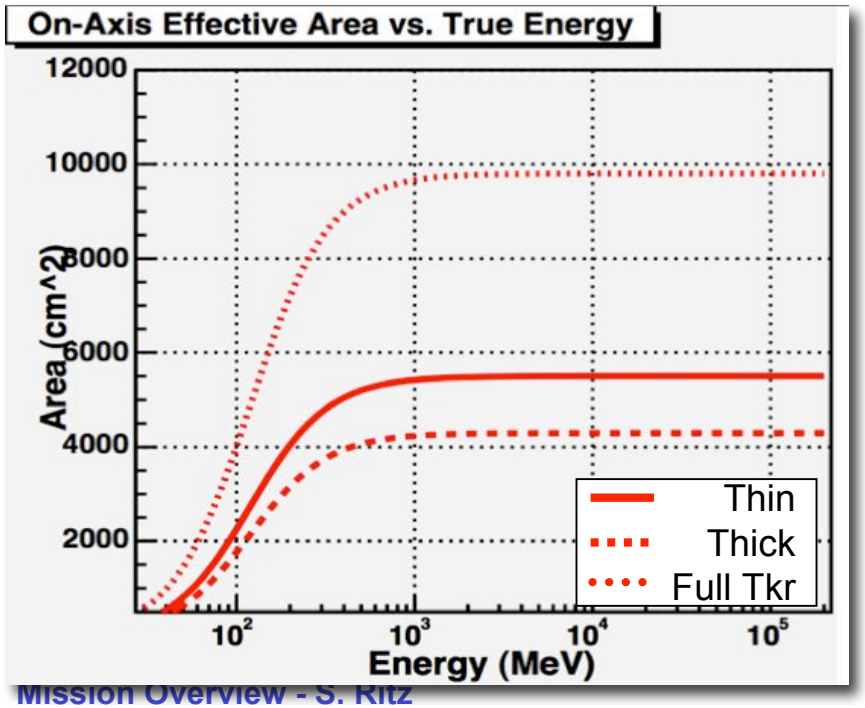


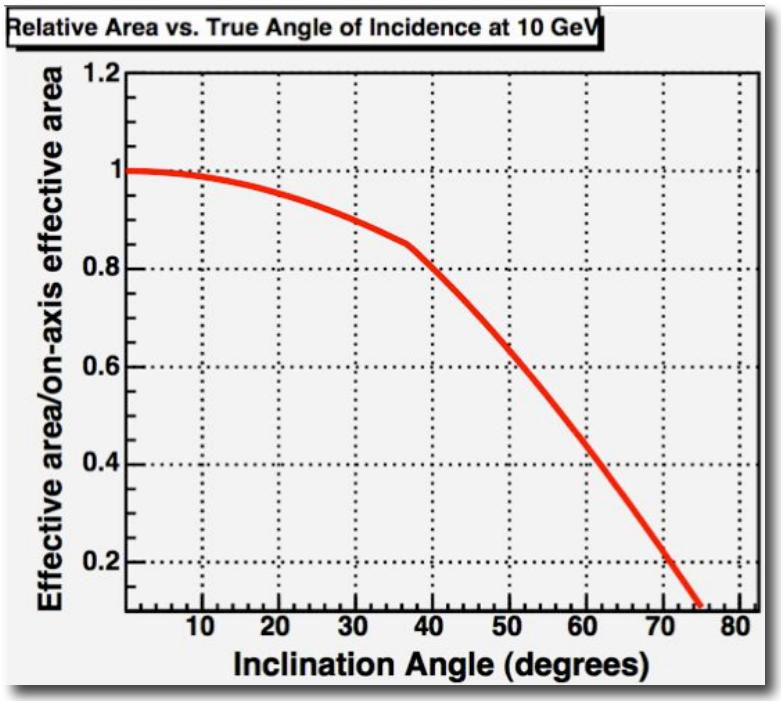


GLAST/LAT performance

(look for updates later this year)

Energy Resolution: ~<10% (~5% off-axis)
PSF (68%) at 10 GeV ~ 0.1°
Point Source sens. (>100 MeV): 4×10^{-9} cm^{-2} s^{-1}
Deadtime per event: 27 microsec





see poster 18.07 Atwood et al

GBM

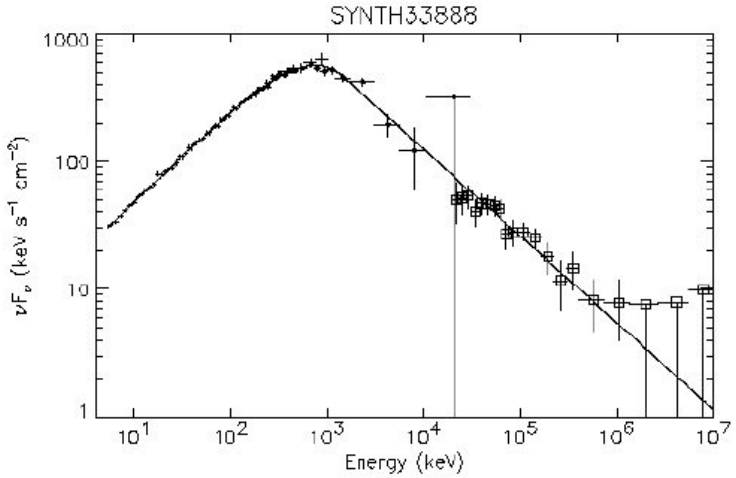
see poster 18.10

- **provides spectra for bursts from 10 keV to 30 MeV, connecting frontier LAT high-energy measurements with more familiar energy domain;**

Simulated GBM and LAT response to time-integrated flux from bright GRB 940217

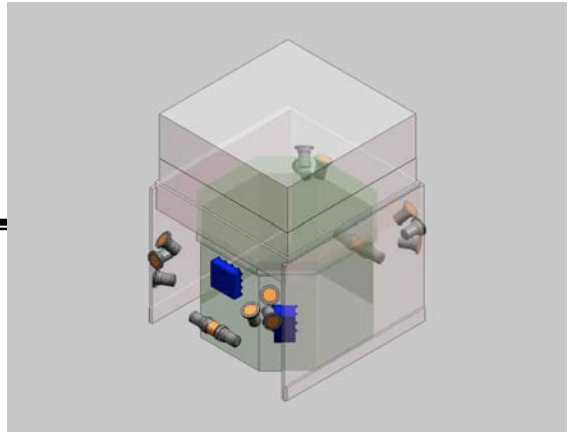
Spectral model parameters from CGRO wide-band fit

1 NaI (14 º) and 1 BGO (30 º)



- **provides wide sky coverage (>8 sr) -- enables autonomous repoint requests for exceptionally bright bursts that occur outside LAT FOV for high-energy afterglow studies (an important question from EGRET);**
- **provides burst alerts to the ground.**

GBM Collaboration



National Space Science & Technology Center

University of Alabama in Huntsville

- Michael Briggs
- William Paciesas
- Robert Preece
- Narayana Bhat
- Marc Kippen (LANL)

On-board processing, flight software, systems engineering, analysis software, and management

NASA Marshall Space Flight Center

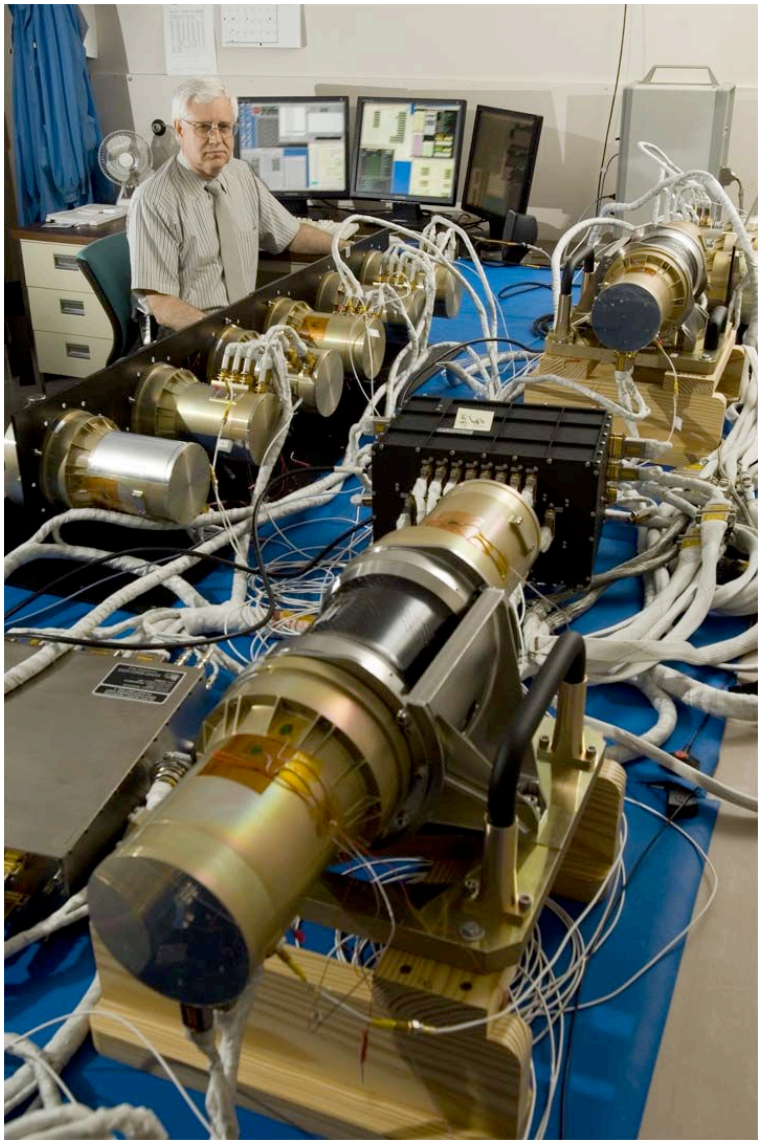
- Charles Meegan (PI)
- Gerald Fishman
- Chryssa Kouveliotou
- Robert Wilson

Max-Planck-Institut für extraterrestrische Physik

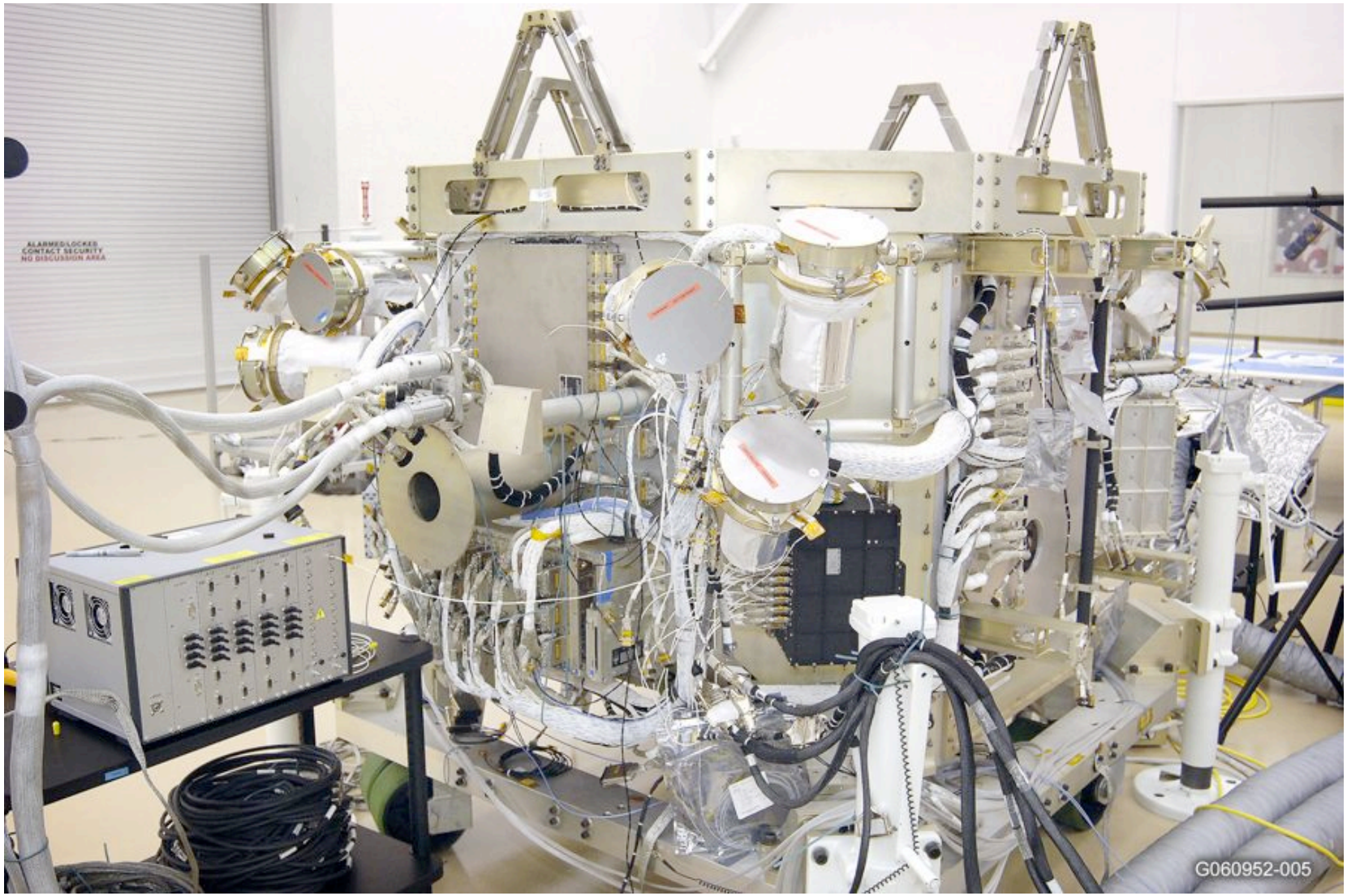
- Giselher Lichti (Co-PI)
- Andreas von Keinlin
- Volker Schönfelder
- Roland Diehl
- Jochen Greiner
- Helmut Steinle

Detectors, power supplies, calibration, and analysis software

GBM Hardware



GLAST Burst Monitor NaI Detectors on Spacecraft!



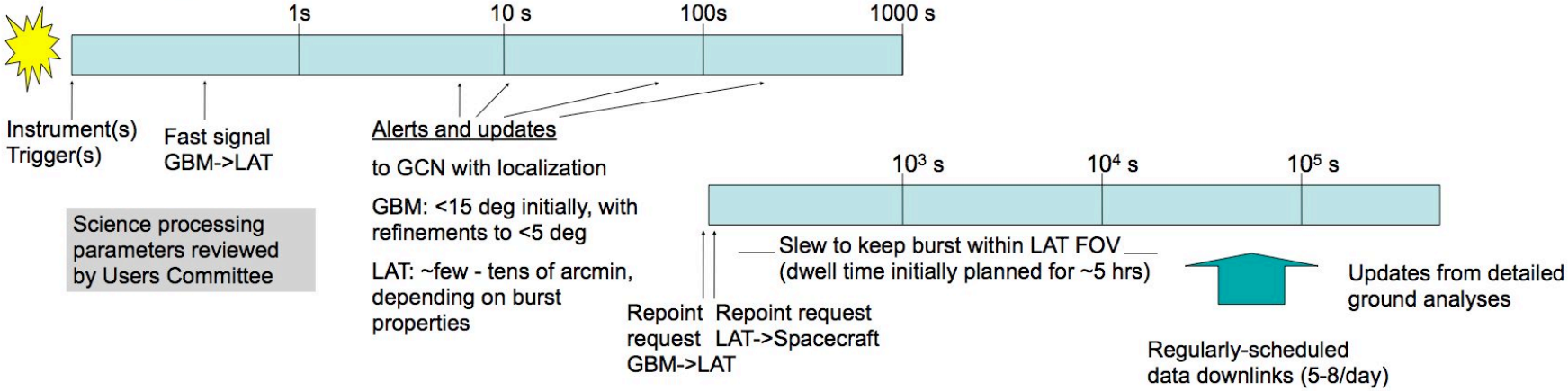
GBM Requirements

Parameter	Level 1 Requirements	Intra-Project Goals	Expected Performance
Energy range	10 keV – 25 MeV	5 keV – 30 MeV	8 keV – 30 MeV (1)
Energy resolution	10% (1σ; 0.1 – 1.0 MeV)	7% (1σ; 0.1 – 1.0 MeV)	<8% at 0.1 Mev (2) <4.5% at 1.0 Mev (3)
Effective area	NaI: >100 cm^2 at 14 keV BGO: >80 cm^2 at 1.8 MeV	NaI: >50 cm^2 at 6 keV BGO: none	NaI: 47.5 – 78 cm^2 at 14 keV BGO: >95 cm^2
On-board GRB locations	(none)	15° accuracy (1σ radius) within 2 seconds	<15°; 1.8 seconds (<8° for S/C <60° zenith)
GRB sensitivity (on ground)	0.5 photons cm^{-2} s^{-1} (peak flux, 50–300 keV)	0.3 photons cm^{-2} s^{-1} (peak flux, 50–300 keV)	0.47 photons cm^{-2} s^{-1} (peak flux, 50–300 keV)
GRB on-board trigger sensitivity	1.0 photons cm^{-2} s^{-1} (peak flux, 50–300 keV)	0.75 photons cm^{-2} s^{-1} (peak flux, 50–300 keV)	0.71 photons cm^{-2} s^{-1} (peak flux, 50–300 keV)
Field of view	>8 steradians	10 steradians	9 steradians

(1) Supported by measurements of window absorption
(2) Measured NaI-system resolution
(3) Measured BGO-system resolution

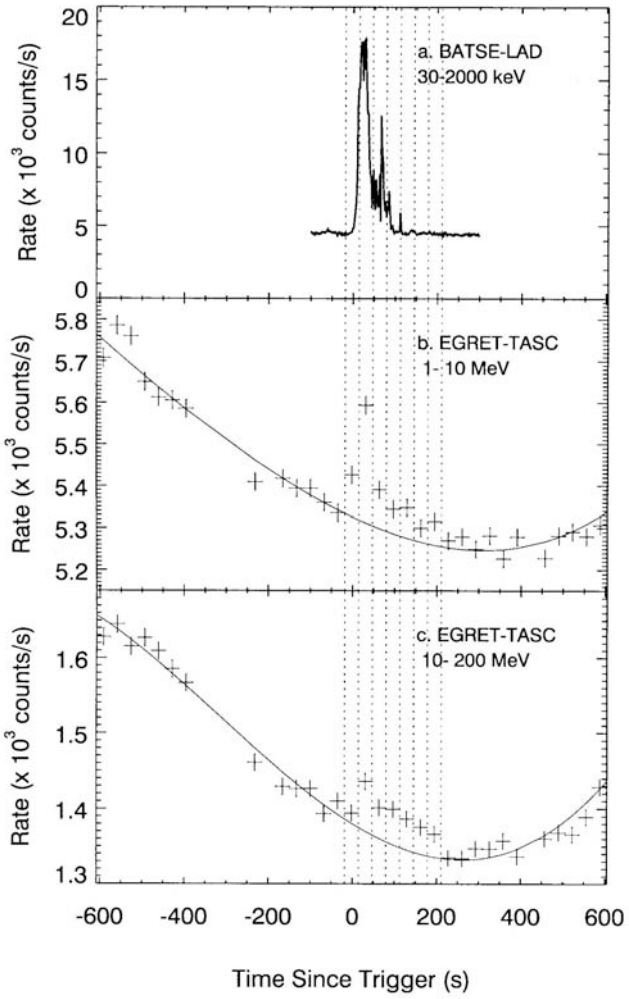
- **on-ground location accuracy: < ~few degrees**
- **expected burst-detection rate of the GBM:**
  - **~70 bursts/year in 55° FoV of LAT**
  - **~215 bursts/year will be detected in total**

Typical GLAST GRB Timeline



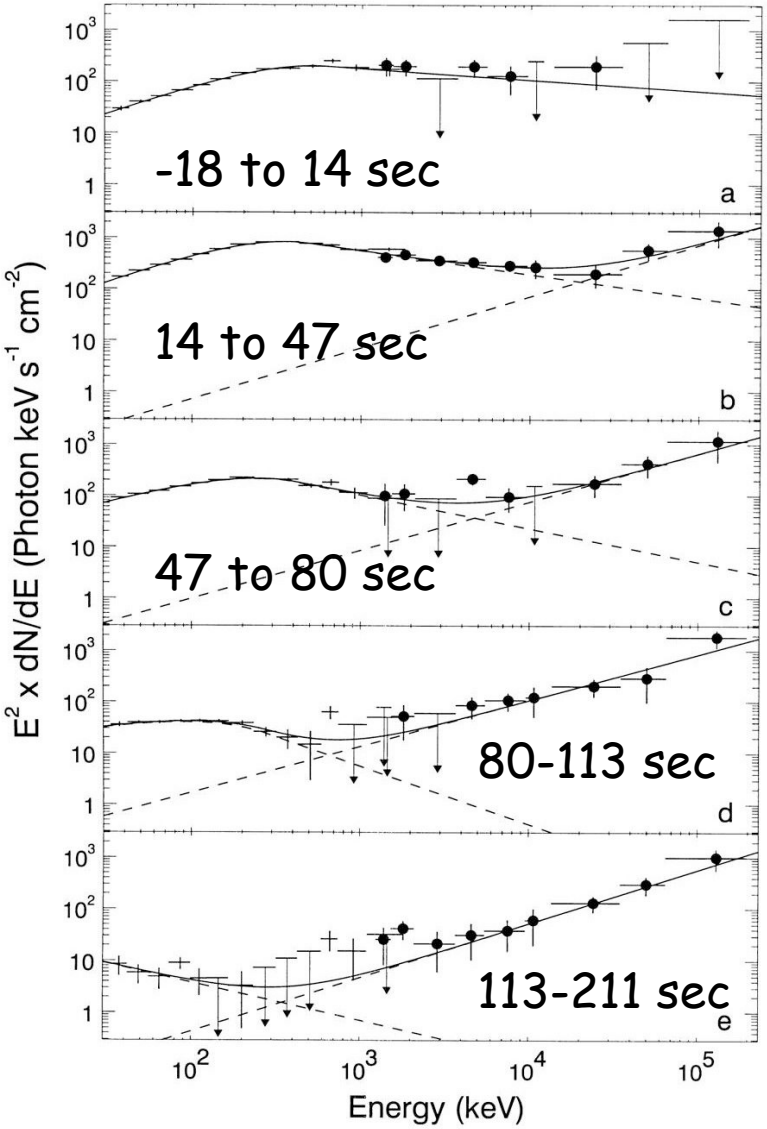
GRB941017

Gonzalez et al., published in Nature

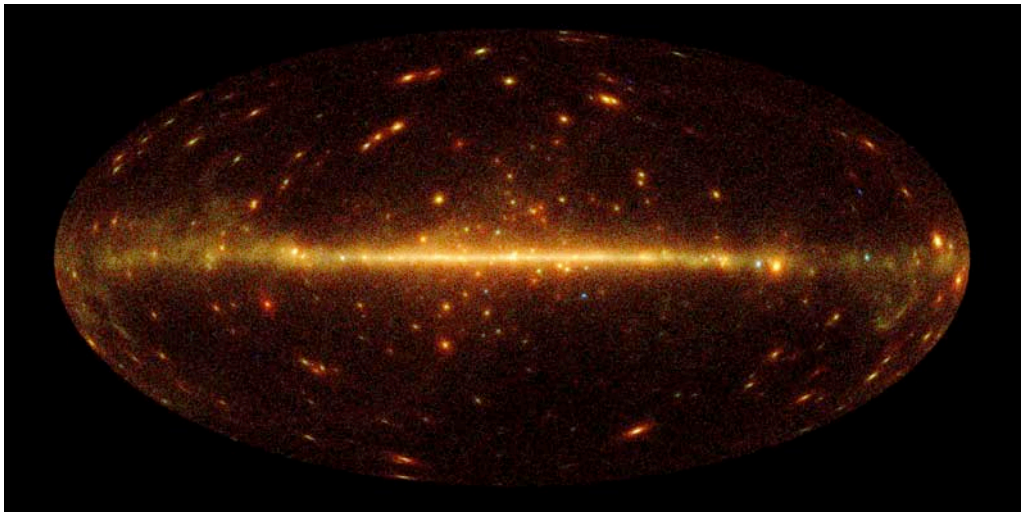


Compare data from EGRET and BATSE: Distinct high-energy component has different time behavior. What is the high-energy break and total luminosity? **Need GLAST data!**

Learn important lessons from the past.



Data Challenges



Data challenges provide excellent testbeds for science analysis software.

Full observation, instrument, and data processing simulation. Team uses data and tools to find the science. "Truth" revealed at the end.

- **A progression of data challenges.**
  - **DC1 in 2004. 1 simulated week all-sky survey simulation.**
    - **find the sources, including GRBs**
    - **a few physics surprises**
  - **DC2 in 2006, completed in June. 55 simulated days all-sky survey.**
    - **first catalog**
    - **add source variability (AGN flares, pulsars). add GBM. benchmark data processing/volumes.**

Schedule

- Launch date to be determined by NASA HQ with the GLAST project later this month. Primary drivers:
  - completion of spacecraft data (C&DH) system and solar arrays
  - completion of observatory I&T activities
- <u>Expect launch in October-November 2007 timeframe</u>

- Observatory I&T in progress:
  - GBM integration nearing completion
  - LAT integration in October
  - Spacecraft testing complete in December
- Observatory pre-environmental review December
- Observatory-level testing complete September 2007
- Launch site operations Sept-Oct 2007

Operations Phases, Guest Observers, Data

- **After the initial on-orbit checkout, verification, and calibrations, the first year of science operations will be an all-sky survey.**
  - every region of the sky viewed for ~30 minutes every 3 hours
  - burst alerts via GCN
  - first year LAT photon candidate event lists initially used for detailed instrument characterization, refinement of the alignment, and key projects (source catalog, diffuse background models, etc.) needed by the community
  - data on flaring sources, transients, and "sources of interest" will be released, with caveats (see following slide)
  - repoints for bright bursts and burst alerts enabled
  - extraordinary ToO's supported
  - workshops for guest observers on science tools and mission characteristics for proposal preparation
- **Observing plan in subsequent years driven by guest observer proposal selections by peer review -- default is sky survey mode. Public data released through the science support center (GSSC).**

Year 1 LAT Data Releases

- **Throughout year 1 and beyond, high-level data releases continuously:**
  - **on any flaring source (flux > 2×10^{-6} $cm^{-2}s^{-1}$, E>100 MeV), followed down to factor ~10 lower intensity. Time-binned spectra (or energy-binned light curves) and associated errors.**
  - **on approximately 20 sources of interest, time-binned spectra (or energy-binned light curves). List vetted through Users Committee. Posted on GSSC website.**
  - **information from GRBs detected both onboard and from ground-based analyses. For GBM bursts with no LAT detections, upper limits provided.**
- **At end of year 1, individual photon candidate event info released. All subsequent (year 2 and beyond) individual photon candidate events released immediately after processing.**
- **Approximately six months into year 1 (in advance of Cycle 2 proposals) a preliminary LAT source list of high-confidence sources will be released**
  - **position, avg flux, peak flux, spectral index, associated errors**

GI Opportunities

- Yearly cycles, starting ~2 months after launch
- Cycle 1:
  - expect to fund ~50 investigations for
    - analyses of released data
    - GLAST-related MW observations
    - GLAST-related theory
    - GLAST-relevant data analysis methodology
- Cycle 2 and onward:
  - expect to fund ~100 investigations for all of the above plus detailed analyses of LAT photon candidate event lists.
  - may propose pointed observations
- GLAST Fellows Program
  - starts in Year 1
  - three new Fellows selected each year, for three-year periods
- Tentative Schedule for Cycle 1 (2007)
  - NRA in ROSES January, proposals due in May, Cycle 1 funding starts in December

GLAST Science Support Center (GSSC)

- Supports guest investigator program
- 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://glast.gsfc.nasa.gov/ssc/

GLAST Users Committee (GUC)

- Growing community eagerly anticipating GLAST data!
- Advises GLAST Project and NASA on NASA-funded Guest Investigator Program and Policies
- Most recent F2F meeting at Goddard, 8-9 May; next F2F meeting in November, featuring a beta-test of the science tools.
- First-year source list vetting.
- See *http://glast.gsfc.nasa.gov/ssc/resources/guc/*

GLAST Users Committee Members

- Josh Grindlay (Chair)
- Roger Brissenden
- Jim Buckley
- Wim Hermsen
- Don Kniffen
- Jim Ling
- Alan Marscher
- Reshmi Mukherjee
- Rene Ong
- Luigi Piro
- Greg Stacy
- Mark Strickman
- Ann Wehrle

Plus

- David Band
- Neil Gehrels
- Rick Harnden
- Julie McEnery
- Chip Meegan
- Peter Michelson
- Steve Ritz
- Rita Sambruna
- Chris Shrader
- Kathy Turner
- Lynn Cominsky

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

SWG Activities

- Membership includes international representatives from LAT and GBM, along with four Interdisciplinary Scientists (IDS)
  - Chuck Dermer, Brenda Dingus, Martin Pohl, Steve Thorsett
- Advises mission and NASA, primarily now on Science Requirements

- SWG will hold a scientific review of the expected performance (LAT, GBM, Observatory) relative to the Science Requirements.

MW Info and Coordination

- **MW observations are key to many science topics for GLAST.**

- **See *http://glast.gsfc.nasa.gov/science/multi/***

for MW campaigners information, coordination.

see poster 18.05

E/PO Highlights (Lynn Cominsky, SSU)

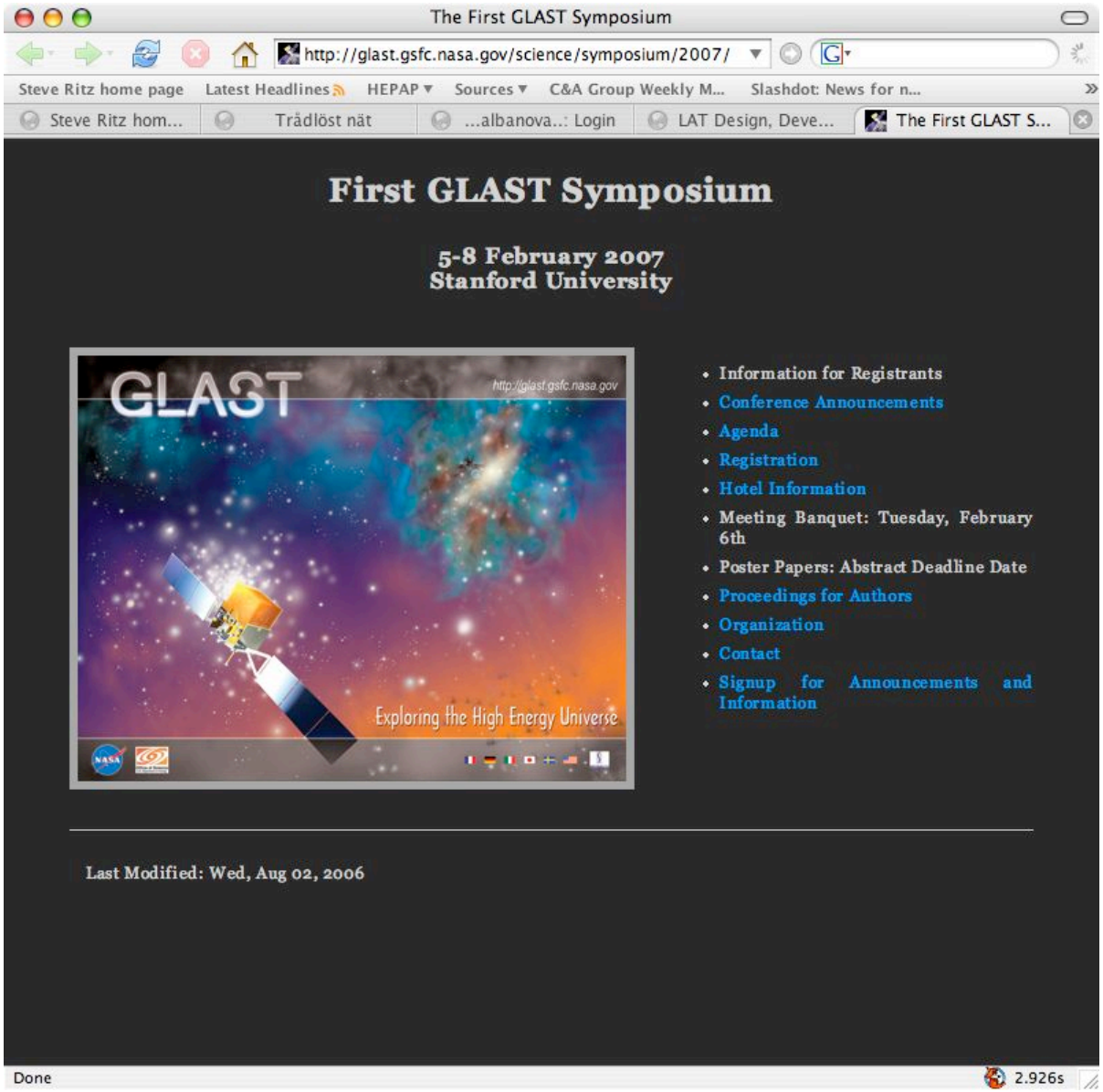
- "Black Holes: The Other Side of Infinity" Planetarium Show.
- Monster of the Milky Way PBS NOVA show premiers on Halloween. Website is live.
- Active Galaxies pop-up book has now been printed and will be available soon and for launch.
- LAT Simulator running on SLAC Virtual Visitor Center website.
- Educator Ambassador training.
- GLAST Optical Robotic Telescope (GORT) is now on SkyNet and part of the PROMPT network (which includes many small telescopes, mostly in the Southern Hemisphere).
- All three TOPS Modules are now complete and in print. They can be downloaded free of charge or ordered from our website for use in the classroom.

First International GLAST Symposium

Please sign up for future notices, and register

Starting monthly GLAST news email. Sign up!

Also, look for special GLAST session at January AAS. J.McEnery organizer



Summary

- All the parts of GLAST are coming together:
  - the instruments are beautiful!
  - observatory integration has started
- Preparation for science and operations in full swing
  - good connections between all the elements
  - MW observations are key to many science topics for GLAST. See *http://glast.gsfc.nasa.gov/science/multi/*
  - First International GLAST Symposium 5-8 February at Stanford.
  - also special sessions at topical meetings and at the January AAS meeting.
- Looking forward to launch in Fall 2007.

- GI Program starts next year. Join the fun!