DRAFT Rev 0

GLAST Large Area Telescope (LAT) Project

Introduction and Project Overview

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Principal Investigator & Spokesperson

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Outline

- GLAST Mission Overview
  - Relationship of LAT Project to GLAST Mission
  - LAT Instrument
- Science Opportunities
- LAT Collaboration and Project Organization
- LAT Project Status and Issues
- Summary

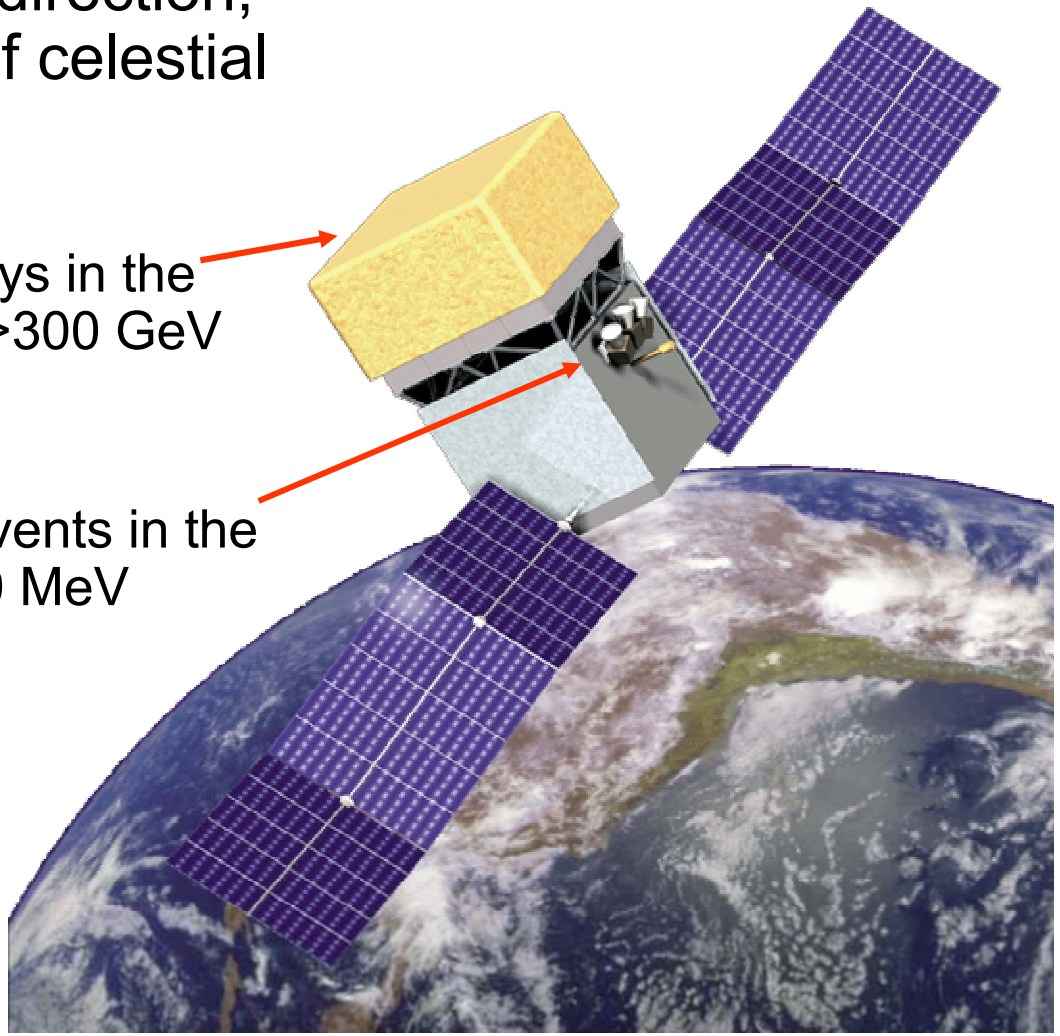
GLAST Mission Overview

GLAST Mission

GLAST measures the direction, energy & arrival time of celestial gamma rays

- LAT measures gamma-rays in the energy range ~20 MeV - >300 GeV

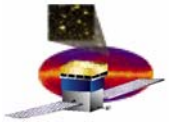
- GBM provides correlative observations of transient events in the energy range ~20 keV – 20 MeV



Launch: **March 2006**

Orbit: **550 km, 28.5° inclination**

Lifetime: **5 years (minimum)**



Why study γ-rays ?

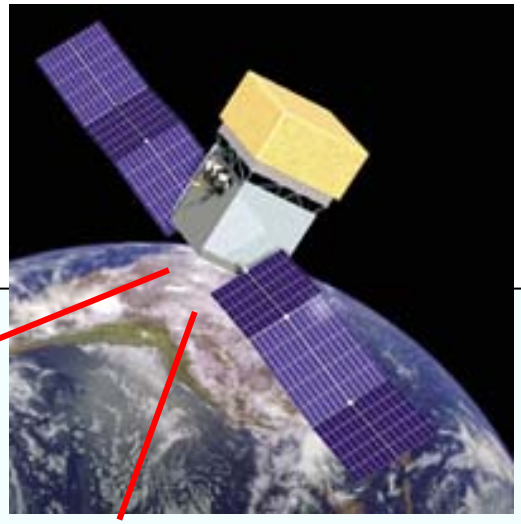
Gamma-rays carry a wealth of information

- γ-rays offer a direct view into Nature's largest accelerators.
- the Universe is mainly transparent to γ-rays: can probe cosmological volumes. Opacity is energy-dependent ($\gamma\gamma \rightarrow e^+ e^-$).
- conversely, γ-rays readily interact in detectors, with a clear signature.
- γ-rays are neutral: no complications due to magnetic fields; point directly back to sources, etc.

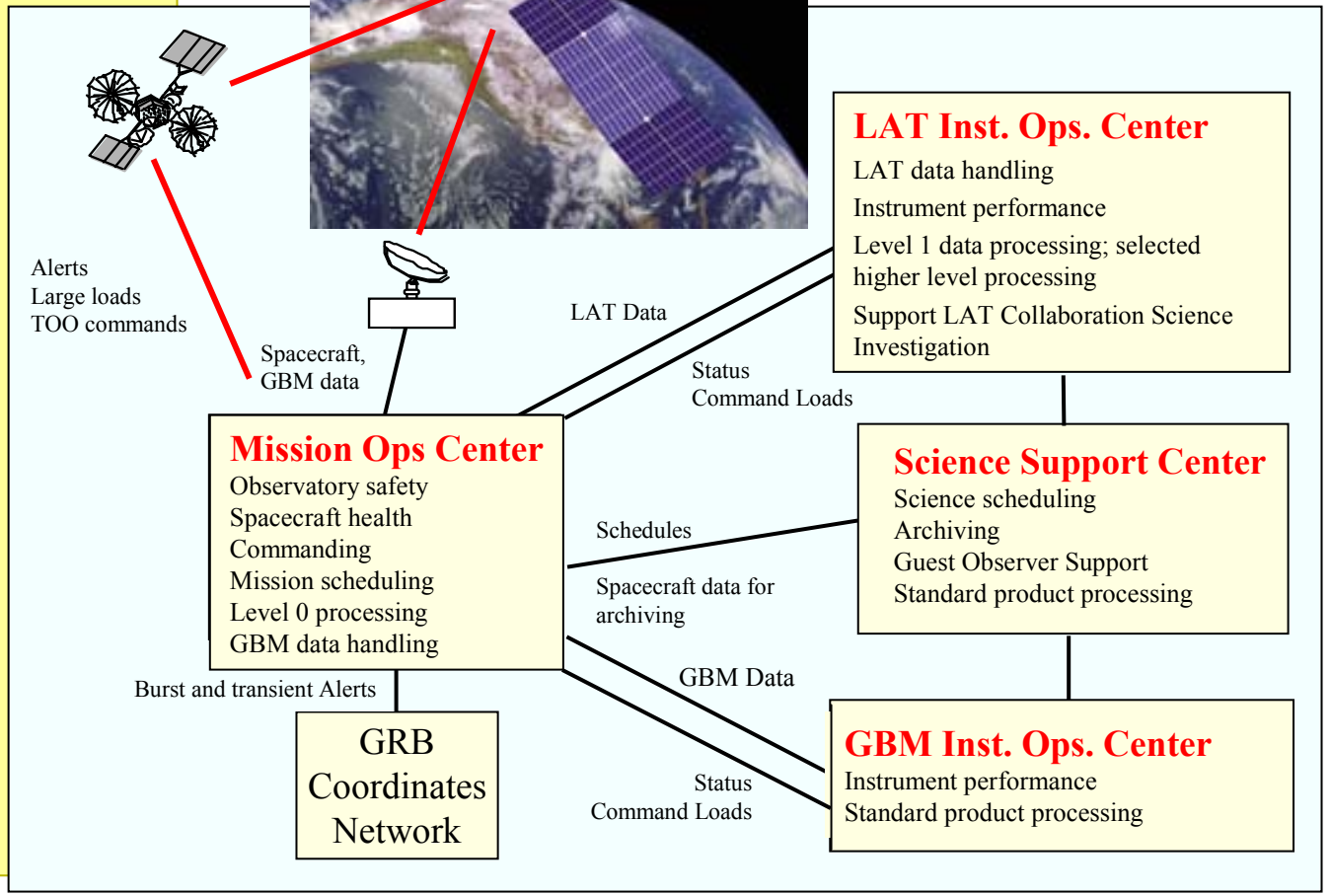
Gamma-ray Large Area Space Telescope

GLAST Mission

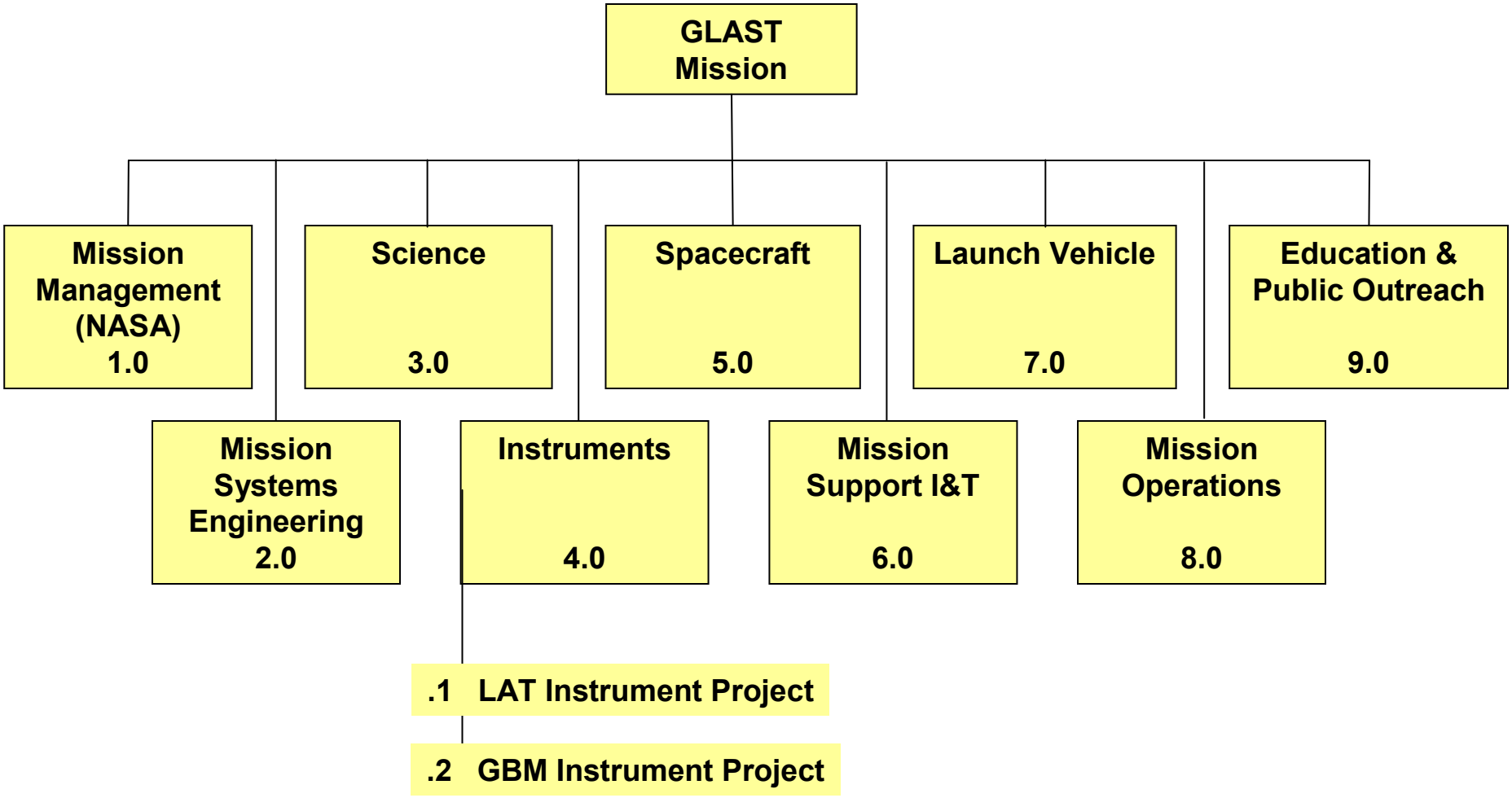
- high-energy gamma-ray observatory; 2 instruments
  - Large Area Telescope (LAT)
  - Gamma-ray Burst Monitor (GBM)
- launch (Sept 2005): Delta 2 class
- orbit: 550 km, 28.5° inclination
- mission operations
- science
  - LAT Collaboration
  - GBM Collaboration
  - Guest Observers
- lifetime: 5 years (minimum)



GLAST Observatory
- spacecraft
- LAT
- GBM



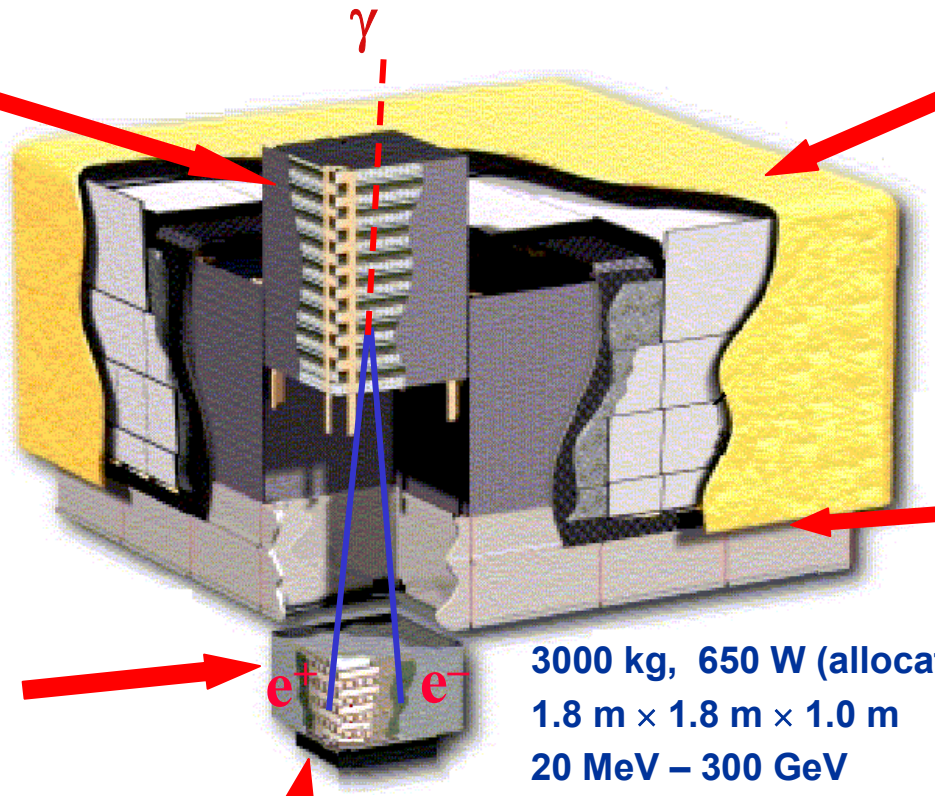
GLAST Mission Overview



GLAST LAT Overview: Design

Si Tracker
pitch = 228 μm
8.8 10^5 channels
12 layers × 2.8% X_0
+ 4 layers × 18% X_0
+ 2 layers

ACD
Segmented scintillator tiles
0.9997 efficiency
⇒ minimize self-veto



Grid (& Thermal Radiators)

3000 kg, 650 W (allocation)
1.8 m × 1.8 m × 1.0 m
20 MeV – 300 GeV

CsI Calorimeter
Hodoscopic array
8.4 X_0 8 × 12 bars
2.0 × 2.7 × 33.6 cm
⇒ cosmic-ray rejection
⇒ shower leakage correction

Data acquisition

Flight Hardware & Spares
16 Tracker Flight Modules + 2 spares
16 Calorimeter Modules + 2 spares
1 Flight Anticoincidence Detector
Data Acquisition Electronics + Flight Software

GLAST LAT Overview: Performance

Instrument performance meets (or exceeds) all requirements in 433-SRD-0001

Single Photon Angular Resolution
3.5° @ 100 MeV
0.15° @ 10 GeV

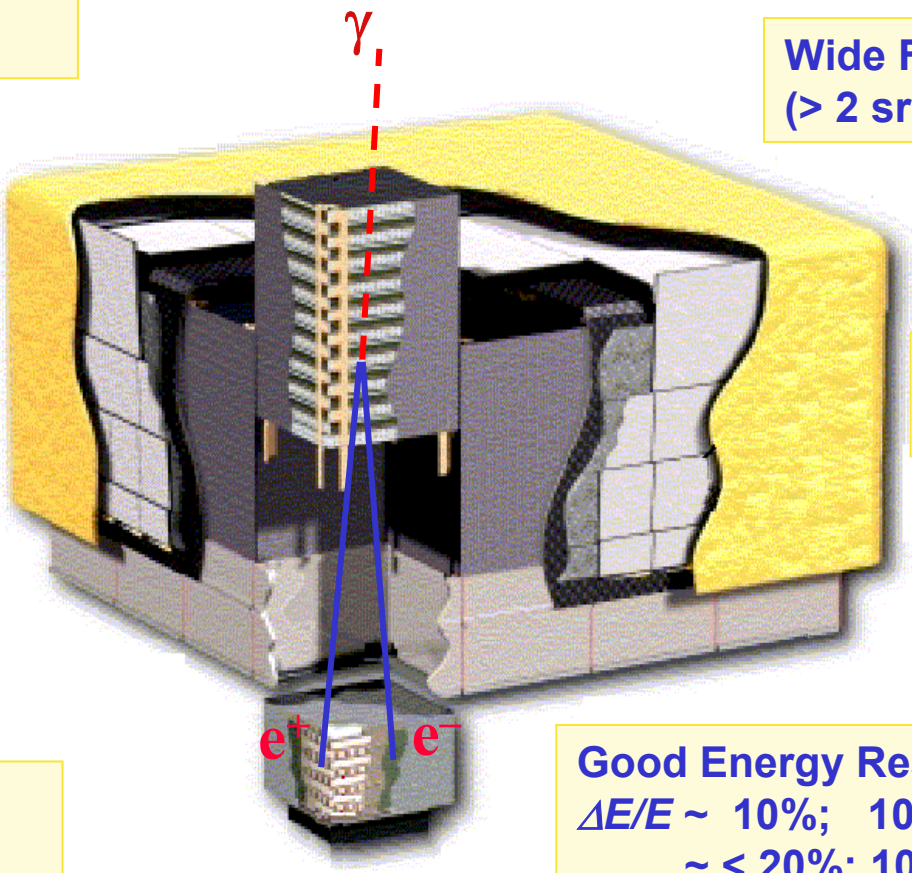
Wide Energy Range: 20 MeV - >300 GeV

Wide Field of View (> 2 sr)

Point Source Sensitivity:
< 6 x 10^{-9} ph $cm^{-2}s^{-1}$
(est. performance: < 3 x 10^{-9} ph $cm^{-2}s^{-1}$)

40 times EGRET's sensitivity

Source Localization:
0.3' – 1' (unid EGRET)



Low dead time:
< 100 μs/event

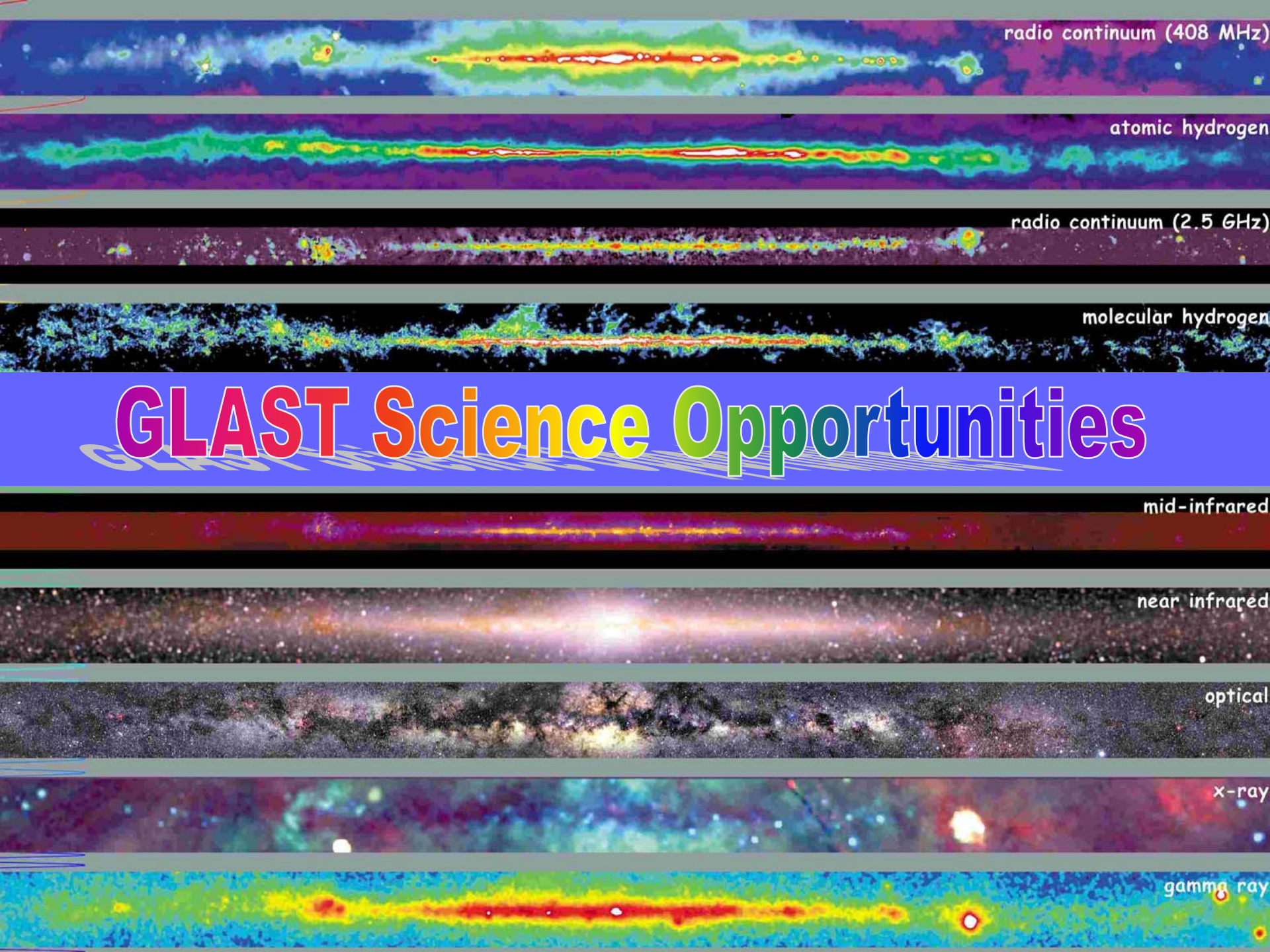
Large Effective Area
$(A_{eff})_{peak}$ > 8,000 cm^2

Good Energy Resolution
$\Delta E/E$ ~ 10%; 100 MeV – 10 GeV
~ < 20%; 10 GeV – 300 GeV

Summary of GLAST Project History

- From its conception, GLAST developed by a collaboration of particle physicists and astrophysicists
- major leap in capability brought by modern HEP detector technology

- LAT concept & technology in development since 1992, with DOE/NASA support
- GLAST endorsed by NASA Space Science Advisory Committee, Nov 1997
- Beam test of mini-tracker & calorimeter; validation of Monte Carlo – Sept 1997
- Presented to HEPAP, Jan 1997; submitted proposal for LAT to DOE, Feb 1998; reviewed by SAGENAP, April 1998
- Beam test of prototype LAT Tower; successful validation of subsystem measurement performance – Dec 1999
- Collaboration Proposal for Flight Instrument accepted by NASA, Feb 2000
- NRC Decadal Astronomy & Astrophysics Review ranks GLAST highest priority "moderate-size" space mission for next decade, Sept 2000
- High-altitude balloon flight of prototype LAT tower; achieves all objectives – August 2001

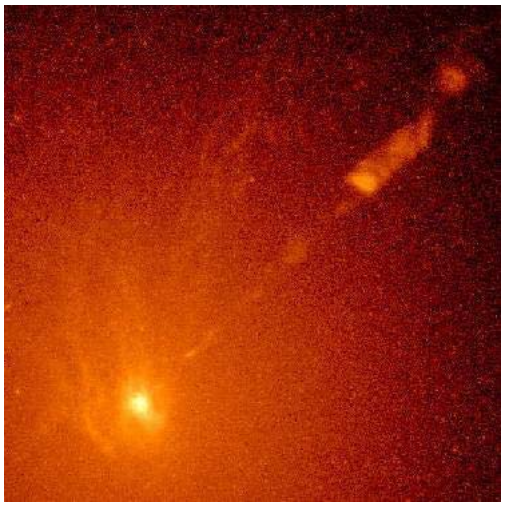

radio continuum (408 MHz)
atomic hydrogen
radio continuum (2.5 GHz)
molecular hydrogen
GLAST Science Opportunities
mid-infrared
near infrared
optical
x-ray
gamma ray

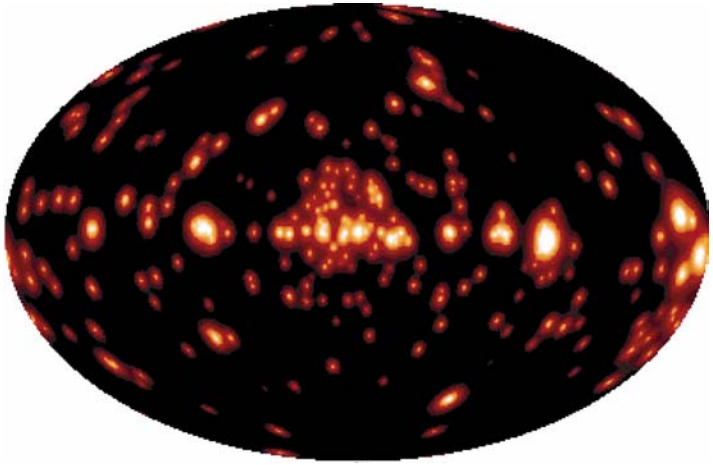
Science Investigation: Key Objectives

- Understand the mechanisms of particle acceleration in AGNs, Pulsars & SNRs
- Resolve the γ-ray sky: unidentified EGRET sources and the diffuse background
- Understand the origin(s) and mechanisms of Gamma-Ray Bursts and other high-energy transients
- Use high-energy γ-rays as probes of the early universe
- Probe the nature of dark matter

GLAST Science Opportunities

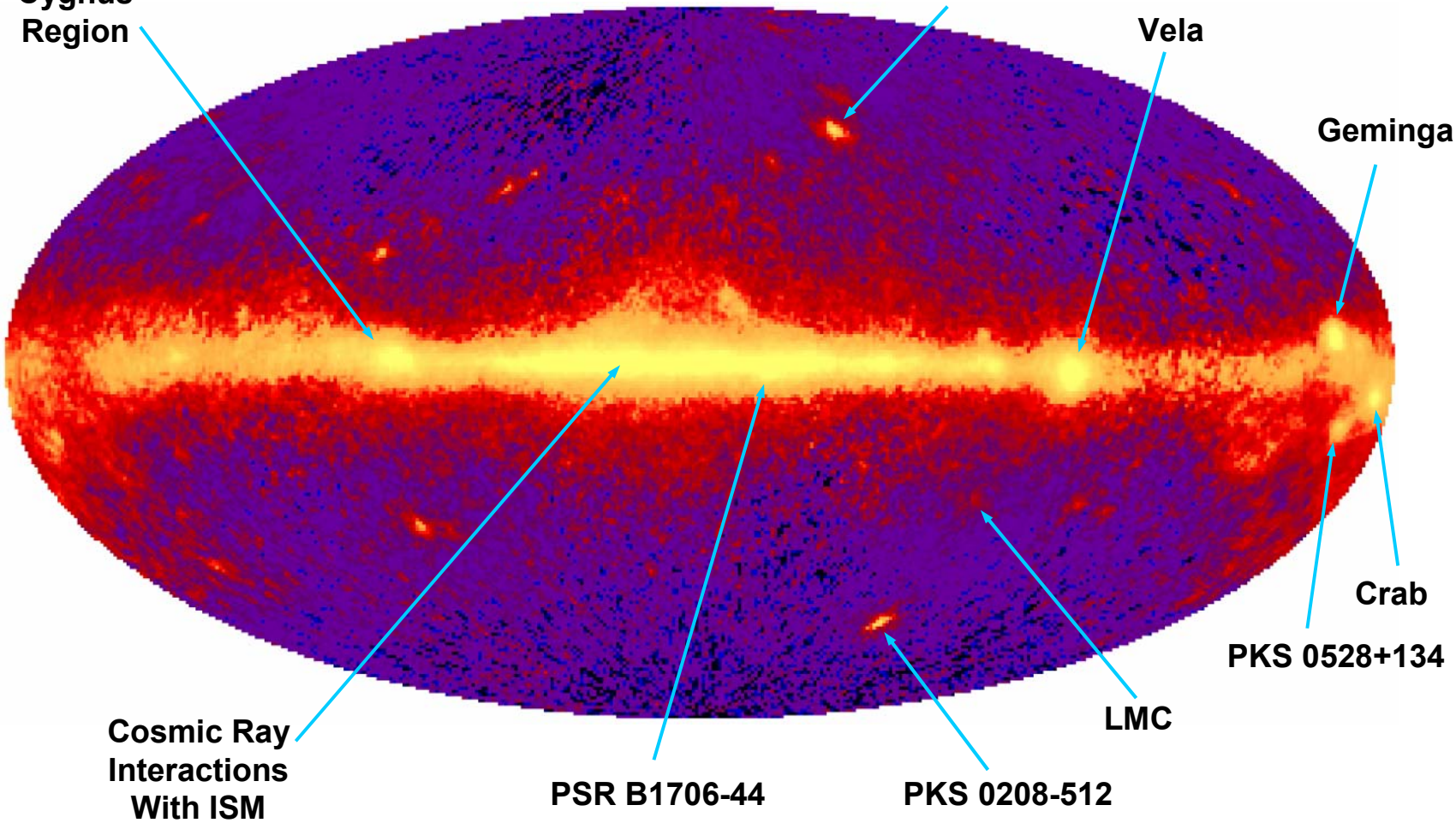
- Active Galactic Nuclei
- Isotropic Diffuse Background Radiation
- Cosmic Ray Production:
  - Identify sites and mechanisms
- Endpoints of Stellar Evolution
  - Neutron Stars/Pulsars
  - Black Holes
- Unidentified Gamma-ray Sources
- Dark Matter
- Solar Physics
- Gamma-Ray Bursts
- DISCOVERY!





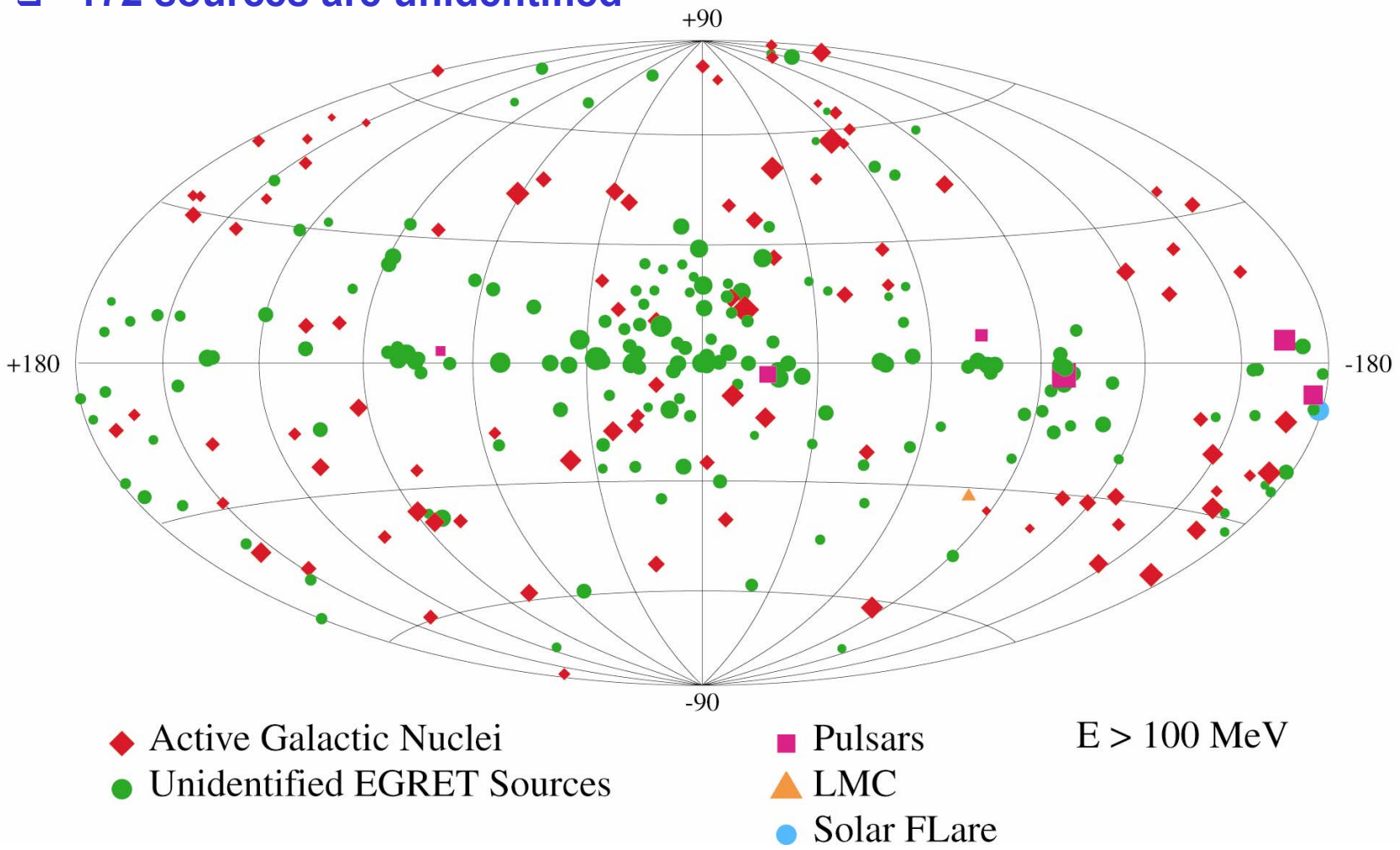
Scientific Heritage: CGRO-EGRET

EGRET All-Sky Map (E> 100MeV)



3rd EGRET Source Catalog

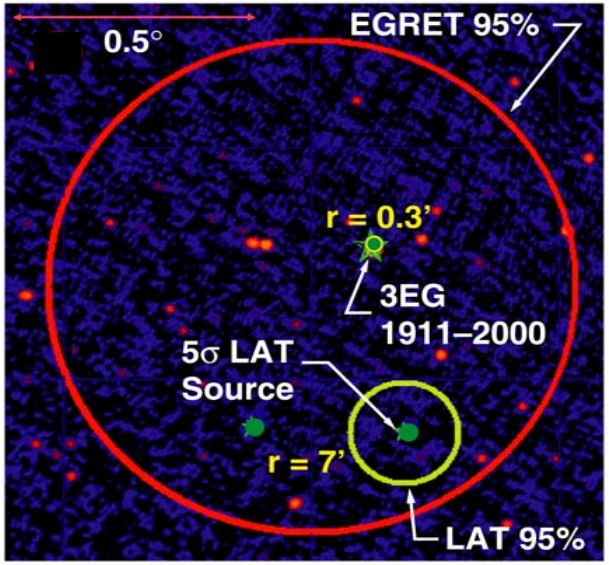
- 271 sources
- 172 sources are unidentified



LAT Science capabilities - resolution

Source identification requires a multiwavelength approach

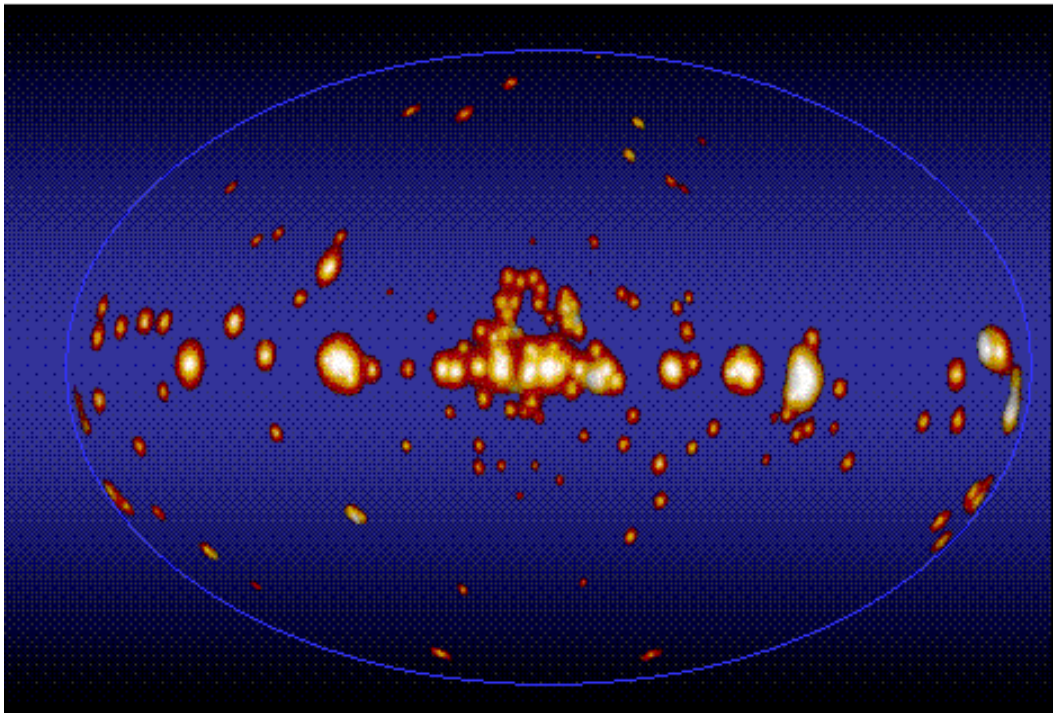
- localization
- variability



Source localization (68% radius)

γ bursts 1 to tens of arcmin

Unidentified EGRET sources 0.3' to 1'

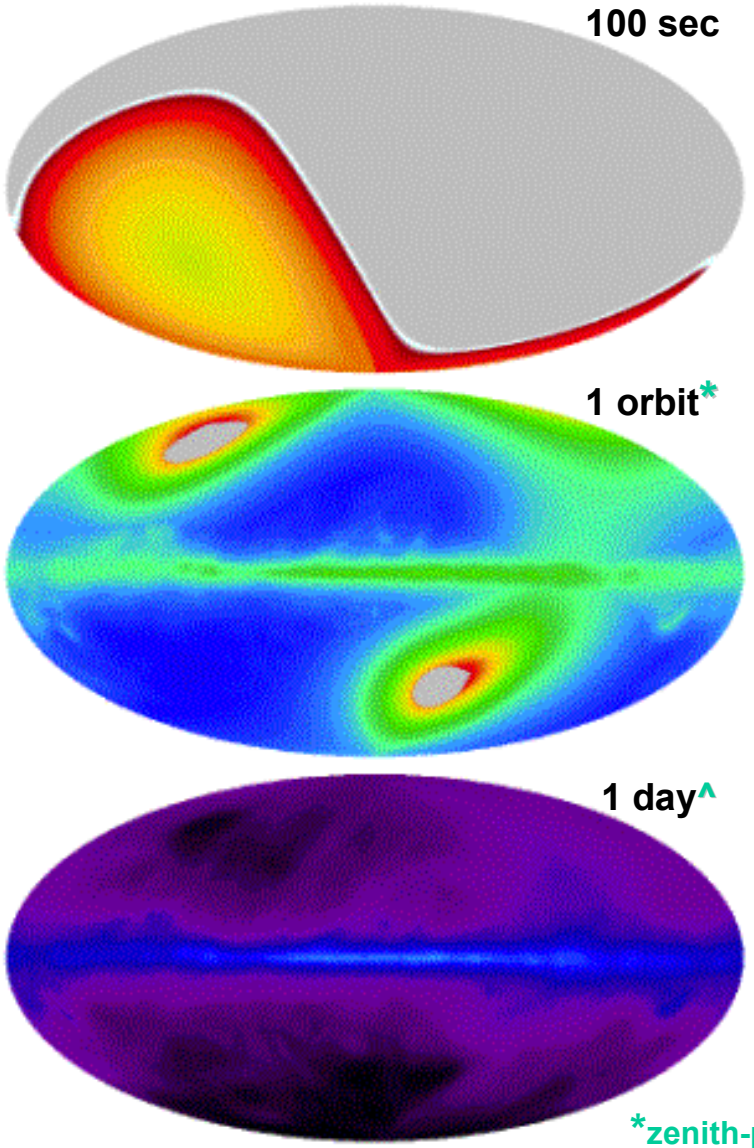


Unidentified EGRET Sources

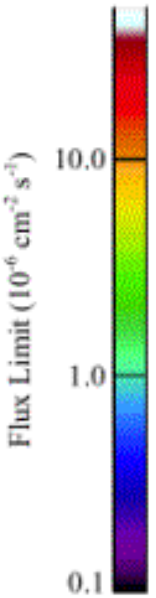
Evidence for at least 2 unidentified Galactic populations:
- time-variable Galactic population
- persistent Gould Belt population

Science capabilities – transient sensitivity

wide field-of-view



EGRET Fluxes



- GRB940217 (100sec)
- PKS 1622-287 flare
- 3C279 flare
- Vela Pulsar

- Crab Pulsar
- 3EG 2020+40 (SNR γ Cygni?)

- 3EG 1835+59
- 3C279 lowest 5σ detection
- 3EG 1911-2000 (AGN)
- Mrk 421
- Weakest 5σ EGRET source

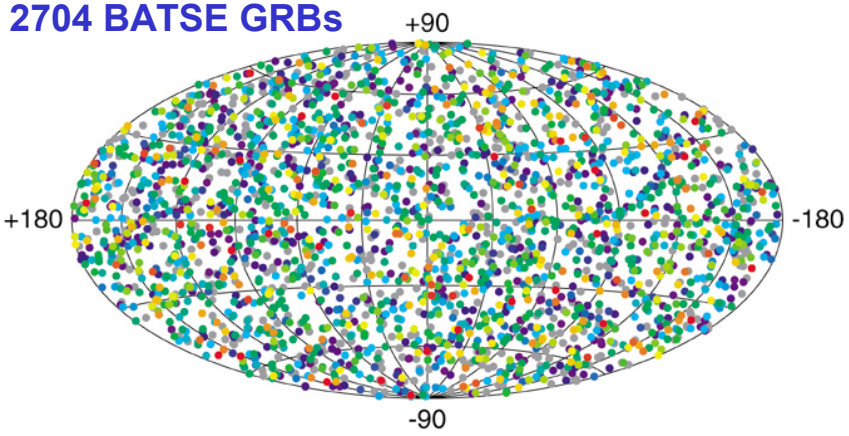
low deadtime (for light curve)

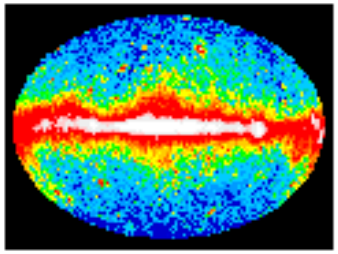
all 3EG sources + 80 new in 2 days
~200 γ bursts per year
AGN flares > few min

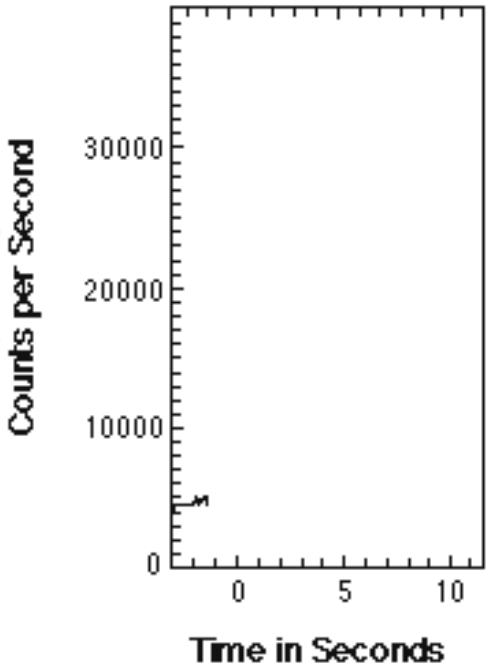
*zenith-pointed, ^"rocking" all-sky scan

Gamma-Ray Bursts

2704 BATSE GRBs







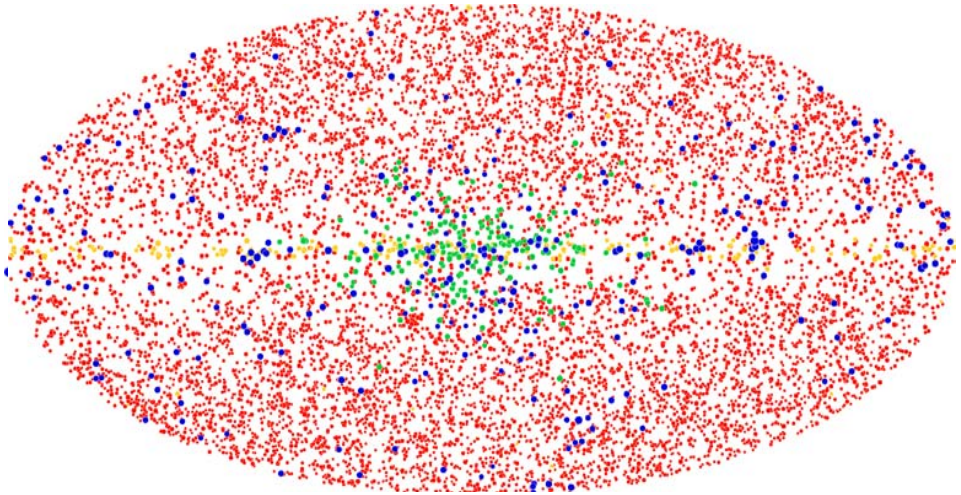
The Gamma-Ray Burst mystery…

- Isotropic on sky (BATSE/ CGRO)
- Last from milliseconds to ~ 100 seconds
- Brightest transient phenomenon in the Universe
- Several per day - no repetitions
- Progenitors still not known

GLAST will….

- place strong constraints on physical conditions within the source region (because GeV photons are strongly susceptible to absorption via gamma-gamma pair conversion..)
- detect a GRB about once every 2 days, quite possibly including bursts from the first generation of stars

LAT Source Catalogs



LAT Catalog: ~10,000 sources (survey)
GRB, AGN, 3EG + Gal. plane & halo sources

Transients or Flares

rapid alert for GRBs (~12 s to the ground)

sky survey data analyzed on a daily basis

timely IAU circulars and WWW announcements

⇒ GRB catalog

Catalog strategy

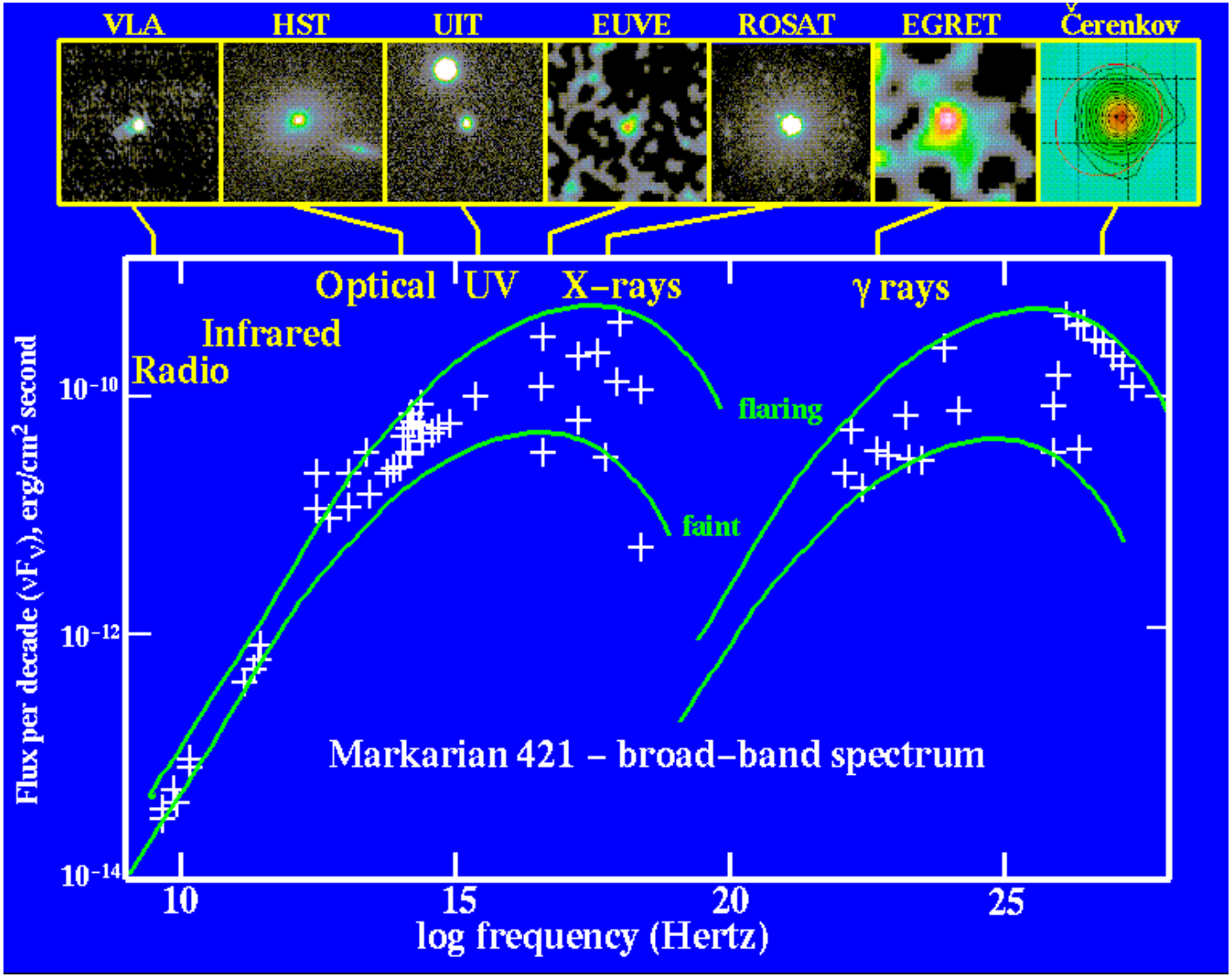
precise interstellar emission model

new statistical analyses including variability and spectral signatures

⇒ distinguish unresolved gas clumps
⇒ flux histories

cross references with astronomical catalogs

AGN Observations: Follow the Energy

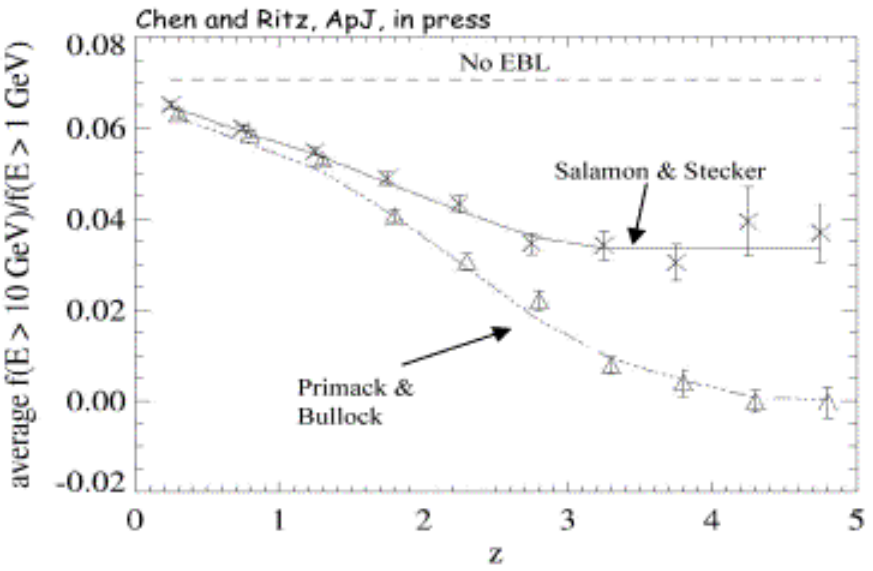


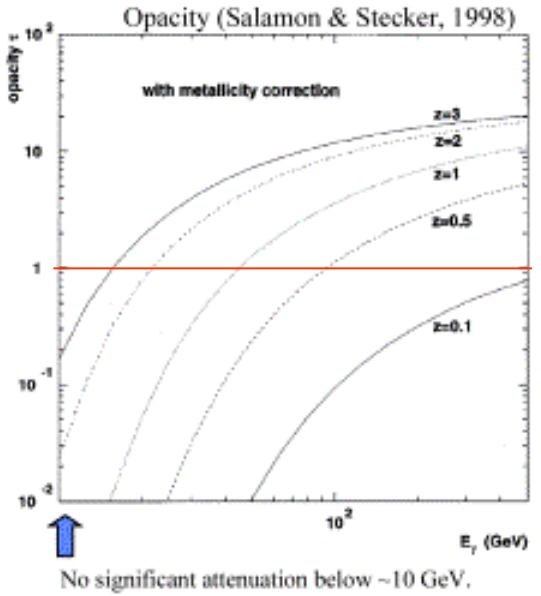
GLAST probes the Optical-UV EBL

large effective area, broad energy range

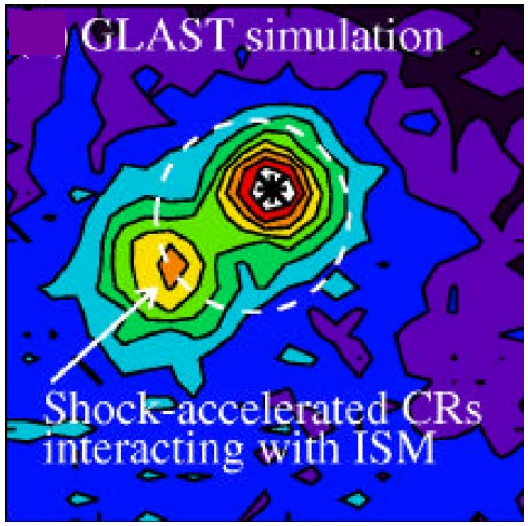
- Important advances made by GLAST:
  1) Detect thousands of blazars; measure spectra of several hundred above 10 GeV: instead of peculiarities of individual sources, look for systematic effects vs. redshift.
  2) key energy range for cosmological distances: (TeV-IR more local due to opacity).
- Effect is dependent on details of EBL model

TeV γ's sensitive to IR ⟷ **GeV γ's sensitive to UV**





LAT Science capabilities - resolution

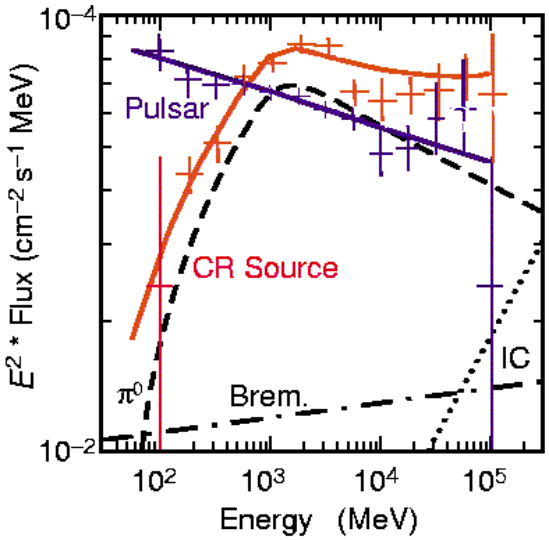


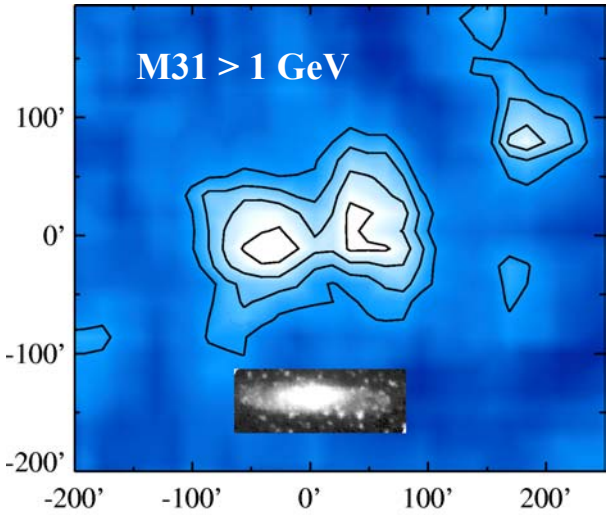
Extended sources spatially & spectrally resolved

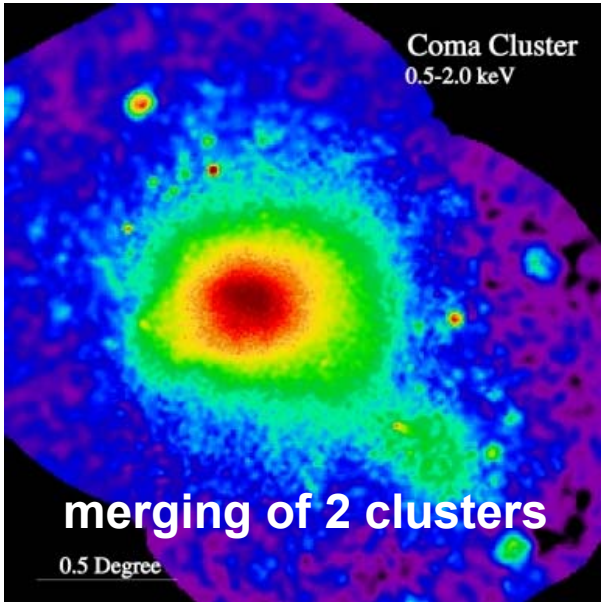
Supernova Remnants ⇒ cosmic-ray & plerion acceleration

Interstellar emission up to TeV, $\Delta E/E \Rightarrow \pi^0$ decay emission
⇒ cosmic-ray propagation pc → kpc

Nearby galaxies & Galaxy clusters
⇒ cosmic-ray production & halos





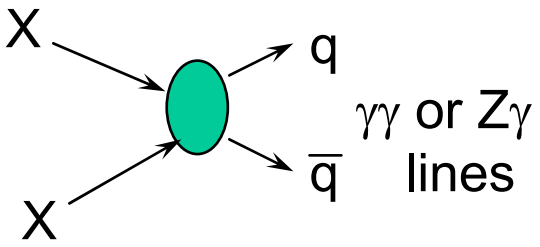


GLAST and Dark Matter

energy resolution, effective area

Good particle physics candidate for galactic halo dark matter is the LSP in R-parity conserving SUSY

If true, there may well be observable Galactic halo annihilations



Example: X is LSP from Standard SUSY:
annihilations to jets produce an extra component of multi-GeV γ flux that follows halo density peaking at ~ 0.1 Mχ or lines at Mχ.
Background is galactic diffuse γ-rays from CR interaction with gas.

Although calculations for γ-rays are less uncertain than for other signals (antiprotons, positrons), a null result will not likely constrain SUSY parameter space. If SUSY is discovered at accelerators, GLAST may be able to determine its cosmological significance quickly.

Just an example of what might be waiting for us to find

GLAST LAT Collaboration and Project Organization

GLAST LAT Collaboration

United States

- California State University at Sonoma
- University of California at Santa Cruz - Santa Cruz Institute of Particle Physics
- Goddard Space Flight Center – Laboratory for High Energy Astrophysics
- Naval Research Laboratory
- Stanford University – Hanson Experimental Physics Laboratory
- Stanford University - Stanford Linear Accelerator Center
- Texas A&M University – Kingsville
- University of Washington
- Washington University, St. Louis

France

- Centre National de la Recherche Scientifique / Institut National de Physique Nucléaire et de Physique des Particules
- Commissariat à l'Energie Atomique / Direction des Sciences de la Matière/ Département d'Astrophysique, de physique des Particules, de physique Nucléaire et de l'Instrumentation Associée

Italy

- Istituto Nazionale di Fisica Nucleare
- Istituto di Fisica Cosmica, CNR (Milan)

Japanese GLAST Collaboration

- Hiroshima University
- Institute for Space and Astronautical Science
- RIKEN

Swedish GLAST Collaboration

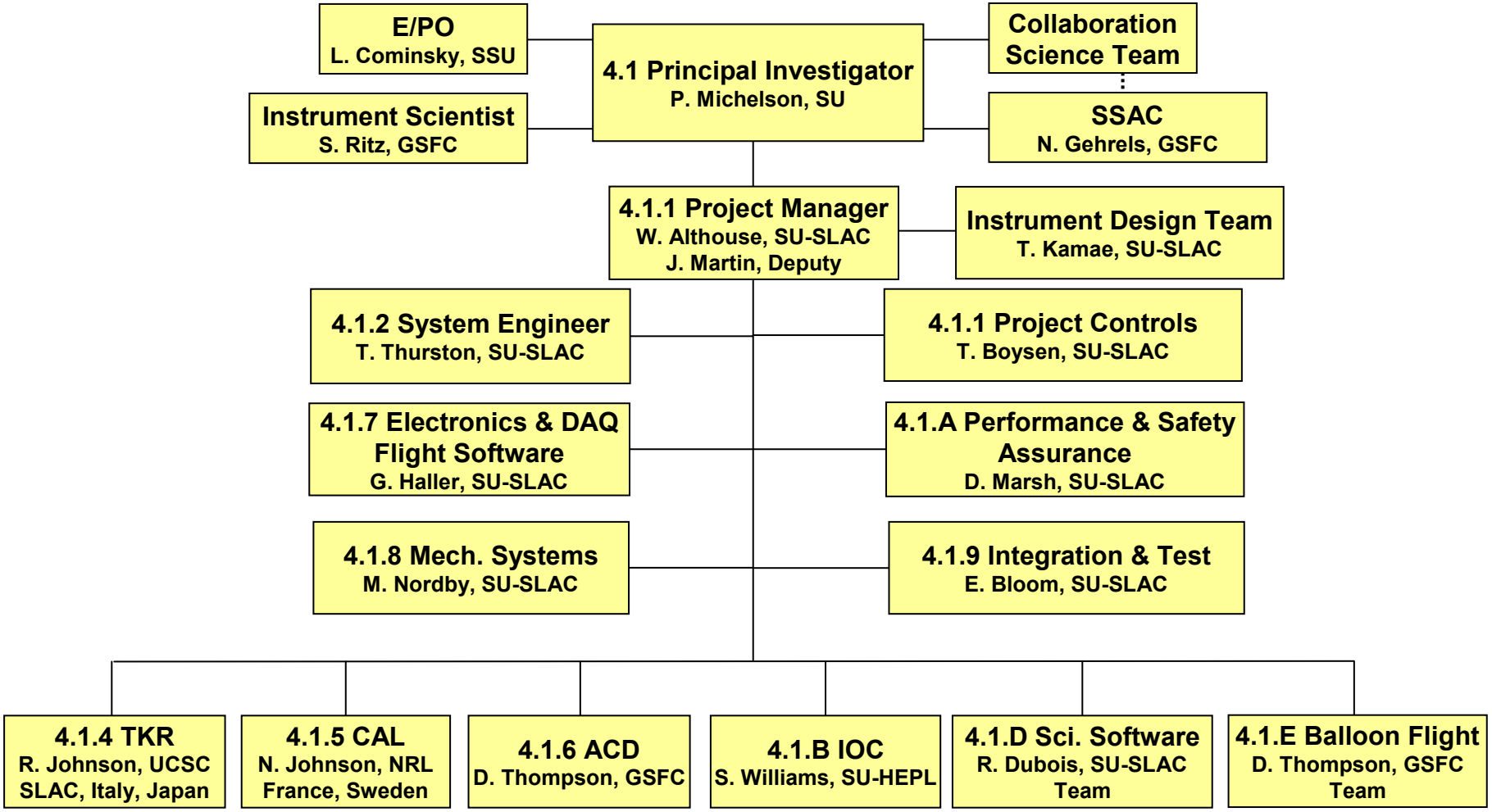
- Royal Institute of Technology (KTH)
- Stockholm University

124 Members (including 60 Affiliated Scientists)

16 Postdoctoral Students

26 Graduate Students

GLAST LAT Organization



Collaboration Organization

Senior Scientist Advisory Committee

- **Membership**
  - N. Gehrels, Chair
  - P. Michelson, PI/Spokesperson
  - G. Barbiellini, Italy
  - R. Bellazzini, Italy
  - E. Bloom, U.S.
  - T. Burnett, U.S.
  - P. Carlson, Sweden
  - R. Dubois, U.S.
  - I. Grenier, France
  - N. Johnson, U.S.
  - R. Johnson, U.S.
  - T. Kamae, Japan
  - J. Ormes, U.S.
  - S. Ritz, U.S.
  - H. Sadrozinski, U.S.
  - D. Thompson, U.S.
  - K. Wood, U.S.

SSAC Charter

- Advise PI/Spokesperson on the conduct of the LAT Science Investigation
- Implement collaboration membership policy and publication policy
- Advise PI and LAT Management on LAT design issues that critically impact science performance
- Meets at least quarterly

Collaboration Organization

Instrument Design Team

- Chair: T. Kamae, Instrument Technical Manager
- Deputy Chairs: R. Bellazzini (Italy), E. Bloom (US)
- Membership includes all subsystem managers & key system engineering personnel
- Reports to Project Manager, W. Althouse

IDT Charter

- Facilitate exchange of information between subsystems to maintain coordinated design; resolve issues or refer to IPO for resolution
- Meetings open to the Collaboration
- Weekly video conference meetings; quarterly face-to-face meetings

LAT Project Status and Issues

Status and Issues

- **Summary of January 8-11, 2002 NASA-DOE Review**
  - 4 subsystems judged not ready for baselining
  - Project contingency judged to be inadequate, particularly the profile (FY02, 03); very aggressive schedule
  - Instrument design judged to be technically at PDR level (exception: mechanical/thermal S/C interface)
- **Since the January Review:**
  - ACD Subsystem WBS, Cost, and Schedule completed
  - CAL Subsystem – on track for June Delta Review (except for uncertainty of CNES funding – see later)
  - Mechanical/Thermal Subsystem – re-design complete; re-analysis underway; schedule tight to complete for June Delta Review
  - I&T Subsystem WBS, Cost, and Schedule completed
  - Overall Contingency and Schedule
    - 3 options developed to mitigate issues – all have cost impact

Status of Key Agreements

- **DOE – NASA Implementing Arrangement**
  - signed on Jan 15 & 18, 2002
  - cleared way for NASA International Division to pursue International Agreements

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- **NASA – ASI (Italian Space Agency) Agreement**
  - draft exists; informally discussed with ASI Science Director
  - NASA ready to formally send to ASI for consideration
    - (GLAST "well-positioned" in ASI Budget plans following meeting between ASI and INFN Presidents)
- **SU/SLAC – INFN –ASI MoA**
  - draft exists; ready for signature by INFN, pending actions by ASI; (critical to have ASI funding flow by October)

- **NASA – CNES (French Space Agency) Agreement**
  - draft exists and formally forwarded to CNES on March 1;
  - agreement reached and ready for signature pending outcome of CNES budget deliberations (see later chart)
- **SU/SLAC – INFN – CEA – NRL MoAs**
  - drafts exist and have been reviewed by the parties; specify management arrangements; ratify plan formulated in December-January
  - ready for signature; pending CNES funding approval

Status of Key Agreements – cont'd

- SU/SLAC – Swedish GLAST Consortium (SGC) – NRL MoA
  - signed and implemented

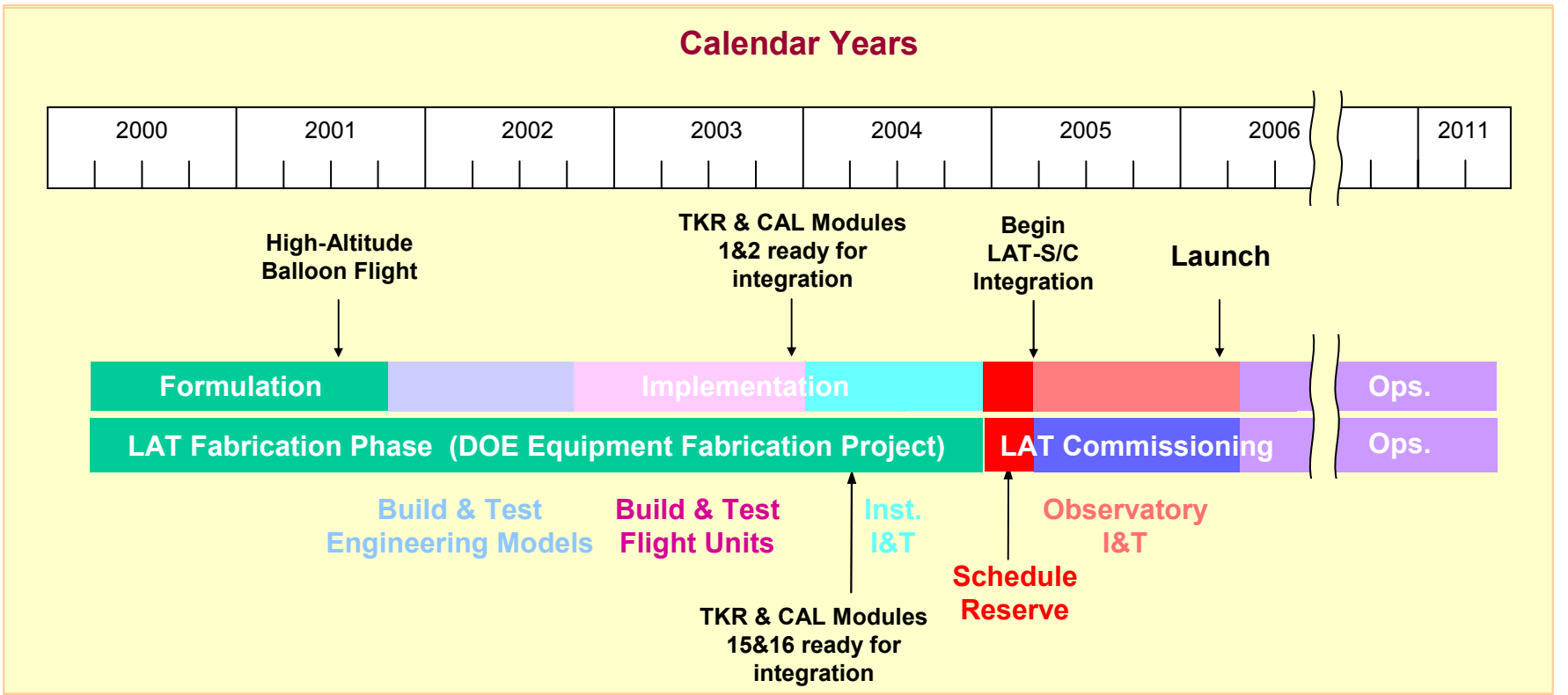
- SU/SLAC – Japan GLAST MoA
  - signed and implemented

- SU/SLAC – GSFC/LHEA MoA
  - signed and implemented (concerning management and reporting for LHEA activities as part of LAT team)

- SU/SLAC – UCSC/SCIPP MoA
  - signed and implemented

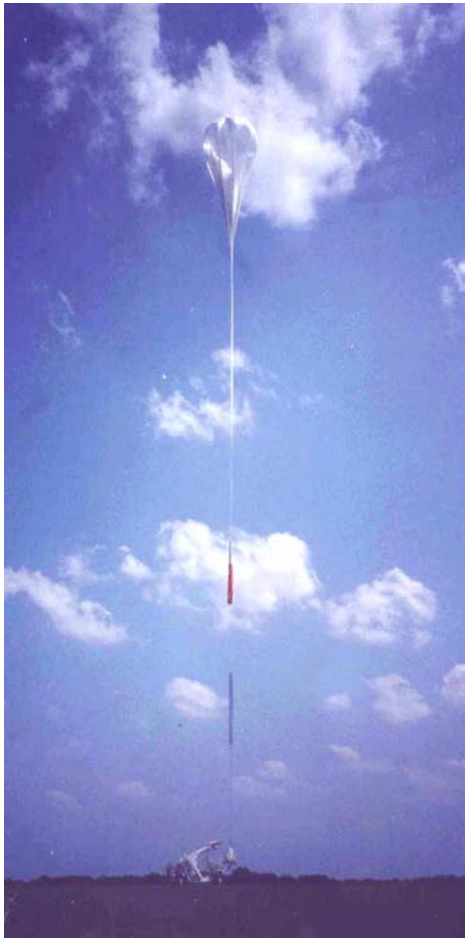
- SU/SLAC – Univ. Washington MoA
  - signed and implemented

Schedule presented at Jan 02 Review



- 03/15/02: DOE (Office of Science), NASA, and JOG agree on definition of DOE Equipment Fabrication Project and LAT Project Phases:
  - LAT Fabrication Phase [04/00 – 12/04 (LAT delivery to NASA)]
  - LAT Commissioning Phase [01/05 – 04/06 (launch + 30 days)]
  - Mission Operations and Data Analysis Phase [05/06 – 05/11]

Results of Balloon Flight



Purpose of balloon test flight: expose prototype LAT tower module to a charged particle environment similar to space environment and accomplish the following objectives:

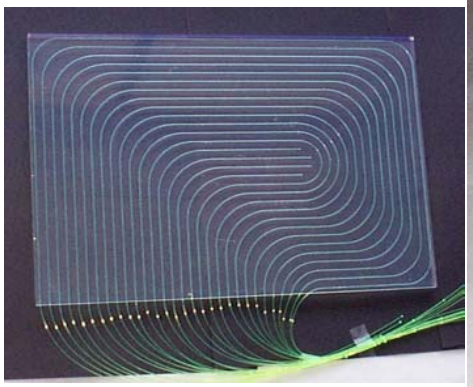
- Validate the basic LAT design at the single tower level.
- Show the ability to take data in the high isotropic background flux of energetic particles in the balloon environment.
- Record all or partial particle incidences in an unbiased way that can be used as a background event data base.

All Objectives met by Balloon Flight on August 4, 2001

Anti-Coincidence Overview

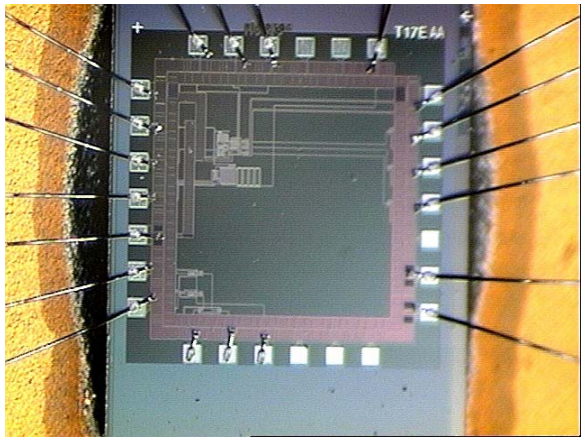
Subsystem Manager: D. Thompson, GSFC

Proto-tile Assemblies from Fermilab



Mockup Recently Completed; Work has begun on Fiber Routing

ASICs Design in Progress; goes to foundry early April

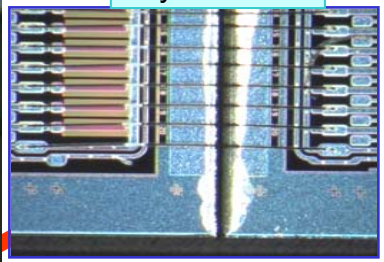


Tracker Overview

Subsystem Manager: R. Johnson, UCSC-SCIPP

Module Structure (walls, flexures,
thermal-gas
Engineering
Procuremen

SSD Ladder
Assembly
Italy



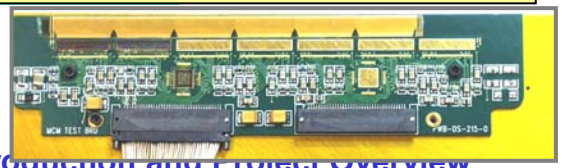
2592

Tray Assembly
and Test
Italy

342

- Power <210 μW/ch

Cable Plant
UCSC



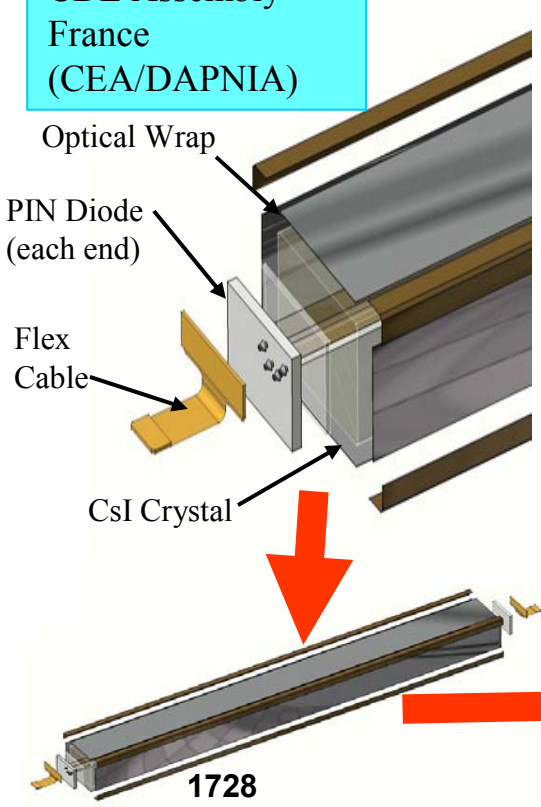
Composite Panel & Converters
Engineering:
SLAC, Hytec, and Italy
Procurement: Italy

Calorimeter Overview

Subsystem Manager: W. N. Johnson, NRL

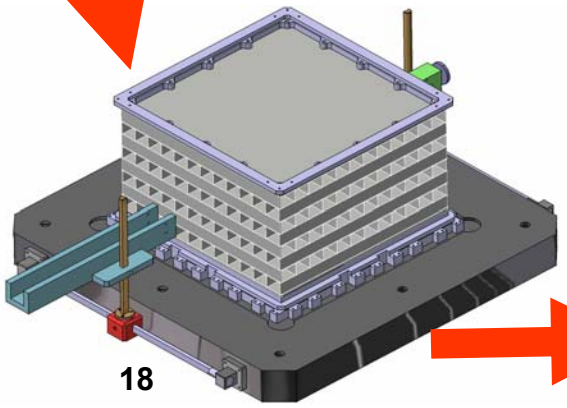
CsI Crystals
Sweden (KTH)

CDE Assembly
France
(CEA/DAPNIA)



16 flight modules + 2 spares

Mechanical Structure
France (IN2P3/Ecole Polytechnique)

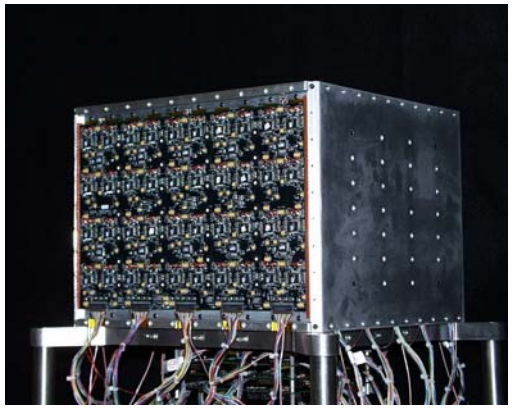


PEM Assembly
NRL

Front-End Electronics
NRL, SLAC

18

Module Assembly
and Test, NRL+collab



LAT Issue: Calorimeter and the CNES Situation

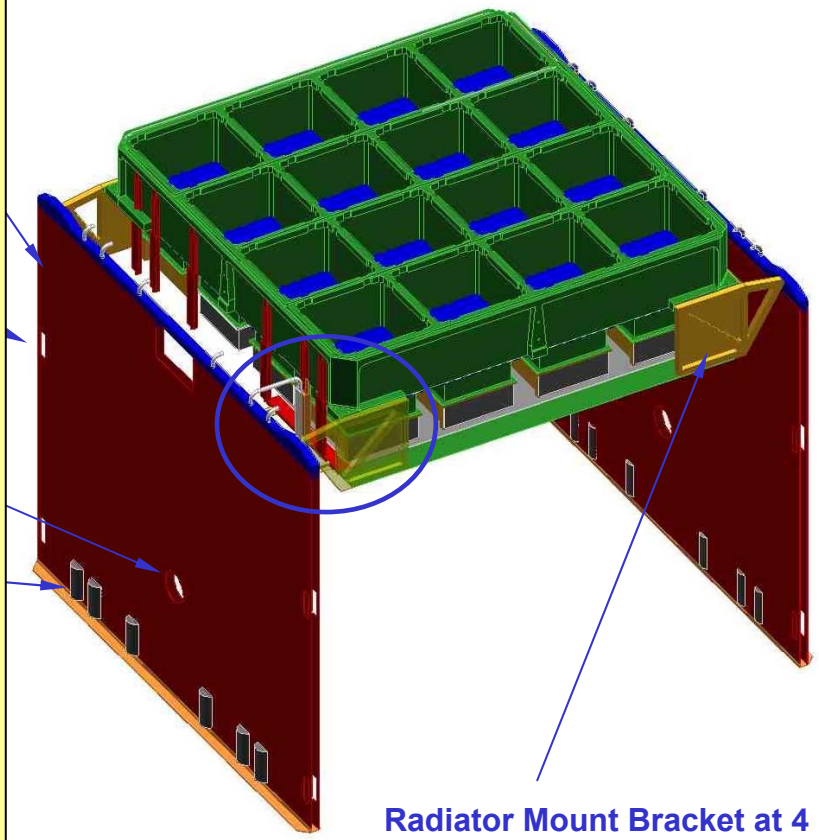
- **Background:**
  - **At March 5 meeting with IN2P3 & CEA/DAPNIA LAT Team leadership and lab management, CNES technical review recommends "pass" for French technical and management plans**
    - At conclusion, R. Bonneville informs group that CNES funding severely impacted and he can likely only provide 1-2M Euros of planned (~8M Euros) CNES funding; (no previous indication that CNES funding was in jeopardy)

- **Actions taken:**
  - **Letters to CNES Director-General:**
    - Joint letter from J. Aubert (IN2P3 Director) and F. Gounand (CEA/DSM Director) appealing for reversal of CNES action
    - Letters from DOE (O'Fallon); phone contact by NASA (Kinney – Bonneville)
    - Letters from prominent concerned scientists
    - Commitment obtained from French Lab management to push for full restoration from CNES and to maintain efforts on CAL EM in the meantime
  - **Meeting held on March 21 with CNES DG (Brachet) & Deputy DG (Bonnet) and IN2P3, CEA management and French LAT team leadership:**
    - Urgency of situation communicated to CNES leadership
    - Funding decisions will be reviewed; support expressed for French participation in GLAST, given French history of scientific work in the field and it's importance
    - Brachet will call for "emergency" meeting of CNES Science Policy Committee to consider full restoration of planned CNES commitments in context of overall CNES budget problems
  - **"Emergency" meeting of CNES Policy Committee scheduled for April 19, 2002**

GLAST-LAT Mechanical Systems Engineering: Thermal Design

Subsystem Manager: M. Nordby, SLAC

- LAT internal design (e.g., Tkr, Cal, ACD) not significantly impacted
- Re-evaluation of spacecraft-LAT thermal interface underway: design driver for radiators
- Evaluation of key risk areas:
  - Carrying margin in current thermal design
  - Utilizing engineering prototypes (e.g. thermal interfaces) to
    i) verify design and margins,
    ii) establish reproducible procedures

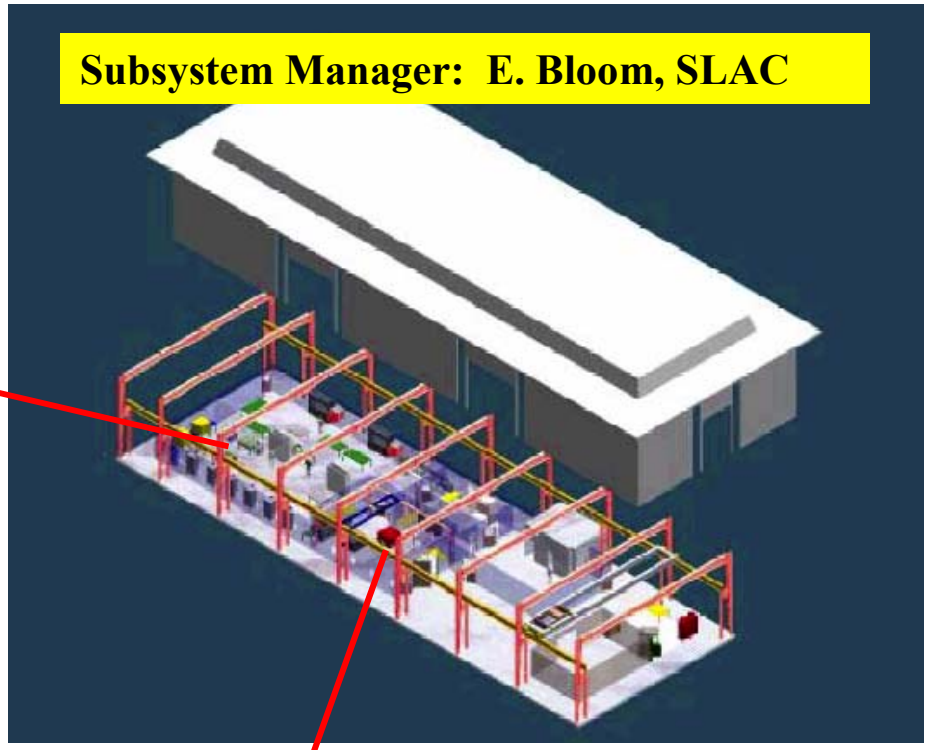


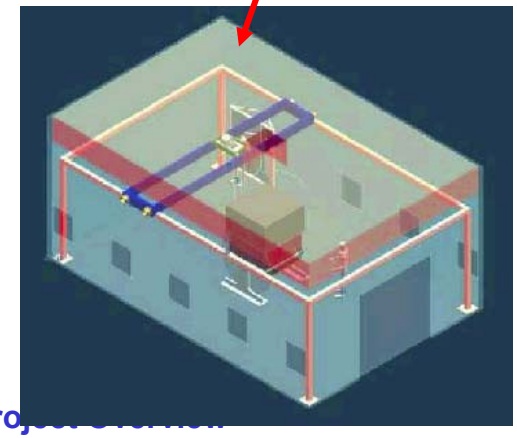
Radiator Mount Bracket at 4 corners of Grid

ay-
ring

LAT I&T Facility

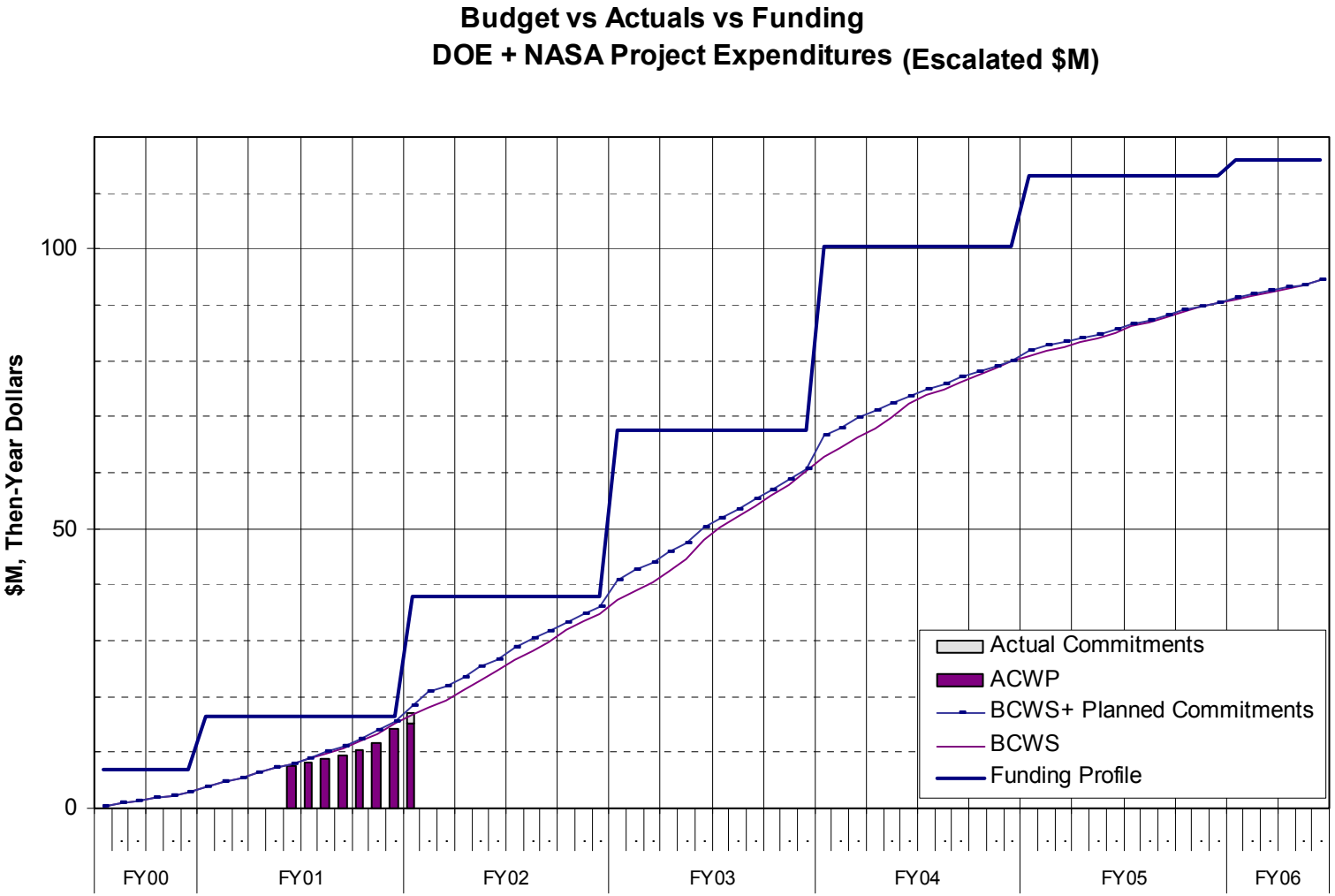
Subsystem Manager: E. Bloom, SLAC





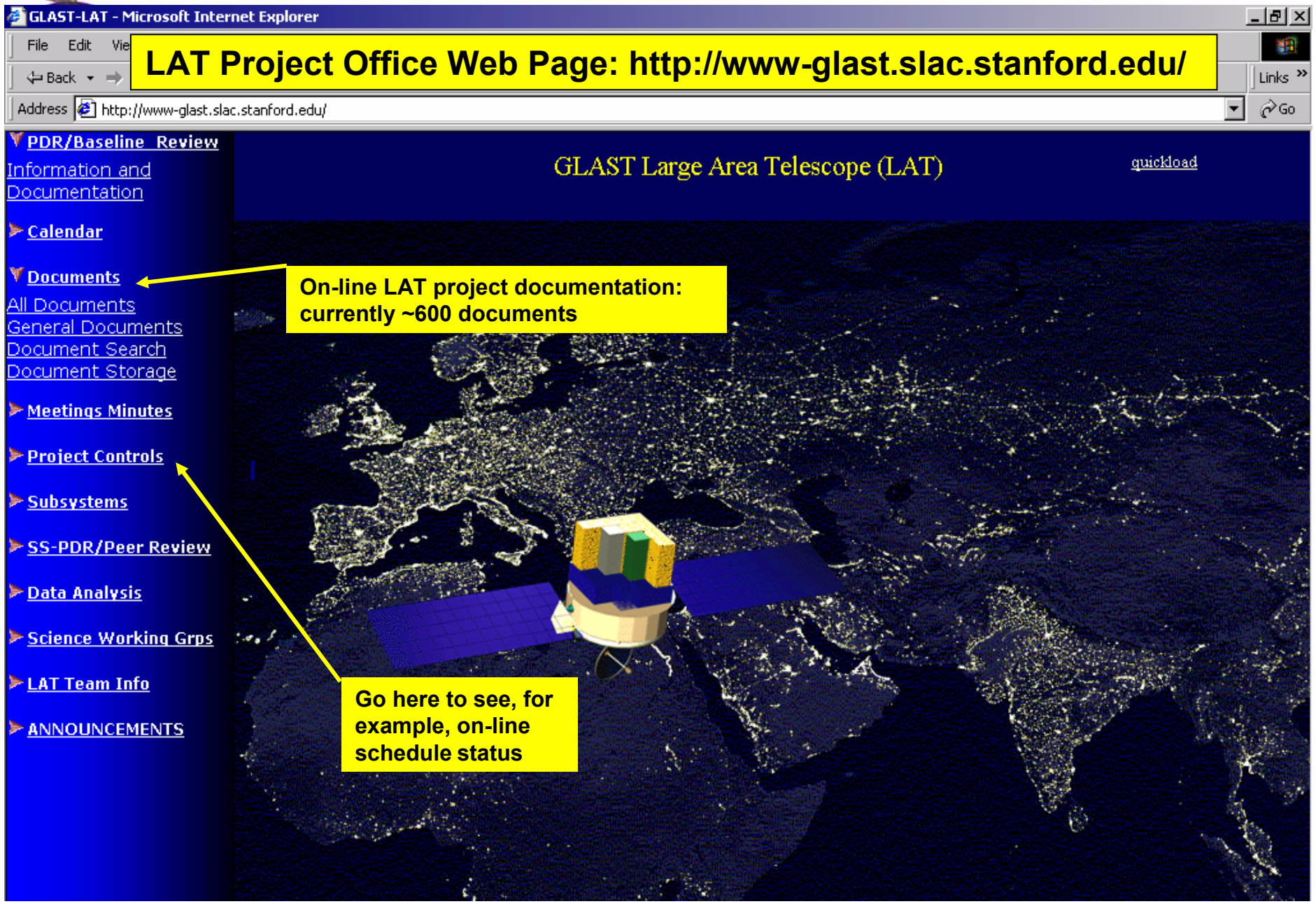
Renovated Light-Assembly Building I&T Facility

Current DOE + NASA Funding Plan, Estimated LAT Project Cost (Jan 02)



Summary

- GLAST Large Area Telescope
  - based on proven technologies – design and technology under development since 1992; SLAC has played key role in supporting collaboration's validation of instrument design
  - Technical performance of instrument design concept successfully demonstrated with balloon flight – August 2001
  - Final Design and construction of Engineering Models of Flight Units underway
- GLAST LAT Collaboration
  - International collaboration of particle physicists & astrophysicists
  - SLAC's role as host laboratory vital to success
- GLAST Science is exciting!


GLAST-LAT - Microsoft Internet Explorer
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ANNOUNCEMENTS
GLAST Large Area Telescope (LAT)
quickload
On-line LAT project documentation: currently ~600 documents
Go here to see, for example, on-line schedule status