GLAST Large Area Telescope:

Exploring the γ-ray Sky

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Outline

- Introduction to GLAST
- The Instrument
  - Pair conversion telescope
- Assembling the hardware
- Assembling the software
- Launch in 2007

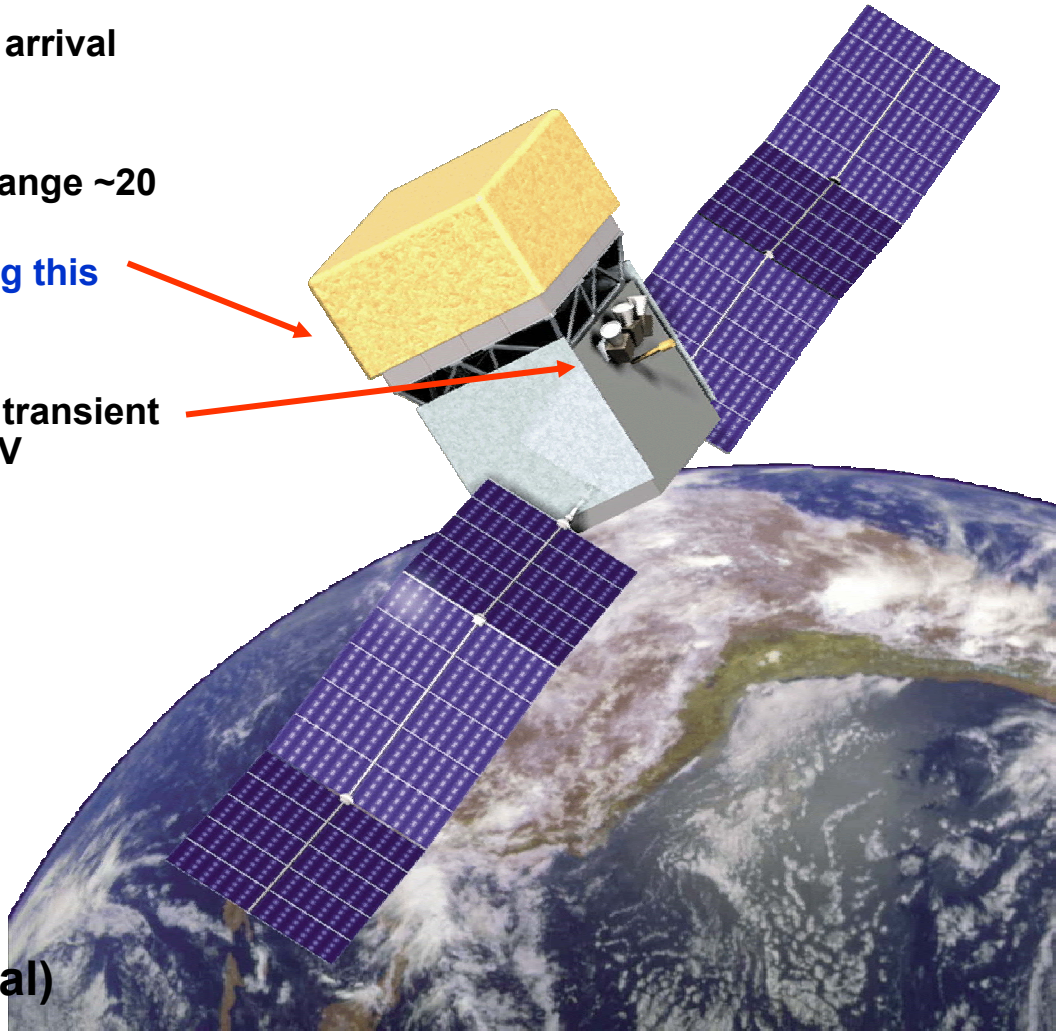
GLAST Mission

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

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

- **There is no telescope now covering this range!!**

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



Launch: February 2007 Florida

Orbit: 565 km, 28.5° inclination

Lifetime: 5 years (minimum; 10 yrs goal)

GLAST Participation

France Germany Italy Japan Sweden USA

NASA - DoE Partnership on LAT

LAT is being built by an international team

- Stanford University (SLAC & HEPL, Physics)
- Goddard Space Flight Center
- Naval Research Laboratory
- University of California, Santa Cruz
- University of Washington
- Ohio State University
- CEA/Saclay & IN2P3 (France)
- INFN & ASI (Italy)
- Hiroshima University, ISAS, RIKEN (Japan)
- Royal Inst. of Technology & Stockholm Univ. (Sweden)

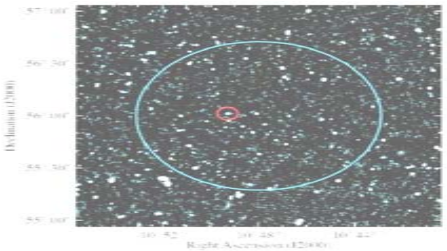
LAT managed by SLAC
PI – Peter Michelson

GBM is being built by US and Germany

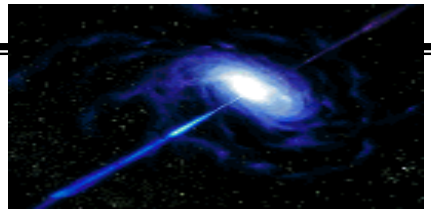
- MPE, Garching (Germany)
- Marshall Space Flight Center

Spacecraft and integration - Spectrum Astro

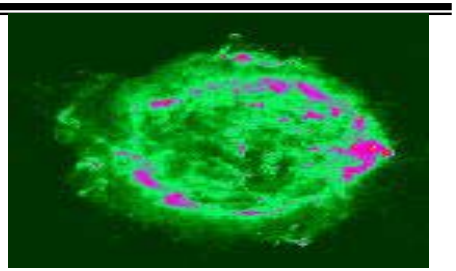
GLAST science - the sky above 20 MeV



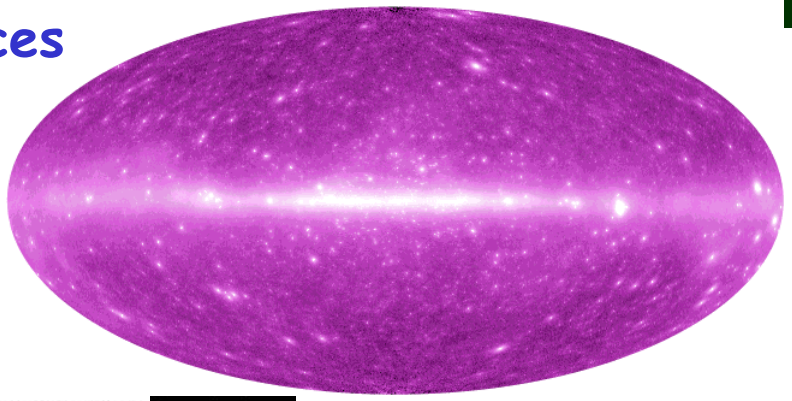
Unidentified sources



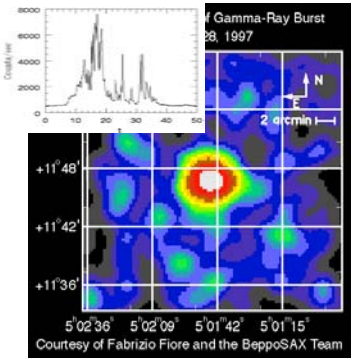
Active Galactic Nuclei



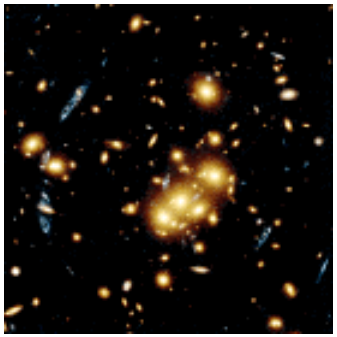
Cosmic ray acceleration



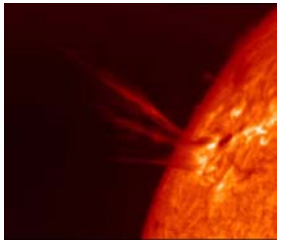
Pulsars



Gamma Ray Bursts



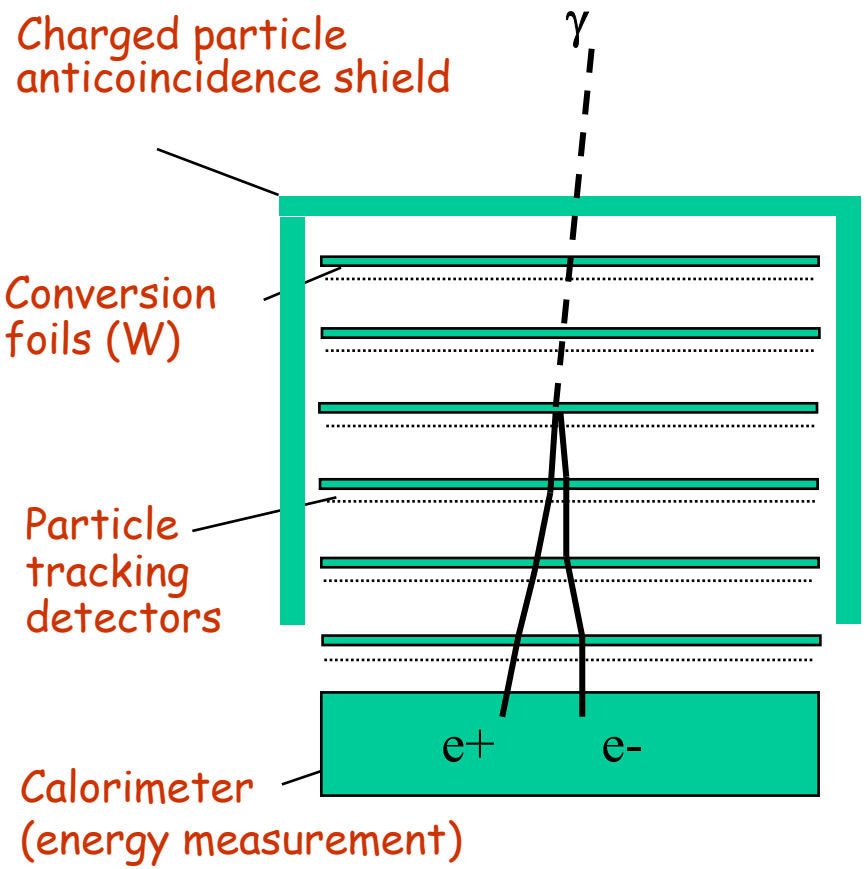
Dark matter



Solar flares

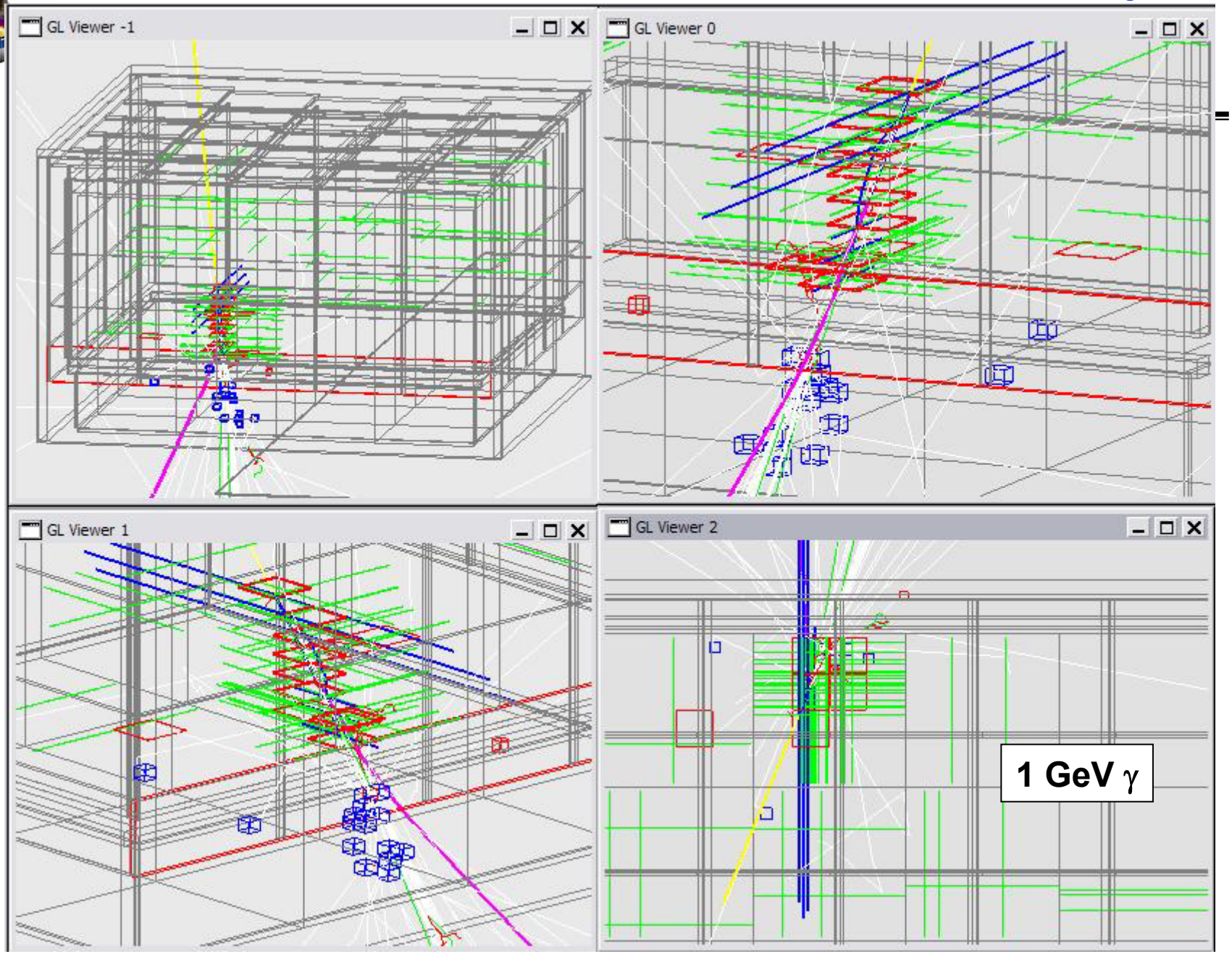
γ detection – pair conversion telescope

Pair production is the dominant photon interaction in our energy range

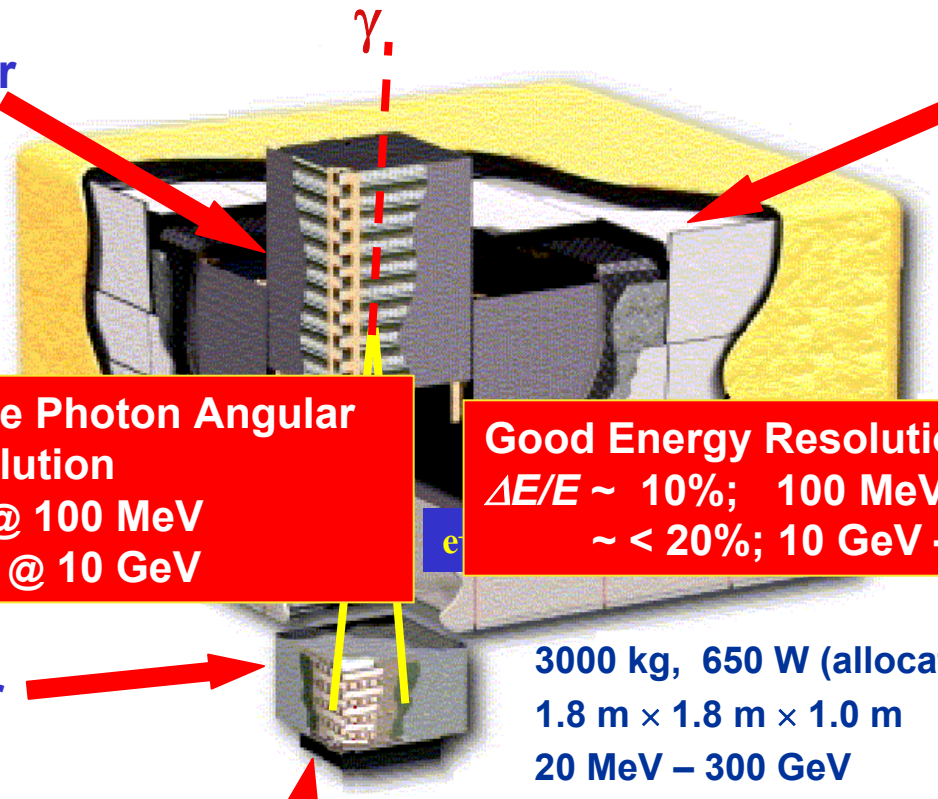


GLAST Concept

- Low profile for wide f.o.v.
- Segmented anti-detector to minimize self-veto at high E.
- Finely segmented calorimeter for enhanced background rejection and shower leakage correction.
- High-efficiency, precise track detectors located close to the conversions foils to minimize multiple-scattering errors.
- Modular, redundant design.
- No consumables.
- Low power consumption (650 W)


GL Viewer -1
GL Viewer 0
GL Viewer 1
GL Viewer 2
1 GeV γ

GLAST Large Area Telescope (LAT)



Si Tracker Tower

pitch = 228 μm
5.52 10^4 channels
12 layers × 3% X_0
+ 4 layers × 18% X_0
+ 2 layers

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

Good Energy Resolution
ΔE/E **~ 10%; 100 MeV – 10 GeV**
~ < 20%; 10 GeV – 300 GeV

ACD

Segmented scintillator tiles
0.9997 efficiency
⇒ minimize self-veto

Thermal
rs)

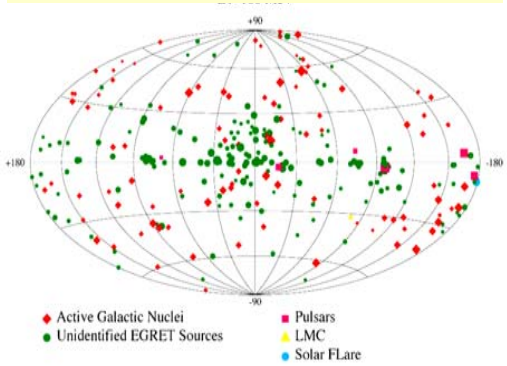
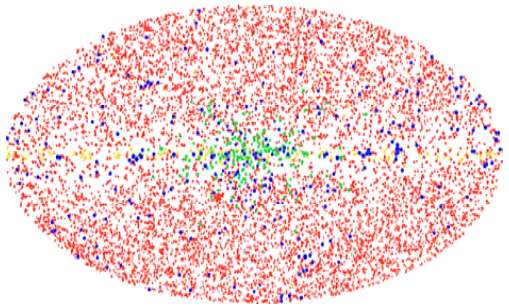
3000 kg, 650 W (allocation)
1.8 m × 1.8 m × 1.0 m
20 MeV – 300 GeV

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

16 identical towers
300 Hz average downlink

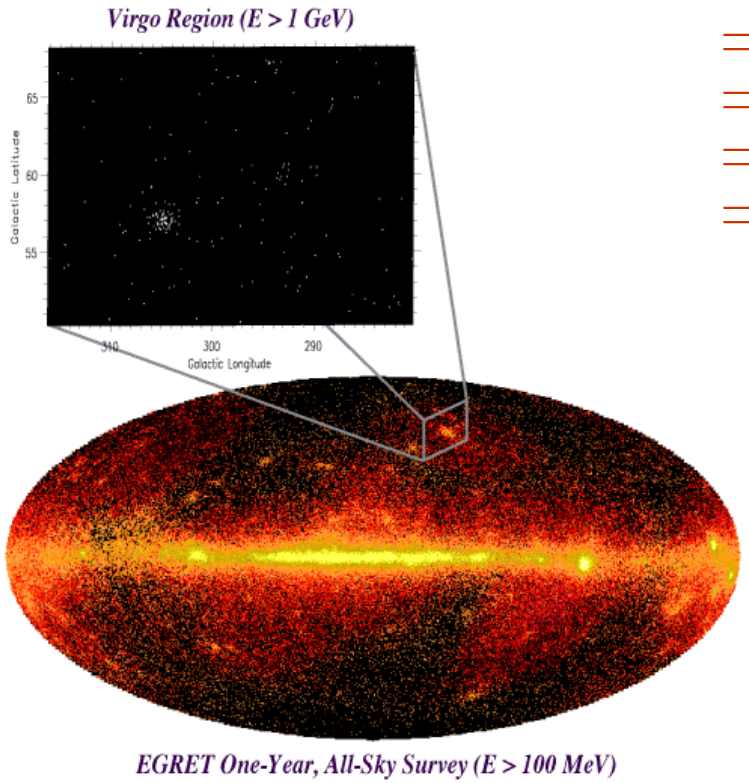
3rd EGRET Catalog E > 100 MeV	EGRET	LAT	LAT Simulation E > 100 MeV
	1991-2000 "de-orbited"	2007 - ? 5 yr operation requirement 10 yr operation goal	

Improvement

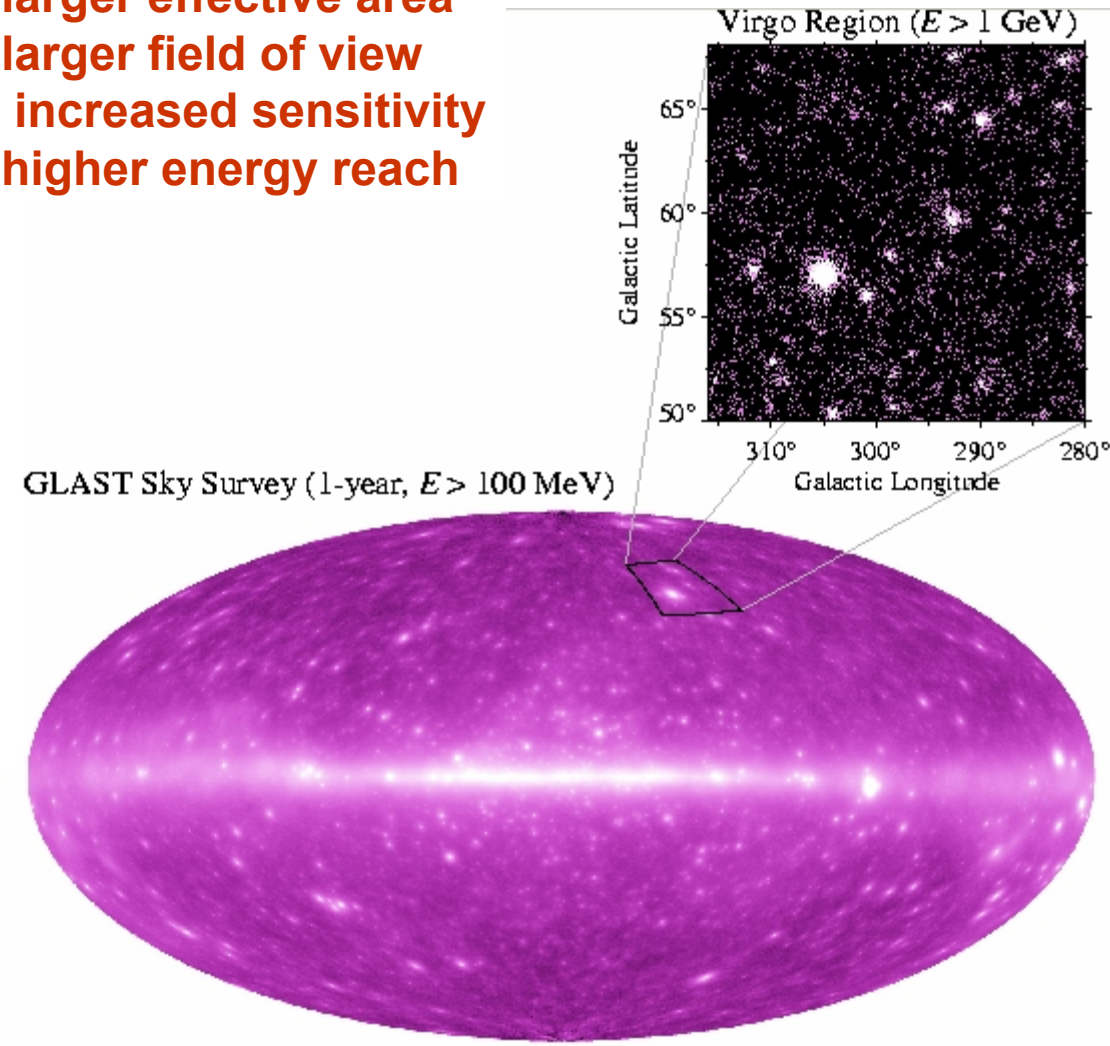
	EGRET	LAT	Improvement
Energy	20 MeV - 30 GeV	20 MeV - > 300 GeV	
Peak Effective area	1500 cm²	> 8000 cm²	> 6
Field of view	0.5 sr	> 2.0 sr	> 4
Sensitivity (1yr)	~ 10^{-7} γ cm^{-2} s^{-1}	< 6 10^{-9} γ cm^{-2} s^{-1}	> 20
Localization	15 '	< 0.5 '	> 30
Deadtime	100 ms	< 100 μs	> 1000

Large area
Low instrumental background

The Gamma-ray Sky



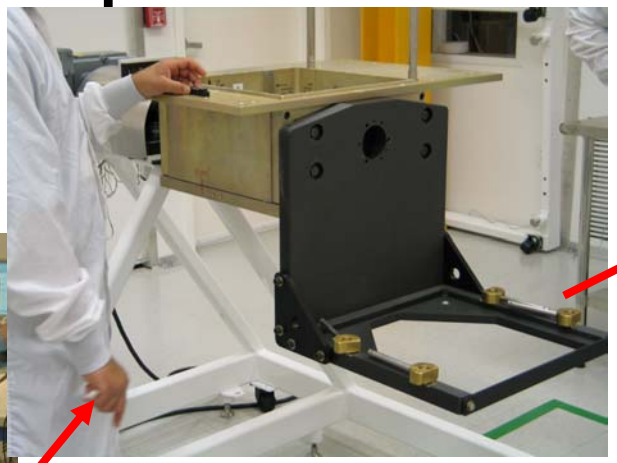
⇒larger effective area
⇒larger field of view
⇒ increased sensitivity
⇒higher energy reach

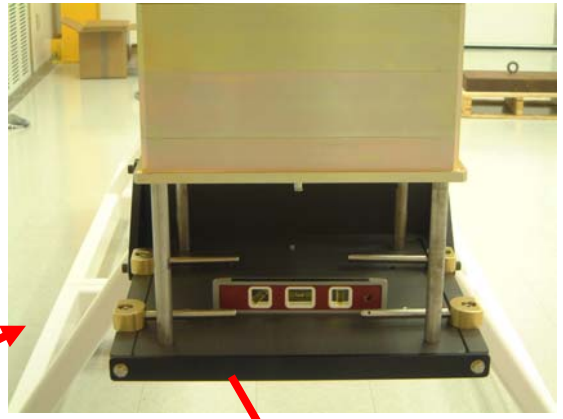


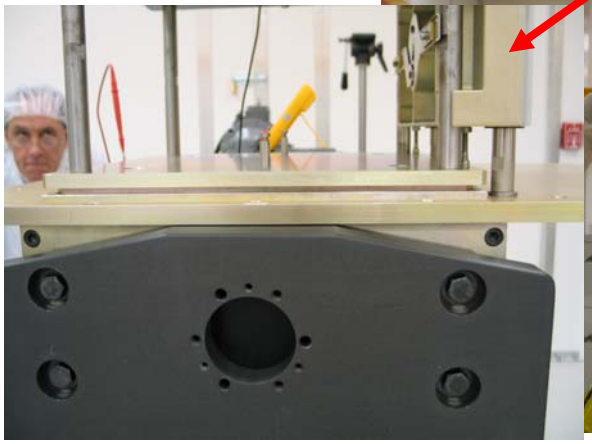
EGRET (1991-2000) – the past

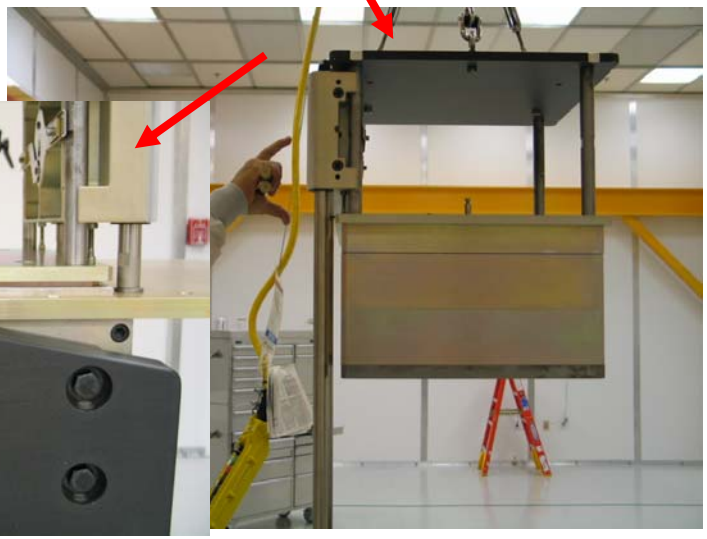
LAT Integration at SLAC: CAL example

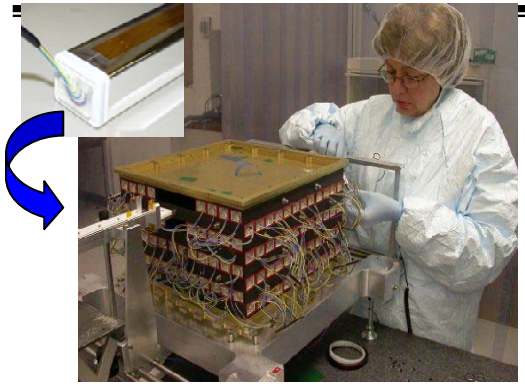
1. Receiving inspection
2. Inversion
3. Insertion



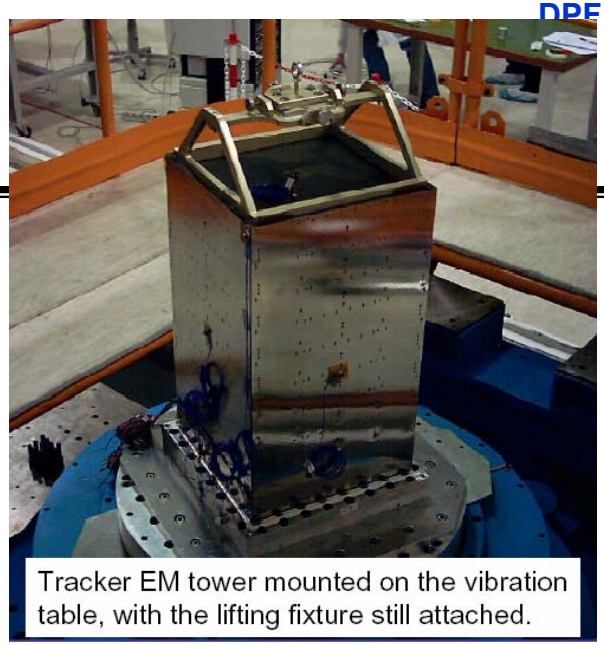






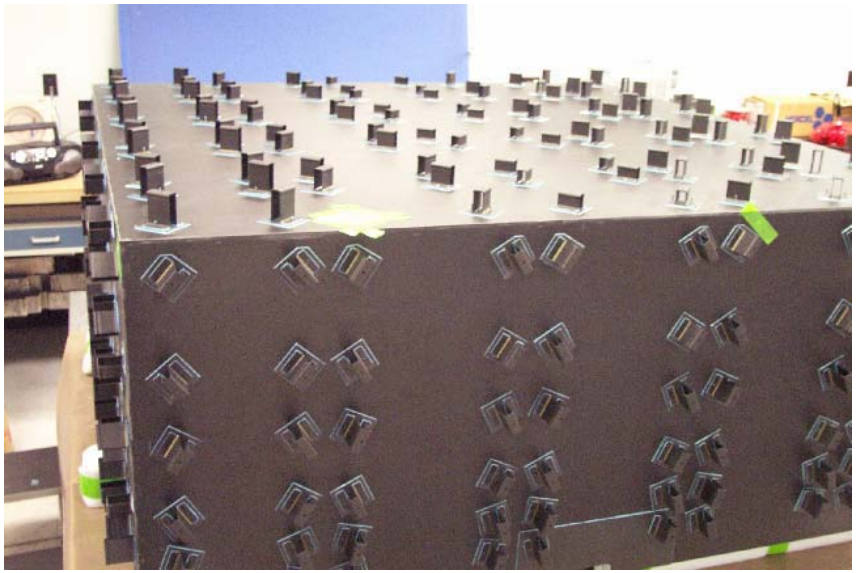


CAL Assembly

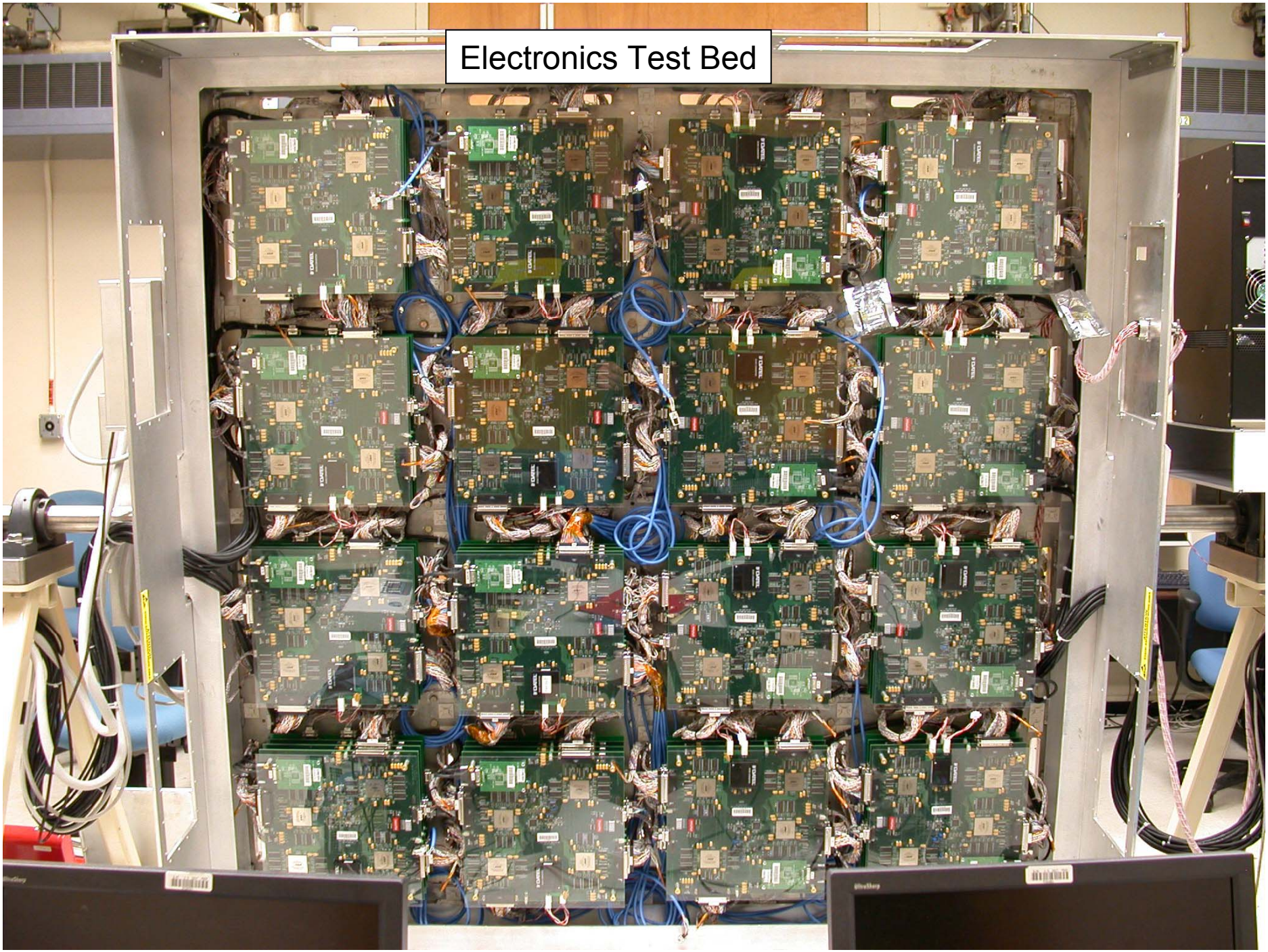


Tracker EM tower mounted on the vibration table, with the lifting fixture still attached.

GRID



ACD support structure

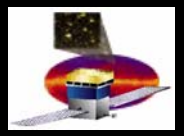

Electronics Test Bed

Data Challenges

- Ground software is amalgam of HEP instrument software and Astro FTOOLS
- Adopt HEP's "Data Challenges" to create a series of end-to-end studies: create a progression of ever more demanding studies
- DC1. Modest goals. Contains most essential features of a data challenge.
  - 1 simulated day all-sky survey simulation
  - find GRBs
  - recognize simple hardware problem(s)
  - a few physics surprises
  - Exercise all the components
- DC2, start mid of CY05. More ambitious goals. Encourage further development, based on lessons from DC1. One simulated month.
- DC3, in CY06. Support for flight science production.

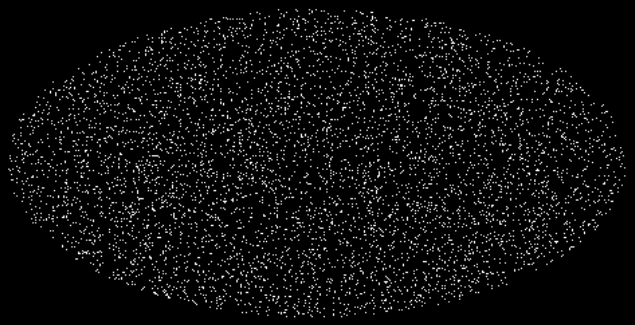
DC1 Components

- Focal point for many threads
  - Orbit, rocking, celestial coordinates, pointing history
  - Plausible model of the sky
  - Background rejection and event selection
  - Instrument Response Functions
  - Data formats for input to high level tools
  - First look at major science tools – Likelihood, Observation Simulator
  - Generation of datasets
  - Populate and exercise data servers at SSC & LAT
  - Code distribution on windows and linux
- Involve new users from across the collaboration
- Teamwork!

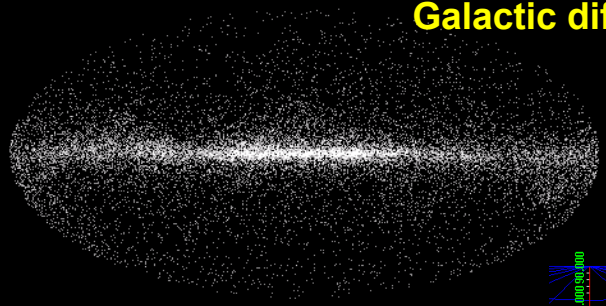


The Simulated Sky

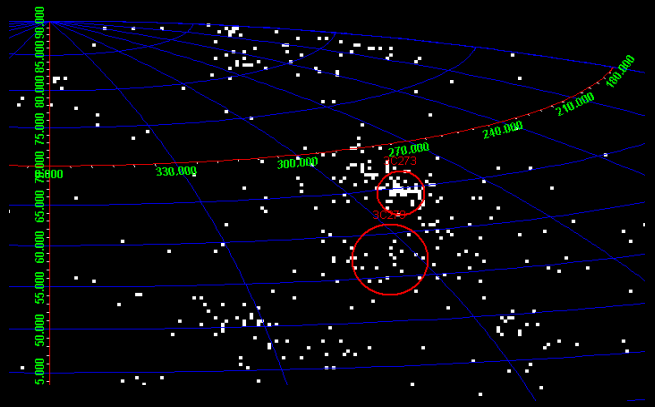
Extragalactic diffuse

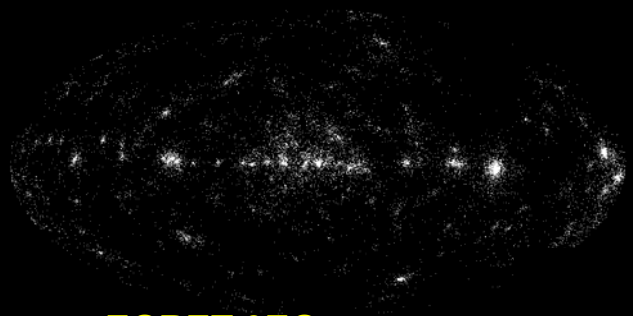


Galactic diffuse



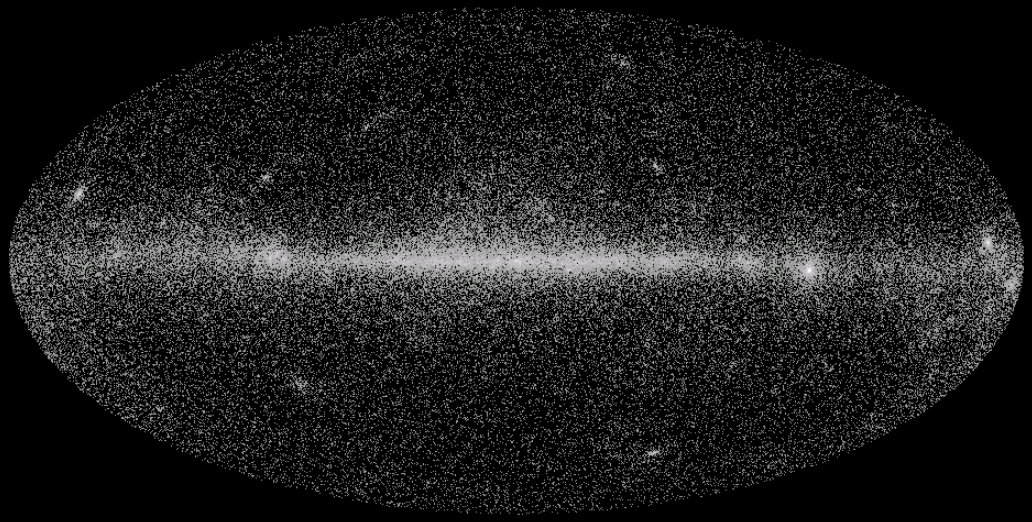
Fiddling 3C273/279



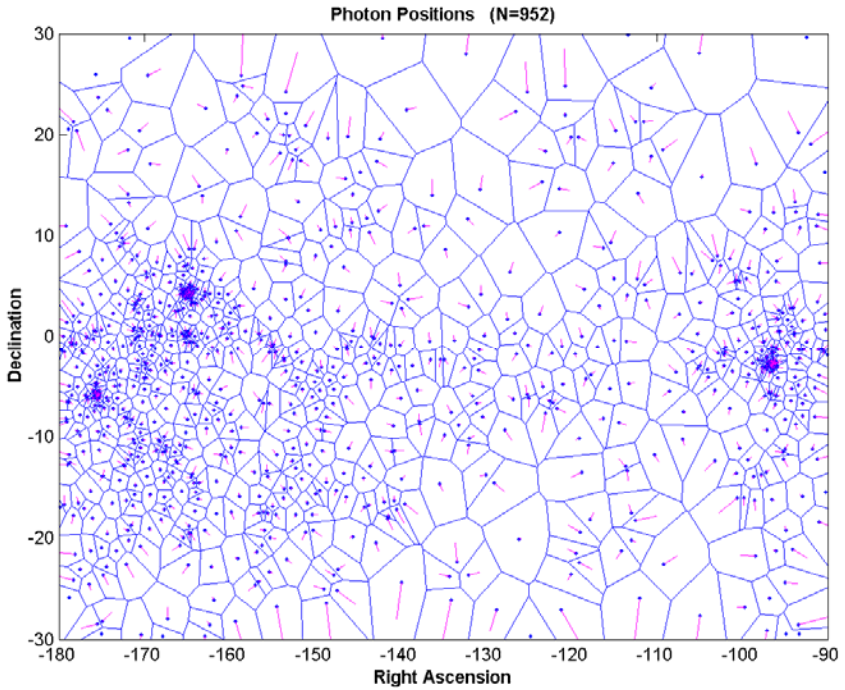


EGRET 3EG

Our Sky



Testing Source Finding techniques

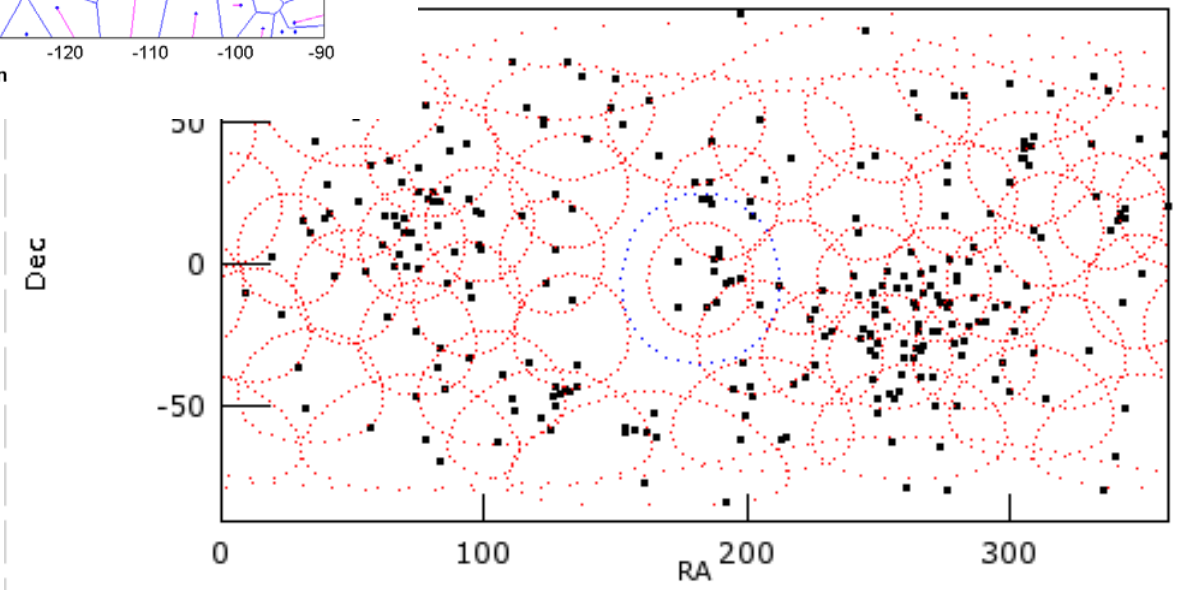


Voronoi tessellation

An opportunity to try different algorithms:

- voronoi tessellations
- region of interest around 3EG
- wavelets
- …

3EG Sources and ROIs



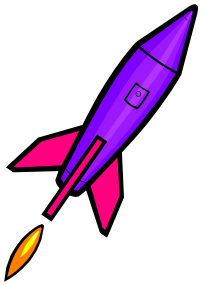
GLAST Master Schedule

- Flight hardware production started
- Integration of hardware starting Oct 2004!
- Completion of the LAT July 2005
  - to NRL for environmental testing
- Delivery to Observatory Integration December 2005
  - mate with Observatory and test
- Launch February 2007
  - Kennedy Space Center
- Sky survey begins May 2007

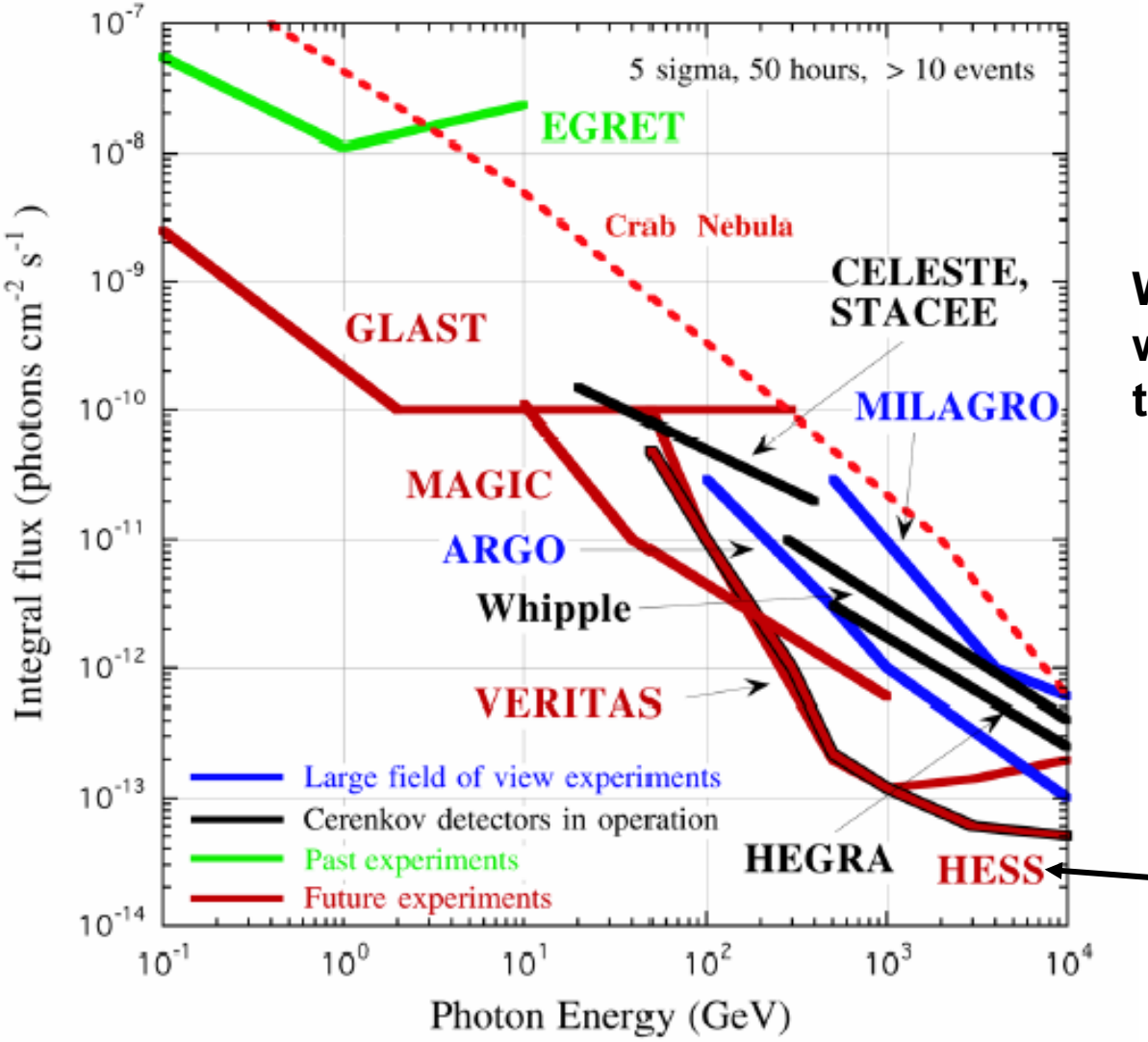
Launch on Delta II from Kennedy Space Center

Summary

- GLAST will be the follow-on to EGRET in mapping the γ-ray sky
  - 20 MeV to 300+ GeV
  - Huge improvement in sensitivity
  - Far higher statistics for studying astrophysical phenomena
  - Black hole, SN, pulsar science …. + discoveries!



Gamma-ray Observatories

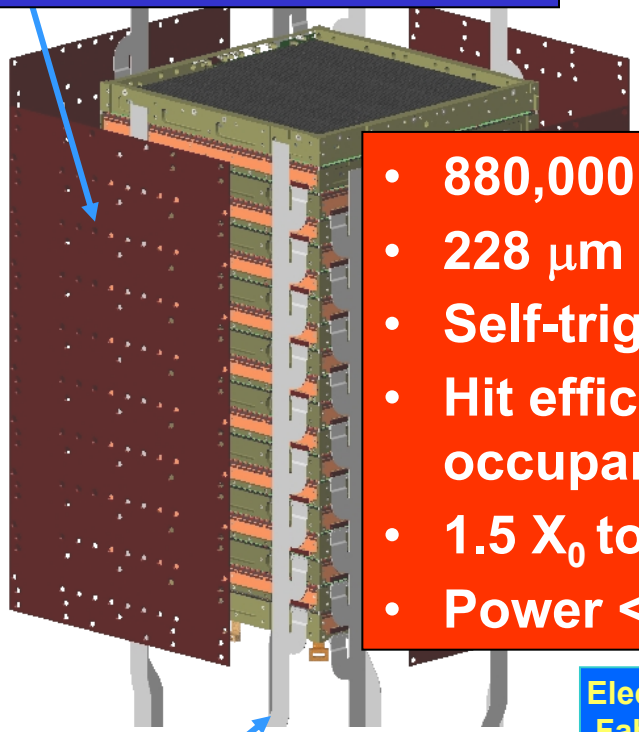


Will get good overlap with the ground based telescopes

Now in operation

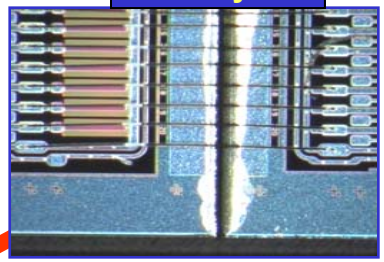
Tracker Overview

Module Structure (walls, flexures,thermal-gasket, fasteners)
Engineering: SLAC, Hytec
Procurement: SLAC



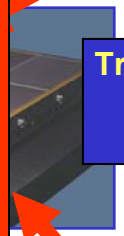
SSD Procurement, Testing
Japan, Italy, SLAC

SSD Ladder Assembly Italy



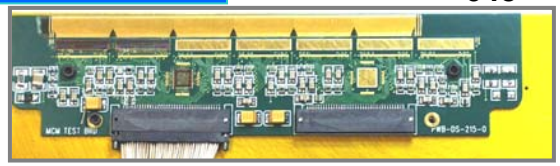
2592

- 880,000 channels (total)
- 228 μm pitch
- Self-triggering
- Hit efficiency > 99% with noise occupancy <<10^{-5}
- 1.5 X_0 total
- Power <210 μW/ch



Tray Assembly and Test Italy

Electronics Design, Fabrication & Test
UCSC, SLAC



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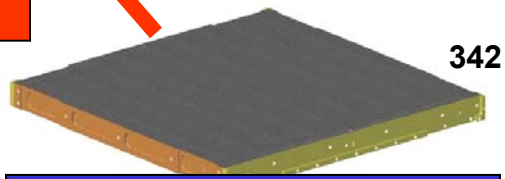

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Composite Panel & Converters
Engineering:
SLAC, Hytec, and Italy
Procurement: Italy

Cable Plant
UCSC

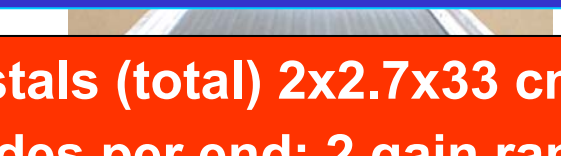
Calorimeter Overview

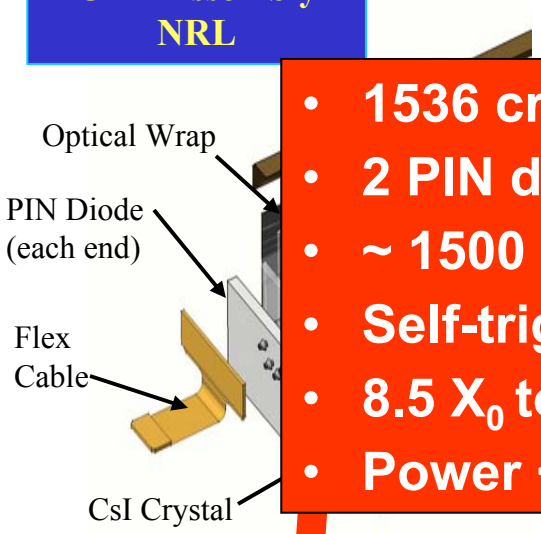
CsI Crystals Sweden (KTH)

CDE Assembly NRL

Mechanical Structure France (IN2P3/Ecole Polytechnique)

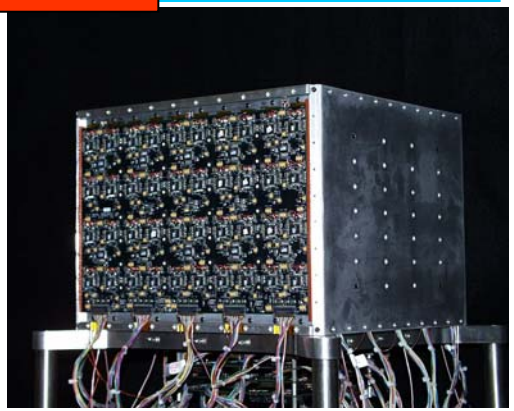
Front-End Electronics NRL, SLAC

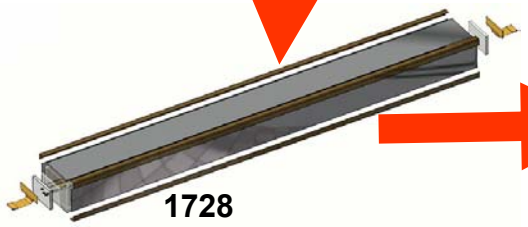


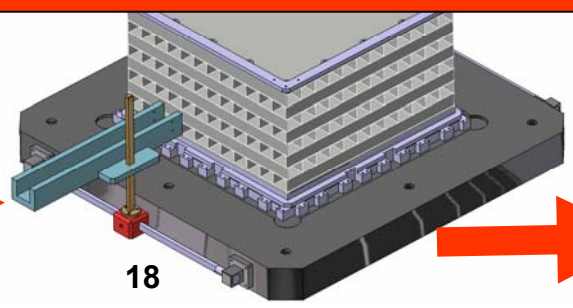


- 1536 crystals (total) 2x2.7x33 cm^3
- 2 PIN diodes per end; 2 gain ranges each
- ~ 1500 kg
- Self-triggering
- 8.5 X_0 total
- Power < 91 W

Module Assembly d Test, NRL+collab





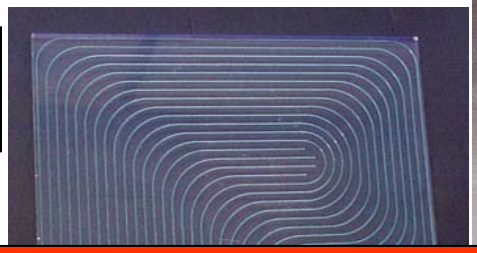


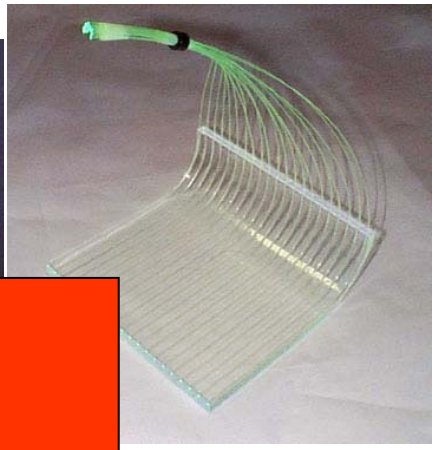
16 flight modules + 2 spares

PEM Assembly NRL

Anti-Coincidence Overview

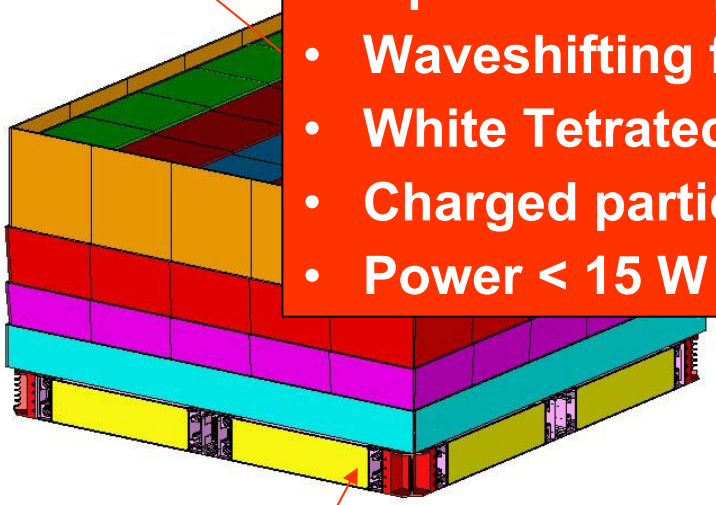
Proto-tile Assemblies from Fermi lab





Tile Shell Assembly (TSA)

- 89 tiles – 1 cm thick
- 2 phototubes per tile
- Waveshifting fiber embedded
- White Tetratec wrapping
- Charged particle efficiency > 0.9997
- Power < 15 W total



Base Electronics Assembly (BEA)

Layout

Electronics & Onboard Processing