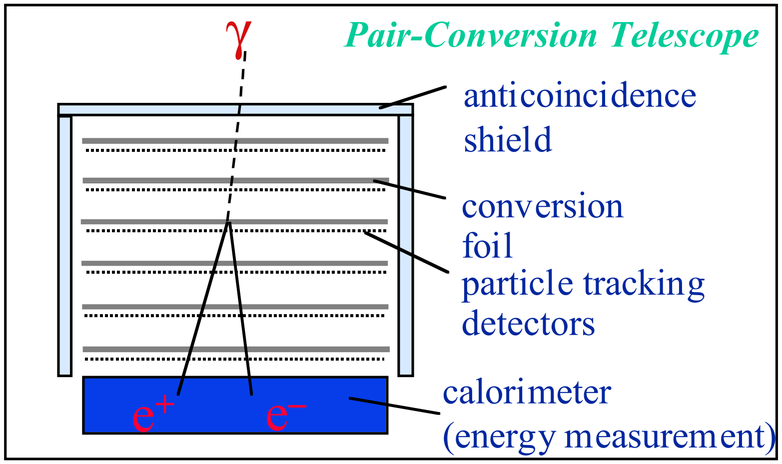
Large Area Telescope (LAT) Overview

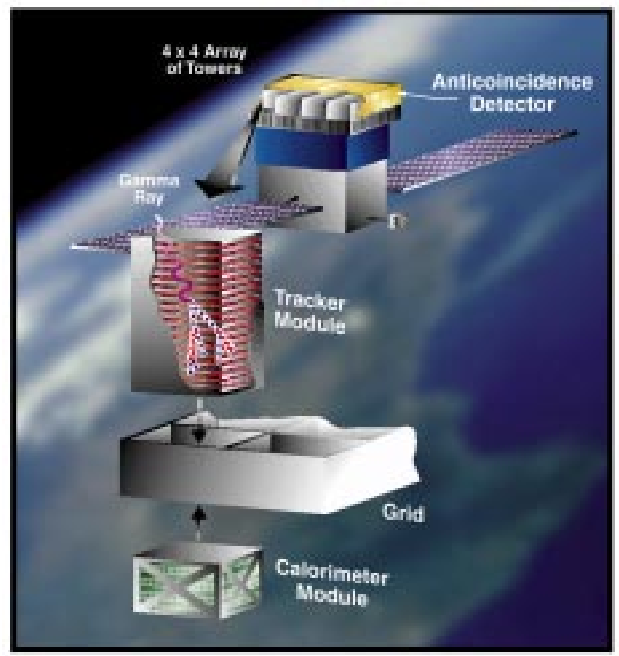
Peter F. Michelson
Instrument Principal Investigator
Stanford University
peterm@leland.stanford.edu

William E. Althouse
LAT Project Manager
Stanford Linear Accelerator Center
wea@slac.stanford.edu

GLAST Large Area Telescope: Overview

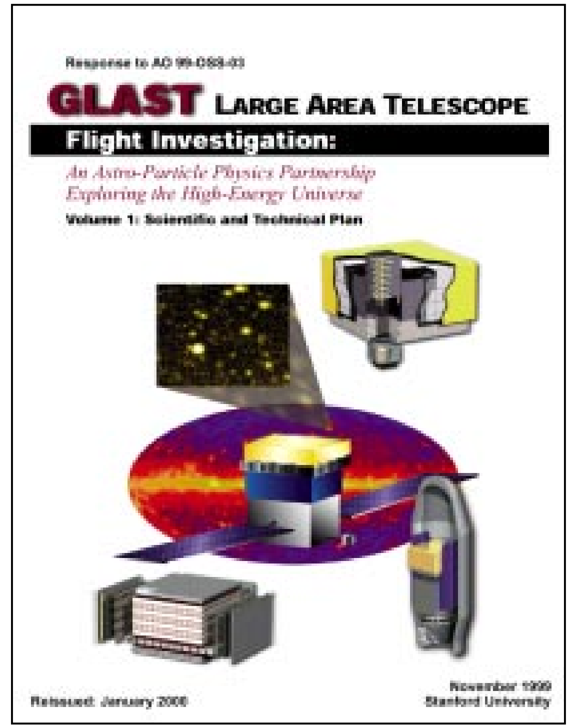
- **LAT: wide field-of-view high-energy gamma-ray telescope**
- **Design optimized for Key Science Objectives**
  - Particle acceleration in Pulsars, SNRs, AGN, & galaxies
  - High-energy behavior of GRBs & Transients
  - Probe dark matter and the Early Universe
- **More than 7 years of design, development & demonstration efforts**
  - 1993-95: First GLAST mission studies as New Mission Concept in Astrophysics
  - 1997-2000: LAT Technology Development and Demonstration Program
- **LAT design based on proven technologies**
  - Precision Si-strip Tracker
  - Hodoscopic CsI Calorimeter
  - Segmented Anticoincidence Detector
  - Advantages of modular design





GLAST Large Area Telescope: Overview

- **GLAST LAT flight instrument and science investigation proposal submitted in response to NASA AO 99-OSS-03 – November 1999**
  - Baseline instrument configuration defined
  - Instrument team defined: US led (supported by DOE & NASA), with international partners
  - Draft international agreements with all foreign partners
- **Flight Proposal selected – February 28, 2000**



Organizations with LAT Hardware Involvement

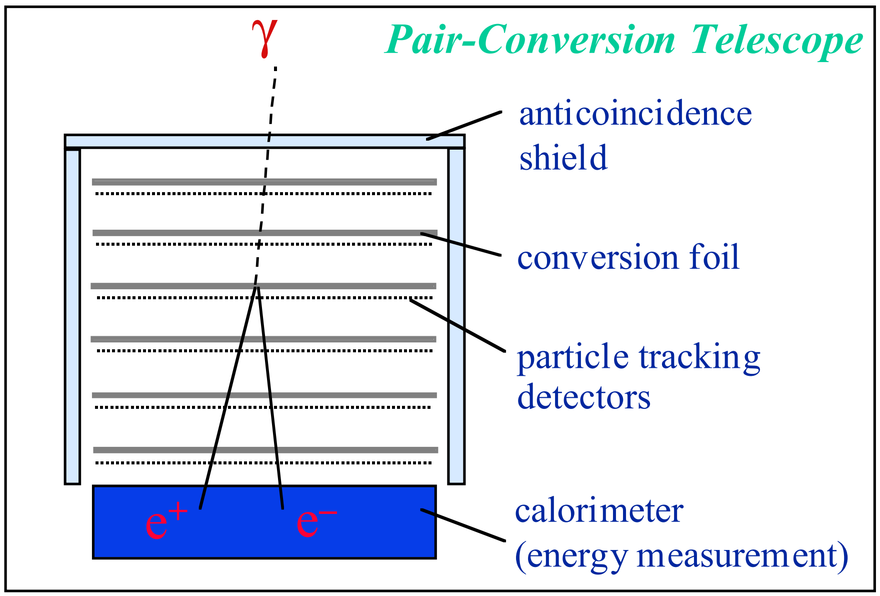
Stanford University: SLAC & HEPL
NASA Goddard Space Flight Center
US Naval Research Laboratory
University of California at Santa Cruz: SCIPP
Hiroshima University, University of Tokyo, ISAS & ICRR, Japan
INFN, Italy
Laboratorie du Commissariat a l'Energie Atomique & IN2P3, France
Royal Institute of Technology, Sweden

Experimental Technique

- Instrument must measure the direction, energy, and arrival time of high energy photons (from approximately 20 MeV to greater than 300 GeV):

- photon interactions with matter in GLAST energy range dominated by pair conversion:
  - ➡ determine photon direction
  - ➡ clear signature for background rejection

- limitations on angular resolution (PSF)
  low E: multiple scattering => many thin layers
  high E: hit precision & lever arm



Energy loss mechanisms:

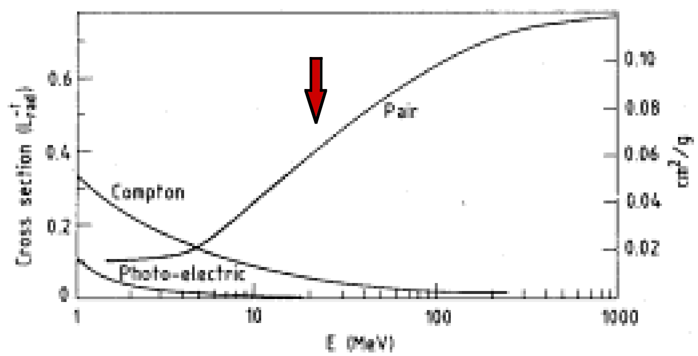


Fig. 2: Photon cross-section σ in lead as a function of photon energy. The intensity of photons can be expressed as $I = I_0 \exp(-\sigma x)$, where x is the path length in radiation lengths. (Review of Particle Properties, April 1980 edition).

- must detect γ-rays with high efficiency and reject the much higher flux ($x{\sim}10^4$) of background cosmic-rays, etc.;
- energy resolution requires calorimeter of sufficient depth to measure buildup of the EM shower. Segmentation useful for resolution and background rejection.

LAT Instrument

Instrument

16 towers ⇒ modularity

height/width = 0.4 ⇒ large field-of-view

TKR

Si-strips: fine pitch: 228 μm, high efficiency

0.44 X_0 front-end ⇒ reduce multiple scattering

1.05 X_0 back-end ⇒ increase sensitivity > 1 GeV

CAL

CsI: wide energy range 0.1-100 GeV

hodoscopic ⇒ cosmic-ray rejection

⇒ shower leakage correction

X_{TOT} = 10.1 X_0 ⇒ shower max contained < 100 GeV

ACD

segmented plastic scintillator

⇒ minimize self-veto

> 0.9997 efficiency & redundant readout

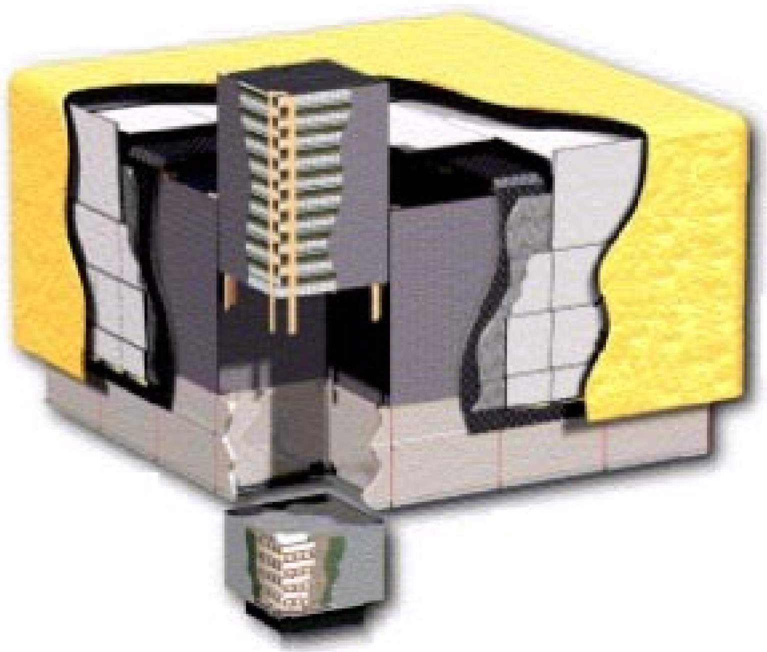
TKR+CAL:

prototypes + 1 engineering model

16 flight +1(qual→spare) +1(spare)

ACD:

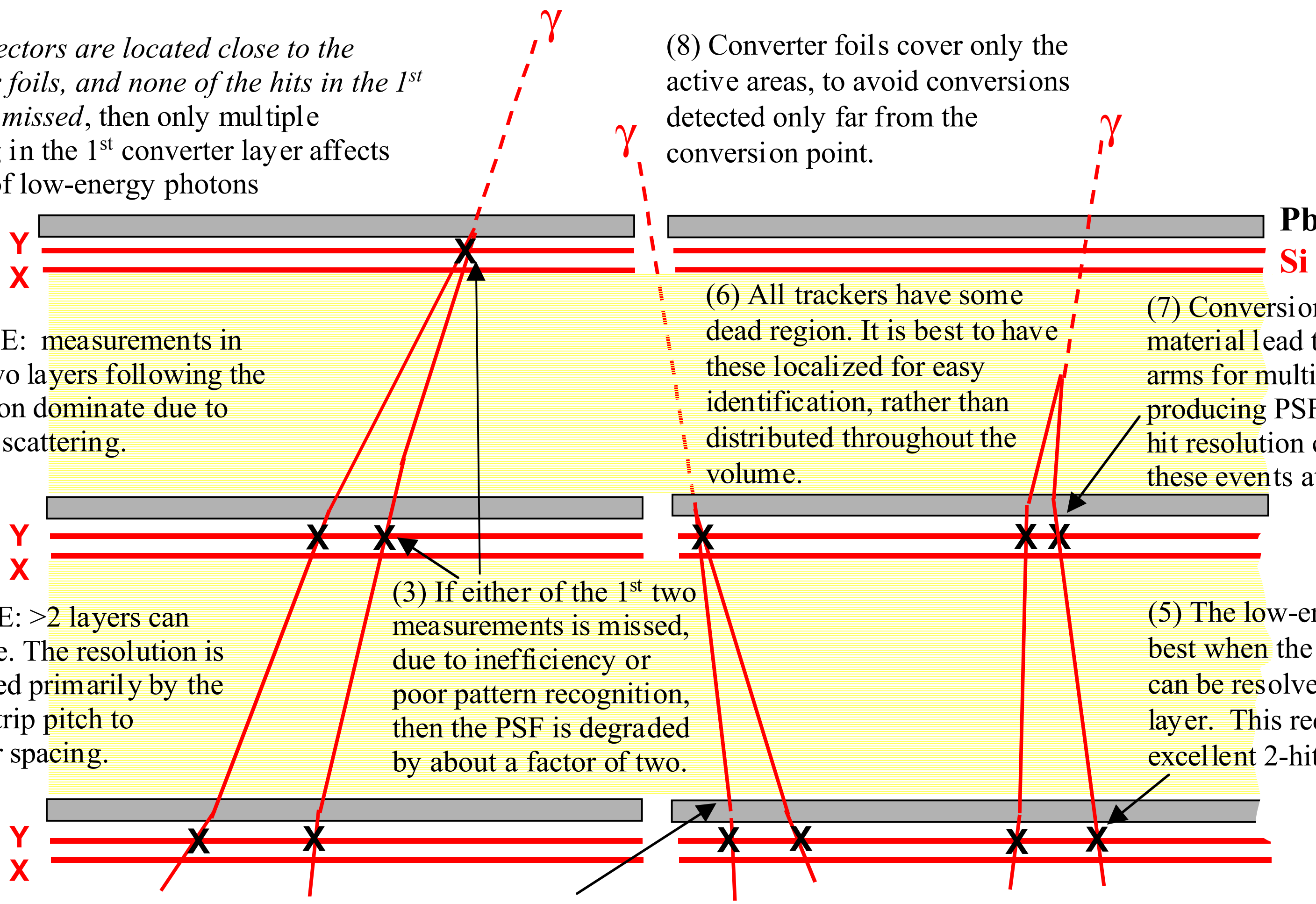
1(qual) +1 flight



Pair-Conversion Tracker Design Considerations

If the *detectors are located close to the converter foils, and none of the hits in the 1st layer are missed*, then only multiple scattering in the 1st converter layer affects the PSF of low-energy photons

(8) Converter foils cover only the active areas, to avoid conversions detected only far from the conversion point.



(1) Low E: measurements in the 1st two layers following the conversion dominate due to multiple scattering.

(6) All trackers have some dead region. It is best to have these localized for easy identification, rather than distributed throughout the volume.

(7) Conversions in structural material lead to large lever arms for multiple scattering, producing PSF tails. Good 2-hit resolution can help identify these events at low E.

(2) High E: >2 layers can contribute. The resolution is determined primarily by the ratio of strip pitch to interlayer spacing.

(3) If either of the 1st two measurements is missed, due to inefficiency or poor pattern recognition, then the PSF is degraded by about a factor of two.

(5) The low-energy PSF is best when the two tracks can be resolved in the 2nd layer. This requires excellent 2-hit resolution.

100 MeV	2 layers
1 GeV	~5 layers
10 GeV	>10 layers

(4) Scattering in the 2nd layer of lead does not degrade the low-energy PSF provided the X and Y measurements are made immediately following the lead layer.

LAT Instrument Performance

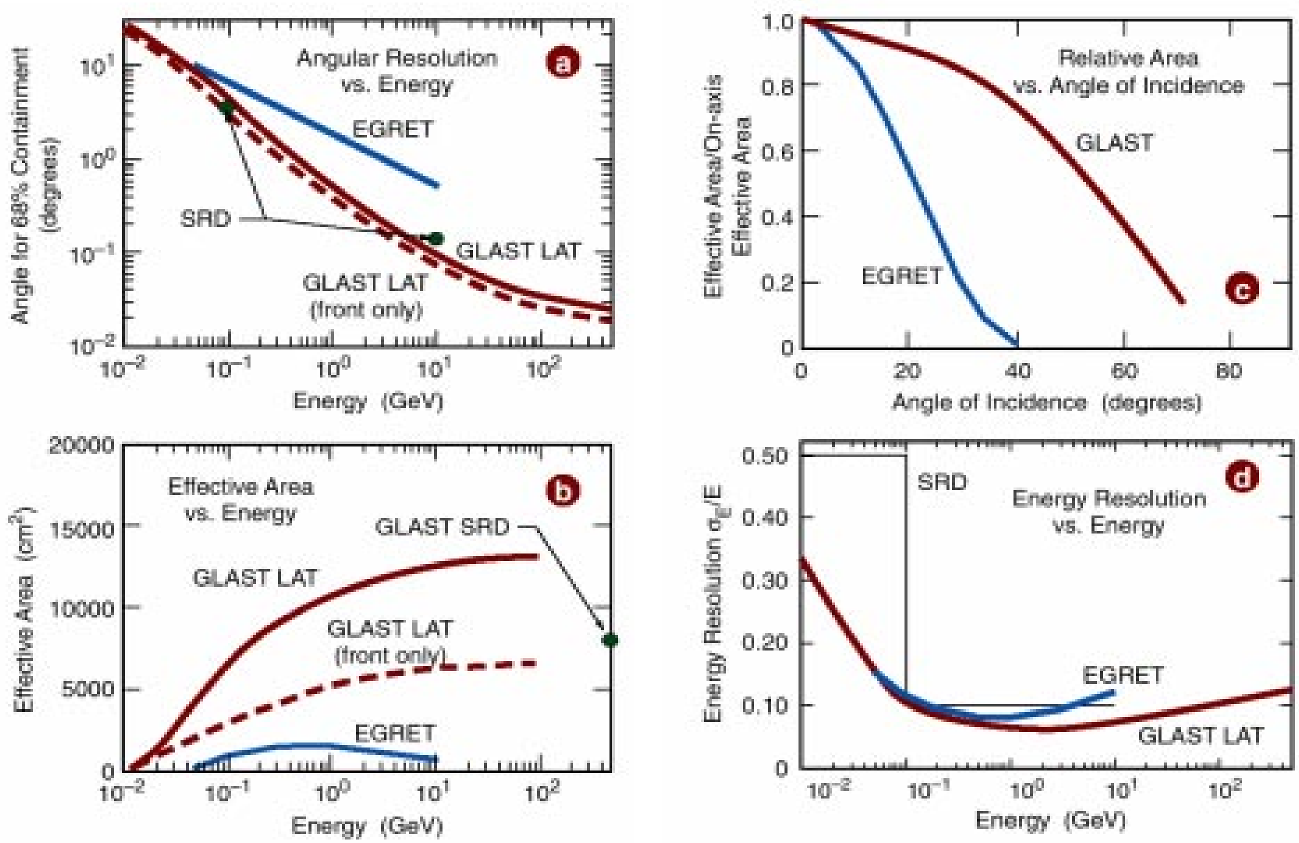
More than 40 times the sensitivity of EGRET

Large Effective Area (20 MeV – > 300 GeV)

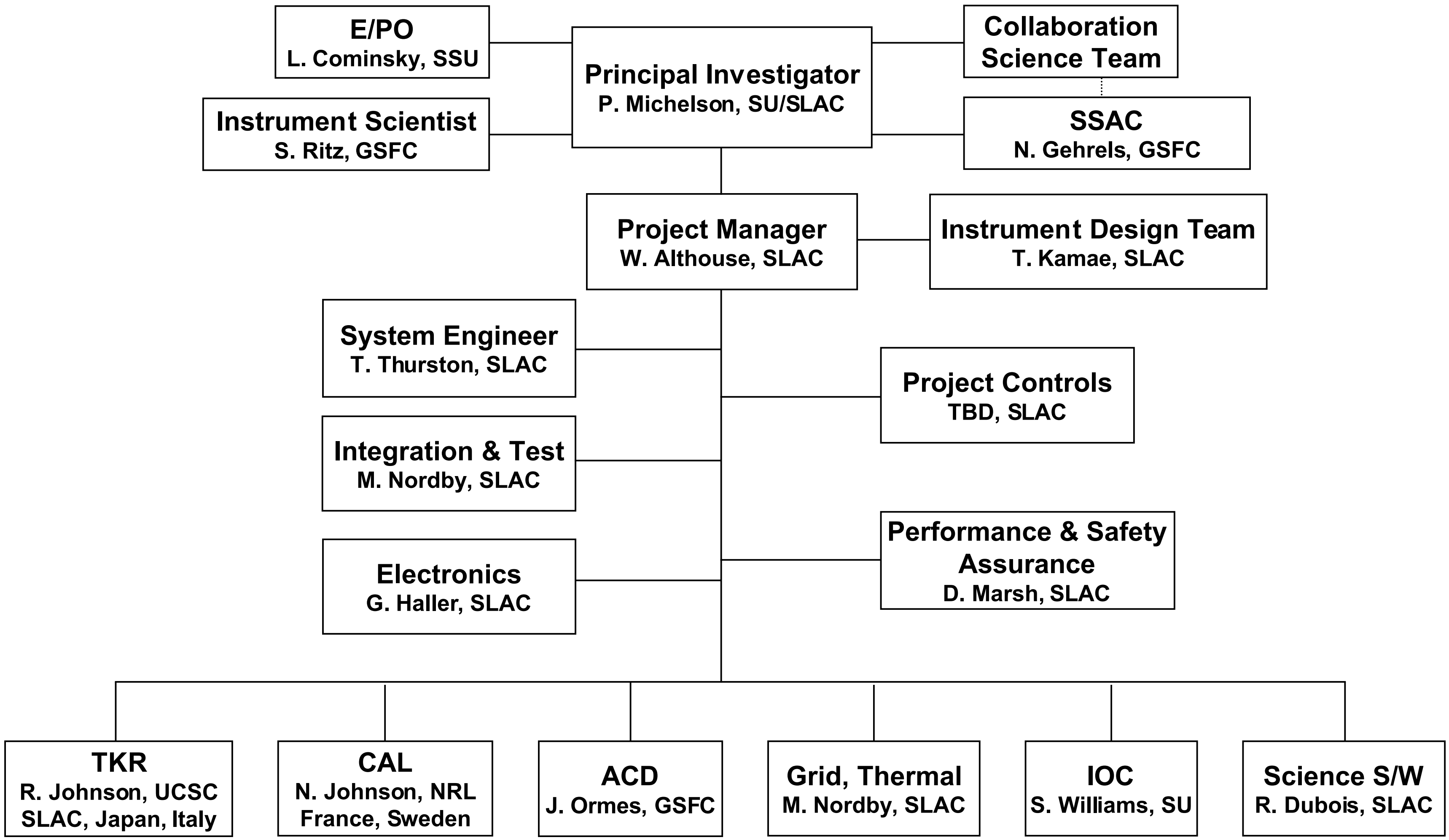
Optimized Point Spread Function (0.35° @ 1 GeV)

Wide Field of View (2.4 sr)

Good Energy Resolution ($\Delta E/E$ < 10%, E >100 MeV)



GLAST LAT Organization



Institutions & Responsibilities

Institution(s)	Areas of Responsibility
SU-SLAC	Management of GLAST LAT project Instrument systems engineering, electrical systems engineering Tracker subsystem mechanical design, construction, testing, integration Software management, Grid development, Instrument integration and test Level-1 data processing, Performance and Safety Assurance DAQ engineering support
SU-HEPL	DAQ Subsystem development; Inst. Ops. Ctr.
SSU	Education and Public Outreach Program
GSFC	ACD Subsystem; thermal blanket/ micrometeorite shield; Instrument Scientist
NRL	DAQ/CPU, DAQ/DSF, S/C Interface Unit; calorimeter digital electronics; calorimeter integration and test
FRANCE - *CEA/DAPNIA* *IN2P3/France*	Calorimeter analog front-end photo-diodes and electronics readout; management of French effort Calorimeter module mechanical design and assembly; calorimeter & inst. simulation
KTH, Stockholm University	Calorimeter CsI crystals
UCSC	Tracker Subsystem: electronics, mechanical design, assembly, testing
JGC, Japan	Tracker: Silicon-strip detectors
INFN, Italy	Tracker: Silicon-strip ladders and tracker tray assembly

GLAST LAT Schedule