



# GLAST Review Teams
# Project Overview Briefing

## April 29, 2003


# Agenda

| | |
|---|---|
| ***Introduction*** | ***A. Vernacchio*** |
| ***Science Summary*** | ***S. Ritz*** |
| ***Mission Overview*** | ***A. Vernacchio*** |
| ***Systems Engineering*** | ***N. Rioux*** |
| ***Observatory*** | ***J. Bretthaeur*** |
| ***LAT*** | ***B. Graf*** |
| ***GBM*** | ***W. Browne*** |
| ***Mission Operations & Ground Systems*** | ***M. Rackley*** |



# Mission Overview


# GLAST is an International Mission


*NASA - DoE Partnership on LAT*

*LAT is being built by an international team*

- *Si Tracker: Stanford, UCSC, Japan, Italy*
- *CsI Calorimeter: NRL, France, Sweden*
- *Anticoincidence: GSFC*
- *Data Acquisition System: Stanford, NRL*

*GBM is being built by US and Germany*

- *Detectors: MPE*


Sweden

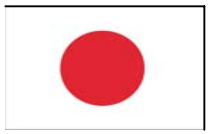

Italy

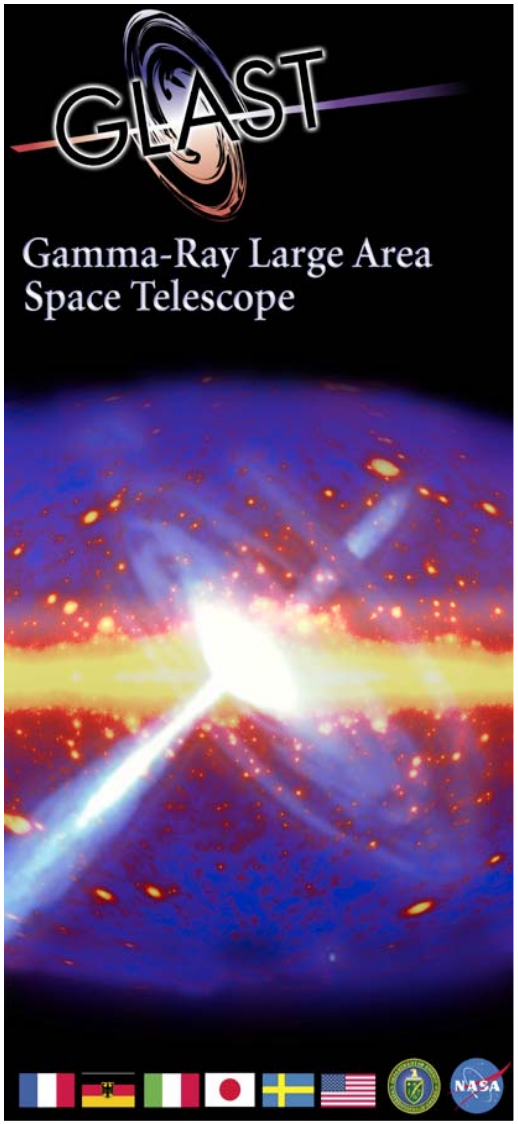

France



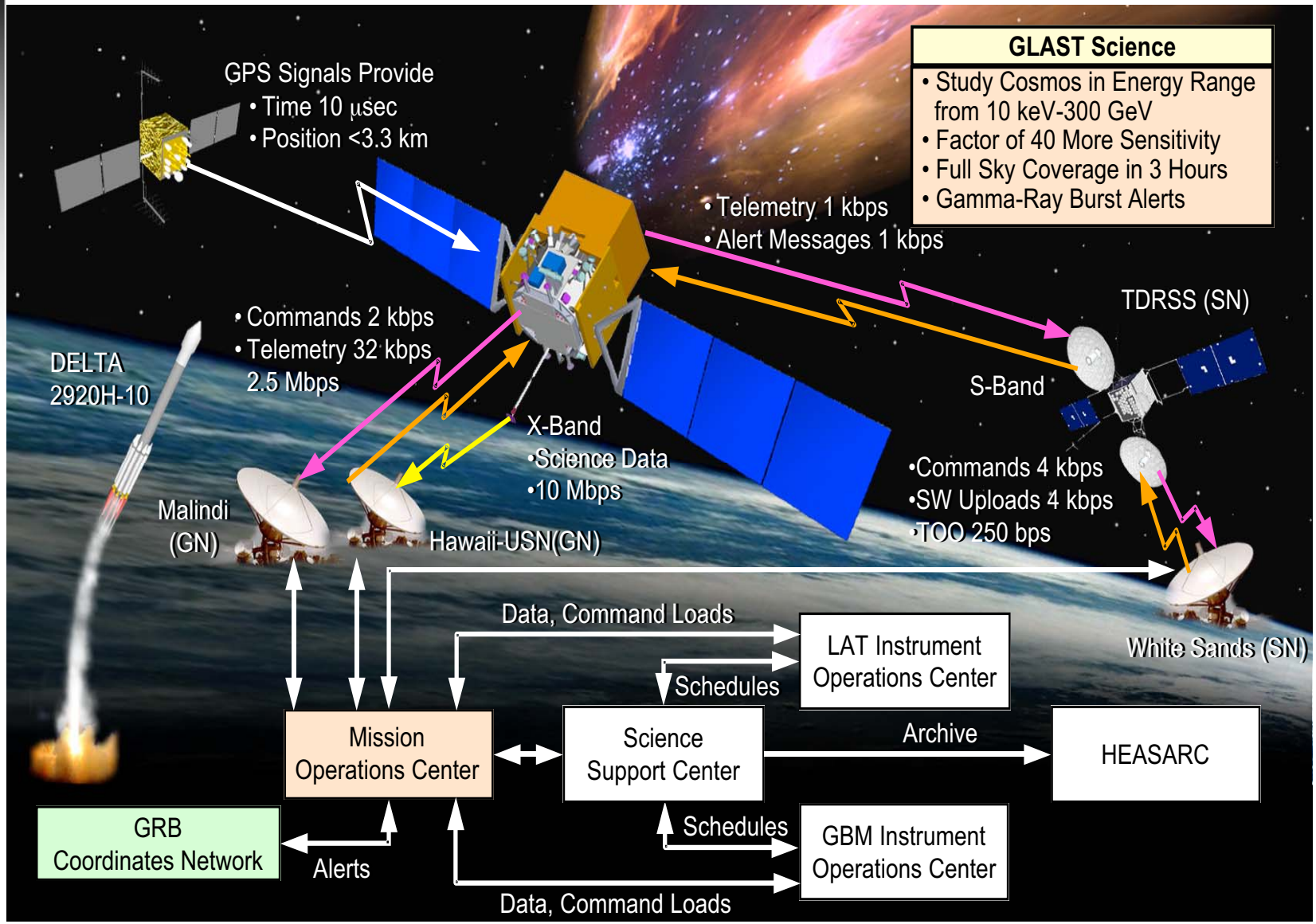
Germany


USA


Japan



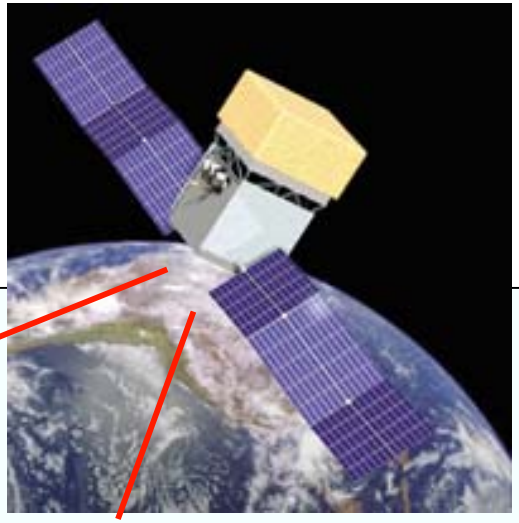
# Mission Overview



# Gamma-Ray Large Area Space Telescope

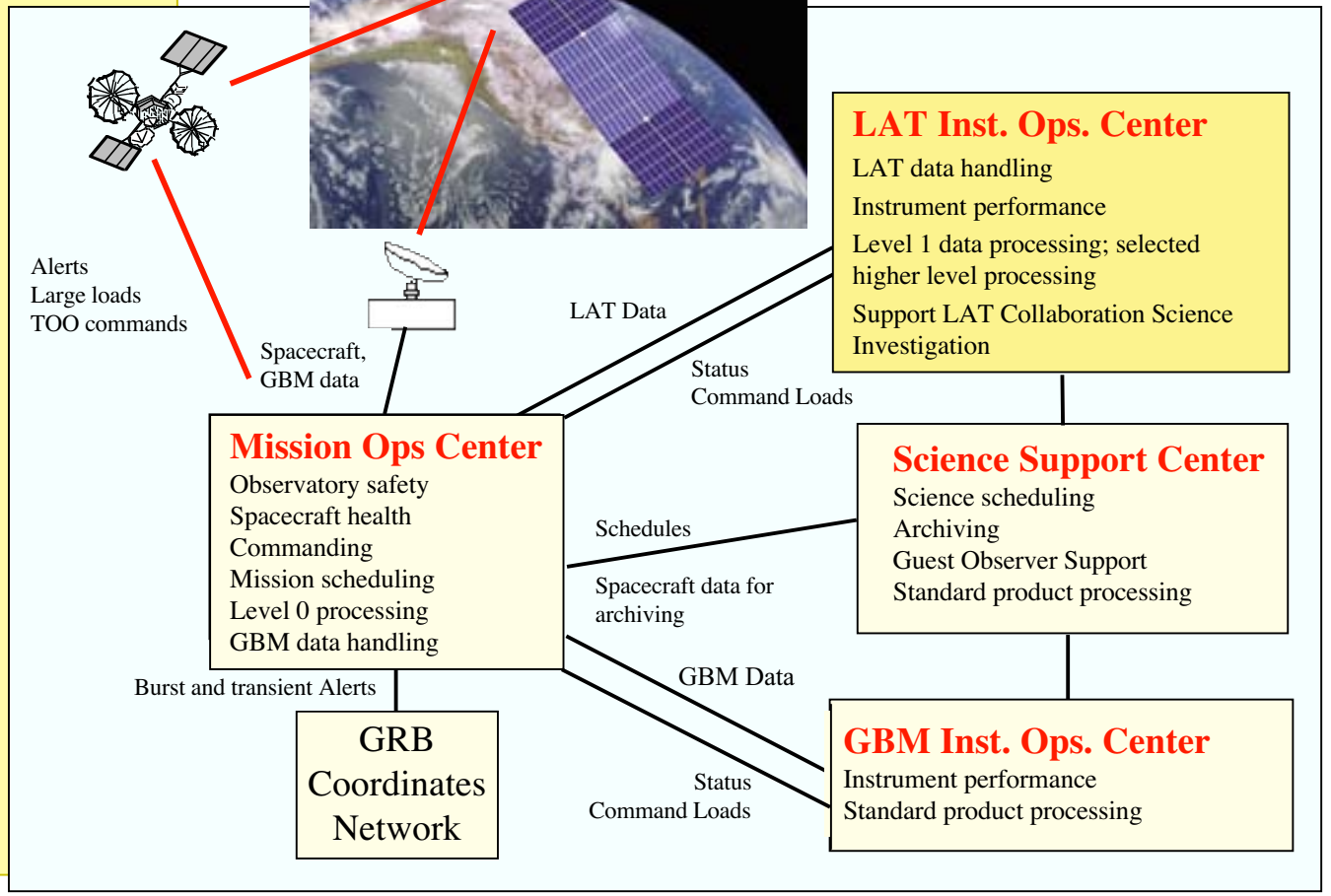
## GLAST Mission

- high-energy gamma-ray observatory; 2 instruments
  - Large Area Telescope (LAT)
  - Gamma-ray Burst Monitor (GBM)
- launch (Sept 2006): Delta 2 class
- orbit: 550 km, 28.5° inclination
- mission operations
- science
  - LAT Collaboration
  - GBM Collaboration
  - Guest Observers
- lifetime: 5 years (minimum)



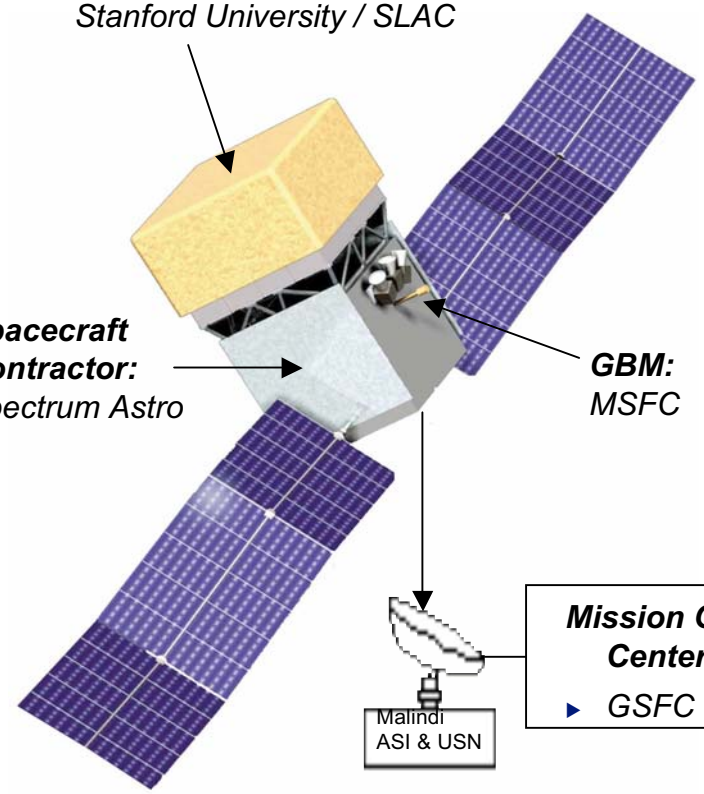
## GLAST Observatory

- spacecraft
- LAT
- GBM



# Mission Elements & Organizations

***LAT:***
*Stanford University / SLAC*



***Spacecraft Contractor:***
*Spectrum Astro*

***GBM:***
*MSFC*

Malindi
ASI & USN

***Mission Ops Center:***
- *GSFC*

***LAT Instrument Ops Center:***
- *Stanford University / SLAC*

***GBM Instrument Ops Center:***
- *MSFC*

***Science Support Center:***
- *GSFC 660*

***HEASARC***

***Launch Vehicle:***
- *KSC*


# NASA/DOE Partnership for the LAT

- ***DOE and NASA are partners in the development of the LAT instrument***
- ***Implementing Arrangement has been signed by DOE and NASA Headquarters***
- ***Coordinated reviews agreed to for the LAT by NASA and DOE***
  - *Major reviews of the LAT to be jointly chaired by DOE Construction Management Division and GSFC Systems Review Offices*
  - *DOE participates in GLAST mission reviews—as observers or members of Review Team as requested*


# Principal Institutions

- ***GLAST Instruments***
  - *Large Area Telescope (LAT), PI: P. Michelson, Stanford Univ (SU)*
    - *Management and Systems Engineering: SU-SLAC*
    - *Instrument Integration: SU-SLAC*
    - *Instrument Mechanical and Thermal: SU-SLAC*
    - *Tracker: UCSC*, SU-SLAC, Italy, Japan*
    - *Calorimeter: NRL*, SU-SLAC, France, Sweden*
    - *Anticoincidence: GSFC**
    - *Data Acquisition System: SU-SLAC*, SU, NRL*
    - *Instrument Operations Center: SU**

  **Denotes Subsystem Lead*

  - *GLAST Burst Monitor (GBM), PI: C. Meegan, MSFC*
    - *Management, Data Processing, Integration: MSFC, UAH*
    - *Detectors: Germany*
- ***Mission***
  - *Mission Management: GSFC*
  - *Ground Station: Italy (USN back-up approach)*

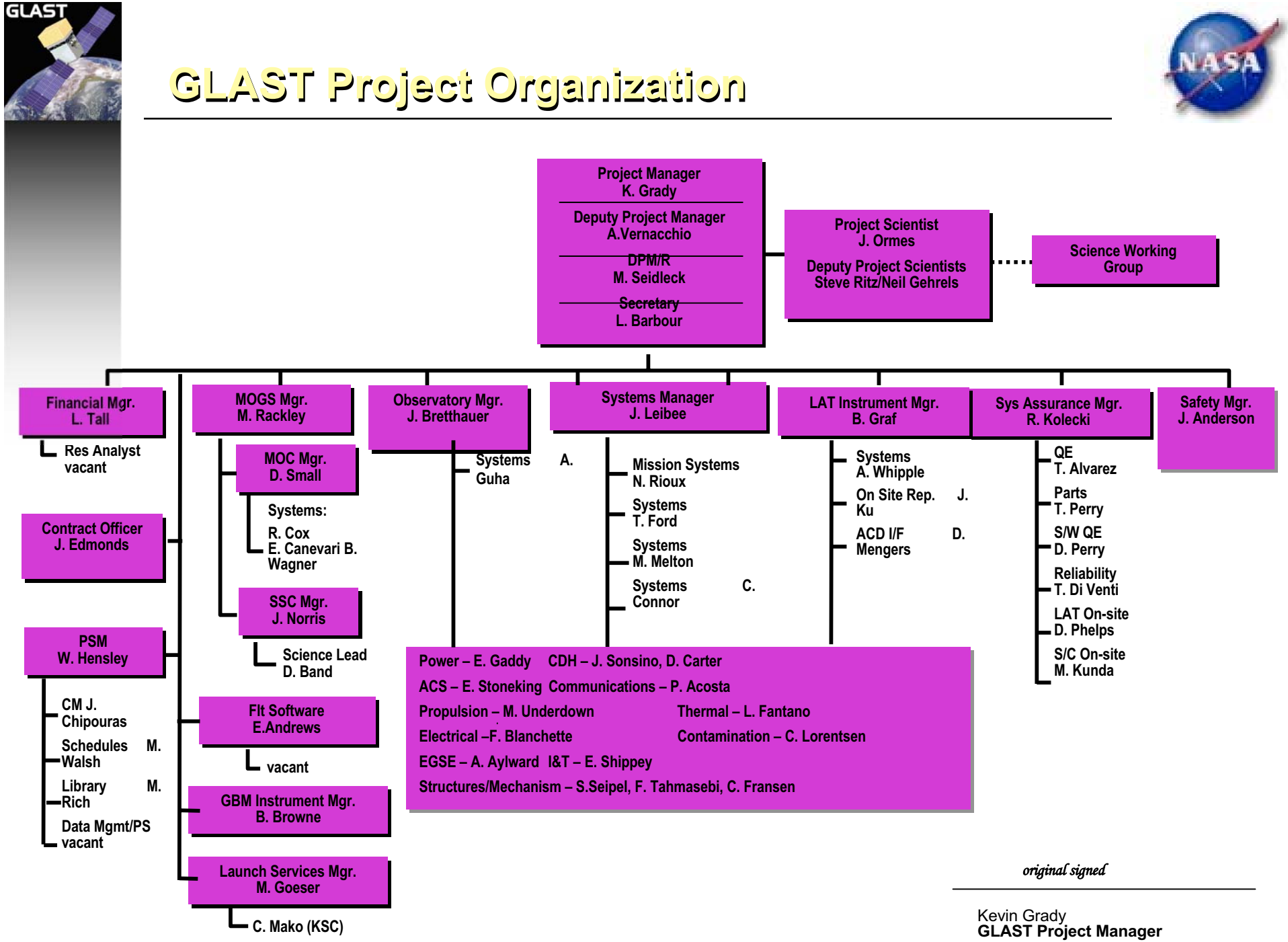

# Contracts

- ***DOE - Stanford University: M&O contract for SLAC***
  - *Work at SLAC on LAT authorized by Project Number KA050102-EQU01CC*
- ***NASA - Stanford University: Contract NAS5-00147***
  - *Authorizes NASA funding for work at SU on LAT Project*
- ***SU - Sonoma State University: Subcontract for E/PO***
- ***NASA - NRL: Defense Purchase Request***
- ***NASA – Spectrum Astro: Contract NAS5-00110 (fixed price)***


# GLAST Burst Monitor (GBM)

- ***Selected through NASA AO***
- ***MSFC developed Project Plan approved by GLAST Project Office***
- ***German collaboration defined in NASA-DLR LOA***

# GLAST Project Organization




*original signed*

Kevin Grady
**GLAST Project Manager**
April 25, 2003


# Schedule

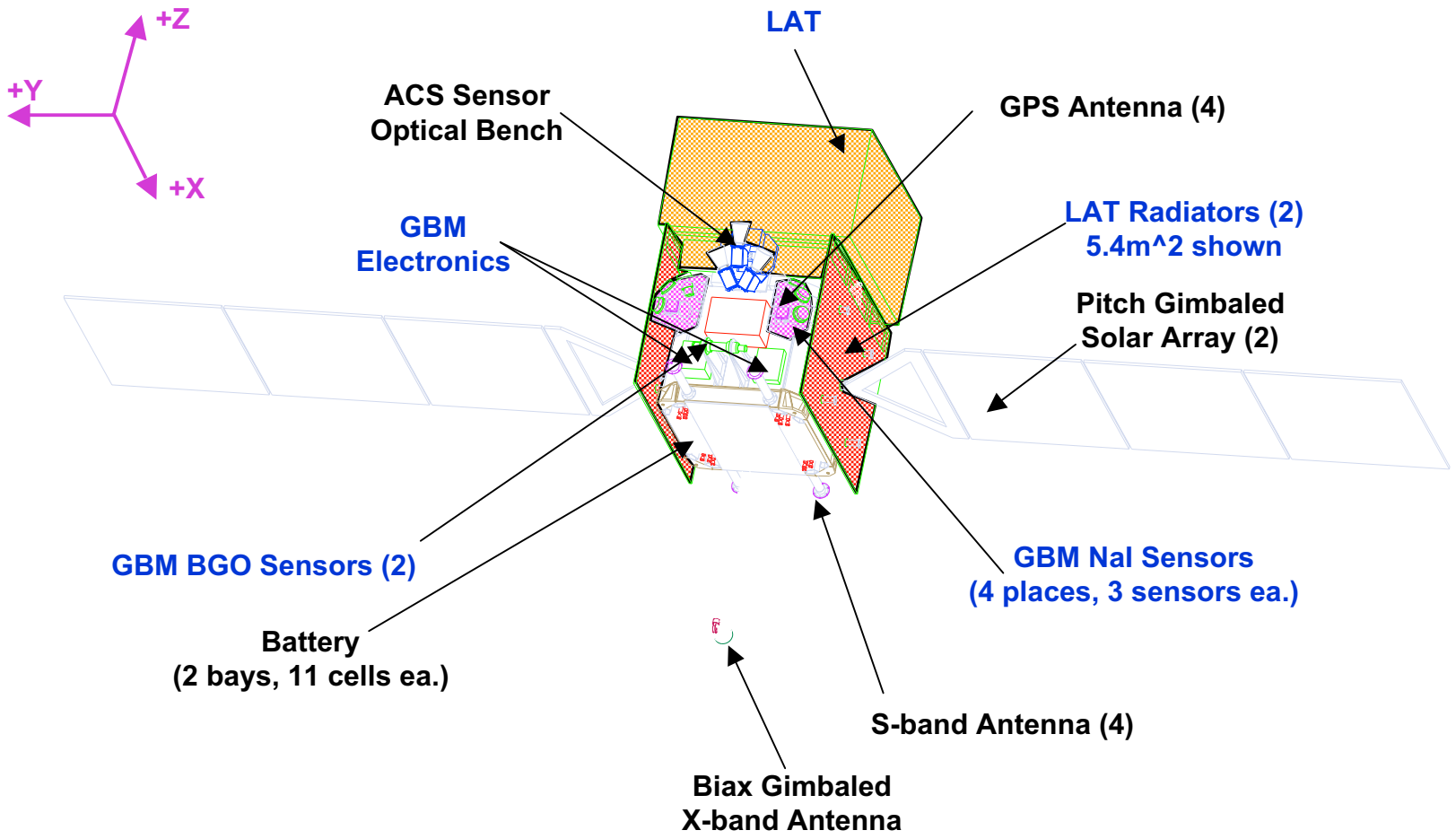

# Links


- ***http://glast.gsfc.nasa.gov/project/***
- ***http://www-glast.slac.stanford.edu/***
- ***http://www.spectrumastro.com/SAIHome11.htm***



# Systems Engineering

# OBSERVATORY LAYOUT

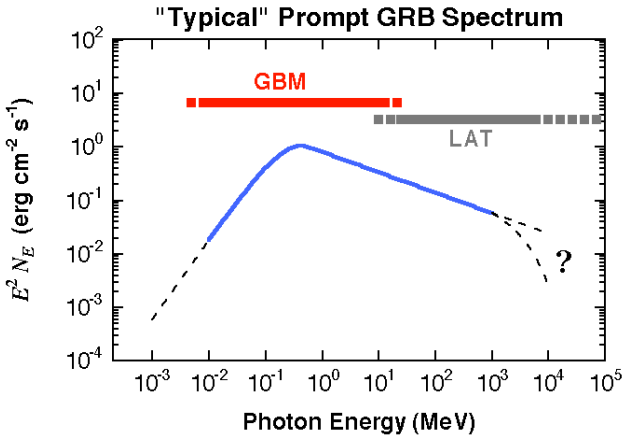


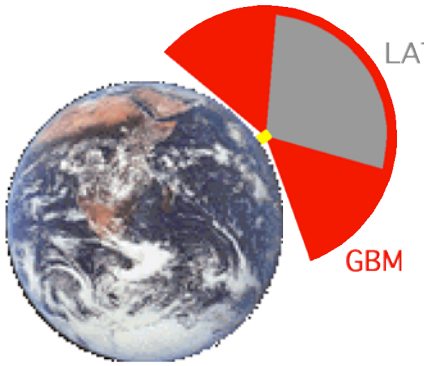

# Ops Concept - Science


- ***Science Data Collected Continuously***
  - *During Sky Survey, Pointed Observations and All Slews*
  - *Science Data and Instrument Housekeeping Store-and-Forward Operation*
- ***Gamma Ray Burst Transients***
  - *Both Instruments Detect Bursts (GBM Signals LAT with Trigger and Data)*
  - *Real-time Notification of Ground Based Gamma Ray Coordinates Network (GCN)*

# Ops Concept

- ***Key features:***
  - *First year all-sky survey scanning operations*
  - *Pointed observations to any celestial target after first year*
  - *Gamma Ray Burst alert messages with low latency to ground*
  - *Accommodate uploadable Targets of Opportunity (TOOs)*
  - *Autonomous repointing to Gamma Ray Bursts*




**20 MeV – 300 GeV ±30° FOV**

**NaI Detector 5 KeV – 1 MeV**
**BGO Detector 150 KeV – 30 MeV**
**±120° FOV**


# Highlights of Key Requirements

- ***Point anywhere, anytime with constraints***
  - *Earth Avoidance*
  - *Keep sun off LAT radiators*
- ***Pointing knowledge error of less than 10 arc seconds***
- ***Accommodate LAT mass of 3000kg***
  - *Structural Loads*
  - *CG*
- ***Slew 75 degrees in less than 10 minutes***
- ***Autonomous acquisition of gamma ray bursts***
  - *Re-pointing of LAT*
  - *7 second notification to Gamma Ray Coordinates Network for 80% of detected bursts*
- ***Accommodate LAT orbit average data rate of 300kbps***
- ***Interface with ASI Malindi, Kenya and USN Hawaii commercial ground terminals***


# GLAST Systems Engineering Processes

- ***Integration of Ops Concept, Mission Architecture, Mission Design***
- ***Requirements Validation***
- ***Requirements Flowdown & Traceability***
- ***Configuration Management***
- ***Interface development and control - ICDs***
- ***Trade Studies***
- ***Technical Resource Budgets***
- ***FTA, FMEA, PRA***
- ***Mission Verification***
- ***Peer Reviews***
- ***Integration of Safety and Mission Assurance***
- ***Risk Management***


# Project SEMP


- ***GLAST Project Systems Engineering Management Plan developed in accordance with GPG 7120.5***
  - *System Engineering Life Cycle, Gates, and Reviews*
  - *Communication*
  - *Key Systems Engineering Functions*
  - *System engineering Reviews*
  - *Configuration Management*
  - *System Engineering Management*
- ***SEMP is complete and in signature cycle***


# Requirements Analysis and Traceability

- ***Mission Requirements controlled under Configuration Management***
- ***Requirements engineering management, analysis and traceability implemented in Dynamic Object Oriented Requirements System (DOORS)***
- ***Spacecraft and LAT also perform requirements systems engineering in DOORS***
  - *Allows traceability linkages between Project, SAI and SLAC DOORS databases*
- ***GBM requirements managed in a separate MSFC database***
  - *Traceability analysis to GBM requirements documented electronically*


# Configuration Management

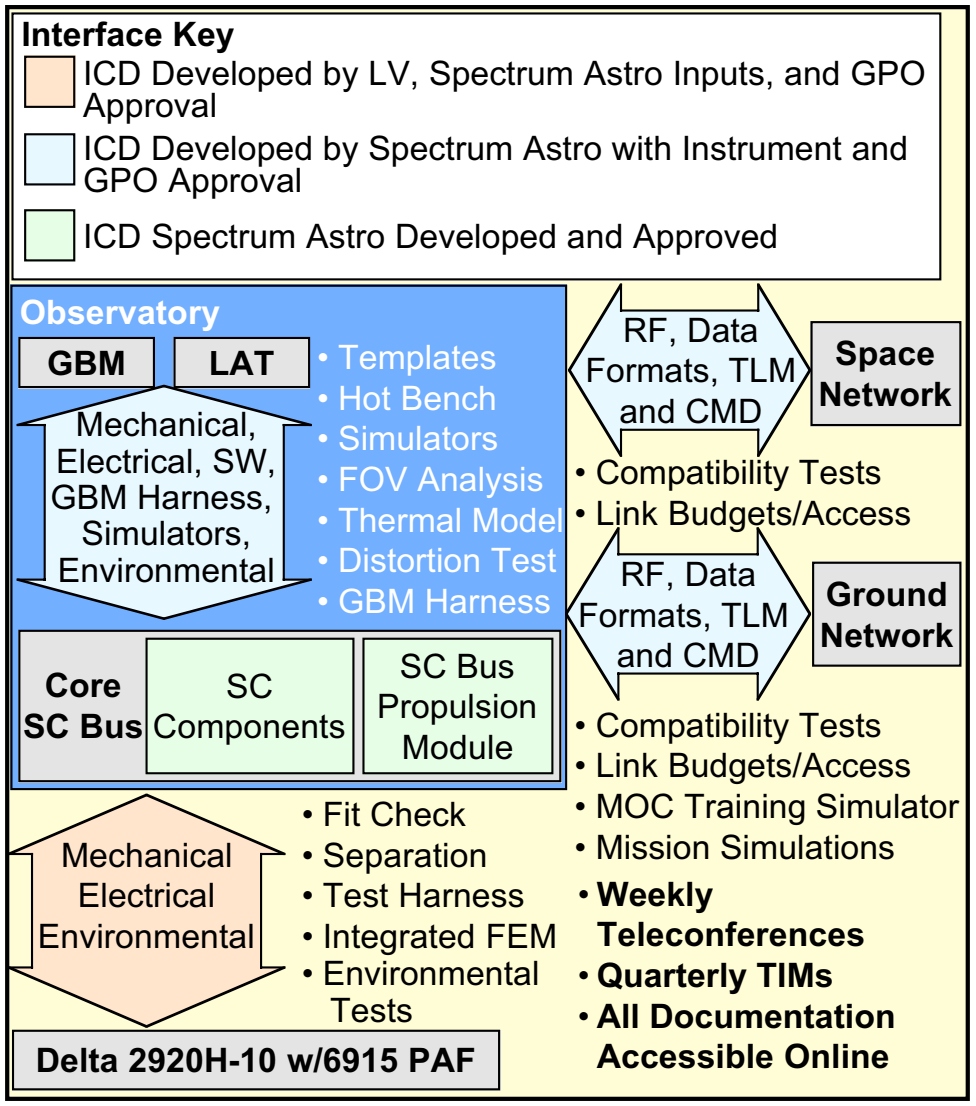

- ***Process Control across mission elements***
  - *SLAC, Spectrum Astro, MSFC, KSC, Ground Segment*
- ***Establishment of  Document Baseline***
- ***Change control***
  - *CCB Process*
- ***Distribution and access to latest document versions***


# Communications Across Elements

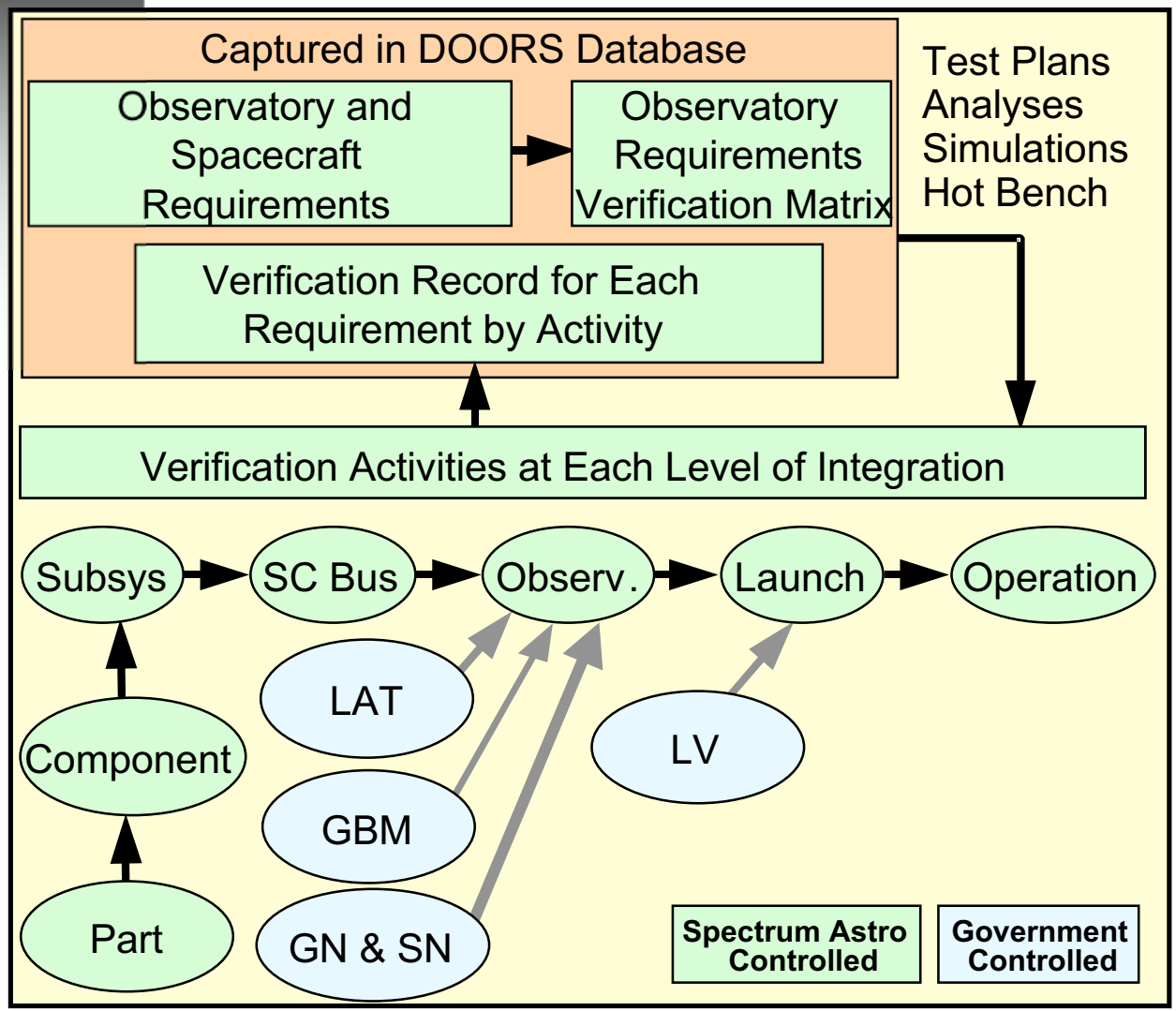
- ***Systems Engineering across mission elements is implemented through working groups***
  - *Organizational members: GSFC, SAI, SLAC, MSFC, KSC*
- ***Integrated Systems Engineering Team (ISET)***
  - *Provides top level integration and coordination of mission architecture, operations concept, requirements, design and trades*
- ***Engineering discipline working groups***
  - *Integrate across mission elements with respect to particular disciplines*
  - *Working Groups:*
    - *Mechanical*
    - *Thermal*
    - *Electrical*
    - *Data*
    - *Operations*
    - *Pointing*
    - *I&T*
    - *Systems Assurance*

# Identification and Management of Interfaces - Space Segment

- ***IRDs***
  - *Define interface requirements between instruments and spacecraft*
- ***ICDs***
  - *Document interface implementation between mission elements*
    - *LAT-SC*
    - *GBM-SC*
    - *LAT-GBM*
    - *OBS-LV*
    - *Space-Ground*



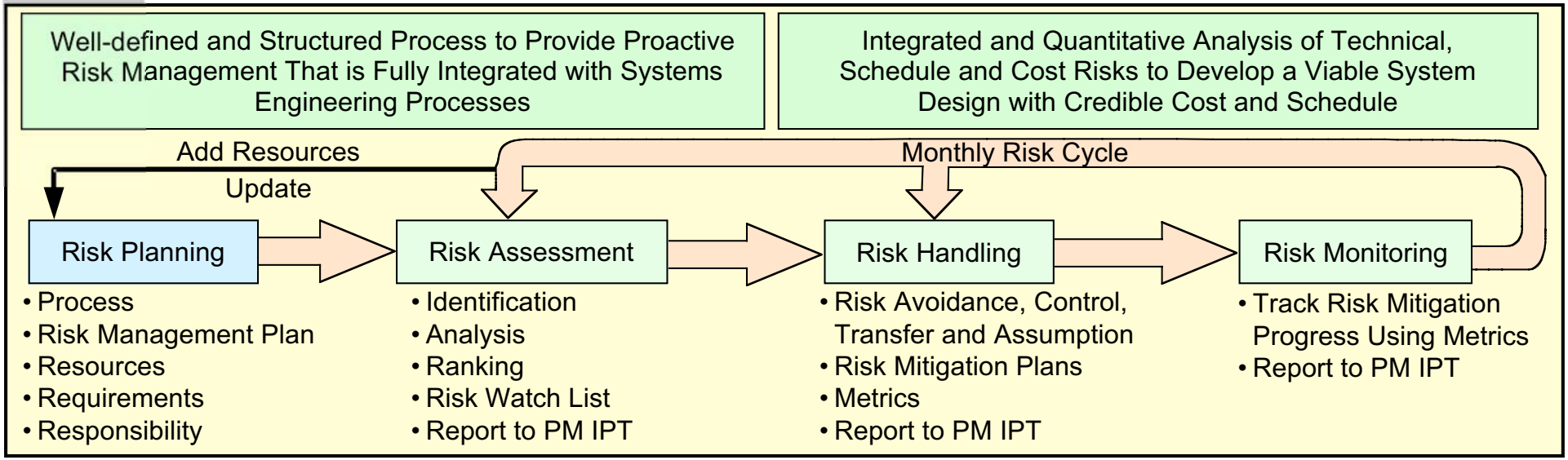
# Verification Approach




- ***The Observatory Performance Verification Plan (OPVP) Identifies Where, How, and When Each Observatory Performance Requirement is Verified***
  - *OPVP Also Contains Description of Component and Subsystem Tests and Analyses*
- ***Verification Includes Interfaces to the MOC and Compatibility Testing With Elements of the Space and Ground Networks***
  - *All Performance, Functional, and Interface Requirements are Verified*
- ***The DOORS Database is Used to Maintain Verification Data***
  - *This Data Includes: Analysis Memo IDs, Test Procedure #'s, and Inspection Report IDs*


# Risk Management Process

- ***Risk Management is a Four Step Iterative Process***
  - *Planning, Assessment, Handling, and Monitoring*

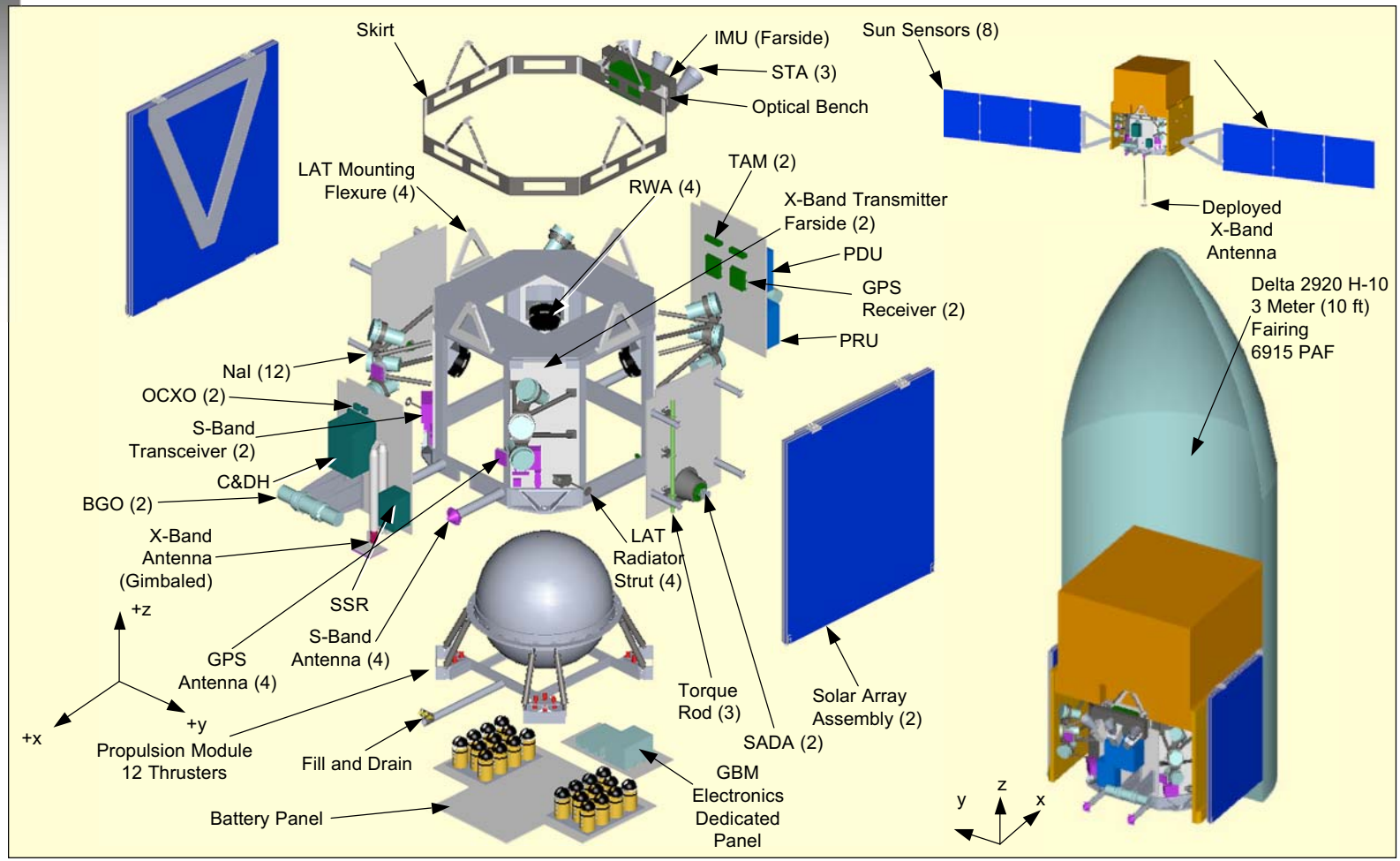



- **Risk management is an integrated process across the organizations**

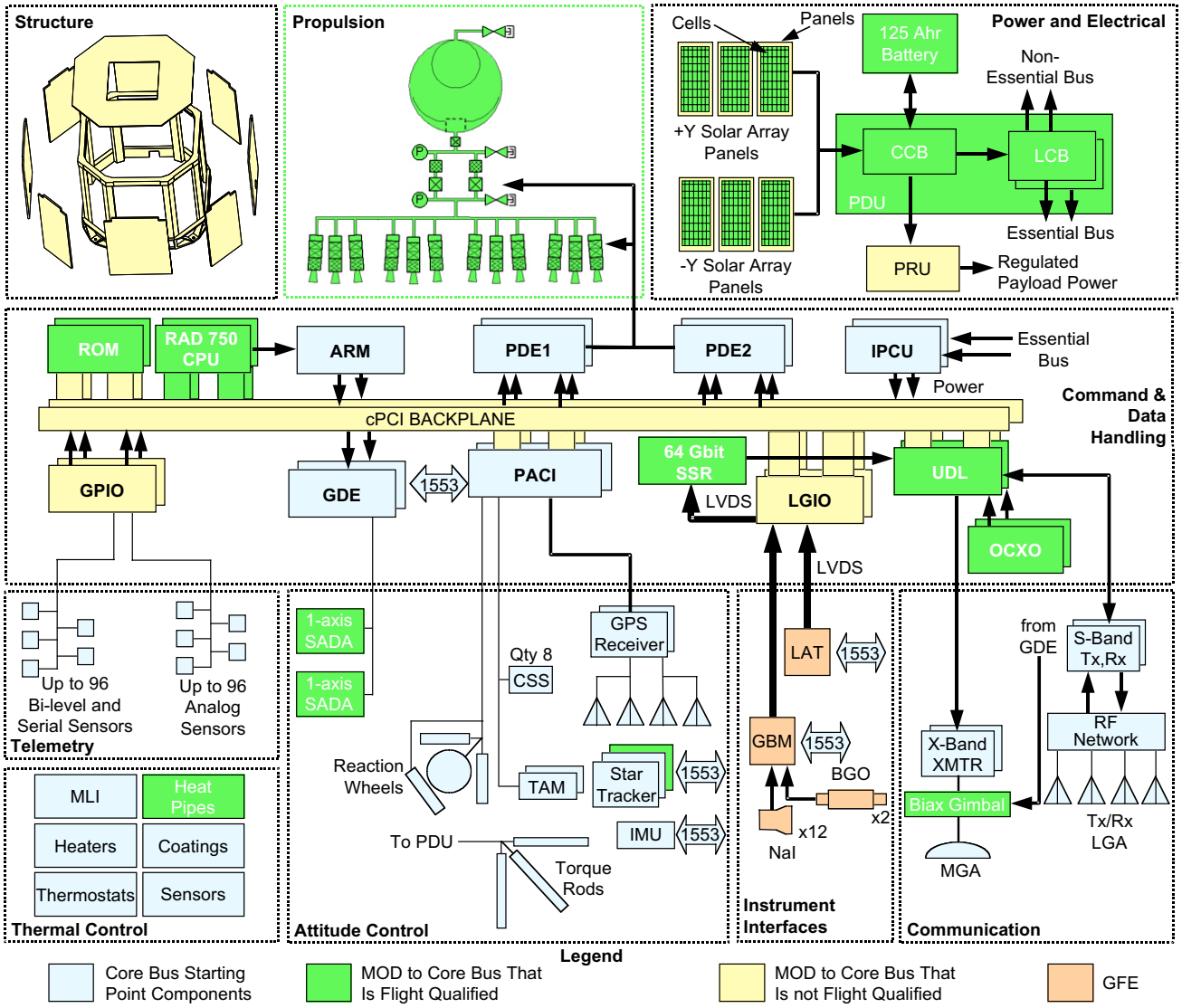


# Spacecraft

# Spacecraft Description



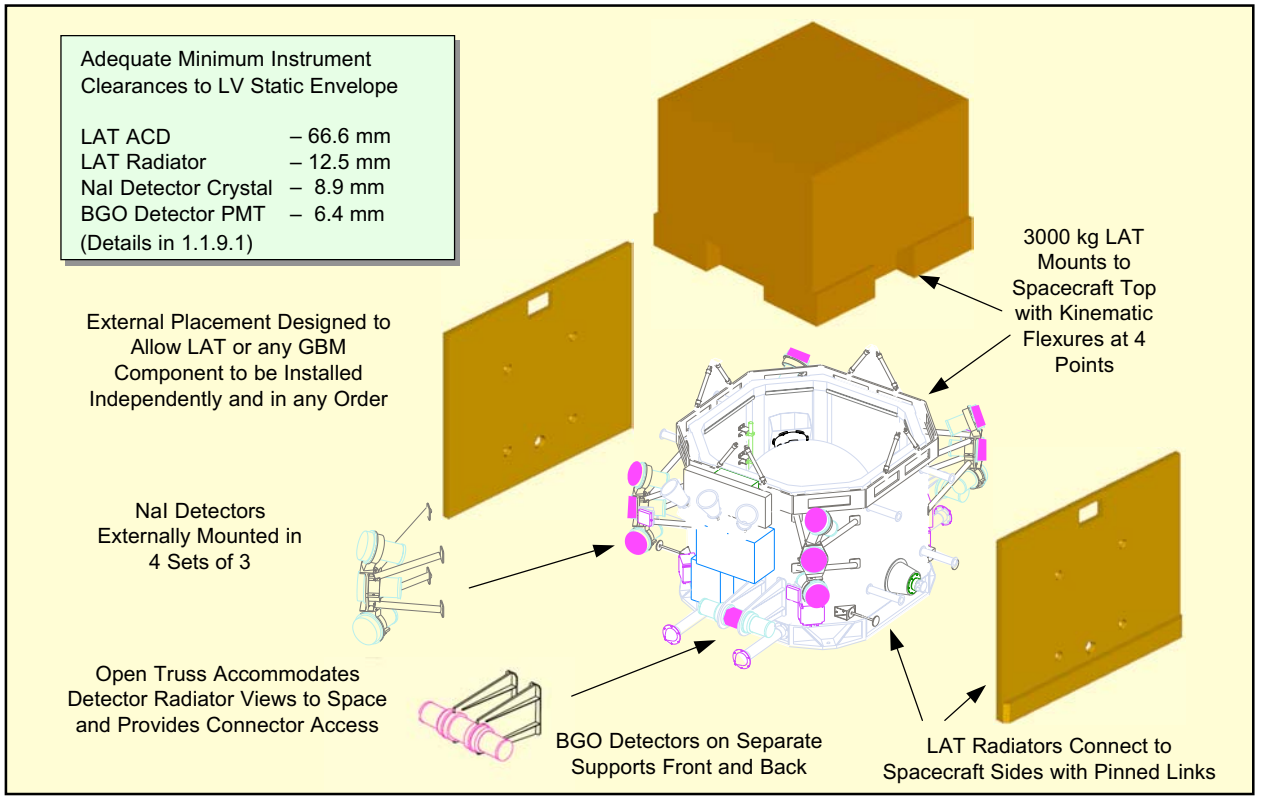
# Spacecraft Block Diagram



# Instrument Accommodation Overview

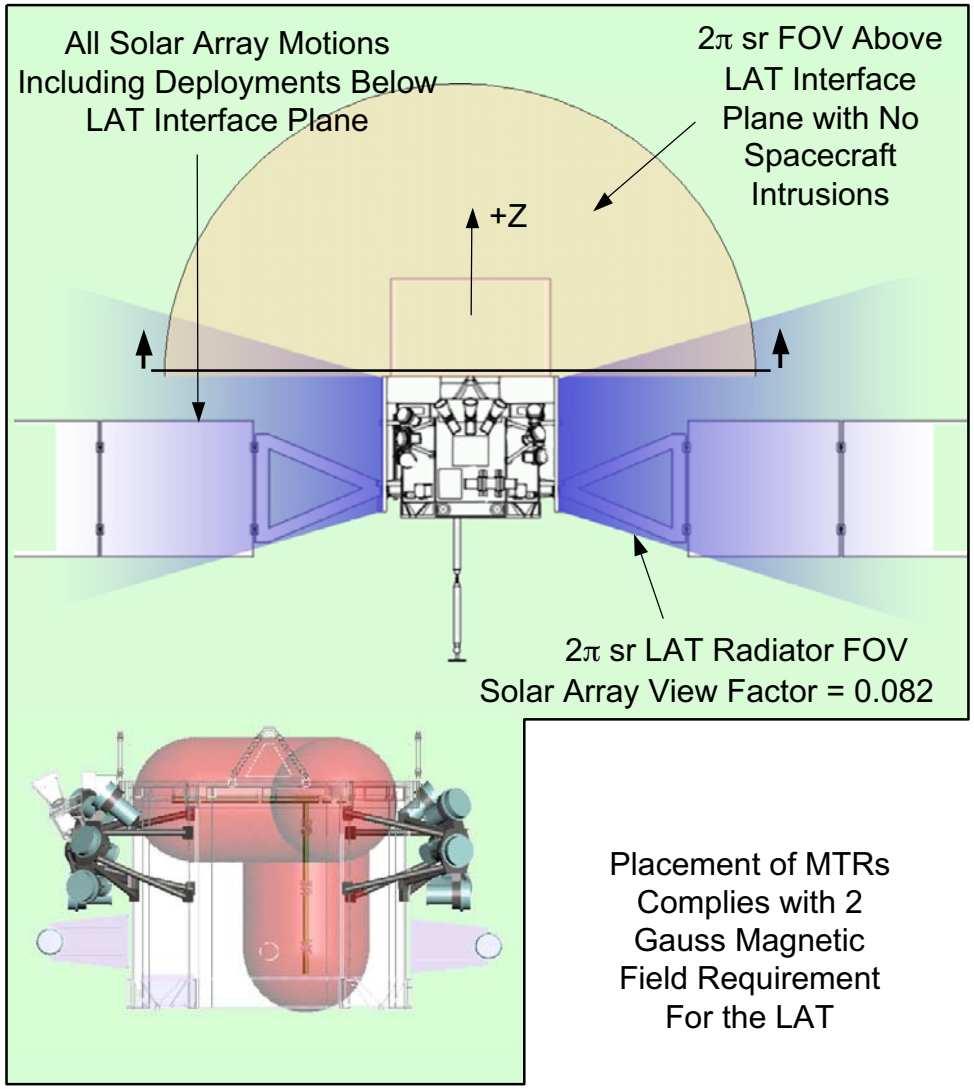
- ***All Independent Instrument Accommodation for Parallel Processing***
- ***GBM Detector Arrangement to Achieve Goal (4 Overlapping FOV, 100%)***

- **GBM Power Box and Data Processing Unit on Dedicated Panel**
- **Robust Mass and Power Margins**
- **Optical Bench Solution to Support Tight Pointing Requirements**



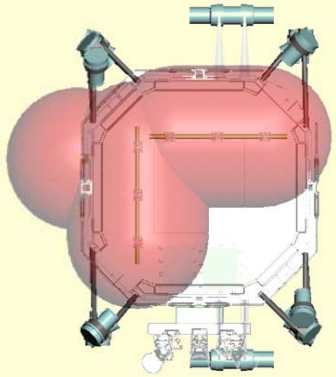
# LAT Accommodations

- ***Simple 4-point Flexure Mount With Thermal Isolation***
- ***Low Mounted Solar Arrays to Maximize Radiator Efficiency and Maximize FOV***
- ***Optical Bench Arrangement Places GNC Components Below LIP***
- ***Radiator Placement Allows up to 7% Growth With No Impact to the Bus***



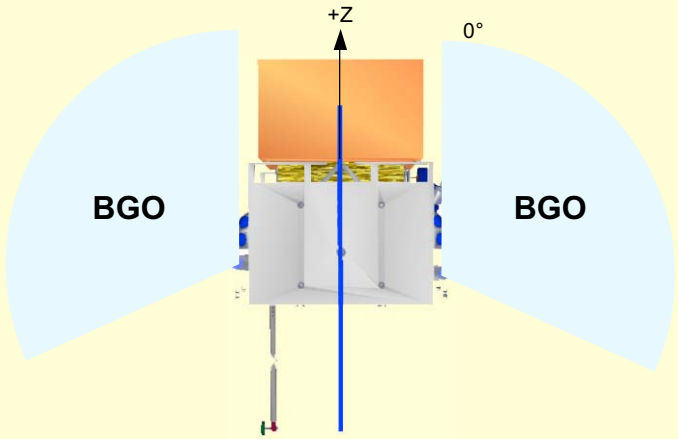

Placement of MTRs Complies with 2 Gauss Magnetic Field Requirement For the LAT

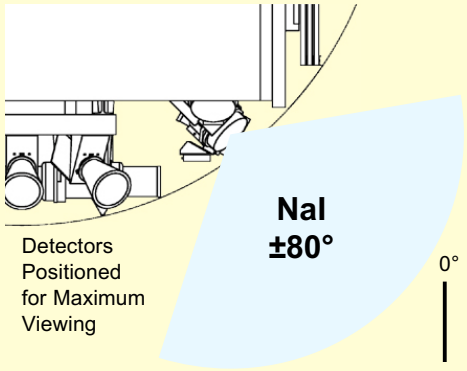
# GBM Accommodations



1 Gauss Magnetic Field Requirement for GBM Met

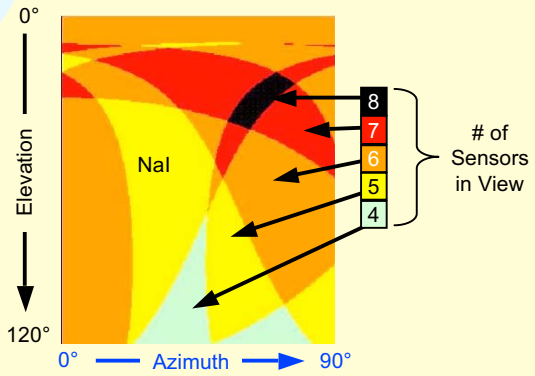
Due to Overlap,
BGO Detectors >100% FOV Even with Minimal ST Shade Intrusion



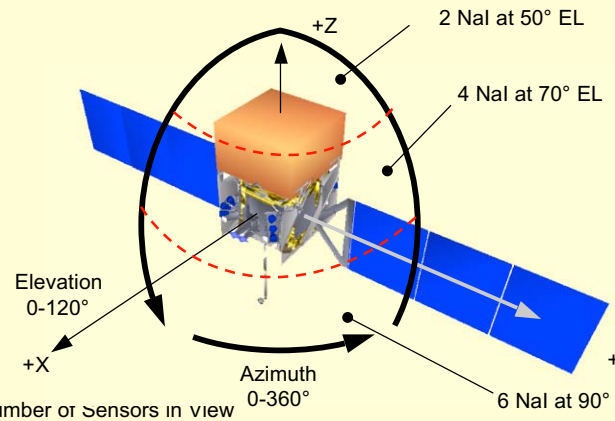




Detectors Positioned for Maximum Viewing

Flat Pattern Illustration of One Quadrant of Coverage



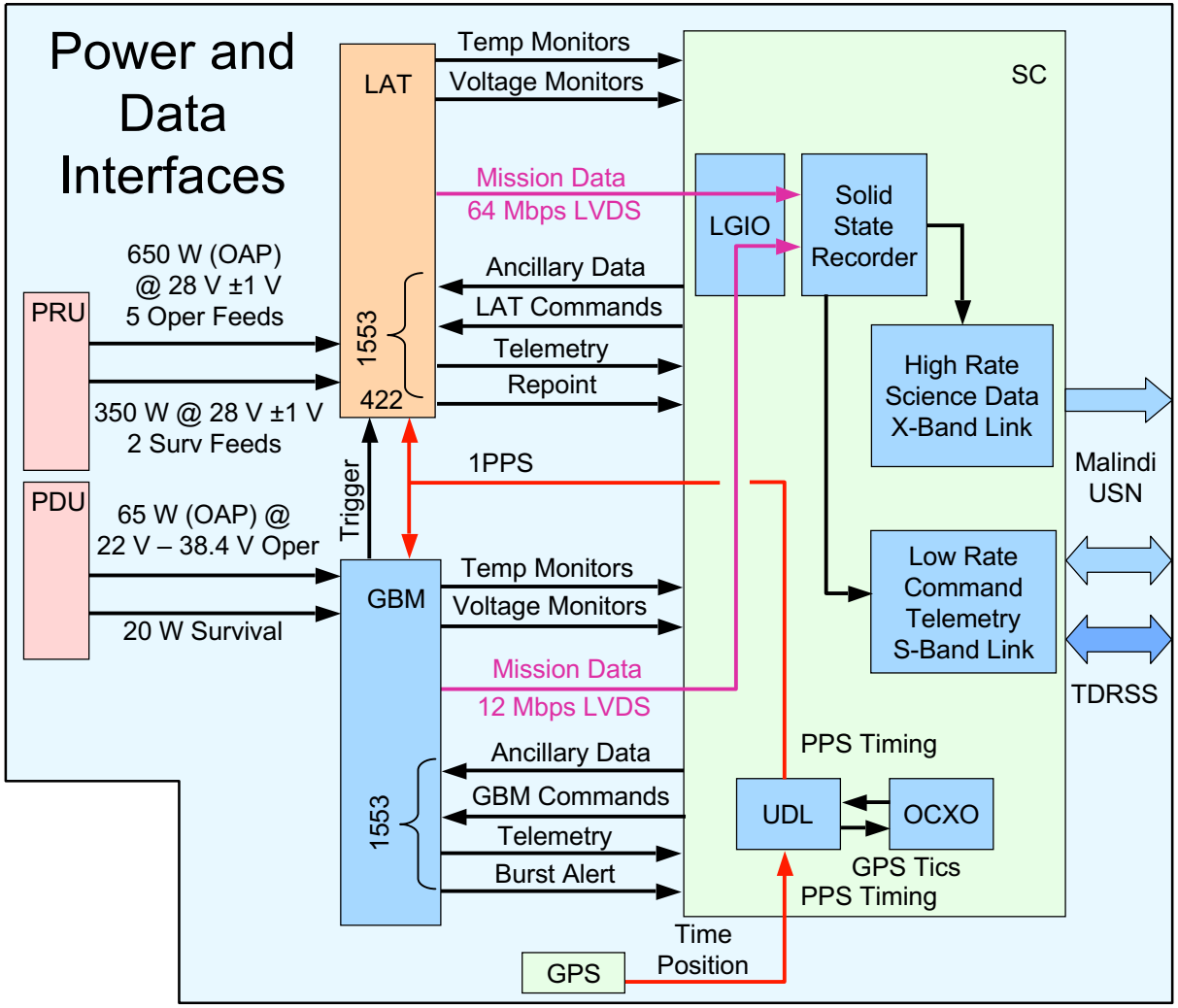

| NaI Boresight Angles | | |
|---|---|---|
| | El | Az |
| 1 | 50° | 0° |
| 2 | 50° | 180° |
| 3 | 70° | 45° |
| 4 | 70° | 135° |
| 5 | 70° | 225° |
| 6 | 70° | 315° |
| 7 | 90° | 0° |
| 8 | 90° | 60° |
| 9 | 90° | 120° |
| 10 | 90° | 180° |
| 11 | 90° | 240° |
| 12 | 90° | 300° |




NaIs Placed to Maximize the Number of Sensors in View

# Power and Data Interfaces

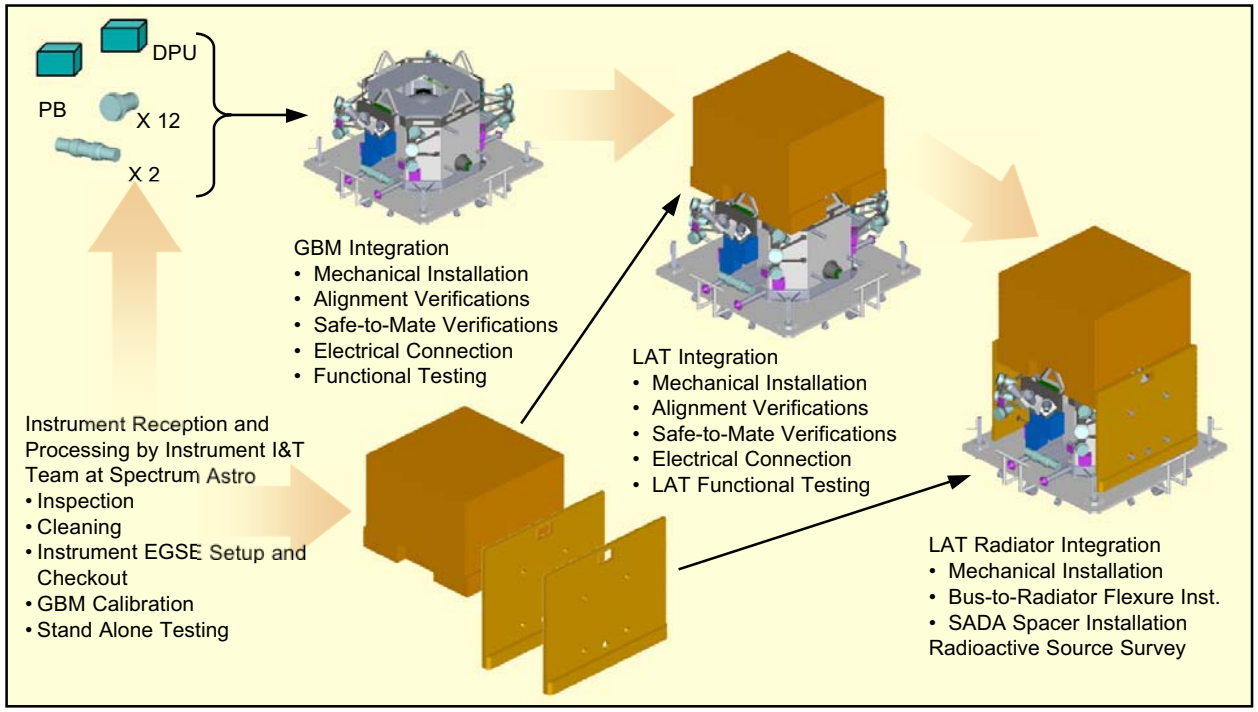
- ***Interlocked Primary and Redundant Power Feeds to Each Instrument***
- ***Survival Feeds Enabled Except During Load Shed***
- ***1553 Data Bus for Commands, Telemetry, Data and Burst Alert Messages***
- ***Science Data Collection Using Dedicated Interface Board***
- ***OCXO Timing Pulse Backup to GPS***



# I&T and Flight Ops Accommodations

- ***Dedicated floor space allocated to each instrument for post-shipment activities and equipment storage***
- ***integration activities can accommodate instrument delivery and test schedules***
- ***Alignments performed at several stages***

- **Minimum of 350 hours of access for compatibility and end-to-end tests**
- **GN2 supplied as needed with purge cart**





# Large Area Telescope (LAT)


# 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 Nucleaire et de l'Instrumentation Associee*
- *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*

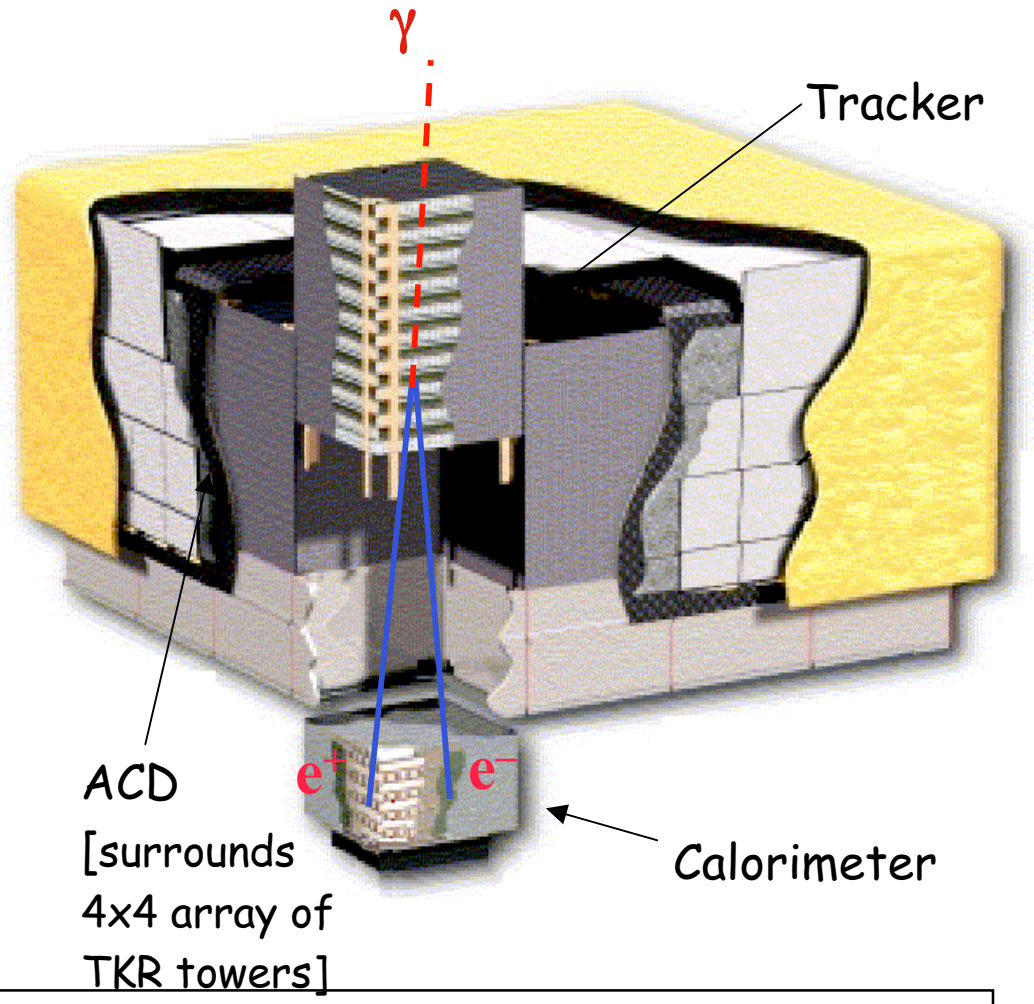
**PI: Peter Michelson** (Stanford & SLAC)

124 Members (including 60 Affiliated Scientists, plus 16 Postdoctoral Students, and 26 Graduate Students)

**LAT Project is a partnership between NASA and DOE, with international contributions from France, Italy, Japan and Sweden. Managed at Stanford Linear Accelerator Center (SLAC).**

# Overview of LAT

- *Precision Si-strip Tracker (TKR) 18 XY tracking planes. Single-sided silicon strip detectors (228 mm 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.**

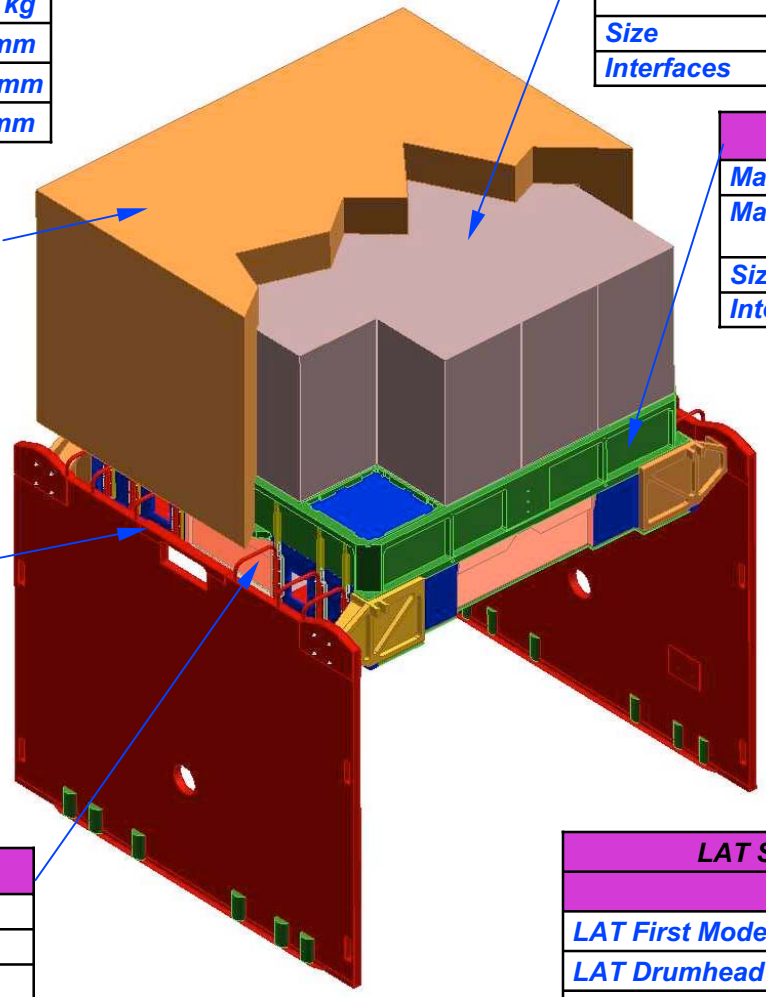
# LAT Structural Design Overview

| LAT Structural Design Parameters | | |
|---|---|---|
| | Design | Spec |
| Mass | 2699 kg | <3000 kg |
| Center of Gravity | 154.5 mm | <185 mm |
| Width | 1796 mm | <1800 mm |
| Height | 1047 mm | 1100 mm |

| Tracker (TKR) | |
|---|---|
| Mass | 504.9 kg (May 2002 est) |
| Materials | GrEp, CC structures, Silicon, Tungsten |
| Size | 372 mm sq x 640 h |
| Interfaces | Grid Ti flexure mount |

| Anticoincidence Detector (ACD) | |
|---|---|
| Mass | 228.1 kg (May 2002 est) |
| Materials | CFC honeycomb, alum base frame, MLI/ Micrometeorite Shield |
| Size | 1796 mm w x 1015 mm h |
| Interfaces | Grid bolted joint, shear pins |

| Calorimeter (CAL) | |
|---|---|
| Mass | 1466.3 kg (May 2002 est) |
| Materials | CFC support shell, alum structure, CsI |
| Size | 364 mm sq x 224 mm h |
| Interfaces | Grid bolted friction joint |



LAT Overview

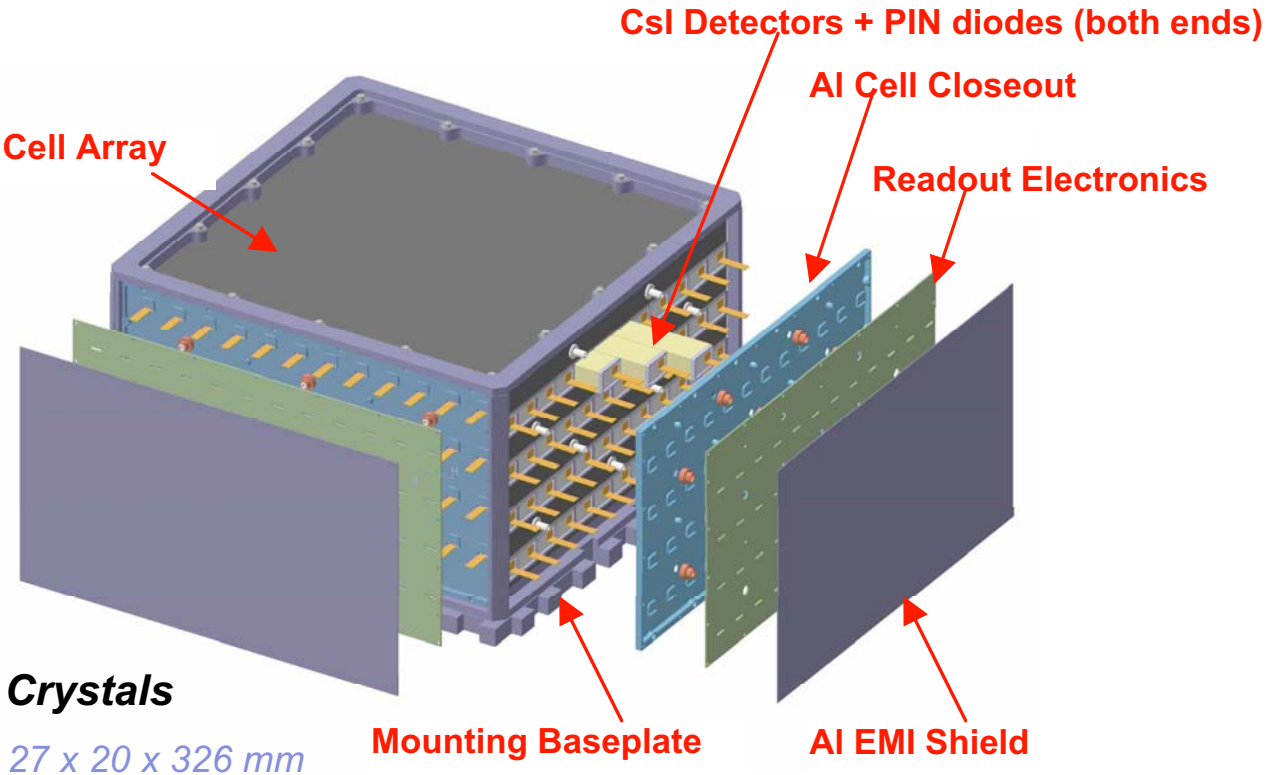
| Grid/X-LAT Plate/Radiators | |
|---|---|
| Mass | 295.3 kg (May 2002 est) |
| Materials | Aluminum, heat pipes, alum honeycomb plates |
| Size | 1566 mm sq x 236 mm h |
| Interfaces | Four-point mount to SC flexures |

| LAT Mass Budget and Current Estimates (kg) | | |
|---|---|---|
| | Estimate | Budget |
| TKR | 504.9 | 510.0 |
| CAL | 1466.3 | 1480.0 |
| ACD | 228.1 | 235.0 |
| Mech | 295.3 | 323.0 |
| Elec | 204.4 | 220.0 |
| LAT Total | 2699.0 | 3000 |
| Source: LAT-TD-00564-3 "LAT Mass Status Report Mass Estimates for May 2002" | | |

| Electronics | |
|---|---|
| Mass | 204.4 kg (May 2002 est) |
| Materials | Aluminum |
| Size | 1417 mm sq x 222 mm h |
| Interfaces | Flexure mount to CAL; bolted friction joint to X-LAT Plate |

| LAT Structural Performance | | |
|---|---|---|
| | Design | Spec |
| LAT First Mode Freq. | 55.5 Hz | >50 Hz |
| LAT Drumhead Freq. | 60.2 Hz | >50 Hz |
| Radiator First Mode Freq. | 65.1 Hz | >50 Hz |
| Deflection at Grid Center | 0.49 mm | --- |

# Calorimeter Module Overview




## Modular Design

**4 x 4 array of calorimeter modules**

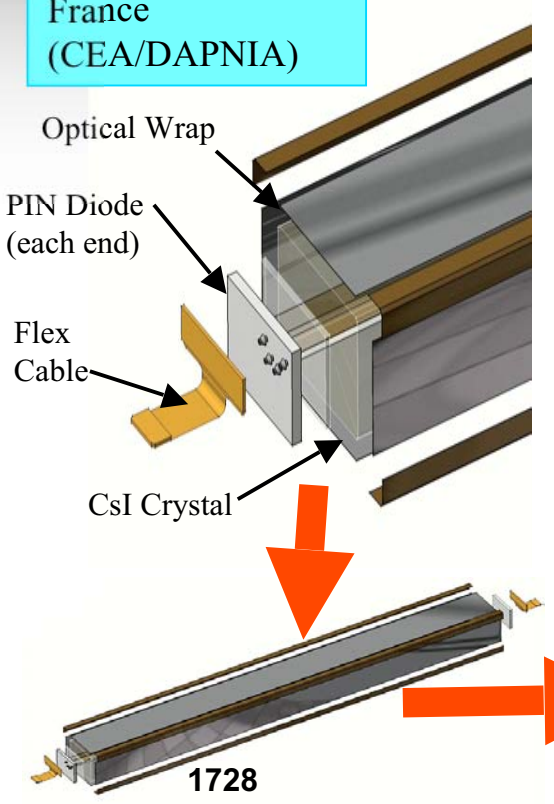
## *Each Module*

- ***8 layers of 12 CsI(Tl) Crystals***
  - *Crystal dimensions: 27 x 20 x 326 mm*
  - *Hodoscopic stacking - alternating orthogonal layers*
- ***Dual PIN photodiode on each end of crystals.***
- ***Mechanical packaging – Carbon Composite cell structure***
- ***Electronics boards attached to each side.***
- ***Electronic readout to connectors at base of calorimeter.***
- ***Outer wall is EMI shield and provides structural stiffness as well.***

# Calorimeter Production Overview

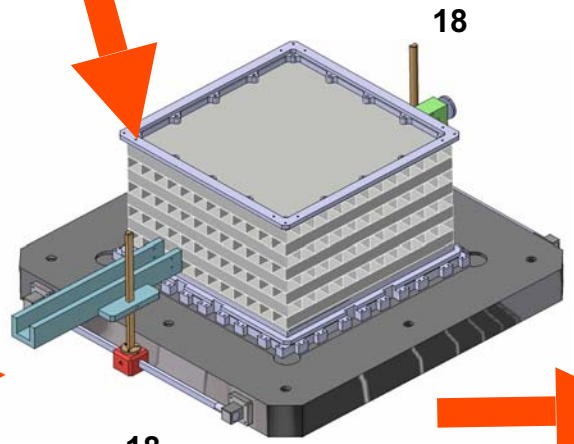
CsI Crystals
Sweden (KTH)

CDE Assembly
France
(CEA/DAPNIA)



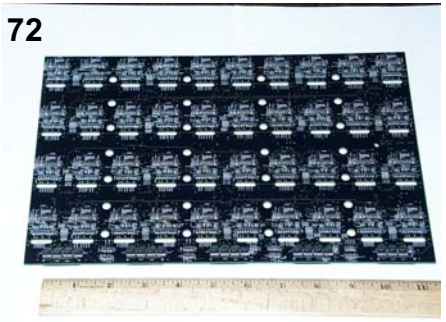

16 flight modules + 2 spares

Mechanical Structure
France (IN2P3/Ecole Polytechnique)



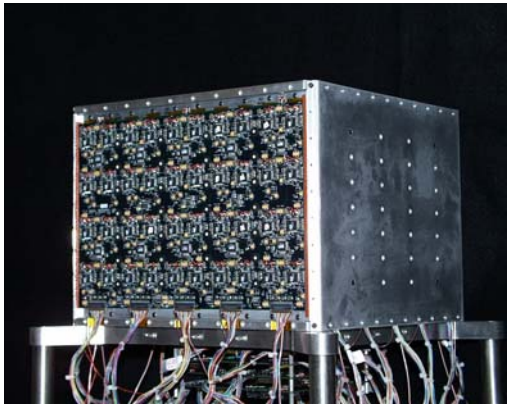

PEM Assembly
NRL

Front-End Electronics
NRL, SLAC

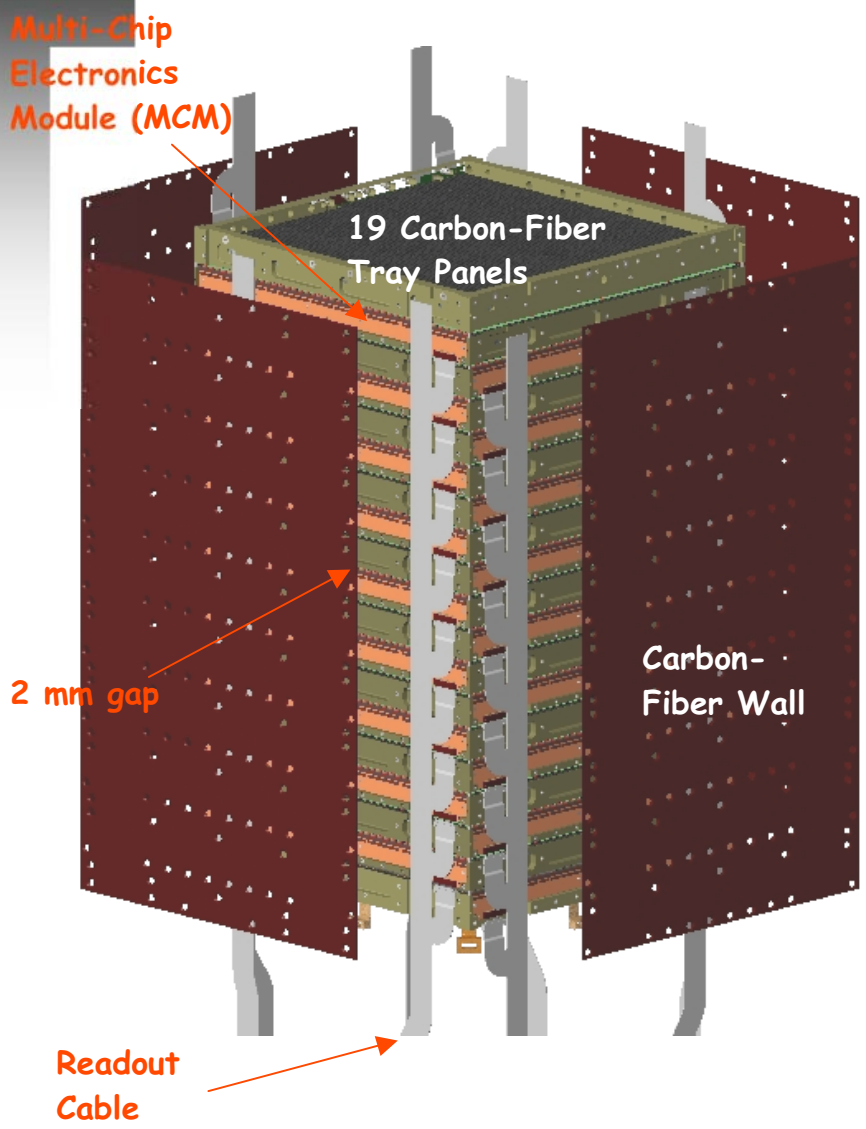



18

Module Assembly
and Test, NRL+collab



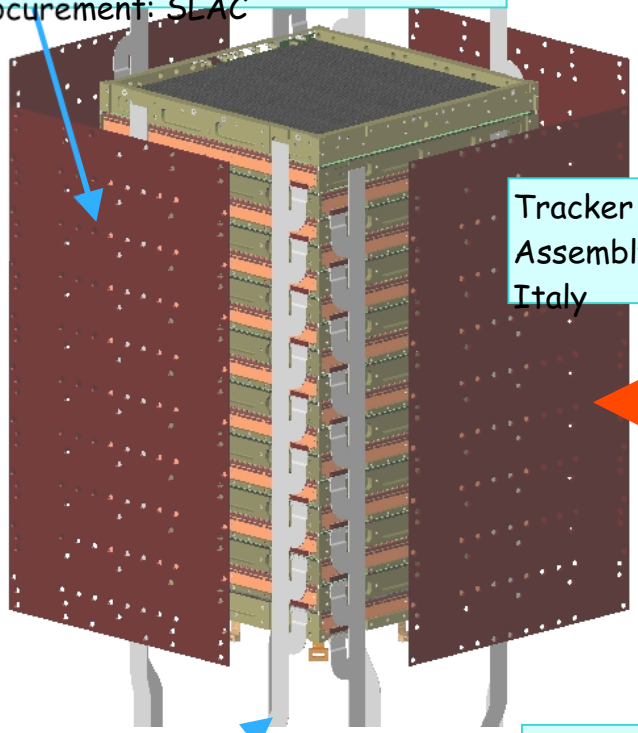
# Tracker Overview




- *16 layers of tungsten converter foils.*
  - *12 layers of 3% $X_0$ converters*
  - *Followed by four 18% layers*
- *x-y Si-strip detector pair closely following each converter foil.*
- *Two additional pairs at the bottom are needed for triggering.*
- *19 stiff composite "tray" panels support SSDs on both faces with electronics on two sides.*
  - *Converters are on the bottom face, just above the SSD plane*
  - *2-mm gap between trays*
- *Carbon-fiber sidewalls conduct heat to the base and stiffen the module.*
- *Electronics are based on 2 ASICs, PC boards, and custom flex cables.*
- *31.6 kg mass per module.*
- *10.5 W of power per module*

# Tracker Production Overview

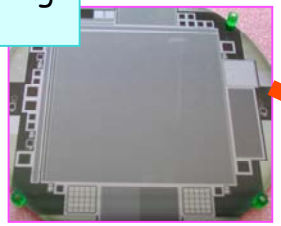
Module Structure (walls, flexures, thermal-gasket, fasteners)
Engineering: SLAC, Hytec
Procurement: SLAC



Tracker Module Assembly and Test
Italy

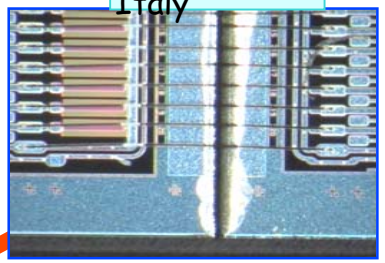
18

SSD Procurement, Testing
Japan, Italy, SLAC



10,368

SSD Ladder Assembly
Italy

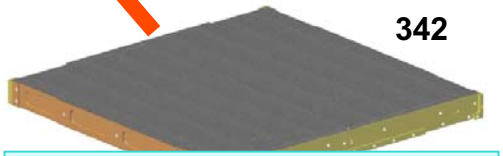


2592

Tray Assembly and Test
Italy

342

342



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

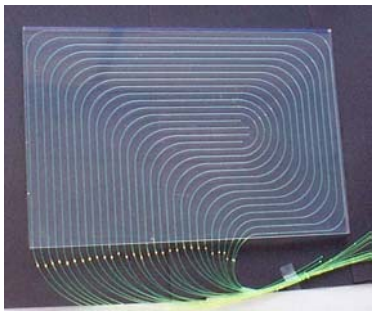
Electronics Design, Fabrication & Test
UCSC, SLAC

64
8

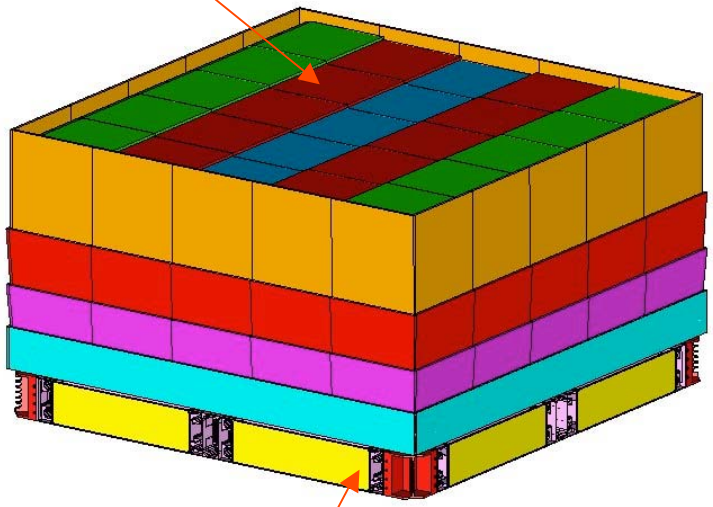
Cable Plant
UCSC

# ACD System Overview

Prototype ACD tile read out with Wavelength Shifting Fiber



Tile Shell Assembly (TSA)

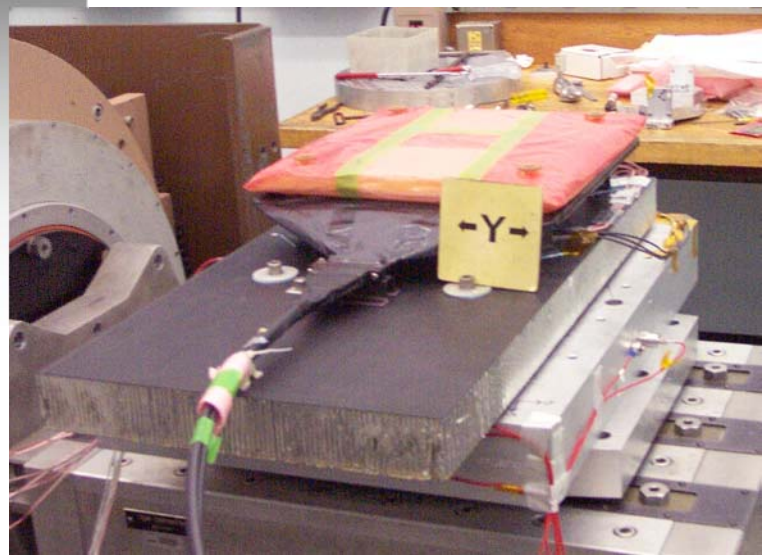


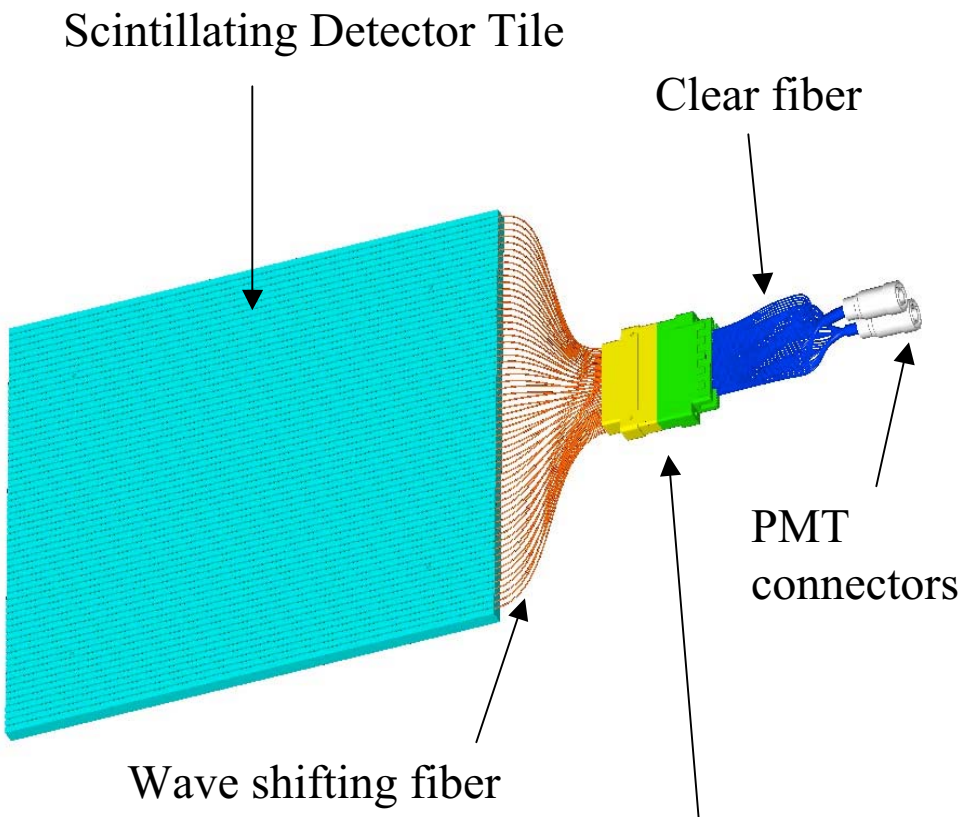
Base Electronics Assembly (BEA)

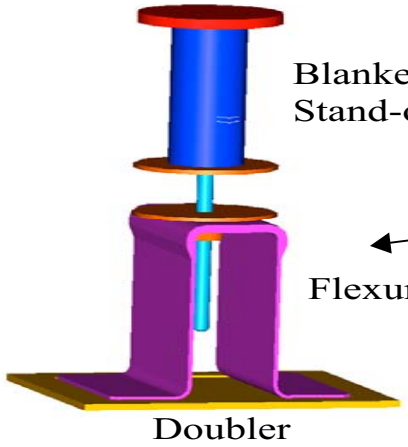
- ***TILE SHELL ASSEMBLY***
  - *89 Plastic scintillator tiles*
  - *Waveshifting fiber light collection (with clear fiber light guides for long runs)*
  - *Two sets of fibers for each tile*
  - *Tiles overlap in one dimension*
  - *8 scintillating fiber ribbons cover gaps in other dimension (not shown)*
  - *Supported on self-standing composite shell*
  - *Covered by thermal blanket + micrometeoroid shield (not shown)*
- ***BASE ELECTRONICS ASSEMBLY***
  - *194 photomultiplier tube sensors (2/tile)*
  - *12 electronics boards (two sets of 6), each handling up to 18 phototubes. Two HVBS per electronic chassis*

# ACD System Overview

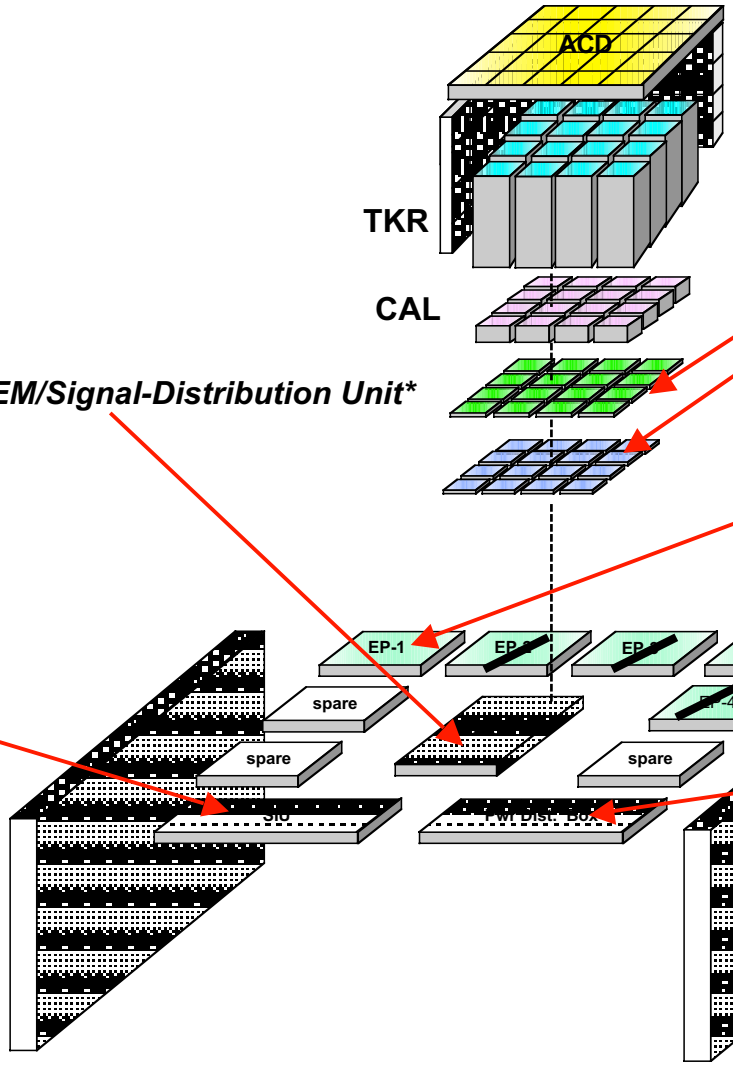
- ***Tile Detector Assembly (TDA)***



# LAT Electronics




***16 Tower Electronics Modules***

- *DAQ electronics module (DAQ-EM)*
- *Power-supplies for tower electronics*

***Global-Trigger/ACD-EM/Signal-Distribution Unit****

***2 Event-Processor Units***

- *Event processing CPU*
- *LAT Communication Board*

*Spacecraft Interface Unit**

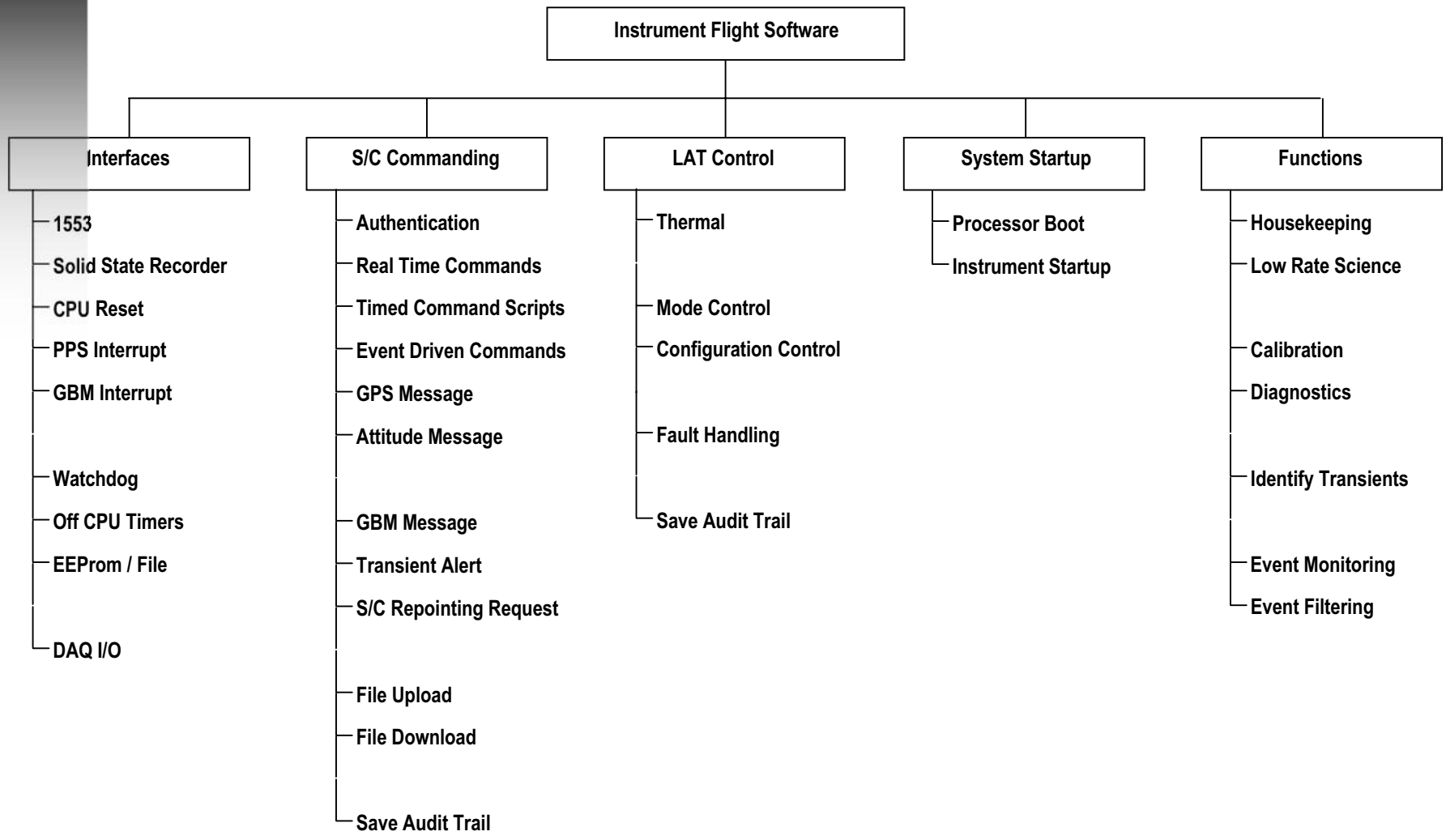
- *Spacecraft Interface Board (SIB): Spacecraft interface, control & data*
- *LAT control CPU*
- *LAT Communication Board (LCB): LAT command and data interface*

***Power-Distribution Unit (PDU)****

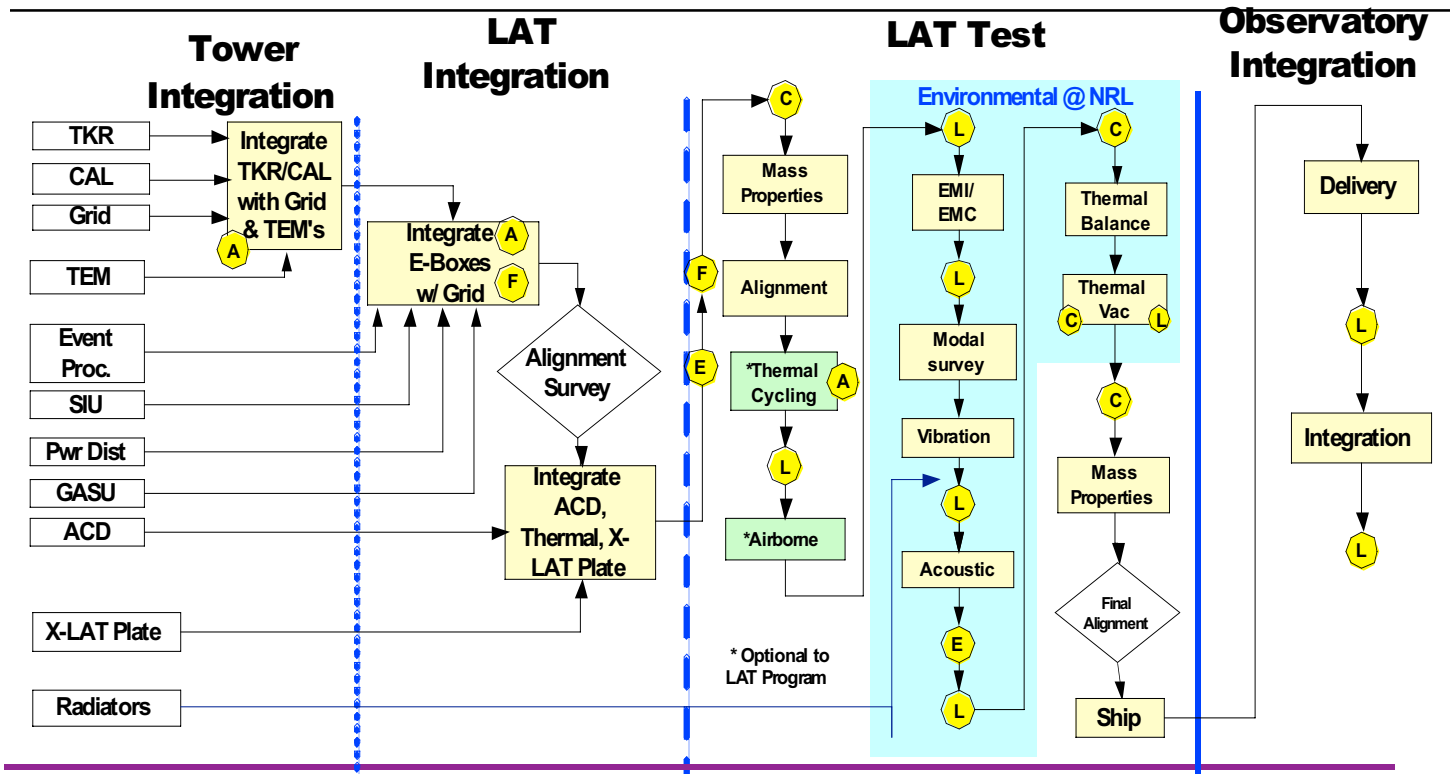
- *Spacecraft interface, power*
- *LAT power distribution*
- *LAT health monitoring*

*** Primary & Secondary Units shown in one chassis**

# LAT Flight Software Functional Requirements



# LAT Integration and Test Flow



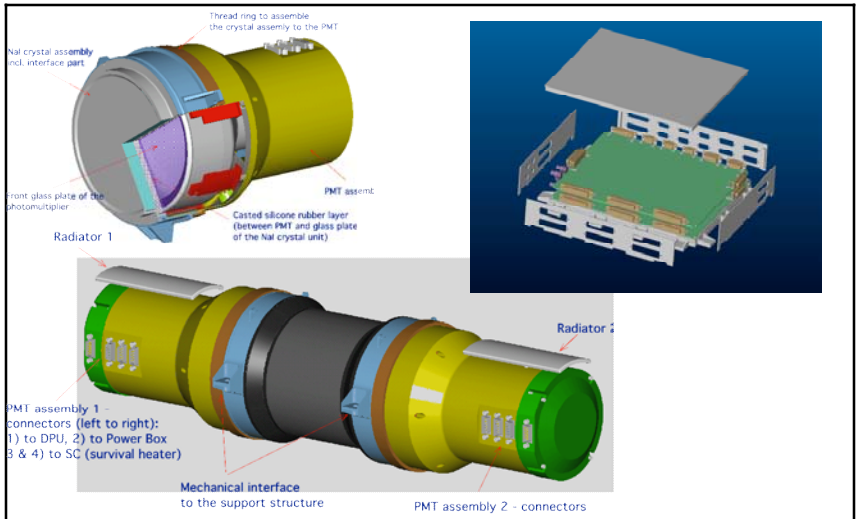

*LAT Integration and Test Flow*



# GLAST Burst Monitor (GBM)

# GLAST Burst Monitor Mission Profile

***GBM is an international science instrument payload being built in partnership with Germany. The primary objective for GBM is to enhance the science return of the GLAST Large Area Telescope (LAT), by detecting Gamma Ray Bursts over a large solid angle.***




***Launch: September 2006***

***Mission lifetime: 5 yrs.***

***Total mass allocation: 97 kg***

***Total power allocation: 65 watts***

***12 NaI detectors / 2 BGO detectors***

***Spectra measured: 10keV to 25MeV***

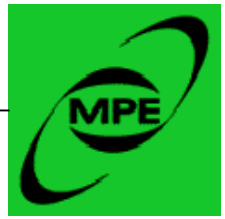
***GBM shall measure the spectra of the Gamma Ray Bursts over a wide energy band and with high temporal resolution. Directions to the bursts will be determined, such that re-pointing of the main instrument (LAT) could occur.***

# GBM Collaboration


National Space Science & Technology Center


University of Alabama
in Huntsville


NASA
Marshall Space Flight Center




Max-Planck-Institut fuï
extraterrestrische Physik

**Michael Briggs**
**William Paciesas**
**Robert Preece**

**Charles Meegan (PI)**
**Gerald Fishman**
**Chryssa Kouveliotou**

**Giselher Lichti (Co-PI)**
**Andreas voŋ Keinlin**
**Volker Schonfelder**
**Roland Diehl**
**Jochen Greiner**

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

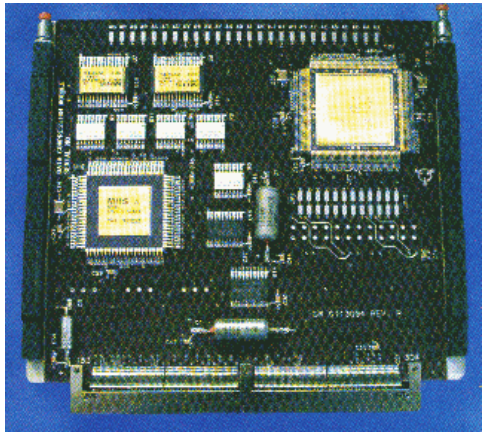
*Detectors, power supplies, calibration, and analysis software*

# GBM Hardware Components

## 12 Sodium Iodide (NaI) Scintillation Detectors

- **Characteristics**
  - *5-inch diameter, 0.5-inch thick*
  - *One 5-inch diameter PMT per Det.*
  - *Placement to maximize FoV*
  - *Thin beryllium entrance window*
  - *Energy range: ~5 keV to 1 MeV*
- **Major Purposes**
  - *Provide low-energy spectral coverage in the typical GRB energy regime over a wide FoV*
  - *Provide rough burst locations over a wide FoV*

## Data Processing Unit (DPU)



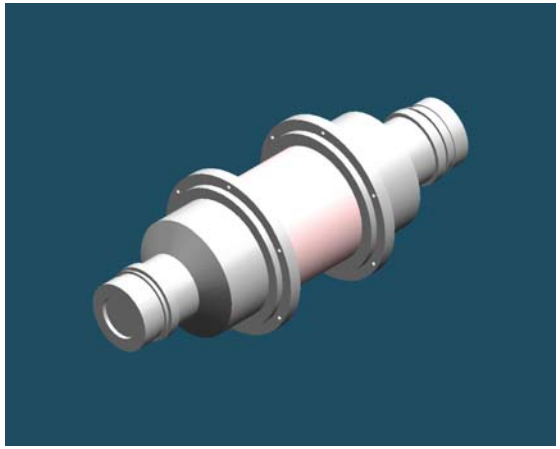
### Characteristics

- *Analog data acquisition electronics for detector signals*
- *CPU for data packaging/processing*

### Major Purposes

- *Central system for instrument command, control, data processing*
- *Flexible burst trigger algorithm(s)*
- *Automatic detector/PMT gain control*
- *Compute on-board burst locations*
- *Issue r/t burst alert messages*

## 2 Bismuth Germanate (BGO) Scintillation Detectors



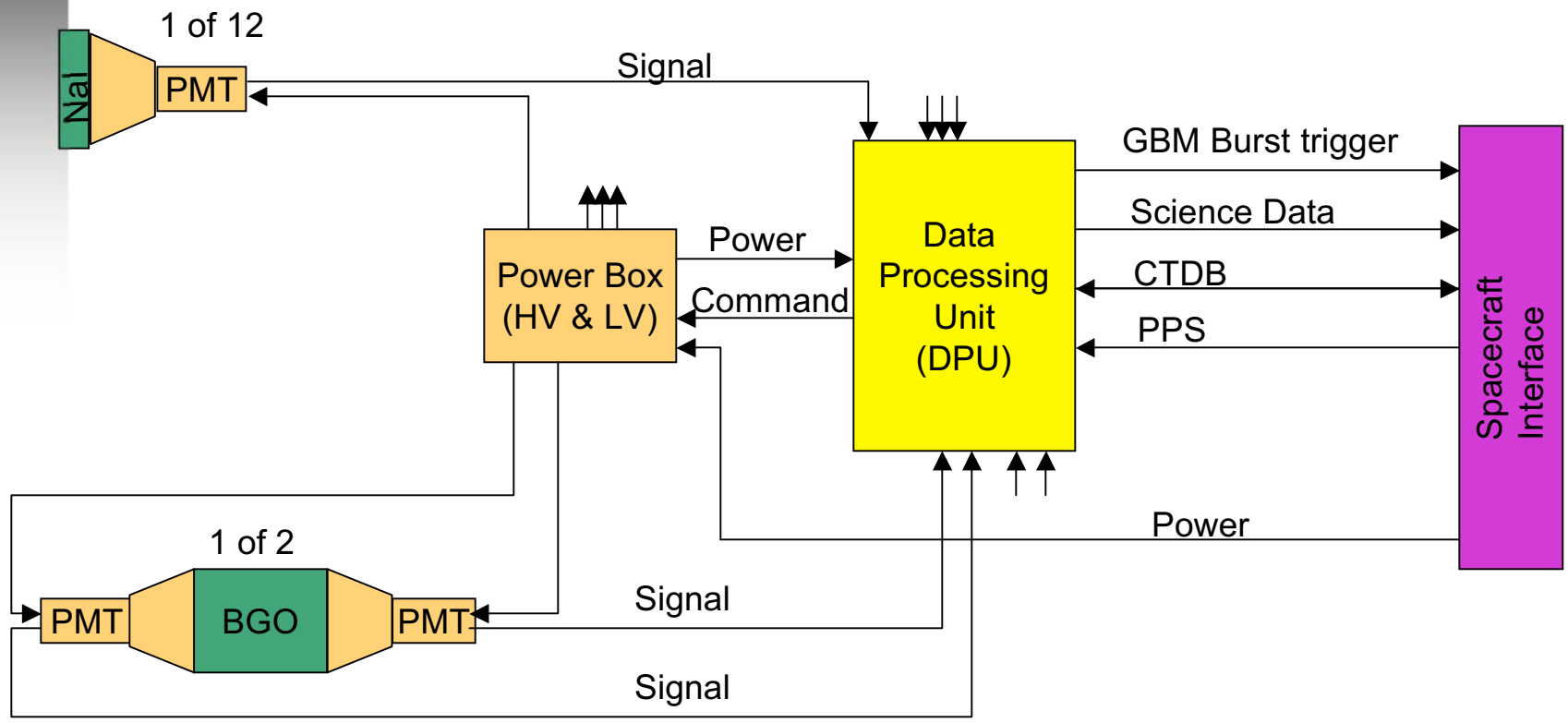
### Characteristics

- *5-inch diameter, 5-inch thick*
- *High-Z, high-density*
- *Two 5-inch diameter PMTs per Det.*
- *Energy range: ~150 keV to 30 MeV*

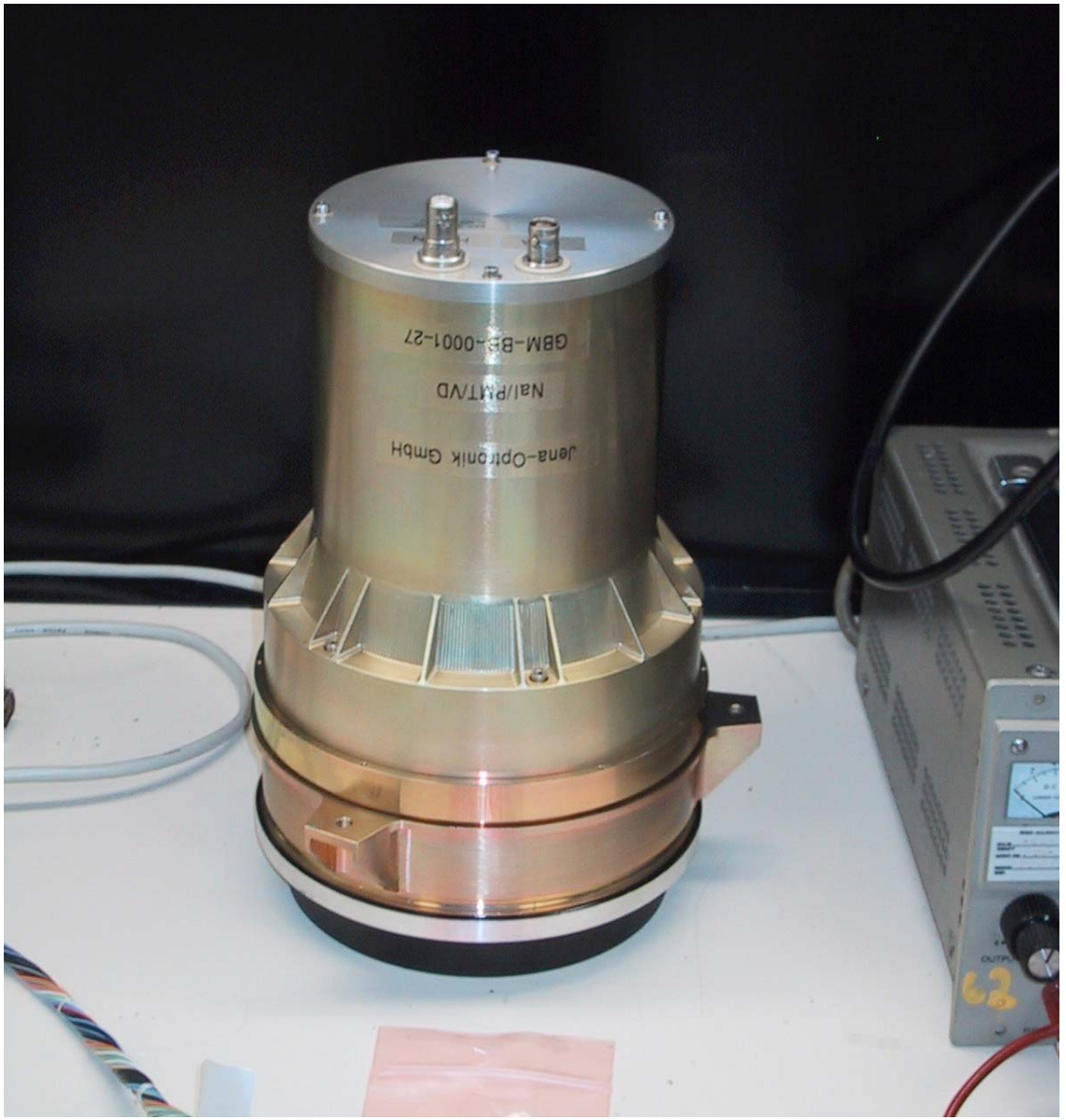
### Major Purpose

- *Provide high-energy spectral coverage to overlap LAT range over a wide FoV*

# Instrument Functional Diagram



# GBM Breadboard NaI Detector





# Mission Operations


# GLAST Operations Concept

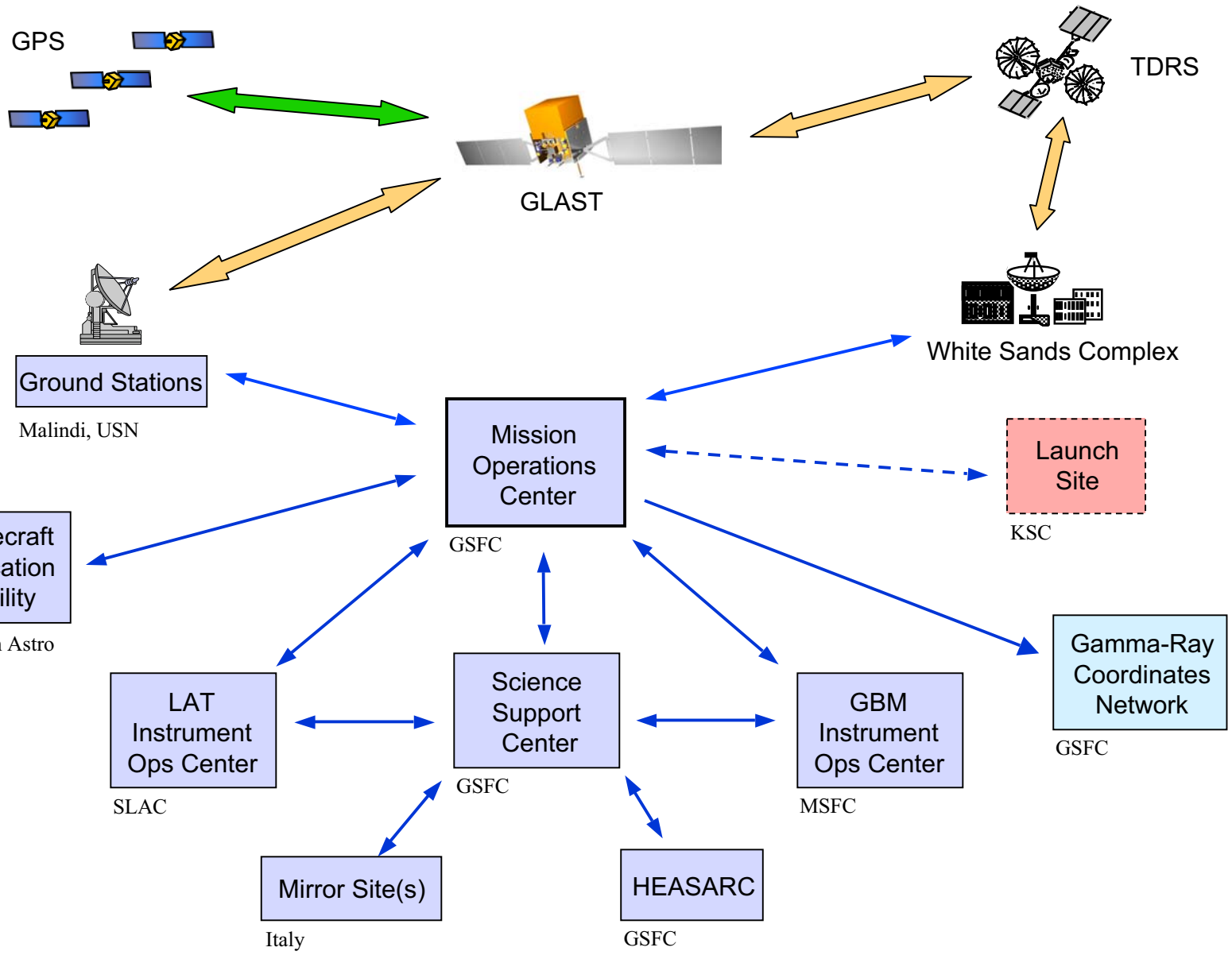
- ***Two distinct methods of data collection have been identified***
  - *Sky Survey*
    - *Cover "entire sky" every two orbits*
  - *Pointed Observation*
    - *Remain "inertially fixed" on a certain target*

- ***Operations will support the mission through***
  - *Providing an efficient scheduling system for normal and special operations*
  - *Assuring data quality throughout the ground system elements*
  - *Performing real time commanding and monitoring as required*
  - *Analyzing engineering data to assess observatory health and status*


# GLAST Operations Concept


- ***The operations includes***
  - *Commanding of observatory*
  - *Telemetry acquisition*
  - *Ground operations support and coordination*
    - *Scheduling*
    - *Data Bases*
    - *Monitoring*
    - *Trending*
  - *Special Operations*
    - *Burst Alerts*
    - *Target of Opportunities*
    - *Orbit Determination/Propagation*
  - *Anomaly Resolution*
    - *Safehold Alerts*
    - *Operator Paging*

# GLAST Operations Concept
# Ground System Interfaces




# GLAST Operations Functions by Location

- ***Mission Operations Center (MOC)***
  - *Real time (R/T) operations*
  - *Mission scheduling*
  - *Low level data processing*
  - *Engineering analysis*
  - *TOO handling*
  - *Burst Alert handling*
- ***Science Support Center (SSC)***
  - *Science planning and scheduling*
  - *Science Data Product distribution*
  - *Target of Opportunity selection*
  - *Guest Observer support*
  - *Archive for GLAST data during mission*
- ***High Energy Astrophysics Science Archive Research Center (HEASARC)***
  - *Archive for GLAST data at the end of GLAST mission*
- ***LAT Instrument Operations Center (IOC)***
  ***LAT Operations Facility(LOF)***
  - *Instrument planning*
  - *Data quality reporting*
  - *Instrument trending and performance analysis*
- ***LAT IOC Science Analysis Software (SAS)***
  - *High-level data processing*
  - *Science Data Product distribution*
  - *Instrument calibration*
  - *LAT data archive*


# GLAST Operations Functions by Location

- ***GBM IOC***
  - *Instrument planning*
  - *Data quality reporting*
  - *High level data processing*
  - *Data quality reporting*
  - *Instrument trending and performance analysis*
- ***Gamma-ray Coordinates Network (GCN)***
  - *Burst Alert Distribution to the world of Gamma-Ray astronomers*
- ***Spacecraft Fabrication Facility (SFF)***
  - *Pre-launch Testing*
  - *Sustaining engineering support (option)*
- ***Launch Site - Kennedy Space Center (KSC)***
  - *Launch Support Data flows*
  - *Mission Rehearsals*
  - *Payload(Observatory) Processing at Pad*
  - *Launch Voice Control*
- ***Space Network (SN)***
  - *R/T Tracking and Data Relay Satellite System (TDRSS) Operations*
  - *Burst Alert Message transmission via Demand Access (DAS) service*
  - *TDRSS scheduling via Space Network Web Services Interface (SWSI)*


# GLAST Operations Functions by Location


- ***Ground Network (GN) Malindi/USN***
  - *R/T Ground-Based Operations*
  - *Data capture and playback*
- ***Italian Mirror Site***
  - *Receive science data from SSC*
  - *Science Data Distribution*
- ***Global Positioning System (GPS)***
  - *Orbit determination*
  - *Clock management*