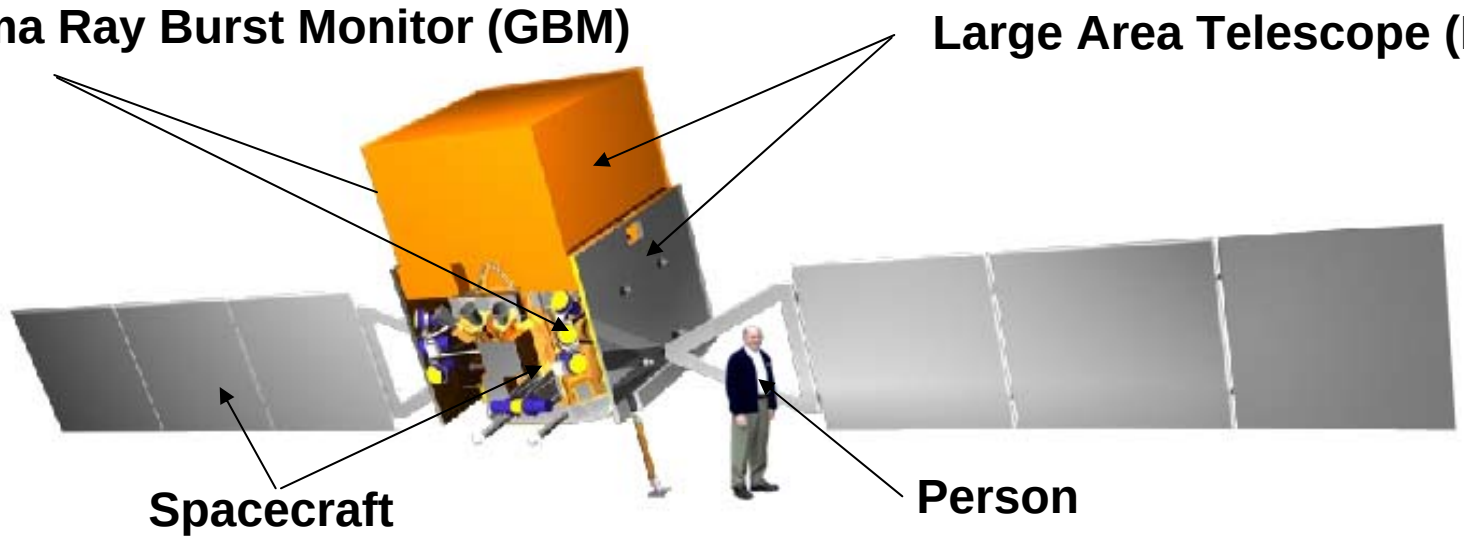
GLAST Large Area Telescope:

Project Status:
Technical and Cost

Lowell A. Klaisner
Stanford Linear Accelerator Center
Project Manager

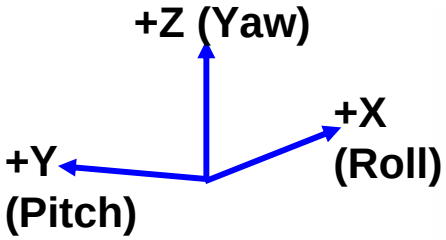
Klaisner@slac.stanford.edu
650-926-2726

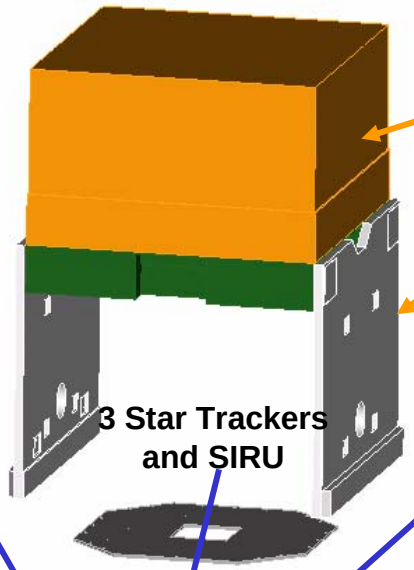
GLAST Observatory



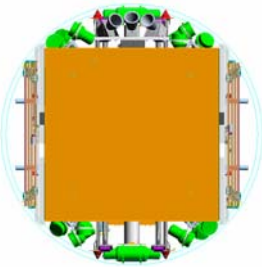
Launch Vehicle	Delta II – 2920-10H
Launch Location	Kennedy Space Center
Orbit Altitude	575 Km
Orbit Inclination	28.5 degrees
Orbit Period	95 Minutes
Orientation	+X to the Sun

OBSERVATORY LAYOUT

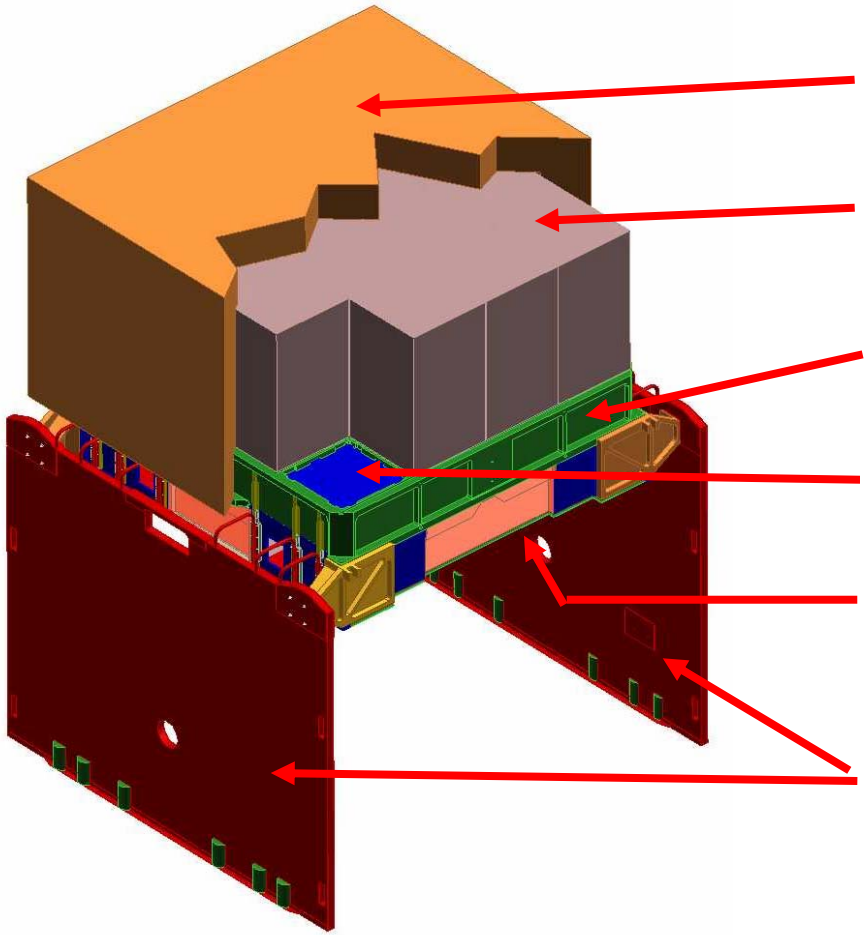




Launch Config.



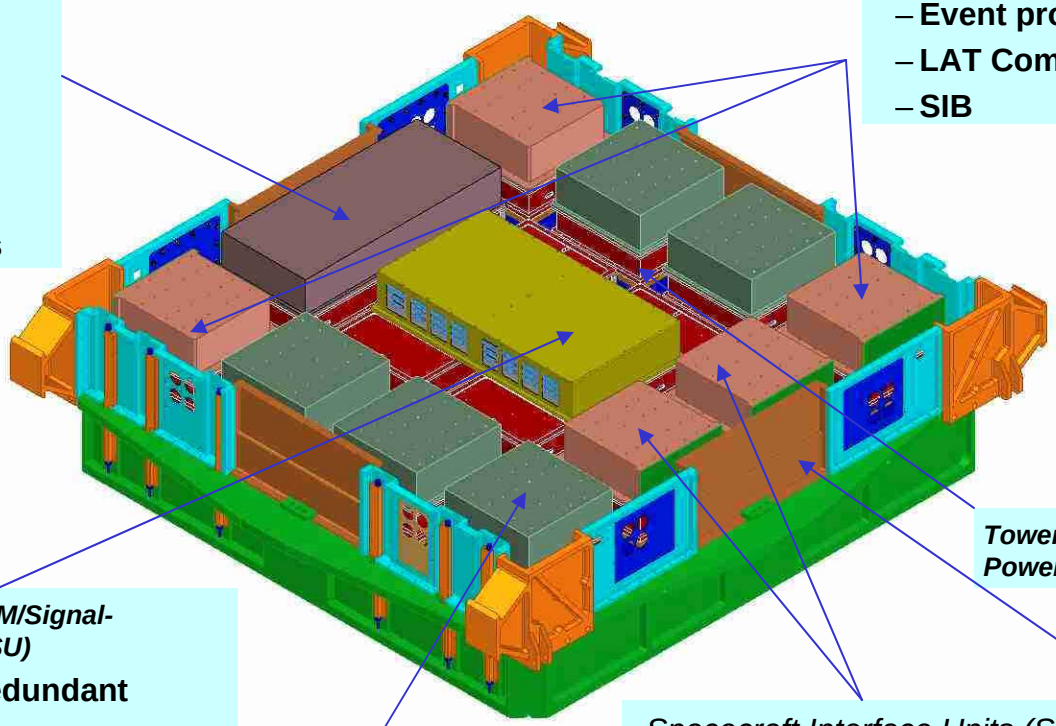
Instrument Structure



LAT Electronics Overview

Power-Distribution Unit (PDU)
- **Spacecraft interface, power**
- **LAT power distribution**
- **LAT health monitoring**
- **Primary and Redundant boards**

3 Event-Processor Units (EPU) (2 + 1 spare)
- **Event processing CPU**
- **LAT Communication Board**
- **SIB**



Tower Electronics Modules & Power Supplies (TEM & TPS) (16)

Global-Trigger/ACD-EM/Signal-Distribution Unit (GASU)
- **Primary and Redundant boards**

EMI Shield

Spacecraft Interface Units (SIU) (2)
- **Storage Interface Board (SIB): Spacecraft interface, control & telemetry**
- **LAT control CPU**
- **LAT Communication Board (LCB): LAT command and data interface**

Empty Chassis (5)
- **Structural and thermal function**

Master Schedule

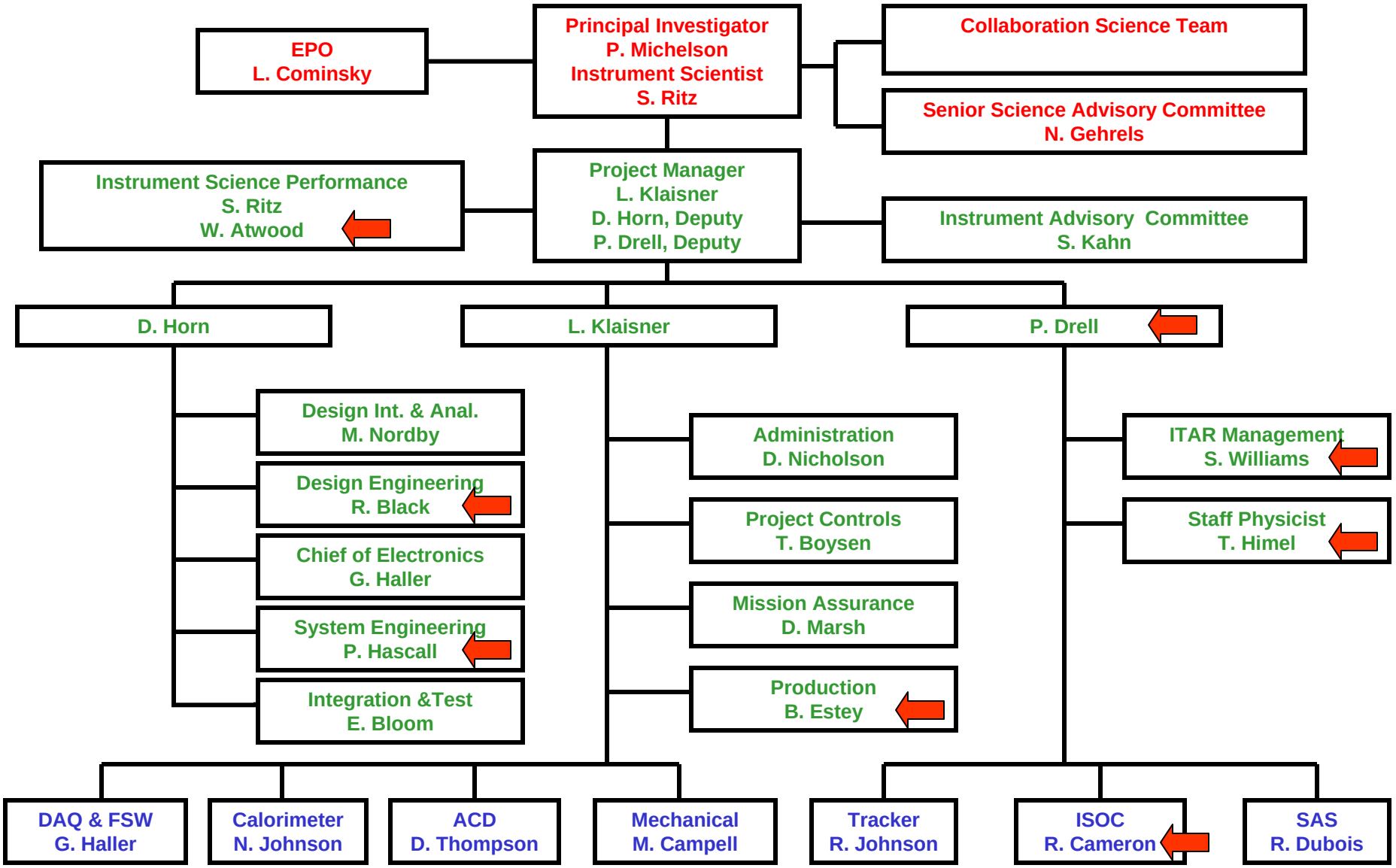
- LAT complete and tested July 2005
  - To NRL for environmental testing
- Delivery to Observatory Integration December 2005
  - Mate with spacecraft and GBM and test
- Launch February 2007
  - Kennedy Space Flight Center
- Science operation begins May 2007

SIRTF Launch on a Delta II Heavy

Key LAT events

• First tower modules ready for installation	November 2004
• Two towers installed and tested in the grid	January 2005
• Two tower Comprehensive Perf. Test Complete	February 2005
• Sixteen towers installed and tested	May 2005
• LAT completely assembled	June 2005
• LAT system test complete	August 2005
• LAT environmental test complete	December 2005
• GLAST observatory integration and test begins	January 2006
• Launch	February 2007

LAT Organization Chart



LAT Status

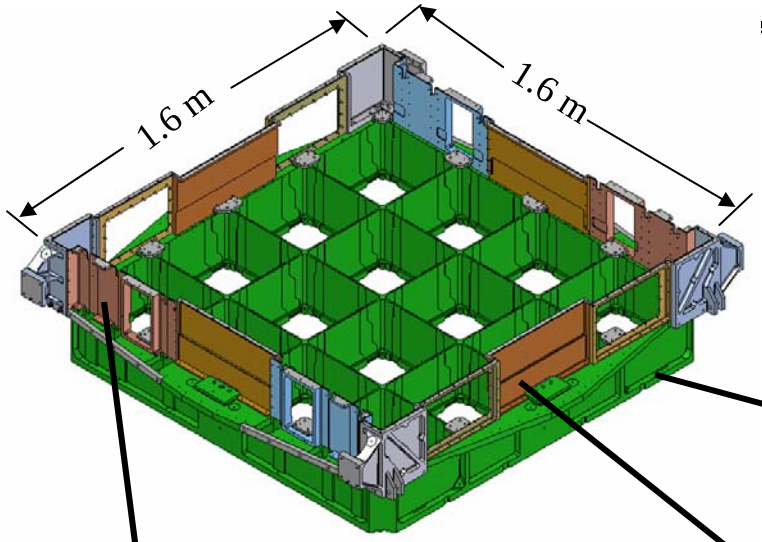
- **Building flight hardware**
  - **All subsystems are fabricating subassemblies**
    - **Calorimeter first flight module in test**
  - **Integration and Test facilities are in place and instrument handling equipment is being assembled**
- **Tight schedule to deliver to observatory integration in Dec '05**
  - **Anomalies have been uncovered during the testing of the flight components in the Tracker, Calorimeter, and Anticoincidence Detector**
  - **The TKR, CAL, ACD and Electronics have had components that failed to meet requirements**
  - **The associated delays in delivery of the first flight unit puts the overall schedule in jeopardy**
  - **The schedule will be reevaluated after the first tower is integrated and all systems are in production**

Subsystem Status

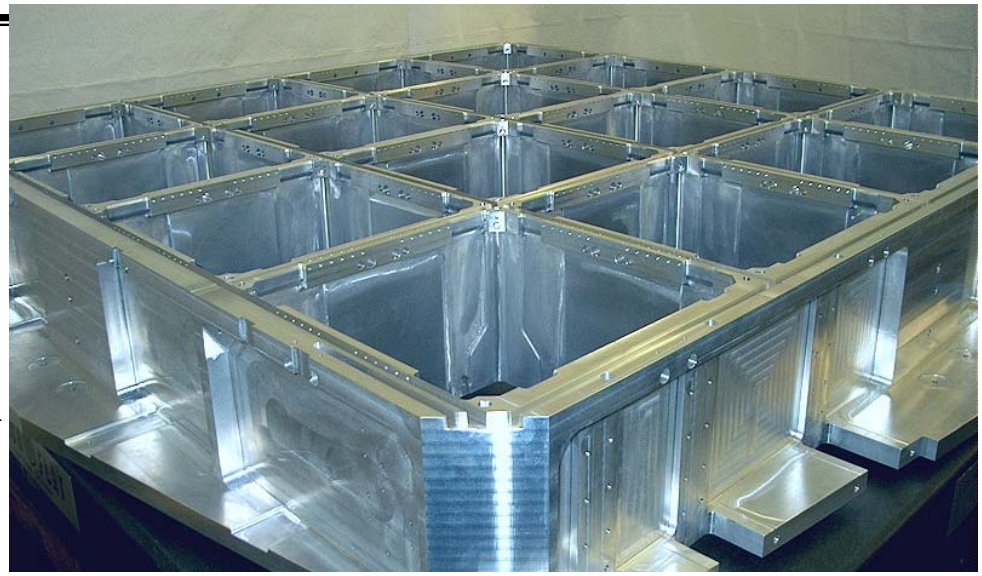
Mechanical Sub-System Overview

- Grid Box Base Assembly (GBBA)
  - Grid + Radiator Mount Brackets + Top Flange Heat Pipes + Thermal Control hardware
    - Configuration delivered to I & T for LAT integration
  - Grid match drilled to ACD Base Frame Assembly
  - Grid drilled to Spacecraft drill template
- Grid Qualification Unit
  - Grid #2 is Qualification unit
  - GBBA + EMI Skirt + Dummy CAL Baseplates
  - Combined Grid Static Load and LAT strength test
- Radiators
  - Fabricated and tested by Lockheed Martin
- X-LAT Plates
  - Fabricated and tested by Lockheed Martin

Mechanical Subsystem

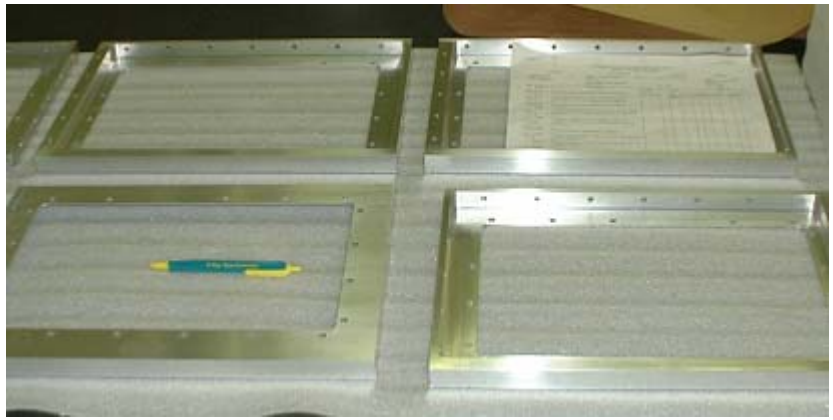


Grid Box Assembly



4 x 4 Grid

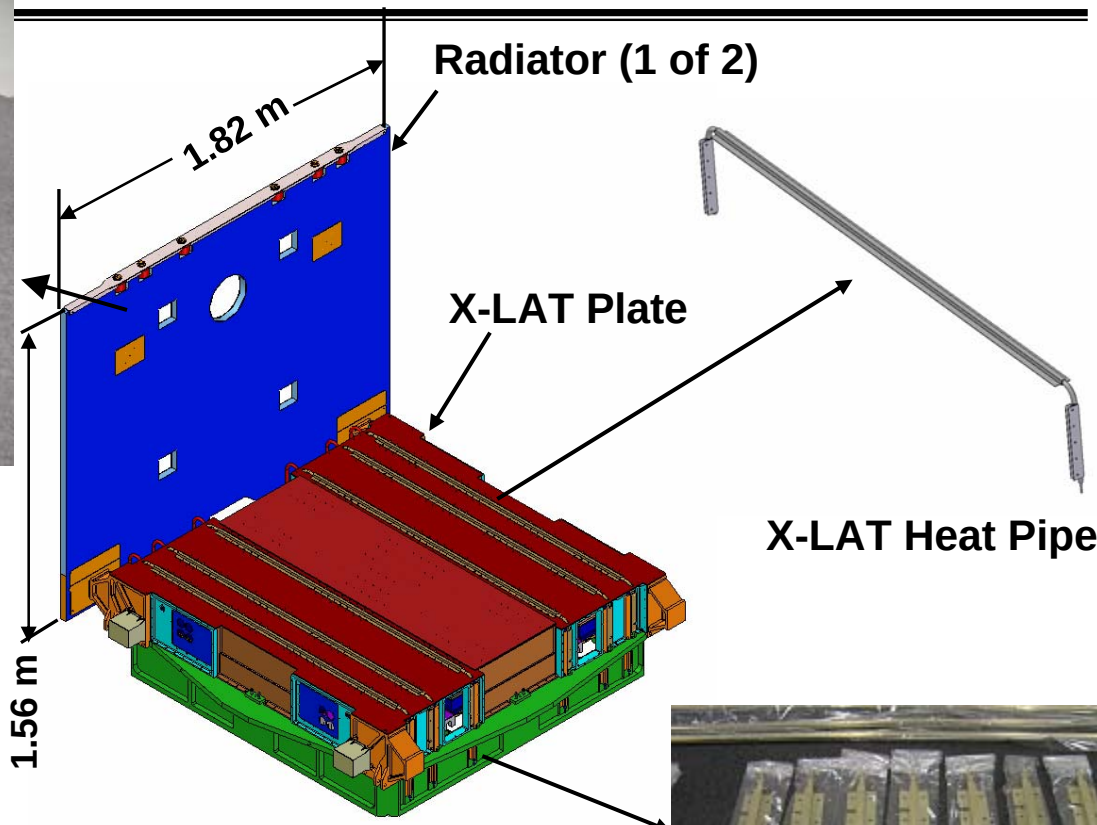
Radiator Mount Brackets

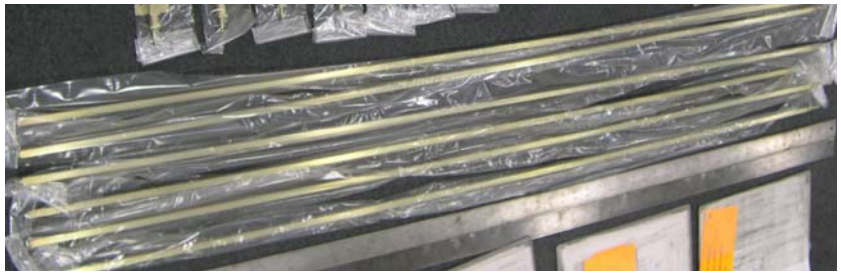


EMI Shields

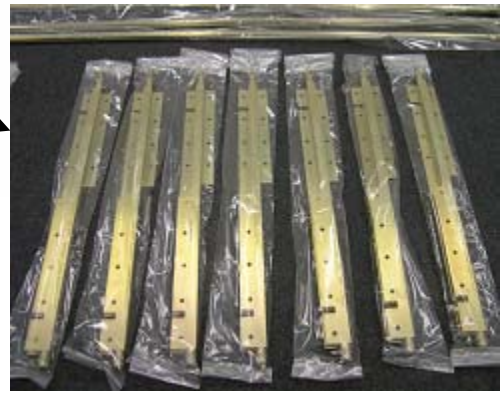
Thermal Control System

Variable Conductance Heat Pipe (embedded in Radiator)





Top Flange Heat Pipe (+Z Grid surface)

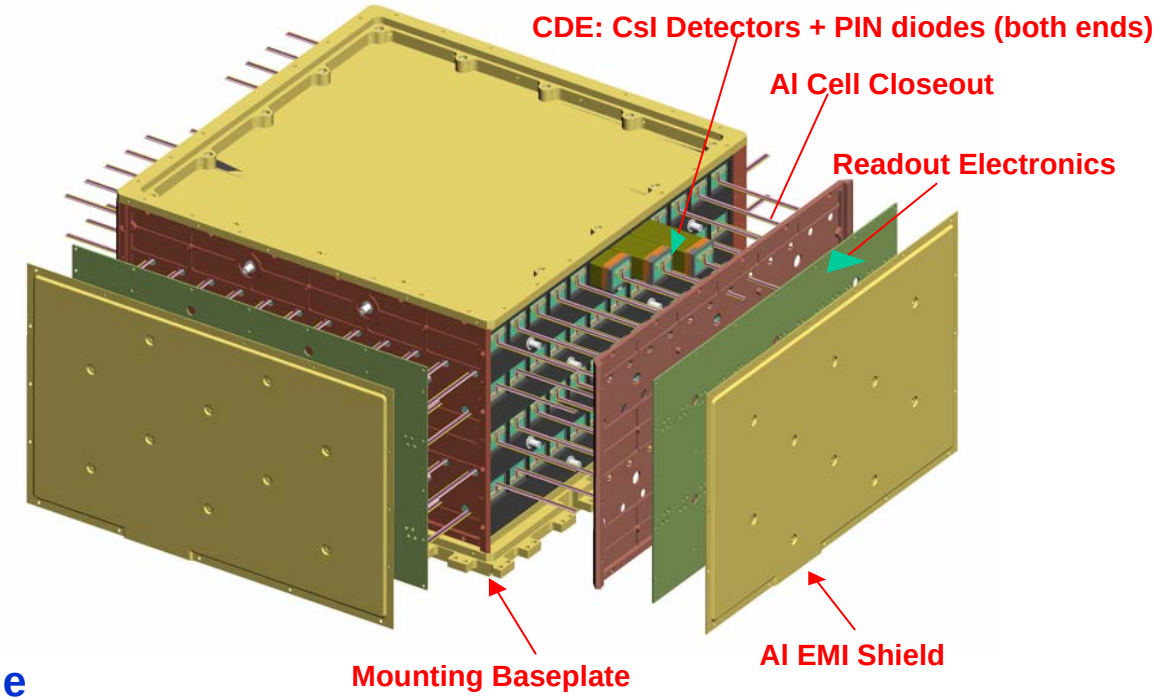


Down Spout Heat Pipe

Flight Grid

Calorimeter Design Overview

- 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
  - Al base plate and side cell closeouts



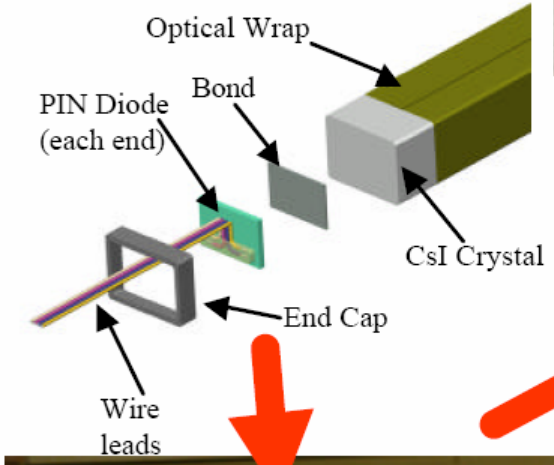
- Electronics boards attached to each side
  - Interface connectors to TEM at base of calorimeter
- Outer wall is EMI shield and provides structural stiffness as well

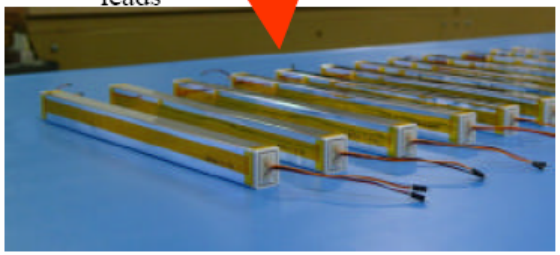
Calorimeter Assembly Flow and Build Status

Dual PIN Diodes
4800 / 4380

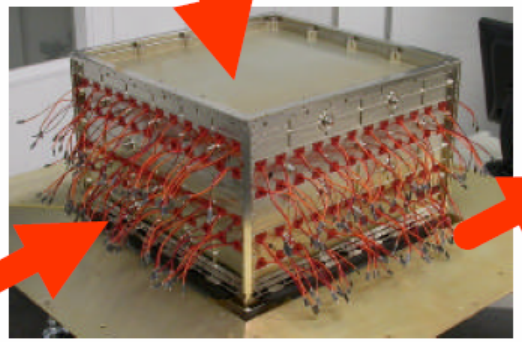
CsI Crystals
1755 / 1830

Crystal Detector Element (CDE) Assembly
1424 / 1830





Mechanical Structure
12 / 18

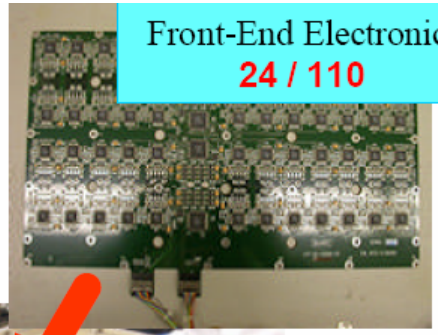


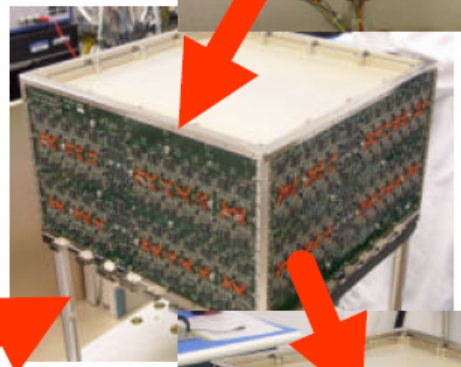
PreElectronics Module (PEM)
8 / 18

complete

planned

Front-End Electronics
24 / 110

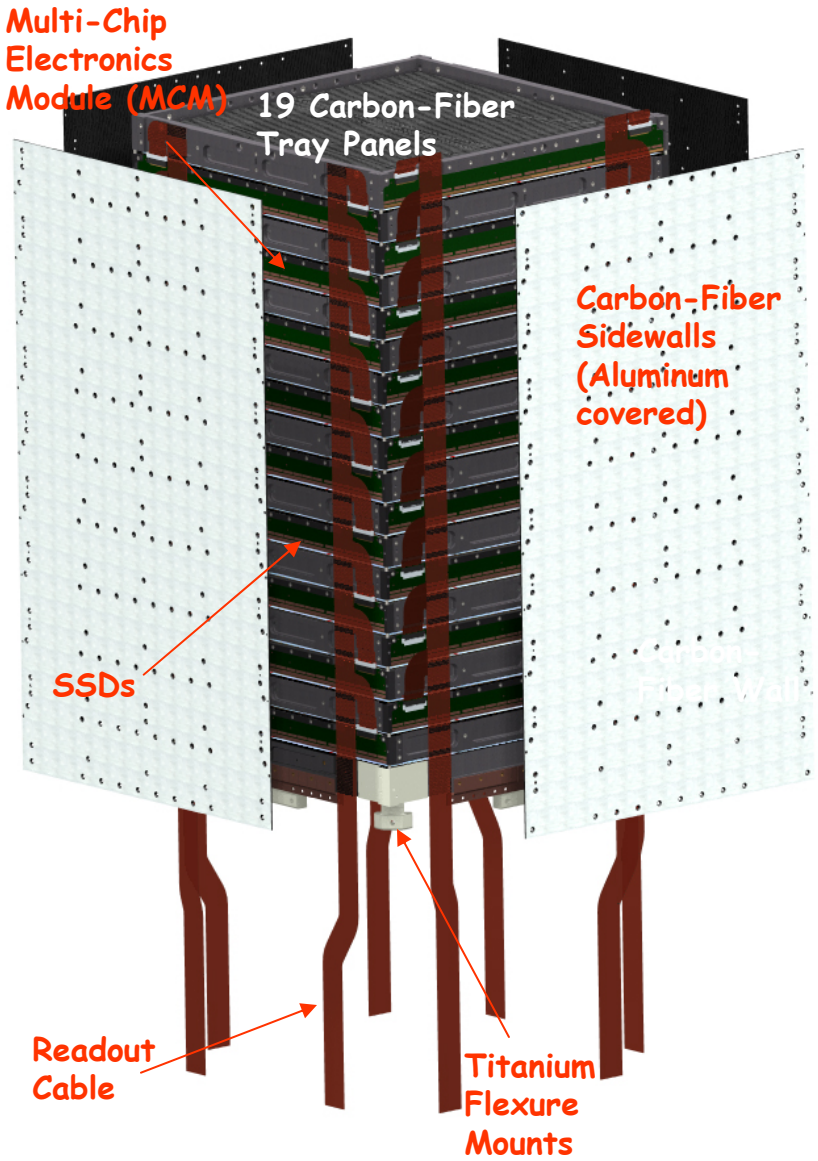




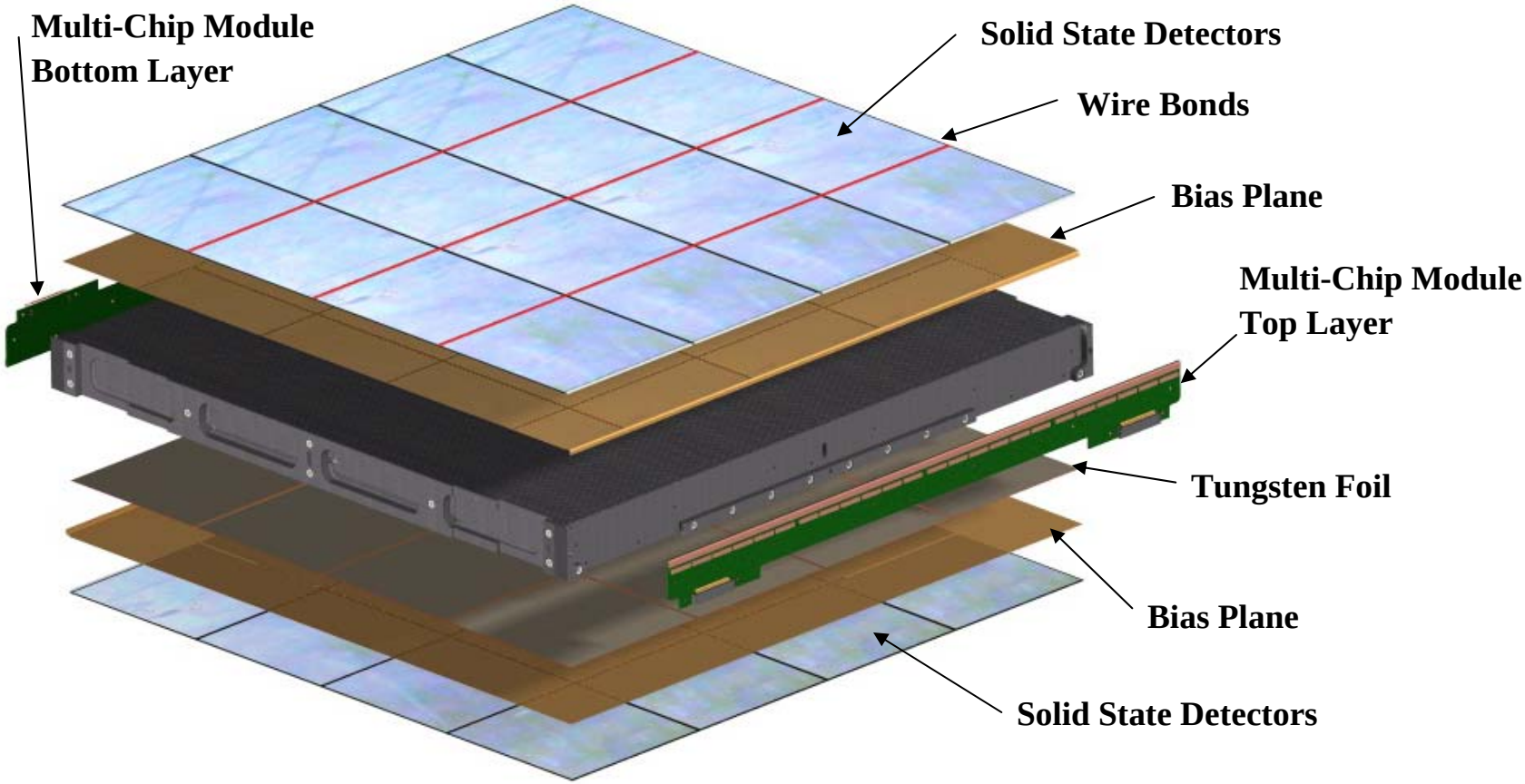
Module Assembly & Test
1 / 16

Tracker Design Overview

- Stiff composite panels (>500 Hz)
  - Allows small gap between x-y SSD layers
- Tungsten foils on panel bottom
- Solid State Detectors (SSDs) on top & bottom faces
- Electronics on panel edges
  - Minimizes the gap between towers (1.59 cm Si to Si)
- Carbon-fiber walls for vertical support
  - Very stiff box structure
  - Passive cooling to tower base
- Flexure attachment to Grid
  - Decouple from thermal expansion
  - Lowest frequency >150 Hz
  - Thermal straps couple sidewalls to the Grid (not shown)



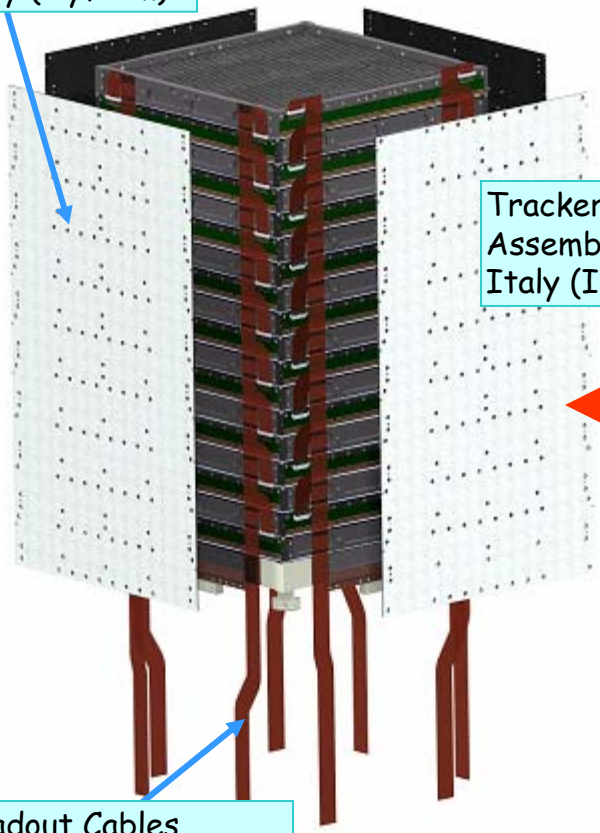
Tracker Tray Structure



Tracker Production Overview

4 / 64

Sidewalls
Italy (Plyform)



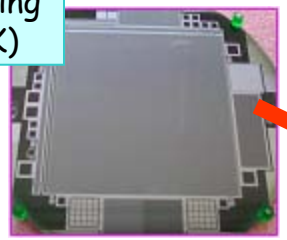
Readout Cables
UCSC, SLAC (Parlex)

16 / 96

complete

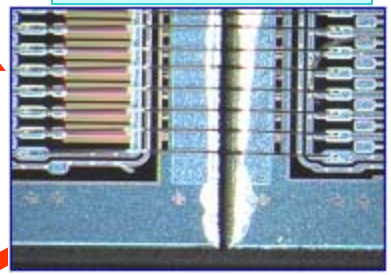
required for flight

SSD Procurement, Testing
Japan, Italy, SLAC (HPK)



11400 / 9216

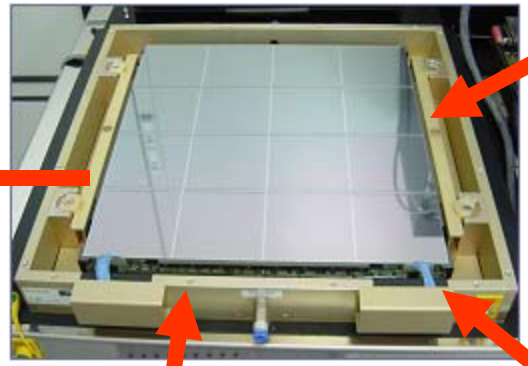
SSD Ladder
Assembly
Italy (G&A, Mipot)



1198 / 2304

Tracker Module
Assembly and Test
Italy (INFN, Alenia)

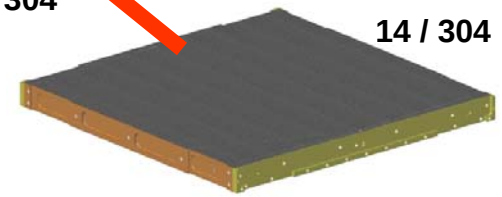
0 / 16



9 / 304

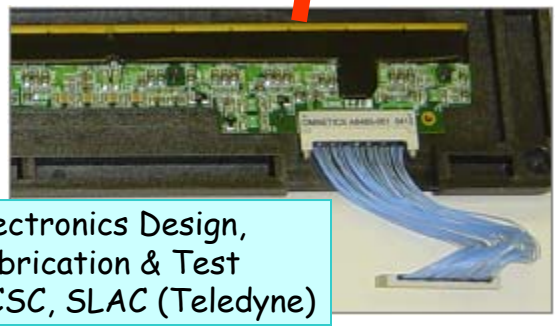
Tray Assembly and
Test
Italy (G&A)

14 / 304



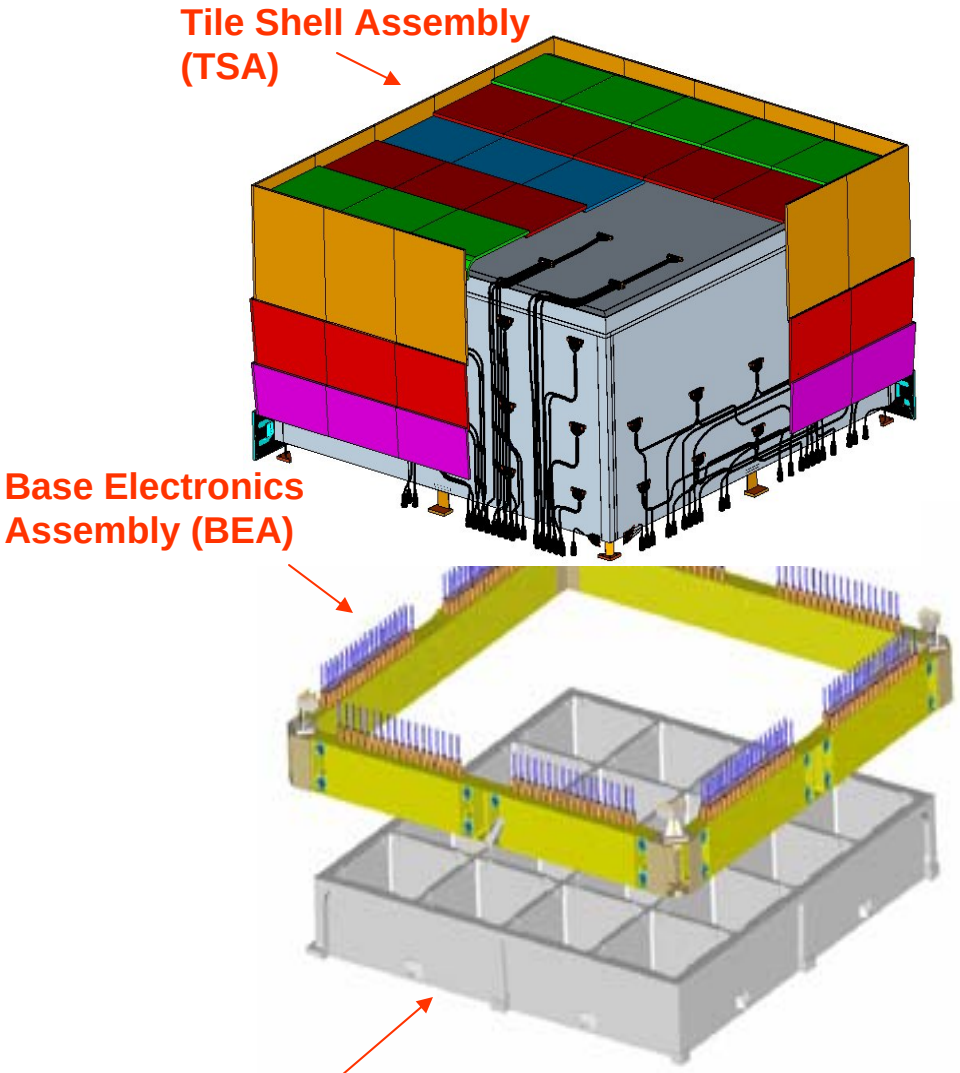
Composite Panel & Converters
Italy (Plyform)

261 / 608



Electronics Design,
Fabrication & Test
UCSC, SLAC (Teledyne)

ACD Design Overview



- **TILE SHELL ASSEMBLY**
  - 89 Plastic scintillator tiles (8.6 m^2 total)
  - Waveshifting fiber light collection, with clear fiber light guides for long runs (6.7 km total)
  - Two sets of fibers interleaved 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
  - 376 composite flexures support tiles
  - 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 High Voltage Bias Supplies on each board.
  - 24 electrical interface connectors (1600 pins total)

ACD Assembly Flow and Build Status

Photomultiplier Tubes
145 / 194

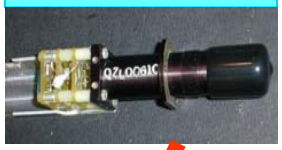
Tile Detector Assemblies
113 / 89

Fiber Ribbon Detectors
8 / 8

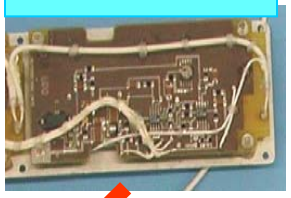
Clear Fiber Cables
130 / 65

Front End Electronics Boards
14 / 12

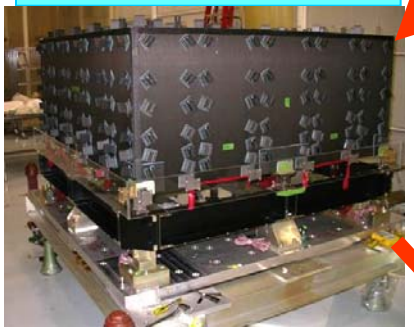
Photomultiplier Tube Assemblies
0 / 194



High Voltage Bias Supplies
30 / 24



Mechanical Structure
1 / 1

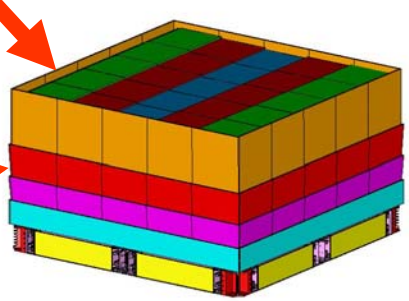


Electronics Chassis
0 / 8

 # complete

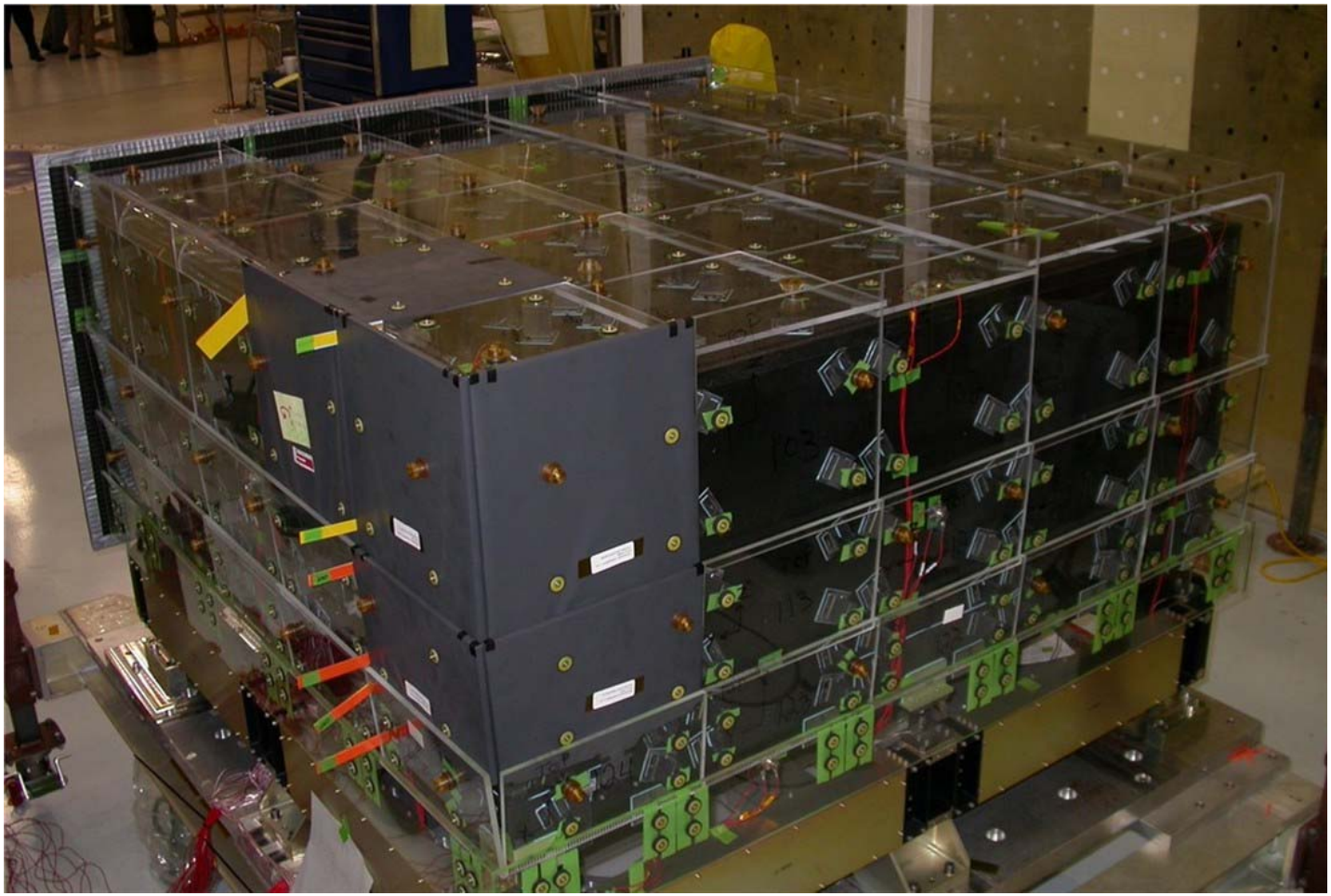
 # required for flight

ACD Assembly **0 / 1**



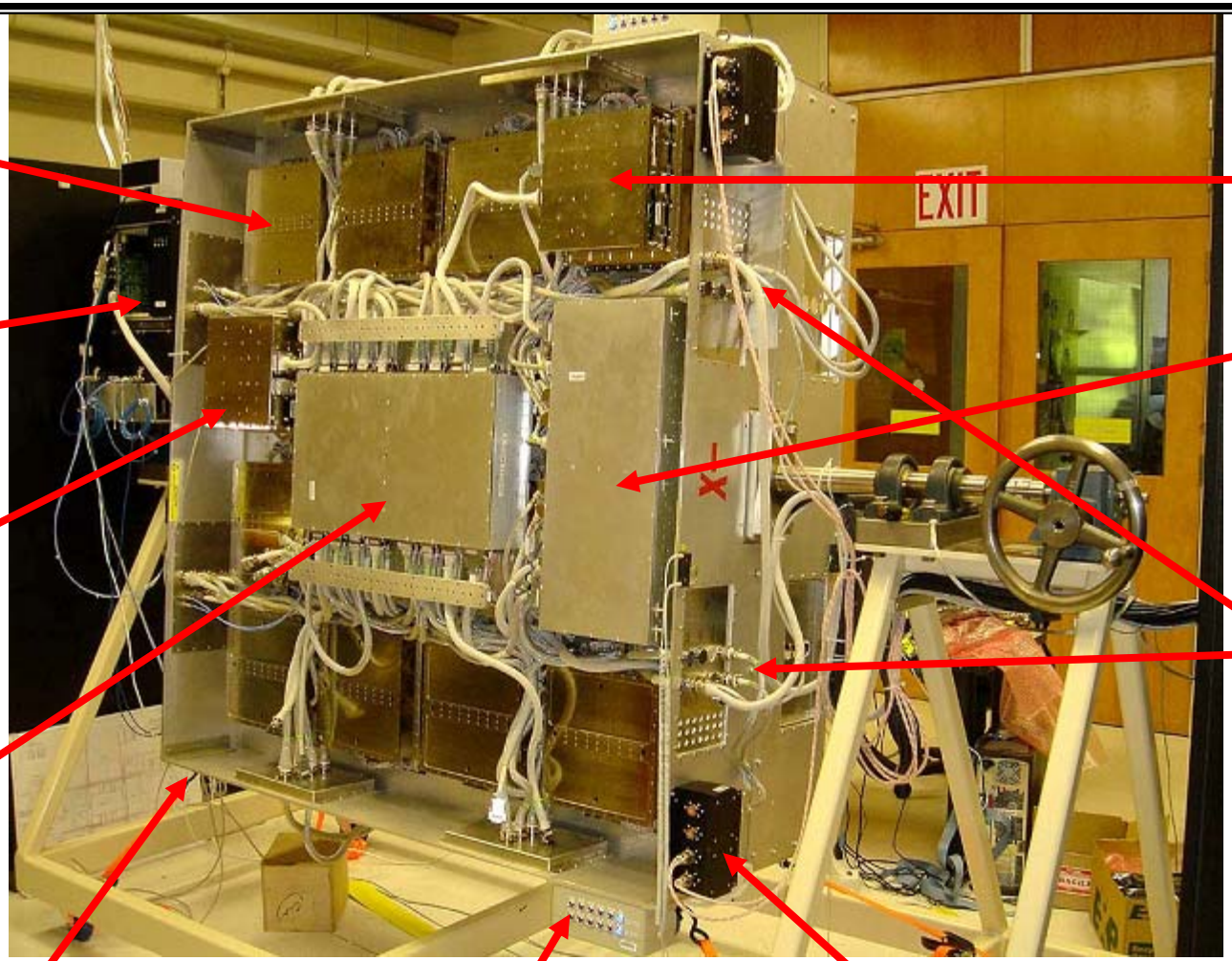
Thermal Blanket / Micrometeoroid Shield
0 / 1

ACD Mechanical Structure



Plastic tiles added to flight structure for testing. Clear tiles are dummy versions; wrapped tiles are flight spare Tile Detector Assemblies.

The LAT Test Bed (-Z side)



1 of 16 TEMs

External Crate

SIU

GASU

RF Shield

1 of 2 Heater Loads

1 of 2 Heater Controls

Power Feeds

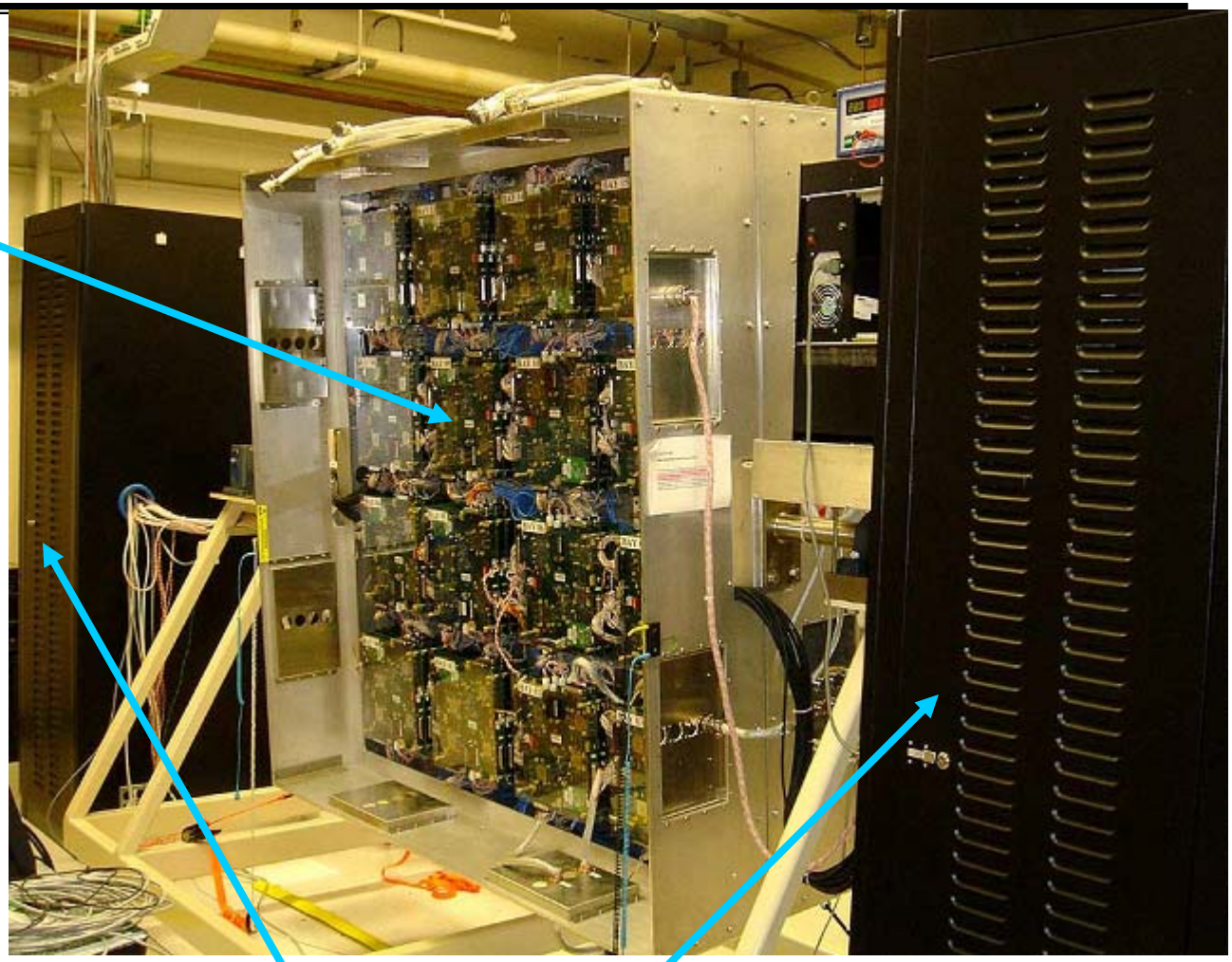
PDU

EPU

The LAT Test Bed (+Z side)

16 TKR FES
16 CAL FES
8 ACD FES
1 Control FES

16 Tower Loads



11 Front End Simulator (FES) Control PCs

Mechanical Ground Support Equip. Status

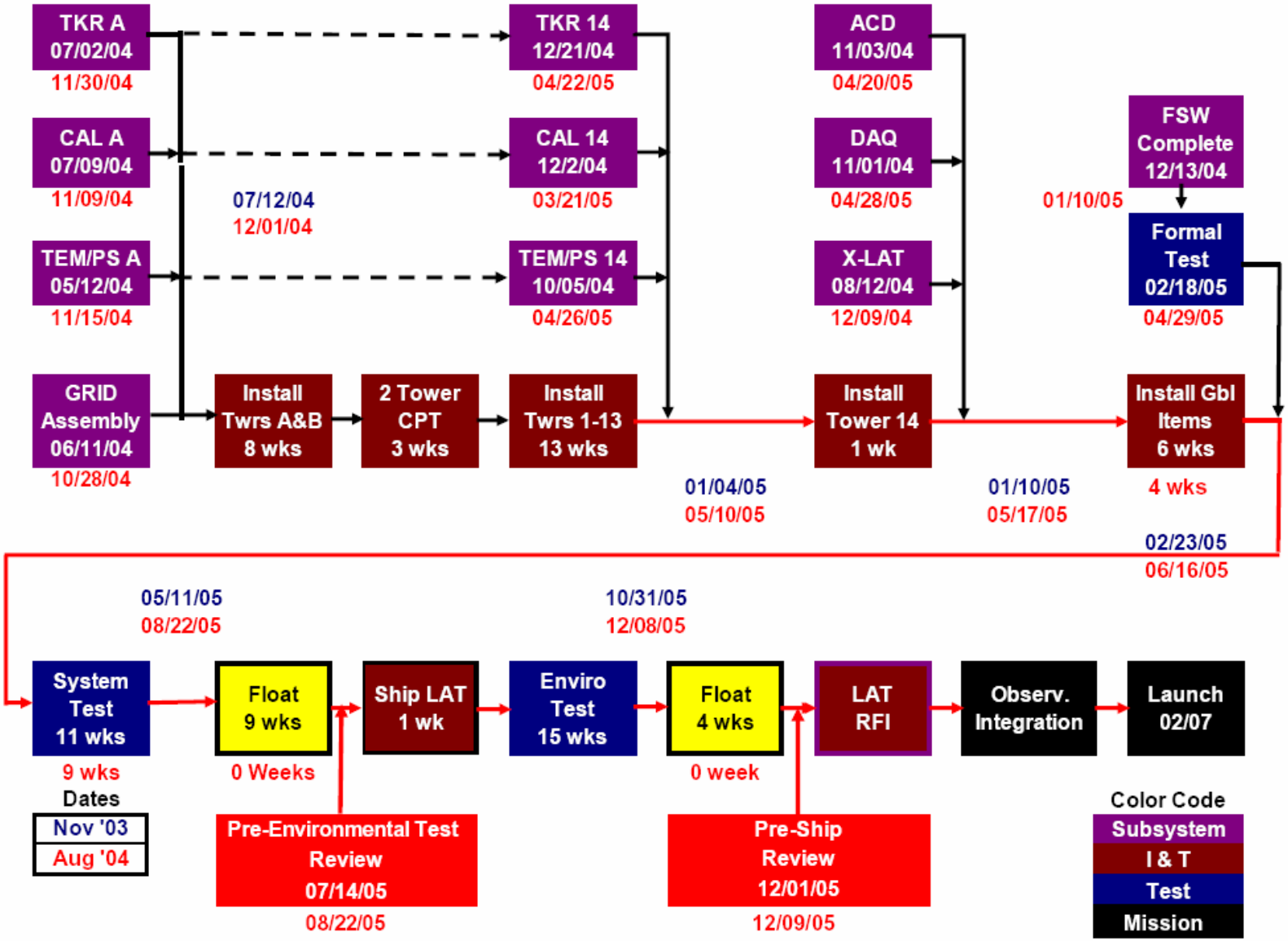
MGSE is on track to support instrument integration

- Peer review 6/22/04
- 4x4 Base Structure delivered and assembled
- 1x4 and 4x4 Lift fixtures delivered
- Grid Perimeter Ring (GPR) delivered
  - Assembly hardware is staged and prepared for installation of the GPR to the base structure.
- Personal Access Platform (PAP) purchase order has been placed.
- Delivery scheduled for 10/15
- Total MGSE Drawing Sheet Count ~ 294 (267 Released)

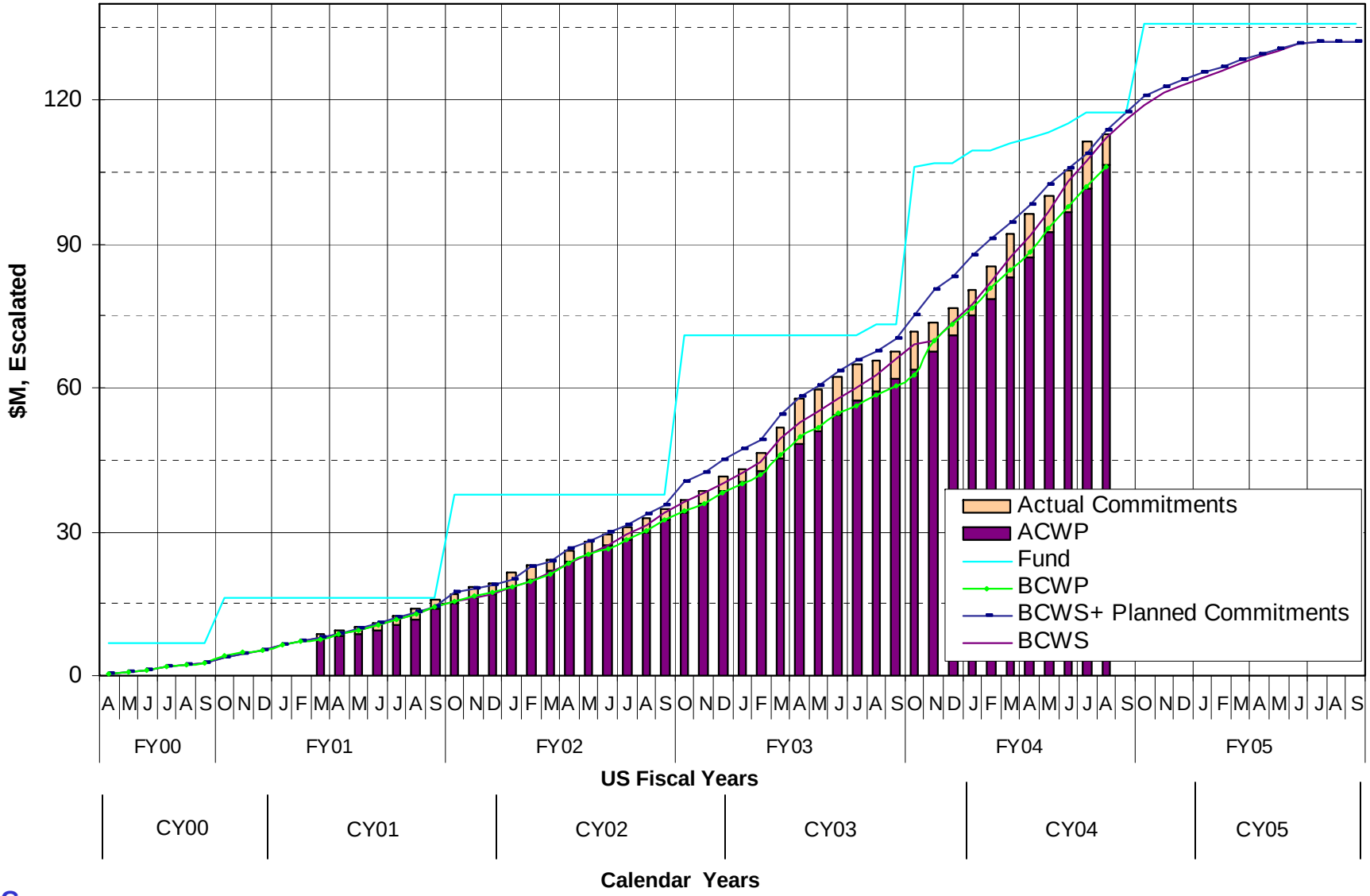
Work to go

- Shipping container design and analysis is in work.
- Environmental test MGSE design is underway

LAT Schedule



Budget, Cost, Funding, Performance



August 04 Status

Total Project Budget:	**$132.2M**
Actual cost through Aug. 04:	**$106.3M**
Cost of remaining work:	**$26.1M**
Contingency:	**$3.8M**
(as % of remaining work):	**(15%)**

International Contributions

Calendar Year	2001*	2002	2003	2004	2005	2006	2007	2008	Total
Funding for the GLAST-LAT Project US$ X 1000									
France	$3,447	$1,873	$1,873	$821	$332	$356	$405	$356	$9,463
Italy - ASI		$800	$2,230	$2,604	$354	$440	$922	$930	$8,280
Italy - INFN	$2,100	$4,319	$1,801	$1,333	$1,200				$10,753
Japan	$1,140	$1,040	$880	$730	$150	$100	$100	$100	$4,240
Sweden									$0
US - DOE Project	$10,709	$8,288	$8,658	$8,030	$6,316				$42,000
US - DOE Ops	$4,200	$3,400	$4,100	$5,200	$7,200	$8,400	$7,500	$7,100	$47,100
US - NASA (Fab Phase)	$10,994	$16,481	$27,051	$25,899	$13,211				$93,636
US - NASA (Comm Phase)					$2,900	$8,800	$6,853	$6,734	$25,287
Scientific and Technical FTE's supporting the LAT Project (not included in the funding above)									
France	10.4	3.4	3.8	6.4	7.8	10.1	10.1	10.1	
Italy			6.0	6.0	4.0	4.0	4.0	4.0	
Japan	4.0	4.5	3.5	3.5	3.5	3.5	4.5	5.0	
Sweden	6.3	7.5	5.6	5.0					
Scientific and Technical FTE's supporting the LAT Project (included in the funding above)									
US	27.4	22.2	22.2	25.6	41.3	48.2	36.3	47.6	

* The 2001 column includes funds from prior years

Issues

- Tracker Schedule
  - Starting flight production Monday
  - Compressed schedule on the instrument critical path
- Electronics Schedule
  - Flight production just beginning
  - Many different boxes to get into production
- Schedule does not include contingency for serious anomalies
  - Consequence grows at each higher level of integration
    - Instrument is hard to deintegrate
- Cost overruns

Summary

- All subsystems have begun flight production
  - Grid complete and being plated
  - First flight Calorimeter module in environmental test
- Anomalies uncovered in first flight unit production have delayed delivery of first flight tower
- Preparations for the Instrument Science Operating Center are well underway
- The LAT plan supports a February 2007 launch
- Cost and schedule will be reviewed after installation of the first tower
  - Review early in 2005
- The GLAST mission continues to have strong support from NASA and DOE
  - The budget is tight and uncertain for both agencies