

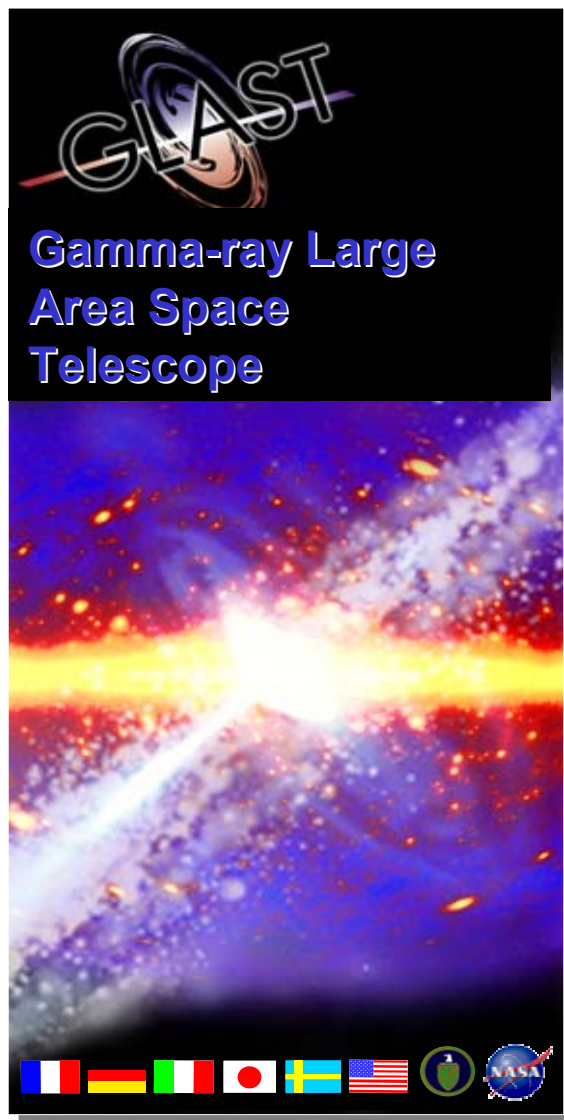
DRAFT REV 2

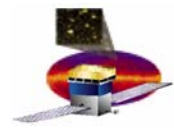
GLAST Large Area Telescope:

Tracker Overview WBS 4.1.4

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University of California at Santa Cruz
Tracker Subsystem Manager

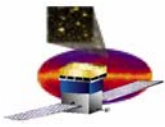
johnson@scipp.ucsc.edu





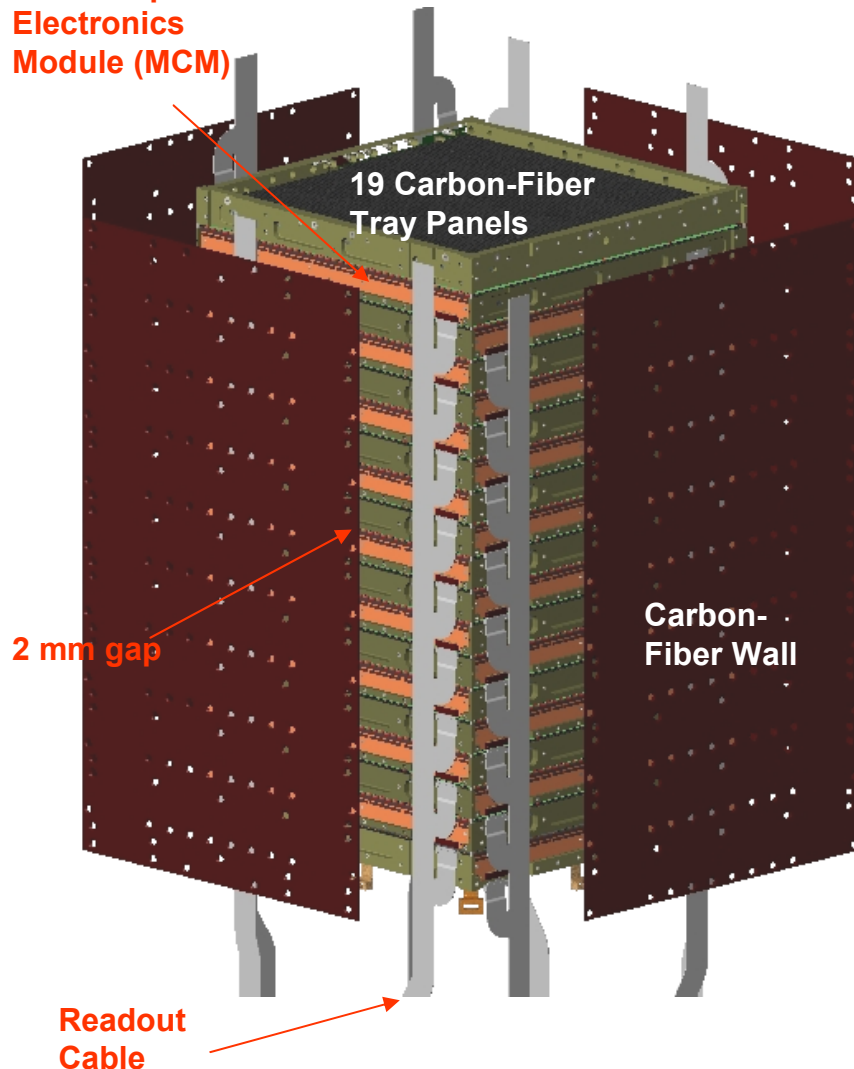
Outline

- **Overview**
- **Level III Requirements Summary**
- **Tracker Heritage & Prototype Experience**
- **Action Items from Previous Reviews**
- **Hardware Status**
- **WBS Interfaces**
- **Organization**
- **Schedule Milestones**
- **Cost**



Tracker Overview

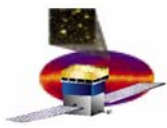
Multi-Chip
Electronics
Module (MCM)



LAT-PR-00663-02

- 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, WBS 4.1.4

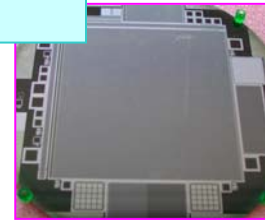


Tracker Production Overview

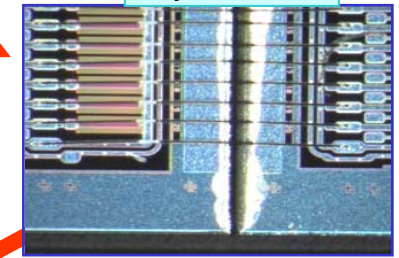
Module Structure (walls, flexures, thermal-gasket, fasteners)
Engineering: SLAC, Hytec
Procurement: SLAC

SSD Procurement, Testing
Japan, Italy, SLAC

SSD Ladder Assembly
Italy



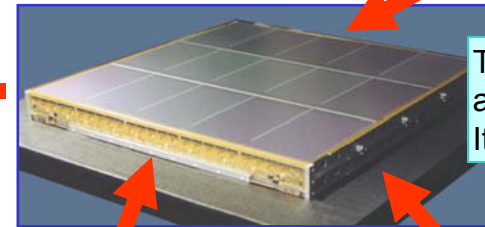
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Tracker Module Assembly and Test
Italy

18



Tray Assembly and Test
Italy

342

Cable Plant
UCSC

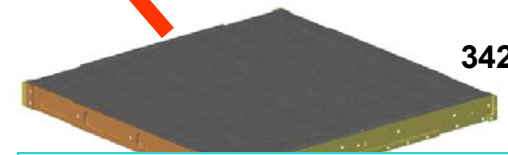
Electronics Design,
Fabrication & Test
UCSC, SLAC

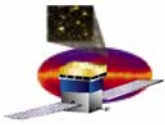
648



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

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Level-III Requirements Summary

Level-III requirements: LAT-SS-00017 (under configuration control)

Level-IV mechanical/thermal requirements: LAT-SS-00134

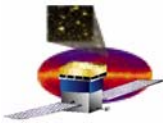
Level-IV electronics requirements: LAT-SS-00152

Mechanical/thermal ICD: LAT-SS-00138

Electrical ICD: LAT-SS-00176

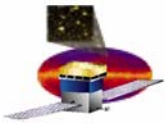
Performance Specifications (flow from the SRD)

Parameter	Requirement	Verification	Expected Performance
Conversion Efficiency	>65% at 10 GeV	Simulation	68%
Active Area	>19,000 cm ²	Analysis	19,600
Layer Detection Efficiency	>98% in the active volume	Cosmic-ray testing	>99%
Dead area	<12%	Analysis	10%
Aspect Ratio	<0.45	Analysis	0.42



Level-III Requirements Summary

Parameter	Requirement	Verification	Expected Performance
2-plane resolution (w/o mult. scatt.)	<0.2°	Analysis	0.15°
Conversions in non-converter material	<35% of conversions in front section	Simulation	33%
Material between modules	<5% rad. len.	Analysis	5.4% rad. Len.
Ionization Measurement	>1 σ separation of 1e ⁻ vs 2e ⁻	Analysis, Test	>1 σ (from BTEM results)
Self Trigger	>90% efficient	Simulation, cosmic-ray test	Meet Requirement
Trigger noise rate	<500 Hz	Test	<100 Hz
Hit occupancy	<10 ⁻⁴	Test	<10 ⁻⁵
Dead Time	<10% at 10 kHz	Test	Meet Requirement
Trigger Jitter	<±450 ns	Test	Meet Requirement



Level-III Requirements Summary

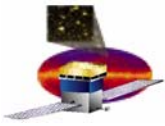
Other Key Specifications

Parameter	Requirement	Verification	Expected Performance
Module Size	0.3720 m wide 0.6400 m tall (stay clear)	Analysis, Test	0.3715 m wide 0.6247 m tall
Tracker Mass	<510 kg	Test	505 kg
Tracker Power	<185 W	Test	167 W
Thermal Control	Passive Cooling with <12°C rise	Analysis, Test	10.3°C
Reliability	96% in 5 yrs (not to lose >10% of channels)	Analysis	Meet Requirement

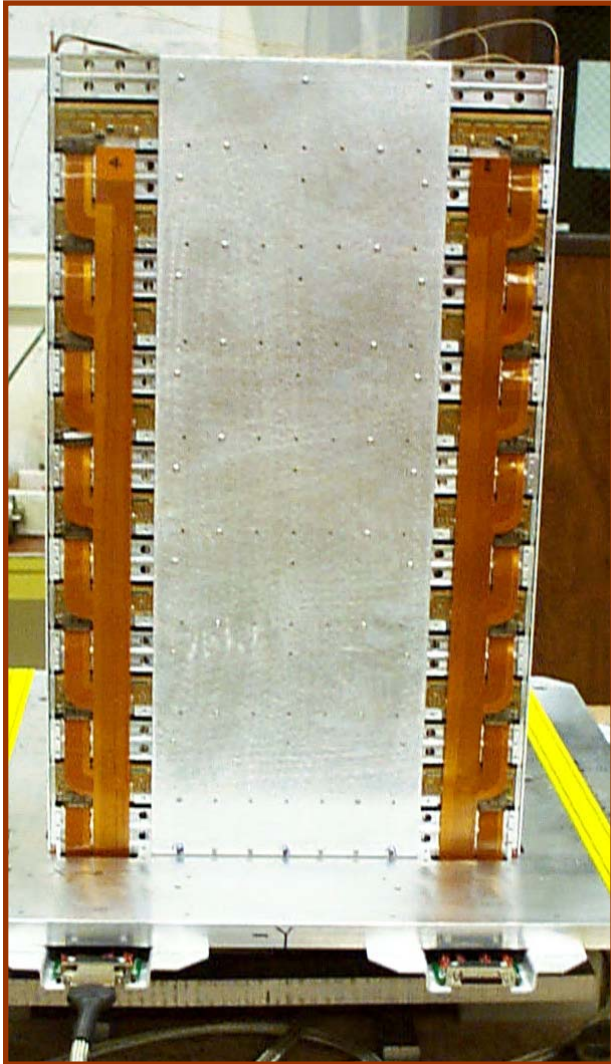


Heritage and Prototype Experience

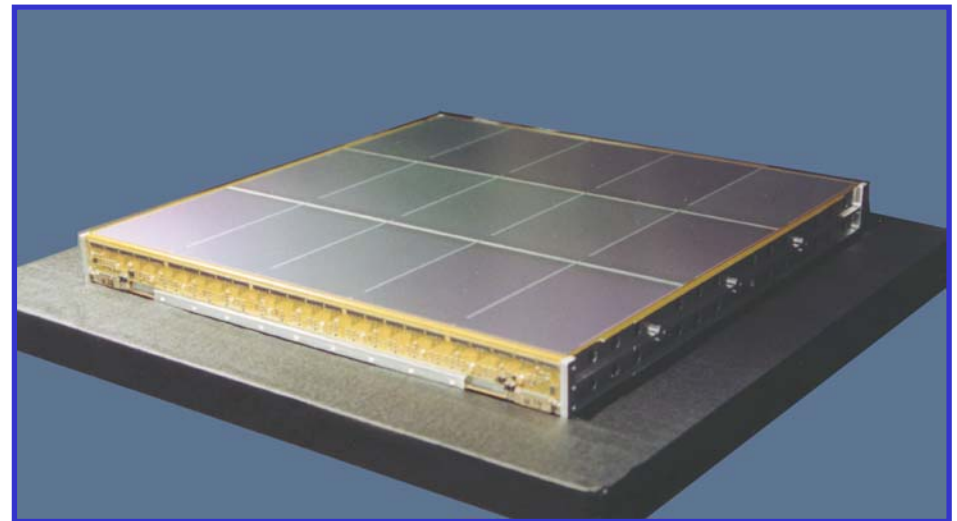
- **Heritage of Silicon-Strip detectors in space:**
 - ISEEC/HIST (1978)
 - ACE/SIS (1996)
 - NINA (1998)
 - AMS (Shuttle, 1998—large, 58k ch., double-sided detector application)
- **High-Energy Physics use of Silicon-Strip tracking detectors:**
 - Large silicon-strip systems in every major colliding-beam experiment since the SLAC Mark-II in 1986.
- **GLAST LAT experience (DOE and NASA ATD):**
 - **1997 SLAC Beam Test** (6 x,y planes; 2300 channels)
 - **1999 Beam-Test Engineering Model**
 - Complete Tracker module with geometry and detector/readout close to the present PDR baseline design
 - 16 x,y planes; 51,200 electronics channels
 - **2001 Balloon-Flight Engineering Model**
 - The same module operated flawlessly in low pressure
 - No damage in the handling, flight, or crash landing



1999 BTEM Tracker Module



- 16 x,y planes of SSDs
- 51,200 electronic readout channels
- Self-triggering
- Hit efficiency > 99% with noise occupancy $\ll 10^{-5}$
- This is with $< 210 \mu\text{W}/\text{ch}$ of power





Action Items from Previous Reviews

- **Further analysis of subsystem-specific failure modes**
 - See FMEA in LAT-SS-00178
- **Develop testing & assembly procedures, especially for electronics**
 - LAT-TD-155: Tracker module mechanical/thermal testing
 - LAT-TD-191: Tracker module electronics testing
 - LAT-TD-154: Tray mechanical/thermal testing
 - LAT-TD-153: Electronics test systems
 - LAT-TD-249: Tray electronics (MCM) testing and burn-in
 - LAT-TD-247: Front-end ASIC wafer testing
 - LAT-TD-248: Controller ASIC wafer testing
 - LAT-TD-246: Front-end ASIC prototype testing
 - LAT-PS-635: SSD ladder assembly procedures (1st draft)
- **Increase electronics engineering support and documentation**
 - Added an ASIC designer and a test engineer at UCSC.
- **Increase schedule reserve**
 - Qualification module delivery is 6 weeks early in PMCS
 - Delivery of the final module is 3 months early in PMCS



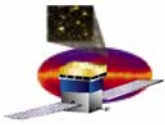
Action Items from Previous Reviews

- **Labor contingency for assembly.**
 - **Electronics:** Teledyne has more than adequate reserve capacity for assembly of MCMs.
 - **Ladders and trays:** we are working with 2 Italian vendors, each of which has sufficient capacity for the entire job.
 - **Mechanical structures:** our Italian vendor has reserve labor capacity, and we also have made prototypes with a U.S. composites vendor, which could be used in an emergency.
- **Vibration testing of silicon-strip detectors and wire bonds.**
 - Complete BTEM trays with SSDs, electronics, and both encapsulated and unencapsulated wire bonds were vibration tested with no damage observed.
 - INFN groups are preparing prototype detector ladders with the flight-design SSDs, wire bonds, and encapsulation for thermal and vibration testing to be carried out in the near future.
 - Recent vibration test at Ames included Si ladders with encapsulated bonds.
- **Procedures for handling of high-value, mission-critical items:**
 - Complete for SSDs: LAT-CR-00082, LAT-TD-00085, LAT-TD-00527
- **MOA with Italy**
 - Drafted, but sign-off still in progress.



Action Items from the January Review

- Baseline the Tracker with increased contingency.
- Evaluate pre-production integrated circuits thoroughly to ensure success of the full production run.
 - The second-round ASIC prototypes have problems that require a third iteration.
 - Testing will continue during the intervening 3 months on the first and second-round prototypes, using FIB to correct a few chips.
 - The test systems will be well understood and highly automated by the time the third-round ASICs are available, allowing rapid verification.
- Refine assembly and test procedures.
 - Refinement of the test procedure documentation is in progress. For the ASIC and electronics testing the procedures are already being implemented in computer code, so that they can be executed rapidly.
 - Documentation of some assembly procedures is in progress
 - SSD inspection and testing is already controlled, since flight SSD receiving and testing is in progress.
 - Ladder assembly is in draft form but must be released soon.
 - Teledyne is documenting the detailed MCM assembly flow.



Tracker Hardware Status

- Design concepts were validated by beam tests and the balloon flight.
- SSD production is on schedule for engineering-model and flight modules. The SSD quality continues to exceed specifications.
- Other long-lead procurements are beginning (tray closeout material).
- The designs of all Tracker components are complete and mature.
- All Tracker components (except cables, which are on order) have been prototyped and tested, with small detailed changes now being incorporated into the engineering-model design.

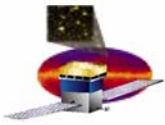


LAT-PR-00663-02

Prototype carbon-
fiber composite
tray panel.



Tracker, WBS 4.1.4

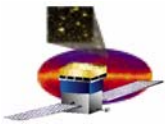


Tracker Hardware Status

- A full-size Tracker module was assembled from prototype carbon-fiber trays of all 3 types (plus some mass-model trays).
- Carbon-fiber walls (aluminum coated) and the flexure interface to the grid are included.
- Two assembly methods and associated tooling were tried out.
- The assembly was random-vibration tested to full qualification levels.
- No damage, except near the bottom tray where some screws backed out. This is being improved with more fasteners and will be retested.



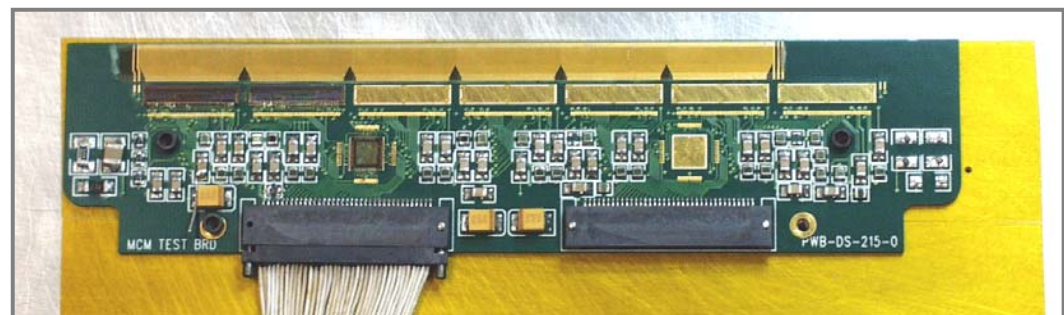
Prototype Tracker Vibration Test at NASA Ames

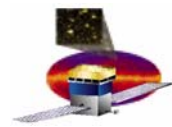


Tracker Hardware Status

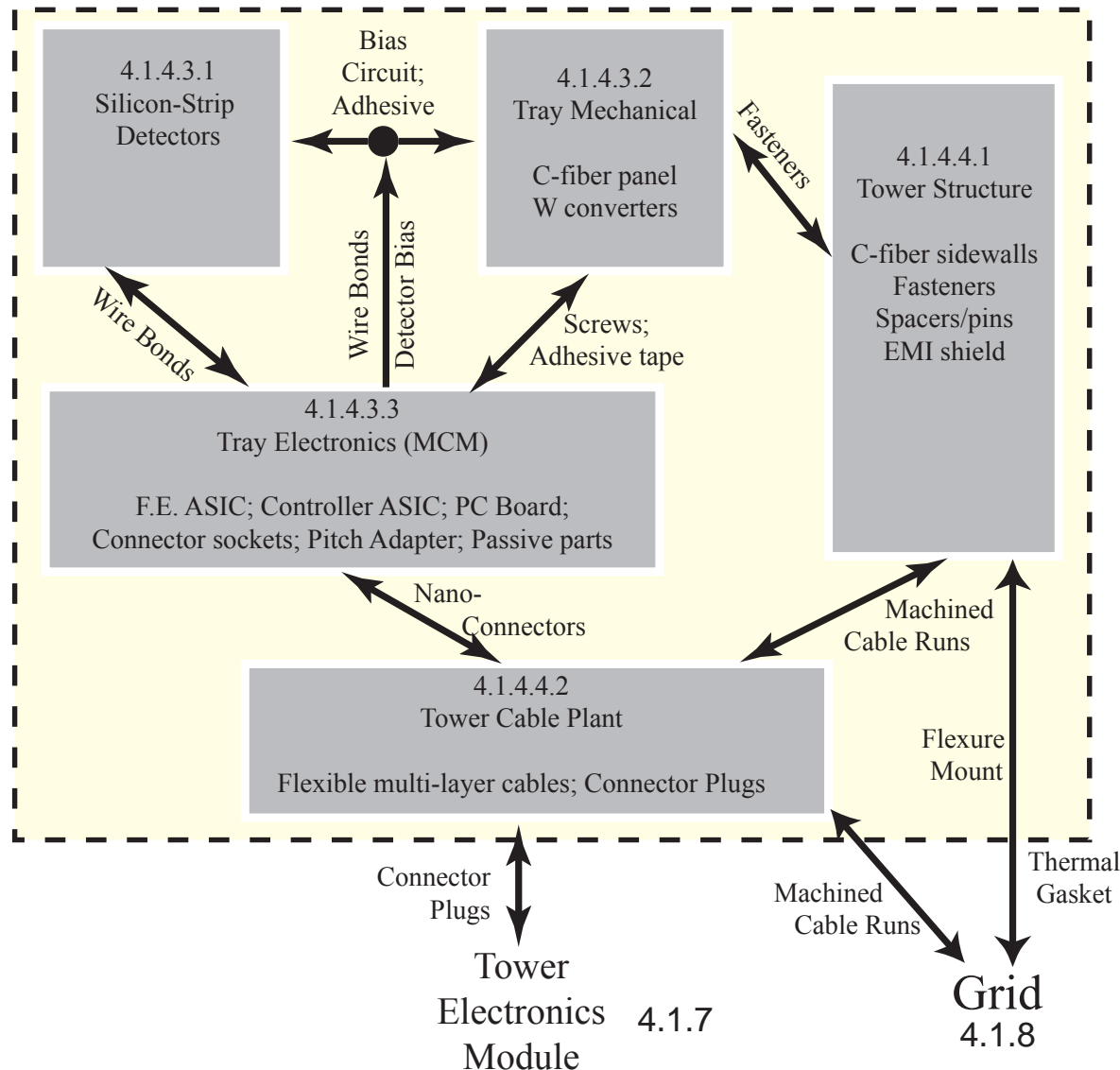
- The 2 Tracker ASIC designs were updated to satisfy new requirements, and prototypes were tested. Second-round prototypes of these ASICs were recently received and are now under test, but problems require a third-round prototype before the production order.
- PWB and flex-circuit designs have been completed and prototypes ordered.
- All SSD-ladder, tray, and Tracker-module assembly fixtures have been prototyped and tested.
- Vendors are under contract for MCM, ladder, composite panel, and tray assembly.
- Engineering model procurement is in progress for all electronic and mechanical parts: ASICs, PWBs, flex circuits, SSD ladders, carbon-fiber structural components, etc.
- Engineering model assembly is in progress for ladders, MCMs, and tray panels.

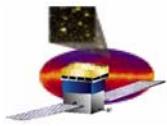
A shortened prototype MCM loaded with 2 prototype front-end chips and 1 controller chip.



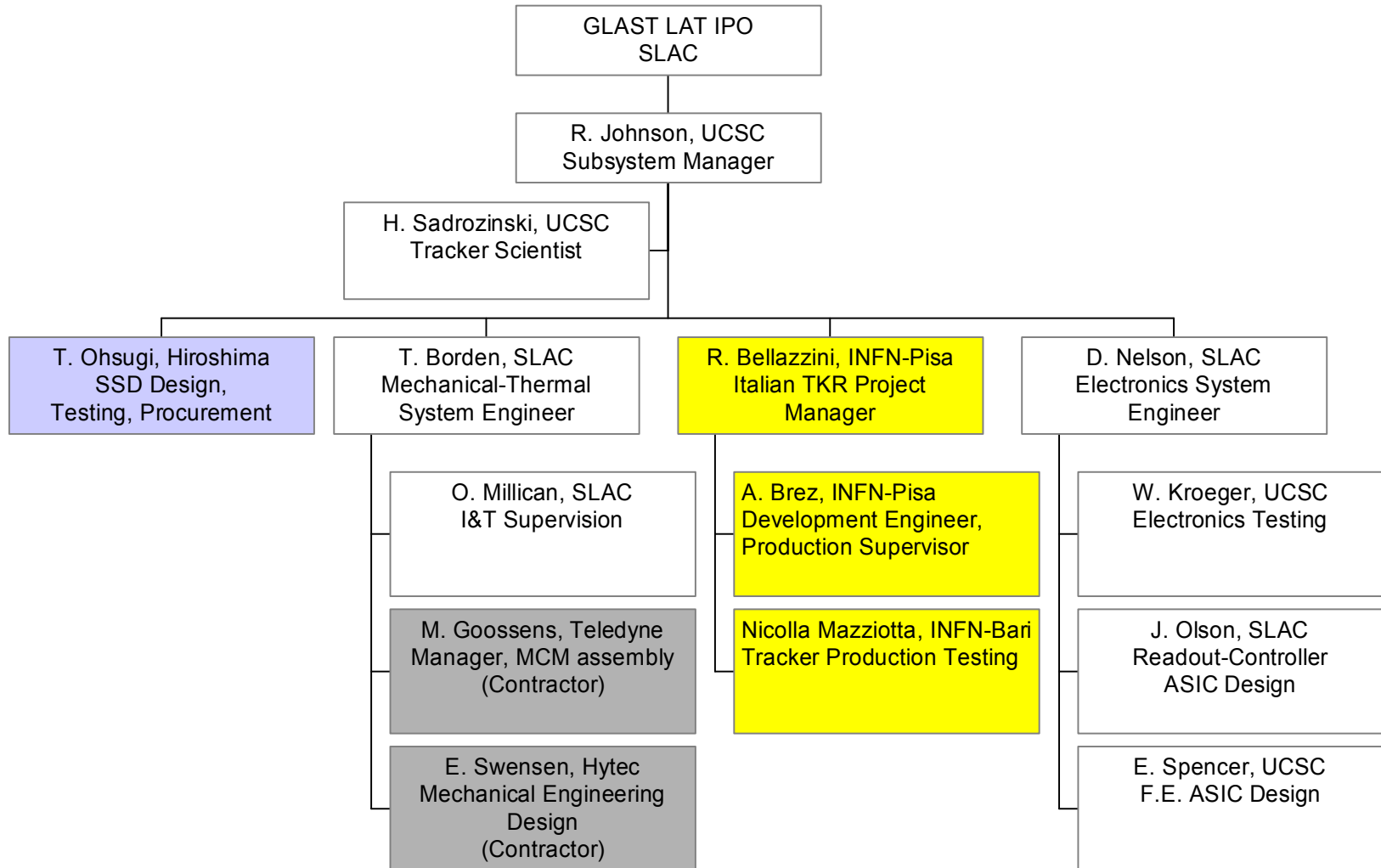


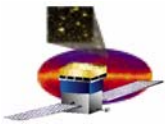
Subsystem WBS Interfaces





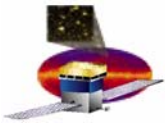
Tracker Organization Chart





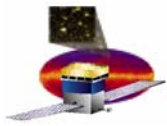
Key Tracker Milestones

Tracker Subsystem Requirements Review	03/22/01
Tracker PDR	06/19/01
Receive Com Card for TKR EM Functional Tests	10/16/01
Deliver 2 Mini MCMs to Elec (1 delivered)	02/07/02
Tracker CDR (delay until August or September)	06/18/02
Receive Pre-Eng Model TEM from Elec	06/19/02
Deliver 9 Eng. Model MCMs to Elec	07/02/02
Receive EM2 TEM for Qual Towers A,B from Elec	01/16/03
Deliver 36 MCMs for EM2 to Elec	03/25/03
TKR Qual Readiness Review	06/12/03
Review of TKR qualification test results	08/08/03

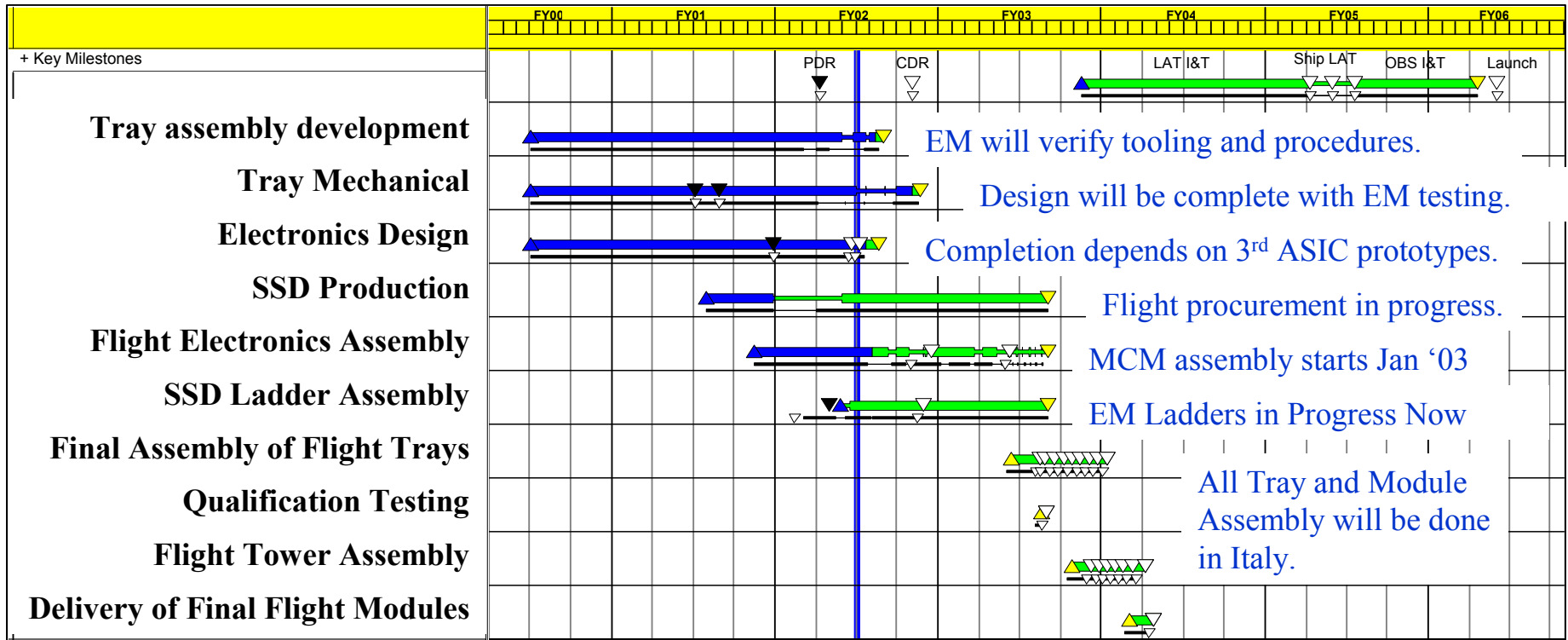


Key Tracker Milestones

Tracker Modules A & B RFI (for Calibration)	08/15/03
Tracker Modules 1 & 2 RFI (for Calibration)	11/03/03
Flight Tracker Tower 3, 4 RFI	01/02/04
Flight Tracker Tower 5, 6 RFI	01/15/04
Flight Tracker Tower 7, 8 RFI	01/29/04
Flight Tracker Tower 9, 10 RFI	02/12/04
Flight Tracker Tower 11, 12 RFI	02/26/04
Flight Tracker Tower 13, 14 RFI	03/10/04
Flight Tracker Tower 15, 16 RFI	03/24/04
Flight Tracker Tower 1, 2 RFI	04/26/04



Summary Tracker Schedule



EM will verify tooling and procedures.

Design will be complete with EM testing.

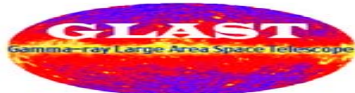
Completion depends on 3rd ASIC prototypes.

Flight procurement in progress.

MCM assembly starts Jan '03

EM Ladders in Progress Now

All Tray and Module Assembly will be done in Italy.

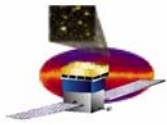


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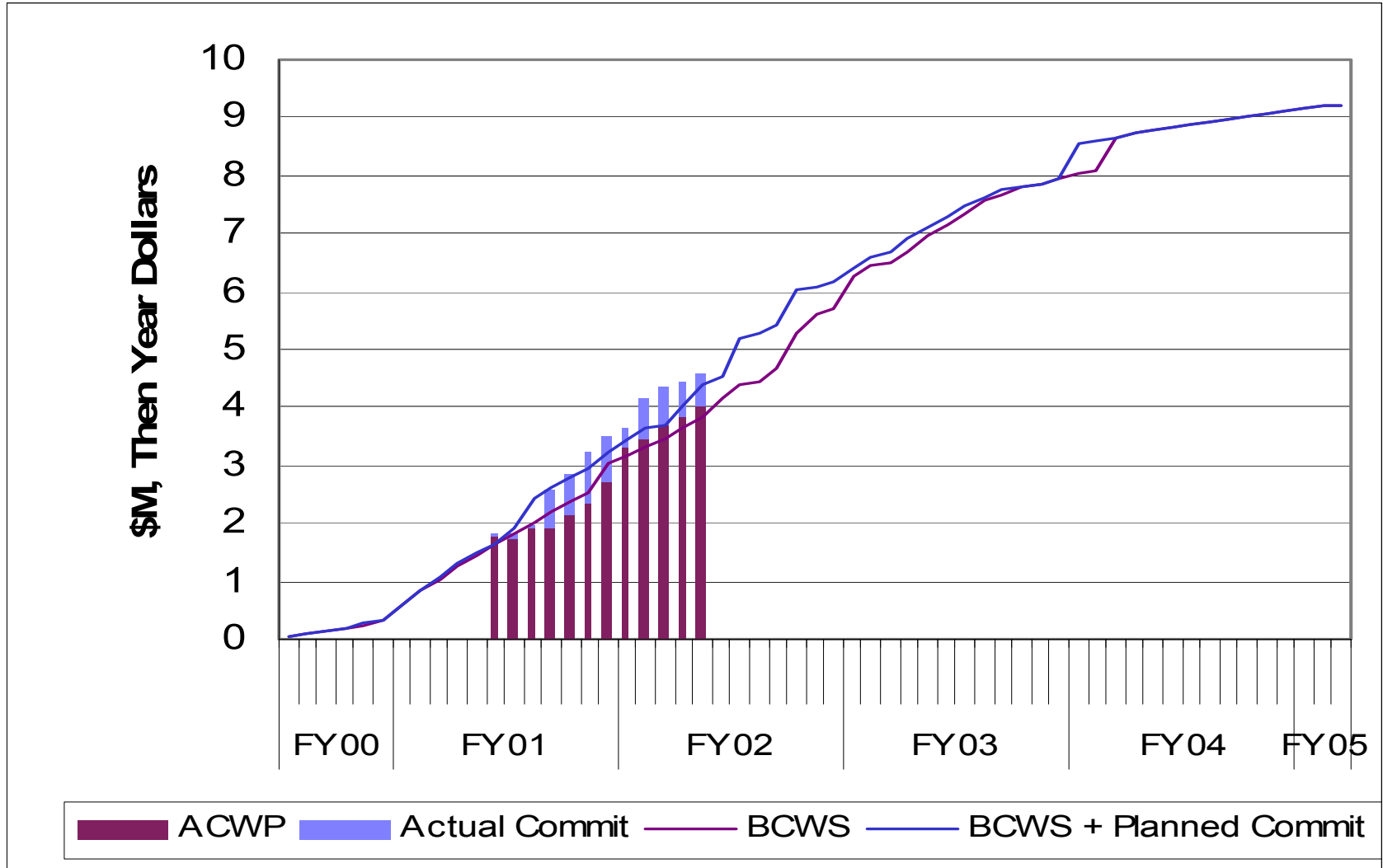


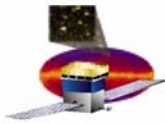
LT-RV Summary Schedule
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414 Tracker



Tracker Cost & Commitments





Tracker Cost Profile

