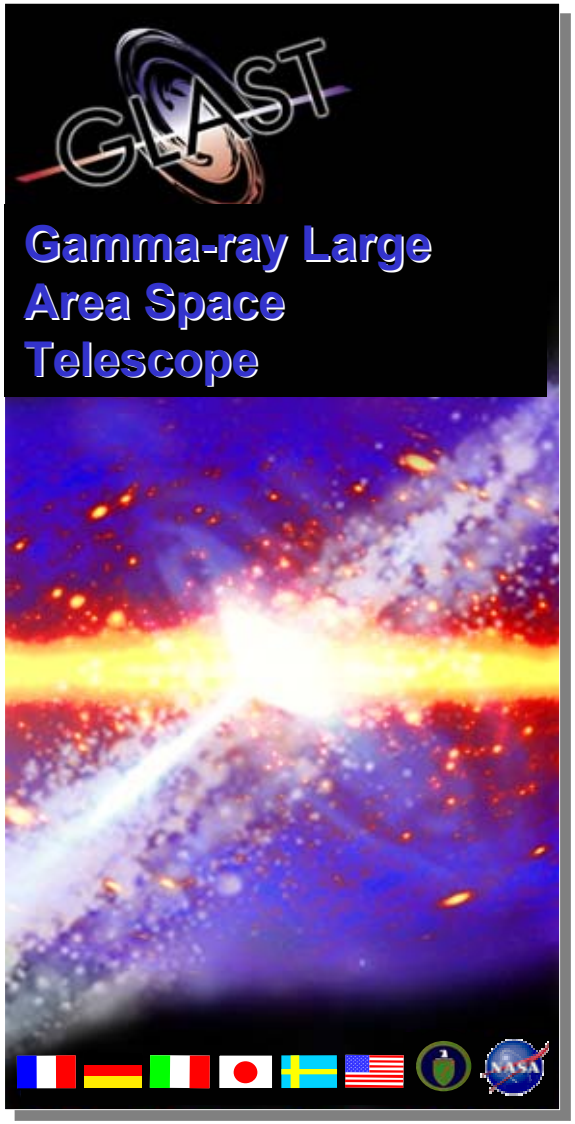

GLAST Large Area Telescope:
DOE/NASA Review
March 31, 2004
AntiCoincidence Detector (ACD) Subsystem
WBS: 4.1.6

David J. Thompson
Thomas E. Johnson
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Subsystem Manager/Instrument Manager

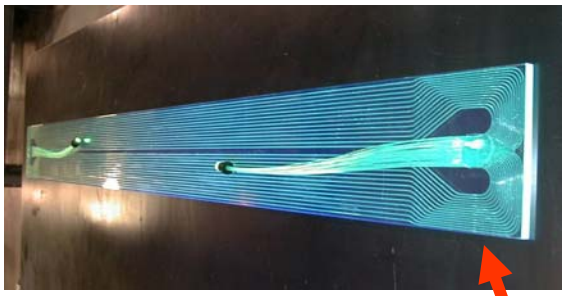
David.J.Thompson@nasa.gov
Thomas.E.Johnson@nasa.gov

Outline

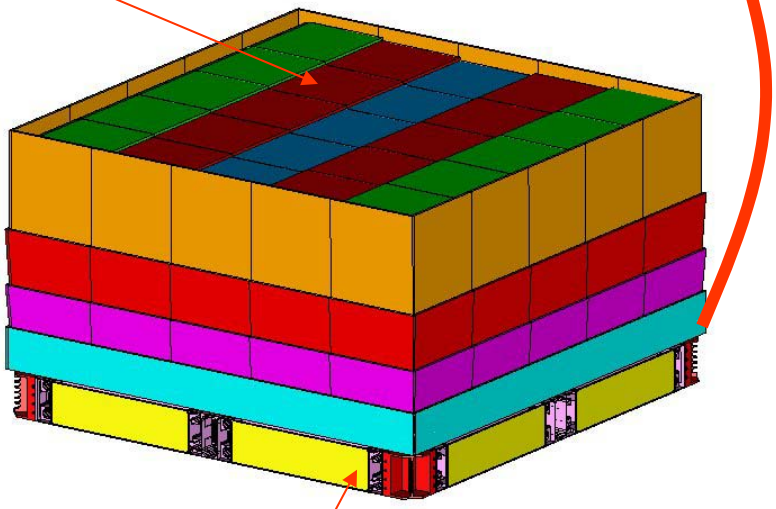
- Overview
- Status Report
- Issues and resolution
- Risk Focus
- Cost and schedule

LAT AntiCoincidence Detector (ACD)

Prototype ACD long tile read out with Wavelength Shifting Fiber



Tile Shell Assembly (TSA)

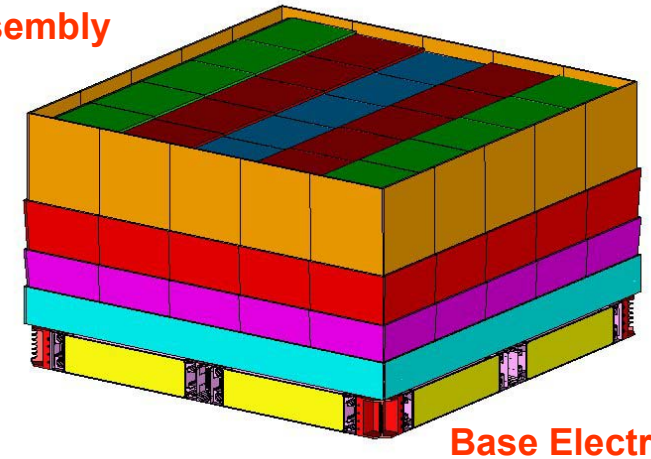


Base Electronics Assembly (BEA)

- **TILE SHELL ASSEMBLY**
  - 89 Plastic scintillator tiles
  - Waveshifting fiber light collection (with clear fiber light guides for long runs)
  - Two sets of fibers 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
  - Covered by thermal blanket + micrometeoroid shield (not shown)
- **BASE ELECTRONICS ASSEMBLY**
  - 194 photomultiplier tube sensors (2/detector)
  - 12 electronics boards (two sets of 6), each handling up to 18 phototubes. Two High Voltage Bias Supplies for each board.

ACD Work Flow Overview

Tile Shell Assembly (TSA)



Base Electronics Assembly (BEA)

Tile Detector Assemblies 04/04

Shell Subassembly 03/04

Tile Shell Assembly 6/04

ASIC Development 04/04

Front End Electronics Card Assembly 06/04

High Voltage Bias Supply 06/04

Photomultiplier tubes 06/04

Electronics Chassis 06/04

Base Electronics Assembly 07/04

ACD Integration 07/04

ACD Performance and Environmental Test 11/04

Ship 12/04

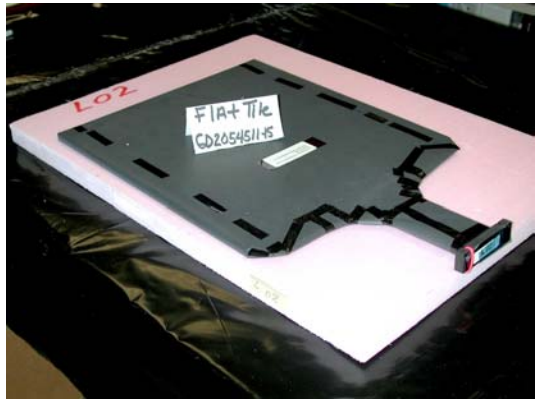
Base Frame Subassembly 03/04

Thermal Blanket Micrometeoroid Shield 07/04

Completion Dates Shown

Tile Detector Assemblies (TDA's)

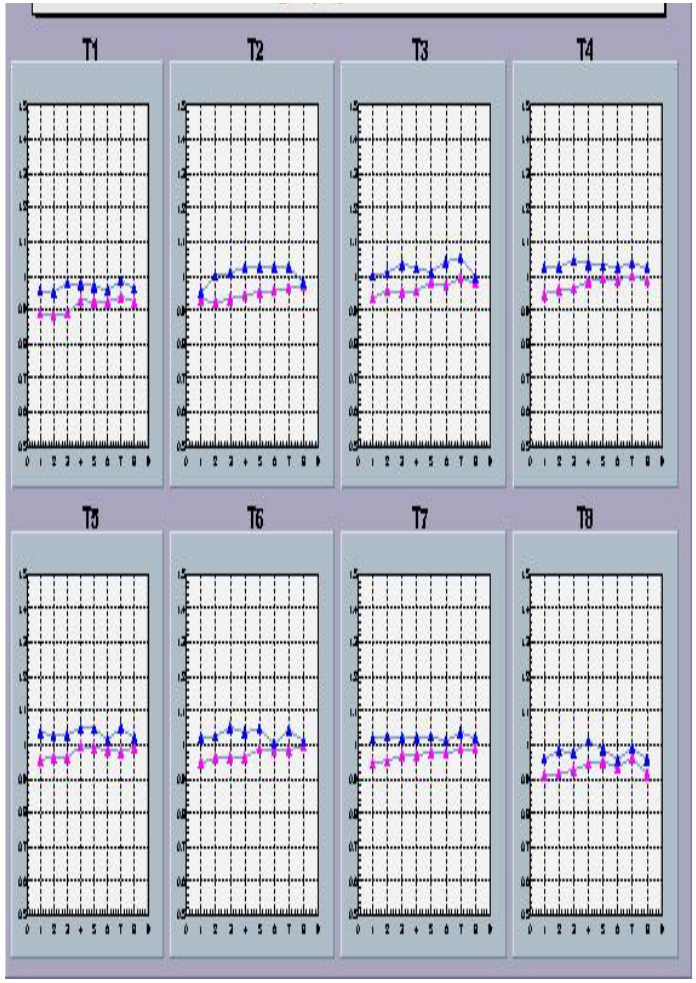
- **Status**
  - All 113 (89 flight, 24 spare) TDA's are in fabrication
  - 61 TDA's delivered by Fermi Lab
  - TDAs are in acceptance and performance testing. All those tested so far (>50) meet requirements
- **Plan**
  - All TDAs will be delivered by the end of April, well before needed for assembly.



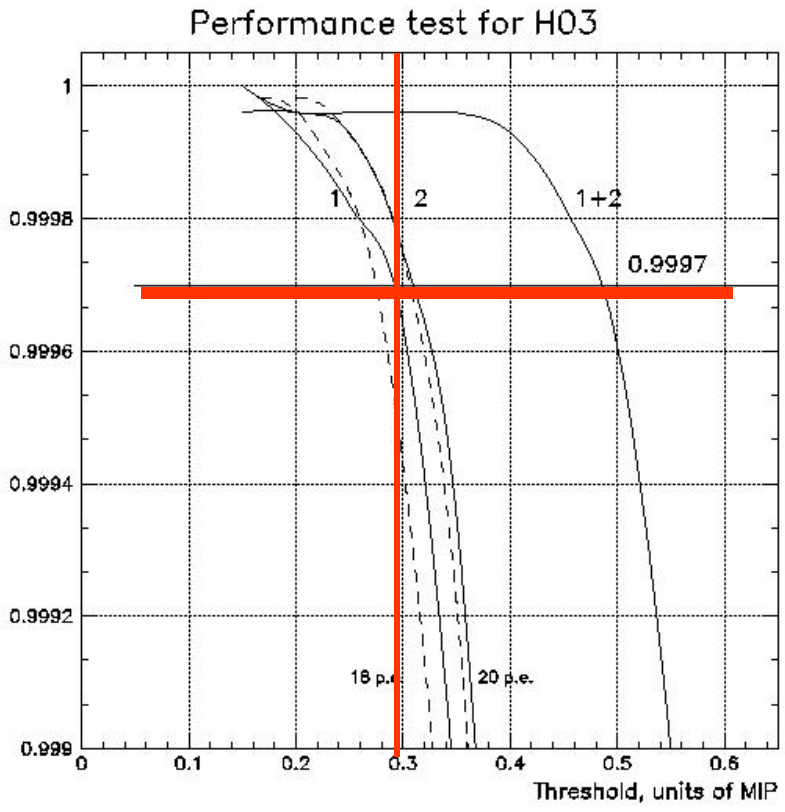
Individual TDAs after delivery

Flight TDAs in storage

Flight TDA Performance



8x8 mapping of TDA shows good uniformity.



Efficiency vs. threshold. Single phototubes meet requirement at 0.3 MIP threshold (as planned). With both phototubes, substantial margin.

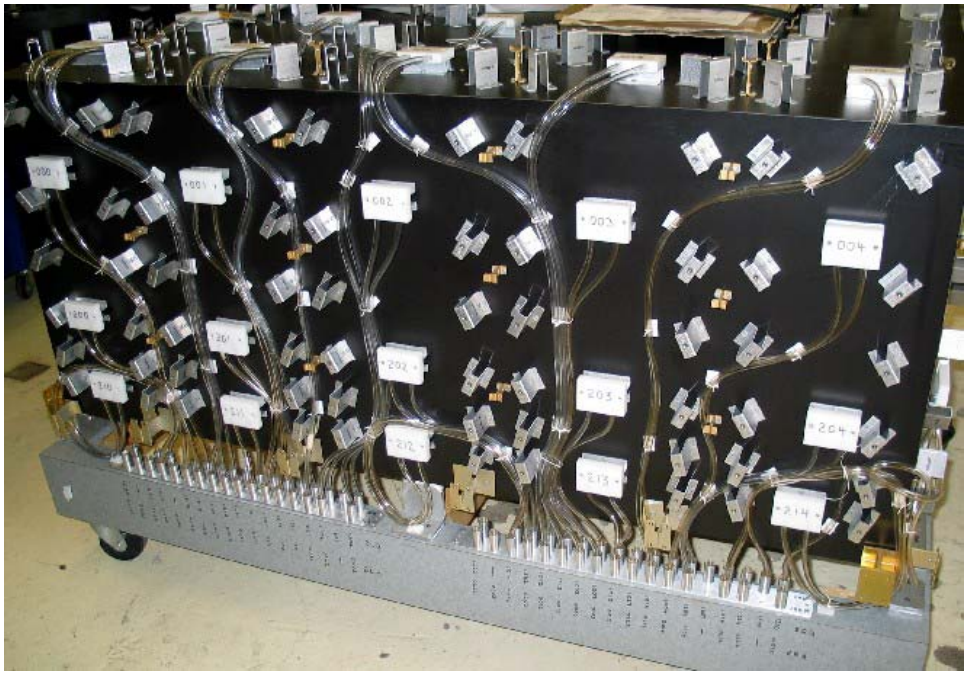
Shell Subassembly

- **Status**
  - **Flight unit assembly complete.**
- **Plan**
  - **Shell Subassembly being prepared for mechanical qualification testing**

Flight composite shell, with tile mounting flexures being bonded.

Tile Shell Assembly

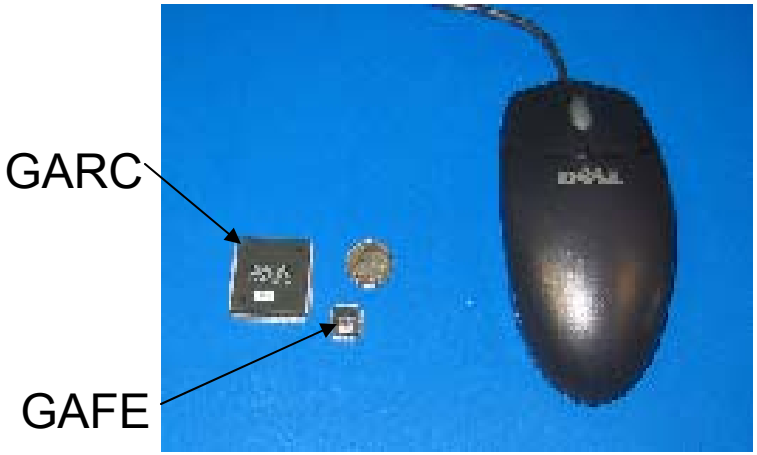
- **Status**
  - **Flight composite shell complete; tile detector assemblies being prepared for integration.**
  - **Full-scale mock-up is being used for cable routing.**
- **Plan**
  - **Following environmental testing of the mechanical structure, assembly of detectors onto the shell will start.**



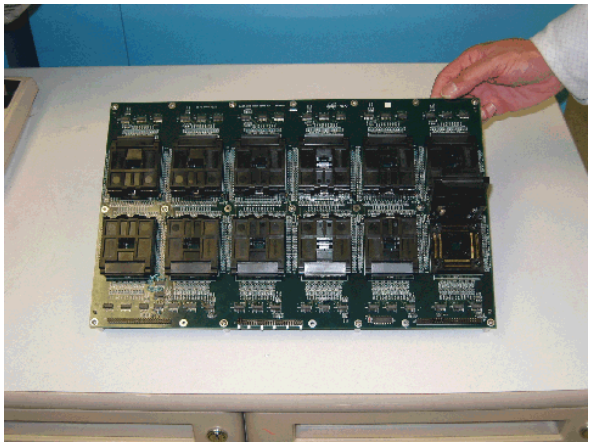
Full-scale mockup used to verify routing of fiber cables and placement of tile and ribbon mounting hardware.

ASIC Development

- **Status**
  - **Flight-packaged analog ASIC (GAFE) and digital ASIC (GARC) are in screening and qualification.**
- **Plan**
  - **ASICS are being mounted on the FRont End Electronics (FREE) boards as screening is completed.**



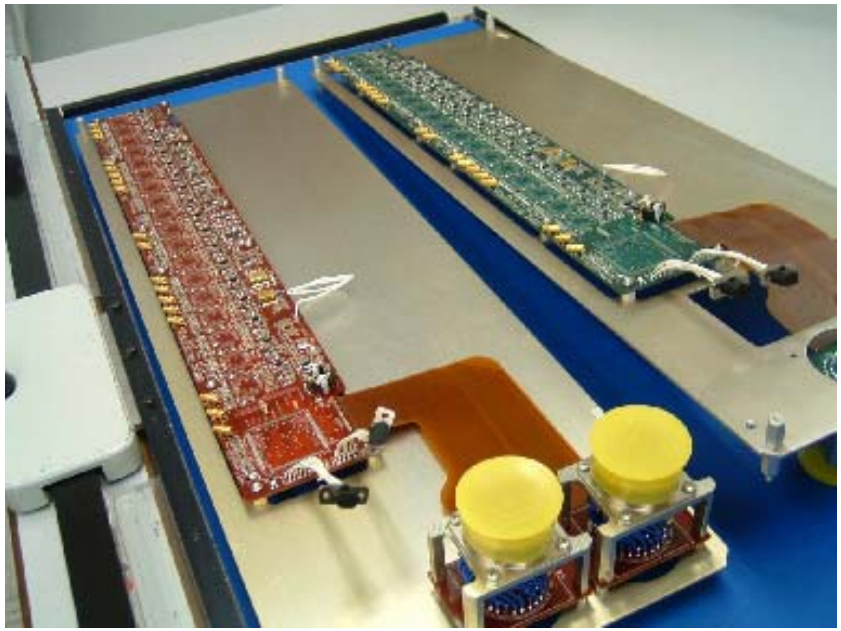
ACD ASIC's



ASIC Test Board

FRont End Electronics Boards (FREE)

- **Status**
  - **Flight quantity of FREE boards have been fully assembled with the exception of ASICs**
  - **The Analog ASICs (GAFEs) are currently being installed as they complete sceening.**
  - **A duplicate set of FREE cards has been delivered to LAT Electronics for the Test Bed.**

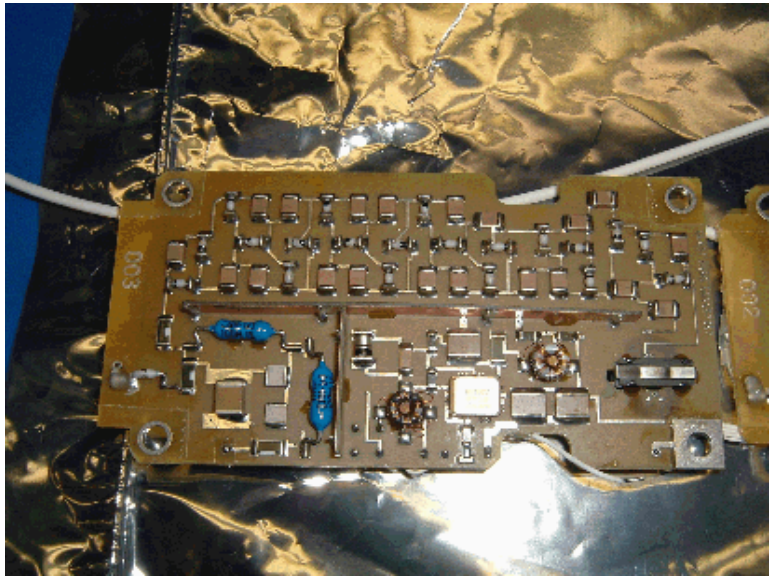


Flight FREE cards – right (red) and left (green)

- **Plan**
  - **The Digital ASICs will begin being mounted on the FREE Boards when screening is completed on March 31.**

High Voltage Bias Supply (HVBS)

- **Status**
  - **All flight parts with the exception of one capacitor that experienced an anomaly during life testing are ready for HVBS assembly**
  - **One side of the flight HVBS Boards have been populated with components.**
- **Plan**
  - **Replacement capacitor received on March 22.**
  - **Begin populating the second side of the HVBS when the new capacitors complete screening on April 10.**



High Voltage Bias Supply

Photomultiplier Tubes (PMT's)

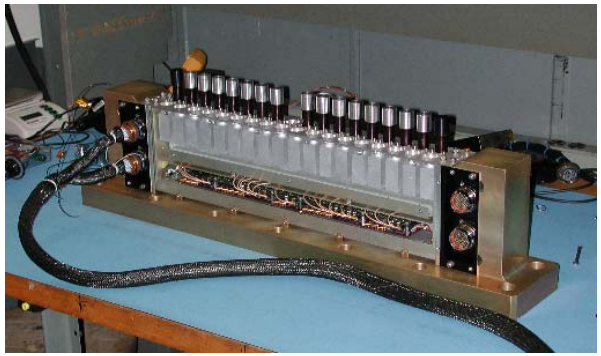
- **Status**
  - **Flight tubes have been received, tested, and are ready for the next level of assembly.**
  - **Qualification of the mounting for the tubes will be complete this week.**
  - **Assembly and installation of the resistor divider networks is starting.**
- **Plan**
  - **Complete assembly of 230 PMT's by June.**

Phototube and resistor network

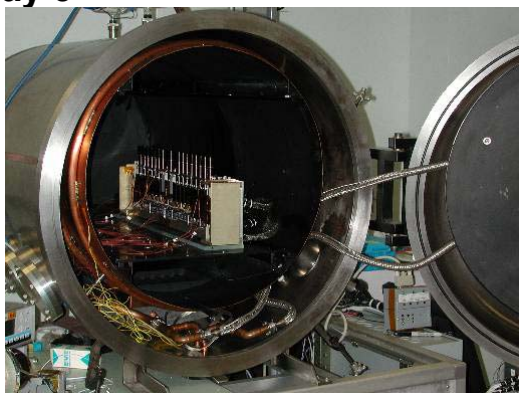
Resistor Network Production Tooling

Electronics Chassis

- **Status**
  - **Electronics Chassis consists of FREE Boards, High Voltage Bias Supply (2 per FREE Board), Photomultiplier Tubes (up to 18 per FREE Board), and the mechanical components required to package the electronics. There are a total of 8 flight Electronics Chassis (4 single FREE Boards and 4 double FREE Boards)**
  - **Completed environmental testing of Engineering Model Electronics Chassis**
  - **All components required for integration of flight Electronics Chassis are in assembly or fabrication**
- **Plan**
  - **Integration of flight Electronics Chassis will begin upon completion of first set of Photomultiplier Tubes, High Voltage Bias Supplies, and Front End Electronics Boards. First of 10 units (8 flight, 2 spare) to be completed on May 3**



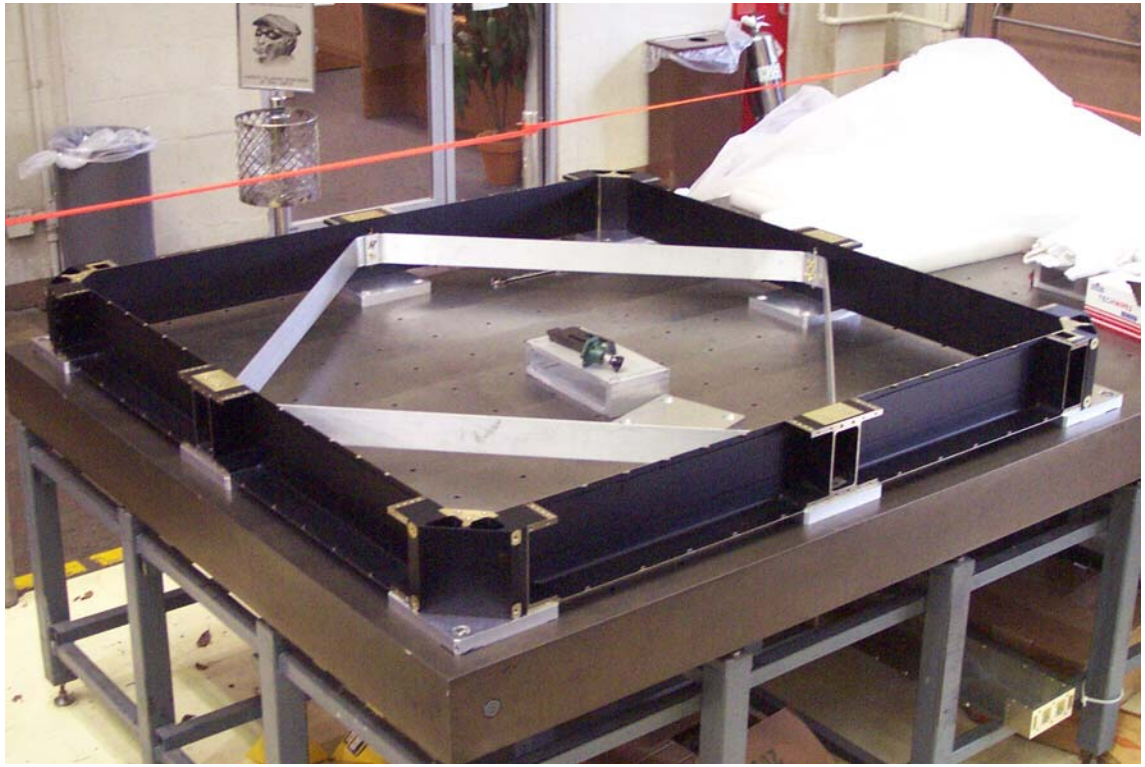
Electronics Chassis



Thermal Vacuum Test

Base Frame Subassembly

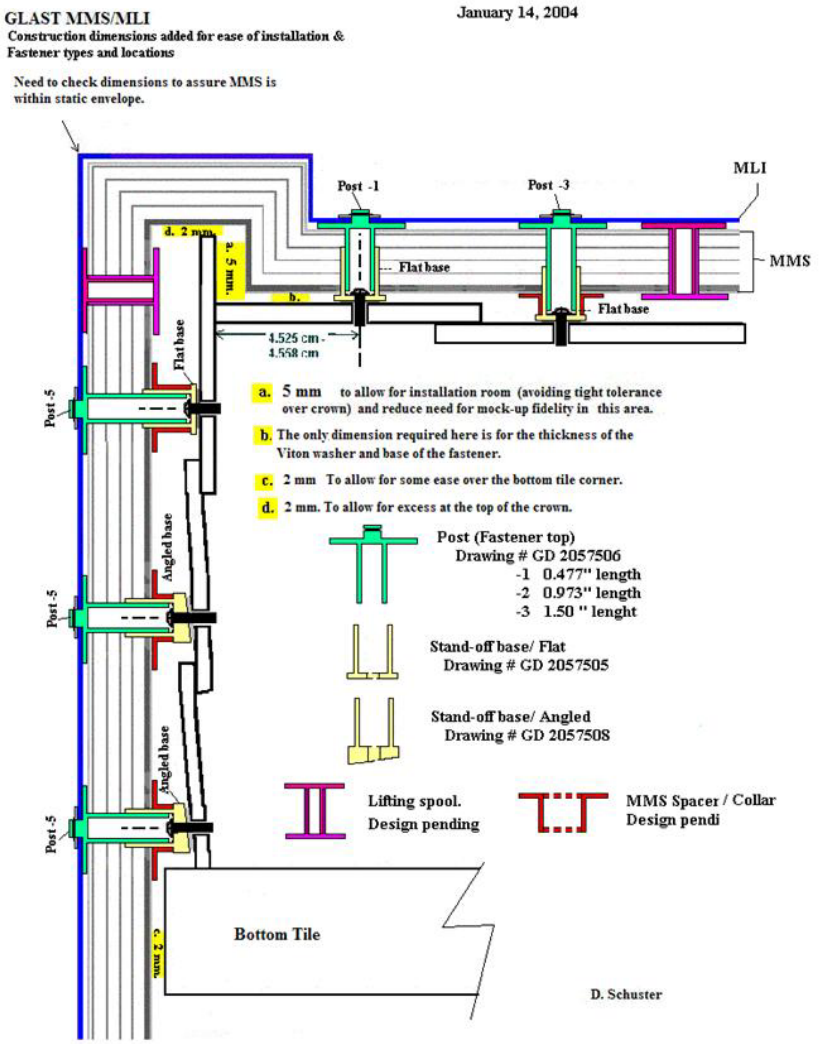
- **Status**
  - **Flight unit complete**



- **Plan**
  - **Mechanical assembly ready for mechanical qualification testing.**
  - **Perform match drilling to the LAT Grid in early May.**

Micrometeoroid Shield (MMS)

- **Status**
  - **Design is complete. Most materials have been purchased.**
- **Plan**
  - **Fabrication will start in May.**
  - **ACD Mockup to be used as a template for the fabrication of the Micrometeoroid Shield.**



Drawing Status/Plan

105 TOTAL DRAWINGS

74 Released, in CM system

31 in progress

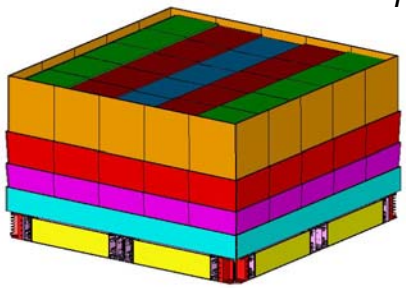
Plan for completion: all drawings completed as needed. 99 complete by end of March; all 105 complete by the end of April.

Fabrication, Assembly and Testing status

Number needed in parenthesis

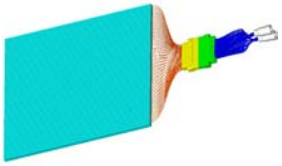
STATUS KEY

- Prototyped
- In Fabrication or Ordered
- Received
- In assembly
- Assembled
- Tested



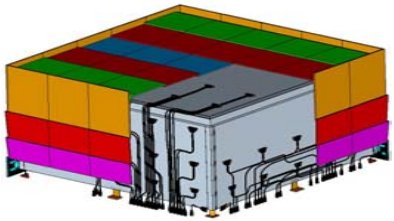
ACD Assembly (1)

Clear fiber cables (130) — 6 / 130

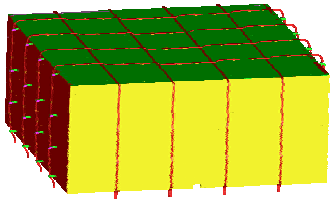


12 / All / 61 / 50

Detector assemblies - TDA - (4 basic types, 89 needed total)

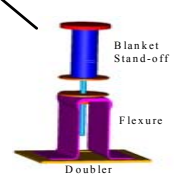


Tile Shell Assembly –TSA (1)



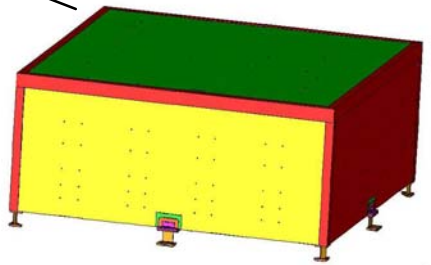
1 / 8

Fiber ribbon detectors (8)



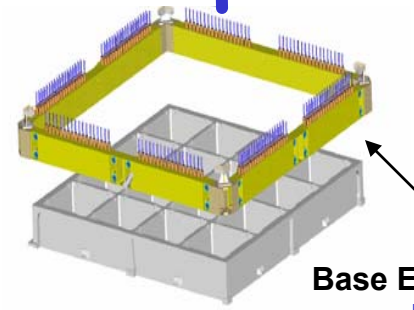
8 / 360 / 360

Detector Flexures (366+20 spares)



1

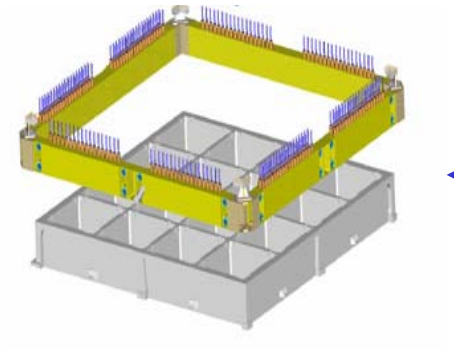
Composite Shell Assembly (1)



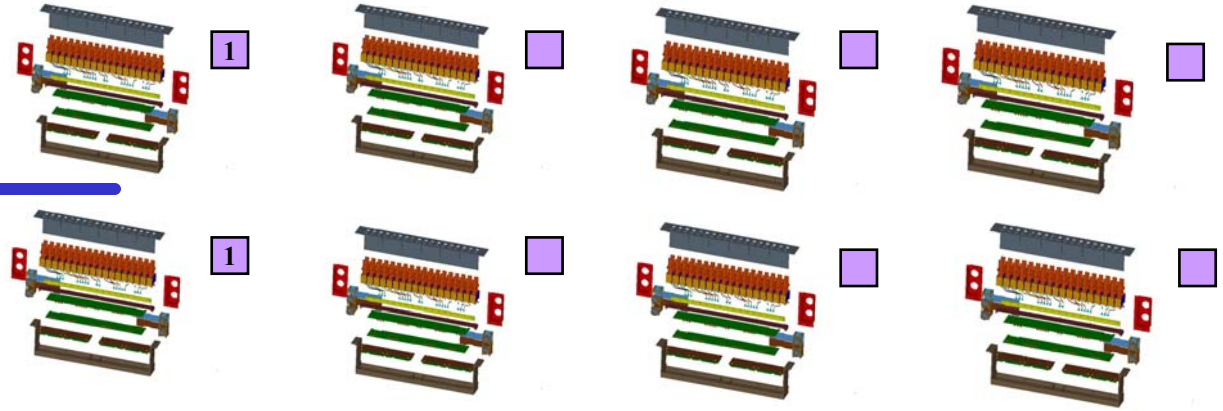
Base Electronics Assembly (BEA) From next page

r

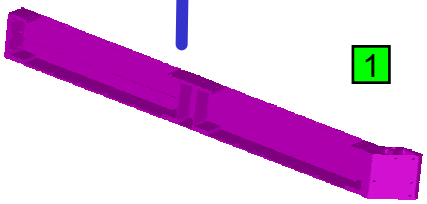
Fabrication, Assembly and Testing status



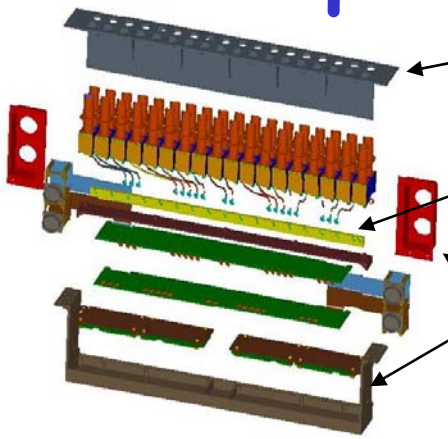
Base Electronics Assembly (1)



Electronics Chassis (8) (4 double + 4 single)



Base Frame Assembly (1)



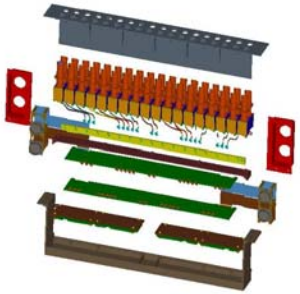
Photomultiplier Tube rails (8 + 2 spares) 1

Power distribution board (8+2 spares) 1

Chassis and connector frames (8) 1

Connectors 32

Fabrication, Assembly and Testing status



Electronics Chassis (8)

(4 double + 4 single)

Electronic Chassis Subassembly Item	Needed	Proto	Assembled or received	Tested	Ready for higher assembly
Photomultiplier Tube Assemblies	194 + 46 spares	Yes			
Photomultiplier Tube (PMT)	194 + 46 spares	Yes	240	240	230
Photomultiplier Tube housings	194 + 46 spares	Yes	240		
Photomultiplier Tube resistor networks	194 + 46 spares	Yes	30	30	30
Front End Electronics (FREE) 'right hand' boards	*4 + 2 spares*	Yes	6	6	6
Front End Electronics (FREE) 'left hand' boards	*8 + 2 spares*	Yes	10	10	10
GLAST ACD Front End chip – GAFE	*216 needed, 650 ordered*	Yes	800	800	60
GLAST ACD Readout Controller chip – GARC	*12 needed, 125 ordered*	Yes	800	40	0
Digital to Analog Converter - DAC MAX 5121	24 + spares	Yes	36	36	36
Analog to Digital Converter – ADC MAX 145	216 + spares	Yes	300	300	300
High Voltage Bias Supplies (HVBS) boards (24 + 6 spares)	24 + 6 spares	Yes	30	30	30
High Voltage Capacitors	218 + 52 spares	Yes	300		

Issues and Resolution

Issue	Impact	Resolution	Status
Interference found between waveshifting fibers and tile mounting hardware	Mechanical engineering and design time redirected, causing internal schedule variance and cost growth.	Design modification to routing of fibers in scintillator, special tooling for fiber routing, and changes in mountings.	Closed.
Flight-packaged analog ASICs delivered 6 weeks late; digital ASICs 9 weeks late	Delay in completion of the electronics assembly. Three week schedule impact to ACD to LAT RFI date. Cost impact due to schedule delay.	ASICs have been delivered; now in screening and qualification	Closed
Design flaw in digital ASIC allowed turn-on in non-functioning mode.	Turn-on of ACD jeopardized.	Adding 4 resistors to Front End Electronics boards corrected problem.	Closed
Photomultiplier Tubes cracked at low temperatures in thermal vacuum tests.	Schedule and cost impact to identify and solve problem. Threat to ACD performance.	Analysis and testing found two design solutions that reduce the stress by an order of magnitude.	New mounting now being qualified.
High voltage capacitor failed lifetime tests.	Delay in start of High Voltage Bias Supply assembly	Replacement part received on March 22	New capacitor in testing.

RISK FOCUS

Rank, Title	Risk Statement	Approach & Plan
1. EEE Part Failure	If: EEE part fails Then: due to the high volume of components, a significant cost and schedule impact will occur.	Mitigate: Order, test, screen, and qualify parts early.
2. Schedule / Milestone slips	If: Technical problems can not be rapidly resolved Then: A schedule slip will occur	Mitigate: Identify potential problems early and develop comprehensive plans to solve the problem. Optimize production flow in order to minimize schedule delays. Provide the required level of staffing to complete the task

RISK FOCUS

Rank, Title	Risk Statement	Approach & Plan
3. Aggressive scheduling of E.M. tests, fabrication and I&T due to schedule and cost pressure	If: Any unexpected problems with E.M. or flight subsystem during performance testing, qualification, or I&T Then: there is little reserve to handle the additional work and schedule delay	Mitigate Received additional schedule during LAT rebaseline. Watch Careful consideration leads us to believe risks are very minor. Risk for ACD because of volume of our parts and low remaining contingency
4. Electrical Interface problem between the ACD and LAT	If: there is an electrical interface problem between the ACD and the LAT. Then: a cost and schedule impact will occur.	Mitigate Test interface in a flight like condition and as early as possible. Re-test interface whenever a change is made.

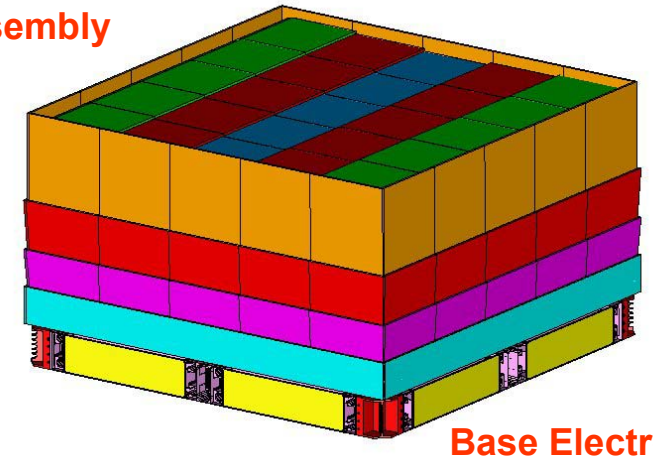
ACD Work Flow Overview – Critical Path

Tile Detector Assemblies 04/04

Shell Subassembly 03/04

Tile Shell Assembly 6/04

Tile Shell Assembly (TSA)



Base Electronics Assembly (BEA)

ASIC Development 04/04

Front End Electronic Card Assembly 06/04

High Voltage Bias Supply 06/04

Photomultiplier tubes 06/04

Base Frame Subassembly 03/04

Thermal Blanket Micrometeoroid Shield 07/04

Electronic Chassis 06/04

Base Electronic Assembly 07/04

ACD Integration 07/04

ACD Performance and Environmental Test 11/04

Ship 12/04

Completion Dates Shown

Critical Path in Red

ACD Cost/Schedule Variances

Budgeted Cost of Work Scheduled	Budgeted Cost of Work Performed	Actual Cost of Work Performed	Schedule Variance	Cost Variance
$11,750K	$11,235K	$10,799K	-$515K	+$435K

Primary Schedule Variances

-$58K Tile Shell Assembly – Tile Detector Assembly production

-$349K Base Electronics Assembly– ASICs late, phototube anomaly, HVBS capacitor failure

-$71K Mechanical Qualification – shipping damage to composite panel

-$32K GSE – design manpower diverted

Primary Cost Variances

+$592K Management, Science, Taxes – Lower than planned science support and GSFC taxes

+$105K Tile Shell – invoices behind

-$846K Base Electronics – phototube anomaly, parts testing, electronics fabrication

+$435K GSE – Civil Service manpower and invoices behind

Approved
Cost Changes Since Rebaseline

(k$)	
4.1.6 Baseline, November 03	$13,870
Changes:	
• BEA Changes	$ 98
• EGSE SW Support	$ 52
• Stanford Benefits Rate Increase	$ 2
Total Change	$ 152
4.1.6 Baseline, February 04	$14,022
Approved Changes in March 04	
• MPS Tax Reduction	$ (820)*
• Mech Mat'ls & Support	$ 195*
• PMT Anomaly Resolution	$ 299*
• BEA Changes	$ 222*
Total March 04 Change	$ (104)

**Corresponding NASA funding change*

ACD Summary

- Over the past several months, the ACD has encountered and overcome several technical and schedule challenges.
- Flight scintillator tile detectors and mechanical structure for the ACD are nearing completion.
- Phototube and electronics assemblies have been tested and are starting into production.
- All elements of the ACD planning are in place for completing the subsystem on schedule.

Backup Material

ACD Schedule Variances

- 4.1.6.3 - TSA Schedule Variances (-$58K cum, -$3K February)
  - ($29K) – Flight Spare TSA Fab
  - ($26K) – Flight TDA Work
- 4.1.6.4 BEA Schedule Variances (-$349K cum, -$53K February)
  - ($33K) – HVBS Flt Unit PCB
  - ($100K) – RN/PMT Integration
  - ($126K) - RN Flt Unit Assemble & Populate All
  - ($38K) - ASIC Delay
- 4.1.6.6 Mech Qual and Cal Unit (-$71K cum, -$74K February)
  - ($71K) – Shipping damage to composite panels
- 4.1.6.B GSE Schedule Variances (-$32K cum, -$4K February)
  - ($32K) – Design support diverted to support Tile Shell Assembly

ACD Cost Variances

- 4.1.6.1 ACD Project Management/Sys Eng/Science (+$592K cum, $243K February)
  - +$253K - Labor support lower than planned due to lower than planned science simulations and test support ($148K), systems engineering being covered by GLAST Project ($52K), Science Support lag in accruals ($45K), Travel ($8K)
  - +$361K - MPS/Lab Tax lower than planned.

- 4.1.6.2 Safety and Mission Assurance (+$41K cum, -$37K February)
  - +$41K - Cross utilizing support with the GLAST project

- 4.1.6.3 Tile Shell Assembly (+$105K cum, -$200K February)
  - ($200K) - Labor higher than planned to complete drawings
  - +$302K - Materials – Invoice for shell panels not submitted and fabrication work not invoiced yet. ($80K) due to 50/50 earned value on TDA's

ACD Cost Variances

- 4.1.6.4 Base Electronics Assembly (-$846K cum, -$131K February)
  - ($295K) Labor - Design changes (EMI and cabling CR for $98K) and performed additional analysis (model updates and cabling). PMT and assembly issues PMT anomaly analysis charges (CR approved for $299K in March).
  - ($349K) M&S – Radiation testing, parts screening, FREE and Resistor Network assembly set up (CR approved for $222K in March).
  - ($46K) SLAC ASIC charges.
- 4.1.6.5 MS/TB (+$27K cum, -$5K February)
  - +$27K – JSC cost reporting behind actual work performed.
- 4.1.6.B Ground Support Equipment (+$453K cum, +$15K February)
  - +$163K of labor covered by GLAST project
  - Using CS support instead of contractor support.
  - Have not been invoiced for work completed on handling dollies.