



GLAST Large Area Telescope:

Calorimeter (CAL) Subsystem

WBS: 4.1.5

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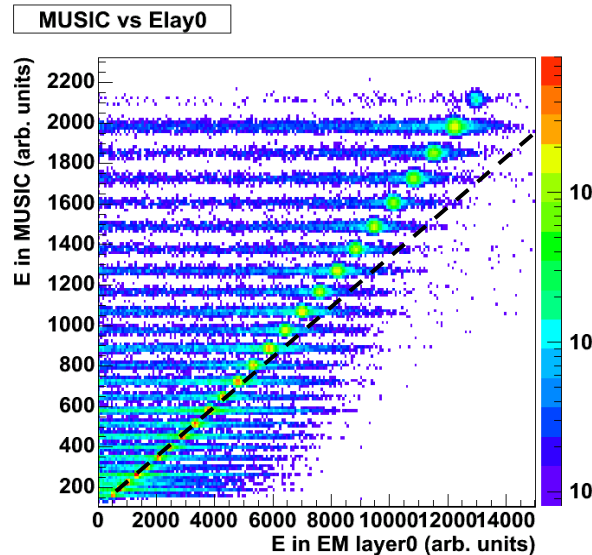
Technical Status Engineering Model

- ❑ Completion of the CAL Engineering Model environmental test program (qualification levels)
 - No problems identified in Vibration or Thermal Vac testing
 - EMI/EMC issues were identified
 - Contributing causes – test configuration issues and fidelity of TEM/PS unit used (GSE not flight-like).
 - Design changes have been applied to flight design to address these problems.

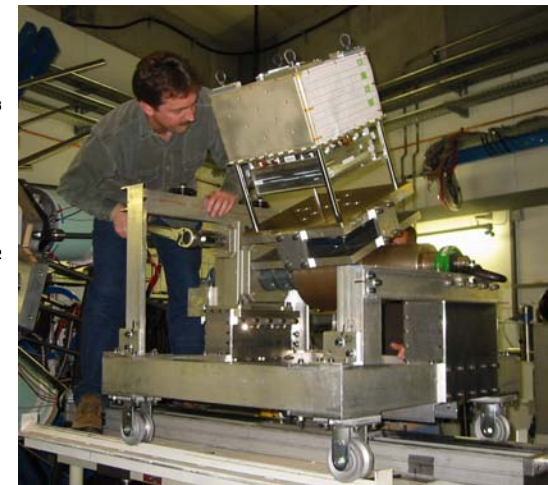
- ❑ EM CAL supported LAT I&T development at SLAC

- ❑ EM CAL performance measured at heavy ion beam test at GSI in Darmstadt, Germany.

EM Energy vs Beam Tagger shows quenching in CsI



EM Calorimeter installation at heavy ion beam facility





Technical Status

Crystal Detector Elements

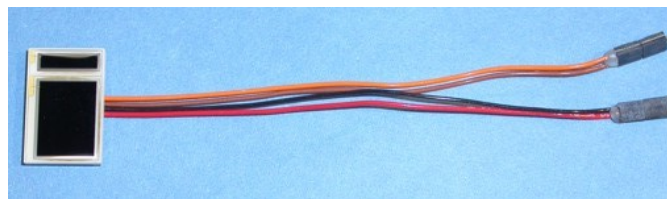
- ❑ Csl Crystal Procurement essentially complete (~80% delivered from Amcrys-H).
- ❑ Hamamatsu photodiode procurement is complete.
- ❑ PIN Diode Assembly process and contract established. Flight production is well under way (> 40% complete).
- ❑ PIN diode and CDE qualification programs are complete.
- ❑ Flight CDE production is well under way (>25% complete.)

ISSUES: None

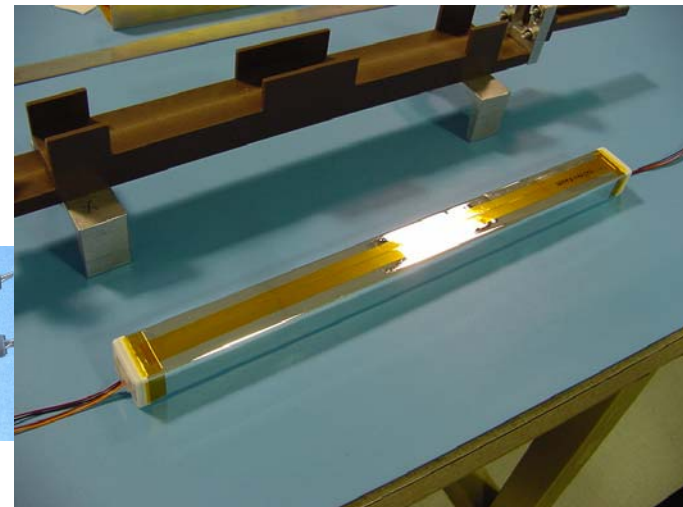
SCHEDULE: Baseline

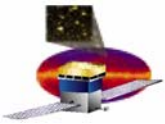


CDE Bonding at Swales Aerospace



PIN Diode Assembly (PDA)



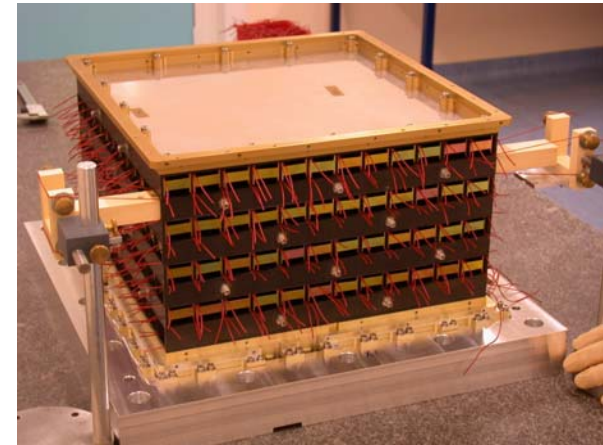


Technical Status

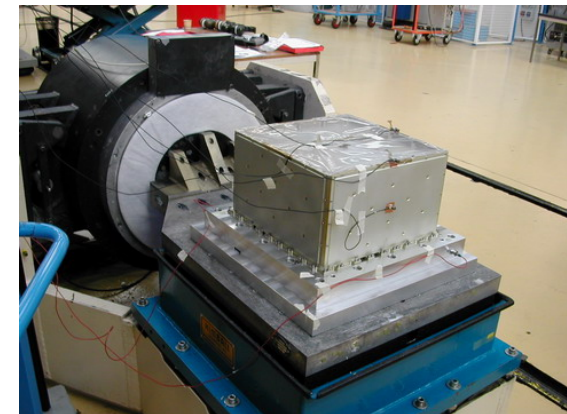
Mechanical Structure

- ❑ All flight machined aluminum, titanium and steel parts have been manufactured and plated as required.
- ❑ Flight carbon composite structure manufacturing process has been finalized at IN2P3/LLR and qualified with Structural Model 2 (SM2) testing.
- ❑ First three flight structures have been manufactured, tested. Two have been delivered to NRL.

ISSUES: None
SCHEDULE: - 35 Day Variance



Carbon structure with test Al parts and dummy CDEs



Vibration test of FMA structure



Technical Status

ASICS

- ❑ New revision of analog ASIC, GCFE9A, has been manufactured and tested.
- ❑ Over 11,000 flight parts were received after two month delay in packaging at ASAT in Hong Kong.
- ❑ Functional test screening provided >7,000 parts. Screening and qualification program is on-going. No problems to date.

Add testing picture

ISSUES:

Recovering from 9 week delay in delivery.
Use before completion of qualification

SCHEDULE: -53 day variance



Technical Status

Analog Front End Electronics

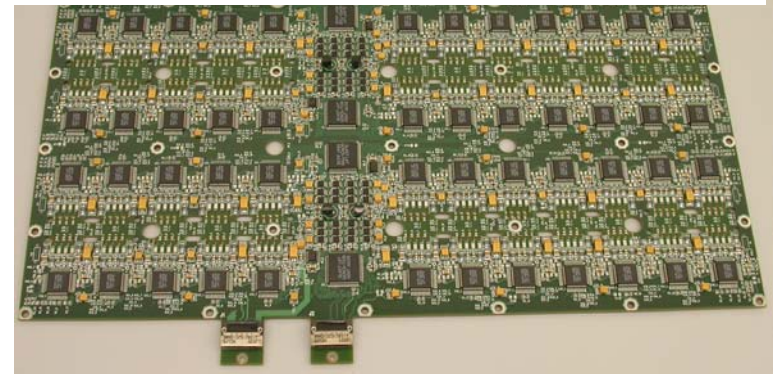
- ❑ All EEE parts are approved except ASICs which are in qualification testing.
 - Radiation testing complete except for Total Dose on ASICs. No problems.
- ❑ Prototype of flight AFEE boards have been manufactured, assembled and tested.
 - Minor adjustments required to avoid potential mechanical interference with structure for parts added for EMI/EMC filtering.
- ❑ Flight PCBs are being manufactured.
 - Contract for assembly of flight AFEE boards is in place.

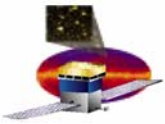
ISSUES:

Rework of mechanical interference problems on PCB and pre-production review

SCHEDULE: -24 day variance

Prototype Flight AFEE Card Assembly





Technical Status Assembly and Test

- ❑ GLAST CAL assembly and test clean room has been commissioned.
 - Upgrades for improved control of humidity are underway.
- ❑ Pre Electronics Module (PEM) for the first flight module has been assembled.



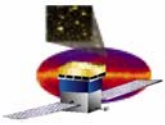
UPDATE
PHOTOS –
these are EM



PEM in cosmic muon test station.

ISSUES: None

SCHEDULE: -17 day variance



Outstanding Issues

□ EMI/EMC performance

- Design changes have been made to address EMI/EMC problems discovered in CAL EM testing.
- Results of these changes will not be known until EMI/EMC testing on 1st flight module.
- Issues are
 - Shielding of CAL – TEM cable and box attach points.
 - Test specification – difficulty in separating CAL and TEM/PS performance issues.
 - Test configuration – identification of subsystem configuration which represents LAT environment, shielding, etc.

First opportunity to close this issue is during testing of FMA.



CAL Risk Summary

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
CAL-0xxx	Moderate	IF a problem is found in EMI/EMC testing at the CAL module level caused by CAL, EM TEM/PS; or test configuration THEN LAT EMI/EMC performance is at risk and can not be verified until system level test.	<ol style="list-style-type: none">1. Based on EM testing, CAL mechanical design modified to include EMI gaskets and "o-rings" to provide improved shielding. Additional filtering added to AFEE electronics cards2. Develop more realistic test configuration and use more flight-like TEM/PS.	Open
CAL-0008	Low	IF a problem is found in CAL AFEE board design, SMT manufacturing, testing, PEM assembly and qualification (due to late qualification) THEN redesign of AFEE boards will cause schedule slip.	<ol style="list-style-type: none">1. Prototype of board layout was manufactured and hand assembled. Several minor layout changes are required for final flight.2. First flight article will be assembled, tested and thermal cycled before release to assembly of remainder. Schedule issue, however.	On Track



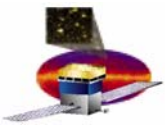
CAL Risk Summary (2)

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
CAL-0010	Low	IF CAL ASICs fail qualification testing; THEN the flight CAL AFEE boards in build will be impacted causing schedule impact and loss of flight parts.	Boards will be assembled in three lots <ol style="list-style-type: none">1. 1st article verification2. lot of 6 modules3. lot of 18 modules the assembly of which will not occur until qualification testing is complete.	On Track
CAL-0011	Moderate	IF CAL problem is found during production; THEN multiple flight units may be impacted due to schedule compression resulting in schedule impact.	<ol style="list-style-type: none">1. Verify production processes during EM program2. Extensive EM environment test program	On Track



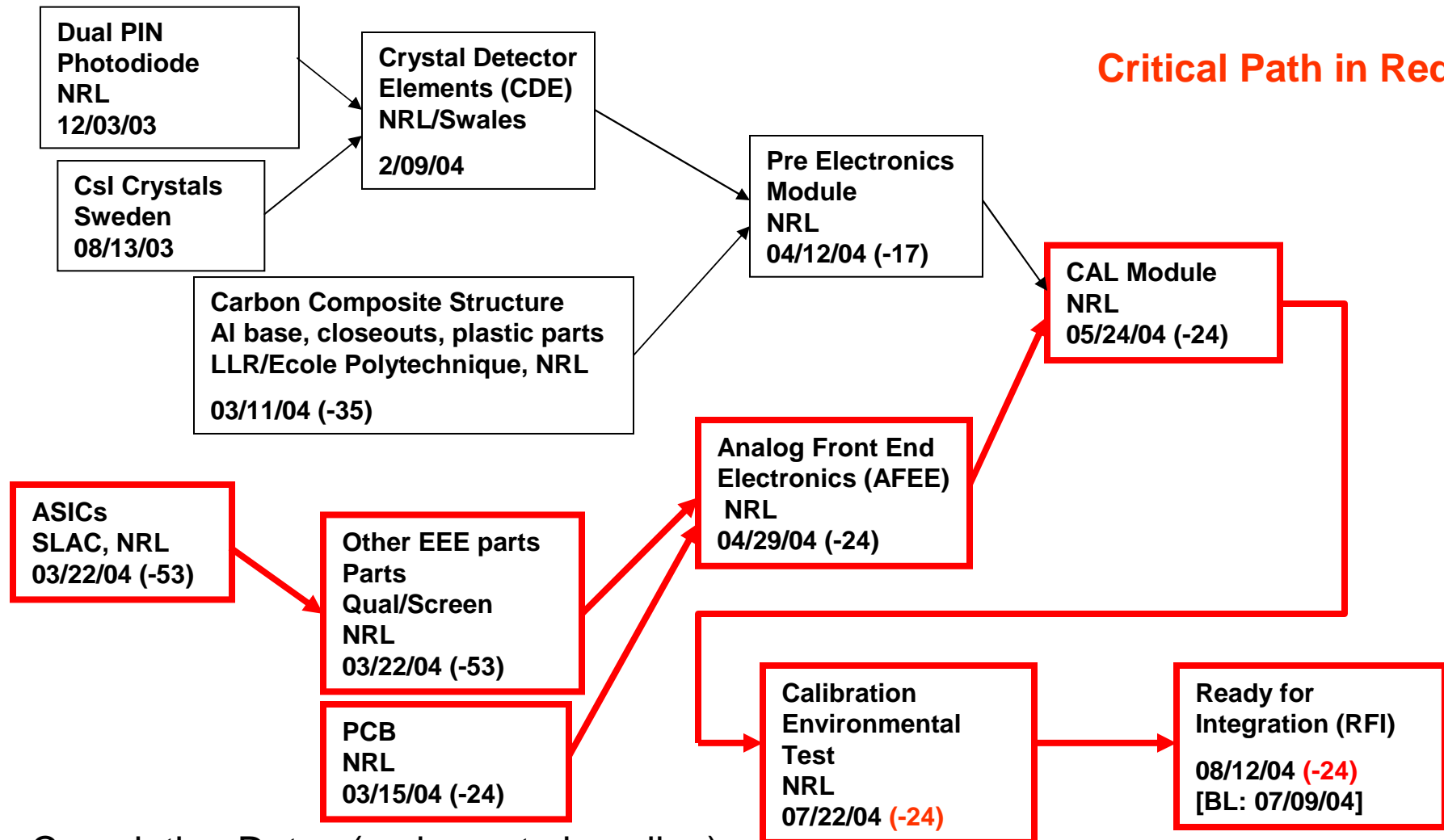
Schedule Variances

- ❑ **Flight ASIC manufacture (-53 days)**
 - **Packaging of CAL ASICs took ~45 days longer than programmed due to vendor work load and priorities.**
- ❑ **AFEE Printed Circuit Board (-24 days)**
 - **Testing of prototype flight PCB and mechanical verification has taken longer than programmed.**
 - **Implementation of layout modifications add additional EMI/EMC filtering, to improve potential mechanical interference issues and to improve reliability were not programmed.**
- ❑ **Carbon Composite Structure (-17 days)**
 - **Materials problems and over test anomalies delayed the manufacture of the 1st flight structure.**

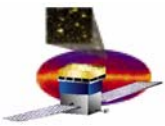


Path to first flight CAL Module (FMA)

Critical Path in Red

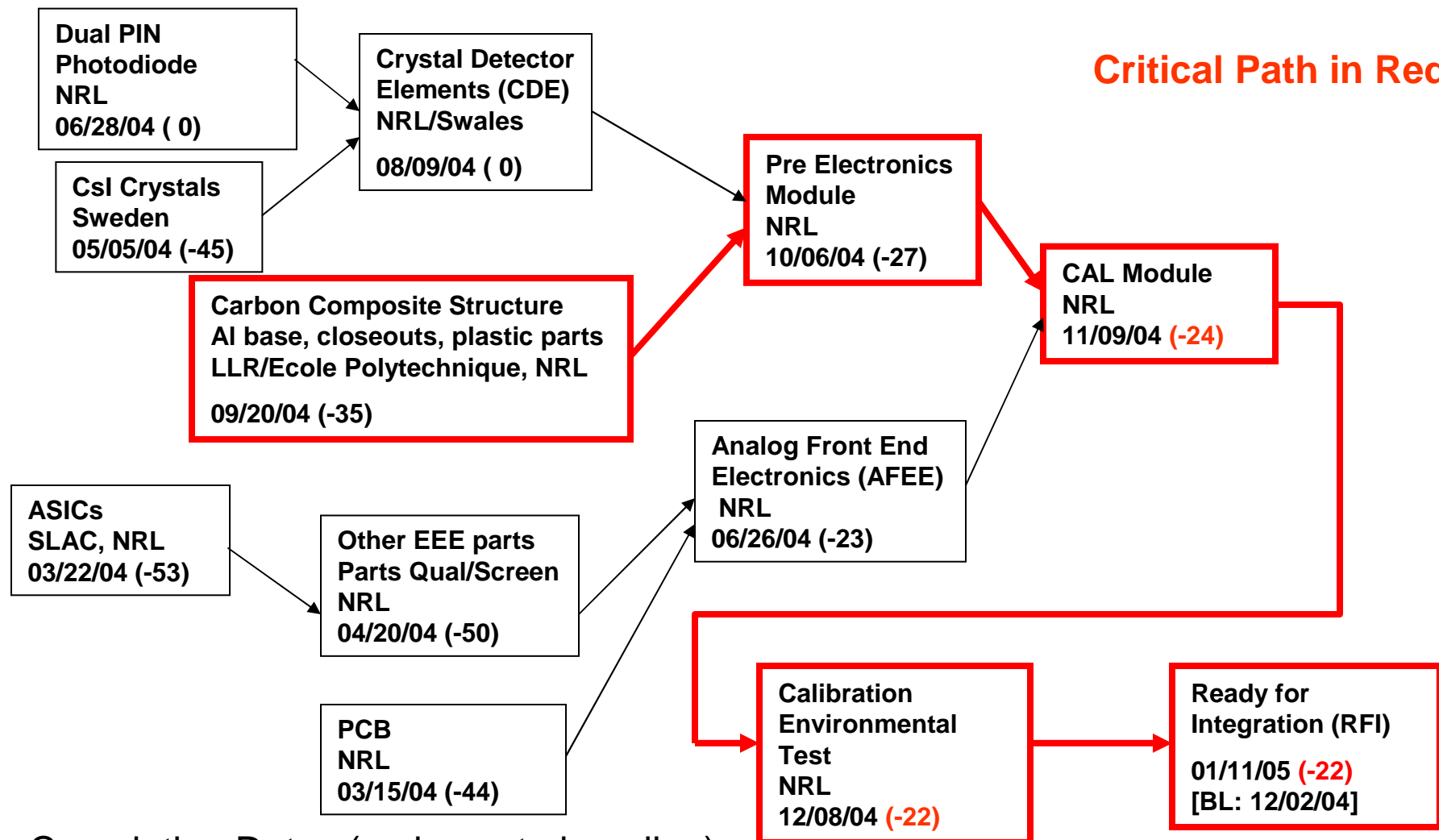


Completion Dates (variance to baseline)

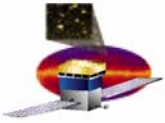


Path to 16th flight CAL Module (FM14)

Critical Path in Red



Completion Dates (variance to baseline)



Cost Summary

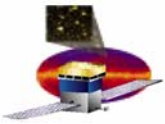
Approved Cost Changes since Rebaseline

4.1.5 Baseline, November 03 \$22,648K

Changes:

CDE Manuf. Develop. Savings \$ (546K)

4.1.5 Baseline, February 04 \$22,103K



Cost Variance

Cumulative Cost Variance: + \$640K

- ❑ **Mgmt, Sys Eng, R&QA: +\$259K (6%)**
 - **Understaffed (60%)**
 - **Travel underrun (40%)**
- ❑ **Crystal Detector Elements: +\$27K (1%)**
- ❑ **PreElectronics Module: +\$168K (18%)**
 - **Invoicing for delivered material and outstanding commitments**
- ❑ **Analog Electronics: +\$3K (0%)**
- ❑ **Module Assembly and Test: +\$161K (9%)**
 - **Invoicing for facilities and GSE**



Cost Liens

Additional duration for Thermal Vacuum Testing

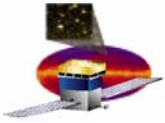
- EM Test experience indicated that CAL temperature changes can not be driven as quickly as estimated in baseline: 3 days per cycle rather than baseline 2 days.
 - Additional TVAC operation time and supporting staff is ~\$30K per TVAC. This affects 8 of the 9 TVACs.
 - Cost increase is partially mitigated by the removal of requirement for 12 cycles of TVAC for FMA/B. This recovers \$111K.
 - Net cost estimate is ~ \$130K. Approximately 50K of this is in FY04.



Next 6 months

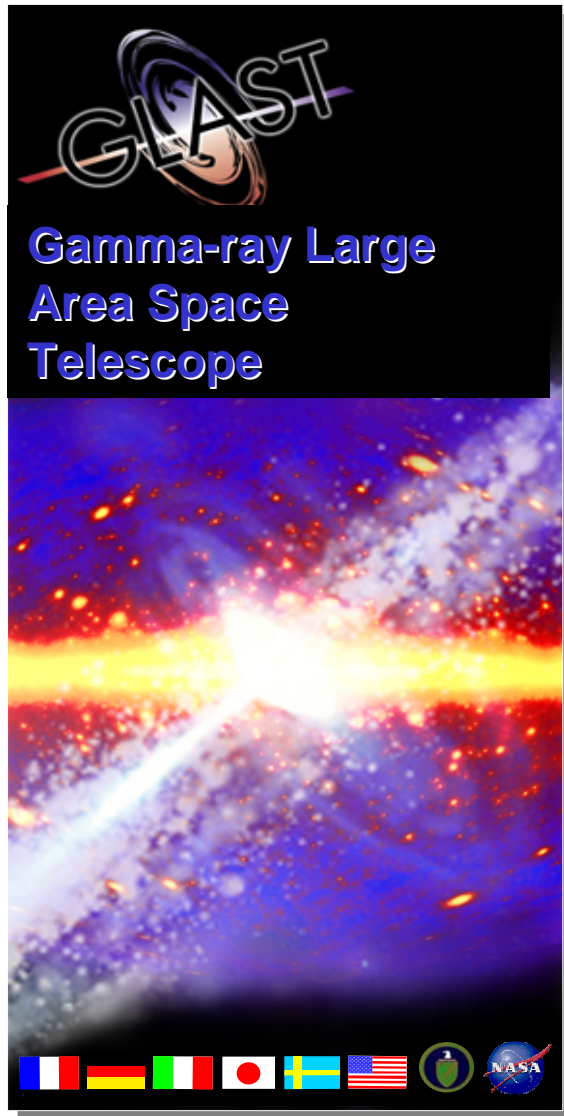
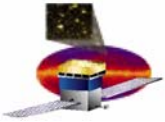
By Oct 1, 2004

- ❑ **Crystal Detector Elements**
 - All CsI crystals delivered from Sweden (by August)
 - All CDE manufactured and tested (~1850 by Sept)
- ❑ **Pre Electronics Modules**
 - 17 of 18 structures delivered to NRL from IN2P3/LLR
 - 15 of 18 PEMs completely assembled and tested.
- ❑ **Analog Front End Electronics**
 - All AFEE circuit cards assembled and tested.
- ❑ **Module Assembly and Test**
 - 11 of 18 Modules completely assembled and in test.
 - 6 of 18 Modules delivered to SLAC.

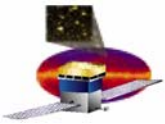


Summary

- ❑ **CAL design and technical issues are well in hand**
 - **EM module verified design and assembly processes. Lessons learned incorporated in flight production.**
 - **EM subjected to qualification level environmental test program. No problems.**
- ❑ **CAL is well into flight module production**
 - **All flight hardware drawings are released.**
 - **Electronics assembly and test continue to define the critical path to the delivery of the first modules.**
 - **Flight parts availability and qualification continue to present schedule vs risk challenges.**
- ❑ **The CAL schedule is aggressive**
 - **Delivery of 1st two modules in August will be a significant challenge.**

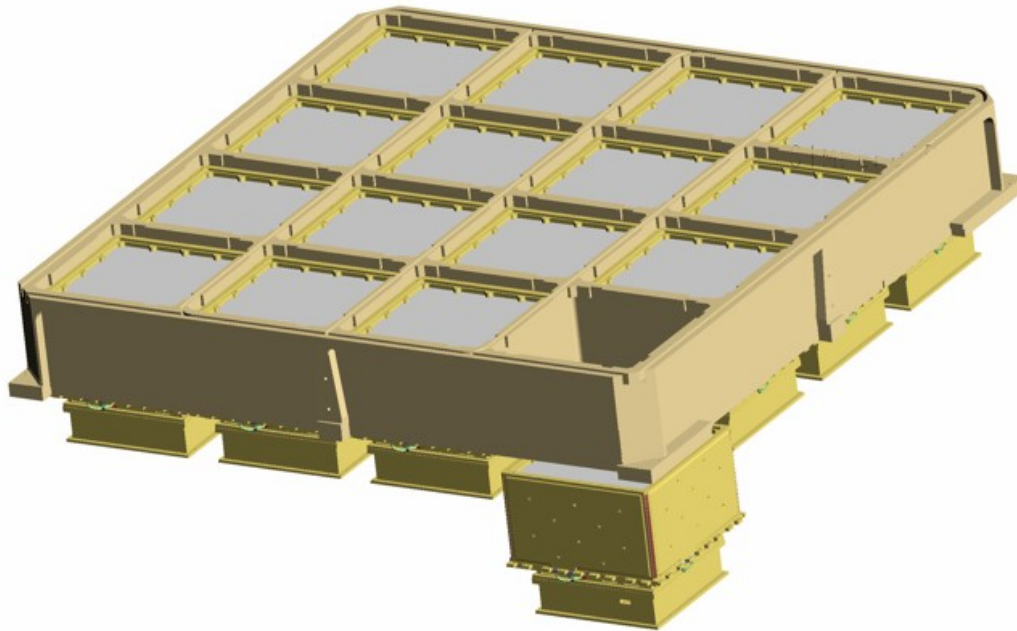


Backup Material Overview

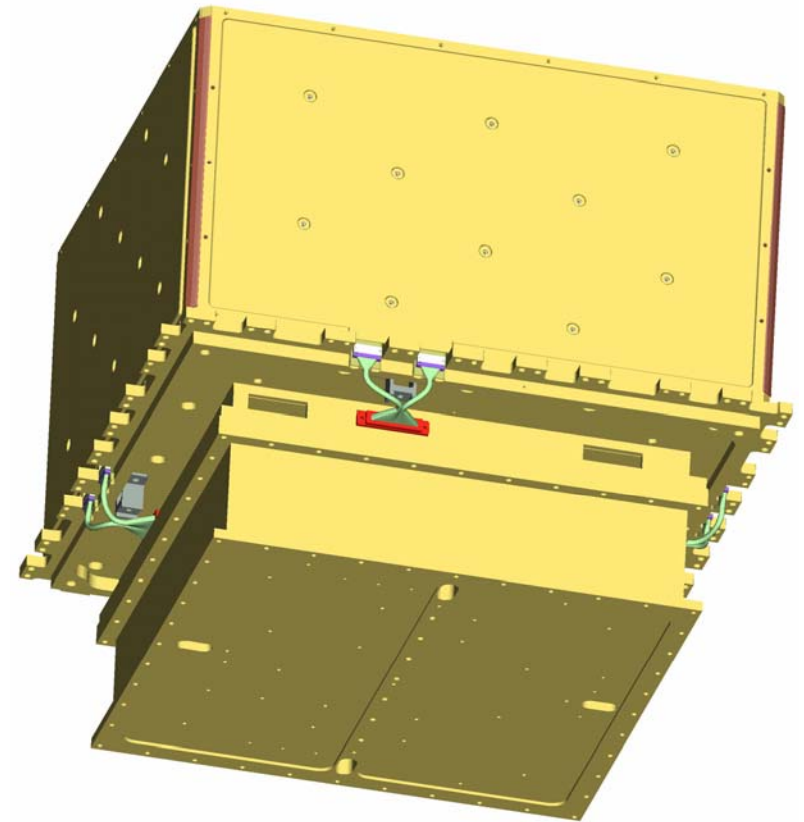


Modular Design

4 x 4 Array of Calorimeter Modules



LAT GRID with 16 CAL Modules

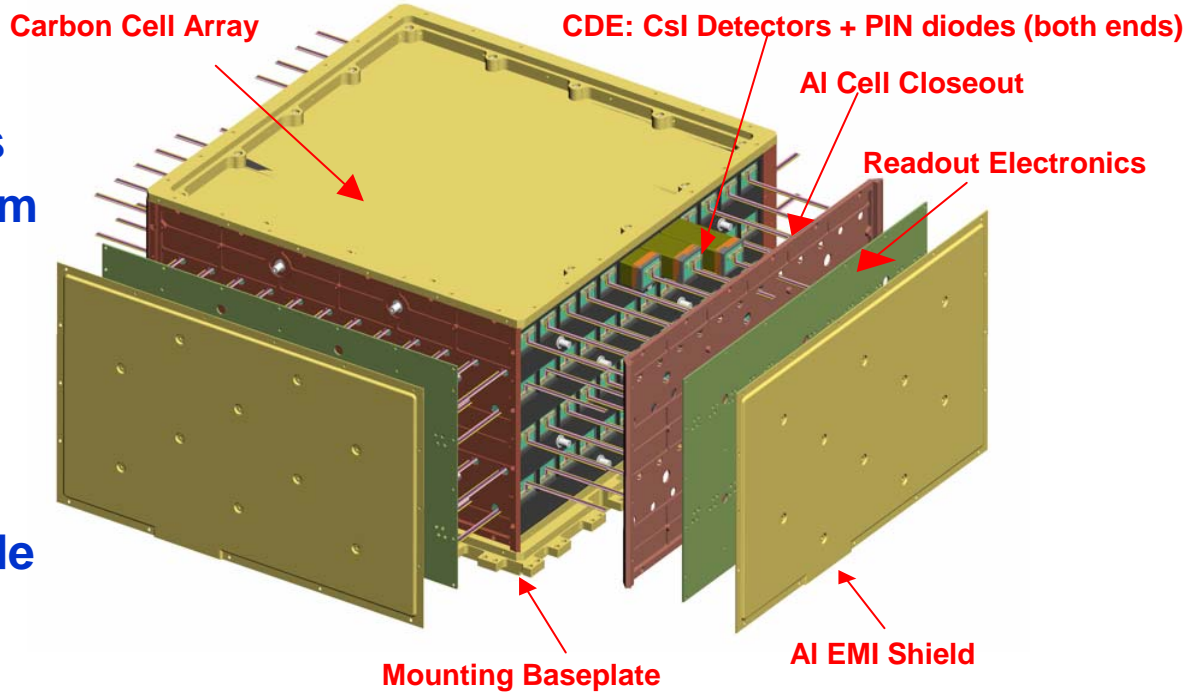


CAL Module with TEM and Power Supply mounted to base plate

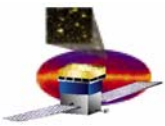


CAL Module

- **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**
 - **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**



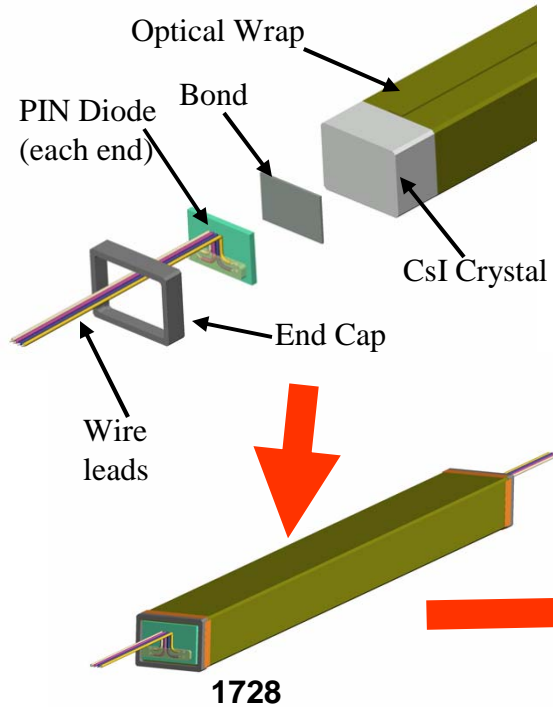
Calorimeter Assembly Flow

Dual PIN Diodes (DPD) NRL
CsI Crystals Sweden (KTH)

Crystal Detector Element (CDE) Assembly
NRL

Mechanical Structure
France / NRL

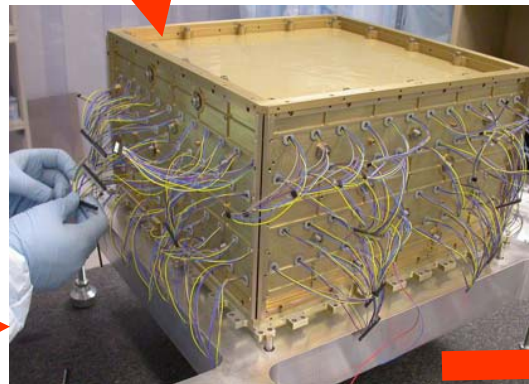
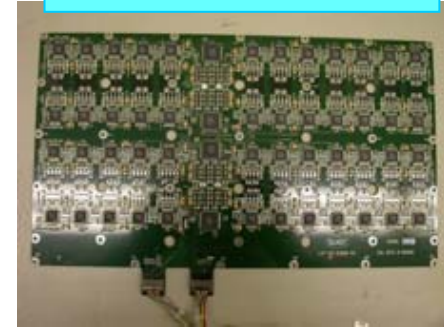
Front-End Electronics
NRL, SLAC



16 Flight modules + 2 Spare

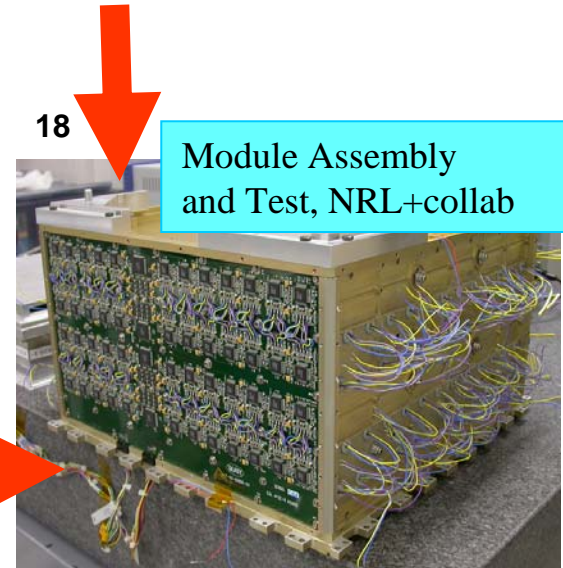


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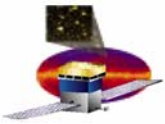
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PreElectronics Module (PEM) Assembly
NRL

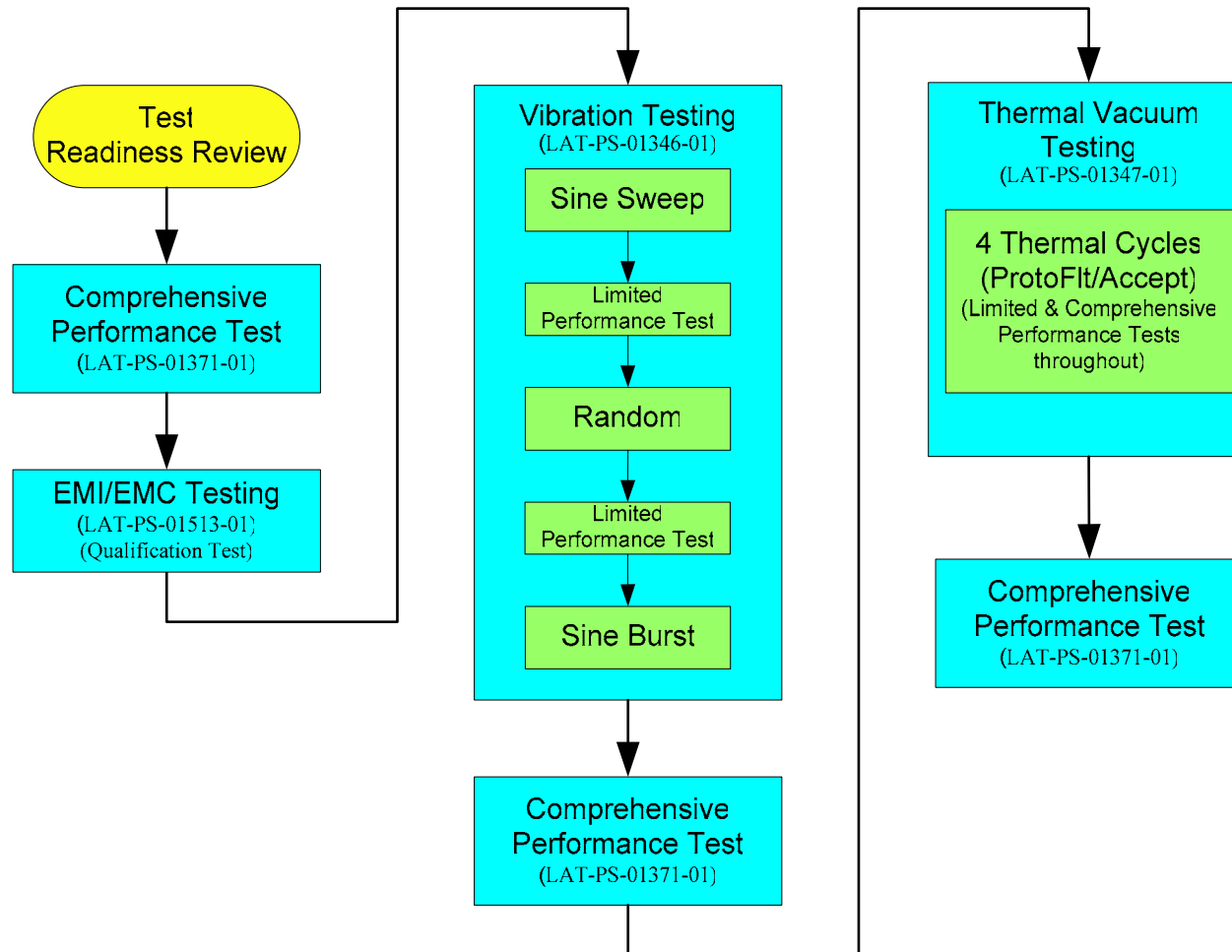


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Module Assembly and Test, NRL+collab



Environmental Test Flow





CAL Hardware Collaborators

Organization	Responsibility
Naval Research Lab	CAL Subsystem Management & System Engineering Safety & Mission Assurance, Subsystem Design PIN photodiode spec and entire procurement CDE manufacture and test. Aluminium, titanium structures manufacture. CAL Electronics Design & Fab, Digital ASIC design, CAL Module Assy & Test, LAT I&T Support
SLAC	CAL Analog ASIC Design and support. EM AFEE PCB layout
Sweden	Csl Crystal procurement and acceptance test
France / CEA	PIN Diode test equipment, CDE shipping containers.
France / IN2P3	Mechanical Structure design and configuration management. Carbon composite cell structure. Elastomer bumpers and cords. Finite element and thermal analyses. Beam Test Planning and Support