GLAST Large Area Telescope:

Calorimeter (CAL) Subsystem
WBS: 4.1.5

W. Neil Johnson
Naval Research Lab, Washington DC
Calorimeter Subsystem Manager

neil.johnson@nrl.navy.mil
(202)–767–6817

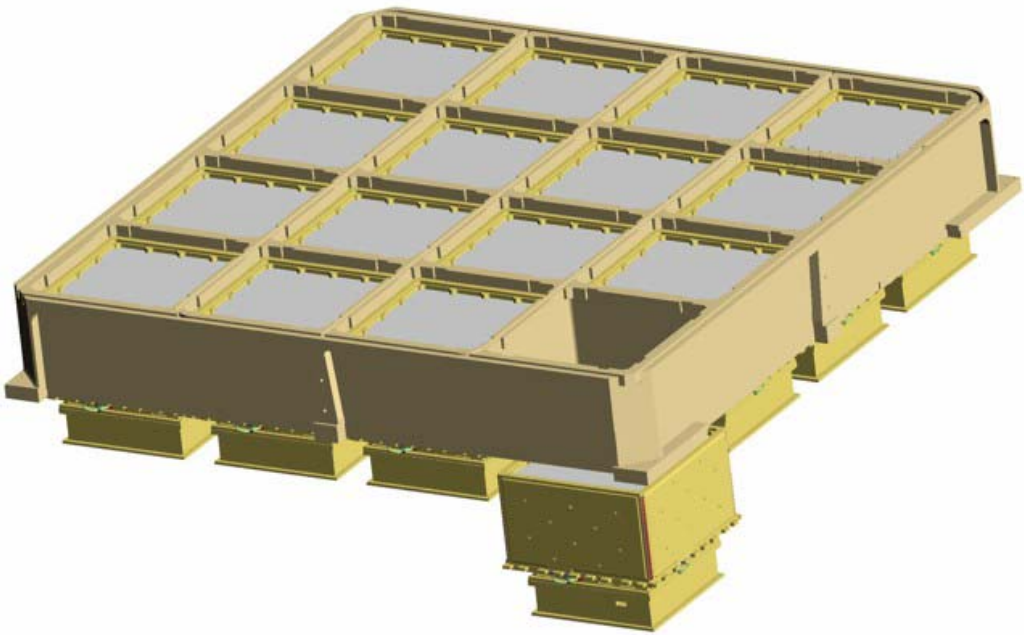
Outline

- Overview
- Progress since August
- Path to first flight article
  - Qualification / Protoflight Testing
- Path to completion of the subsystem
- Outstanding issues
  - Path to closure
- Risks and mitigation
- Cost and schedule
  - Variances and plan for correction
- Summary

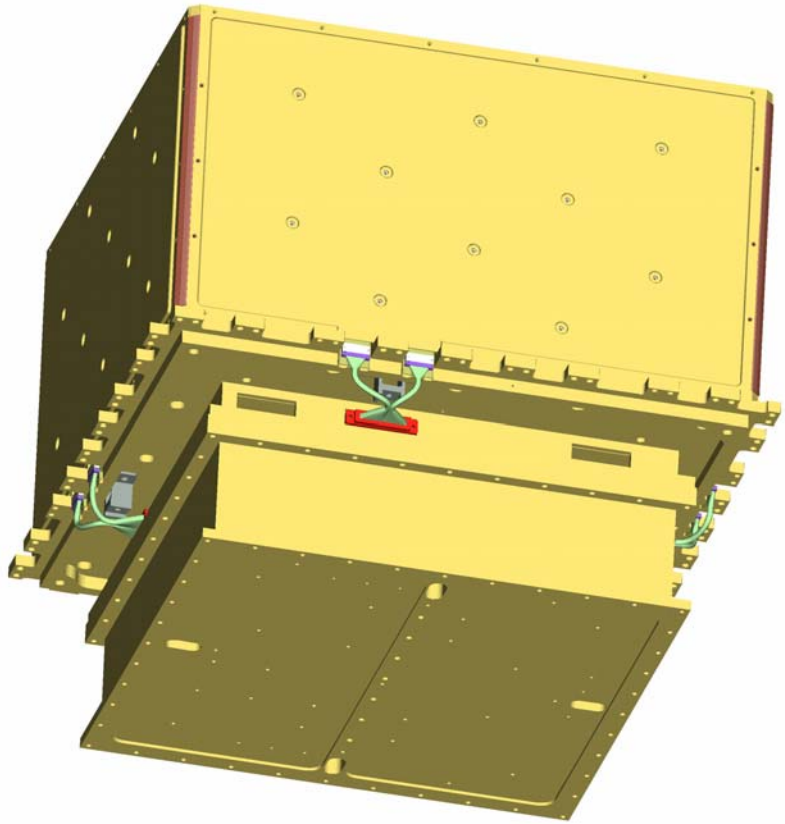
Overview

Modular Design

4 x 4 Array of Calorimeter Modules



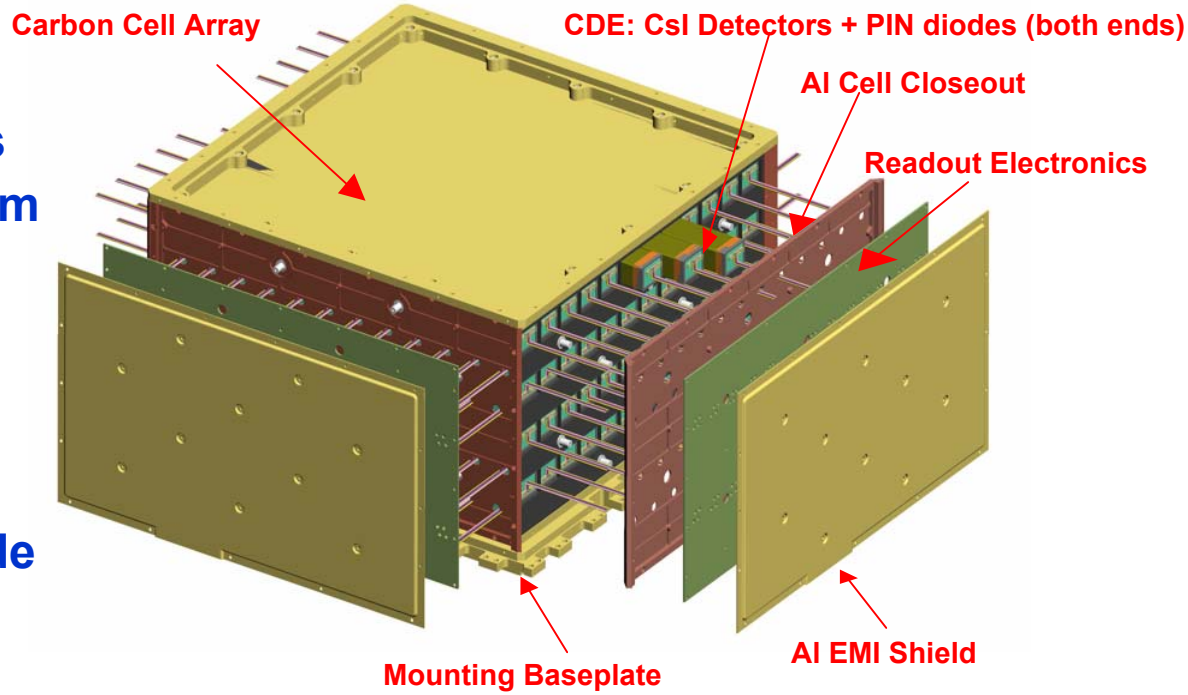
LAT GRID with 16 CAL Modules



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



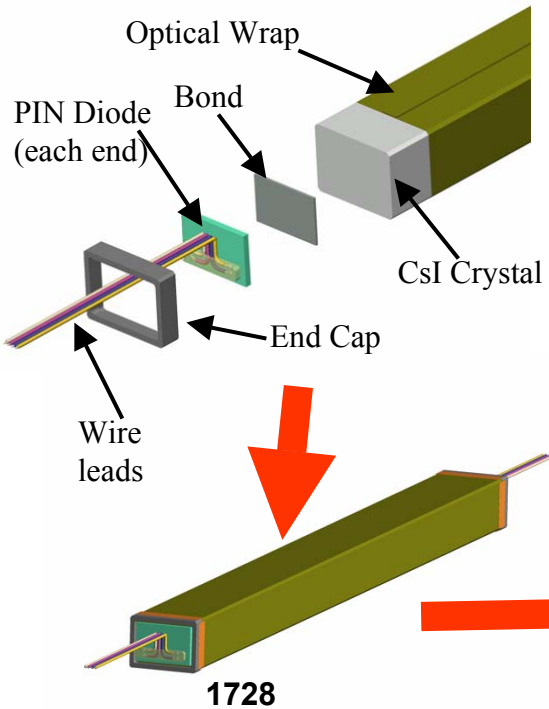
- Electronics boards attached to each side
  - Interface connectors to TEM at base of calorimeter
- Outer wall is EMI shield and provides structural stiffness as well

Calorimeter Assembly Flow

Dual PIN Diodes (DPD) NRL

CsI Crystals Sweden (KTH)

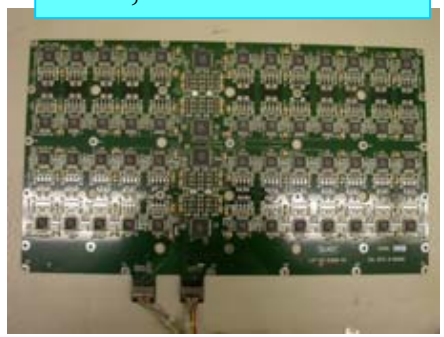
Crystal Detector Element (CDE) Assembly NRL

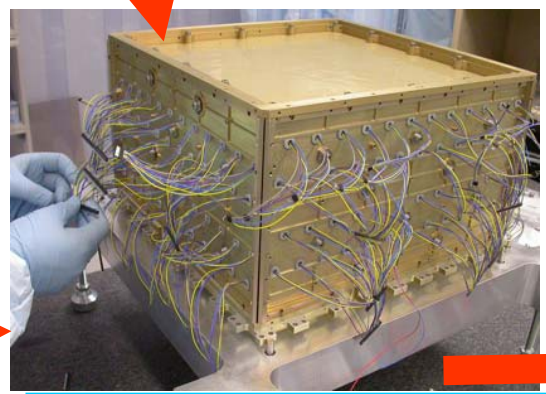


Mechanical Structure France / NRL

18

Front-End Electronics NRL, SLAC





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PreElectronics Module (PEM) Assembly NRL

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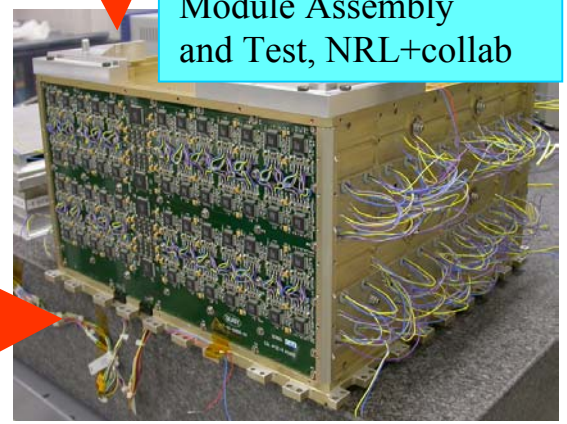
Module Assembly and Test, NRL+collab



16 Flight modules + 2 Spare

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	CsI 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

Organizational Changes since CDR/CD-3

- CNES withdrawal of support for French contributions
  - CEA/Saclay unable to provide crystal detector elements and supporting test equipment.
  - CEA/Saclay unable to procure and qualify PIN photodiodes
  - IN2P3 unable to procure machined aluminum and titanium parts for mechanical structure.
- These responsibilities were transferred to NRL with support from USA sponsors
  - CDE manufacturing under NRL contract to Swales
  - PIN diode qualification and testing at NRL and GSFC
  - Aluminum and titanium machining at NRL with drawing and configuration mgmt at IN2P3.

Technical Changes since CDR/CD-3

- CAL base plate design was modified to meet CAL-Grid interface requirements imposed by IPO.
  - Modifications to Grid mounting tabs
  - Addition of steel shear pins
- Improvements to design of Al structure closeout plates to facilitate safer routing of PIN diode electrical connections thru the closeout to the AFEE printed circuit card.
- Several changes to mechanical structure to address EMI/EMC performance
  - EMI/EMC gaskets under side panels
  - Serpentine EMI “o-ring” at vertical joints of closeout plates.
- Additional filtering on AFEE boards to improve EMI/EMC performance.
- Upgrade CAL front end ASIC to version 9A.

Progress since CDR/CD-3 Engineering Model

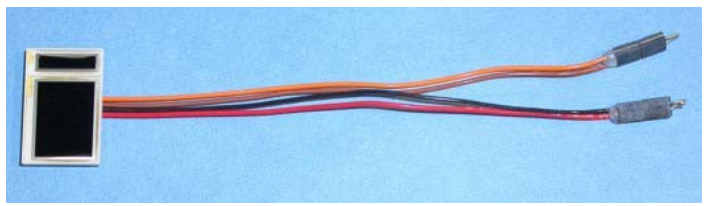
- Completion of the CAL Engineering Model environmental test program (qualification levels)
  - No problems identified in Vibration or Thermal Vac testing
  - EMI/EMC problems were identified
    - Contributing causes – test configuration issues and fidelity of TEM/PS unit used (GSE not flight-like).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

< show picture>

Progress since CDR/CD-3
Crystal Detector Elements

- **Crystal Detector Element Manufacturing**
  - CsI 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 (> 50% complete).
  - PIN diode qualification program is complete.
  - NRL/Swales Aerospace established team, developed tooling and qualified process for CDE manufacturing. Flight production is well under way (>40% complete.)
  - CDE qualification program is complete.

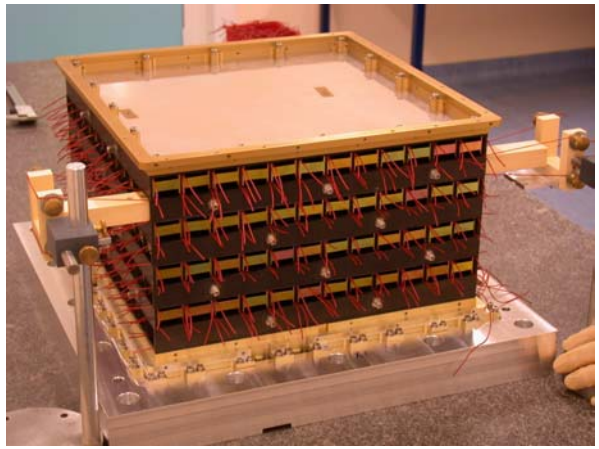
CDE Bonding at Swales Aerospace



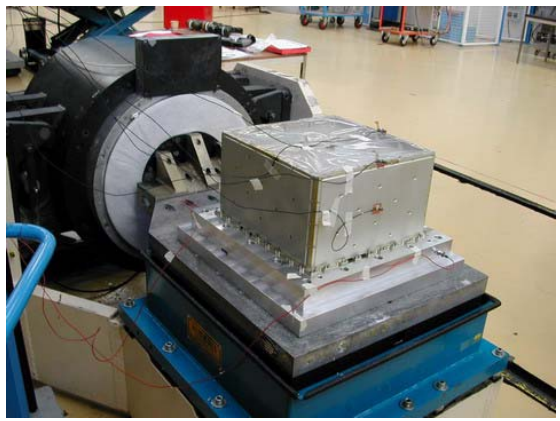
PIN Diode Assembly (PDA)

Progress since CDR/CD-3 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 two flight structures have been manufactured, tested, and delivered to NRL.



Carbon structure with test Al parts and dummy CDEs



Vibration test of FMA structure

Progress since CDR/CD-3
Analog Front End Electronics

- 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.
- All EEE parts are approved except ASICs which are in qualification testing.
- 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 have been manufactured.
  - Contract for assembly of flight AFEE boards is in place. Assembly awaiting delivery of tantalum capacitors.

Progress since CDR/CD-3 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.
  - Photo – CDE insertion
  - Photo – PEM in muon test station…

Path to first flight CAL Module (FMA)

NEED UPDATE

Critical Path in Red

Dual PIN Photodiode
NRL
12/03/03

CsI Crystals
Sweden
08/13/03

Crystal Detector Element (CDE)
NRL/Scale
2/27/04 (45)

Pre Electronics Module
NRL
04/12/04 (42)

Carbon Composite Structure
Al base, closeouts, plastic bar
LLR/Ecole Polytechnique, NRL
03/09/04 (42)

CAL Module
05/20/04 (36)

ASICs
SLAC, NRL
03/02/04 (40)

Other EEE parts
Parts
Qual/Screen
NRL
03/02/04 (40)

PCB
NRL
03/08/04 (35)

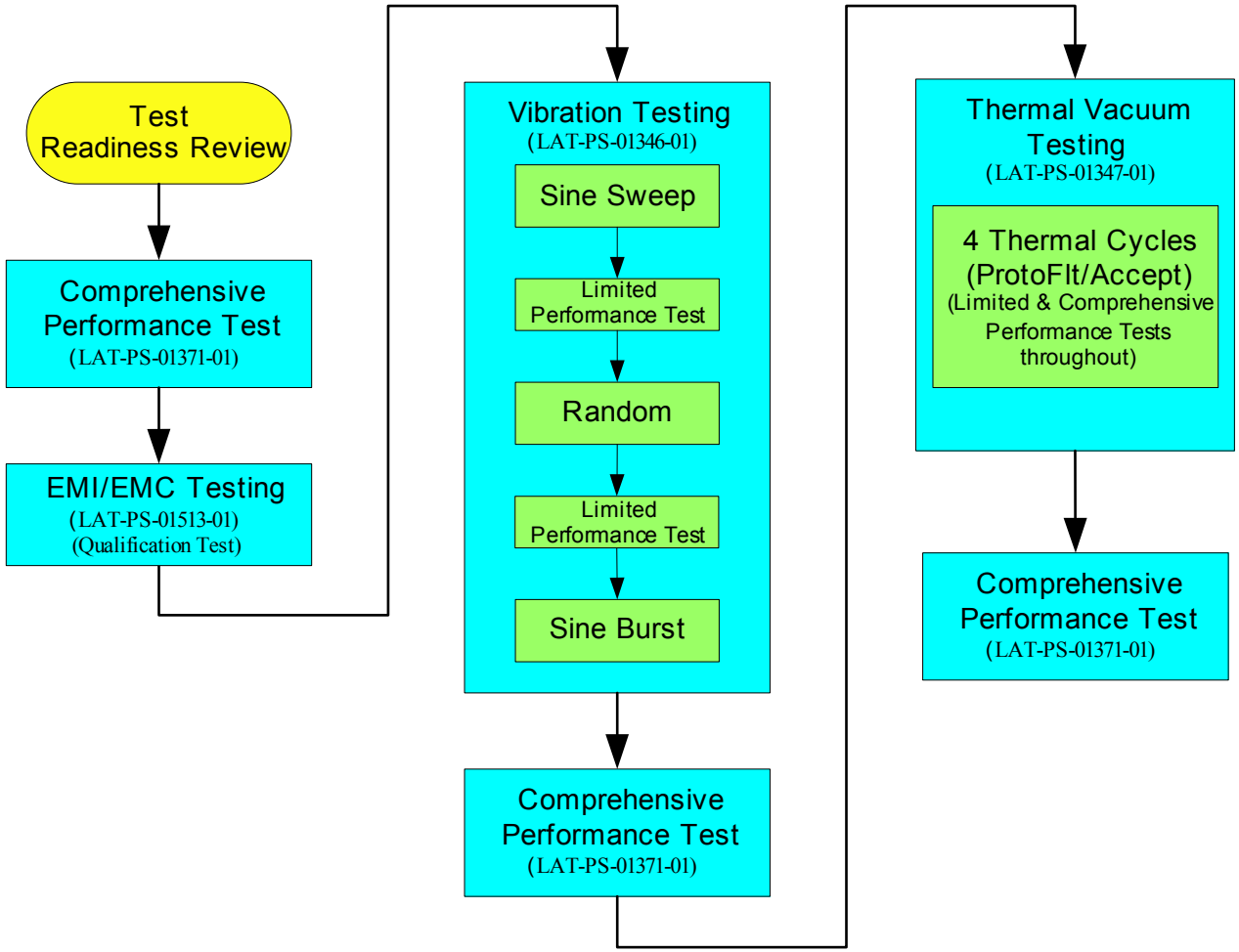
Analog Front End Electronics (AFEE)
NRL
04/23/04 (35)

Calibration Environmental Test
NRL
07/16/04 (35)

Ready for Integration (RFI)
08/06/04 (35)
[BL: 07/09/04 (55)]

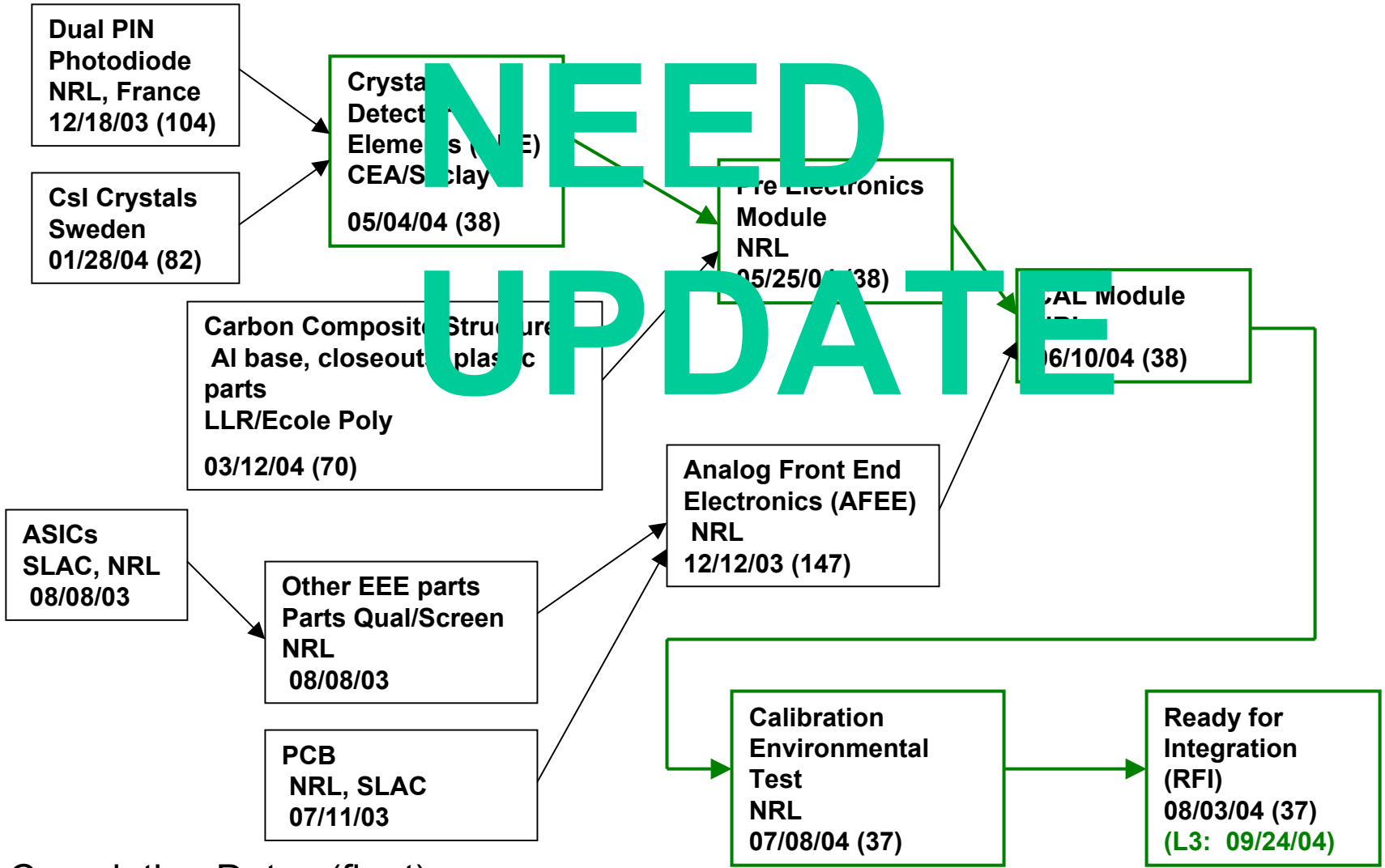
Completion Dates (float)

Environmental Test Flow



Path to Completion of Subsystem

CAL Flight Module 14



Completion Dates (float)

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-991	Moderate	❑ CAL module EMI/EMC performance problem detected in protoflight qualification testing. ❑ EM Module with GSE TEM/PS did not meet EMI/EMC performance requirements.	1) CAL mechanical design modified to include EMI gaskets and "o-rings" to provide improved shielding. 2) Additional filtering added to AFEE electronics cards 3) Develop more realistic test configuration and use more flight-like TEM/PS.	Open
CAL-992	Low	❑ CAL AFEE board design, SMT manufacturing, testing, PEM assembly and qualification issues still to be verified.	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-going

CAL Risk Summary (2)

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
CAL-993	Low	Use of CAL ASICs before completion of qualification testing. To improve the schedule for delivery of the first modules CAL AFEE board assembly will begin prior to completion of qualification testing of the CAL ASICs. This risks all CAL flight parts not just the ASICs.	Boards will be assembled in three lots 1. 1st article verification 2. lot of 6 modules 3. lot of 18 modules the assembly of which will not occur until qualification testing is complete.	On track
CAL-994	Moderate	CAL module production schedule compression. By the time the 1st CAL flight module has completed environmental testing, at least eight other modules are in assembly. ❑ Risk of late discovery of problem which impacts rework on all in-process modules. ❑ Risk of production problem causing a backup in the assembly pipeline impacting all subsequent module deliveries.	❑ Most of the production processes were verified in the assembly of a relatively high fidelity engineering model CAL. ❑ Lessons learned were incorporated in new tooling and procedures.	On Track

Cost and Schedule

- Variances and plan for correction

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.