
# GLAST Large Area Telescope:

## Calorimeter Subsystem
## WBS 4.1.5

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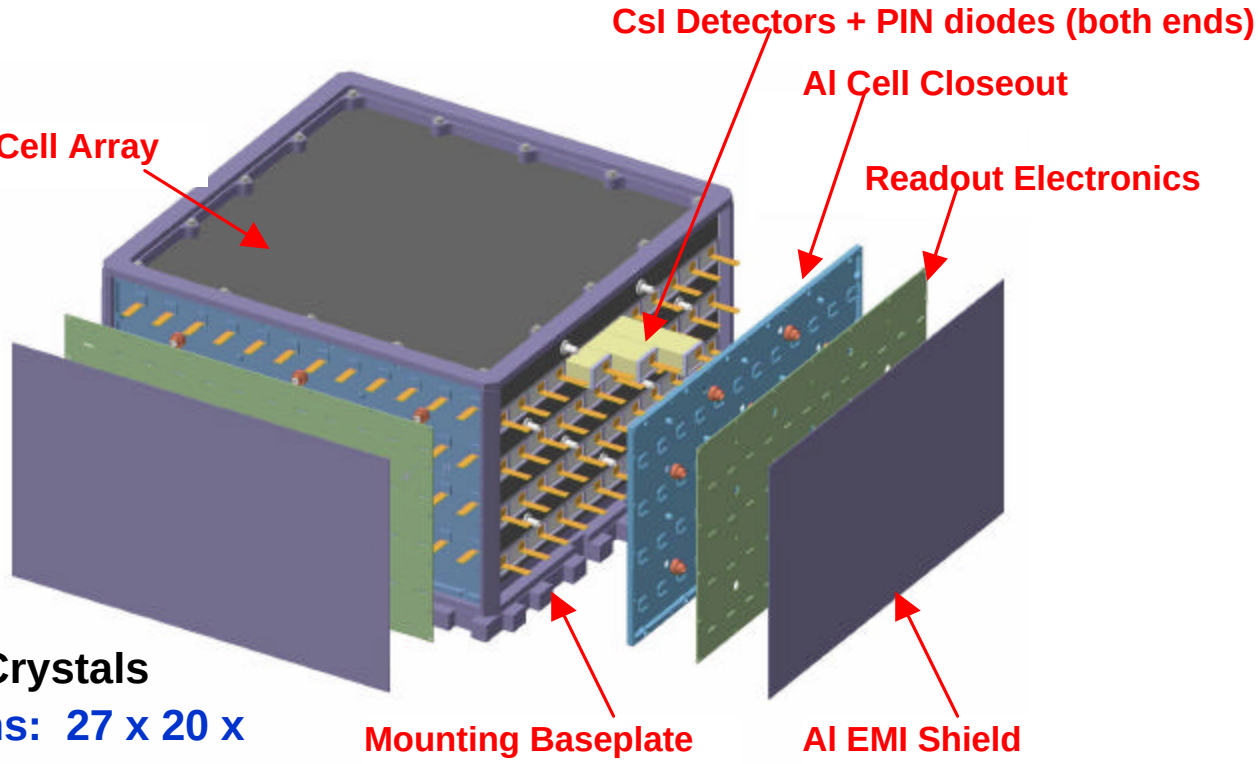
# Outline

- Overview
  - Design Overview
  - Organization
  - Requirements
  - Progress and Status
- Results from January PDR/Baseline review
  - Findings and recommendations
- Schedule and Budget
- New technical issues
- Summary

# Calorimeter Module Overview




## Modular Design

**4 x 4 array of calorimeter modules**

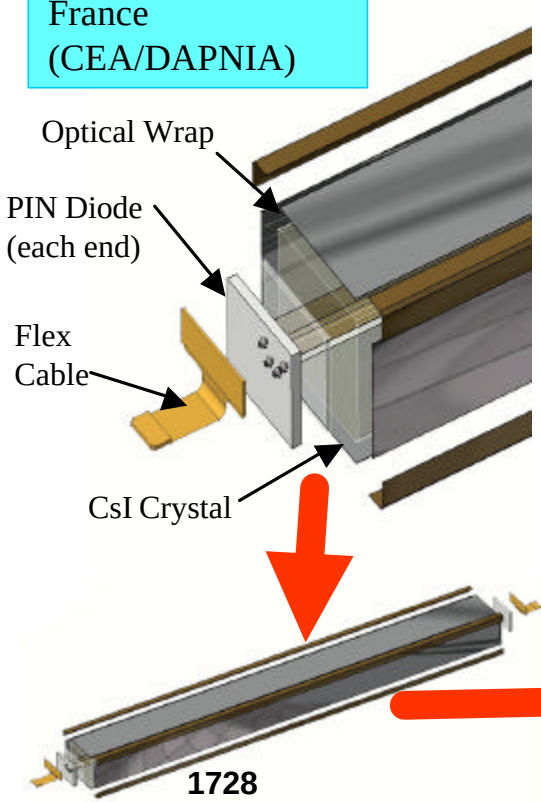
## Each Module

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

# Calorimeter Production Overview

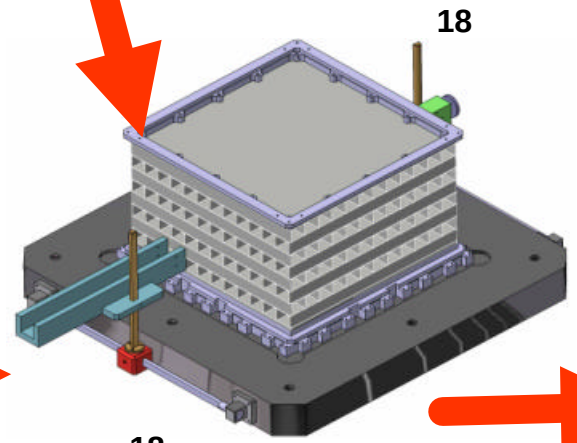
CsI Crystals
Sweden (KTH)

CDE Assembly
France
(CEA/DAPNIA)



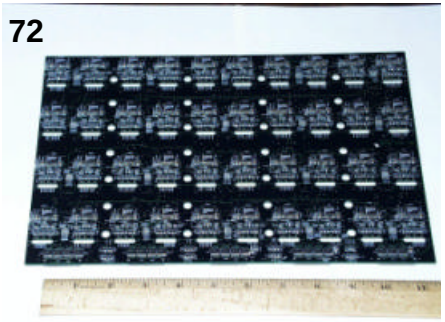

16 flight modules + 2 spares

Mechanical Structure
France (IN2P3/Ecole Polytechnique)




PEM Assembly
NRL

Front-End Electronics
NRL, SLAC

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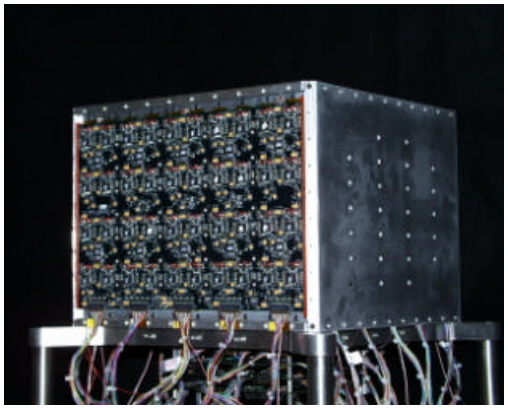
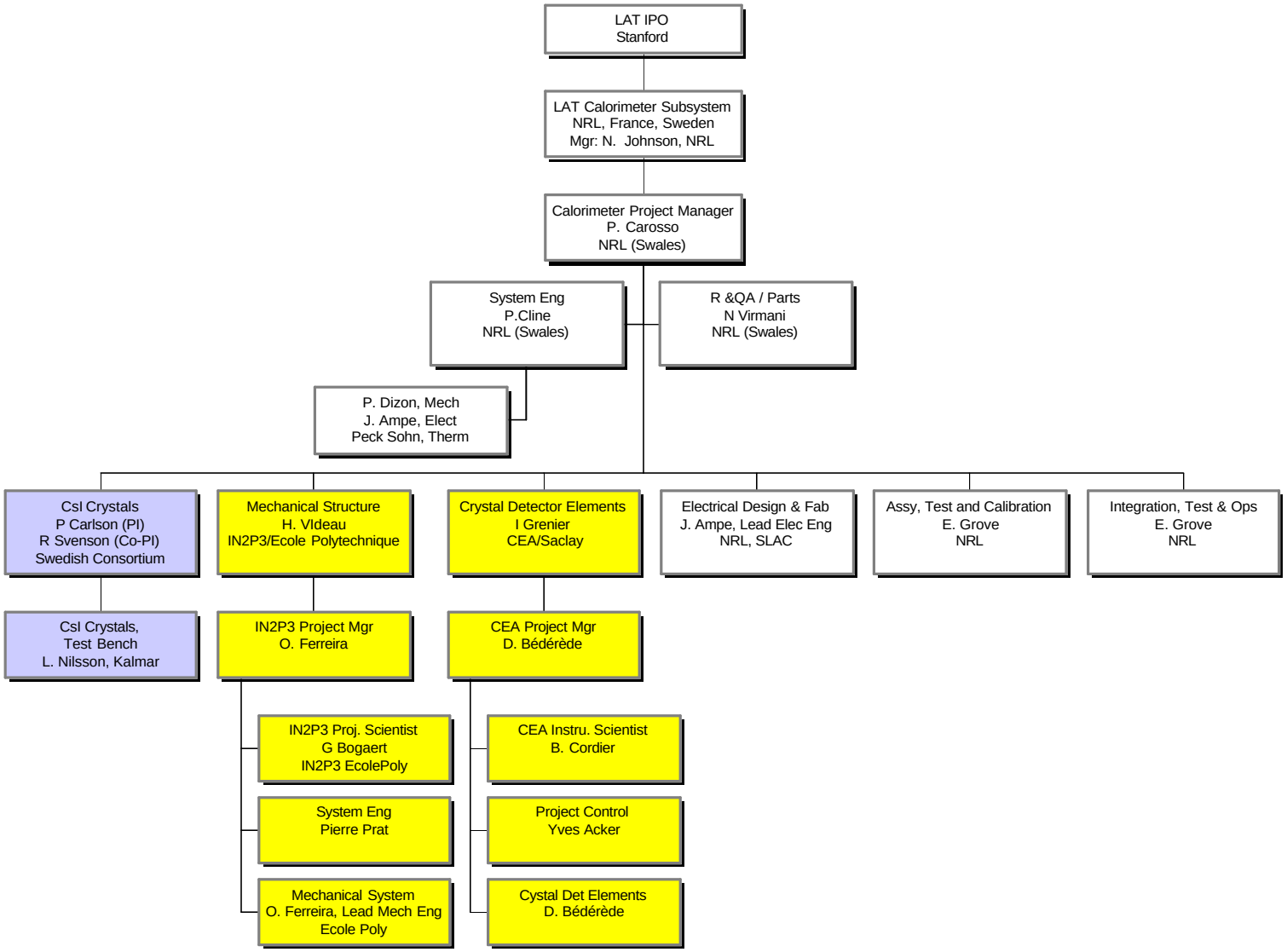
Module Assembly
and Test, NRL+collab



# Calorimeter – Institutional Organization



# CAL Subsystem WBS

| | | | | |
|---|---|---|---|---|
| **4.1.5** | | **Calorimeter** | **NRL** | **N. Johnson** |
| | **4.1.5.1** | **Calorimeter Program Management and Administration** | NRL | P. Carosso |
| | **4.1.5.2** | **Systems Engineering** | NRL | P. Carosso |
| | **4.1.5.3** | **Reliability and Quality Assurance** | NRL | N. Virmani |
| | **4.1.5.4** | **Calorimeter Design** | NRL | B. Phlips |
| | **4.1.5.5** | **CsI Crystal Detector Elements (CDE)** | NRL | P. Carosso |
| | 4.1.5.5.1 | CDE design | NRL | P. Carosso |
| | 4.1.5.5.2 | Csi(TI) Scintillation Crystals | KTH Sweden | P. Carlson |
| | 4.1.5.5.3 | Dual PIN photoDiode (DPD) | NRL/CEA | N. Johnson |
| | 4.1.5.5.4 | Dual PIN Photodiode Interconnect | NRL | J. Ampe |
| | 4.1.5.5.5 | CDE I&T | CEA-Saclay | D. Bederede |
| | 4.1.5.5.6 | CDE Bonding Study | NRL | P. Carosso |
| | **4.1.5.6** | **Pre-Electronics Module (PEM)** | NRL | P. Carosso |
| | 4.1.5.6.1 | PEM Structure Fabrication & Test | IN2P3 | O. Ferreira |
| | 4.1.5.6.2 | PEM Assembly & Test | NRL | P. Carosso |
| | 4.1.5.6.3 | PEM Delivery to NRL | NRL | P. Carosso |
| | **4.1.5.7** | **Analog Front End Electronics** | NRL | J. Ampe |
| | **4.1.5.8** | **Calorimeter Tower Controller** | NRL | J. Ampe |
| | **4.1.5.9** | **Calorimeter Module Assembly, Test & Calibration** | NRL | E. Grove |
| | **4.1.5.A** | **Instrument I&T Support** | NRL | E. Grove |
| | **4.1.5.B** | **S/C Integration Support** | NRL | E. Grove |
| | **4.1.5.C** | **Mission Operations Support** | NRL | E. Grove |

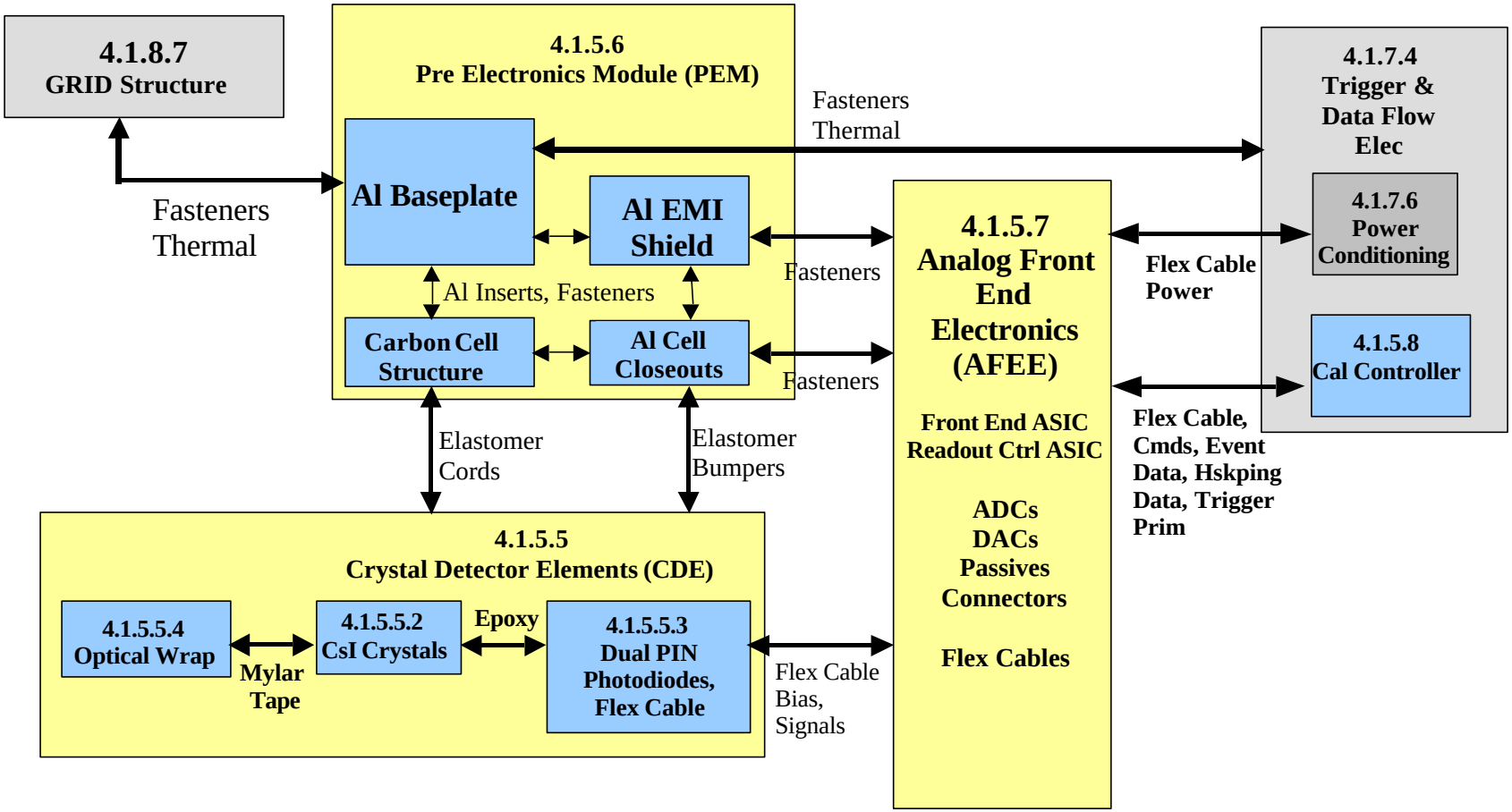
# CAL Hardware Collaborators

| Organization | Responsibility |
|---|---|
| **Naval Research Lab** | CAL Subsystem Management & System Engineering<br>Safety & Mission Assurance, Subsystem Design<br>PIN photodiode spec and shared procurement<br>CAL Electronics Design & Fab,<br>CAL Module Assy & Test, LAT I&T Support |
| **SLAC** | CAL Analog ASIC Design<br>LAT-wide Electronics support |
| **Sweden** | CsI Crystal procurement and test |
| **France / CEA** | Crystal Detector Element design, fabrication and test<br>Part of PIN photodiode procurement, Flex Cable procurement, PIN-CsI bonding, CsI optical wrap. |
| **France / IN2P3** | Mechanical Structure design and fabrication<br>Carbon composite cell structure<br>Al baseplate and closeout shells<br>Finite element and thermal analyses. |

# CAL Key Suppliers

| Vendor | Element |
|---|---|
| **Amcrys-H (Ukraine)** | **CsI(Tl) crystal elements**<br>Procurement in place by Sweden for all CAL CsI (~2000 crystals or 1640 kg)<br>240 prototypes in hand for Eng Model.<br>Delivery rate: 200 crystals/month |
| **Hamamatsu Photonics** | **Custom Dual PIN Photodiode**<br>NRL and France / CEA shared procurement<br>600 Design prototypes in hand for Eng Model.<br>Spec for flight version diodes in development.<br>Flight procurement: ~4500 diodes<br>Delivery rate: 600 / 5 weeks. |
| **Maxim Integrated Products** | **COTS ADCs and DACs**<br>NRL Procurement for all LAT subsystems<br>Prototypes in hand for EM and qualification testing.<br>10,000 ADCs (MAX145), 1000 DACs (MAX5121) |

# CAL Subsystem & External Interfaces



# CAL Level III Requirements

## Reference: LAT-SS-00018

| Parameter | Requirement | Verification | Expected Performance |
|---|---|---|---|
| Energy Range | 20 MeV – 300 GeV<br>20 MeV – 1 TeV (goal)<br>5 MeV – 100 GeV, single crystal | Simulation, Beam Tests | Required performance<br><br>~2 MeV threshold (BOM) |
| Energy Resolution (1 sigma) | < 20% (20 MeV < E < 100 MeV)<br>< 10% (100 MeV < E < 10 GeV)<br>< 6% (10 GeV < E < 300 GeV, incidence angle > 60 deg) | Simulations and EM and LAT calib unit Beam Tests | Simulations demonstrate required performance |
| Energy Resolution (1 sig) Single Crystal | < 2% for Carbon Ions of energy >100 MeV/nuc at a point. | EM (and Calib Unit) beam test | < 0.5% (correlation of ends removes Landau) |
| Design | Modular, hodoscopic, CsI<br>> 8.4 RL of CsI on axis | Inspection | > 8.5 RL |
| Active Area | >1050 $cm^2$ per module<br>< 16% of total mass is passive mtrl. | Inspection | >1100 $cm^2$ per module |
| Position Resolution | < 3 cm in 3 dims, min ionizing particles, incident angle < 45 deg. | Test with cosmic muons, all modules | < 1.75 cm in longitudinal measurement |
| Angular Resolution | 15 ´ cos(q) deg, for cosmic muons in 8 layers | Test with cosmic muons, all modules | 8.5 ´ cos(q) deg |
| Dead Time | < 100 ms per event<br>< 20 ms per event (goal) | Test | < 19 ms per event |

# CAL Level III Requirements (cont)

| Parameter | Requirement | Verification | Expected Performance |
|---|---|---|---|
| Low Energy Trigger | >90% efficiency for 1 GeV photons traversing 6 RL of CsI<br>< 2 μs trigger latency | Simulations | > 93%<br>< 1 μs |
| High Energy Trigger | >90% efficiency for 20 GeV photons depositing at least 10 GeV<br>< 2 μs trigger latency | Simulations, Calib unit test in beams | > 91%<br>< 1 μs |
| Size (module) | < 364 mm in width (stay clear)<br>< 224.3 mm in height (stay clear) | Inspection | 363 mm<br>224 mm |
| Mass | < 1492 kg (93.25 kg/module) | Test | < 1476 kg |
| Power | < 91 Watts (conditioned)<br>(5.69 W/module) | Test | < 67 Watts (conditioned) |
| Temperature Range | – 10 to +25 C, operational<br>– 20 to +40 C, storage<br>– 30 to +50 C, qualification | Subsystem TV Test, 4 cycles | Required performance |
| Reliability | > 96% in five years | Analysis | > 99% in five years (15/16 modules)<br>LAT-TD-00464-01 |

# Calorimeter Heritage

- **CsI Detector Systems in Space**
  - **1970's – HEAO 1 & 3 (CsI (Na))**
  - **1990's – CGRO OSSE (CsI (Na))**
  - **2002 – Integral IBIS (CsI(Tl)+PIN diodes)**
- **CsI Calorimeters in High Energy Physics**
  - **B-Factory experiments at Cornell, SLAC and KEK**
- **GLAST LAT Experience (NASA ATD Program)**
  - **1996 16 crystal prototype in SLAC beam test**
  - **1997 24 crystal hodoscopic prototype in SLAC beam test**
  - **1998 2 beam tests – MSU (heavy ions) and CERN (muons)**
  - **1999 CERN beam test**
  - **1999 – 2000 full sized (80 crystal) hodoscopic prototype w/ flight-like electronics (BTEM CAL) in LAT tower beam test at SLAC**
  - **2000 GSI beam (heavy ions – C, Ni) BTEM CAL**
  - **2001 Balloon Flight of the BTEM CAL**

# CAL Technical Progress Summary

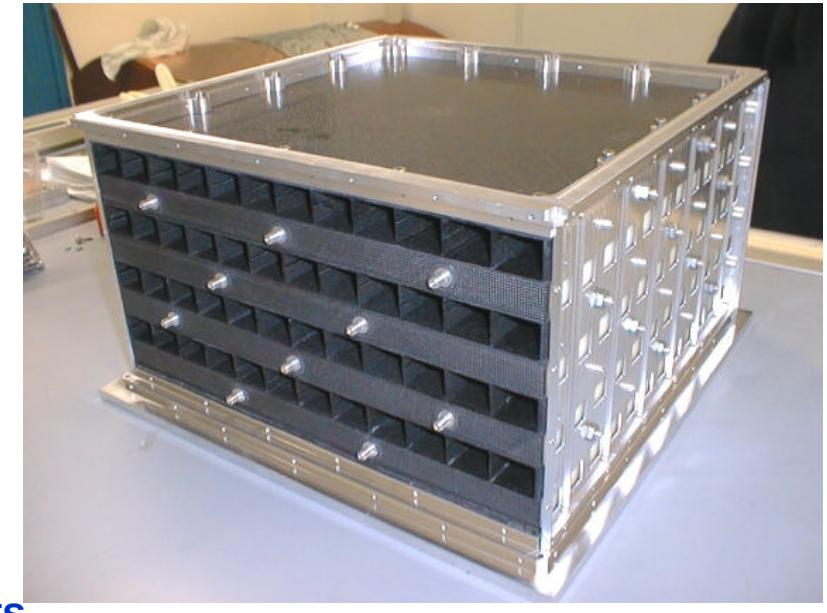
1) Environmental testing of CAL module prototype (VM2) has been successfully completed.
2) Aggressive CDE development program was initiated in USA to augment and support French program in developing reliable manufacturing process and to provide alternate source of CDE for the Engineering Model CAL module
3) Prototype AFEE boards have been fabricated and tested. Prototypes are being used to support TEM development, I/F testing and EGSE and test procedure development.
4) Review of EEE parts qualification and screening program with GSFC has resulted in approved plan for CAL commercial parts and plastic-encapsulated ASICs.
5) Major review of CAL element tolerance build up and manufacturability has resulted in modifications to CsI crystal, PIN Diode and mechanical structure dimension specifications. Reduced risk, no impacts on US cost or schedule.

*Details on following Slides*

# CAL Technical Progress (1) Mechanical Structure – VM2

- VM2 mechanical structure has successfully undergone vibration and thermal cycling.
  - Thermal cycles (qual levels) and Vibration (qual + 20% levels) with 12 active CDE and 84 dummy CDE.
  - Extended thermal cycling performed to validate stresses on titanium inserts and fasteners of carbon composite structure to outer Al shell and no anomalies were noticed.
- Review of carbon composite structure manufacturing process and inspection of prototype structures has resulted in improvements for EM structure (same mech performance, but increased repeatability and reliability)
  - Selection of more appropriate prepreg material (outgassing and flow properties).
  - Improved monitoring and control of manufacturing temperature and processes.
  - Addition of autoclave and vacuum bagging process will occur for flight structures.
- Review of tolerances and interfaces to CDE and Electronics (AFEE) resulted in reduction in carbon cell length to accommodate more clearance to DPD electrical pins and larger volume for AFEE printed circuit card.
  - No impact on Level III CAL performance specifications.

# CAL Technical Progress (1)
# VM2 Model



- Composite structure
  - 96 cell solid composite structure
    - SEAL CC 120 ET 441 prepreg
      - Plain fabric 122 g/m², HS 1K carbon fibers
      - ET441 epoxy resin, cure temperature 125°C
  - Titanium TI AL6V4 alloy inserts
- Dummy circuit boards
  - aluminum plates (1.5 mm thick)
- Aluminum parts
  - 2618A aluminum alloy machined parts
    - Base plate design: very close to EM design
    - Large openings on close-out plates for clearance of photodiodes electrical pins.
    - Flat side panels (0.8 mm thick)
- Polymeric parts
  - Delrin plastic frames (or plates)
  - Silicone rubber cords: diameter 1 mm, durometer 55 shore A
  - RTV 141 silicone bumpers: durometer 55 shore A

# CAL Technical Progress (1)
# VM2 Logs

- **Dummy logs**
  - **87 steel dummy logs with slots to adjust weight**
    - **Transverse dimensions: 26.5 x19.5 mm ±0.05mm**
    - **Length: 332.9 and 332.7 mm ±0.05mm (half / half)**
    - **Weight: 0.765 Kg ±0.010 Kg**
- **CDE**

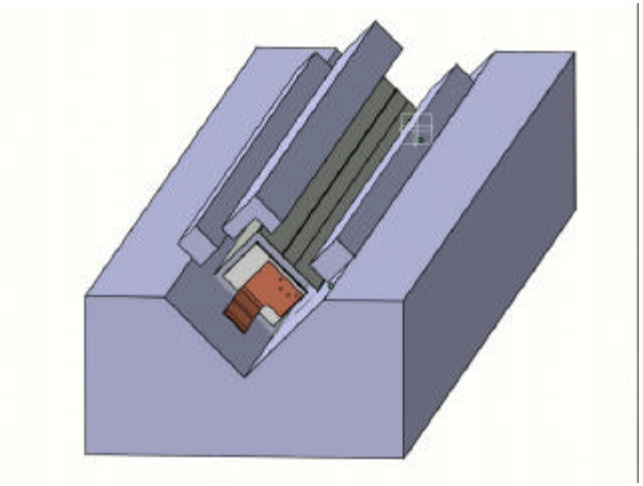
**•9 CDEs with photodiodes at both ends equipped with flex cables**

**•3M VM2000 film**

**•Logs wrapped at LLR**

**–1 layer of VM2000 with overlap**

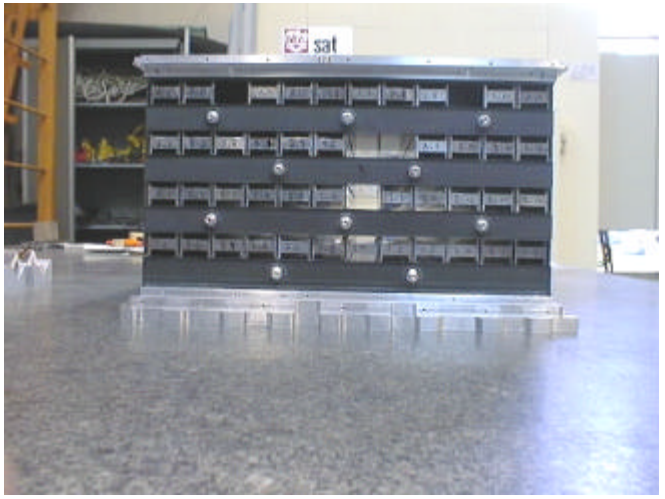
**– 3M 850 white tape: 5 mm strip + 20 mm strip (2 layers on top of overlap)**



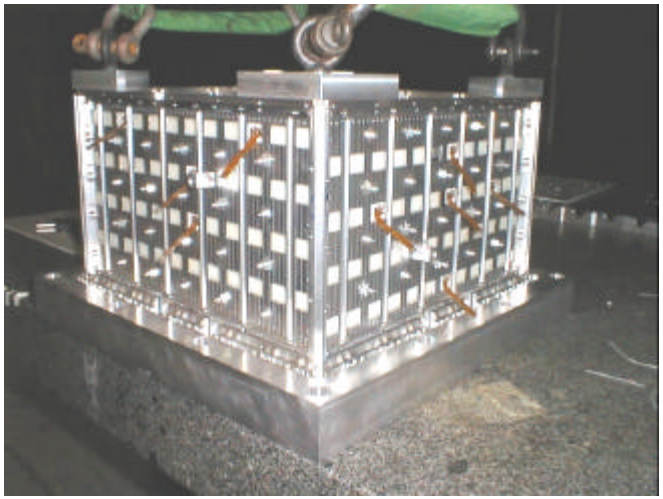
*Wrapping of CsI logs*

# CAL Technical Progress (1)
# VM2 assembly

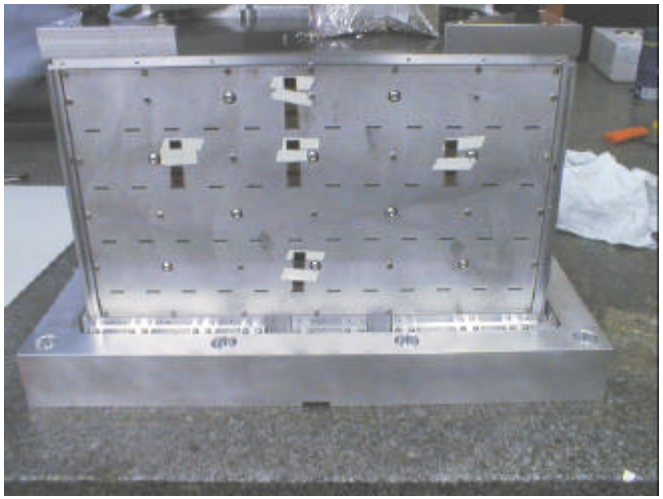
*CDEs on V block*



*Composite structure with dummies*

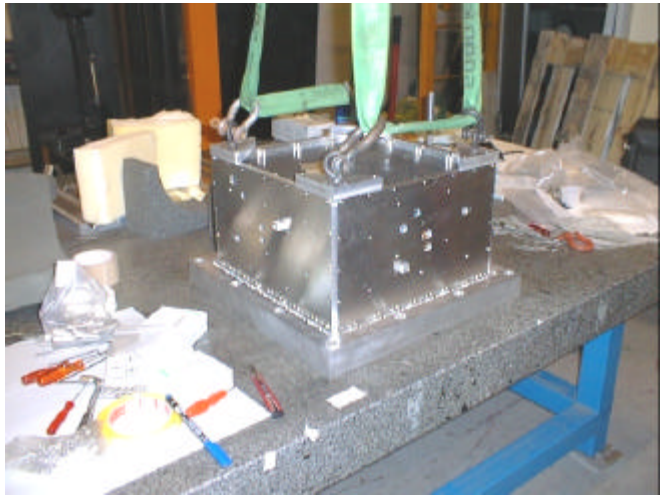


*Close-out plates assembled*



*Flex cable taped on Al dummy board*

# CAL Technical Progress (1)
# VM2 handling / interface



**Holes machined on the dummy boards and side panel to easily mount the accelerometers without disassembling the structure**

**Handling of VM2 model**

- **Model lifted from the top with 4 blocks bolted to the top frame and equipped with rings**

**Interface with the shaker**

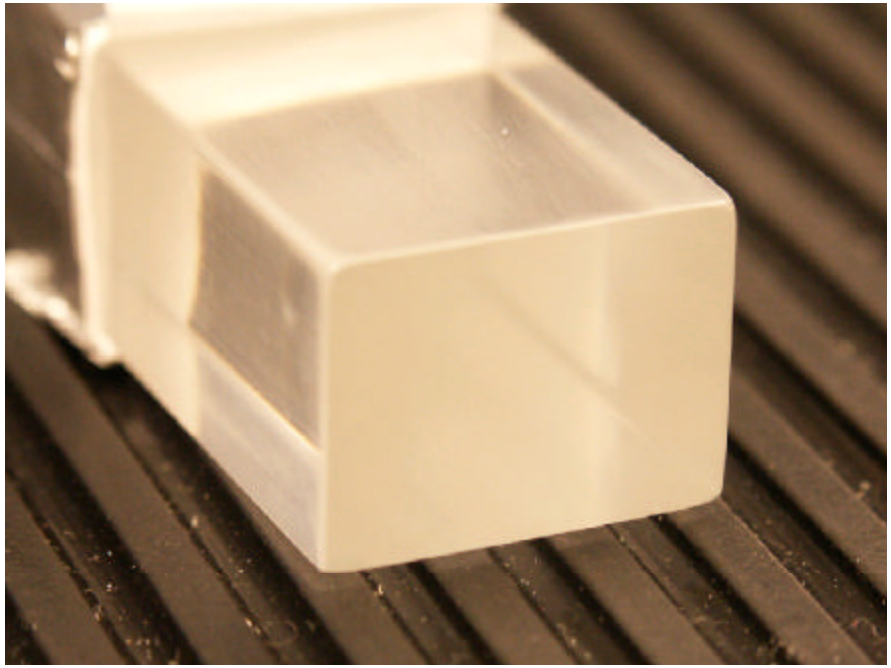
- **Aluminum frame to support the module only by the tabs of the base plate: same contact area, slightly different config from interface with the grid**
- **72 M3 bolts to attach the base plate to the frame**

# CAL Technical Progress (2)
# Crystal Detector Elements (CDE)

- **CsI Crystals**
  - CsI Crystal contract is in place for prototype and flight crystals.
  - 240 crystals have been received by Swedish. (Sufficient for 2 EM modules)
  - Adjustment to original specs were required: 7 mm removed from length, chamfer definition and tolerance changed. 120 crystals have been modified to new requirements. All crystals modified by Oct 2002.
  - Length adjustments performed at Amcrys-H, chamfers modified in Sweden and Amcrys-H.

Crystal modified in Sweden

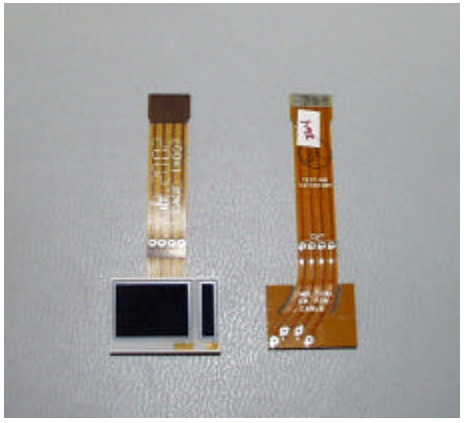
CsI crystal end showing modified chamfer and finished end surface



# CAL Technical Progress (2)
# Crystal Detector Elements (CDE)

- **Dual PIN Photodiode (DPD)**
  - 650 EM prototype DPD have been received. (Sufficient for 2 EM modules)
  - Radiation testing in France indicates no problem with GLAST environment but results differ somewhat from vendor-provided measurements.
  - Reduction of 1 mm from width and length of DPD carrier (3% change in active area of large diode, no change to small diode) is required for flight.
  - Revisions to the DPD specification are being negotiated with the vendor. Flight procurement requires resolution of micro-cracking during thermal cycling. Vendor is very supportive in investigating this problem.
  - Use of flex cable for interconnect to AFEE board is being reconsidered to provide more freedom in AFEE board layout. Twisted pair wires to PCB permit interconnect length variation to optimize AFEE layout for noise reduction.

Dual PIN photodiode with flex cable = photodiode assembly



# CAL Technical Progress (2)
# Crystal Detector Elements (CDE)

- **CDE Manufacturing (USA)**
  - Bonding material (DC 93-500) and processes have been tested with over 90 sample bonds of PIN photodiodes to CsI crystals.
    - Test samples have been thermal cycled to qual levels ( -30°C, +50 °C).
    - Up to 100 thermal cycles have been performed on some samples.
    - Light yield performance was tested at 6 - 8 cycle intervals.
    - Light yield performance after cycling was found to be sensitive to amount of primer applied (DC 92-023). Primer quantity influences hardness of bond. Large margin on mechanical properties is retained.
  - Bond strengths have been tested before and after thermal cycling. Adhesion problem has been solved.
    - typical shear strength = 250 N (reqmt = 35 N)
    - typical pull strength = 250 N (reqmt = 10 N)
  - Bonding Procedure (LAT-PS-00385-01) has been completed.
  - 1st two copies of bonding tools and associated workstation have been fabricated.
  - First EM CDE (4) have been bonded.
  - Light yield tests on 19 cm CDEs manufactured by proposed bonding process but using Tetratex wrap demonstrated 6200 – 7000 e/MeV. This translates to an expected yield of > 7500 e/MeV for EM dimensions with VM2000 wrap. (reqmt > 5000 e/MeV)
  - Process for forming VM2000 wrap to CsI crystal using heated mandrels has been tested and shown to provide tight wraps on CsI and to have no adverse affect on reflective properties. Wrap problem solved, heat-formed VM2000 easy to apply.

*Separate Presentation on CDE Manufacture available*

# CAL Technical Progress (3)
# Analog Front End Electronics (AFEE)

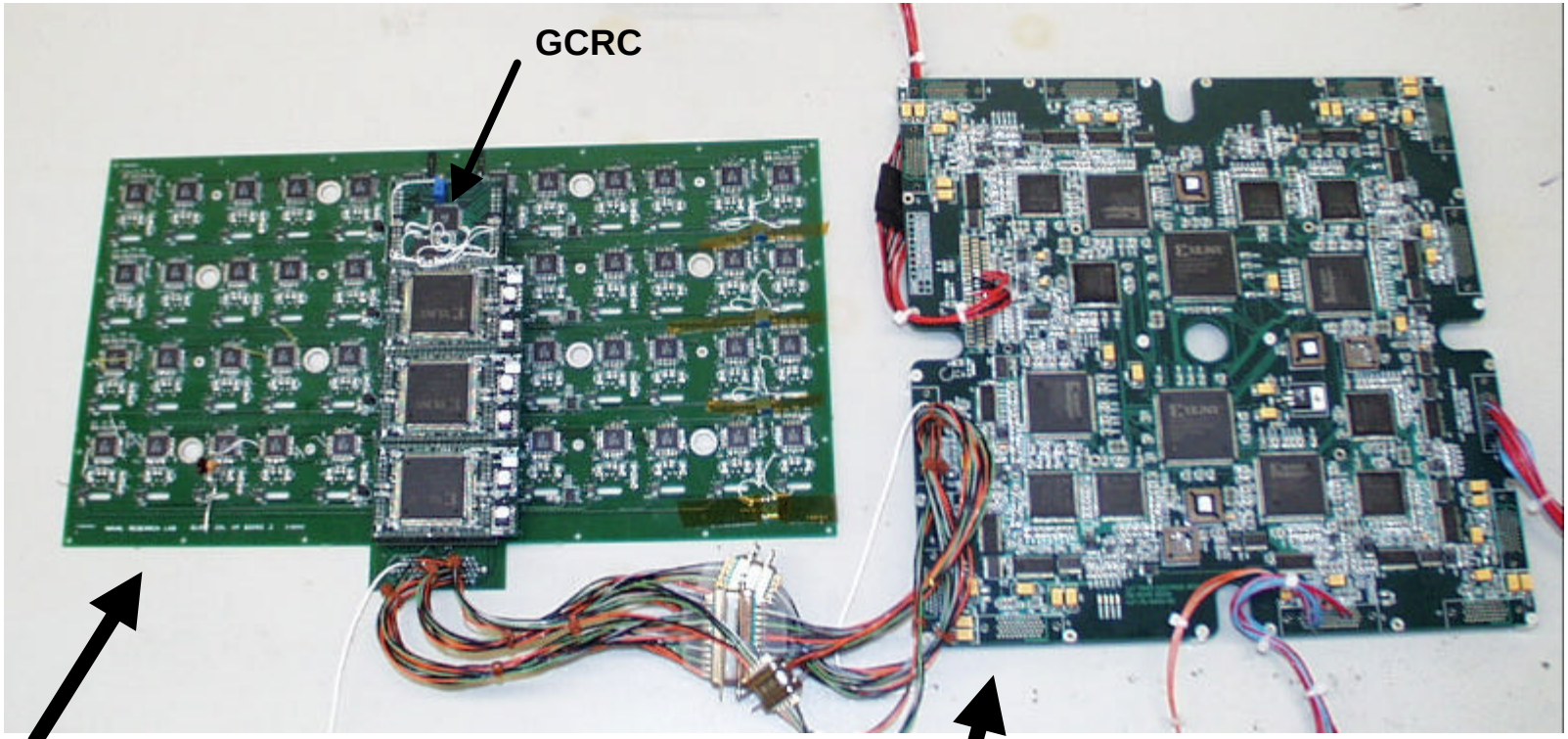
- GCFE (analog front end) ASIC
  - Design and performance have evolved through several iterations.
  - Essentially all required functionality has been demonstrated. Performance issues are still under investigation.
    - Noise: 1200 – 1800 $e^-$, reqmt: 2000 $e^-$
    - Integral Linearity: +/- 0.5% to +/- 4.0%, reqmt: +/- 0.5%
    - Triggering performance
  - Remaining issues (to be tested in parts delivered in August) :
    - Overload recovery circuitry.
    - New pinout to improve front end parasitic noise current sensitivity.
- GCRC (digital readout controller) ASIC
  - First version of ASIC was received in March.
  - Full functionality has been demonstrated. Minor improvements and adjustments have been incorporated in parts to be received in August:
    - Additional LVDS drive current adjustment capability.
    - Increased drive current on CMOS outputs.

# CAL Technical Progress (3)
# Analog Front End Electronics (AFEE)

- **AFEE Printed Circuit Board**
  - **Two prototype versions (VM and VM2) of the AFEE PCB have been fabricated for testing of CAL readout components**
    - **VM2 is fully populated with GCFE and GCRC ASICs as well as COTS ADC and DAC components**
    - **Several copies of VM2 have been produced to support LAT TEM design and testing (T&DF subsystem) as well as CAL EGSE software and test procedures.**
  - **Engineering model AFEE PCB is currently in layout design at SLAC.**

# CAL Technical Progress (3)
# Analog Front End Electronics (AFEE)

## CAL AFEE testing with TEM




**CAL VM2 prototype AFEE board**

- 48 analog chans (GCFE – ADC)
- 1 GCRC & 3 FPGA simulators of GCRC

**EM1 TEM CAL & TKR Readout**

# CAL Technical Progress (3)
# EEE Parts Qualification & Screening

- **PDR review of CAL parts qualification cost and schedule identified concern of inadequate planning.**
- **New CAL EEE parts qualification plan for commercial and plastic encapsulated ASICs was developed and approved by GLAST Project Office and GSFC parts branch.**
- **Revised qualification and screening plan and associated cost increase has been incorporated in CAL costs via LAT CCB approval. Issues:**
  - **Qualification and screening of ~12,000 COTS parts.**
  - **Qualification and screening of ~4,000 plastic encapsulated ASICs**

*Separate Presentation on EEE Parts Qualification and Screening available*

# January 2002 Review Final Report

## Findings:

- **CAL technical design is sound, at PDR level (PASS).**
- **CAL NOT READY for baseline**
  - **foreign contributions need to be resolved**
  - **Cost and schedule impact of changes need to be identified**

# Jan 2002 Review Recommendation Status (1)

- **Calorimeter should not be baselined until the French commitments are finalized and changes in the scope of the U.S. contributions are fully understood**
  - **French commitments have been finalized in two Memoranda of Agreement – one with IN2P3 and one with CEA/DAPNIA.**
  - **Increased US scope implemented in baseline schedule**
  - **US costs for the changes in responsibilities have been established and are included in LAT PMCS.**

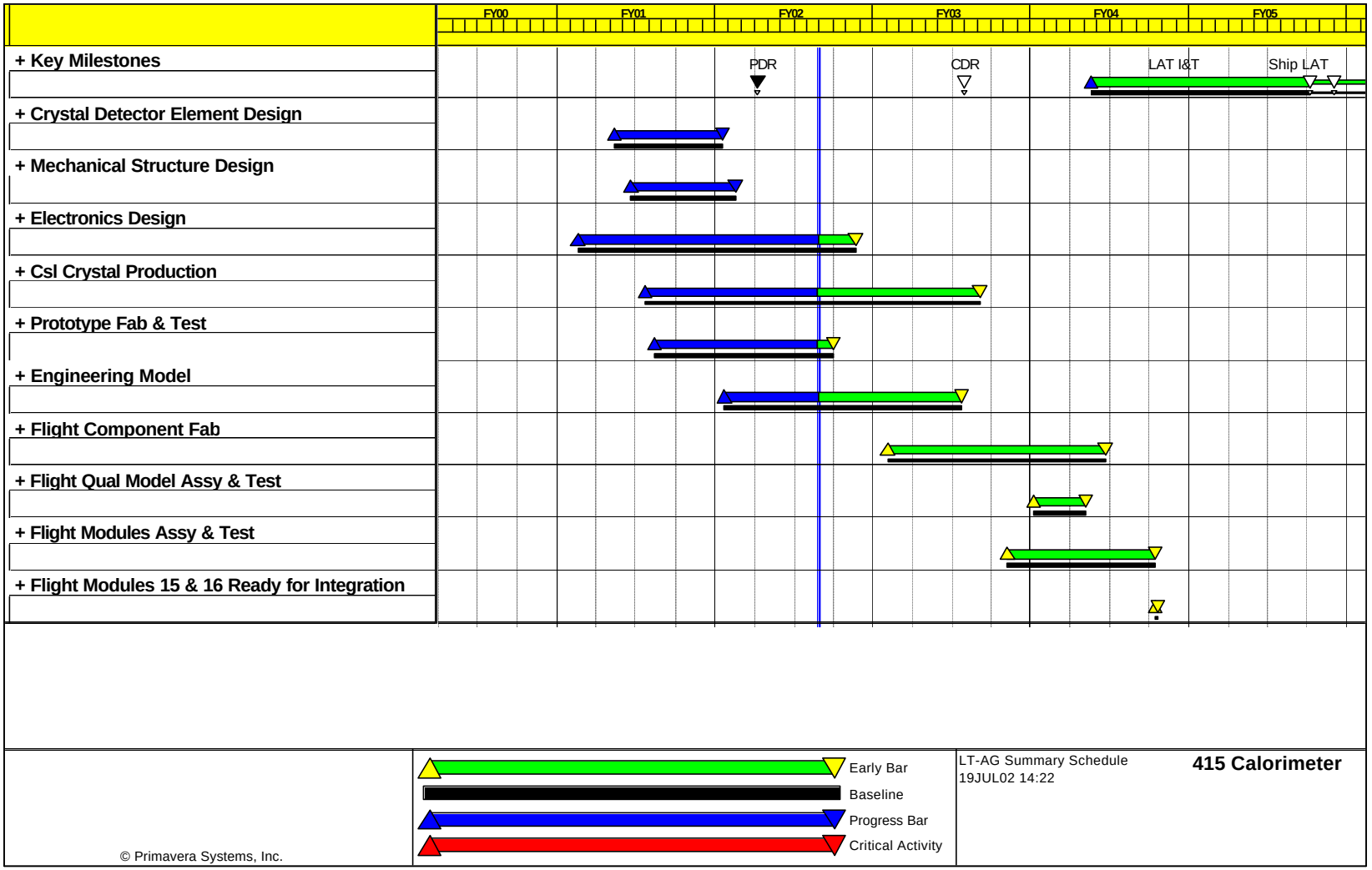
# Jan 2002 Review Recommendation Status (2)

- **The French collaborators, LAT management, and the relevant agencies should quickly reach and implement a final agreement on the responsibilities of the French institutions**
  - **French contributions organized according to plan agreed upon by French collaborators and agencies (IN2P3, CEA, CNES) that was outlined at the Jan 2002 Review.**
  - **MoA among NRL, IN2P3 and Stanford has been signed.**
  - **MoA among NRL, CEA/DAPNIA and Stanford is in signature process; CEA and CNES are currently negotiating "banking" issues (CNES to reimburse CEA expenditures). Hiatus until mid August due to summer holidays.**
  - **Letter of Agreement between NASA and CNES is ready for signatures**

# Jan 2002 Review Recommendation Status (3)

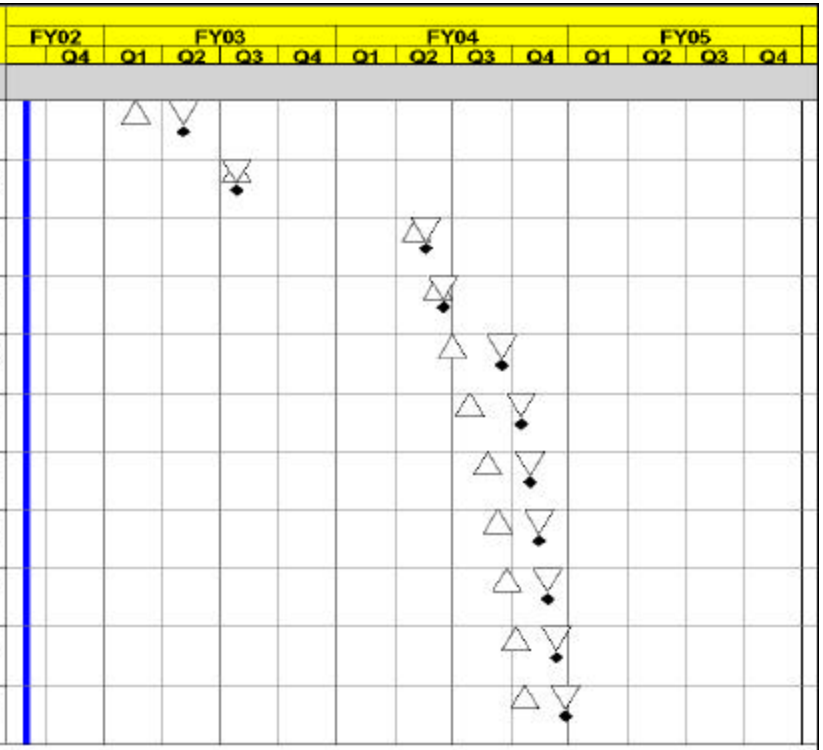
- **Establish a new budget and schedule**
  - **Cost and schedule impact of new agreements on French responsibilities have been incorporated in LAT PMCS via change requests approved by LAT Change Control Board:**
    - **New base program: + $2,371K (LAT-XR-00699 & -00743)**
    - **CDE Bonding Studies: + $418K (LAT-XR-00700)**
    - **PIN Photodiodes: + $400K (LAT-XR-00821)**
  - **Revised EEE parts, qualification and screening plan was developed, costed, and approved by GLAST Mission Office and GSFC Parts Branch.**
    - **Parts, Qual & Screening: + $921K (LAT-XR-00713)**
  - **The 6 month extension of the LAT schedule was applied after these costs were understood and incorporated in the LAT PMCS**

# Summary Schedule



# Key Milestones

| Activity Description | AV: Early Finish | Float | Baseline Finish |
|---|---|---|---|
| *4.1.5 Calorimeter* | | | |
| CAL AFFE Engr Model-CAL to Elec | 11/19/02 | 44 | 02/03/03 |
| EM from CAL to I&T | 04/25/03 | 0 | 04/25/03 |
| Calorimeter Modules A & B RFI ( for Calibration) | 02/04/04 | 8 | 02/17/04 |
| Calorimeter Modules 1 & 2 RFI (for Calibration) | 03/08/04 | 5 | 03/15/04 |
| Flight Calorimeter Tower 3, 4 RFI | 03/30/04 | 54 | 06/15/04 |
| Flight Calorimeter Tower 5, 6 RFI | 04/28/04 | 54 | 07/15/04 |
| Flight Calorimeter Tower 7, 8 RFI | 05/25/04 | 45 | 07/29/04 |
| Flight Calorimeter Tower 9, 10 RFI | 06/09/04 | 45 | 08/12/04 |
| Flight Calorimeter Tower 11, 12 RFI | 06/23/04 | 45 | 08/26/04 |
| Flight Calorimeter Tower 13, 14 RFI | 07/07/04 | 46 | 09/10/04 |
| Flight Calorimeter Tower 15, 16 RFI | 07/22/04 | 45 | 09/24/04 |

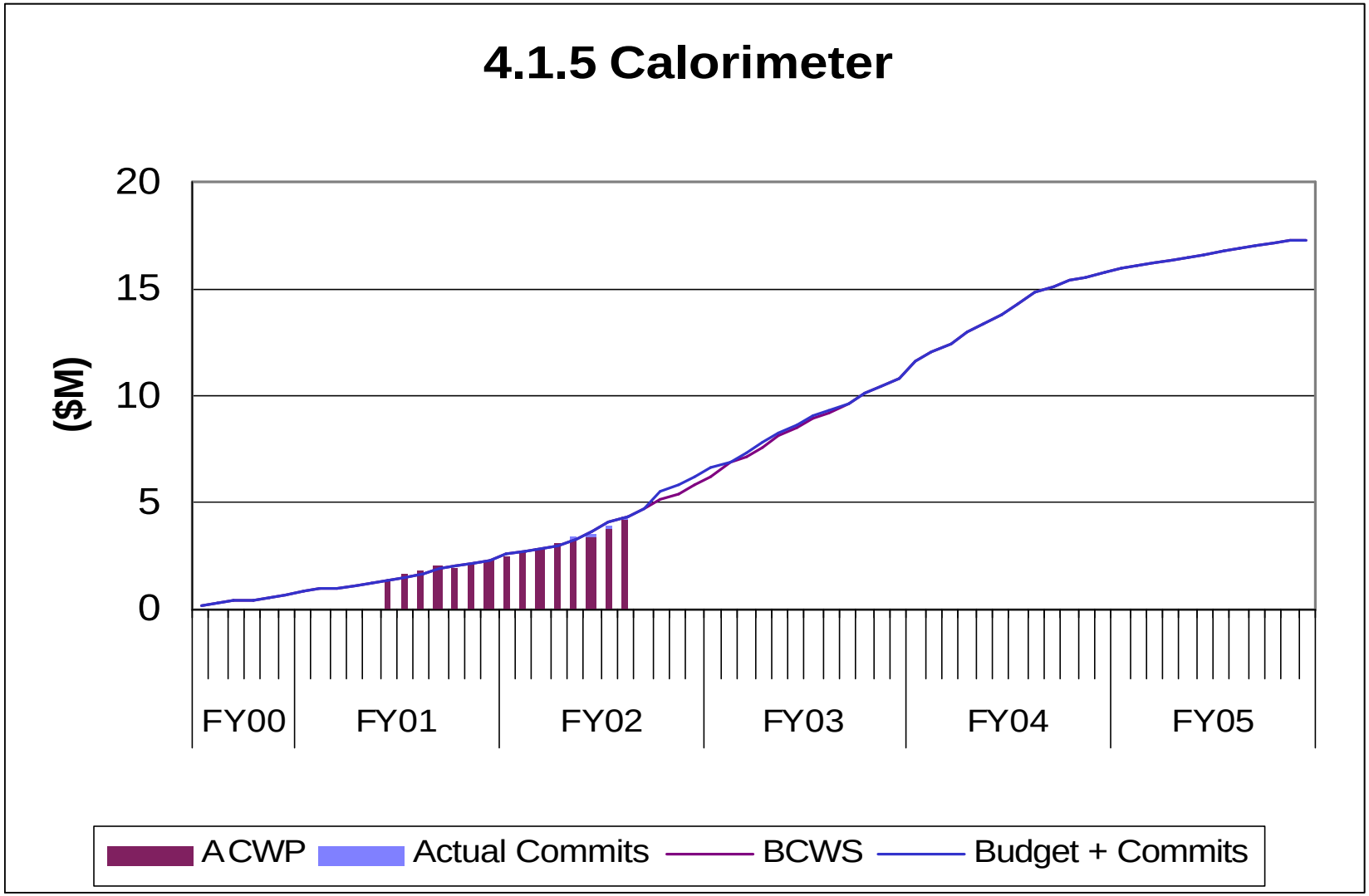



Run Date 07/19/02 10:53
Data Date 06/01/02

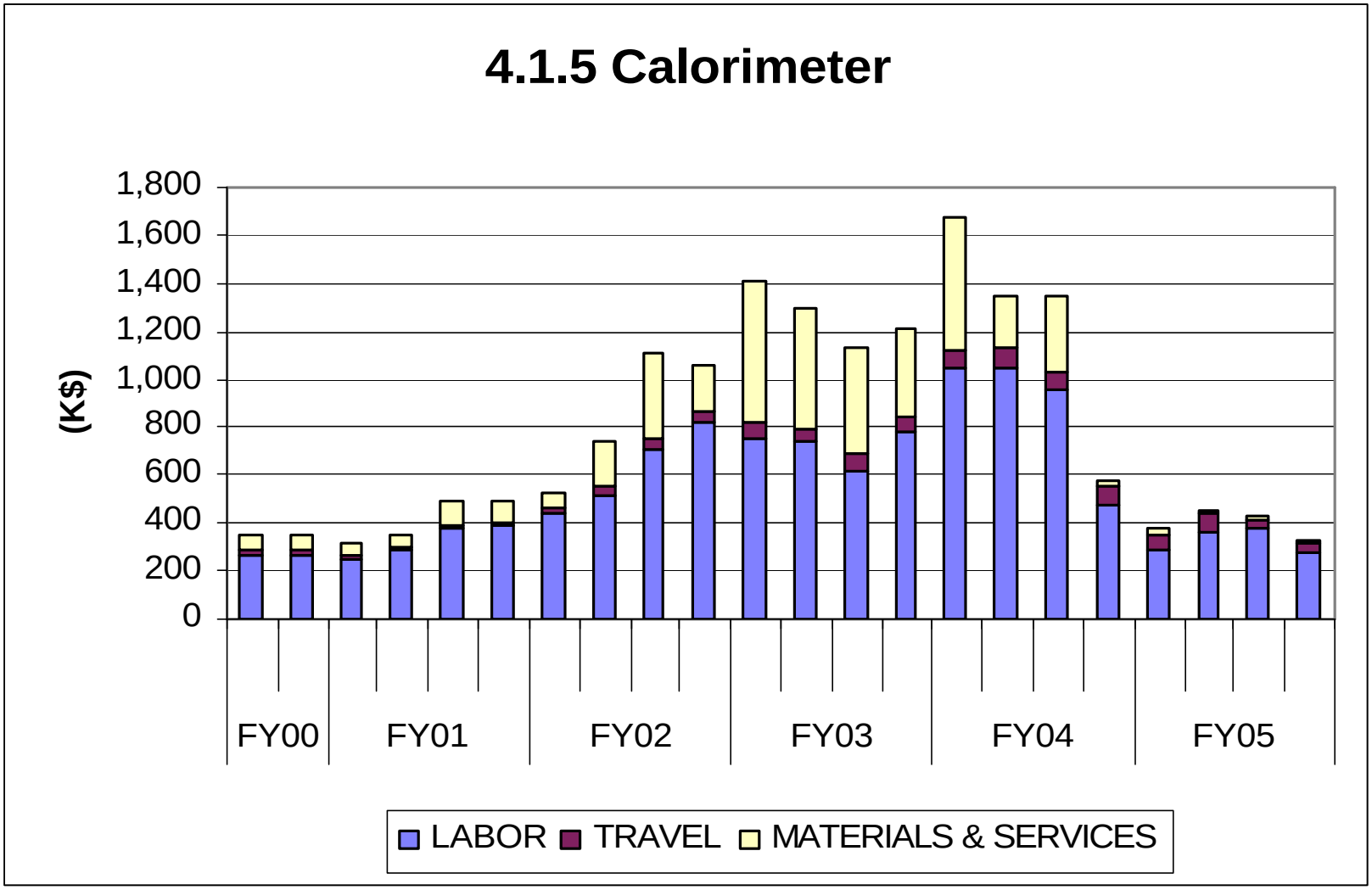

*GLAST LAT PROJECT*
*Key Milestones*

LAT3
LT-D4 : Key Milestones
FL-D4 : Key Milestones
Sheet 2

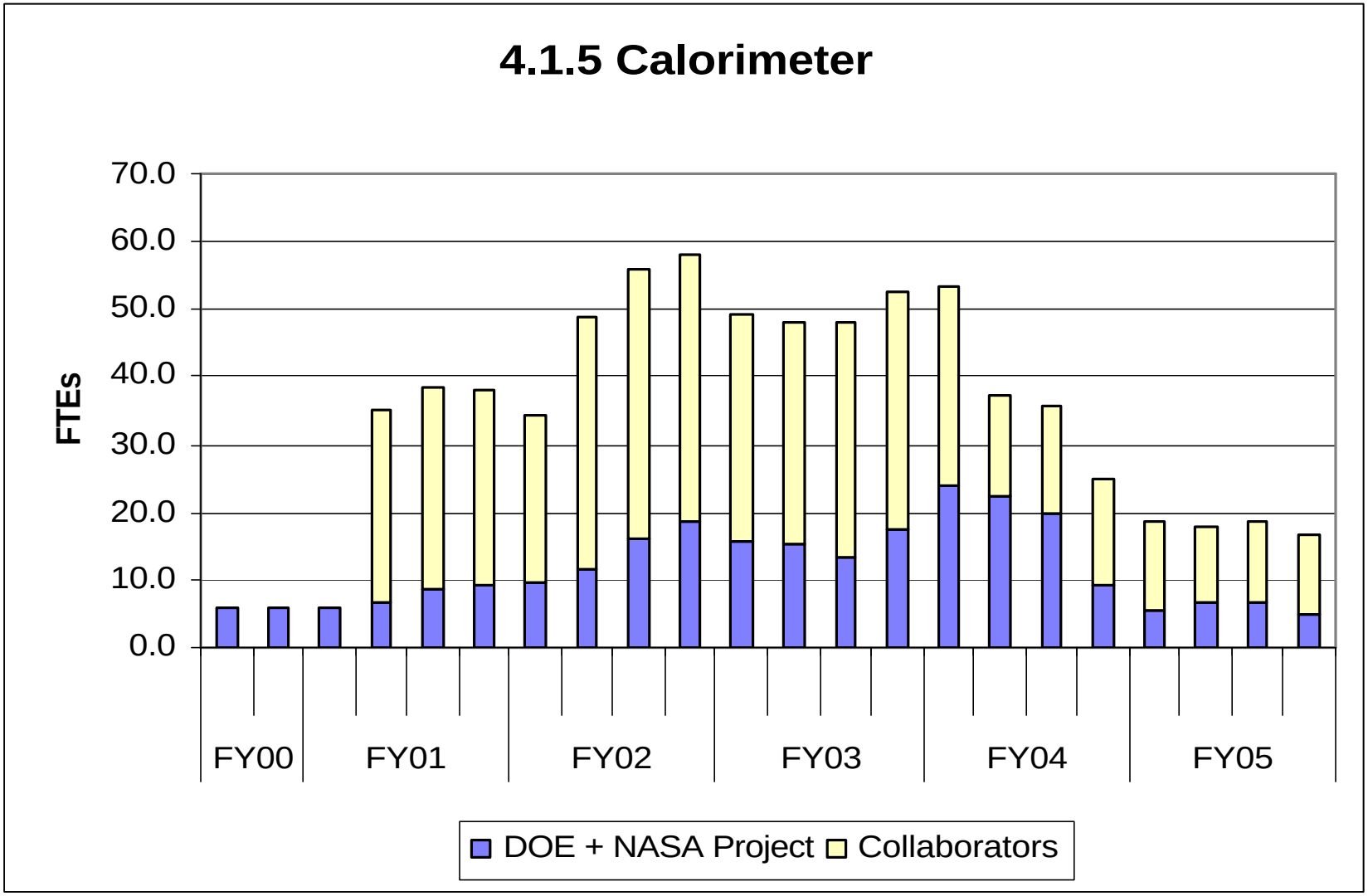
# Cost & Commitments



# Cost Profile



# Manpower Plan



# CAL Critical Path

- **Engineering Model Development**
  - Ready for CDR
    - ↖ Completion of EM Environmental Testing
      - ↖ Assy of EM Module
        - ↖ Availability of AFEE Boards
          - ↖ Availability of GCFE ASICs
- **First Flight Model**
  - Ready for Integration in Calibration Unit
    - ↖ Assy & Test of FMA Module
      - ↖ Availability of AFEE Boards
        - ↖ Availability of GCFE ASICs
- **Last Flight Model**
  - Ready for Integration in LAT
    - ↖ Assy & Test of FM16 Module
      - ↖ Availability of Pre Electronics Module
        - ↖ Availability of CDE

# CAL Critical Path (2)

| | Total Float (days) | | | |
|---|---|---|---|---|
| **Element** | **Eng Model** | **1st Flight (Qual)** | **5th Flight (FM 3)** | **Last Flight** |
| **CDE** | -51 (CEA 48, NRL 48)<br>-17 (CEA 16, NRL 80)<br>+5 (NRL 96) | + 57 | + 91 | + 84 |
| **Structure** | +28 | + 93 | + 131 | + 135 |
| **Electronics** | +3 | +3 | + 86 | + 147 |
| **Module A&T** | +67 | + 44 | + 54 | + 45 |
| **RFI** | | +44 | + 54 | + 45 |

Three options are considered for EM CDEs:

1) CEA building 48 CDE with flight-like process, NRL providing 48 flight-like
2) CEA providing 16 flight-like and NRL providing 80 flight-like.
3) NRL providing all 96 CDE with flight-like process

# 6 Month Schedule Extension - CAL

- 6 month extension was applied by shifting all existing CAL module deliveries (RFI) by six months.
  - EM schedule was preserved – aggressively complete and test EM.
  - Delay CAL CDR until EM testing is complete (~ Mar ’03)
- Benefits from new schedule
  - EM environmental testing complete prior to significant flight module construction
  - All CAL module deliveries have significant float on critical deliveries
    - FM 3 & FM 4 avail 03/30/04 w/ ~ 54 days float.
    - FM 15 & FM 16 avail 07/22/04 w/ ~ 45 days float
  - ASIC schedule permits additional fab cycle, if necessary. (float is reduced on 1st module deliveries).

# New Issues

## Dual PIN Photodiode Qualification

- **Qualification testing in France and US of DPD indicate problems with extended thermal cycling.**
  - **Micro-cracking in optical epoxy detected in test samples after ~50 thermal cycles at qualification temperature extremes ( -30°C, +50 °C).**
  - **Investigations are continuing with vendor.**
    - **Process control, cleaning, die attach, epoxy cure cycle, etc.**
  - **No degradation in optical or electrical performance have been detected with presence of micro-cracking, even after 100 thermal cycles.**
  - **Bonds to diodes with micro-cracks still meet strength requirements.**
  - **All issues will be resolved before flight procurement.**

# Summary

- **Technical Progress**
  - **No outstanding technical design issues**
  - **Diode – CsI Bonding problems are resolved.**
    - **Development work at CEA/Saclay is continuing**
    - **alternate processes developed and verified in NRL**
  - **ASIC performance issues to be verified in August ’02 delivery**
- **Schedule/Cost Status**
  - **Programmatic and technical changes are completely covered in baseline PMCS cost and schedule**
  - **ASIC development and fab remain the critical path**
- **Outstanding Issues or Concerns**
  - **Resolve PIN Photodiode low temperature epoxy cracking.**