Quarterly Report

For the Period October 1 – 31 December 2000

Gamma-ray Large Area Space Telescope (GLAST) Project

GLAST Large Area Telescope (LAT) Flight Investigation

DOE Project No. KA050102-EQU01CC

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GLAST LAT Instrument Project Office
Stanford Linear Accelerator Center (SLAC)
Stanford University

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Participating Institutions:

California State University at Sonoma (SSU)

University of California at Santa Cruz - Santa Cruz Institute of Particle Physics (UCSC/SCIPP)

Centre National de la Recherche Scientifique / Institut National de Physique Nucléaire et de Physique des Particules (CNRS/IN2P3)

Commissariat à l'Energie Atomique / Direction des Sciences de la Matière/ Département d'Astrophysique, de physique des Particules, de physique Nucléaire et de l'Instrumentation Associée (CEA/DSM/DAPNIA)

Goddard Space Flight Center – Laboratory for High Energy Astrophysics (NASA/GSFC/LHEA)

Hiroshima University

Institute for Space and Astronautical Science (ISAS)

Istituto di Fisica Cosmica

Istituto Nazionale di Fisica Nucleare (INFN)

Naval Research Laboratory (NRL)

RIKEN

Royal Institute of Technology (KTH)

Stanford University – Hanson Experimental Physics Laboratory (SU-HEPL)

Stanford University - Stanford Linear Accelerator Center (SU-SLAC)

Stockholm University

Texas A&M University - Kingsville

Tokyo Institute of Technology

University of Washington

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1 Introduction

The GLAST LAT Flight Investigation[1] was proposed by a collaboration of scientists and institutions led by Prof. Peter Michelson of Stanford University/SLAC. NASA selected it for the GLAST mission in February 2000. The LAT Instrument Project Office is located at and supported by the Stanford Linear Accelerator Center (SLAC), a national laboratory supported by the U.S. Department of Energy. DOE, NASA and other domestic and foreign funding and resources are being applied to optimize the success of the LAT effort. The LAT instrument is planned to fly aboard the GLAST observatory (Fall 2005 launch). NASA's Goddard Space Flight Center (GSFC) manages the GLAST mission.

Currently, the project team is carrying out the Formulation Phase, leading to a LAT Preliminary Design Review scheduled for August 2001.

Highlights of the reporting period:

- Work on development of the Anticoincidence Detector at GSFC/LHEA was initiated.
- A trade study was completed to determine the distribution and thickness of photon converter material in the Tracker and a final design configuration was adopted.
- Draft Memoranda of Agreement with all of the LAT foreign partners were circulated for comment and negotiation.

[1] *GLAST Large Area Telescope Flight Investigation: An Astro-Particle Physics Partnership Exploring the High-Energy Universe*, November 1999, Stanford University.

2 Recent Progress, Status, Work Planned Next Quarter

2.1 System Engineering

2.1.1 Mechanical Systems and Integration and Test

2.1.1.1 Current Design Status

2.1.1.1.1 Mechanical Design Integration

Mechanical Systems activities continue to focus on design integration issues within and outside the LAT. The following list describes the most significant aspects of this work.

LAT Footprint

Re-designing of the Tracker cabling and electromagnetic interference shielding showed that the earlier design had insufficient space. The re-design forced the LAT subsystem to expand beyond its stay-clear. Subsequent dimensional analysis, and scaling of dead area resulted in expanding the stay-clear of the LAT to accommodate the change. This enlarged the LAT footprint by 4 mm. The LAT still carries a healthy margin with respect to its outer stay-clear of 36.3 mm all around.

The LAT project adopted the carbon fiber Calorimeter structure design. The carbon fiber composite support box is shorter than the earlier design, so the height of the Calorimeter was shortened. The Calorimeter flange mounting on the Grid was also adopted, adding a flange on the backside of the Calorimeter. The net effect on the Calorimeter was to increase its stay-clear height by 1.956 mm to 223.800 mm.

LAT Radiator Conceptual Design

Conceptual mechanical design and analysis work was completed for the LAT radiators. The primary issue investigated was how best to support the radiators off the LAT and spacecraft. Since the radiators are supported off of both the LAT and spacecraft, the supports must accommodate possible differential motion between the two. Otherwise, such motion would impart loads into the radiators. Our analysis (summarized in Technical Note LAT-TD-00037) shows that a two-point strut support to the spacecraft provides the optimal load configuration for the radiators. This support method eliminates all over-constraint, except for relative twisting about the z-axis. However, the radiators are very flexible in this out-of-plane twisting, and can handle these relative motions.

The primary analysis driver surrounding this study was how to maintain a relatively high natural frequency of the radiator, while minimizing the number of supports to the spacecraft. Figure 2.1.1 shows a contour plot of the first mode shape of a radiator, supported at two points off the spacecraft and along the top by the Grid. The expected deflections in the radiator have been balanced to maximize the natural frequency. This ra-

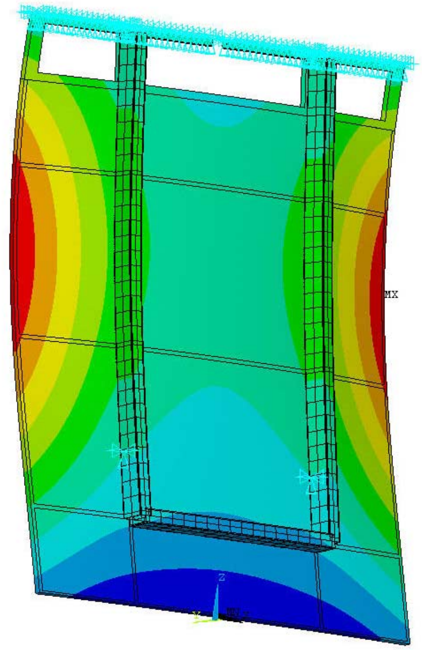

Figure 2.1.1 Radiator first mode shape, with natural frequency of 78 Hz

diator concept requires stiffening on the spacecraft side of the radiator, to improve its natural frequency.

The radiator analysis technical note was forwarded for inclusion in the spacecraft accommodation study this spring. We anticipate investigating this further with the spacecraft contractors for this study.

Optical Bench Conceptual Analysis

Another conceptual study that was performed this quarter was analysis of mounting concepts for a spacecraft optical bench for supporting the spacecraft star trackers and gyros. The issue here is that the 10 arc-second pointing knowledge requirement in the LAT-spacecraft Interface Requirements Document is difficult to attain. This requires close mechanical and thermal coupling between the LAT and these spacecraft components. One option to improve this coupling is to mount these components on an optical bench, supported off of the Grid.

Our analysis showed that such an optical bench should not be supported off the center of the Grid. The center flexes due to temperature gradients in the Grid. The preferred mounting points for an optical bench are around the perimeter, either at the spacecraft mounting points or at the quarter points along each side. LAT Technical Note LAT-TD-00045 discusses this analysis work.

Calorimeter Interface Development

Within the LAT, design integration activities have focused on developing the interface designs for each subsystem. The Calorimeter interface to the underside of the Grid has been under investigation for some time. This quarter, the expected bolt loadings were used to size the bolts and investigate thread shear strength and the types of inserts needed in the Grid wall. This work is leading to prototype strength and shear tests of the Calorimeter bolted connection this spring.

Anticoincidence Detector Interface and Conceptual Design

The conceptual mechanical design of the Anticoincidence Detector has undergone close scrutiny over the past quarter, both because of new Anticoincidence Detector personnel coming on the project, and because potential shortcomings of the original conceptual design had become apparent. A brainstorming session was held with Anticoincidence Detector subsystem personnel, where many of the design constraints and requirements were reviewed. A new conceptual design is being developed, and we are working to clarify the impacts of the new design on LAT dimensions, mass, and performance.

Tracker Interface Analysis

At the start of the quarter, it was clear that there was an interface problem with the Tracker. Since the baseline Grid is aluminum and most of the Tracker is fabricated from carbon fiber composite and carbon-carbon material, there was a potential problem in accommodating the mismatch of the coefficient of thermal expansion. Analysis showed that the interface couldn't sustain the large coefficient of thermal expansion mismatch over the entire LAT survival qualification test temperature range of –30 C to +50 C. In working with Tracker subsystem engineers, we have developed a concept for a flexible connection, allowing relative thermal motion while providing adequate stiffness to handle launch loads.

However, our finite element analysis shows that such a flexure joint reduces the overall stiffness of the LAT. The first-mode natural frequency of the LAT (without Anticoincidence Detector and radiators) was reduced 10% to 48 Hz with the flexure design. This is just under the Interface Requirements Document requirement of 50 Hz. We are continuing to study this problem. One issue is to understand the expected loads imparted on the LAT due to excitation of this first mode. It is a twisting mode, which should not normally be excited. We are now developing a reduced model of the LAT for a coupled-loads analysis of the observatory by the spacecraft Accommodation Study contractors. This should provide insight into the level at which this mode is excited.

Compiling of Finite Element Model

A "reduced" finite element model is being developed, to be delivered to the GLAST project team, for use by the spacecraft study contractors. This is a full model of the LAT, with enough detail to ensure that all significant frequencies of the LAT are modeled well. This will be ready for delivery in first quarter of calendar 2001.

2.1.1.1.2 Thermal Engineering

The dynamic environmental model of the LAT while on-orbit has been completed. This has been used to investigate the placement and heat loading on the LAT radiators. Initial results corroborate past hand calculations, which show that placing the LAT radiators on the sides of the spacecraft facing the solar arrays results in the lowest environmental heat loading, on average. Dynamic analysis of LAT environmental heating shows that the external heat load on a radiator varies from 0 to 500 watts. This is for the hot-case environmental heat loads, for GLAST pointing 90 degrees off the orbital plane, and a beta angle of 0 degrees. This large fluctuation is on the order of the total heat load from the LAT that needs to be radiated (650 watts). Thus, we will be carefully investigating how such a large fluctuation in radiative power dissipation will affect the radiator (and LAT) temperatures.

We are currently building a LAT radiation/conduction model to investigate the effect of these dynamic variations on the LAT, and at the thermal coupling to the inside of the LAT. This will be used to specify design requirements on the heat shield, and design and operational requirements on the radiators.

2.1.1.1.3 Grid Development

Grid development progress has been coupled to the design integration activities detailed above. At the Calorimeter mount interface, this has involved sizing the mounting hardware, and developing test plans for prototype joint testing. At the Tracker interface, Grid development has involved investigating the impact of changing the Tracker mount to a flexure design. Once these interfaces are solidified, the prototype testing program for the Grid will begin.

2.1.1.1.4 Integration and Test Planning

Verification Planning

We continued to add detail to the LAT environmental and performance verification plans. This began with the Verification Matrix, which was completed earlier for the SRR. The matrix was re-configured into a flowchart of verification activities, starting at the subsystem sub-assembly level, and continuing through observatory-level verification. One goal was to identify any areas where we may have had insufficient environmental verification plans. This flowchart was used for discussions with GLAST project personnel, to ensure a complete dovetailing of verification activities at the observatory level. The verification flowchart will be the core of the LAT Verification Plan.

Observatory Integration Planning

Conceptual work was also done on observatory-level integration plans. We investigated possible alternate integration strategies, including “+Z down” integration. This may simplify some of the integration processes, notably integrating the LAT radiators and spacecraft solar arrays. However, this configuration relies more on LAT ground support equipment to support the observatory. Our first look at this showed that this orientation looks very feasible. Since the LAT comprises 75% of the mass of the observatory, the LAT ground support equipment should be able to accommodate the full mass of the observatory with little additional strengthening. Also, given this mass distribution, integrating with “+Z down” may result in a more stable configuration.

This research also revealed how closely coupled the LAT and spacecraft will be. Because the center of gravity of the observatory lies between the two major subsystems, we expect that the handling ground support equipment will need to interface with both of them. An activity like flipping the observatory end-for-end will require hard-mount and rigging attach points on both the LAT and spacecraft, and even the final integration on the launch vehicle will most likely need to be done while hanging off of the LAT.

The conclusion is that more careful study of these activities is needed, and that close coordination between the LAT and spacecraft integration teams could save time and cost in ground support equipment development. We expect that this will be an issue to investigate with the spacecraft study contractors this spring.

Integration Facilities

Construction has started on the SLAC integration clean room facility. This work had been slowed by problems with the existing building foundation. Limited foundation rework is nearly complete, and all other building upgrades have been completed. First shipments of the pre-fabricated clean room materials have been received, and actual construction should start in January 2001.

2.1.1.2 Key Accomplishments

- Radiator support trade-off study completed.
- LAT thermal radiation environment model completed and in use. Initial radiator analyses confirmed by this work.

2.1.1.3 Identified Risks and Mitigation Plans, Issues and Concerns

- Risk: Further reduction in LAT structural stiffness may make it susceptible to coupling to launch vibration loads.
- Mitigation Plan: LAT team is completing overall LAT finite element model. LAT stiffness is the key parameter being used to optimize subsystem interfaces and the Grid design. We expect to work with the spacecraft study contractors in better characterizing coupling from the launch vehicle through the spacecraft.

2.1.1.4 Work Planned Next Quarter

- Continue construction of integration facility clean room at SLAC
- Complete Tracker, Calorimeter, and Anticoincidence Detector interface conceptual designs
- Deliver LAT structural finite element model to GLAST project
- Complete Process and Material Assurance Plan
- Begin radiator baseline design and analysis process
- Begin Grid prototype test program

2.1.2 Electronics

2.1.2.1 Current Status and Accomplishments

The LAT electronics activities continued to concentrate on the integration of the front-end systems including allocation of function blocks and interfaces. The function blocks on the Tower Electronics Module were discussed and a conceptual design document is being created. The Calorimeter interfaces were worked on and are almost complete. Issues were data format, interface to the Calorimeter analog front-end application specific integrated circuit (ASIC), and the Calorimeter digital ASIC. The only issue to be decided on is whether the Calorimeter data will be zero-suppressed on the Calorimeter electronics board or on the Tower Electronics Module. This however does not affect the front end ASIC, which is now in design.

Meetings were held with representatives of the Southwest Research Institute who presented central processor and interface electronics as applicable to the LAT. One key issue is inter-processor communication. Progress was made in the area of digital ASIC design tools, which were updated for the LAT electronics. Synopsis™ synthesis and simulation tools as well as Cadence™ layout and place & route tools were installed to be used for the LAT application specific integrated circuits.

2.1.2.2 Identified Risks and Mitigation Plans, Issues and Concerns

The main concern is still the shortage of available manpower for the on-board software development. Management is aware of the issue and is working on a solution.

2.1.2.3 Work Planned Next quarter

The principal effort of the electronics team in the next quarter will be software effort for the balloon flight and design of the LAT electronics system. In addition, the work on the hardware for the balloon-flight will continue. In the next quarter the balloon flight electronics will be integrated at SLAC and commissioned. Schedules and budgets for the PCMS will be refined.

The LAT electronics effort will concentrate on the central processor details and communication between processors and to the towers. The conceptual design phase for the Tower Electronics Module will be completed. The trigger system will be refined.

Synopsys™ and Cadence™ digital cell libraries will be created for the Agilent, TSMC™, and Peregrine technologies.

2.2 Tracker

2.2.1 Management

The most intensive area of work this quarter involved the incorporation of the Italian groups into the development effort and planning for Tracker fabrication. Tracker hardware development work has begun in earnest, particularly within the Pisa group, but with contributions also from Trieste and Perugia. Recently a group in Bari has expressed interest in contributing to the project, and discussions with them are ongoing.

At a meeting at SLAC in November, a plan for Italian participation in the Tracker fabrication was formulated, and afterwards a complete Memorandum of Agreement concerning INFN/ASI participation in the LAT project was drafted. The plan represents a substantial increase in Italian responsibility for Tracker fabrication with respect to our NASA proposal. In the new plan, the INFN groups will be responsible for assembly of all of the flight ladders and trays and all but the first two of the flight towers. In addition, they will procure about 40% of the silicon detectors and all of the carbon-fiber tray panel structures. Guido Barbiellini of Trieste will serve as the scientific spokesman of the INFN institutions, and Ronaldo Bellazzini of Pisa will serve as the Italian Project Manager for Tracker fabrication.

Work has also concentrated on improving the Tracker WBS, schedule, and budget. The Tracker WBS dictionary was finalized to level 6, and the schedule was adjusted to the same level and brought into accord with the project-level milestones. Work continued on detailing the schedule to WBS levels 7 and 8. The budget detail was modified to agree with the WBS and to allocate responsibilities to INFN in accordance with the draft Memorandum of Agreement. Work is now in progress to reevaluate the budget estimates.

2.2.2 Silicon Strip Detector Development and Procurement

2.2.2.1 Prototyping

The first flight prototypes of the GLAST2000 silicon strip detector were produced by Hamamatsu Photonics in Japan, based on the detector layout agreed upon by the collaboration, which incorporates the dimensions finalized in the review of the detector size in spring 2000 (see Figure 2.2.1). In all, 35 sensors were shipped to us after extensive testing at the factory (see below). Of these, 20 sensors are being tested at Hiroshima University, 5 at SLAC, and 10 at INFN Pisa. Testing will proceed through January 2001, and the go-ahead for production is expected at the end of the month, following a formal review of the detector specifications.

In addition to Hamamatsu, STM (Italy), Micron (UK), and CSEM (Switzerland) are working on prototypes based on the LAT silicon strip detector specifications, in collaboration with INFN institutions.

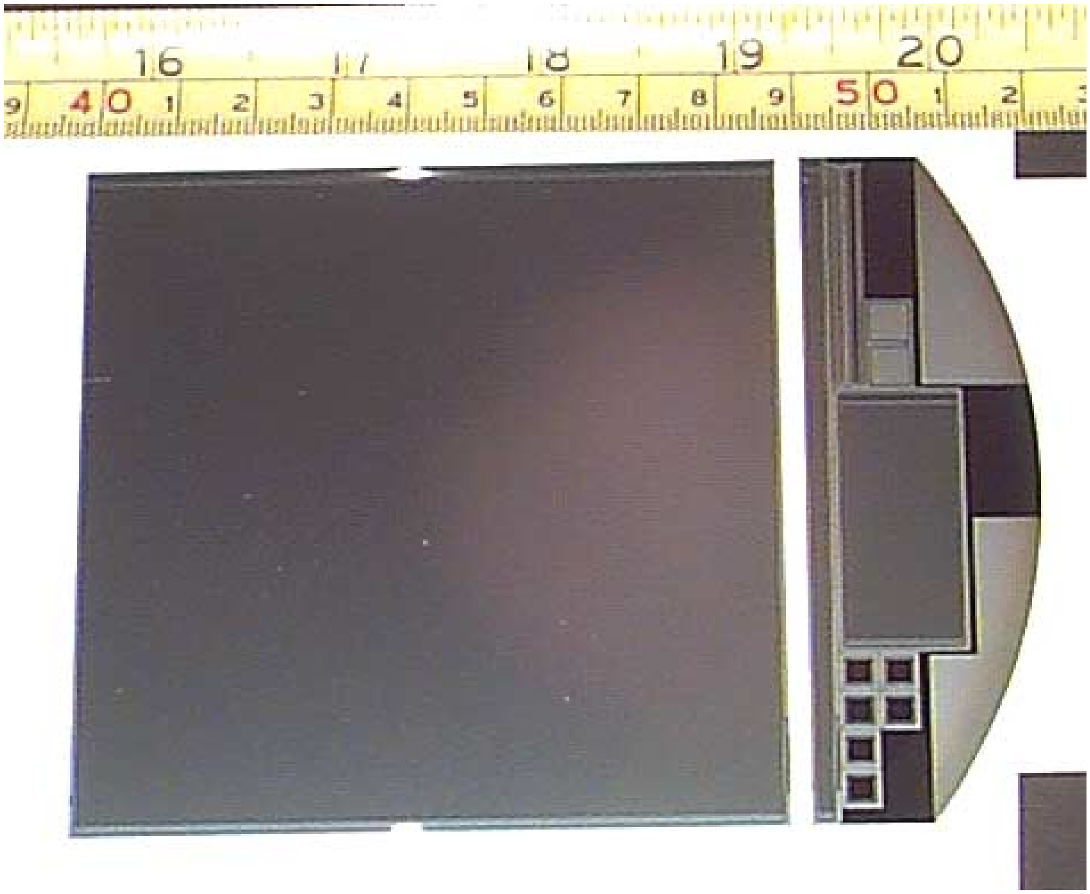

Figure 2.2.1. GLAST2000 silicon strip detector prototype and test structures. The detector (on the left) is full size (8.95cm x 8.95cm) with 384 strips. The test structure (on the right) from the same 6” wafer contains a full length, but narrow silicon strip detector, a “baby” silicon strip detector with 32 strips, a bond test structure, and several diode and metal-oxide-semiconductor structures.

2.2.2.2 Silicon Strip Detector Specifications

Detailed technical specifications for the silicon strip detector were written, including test procedures and performance criteria. They are used as the basis for the prototyping of flight detectors and have been entered into the LAT database as LAT-DS-00011-06. The critical design review of the specifications is scheduled for January 30, 2001.

2.2.2.3 Silicon Strip Detector Procurement

In the tender process to procure 400 silicon strip detectors to the new specifications, KEK selected Hamamatsu as the supplier. Only Hamamatsu has demonstrated that they can produce LAT detectors to the quality and performance level required in the specifications. The production and testing capacity of Hamamatsu is large enough to fabricate all LAT silicon strip detectors (11,500 pieces) in the time required (Spring 2001 to Spring 2003).

Table 2.2-1 Tests performed on GLAST2000 prototypes from Hamamatsu.

Test	Hamamatsu	SLAC/ Hiroshima	Test Structures
Electrical			
I (150V)	×	×	×
I (175V)	×	×	
V (dep)	×		×
C (dep, 1kHz)	×		×
# of Bad Channels	×		
R(Ave)	×		
R(High)	×		
R(Low)	×		
R(Al Strip)	×		
R(Int-2neighb.)			
C(Int-4neighbors)		×	
C(Coupling)	×		
Mechanical			
Thickness			
Width		×	
Length		×	
Bias Width [cm]		×	
Bias Length [cm]		×	
Width Distance [um]		×	
Length Distance [um]		×	
Pitch		×	
Implant Width [um]		×	
Metal Width [um]		×	
Alignment First [um]		×	
Alignment Last [um]		×	
Bonding Pads Location			
Fiducial Marks Location			
Test Structures			

2.2.2.4 Silicon Strip Detector Testing

The LAT silicon strip detector procurement plan is based on the assumption that we will buy high quality detectors that have been tested completely by the manufacturers to tight specifications. Detector testing by LAT institutions will be done on flight sensors before every new Tracker tray fabrication step to detect catastrophic failures. In addition, we will monitor the product quality during production through custom designed test structures implemented on each wafer. The testing of the first 35 prototypes thus serves four purposes:

1) Qualify the mask design and the fabrication process

2) Establish acceptance windows for the detector parameters still under review

3) Correlate the performance of flight sensors with the test structures implemented on the same wafer, to calibrate and validate the production monitoring strategy

4) Crosscheck the measurements made at the factory with those of the LAT institutions.

Initial measurements have shown excellent agreements of the measurements made at Hamamatsu with those made at SLAC and Hiroshima. They have shown that the 35 detectors meet the specifications of LAT-DS-00011-06. A list of measurements to be performed for the testing is given in Table 2.2-1. An “x” indicates tests already performed and found to be within specifications. The remainder of the measurements will be completed in January 2001.

The small spread of the parameter values is evidence for excellent performance of the Hamamatsu detectors. For example, the leakage current at 150V is shown in Figure 2.2.2. The values scatter tightly around a mean of 143 nA, with the highest at 200 nA, while the specification for the mean is below 240 nA, with no detector above 800 nA.

Another example for the tight process control is the depletion voltage, which clusters closely around either 60V for higher resistivity material or 120V for lower resistivity wafers. The bias resistors are well within specs, with resistance values above 30 Mohm, and are very uniform across a wafer, with a maximum deviation of about 2 Mohm.

As we have seen before in the Hamamatsu process, the number of bad strips is extremely low, with only 4 strips out of 35×384=13440 detected by the manufacturer as being defective (3 of them on a single detector). That is a bad channel rate of 0.03%, a factor of 10 lower than the specifications.

2.2.3 Design and Specifications

The Tracker dimensions were finalized, with a 1 mm increase of the tray size and a 0.5 mm increase in space between towers. Some of the extra space was required for the electronics redesign (see below), while the rest was needed in order to make fabrication tolerances less critical.

The Tracker Level-4 requirements document was completed but not yet formally reviewed. Level-4 specifications and Interface Control Drawing rough drafts were written.

2.2.4 Tracker Mechanical Structure

Hytec completed and delivered to SLAC a simplified model of the Tracker module for use in the LAT system model. Work is ongoing between SLAC and Hytec to understand the mechanical interplay between the Tracker and Grid. Hytec also updated their own system model and did some analysis with it, from which they concluded that the towers should *not* be clipped solidly together at the top.

Hytec ordered the materials for all of the carbon-fiber tray prototypes needed through Preliminary Design Review. They also sent the two sidewall material candidates out for testing the mechanical strength and thermal properties, the preliminary results of which look very good. They also began conducting in-house pullout tests of fasteners in the sidewall material.

The detailed closeout design progressed during this quarter with numerous small adjustments required in order to accommodate the electronics interface. That process is nearly complete, with the electronics board size and depth fixed and the fastener hole positions and sizes final. The corner joint between closeout sides was prototyped to test that concept. The face-sheet drawings were finalized and released to the vendor for fabrication of the prototypes. The overall Tracker mechanical drawing package was converted to metric, for primary units, and was updated to the new dimensions and designs.

Progress has been made on the design of assembly techniques and fixtures for the carbon-fiber tray panels. This work should be completed in January 2001. The Tracker lead engineer and the Hytec engineers visited two composites vendors to work out ideas for precision assembly of the carbon-fiber panels, including concepts for the necessary fixtures. The vendors were comfortable with the required assembly tolerances. Planning began for similar visits to vendors in Italy.

A flexure concept was worked out for mounting of the Tracker modules onto the Grid and preliminary drawings were made. Recently this concept was included in the finite-element model and analyzed. This work firmed up our ideas for that crucial interface and allowed work to begin on the detailed bottom tray design. A finite-element model of the bottom tray was built and exercised to study issues with the core thickness.

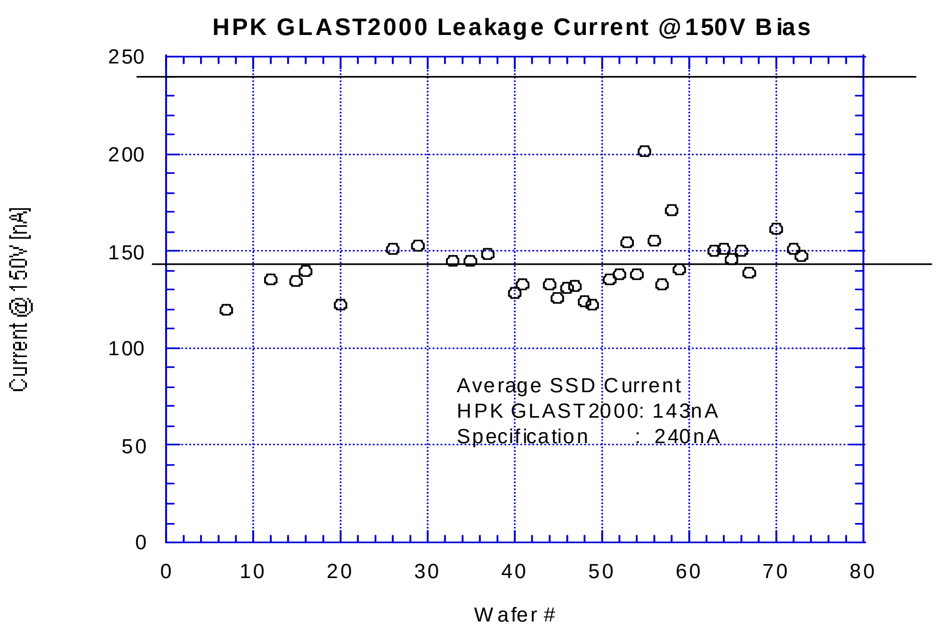

Figure 2.2.2. Leakage current at 150 V bias for the first 35 Hamamatsu LAT2000 prototypes, as a function of the detector ID#. Both the mean of the values measured by Hamamatsu (143 nA) and the LAT specification of the mean (240 nA) are indicated by the horizontal lines.

2.2.5 Tray Assembly

Investigation of thermal stress issues continued. We bonded detectors to aluminum slabs and cycled through the full test range without damage or excessive stress. Those tests will be repeated with the final adhesive candidates and dot patterns. A complete, functional 32-cm long ladder bonded to the full stack-up of carbon-fiber face sheet, thin lead converter, and polyamide bias circuit was also thermally cycled through our full test range without damage or increase in leakage current. A tentative decision was made to use silicone adhesives for detector attachment, but tests with those adhesives remain to be done.

The Pisa group completed preliminary designs of the tray assembly fixturing, including a revision of the SLAC ladder assembly fixture. They began making test ladder assemblies using glass wafers and blank silicon wafers. They also completed a 2D thermal finite-element model of the tray and payload (with thick converters) and began work on a 3D version.

The Pisa group designed and began fabricating, in industry, carbon-fiber panels for testing the payload attachment. The first panels will be made with simple C-channel closeouts. Hytec ordered extra carbon-fiber material to make complete closeout prototypes for the second round of tray assembly prototyping in Italy.

2.2.6 Tracker Front-end Electronics

Work continued on the detailed design of the front-end electronics. The specifications for the interface with the data-acquisition were finalized and documented, as was the interface between the front-end readout chip and the readout-controller chip. A Cadence™ computer-aided design system was set up and tested at SLAC for completion of the layout of the controller chip, and the automated place and route will begin in January with help from an outside consultant (the designer of the Beam Test Engineering Model readout-controller chip).

The schematic of the front-end readout chip logic was finalized and simulated at the digital level, although further simulation checks remain to be done. The complete control block was successfully laid out by automated place and route within the Tanner tool set. The pad frame and dimensions of the chip were also finalized.

Three prototype chips are in fabrication to test elements of the design that are completely new or are heavily modified at the transistor level:

- A chip with multiple amplifier/discriminator channels and test transistors was submitted to both the Agilent 0.5 μm bulk CMOS and Peregrine 0.5 μm silicon-on-insulator processes. These chips will be delivered in January and will be used to test the modified amplifier/discriminator design and to evaluate the noise and threshold-matching performance of these processes.
- Another chip was submitted to the Agilent 0.5 μm process with improvements in the amplifier design to allow operation at lower voltage. In addition, a set of

shift registers employing our new single-event-upset-safe flip-flop design was included (as well as standard registers for comparison). These registers will be used to test both single event upset and single event latchup resistance.

The mechanical layout of the front-end readout module was finalized, with the possible exception of an open question of the mounting screw size (which will be finalized once the implications for the electrical layout are understood). This has allowed us to finalize the mechanical interface of the readout module with the tray and to begin the detailed electrical layout of the printed circuit board. We decided to use aramid fiber for the board and began investigating vendors for its fabrication. Adherence to Institute of Printed Circuit standards and approved parts for the front-end readout module and readout cables led to a need for slightly more space for the electronics and therefore slightly larger towers. All of the tower dimensions should now be final.

We visited two vendors for front-end readout module assembly and recently received quotations, one of which meets our original budget estimates. We also continued to make prototype readout module mechanical assemblies in the lab. Prototype Kapton pitch adapters were fabricated at CERN by the Pisa group and are being used in the current prototyping round. Samples of integrated circuit wire-bond potting compound were obtained, and initial tests of its application are being carried out.

An alternate vendor for miniature connectors was found, and quotes are being obtained from both vendors. The front-end readout module and readout cables are being designed at this time to accommodate both brands of connectors.

2.2.7 Balloon-Flight Tracker Module

During this quarter we repaired the Beam Test Engineering Model trays with loose ladders, improved the bonding of all ladders, and reassembled the tower with three fewer trays at the top. The resulting Balloon Flight Engineering Model Tracker module was tested electronically. Three front-end readout modules would not read out to one side or the other and could not be repaired. The problems appear to be related to damaged wire bonds between chips in the region of the readout cables (reinforcing our decision to use hard potting material in the flight versions). Nevertheless, all detector ladders can be read out — only a small amount of the redundancy in the system has been lost.

2.2.8 Identified Risks and Mitigation Plans, Issues and Concerns

- Funding in Italy is likely to be very tight in 2001. In order not to delay progress, priority will be place on funding the tray-assembly development work while deferring less urgent items, such as the purchase of equipment that will be needed during the implementation phase.
- With Italian funds in 2001 committed to tray assembly development, and available Japanese funding unable to cover the full 2001 needs for silicon detector procurement, SLAC will fund some of the procurement in 2001 (and 2002). In return, Japanese funds will be used to cover certain planned SLAC procurements later in the project.

2.2.9 Work Planned Next Quarter

- Support the joint DOE/NASA review for the Tracker subsystem.
- Resource-load the Tracker schedule and refine the budget. Incorporate them into the LAT project management system.
- Produce rough drafts of Tracker interface specification documents.
- Produce a Tracker database that is at least sufficient to handle the start of detector procurement and testing.
- Complete testing of surface coating for carbon-carbon structures.
- Fabricate standard prototype trays according to the new carbon-fiber design.
- Complete selection and testing of tray payload attachment adhesives. Complete carbon-fiber tray mockups for conclusive payload attachment and thermal tests. Conduct alignment tests of the mockup trays and thermal tests of the full stack up of converters, bias circuit, and detectors on mockup trays.
- Complete the testing of detectors from the prototype runs and review the specifications. Begin the detector preproduction run.
- Implement test and storage equipment for detector production.
- Fabricate complete ladder prototypes in Italian industry.
- Complete the design of tray work holders and the ladder placement jig.
- Complete the new layouts for the front-end readout module printed circuit board.
- Complete design work and development in preparation for fabrication of complete mockup front-end readout module assemblies.
- Test and evaluate the prototypes for the new front-end amplifier/discriminator design.
- Complete the redesign of the prototype ASICs. Begin preparations for testing of the prototypes.
- Begin design and prototype work on the bias-circuit/converter-foil assembly.
- Integrate the Tracker module into the balloon flight payload.

2.3 Calorimeter

2.3.1 Management

In France, a new project manager was identified and began organizing the French activities. A new French system engineer will join the project in March.

A Calorimeter working group meeting in Paris in October identified a critical problem for the design schedule for the Calorimeter. That problem was the continuing inability to find the necessary resources in France to initiate the design of the Calorimeter front end ASIC. On November 14, the LAT Project Manager announced the decision to initiate a backup ASIC design activity at SLAC. In a teleconference later that day, CEA/DAPNIA decided to terminate its development activity for the analog ASIC.

This change in the responsibility for the ASIC development resulted in a full review of the organization of the entire French contribution to GLAST. The change directly impacted assigned responsibilities both at CEA and at IN2P3 labs. The lost work at CEA required identification of alternate contributions for CEA and reconsideration of all French contributions to GLAST. The new contribution from CEA will be power supplies for the Calorimeter and Tracker.

Meetings and telephone conferences relating to this restructuring of the roles and responsibilities of the French collaborators and the allocations of responsibilities to the various French institutions consumed the remainder of November and most of December. Consequently, little or no progress was made on organization, scheduling and costing of the Calorimeter program.

The Memorandum of Agreement among SLAC, NRL and French Institutions became the focus for the definition of the reorganization and responsibilities of the French. Several drafts of the Memorandum of Agreement were created and reviewed. The document is essentially ready for signatures.

Significant progress has been made in organizing the Swedish contributions to LAT. The Royal Institute of Technology has been joined by Kalmar University for the development and testing of the cesium iodide (CsI) crystals for Calorimeter. The CsI procurement specification was reviewed, and the official announcement for the CsI procurement appeared in the European Union journal on December 8th. The deadline for offers is 22 January following the European Union rules.

The project manager for the Calorimeter efforts at NRL has focused on establishing the baseline organization, schedule and cost for the Calorimeter subsystem. Critical near-term milestones have been created to track the development of the Calorimeter design.

2.3.2 Systems Engineering and Performance Assurance

A draft of the Calorimeter Parts Program Control Plan was developed and submitted to the LAT Instrument Project Office for review.

2.3.3 Calorimeter Design and Verification

2.3.3.1 Software and Data Analysis

The Calorimeter ground software working group continues to hold electronic meetings most weeks. Minutes of those meetings can be found at the NRL web site, at http://gamma.nrl.navy.mil/glast/calsw/Index_to_Cal_SW_Minutes.html.

2.3.3.1.1 SLAC beam test 1999

We completed analysis of the SLAC beam test data from Winter 1999/2000 for the summary paper.

2.3.3.1.2 GSI Beam Test

The CENBG group has initiated the analysis of the ion-beam data collected at the GSI Darmstadt facility in summer 2000, in collaboration with the NRL team. The purpose of the experiment was to study the Calorimeter response to heavy ions (carbon, nickel) with energies comparable to those of the cosmic rays used for calibration in orbit. In addition to the determination of the light response as a function of the energy and atomic number of the impinging ions, the procedure for selecting non-interacting ions is to be established from these data.

2.3.3.1.3 Documentation

The energy reconstruction classes of the beam test reconstruction code (Tbrecon) were documented using the collaboration documentation tool doxygen. An example can be seen at http://cdfinfo.in2p3.fr/~terrier/tb_doc/class_CalClustersAlg.html.

A local version of the instrument simulation code, Glastsim, is now partly documented. The process is now stopped awaiting the migration to the new code infrastructure, Gaudi, to be completed.

2.3.3.1.4 Energy Reconstruction Algorithms

A special output format for Glastsim was defined, and a large number of files (~10^7 events total) were produced to cover energies from 1 GeV to 300 GeV with a uniform angle distribution and a uniform illumination. A prototype method was developed and tested on various energies and angles. It gives sensible results, but it is rather weak as regards geometrical effects. It is planned to improve this by a tighter event selection.

2.3.3.1.5 Simulations and Reconstruction algorithm development for Calorimeter imaging

Simulations using a simple geometry in GEANT were made to determine the barycenter position fluctuation per layer. This yielded the optimal position resolution one can achieve (physical limit). The results are similar to those obtained during the 1997 beam test.

However, it was shown that at non zero incident angles, the position given by the longitudinal measurement is biased, because the barycenter is different from the shower axis position in a given layer. The evolution of the bias was determined for several energies and incidence angles. It was also shown that for the transverse measurement, there is a bias having the classical S shape as a function of the reconstructed position. Finally, a simple direction calculation was implemented and will be tested on a toy model, which was developed as well.

2.3.3.1.6 Simulation of the Carbon Fiber Cell Design

The carbon fiber cell design geometry description was implemented in Glastsim. It includes carbon fiber structure with air gaps between structure and crystals, correct geometry of top and bottom support frames, and detailed geometry of printed circuit board with aluminum supports.

2.3.3.1.7 Study of the false Multi-MIP rate due to galactic cosmic ray protons

Simulations with Glastsim and data analysis were made in order to investigate the rate of galactic cosmic ray protons that, because of nuclear interactions in or near the instrument, deposit enough energy in the Anticoincidence Detector to exceed the nominal Carbon threshold for galactic cosmic ray calibration events. These are proton events - which should be rejected - that falsely suppress the Anticoincidence Detector veto because they pass the galactic cosmic ray calibration event criterion. This work shows that the rate of false veto suppressions is a few Hz, which does not stress the data downlink rate.

See the presentation at http://doc.in2p3.fr/themis/CELESTE/vrvs/index.htm.

2.3.4 CsI Detector Elements

2.3.4.1 Crystal Acceptance Test Bench

In a meeting between NRL and the Swedish collaborators, the requirements and fabrication of the crystal test bench was discussed. To meet the need date for testing of the engineering model crystals, NRL agreed to design and manufacture the first two benches and the Swedish collaborators would manufacture all subsequent units. A new test bench was designed based on an adaptation of the BaBar crystal test box. The test bench (Figure 2.3.1) will consist of a black box, a Nuclear Instrument Module (NIM) bin, and a personal computer. The personal computer will control the data acquisition and will archive the data. The system will be controlled by Labview software.

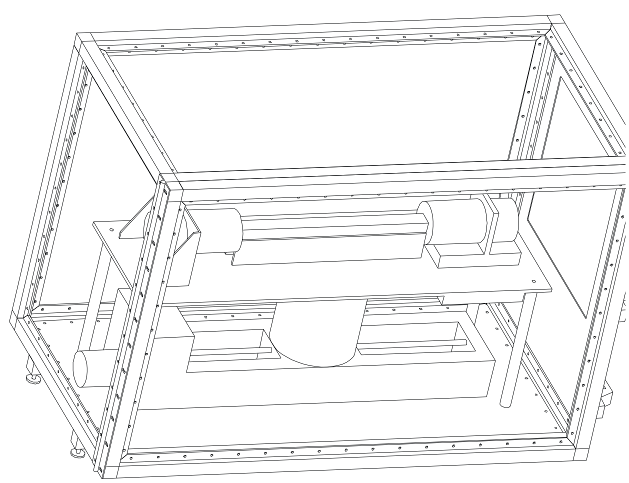

Figure 2.3.1. Crystal acceptance test bench. Two PMTs measure response of CsI crystal to collimated radioactive source on automated scanning slide.

The NIM bin will hold shaping amplifiers, the high-voltage power supplies and analog-to-digital converters (ADCs), as well as a custom built-interface box. The black box will contain a motor-driven slide to move a radioactive source held in a lead pig with collimators. It will also contain red-sensitive photo-multiplier tubes for each end of the CsI crystals, and a platform to hold the crystals. Parts have been ordered and assembly will start in the next quarter.

2.3.4.2 Photodiodes

Several drafts for the specification of the photodiodes have been generated. Electrical, optical and mechanical properties of the photodiode were the subject of many discussions between the Calorimeter team and Hamamatsu in the evolution of the specification. The ratio of the areas for the large and small photodiodes has been changed to 6:1. The large area photodiode has been increased to 150 mm^2 and the material changed to depletion depth of 300 μm to keep the capacitance low. Electrical connection between photodiodes and electronic card has fundamental implication on electronic noise and mechanics through a possible coupling of the photodiodes with the electronic card. More work is necessarily on the connection.

2.3.4.3 Gluing photodiodes on CsI

2.3.4.3.1 Tests of different glues

Investigations have been made to get to a final design for crystal to photodiode coupling. Contacts have been taken with Bologna Italian group who have already studied the problem for PICsIT detectors (for ESA's INTEGRAL mission). A baseline solution has been defined which should minimize risks. The choice has been taken to decouple mechanical and optical functions. A silicone glue will be used instead of epoxy for the optical coupling. It should offer stable optical properties and a flexible bonding, able to cope with thermal cycling. A plastic frame will be used to preserve the coupling and compensate for the low mechanical strength of the silicone. Test parts have been machined and equipment ordered to better control preparation and deposit of bonds. The silicone needs to be injected through the plastic frame to fill the space around the photodiode without introducing bubbles. Ecole Polytechnique and Saclay groups are collaborating to quickly propose a working solution.

2.3.4.3.2 Tests with vacuum chamber

A vacuum chamber, including temperature control between -5 and 30 degrees centigrade has been built for the design and validation of the optical bond (dedicated to explore the silicon bond solution) between the CsI xtals and the photodiodes. It is dedicated to be functional within the cosmic muon telescope and test bench at Saclay. A fine pitch pressure control system is included as well as sensors to study the range of acceptable bond pressures. First runs are scheduled in the second half of January 2000. In a second step this chamber could be used for preliminary study of the temperature cycling effects between -30 and +50 degrees.

2.3.4.4 Crystal Reflective Material Testing

Experiments were performed on CsI crystal enclosures to compare the light collection effects of various reflective materials and methods of fabrication. We tested crystals wrapped in Tyvek and Tetratak, as well as crystals inserted into carbon composite crystal sleeves: one lined with a 3M birefringent-polymer multilayer optical material applied during the sleeve layup (which we called the "3M hot" cell); the second sleeve was lined with the same 3M birefringent optical material applied to the sleeves with spray adhesive after they were baked (which we called the "3M cold" cell).

We measured the absolute light yield, i.e. the number of electrons collected in the 1-cm^2 photodiode per MeV deposited in the crystal, for various wraps and sleeve linings. We used a nuclear line source to provide an absolute energy (^{228}Th at 2.61 MeV), and we calibrated the electronic gain scale. We compared the absolute scintillation light yield for a number of configurations, summarized in Table 2.3-1.

The testing with Tyvek and Tetratek confirm conclusions in Beam Test Engineering Model prototype development. The new results with the 3M material are quite encouraging.

The Tetratek + adhesive aluminized Mylar wrapping performed consistently with the value we typically observed in the Beam Test Engineering Model Calorimeter in the same wrapping after 10 months under pressure *("Americium calibration of electron yields in BTEM crystals"*, NRL SEM 2000-01, by Grove and Sandora, 14 Sep 2000).

The best-performing wrap was the 3M birefringent material loosely wrapped around the crystal, yielding ~25% more light than the Tetratek wrap. It is not clear why this loose wrapping was decidedly superior to the 3M cold cell. Indeed we applied this wrap quite loosely, without creasing the material at the edges of the crystal. The material was free to separate from the long crystal surfaces by up to a few millimeters.

Wrap or lining	**Yield (e/MeV)**
3M loosely wrapped	5300
Tetratek + adhesive aluminized Mylar	4630
3M cold	4200
3M hot	3900
Tyvek	3530
3M loosely wrapped, after light tapering	5120

Table 2.3-1: Light yields with various crystal wraps or sleeve linings for a Crismatec crystal.

Earlier measurements demonstrated that tapering the light along the length of a crystal does not change the mean light yield *("Effect of Light Tapering on Light Yield"*, NRL SEM 2000-02, by J. Eric Grove, 20 Oct 2000). We repeated the untapered and tapered light yield measurements here and confirmed that the mean yield was unchanged by tapering.

Conclusions:

- The 3M birefringent material gives excellent light yield, but it suffers some degradation during its application to the composite cell. It certainly merits further study, either as a crystal wrap or a sleeve liner.
- Tapering does not necessarily reduce the light yield of the crystal, but it can

smooth the position response and simplify the mapping and modeling of the position dependence of light yield.

- Dimension control for the crystals is critical for prevention of optical damage during insertion and removal from optical cells. We experienced some difficulty in inserting the available crystals into the test cell. More work is needed in improving the procedure and/or the crystal sizes and tolerances might need to be adjusted.

Figure 2.3.2. Insertion of dummy logs into VM1 carbon cell structure.

2.3.5 Pre-electronics Module

2.3.5.1 Mechanical design

The inner and outer dimensions of the Calorimeter modules have been finalized. This includes final mechanical specifications for the CsI logs: dimensions and tolerances. Mass budget spreadsheet has consequently been updated. Numbers should be progressively adjusted as detailed design on mechanical parts progresses.

Slight modifications of the mechanical drawings have been made to comply with new crystal dimensions and the design of the printed circuit board attachment and interface with Grid finalized. Since no more evolution is expected, work on fabrication drawings for tooling and mechanical parts should begin soon.

Finite element model is still based on an initial vibration model (VM0) prototype and has to be updated to take into account the modifications of the mechanical design. It should be then adjusted to fit vibration test results on the next model VM1 and investigate possible improvements. It will also help producing a simplified thermal and structural model to deliver to SLAC for integration on a general finite element model.

2.3.5.2 Structural model VM1

The second prototype (three molded parts glued together) of carbon composite structure has been completed for the vibration test.

2.3.5.3 Vibration test of VM1

The model has been loaded with 93 steel logs (with slots to reduced weight to 1 kg) and three CsI logs. The crystals had been previously optically tested at Saclay and cross-checked at Ecole Polytechnique.

All the logs have been mounted inside the cells with four silicone rubber bands (see Figure 2.3.2). The assembly process has consequently been tested with a significant number of logs. No problem has been encountered during the insertion of the dummies.

The process has been achieved in one of day work. A simple tooling has been used to ease the insertion, mainly to hold the rubber bands stretched. The mounting of the crystals has been more difficult due to out of shape problems, particularly for one of the crystals (flatness above 0.5mm). This is certainly due to a lack of care during handling or storage, since a crystal bends under its own weight if not placed on a flat surface. Keeping the crystals inside a V shape support till it is mounted seems a good option for future models.

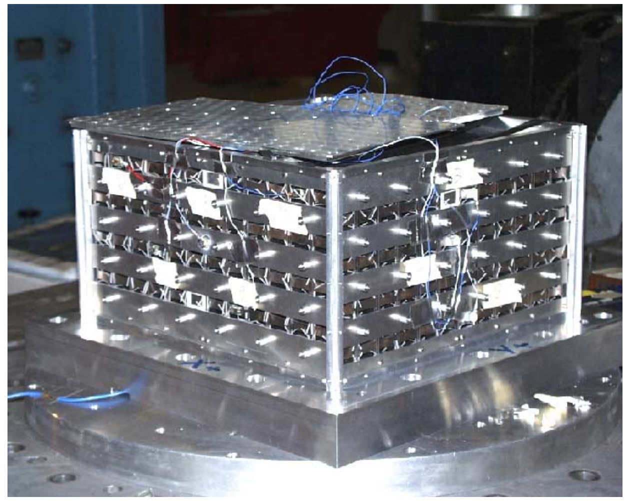

Figure 2.3.3. Instrumentation of VM1 for vibration test (December 2000)

The vibration test has been performed by SOPEMEA, a private company specialized in environmental testing. Ground transportation has been used to deliver the model to the test area (a few km away from Ecole Polytechnique). The instrumentation of the model has been made by the company, following a detailed test procedure they had been given. Sine sweep, sine burst and random vibration tests have been performed along 2 axes, with qualification levels. The model has been fixed on a rigid aluminum frame so that support was only provided on the perimeter of the bottom plate. The attachment was similar to what is foreseen for the interface with the grid, except for the tabs (see Figure 2.3.3).

The mechanical structure has been visually inspected to detect any delaminating of the composite or break of the inserts. No damage on the mechanical structure or on the polished surface of the crystals has been noticed. The CsI logs will be optically tested again.

The company has not yet delivered the vibration test report but results are already available. The first vibration frequencies have been measured at 115 Hz for transverse axis and 185 Hz for vertical axis.

2.3.5.4 Light measurement

The cosmic bench (Figure 2.3.4) for the crystal light measurement has been completed with a mechanical set-up.

Tests have been performed before and after the vibration test of the Calorimeter structure. The Calorimeter was full with dummies, except three crystals. A crystal follows all the phases of the crystal inside the Calorimeter but was kept outside the vibration.

Tests are going on to bring under control the discrepancies and to overcome the actual dispersion of the values.

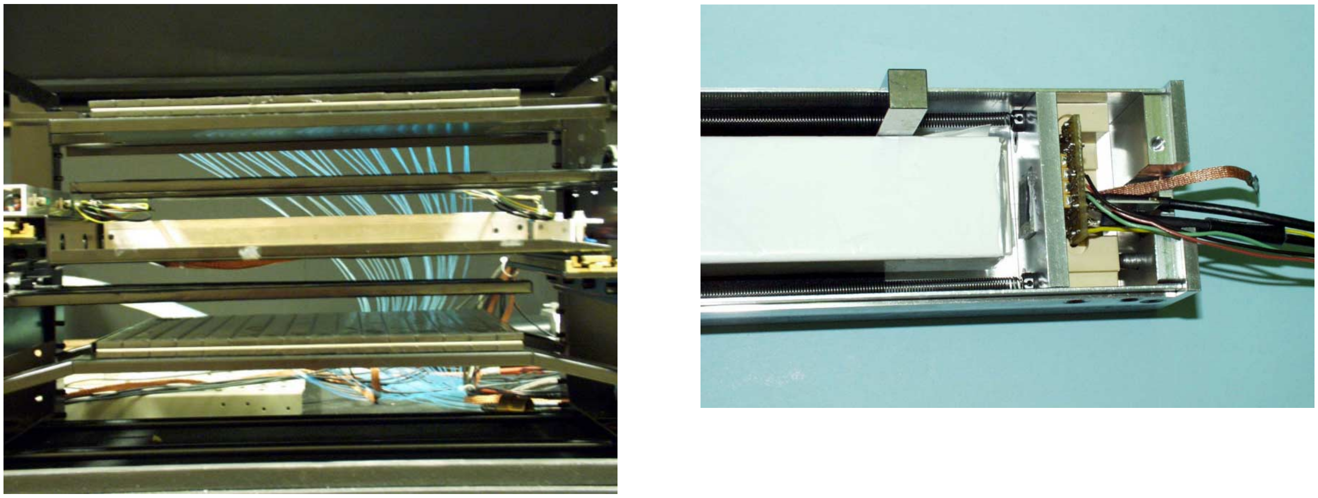

Figure 2.3.4. (*Left*) Photo of optical test bench at Saclay. From top to bottom: a first layer of 16 scintillator strips read by scintillating fiber optics, a layer of 3 scintillator strips (the trigger), the test cell which contains the crystal and the proximate read out, then 3 scintillator strips and a bottom layer of 16 scintillator strips. *(Right*) Crystal test cell showing photodiode coupling.

2.3.5.5 Development plan

Ground support equipment specifications were investigated for optical contact performance and qualification.

Design and test of commercial electronics initiated for equipment of pre-electronics module functional test bench. This test bench will have 200 channels, and will be installed in the integration area at Ecole Polytechnique and NRL.

The participation of the mechanical engineering group of the Ecole Polytechnique in the production of the flight parts and the assembly of the Calorimeter modules has started being evaluated at the laboratory level. Important developments on composite cell structures have already been done and the group has acquired a good experience. The transfer to the industry might be a difficult task. The amount of required work fits quite well with the group capacity.

2.3.6 Calorimeter Electronics

In cooperation with the LAT Instrument Project Office, design concepts have been developed for communications interfaces between the Calorimeter subsystem and the trigger and data acquisition systems. Interface concepts and protocols are being considered that provide commonality among all LAT subsystems.

2.3.6.1 Radiation Testing

Single Event Latchup (SEL) and Single Event Upset (SEU) testing of the candidate analog to digital converters (ADCs) with heavy ions at Brookhaven Lab is expected to occur in February 2001. We have expanded our testing to include two more ADC chips, bringing our total to six. In the last quarter we have laser tested two new candidate ADCs, and performed differential non-linearity (DNL) tests on them. DNL results below

Table 2.3-2. Comparison of COTS ADCs

Part	SEL	Differential Linearity	Comments
MAX1241	LET >150	Good DNL	12 bit ADC
MAX189	LET about 70	Best DNL	12 bit ADC
MAX194	LET about 70	Good DNL	14 bit ADC
ADS7816	LET between 15-20	Poor DNL	12 bit ADC
ADS8320	not laser tested	Poor DNL	16 bit ADC.
MAX145	not laser tested	Poor DNL	12 bit ADC

are compared at 12-bit resolution. The destructive latchup tests were performed at the NRL Laser Radiation Test Facility.

Table 2.3-2 summarizes the results on our candidate ADCs, in order from most promising for use on the flight Calorimeter.

DNL plots of the MAX189, MAX194, ADS7816 and ADS8320 were previously shown in the 3rd Quarter 2000 report. Figure 2.3.5 shows the DNL plots for the MAX1241, and Figure 2.3.6 repeats the MAX189 plot for comparison.

2.3.6.2 Photodiode noise pickup investigations

Investigations were performed into what type of shielding is required for the photodiode to reduce noise pickup from the Calorimeter electronics front-end circuit board. In the LAT Calorimeter configuration, the photodiode lies in a plane parallel to the circuit board, and 5 mm below it. This close proximity and orientation leaves the diode susceptible to radiated electromagnetic interference from the circuit board. One of the balloon flight spare Calorimeter boards and diode was used for the testing.

The results of the testing has shown that grounded metalization on the back of the photodiode does not significantly reduce electromagnetic interference. The best method for reducing pickup is a large grounded metallic sheet between the diode and the circuit board. The large metallic sheet does have holes for the diode leads to pass through to the circuit board. With the grounded metallic sheet, the noise pickup though the photodiode is equal to the noise caused by the ADC digital switching ground noise.

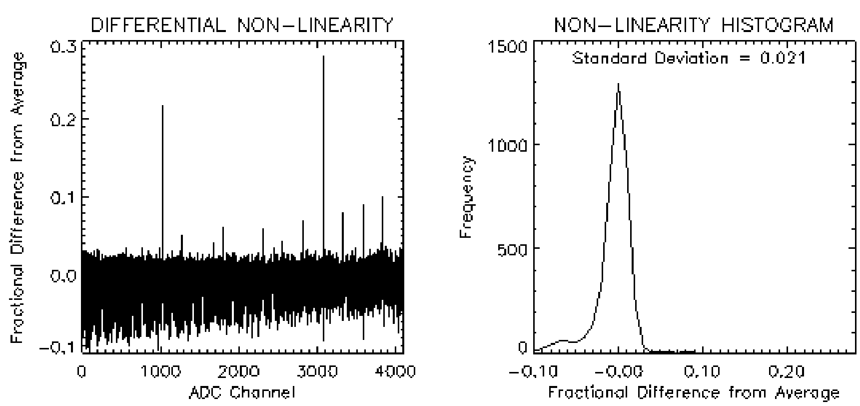

Figure 2.3.5. MAX1241 Differential Non-Linearity Measurement.

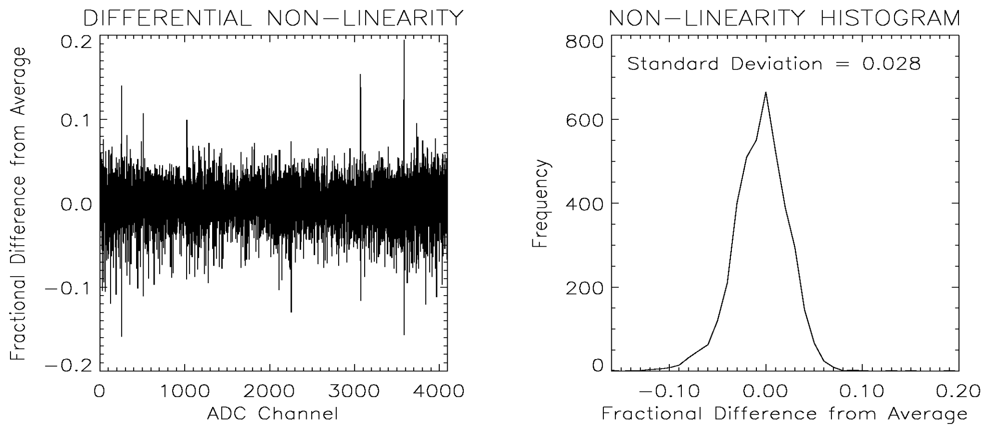

Figure 2.3.6. MAX189 Differential Non-Linearity Measurements.

2.3.7 Balloon Flight Preparations

2.3.7.1 Diode bond stabilization

In the previous quarterly report (LAT-MR-00028-02), we summarized laboratory tests of spare Beam Test Engineering Model CsI crystals to study the stability of the optical bond of the photodiodes under thermal cycling. We found that (1) the safe storage temperature range for the Beam Test Engineering Model is roughly 25C ± 5C; (2) outside of the safe range, the optical quality of the bond degrades to give a signal about half that from a good bond; (3) once a bond degrades optically, it does not recover; and (4) once a bond degrades optically, further temperature cycling does not further degrade the light output.

Because we cannot guarantee that the storage or balloon flight temperature will remain within the safe range, we chose to stabilize the optical bonds throughout the Balloon Flight Engineering Model Calorimeter at the degraded level by thermal cycling the entire module. We cycled the Calorimeter twice from room temperature to ~5C and back, and twice from room temperature to ~40C and back, over periods of ~12 hours. Approximately 130 of the 160 bonds degraded as a result of this procedure, and we do not expect additional degradation during the balloon flight.

2.3.7.2 Mechanical Accommodation

A new mechanical design and mechanical interface were agreed upon with the mechanical designers at SLAC to provide the support for the Calorimeter that in space flight will be provided by the LAT Grid. This lateral support is provided by “flying buttresses” which form a miniature grid around the Calorimeter. This was not present during the beam tests. The miniature grid was designed and built at NRL. The base-plate was shipped from SLAC for a fit test at NRL and has now been returned to start integration at SLAC in the next quarter. Figure 2.3.7 shows the Calorimeter with the miniature grid mounted on the balloon flight base plate. The interface electronics is located in and below a hole in the base plate and is not visible in this photograph.

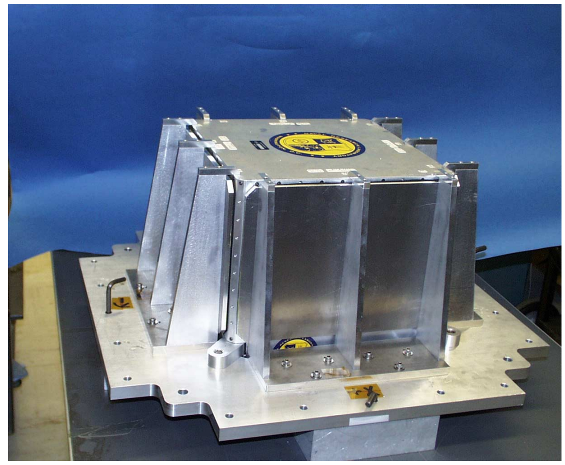

Figure 2.3.7. BFEM Calorimeter on base plate with "flying buttresses" for lateral support.

2.3.7.3 Balloon Flight Engineering Model Calorimeter Software

The Calorimeter test software was updated to incorporate new features provided by the latest Tower Electronics Module interface board from Stanford/HEPL. The test software now performs flow control checks and provides warning messages when the event rate is overloading the system. The Calorimeter test trigger uses a constant, 100 µsec deadtime. This improves the reliability of the system when performing long calibration sessions. The Calorimeter software was set up for use in the VxWorks environment at SLAC during the Balloon Flight Engineering Model integration. Both standalone and Solaris environments are supported to provide flexibility depending on what computer resources are available.

2.3.7.4 Ground Calibration

One of the issues during the SLAC 1999/2000 beam test was the stability and knowledge of the energy calibration of the Balloon Flight Engineering Model Calorimeter. We have rewritten the electronic calibration process to sample the four Calorimeter gain ranges more thoroughly. This will provide more complete knowledge of the gain scale near the muon peak – from which we derive the absolute energy reference on the ground – and of the integral non-linearities present in the front-end electronics. We plan to repeat this electronic calibration at convenient intervals throughout the balloon flight payload integration and prior to declaring balloon-flight readiness.

2.3.7.5 In-Flight Calibration

The Spring/Summer 2001 balloon flight will provide a number of galactic cosmic rays we can use to develop Calorimeter calibration algorithms, e.g. learn how to identify charge-changing spallation interactions in the instrument. In preparation, we calculated the rate of galactic cosmic rays expected to pass through the Balloon Flight Engineering Model Calorimeter during a flight from Palestine.

We ran CREME96 with the geomagnetic transmission function at 35 km above Palestine and simulated the propagation of galactic cosmic rays through 4 g/cm^2 of atmosphere, 1 g/cm^2 of aluminum (to simulate the pressure vessel and thermal blankets), and the Anticoincidence Detector, Tracker, and Calorimeter detectors. The incident spectrum included primary galactic cosmic rays from hydrogen to nickel, anomalous cosmic rays, and proton re-entrant albedo. To be useful in the Calorimeter calibration process, galactic cosmic rays must pass through several layers of silicon Tracker to define a precise trajectory, so he required that galactic cosmic rays travel from the uppermost complete silicon layer through the bottom of the CsI.

Table 2.3-3 lists the rates (in counts per hour at float altitude) of the most abundant useful galactic cosmic rays during the balloon flight, both the total rate satisfying the geometry requirement and the rate of particles that do not suffer charge or mass-changing interactions within the instrument. The rate of useful medium to heavy galactic cosmic rays is fairly modest. Assuming five hours at float, we'll have ~1000 each of carbon and oxygen and ~150 iron nuclei to search through for signatures of interactions. Most useful for an in-flight calibration would be the ~300 each of carbon and oxygen and the ~20 iron nuclei that do not interact within the Balloon Flight Engineering Model.

The summary report, *GCR Rates for the Palestine Balloon Flight* (NRL SEM 2000-05), by Grove, dated 29 November 2000 can be found at the NRL GLAST website, http://gamma.nrl.navy.mil/glast/tech_memos/cremeballoon.pdf.

2.3.8 Identified Risks and Mitigation Plans, Issues and Concerns

- The program in France has undergone significant reorganization. Establishment of working relationships, work plans and schedules will take some time.

2.3.9 Work Planned Next Quarter

2.3.9.1 Management

- Completion of the baseline Calorimeter organization, schedule and cost estimation in support of the LAT PMCS system.
- Establishment of the French management team and development of responsibilities and schedules.

Species	Total rate (events per hour)	Non-interacting rate (events per hour)
C	220	63
N	58	15
O	220	55
Ne	35	8
Mg	46	10
Si	35	7
Fe	29	4

Table 2.3-3: Galactic cosmic ray rates between the topmost full Tracker layer and the bottom of the CsI for Palestine. Note that the units are counts per hour.

2.3.9.2 System Engineering

- Completion of the digital controller ASIC requirements specification.

2.3.9.3 Vibration test

- Vibration test of VM1 was completed in December. Complete the test analysis and create the report.

2.3.9.4 Optical reflector

- Evaluation of optical coatings for the CsI logs will continue. A good candidate material is now available. The effort should be put mainly on characterization and acceptance tests. The ability of the material to support the fabrication process of the carbon cell structures needs to be checked (temperature and pressure during epoxy resin cure time). Investigation will start to evaluate the ability of the material to be used in space applications (outgassing measurements).

2.3.9.5 Crystal photodiode optical coupling

- Several options are still foreseen to couple the CsI logs and the photodiodes. This remains the critical point for the completion of Calorimeter design. An important effort needs to be made to get to a final solution. The studies that have already been made should allow quickly choosing a baseline solution and concentrating the developments, tests and validation on it. A backup solution could remain.

2.3.9.6 Pre-Electronics Module Developments

- The main task for next quarter will be the production of a pre-electronics module structure with final dimensions that integrates all required elements. The deadline is the Preliminary Design Review in August. For that, special efforts should be made to quickly validate the diode to crystal optical coupling. The 3-layer tooling (used for VM0 and VM1) will be used after new modifications. In house and industry options will be evaluated for flight mechanical parts production and Calorimeter PEM assembly.

2.3.9.7 Analog Front End ASIC

- Submit first run of analog front end ASIC.

2.3.9.8 ADC Radiation Testing

- SEU/SEL testing at the Brookhaven heavy ion accelerator in February will more precisely determine the radiation threshold for Single Event Upsets (incorrect data output) and the threshold for Destructive Latchup (permanent circuit failure).

2.3.9.9 Balloon Flight Preparations

- Deliver BFEM Calorimeter to SLAC. Support integration and testing of BFEM Calorimeter at SLAC.

2.4 Anticoincidence Detector

2.4.1 Current Status and Accomplishments

2.4.1.1 Design Status

The most concentrated design effort over the last quarter has been in the following mechanical and electrical areas:

- Driven by constraints in volume and mass, the Anticoincidence Detector is currently of a single layer design. The single layer of detector tiles are overlapping in one dimension and in the other dimension, their edges are covered by scintillating fiber tapes to maintain the background rejection efficiency of .9997. The tapes will be read out with photomultiplier tubes to signal events along the tile gaps. We are considering reducing bottom side facing tiles by 40 (80 channels) and then adding the scintillating fiber tapes with a gain of 24 channels. Thus, the Anticoincidence Detector channels number drops from 290 to 234, with a lowered demand on electronics packaging. However, the decrease in tile segmentation required to permit this needs approval by the LAT science team.

- The front-end electronics boards are planned to be located below the last row of tiles on the Anticoincidence Detector's side faces. Electronic boxes housing rows of these boards will be distributed in the channel around the outside of the grid. A current trade-off issue being examined is whether the photomultiplier tubes should be located on the front-end electronics boards or located near each detector tile. The former has the increased signal attenuation of long bundles of optical fibers but simplifies high voltage connections. The latter allows less optical signal loss, but has the complexity of remotely located photomultiplier tubes with associated signal and high voltage cabling, connectors, power dividers and filters. These are higher density components, which are undesirably in view of the Tracker and Calorimeter.

On the other hand, attenuation of long fiber bundles would have to be compensated by increased signal from thicker detector tiles.

2.4.1.2 Requirements, Design, and Planning

- We have revisited our basic requirements and confirmed that our requirement of 0.9997 efficiency is correct. The requirement is driven by the removal of 1 to 10 GeV electrons which are 3×10^3 more abundant than photons. Without the Calorimeter to help (showers look the same for both electrons and photons) we need to rely on the outermost layers of the Tracker for the additional factor of ten rejection power to meet the science requirement for studying the diffuse extragalactic background.

- The Level III requirements for the Anticoincidence Detector have been documented, document # LAT-SP-0016-D3. The document has been circulated, and a formal review will take place early in the next quarter.

- The decision to accelerate the work on the Anticoincidence Detector to meet the August 2001, Preliminary Design Review has produced a significant response in Anticoincidence Detector effort. In particular, the Anticoincidence Detector group has had to ramp up staffing to immediately address Work Breakdown Structure (WBS), schedule and cost re-estimating, and also to accelerate testing, simulation, and trade studies. At the end of this quarter the Anticoincidence Detector group is heavily engaged in these efforts. A WBS budget and schedule submission for the Project Management Control System is planned in January, and work on these will continue into the next quarter. Work on the WBS dictionary has started.

- Measurements of efficiency of light collection were conducted on a number of different cases to study the effect of wave shifting fiber groves, spacing, fiber end treatments, etc. Our results are in surprisingly good agreement with the literature giving us confidence that we understand the design tradeoff parameters.

- Ongoing simulation work has shown two potential sources of background that are not as well understood as needed: splash/reentrant albedo particles and cosmic ray electrons. These potential backgrounds re-emphasize the importance of achieving a very high efficiency with the Anticoincidence Detector, at least the 0.9997 of the baseline. Modeling has shown that the highest efficiency for the Anticoincidence Detector could be achieved with a two-layer design, offsetting the tiles to eliminate gaps, but the current mass constraint effectively precludes this option. If additional mass were to become available, we may wish to revisit this option.

- Progress has been made on study of the tile segmentation. Although initial work suggests that fewer tiles than the 145 in the baseline design may be workable, this work is not yet complete. A description of the tile numbering system and geometry has been developed. This scheme will apply to the baseline design or any reduced number of tiles.

2.4.1.2.1 Mechanical Design

A mechanical design review was held November 14-15, with Goddard personnel and Martin Nordby in attendance. The flow-down of requirements, mass constraints, volume constraints, materials issues, thermal concerns, and design options were all discussed in detail. The principal design effort will pursue a single-layer design. Finding space for the phototubes, high voltage power supplies, and front-end electronics is a challenge.

2.4.1.2.2 Electrical Design

Photomultipliers - Discussions were held with Hamamatsu, the only company that makes tubes in the small size needed for the LAT Anticoincidence Detector. The R1635 baseline tube has the advantage of having a flight heritage. A higher-gain tube of nearly the same size may offer advantages, including a flying lead package that might be easier to mount. Trade studies with samples of both tube types will be conducted.

High voltage power supplies - A market survey showed that no off-the-shelf high voltage supplies could be found in a small enough flight qualified version. Consequently, a competitive procurement for a prototype that will meet our requirements has been initiated.

2.4.1.2.3 Application-specific Integrated Circuits (ASICs)

The transition to a new ASIC process (Peregrine) is underway, and a test submission will be made early in the next quarter. Two ASICs will be designed, one principally for the analog front end and the other to handle digital signals.

2.4.1.2.4 Balloon Flight Engineering Model (BFEM)

Refurbishing of the test beam Anticoincidence Detector for use in the balloon flight was completed. Failure of Bicron (which is changing its name to Saint-Gobain) to deliver new scintillators led to the addition of a second layer of scintillator at the top of the Anticoincidence Detector, in order to ensure hermeticity. Electronics were reworked to reduce noise problems that had been seen in testing, and interface tests were carried out with the improved tower electronics module electronics. Software was re-written to display tile histograms, and a plan for commanding of the Anticoincidence Detector was developed.

2.4.2 Identified Risks and Mitigation Plans, Issues and Concerns

- The accelerated schedule represents a risk to being ready for the Preliminary Design Review. Mitigation is additional staff and funding.

- The mass constraint represents a risk to the efficiency, redundancy, and margin of the Anticoincidence Detector. The mitigation will be a careful design, but we reiterate the interest is using additional mass to enhance the performance of the Anticoincidence Detector.

- The thermal blanket/micrometeoroid shield represents a risk to the durability of the Anticoincidence Detector over its lifetime. Mitigation is to seek design help from a group at Johnson Space Center, which specializes in protection against penetrations.

- Collection of light from the scintillator tiles remains an issue that affects redundancy and maintaining efficiency throughout the life of the mission. A variety of tests is being undertaken to optimize the light collection, including aluminizing the ends of the waveshifting fibers, testing scintillators of different thickness, testing improved wrapping, examining edge effects, and reviewing the waveshifting fiber size, shape, and placement.

- Sealing the potential gaps between scintillator tiles is a concern: some gaps are unavoidable, especially allowing for thermal expansion, and gaps represent inefficiencies. A potential solution that is being studied is to cover the gaps with thin bands of scintillating fibers.

The frequency and level of Anticoincidence Detector reporting to SLAC has been underestimated here, especially in view of our recent need to concentrate on ramping up and educating staff to provide project control data and accelerate design effort to meet the August 2001 Preliminary Design Review. Additional resources may be needed to meet these reporting requirements.

2.4.3 Work Planned Next Quarter

The coming quarter (January-March, 2001) will include these activities:

- Support the joint DOE/NASA review and resulting actions.
- Pursue essential design studies, trades, simulations, electrical, mechanical, thermal.
- Complete integrated Anticoincidence Detector WBS and schedule and iterate with SLAC overall schedule.
- Conduct full grassroots cost estimate to verify proposal estimate.
- Define Engineering Test Unit, Calibration Unit, calibration plans, integration and test plans, etc.
- Release high voltage power supply prototype procurement.
- Measure uniformity of tile response and edge effects at mm scale.
- Determine impact of tile segmentation options on science performance (e.g. background rejection and efficiencies and effective areas at high energy).
- Conduct materials trade studies.
- Support the Balloon Flight Engineering Model as it prepares for a June flight.
- Prepare for the Preliminary Design Review.

2.5 Balloon Flight

During the quarter, work on the LAT Balloon Flight Engineering Model (BFEM) moved through detailed planning into hardware procurement, subsystem testing, and preparations for assembly of the BFEM. The goal remains to have a balloon flight in June 2001.

2.5.1 Current Status and Accomplishments

To some extent, the BFEM development is a microcosm of the larger LAT effort. Essentially all flight unit subsystems are represented by similar parts of the BFEM:

- Tracker - the BFEM Tracker is a modified version of the Beam Test Engineering Model (BTEM) Tracker. Three of the incomplete Tracker layers have been removed from the top of the Tracker for the BFEM. See also section 2.2.

- Calorimeter - the CsI logs and photodiodes are the same ones used for the BTEM. Additional mechanical support has been added around the Calorimeter to protect it during parachute opening and landing after the balloon flight. See also section 2.3.

- Anticoincidence Detector - the scintillators and phototubes are the same ones used for the BTEM; the electronics have been modified to reduce noise problems encountered during the beam test. See also section 2.4
- Electronics - a major revision of the BTEM electronics was undertaken in order to increase the throughput of the system for the higher rates expected in the balloon flight. In particular, all the Tower Electronics Modules are housed in a single crate, and the event data are read out through the backplane instead of being collected from network connections. Each hardware subsystem was tested with the new electronics. In the balloon flight, only a three-in-a-row hardware trigger will be used, with all data being recorded on disk for ground analysis.
- On-board software - although a basic system was developed for the electronics testing, a significant effort continues in order to build a robust BFEM command and readout system.
- Ground software - the data display and analysis software needed for the balloon flight is being incorporated into the framework of the flight unit development.
- Balloon Interface Unit - these electronics, designed and under construction, handle the formatting of uplink commands and downlink data (a sample of the total data stream), providing the interface to the standard balloon Consolidated Instrument Package that handles the telemetry signals (the equivalent of the spacecraft). Coding/decoding electronics/software are in preparation and testing for the ground receipt of signals and encoding of commands.
- External targets - four scintillators with phototubes have been built and will be mounted above the BFEM to provide active "tags" of proton interactions that may produce gamma rays. These targets are unique to the balloon system and have been included to increase the signal/noise for testing.
- Mechanical/thermal - an existing balloon pressure vessel and an existing balloon gondola are being modified for the BFEM flight.
- Modeling - a GEANT4 simulation of the BFEM is being developed and will be used to model the response of the instrument.

The following documents have been prepared:

- GLAST Balloon Flight Engineering Model - Plan for Balloon Flight, BFEM-00001-P1, 10/6/00
- GLAST Balloon Flight - Results Needed to Meet Objectives and How to Obtain Them, 10/30/00
- Risk Assessment/Mitigation for the GLAST Balloon Flight, 11/13/00
- Project Plan for Thermal Modeling and Analysis of the NASA/GSFC/LHEA GLAST Science Payload, 11/16/00
- GLAST Balloon Flight 2000, 12/6/00

- GLAST Offline Software Tasks and Schedule, 12/14/00
- Balloon Flight WBS and Schedule, 12/26/00

2.5.2 Identified Risks and Mitigation Plans, Issues and Concerns

A number of risks and mitigations were considered and documented. A brief summary:

- Pressure - the pressure vessel has been tested to 1.5 times the differential it will see in flight. The measured leak rate is acceptable for the length of flight planned.
- Thermal - a thermal analysis by a qualified balloon thermal engineer is planned.
- Shock - all subsystems have been strengthened; the pressure vessel and gondola have flown before; particular care must be used in planning and building the landing gear.
- Background rate - a model of the BFEM will be used to estimate the response to the atmospheric radiation at various altitudes.
- Analysis - the analysis software will be developed as part of the mainstream LAT ground software system.

The schedule is tight. Opportunities for a balloon flight are limited to the April-October time frame, and both ends of this window have conflicts with other projects. In addition, the Preliminary Design Review scheduled for August 2001 requires support from many of the same people involved in balloon planning.

The on-board command/data handling software is complex and unlike the flight design; therefore this work cannot draw on the efforts being made for the flight unit. Concern has been expressed in this area for meeting the schedule for the balloon flight. Efforts are being made to simplify this software as much as possible, in order to have a minimal working system.

2.5.3 Work Planned Next quarter

During the upcoming quarter, all internal subsystems will be integrated into the pressure vessel at SLAC. Performance of each subsystem independently and working as a system will be tested. Once the instrument performance is satisfactory (determined by a performance review), the instrument will be shipped to Goddard for integration into the gondola and final integration of the Balloon Interface Unit and other external systems.

2.6 Instrument Operations Center

2.6.1 Current Status and Accomplishments

A schedule for level of effort activities and milestones was developed for FY01. The Work Breakdown Structure for the Instrument Operations Center was revised to reflect the separation of Science Analysis Software activities.

2.6.2 Issues and Concerns

A concern is the very small allocation of resources to support early Instrument Operations Center requirements and mission concept development during the formulation phase. A further concern is that the current schedule for selecting the Mission Operations Center may impede the ability to use common commanding tools and prevent detailed development of Instrument Operations Center – Mission Operations Center interface requirements in a timely fashion.

2.6.3 Plans for next quarter

- Complete the LAT Operations Facility performance specification.
- Produce a draft plan for LAT Operations Facility development.
- Begin trade studies on hardware and software to support the LAT Operations Facility plan.
- Participate in the development of electrical ground support equipment for the balloon flight.
- Support the balloon flight as a means of prototyping LAT Operations Facility processes and procedures.

2.7 Science Analysis Software

2.7.1 Current Status and Accomplishments

Our efforts during this quarter were mostly directed towards:

- Infrastructure and documentation.
- Simulation/reconstruction code architecture upgrade.
- Schedule development.
- Balloon flight support.

In the process we ran a one-week working meeting in December.

2.7.1.1 Infrastructure and Documentation

After much discussion with the SLAC Computing Center security people, we succeeded in moving the cvs code repository up from Stanford campus to SLAC, where it resides on a robust system with 24x7 support. We also put considerable effort into documenting use of the new infrastructure and tools, as well as introductions for new users. All of this is linked to the software home page (http://www-glast.slac.stanford.edu/software/), which was also moved to a robust central server at SLAC.

2.7.1.2 Simulation/reconstruction Code

Following on from our initial demonstration last quarter of the viability of the GAUDI framework, we have proceeded to put the Calorimeter and Tracker reconstruction packages into the framework also.

We have demonstrated the workings of all components of the new architecture.

The next step in the progression is to replace the ASCII Instrument Response Files with more descriptive and flexible structures. These are separated into two steps: Monte Carlo Truth and Digitizations. The Monte Carlo Truth stage records the actual energy deposits of particles traversing the detector; Digitizations represent the signal as seen in the electronic readout. We have defined the Monte Carlo Truth classes and have started implementing them. This separation will allow us to simulate the passage of particles through the LAT once and then try different digitization algorithms from that source. These Monte Carlo Truth classes will also allow us to track all energy in the events in detail, including in dead materials. The Digitization classes are under active discussion now.

2.7.1.3 Manpower Needs

During the past quarter, we did a manpower projection and estimated that we were 6 FTEs short for supporting the non-subsystem parts of the software. 2 of these FTEs have been covered in the meantime: a University of Victoria CoOperative student came on board at the end of September, and we have been able to hire a new Scientific Programmer at SLAC, to start Feb 1, 2001. This has exhausted our budget and further manpower must come from the collaboration. A strong group from Italy has joined and we are in negotiations as to whether they can supply a significant fraction of the needed effort. To this end, a detailed work-plan was drawn up and is posted on our website. This acts in conjunction with our task schedule, which we use on a daily basis to track progress.

The two new physicists from SLAC added to the Tracker software effort have come up to speed and are starting to contribute.

2.7.1.4 Balloon Flight Support

Good progress in code migration to the new architecture and tools has given us confidence that we can provide the balloon support in that model. We are working with the

Hiroshima group to ensure that the GEANT4 work is consistent with this model, specifically that G4 will output the same Monte Carlo Truth classes described above. Our path to feed them to the reconstruction package will complete the chain of processing.

The critical path for balloon support includes:

- Filling of Monte Carlo Truth classes from GEANT4.
- Completion of the digitization class definition.
- Port of existing Glastsim digitization algorithms into the new framework and modification of the reconstruction algorithms to input those digitization classes.
- Writing a converter for the balloon raw data format to the digitization classes.

Our schedule shows this work being ready in mid-February. Currently the milestone of cosmic rays from the integrated instrument is early March.

We hope to include an updated geometry scheme in time for the balloon flight as well. This is not mandatory.

2.7.2 Identified Risks and Mitigation Plans, Issues and Concerns

- Our manpower levels are too low. We must work with the collaboration to acquire more people. Presumably this will be in the form of graduate students and post-docs.
- The support of the balloon flight in the mainstream involves an aggressive development schedule. Most of the steps are mechanical and should not give any real surprises. The mitigation is to reuse the TB99 (1999 beam test) code. For simulations, this means modifying the GEANT4 simulation to output the Instrument Response File format. This would not involve an enormous effort. For real data, we would have to modify the existing converter to address the modified wrapping of the subsystem data; the subsystem data format is unchanged from TB99.

2.7.3 Work Planned Next Quarter

- Produce a full production chain for the balloon simulation and reconstruction.
- Complete a detailed schedule for our activities for FY2001 and a less detailed schedule for out years. This will be done in conjunction with preparation for the joint DOE/NASA review.
- Continue to extract additional manpower from the collaboration to cover our needs. The new SLAC Scientific Programmer will start in this quarter. We expect to quickly upgrade our support of the UNIX operating systems as well as a start to release management and validation.
- Hold the next general workshop in mid-January. The workshop will feature detailed reviews of the Tracker and GAUDI code.

2.8 Performance Assurance and Safety

The GSFC Project Office released the LAT Mission Assurance Requirements document. As required by the Mission Assurance Requirements, a LAT Performance & Safety Assurance Implementation Plan has been prepared that details the LAT's plans for implementing the System Safety and Mission Assurance Program. The draft Performance & Safety Assurance Implementation Plan was routed to LAT project management for review and comments and will be submitted to the GSFC Project Office by the end of January 2001.

The GLAST LAT Nonconformance Reporting & Corrective Action System is currently under development. The system will be a web-based system (http://www-project.slac.stanford.edu/glastqa/Default.htm) accessible to all LAT personnel for their utilization. It is anticipated the system will be completed next quarter. Once completed, the system will be demonstrated to selected LAT sub-system personnel for feedback and comments on the system.

A draft Systems Safety Program Plan has been prepared and reviewed with the GSFC Project Office for initial feedback. The Systems Safety Program Plan describes in detail the tasks and activities of system safety management and engineering required to identify, evaluate, and eliminate and control hazards, or reduce the associated risk to a level acceptable to NASA Range Safety throughout the system life cycle. Minor suggestions (org. chart, schedule milestones, etc.) recommended by GSFC Systems Safety personnel will be incorporated into the Systems Safety Program Plan. When completed, the Systems Safety Program Plan will be distributed to LAT project management for review and approval.

2.9 Education and Public Outreach (EPO)

2.9.1 Current Status

Considerable effort during this quarter was expended on working with Stanford personnel to translate the preliminary GLAST project Education and Public Outreach plan into the WBS system, complete to Level 4, including schedule and budget. This work was then suspended, awaiting the results of the meeting with NASA Headquarters (see below.)

The GLAST exhibit booth made its first appearance at the High Energy Astrophysics Division meeting of the American Astronomical Society in Honolulu, Hawaii during November 6-10, 2000. The booth was designed in conjunction with Joan Carol Design Group in Maryland. It features a backlit 6-foot high graphic as well as space for additional display information and a podium with the new small GLAST graphic. Sonoma State University student Tim Graves staffed the booth at the meeting as well as taking photos of a teacher's workshop and other convention activities. Distributed from the booth were copies of the pre-instrument selection GLAST Facility Science Team Report and science brochures (both provided by GSFC) as well as a new one page flyer designed and printed at Sonoma State, which provided descriptions of the selected instruments. A poster of the GLAST instruments that filled the additional display space was created at GSFC by JD Myers, who also split booth duties between GLAST and Swift.

The main GLAST Education and Public Outreach web page header has been changed to add links to the Quest chats and to show the DOE logo and new GLAST small graphic. Updates to the GLAST instrument and Education and Public Outreach program sections were installed. A new page has been created to archive and link to the Quest chats (http://perry.sonoma.edu/quest.htm). A successful Quest chat was held with Prof. Elliott Bloom on October 25, 2000. The scheduled Quest chat for November 22, 2000 with Dave Thompson was held, but neither of the two people who were registered actually showed up to chat (probably due to the proximity to the Thanksgiving holiday). Thompson was rescheduled for January. The December Quest chat featured Swift scientist Dave Burrows, and was a great success. All chats are archived, and can be viewed through the above URL.

A new 1-hour PowerPoint talk about GLAST, Swift and gamma-ray astronomy, suitable for college students or amateur astronomy audiences, has been created by Cominsky. This talk is posted on the web at: http://perry.Sonoma.edu/materials, and is also available in html and PowerPoint formats at our anonymous ftp site: ftp://perry.sonoma.edu/grtalkfolder

A beautiful poster was created by SSU Scientific Illustrator Aurore Simonnet for the AAS/AAPT meeting to be held in San Diego on January 7-10, 2001. The poster advertises for applicants for the GLAST Ambassador program. Following a teleconference on December 8, 2000 with Jet Propulsion Laboratory Solar System Ambassador personnel, we adapted their application form and Announcement of Opportunity. The Announcement of Opportunity and application form were then rewritten for GLAST and posted on the web. They can be found at: http://www-glast.sonoma.edu/ambassadors. The application date will be set to sometime this summer, so that we may choose our 10 Ambassadors by the beginning of Fiscal 2002.

Plans for the Teacher's Workshop at Gamma 2001 were discussed with James Lochner. This meeting will occur during the fourth quarter of FY01. Work on the Goddard GLAST web site was discussed with JD Myers, who has extensively revamped the site. This website links to the Education and Public Outreach site at Sonoma State University, and can be found at http://glast.gsfc.nasa.gov. Discussions between GSFC and Sonoma State continued on the role of Public Relations vs. Education and Public Outreach.

Cominsky reviewed the contents of the GLAST science brochure written by Seth Digel, and assisted in its layout and design. Bonnell also contributed figures and text to this brochure About 250 copies of this brochure were printed at SLAC and shipped to San Diego for the AAS/AAPT meeting to be held in January. The GLAST booth was also shipped to San Diego. Booth registration was arranged for Stanford grad student Alicia Kavelaars, new GLAST Education and Public Outreach Research Manager Dr. Phil Plait, Sonoma State student Sarah Silva, and JD Myers (GSFC).

Bonnell and Myers have been working on a tri-fold GLAST brochure to be distributed at the Gamma 2001 meeting as part of the planned Teacher's workshop. Bonnell has also continued discussions with the Maryland Science Center about a possible GLAST exhibit.

2.9.2 Work Planned Next Quarter

The GLAST booth will be in residence in San Diego for the joint AAS/AAPT meeting from January 7-10, 2001. Sonoma State and Stanford personnel will staff the booth, hand out our one-page GLAST fliers, the new GLAST Science Brochure, GLAST stress balls (blue squishy balls with the blazar line drawing and the GSFC web URL imprinted on them) and other educational materials about gamma-ray bursts from Imagine the Universe! and Starchild. NASA Administrator Dan Goldin will give a public address that mentions GLAST and will happily receive a stress ball on his visit to the GLAST exhibit booth. The GLAST Teacher Ambassador program poster will appear at the meeting on January 9, 2001, and will attract the notice of many teachers, some of who will apply to be GLAST Ambassadors.

The process of publicizing the GLAST Ambassador program will continue. The Announcement of Opportunity will be publicized at the national teacher's conferences, which are held the third quarter of FY01. It will also appear in the publications of several teachers' organizations. The application due date will be set to allow the printing of the notices in these publications.

Quest Chats will be held on January 24, February 28 and March 28, featuring GLAST and/or Swift personnel. The January chat will feature David Thompson (NASA/GSFC) and will discuss gamma-rays from pulsars. The February chat will feature Neil Gehrels, representing both Swift and GLAST, and discussing gamma-ray bursts.

A meeting will be held on January 16, 2001 with NASA Headquarters personnel. The proposed GLAST Education and Public Outreach program will be presented, and budgetary advice will be sought. Once we have received instruction from Headquarters, the work of reconfiguring the GLAST Education and Public Outreach WBS will begin, along with a new schedule, budget and work plan. The draft program plans will be presented at the joint DOE/NASA review at Stanford in February.

Further planning of the workshops for the teachers to accompany Gamma 2001 will continue, with Cominsky, Whitlock, Lochner, Bonnell and Myers, all of whom plan to contribute materials. Plait will also attend the workshop and will be learning to present the electromagnetic spectrum workshop that is under development by Whitlock.

Further planning for the GLAST video, Maryland Science Center activities and Public Broadcasting System television show will occur, assuming that they remain part of the program approved by NASA Headquarters.

We will begin work on the Unified Model of Active Galactic Nuclei poster/booklet set, which is the first bi-yearly publication from the GLAST project, designed for teachers.

3 Technical Resources

3.1 Mass Summary

The current subsystem mass estimates are shown in Table 3.1-1, below, along with the estimates shown in last quarter's report, and target maximum values for the Preliminary Design Review. The status date for the current estimate is 29 Nov 00, and no changes have been made since then. We are currently mid-way through the process of refining all subsystem designs, in preparation for the Preliminary Design Review. Thus, we have seen some significant changes at the subsystem level, as designs are becoming better understood, and we anticipate more to come. As the table shows, our expected mass has been reduced, due largely to lightening the estimates for the structural elements of the Tracker and Calorimeter, and a very small decrease in active volume of the Calorimeter CsI. The most significant increase was in the Electronics subsystem, where better estimates were made for electronics mass. Note that none of these changes have been incorporated into the baseline yet, since we are still working with them.

Preliminary Design Review Max values show an 11.0% reserve with respect to the mass specification of 3000 kg. This level was computed using the current mass values. It is more than our target Preliminary Design Review reserve (shown at the SRR), which is 9.9%. This target came from the AIAA reserve estimating specification. Thus, we anticipate carrying a small margin at Preliminary Design Review.

Potential Mass Increases

The primary candidate for potential mass increase is the Anticoincidence Detector. Anticoincidence Detector electronics mass has been increased this quarter (part of the Electronics subsystem increase). However, the structural design of the Anticoincidence Detector is currently being revised, and the new design is expected to be heavier. The Anticoincidence Detector subsystem is working closely with Mechanical Systems in evaluating these potential increases, and they will be weighed (no pun intended) against the expected performance gains.

Status date:	**Q3 2000 (SRR)** 4 Nov 00	**Current** 29-Nov-00	**PDR Max** 02-Aug-01
LAT Total	**2557 (kg)**	**2521 (kg)**	**2671 (kg)**
TKR	522	487	528
CAL	1550	1463	1479
ACD	174	171	191
Mech. Systems	220	219	258
Electronics	92	180	214
Other	0	0	0

Table 3.1-1: Summary of LAT and Subsystem Mass (kg)

4 Cost/Schedule Status

The Project Management Control System (PMCS) development team has been working closely with the subsystem managers to develop the detailed work breakdown structure (WBS), a WBS dictionary, schedules, validated cost estimates, and contingency analyses. Preparations are well underway for the first joint DOE/NASA review, to be held February 13-15, 2001. A deadline of January 17 has been given to subsystem managers to "freeze" the PMCS data inputs so that we may fully incorporate them in the system for the review. Development will then continue for a short time after the review. Expectations are that a trial baseline will be set by April.

4.1 Tracker

A first pass at updating the Tracker budget based upon the current plans for Italian contributions to the Tracker fabrication is in progress. In this scenario the overall Tracker budget looks comfortable, but there may be some difficulty with the spending profile for the DOE contribution, which is peaked toward the early years. Also, the Italian contribution for FY2001 is still not known but is expected to be tight and perhaps only enough to cover the engineering and development work in progress there. More quantitative information will be compiled in time for the February reviews.

The engineering work in progress in preparation for Preliminary Design Review is proceeding reasonably well according to schedule. The Hytec mechanical engineering program has fallen about a month behind, due to material procurement delays, but the engineers believe that the time can be made up in order to complete the design and prototyping work in preparation for Preliminary Design Review. On the electronics side, the critical-path item is the ASIC development, due to the desire to schedule two complete prototyping/testing rounds. The chip redesign effort is proceeding well, but with some concern as to whether the first prototype submissions can be made as hoped for in February.

4.2 Calorimeter

Calorimeter activities are behind schedule in France. This is largely due to the lost time this quarter caused by management and organization crisis in November and December. The ability of the Calorimeter team to support the PMCS development is delayed.

The specification and procurement planning for the photodiode is behind schedule.

The specification and design of the analog front end ASIC design is behind schedule. An aggressive development plan at SLAC may recover lost time caused by the delayed start.

Actual costs at NRL are as planned.

4.3 Anticoincidence Detector

The Anticoincidence Detector financial system has just been established. There are some issues of compatibility with the PMCS that may need to be worked as GSFC financial reporting does not go to the required level of reporting. The proposal budget did not anticipate the level of reporting necessary to meet the requirements of the PMCS system reporting. It also did not include funding for a Thermal test model or an Engineering Test Unit. A complete grass roots cost estimate including vendor quotes, costs of reporting, cost of new requirements, etc. will be developed once we have complete understanding of the schedule and WBS.

Due to the acceleration of the Anticoincidence Detector schedule, our inputs at this February review will not be complete, but we have greatly accelerated our efforts. We are getting much more support from the Center now, including a key full time mechanical engineer. We expect to be much closer to being caught up by the time of the Preliminary Design Review.

4.4 Electronics, Data Acquisition and Flight Software

The schedule and budget for the electronics is being developed for the PCMS to enable status reporting and tracking. No variances compared to the proposal are apparent at this time.

4.5 Mechanical Systems

Budgeting and scheduling for the Mechanical Systems element of the LAT budget is complete for all work at SLAC. Budgeting for sub-contractor work is nearly complete, and will be finished in January 2001.

An I&T budget and schedule is complete. This was used to generate LAT project-level integration milestones, and will be used to plan LAT timing for meshing into Observatory I&T activities. A WBS dictionary is also complete.

4.6 Electronics

The schedule and budget for the electronics is being developed for the PCMS to enable status reporting and tracking. No variances compared to the proposal are apparent at this time.

4.7 Instrument Operations Center

Current Instrument Operations Center activity is on budget. The development of the level III specification is delayed one month pending completion of the PMCS

WBS/schedule by the Instrument Operations Center Manager and release of the MSS by the GLAST Project Office.

4.8 Education & Public Outreach

A meeting will be held on January 16, 2001 with NASA Headquarters personnel. The proposed GLAST Education and Public Outreach program will be presented, and budgetary advice will be sought. Once we have received instruction from Headquarters, the work of reconfiguring the GLAST Education and Public Outreach WBS will begin, along with a new schedule, budget and work plan. The draft program plans will be presented at the joint DOE/NASA review at Stanford in February.

4.9 Balloon Flight

Balloon planning costs are dominated by manpower. The personnel working on the balloon flight appear to be those planned. No unexpected purchases have been made.

Milestones Reached	
Baseline Balloon Flight Plan	Nov. 3, 2000
Determine BFEM Tracker configiguration	Nov. 6, 2000
Pressure vessel tests	Dec. 1, 2000
Detailed WBS/Schedule	Dec. 26, 2000