| GLAST LAT SYSTEM SPECIFICATION | Document # **LAT-SS-00240-D1** | Date Effective **Draft June 23, 2001** |
|---|---|---|
| | Prepared by Gilles Bogaert | supersedes |
| | Subsystem/office Calorimeter Subsystem | |
| Document tilte **CAL Pre Electronics Module Specification** | | |

# Gamma-ray Large Area Space Telescope (GLAST)
# Large Area Telescope (LAT)

# CAL Pre Electronics Module (PEM) Specification

## CHANGE HISTORY LOG

| Revision | Effective date | Description of Changes | DCN# |
|---|---|---|---|
| 1 | | Initial Release | |
| 2 | | | |
| | | | |

# 1INTRODUCTION

## 1.1PURPOSE

This document describes the  requirements for the Pre Electronic Module (PEM) part of the Calorimeter (CAL) derived from level 4 detailed system requirements for the GLAST Large Area Telescope (LAT)  Calorimeter (CAL)

## 1.2SCOPE

This document is one level below the LAT-CAL Specification level IV, LATxxxxx
This specification captures the CAL overall requirements for the PEM. This encompasses the subsystem level requirements and the design requirements for the CAL.
It describes the documentation structure for detailed requirements on  the design of PEM structure, PEM CDE, for the PEM internal interfaces and external interface.

## 1.3APPLICABLE DOCUMENTS

Documents that are relevant to the development of the GLAST LAT PEM and its requirements include the following:

| | |
|---|---|
| GE-00010 | 'GLAST LAT Performance Specification', August 2000 |
| GLAST00110 | 'Mission Assurance Requirements (MAR) for Gamma-Ray Large Area Telescope (GLAST) Large Area Telescope (LAT)' , NASA Goddard Space Flight Center, Current Draft Sept 20, 2000 |
| NPD 8010.2B | ' NASA Policy Directive, Use of Metric System of Measurement in NASA Programs' |
| LAT-SS-00018-D4 | 'LAT CAL Subsystem Specification - Level III Specification', 20 March 2001 |
| LAT-DS-00072-03 | ' Specification for the Calorimeter PIN Photodiode Assembly', 20 February 2001 |
| LAT-DS-00095-03 | 'LAT Calorimeter Csi Crystal Specification', 5 April 2001 |
| LAT | LAT Subsystem Mechanical Interface Control Document |
| LAT | Conceptual Design of the Glast Calorimeter Front-End Electronics (GCFE) ASIC |
| GEVS | |
| | |

## 1.4 DEFINITIONS AND ACRONYMS

### 1.4.1 Acronyms

| | |
|---|---|
| ACD | Anticoincidence Shield |
| AFEE | Analog Front End Electronics of the CAL |
| CAL | the Calorimeter subsystem of the LAT |
| CDE | Crystal Detector Element of  the PEM |
| GEVS | General Environmental Verification Specification |
| GLAST | Gamma-Ray Large Area Telescope |
| IRD | Interface Requirements Document |
| I&T | Integration and Test |
| LAT | Large Area Telescope |
| MAR | Mission Assurance Requirements |
| MECO | Main Engine CutOff |
| MSS | Mission System Specification |
| PEM | Pre electronic module of the CAL |
| SI/SC IRD | Science Instrument - Spacecraft Interface Requirements Document. |
| SIU | |
| TEM | Tower Electronics Module |
| TBR | To Be Resolved |
| TKR | Tracker |
| T&DF | Trigger and Data flow system |

### 1.4.2 Definitions

Analysis - A quantitative evaluation of a complete system and/or subsystems by review/analysis of collected data

cm centimeter

Demonstration To prove or show, usually without measurements of instrumentation, that the project/product complies with requirements by observation of the results.

Inspection To examine visually or use simple physical measurement techniques to verify conformance to specified requirements.

Primary structures The instrument primary structures include the support grid, ACD, Radiators and Thermal/micrometeorite shield

Simulation To examine through model analysis or modeling techniques to verify conformance to specified requirements

Testing A measurement to prove or show, usually with precision measurement or instrumentation, that the project/product complies with requirements.

Validation Process used to assure the requirement set is complete and consistent, and that each requirement is achievable.

Verification Process used to ensure that the selected solutions meet specified requirements and properly integrate with interfacing products

# 2 PEM CONCEPTUAL DESIGN OVERVIEW

## *2.1 LAT/CAL CONCEPT*

The calorimeter consists of 16 calorimeter modules arranged in a four by four array. Each calorimeter module consist of one PreElectronic Module (PEM) and 4 AFEE cards mounted inside.

Each PEM contains 8 layers of 12 CsI(Tl) crystal logs. The CsI(Tl) crystals inside the PEM convert the energy from ionizing rays to visible light that is readout at both crystal ends by photodiodes. The signals from each CsI(Tl) log end are then processed by the AFFE electronics. The energy loss and its pattern in the PEM crystals assembled in compact geometry allows to determine the energy and direction of the electromagnetic shower started in the tracker or in the calorimeter itself. The hodoscopic properties of the calorimeter are improved by the localization capability of each crystal, thank to their light collection asymmetry.

Each calorimeter module is inserted in the aluminum grid, and attached to its bottom. Each calorimeter module support a Tower Electronic Module (TEM) fixed underside its bottom. SIU boxes are placed for 4 towers underside the TEM boxes. The heat generated in the calorimeter AFEE and in the TEM and SIU Boxes is removed through the Grid to the Radiators.

## *2.2 PEM DESIGN OVERVIEW*

Each PEM is made of one carbon fiber structure that supports the stack of CDE .

The CsI Detector Element (CDE) is the detection unit of the LAT Calorimeter. It is made up of one CSI(Tl) crystal wrapped in reflective material to improve the light collection at crystal ends where the readout is performed by PIN photodiodes.

The design of the CDE must consider : high light yield for a low threshold detection, high energy resolution, position resolution thanks to the light attenuation length, high stability over the mission life.

CDE are inserted in structure cells which protect individual CDE's and provide high stability of CDE positioning and properties through integration, storage, launch and orbital environmental conditions. The surface of detection inside the calorimeter available space is maximized.

For protection and stability purposes, CDE aren't in direct contact with the Cal Structure. Elastomeres rubber bands at the chamfered crystal edges and Bumpers at the crystal ends are key element that prevent the CDE to be damaged by chocks and maintain crystals in their very position and shape. They allow also the crystal dimension change in the allowed temperature range. The Bumpers at the crystal ends are attached to the Close Out Plate that closes all the cells on each PEM side.

The Close Out plates are also used for shielding the PIN diode elements from AFEE electronic noise. Kapton flex are attached to the PIN diode and shall be connected to the AFFE connectors across the Close Out Plate at each crystal end.

The PEM structure is closed by Side Panels to shield the AFFE electronics that is closed up in the PEM modules.

The fiber carbon structure is attached to the aluminum Bottom Plate that is attached to the Grid bottom. On the Bottom Plate undersides are attached the TEM boxes.

On the top of the carbon fiber structure is an aluminum Frame which allows handling of the PEM.

Cables from AFFE plates to Power Supplies and SIU located under the Calorimeter modules exit the calorimeter trough the Grid Calorimeter interface.

## *2.3 EXPECTED GLOBAL CALORIMETRIC AND HODOSCOPIC PERFORMANCES*

The calorimeter design shall meet the expected performances as detailed in the level IV specification document. The overall performances for calorimetry and hodoscopy must be verified by analysis, and rely on PEM and CDE performances that are verified by inspection, demonstration, and test, and cannot be proven on PEM alone.
Here below are given the specifications the entire Cal must meet that will be verified by analysis.

2.3.1Energy Measurement Range

2.3.2Energy easurement Range

2.3.2.1Energy range low limit (Analysis)

2.3.2.2Energy range High Limit (Analysis)

2.3.2.3Single CsI Crystal Energy Measurement Range (Analysis)

2.3.3Energy resolution (Analysis)

2.3.3.1On axis Energy resolution - Low energy (Analysis)

2.3.3.2On axis Energy Resolution High energy (Analysis)

2.3.3.3Off axis Energy Resolution High Energy (Analysis)
2.3.4Single Crystal Energy Resolution (Analysis)
2.3.5On Orbit Calibration (Analysis)
2.3.6Field of view (Analysis)
2.3.7Performance life (Analysis)

# 3PEM REQUIREMENTS

## 3.1PEM CONFIGURATION REQUIREMENTS

### 3.1.1Mass

[Derived from LAT -xxx CAL level 4 specification]
The total mass of the PEM shall not exceed the Cal mass (1492 kg/16 = 93.25 kg) less the AFEE mass. (TBR)

### 3.1.2PEM geometry

Each Calorimeter module shall not exceed 36.3 cm in lateral extent (XY)
The PEM diagonal shall not exceed xxx cm.
The total height of the PEM inside the Grid structure shall be less than 20.9 cm (TBR). This is the total height less the height of the mounting tabs on the bottom plate

### 3.1.3 PEM Alignment

PEM alignment shall be ± xxx mm

### 3.1.4 Orientation

[Derived from LAT-TD-00035-01]
The PEM layer 0 (top) has X logs and the layer 7 has Y logs. The four PEM sides of a given CAL module are distinguished by their relative location in X and Y, and are labeled -X, -Y, +X, +Y

### 3.1.5Crystal total depth

[from LAT-SS- Level IV specification]

The total depth of the crystal must be greater or equal to 8.4(TBR) radiation length, ie, 15.5 cm of CsI(Tl) material. So, the height of each crystal must be greater than 1.94 cm (TBR).

### 3.1.6 Projected CsI(Tl) area

Each PEM shall provide a projected CsI area of greater than 1100 cm2 for normally incident particles

### 3.1.7 Passive material

Passive material (every thing not CsI) shall represent no more than 16 %(TBR)of the total mass of the calorimeter.

### 3.1.8 Distance from Side Panel to Close Out Plate

The Total Length of the CDE is limited by the thickness of Close Out Plate, AFEE board and Side Panels, and the spacing between each of them. AFFE Board is located between the Close Out Plate and the Side panel. The distance from the Close Out Plate to Side Panel is 8.5 mm

## 3.2HODOSCOPIC PERFORMANCES

### 3.2.1Position resolution

Each layer of the calorimeter shall position the centroid of a minimum ionizing charged particle energy deposition to less than 1.5 cm (1 sigma) (TBD) in all three dimensions for particle incident angles of less than 45 degrees off axis

### 3.2.2 Angular resolution

The single particle angular resolution at 68 % containment for the calorimeter shall be better than 7.5 x cos2(theta) degrees for cosmic muons traversing the eight layers. (theta is the off-axis angle)

## 3.3CDE SPECIFICATION

CDE will be composed of the following parts :

- CsI scintillation crystal. It will be rectangular parallelepiped with a chamfer on the edges of the long dimension

  Length = 333,0 mm ; Height = 19,9 mm and width = 26,7 mm.
- 2 dual pin photodiodes at both ends of the CsI crystal.

  External dimensions 22,3 mm x 15,0 mm x 1,8 mm.

  Pin photodiodes are gluing on CsI using an optical epoxy or silicon glue ( TBD )

  Pin photodiodes are equipped with kapton cable before gluing.
- Wrapping.

  Wrapping is not treated in this procedure ( see procedure CF-XXXXX ).

#### 1.1.1.1

CDE detailed specification is in document xxxxx
CDE Interface specification with PEM Structure is in doc xxxx
CDE Interface with AFEE Board is in doc xxxx

## 3.4PEM THERMAL SPECIFICATIONS

### 3.4.1 Power dissipation

The PEM shall dissipate the AFEE electronic power to the Grid through the Bottom Plate.

The PEM Bottom plate shall dissipate the TEM power to the Grid through the Bottom Plate.

### 3.4.2 PEM thermal specification

PEM thermal specification is in document xxxxx

## 3.5PEM EMI EMC SPECIFICATION

### 3.5.1Grounding

The structure is conductive and grounded to the Grid. All plates are electrically connected to the structure.

### 3.5.2AFEE shielding

The Side Panels shield the AFEE Board from external noise.

#### 3.5.2.1CDE Shielding

The Close-Out plates shield the DPD from AFFE noise.

## 3.6ENVIRONMENTAL CONSTRAINTS

[From LAT-SS-00010, section 5.3.12, Environmental]

### 3.6.1 Environmental conditios specification

The PEM shall be capable of normal operation after being subjected to environmental conditions given in LAT-SS-00010, section 5.3.12, Environmental.

### 3.6.2 Dummy parts

For environmental testing purpose, dummy AFEE boards shall be used to simulate mecanical and thermal CAL behaviour. They can be uesed to attache the Kapton flex ribbons.

## *3.7INTERFACE WITH CAL AFEE*

The PEM interface with AFFE requirements are in doc xxxx

## *3.8EXTERNAL INTERFACE REQUIREMENTS*

Structure to Grid, TEM boxes Interface requirements are in doc xxxx

## *3.9OUTGASING AND CONTAMINATION*

### 3.9.1<u>Outgassing</u>

All materials used in the PEM shall meet the NASA outgassing requirements.

### 3.9.2<u>Contamination</u>

Contamination SI contamination is caused by particles generated from materials, machining and assembly procedures. Care will be taken to keep contamination to a minimum.

## *3.10LOGISTIC CONSTRAINTS*

### 3.10.1<u>Handling</u>

#### 3.10.1.1<u>Attachment points</u>

The top tray of each PEM shall include special attachment points. These points will allow lifting from the top , and must support the mass of the PEM.

#### 3.10.1.2<u>Procedures</u>

The PEM shall be handled per controlled procedures during all phases of ground processing to minimize exposure to structural and mechanical load.

### 3.10.2<u>Packaging and transportation</u>

PEM shall be transported in containers. Transportation and storage container detailed specifications are given in xxx

#### 3.10.2.1<u>Kapton cable attachment</u>

During transportation the PIN Kapton ribbon are attached to prevent their move and contact pads are protected against short circuit.

### 3.10.3<u>PEM Ground environmental</u>

The PEM shall be housed in environmental controlled and monitored facilities during all phases of ground processing.

#### 3.10.3.1 PEM Environment Cleanliness

The PEM environment shall be free of dust at the level defined by ISO 7 norm.

#### 3.10.3.2 PEM environment Temperature

Temperature environment which the instrument may be exposed during ground operations is in the range 19 to 25 °C.

#### 3.10.3.3 PEM environment Humidity

Humidity environment which the instrument may be exposed during ground operations must be lower than 40 % HR.

### 3.10.4 Identification and marking

TBD

## 4Verification strategy

The table 4.1 indicates the methods of verification employed to verify the PEM Test Bench performances

**Table 4.1 : verification matrix**

| Req't # | Title | Summary | Verif. Method |
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