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GLAST Tracker
Subsystems Requirements

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1 Introduction

1.1 Purpose This document describes the requirements for the LAT tracker. The aim is to assure that the science requirements and goals are met with a predictable performance during assembly, test and operations.

1.2 Scope The tracker encompasses the following parts of the GLAST LAT tracking modules: Silicon Detectors ("sensors"), Electronics, Cables, trays, tower walls and fasteners connecting them either to themselves, the ACD or the grid. Where possible, the tracker requirements will be decomposed into three separate blocks: electronics, sensors and mechanical structures.

1.3 Definitions The following definitions are used throughout the document

COSMIC RAY – C.R. Charged cosmic ray (electrons, protons and heavy ions) constituting a background to the gamma-ray signal.
CALORIMETER – CAL The part of the instrument where the visible energy of particles is determined
CHIP – ASIC with analog and/or digital function
EFFECTIVE AREA – A_{eff} Product of geometrical area, gamma conversion probability and detection efficiency. includes all cuts to reject charged C.R. and to improve the PSF
FIDUCIAL – Physical mark on surfaces to allow positioning, alignment and metrology
HYBRID – Multi-chip module containing ASIC's, surface-mount parts and connectors
LADDER – Assembly of 4 detectors with strips aligned to allow serial bonding of strips to electronics channels. The ladder length is ~4 times the sensor length, the ladder width is equal to the sensor width.
POINT SPREAD FUNCTION – PSF, angular resolution function of the instrument
PSF68 – Space angle containing 68% of the photons. PSF68 is highly energy dependent.
PSF95 – Space angle containing 95% of the photons. PSF95 is highly energy dependent.
RADIATION LENGTH – R.L. Material specific measure of the scattering and conversion probability
SENSOR – Silicon microstrip detector
TOWER – Physical and functional sub-division of the LAT of either tracker and calorimeter modules.
TKR – The Tracker part of LAT, where photons convert to e+e- pairs which are tracked.
TRAY – Mechanical structure holding two planes of silicon detectors at a prescribed distance.

1.4 Testing and Verification The tracker functionality requirements and specifications will be tested in various ways: wafer tests of ASIC's and sensors, bench-tests of sub-assemblies, metrology, environmental tests of trays and towers and beam and cosmic ray tests.

2 Tracker Performance Requirements

2.1 Effective Area vs Angle of Incidence The effective area of the events converting in the tracker shall be known to 10% (TBR) as a function of energy.

- Justification: Spectral investigations
- Status: Under investigation
- Verification: Comparison of BTEM data with simulations.

2.2 Angular resolution PSF The angular resolution function, Point spread function PSF, (e.g. PSF68 and PSF95) shall be known with 10% (TBR)accuracy .

- Justification: Background reduction, source separation
- Status: Under investigation
- Verification: Comparison of BTEM data with simulations.

2.3 Trigger Performance The TKR shall supply single plane OR'd signals to allow for an efficient (>95% at 1GeV, TBR) and robust (<0.1kHz noise rate,TBR) tracking trigger, operating at 15kHz maximum rate (TBR) with less than 10% deadtime(TBR).

- Justification: Effective area determination
- Status: Under investigation
- Verification: Analysis of BTEM data in the beam and on the bench.

3 Electronics Requirements

Detailed technical specifications are found in the Tracker Electronics Requirements.

3.1 Power Consumption The power consumption of the tracker electronics shall be less than 250uW/channel.

- Justification: Limited resources, ~1M channels
- Status: Present prototypes achieve this
- Verification: Measure power consumption, including power conversion efficiency

3.2 Noise Occupancy The noise occupancy within a trigger window shall be less than 10% (TBR) in a single plane.

- Justification: Data rate in trigger OR, Noise trigger rate
- Status: Present prototypes achieve this
- Verification: Bench tests

3.3 Efficiency The electronics shall allow a low enough threshold to permit a sensor efficiency of at least 99% (TBR) efficient at 90deg impact. At End-of-Mission, the single channels efficiency shall be at least 98%.

- Justification: Good PSF requires high detector efficiency.
- Status: Present detectors have >99% efficiency in beam tests
- Verification: Beam and Cosmic Ray tests.

3.4 Dead Time The electronics shall have an average dead time of less than 20us.

- Justification: The calorimeter introduces a dead time of 20us, and the tracker should not exceed this number.
- Status: Impact of long pulses from heavy ions has to be studied.
- Verification: Bench tests with injected charge.

4 Silicon Detector Requirements

The specific technical specifications are documented in the silicon detector specification (latest version on the GLAST TKR detector web site)

4.1 Active Detector Area The active area of the sensors shall be at least 95% (TBR) of the total detector area

- Justification: Good PSF requires high tracking efficiency.
- Status: Present detectors have 96.6% active area
- Verification: Add area of dead channels to known dead area in the layout

4.2 Detector Efficiency The sensors shall be at least 99% (TBR) efficient at 90deg impact. At End-of-Mission, the single channels efficiency shall be at least 98%.

- Justification: Good PSF requires high detector efficiency.
- Status: Present detectors have >99% efficiency in beam tests
- Verification: Beam and Cosmic Ray tests.

4.3 Detector Noise All sensors noise sources except the capacitance shall contribute less than 10% (TBR) additional noise RMS to the one attributed to the ASIC coupled to the detector capacitance.

- Justification: Noise occupancy critical for triggering.
- Status: Present detectors have enough noise margin
- Verification: Beam and bench tests.

4.2 Detector Health during Operation The leakage current of the sensors/ladders shall be monitored at intervals of about 10min. Increased leakage current shall be correlated with increased single channel noise.

- Justification: Detectors with high currents and bad channels have to be isolated and/or masked.
- Status: Detectors with low leakage current allow detection of malfunctioning of 1 out of 16 detectors in one plane. Noise occupancy plots allow identification of bad channels.
- Verification: Bench tests.

5 Mechanical Supports Requirements

The mechanical system has to assure survival of the launch, predictable location of the silicon detectors on the ground and in space and provide for heat transfer from the front-end electronics to the grid. All tolerances are absolute values, i.e. “not to exceed”.

5.1 Mechanical Tolerances in the silicon plane

In plane, positioning of silicon to 50um (TBR) normal to strips, 100 micron along strips.

- Justification: Positioning of detectors should contribute negligible error wrt single strip resolution RMS = pitch/sqrt(12) = 80micron, permit simple assembly.
- Status: BTEM
- Verification:

5.2 Mechanical Tolerances out of the silicon plane The distance between silicon planes on one tray shall be within 100um (TBR) of the design value. The location of each silicon detectors shall be within 100um of the design value.

- Justification: Tracks under large angle of incident
- Status: BTEM
- Verification: Bench tests.

5.3 Amount of dead material within active area Within the active area of the trays, the dead material outside of the converter should be <25% of total mass of the tray (in R.L). Walls and closeout

- Justification: Limit tails in PSF, C.R. rejection
- Status:
- Verification: Material audit

5.4 Amount of dead material outside active area Outside the active area of the trays, the dead material should not exceed the total mass within the trays, in R.L., averaged over the trays. This refers to electronics boards, closeout and walls

- Justification: Limit tails in PSF, C.R. rejection
- Status:
- Verification: Material audit

5.5 Distance between converter and the 2nd silicon plane The distance between the converter and the 2nd silicon plane following (i.e. first plane in the next tray), shall be less than 3mm.

- Justification: Limit deterioration of PSF at low energy by multiple scattering
- Status:
- Verification:

5.6 Tolerance on Converter Thickness The Converter thickness shall be within 5% (TBR) of design value.

- Justification: Understand active area**,** control mass
- Status:
- Verification:

5.7 Tolerance on Converter Dimensions The converter lateral dimensions shall be equal to the active area of the silicon sensors within 100um (TBR).

- Justification: Understand active area**,** minimize multiple scattering
- Status: Done in BTEM
- Verification: Inspection

5.8 Positioning of Converter The Converter shall be located within 100 um (TBR) within the active area of the silicon sensors.

- Justification: Understand active area**,** control mass
- Status:
- Verification:

5.9 Temperature Regulation The mechanical system shall maintain a silicon sensor temperature of below 25°C during operation during the entire mission.

- Justification: Limit the leakage current which causes shot noise
- Status: Introduced into the SRD
- Verification: Testing Thermal-Vac

6 Mechanical Interfaces

See HTN-102050-0021-Draft 07/06/2000

7 Safety