DOCUMENT CHANGE NOTICE (DCN)

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DATE: 11/26/01

CHANGE TITLE: Initial Release of Tracker Level III Specification
ORG.: Systems Engineering

DOCUMENT NUMBER | TITLE | NEW REV.
-----------------|-------|---------
LAT-SS-00017     | GLAST LAT Tracker Subsystem Specification | 5

CHANGE DESCRIPTION (FROM/TO):

This is the initial release of the LAT-SS-00017 document to configuration management. This release version includes the recommendations of the 3/22/01 peer requirements review.

The following changes were made after the 3/22/01 review:

1) Req. 5.12 - Changed noise occupancy from "not exceed one in 1000 channels per trigger" to "not exceed one in 10,000 channels per trigger."

2) Req. 5.22 - Updated reliability requirement to read, "The reliability of the tracker shall be at least 96% in five years. Reliability is the probability that the tracker will not experience a reduction in operability below 90% due to failure of its components. Operability is the percentage of tracker channels that are operational."

3) Deleted 5.23, old operability requirement, due to updated requirement 5.22.

REASON FOR CHANGE:
Initial Release

ACTION TAKEN: ☒ Change(s) included in new release  ☐ DCN attached to document(s), changes to be included in next revision  ☐ Other (specify):

DISPOSITION OF HARDWARE (IDENTIFY SERIAL NUMBERS):

☒ No hardware affected (record change only)
☐ List S/Ns which comply already:
☐ List S/Ns to be reworked or scrapped:
☐ List S/Ns to be built with this change:
☐ List S/Ns to be retested per this change:

SAFETY, COST, SCHEDULE, REQUIREMENTS IMPACT? ☐ YES ☒ NO
If yes, CCB approval is required. Enter change request number:

APPROVALS | DATE | OTHER APPROVALS (specify) | DATE
-----------|------|---------------------------|------
ORIGINATOR: (Davis) Signature on file | 11/28/01 | Sys. Eng. - Elec. (Haller) Signature on file | 12/17/01
TKR Manager (R. Johnson) Signature on file | 11/29/01 | | |
Sys. Eng. Manager (Thurston) Signature on file | 11/29/01 | | |
Inst. Scientist (Ritz) Signature on file | 12/13/01 | | |
DCC RELEASE: Signature on file | 12/18/01 | Doc. Control Level: ☐ Subsystem ☒ LAT IPO ☐ GLAST Project
Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Tracker (TKR) Subsystem Specification
## CHANGE HISTORY LOG

<table>
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<th>Effective Date</th>
<th>Description of Changes</th>
<th>DCN #</th>
</tr>
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<tbody>
<tr>
<td>Draft 4</td>
<td>3/26/01</td>
<td>Introduced changes requested at the review on 3/22/01. R.P. Johnson</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
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1 PURPOSE

This document defines level III subsystem requirements for the GLAST Large Area Telescope (LAT) Tracker (TKR).

2 SCOPE

This specification captures the GLAST LAT requirements for the TKR. This encompasses the subsystem level requirements and the design requirements for the TKR. The verification methods of each requirement are identified.

This specification is identified in the specification tree of Figure 2-1.

FIGURE 2-1 SPECIFICATION TREE
3 DEFINITIONS

3.1 Acronyms

ACD – Anticoincidence Detector
CAL – Calorimeter
FOV – Field of View
GLAST – Gamma-ray Large Area Space Telescope
IOC – Instrument Operations Center
IRD – Interface Requirements Document
LAT – Large Area Telescope
MOC – Mission Operations Center
MSS – Mission System Specification
SAS – Science Analysis Software
SRD – Science Requirements Document
SSC – Science Support Center
T&DF – Trigger and Dataflow
TBR – To Be Resolved
TKR – Tracker

3.2 Definitions

µsec, µs – Microsecond, 10\(^{-6}\) second

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

Back Response – Response as measured in the thick layers of the Tracker

Beam Test – Test conducted with high energy particle beams

cm – centimeter

Dead Time – Time during which the instrument does not sense and/or record gamma ray events during normal operations.
Demonstration – To prove or show, usually without measurement of instrumentation, that the project/product complies with requirements by observation of results.

eV – Electron Volt

Field of View – Integral of effective area over solid angle divided by peak effective area.

Front Response – Response as measured in the thin layers of the Tracker

GeV – Giga Electron Volts. $10^9$ eV

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

MeV – Million Electron Volts, $10^6$ eV

s, sec – seconds

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

sr – steradian, A steradian is the solid (3D) angle formed when an area on the surface of a sphere is equal to the square of the radius of the sphere. There are 4 Pi steradians in a sphere.

Testing – A measurement to prove or show, usually with precision measurements 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.

4 APPLICABLE DOCUMENTS

Documents that are relevant to the development of the LAT design concept and its requirements include the following:


GSFC 433-SRD-0001, “GLAST Science Requirements Document”


GSFC 433-OPS-0001, “GLAST Operations Concept”

GSFC 433-MAR-0001, “Mission Assurance Requirements (MAR) for Gamma-Ray Large Area Telescope (GLAST) Large Area Telescope (LAT)”
5 REQUIREMENTS

5.1 System Description

The LAT science instrument (SI) consists of an Anticoincidence Device (ACD), a silicon-strip detector tracker (TKR), a hodoscopic CsI calorimeter (CAL), and a Trigger and Dataflow system (T&DF). The principal purpose of the SI is to measure the incidence direction, energy and time of cosmic gamma rays. The measurements are streamed to the spacecraft for data storage and subsequent transmittal to ground-based analysis centers.

The TKR converts gamma rays to charged particles and precisely measures the path of the charged particles within the TKR. Fast signals from tracks are examined in the T&DF system for likely gamma ray candidates. Once identified, and at the request of the trigger system, data are read out via the dataflow system. The dataflow system uses the data to assemble particle tracks and, coupled with the ACD and CAL, identify gamma rays.

5.2 Gamma Ray Conversion Efficiency

The TKR shall convert at least 65% of the gamma rays with energy >10 GeV impinging upon the device at normal incidence.

5.3 Converter Configuration

At least 25% of the gamma-ray conversions shall occur in high-Z converter foils no greater than 3.5% radiation lengths thick, with the remainder occurring in other material and converter material no more than 25% radiation lengths thick.

5.3.1 Converter/Sensor Spacing

The converter material shall not lie more than 3 mm above the corresponding sensors.

5.4 Other Material

5.4.1 Within a module active volume:

At normal incidence and within the active area of the thin-converter region, no more than 35% of the gamma-ray conversions shall occur in material other than the high-Z converter foils.

5.4.2 Between modules:

A particle traversing the boundary between TKR modules and at normal incidence to the module walls shall not encounter more than 5% radiation lengths of material, on average.

5.5 Geometric Area

The TKR shall have an active area at normal incidence of at least 19,000 cm$^2$. 

Hard copies of this document are for REFERENCE ONLY and should not be considered the latest revision.
5.6 Aspect Ratio

The ratio of height to width of the TKR active volume shall not exceed 0.45 (for large field-of-view).

5.7 Charged Particle Detection

The TKR shall measure immediately following each converter foil, in both x and y views and within the active area, the position of passage of a minimum ionizing particle at normal incidence with an efficiency of greater than 98%.

5.8 Spatial Measurement Resolution

The TKR shall measure the direction of a charged particle of straight trajectory (negligible multiple scattering), in both x and y views and using just two consecutive measurement planes, to a precision of no worse than 0.2°.

5.9 Dead Area

The fraction of non-active area presented by the top of the TKR shall not exceed 12%.

5.10 Ionization Measurement

For an event with a single track detected, the TKR shall distinguish, on the basis of charge deposition, a single minimum-ionizing particle from two minimum-ionizing particles to a level of at least 1-sigma.

5.11 Self Trigger

The TKR shall provide prompt signals to be used by the T&DF system to form a trigger for readout of the TKR and other subdetectors.

5.11.1 Trigger Efficiency

The TKR trigger shall be on average at least 90% efficient for the set of gamma-ray conversions from which the conversion products traverse the active areas of at least 3 consecutive measurement planes.

5.11.2 Trigger Noise

In the case that no charged particles or gamma rays are incident upon the TKR, the TKR trigger shall not exceed a rate of 500Hz.

5.11.3 Trigger Saturation Recovery Time

The trigger signals from a TKR readout module shall not hold true for longer than 250 µs in the case of passage of a high-momentum fully-ionized iron nucleus.
5.12 **Data Noise Occupancy**

The noise occupancy in the TKR data stream shall not exceed one in 10,000 channels per trigger.

5.13 **Dead Time**

The dead time imposed by the TKR readout shall not exceed 10% at a cosmic-ray trigger rate of 10 kHz.

5.14 **Tracker Mass**

The mass of the TKR shall not exceed 530 kg.

5.15 **Tracker Power**

The power consumption of the TKR shall not exceed 184 W of conditioned power.

5.16 **Control Signals**

The TKR shall receive control signals from the T&DF system to reset and to configure its readout, to perform in-flight calibration tasks, to trigger acquisition of events, and to control the flow of data to the T&DF.

5.16.1 **Configuration Read-Back**

The TKR shall provide a facility for read-back of all electronic configuration settings.

5.17 **Data Flow**

The TKR shall deliver its data in a zero-suppressed format to the T&DF system, by way of at least two independent paths.

5.18 **Internal Calibration System**

The TKR readout electronics shall include a system for calibration and test by means of injection of signals and trigger from the T&DF system.

5.19 **Temperature Monitoring**

The TKR shall provide temperature sensors within its volume for monitoring the TKR temperature and temperature gradient.

5.20 **Thermal Control**

The TKR shall be cooled by passive flow of heat through its interface to the Grid.
5.21 Environmental

The TKR shall meet the structural and thermal environment requirements defined in its interface control document.

5.22 Reliability

The reliability of the tracker shall be at least 96% in five years. Reliability is the probability that the tracker will not experience a reduction in operability below 90% due to failure of its components. Operability is the percentage of tracker channels that are operational.
## 6 VERIFICATION STRATEGY

The verification strategy will test, analyze (may include modeling/simulation), inspect, or demonstrate all requirements of section 5 to ensure that the instrument meets its specified requirement. The matrix below indicates the methods of verification employed to verify the science performance.

### Table 6-1. Requirements Verification Matrix

Note: Verification methods are T = Test, A = Analysis, D = Demonstrate, I = Inspect

<table>
<thead>
<tr>
<th>Req’t #</th>
<th>Title</th>
<th>Summary</th>
<th>Verif. Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2</td>
<td>Gamma Ray Conversion Efficiency</td>
<td>Convert at least 65% of all impinging gamma rays</td>
<td>A</td>
</tr>
<tr>
<td>5.3</td>
<td>Converter Configuration</td>
<td>At least 25% of the conversions shall occur in foils no greater than 3.5% radiation lengths thick, with the remainder occurring in other material and converter material no more than 25% radiation lengths thick.</td>
<td>A</td>
</tr>
<tr>
<td>5.3.1</td>
<td>Converter/Sensor Spacing</td>
<td>The converter shall not lie more than 3 mm above the corresponding sensors</td>
<td>I</td>
</tr>
<tr>
<td>5.4.1</td>
<td>Other Material in Active Volume</td>
<td>Not more than 35% of conversions shall occur in material other than converter foils (normal incidence, active region)</td>
<td>A</td>
</tr>
<tr>
<td>5.4.2</td>
<td>Other Material Between Volumes</td>
<td>Not more than 5% radiation lengths on average for particle traversing boundary at normal incidence.</td>
<td>A</td>
</tr>
<tr>
<td>5.5</td>
<td>Geometric Area</td>
<td>At least 19,000 cm²</td>
<td>A</td>
</tr>
<tr>
<td>5.6</td>
<td>Aspect Ratio</td>
<td>Not to exceed 0.45</td>
<td>A</td>
</tr>
<tr>
<td>5.7</td>
<td>Charged Particle Detection</td>
<td>X,Y position of charged particles measured with efficiency &gt;98%</td>
<td>T</td>
</tr>
<tr>
<td>5.8</td>
<td>Spatial Measurement Resolution</td>
<td>Direction of charged particle measured to precision no worse than 0.2°.</td>
<td>A, T</td>
</tr>
<tr>
<td>5.9</td>
<td>Dead Area</td>
<td>Not to exceed 12%</td>
<td>A</td>
</tr>
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<td>5.10</td>
<td>Ionization Measurement</td>
<td>For a single-track event, the TKR shall distinguish a single minimum-ionizing particle from two minimum-ionizing particles to a level of 1-sigma.</td>
<td>A, T</td>
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<td>5.11</td>
<td>Self Trigger</td>
<td>TKR shall provide prompt signals to the trigger subsystem.</td>
<td>D</td>
</tr>
<tr>
<td>5.11.1</td>
<td>Trigger Efficiency</td>
<td>At least 90%</td>
<td>A, T</td>
</tr>
<tr>
<td>5.11.2</td>
<td>Trigger Noise</td>
<td>Not to exceed 500 Hz</td>
<td>T</td>
</tr>
<tr>
<td>5.11.3</td>
<td>Trigger Saturation Recovery Time</td>
<td>&lt;250 µs</td>
<td>A, T</td>
</tr>
<tr>
<td>5.12</td>
<td>Data Noise Occupancy</td>
<td>Not to exceed one in 10,000 channels per trigger.</td>
<td>T</td>
</tr>
<tr>
<td>5.13</td>
<td>Dead Time</td>
<td>Not to exceed 10% at a cosmic-ray trigger rate of 10 kHz.</td>
<td>T, A</td>
</tr>
<tr>
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<td>Tracker Mass</td>
<td>Not to exceed 530 kg</td>
<td>I</td>
</tr>
<tr>
<td>5.15</td>
<td>Tracker Power</td>
<td>Not to exceed 185 W</td>
<td>T</td>
</tr>
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<td>5.16</td>
<td>Control Signals</td>
<td>The TKR shall receive control signals from the T&amp;DF to reset and to configure its readout, to perform in-flight calibration tasks, to trigger acquisition of events, and to control the flow of data to the T&amp;DF.</td>
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<td>The TKR shall provide a facility for read-back of all electronic configuration settings.</td>
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<td>Internal Calibration System</td>
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<td>The TKR shall provide temperature sensors within its volume for monitoring the TKR temperature and temperature gradient.</td>
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<td>The TKR shall be cooled by passive flow of heat through its interface to the Grid.</td>
<td>T, A</td>
</tr>
<tr>
<td>5.21</td>
<td>Environmental</td>
<td>TKR shall meet structural and thermal environment requirements defined in its ICD.</td>
<td>T</td>
</tr>
<tr>
<td>5.22</td>
<td>Reliability</td>
<td>The reliability of the tracker shall be at least 96% in 5 years.</td>
<td>A</td>
</tr>
</tbody>
</table>