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	Subsystem/Office Anticoincidence Detector Subsystem	
Document Title **LAT ACD Tile Detector Assembly Quality Plan and Acceptance Tests**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

ACD Tile Detector Assembly Quality Plan and Acceptance Tests

DRAFT

Document Approval

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes

1. Purpose

This document provides a quality plan for the GLAST ACD Tile Detector Assemblies.

Definitions and Acronyms

ACD	The LAT Anti-Coincidence Detector Subsystem
ADC	Analog-to-Digital Converter
AEM	ACD Electronics Module
ASIC	Application Specific Integrated Circuits
BEA	Base Electronics Assembly
CAL	The LAT Calorimeter Subsystem
DAQ	Data Acquisition
EGSE	Electrical Ground Support Equipment
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FM	Flight Module
FMEA	Failure Mode Effect Analysis
FREE	Front End Electronics
GAFE	GLAST ACD Front End – Analog ASIC
GARC	GLAST ACD Readout Controller – Digital ASIC
GEVS	General Environmental Verification Specification
GLAST	Gamma-ray Large Area Space Telescope
HVBS	High Voltage Bias Supply
ICD	Interface Control Document
IDT	Instrument Development Team
I&T	Integration and Test
IRD	Interface Requirements Document
JSC	Johnson Space Center
LAT	Large Area Telescope
MGSE	Mechanical Ground Support Equipment
MLI	Multi-Layer Insulation
MPLS	Multi-purpose Lift Sling
PCB	Printed Circuit Board
PDR	Preliminary Design Review

PMT	Photomultiplier Tube
PVM	Performance Verification Matrix
QA	Quality Assurance
SCL	Spacecraft Command Language
SEL	Single Event Latch-up
SEU	Single Event Upset
SLAC	Stanford Linear Accelorator Center
TACK	Trigger Acknowledge
TDA	Tile Detector Assembly
T&DF	Trigger and Data Flow Subsystem (LAT)
TBD	To Be Determined
TBR	To Be Resolved
TSA	Tile Shell Assembly
TSS	Thermal Synthesizer System
TKR	The LAT Tracker Subsystem
VME	Versa Module Eurocard
WBS	Work Breakdown Structure
WOA	Work Order Authorization

2. Applicable Documents

Documents relevant to the ACD Photomultiplier Quality Plan include the following.

1. LAT-SS-00016, LAT ACD Subsystem Requirements – Level III Specification
2. LAT-SS-00352, LAT ACD Electronics Requirements – Level IV Specification
3. LAT-SS-00437, LAT ACD Mechanical Requirements – Level IV Specification
4. LAT-MD-00039-01, LAT Performance Assurance Implementation Plan (PAIP)
5. LAT-MD-00099-002, LAT EEE Parts Program Control Plan
6. LAT-SS-00107-1, LAT Mechanical Parts Plan
7. LAT-MD-00078-01, LAT System Safety Program Plan (SSPP)
8. ACD-QA-8001, ACD Quality Plan
9. LAT-TD-00760-D1 Selection of ACD Photomultiplier Tube

10. LAT-DS-00739-1 Specifications for ACD Photomultiplier Tubes
11. LAT-TD-00438-D2 LAT ACD Light Collection/Optical Performance Tests
12. Fabrication and Assembly Procedure for the Anticoincidence Detector (ACD) Tile Detector Assembly (TDA), ACD-TBD.

4. Introduction

The ACD Subsystem principal sensors are the Tile Detector Assemblies (TDAs - scintillator tiles with embedded waveshifting fibers). They have characteristics (such as being made individually, not in batches) that require special quality considerations. The TDAs will be purchased from Fermi National Laboratory (Fermilab), a leading maker of scintillator tiles with waveshifting fibers. Many of the tests for the ACD TDAs are carried out as part of the procurement, so that GSFC is responsible principally for the acceptance tests, performance monitoring, and careful handling of the flight detectors.

5. ACD TDA Purchase from Fermilab

Plastic scintillator detectors with photomultiplier tube readout have a long and successful history in space, dating back some 40 years. All the Compton Gamma Ray Observatory instruments, for example, carried plastic scintillator detectors. Generically, scintillator can be considered a well-established space technology. Scintillators are relatively rugged, and they are not damaged by radiation at the level expected for the LAT or by temperature changes over a fairly wide range. Known risks are breakage, surface deterioration (crazing) caused by stress or solvents, and deformation at high temperatures (above 60 C).

Quality procedures for the Fermilab work, along with detailed drawings for the various types of tile, are described in the document, “Fabrication and Assembly Procedure for the Anticoincidence Detector (ACD) Tile Detector Assembly (TDA)”, ACD-TBD. The Fermilab Quality Plan is consistent with the LAT and ACD Quality Plans (LAT-MD-00039-01, LAT Performance Assurance Implementation Plan (PAIP), ACD-QA-8001, ACD Quality Plan).

6. Performance/Acceptance Testing of the TDAs

The essential performance requirements, listed in the Level III and Level IV documents (LAT-SS-00016, LAT ACD Subsystem Requirements – Level III Specification, LAT-SS-00352, LAT ACD Electronics Requirements – Level IV Specification) are the efficiency for detection of charged particles and the signal size for charged particles passing through an ACD scintillator, quantities that depend on the assembled scintillator/waveshifting fiber/phototube system. These requirements are not, therefore, directly measurable properties of the TDA. The basic principle of the testing by the ACD team is therefore to compare the TDA performance with that of other TDAs that have demonstrated the performance requirements in a complete assembly. We establish two general tests:

1. Performance. The TDA is attached to two reference phototubes, and a triggering telescope is used to identify cosmic ray muons (Minimum Ionizing Particles, or MIPs), which produce the same signals that the ACD requirements specify. The actual efficiency for detection of charged particles can also be determined as a function of threshold for the pulse height. The procedure is "ACD TDA Performance Test Procedure." (Appendix A outlines the procedure.)

2. Inspection. This is a visual inspection to insure that no damage has taken place during shipment, also to verify that the physical properties of the TDA, as shown on the control drawings are met. This verification will be performed using the "ACD TDA Inspection Procedure." (Appendix B outlines the procedure)

In practice, the damage inspection will be done first, followed by the performance test and then the measurement of the dimensions. (If the TDA does not meet our performance requirements, then it does not matter whether it is the correct size).

7. Quality Assurance for the Tile Detector Assemblies

As with all flight hardware for the ACD, TDAs will be handled, processed, and controlled under the provisions of the PAIP (LAT-MD-00039-01, LAT Performance Assurance Implementation Plan) and the LAT ACD Quality Plan (ACD-QA-8001, ACD Quality Plan). Some aspects (not intended to be a exhaustive list) of these plans as applied specifically to the phototubes are:

1. All work will be documented with a Work Order Authorization (WOA), GSFC Form 4-30. This WOA will remain with the phototube as a traveler until the phototube is integrated into the ACD electronics assembly, after which it will be retained as a reference document.

2. All work on flight TDAs will be done by certified technicians.

3. All work will be inspected by a representative of the Product Assurance group.

4. The TDAs will be stored in a locked facility except while actual work on them is in progress.

5. Because TDAs can suffer degraded performance after excessive exposure to some solvents, the areas where phototubes are stored or being worked on will be using only alcohol for cleaning.

6. When the TDAs are assembled into their wrapping, the serial number of the TDA will be transferred to the wrapping in a permanent and visible marking.

7. The performance characteristics of the TDAs measured during the acceptance tests will be recorded in a database. For any TDA with sensitivity change greater than 10%, a Nonconformance Report (NCR) will be written.

8. Except for solvents, there are no special environmental conditions for the Tile Detector Assemblies. Normal laboratory conditions are acceptable.

Appendix A - ACD TDA Performance Test Procedure Outline

In this procedure, the TDA sensitivity for detection of charged particles is measured. Reference LAT-TD-00843-D2, Design Qualification Tests for ACD TDA and Phototubes.

This test is to be performed on each TDA after their delivery to GSFC:

4 main types of TDA:

- flat top tile with fiber-to-fiber connector (15 of them + spares)
- bent top tile with fiber-to-fiber connector (10 of them + spares)
- flat side tiles of different sizes with WLS fiber bundles and PMT adapters (60 of them + spares)
- long side bottom tiles with PMT adapters (4 of them + spares)

Each of these types has a reference prototype, carefully tested, supplied by the reference PMT.

Every tile was inspected at FNAL for workmanship of fiber gluing, edge polishing, compliance of dimensions, etc. before giving approval for wrapping.

1. Visual inspection. Inspect the TDA for quality of wrapping and absence of wrapping damages. Each TDA gets a number in the TDA log book (see Appendix B).

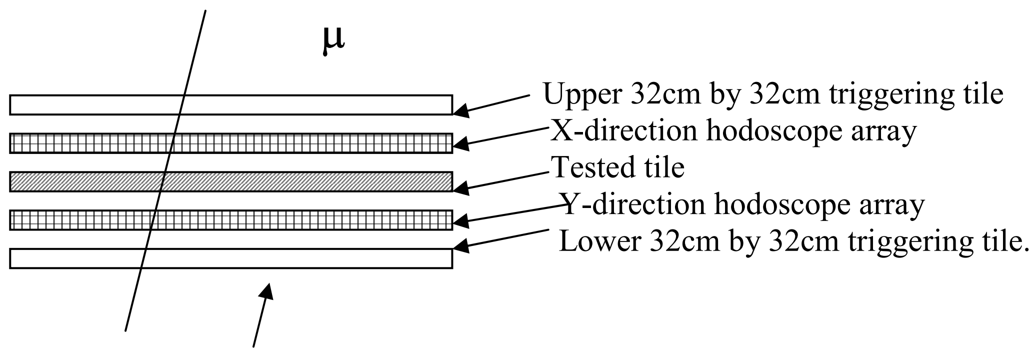
2. Light tightness. Connect to the reference PMTs (through the clear cable for top TDA's). Test the light tightness using the oscilloscope, gradually raising the HV in the first turn on. This test is first done in a light tight box, and after that in open light to compare the oscilloscope pictures. In a case of a light leak the leak source has to be located and fixed (if it is minor). A failure report is to be filed for any leak.

3. Light yield and efficiency test. Install the TDA into the 8 x 8 tomography setup (between two crossed hodoscopes, each with 8 scintillator strips). Collect the data for 4-5 hours to collect ~ 80,000 events. The HV is set to 1,000 V.

4. Analyze the data for 3 tasks:
   - select 36 (6 by 6) central hodoscope pixels (~ 40,000 events) to measure the average light yield in the center. Compare with the reference TDA of this type. The MIP peak position should not differ by more than 10%.
   - Determine the MIP detection efficiency from this data set (36 central pixels)
   - Map the light yield for 64 pixels; compare with the reference TDA. This test determines if there are any broken/damaged WLS fibers

5. For TDA's which have clear fiber extensions, steps 2, 3, and 4 have to be repeated (probably later) but connecting with assigned clear cable (keep the reference PMT's). The goal of this test is to check the real light yield for this TDA (with assigned different length clear cable) and to check if the clear fibers in the cables are intact and the fiber-to-fiber connector is aligned (light yield mapping answers these issues)

There is a possibility to run tomography test for 4 TDA's in one time, but there will be needed 4 sets of reference PMT's, previously separately tested with reference tile.



Experimental setup

Each hodoscope array consists of eight 4cm by 32cm scintillating strips. X- and Y-direction arrays are positioned orthogonally to each other, so selecting the coincidence between pair of strips in X- and Y-hodoscope, we will know the 4cm by 4cm box position of the muon crossing the tested tile. Selecting the signals from tested tile according to this principle, the light yield map with 4cm by 4cm pixels can be created.

Appendix B - ACD TDA Inspection Procedure

In this procedure, the TDA is visually inspected for conformance to physical specifications and absence of shipping damage. All tests are pass/fail.

For each TDA, the dimensions are compared to the corresponding drawing.

Damage Inspection

Item #	**Parameter**	**Pass/Fail**
1	No white Tyvek visible	
2	All fibers visible in the connector	
3		
4		

Dimensions

Item #	**Parameter**	**Dimensions**	**Pass/Fail**
1	Thickness, including wrapping	1.01 cm ± 0.01 except for top center tiles	
2	Width (across fibers)	As defined in drawing	
3	Length (along fibers)	As defined in drawing	
4	Diameter of connector (if no clear fiber connector)		
5	Length of fibers (edge of tile to connector)	As defined in drawing	
6			
7			