GLAST LAT SYSTEM SPECIFICATION	Document # **LAT-SS-00573**	Date 16 June 2002
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	Subsystem/Office Integration and Test	
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Change History Log

Revision	Effective Date	Description of Changes

Contents

1. Purpose

This document defines the Calibration and Data Analysis Plan for the Engineering Model of the Large Area Telescope (LAT) of the Gamma-ray Large Area Space Telescope (GLAST) Mission.

2. Scope

This document defines the infrastructure needed for Data Analysis and Calibration activities.

3. Acronyms and Definitions

3.1. Acronyms

ACD	Anti Coincidence Detector
ADC	Analog-to-Digital Count
AGN	Active Galactic Nuclei
CAL	Calorimeter
CNO	Carbon, Nitrogen, Oxygen
CsI	Cesium Iodide
CsI(Tl)	Cesium Iodide doped with Thallium
CR	Cosmic Rays
CU	Calibration Unit (four towers)
DAQ	Data Acquisition System
EGRET	Energetic Gamma Ray Experiment Telescope
EGSE	Electrical Ground Support Equipment
ELX	Electronics
EM	Engineering Model (single tower)
ENV	Environmental
Fe	Iron
FEE	Front-End Electronics
FSW	Flight Software
FOV	Field of View
FU	Flight Unit (single tower)
GBM	Gamma-Ray Burst Monitor
GCR	Galactic Cosmic Rays
GLAST	Gamma ray Large Area Space Telescope
GRB	Gamma Ray Burst
GSFC	NASA Goddard Space Flight Center, Greenbelt MD
GUI	Graphical User Interface
HEX1	High-gain low-energy range
HEX8	High-gain high-energy range
IFCT	Integration Facilities Configuration and Test
IOC	Instrument Operations Center
I&T	Integration and Test
LAT	Large Area Telescope (sixteen towers)
LEX1	Low-gain low-energy range
LEX8	Low-gain high-energy range
MC	Monte Carlo
N/A	Non applicable

PMT	Photomultiplier Tube
PSF	Point Spread Function
QU	Qualification Unit
SAS	Science Analysis Software
SLAC	Stanford Linear Accelerator Center
SPAR	Single Photon Angular Resolution
SSD	Silicon Strip Detector
SVAC	Science Verification, Analysis and Calibration Department
TBD	To be determined
TBR	To be reviewed
TEM	Tower Electronics Module
TKR	Tracker
TOT	Time-over-Threshold

3.2. Definitions

Engineering Model (EM): Non-flight hardware that will be used to qualify the design for flight hardware.

Flight Hardware: Hardware intended for flight and tested to flight acceptance levels and durations. Consists of protoflight, follow-on, and spare hardware.

Functional Test: The operation of a unit in accordance with a defined procedure to demonstrate that the performance meets specifications.

Performance Verification: Determination by test, analysis, or a combination of the two that the component or instrument satisfies the performance requirements.

PIN diode: Semiconductor structure made of layers of p and n doped material interleaved with an insulator, generally used as a photodetector, and used in the calorimeter.

Qualification: The process of demonstrating that a given design and manufacturing approach will produce hardware that will meet performance when subjected to defined conditions more severe than expected during its intended use.

Subsystem: LAT subsytems: ACD, CAL, TKR, ELX, IOC, I&T.

System: A functional unit consisting of two or more components, assemblies and/or subsystems

fC: femto Coulomb, 10^{-15} Coulombs

MeV: million electron volts, 10^{6} electron volts

μs: microsecond, 10^{-6} seconds

4. Applicable Documents

LAT-SS-00010, “LAT Performance Specification-Level II(b)”.

LAT-SS-00016, “LAT ACD Subsystem Specification-Level III”.

LAT-SS-00017, “LAT TKR Subsystem Specification-Level III”.

LAT-SS-00018, “LAT CAL Subsystem Specification-Level III”.

LAT-TD-00191,”Tracker Tower Electrical Tests”

LAT-TD-00444, “LAT Beam Test Plan”

LAT-TD-00446, “LAT SVAC Plan”

LAT-SS-00570, “LAT– I&T/SAS Interface Control Document for the Engineering Model”

LAT-TD-00578 "LAT – SVAC Database for the Engineering Model"

5. Overview

6. Hardware Configuration

6.1. Trigger

The main triggering mode used will be the TKR self-trigger. For events entering at the sides of CAL, which do not reach the TKR, the main trigger used will be the CAL-LO trigger. The hardware will allow input from external triggers (e.g. scintillating counters in coincidence) if needed (TBR).

6.2. Van der Graaf Generator

A Van der Graaf generator will be used as a source of low energy photons. This photon source is not completely monochromatic. The energy spectrum is expected to peak at 17.6 MeV with a small reflection component at about xx MeV.

6.3. Data Taking Configurations

There will be two particle sources. Cosmic rays that come from all directions and photons that will be produced in given configurations. We will collect about 10^6cosmic rays needed for calibration and Monte Carlo validation. The number of expected reconstructed low energy photons (TBR) is shown in Table 1. for several data taking configurations (TBR).

Table 1. EM Low Energy Photon Data Taking Configuration

Source	(X,Y,Z)	(θ,ϕ)	Reconstructed Events	Estimated data taking (hrs)	Comment
Photons	TBD	TBD	TBD	TBD	On axis
Photons	TBD	TBD	TBD	TBD	Off axis
Photons	TBD	TBD	TBD	TBD	On axis
Photons	TBD	TBD	TBD	TBD	On axis
Photons	TBD	TBD	TBD	TBD	On axis

7. Infrastructure

7.1. Run Catalog

To support data analysis (see section 5.1), a web accessible catalog with data and Monte Carlo runs will be defined and implemented by SAS and I&T groups. A prototype has already been implemented during the 1999/2000 beam test.

7.2. EGSE Calibration Scripts

After going through acceptance and functional tests the EM will be available for data taking. Prior to any data taking period we will perform a subset of functional tests that are directly related to calibrations. To this end, if a EGSE script is needed, it will be adapted from the functional test scripts defined by subsystems in conjunction with I&T IFCT. Most of the calibrations will be done offline using the SAS software.

7.3. Databases

This EM data will be stored in the SVAC database for trend analysis. The database definition and queries are described in LAT-TD-00574. We will also test interfaces between the SAS calibration infrastructure the and SVAC database and prototype the format for TKR and CAL reference calibration datasets to be transferred to SAS & I&T.

8. Calibrations

The set of calibrations to be performed has been outlined in the SVAC Plan (LAT-MD-00446). Table 2 shows how often calibrations will be performed and which software will be used to extract the calibration data.

Table 2. EM Calibrations

ID	Name	SAS Software	EGSE Script	How often ?	Comments
C9	TKR Single-hit MIP efficiency	●		Once	Measured for the entire tracker as function of TBD incident angles
C10	TKR Noisy Channels	●		Once	Measured for each layer during CR tests
C11	TKR Dead Channels	●	●	Once/configuration	Measured for each layer. Prior to data taking at every different configuration run an EGSE script to get reference list of channels.
C12	TKR Time-Over-Threshold Signal		●	Once/configuration	Measured for both GTRC in each layer to check linearity and saturation
C13	TKR Time-Over-Threshold Count Distribution	●		Once/particle source	Measured for each layer to check mean and widths as function of energy and particle type
C14	CAL Light Asymmetry	●		Once	Function of position in a log
C15	CAL Light Attenuation	●		Once	Function of position in a log
C16	CAL Light Yield	●		Once	Measured for each face and for the sum of faces of the log
C17	CAL Scintillation Efficiency	●		Once	Only measured prior to delivery to I&T in a heavy ion beam test
C18	CAL Pedestals	●	●	Once/configuration	Prior to data taking run an EGSE script to get reference centroid and widths for all energy ranges
C19	CAL Electronic Gain	●	●	Once/configuration	Prior to data taking run an EGSE script to get reference gains for all energy ranges
C20	CAL Integral non-linearity	●		Once	
C21	CAL Differential non-linearity	●		Once	Only measured prior to delivery to I&T
C22	CAL Noisy Channels	●		Once	
C23	CAL Dead Channels	●	●	Once/configuration	
C24	CAL LO Discriminator		●	Once/configuration	
C25	CAL HI Discriminator		●	Once/configuration	

C26	CAL Zero-Suppress Threshold		●	Once/configuration	
C27	Deadtime		●	Once/configuration	
C28	Time Accuracy		●	Once/configuration	

9. Data Analysis

9.1. Validation of Monte Carlo distributions

Monte Carlo Simulations will be tested prior to data analysis following a test suite developed by SAS. After these acceptance tests , the Monte Carlo simulations will be compared with data for different configurations. Table 3 shows the minimum set of Monte Carlo distributions to be validated with data.

Table 3. Minimum set of Monte Carlo distributions to be validated with Data

	Cosmic Rays (muons)	Low Energy Photons
TKR Strip hit multiplicity for each layer (on axis)	●	●
TKR Strip hit multiplicity for each layer (off axis)	●	●
TKR Cluster multiplicity (num strips) for each layer (on-axis)	●	●
TKR Cluster multiplicity for each layer (off-axis)	●	●
TKR ratio of double/single hits for each layer (on-axis)	●	●
TKR ratio of double/single hits for each layer (off-axis)	●	●
TKR TOT count distribution for each layer (on-axis)	●	●
TKR TOT count distribution for each layer (off-axis)	●	●
CAL Raw Energy Deposition for each layer (on-axis)	●	●
CAL Raw Energy Deposition for each layer (off-axis)	●	●
CAL Shower Longitudinal Profile (on-axis)	●	●
CAL Shower Longitudinal Profile (off-axis)	●	●
CAL Shower Transverse Profile (on-axis)	●	●
CAL Shower Transverse Profile (off-axis)	●	●
CAL MIP Energy Peak (on-axis)	●	

9.2. TKR Alignment

Since the TKR is not fully instrumented the EM will be used only to test the alignment algorithms develop to date. There is no requirement to verify the alignment precision since we are only prototyping alignment algorithms.

9.3. Measurement of the Energy Spectrum

For the EM test the only requirement is to measure the energy spectrum.The goal is to demonstrate the feasibility of the Van der Graaf generator as a possible source of low energy photons to be used for future hardware tests (CU and LAT)..

9.4. Energy Resolution for Low Energy Photons

For the EM test we do not have to verify our energy resolution requirement .This measurement is intended to prototype algorithms to do energy estimation, mostly for events that deposit a large fraction of their energy in the TKR (low energy photons).