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Environmental tests of the flight GLAST LAT tracker towers

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Abstract

The Gamma-ray Large Area Space telescope (GLAST) is a gamma-ray satellite scheduled for launch in 2008. Before the assembly of the Tracker subsystem of the Large Area Telescope (LAT) science instrument of GLAST, every component (tray) and module (tower) has been subjected to extensive ground testing required to ensure successful launch and on-orbit operation. This paper describes the sequence and results of the environmental tests performed on an engineering model and all the flight hardware of the GLAST LAT

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Tracker. Environmental tests include vibration testing, thermal cycles and thermal-vacuum cycles of every tray and tower as well as the verification of their electrical performance.

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1. Introduction

The Gamma Ray Large Area Space Telescope (GLAST) is an international space mission scheduled for launch in 2008 on a Delta-II rocket. It will explore the gamma-ray sky in an energy range between 10 keV and 300 GeV that was mainly unexplored by previously flown instruments, [1–3]. The GLAST mission was conceived to address important outstanding questions in high energy astrophysics, many of which were raised but not answered by results from EGRET on board of the Compton Gamma Ray Observatory (CGRO) that made the first complete survey of the sky in the 30 MeV to 10 GeV range [4].

GLAST consists of two scientific instruments, the Large Area Telescope (LAT) [5] and the Gamma-ray Burst Monitor (GBM) [6]. The LAT is a gamma-ray telescope covering the energy range from 20 MeV up to 300 GeV. The GBM will have a very large field of view, covering all the sky not occulted by Earth, and will provide spectral coverage of gamma-ray bursts from the lower energy limit of the LAT down to 10 keV. It includes two sets of detectors: 12 NaI scintillators, each 12.7 cm in diameter by 1.27 cm in thickness, and two cylindrical BGO scintillators, each 12.7 cm in diameter and 12.7 cm in height.

As for all space-based instruments, an environmental verification for GLAST as a whole and for all its subsystems (see for instance Ref. [7]) is required before launch to ensure successful launch and on-orbit operation. The primary purpose of this testing is risk mitigation, since these instruments typically do not operate in a benign environment and are not accessible for repair. The main ground environmental tests for space-bound articles include thermal, structural (vibration and acoustic), and electromagnetic interference proofs.

Environmental test campaigns have always been considered a mandatory phase in the construction and verification process of satellites and space-based instruments considering the inaccessibility of the hardware in the operation environment. However, environmental tests could also play a basic role in the development and testing of future ground-based high energy physics experiments, which are becoming so complex and are so inaccessible during operation that planning and performance of adequate environmental testing is needed to ensure their correct operation.

The LAT Tracker was designed to satisfy the GLAST science requirements, while fitting within the constraints of a Delta-II rocket payload fairing. The Tracker mechanical structure must support and protect the detectors during launch. It must also provide passive cooling paths for the waste heat of the electronics, survive worst-case temperature extremes, and serve as a shield from electromagnetic interference. The Tracker design is fully described in Ref. [8].

This article focuses on the procedures and results of the environmental tests on the LAT Tracker trays and towers started in 2003 and completed in October 2005. Vibration, thermal-cycles and thermal-vacuum tests were successfully performed on all the items. The activity on the flight hardware also included electrical tests necessary to verify the detectors performance before, during and after the environmental test sequence. This activity was preceded by a compelling study on pre-engineering and engineering models that were tested at qualification levels in order to validate the design and verify workmanship before building the flight modules. The results obtained on the engineering model units were of primary importance in the definition and the approval of the final design and they were also used to optimize the plans and procedures of the tests on the flight modules that are explained in the following sections.

2. Environmental test strategy

Verification tests are usually performed at different phases during the construction sequence. Lower level components or subassemblies are individually tested over the widest range as is appropriate for that level of testing. Higher assembly levels in subsystems are tested in a narrower range. At the final level, the instrument system is tested in the narrowest range, which is appropriate for system level acceptance testing. This test methodology ensures that a component or subassembly never experiences a more extreme level than what was previously tested.

Environmental tests can be classified on the basis of the hardware assembly level (starting from the component or unit level of assembly through the system level) and on the type of hardware being tested. In the latter case, two major categories of hardware can be considered:

- prototype hardware: new design hardware, subject to a design qualification test program and not intended for flight, such as engineering model or qualification hardware;
- flight hardware: hardware to be used operationally in space, including proto-flight, flight, flight-spare, re-flight.