The GLAST Gamma-Ray Telescope Mission

Robert P. Johnson

Institute for Particle Physics, University of California
Santa Cruz, CA 95065

Abstract. The Gamma-ray Large Area Space Telescope, GLAST, is an orbital mission under construction to measure the cosmic gamma-ray flux in the energy range 20 MeV to >300 GeV, with supporting measurements for gamma-ray bursts from 10 keV to 25 MeV. With its launch in 2007, GLAST will open a new and important window on a wide variety of high energy phenomena, including black holes and active galactic nuclei; gamma-ray bursts; the origin of cosmic rays and supernova remnants; and searches for hypothetical new phenomena such as supersymmetric dark-matter annihilations, Lorentz-invariance violation, and exotic relics from the Big Bang. In addition to a short review of the science opportunities, this talk will describe the high-energy gamma-ray telescope and its components and review the mission status.

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INTRODUCTION

The EGRET experiment on NASA's Compton Gamma-Ray Observatory revolutionized the field of gamma-ray astronomy [1]. It was the first instrument with sufficient effective area and background rejection to detect and observe a large number of galactic and extragalactic gamma-ray sources. Such sources are inherently interesting to astrophysicists and particle physicists studying high-energy, nonthermal astrophysical processes. Satellite instruments capable of studying emission of the highest energy gamma rays play an important role in completing the broad, multi-wavelength-band coverage that is crucial to progress in modern astrophysics.

The NASA/DOE GLAST mission includes two instruments [2]: the Large Area Telescope (LAT) [3] and the Gamma-ray Burst Monitor (GBM) [4]. The LAT is designed to improve upon the sensitivity of EGRET by a factor of 30 at 100 MeV and by even more at higher energies, including the largely unexplored 30–300 GeV band. It is being designed and built by a multinational collaboration, including scientists and engineers from France, Italy, Japan, Sweden, and the United States.

The high sensitivity of the LAT stems from several improvements over EGRET. The effective area is increased by more than a factor of 5, the field of view is more than 4 times greater, and the angular resolution is 3 times better for photon energies above 1 GeV. In addition, the energy range is extended at the high end into the unexplored region between 10 GeV and a few hundred GeV, and the detector dead time is reduced by a factor of 4000 to ensure that no photons are missed during intense gamma-ray bursts. Finally, the detector system has no expendable resources, to ensure a long mission lifetime without degradation of its science capabilities.

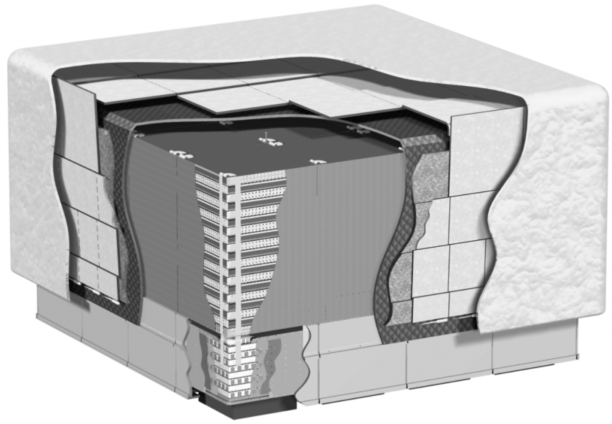

FIGURE 1. Cutaway view of the GLAST instrument, composed of a 4×4 array of tower modules surrounded by a veto shield and thermal blanket.

GLAST SCIENCE CAPABILITIES

The planned scientific program of GLAST follows closely along the lines of those subjects already studied by EGRET. However, the large increase in sensitivity of GLAST with respect to EGRET raises the distinct possibility of discoveries of new phenomena and new types of gamma-ray sources.

The third EGRET catalog of point sources contains 271 point-like sources, of which 172 are as yet unidentified [5]. Those that are identified with known objects fall into only a few classes, most notably active galactic nuclei (AGN) at high galactic latitudes and pulsars within the plane of the galaxy. During its first years of operation, GLAST is expected to produce a catalog of around 10,000 sources, including several thousand AGN, while operating primarily in a zenith-pointed, scanning mode to take full advantage of its wide field of view. In addition, rapid alerts will be produced for transients such as gamma-ray bursts and AGN flares with latencies as small as 12 seconds.

THE LAT DETECTOR

Like EGRET, the LAT is a pair-conversion telescope. Figure 1 shows a cutaway view of the LAT, which is composed of a 4×4 array of tower modules surrounded by a scintillator veto shield. Each tower module contains a tracker-converter, based on silicon-strip detectors and tungsten converter foils, followed by a cesium-iodide calorimeter. All 3 detector systems are finely segmented to optimize angular resolution, background rejection, energy reconstruction, and in the case of the veto system to minimize self-veto of high-energy photons due to calorimeter back-splash. The entire LAT, including data acquisition electronics and computers, cannot weigh more than 3 metric tons and cannot consume more that 650 W of electrical power.

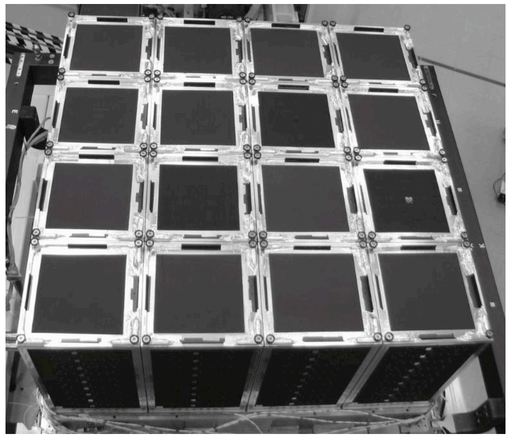

FIGURE 2. The 16 tower modules integrated into the LAT instrument structure.

The tracker-converter system detects the initial gamma-ray conversion, provides the principle trigger for the data acquisition, measures the incident photon direction, and provides detailed event information for background discrimination. Each of its modules includes 36 layers of silicon-strip detectors and 16 planes of tungsten foils, all supported on a high-precision carbon-composite structure. The 16 modules have a total of 884,736 readout channels, operating on only 160 W of conditioned power. Averaged across the aperture, each silicon-strip layer is 89.4% active, with >99.5% efficiency in the active area. This high efficiency and low power consumption is achieved while maintaining a noise occupancy of less than 1 in a million channels per trigger.

All 3 detector systems are complete and integrated into the instrument. Figure 2 shows the tracker-converter modules (with calorimeter modules hidden below) before installation of the veto shield. Environmental testing will be completed by mid 2006, followed by integration with the spacecraft bus, which is being fabricated by Spectrum Astro of General Dynamics. The launch is scheduled for August 2007, followed by an operational period of at least five years.

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