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THE GLAST TRACKER TEST AND DEVELOPMENT

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Abstract

The GLAST (Gamma-ray Large Area Space Telescope) observatory is an astroparticle mission that will study gamma-rays emissions from a wide range of cosmological sources in the energy band extending from 20 MeV to more than 300 GeV. The silicon tracker is the heart of the photon detection system: we show here the assembly steps and performance test of its components.

1 The Gamma-ray Large Area Space Telescope (GLAST)

GLAST (Gamma-ray Large Area Telescope) [1] is a next generation high energy gamma ray observatory designed for making observations of celestial gamma ray sources in the energy band extending from 20 MeV to more than 300 GeV. In figure 1 is reported the energy range-timeline placement of the experiment. It follows in the footsteps of the CGRO-EGRET experiment, which was operational between 1991 and 1999.

The scientific goals of the experiment are:

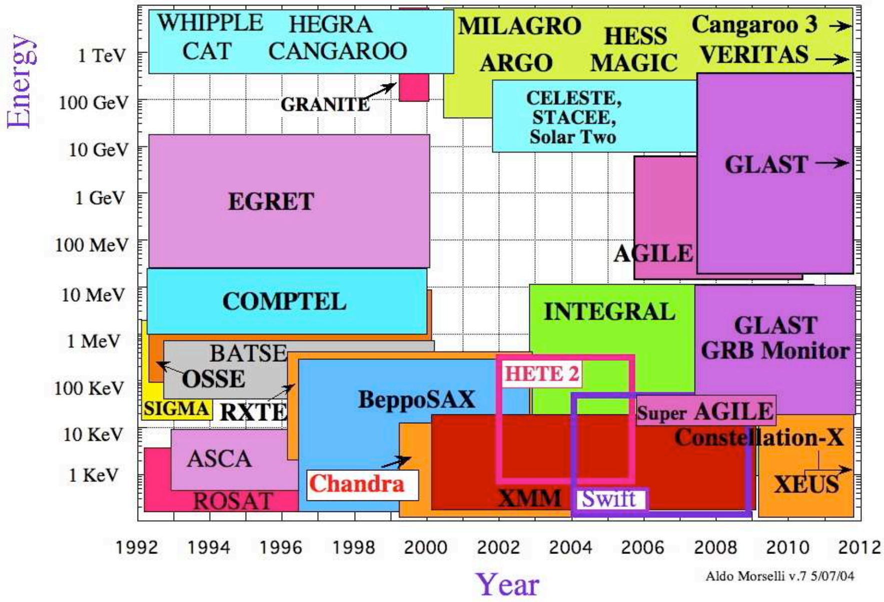

Figure 1: Timeline schedule versus the energy range covered by present and future detectors in X and gamma-ray astrophysics

1. To understand the mechanisms of particle acceleration in AGNs, pulsars, and SNRs.
2. Resolve the gamma-ray sky: unidentified sources and diffuse emission.
3. Determine the high-energy behavior of gamma-ray bursts and transients.
4. Probe dark matter and early Universe.
5. Probe quantum gravity effects.

2 The Large Area Telescope (LAT) structure

The Large Area Telescope (LAT), the main instrument onboard GLAST, is a pair-conversion telescope that will measure direction and energy of photons over a broad energy range. It is structured as an array of 4x4 identical towers each equipped with: Si-strip Tracker Detectors and converters arranged in 18 XY tracking planes for the measurement of the photon direction; a segmented array

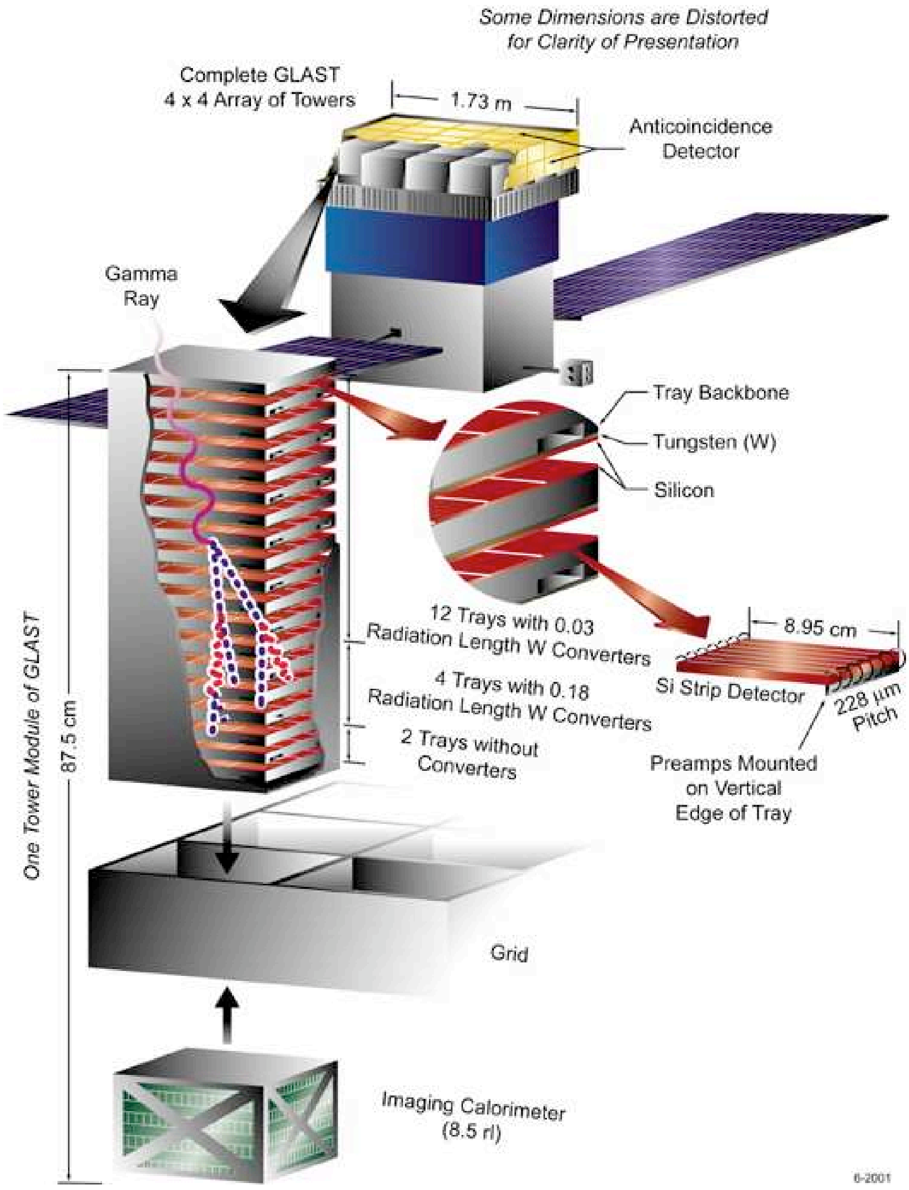

Figure 2: The LAT structure

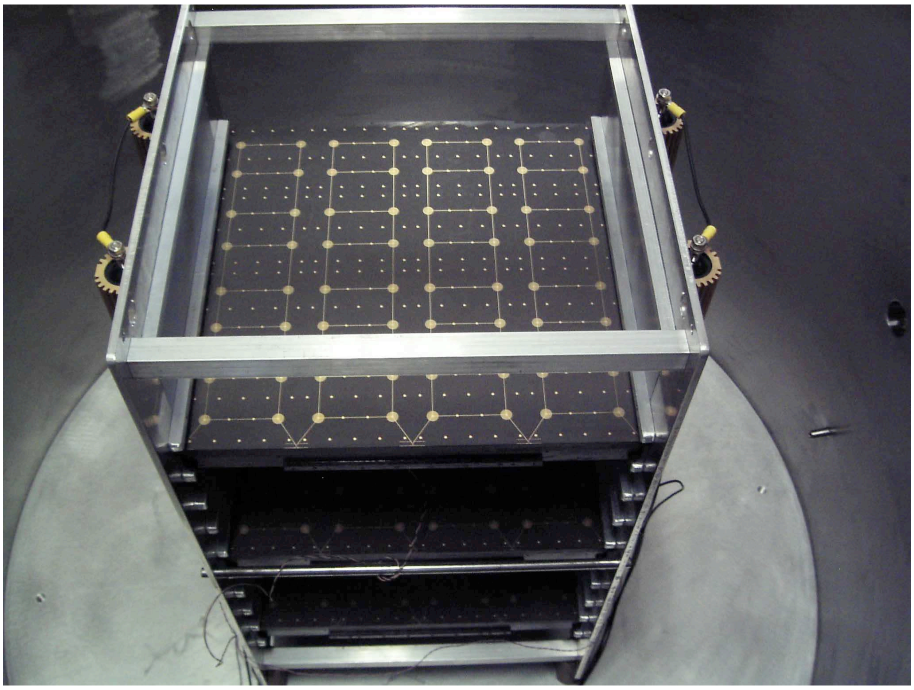

Figure 3: Thermo-Vacuum test: the LAT ladders are mounted on the heating rack inside the vacuum chamber

of CsI(TI) crystals for the measurement of the photon energy (Calorimeter); a segmented Anticoincidence Detector (ACD) (figure 2).

The main characteristic are an energy range between 20 MeV and 300 GeV, a field of view of 3 sr, an energy resolution of 5% at 1 GeV, a point source sensitivity of $2x10^{-9}(phcm^{-2}s^{-1})$ at 0.1 GeV, an event dead-time of $20\mu s$ and a peak effective area of 10000 cm^2, for a required power of 600W and a payload weight of 3000 Kg.

3 Trays Thermo-Vacuum Test

The LAT trays are the panels that will support detectors, converters and electronics, composed of a carbon fiber structure surrounding an aluminium honeycomb core, with kapton bias circuits glued on their top and bottom faces. The main scope of the thermo-vacuum procedure is to check, on the LAT trays, the bias circuit adhesion to individuate eventual delamination under vacuum, due to air trapping, before electronics and detectors are mounted on them,

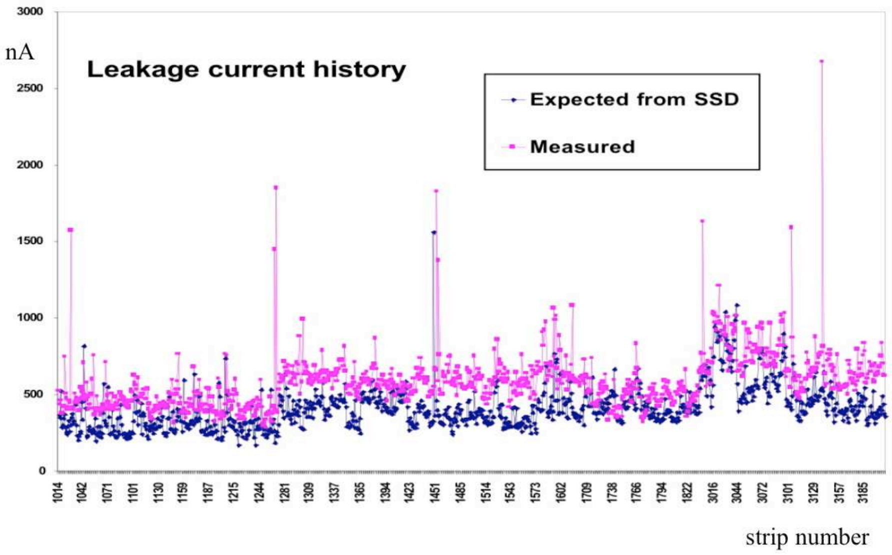

Figure 4: History of the expected and measured leakage currents of LAT Ladders. The values above 1000nA indicates a bad connection of the wafers within the ladder

with a cycle at 65(±5)°C for 24 hours and at pressure < 0.01 bar for at least 1 hour. This will also permit removal of any surface impurities, if any, on the kapton bias circuits. To heat the trays, they are mounted in a metallic grid warmed by twelve 220 Ω resistors in which flows a 0.5 A current (see figure 3). The temperature is monitored in real time with eight sensors on the grid and ten or more floating on the trays. An automatic system for recording and control switches on or off the heating resistors depending on the grid detected temperature.

4 Silicon Ladders assembly and test

The silicon strip detectors on the LAT trays surfaces are composed by four parallel ladders: each one is the result of four consecutive six inches wafers, whose 380 microstrips are serially connected, with a delicate procedure of gluing, bonding and protective encapsulation ("Dam and Fill"). The connections and the characteristic of the device are then checked. A Karl Suss Probe Station PA 200 is used to perform measurements of:

1. The C-V characteristic for each microstrip and each ladder.

2. The I-V characteristic for each ladder.

4.1 Efficiency test with cosmic Rays

The trays are assembled in triple coincidence blocks and then they are mounted in one rack between three planes of two plastic scintillator detectors. Using cosmic rays as sources of particles it is possible to determine the efficiency of the Silicon Strip Detectors

4.2 Global results

Al the tests on the Silicon Strip Detectors showed a good agreement with the required parameters. The small differences between the expected values and measured ones indicates the good quality of the assembly procedure. We found:

1. An average depletion voltage of 63.553 V;
2. An average bulk capacitance at 150 V of 7505.5 pf;
3. An average leakage current at 150 V of 584.33 nA (see fig. 4);
4. a 10^{-5} bad strips fraction of the whole tested ones.

References

[1] Proposal for the Gamma-ray Large Area Space Telescope, SLAC-R-522 (1998).

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see also http://www-glast.stanford.edu/