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The GAMMA-RAY LARGE AREA SPACE TELESCOPE (GLAST)

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The Gamma-ray Large Area Space Telescope (GLAST) is a proposed next-generation high-energy gamma-ray telescope for studying emission from astrophysical sources in the 10 MeV to 300 GeV energy range. GLAST will use a large area, wide field of view, imaging telescope and will have a maximum effective area of $\sim$ 8000 cm^2 above 300 MeV, a field of view of 2.6 sr, and a single photon angular resolution (rms projected) of 0.3^0 at 1 GeV, approaching 0.03^0 above 20 GeV. The primary scientific targets include active galactic nuclei, gamma-ray bursts, neutron stars and diffuse galactic and extragalactic high-energy radiation. Moreover GLAST will explore the unexplored energy band above EGRET's reach, filling in the present gap in the photon spectrum (O(10)-300 GeV) and opening a new window on the dark matter and supersymmetry problems searching for a narrow "line" in the gamma ray spectrum at the mass of the neutralino. A more extensive description of the instrument, the physics performance, the people and istitution involved in the collaboration is avaliable at http://www-glast.stanford.edu.

1 Introduction

A picture of the instrument is shown in fig.1. Like previous high-energy telescopes, GLAST relies on the unambiguous identification of incident gamma-rays by detection of the electron and positron that result from pair creation in a thin converter material. Measurement of the energy and direction of the $e^+ - e^-$ shower provides information about the energy and direction of the incident gamma-ray. In contrast to earlier orbiting telescopes, the GLAST design utilizes modern solid-state particle detector technology and recently developed advanced space-qualified computers. In particular, GLAST uses position-sensitive silicon strip detectors, interleaved between thin converters of high-Z converter material, to track particles. The tracker is backed

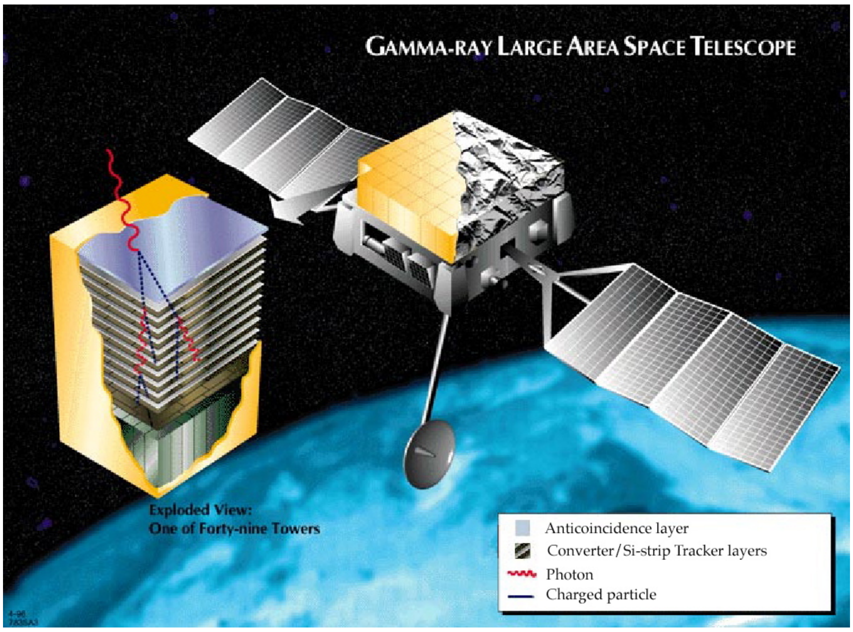

Figure 1: the GLAST apparatus

by an electromagnetic calorimeter of ten radiation lenght and is covered by a segmented charged particle anticoincidence shield.

The GLAST detector is modular, as can be seen from fig.2. The modular design has the advantages associated with a large degree of redundancy.

There are several aspects of the GLAST design that are significant departures from previous orbiting high-energy gamma-ray telescopes operating in the pair conversion regime. These include:

• the use of silicon strip detectors (operating at relatively low voltages) rather than spark chambers to measure the direction of the converted electron and positron. The silicon strip detectors have > 10 times better position resolution than spark chambers, essentially no deadtime compared to a spark chamber, and there will be no consumables (i.e., chamber gas) to limit the telescope's lifetime. The absence of chamber gas and a replenishment system also gives improved safety and reliability. In figure 3.b it is shown a comparison between GLAST and EGRET single photon angular resolutions.

• the use of a segmented charged particle anticoincidence shield. EGRET uses a monolithic anticoincidence dome. A segmented shield nearly eliminates the degradation in the effective area as the energy of the gamma rays increase because self vetos caused by shower back-splash from the calorimeter are unlikely to fall sufficiently close to the gamma-ray trajectory;

• elimination of the time-of-flight system. This has two advantages: i) the aspect ratio of the instrument is greatly improved, making possible a very large field of view, and ii) the elimination of material between the tracking section and the calorimeter extends the response to lower energies because the initial e^+e^- pair is less likely to range out or scatter out the sides of the tracker.

• the baseline calorimeter is a CsI calorimeter. In figure 3.a a comparison between GLAST and EGRET energy resolutions is presented. A possible option based on a lead/scintillating fiber sandwich is under study. It allows not only a good energy resolution but also an indipendent measurement of the gamma arrival direction, with high efficiency and a powerfull discrimination between hadronic and electromagnetic shower.

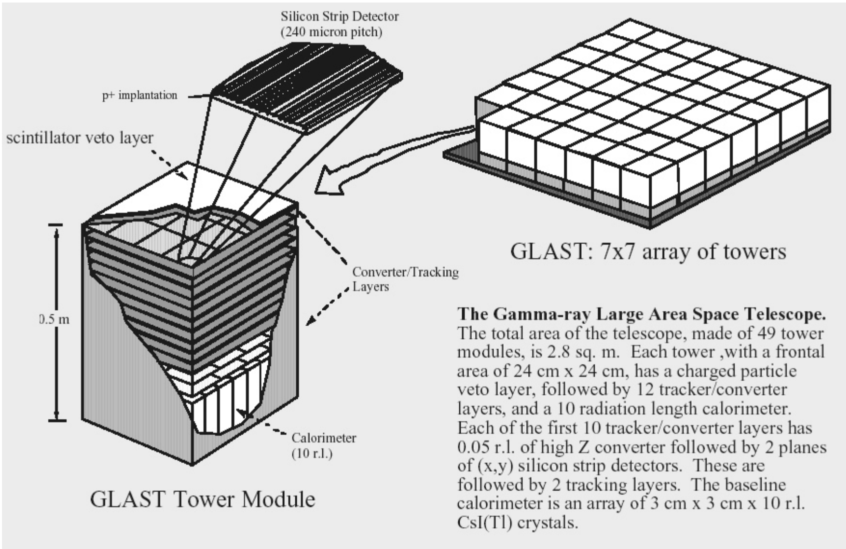

Figure 2: The modularity of Glast

2 GLAST Scientific objectives

High-energy gamma rays are excellent probes of the most energetic phenomena in nature, that typically involve dynamical non-thermal processes and include interactions of high energy electrons with matter, photons and magnetic fields; high energy nuclear interactions; matter-antimatter annihilation and possibly other fundamental particle interactions. Here there is a non-exaustive list of scientific objectives:

• *Active Galactic Nuclei*

The nuclear activity in AGNs is widely believed to be ultimately powered by accretion onto a massive black hole (for reviews, see[1]). While there appears to be little doubt that relativistic jets are involved, the mechanisms responsible for collimating and accelerating the jets are still speculative. GLAST can study in detail the origin of AGN jets. From the Whipple[2] and EGRET data[3] there is the evidence of a weakening of extragalactic radiation in the range above 100 GeV, probably due to interactions of high energy gamma rays with the intergalactic infrared radiation[4]. The future detection of sharp drops in AGN's spectra can be used as an indirect measurement of the intensity of the intergalactic infrared radiation; this component is hard to measure due to the contamination of the galactic emission but is is important because it is correlated with the ratio of hot dark matter and cold dark matter in the early universe. On the other hand, if the next generation infrared experiments will measure the extragalactic infrared background, the observation of an absorption in the spectra can give independent information on the distance of the source.

• *Galactic diffuse emission*

The diffuse gamma emission from the Galaxy is strongly correlated with the matter distribution in the Milky Way, because of its origin from the interaction between cosmic rays and interstellar gas. A detailed spectrum - also in the high energy range - and a fine-grained sky map of this emission will clarify the existing ideas about the galactic matter distribution.

• *Extragalactic diffuse emission*

GLAST large exposition at high latitudes allows to collect a high statistics in the study of extragalactic diffuse gamma ray emission. Accurate investigations with a good spatial resolution are required for a separation of this radiation from the stronger galactic emission; these studies will help to solve the problem of the extragalactic component origin.

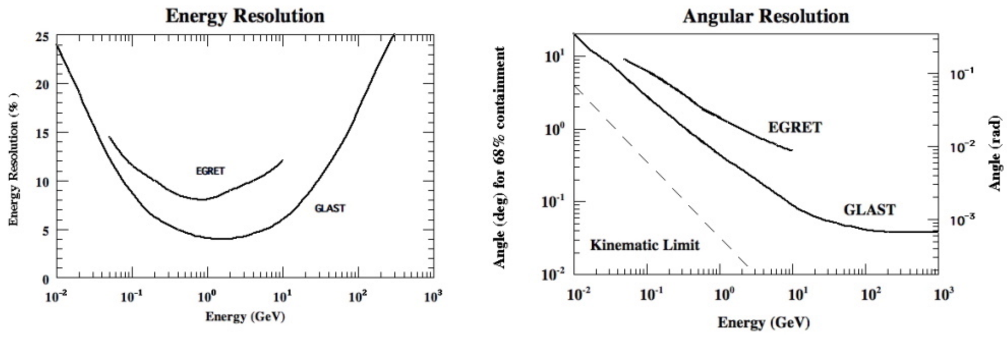

Figure 3: Comparison between GLAST and EGRET energy and angular resolutions.

• *Search for Dark Matter and new particles*

A large amount of study has been devoted to the search of Weakly Interacting Massive Particles (WIMP), due to their great importance from the cosmological point of view, since these particles are possible candidates of Dark Matter. Spectral features like gamma ray lines in the energy range above 10 GeV may be considered as the manifestation of their annihilation processes [5].

• *Gamma ray bursts*

They are now the most interesting and mysterious objects in the sky. The theoretical models trying to understand them can be divided in two big classes: cosmological and galactic. The major difficulty for galactic models is the explanation of the complete isotropy of the bursts distribution, while for the cosmological ones is the very high value of energy that must be released at the source ($\sim 10^{51}$ ergs). All the experimental data collected up to now do not give the possibility to discriminate among these options. Detection of the burst spectra extension and the spectra shape can be the way to establish the distance scale, through the intergalactic and at the source absorption mechanism.

•*Galactic gamma-ray sources*

It is well established that radio pulsars are rotating neutron stars with strong magnetic fields. Current models of gamma-ray emission from pulsars fall into two general categories. Outer gap models and Polar cap model. With larger area and extended energy response, GLAST can extend the measurement of pulsed energy spectra in known sources upward, well into the region where the models predict "cutoffs" in the spectrum. The measurement of an energy cutoff and its dependence on pulse phase is an important constraint on any model.

• *Solar gamma flares*

In 1991 two flares from the Sun (E $\simeq$ hundred of MeV) were detected in the Gamma-1 experiment; some solar flares in the same range were detected by EGRET. These unexpected events emphasize the importance of an active monitoring of the Sun as a scientific objective of GLAST experiment.

References

1. Rees, M.J. 1984, Ann. Rev. Astron. Astrophys., 22, 471
2. M. Punch et al. , *Nature*, **358**, 477, (1992).
3. C.E. Fichtel et al., *Ap.J.S.*, **94**, 551, (1994).
4. F.W. Steker, O. C. De Jager & M. H. Salamon, *Ap.J*, **L49**, 390, (1992).
   D.MacMinn and J.Primack, SCIPP 94/23, May 1995
5. A. Morselli, *The dark side of the Universe*, Ed.: R.Bernabei & C.Tao, World Sci., (1984).