The Gamma Ray Large Area Telescope (GLAST)

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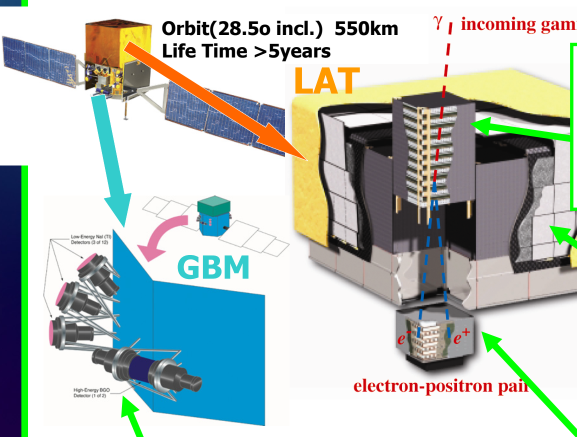
Abstract

The Gamma Ray Large Area Telescope(GLAST) is a next generation high-energy gamma-ray observatory. It will measure from 20 MeV to 300 GeV with much improved sensitivity, with supporting measurements for gamma-ray bursts from 10 keV to 25 MeV. The launch is scheduled for August of 2007. GLAST will open a new and important window on a wide variety of high energy phenomena, including active galactic nuclei; gamma-ray bursts; the origin of cosmic rays and supernova remnants; pulsars; 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 description of the instrument and the science opportunities, the poster includes the study of the background produced by charged particles. It is essential to know the property of the background especially for measurements of diffuse/faint sources, because the background level is comparable to the diffuse emission so that we cannot neglect it. For studying the background, we used the simulation data including the full detector simulation and the orbit dependent effects. Considering our analysis results, we proposed to study the background in the beam test with LAT Calibration Unit on August of 2006.

The Gamma-ray Large Area Space Telescope (GLAST)

GLAST is an international and multi-agency space mission that will study the cosmos in the energy range 10 keV–300 GeV. The Energetic Gamma Ray Experiment Telescope (EGRET) instrument on the Compton Gamma Ray Observatory (CGRO) made the first complete survey of the sky in the 30 MeV–10 GeV range. EGRET showed the high-energy gamma-ray sky to be surprisingly dynamic and diverse, with sources ranging from the sun and moon to massive black holes at large redshifts. In light of the discoveries with EGRET, the great potential of the next generation gamma-ray telescope can be appreciated. GLAST will have an imaging gamma-ray telescope vastly more capable than instruments flown previously, as well as a secondary instrument to augment the study of gamma-ray bursts. The main instrument, the Large Area Telescope (LAT) will have superior area, angular resolution, field of view, and deadtime that together will provide a factor of 30 or more advance in sensitivity, as well as provide capability for study of transient phenomena (Table 1). The GLAST Burst Monitor (GBM) will have a field of view several times larger than the LAT and will provide spectral coverage of gamma-ray bursts that extends from the lower limit of the LAT down to 10 keV. With the LAT and GBM, GLAST will be a flexible observatory for investigating the great range of astrophysical phenomena best studied in high-energy gamma rays. NASA plans to launch GLAST in August of 2007.



Precision Tracker (TKR): Single-sided silicon-strip particle detectors and converters arranged in 18 x,y tracking planes, providing precision determination of photon direction; gamma ID.

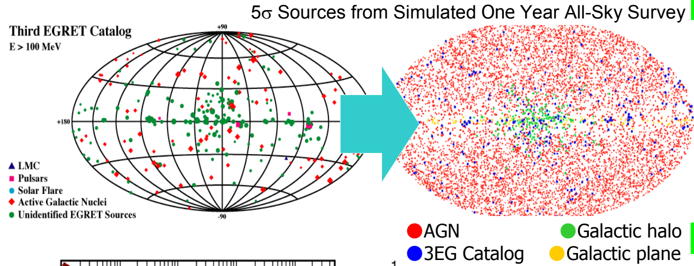
Anticoincidence Detector (ACD): Array of plastic scintillator tiles covering TKR, read out by waveshifting fibers and PMTs. Reject background of charged cosmic rays. Segmentation removes self-veto effects at high energy.

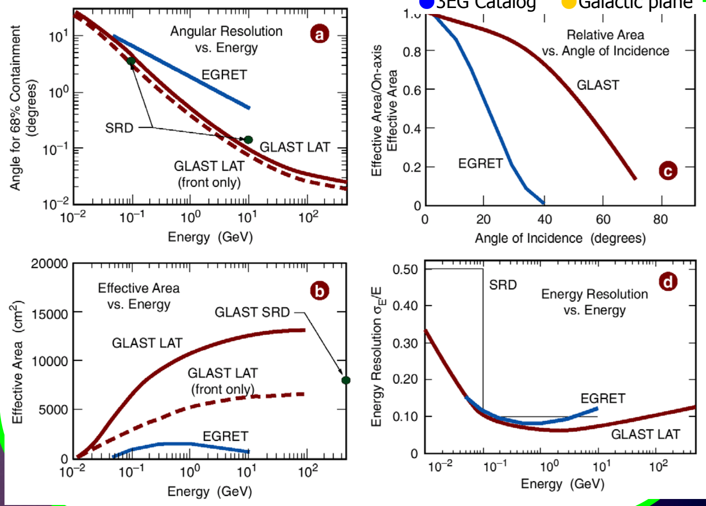
Calorimeter (CAL): Finely segmented array of CsI(Tl) crystals, read out by PIN diodes for energy measurement and precise shower localization.

GLAST Burst Monitor(GBM): The GBM will include two sets of detectors: twelve sodium iodide (NaI) scintillators, each 12.7 cm in diameter by 1.27 cm thick (10keV-1MeV), and two cylindrical bismuth germanate (BGO) scintillators (150keV-30MeV). Locating the origin of the burst by comparing the count rates of different NaIs.

GLAST LAT Specifications and Performance Compared with EGRET

	EGRET	GLAST
Energy Range	20MeV--30GeV	20MeV--300GeV
Peak Effective Area	1,500cm2	>8,000cm2
Field of View	0.5sr	>2sr (20% of 4π)
Angular Resolution	5.8º(100MeV)	<3.5º(100MeV) <0.15(>10GeV)
Energy Resolution	10%	<10%
Deadtime per Event	100ms	<100μs
Source Location Determination	15'	<0.5'
Point Source Sensitivity	~1×10^{-7}cm^{-2}s^{-1}	~1×10^{-7}cm^{-2}s^{-1}(1day) ~2×10^{-9}cm^{-2}s^{-1}(2years)



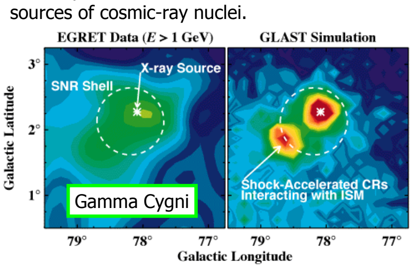


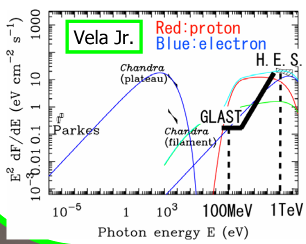
Science

GLAST will have a major impact on many topics, including: Particle acceleration in the Universe (Supernova remnants, pulsars, AGNs(Active Galactic Nuclei), GRBs); Origin of Gamma-ray bursts (GRBs); Probing the era of galaxy formation, optical-UV background light; Solar physics; Solving the mystery of the high-energy unidentified sources; Particle Physics(Dark Matter, Other relics from the Big Bang,Testing Lorentz invariance); New source classes. Important overlap and complementarity with the next-generation ground-based gamma-ray observatories. Some of the topics are described here.

Supernova remnants

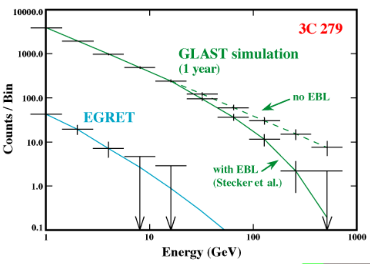
GLAST will spatially resolve some supernova remnants and precisely measure their spectra, and may determine whether remnants are sources of cosmic-ray nuclei.





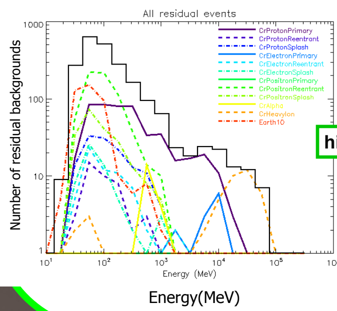
Extragalactic Background Light

The sensitivity of GLAST at high energies will also permit study of the extragalactic background light by measurement of the attenuation of AGN spectra at high energies. This attenuation is from pair production with photons in the background light primarily produced by young stars at visible to ultraviolet wavelengths. Owing to the large size of the AGN catalog that GLAST will amass, intrinsic spectra of AGNs will be distinguishable from the effects of attenuation. The measured attenuation as a function of AGN redshift will relate directly to the star formation history of the Universe.



Background study

In order to obtain the spectra from diffuse or faint sources, we have to understand the diffuse emission and the background produced by the cosmic particles because they are not negligible compared with gamma-ray signals. The background effect is significant especially in energies < ~100MeV, where the large number of photons are expected. Therefore we studied the background. We analyzed the full simulation data (Data Challenge II). S. Digel has already obtained residual background as shown in the left figure. You can see dominant components. We investigated the properties of such components, i.e., particle trajectory, reconstructed energy, etc. The right figure shows an example of particle trajectory of positrons. Considering these results, we proposed to study the background in the beam test with LAT Calibration Unit on August of 2006.



Intersect position of particle trajectory and LAT (imaginary box which encloses LAT).