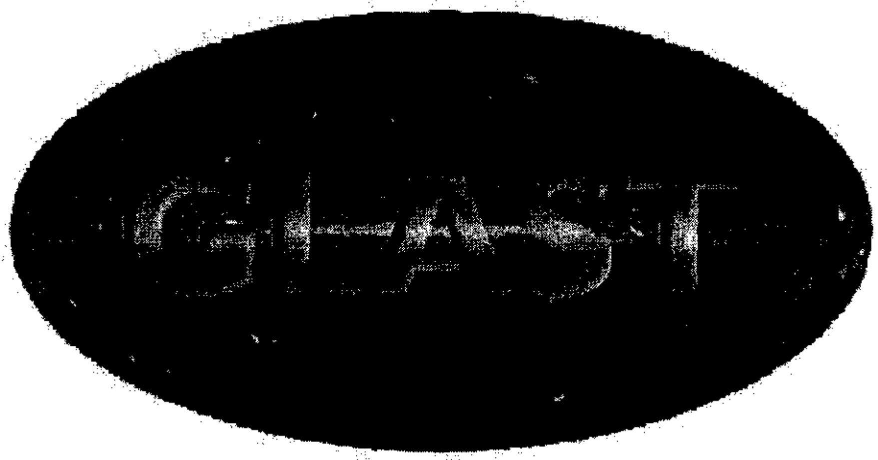

A Partnership in Astrophysics and Particle Physics

Elliott D. Bloom

SLAC

Presentation to HEPAP
August 24-25, 1998

GLAST Collaboration, August 1998

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GLAST Collaboration, July 1998

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Progress with Agencies, DOE and NASA

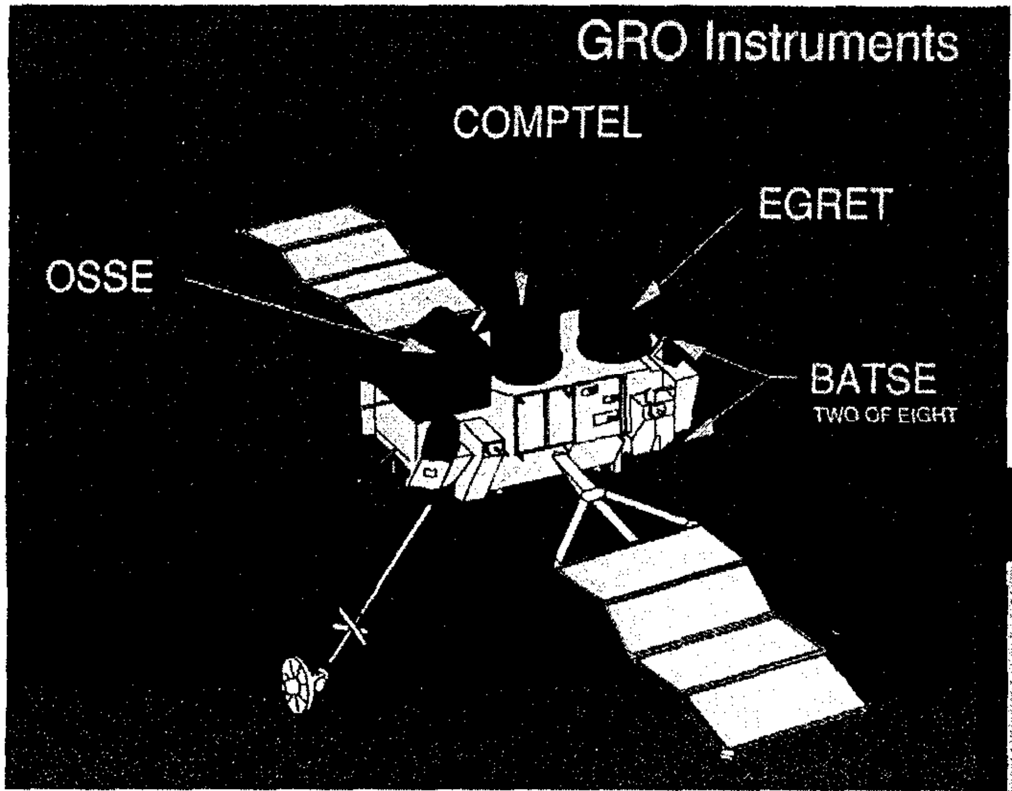
- *The collaboration has now formally presented the GLAST experiment to both DOE (SAGENAP)and NASA. It is in the NASA strategic plan for a new mission start in 2002, and a launch in 2005.*

- *SLAC sees GLAST as a first class science program and broad new US and international user community, that includes HEP.*

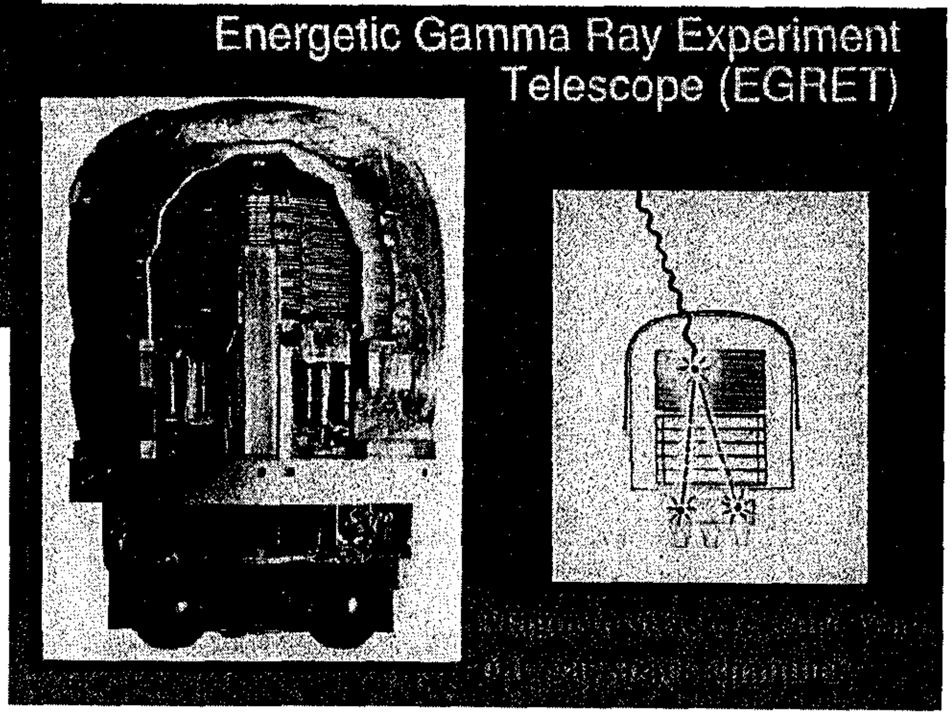
- *The international communities are interested in the experiment, and their agencies seem ready to commit resources. The collaboration is about half HEP in the US, Italy and France.*

- *SLAC's proposal is that the DOE should support the GLAST experiment...and support it in the "scientist designed/built" tradition of HEP. GLAST is part of SLAC's strategic plan and promises a broader science program for the future.*

First Came EGRET



>50 Active Galactic Nuclei in > 100 MeV γs



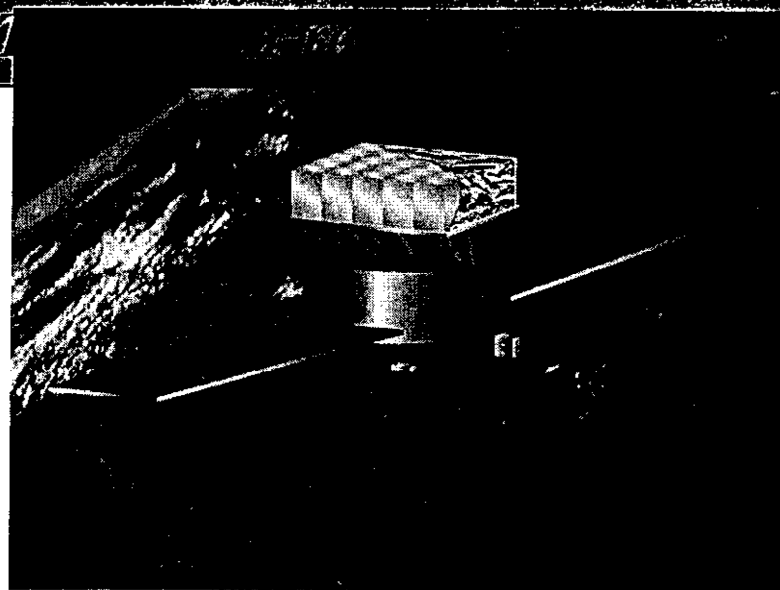
Launched in April 1991

Raised many interesting issues and questions which can be addressed by a NASA mid-class mission (Delta II).

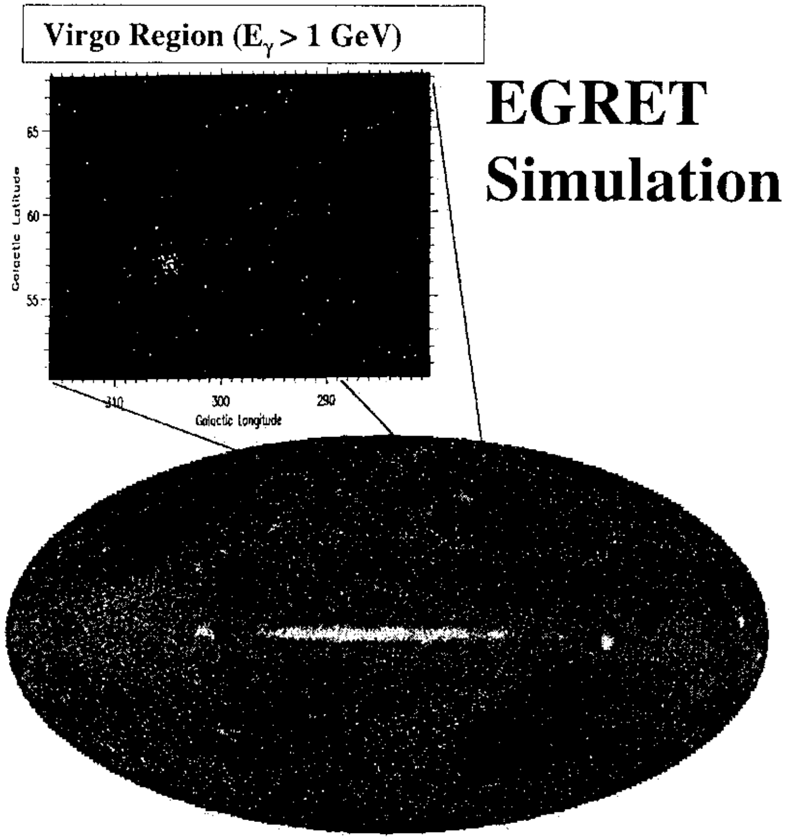
Overview of Physics motivation for GLAST

- *GLAST detects thousands of Active Galactic Nuclei (AGN)*
- *Triggers on transients over ~2π of the sky while in scanning mode*
- *Measures source spectra in the "gap" region of 20 - 300 GeV (including diffuse γ-ray background)*
- *Probes the origin of cosmic rays*
- *Tests models of high-energy particle acceleration by neutron stars*
- *Searches for particle dark matter*
- *Searches for particle relics of the Big Bang*
- *Observes γ-ray bursts in a new high energy regime*

GLAST ... ace Telescope

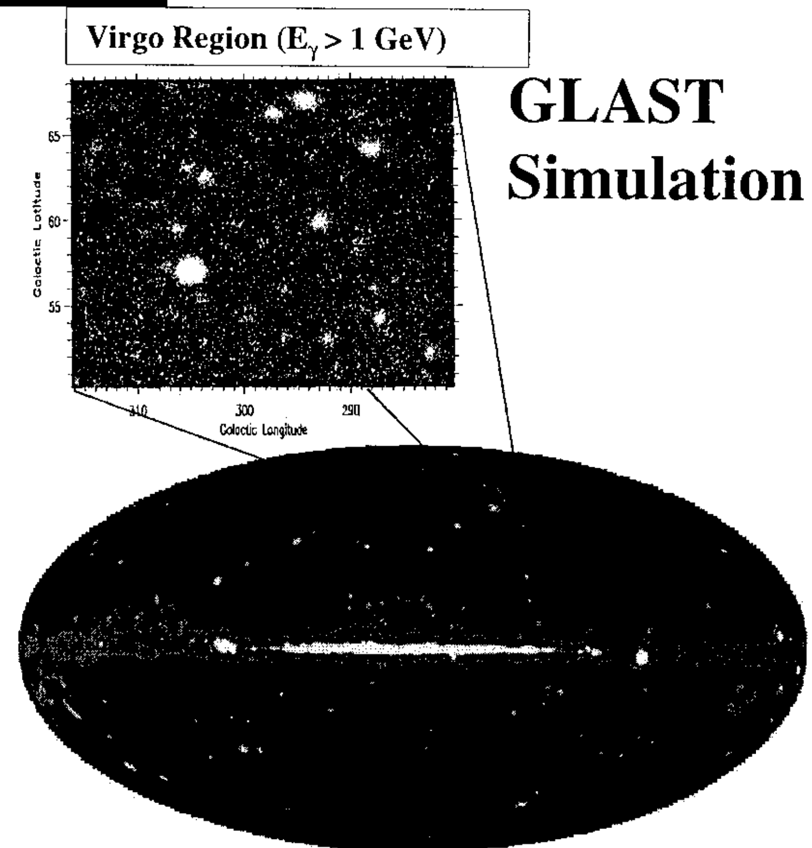


EGRET Simulation



EGRET 1 Year All-Sky Survey ($E_\gamma > 100$ MeV)

GLAST Simulation



GLAST 1 Year All-Sky Survey ($E_\gamma > 100$ MeV)

Possible Measurement of Effects of Quantum Gravity

See: G. Amelino-Camelia, John Ellis et al., astro-ph/9712103 1998
Using GLAST, Search for possible *in vacuo* velocity dispersion,

$$\mathrm{d}v \sim E/E_{QG},\ E_{QG} \sim 10^{19}\ GeV,$$

of gamma rays from gamma ray bursts at cosmological distances.
Current best guess is $dN_\gamma/dE_\gamma \sim 1/E_\gamma^2$ for many GRB (EGRET).

For certain string formulations of an expanding Robertson-Walker-Friedman cosmology, photon propagation appears increasingly tachyonic as energy increases,

$$v_\gamma = c(1 + E_\gamma/E_{QG} + O[(E_\gamma/E_{QG})^2])$$

For GRB @ 1 Gly, and $E_\gamma = 10$ GeV should observe time advance relative, to 100 MeV γ of about 30 ms. At 100 GeV, $\Delta t \sim 0.3$ sec time advance relative to 100 MeV. Should be straight forward to detect with GLAST.

Conclusions

- *GLAST offers a major leap forward, ~ two orders of magnitude in sensitivity. The GLAST program portends a golden era of discovery in this field, with rich and diverse physics opportunities, and has a strong synergy with the ground based programs.*
- *The Baseline GLAST Instrument meets or exceeds the GLAST NASA Mission Requirements, and there are no show stoppers.*
- *The GLAST baseline design has been well supported by a vigorous R& D program which has shown dramatic progress over the past two years.*
- *GLAST has been a collaboration of HEP and Astrophysics scientists from its inception in early 1992. Participation of DOE, NASA , NSF and foreign funded collaborators has been essential to the success of the GLAST Instrument R&D program.*
- *Forging partnerships with other disciplines expands opportunities for doing high-energy physics and maximizes the possibility of discoveries. The diversity and potential for new directions that GLAST provides are important for the long-term health and vitality of high-energy physics.*

Extra Overheads For Bloom Presentation

Cosmic γ-rays Offer a Wealth of Fundamental Information

- *γ-rays travel along straight lines (geodesics) and so point to their sources.*

- *Small cross section allows γ-rays to escape from deep inside nature's largest accelerators thus probing the workings of the central engine.*

- *Similarly, the mean free path for γ-rays in the universe is huge. Astronomical sources with redshifts as large as 3 or more should be visible to GLAST for $E_\gamma \leq 20$ GeV or so.*

- *To the extent that the universe is not transparent to γ-rays, which is energy dependent, the spectral dependence of distant sources for $E_\gamma > 20$ GeV or so yields information of the early universe.*

- *Importantly, γ-rays are easily detected due to their E-M interaction.*

What are the GLAST HEP goals? *(sharply stated)*

1) **PRECEDENTS:** GLAST addresses the same physics topics as other SAGENAP-approved experiments (Whipple, STACEE, MILAGRO)

- Active galactic nuclei (accreting super-massive black holes, origin of high energy particle jets)
- Probing the epoch of galaxy formation (EBL over cosmological distances)
- Origin of cosmic ray production and acceleration
- Supernova remnants (pulsars, nebulae)

Unique capabilities of GLAST => major contributions to all these topics standalone, and enhances measurements by other experiments.

What are the GLAST HEP goals? (sharply stated) (continued)

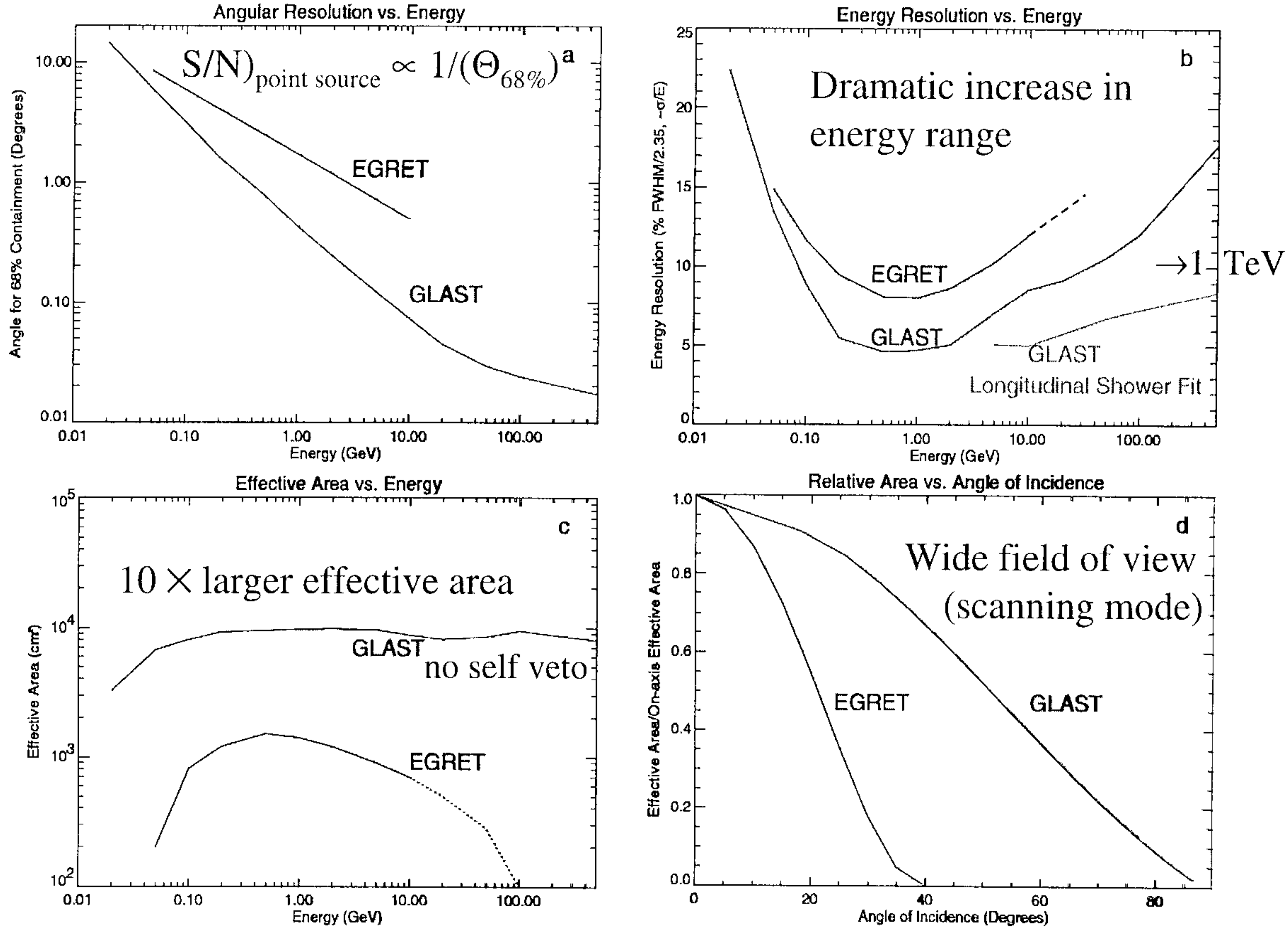
2) **EXPERTISE AND INTEREST:** Our (HEP) expertise and training is necessary to do this science; and we find this science highly compelling. It will be done best by a partnership of High Energy Particle Physicists and High Energy Astrophysicists. The particle physics, astrophysics, and experimental techniques of GLAST are tightly braided together. The sources involve the interplay of all the forces of Nature -- what is their impact on the evolution of the Universe?

3) **Discovery potential of GLAST is pure HEP!:**

- gamma-ray lines from SUSY LSP dark matter annihilations
- primordial black holes
- relics: cosmic strings (prediction of gauge theories not testable at accelerators), decayed massive particles in the early universe (distortions in the diffuse spectrum).
- Something new!

… **PLUS:** exploring the origin of the extra-galactic diffuse flux, definitive and unique information about the tantalizing high energy behavior of gamma-ray bursts, …

GLAST and EGRET Performance Comparison



A comparison of GLAST Monte Carlo performance (red) and EGRET performance (blue). GLAST represents about two orders of magnitude improvement in sensitivity

GLAST Baseline Capabilities

Parameter	GLAST Baseline Design
Energy Range	< 0.02 - 300 GeV → 1 TeV
Single Photon Angular Resolution	
• on-axis space angle for 68% containment	3.1° @ 100 MeV, 0.41° @ 1 GeV, < 0.1°, E > 10 GeV
• off-axis at 50% of on-axis effective area; space angle for 68% containment	= 1.4 x $(\theta_{68\%})_{on\text{-}axis}$
• space angle for 95% containment	2.3 x $\theta_{68\%}$, (at all energies)
Point Source Sensitivity (1 yr; high lat; E>100 MeV; 5σ	3.5 x 10^{-9} ph cm^{-2} s^{-1}
Point Source Location	30 arcsec - 5 arcmin
Energy Resolution	< 25%, (10 MeV - 300 GeV); < 10%, (100 MeV - 10 GeV)
Field of View (FWHM)	2.6 sr
Effective Area (including inefficiencies due to background rejection.)	8000 cm^2, (above 1 GeV); 4000 cm^2, @ 50 MeV; >800 cm^2, @ 20 MeV
Dead Time	sustain total trigger rate (cosmic rays + gamma-rays) up to 20 kHz with less than 10% deadtime
Background Rejection	cosmic ray rejection efficiency: 10^6 :1
Instrument Lifetime	expected lifetime: >5 yrs (no consumables)

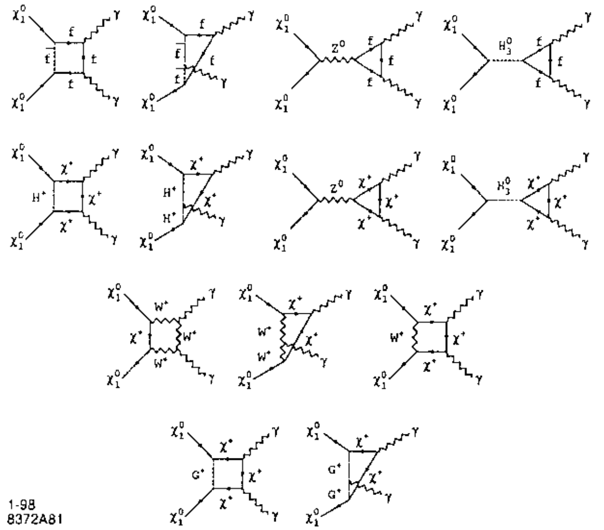
The Relevance of GLAST to the DOE NAP Program

GLAST has its roots firmly in HEP as well as Astrophysics.

GLAST has been a collaboration of HEP and Astrophysics scientists from its inception in early 1992. Most of the initial ideas for the instrument came from particle physicists (principally Bill Atwood at SLAC) exploiting state-of-the-art technology initially developed for colliding beam physics experiments. An international community of particle physicists has been central in the development of the instrument ever since.

GLAST Expands Opportunities for the HEP Community.

"Non-accelerator experiments have historically played an important role in high-energy physics. While some projects are aimed at directly addressing particle physics questions, others are broad interdisciplinary approaches to issues in astrophysics and cosmology. Forging partnerships with other disciplines expands opportunities for doing high-energy physics and maximizes the possibility of discoveries. The diversity and potential for new directions that non-accelerator experiments provide are important for the long-term health and vitality of high-energy physics." ***- Gilman Subpanel report.***



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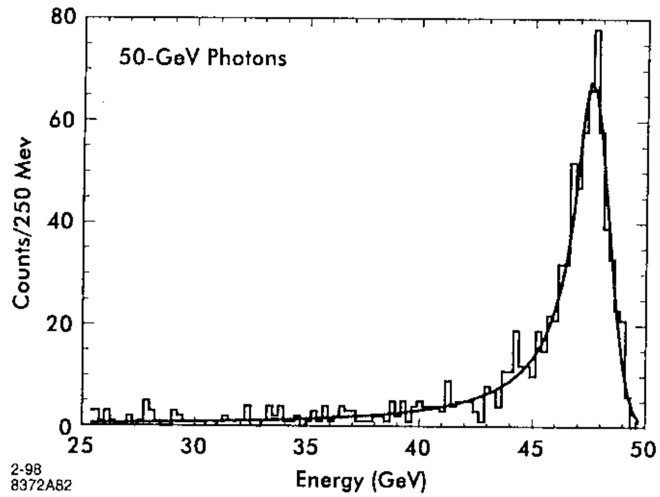

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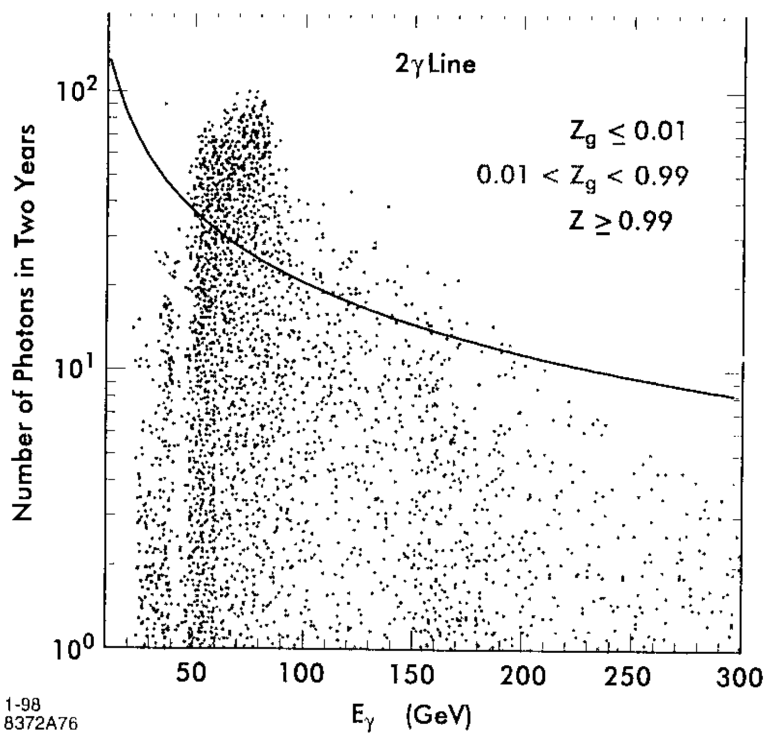

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