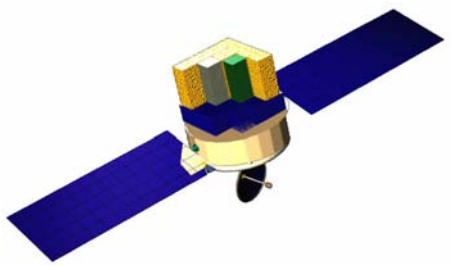
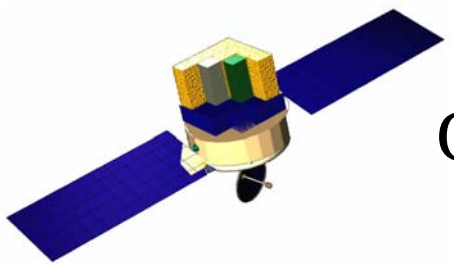


GLAST Science Requirements Document

Neil Gehrels

GLAST SWG Meeting

May 25-26, 20000



GLAST Requirements Development Process

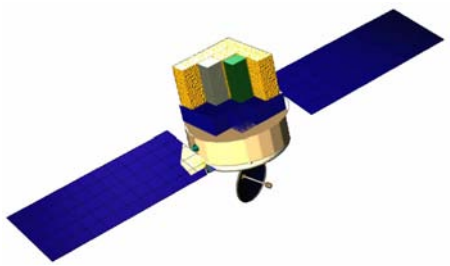
GLAST scientific requirements developed and sanctioned by NASA and DOE committees over past ~5 years

Foundation

• EGRET science	1991-2000
• SR&T/ATD/DOE GLAST development programs	1994-1999

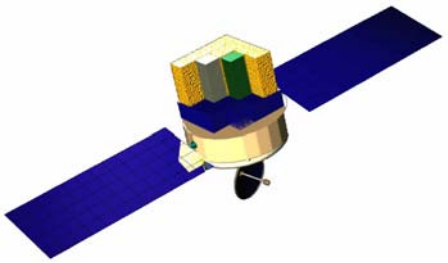
Committees / Working Groups

• NASA Gamma Ray Astronomy Program Working Group (GRAPWG)	1997-1999
• NASA SEU Subcommittee	1997-2000
• DOE Scientific Assessment Group for Experiments on Non-Accelerator Physics (SAGENAP)	1998-1999
• NAS Decadal Review of Astronomy & Astrophysics	1999-2000
• GLAST Facility Science Team	1998-1999
• GLAST Science Working Group	2000-



Facility Science Team (FST)

- Formed by NASA in 1997 to develop GLAST science and generate Science Requirements Document (SRD)
- Members chosen from astrophysics and particles physics communities. Technology development team members, community data experts and theoreticians included.
- Final report is SRD. Signed off at NASA in January 2000. FST disbanded in June 1999.
- FST Membership
  - Bill Atwood (SLAC)
  - Guido Barbiellini (Trieste)
  - Elliott Bloom (SLAC)
  - Alan Bunner (NASA HQ) Ex-Officio
  - Patricia Caraveo (CNR)
  - Lynn Cominsky (Sonoma State)
  - Brenda Dingus (Utah)
  - Jerry Fishman (MSFC)
  - Neil Gehrels (GSFC) Co-Chair
  - Isabelle Grenier (Saclay)
  - Alice Harding (GSFC)
  - Dieter Hartmann (Clemson)
  - Neil Johnson (NRL)
  - Robert Johnson (UCSC)
  - Tsuneyoshi Kamae (Tokyo)
  - Marc Kamionkowski (Columbia)
  - Don Kniffen (Hampden-Sydney College)
  - Scott Lambros (GSFC) Ex-Officio
  - Hans Mayer-Hasselwander (MPE)
  - Peter Michelson (Stanford) Co-Chair
  - Jay Norris (GSFC)
  - Mark Oreglia (U Chicago)
  - Jonathan Ormes (GSFC)
  - Geoff Pendleton (UAH)
  - Steve Ritz (GSFC)
  - Roger Romani (Stanford)
  - Jim Ryan (UNH)
  - Hartmut Sadrozinski (UCSC)
  - Dave Thompson (GSFC)
  - Trevor Weekes (Smithsonian - Hopkins)
  - Kent Wood (NRL)
  - Allen Zych (UC Riverside)



GLAST SRD

SIGNATURE PAGE

Gamma-ray Large Area Space Telescope

Science Requirements Document

Prepared by: GLAST Facilities Science Team

Approved by:

Neil Gehrels 7/14/99
Dr. Neil Gehrels Date
Co-Chair
GLAST Facilities Science Team

Peter L. Michelson 6/25/99
Prof. Peter Michelson Date
Co-Chair
GLAST Facilities Science Team

Reviewed by:

Alan N. Bunner 1/4/00
Dr. Alan Bunner Date
Science Theme Director
Structure and Evolution of the Universe, NASA

David L. Bertsch 1/3/00
Dr. Dave Bertsch Date
GLAST Project Scientist

Scott Lambros 10/13/99
Mr. Scott Lambros Date
GLAST Project Formulation Manager

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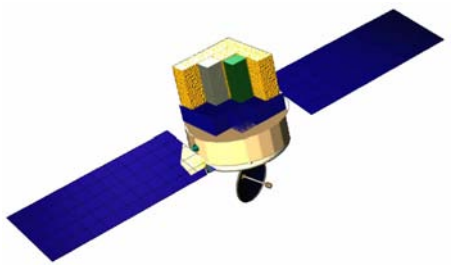
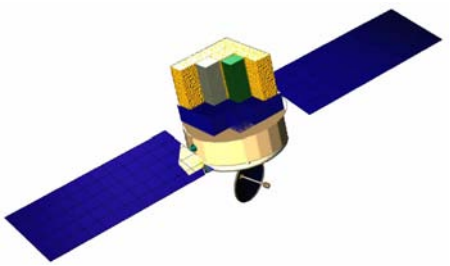


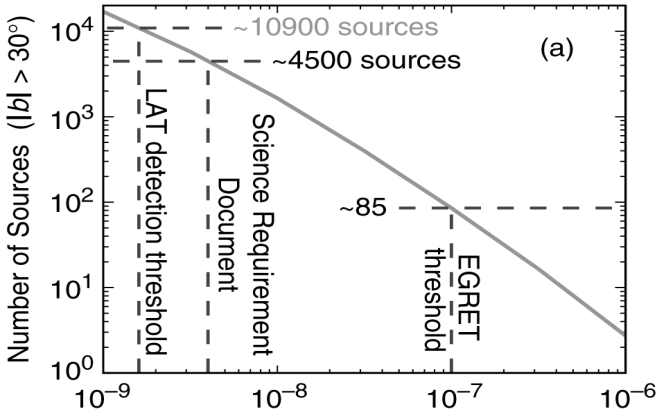
Sources Classes Predicted for GLAST

Source Class	Basis for Prediction
Active Galactic Nuclei (AGN)	EGRET quasars
Diffuse Cosmic Background	EGRET, Theory
Gamma Ray Bursts (GRBs)	EGRET, BATSE, Milagrito
Molecular Clouds, Supernova Remnants Normal Galaxies	COS-B, EGRET, Theory
Galactic Neutrons Stars (NS) & Black Holes (BHs)	COS-B, EGRET
Unidentified Gamma-ray Sources	COS-B, EGRET
Dark Matter	Theory

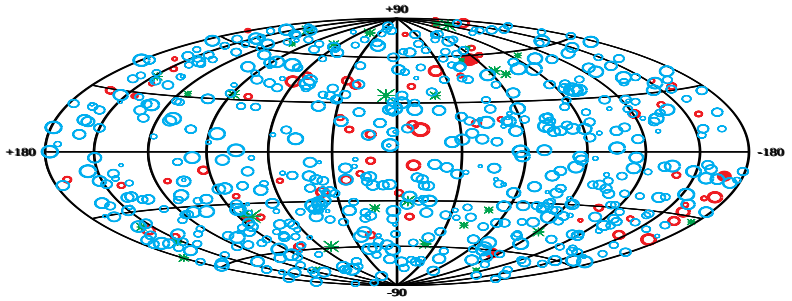


Requirements Flowdown, AGN

- Objectives
  - Determine population of gamma-ray AGN
  - Measure spectra of AGN to study source physics
  - Detect AGN flares
- Requirements
  - Broad energy range (20 MeV - >300 GeV) for spectroscopy
  - Good energy res. (<10%) for spectroscopy
  - Large area (>8000 cm^2) for flare studies
  - Large FOV (>2 sr) for flare detection



GLAST AGN Simulation

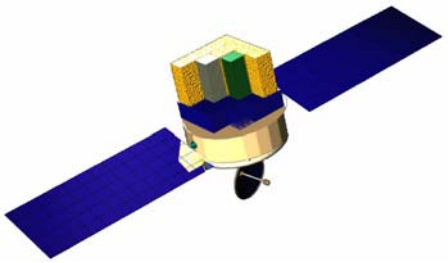


= **EGRET blazars seen sometimes**

= **EGRET blazars seen always**

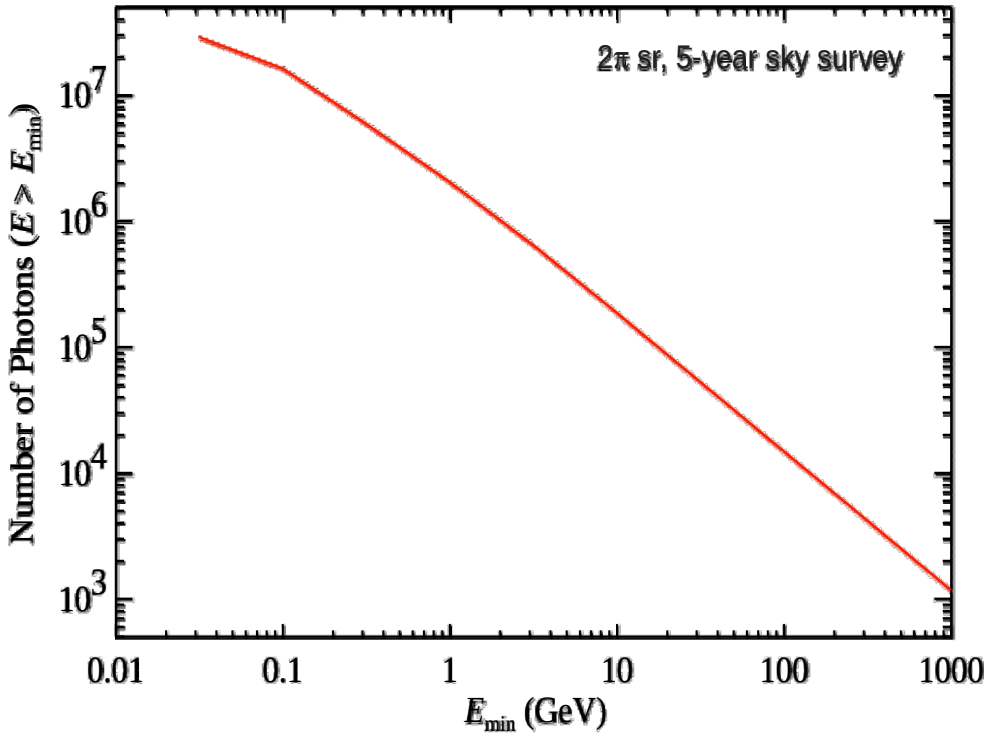
= **EGRET unidentified high-latitude variables**

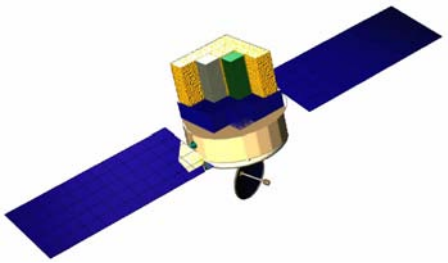
= **Simulated GLAST 20σ AGN detections**



Requirements Flowdown, Cosmic Background

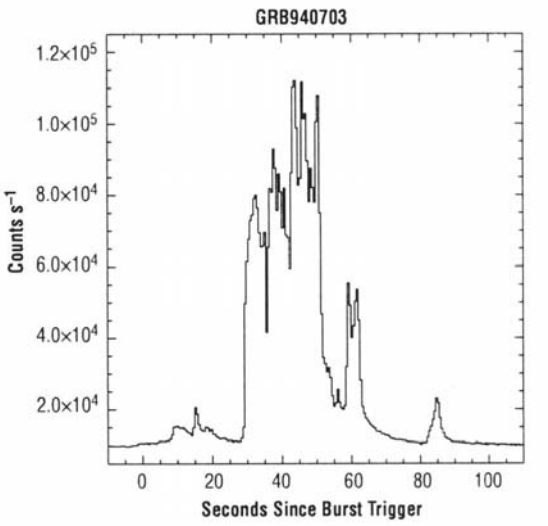
- Objectives
  - Determine origin of cosmic flux
  - Measure broadband spectrum
  - Resolve out sources
- Requirements
  - Reject unwanted particle background (10^5:1)
  - Broad energy range (20 MeV-300 GeV)



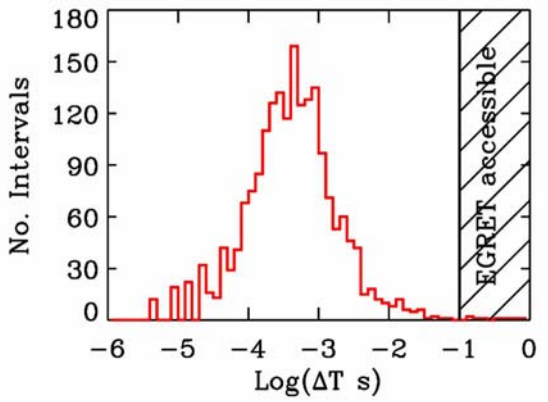


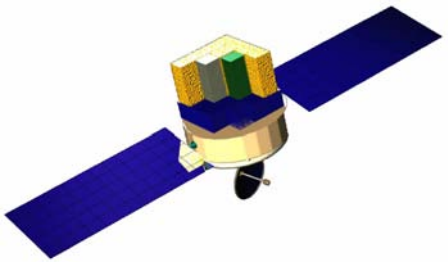
Requirements Flowdown, GRBs

- Objectives
  - Determine physical mechanism of GRB explosions
  - Find GRB classifications
  - Measure broad-band spectrum for physical studies
  - Study GRB afterglows
- Requirements
  - Large FOV (>2 sr) for detecting large number of GRBs
  - Rapid recognition, localization and notification
  - Separate instrument for low energy gamma rays
  - Goal: autonomous S/C repointing



Modeled Photon Arrival Time A's

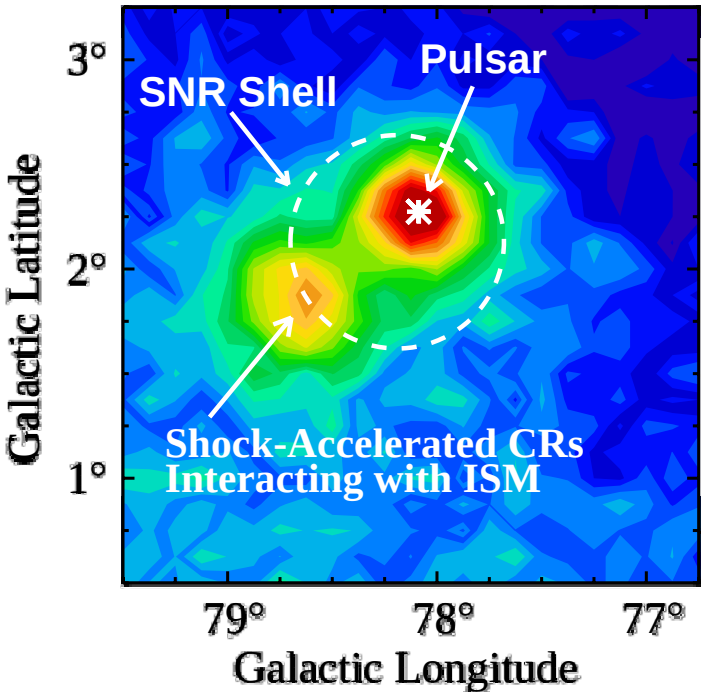


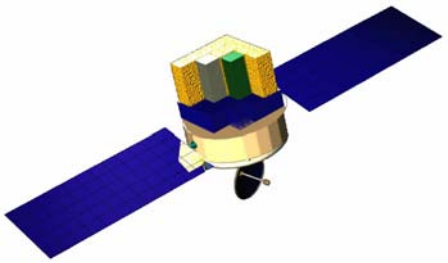


Requirements Flowdown, Clouds & Supernovae

- Objectives
  - Determine sites and mechanisms of particle acceleration in Galaxy
  - Study cosmic ray confinement in galaxies
  - Resolve angular structure of molecular clouds, supernova remnants and galaxies
  - Measure spectra
- Requirements
  - Good (< 1) angular resolution
  - Good spectral resolution (<30%)

GLAST SNR Simulation

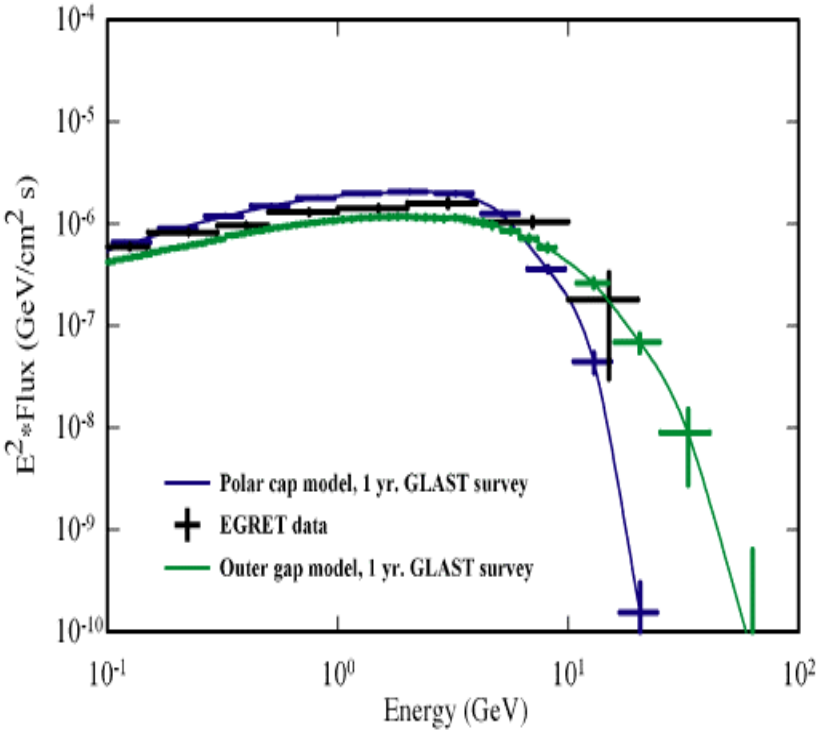


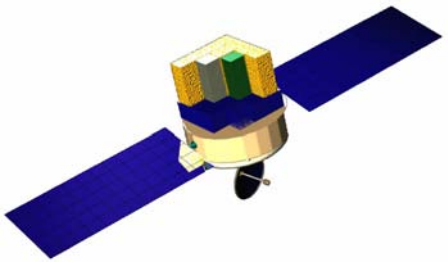


Requirements Flowdown, NSs & BHs

- Objectives
  - Determine physics of pulsars and BH jets
  - Discover new pulsars
  - Search for radio-quiet pulsars
  - Determine NS population of Galaxy
  - Discover galactic BH jets through gamma-ray detection
- Requirements
  - Good (10%) spectral resolution
  - Absolute timing to 10 μsec

Modeled Pulsar Spectra





Requirements Flowdown, unidentified Sources

- Objectives
  - Discover nature of unidentified sources
  - Learn about new types of galactic and extragalactic objects
- Requirements
  - Accurate (few arcmin) source locations
  - Broad energy range for spectral studies and correlation with other wavelengths

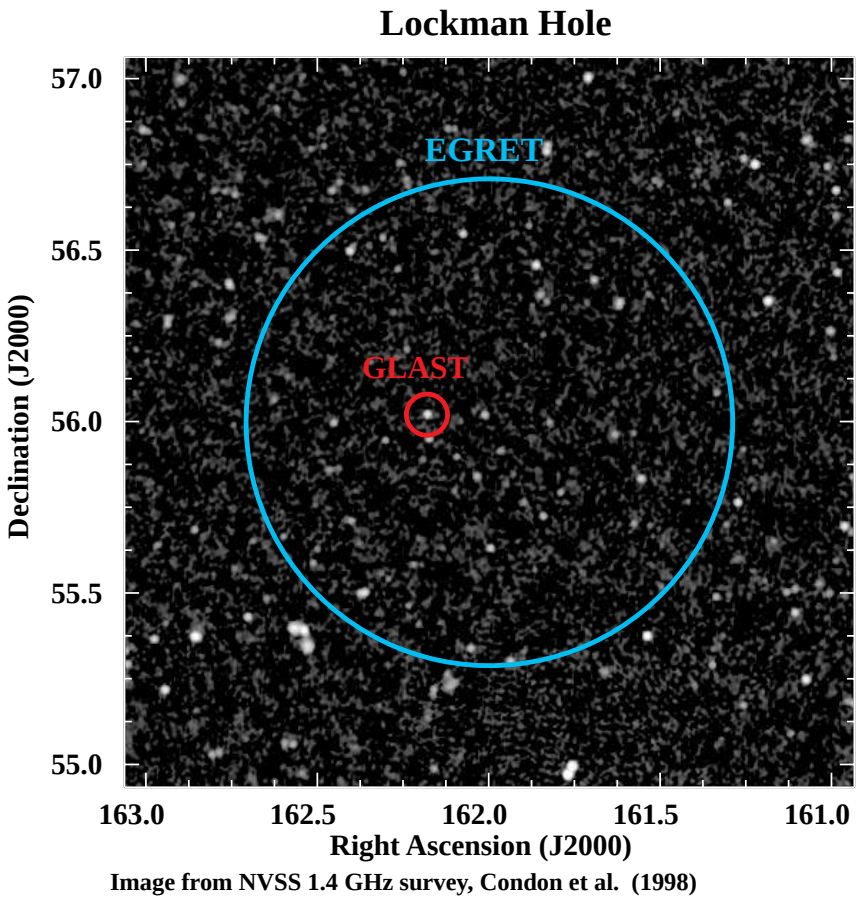
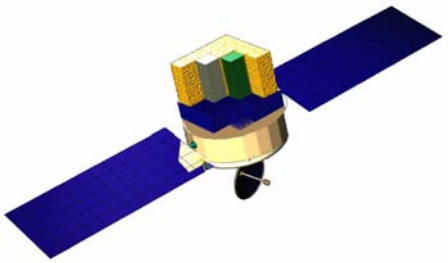


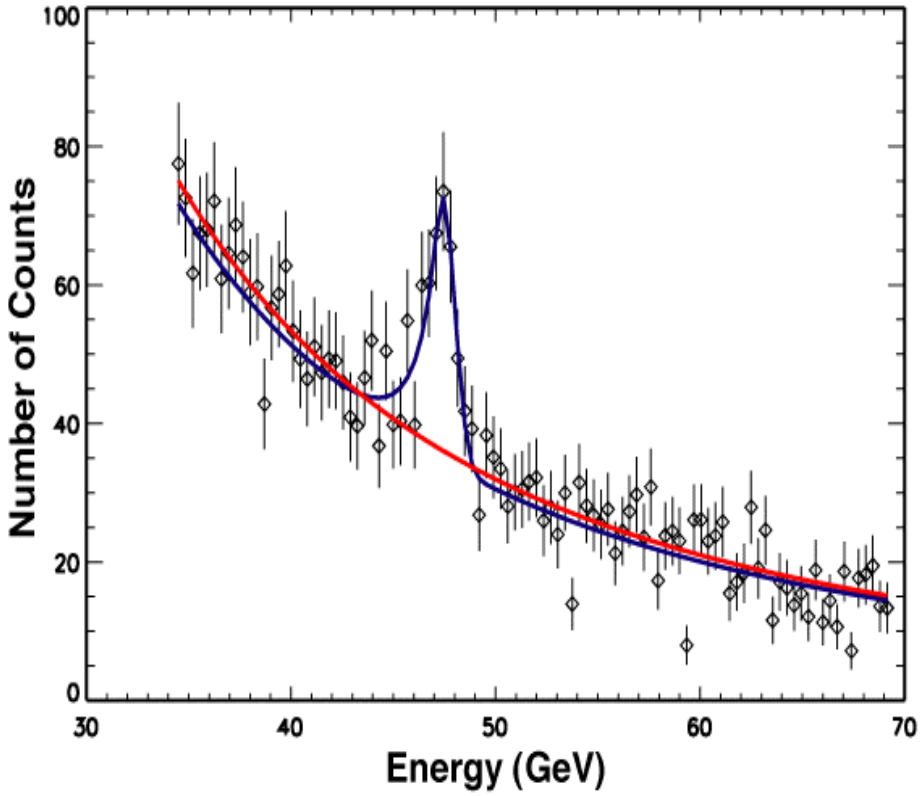
Image from NVSS 1.4 GHz survey, Condon et al. (1998)

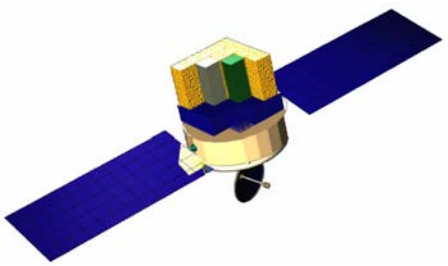


Requirements Flowdown, Dark Matter

- Objectives
  - Search for dark matter signatures with gamma rays
  - Perform detailed spectroscopy at high energies (<10 GeV) over wide regions of sky
- Requirements
  - Broad energy range (to >300 GeV)
  - Goal: Excellent spectral resolution (2%) at high energies (>10 GeV)

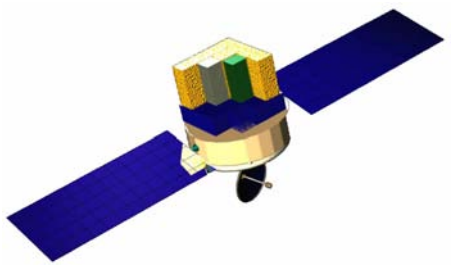
Dark Matter Modeled Spectral Line





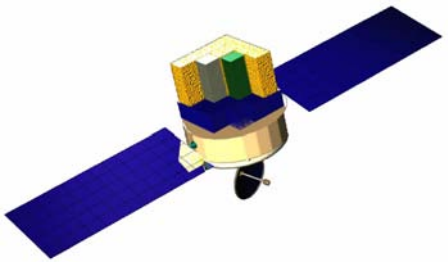
GLAST LAT Requirements

Quantity	*EGRET*	*GLAST Requirement*	*GLAST Goal*	*Science Driver*
Energy Range	20 MeV - 30 GeV	20 MeV - 300 GeV	10 MeV - >300 GeV	ALL
Energy Resolution	10%	10% (100 MeV–10 GeV) [1]	2% (E > 10 GeV)	ALL
Effective Area [2]	1500 cm^2	8000 cm^2	> 10,000 cm^2	ALL
Single Photon Angular Resolution - 68% [3] (on-axis)	5.8° (@100 MeV)	< 3.5° (@100 MeV) < 0.15° (E > 10 GeV)	< 2° (@ 100 MeV) < 0.1° (E > 10 GeV)	ALL
Single Photon Angular Resolution - 95% [3] (on-axis)		< 3 x $\theta_{68\%}$	2 x $\theta_{68\%}$	ALL
Single Photon Angular Resolution (off axis at FWHM of FOV)		< 1.7 times on-axis	< 1.5 times on-axis	ALL
Field of View [4]	0.5 sr	2 sr	>3 sr	ALL
Source Location Determination [5,8]	5 - 30 arcmin	1-5 arcmin	30 arcsec - 5 arcmin	Unidentified EGRET Sources, GRBs
Point Source Sensitivity [6,8] (> 100 MeV)	~1 x 10^{-7} cm^{-2} s^{-1}	4 x 10^{-9} cm^{-2} s^{-1}	< 2 x 10^{-9} cm^{-2} s^{-1}	AGN, Unidentifieds, Pulsars, GRBs



GLAST LAT Requirements

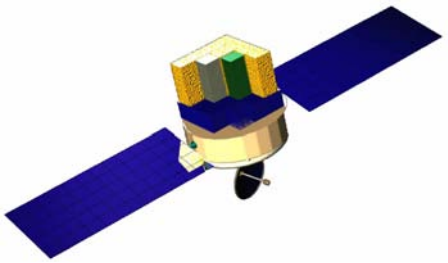
Quantity	*EGRET*	*GLAST Requirement*	*GLAST Goal*	*Science Driver*
Time Accuracy	0.1 ms	10 μsec absolute [7]	2 μsec absolute [7]	Pulsars, GRBs
Background Rejection	$> 10^6$:1	$> 10^5$:1	$> 10^6$:1	ALL, Especially Diffuse
Dead Time	100 ms/event	< 100 μs /event	<10% instrument ave. for bursts up to 10kHz (<20 μs/event)	GRBs
Transients			Complementary low-energy observations Trigger and location for S/C repointing High efficiency recognition and reconstruction of multi-γ events	GRBs,Primordial BHs



GLAST GBM Requirements

Expected Performance of the Gamma-Ray Burst Monitor

Quantity	Baseline
Energy Range	**Low energy gamma-ray, X-ray**
Field of View	**> ~ 3 sr**
Sensitivity	**0.5 photons cm^{-2} s^{-1}**



GLAST Mission Requirements

Quantity	*GLAST Requirement*	*GLAST Goal*	*Science Driver*
Mission Life	5 years, with no more than 20% degradation	10 years	ALL
Telemetry Downlink - Orbit Average	300 kbps 1 kbps near-realtime for notifying ground of transients in progress	>1 Mbps	GRBs,AGN,ALL
Telemetry Uplink	4 kbps	1 kbps near-realtime for notifying GLAST of transients in progress	GRBs,AGN,ALL
Spacecraft Repointing		< 5 min. autonomous	GRBs,AGN
Pointing Accuracy [1]	2^{o} accuracy <30 arcsec knowledge		ALL
Observing Modes	Rocking zenith pointing Pointed mode		ALL
Targeting		Point anywhere in the sky at any time. More than 1 target per orbit.	ALL
Spacecraft Clock Accuracy	8 μsec absolute [2]	1 μsec absolute [2]	PULSARS,GRBs
Spacecraft Position Accuracy	3 km	1 km	PULSARS,GRBs
Data Loss **Data Corruption**	< 2 % $< 10^{-10}$ undetected corrupted event fraction		ALL