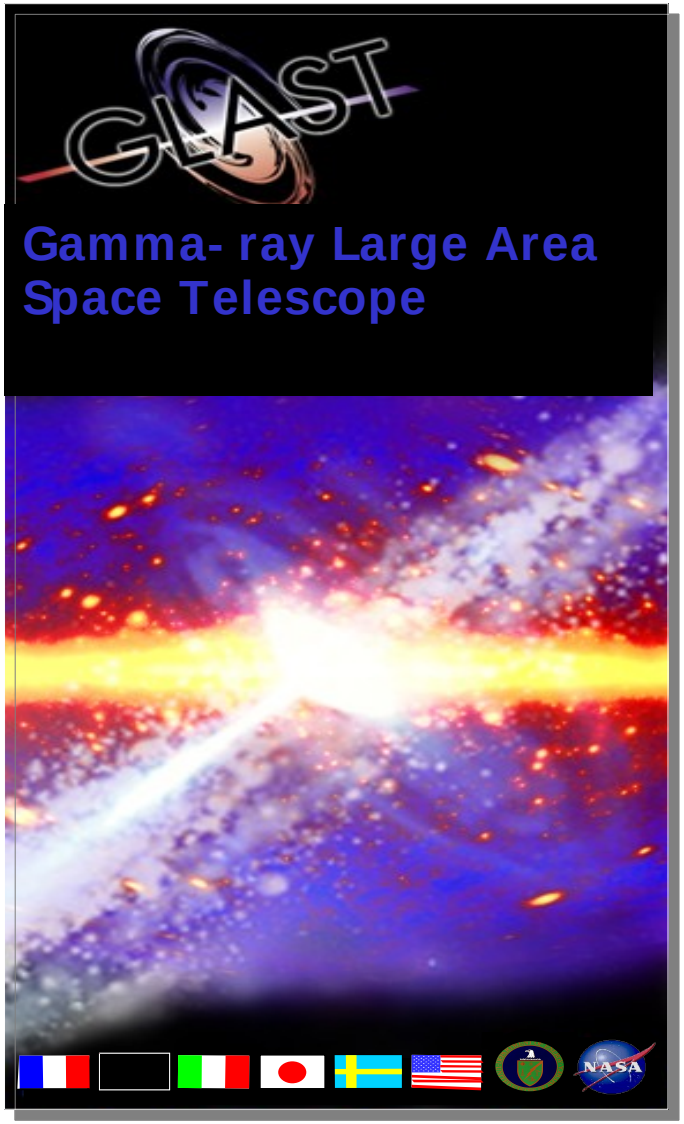


GLAST

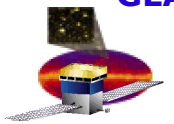
Status and Science Prospects

Johann Cohen-Tanugi
SLAC – Stanford University

on behalf of the GLAST-LAT collaboration

cohen@slac.stanford.edu

http://glast.gsfc.nasa.gov/
http://www-glast.stanford.edu



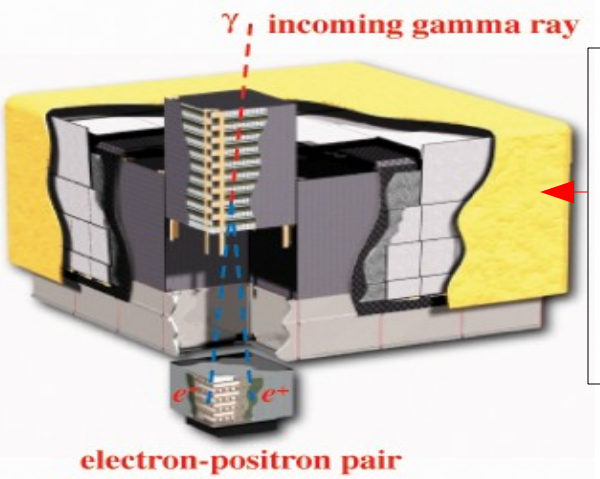
Outline

- Overview of GLAST observatory
- Status of the construction
- Illustrations of performance:
  - All sky monitoring
  - Time variability
  - Energy range
- A few Science topics
  - Source catalog and diffuse emission
  - Particle acceleration
  - Dark Matter search

– Check out the TeV symposium during September LAT collaboration meeting :
http://www-glast.slac.stanford.edu/GLAST_CollaborationSEP04/GLAST_TeV_Symposium.htm

– A “Multiwavelength Observation” planning team has been created :
http://glast.gsfc.nasa.gov/science/multi/

GLAST Mission Summary



Large Area Telescope (LAT)

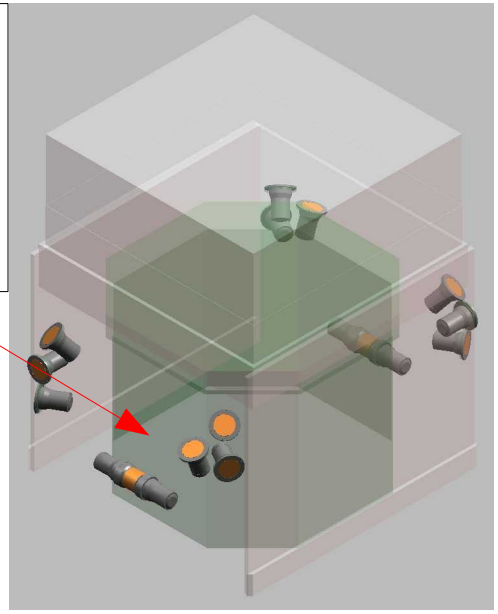
~20 MeV to 300+ GeV.

No other telescope currently covers this range.

GLAST Burst Monitor (GBM)

correlative observations of transient events

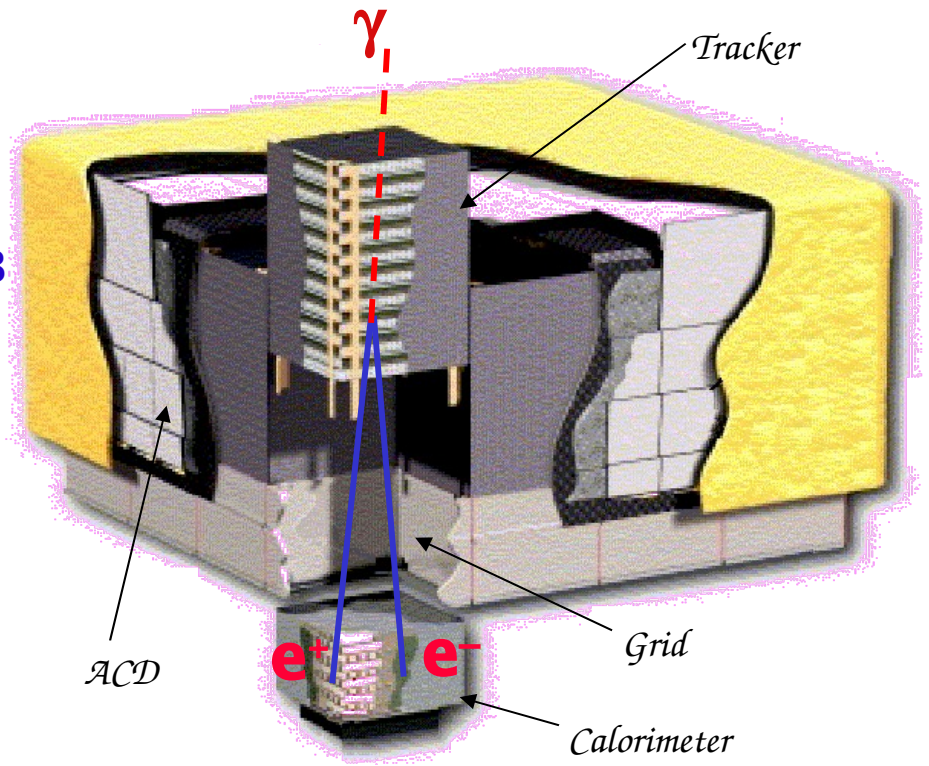
10 keV – 25 MeV.



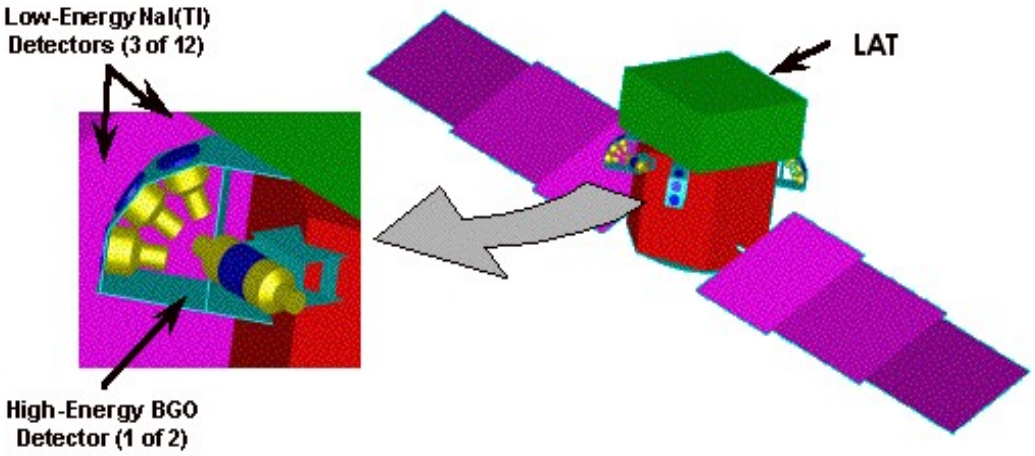
- **Launch in August 2007**
- **Circular orbit, 565 km altitude, 28.5° inclination**
- **Mission lifetime: 5 years, with a goal of 10 years**
- **Sky survey + pointed observing programs**
- **Autonomous targeted re-pointing capability, with rapid slew speed:**
  75° in <10 minutes (5 minutes goal)

Overview of the LAT

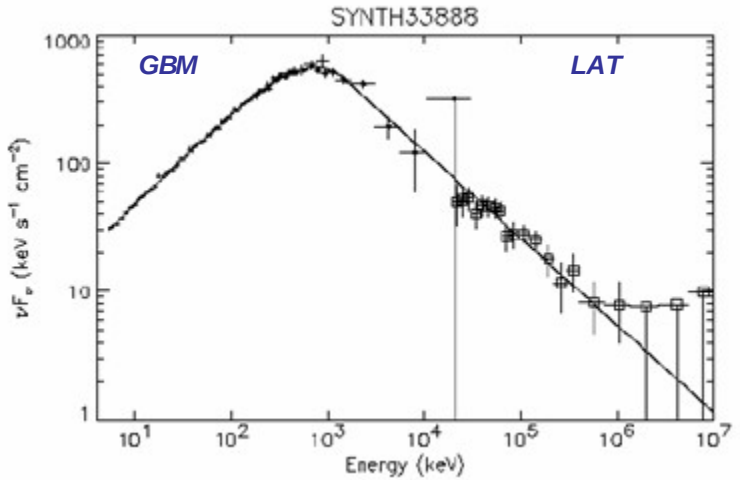
- **Precision Si-strip Tracker (TKR)**
  - ~80 m² Si, 18 XY tracking planes
  - Single-sided silicon strip detectors (228 um pitch)
  - Measure the photon direction; gamma ID.
- **Hodoscopic CsI Calorimeter (CAL)**
  - Array of 1536 CsI(Tl) crystals in 8 layers.
  - Measure the photon energy; image the shower.
- **Segmented Anticoincidence Detector (ACD)**
  - 89 plastic scintillator tiles.
  - Reject background of charged cosmic rays;
  - segmentation removes self-veto effects at high energy.



GLAST Burst Monitor - GBM



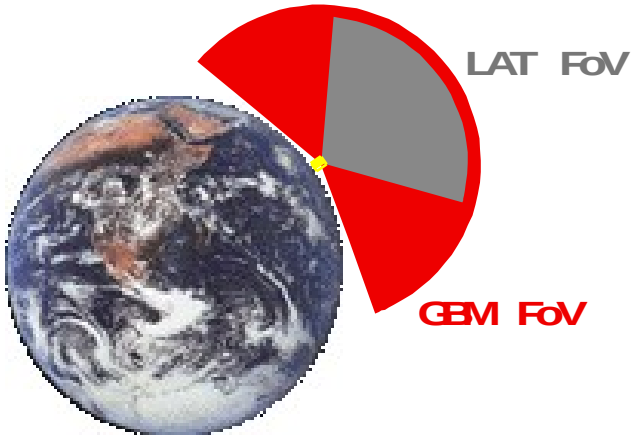
12 NaI :~10 keV to ~1 MeV
2 BGO : ~150 keV to ~30MeV



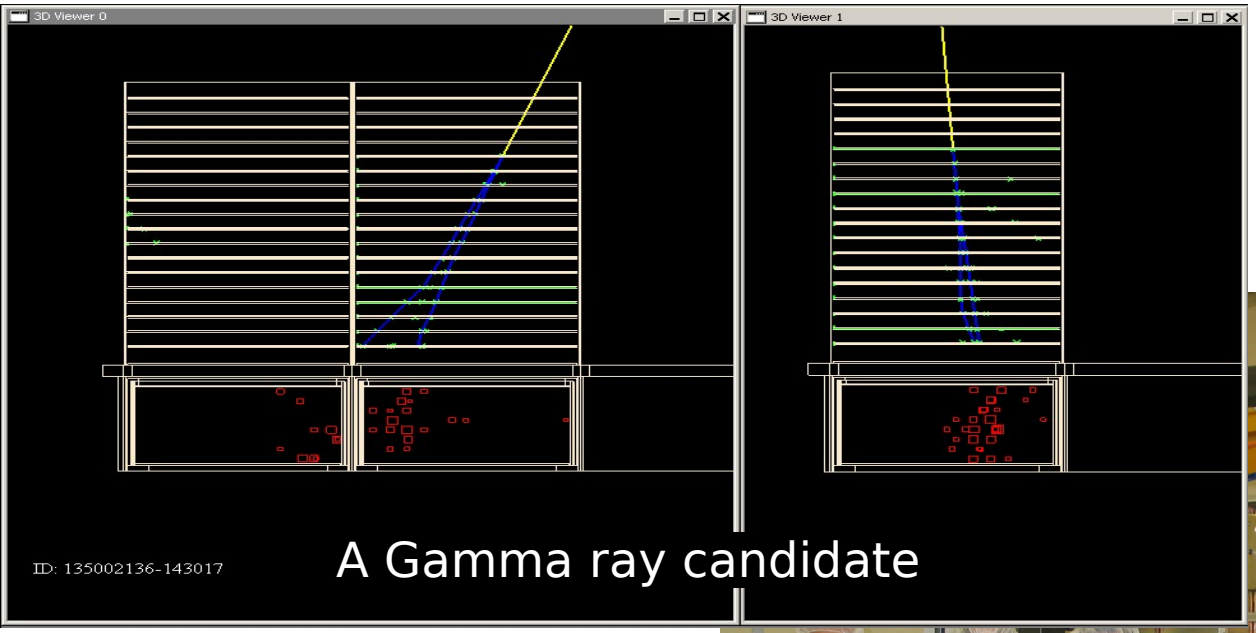
Simulated burst based on GRB 940217

Provides:

- spectra for bursts from 10 keV to 30 MeV, connecting frontier LAT high-energy measurements with more familiar energy domain;
- wide sky coverage (8 sr) -- enables autonomous repoint requests for exceptionally bright bursts that occur outside LAT FOV for high-energy afterglow studies
- burst alerts to the ground.

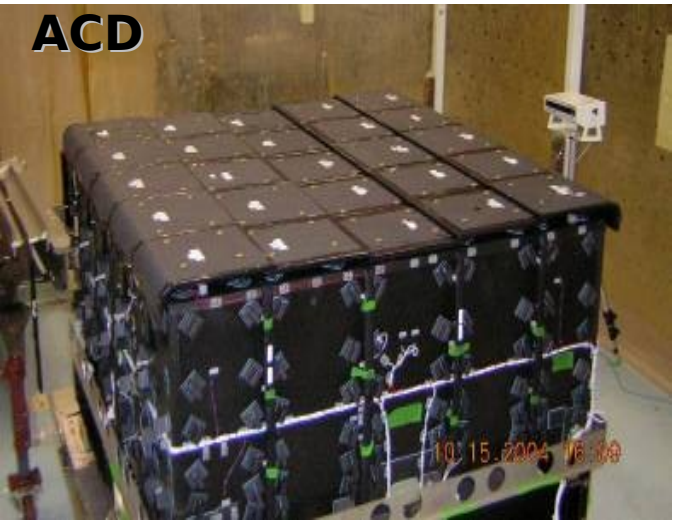


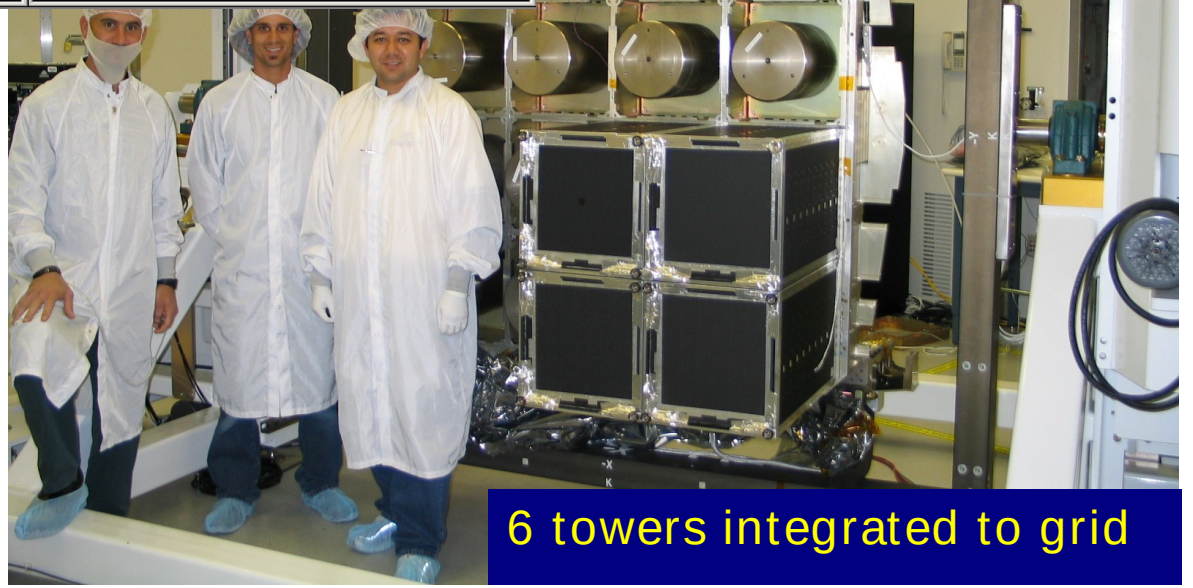
Status of LAT Assembly



A Gamma ray candidate

- 7 TKRs at SLAC
- All 16 CAL. at SLAC
- ACD: end of month





6 towers integrated to grid

Performance

http://www-glast.slac.stanford.edu/software/IS/glast_lat_performance.htm

Science Performance Requirements Summary

From the SRD:

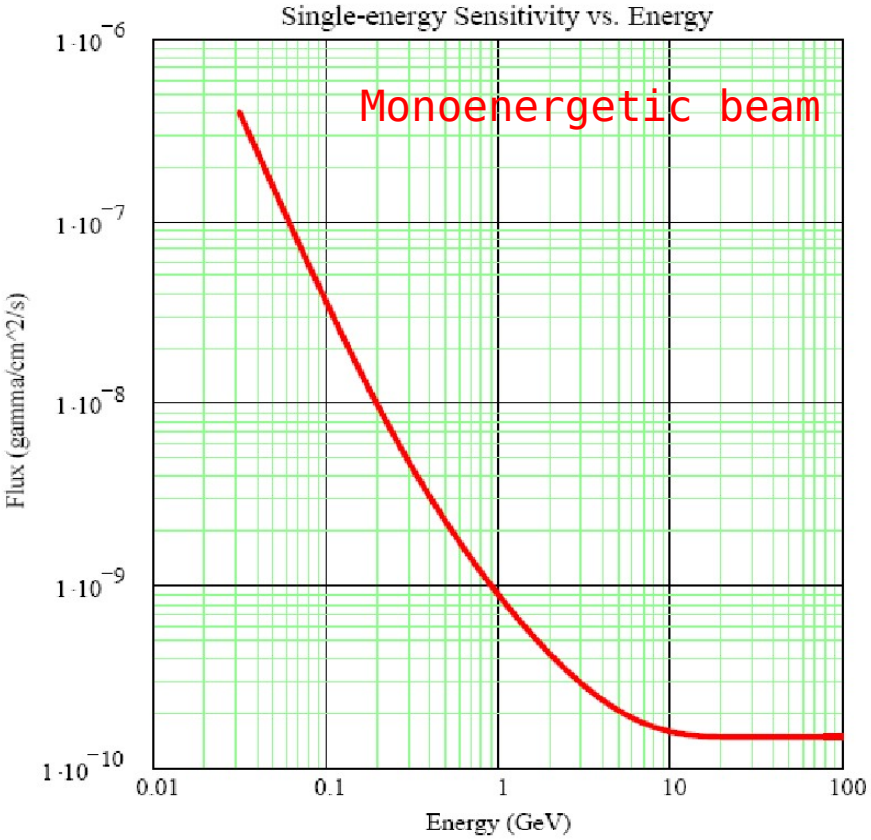
Parameter	SRD Value	Present Design Value
Peak Effective Area (in range 1-10 GeV)	>8000 cm^2	10,000 cm^2 at 10 GeV
Energy Resolution 100 MeV on-axis	<10%	9%
Energy Resolution 10 GeV on-axis	<10%	8%
Energy Resolution 10-300 GeV on-axis	<20%	<15%
Energy Resolution 10-300 GeV off-axis (>60°)	<6%	<4.5%
PSF 68% 100 MeV on-axis	<3.5°	3.37° (front), 4.64° (total)
PSF 68% 10 GeV on-axis	<0.15°	0.086° (front), 0.115° (total)
PSF 95/68 ratio	<3	2.1 front, 2.6 back (100 MeV)
PSF 55°/normal ratio	<1.7	1.6
Field of View	>2sr	2.4 sr
Background rejection (E>100 MeV)	<10% diffuse	6% diffuse (adjustable)
Point Source Sensitivity(>100MeV)	<6×10^{-9} $cm^{-2}s^{-1}$	3×10^{-9} $cm^{-2}s^{-1}$
Source Location Determination	<0.5 arcmin	<0.4 arcmin (ignoring BACK info)
GRB localization	<10 arcmin	5 arcmin (ignoring BACK info)

Document: LAT-PR-00403 Section 3.0 Science Requirements & Instrument Design 39

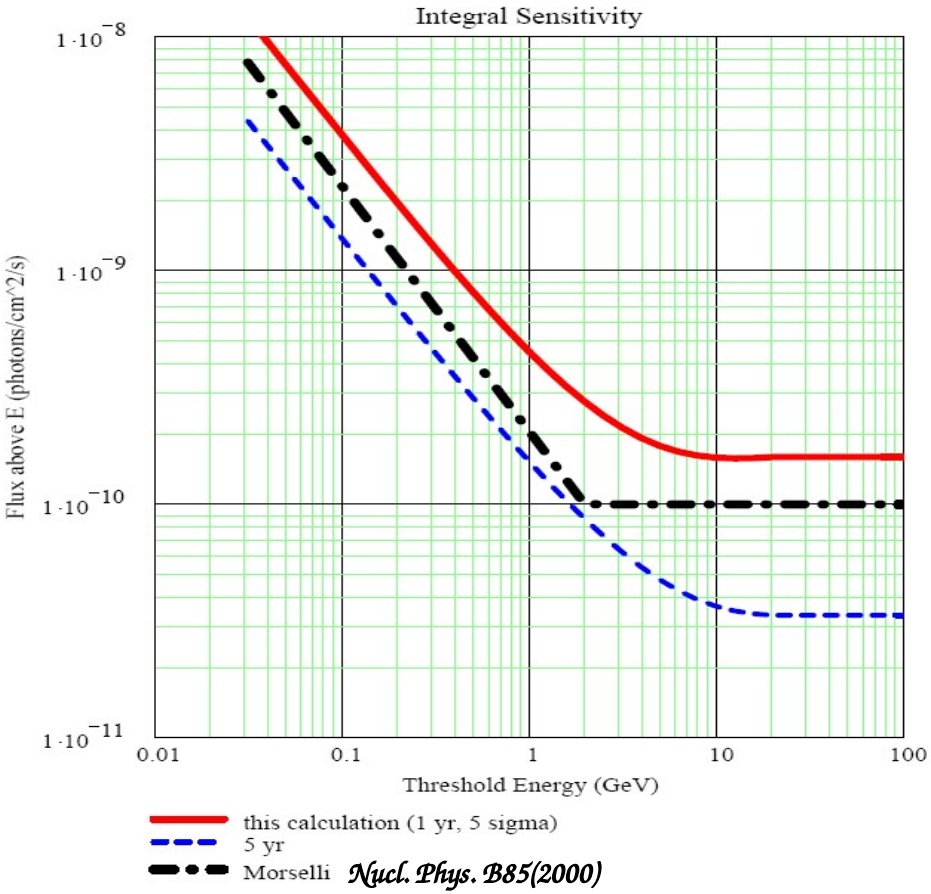
Expect updates soon!

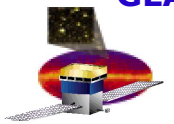
Point Source Sensitivity

- *One-year (livetime) all-sky survey*
- *diffuse background flux 1.5×10^{-5} /cm^2/s/sr (E>100 MeV), spectral index -2.1*
- *5σ , high latitude source*



- *5σ sensitivity for E>E0*
- *1/E2 spectrum source at high latitude.*





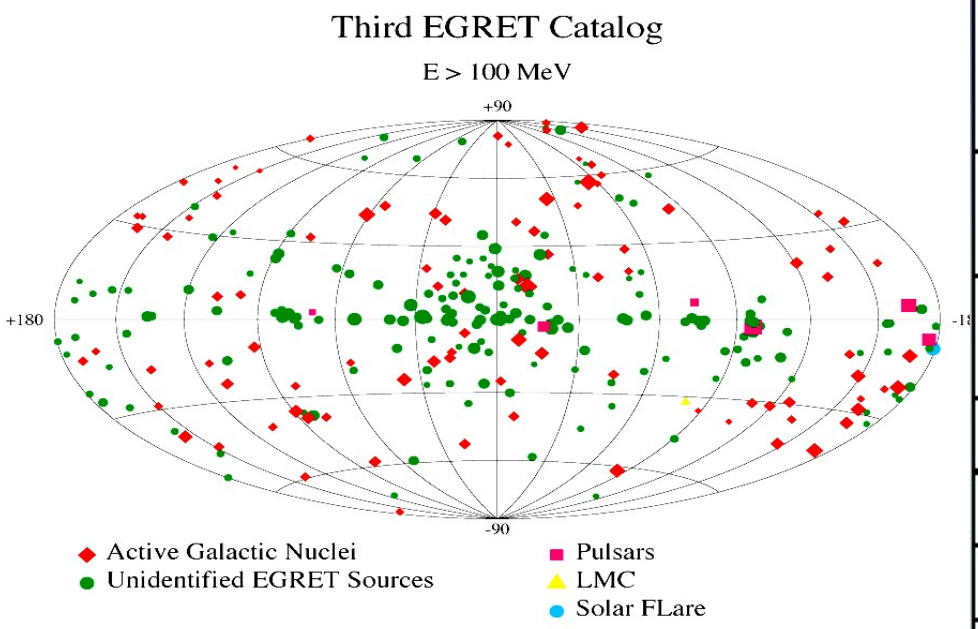
GLAST Science

- **High Energy Sky Survey :**
  - **EGRET unidentified sources**
  - **Catalog + Population Studies : AGN, Pulsar, SNR**
  - **Galactic and Extra-Galactic Diffuse emission**
  - **Mechanisms of particle acceleration :**
    - **formation of jets,**
    - **extraction of rotational energy from spinning neutron stars,**
    - **dynamics of shocks in SNRs.**
- **High-energy behavior of transients :**
  - **Gamma Ray Burst**
  - **Solar Flare**
- **Discovery Window :**
  - **New astrophysical objects?**
  - **Dark Matter and Exotic Physics.**

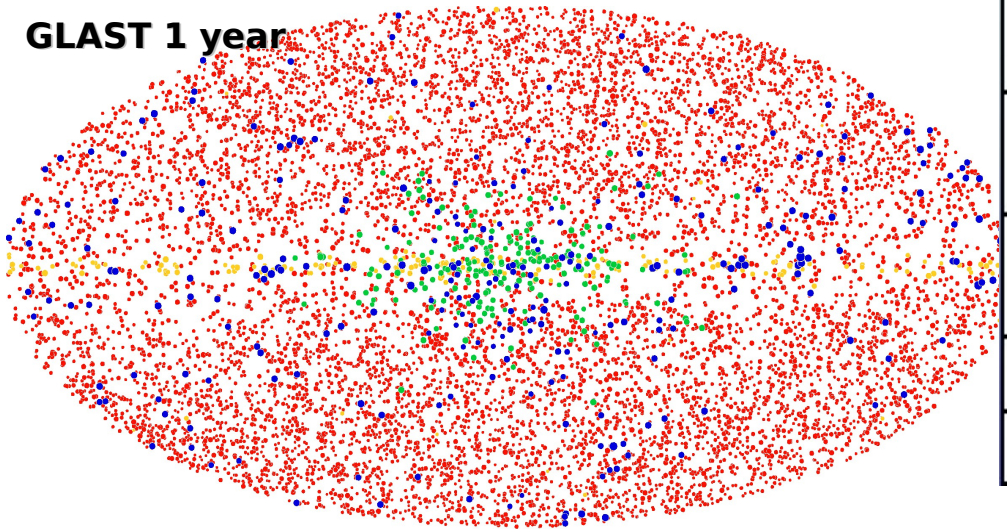
3 Key Strengths :

- All-sky monitoring
- Broad range of time scales
- Energy range

Performance : All Sky Monitoring (I)



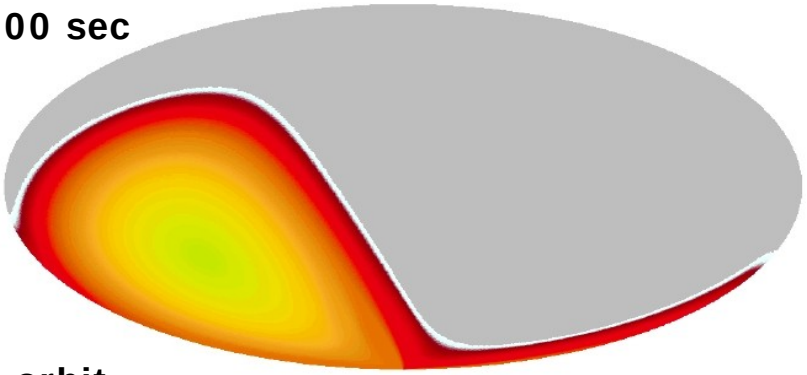
GLAST 1 year



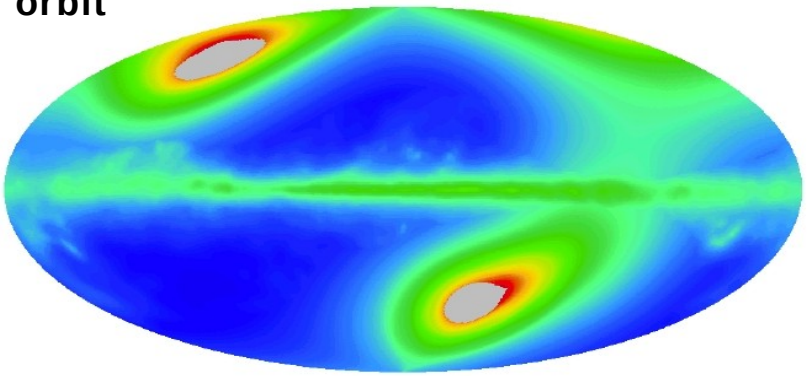
Source Class	Number seen by EGRET	Number anticipated with GLAST
Rotation-powered pulsars	6 definite 3 possible	100-500
Blazars	80 definite 50 possible	>2000
Normal galaxies	2	4-5
Gamma-ray bursts	5	>500
Unidentified sources	170	?
Supernova remnants/plerions	1 likely ~5 possible	>10
Radio galaxies	1 likely 1 possible	?
X-ray binaries/microquasars	1 likely 1 possible	?
Starburst galaxies	0	?
Clusters of galaxies	0	?

Performance : all sky monitoring (II)

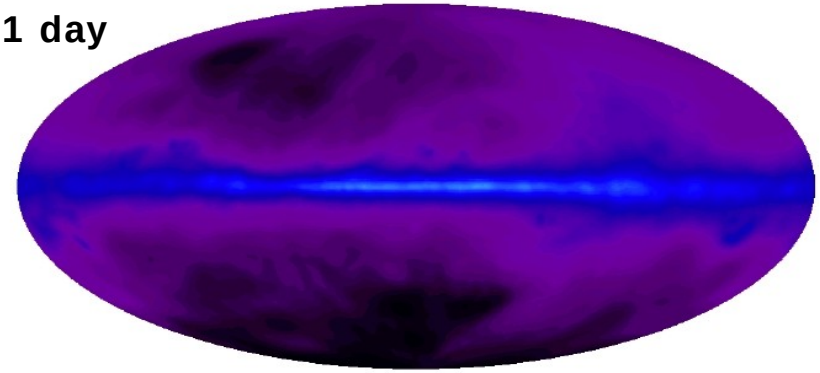
100 sec

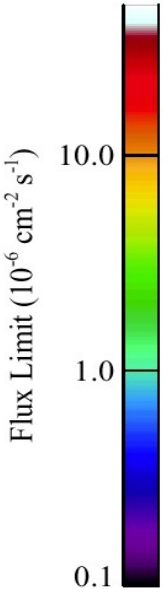


1 orbit



1 day





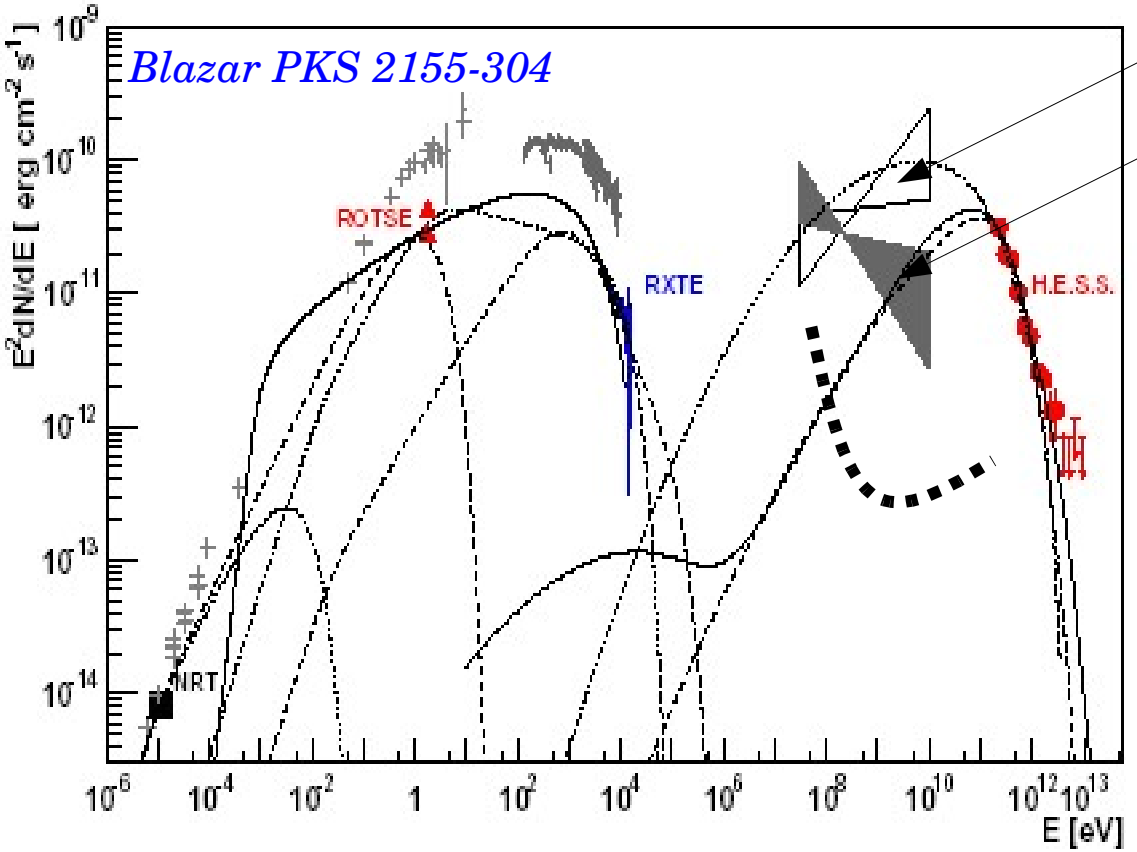
EGRET Fluxes

- GRB 940217 (100sec)
- PKS 1622-287 flare
- 3C279 flare
- Vela Pulsar
- Crab Pulsar
- 3EG 2020+40 (SNR γ Cygni?)
- 3EG 1835+59
- 3C279 lowest 5σ detection
- 3EG 1911-2000 (AGN)
- Mrk 421
- Weakest 5σ EGRET source

During the all-sky survey, GLAST will have sufficient sensitivity after O(1) day to detect (5σ) the weakest EGRET sources.

Performance : Time Variability

- GLAST sky monitoring will be sensitive to very different time scales : from ~30µs to the mission lifetime
- "continuous" baseline in GeV for IACTs
- An illustration from Aharonian et al. (astro-ph/0506593) :



3rd EGRET catalog

High γ-ray state (Verstrand et al. 1995)

GeV-TeV campaigns will be key to GLAST science!

Multiwavelength planning started, see :

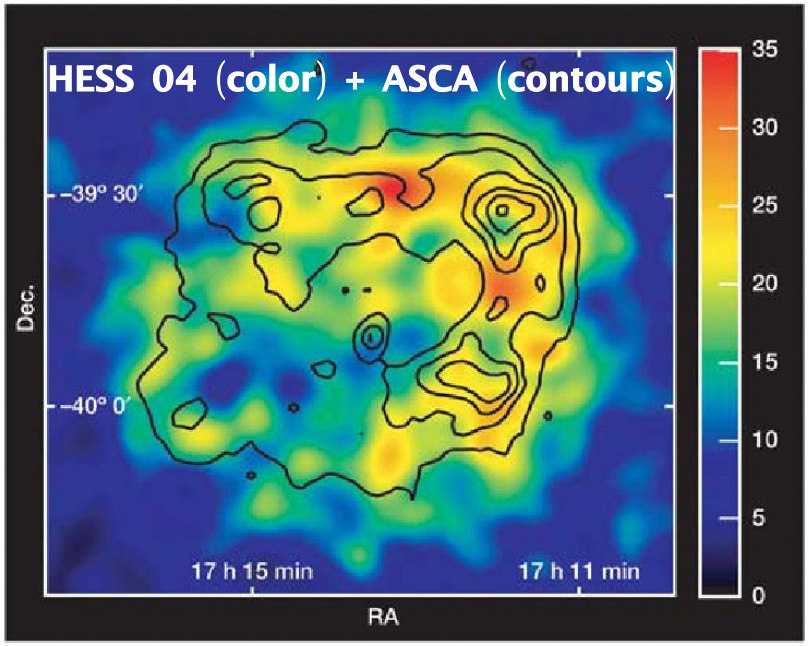
http://glast.gsfc.nasa.gov/science/multi/

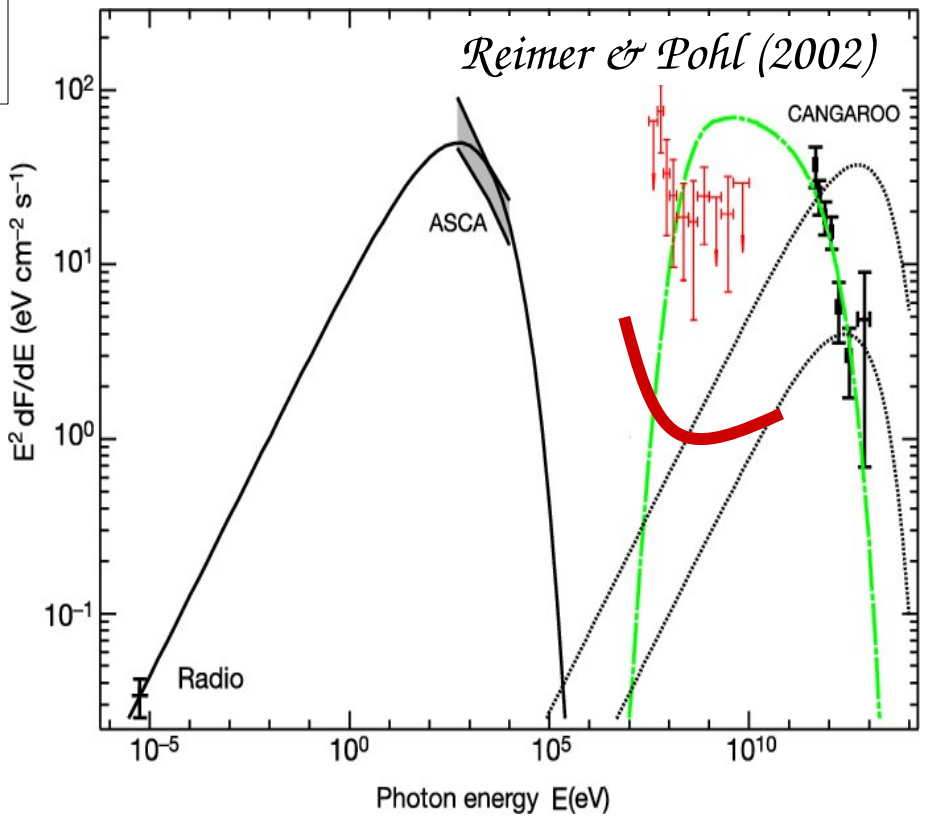
Performance : Energy Coverage

- Energy Coverage of GLAST- LAT: 20MeV- 300GeV
  - Discovery Domain
  - Optimum to differentiate between $pp \rightarrow \pi^0$ and $e^{+/-}$ + CMB/ IR$\rightarrow \gamma$

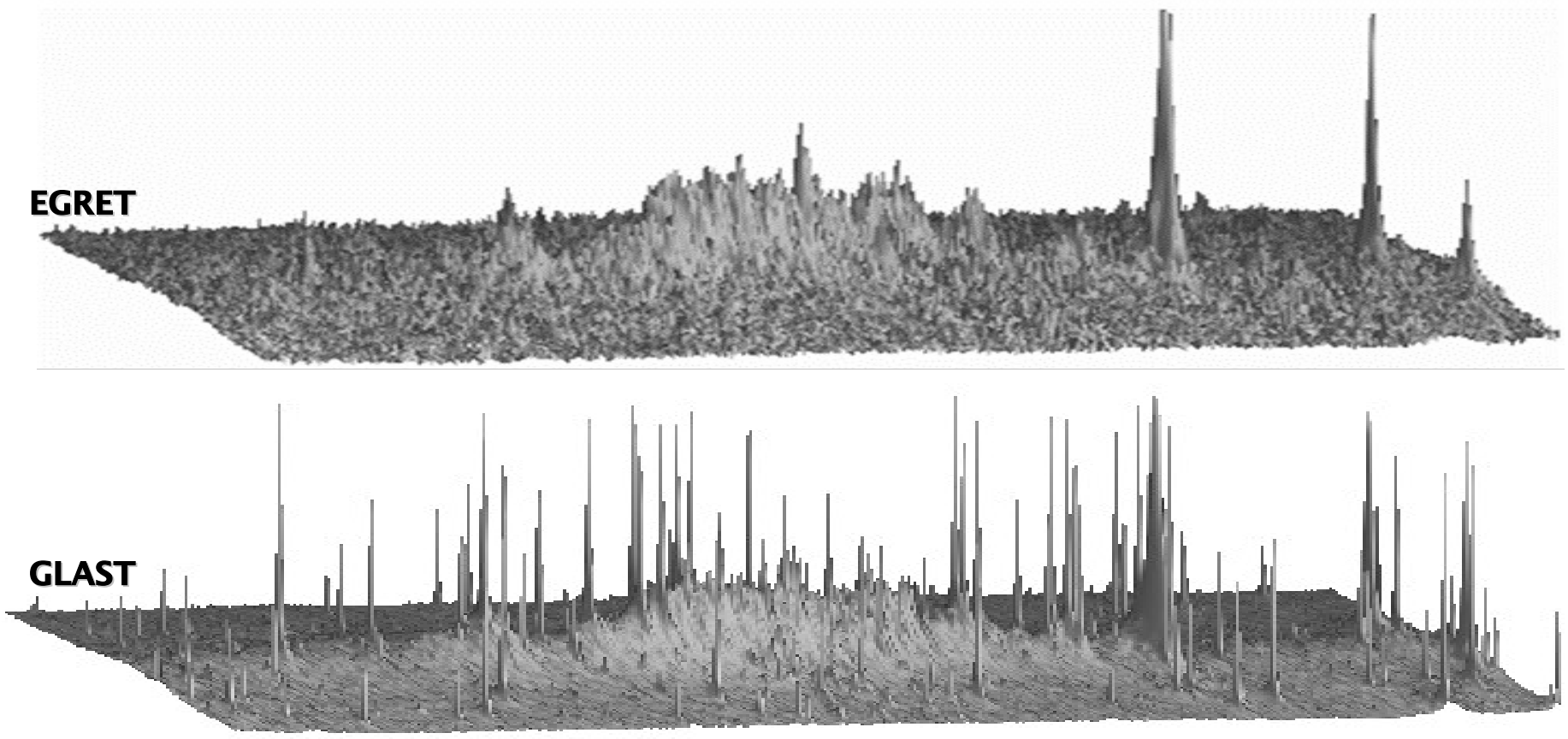
Hadronic component in cosmic ray acceleration sites?

A 2nd exemple where multiwavelength campaigns will pay off!





Diffuse Gamma Ray Sky



- Many more point sources
- Sharper definition of the diffuse background
- accurate modeling essential

Diffuse Emission Model: *pp* Interaction

Kamae et al. 05, Kamae, Karlsson, Mizuno et al. 05, Kamae, Karlsson, Cohen-Tanugi, Mizuno et al. In prep.

See also Talk by Tijana Prodanovic in Parallel session 2

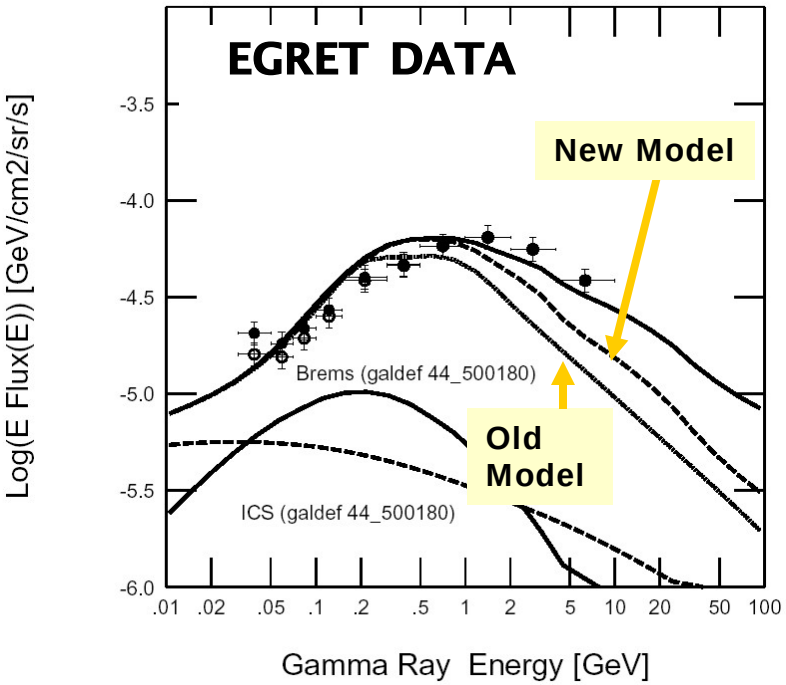
Old models

- Constant inelastic cross-section
- Feynman scaling
- No diffraction dissociation

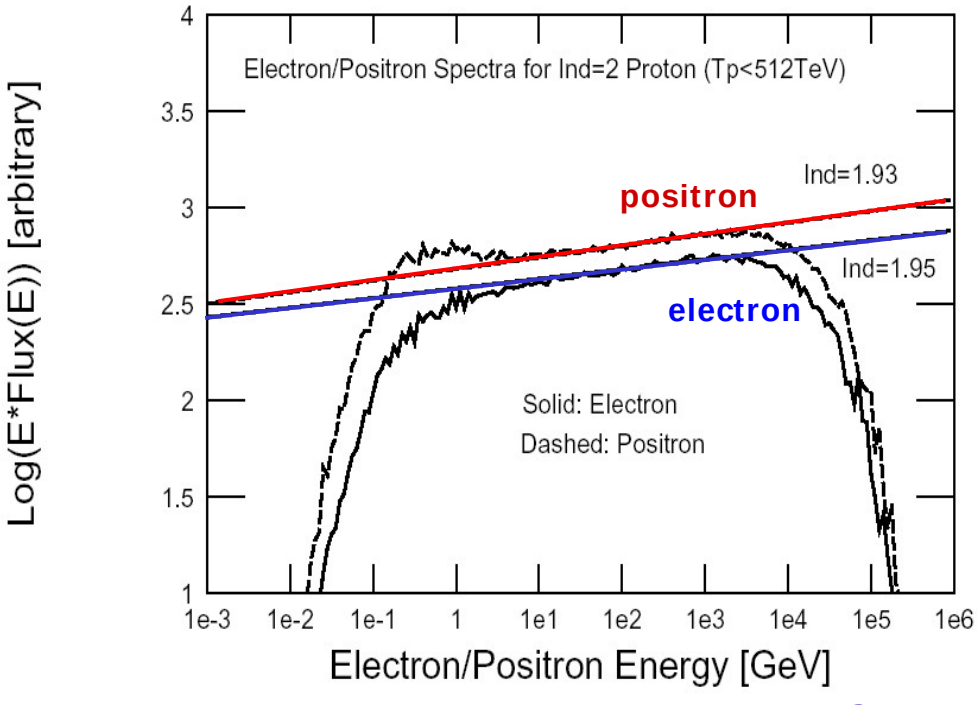
New model

- Rising cross-sections
- Scaling violation: Pythia + CDF TuneA
- Diff. dissociation: CDF Goulianos

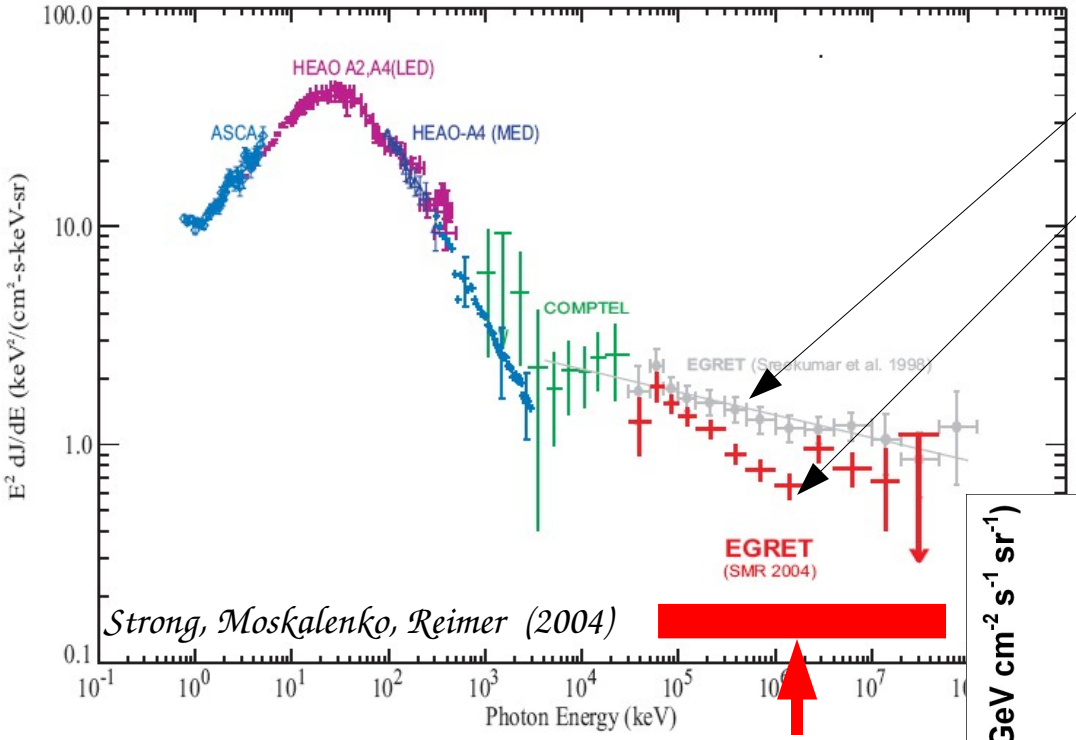
"GeV Excess" >50% explained?



"Positron excess" predicted



Origin of Extragalactic Diffuse Radiation

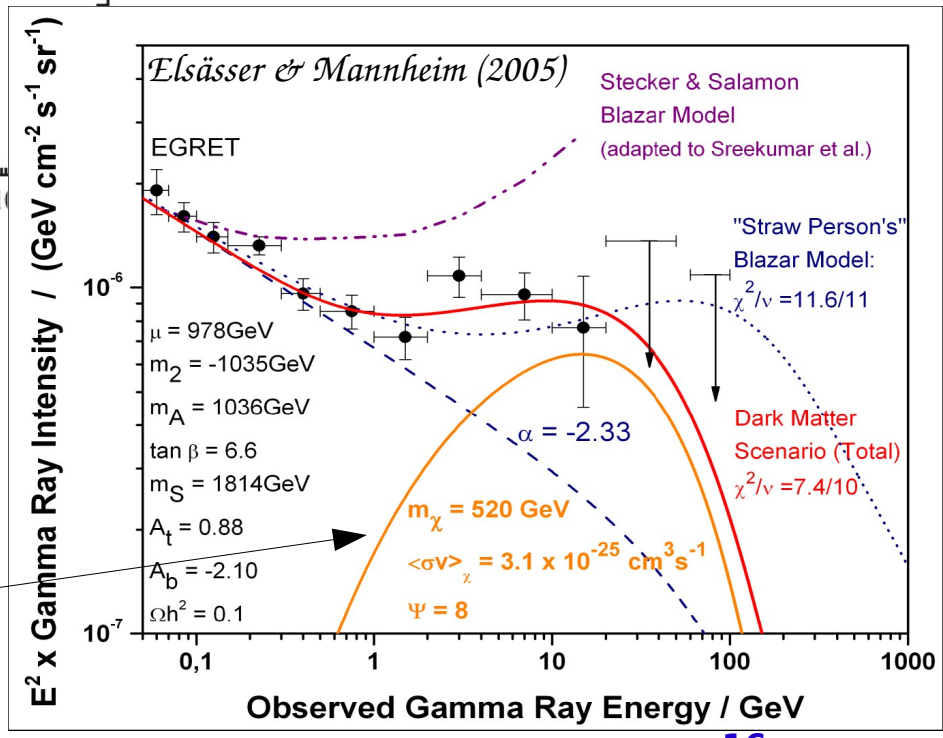


Original EGRET spectrum

Reanalysis : slight mod. of e- spectrum wrt LIS

Discovery Region for GLAST!

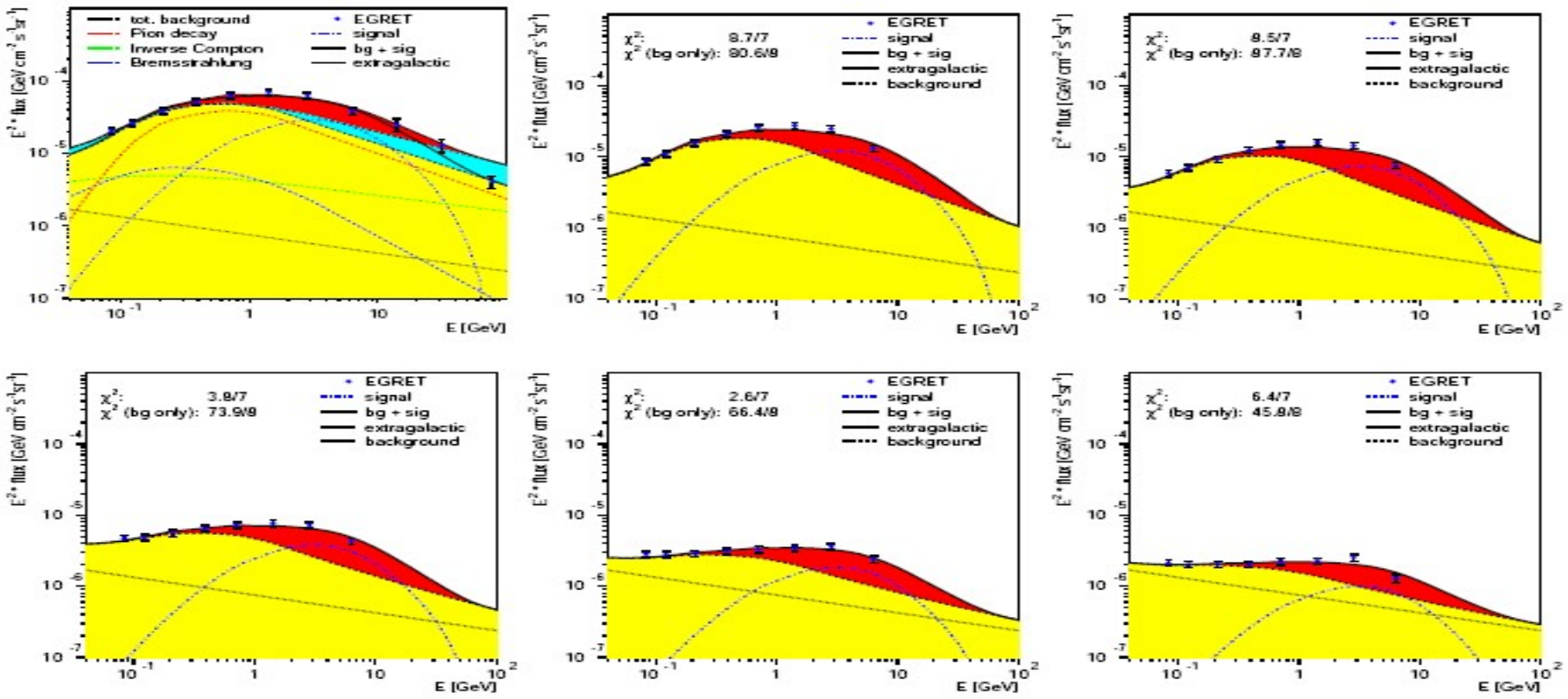
- blazars
- normal galaxies
- cluster mergers
- primordial diffuse
- new physics



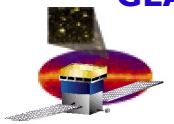
Dark Matter Search: The EGRET Excess

For illustration, one DM scenario to try to explain the GeV Excess :

d**e Boer, astro-ph/0412620 (2004)** "EGRET data show an intriguing hint of DM annihilation"



- ***Beware the diffuse model adopted!***
- **GLAST will investigate this excess with much better accuracy**



Halo Dark Matter Search with GLAST

- **Wimp Annihilations in halo Clumps (b >|10| deg):**
  - **gamma continuum from pions @ ~100 MeV**
  - **lines (2 γ, γZ)**
  - **Depends on models of clumps**
  - **Parallel Session 1 on Friday**

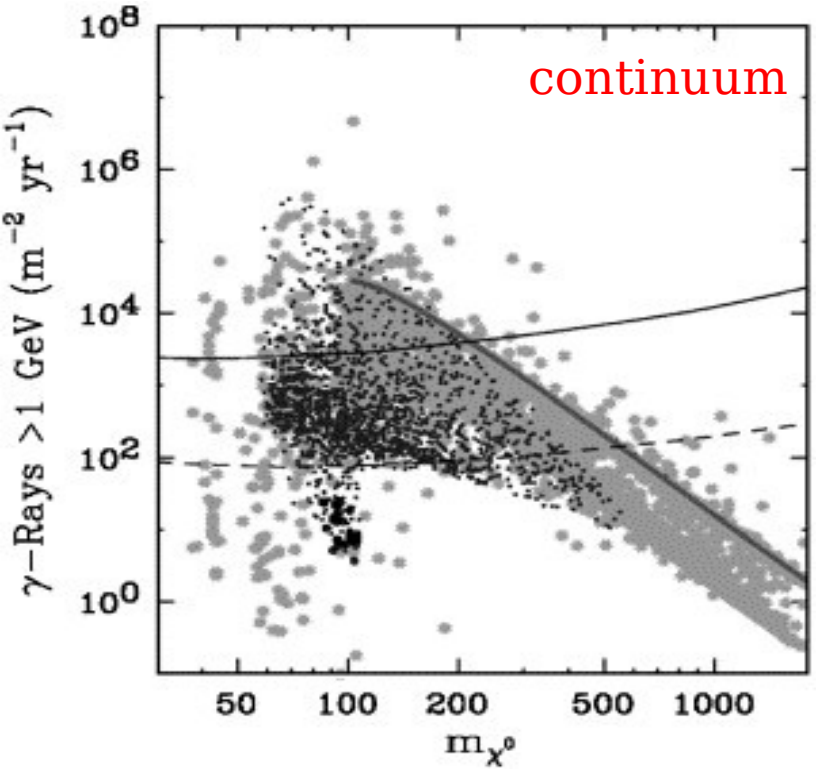
- **IC from secondary electrons (Baltz & Wai 04)**
  - **>GeV IC from e + starlight**
  - **near galactic plane < 30 deg (trapping by B field)**

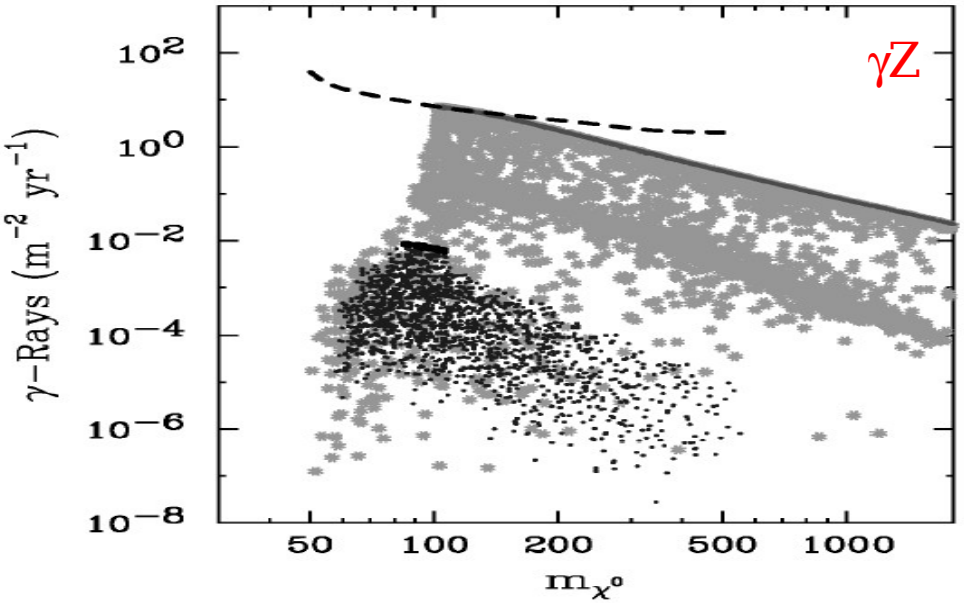
- **KK DM Scenario – electron "line" (20% Br) smeared into a sharp edge via mainly IC**
  - **>500 GeV: ~ 100$e^{\pm}$/year edge height (Baltz & Hooper 05)**
  - **all-sky signature!**
  - **See talk by Tim Tait tomorrow**

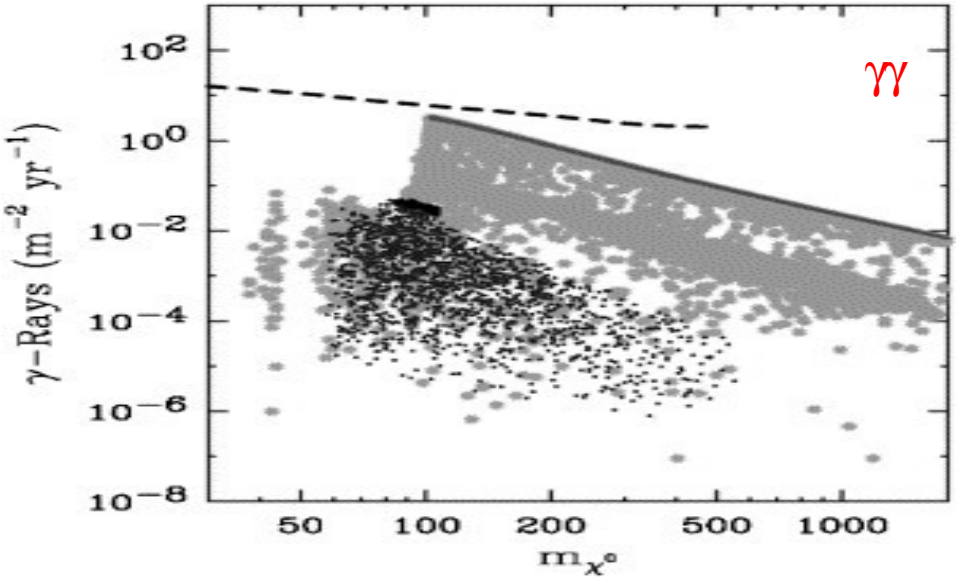
GLAST Sensitivity to DM signals

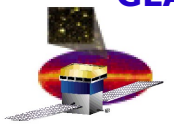
- From Hooper & Wang (2004)
- Very dependent on clump density profile
- See e.g. Ted Baltz's talk tomorrow

Predictions are quite uncertain!









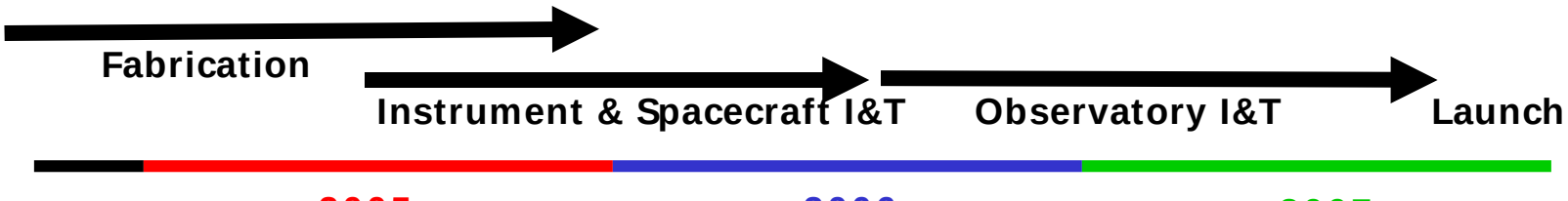
Operation Phases

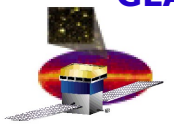
- After the initial on-orbit checkout, verification, and calibrations, the first year of science operations will be an all-sky survey.
  - first year data used for detailed instrument characterization, refinement of the alignment, and key projects (source catalog, diffuse background models, etc.) needed by the community.
  - data on transients will be released, *with caveats.*
  - *repoints for bright bursts and burst alerts enabled.*
  - *extraordinary Targets of Opportunities* supported.
  - *limited first-year guest observer program*
  - workshops for guest observers on science tools and mission characteristics for proposal preparation
- Observing plan in subsequent years driven by guest observer proposal selections by peer review. All data released through the science support center (GSSC).

The Look Ahead

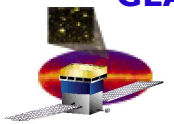
- The GLAST mission is
  - completing the fabrication phase and
  - is well into integration.
- LAT, GBM, and spacecraft assembly
  - complete by early 2006.
- Delivery of the LAT and GBM instruments
  - for observatory integration in spring 2006.
- Observatory integration and test
  - spring 2006 through summer CY07.
- Major scientific conference,
  - the First GLAST Symposium, being planned for early 2007.

Launch Scheduled August 2007!





Backup Slides



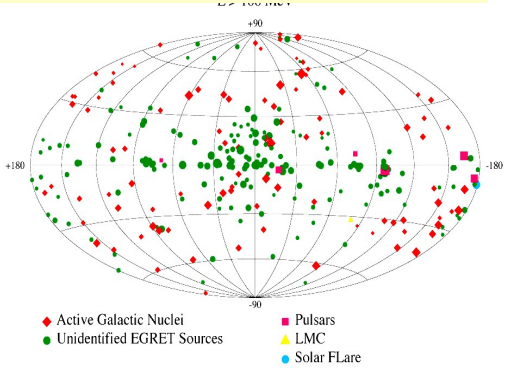
GBM Specifications

PARAMETER	REQUIREMENT	GOAL	CURRENT CAPABILITY
Energy Range	10 keV -- 25 MeV	5 keV -- 30 MeV	~ 8 keV -- 30 MeV
Energy Resolution	20% FWHM at 511 keV	(no stated goal)	12% FWHM at 511 keV
Time resolution	10 μsec	2 μsec	2 μsec
On-board GRB Locations	15 ^{o} accuracy (1 σ radius) within 2 sec	10 ^{o} within 1 sec	<15 ^{o} in 1.8 sec (<8 ^{o} for S/C < 60 ^{o} zenith)
Rapid ground GRB Locations	5 ^{o} accuracy (1 σ radius) within 5 sec	3 ^{o} within 1 sec	TBD by analysis (scattering influenced)
Final GRB Locations	3 ^{o} accuracy (1 σ radius) within 1 day	(no stated goal)	TBD by analysis (scattering influenced)
GRB sensitivity (on ground)	0.5 photons $cm^{2}s^{-1}$ (peak flux, 50--300 keV)	0.3 photons $cm^{2}s^{-1}$ (peak flux, 50--300 keV)	~0.4 photons $cm^{2}s^{-1}$ (peak flux, 50--300 keV)
GRB on-board trigger sensitivity (50% efficiency)	1.0 photons $cm^{2}s^{-1}$ (peak flux, 50--300 keV)	0.75 photons $cm^{2}s^{-1}$ (peak flux, 50--300 keV)	0.71 photons $cm^{2}s^{-1}$ (peak flux, 50--300 keV
Field of view	8 steradians	10 steradians	9.5 steradians
Deadtime	<10 μsec/count	<3 μsec/count	<2 μsec/count

Performance : LAT/EGRET

3rd EGRET Catalog

E > 100 MeV



EGRET

Pointing

1991- 1999

LAT

All sky

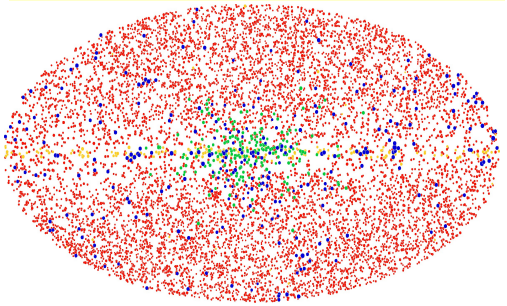
2007 - ?

5 yr operation requirement

10 yr operation goal

LAT Simulation

E > 100 MeV



Improvement

	EGRET	LAT	Improvement
Energy	30 MeV - 30 GeV	20 MeV - 300 GeV	
Peak effective area	1500 cm^2	> 8000 cm^2	> 5
Field of view	0.5 sr	> 2.0 sr	> 4
Sensitivity (1yr)	~ 10^{-7} γ cm^{-2} s^{-1}	< 6 10^{-9} γ cm^{-2} s^{-1}	> 20
Localization (bright source)	15 '	< 0.5 '	> 30
Deadtime	100 ms	< 30 μs	> 1000

Large area
Low instrumental background
No consumable

Particle Acceleration : Site for UHE protons?

Large scale shock (~1Mpc): Slow accel. over >1Gy ⇒ Only *p* reaches UHE

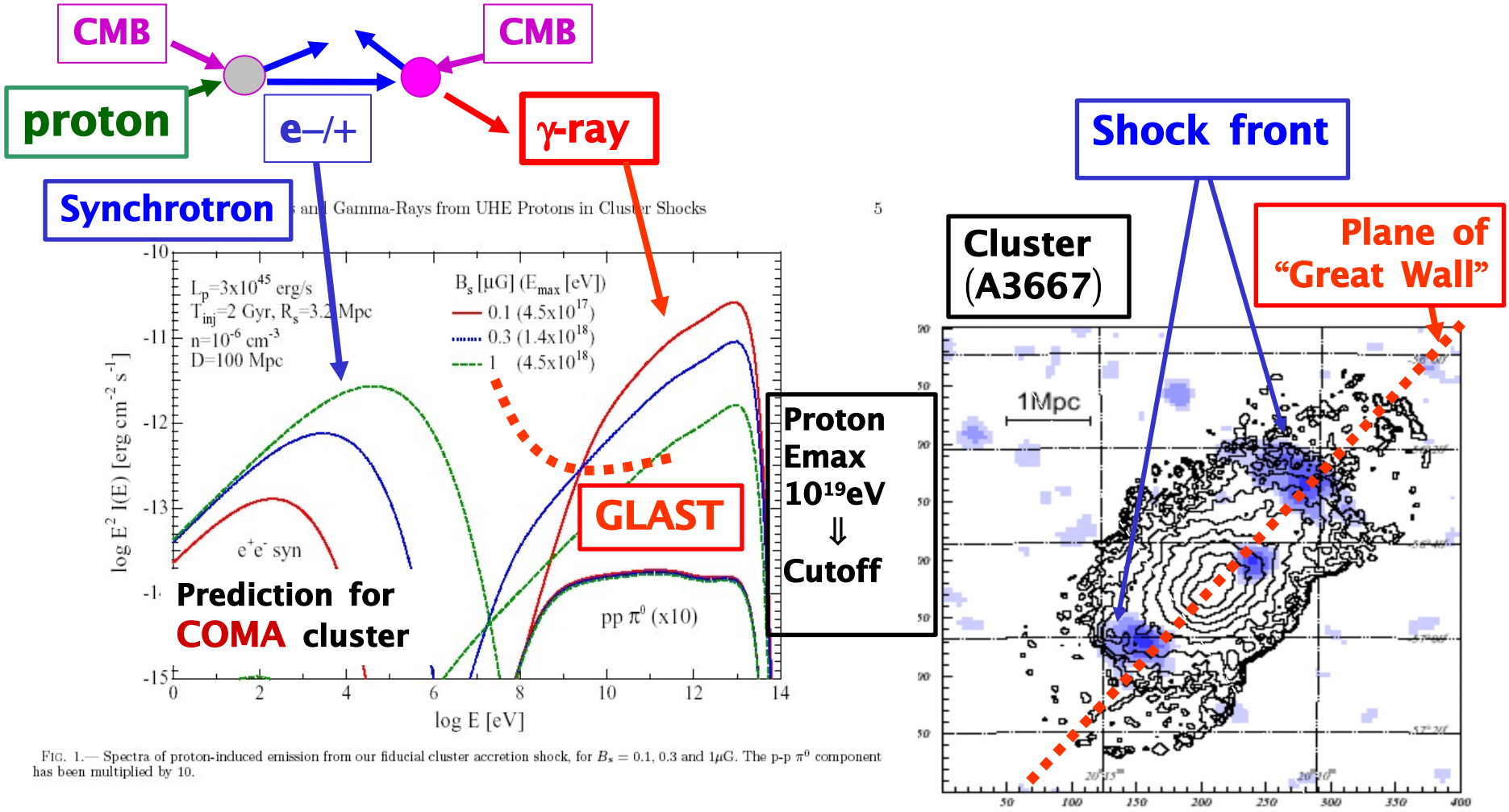


FIG. 1.— Spectra of proton-induced emission from our fiducial cluster accretion shock, for B_s = 0.1, 0.3 and 1μG. The p-p π^0 component has been multiplied by 10.