

Galactic sources between 1 GeV and 1 TeV

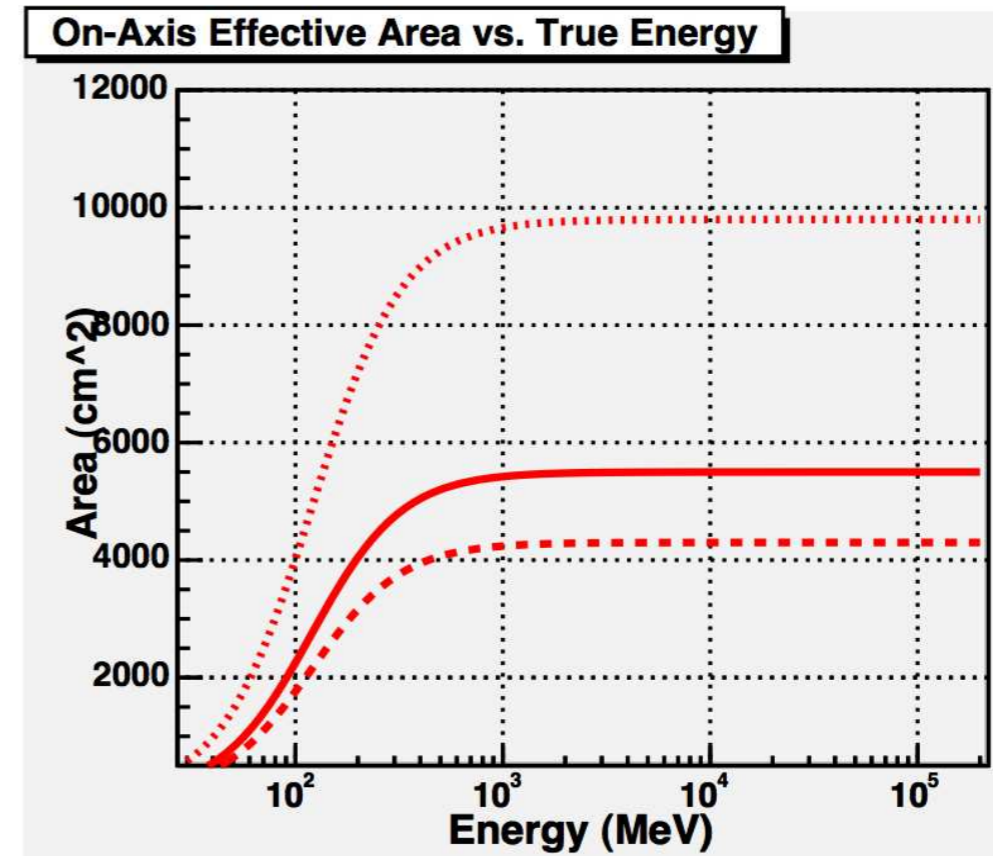
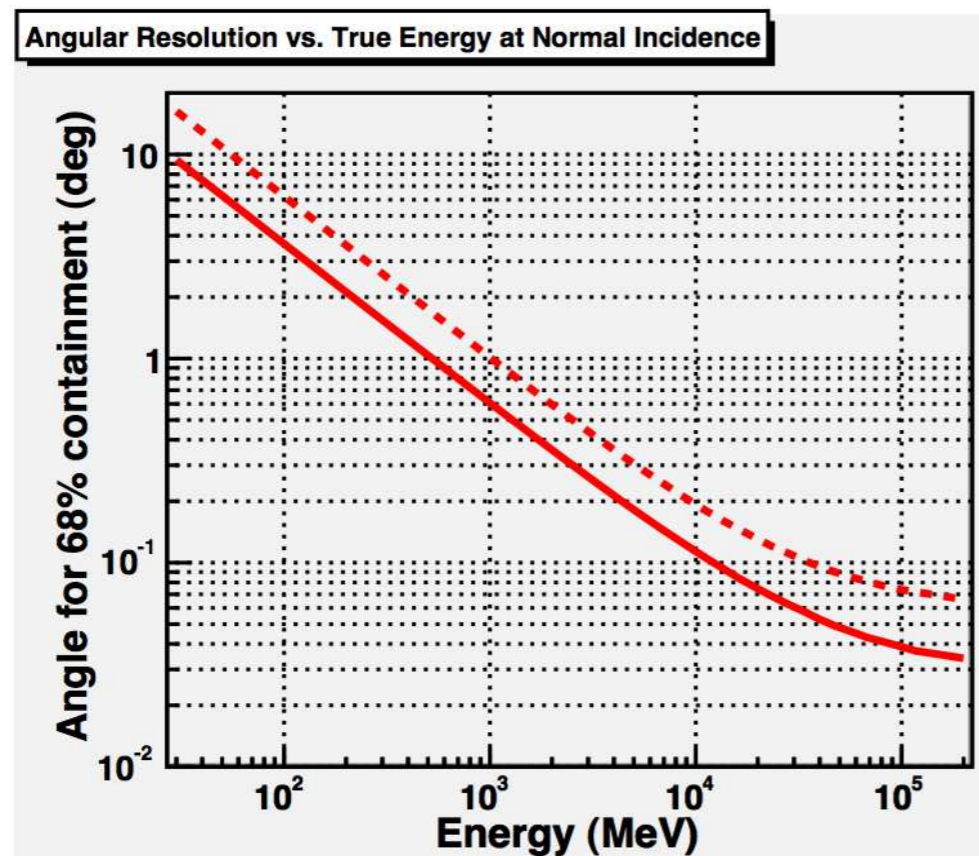
Martin Pohl

Iowa State University

Outline

- **Capabilities of GLAST and ACT-2005**
- **Expected results for different source classes**
- **Important scientific questions**
- **Possible punchlines for a future observatory**

Capabilities: GLAST



Background : galactic plane

$$E I(E) \simeq E_{0.1}^{-1} (5 \cdot 10^{-4} \text{ cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1})$$

Duty cycle $\eta \simeq 0.8$

$$\text{Total efficiency } X = \eta A_{\text{eff}} \frac{\Omega}{4\pi} \simeq 1000 \text{ cm}^2 \text{ @ } 1 \text{ GeV}$$

Capabilities: ACT-2005

$$\text{PSF } \theta(68\%) \simeq 0.1^\circ \qquad \text{FOV} \qquad \Omega \simeq 4 \cdot 10^{-3} \text{ sr}$$

$$A_{\text{eff}}(300 \text{ GeV}) \simeq 10^9 \text{ cm}^2$$

$$\text{Background : cosmic rays} \qquad E I(E) \simeq E_{100}^{-1.7} (2 \cdot 10^{-10} \text{ cm}^{-2} \text{ s}^{-1} \text{ psf}^{-1})$$

$$\text{Duty cycle } \eta \simeq 0.08 \qquad \text{Total efficiency } X = \eta A_{\text{eff}} \frac{\Omega}{4\pi} \simeq 25.000 \text{ cm}^2 \text{ @ } 300 \text{ GeV}$$

Event rate similar to GLAST at 25 GeV for $\alpha = -1.3$ sources!

AC sources: variability timescales

Above a few GeV GLAST is background-free

→ **Three photons are a flare!**

Detectable flux $EF \simeq t_h^{-1} (10^{-6} \text{ cm}^{-2} \text{ s}^{-1})$

ACT-2005: flux doubling from $EF(300 \text{ GeV}) = (10^{-10} \text{ cm}^{-2} \text{ s}^{-1})$

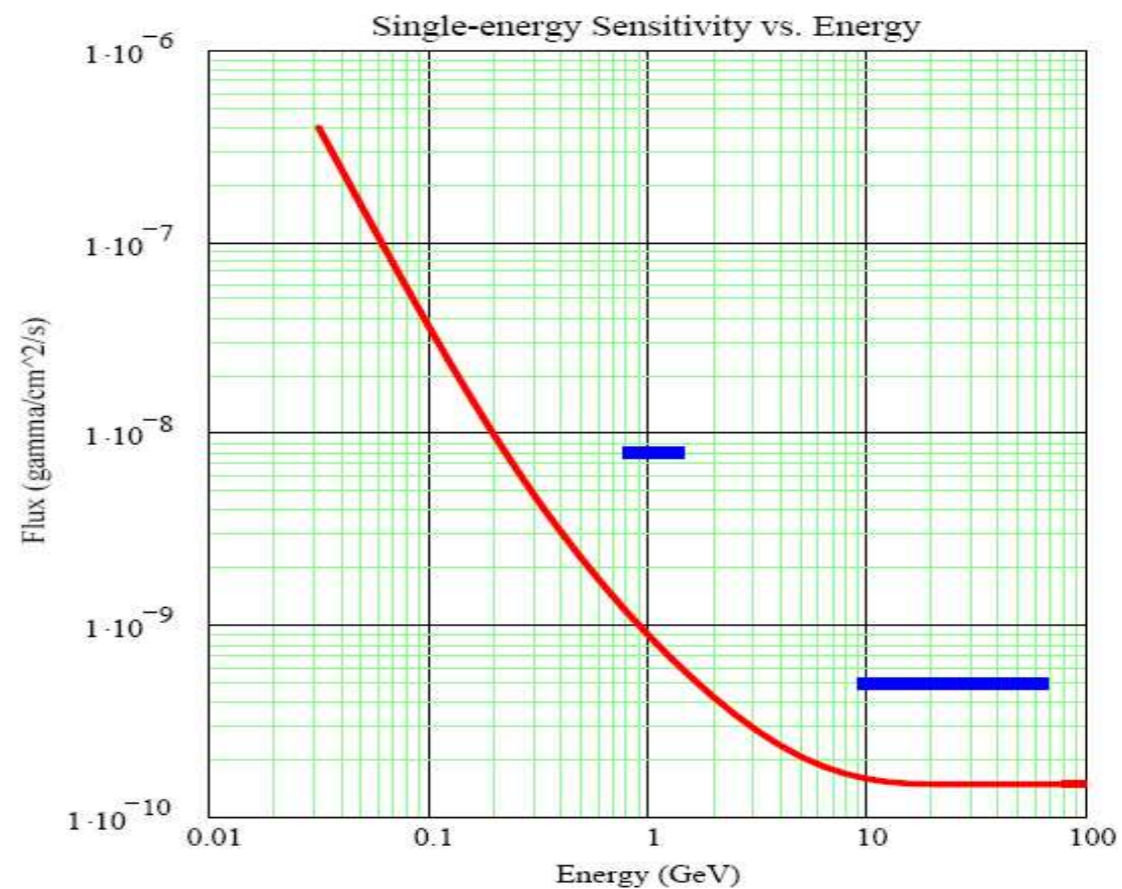
5 σ in 6 minutes!

DC sources: point sources anywhere in one year

GLAST:

Any source!

Blue: in Galactic Plane



ACT-2005: only 700 hours \rightarrow obs. prob. $P_{\text{obs}} \simeq 0.16 \left(\frac{t_{\text{obs}}}{h}\right)^{-1}$

Sensitivity $F_S(250 \text{ GeV}) \gtrsim (10^{-10} \text{ cm}^{-2} \text{ s}^{-1}) \left(\frac{t_{\text{obs}}}{h}\right)^{-0.5}$

At 100 GeV GLAST is the better survey instrument!

DC sources: extended sources anywhere in one year**GLAST:** psf width $\theta(10 \text{ GeV}) \simeq 0.15^\circ$

$$E I_S(1 \text{ GeV}) \gtrsim 5 \cdot 10^{-9} \text{ cm}^{-2} \text{ s}^{-1} \text{ deg}^{-2} \qquad E I_S(10 \text{ GeV}) \gtrsim 7 \cdot 10^{-9} \text{ cm}^{-2} \text{ s}^{-1} \text{ deg}^{-2}$$

$$E I_S(100 \text{ GeV}) \gtrsim 1.3 \cdot 10^{-8} \text{ cm}^{-2} \text{ s}^{-1} \text{ deg}^{-2}$$

ACT-2005: $E I_S(250 \text{ GeV}) \gtrsim \left(\frac{t_{\text{obs}}}{h}\right)^{-0.5} (3 \cdot 10^{-9} \text{ cm}^{-2} \text{ s}^{-1} \text{ deg}^{-2})$

Suppose $I_S \propto E^{-2}$ and $t_h \simeq 6 \text{ h}$ **At 30 GeV GLAST does deeper imaging than ACT-2005!**

Expected results per source class

SNR/PWN:

Spectral imaging on 0.1° -scale between 20 GeV and 10 TeV

Not fully done!

RX 1713 has on average $E I_S(250 \text{ GeV}) \simeq 3 \cdot 10^{-10} \text{ cm}^{-2} \text{ s}^{-1} \text{ deg}^{-2}$

100 h with ACT-2005

GLAST at 10 GeV $\rightarrow \theta \gtrsim 0.15^\circ$

Size of nonthermal structures in X-rays: $\theta_X \lesssim 0.01^\circ$!

Pulsars:

If ephemerides are known, GLAST is efficient at $\gtrsim 10$ GeV

$$E F = 3 \cdot 10^{-9} \text{ cm}^{-2} \text{ s}^{-1}$$

→ 10-bin lightcurve with 10 events per bin in one year

ACT-2005 doesn't have enough sensitivity below 50 GeV!

Diffuse emission/Molecular clouds:

Isolated molecular clouds measure CR flux at defined location

Example: Mon R2 $E I_S(1 \text{ GeV}) \simeq 10^{-8} \text{ cm}^{-2} \text{ s}^{-1} \text{ deg}^{-2}$

If no GeV excess:

$$E I_S(10 \text{ GeV}) \simeq 2.5 \cdot 10^{-10} \qquad E I_S(100 \text{ GeV}) \simeq 5 \cdot 10^{-12}$$

GLAST below a few GeV $\rightarrow \theta \gtrsim 0.6^\circ$

ACT-2005 doesn't have enough sensitivity!

Microquasars/compact binaries:

Wouldn't know what to say, if we hadn't observed two.....

PSR B1259-63 would have been seen by GLAST

at 1 GeV within a day

LS 5039 would have been seen by GLAST

at 0.5 GeV within two months

at 5 GeV within a year

New galactic source classes:

Already have about 100 in EGRET catalogue!

Will have a few thousand more with GLAST....

3EG sources can be localized to 1 arcmin in a year...

Will identify OB-ass., stellar binaries, whatever!

Dark matter:

Must be lucky to see line

Must be lucky to unambiguously identify continuum

Important scientific questions:

- Dark matter
- Particle acceleration
- Black holes
- Cosmic-ray origin
- Variability of earth radiation environment

Dark matter:

What is a clear signal?

A gamma-ray line around 100 GeV

A fitting continuum component that is not related to gas and not IC
→ otherwise dark hot spots!

GLAST would see them

if degree-sized and 50% of high-latitude intensity at a few GeV.

Most likely they are weaker

Particle acceleration:

We want to know: where, when, and to what spectrum.

Needs spatial and temporal correlation studies with X-rays etc.

Applies to SNR as well as compact sources!

Extrapolate to AGN, GRB, etc.

X-rays: relevant scales are sub-arcmin and sub-hour

Black holes

Where do the $\gtrsim 10^6 M_{\odot}$ black holes in galactic centers come from?

- primordial?
- grown from stellar-mass black holes?

Where are the intermediate-mass black holes?

absorbed at X-rays and in radio?

Are there Kerr-Newman black holes?

collapse of massive magnetized rotating stars

pair-wind with $P \approx 10^{32}$ erg/s

Origin of cosmic rays

We will know many potential accelerators in the galaxy.

How to distinguish?

Measure CR flux in vicinity of accelerators

How much does the CR flux vary in the Galaxy?

Measure CR flux at various locations

Are there GRB remnants in the galaxy?

Would be gamma-ray hot spots

Variability of earth radiation environment

We want to measure

- The amplitude and frequency of CR flux variations
- The frequency of extreme events like GRBs

We would infer changes in the earth radiation environment

Compare with geological records of radiation environments

- We may disentangle solar and external causes for variations
→ Important for climate history studies
- We may find causes for faunal cuts

Needed for future observatory:

(In order of importance)

- Increase the Field-of-view by factor 10

Allows to access whole sky in a year

Much larger detection potential

Directly improves sensitivity for DC sources

- Increase the effective area by factor 5!

Improve sensitivity for campaign sources

Allows good imaging on psf-scales

- Lower the energy threshold to about 20 GeV

Links to GLAST results for DC sources
Important for diffuse emission and dark matter

- Reduce cosmic-ray background intensity

Reduces systematics
Improves sensitivity

- Improve PSF

Arcmin-scales imaging of bright SNR
Improves sensitivity for compact sources