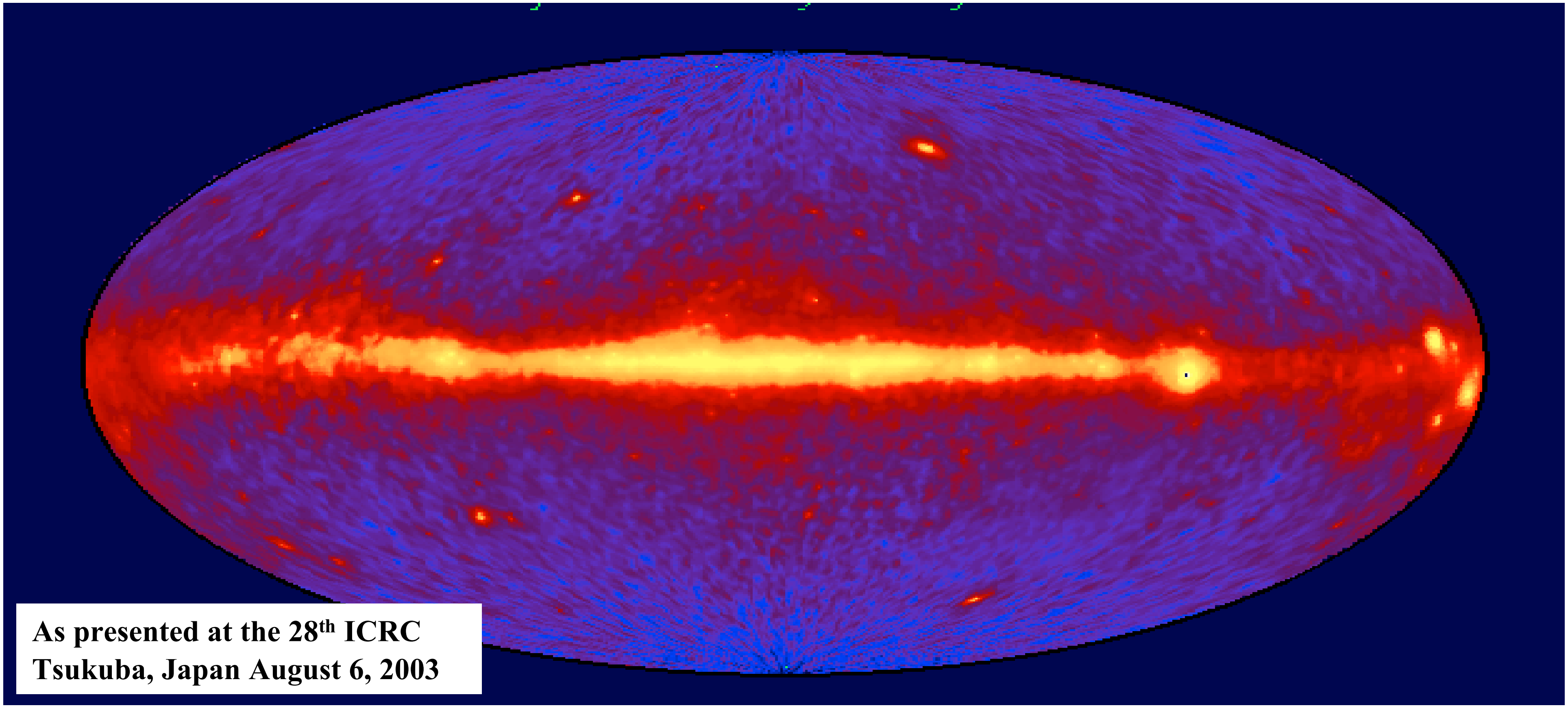
Diffuse TeV Gamma Rays from the Galactic Plane with Milagro

Brenda Dingus
For the Milagro collaboration
(Roman Fleysher/NYU PhD. Thesis)



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The Milagro Collaboration

R. Atkins,[1] W. Benbow,[2,9] D. Berley,[3] E. Blaufuss,[3] J. Bussons,[3,10] D. G. Coyne,[2] T. DeYoung,[2,3] B. L. Dingus,[7] D. E. Dorfan,[2] R. W. Ellsworth,[4] L. Fleysher,[6] R. Fleysher,[6] G. Gisler,[7] M. M. Gonzalez,[1] J. A. Goodman,[3] T. J. Haines,[7] E. Hays,[3] C. M. Hoffman,[7] L. A. Kelley,[2] J. E. McEnery,[1,11] R. S. Miller,[5] A. I. Mincer,[6] M. F. Morales,[2,12] P. Nemethy,[6] D. Noyes,[3] J. M. Ryan,[5] F. W. Samuelson,[7] A. Shoup,[8] G. Sinnis,[7] A. J. Smith,[3] G. W. Sullivan,[3] D. A. Williams,[2] S. Westerhoff,[2,13] M. E. Wilson,[1] X. Xu[7] and G. B. Yodh[8]

[1] University of Wisconsin, Madison, WI 53706

[2] University of California, Santa Cruz, CA 95064

[3] University of Maryland, College Park, MD 20742

[4] George Mason University, Fairfax, VA 22030

[5] University of New Hampshire, Durham, NH 0382

[6] New York University, New York, NY 10003

[7] Los Alamos National Laboratory, Los Alamos, NM

[8] University of California, Irvine, CA 92717

[9] Now at Max Planck Institute, Heidelberg, Germany

[10] Now at Universite de Montpellier II, Montpellier, France

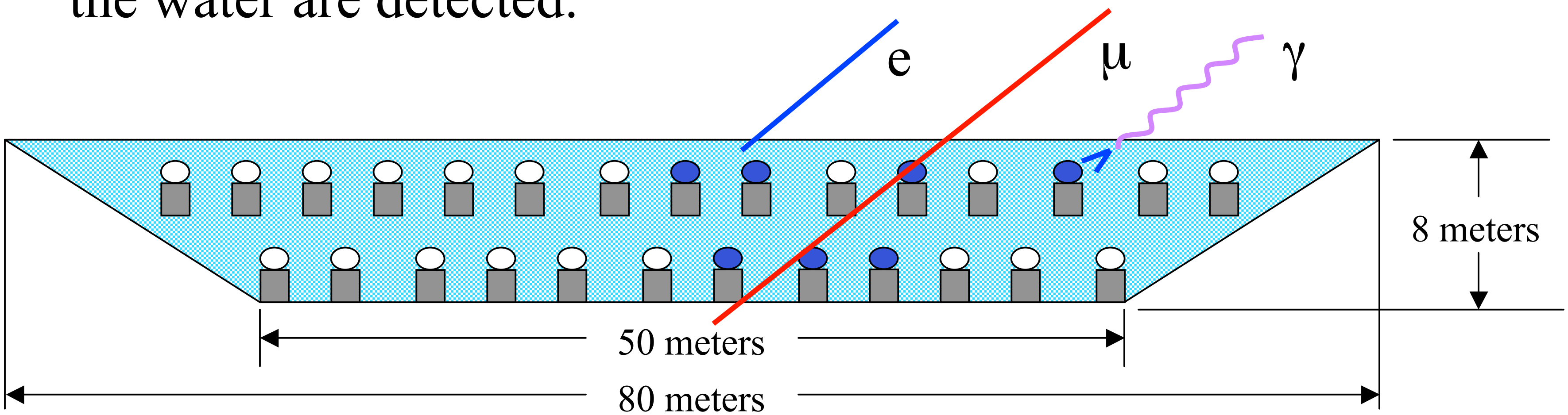
[11] Now at NASA Goddard Space Flight Center, Greenbelt, MD 2(

[12] Now at Massachusetts Institute of Technology, Cambridge, MA

[13] Now at Columbia University, New York, NY 10027

Milagro Schematic

- Use water to detect Extensive Air Shower particles
- 100% of the area is sensitive so ~50% of all particles hitting the water are detected.

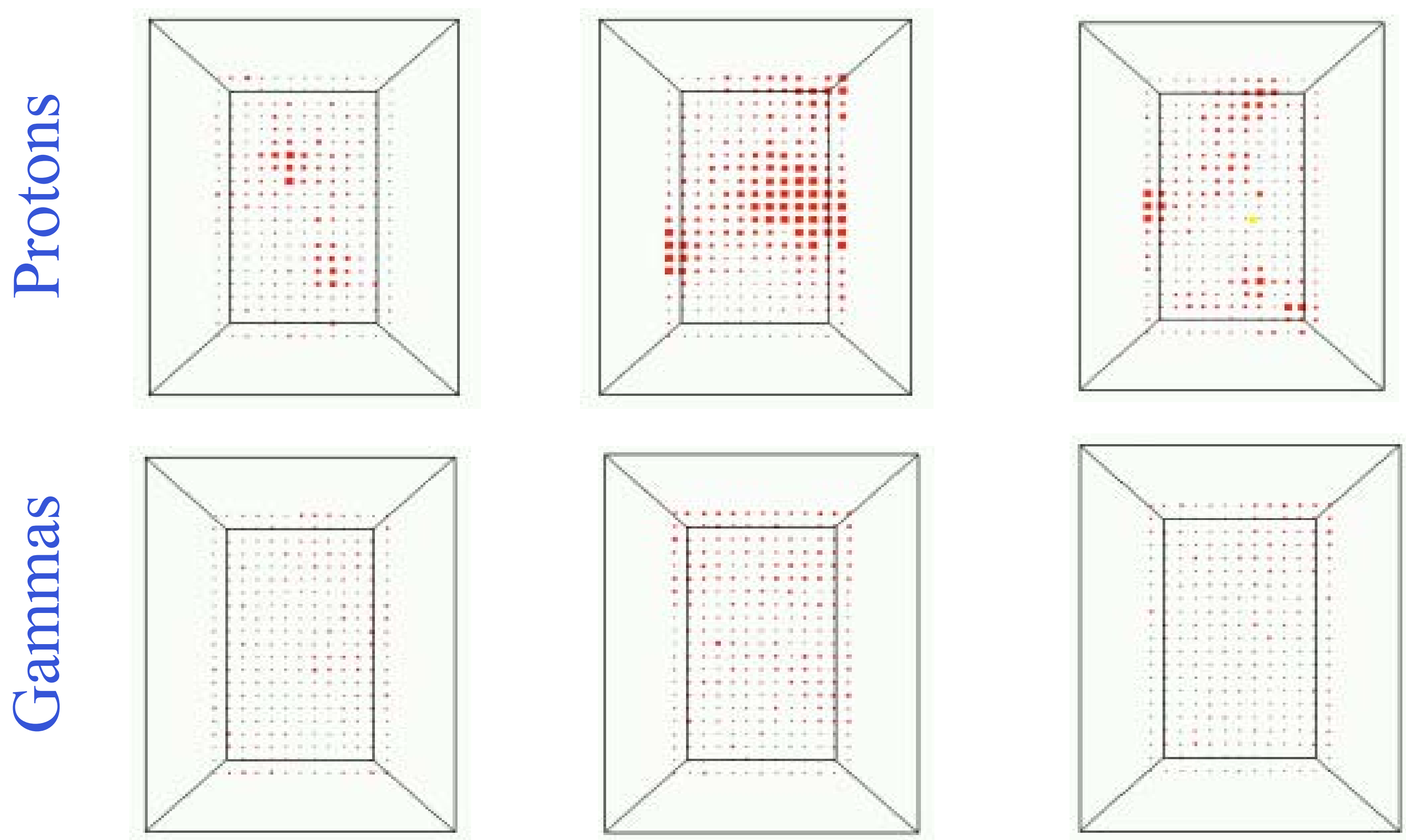


Median energy ~2.5 TeV (for this analysis)
High duty cycle (~90%)
Large field of view (~2 sr)
Good background rejection (~90%)
Trigger Rate 1.7 kHz

Milagro Detector

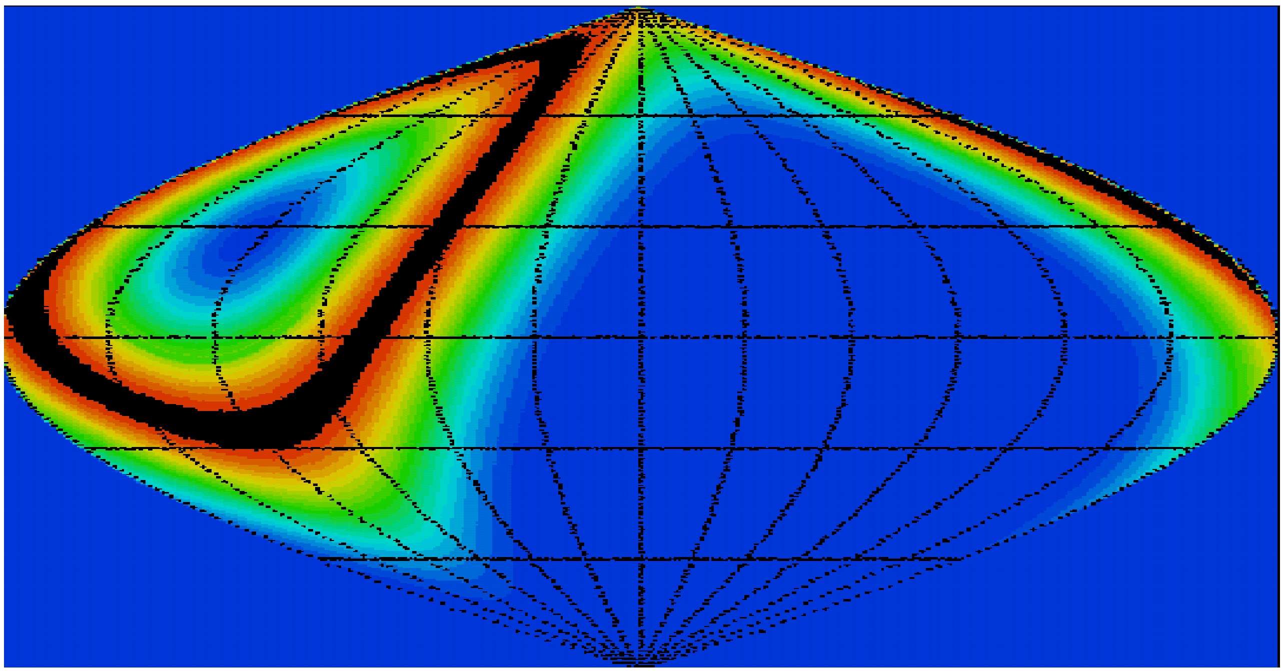
Background Rejection in Milagro

- Hadronic cosmic ray showers contain penetrating particles
  - Muons and hadrons
- Deposit energy deep in Milagro – use bottom layer



Diffuse Emission from The Galaxy

2 Years of Data: 12/00-12/02
Milagro Exposure to Galaxy

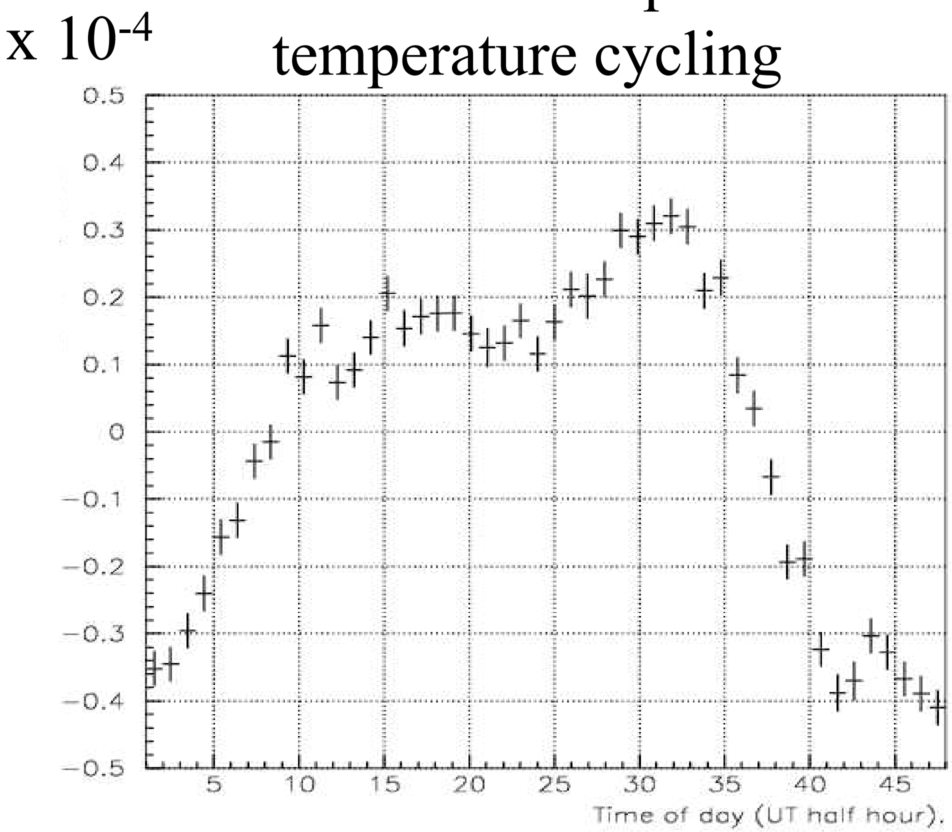


Inner galaxy: 20-100 degrees
Outer galaxy: 140-220 degrees
Gamma-ray cut applied to data

Background Estimation

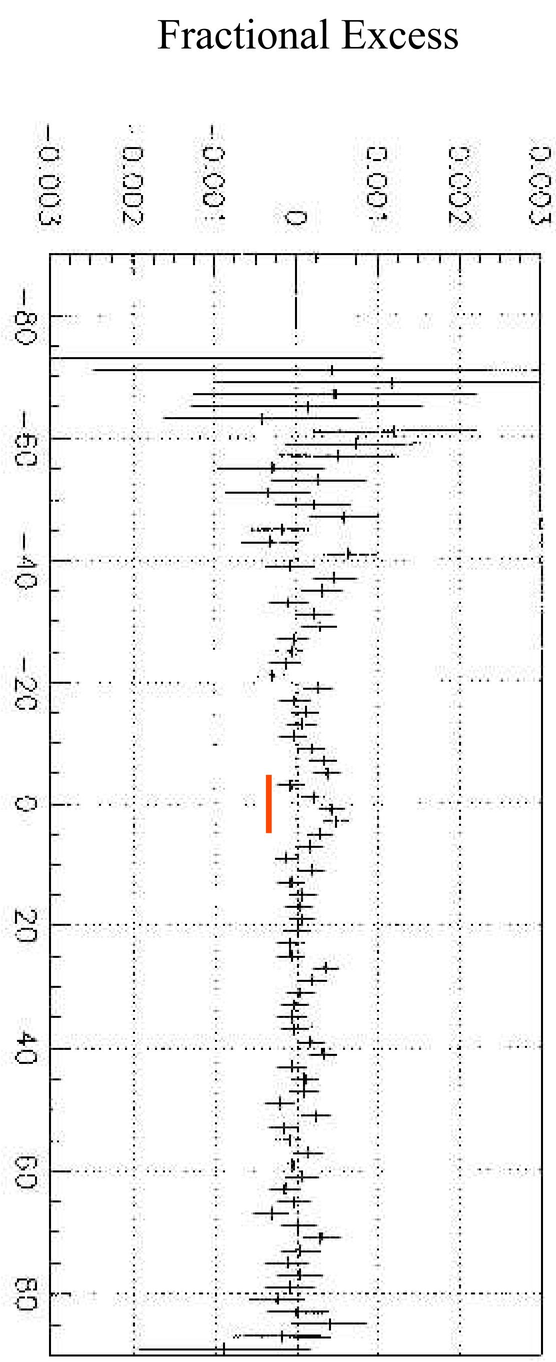
- **721 days of data analyzed**
  - Nfit > 20, zenith angle < 50°,C>2.5
- **Background estimation**
  - Extended source requires modification of our standard technique
  - Use data taken at different time with same local coordinates.
  - Use 8 hours of data to obtain background
  - Correct for changing response of detector (breathing of atmosphere)
  - Remove source region from background estimate

Effect of atmospheric temperature cycling

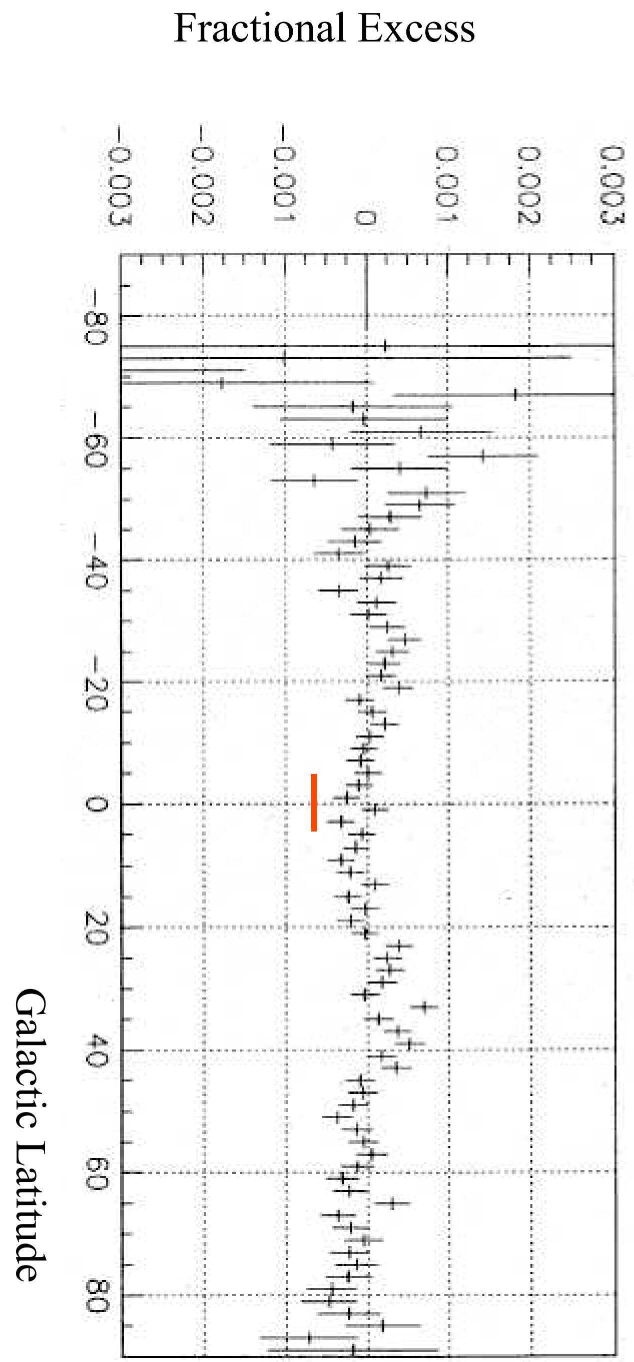


Time of Day UT (1/2 hr bins)

Results: Latitude Profile



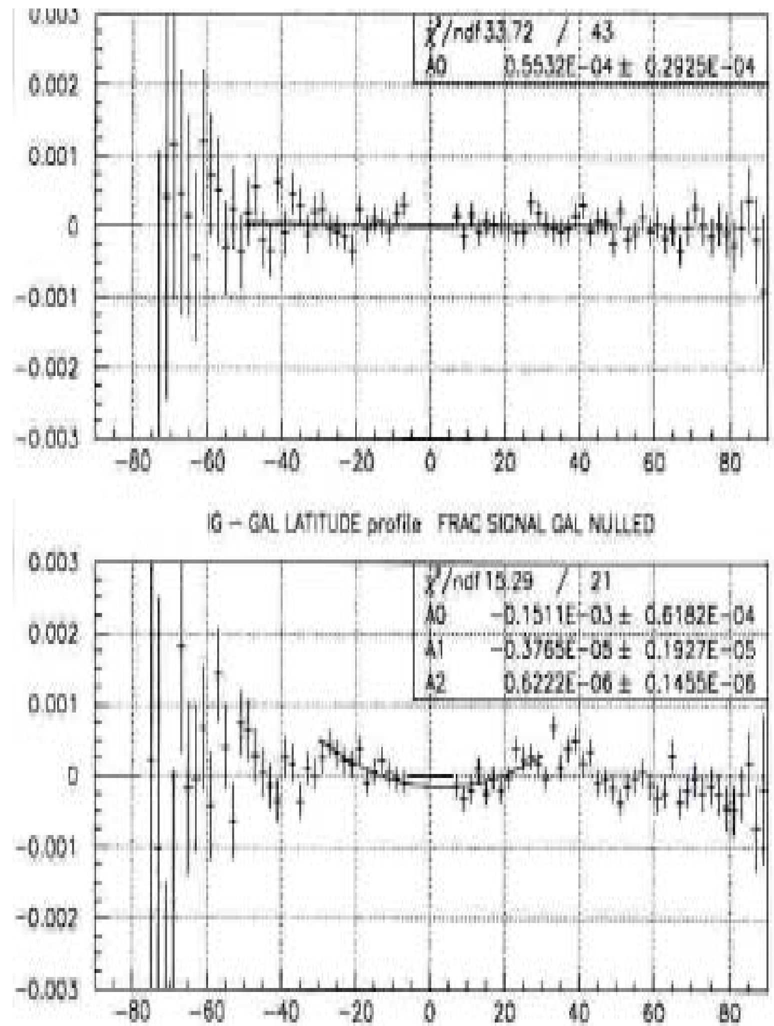
Inner Galaxy
20°<b<100°



Outer Galaxy
140°<b<220°

Investigation of Systematic Effects

- Independent analysis performed
  - Different implementation of background estimation method
- Large scale anisotropy present?
  - Fit latitude profile (excluding galactic plane)
- Global check of entire analysis
  - Repeat analysis with data not passing γ-ray cut (10*x* the statistics)
  - Confirms ability to estimate background to 1 part in 10^5
  - Confirms the existence of a small contribution from a large-scale anisotropy

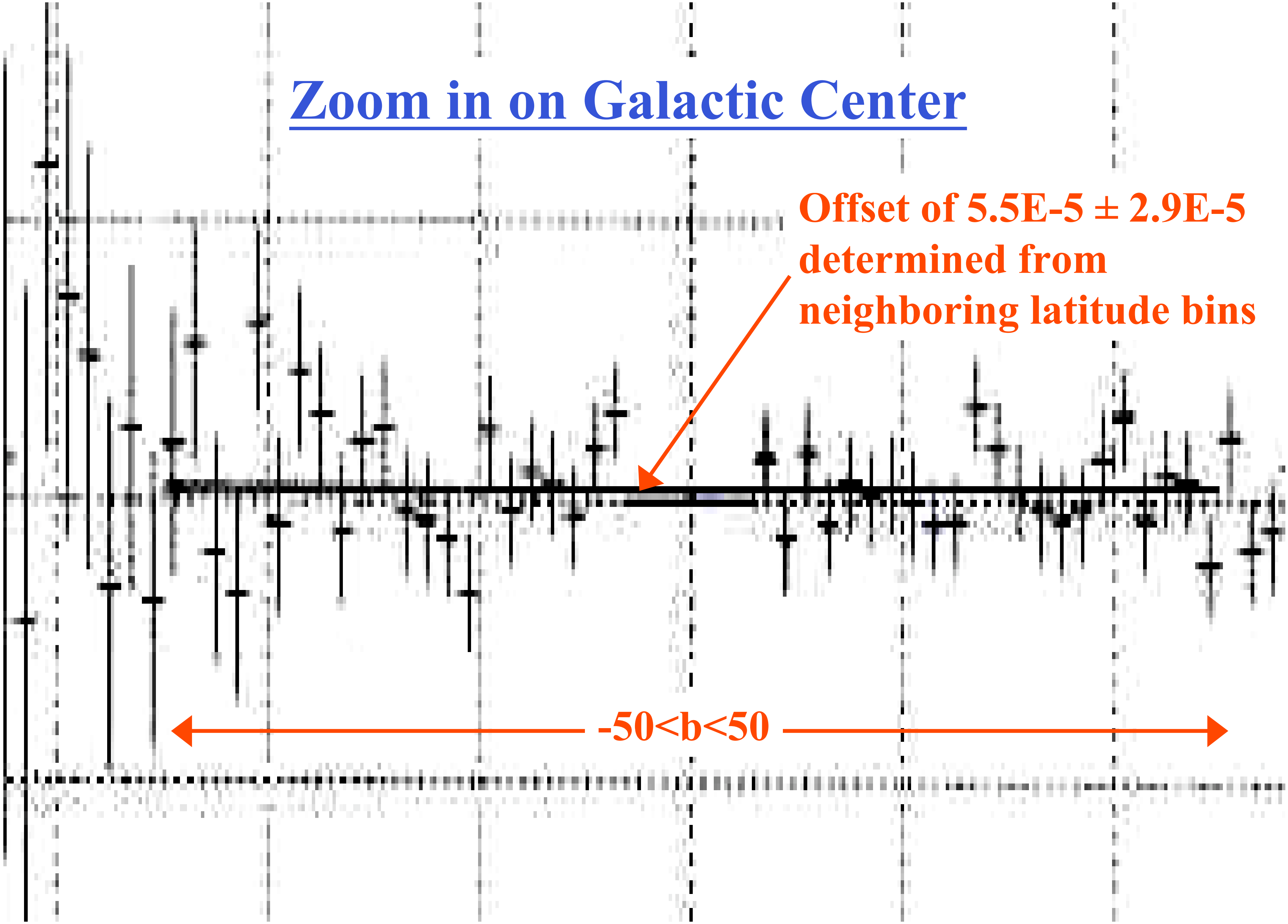


Inner Galaxy

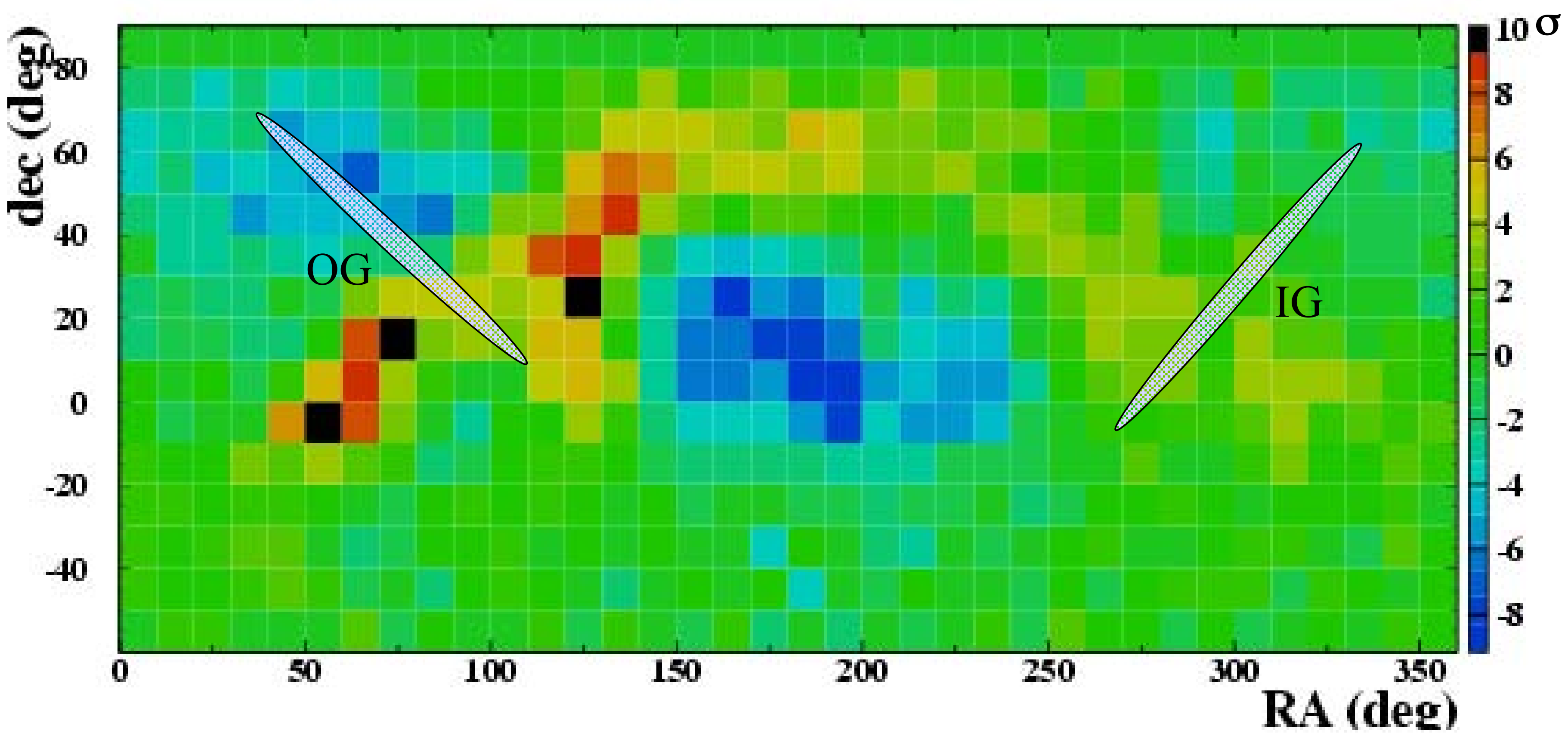
Outer Galaxy

Galactic Latitude

Zoom in on Galactic Center



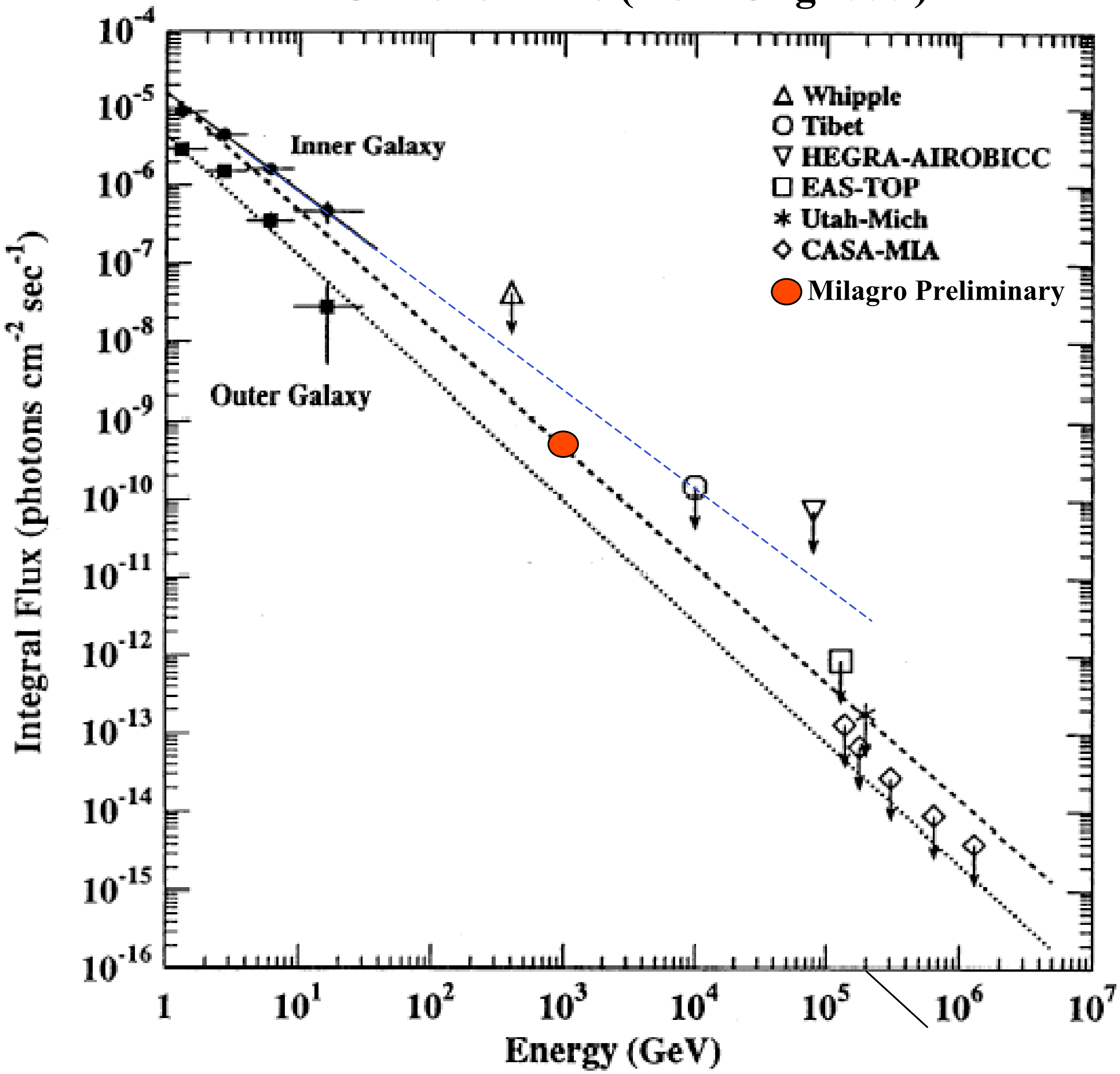
Global Cross Check
Without Gamma-Ray Cut on Data



Galactic Plane Results

	Inner Galaxy		Outer Galaxy	
	Raw	Subtracting Anisotropy	Raw	Subtracting Anisotropy
Excess/ Bkg	58,301/ 1.99×10^8 3.7σ	na	-20,790/ 2.12×10^8 -1.2σ	na
F_γ/F_{cr} $\times10^{-5}$	6.5 ± 1.8 $3.7\ \sigma$	3.1 ± 1.1 $2.8\ \sigma$	-2.2 ± 1.8 $-1.2\ \sigma$	1.1 ± 2.2 $0.5\ \sigma$
$F_\gamma(>1\ \text{TeV})$ $10^{-10}\ \text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$	na	5.3 ± 1.9 <8.0 (90% C.L.)	na	< 4.8 (90% CL)

Galactic Plane (from Ong 1999)



Cautionary Note

EGRET measurement averaged over different longitude band than Milagro measurement.

Conclusions

- Milagro observations of the galactic plane are the most sensitive at TeV energies
- Systematic errors are controlled to << 10^{-4}
- Indications of large scale anisotropy in cosmic-rays (non-gamma-ray) data
- Observed a signal of marginal statistical significance (2.8 σ) after the subtraction of a large scale anisotropy.
- Must wait for 2-3 more years of data for a solid detection

Background Rejection: *C*

Search for large pulses in small number of tubes

$$C = \frac{NBottom(>2Pes)}{PE_{Max}(Bottom)}$$

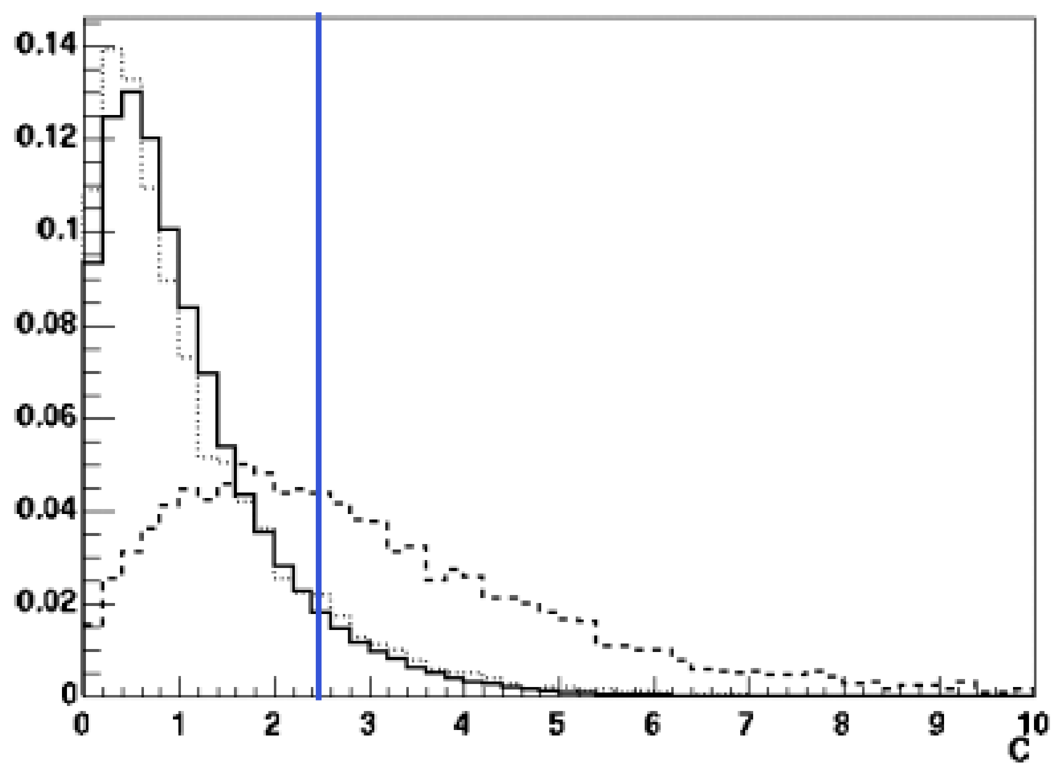
<u>Demand C > 2.5</u>

Retain:

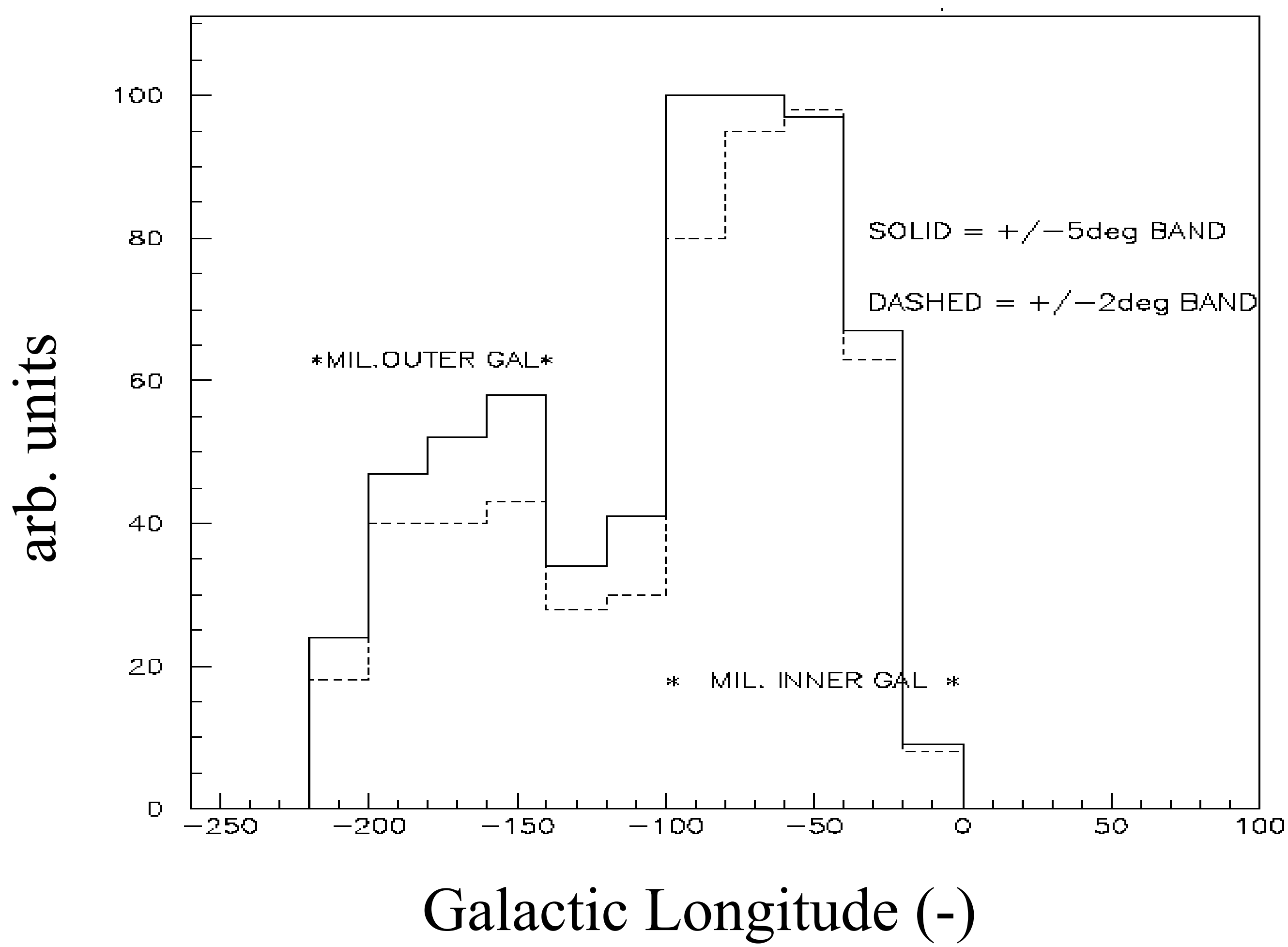
53% of Gammas

11% of Protons/Data

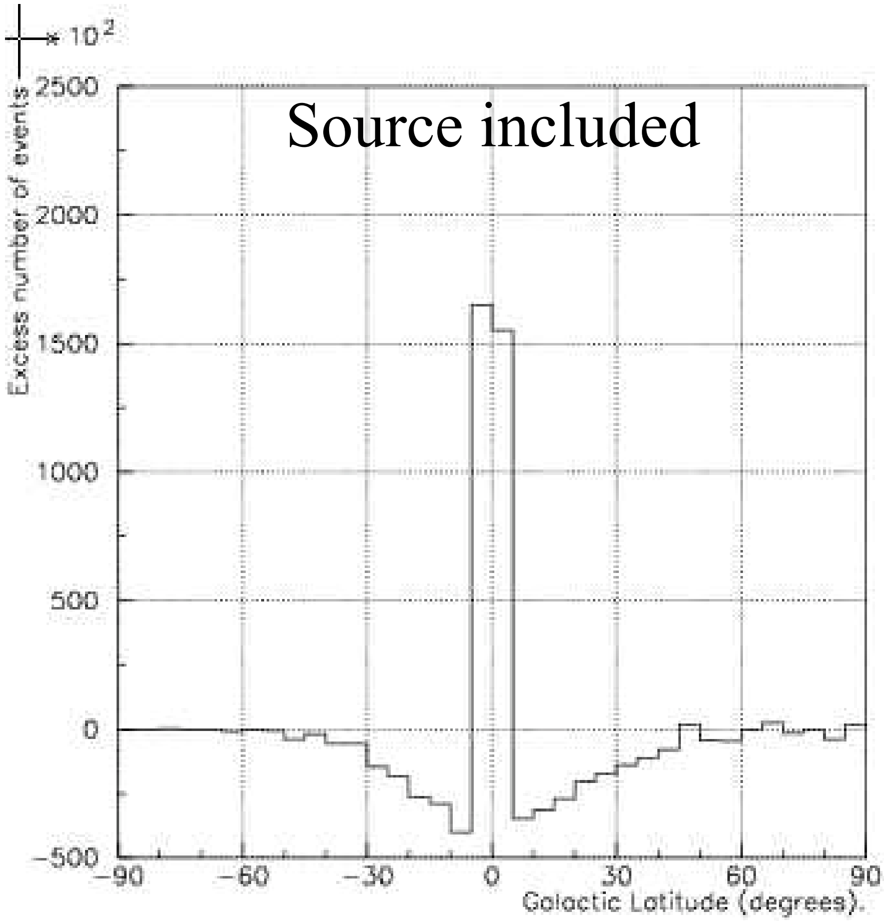
Q = 1.7

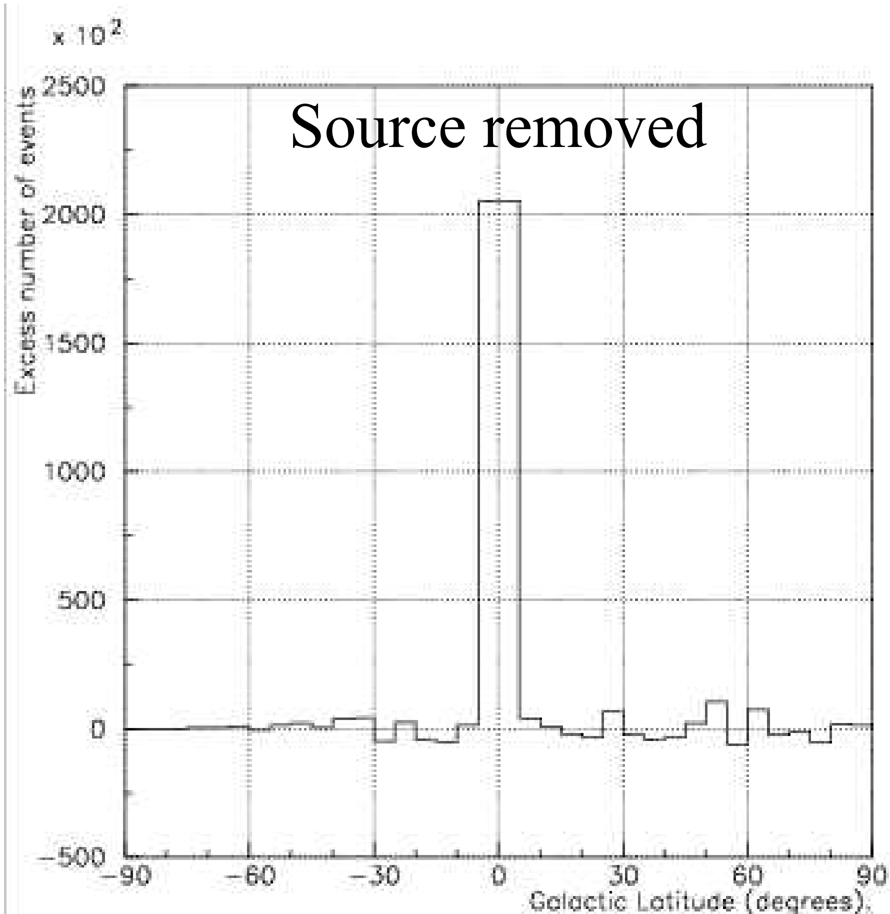


Expected Signal from EGRET



Removal of Source Region





- -25% effect on significance of observation
- Local distortion of background

Large Scale Anisotropy