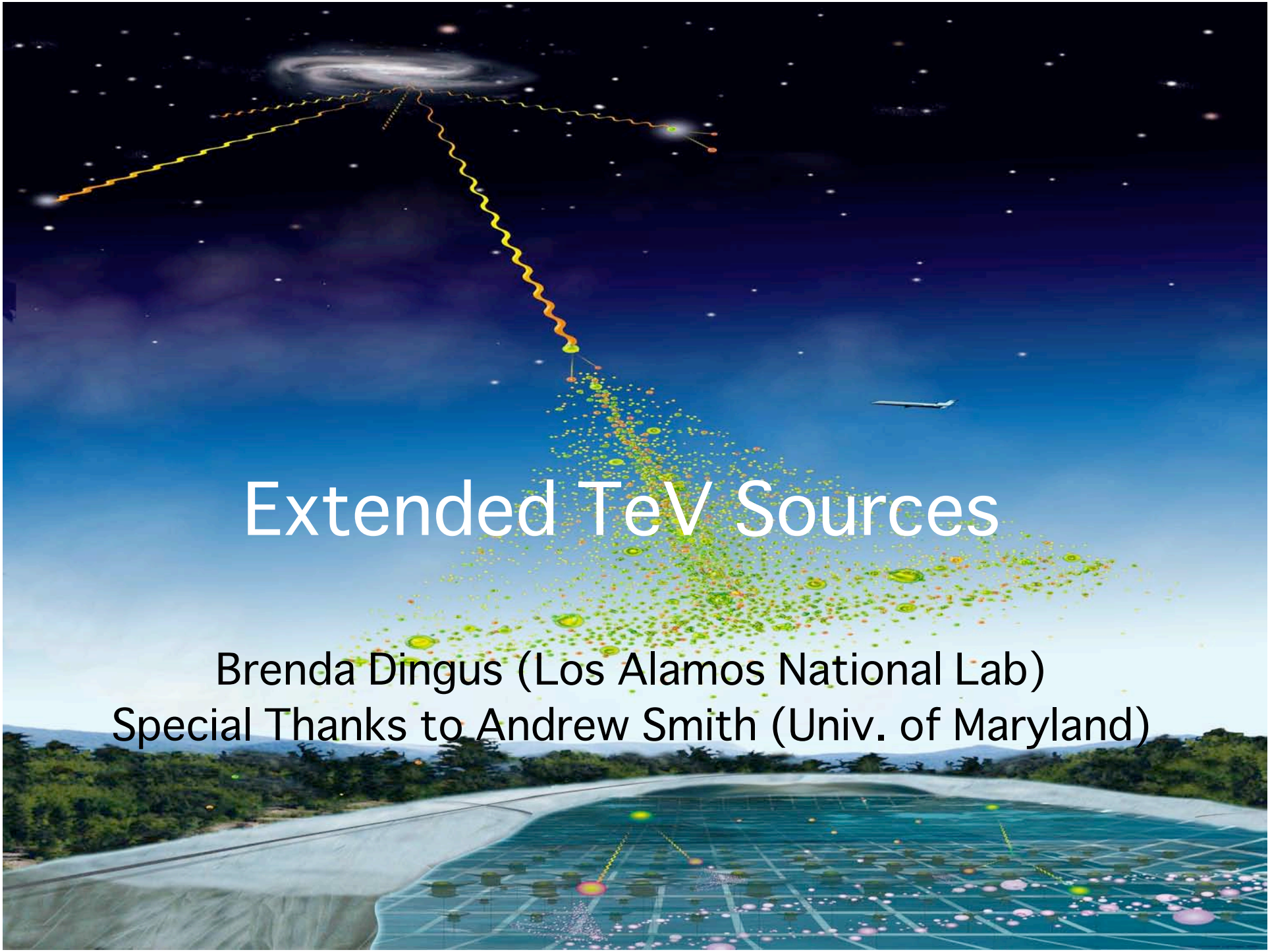


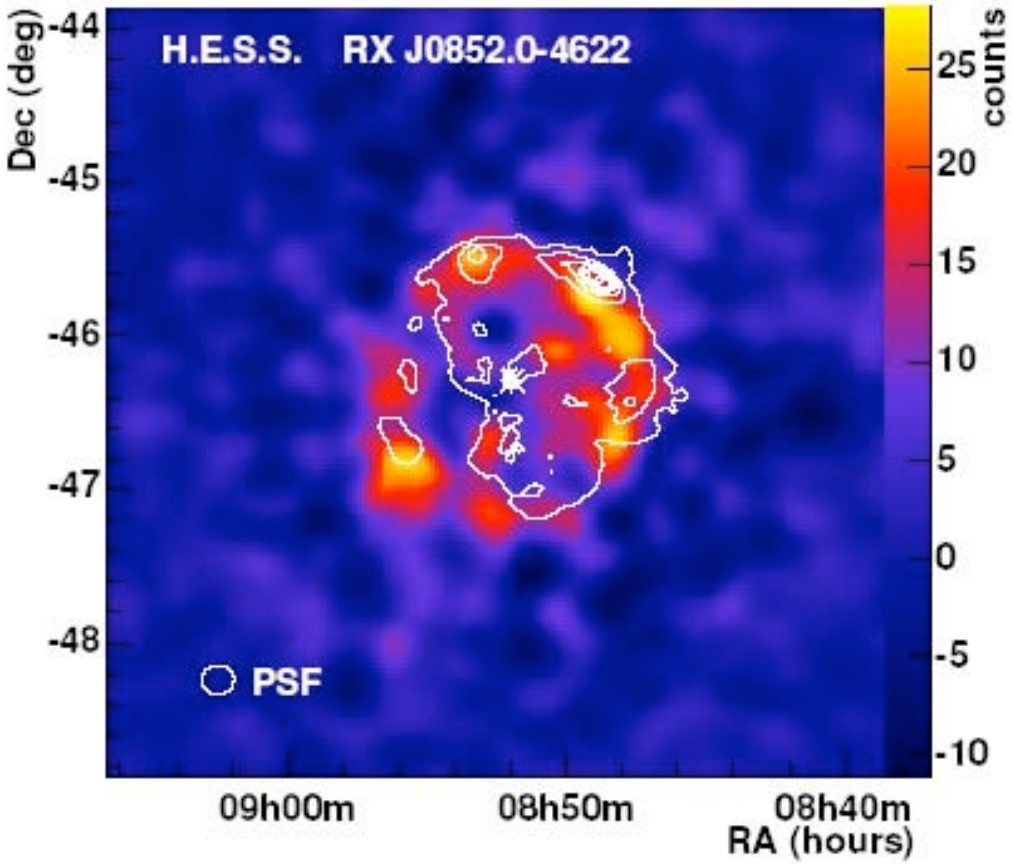
Extended TeV Sources

Brenda Dingus (Los Alamos National Lab)
Special Thanks to Andrew Smith (Univ. of Maryland)

HESS Observations of Galactic Sources

- Most HESS detections in the Galactic Plane are extended sources
- Largest Source is Vela Jr with diameter of 2 degrees

  (F. Aharonian et al., Astron. Astrophys. 437 (2005) L7-L10)



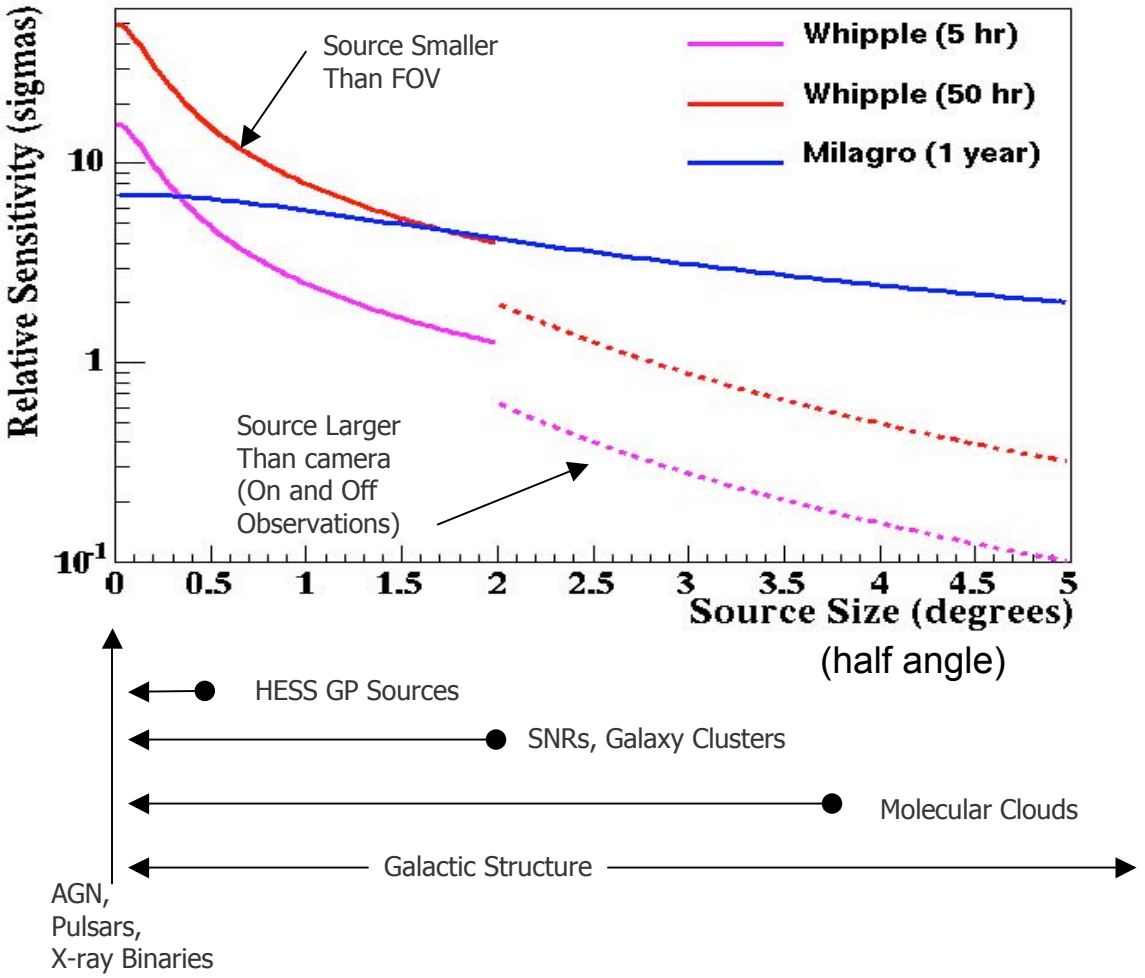
Extended Source Sensitivity

ACT's rely on angular resolution for excellent background rejection.

When the source size is large compared to PSF, sensitivity is reduced by a factor of

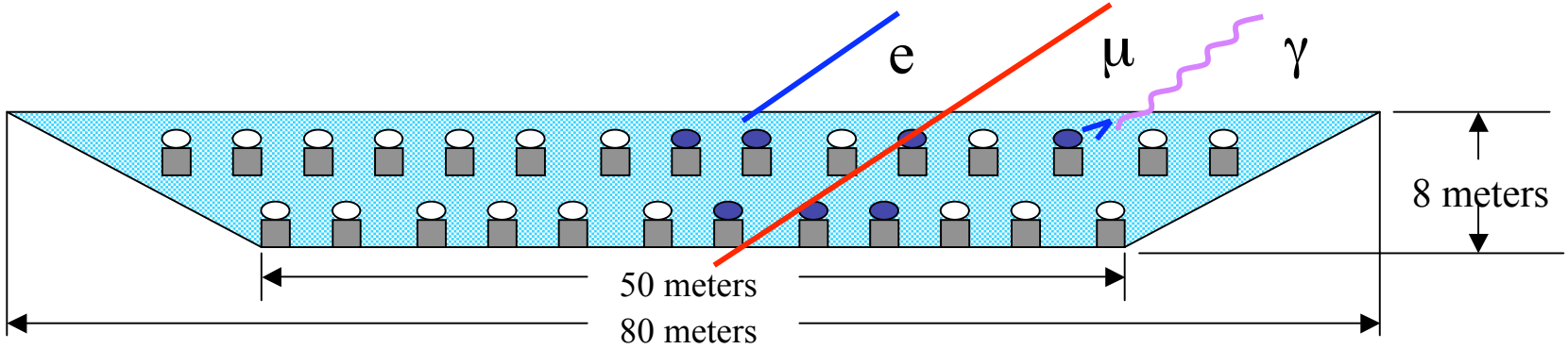
$$\sim \sigma_{detector} / \sigma_{source}$$

When the source size is large compared to the FOV, sensitivity is reduced much more.



Milagro TeV Observatory for Extended Sources

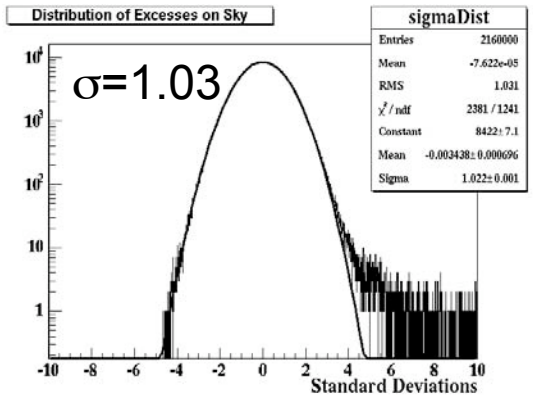
- Detect Particles in Extensive Air Showers from Cherenkov light created in 60m x 80 m x 6m pond containing filtered water.
- Reconstruct shower direction to ~ 0.5 degrees from the time different photodetectors are hit.
- 1700 Hz trigger rate mostly due to Extensive Air Showers created by cosmic rays
- Field of view is ~2 sr (± 45 degrees) and the average duty factor is >90%

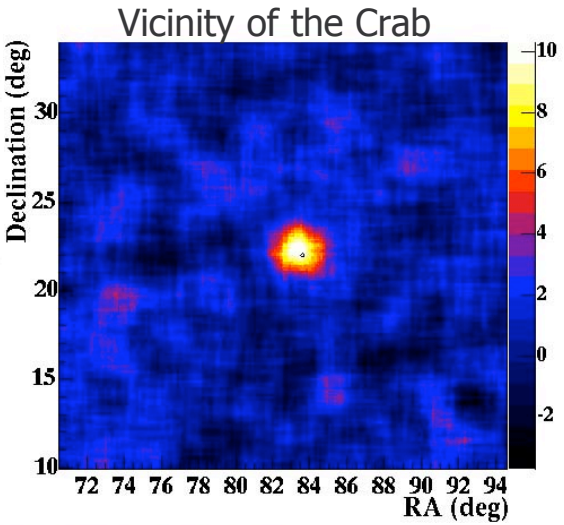


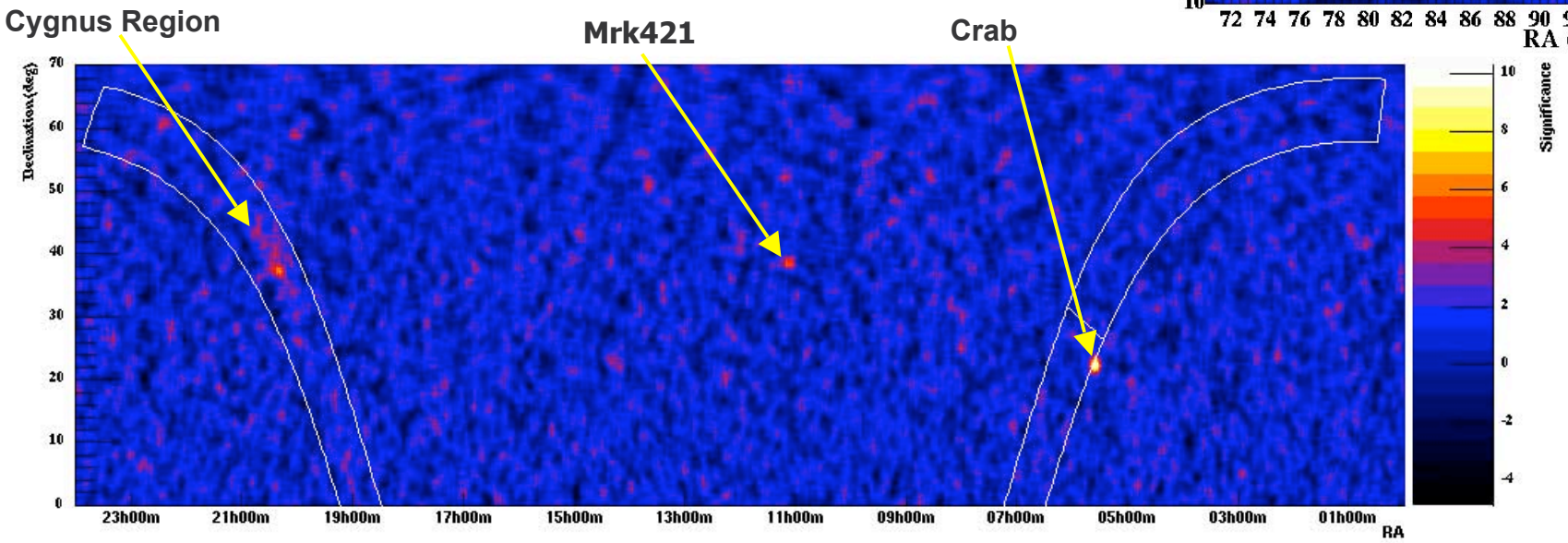
Point Source Search - Weighted Analysis

Event Weighting: Bin Size =2.1º (Optimal for Point Sources)

Crab significance	10.0σ.
Mrk421 significance	5.4σ.
Point in Cygnus Region at	5.9σ.





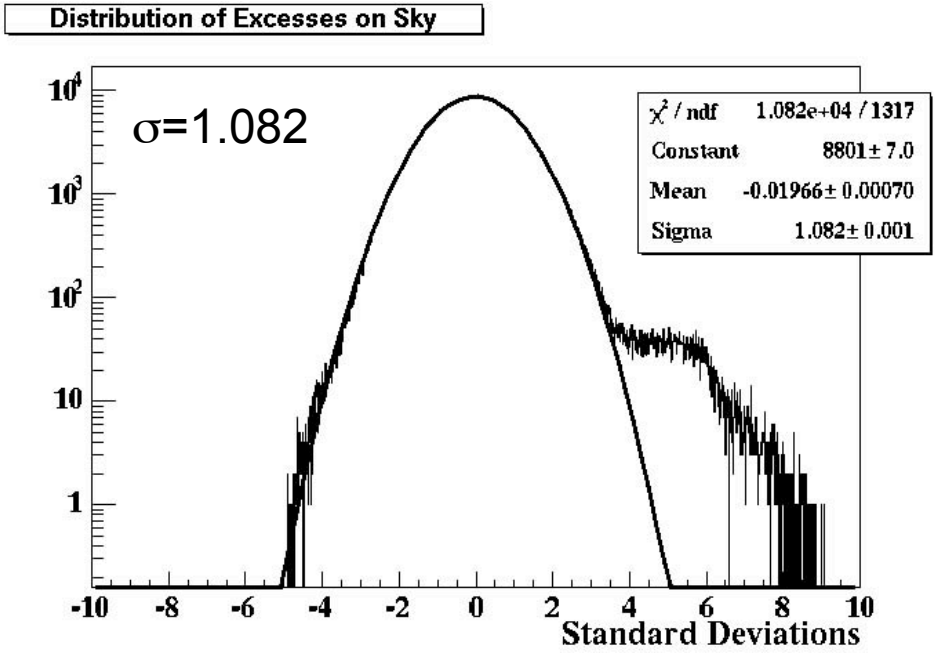


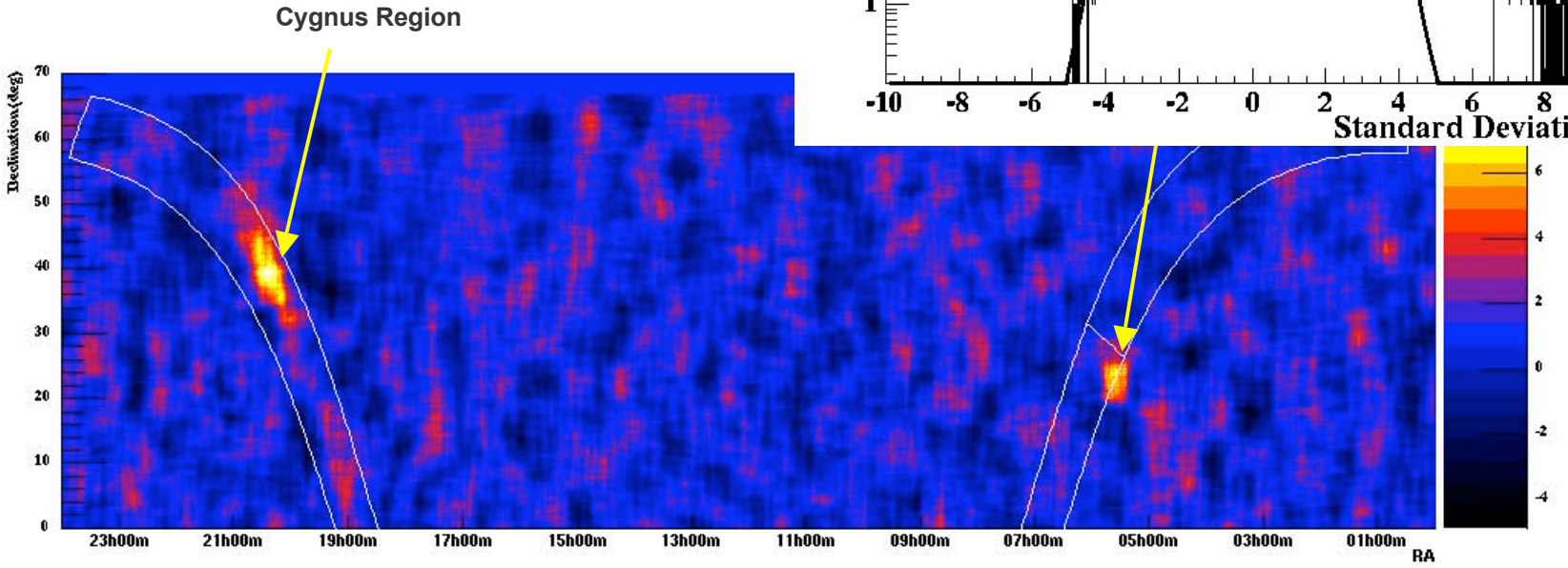
Extended Source Search Weighted Analysis

Event Weighting: Bin Size =5.9^{O}
(Optimal for ~5^{O} source)

Cygnus Region Significance: 9.1σ
Post-trials probability: >7σ

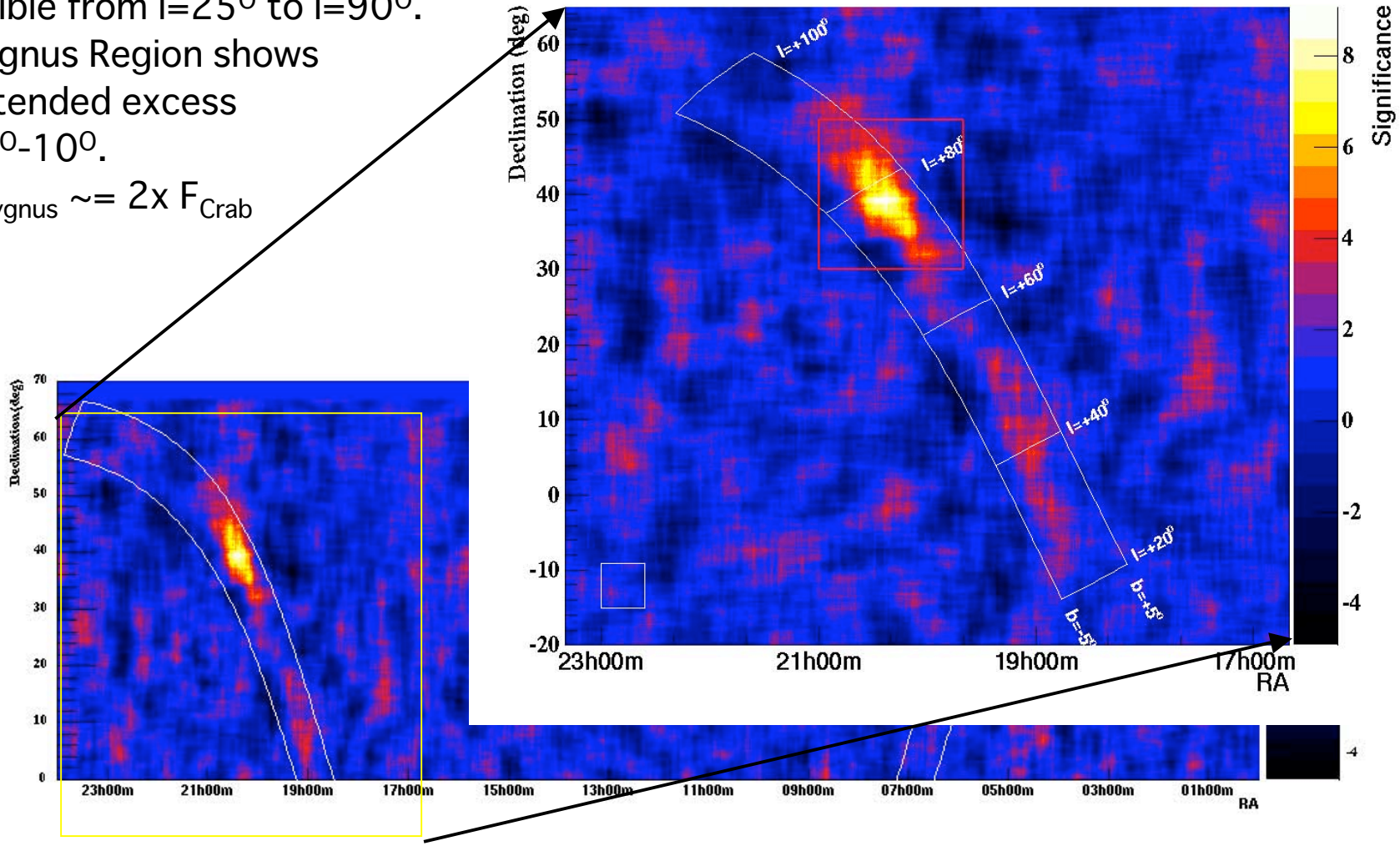
Cygnus Region is the most luminous source of VHE γ-rays in the northern sky.





A Closer Look at the Galactic Plane

- GP diffuse excess clearly visible from l=25^{o} to l=90^{o}.
- Cygnus Region shows extended excess ~5^{o}-10^{o}.
- F_{Cygnus} ~= 2x F_{Crab}



Galactic Plane Excess:

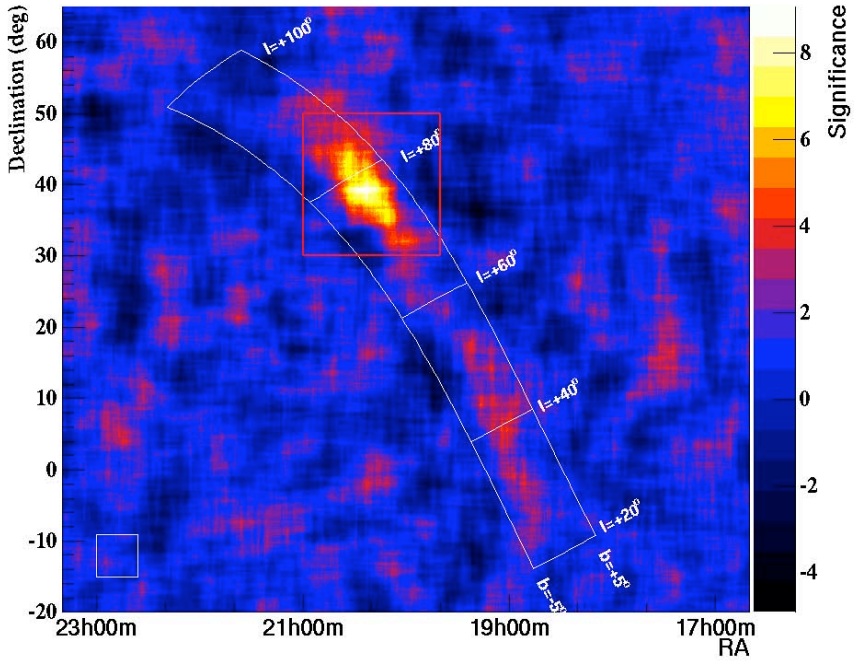
($-2^{o}<b<2^{o}$)

Consider Region l = 20^{o}-100^{o}

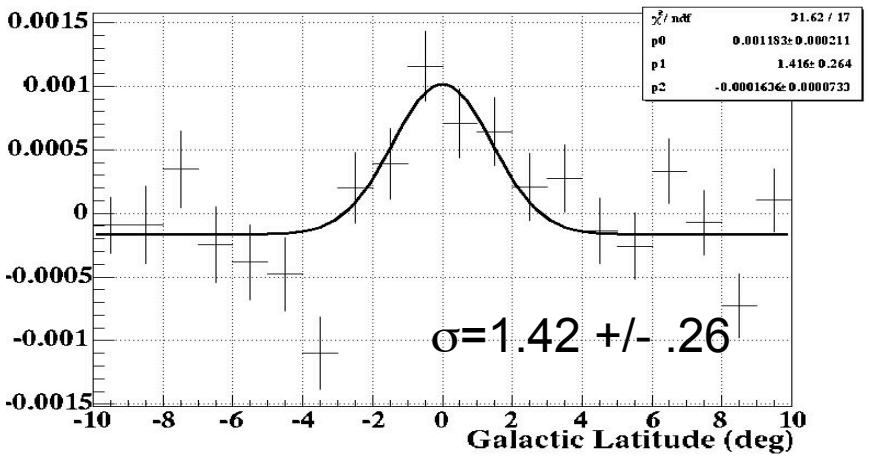
Weighted Map: 7.5σ

Exclude the Cygnus Region: l=20^{o}-75^{o}

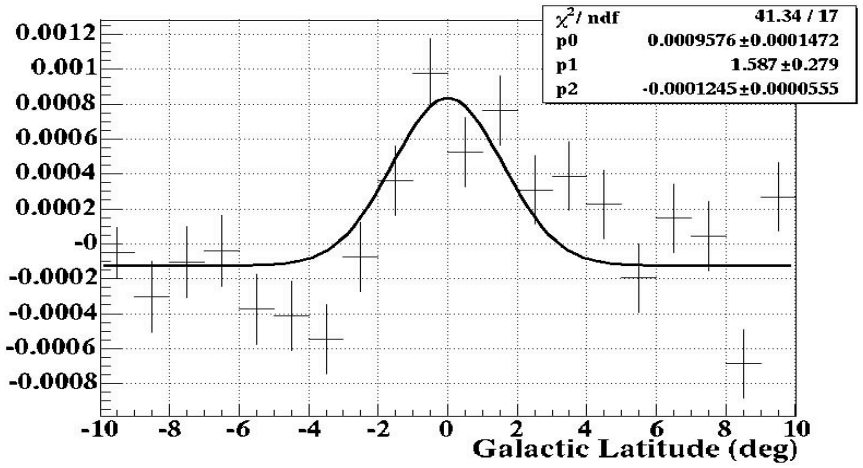
Weighted Map: 5.8σ



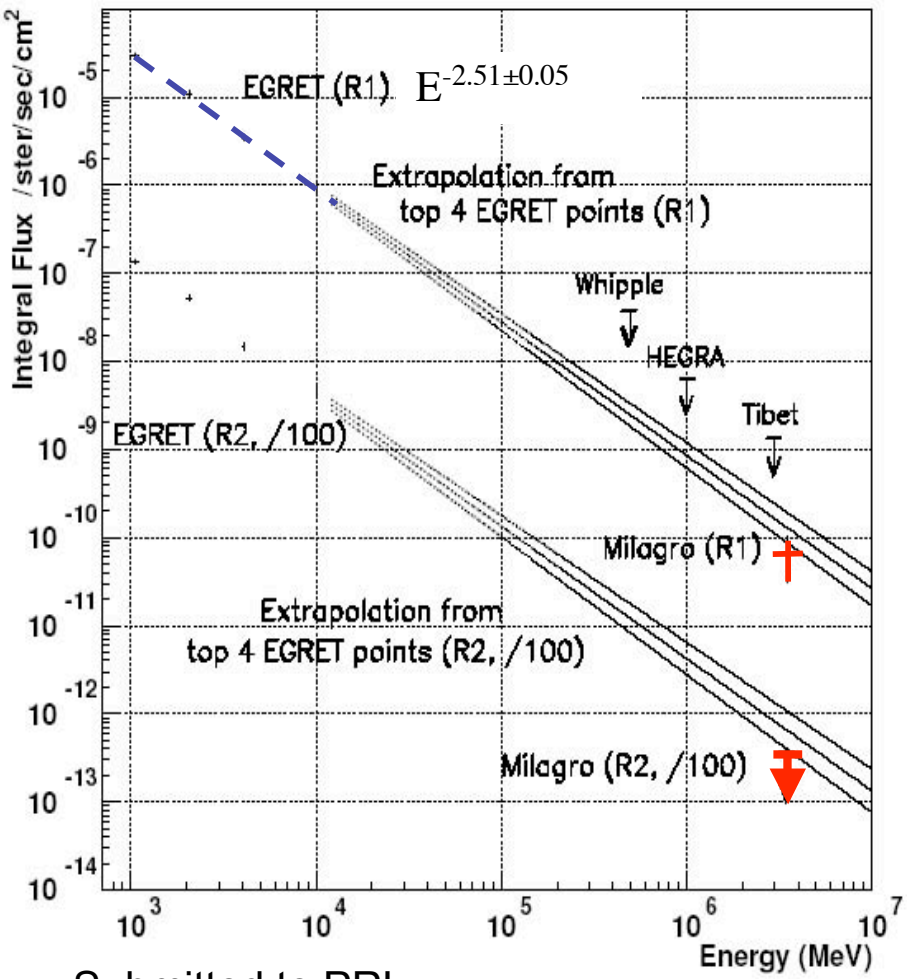
Galactic longitude 20-75 excludes Cygnus region



Galactic longitude 20-100 includes Cygnus region



Integral Flux: Milagro & EGRET



Submitted to PRL

R1 (Gal. Long. 40 to 100 deg)

- Based on 3ys of data, 4.5σ
- Flux(>3.5 TeV)
  $= (6.8 \pm 1.5 \pm 2.2) \times 10^{-11}$ cm^{-2} sec^{-1} sr^{-1}
- Spectral Index to connect with EGRET = $-2.61 \pm 0.03 \pm 0.05$
- With outriggers we can measure the spectrum at TeV energies
- 2 more years of data needed for ±0.1 on spectral index at TeV energies

R2 (Gal. Long. 140 to 200 deg)

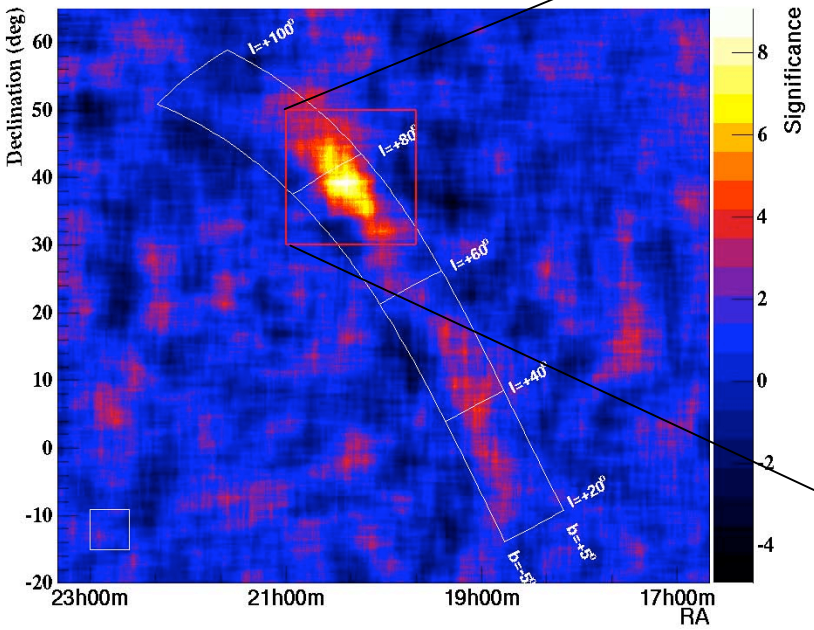
- Flux(>3.5 TeV)
  $< 4 \times 10^{-11}$ cm^{-2} sec^{-1} sr^{-1} (99% c.l.)
- Spectral index to connect with EGRET < -2.66 (99% c.l.)
- Not yet a crisis but spectrum may be softer in outer Galaxy
- Additional data will tell

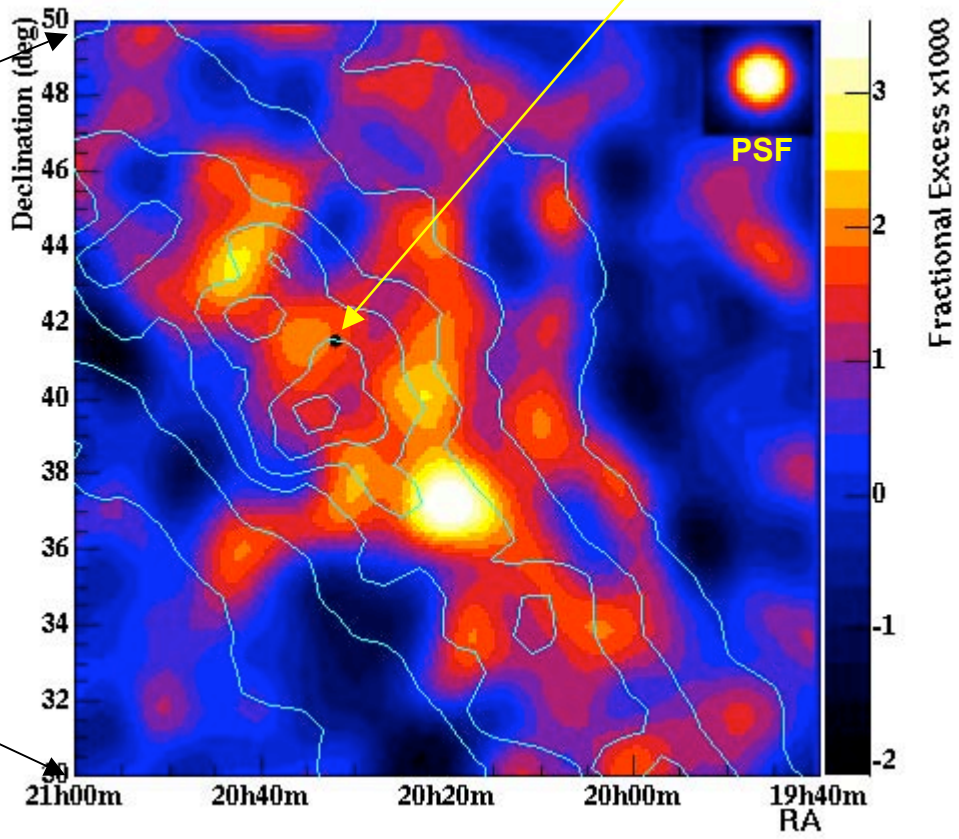
Cygnus Region Morphology

- Convolve Cygnus region excess with Milagro PSF(0.75^{O}).
- Region shows resolvable structure.

EGRET Diffuse Model

HEGRA detected TeV Source: TEV J2032_4130.



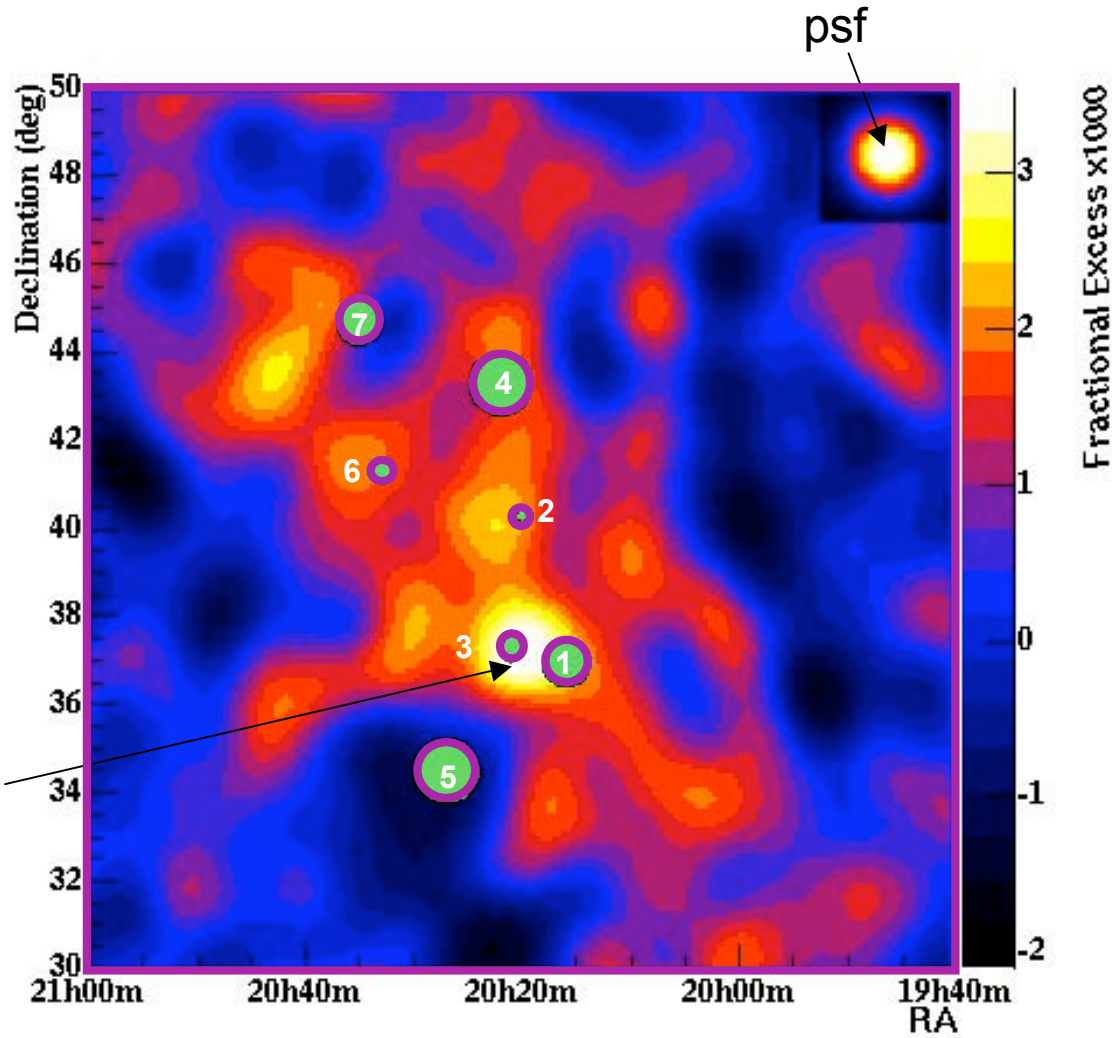


EGRET Unidentified Sources in the Cygnus Region

3rd EGRET Catalog sources shown with 95% position error circle.

		$\Phi > 100$ MeV/cm^{2}s	γ
1	3EG J2016+3657	$(34.7 \pm 5.7) \times 10^{-8}$	2.09
2	3EG J2020+4017	$(123. \pm 6.7) \times 10^{-8}$	2.08
3	3EG J2021+3716	$(59.1 \pm 6.2) \times 10^{-8}$	1.86
4	3EG J2022+4317	$(24.7 \pm 5.2) \times 10^{-8}$	2.31
5	3EG J2027+3429	$(25.9 \pm 4.7) \times 10^{-8}$	2.28
6	3EG J2033+4118	$(73.0 \pm 6.7) \times 10^{-8}$	1.96
7	3EG J2035+4441	$(29.2 \pm 5.5) \times 10^{-8}$	2.08

Flux of maximum point: 500mCrab (May be extended)



Hot Spot

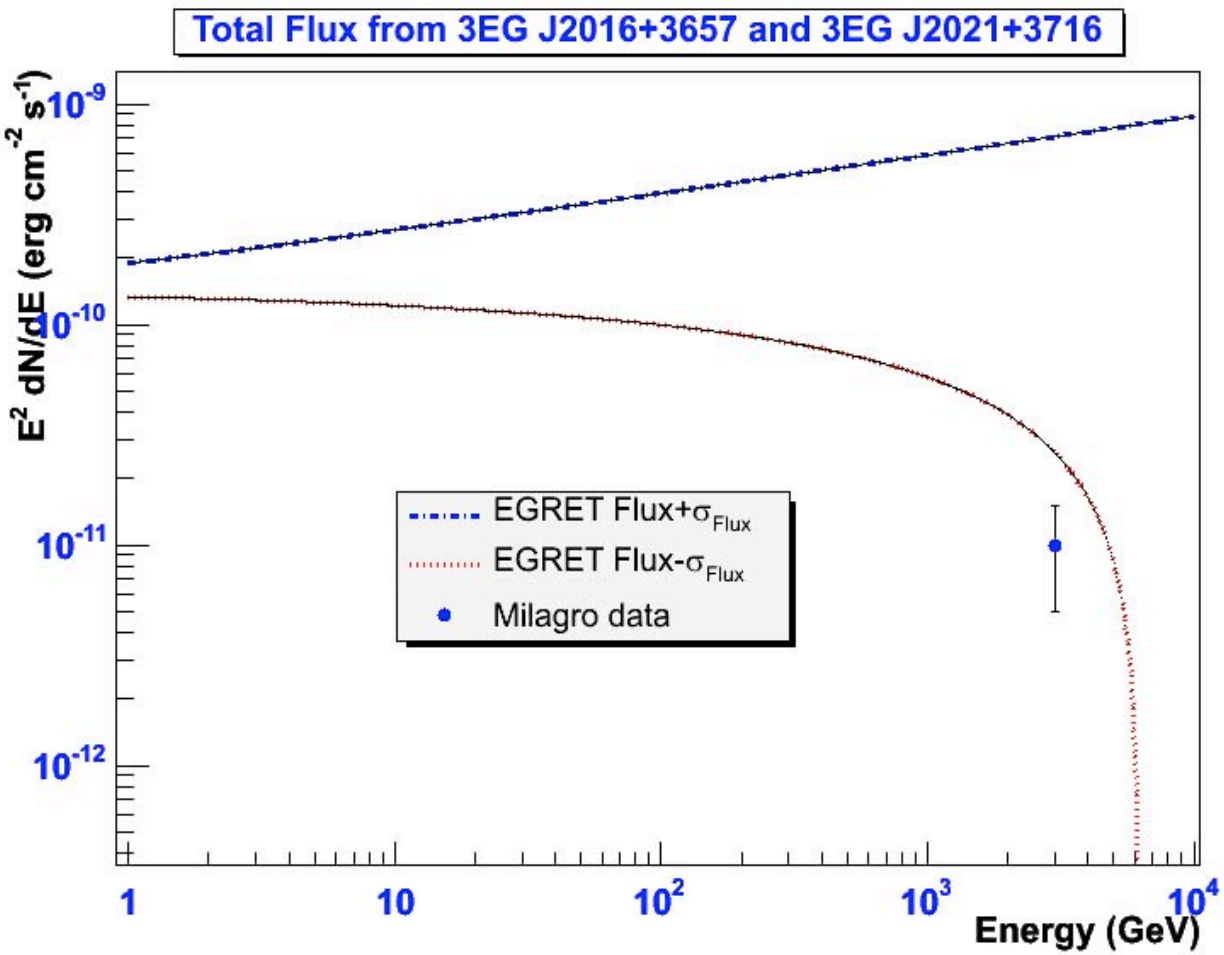
Both EGRET sources have hard spectrum of 1.86 and 2.09

Milagro flux is ~ 1 σ below extrapolation of combined 2 source EGRET spectrum

Neither EGRET source is variable

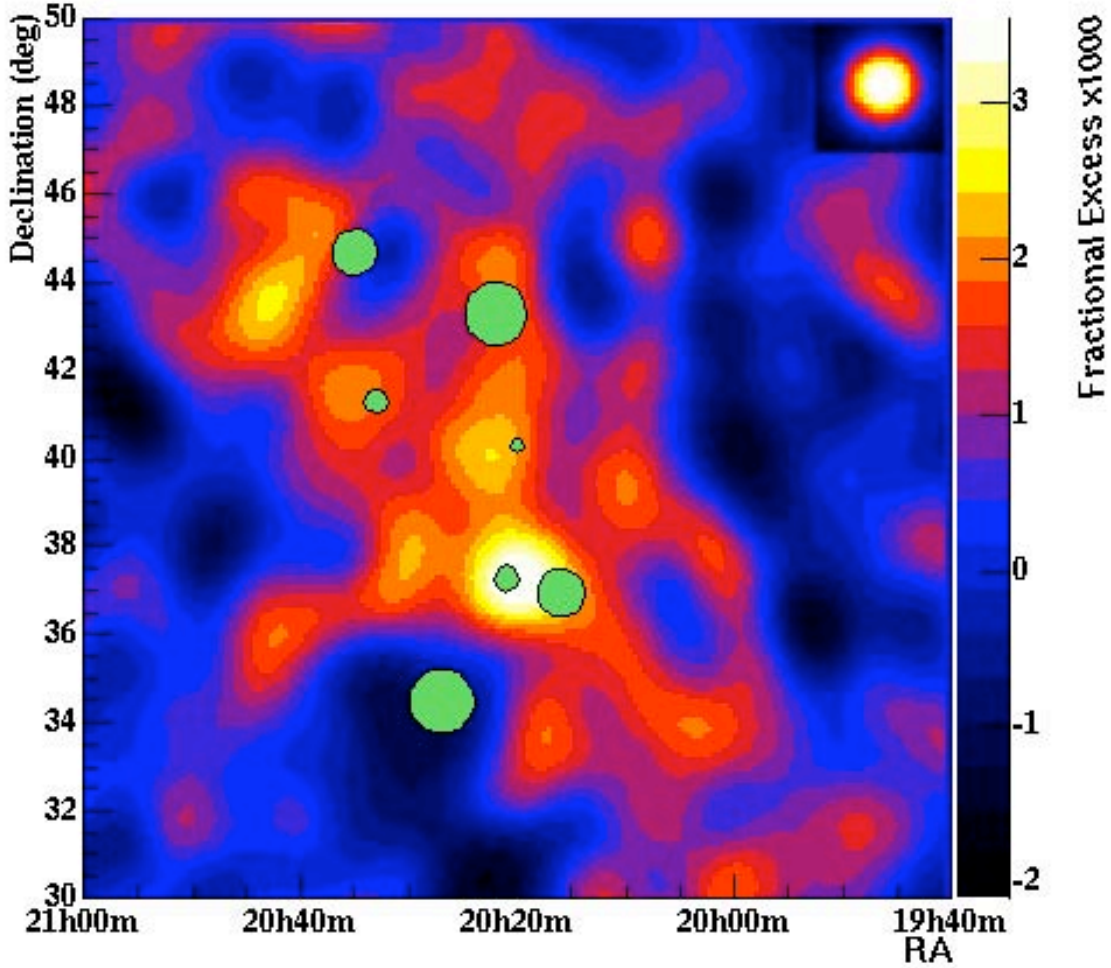
Proposed Counterparts of the 2 EGRET sources

- Blazar 2Jy@ 5GHz (Mukherjee et al. 2000, Halpern et al. 2001)
- Young Pulsar with Nebula (Roberts et al. 2002)



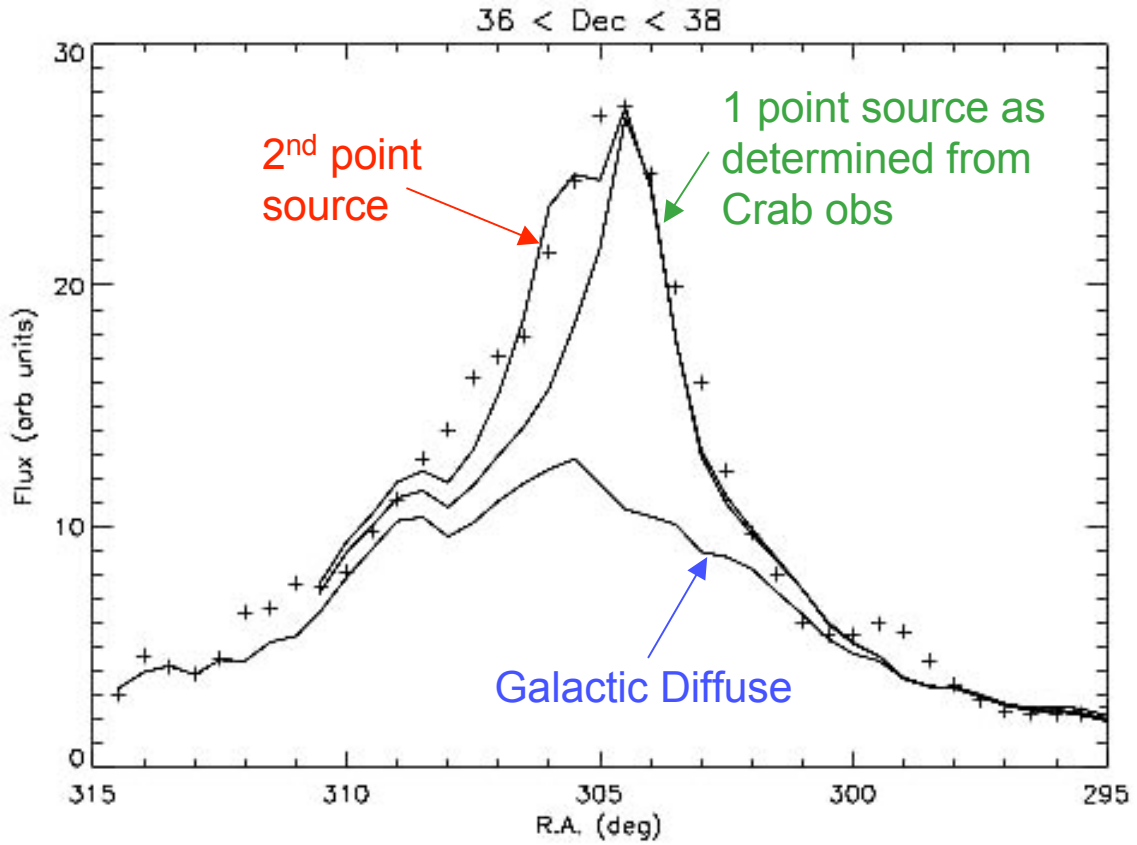
EGRET Data >1 GeV

Smooth EGRET >1 GeV γ-rays by EGRET's energy dependent psf



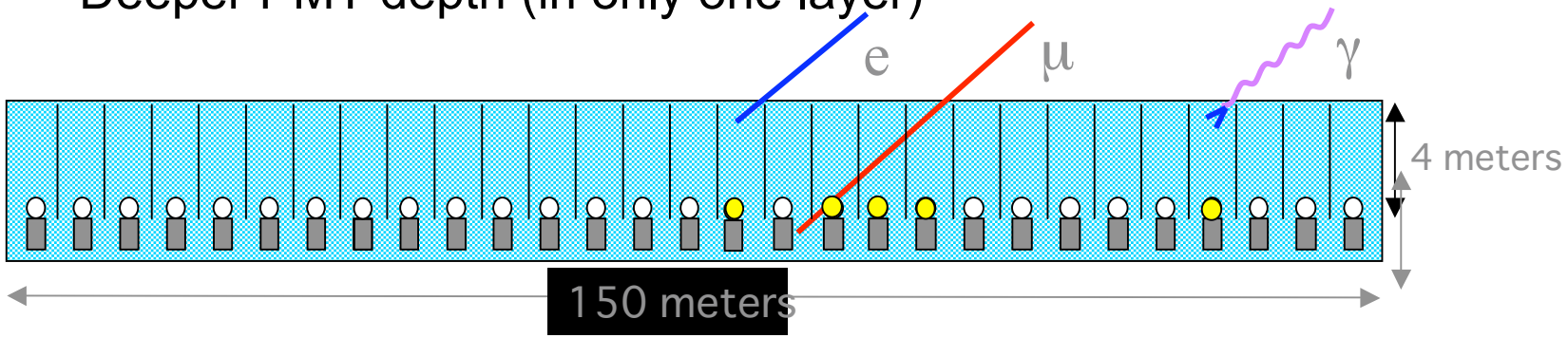
Slice of EGRET Data

- Cut on the Dec. band around Milagro's bright spot
- 2 point sources or 1 extended source?
- EGRET catalog sources were fit as point sources ONLY
- How close together can GLAST resolve 2 sources of this signal strength?



What's Next?
miniHAWC (High Altitude Water Cherenkov)

- Reuse Milagro's 900 PMTs and DAQ system
- Build pond at extreme altitude (Tibet 4300m or Mexico 4200m)
- Incorporate new design
  - Optical isolation between PMTs
  - Larger PMT spacing (5 m vs 3 m in Milagro)
  - Deeper PMT depth (in only one layer)



~$2-3 M for complete detector construction

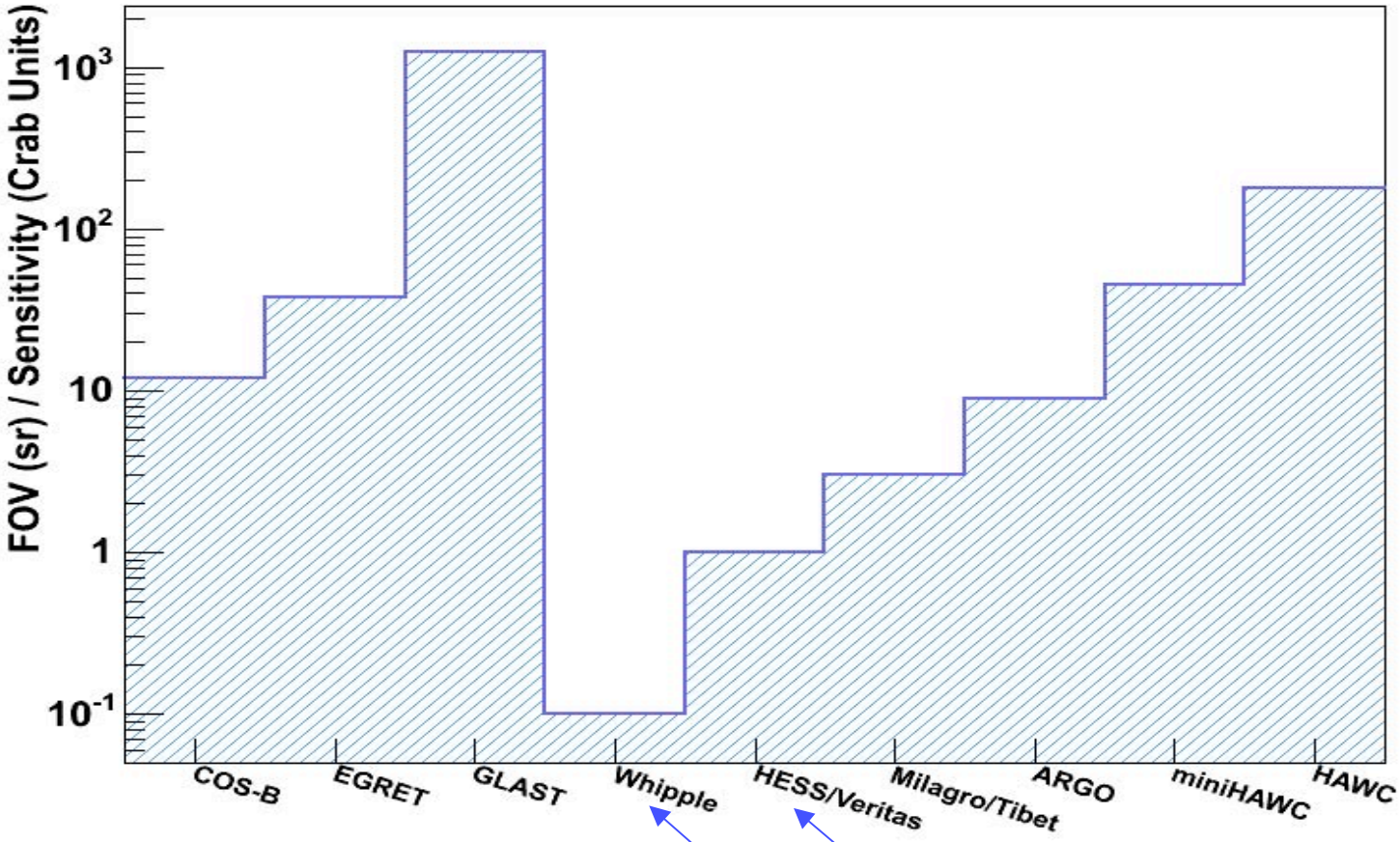
~15x sensitivity of Milagro

Crab Nebula at 4 σ in 1 day

60 mCrab at 5 σ in 1 year on entire sky

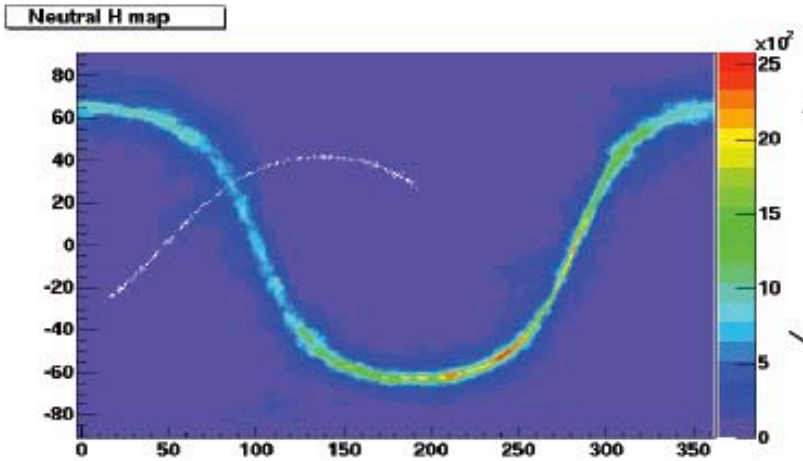
NSF proposal to be submitted in 2006 to begin operation in 2008

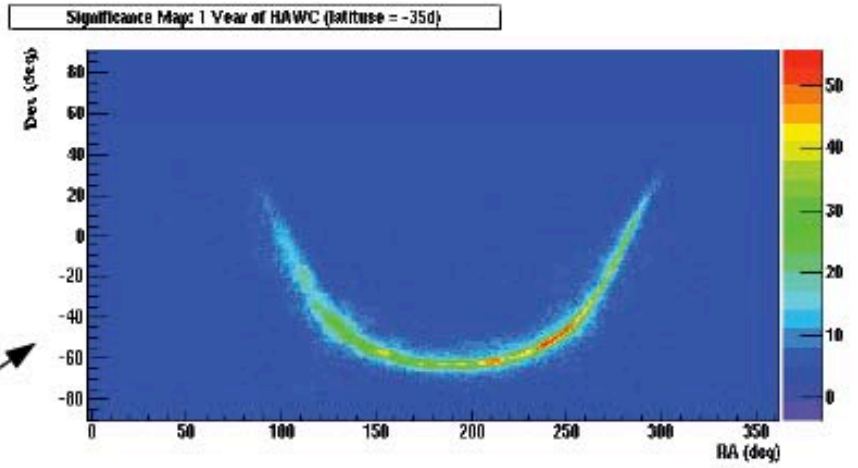
One Year Survey Sensitivity

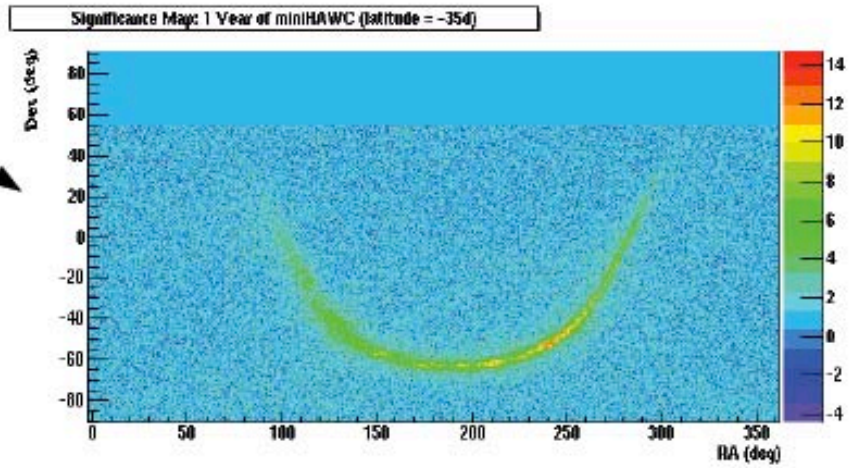


Assume 50 hr observations of 18 regions
(10% duty factor)

The Diffuse Galactic Plane in miniHAWC and HAWC







Use Neutral H map to trace out VHE Gamma-Ray flux. Normalize to Milagro observed TeV diffuse Galactic plane.

Summary

- Work this next year includes
  - Milagro Run Manager
  - Publication of the Cygnus Region Morphology
  - Development of Energy Resolution for Milagro
  - Search of Milagro data for GRBs coincident with SWIFT
  - Monte Carlo and Budget preparation for miniHAWC proposal
  - GLAST DC2 and calculations of relevant GLAST sensitivities to GRBs and steady