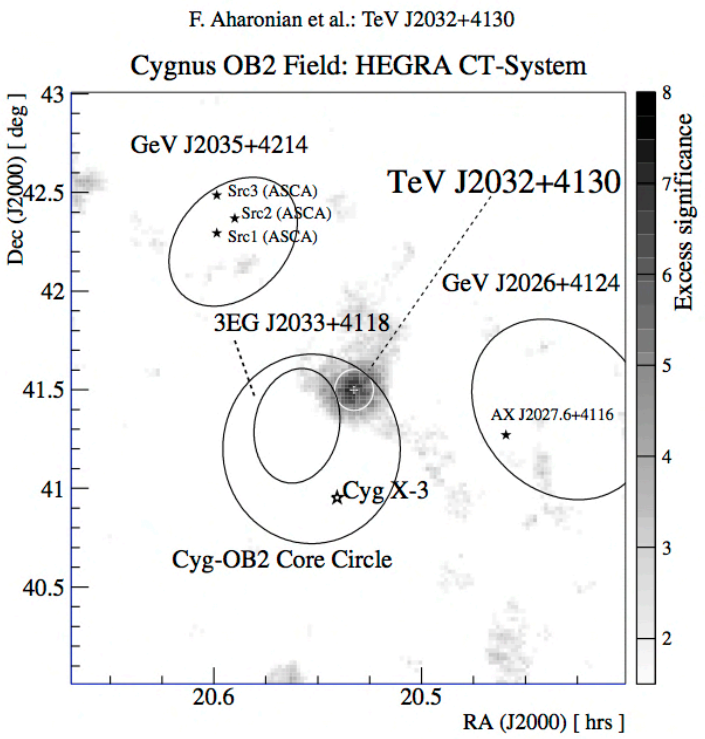
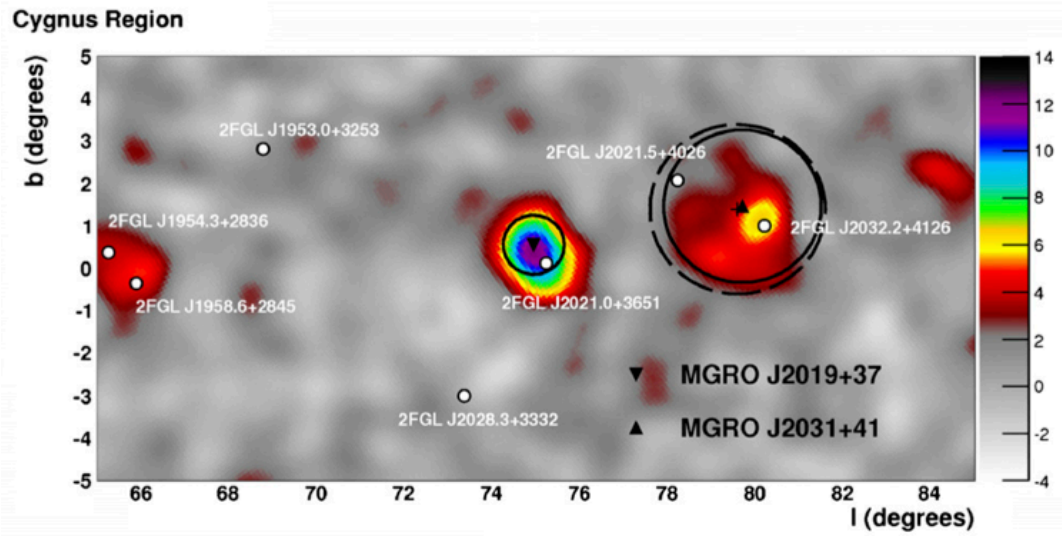
The VERITAS Survey of the Cygnus Region

A. Popkow, for The VERITAS Collaboration

History of VHE Detections



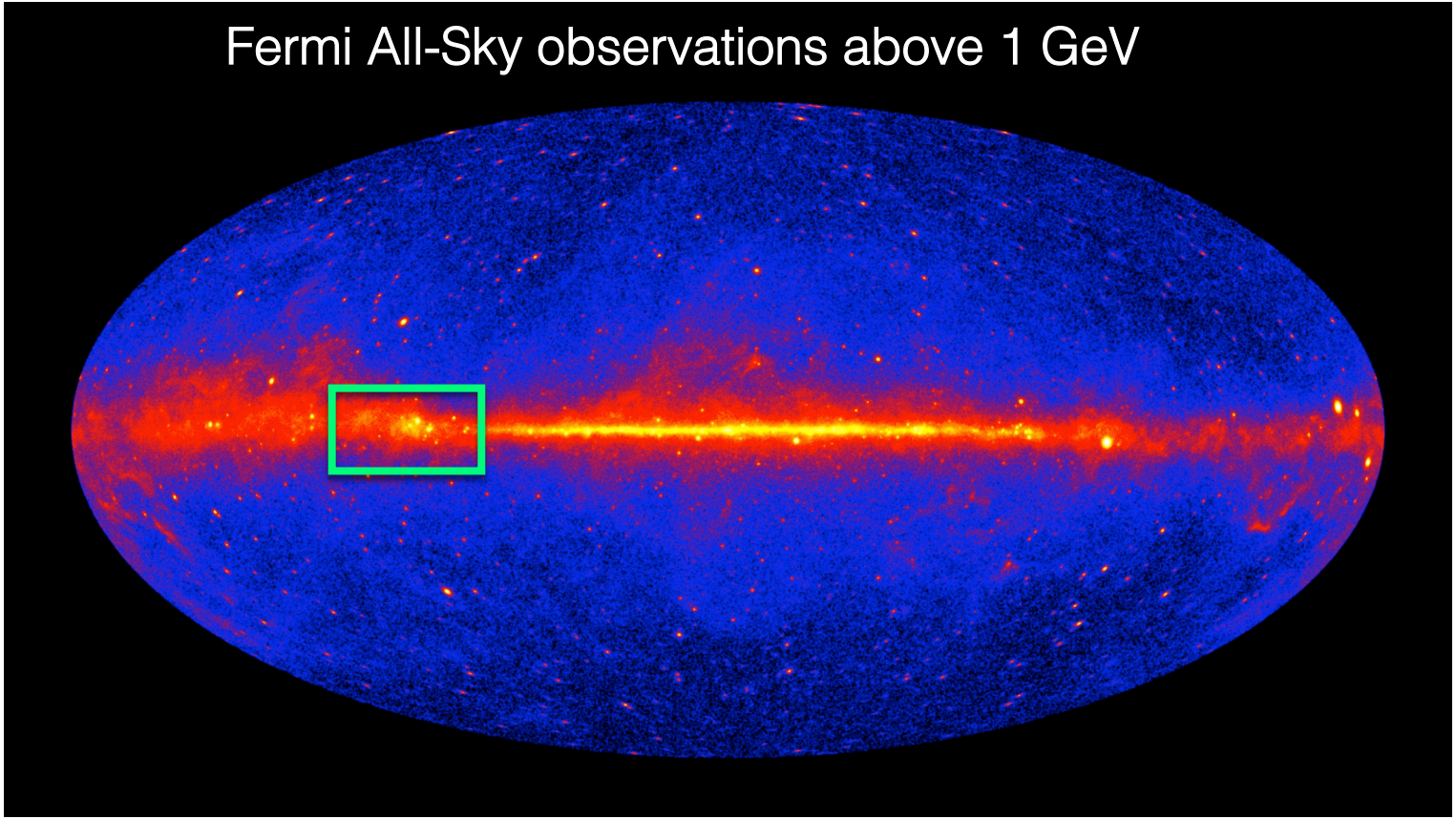
HEGRA

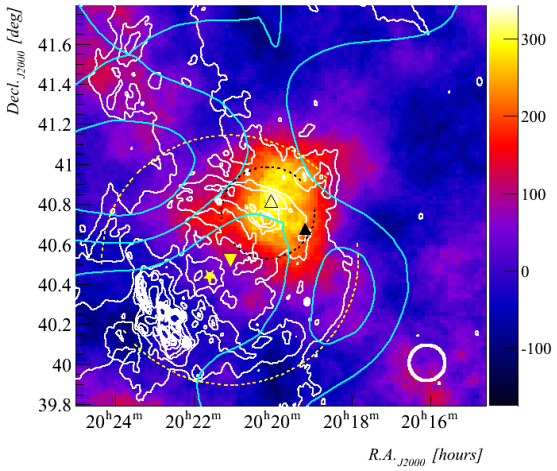


Milagro

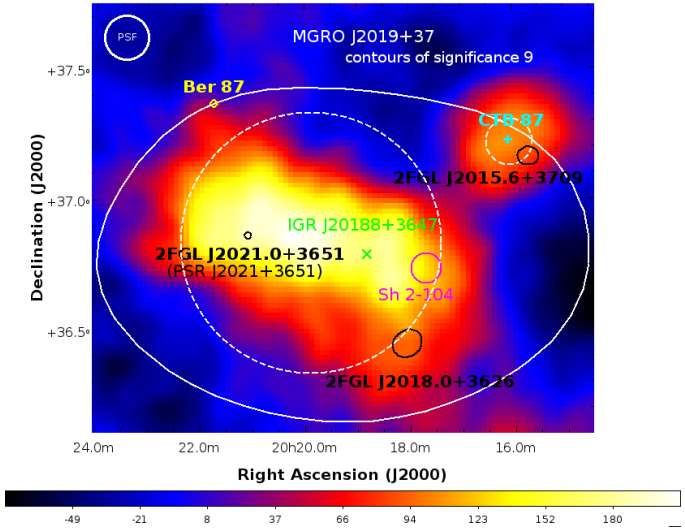
astro-ph/0207528 , astro-ph/1202.0846

Bright GeV Emission in the Cygnus Region

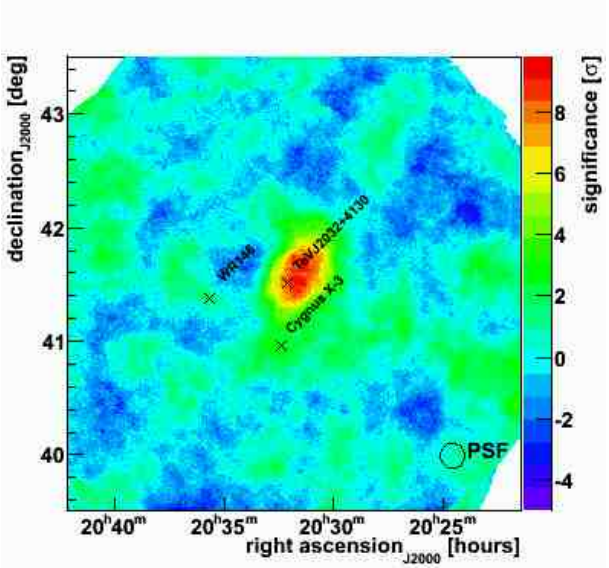




VER J2019+407



CTB87 (VER J2016 +371)
& VERJ2019+368



TeV2032

VERITAS results in the region

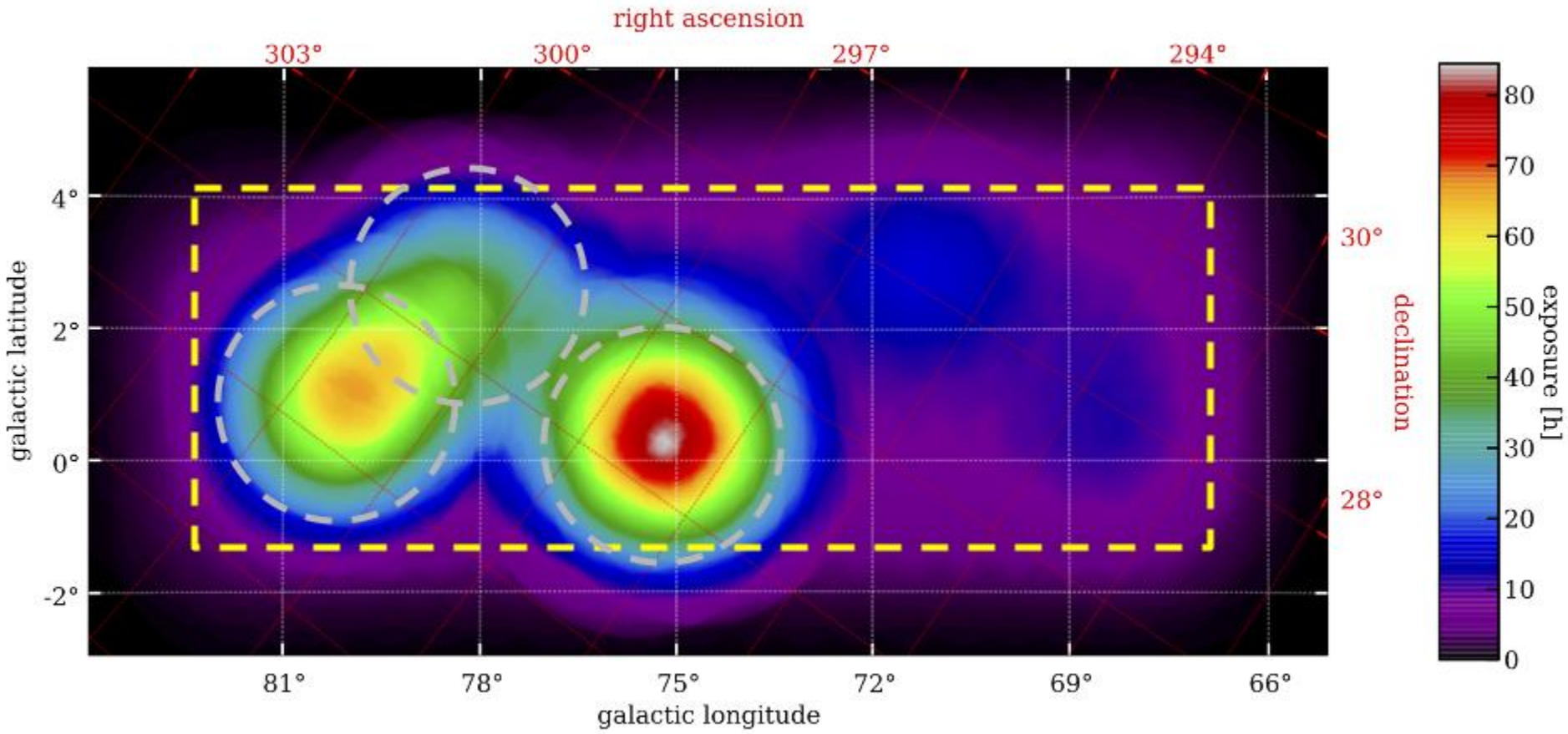
astro-ph/1305.6508, astro-ph/1404.1841, astro-ph/1401.2828

The VERITAS Array

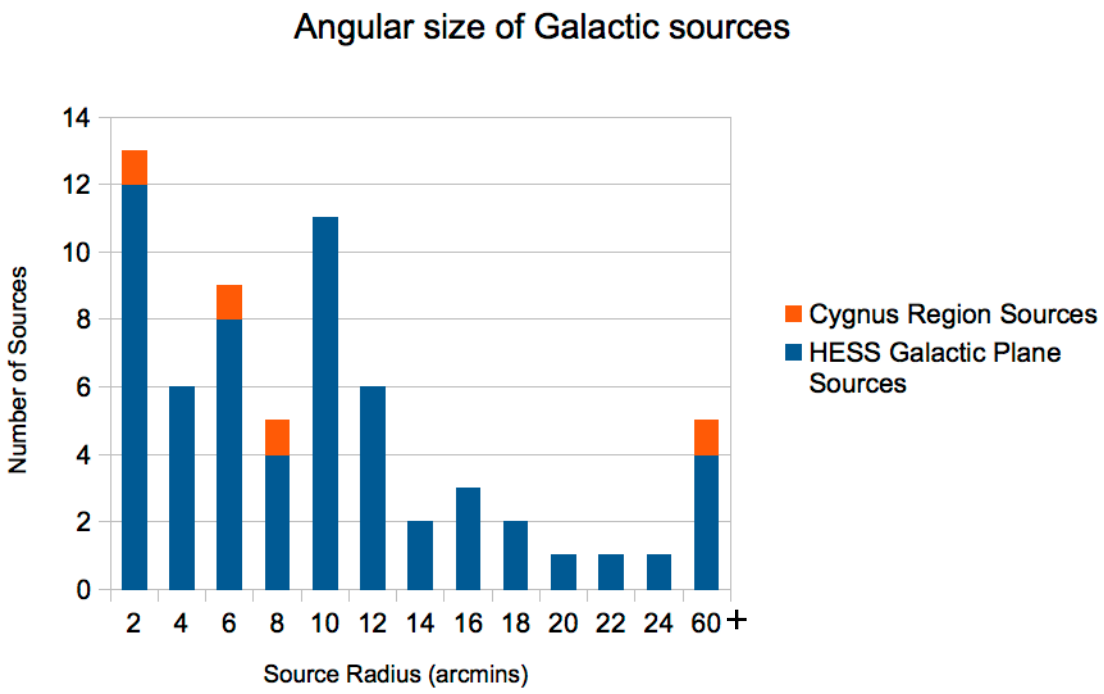
- Energy range: 85 GeV to >30 TeV
- Energy resolution: 15 to 25%
- 1% Crab in ~25 hr
- Angular Resolution: R_{68}<0.1° at 1 TeV
- Pointing Accuracy: < 50 arcsec
- Operations began: 2007
- Located at FLWO in Southern AZ, USA

VERITAS Cygnus Region Dataset

- 944 quality selected data runs
- 297 hours
- Average elevation: 69.8
- Taken 2007 – 2012
- Base survey – average 6-7 hours of exposure over region


right ascension
303°
300°
297°
294°
4°
2°
0°
-2°
galactic latitude
30°
28°
declination
81°
78°
75°
72°
69°
66°
galactic longitude
80
70
60
50
40
30
20
10
0
exposure [h]

Determining Ideal Bin Size

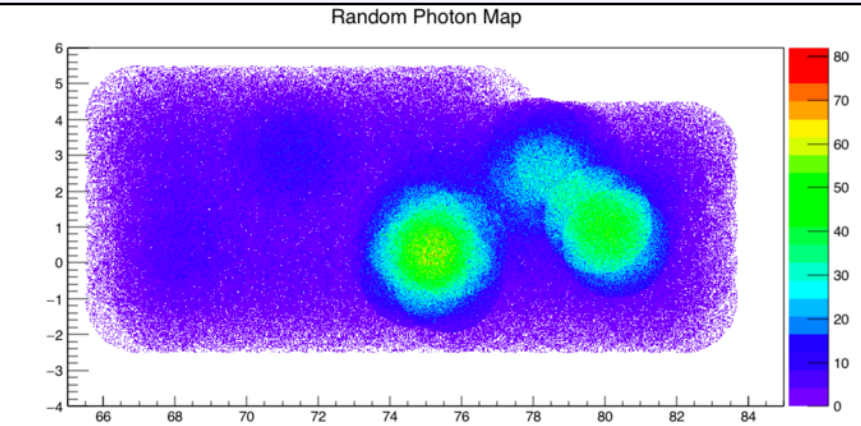


- Many Galactic sources are extended
- Optimal bin is proportional to Gaussian size and inversely proportional to the cube root of flux
- Found to be ~0.1°

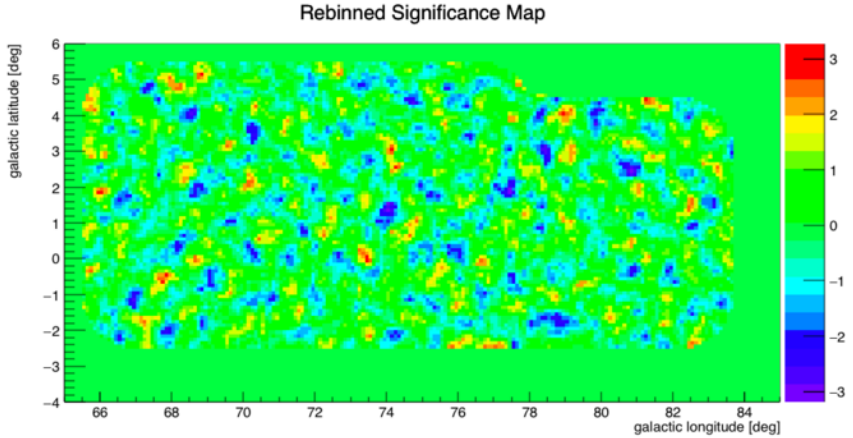
D. W. Scott, *On Optimal and Data Based Histograms*, *Biometrika*, Vol. 66, No. 3 (Dec., 1979), pp. 605-610

Trials Factor Monte Carlo

2.



4.



1. Generate acceptance corrected baseline map
2. Simulate random photons according to the baseline
3. Run ring background analysis
4. Re-bin, save values of highest significance bin, and reference bin

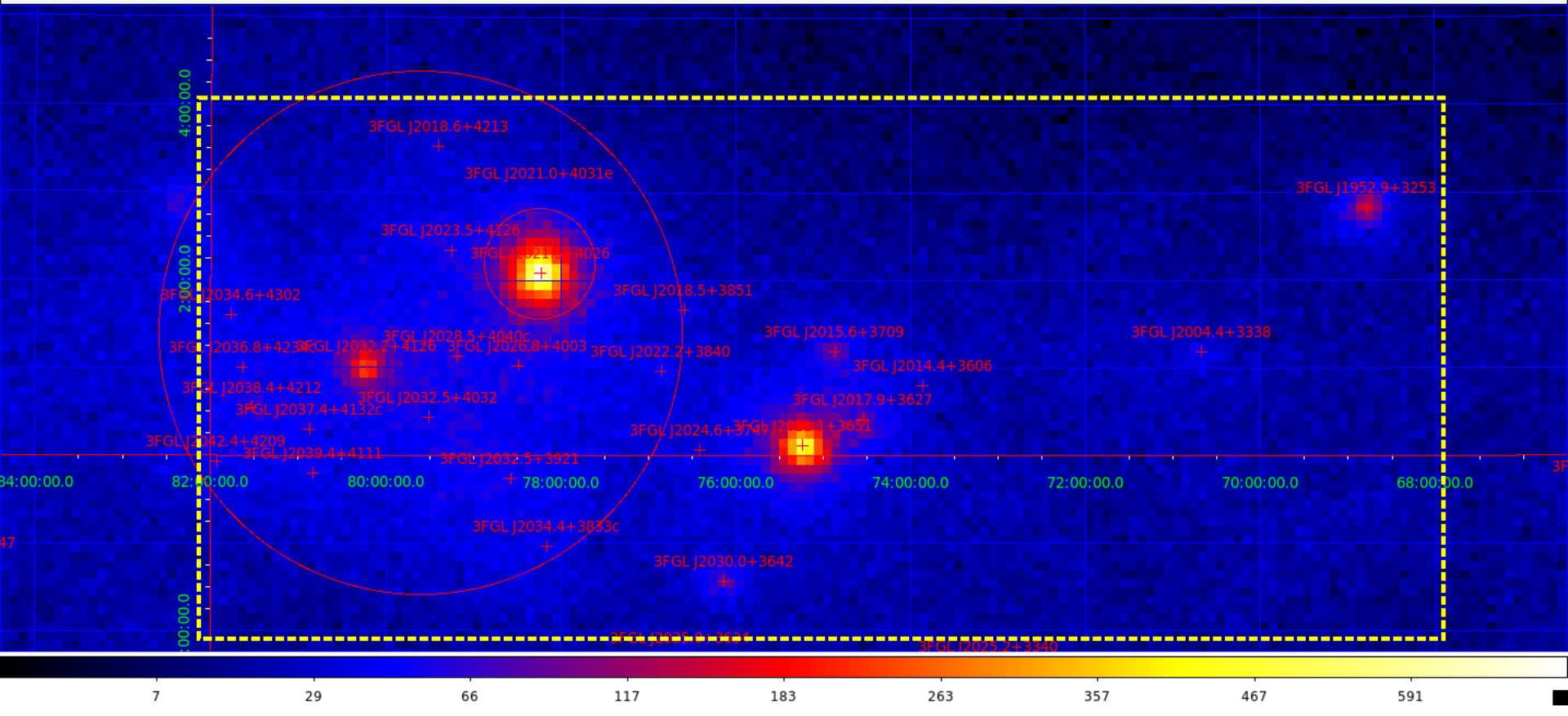
Current status of VERITAS analysis

- Sky map and significance distribution in VERITAS paper (end of 2015)
- Wanted to fully understand systematics
  - Crab point source (hard and moderate cuts) and MGRO J1908 (outside of region) extended (hard and moderate cuts) are consistent over two analysis packages, over many seasons of observing

Fermi Analysis Data

- Pass 7 (v9r33p0)
- Nearly 6 years (Aug 4, 2008 – June 10, 2014)
- 1-300 GeV
- xml input for fit generated using 3FGL

Fermi Counts Map of the Region (1-300 GeV)



TS and Flux from fit, rough extrapolation from fit values

3FGL name	Association(s)	TS	Flux (1 - 300 GeV) ($cm^{-2}s^{-1}$)	Spectral shape	Extrapolated Flux (300 GeV - 1 TeV) ($cm^{-2}s^{-1}$)
J1952.9+3253	PSR J1952+3252 1FHL J1953.3+3251	5973	1.96E-08+/-4.17E-10	broken power law	1.19E-09
J2004.4+3338	1FHL J2004.4+3339	246	3.48E-09+/-3.04E-10	power law	6.97E-13
J2015.6+3709	MG2 J201534+3710 1FHL J2015.8+3710	908	9.06E-09+/-4.30E-10	log parabola	1.11E-13
J2017.9+3627	MGRO J2019+37	667	9.84E-09+/-5.16E-10	log parabola	1.72E-15
J2018.5+3851	TXS 2016+386 1FHL J2018.3+3851	76	1.88E-09+/-3.09E-10	power law	7.39E-13
J2018.6+4213		34	1.41E-09+/-2.90E-10	power law	1.27E-12
J2021.1+3651	PSR J2021+3651 MGRO J2019+37 1FHL J2021.0+3651	23561	6.84E-08+/-8.04E-10	broken power law	4.15E-10
J2021.5+4026	LAT PSR J2021+4026	46339	1.13E-07+/-9.45E-10	broken power law	2.79E-10
J2022.2+3840		98	3.35E-09+/-3.90E-10	log parabola	4.50E-20
J2023.5+4126		84	3.29E-09+/-4.25E-10	log parabola	3.52E-14
J2024.6+3747		28	1.37E-09+/-4.78E-10	log parabola	3.69E-15
J2026.8+4003		68	3.19E-09+/-4.46E-10	log parabola	1.13E-14
J2032.2+4126	LAT PSR J2032+4127 TeV J2032+4130 1FHL J2032.1+4125	4717	2.45E-08+/-5.74E-10	broken power law	1.23E-09
J2032.5+3921		132	4.38E-09+/-4.32E-10	log parabola	6.70E-16
J2032.5+4032		116	4.20E-09+/-6.33E-10	log parabola	7.13E-22
J2034.6+4302		69	2.65E-09+/-5.01E-10	log parabola	1.60E-18
J2036.8+4234c		75	2.52E-09+/-4.38E-10	power law	4.53E-14
J2037.4+4132c		62	2.42E-09+/-4.24E-10	power law	1.19E-13
J2038.4+4212		129	3.64E-09+/-4.68E-10	log parabola	3.20E-14
J2039.4+4111		75	2.71E-09+/-3.98E-10	log parabola	1.97E-14
J2042.4+4209		76	2.68E-09+/-3.82E-10	log parabola	4.70E-14

- Potentially extragalactic
- Associated with pulsars
- Other TeV associations
- The remaining 14 are unidentified

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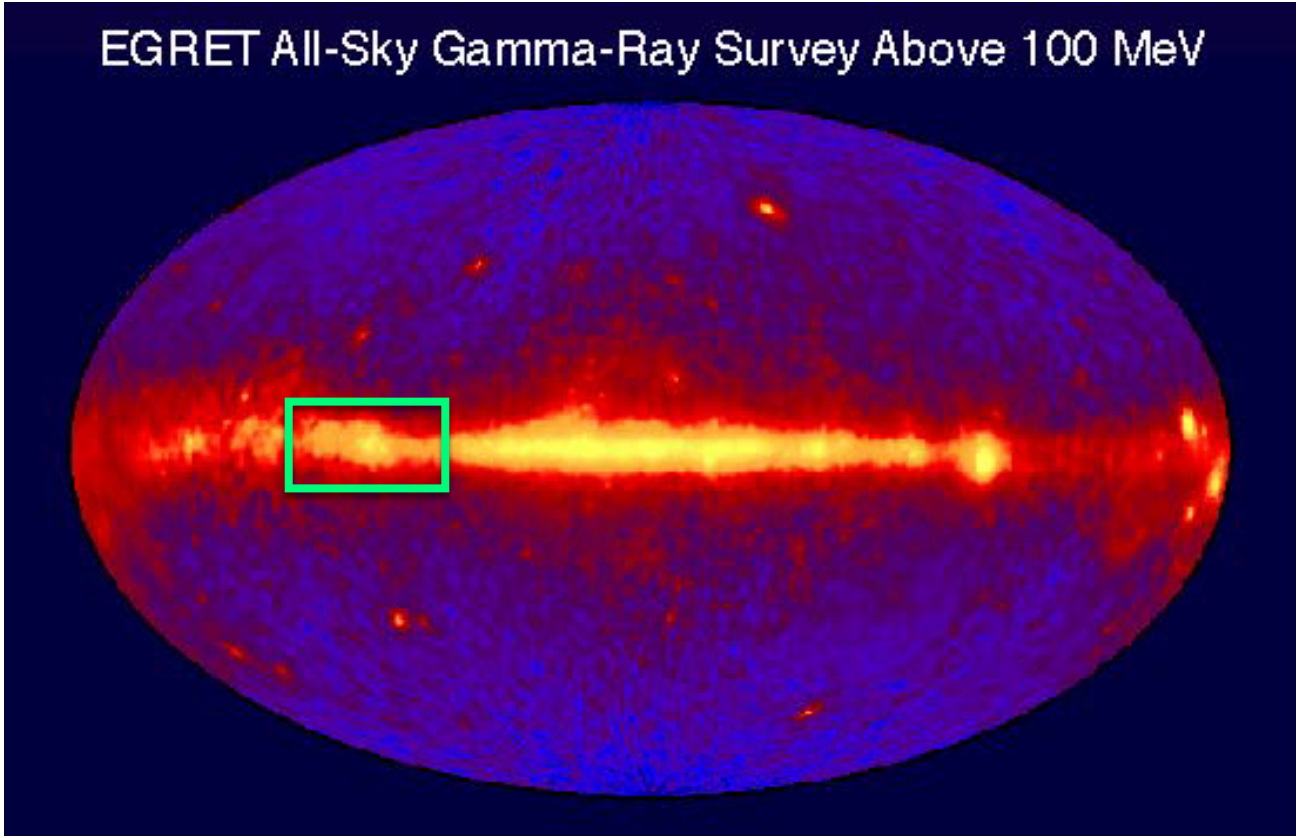
Conclusions

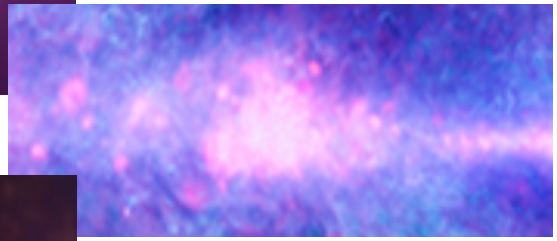
- The VERITAS Cygnus region data is being reanalyzed at greater sensitivity
- A *Fermi* analysis will allow for cross-correlation studies in this active region of the Galaxy
- In the future HAWC results may complement the VERITAS view of this complex region of emission

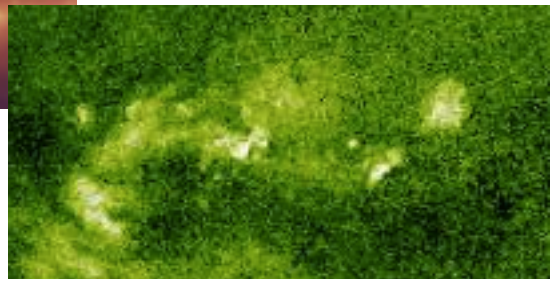
GeV detections in the Cygnus Region



https://heasarc.gsfc.nasa.gov/docs/cgro/egret/

Multiwavelength Perspective





- Emission in:
  - Radio
  - Microwave
  - Infrared
  - X-rays

408 MHz, Haslam, et al.; Plank ; IRAS; ROSAT (fromhttp://www.chromoscope.net/)