
100 TeV Observations of the Cygnus Region by CASA-MIA

Rene Ong & Corbin Covault for the CASA-MIA Collaboration



Photo:
K. Gibbs

CASA-MIA
Dugway, UT USA
c1994

CASA-MIA Collaboration: then and now



22nd ICRC, Dublin, 1991



Cronin-Fest, 2006

CASA-MIA Collaboration

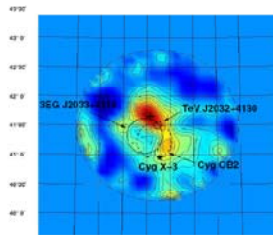
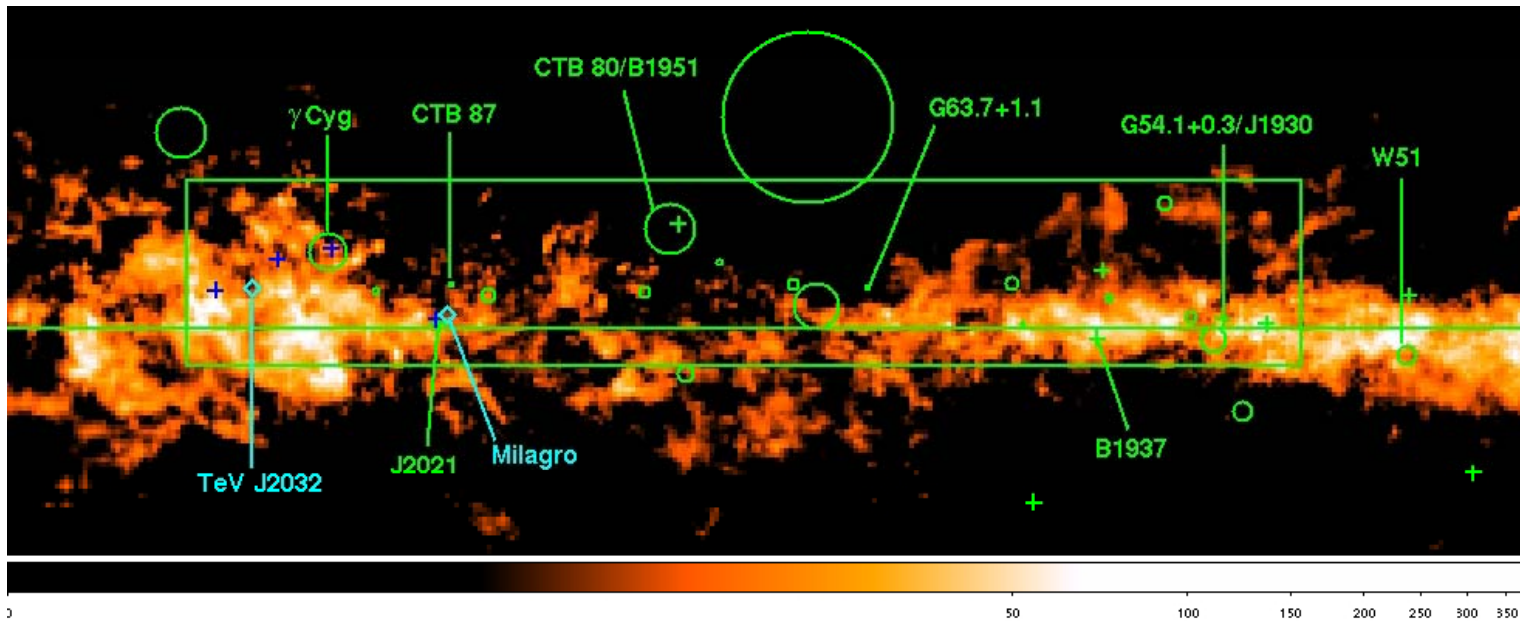
A. Borione¹, M.A. Catanese², M.C. Chantell¹, C.E. Covault¹, J.W. Cronin¹,
B.E. Fick¹, M.A.K. Glasmacher², J.W. Fowler¹, L.F. Fortson¹, K.G. Gibbs¹,
K.D. Green¹, D. Kieda³, J. Matthews², B.J. Newport¹, D.F. Nitz²,
R.A. Ong¹, S. Oser¹, L.J. Rosenberg¹, D. Sinclair², J.C. van der Velde²

¹University of Chicago, ²University of Michigan, ³University of Utah

Cygnus Arm of Galaxy

Rich region of the galactic plane.
Many potential VHE γ -ray sources.

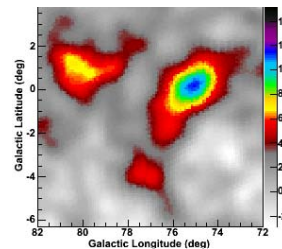
CO map, circles=SNRs, blue plus=EGRET GeV, green plus=pulsars.



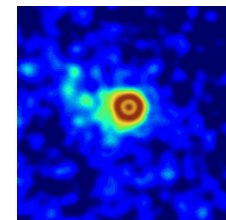
TeV J2032+41



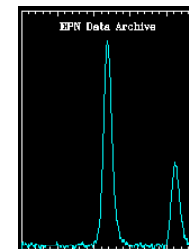
IC 1318
 γ -Cygni
(Palomar)



MGRO J2031+41
MGRO J2019+37



CTB 80
(Einstein)



PSR B1937+21
(Jodrell Bank)

Milagro Results & CASA-MIA Search Region

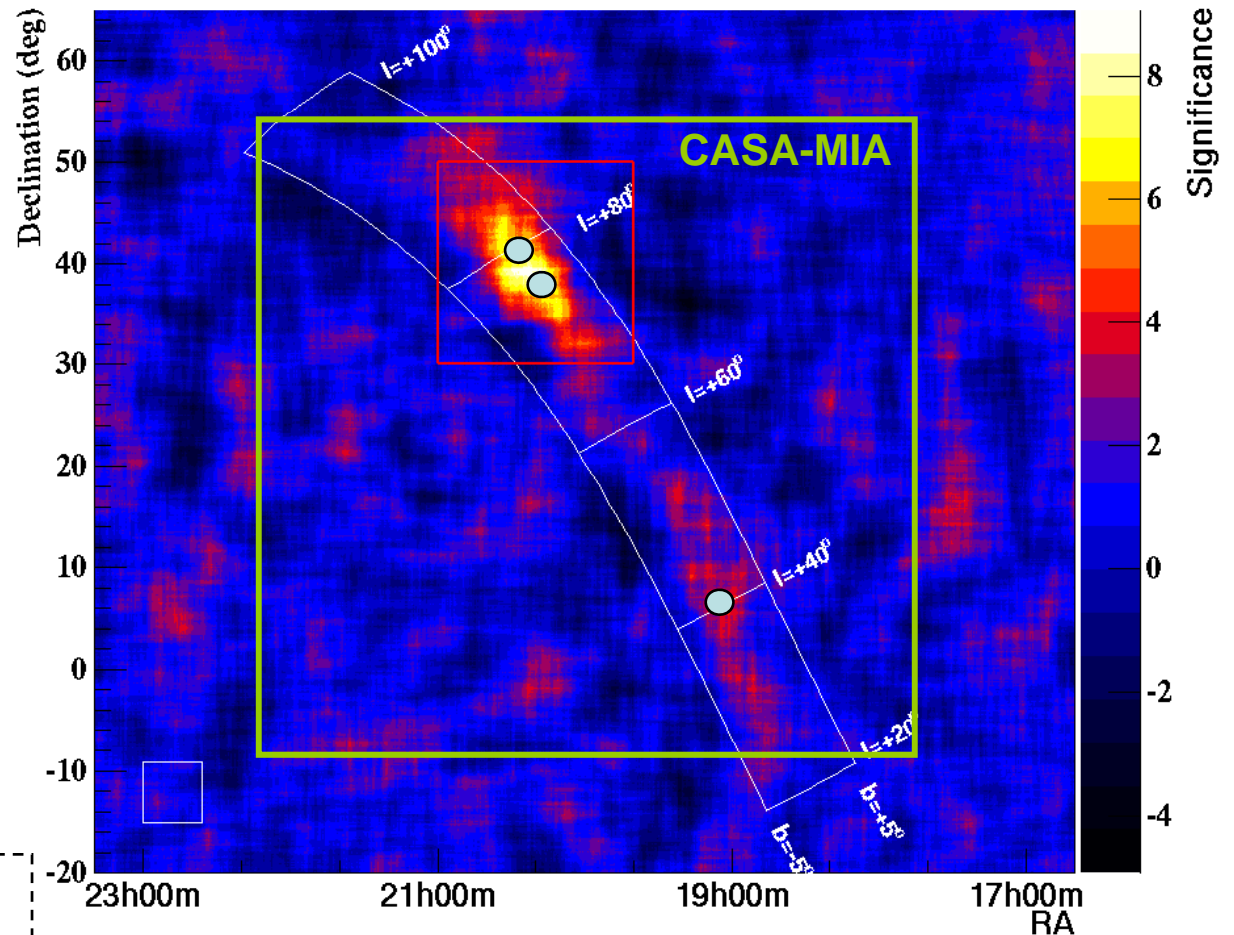
Milagro:

- Sky survey at median $E \sim 20$ TeV.
- 3 reported detections with significance $> 5\sigma$.
- Strong sources: fluxes $> 75\%$ Crab.
- Extended sources: diameters $\sim 1-3^\circ$
- Hard spectra?

see also:

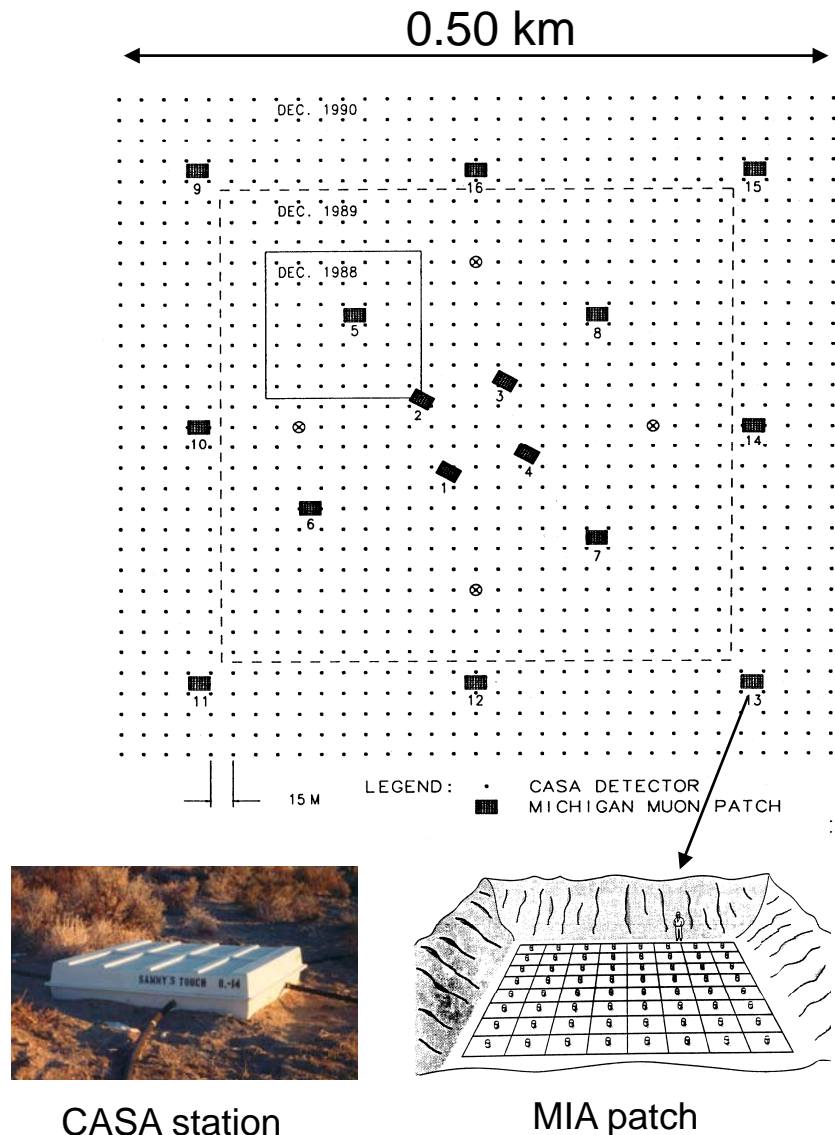
OG 2.2, Abstract 1183
D. Kieda et al.
"A VERITAS Search for VHE γ -ray Point Sources Near Selected Milagro Target Regions"

A. Smith et al. ICRC 2005
A.A. Abdo et al, astro-ph/0705.0707



CASA-MIA 60° x 60° search region

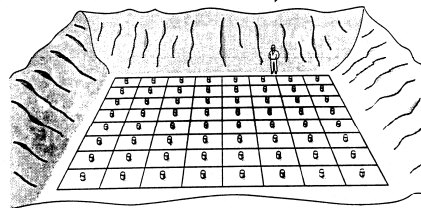
CASA-MIA Detector



- Largest air shower array built at TeV / PeV energies.
- 1089 surface detectors (CASA).
- 1024 buried muon detectors (MIA).
- Ang. Resolution $\sim 0.4^\circ - 2.0^\circ$.
- Median Energy $E \sim 110 \text{ TeV}$.
- γ -ray selection by muon content. Q-factor varies 1.8 – 50.0. For all data Q-factor ~ 3.0 .



CASA station



MIA patch

Observations and Data Sample

Earlier Results:

I. All-Sky pt. source Survey:

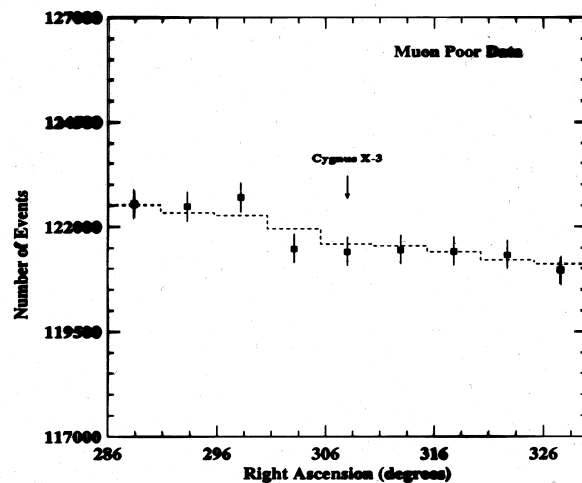
T.A. McKay et al. ApJ 417, 742 (1993)
Used 20% of data sample.

No significant pt. sources detected.

II. Search for Cygnus X-3:

A. Borione et al., PRD 55, 1714 (1997)
Used full data sample.

Cyg X-3 not detected.



New Analysis (2007):

- Observations:
March 1990 – August 1995.
Live time: 1378.4 days.
- Quality cuts on good runs and good events.
- Require high % of operating CASA detectors.
- Require working and reliable μ array.

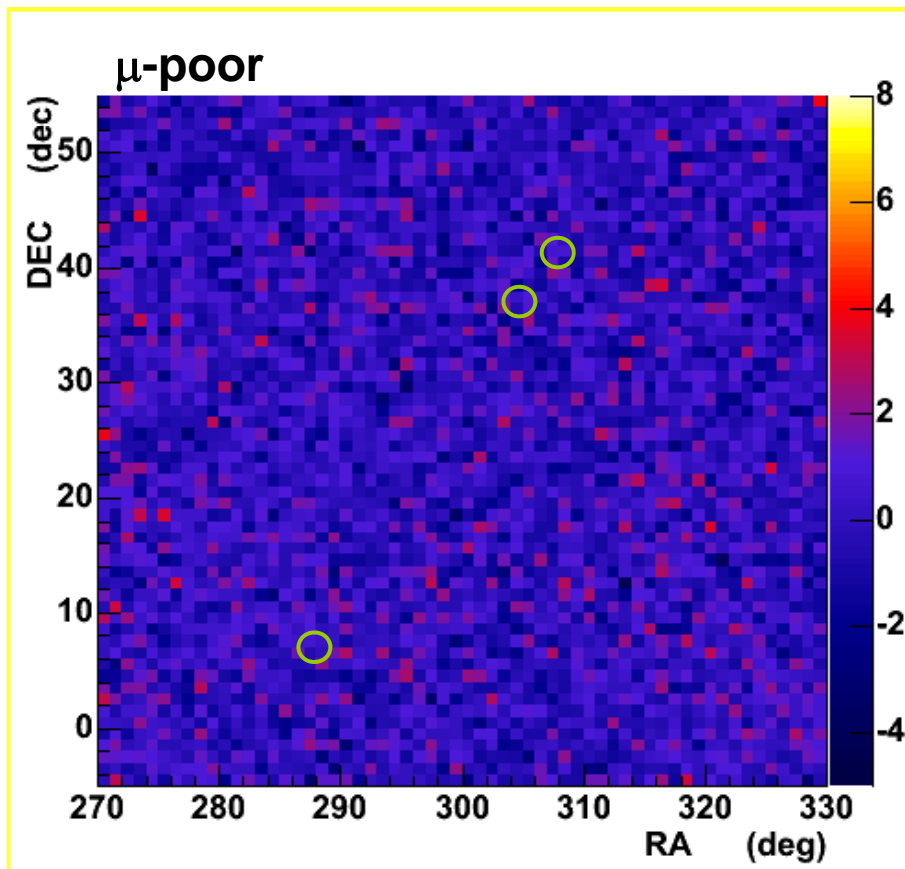
Data Sample	Events (M)
All Data	2173.
Run Cut Data	1769.
Run & Evt Cut Data	Total: 1662.

Analysis Procedure

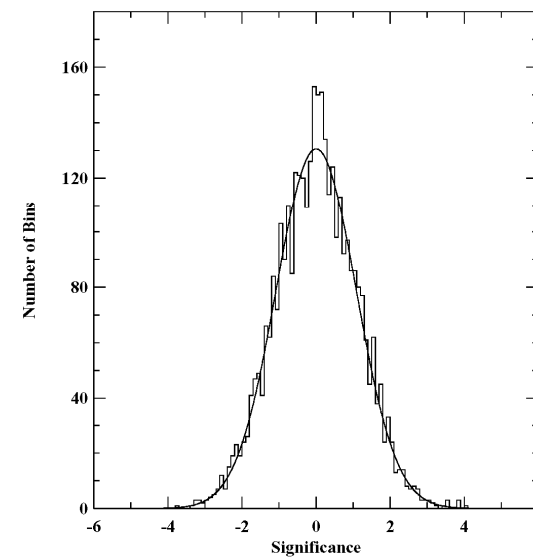
- Recover archival data from tape.
- Redo analysis software, run cuts and event cuts.
- Define Region I (search): $\delta = [-5^\circ, 55^\circ]$ $\alpha = [270^\circ, 330^\circ]$.
Region II (control): $\delta = [-5^\circ, 55^\circ]$ $\alpha = [90^\circ, 150^\circ]$.
- Binned search, 3 scales: $1^\circ \times 1^\circ$, $2^\circ \times 2^\circ$, $4^\circ \times 4^\circ$.
Each scale has 3 searches using offset bin boundaries.
- Background from local coordinate maps determined every 4200s and oversampled by factor = 10. Background calculation must be accurate to $< 0.2\%$ level with $\sim 0.3\text{M}$ events in a $2^\circ \times 2^\circ$ bin.
- Separate searches for **all-data** and **muon-poor** data.

PRELIMINARY results presented here ... Analysis ongoing.

(Preliminary) Results



- No non-statistical excess in either $1^\circ \times 1^\circ$ or $2^\circ \times 2^\circ$ searches.
- No significant excess on the 3 MGRO candidates.
- Significance distributions consistent with fluctuations.



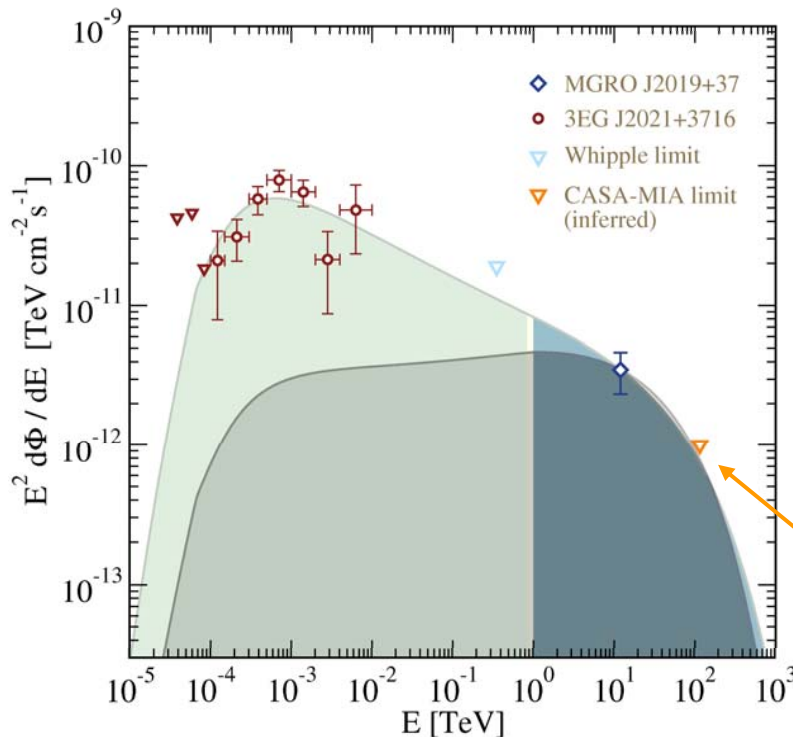
$1^\circ \times 1^\circ$ μ -poor

Gaussian Fit: $\mu = 0.04 \pm 0.02$

$\sigma = 1.08 \pm 0.03$

Science Interpretation

- Weak VHE sources, such as TeV J2032+41 would not expect to be detected at 100 TeV by CASA-MIA.
- Stronger sources, such as MGRO candidates, should be detected if their spectrum continued to 100 TeV, only factor of 5 above Milagro.



- Source spectrum must turn over rapidly above 20 TeV.
- Possibly consistent with hadronic acceleration model ?
- Possible ν source at 1-20 TeV ?

not a CASA-MIA result

Beacom & Kistler
PRD 75, 083001 (2007)

Summary

- Cygnus arm of Galaxy is potentially rich source of VHE cosmic rays and γ -rays. Surveys underway by **VERITAS** and **MAGIC** will map the region with great sensitivity.
- CASA-MIA data in 1990-1995, the largest sample of air shower data at 100 TeV, have been re-analyzed and show no strong sources of 100 TeV γ -rays in Cygnus.
- For consistency with Milagro results, source spectra should turn over rapidly above 20 TeV.
- CASA-MIA analysis will be completed – additional search of lower energy data ($E < 100$ TeV). Results to be included in final paper for proceedings.
- It's good to save data in a recoverable fashion!

Acknowledgements

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