

News from VERITAS

**Wei Cui, for the VERITAS Collaboration
Department of Physics, Purdue University**

Very Energetic Radiation Imaging Telescope Array System



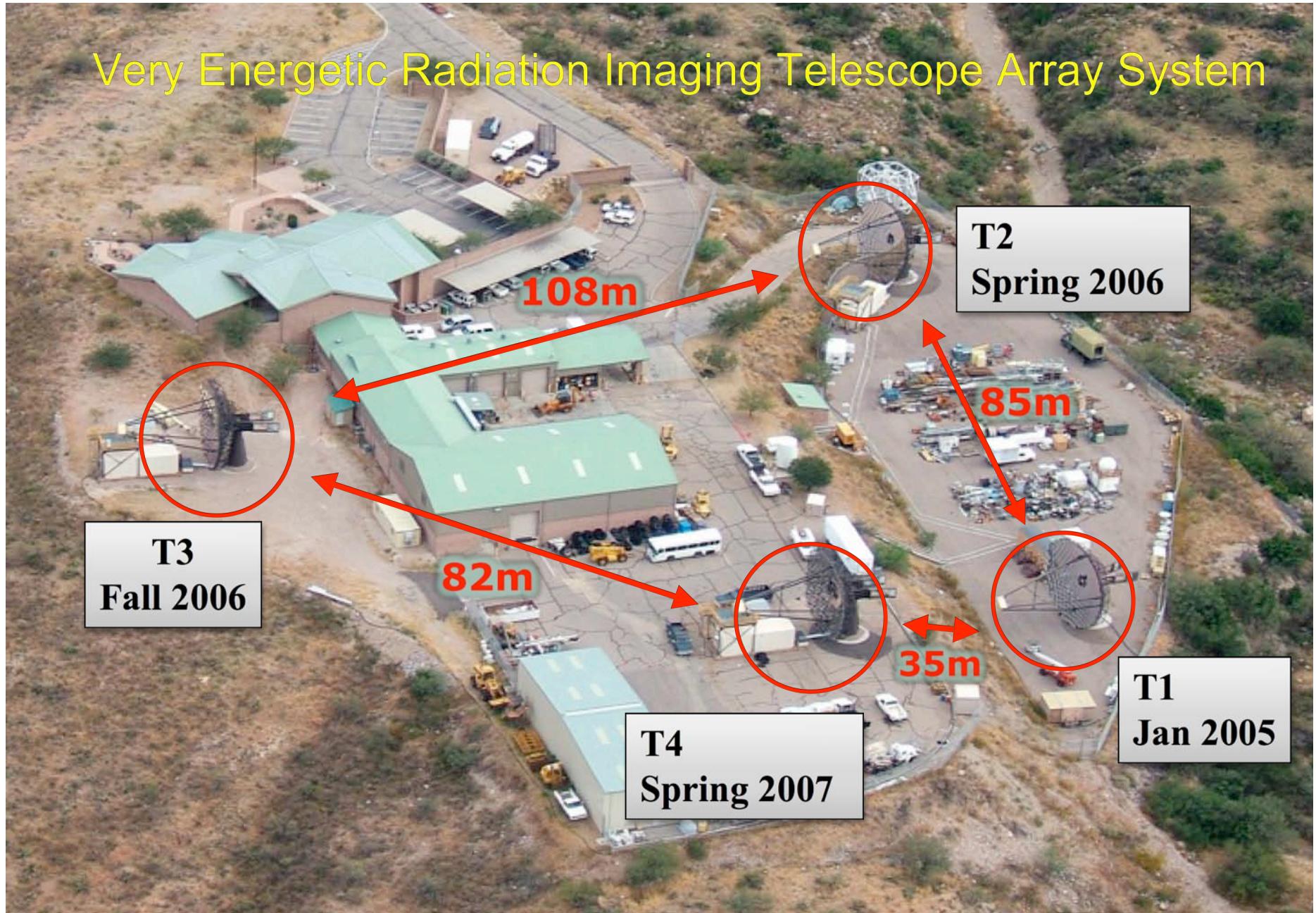
September 24-28, 2008

TeV Particle Astrophysics, IHEP, Beijing, China

2

Very Energetic Radiation Imaging Telescope Array System





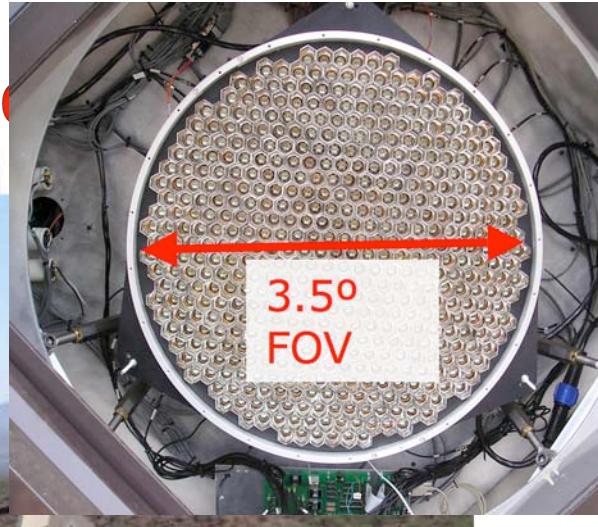
The VERITAS Telescope

Davies-Cotton f/1.0 Optics.
Total area=110m²



The VERITAS Telescope

Davies-Cotton f/1.0 Optics.
Total area=110m²



VERITAS Operation



Last Observing Period: October 2007- June 2008

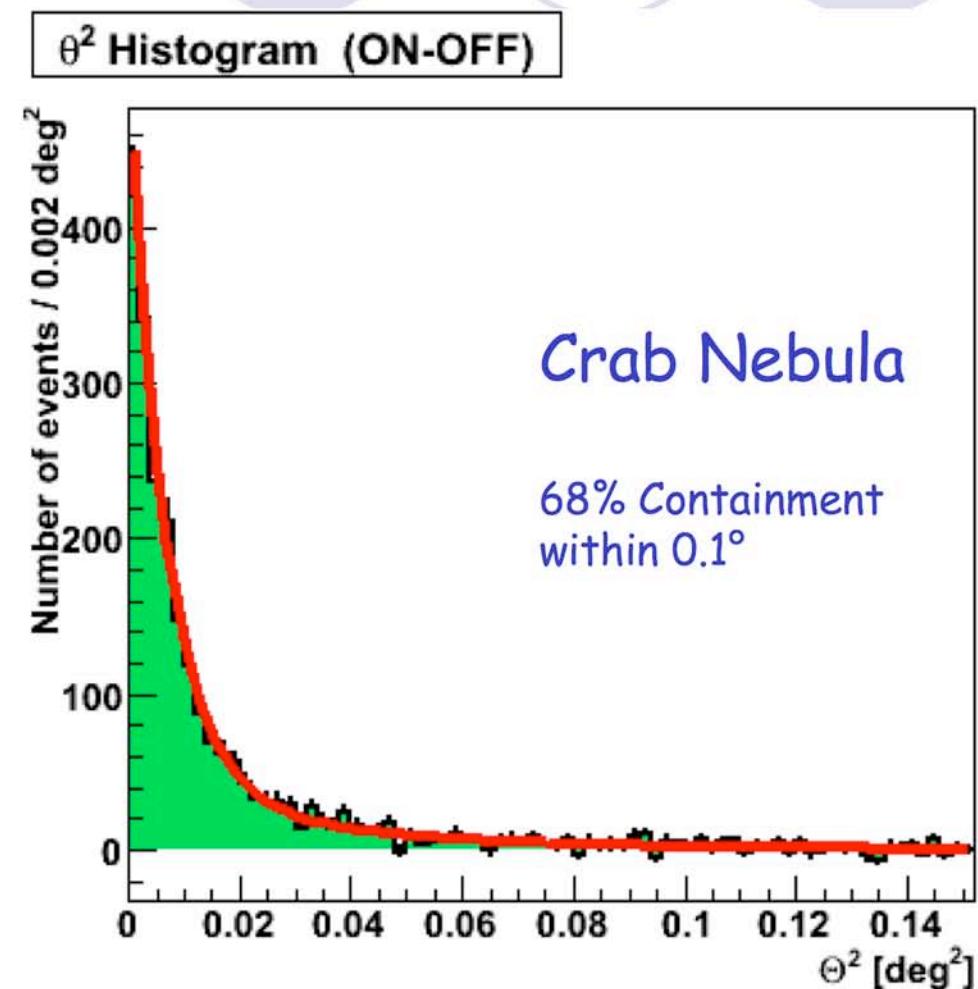
Good weather, 4-telescope data: ~700 hours

Moonlight data: ~100 hours

Point Spread Function

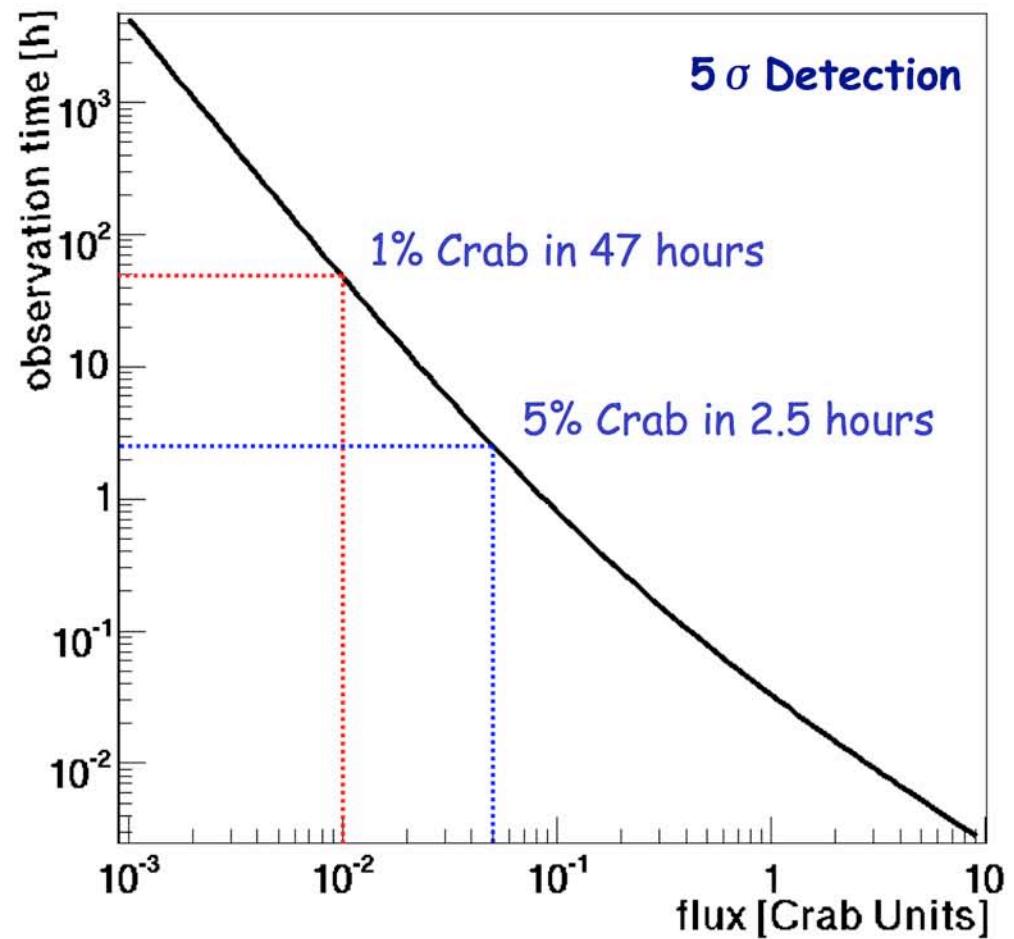
Tight cuts:

- Image size/telescope
 > 400 d.c (75 p.e.)
- Reduced mean-scaled width or length < 0.5
- 4 telescope events only
- $\Theta^2 < 0.015 \text{ degrees}^2$



Point Source Detectability

**Inferred from on-axis,
high-elevation ($>65^\circ$)
observations of the
Crab Nebula.**



Point Source Detectability

**Inferred from on-axis,
high-elevation ($>65^\circ$)
observations of the
Crab Nebula.**

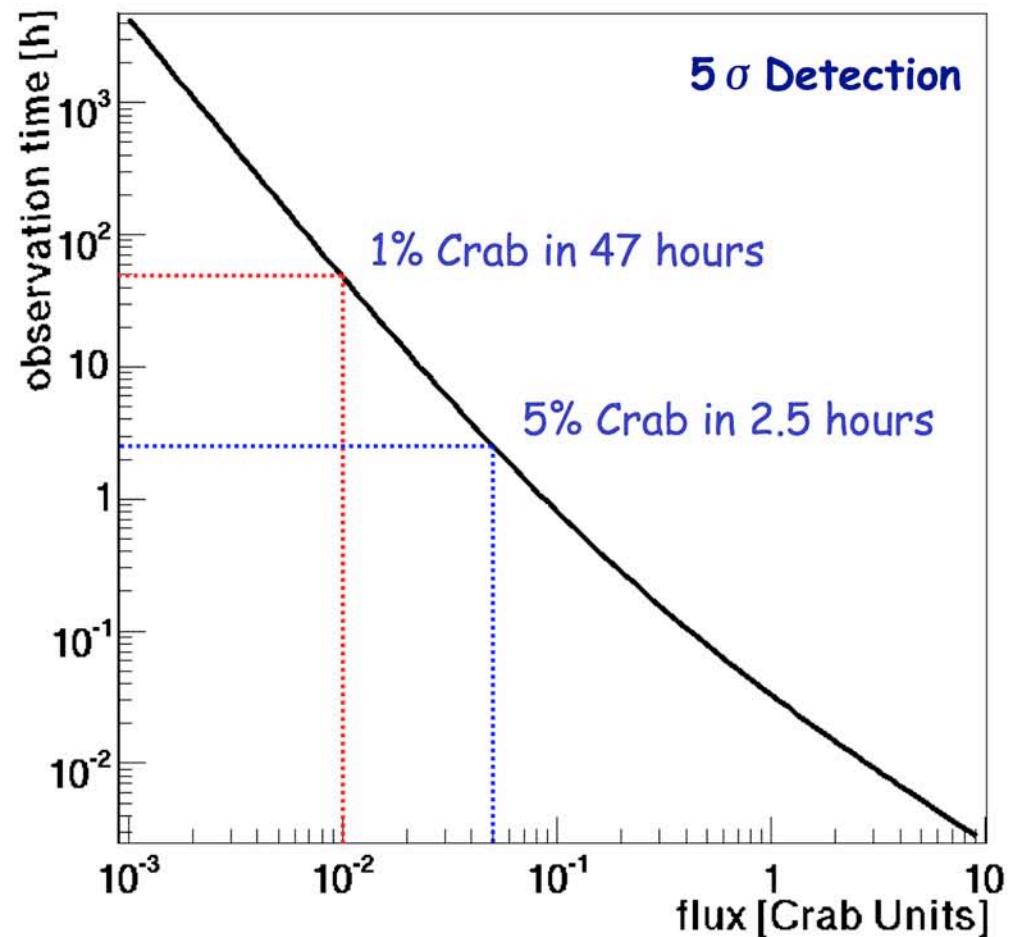
For comparison

HESS:

1% Crab in 25 hrs

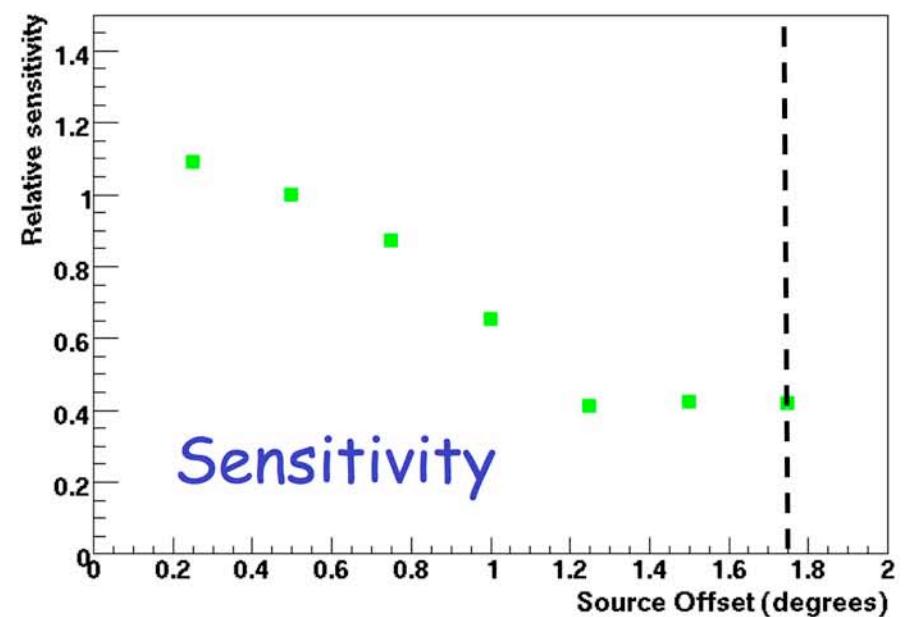
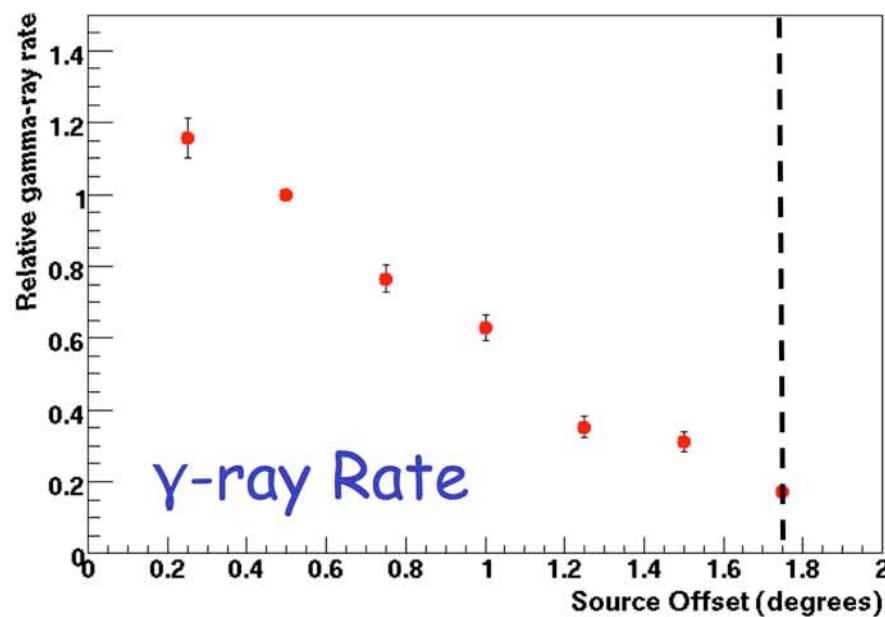
MAGIC:

2% Crab in 50 hrs



Off-Axis Sensitivity

- Measured on the Crab Nebula
- Physical camera radius=1.75°



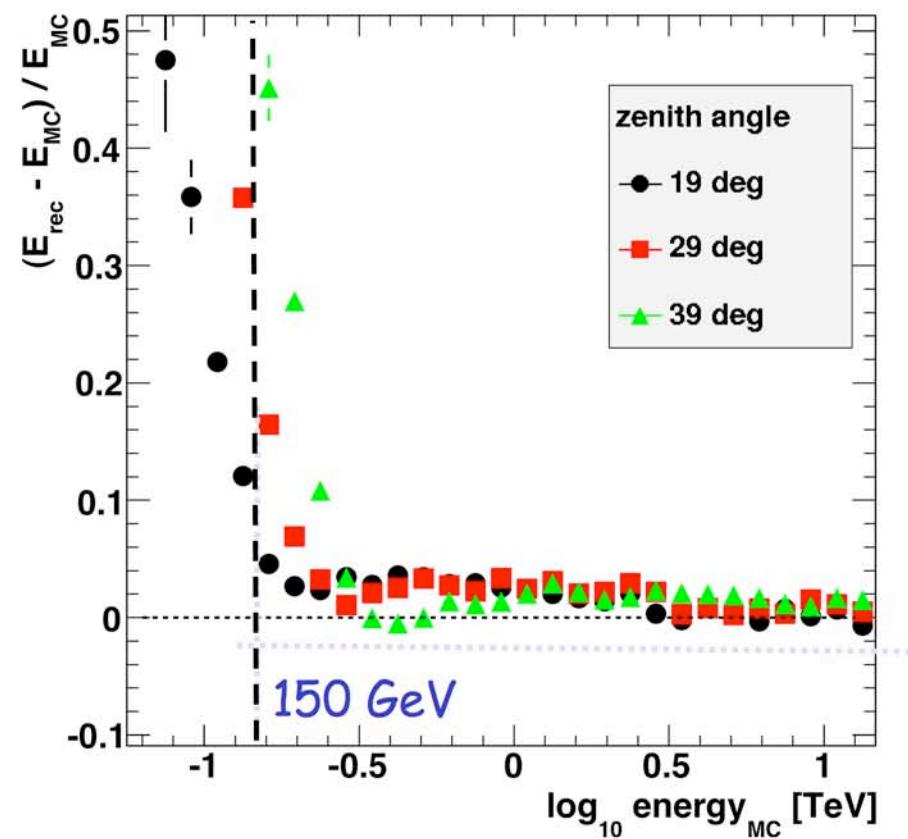
Energy Reconstruction

Loose Cuts:

- Number of image pixels/telescope > 4
- Reduced mean-scaled width or length < 1.0
- ≥ 2 telescope images but not T1 + T4
- $\Theta^2 < 0.025$ degrees²
- loss (light fraction in outer pixel ring) < 10%

Energy Resolution:

15-20 %





The VERITAS Collaboration

September 24-28, 2008

TeV Particle Astrophysics, IHEP, Beijing, China

The VERITAS Collaboration



- Smithsonian Astrophysical Observatory *
- Adler Planetarium
- Purdue University *
- Barnard College, NY
- Iowa State University *
- DePauw University, IN
- Washington University, St. Louis *
- Grinnell College, IA
- University of Chicago *
- University of California, Santa Cruz
- University of Utah *
- University of Massachusetts
- University of California, Los Angeles *
- Cork Institute of Technology
- McGill University, Montreal *
- Galway-Mayo Institute of Technology
- National University of Ireland, Dublin *
- National University of Ireland, Galway
- University of Leeds *
- Argonne National Lab
- Associate Members

Project office: Whipple observatory SAO

Funding from
NSF/DOE/Smithsonian/PPARC/SFI/NSERC



Science Working Groups

- Astroparticle Physics
- Blazars
- Dark Matter
- Extragalactic (Non-blazar) Sources
- Galactic Compact Objects
- Galactic Plane
- Gamma Ray Bursts
- Sky Survey
- Supernova Remnants
- Unidentified Sources



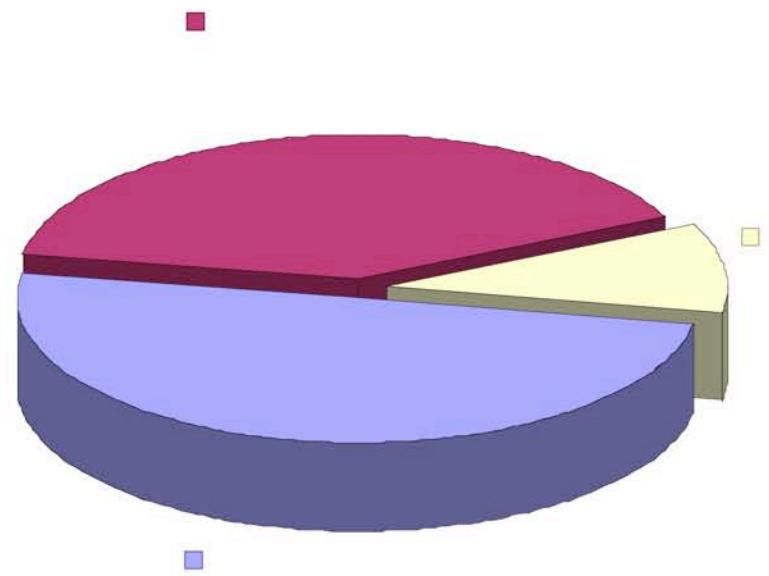
Science Working Groups

- Astroparticle Physics
- Blazars
- Dark Matter
- Extragalactic (Non-blazar) Sources
- Galactic Compact Objects
- Galactic Plane
- Gamma Ray Bursts
- Sky Survey
- Supernova Remnants
- Unidentified Sources

Collaboration
welcome!

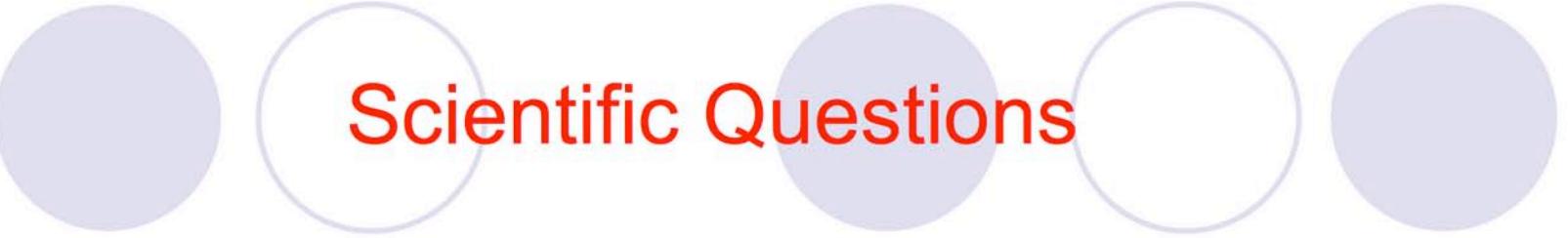
VERITAS Scientific Programs

- Key Science Projects
 - Blazars
 - Dark Matter
 - Galactic Plane Survey
 - Supernova Remnants
- Open time for SWG proposals, administered by the VERTIAS TAC
- Spokesperson's Discretionary Time for Engineering and ToOs





Scientific Questions



Scientific Questions

- Radiation mechanisms

- Inverse Compton scattering, π^0 decay, synchrotron



Scientific Questions

- Radiation mechanisms
 - Inverse Compton scattering, π^0 decay, synchrotron
- Properties of radiating particles
 - Leptonic vs hadronic



Scientific Questions

- Radiation mechanisms
 - Inverse Compton scattering, π^0 decay, synchrotron
- Properties of radiating particles
 - Leptonic vs hadronic
- Particle acceleration processes
 - Shock, magnetic reconnection



Scientific Questions

- Radiation mechanisms
 - Inverse Compton scattering, π^0 decay, synchrotron
- Properties of radiating particles
 - Leptonic vs hadronic
- Particle acceleration processes
 - Shock, magnetic reconnection
- Origin of cosmic rays
 - SNR? GRB? AGN?

Scientific Questions

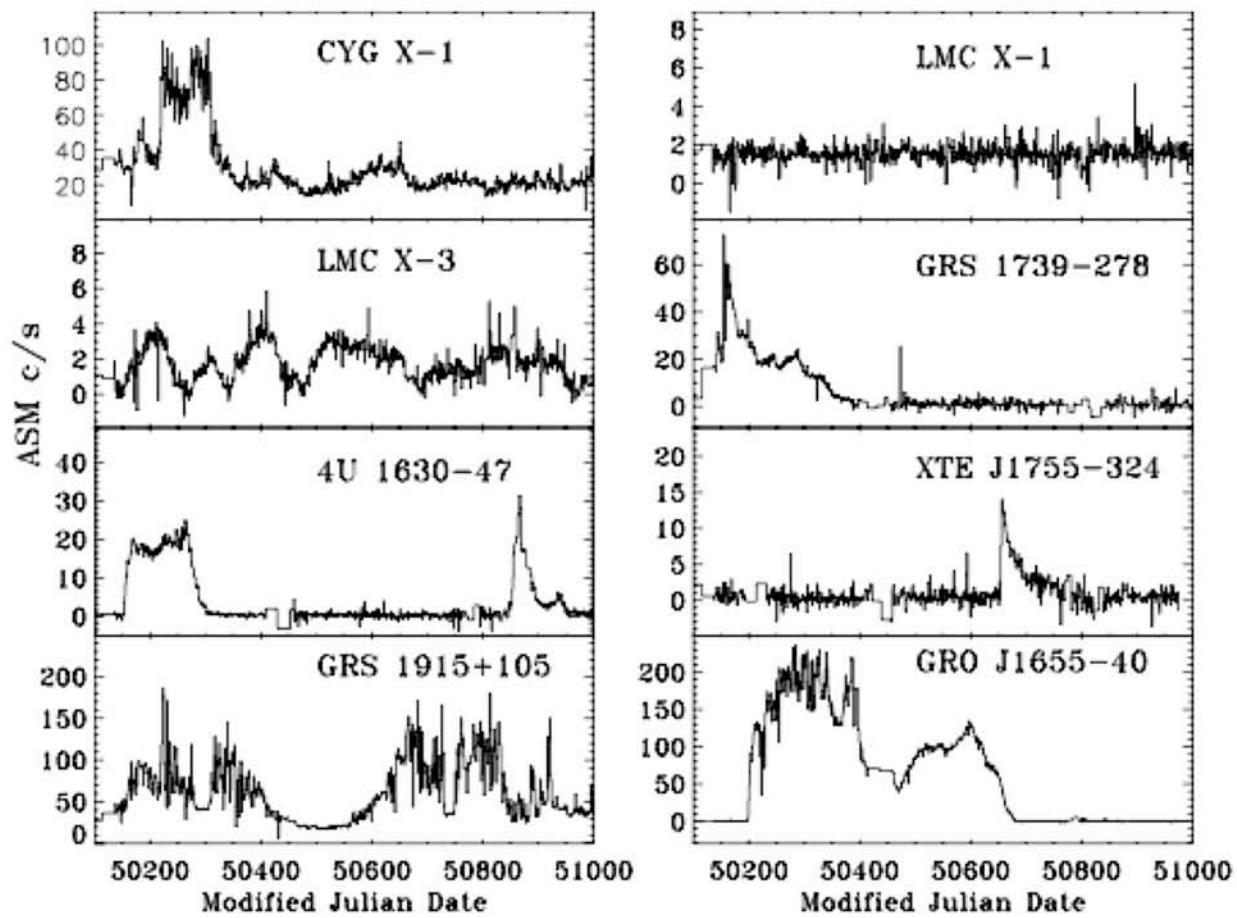
- Radiation mechanisms
 - Inverse Compton scattering, π^0 decay, synchrotron
- Properties of radiating particles
 - Leptonic vs hadronic
- Particle acceleration processes
 - Shock, magnetic reconnection
- Origin of cosmic rays
 - SNR? GRB? AGN?
- Cosmic background radiation
 - Absorption of gamma rays



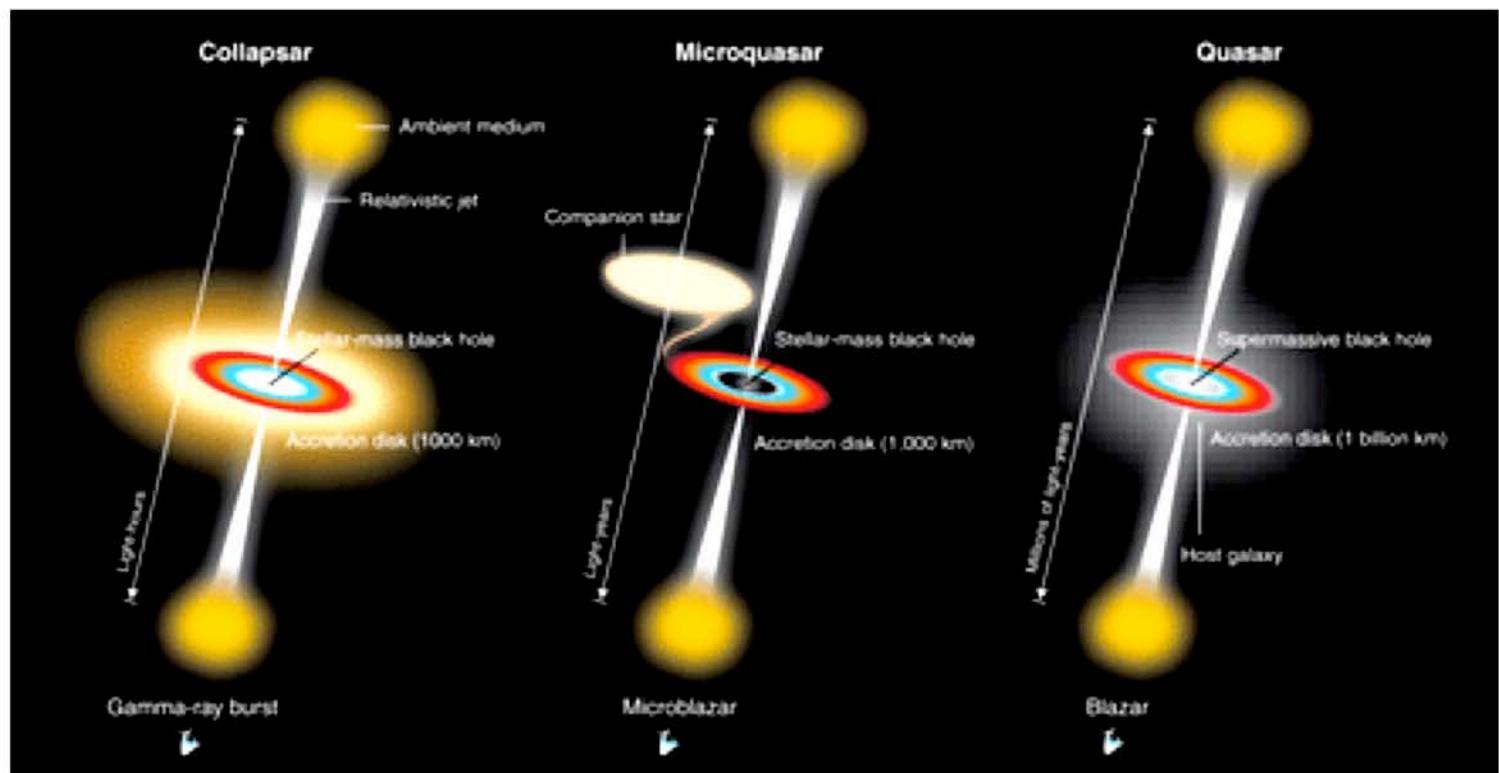
Scientific Questions

- Radiation mechanisms
 - Inverse Compton scattering, π^0 decay, synchrotron
- Properties of radiating particles
 - Leptonic vs hadronic
- Particle acceleration processes
 - Shock, magnetic reconnection
- Origin of cosmic rays
 - SNR? GRB? AGN?
- Cosmic background radiation
 - Absorption of gamma rays
- Nature of dark matter

Messy Laboratories

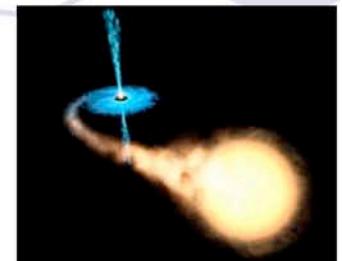


Particle Acceleration near Black Holes



Galactic Sources

- X-ray Binaries



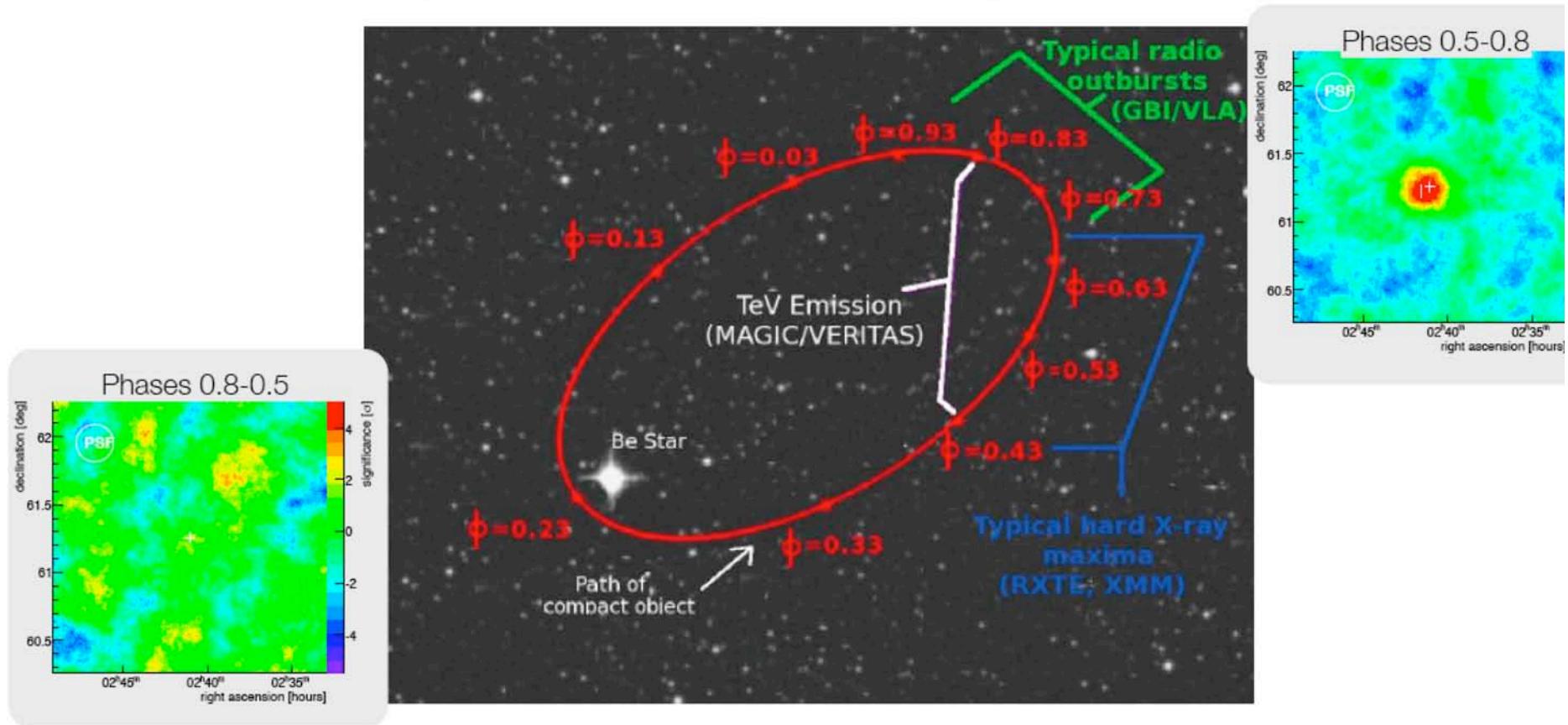
- Supernova Remnants



- Unidentified Sources

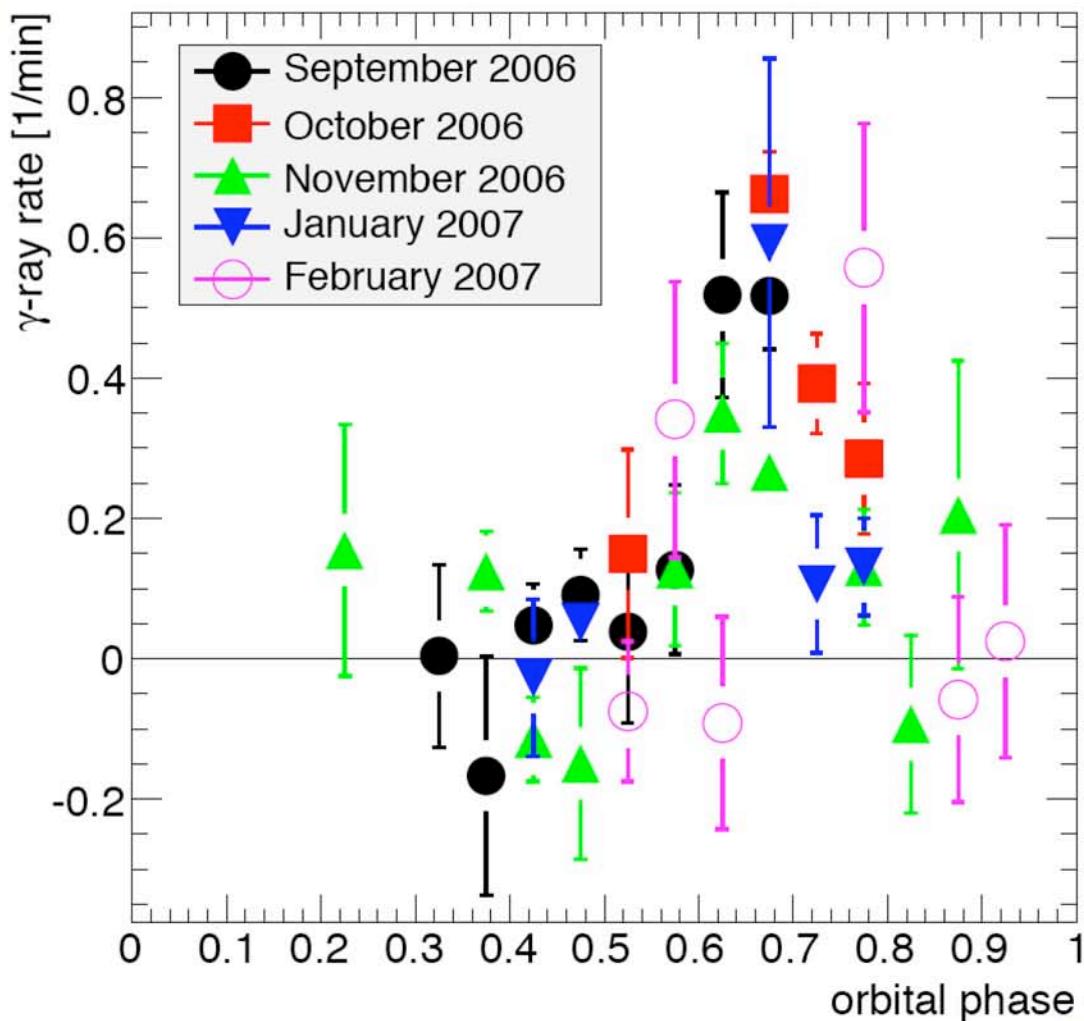


X-ray Binary: LS I +61 303



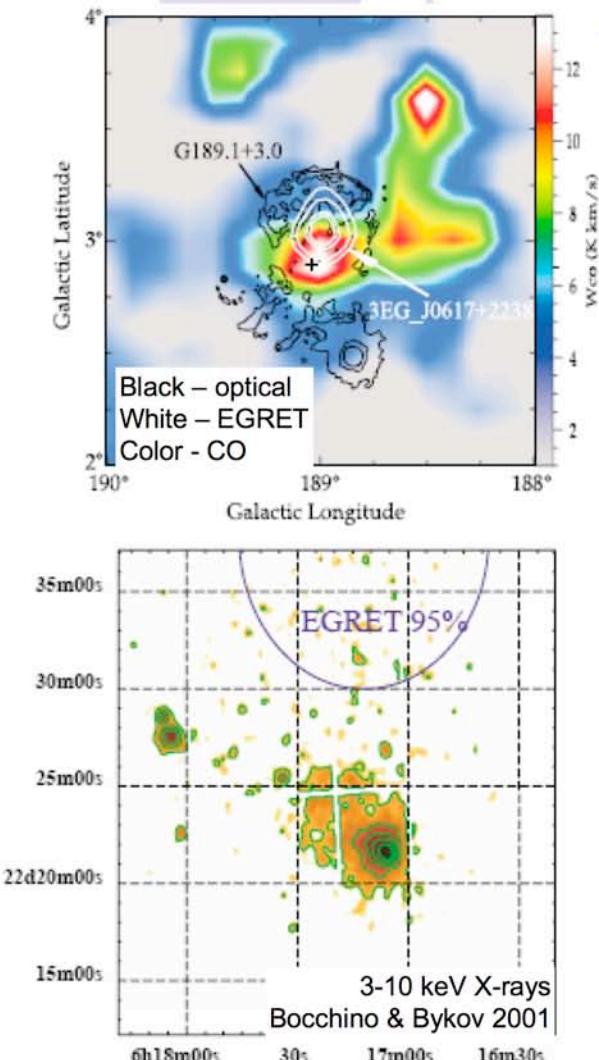
G. Maier, Gamma08

X-ray Binary: LS I +61 303



G. Maier, ICRC, 2007

Supernova Remnant: IC 443



September 24-28, 2008

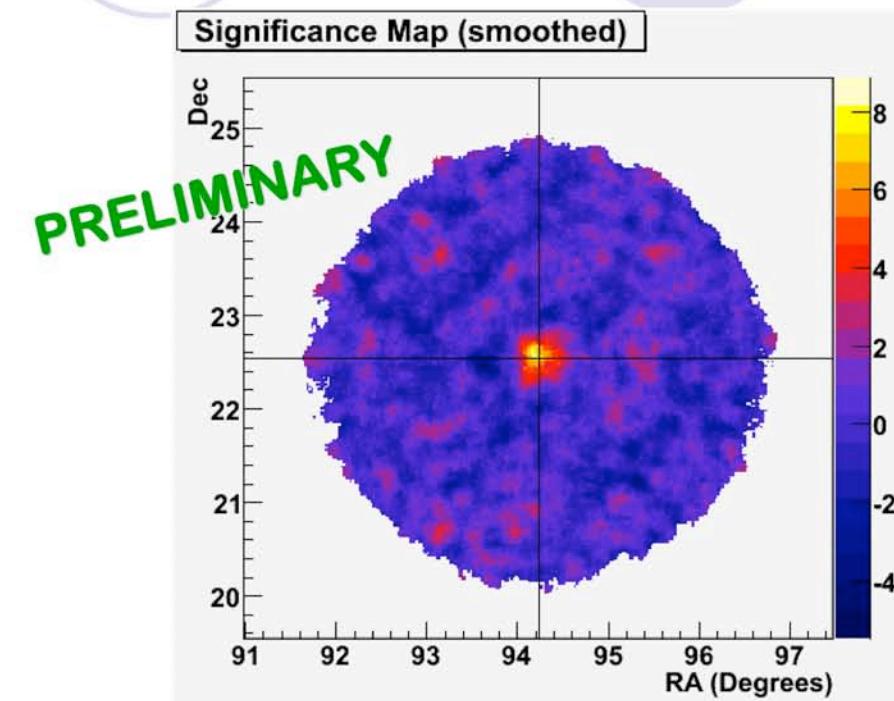
TeV Particle Astrophysics, IHEP, Beijing, China

- Discovered in TeV in 2007
 - by VERITAS ($7.1/6.0\sigma$ pre/post-trials in 15.9 hrs)
 - by MAGIC (5.7σ in 29 hrs)
- Observed during two epochs:
 - Feb / Mar 2007 with 3 telescopes
 - PWN location, CXOU J061705.3+222127
 - Oct / Nov 2007 with 4 telescopes
 - Center of Feb/Mar hot spot: 06 16.9 +22 33
- Total livetime: 37.1 hrs.

Figures from Torres *et al.* Phys. Rep. 382, 303 (2003)
MAGIC point from Albert *et al.* astro-ph/0705.3119v1

B. Humensky, Gamma08

Supernova Remnant: IC 443

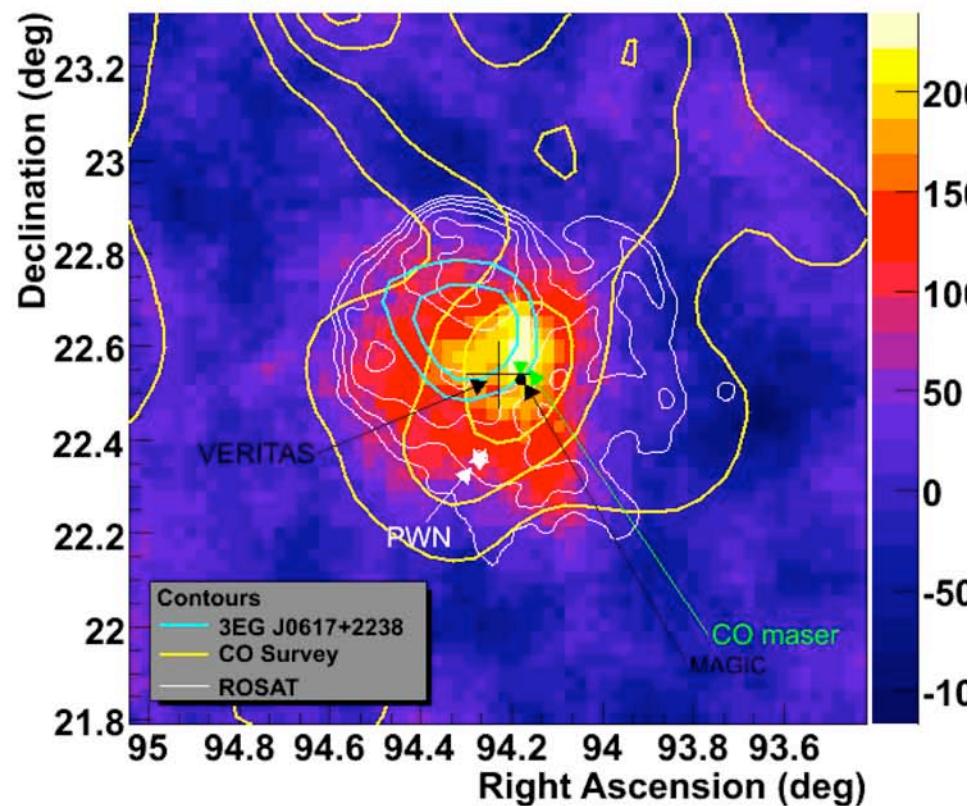


- **8.2σ peak significance pre-trials (standard point-source cuts)**
- **Assuming 2-d gaussian profile, fitting uncorrelated excess map:**
 - **Centroid: $06^{\circ} 16.9' +22^{\circ} 32.4'$ $\pm 0.03^{\circ}_{\text{stat}} \pm 0.07^{\circ}_{\text{syst}}$**
 - **Extension: $\sigma \sim 0.17^{\circ} \pm 0.02^{\circ}_{\text{stat}} \pm 0.04^{\circ}_{\text{syst}}$**

Supernova Remnant: IC 443

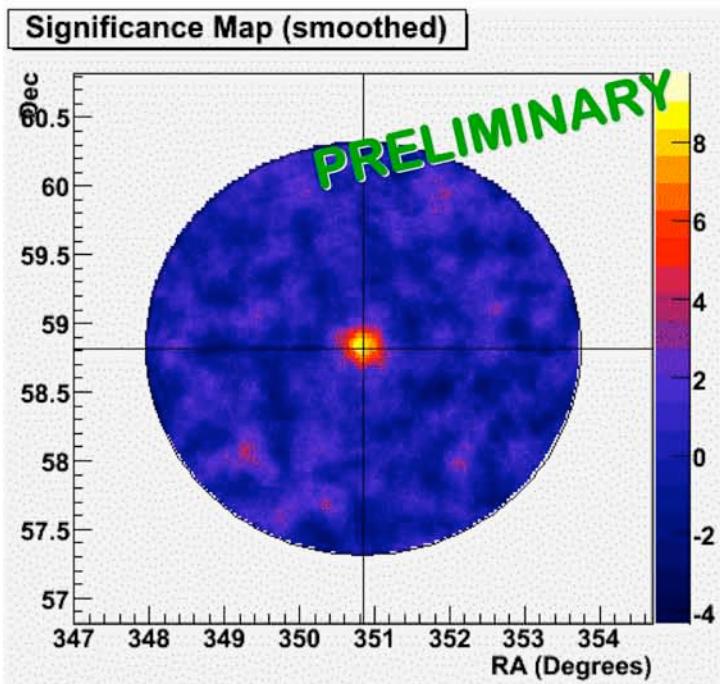
- Centroid: 06 16.9 + 22 32.4
 - consistent with MAGIC
- Overlap with CO indicating molecular cloud along line of sight
- Maser emission suggests SNR shock interacting with cloud
- TeV emission could be
 - CR-induced pion production in cloud
 - associated with the pulsar wind nebula to the south

Excess Map (smoothed)



B. Humensky, Gamma08

Supernova Remnant: Cas A



- Exposure: 20.3 hrs, with 4 tels
- 9.8σ detection
- Flux: ~ 0.03 Crab
- Consistent with a point source

B. Humensky, Gamma08

MGRO J1908+106/HESS J1908+063

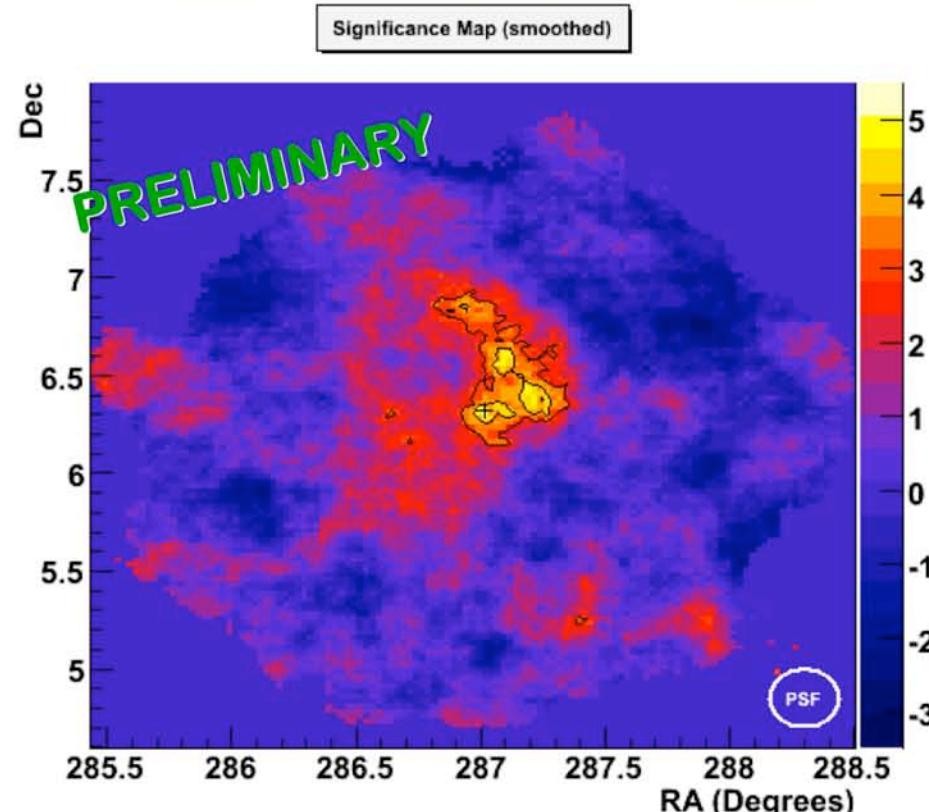
On-source time:

- Survey: 5.7 hrs
- Wobble: 16 hrs

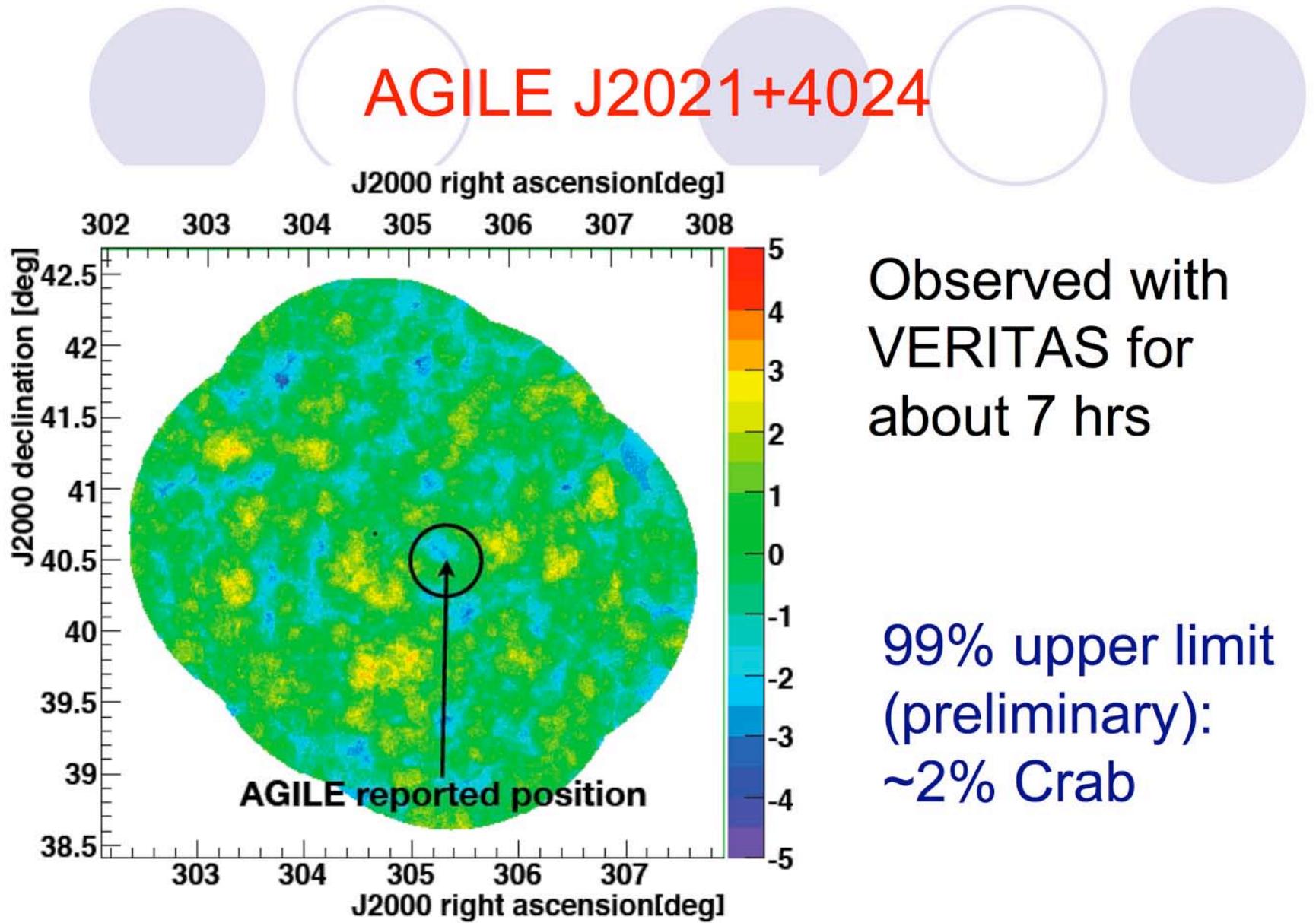
Detection at ~5 sigma

Source appears to be extended:

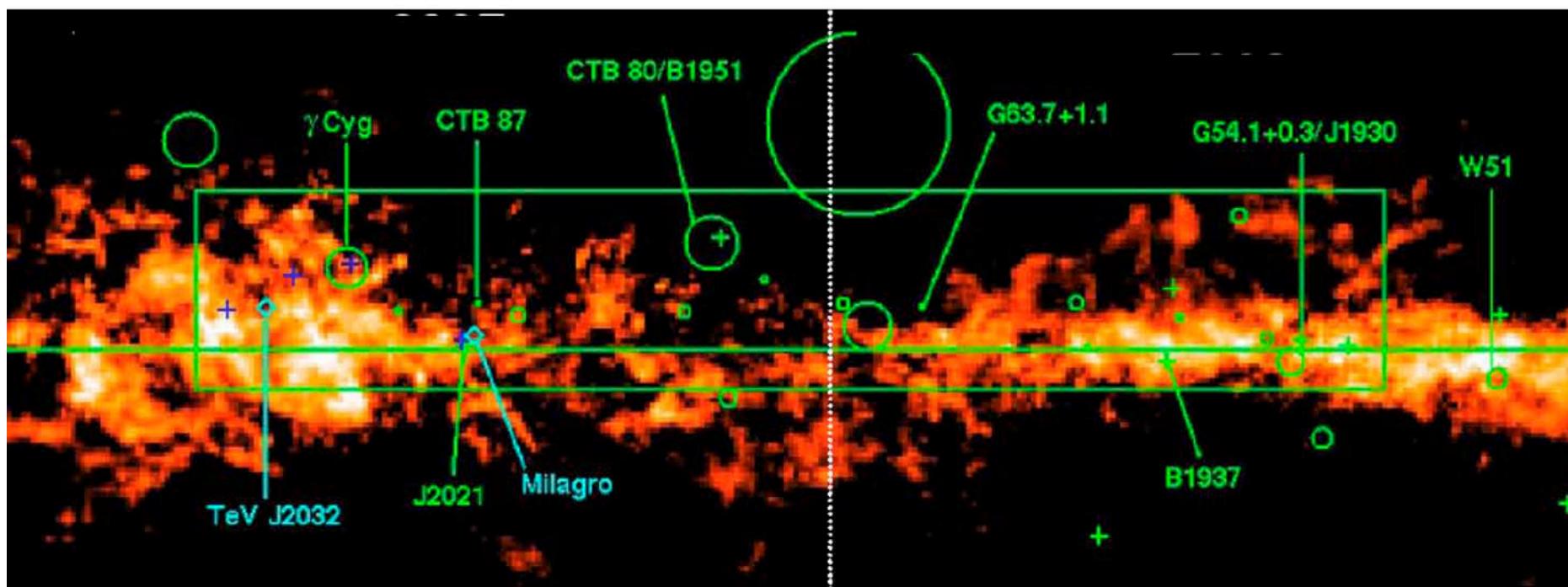
$$\sigma \sim 0.19^\circ \pm 0.04^\circ_{\text{stat}}$$



J. Ward, Gamma08

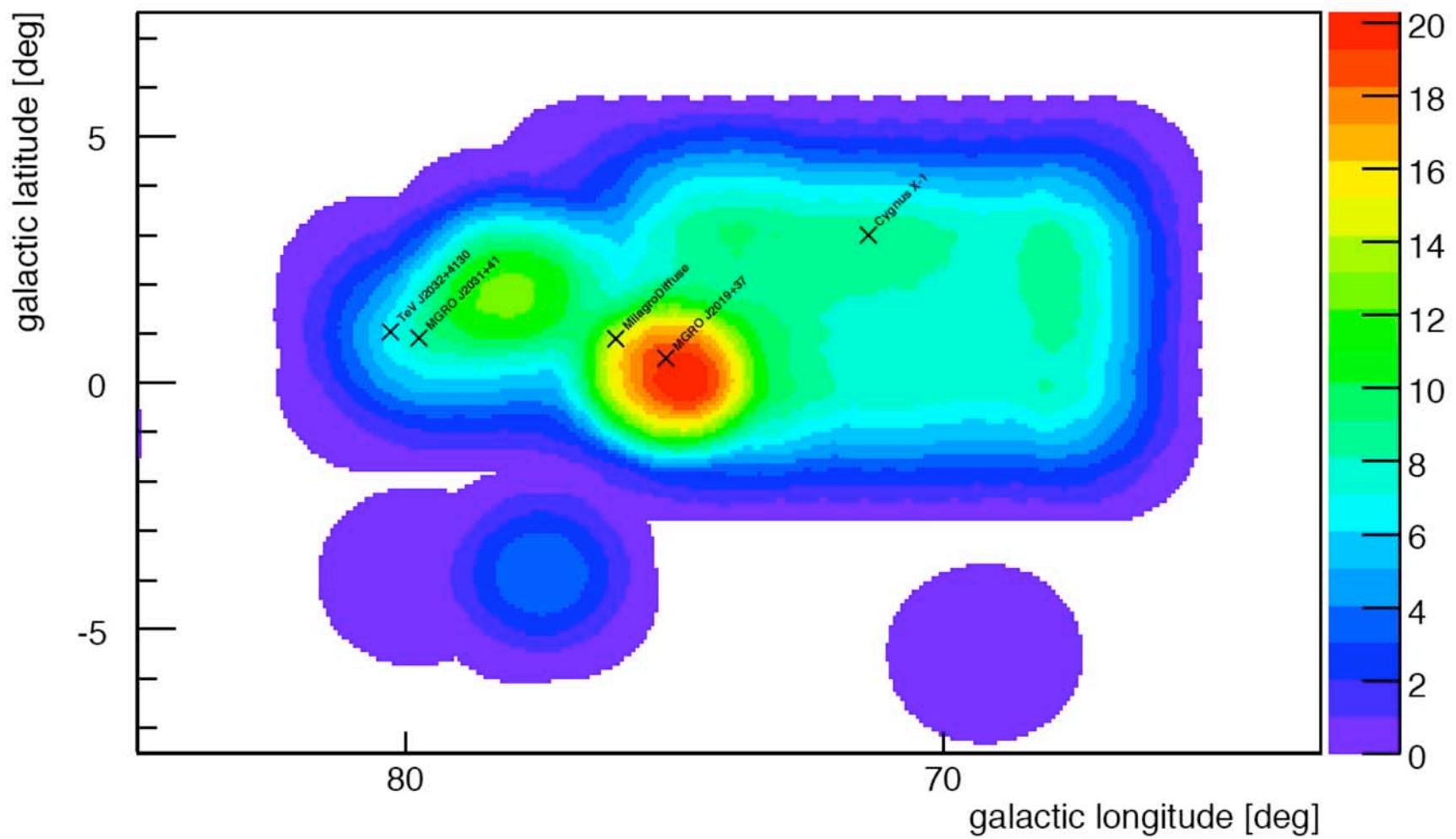


Cygnus Survey



On-going ...

Coverage Achieved



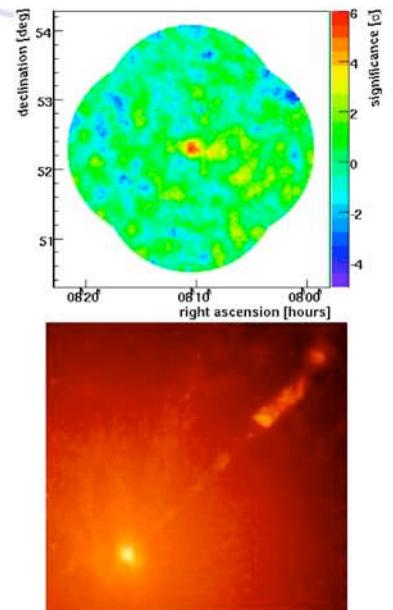
Extragalactic Sources

- Blazars

- Radio Galaxies

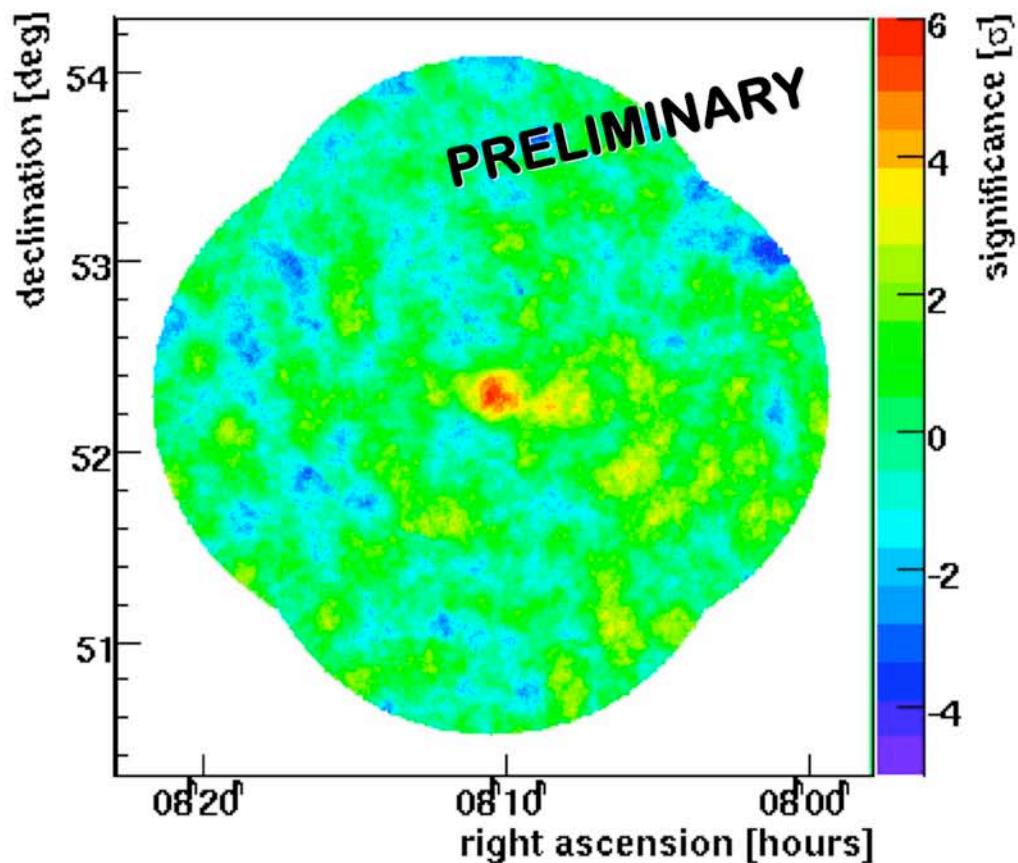
- Dwarf Galaxies, Starburst Galaxies, Clusters of Galaxies, Gamma Ray Bursts, ...

See Frank Krennrich's talk for details



1ES 0806+524 Discovered

S. Swordy, Atel 1415

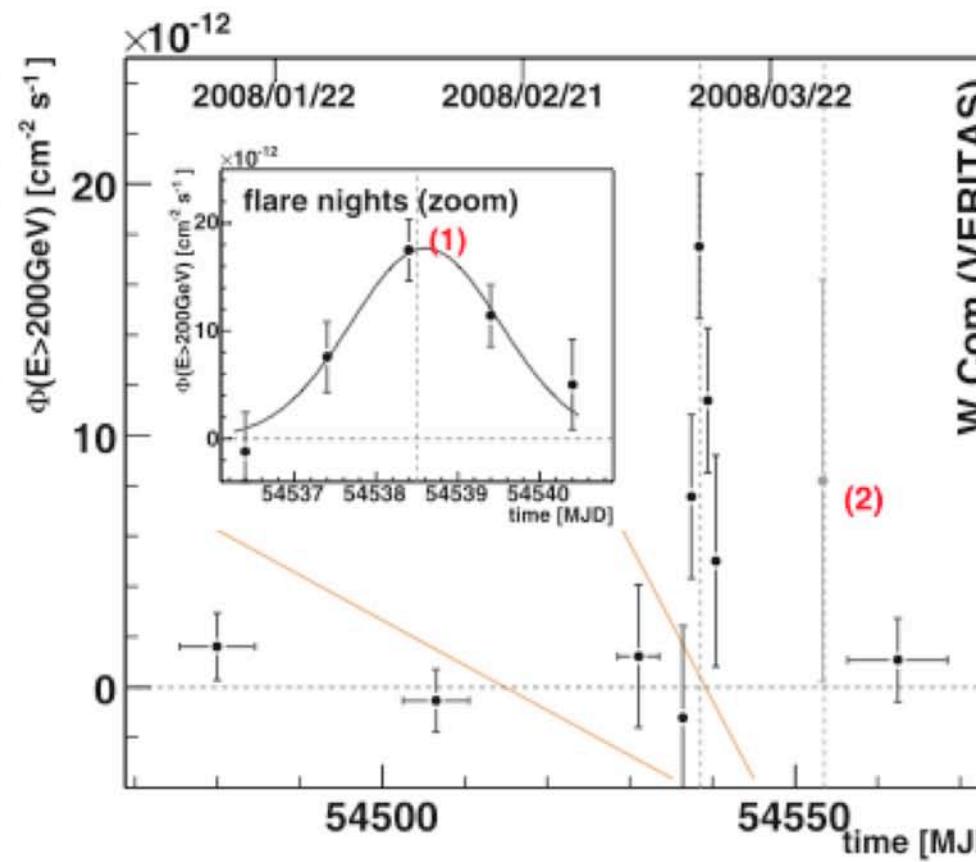
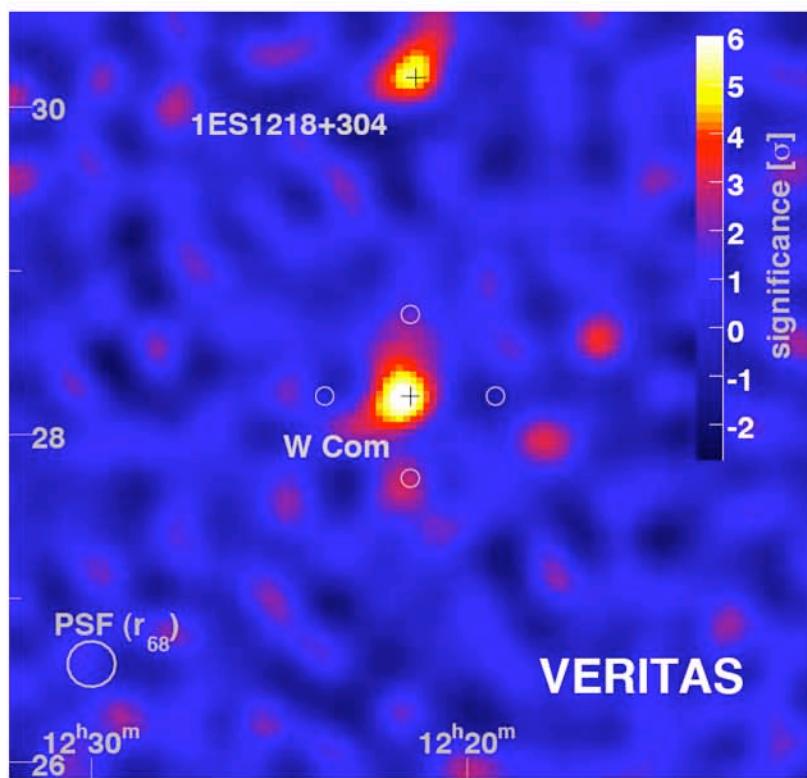


- $z=0.138$
- ~ 40 hrs
- $5.8\sigma, 1.1\%$ Crab

Contact: P. Cogan (in prep)

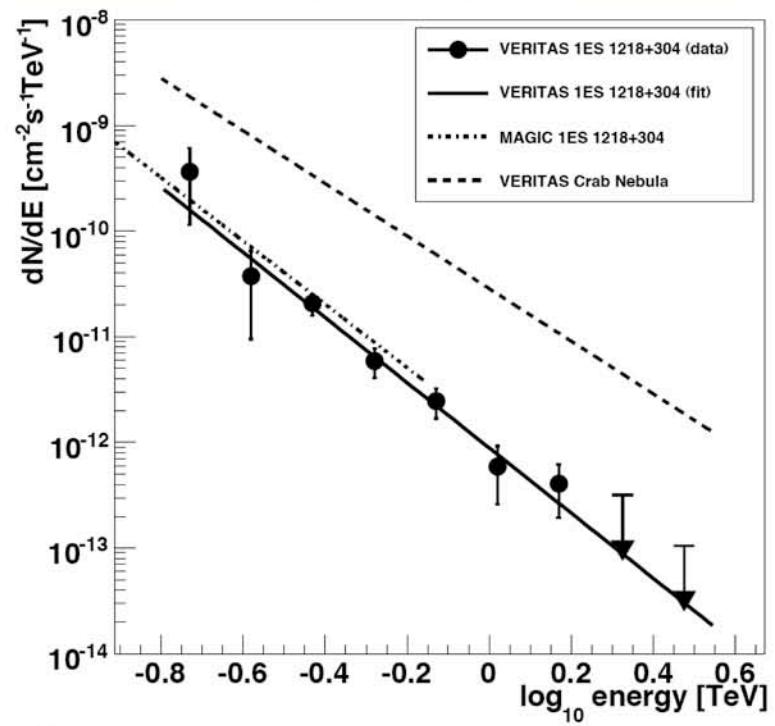
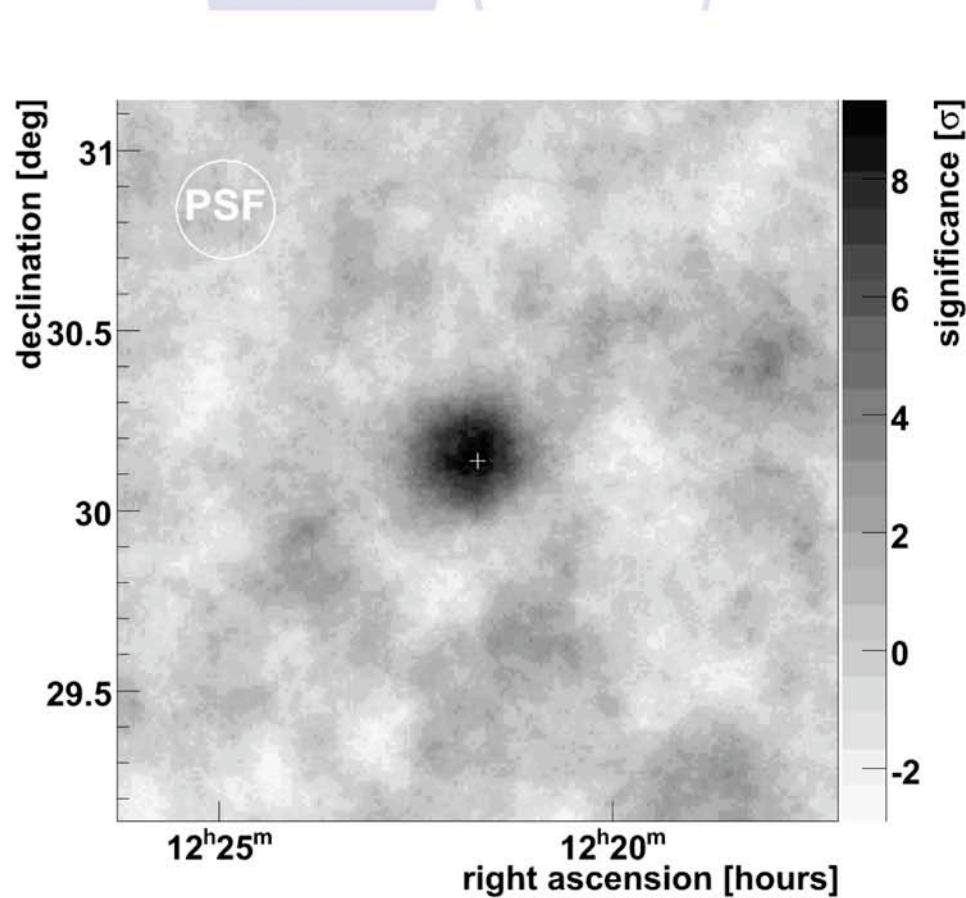
W Comae Discovered

S. Swordy, Atel 1422



Acciari et al. 2008, ApJ, 684, L73

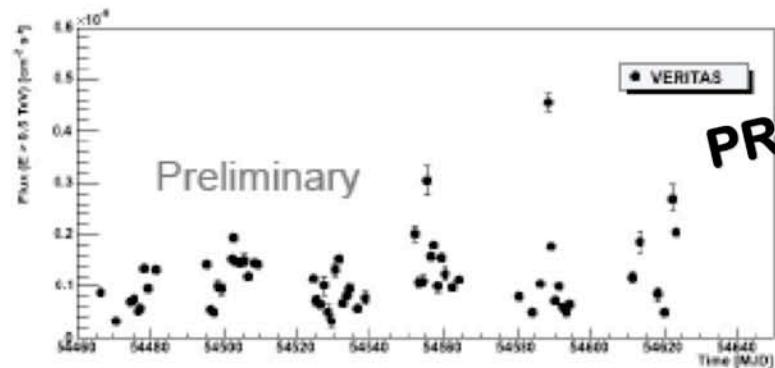
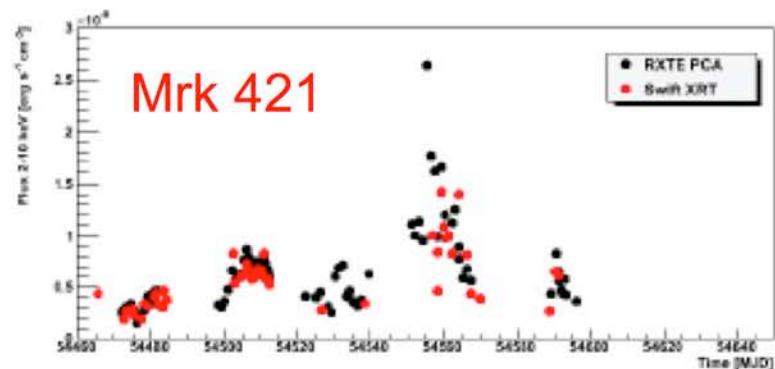
1ES 1218+304 Confirmed



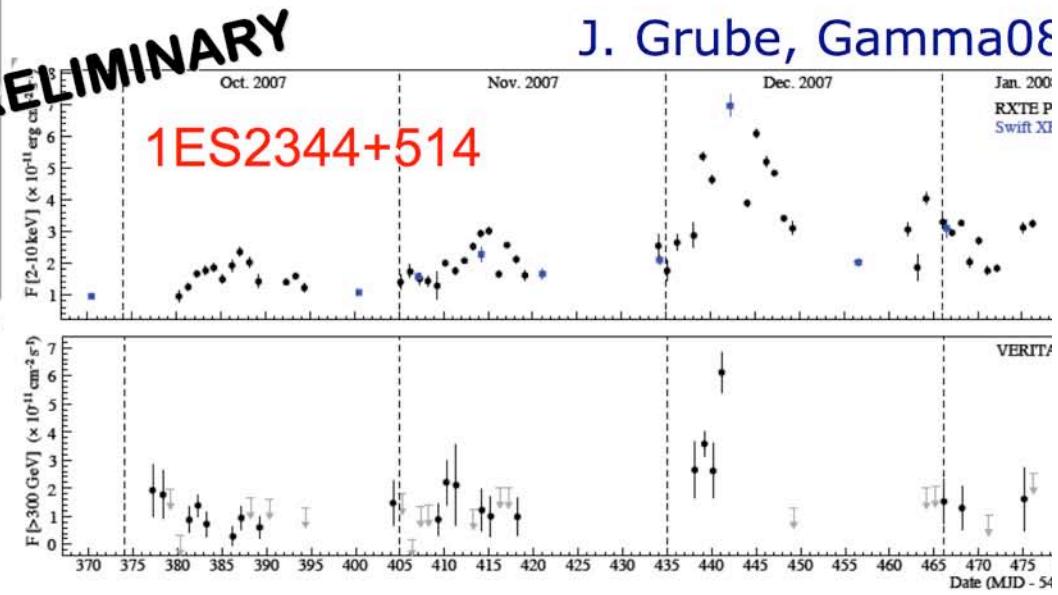
- $z=0.182 \Rightarrow$ 2nd farthest VHE blazar
- MAGIC 8.2 hrs, 6.4σ , $E>120$ GeV
- VERITAS: 3 tels only, 17.4 hrs
- 10.4σ , 6% Crab, $E>200$ GeV

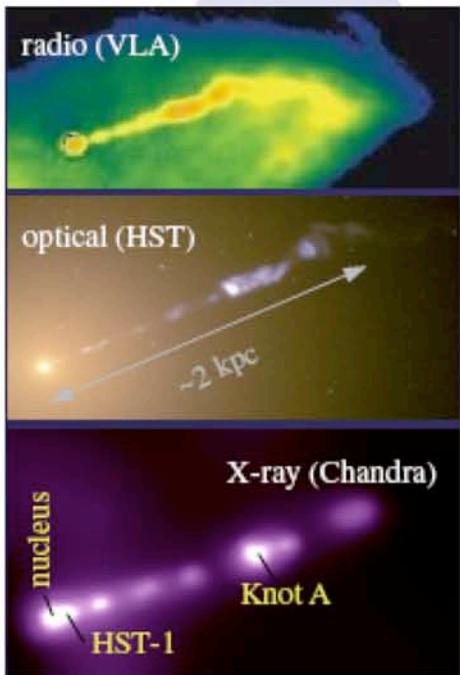
Contact: P. Fortin (ApJ, submitted)

Old Friends

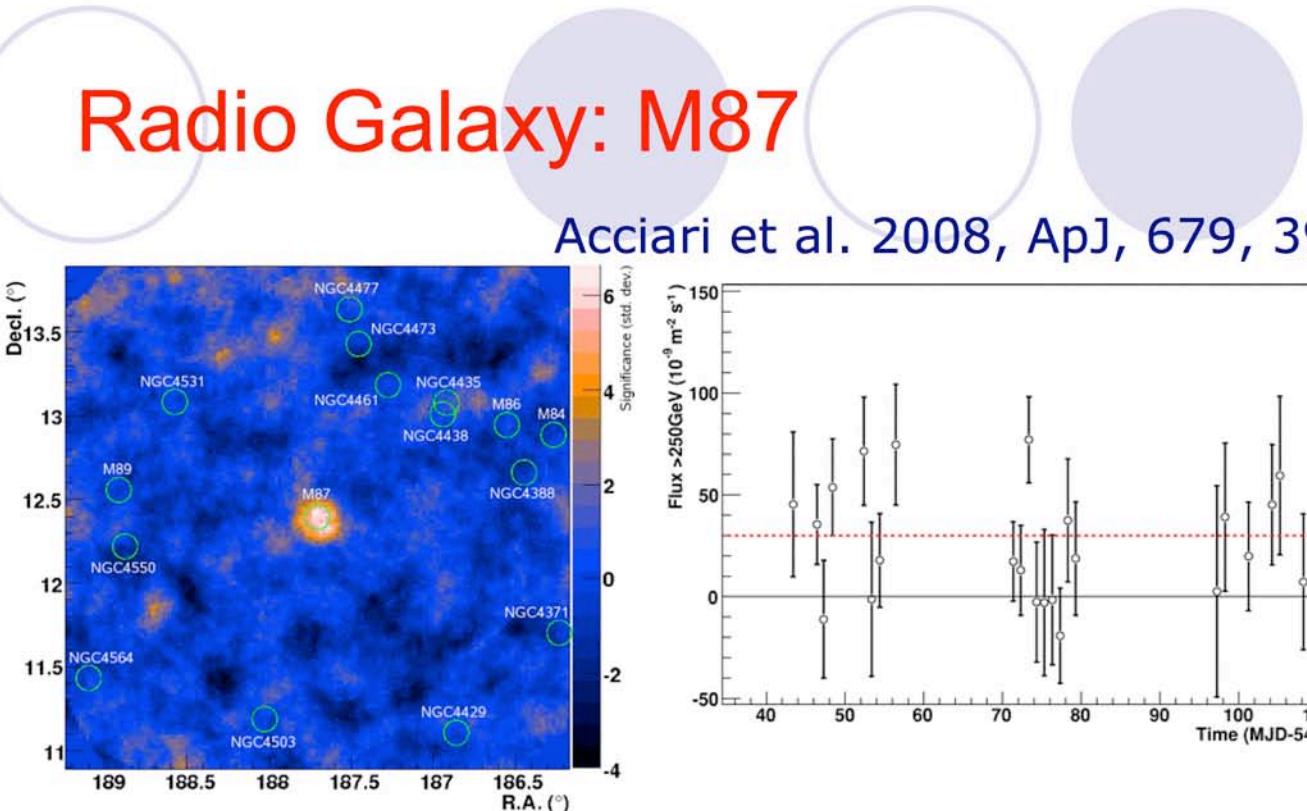


L. Reyes, Gamma08

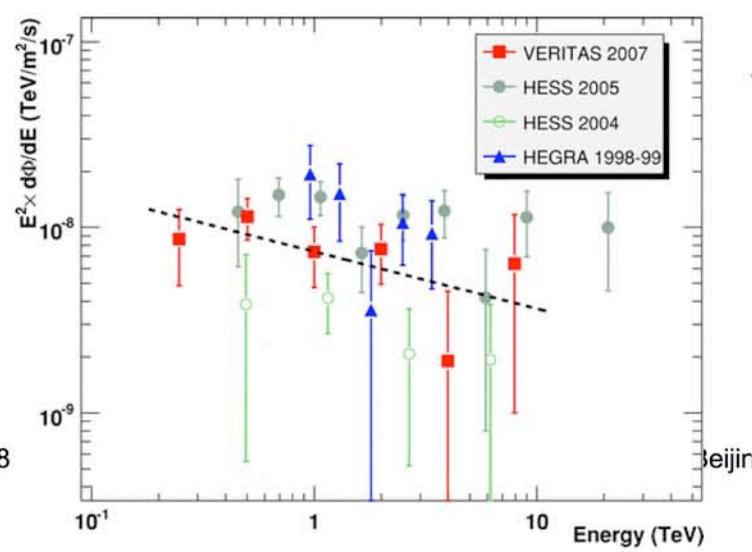




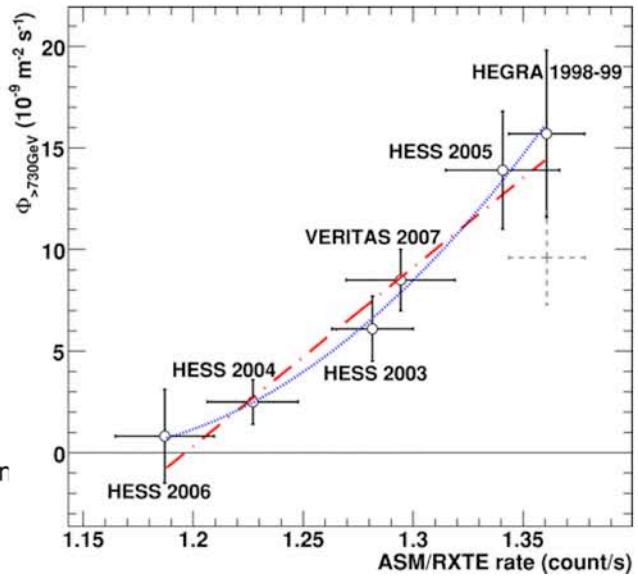
Wilson & Yang, 2002



Wilson & Yang, 2002

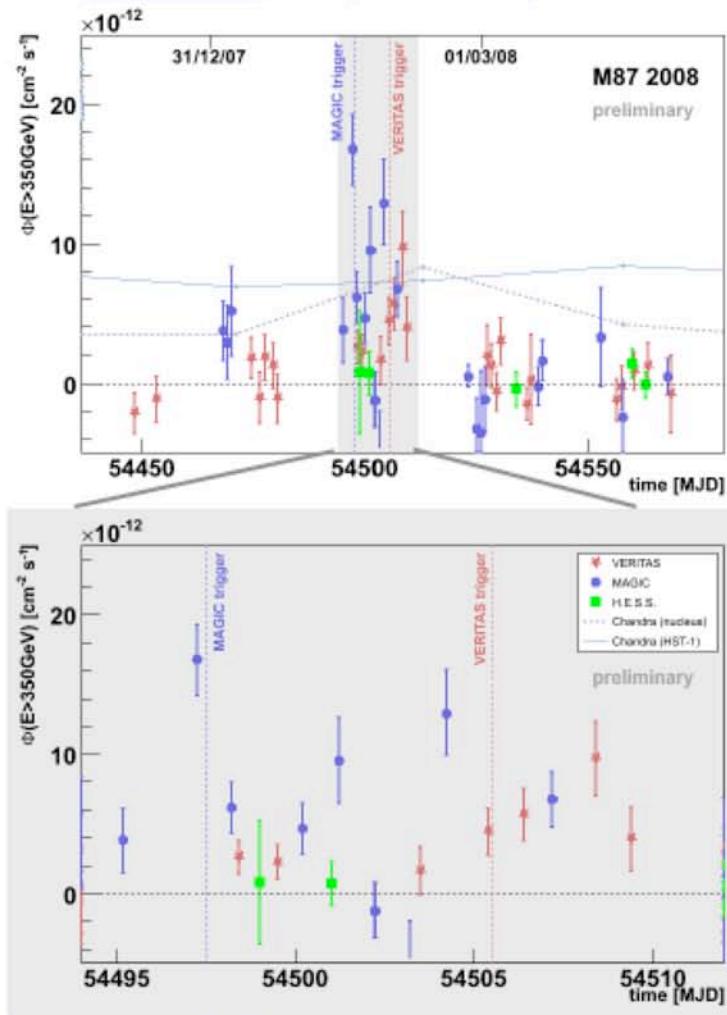


September 24-28, 2008



31

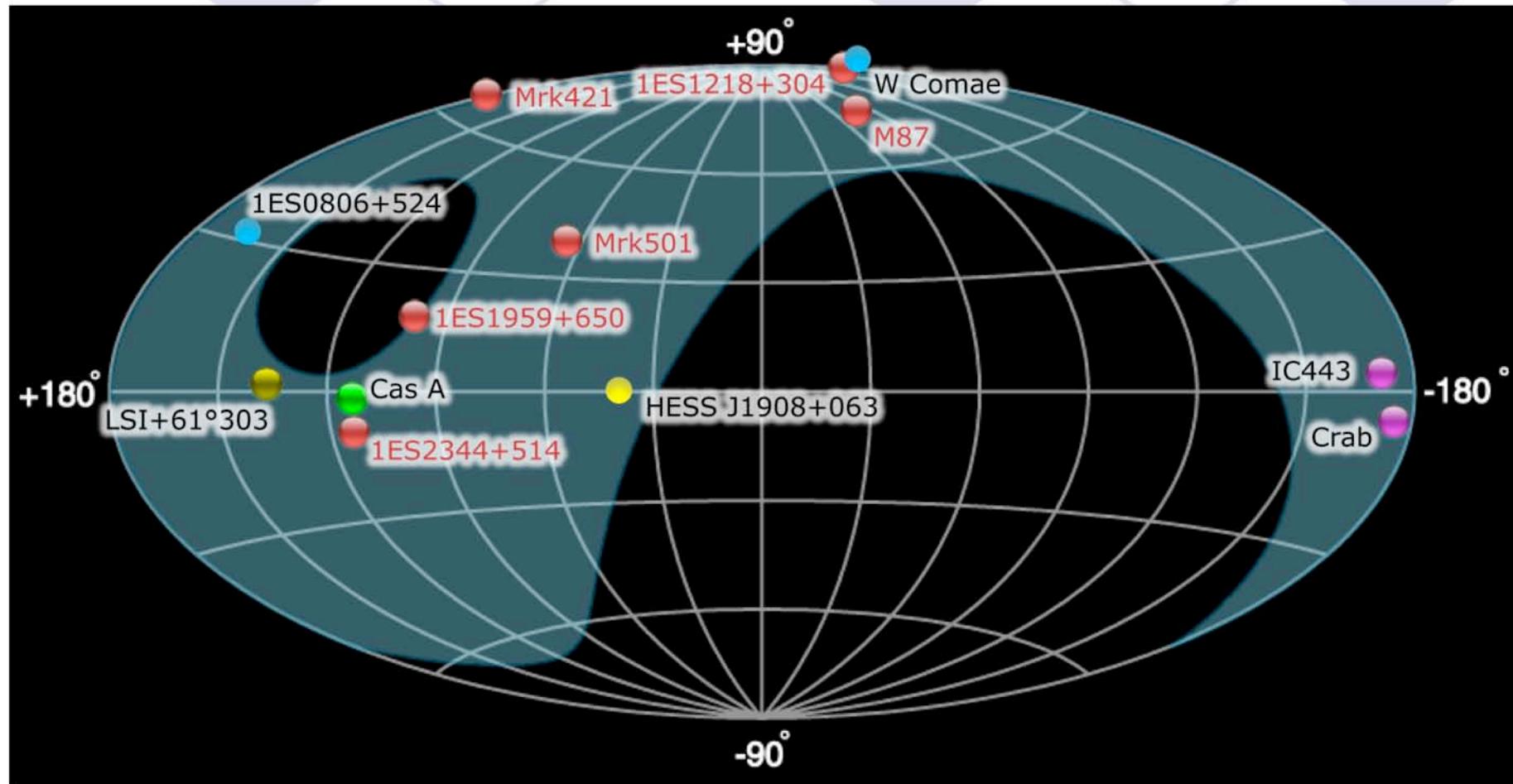
Radio Galaxy: M87



Light curve from a joint
HESS/MAGIC/VERITAS
monitoring campaign, as
presented at Gamma08
(Heidelberg)

M. Beilicke, Gamma08
M. Hui, Gamma08

VERITAS Source Catalogue



September 24-28, 2008

TeV Particle Astrophysics, IHEP, Beijing, China

Courtesy of TevCat
<http://tevcat.uchicago.edu>



Future Plans

- Explore synergy with Fermi
 - Collaboration with the Fermi LAT Team
 - Guest observing programs
- Pursue Multiwavelength observations of known TeV gamma-ray sources
 - Many programs already in place
- Formulate strategy to discover new sources and new source populations.

Concluding Remarks

- VERITAS is working very well.
 - ⇒ Completion of the first full year of operations
- Performance and reliability are good.
 - ⇒ ~800 hours of clear sky observations
- Scientific results have started to come out.
 - ⇒ Have seen the things that we are supposed to see
 - ⇒ Have begun to make new discoveries.

STAY TUNED!