Detection of M87 with the VERITAS Observatory

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Introduction

- What is M87 and why should we study it.
- VERITAS Experiment
- Data Analysis
- Significance of our measurement
- Flux – VERITAS vs. HEGRA vs. HESS
- Conclusion
M87

- Messier Object Number 87
- Elliptical Galaxy
- Virgo Cluster
- Distance ~ 16 Mpc

Why Study It?

- Only extragalactic non-blazar that emits TeV γ-rays
  - Jet offset ~ 19° to 33°
- Source emission is controversial
- Time variability of the source
VERITAS $\gamma$-Ray Observatory

- Located south of Tucson in Amado Arizona
- Atmospheric Cherenkov Light Detectors
- Fully operational since January 2007
- Sensitive from $10^{10}$ to $10^{13}$ eV
- Observed M87 from February to April 2007
- 44 hours of good weather data
Data Analysis

- GrISU
  - Image cleaning
    - Thresholds
    - Minimum Number of Pixels
  - Stereo reconstruction
    - To determine the direction of the event
  - Cosmic-ray rejection
    - 99.9% of all events
  - Background estimate
    - “Wobble mode” – Reflected Region method
  - Statistical significance
    - Li & Ma formula
      - Likelihood ratio method

Separation Distance = \theta
Theta^2 Measurement

[Graph showing data for Simulation, M87 Source, and Background]
Where did the center hit the ground?
Wobble Mode?

Source

Reflected Regions
The Significance

Excess $> 5 \sigma$
The Flux

Flux (% of the Crab nebula)

Hegra (E > 730 GeV)
Whipple (E > 400 GeV)
Hess (E > 400 GeV)
Veritas (E > 250 GeV)
Conclusion

- We do observe $\gamma$-rays from M87 in the TeV energy range.
- Rate: $0.11 \pm 0.02 \, \gamma$/min.
- Significance $> 5\sigma$.
- Marginal evidence for flaring.