DISCOVERY OF EXTRAGALACTIC SOURCES OF VERY HIGH ENERGY GAMMA RAYS

Recent Highlights from VERITAS, January 2009

1ES 0806+524, W Comae and 3C 66A

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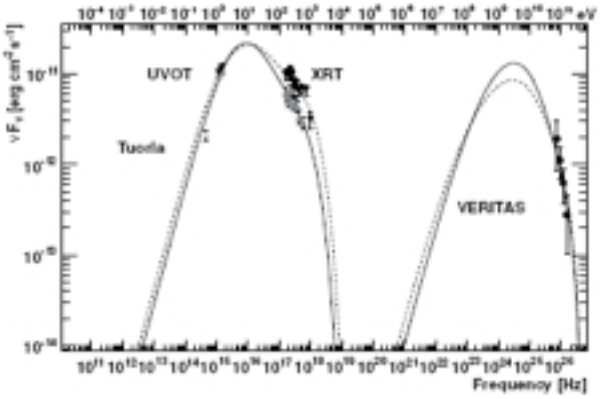
Introduction

Gamma rays constitute the highest-energy electromagnetic radiation observable and are generated by the most violent cosmic objects such as supernovae, active galactic nuclei, and gamma-ray bursts. They allow us to zoom into a realm of extreme physical conditions, far beyond what can be studied in terrestrial laboratories. Gamma rays are important messengers in modern astroparticle physics; they provide precious information about the processes that generated them, without deflections by magnetic fields that affect all charged cosmic rays. Since such particles travel for distances comparable with the radius of the Universe, they also give important information on fundamental physics and cosmology, in particular about the evolution of the Universe.

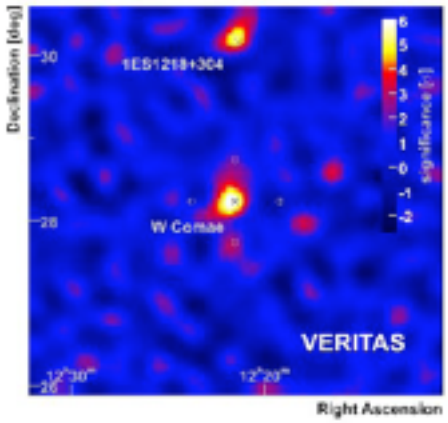
Three Newly Detected Objects

From data collected up to November 2008, VERITAS has recently announced the discoveries of three extragalactic sources undetected before at TeV gamma-ray energies. These three sources are generally believed to be powered by the accretion of matter onto a supermassive black hole. The VERITAS array of telescopes, located in southern Arizona, (1268 m a.s.l.) began full, four-telescope array observations in September 2007; VERITAS is the most sensitive imaging atmospheric Cherenkov telescope (IACT) array in the northern hemisphere and it is ideally suited to observations of extragalactic objects. The array is comprised of four 12m-diameter telescopes with tessellated mirror structures, each consisting of 350 hexagonal mirror facets (comprising a total mirror area of 100 m^2). Each telescope focuses light onto cameras, comprising 500 pixels, with a total field of view of ~3.5°. VERITAS is sensitive to very high energy (VHE) gamma rays in the 100 GeV to 30 TeV energy band, with an energy resolution of ~15-20% and an angular resolution of < 0.1° on an event by event basis.

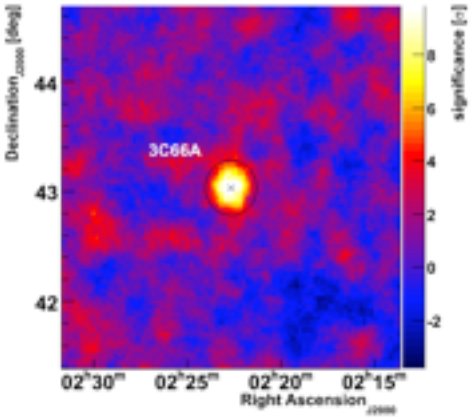
The three newly detected objects are:



I. **1ES 0806+524** - this is a BL Lacertae (BL Lac) object at a redshift z = 0.138. The analysis of 65 hours of VERITAS data results in a clear detection at the 6.3 standard deviation level. Little or no measurable variability on monthly timescales is found. The photon spectrum for the period of November 2007 to April 2008 (see Figure 1) can be characterized by a power law with a spectral index γ ~ 3.6 between energies of 300 and 700 GeV. The integral flux above 300 GeV corresponds to 1.8% of the Crab Nebula flux; these results are published in ApJ **690**, L126 (2009).



II. **W Comae** - this object is a BL Lac at a redshift z = 0.102, which places it at a distance of >400Mpc from us; the gamma rays from this source take over a billion years to reach VERITAS. This is the first time VHE emission has been observed from an intermediate-frequency peaked BL-Lac (IBL) object. These results are published in ApJ **684**, L73 (2008). The emission exhibited a strong flare near the middle of March 2008 that lasted for four days and then faded. Reconstructing the VHE energy spectrum results in a steep power law spectral index (Γ ~ 3.8, compared to Γ ~ 2.5 for the Crab Nebula). Figure 2 shows a skymap of the VERITAS detection of W Comae. Also seen in this image is the detection of the known extragalactic source 1ES 1218+304 demonstrating the off-axis capability of VERITAS. The distance between the two objects is around a billion light years, so there is no direct association between them.



III. **3C66A** – VERITAS discovered VHE emission from this IBL source based on 32.8 hours of observing time. Figure 3 shows the strong detection of 3C66A by VERITAS. 3C66A and W Comae are the only IBLs that have been detected in the VHE waveband and both were discovered by VERITAS. The energy spectral index is very steep with spectral index γ ~ 4.1 and the integral flux above 200 GeV corresponds to 6% of the Crab Nebula flux; these results are published in ApJ **693**, L104 (2009).

VERITAS Source Catalogue

We conclude by presenting the VERITAS source catalogue obtained at the end of the first full season of observing, already containing 15 northern hemisphere VHE sources. Further studies by VERITAS in the VHE band, in association with measurements in other bands, can be expected to lead to breakthroughs in our understanding of these extremely energetic objects.

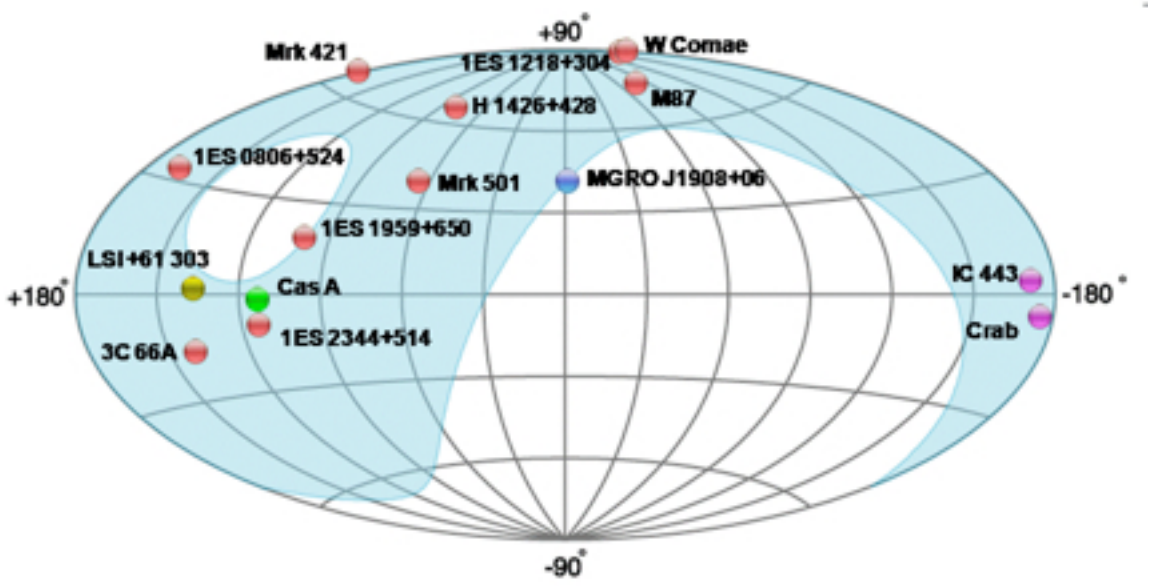


Figure 4 shows the VERITAS source catalogue as of November 2008 (in galactic coordinates). Extragalactic sources are labeled in red; those within our galaxy are labeled in other colors (depending on the source type). The shaded area shows the region of the sky visible to VERITAS at elevations greater than 55°. Figure provided courtesy of TeVCat (http://tevcat.uchicago.edu/).