Gamma-Ray Emission by the BL Lac Markarian 501

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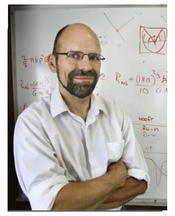

(credit: Salt Lake Tribune)

Dr. David B. Kieda

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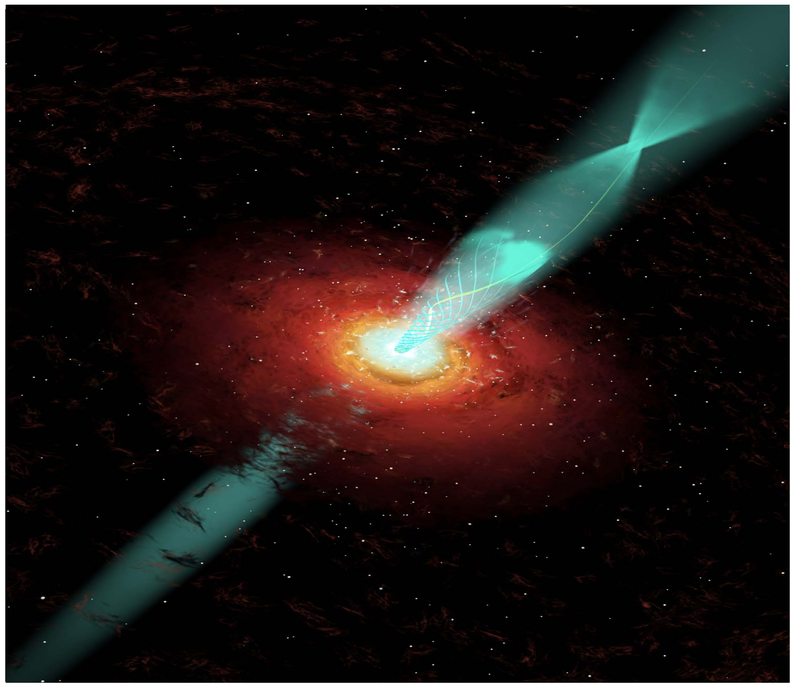
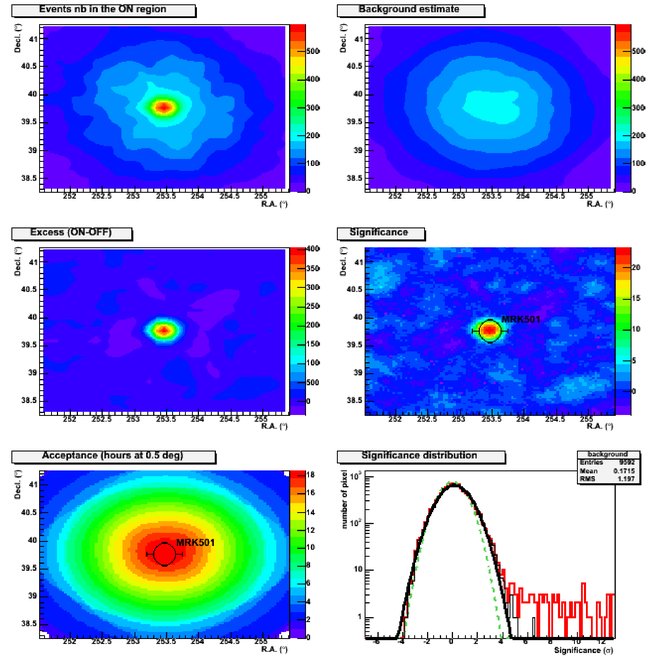
Gamma Ray Astronomy

Optical astronomy is the study of the heavens as they emit light, or the visible portion of the electromagnetic spectrum. Gamma-ray astronomy is the study of astrophysical sources that emit the most energetic form of electromagnetic radiation (ie: gamma-rays). High Energy gamma-rays are much too faint to be directly see with the human eye. Thus they are detected using arrays of large diameter (39 ft) mirrors and fast digitizing cameras which image the light emitted from the gamma-ray as it is absorbed in the Earth's atmosphere. The VERITAS telescope array, located in Amado, Arizona, (see picture below) is the world's most sensitive high-energy gamma-ray observatory. Since May 2009, I have worked with the VERITAS gamma-ray group at the University of Utah to observe sources of high energy gamma rays as well as participate in the maintenance and upgrade of the telescopes (See picture below).

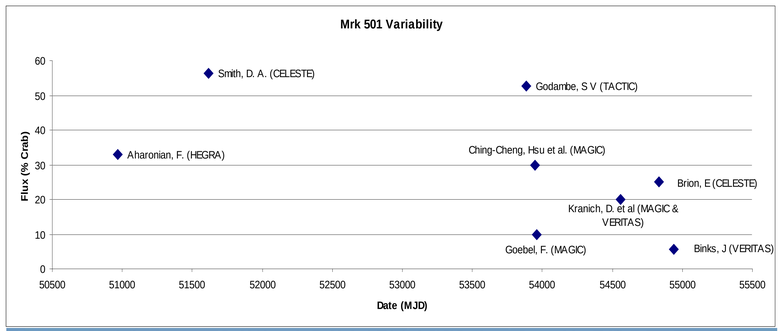
The field of very high energy (VHE) gamma-ray astronomy is extremely young. The first source, the Crab Nebula, was detected in 1989. Since that time, nearly one hundred sources have been discovered. These different sources constitute a variety of astrophysical objects and phenomena. A particularly impressive source of high energy gamma-rays are Active Galactic Nuclei, or AGN. These sources emit large amounts of radiation due to a super massive black hole (greater than 100 million solar masses) at the center ("nuclei") of the active galaxy. In this research project, I have studied the gamma-ray emission from the AGN source Markarian 501, located at a distance of 500 million light years.



Artist rendition of an AGN with a central supermassive black hole (white) emitting relativistic jets of gas (blue) (credit: Cosmovision)



Graphs of the analysis of Markarian 501. Markarian 501 appears as the bright red spot in the larger field of view of the telescope



Above: Graph displaying variability of Markarian 501 over time
Below: A photograph of the four VERITAS telescopes at the Whipple Observatory, Amado, AZ (credit: VERITAS)

A picture of me (JB) and several other Utah undergraduate students cabling VERITAS Telescope #1 during Summer 2009

Markarian 501

The data analyzed for this source was collected from VERITAS, or Very Energetic Radiation Imaging Telescope Array System. VERITAS has been fully operational since the spring of 2007. These telescopes detect incoming high energy-gamma rays using the Cherenkov Telescope Technique. Each telescope has a 39 foot diameter optical reflector, a 499 pixel camera on each dish, and a 3.5 degree field of view. Funding for VERITAS is provided by the U.S. Department of Energy, the Smithsonian Institution, the U.S. National Science Foundation, the NSERC (Canada), PPARC (UK), and Enterprise-Ireland. Approximately 30 University of Utah undergraduate students have participated in research associated with VERITAS since summer 2003.

The Active Galactic Nuclei Markarian 501 was observed by the VERITAS gamma ray telescope array between April and June 2009. A total of 1116 minutes of good weather data was selected for this analysis. In this data set, Markarian 501 was detected at a statistical significance of 24.1 sigma. A typical object is said to be a gamma ray source at about 5 sigma, thus indicating that this is a very strong source. The data indicates that Markarian 501 is emitting 0.428 gamma rays per minute during these observations. During previous observations (beginning in the mid-1990's) , the measured gamma ray rate was substantially higher (see figure).

Our data indicates that the gamma-ray flux for Markarian 501 is in a low state, and is following a progressively decreasing trend. The reason for this sudden change is not understood, but it may be related to changes in the amount of material falling into the central black hole of Markarian 501, or changes in the magnetic field structure associated with the relativistic gas jet .