

VERITAS supplies critical piece to neutrino discovery puzzle

July 12 2018



One of the telescopes in the Very Energetic Radiation Imaging Telescope System (VERITAS) in southern Arizona. VERITAS is operated and managed by the Smithsonian Astrophysical Observatory. Credit: Steve Criswell (SAO)

The VERITAS array has confirmed the detection of high-energy gamma rays [from the vicinity of a supermassive black hole](#) located in a distant galaxy, TXS 0506+056. While these detections are relatively common for VERITAS, this blackhole is potentially the first known astrophysical source of high-energy cosmic neutrinos, a type of ghostly subatomic particle that can be made at astrophysical sources of ultra-high energy cosmic rays.

The University of Utah is one of the founding collaborating institutions of the VERITAS observatory. Co-author Dave Kieda, professor of physics and astronomy and the dean of the U's graduate school, led the design, construction and upgrade of VERITAS that gave the instrument enhanced sensitivity to the lower-energy gamma rays critical to the discovery. Anushka Udara Abeysekara, research assistant professor of physics and astronomy at the U, is also a coauthor on the paper.

"This is the first time we've seen [high-energy gamma-rays](#) and [neutrinos](#) being generated by a common astrophysical source. This is evidence that nearby and faraway galaxies with supermassive blackholes at their centers are actively creating [high-energy cosmic rays](#)," said Kieda. "It's one of the pieces of the puzzle needed to solve the mystery of where these cosmic rays come from."

The University of Utah also operates the Telescope Array cosmic ray observatory based in Delta, Utah. In 2015, the University of Utah Telescope Array Group identified a potential hotspot of ultra-high energy cosmic rays coming from a broad region of the sky containing numerous potential extragalactic cosmic-ray sources. Because our Galaxy's magnetic field bends the trajectory of incoming cosmic particles, the Telescope Array was unable to pinpoint any individual galaxy as the origin of the high energy cosmic rays. The VERITAS gamma-ray discovery, in combination with the ICECUBE neutrino detection, provides a way to directly identify a single galaxy as a source

of high energy cosmic rays. This "multi-messenger" approach to astronomy—employing joint observations of neutrinos, gamma-rays, X-rays and cosmic-rays—provides a major breakthrough in the understanding of the astrophysical origin of the most energetic particles in the universe.

"The era of multi-messenger astrophysics is here," said National Science Foundation director France Córdova. "Each messenger—from electromagnetic radiation, gravitational waves and now neutrinos—gives us a more complete understanding of the universe, and important new insights into the most powerful objects and events in the sky. Such breakthroughs are only possible through a long-term commitment to fundamental research and investment in superb research facilities."



This artist's conception shows a blazar - the core of an active galaxy powered by a supermassive black hole. Scientists using the VERITAS array have detected gamma rays from the blazar TXS 0506+056, which is also thought to be a source of neutrinos. Credit: M. Weiss/CfA

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On September 22, 2017 the IceCube Neutrino Observatory, a cubic-kilometer neutrino telescope located at the South Pole, detected a high-energy neutrino of potential astrophysical origin. However, IceCube is not capable of locating a source of neutrinos on the sky. For that, scientists needed more information.

Very quickly after the detection by IceCube was announced, telescopes around the world including VERITAS (which stands for the "Very Energetic Radiation Telescope Array System") swung into action to identify the source. The VERITAS, MAGIC and H.E.S.S. gamma-ray observatories all looked at the neutrino position. In addition, other gamma-ray observatories that monitor much of the sky at lower and higher energies also provided coverage.

These follow-up observations of the rough IceCube neutrino position suggest that the source of the neutrino is a blazar, which is a

[supermassive black hole](#) with powerful outflowing jets that can change dramatically in brightness over time. This blazar, known as TXS 0506+056, is located at the center of a galaxy about 4 billion light years from Earth.

Initially, NASA's Fermi Gamma-ray Space Telescope observed that TXS 0506+056 was several times brighter than usually seen in its all-sky monitoring. Eventually, the MAGIC observatory made a detection of much higher-energy gamma rays about two weeks after the neutrino detection, while VERITAS, H.E.S.S. and HAWC did not see the blazar in any of their observations during the two weeks following the alert.

Given the importance of higher-energy gamma-ray detections in identifying the possible source of the neutrino, VERITAS continued to observe TXS 0506+056 over the following months, through February 2018, and revealed the source but at a dimmer state than what was detected by MAGIC.

The detection of gamma rays coincident with neutrinos is tantalizing, since both particles must be produced in the generation of cosmic rays. Since they were first detected over one hundred years ago, cosmic rays—highly energetic particles that continuously rain down on Earth from space—have posed an enduring mystery. What creates and launches these particles across such vast distances? Where do they come from?

"The potential connection between the neutrino event and TXS 0506+056 would shed new light on the acceleration mechanisms that take place at the core of these galaxies, and provide clues on the century-old question of the origin of [cosmic rays](#)," said co-author and Spokesperson of VERITAS Reshmi Mukherjee of Barnard College, Columbia University in New York, New York.

"Astrophysics is entering an exciting new era of multi-messenger observations, in which celestial sources are being studied through the detection of the electromagnetic radiation they emit across the spectrum, from radio waves to high-energy [gamma rays](#), in combination with non-electromagnetic means, such as gravitational waves and high-energy neutrinos," said co-author Marcos Santander of the University of Alabama in Tuscaloosa.

A paper describing the deep VERITAS observations of TXS 0506+056 appears online in *The Astrophysical Journal Letters* on July 12, 2018.

Provided by University of Utah

Citation: VERITAS supplies critical piece to neutrino discovery puzzle (2018, July 12) retrieved 26 April 2024 from <https://phys.org/news/2018-07-veritas-critical-piece-neutrino-discovery.html>

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