HAWC Observatory captures first image

April 30, 2013

An international team of researchers, including scientists from Los Alamos, has taken the first image of the High-Altitude Water Cherenkov Observatory, or HAWC. The facility is designed to detect cosmic rays and the highest energy gamma rays ever observed from astrophysical sources. HAWC is under construction inside the Parque Nacional Pico de Orizaba, a Mexican national park. Although only 10 percent of the observatory is constructed, the team has made its first astrophysical image—a shadow in the detected directions of cosmic rays caused by the Moon.

Full-time operations at HAWC will begin this summer with one third of the observatory, making HAWC the most sensitive, wide field of view, continuously operating gamma-ray observatory. The observatory will survey the sky at energies between 100 GeV (billion electron volts) and 100 TeV (trillion electron volts). The TeV gamma rays come from the most extreme environments in the known universe: supernova explosions, active galactic nuclei, and gamma-ray bursts. The gamma rays are signatures of the acceleration sites of charged cosmic rays—energetic particles whose origins have been a mystery for 100 years. To record the particles created in cosmic-ray and gamma-ray air showers, the HAWC detector will use the water Cherenkov method pioneered by

Los Alamos scientists and collaborators at the Milagro experiment in New Mexico's the Jemez Mountains of New Mexico.

Significance of the research

The observatory examines the high energy gamma ray and cosmic ray signatures from astrophysical phenomena. HAWC will detect the highest energy gamma rays ever observed from astrophysical sources, such as supermassive black holes, supernova remnants and neutron star winds. Researchers will likely discover sources that may not even emit in optical or X-rays or radio waves, such as clumps of dark matter that are self-annihilating into gamma-rays. By observing the spatial distribution and intensity of gamma rays across the sky, scientists will attempt to identify the locations of cosmic ray accelerators. The team will use the time variability and energy spectra of the gamma-ray emission to study the environment of the accelerators and the mechanisms of charged-particle acceleration. The highest-energy gamma rays (above 1 TeV) and the shortest timescales of variability will provide important clues to the mechanisms at work in acceleration sites and could help researchers solve the mystery of cosmic-ray origin.

Research achievements

After completing the first 30 of the planned 300 detectors in September 2012, researchers have been operating them for the last few months. Scientists verified the newly collected data with the strong detection of the deficit in cosmic rays from the direction of the moon. Cosmic rays arrive at Earth from all directions due to random deflections by the magnetic fields within the Galaxy. The moon creates a cosmic-ray shadow because the cosmic rays do not pass through it. The shadow is not precisely in the direction of the moon due to the deflection of the cosmic rays by the Earth's magnetic field. The amount of the deflection, which is inversely proportional to the energy of the cosmic rays, confirms the energy range of cosmic rays that HAWC can detect.

The telescope builds on the experience of Milagro, a detector experiment that discovered new sources of TeV gamma rays. The HAWC observatory is based on the water Cherenkov detection technique pioneered at the Milagro observatory by Los Alamos researchers and collaborators. The detectors sample air-shower particles at ground level by recording the Cherenkov light produced when the particles pass through tanks full of purified water. The properties of the initial gamma rays can be reconstructed from these measurements. The improvements in the HAWC design will make it 15 times more sensitive than Milagro.

The research team

The HAWC collaboration is composed of approximately 150 scientists from the Laboratory's Neutron Science and Technology and Subatomic Physics groups, 15 universities in the United States and 15 in Mexico. Brenda Dingus of P-23 is the U.S. spokesperson for the collaboration and the deputy project manager. The DOE Office of Science's High Energy Physics program, the National Science Foundation and Consejo Nacional de Ciencia y Tecnología (Mexico's science funding agency) fund the construction of HAWC. The work supports the Laboratory's Global Security mission area and the Science of Signatures science pillar.

Caption for image below: This image shows the "shadow" of the Moon, which blocks the arrival of cosmic rays.