Draft Version: (for local web site)

November 8, 2007

Case Western Reserve University, High Energy Astrophysics group

Corbin Covault, Department of Physics

Phone: 216-368-4006, Mobile: 216-496-2077, email: cec8@case.edu

OBSERVATORY BUILT BY TEAM INCLUDING CASE WESTERN PHYSICISTS LINKS HIGHEST ENERGY COSMIC RAY PARTICLES TO GIANT BLACK HOLES

Case Western Reserve University Physicist Corbin Covault and his research group are part of an international collaboration that has built the world's largest cosmic ray observatory in Argentina. This collaboration has recently reported a major discovery which apparently tracks the origins of near speed-of-light cosmic ray particles to a special type of massive black hole found in some nearby galaxies called Active Galactic Nuclei (AGN).

The findings of the collaborative efforts of Case Western Reserve University and 370 researchers from 17 countries that have built and operated the Pierre Auger Cosmic Ray Observatory are reported in the *Science*. The article entitled, "Correlation of the Highest Energy Cosmic Rays with Nearby Extragalactic Objects," reports a breakthrough in efforts to understand the origin of these cosmic rays which are believed to be the most energetic particles in the Universe.

Cosmic rays continually bombard the upper atmosphere of the Earth resulting in showers of energetic particles that can be detected on the ground. The very highest energy cosmic rays are believed to be comprised of protons and atomic nuclei, but tracking their origins in the Universe has proved elusive in the past due to the very small number of such particles detected. Until quite recently, only a handful of cosmic rays at the very highest energies have been recorded, according to Covault. These cosmic rays have energies of 10^{20} electron volts (eV), much greater than the 10^{14} eV corresponding to highest energies achievable by earth-bound particle accelerators. "Many cosmic rays continually bombard us, but we are interested only in the very highest energy ones," said Covault. He added that the highest energy particles have been picked for study because the cosmic rays particles with lower energies tend to bend in their paths when traveling through magnetic fields in the universe, while those with the highest energy bend the least and therefore have more stable paths for tracking.

The Pierre Auger Observatory in Malargüe, Mendoza consists of an array of 1,600 particle detectors spread over an area the size of Rhode Island (1,200 square miles). The Observatory provides scientists with capabilities to monitor the entire sky in the southern hemisphere. A similar array of detectors to monitor the sky in the northern hemisphere is under consideration for a site in the United States.

The Auger Observatory recorded 27 of the highest energy cosmic rays during the period from January 2004 through the past summer. Of these 27 highest energy cosmic rays, 19 have arrived from positions in the sky that are quite close to the directions to known AGNs. "This result is quite striking, especially since probability would have predicted that less than six of these 27 should be found coming from so close to AGN by random chance ," explained Covault, who began working on the experiment shortly after his arrival at the university in 2001. Furthermore, of the 8 cosmic rays not associated with AGNs, 6 lie quite close to the dusty plane of our Milky Way galaxy. "The dust almost certainly makes it impossible to catalog AGN in this region," said Covault. "This suggests that nearly every high energy cosmic that ray we have detected might be coming from one of these AGN objects."

There is quite a bit of excitement and surprise over this result among the researchers associated with the Auger Observatory. "If you had asked me when we started out if we would find anything this significant so quickly, I would have said I'd be surprised if we did." Covault added that there is particular interest in the apparent link between cosmic rays and these AGNs, which are believed to be giant black holes that are found at the centers of some galaxies. In an AGN, the gravitational forces of the black hole are believed to be swallowing up galactic dust, gas and other matter, and then using the energy to subsequently jettison some of particles into fast-moving streams which fly back into the universe. Researchers hope that this result will be the first step in developing an explanation for how it might be possible to create cosmic rays at such high energies. "Before this result, scientists really had no good idea where in the Universe these cosmic rays might be coming from," said Covault. "With our result, we have narrowed the possibilities down considerably. We now know much better where to look for these cosmic particle accelerators." Covault emphasizes that this result does not yet prove that cosmic rays originate AGN black holes. "We have not yet collected enough data to determine if AGNs are the actual sources of cosmic rays. It is possible that AGN's might just be tracers for some other object that corresponds to the real sources."

For such a large experiment as the Auger Observatory, the design and construction has been shared among many institutions. At Case Western, Covault's research team designed and tested a set of Global Positioning System (GPS) receivers which were reconfigured to be used as clocks to obtain timing as accurate as a few nanoseconds. "We use the GPS to precisely determine the arrival times of these cosmic ray particles that are moving at almost the speed of light," said Covault.

“To track the path of that ray, you have to time that flash to within a few nanoseconds.” Covault’s group also tested each GPS unit to ensure that it would perform properly in the harsh desert-like pampas landscape where temperatures fluctuate from near zero degrees on winter nights to highs of 120 degrees during the summer days. Altogether, the group at Case Western tested and calibrated over 1,600 GPS receivers which are now deployed into the array of detectors within the Observatory in Argentina.

The Auger Observatory detectors look like cylindrical water tanks, each about 10 feet in diameter, set in the middle of an agricultural field or on grazing land, said Covault. Each detector is self-powered with solar-panel energy and is spaced approximately one kilometer apart. Within each tank, a light-tight, black “baggie”-like plastic liner is filled with water. When a cosmic ray particle impacts and penetrates the water, the result is a shock wave, similar to a sonic boom, but in optical light instead of audible sound, said Covault. The shock wave generates a very tiny flash of light invisible to the human eye but easily picked up by the sensitive phototubes in the tank. The signal from the phototubes is timed by the GPS system, and this provides an accurate mechanism for the researchers to reconstruct the original cosmic ray arrival direction.

###