Physicist celebrate expansion of international agreement at Auger Observatory

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LSU Physics Professor James Matthews and colleague at the Pierre Auger Observatory in Argentina. Credit: LSU

LSU Physicist James Matthews and an international team of scientists are reconstructing the path of the universe's most energetic cosmic rays, bringing new insights into the origin and nature of this intergalactic phenomenon. A founding member of the worldwide research collaboration at the Pierre Auger Observatory in Argentina, Matthews is celebrating 15 years of achievement at the observatory and the extension of a new international agreement that will allow this work to continue for the next 10 years.

The Pierre Auger Observatory in western Argentina is the world's leading science project for the exploration of the highest energy cosmic rays. More than 450 scientists from 83 institutions in 17 countries have been working together since 1998 in the Province of Mendoza, Argentina, to elucidate the origin and properties of the most energetic particles in the universe.

Work at the observatory measures gigantic showers of relativistic particles that are the result of collisions between the very rare, highest energy cosmic rays and atomic nuclei of the atmosphere. Properties of such air showers are used to infer the energy, direction and mass of the cosmic particles.

Matthews' group at LSU has been engaged in diverse projects on hardware, electronics, data analysis and computer simulations.

"We're trying to solve a 100-year old mystery: where do these energetic particles come from?" Matthews said. "How do they get so energetic? We're trying to understand nature. Our work, like all scientific research, communicates physics concepts and trains the next generation of scientists and engineers. LSU has played a key role in this worldwide endeavor. It's a lot of fun, too."

Results from the Pierre Auger Observatory have brought new

fundamental insights into the origin and nature of highest-energy cosmic rays.

"At Auger, we observe high in the sky trying to reconstruct the path of the universe's most energetic cosmic rays," said Guofeng Yuan, a 2012 LSU Ph.D. alumnus, who is a seismic imager at Compagnie Générale de Géophysique, or CGG. "At CGG, we search deep down the Earth looking for the locations of the most needed energy resources. The methods and techniques are quite similar. Being part of the Auger Collaboration at LSU definitely prepared me for my career and still helps me every day."

One of the most exciting results at the observatory is the experimental proof that at the highest energies—7 orders of magnitude above what can be achieved at the European Organization for Nuclear Research, or CERN's Large Hadron Collider—the cosmic-ray flux appears to diminish suddenly in intensity. Data indicate that, in addition to cosmic ray losses during propagation to Earth, this flux suppression may mark the limiting energy of the most powerful cosmic particle accelerators. An even more detailed measurement of the nature of cosmic particles at the highest energies is crucial to understand the mechanisms responsible for this decrease, and to identify the astrophysical sites violent enough to accelerate particles to such tremendous energies.

"My interest in particle astrophysics made me choose LSU for my graduate studies," said Azadeh Keivani, a 2013 LSU Ph.D. alumnus, who is a postdoctoral scholar at Penn State University. "I joined Professor Matthews' research lab, which had a significant role in the Pierre Auger Observatory. Auger is one of the greatest scientific collaborations worldwide that provided the opportunity for me to collaborate with many outstanding scientists. As a member of the Auger collaboration, I was also considered a member of the larger particle astrophysics community with many great observatories across all high-

energy astronomical messengers. I am currently a postdoctoral scholar working on the Astrophysical Multimessenger Observatory Network, or AMON, at Penn State, a project to link all the high-energy multimessengers and follow-up observatories. This all started for me from Professor Matthews' Auger Lab in the Department of Physics & Astronomy at LSU."

The AugerPrime upgrade to the observatory enhances the 1,660 existing surface detectors, or water tanks sensitive to Cherenkov light generated by the shower products, with new scintillation detectors, so that electromagnetic and muonic shower particles can be separated more efficiently. This in turn, together with a smaller area of buried muon detectors, improves the determination of the mass of the primary cosmic rays, otherwise not directly measurable. Faster and more powerful electronics also facilitates the readout of the new detector components and enhances the overall performance of the observatory elements.

The new international agreement for continued operation of the Pierre Auger Observatory until 2025 will provide the basis for doubling the present statistics with the upgraded observatory, and for solving the long-standing puzzle of the origin of the most energetic particles in the universe.

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