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Photos as well as press information from the countries participating in the Auger Project may be found at:
http://www.auger.org/media

Auger Observatory closes in on long-standing mystery, links highest-energy cosmic rays with violent black holes

MALARGÜE, Argentina—Scientists of the Pierre Auger Collaboration announced today (Nov. 8) that Active Galactic Nuclei are the most likely candidate for the source of the highest-energy cosmic rays that hit Earth. Using the Pierre Auger Observatory in Argentina, the largest cosmic-ray observatory in the world, a team of scientists from 17 countries found that the sources of the highest-energy particles are not distributed uniformly across the sky. Instead, the Auger results link the origins of these mysterious particles to the locations of nearby galaxies that have active nuclei in their centers. The results will appear in the Nov. 9 issue of the journal *Science*.

Active Galactic Nuclei (AGN) are thought to be powered by supermassive black holes that are devouring large amounts of matter. They have long been considered sites where high-energy particle production might take place. They swallow gas, dust and other matter from their host galaxies and spew out particles and energy. While most galaxies have black holes at their center, only a fraction of all galaxies have an AGN. The exact mechanism of how AGNs can accelerate particles to energies 100 million times higher than the most powerful particle accelerator on Earth is still a mystery.

“We have taken a big step forward in solving the mystery of the nature and origin of the highest-energy cosmic rays, first revealed by French physicist Pierre Auger in 1938,” said Nobel Prize winner James Cronin, of the University of Chicago, who conceived the Pierre Auger Observatory together with Alan Watson of the University of Leeds. “We find the southern hemisphere sky as observed in ultra-high-energy cosmic rays is non-uniform. This is a fundamental discovery. The

age of cosmic-ray astronomy has arrived. In the next few years our data will permit us to identify the exact sources of these cosmic rays and how they accelerate these particles."

Cosmic rays are protons and atomic nuclei that travel across the universe at close to the speed of light. When these particles smash into the upper atmosphere of our planet, they create a cascade of secondary particles called an air shower that can spread across 40 or more square kilometers (15 square miles) as they reach the Earth's surface.

"This result heralds a new window to the nearby universe and the beginning of cosmic-ray astronomy," said Watson, a spokesperson of the Pierre Auger Collaboration. "As we collect more and more data, we may look at individual galaxies in a detailed and completely new way. As we had anticipated, our observatory is producing a new image of the universe based on cosmic rays instead of light."

The Pierre Auger Observatory records cosmic ray showers through an array of 1,600 particle detectors placed 1.5 kilometers (about one mile) apart in a grid spread across 3,000 square kilometers (1,200 square miles). Twenty-four specially designed telescopes record the emission of fluorescence light from the air shower. The combination of particle detectors and fluorescence telescopes provides an exceptionally powerful instrument for this research.

While the observatory has recorded almost a million cosmic-ray showers, only the rare, highest-energy cosmic rays can be linked to their sources with sufficient precision. Auger scientists so far have recorded 81 cosmic rays with energy above 4 $x10^{19}$ electron volts, or 40 EeV. This is the largest number of cosmic rays with energy above 40 EeV recorded by any observatory. At these ultra-high energies, the uncertainty in the direction from which the cosmic ray arrived is only a few degrees, allowing scientists to determine the location of the particle's cosmic source.

The Auger collaboration discovered that the 27 highest-energy events, with energy above 57 EeV, do not come equally from all directions. Comparing the clustering of these events with the known locations of 381Active Galactic Nuclei, the collaboration found that most of these events correlated well with the locations of AGNs in some nearby galaxies, such as Centaurus A.

"Low-energy cosmic rays are abundant and come from all directions, mostly from within our own Milky Way galaxy. Until now the only source of cosmic ray particles known with certainty has been the sun. Cosmic rays from other likely sources such as exploding stars take meandering paths through space so that when they reach Earth it is impossible to determine their origins. But when you look at the highest-energy cosmic rays from the most violent sources, they point back to their sources. The challenge now is to record enough of these cosmic bullets to understand the processes that hurl them into space," said Paul Mantsch, project manager of the Pierre Auger Observatory.

Cosmic rays with energy higher than about 60 EeV lose energy in collisions with the cosmic microwave background, radiation left over from the Big Bang that fills all of space. But cosmic rays from nearby sources are less likely to lose energy in collisions on their relatively short trip to Earth. Auger scientists found that most of the 27 events with energy above 57 EeV came from locations in the sky that include the nearest AGNs, within a few hundred million light years of Earth.

Scientists think that most galaxies have black holes at their centers, with masses ranging from a million to a few billion times the mass of our sun. The black hole at the center of our Milky Way galaxy weighs about 3 million solar masses, but it is not an AGN. Galaxies that have an AGN seem to be those that suffered a collision with another galaxy or some other massive disruption in the last few hundred million years. The AGN swallows the mass coming its way while releasing prodigious amounts of radiation. The Auger result indicates that AGNs may also produce the universe's highest-energy particles.

Cosmic-ray astronomy is challenging, because low-energy cosmic rays provide no reliable information on the location of their sources: as they travel across the cosmos, they are deflected by galactic and intergalactic magnetic fields that lead to blurry images. In contrast, the most energetic particles come almost straight from their sources, as they are barely affected by the magnetic fields. Unfortunately, they hit Earth at a rate of only about one event per square kilometer per century, which demands a very large observatory.

Because of its size, the Auger Observatory can record about 30 ultra-high-energy events per year. The Auger collaboration is developing plans for a second, larger installation in Colorado to extend coverage to the entire sky while substantially increasing the number of high-energy events recorded.

“Our current results show the promising future of cosmic-ray astronomy,” said Auger cospokesperson Giorgio Matthiae, of the University of Rome. “So far we have installed 1400 of the 1600 particle detectors of the Auger Observatory in Argentina. A northern site would let us look at more galaxies and black holes, increasing the sensitivity of our observatory. There are even more nearby AGNs in the northern sky than in the southern sky.”

The Pierre Auger Observatory is being built by a team of more than 370 scientists and engineers from 17 countries.

“The collaboration is a true international partnership in which no country contributed more than 25 percent of the US$54-million construction cost,” said Danilo Zavrtanik, of the University of Nova Gorica and chair of the Auger Collaboration Board. The names of the funding agencies contributing to the Pierre Auger Observatory as well as the names of the participating institutions are listed below.

Groundbreaking for the southern hemisphere site of the Pierre Auger Observatory took place on March 17, 1999, in Argentina's Mendoza Providence. Following a period of detector deployment and testing, scientific data collection began in January, 2004.

"Argentina is pleased to host and participate in this unique scientific endeavor," said Alberto Etchegoyen, of Laboratorio Tandar, and Southern Observatory spokesperson, "and now, looking back into these years of efforts and excitement, a feeling of gratitude and respect arises for all collaboration members who took care of every single minor detail leading to today's announcement."

The observatory is named for French scientist Pierre Victor Auger (1899-1993), who in 1938 was the first to observe the extensive air showers generated by the interaction of high-energy cosmic rays with the Earth's atmosphere.

Notes for editors:

Auger Observatory funding agencies (by country):

International

ALFA-EC / HELEN
UNESCO

Argentina
Comisión Nacional de Energía Atómica
Fundación Antorchas
Gobierno De La Provincia de Mendoza
Municipalidad de Malargüe

Australia
Australian Research Council

Brazil
Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)
Financiadora de Estudos e Projetos (FINEP)
Fundação de Amparo à Pesquisa do Estado de Rio de Janeiro (FAPERJ)
Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP)
Ministério de Ciência e Tecnologia (MCT)

Czech Republic
Ministry of Education, Youth and Sports of the Czech Republic

France

Centre National de la Recherche Scientifique (CNRS)
Conseil Régional Ile-de-France
Département Physique Nucléaire et Corpusculaire (PNC-IN2P3/CNRS)
Département Sciences de l'Univers (SDU-INSU/CNRS)

Germany
Bundesministerium für Bildung und Forschung (BMBF)
Deutsche Forschungsgemeinschaft (DFG)
Finanzministerium Baden-Württemberg
Helmholtz-Gemeinschaft Deutscher Forschungszentren (HGF)
Ministerium für Wissenschaft und Forschung, Nordrhein Westfalen
Ministerium für Wissenschaft, Forschung und Kunst, Baden-Württemberg

Italy
Istituto Nazionale di Fisica Nucleare (INFN)
Ministero dell'Istruzione, dell'Università e della Ricerca (MIUR)

Mexico
Consejo Nacional de Ciencia y Tecnología (CONACYT)

Netherlands
Ministerie van Onderwijs, Cultuur en Wetenschap
Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO)
Stichting voor Fundamenteel Onderzoek der Materie (FOM)

Poland
Ministry of Science and Higher Education

Portugal
Fundação para a Ciência e a Tecnologia

Slovenia
Ministry for Higher Education, Science, and Technology
Slovenian Research Agency

Spain
Comunidad de Madrid
Consejería de Educacíon de la Comunidad de Castilla La Mancha
FEDER funds
Ministerio de Educacíon y Ciencia
Xunta de Galicia

United Kingdom
Science and Technology Facilities Council

United States

Department of Energy
Grainger Foundation
National Science Foundation

Auger Observatory collaborating institutions (by country):

Argentina
Centro Atómico Bariloche (CNEA); Instituto Balseiro (CNEA & UNCuyo); CONICET
Instituto de Astronomía y Física del Espacio (CONICET)
Laboratorio Tandar (CNEA); CONICET; Univ. Tec. Nac. (Reg. Buenos Aires)
Pierre Auger Southern Observatory
Universidad Nacional de la Plata; IFLP/CONICET; Univ. Nac. de Buenos Aires
Universidad Tecnológica Nacional - Regionales Mendoza y San Rafael

Australia
University of Adelaide

Bolivia
Universidad Catolica de Bolivia
Universidad Mayor de San Andrés

Brazil
Centro Brasileiro de Pesquisas Fisicas (CBPF)
Pontifícia Universidade Católica, Rio de Janeiro
Universidade de Sao Paulo, Inst. de Fisica
Universidade Estadual de Campinas (UNICAMP)
Universidade Estadual de Feira de Santana (UEFS)
Universidade Estadual do Sudoeste da Bahia (UESB)
Universidade Federal da Bahia
Universidade Federal do ABC (UFABC)
Universidade Federal do Rio de Janeiro (UFRJ)
Universidade Federal Fluminense

Czech Republic
Charles University Prague, Institute of Particle and Nuclear Physics
Institute of Physics (FZU) of the Academy of Sciences of the Czech Republic

France
Institut de Physique Nucléaire, Orsay (IPNO)

Laboratoire AstroParticule et Cosmologie Université Paris VII
Laboratoire de l'Accélérateur Linéaire (LAL), Orsay
Laboratoire de Physique Nucléaire et de Hautes Energies (LPNHE), Université Paris 6
Laboratoire de Physique Subatomique et de Cosmologie (LPSC) - Grenoble

Germany
Bergische Universität Wuppertal
Forschungszentrum Karlsruhe - Institut für Kernphysik
Forschungszentrum Karlsruhe - Institut für Prozessdatenverarbeitung und Elektronik
Max-Planck-Institut für Radioastronomie and Universität Bonn
Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen
Universität Karlsruhe (TH) - Institut für Experimentelle Kernphysik (IEKP)
Universität Siegen

Italy
Dipartimento di Fisica dell'Università and INFN, L'Aquila
Dipartimento di Fisica dell'Università and Sezione INFN, Milano
Dipartimento di Fisica dell'Università di Napoli "Federico II" and Sezione INFN, Napoli
Dipartimento di Fisica dell'Università di Roma "Tor Vergata" and Sezione INFN Roma II
Dipartimento di Fisica e Astronomia dell'Università di Catania & Sezione INFN, Catania
Dipartimento di Fisica Sperimentale dell'Università and Sezione INFN, Torino
Dipartimento di Fisica, Università del Salento and Sezione INFN
Istituto di Fisica dello Spazio Interplanetario (INAF), Dipartimento di Fisica Generale dell'Università and Sezione INFN, Torino
Laboratori Nazionali del Gran Sasso, INFN
Osservatorio Astrofisico di Arcetri

Mexico
Benemérita Universidad Autónoma de Puebla (BUAP)
Centro de Investigación y de Estudios Avanzados del IPN (CINVESTAV)
Universidad Michoacana de San Nicolás de Hidalgo
Universidad Nacional Autónoma de México

Netherlands
Institute for Mathematics, Astrophysics and Particle Physics (IMAPP), Radboud Universiteit
Kernfysisch Versneller Instituut (KVI), Rijksuniversiteit Groningen
Nationaal Instituut voor Kernfysica en Hoge Energie Fysica (Nikhef)
Stichting Astronomisch Onderzoek in Nederland (ASTRON), Dwingeloo

Poland
Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences

University of Łódź

Portugal
Laboratory of Instrumentation and Experimental Particle Physics (LIP)

Slovenia
University of Nova Gorica

Spain
Instituto de Física Corpuscular, CSIC-Universitat de València
Universidad Complutense de Madrid
Universidad de Alcalá de Henares
Universidad de Santiago de Compostela
University of Granada

United Kingdom
Oxford University
University of Leeds, School of Physics & Astronomy

United States
Argonne National Laboratory
Case Western Reserve University
Colorado School of Mines
Colorado State University, Fort Collins
Colorado State University, Pueblo
Columbia University
Fermi National Accelerator Laboratory
Louisiana State University
Michigan Technological University
New York University
Northeastern University
Ohio State University
Pennsylvania State University
Southern University
University of California, Los Angeles
University of Chicago
University of Colorado
University of Hawaii
University of Minnesota
University of Nebraska
University of New Mexico

University of Utah
University of Wisconsin-Madison
University of Wisconsin-Milwaukee

Vietnam
Institute of Nuclear Science and Technology of Hanoi (INST)

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