PIERRE AUGER OBSERVATORY

Education and Outreach

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For the Pierre Auger Collaboration
Outline

- Lightning intro to the Auger Observatory
- Education and Outreach Task goals
- Annual Malargüe Day Parade
- Auger Visitor Center on Observatory campus
- Science Fairs on Observatory campus
- Rural Schools Program
- James Cronin School
- Outreach events away from the Observatory
- Online education/outreach resources
Malargüe is a small town on the high plains, the foothills of the Andes. **Mendoza Province is also the wine making region of AR.**
Surface Detector (SD) Array
1600 detector stations
1.5 km spacing
3000 km²

Fluorescence Detectors (FD)
4 Telescope enclosures
6 Telescopes per enclosure
24 Telescopes total

Headquarters
To learn more about Auger and its upgrade AugerPrime, see the June 2016 CERN Courier Article

This image will also be featured in CERN’s Microcosm Visitor Center

Montage: Helmholtz Alliance for Astroparticle Physics / A. Chantelauze

Photo: S. Staffi / University of Adelaide

Shower: ASPERA / Novapix / L. Bret
AugerPrime looks to the highest energies

The world’s largest cosmic-ray experiment, the Pierre Auger Observatory in Mendoza Province, Argentina, is embarking on its next phase, named AugerPrime.

Since the start of its operations in 2004, the Auger Observatory has illuminated many of the open questions in cosmic-ray science. For example, it confirmed with high precision the suppression of the primary cosmic-ray energy spectrum for energies exceeding $5 \times 10^{18}$ eV, as predicted by Kenneth Greisen, George Zatsepin and Vladimir Kuzmin (the “GZK effect”). The collaboration has searched for possible extraterrestrial power sources of the highest-energy cosmic-ray particles ever observed, as well as for large-scale anisotropies of arrival directions in the sky (CERN Courier December 2007 p5). It has also published unexpected results about the specific particle types that make up the Earth’s atmosphere — especially at the “mass composition” of the primary particles. The observatory has set the world’s most stringent upper limits on the flux of neutrinos and photons with EeV energies ($1 \text{ EeV} = 10^{19}$ eV). Furthermore, it contributes to our understanding of hadronic showers and interactions at centre-of-mass energies well above those accessible at the LHC, such as in its measurement of the proton-proton elastic cross-section at 6-57 TeV (CERN Courier September 2012 p6).

The current Auger Observatory

The Auger Observatory learns about high-energy cosmic rays from the extensive air showers they create in the atmosphere (CERN Courier July-August 2006 p3). These showers consist of billions of subatomic particles that rain down on the Earth’s surface, spread over a footprint of tens of square kilometers. Each air shower carries information about the primary cosmic-ray particle’s arrival direction, energy and particle type. An array of 1600 water-Cherenkov surface detectors, placed on a 1500 km grid covering 3000 km$^2$, samples some of these particles, while fluorescence detectors around the observatory’s periphery observe the faint ultraviolet light the shower creates by exciting the air molecules it passes through. The surface detectors operate 24 hours a day, and are joined by fluorescence-detector measurements on clear moonless nights. The duty cycle for the fluorescence detectors is about 10% of that of the surface detectors. An additional 60 surface detectors in a region with a reduced 750 km spacing, known as the “illuminated array,” focus on detecting lower-energy air showers whose footprint is smaller than that of showers at the highest energies. Each surface-detector station (see image above) is self-powered by a solar panel, which charges batteries in a box attached to the tank (at left in the image), enabling the detectors to operate day and night. An array of 150 radio antennas, named AERA and spread over a 7 km area, completes the surface detectors and fluorescence detectors. The antennas are sensitive to coherent radiation emitted in the frequency range 30-50 MHz by air-shower electrons and positrons deflected in the Earth’s magnetic field.

The motivation for AugerPrime and its detector upgrades

The primary motivation for the AugerPrime detector upgrades is to understand how the suppression of the energy spectrum and the mass composition of the primary cosmic-ray particles at the highest energies are related. Different primary particles, such as pions, kaons, protons or heavier nuclei, create air showers with different average characteristics. To date, the observatory has measured the average primary-particle mass at a given energy from measurements provided by the fluorescence detectors. These detectors are sensitive to the number of air-shower particles versus depth in the atmosphere through the varying intensity of the ultraviolet light emitted along the path of the shower. The atmospheric depth of the shower’s maximum number of particles, a quantity known as $X_{max}$, is deeper in the atmosphere for proton-induced air showers relative to showers induced by heavier nuclei, such as iron, at a given primary energy. Owing to the 10% duty cycle of the fluorescence detectors, the mass composition measurements using the $X_{max}$ technique do not currently extend into the energy region $E > 5 \times 10^{18}$ eV where the flux suppression is observed. AugerPrime will capitalize on another feature of air showers (induced by different primary-mass particles, namely, the different abundances of muons, photons and electrons at the Earth’s surface. The main goal of AugerPrime is to measure the relative numbers of these shower particles to obtain a more precise handle on the primary cosmic-ray composition with increased statistics at the highest energies. This knowledge should reveal whether the flux suppression at the highest energies is a result of a GZK-like propagation effect or of astrophysical sources reaching a limit in their ability to accelerate the highest-energy primary particles.

The key to understanding the ground-level air-shower particles lies in improving the detection capabilities of the surface array. AugerPrime will cover each of the 1600 water-Cherenkov surface detectors with planes of plastic-scintillator detectors measuring 4m$^2$. Surface-detector stations with scintillators above the Cherenkov detectors will allow the Auger team to determine the electron–photon

versus muon content of air showers more precisely compared with using the Cherenkov detectors alone. The scintillator planes will be housed in light-tight, weatherproof enclosures attached to the existing water tanks and will be supported from a frame, as shown above. The scintillator light will be broadened with wavelength-shifting fibres inserted into extended tubes in the scintillator planes, which are bundled and attached to photomultiplier tubes. Also above, an image shows how the green wavelength-shifting fibres emerge from the scintillator planes and are grouped into bundles. Because the surface detectors operate 24 hours a day, the AugerPrime upgrade will yield mass-composition information for the full data set collected in the future.

The AugerPrime project also includes other detector improvements. The dynamic range of the Cherenkov detectors will be extended with the addition of a fourth photomultiplier tube. Its gain will be adjusted to what particle densities can be accurately measured close to the core of the highest-energy air showers. New electronics with faster sampling of the photomultiplier signals will better identify the narrow peaks emitted by muons. New GBT receivers at each surface-detector station will provide better timing accuracy and calibration. A subproject of AugerPrime called AMIGA will consist of scintillator planes mounted on the 60 surface detectors at the mill array. The AMIGA detectors are directly sensitive to the muon content of air showers, because the electromagnetic components are largely absorbed by the overburden.
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Goals of the Education/Outreach Task

• Use the Auger Observatory and international collaboration to enhance science literacy and technology skills in the region of the Auger site and internationally

• Increase public awareness and support for basic research in physics, astrophysics, and all areas of science

• Encourage and support a wide range of education/outreach projects which link schools, community groups, and the public with the science and scientists of the Auger Observatory

• Provide technical and non-technical information on Auger to a wide range of audiences – students, public, government officials, scientific colleagues

• Recruit and encourage the participation of groups underrepresented in science in Auger education/outreach activities

We have found that establishing and maintaining good relationships with the local community in Malargüe is important to the success of the Observatory.
Education and Public Outreach for the Pierre Auger Observatory

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Abstract. The scale and scope of the physics studied at the Auger Observatory offer significant opportunities for original outreach work. Education, outreach and public relations of the Auger collaboration are coordinated in a separate task whose goals are to encourage and support a wide range of education and outreach efforts that link schools and the public with the Auger scientists and the science of cosmic rays, particle physics, and associated technologies. The presentation will focus on the impact of the collaboration in Mendoza Province, Argentina, at: the Auger Visitor Center in Malargüe that has hosted over 40,000 visitors since 2001, a collaboration-sponsored science fair held on the Observatory campus in November 2007, the Observatory Inauguration in November 2008, public lectures, school visits, and courses for science teachers. A Google-Earth model of the Observatory and animations of extensive air showers have been created for wide public release. As the collaboration prepares its northern hemisphere site proposal, plans for an enhanced outreach program are being developed in parallel and will be described.

Keywords: Auger Education and Outreach

I. INTRODUCTION

Education and public outreach (EPO) have been an integral part of the Auger Observatory since its inception. The collaboration’s EPO activities are organized in a separate Education and Outreach Task that was established in 1997. With the Observatory headquarters located in the remote city of Malargüe, population 20,000, early outreach activities, which included public talks, visits to schools, and courses for science teachers and students, were aimed at familiarizing the local population with the science of the Observatory and the presence of the large collaboration of international scientists in the isolated communities and countryside of Mendoza Province. The collaboration has been successful becoming part of the local culture. As an example of the Observatory’s integration into local traditions, the collaboration has participated in the annual Malargüe Day parade since 2001 with collaborators marching behind a large Auger banner (see Fig. 1). The Observatory’s EPO efforts have been documented in previous ICRC contributions [1]. We report here highlights of recent education, outreach, and public relations efforts.

II. THE AUGER VISITOR CENTER IN MALARGÜE

The Auger Visitor Center (VC), located in the central office complex and data acquisition building in Malargüe, continues to be a popular attraction. Through the end of April 2007, the VC has hosted 43,777 visitors with an average of about 6000 per year. A noticeable increase of visitors occurred after the opening of a new, nearby planetarium [2] in August 2008. Fig. 2 shows the number of visitors logged per year from November 2001 through April 2009. The VC is managed by a small staff led by Observatory employee Anaíla Cáceres which includes local teacher Miguel Herrera and other Auger collaborators. Fig. 2 shows Auger physicist Julio Rodríguez explaining the Observatory to a visiting school group in the data acquisition center.

Recent exhibits that were field tested at the VC, notably the illuminated scale model of the Observatory developed at the Forschungscentrum Karlsruhe [1] and the Google Earth fly-over animation [3] developed by Stephane Coutu of Pennsylvania State University, have since been replicated elsewhere. As examples, copies of each display are in the interim Auger North VC at Lamar Community College in Colorado and in a new physics and astrophysics learning center called the Galileum in Teramo, Italy, whose director is Auger collaborator Aurelio Grillo.

III. THE 2007 AUGER SCIENCE FAIR

Following a successful Science Fair held in November 2005, the Collaboration sponsored a second Fair on November 16-17, 2007, that attracted the exhibition of 40 science projects in the areas of natural science, mathematics, and technology (see Fig. 3), in contrast to
Auger collaborators participating in Malargüe Day parade - a tradition!!
Auger collaborators participating in Malargüe Day parade - a tradition!!
November 2015 Malargüe Day Parade

Hundreds of gauchos

Mayor and other VIPs
Visitor Center at Auger Office Building

Data Acquisition

Visitor Center

10 × 12 m²
Visitor Center at Auger Office Building

- Seats 60 people
- Glass cabinet for library and displays
- PC and multimedia projection
- Quarter-size FD mirror set-up from Karlsruhe
Recent Renovation of Visitor Center

- Stations, self-guided
- Audio for vision-impaired
- Interactive shower detection display
- Interactive dual Geiger display
Scientific Tourism in Malargüe Region

Auger Visitor Center Visits vs. Year

- 101,949 visitors since opening in 2001

Malargüe Planetarium

Payunia volcano region

Also nearby caves and fossil fields
November 19-21, 2014, Science Fair participants
The fifth and most successful Science Fair to date

Participants come from all over Mendoza Province and beyond

The next Science Fair is foreseen on the dates November 17, 18, 19, 2016 Thursday, Friday, Saturday during our November Collaboration Meeting
November 2014 Science Fair

Setting up stands

National anthem

Collaborators serve as judges
Participants range from primary school through high school

Solar oven – it works!
November 2014 Science Fair

Visitor Center presentation on Auger

Award presentations
Rural Schools Program

Observatory staff volunteer their time and money to bring cosmic ray science and infrastructure improvements to remote schools that cannot travel to Malargüe.

Science presentation

Donation of electric heaters
James Cronin School Inauguration

New school opened November 2007

Funding from Malargüe, Mendoza Province, U.S. Grainger Foundation (via Cronin contact)
From the Big Bang to the Universe

Many public events hosted by collaborating institutions

Highlights of Physics 2013

Annual event once per year in one German city

2013 hosted by Physics Department at University Wuppertal

Central Theme: Particle and Astroparticle Physics

Exhibition dominated by CRs

More than 30,000 visitors in 5 days

K.-H. Kampert

Malargüe, Nov. 2013
Lectures for pupils...

Julian Rautenberg showing water Čerenkov detector using simple materials

...and general public about Auger
High altitude balloon flight
September 15, 2012

Commemorating 100th anniversary of Victor Hess balloon flights

University of Nebraska football stadium
80,000 spectators
Geiger counter transmits radiation counts in real time
Greater fluctuations and tendency to decrease as balloon rises above first interactions for air showers.

Increase in CR radiation as balloon rises above protection from atmosphere.

Commercial airline altitude.
Online Resources

- Recently updated website http://www.auger.org
- Social media presence
- Documentary videos
- Air shower data available to the public
- 44,000 events as of today

The Public Event Explorer

The public event display of the Pierre Auger Observatory is hosted at the Colorado State University. (Please note that it does take a while to load up)

The Pierre Auger Collaboration agreed on making 1% of its data available to the public. The Colorado State University website allows browsing over the events collected since 2004, and is updated daily. You can enter an eventId in the search window, search for an event with the event selection menu, or display an event already in cache. You can also download an ascii file with all events.

Instructions for use

- Guide To Downloading and Formatting Pierre Auger Observatory Data
- Guide To Making an Energy Histogram Using Pierre Auger Observatory Surface Detector Data

User-friendly Visual Physics Analysis (VISPA) tool