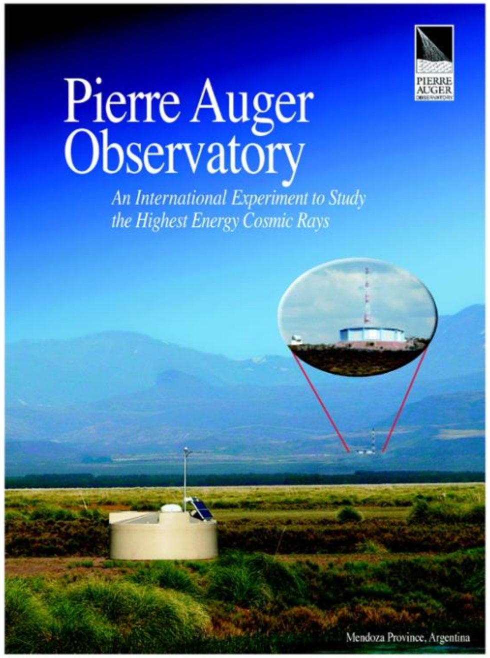
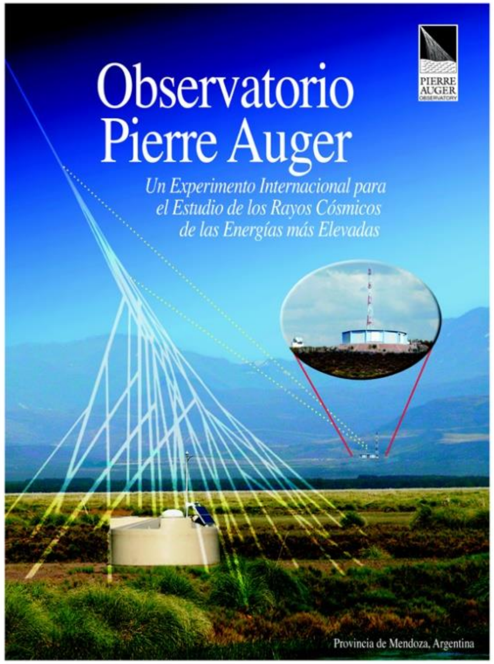
PIERRE AUGER OBSERVATORY



Education and Outreach



ICHEP, Chicago, August 6, 2016

Gregory Snow / University of Nebraska-Lincoln
For the Pierre Auger Colllaboration

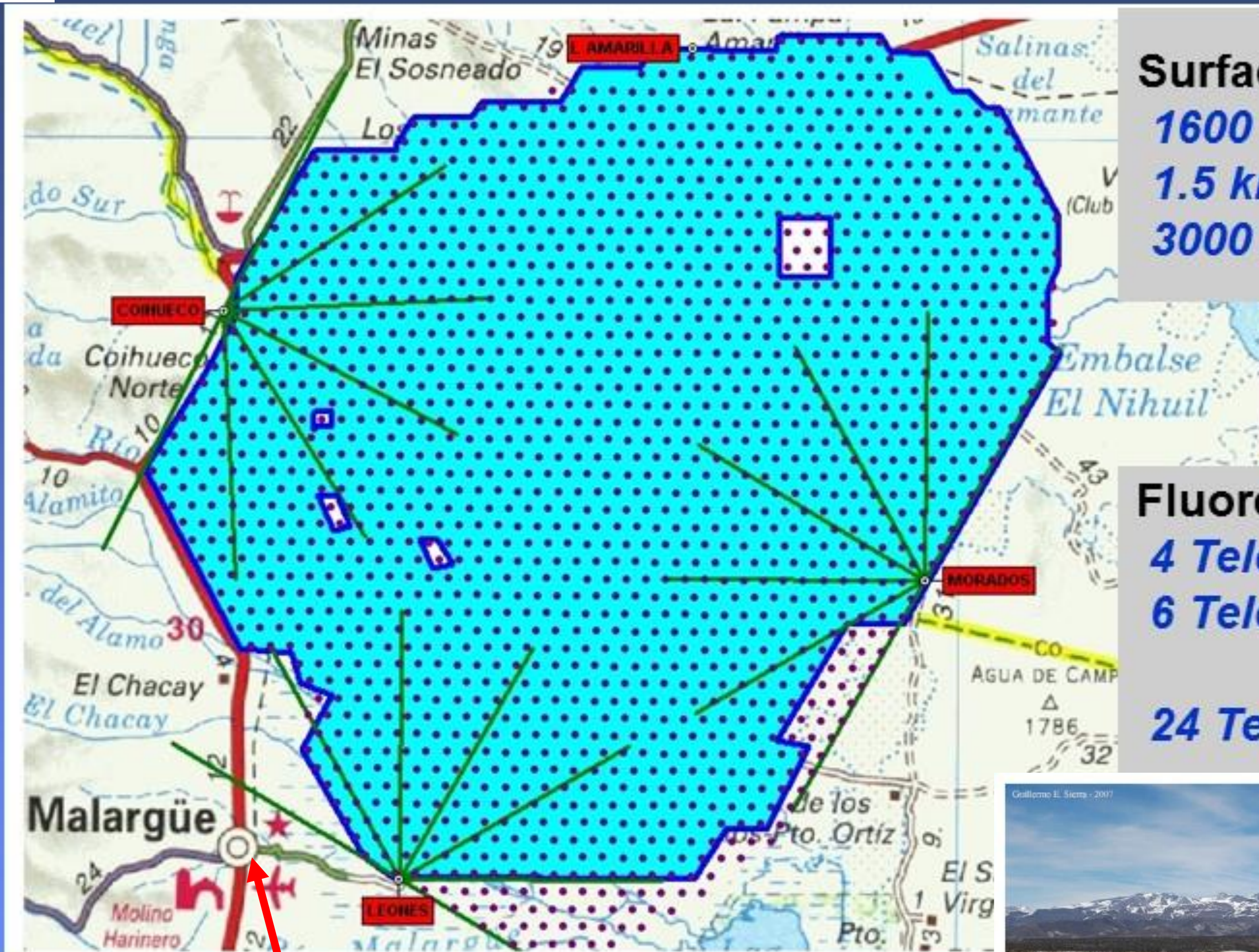
Outline

- 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

The Pierre Auger Observatory

Malargüe is a small town on the high plains, the foothills of the Andes. Mendoza Province is also the wine making region of AR.

Observatory Layout



Headquarters

Surface Detector (SD) Array

1600 detector stations

1.5 km spacing

3000 km^2

Fluorescence Detectors (FD)

4 Telescope enclosures

6 Telescopes per enclosure

24 Telescopes total

Aerial Photos of Fluorescence Buildings
November 2006

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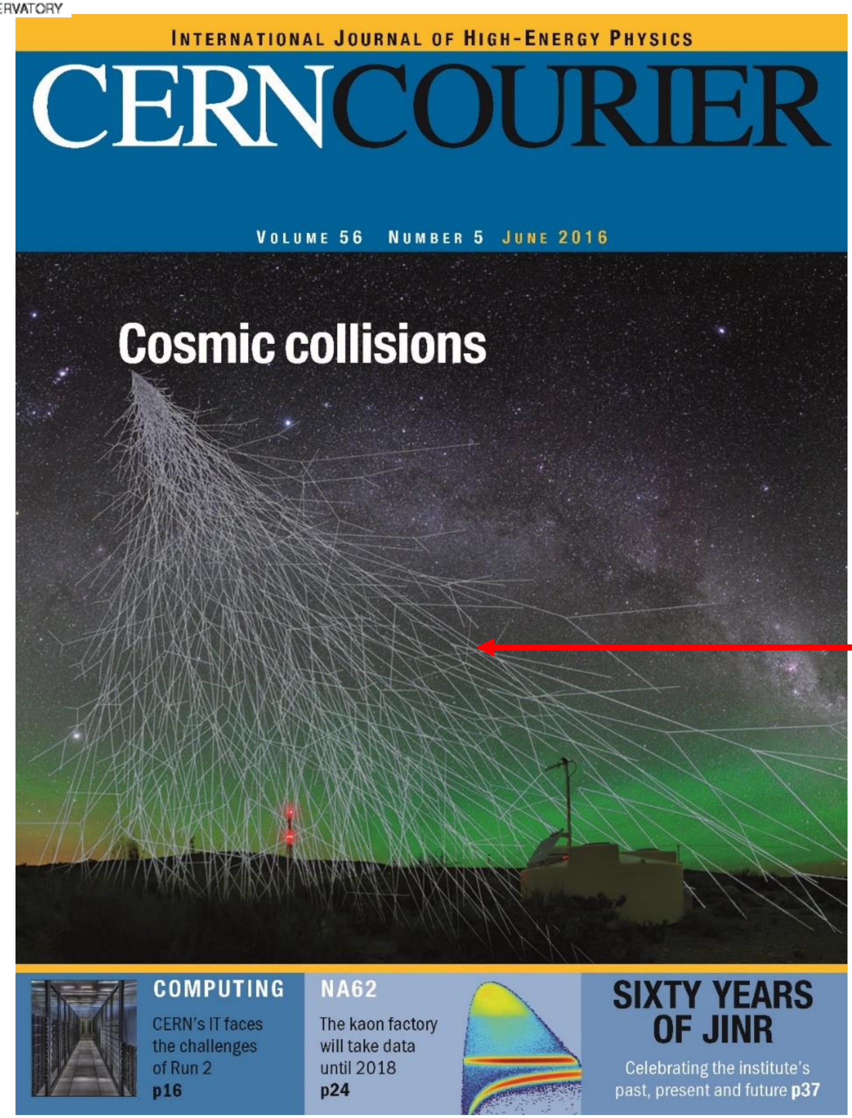
To learn more about Auger and it's upgrade AugerPrime, see the June 2016 CERN Courier Article



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

All image credits: Pierre Auger Col

An Auger Observatory water-Cherenkov surface detector on the Pampa Amarilla.

AugerPrime looks to the highest energies

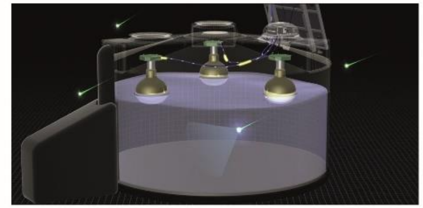
The world's largest cosmic-ray experiment, the Pierre Auger Observatory in Mendoza Province, Argentina, is embarking on its next phase, named AugerPrime.

Gregory Snow, University of Nebraska, US, for the Pierre Auger Collaboration.

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 5×10^{19} eV, as predicted by Kenneth Greisen, Georgiy Zatsepin and Vadim Kuzmin (the "GZK effect"). The collaboration has searched for possible extragalactic point sources of the highest-energy cosmic-ray particles ever observed, as well as for large-scale anisotropy of arrival directions in the sky (*CERN Courier* December 2007 p5). It has also published unexpected results about the specific particle types that reach the Earth from remote galaxies, referred to as 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 EeV = 10^{18} 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 inelastic cross-section at $\sqrt{s} = 57$ 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 p12). These showers consist of billions of subatomic particles that rain down on the Earth's surface, spread over a footprint of tens of square kilometres. 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 m grid covering 3000 km², samples some of these particles, while fluorescence detectors around the observatory's perimeter 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% that of the surface detectors. An additional 60 surface detectors in a region with a reduced 750 m spacing, known as the infill 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 ▷



Cherenkov light produced by air-shower particles is detected by three photomultiplier tubes, which view the water volume.

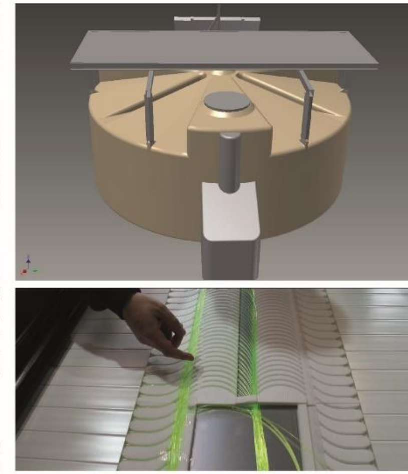
by a solar panel, which charges batteries in a box attached to the tank (at left in the image), enabling the detectors to operate day and night. An array of 153 radio antennas, named AERA and spread over a 17 km² area, complements the surface detectors and fluorescence detectors. The antennas are sensitive to coherent radiation emitted in the frequency range 30–80 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 suppressed energy spectrum and the mass composition of the primary cosmic-ray particles at the highest energies are related. Different primary particles, such as γ-rays, neutrinos, protons or heavier nuclei, create air showers with different average characteristics. To date, the observatory has deduced 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 $E > 5\times10^{19}$ eV where the flux suppression is observed. AugerPrime will capitalise 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 differentiating the ground-level air-shower particles lies in improving the detection capabilities of the surface array. AugerPrime will cover each of the 1660 water-Cherenkov surface detectors with planes of plastic-scintillator detectors measuring 4 m². Surface-detector stations with scintillators above the Cherenkov detectors will allow the Auger team to determine the electron/photon versus muon abundances 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 with a sturdy support frame, as shown above. The scintillator light will be read out with wavelength-shifting fibres inserted into straight extruded holes 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 so that particle densities can be accurately measured close to the core of the highest-energy air showers. New electronics with faster sampling of the photomultiplier-tube signals will better identify the narrow peaks created by muons. New GPS receivers at each surface-detector station will provide better timing accuracy and calibration. A subproject of AugerPrime called AMIGA will consist of scintillator planes buried 1.3 m under the 60 surface detectors of the infill array. The AMIGA detectors are directly sensitive to the muon content of air showers, because the electromagnetic components are largely absorbed by the overburden.



Top: Drawing of an AugerPrime surface-detector station with scintillator planes measuring 4 m², housed in a weatherproof enclosure above a water-Cherenkov detector. Above: An AugerPrime scintillator detector with green wavelength-shifting fibres, which carry light to a photomultiplier tube (not shown).

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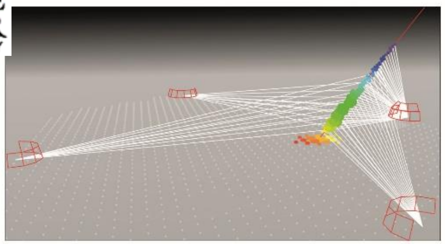
Cosmic rays



Event display of an ultra-high-energy air shower, showing surface detectors recording hits and light seen by all four fluorescence-detector sites.

The AugerPrime Symposium

In November 2015, the Auger scientists combined their biannual collaboration meeting in Malargüe, Argentina, with a meeting of its International Finance Board and dignitaries from many of its collaborating countries, to begin the new phase of the experiment in an AugerPrime Symposium. The Finance Board endorsed the development and construction of the AugerPrime detector upgrades, and a renewed international agreement was signed in a formal ceremony for continued operation of the experiment for an additional 10 years. The observatory's spokesperson, Karl-Heinz Kampert from the University of Wuppertal, said: "The symposium marks a turning point for the observatory and we look forward to the exciting science that AugerPrime will enable us to pursue."

While continuing to collect extensive air-shower data with its current detector configuration and publishing new results, the Auger Collaboration is focused on finalising the design for the upgraded AugerPrime detectors and making the transition to the construction phase at the many collaborating institutions worldwide. Subsequent installation of the new detector components on the Pampa Amarilla is no small task, with the 1660 surface detectors spread across such a large area. Each station must be accessed with all-terrain vehicles moving carefully on rough desert roads. But the collaboration is up to the challenge, and AugerPrime is foreseen to be completed in 2018 with essentially no interruption to current data-taking operations.

● For more information, see auger.org/augerprime.

Résumé

Lancement d'AugerPrime

Des rayons cosmiques d'ultra-haute énergie en provenance du fin fond de l'Univers seront bientôt observés par un œil plus acéré. L'Observatoire Pierre Auger a en effet mis en route sa prochaine phase, appelée AugerPrime, consacrée à l'amélioration des détecteurs. En novembre 2015, un nouvel accord a été signé pour la poursuite de l'exploitation de l'expérience pour une durée supplémentaire de dix ans. Cette nouvelle phase vise principalement à comprendre le lien entre la partie supprimée du spectre d'énergie et la composition des masses des rayons cosmiques primaires aux plus hautes énergies. Elle devrait prendre fin en 2018, sans interruption des opérations de collecte de données.

Many thanks to:

Piera Ghia, Stephane Coutu, Astrid Chantelauze, Michael Unger, Charles Timmermans, Ralph Engel, Jim Matthews, Bruce Dawson, Karl-Heinz Kampert, Carola and the Publications Committee

Antonella del Rosso from the CERN Courier

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.

- **Auger Education and Outreach paper and poster presented at each ICRC along with science papers**

Education and Public Outreach for the Pierre Auger Observatory

G. R. Snow*, for the Pierre Auger Collaboration†

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†Observatorio Pierre Auger, Av. San Martín Norte 304, (5613) Malargüe, Mendoza, Argentina

***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, as: 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 Observatorys 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.

Fig. 1: The Auger collaboration and Science Fair participants in the November 2007 Malargüe Day Parade.

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 occured 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 Analía Cáceres which includes local teacher Miguel Herrera and other Auger collaborators. Fig. 2 shows Auger physicist Julio Rodriguez 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 Forschungszentrum 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 Galileium 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

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Auger collaborators participating in Malargüe Day parade – a tradition !!

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Auger collaborators participating in Malargüe Day parade – a tradition !!

November 2015 Malargüe Day Parade

Mayor and other VIPs

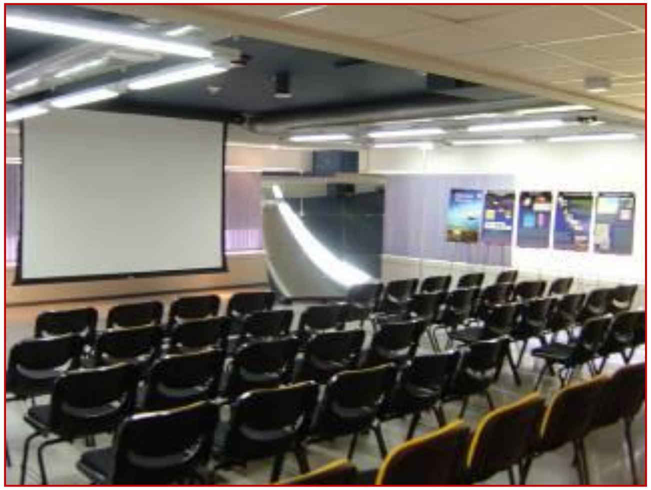
Hundreds of gauchos

Visitor Center at Auger Office Building

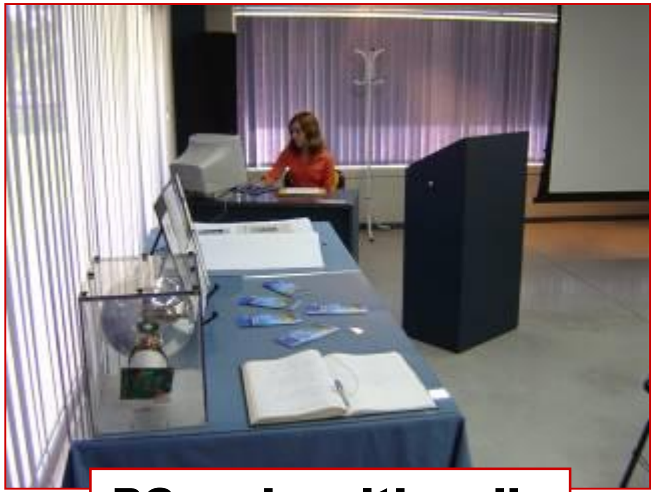
Data Acquisition

Visitor Center
10 × 12 m²

Visitor Center at Auger Office Building



Seats 60 people



PC and multimedia projection

Glass cabinet for library and displays

Quarter-size FD mirror set-up from Karlsruhe

Recent Renovation of Visitor Center

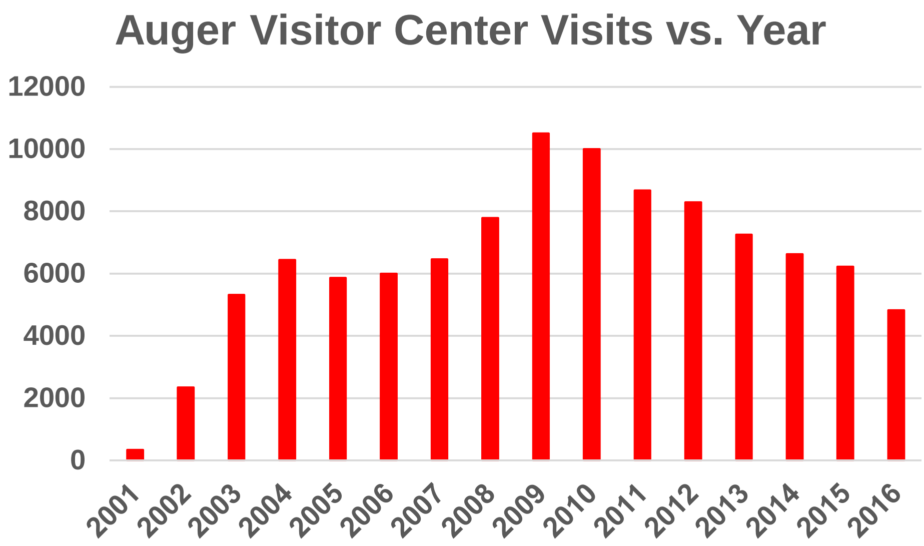
Stations, self-guided

Audio for vision-impaired

Interactive shower detection display

Interactive dual Geiger display

Scientific Tourism in Malargüe Region



101,949 visitors since opening in 2001

Malargüe Planetarium

Payunia volcano region

Also nearby caves and fossil fields

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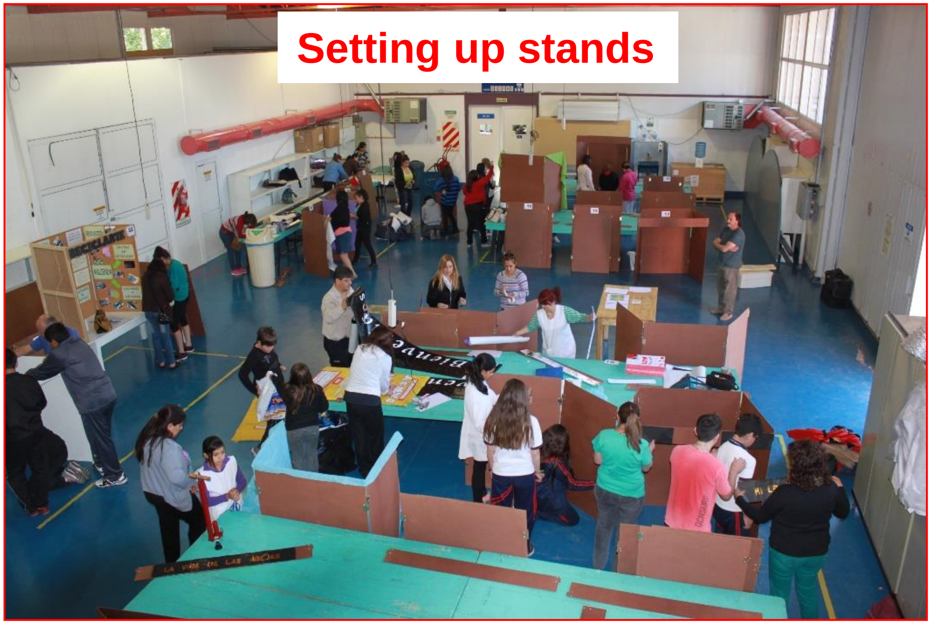
November 19-21, 2014, Science Fair participants
The fifth and most successful Science Fair to date

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



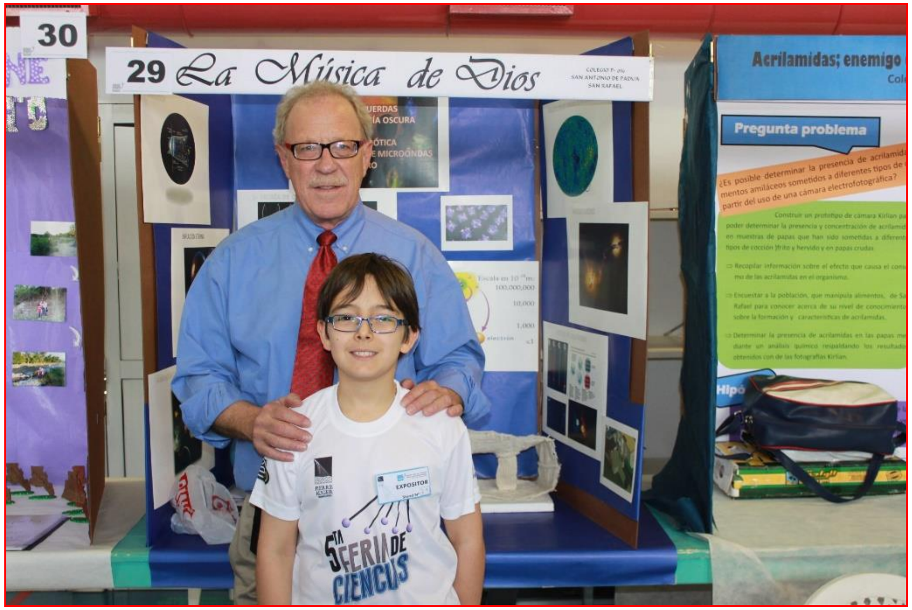
Setting up stands

National anthem

Collaborators serve as judges

Participants range from primary school through high school

Solar oven – it works!



November 2014 Science Fair

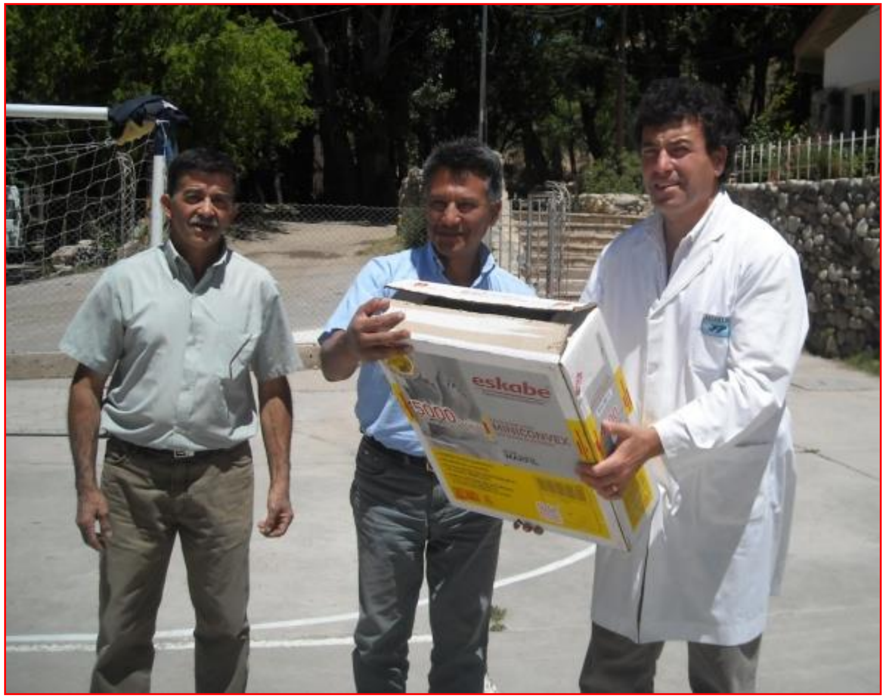
Visitor Center presentation on Auger

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

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James Cronin School Inauguration

New school opened November 2007

Funding from Malargüe, Mendoza Province, U.S. Grainger Foundation (via Cronin contact)

Many public events hosted by collaborating institutions

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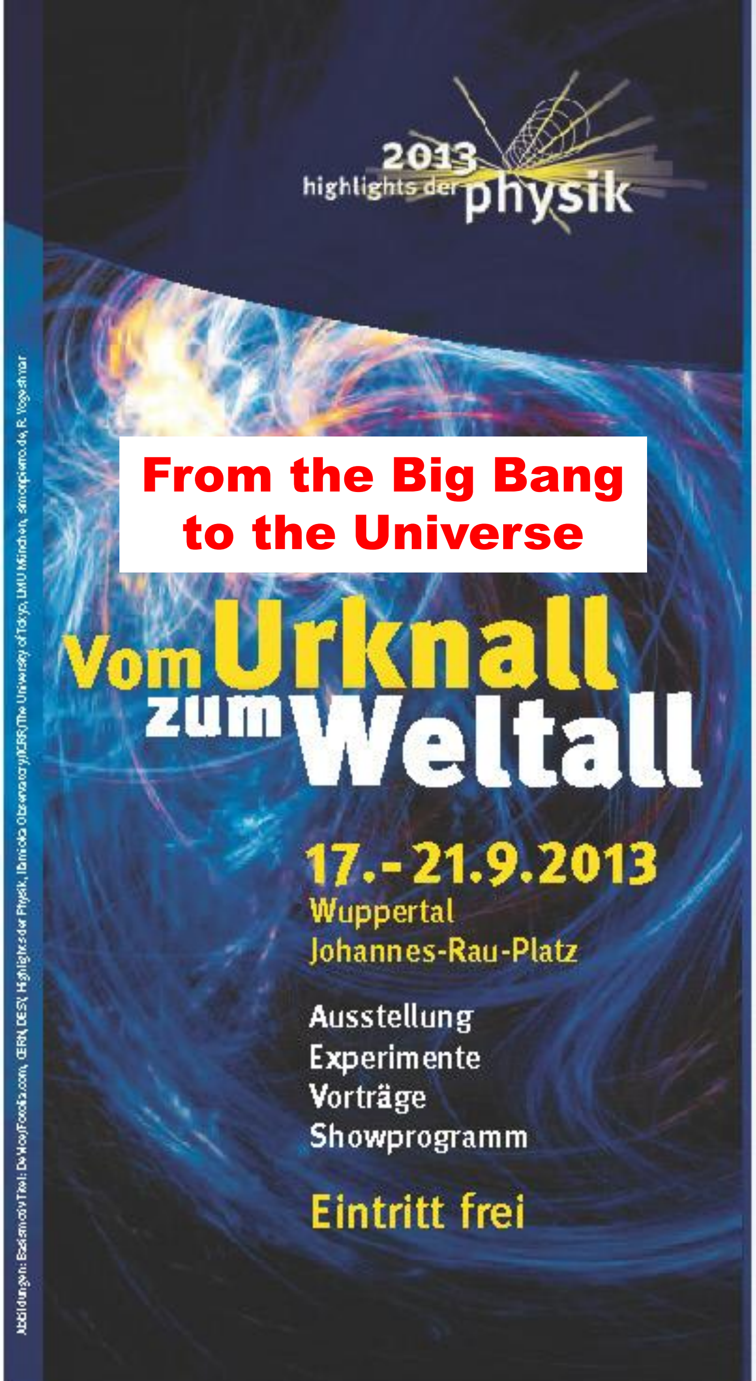

From the Big Bang to the Universe

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

Lectures for pupils...

Julian Rautenberg

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...and general public about Auger

Spokesperson showing water Čerenkov detector using simple materials

High altitude balloon flight
September 15, 2012

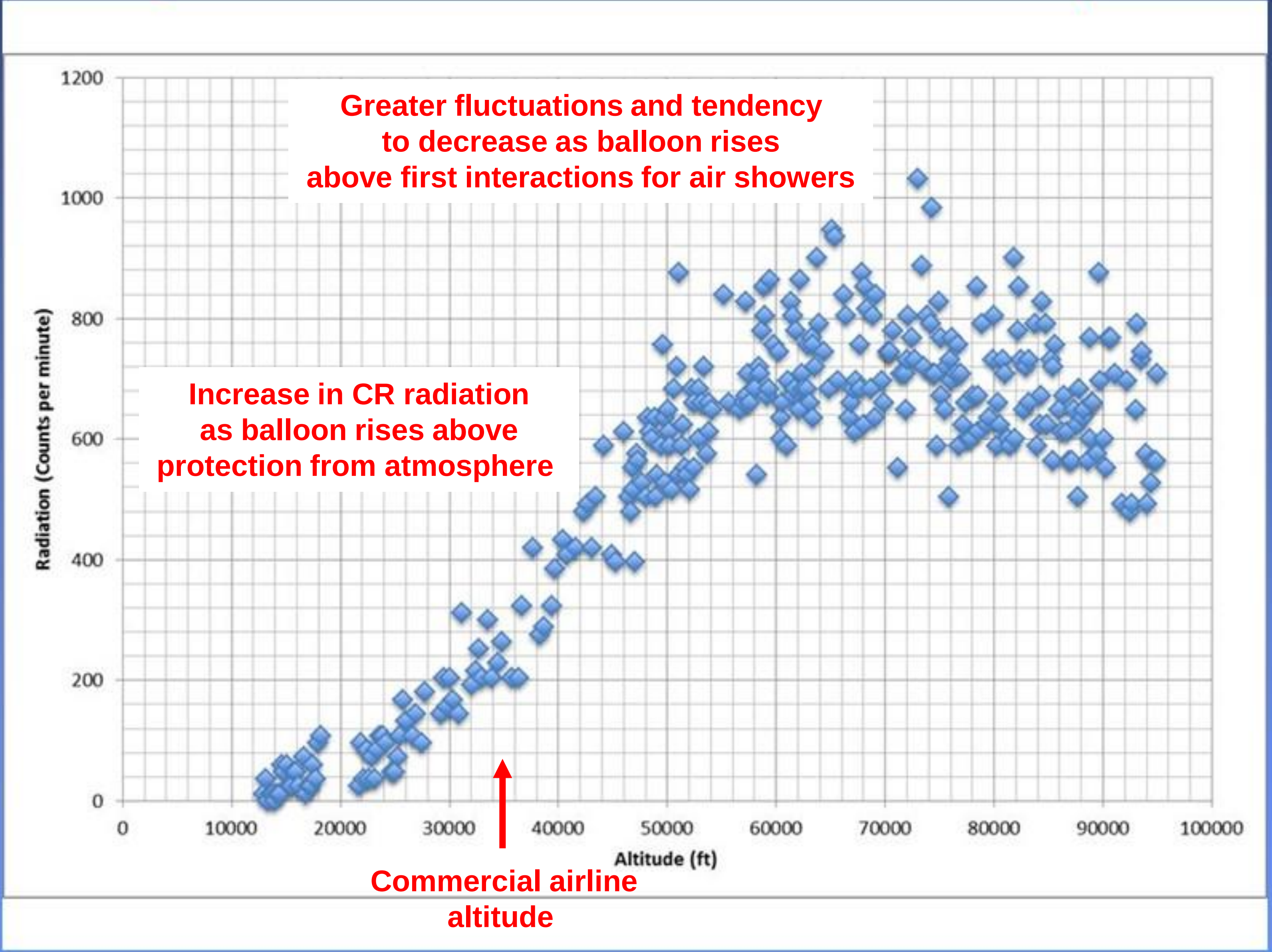
Commemorating 100th anniversary of Victor Hess balloon flights

University of Nebraska football stadium 80,000 spectators

High altitude balloon flight
September 15, 2012

Geiger counter transmits radiation counts in real time

High altitude balloon flight September 15, 2012

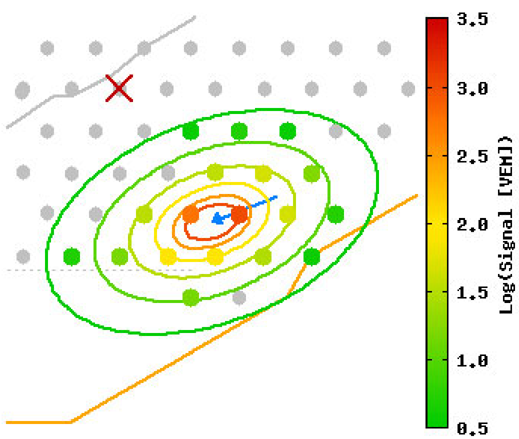


Online Resources

- 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 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 event Id 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.

Display # 10

Read On

Guide To Downloading and Formatting Pierre Auger Observatory Data ← **Instructions for use**

Guide To Making an Energy Histogram Using Pierre Auger Observatory Surface Detector Data

Edu & Outreach

- Auger Visitor Center
- **Event Display**
- FAQ
- Games
- Google Earth
- James Cronin School
- Journey to Auger
- Science Fair
- VISPA ← **User-friendly Visual Physics Analysis (VISPA) tool**