



The Pierre Auger Observatory staring science: Open Data and Outreach activities



XIII International Conference
on New Frontiers in Physics

26 Aug - 4 Sep 2024, OAC, Kolymbari, Crete, Greece

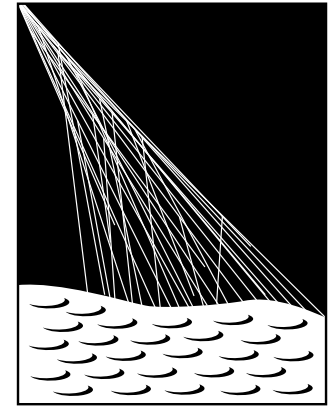
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Collaboration

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Overview

- Pierre Auger Observatory, Visitor Center
- Web page
- VR3D
- Women in Science
- Talks and Science fairs
- Data release and Software approach
- Masterclasses (IPPOG)
- Auger goes to School
- International Cosmic Day and other events
- QR, Wikipedia, videos, brochure and Auger in Focus



PIERRE
AUGER
OBSERVATORY

The Pierre Auger Observatory

Physics of Astro-Particles
Malargüe, Argentina

WCD, FD, Scintillator,
Radio antenna

WCD (SD)

FD
building

FD

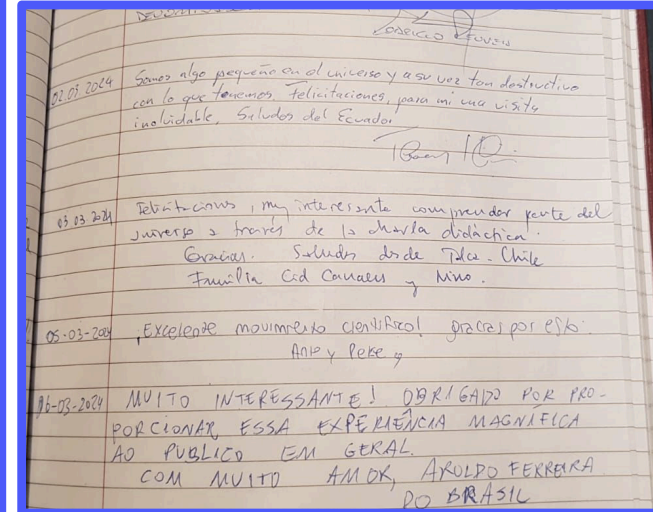
The Pierre Auger Collaboration

- Planned in 1992 -> 1999 Agreement
- Inaugurated in 2008
- Finished in 2009 (First part)
- Continued to Auger Prime 2015
- ~ 400 collaborators, ~17 countries
70 institutions



- <https://auger.org/>
- <https://visitantes.auger.org.ar/>

Visitor Center

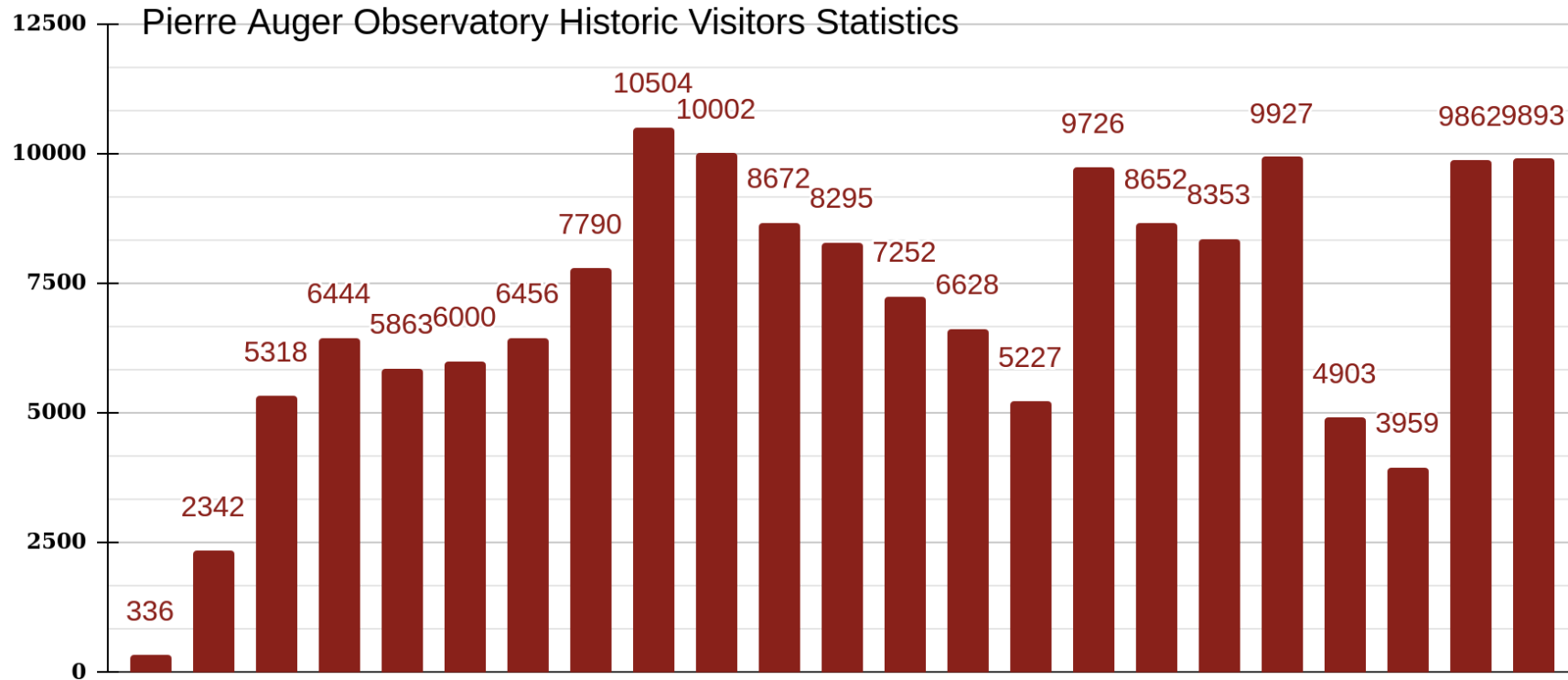


Guests Book

Virtual Ballon Flight (VR station)

Models, posters, experiments, guided visit, videos, etc.

Visitor Center



*Since 2001, at Malargüe, up to 3rd quarter of 2023

*~8000 visitors a year

Visitor Center

2024 Events (mainly International Days)

January

04 - International Day of Braille

February

11 - International Day of W&G in Science

March

08 - Women International Day

16 - Women and Girls in Science exhibition
in the Convention Center, Malargüe

April

02-08 - Dark skies week

14-19 - **Pierre Auger Meeting**

21 - [World Day of Creativity and Innovation](#)

May

16 - International Day of Light

28 - Day of Kindergartens

June

05 - **World Environment Day**

21 - Solstice

30 - International Asteroid Day

21 - International day of the Sun



- Virtual and audio Tours
- <https://izi.travel/en/6095-pierre-auger-observatory/en>

Visitor Center



- Anual parade during the November Meeting in Malargüe Anniversary

Web page

The screenshot shows the homepage of the Pierre Auger Observatory website. The browser's address bar displays "auger.org". The navigation menu includes "Home", "News", "Observatory", "Collaboration", "Science", "Outreach", and "Internal". The main content area is organized into six columns: "COSMIC RAYS", "MALARGUE", "PUBLIC DATA", "EDUCATION", "EQUAL OPPORTUNITIES", and "PHOTO & VIDEO". Each column lists various resources and links. Below the navigation menu, there are two large images: one showing a telescope structure at night and another showing a person in a white shirt and blue cap working on a structure under a blue sky.

PIERRE AUGER OBSERVATORY

Home News Observatory Collaboration Science Outreach Internal

COSMIC RAYS	MALARGUE	PUBLIC DATA	EDUCATION	EQUAL OPPORTUNITIES	PHOTO & VIDEO
Cosmic Ray Mystery	Auger Visitor Center	Open Data	Auger Masterclasses	Women in Auger	Photo Galleries (flickr)
Big Events	Virtual Tour	Data & Tables	Auger Visitor Center	News: Women in Science	Videos
Detection	Science Fair	3D Visualizer	Auger in Focus		Picture Stories
Shower Simulations	Google Earth	VISPA	Virtual Tour		Media Guidelines
Timeline Cosmic Rays	James Cronin School		Science Fair		
About Pierre Auger	Journey to Auger		Edu & Outreach		
Games	Safety Flyer				
FAQ	Edu & Outreach				

<https://auger.org/>

Web page

This page provides the Event Browser, that can be used to display any cosmic-ray event in the data release. Events can be selected by providing their id or by selecting the value of some of their main properties. Some example events can also be selected from the menu below. Once an event is selected its components can be browsed in different tabs.

[Visualize some example events ▶](#)

	Nb of stations	Energy [EeV]	Zenith Angle [deg]	Time [gps]
Min.	<input type="text" value="5"/>	<input type="text" value="5"/>	<input type="text" value="38"/>	<input type="text" value="756950413"/>
Max.	<input type="text" value="20"/>	<input type="text" value="1000"/>	<input type="text" value="60"/>	<input type="text" value="1261872018"/>
Event type	<input type="text" value="Hybrid"/> ▼	<input type="button" value="Select"/>	<input type="text" value="93 selected events ▶"/>	

Select an event by id:

1500m array 750m array

🌐 <https://auger.org/>

Web page

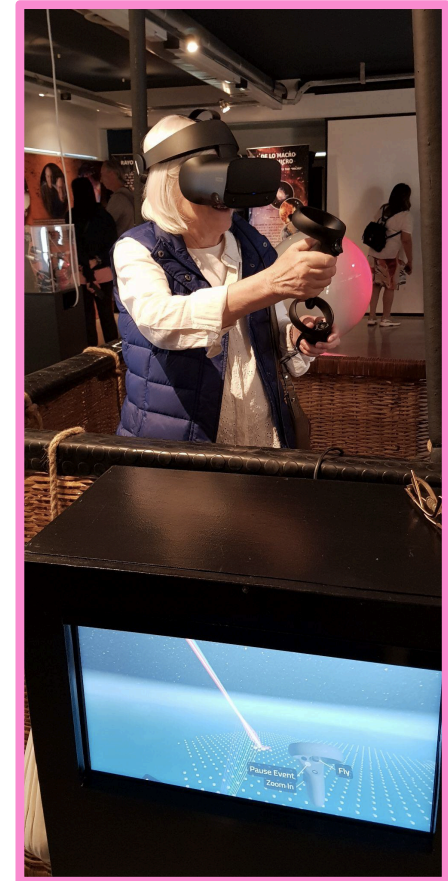
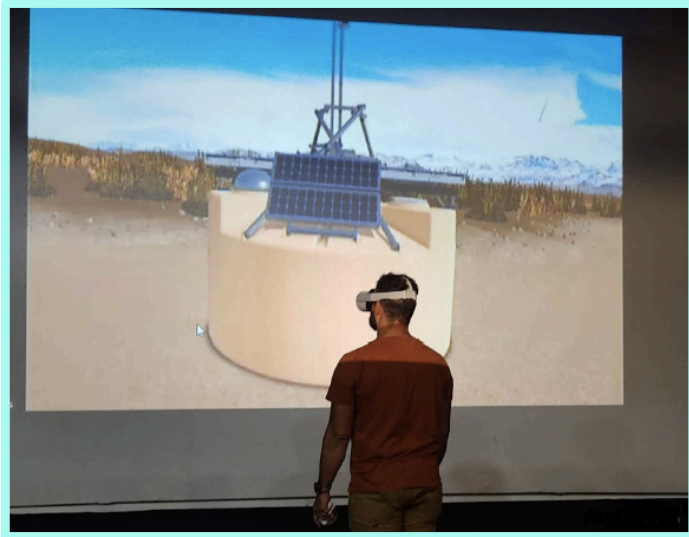


Pierre Auger Visualizer

VR3D



VR3D



Women in Science

Women hold up half the sky

Audio tours



IAU - Las Mujeres sostienen la mitad del

★★★★★ 3 reviews

Exhibits
Exhibits featured with audio

Museum

Las Mujeres sostienen la mitad del cielo

★★★★★ 2 reviews | Godoy Cruz | Free

Download Tour to your Phone



 Henrietta Swan Leavitt	 Willamina Fleming	 Dorothea Klumpke	 Hipatia	 Antonia Moury
 Vera Cooper Rubin	 Cecilia Payne	 María Mitchell	 Las Calculistas de Harvard I	 Annie Jump Cannon
 Jacelyn Bell	 Argentina, 1958 y 1960	 Argentina, La Pleta, 1936 y 1950	 Adela Ringuelet	 Aglonise y Fátima
 Beatrice Tinsley	 Catherine Cesarsky	 Debra Meloy Elmegreen	 Felicitas Arias	 Ewine van Dishoeck

<https://izi.travel/en/c824-women-hold-up-half-the-sky/en>

<https://izi.travel/en/c824-las-mujeres-sostienen-la-mitad-del-cielo/es>

Women in Science



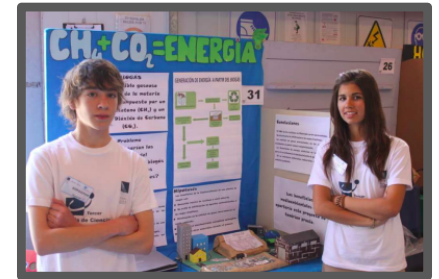
Exhibitions, Drawing contests and calendar for International Day of Women and Girls in Science

Talks and Science fairs



Talks and Science fairs

Science fair every year



Data release and Software approach

Pierre Auger Observatory Open Data

February 2021 release

Pierre Auger Observatory Open Data

March 2024 release

The Pierre Auger 2021 Open Data is the public release of 10% of the Pierre Auger Observatory data presented at the [36th International Cosmic Ray Conference](#) held in 2019 in Madison, USA, following the [Auger collaboration open data policy](#).

This website hosts [the datasets for download](#). An [online event display](#) is available to explore the released events, and example [analysis codes](#) are provided. See below for a brief overview of the [Pierre Auger Observatory](#) and of the [Auger Open Data](#).



Datasets

[the complete released datasets and their complementary data](#)



Visualize

[an online look at the released pseudo raw data](#)

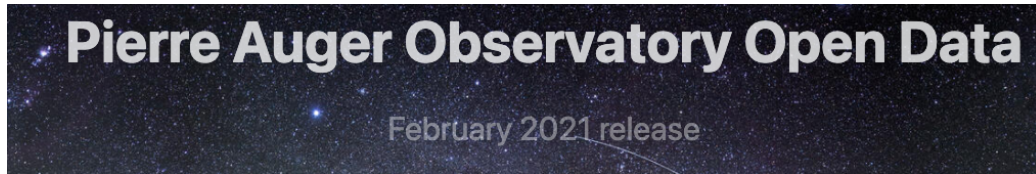


Analyze

[example analysis codes in online python notebooks to run on the datasets](#)

<https://opendata.auger.org/>

Data release and Software approach



Analysis

Auger Open Data can be used in programming applications such as Python notebooks. Some examples are provided in this page, as well as a tutorial to introduce Python and Auger Open Data. You can download and modify them for your own purposes or run them online in your web browser. More details are given [below](#).

Tutorial notebooks

- [Reading CSV summaries](#)
to produce basic histograms
- [Reading JSON files](#)
using both pseudo-raw and higher level data

Physics analysis notebooks

- [The UHECR sky](#)
- [The energy spectrum](#)
- [The depth of the shower maximum](#)
- [The measurement of the p-air cross-section](#)
- [The energy calibration](#)

Physics analysis notebooks

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<https://opendata.auger.org/>

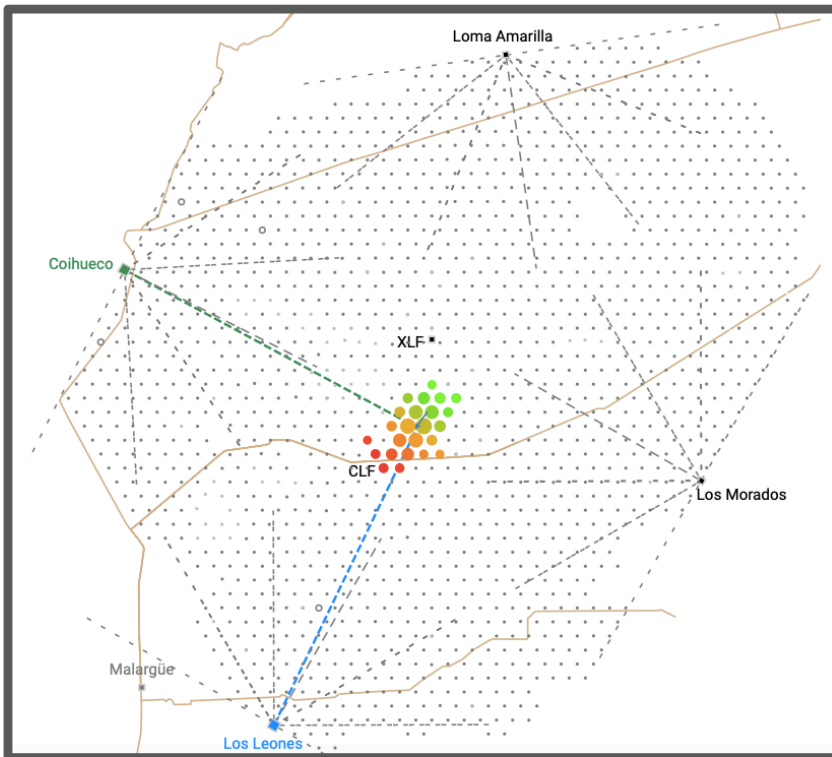
Data release and Software approach

Pierre Auger Observatory Open Data

February 2021 release

Pierre Auger Observatory Open Data

March 2024 release



PoS

PROCEEDINGS
OF SCIENCE

ONLINE ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
MARCH 13-18 2021
37th International
Cosmic Ray Conference
12-18 JUNE 2021

The 2021 Open-Data release by the Pierre Auger Collaboration

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E-mail: spokespersons@auger.org

<https://opendata.auger.org/>

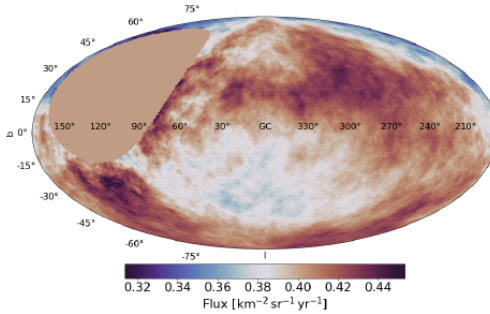
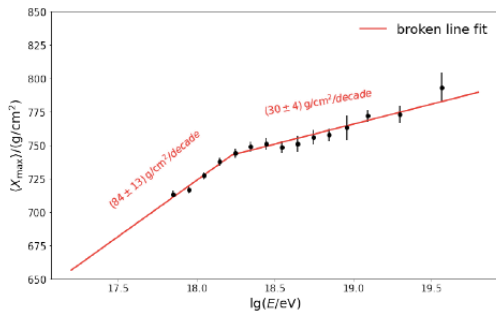
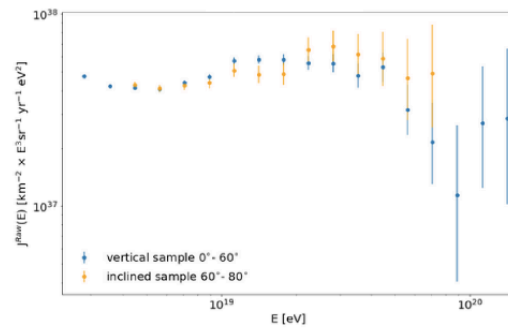
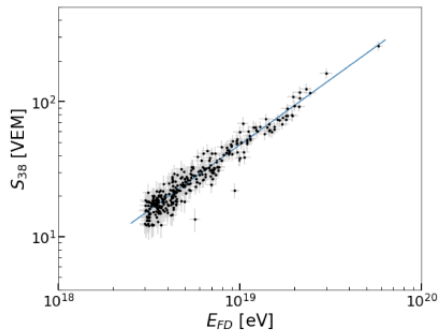
Data release and Software approach

Pierre Auger Observatory Open Data

February 2021 release

Pierre Auger Observatory Open Data

March 2024 release



The Pierre Auger Observatory Open Data

Pierre Auger Collaboration • A. Abdul Halim (Adelaide U.) [Show](#)

Sep 28, 2023

18 pages

e-Print: [2309.16294 \[astro-ph.HE\]](#)

Experiments: [AUGER](#)

View in: [HAL Science Ouverte](#), [ADS Abstract Service](#)

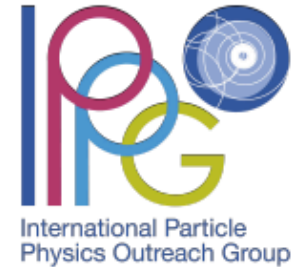
<https://opendata.auger.org/>

Masterclasses

International Masterclasses (astro)particle physics



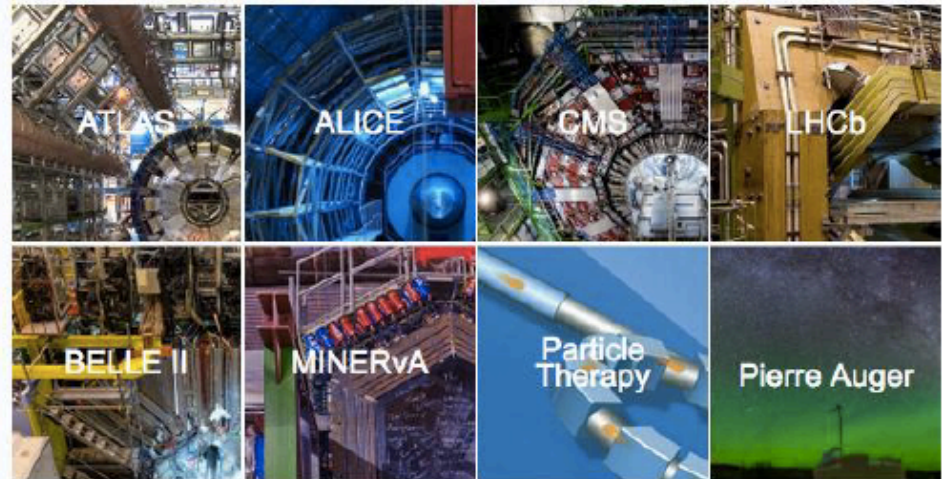
<http://physicsmasterclasses.org>



- Every year ~13000 **high-school students** from 60 countries
- “Scientists for one day with the hands on particles”
- **Auger premiered at the IPPOG IMC2023!**



International Masterclasses
19th International Masterclasses 2023



Masterclasses

International Masterclass 08/03/2024

08 MARCH 2024

Prague - CZ

Braga - PT

International Masterclass 12/03/2024

12 MARCH 2024

Tokyo - JP

Beijing - CN

Ciudad Juárez - MX

International Masterclass 19/03/2024

19 MARCH 2024

Debrecen - HU

Constantine - DZ

Lecce - IT

Milan - IT

International Masterclass 16/03/2024

16 MARCH 2024

Lisbon - PT

Funchal - PT

Bucharest - RO

Évora - PT

International Masterclass 01/03/2024

01 MARCH 2024

Nairobi - KE

Naples - IT

L'Aquila - IT

ENEF2024

17 FEBRUARY 2024

<https://augermasterclasses.lip.pt/>





Masterclasses

SOFTWARE



DOCUMENTATION

General instructions to participating institutes



Checklist for participating institutions



Slides introduction to the measurement



Slides tutorial for the analysis



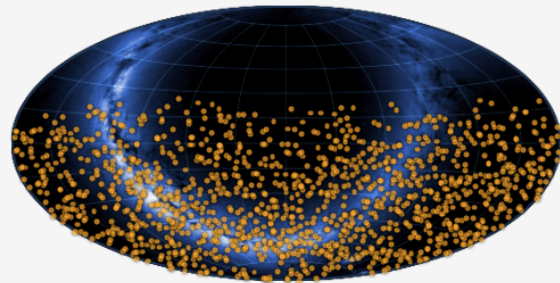
Student activity guide



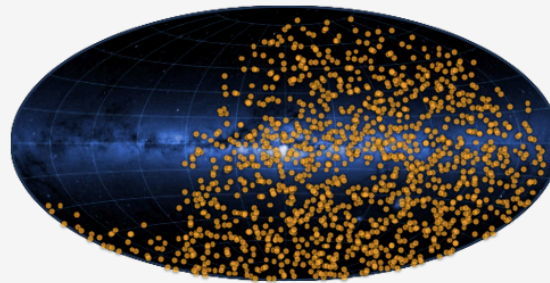
Video conference guide



Equatorial



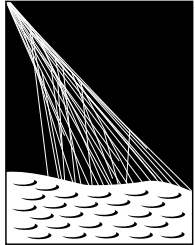
Galactic



REMOVE SKY BACKGROUND

<https://auger.org/outreach/education/auger-masterclasses>

<https://auger-masterclasses.lip.pt/>



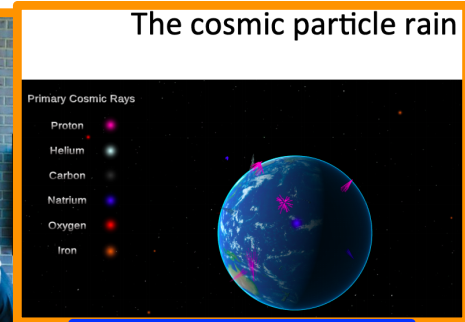
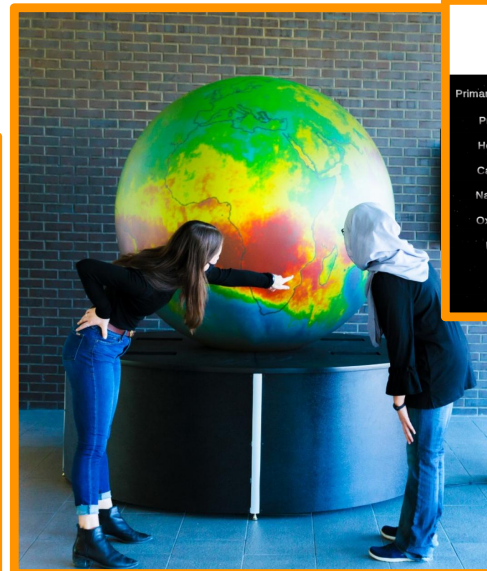
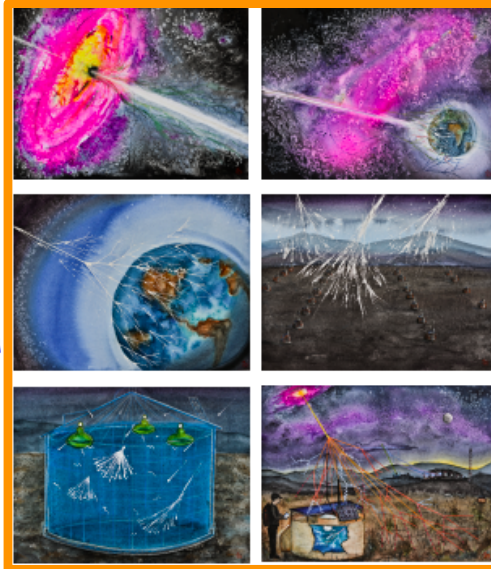
PIERRE
AUGER
OBSERVATORY

Auger goes to School



Other events and efforts

- Puzzle games and cosmic rain
- Summer Camps
- Schools
- Workshops
- Artwork based on Auger
- A projection Globe
- Inauguration of James Cronin School (16/11/2006)



- Auger stamp (2007)
- Planetarium Inauguration & production of 2 full dome shows (9/8/2008)

**Pierre Auger Observatory
Fluorescence Detectors
Puzzle Game**

Pierre Auger Observatory is the world's largest and super-hybrid experiment of ultra high energy cosmic rays air showers in the Argentinian pampas. Its Fluorescence Detector consists of 27 UV Telescopes that are operated during moonless nights only, with clear sky (no high wind, rain or snow). Each telescope has a 440 pixel camera, which is the goal of this game.

Have Fun!

Play
1 bay mode
3 bays mode
6 bays mode
6+3 bays mode
Credits
Quit

QR , Wikipedia, videos, brochure and Auger in Focus

PIERRE AUGER OBSERVATORY Quarterly Report (PAO-QR)
October, November, December 2023

A. Institutional actions

1. Visits and Visitor Center

With new records, we have the Pierre Auger Headquarter full of visitors along the last quarter and the year. In Figure 1, the statistics of visitors is presented. A record 13,426 visitor in 2023 is part of the efforts of the scientists and staff of PAO throughout the year. Many of the students and teachers and professors visited the observatory after the program "The Observatory goes to the school"



<https://youtu.be/1QO41a8A-hQ>

Interviews, Documentaries, etc.

QR ,Wikipedia, videos, brochure and Auger in Focus

SURFACE DETECTORS



Covered area: 3000 km².
Water-Cherenkov Detectors: 1660.
Distance between detectors: 1.5 km.
Type of detectors: water-Cherenkov, each of 10 m³ and 1.2 m deep, filled with 12000 liters of purified water and viewed by three 9 inch photomultipliers.

FLUORESCENCE TELESCOPES



Telescopes: 27 located in 4 buildings.
Range: greater than 30 km for cosmic rays of 10¹⁹ eV.
Mirrors: 3.6 m x 3.6 m spherical surface with 30° x 30° opening.
Cameras: 440 photomultiplier tubes of 4 cm each.

PIERRE AUGER OBSERVATORY

400 Scientists.
91 Institutions.
18 Countries.



<https://visitantes.auger.org.ar>
<https://www.auger.org>
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+54 (260) 4471556





PIERRE AUGER OBSERVATORY

Av. San Martín 304
Malargüe - Mendoza

ARGENTINA



QR ,Wikipedia, videos, brochure and Auger in Focus

ULTRA - HIGH ENERGY COSMIC - RAYS

Cosmic rays are charged particles that constantly bombard the Earth and are one type of the cosmic messengers that help us understand our Universe. At the highest energies, the deflection of the trajectories by the Galactic and extragalactic magnetic fields is reduced, thus opening a new window of charged-particle astronomy. The goal of the Pierre Auger Observatory is to study the nature and origin of these Ultra-Energy Cosmic-Rays with unprecedented accuracy and statistical precision.



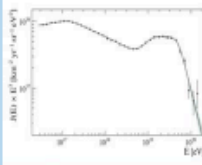
A BRIEF HISTORY OF THE OBSERVATORY

The Pierre Auger Observatory was conceived in the 1990s by Jim Cronin, Alan Watson and other colleagues, to address the mysteries of the origin and nature of the highest-energy particles. It was clear that only a very large detector would provide the exposure to collect enough events to answer the questions raised during nearly a century of earlier experiments.

The Observatory design evolved to a "hybrid" detector system consisting of an array of 1660 particle detectors, deployed over 3000 km², and overlooked by 27 telescopes used to detect the auroral-like emission from the atmosphere, detectable on dark nights. This "so-called" fluorescence radiation enables the energy of the events to be determined without assumptions about the nature of the primary particles or off the hadronic interactions involved.

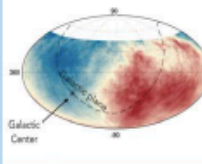
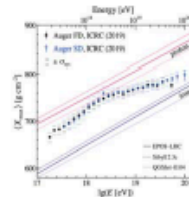
- 1991. Concept of the Pierre Auger Observatory developed.
- 1993. Collaborators recruited.
- 1995. Six-month design study at Fermi Lab.
- 1995. Argentina selected as the country to host the site of the Observatory during meeting at UNESCO in Paris.
- 1999. 19 March, Ground-breaking Ceremony and International Agreement signed in Malargüe.
- 2001. Construction initiated with the Engineering Array.
- 2004. 1 January: Science data taking started.
- 2008. June: Construction completed, with Inauguration later in year.
- 2015. International Agreement renewed.
- 2016. First upgraded-detectors positioned on the Pampa.
- 2019. A bright future beckons with start of full-scale construction of the upgrade.

MAIN RESULTS OF THE OBSERVATORY



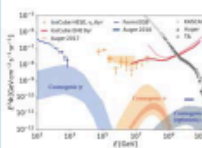
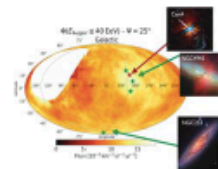
Confirmation of existence of a strong suppression of the flux of the highest energy particles. Its origin is not yet fully understood. [(ICRC2019) 450].

First indication that the primary composition of ultra-high energy cosmic-rays is getting heavier at higher energies. [(ICRC2019) 482].



Discovery of a large-scale anisotropy in the arrival directions of ultra-high energy cosmic rays indicating that their origin is outside our Galaxy. [Science357 (2017) 1266].

Intermediate scale anisotropies suggested by correlation with different astrophysical catalogs. [ApJL 853:L29, 2018].



Best upper limits on the flux of UHE neutral primaries and a key role in the field of multi-messenger astrophysics. [JCAP 1910 (2019) 022], [JCAP 1704 (2019) 009].

A BRIGHT FUTURE

Spurred by the science results obtained so far, the Observatory is currently undergoing an upgrade ("AugerPrime"), aimed mostly at improving the sensitivity of the surface detector to primary mass composition. New electronics are being installed with a small PMT in each water-Cherenkov detector. With additional complementary detectors with the aim of a better separation of the electromagnetic and muonic components on an event-by-event basis, with three types of detectors.

The new detectors are:

- * a slab of scintillators, over the surface detectors,
- * radio antennas (30-80 Mhz), recording the radio signal from extensive air showers, both to be installed atop of the existing stations,
- * an array of buried muon counters in the dense part of the array.



The additional observables are critical to the selection of the subset of showers likely to arise from lighter primaries, which in turn may hold the key to identifying and studying the cosmic accelerators outside our own galaxy.

More generally, the data collected with AugerPrime will be used to explore fundamental particle physics at energies beyond those accessible at terrestrial accelerators, and perhaps allow the observation of new physics phenomena.

QR ,Wikipedia, videos, brochure and Auger in Focus

AUGERINFOCUS

2024



WHO WE ARE

To decode the enigma of ultra-high-energy cosmic rays, the Pierre Auger Observatory, where over 400 scientists, engineers, technicians, and students from 18 countries work, measures the particle cascades that occur each time a cosmic ray collides with molecules in the upper atmosphere. This allows them to determine the energy, direction of arrival, and nature of cosmic rays of the highest observable energies. The Observatory is located in the Southern Hemisphere, in the Malargüe area, Mendoza Province, Argentina, and consists of a network of 1,660 detectors, spaced 1.5 km apart, covering a total area of 3,000 square km. The surface detector network is complemented by a set of 27 highly sensitive telescopes that, on clear nights around the new moon, scan the atmosphere to observe the faint ultraviolet light produced by cosmic ray cascades as they pass through the air.

AUGERINFOCUS OBJETIVES

The Pierre Auger Observatory receives an average of 10,000 visitors per year. During each visit, a series of questions arise that would require more detailed explanations than those provided during a tour. In this context, the Observatory decided to select specific topics that are repeated as part of the public's questions. These texts can be consulted by those interested in learning more about the research and developments of the Observatory, and in particular by teachers, as they are designed as educational and dissemination material. This is how Auger en Foco was born



COMMUNICATIVE STRATEGY

Information about the Pierre Auger Observatory can be found on it's websites:

www.auger.org
www.auger.org.ar

In addition, an online audio guide allows you to take a virtual tour (Spanish,English)



AUGERINFOCUS

No. 1, May 2024

www.auger.org.ar



SPARK CHAMBER

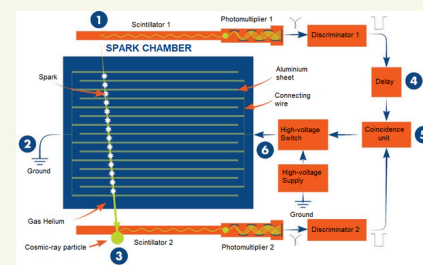
A large part of natural environmental radioactivity is due to cosmic rays, which come from space and are mainly atomic nuclei of hydrogen (protons), helium, carbon, oxygen, etc., accelerated to a very high speed. When entering the atmosphere, cosmic particles collide violently with atmospheric gas molecules and produce "atmospheric showers" or "atmospheric showers" of secondary particles. Some of these particles generated in the atmosphere, mainly muons and electrons, reach the ground and can be detected. The "Spark Chamber" is a device that allows the existence of these particles to be verified, at least those that have an electric charge. This equipment detects them and allows their trace or path that they followed to be visualized, thanks to the sparks that are produced in their passage.

WORKING PRINCIPLE

At the top and bottom of the chamber (see figure) there are 2 plastic scintillator plates (1 and 3). The chamber has several modules, formed by 2 parallel grounded plates (2) and a plate in the center, connected to a high-voltage generator (6). The chamber is filled with helium. When a charged particle, normally a muon, passes through the entire device, it ionizes the gas contained in the chamber and also causes the emission of light in the scintillators.

DESCRIPTION OF OPERATION

- The light from each scintillator plate is converted into an electrical signal; the two electrical signals arrive almost simultaneously. This coincidence is detected by a small electronic circuit that produces a very fast 8 kV pulse (depending on the design) transmitted to each electrode (5).



Spark Chamber diagram. The numbers are explained in the text. (Image modified from: Discovering particles: fundamental building blocks of the Universe)

- The central plate suddenly drops to -8000 V, and sparks can be formed where the gas has been ionized by the passage of the charged particle.
- The sparks align along the track and allow the particle's trajectory to be visualized, slightly delayed.
- After the passage of a muon, the chamber has a dead time, which is necessary to recharge the capacity of the electrical circuit made up of resistors and capacitors.

Observatorio Pierre Auger
info@auger.org.ar



Bulletin

A banner for the Pierre Auger Observatory. On the left, a blue-tinted image shows the Earth's horizon with several bright blue lines representing cosmic rays striking the surface. The background is a dark starry sky. On the right, there is a small inset image showing a top-down view of the observatory's detector array, consisting of a grid of circular detectors with lines radiating from a central point.

PIERRE AUGER OBSERVATORY

Thank you!



XIII International Conference
on New Frontiers in Physics

26 Aug - 4 Sep 2024, OAC, Kolymbari, Crete, Greece

A wide-angle photograph of the coastal town of Kolymbari in Crete, Greece. The town is built on a hillside overlooking the sea. In the foreground, there is a long pier extending into the water. The sky is clear and blue.

Σας ευχαριστώ