

Communicating astroparticle physics with the public: The Pierre Auger Experience

Beatriz García^{a,b,*}, for the Pierre Auger Collaboration^d

^a*National Council of Scientific Research (CONICET),
Argentina*

^b*National Technological University, Faculty Mendoza,
Rodríguez 273, Mendoza, Argentina*

^d*Pierre Auger Observatory,
Av. San Martín Norte 304, 5613 Malargüe, Mendoza, Argentina
Full author list: https://www.auger.org/archive/authors_2024_11.html*

E-mail: spokesperson@auger.org.ar

The Pierre Auger Observatory has developed various activities along the last year in the field of education and dissemination of astrophysics and high-energy astroparticle physics. Since 1999 different approaches and improvements of the tools used to explain what cosmic rays are have been implemented, tested, and redesigned based on public feedback in its headquarters in Malargüe city. This presentation highlights the Observatory's engagement with the community, focusing on the new initiatives. The open data policy, master classes for middle-level students and teachers, the design of innovative activities that involve the community, and the presence of the Observatory in special events with the participation of students are also described.

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*Speaker

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1. Introduction

Since its groundbreaking ceremony in 1999, the Pierre Auger Observatory has been actively involved in education and the dissemination of astrophysics and high-energy astroparticle physics. Over more than two decades, the Observatory has continuously improved its tools, resources, and activities for communicating over 100 years of cosmic ray research. Innovations in visitor facilities, which are updated approximately every five years, ongoing training for guides, personnel capability evaluations, and collaboration with researchers from the 17 countries in the Pierre Auger Collaboration are central to its efforts. The connection between the outreach office and members of the Collaboration who contribute to these activities has also been strengthened.

The Outreach group at the observatory have closely monitored the evolution of the visitor's trends and feedback during the face-to-face visits, and comments in the Guest Book confirm the enhance of their offer. In Figure 1, the number of visitors to the Pierre Auger Observatory in the last 20 years is presented.

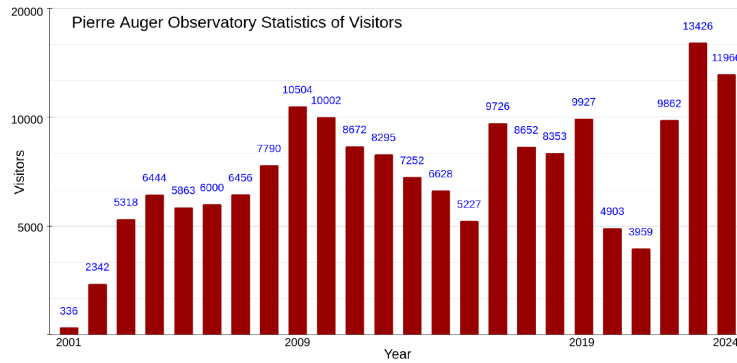


Figure 1: Pierre Auger Visitors Statistics 2001-2024.

2. Methodology

To achieve its Outreach objectives, the Observatory has developed a diverse set of activities:

- Open data access.
- Masterclasses for high school students and teachers (now available through IPPOG¹).
- Innovative activities involving the community.
- Participation in large public events.
- Organization of events involving students.
- Art and science exhibitions.
- Fairs of science.
- Virtual visits.

2.1 Open Data Policy

Over more than 20 years of continuous data acquisition, the Pierre Auger Observatory has collected a vast and diverse dataset covering complementary fields of research from astroparticle and fundamental physics to space weather science. Data collected by the Pierre Auger Observatory originate from a variety of instruments starting from raw experimental or simulated data through

¹International Particle Physics Outreach Group, <https://ippog.org/>

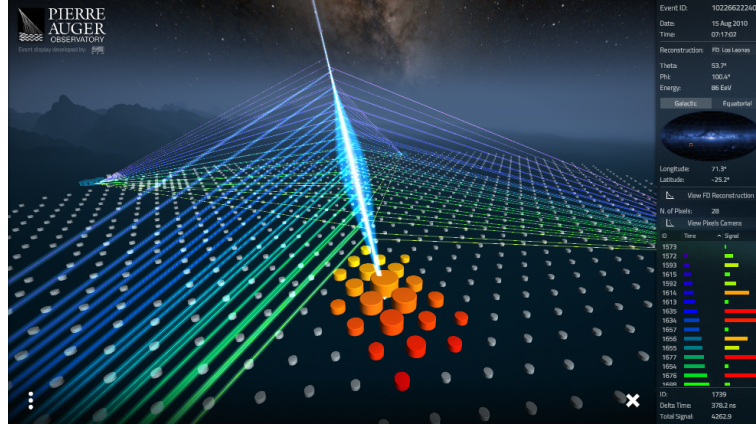


Figure 2: The highest energy hybrid event in the UHECR catalog, ID 102266222400 (Pierre Auger Observatory 100815).

reconstructed data, and higher-level data generated by analysis workflows, to those presented in scientific publications. Since its inception, the Pierre Auger Collaboration has embraced the principle of open access to research data. A gradual release process was initiated a few years ago, supported by the establishment of a dedicated task group to implement and sustain this effort over the long term. This initiative aligns with the FAIR principles (Findable, Accessible, Interoperable, and Reusable), ensuring the accessibility and usability of the Observatory's data for the global scientific community.

Access to data is provided through the "Open Data Portal"², first released in February 2021 with 10% of the collected cosmic rays data and it has been regularly updated since then. The portal currently includes approximately 81,000 events collected by the surface detector between 2004 and 2018, as well as around 3,300 hybrid events, recorded simultaneously with the fluorescence detector and selected based on specific analyses [1]. In addition to cosmic ray data, the portal also contains atmospheric data, with local weather condition parameters measured at the Auger site using weather stations, and scaler mode data, which include particle rates acquired by surface detector stations operating in low-threshold counter mode for space weather studies.

The portal offers a user-friendly interface for browsing data, complemented by an immersive 3D animation of events in its Visualization section. The Analysis section includes Python notebooks that explain the main physics analyses published by the Pierre Auger Collaboration, helping users better understand the results [3]. Figure 2 illustrates the reconstruction of the highest-energy hybrid event in the released UHECR catalog [5]. This event, recorded on August 15, 2010, had a reconstructed zenith angle of 53 degrees and an energy of 82 EeV. The UHECR Catalog section contains the events published in the catalog of the 100 highest-energy cosmic-ray events ($78 \text{ EeV} < E < 166 \text{ EeV}$) collected during Phase I of the data acquisition (2004-2022)[2], along with the 9 highest-energy hybrid events used for calibration. These data are also fully accessible for inspection and download. The Outreach section of this tool, designed for a broader audience and translated into several languages, is built in the same spirit as the research section but in a simplified format. It provides exemplary tutorials and analysis tools to explore the released data and facilitate its use in innovative education and outreach activities.

²<https://opendata.auger.org/>

2.1.1 Impact and use of the Open Data

The Auger Open Data have been used in various scientific publications in peer-reviewed journals and on ArXiv. They have also been featured in global outreach events targeting to high school and university students. Moreover, the open data are used in special activities focused on learning physics and enjoying programming and data analysis, such as the International Cosmic Day (ICD)³ and the IPPOG-International Masterclasses program. Since its launch in 2021, the portal has received more than 60,000 visits from around the world, while cosmic-ray data samples have been downloaded more than 4,000 times. The planned increase in the fraction of cosmic-ray data released to 30%, along with the addition of new detectors, will further enhance the scientific community's interest in the Observatory's data, promoting their use for both research and educational initiatives.

2.2 Masterclasses

The first edition of the International Masterclasses on Particle Physics took place in 2005, organized by CERN. Since then, this hands-on program has brought together thousands of high school students from around the world each year, allowing them to become "scientists for one day" and analyze real data from particle physics experiments. During these masterclasses, students spend a day at a research institute or university with their teachers. They begin the day by listening to scientists explain what particle physics and its experiments are about. Not only do they listen, but they also engage in direct conversation and have the opportunity to ask their own questions. After lunch, it is time for the students to get to work: all they need is a computer and a dataset to analyze. At the end of the day, the students participate in a videoconference with their peers from other locations and with scientists involved in the experiments to discuss their findings.

The Pierre Auger Observatory joined the international masterclasses program in 2023. The proposed activity is based on the analysis of data released to the public by the Pierre Auger Collaboration and consists of the reconstruction of the arrival direction and energy of events, and in selecting the highest-energy ones to produce a sky map of arrival directions and concluding about the origin of such particles. In Figure 3a and 3b, two aspects of the same activity are presented: the moment of the science conference and the work of the students in the lab, with their teachers and scientists from the Pierre Auger Collaboration.

Virtual visits, originally designed to maintain communication with the public during the COVID-19 pandemic, have now become a regular part of the closing session. Participants from around the world have the opportunity to take a virtual tour of the Pierre Auger Observatory headquarters, including not only the Visitor Center but also the Data Center and the laboratories in Malargüe. The closing ceremony is held in a hybrid mode, with students in their countries, the main Pierre Auger Observatory organizers in different institutions, and the Observatory staff in Malargüe. In Figure 4 a view of the hybrid meeting at the end of a masterclass shows part of the general discussion of the statistical results after the work of all groups of students.

2.3 Activities for and with the community

One example of the activities developed for the community is the "The Observatory Goes to the School" program. Since 2023, outreach staff have visited all the schools in Malargüe City and

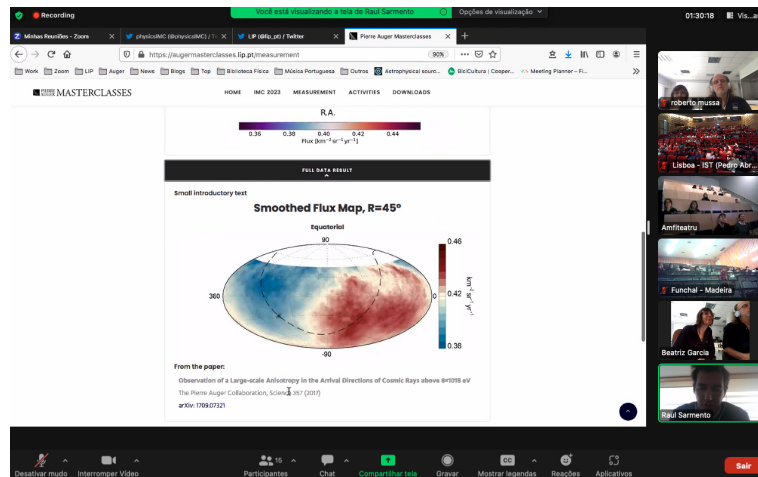
³International Cosmic Day, <https://icd.desy.de/>



(a) Conference at the INFN, Catania.



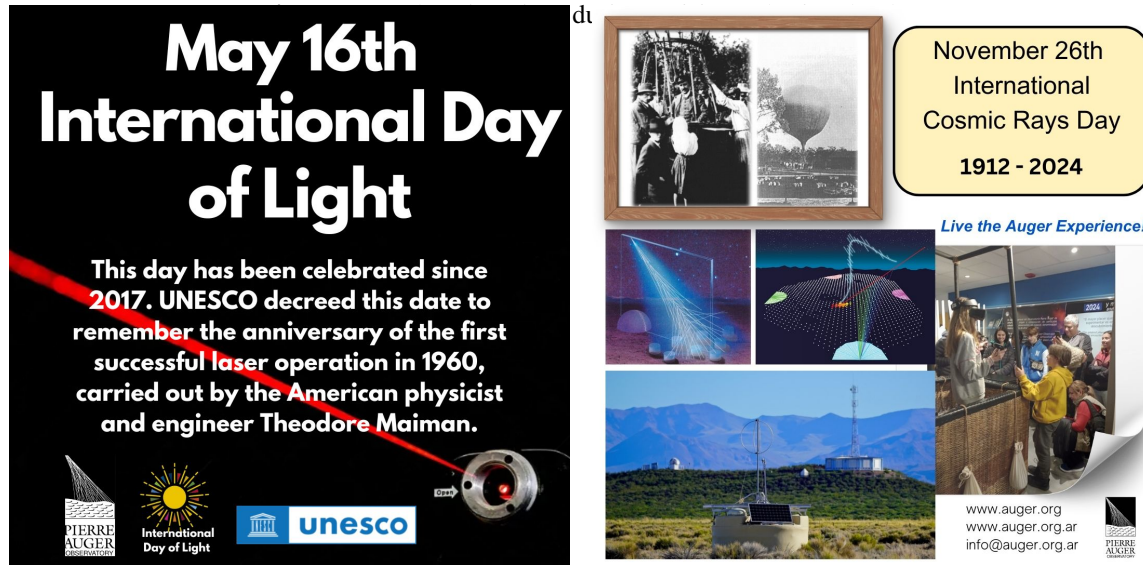
(b) Students at the Lab during the Masterclass.

Figure 3: Examples of Masterclasses in Italy.**Figure 4:** Print screen of a Virtual closing activity of a Masterclass.

surrounding areas, as the schools in San Rafael, near the Observatory site. The program includes presentations on the topics studied by the Observatory, its key characteristics, the work carried out by the staff, and other subjects related to general astronomy and astrophysics. More than 5,000 students have participated in the program and several of the participating schools have later visited the Observatory following the proposed activity at their institutions. The program has become well-established, and now schools regularly request visits as well as the development of new specialized workshops in the classroom (Figure 5).

2.4 Events

Throughout the year, a special event is selected each month to feature a different activity in the Visitor Center of the Observatory. Pi Day, the International Days of Light, Dark Matter and the



(a) Announce of the IDL-16M 2024.

(b) Celebration of the ICD 2024.

Figure 6: Example of yearly events in Malargüe.

Cosmic Rays Day among others, as well as remarkable ephemerides such as a planet alignment, solar or lunar eclipses, and the anniversary of remarkable scientists are triggers to make an impact on the visitors. One of these events was the closing days of Bridges Between Cultures, an activity proposed by the Network for Astronomy School Education, which in 2024 celebrated the UNESCO International Day of Light (IDL-16M) with a Party of the Stars in the city, remembering the famous catalog by Charles Messier, inviting students and their teacher to observe several objects of the catalog and at the closing day, to expose the work performed along the year, in different formats: photos, designs, paintings and performances in several stands and scenarios throughout the city (Figure 6a and 6b). More than 1,000 inhabitants and visitors in Malargüe participated in this initiative.

2.5 Fairs of Art and Science

The special activity "Women and Girls in Science" was a key initiative for the period 2023-2024. It started with an art contest, from which 13 works of art were selected for the Pierre Auger



Figure 7: Women and Girls in Sciences Art Exhibition at UTN-Mendoza.



Figure 8: Photo of participants at the Pierre Auger Fair of Sciences 2024.

calendar, and continued with an art exhibition that toured several locations throughout the country, concluding the year at the National Technological University in Mendoza City (Figure 7). The 9th Edition of the Pierre Auger Fair of Science took place in 2024. The Observatory received 51 reports, of which 25 were selected for exhibition. For the first time two countries were represented in the Fair: Argentina and Chile. Argentine stands came from 5 provinces. The proposals were aligned with the UNESCO Sustainable Development Goals. As in previous editions, the jury was composed of scientist from Pierre Auger Collaboration and the National University of Cuyo, in Malargüe. More than 500 people visited the Fair. The 90 participants with their projects are shown in Figure 8, at the main entrance of the Pierre Auger headquarters.

3. Results and Evaluation

The open data policy, masterclasses for middle-level students and teachers, the design of innovative activities, and the presence of the Observatory at particular events with the community participation, all have a significant impact in the countries of the Collaboration.

In recent years, several books on the history of the Observatory have been published, such as "Exploring a Violent Universe: The Story of the Pierre Auger Cosmic Ray Observatory", by Paul Mantsch [7], which is an excellent resource for those interested in learning about the journey of the Pierre Auger Observatory's installation in Argentina.

The evaluation of the work in Education and Outreach, as well as the social impact of the Observatory allows for the redesign of strategies to improve communication with the public. The

Pierre Auger Observatory receives an average of 10,000 visitors per year. During each visit, a series of questions and suggestions arise that require more detailed explanations than those provided during a tour. In this context, the Observatory decided to focus on specific topics that are frequently mentioned as part of the public's questions and produce a newsletter. These texts, designed as educational and dissemination material, can be consulted by those interested in learning more about the research and developments of the Observatory, particularly by teachers. This new project, *Auger in Focus* [6], has become widely consulted, and members of the International Collaboration in the Pierre Auger Observatory are the authors of the brief texts.

4. Conclusions

The Pierre Auger Observatory follows the approach in Education and Outreach based on the visitors' demand and developed within the framework of the Open Science, which allows better communication to the public. This approach improves not only the way in which astroparticle physics is communicated with the public, but also significantly increases the number of visitors and the possibility of spreading the activities of the Observatory beyond Malargüe and Mendoza.

The open data policy and the Masterclasses [4] are probably the most important and influential outreach activities designed by the Pierre Auger Collaboration. This is evident in the use of public data by different researchers around the world and the increasing interest of schools to be part of the global IPPOG initiative. The evaluation of the impact of the activities and the ongoing innovation are part of the success of the Outreach task at the Pierre Auger Observatory.

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