AUGERINFOCUS

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PIERRE AUGER OBSERVATORY OPEN DATA

Over 20 years of regular data acquisition, the Pierre Auger Observatory has collected a vast and diverse dataset covering complementary research fields, ranging from astroparticle physics and fundamental physics to space weather sciences. The Pierre Auger Collaboration has embraced the concept of open access to research data since its inception. Since then, a gradual data release process has been initiated, supported by a dedicated working group to implement and sustain this effort in the long term. The Pierre Auger Open Data Portal contains 10% of the cosmic ray data and 100% of the atmospheric and space weather data. It includes a detailed catalog of showers created by the highest-energy particles and an outreach section designed to engage the general public in the science of cosmic rays. Plans are underway to increase the fraction of cosmic ray data released to 30% and to include new detectors, further enhancing the scientific community's interest in the Observatory's data and promoting their use for research and in education and outreach initiatives.

MOTIVATION AND CHALLENGES

The data from the Pierre Auger Observatory come from a variety of instruments and exist in many forms, starting from raw experimental or simulated data, moving through reconstructed data and higher-level data generated by analysis workflows, and ultimately reaching the data presented in scientific publications. The data are the result of a vast and prolonged human and financial investment by the international community. The collaboration is committed to their public release and provides accompanying software tools to offer a broader community, including professional scientists and citizens, a unique opportunity to explore and analyze the data at various levels of complexity. This is inspired by the FAIR principles (Findable, Accessible, Interoperable, and Reusable).

OPEN DATA PORTAL

- ~ 81,000 events collected by the surface detector (SD) during the period 2004-2018.
- ~ 3,300 selected hybrid events, simultaneously collected with the fluorescence detector (FD).
- 100% of atmospheric data: parameters of local conditions such as pressure, temperature, humidity, and wind speed measured at the Auger site by weather stations and monitoring devices.
- 100% of the surface detector data in low-threshold particle counter mode for space weather studies.

DATA VISUALIZATION

The data can be explored through an easy-to-use interface to select and explore each of the public events (Fig. 1), specifying their identification or a range of variables such as energy or zenith angle. The browser includes an immersive 3D animation from the arrival direction of cosmic rays to the detection of the extensive air shower, with the instruments of the Observatory.

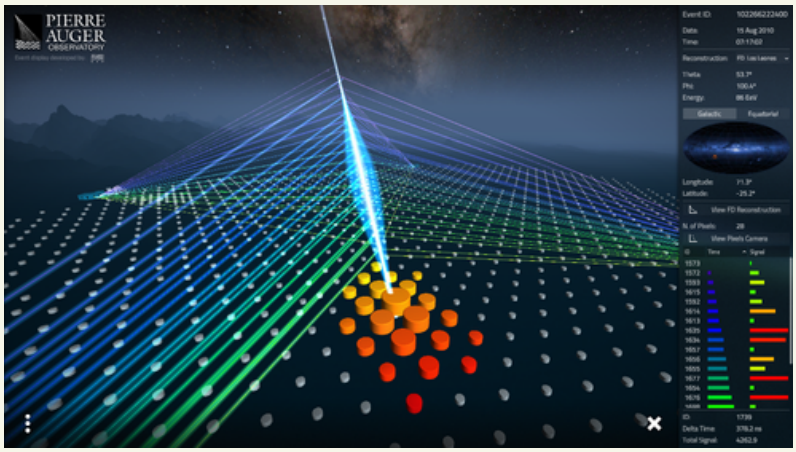

Figure 1. The highest energy hybrid event in the UHECR catalog, ID 102266222400, registered on Aug 15th 2010, with reconstructed zenith angle 53 degrees and energy 82 EeV.

UHECR CATALOG

The Ultra High Energy Cosmic Rays Catalog (UHECR) section contains the events published in the catalog of the 100 highest-energy cosmic-ray events (76 EeV < E < 166 EeV) collected during Phase I of the data taking (between 2004 and 2021), along with the 9 highest-energy hybrid events used for their calibration. These data are also fully available for inspection and download. For these events, the reconstruction parameters and calibrated traces are available, and additional features can be viewed, the footprint at ground projected on the shower plane and the time delays of the signals with respect to a flat shower front.

VISUALIZATION, ANALYSIS AND OUTREACH

Data can be browsed with a user-friendly interface and an immersive 3D animation of the events is available in the Visualization section. The Analysis section contains Python Notebooks presenting the details of the main physics analyses published by the Pierre Auger Collaboration, to facilitate the users in understanding the obtained results.

The Outreach section, aimed at a wider audience and translated into several languages, is built in the same spirit as the research part but in a simplified format, and provides exemplary tutorial and analysis tools to manipulate the released data, and facilitate their use in original education and outreach activities.

IMPACT AND USE OF OPEN DATA

The Auger Open Data have been used in diverse scientific publications in refereed journals and in repositories.
They have also been exploited in world-wide outreach events, dedicated to high-school and higher-level students, focused on learning physics and enjoying programming and data analysis, such as the International Cosmic Day and the IPPOG International Masterclasses program.
Since the first publication of the portal in 2021, the total visits are over 60,000 from all around the world, while downloads of cosmic-ray data samples count more than 4,000.

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