Acronyms

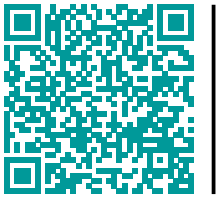
This is a list of alphabetically sorted acronyms used throughout this work.

Contents

Todo list

remove todos

add pdf hyperref keywords



Introduction

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Part 1: Cosmic rays and extensive air showers

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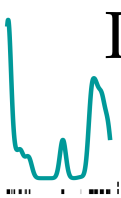
Contents

*Cosmic Ray*s (CRs) are particles of extraterrestrial origin that travel very close to the speed of light. Their relativistic kinetic energy pc far exceed their rest mass mc^2. In particular, *Ultra High Energy Cosmic Ray*s (UHECRs) are typically defined as CRs with energies exceeding $1\,\mathrm{EeV} = 10^{18}\,\mathrm{eV}$ [**AlvesBatista2019**]. Such fragments

1.1 Acceleration Mechanisms

1.2 Cosmic Ray Propagation

1.3 Extensive Air Showers

Part 2: The Pierre Auger Observatory

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The *Pierre Auger Observatory* (PAO) is the (by area) largest scientific experiment in the world. It consists of an array of 1660 *Water Cherenkov Detector*s (WCDs), which form the *Surface Detector* (SD), and 27 fluorescence telescopes, that make up the *Fluorescence Detector* (FD).

With a region spanning roughly 3000 km^2 it offers a unique possibility to observe UHECRs at the tail-end of the CR energy spectrum.

We begin this chapter in Section 2.1 by formulating open questions that the PAO aims to answer. Design details for the FD and for the SD are given in Section 2.2 and Section 2.3 respectively. After a discussion on the local *Data Acquisition* (DAQ) process and the centralized event detection in Section 2.4, we finish by detailing the procedure of the event reconstruction and higher level analysis in Section 2.5.

2.1 Science Goal and Open Questions

The flux of cosmic rays with energies exceeding the ankle, 5×10^{18} eV, is very low, and measures approximately 1 event per $\mathrm{km}^2\,\mathrm{sr}\,\mathrm{yr}$ [P2]. It is evident that one needs a large detector and a lot of time in order to make statistically relevant statements about the physics of UHECRs. Altough only one of the initially planned two data taking sites [for white paper see P1] has been constructed, the Pierre Auger observatory is a world-leading experiment in terms of measured exposure since the begind of DAQ in January 2004 [**Abraham2004**] until possibly beyond 2030 [C1].

Many insights, such as the existence of the CR dipole discussed in ????? , have been gathered from its measured data as a consequence. Still, a plethora of mysteries remain. It follows a

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list of, in no particular order, important missing links of information that motivate not least this thesis, but the continued effort and daily work done by the Auger collaboration.

2.1.1 Flux supression at highest energies

2.1.2 Validity of shower simulations

2.1.3 Exotic events

Photon showers

Neutrino showers

GZ effect

2.2 The Fluoresence Detector

2.3 The Surface Detector

2.4 Central Data Acquisition System

2.5 $\overline{\text{Off}}\underline{\text{line}}$ and Event Reconstruction

Bibliography

The Pierre Auger observatory hosts an internal database of papers. These typically short reports serve to accelerate the exchange of knowledge within the collaboration, and are called *Giant Array Project* (GAP) notes. Since they contain information that is not freely accessible outside the Pierre Auger collaboration, they are listed in a special category with the prefix ***A***. Similarly, sources from personal correspondence are grouped with the prefix ***C***. Physical references, also containing official publications by the Pierre Auger collaboration, can be found with label ***P***. All other references are indexed under the label ***O***.

Personal Correspondence

[C1] Antonella Castellina. "Outcome of the Finance Board". Dec. 2023.

Physics References

[P1] Danilo Zavrtanik and P. Auger Collaboration. "The Pierre Auger Observatory". In: *Nuclear Physics B-Proceedings Supplements* 85.1-3 (2000), pp. 324–331.

[P2] Francesco Fenu. "The cosmic ray energy spectrum measured with the Pierre Auger Observatory". In: *Advances in Space Research* 72.8 (2023), pp. 3531–3537. ISSN: 0273-1177. DOI: https://doi.org/10.1016/j.asr.2023.06.020. URL: https://www.sciencedirect.com/science/article/pii/S0273117723004581.