UNRAVELLING THE MISTÉRIES OF ULTRAENERGETIC COSMIC RAYS WITH AUGERPRIME

C. DOBRIGKEIT
II LATIN AMERICAN STRATEGY FORUM FOR RESEARCH INFRASTRUCTURE

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The Pierre Auger Collaboration

More than 450 collaborators from 90 institutions in 16 countries

Argentina – Australia – Brazil – Colombia – Czech Republic – France – Germany – Italy – Mexico – Netherlands – Poland – Portugal – Romania – Slovenia – Spain – United States
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Latin-America in Auger:

• Argentina: 11 institutions, 70 members

• Brazil: 12 institutions, 26 members

• Colombia: 2 institutions, 6 members

• México: 5 institutions, 13 members
The Pierre Auger Observatory

• The Auger Observatory was built twenty years ago to study the most energetic cosmic particles that reach the Earth, those with energies above $10^{17}$ eV.

• The Observatory has been collecting data now for over more than 16 years, accumulating the world’s largest exposure to ultrahigh-energy cosmic rays. Data taken over these years have already led to major breakthroughs in the field.

• In the last four years, the Auger Collaboration began an effort dubbed **AugerPrime**, aiming to improve the determination of the primary mass composition.
The Auger Observatory: 3000 km²

- 1660 water-Cherenkov surface detectors
- 27 fluorescence telescopes
- 7 underground muon detectors
- Array of radio antennas
- Atmospheric monitoring devices (CLF, XLF, Lidar,..)
The energy spectrum

$J(E) \times E^3 [km^{-2} yr^{-1} sr^{-1} eV^2]$

$\gamma_0 = 2.92 \pm 0.05$

$\gamma_1 = 3.27 \pm 0.05$

$\gamma_2 = 2.2 \pm 0.2$

$\gamma_3 = 3.2 \pm 0.1$

$\gamma_4 = 5.4 \pm 0.6$

Events 891972
Exposure $\sim 80000 km^2 sr yr$

$E_{01} = 0.15 \pm 0.02$

$E_{12} = 6.2 \pm 0.9$

$E_{23} = 12 \pm 2$

$E_{34} = 50 \pm 7$

(energies in EeV units)
Studying mass composition through the $X_{\text{max}}$
Large scale anisotropy

Amplitude above 8 EeV:

\[ (6.6^{+1.2}_{-0.8})\% \]


\[ (\alpha, \delta) = (98^\circ, -25^\circ) \]

125° off the Galactic center
Intermediate scale anisotropy

Total SD events with $E > 32$ EeV: 2157
Total exposure $101,400$ km$^2$ sr yr

Muon content in air showers

(UMD = Underground Muon Detector)

Simulations fail to reproduce the data in the energy range $3 \times 10^{17}$ eV to $2 \times 10^{18}$ eV.

Motivation for the upgrade:

With the upgrade of the detectors we aim at:

- Studying the origin of the observed suppression in the energy spectrum at the highest energies,
- Select showers initiated by light particles to allow for the identification of sources and charged particle astronomy,
- Improve estimates of neutrino and photon fluxes,
- Improve measurements of shower components to study hadronic interactions at UHE and looking for Physics beyond the SM.
AugerPrime
The upgrade AugerPrime

• New plastic scintillator detectors on top of each existing water-Cherenkov station.
• Extension of underground muon detectors and of the array of radio antennas.
• Substitution of the electronics for faster data acquisition.
• Adding a fourth photomultiplier tube in the surface detector to prevent saturation of the signal of the high-energy showers.
• Extending the operation time of the fluorescence telescopes into periods with higher background light.
• Extending the data taking up to ≥ 2025.
In Brazil,

• Over the years, we could count with the continuous support of FAPESP, FAPERJ, CNPq, RENAFAE, and for our contribution to the construction of the Observatory, also from FINEP and MCTI.