AUGERINFOCUS

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PIERRE AUGER OBSERVATORY

Over the past twenty years, the Pierre Auger Observatory has revolutionized the study of ultra-high energy cosmic rays (UHECRs), the most energetic particles known to humanity.

UHECR SPECTRUM MEASUREMENT

The observatory has confirmed a cutoff of UHECRs around 5×10^{19} eV, meaning that very few UHECRs are detected above 10^{20} eV, and none above 10^{21} eV. Additionally, new features in the spectrum have been discovered, providing input for models of their sources and propagation, which remain active areas of research.

EXTRAGALACTIC ORIGIN

It is now known that UHECRs above 8×10^{18} eV likely originate from outside our Galaxy. This conclusion is based on the measurement of dipolar anisotropy in their arrival directions, which differs significantly from the direction of the Galactic plane (Fig. 1).

HEAVIER COMPOSITION AT HIGHER ENERGIES

While UHECRs primarily consist of protons at 10^{18} - $10^{18.5}$ eV, they are composed of increasingly heavier nuclei, such as helium or nitrogen, at higher energies.

Despite these achievements, many questions remain unanswered. The next step is to measure the charge of UHECRs, as the trajectories of more charged nuclei are more deflected by magnetic fields in the Universe. This deflection blurs the pointing of UHECRs back to their original sources. If protons or helium nuclei, which have lower charges, can be isolated, the source pointing can become more precise.

Another puzzle is the discrepancy in the number of muons in the extensive air showers (EASs) initiated by UHECRs (see Auger in Focus 4). The number of muons is higher than expected from models, therefore improved measurements of the muon number in EAS are required.

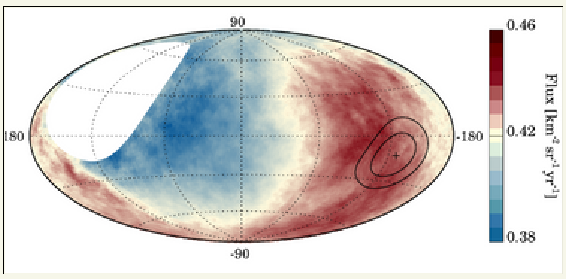

FIGURE 1. UHECR ARRIVAL DIRECTIONS IN GALACTIC COORDINATES (GALACTIC PLANE IS HORIZONTAL ALONG 0 DEG IN LATITUDE)

AUGER PRIME

To address these challenges, the Pierre Auger Collaboration has initiated a significant upgrade to the observatory, known as AugerPrime. This upgrade includes the addition of scintillator detectors (SSD) and radio detectors (RD) to each existing surface detector station (Fig. 2). The new configuration enhances the ability to distinguish between the muonic and electromagnetic components of EASs due to the different responses of these detectors.

In the shower's core region, where particle density is highest, the three photomultiplier tubes (PMTs) in the surface stations may become saturated, causing inaccurate signal measurements. To mitigate this, AugerPrime introduces a small photomultiplier (sPMT) alongside the three existing large PMTs. The sPMT is designed to extend the dynamic range of the station’s measurements, allowing for more accurate sampling of the shower.

The observatory's array also includes regions where the distance between tanks is less than the standard, 1500 meters. In one such region, where the stations are spaced 750 and 433 meters apart, the upgrade involves the installation of underground muon detectors (UMD). These detectors will provide critical direct measurements of the muonic component of atmospheric showers, as the electromagnetic part of the EAS is absorbed by the ground, while muons pass through and reach the UMD.
The surface detector electronics have also been enhanced to support the new detectors. The updated electronics board is not only compatible with the existing configuration but also with the SSD, RD, UMD, and sPMT. This advanced board features a faster sampling rate and improved timing accuracy.

Our special thanks to
AUGER Early Career Collaborators Assembly

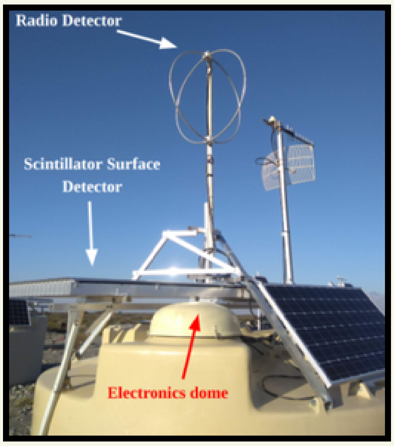

FIGURE 2. UPGRADED SURFACE STATION

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