The Pierre Auger Observatory

P. Bernardini [1] [2] C. Bleve[12] [3] G. Cataldi[2], M. R. Coluccia[12], A. Corvaglia, [2] P. Creti,[2] S. D'amico[4] [2], I. De Mitri[12], U. Giaccari[12], G. Mancarella[12], G. Marsella [42], D. Martello[12], M.Panareo[42], L.Perrone[42], C. Pinto[42], M. Settimo[12] [5] and the AUGER Collaboration

[1]Dipartimento di Fisica, Università del Salento, Italy

[2]Istituto Nazionale di Fisica Nucleare sez. di Lecce, Italy,

[3]now at the Dept. of Physics, Bergische Universität Wuppertal, Germany ,

[4]Dipartimento di Ingegneria dell'Innovazione, Università del Salento, Italy

[5]now at the Dept. of Physics, University of Siegen, Germany ,

The Pierre Auger Observatory has been conceived to measure the flux, arrival direction distribution and mass composition of cosmic rays from 10^{17} eV to the very highest energies with high statistical significance over the whole sky. To achieve this coverage, the Observatory will have instruments located at two sites, one in each of the Northern and Southern Hemispheres. The astrophysical interest in this energy range is well known, stemming largely from the expectation of spectral features in the decade above 10^{19} eV. In particular, it has been predicted [1,2] that the energy spectrum should steepen sharply above about $6 \times 10^{19} eV$ because of the interaction of primary cosmic rays with the microwave background radiation. There is considerable controversy [3] about the existence, or not, of the predicted steepening, commonly known as the Greisen-Zatsepin-Kuzmin (GZK) cut-off. It is clear, however, that there are cosmic rays with energies well beyond $10^{20} eV$ and major issues are the flux of these events and the accurate measurement of the spectral shape. It is known that the spectrum of cosmic rays extends to at least $3 \times 10^{20} eV$. Above $10^{20} eV$, the rate of events is about $1\ km^2 \times\ sr \times 1\ century$, so that vast areas must be monitored to collect a large statistical sample.

The southern site of the Pierre Auger Observatory covers a total surface of about 3000 km^2 at an altitude of 1400 m near the town of Malargue, in the province of Mendoza, Argentina. The surface detector (SD) is a triangular array of 1600 stations distant 1.5 km from each other. It is overlooked by 24 telescopes arranged in four clusters that altogether make up the fluorescence detector (FD). A layout of the Observatory is presented in Fig. 1.

The water tanks respond to the particle component (mainly muons, electrons and positrons and photons at the distances of importance) and the fluorescence cameras measure the emission from atmospheric nitrogen, which is excited by the charged particles of the shower as they traverse the atmosphere. Both techniques, already used for many years to study extensive air showers [4,5], are brought together in a *hybrid* detector to observe showers simultaneously with different techniques.

The surface array will have the following properties:

- 100% duty cycle.
- A well-defined aperture that is independent of energy above 10^{19} eV.
- Uniform coverage in right ascension on a daily basis.
- A response that is largely independent of weather conditions.
- The quality of the data for each event improves with energy.
- Sensitivity to showers arriving at large zenith angles.
- In situ calibration of the detectors by cosmic ray muons.
- Measurement of the time structure of the arriving signals, which is sensitive to the mass of the primary particles.

The fluorescence detectors can be operated during clear nights with little moonlight and have the following characteristics:

- Every event above 10^{19} eV is registered by at least one fluorescence detector: 60% of these events will be recorded by two or more fluorescence detectors. Essentially, every trans-GZK event will be a stereo event. Multiple station coverage improves the energy resolution.

- The longitudinal development profile is measured directly.

- The fluorescence detectors provide a more direct measure of the shower energy. The small, unseen, fraction of the total energy carried by neutrinos and muons depends somewhat on the mass of the primary particle as well as on the hadronic interaction model.

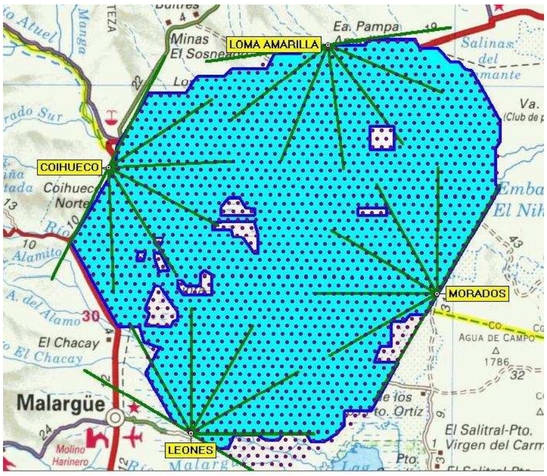

Figure 1. Layout and status of the Pierre Auger Southern Observatory. Each dot marks the position of one SD station; the shaded (blue) area covers the stations active. The 4 FD sites are labeled in yellow, with the field of view of each telescope (6 per site) indicated by green lines (whose length, to illustrate the scale, corresponds to 20 km

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