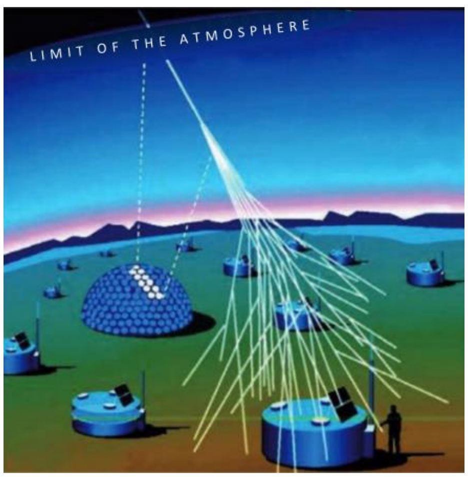
The Pierre Auger Observatory

Some particles from the cosmos carry as much energy as a bullet. Where do these ultra-high-energy cosmic rays come from? This enigma has motivated the construction of the largest network of detectors ever designed, the Pierre Auger Observatory.



Credit: Pierre Auger Observatory

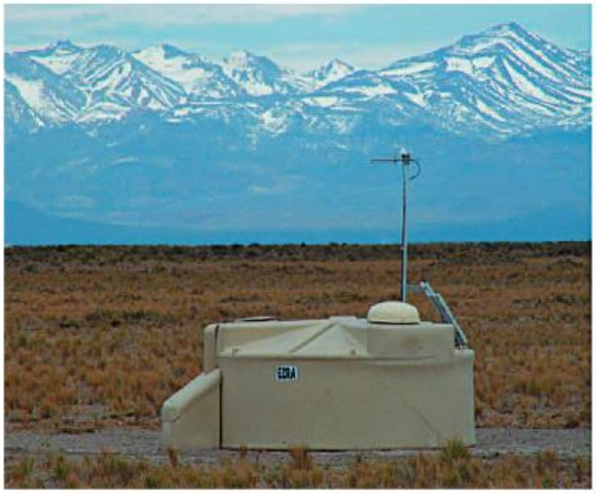
An atmospheric shower

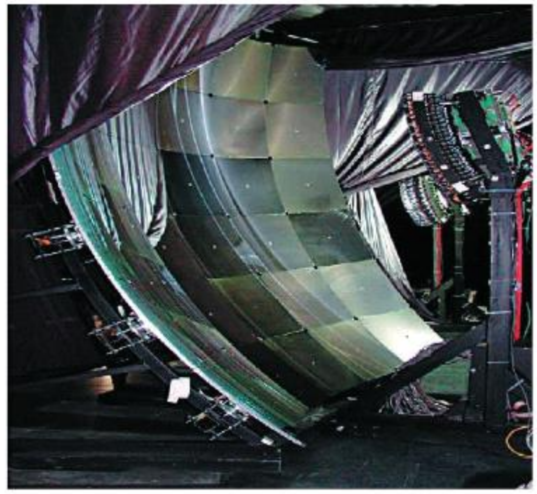
The high-energy cosmic ray interacts with the molecules in the atmosphere, producing a great number of secondary particles. The passage of this shower is detected from the ground by Auger's instruments (water tanks and a fluorescence telescope).

Cosmic rays reaching extreme energies are very rare events. At energies higher than ten billion billion electron volts, their flux drops to the level of a few particles per square kilometer and per century. When they interact with the upper atmosphere they produce a shower of secondary particles which travels all the way to the ground, with an extent of over a hundred square kilometers. A network of detectors deployed on Earth enables us to trace back the properties of the primary particle. A fruitful study of the most energetic cosmic rays requires their detection in large numbers, hence the deployment of measuring tools over extensive areas.

The Pierre Auger Observatory, named in honour of the French discoverer of the great cosmic showers at the end of the 1930s, covers more than 3,000 km^2 of pampas in Argentina, near Malargüe, in the province of Mendoza. Inaugurated on 14 November 2008, it uses two complementary techniques:

- water tanks, with 1,660 units deployed on the high plateaux of Pampa Amarilla. When they travel through the water of the tanks, the secondary particles coming from an atmospheric shower produce a brief flash of blue light through the Cherenkov effect, which is detected by photomultipliers
- fluorescence telescopes, each of which monitors a small portion of the sky of about 1.5 degrees square. These instruments detect the light produced by the nitrogen molecules





Credit: Pierre Auger Observatory

in the air when they have been excited by the secondary particles of the shower passing through the atmosphere above the site. Even though this fluorescence is very weak ultraviolet radiation (its flux equates that radiated by a lamp of a few tens of watts), it can be detected by Auger's very sensitive instruments up to tens of kilometers away on a clear, moonless night.

Combining the two techniques helps significantly reduce the measurement errors and identify the properties of primary cosmic rays with hitherto unequalled precision. Thus, the many scientists from around a hundred laboratories in the world that work on the Pierre Auger Observatory have established that the arrival directions of ultra-high-energy cosmic rays seem to be concentrated in the sky regions with the greatest densities in galaxies in the local Universe. In addition, the limits obtained regarding the proportions of photons and neutrinos in the observed cosmic particles have helped eliminate a large number of hypotheses and theoretical models on the origin of these ultra-high-energy cosmic rays.

Detectors at the Pierre Auger Observatory

The Pierre Auger Observatory combines two techniques to detect atmospheric showers. A regular grid of Cherenkov effect tanks (on the left, one of the 1,660 surface detectors at the Pierre Auger Observatory, deployed on the Andean foothills) and fluorescence detectors comprising mirrors and cameras (on the right) enable scientists to identify the properties of the cosmic ray at the origin of the shower with unequalled precision.

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