# AUGERINFOCUS

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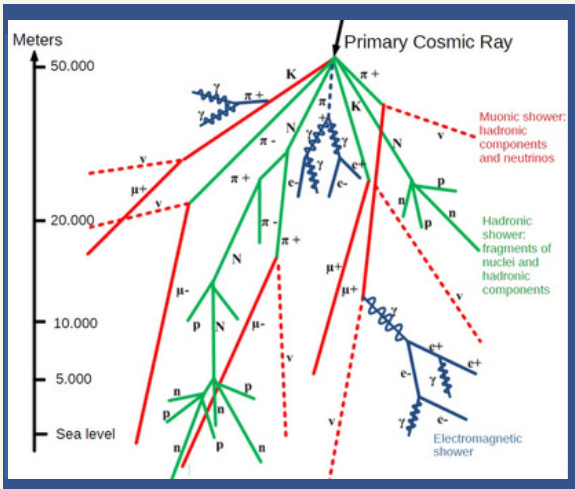
## COSMIC RAYS: SECONDARY PARTICLES SHOWER AND FLUX

Cosmic Rays (CRs) are subatomic particles that come from outer space and constantly strike the Earth from various directions. Discovered in 1912 by Victor Hess, most of these particles are protons, i.e. nuclei of hydrogen atoms, but there are also heavier nuclei such as helium, carbon or iron.




**Shower of secondary particles**

*References*

N = heavy nuclei
K = Kaon
$\pi^{\pm}$ = pion
v = neutrino
n = neutron
p = proton
e- = electron
e+ = positron
$\gamma$ = gamma rays
$\mu^{\pm}$ = muon

**FIGURE 1. SECONDARY PARTICLES CASCADE**

## PRIMARY CR AND ATMOSPHERIC CASCADES

RCs are detected in a huge energy range and are very numerous, but the higher their energy, the lower their abundance. They are known to travel at speeds close to the speed of light, but their origin is still uncertain. It has also been discovered that there is a maximum energy above which there are no cosmic rays (about $10^{20}$ eV) [1].

These nuclei, upon reaching our planet, interact with air molecules and generate cascades or showers of secondary particles (mostly electrons, positrons, photons and muons). These cascades were discovered by Pierre Auger in 1938 (Figure 1).

The calculation of the cosmic ray flux on Earth requires the measurement of the amount of high-energy particles arriving in a specific area in a given period of time.

Research in this field is based on the analysis of long-term data and comparison with theoretical models to gain an understanding of the nature of cosmic rays, i.e. to determine their energy, their trajectory, what type of particle they are, and finally, their origin.

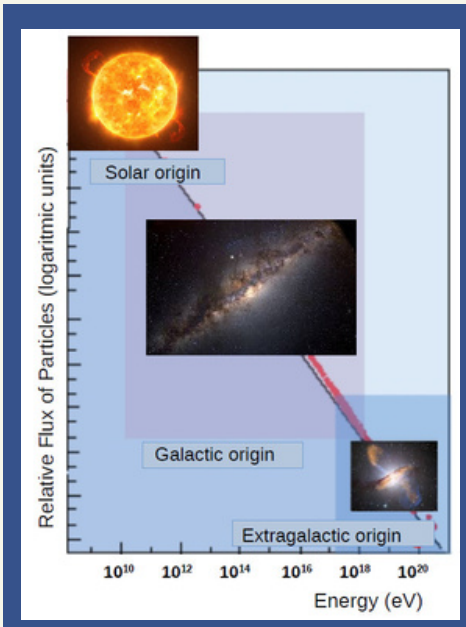



**FIGURE 2. ORIGIN OF CRS**

## EVENTS

The number of CR events as a function of their energy observed from Earth depends on the sources and the changes in energy and direction that the subatomic particles undergo as they propagate through space.

In the low energy range the spectrum is dominated by the solar wind. For higher energies, about $10^{11}$ eV (100 times the particle energy in the solar wind), the statistic is 1 particle per square metre per second; while for the highest energies, about $10^{20}$ eV (a hundred billion times the particle energy of the solar wind), the incidence is less than 1 particle per square kilometre per millennium.

[1] The electron-volt (eV) is a unit of energy. $10^{20}$ eV is equivalent to 16 joules.

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