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## *CREDO penetrates the unknown*

Since the very beginning, CREDO has been a worldwide multi-detector, combining data from a wide variety of physical detectors and observatories to record the high-energy particles and photons that make up cosmic radiation. The physical 'multiculturalism' of this research is therefore integral in its design and is associated with the special significance of cosmic radiation. The latter is an important, though usually an unconscious, factor affecting human life yet its origins still remain far from fully explained. The influence of cosmic ray particles on the shaping of our planet's climate or certain biological or medical issues, including its impact on the evolution of life, is currently under study by scientists and offers unique research opportunities for CREDO in fields other than physics and astronomy.

From time to time even amongst high energy cosmic radiation there are single particles with mindbogglingly high energies. The very fact that they can be observed at all is astonishing. This is because the Universe is filled with the afterglow of the Big Bang, known as the cosmic microwave background. In 1966, physicists K. Greisen, G. T. Zatsepin and V. A. Kuzmin showed that cosmic ray particles with extremely high energies should collide with photons of this cosmic microwave background and lose their energy. As a result, after travelling a distance of only 150 million light years, their energies should not be greater than 40 billion billion electron volts. In the cosmic ray spectrum this cutoff, called the GZK limit (from the authors' surnames) should be visible as a rapid reduction of the flux of particles in this energy range. In fact, such a cutoff is observed, but at slightly higher energies than expected, and in addition, various observatories give different values of energy at which the GZK cutoff takes place. What is especially interesting, cosmic ray particles with energies that markedly exceed the GZK limit – even ten-fold! – reach the Earth. This could mean that the sources of such high energy particles are located in astrophysically short distances from Earth, i.e. closer than the above-mentioned 150 million light years. However, within this radius we have seen no such possible astrophysical source for these particles with such high energies.

Various data collected under the CREDO project may give physicists the chance to solve the puzzle of the existence of particles with extremely high energies and to explain the reasons for the observed discrepancies in the measurements of the GZK cutoff. What's more, since the GZK cutoff is in some way a consequence of the application of Einstein's theory of relativity, the planned measurements may make it possible to verify the scope of its applicability.

CREDO could also solve other interesting issues. Does the lack of observation of photons with energies higher than a billion billion electron volts result from the fact that there are no processes taking place in the Universe that could result in extremely high energy photons, or is it related to theoretically acceptable, but so far unobserved processes in which photons with extremely high energies are formed, but their lifetime is very short (e.g. one second) due to the photon decay? In the latter scenario, the distributed CREDO infrastructure would provide an opportunity to detect the breakdown products of a high-energy photon in space, arriving to us in the form of a set of secondary cosmic rays, mainly photons.

An interesting hypothesis to consider is that at least some of the high-energy cosmic ray particles come from the decay of particles of dark matter. Astronomers came across dark matter at the beginning of the 20th century, analysing first the movements of stars in nearby galaxies and then entire galaxies in clusters of galaxies (the statistical method of analysing the movements of stars in our galaxy was first successfully used in 1859 by Marian Kowalski, a Polish astronomer born in

Dobrzyń nad Wisłą). Currently, it is estimated that there is five times more dark matter in the Universe than ordinary matter. Despite its predicted abundance and the numerous detectors built to find it, no detector has been able to confirm a single particle of dark matter. Currently, work on measurement techniques in CREDO, which would potentially allow this detection, is under way.

No less interesting are CREDO's possibilities in the field of quantum gravity research. Theoretical considerations show that if spacetime is not a continuous but rather discrete (i.e. quantum) structure, then high-energy cosmic ray particles moving in this space should interact with it depending on their energy and in effect they would undergo an extension in time. In an experiment in 1983, a network of cosmic ray detectors recorded 32 cases of giant air showers in the space of just a few minutes in the province of Manitoba, Canada, when only one was expected! Were the air showers detected then the effect of the above-mentioned blurring in time, and thus the proof of the existence of the quantum structure of the spacetime continuum? Currently, this question cannot be answered due to the individual nature of this observation. However, CREDO detectors could record more potential 'extensions in time', which would probably contribute to the explanation of the nature of the phenomenon (if its existence is even confirmed). The Quantum Gravity Previewer experiment, designed for this type of research on quantum gravity, is already operating within CREDO.