The Henryk Niewodniczański
Institute of Nuclear Physics
Polish Academy of Sciences

Radzikowskiego 152
31-342 Kraków, Poland
switchboard: +48 12 6628000
director: +48 12 6628200
fax: +48 12 6628458
www.ifj.edu.pl
dyrektor@ifj.edu.pl

CREDO – a detector like never before

Currently, cosmic radiation particles are registered using various physical phenomena and almost exclusively by observatories specifically designed for this purpose. These are usually underground or above ground installations with detection capabilities directed at particles of a certain type and/or a specific energy. One of the largest ground-based observatories is the Pierre Auger Observatory in Argentina, where the detectors are located over an area of several thousand square kilometres, comparable to the area of Luxembourg.

Periodically, measurements of cosmic radiation are carried out over the surface of the Earth, including by means of apparatus installed in stratospheric balloons. In such experiments, however, the working time is necessarily limited by the length of the flight. This is why many devices have for years been placed on board orbital or space probes. Already the first American satellite, Explorer 1 launched in 1958, was equipped with instruments for measuring cosmic radiation. Changes in this radiation are also recorded by the famous Voyager 1 and Voyager 2 probes, the most distant man-made objects, today located near the borders of the Solar System.

A common feature of ground and underground cosmic radiation detectors is that they typically only allow the examination of single cascades of secondary particles in the atmosphere, and in addition only for the energy and particle type for which they have been designed. However, extensive atmospheric showers are local phenomena. Knowledge about them alone does not make it possible to study phenomena and correlations potentially occurring in the whole stream of particles flowing to Earth from the cosmic abyss.

The CREDO project is a qualitatively new method of acquiring knowledge about cosmic radiation. The main idea here is not to create a new, gigantic and extremely expensive detection infrastructure, but to skilfully combine data collected by already existing detectors, registered by different methods and concerning different types of radiation, over different ranges of energy.

However, CREDO is not limited to the collection and processing of data coming exclusively from detectors adapted for recording cosmic radiation, such as the Pierre Auger Observatory apparatus mentioned above. In astronomy, for example, images are registered even when the telescope's lens is obscured. The aim here is to identify malfunctioning pixels in CCD matrices. However, sometimes on dark frames obtained in such a way, light points can be seen in places where a particle of cosmic radiation has passed through the sensor matrix. Thus, something that has been treated by some observers as unwanted or even troublesome noise, may in the CREDO project become a valuable source of information, increasing the reliability of research on the fundamental properties of the Universe. Another source of data for CREDO can be specialized muon detectors, used in accelerator centres to register particles produced in collisions (e.g. in experiments in the LHC and Tevatron accelerators) and scintillators and photomultipliers, mounted in large numbers in observatories designed to detect neutrinos (e.g. ICECUBE, Super-Kamiokande) or potential dark matter particles (DAMA, XENON1T).

The cloud of CREDO detectors is created not only by expensive, specialized detectors from large scientific experiments. One of its essential elements is much simpler detectors, whose strength is not sensitivity or precision, but simply their number. We are talking here especially about the CMOS matrices of cameras installed in smartphones, devices produced on a really massive scale. These matrices are certainly not ideal detectors of cosmic radiation particles, if only because of their very small size, reaching only a fraction of a square centimetre. Nonetheless, today there is practically no place in the world where there are no smartphones.

To become a cosmic radiation particle detector, a smartphone just has to take pictures with the camera lens obscured. After pre-processing, images with detected particle traces are sent to a common database. On smartphones with the Android operating system, all these operations are performed by the CREDO Detector application, created at the Institute of Nuclear Physics Polish Academy of Sciences and now maintained and developed by the Cracow University of Technology. The collected data (including data from professional detectors) are processed by the Academic Computer Centre Cyfronet of the AGH University of Science and Technology in Cracow.

Smartphones do not allow easily for the collection of valuable (in the sense of the state of the art) data on extensive air showers – this would require their unrealistically high density. Fortunately, the large geographical dispersion combined with the huge number of detectors makes it possible to track another phenomenon: time correlations between particles recorded by the matrices of individual smartphones. It turns out that these correlations can carry valuable information about ensembles of cosmic rays, flowing from the depths of space to our planet.

The specificity of the project makes the structure of the CREDO detector network extremely dynamic. Individual users connect and disconnect their smartphones virtually every second. What's more, at any time the infrastructure included in the project can be easily expanded with new networks of inexpensive, dedicated detectors, run by enthusiasts or students, or fully professional detectors operating at the most sophisticated scientific experiments in the world.

Data coming from clouds scattered all over the globe, with a wide variety of detectors, opens up new research opportunities for CREDO in terms of quality. For the first time, there is an opportunity to monitor global changes in the cosmic radiation flux reaching our planet. When used skilfully, this knowledge may help to unravel many puzzles related to the fundamental characteristics of our physical reality.