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Mini Review

Prospects and future development of the CREDO Maze project

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Abstract

CREDO-Maze Project allows the creation of a unique global physical apparatus, consisting of a network of local (school) cosmic-ray monitoring stations. Nothing like this has been developed before and there are no other plans to create something like this. It is currently being launched on a small national scale. We are preparing to expand, starting with the friendly Walailaki University in Thailand, where a station is about to start operating. In principle, there is nothing to stop further stations being established wherever there are interested individuals/students. The purely physical questions of the most important problems in particle physics and astrophysics, to which such a global facility would be dedicated, are addressed in a slightly different way by the CREDO Project [1]. The equipment developed in our CREDO-Maze Project will be automatically integrated into this large project. Students will have access to the entire CREDO Project. Furthermore, we envisaged that the modular design of the apparatus would allow it to be used as a teaching aid within regular school classes for the study of nuclear radiation, relativistic physics, and particle physics, thus modernizing the standard teaching method.

Introduction

Cosmic rays have been the phenomenon known for over a hundred years, but so far, its origin, acceleration and variability mechanisms are not clear in details. Many questions about, e.g., the cosmic weather and the impact of cosmic radiation on humans and human activities have not yet been answered definitively. Extensive Air Showers (EAS) [2] are initiated by a single cosmic ray particle interacting in the upper atmosphere and creating a cascade of elementary particles traveling to the surface of the Earth. They arrive as a disk of millions of particles for one short instance. Recently there has been proposed an even larger shower like event, so-called Cosmic Ray Ensembles [3], in which bundles of ultra-high energy cosmic rays can produce simultaneous showers over the entire exposed surface of the Earth. Such a phenomenon has never been seen, but there are several models under which such an event is a possibility, including the decay/annihilation of superheavy dark matter particles [4]. Searching for such hypothesized Cosmic Ray Ensembles (CRE) is the driving science case behind the CREDO Project [5]. It formally commenced operations on Sept. 11, 2019, after approximately three years of network and software infrastructure development [6]. By design it was imagined as a global research endeavor, and currently consists of 17 countries involving many scientific and educational institutions [7,8].

Some technical details

The CREDO-Maze Project uses high-tech measuring equipment in an extracurricular activity: detectors of charged relativistic elementary particles will be made of small (0.02 m2) plastic

scintillators. Light pulses will be collected by optical fibers that transform the wavelength from ultraviolet to green, and the light will then be converted into electrical signals by silicon photomultipliers (SiPMs). These solutions represent the state of the art in measurement technology. Other electronics will be based on high-speed digital circuits and microcontrollers, which will manage registers, GPS circuits and store data on memory cards and/or send it on-line to local computers.

From a technological point of view, it can be concluded that the level of advancement of the CREDO-Maze Project is currently achieved can be described as TRL 4/5 (technology validated in lab/ technology validated in relevant environment). The report on the operation of the prototype measuring station was presented, e.g., at the Vysehrad meeting in Opava and published [9,10].

These devices are designed and implemented in such a way that, while maintaining high standards, they are as inexpensive as possible. We will try to develop to ensure that the station measurement kits can be duplicated and distributed to end users as" self-assembly kits" with different degrees of sophistication of the finished components. As potential business projects they will be able, together with educational material pledges and software, to provide a ready-made market product. With positive recommendations based on our research results, the potential market, the demand for educational institutions, seems to be quite considerable.

Educational effects

The CREDO-Maze Project is based on a new concept of extracurricular activities using technologically advanced but conceptually simple measurement apparatus. Prototypes of individual devices have been developed and extensively tested at the University of Lodz.

We have developed and are currently implementing technology to replicate them on a larger scale. An interesting concept is to involve some of the end users, the high-school students, in building and testing kits for their schools. This will allow students in local groups to build and complete a fully functioning measurement station, all under the supervision of scientific staff, of course. Building working scientific equipment themselves is an additional motivating element and undoubtedly increases the involvement of young people and the general interest of non-participants. These effects have been observed in previous attempts to implement similar activities on a smaller scale.

section other effects the CREDO-Maze Project concerns a particular subject at the interface of micro-world physics and macro-world astronomy and has been chosen precisely because of its complexity and scope, covering a large number of interesting issues. We have developed a method of bringing these topics, which are virtually absent from school curricula, closer to students in a cheap and attractive way. If direct and serious involvement of young people in scientific research proves to be pedagogically justified, similar types of lessons can be designed in a wider range of fields, not only in physics, but also in chemistry, biology, geography, ecology, and most likely in disciplines not covered by STEM. This will require conceptual work by specialized groups of scientists and educators. The creation of research equipment directly accessible to the young people participating in the activities seems to be crucial and, as we intend to demonstrate with the CREDO-Maze project, the cost of this equipment is negligible. This equipment, if considered flexible enough, can provide additional support to curricular activities at school, as is the case in our project.

The creation of local structures comprising young people involved and organized in research groups (led by teachers/ educators) using network communication and based on science centers, as, e.g., higher education institutions, universities, is an important step in the development and institutional activities research performing organizations, including, as well as research funding organizations. The proposed actions open new areas of innovation in non-formal non-school education. Creating a model system of social communication

networks and demonstrating its effectiveness in the proposed field being an element of STEM will allow us to plan and create similar networks realized in other areas of education. There are no contraindications for such networks to cover different groups of young people and different research centers, for local communication to overlap and overlap. It even seems advisable for the integration of local student communities, but not only.

The mere transmission of the contents of the teaching of science in the broad sense, as it appears in the activities of our project, has the nature of side effects, so to speak, on the way to the set goal. The goal is to search for and discover in the world of science the relations between space, elementary particles, the cosmos, which are unknown or unknown to anybody. In order to achieve this goal, it is necessary to assimilate elements of knowledge that describe this reality. Of course, it is not assumed that the participants will acquire a systematic and scientific image of at least this small part of the world around them, and even less can it be assumed that their knowledge will be enriched with elements that are not covered by school curricula and conventional teaching.

It seems obvious that there will be an increase in specific knowledge among the young people directly involved in the project, but we also expect an increase in general knowledge not only among the participants, but also in their immediate environment, such as the classes from which the pupils working in the project will come. An additional element is an increase in the level of knowledge of the teachers who carry out the extracurricular activities of the project. But not only do we expect an increase in knowledge, but we also expect an increase in interest from people who are not directly involved in the project.

Members of families, friends, and the local community in places where the activities of the project participants will have an impact on the local population. Participation in, for example, science fairs and other such events, if organized in the neighborhood, is an additional element that introduces the informal education of the project to the local community.

Acknowledgment

None.

Conflict of Interest

No conflict of interest

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