

# Snowmass2021 - Letter of Interest

## *The Cosmic Ray Extremely Distributed Observatory as a new quality public engagement and edutainment environment.*

### Topical Groups:

- (CommF3): Diversity & Inclusion
- (CommF4): Physics Education
- (CommF5): Public Education and Outreach

### Contact Information:

P. Homola (Institute of Nuclear Physics Polish Academy of Sciences) [Piotr.Homola@ifj.edu.pl]  
Collaboration: Cosmic Ray Extremely Distributed Observatory (<https://credo.science>)

**Authors:** P. Homola, K. Adhikari, D. Beznosko, G. Bhatta, Ł. Bibrzycki, N. Budnev, D. E. Alvarez Castillo, K. Almeida Cheminant, A. Ćwikła, N. Dhital, A. R. Duffy, J. Gancarson, D. Góra, A. Gupta, M. Kasztelan, M. Knap, P. Kovacs, I. Lukyanyk, M. Magryś, M.V. Medvedev, J. Miszczyk, A. Mozgova, Y. Jack Ng, M. Niedźwiecka, M. Niedźwiecki, B. Ogan, D. Ostrogórski, K. Oziomek, M. Pawlik, M. Piekarczyk, K. Rzecki, A. Rzecznik, K. Smelcerz, K. Smolek, J. Stasielak, S. Stuglik, M. Svanidze, O. Sushchov, V. Nazari, A. Tursunov, J. M. Vaquero, Q. Wang, T. Wibig, K. W. Woźniak, J. Zamora-Saa

### Abstract:

The Cosmic-Ray Extremely Distributed Observatory uses the hunt for particle cascades from deep space as a vehicle for a unique “bottom-up” approach to scientific research. By engaging the non-specialist public of all ages as “citizen scientists” we create opportunities for lifelong learning for individuals as well as for cooperation and the sharing of common educational tools amongst institutions. The discoveries of these citizen scientists will feed directly into a pioneering new area of scientific research oriented on cosmic ray ensembles. The detection (or non-detection) of such particle groups promises to open up a new method for exploring our universe, and a new channel on the multi-messenger stage, oriented on both astro- and geo-investigations. The opportunities this would create for cross-disciplinary research are significant and beneficial for individuals, networks of institutions and the global communities of both professional scientists and science enthusiasts.

**Introduction** The Cosmic-Ray Extremely Distributed Observatory ([CREDO](#)) aims at searching for the yet not checked multi cosmic-ray signatures that are composed of many air showers and individual particles arriving simultaneously to the Earth, so-called cosmic-ray ensembles (CRE) [1,2]. The signals from CRE might be spread over very large surfaces which might make them hardly detectable by the existing detector systems operating individually. On the other hand, if these detector systems operate under a planetary network, as proposed by CREDO, the chances for detection of CRE, even as zero-background events, will naturally increase. The components of individual CRE might have energies that span practically the whole energy spectrum of cosmic rays. Thus, all the cosmic-ray detectors working in this range, beginning from smartphones and pocket scintillators, through numerous larger educational detectors and arrays to the professional infrastructure capable of registering cosmic rays as a signal or as a background, can contribute to a common effort towards a hunt for CRE. Since a planetary scale and massive, geographically spread data acquisition with even small detectors such as smartphones are essential for the CREDO mission, the CREDO Collaboration considers an active engagement in the project of non-expert science enthusiasts as a methodological must: beneficial for both for the project and for the contributors, and making science experts and non-professionals just one community, working hand-in-hand towards common goals. The unprecedented cosmic-ray data set to be collected and processed by CREDO will require a continuous overlook and vigilance of humans, many of us. Thus public engagement must be planned on many levels: from passive data taking with smartphones, through simple data monitoring, mining and analysis via the Internet, to more advanced activities. In practice, it means that CREDO will offer long-lasting educational and developmental paths for individuals who became amazed after their first, very close and active contact with science, and who will be ready for more. If the scale of the CREDO network is as large as planned, our format must bring benefits not only to the whole science community but also to the society. Universally useful educational and mind formation opportunities together with the availability of indirect and immediate participation in a top-science project for the so-far-excluded countries, regions and individuals, should contribute to the overall, sustainable civilizational development of society.

**Public engagement in CREDO: for science, through contributing to science** The key concept of public engagement in CREDO is tightly connected with the big science questions and challenges that might be undertaken with help of a global cosmic-ray infrastructure. What is dark matter? What is the structure of space-time? Is there any observable New Physics in cosmic rays correlated on large scale? These are examples of questions explorable within CREDO only from the field of astroparticle physics, potentially with much wider impact, e.g. on the foundations of science, cosmology, or particle physics. And contributing to data acquisition for CREDO, a typical title to co-author scientific publications, is in reach for every owner of a mobile device with a camera and a suitable application. Hence, a simple and powerful message can be transmitted to society, and in particular to its part enthusiastic about science and considering science as a possible career path: **“you are needed and welcome to co-author breakthrough discoveries”**. This way the traditional outreach activity gains a new dimension - *the scientific purpose* of the public participation on a massive scale, with as many private and small devices as possible. Already the pure definition of a scientific subject, CRE, determines the necessity of a large scale social engagement. It is only a matter of further and deeper investigations to quantify *how much* CREDO needs non-experts and how big can be the difference they can make in which areas of activities within the project.

Apart from data acquisition, CREDO asks for massive participation of both expert and non-expert science enthusiasts to work hand-in-hand towards a better understanding of the data acquired by the smartphone cloud within necessarily advanced and complex pattern recognition strategies. As proven in similar projects dealing with massive scale pattern recognition tasks (see e.g. [Planet Hunters](#)), a human eye might serve as an indispensable tool to reinforce machine learning. This is particularly obvious when the research is oriented on identifying unexpected anomalies in patterns and in the signal strength - where no a priori knowledge and training can be applied, and where unsupervised machine learning might fail in getting tuned to the signal



Figure: The variety of particle tracks candidates as registered by a smartphone using the CREDO Detector app.

features that are "too strange" or on borders of categories. CREDO is already a self-standing doubly open (both for data upload and access) observatory and international collaboration of 39 institutions from 17 countries on 5 continents, including scientific institutes and universities, science centers, schools, non-governmental organizations and commercial partners. (see [the updated list of member institutions](#)). We have already enabled mass participation in data acquisition with smartphones (the [CREDO Detector app](#) [3]: ~ 20k installs, > 1000 years total detection time, > 1 million particle track candidates - see the Figure for examples), with first

peer-reviewed scientific articles on data analysis pending publication (see [the updated list of CREDO publications and proceedings](#)). The CREDO data is being stored, processed and made available continuously in the CREDO central computing system operated by ACC Cyfronet AGH-UST, in Krakow, Poland. **The data center is open on two ends:** every experiment or private detector can submit its own data, if it only matches the API protocols. Also the access to data is open to the registered users with scientific or educational motivations. All the CREDO codes are open under the MIT license - so that the community of participants can also get engaged in software development - for science and for their education. Regarding the already visible societal benefits we list e.g. the [Particle Hunters League](#) - a prototype component of the CREDO user web interface that facilitates team competition in particle hunting with smartphones. To date, ~2000 pupils from ~100 schools in Poland participated in the program with their teachers, not only offering their smartphones as the detectors, but also using the educational materials provided by CREDO (a lesson plan and the accompanying materials, available also in English). The popularity and universality of Particle Hunters League give prospects for expansion not only on a country level in Poland, but also internationally, beginning from the CREDO member countries. The other components of the competition system that are already under preparation will further widen the spectrum of scientific activities, educational opportunities and simple, positive competitions coupled to international cooperation and contacts available for the engaged youth. CREDO as a whole will become an attractive, long-term option for young people hopefully even for a life-long journey with science. **The door to CREDO is open, feel invited, everybody is welcome.**

## References:

- [1] P. Homola, et al. (CREDO Collab.), “Search for Extensive Photon Cascades with the Cosmic-Ray Extremely Distributed Observatory”, CERN Proceedings, 1 (2018) 289, 2018; [[arXiv:1804.05614](https://arxiv.org/abs/1804.05614) , DOI: [10.23727/CERN-Proceedings-2018-001.289](https://doi.org/10.23727/CERN-Proceedings-2018-001.289)].
- [2] P. Homola, et al. (CREDO Collab.), *Public engagement as a scientific tool to implement multi-messenger strategies with the Cosmic-Ray Extremely Distributed Observatory*, PoS (Asterics2019) 034, 2019; [[arXiv:1908.09734](https://arxiv.org/abs/1908.09734), DOI: [pos.sissa.it/357/034/](https://pos.sissa.it/357/034/)].
- [3] CREDO Collaboration, EurekAlert! 12 June 2018, *CREDO: You too can help unveil the deepest puzzles of the universe*, [https://www.eurekalert.org/pub\\_releases/2018-06/thni-cyt061218.php](https://www.eurekalert.org/pub_releases/2018-06/thni-cyt061218.php)