OCRA – an outreach program on cosmic rays for teachers and students

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OCRA – an outreach program on cosmic rays for teachers and students

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Abstract. The Outreach Cosmic Ray Activities (OCRA) project was created in 2018 within the Italian Istituto Nazionale di Fisica Nucleare (INFN) to offer a platform for all outreach activities focusing on cosmic rays within the institute. OCRA now counts 22 of the institute's divisions all over Italy as members. The project offers activities both for students and teachers. The one activity common to all local groups is the participation in the yearly International Cosmic Day, organized by DESY, inviting high school students to carry out hands-on measurements of the cosmic ray flux and learn about the related physics background. Two students from each division are then selected to participate in the annual OCRA science camp, a three-day full immersion into the life of a physicist. For both teachers and students, the OCRA website https://web.infn.it/OCRA/, offers a series of online laboratories designed both to be used by students individually but also to be offered in the classroom by teachers. A section dedicated to teachers provides ample material to help bring these laboratories to the classroom. The online materials were presented in a course for teachers in spring 2021. In addition to the national efforts, there are also local initiatives of the OCRA member groups: workshops and secondments, science competitions and the development of new detectors for outreach activities offer a multitude of possibilities for students to engage with our researchers and to explore the world of cosmic rays. This article provides an overview on all activities offered by OCRA with a particular focus on the 2022 science camp.

1. Introduction

OCRA – Outreach Cosmic Ray Activities was created in 2018 as a national outreach project of the Istituto Nazionale di Fisica Nucleare (INFN) with the aim of building a national framework for the institute's numerous public engagement activities in the field of cosmic ray physics already present at a local level in its divisions and national laboratories. Currently 22 INFN divisions and laboratories, located all over Italy, participate in the project.

Over the past years both the number of participants as well as the number of activities proposed by the OCRA network have been growing constantly. The project offers activities for students, like the yearly participation to the International Cosmic Day organized by DESY [1], interactive online laboratories, and a summer camp for high school students, as well as a broad variety of local events and programs. OCRA also addresses teachers, as done with the online course on the interactive labs present on the project's website that was held in spring of 2021 [2]. Finally, on a local level OCRA regularly participates in outreach events for the general public, like the European Researchers' Night and science festivals like Futuro Remoto, Galassica and BergamoScienza.

All activities offered by OCRA evolve around the exploration of cosmic rays: easily detectable and made "visible" through simple telescopes they offer a unique way for bringing non-experts, in particular students, closer to physics and the study of its underlying phenomena.

In this article we shortly present the main activities of the OCRA project, with a focus on the 2022 edition of the science camp for students.

2. Being a researcher for a day: the International Cosmic Day

DESY's yearly International Cosmic Day (ICD) [1] brings together high school students, schools, and researchers from all over the world for an immersive astroparticle physics outreach event. Usually, all participating groups investigate the same question: the zenith angle distribution of atmospheric muons. Like real researchers, students work together in a team and, at the end of the day, present and discuss their findings via videocalls with other student groups from all over the world. In the following, they can summarize their experience in a short article that is published by DESY in a booklet.

The ICD in 2021, the 10th edition of the initiative, took place on November 10. The sanitary situation due to the Covid19 pandemic did not yet allow to fully go back to pre-pandemic modalities but it was possible to invite a small number of students to the INFN divisions and laboratories for activities in presence. OCRA succeeded in organizing 12 local events in presence, distributed all over Italy, for a total of 443 students from 76 schools and 52 towns, and one local online event with a total

of 1200 students participating. In parallel, a national online event was organized by the INFN Lecce group which saw the participation of more than 4000 students from all over Italy.

3. Full immersion into research: OCRA Science Camp 2022

OCRA also organizes science camps for students that take place once a year. Each local INFN division that participates in the ICD selects two students that are invited to the camp the following spring. The first OCRA science camp was organized in April 2019 and took place in L'Aquila. More than 30 students from all over Italy participated. The students, together with the researchers and five accompanying teachers, took measurements of the cosmic ray flux in several locations around the Gran Sasso massif in central Italy and analyzed the data to determine the dependency of the flux on the locations' altitudes [3].

The 2020 science camp, foreseen at the INFN Laboratori Nazionali di Frascati (LNF) near Rome, could not be carried out due to the restrictions imposed by the COVID19 pandemic. Only in spring 2022 it was again possible to organize an in-person science camp: from May 3-6, 2022, 28 students, selected by the local competitions in 14 INFN divisions and laboratories following the ICD 2021 events organized by OCRA, both in-person and online, came to the LNF for 3 days. The students were accompanied by five teachers that acted as a support to the eight INFN researchers for all practical and organizational aspects regarding the students. Figure 1 shows a group picture of all participants.

Figure 1 Group picture of all participants of the OCRA science camp.

The goal of the camp was to create a diverse offer that allowed for a full immersion of the students into the world of physics research and cosmic rays. The program contained lectures on cosmic rays and cosmic ray experiments, a visit of the INAF observatory of Monte Porzio Catone and of the facilities and visitor centre of LNF. The core of the experience was the flight of a stratospheric balloon with instrumentation to measure the muon flux during the flight and the analysis of the data collected, similar to the experience presented in [4]. The flight was carried out by a group of four balloon flight experts [5]. Figure 2 shows a picture of the balloon before take-off and the preparation of the payload containing two detectors to measure the muon flux as well as a camera to film the flight.

Figure 2 On the left the balloon right before take-off. On the right, the preparation of the payload of the balloon.

The particle detector used during the flight of the balloon to measure the muon flux needs to satisfy several requirements: it needs to work with low power consumption, be very light-weight and small, and requires an independent system so that no external computer is needed. These criteria are satisfied by the ArduSiPM detectors [6] developed by researchers from INFN Rome and depicted in Fig. 3. The ArduSiPM consume less than 1 W, have a weight of less than 200 g, and the Arduino allows to operate them independently.

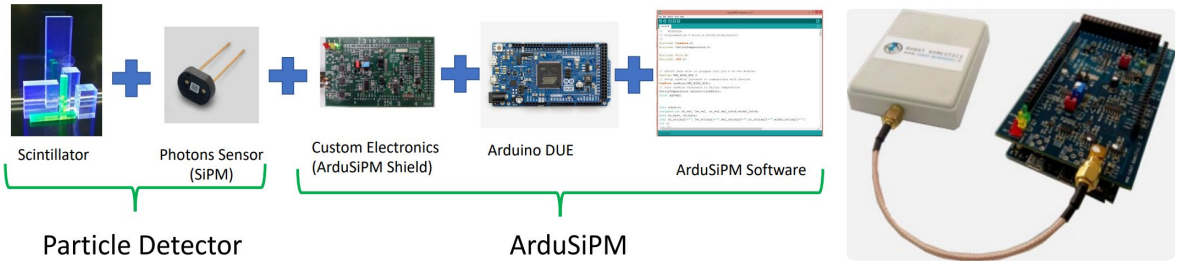

Figure 3 Schematic and picture of the ArduSiPM detector [6] used during the balloon flight to measure the muon flux.

The balloon was launched in the morning of May 5, 2022, from within the LNF in Frascati. The balloon reached a maximum altitude of 28.4 km and landed at a distance of about 64 km from the starting point after approximately 1.5 hours of flight. Figure 4 shows two pictures taken during the flight, the landing situation of the payload and a map with the starting and landing point of the balloon.

Under the guidance of the researchers, students analyzed the data taken during the flight. This included the study of correlations and dependencies of several parameters including pressure, altitude, time, acceleration, and, most importantly, the muon flux. Two examples of the graphs produced by the students are shown in Fig. 5.

Figure 4 Left: pictures taken during the flight. Middle: the landing of the payload. Right: map indicating starting and landing point of the balloon.

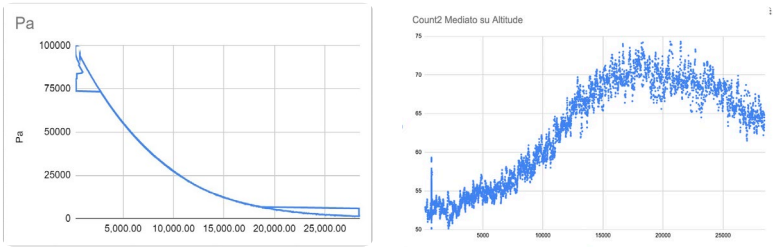

Figure 5 Two examples of graphs, produced by the students, to analyze dependencies of parameters measured during the flight: on the left, pressure vs. altitude, on the right the average counts vs. altitude.

The students were invited to answer two questionnaires, one at the beginning of the science camp and one at the end. Both questionnaires contained questions about their idea of a physicist and what research in physics means, the significance of the participation in the camp for their studies and future, their expectations (pre) and if they were fulfilled (post) as well as some basic knowledge questions on cosmic rays. The questionnaire they answered after the activities also contained inquiries on their level of satisfaction regarding the experience, its organization, and the contents. The analysis of the questionnaires is ongoing.

Finally, before leaving, students were asked to describe their experience in the camp in three words. A small selection of the answers is depicted in Fig. 6.

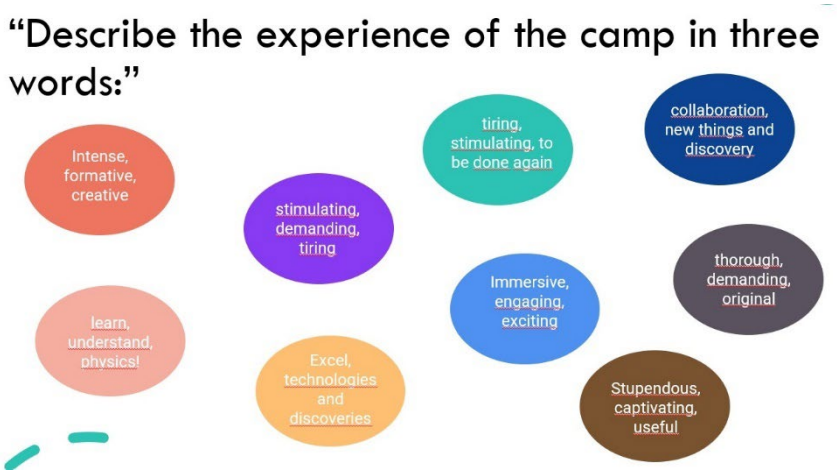

Figure 6 A small selection of words used by students to describe their experience of the OCRA science camp.

4. Participating remotely: OCRA online resources for teachers and students

In the spring of 2020, the first lockdown in Italy due to COVID19 forced a stop to the numerous in-person activities organized by OCRA, both nationally as well as locally. At the same time the schools had the necessity for new online resources to respond to their students needs, for example for the thesis work required during the last year of high school and part of the students' final exams. The OCRA collaboration therefore worked together and was able to offer in just a few weeks' time several interactive laboratories and online resources on their website [7]. The educational paths are all based on cosmic ray experiments and students are guided in the analysis of real data, similar to the work they would have done if coming to the physics labs. To facilitate teachers in integrating these resources into their educational offer, a working group composed of teachers collected and developed materials that are also available on the website [8]. In spring 2021, an online course for teachers about the OCRA online resources was organized. An introduction on cosmic ray physics and the presentation of all online laboratories allowed the teachers to discover all resources in a hands-on approach. Details can be found in [2].

5. OCRA in the local divisions and laboratories

As mentioned above, OCRA is now present in 22 INFN divisions and laboratories. In many of these sites, additional activities are organized within the OCRA framework, complementing the above presented national efforts. They strongly depend on the local groups, their research focus, and the composition in terms of expertise. The activities therefore cover a wide range, from student internships to the development of muon telescopes for various educational scopes. Examples also comprise a competition named "A scuola di astroparticelle" for high schools on several subjects organized every year by the Naples group [9,10], measurements of cosmic rays in several conditions, for instance in water, as done by the OCRA group of Cosenza [11], and the participation in educational research programs [12].

6. Conclusions

The OCRA project provides the framework for the national and local outreach activities on cosmic rays in INFN. Each year, all 22 local groups participate to the ICD. Other national efforts comprise a yearly summer camp for students and the creation of a broad variety of hands-on online resources for students and teachers. In the near future, more focus will be given to teacher training. Only by training also teachers will it be possible to multiply the efforts and to expand the reach in an indirect manner, allowing many more students to explore the fascinating world of cosmic rays and astroparticle physics.

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