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PoS(ICRC2023)1626

The OCRA International Cosmic Day

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The INFN Outreach Cosmic Ray Activities (OCRA) project involves 24 divisions of the Institute all over Italy and offers activities for both students and teachers. The International Cosmic Day - ICD, organized by DESY, is one of the OCRA activities common to all local groups and consists in inviting high school students to carry out hands-on measurements of the cosmic ray flux and to learn about the related physics background.

This paper describes in detail the latest edition of the OCRA ICD, which was organized both in presence at the different sites and online, focusing on the educational value of both modes, also through the use of a questionnaire administered to the participating students at the end of the day's activities.

38th International Cosmic Ray Conference (ICRC2023)
26 July - 3 August, 2023
Nagoya, Japan

*Speaker

1. Introduction

OCRA - Outreach Cosmic Ray Activities [1] was founded in 2018 as a national outreach project of the INFN, with the aim of bringing together in a national framework, the many public engagement activities in cosmic ray physics that already exist at the local level. Today, OCRA counts 24 of the INFN divisions and laboratories as members, with more than 100 people involved (https://web.infn.it/OCRA/collaborazione/).

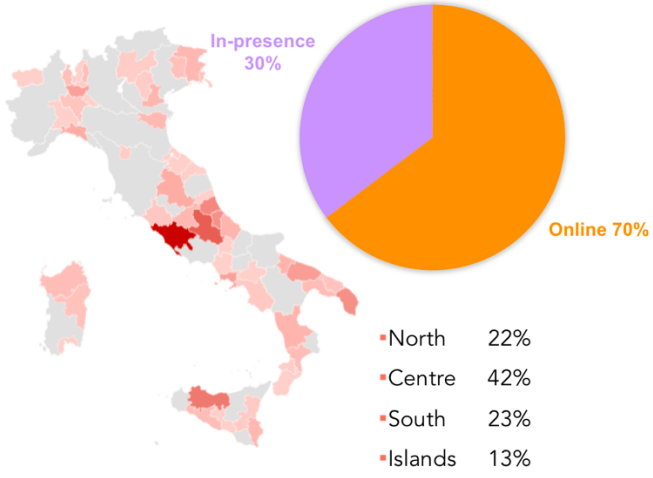
The activities organized within OCRA give students the opportunity to approach the subject in a practical and concrete way, which is not usually offered at school. In fact, OCRA organizes for students: International Cosmic Day, online laboratories, local activities such as internships, laboratories, competitions, science camps [2] and also the Pierre Auger Masterclass [3]. For teachers, OCRA organizes: an online course on interactive laboratories on the OCRA website, an in-person course on technology and science (as part of the PNRR-CTA+ outreach programme) and, finally, for the general public, participation in events such as the European Researchers' Night in different Italian cities, the Futuro Remoto Festival in Naples, the Festival of Genova, Galassica Festival in Esanatolia and many others.

However, the core of the OCRA project is the participation of all INFN sites in the International Cosmic Day (ICD) (https://icd.desy.de/). The ICD, which is organized internationally by DESY in cooperation with the Teilchenwelt network, the International Particle Physics Outreach Group (IPPOG), QuarkNet and Fermilab, will be celebrated for the eleventh time in 2022 and allows students to look beyond the usual stereotypes, to participate in a real data-taking session and to dive into the fascinating world of cosmic ray research, from history to frontier research.

This article describes in particular the OCRA ICD: groups of scientists, teachers and students from all over Italy meet for one day to learn about cosmic rays and to perform an experiment with atmospheric muons. Participation was very wide with 124 schools, 109 in-presence and 15 online, and 89 cities, 77 in-presence and 28 online (Figure 1). Usually, all participating groups investigate the same question: the zenith angle distribution of atmospheric muons. Using muon telescopes, the students, with the help of the researchers, try to answer the following questions: Is the number of air shower particles arriving from the horizon the same as from the zenith? What is the angular distribution of the cosmic muon flux? The students will be able to work together as in an international collaboration, discussing their results in joint videoconferences at the end of the day. At the end, they will be invited to publish the results of their measurements in the proceedings and will receive a certificate of participation.

Fig.1: Map of schools participating to the INFN OCRA ICD

The INFN has participated in the ICD since the first edition with the Lecce and Rome I divisions. In 2022, the ICD was organized in 19 locations participating in OCRA in-presence, of which one in dual mode and one online (Figure 2). In total, 910 students participated in the in-presence activities and 2098 in the online mode. The venues are smaller than the total number of participating INFN institutions, because some venues carried out the activity in collaboration (LNGS/GSSI, LNL/Padova), Milan could not hold an event because all OCRA members were absent on the day of the ICD. The event in dual mode, organized by LNGS and GSSI, was open to national participation. Figure 2 also shows the summary of the geographical balance and the percentage of student participation in the different INFN locations.



OCRA ICD Sites	
LNGS/GSSI (online)	21,6%
Roma	13,3%
Lecce	7,2%
Palermo	6,7%
Bari	5,1%
Trieste	4,9%
LNGS/GSSI	4,8%
LNF	4,7%
Milano Bicocca	4,6%
Cosenza (online)	4,5%
Catania	3,7%
Genova	2,8%
Perugia	2,8%
Sassari	2,8%
Napoli	2,4%
Padova/LNL	2,2%
Ferrara	1,8%
Pavia	1,7%
Trento/TIFPA	1,2%
Roma Tor Vergata	1,0%
Firenze	0,4%
Totale	100,0%

Fig.2: Map of INFN locations participating in presence (30%) and online (70%). The location with the most participants in presence was Rome, while the one with the most participants online was LNGS/GSSI.

The core programme, common to all INFN divisions, included an introductory seminar, the measurement of the cosmic muon flux from different angles at the site, the analysis of the data and the exchange with groups from all over the world at the end of the day. In addition, each department added complementary elements to the programme according to their possibilities, such as laboratory visits, exchanges with researchers and other staff about their careers, or the presentation of a cloud chamber. At the end of the day, all students were invited to answer a short questionnaire to assess their satisfaction, the results of which are reported in section 3. Figure 3 shows various moments of the ICD at some of the INFN divisions.

Fig.3: Different moments of the ICD, from the seminars to the measurements, the analysis of the data and the connection with the other participating groups, at some of the INFN divisions.

2. Analysis of the online survey

With the help of a sociologist, a survey was designed and administered at the end of the ICD to all participating students, both in-presence and online, with the specific aim of understanding not only the students' level of satisfaction with the event, but also which part of the ICD activities they found most interesting and why. A total of 1193 responses were received, of which 830 were complete, giving a response rate of 69.57%.

Figure 4 shows the gender balance of the survey and, as can be seen, participation was only slightly higher for boys. Furthermore, as the ICD was aimed at students in the last three years of secondary school, the age of participants ranged from 16 to over 19 years, with a peak at around 18 years. The level of satisfaction with the whole event is shown in Figure 5, with ratings ranging from 1 (poor) to 10 (excellent) for both face-to-face and online student participation. This means that, overall, the event met the initial expectations in a positive way, disseminating knowledge about cosmic rays in a clear and engaging way, increasing general interest in scientific research and sowing the seeds for later deepening of the knowledge gained. There is no significant difference between the students who participated in presence and those who participated online, as the average for presence is 8.1 and for online it is 7.5. This may be due to the special telescope used for the online event, the Cosmic Ray Cube [4], which allows students to take measurements remotely thanks to its app, as reported in section 3.

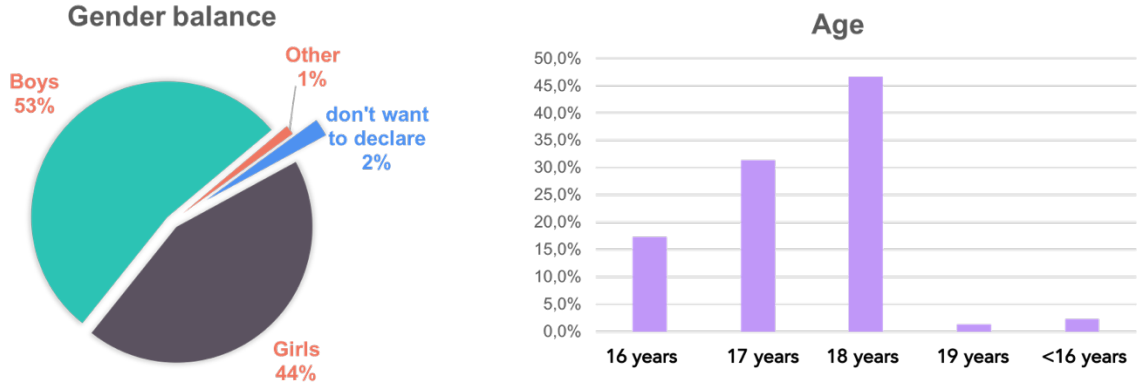
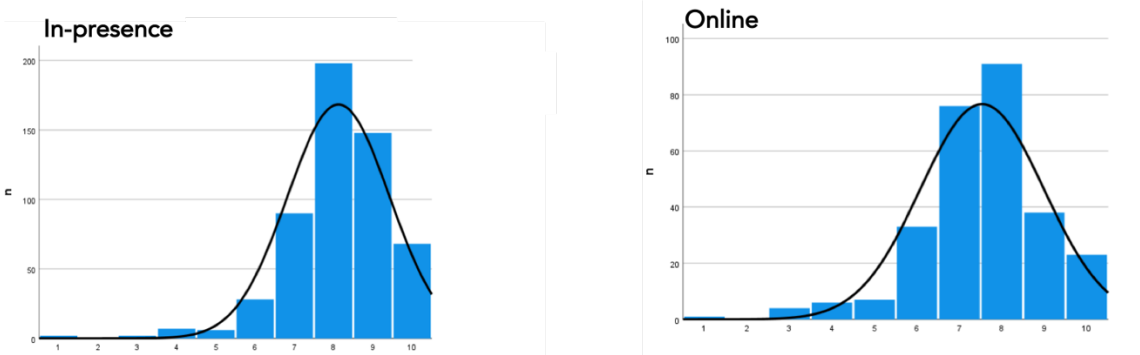


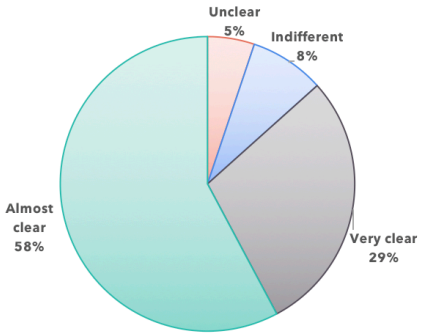
Fig4.: Gender balance and age range of students participating in OCRA ICD survey.



Statistics		
	online	In-presence
#	279	549
Average	7,5	8,1
Median	8,0	8,0

Fig.5.: The degree of satisfaction with the entire event ranged from 1 (bad) to 10 (excellent), for student participation online and in-presence, with related statistics.

The students were then asked if the event was clear and which moments of the ICD were most appreciated. As can be seen in Figure 6, the clarity of the event was 87% and only 5% answered that it was not clear. The responses also showed that the most appreciated moments of the event were the initial seminars and the measurement and data analysis. The least appreciated moment was the video-call with the other groups, perhaps due to organizational difficulties and connection problems. The laboratory tour, in the activities of some INFN divisions, was also appreciated by 60% of the students. Furthermore, when comparing the level of clarity between in-presence and online participation, there is again very little difference between the two (Figure 7). Both online and in-presence, students said that the information they received during the event was clear.



Indicate your level of satisfaction with the following moments of the ICD

(% n= 826)	Seminars	Data collection	Data analysis	Video-call with other groups	Laboratory tour
Not satisfactory	6,3	9	11,8	29,3	18,5
Indifferent	25,5	22,1	25,5	30,7	20,9
Very satisfactory	68,1	68,9	62,7	40,2	60,6
Total	100,0	100,0	100,0	100,0	100,0

Fig.6.: The degree of satisfaction for OCRA ICD – left and for the different moment of the ICD – right.

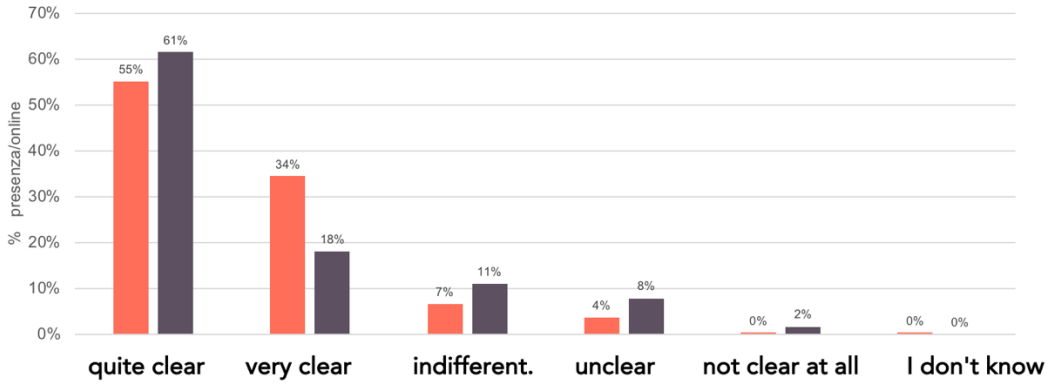


Fig.7.: The degree of satisfaction for OCRA ICD events, for online (orange) and in-presence (brown).

Among the many questions in the questionnaire, which are not shown in this article for reasons of space, one that seems very interesting is shown in Table 1, as the students were asked: "Which of these aspects of physics would you say fascinates you the most?" Multiple answers were possible. The answers show that curiosity, investigation and discovery are the key words for students 'interest in physics. The desire to explore the evolution of the universe is the most fascinating aspect, regardless of the mode of participation. In fact, more than 45% of respondents say that the possibility of investigating the evolution of our universe is the aspect that fascinates them the most. In addition to the question: "Would you advise your colleagues to take part? And why?" Almost 95% replied in the affirmative, giving a wide range of reasons such as "Wonderful experience"; "Interesting to deepen one's knowledge or to learn new things"; "It is an innovative project and very interesting for those interested in scientific subjects"; "Because it is an experience that allows you to get closer to the work of researchers, to learn more about them. At the same time, it allows you to deepen your scientific knowledge and satisfy those who are passionate about it"; "It makes the importance of scientific research and the influence of cosmic rays in current research very clear. It is very interesting to have taken part in this experience". Only 5% said they

would not recommend attending the event and justified this by the fact that "To understand many things requires skills that we do not have" or "I expected to be more involved".

% Of yes	In-presence	Online
The possibility of investigating the evolution of our universe	47%	45%
Study as continuous research and discovery	23%	23%
The discovery of new aspects of the universe that upset past conceptions	36%	31%
Curiosity towards the unexplained	35%	33%
A desire to understand and describe the world	21%	18%
The particular way of knowing, studying, asking questions	6%	8%
The analysis of experimental data	6%	4%
Career prospects	4%	5%
None of these aspects appeal to me	1%	4%

Table1: The answers to the question: "Which of these aspects of physics would you say fascinates you the most?" Multiple answers were possible.

3. The Cosmic Ray Cube – CRC

The CRC is a simple, compact and portable telescope designed by the INFN Laboratori Nazionali del Gran Sasso (LNGS) and used as a detector for the OCRA online ICD. It measures the flux of muons and their angular distribution. The track of the muon is revealed by the use of: plastic scintillators; the optical Wave Length Shifter (WLS), which collects the light and converts it into light of a different wavelength; silicon photomultipliers, which convert the light collected by the WLS into an electrical signal that is in turn digitized. The CRC has LEDs that are switched on when the particle passes through the detector, allowing the signal to be digitized. Thanks to its compact structure of 4 double-plane horizontal scintillation levels orthogonal to each other, and the possibility of being battery powered, it is easy to carry and allows to measure the flow of particles at various altitudes, their angular distribution, the efficiency of the detector for the variation of some operating parameters.

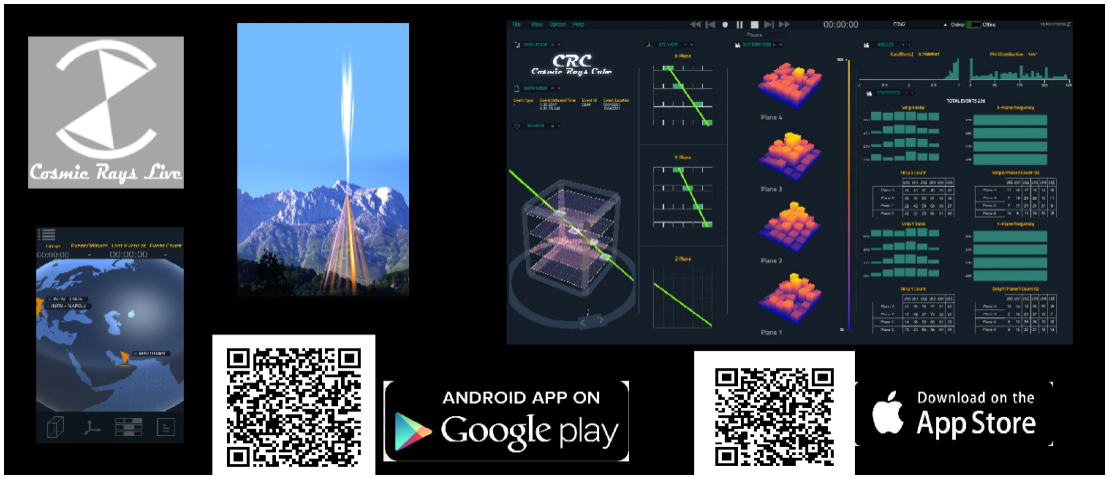


Fig.8: Cosmic Ray Cube and its App "Cosmic Rays Live".

The App "Cosmic Rays Live" has been developed downloadable from any smartphone, on which entire sets of data collected by the CRC can be saved. With Android or iOS system the data are automatically saved on the phone every time you connect to one of the sites where the telescopes are located. The data can then be analyzed to reconstruct the tracks left by muons in the telescope. The ability to use the App to take muon flux measurements allowed the students to follow the ICD online as if they were in presence, and resulted in the possibility of greater involvement during the activities. We currently have 5 CRCs in the OCRA and, with the new CTA+ programme [5], a further 9 CRCs have been funded to be distributed across the different sites.

4. Conclusions

Since its creation in 2018, OCRA has grown steadily. It has achieved its goal of providing a national framework for the many local outreach events on cosmic rays in the INFN. It has maintained its core activity, the participation of all local groups in the ICD. In 2022, the ICD was organized in 19 locations participating in the OCRA presence, of which one in dual mode and one online. A total of 910 students participated in the in-presence activities and 2098 in the online mode. The ICD OCRA event met the initial expectations in a positive way, disseminating knowledge about cosmic rays in a clear and engaging way, increasing general interest in scientific research and sowing the seeds for later deepening of the knowledge gained. The students' answers to the questions in the online survey show that there is no significant difference between the students who participated in the presence and those who participated online, as the average for the presence is 8.1 and for the online is 7.5. This may be due to the special telescope used for the online event, the Cosmic Ray Cube, which allows students to take measurements remotely thanks to its app.

5. Acknowledgements

Special thanks go to the group of local researchers from LNGS and GSSI who organized the OCRA ICD 2022 online event. The authors would also like to thank Suania Acampa for her support and work on the online survey.

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