PROCEEDINGS OF SCIENCE

Outreach, Education and Communication Programme of the CTAO

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The Cherenkov Telescope Array Observatory (CTAO) will be the world's largest and most sensitive instrument for the detection of gamma rays and the first open observatory of its kind, making our data from unique, high-energy astronomical observations accessible to all. The CTAO is in the process of becoming an ERIC (European Research Infrastructure Consortium), and the official start of construction on our two array sites in La Palma (Spain) and Paranal (Chile) is on the horizon. In this talk, we will present some of the international outreach and education programmes that are being deployed by the CTAO Outreach, Education and Communication Office during this exciting time.

We will present the educational programme, with a focus on the "Physicist On-Call" project to bring astronomy into the classroom. We will discuss the use of environmentally-friendly online communication and outreach tools, such as the Virtual Tour of CTAO-North, the CTAO array site on La Palma (Spain), and the CTAO virtual exhibit environment, used in science and technology conferences. Finally, we will delve into the "Astrodiversity Project," which includes guidelines for colour-blind friendly material, the "Women of CTA" event and "Building from Diversity," a monthly series of articles that features leading figures from underrepresented groups in science.

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1. Introduction

The Cherenkov Telescope Array Observatory (CTAO) will be the world's largest and most sensitive instrument for the detection of gamma rays. The CTAO will transform our understanding of the high-energy Universe by seeking to address a wide range of questions in and beyond astrophysics falling under three major themes: 1. Understanding the origin and role of relativistic cosmic particles, 2. Probing extreme environments, and 3. Exploring frontiers in physics. Moreover, it will be the first of its kind to be open to the world-wide astronomical and particle physics communities as a resource for data from unique, high-energy astronomical observations.

The CTAO will host dozens of telescopes on two sites: one in the northern hemisphere, CTAO-North, at the Roque de los Muchachos Observatory on the island of La Palma (Spain), and one in the southern hemisphere, CTAO-South, near the Paranal Observatory in the Atacama Desert (Chile). The so-called "Alpha Configuration" includes four Large-Sized Telescopes (LSTs) and nine Medium-Sized Telescopes (MSTs) at CTAO-North, and 14 MSTs and 37 Small-Sized Telescopes (SSTs) at CTAO-South. The CTAO gGmbH is the interim legal entity in charge of the design and implementation of the Observatory until the final legal entity, a European Research Infrastructure Consortium (ERIC), is achieved. The CTAO ERIC will be responsible for the construction and operation of the CTAO. The CTAO works in close cooperation with partners worldwide (In-Kind Contributors and science collaborators) for the development of the Observatory.

The CTAO's outreach, education and communication strategy has, thus far, been dedicated to developing a solid foundation for long-term communications and the gradual expansion of initiatives and materials for various target groups, including the general public, students and educators at all levels, the global science community, media and the local/national communities and key stakeholders of the CTAO sites. The CTAO aims to be a reference for inclusion and respect in science, to work internationally to achieve equity in our field, as well as to carry out activities that are environmentally, socially and economically sustainable. Thus, in developing the outreach, education and communication initiatives, we follow the diversity and sustainable values that characterize the Observatory.

In this proceeding, we report on the various programmes carried out in the past year by the CTAO Outreach, Education and Communication Office to bring high-energy gamma-ray astronomy to a broad public with especial emphasis on diversity and inclusion frameworks. It is divided as follows: Section 2 reports on the CTAO educational materials, particularly on the "Physicists On-Call" programme. Section 3 is dedicated to digital tools, with the aim of converting CTAO's communication material into a format that is more environmentally and economically sustainable. Finally, Section 4 describes some of the activities developed within the CTAO's Astrodiversity project, including the new programme: "Building from Diversity."

1. Education Programmes: Physicists On-Call

One of the CTAO's key target groups is the educational community. In order to provide material to explore the highest-energy Universe and bring the newly scientific field of gamma-ray astronomy into the classrooms or home, the CTAO has developed a dedicated webpage,

"CTAO for Educators." This webpage contains tools divided into different educational levels (Elementary, High-School, University and "All ages") that helps educators to find the most appropriate material for their students. "CTAO for Educators" provides videos and handbooks to work with the youngest, games and worksheets to explore specific topics of the field such as pulsars, explanatory and illustrative posters, as well as the "Dictionary of the Extreme Universe." The latter is a complete list of typical words used in (very) high-energy astrophysics with brief descriptions. This dictionary is the perfect tool to help and support different educational activities, including those available at "CTAO for Educators." The entire "CTAO for Educators" page, and the material therein (including the dictionary), is also available in Spanish in "CTAO para Educadores."

Additionally, the CTAO organizes "Physicists On-Call," an ongoing education programme that brings experts working on the science and technology of the CTAO into the classrooms and meetings of both inquisitive students and astronomy professionals around the world. To do so, any member of an education institution (primary, secondary, collegiate or post-graduate levels) or of an astronomy association can request a talk through a request form available on the "CTAO for Educators" page. While the request form is available in English, Spanish and Italian, presentations can be requested in any of the many languages spoken by the members from dozens of countries within the project. Presentations are initially carried out online, but in-person talks could be possible according to the speakers' availability. Educators can select the main topic already in the request form (delve into the Observatory, its science, technology, or general astrophysics talks and inclusive topics). However, based on the information provided, the topic is adapted to the level agreed upon between the speaker and the educator.

While the programme is always open and accessible through the website, dedicated advertisement is carried out on social media to reach a worldwide audience.

Edition	# Talks	Type	# Countries Reached	# Languages	Total People Reached	Gender Distribution Speakers
2020/2021	12	Fully online	5	5	~ 420	4 women 4 men
2021/2022	8	5 online 3 in-person	2	2	~ 275	3 women 3 men
2022/2023	3	1 online 2 in-person	1	1	~ 140	2 women 2 men
Total	23	--	--	--	**~ 835**	--

Table 1. Results for each edition of the CTAO's "Physicists On-Call" programme.

In the lifetime of the programme, more than 830 people have been reached, which implies an average of ~36 people/talk. The audience that was most reached was high-school students. Despite the difference in the number of talks requested per year (most likely due to later start and reduced promotion that took place because of other active programs), we can see a clear trend towards face-to-face talks. It should be noted that during the first year there were still mobility limitations due to the pandemic. The first year, five countries participated (Argentina, Iran, Italy, Spain, and the UK), and talks were held in 5 different languages. In 2022, two countries were reached, Spain and Italy, both hosting partners of the CTAO. Finally in 2023, three talks were

held, all of them in Spain with groups that had already participated in previous editions and that were satisfied with the result.

In terms of speakers, the number of speakers does not always match the number of talks, either because one speaker made multiple presentations or multiple speakers participated in the same talk. It is worth highlighting that in all editions gender equity is maintained, with exactly 50% of women and men participating, thus following the values of the Observatory.

"Physicists On-Call" is supported by members of the CTAO gGmbH, In-kind Contribution teams and science collaboration. Currently, the programme is coordinated by the CTAO Outreach, Education and Communication Officer, which receives the applications, searches for volunteers among the different groups, puts them in contact with the educators and organizes the meeting platforms, when necessary. In the future, one improvement will be the automation of speaker assignments, so that volunteers can access requests, accept them and contact educators or astronomical associations directly.

2. Towards Environmental & Economic Sustainability: Digital Tools

With the aim of moving towards a more responsible use of communication material that is respectful of the environment, the CTAO Outreach, Education and Communication Office decided to increase the use of digital tools in communication events. This practice is more sustainable on different fronts:

1. Printed material is significantly reduced: Although there are certain situations in which printed material is necessary, the use of digital tools helps to reduce paper waste, which is more environmentally and economically sustainable.

2. Discarded material is reduced: Especially in projects that are still evolving and growing, such as the CTAO, the information is constantly being updated. This implies that all printed material with outdated information cannot be used and must be discarded, which not only wastes money but has a negative impact on the environment. Digital tools allow immediate changes, without additional costs.

3. The carbon-foot print is reduced: Communication material is commonly used in conferences that take place in countries around the world. By using digital tools, we reduce the number of packages that are shipped internationally.

To this end, the CTAO Outreach, Education and Communication Office developed two tools: the CTAO-North Virtual Tour and the Virtual Exhibit Room.

3.1. CTAO-North Virtual Tour

The CTAO-North Virtual tour is an interactive tool specially designed for outreach and education activities. By means of 360-degree photographs (including aerials), the user can navigate and get to know the CTAO-North site on La Palma (Spain). The tour includes key information about the CTAO, as well as the site, with a special focus on interesting science and technology details from the prototype of the Large-Sized Telescope, the LST-1. Each information point is duly marked on the tour and the text is enriched by photographs, renderings or videos (Figure 1).

Figure 1. CTAO-North Virtual Tour landing page. The information points are marked with the "i" icon.

This tool is intuitive and easy to use so that the user can enjoy it independently or it can be used in public events, guided by a speaker. The tour is made up of eight spaces with 360-degree panoramic views that can be reached linearly from each scene or through a drop-down menu. Developed on the Klapty platform, the tour can be embedded or linked into web pages, as well as used with virtual reality headsets.

Both online and face-to-face activities have been carried out with this tool, including an online talk at the Futuro Remoto Festival and in-person conferences such as the European Astronomical Society Meeting (EAS2022) or the Big Science Business Forum (BSBF2022). The captivating images, the simplicity of the information and the fun, interactive element increase the versatility of this tool in terms of audience, being useful for both young students and for adult targets within or outside the astronomical field. When used in person, the use of an Ethernet connection is recommended to improve fluidity given the high quality of the images.

3.2. Virtual Exhibit Room

Imitating a typical conference stand, the CTAO Virtual Exhibit allows the user to click and read different communication materials, such as banners, fact sheets and brochures or watch a featured video (Figure 2). The entire space is customizable to the audience of each event. Its series of "action buttons" can take users to a list of the latest news linked to the CTAO website, to the aforementioned CTAO-North virtual tour or to topics related to the event audience. For example, "CTAO Performance" was featured for EAS2022 (where the target audience was researchers) and "Procurement" for BSBF2022 (focused on industry). Additionally, the page presents direct links to the website and social networks, as well as a QR code that is also customizable and adaptable to the target audience.

This tool was used during the ICRC2021, where the exhibitions were held online, as well as during the EAS2022 and the BSBF2022, both in person. In the latter cases, a touch monitor with an Ethernet connection was used. The result was very positive: more people came to the stand and spent more time exploring this virtual room, as well as the tour, which led to more questions and interaction with the public. Also, when conference participants came with a question, booth

members could easily make use of the monitor and show information through the virtual room, displaying specific web pages, the latest news on the website and allowing them to take the information with them, thanks to the QR link.

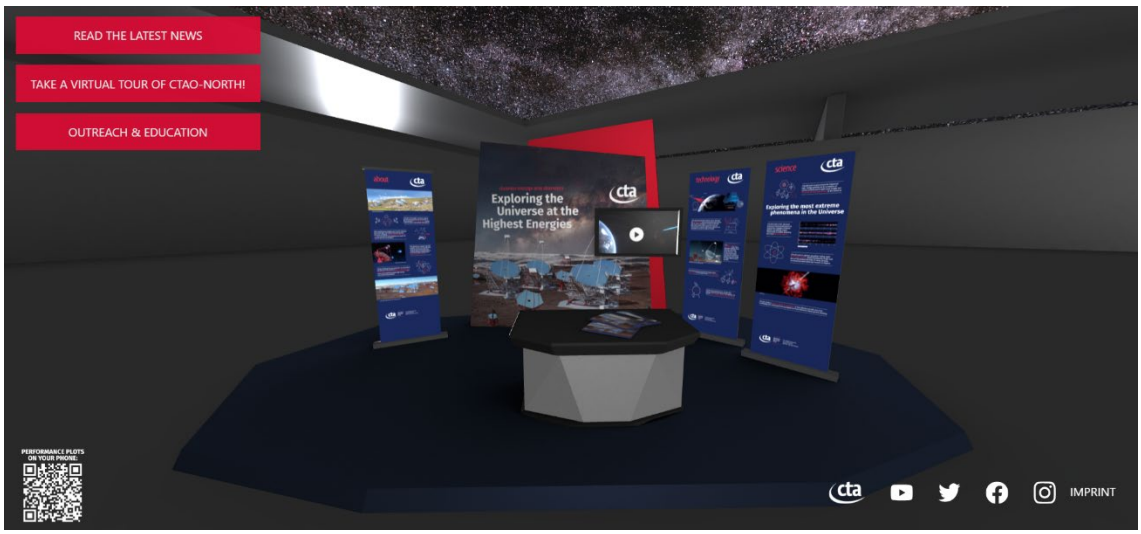

Figure 2. View of the CTAO's virtual exhibit. The material shown in the stand is clickable.

4. Inclusive Outreach: CTAO's Astrodiversity Project

The CTAO would not be possible without the efforts of an international network of contributors from dozens of countries that work together to implement what will be the first open ground-based gamma-ray observatory. We are proud of our diversity, which is also beneficial to the working environment, increasing creativity and providing different points of view that help to approach and solve problems. Based on this idea, the CTAO Outreach, Education and Communication Office created the Astrodiversity Project in 2019: an initiative to develop and support activities organized under the diversity and inclusion framework. In this proceeding, we highlight three of the activities included in this project: Guidelines for colour-blind friendly publications, the "Women of CTA" event and the "Building from Diversity" article series.

4.1. CTAO's Best Practices for Colour-Blind Friendly Publications and Descriptions

Colour blindness (or colour vision deficiency, CVD) refers to a reduced capacity or complete incapacity to distinguish colours and affects approximately one in 12 men and one in 200 women [1]. While there are different types of CVD, the most common one is the red-green colour blindness, which despite its name, does not only affect the visibility of red and green but the whole spectrum of colours, as red and green are part of every other colour to some extent.

Considering that the CTAO is an international observatory, whose work reaches the public worldwide, the CTAO Outreach, Education and Communication Office created the document "Best Practices for Colour Blind Friendly Publications and Descriptions" in 2020 [2]. All CTAO members and partners are encouraged to keep those best practices in selecting suitable patterns and colour palettes for the publication of scientific and outreach plots in papers, posters and presentations, as well as to provide inclusive descriptions. The CTAO Speakers and Publications Office (SAPO) and the Outreach, Education and Communication Office consider these guidelines during the review of all papers and materials.

The document, publicly available on the CTAO website so that anybody can read, share and follow the guidelines to reach a more inclusive workspace, provides clear and simple guidelines to facilitate the creation and dissemination of colour-blind friendly figures, as well as written and oral descriptions in and beyond the scientific field. Tips for using Python are also included. The document is expected to be updated with more tools and we welcome comments and suggestions via email.

4.2. Women of CTA

In recognition of the United Nations' International Day of Women and Girls in Science, the CTAO hosts the "Women of CTA" on or around February 11. The goal of this event is to gather three experts from the astrophysics and engineering fields to share their academic, professional and personal experience in science and their contribution to the CTAO. "Women of CTA" was launched in 2019 as a pioneering event for the CTAO's Astrodiversity Project, being the longest-running and most popular outreach event. While the first two editions of the event were performed in person in Bologna (Italy), during the pandemic, it was decided to move it into the online format (livestreamed on Facebook and YouTube) in English, which helped enlarge the audience, as well as the possible speakers.

The event was created as part of the global effort to raise awareness and find solutions to gender inequality and the overall under-representation of women in science. As one of the important factors that gives rise to gender inequities in the field is the reduced visibility of female leaders and their achievements in STEM (science, technology, engineering and mathematics) careers, the CTAO hopes that highlighting women who are leading and contributing to the Observatory will create a spark for girls and women interested in or already pursuing a STEM career. The fourth and fifth editions of the "Women of CTA" event (in 2022 and 2023) were carried out under the patronage of the International Astronomical Union Office for Astronomy Outreach (IAU-OAO) in Italy.

The format of all editions was based on formal presentations followed by a Questions & Answer session, except for the latest one, in 2023, where the discussion was prioritized. Thus, to further instigate the exchange of ideas, we changed the structure of the event to a round table focused on the following discussion themes:

1. *The future of Astrophysics: Gamma-ray Astronomy*
    - What impact does gamma-ray astronomy have on society?
    - What discoveries can we expect with the CTAO and how will it change our knowledge of the Universe?
2. *Women in Astrophysics*
    - What motivated you to pursue a career in STEM?
    - What are some of the challenges in your field and how can they be overcome?
3. *Science Education: From Citizen Science to Art*
    - Why is science education important and how can we engage more people?
    - What level of education should we be targeting?
    - How can art help bring science to the public?
    - How can we make science more inclusive?

The online format of "Women of CTA" not only allows feedback and interaction with the public

through questions on Facebook and YouTube, but it also allows us to keep a visual archive of the event. Analytics showed that views keep increasing after the livestream (i.e. offline views). On YouTube, it is among the Top 5 most viewed videos for the CTAO channel in 2023.

4.3. Building from Diversity

The observatories of the future, like the CTAO, own their progress not only to current researchers but also to past scientists that have expanded our scientific knowledge and worked hard to create a more inclusive and open environment. It is on their legacy that we build the CTAO. "Building from Diversity" is a monthly series of articles that features leading figures from underrepresented groups in science (women, LGTBQIA+, people with disabilities, etc.), whose work and actions have had a positive impact and helped to develop today's CTAO science, technology and education values. Written by CTAO members and external collaborators from partner institutions, each month the series delves into the work and lives of these researchers through short articles.

The series was launched in 2022 and has two editions. The first edition is composed of 11 articles, published from February to December, while the second, still on going, began in April 2023. Since its publication on April 28, 2022, the total number of visits on the article pages at the CTAO website sums ~4700, without considering visits to the dedicated page of the series. Additionally, each article is regularly promoted on social media, which help us introduce diverse scientists and their achievements on the CTAO feeds to thousands of followers each month. Thus, the series helps increase the traffic to the overall website but, more importantly, serves also as a tool for educational activities as an archive of information, references and open-source images.

To foster this educational objective, in November and December 2022, Francesco Longo (INFN) and Alba Fernández-Barral (CTAO) led a course dedicated to diversity in science at the Collegio Universitario Luciano Fonda in Trieste, Italy. The course, which included explanatory talks about the project, was focused on the presentations by the students who, using the articles in the series, further explained these scientific figures to their classmates. Moreover, one student chose a new scientist to research and wrote the article that closed the first edition of the series.

5. Conclusions

Continuing with its values, the CTAO seeks to create educational and outreach projects that: 1. Make information about the field and, especially, about the CTAO available to everybody, thus bringing the latest news with transparency and rigor; 2. Promote diversity and inclusion, either by raising awareness and informing, or by actively adapting tools for the entire population; and 3. Are economically and environmentally sustainable, understanding that science must advance while being respectful of the planet and available resources.

CTAO projects are evaluated and adapted annually. All the information is available through the official website. Comments, suggestions and synergy proposals are always welcome via email.

References

[1] Colour Blindness simulator and CVD information: https://www.color-blindness.com/

[2] Cherenkov Telescope Array Observatory (CTAO). (October, 2020). Best Practices for Colour Blind Friendly Publications & Descriptions.