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Research on the development of stereoscopic contents for experiencing cosmic ray air showers and information provision methods.

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Abstract. Air showers caused by high-energy cosmic rays are very large-scale natural phenomena in which a single particle interacts with an atmospheric nucleus and grows into hundreds of billions of particles on the ground. The air showers appear to reach the ground from an altitude of about 10 km, and their footprint on the ground is several kilometers in diameter. Despite this dynamic and interesting phenomenon, it is not well known to the general public. Most cosmic ray exhibits in science museums are based on real-time detection of natural radiation on the ground, and there are very few ways to convey the fascination of cosmic ray air showers. Therefore, we developed interactive content that shows cosmic ray air showers in a three-dimensional global panoramic image space. This content will be used in science museum exhibitions and educational events to promote awareness of cosmic rays. If the person experiencing the developed tool is interested in cosmic rays, explanatory video content will also be created to provide more detailed information about cosmic rays. The video content was published on YouTube by influencers. In this report, we will introduce the content of the air shower experience and discuss new information dissemination methods using the number of hits from the experience content to the explanatory video as a reference.

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1. Introduction

“What does the study of cosmic rays have to do with society?" is a question I receive with reasonable frequency. Is this because we are in Japan? Is it because I am an engineering researcher? I do not know. However, I can understand that the simple question includes "How is it useful to society?”. According to the SINIC-theory[1], science is positioned as follows. Science, technology, and society have a cyclical relationship. Scientific progress creates new technologies that benefit society. Society’s needs stimulate technological development and raise expectations for new scientific advances. "Muon radiography", a technique that uses secondary particle muons to see through large structures, is an application of detection technology, but it would be difficult to make it directly and intuitively understood as a benefit of air shower research.

However, the words "dark matter" and "black hole" seem to stand in a similar position, but the words are widely recognized. In addition to giving the words themselves a sense of wonder and interest, making them visible, as in the movie "Interstellar," is a necessary procedure for their widespread recognition. In Japanese culture, the phrase "Cosmic Ray" is often translated as "energetic particles (radiation)" in movies. This is one of the evidence of "Cosmic Ray" is not widely used in Japan. I once gave a data science lecture/exercise to a high school teacher and talked a little about cosmic rays. Many of them were math, science, and technology teachers, but they had never heard of the word "cosmic rays. However, they seemed to be more interested in the subject than in my data science lecture, and many of their questions were about cosmic rays. I feel that cosmic rays have the potential to be an attractive content for non-researchers as well. The problem here is that cosmic rays are not well known even to science teachers like them. According to Ralph C. Tillinghast and Mo Mansouri, about 70% of those who are Scientists and/or Engineers by profession develop an interest in science and technology by about age 12 (K-6)[2]. Subsequently, they appear to consider Scientist and/or Engineer as a job candidate at around age 15, and make the choice as a specific career goal at age 17 or later. In other words, in Japan, from the early stages of a child’s interest in science to the time when he or she chooses a future career, there is no exposure to, or even hearing of, cosmic rays. The GCOS project, which is the world’s largest unification project for ultra-high energy cosmic ray experiments, is actively discussing the next generation of experiments, which is my main field of research. In order to increase the number of human resources in Japan, we should immediately provide children, who will be future scientists and engineers, with the fascination of cosmic rays. According to Ralph and his colleagues, the development of professionals such as scientists/engineers is a key focus of science, technology, engineering, and mathematics (STEM) education and outreach programs. According to Ralph and his colleagues, the development of professionals such as scientists/engineers is a key focus of science, technology, engineering, and mathematics (STEM) education and outreach programs. It is supposed to be formed by a circular pipeline as shown in Fig1.

If the cycle by Introduce, Promote, Nurture, Recruit, and Retain is healthy, children will have our field as one option in the future. I feel that we (many Japanese cosmic ray researchers) neglect "Retain", "Introduce" and "Promote". It will be tapering off if we only "Nurture" the interest in science that has been generated in other fields.

We must discuss how air showers develop society. And we must share our genuine interest with the public to spread awareness.

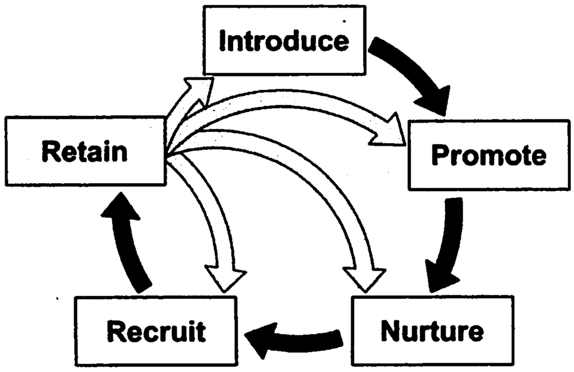

Figure 1: The circular pipeline of the STEM career.[2]

2. How to get into primary education?

In Japan (and probably around the world), the curriculum in the field of elementary education is meticulously structured, making it difficult for cosmic rays to penetrate easily. It is worth noting here that the Japanese government has been promoting DX in recent years, and under Covid-19, tablet PCs are now being distributed to each student in many elementary schools in Japan. This was used to facilitate home-based classes under Covid-19. Now that students are able to commute to school, tablet PCs are used for educational support applications for calculation and writing(Kanji-character). They are also used for extracurricular activities, such as taking pictures of small animals, insects, plants, and flowers and sketching them in the classroom. We believe that such usage is merely a reinforcement of past education. On the other hand, the field of educational technology is working day and night to research and develop new tools for the acquisition of some knowledge and skills. Some of them have confirmed that virtual reality (VR) tools can speed up the acquisition of introductory skills in kendama (a traditional Japanese game), and they are trying to teach algorithms through programming by combining blocks. How the cosmic rays enter into it is important. I believe that there is a way to take advantage of the fact that cosmic ray air showers are a large-scale phenomenon that occurs all the time around us, but is not recognized by the human eye because it is invisible to the human eye. We should give people the opportunity to experience natural radiation through experiential contents that are made realistic enough by VR and augmented reality (AR). Of course, it is an opportunity for students to be exposed to the latest technology such as VR/AR (DX promotion), but it is also in science education. The evaluation of whether or not interest in natural radiation, which is invisible to the human eye, is generated by the latest VR and AR technology can be used for research in the field of educational technology. However, cosmic rays do not necessarily have to be the object when evaluating the occurrence of interest. That is why we should participate. Of course, it would be more impressive if there was an intuitive detector like the one developed in SNOLAB's The Cosmic Ray Live Project[3]. However, it would be expensive and difficult to distribute. If two simple scintillation counters could be coinsidence, it would be possible to tell the track of radiation.

3. Why Virtual Reality(VR)?

There is a Japanese proverb that says, "Seeing is believing. The exhibits of cosmic rays at science museums are "fog boxes," "spark chambers" and “scintillator trackers". These are intended to visually capture secondary particles and show that they are indeed present in what seems to be empty space. However, it is difficult to intuitively connect this to the fact that they are flying in from space. They only indicate that something passes in a straight line. If visitors are interested they might read a sign explaining that it is radiation. If they are interested in that radiation, they can trace their interest to air showers (cosmic rays). Air showers in virtual reality more directly connect the track signal of the exhibit to its source, cosmic rays. It creates a more "air shower dynamic" than a detector placed on a table. And it can be expected to increase interest in the detector’s signal. As scientists, we often insist on being "real." Planetariums are not real stars, but we love them too.

We have developed head-mounted VR content for cosmic ray outreach that can be used as an alternative to planetariums. Planetariums are suitable for reproducing celestial objects, but are not suitable for reproducing air showers caused by cosmic rays in a realistic manner. Air showers occur around us, and their distance is too close to be attached to the celestial sphere. In VR, the distance and the size of the air showers can be represented by buildings, trees, and mountains in the background. AR may be more suitable for reproducing only air showers on a real background, but it is difficult to adjust the size of air showers according to distance based on location information and to represent shielding such as buildings in a flexible manner. In addition, the fact that it can be used indoors was a factor in our decision to use VR in this case.

In addition to VR content that runs on head-mounted displays, we are also developing 360-degree panoramic content that runs on tablet devices. The figure2 shows an image of the VR content and a QR code. Since you may not be able to see it with a still image, we hope you will experience it with your tablet. Few people, even researchers like us, know the magnitude of a 10^{18}eV air shower generated 80 km away and projected onto the landscape.

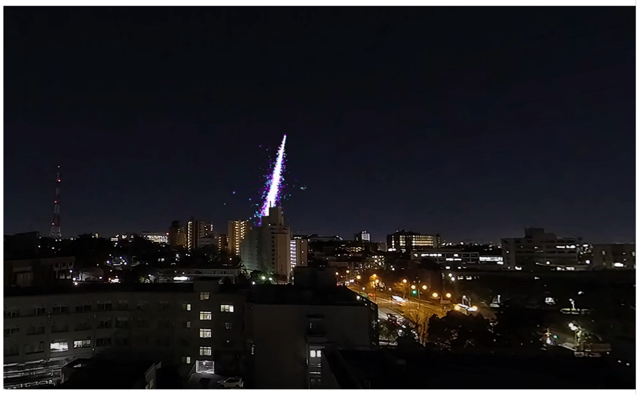

Figure 2: The image of the VR content and access QR.

4. Why this collaboration with YouTubers?

This is not an era in which the primary media in gathering information for interested people is the written media. They will first look for easy-to-understand explanations by video after bringing home their interest in cosmic rays (air showers) through hands-on experiences, tracker exhibits, and classroom. Parents who are asked by their children for explanations will also choose video first as an explanatory tool. In Japan, there are far fewer videos explaining air showers. There are only esoteric (class-like) instructional videos showing us and our peers. The number of views is about 1,000 at most. Perhaps there is more of a gap between us and the general public than we realize, or perhaps the language is too technical. Even if we bring back interest in cosmic rays (air showers) through VR air shower experiences and tracker exhibits, we are not "Promote" to do so. Influencers who produce science-related instructional videos have the skills to close that distance. And they can reach tens of thousands of people with a single video. If we were to conduct lectures or events for the general public, it would be impossible to reach tens of thousands of people at once with information about cosmic rays.

We collaborated with a Japanese YouTube channel (Uchu Yabai ch.) to create and publish the video. We supervised the creation of the video, but avoided modifying the language as much as possible. The channel has 270,000 subscribers, and the videos on the high-energy cosmic rays, air showers, and the Telescope Array experiment have 45,000 views3.

The muon radiography video created in the same collaboration has 67,000 views. Videos on astronomical subjects on the channel have more than 100,000 views, but cosmic rays are also apparently enough to attract a large number of people. According to the channel's administrator, the continuity of video publication and thumbnails are important. We will be difficult for us to continue to publish information every week and to acquire the know-how of thumbnailing, etc. On the other hand, a similar video was released on the YouTube channel of Shinshu University's Faculty

Figure 3: Playback status of the video (2023.08.17) and QR link to the English version of the same video.

of Engineering, but the number of views was only 100 at most. We need to not only bring people together at speaking events, but also take advantage of the places where people already congregate.

5. Science Museum events and other activities

The tools we have developed are already being used in some situations. One of them was offered as the main part of a lecture at the Osaka Science Museum in March 2023[4]. We have received positive feedback from visitors, such as "I have been to the science museum several times, but I used to pass by the cosmic ray section, but this event got me interested in cosmic rays." In addition, the following questions and comments were received regarding air showers and observations of dimming energy cosmic rays.

- I found XX shower!
- What is the difference from aurora borealis?
- Why doesn't the telescope move?
- Why doesn't the telescope move?

The roughness of the resolution of the air shower object is noted. We believe this is an indication of the desire to see air showers blended into the landscape in more natural detail. In other words, interest in cosmic rays is beginning to grow. This will need to be corrected as soon as possible to make the content more effective.

Figure 4: An act in a lecture event at the Osaka Science Museu.

Other applications include lectures at junior high school science clubs in Nagano (that is local city in Japan), lectures at the University of Tokyo, Special lectures for high school students, lectures for the elderly, and open campuses at various universities. The participants' opinions infer that all of them have increased their familiarity with air showers (cosmic rays). The next step will be to evaluate these quantitatively.

6. Summary

We must outreach to the general population to maintain cosmic ray research. We can expect further effects by collaborating with educational engineering and science museums targeting elementary education. We have developed VR contents that can be experienced with a head-mounted display, which can be a gateway to learn about cosmic rays. The contents have already been used in several situations and have been well received. Quantifying these effects is a future challenge.

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[3] Attanasio Candela Silvia Scorza, Aldo Ianni and Massimiliano De Deo. The Cosmic Ray Live Project @SNOLAB. 17th International Conference on Topics in Astroparticle and Underground Physics (TAUP 2021), 2021.