PROCEEDINGS OF SCIENCE

HEPScape! The High Energy Physics Escape Room

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HEPScape is an escape room about particle physics built in 2021 by a team of INFN researchers. The visitors have the impression of entering one of the experimental control rooms of the Large Hadron Collider at CERN. Through clues hidden in the room, and with the help of a moderator, they discover the purpose of high energy physics and how particle accelerators work. HEPScape is made of portable equipment and this allows to use it in science fairs, exhibitions and schools. The experience from three science fairs in Italy is presented.

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1. Introduction

In recent years escape rooms became very popular. An escape room is a sort of treasure hunt in a closed room, where partecipants have to solve quizzes and puzzles in a given amount of time to escape from the room. An external moderator guides the experience, helping the team to find the clues hidden in the room and solve them in time. Escape rooms are very popular nowadays among teenagers, because they're really fun. They are also often used by adult co-workers as a team building exercise, since partecipants have to work together to accomplish a goal.

For their characteristics, escape rooms can be used for teaching purposes. The different activities which are offered help in developing multiple skills, from critical thinking to communication and organization, to the ability of working in a team. The students' curiosity is stimulated through the active discovery of a new topic. Therefore in the past few years escape rooms were adopted by some teachers as an innovative way to teach their subject, see e.g. [1]; the initial feedback has been quite good.

Escape rooms have already been adopted for science outreach. In 2019 a CERN team proposed an escape room about particle physics as an activity for the CERN Open Days visitors. In 2020 a group of scientists from the CMS experiment organized a similar activity for a high school student internship, and the students really enjoyed it. In 2021 a group of researcher from INFN Rome proposed an escape room named HEPScape [2]. It was presented as an attraction in 2021 at the European Researcher Night in Rome and at the Genova Science Festival, then in 2022 at the Open Day of the INFN National Laboratory of Frascati. The activity reached so far more than 1200 people and it was received with great success, as discussed in this paper.

2. HEPScape setup

HEPScape has been conceived as a portable kit, which fits a normal size car and can be mounted in roughly two hours by three people. It can be installed indoor in a room or outdoor in a gazebo, with a total needed space of about 25m^2. Partecipants have the impression of visiting the CERN Large Hadron Collider LHC [3], the largest particle accelerator in the world which is hosted in a tunnel underground. The door of the escape room is made with a PVC curtain showing the image of the LHC tunnel, and pictures of the LHC and its experiments are also available on several posters both inside and outside the room. Inside the room there are also posters giving visitors the informations which are needed to solve the games: the periodic table of the elements, a picture showing the structure of the atom and one with the quarks inside a proton. In the room there are three projectors controlled by a laptop: a big one pointing to the largest wall and other two ones projecting on the side walls. Six LED lights controlled via bluetooth are used to create special effects and to drive the visitors' attention to the clues. When the game starts the visitors are told that they're going underground, and the three projectors show the movie of a lift going underground in one of the LHC pits, courtesy of the CERN superconducting magnets SM18 visitor point. The video is projected on three walls of the room, creating a truly immersive experience. After that a sequence recorded in the CMS experiment control room by Z. Szillasi and N. Beni in 2021 is projected on the lateral walls and it runs during all the activity. The film was recorded with a special 360 degrees camera and then reframed to show the two opposite sides of the room. People

working in the control room are shown, and moving from one side to the other the visitors have the impression of really being inside the CMS control room. The main projector is used to show the games content and videos where scientists explain how a particle accelerator works and give some informations on the matter constituents.

To run HEPScape two or three persons are needed. A moderator inside the room guides the visitors and explains the science behind the games: how the accelerator and the magnets work, what are the building blocks of the matter and finally how the Higgs boson was discovered. One or two extra persons are needed to control the room lights and the projectors.

3. The game

The visitors are welcomed outside the room: they are asked to wear a helmet and they are

Figure 1: Photos of HEPScape: (left) entrance of the escape room installed outdoor in a gazebo and (right) CMS magnetic puzzle.

told that they are going to visit the LHC. The game starts as soon as all the visitors are inside the room and seated. The escape room is available in two versions, tuned on the visitors' age: one for children (approximately 8-11 years old) and one for adults and teenagers. Visitors have to solve quizzes with the help of the moderator. A few closed locks are hidden in the room and they are opened with a numeric code when a game is solved. Everytime a lock is opened the visitors find an explanation about the scientific content that was used to open the lock. They also find pieces of a magnetic puzzle representing the CMS detector, which they have to 'repair'. A group is composed by 20 visitors in average and the entire experience is about 30-40 minutes long.

During the first game the visitors have to guess the depth of the LHC tunnel. Adults have to solve a system of simple mathematical equations, while for children there is a game based on symmetries. Everyone is shown pictures of the tunnel and the magnets.

In the second game the partecipants discover that LHC employs Nb-Ti magnets solving a cross-word. Using the atomic number of these elements they can open the lock and find some informations about the magnets.

The third game is about the Standard Model of particle physics: using plastic balls with different weight the visitors have to identify the proton constituents.

Once the third game is solved, a movie shows how the protons are accelerated and collide in the LHC originating other particles. The moderator explains that some particles are unstable and decay into other particles, which may be recorded in our detectors. As an example, the visitors search for the Higgs boson decay in four muons as the real scientists do: they look some event displays which are projected on the screen and count the number of muons in each event, until they identify a candidate Higgs boson event with four muons. The HEPScape experience ends with the video of the announcement of the Higgs boson discovery, which happened in the CERN main auditorium on July 4th, 2012. After that there is a brief discussion time when the moderator answers the visitors' questions. Images of HEPScape are shown in Fig. 1.

4. Satisfaction test

When exiting the room the visitors are asked to fill a survey with two questions: their age and their satisfaction, in a scale from 1 to 5. The goal of this simple survey is to collect a large number of responses to have a representative sample of the visitors' satisfaction.

The results of the survey at the Genova Science Festival are shown in Figure 2. The left

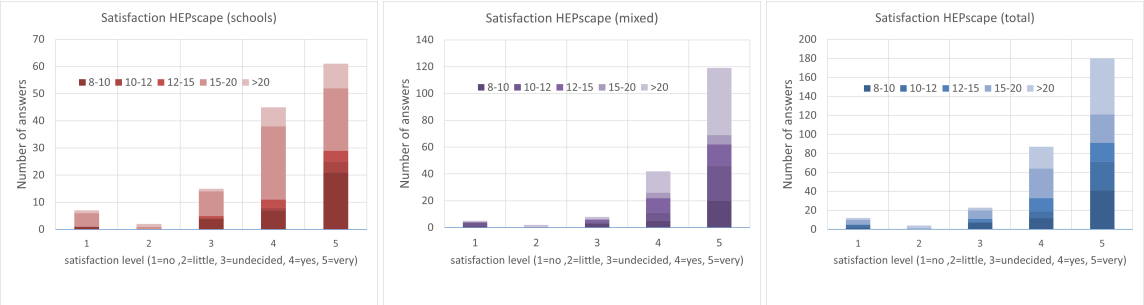

Figure 2: Result of the HEPScape satisfaction survey at the Genova Science Festival for (left) school groups, (middle) mixed groups and (right) total audience. Votes range from 1 (not at all satisfied) to 5 (very satisfied). The visitor ages are indicated in the legend.

figure shows the satifaction for groups of school students with their teachers; the children or adult version of HEPScape was run depending on the age of the class. The central figure refers to mixed groups: adults curious of science, families with kids etc. Since these groups were mixed the escape room was always run in its version for adults. The right figure is the combination of the other two ones and it shows that overall the visitors liked the experience, with an average mark of 4.4/5. Comparing the left and central figures, it can be noticed that children liked the HEPScape version tuned on their age much more than the one for adults. Also teenagers who played the escape room in mixed groups enjoyed the activity more than those in school groups, probably because of an interest in science which brought them to visit the festival.

5. Next steps

So far the HEPScape activity was presented in 2021 at the European Researchers' Night in Rome and at the Genova Science Festival, and in 2022 at the Open Day of INFN National Laboratory of Frascati, for a total of about 1200 visitors. HEPScape was also presented in Bologna during the ICHEP 2022 conference. Our goal is to increase the diversity of our public, for instance bringing the escape room to schools in regions far away from big cities. The translation of the games in languages other than italian is ongoing, and a version of HEPScape in the language of signs is in preparation. Finally, a network of interested institutes is being created to share ideas and contents.

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