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TACTILE COLLIDER : ACCELERATOR OUTREACH TO VISUALLY IMPAIRED AUDIENCES

R.B. Appleby †, B. Kyle, M. Hibbard, B. Jeffrey, T. Pacey, H. Rafique, S. Tygier, R. Watson
The University of Manchester and the Cockcroft Institute of Accelerator Science and Technology.
C.S. Edmonds,
The University of Liverpool and the Cockcroft Institute of Accelerator Science and Technology , UK
A. Healy, T. Boyd
The University of Lancaster and the Cockcroft Institute, UK

Abstract

The Large Hadron Collider (LHC) has attracted significant attention from the general public. The science of the LHC and Higgs Boson is primarily communicated to school children and the wider public using visual methods. As a result, people with visual impairment (VI) often have difficulty accessing scientific communications and may be culturally excluded from news of scientific progress. Tactile Collider is a multi-sensory experience that aims to communicate particle accelerator science in a way that is inclusive of audiences with VI. These experiences are delivered as a 2-hour event that has been touring the UK since 2017. In this article we present the methods and training that have been used in implementing Tactile Collider as a model for engaging children and adults with science. The event has been developed alongside experts that specialise in making learning accessible to people with VI.

INTRODUCTION

The largely visual communication of the leading science of the 21st century excludes the large fraction of the world's population with some kind of visual impairment. For example, pictures of galaxies, a Higgs boson event or a photograph of the lattice of the LHC. This exclusion is large - the UK alone has 3M people with some kind of registered VI [1] - and often this audience has other, related disabilities. Tactile Collider [2] is a first of its kind project to engage this audience in fundamental science and develop new models and approaches to the audience engagement. The Tactile Collider team has worked with VI experts and consultants to understand the audience and make communication materials that really work. In this paper we describe the methods used to produce the Tactile Collider materials and the formulation of the Tactile Collider touring event, which has toured VI centres, schools and events since 2017. To understand what Tactile Collider event looks like, Fig. 1 shows an event in a VI school, with scientists engaging in new ways with VI audience members. The event is focused around four interactive stations and an accelerator model called Cassie. We shall describe these, and the design process, in this paper. For the Tactile Collider model and event evaluation see [3].

† Corresponding author, robert.appleby@manchester.ac.uk

Figure 1: The centrepiece of a Tactile Collider event is CASSIE particle accelerator model. This is surrounded by four breakaway activity stations that focus on particles, magnets, acceleration and the Higgs Boson.

DESIGN OF THE TACTILE COLLIDER EVENT

The strategy of Tactile Collider is an event focused on the needs of the audience. Each of the stations described in the next section and the experience was designed to be authentic, in the sense that the science message and experience given to a VI audience should be in no way different to that given to a non-VI audience in content or depth. Materials need to be adapted to a number of different mediums and the time taken to deliver content needs to be extended to allow the target audience time to engage with complicated theories and ideas. For example, visually communicated ideas on how we use magnets to bend and focus particle beams should be done using Tactile map, tactile objects through games and using audio in terms of sonification. This audience equality is crucial to the democratizing of the scientific debate. In the same way, authentic scientific language should be used where possible, with appropriate definitions and clarifications.

The material should be communicated in several different ways, to accommodate varying degrees and impact of personal sight loss and personal learning strategies which have evolved as a result. This multi-mode approach reinforces the key learning points and gives the learner the option of different methods. For example using a tactile diagram alongside a tactile object and audio soundscape to explain the movement of particles in a particle accelerator; or the combination

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of a tactile object and a tactile diagram for the concept of a bar magnet. Next, the needs of the learners with VI require close interaction with a scientist-presenter in a group of no bigger than four participants. The scientist should be trained in visual impairment awareness, sight guiding, audio description and presentation of a tactile narrative linked to the learning outcomes. The range of visual impairments in the audience group is broad, with total sight loss uncommon and the requirements of text size and materials very person dependent. For example modified large print, alongside Braille, is needed on all material. This awareness is essential for the presenter, and defines the mode of interaction, with a strong audience-led approach. The training of presenters for a project with an audience with VI is essential and core to success.

A variety of techniques and tools were used to create the Tactile Collider materials.

3D Printing and Casting

3D printing in Tactile Collider is very important as a way to produce new tactile objects, based on abstractions or technical drawings. The team was trained in CAD design and 3D printing and, once the core science messages were defined, the objects were created. Figure 2 shows this process for a tactile model of a quadrupole, showing the CAD drawing and the printed result. 3D printing produces low cost, light, safe and easy to handle objects.

The large Tactile Collider events need many objects, so that each audience member can use the materials. This was achieved with casting, where a silicon mould was made from a printed object and then the mould was used to form resin casts. The mass-produced, cast, quadrupole models can be seen in Fig. 3, also showing a beam model in white.

Tactile Diagrams

Important ideas in Tactile Collider are communicated in several different ways to allow the learner to choose the method best suited to them. Tactile Diagrams are made on a swell paper printer, which causes raised bumps to appear on swell paper marked in black ink. This means diagrams can be created which can be felt, as well as seen. For details see our web-site [2].

Sonification

A further technique is sonification, where the scientific ideas are made into sound and soundscapes. For example, Higgs events from the LHC are turned into 3D sound with the particle direction from the collision point encoded into the direction of the sound and the momentum mapping to pitch. These techniques are under development and used in three of the four Tactile Collider stations. For details see our web-site [2] and contact us for other sonification projects.

CASSIE

The centre-piece of the Tactile Collider events is CASSIE - Conceptual Accelerator Set-up Supporting Inclusive Education - which is a 3.5m diameter portable particle accelerator model. The aim of CASSIE is bringing a model of an accelerator to a audiences who may not have the opportunity to visit a laboratory like Daresbury or CERN. The Cassie tactile quadrupoles are shown in Fig. 4.

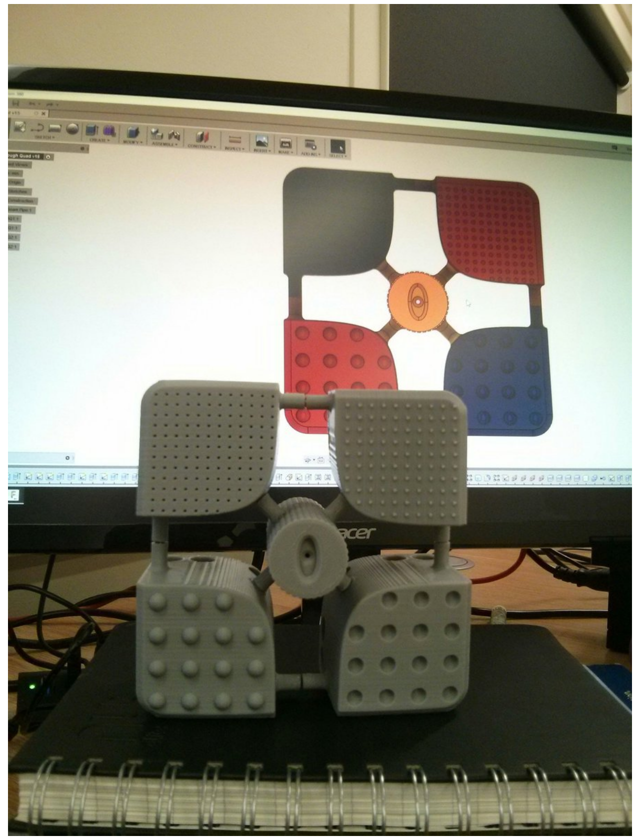

Figure 2: 3D printed models feature bumps and indentations that represent North and South poles respectively. The shape of the beam insert (centre of magnet) matches the dimensions of the particle beam, giving a tactile representation of the quadrupole's focusing effect.

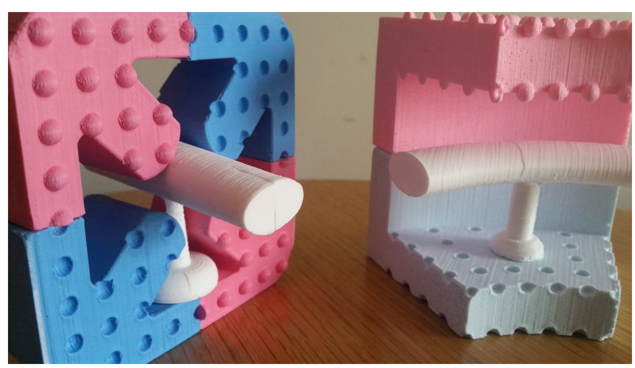

Figure 3: 3D printed magnets (shown in figure 2) are finished with carefully selected contrasting colours that allowing easy differentiation between North and South by a person with colour blindness.

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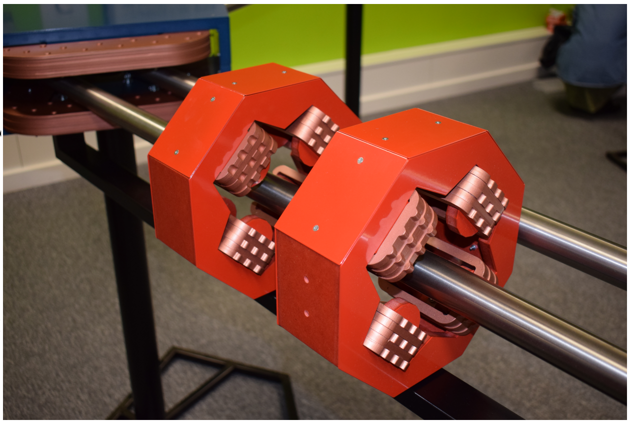

Figure 4: The CASSIE magnets use bumps and indentations to represent north and south poles in a way similar to the 3D model shown in Fig. 2.

FOUR ACTIVITY STATIONS

Tactile Collider is built around the concept of four stations, corresponding to the four science areas of the project, based on LHC and the Higgs boson, and each of the stations has a set of learning outcomes and draws upon the full range of techniques and communication methods. The four stations cover material needed for understanding the event concepts.

The script for each station covers learning outcomes and the suggested use of the materials, whilst learning the presenter free to interact naturally with the audience. The half-time break is an opportunity for a guided exploration of the 3.5m tactile teaching particle accelerator called Cassie. The content was the same as that delivered to a non-VI audience. The materials for each scientific station were multi-mode, with a learner able to select the method that suits them best, and developed over a long period of time. For example, the Higgs boson station represented the physics of a Higgs boson using touch, sound and speech. The events also included public 'drop-in' events and teacher training (CPD) sessions. The event includes drama activities for the introduction and half-time break of Tactile Collider events. This got the audience moving, broke down barriers and reinforced learning outcomes. The drama took the form of small groups of audience members performing small pieces to the rest of the group, with a Tactile Collider team member audio describing.

The first station is the particle station, where the learning outcomes are

- Everything is made out of a set of very small fundamental particles.
- These particles interact with each other through forces (exchanged particles).
- We have a theory – the standard model - that describes these particles and their interactions.

In this station, materials were developed such as particle sorting games, tactile diagrams and tactile models to explain the size and structure of particles.

The next station is the magnet station, where the learning outcomes of the magnet station are

- The concept of a magnet, magnetic poles and attraction/repulsion of magnets.
- Controlling a beam with a magnet, bending (dipoles) and focusing (quadrupoles).
- Building a ring with magnets.

The aim of the magnet station communicates the concept of a magnet and how they are used to bend and focus particle beams in particle accelerators. In this station, materials were developed to build up the ideas of magnets, dipoles, quadrupoles and magnetic lattices. The concept of a tactile magnet was central to this station.

The acceleration station communicates what acceleration is and how we use electric fields in cavities to accelerate charged particles.

- What is acceleration: linear (and ring).
- Accelerate using waves of energy.
- Create waves of energy with radio frequency accelerating cavities.

In this station, materials were developed such as static electricity games, tactile models and maps of cavities.

Finally the Higgs station has learning outcomes,

- Squeezing of the beam, beam envelopes.
- Detectors and collisions.
- Higgs and Higgs events,

and aims to communicates the idea of the Higgs boson and the observation using particle detectors. In this station, materials were developed such as tactile real Higgs decay events from the LHC, jigsaws of particles detectors from the LHC, models of real detectors and tactile diagrams.

CONCLUSIONS

Our conventional science communication in accelerator science is largely visual, excluding large audience groups. Tactile Collider is a novel project to develop communication techniques for this audience, benefiting also non-VI people who can learn through multi-mode techniques. Full details and teacher packs for all materials in [2, 3]. We're very keen to work with any group in our field to enhance communication techniques and consult on reaching a VI or other disadvantaged audience. Please contact us!

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