PARTICLE ACCELERATORS FOR HUMANITY: RESOURCES FOR PUBLIC ENGAGEMENT WITH PARTICLE ACCELERATORS

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Abstract

To those who work in the accelerator field, it is obvious that there are many applications of accelerators beyond particle physics. Yet the public remain largely unaware of the far reaching uses of accelerators, or the scientific and engineering challenges that lay behind them. A recent project Particle Accelerators for Humanity has addressed this gap by creating a series of video resources, based on a programme of live events, short films and a specially commissioned animation. The project captured the dedication and diversity of those who design, operate and work with accelerators and highlights the varied ways in which their work is impacting on our lives. Here we overview the project and the resources, available under Creative Commons license, and provide an overview of the impact of the project so far. We encourage the accelerator community to use the resources in their teaching and public engagement activities.

INTRODUCTION

The 'Particle Accelerators for Humanity' project was an STFC-funded public engagement project designed to communicate the science, applications and diverse community in the field of particle accelerators. The project was delivered by the Royal Institution (Ri), a UK science institution with over 200 years of experience in science communication. Alongside live events the Ri also run an online channel, the Ri Channel[1] and have an in-house production team, enabling them to reach a much wider audience with science.

In a recent survey, roughly 75% of science-interested respondents could not name an application of particle accelerators outside of particle physics [1]. In this project, the Ri teamed up with Dr. Suzie Sheehy (the author) to address the shortfall of high quality public resources about particle accelerators. In particular, the project aimed to communicate about accelerators beyond those used in particle physics. Two live events, four short films, an animation and a 3D fly-through video were produced, along with a dissemination event for UK-based accelerator scientists and public engagement professionals. Here we give an overview of the contents of the films, and show some results from the evaluation of the project.

VIDEO RESOURCES

Powering a Particle Accelerator

In this video, the team went behind the scenes at the ISIS neutron and muon source in the UK to meet scientists, engineers and an apprentice all working toward the common goal of keeping a high power proton accelerator running in a 24/7 user facility. Running the synchrotron magnets requires a custom electrical system that uses a resonant circuit to establish the high currents needed 50 times per second. This system, however, is built in-part around an old 'choke' that was inherited from a previous machine when ISIS was built over 30 years ago. This video focuses on a major electrical engineering project to upgrade the power system of a particle accelerator, and shows what it takes to keep control of a machine this complex.

Figure 1: Still image of a short film about people and power circuits of the ISIS Neutron and Muon Source

Protein Folding and Particle Accelerators: A New Solution

The role of water in sustaining life is well known, but scientists have assumed for many years that it plays no role in the biological processes such as protein folding. In this video, Dr. Sylvia McLain, a University Research Lecturer within the Department of Biochemistry at the University of Oxford, and her team are using the ISIS Neutron Source to test the role water plays in protein folding, and are finding that it may not be quite as passive at it seems.

Figure 2: Still image of the short film on Dr. Sylvia McLain's groups research on the role of water in protein folding.

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[1] http://richannel.org

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How to Trap Particles in a Particle Accelerator

Being able to focus and contain particles is a key idea in accelerator science. In this video, Dr. Suzie Sheehy uses two versions of Paul traps which rely on the same equations of motion as beams in strong focusing accelerators. First, a mechanical analogue is shown in which a ball on a saddle apparatus shows how the alternating gradient of the sides of the saddle contains the ball in the centre, in analogy to quadrupole focusing systems in accelerators. Next, a more sophisticated setup is shown, a quadrupole linear Paul trap, in which pollen grains are held in place using oscillating AC fields in a quadrupole formation. These analogies tie in to Dr. Sheehy's own research in collaboration with Hiroshima University using Paul traps to explore fundamental concepts in beam physics.

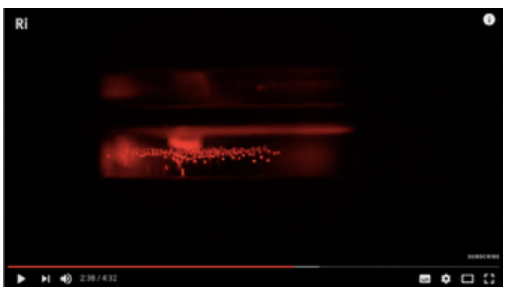

Figure 3: Pollen grains trapped in a linear quadrupole Paul trap, from the short film on particle trapping and its relevance to accelerators.

Curing Cancer with Proton Beams

This video takes a look at the history and promise of proton therapy, using particle accelerators to fight cancer. The use of radiation to treat cancer begins with the discovery of X-rays in 1895, and the application of these rays to medicine utilising the ionising effect of X-ray photons. Another option is to use protons, rather than X-ray photons. Particle accelerators can take protons from inside a Hydrogen atom, form them into high energy beams and target a tumour. However, instead of passing through the body like X-ray photons, the proton energy can be tuned such that they stop at the tumour, thanks to a phenomenon called the 'Bragg peak'. By tuning the energy of a proton beam, the dose can be more carefully controlled.

Animation - How to Design a Particle Accelerator

In this animation by Andrew Khosravani [2], voiced by Dr. Sheehy, we are led through the world of accelerators including how they work, the various forms they take, and a few quirky facts like what champagne means to an accelerator physicist. There are tens of thousands of accelerators in the world, yet they all share the same basic ingredients: particles, energy, control, collision and detection, and typically fall into three categories: linear, cyclotron and synchrotron.

[2] http://andrewkhosravani.com

Figure 4: Dr. Sheehy explaining the Bragg peak with animated overlay, in a short video on proton therapy.

This is a good overview for high school students who are interested in knowing more about particle accelerators.

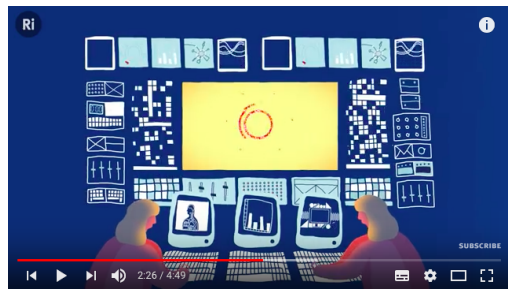

Figure 5: Still image of the animation, exploring some of the creative and quirky aspects of designing particle accelerators.

Event video - Friday Evening Discourse: Accelerators Reimagined

This 1 hour lecture was aimed at an adult science-literate audience, and is also suitable for upper secondary physics students. The lecture was presented as part of a series of Friday evening lectures which have been running at the Royal Institution since the 18th century. Dr. Suzie Sheehy presents an overview of her work in high intensity particle accelerators, motivated by current and future applications including radioisotope production and accelerator driven systems. The lecture features her work on Paul traps [2] and FFAG accelerators [3] along with key demonstrations including a cathode ray tube, 'accelerator bowl' [4] and the particle trapping demonstration featured in the short film.

Figure 6: Accelerators Reimagined lecture at the Royal Institution.

Panel Event: What's the Future of Particle Accelerators?

This 1.5 hour long panel event at the Royal Institution in London features four prominent accelerator scientists and spokespeople discussing future options for particle physics colliders. A key part of the event was audience questions and discussion, covering the motivations and decision making processes on how we might decide what the next big machine will be.

Figure 7: Panel event at the Royal Institution the panel (left to right) featured Prof. Phil Burrows (University of Oxford) discussing linear colliders including the ILC and CLIC, Dr. Frank Zimmermann (CERN) on future circular colliders (FCC-hh and FCC-ep), chaired by Dr. Suzie Sheehy (University of Oxford), along with Prof. Ken Long (Imperial College London) on muon accelerators and neutrino factories and Dr. Stuart Mangles (Imperial College London) on laser-plasma based accelerator options.

EVALUATION AND IMPACT

An independent evaluation of the project was commissioned. Both quantitative (viewer statistics and surveys) and qualitative methods (interviews) were used. Overall, the evaluation showed that the videos reached the intended audience, that they are well liked by the audience and that three videos in particular were most popular. However, a few viewers wanted even more information, such as primer videos that could be linked to the main series.

Number of People Reached

The main engagement of the project is online. At the time of writing this paper, the viewer statistics on YouTube are in excess of 200,000 views. As of 21 February 2017 the videos had been viewed 178,362 times in total on the Ri Channel [5] and YouTube [6] (N.B. some of the videos had only been up for about four months), with 16,476 views on Facebook, taking the total viewing count to 194,838. The videos are still accumulating c.10,000 views per month on YouTube. As part of the social media campaign, the team created and posted additional content, in the form of short blog posts and animated gifs on Tumblr, one of which had over 9,000 likes. The audience statistics for live events totalled around 500 people. The online 'realscientists' week on particle accelerators also had a good engagement on twitter, but the statistics were not available for this report. Around 20 accelerator scientists and engineers were engaged directly in the project.

Who was the Audience?

The project aimed to reach an audience with a casual interest in science, evidenced by survey results showing that 53% of the audience had a general interest in science. Another aim was to reach the age group of 18-35 year olds, which was successfully achieved with 60% of surveyed viewers falling into this category. Google Analytics showed an international audience with high audience numbers predominantly in the USA followed by the UK, Canada, Netherlands and Germany. However, one surprising result emerged from the audience statistics, that the audience was predominantly male (over 90%) and white (over 70%). While this seems disappointing at first, not to reach a more diverse audience, further investigation into YouTube viewing statistics and trends revealed that this may be due to the medium (YouTube) rather than the videos themselves. Opportunities to share the videos through channels reaching more diverse audiences are being sought.

Impact on Audience

One objective was to convey that there are many thousands of particle accelerators in the world. Before the videos were released a twitter survey found that 37% of respondents incorrectly chose 'under 10' accelerators in the world, whereas after the series the poll found this to be just 13% from the 735 detailed survey respondents. It also appears that this knowledge increases with more videos watched from the series ('under 10' response of 12% with 2 videos, 7% with 3-5).

Another objective was to convey the fact that there are a wide range of applications for particle accelerators, evidenced by the fact that 14 of 34 comments on the animation noted surprise at the number of applications, one interviewee said:

'I used to think these are just the tools for understanding quantum mechanics, cosmology etc. But what I came to know is that it has medical research applications, [...] there are a lot of real life benefits for people... '

The author and team would like to encourage the accelerator physics community to use the resources freely for their own public engagement and teaching purposes. The original video files are available under creative commons license, or you can use the YouTube hosted videos for educational purposes. Please let us know if you use the videos, and how you use them for your own activities.

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