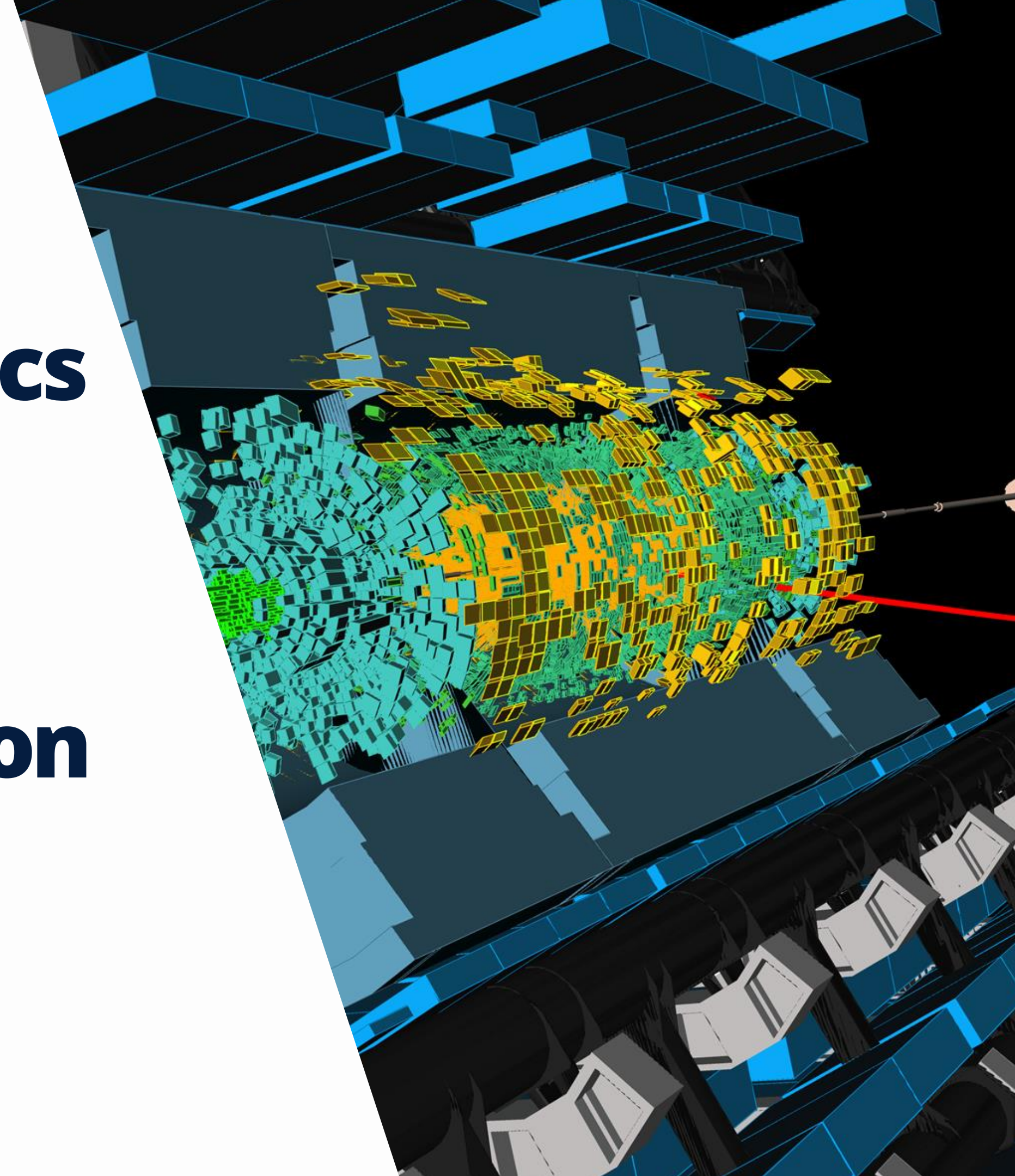




# Opening Particle Physics

# Outreach, Communication, Inclusion & Participation

KATE SHAW  
UNIVERSITY OF SUSSEX  
10 April 2026, IOP Annual APP and HEPP Conference



# Physics & the UK

*Physics is foundational to the UK's future economically, technologically, and societally.*

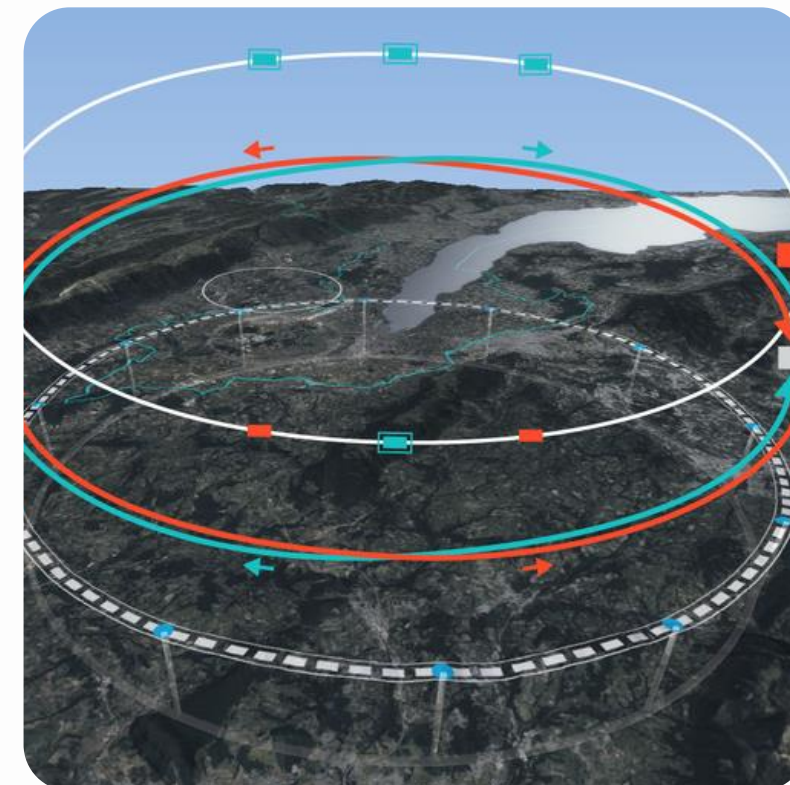


Our physics community are enduring a period of **funding** pressures from both UKRI cuts and university pressure.

Without intervention, the UK risks losing **talent, innovation** capacity, and global **leadership**.

Our community wants to continue pursuing blue-skies, **curiosity-driven** research

The government seeks to address national **skills gaps** and drive **economic growth**



# Outreach and Communication

## 1) Inspiration, curiosity and building science capital

- **Communicate** our inspirational science to the public
  - Reach people with **less access** to science
  - Reach people **low science capital**
- **Build science capital** in low science capital areas
- Communicate with **policy makers**, interact with the **media**, and build **support** for blue sky science



# Outreach and Communication

## 2) Train & motivating the next generation of physicists

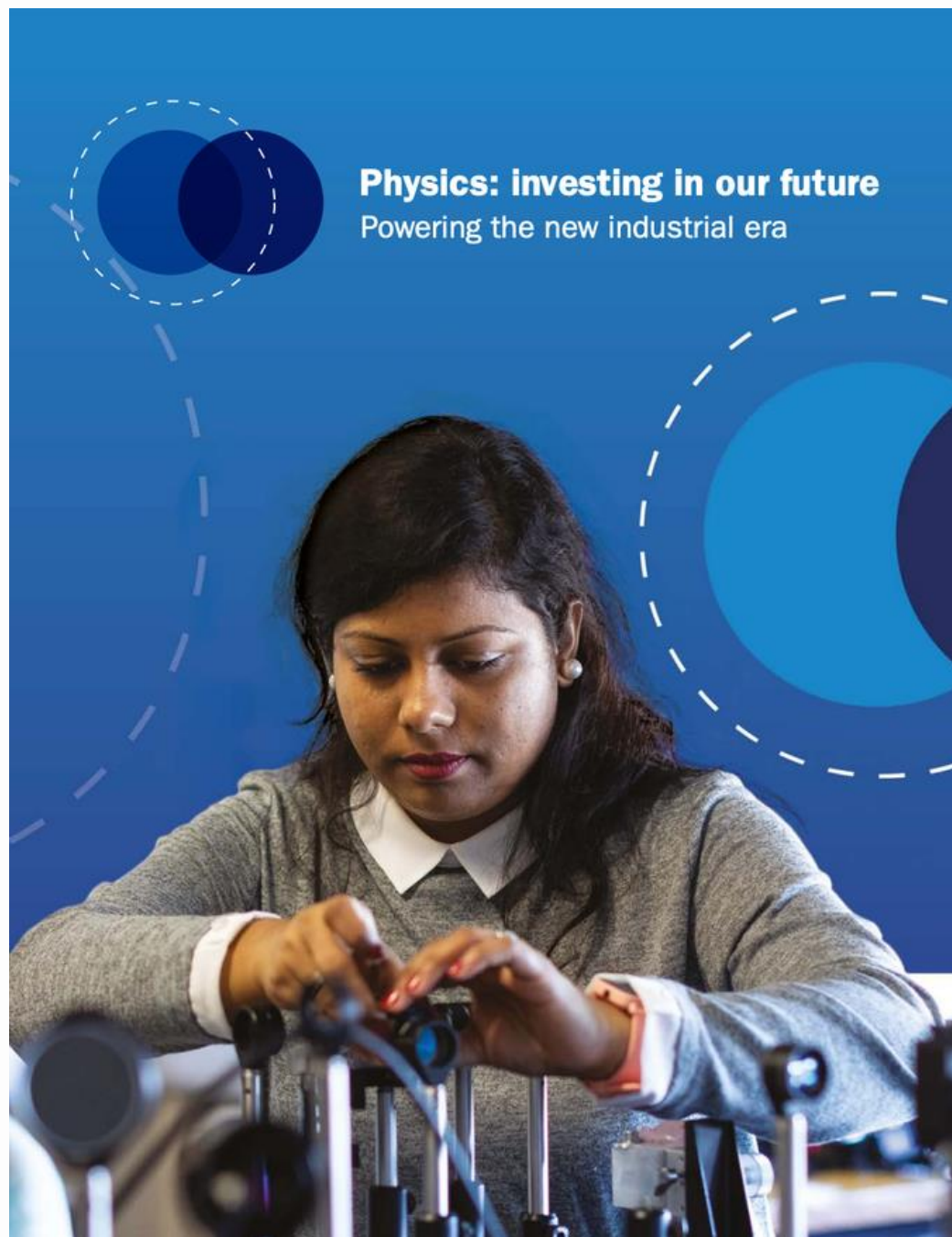
- With vital skills in particle physics, data science, machine learning and AI, computing and hardware
- With professional skills with working in teams, and with big collaborations with a diverse set of colleagues

**This makes brilliant physicists!**

- for our academic workforce
- for **industry, teaching** careers, and **business!**



# Physics Ecosystem

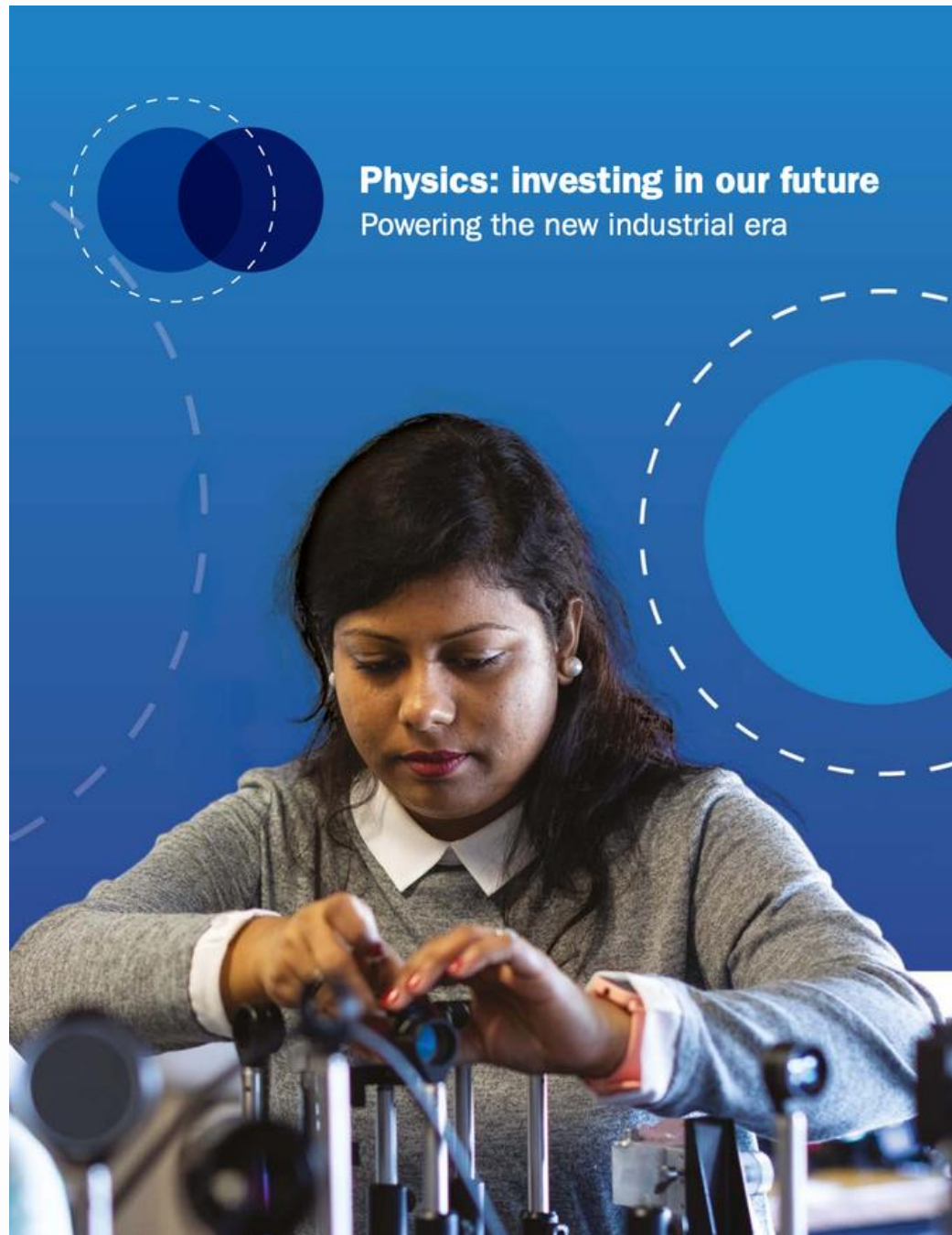


IOP Report: [Physics: investing in our future](#)

**“Increasing R&D investment to 2.4% of GDP by 2027 would generate an additional 80,000 jobs and £30.5bn in GDP<sup>1</sup>.”**

**“Physics knowledge and skills are powerful drivers of productivity and innovation and open doors to a range of rewarding careers across the entire economy.”**

# Understanding Barriers



IOP Report: [Physics: investing in our future](#)

***What are the most significant barriers preventing the UK from developing the workforce needed for physics R&D to thrive?***

1. Shortage of physics-trained teachers.

**1. Lack of diversity and inclusive culture:** women, people from disadvantaged backgrounds, people with disabilities, those who identify as LGBT+, and minority ethnic groups are all underrepresented.

1. Inflexible research careers limiting movement between academia and industry

# EDI: Very important for our community

**Equity:** Treating people of all identities and backgrounds fairly and respectfully with regard to opportunities, access, , power, outcomes, and resources.

**Diversity:** Embracing differences, which may include ethnicity, gender identity or expression, family status, disability status, sexual orientation, age, and socioeconomic situation.



**Inclusion:** Intentionally creating welcoming and respectful environments and systems in which inequities in power and privilege are addressed and everyone is given an opportunity to flourish.

# Diversity Drives Discovery

**Monoculture** can create mono approaches and limited perspectives

A group of people with different experiences and **perspectives** brings **innovation** and creativity

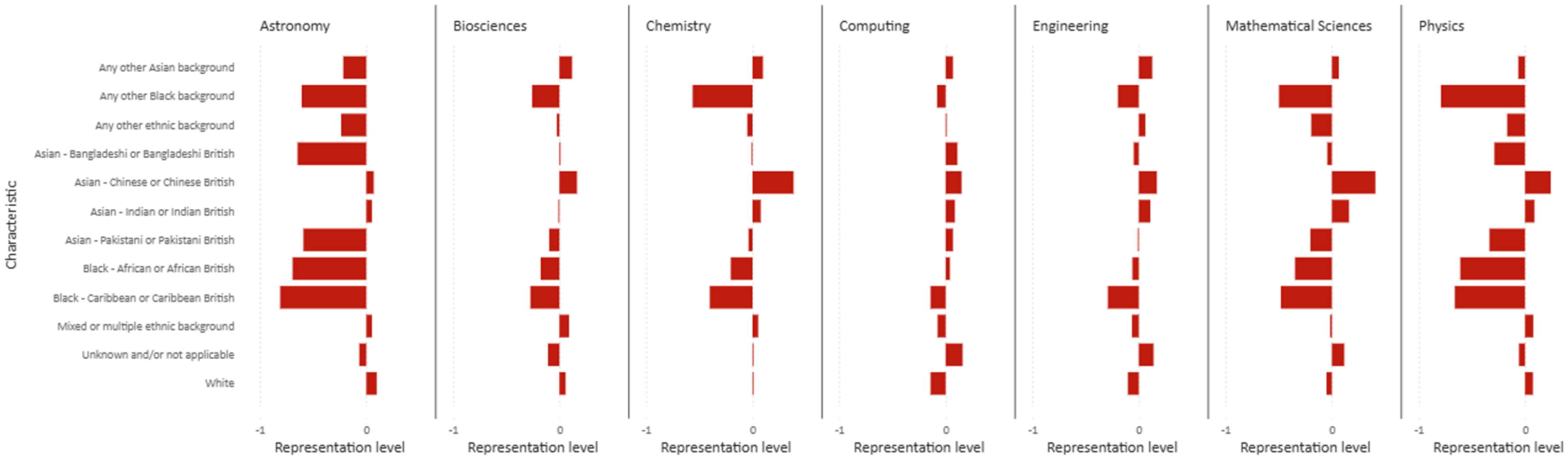
Hierarchies & informal networks favour dominant groups. If certain groups are under-represented, our **talent pool** is smaller

Increased diversity creates a more **inclusive** and **welcoming** environment for everyone, and **amplifies** diversity



# Representation levels – ethnicity (all students, 2023/24)

Representation level by Characteristic and Subject

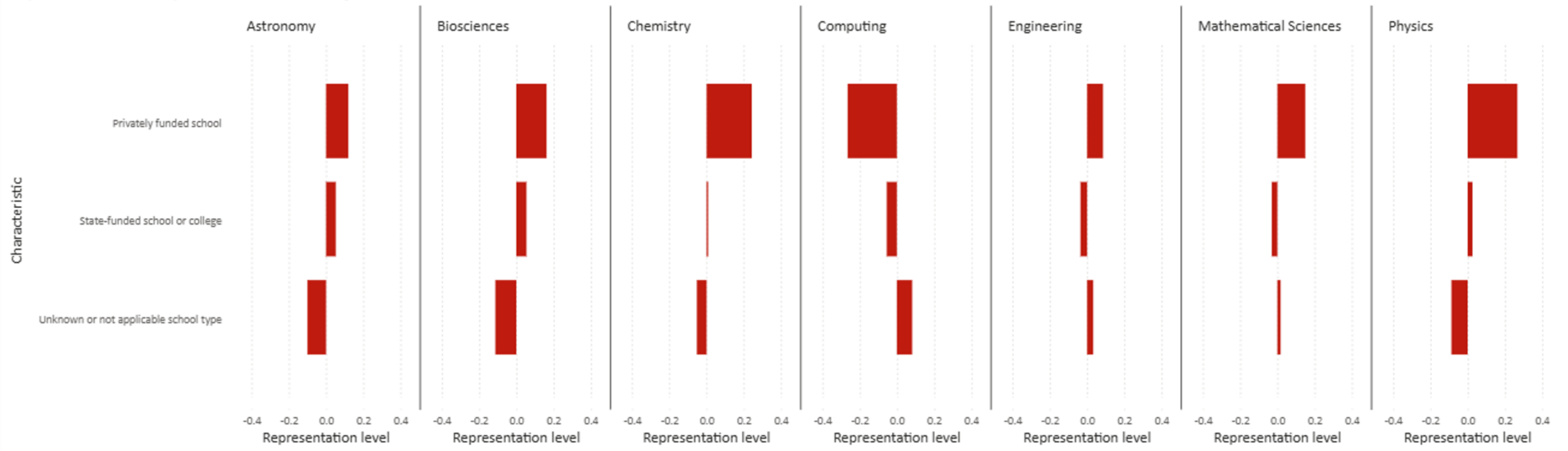


Physics undergraduate students are less ethnically diverse than all other STEM subjects

# Representation levels – Students from Privately / Publicly Funded Schools (all students, 2023/24)

Subject	All subjects		Astronomy		Biosciences		Chemistry		Computing		Engineering		Mathematical Sciences		Physics	
Characteristic	Count	Proportion	Count	Proportion	Count	Proportion	Count	Proportion	Count	Proportion	Count	Proportion	Count	Proportion	Count	Proportion
<b>School Classification</b>																
Privately funded school	128465	5%	225	6%	4705	7%	1880	9%	4645	3%	9320	6%	3050	7%	2025	9%
State-funded school or college	1424750	54%	2140	61%	40660	61%	12165	55%	83590	48%	78280	50%	22360	50%	12895	57%
Unknown or not applicable school type	1085080	41%	1150	33%	21090	32%	8065	36%	87155	50%	69740	44%	18995	43%	7570	34%

Representation level by Characteristic and Subject

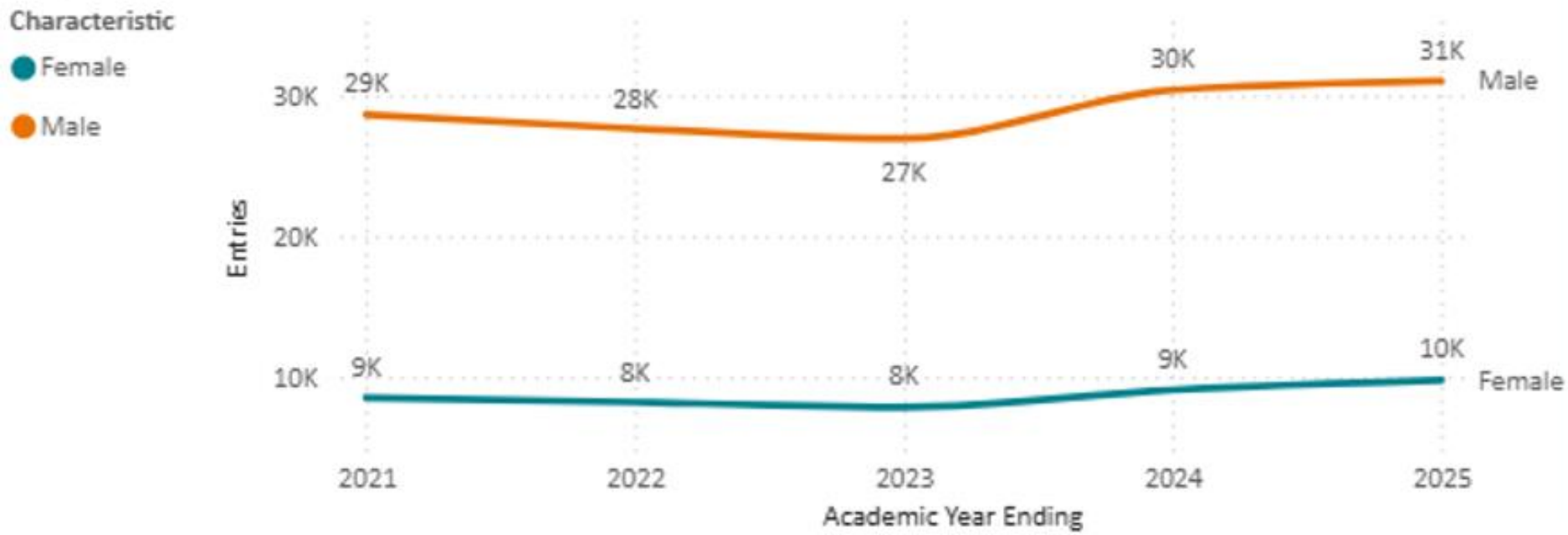


**Physics University Students from the UK are especially likely to come from more advantaged parts of the country.**

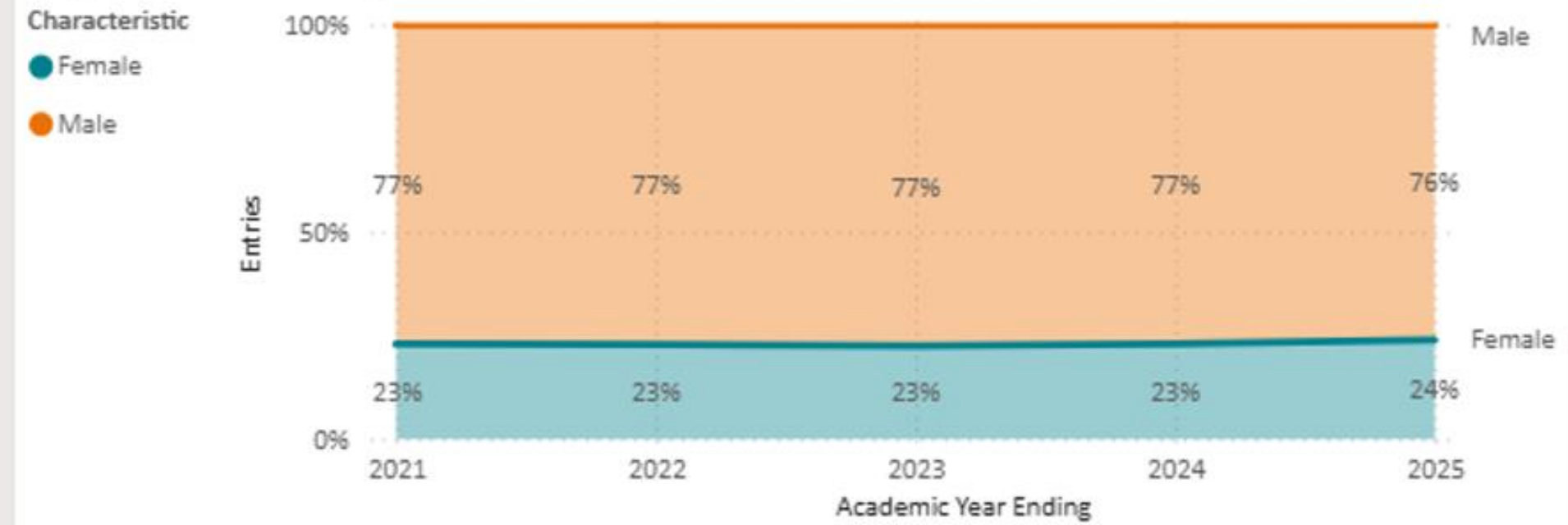
**Physics has double the proportion of undergraduate students from private schools than all other subjects**

# A-Levels (England)

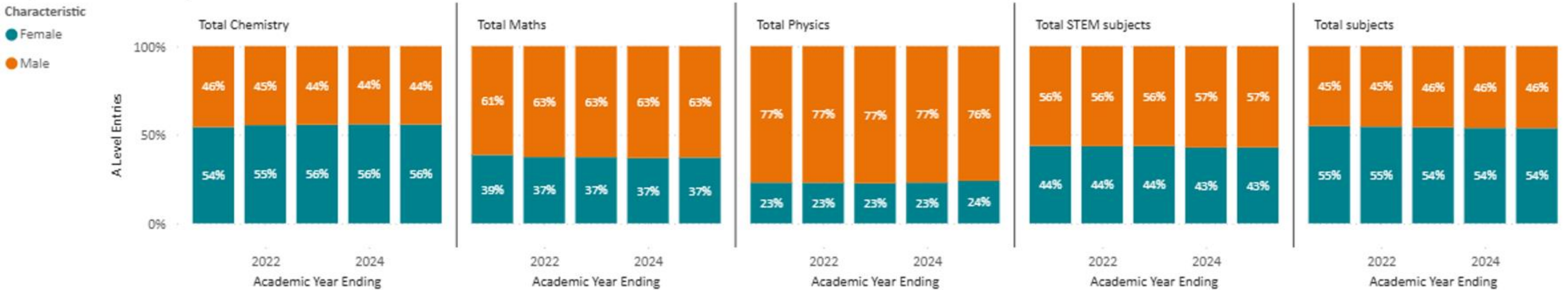
## Physics Entries: Count



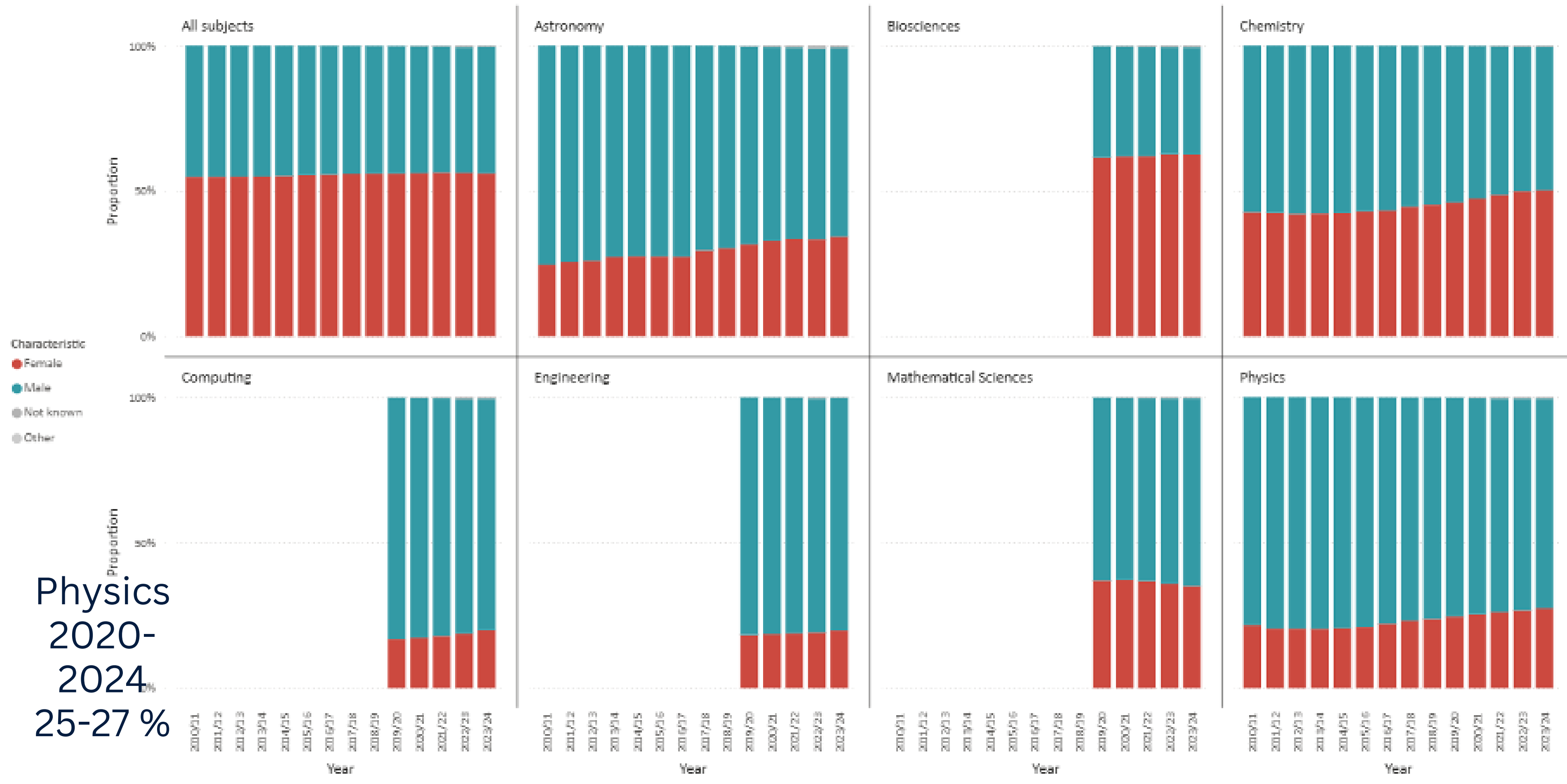
## Physics Entries: Proportion



## Physics & Other Subject Entries



# Student Breakdown by Characteristic



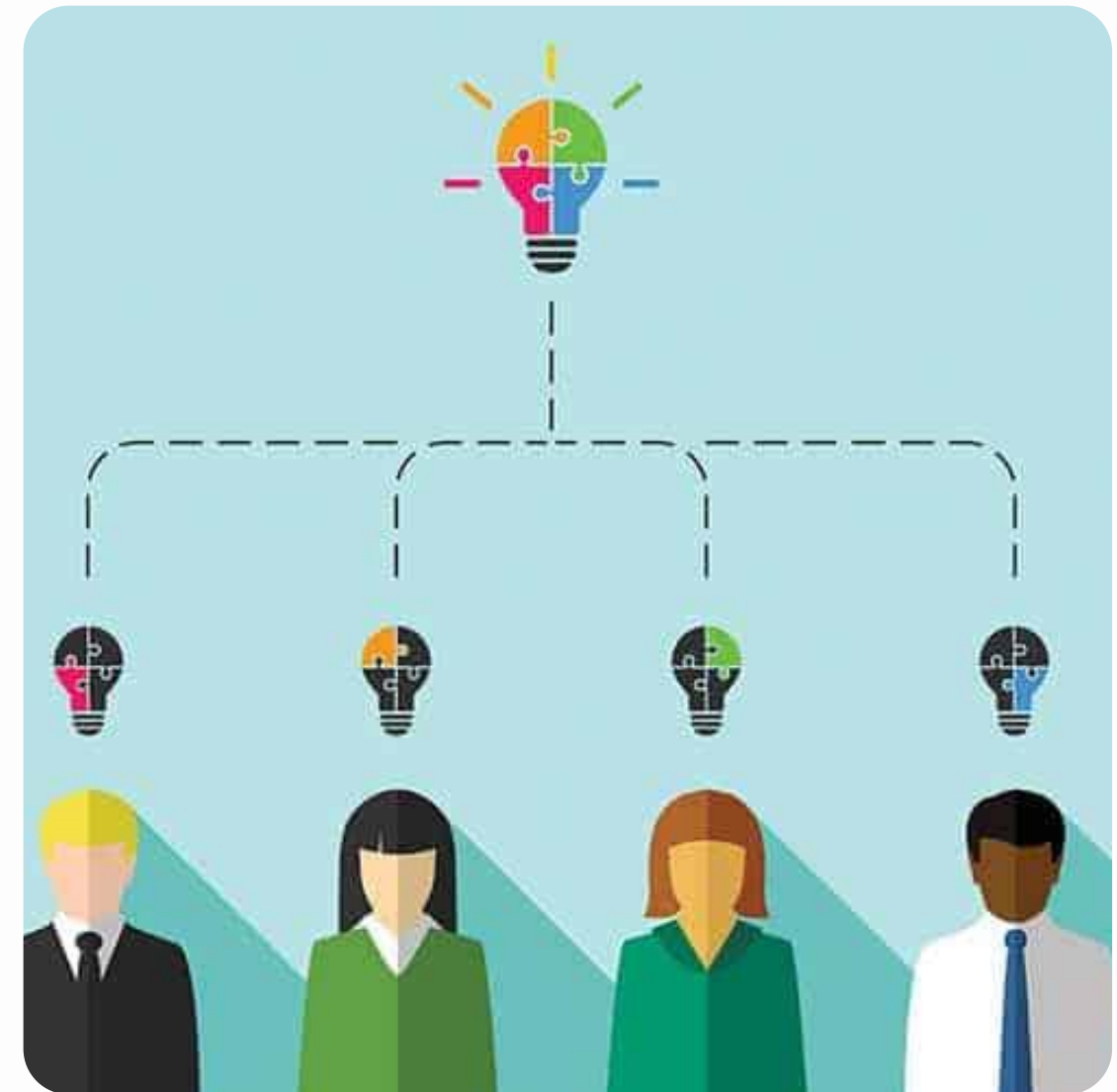
Physics  
2020-  
2024  
25-27 %

# Reaching Beyond the Monoculture

*Science should be for everyone!*

Predominantly male, white, and middle-to-upper class

- This can create a monoculture of experience, assumptions, and opportunity
- Many talented people never even enter the field because of subtle barriers (financial, cultural, social, or implicit bias)
- Diverse backgrounds → different ways of thinking
- **Groups solve hard problems better when they think differently, not just when they're individually clever**



# Why do we have this underrepresentation?

## *Why are we not diverse?*

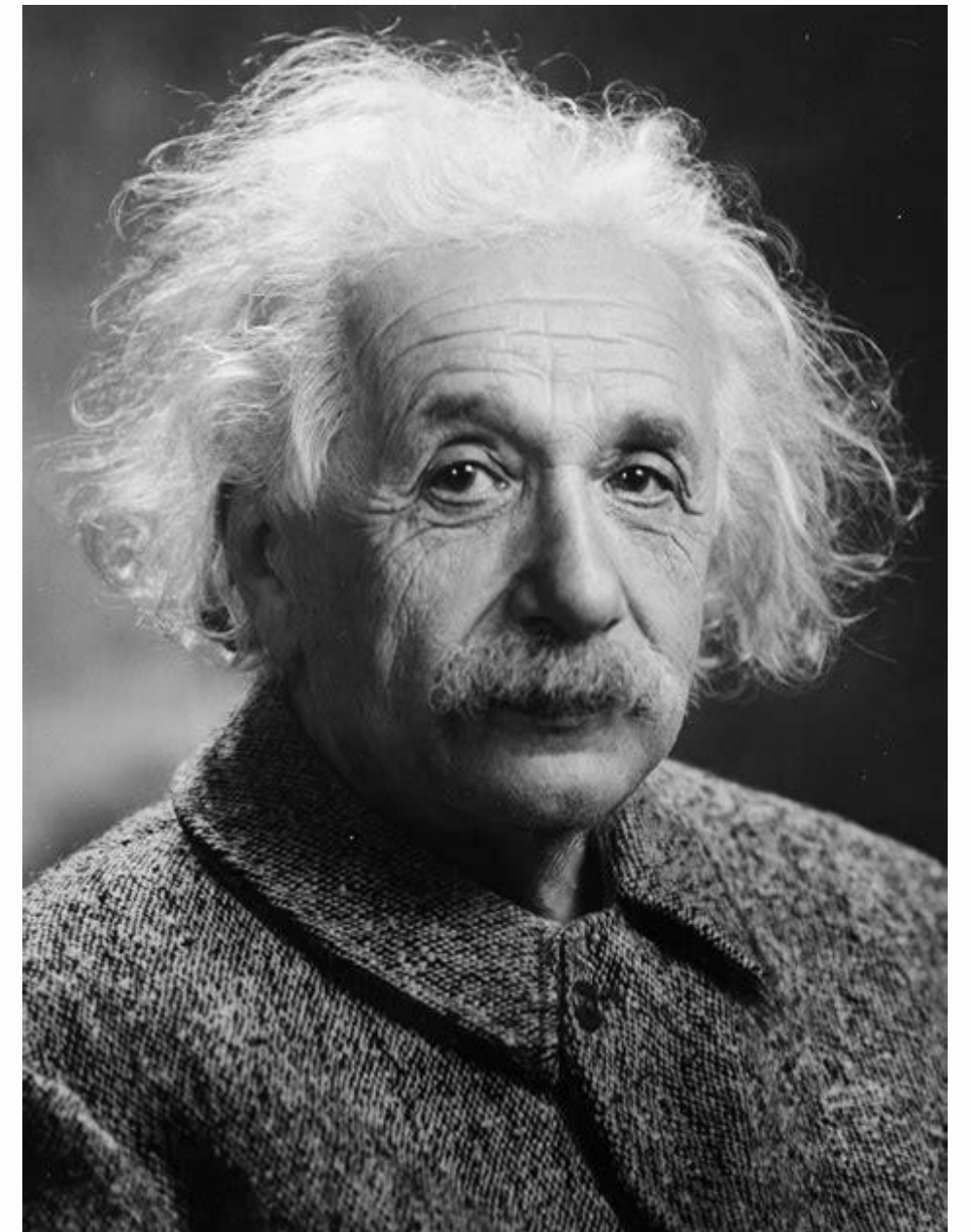
The causes of this underrepresentation are clear.

Many young people from under-represented groups do not pursue physics as they may see that it is not for them or they feel they don't fit in

- I don't look like a scientist
- People like me don't do science
- I am not clever enough - scientists are geniuses

→ Many also have less access to opportunity

***There is also a lack of guidance available on physics-related technical routes post-16 despite growing employer demand for the skills that higher technical education provides***

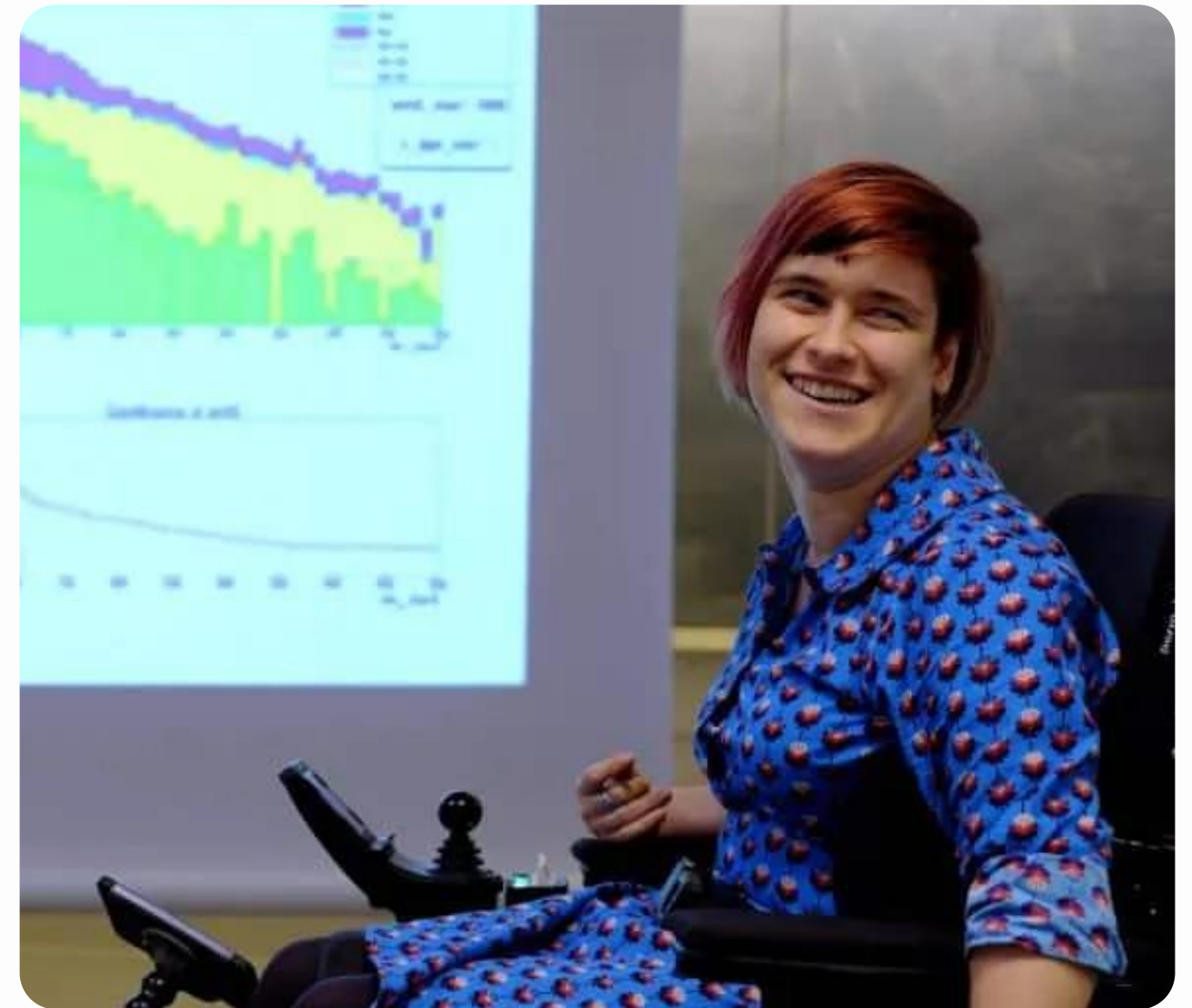


# Outreach and communication projects

*Let's reach out*

Outreach and communication projects

- Access people from diverse backgrounds and those with less access to science
- Learn about and work with those under-represented in our community, what invisible barriers do they face
- Provide diverse role models, who think and act differently to welcome a broader community
- Provide accessible and varied educational resources to engage with different audiences

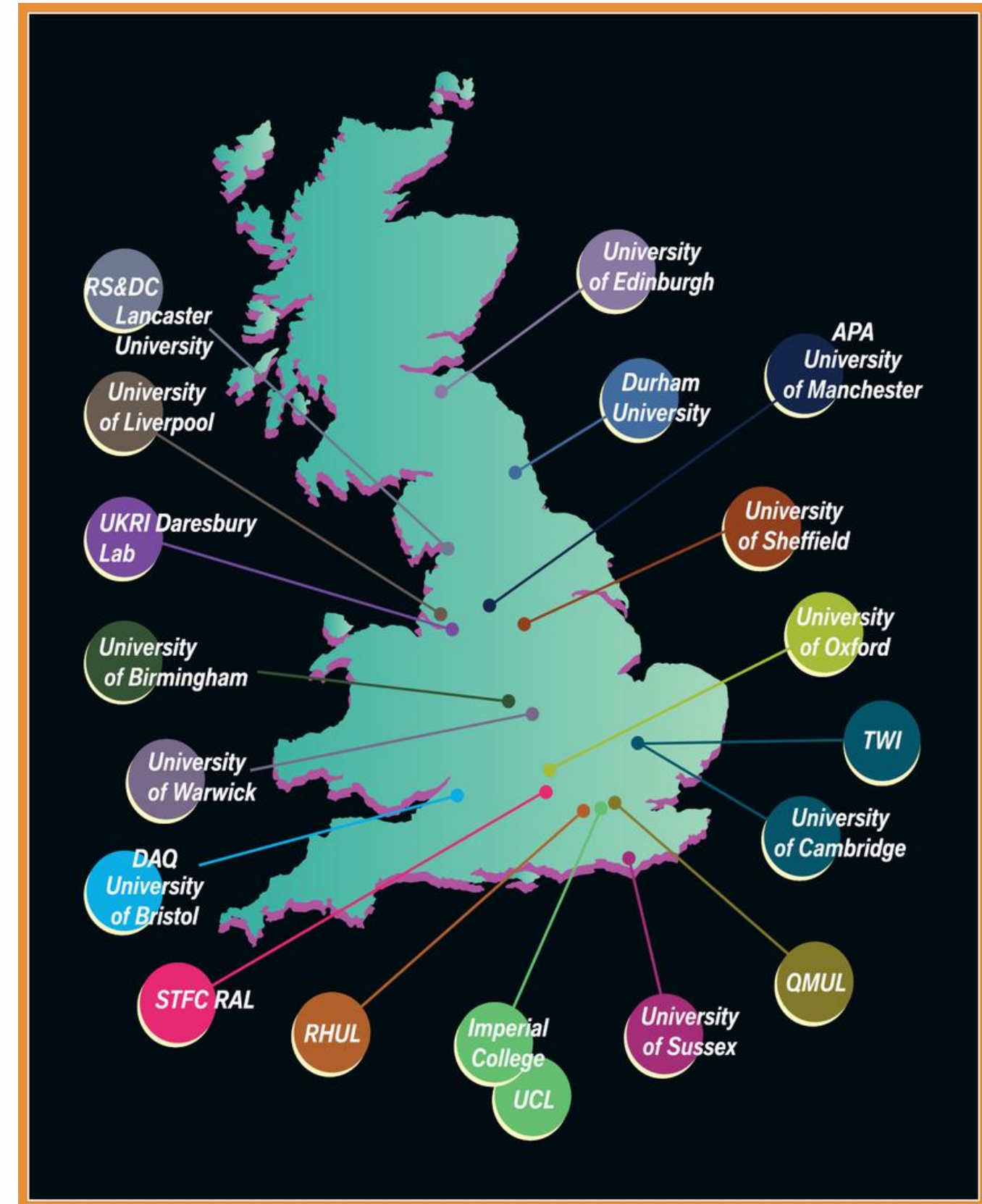


Claire Malone, Science Communicator

# DUNE Exhibition at the Royal Society

- 18 UK institutions worked together to create, build and showcase a DUNE exhibition for public engagement
- Creation of exhibition and design elements, brochure and merchandise, volunteer coordination
- Flagship exhibition in July 2024 at the Royal Society Summer Science Exhibition, London

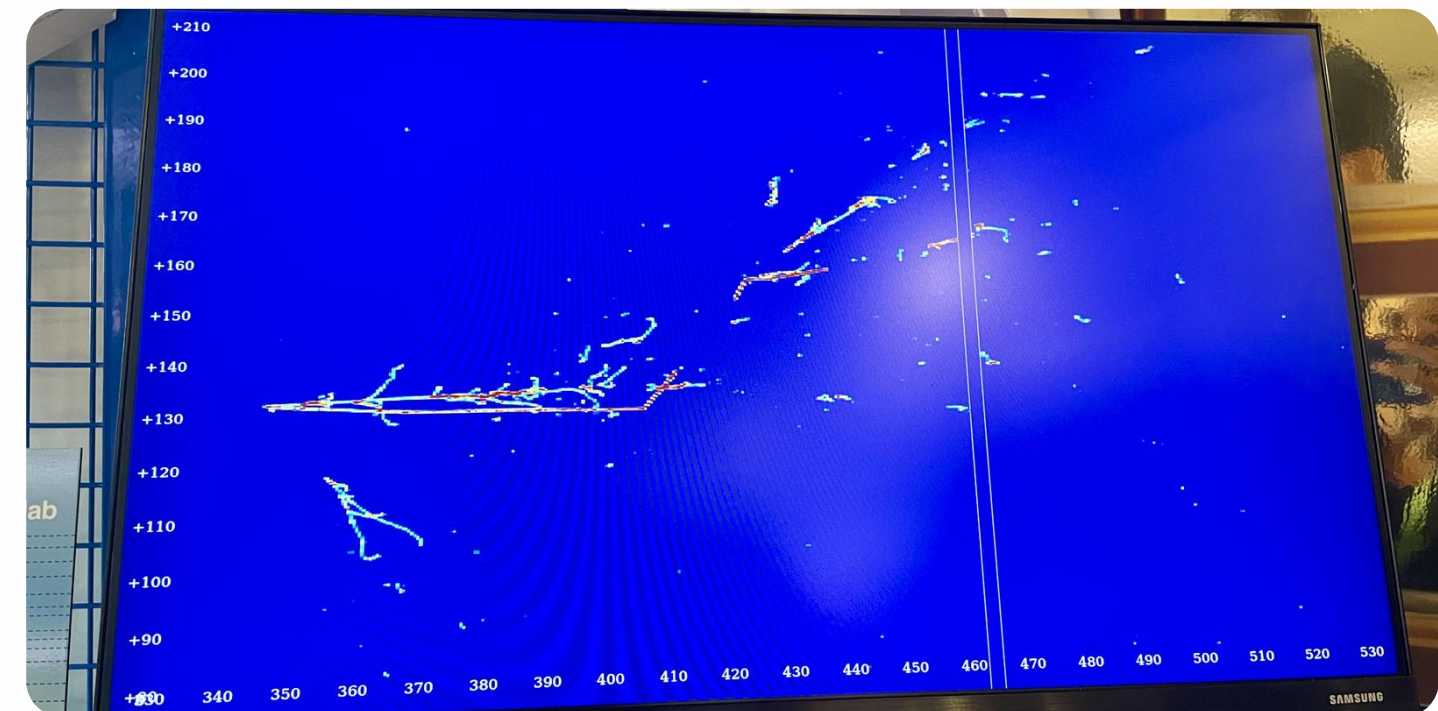
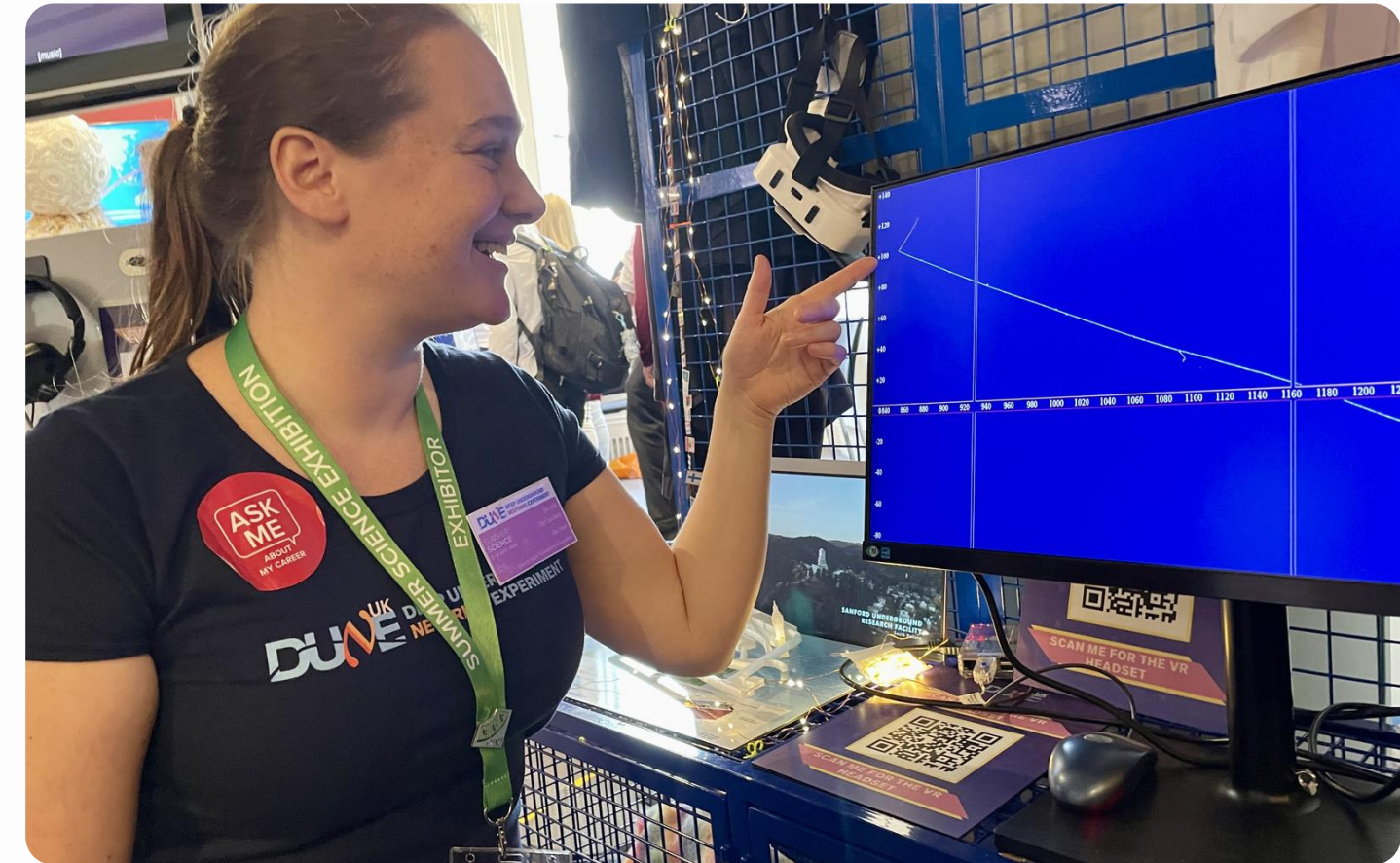
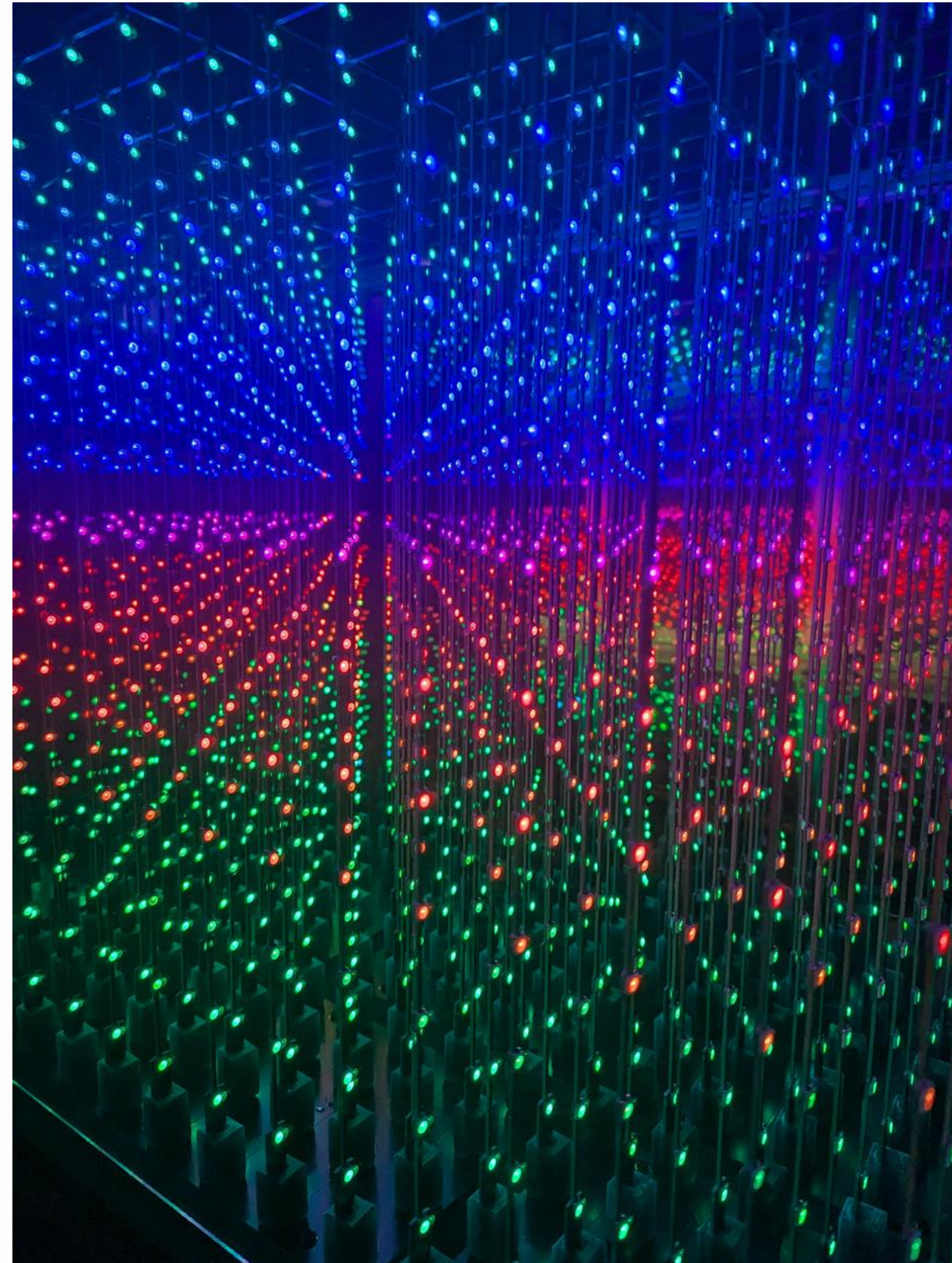
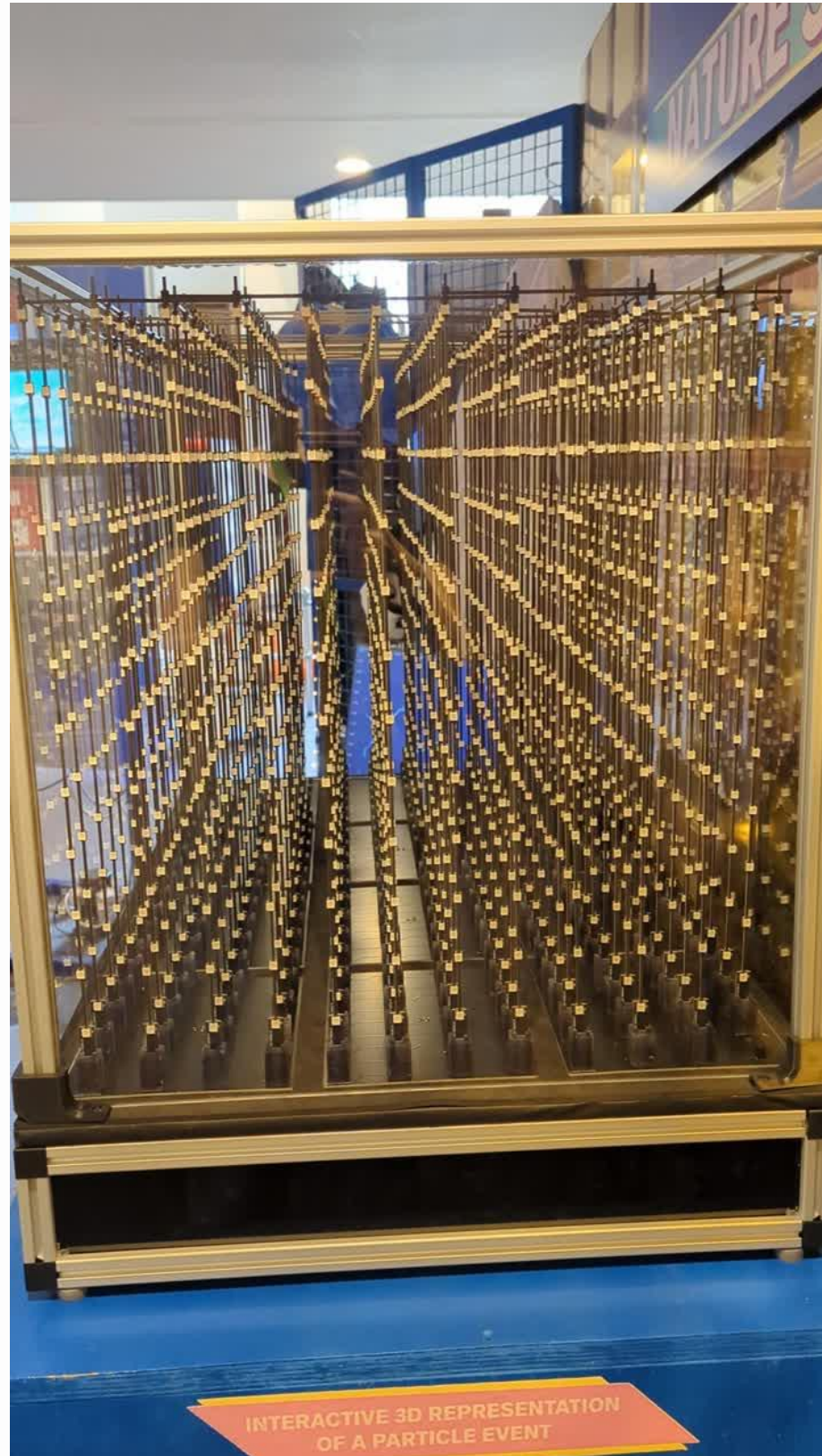
***Universities are often encouraged to compete, but we achieve mutual goals by working together!***



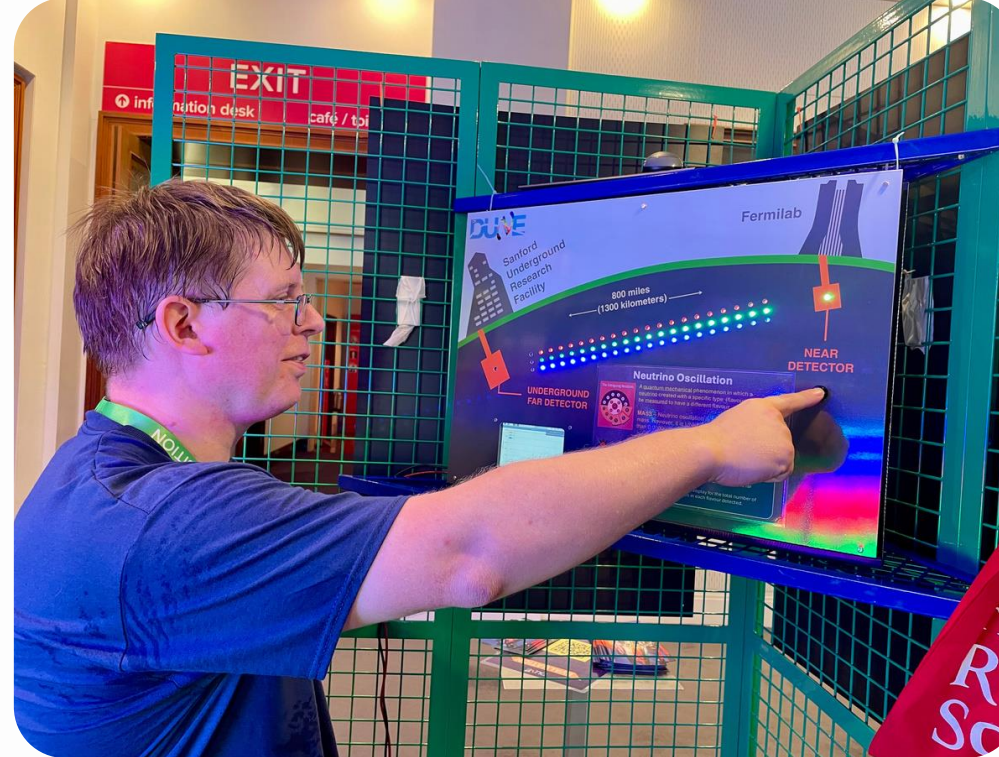
# DUNE @ Royal Society Summer Exhibition



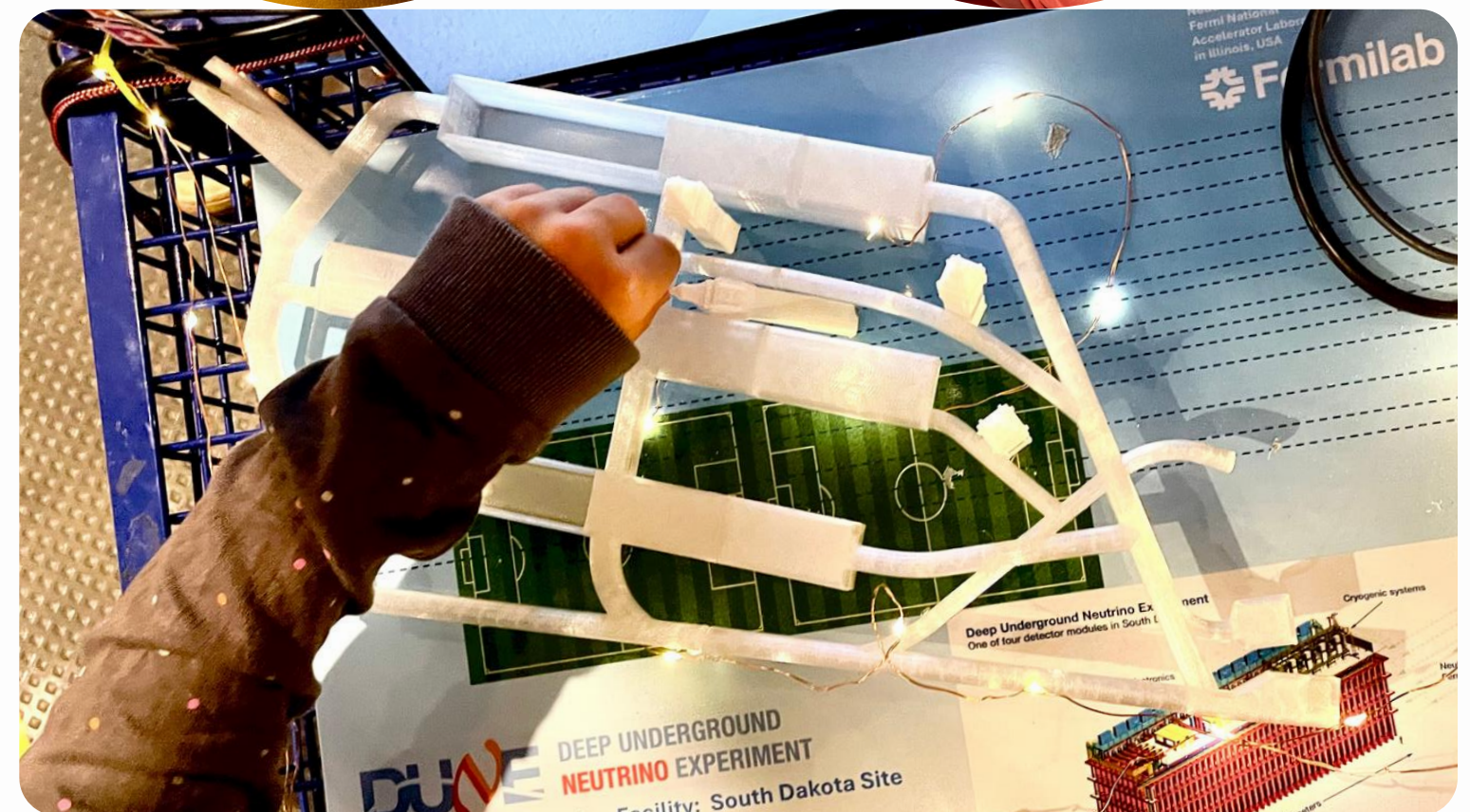
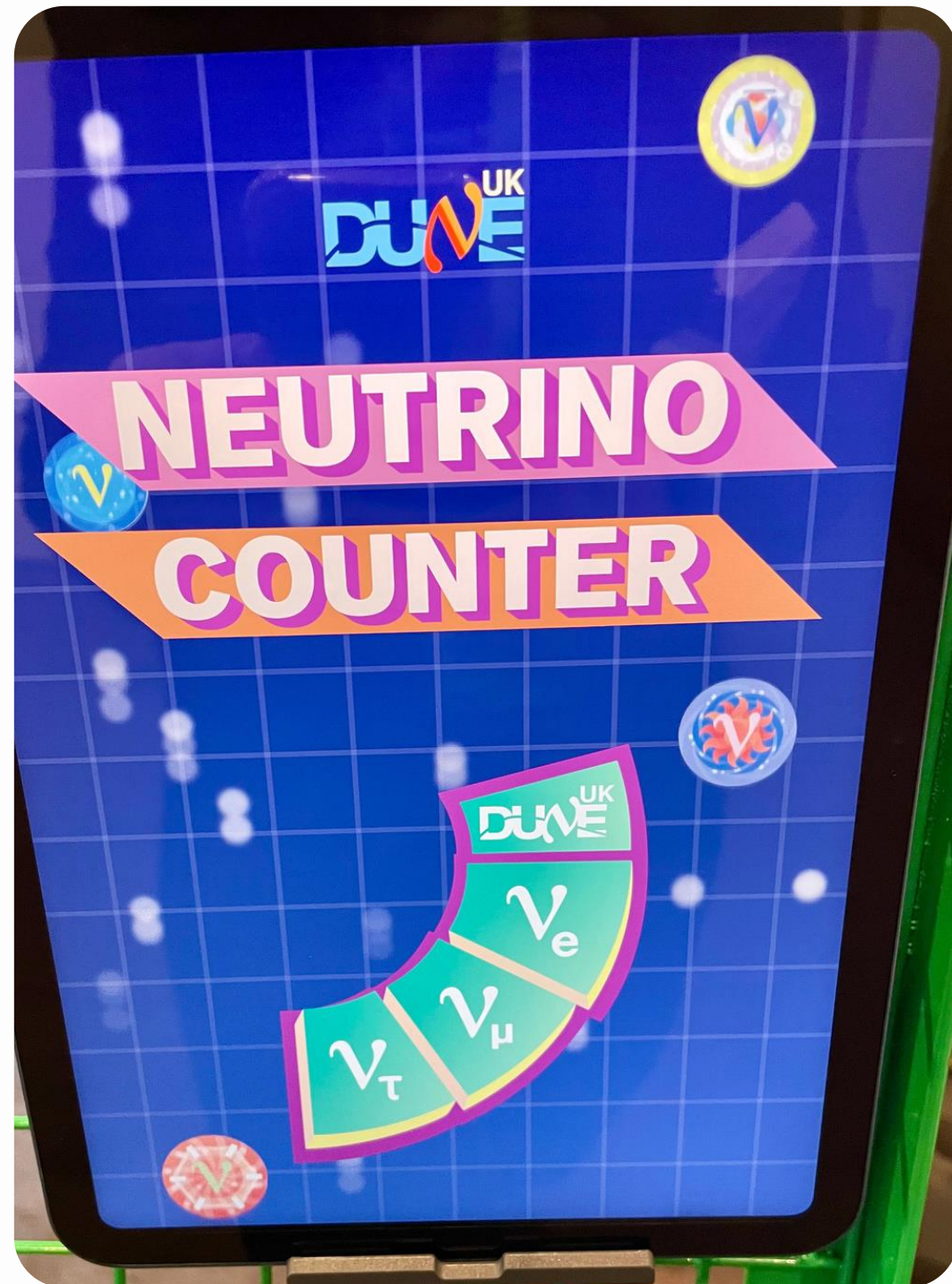
# DUNE @ Royal Society Summer Exhibition



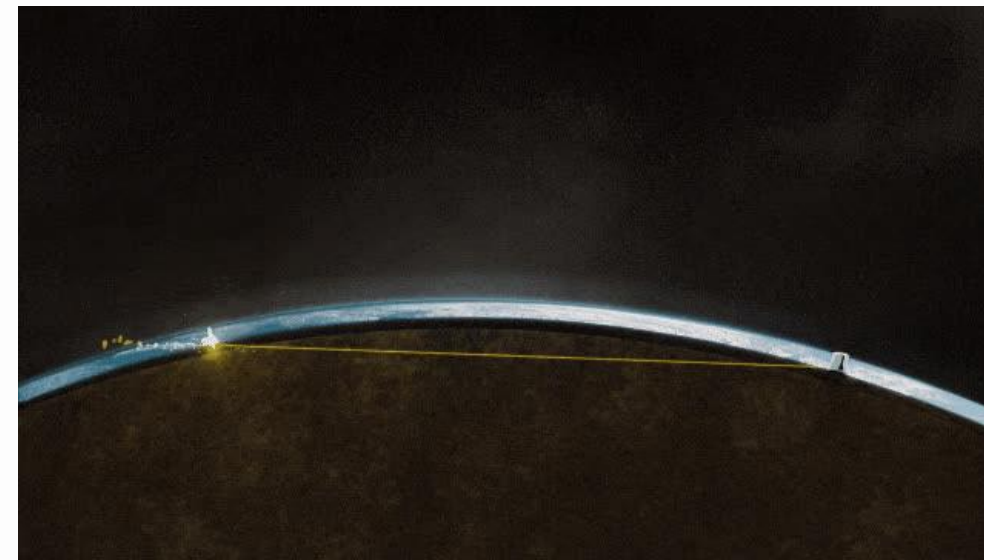
# DUNE @ Royal Society Summer Exhibition



# DUNE @ Royal Society Summer Exhibition



# DUNE Exhibition at the Royal Society



### IMPACT OF DUNE ON THE UK ECONOMY

DUNE UK is having a positive impact on the British economy, both in terms of contracts with local companies and the creation of new technical jobs. Thanks to the great expertise of British industry, numerous UK companies are engaged in providing crucial advanced components to the experiment, including contracts in excess of £1M in the north of England.

DUNE UK has adopted and developed new technologies, such as the 'wire-winding robot' that is used to accurately position approximately 4000 copper wires, each not much thicker than a human hair, into huge, 6 metre long, 2.5 metre wide planes that will collect the data from the neutrino detector. DUNE UK is building 137 of these planes, which will eventually be installed in a 10000 tonne liquid argon cryostat a mile underground at the SURF lab in South Dakota.

At the Dererbury Laboratory, where the APAs are assembled, more than 20 new high skill jobs have been created, ranging from technicians through to mechanical engineers. The people taking up these jobs are gaining valuable skills in cutting edge techniques and technologies.

The DUNE detector will produce enormous amounts of data, equivalent to 1600 high-definition movies per second. DUNE UK is leading the development of the data-acquisition system, which ensures that this vast stream of data is captured, requiring cutting-edge computing engineering, supported by engineers at the Rutherford Appleton Laboratory, and DUNE researchers must reconstruct the particle interactions in real-time which rely on the latest computational techniques, data science, and machine learning.

A rapidly growing number of new PhD students are joining DUNE to learn the skills of world-class research in particle physics, ensuring that the next generation of scientists is trained and ready to enhance innovation, maintaining the leading role that the UK has in science and research.

### FINAL WORD

**Prof. Gary Barker**  
LBNF/DUNE UK Spokesperson

"The LBNF/DUNE UK project, funded by DSIT/UKRI-STFC, is delivering key components of the international project including elements of the proton LINAC, the neutrino beam target, the majority of the charge collection planes of the DUNE horizontal drift detector, the data acquisition system for first stage of the project and major computing/software contributions. We are the largest international partner and central to its success."

**Prof. Morgan Wascko**

"Neutrinos play a key role in the origin and development of our universe. The major responsibility that the UK neutrino community have taken within the Long Baseline Neutrino Facility (LBNF) / DUNE project puts our scientists at the forefront of the global effort to measure the properties of neutrinos and hence finally understand the way that nature works at the most fundamental level."

### DUNE UK Projects:

The DUNE-UK project is funded by the Science and Technology Facilities Council (STFC), part of the United Kingdom Research and Innovation.

Anode Plane Assemblies construction - Prof. Justin Evans (University of Manchester)  
Reconstruction Software and Distributed Computing - Dr Andy Blake (Leicester University)  
Data Acquisition System - Dr Jim Brook (University of Bristol)

LBNF UK project  
High Power Neutrino production Target- Dr Chris Desbain (STFC - Rutherford Appleton Laboratory)  
Superconducting RF Cryomodule for PIP-II - Dr Peter McIntosh (STFC/ASTeC, Dererbury Labs.)

**CONTACT**  
<https://www.dunescience.org/>



### WHAT IS DUNE?

**Karolina Wresilo**  
PhD student in High Energy Physics at the University of Cambridge

DUNE is a next-generation neutrino experiment utilising the world's most intense neutrino beam and an ambitious human endeavour with more than 1400 collaborators worldwide.

"I became fascinated with neutrinos when I learned about how different they are from other particles that make up all the matter in the Universe. The Standard Model describes particles that have a mass, which surprisingly disagrees with our best theories up to date, and therefore indicates new physics is out there! Due to the elusive nature of neutrinos, they remain the most understood particle. This makes them ordinary to study, with theories and questions still to be answered."

DUNE will be a key player in neutrino physics in the years to come. Its main physics goals include:

- Measurement of neutrino oscillations with unprecedented precision.
- Measuring the CP-violating phase - a parameter that is crucial to explain the dominance of matter over antimatter in the early Universe, and hence why we exist.
- Detection of neutrinos originating in the Sun and supernova explosions.
- Searches for exotic physics that may potentially challenge our understanding of the world at a fundamental level.

Deep Underground Neutrino Experiment

### WHO IS DUNE UK?

The DUNE UK collaboration is a leading force in developing, integrating and testing the Data Acquisition (DAQ) and Anode Plane Assembly (APA) technologies, therefore playing a crucial role in the construction of the experiment.

**Prof. Jaroslaw Nowak**  
Leicester University  
LBNF/DUNE UK Institutions Board Chair

"Since neutrinos cannot be observed directly their presence is inferred through the detection of particles produced in their interactions with the liquid Argon. These particles leave trails of ionisation as they pass through the detector and are collected by the wires of the APAs. Each APA is connected to the DAQ system, which then evaluates and selects interesting data for storage and further analysis. This data is then used to create a 3D snapshot of the neutrino event, that can be then studied."

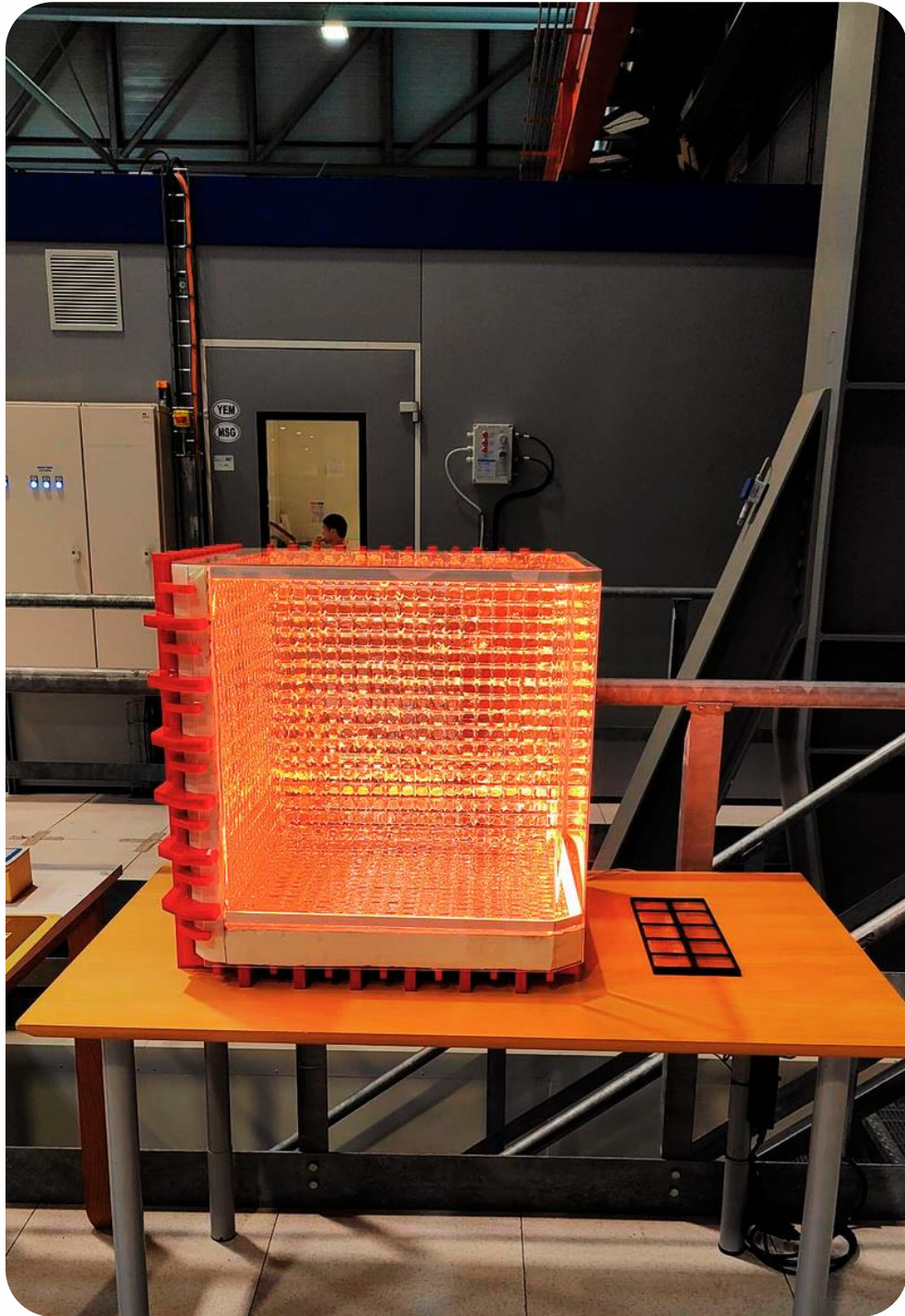
### HOW DOES DUNE WORK?

**Tiago Alves**  
PhD student in High Energy Physics at Imperial College

The DUNE UK collaboration is a leading force in developing, integrating, and testing the Data Acquisition (DAQ) and Anode Plane Assembly (APA) technologies, therefore playing a crucial role in the construction of the experiment.

"Since neutrinos cannot be observed directly their presence is inferred through the detection of particles produced in their interactions with the liquid Argon. These particles leave trails of ionisation as they pass through the detector and are collected by the wires of the APAs. Each APA is connected to the DAQ system, which then evaluates and selects interesting data for storage and further analysis. This data is then used to create a 3D snapshot of the neutrino event, that can be then studied."

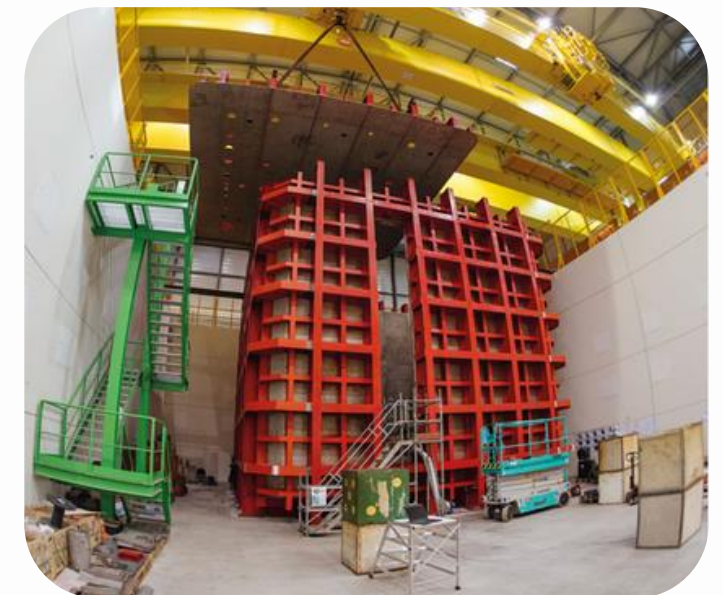
# DUNE Exhibition at the Royal Society



Model of **ProtonDUNE** with model **APA** next to it gifted to the **Neutrino Platform** at CERN, and lent to local outreach events

Many of the exhibition pieces available to download and use for your own exhibitions:

- Neutrino counting IPAD game
- 3D DUNE model
- Videos
- Event displays
- Posters
- Particle Menu
- DUNE VR



# DUNE Exhibition at the Royal Society

Travelling exhibition around the UK 2024 - 2027

**Over 20,000 people have engaged with exhibition**



Reached families, school students,  
and communities who may never  
have engaged with particle physics

*People who had never heard of  
neutrinos suddenly asking profound  
questions about the universe*

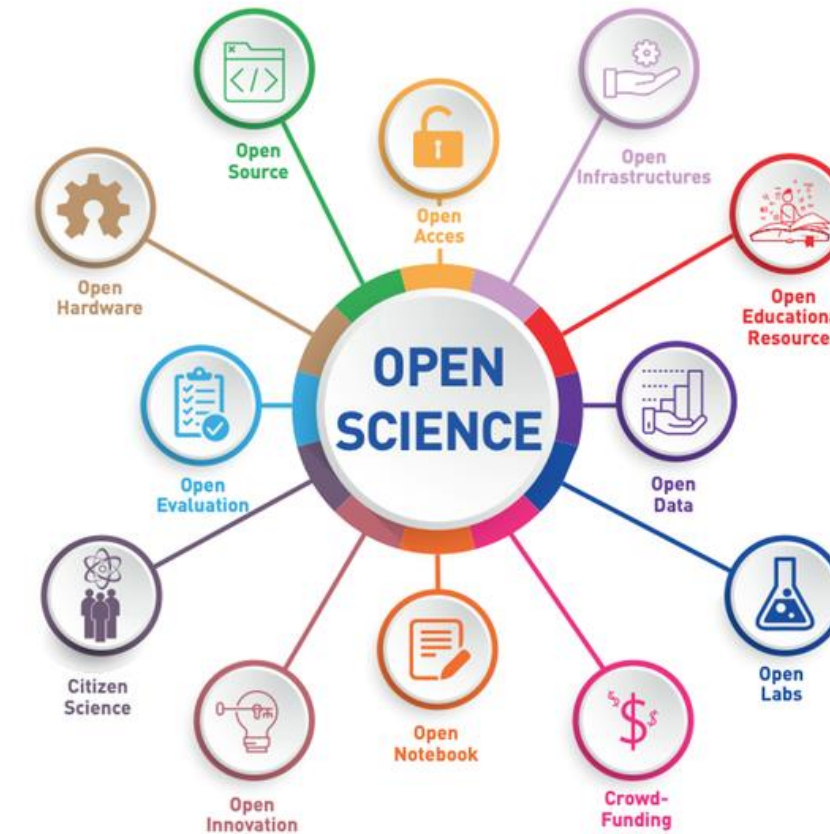


# Open Data

**Open Science** is an accelerator for the Sustainable Development Goals 2030

A powerful tool to **bridge the gap** between country's access to science, scientific capabilities, and outputs to support sustainable development.

Helps to promote **equal opportunities** for all scientists and citizens and increase scientific **capacity** and science **education**.



# ATLAS Open Data for Education

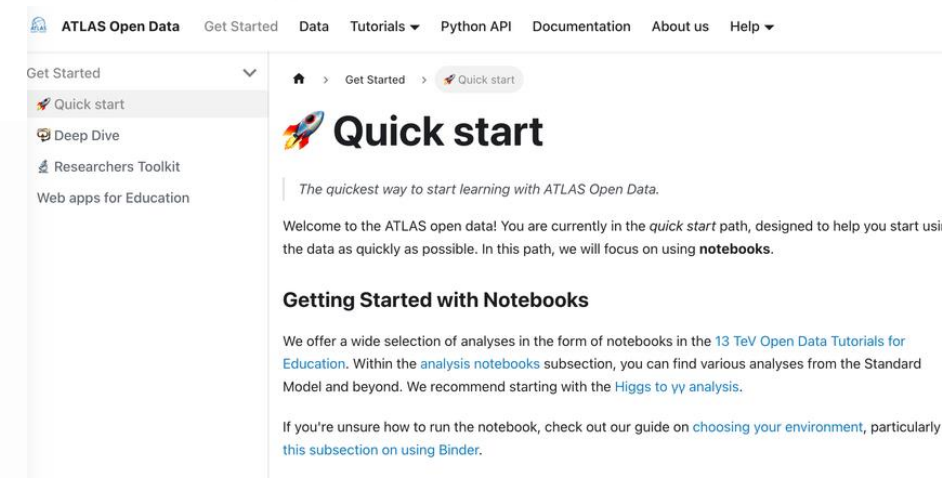
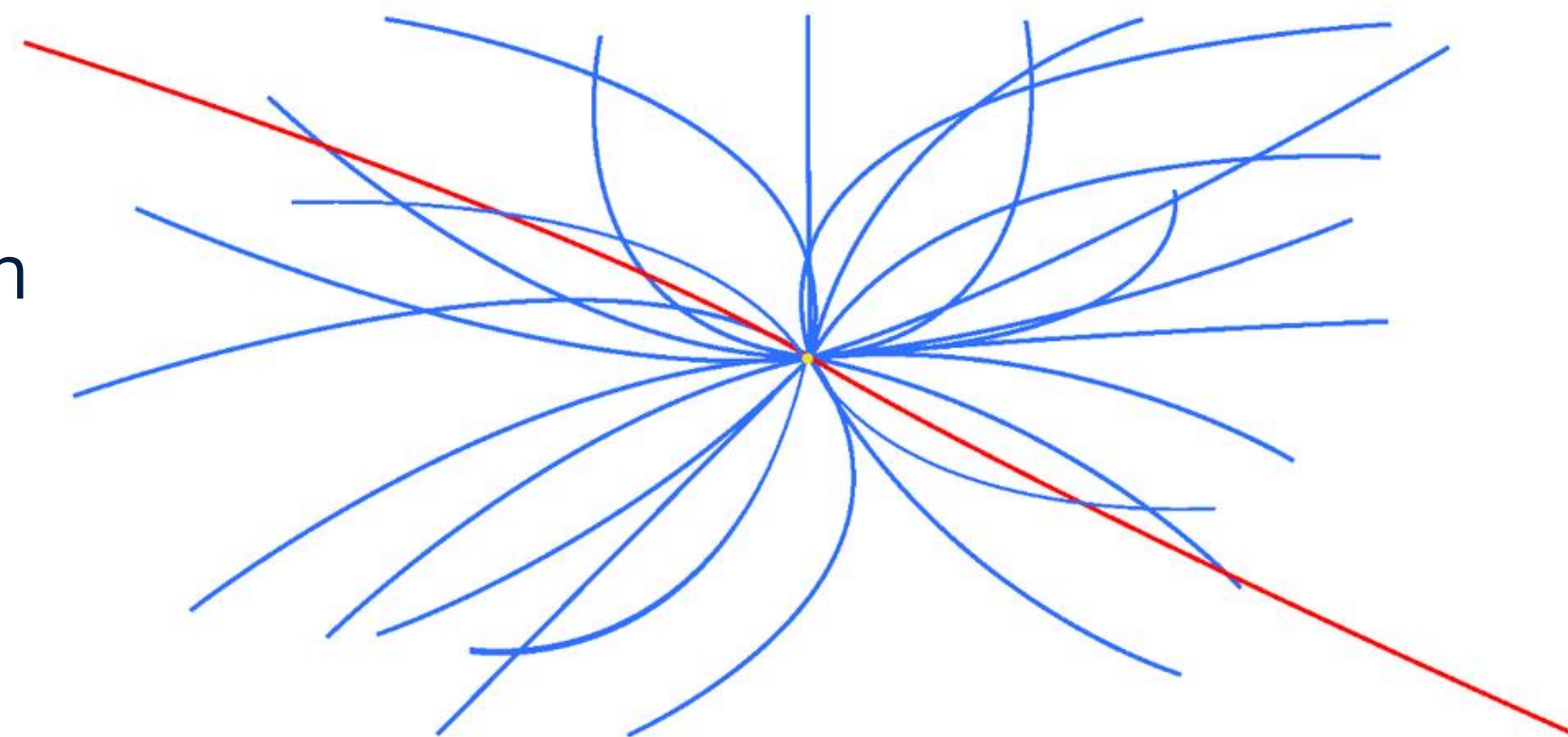
We developed open educational resources based on real data from the ATLAS experiment

- to build advanced data and scientific skills
- widen access to frontier research
- maximise the societal value of large-scale research infrastructure like the Large Hadron Collider

Can be used to address

- Particle physics outreach and education
- UK STEM skills training
- Data science / AI readiness
- Widening participation

## ATLAS Open Data



# ATLAS OPEN DATA for Education

## Accessibility

Make the data and the tools openly available for everyone to use, without technology, region, or knowledge restrictions.

## Transferable expertise

Along with particle physics analysis and ATLAS learning objectives, provide skills in programming, software and machine learning.

## Usability

Different target audiences, with different backgrounds and skills must be able to use the data and tools for a wide range of learning objectives.

Opens our data & tools for everyone: [opendata.atlas.cern](https://opendata.atlas.cern)

- Data, tools, software framework, web applications, Notebooks, tutorials, documentation

Run online and in person training for students: undergraduates, secondary school students

Develops skills

- Particle physics
- Data analysis and analysis techniques
- Programming and computational skills
- Machine learning in particle physics

# ATLAS OPEN DATA : Particle Physics Training

## How to Separate Signals: Higgs to WW

Let's look at the simulated data. Using the Histogram Analyser we can look at each sample separately and understand a little more about their characteristics. This will help us separate our signal from the background later.

Select the sample by clicking on the bar in the Expected Number of Events histogram. The rest of the histograms now just display the characteristics of your chosen sample.

$$H \rightarrow W^+W^-$$

$$H \rightarrow W^+W^- \rightarrow \ell^+\ell^-\nu\bar{\nu}$$

( $\ell$  = electron, muon)

## Curriculum Learning Objective: Particle decay balancing with charge

[see e.g. OCR A-level physics 6.4.2]

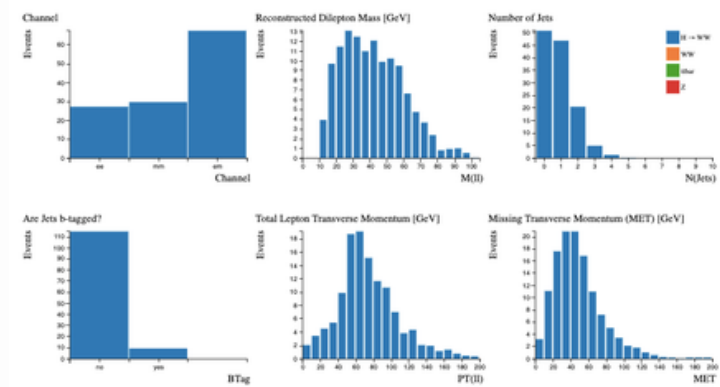
Why does the higgs boson decay into particles whose charges sum to zero?

## Curriculum Learning Objective: Classification of leptons

[see e.g. OCR A-level physics 6.4.2(d)]

Electron and muon channels are shown separately in the histograms.

Our signal is the Higgs boson which decays into two  $W$  bosons which subsequently decay into leptons and neutrinos.



## The histograms explained

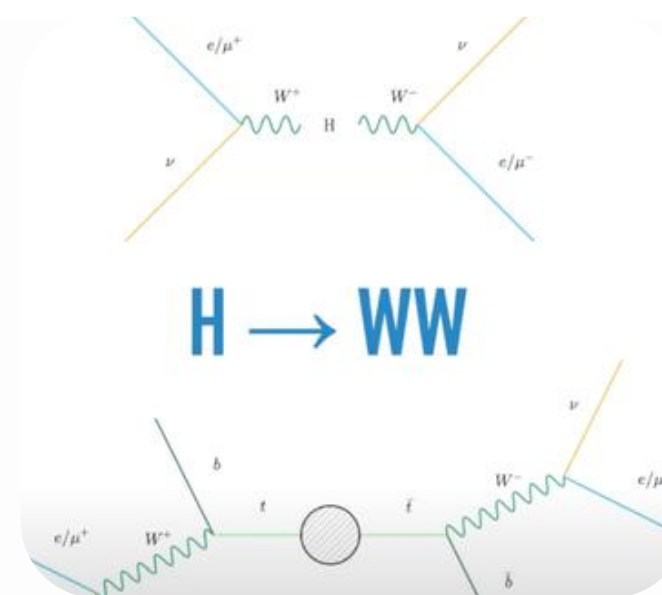
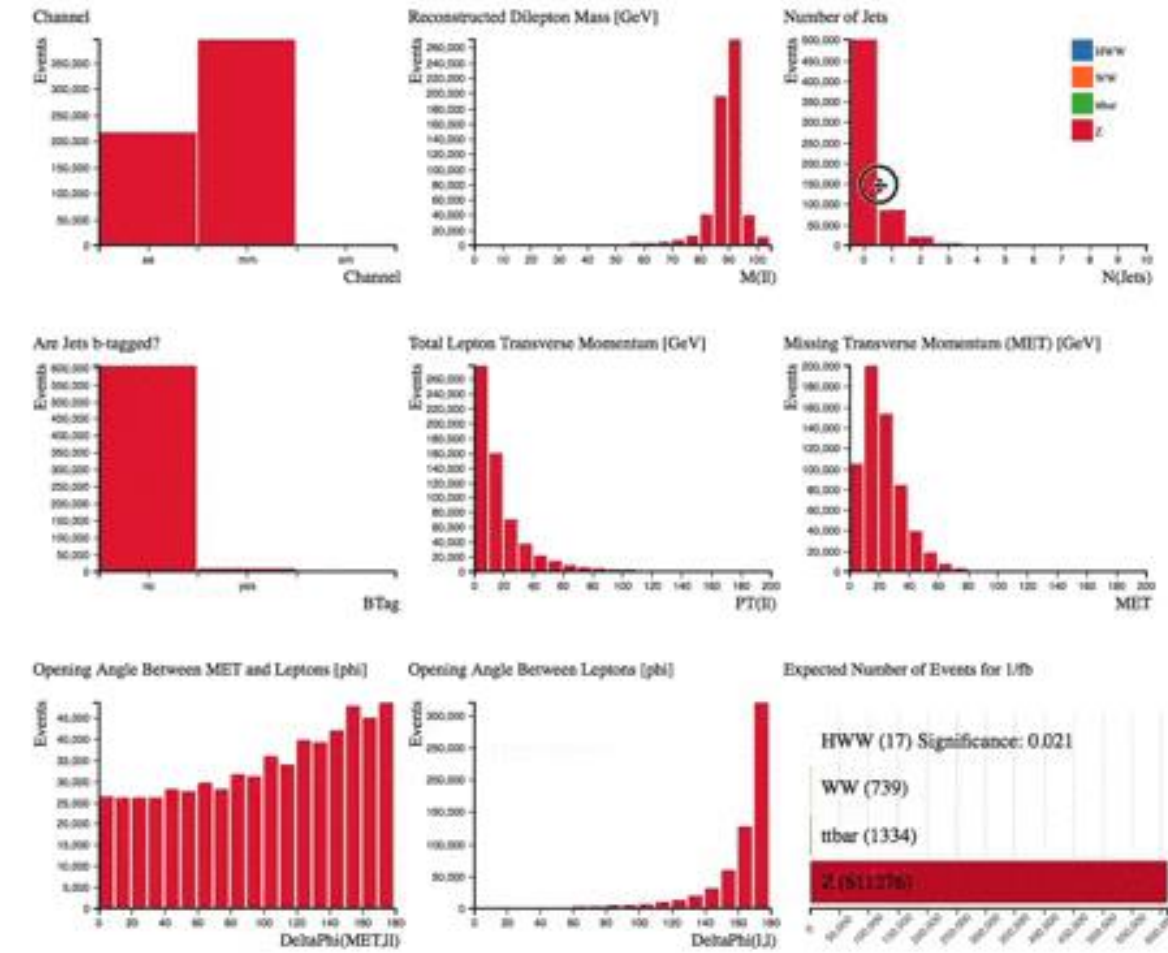
Histogram Analyser displays nine histograms. The description of each follows.

The histograms can take about 30 seconds to load. Whilst loading you'll only see the histogram titles. Once loaded you'll see the histograms appear under their titles.

We think it really helps to be able to see all nine histograms on your screen at the same time. So if this isn't the case to start with, we suggest decreasing the zoom in your web browser until you can see all nine (e.g 67%).

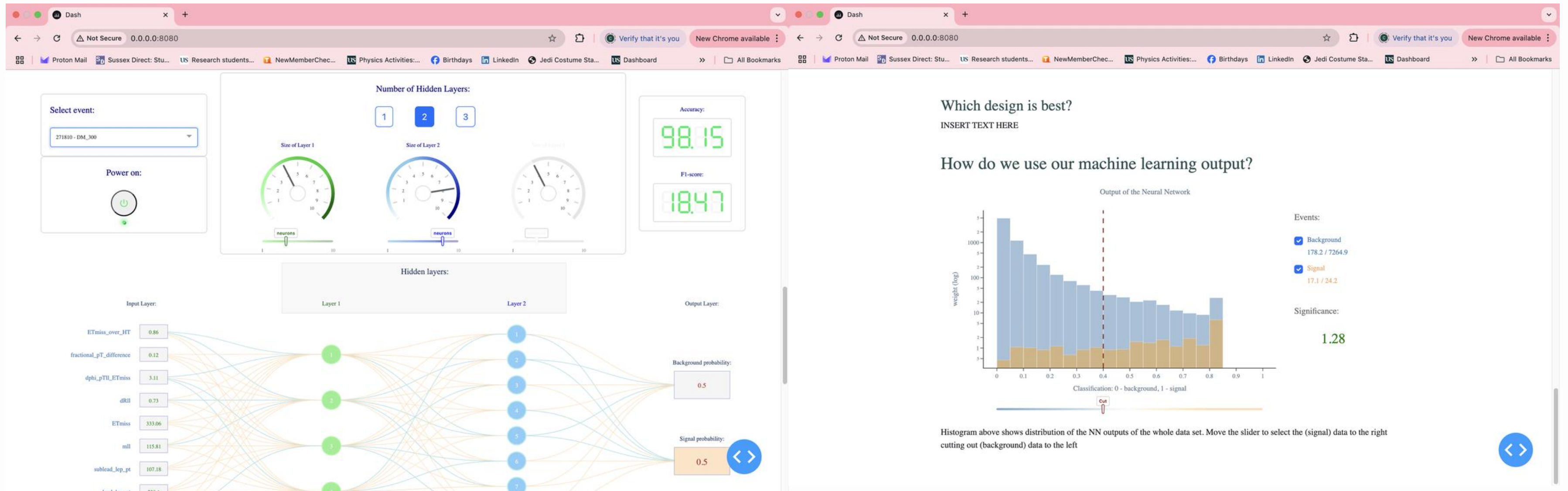


You can select just the  $t\bar{t}Z$  events by clicking on the  $t\bar{t}Z$  in the 'Expected Number of Events' histogram.



Accessible - analyses using only your mouse!

# ATLAS OPEN DATA : Training in Machine Learning



The screenshot displays a web application interface for training a neural network. On the left, there is a control panel with a 'Select event' dropdown menu set to '271810 - DM\_300' and a 'Power on' button. The main area shows the 'Number of Hidden Layers' set to 2, with 'Size of Layer 1' and 'Size of Layer 2' represented by gauges. A network diagram below shows an input layer with 7 nodes, two hidden layers (Layer 1 and Layer 2) with 3 nodes each, and an output layer with 7 nodes. Performance metrics on the right include 'Accuracy: 98.15' and 'F1-score: 18.47'. Below these are 'Background probability: 0.5' and 'Signal probability: 0.5' with a slider. On the far right, a histogram titled 'Output of the Neural Network' shows the distribution of NN outputs, with a vertical dashed line at approximately 0.4. A legend indicates 'Background' (178.2 / 7264.9) and 'Signal' (17.1 / 24.2) events, and a 'Significance: 1.28' is displayed. A slider below the histogram allows for selecting signal data to the right and cutting out background data to the left.

Find Dark Matter using only your mouse!

Interactive web application to learn about machine learning without the need of coding

<https://opendata.atlas.cern/docs/webapps/mlapp>

# ATLAS OPEN DATA : Training in Machine Learning

## Machine Learning Workbook

```

In [ ]: data_for_ml = {} # define empty dictionary to hold dataframes that will be used to train the ML
# inputs = ['sig_pt_1', 'sig_pt_2'] # list of features for neural network
for key in data: # loop over the different keys in the dictionary of dataframes
    data_for_ml[key] = data[key][0][0].copy()

Organise data ready for the ML

In [ ]: # for sklearn data is usually organised
# into one 2D array of shape (N_samples, n_features)
# containing all the data and one array of categories
# of length n_samples

all_mc = [] # define empty list that will contain all features for the MC
for key in data: # loop over the different keys in the dictionary of dataframes
    if key != 'sig_pt_1' and key != 'sig_pt_2': # only MC should pass this
        all_mc.append(data_for_ml[key]) # append the MC dataframes to the list containing all MC features
# x = np.concatenate(all_mc) # concatenate the list of MC dataframes into a single 2D array of features, called x
x = pd.concat(all_mc)

all_y = [] # define empty list that will contain labels whether an event is signal or background
for key in data: # loop over the different keys in the dictionary of dataframes
    if key != 'sig_pt_1' and key != 'sig_pt_2': # only background MC should pass this
        all_y.append(data_for_ml[key].shape[0]) # background events are labelled as 0
all_y.append(data_for_ml['sig_pt_1'].shape[0]) # signal events are labelled with 1
y = np.concatenate(all_y) # concatenate the list of labels into a single 1D array of labels, called y

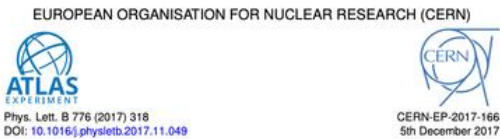
The Training and Testing split
One of the first things to do is split your data into training and testing sets. This will split your data into train-test sets: 90%-10%. It will also shuffle entries so you will not get the first 90% of i for training and the last 10% for testing. This is particularly important in cases where you load all signal events first and then the background events.
Here we split our data into two independent samples. The split is to create a training and testing set. The first will be used for training the classifier and the second to evaluate its performance.
We don't want to test on events that we used to train on, this prevents overfitting to some subset of data to the network would be good for the test data but much worse

```

[ACCESS WORKBOOK HERE](#)

This online workbook, created by Thomas Stevenson, will introduce the basics of Machine Learning and how it can be exploited in an experimental physics context. Experience with python is required, however no knowledge of ML is necessary. Warning: it may take a long time to load the workbook and associated repositories! A preview is available by clicking on the image.

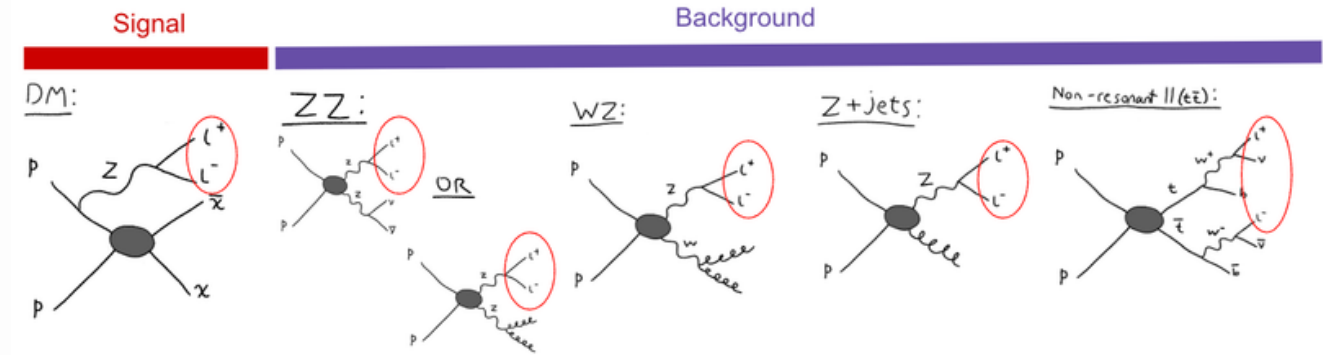
The notebook uses real proton-proton collision data from the ATLAS experiment at CERN to explore some hands-on examples, implementing some of the most commonly used Machine Learning techniques and exploring the potential uses of Machine Learning.



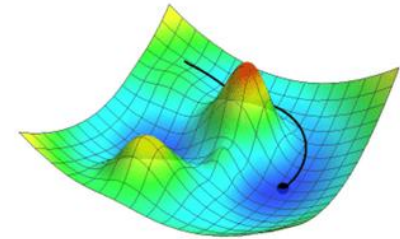
### Search for an invisibly decaying Higgs boson or dark matter candidates produced in association with a Z boson in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector

The ATLAS Collaboration

A search for an invisibly decaying Higgs boson or dark matter candidates produced in association with a topically decaying Z boson in proton-proton collisions at  $\sqrt{s} = 13$  TeV is presented. This search uses  $36.1 \text{ fb}^{-1}$  of data collected by the ATLAS experiment at the Large Hadron Collider. No significant deviation from the expectation of the Standard Model backgrounds is observed. Assuming the Standard Model  $ZH$  production cross-section, an observed (expected) upper limit of 67% (39%) at the 95% confidence level is set on the branching ratio of invisible decays of the Higgs boson with mass  $m_H = 125 \text{ GeV}$ . The corresponding limits on the production cross-section of the  $ZH$  process with the invisible Higgs boson decays are also presented. Furthermore, exclusion limits on the dark matter candidate and mediator masses are reported in the framework of simplified dark matter models.



In the animation below, the black dot represents the position. Just like you might see in a topographic map, the gradient of are the valleys. Note how the descent slows down as the gra



### Search for Dark Matter with Cut Optimisation

### Then learn Machine Learning from scratch and implement in the analysis

### Jupyter Notebook Series developed for Secondary School Students

Introduction to Machine Learning using ATLAS Open Data  
Dr. Tom Stevenson and Caley Yardley  
University of Sussex

## Advanced Machine Learning Notebooks

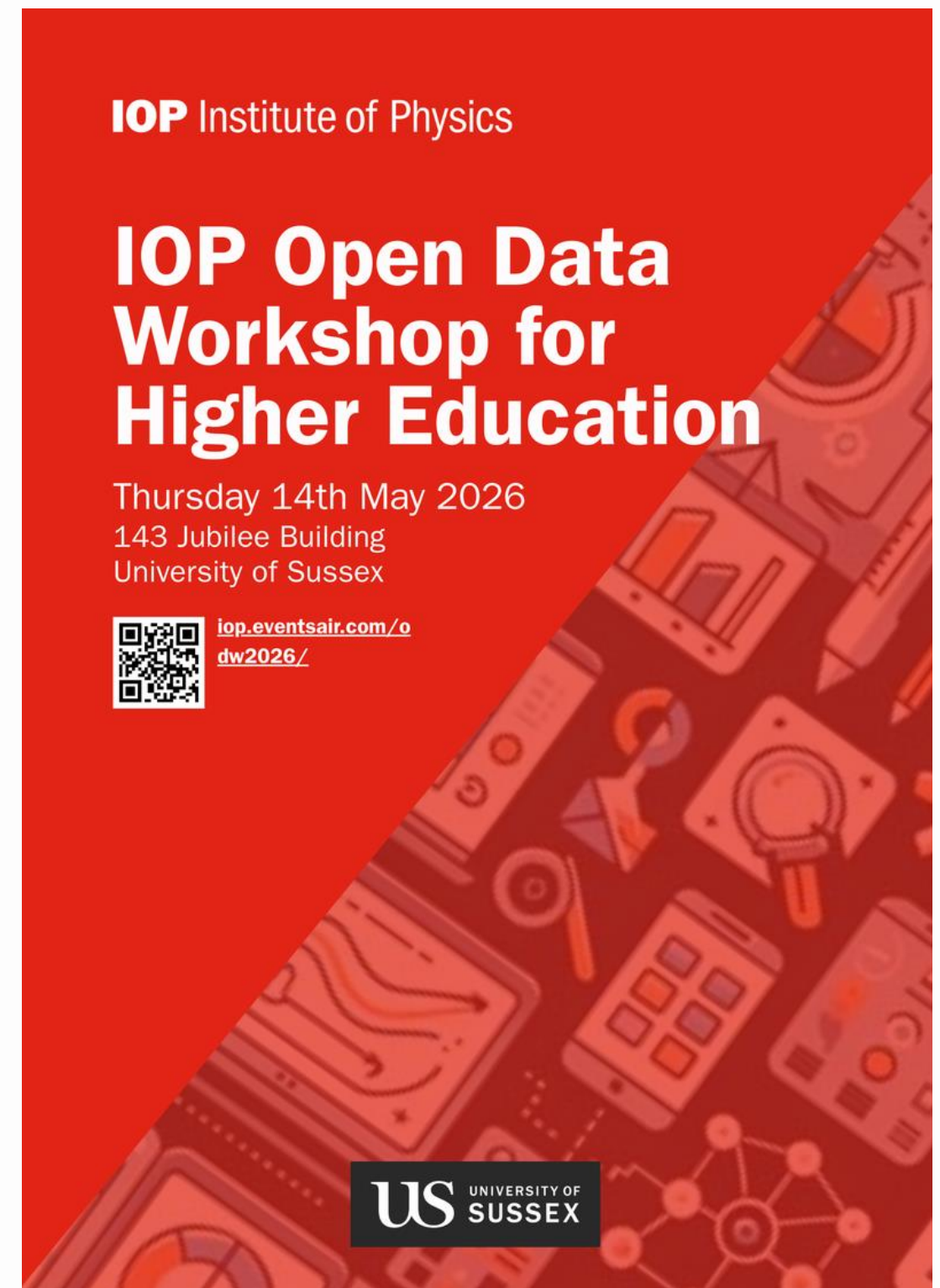
# Open Data for Education

IOP Open Data Workshop for Higher Education

[iop.eventsair.com/odw2026](https://iop.eventsair.com/odw2026)

Open to all, we have talks from LHC experiments, G-2, CERN Open Data portal, The Sloan Digital Sky Survey & The Dark Energy Spectroscopic Instrument (DESI)


*Discuss and plan how as a UK community we could further integrate HEP/APP Open Data into University and secondary school [curriculum](#), and deliver to new audiences*

The poster features a red background with a diagonal split. The top-left portion is solid red, while the bottom-right portion is a lighter red with a pattern of faint, overlapping icons representing scientific and educational tools like a microscope, a laptop, a calculator, and a network diagram. The text is white and black. At the top left, it says 'IOP Institute of Physics'. The main title is 'IOP Open Data Workshop for Higher Education'. Below that, it lists the date and location: 'Thursday 14th May 2026, 143 Jubilee Building, University of Sussex'. A QR code is positioned to the left of the URL 'iop.eventsair.com/odw2026/'. At the bottom right, the University of Sussex logo is displayed in a dark grey box.

**IOP** Institute of Physics

**IOP Open Data Workshop for Higher Education**

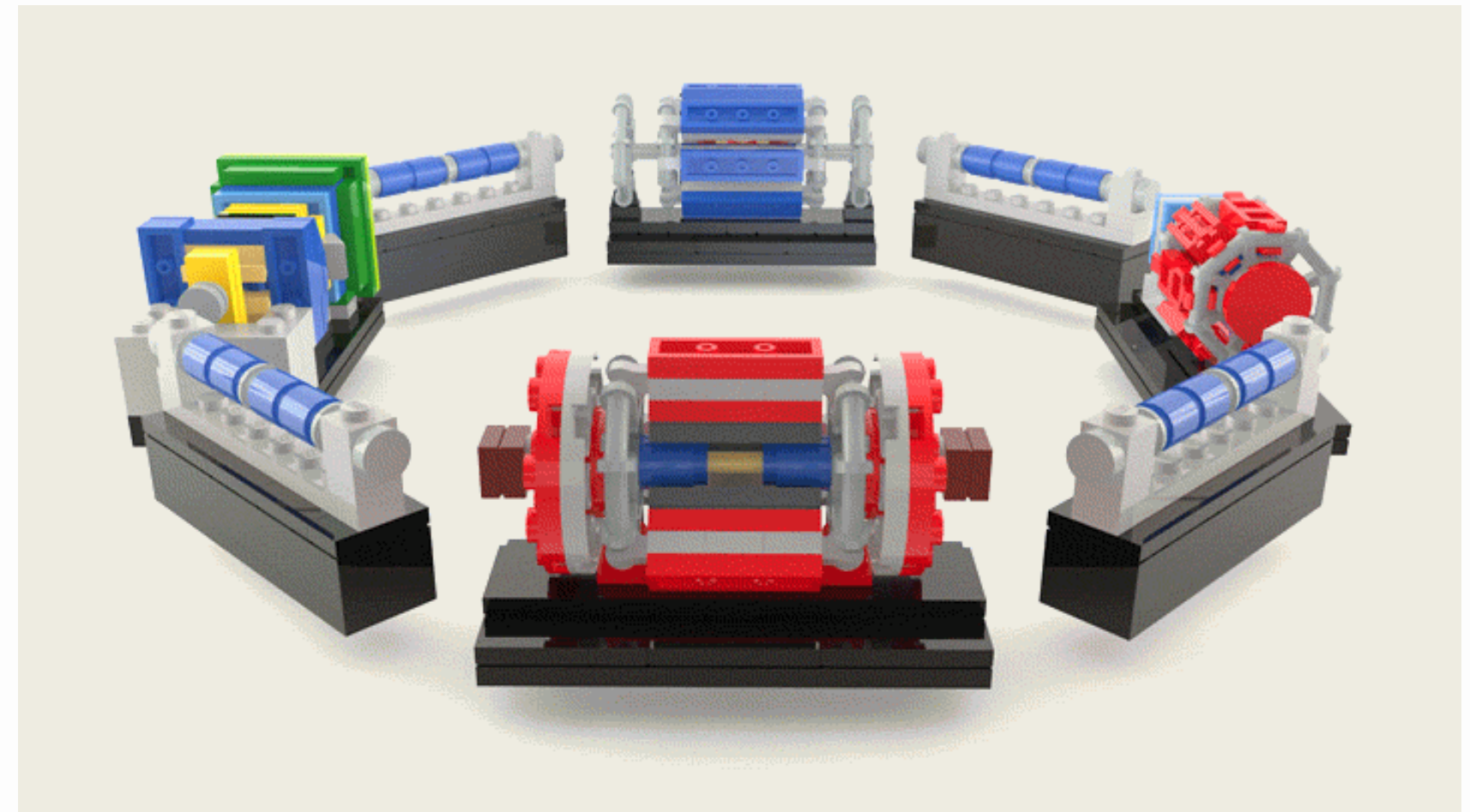
Thursday 14th May 2026  
143 Jubilee Building  
University of Sussex

 [iop.eventsair.com/odw2026/](https://iop.eventsair.com/odw2026/)

**US** UNIVERSITY OF SUSSEX

# Summary

- It is important that we engage in outreach and communication to the public, policy makers, and students
- Diversity strengthens science and innovation: Talent is universal, opportunity is not.
- Working inter-university & cross experiment builds outreach capacity
- Strategic approaches ensures UK physics remains world-leading.



**Opening particle physics is essential. Let's make the universe open to everyone.**