Outreach and Diversity in HEP

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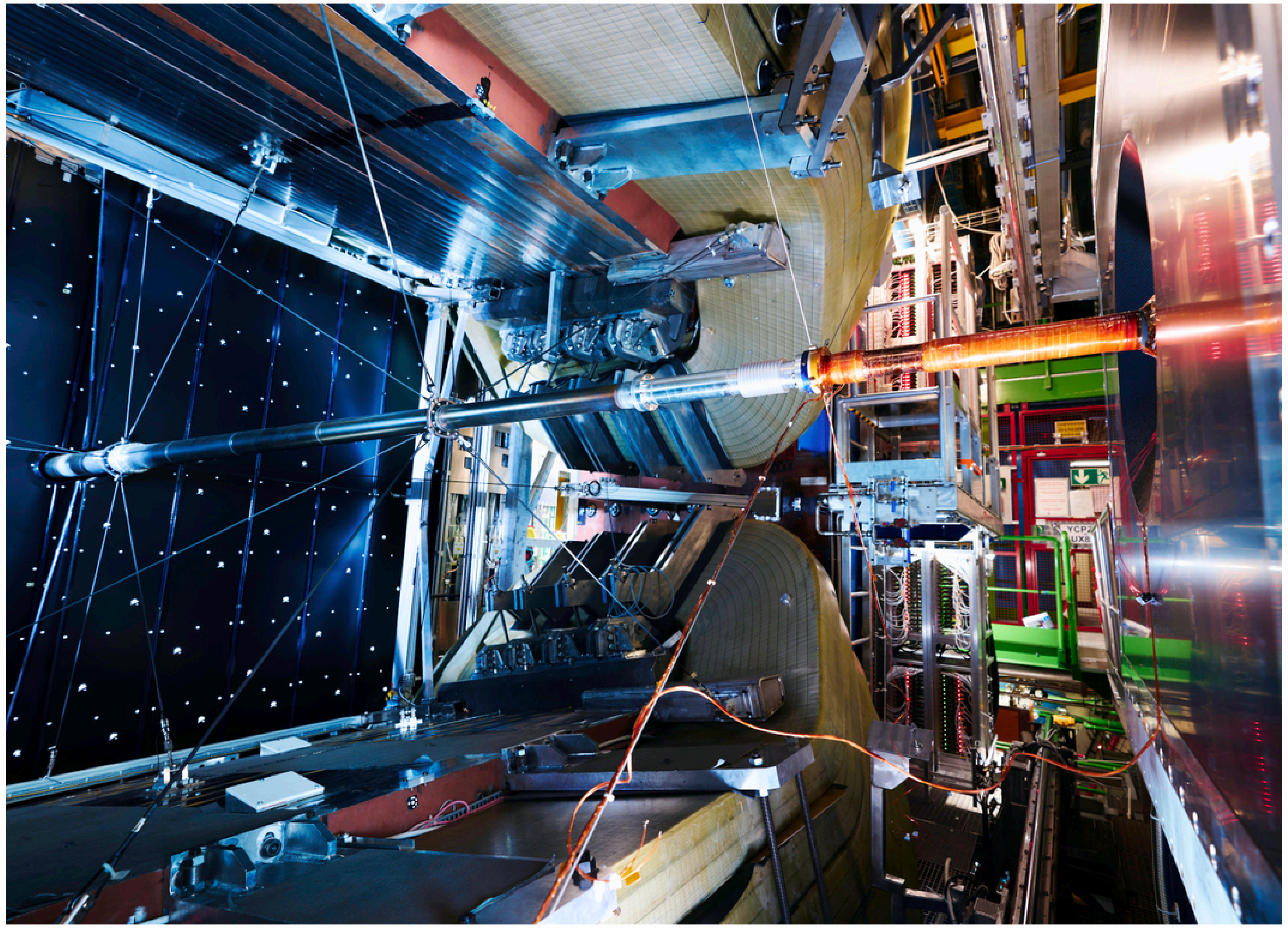
UNIVERSITY OF SUSSEX

Imperial Collage, London
16 January 2026

Diversity and Outreach in High Energy Physics



High Energy Physics is inherently **international**, and our community understands that to get the **best talent** we need to encourage diversity, equity and inclusion!

To achieve our ambitious goals in HEP we need **national** and **international support**.

As scientists we know its our responsibility to reach out to the public, students and policy makers to **communicate** what we do and why!

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EDI: Very important for our community

Equity: Treating people of all identities and backgrounds fairly and respectfully with regard to opportunities, access, treatment, 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.

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Mark Thomson, CERNs new Director General

"I am really passionate about the importance of diversity in all its forms and this includes national and regional inclusivity."

"It is an agenda that I pursued in my last two positions. At the Deep Underground Neutrino Experiment, I was really keen to engage the scientific community from Latin America, and I believe this has been mutually beneficial. At STFC, we used physics as a way to provide opportunities for people across Africa to gain high-tech skills. "

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Mark Thomson, CERNs new Director General

Inclusivity

The goal: "establish CERN as a beacon of inclusivity in science, actively promoting diversity in all its forms and providing an environment where all ca

- I believe a high-level of ambition with regards to diversity, e… …sential for CERN (and indeed any other large organization) to t…
- We will develop a detailed inclusivity **acti…** …steps…

Some immediate actions

- Establish a new hi… …with the goal to develop a pipeline of possible… …mented by CERN management
- B… …us goals for gender balance in both **recruitment (in all rol… …and progression**
- I int… …e as soon as possible our maternity/paternity offering:
  - …oubling the paternity/partner leave from 2 to 4 weeks (following concertation with the Staff Association and Council approval)
  - Immediately moving to a 5-month maternity leave provision, rather than 4 + 1

Inclusivity is an important part of my personal values and I strongly believe it is important for CERN's continued success

[CERN Welcome]

DIVERSITY IS THE KEY TO SUCCESS OF PHYSICS

Monoculture can create mono approaches

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

If certain groups are under-represented, our **talent pool** is smaller

We see that the more diverse a group is, the more **inclusive** it becomes for everyone, and more people are attracted to a **welcoming** environment

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Is Physics Diverse?

Well.. not as much as we would like

Nationally

- Many under-represented groups in physics (aspects such as gender, sexuality, disability, ethnicity, social-economic background, geographical location)
- Its not enough for under-represented groups to be welcomed, they must also **have a seat and a voice at the table**

IOP Report on the Potential of Physics

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

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

1. Teaching workforce challenges: There are serious shortages of teachers with a physics background in secondary and further education.

2. Lack of diversity and inclusive culture: Women, people from disadvantaged backgrounds, disabled people, those who identify as LGBT+, and minority ethnic groups are all underrepresented.

3. Inflexible research careers & interaction with industry: Research career structures are narrow with few incentives for industrial engagement, preventing people from moving easily between academia and industry.

"Increasing R&D investment to 2.4% of GDP by 2027 would generate an additional 80,000 jobs and £30.5bn in GDP[1]."

IOP Report: Physics: investing in our future

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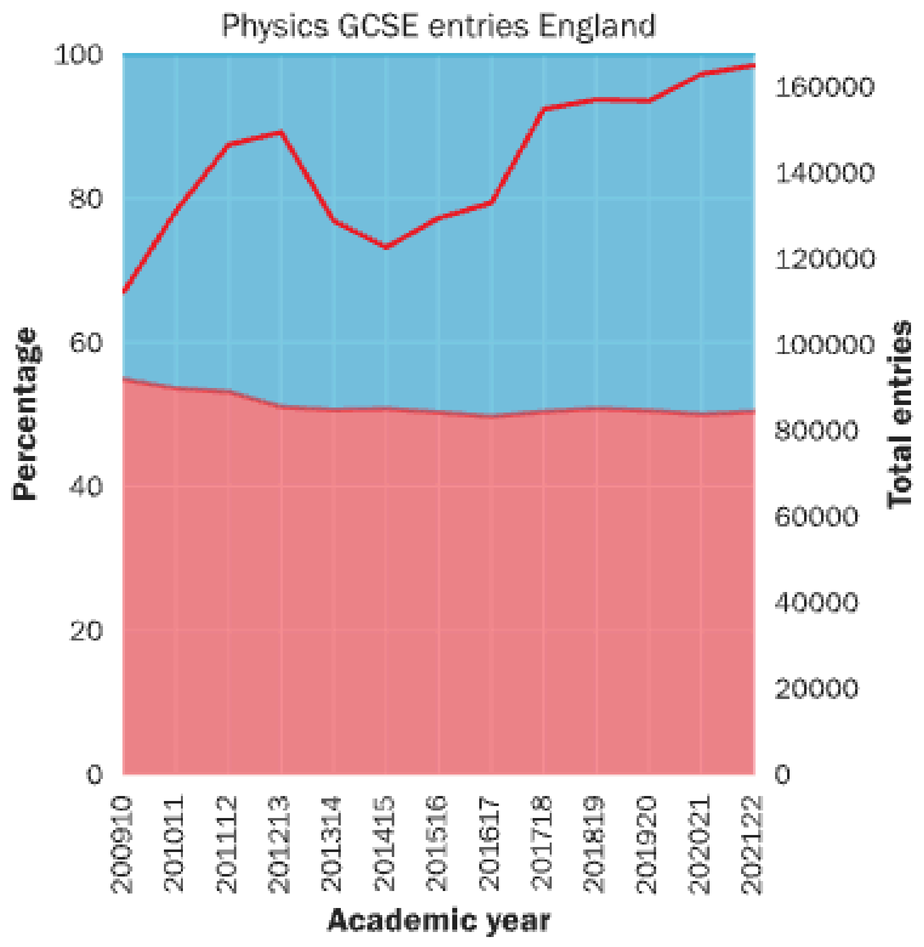
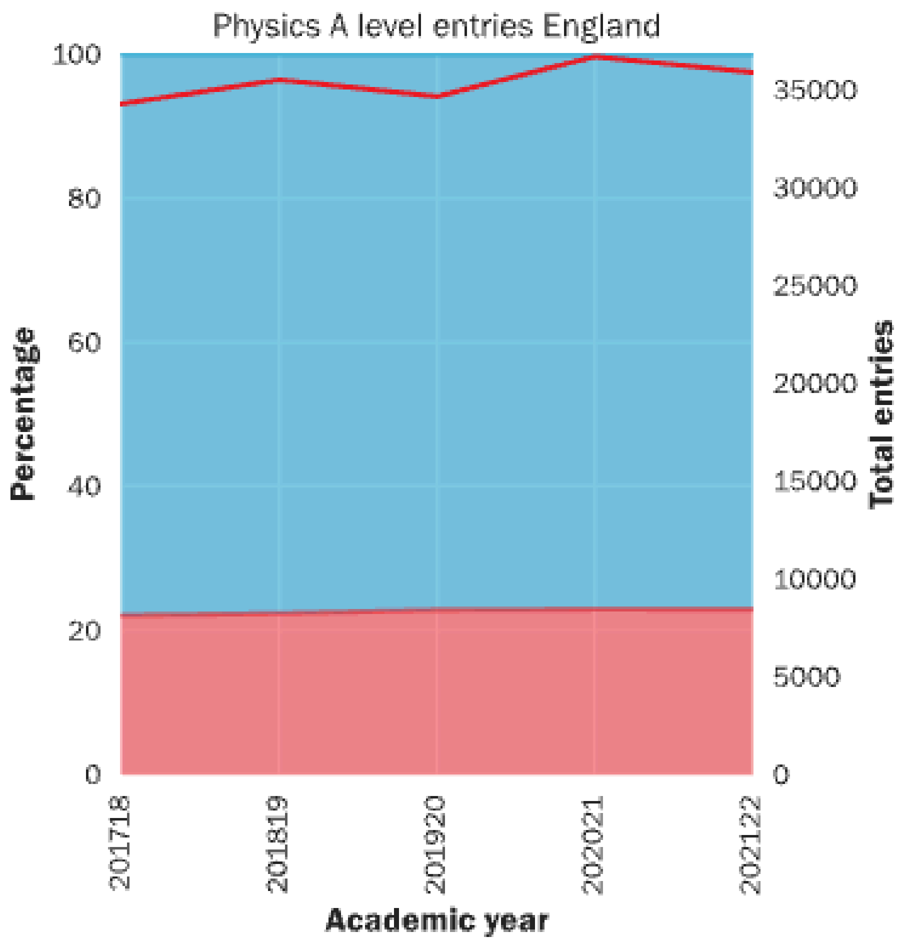
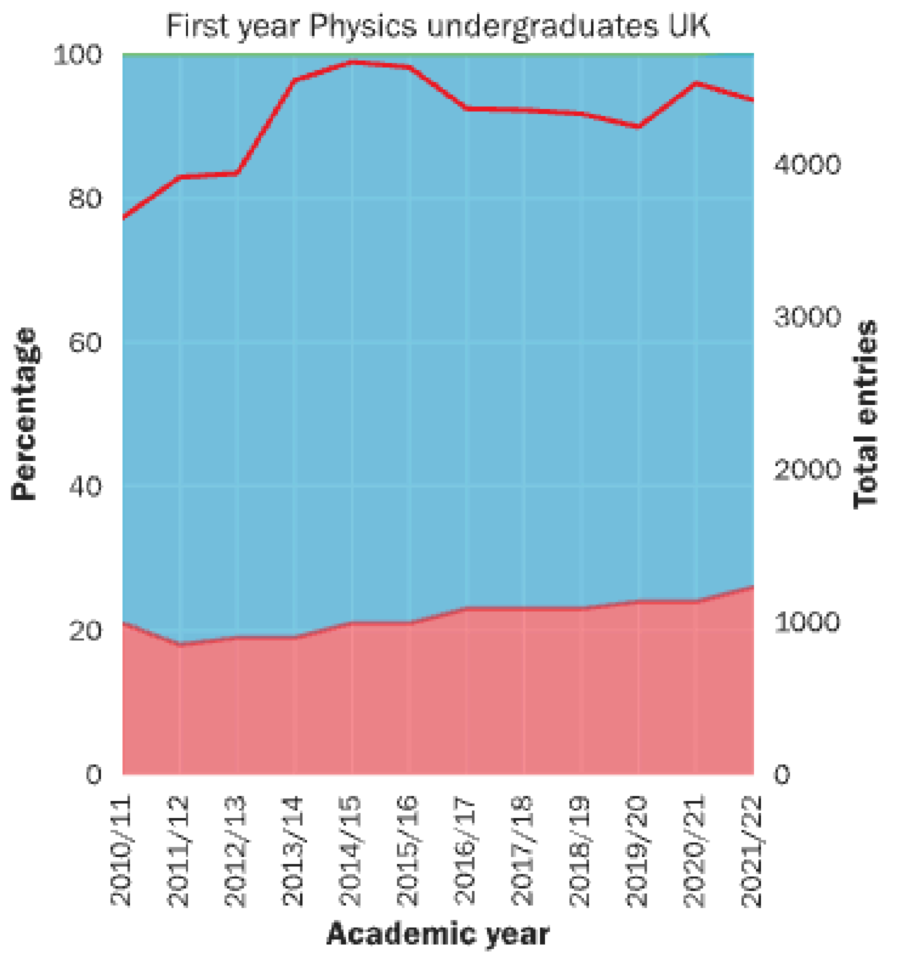
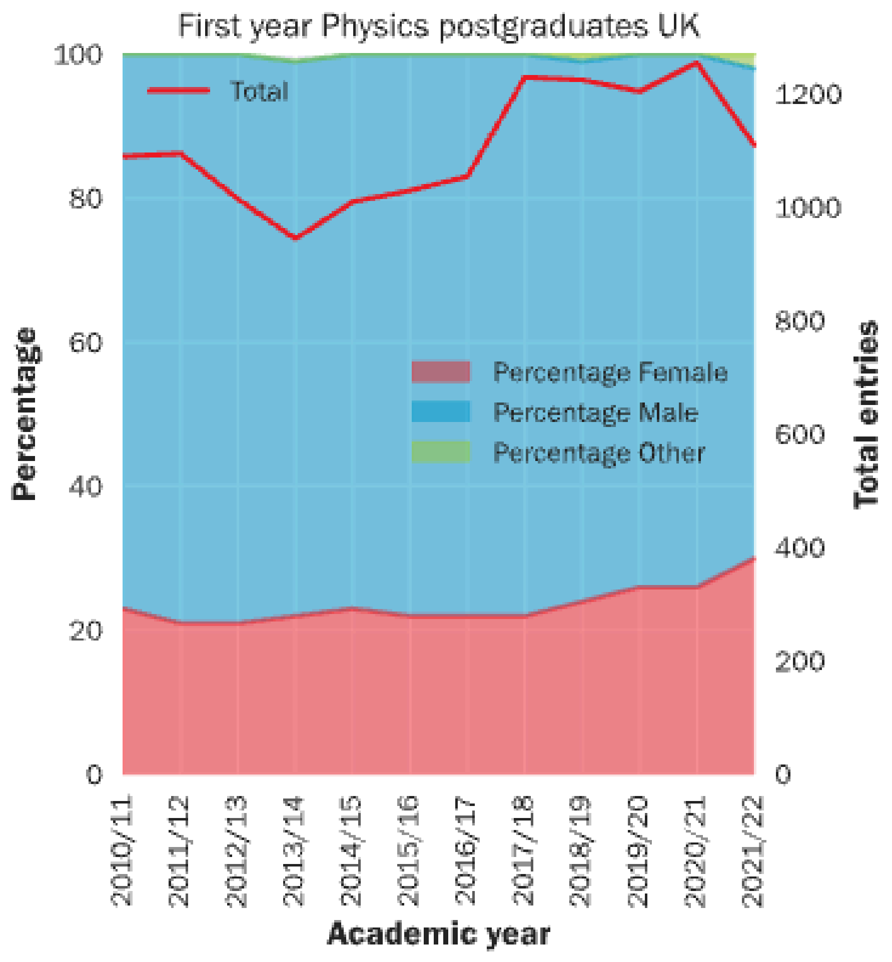
IOP: Physics Education in Schools & Universities

Physics Student numbers have been on the up (until 2021/22): Gender balance has been improving at UK universities, but less in schools.









Sources: Department for Education (DfE), HESA/JISC

Gender & Participation: The Pipeline

Physics has an even gender split at GCSE in England & Wales. It's then very male-dominated at further education- slightly less so in higher education.

Broad Category	Category	Number doing physics	Physics % Female	All Subjects % Female
Secondary Education	GCSE (Northern Ireland 2022/23)	2,759	42%	51%
16 years old	GCSE (Wales, aged 15- 2021/22)	8,159	51%	50%
	National 5 (Scotland, 2022/2023)	13,235	28%	50%
	GCSE (england- 2021/22)	164,948	50%	49%
Further Education	A Levels in Wales	1,326	20%	56%
	A Levels in England (2021/22)	35,894	23%	55%
18 years old	Scottish Advanced Highers (2022/23)	2,085	22%	55%
	Scottish Highers (2022/23)	7,995	26%	54%
	Science T-Levels	152	49%	51%
	Engineering T-Levels	1,632	9%	51%
	English Apprenticeships (any connection to physics)	29,360	19%	50%
	English Apprenticeships (strong connection to physics)	210	19%	50%
Higher Education (Students)	First Year Postgrad Degrees (English Domiciled)	2,120	30%	65%
	First Year of Postgrad Degrees (Scottish Domiciled)	125	28%	65%
University	First Year of Undergrad Degrees (Scottish Domiciled)	425	28%	60%
BSc/ MPHYS	First Year of Undergrad Degrees (English Domiciled)	5,195	26%	56%
Graduates (in work in GB in 2021)	Graduates working in Education (graduating 5 years before 2021)	235.62	19%	74%
	Graduates in industry, graduating 1 year before 2021	1,340	31%	59%
	Graduates graduating 3 years before 2021	1,720	20%	58%
	Graduates graduating 5 years before 2021	1,870	21%	58%
	Graduates Graduating 10 years before 2021	1,500	21%	57%
	Graduates working in Financial Services (graduating 5 years before 2021)	186	19%	44%
	Graduates working in Manufacturing (graduating 5 years before 2021)	160.82	15%	36%
Higher Education (Staff)	All non-academic staff	1,850	41%	63%
	Technical Professionals	500	32%	61%
Researcher	Junior Researchers / Lecturers	2,005	24%	52%
	Mid-Level Researchers / Lecturers	875	25%	51%
	Senior Researchers / Lecturers	805	18%	43%
PROF	Professors	1,015	14%	30%

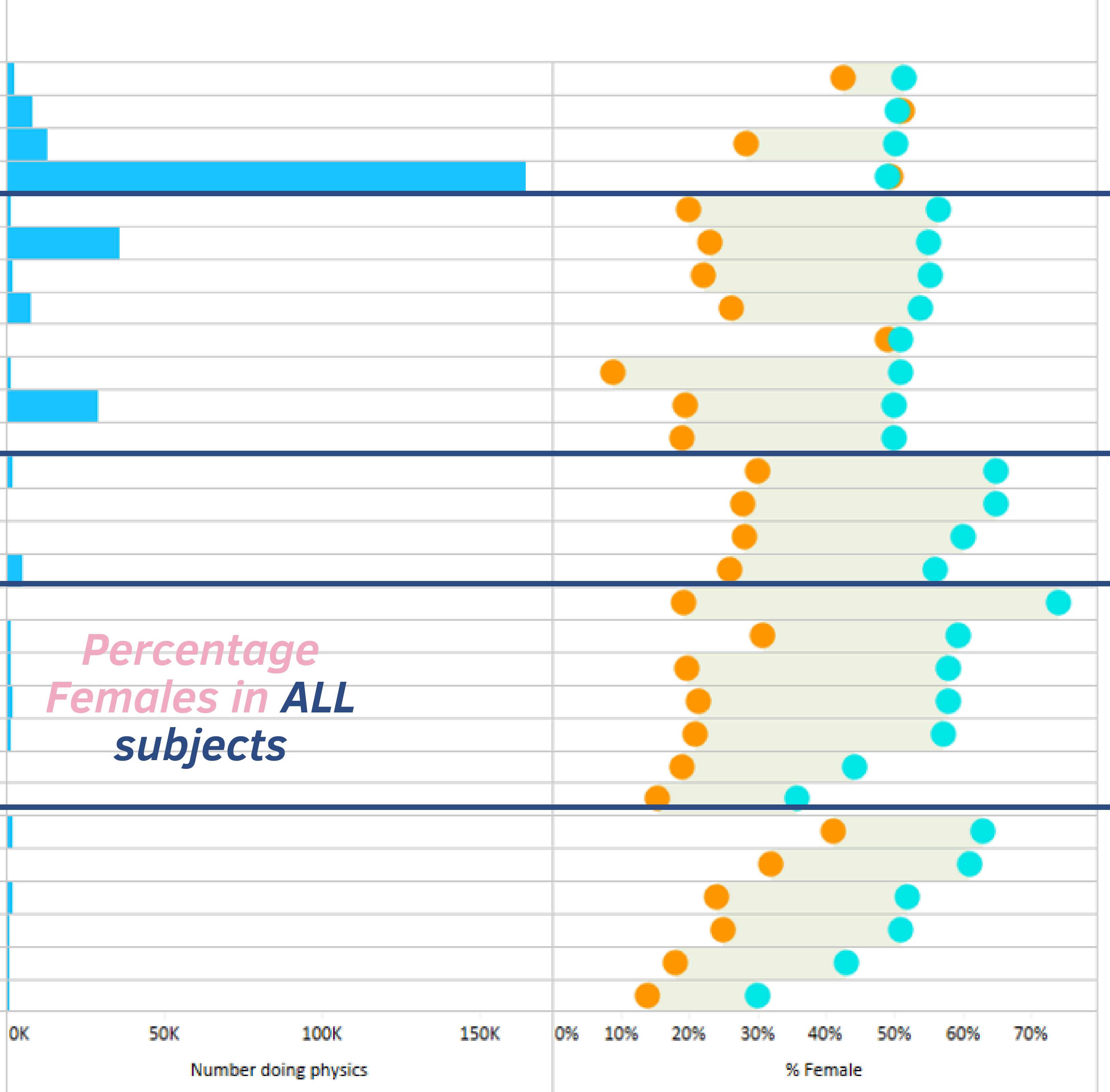
~50%

~23%

~30%

~14%

Percentage Females in Physics

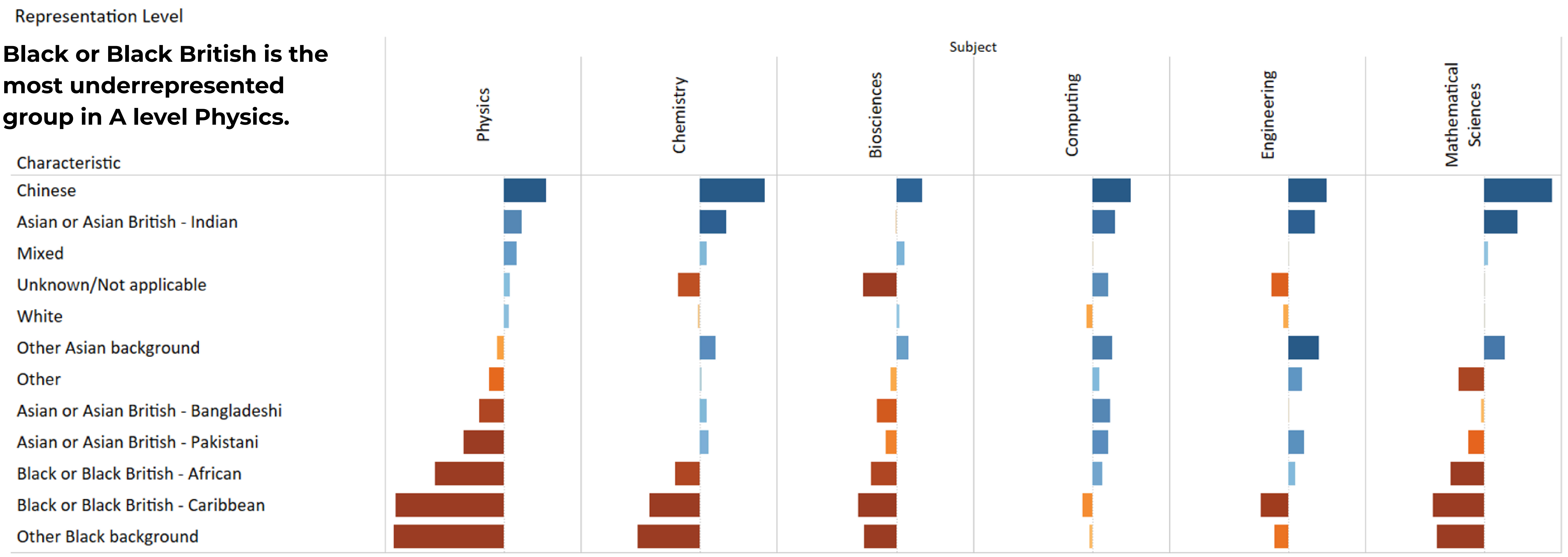


Measure Names
- All Subjects % Female
- Number doing physics
- Physics % Female

Sources:
Department for Education (England)
SQA (Scotland)
CCEA (Northern Ireland)
StatWales (Wales)
HESA / JISC (University Data)
IOP

IOP: University Physics Student Ethnicity

Black or Black British is the most underrepresented group in A level Physics.



Students from Black and some Asian backgrounds continue to be under-represented in physics at university: More-so than in many other comparable subjects

Sources: Department for Education (DfE), HESA/JISC

IOP: Socio-economic background

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

Characteristic
- Unknown/Not applicable
- Quintile 5 (Least disadvantaged)
- Quintile 4
- Quintile 3
- Quintile 2
- Quintile 1 (Most disadvantaged)

Among comparable subjects, Physics students are the most likely to have attended privately funded schools

- Unknown/Not applicable
- State funded school or college
- Privately funded school

Sources: Department for Education (DfE), HESA/JISC

Promoting EDI in Physics

- In our different scientific communities we must work on cultivating an **inclusive environment for all**
- **Investigate** and tackle **barriers** and **issues** encountered by different groups and different stages of their careers
- Develop **outreach initiatives** to encourage the next generation of scientists, focused on those under represented groups

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Is Physics Diverse?

Well.. not as much as we would like

Internationally countries in the **Global South** fare much worse (in general!!)

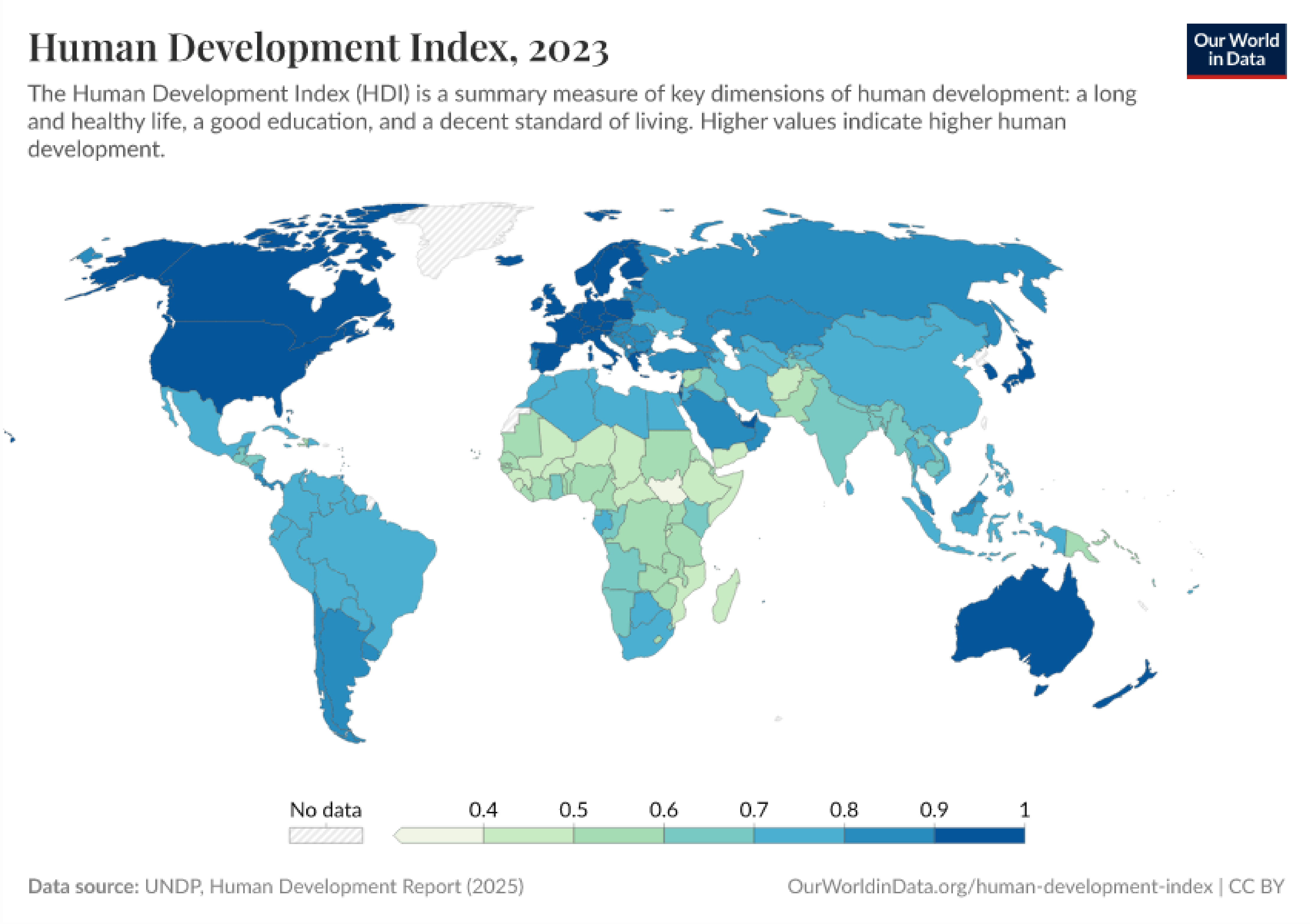
→ Many students, researchers and scientists live in countries that lack educational and **training resources**, their universities lack investment

→ Many scientists do not have any access to research / travel **funding,** or governmental support

→ Many students and young people lack **exposure** to research, and access to research **opportunities**

→ This costs us valuable talent and scientists!

Research Gap between Global North and South



Global South countries account for 80% of the worlds population but only 28% of the worlds scientists come from these countries

[UNESCO Science Reports]

[Our World in Data]

Physics for Sustainable Development

Countries at all income levels are looking to transition towards **digital and green economies** and **sustainably develop**

This vitally involves **investment into science**, and accelerating technology transfer into industry

To reach SDG by 2030 countries will need to **invest** more into **scientific research** and innovation

The Sustainable Development Goals Report: https://sdgs.un.org/documents/sustainable-development-goals-report-2023-53220

Physics for Sustainable Development

Physics **outreach** and **communication** in all countries around the world is vital to promote **scientific literacy** in the population:

School students benefit from **enquiry based learning** (observation, measurement and experimentation)

Understanding scientific discovery requires continual **readjustment** with new **facts**

Democracy relies on a scientific literate population

International Cooperation

International cooperation builds **bridges** across nations, **soft diplomacy** has real impact

CERN has become a model for **cooperation** in terms of research, embodying the ‘one-earth’ approach that the world needs to tackle the global challenges we are facing.

Today CERN has 24 member states
Over 12000 scientists from ~110 nations use CERN’s laboratories.

International Cooperation

SESAME: Synchrotron-light for Experimental Science and Applications in the Middle East, Jordan.

Pooling resources to build scientific capacity within the region, create research and career **opportunities** that can limit the brain drain

Functions as a **bridge** between its diverse culturally and politically conflicting societies

ICTP Physics Without Frontiers @ictpPWF

Internationally, richer countries have the lions share of scientists, funding, supportive scientific environments

- many countries **lack resources** and their universities lack investment
- many scientists do not have the same access to **funding** and governmental support
- many students and young people **lack exposure, access and opportunity**

- **This costs us valuable scientists!**

-Lacks time for research
-No access to research grants
-No funding to travel to conferences to present results and meet new collaborators

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Physics Training & Outreach

We must reach out to students and researchers across the **world**

→ Seek out & provide **study** (MSc/PhD) or training **opportunities**

→ **Provide funding** for students/scientists to come to your **conference or workshop** (or/and provide free online access)

→ Build cooperation and **networks** with new collaborators

→ Go to conferences in **underrepresented** regions

Physics Without Frontiers	AIMS	African School of Physics	Scholar Rescue Fund
ictp.it/home/physics-without-frontiers	nexteinstein.org	africanschoolofphysics.org/	scholarrescuefund.org/

ICTP Physics Without Frontiers @ictpPWF

ICTP Physics Without Frontiers works to teach, train and motivate physics and mathematics university students worldwide **<u>to help build the next generation of scientists</u>**. Each project is unique, developed with the country's specific needs in mind.

- **Inspire** and **motivate** the next generation of physicists
- **Train** and **educate** those with hands-on physics and transferable skills
- **Collaborate**, providing stimulating networking environments
- **Mentor** students onto further study and provide career advice


HEP Workshop, Afghanistan

ICTP Physics Without Frontiers @ictpPWF

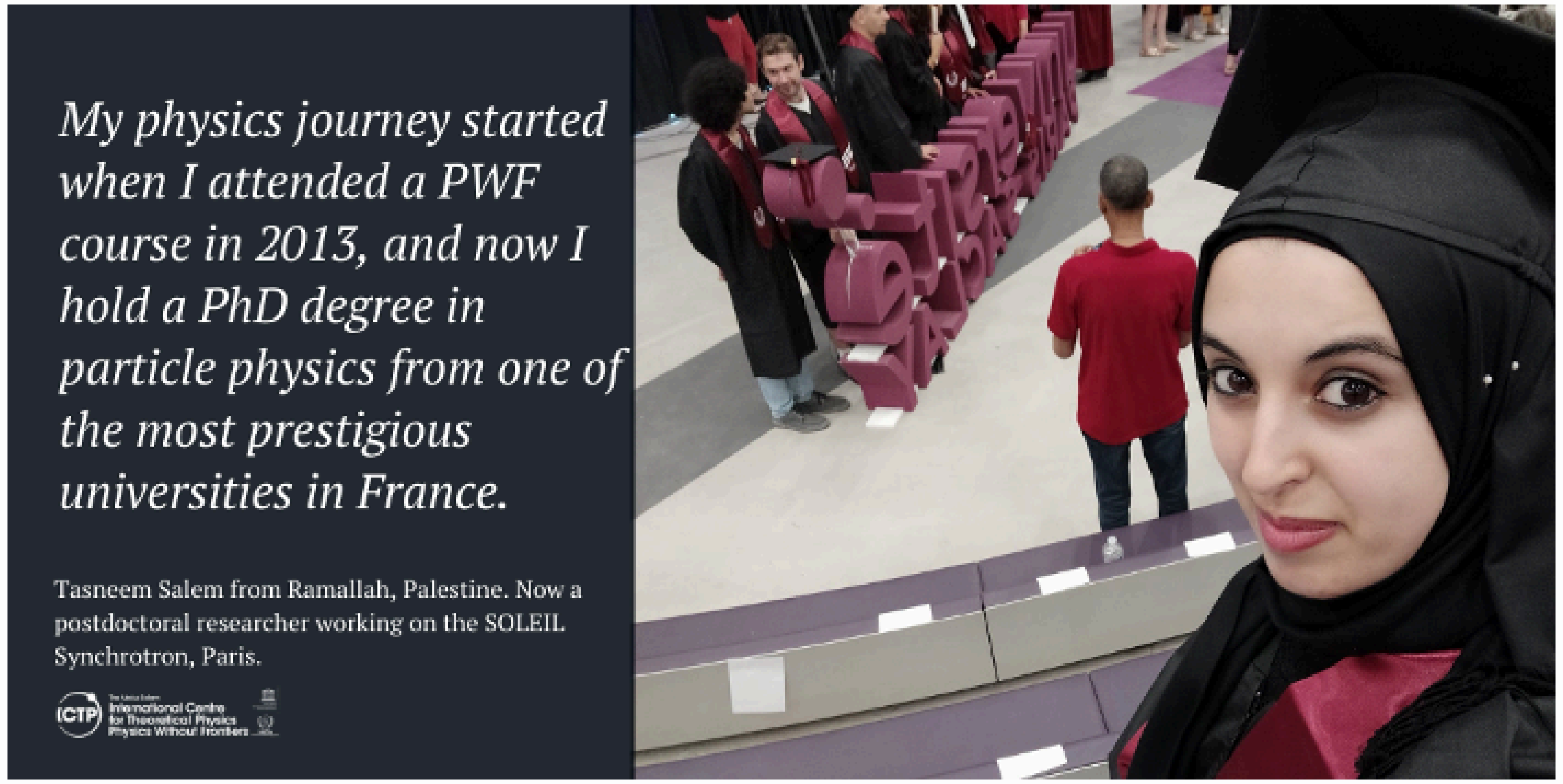
Aims of the Project

- To **expose** and introduce new ideas in physics to undergraduate and master students, provide **courses** and **training** in key analysis and transferable skills

- To identify top students, provide mentoring and support for further study and career

- To **connect** with scientists, build **networks** and support them with international opportunities and collaboration

- Bring **awareness** to the university and **policy makers** to the importance of supporting physics departments and ultimately research



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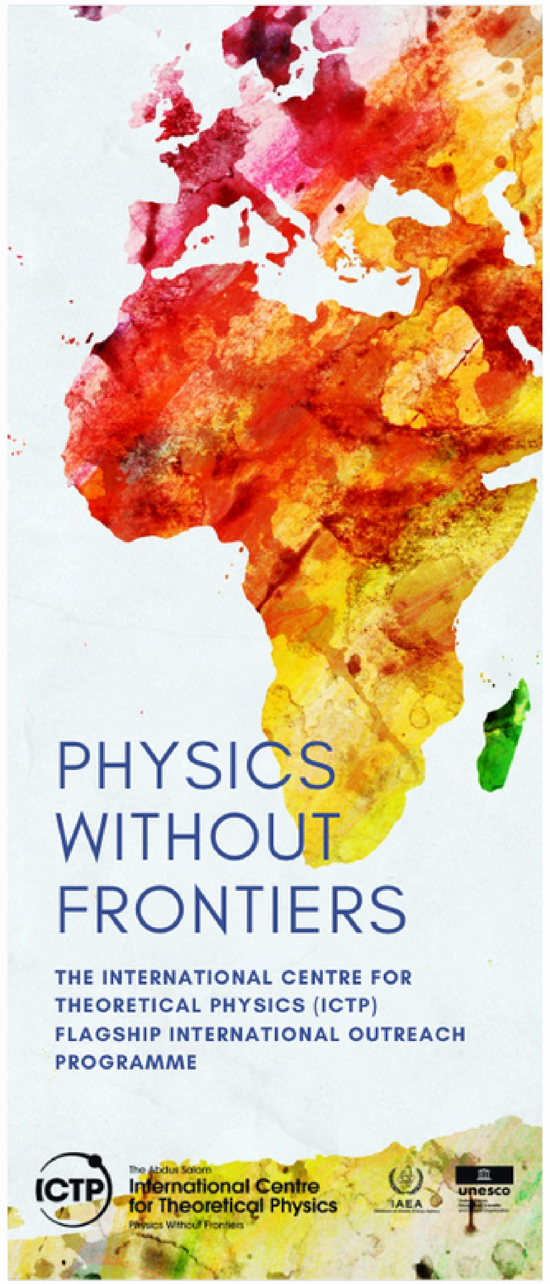
The Abdus Salam International Centre for Theoretical Physics
Physics Without Frontiers

ICTP Physics Without Frontiers @ictpPWF

We run around 25 PWF projects around the world every year, in all areas of physics with some focus on least developed countries and conflict regions



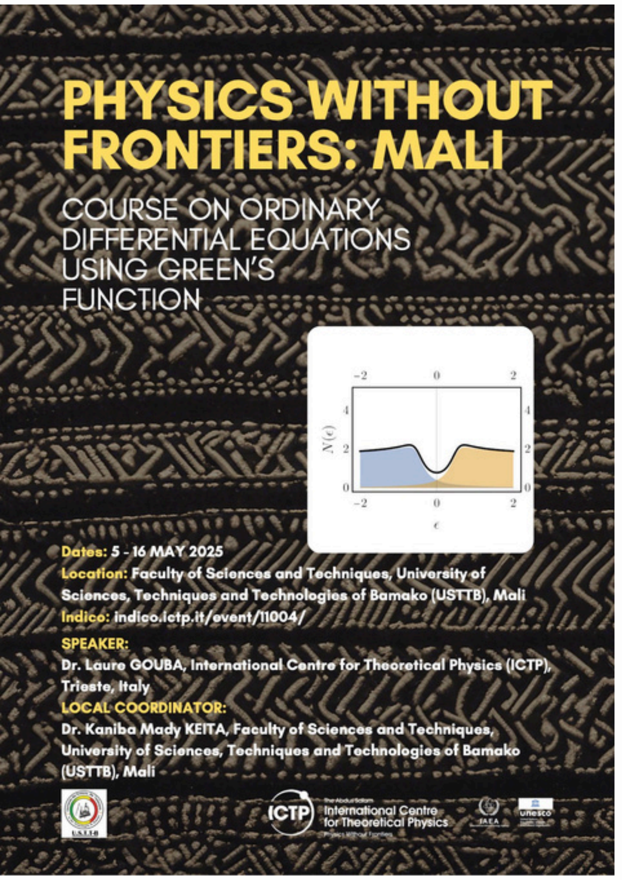
50 COUNTRIES IN THE GLOBAL SOUTH

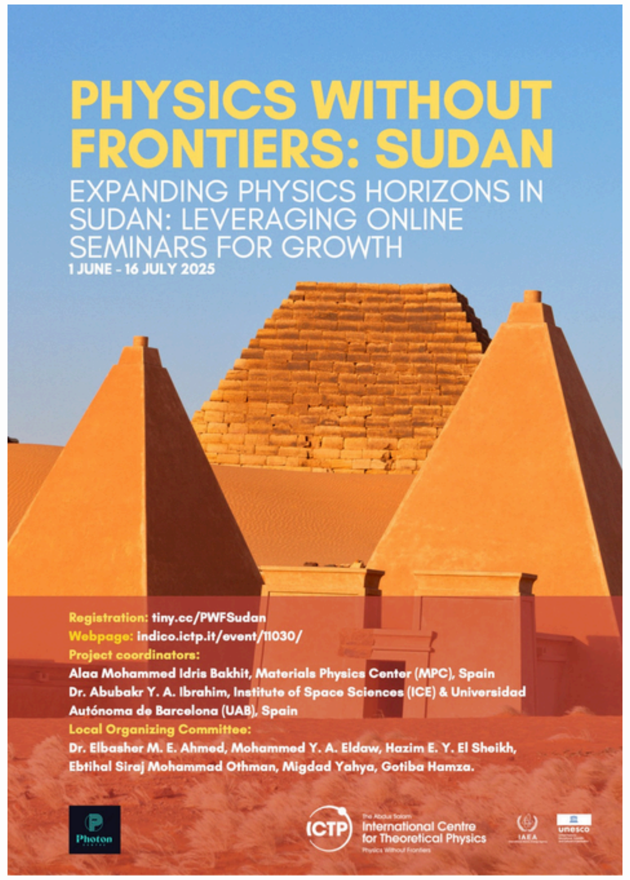
160 UNIVERSITIES

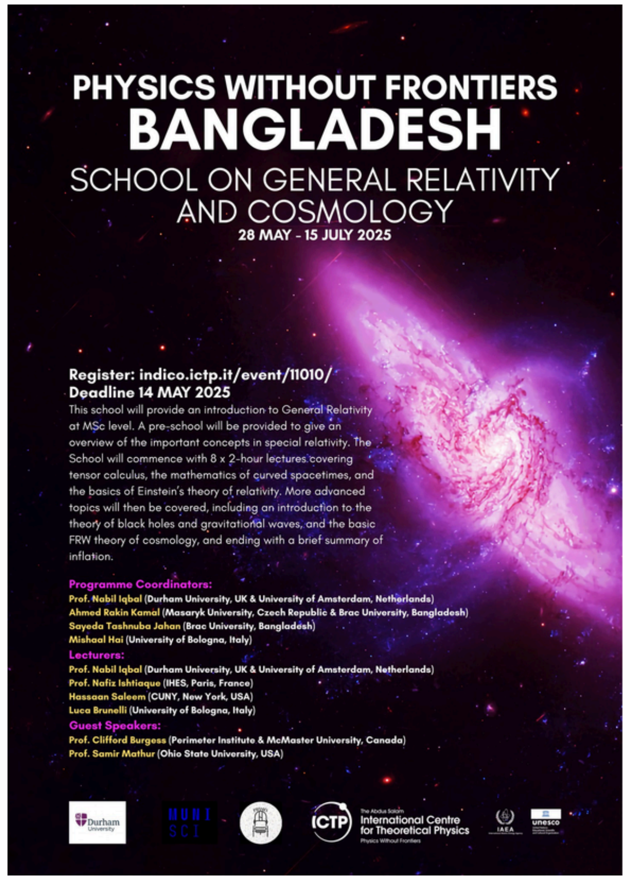
14k STUDENTS

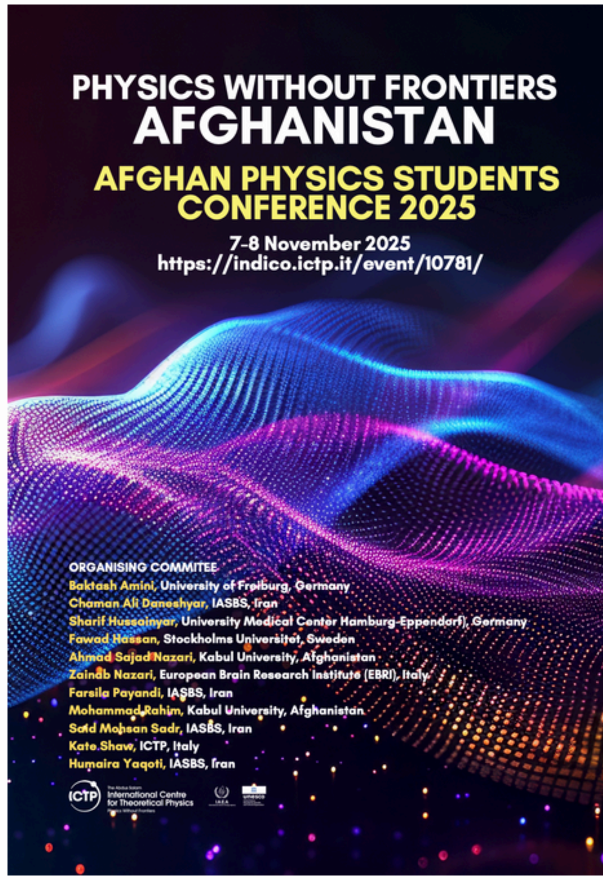
600 ALUMNI

ICTP Physics Without Frontiers @ictpPWF





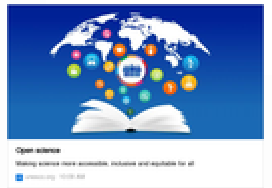




We work to bring physics to each corner of the Globe, with focus on:

- **Economic** Frontiers: Low income & science & technology lagging countries
- **Social** Frontiers: Women and Girls, cultural frontiers
- **Geographical** Frontiers: Rural and remote areas
- **Sociopolitical** Frontiers: under represented ethnicities and conflict regions or political turmoil

Open Science Movement



UNESCO Open Science website

Open science is an **accelerator** for the **Sustainable Development Goals (SDGs) 2030** and a powerful tool to bridge the science divide between and within countries

Open science aims at making scientific knowledge openly **available**, **accessible** and **reusable**.

The key elements include open access to scientific publications, **data**, educational resources, software and hardware, and open infrastructures

Open Science at CERN website

CERN OPEN DATA POLICY

Open Science at CERN website

CERN Open Data Policy for the LHC Experiments."
https://cds.cern.ch/record/2745133 , November 2020

Level 1: Published Results

- Available with Open Access
- HEPData: Repository for publication-related HEP data
- Rivet toolkit: Robust Independent Validation of Experiment and Theory

Level 2: Outreach and Education

- Dedicated subsets of data selected and formatted to provide rich samples to maximise their educational impact, and to facilitate the easy use of the data.

Level 3: Reconstructed Data

- Experiments release calibrated reconstructed data useful for algorithmic, performance and physics studies

Level 4: Raw Data - Not feasible

CERN Open Data Policy for the LHC Experiments
November, 2020

The CERN Open Data Policy reflects values that have been enshrined in the CERN Convention for more than sixty years that were reaffirmed in the European Strategy for Particle Physics (2020)[1], and aims to empower the LHC experiments to adopt a consistent approach towards the openness and preservation of experimental data. Making data available responsibly (applying FAIR standards[2]), at different levels of abstraction and at different points in time, allows the maximum realisation of their scientific potential and the fulfillment of the collective moral and fiduciary responsibility to member states and the broader global scientific community. CERN understands that in order to optimise reuse opportunities, immediate and continued resources are needed. The level of support that CERN and the experiments will be able to provide to external users will depend on available resources.

This policy relates to the data collected by the LHC experiments, for the main physics programme of the LHC — high-energy proton–proton and heavy-ion collision data. The foreseen use cases of the Open Data include reinterpretation and reanalysis of physics results, education and outreach, data analysis for technical and algorithmic developments and physics research. The Open Data will be released through the CERN Open Data Portal which will be supported by CERN for the lifetime of the data. The data will be tailored to the different uses, and will be made available in formats defined by each experiment that afford a range of opportunities for long-term use, reuse and preservation. In general, four levels of complexity of HEP data have been identified by the Data Preservation and Long Term Analysis in High Energy Physics (DPHEP) Study Group[3], which serve varying audiences and imply a diversity of openness solutions and practices.

Published Results (Level 1) Policy: Peer-reviewed publications represent the primary scientific output from the experiments. In compliance with the CERN Open Access Policy, all such publications are available with Open Access, and so are available to the public. To maximise the scientific value of their publications, the experiments will make public additional information and data at the time of publication, stored in collaboration with portals such as HEPData,[4] with selection routines stored in specialised tools. The data made available may include simplified or full binned likelihoods, as well as unbinned likelihoods based on datasets of event-level observables extracted by the analyses. Reinterpretation of published results is also made possible through analysis preservation and direct collaboration with external researchers.

Outreach and Education (Level 2) Policy: For the purposes of education and outreach, dedicated subsets of data are used, selected and formatted to provide rich samples to maximise their educational impact, and to facilitate the easy use of the data. These data are released with a schedule and scope determined by each experiment. The data are provided in simplified, portable and self-contained formats suitable for educational and public understanding purposes; but are not intended nor adequate for the publication of scientific results. Lightweight environments to allow the easy exploration of these

[1] European Strategy Group (2020), '2020 Update of the European Strategy for Particle Physics'.
[2] FAIR Guiding Principles for scientific data management and stewardship. Available at: https://www.go-fair.org/fair-principles/.
[3] Data management plans are defined by the LHC experiments to address the long-term preservation of internal data products. See: Akopov et al., Status report of the DPHEP Study Group: Towards a global effort for sustainable data preservation in high energy physics. arXiv preprint arXiv:1205.4667 (2012).
[4] Repository for publication-related High-Energy Physics data: http://www.hepdata.net.

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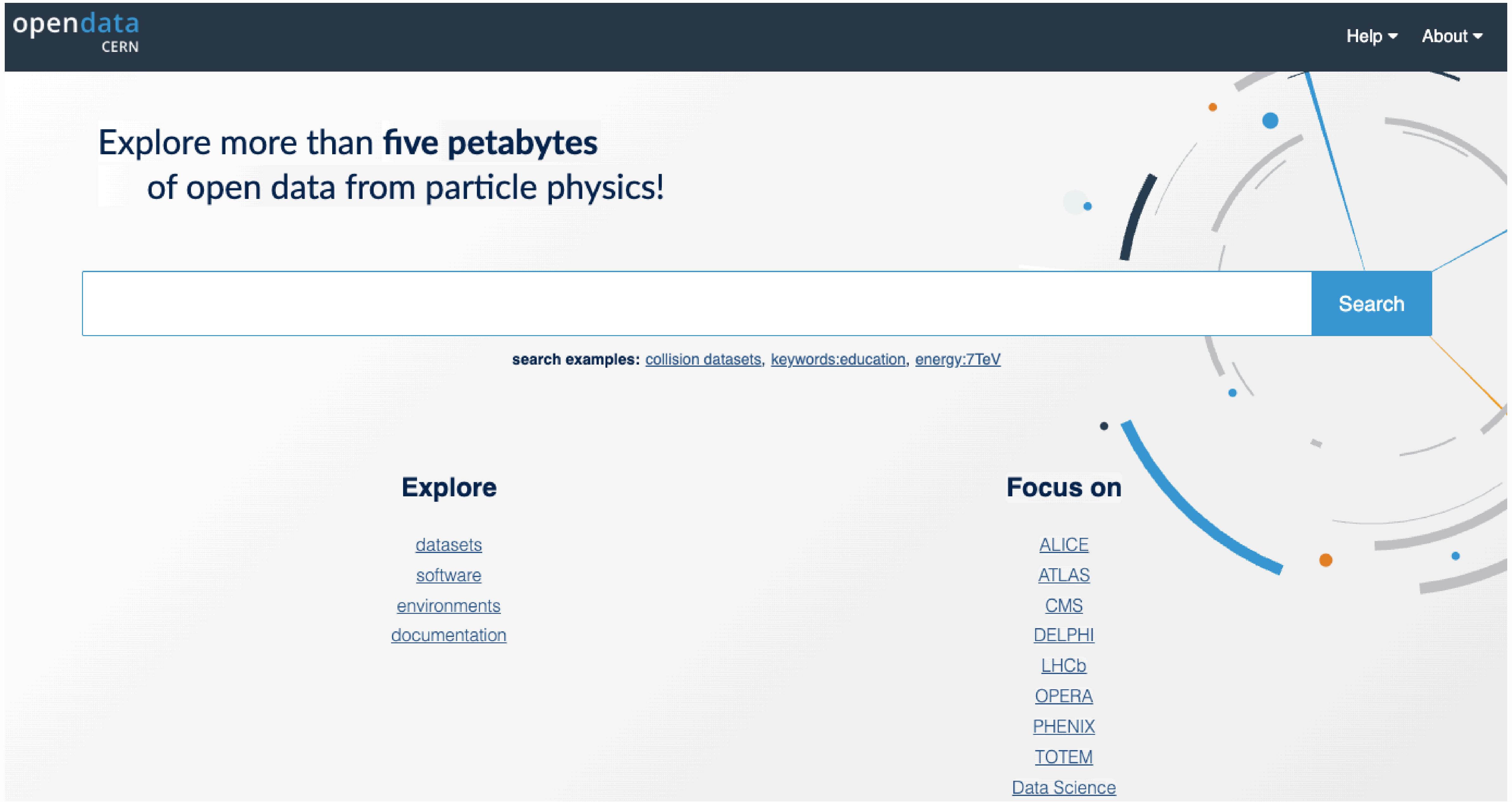
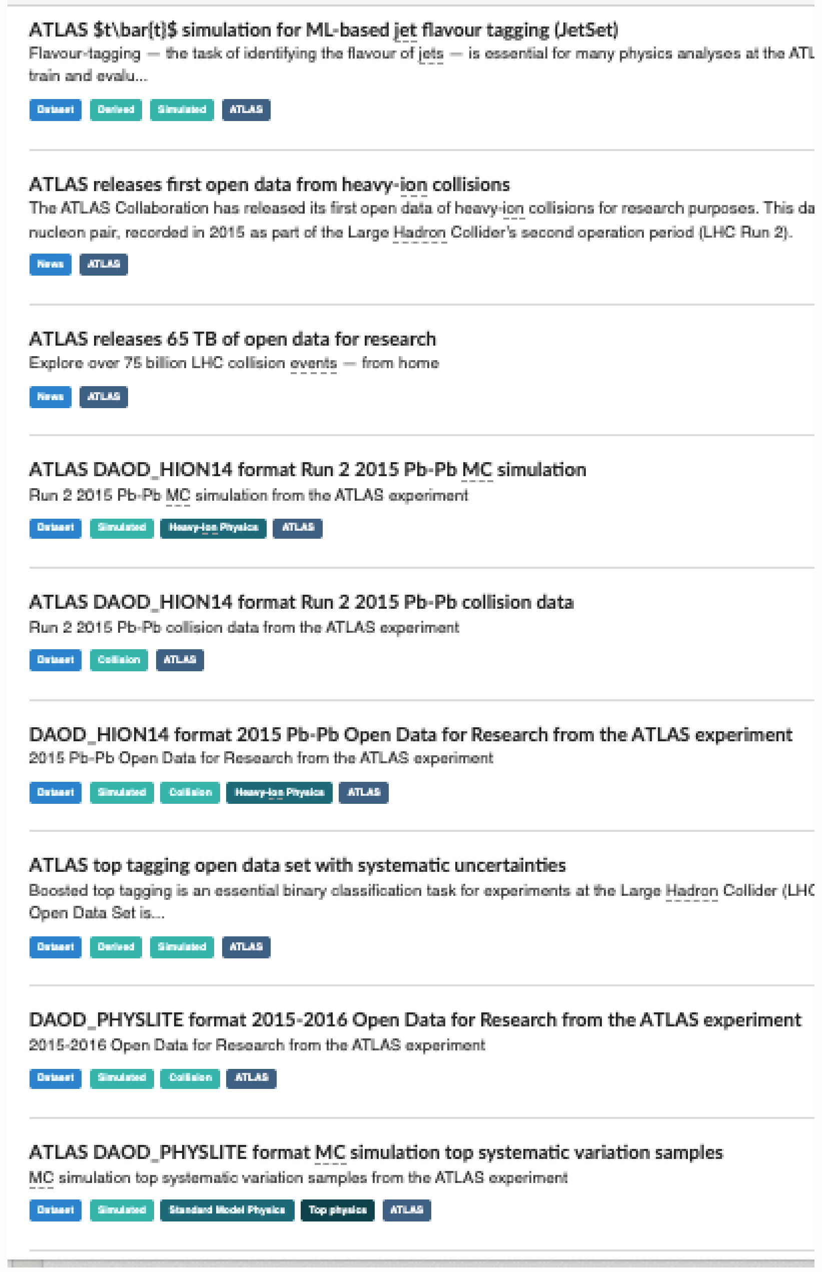
CERN OPEN DATA PORTAL





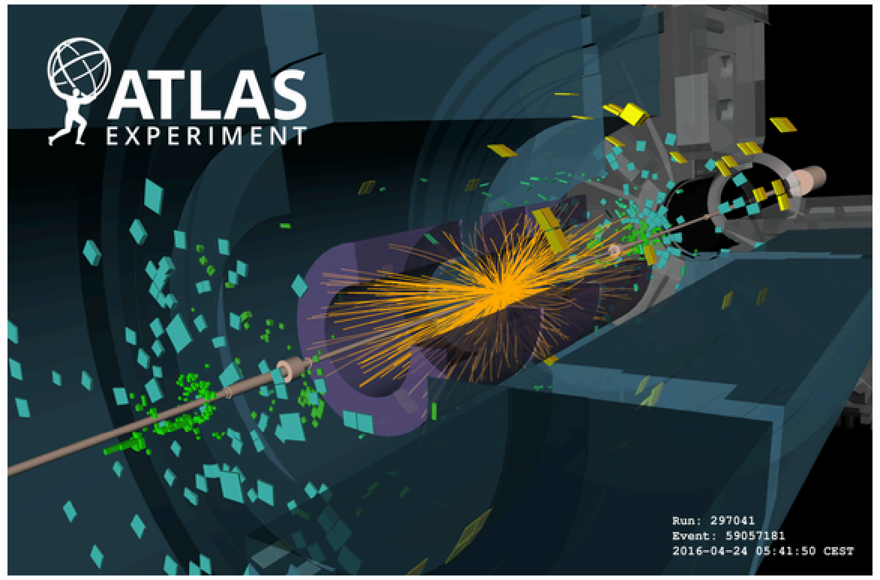
ALICE ATLAS CMS LHCb OPERA PHENIX TOTEM

https://opendata.cern.ch

ATLAS OPEN DATA for Research

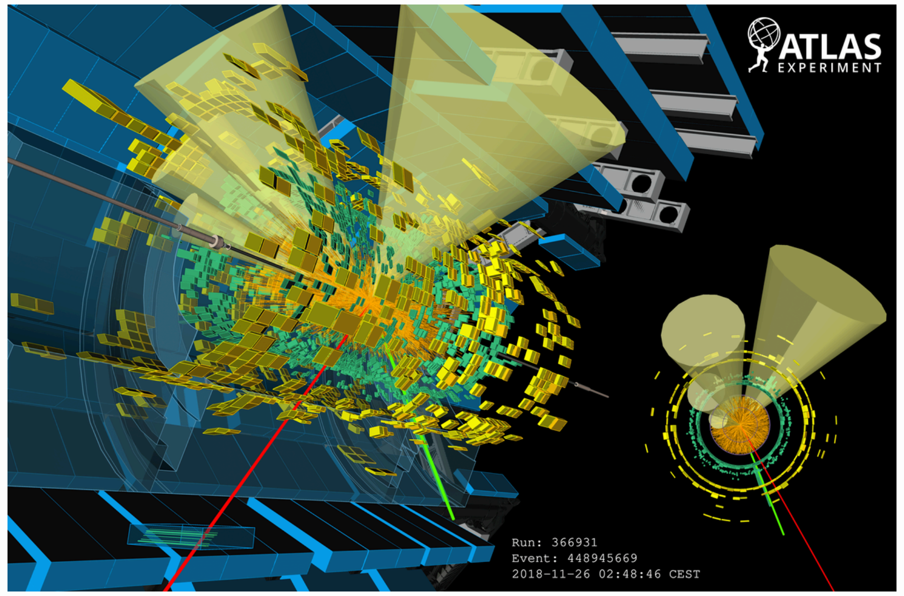
Webpage

Proton-Proton Collisions



13 TeV Proton-Proton collision datasets, 36 fb^{-1}, 2015-2016, 65 TB in PHYSLITE files , with 2 billion events of simulated data

Lead-Lead Collisions



5 TeV Lead-Lead collision datasets, 486μb^{-1} , 2015, 4 TB in DAOD_HION14 files, with corresponding simulations

Coming soon

- **Event generation data** in HEPMC format
  - provided in 10,000 event text files, tarred and gzipped to save space, for both 13 TeV and 13.6 TeV configurations
- **Heavy ion data** from the hard probes stream with corresponding simulations

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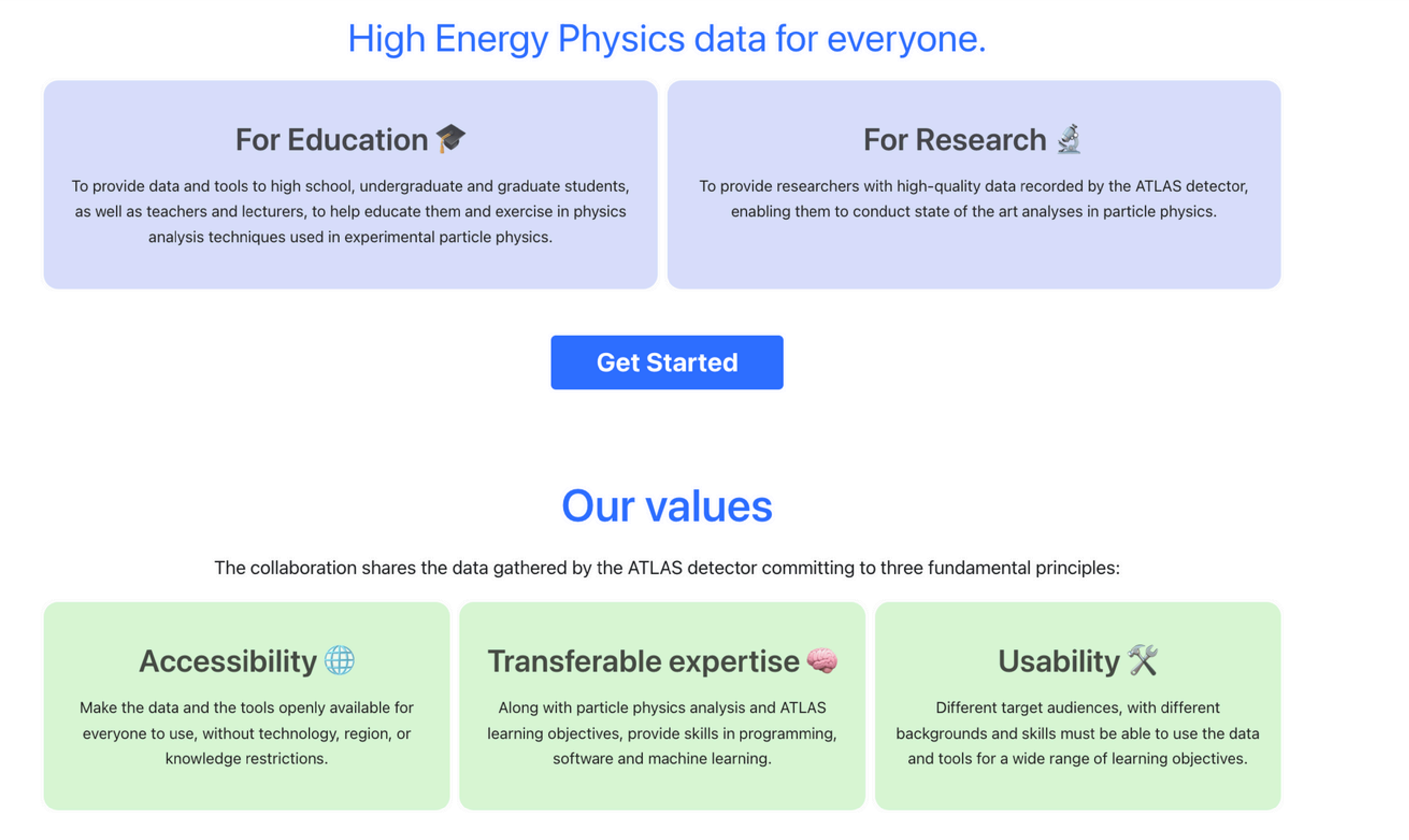
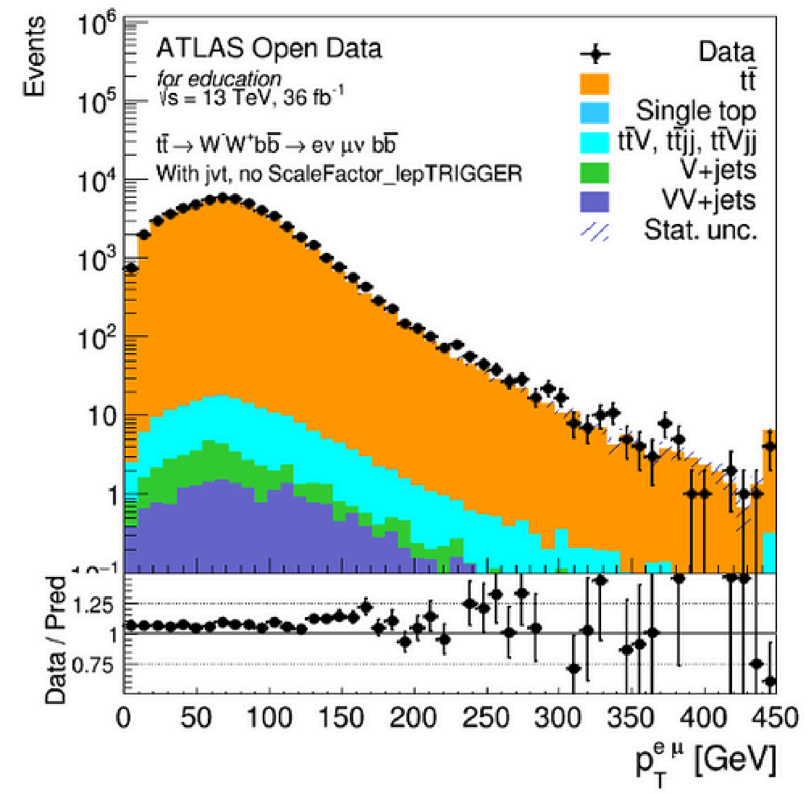
ATLAS OPEN DATA Wesbite





Datasets on CERN Open Data Portal inlcuding first and second releases.

For Education Webpage

Fully accessible website with step-by-step tutorials, tools, videos, data visualisation (Histogram Analyser, Machine Learning online application, teacher workshop, Jupyter Notebook analyses, and analysis facilities.

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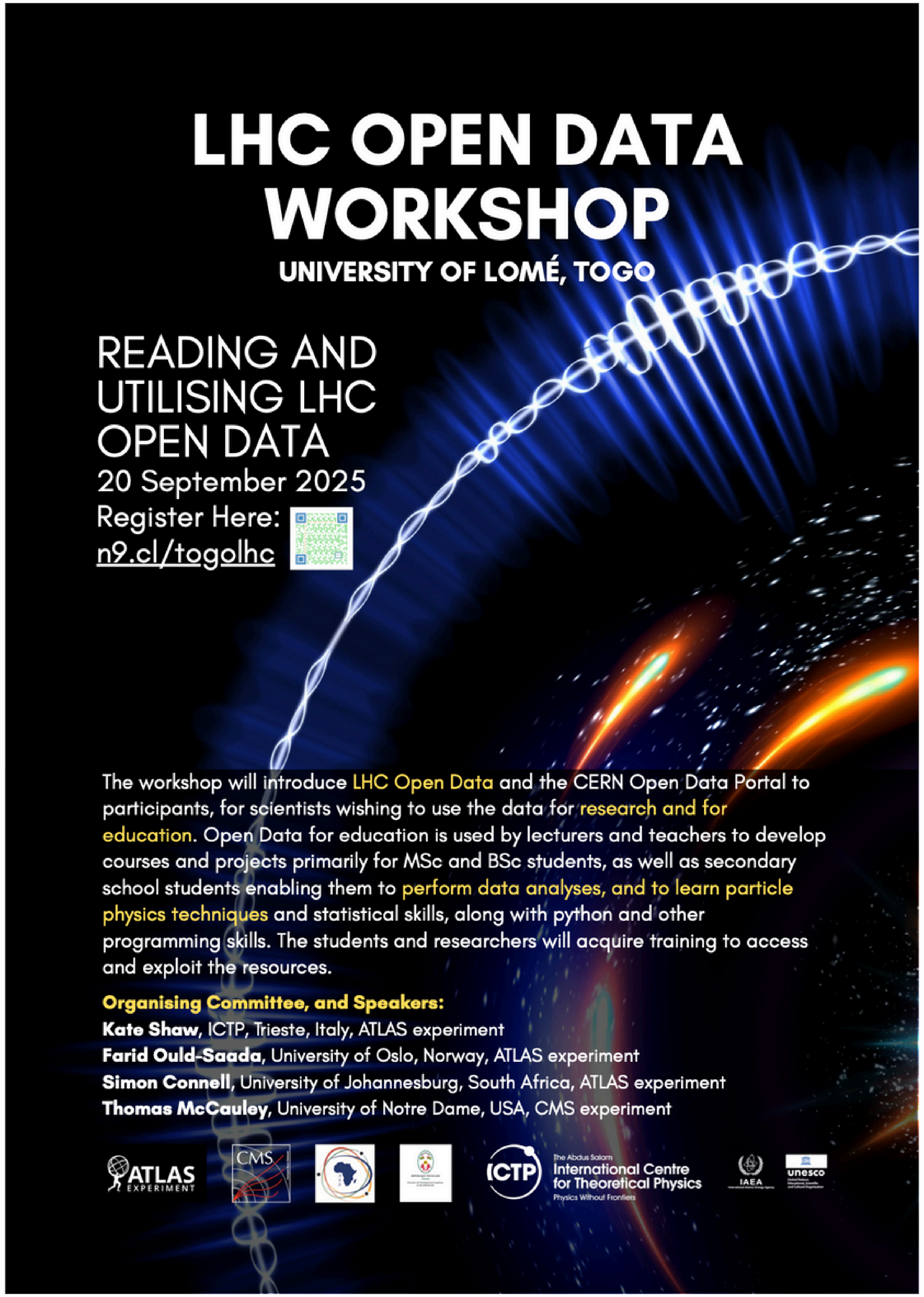
OPEN DATA: How is it used?

Theorists/ scientists wanting to do studies

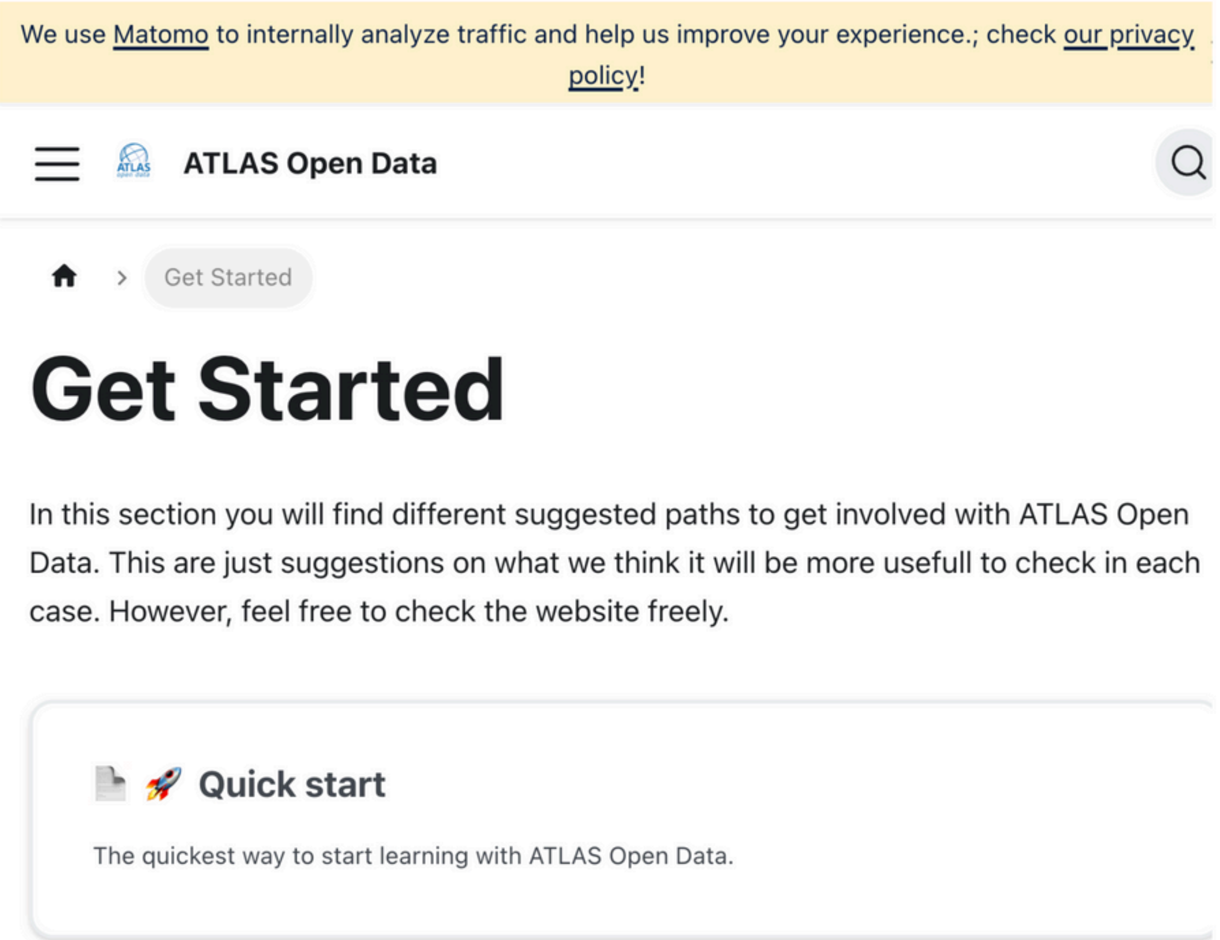
PhD training, undergraduate courses and BSc and MSc projects

- Students can dive into the learning objectives immediately (physics, statistics, analysis skills such as fitting and machine learning);

Training and **outreach** activities such as **hackthons** and **workshops**, with PhD students, university students, 16-18 year olds or even younger



Getting Started


We use Matomo to internally analyze traffic and help us improve your experience.; check our privacy policy!

ATLAS Open Data

Get Started

Get Started

In this section you will find different suggested paths to get involved with ATLAS Open Data. This are just suggestions on what we think it will be more usefull to check in each case. However, feel free to check the website freely.

🚀 Quick start

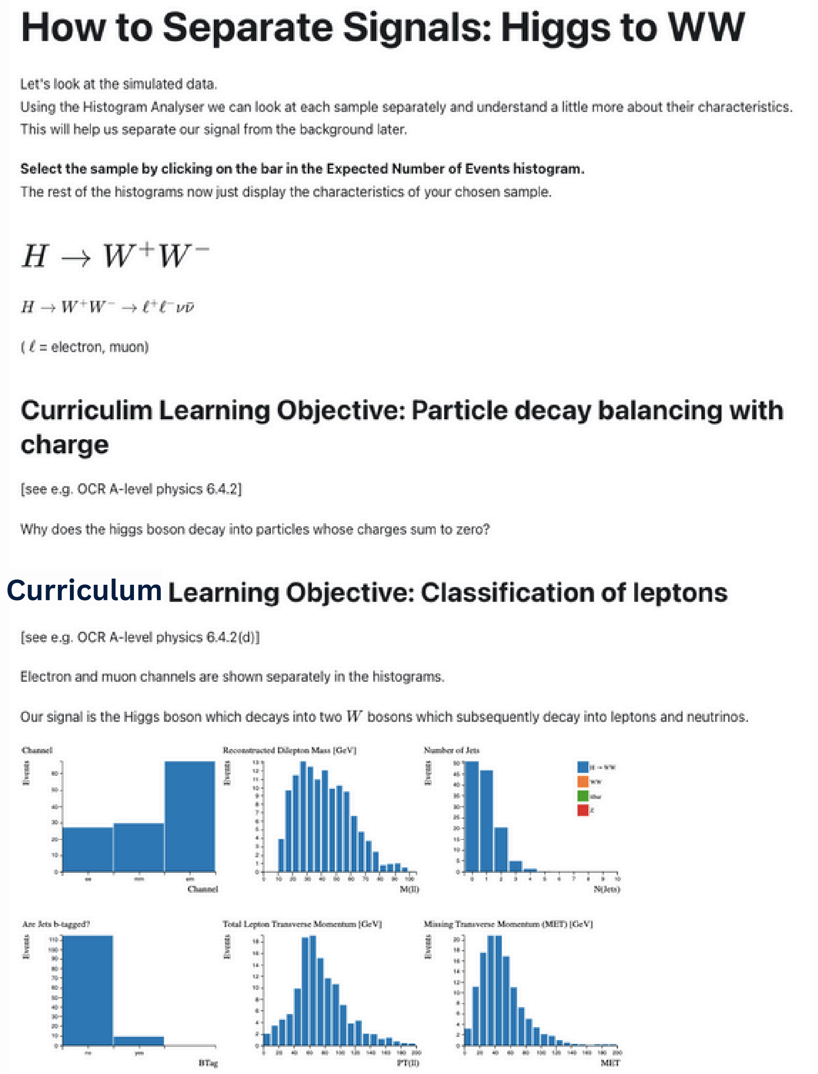
The quickest way to start learning with ATLAS Open Data.

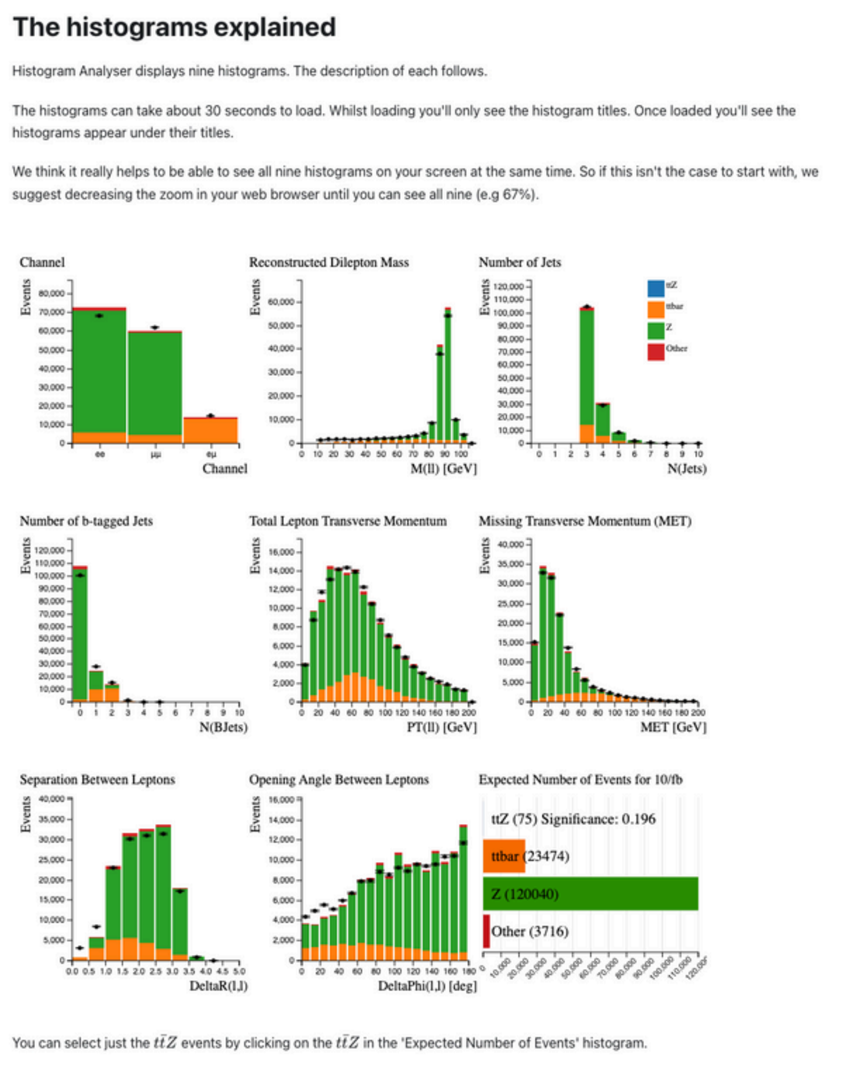
- No technical knowledge required
- Full introduction provided
- Step-by-step tutorials
- Instructions how to access data
- Histogram Analyser

Get Started Webpage

Histogram Analyser

Tool shows how physicists differentiate between physics processes applying cuts using just your mouse.

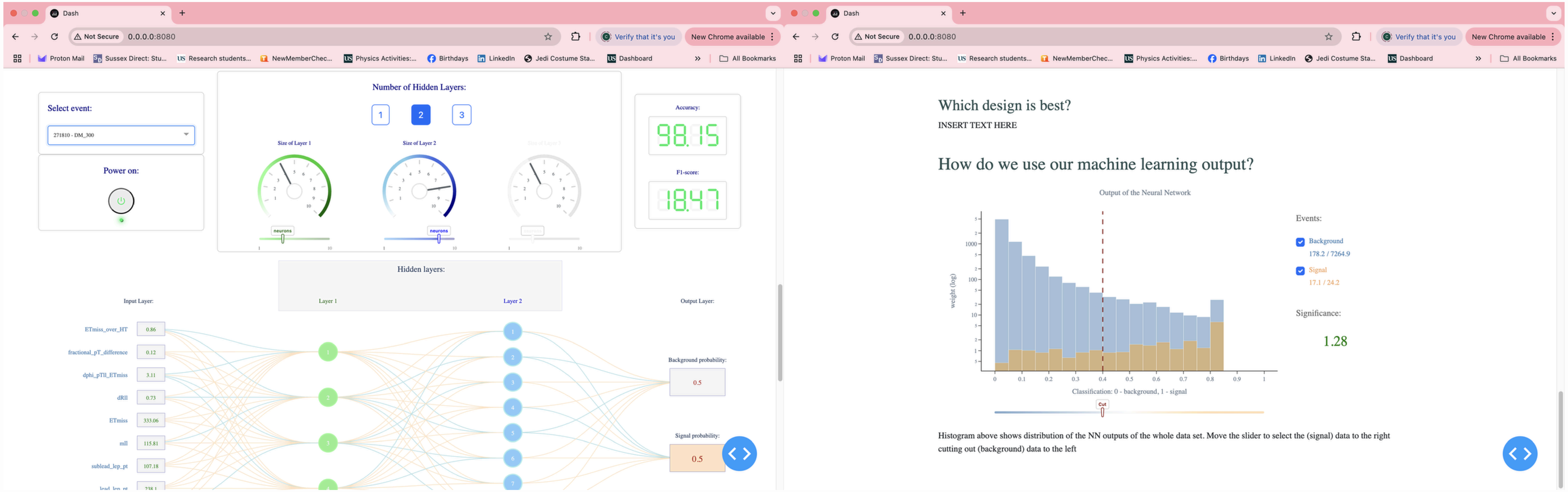




Machine Learning Online Interactive Application

- Machine Learning tutorial using only your mouse!!
- https://ml-visual-dashboard-atlas-open-data.app.cern.ch/
- Run a Neutral Network to discover Dark Matter!

NEW



Teacher workshop

Welcome to ATLAS Open Data in the Classroom

[Webpage](#)

An application to facilitate the learning of useful experimental particle physics techniques

Available in languages:
English, Spanish, Italian

Google Chrome

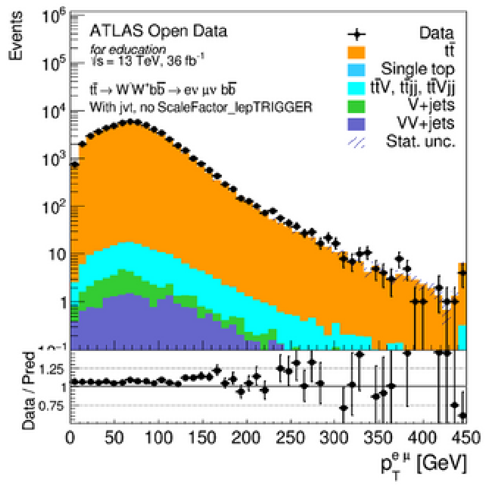
ATLAS Open Data in the Classroom

- **Getting Started**
- Foundations of Particle Physics
- Experimental Particle Physics
- Analyze ATLAS Open Data
- Intro to Python
- Classroom Toolkit

CITATION

Advanced Tutorials

Jupyter Notebooks



Uproot

Higgs to ZZ NEW

This notebook uses the 2025 release of the ATLAS Open Data to show you
to rediscover the Higgs boson yourself! You will discover the Higgs boson
into a pair of Z bosons, which are in turn decaying into a lepton-antilepton

Physics: ⭐

Coding: ⭐ ⭐

Time: ⭐ ⭐ ⭐

launch binder | Open in Colab

Higgs to γγ analysis NEW

This notebook uses the 2025 release of ATLAS Open Data, with 36.1 fb^{-1},

Jupyter Notebooks

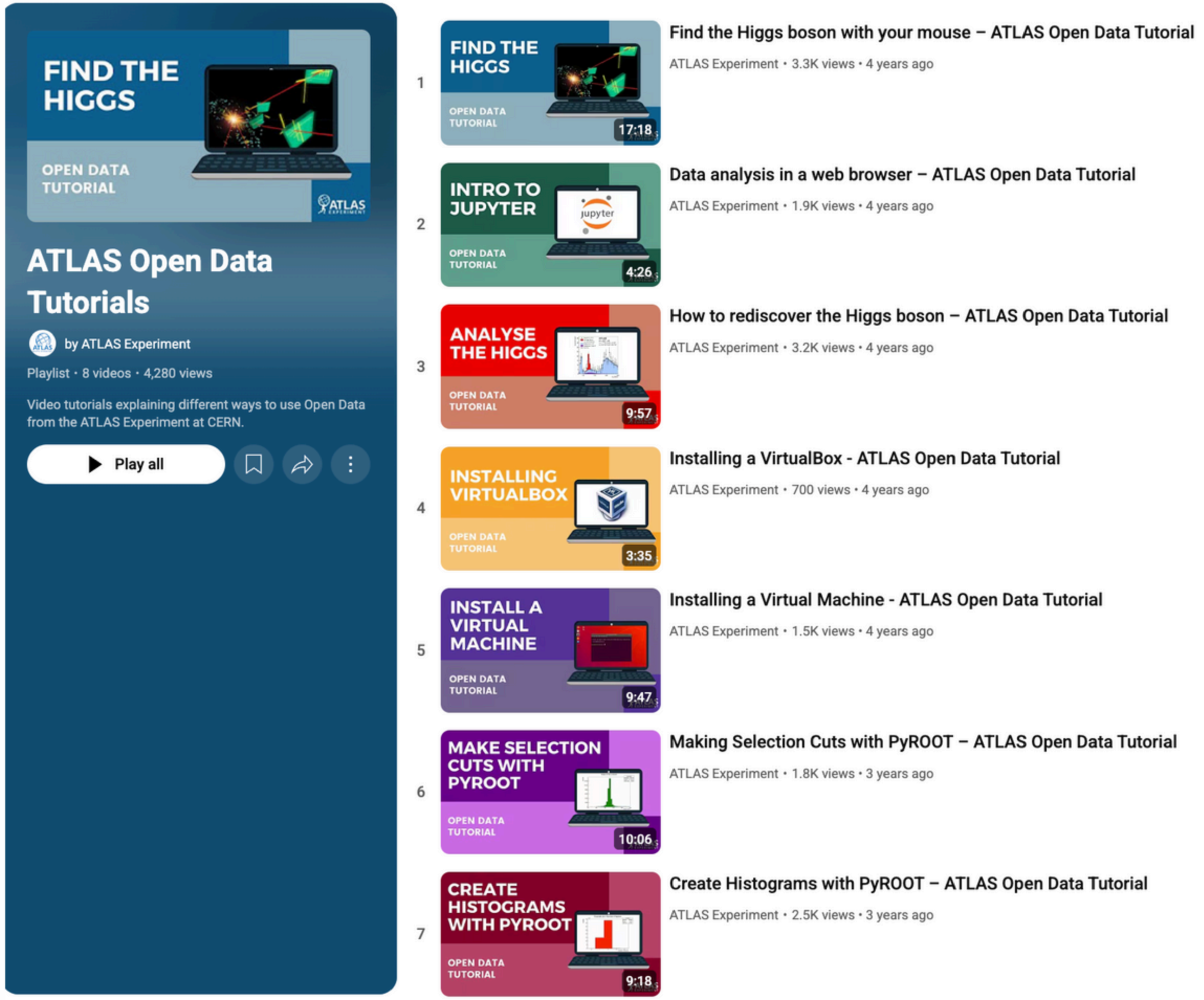
Developing of online tutorials:
Jupyter notebooks analyses (with & without ROOT framework), in C++, pyROOT 8 TeV and 13 TeV & uproot.

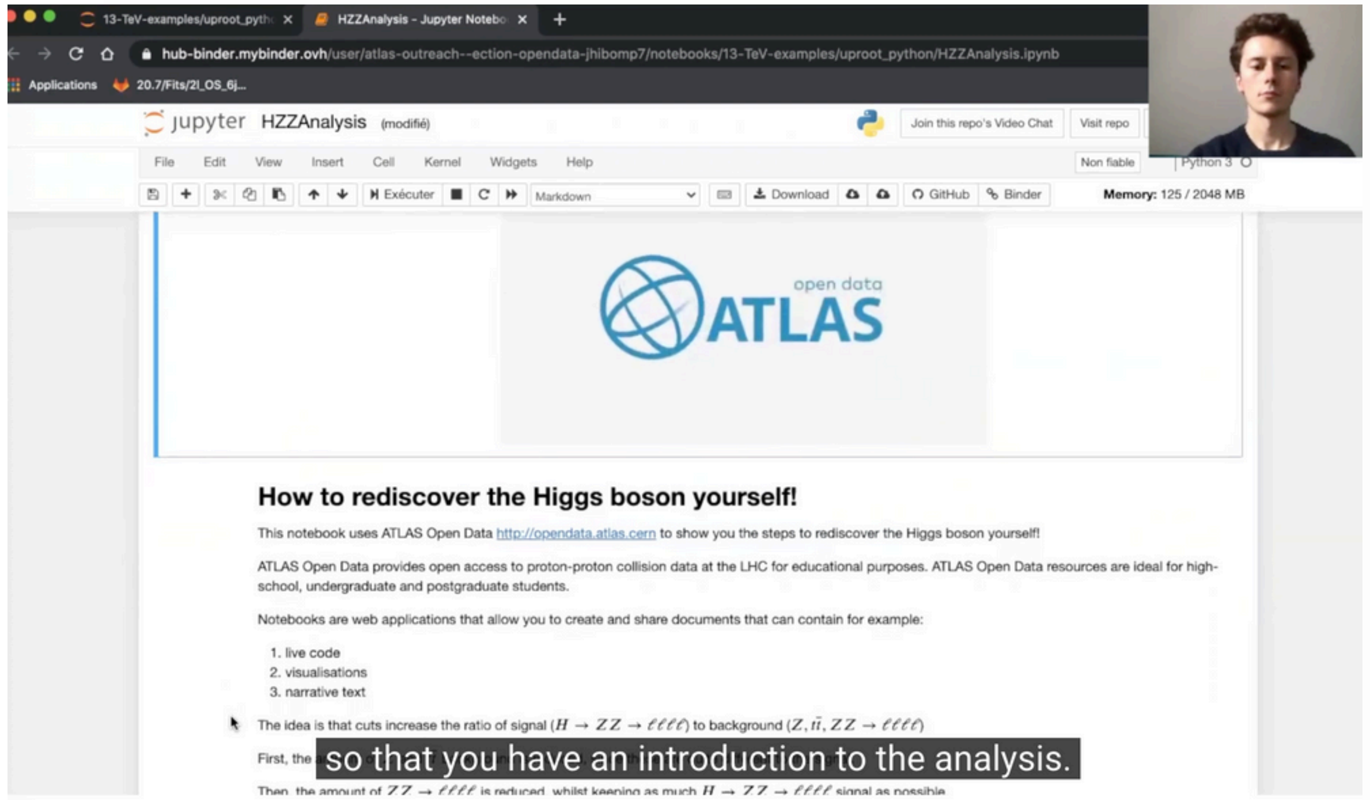
Different frameworks available to suit different learning objectives and use cases:

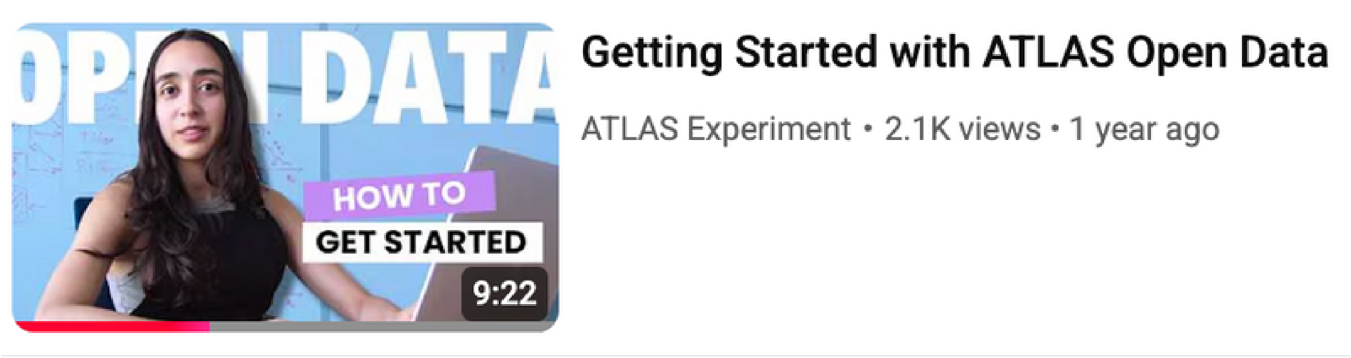
- Python
- C++
- RDataFrame
- Uproot / Coffea
-

All Notebooks are available on the GitHub repository.

ATLAS Open Data Videos on YouTube







[Find the videos here]

Summary

EDI is such an important part of building our community, we all must invest in supportiing initiatives, and support the **international** community

Outreach and **Open Data** is an important part of our experiments deliverables, for research and education, to build trust and help secure support

Get in touch with your **collaboration EDI** team or **outreach** team, many resources out there.

US
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Mark Thomson, CERNs new Director General

Pillars 3 & 4

Pillar 3 (Value for CERN's stakeholders), where the main priorities will be

- **Improve the balance of return to CERN's Member States and Associate Member States**
  - At a time when we will soon be seeking approval for FCC-ee, **this is absolutely essential, we will need the strong support of our member states**
  - We need to achieve balance in both "industrial return" and "personnel return"
- **Strengthen our relations with the EU and other key partners**
  - Including Canada, Japan and the US, as well as with other laboratories in CERN's member states
- **Continue to collaborate with neighbouring scientific fields within resource constraints**
  - We will prioritise existing commitments and activities that support of CERN's other strategy goals
  - Including projects important to European Science and our Member States, e.g. Einstein Telescope

Pillar 4 (Wider impact), with main priorities to

- **Inspire the next generation**
- **Support the European technological landscape**
- **Further increase the impact of CERN's KT activities**

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European Strategy for Particle Physics

Talk from the Open Symposium on the European Strategy for Particle Physics

General guiding principles

Outreach and Communication

- Strengthen public trust in science through outreach that fosters critical thinking, counters misinformation, and inspires future scientists.
- Shift science communication from scientific discoveries to research processes, personal stories, and the value of international collaboration and DEI.
- Expand outreach to diverse and underrepresented audiences to boost interest in STEM. Use social media to ensure a broad reach.
- Communicate effectively and transparently to build public and political support for the next European flagship project.

Training and Education

- Strengthen training in instrumentation (and thereby support a timely execution of the ESPP).
- Establish closer ties with industry.
- Integrate modern physics into school curricula.

Open Science

- Promote Open Access to scientific knowledge.
- Encourage the use of Open Data in education, outreach, and citizen science.

WG6 Composition

- M. Bombara (Slovakia)
- M.J. Costa (Spain)
- L. de Paula (Brazil)
- S. Özkorucuklu (Türkiye)
- M. Pimenta (Portugal)
- P. Van Mechelen* (Belgium)
- L. Zivkovic (Serbia)

* chair