

ATLAS Outreach and Education



UNIVERSITÀ
DEGLI STUDI
DI TRIESTE



Leonardo Toffolin^{1,2,3}
on behalf of the ATLAS Outreach group

¹ University of Trieste

² INFN Trieste, Gruppo Collegato di Udine

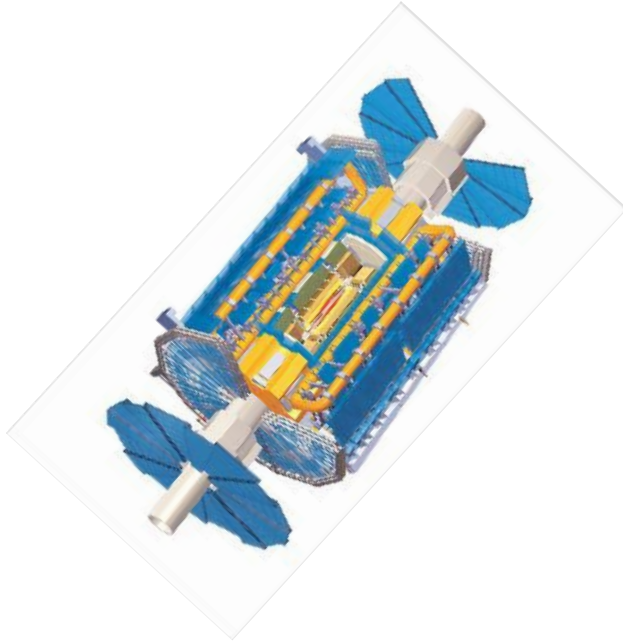
³ CERN



EPS-HEP 2025

7-11 July 2025, Marseille, France

The importance of outreach

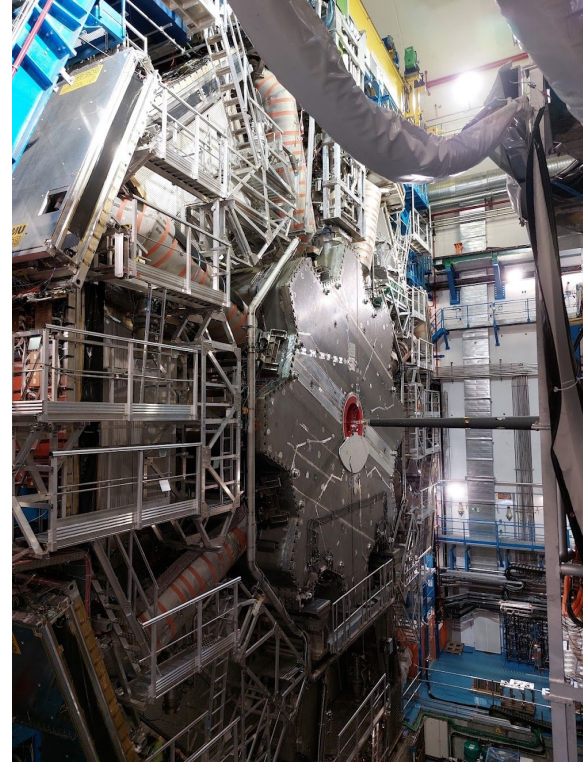


- A good physicist has at least 3 missions:
 - **research**
 - **teaching** - especially in academic settings
 - **outreach**, engaging with the outer public
- Communicate our work to others is essential for several reasons:
 - spark interest in Particle Physics
 - meet the growing expectations of national governments and science funders
 - satisfy public curiosity about major experiments like those ones at the LHC
 - contribute to improve public scientific literacy over the long term
 - provide learning resources and transferable skills in programming and data analysis
 - support teachers with real data and tools for modern physics education

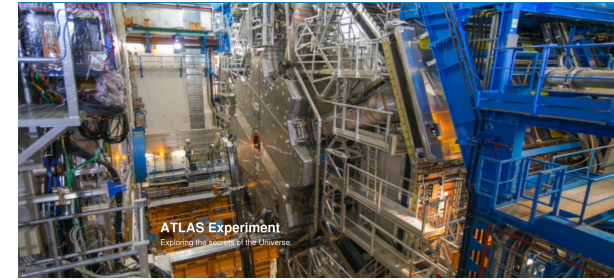
ATLAS outreach programme

Wide ATLAS Outreach programme

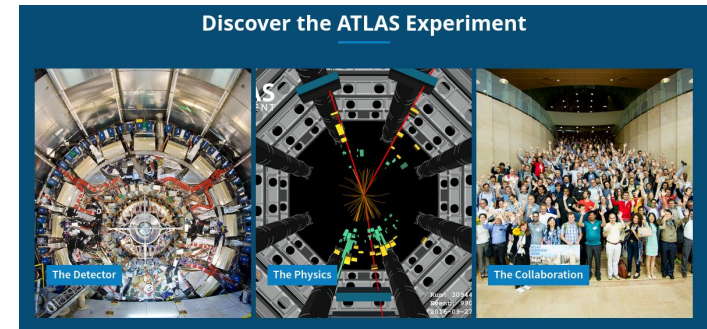
- Public website
- Communications and social media
- Printables
- Lego model
- Open Data



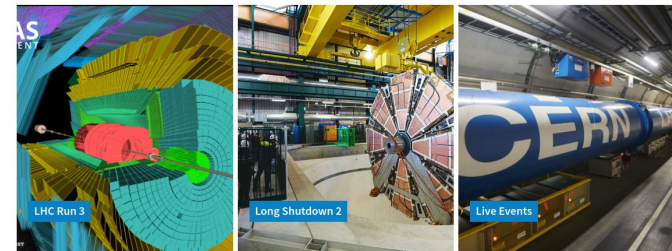
Public website



- Our main gateway to the world: <https://atlas.cern/>
- Structure:
 - [Latest news](#) → physics briefings
 - Discover the ATLAS Experiment
 - [The Detector](#)
 - [The Physics](#)
 - [The Collaboration](#)
 - Learn about LHC Run 3
- Audience:
 - General public
 - [Resources](#) devoted to specific public:
 - [Primary students](#)
 - [Secondary students](#)
 - [University students](#)
 - [Teachers](#)
 - [Citizen scientists](#)

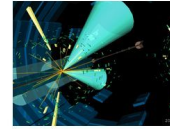


Learn about LHC Run 3



Public website - briefings

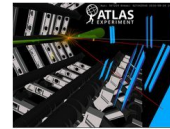
- Continuous flow of physics briefings:
<https://atlas.cern/Updates/Briefing>
 - attention to high impact analyses
 - submitted papers on new searches
 - results from recent conferences
 - new ATLAS management appointments
 - celebration of **thesis awards**



ATLAS sets record limits on Higgs self-interaction using Run 3 data

A new study of the Higgs boson marks the first ATLAS measurement based on over 300 fb^{-1} of proton-proton collision data, achieving an expected sensitivity comparable to that of the full Run 2 combination across all Higgs boson pair production channels.

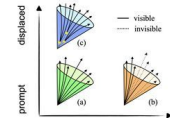
Physics Briefing | 22 May 2025



Studying the Higgs boson across the scales

Using the full LHC Run 2 dataset (collected 2015 to 2018) and early Run 3 data (collected in 2022 and 2023), ATLAS physicists performed detailed measurements of Higgs-boson decays to W and Z boson pairs.

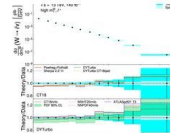
Physics Briefing | 16 May 2025



Shedding light with jets from the dark side

Researchers at the ATLAS Experiment are searching for a hidden "dark sector", a realm of new sets of particles and forces that interact very weakly with the known matter, potentially producing elusive and puzzling signatures. In two new results, ATLAS physicists hunted for dark-sector physics using these distinctive jet signatures.

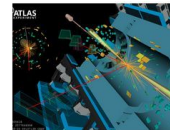
Physics Briefing | 15 May 2025



Exploring the W boson at extreme mass scales

ATLAS physicists have measured the cross section for W bosons with transverse masses between 200 GeV and 5 TeV.

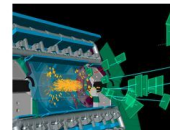
Physics Briefing | 15 April 2025



ATLAS probes the Higgs mechanism in the scattering of W boson

The ATLAS Collaboration reported the first evidence – with 3.3σ significance – of vector boson scattering involving longitudinally polarised, same-sign W bosons

Physics Briefing | 4 April 2025



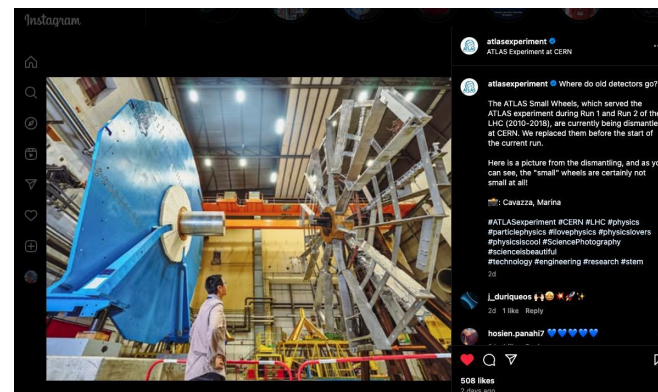
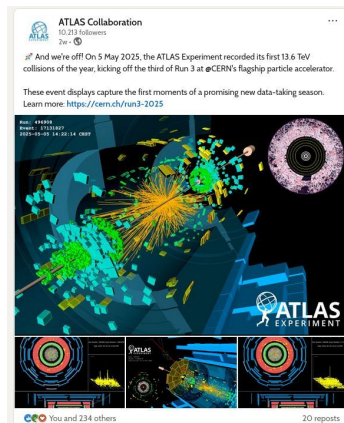
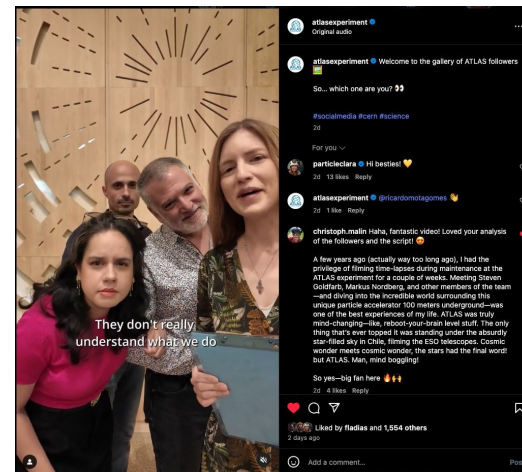
Displaced but not unnoticed: ATLAS in pursuit of Long-Lived Particles

In a new study submitted to Physical Review D, scientists at the ATLAS experiment leveraged the muon spectrometer's size and precision tracking capabilities to search for neutral LLPs by identifying displaced decay vertices.

Physics Briefing | 1 April 2025

Social media

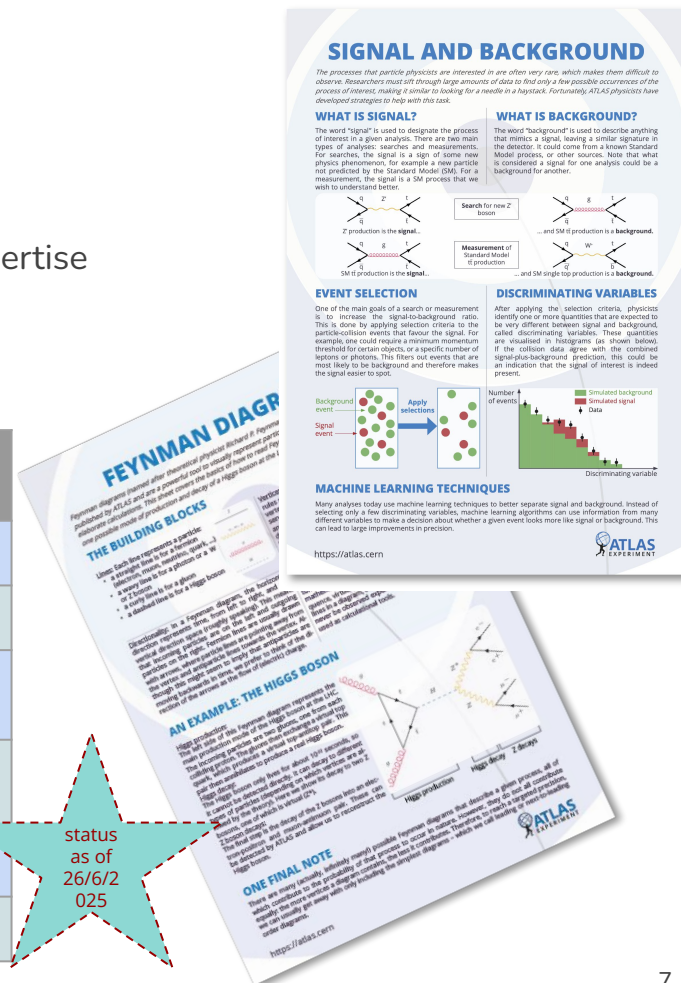
- ATLAS is quite active in several social media
 - [Instagram](#) → 70.7 k followers
 - [Facebook](#) → 44.4 k followers
 - [X \(Twitter\)](#) → 95 k followers
 - [Youtube](#) → 10 k followers
 - [Linkedin](#) → 10 k followers
 - [TikTok](#) → 50 k followers
 - [Threads](#) → 15 k followers
- Preferred way to quickly reach out to the general public, especially targeting young people



Printables

- Wide range of educational materials for all ages and levels of expertise
 - available for download on the [ATLAS Resources page](#)

Resource type	Target audience	Number of resources	Available languages
colouring books	children	2	up to 22
activity sheets	children	6	up to 7
cheat sheets	beginners in particle physics	9	up to 6
fact sheets	beginners in particle physics	10	up to 8
parent/teacher guide	parents/teachers	1	2: Portuguese, English
seasonal activities	anyone	7	1: English



Printables - Cheat sheets

- Realisation procedure
 - proposal
 - draft submission to CDS (CERN Document Server)
 - revised version approved and published
 - translations → cross-checked by at least one other native speaker other than the translator

STATISTICAL SIGNIFICANCE

When physicists make statements about whether or not a given process has been observed in the LHC data, they must back up their claim with strong statistical evidence.

HYPOTHESIS TESTING

Most particle physics analyses are based on hypothesis testing, meaning that the goal is to use data to support or disprove a given hypothesis. For example, if we are looking for a new particle not predicted by the Standard Model, then our hypothesis would be the presence of this new particle in our data. The null hypothesis would exactly correspond to the Standard Model prediction, assuming no new particle. Sometimes, the goal is just to exclude the null hypothesis without knowing the alternative hypothesis.

WHAT IS A TEST STATISTIC?

A test statistic is a measurable quantity that is derived from data and is used for hypothesis testing. It can indicate whether the data is closer to the hypothesis or the null hypothesis. An example of a test statistic is the number of observed collision events passing a set of criteria. If this is close to the expected number from the Standard Model, it would tend to support the null hypothesis of no new physics, whereas a larger number could indicate the presence of new physics.

WHAT IS A P-VALUE?

The p-value corresponds to the likelihood that an observed test statistic can be explained by the null hypothesis, without the need for an alternative. More specifically, it equates to the fraction of times you would get an observed test statistic showing worse agreement with the null hypothesis than that observed, assuming the null hypothesis is true. The smaller the p-value, the more confidence we have that the null hypothesis can be excluded.


WHAT IS SIGNIFICANCE?

Significance is a quantity that expresses how certain we are that the null hypothesis can be excluded. It is closely related to the p-value: the lower the p-value, the higher the significance, and vice versa. It is often expressed as the number of "standard deviations" the observed test statistic is away from the null hypothesis. If the test statistic is distributed like a Gaussian (a bell shape) and the null hypothesis is true, then a randomly sampled test statistic will be within 1 standard deviation (1 σ) of the mean 68% of the time. Therefore, for a 1 σ significance, there is a 32% probability that the observed test statistic was obtained outside of this range by random chance, despite the null hypothesis being true.

EVIDENCE AND DISCOVERY

In order to avoid wrongly claiming a discovery by excluding the null hypothesis when a discrepancy is in fact due to random fluctuations in the data, physicists set high thresholds for the significance. "Evidence" is claimed if the significance surpasses 3 σ (0.3% probability of obtaining this test statistic by chance) and "discovery" if it surpasses 5 σ (0.00005% probability of obtaining it by chance). These are simply choices that particle physicists agree upon so that a statistically significant "discovery" has the same meaning for everyone.

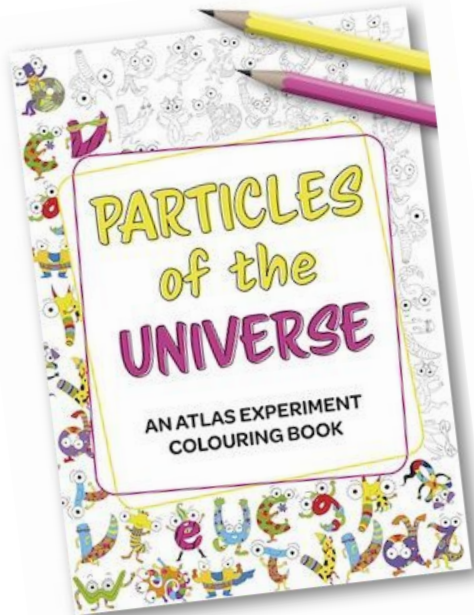
<https://atlas.cern>



Topic	Status	Translations
Feynman Diagrams	Published	French, Spanish, German, Italian, Dutch, Portuguese (in progress), Greek (in progress), Russian (interest expressed)
Conservation Laws	Published	French, Spanish, German, Italian, Dutch, Portuguese (in progress), Greek (in progress), Russian (interest expressed)
Standard Model	Published	French, Spanish, German, Italian, Dutch, Portuguese (in progress), Russian (interest expressed)
Signal and Background	Published	German, Italian, Dutch, French, Portuguese (in progress), Russian (interest expressed)
Cross Section and Luminosity	Published	German, Italian, Dutch, French, Portuguese (in progress), Russian (interest expressed)
Statistical Significance	Published	German, Italian, Dutch, French, Portuguese (in progress), Russian (interest expressed)
4-vectors and particle mass	Published	German
Monte Carlo	Published	German
Particle decays, width and lifetime	Published	
Inside a Collision	Internal review	
Supersymmetry	Draft in progress	
Fundamental Constants and Natural Units	Draft in progress	
Limits	To-do	
Counting Experiments	To-do	
Coordinate system	To-do	
Spin and polarization	To-do	

Printables - Colouring books & activity sheets

- Target: children, middle schools students



Particles of the Universe
Colouring Book

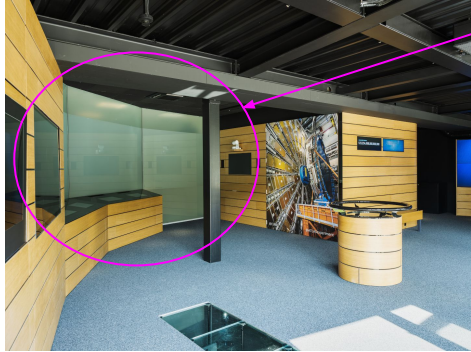
Colouring Books:

Title	Status	Translations
ATLAS Experiment Colouring Book	Published	22 languages (see here for full list)
Particles of the Universe	Published	12 languages (see here for full list)

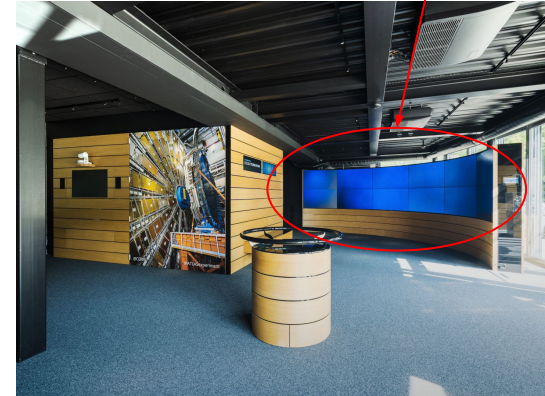
Activity Sheets

Title	Status	Translations
Particles vs. Antiparticles	Published	French, Spanish, German, Italian, Portuguese, Chinese
Follow particle decays through a maze	Published	French, Spanish, German, Italian, Portuguese, Chinese
Label the detector	Published	French, Spanish, German, Italian, Portuguese, Chinese
Make your own Standard Model	Published	French, Spanish, German, Italian, Portuguese, Chinese
Spot the Differences	Published	French, Spanish, German, Italian, Portuguese, Chinese
Word Search	Published	French

ATLAS Visitor Centre



- [Permanent exhibit](#) with interactive screens outside the **Control Room** at LHC Point 1 → become transparent, so that visitors can see what's behind!
 - [3D movie](#) to explain how the detector works
 - (normal) movie about Higgs Boson discovery and how the Collaboration pursues its physics research
 - **LEGO model** of the detector
 - exposition of real pieces of the detector
- Available for guided and private tours
 - open every day 9:00-17:00 (only with reservation)



Virtual visit programme

- One of the most successful ATLAS Outreach initiatives
 - much exploited during the pandemic
 - overcome the impossibility to access to the ATLAS Visitor Centre or to the cavern
- Target:
 - school and university students
 - general public
 - funding agencies
 - any generic group of at least 10 visitors
 - typically not open for individuals
- Full information in the website:
<https://atlas.cern/Discover/Visit/Virtual-Visit>
 - directly bookable from there via this [form](#)
 - full [list](#) of visits
- Languages:
 - English
 - French
 - Italian
 - German
 - Portuguese
 - Arabic
 - Greek

→ additional languages depending on the availability of guides

group virtual visits

open virtual visits

Group Virtual Visits

Groups of at least 10 visitors (such as classrooms) can schedule their own visit by completing [this form](#).

Schedule a Group Virtual Visit

Upcoming Virtual Visits

Programa "Desafiar os Limites"	+
Tue, 01 Jul 2025, 16:45	
Segundo programa "Desafiar os limites"	+
Wed, 02 Jul 2025, 16:45	
Boson Higgs day in the IFRN EXPOTEC	+
Fri, 04 Jul 2025, 14:00	
CEFET - Rio de Janeiro	+
Fri, 04 Jul 2025, 18:00	
University of Warwick	+
Sat, 05 Jul 2025, 13:15	

[Search all visits](#)

Open virtual visits

- Very popular virtual visits with live streaming
 - period: Extended Year-End Technical Stop (EYETS) 2024-2025, from December 2024 to March 2025
 - aim to re-propose it next year
 - live views: between 500 and 2000 per video
 - languages: English, Greek, Spanish, Portuguese, German, French
 - platforms: YouTube, TikTok



Virtual visits - statistics

- Statistics to be collected in an ATLAS paper for the first time!
 - foreseen in late 2025
- For more details, please checkout [Alberto Carnelli's talk](#): "ATLAS on the Air! - Measuring the Success of the ATLAS Virtual Visit Programme"

Year	Number of (booked) virtual visits
2019	74
2020	34
2021	155
2022	121
2023	88
2024	122
2025	77

671 virtual visits **since 2019**



mostly in January-April → driven by school and university groups



mainly from Greece, United Kingdom, Brazil (due to guides' activeness), over 6 continents

Lego ATLAS model

Lego model of ATLAS designed for the first time by Sascha Mehlhase (Munich) in 2011

- approximately 1:50 scale
- size: $\sim 1 \times 0.5 \times 0.5$ (in meters)
- around 9500 bricks, built at institutes around the world

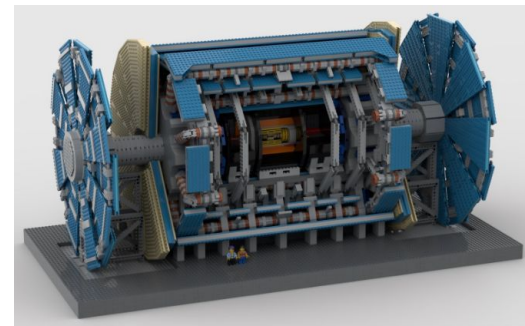
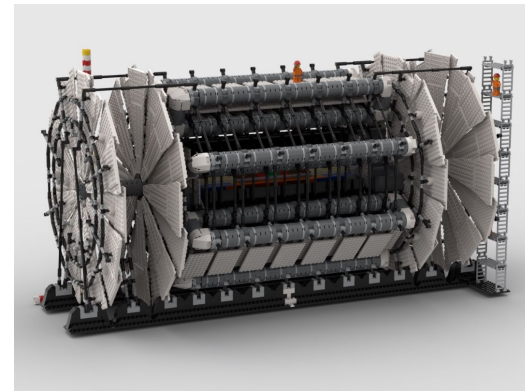
Required **upgrade**:

- fragile: fine if left on display in AVC, nearly impossible to transport
- inaccuracies :
 - Barrel slightly elongated
 - no muon chambers suspended between toroid coils
 - no outer muon layer!
 - inaccurate muon wheels



Upgraded (Phase-II-like) Lego model designed by **Nathan Readioff** (Sheffield)
→ [talk](#) at EPS-HEP 2025

- over 21400 Lego pieces
- hyper-accurate 1:50 scale
- over 100 cm long
- crafted over the last 2.5 years
- fully modular - removable ITk, calorimeters, toroids, muon chambers



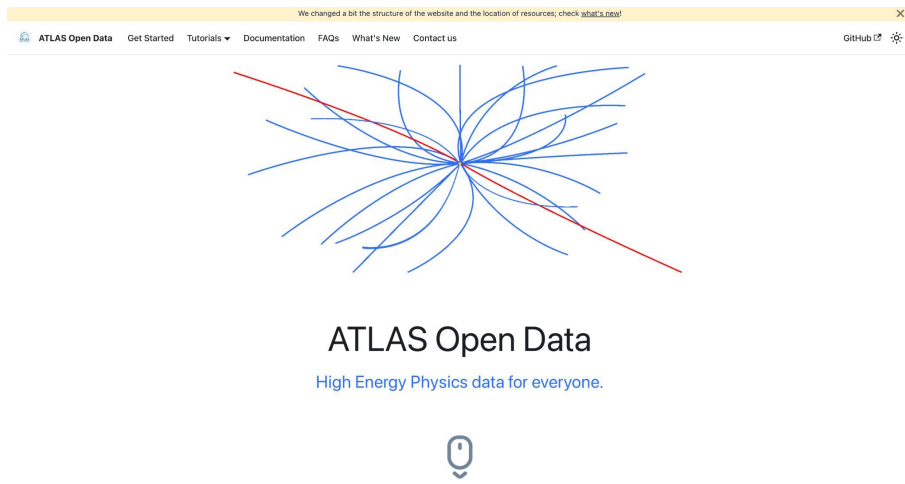
ATLAS Open Data project

- **Education:** two pp datasets - 8 TeV (2016) and 13 TeV (2020); one $PbPb$ dataset - 5 TeV (2024)
- **Research:** one pp dataset - 13 TeV (2024, 65 TB)
 - available in the [CERN Open Data Portal](https://opendata.cern/)
 - download from the website or with the [cernopendata client](https://github.com/ATLAS/ODPClient)
 - DAOD_PHYSLITE format
 - detector data (10 kB per event) with accompanied Monte Carlo datasets (12 kB per event)
 - Standard Model nominal samples, and alternatives for systematic variations
 - Beyond the Standard Model signal samples



High Energy Physics data for everyone.

opendata.atlas.cern/



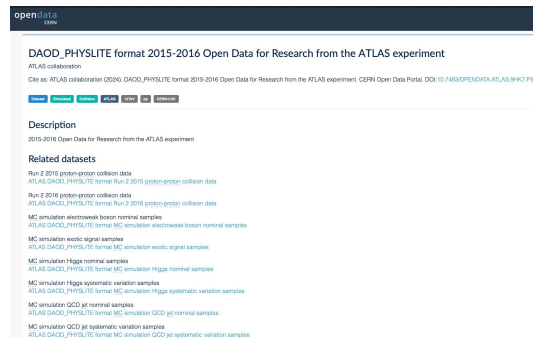
For Education

To provide data and tools to high school, undergraduate and graduate students, as well as teachers and lecturers, to help educate them and exercise in physics analysis techniques used in experimental particle physics.

For Research

To provide researchers with high-quality data recorded by the ATLAS detector, enabling them to conduct state of the art analyses in particle physics.

Get Started



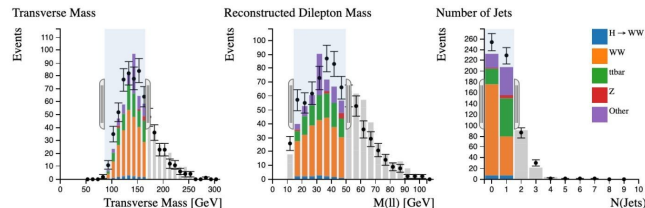
ATLAS Open Data - infrastructure and tools

- Information, tutorials and instructions on the website
- Histogram analysers: interactive and intuitive web-based tool for fast, cut-based analysis of data, and for online visualization
- Interactive analysis with [lupyter notebooks](#)
- Languages:
 - C++
 - Python
 - RDataFrame
 - Uproot/Coffea

Kate Shaw's talk



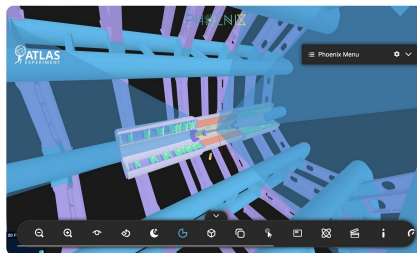
Application for visualizing High Energy Physics data.



Tutorials for Research > Phoenix for Event Visualisation

Phoenix for Event Visualisation

Visualizing an event inside the detector opens a path to a deeper understanding of the physical processes resulting from a collision. One commonly used tool for event visualisation is Phoenix, a framework that allows 3D visualisation of collision events inside the detector.



I have a CERN account

SWAN



- Requires CERN credentials
- CERNBox as home directory
- Complete scientific software suite
- Integrated with CERN services

I don't have a CERN account

Binder



- Anonymous
- Temporary storage
- Download capability
- Some software packages

Conclusion



- **ATLAS** is hugely involved in outreach activities
 - big success of many of the initiatives
 - growing interest in the HL-LHC ATLAS Lego model
 - great tradition of the Open Data project for education and research → extended to LHC heavy-ions data as well
- **Virtual** and **live events** are very important tools
 - profit from our experience of the pandemic years to make the organisation of such events very smooth
- New online material helps to reach more people, *e.g.* from remote geographical areas and from different social backgrounds
 - Several languages available
- Huge thanks to everyone who is actively involved in outreach activities within the Collaboration!



THANK YOU FOR YOUR ATTENTION!



BACKUP