Particle Physics Educational Activities

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10th Edition of the Large Hadron Collider Physics Conference

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ATLAS EXPERIMENT

UNIVERSITY OF SUSSEX

Particle Physics Outreach

During 2020, all our outreach programmes were cancelled , with everyone was at home, students lost a lot of engagement

We wanted to ***reach out*** to some local secondary school students to ***inspire*** them with physics research my using an ***innovative online approach*** to **teaching data analysis using data from the ATLAS experiment at CERN**.

We wanted to provide an ***challenging*** yet ***safe*** environment where students felt at ease to ask many questions, and learnt the process of tackling university level material in a growth environment.

We also did some learning resource co-creation with the students, so they gave feedback and helped us to improve our documentation for future students at that age.

Our team

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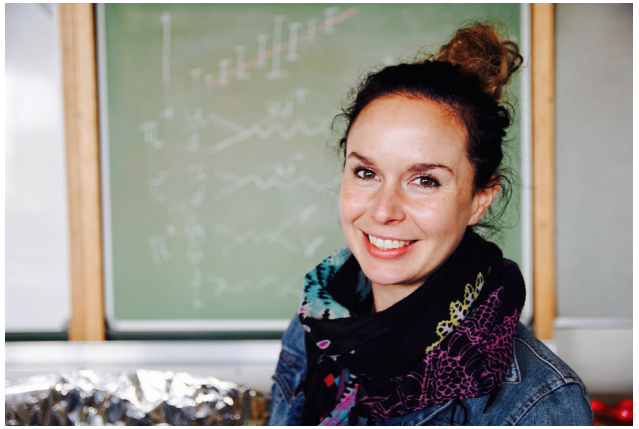
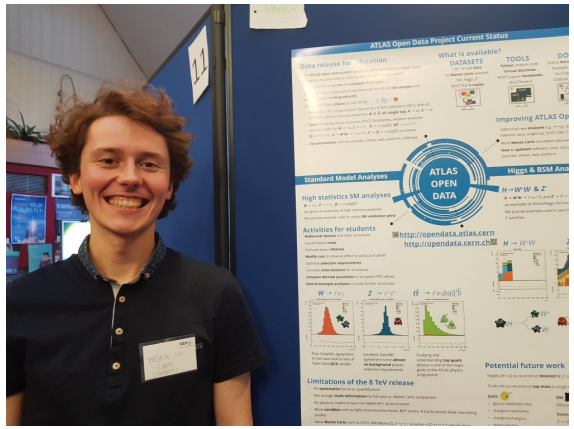


Kate Shaw, Lecturer
Researcher on ATLAS

Tom Stevenson
Postdoc on ATLAS



Meirin Evans
PhD student on ATLAS

Darren Baskill, outreach officer
Outreach advisor to project

Our core team developed the 6 month course using lectures and discussion sessions, ATLAS masterclass event display activities, ATLAS Open Data activities including Histogram Analyser and analyses using Jupyter Notebooks, and students developed documentation, abstracts, posters and presentations.

Many other Sussex ATLAS scientists gave their time to teach lessons, run break out rooms and mentor the students posters.

The programme

- Worked with local sixth form college, 16-18 year olds, at **BHASVIC**, Brighton
  - ***Widening participation*** school. Has over 400 students studying physics!
- Advertised on BHASVIC message boards with short video and text, for the first year students,
  - Offered 10 places providing ***high impact*** outreach!
- December 2020 – May 2021. Event and poster session November 2021.

Six month online programme, 2+ hour sessions a week

- **Session 1**: Online **Teams** / **Zoom** sessions recorded
  - Micro-lectures, interactive teaching
  - Breakout rooms for discussion and analysis
- **Session 2**: Independent homework session (1+ hour)

Approach: Learn by doing!

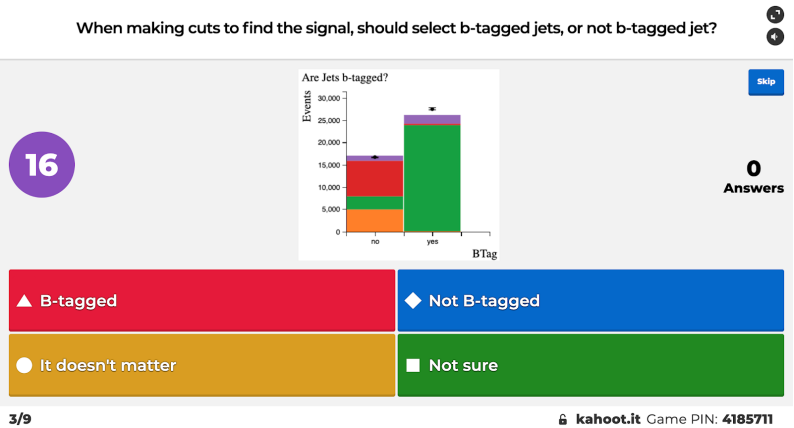
- Lectures: Used ***micro-talks*** 15 minutes max!
- Sessions must be ***interactive*** and students should be ***active***.
- Allow learning to ***build up*** over several weeks, - don't need to teach every thing in one go!
- Students learn through doing, using ***online learning activities***.
- Students slowly get used to ***asking questions*** and being ***confident*** that its ok not to know and asking questions is the route to knowledge and skills (growth approach).

Approach: Keep Engagement

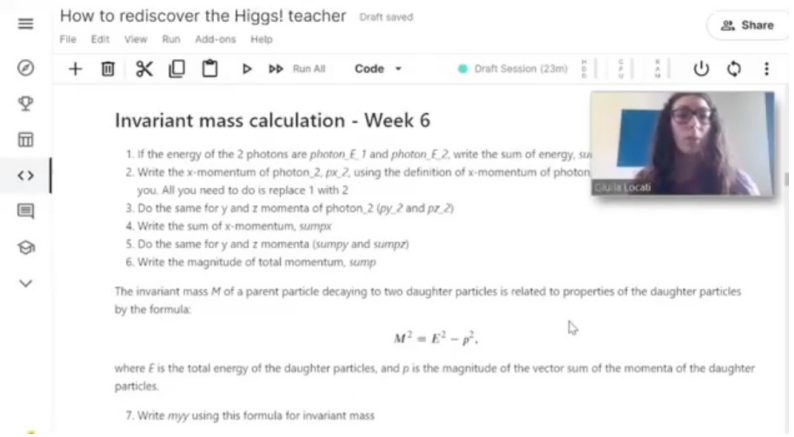
Typical Session:

- Start with **Kahoot** quiz (~ 5 questions)
- Micro-talks, Interactive activity
- Links **to home-made videos** for indepedent work
- **Break out rooms** to provide close interactions between researchers and students, prepare students for independent work

- We started the interactive activities very early on, we expect them to learn as we go!



Kahoot Quiz



Home made video by Sussex undergraduate student with instruction tutorials

Learning Activities

1. ATLAS Visualization with MINERVA and HYPATIA

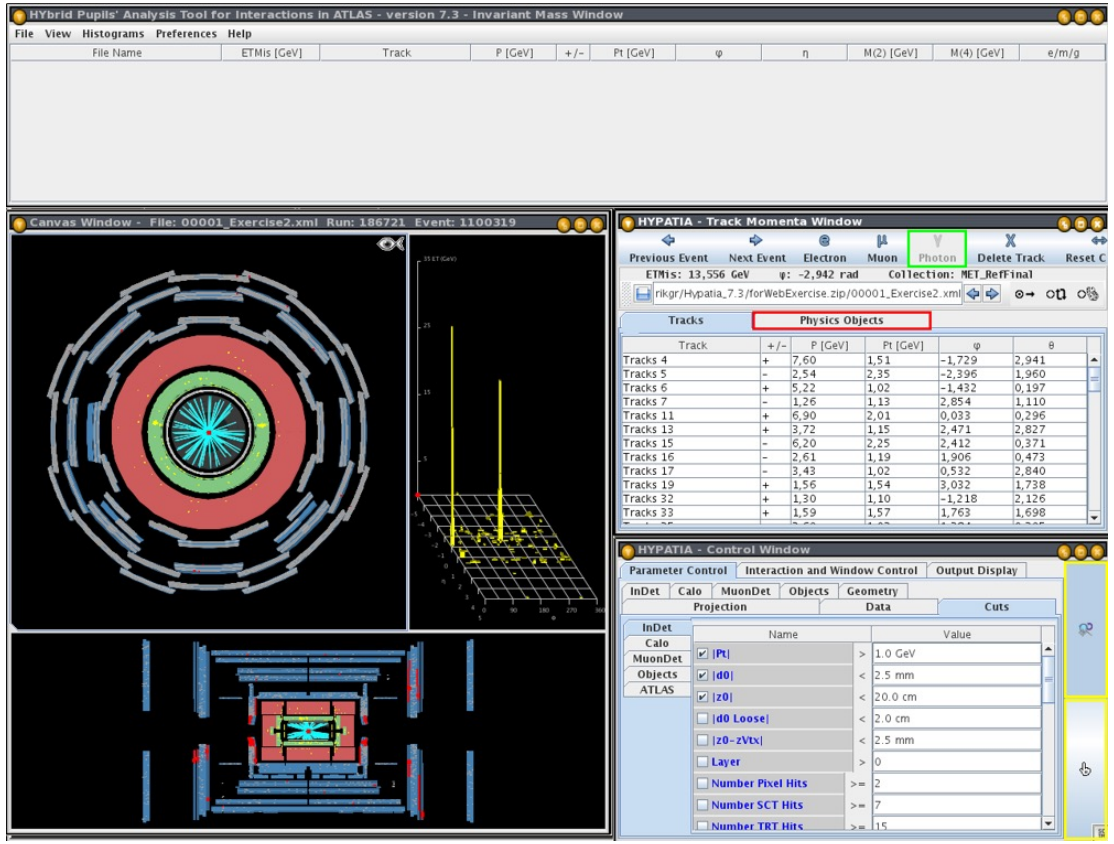
Using the detailed activities of the ‘International Masterclasses Hand on Particle Physics” website.

Students learn **topics** through micro-talks and activities

- Particle physics and the SM
- CERN, the LHC and ATLAS
- The ATLAS detector and particle / event identification

Activities

- Measure W+/ W- ratio
- Measure the Z boson mass



Learning Activities

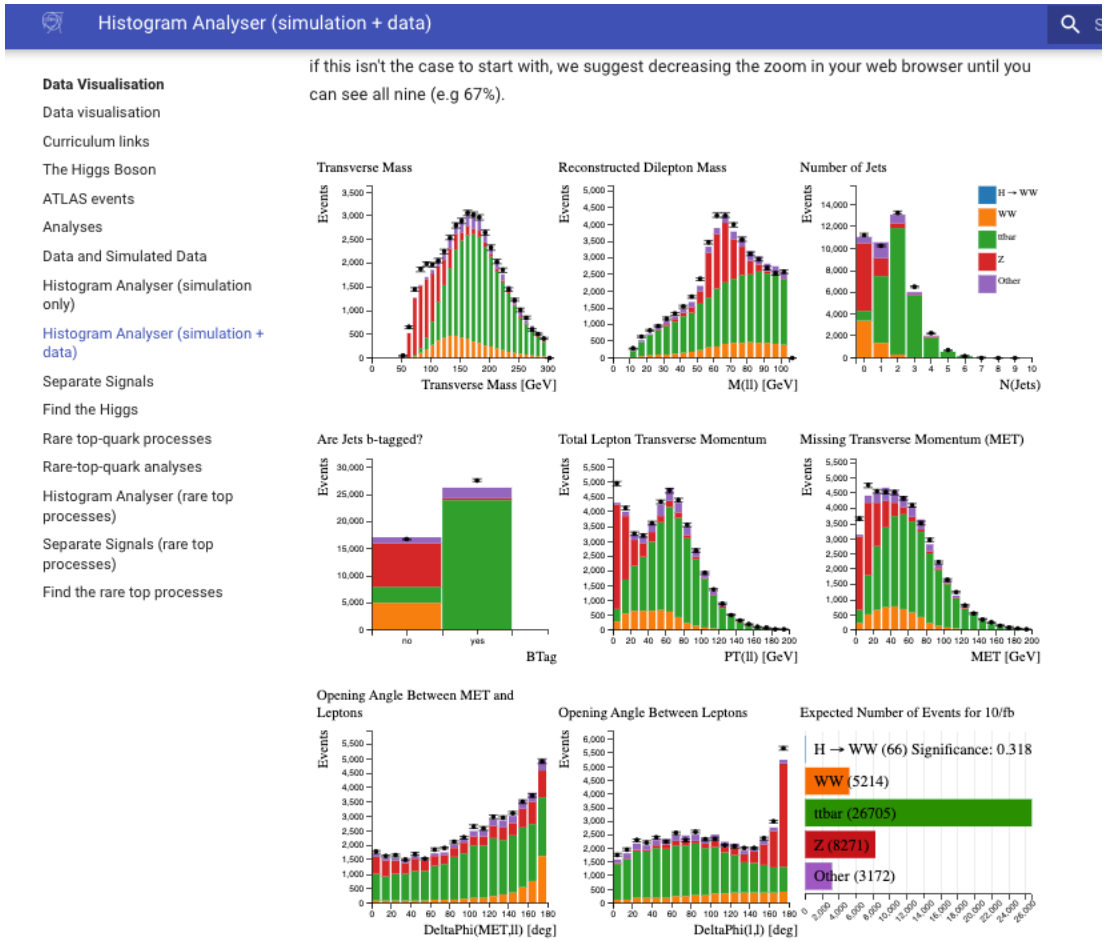
2. ATLAS Open Data Visualisation using the Histogram Analyser. From the 13 TeV ATLAS Open Data toolkit, all available on the website.

Students learn **topics** through micro-talks and activities

- Technical side of data analysis, and histogramming
- Simulation of data
- Cuts, and cut based analyses
- Optimisation of signal over background

Activities

- Find the Higgs
- Study of rare-top-quark analyses



Learning Activities

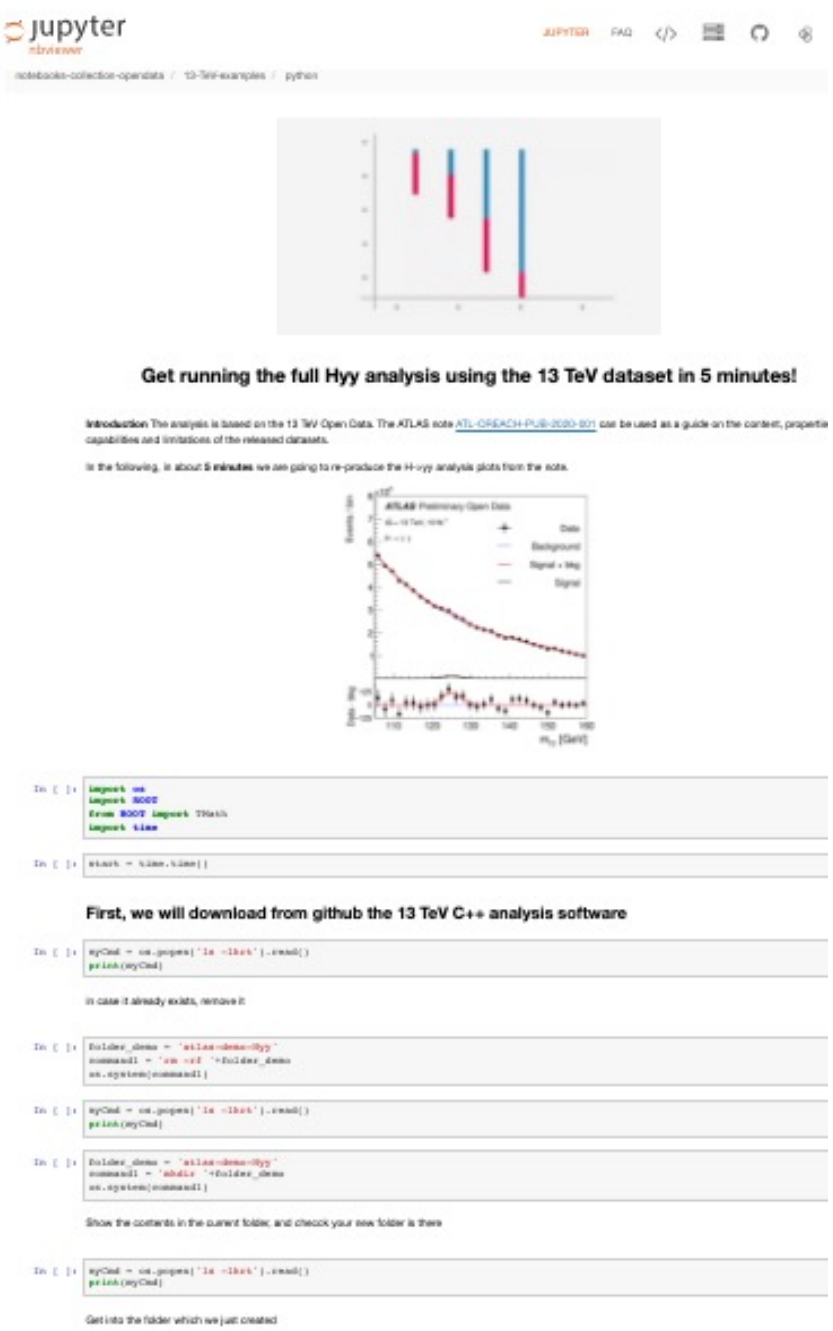
3. ATLAS Open Data analysis using Jupyter notebooks. From the 13 TeV ATLAS Open Data toolkit, all available on the website.

Students learn **topics** through micro-talks and activities

- Basics of Python Coding, Kaggle, Github
- Cut based analysis in Python and drawing of histograms, invariant mass reconstruction etc
- Analysis techniques, such as fitting to data

Activities

- Higgs -> two photon analyses



Learning resources co-creation

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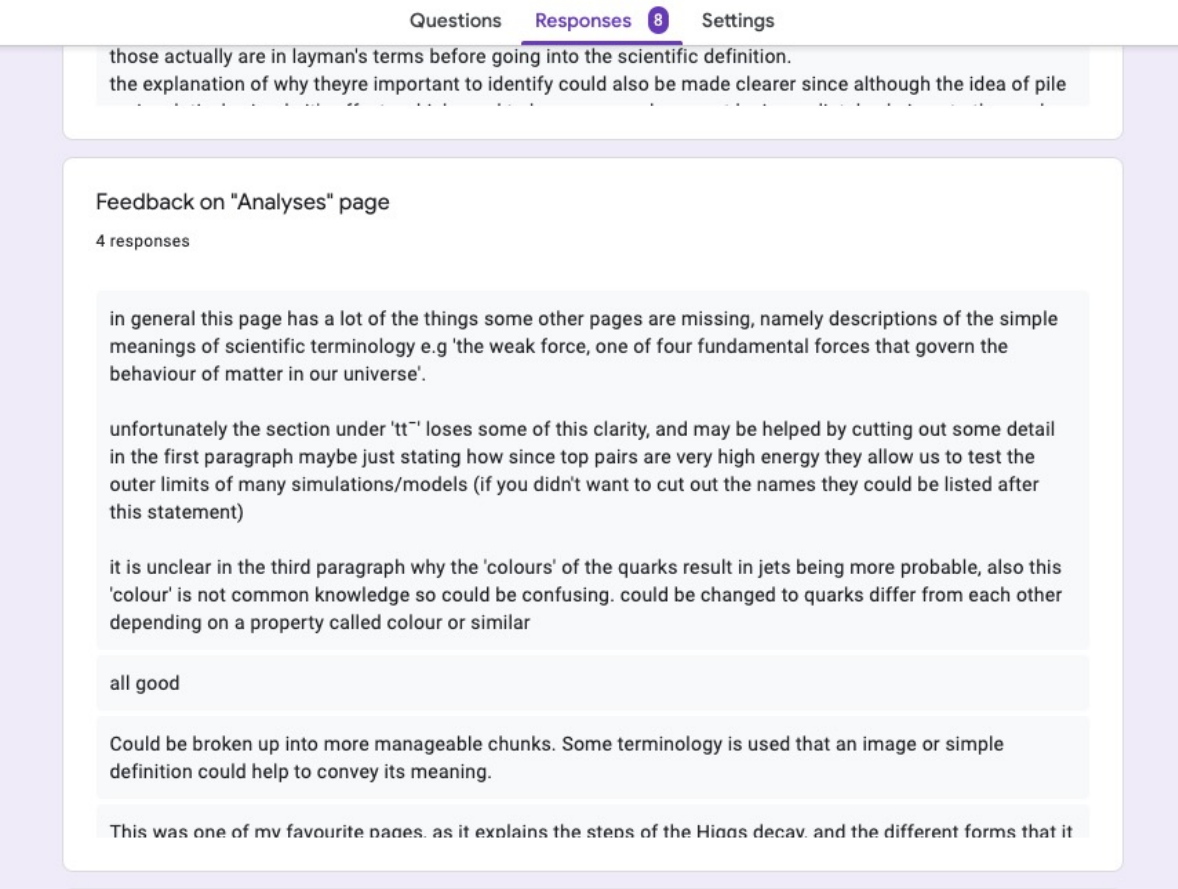
As the students worked through the ATLAS Open Data Documentation they gave **direct feedback** to improve clarity and student engagement

Students also:

- Designed quiz questions
- Created a glossary page
- Prepared documentation and peer-reviewed others
- Gave presentations to one another about their analysis, holding discussions



Questions Responses 8 Settings

those actually are in layman's terms before going into the scientific definition.
the explanation of why theyre important to identify could also be made clearer since although the idea of pile

Feedback on "Analyses" page

4 responses

in general this page has a lot of the things some other pages are missing, namely descriptions of the simple meanings of scientific terminology e.g 'the weak force, one of four fundamental forces that govern the behaviour of matter in our universe'.

unfortunately the section under 'tt¯' loses some of this clarity, and may be helped by cutting out some detail in the first paragraph maybe just stating how since top pairs are very high energy they allow us to test the outer limits of many simulations/models (if you didn't want to cut out the names they could be listed after this statement)

it is unclear in the third paragraph why the 'colours' of the quarks result in jets being more probable, also this 'colour' is not common knowledge so could be confusing. could be changed to quarks differ from each other depending on a property called colour or similar

all good

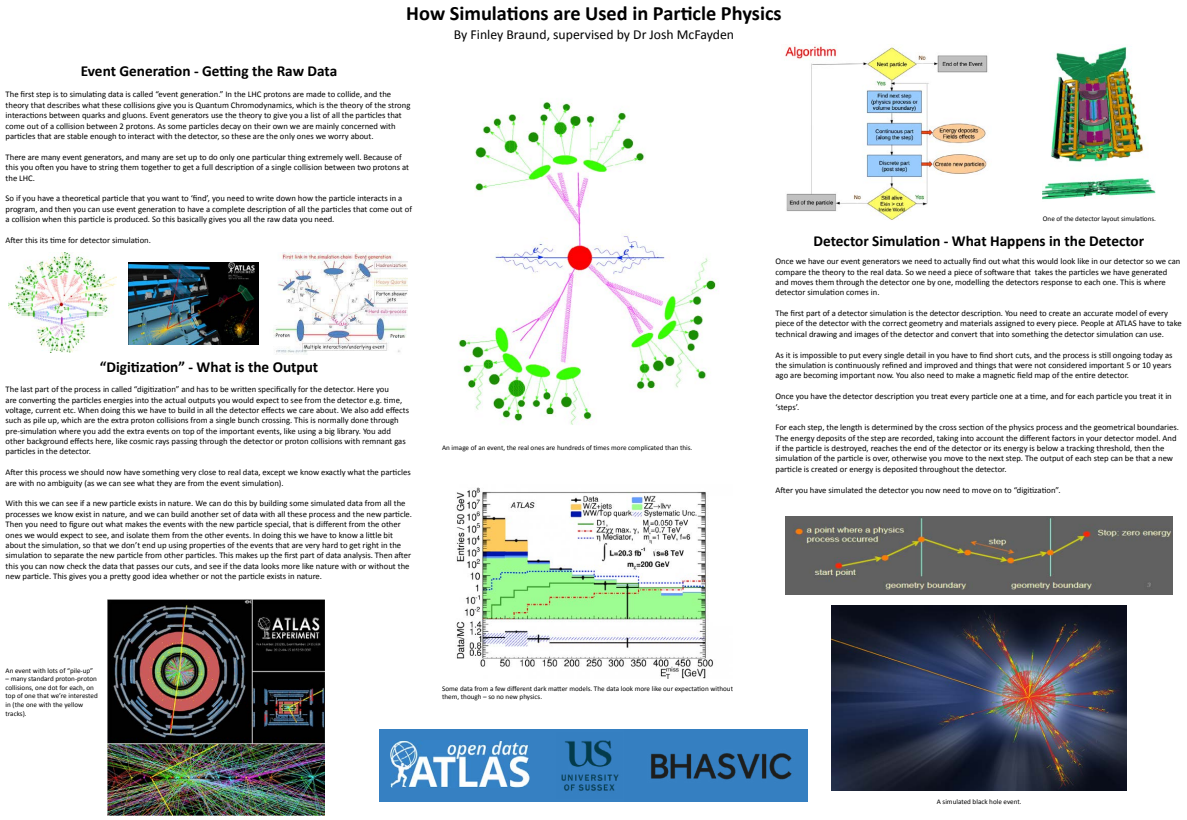
Could be broken up into more manageable chunks. Some terminology is used that an image or simple definition could help to convey its meaning.

This was one of my favourite pages, as it explains the steps of the Higgs decay, and the different forms that it

Poster presentations

Summer 2021 : small research project

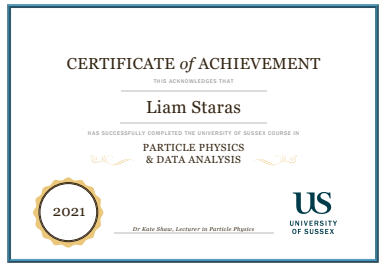
- Each student worked with a supervisor at Sussex to create a **poster** on a topic of their choice
- Students prepared a **3 minute flash talk**
- **Learning objectives**
  - Working with a supervisor, in particular being proactive
  - Understanding how to benefit from critical review of work
  - Planning a project and the presentation of the poster



Event and poster presentations

November 2021: One hour in-person event!

- Approx **100 students** attended
- Students each presented 3 minute flash talk of their poster
- Each student had one question from the audience!
- We were ***SO impressed*** by the level the students were talking at, could say ~***MSC level*** physics discussion!
- Posters stayed mounted in main court yard for 6 months, amplifying impact.
- Students all received certificates!



Feedback

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From the researchers

Number of students: In general we felt having 10 students allowed ***high impact outreach*** and educational teaching! We got to know each other. Could expand to ~20 but more would reduce the impact of the activity.

Working online: Worked perfectly for this activity, could easily be done inperson too!

- Zoom **chat** well, students interacted with each other or researchers answering questions.
- Zoom **break out rooms** allowed tutorial style interaction (one researcher – 3 or 4 students), really probing the students knowledge and preparing them for the independent work through studies of the activities
- **Teams** gave us space for week by week instructions, files, spaces for students to share their work

Feedback

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From the students

- Students were very appreciative of this enriching experience, particularly during lockdown
- Students felt the level was pitched correctly
- Students enjoyed the learning through doing approach, found it engaging
- Students mentioned they appreciated feeling safe and not intimidated
- Students mentioned they felt much more confident in their learning and analysing abilities
- Students found this was an instrumental part of the CV and many used it for their statement for University applications
- Students were exceedsingly happy with the programme and would definetly recommend.

Conclusion

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We were very happy with the programme, which evolved and grew as we learnt and interacted. Students were very happy and we reached our goals.

We have taught another online programme with a group of students, however without zoom chat / break outs this did not work as well. Thus we conclude it should be done in person or directly over zoom with each student.

We are putting together the whole programme into an online workbook to be ran again with ease and will look for further improvements