Queen Mary
University of London

Using ATLAS Open Data in schools projects

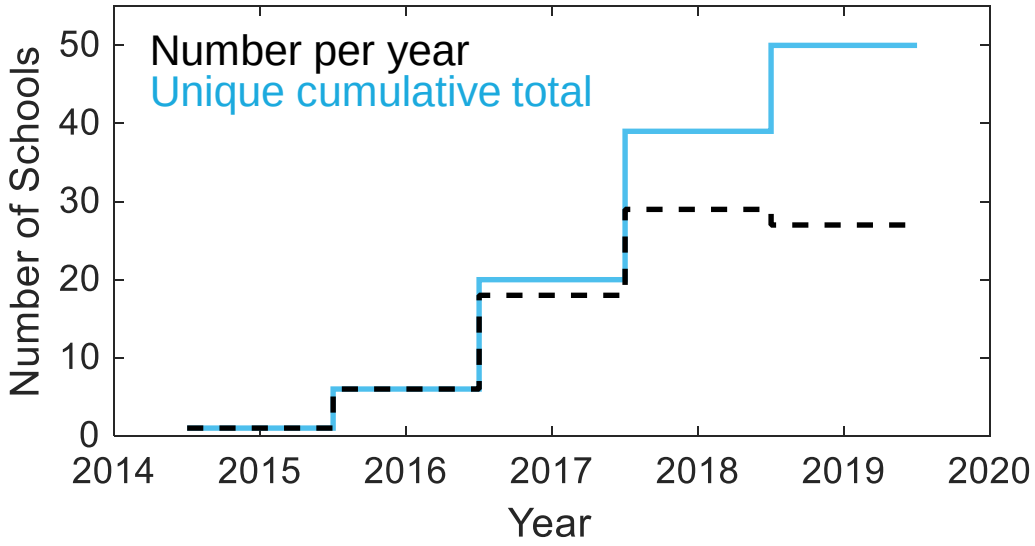
Dr Seth Zenz

Natasha Hehir

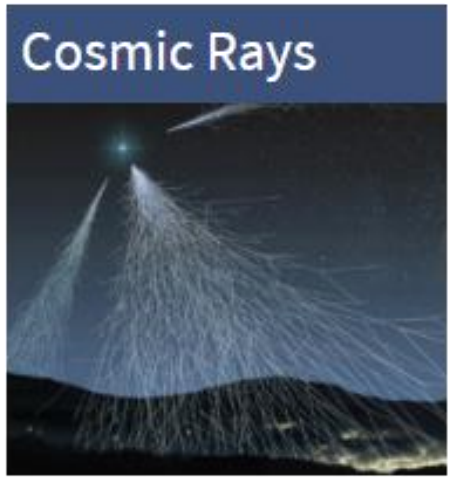
School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom

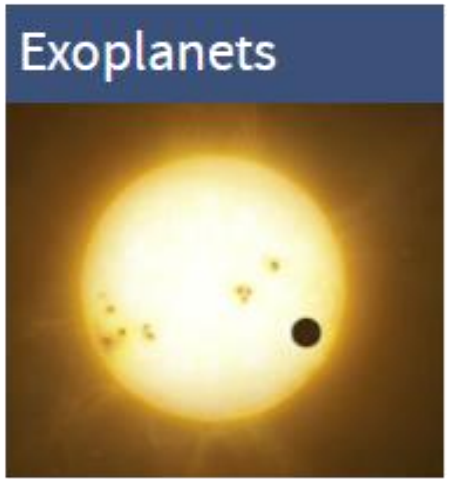
qmul.ac.uk/spa/researchinschools

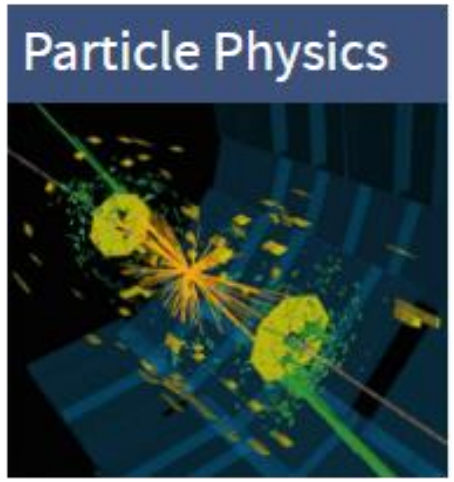
Physics Research in School Environments (PRiSE)



Award-winning framework for researcher-supported independent research projects developed from 2014 onwards that has carefully grown across London







ATLAS Open Data

Queen Mary University of London

Project structure

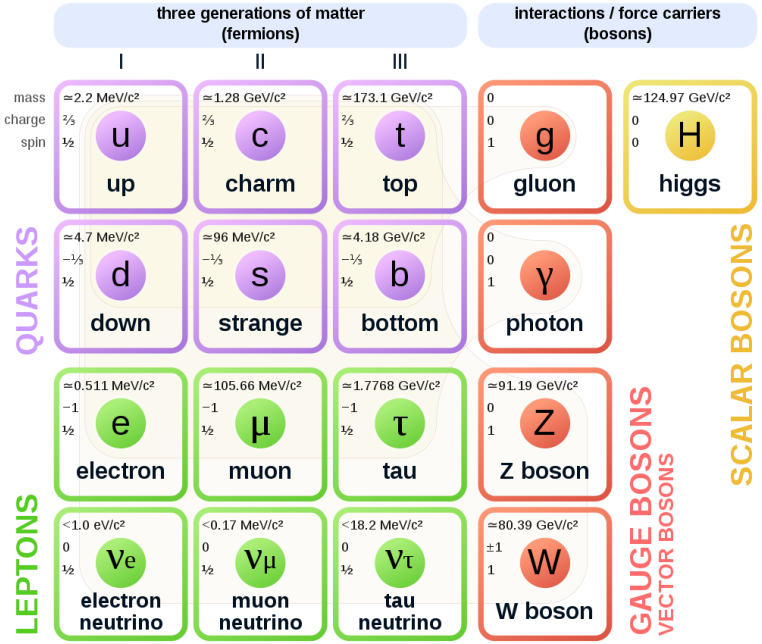
Building confidence → **Gaining independence** → **Completing a piece of research**

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Interventions	Assignment			Kick-Off			Visit(s)			Comments on work
Activities				Prescribed Work						
							Independent Project			
									Writing Up	
										Conference

ATLAS Open Data PRiSE project

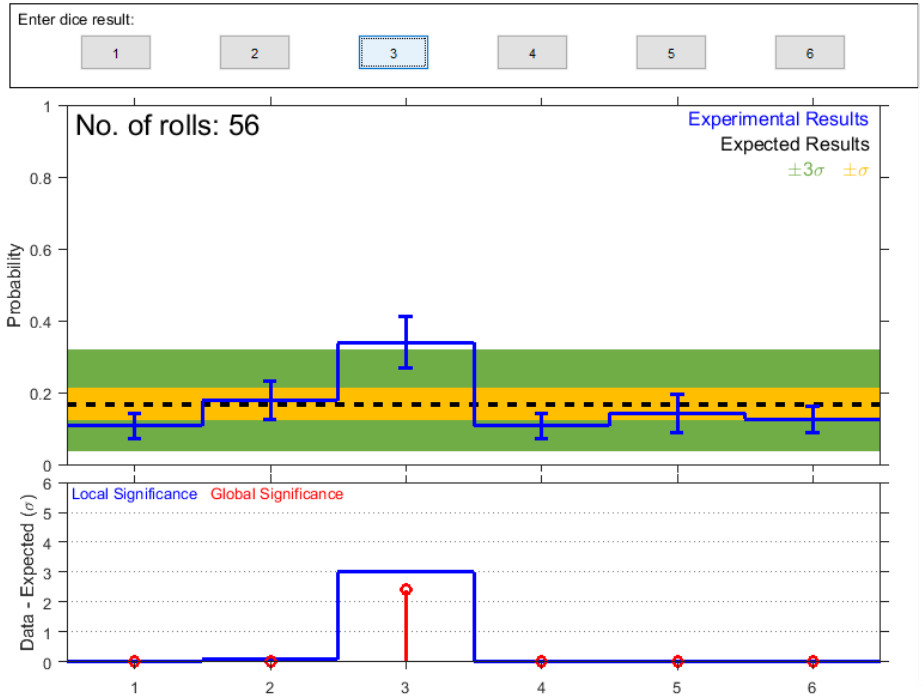
Kick-off workshop:

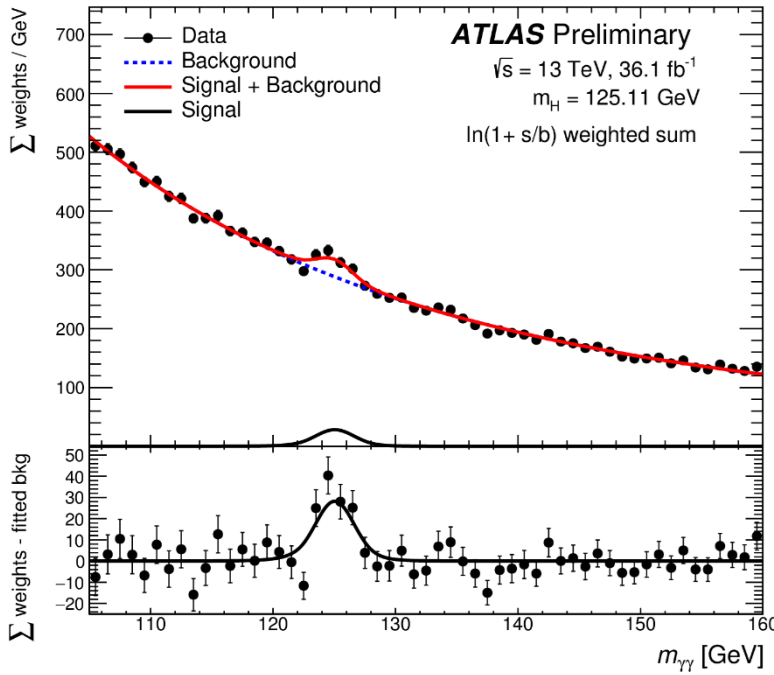
Introductory talk to particle physics / ATLAS



Loaded dice game analogy for significance

https://www.qmul.ac.uk/spa/outreach/in-school/teacher-resources/

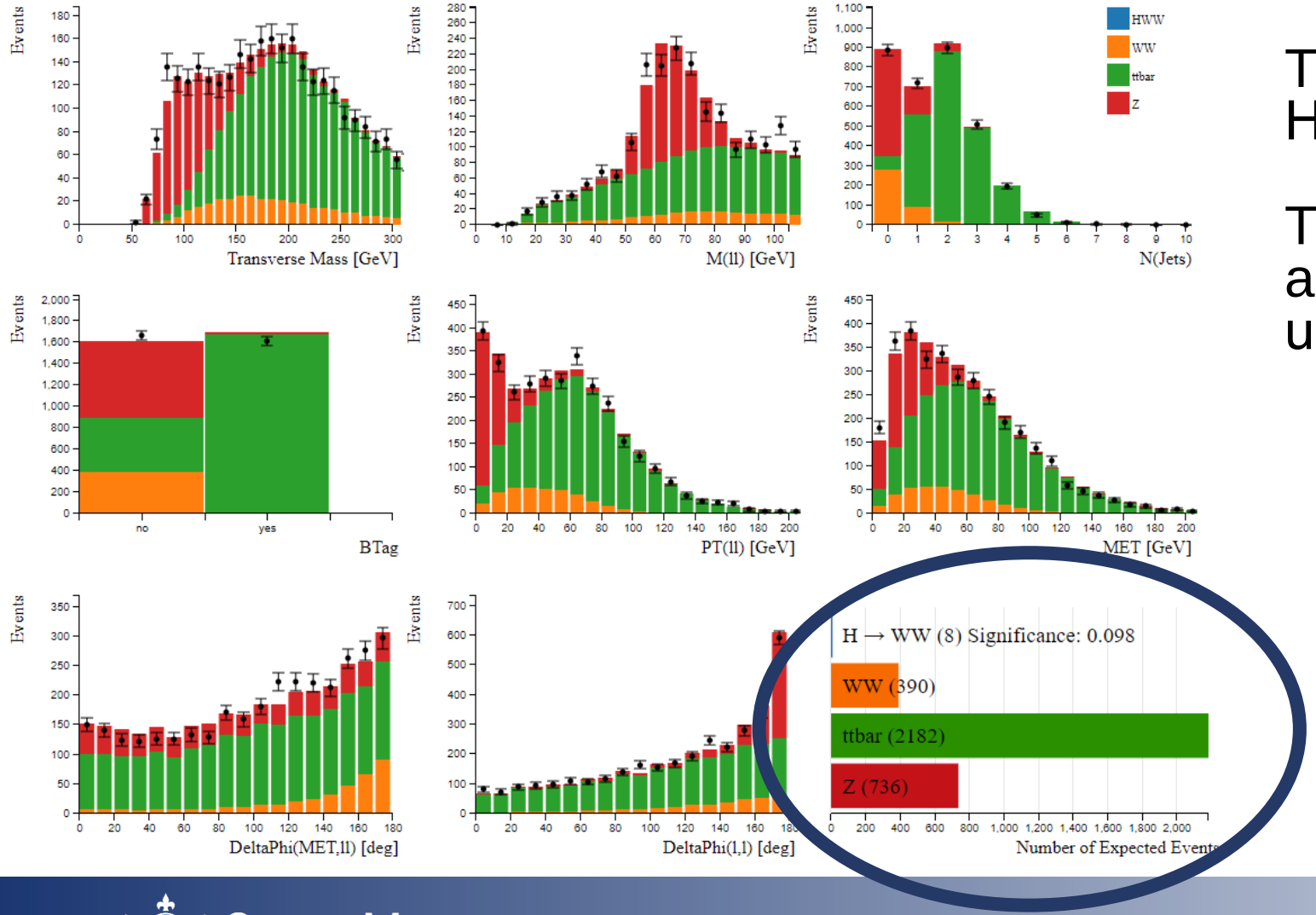




Queen Mary University of London

ATLAS Open Data PRiSE project

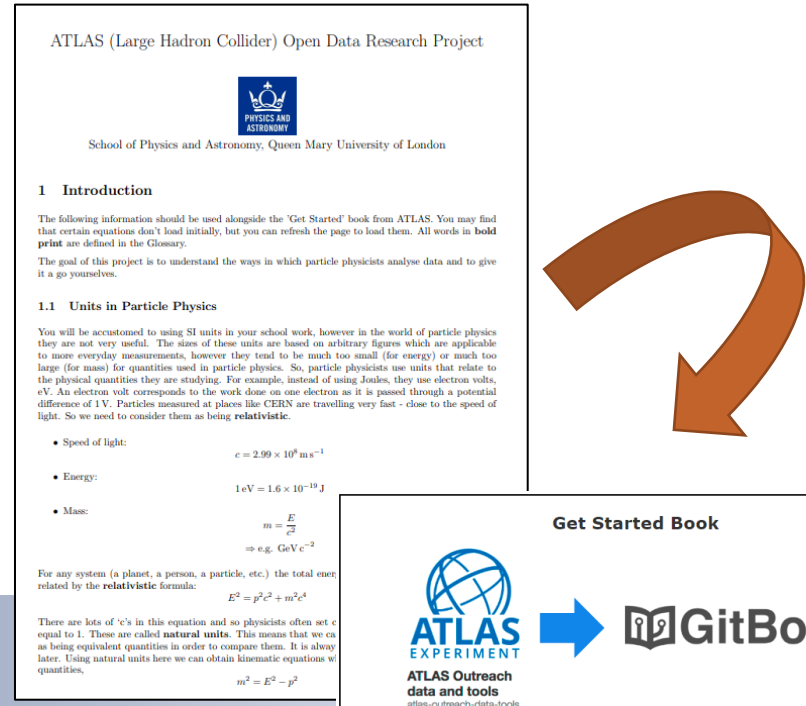
Kick-off workshop:



Intro to histogram analyser

Try to maximise significance of H→WW with cuts

Tasked with reading our guide and online documentation to understand what they're doing


ATLAS (Large Hadron Collider) Open Data Research Project

School of Physics and Astronomy, Queen Mary University of London

1 Introduction

The following information should be used alongside the 'Get Started' book from ATLAS. You may find that certain equations don't load initially, but you can refresh the page to load them. All words in **bold print** are defined in the Glossary.

The goal of this project is to understand the ways in which particle physicists analyse data and to give it a go yourselves.

1.1 Units in Particle Physics

You will be accustomed to using SI units in your school work, however in the world of particle physics they are not very useful. The sizes of these units are based on arbitrary figures which are applicable to more everyday measurements, however they tend to be much too small (for energy) or much too large (for mass) for quantities used in particle physics. So, particle physicists use units that relate to the physical quantities they are studying. For example, instead of using Joules, they use electron volts, eV. An electron volt corresponds to the work done on one electron as it is passed through a potential difference of 1 V. Particles measured at places like CERN are travelling very fast - close to the speed of light. So we need to consider them as being **relativistic**.

- Speed of light: $c = 2.99 \times 10^8\,\mathrm{m\,s^{-1}}$
- Energy: $1\,\mathrm{eV} = 1.6 \times 10^{-19}\,\mathrm{J}$
- Mass: $m = \frac{E}{c^2}$ $\Rightarrow$ e.g. $\mathrm{GeV\,c^{-2}}$

For any system (a planet, a person, a particle, etc.) the total ener related by the **relativistic** formula: $E^2 = p^2c^2 + m^2c^4$

There are lots of 'c's in this equation and so physicists often set c equal to 1. These are called **natural units**. This means that we ca as being equivalent quantities in order to compare them. It is alway later. Using natural units here we can obtain kinematic equations w quantities, $m^2 = E^2 - p^2$

Get Started Book

ATLAS EXPERIMENT

ATLAS Outreach data and tools

atlas-outreach-data-tools

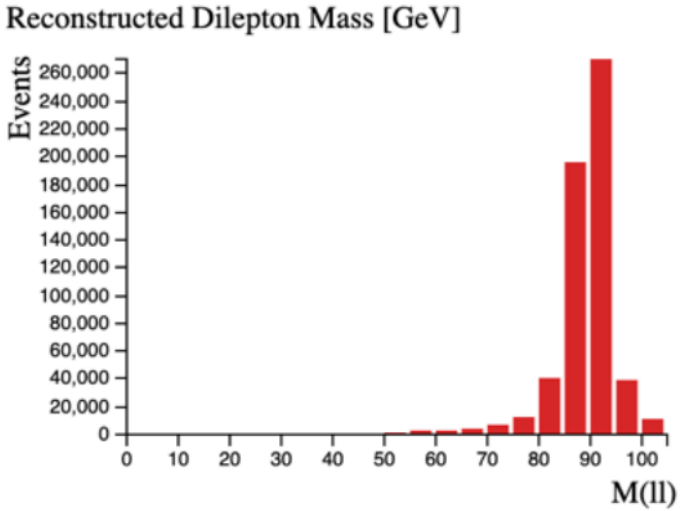
GitBook

Queen Mary University of London

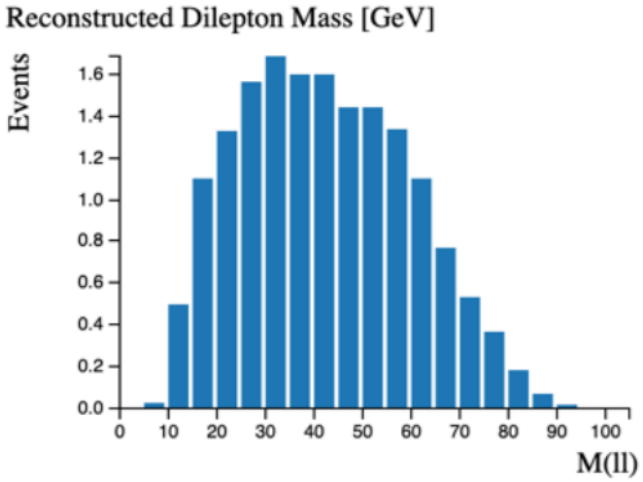
ATLAS Open Data PRiSE project

Suggested research project topics:

- Explain why their chosen cuts optimise Higgs (what processes are they eliminating)
- Estimate how much data you might need for statistically significant discovery
- Explain differences between data and Monte Carlo simulations
- Measure the masses and/or lifetimes of unstable particles



Z



Higgs

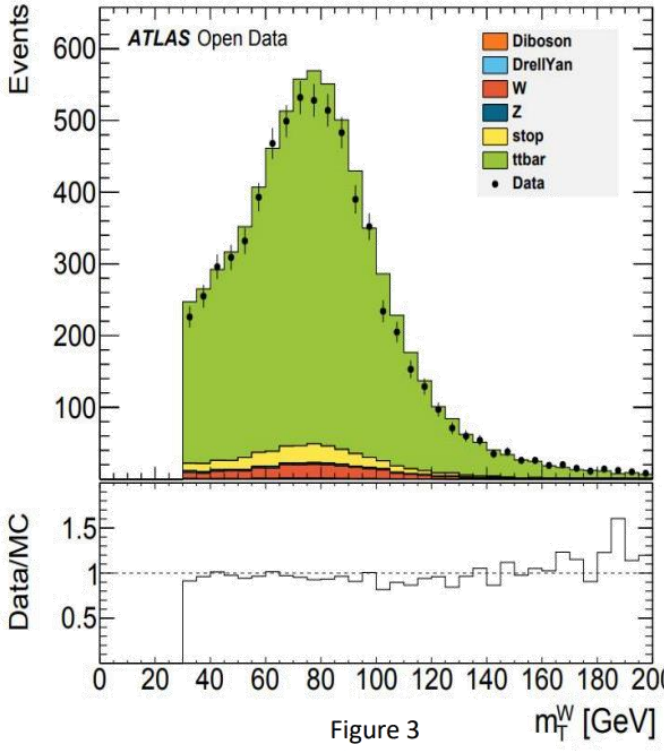


Figure 3

Impact on students

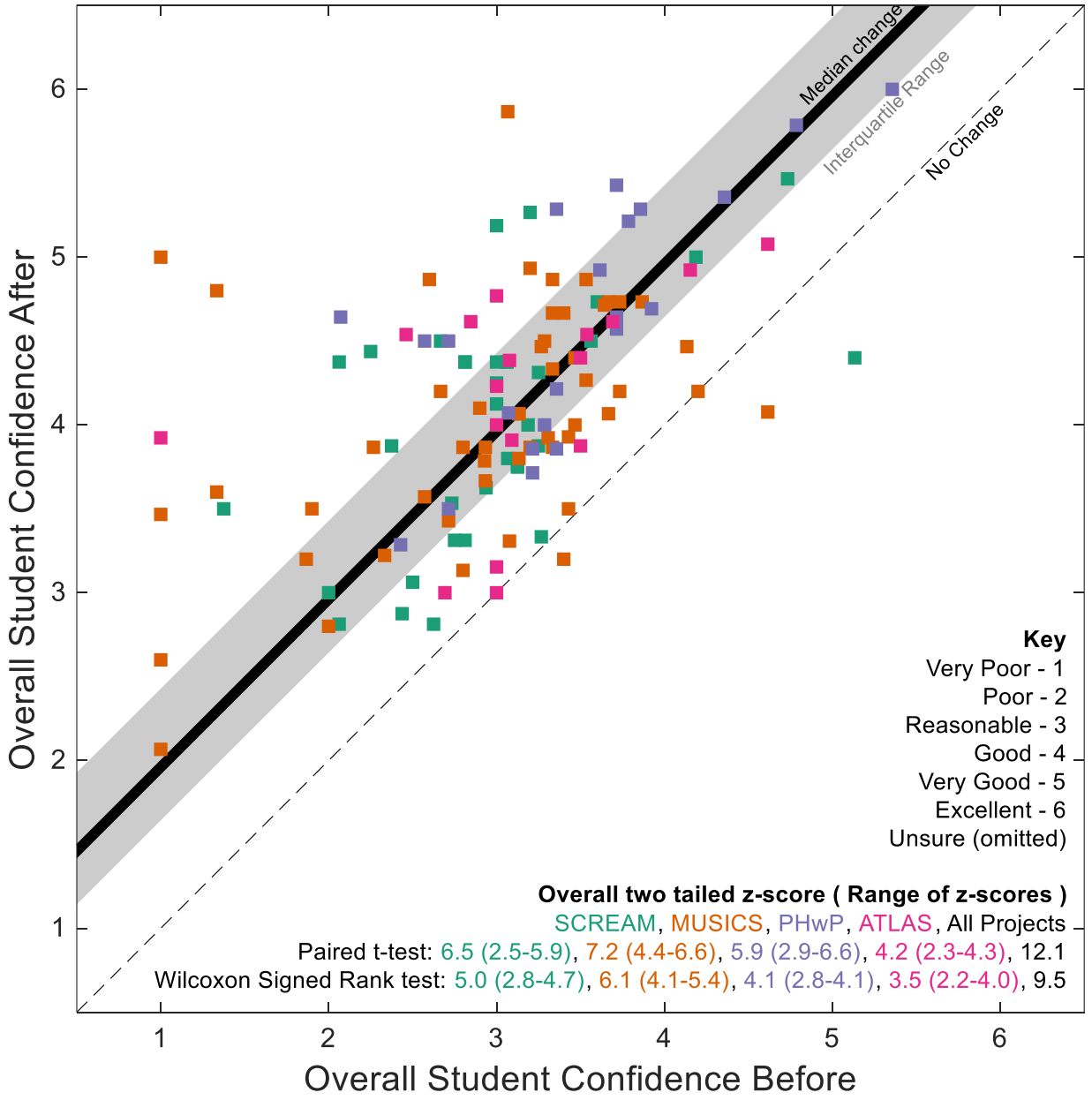
Confidence in scientific topics / methods

Before vs after measured at 6 month stage

~10 categories related to project Average for an overall measure

Effect size: Median change
Significance: Wilcoxon signed rank test

Remember, most outreach shows no statistically significant changes whereas PRiSE model shows highly significant result



Queen Mary University of London

Archer, M. O. and DeWitt, J.
Thanks for helping me find my enthusiasm for physics! The lasting impacts "research in schools" projects can have on students, teachers, and schools, Geosci. Commun. Discuss. [preprint], https://doi.org/10.5194/gc-2020-36, in review, 2020

Impact on students

Skills development

Key
Teachers Students
Both

Experience

Long-term evaluation (3yrs later)

"[The experience] Really helped to develop our teamwork skills, which I have used frequently in most things that I do in my academic education. Also there is a huge element [of] problem-solving and how to undertake the project/study is fundamental in my Engineering degree for electronics. I have used it a lot."
Male student from deprived area

"I enjoyed the opportunity to do science instead of just learning it"

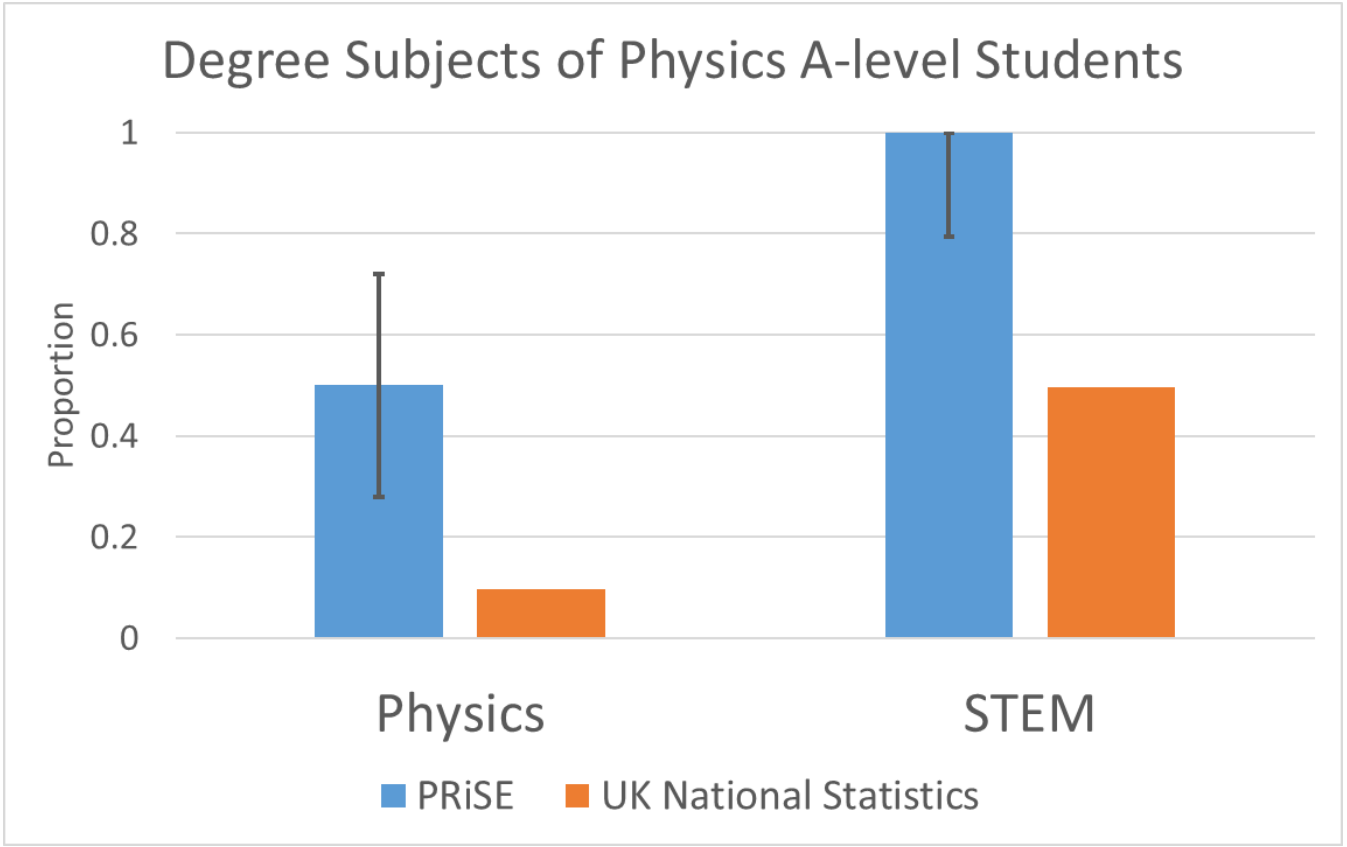
Queen Mary University of London

Archer, M. O. and DeWitt, J.
Thanks for helping me find my enthusiasm for physics! The lasting impacts "research in schools" projects can have on students, teachers, and schools, Geosci. Commun. Discuss. [preprint], https://doi.org/10.5194/gc-2020-36, in review, 2020

Impact on students

47% increased likelihood to continue with STEM as a result after 6 months

Note students' aspirations are thought to be highly resilient with most outreach showing no overall change



Long-term evaluation (3 yrs later):

"Thanks for helping me find my enthusiasm for physics"

60% state PRiSE affected their subject choice

Queen Mary University of London

Archer, M. O. and DeWitt, J.
Thanks for helping me find my enthusiasm for physics! The lasting impacts "research in schools" projects can have on students, teachers, and schools, Geosci. Commun. Discuss. [preprint], https://doi.org/10.5194/gc-2020-36, in review, 2020

Impact on teachers

- Learnt new physics
- Developed teaching skills
- Developed mentoring skills
- Gained confidence discussing research
- Referred to in lessons
- Shared students' work across school
- Raised STEM profile in school
- Developed relationship with HEI

On average teachers/schools affected by **5.5 of these 8 categories**

71% of schools who complete a PRiSE project return for multiple years

> "I am now more aware of what our students are capable of - not just listening to visiting speakers but being actively engaged in real-world research!
>
> — Teacher

Development

- Develop additional “standard” material appropriate to PRiSE
- Base on new Open Data release
- Test alternative venues and formats for this project

In School Project

One-day Workshop

‘Do at Home’ Project

13-14 year old Suitable Project

Focus delivery on state schools from less privileged areas, particularly within Tower Hamlets.

In School Project

- Expand on current PRiSE programme in schools
- Improve support for classrooms participating in the existing programme
- Make use of the latest release of new data and new tools provided by the ATLAS Collaboration at CERN
- Make versions of the project available to a broader range of audiences

One Day Workshop

- Development of a one-day activity version of the programme
- Including distribution of materials for further research and support at home
- Work with community members to deliver activities through effective routes outside of schools, e.g. Queen Mary Mile End campus and other local venues

- Considerations towards the Covid pandemic.
- Ensure Covid safety during the workshop.
- Be prepared to adapt to online format if necessary.

‘Do at home’ Project

- Develop a version of the project for students and community members to pursue at home
- Online or by-mail version for those unable to participate in the workshop/in schools projects
- Ensure widest possible participation – inclusion of those with home computers but lack of fast internet connection
- Provide materials and data in a format that can deliverable by mail and completed in the participants own time

Adapting to Younger Audiences (13-14 year olds)

- Physics Outreach usually focuses on students age 15 and older
- Introducing physics data analysis to younger students is very challenging
- Potential to increase science self-efficacy at an age when this has much more significant impact on future career and educational choices
- Develop and adapt the materials to be suitable for activities for this younger age group

Conclusions

- ATLAS Open Data is useful at many levels, with many examples
- Very useful to have the same datasets at each level
- Effective at raising STEM profile in schools
- Positive impact on student and schools in under privileged areas
- Currently developing further uses of the Open Data to reach wider audiences

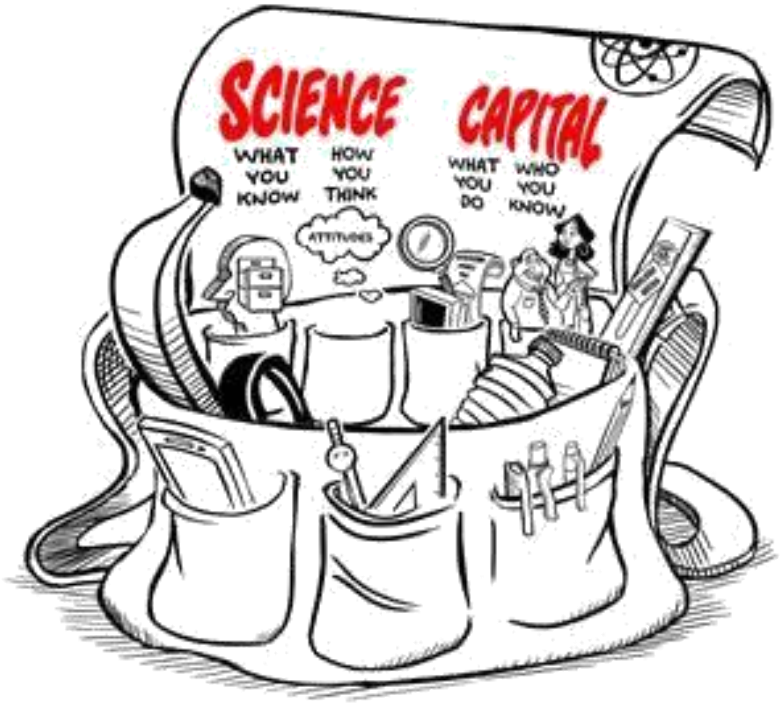
Thanks!

Backup

Context from Educational Research

Students' aspirations incredibly resilient typically showing no changes, even following protracted programmes [Archer+, 2014, Res. Sci. Tech. Educ.]

Barrier to pursuing science further isn't lack of interest, it's a lack of **science identity** [Archer+, 2013, J. Res. Sci. Teach.]



Confusion among students between 'research as information gathering' and a 'research question' [Yeoman+, 2017, Br. J. Educ. Stud.]

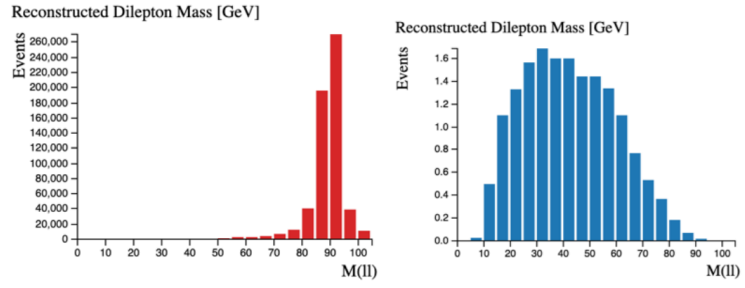
Opportunities for students to undertake research in school rare globally and only sometimes supported by university/industry mentor [Bennet+, 2018, Int. J. Sci. Educ.]

Expanded use of ATLAS Open Data

- Current particle physicist support for PRiSE after kickoff: skype call for questions
- Other PRiSE projects have support for multiple steps over months
- What would we do with similar effort in particle physics?
- ATLAS Open Data can support very rich analysis projects (e.g. MSci, using ROOT)

<table>
<tr><th></th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th><th>Jan</th><th>Feb</th><th>Mar</th></tr>
<tr><td>Interventions</td><td colspan="2">Assignment</td><td></td><td colspan="2">Kick-Off</td><td></td><td colspan="3">Visit(s)</td><td>Comments on work</td></tr>
<tr><td rowspan="4">Activities</td><td colspan="3"></td><td colspan="3">Prescribed Work</td><td colspan="3"></td></tr>
<tr><td colspan="6"></td><td colspan="4">Independent Project</td></tr>
<tr><td colspan="8"></td><td colspan="2">Writing Up</td></tr>
<tr><td colspan="9"></td><td>Conference</td></tr>
</table>

Challenge: connecting tools



Z Higgs

- Cut-flow histograms are very nice real-time illustrations
- As students build understanding they may want more control
- How to do this without the ”usual” overheads of ntuple analysis?
- Need to connect quick illustration to longer-term project

```
type,Channel,NJets,MET,Mll,LepDeltaPhi,METLLDeltaPhi,SumLepPt,BTags,weight
3,0,1,7.57,11.27,0.03,2.61,66.87,0,0.04678
3,0,1,12.99,12.17,0.31,-2.91,81.43,0,0.11052
3,0,1,34.26,14.36,0.32,2.42,87.85,0,0.06163
```

Current work in progress

- Teacher-defined need for python code to automate cut optimisation
- Asked for csv input for plots (thanks, Arturo!)
- Wrote short code snippet so teacher and students can develop further
- Provide more support in this direction, sooner, next year?

Back to the big picture

PRiSE has lasting impacts on participants

Interacts with and affects wider learning ecology

These impacts permeate this ecology and can affect others as well e.g.