Nuclear Physics Masterclass – Birmingham Event Report

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Introduction

This nuclear physics masterclass was held at Birmingham University on Thursday 14th January 2016. The masterclass was attended by 48 A level students from seven schools/colleges. This was a pilot event motivated by the success of nuclear physics masterclasses held at the Universities of Liverpool, Surrey and at Daresbury Laboratory in previous years.

Outline of Masterclass

The schedule of the masterclass is given in Table 1 below. The day started with a quick welcome by the event organiser Dr Tzany Kokalova (TK – Birmingham) before the introduction to nuclear physics lecture given by Prof Martin Freer (MF – Birmingham). The students were then split into two groups and while half visited the radiations labs with Dr Carl Wheldon (CW – Birmingham), the others went on a tour of the Birmingham cyclotron with TK. After an hour the groups swapped activities. After a short break MF gave his second talk detailing some of the features of nuclear physics that allow life as we know it to exist. After lunch, Prof Peter Jones (PJ – Birmingham) gave a talk on the ALICE experiment at CERN and went on to talk about the career opportunities a general physics degree and a nuclear physics specialism can open up. The day finished with a nuclear physics quiz, in which the students scored very highly, and a feedback session using TurningPoint voting pads. The event was also supported by the Birmingham schools liaison officer Dr Maria Pavlidou, the STFC particle and nuclear physics outreach officer Dr Elizabeth Cunningham (EC), two PhD students and several undergraduates from the Birmingham physics department.

Time	Session	Contributor
09:00-09:15	Arrival/Registration	
09:15-09:30	Welcome	TK
09:30-10:10	Introductory Lecture: Nuclear Physics – "What's it all about"	MF
10:10-10:20	Break	-
10:20-12:20	Radiation Lab and Cyclotron Visit	TK + CW
12:20-12:30	Break	-
12:30-13:00	'Why you are lucky to be here' Lecture	MF
13:00-14:00	Lunch	-
14:00-14:30	ALICE (creating mini big bangs) Lecture	PJ
14:30-15:10	Nuclear Physics Career and Research Talk	PJ
15:10-16:00	Quiz and Evaluation	TK + EC
16:00	End	-

Table 1: Schedule for nuclear physics masterclass, 14th January 2016.

Profile of Attendees

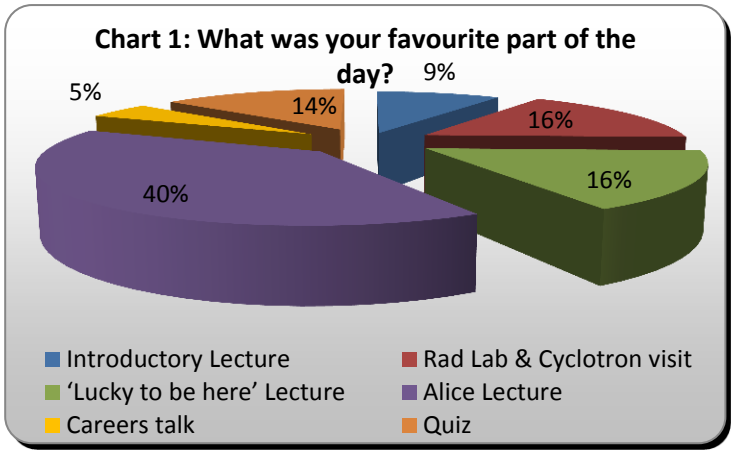
Forty-eight A level students from Ark St Albans Academy, King Edward's School, Waverley School, Akeley Wood School, Mander Portman Woodward College, Marling School and Birmingham Metropolitan College attended this masterclass with:

Male : Female = 78% : 22%.

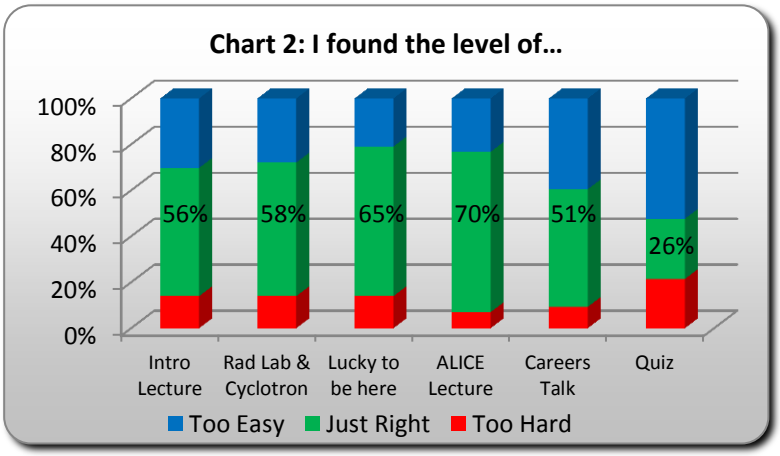
Evaluation

Feedback on Masterclass Sessions – Data collected using voting pads

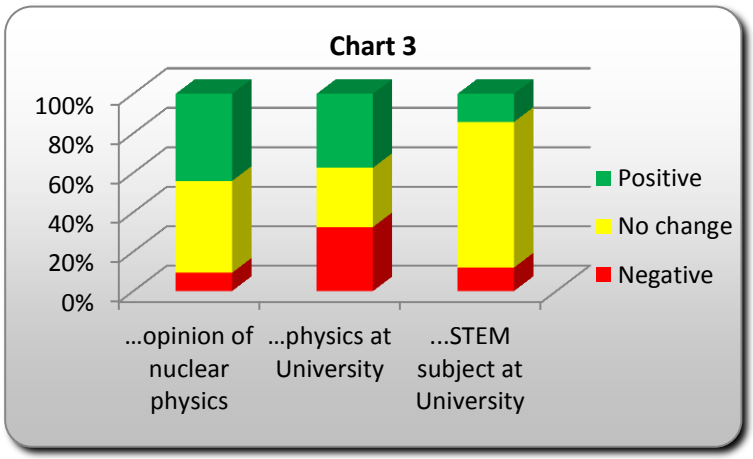
Chart 1 shows the most popular session was the ALICE talk given by Peter Jones. All the talks were of an excellent quality, but Prof Jones had more time to give his talk and answer questions at the end. The 'Rad lab & Cyclotron visit' and the 'Lucky to be here lecture' were the joint second most popular activity. Three out of the five teachers who filled in feedback forms also said that the cyclotron visit was their favourite part of the day (see Appendix A). The least popular session was the careers talk, which was the last talk of the day and unfortunately had to be a bit rushed for the event to end on time. Student and teacher feedback (Appendix A and C) on the different sessions included: include a Q&A session after every lecture and make sure groups of students are not left doing nothing in the radiation laboratory.



Each participant was also asked to evaluate how they found the level of each activity. The data from these questions can be seen in Chart 2, with the percentage for 'Just Right' shown for each session. The ALICE lecture and 'Lucky to be here' lecture were pitched at the correct level with 'Just right' values of 70% and 65% respectively. The careers talk and the quiz were found to be too easy by 40% and 52% of the audience respectively.



At the end of the day the students were also asked: 'Has this masterclass changed your opinion about nuclear physics?', 'After today are you more likely to consider studying physics at University?' and 'After today are you more likely to consider studying a STEM subject at University?'. The results are shown in Chart 3. 44% (green) of the students answered positively and felt they liked nuclear physics more after attending the masterclass and 47% (yellow) said their feelings had not changed. 38% (green) of the students said they were more likely to consider studying physics at University now, in addition to the 30% (yellow) who were already considering it. 14% (green) said they were more likely to consider studying a STEM subject at University after attending this event, while 74% said they



were already considering it. The students were also asked to write comments about the day on post it notes, these are summarised in Appendix C.

Nuclear Physics Quiz – Data collected using voting pads

At the end of the day the students were asked 16 multiple choice questions, these questions are given in Appendix B. The percentage of pupils getting the correct answer, averaged over all the questions, is 75%. One student got 15/16.

Feedback from Teachers – Data collected using feedback forms

The teachers were given a separate feedback form asking them nine questions. A summary of their responses is given in Appendix A. All the teachers who filled in the survey found the masterclass to be enjoyable and of good quality. The majority of teachers found the event useful for both themselves and their pupils and rated the level of the material presented to be appropriate. All teachers would bring another class if the masterclass was repeated again next year. There was no consensus over a better time of year to hold the masterclass, but Easter and the of June/beginning of July were both suggested.

Summary

The first nuclear physics masterclass at Birmingham was overwhelmingly successful – thanks mostly to the enthusiasm and hard work of all the contributors. The overall feedback was very positive, 91% of those who attended said they found the masterclass useful and 86% said they enjoyed the event. All teachers said they would bring students back next year and the organisers at Birmingham are keen to repeat the event. Feedback from the teacher forms and the student post it notes indicate that the following would make beneficial improvements for future events:

Improvements for future:

Provide teachers advance information about what is included in the masterclass.
Offer a Q&A session after all lectures.
Don't leave groups of students in the radiation lab with nothing to do.
Later start, shorter lunch.
Think about how to improve careers talk (possibly more contributors/examples).
Make quiz harder!

Feedback from EC:
Would it be possible to have two guides for the cyclotron visit and split the group in two so half can go to the experimental station and half can go to the cyclotron and no one is unable to see what is being described.
Give the students something to do in the radiation lab – simple experiment?

Appendix A

Feedback of the teachers from four schools labelled A, B, C, D and E.

*1) How **useful** do you think this Nuclear Physics Masterclass was to your **pupils**?*

1 2 3 4 (B,C) 5 (A,D,E)

(Not at all) (Very useful)

Comments:

*2) How **enjoyable** do you think this Nuclear Physics Masterclass was to your **pupils**?*

1 2 3 4 (A, B) 5 (C,D,E)

(Not at all) (Very enjoyable)

Comments:

*3) How **useful** do you think this Nuclear Physics Masterclass was for you as a **teacher**?*

1 2 3 4(A) 5 (B,C,D,E)

(Not at all) (Very useful)

Comments:

*4) How did you find the overall **quality** of the course?*

1 2 3 4 (A) 5 (B,C,D,E)

(Not at all) (Just right)

Comments:

5) How appropriate was the level of material presented?

1 2 3 (A) 4 (B,C,E) 5 (D)

(Not at all) (Just right)

Comments:

6) If the masterclass was repeated next year, would you like to bring another class?

No Maybe Yes (A,B,C,D,E)

Comments:

7) What was your favourite part of the day and why?

A: Lectures/Visit.

B: Cyclotron visit because if allowed students to see physics in action.

C: Visit to the cyclotron – I'd never seen one before.

D: What's it all about talk.

E: Cyclotron – students have seen this first time.

8) Is there a better time of year for the masterclass to be held?

A: Perhaps after June exams/Early July.

B: Closer to exam time, around Easter so it would help stimulate students beginning their revision.

C: No, but in a couple of weeks it would have coincided with mocks.

D: Not really.

E: July.

Do you have any other feedback you would like to give us for planning future masterclasses?

A: Perhaps information regarding what is on the course.

B: N/A

C: The visit to the nuclear physics lab, could have arranged so that all students were looking at something all the time.

D: Difficult driving through rush hour traffic, could we start at 10am and have a shorter lunch break?

Appendix B

The questions asked during the Nuclear physics quiz. The percentages reflect the number of pupils getting the correct answer.

90% 1) Warm up: What did Rutherford discover at the centre of the atom?
1. Neutrinos 2. A Higgs Boson 3. Plum Pudding 4. The nucleus

85% 2) What percentage of the mass of an atom is contained within the nucleus?
1. 50% 2. 0.1% 3. 99.9% 4. 90%

79% 3) Which property of an atomic nucleus determines the chemical element of the atom?
1. No. of neutrons 2. No. of electrons 3. Mass 4. No. of protons

97% 4) What is a proton made up of?
1. Muons 2. Mangos 3. Neutrons 4. Quarks

95% 5) What is the heaviest naturally occurring element?
1. Iron 2. Uranium 3. Hydrogen 4. Dubnium

97% 6) The top quark is as heavy as which atomic nucleus?
1. Uranium 2. Plutonium 3. Gold 4. Silver

62% 7) Nuclides with equal number of protons and neutrons lie along?
1. The line of equality 2. The proton dripline 3. The decay line 4. None of the above

87% 8) If an atom was the size of the Sun, how much smaller than the Earth would the nucleus be?
1. 25 2. The same size as the earth 3. 100 4. 1000

92% 9) Which of the following is most likely to prevent a nucleus exploding apart?
1. The strong nuclear force 2. Electrostatic force in the nucleus
3. Gravitational force 4. Magnetic force

61% 10) When gamma-rays interact in a scintillation material, what is ultimately produced?
1. Electrons 2. Electron-hole pairs 3. Light 4. Sound

90% 11) Quarks have a type of charge called colour. What colours are they?
1. Blue, red and white 2. Yellow, red and green
3. Pink, red and blue 4. Red, green and blue

82% 12) The maximum energy for protons in the LHC is 7 TeV. If you tried to make the LHC out of 1 V batteries, how many would you need?
1. 7 trillion 2. 70,000 3. 7 million 4. 700,000

69% 13) What are we predominantly made of (by mass)?
1. Hydrogen 2. Oxygen 3. Nitrogen 4. Carbon

87% 14) Roughly how old is the Universe?
1. 23.4 billion years 2. 13.7 billion years 3. 3 billion years 4. 13 million years

90% 15) Approximately how much electricity in the UK is produced by nuclear energy?
1. 80% 2. 5% 3. 20% 4. 50%

26% 16) What is the half life of uranium-238?
1. 4.5 years 2. 45 years 3. 4.5 million years 4. 4.5 billion years

75% Average

Appendix C

Post it note comments from the students.

Positive	Feedback	Silly
The lectures were fascinating	Not enough super symmetry	The Sun is real
Very interesting!	It would have been better if Martin Freer was around to finish his lectures and stay afterwards so we could go talk to him	The Sun is very big yet small (in Universe)
Very interesting to learn about nuclear physics – learnt so much!		Nothing!
Very enjoyable!		I still prefer maths!
Enjoyed it		Food was nice ☺
Amazing class and very useful information.		That was the old atom model
Was good		I am now thinking about failing this year to attend next year's class
Very informative		
It was very enjoyable and well delivered so as to be understandable		
It was great loving physics more		