

D3.1.1 Particle Physics Masterclass (extension)

Project Reference: H2020-SEAC-2014-2015/H2020-SEAC-2014-1 , 665917

Code: D 3.1.1

Version & Date: 20 September 2016

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1 Introduction / Demonstrator Identity

1.1 Subject Domain

Particle Physics

1.2 Type of Activity

School or University based: Particle Physics Masterclass (international PPM and mini PPM)

1.3 Duration

half day (mini PPM) or full day (international PPM)

1.4 Setting (formal / informal learning)

Both formal and informal settings - formal lecture, informal tour of the campus in small groups, workshop activity in teams, opportunities for questions throughout.

1.5 Effective Learning Environment

Simulations aiming to enable the visualization of theoretical models and facilitate inquiry-based experimentation

- Students and teachers will take part in computer workshops, using MINERVA visualization and analysis package.

Dialogic space / argumentation aiming to engage students in argumentation and dialogic processes for a better insight into the nature of scientific enquiry and the ways in which scientists work

- Students and teachers are encouraged to question and interact with scientists during the workshop, tour and informal lunch session (only during international PPM).

Experimentation (Science laboratories and eScience applications) aiming to enhance students' physical and intellectual interaction with instructional materials through 'hands-on' experimentation and 'minds-on' reflection.

- Students and teachers will use real LHC data in order to discover the Higgs Boson and specific properties of bosons.

Visits to research centres (virtual/physical) aiming to connect the science classroom with research infrastructures, addressing the enhancement of informal learning settings.

For the mini PPM there is no time to link with CERN. For the international PPM a link to CERN will allow students to discuss/question researchers on their findings.

Communication of scientific ideas to audience addressing the need to establish settings in which learners will be enhanced to externalize and elaborate on scientific concepts they have acquired while interacting with an audience (learners, teachers, scientists, parents, etc.); promoting this way a dual channel of communication: a) reflective processes (self-engagement for scientific consistency and verification) and b) explicit elaboration of scientific ideas through interaction and 'extroversion'.

For the international PPM, students and teachers will follow a series of lectures. For the mini PPM, students and teachers will hear one introductory lecture.

2 Rational of the Activity / Educational Approach

2.1 Challenge

Particle physics and the work of the Large Hadron Collider are very inspirational topics and students are curious about the ongoing research. Often, though, teachers do not feel they have the knowledge and background to be able to answer their students' questions. The particle physics masterclass allows students, and teachers, to interact with the scientists working at the Large Hadron Collider, and gives them to opportunity to experience particle physics for themselves.

2.2 Added Value

The collaborative computer workshops use the MINERVA tool, which has been developed to help students learn more about the ATLAS experiment and particle physics at CERN. It is based on Atlantis, the event display used at ATLAS to visualise what happens in the detector. The aim of MINERVA is to give students a better understanding of how particle detectors work and the physics that they study. Currently, in MINERVA, students are able to study W and Z boson events by observing their decay products and apply this knowledge to search for the Higgs boson. By taking an inquiry based approach to finding the Higgs, this workshop enables students to experience what it is like to be a particle physics researcher.

The masterclasses give students the opportunity to interact with scientists in both formal and informal settings. During the workshop students are in small groups and have the chance to question their guides and demonstrators.

Throughout the masterclass there are opportunities for the students and teachers to question the particle physicists working at CERN: both on the curriculum material and on further questions.

The content of the masterclass is designed to link very closely to the English school curriculum in the final two years of school (age 16-18). This gives students and teachers more confidence to address and study these inspiring topics.

3 Learning Objectives

3.1 Domain specific objectives

The main aim of the Particle Physics Masterclasses is to **inspire students with the cutting-edge and popular subject of particle physics.**

The domain specific objectives of the Particle Physics Masterclass are:

- Give students and teachers the chance to interact with particle physicists working with and at CERN (only for the international PPM)
- Give students and teachers access to LHC data so that, working collaboratively within a group, they can discover the Higgs for themselves as well as calculate characteristics of bosons
- Assist teachers to build confidence in teaching relevant subjects

3.2 General skills objectives

The general skills objectives for the Particle Physics Masterclass are:

- Develop an understanding of scientific inquiry and careers
- Highlight the achievements of science and technology
- Understand the methodology that guides scientific investigation
- Value science and technology for its economic, social and cultural contribution to society

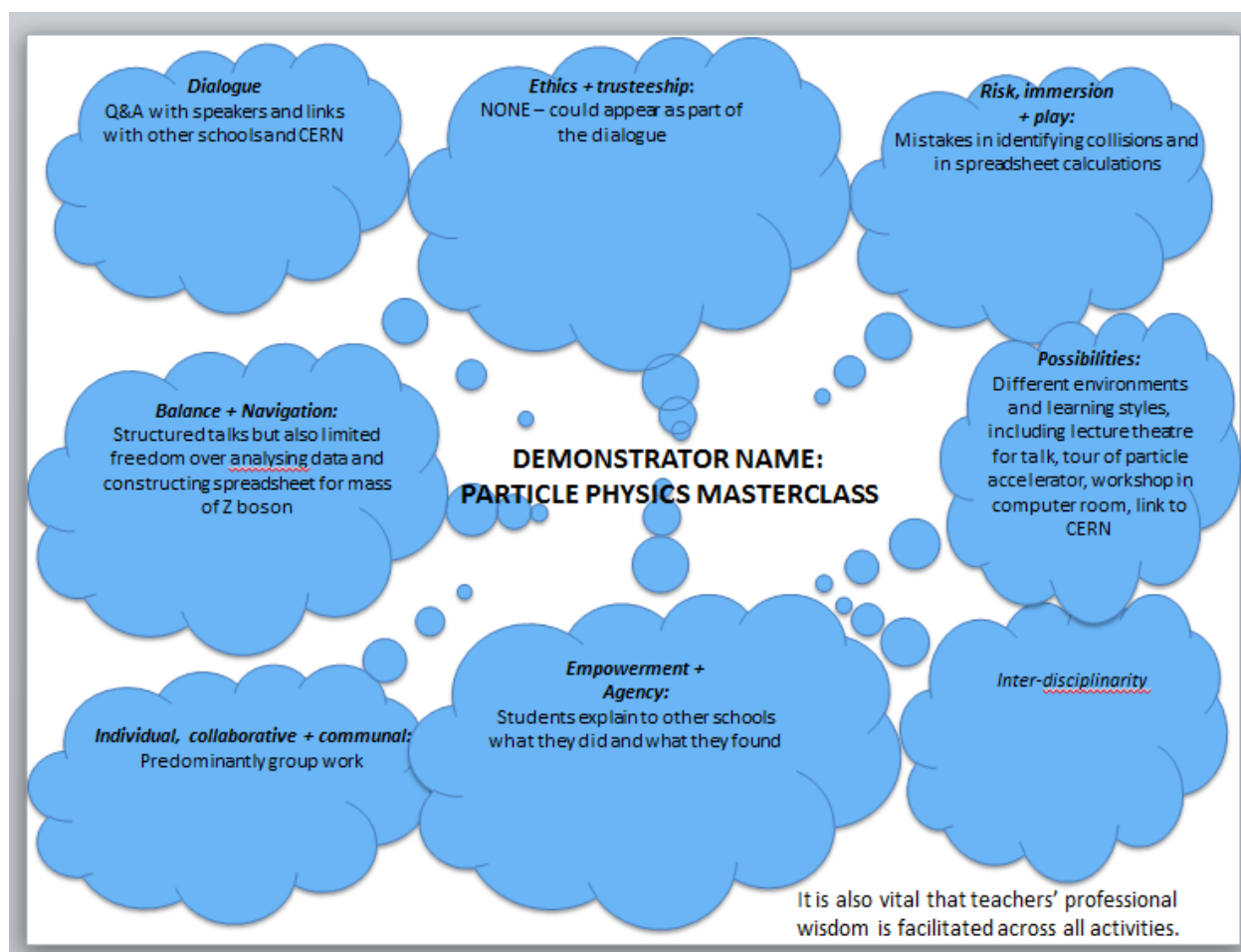
4 Demonstrator characteristics and Needs of Students

4.1 Aim of the demonstrator

The demonstrators main aim is to engage 16-18 year old high school students studying physics and science teachers with particle physics through:

- Lectures and discussions with particle physicists
- Hands on computer workshop using LHC data and the MINERVA tool
- Link with CERN to discuss findings (only the international PPM)

The masterclass improves the knowledge and confidence of both students and teachers in particle physics.



4.2 Student needs addressed

- Particle physics is a topic that interests and inspires, but which some teachers are not confident teaching.
- Using IBSE for the masterclass, allowing students to use real LHC data for themselves, acts to dispel the notion that 'particle physics isn't for me'.
- Gives students and teachers access to experts in what is considered to be a complicated field.
- Students are able to understand how the direct applications of particle physics affect their lives.

5 Learning Activities & Effective Learning Environments



Science topic: Particle Physics

(Relevance to national curriculum) Key component of A level syllabus (UK students, age 16-18)

Class information

Year Group: Year 12 & 13 (sixth form)

Age range: 16-18

Sex: both

Pupil Ability: Mixed (The scenario allows space for pupils of various abilities to participate)

Materials and Resources

What do you need? (eg. printed questionnaires, teleconference, etc.) Lecture facilities, computers with internet access, evaluation questionnaires.

Where will the learning take place? On site or off site? In several spaces? (e.g. science laboratory, drama space etc), or one? Masterclasses will be held at the university or in various schools around the country.

Health and Safety implications? Knowledge of local fire and radiation procedures.

Technology? Computer and internet access.

Teacher support? Reference material.

Prior pupil knowledge

- Basic ICT skills
- Commitment to attend the full day's event (for International PPM)



Individual session project objectives (*What do you want pupils to know and understand by the end of the lesson?*)

During this scenario, students will:

Lectures: Learn about: the principles and applications of particle accelerators, fundamentals of the standard model, large hadron collider.

Workshop: Empowerment from using real LHC data to solve a challenge and appreciation of collaborative nature of scientific research.

Link to CERN: discussion with other groups on the findings of the day

Assessment

During the workshop via discussion with researchers and from student and teacher questionnaire.

Differentiation

How can the activities be adapted to the needs of individual pupils?

All the students do the same activities, there are opportunities for students to ask questions and clarify points throughout the day. Weaker students will analyse fewer collision events.

Key Concepts and Terminology

Science terminology:

Maths, Particle and Accelerator physics.

Arts terminology: visual arts, performing arts, freedom and choice of expression

Session Objectives:

During this scenario, students will deepen their understanding of particle physics concepts and phenomena, through both formal and informal sessions. Masterclasses encompass the CREATIONS features of creativity: including dialogue; risk, immersion and play; possibilities; empowerment and agency; individual, collaborative and communal; balance and navigation.



Learning activities in terms of CREATIONS Approach

IBSE Activity	Interaction with CREATIONS Features	Student	Teacher	Potential arts activity
<p>Phase 1: QUESTION: students investigate a scientifically oriented question</p>	<p>Students pose, select, or are given a scientifically oriented question to investigate. <i>Balance and navigation</i> through <i>dialogue</i> aids teachers and students in creatively navigating educational tensions, including between open and structured approaches to IBSE. Questions may arise through <i>dialogue</i> between students' scientific knowledge and the scientific knowledge of professional scientists and science educators, or through <i>dialogue</i> with different ways of knowledge inspired by <i>interdisciplinarity</i> and personal, embodied learning. <i>Ethics and trusteeship</i> is an important consideration in experimental design and collaborative work, as well as in the initial choice of question.</p>	<p>Students will engage with lecturers and workshop leaders, creating a dialogue between students and researchers.</p>	<p>Teachers will engage along with their students.</p>	
<p>Phase 2: EVIDENCE: students give priority to evidence</p>	<p>Students determine or are guided to evidence/data, which may come from <i>individual, collaborative and communal activity</i> such as practical work, or from sources such as data from professional scientific activity or from other contexts. <i>Risk, immersion and</i></p>	<p>Students will explore real data from the LHC</p>	<p>Teachers will explore real data from the LHC</p>	



	<i>play</i> is crucial in <i>empowering</i> pupils to generate, question and discuss evidence.			
Phase 3: ANALYSE: students analyse evidence	Students analyse evidence, using <i>dialogue</i> with each other and the teacher to support their developing understanding.	Students will analyse the LHC data using MINERVA – based on ATLAS event display. Students work collaboratively in teams – both within their school groups and, when combining data, across different schools.	Teachers will support their students throughout the analysis, alongside workshop leaders	
Phase 4: EXPLAIN: students formulate an explanation based on evidence	Students use evidence they have generated and analysed to consider <i>possibilities</i> for explanations that are original to them. They use argumentation and <i>dialogue</i> to decide on the relative merits of the explanations they formulate, <i>playing</i> with ideas.	Students use the data they have analysed to find the Higgs boson and calculate the mass of the Z boson (or of another boson).	Teachers work alongside their students.	
Phase 5: CONNECT: students connect explanations to	Students connect their explanations with scientific knowledge, using <i>different ways of thinking and knowing</i> ('knowing that', 'knowing how', and 'knowing this') to relate their ideas to both disciplinary knowledge and to <i>interdisciplinary</i> knowledge to	Students use the knowledge they have learned in class and during the masterclass lectures to interrogate	Teachers encourage their students to connect their background	



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scientific knowledge	understand the origin of their ideas and reflect on the strength of their evidence and explanations in relation to the original question.	the data and their analysis of it.	information with the data and analysis work they have been undertaking.	
Phase 6: COMMUNICATE: students communicate and justify explanation	Communication of <i>possibilities</i> , ideas and justifications through <i>dialogue</i> with other students, with science educators, and with professional scientists offer students the chance to test their new thinking and experience and be <i>immersed</i> in a key part of the scientific process. Such communication is crucial to an <i>ethical</i> approach to working scientifically.	During the final phase of the MINERVA workshop, different teams of students come together to communicate their findings and work together to find a final result. This is done in length via the link to CERN	Teachers work alongside their students, encouraging them to contribute to the final group discussion.	Students will be asked to create, as an individual or as a group, an artistic piece, inspired by the masterclass which will be displayed in the Art Exhibition at the University of Birmingham during an Open Day.
Phase 7: REFLECT: students reflect	<i>Individual, collaborative and community-based</i> reflective <i>activity for change</i> both consolidates learning and enables students and teachers to balance educational tensions such as that between open-ended inquiry learning and the curriculum and assessment	Students will take part in a questionnaire based on all aspects of the masterclass.	Teachers will take part in a questionnaire alongside their	Students will be asked to create, as an individual or as a group, an artistic



<p>on the inquiry process and their learning</p>	<p>requirements of education.</p>		<p>students</p>	<p>piece, inspired by the masterclass which will be displayed in the Art Exhibition at the University of Birmingham during an Open Day.</p>
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6 Additional Information

Further information can be found at:

<http://atlas-minerva.web.cern.ch/atlas-minerva/>

<http://www.stfc.ac.uk/public-engagement/for-schools/schools-rutherford-appleton-laboratory/#ppm>

<http://physicsmasterclasses.org/>

<http://www.stfc.ac.uk/public-engagement/for-schools/particle-physics-for-you/particle-physics-masterclass-programme/>

<http://www.birmingham.ac.uk/schools/physics/outreach/Secondary-Schools/particle-physics-masterclasses.aspx>



7 Assessment

Students and teachers will undertake a final questionnaire to gauge their learning from the masterclass and to evaluate the masterclass.

8 Possible Extension

Students will be encouraged to explore the LHC for themselves by visiting

<https://www.higgshunters.org/>

so that they can become involved in further analysing LHC data, as part of the citizen science project.

Teachers can engage in further projects, such as:

- CERN@school
 - A project that brings technology from CERN into the classroom, allowing students to design and analyse their own experiments
 - <https://cernatschool.web.cern.ch/>
- HiSPARC
 - HiSPARC is a project in which secondary schools and academic institutions join forces and form a network to measure cosmic rays with extremely high energy.

<http://www.birmingham.ac.uk/schools/physics/outreach/Secondary-Schools/HiSPARCproject.aspx>

These projects will allow teachers and their students to continue engaging with particle physics in an empowering, IBSE-based manner.

9 References

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