



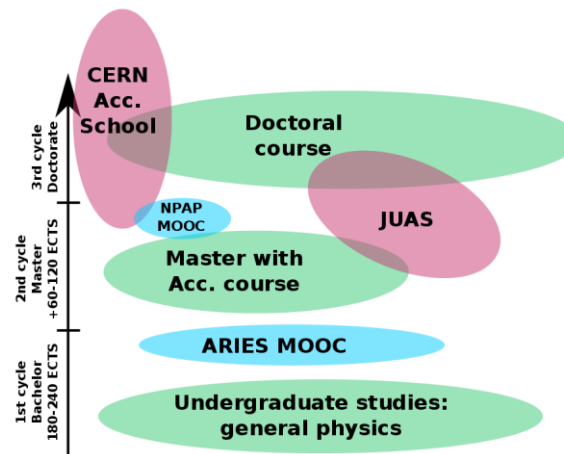
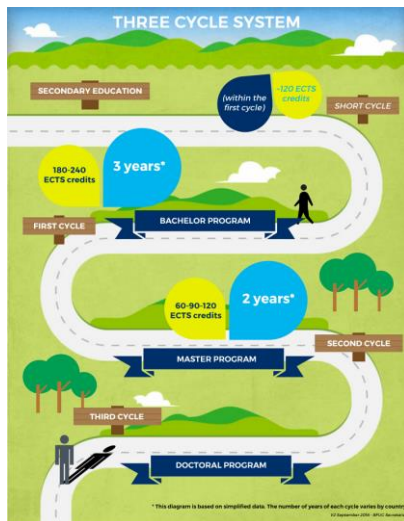
The ARIES Massive Online Open Course

CERN, 3rd May 2022

Nicolas Delerue, IJCLab, CNRS & Université Paris-Saclay

Motivations - Reminder

- This Massive Open Online Course aims at raising awareness on Accelerator Science and Technology.
- It is aimed at 3rd year students (end of the 1st cycle – before the master).
- So its target audience is younger than that of JUAS and CAS.
- It can also help train young professionals joining the field.



Goals and deliverables

Task 2.4. Provide an e-learning course: introduction to accelerator science, engineering and technology

- Survey existing e-learning initiatives in relevant physical sciences disciplines.
- Define the intellectual content of the e-learning course.
- Survey e-learning tools and select an appropriate tool.
- Set up the e-learning course in test mode.
- Define resources required to launch, maintain and run the course on a sustainable basis.

Milestone	Month 12	Meeting to agree MOOC platform and academic structure and content of e-learning course.
Deliverable	Month 36	e-learning course delivered in test mode, ready for use.

Define the content of the e-learning course.

- The course will be split in two parts:
 - An Introductory part of 4 hours
 - Introduction to accelerators (Coordinated by Philippe Lebrun)
 - Electromagnetism with no pre-requisites (Coordinated by Vittorio Vaccaro)
 - Special Relativity with no pre-requisites (Coordinated by Elias Metral)
 - Applications of accelerators (Coordinated by Angeles Faus Golfe)
 - An advanced part with 3 modules of 6 hours
 - Accelerator physics
 - Accelerator Engineering
 - RF (Coordinated by Graeme Burt)
 - Magnets (Alex Bainbridge)
 - Applications of accelerators
- **See presentation at ARIES' Budapest meeting and IPAC'18 Paper on the ARIES MOOC.**

WP 2.4 Milestone

Survey [and] select an appropriate tool

- A technical committee had been setup to survey e-learning tools and select the most appropriate.
- The MOOC will be released on a international platform.
- As these platform require a full course, the test mode will be on You Tube.
- The recordings are released with an open license (Creative Commons) so that any University or organisation can use the MOOC internally if it wishes so.
- The language is English but any country or language group is welcome to translate it (or add sub-titles) if it wishes so.
- More details in IPAC'18 paper.

Set up the e-learning course in test mode

- Five lectures have been fully produced:
 - Introductory
 - Introduction to accelerators (Coordinated by Philippe Lebrun)
 - Electromagnetism with no pre-requisites (Coordinated by Vittorio Vaccaro)
 - Special Relativity with no pre-requisites (Coordinated by Elias Metral)
 - Applications of accelerators (Coordinated by Angeles Faus Golfe)
 - Accelerator Engineering
 - RF (Coordinated by Graeme Burt)
- All these lectures are available at <http://mooc.particle-accelerators.eu/>
- One lecture is recorded and in post-processing phase:
 - Magnets (Alex Bainbridge)


WP 2.4 Deliverable

Lecturers diversity

- Special attention was paid to lecturers diversity:
 - 11 men and 7 women
 - Different career stage
 - Different labs and universities
 - 6 different countries

Teaser


- <http://mooc.particle-accelerators.eu/teaser/>



HOW TO ACCELERATE PARTICLES

The accelerator is (almost) ready

What are the main building blocks of accelerator?




Also needed

- beam diagnostics, controls, radiation shielding, safety, building, infrastructure etc.

and lots of people and experts

- technicians, engineers, operators, electricians, architects, and many



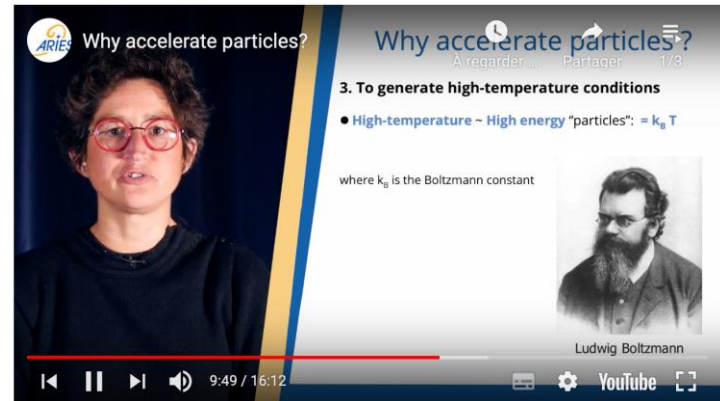
Nicolas Delerue, Accelerator Physicist at CNRS

Introduction to accelerators

- <http://mooc.particle-accelerators.eu/introduction-to-particle-accelerators/>



Philippe Lebrun (CERN)



Marie Labat (SOLEIL)



Nicoleta Baboi (DESY)



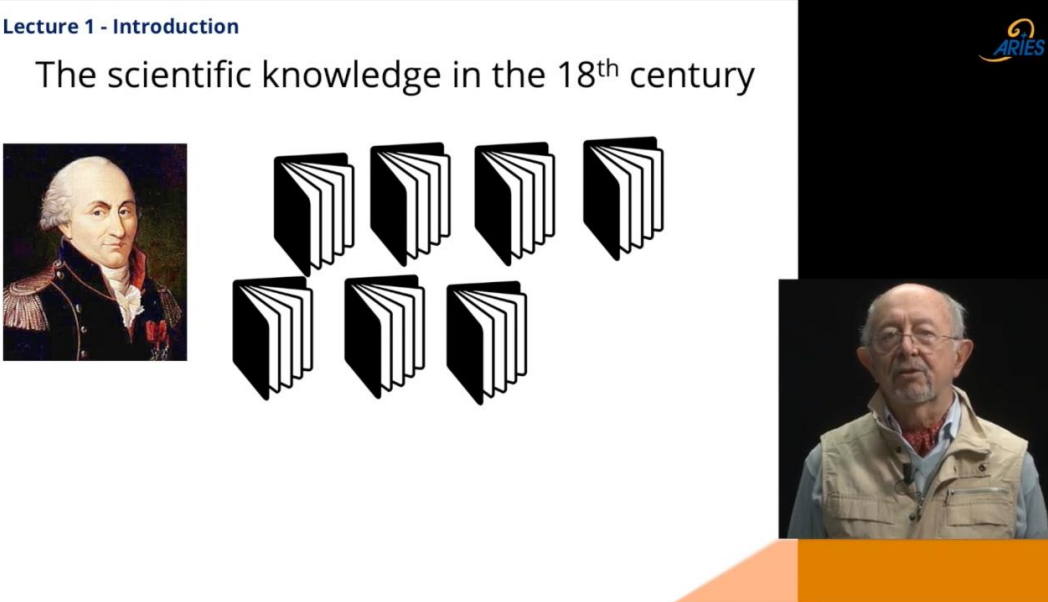
Simona Bettoni (PSI)

Electromagnetism

- <http://mooc.particle-accelerators.eu/electromagnetism/>

Lecture 1 - Introduction

The scientific knowledge in the 18th century



The slide features a portrait of a man in 18th-century attire on the left, seven icons of books in the center, and a video frame on the right showing a man speaking, with the ARIES logo in the top right corner of the video.

Vittorio Vaccaro (INFN)

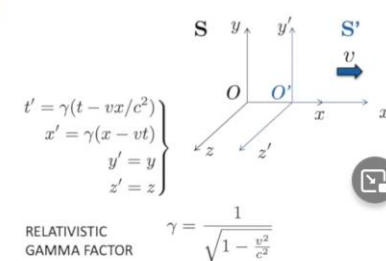

Special Relativity

- <http://mooc.particle-accelerators.eu/special-relativity/>




At 10 m/s: $L = 29.999999999999998$ cm
At 70 km/s: $L = 29.9999992$ cm

Elias Metral (CERN)



RELATIVISTIC GAMMA FACTOR $\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$

Tatiana Pieloni (EPFL)



Electric and magnetic fields produced by a relativistic charged particle with constant velocity

Mauro Migliorati
(La Sapienza)

Applications

- <http://mooc.particle-accelerators.eu/applications-of-particle-accelerators/>



APPLICATIONS OF ACCELERATORS

- Colliders for High Energy Physics
- Material analysis
- Health applications
- Industrial applications

ACCELERATORS HAVE A VERY IMPORTANT, BUT OFTEN UNSEEN, IMPACT ON OUR EVERYDAY LIVES

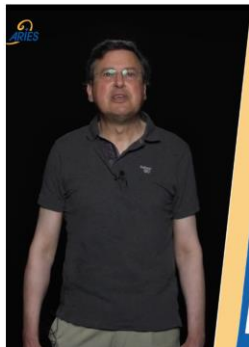
Angeles Faus-Golfe (CNRS)



APPLICATION OF ACCELERATORS

- Colliders for HEP
- **Material analysis**
- Health applications
- Industrial applications

Mike Seidel (PSI)




MEDICAL APPLICATIONS

Accelerators

<p>Radiotherapy for treating cancer</p> <ul style="list-style-type: none"> • Electrons: up to 20 MeV • Protons: up to 250 MeV • Light ions: up to 400 MeV/n <p>Around 50% of cancer patients in Europe receive radiotherapy</p>	<p>Production of radioisotopes for imaging and treatment</p> <ul style="list-style-type: none"> • Protons: up to 70 MeV, but mainly < 30 MeV • Light ions: few research <p>More than 1000 accelerators in regular use</p>
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Rob Edgecock
(U. of Huddersfield)



INDUSTRIAL APPLICATIONS

Electron Beams

<ul style="list-style-type: none"> • Sharp focussed • High power density 10^5-10^6 W/cm² • Low energy 20-150 keV • Vacuum processes 	<ul style="list-style-type: none"> • De-focussed or scanned • Low power density <math>10^4</math> W/cm² • High energy 0.08-10 MeV • Atmospheric processes
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Industrial Applications

Interaction of electrons with matter transfers energy

<p>Thermal</p> <p>Processing material using heating effects</p>	<p>Non-thermal</p> <p>Changing material properties using radiation chemistry</p>
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VARIOUS FIELDS OF INDUSTRIAL PROCESSES

Frank Holm Roegner
(Fraunhofer Institute)

Electron beam processing


- Electron accelerators are producing beams of energy from 80 keV up to 10 MeV.

OVER 2500 INDUSTRIAL ACCELERATORS ARE WORKING OVER THE WORLD

Dagmara Smietanko
(INCT, Warsaw)

RF for Accelerators


- <http://mooc.particle-accelerators.eu/radiofrequencies-for-particle-accelerators/>



Lorentz Force


- The Lorentz force is $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$.

Erk Jensen (CERN)




Typical RF system

LLRF



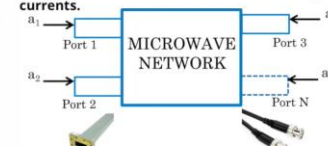
- A typical RF system contains
 - A low level RF (LLRF) system for amplitude and phase control
 - An RF amplifier to boost the LLRF signal

Graeme Burt (Lancaster)




S-PARAMETERS AND REFLECTIONS: INTRODUCTION

S \Rightarrow scattering.
high frequencies \Rightarrow waves rather than voltages or currents.




rf network: device accessible by N ports with incident (a) and reflected (b) waves

David Alesini (INFN)



RF Superconductivity: why ?

RF cavities: Depends on duty cycle



$J_{\text{surface}} = 1-100 \cdot 10^{10} \text{ A/m}^2$ (first 50 nm)

gain in plug power: 2 to 500 according to apps

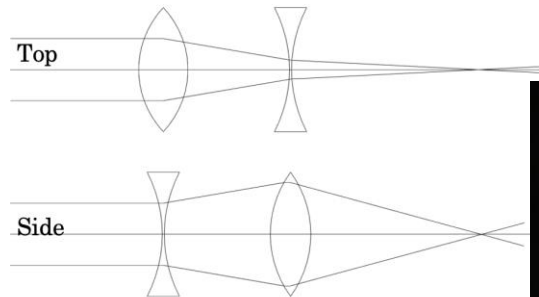
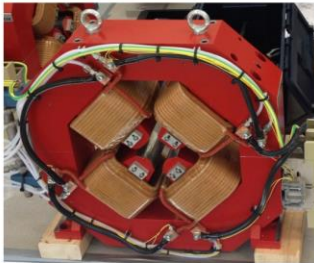
Claire Antoine (CEA)

Magnets

- Post processing in progress

Quadrupole magnets

Quadrupoles are magnets with 4 poles, 2 north and 2 south. They can be used to focus particle beams down to a sharp point, or make them diverge. They are vital for controlling the natural divergence of the beam.



Alex Bainbridge (STFC)

MOOC engineering

- Video recording:
 - Université Paris-Saclay
 - CERN Video studio
 - Other external contractor
- And because of the pandemics, some video were self recorded with the remote help of an engineer to check video and sound quality.
- The MOOC post-processing was done by Aurelie Rousseau and Hugues Cazin from Université Paris-Saclay

Administrative issues

- Large turnover of administrative staff in charge of the contract management delayed the project, especially procurement.
- Some colleagues had their travel expenditures reimbursement delayed by more than a year (I am very sorry for that).
- Due to new internal rules, most indirect costs (~60k€) were not available for the project and will only become available two years after the end of the project...

Define resources required...

- *Define resources required to launch, maintain and run the course on a sustainable basis*
- Cost of the MOOC so far:
 - ~30k€ for 5 hours => ~6k€/hours
 - Large variation of the cost depending on the lecture (travel, recording mode, post-processing,...)
- To *launch the MOOC* with 10 lectures would require 3-4 additional lectures at a total cost of 24k€ (well within indirect costs if they become available).
- Some coordination with the Nordic MOOC could give access to more lectures at very little cost.
- To *maintain and run the course* requires someone to operate a forum, answering question of the participants. Could probably be done on a part-time basis by a graduate student (cost 1-2k€/year).
- *Sustainable basis*: The MOOC will be sustainable if it is used by the community. JUAS is already using some lectures as pre-requisite.

Outlook

- The ARIES MOOC is available in test mode at <http://mooc.particle-accelerators.eu/>
- It is complementary to JUAS and CAS and universities Graduate training in accelerators.
- JUAS is already using some lectures as pre-requisite.
- Hopefully some lectures will be added once indirect costs are released (Magnets, Beam diagnostics, Beam dynamics,...).
- All lectures are released on Creative Commons license to make them freely available.
- This MOOC will be sustainable if it is used by the community. Is it useful to give some insight of accelerator physics to incoming graduate students or interns? To new staff joining the field? What need to be added? Language issues?
- Please try it and send me your feedback...



Thank you