



# Education Resources

Finnish Teacher Programme 2017



# Virtual Visits

[cern.ch/atlas-live-virtual-visit](http://cern.ch/atlas-live-virtual-visit)

[cms.web.cern.ch/content/virtual-visits](http://cms.web.cern.ch/content/virtual-visits)

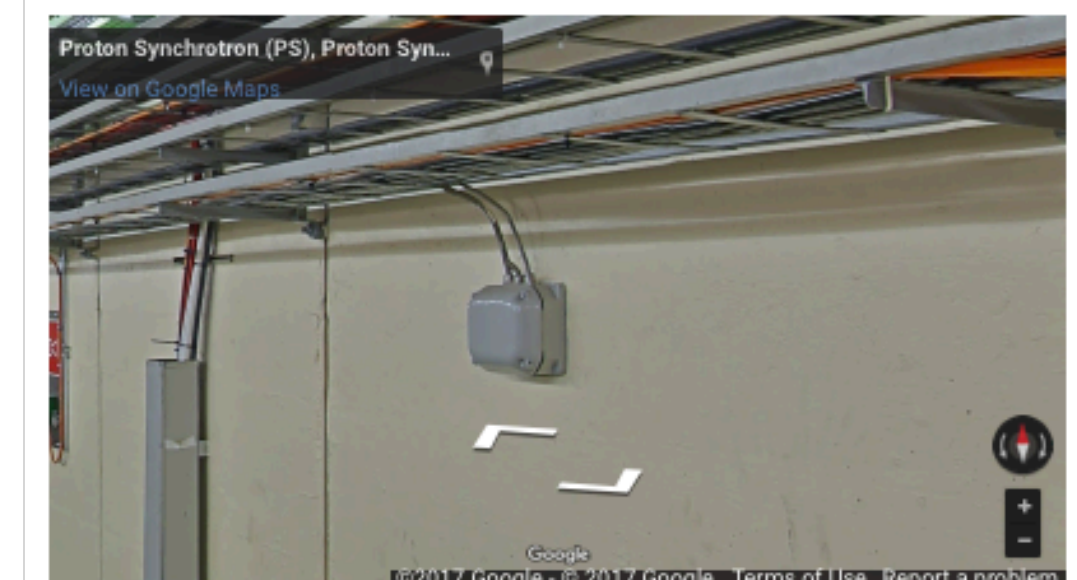
## Online Visits

Virtual visitors worldwide can now explore many CERN sites directly from Google Maps via Google Street View. From the CERN Meyrin campus, which sits astride the Franco-Swiss border near Geneva, to CERN's first synchrotron: the [Proton Synchrotron](#), users can now navigate their way around CERN directly from Google Maps.



Google Street Views are now available for many of CERN's sites above ground, including the Meyrin campus (Image: Google Street View)

CERN and Google began collaborating on this project in 2010. The first release of images was in 2013, with Google Street Views of the Large Hadron Collider tunnel as well as the underground caverns of the [ALICE](#), [ATLAS](#), [CMS](#) and [LHCb](#) experiments, accessible through a dedicated CERN part of Google Street View.

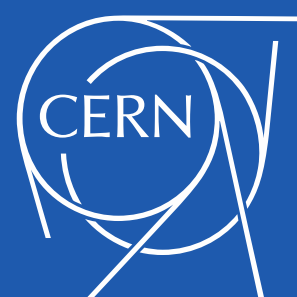


New to Google Street View, the [Proton Synchrotron](#) (Image: Google Street View)

"Google Maps Street View allow[s] anyone, anywhere in the world to take a peek into [CERN's] laboratories, control centers and its myriad underground tunnels housing cutting-edge experiments" said Pascale Millite, an operations lead at Google.

The new above-ground images, integrated into Google Maps, enable people to navigate the streets of CERN's Meyrin site, named after prominent physicists, view the different [points](#) around the 27-km Large Hadron Collider and peer inside the control rooms of the [experiments](#) and the [CERN Control Centre](#), as well as the [CERN Data Centre](#), which was the focus of an [online scavenger hunt](#) in 2013.

[visit.cern/tours/online-visits](http://visit.cern/tours/online-visits)





# Open Data

opendata  
1998

ABOUT SEARCH EDUCATION RESEARCH

## Education

Visualise events, check reconstructed data, run tools or build your own!

Start learning

## Research

Get the genuine working environments, virtual machines and datasets to start your research

Start analysing

[opendata.cern.ch/](http://opendata.cern.ch/)

International Particle Physics Outreach Group

## INTERNATIONAL MASTERCLASSES

hands on particle physics

Home  
Participate!  
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My Country  
Physics  
Local Organisation  
In the Media  
Teachers and Educators  
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### International Masterclasses

13<sup>th</sup> International Masterclasses 2017

Each year more than 13.000 high school students in 52 countries come to one of about 200 nearby universities or research centres for one day in order to unravel the mysteries of particle physics. Lectures from active scientists give insight in topics and methods of basic research at the fundamentals of matter and forces, enabling the students to perform measurements on real data from particle physics experiments themselves. At the end of each day, like in an international research collaboration, the participants join in a video conference for discussion and combination of their results. See [here](#) for media coverage.

International Masterclasses 2017 will take place from 1.3. - 11.4.2017.

#### Discover the world of Quarks and Leptons with real data

- get out of school for one day and come to a nearby university or research centre
- get insight into topics and methods of basic research at the fundamentals of matter and forces
- perform measurements on real data from particle physics experiments at CERN
- participate in an international video conference for discussion of results

#### International Masterclasses

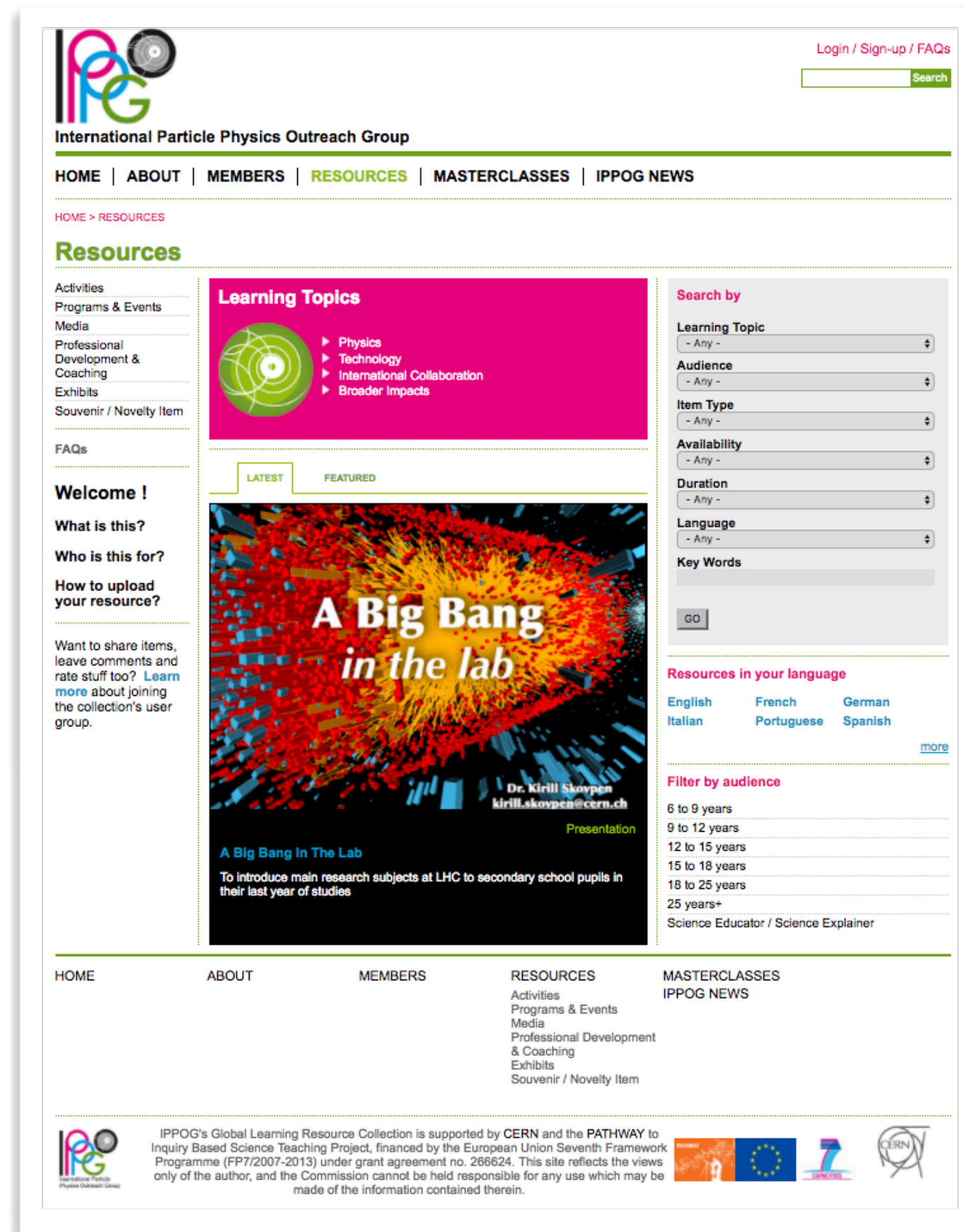
- provide an opportunity for 15- to 19-year old students to discover particle physics
- take place in more than 200 places in 52 countries with more than 13.000 participants worldwide
- are organized every year in March
- are organized at TU Dresden in the framework of the International Particle Physics Outreach Group (IPPOG)

TECHNISCHE UNIVERSITÄT DRESDEN QuarkNet Vidyo CERN

[physicsmasterclasses.org/](http://physicsmasterclasses.org/)

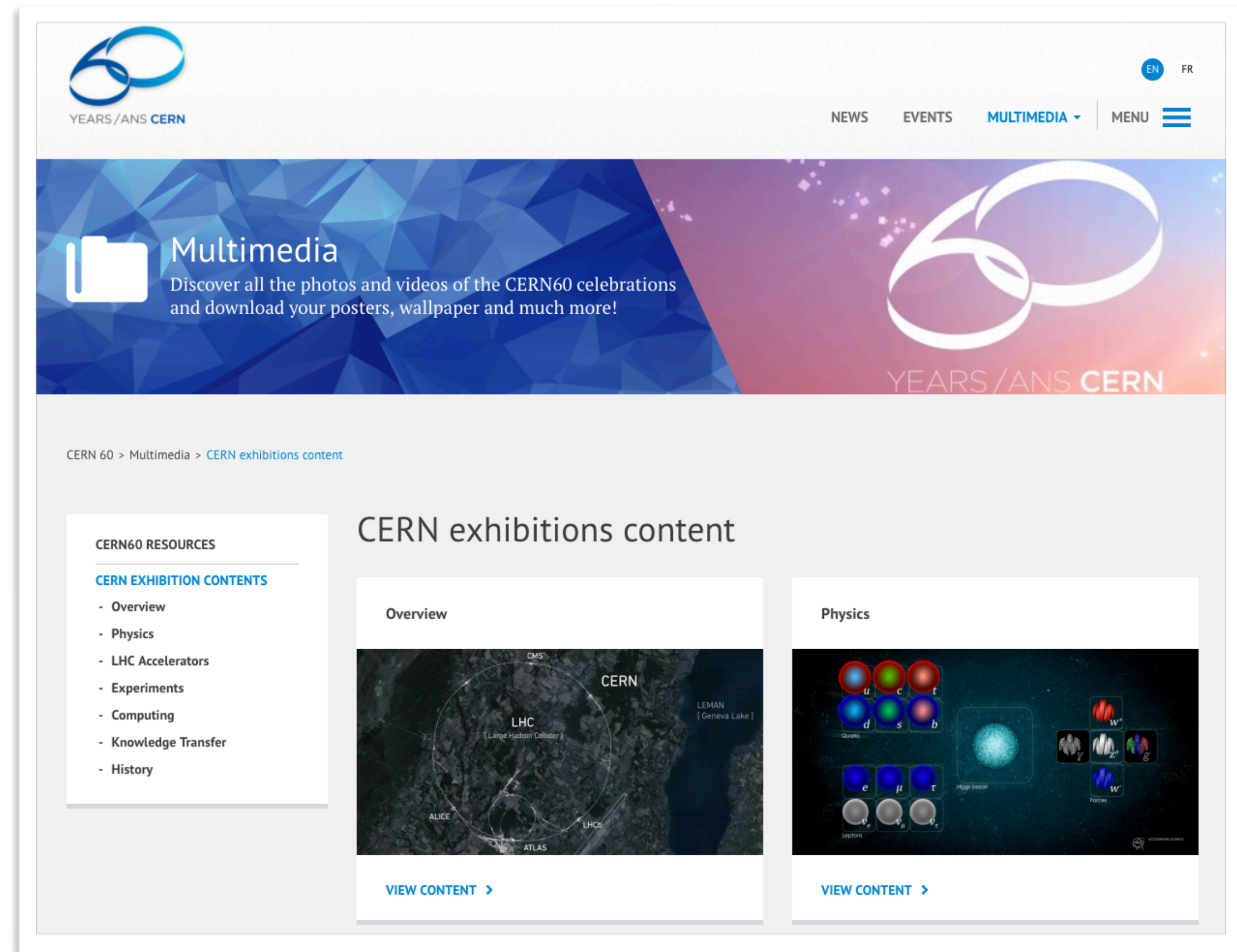


# Online resources



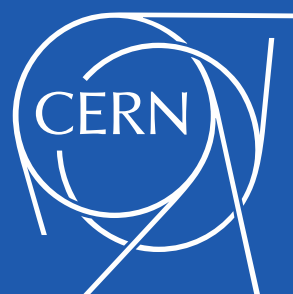
The screenshot shows the IPPOG Resources website. At the top left is the IPPOG logo. The navigation menu includes HOME, ABOUT, MEMBERS, RESOURCES, MASTERCLASSES, and IPPOG NEWS. A search bar is located at the top right. The main content area features a 'Resources' section with a 'Learning Topics' sidebar listing Physics, Technology, International Collaboration, and Broader Impacts. A featured resource titled 'A Big Bang in the lab' is highlighted, with a description: 'To introduce main research subjects at LHC to secondary school pupils in their last year of studies'. A 'Filter by audience' section lists age groups from 6 to 9 years to 25 years+, and a 'Resources in your language' section offers options for English, French, German, Italian, Portuguese, and Spanish.

[ippog.org/resources](http://ippog.org/resources)



The screenshot shows the CERN60 Multimedia website. The top navigation includes NEWS, EVENTS, MULTIMEDIA, and MENU. The main banner features the CERN logo and the text 'Multimedia Discover all the photos and videos of the CERN60 celebrations and download your posters, wallpaper and much more!'. Below the banner, the breadcrumb trail reads 'CERN 60 > Multimedia > CERN exhibitions content'. The main content area is titled 'CERN exhibitions content' and includes a 'CERN60 RESOURCES' sidebar with a list of categories: Overview, Physics, LHC Accelerators, Experiments, Computing, Knowledge Transfer, and History. Two featured content cards are visible: 'Overview' with a satellite image of the LHC and 'Physics' with a diagram of particle interactions. Both cards have a 'VIEW CONTENT >' button.

[cern60.web.cern.ch/en/cern-exhibitions-content](http://cern60.web.cern.ch/en/cern-exhibitions-content)





# Preselected resources

**OPEN ACCESS** **PAPERS**  
Phys. Educ. **51** (2016) 035001 (7pp) iopscience.org/ped

## Introducing the LHC in the classroom: an overview of education resources available

Gerfried J Wiener<sup>1,2</sup>, Julia Woithe<sup>1,3</sup>, Alexander Brown<sup>1,4</sup> and Konrad Jende<sup>1,5</sup>


<sup>1</sup> CERN, European Organization for Nuclear Research, Geneva, Switzerland  
<sup>2</sup> Austrian Educational Competence Centre Physics, University of Vienna, Austria  
<sup>3</sup> Department of Physics/Physics Education Group, University of Kaiserslautern, Germany  
<sup>4</sup> Institut Universitaire pour la Formation des Enseignants, University of Geneva, Switzerland  
<sup>5</sup> Institute of Nuclear and Particle Physics, TU Dresden, Germany

E-mail: [gerfried.wiener@cern.ch](mailto:gerfried.wiener@cern.ch), [julia.woithe@cern.ch](mailto:julia.woithe@cern.ch), [alexander.brown@cern.ch](mailto:alexander.brown@cern.ch) and [konrad.jende@cern.ch](mailto:konrad.jende@cern.ch)

**Abstract**  
In the context of the recent re-start of CERN's Large Hadron Collider (LHC) and the challenge presented by unidentified falling objects (UFOs), we seek to facilitate the introduction of high energy physics in the classroom. Therefore, this paper provides an overview of the LHC and its operation, highlighting existing education resources, and linking principal components of the LHC to topics in physics curricula.

**Introduction**  
Early in 2015, CERN's Large Hadron Collider (LHC) was awoken from its first long shutdown to be re-ramped for Run 2 at unprecedented beam energy and intensity. Intense scrutiny was required to verify the full and proper functioning of all systems. This included a special run of the machine to ensure a well-scrubbed LHC [1]. However, due to the increased beam currents, a critical but familiar issue reared its head during the run. Interactions between the beams and unidentified falling objects—so called UFOs—led to several premature protective beam dumps (see figure 1). These infamous UFOs are presumed to be micrometre-sized dust particles and can cause fast, localised beam losses with a duration on the order of 10 turns of the beam. This is a known issue of the LHC which has been observed before. Indeed, between 2010 and 2011, about a dozen beam dumps occurred due to UFOs and more than 10000 candidate UFO events below the dump threshold were detected [2]. Thus, UFOs presented more of an annoyance than a danger to the LHC, by reducing the operational efficiency of the machine. However, as beam currents increase, so does the likelihood of UFO-induced magnet quenches at high energy, creating a possible hazard to the machine. Therefore, particular care is taken to keep an eye on the timing and frequency of UFO occurrences. As the number of UFOs during Run 1 decreased over time, it is hoped that this will be the same in Run 2.

The recent re-start of the LHC at higher collision energies and rates presents high school

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[doi.org/10.1088/0031-9120/51/3/035001](https://doi.org/10.1088/0031-9120/51/3/035001)

**OPEN ACCESS** **PAPER**  
Phys. Educ. **52** (2017) 034001 (9pp) iopscience.org/ped

## Let's have a coffee with the Standard Model of particle physics!

Julia Woithe<sup>1,2</sup>, Gerfried J Wiener<sup>1,3</sup> and Frederik F Van der Veken<sup>1</sup>


<sup>1</sup> CERN, European Organization for Nuclear Research, Geneva, Switzerland  
<sup>2</sup> Department of Physics/Physics Education Group, University of Kaiserslautern, Germany  
<sup>3</sup> Austrian Educational Competence Centre Physics, University of Vienna, Austria

E-mail: [julia.woithe@cern.ch](mailto:julia.woithe@cern.ch), [jeff.wiener@cern.ch](mailto:jeff.wiener@cern.ch) and [frederik.van.der.veken@cern.ch](mailto:frederik.van.der.veken@cern.ch)

**Abstract**  
The Standard Model of particle physics is one of the most successful theories in physics and describes the fundamental interactions between elementary particles. It is encoded in a compact description, the so-called 'Lagrangian', which even fits on t-shirts and coffee mugs. This mathematical formulation, however, is complex and only rarely makes it into the physics classroom. Therefore, to support high school teachers in their challenging endeavour of introducing particle physics in the classroom, we provide a qualitative explanation of the terms of the Lagrangian and discuss their interpretation based on associated Feynman diagrams.

**1. Introduction**  
The Standard Model of particle physics is the most important achievement of high energy physics to date. This highly elegant theory sorts elementary particles according to their respective charges and describes how they interact through fundamental interactions. In this context, a charge is a property of an elementary particle that defines the fundamental interaction by which it is influenced. We then say that the corresponding interaction particle 'couples' to a certain charge. For example, gluons, the interaction particles of the strong interaction, couple to colour-charged particles. Of the four fundamental interactions in nature, all except gravity are described by the Standard Model of particle physics: particles with an electric charge are influenced by the electromagnetic interaction (quantum electrodynamics, or QED for short), particles with a weak charge are influenced by the weak interaction (quantum flavour dynamics or QFD), and those with a colour charge are influenced by the strong interaction (quantum chromodynamics or QCD). Contrary to the fundamental interactions, the Brout-Englert-Higgs (BEH) field acts in a special way. Because it is a scalar field, it induces spontaneous symmetry-breaking, which in turn gives mass to all particles with which it interacts (this is commonly called the Higgs mechanism). In addition, the Higgs particle (H) couples to any other particle which has mass (including itself).

Interactions are mediated by their respective interaction particles: photons ( $\gamma$ ) for the

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[doi.org/10.1088/1361-6552/aa5b25](https://doi.org/10.1088/1361-6552/aa5b25)

**OPEN ACCESS** **PAPER**  
Phys. Educ. **52** (2017) 044001 (8pp) iopscience.org/ped

## Introducing 12 year-olds to elementary particles

Gerfried J Wiener<sup>1,2</sup>, Sascha M Schmeling<sup>1</sup> and Martin Hopf<sup>2</sup>

<sup>1</sup> CERN, European Organization for Nuclear Research, Geneva, Switzerland  
<sup>2</sup> University of Vienna, Austrian Educational Competence Centre Physics, Vienna, Austria

E-mail: [jeff.wiener@cern.ch](mailto:jeff.wiener@cern.ch), [sascha.schmeling@cern.ch](mailto:sascha.schmeling@cern.ch) and [martin.hopf@univie.ac.at](mailto:martin.hopf@univie.ac.at)

**Abstract**  
We present a new learning unit, which introduces 12 year-olds to the subatomic structure of matter. The learning unit was iteratively developed as a design-based research project using the technique of probing acceptance. We give a brief overview of the unit's final version, discuss its key ideas and main concepts, and conclude by highlighting the main implications of our research, which we consider to be most promising for use in the physics classroom.

**1. Introduction**  
Integrating modern physics into the curriculum is a question that has recently received ever increasing attention. This is especially true since in most countries the topic of modern physics is usually added at the end of physics education—if at all [1]. However, since these chapters—and here especially the Standard Model of particle physics—are considered to be the fundamental basics of physics, this situation might hinder the development of coherent knowledge structures in the physics classroom. Hence, one is faced with the question of whether it makes sense to introduce elementary particle physics early in physics education. Therefore, to investigate this research question, we have developed a learning unit, which aims to introduce 12 year-olds to elementary particles and fundamental interactions [2].

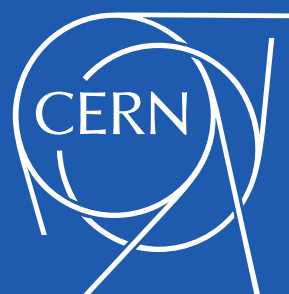
The learning unit consists of two consecutive chapters. It starts with an accurate description of the subatomic structure of matter by showcasing an atomic model from electrons to quarks. This first chapter is followed by the introduction of fundamental interactions, which on the one hand complete the discussion of the atomic model, and on the other hand set up possible links to other physics phenomena. An integral component of the learning unit is its independence from the physics curriculum and students' prior knowledge about particle physics. Indeed, since every physics process can be traced back to fundamental interactions between elementary particles, the use of the learning unit is not restricted to a certain age-group. Ideally, it can even be used at the beginning of physics education to enable an early introduction of key terms and principal concepts of particle physics in the classroom.

Following the framework of constructivism [3], the initial version of the learning unit was based on documented students' conceptions. Taking these into account enabled us to avoid potential difficulties for students, which might occur due to inadequate information input. As a next step, the initial version was developed by means of a design-based research [4] project with frequent adaptations of the learning unit. Here, we used the technique of probing acceptance [5] to conduct one-on-one interviews with 12 year-olds

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[doi.org/10.1088/1361-6552/aa6cfe](https://doi.org/10.1088/1361-6552/aa6cfe)





# @ CERN

**S'Cool LAB**

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## Welcome to S'Cool LAB

**What is S'Cool LAB?**

S'Cool LAB is a new **Physics Education Research** facility at **CERN**, the European Organization for Nuclear Research in Geneva, Switzerland. High school students and their teachers are invited to contribute to our research projects by taking part in hands-on & minds-on particle physics experiments on-site at CERN. Participating in S'Cool LAB research enables teachers to give their students a glimpse of life and work in a world-leading international research institute. By getting hands-on with physics in S'Cool LAB, students can make discoveries independently, learn to work scientifically and apply their knowledge in a new setting. Students also have the chance to engage directly with members of CERN's scientific community.

high school students → **Physics Education Research** (hands-on & minds-on particle physics experiments) ← high school teachers

Our **research interests** include students' conceptions in particle physics, the impact of out-of-school learning on students' motivation, the use of online learning for preparing field trips, teachers' motivations for field trips, and low-cost experiments for classrooms. Details of our research findings to date are available on our [publications page](#).

[cern.ch/scool-lab](http://cern.ch/scool-lab)

**beamline for schools** **A Beamline for Schools**

The competition Everything about BL4S 2018 Resources Prizes Editions Winners Supporters

## Everything about BL4S 2018

**Beamline for Schools Competition 2018 will be soon announced!**

Everything about it can be found in the pages below:

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[Useful Documents](#)

[Contacts](#)

[Prizes](#)

[FAQs](#)

[How to apply](#) \*Pre-registration will start soon. Stay tuned!

*\*Some of the useful documents on this website are not yet up to date. We will update them as soon as possible.*

[Home](#)

[cern.ch/BL4S](http://cern.ch/BL4S)

**High-School Students Internship Programme**

Home National Programmes FAQ Contact

## “There is nothing more enriching and gratifying than learning.” [Fabiola Gianotti, CERN Director-General]

**Are you a young and motivated high-school student? Did you ever want to know how fundamental research works? Did you ever want to get an insight into an international organization?**

In a close collaboration with its member states, CERN invites high-school students (aged 16-19) to come to CERN for two weeks, to gain practical experience in science, technology, and innovation. It focuses on giving students the chance to discover STEM in the CERN context and environment, strengthening their understanding of science, and developing their skills in a high-tech environment.

This programme is a unique opportunity for high-school students to be introduced to CERN, its technologies and physics, as well as to learn through workshops and by shadowing, observing, and working with a member of personnel.

[National Programmes](#)

CONNECT WITH CERN

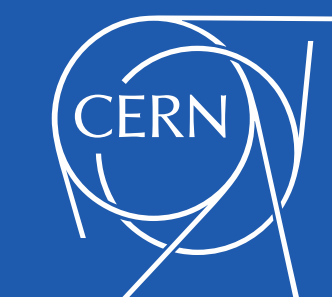
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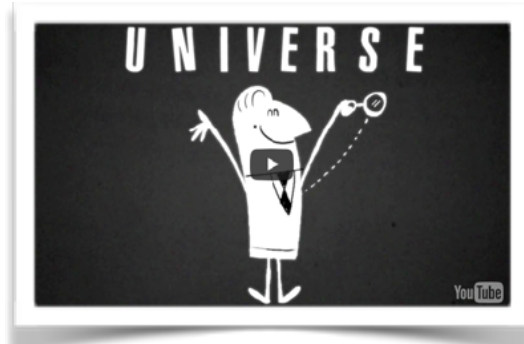
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# TEDEd



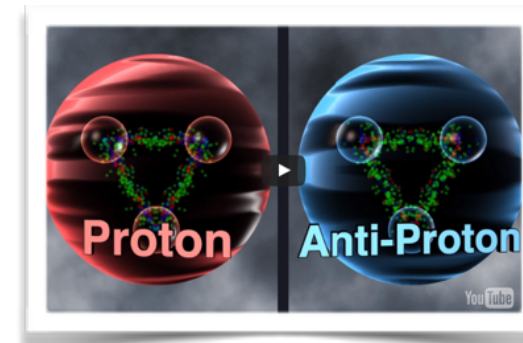
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[ed.ted.com/lessons/what-happened-to-antimatter-rolf-landua](https://ed.ted.com/lessons/what-happened-to-antimatter-rolf-landua)




[ed.ted.com/lessons/the-basics-of-boson-dave-barney-and-steve-goldfarb](https://ed.ted.com/lessons/the-basics-of-boson-dave-barney-and-steve-goldfarb)



# Links

The logo for the Institute of Physics (IOP) features the letters 'IOP' in a bold, red, sans-serif font, followed by the words 'Institute of Physics' in a black, sans-serif font, all contained within a white rectangular box with a thin black border.

Resources for the classroom  
[iop.org/education/teacher/resources](http://iop.org/education/teacher/resources)

The logo for 'The Particle Adventure' has a dark blue background. The words 'THE PARTICLE ADVENTURE' are written in a light blue, stylized, sans-serif font. Below this, the subtitle 'THE FUNDAMENTALS OF MATTER AND FORCE' is written in a smaller, white, sans-serif font.

The particle adventure  
[particleadventure.org](http://particleadventure.org)

The logo for 'Interactions.org' features a stylized particle detector symbol on the left, consisting of a vertical line with several radiating lines. To the right, the text 'INTERACTIONS.ORG' is in a bold, black, sans-serif font, with 'PARTICLE PHYSICS NEWS AND RESOURCES' in a smaller, black, sans-serif font below it.

Particle physics news and resources  
[interactions.org](http://interactions.org)

The logo for 'The Feynman' lectures features the words 'The Feynman' in a white, cursive script font, set against a solid red rectangular background.

The Feynman lectures  
[feynmanlectures.info](http://feynmanlectures.info)



VEGA science videos  
[vega.org.uk](http://vega.org.uk)



Merci bien!  
Questions?

[jeff.wiener@cern.ch](mailto:jeff.wiener@cern.ch)

33/R-010 | +41 75 411 9010

