

Education Resources

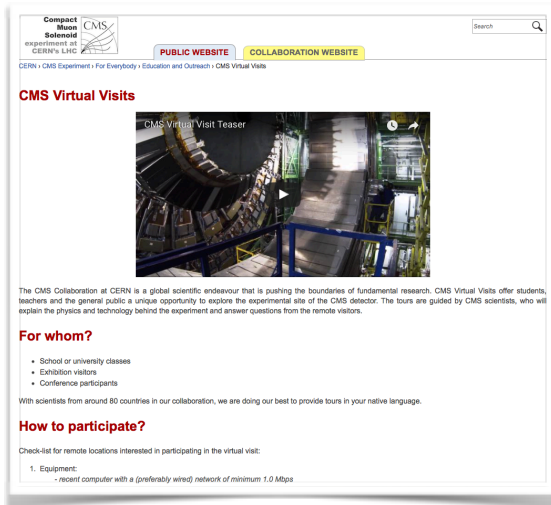
Bulgarian Teacher Programme 2018

Virtual Visits

Virtual Visits



cern.ch/atlas-live-virtual-visit



cms.web.cern.ch/content/virtual-visits

Virtual Visits

ATLAS VIRTUAL VISITS

The ATLAS Experiment at CERN is one of the largest most complex scientific instruments ever constructed. It is designed to explore the inner workings, pioneering our understanding of the basic building blocks and fundamental forces of nature.

Five thousand physicists from about 160 institutions in 36 countries around the world participate in ATLAS. When the LHC is in operation, up to 800 million protons collide every second inside the detector. ATLAS Virtual Visits gives the public a unique opportunity to be part of this great scientific adventure.

Using web-based video conferencing tools, participants talk with an ATLAS physicist, receive a tour of the control room, and get answers to their questions.

Next Events

June 8

Knowledge Explorers - Brazil

ATLAS Experiment
Discover one of the world's greatest scientific adventures

Future Events
A list of upcoming Virtual Visits

Past Events
Some recordings from past Virtual Visits

Book Your Visit
How to organise your own Virtual Visit

About ATLAS
Some images to prepare your visit

Visit CERN
Come see the world's largest particle physics laboratory

Contacts and booking

Find ATLAS on: [Facebook icon] [Twitter icon] [YouTube icon] [Instagram icon]

Best Online Chat: [ATLAS Virtual Visits logo]

cern.ch/atlas-live-virtual-visit

Compact Muon Solenoid
EXPERIMENT AT CERN'S LHC

PUBLIC WEBSITE **COLLABORATION WEBSITE**

CERN - CMS Experiment - For Everybody - Education and Outreach - CMS Virtual Visits

CMS Virtual Visits

CMS Virtual Visit Teaser

The CMS Collaboration at CERN is a global scientific endeavour that is pushing the boundaries of fundamental research. CMS Virtual Visits offer students, teachers and the general public a unique opportunity to explore the experimental site of the CMS detector. The tours are guided by CMS scientists, who will explain the physics and technology behind the experiment and answer questions from the remote visitors.

For whom?

- School or university classes
- Exhibition visitors
- Conference participants

With scientists from around 80 countries in our collaboration, we are doing our best to provide tours in your native language.

How to participate?

Check-list for remote locations interested in participating in the virtual visit:

1. Equipment:
 - recent computer with a (preferably wired) network of minimum 1.0 Mbps

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.

Meyrin, Geneva
View on Google

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 View 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.

Proton Synchrotron (PS), Proton Synchrotron
View on Google

New to Google Street View, the **Proton Synchrotron** (Image: Google Street View)

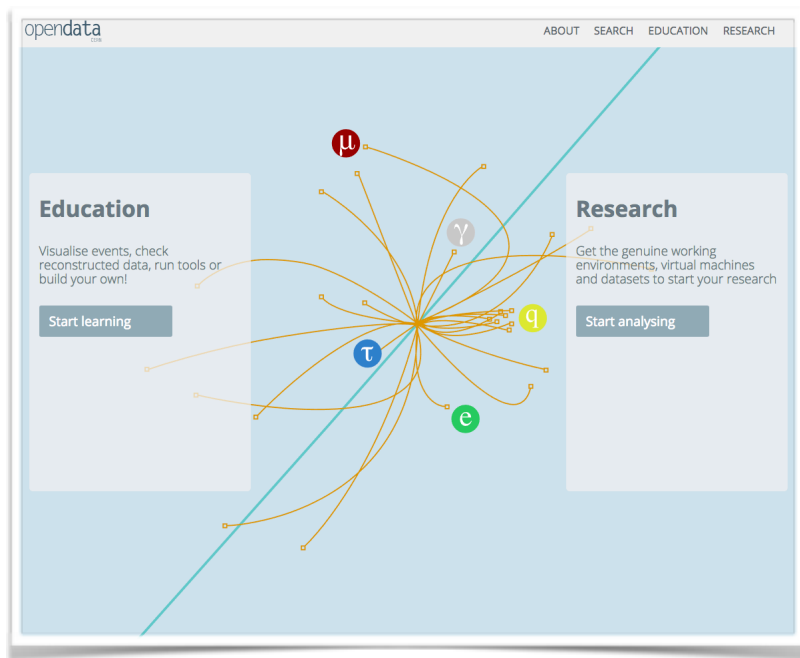
"Google Maps Street View allow[s] anyone, anywhere in the world to take a peek into [CERN's] laboratories, control centers and its myriad underground tunnels housing cutting-edge experiments" said Pascale Millie, an operations lead at Google.

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 2015.

visit.cern/tours/online-visits

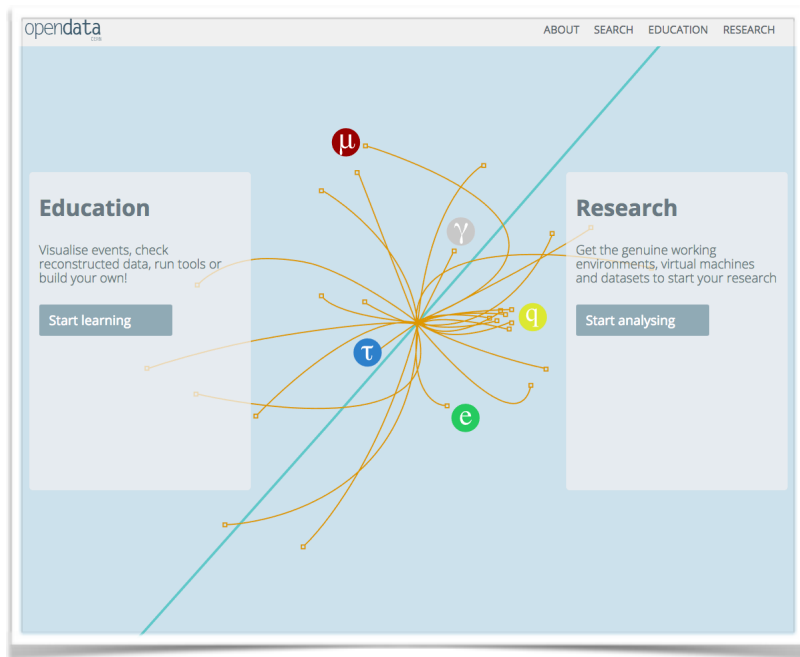
Open Data

Open Data



opendata.cern.ch

Open Data

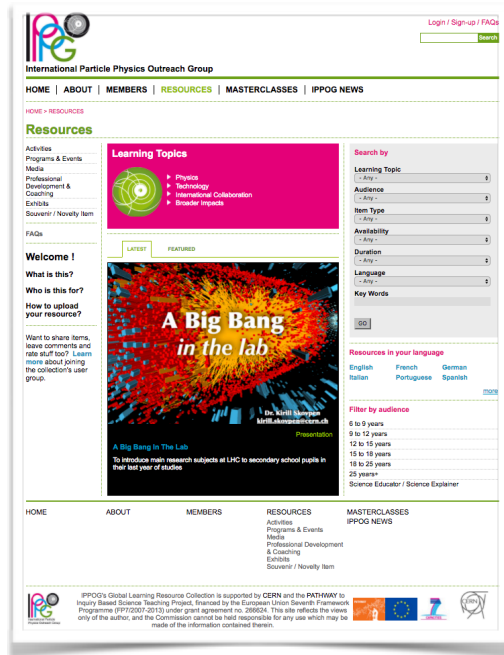


opendata.cern.ch

physicsmasterclasses.org

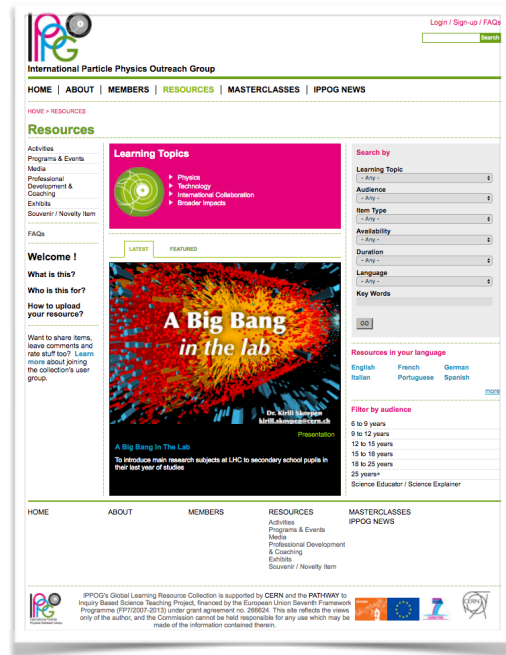
Online Resources

Online Resources



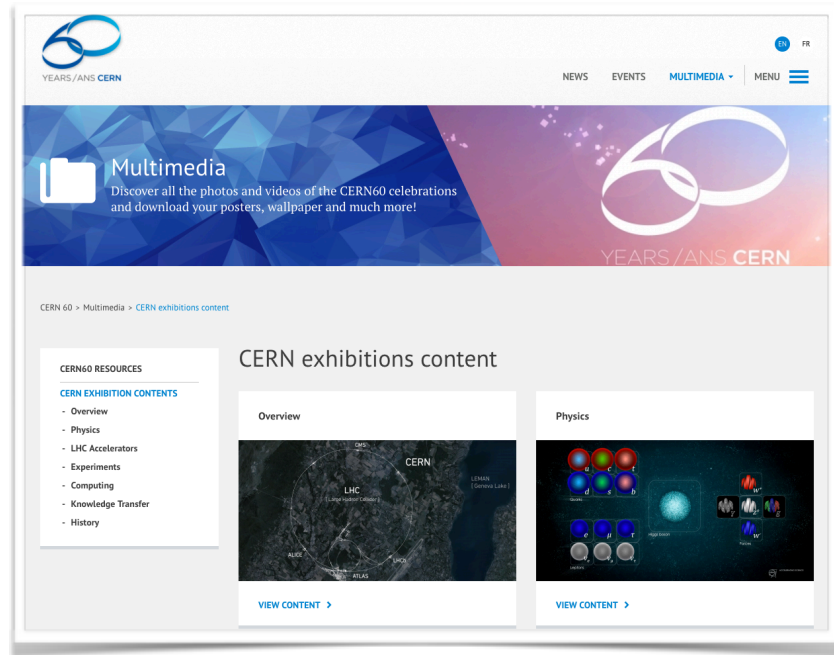
ippog.org/resources

Online Resources



The screenshot shows the IPPOG (International Particle Physics Outreach Group) Resources page. The header includes the IPPOG logo and navigation links: HOME, ABOUT, MEMBERS, RESOURCES, MASTERCLASSES, and IPPOG NEWS. A 'Resources' sidebar on the left lists categories like Activities, Programs & Events, Media, Professional Development & Coaching, Exhibits, and Souvenir / Novelty Item. The main content area features a 'Learning Topics' section with a 'Big Bang in the Lab' image and a 'Search by' filter with dropdowns for Learning Topic, Audience, Item Type, Availability, Duration, Language, and Key Words. A 'Resources in your language' section offers filters for English, French, German, Italian, Portuguese, and Spanish. The footer contains a disclaimer about the IPPOG Global Learning Resource Collection and logos for CERN and the European Union.

ippog.org/resources

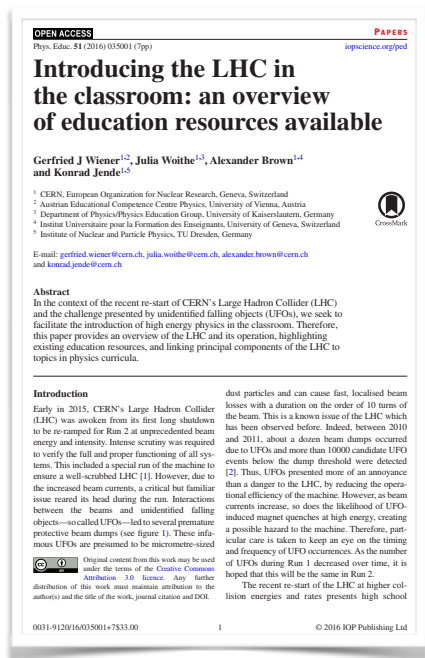


The screenshot shows the CERN60 Multimedia website. The header includes the CERN60 logo and navigation links: NEWS, EVENTS, MULTIMEDIA, and MENU. A large banner at the top reads 'Multimedia Discover all the photos and videos of the CERN60 celebrations and download your posters, wallpaper and much more!'. Below the banner, a section titled 'CERN60 RESOURCES' lists 'CERN EXHIBITION CONTENTS' with a list of links: Overview, Physics, LHC Accelerators, Experiments, Computing, Knowledge Transfer, and History. The 'Overview' section features a map of the LHC and CERN sites, and the 'Physics' section features a diagram of particle interactions. Both sections have a 'VIEW CONTENT' link.

cern60.web.cern.ch/en/cern-exhibitions-content

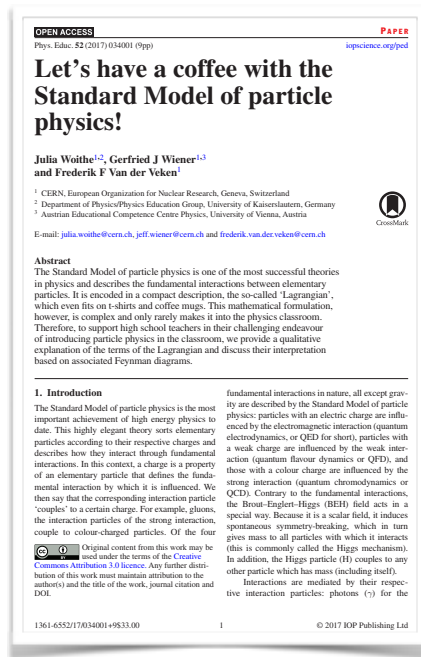
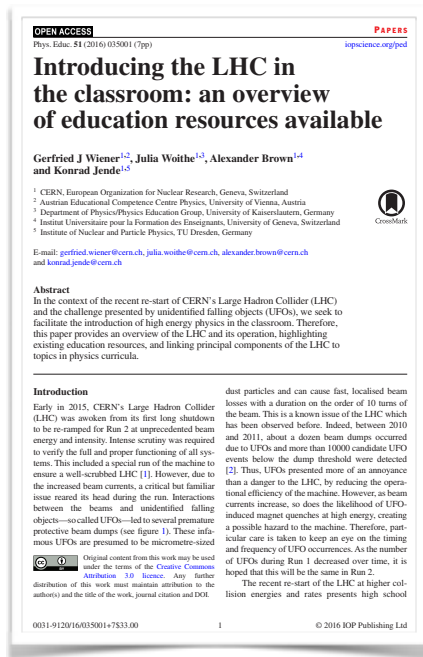
Preselected Resources

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

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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-scribed 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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PAPER
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Let's have a coffee with the Standard Model of particle physics!

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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 Broat-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 (γ) for the

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PAPER
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Introducing 12 year-olds to elementary particles

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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 (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 (γ) for the

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.

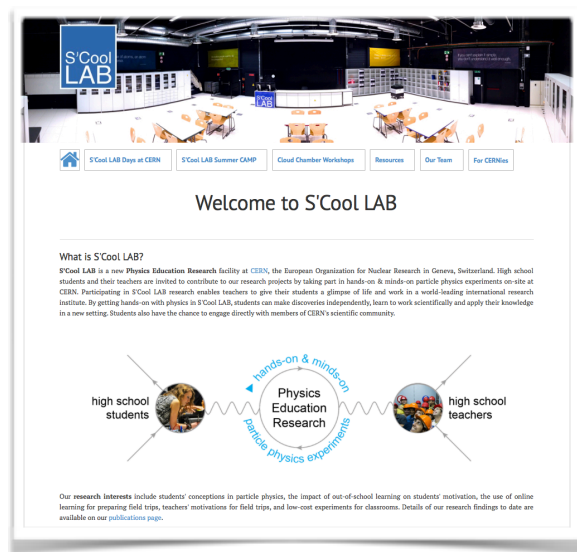
Following the framework of constructivism [3], the initial version of the learning unit was based on documented students' conceptions. Taking these into account enabled us to avoid potential difficulties for students, which might occur due to inadequate information input. As a next step, the initial 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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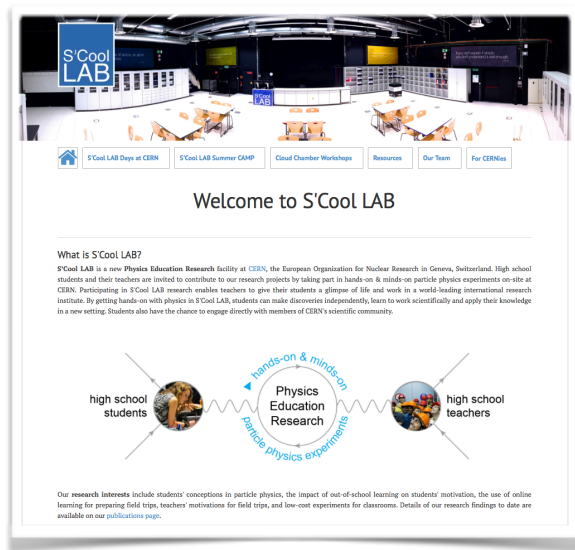
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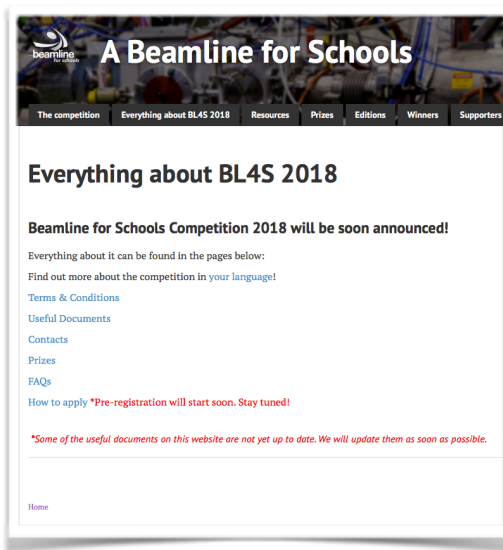
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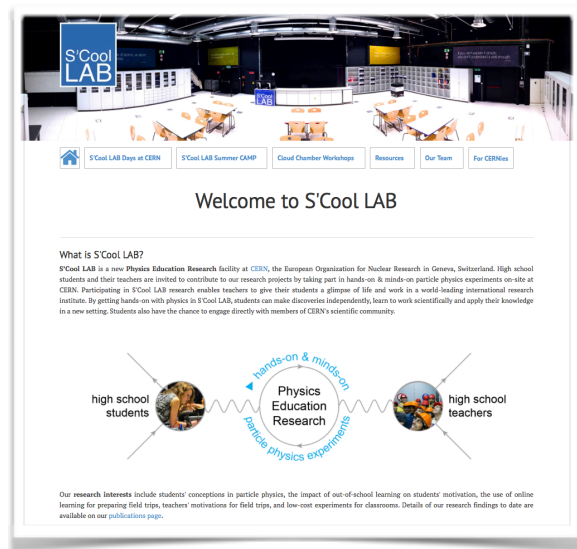
cern.ch/scool-lab



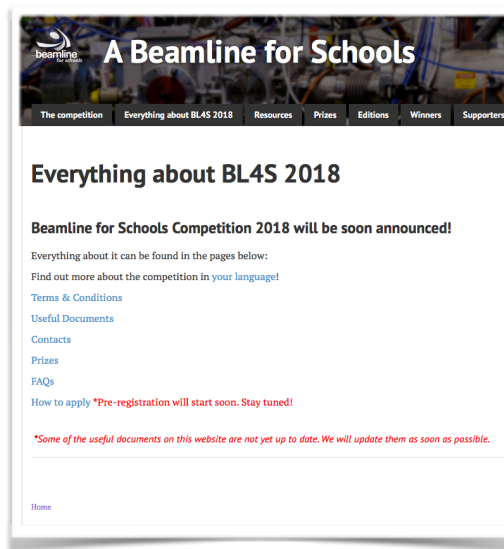
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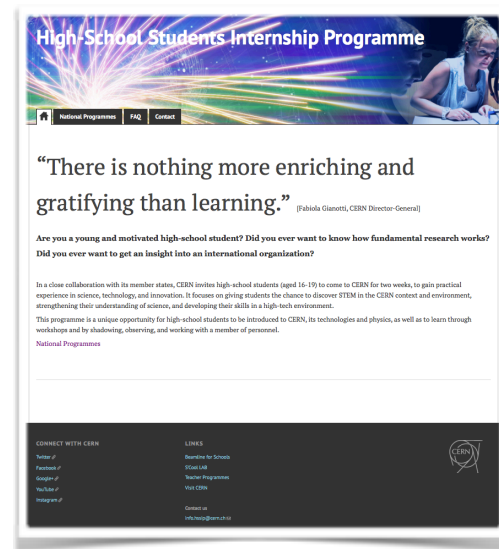
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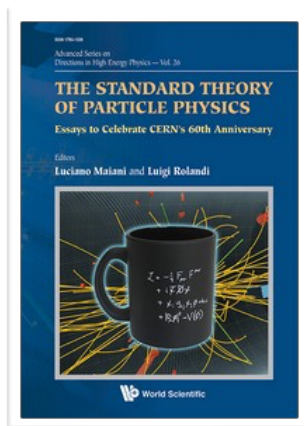


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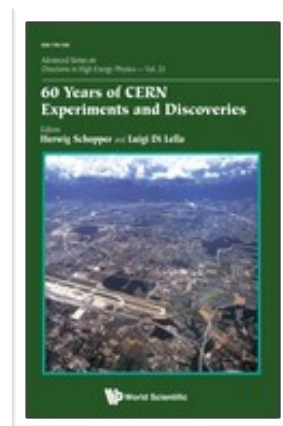
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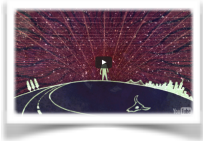
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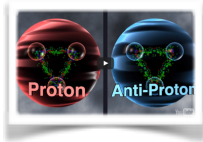
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Links

IOP Institute of Physics

Resources for the classroom
iop.org/education/teacher/resources

THE PARTICLE ADVENTURE
THE FUNDAMENTALS OF MATTER AND FORCE

The particle adventure
particleadventure.org

 **INTERACTIONS.ORG**
PARTICLE PHYSICS NEWS AND RESOURCES

Particle physics news and resources
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The Feynman

The Feynman lectures
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Merci bien!

Questions?

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