CERN – a short and sweet introduction

Jeff Wiener

14. Juni 2021

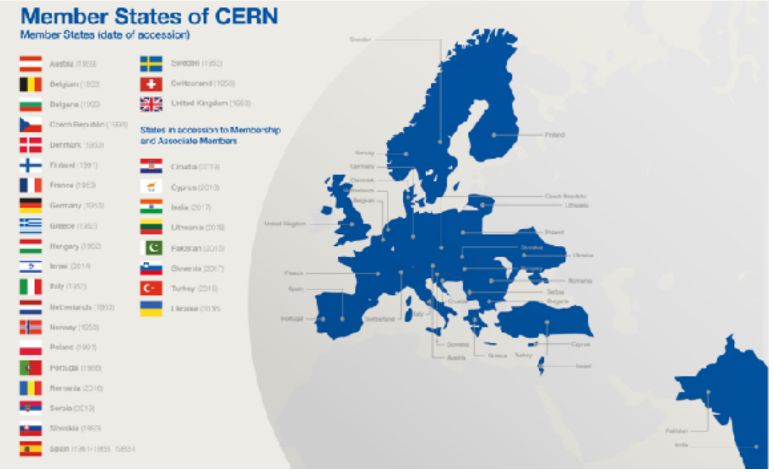
Conseil Européen pour la Recherche Nucléaire

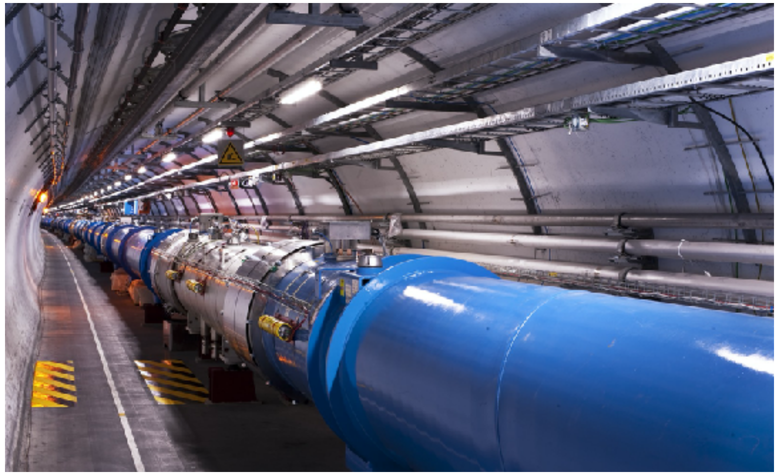
International Collaboration

Education

Fundamental Research

New Technology





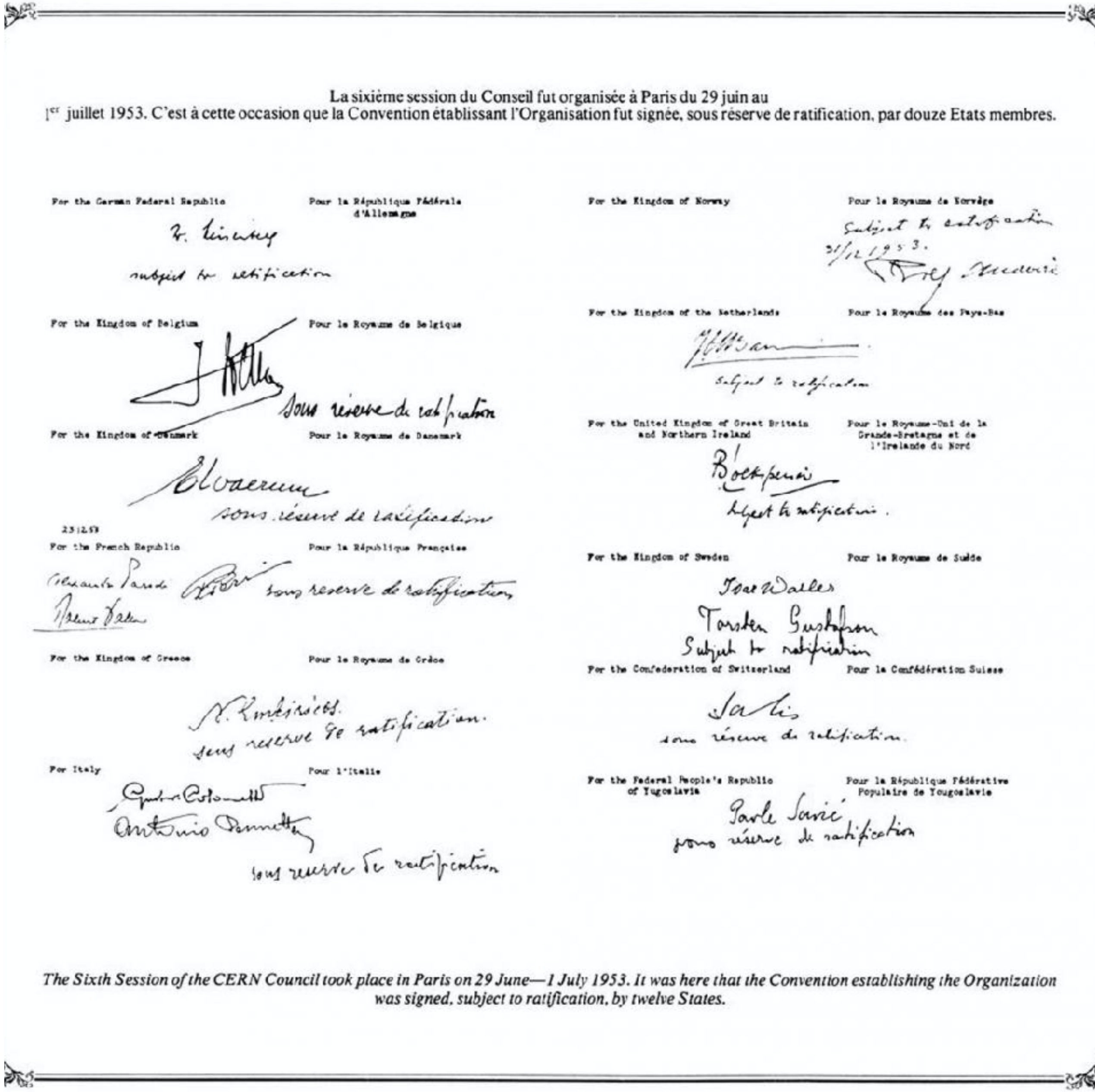
History

1949
First steps towards civilian research in the field of nuclear technology

1952
Foundation of CERN under the auspices of UNESCO in Geneva

1953
Signing of the CERN charta

1954
Completion of the ratification process of the 12 Member States



La sixième session du Conseil fut organisée à Paris du 29 juin au 1er juillet 1953. C'est à cette occasion que la Convention établissant l'Organisation fut signée, sous réserve de ratification, par douze Etats membres.

For the German Federal Republic	Pour la République Fédérale d'Allemagne	For the Kingdom of Norway	Pour le Royaume de Norvège
For the Kingdom of Belgium	Pour le Royaume de Belgique	For the Kingdom of the Netherlands	Pour le Royaume des Pays-Bas
For the Kingdom of Denmark	Pour le Royaume de Danemark	For the United Kingdom of Great Britain and Northern Ireland	Pour le Royaume-Uni de la Grande-Bretagne et de l'Irlande du Nord
For the French Republic	Pour la République Française	For the Kingdom of Sweden	Pour le Royaume de Suède
For the Kingdom of Greece	Pour le Royaume de Grèce	For the Confederation of Switzerland	Pour la Confédération Suisse
For Italy	Pour l'Italie	For the Federal People's Republic of Yugoslavia	Pour la République Fédérative Populaire de Yougoslavie

The Sixth Session of the CERN Council took place in Paris on 29 June—1 July 1953. It was here that the Convention establishing the Organization was signed, subject to ratification, by twelve States.

Member States of CERN

Member States (date of accession)

- Austria (1959)
- Belgium (1953)
- Bulgaria (1999)
- Czech Republic (1993)
- Denmark (1953)
- Finland (1991)
- France (1953)
- Germany (1953)
- Greece (1953)
- Hungary (1992)
- Israel (2014)
- Italy (1953)
- Netherlands (1953)
- Norway (1953)
- Poland (1991)
- Portugal (1986)
- Romania (2016)
- Serbia (2019)
- Slovakia (1993)
- Spain (1961-1968, 1983-)
- Sweden (1953)
- Switzerland (1953)
- United Kingdom (1953)

States in accession to Membership and Associate Members

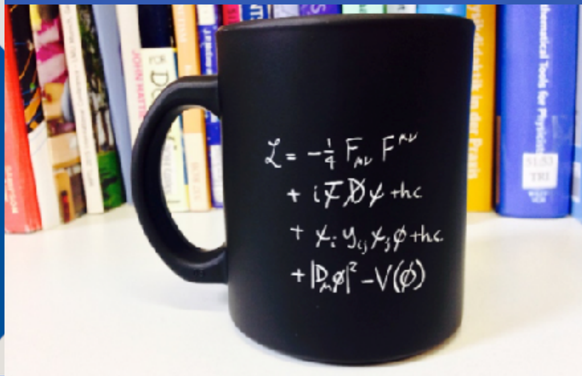
- Croatia (2019)
- Cyprus (2016)
- Estonia (2021)
- India (2017)
- Lithuania (2018)
- Pakistan (2015)
- Slovenia (2017)
- Turkey (2015)
- Ukraine (2016)

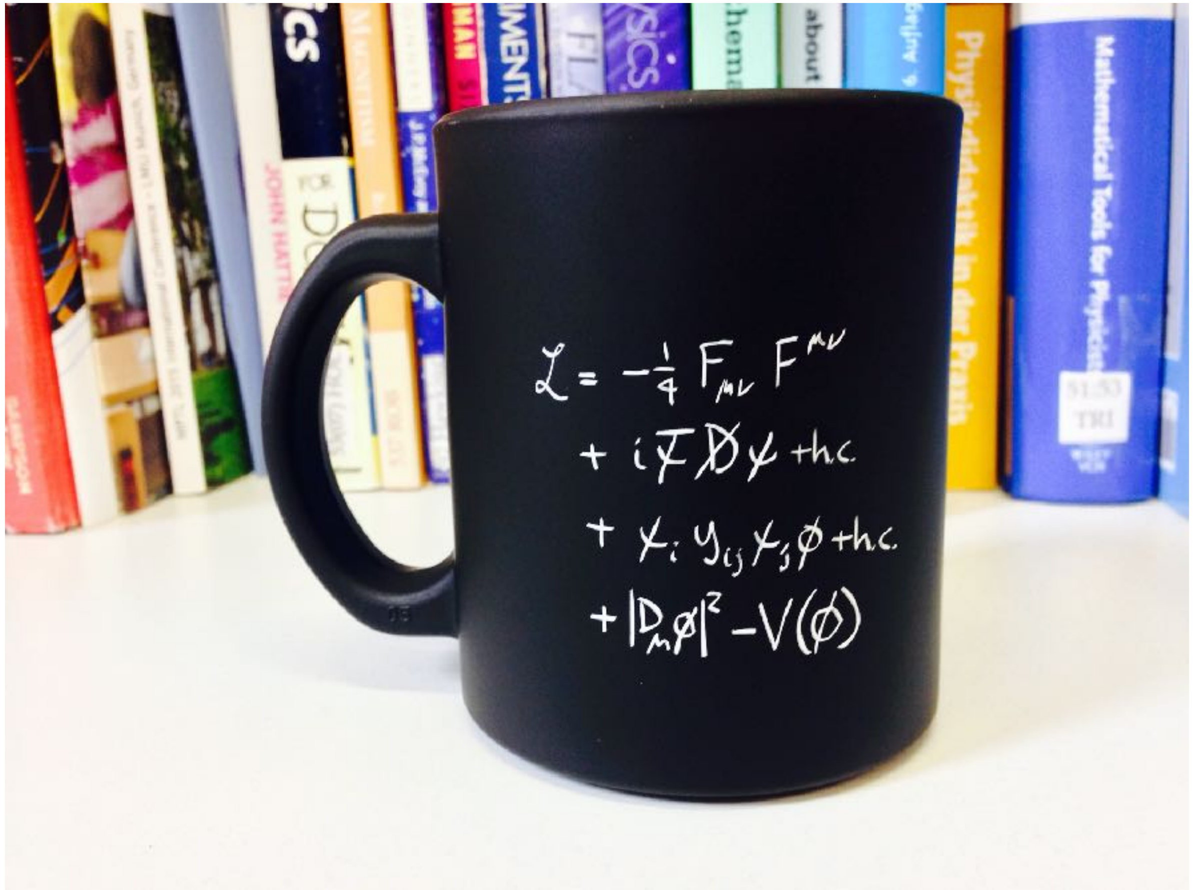
CERN Today

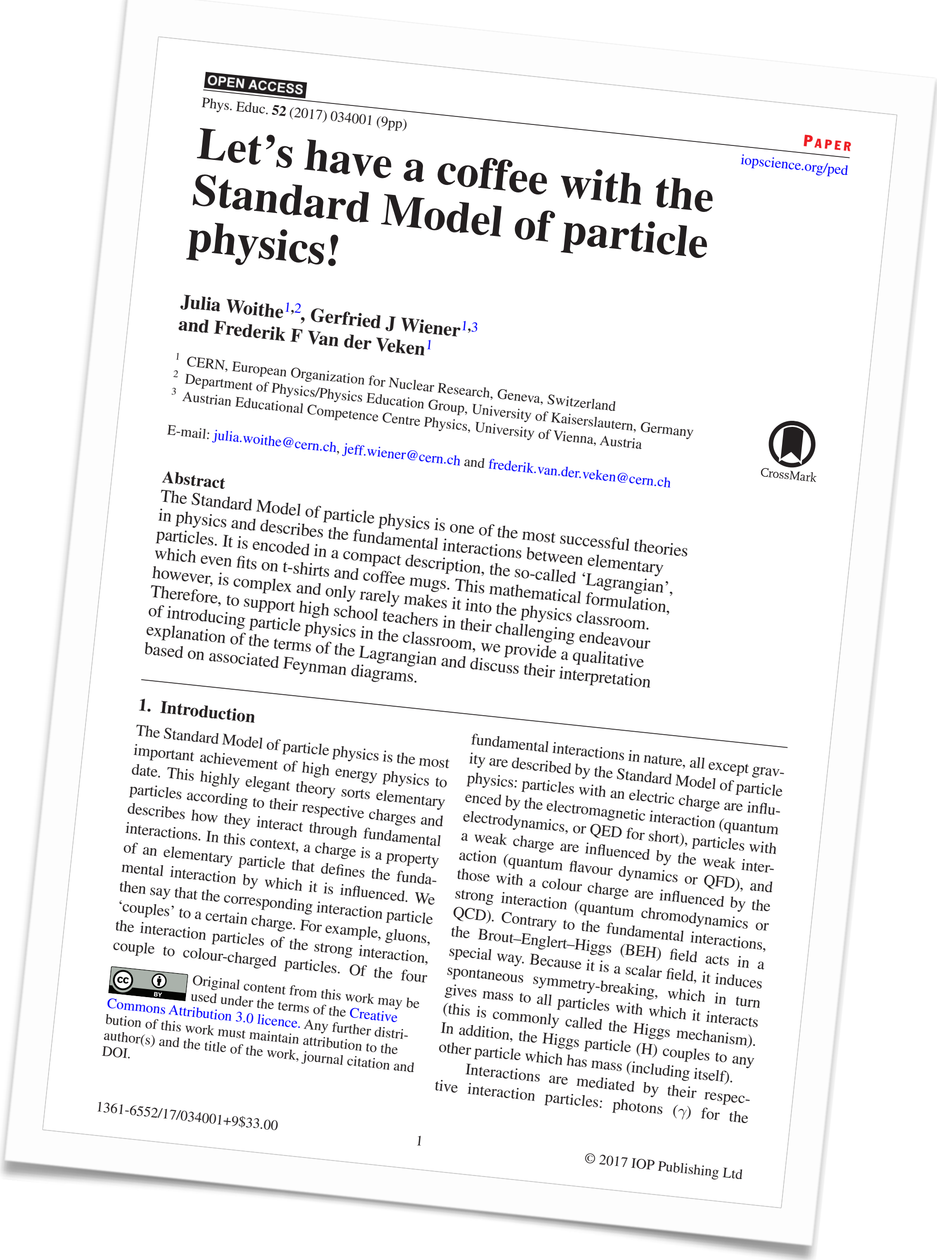
23 Member States

9 Associate Member States

Annual budget
1.2 billion CHF
1.1 billion EUR
1.3 billion USD







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PAPER

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

Julia Woithe[1,2], Gerfried J Wiener[1,3] and Frederik F Van der Veken[1]

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

E-mail: julia.woithe@cern.ch, jeff.wiener@cern.ch and frederik.van.der.veken@cern.ch

CrossMark

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 (γ) for the

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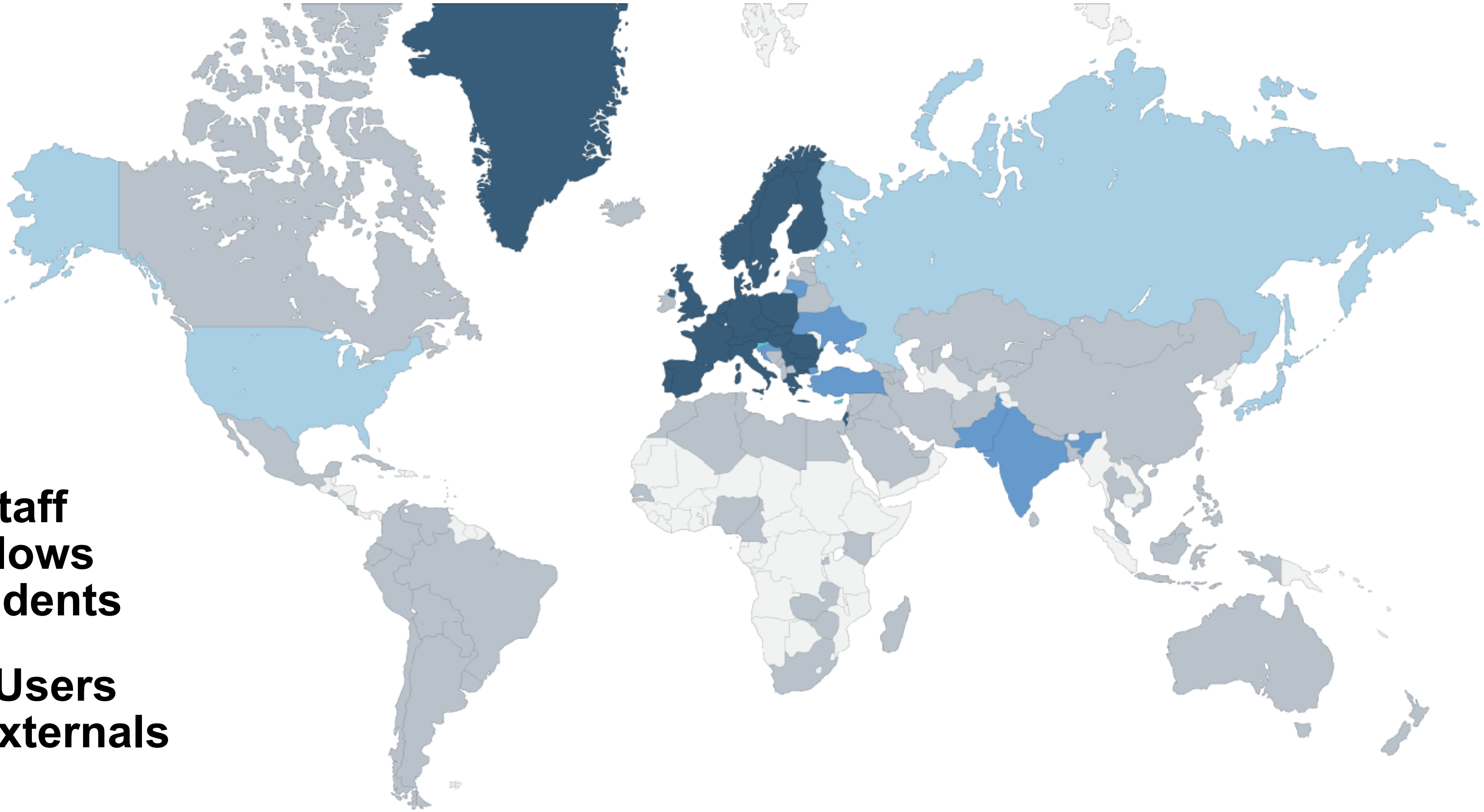
More than 20,000 scientists from around the world



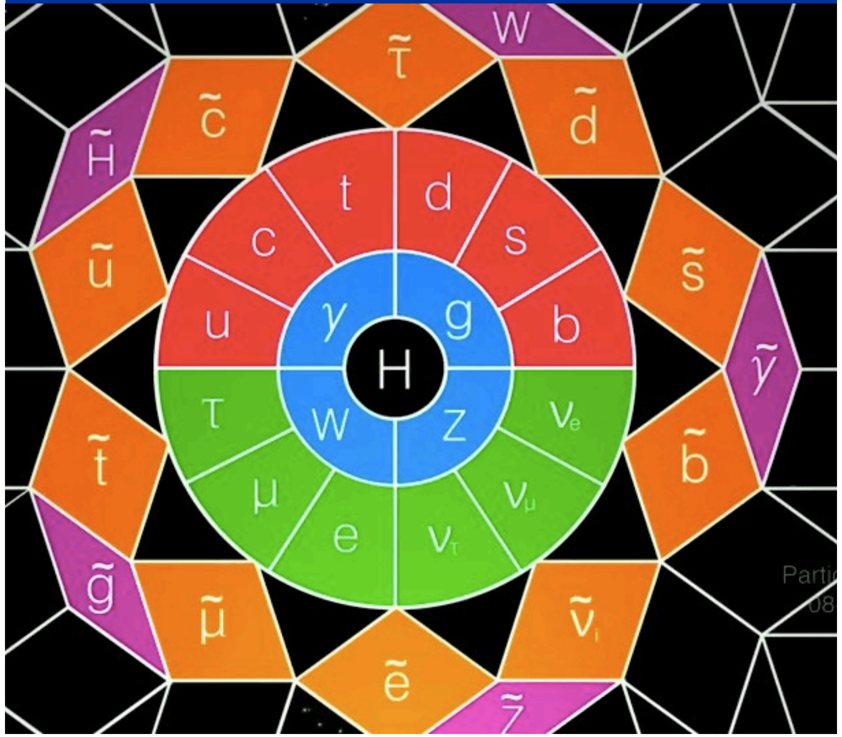
2,600 Staff
800 Fellows
550 Students

15,000 Users
2,000 Externals

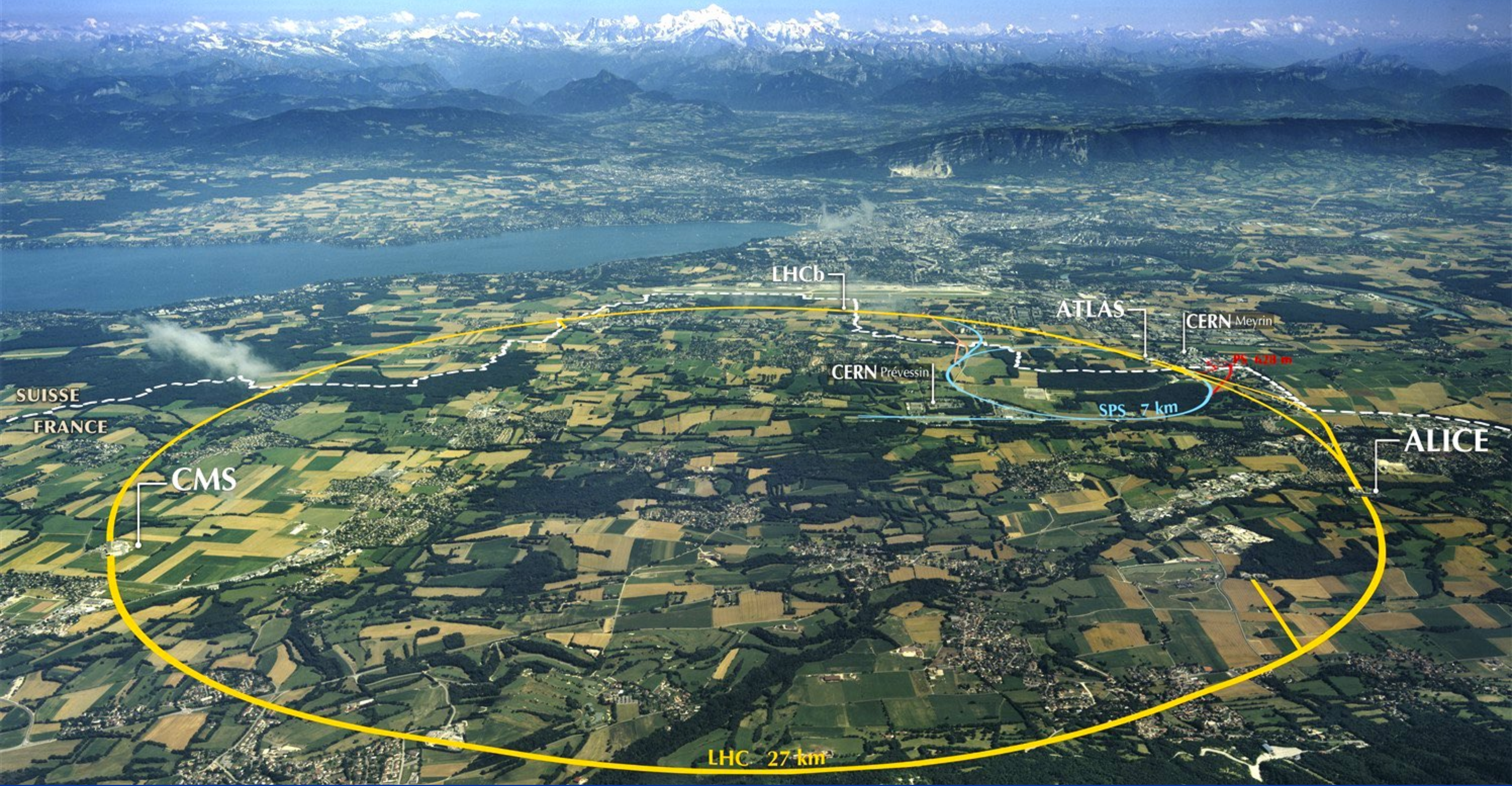
Fundamental questions of humankind

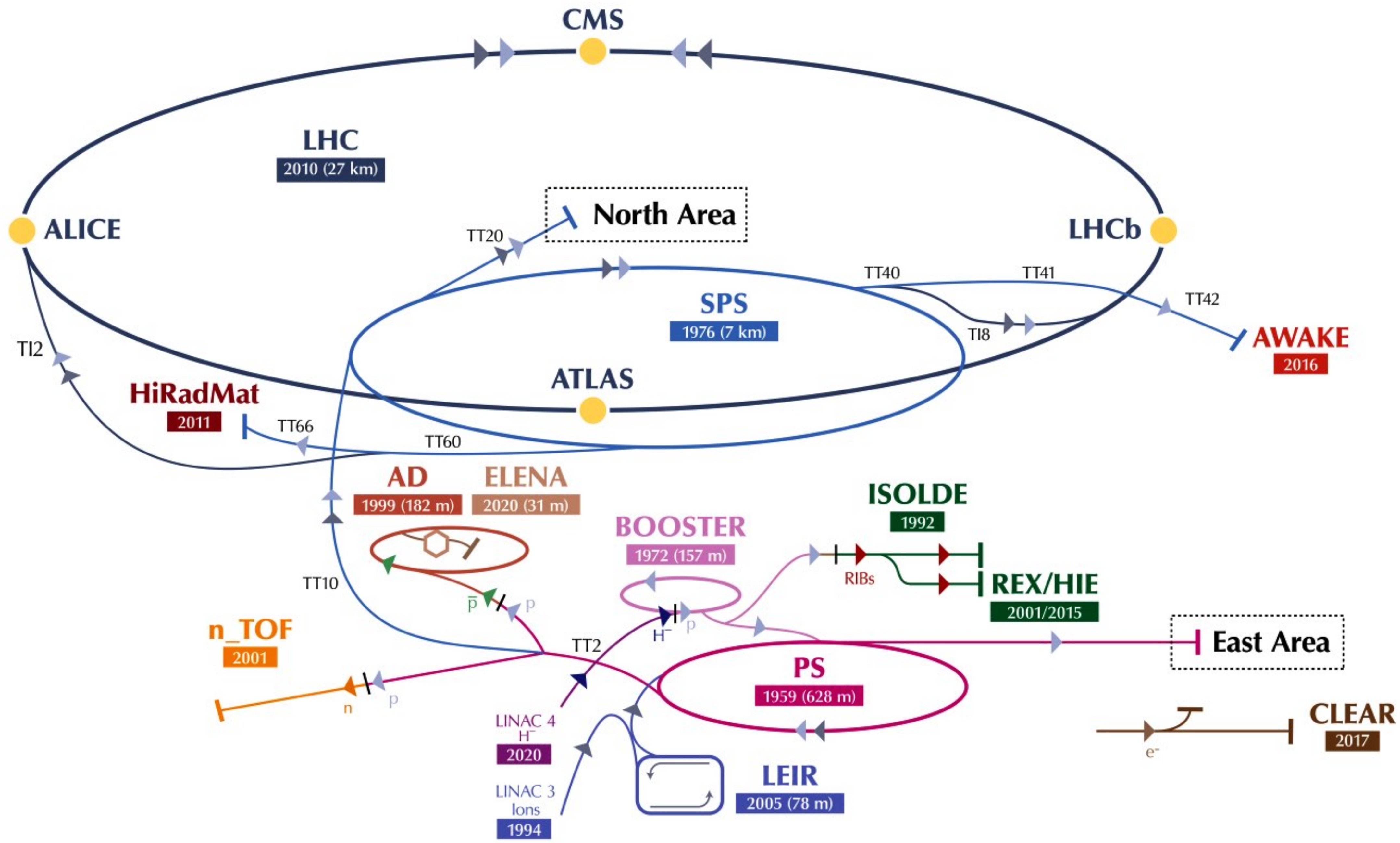
Where do we come from?

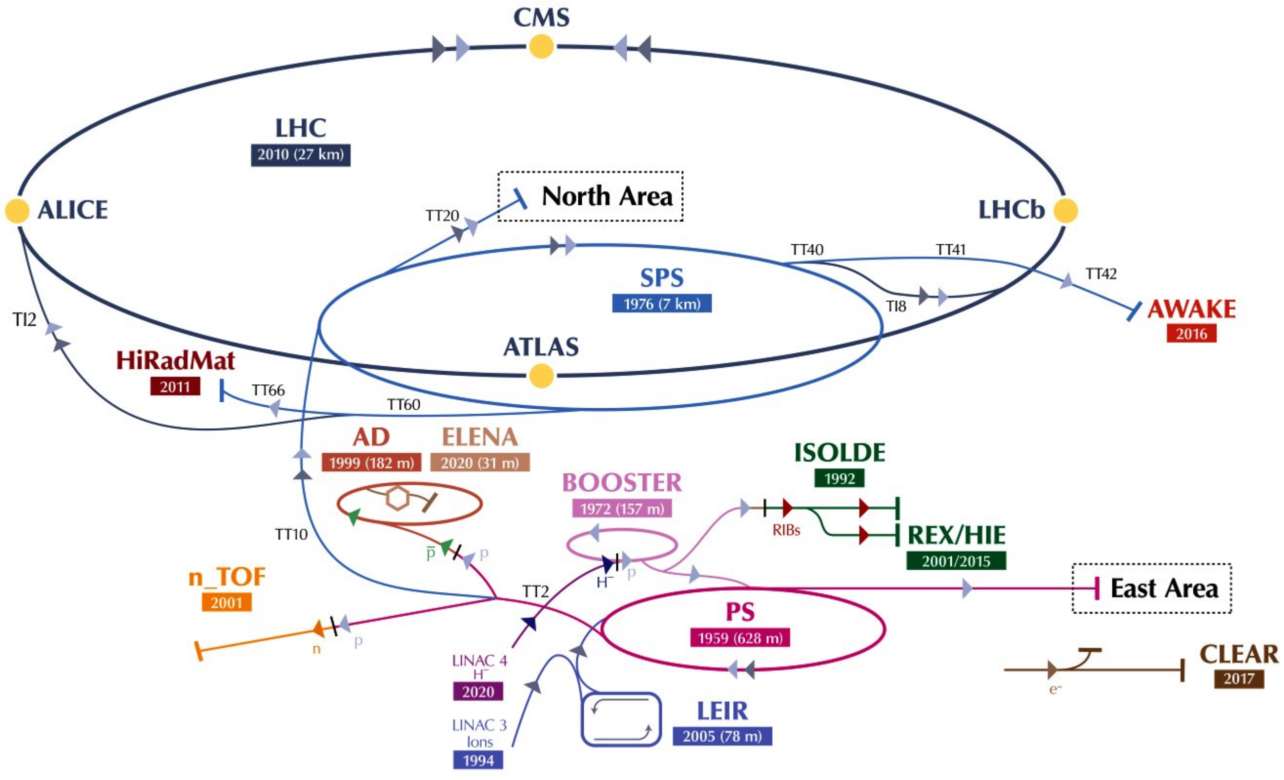
What are we made of?

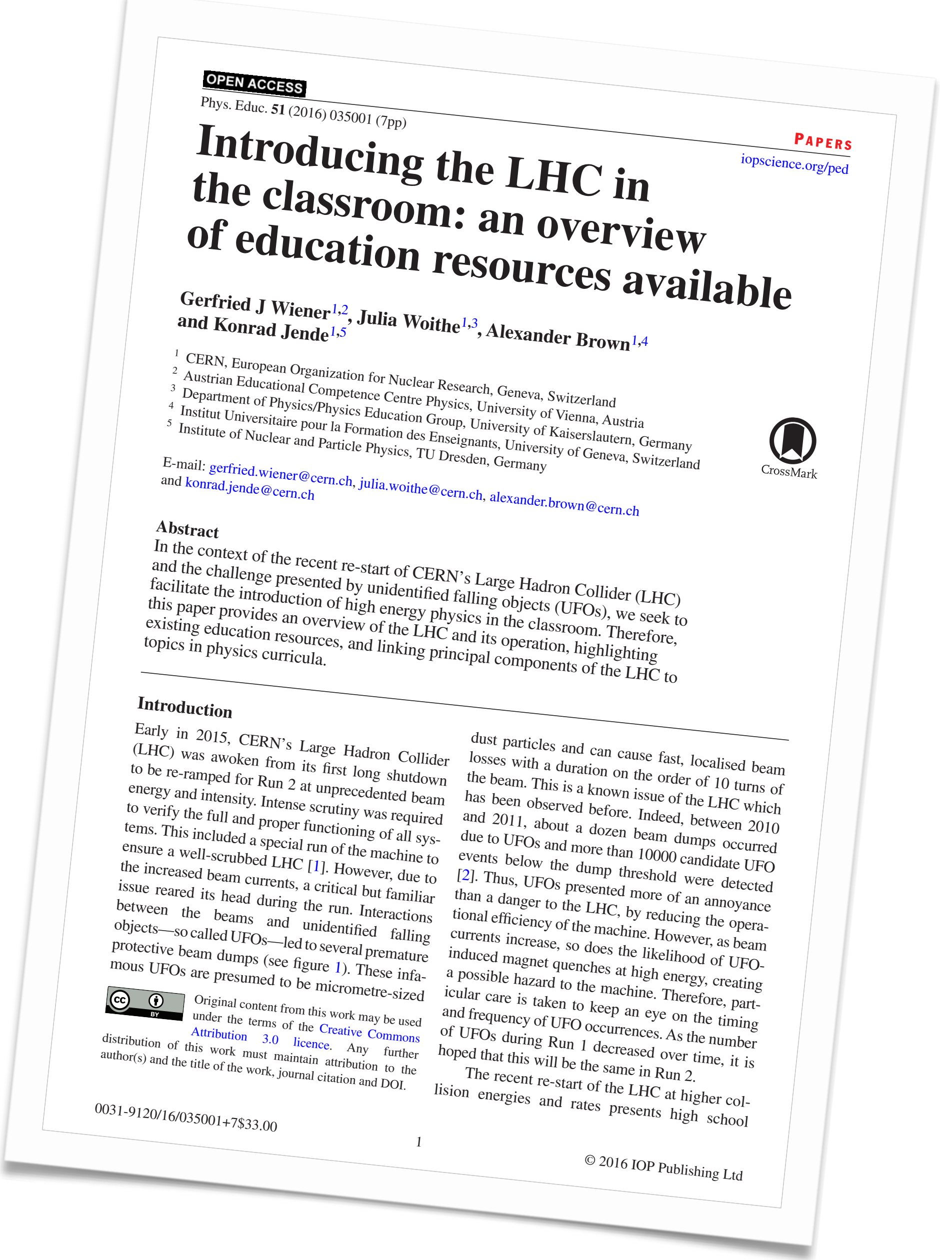


Where are we going?


LHCb
ATLAS
CERN Meyrin
PS 628 m
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
ALICE
CMS
LHC 27 km


CMS
LHC
2010 (27 km)
North Area
ALICE
TT20
LHCb
TT40
TT41
SPS
1976 (7 km)
TT42
TI8
AWAKE
2016
TI2
ATLAS
HiRadMat
2011
TT66
TT60
AD
1999 (182 m)
ELENA
2020 (31 m)
ISOLDE
1992
BOOSTER
1972 (157 m)
RIBs
REX/HIE
2001/2015
TT10
p̄
p
H⁻
p
n_TOF
2001
TT2
East Area
PS
1959 (628 m)
n
p
LINAC 4
H⁻
2020
CLEAR
2017
e⁻
LINAC 3
Ions
1994
LEIR
2005 (78 m)





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

Gerfried J Wiener[1,2], Julia Woithe[1,3], Alexander Brown[1,4] and Konrad Jende[1,5]

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

E-mail: gerfried.wiener@cern.ch, julia.woithe@cern.ch, alexander.brown@cern.ch and konrad.jende@cern.ch

CrossMark

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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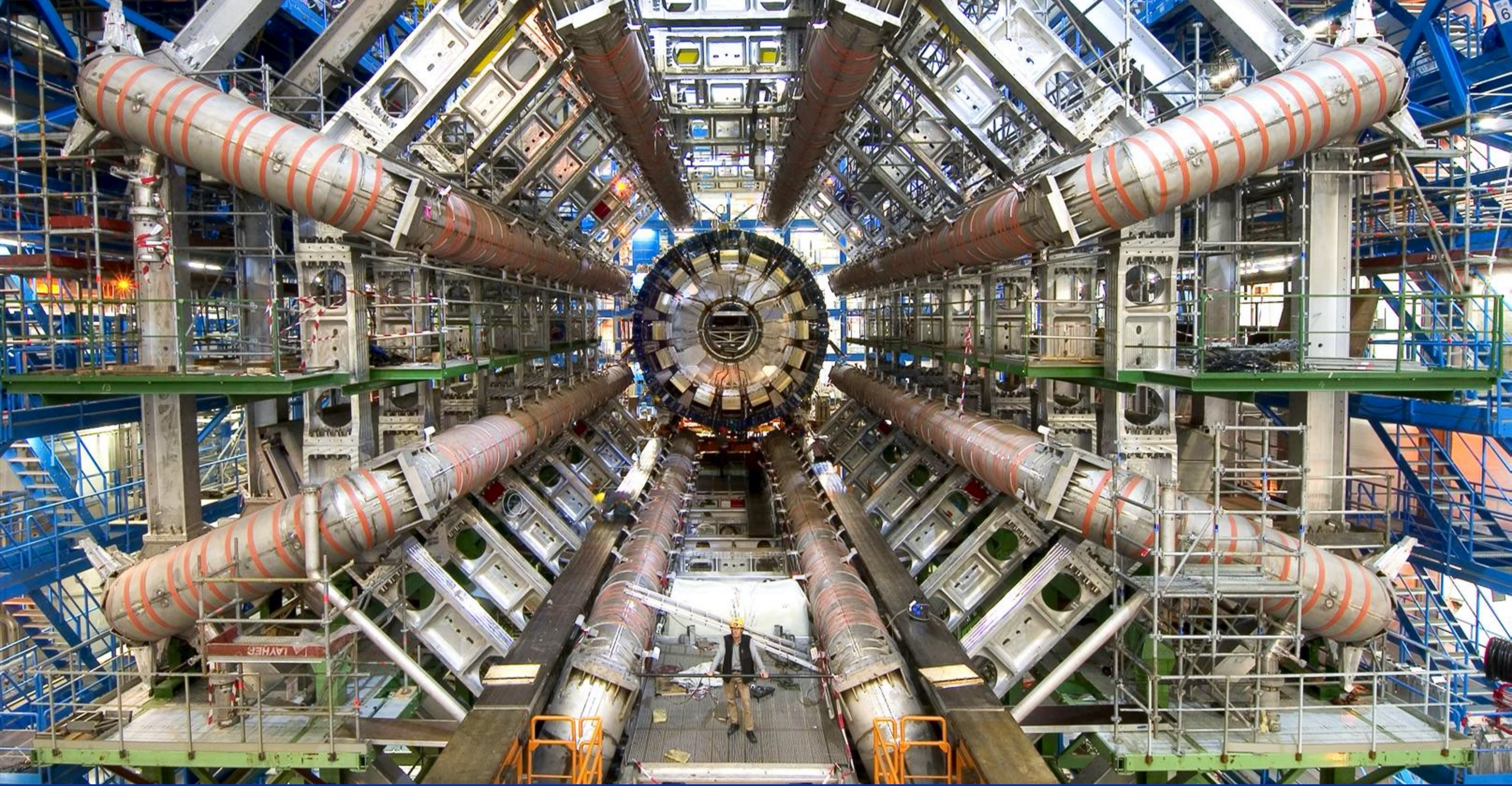
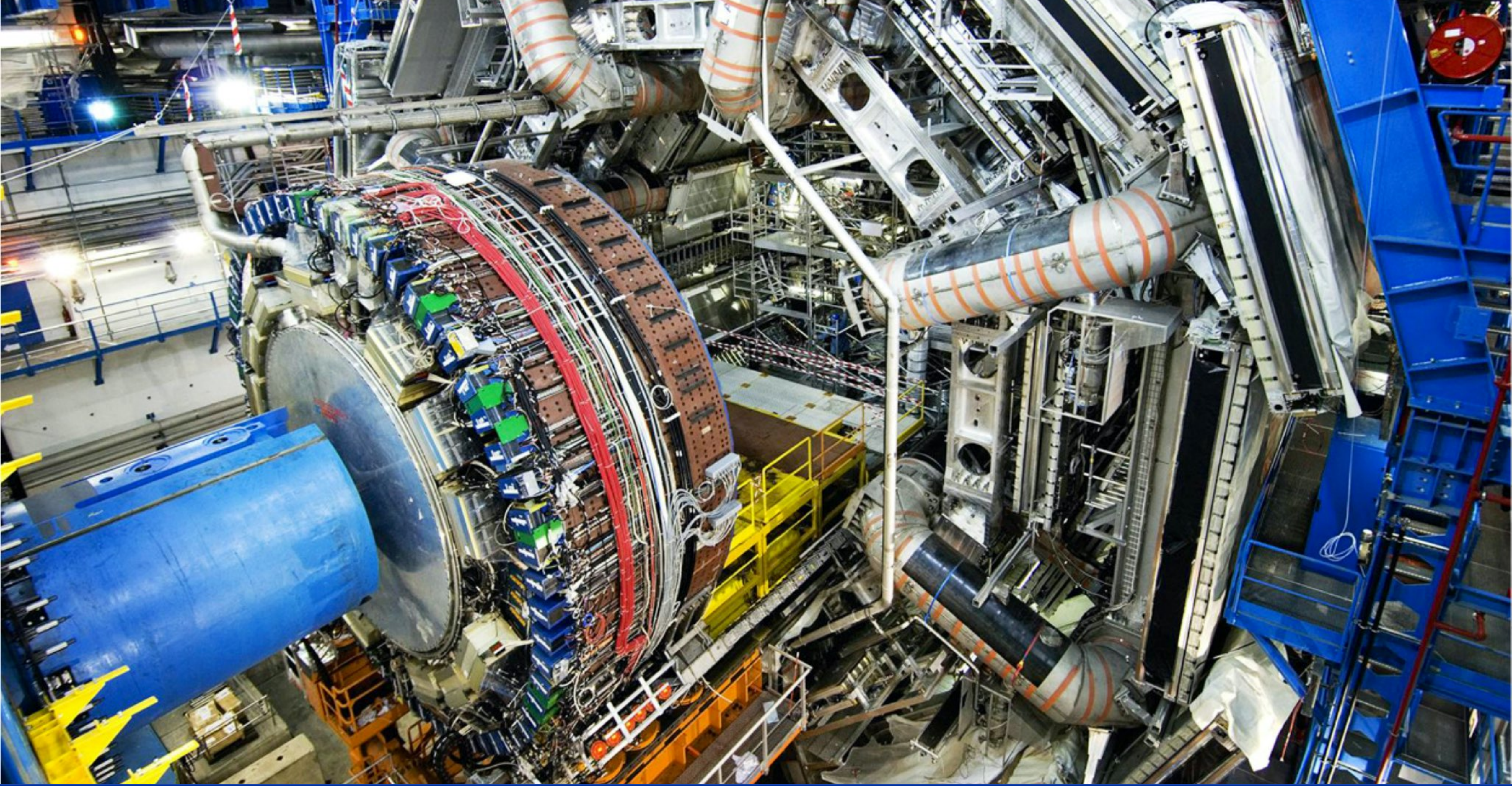
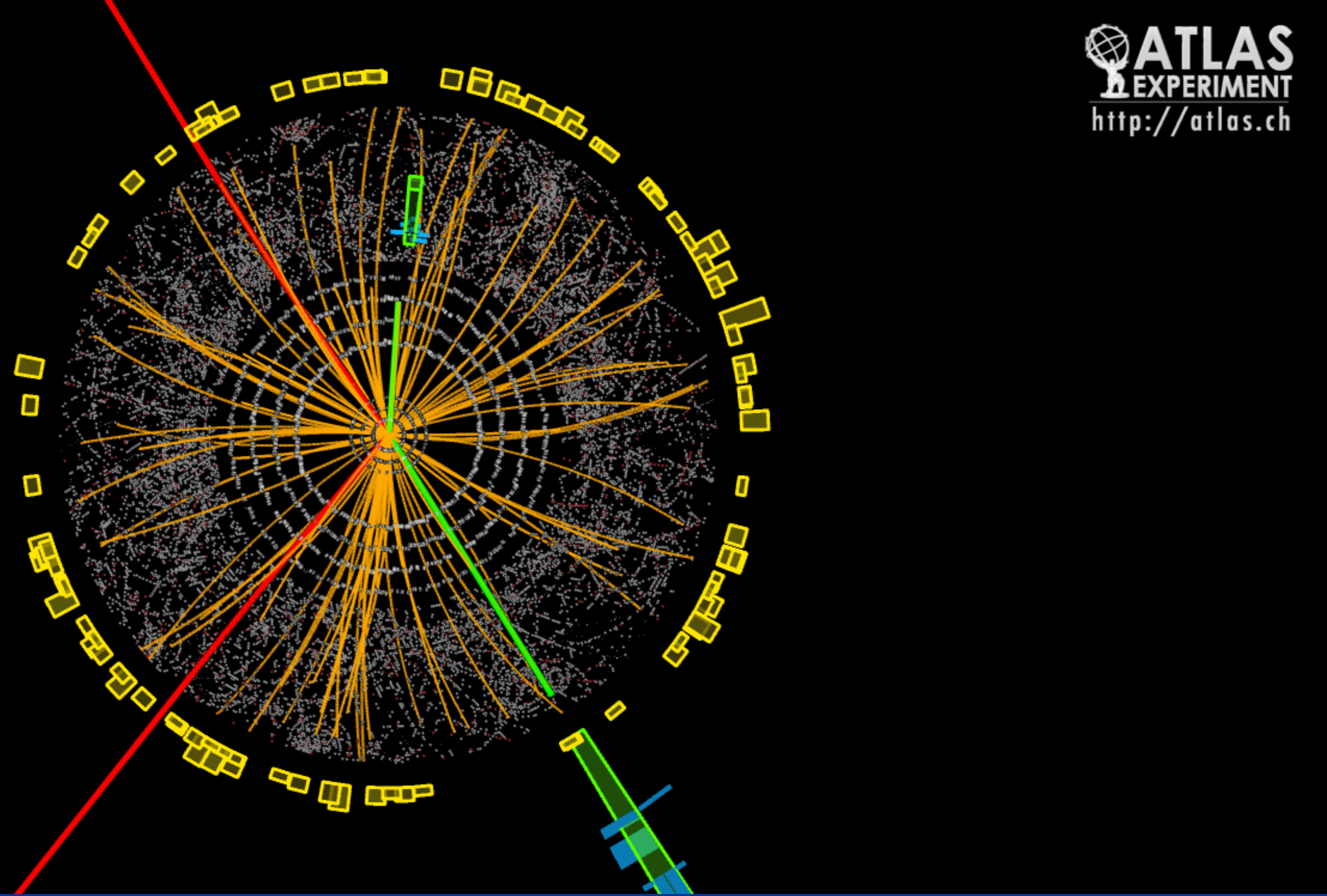


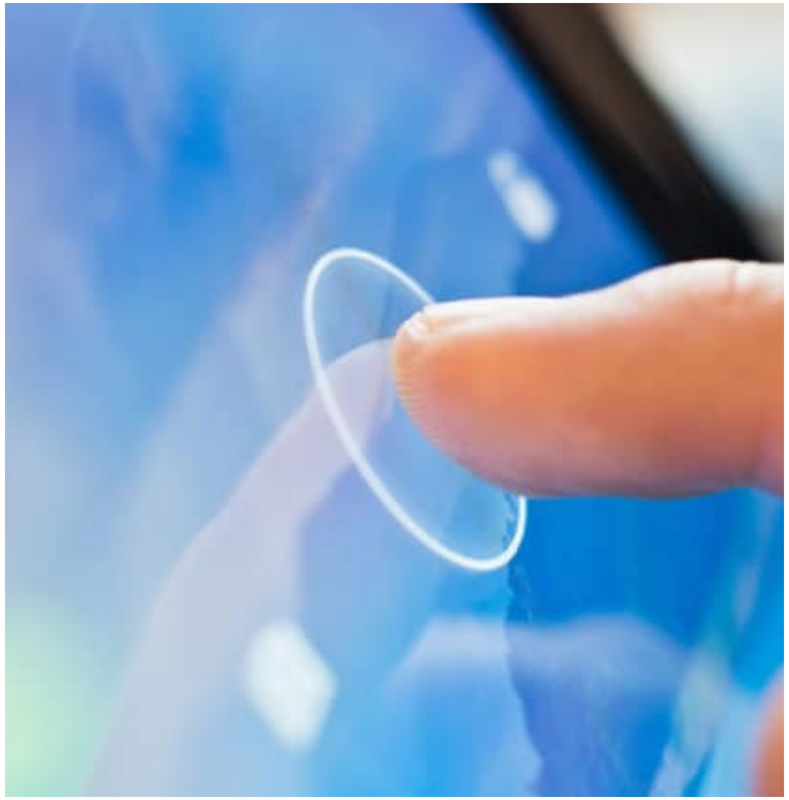



ATLAS
EXPERIMENT
http://atlas.ch

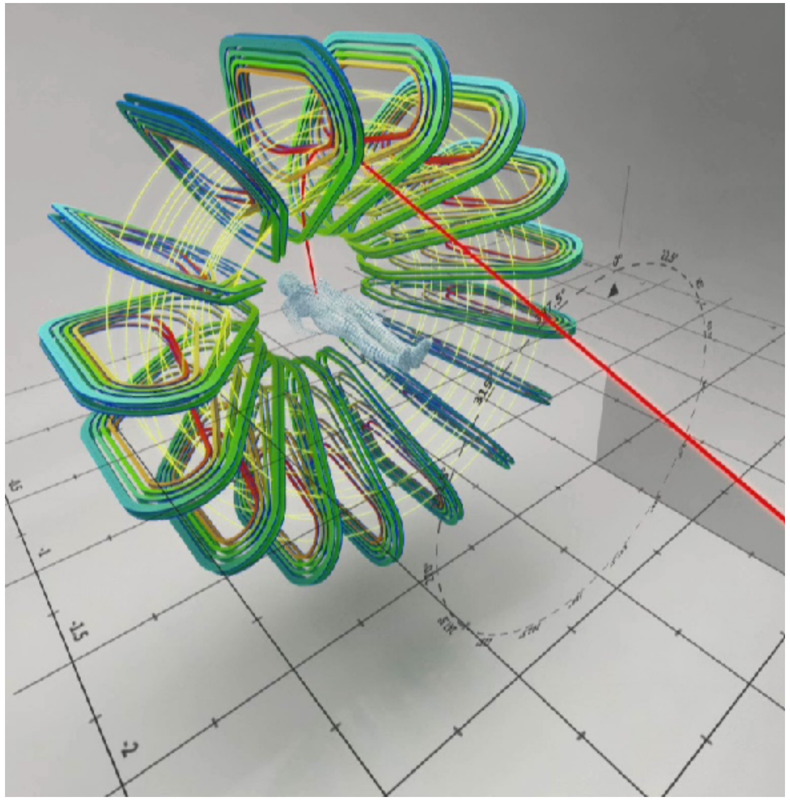
Knowledge Transfer

WWW

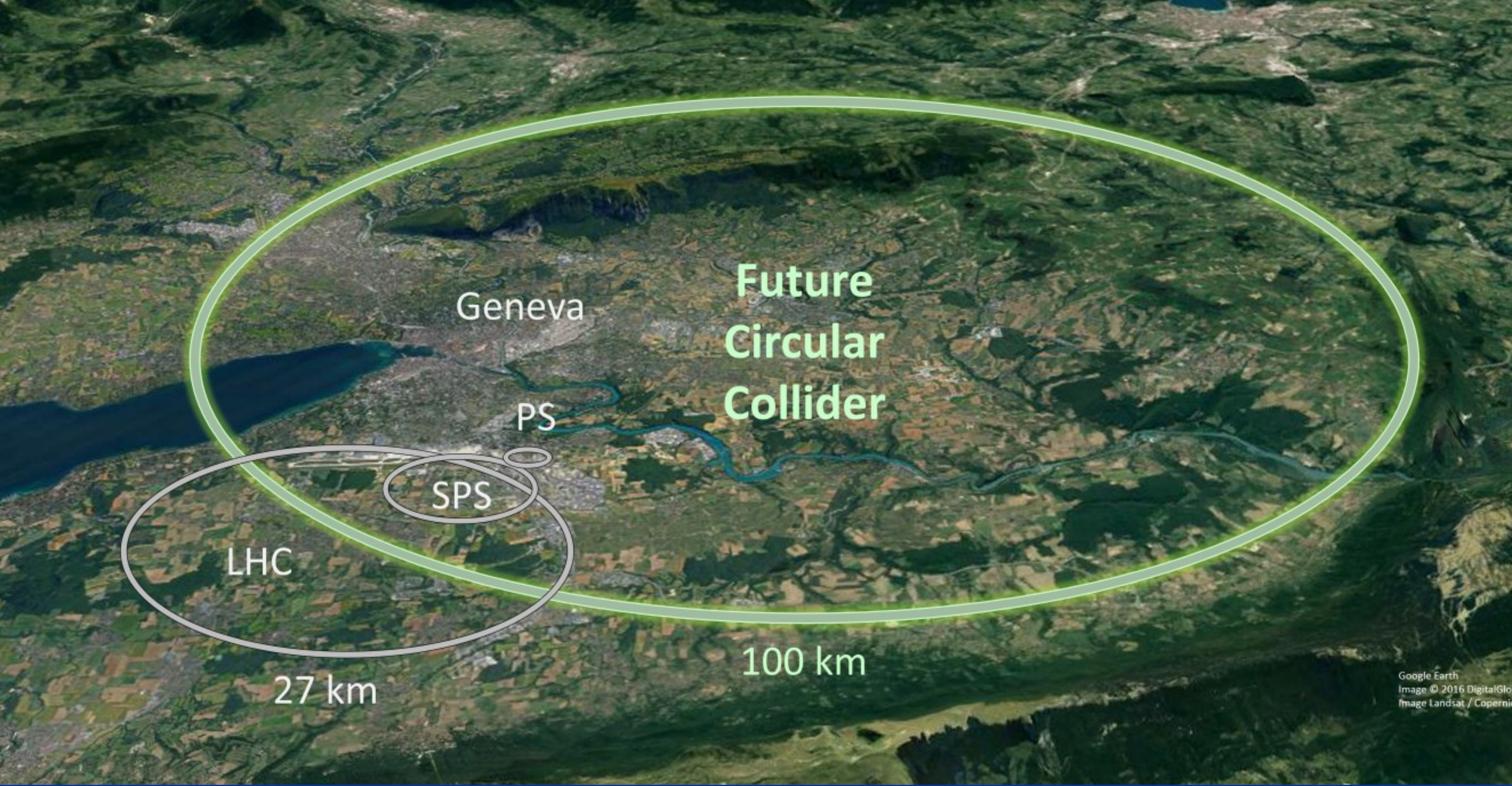
Touchscreens



Medical applications



What’s next?


Future
Circular
Collider
Geneva
PS
SPS
LHC
27 km
100 km
Google Earth

We need the next generation of scientists and engineers!

Merci bien!

Questions?

cern.ch/jeff.wiener