

# The international research laboratory

# CERN

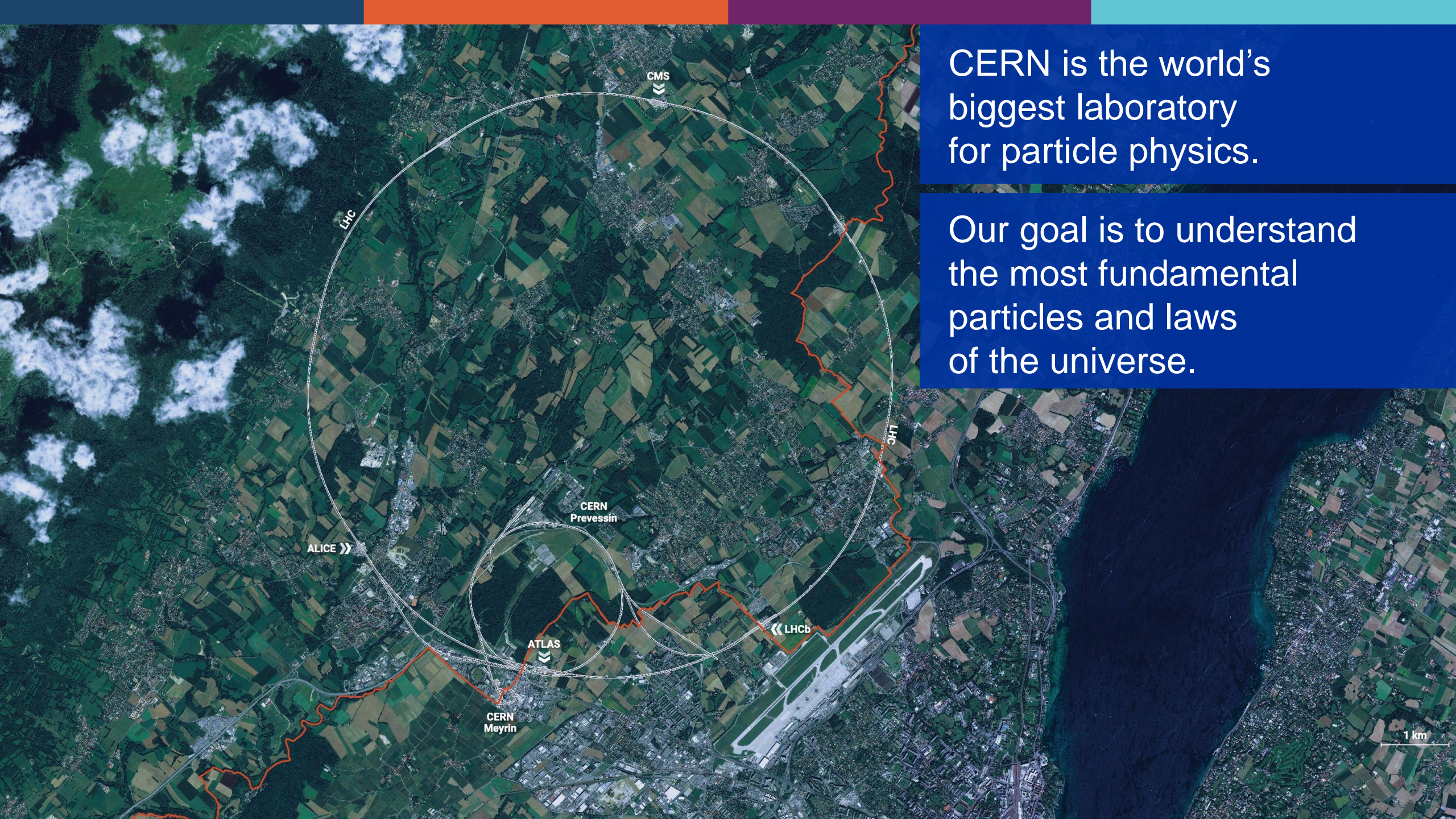


**Joachim Mnich**

**30<sup>th</sup> anniversary of the accession  
of the Czech and Slovak Federal  
Republic to CERN**

**Prague, October 12<sup>th</sup>, 2022**





CERN is the world's biggest laboratory for particle physics.

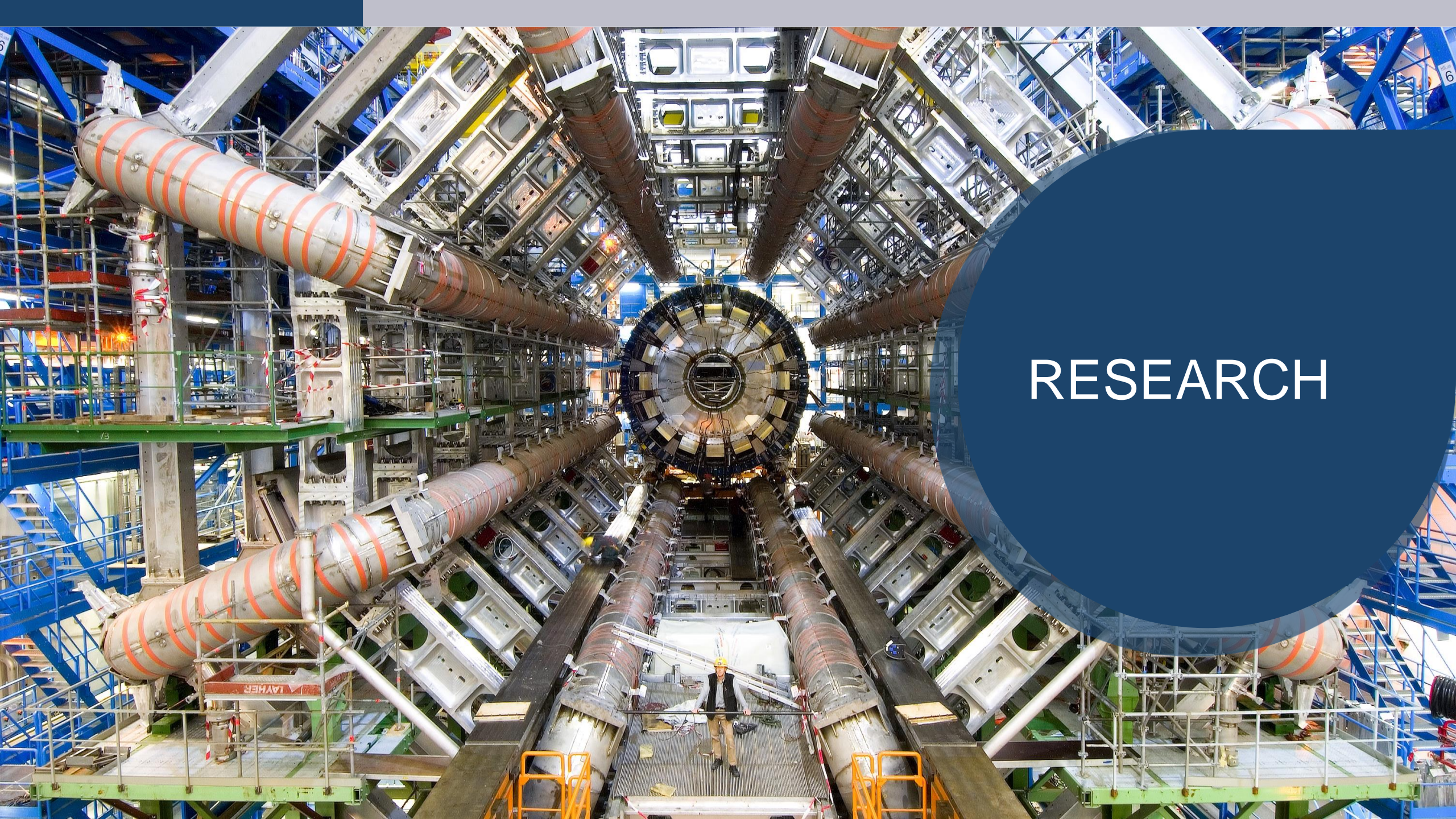
Our goal is to understand the most fundamental particles and laws of the universe.



# Four pillars underpin CERN's mission





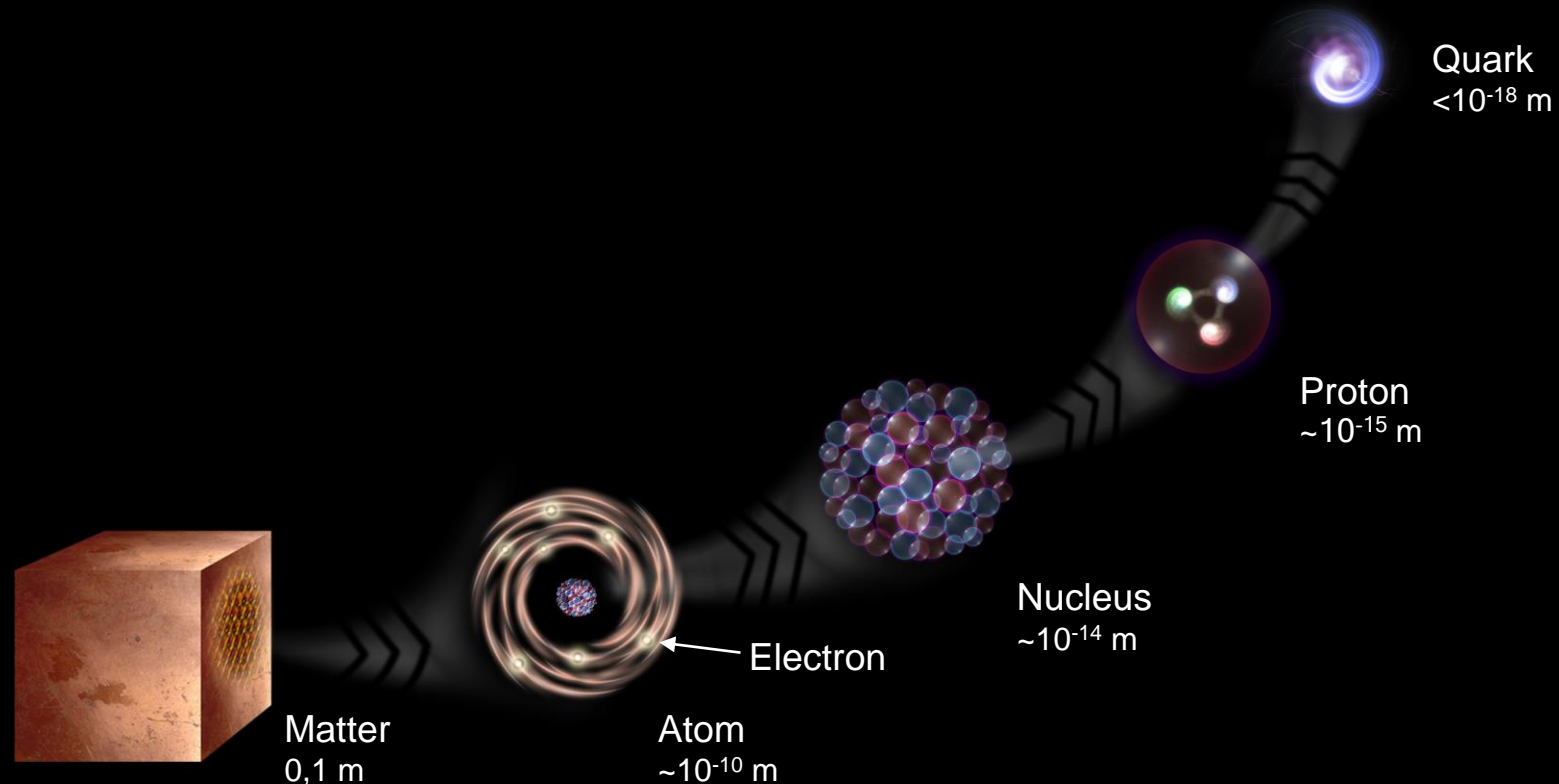


RESEARCH

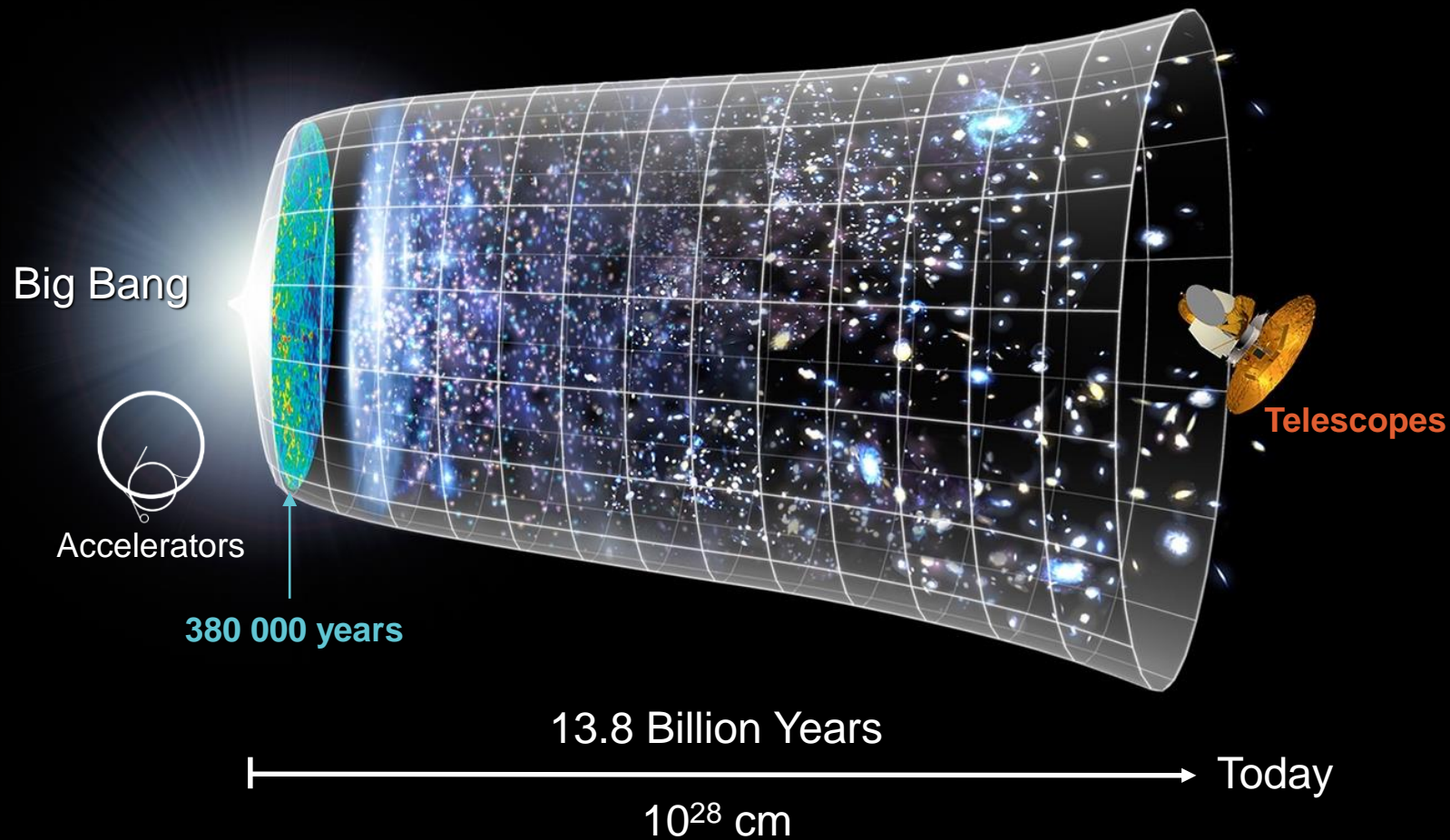


# What is the universe made of?

We study the elementary building blocks of matter and the forces that control their behaviour







# How did the universe begin?

We reproduce the conditions a fraction of a second after the Big Bang, to gain insight into the structure and evolution of the universe.



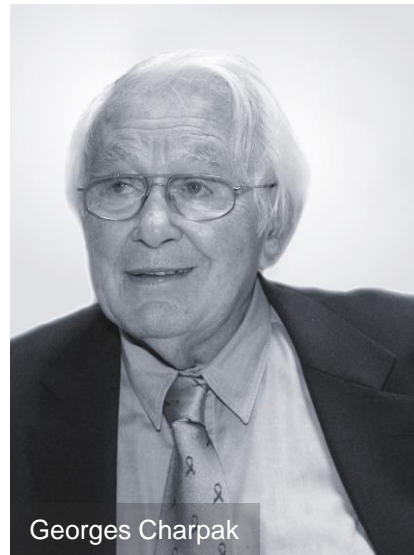
# At CERN we help to answer these questions



Carlo Rubbia



Simon Van der Meer



Georges Charpak

Several CERN scientists have received Nobel Prizes for key discoveries in particle physics.

The Higgs boson was discovered in 2012; without it fundamental particles would be massless and atoms could not form.



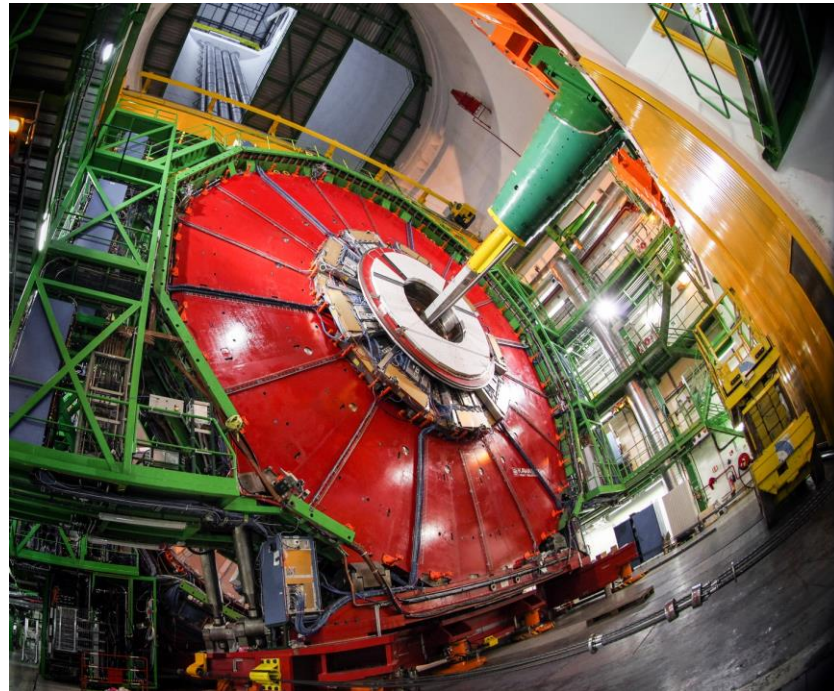
François Englert and Peter Higgs. With Robert Brout, they proposed the mechanism in 1964.



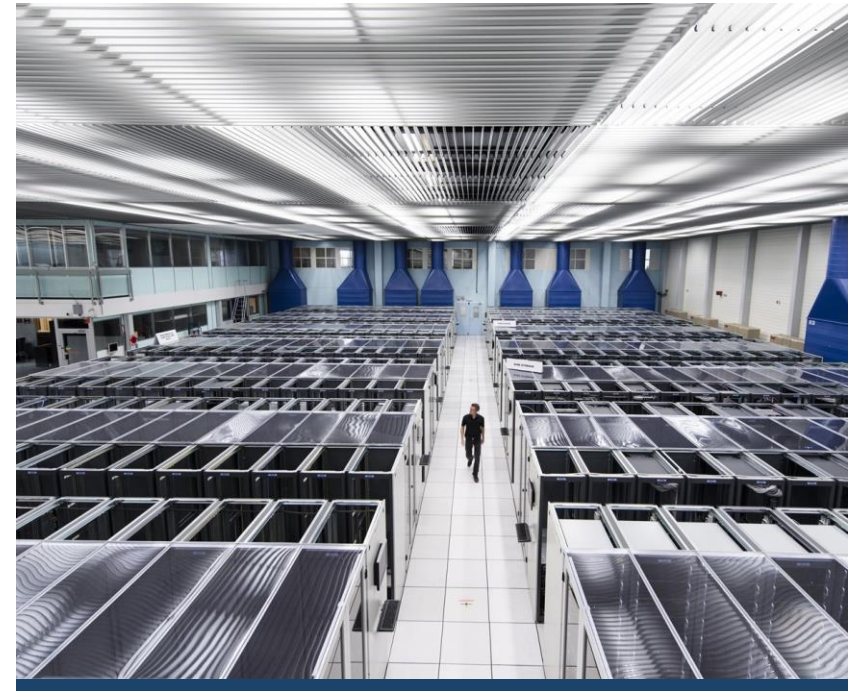
# We develop technologies in three key areas



ACCELERATORS

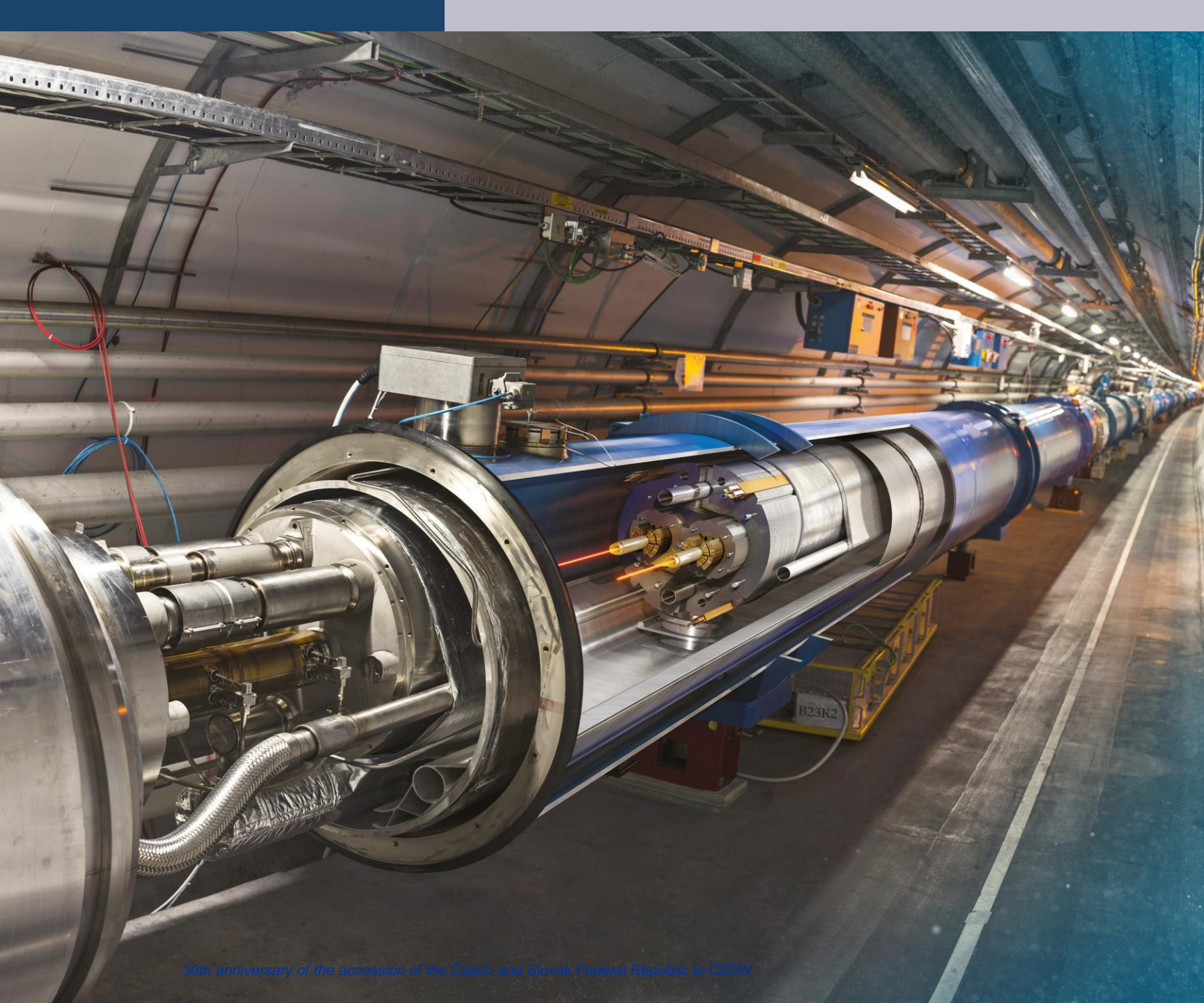


DETECTORS



COMPUTING



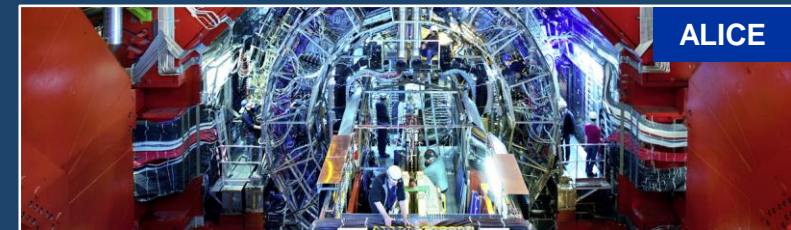
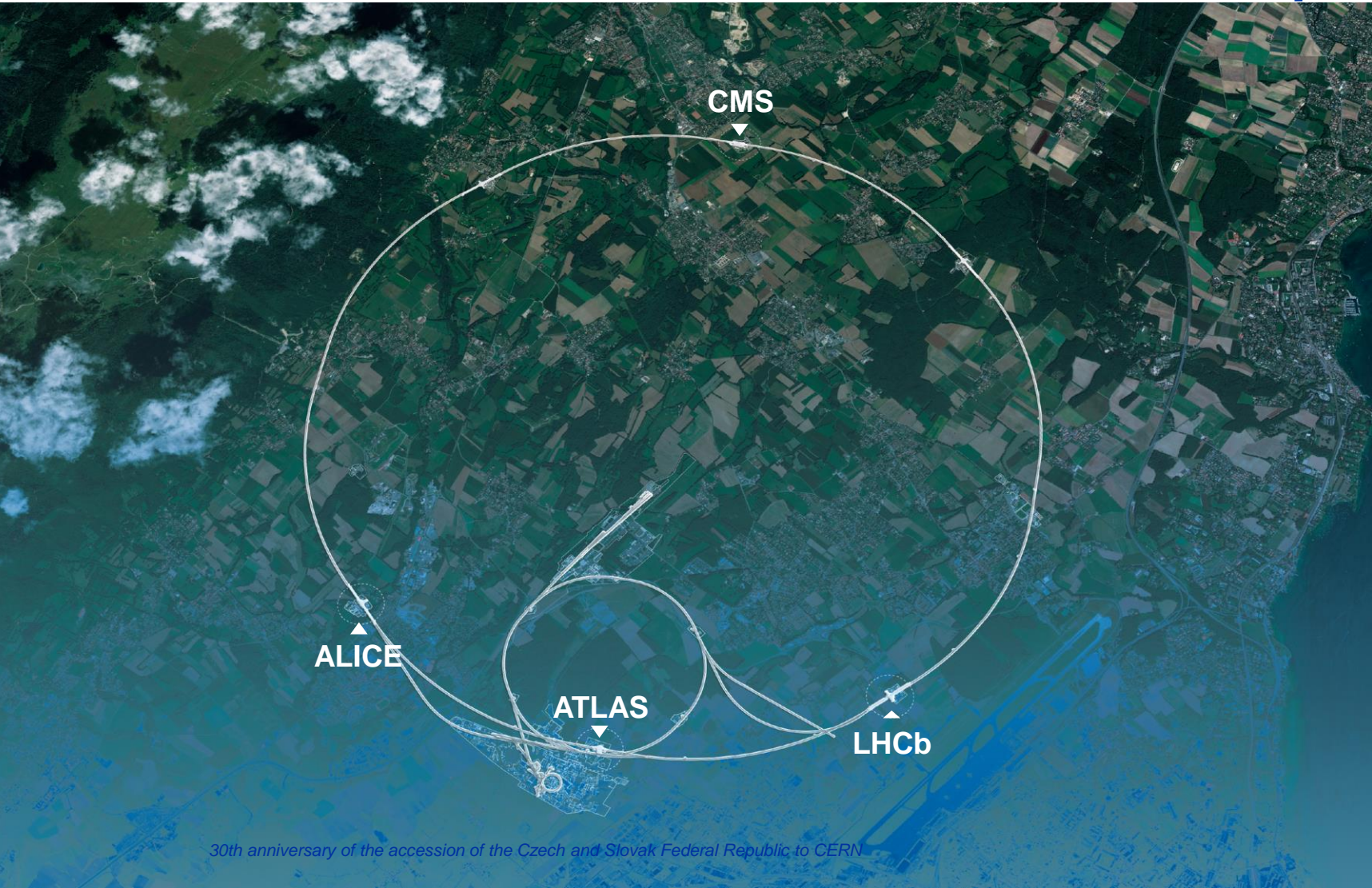


# Large Hadron Collider (LHC)

- 27 km in circumference
- About 100 m underground
- Superconducting magnets steer the particles around the ring
- Particles are accelerated to close to the speed of light (99.9999991%)

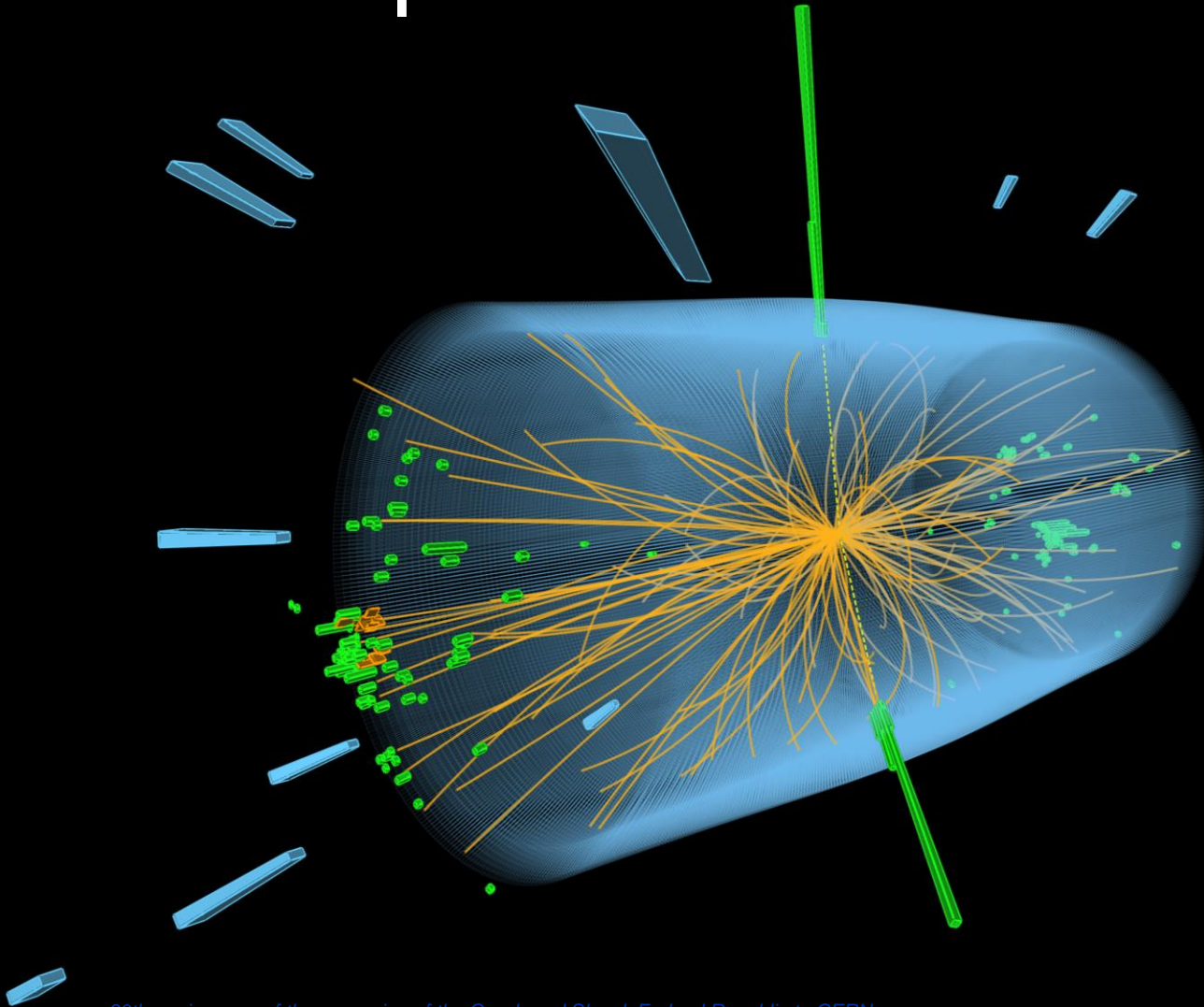


# Giant detectors record the particles formed at the four collision points





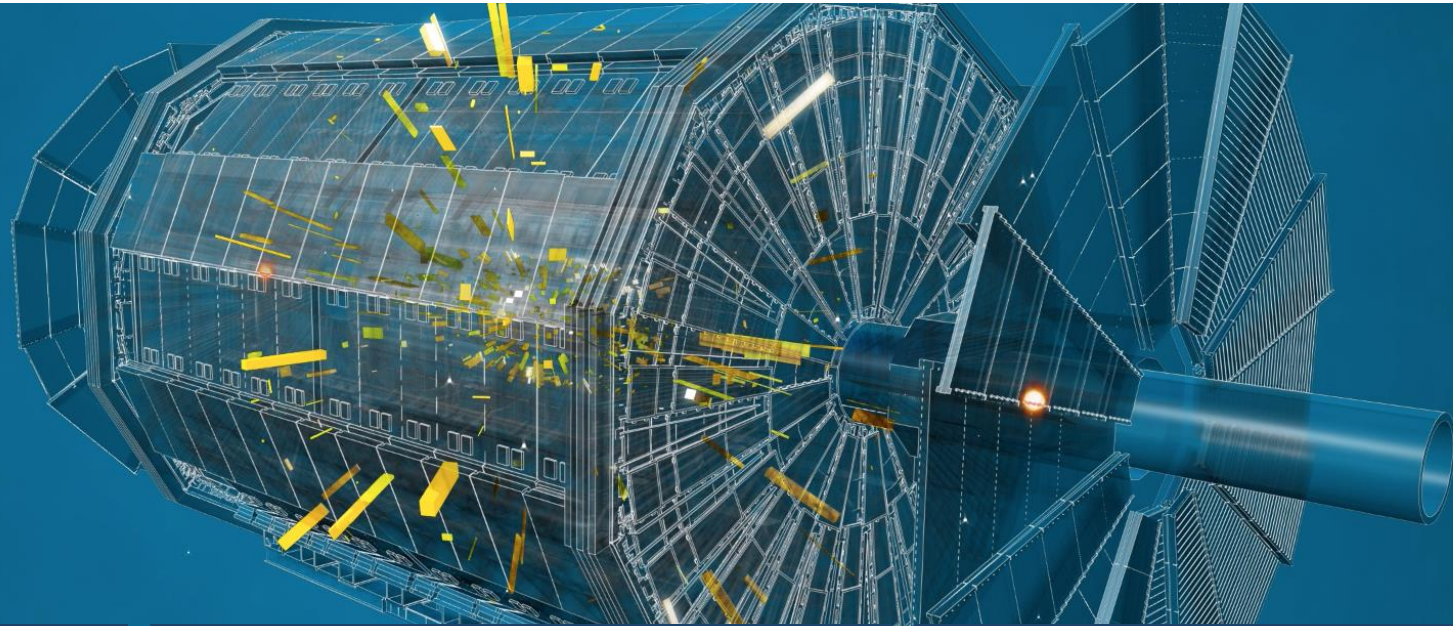
# The LHC produces more than 1 billion particle collisions per second



The energy of the particles in collision is converted into new particles.



# The LHC detectors are analogous to 3D cameras



The detectors measure the energy, direction and charge of new particles formed.



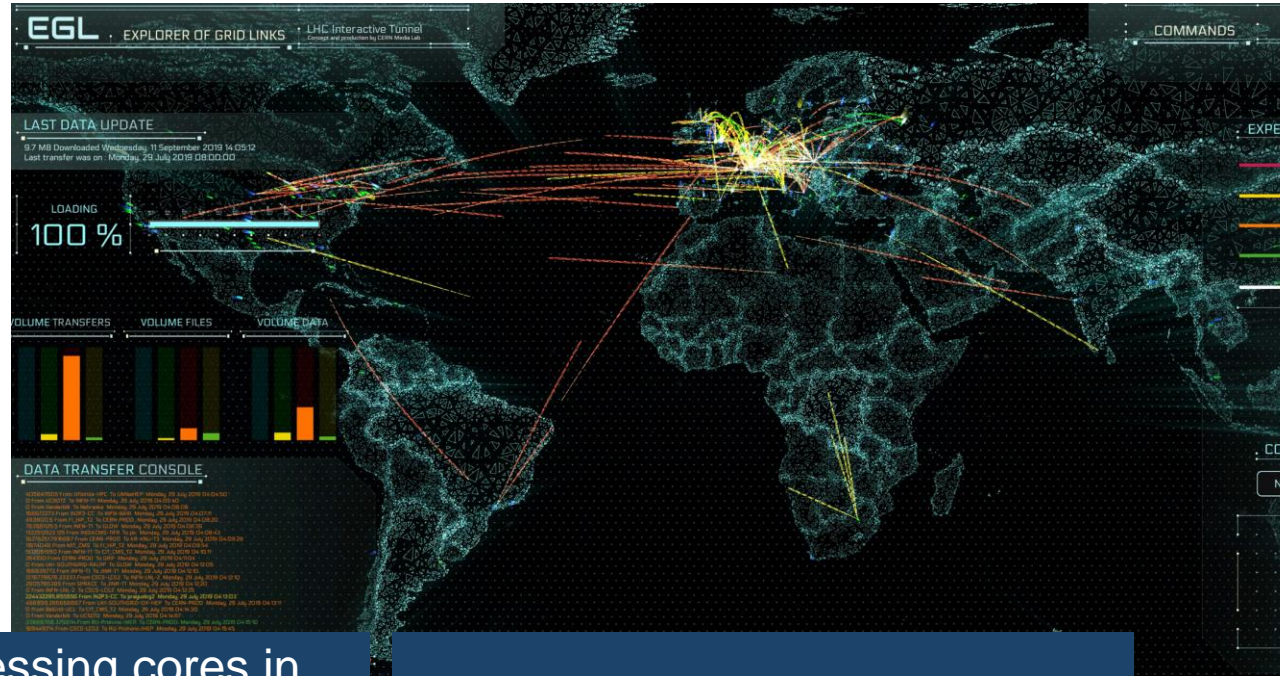
They take 40 million pictures a second. Only 1000 are recorded and stored.



The LHC detectors have been built by international collaborations covering all regions of the Globe.



# The Worldwide LHC Computing Grid (WLCG)



Used to store, distribute, process and analyse data.

1 million processing cores in about 170 data centres and 42 countries.

More than 1000 Petabytes of CERN data stored world-wide.

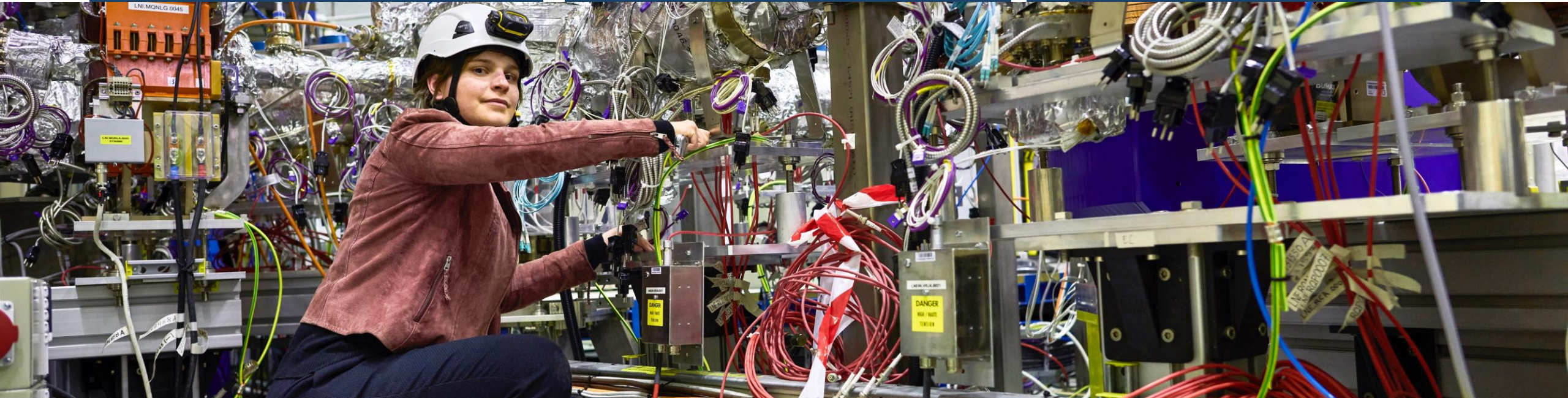


# CERN has a diverse scientific programme

Nuclear Physics  
(ISOLDE)

Antimatter Research  
(Antiproton Decelerator)

Cosmic rays and cloud formation  
(CLOUD)



Fixed-target experiments,  
which include searches for rare phenomena

Contribution to the Long Baseline  
Neutrino Facility in the USA (LBNF)



# There are many unanswered questions in fundamental physics

Including

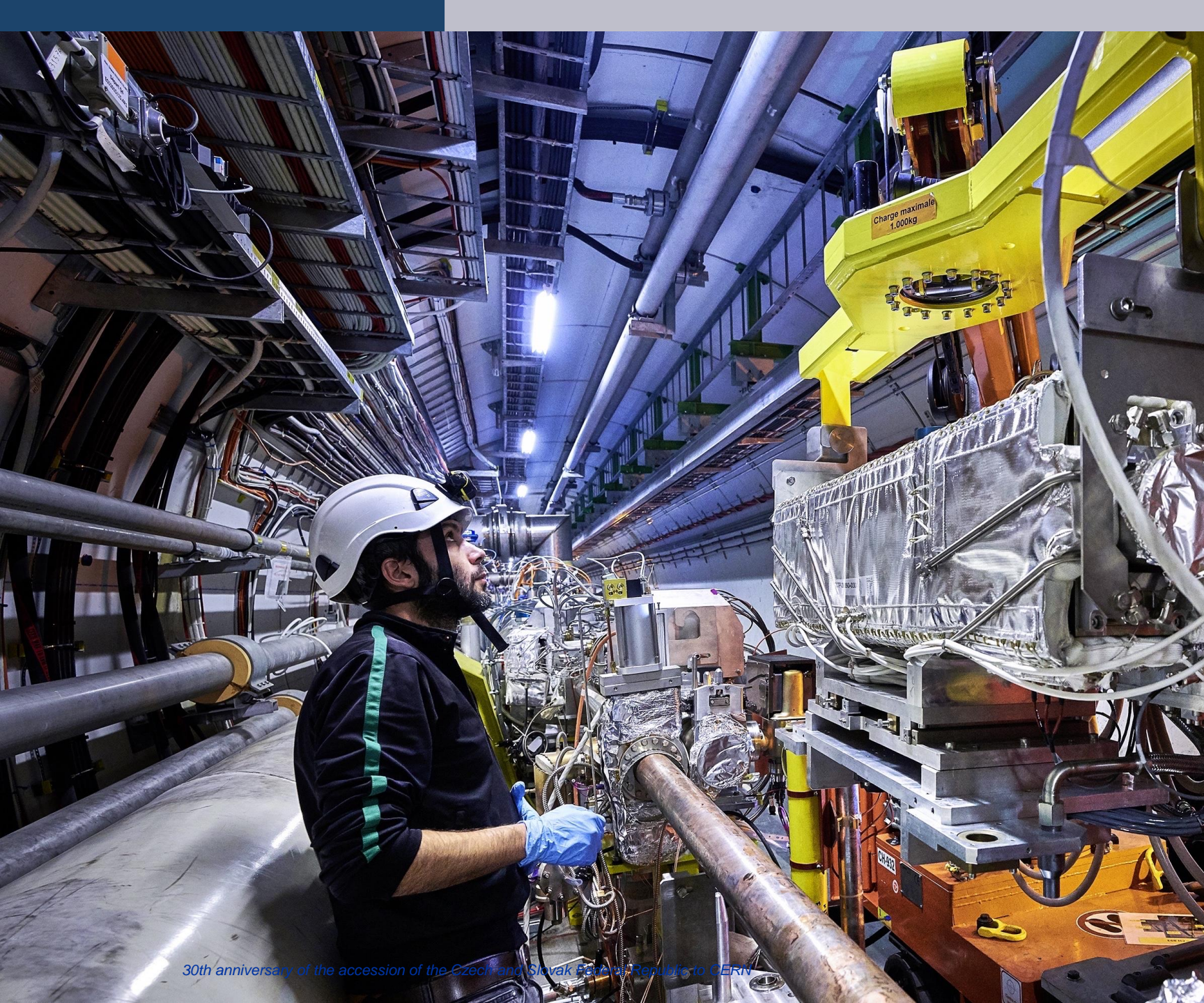
What is the unknown  
95% of the mass  
and energy  
of the universe?

Is there only one Higgs  
boson, and does it  
behave exactly as  
expected?

Why is the universe  
made only of matter,  
with hardly any  
antimatter?

Why is gravity so weak  
compared to the other  
forces?





# Upgrade to the High-Luminosity LHC is under way

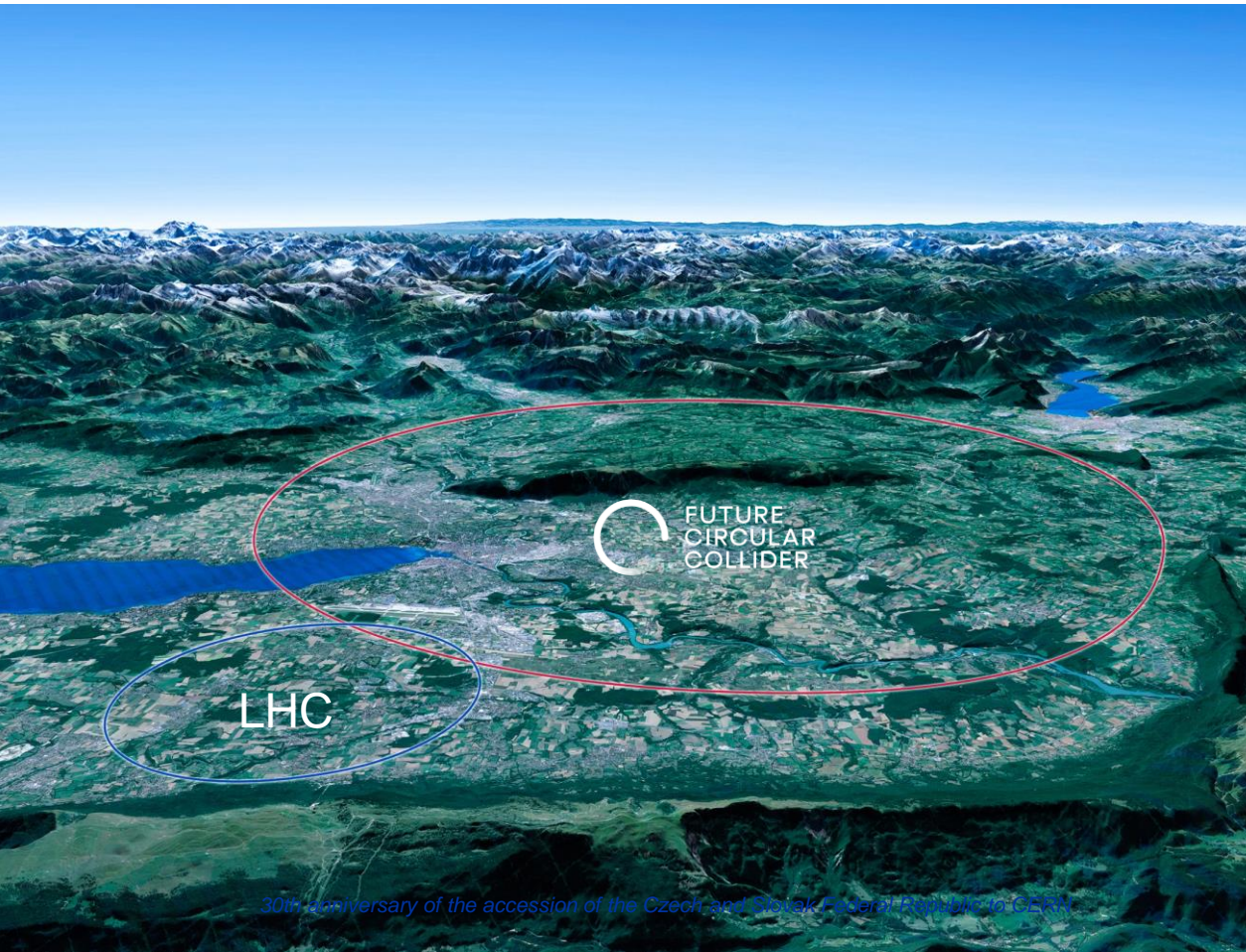
- The HL-LHC will use new technologies to provide 10 times more collisions than the LHC.
- It will give access to rare phenomena, greater precision and discovery potential.
- It will start operating in 2029, and run until approx. 2040.



# Scientific priorities for the future

Implementation of the recommendations  
of the **2020 Update of the European Strategy  
for Particle Physics:**

- Fully exploit the HL-LHC
- Build a Higgs factory to further understand this unique particle
- Investigate the technical and financial feasibility of a future energy-frontier 100 km collider at CERN FCC: Future Circular Collider
- Ramp up relevant R&D
- Continue supporting other projects around the world





# Future Circular Collider (FCC) Study

- 90 km ring, 200-400 m underground

- 2-stage collider:

**1<sup>st</sup> stage: Higgs and electroweak factory**

FCC-ee: high-intensity electron-positron collider for

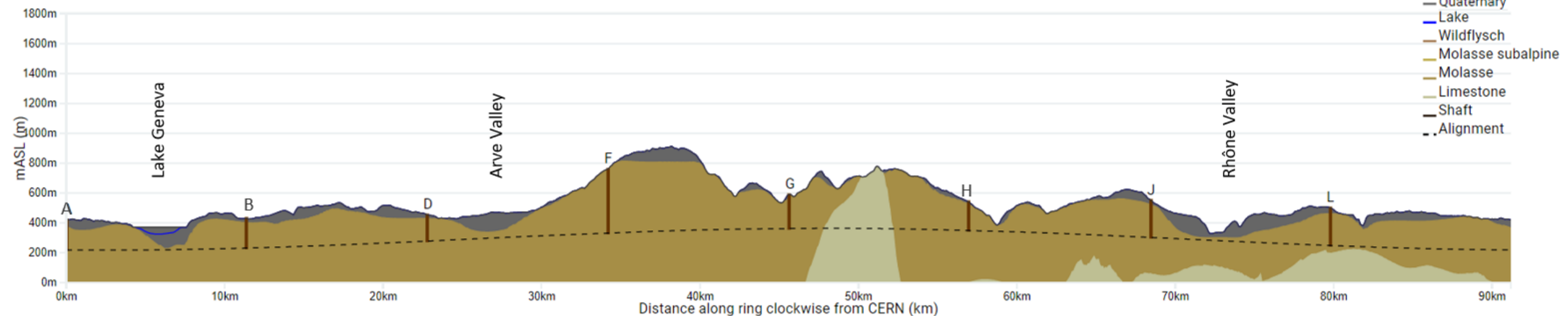
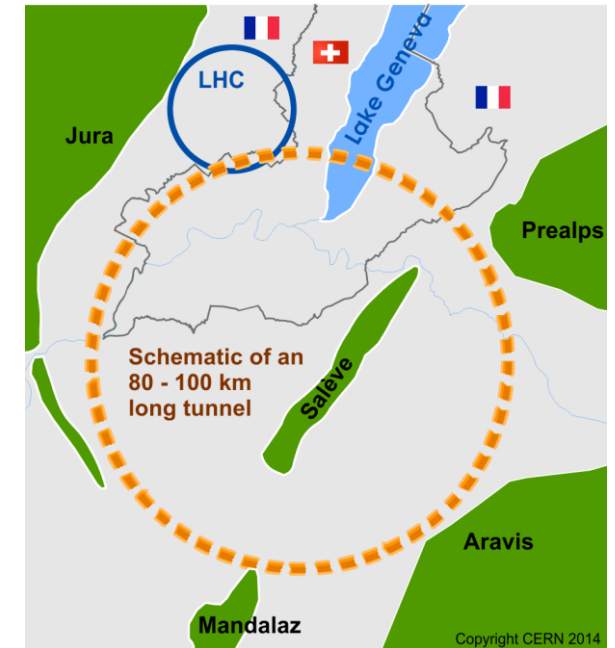
detailed study of the Higgs boson ( $10^6$  events), top-quark ( $10^6$ ), W ( $10^8$ ), Z ( $10^{12}$ )

→ indirect sensitivity to new physics up to  $\sim 70$  TeV ( $> 10$  times the LHC)

**2<sup>nd</sup> stage: hadron collider**

FCC-hh: proton-proton collider with collision energy of at least 100 TeV

→ direct discovery potential for new physics up to  $\sim 40$  TeV ( $\sim 10$  times the LHC)





COLLABORATION





# Science for peace

## CERN was founded in 1954 with 12 European Member States



### 23 Member States

Austria – Belgium – Bulgaria – Czech Republic  
Denmark – Finland – France – Germany – Greece  
Hungary – Israel – Italy – Netherlands – Norway  
Poland – Portugal – Romania – Serbia – Slovakia  
Spain – Sweden – Switzerland – United Kingdom

### 3 Associate Member States in the pre-stage to membership

Cyprus – Estonia – Slovenia

### 7 Associate Member States

Croatia – India – Latvia – Lithuania – Pakistan  
Türkiye – Ukraine

### 6 Observers

Japan – Russia (suspended) – USA  
European Union – JINR (suspended) – UNESCO

### Around 50 Cooperation Agreements with non-Member States and Territories

Albania – Algeria – Argentina – Armenia – Australia – Azerbaijan – Bangladesh – Belarus – Bolivia  
Bosnia and Herzegovina – Brazil – Canada – Chile – Colombia – Costa Rica – Ecuador – Egypt – Georgia – Honduras  
Iceland – Iran – Jordan – Kazakhstan – Lebanon – Malta – Mexico – Mongolia – Montenegro – Morocco – Nepal  
New Zealand – North Macedonia – Palestine – Paraguay – People's Republic of China – Peru – Philippines – Qatar  
Republic of Korea – Saudi Arabia – Sri Lanka – South Africa – Thailand – Tunisia – United Arab Emirates – Vietnam

CERN's annual budget  
is 1200 MCHF (equivalent  
to a medium-sized European  
university)

As of 31 December 2021  
Employees:  
**2676** staff, **783** fellows

Associates:  
**11 175** users, **1556** others



# A laboratory for people around the world

## Distribution of all CERN Users by the country of their home institutes as of 31 December 2021



Geographical & cultural diversity  
Users of **110 nationalities**  
**19.4% women**

### Member States **6642**

Austria 74 – Belgium 122 – Bulgaria 39 – Czech Republic 227  
Denmark 42 – Finland 71 – France 811 – Germany 1129  
Greece 133 – Hungary 69 – Israel 67 – Italy 1423  
Netherlands 157 – Norway 69 – Poland 278 – Portugal 89  
Romania 105 – Serbia 36 – Slovakia 66 – Spain 328  
Sweden 88 – Switzerland 372 – United Kingdom 847

### Associate Member States in the pre-stage to membership **55**

Cyprus 10 – Estonia 24 – Slovenia 21

### Associate Member States **367**

Croatia 36 – India 130 – Latvia 11 – Lithuania 12 – Pakistan 30  
Türkiye 122 – Ukraine 26

### Observers **2917**

Japan 189 – Russia (suspended) 971 – United States of America 1757



### Numbers for Czech Rep.

- Personnel by nationality as of 31 December 2021
  - **206 users**
  - **10 staff**
  - **9 fellows**

### Numbers for Slovakia

- Personnel by nationality as of 31 December 2021
  - **115 users**
  - **14 staff**
  - **9 fellows**

### Non-Member States and Territories **1194**

Algeria 3 – Argentina 16 – Armenia 10 – Australia 20 – Azerbaijan 3 – Bahrain 2 – Belarus 24 – Brazil 106  
Canada 189 – Chile 23 – Colombia 18 – Cuba 3 – Ecuador 6 – Egypt 16 – Georgia 36 – Hong Kong 17  
Iceland 3 – Indonesia 6 – Iran 11 – Ireland 6 – Jordan 5 – Kuwait 5 – Lebanon 15 – Madagascar 1  
Malaysia 4 – Malta 2 – Mexico 48 – Montenegro 5 – Morocco 18 – New Zealand 8 – Oman 1 – People's  
Republic of China 314 – Peru 2 – Philippines 1 – Republic of Korea 113 – Singapore 3 – South Africa 52  
Sri Lanka 10 – Taiwan 45 – Thailand 18 – United Arab Emirates 6



# CERN is a model for open and inclusive collaboration



The LHC experiments are models of consensus building, competition and cooperation.

SESAME, a synchrotron light source in Jordan, is modelled on CERN's governance structure.



CERN provides the IT infrastructure for the satellite-analysis technology used for emergency response.





# TECHNOLOGY & INNOVATION



# CERN's technological innovations have applications in many fields

CERN is the birthplace of the World Wide Web

**And there are many more examples**

Medical imaging, cancer therapy, material science, cultural heritage, aerospace, automotive, environment, health & safety, industrial processes.

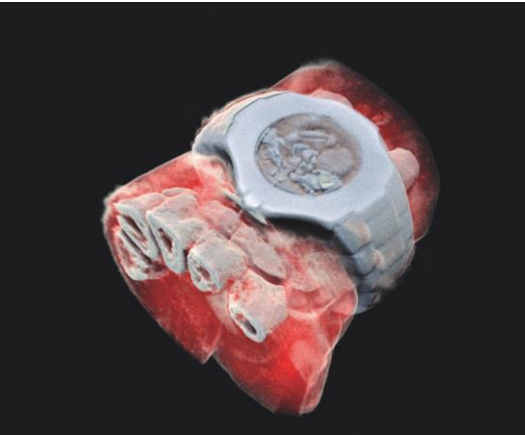
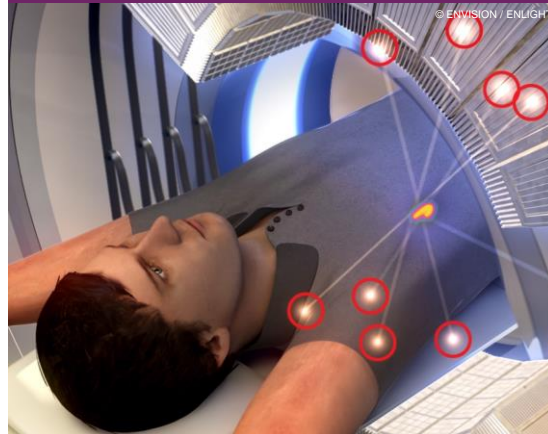


# CERN's technological innovations have important applications in medicine and healthcare



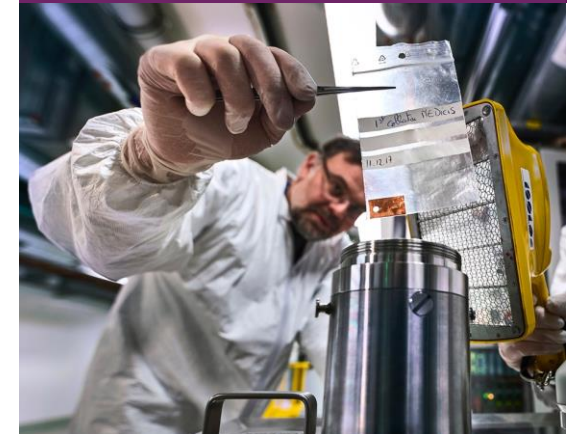
Technologies applied at CERN are also used in PET, for medical imaging and diagnostics.

Accelerator technologies are applied in cancer radiotherapy with protons, ions and electrons.



Pixel detector technologies are used for high resolution 3D colour X-ray imaging.

CERN produces innovative radioisotopes for nuclear medicine research.



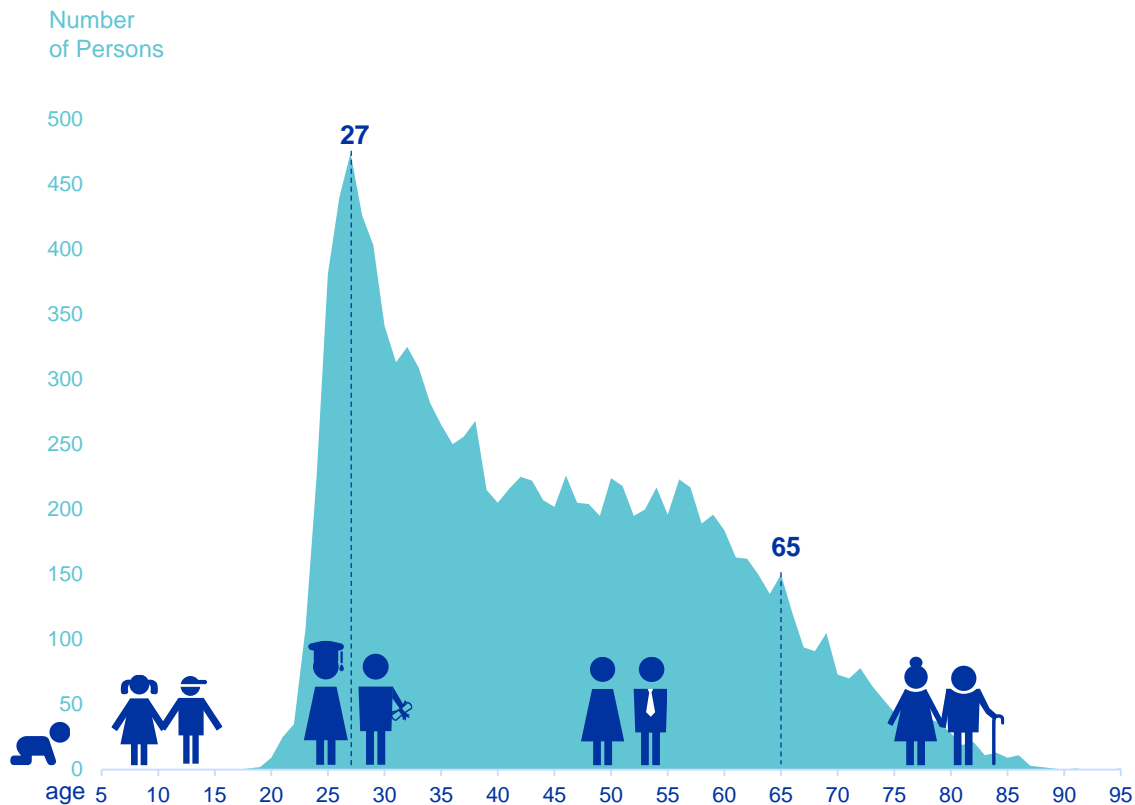


A group of students, both male and female, are wearing hard hats (yellow and blue) and are focused on a large, dark, cylindrical piece of equipment mounted on a metal frame. They appear to be in a laboratory or workshop setting. One student in the foreground is adjusting the equipment. In the background, there are other students and a green exit sign with a white arrow pointing down. A teal circular graphic is overlaid on the left side of the image, containing the text 'EDUCATION & TRAINING'.

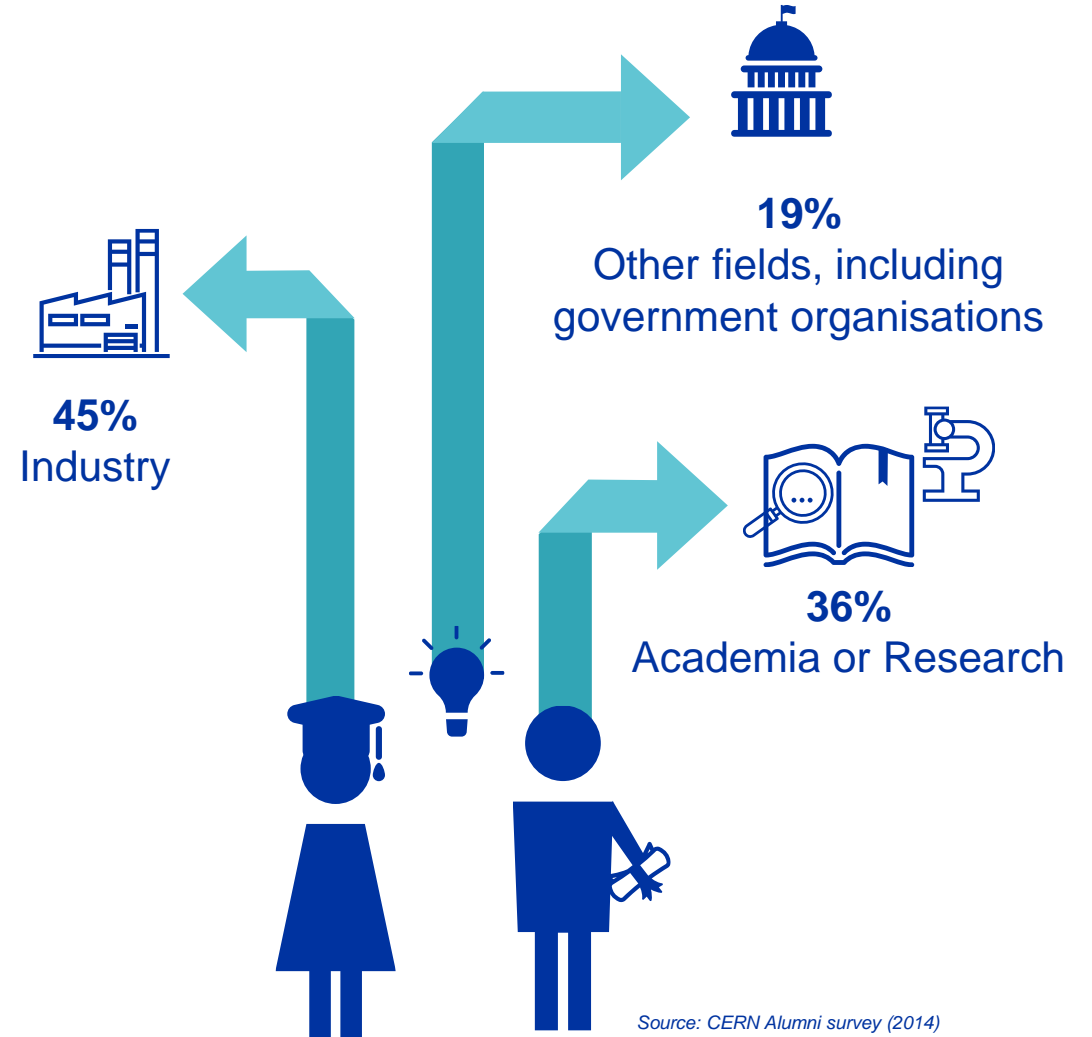
# EDUCATION & TRAINING



# CERN opens a world of career opportunities



**Age Distribution of Scientists working at CERN**



**PhD and Technical students leaving CERN**

Source: CERN Alumni survey (2014)



# CERN's training, education and outreach programmes

300 Undergraduate students in Summer programmes  
>3000 registered PhD students.

>1000 Fellows, Technical and Doctoral Students in research and applied physics, engineering and computing.

13 304 teachers since 1998 and 2000 participants in the webinar since 2020.



## Numbers for Czech Rep.

4 summer students during 2019  
170 teachers in Teacher Programmes since 1998  
3 teams in BL4S competition since 2014  
552 students participating in S'Cool LAB since 2015

## Numbers for Slovakia

2 summer students during 2019  
305 teachers in Teacher Programmes since 1998  
7 teams in BL4S competition since 2014  
534 students participating in S'Cool LAB since 2015

151 000 visitors on guided tours of CERN in 2019, from 95 countries.

CERN engages with citizens across the globe: on-site and travelling exhibitions in 15 countries, > 1 million visitors

Science Gateway will open in 2023, expanding CERN's outreach reach and impact, locally and globally.



# CERN Science Gateway



CERN's new education and outreach centre for all publics aged 5-plus.

Opening summer 2023.

Immersive exhibitions, education labs, events and shows.





# Czech Republic has a strong tradition in particle physics



**Czech Republic became a CERN Member State in 1992 and in 1993 as an independent state**

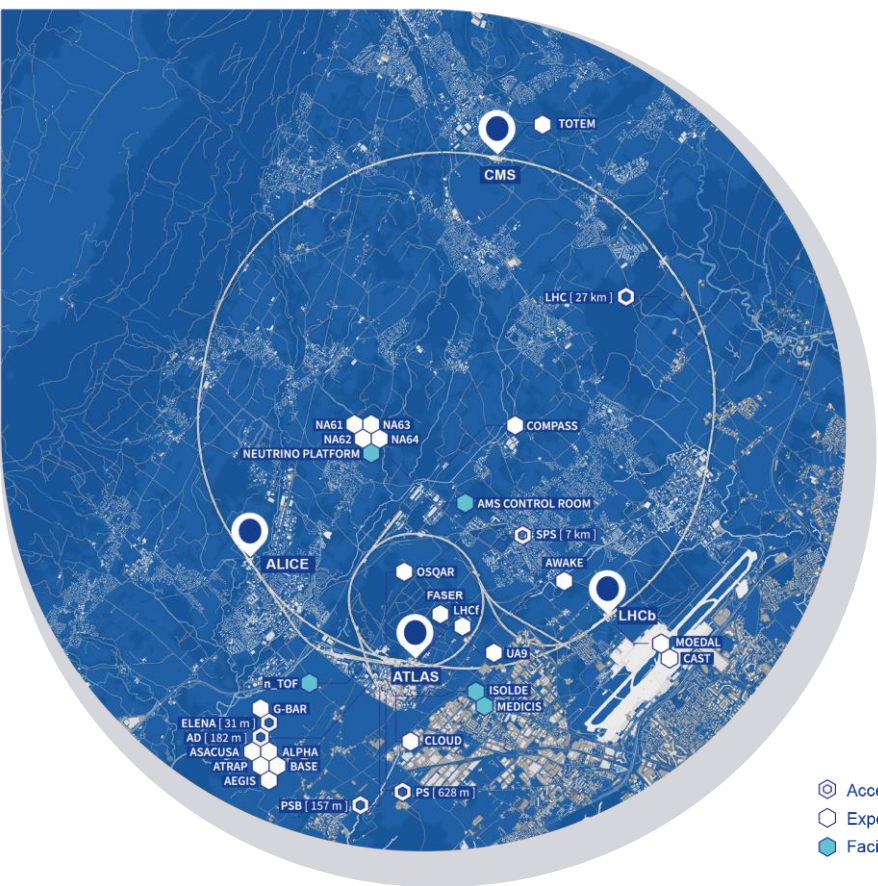
**Today research in particle physics is carried out mainly at:**

- **Charles University**
- **Czech Academy of Sciences**
- **Czech Technical University in Prague**
- **Liberec Technical University**
- **Palacky University**
- **University of West Bohemia**

21 May, 2019; Senate Vice President J. Hornik signing the guest book with CERN Director for International Relations C. Warakaulle.



# Czech Republic has a strong involvement across the whole CERN experimental programme



## LHC EXPERIMENTS:

- ALICE** 3 Institutes, 37 Participants
- ATLAS** 5 Institutes, 155 Participants
- CMS** 1 Institute, 8 Participants

## OTHER LHC Experiments

- TOTEM** 2 Institutes, 11 Participants

## FIXED TARGET EXPERIMENTS

- COMPASS** 4 Institutes
- nTof** 1 Institutes
- NA62** 1 Institute
- Neutrino Platform** 5 Institutes

8 institutes, 57 Participants

## ISOLDE

2 institutes, 7 Participants

## ANTI-PROTON EXPERIMENTS

- AEGIS**  
1 institute, 2 Participants

## A high-performance Tier-2 centre is in operation in Prague

- Almost 7 PB of storage (more than 1.5 million DVDs), 10000 parallel jobs for HEP
- Collaboration with IT for Innovations, High performance Computing centre in Ostrava
- Resources usage: 74% CERN experiments, 16% astronomy, 10% Fermilab





# Czech Republic and Industrial Sector

## HIGH-TECH SECTOR:

### VAKUUM PRAHA

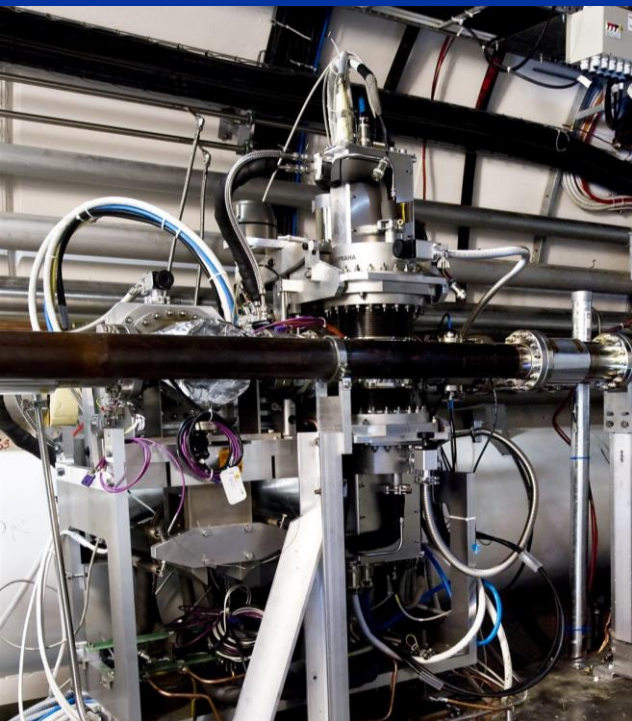
- All sorts of components and complete systems for Ultra-high vacuum
- Roman pots for Totem experiment

### CRYTUR

- Provider of scintillators, sapphire windows and profiles
- Crypix particle/radiation monitor based on Medipix
- LHCb Spaghetti calorimeter (SPACAL) prototype

### ADVACAM

- Detectors using Timepix technology for scanning object up to relatively large sizes
- Unravel secrets of paintings, e.g. a [lost painting by Raphael](#)



## INDUSTRIAL SECTOR:

### PRINTED

- Fabrication of printed circuit boards

### POZEMNÍ STAVBY JIHLAVA

- Reconstruction of CERN hostel buildings

## INDUSTRIAL RETURN:

- 2016-2020 returned to the Czech Republic **14.5MCHF** in form of industrial contracts
- Classified as well-balanced country







# Slovakia has a strong tradition in particle physics



**Slovakia became a CERN Member state in 1993**

**Today research in particle physics is carried out mainly at:**

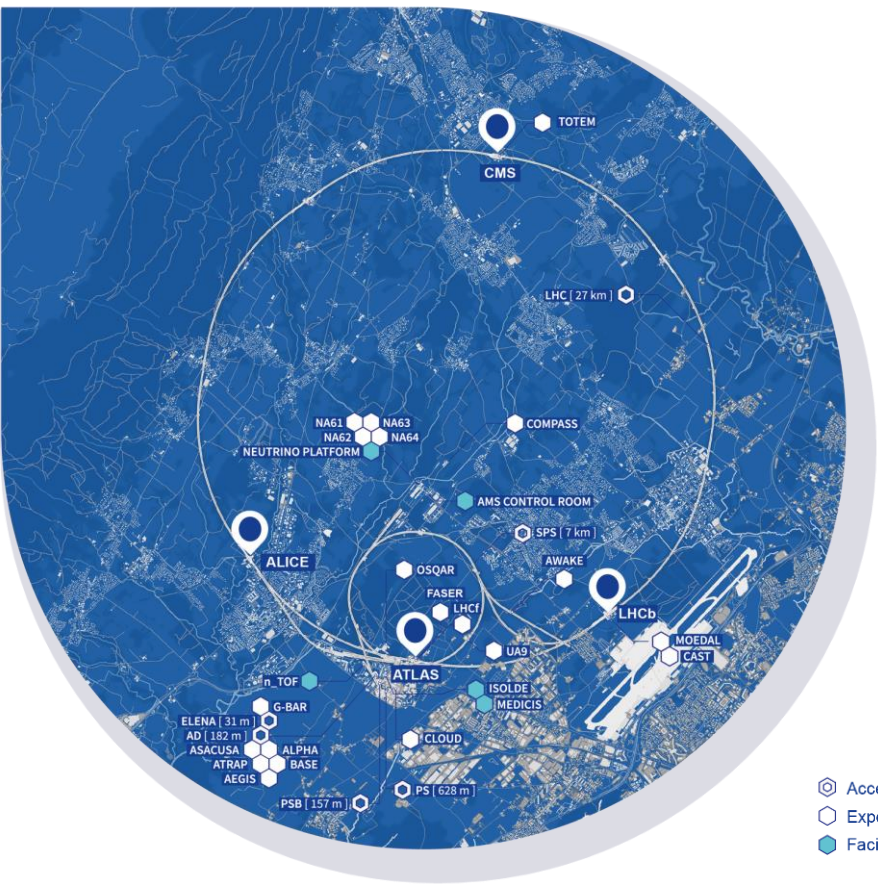
- Comenius University Bratislava
- Šafárik University Košice
- Technical University at Košice
- Matej Bel University at Banská Bystrica
- University od Žilina
- Slovak Academy of Sciences (Bratislava and Košice)

11 September 2012 - President of the Slovak Republic I. Gašparovič and First Lady visiting the ALICE experimental area and LHC tunnel at Point 2 with CERN Director-General R. Heuer





# Slovakia has a long-standing association with experiments at CERN



**LHC EXPERIMENTS:**  
**ALICE** 4 Institutes, 29 Participants  
**ATLAS** 3 Institutes, 29 Participants

**FIXED TARGET EXPERIMENTS:**  
**NA62** 1 institute, 10 Participants  
**ISOLDE** 2 institutes, 16 Participants

41 Members from Comenius University and the Academy of Sciences participate in ALICE and ATLAS

ATLAS Collaboration meeting was in Bratislava in October 2017



# Contributions to the LHC project from Industry in Slovakia



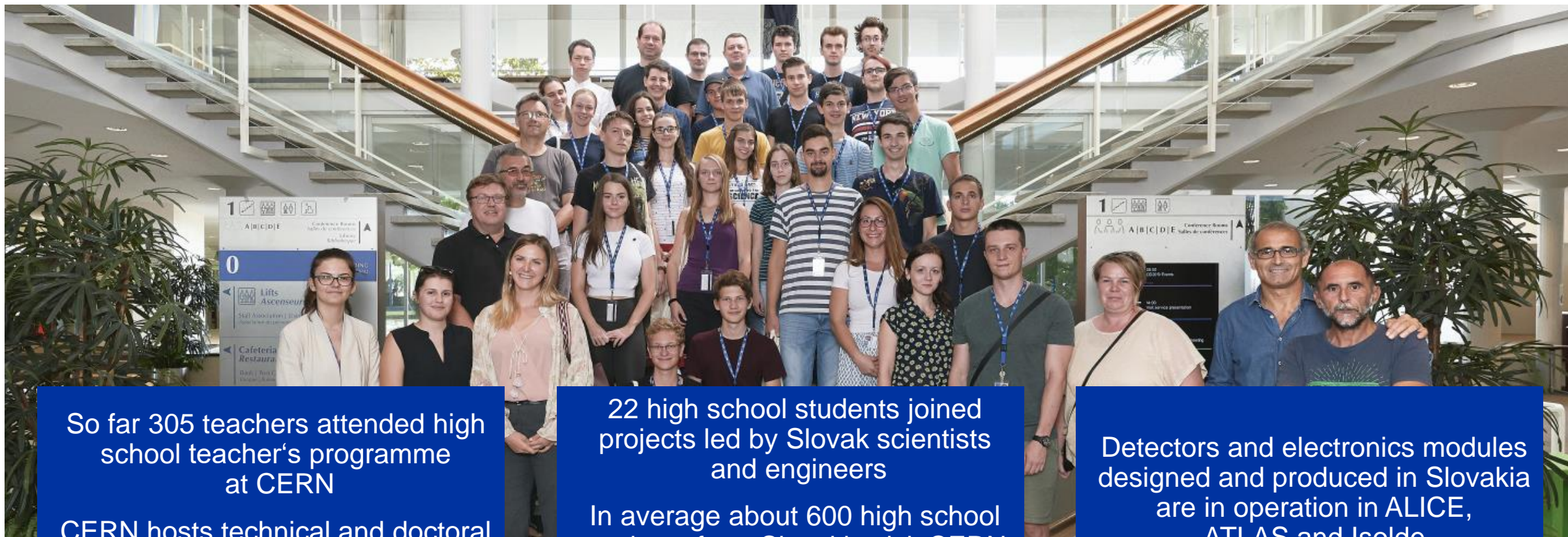
Grey cryostat for LHC short straight section magnets produced at SES (Slovenské energetické strojárne) in Tlmače

Robots carry LHC magnets and align them with magnet support jacks made by ZŤS (Závody ťažkého strojárstva) in Košice

ZŤS won a prestigious LHC Industry award



## Slovakia actively takes part in knowledge and technology transfer



So far 305 teachers attended high school teacher's programme at CERN

CERN hosts technical and doctoral students from Slovakia

22 high school students joined projects led by Slovak scientists and engineers

In average about 600 high school students from Slovakia visit CERN each year

Detectors and electronics modules designed and produced in Slovakia are in operation in ALICE, ATLAS and Isolde





There are many unanswered questions  
in fundamental physics

**CERN will continue to play a crucial role  
in the journey of exploration**