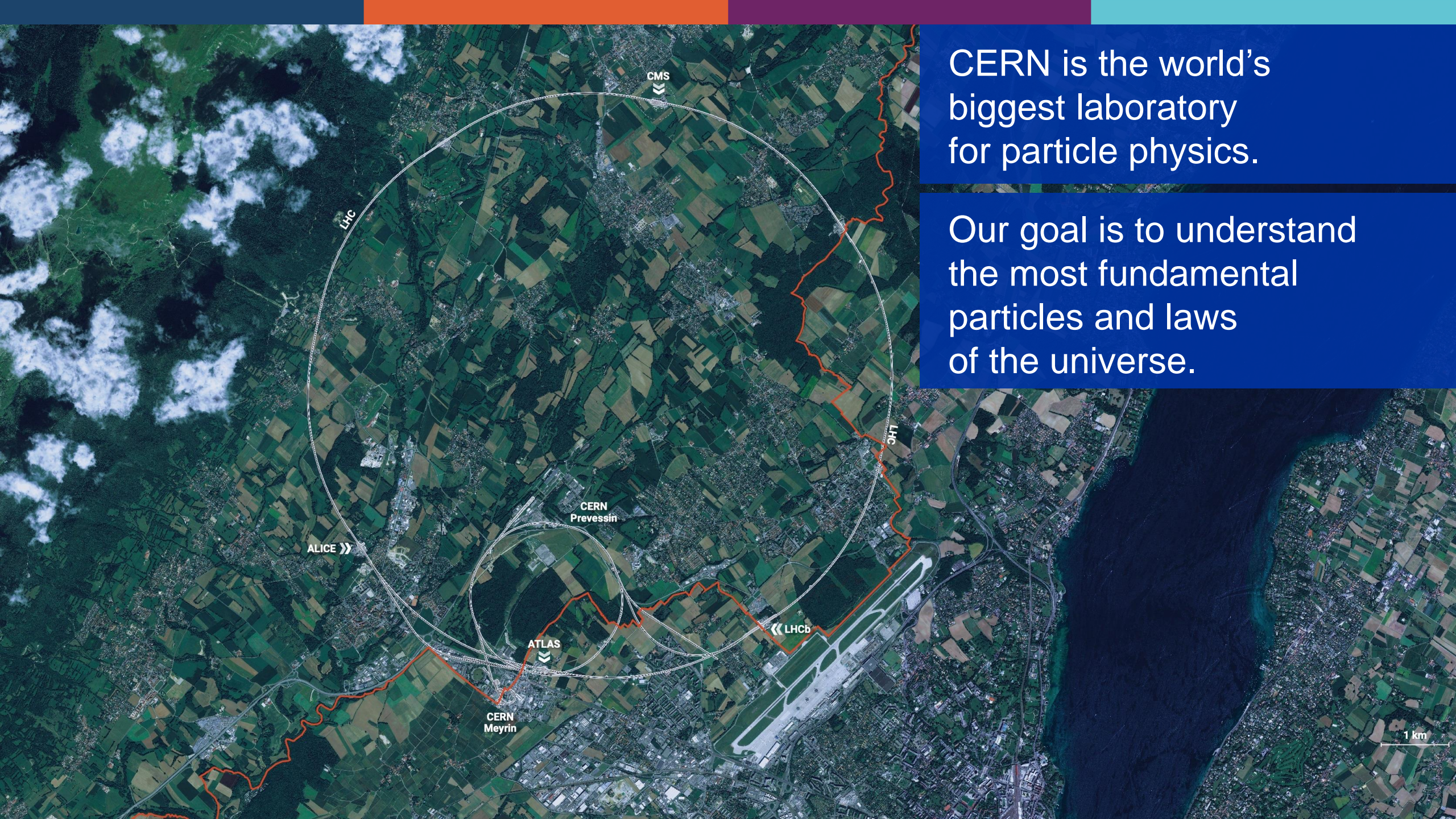




**WELCOME TO CERN**

**Manfred Krammer**  
**Head of the Experimental Physics Department**



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



A low-angle photograph of several flagpoles against a clear blue sky. The sun is visible in the upper right quadrant, creating a lens flare. The flagpoles are arranged in a diagonal line from the bottom left towards the top right. Various national flags are flying from the poles, including the Spanish flag, the Greek flag, the Italian flag, the German flag, the Danish flag, the Hungarian flag, the Finnish flag, and the flag of the European Union. A large, semi-transparent orange circle is overlaid on the left side of the image, containing the word "COLLABORATION" in white, uppercase, sans-serif font.

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 2022  
Employees:  
**2658** staff, **900** fellows

Associates:  
**11 860** users, **1516** others

# A laboratory for people around the world

Distribution of all CERN Users by the country of their home institutes as of 31 December 2022



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



## Numbers for country

- Personnel by nationality as of 31 December 2022
  - **89 users**
  - **56 staff**
  - **14 fellows**

## Member States **7147**

Austria 85 – Belgium 129 – Bulgaria 43 – Czech Republic 244  
Denmark 49 – Finland 90 – France 844 – Germany 1225  
Greece 119 – Hungary 73 – Israel 64 – Italy 1527  
Netherlands 169 – Norway 79 – Poland 305 – Portugal 100  
Romania 109 – Serbia 33 – Slovakia 70 – Spain 383  
Sweden 103 – Switzerland 406 – United Kingdom 898

## Associate Member States in the pre-stage to membership **69**

Cyprus 15 – Estonia 30 – Slovenia 24

## Associate Member States **382**

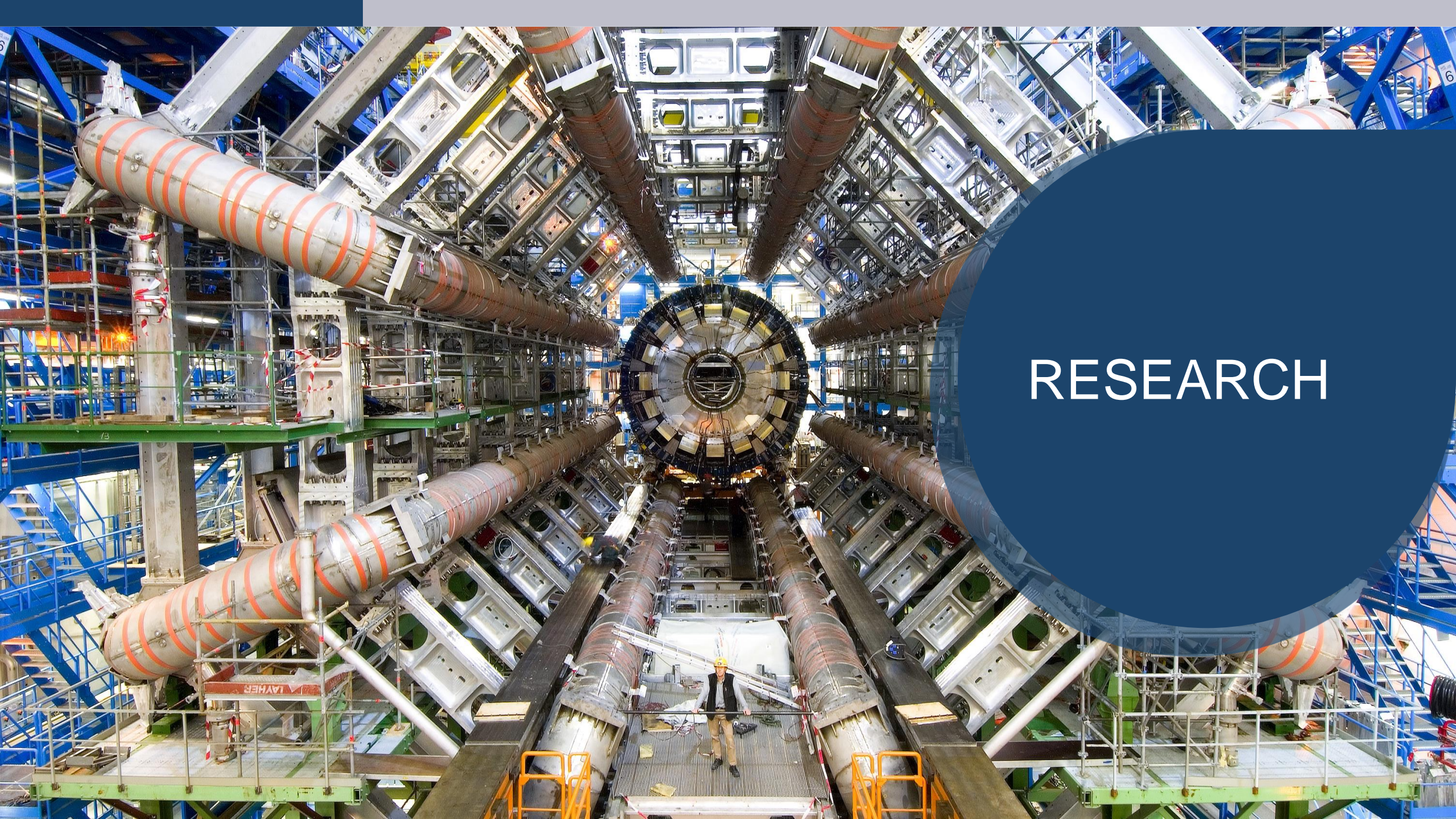
Croatia 38 – India 132 – Latvia 16 – Lithuania 14 – Pakistan 35  
Türkiye 122 – Ukraine 25

## Observers **2991**

Japan 216 – Russia (suspended) 873 – United States of America 1902

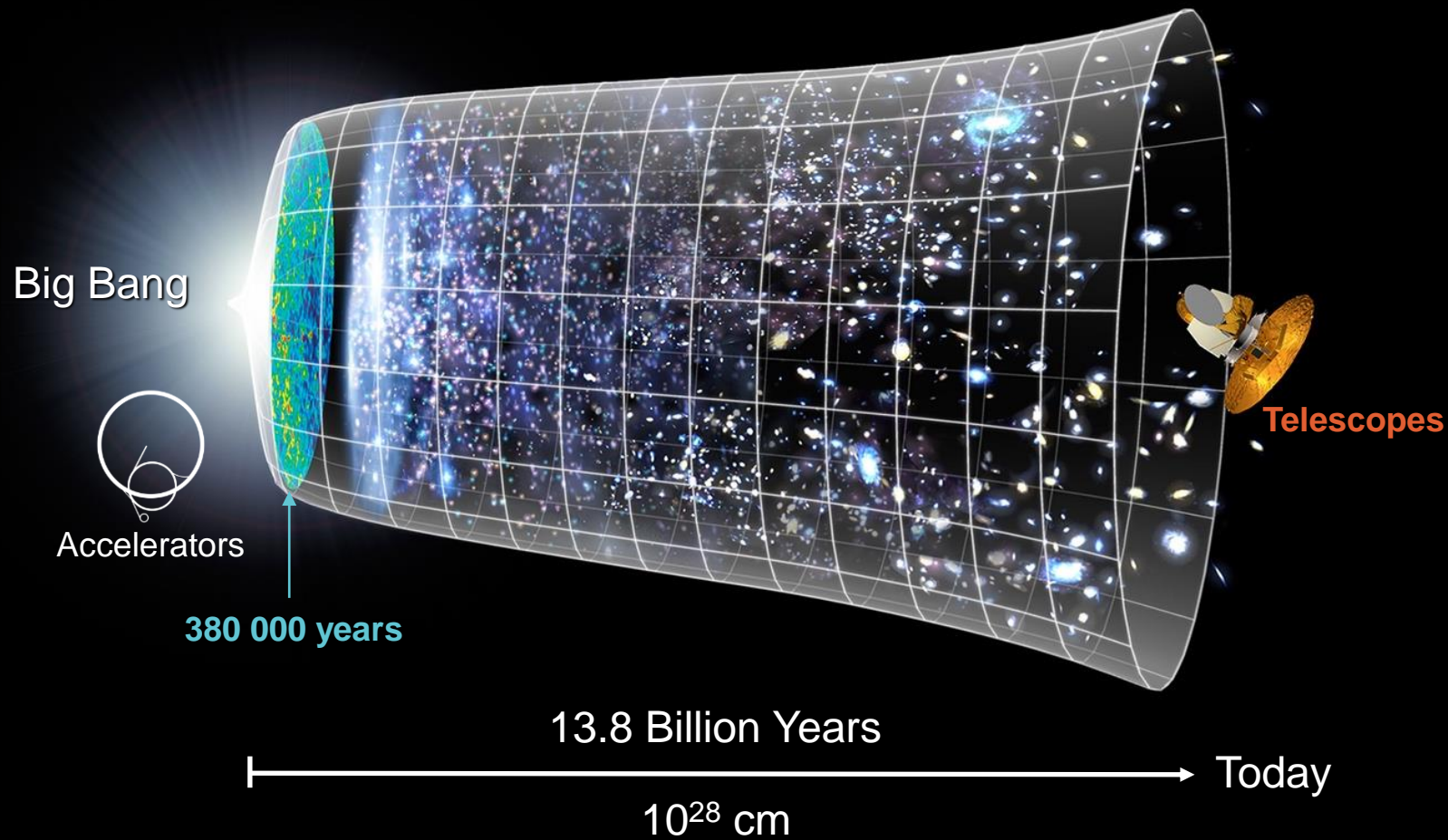
## Non-Member States and Territories **1271**

Algeria 2 – Argentina 13 – Armenia 8 – Australia 21 – Azerbaijan 2 – Bahrain 4 – Belarus 18 – Brazil 122  
Canada 199 – Chile 34 – Colombia 21 – Costa Rica 2 – Cuba 3 – Ecuador 4 – Egypt 20 – Georgia 32  
Hong Kong 15 – Iceland 3 – Indonesia 5 – Iran 11 – Ireland 5 – Jordan 5 – Kuwait 4 – Lebanon 13 – Madagascar 1  
Malaysia 4 – Malta 1 – Mexico 49 – Montenegro 4 – Morocco 19 – New Zealand 5 – Nigeria 1 – Oman 1  
Palestine 1 – People's Republic of China 333 – Peru 2 – Philippines 1 – Republic of Korea 147 – Singapore 2  
South Africa 52 – Sri Lanka 10 – Taiwan 45 – Thailand 17 – Tunisia 2 – United Arab Emirates 7 – Viet Nam 1



RESEARCH



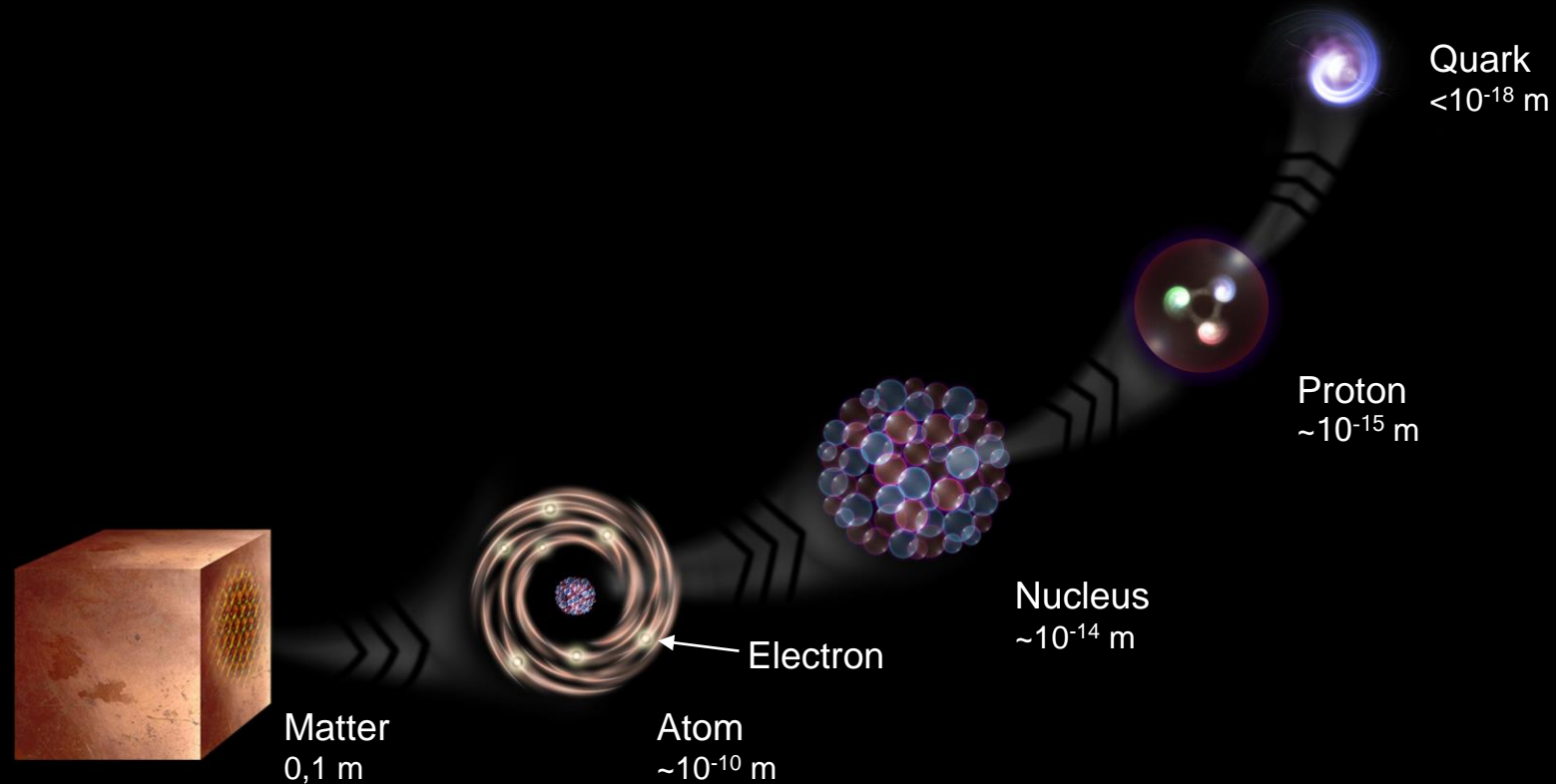


# How did the universe begin?

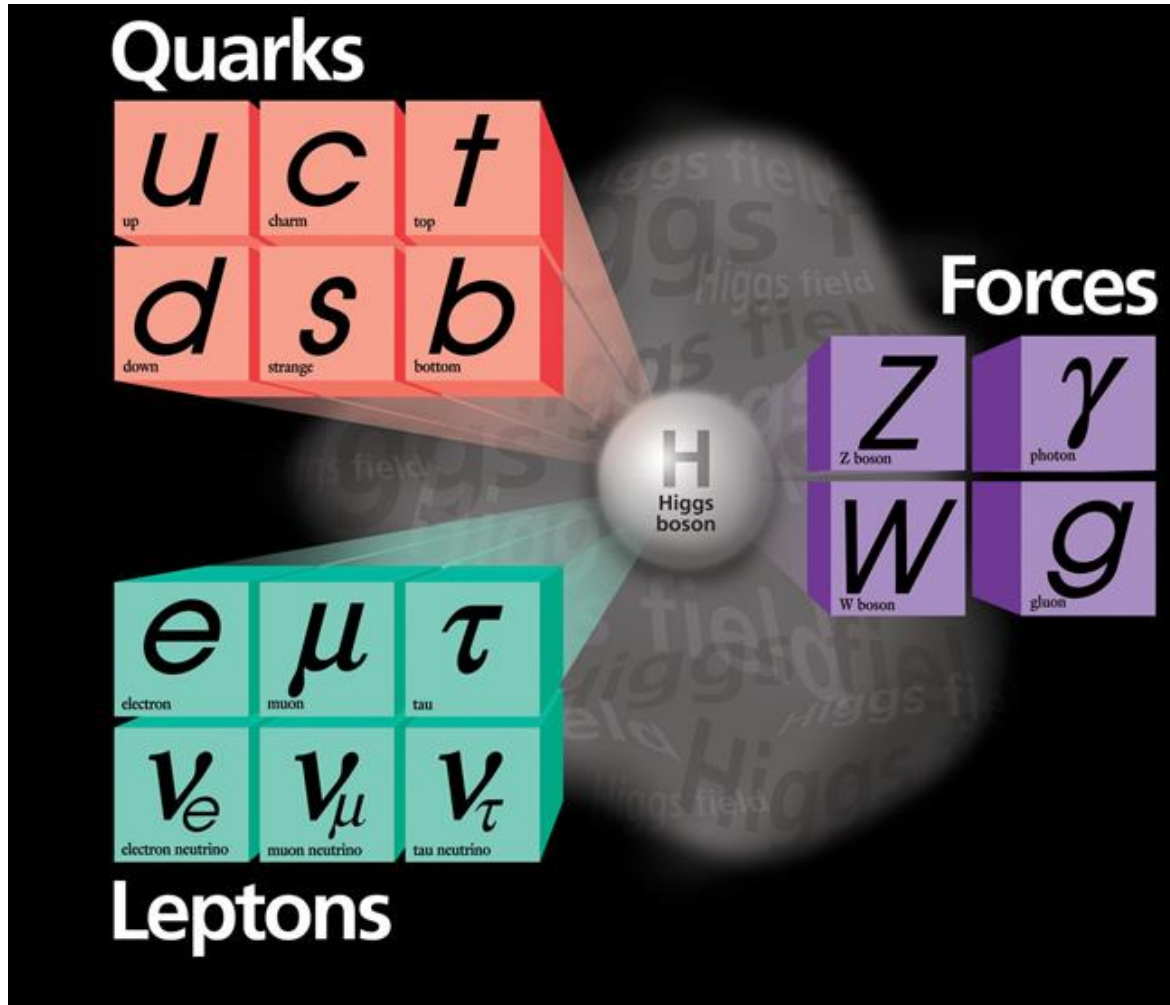
We reproduce the conditions a fraction of a second after the Big Bang, to gain insight into the structure and evolution of the universe.

# What is the universe made of?

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



# The Standard Model of Particle Physics



**Fermions** (spin  $\frac{1}{2}$ ) quarks and leptons: the building blocks of matter

**Bosons** (integer spin) carry the forces: electromagnetic (Photon), weak force (W, Z) and strong force (Gluons)

Higgs Boson (spin 0), gives mass to particles

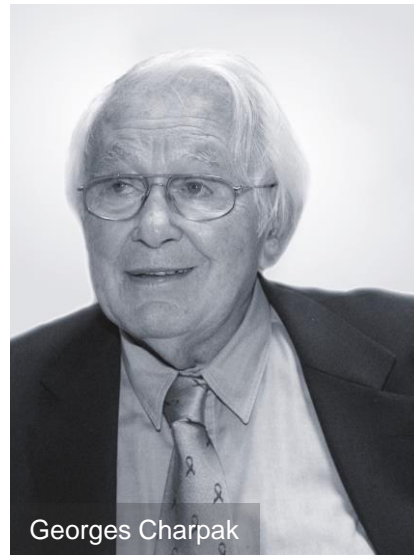
# At CERN we help to answer these questions



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.

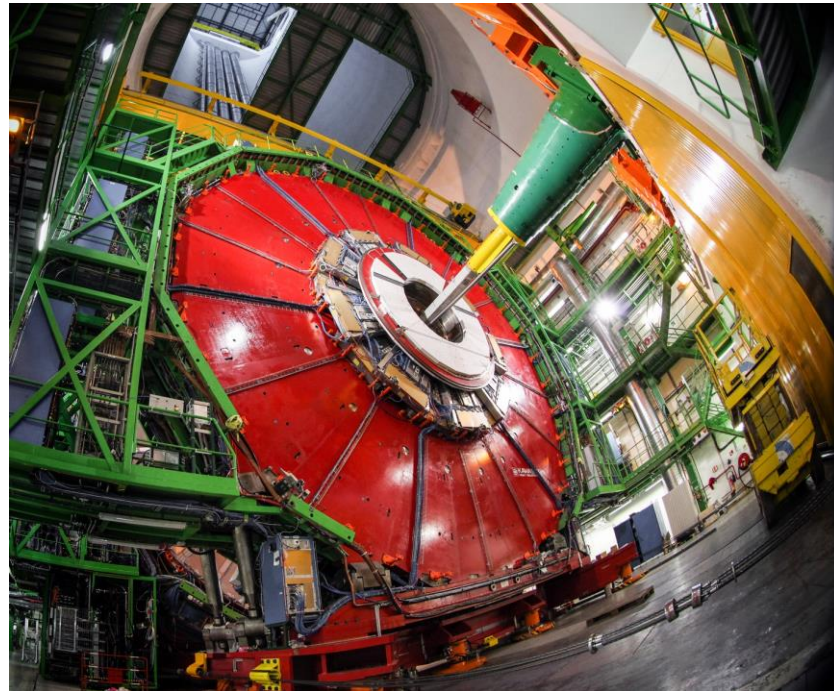


François Englert and Peter Higgs. With Robert Brout, they proposed the mechanism in 1964.

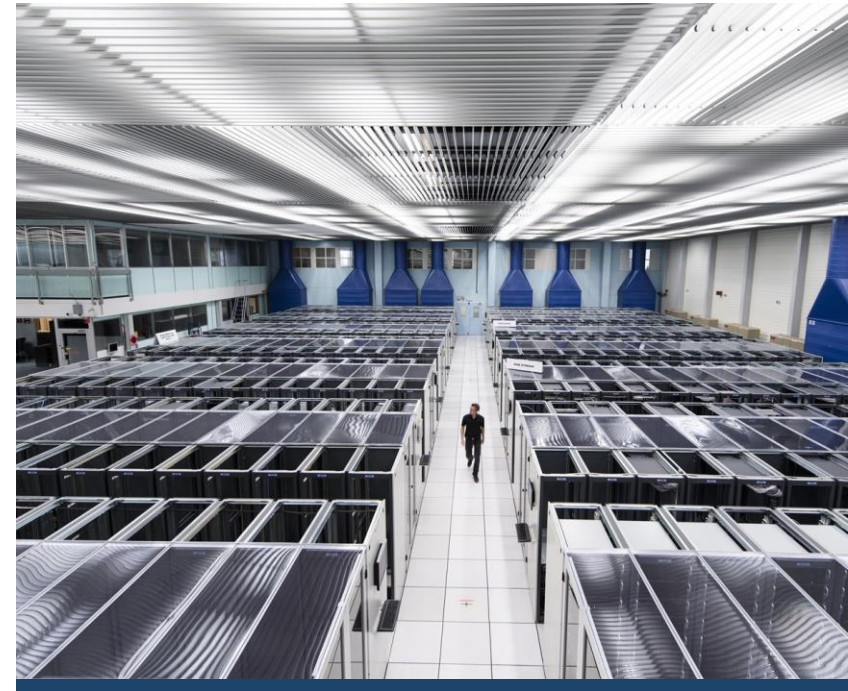
# We develop technologies in three key areas



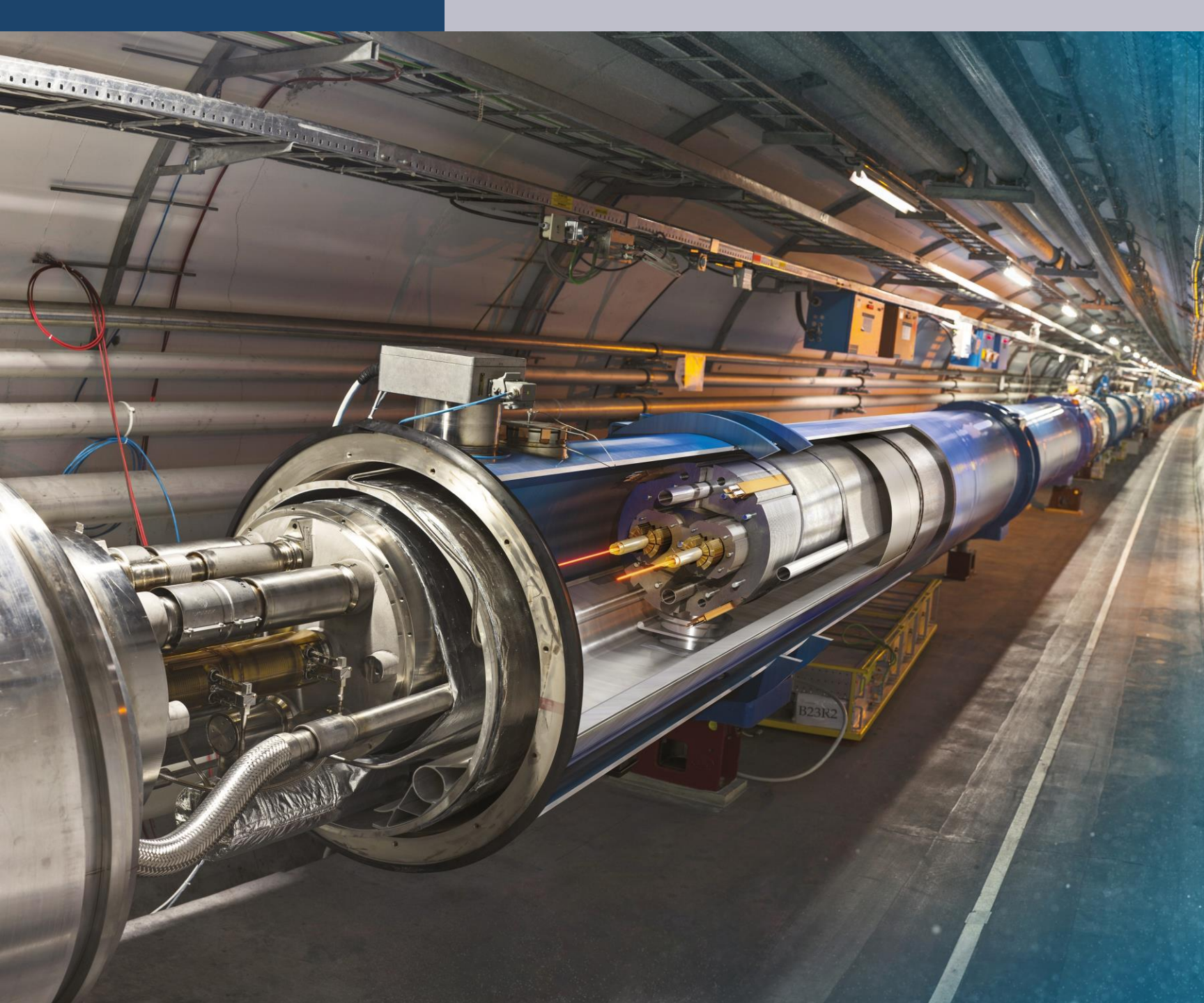
ACCELERATORS



DETECTORS



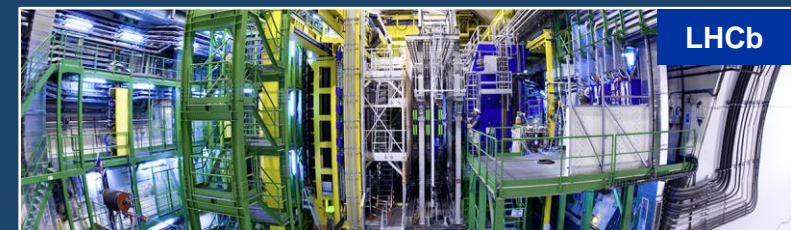
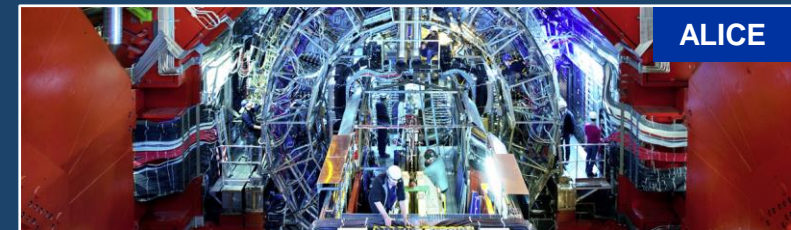
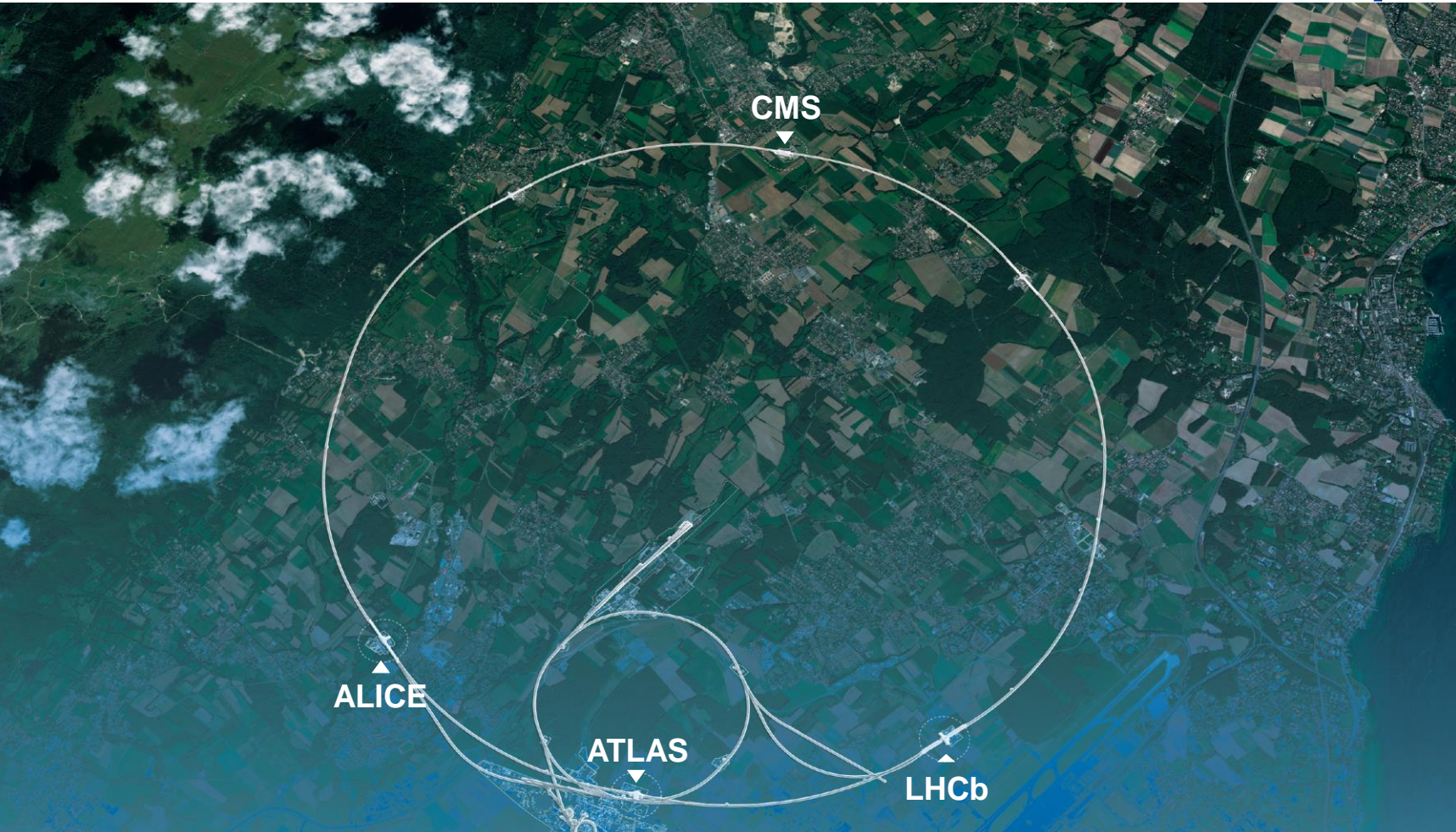
COMPUTING



# Large Hadron Collider (LHC)

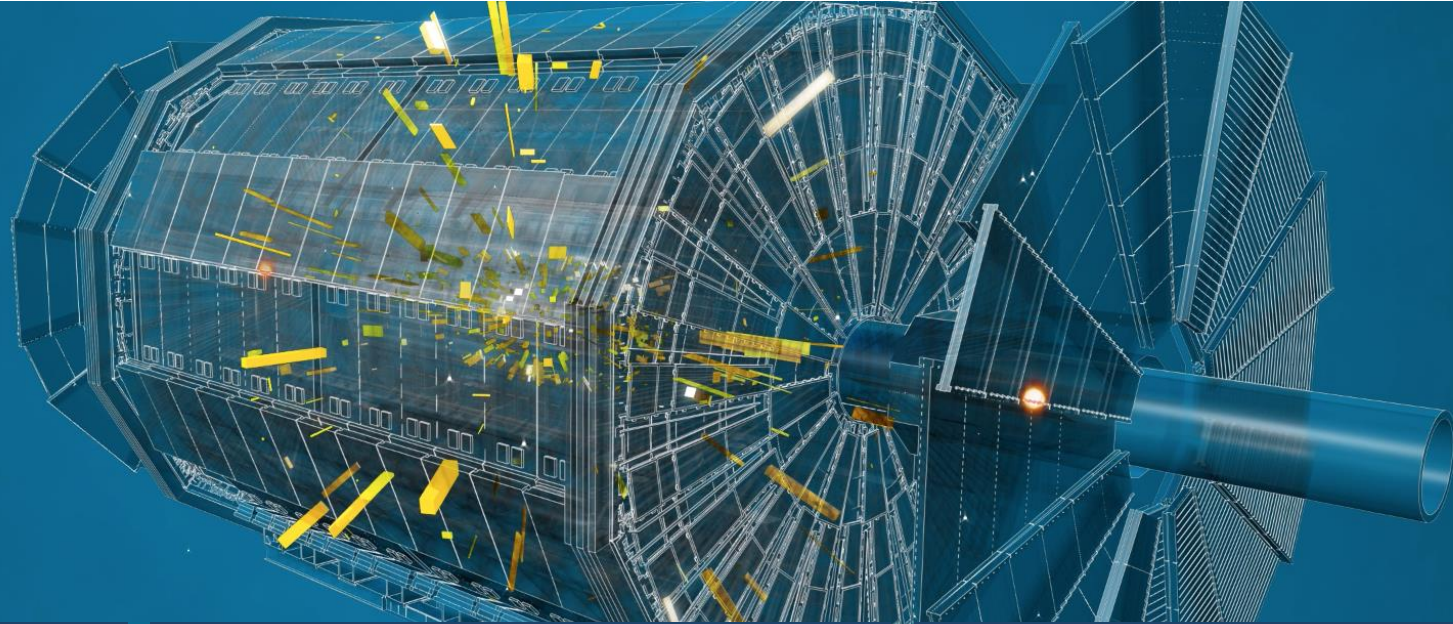
- 27 km in circumference
- About 100 m underground
- Superconducting magnets steer the particles around the ring
- Particles are accelerated to close to the speed of light

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



+ TOTEM, LHCf, MoEDAL-MAPP, FASER, SND@LHC

# The LHC detectors are analogous to 3D cameras



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



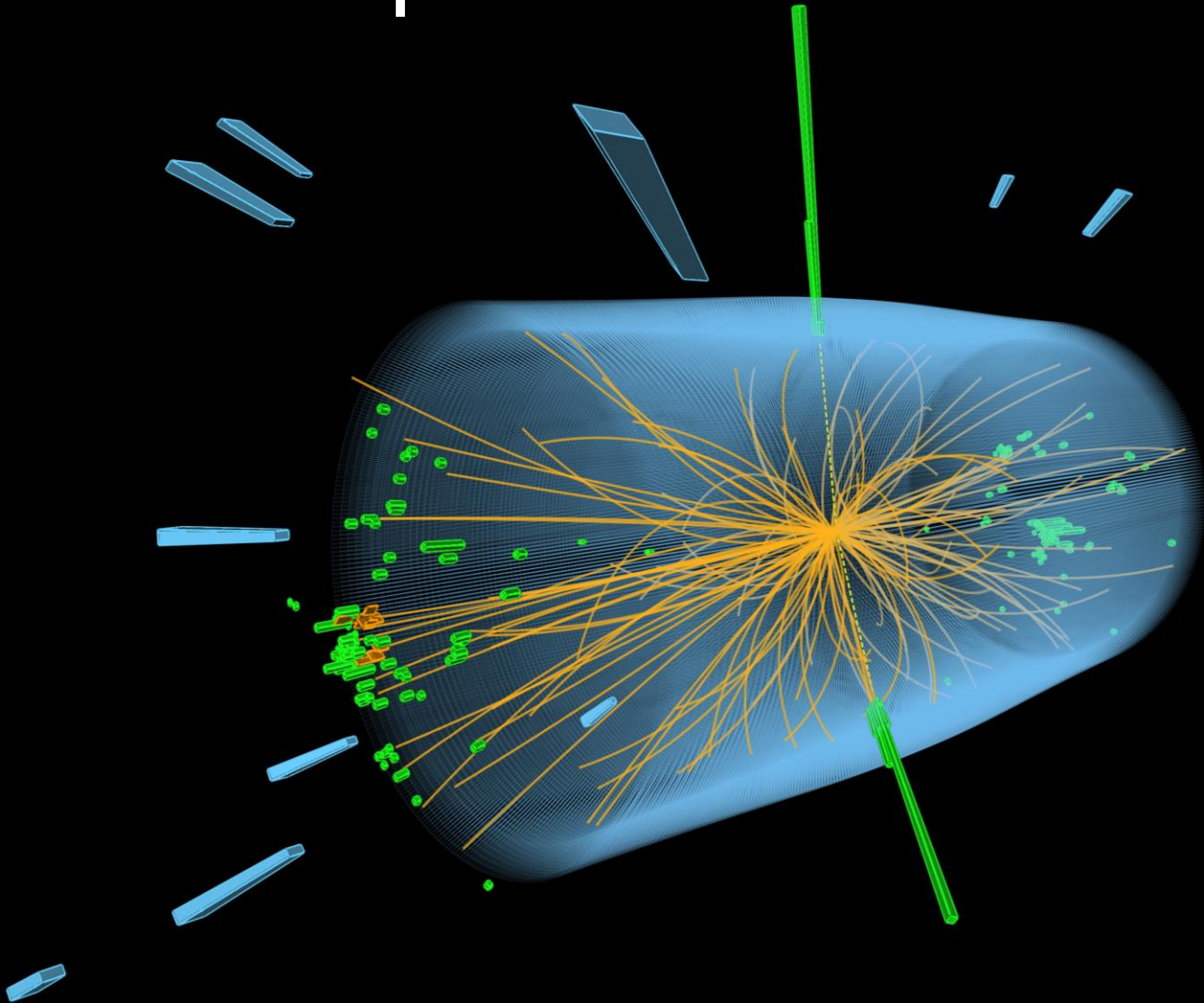
They take 40 million pictures a second. Only 1000 are recorded and stored.



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



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

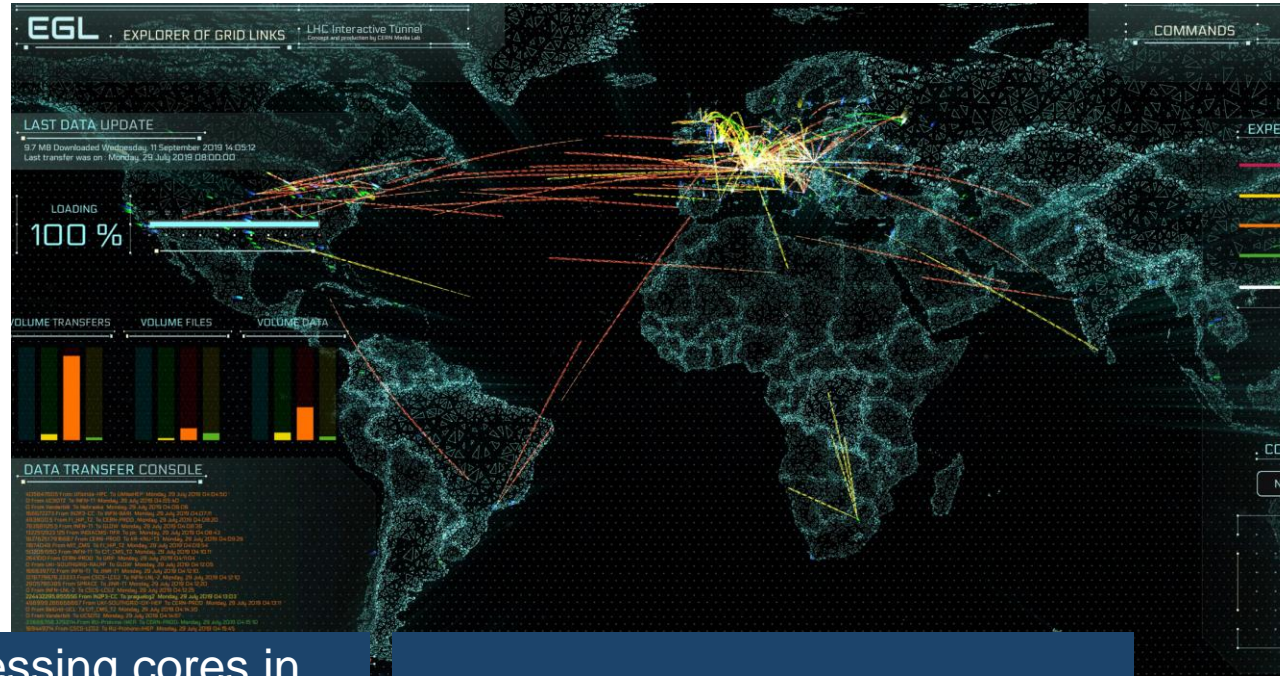


The energy of the particles in collision is converted into new particles.

# The Worldwide LHC Computing Grid (WLCG)



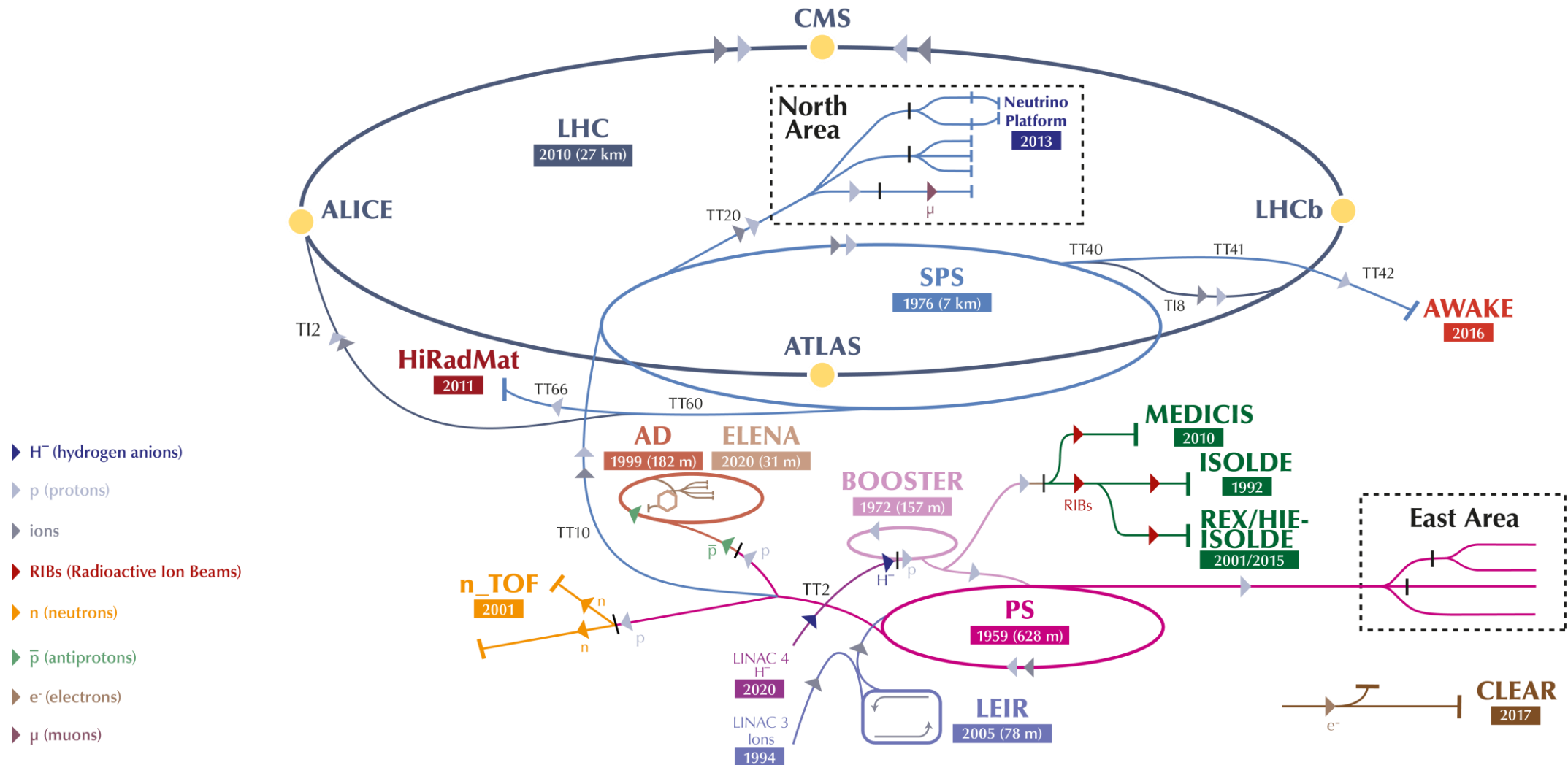
Used to store, distribute, process and analyse data.



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

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

# The CERN accelerator complex

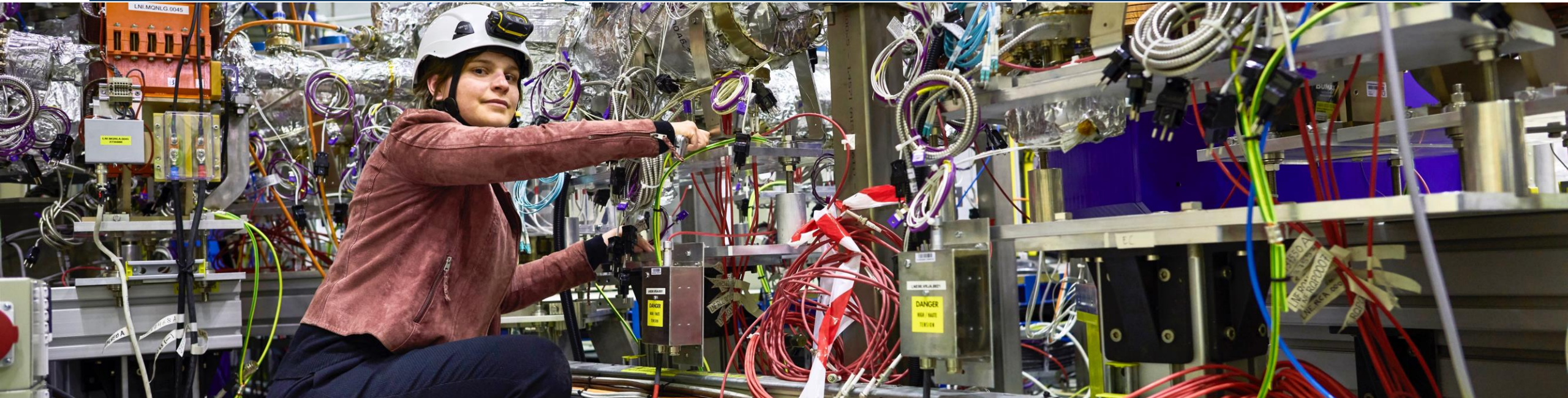


# CERN has a diverse scientific programme

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)

CERN Theory Programme

# There are many unanswered questions in fundamental physics

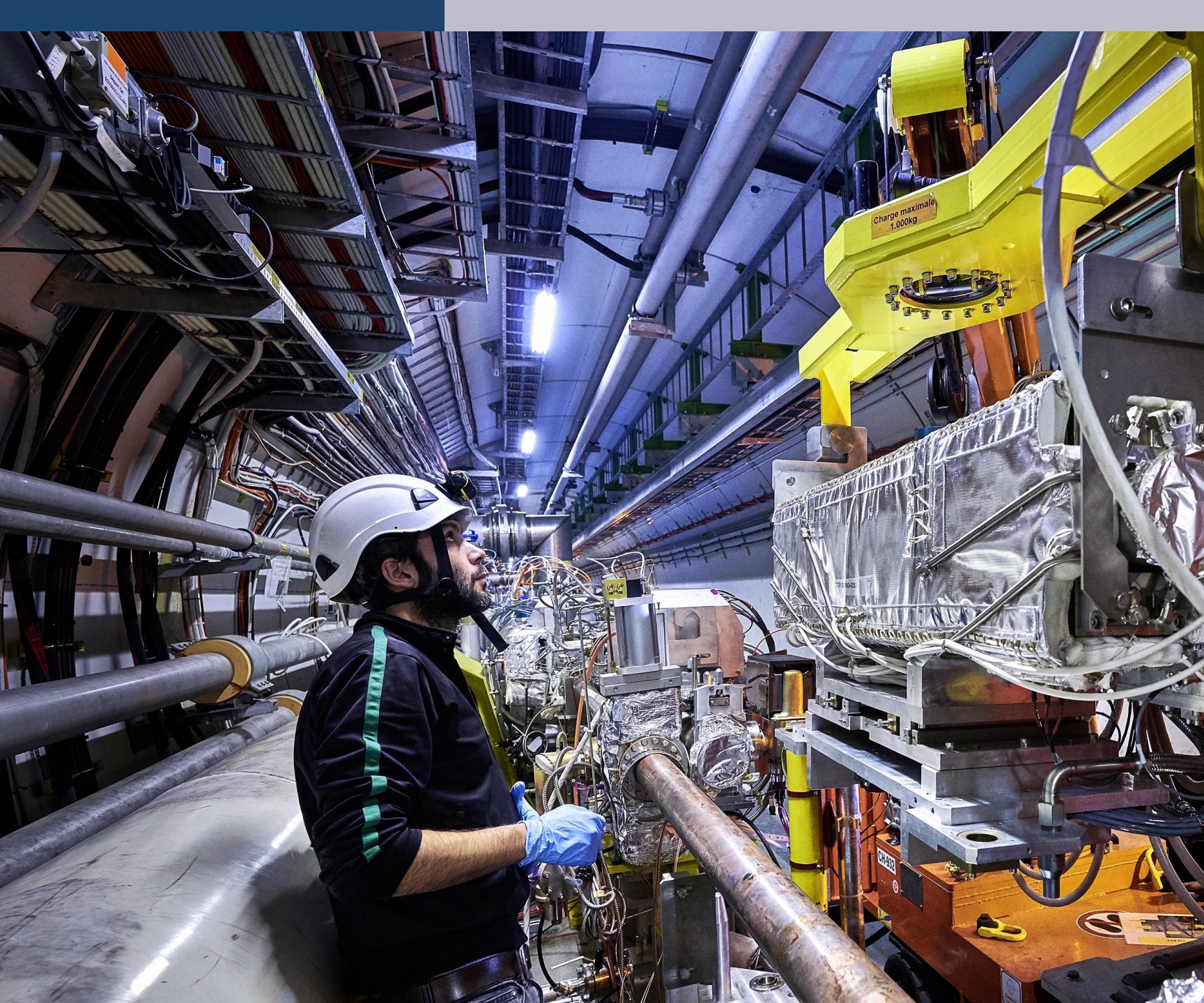
Including

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

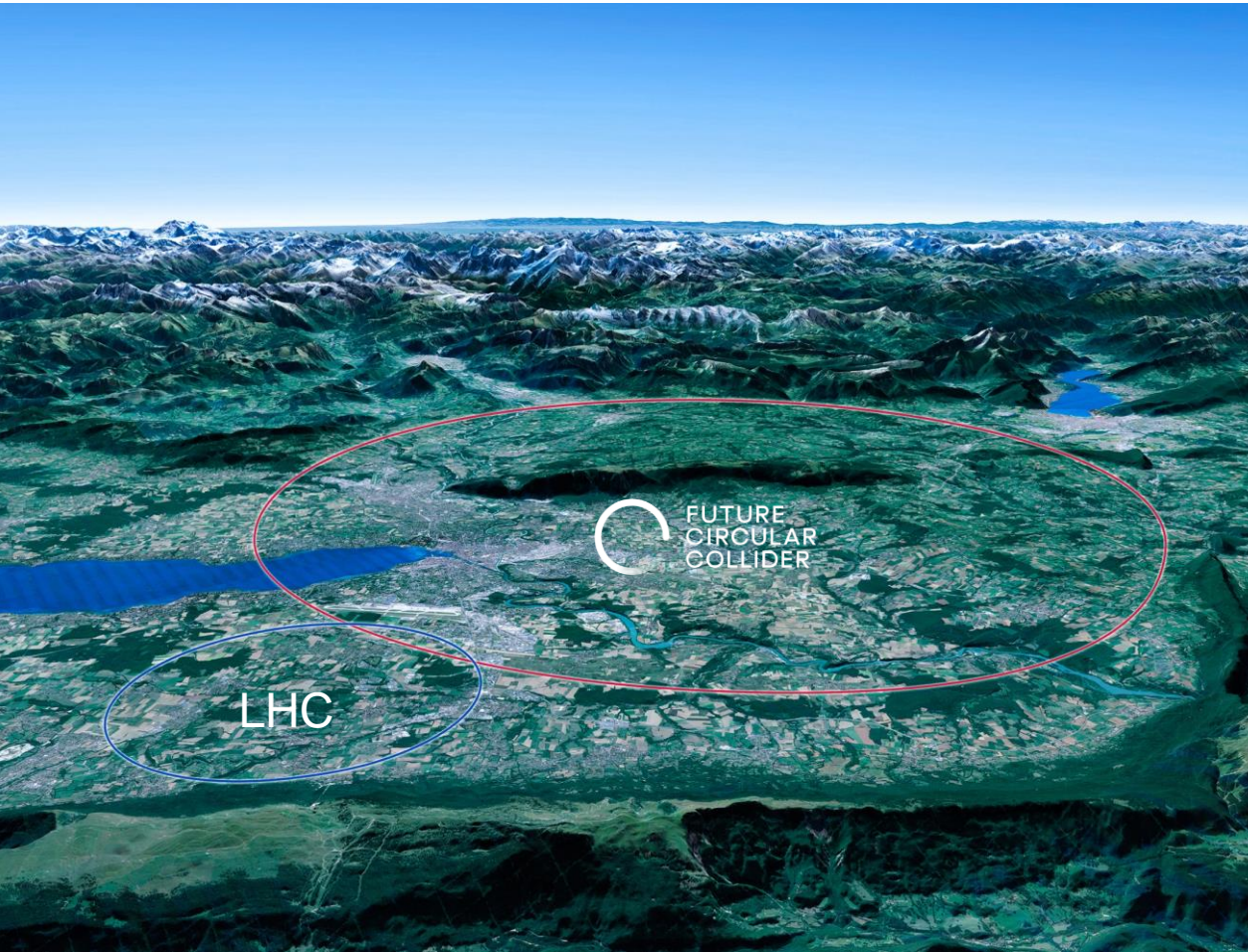
- The HL-LHC will use new technologies to provide 10 times more collisions than the LHC.
- It will give access to rare phenomena, greater precision and discovery potential.
- It will start operating in 2029, and run until approx. 2041.



# 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
- Ramp up relevant R&D
- Continue supporting other projects around the world



# Future Circular Collider

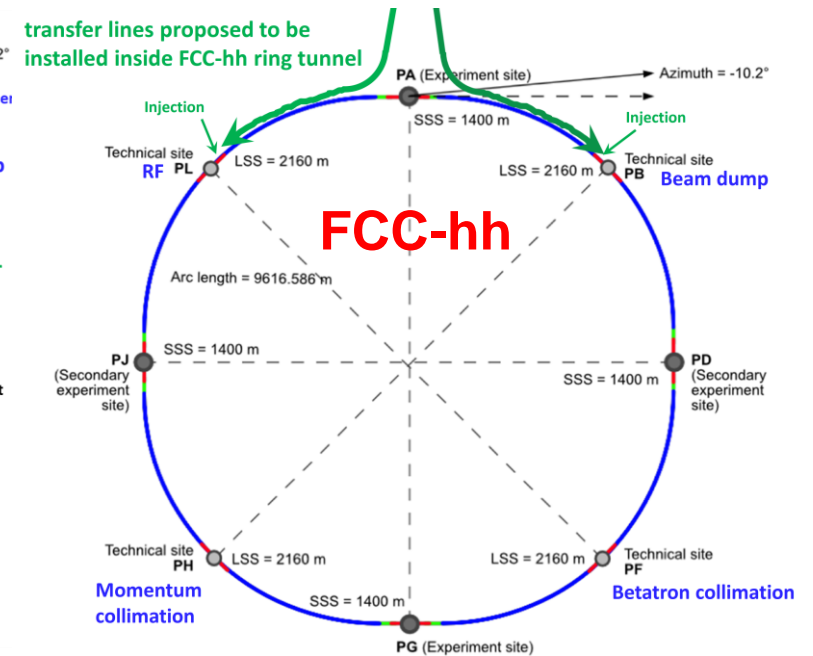
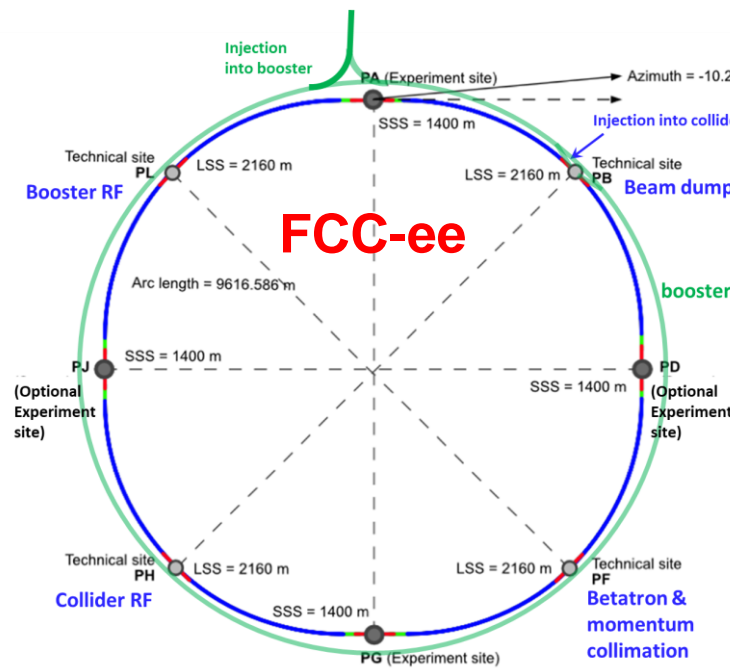
## Comprehensive long-term program maximizing physics opportunities

- stage 1: FCC-ee (Z, W, H,  $t\bar{t}$ ) as Higgs factory, electroweak & top factory at highest luminosities
- stage 2: FCC-hh (~100 TeV) as natural continuation at energy frontier, pp & AA collisions; e-h option

Common civil engineering and technical infrastructures, building on and reusing CERN's existing infrastructure  
 FCC integrated project allows the start of a new, major facility at CERN within a few years of the end of HL-LHC

### Realistic schedule:

- 2025 FCC Feasibility Study delivered
- ~2028 Project approval by CERN Council
- ~2030 Construction of tunnel and FCC-ee starts
- ~2041 HL-LHC ends
- 2045-2048 Operation of FCC-ee  
15 years physics operation
- ~2070 Operation of FCC-hh starts  
~20 years physics operation



2020 - 2040

2045 - 2063

2070 - 2095





# 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**

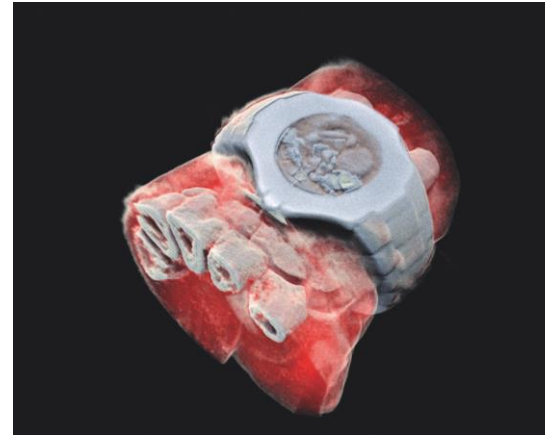
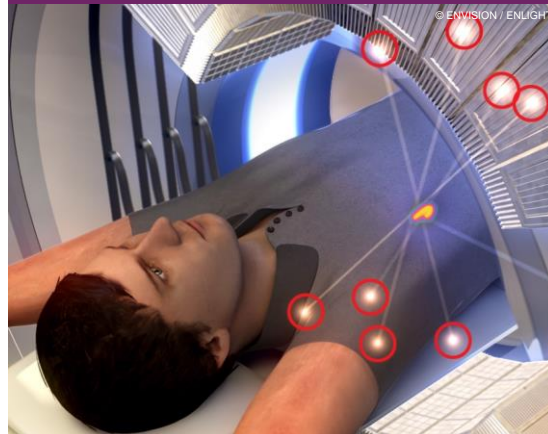
Medical imaging, cancer therapy, material science, cultural heritage, aerospace, automotive, environment, health & safety, industrial processes.

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



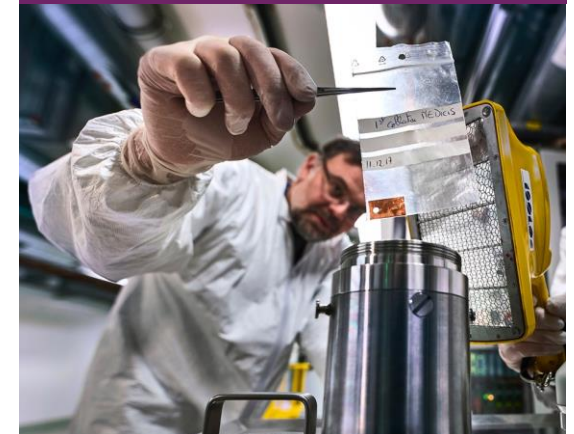
Accelerator technologies are applied in cancer radiotherapy with protons, ions and electrons.

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



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

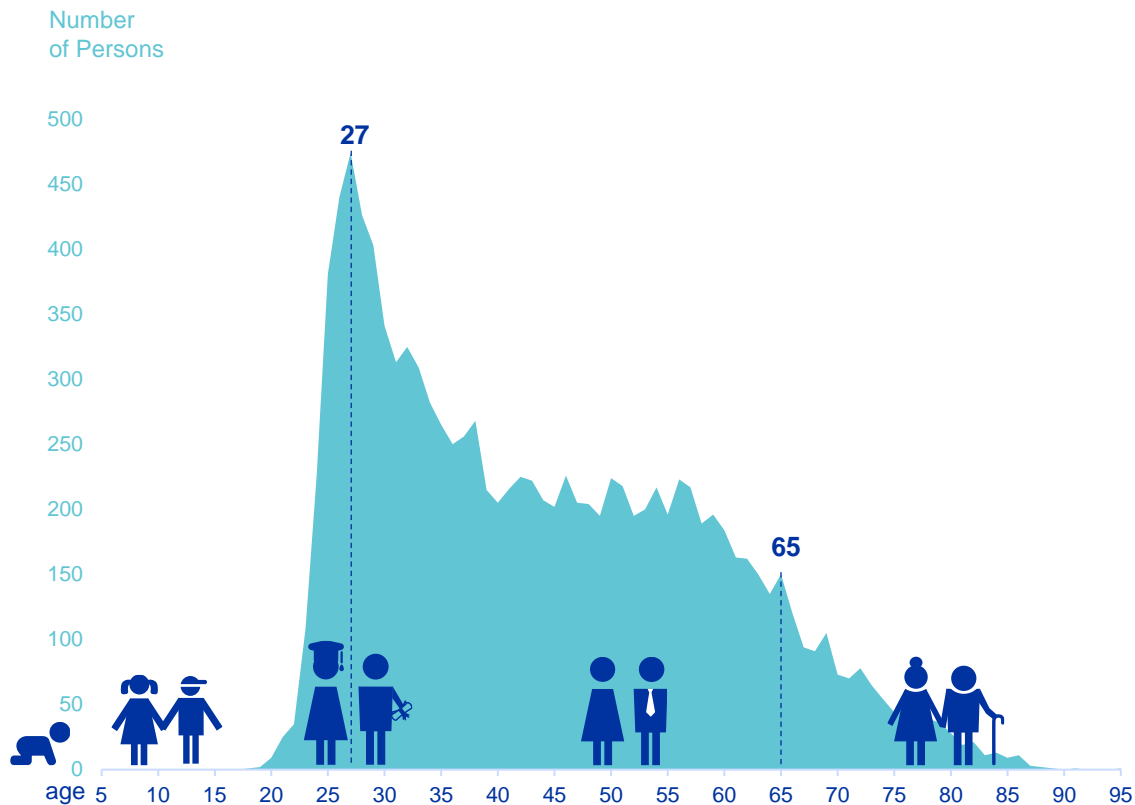
CERN produces innovative radioisotopes for nuclear medicine research.



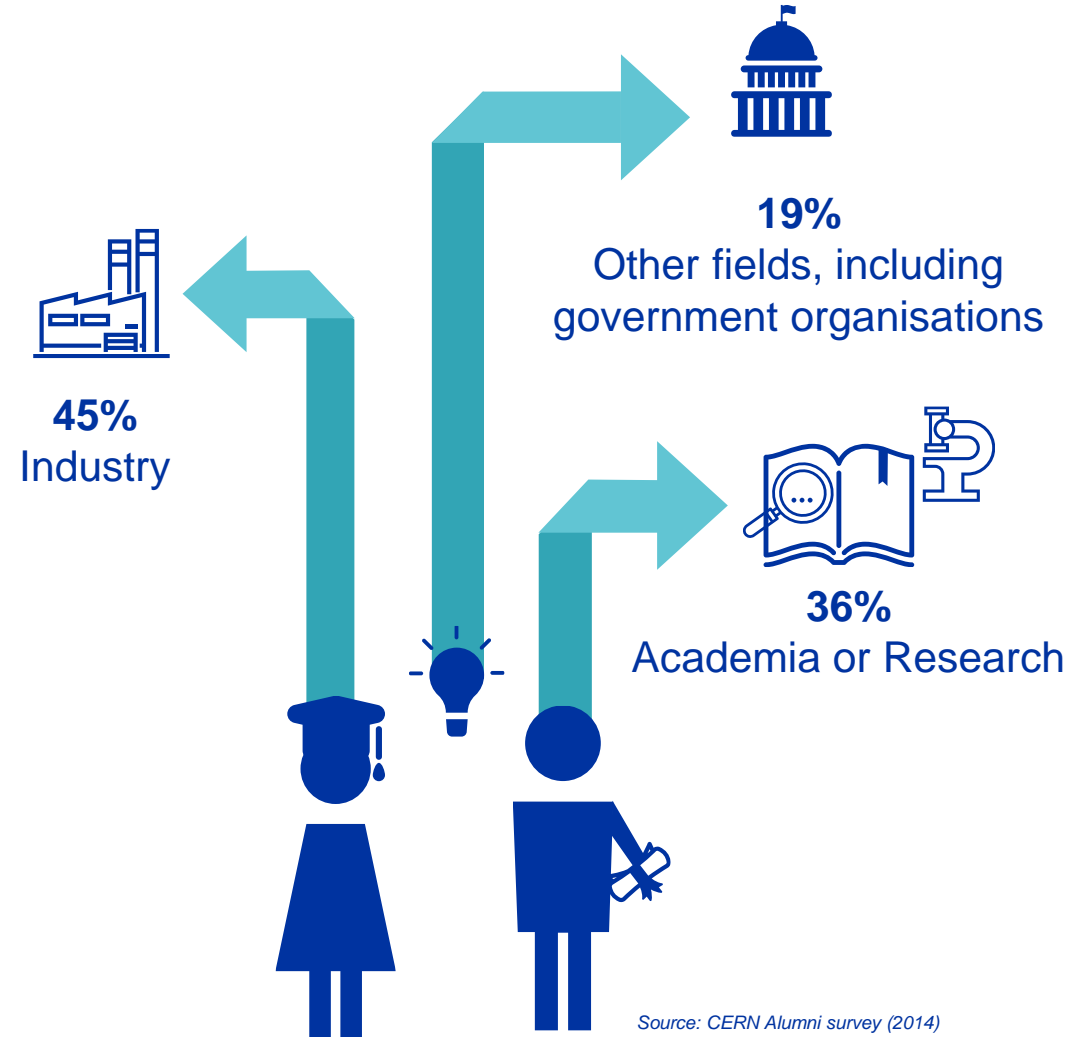
A group of students, both male and female, are wearing hard hats (yellow and blue) and are focused on a large, dark, cylindrical piece of equipment mounted on a metal frame. They appear to be in a laboratory or workshop setting. One student in the foreground is adjusting the equipment. In the background, 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.



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

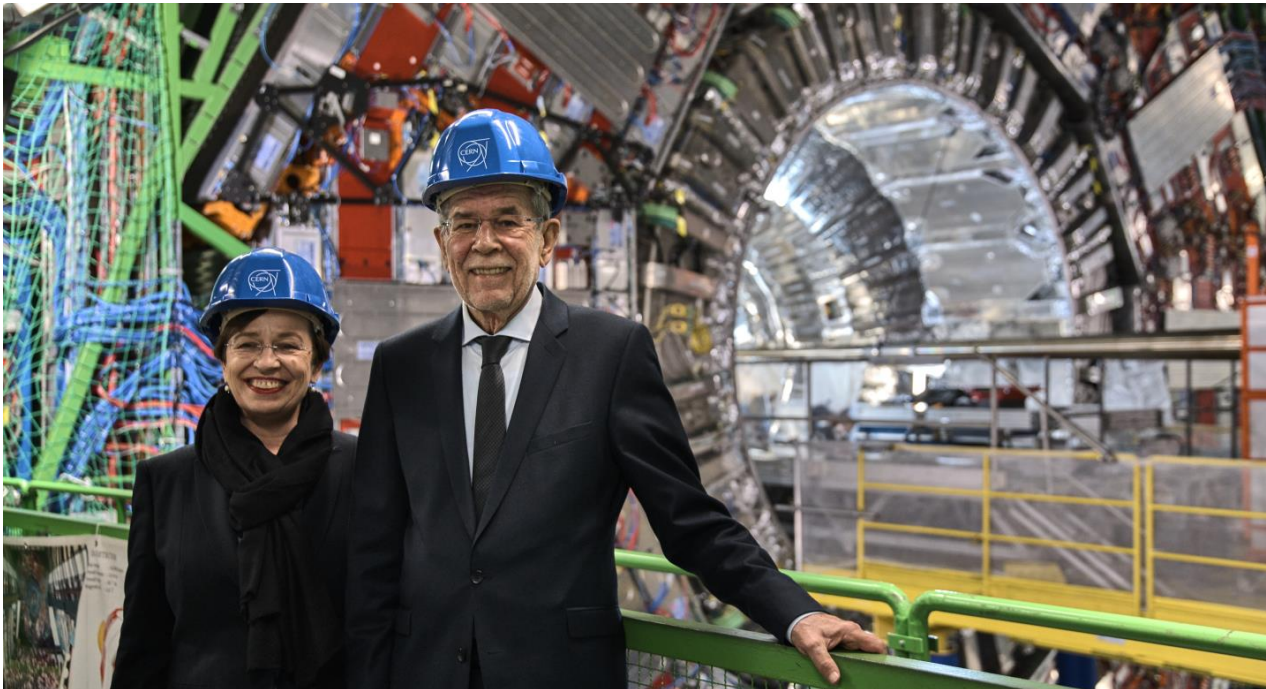


CERN's new education and outreach centre for all publics aged 5-plus.

Inaugurated October 2023.

Immersive exhibitions, education labs, events and shows.

# Austria has a strong tradition in Particle Physics



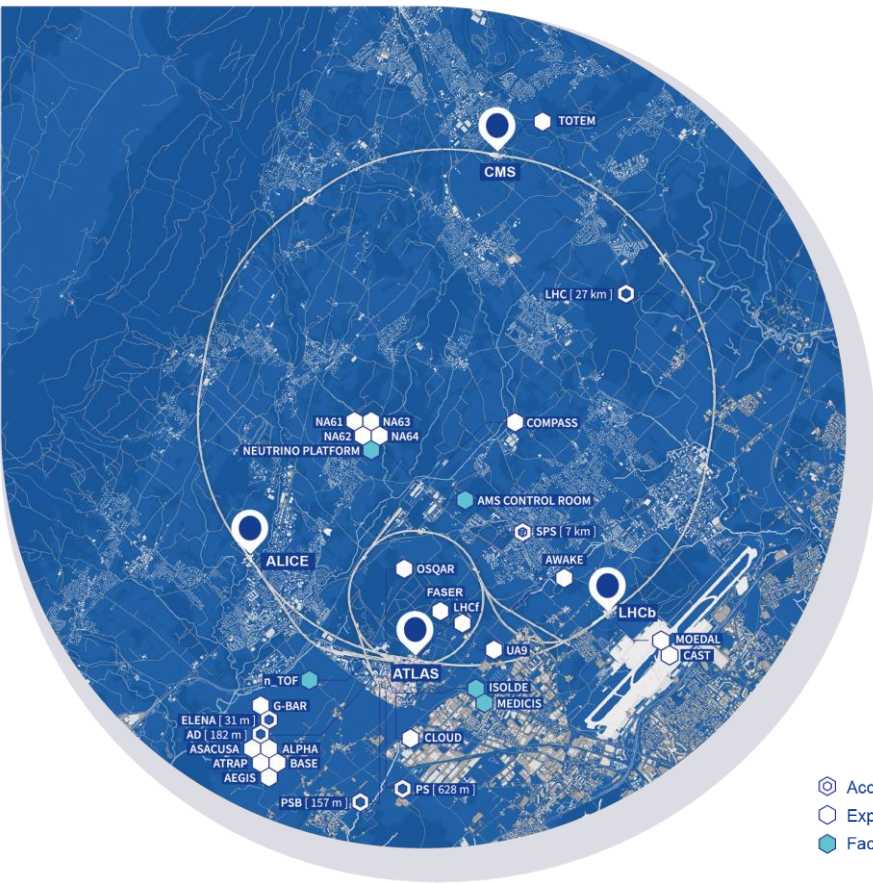
27 February 2018 - Austrian Federal President A. Van der Bellen and Ms Schmidauer in front of the CMS detector at LHC Point 5.

- **Became a Member State of CERN in 1959**
- **Victor Weisskopf (Austrian-American)  
Director General (1961-1965)**
- **Willibald Jentschke  
Director General (1971-1975)**





# Austria has a strong involvement across the CERN experimental programme



## LHC EXPERIMENTS:

**ALICE** 1 Institute, 11 Participants

**ATLAS** 2 Institutes, 13 Participants

**CMS** 1 Institute, 63 Participants

## FIXED TARGET EXPERIMENTS

- CLOUD
  - nToF
- 3 institutes, 11 Participants

**ISOLDE**  
3 institutes, 10 Participants

## ANTIPROTON EXPERIMENTS

- ASACUSA
  - AEGIS
- 2 institutes, 22 Participants

- **LHC Grid Computing Tier-2 centre in Vienna (HEPHY/CLIP)**
- **Significant involvement in studies for the future (FCC) with several institutes/universities strongly involved**
- **Austrian PhD Programme at CERN**
- **MEDAUSTRON**



There are many unanswered questions  
in fundamental physics

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

