

# An Overview of the Research Infrastructure at CERN

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Principal Physicist

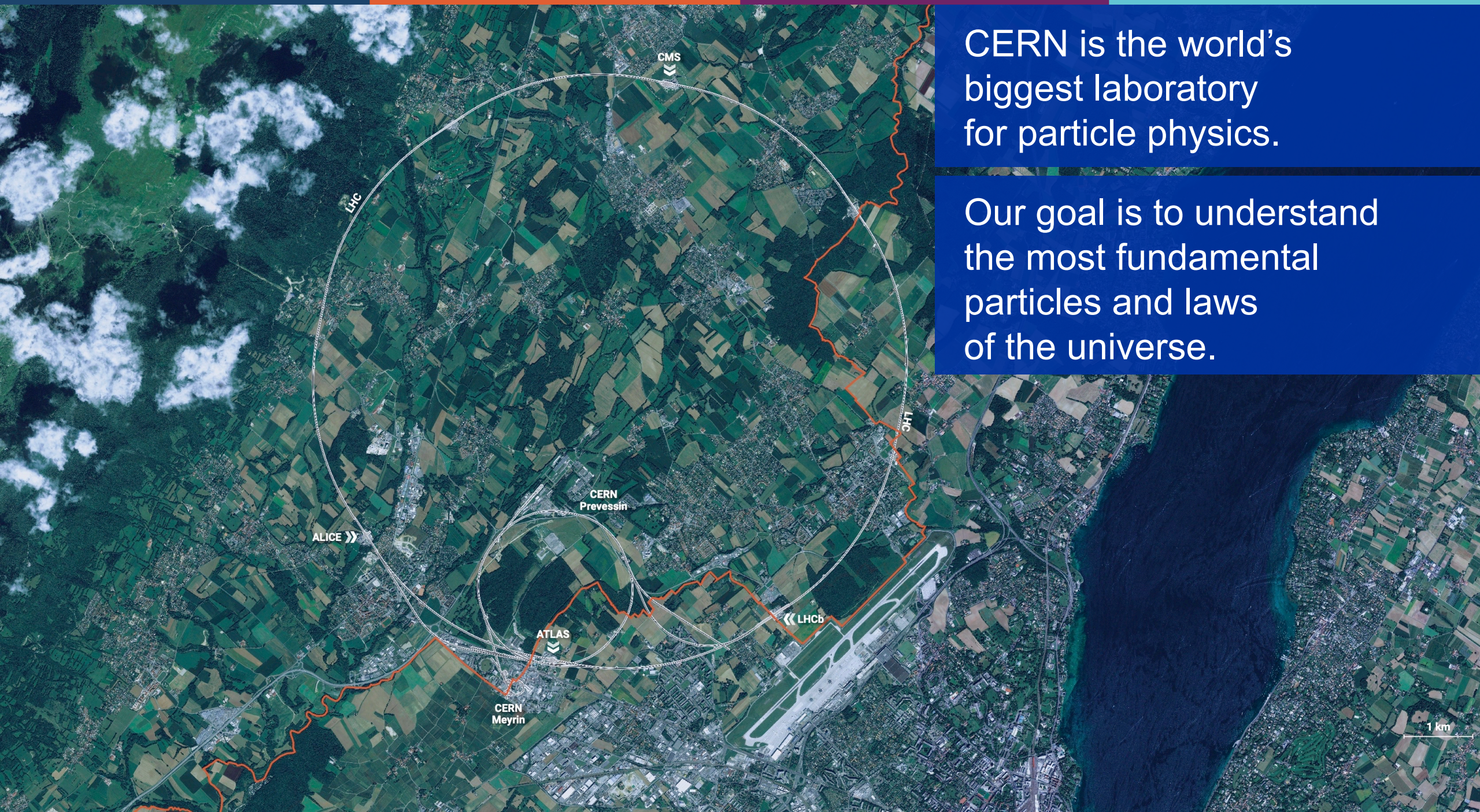
Head of Associate and Non-Member State Relations

CERN



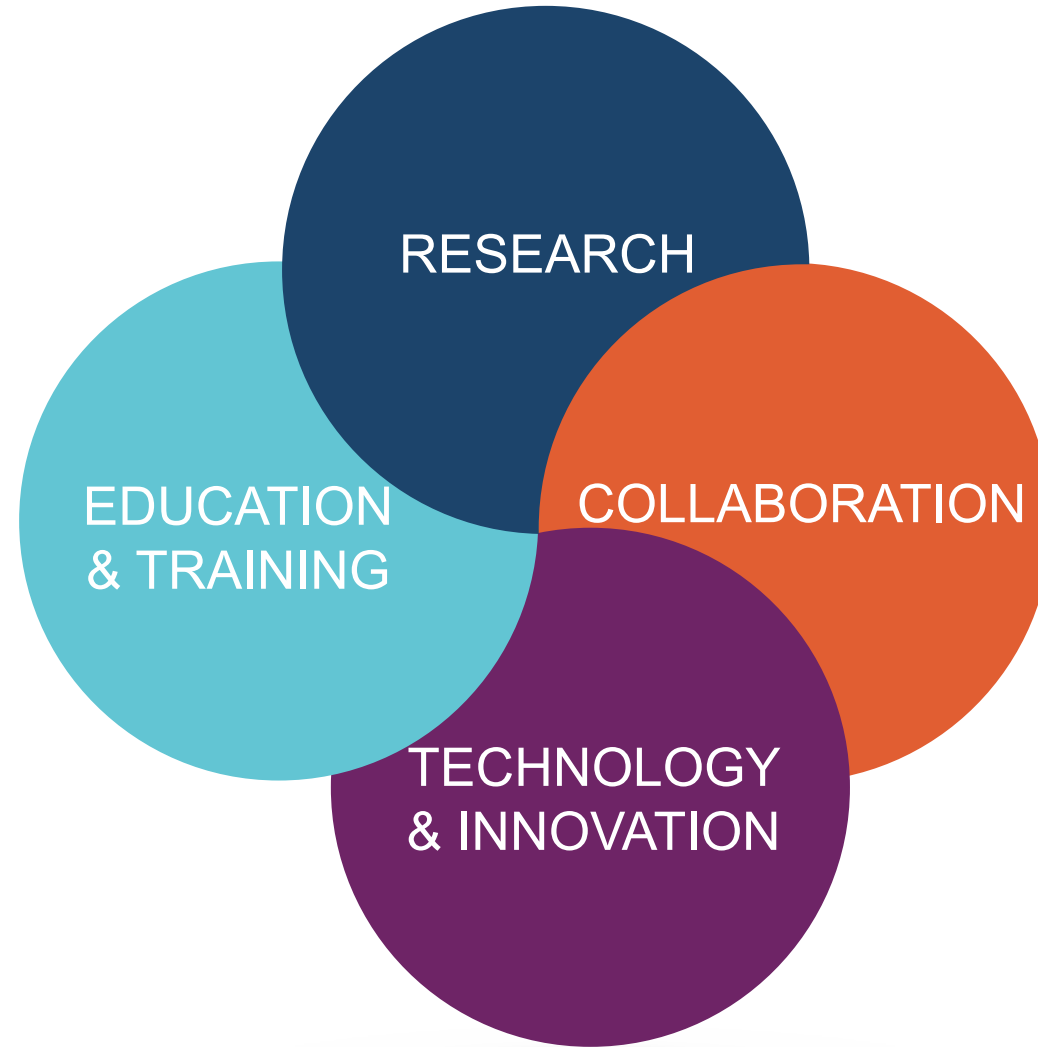
CERN is the world's  
biggest laboratory  
for particle physics.

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

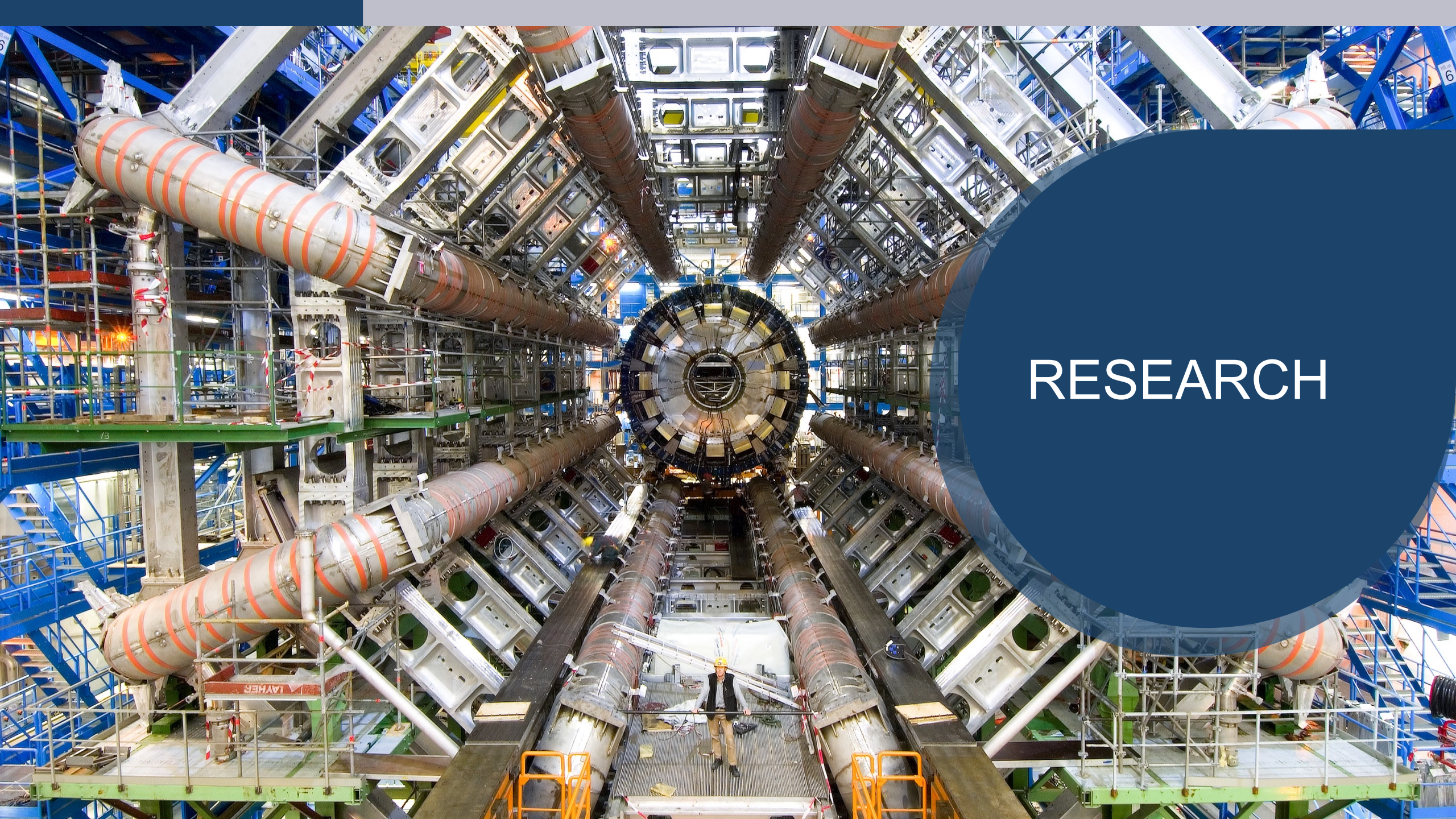




# Four pillars underpin CERN's mission





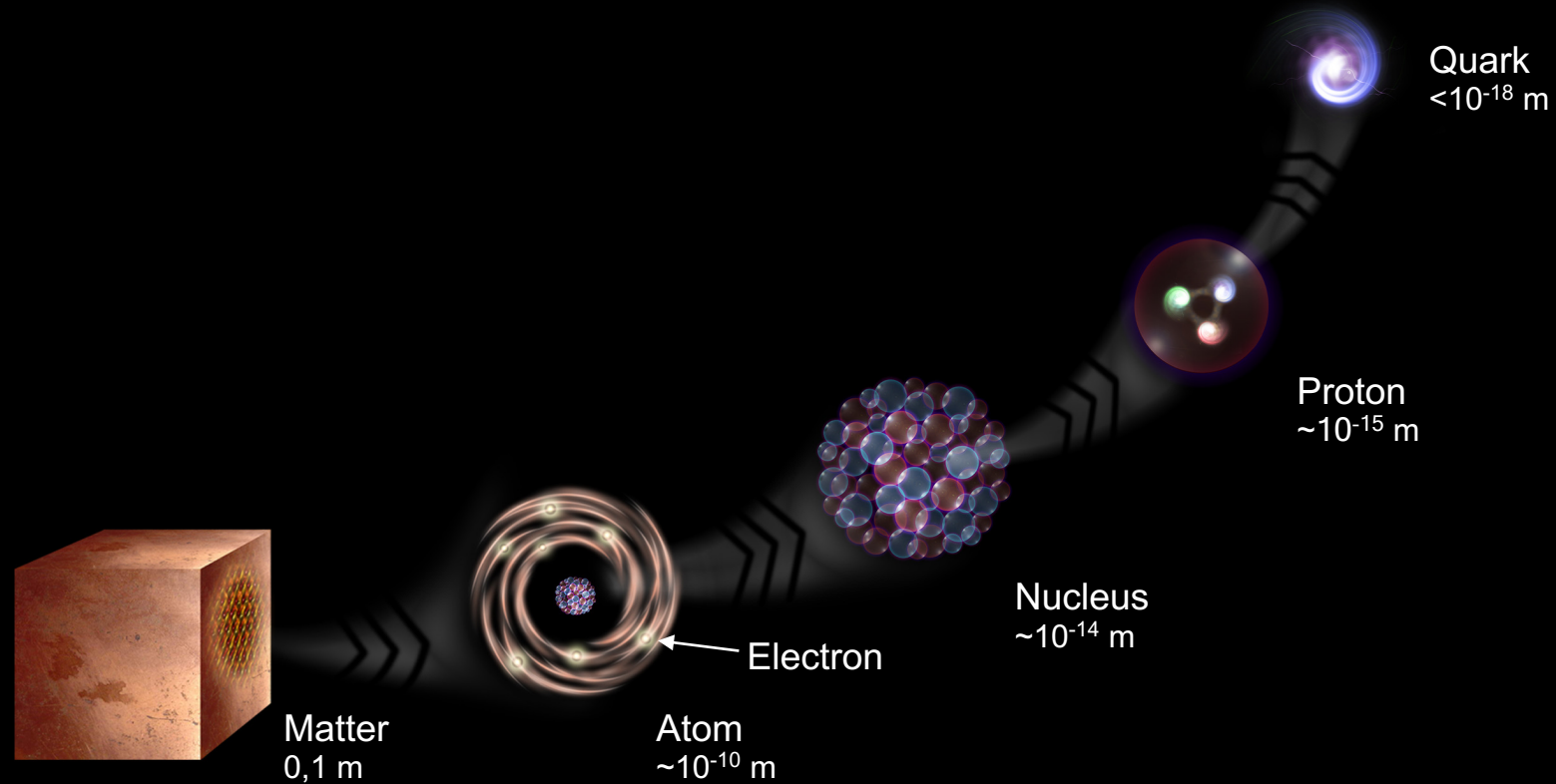


RESEARCH

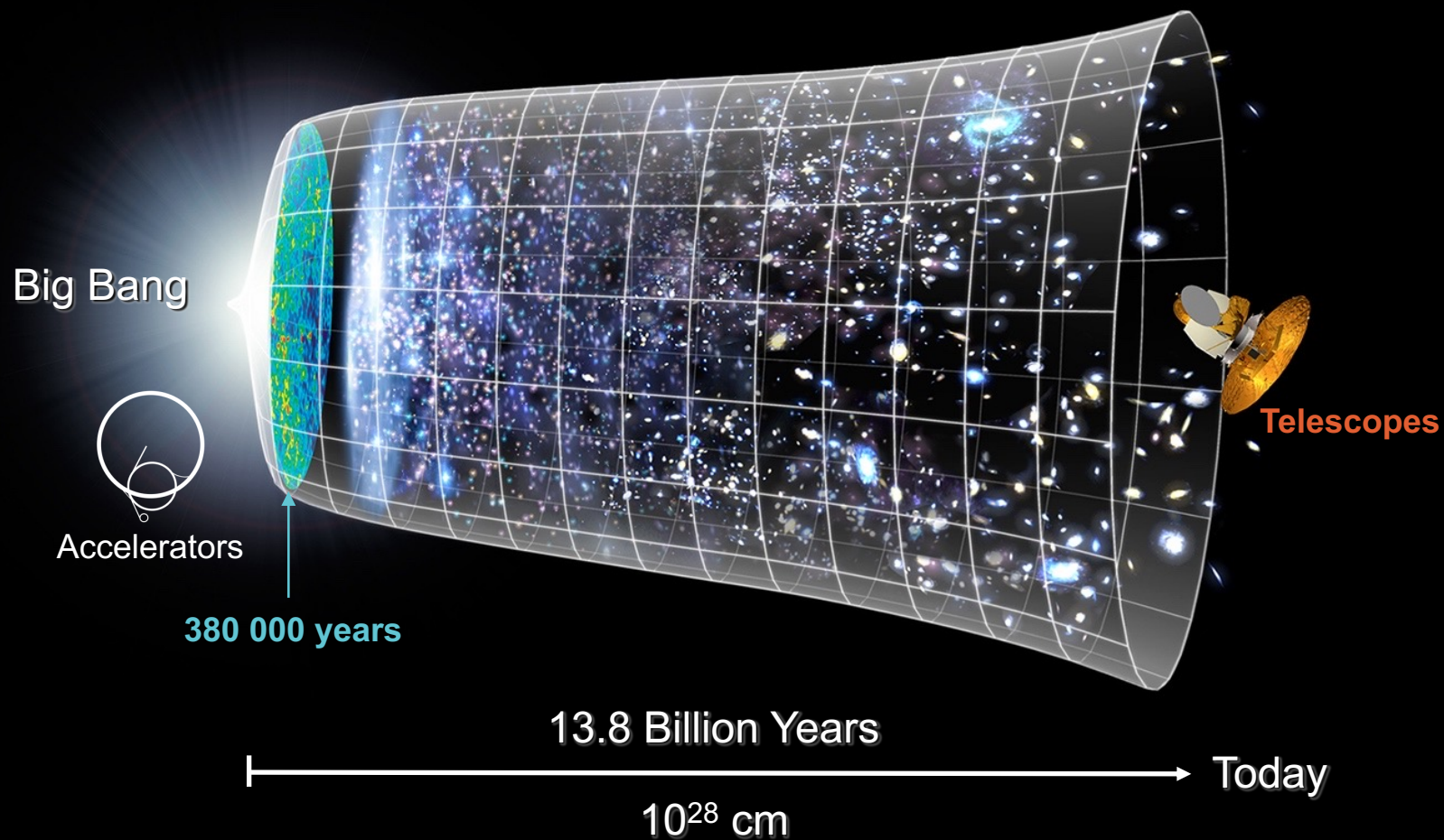


# What is the universe made of?

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.

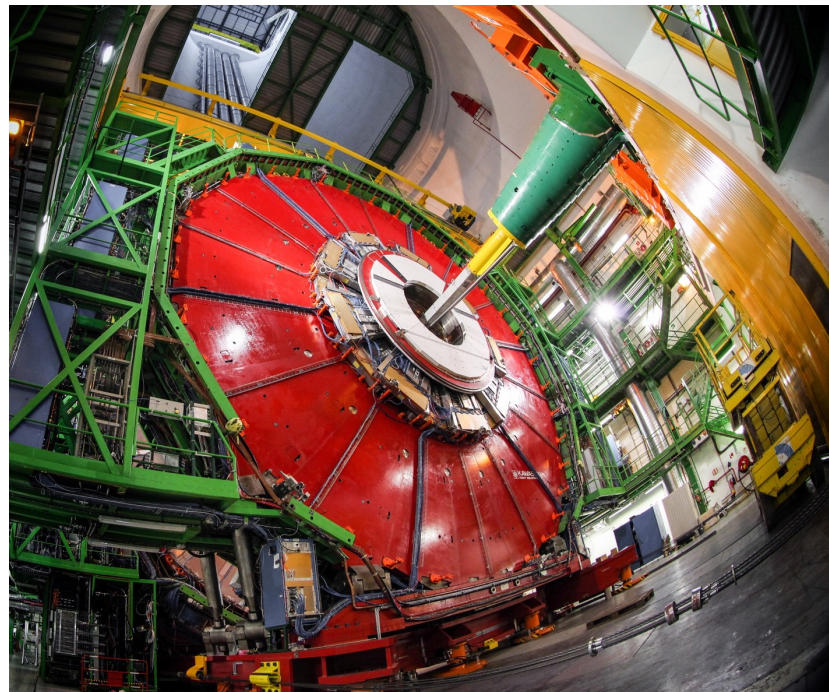


# How do we do it?

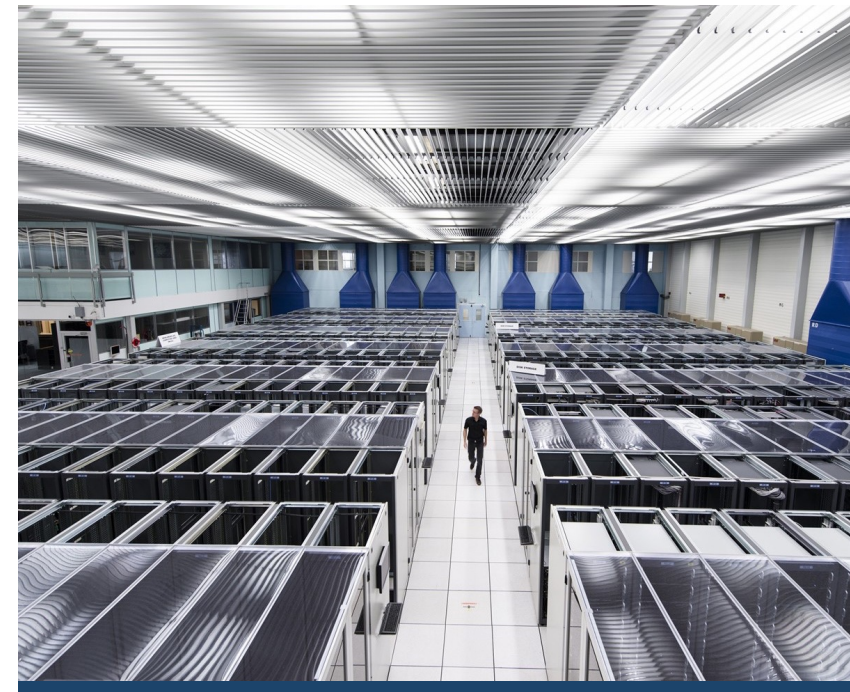
- We build the largest machines to study the smallest particles in the universe
- We develop technology to advance the limits of what is possible
- We perform world-class research in theoretical and experimental particle physics



ACCELERATORS

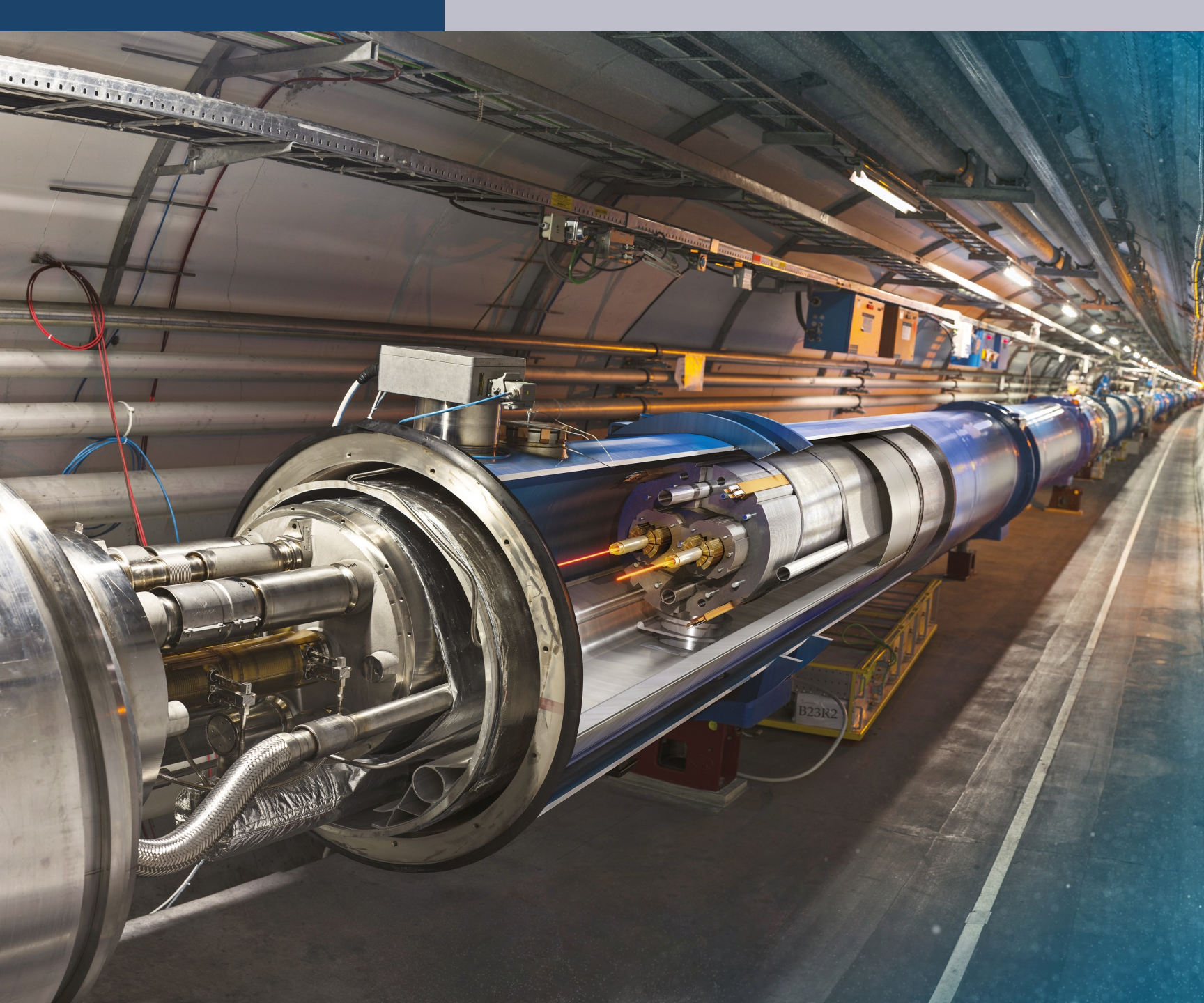


DETECTORS



COMPUTING



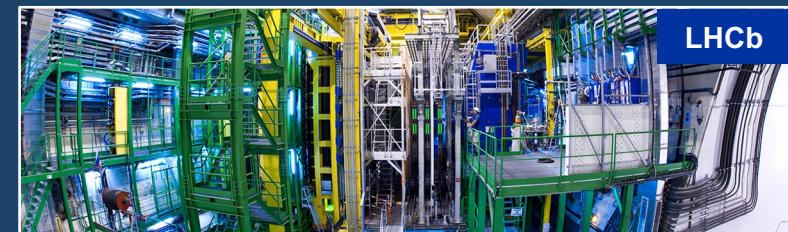
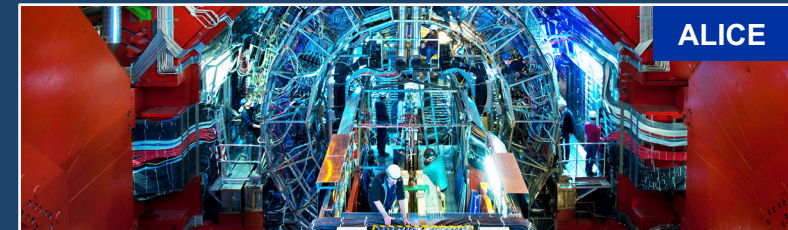
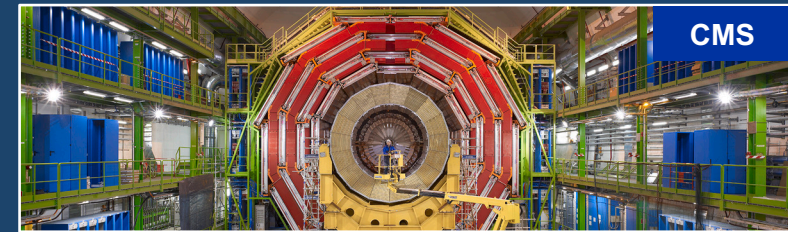
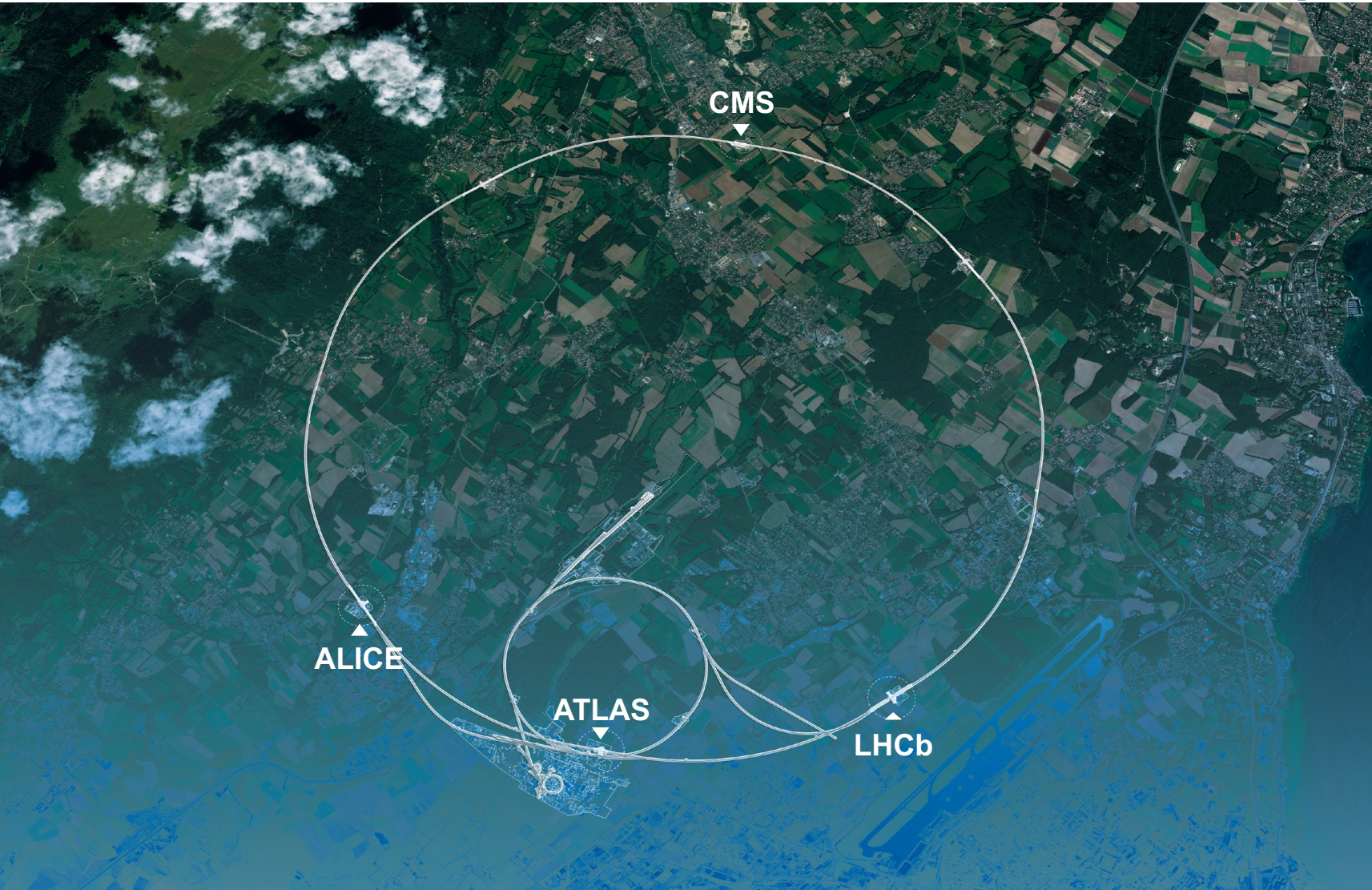


# Large Hadron Collider (LHC)

- 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



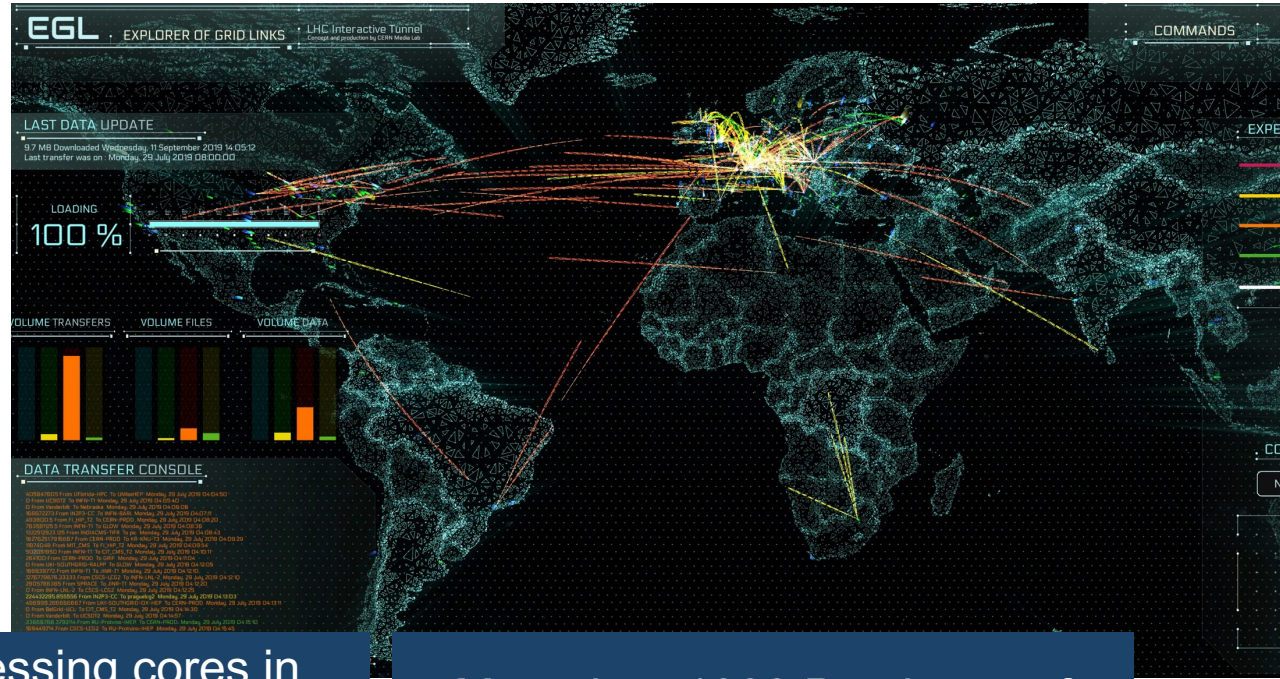


# The Worldwide LHC Computing Grid (WLCG)



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.



# There are many unanswered questions in fundamental physics

Including

95% of the mass and energy of the universe is unknown.

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

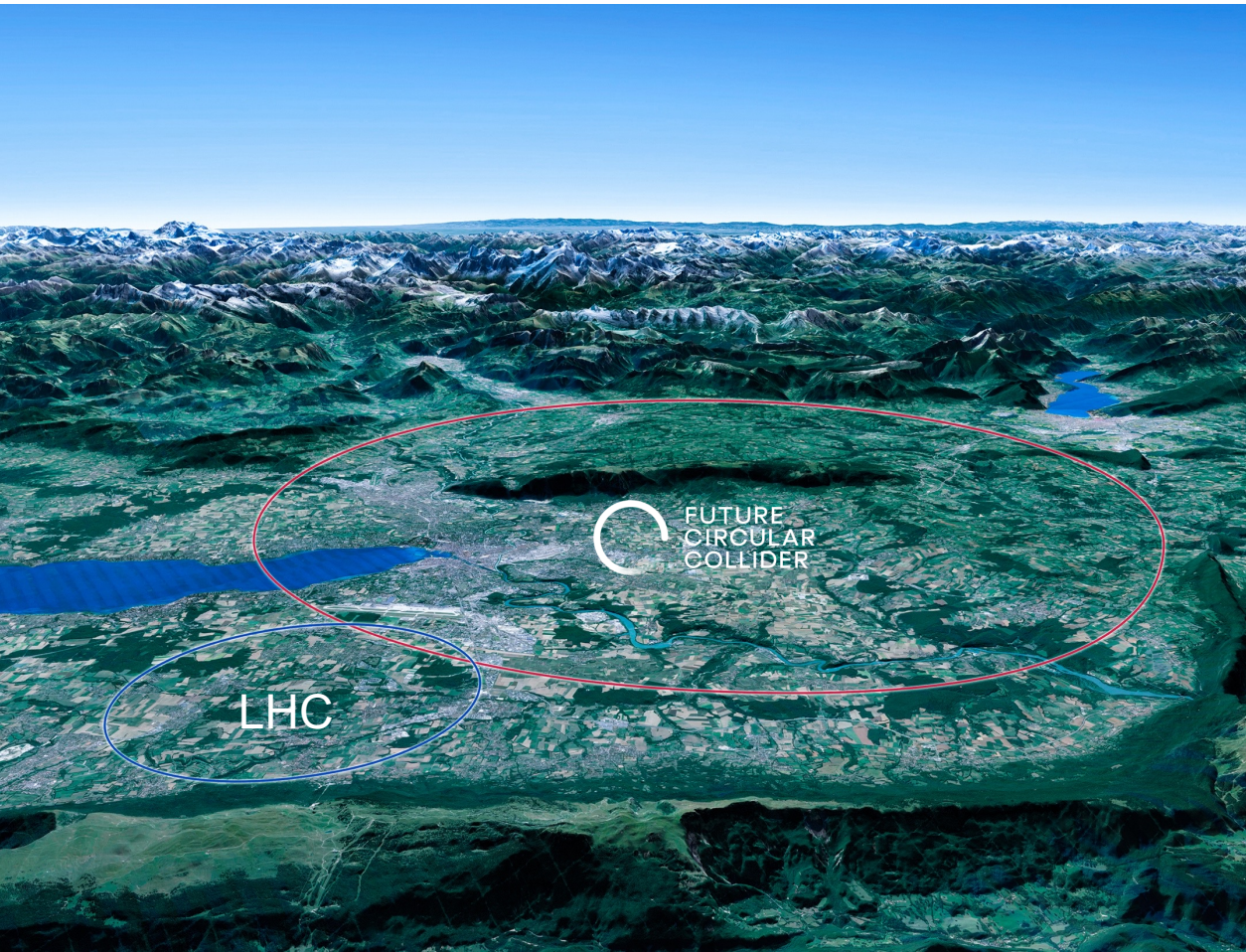
- The HL-LHC will use new technologies to provide 10 times more collisions than the LHC.
- It will give access to rare phenomena, greater precision and discovery potential.
- It will start operating in 2027, and run until 2040.



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





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 Associates Member States in the pre-stage to membership

Cyprus – Estonia – Slovenia

### 7 Associate Member States

Croatia – India – Latvia – Lithuania – Pakistan  
Turkey – Ukraine

### 6 Observers

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

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

As of 31 December 2020  
Employees:  
**2635** staff, **756** fellows

Associates:  
**11 399** users, **1687** others

### More than 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 – 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



# A laboratory for people around the world

Distribution of all CERN Users by the country of their home institutes as of 31 December 2020



Geographical & cultural diversity  
Users of **110 nationalities**  
~ **23% women**

## Member States **6632**

Austria 82 – Belgium 122 – Bulgaria 37 – Czech Republic 221  
Denmark 35 – Finland 79 – France 794 – Germany 1185  
Greece 138 – Hungary 67 – Israel 63 – Italy 1388  
Netherlands 166 – Norway 78 – Poland 272 – Portugal 80  
Romania 99 – Serbia 35 – Slovakia 66 – Spain 325  
Sweden 96 – Switzerland 329 – United Kingdom 875

## Associate Member States **27** in the pre-stage to membership

Cyprus 11 – Slovenia 16

## Associate Member States **390**

Croatia 38 – India 151 – Lithuania 13 – Pakistan 35  
Turkey 124 – Ukraine 29

## Observers **3071**

Japan 211 – Russia 1021 – United States of America 1839



## Non-Member States and Territories **1279**

Algeria 2 – Argentina 15 – Armenia 10 – Australia 23 – Azerbaijan 2 – Bahrain 2 – Belarus 26 – Brazil 108  
Canada 196 – Chile 22 – Colombia 15 – Cuba 3 – Ecuador 4 – Egypt 14 – Estonia 26 – Georgia 35  
Hong Kong 20 – Iceland 3 – Indonesia 7 – Iran 13 – Ireland 6 – Kuwait 2 – Latvia 6 – Lebanon 17  
Malaysia 4 – Malta 3 – Mexico 49 – Montenegro 5 – Morocco 18 – New Zealand 11 – Oman 1  
People's Republic of China 334 – Peru 2 – Puerto Rico 2 – Republic of Korea 132 – Singapore 3  
South Africa 57 – Sri Lanka 8 – Taiwan 50 – Thailand 16 – United Arab Emirates 2



# 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.



A photograph of a complex industrial piping system. The system consists of numerous large, polished stainless steel pipes that are bent and connected at various angles. These pipes are supported by metal brackets. Several blue electric motors, which are part of pumps, are visible at the base of the pipe network. In the background, there are large orange electrical control cabinets. The entire setup is located in a room with concrete walls and a light-colored floor. A large purple circle is overlaid on the right side of the image, containing the text 'TECHNOLOGY & INNOVATION'.

# 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.

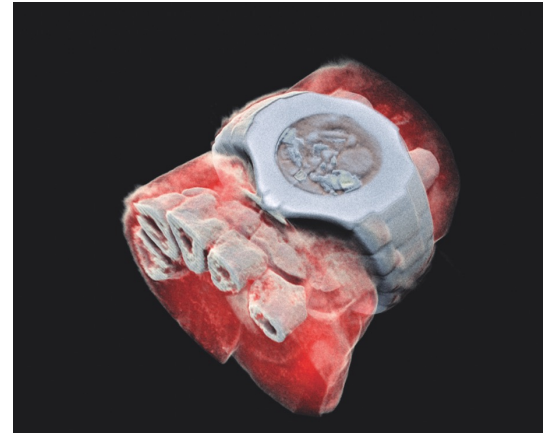
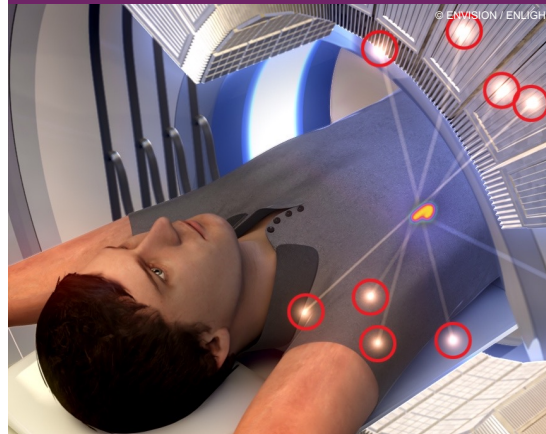


# CERN's technological innovations have important applications in medicine and healthcare



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 wearing hard hats (yellow and blue) are gathered around a piece of equipment, possibly a particle detector component, mounted on a metal frame. They are looking intently at the device, which has a black cylindrical part. One student in the foreground is adjusting a wire. The background shows a white wall with a green exit sign and some cables.

# EDUCATION & TRAINING



# CERN trains the next generation of physicists, engineers and technicians

>3000 PhD students are registered at CERN.

600 PhD theses are completed each year.

300 undergraduate students in Summer programmes.



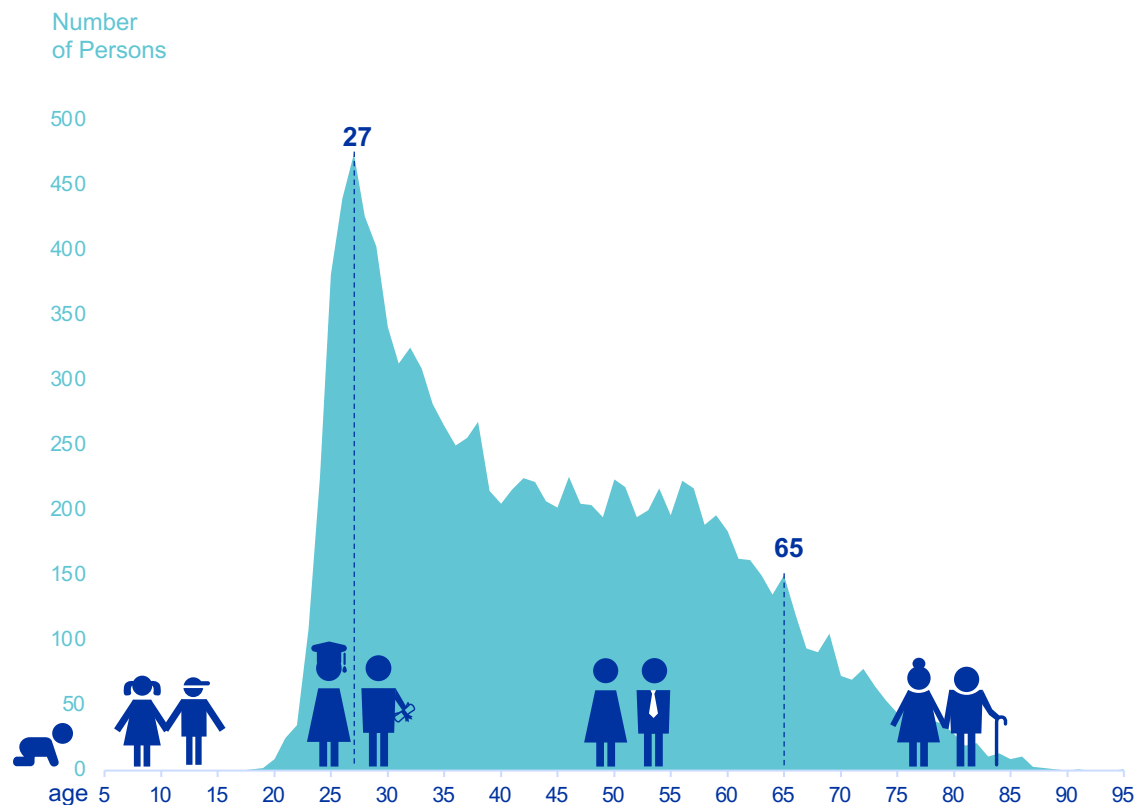
~800 fellows in research and applied physics, engineering and computing.

~200 Technical and Doctoral Students in applied physics, engineering and computing.

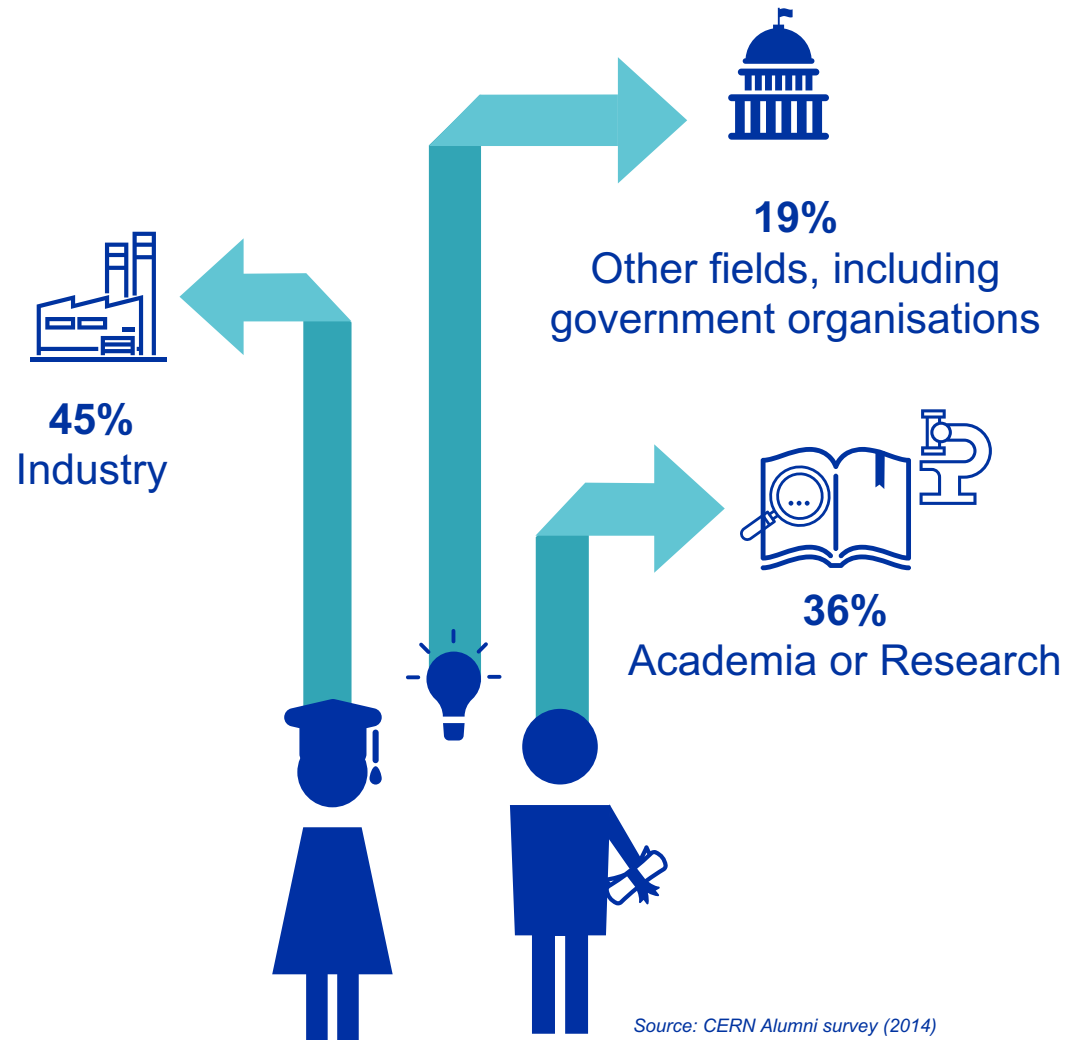
CERN organises schools for undergraduates and postgraduates, in all regions.



# CERN opens a world of career opportunities



**Age Distribution of Scientists working at CERN**





# Our education programmes reach thousands of teachers and students from around the world each year



Teachers from > 40 countries participate in National and International Teacher Programmes

> 6000 students use S'Cool Lab, for hands-on physics experiments

> 1000 students propose an experiment to carry out at CERN in the Beamline4Schools competition

22 students from each Member State shadow researchers in the High-School Student Internship Programme

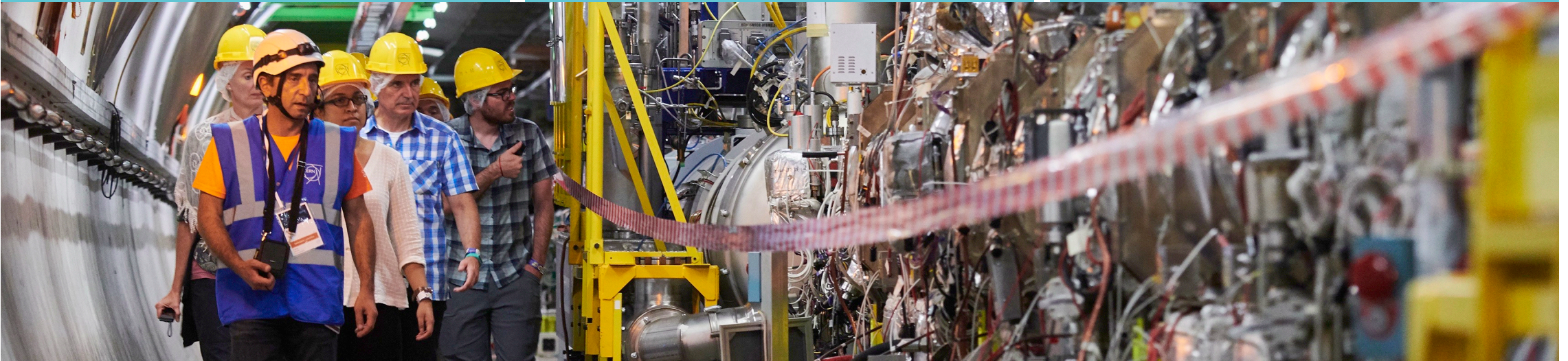


# CERN engages with citizens across the globe

151 000 visitors on guided tours of CERN in 2019, from 95 countries (> 60% come from more than 600 km away).

On-site and travelling exhibitions in 15 countries, with >1 million visitors.

Open Days during Long Shutdowns: two days in 2019, 75 000 visitors, 2800 volunteers.



During the COVID-19 pandemic, several outreach and education activities moved online: virtual talks by CERN guides for schools and general public; educational resources; social media “lives” from LHC experiments and other facilities.



# CERN Science Gateway



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

Opening beginning of 2023.

Immersive exhibitions, education labs, events and shows.



The background of the slide is a deep space image featuring a dense field of galaxies and stars. A prominent, bright, pinkish-red light source is located in the upper center, creating a radial glow. The overall color palette transitions from dark blue and purple at the edges to a vibrant magenta and red near the central light source. At the very top, there are three horizontal bars in dark blue, orange, and light blue.

There are many unanswered questions  
in fundamental physics

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