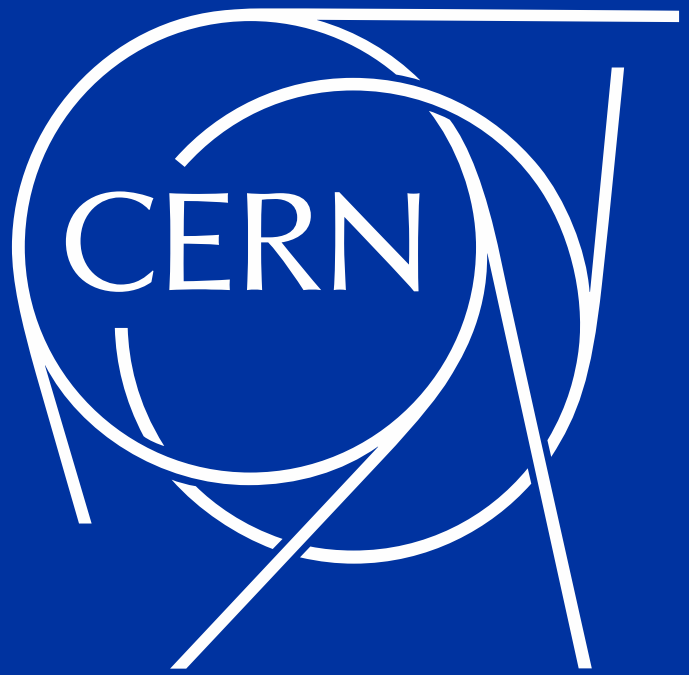
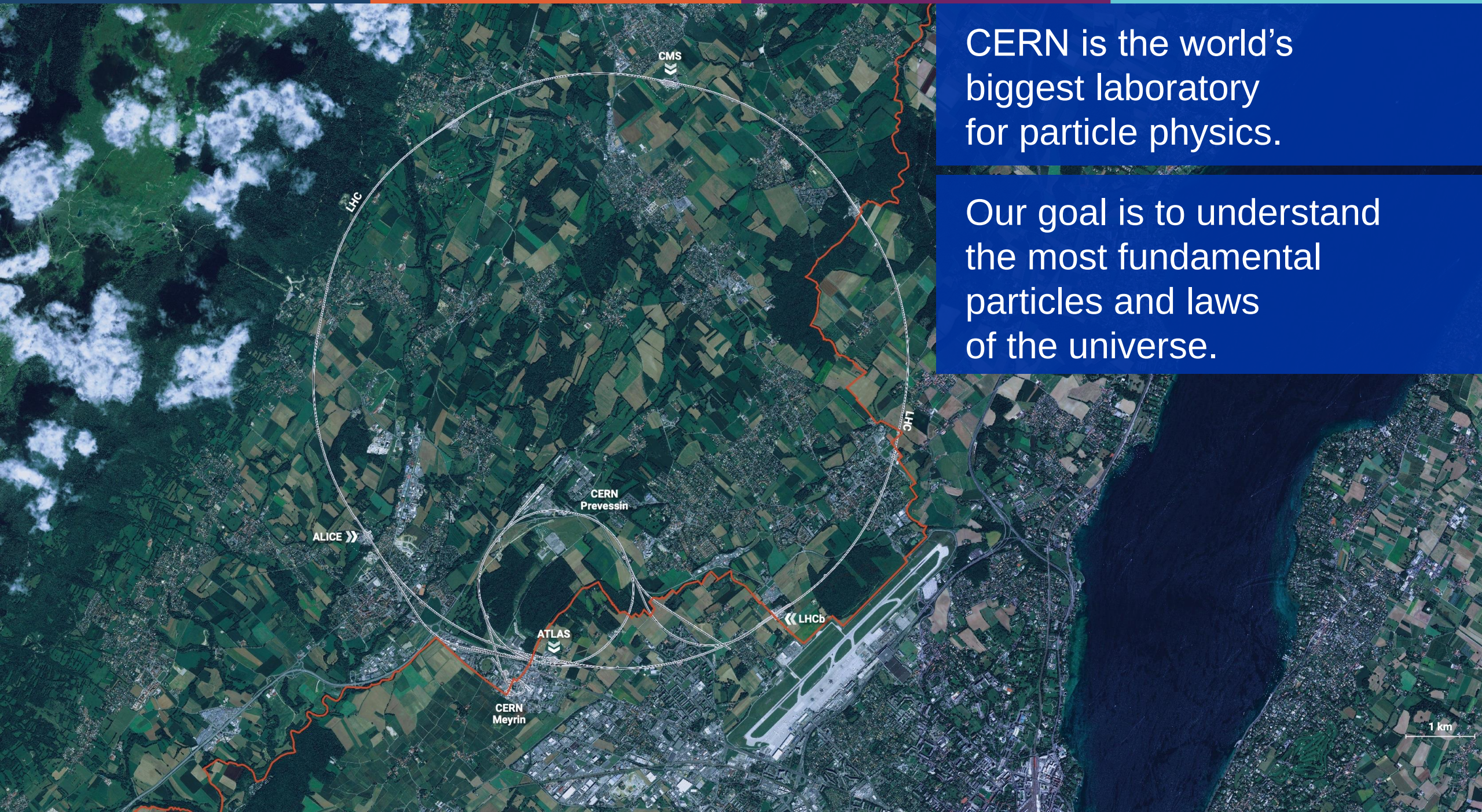

CERN

WELCOME TO CERN

Russel Furr

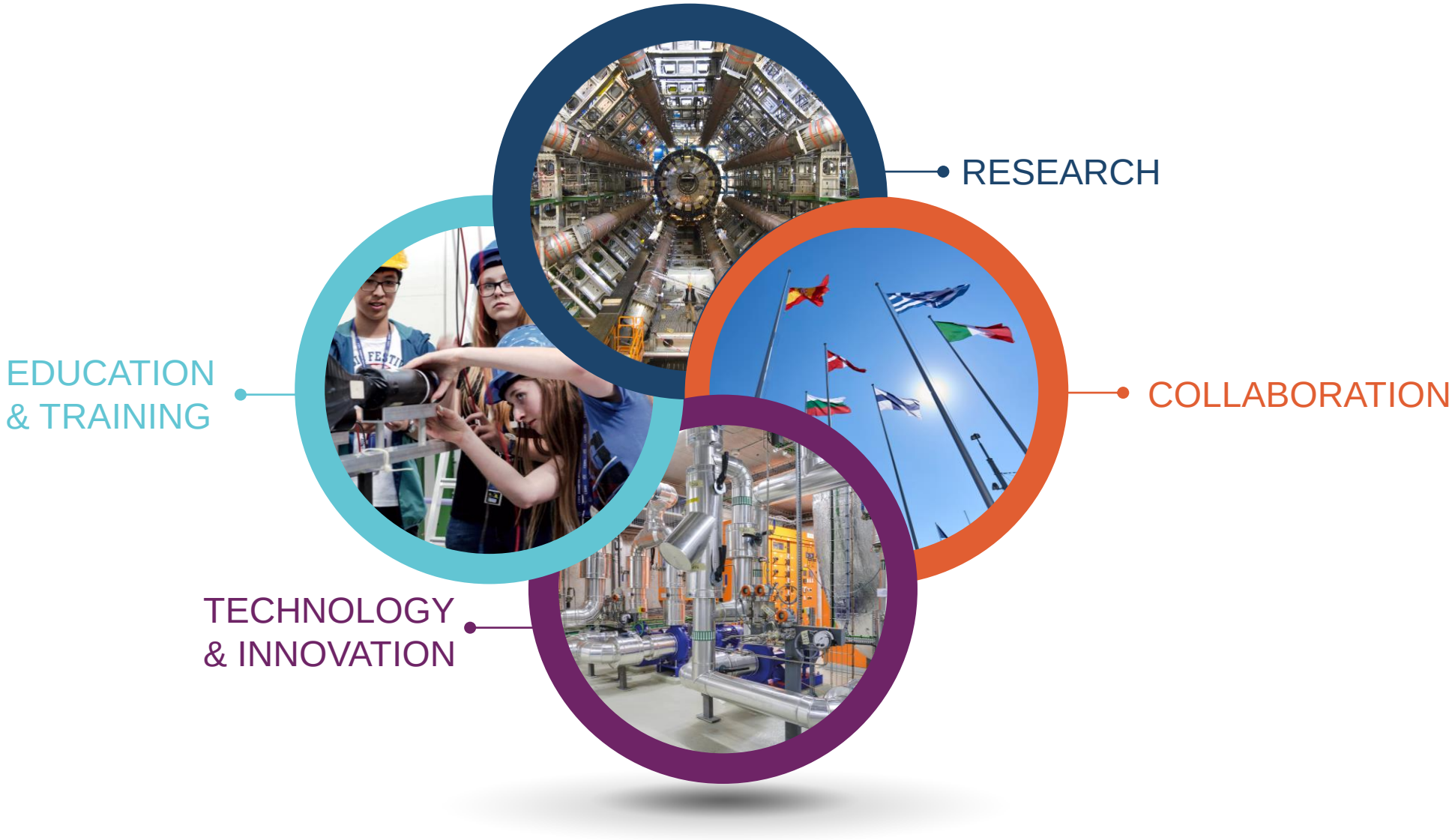
Associate Vice Provost for Environmental Health & Safety,
Stanford University

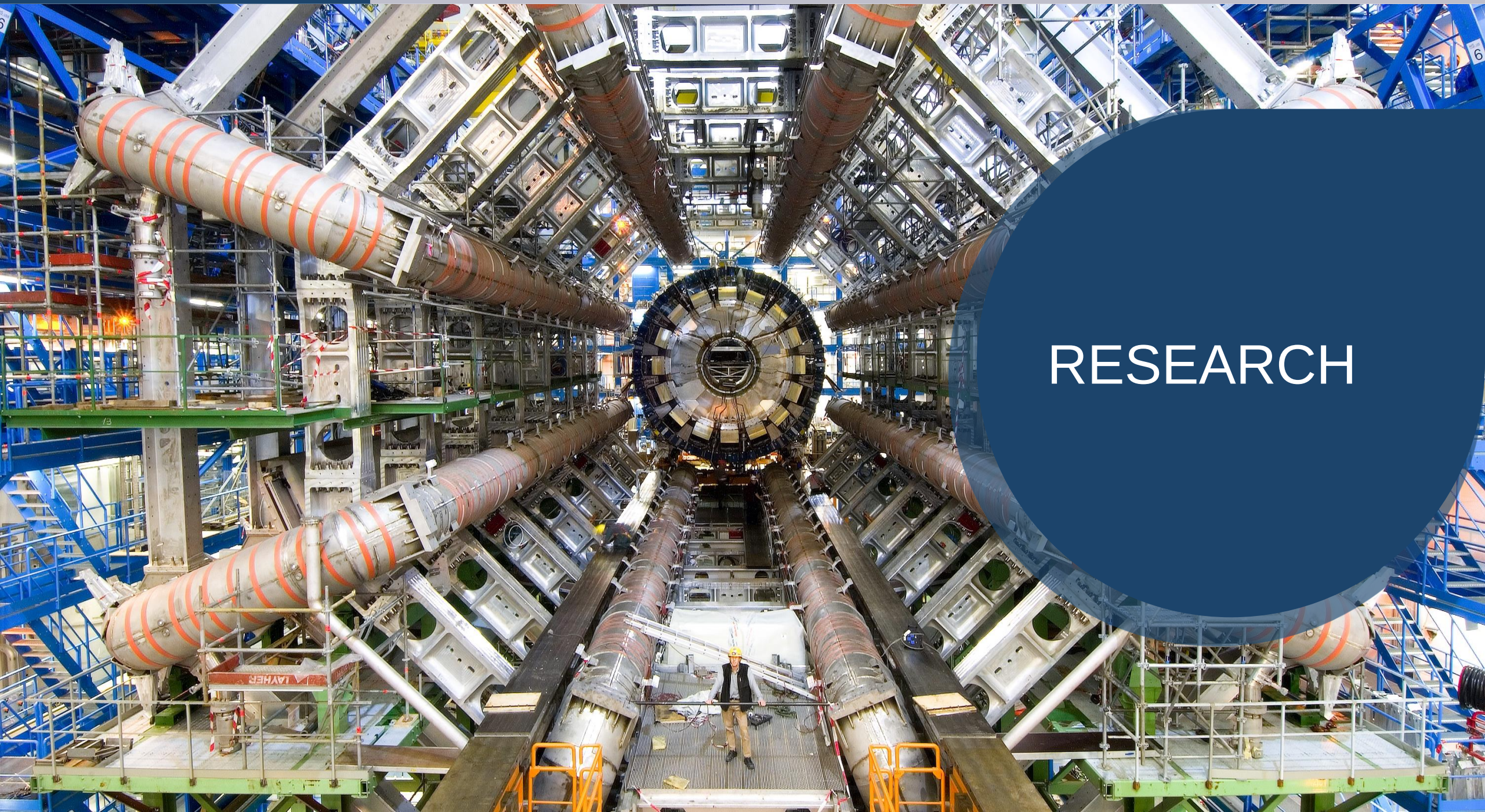


CERN is the world's biggest laboratory for particle physics.

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

Four pillars underpin CERN's mission

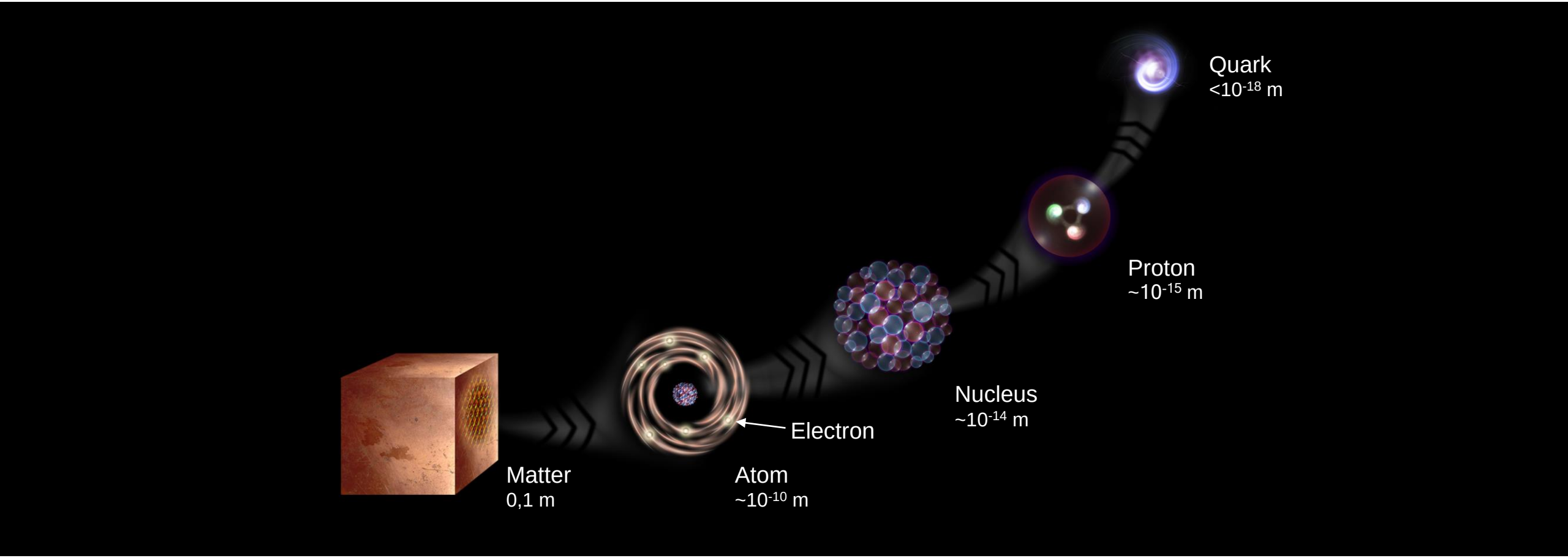


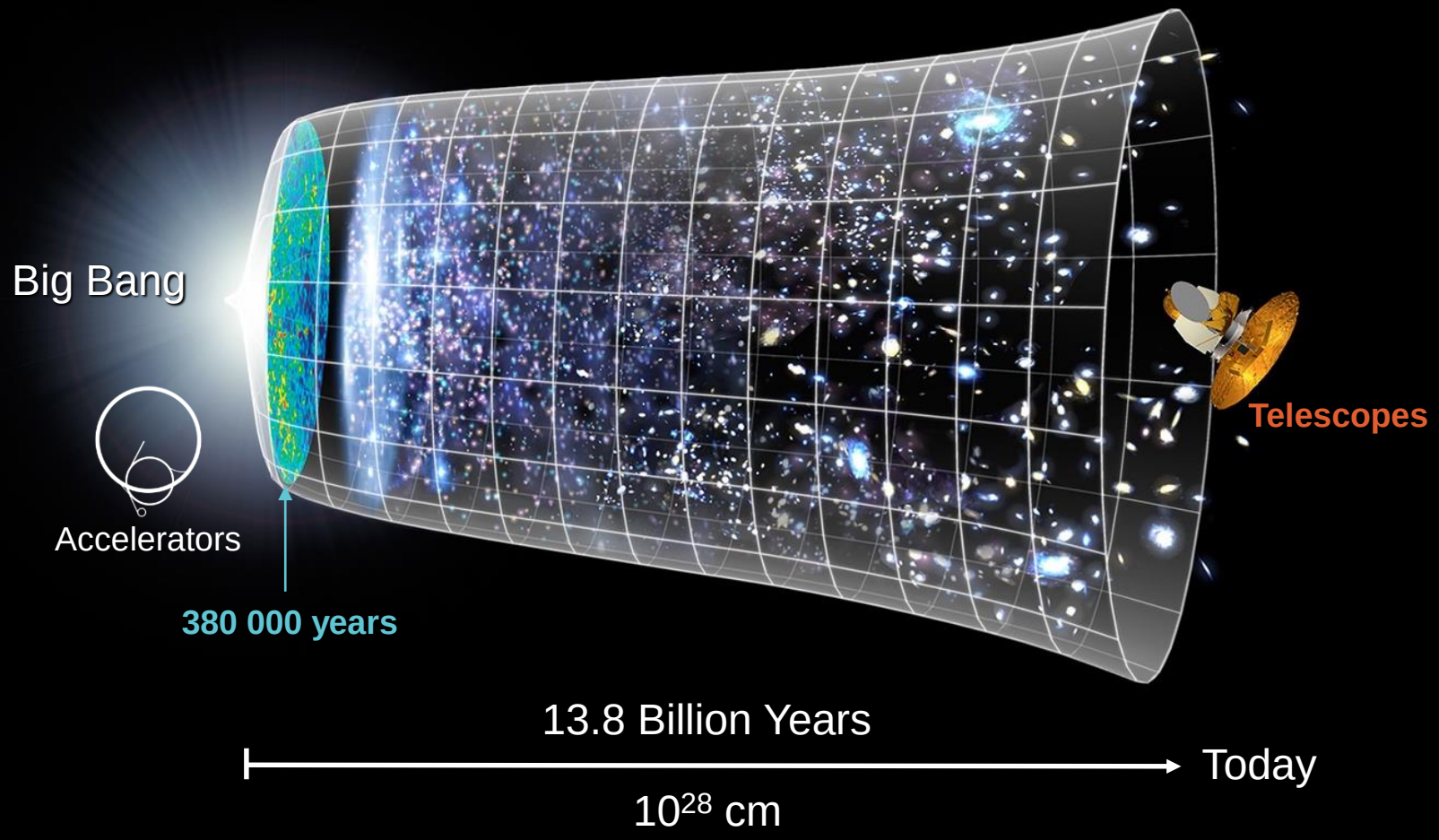


RESEARCH

What is the universe made of?

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





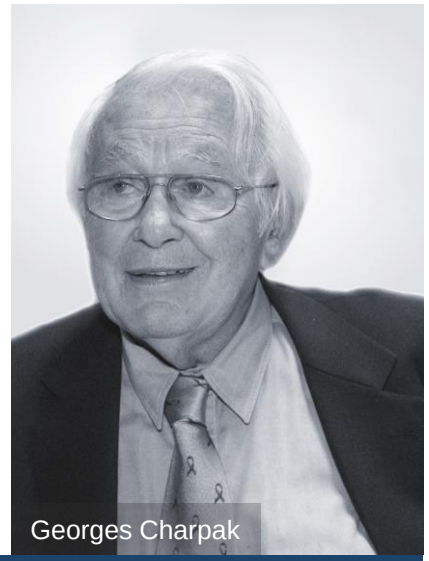
How did the universe begin?

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

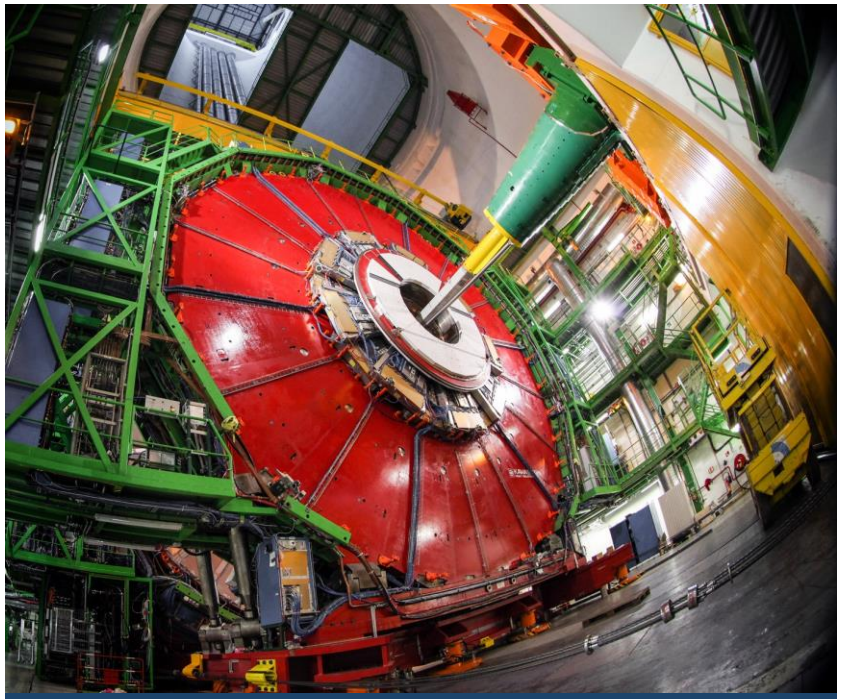
Several CERN scientists have received Nobel Prizes for key discoveries in particle physics.

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

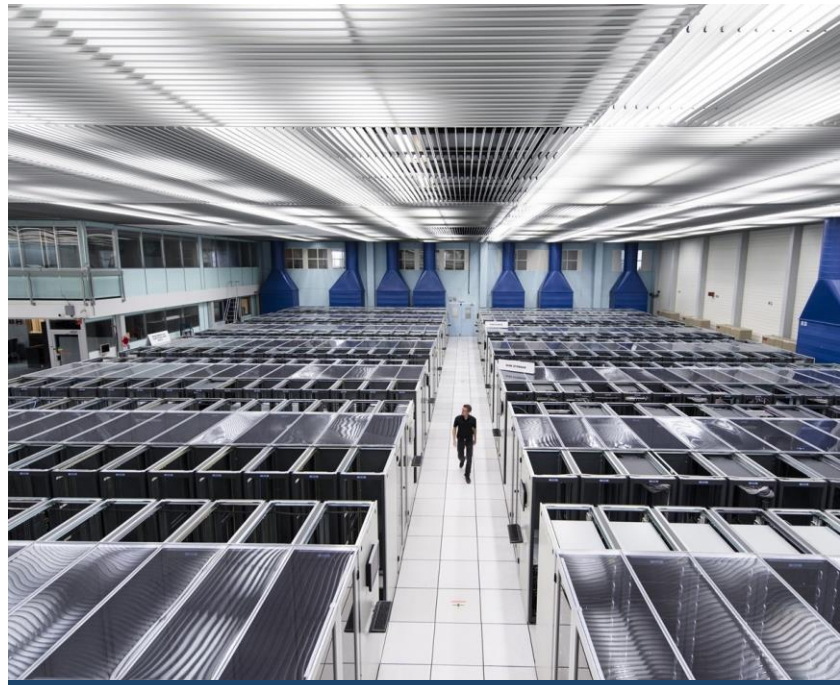

François Englert and Peter Higgs. With Robert Brout, they proposed the mechanism in 1964.

We develop technologies in three key areas

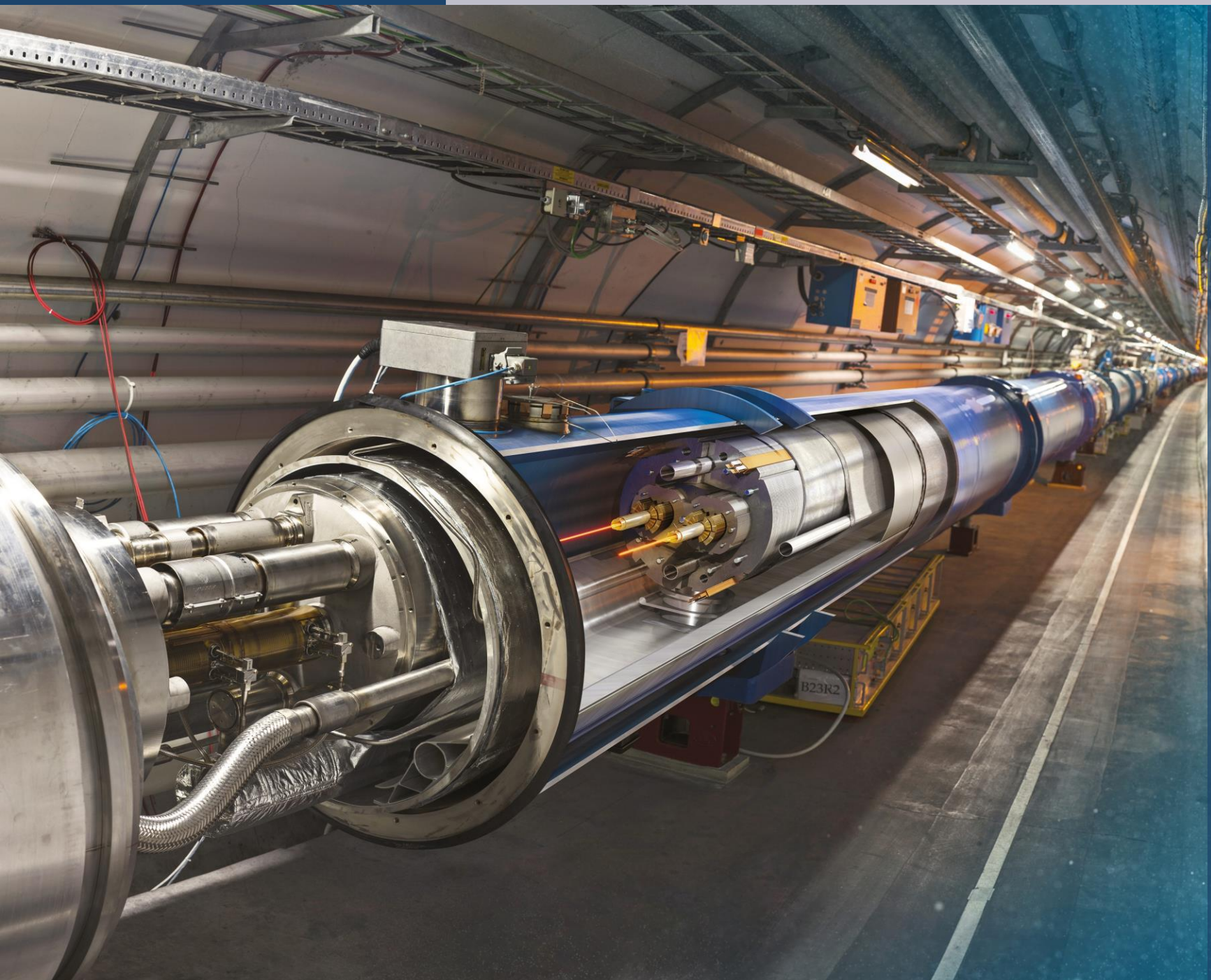
ACCELERATORS



DETECTORS



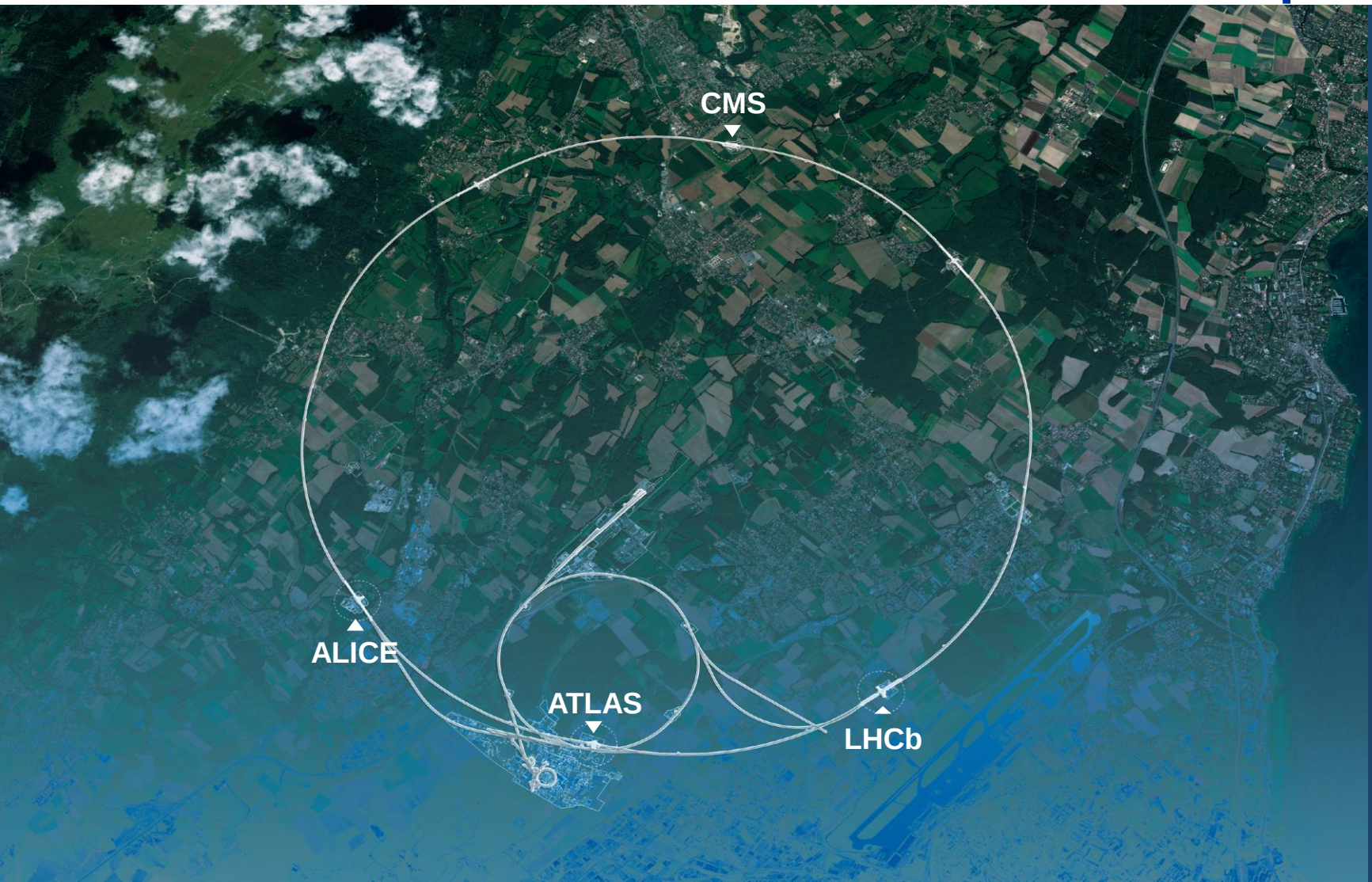
COMPUTING

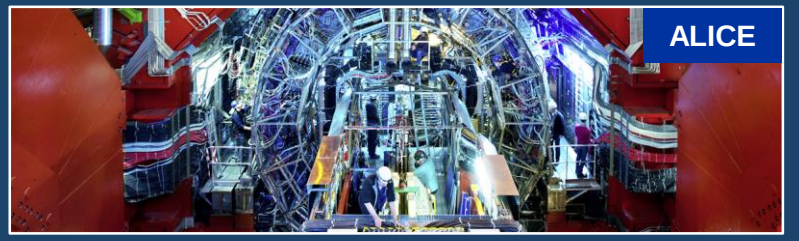


Large Hadron Collider (LHC)

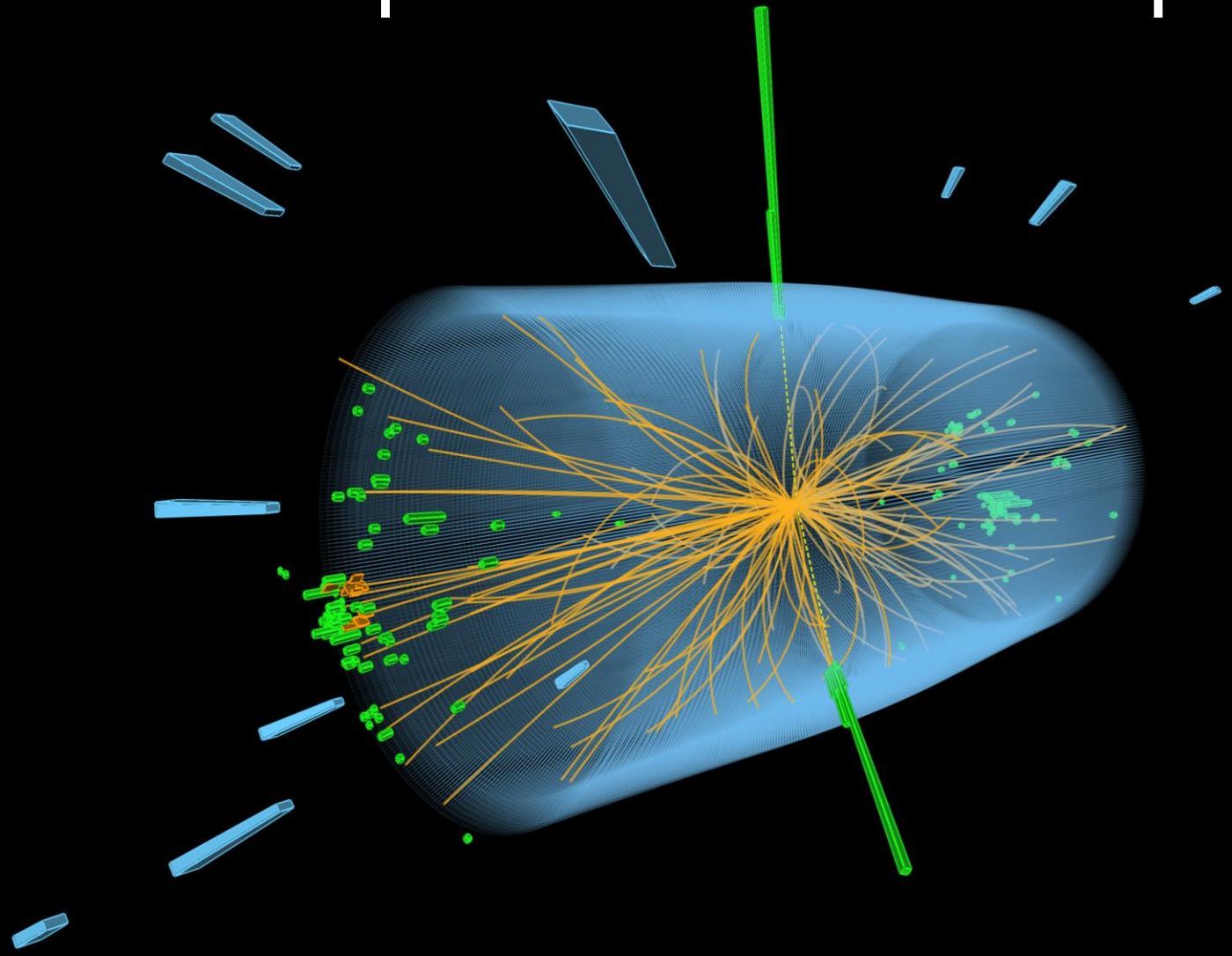
- 27 km in circumference
- About 100 m underground
- Superconducting magnets steer the particles around the ring
- Particles are accelerated to close to the speed of light

Giant detectors record the particles formed at the four collision points



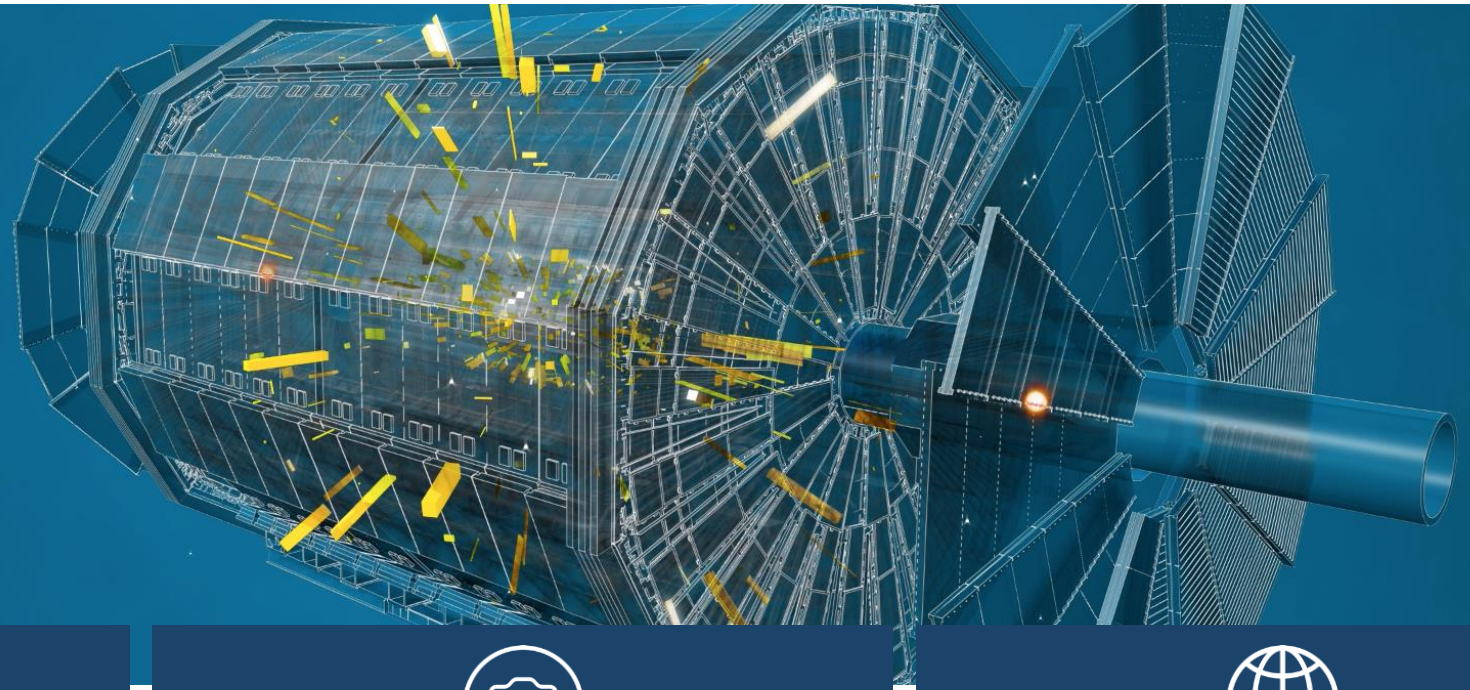


The LHC produces more than 1 billion particle collisions per second



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

The LHC detectors are analogous to 3D cameras

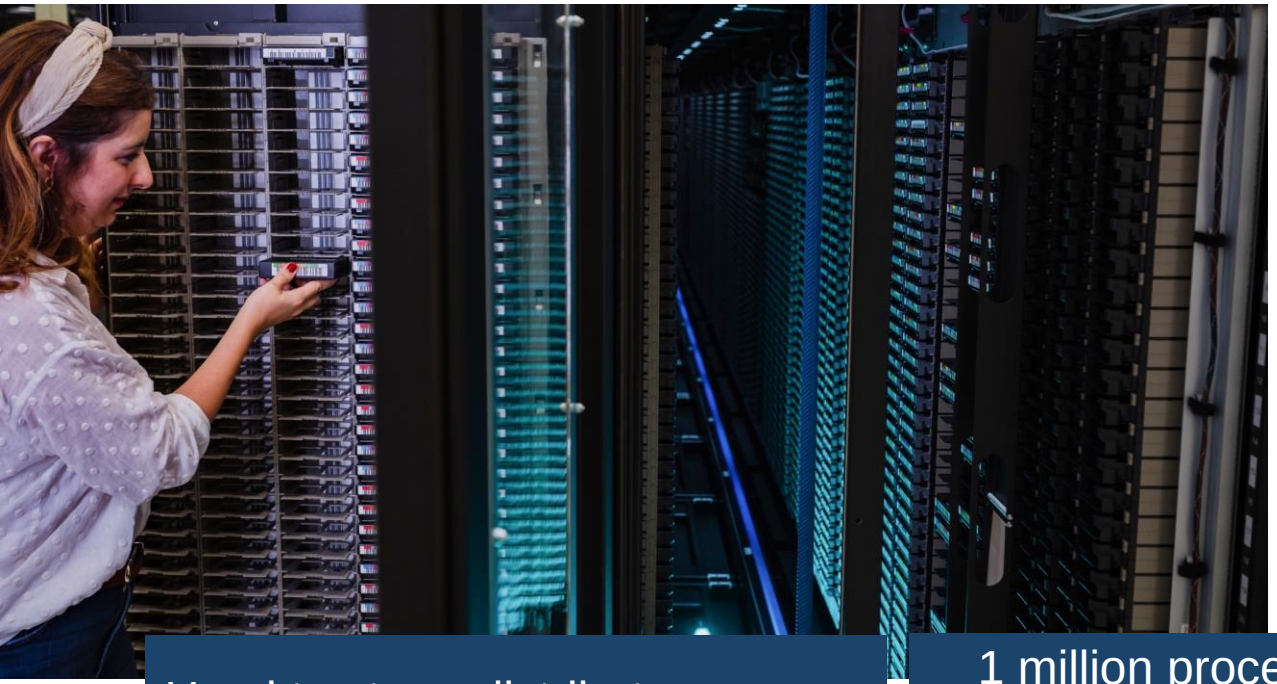


The detectors measure the energy, direction and charge of new particles formed.

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.

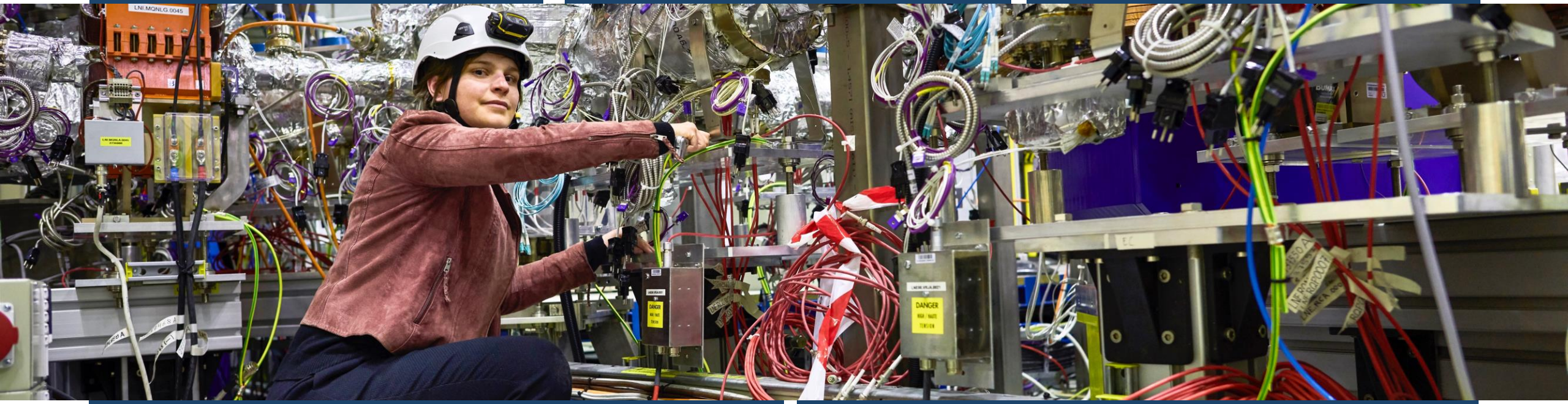
More than 1000 Petabytes of CERN data stored world-wide.

CERN has a diverse scientific programme

Nuclear Physics
(ISOLDE)

Antimatter Research
(Antiproton Decelerator)

Cosmic rays and cloud formation
(CLOUD)



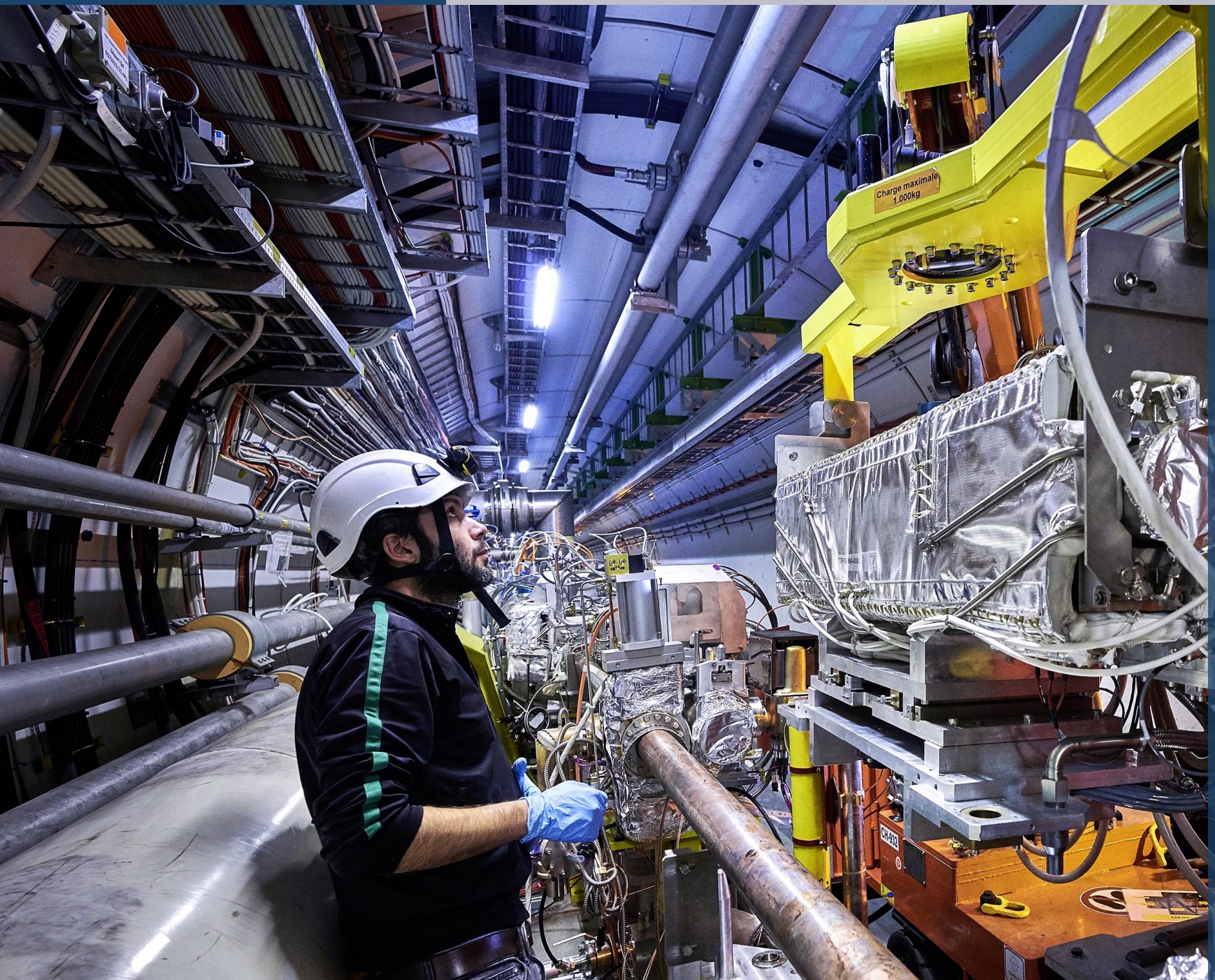
Fixed-target experiments,
which include searches for rare phenomena

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

There are many unanswered questions in fundamental physics

Including

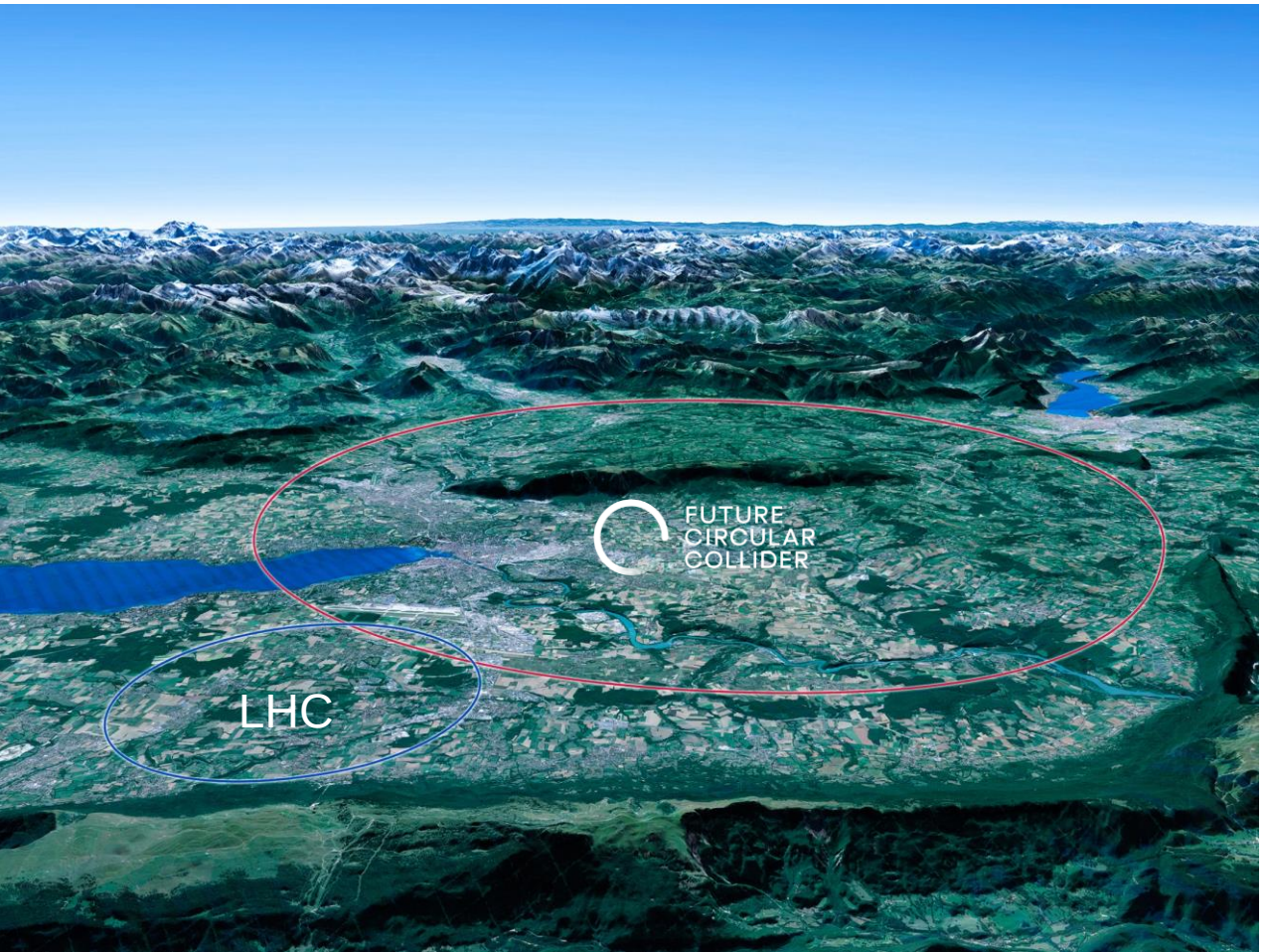
What is the unknown 95% of the mass and energy of the universe?	Is there only one Higgs boson, and does it behave exactly as expected?
Why is the universe made only of matter, with hardly any antimatter?	Why is gravity so weak compared to the other forces?



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.

European Strategy Update



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 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

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

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

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 USA

1757 Number of Users
142 Institutes

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

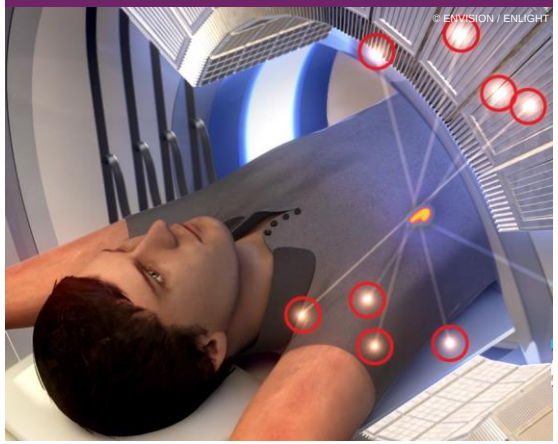
CERN is the birthplace of the World Wide Web

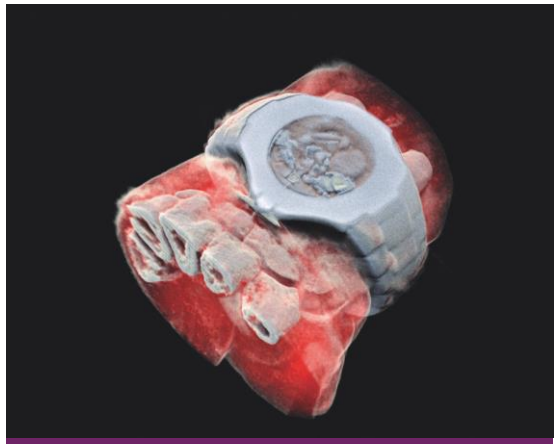
And there are many more examples
Medical imaging, cancer therapy, material science, cultural heritage, aerospace, automotive, environment, health & safety, industrial processes.

CERN’s technological innovations have important applications in medicine and healthcare

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.

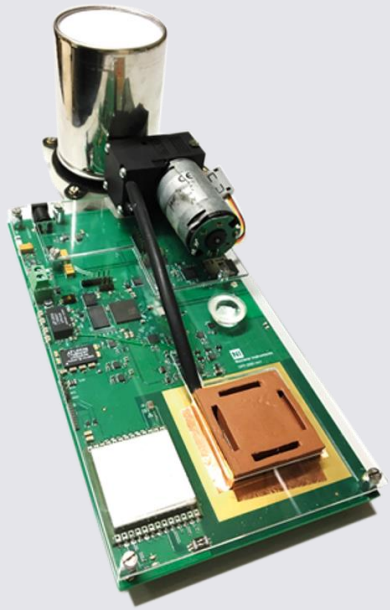




Pixel detector technologies are used for high resolution 3D colour X-ray imaging.

CERN produces innovative radioisotopes for nuclear medicine research.

... and in other areas…



Radon dose monitor for better air quality

Machine learning for car automation

ZENUITY	Jun 2019 | Jun 2021	**Automotive** Fast machine learning for autonomous driving

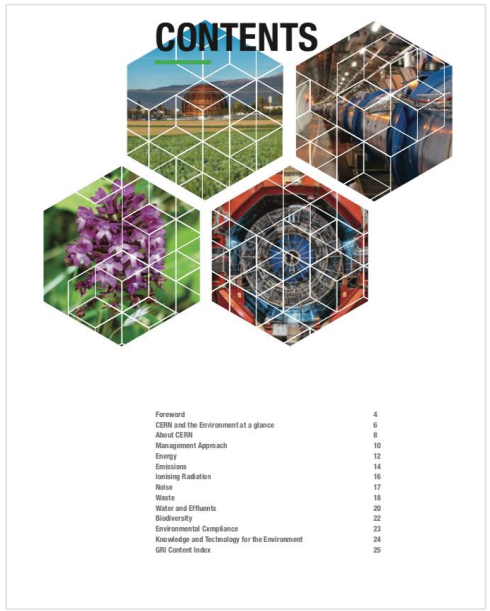
Collaboration R&D
ZENUITY (company owned by Volvo Group and Veoneer) is innovating in driver-assistance and autonomous-driving technologies. For this purpose, fast machine learning using FPGAs is relevant to the automotive worlds. Collaboration HSL4ML with CERN.

Cultural Heritage InsightART

Measuring the DNA of your art

Sustainability and the environment at CERN (examples)

CERN's first two public reports, issued in 2020 and 2021

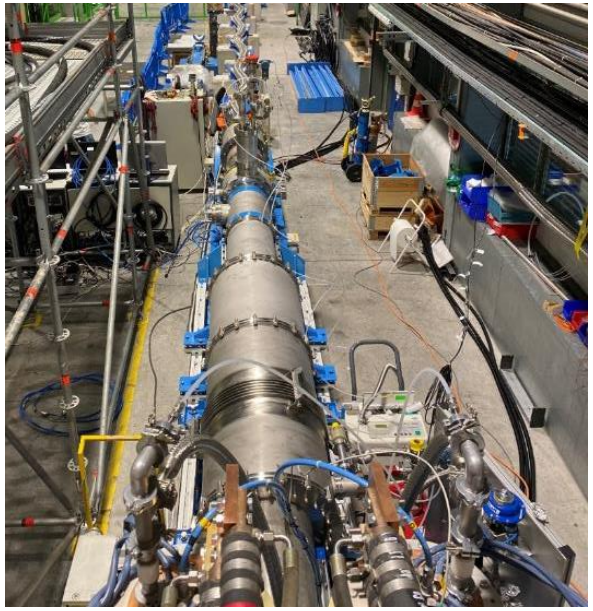


Ambitious objectives for the future: e.g. reduce greenhouse gas emissions by ~ 30% by 2024

Energy savings and recovery

Heat from the LHC cooling towers is used to heat a nearby residential neighbourhood in Ferney-Voltaire (~ 8000 people)

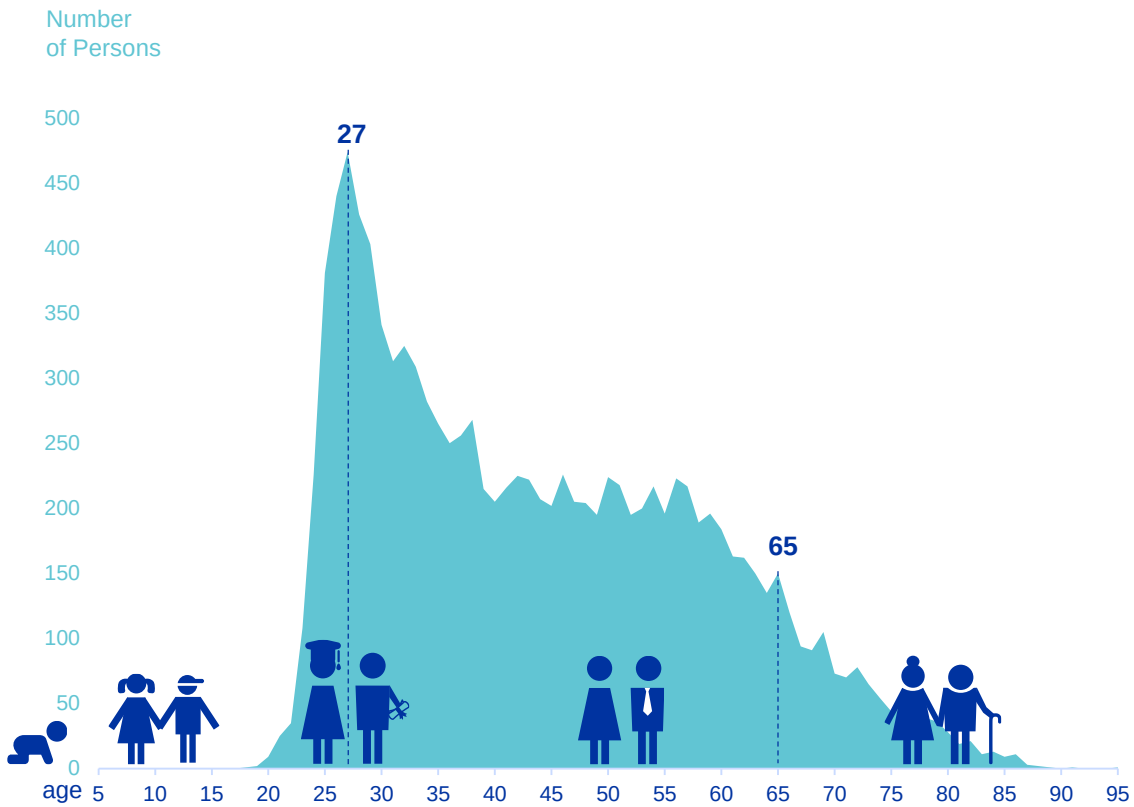
CERN technologies for loss-free transport of electricity



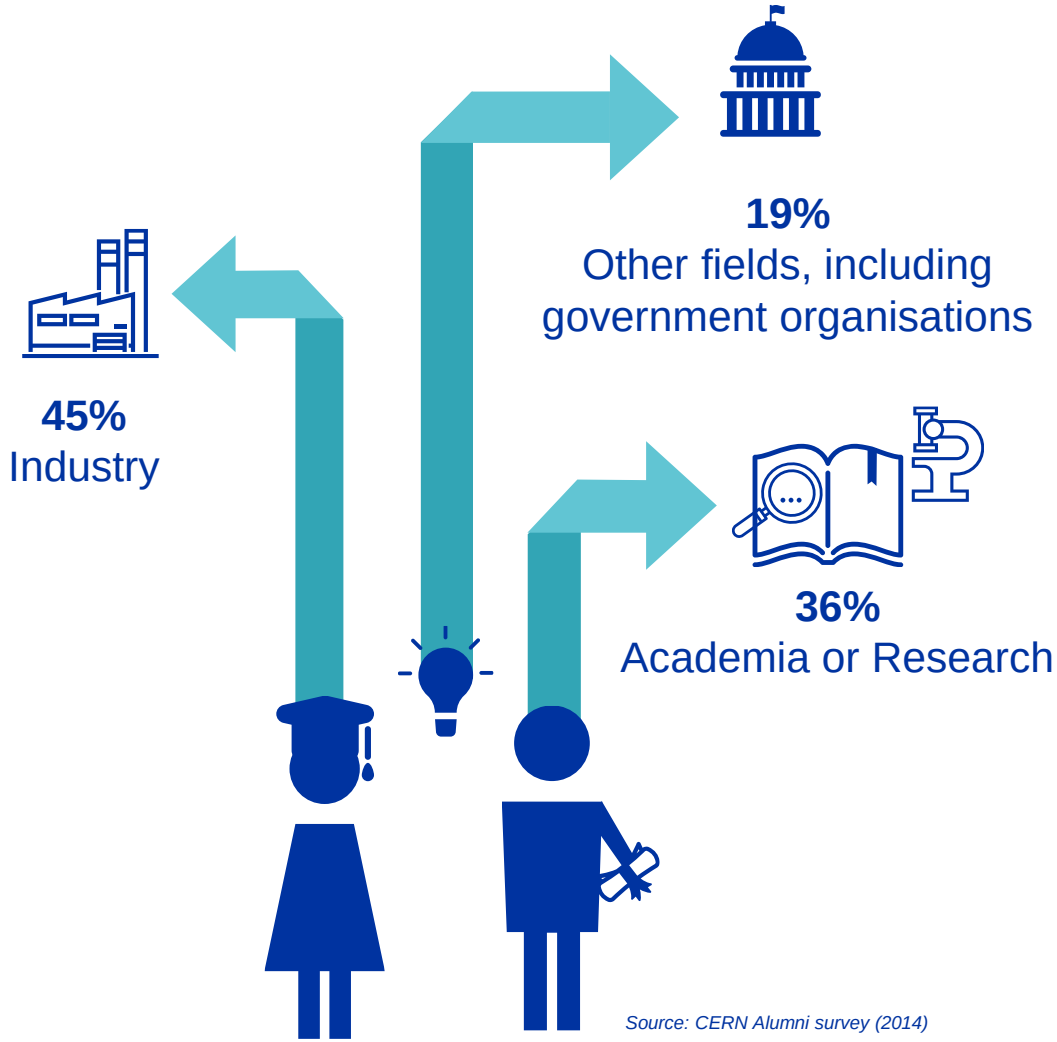
Thanks to "high-temperature" superconducting materials

EDUCATION & TRAINING

CERN opens a world of career opportunities



Age Distribution of Scientists working at CERN



PhD and Technical students leaving CERN

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 the USA

20 Summer Students in 2019
126 teachers in Teacher Programmes since 1998
95 teams in BL4S competition since 2014
380 students participating in S'Cool LAB since 2015
2280 visitors from the USA in 2019

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

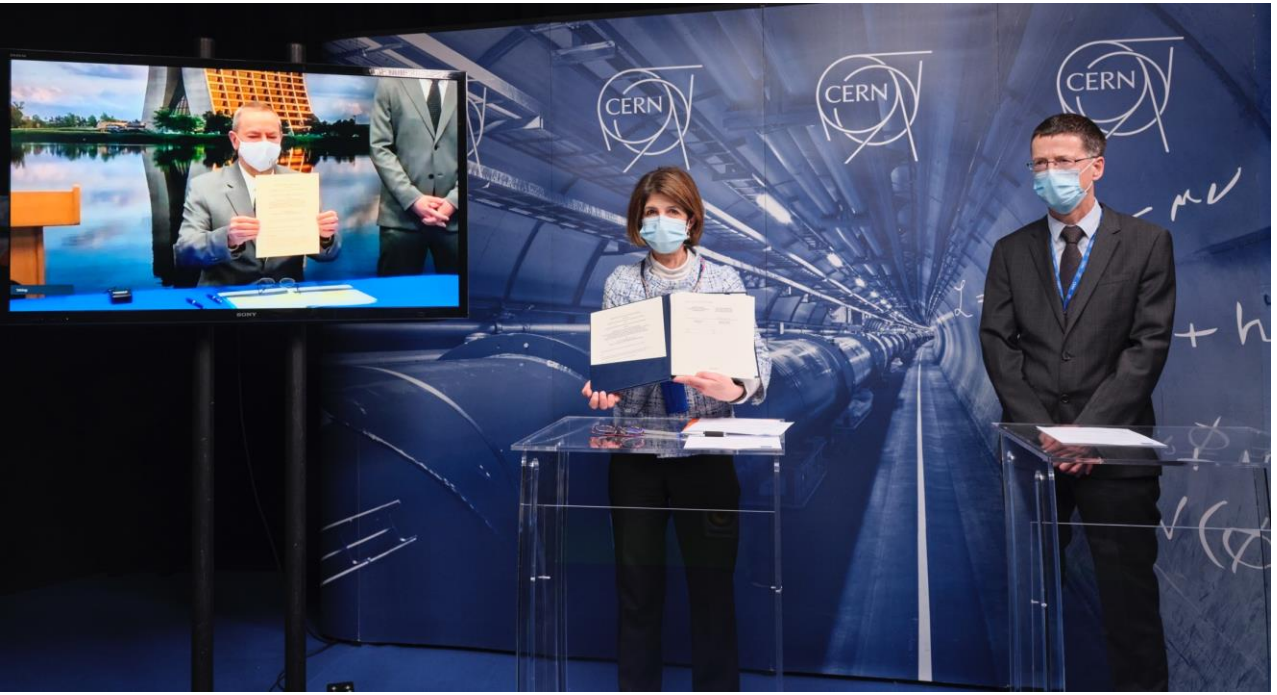
CERN’s new education and outreach centre for all publics aged 5-plus.

Opening summer 2023.

Immersive exhibitions, education labs, events and shows.

United States and CERN

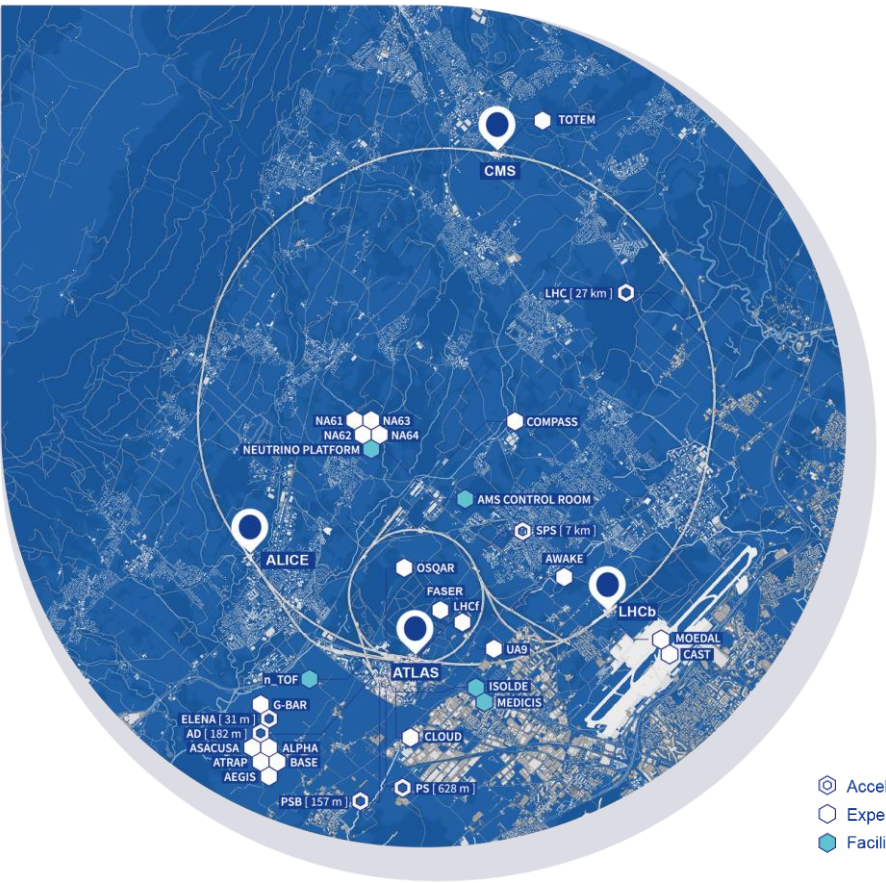
Contributions to LHC construction coordinated by FNAL and BNL



Remote signature ceremony of MoU between CERN and Fermilab for HiLumi

- US has Observer status at CERN since 1997 with the right to attend restricted Council sessions for discussions of LHC matters.
- In 2020, the Council granted the US Observer status also in respect of the HL-LHC.
- US physicists have been participating in a wide range of experiments at CERN for over 40 years, from the ISR through SPS fixed-target experiments, all the LEP experiments (L3, ALEPH, OPAL, DELPHI) to heavy-ion experiments (NA45, NA49) and ISOLDE.

Very strong involvement in the LHC experimental programme CMS, ATLAS, ALICE, LHCb and TOTEM



LHC EXPERIMENTS:

ALICE 15 Institutes
ATLAS 46 Institutes
CMS 56 Institutes
LHCb 6 Institutes

OTHER LHC EXPERIMENTS:

TOTEM 1 Institute
MoEDAL 2 institutes
FASER 3 institutes

FIXED TARGET EXPERIMENTS

AWAKE 1 institute
CLOUD 3 institutes
NA58 (COMPASS) 1 institute
NA61 (SHINE) 4 institutes
NA62 3 institutes
NeutrinoPlatform 41 institutes

ANTIPROTON EXPERIMENTS

ALPHA 2 institutes

ISOLDE
20 institutes

US has also contributed to the development of the WLCG and operates two Tier-1 centres and several Tier-2 centres.

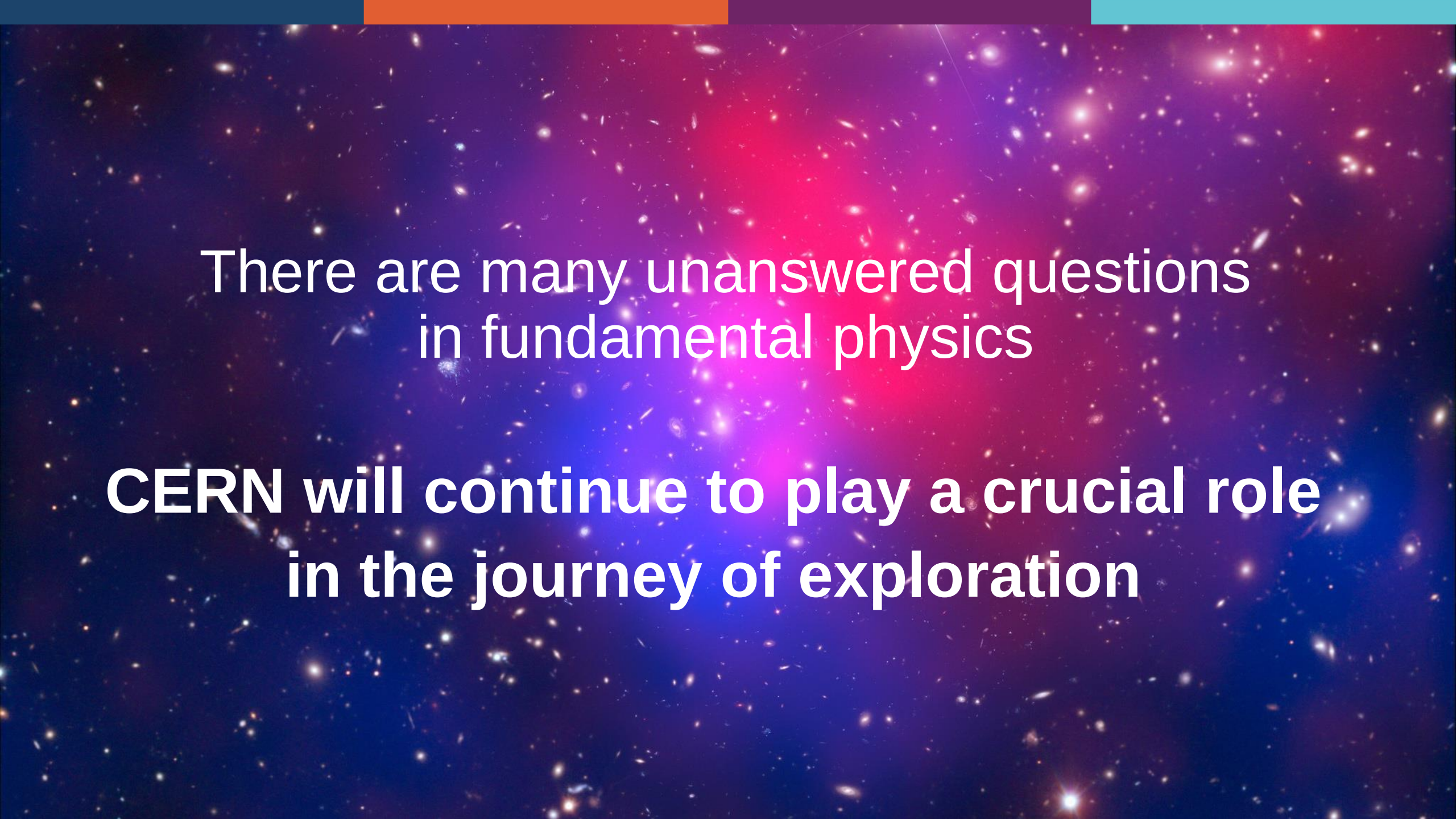
For LHC: 116 Institutes, ~1000 Scientists holding PhD degree, ~600 PhD students

DOE-NSF-CERN
International Cooperation Agreement
signed in Washington D.C. on 7 May 2015

- With the European Strategy, the US P5 process, and the Japanese roadmap there was for the first time a global vision for particle physics going beyond regional boundaries.

- Strong collaboration, in particular on LHC and its luminosity upgrade (HL-LHC), CLIC/CTF3 & FCC in Europe and on the neutrino programme at Fermilab.

- European Strategy updated in 2020 and US strategy update is underway.


There are many unanswered questions
in fundamental physics
CERN will continue to play a crucial role
in the journey of exploration