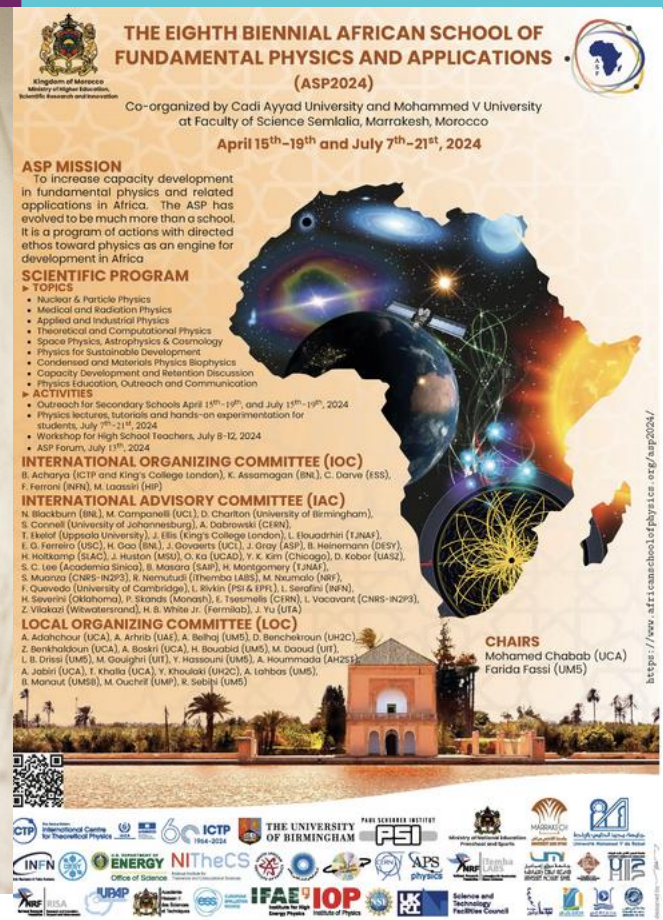
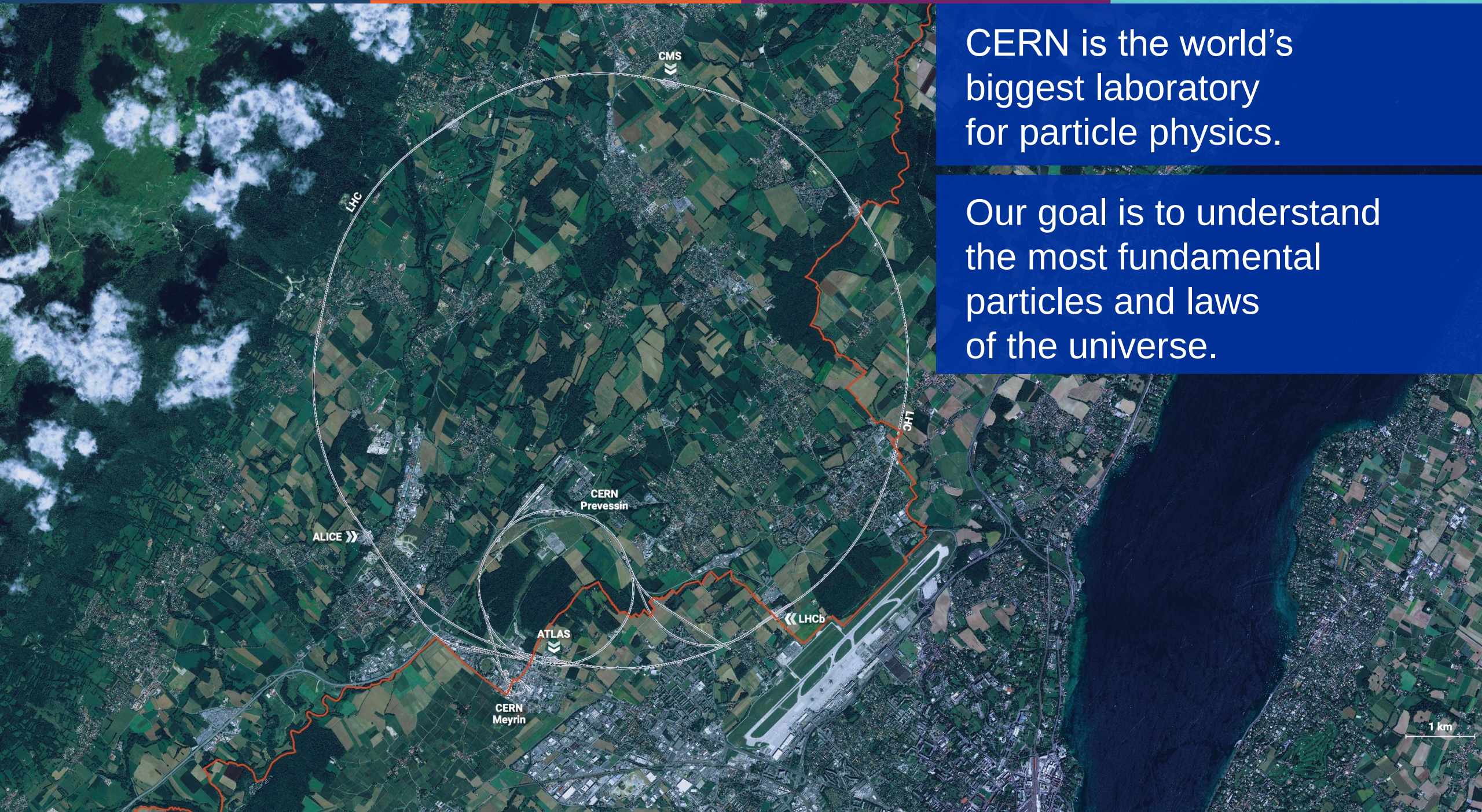
Introduction to CERN and the Collaboration with Africa



Emmanuel Tsesmelis
CERN
Principal Physicist
Head of Associate Member State and Non-Member State Relations

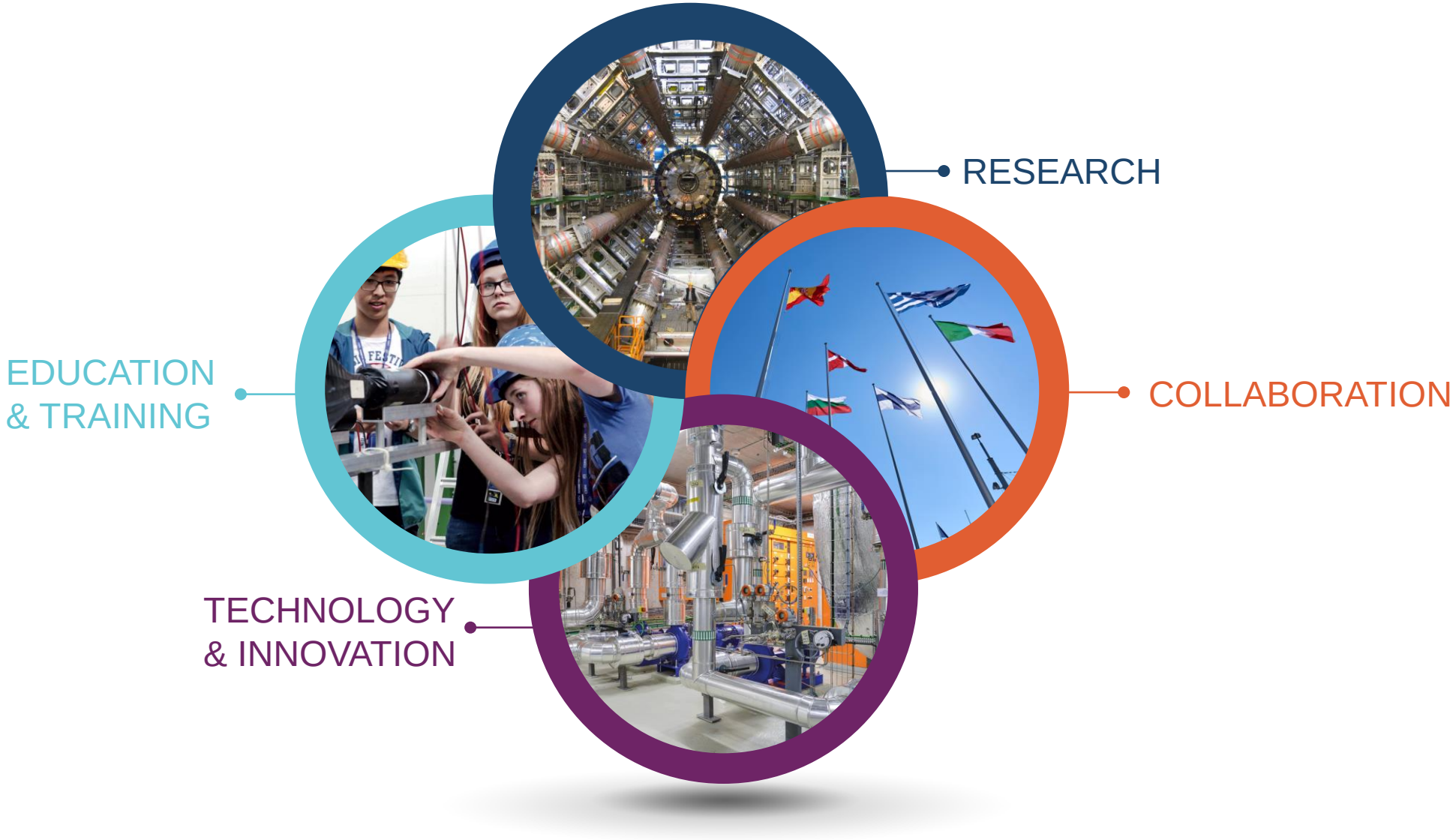
8th African School of Physics (ASP2024)
Cadi Ayyad University
Marrakesh, Morocco
7-21 July 2024

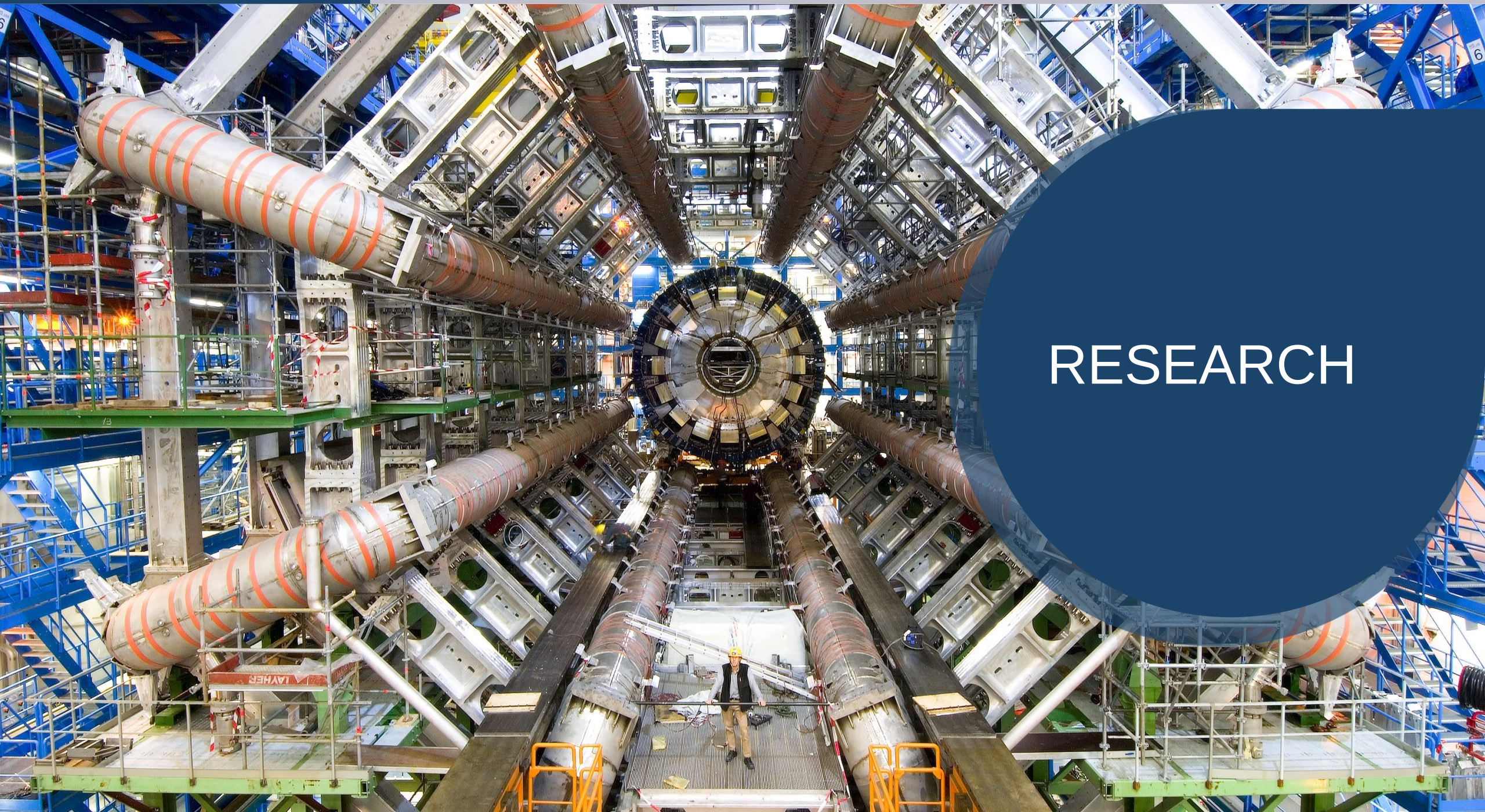


CERN is the world's biggest laboratory for particle physics.

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

Four pillars underpin CERN's mission

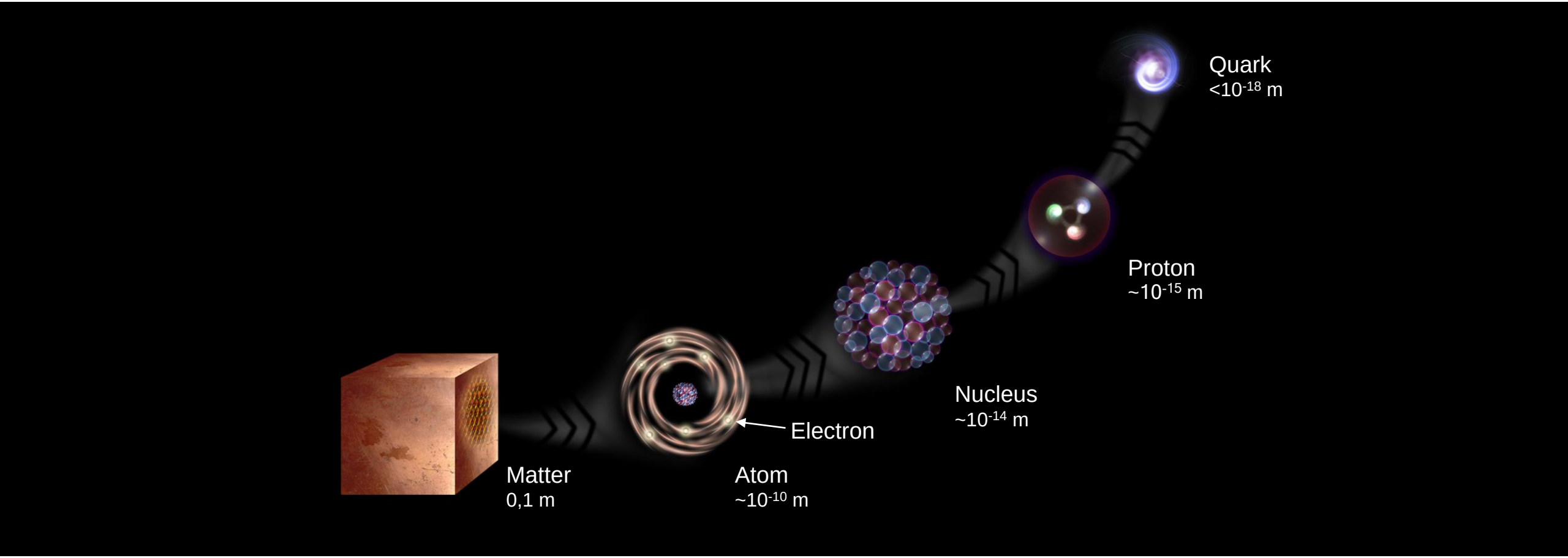


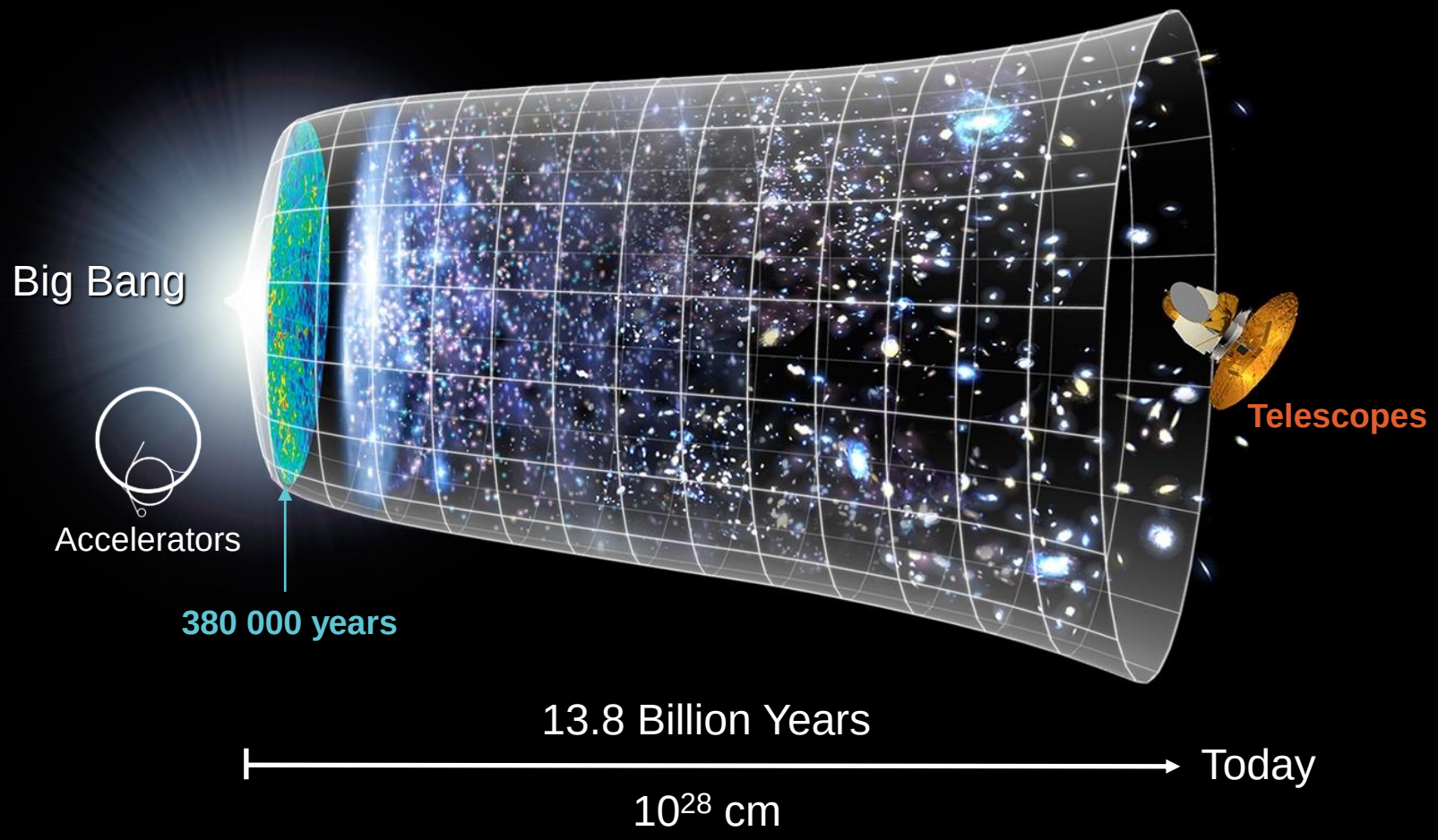


RESEARCH

What is the universe made of?

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





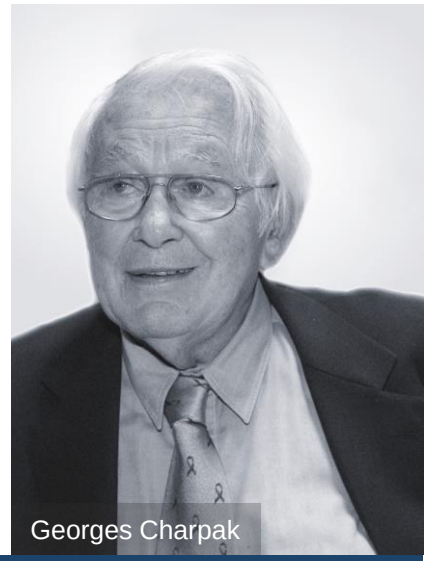
How did the universe begin?

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

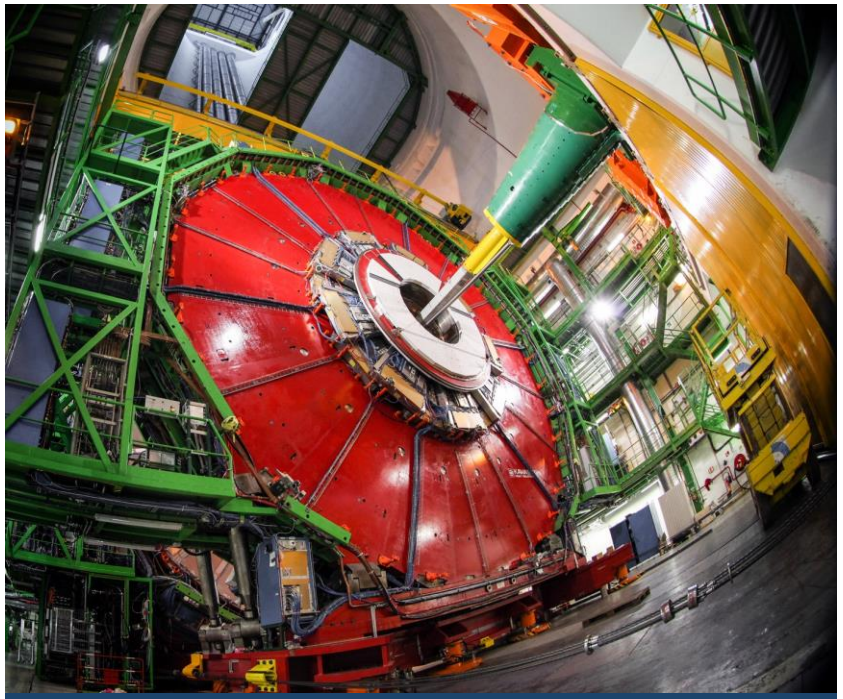
Several CERN scientists have received Nobel Prizes for key discoveries in particle physics.

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

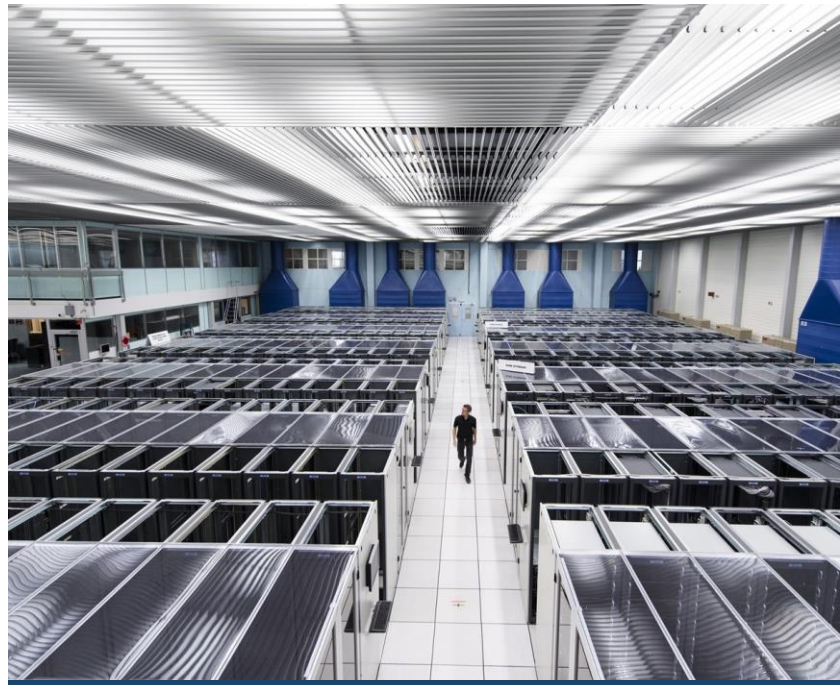

François Englert and Peter Higgs. With Robert Brout, they proposed the mechanism in 1964.

We develop technologies in three key areas

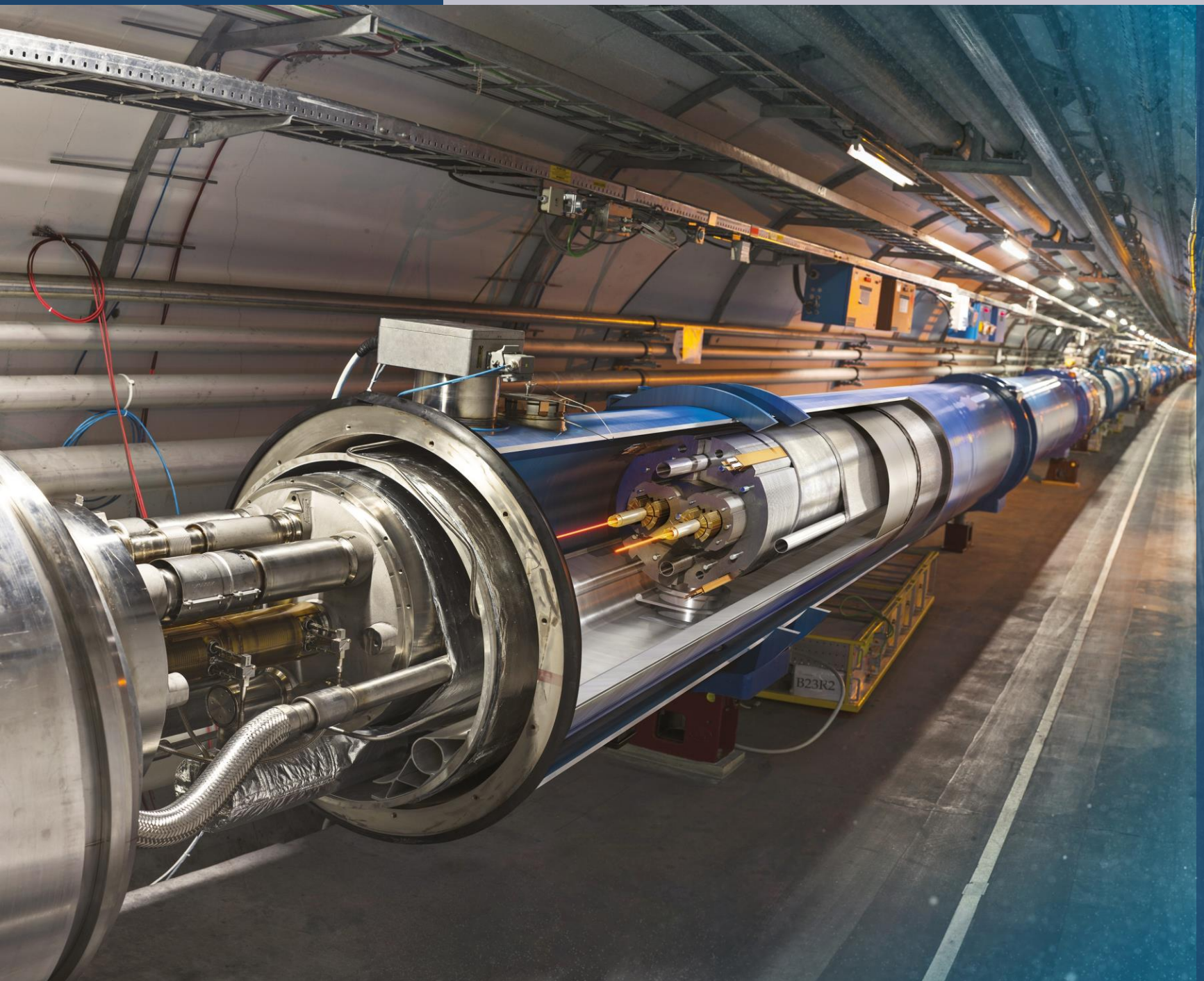
ACCELERATORS



DETECTORS



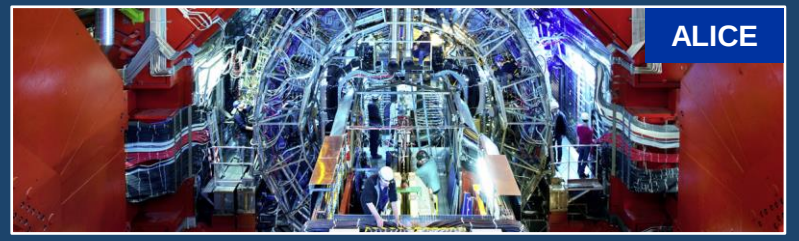
COMPUTING



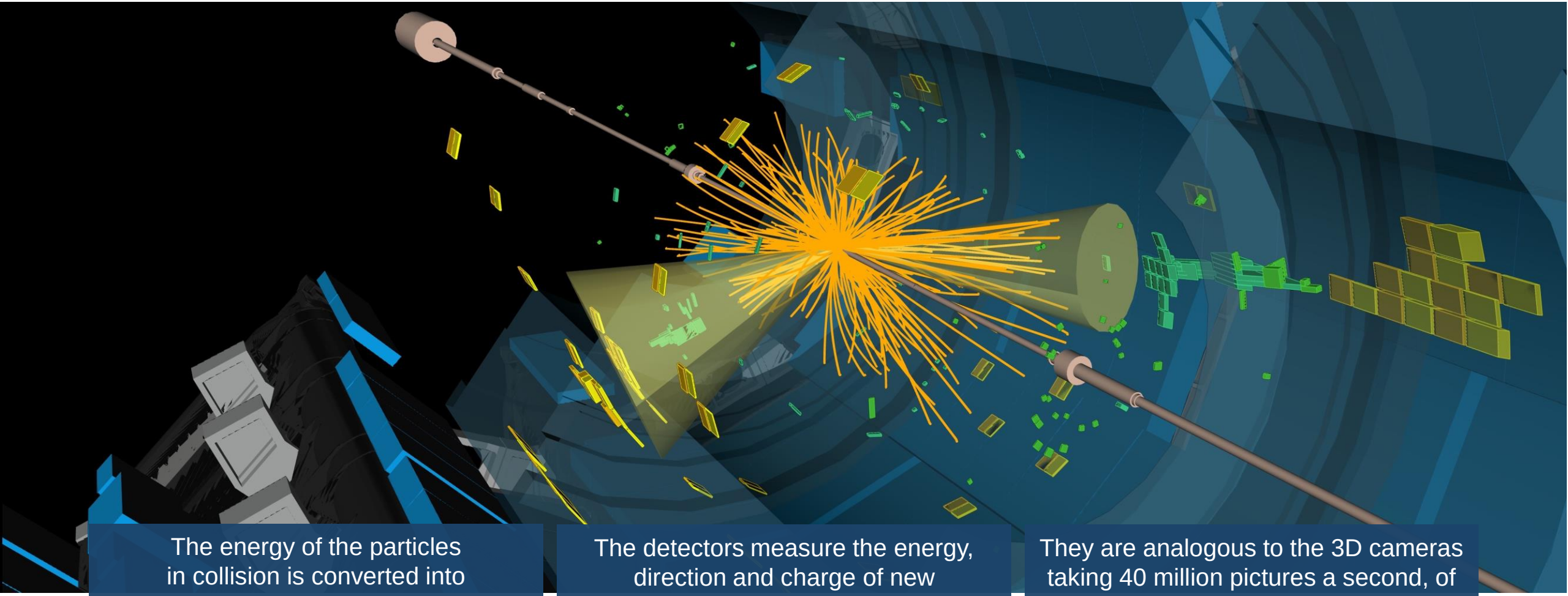
Large Hadron Collider (LHC)

- 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

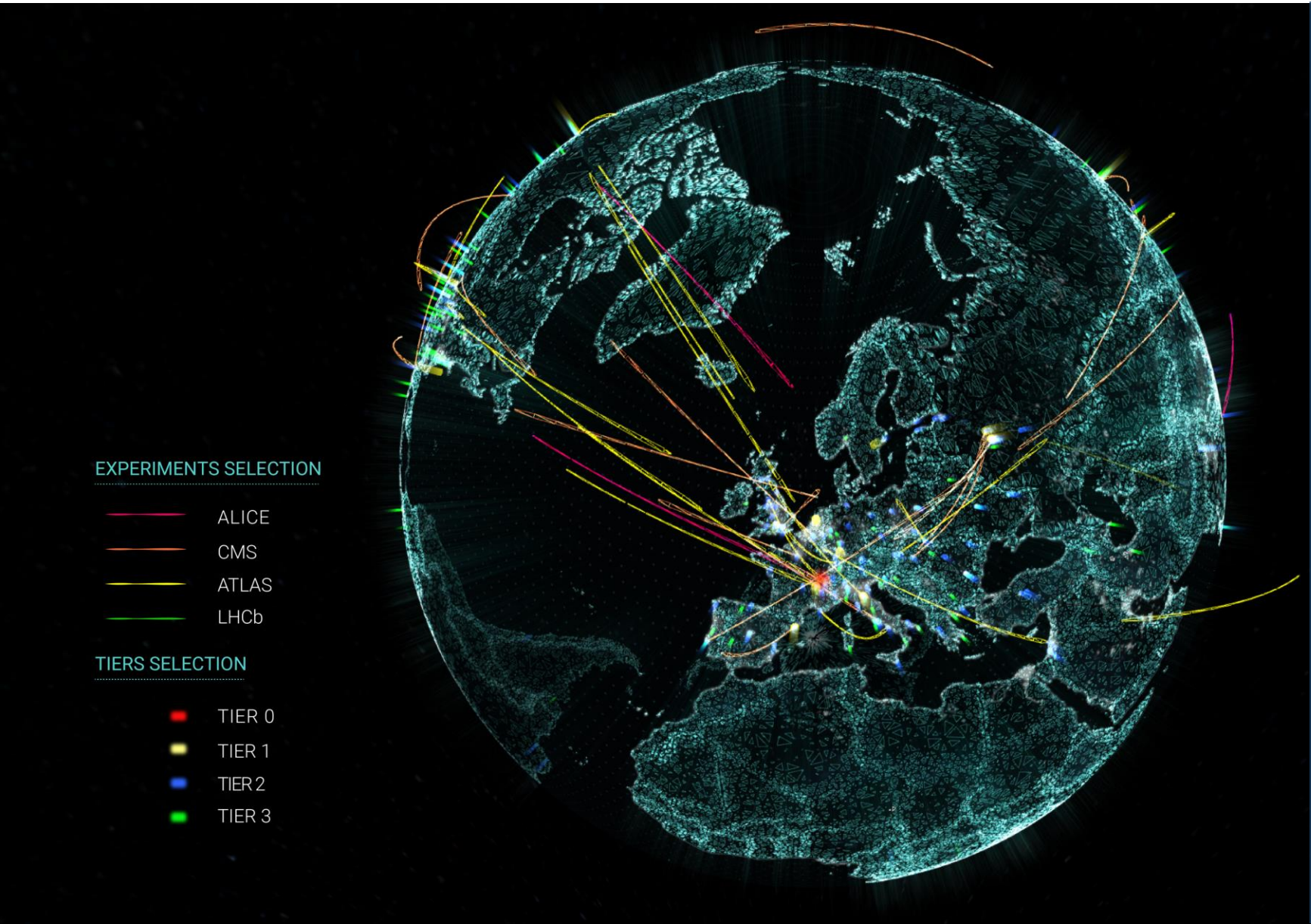


The energy of the particles in collision is converted into new particles.

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

They are analogous to the 3D cameras taking 40 million pictures a second, of which 1000 are selected and recorded.

The Worldwide LHC Computing Grid (WLCG)



WLCG

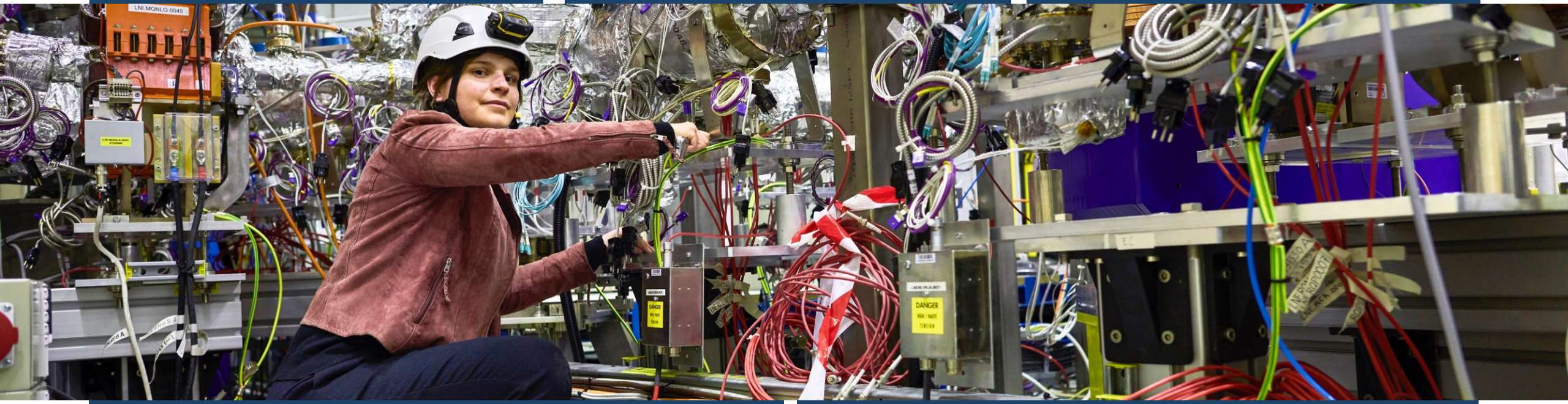
- Stores, distributes, processes and analyses LHC experiments' data.
- 1.4 million processing cores in 170 data centres and more than 40 countries.
- 1500 Petabytes of CERN data stored world-wide.

CERN has a diverse scientific programme

Nuclear Physics
(ISOLDE, n_TOF)

Antimatter Research
(Antiproton Decelerator)

Cosmic rays and cloud formation
(CLOUD)



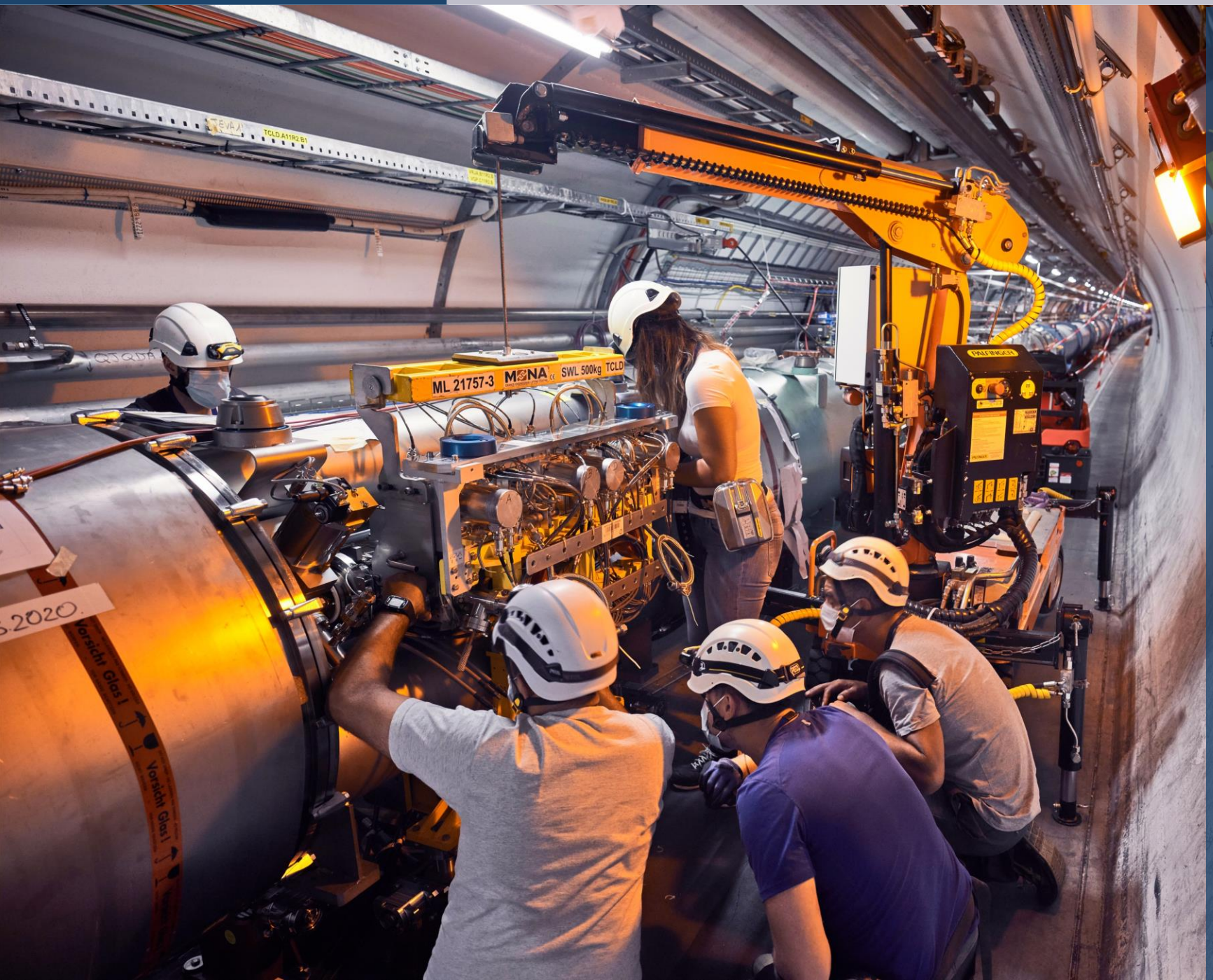
Fixed-target experiments,
which include searches for rare phenomena

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?



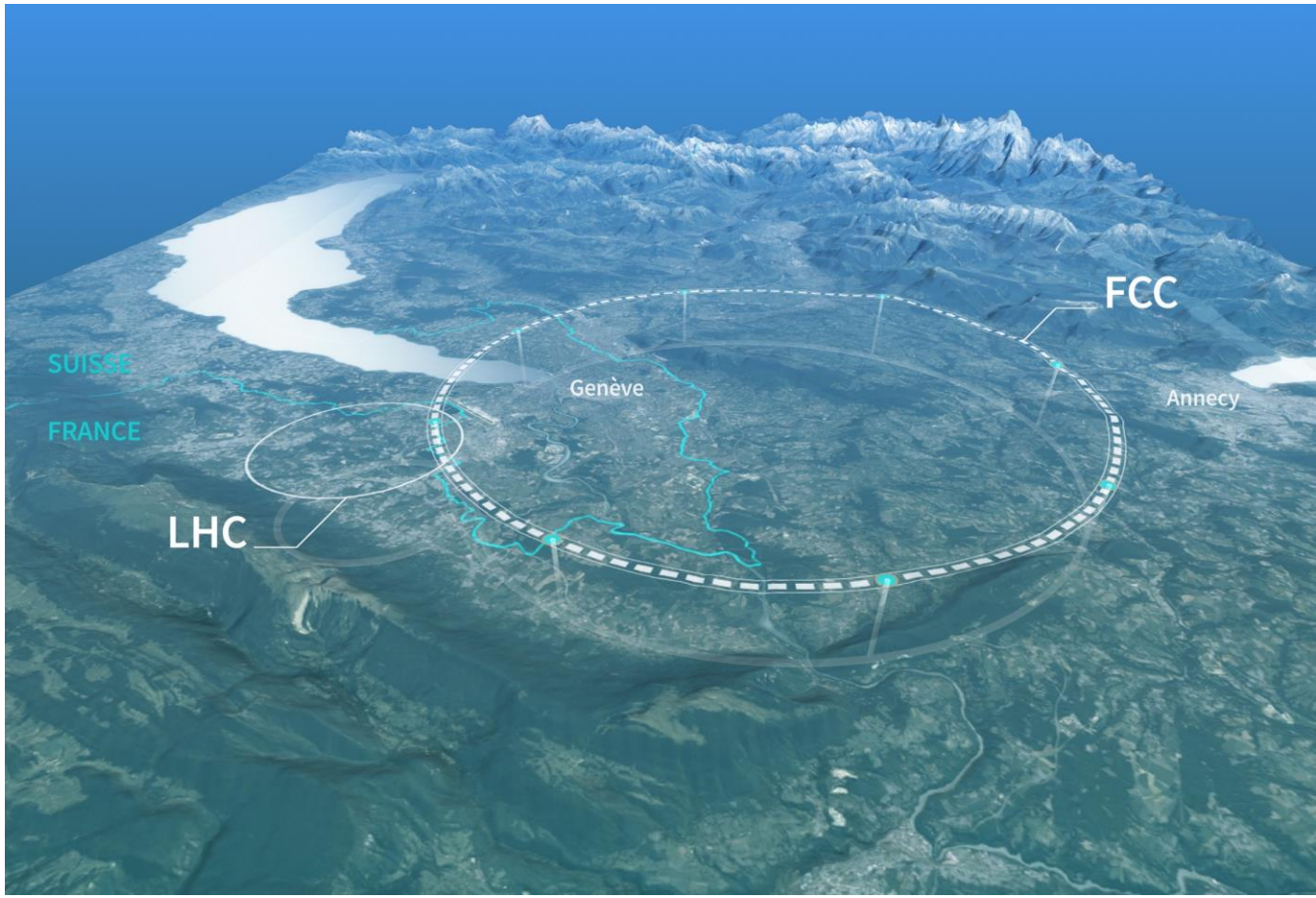
Upgrade to the High-Luminosity LHC is under way

- 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 2041.

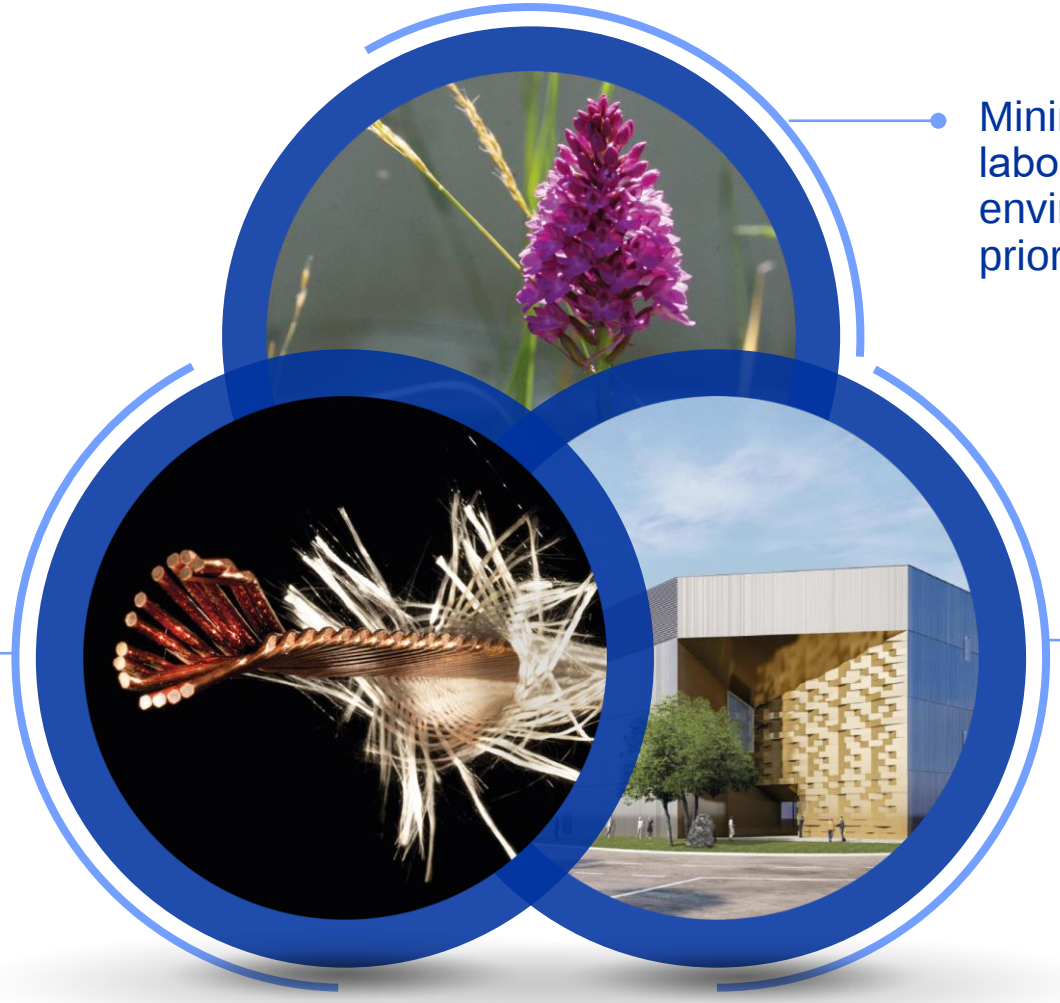
Preparing CERN's future

Driven by the **2020 Update of the European Strategy for Particle Physics**

- Technical and financial feasibility study of a Future Circular Collider (report for early 2025)
- Accelerator R&D to develop technologies for FCC and for alternative options
- Detector and computing R&D
- Maintain and expand a compelling scientific diversity programme
- Continue to support other projects around the world



Committed to environmentally responsible and sustainable research



Minimize the impact of the laboratory's activities on the environment with defined priority actions

Identify and develop CERN technologies that would help mitigate society's impact on the environment

Energy:

Consume less, improve efficiency, and recover more

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

8 Associate Member States

Brazil - 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 2023
Employees:
2666 staff, **1002** graduates
Associates:
12 370 users, **1513** others

Egypt and Morocco have signalled interest in applying for CERN Associate Membership

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 2023

Geographical & cultural diversity
Users of **110 nationalities**
22.5 % women

Member States 7438

Austria 86 – **Belgium** 129 – **Bulgaria** 46 – **Czech Republic** 252
Denmark 47 – **Finland** 88 – **France** 842 – **Germany** 1296
Greece 112 – **Hungary** 80 – **Israel** 74 – **Italy** 1609 – **Netherlands** 167
Norway 77 – **Poland** 322 – **Portugal** 105 – **Romania** 113
Serbia 38 – **Slovakia** 67 – **Spain** 413 – **Sweden** 106
Switzerland 419 – **United Kingdom** 950

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

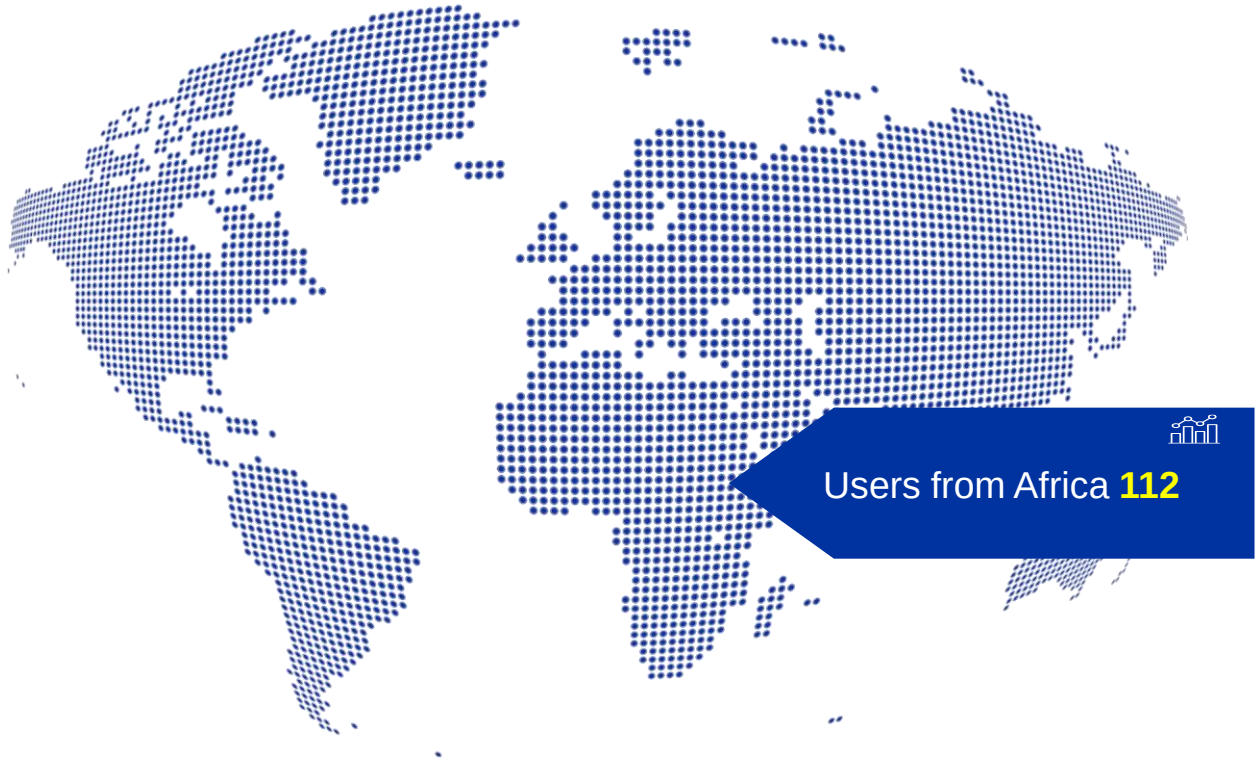
Cyprus 14 – **Estonia** 29 – **Slovenia** 26

Associate Member States **541**

Brazil 135 – **Croatia** 37 – **India** 145 – **Latvia** 21 – **Lithuania** 17 – **Pakistan** 30
Türkiye 129 – **Ukraine** 27

Observers **3005**

Japan 219 – **Russia** (suspended) 779 – **United States of America** 2007



Non-Member States and Territories 1317

Algeria 2 – **Argentina** 16 – **Armenia** 16 – **Australia** 26 – **Azerbaijan** 3 – **Bahrain** 3 – **Belarus** 14 – **Canada** 206
Chile 45 – **China** 414 – **Colombia** 24 – **Costa Rica** 3 – **Cuba** 3 – **Ecuador** 4 – **Egypt** 24 – **Georgia** 34 – **Hong Kong** 15
Iceland 3 – **Indonesia** 7 – **Iran** 14 – **Ireland** 4 – **Jordan** 3 – **Kazakhstan** 3 – **Kuwait** 2 – **Lebanon** 7 – **Madagascar** 1
Malaysia 4 – **Malta** 1 – **Mexico** 56 – **Montenegro** 3 – **Morocco** 18 – **New Zealand** 2 – **Nigeria** 2 – **Oman** 1
Palestine 1 – **Peru** 3 – **Philippines** 1 – Republic of Korea 168 – **Saudi Arabia** 6 – **South Africa** 61 – **Sri Lanka** 10
Taiwan 52 – **Thailand** 17 – **Tunisia** 4 – **United Arab Emirates** 10 – **Vietnam** 1

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

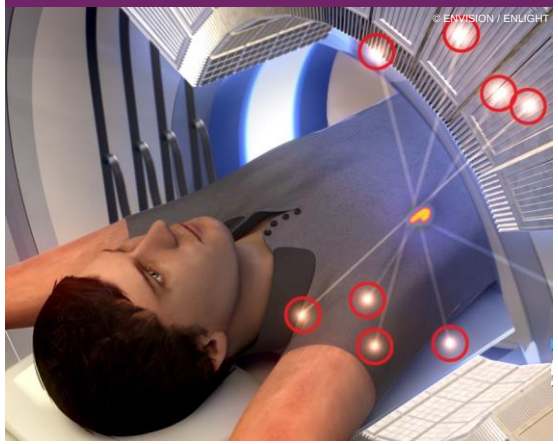
CERN is the birthplace of the World Wide Web

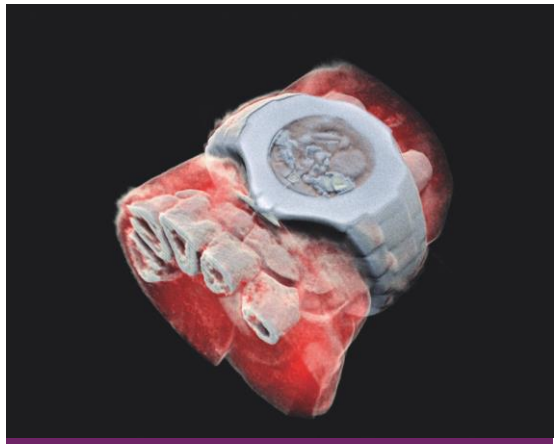
And there are many more examples
Medical imaging, cancer therapy, material science, cultural heritage, aerospace, automotive, environment, health & safety, industrial processes.

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.



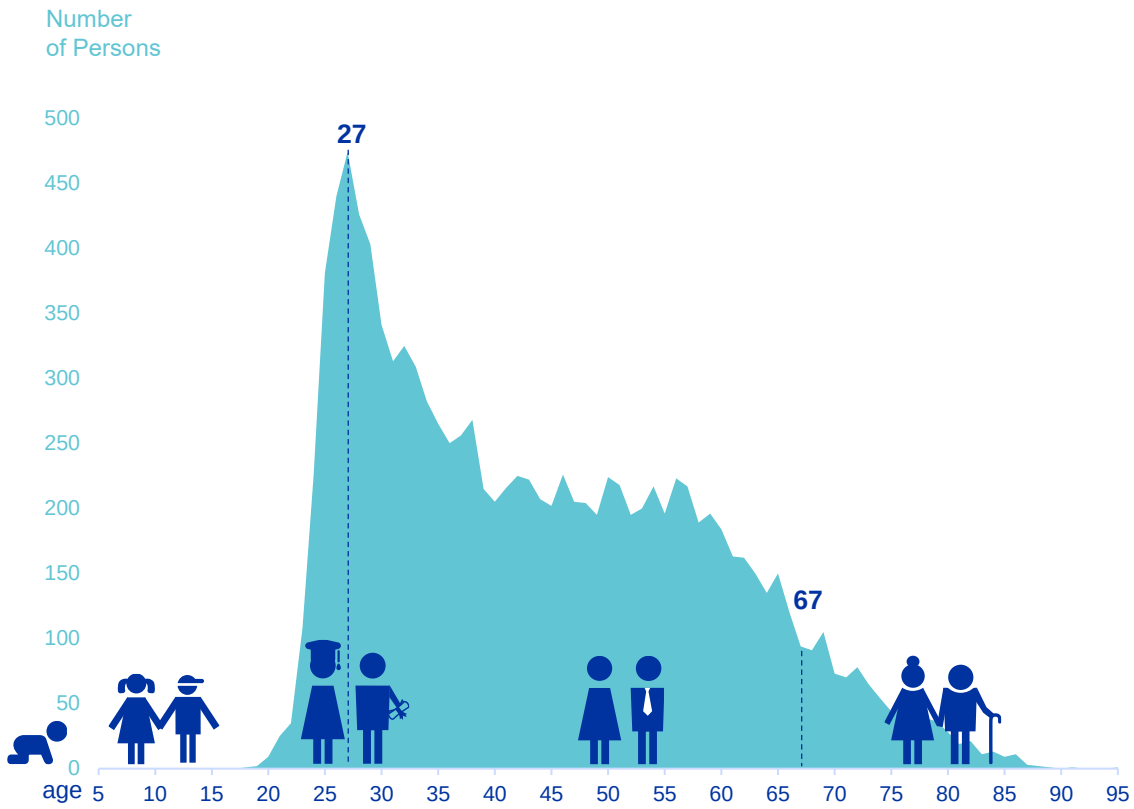


Pixel detector technologies are used for high resolution 3D colour X-ray imaging.

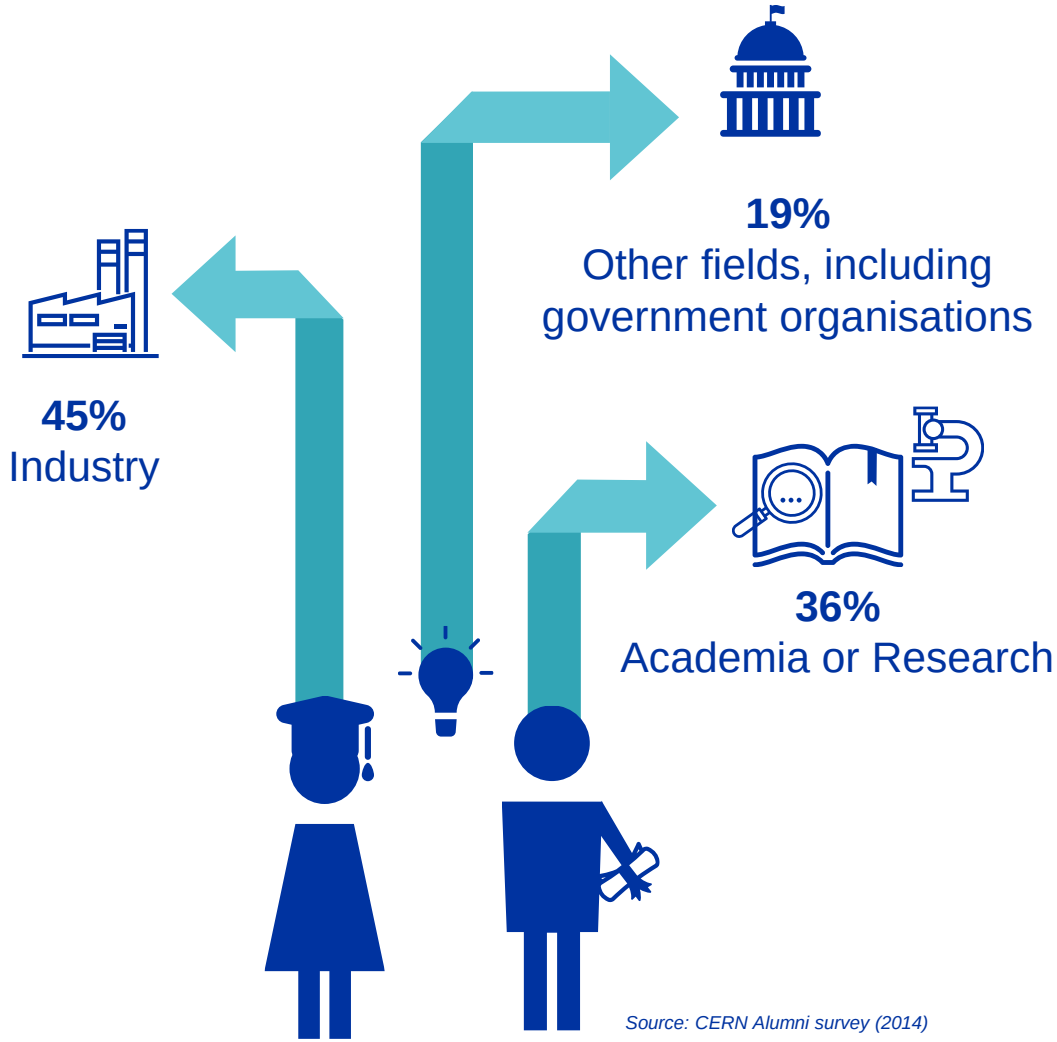
CERN produces innovative radioisotopes for nuclear medicine research.

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

900 graduates
(including Research Fellows)

3 000 PhD students

300 Undergraduate students in Summer programmes

>14 000 teachers participating in dedicated programmes, since 1998

Around **150 000 visitors** on guided tours of CERN, from >50 countries

4.7M followers on social media, from around the globe

CERN Science Gateway

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

Inaugurated
7 October 2023.

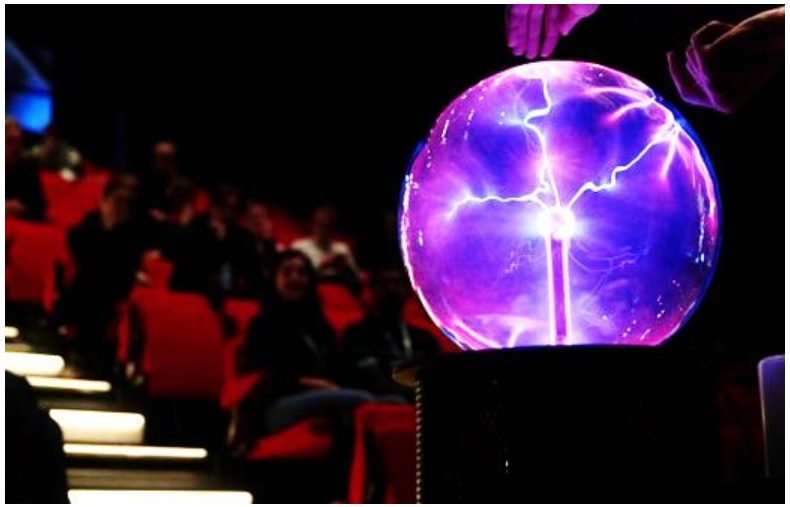
Number of visitors: **>250 000**

Immersive exhibitions, education labs, events and shows.

Science Gateway Education Activities 2023

Science Shows

- 5 different shows
- 36 shows at the Globe (Jan-Sept) with 1800+ visitors
- 40 shows at Science Gateway (Oct-Dec) with 2500+ visitors



Lab Workshops

- 10 different lab workshops
- 270 workshops with 5200+ participants (15% 5-15 y, 35% 16-19 y, 10% teachers or adults, 40% families & individual visitors)

CERN-Solvay programme

- 12 new education videos with 2.2 million views online
- 1000 certificates for online course
- 600+ applications from 60+ countries for camp (30 selected)

CERN Scientific Programme

The participation of physicists, computer scientists and engineers from **Africa** in CERN experiments and other activities has become **increasingly visible**, offering **interesting prospects for the future**.

Algeria – PhD student in **ATLAS**.

Egypt – Member of **CMS.**

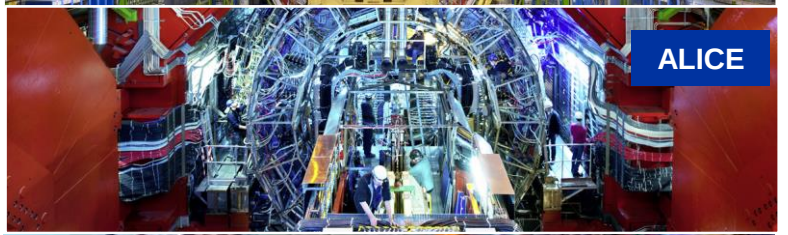
Madagascar – CLIC / CTF3.

Morocco – Member of **ATLAS**.

Nigeria – Member of **CMS**.

South Africa – Member of **ALICE, ATLAS, ISOLDE**.

Tunisia – Associated Institute of **CMS**.



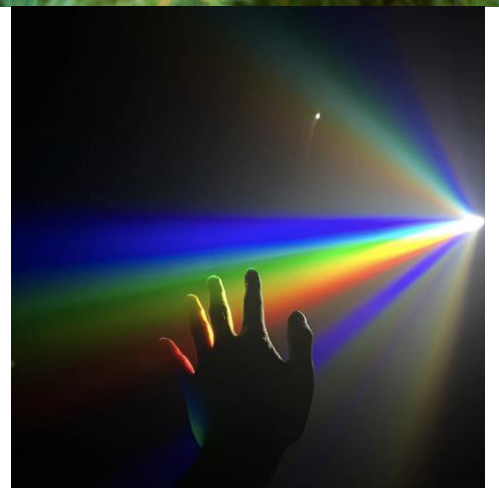
Interest to collaborate with CERN from:
Botswana, Ethiopia, Kenya, Namibia, Rwanda, Sudan, Tanzania

Capacity-building at CERN

- Participation in CERN **education & training** programmes
  - Students in the **Summer Student Programme** & **Doctoral Studentship Scheme** for nationals of non-Member States.
  - Students in **Beamline for Schools.**
  - Teachers in the **Teacher Programmes.**

- Capacity-building activities - CERN & Society Foundation
  - **Arts at CERN "Connect" programme with residencies for African artists at CERN** with South African Astronomical Observatory & South African Radio Astronomy Observatory.

CERN Summer Student Programme



Kamil Hassim
Event Horizon installation
at Constitution Hill, Johannesburg.
Courtesy the artist

Capacity-building in Africa

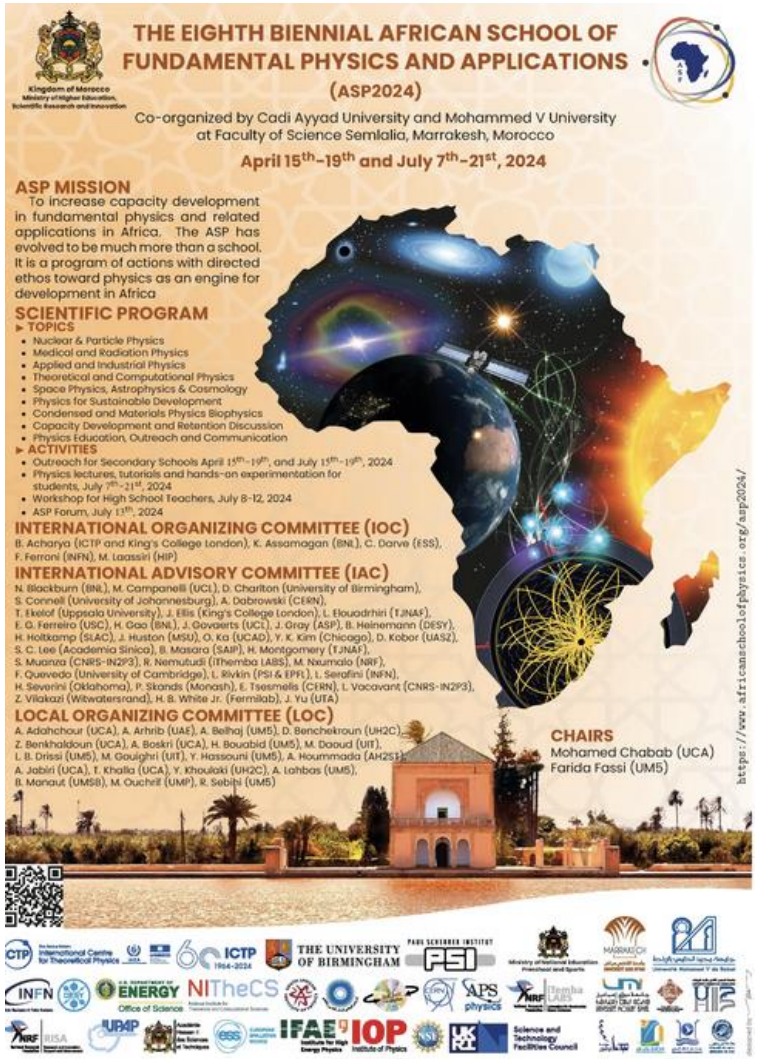
Capacity-building activities - **CERN & Society Foundation**

- **CERN-UNESCO Schools on Digital Libraries** → 5 schools (Ghana, Kenya, Morocco, Rwanda, Senegal) organized across Africa with 25 countries.
- Funds are available for one more school and this will be organised in collaboration with the Africa Open Science Platform — an NRF (South Africa) supported initiative.
  - Planning to have the school in **Pretoria** in **February 2025**.

Capacity-building in Africa

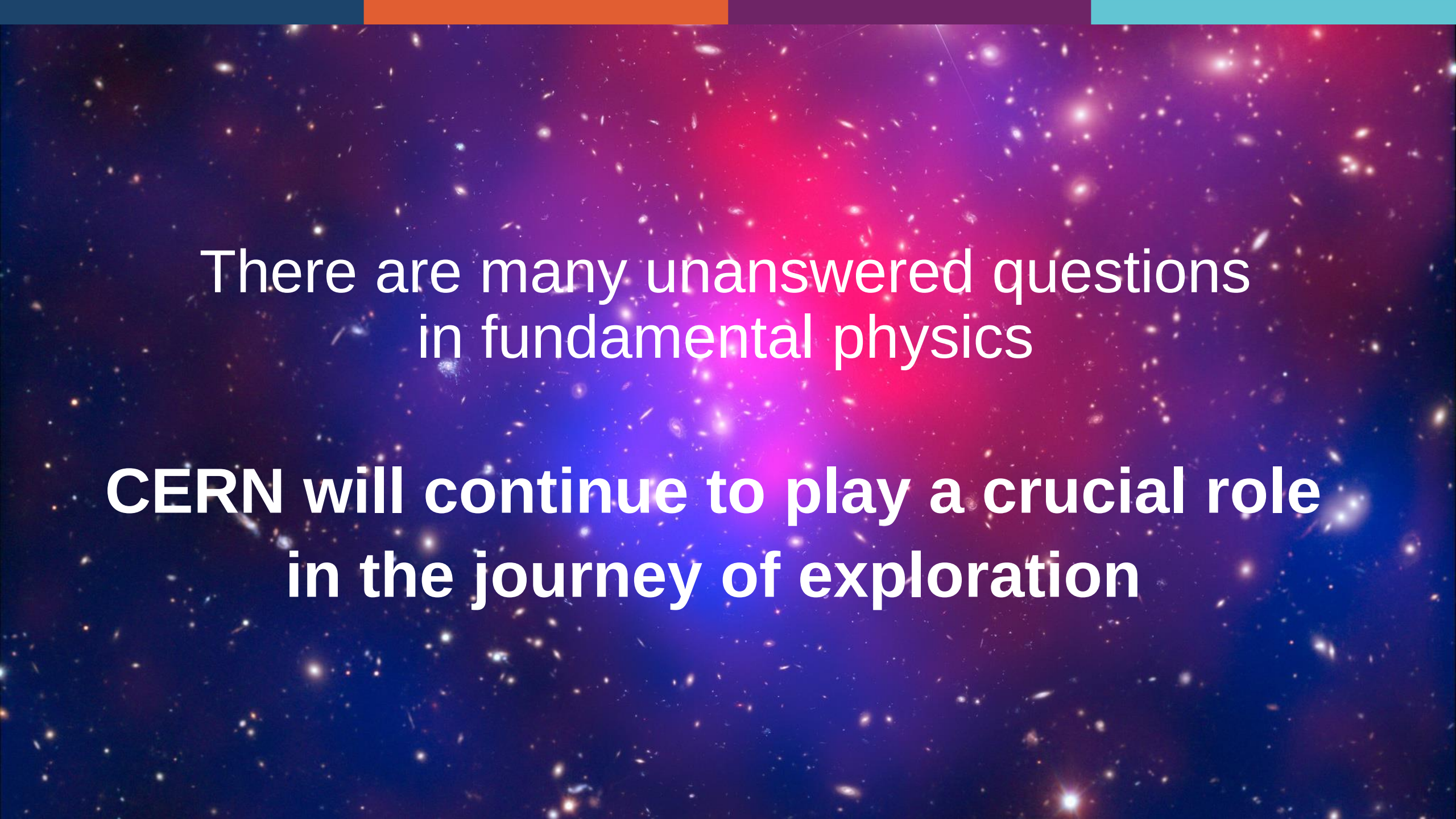
- Support for **African School for Fundamental Physics and Applications**
  - 8 editions starting in 2010 in South Africa with latest in July 2024 in Morocco.

- CERN organises the open access consortium **SCOAP3**, letting students around the world read and publish for free in top journals.
  - SCOAP3 has also an open access book offer the students should take note of, with currently close to 100 free books.



African Strategy for Fundamental & Applied Physics

- Support for process of development of **African Strategy for Fundamental and Applied Physics** to increase African education and research capabilities:
  - launched in 2020, engaging African scientists and the international community in the Strategy development;
  - suggest the direction for the field, with actionable items for the next decade, to repeated periodically, every 7-10 years;
  - expecting further opportunities for closer collaboration between Africa, CERN and other partners.


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