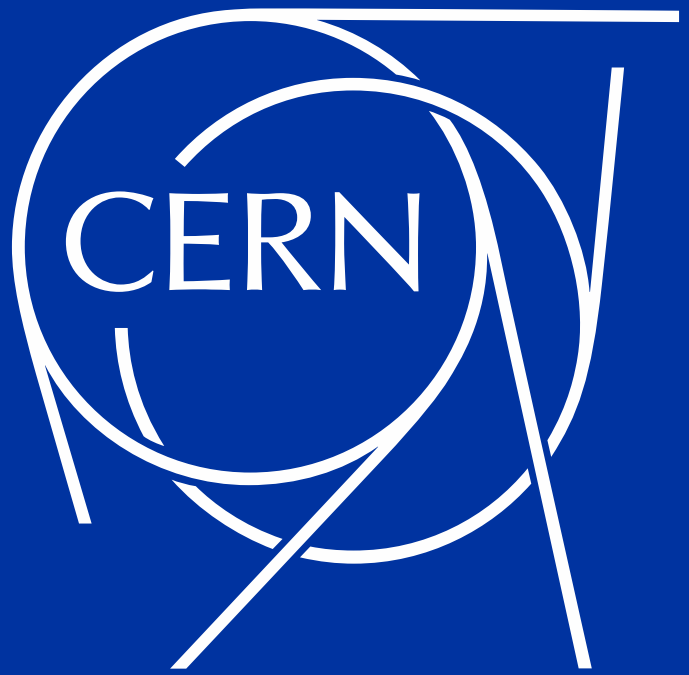
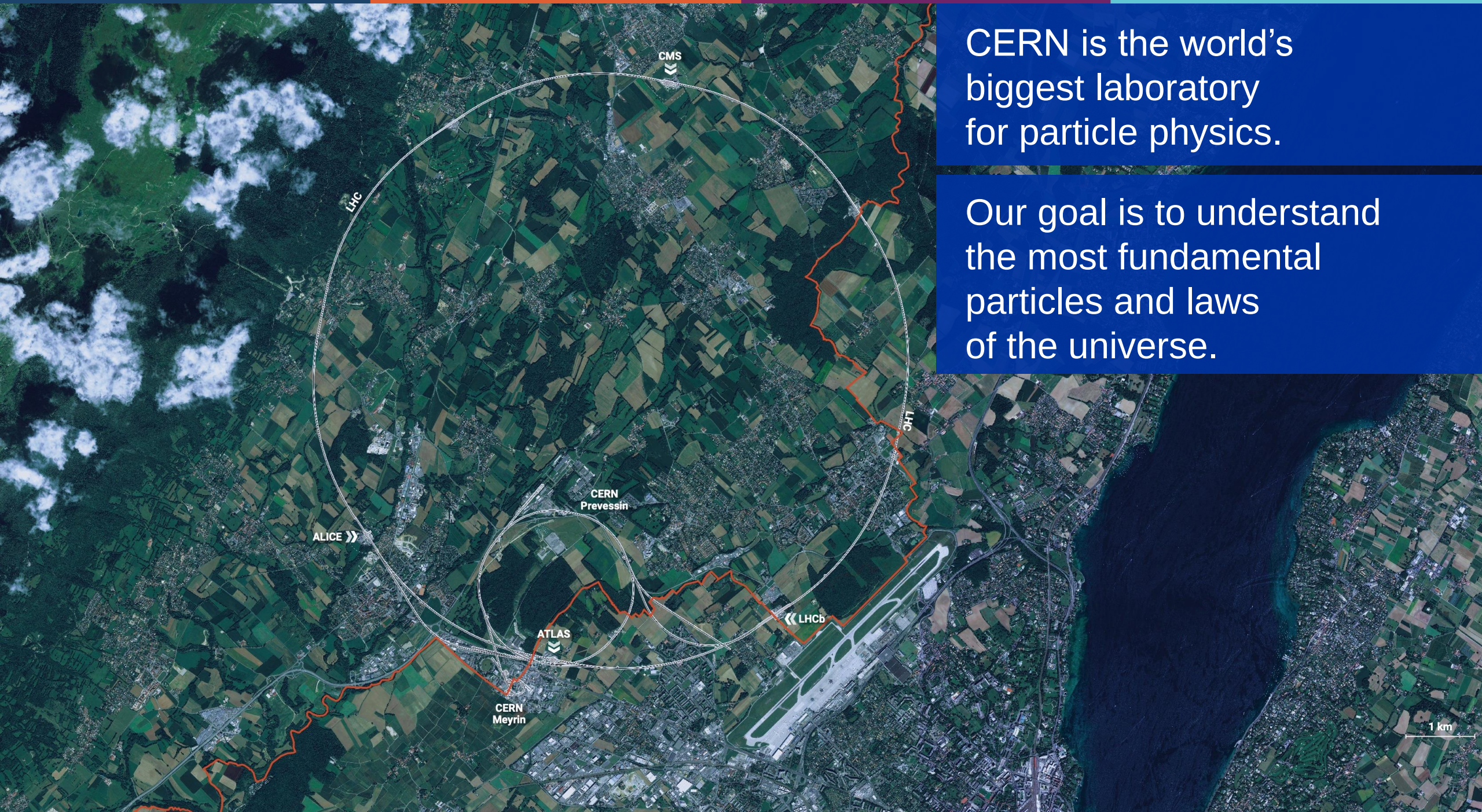

CERN

WELCOME TO CERN

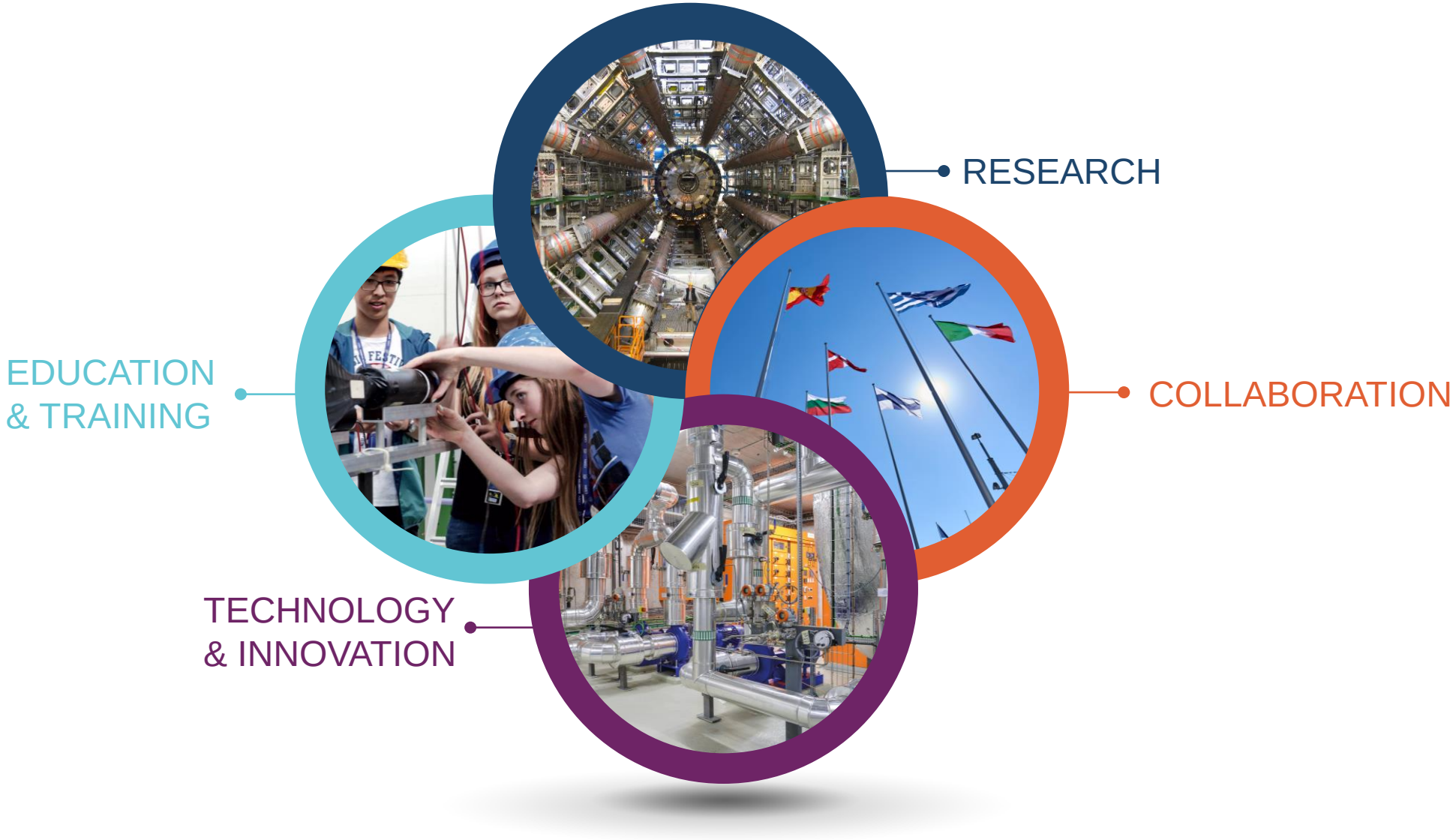
John Wood & Friends, January 31, 2023

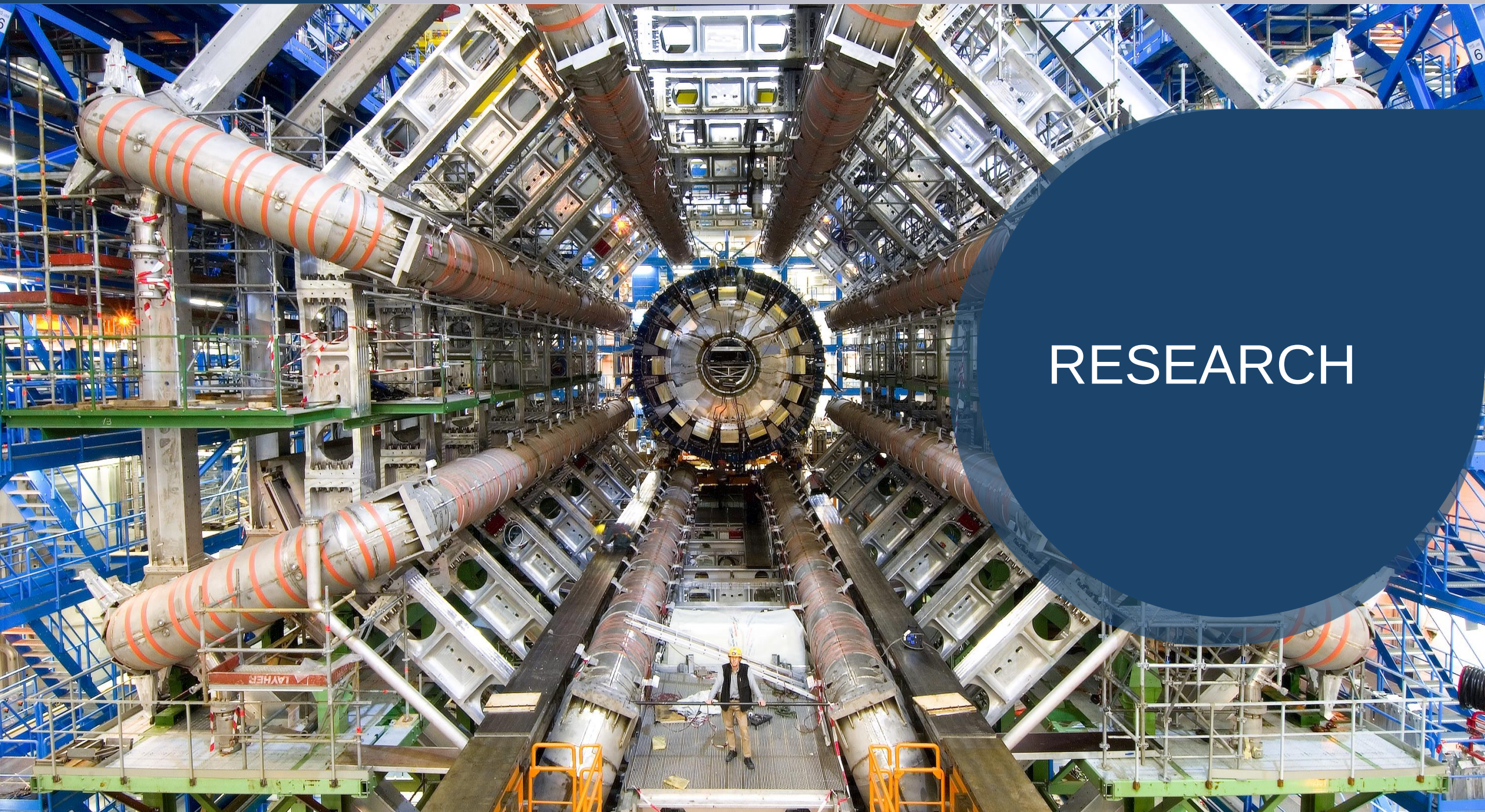


CERN is the world's biggest laboratory for particle physics.

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

Four pillars underpin CERN's mission



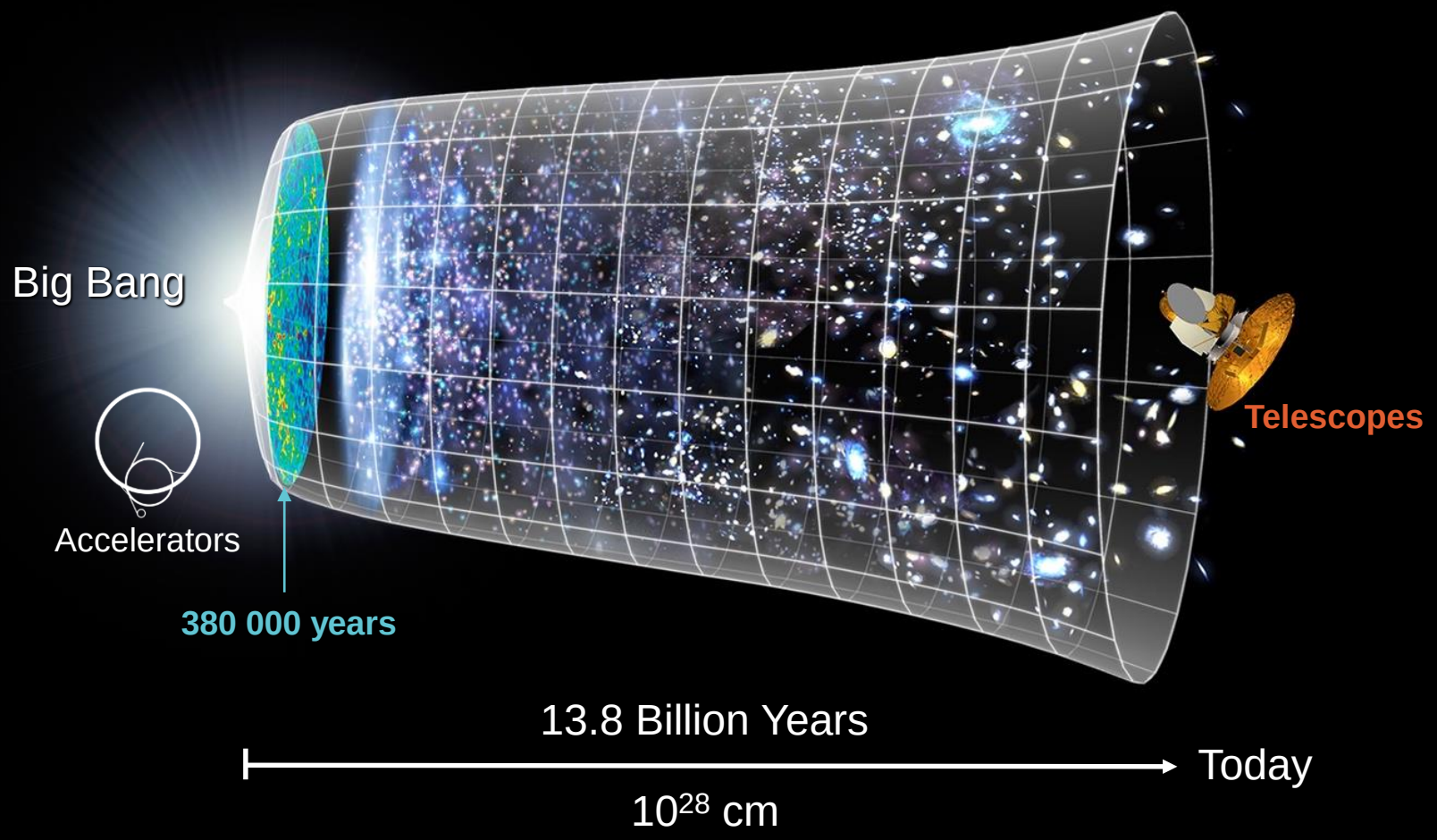


RESEARCH

There are many unanswered questions in fundamental physics

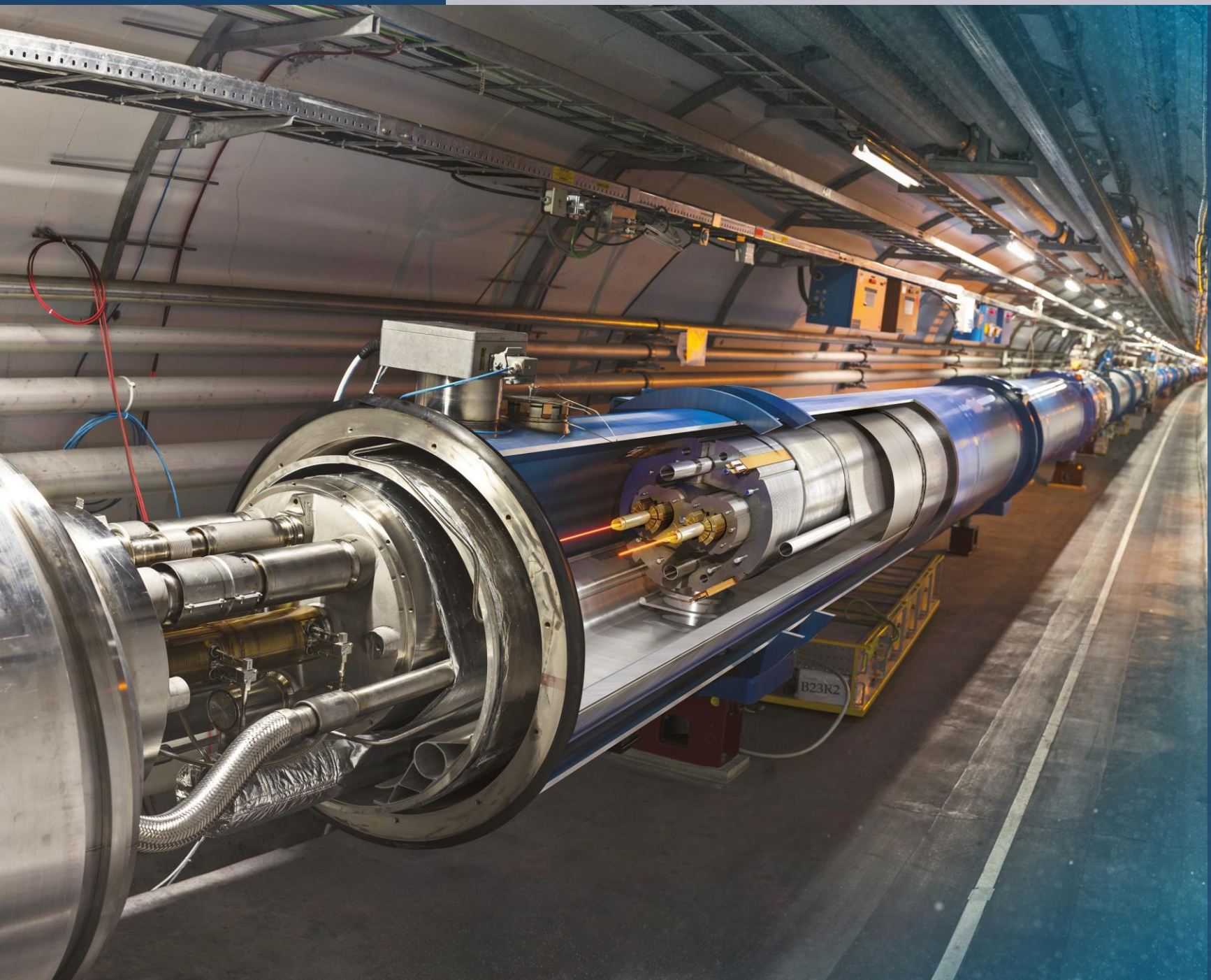
Including

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?



How did the universe begin?

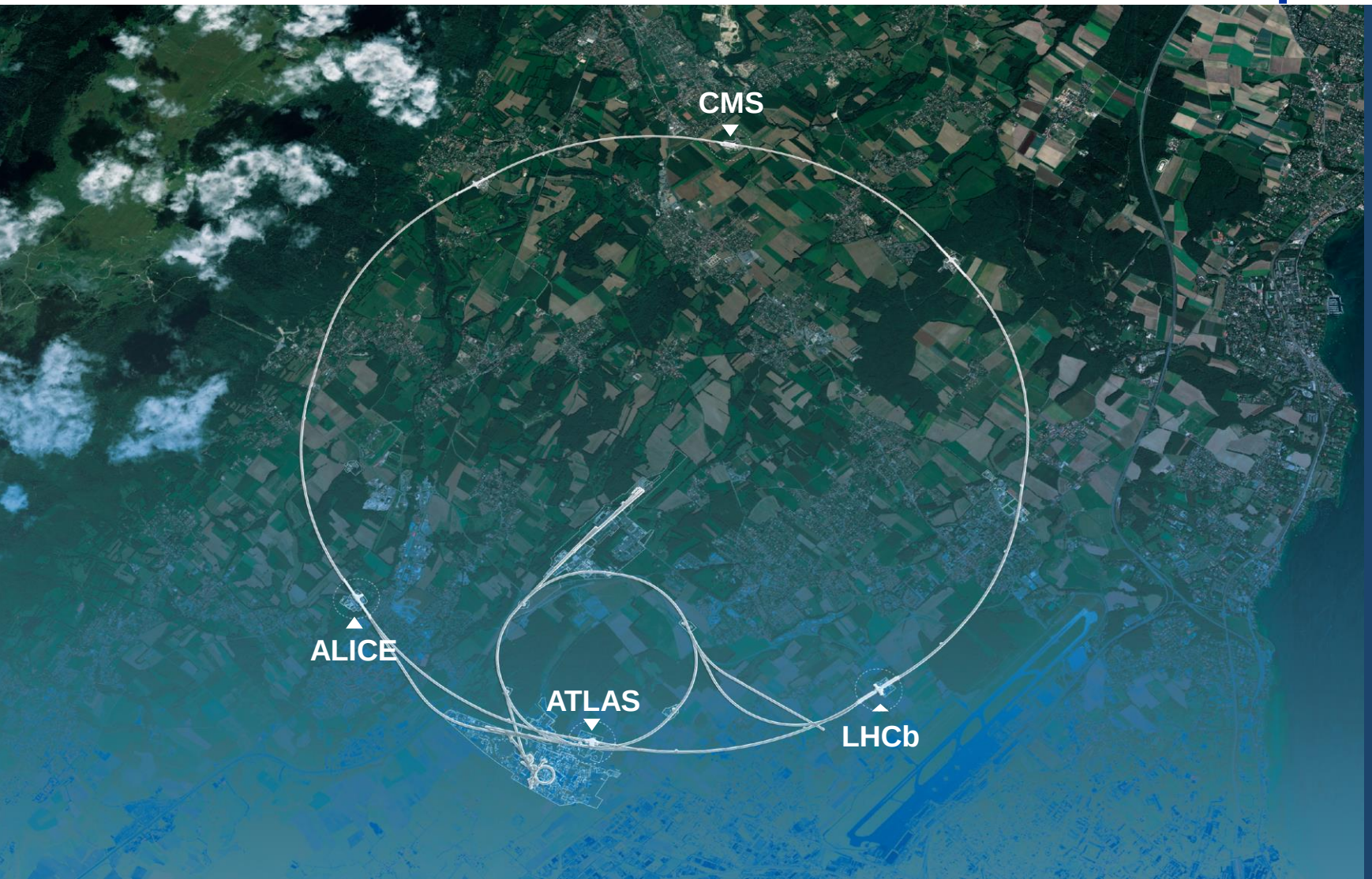
We reproduce the conditions a fraction of a second after the Big Bang, to gain insight into the structure and evolution of the universe.

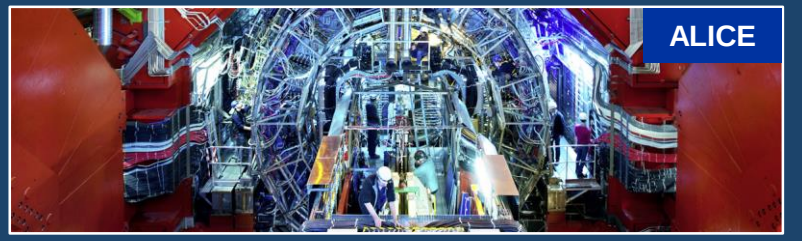


Large Hadron Collider (LHC)

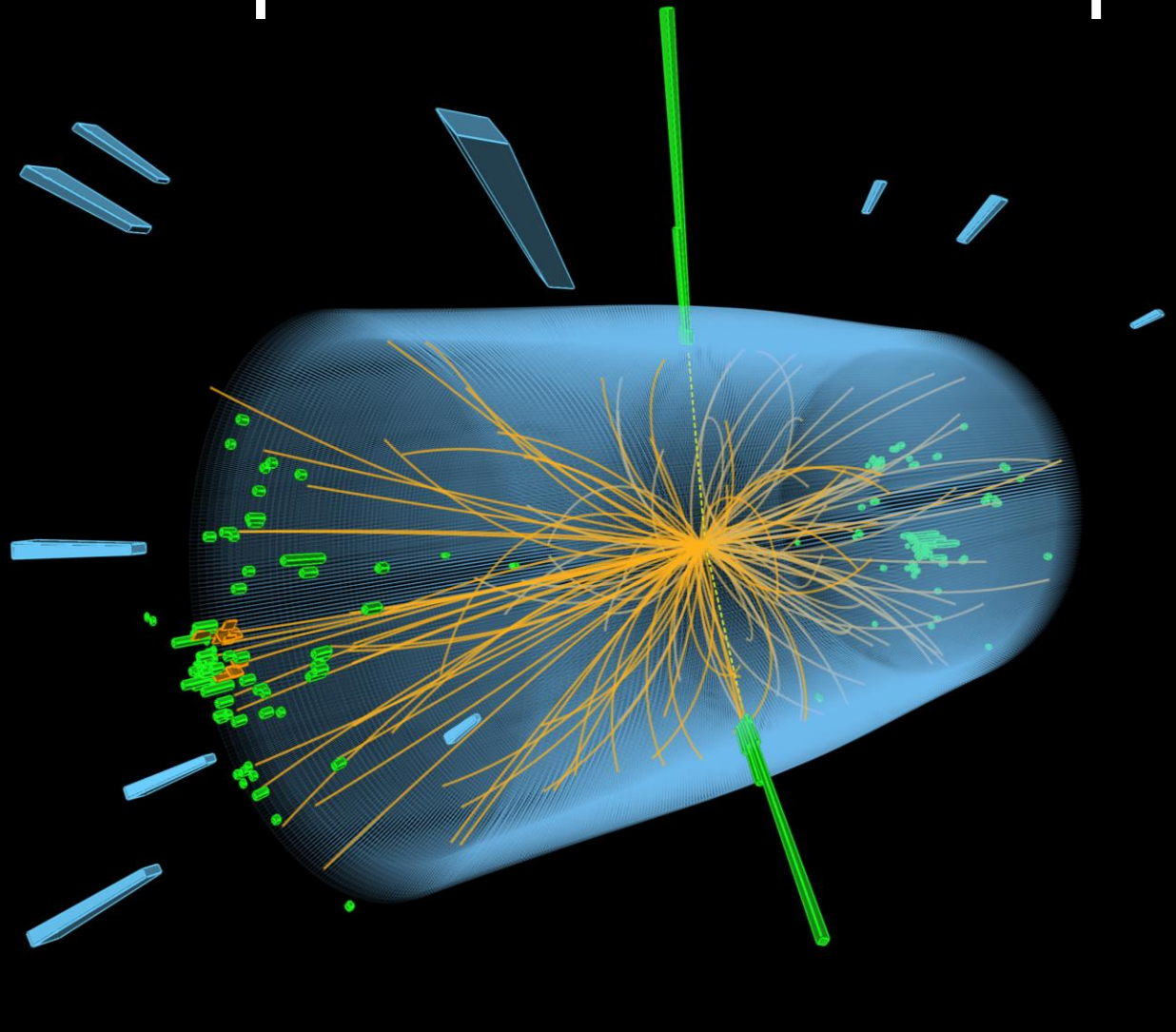
- 27 km in circumference
- About 100 m underground
- Superconducting magnets steer the particles around the ring
- Particles are accelerated to close to the speed of light

Giant detectors record the particles formed at the four collision points



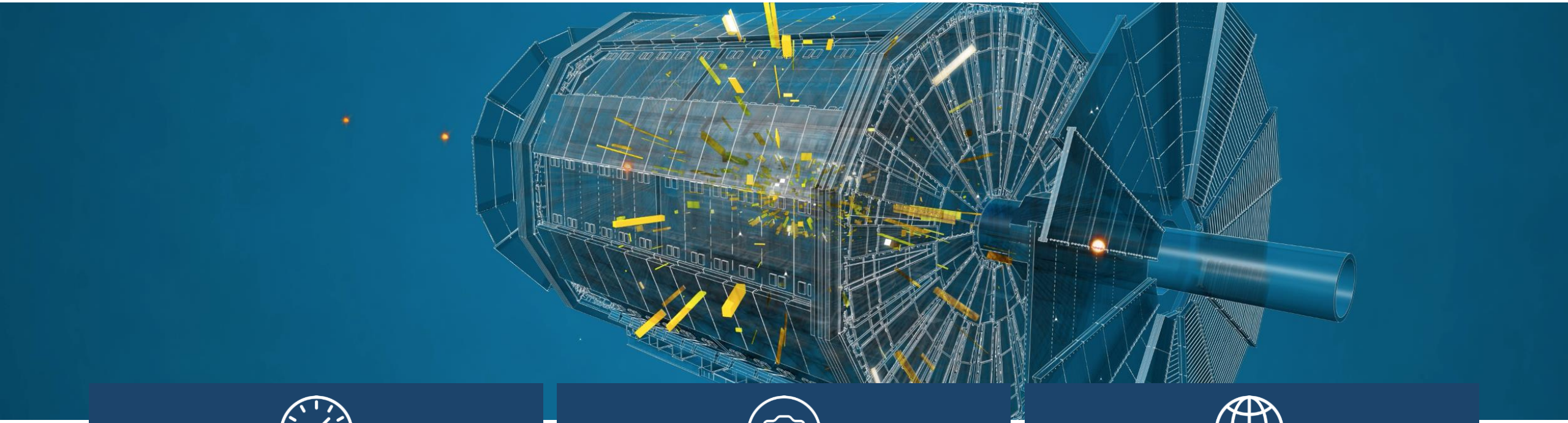


The LHC produces more than 1 billion particle collisions per second



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

The LHC detectors are analogous to 3D cameras

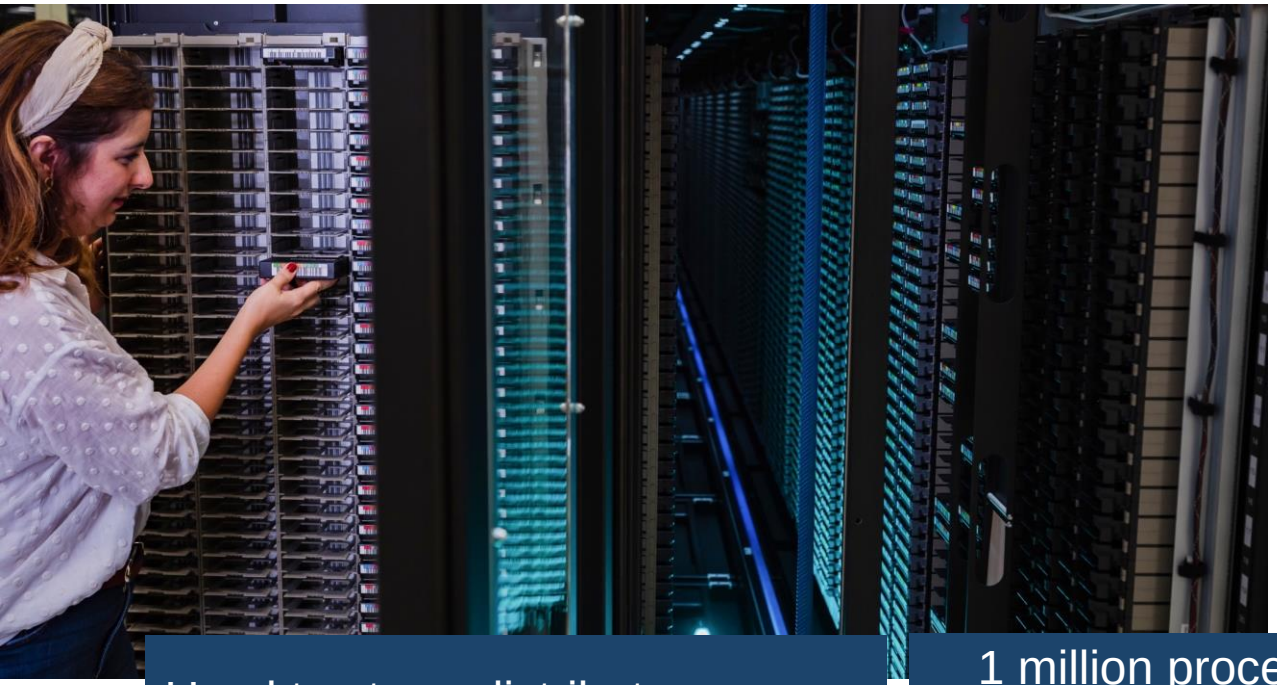


The detectors measure the energy, direction and charge of new particles formed.

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.

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

Numbers for UK

- Personnel by nationality as of 31 December 2021
  - **645** users
  - **196** staff
  - **48** fellows

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

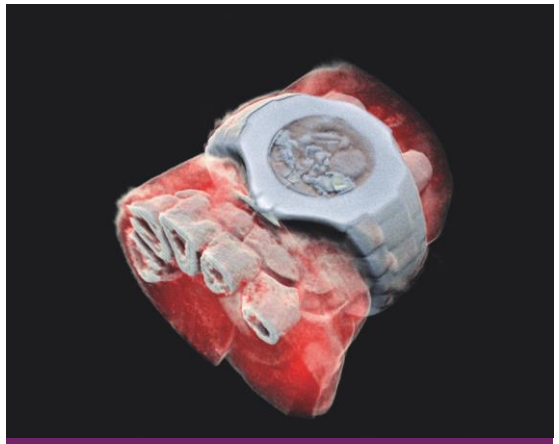
Non-Member States and Territories **1194**

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

TECHNOLOGY & INNOVATION

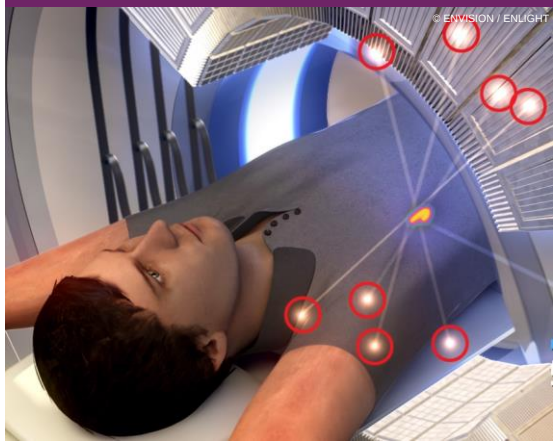
CERN’s technological innovations have important applications in medicine and healthcare

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



CERN produces innovative radioisotopes for nuclear medicine research.

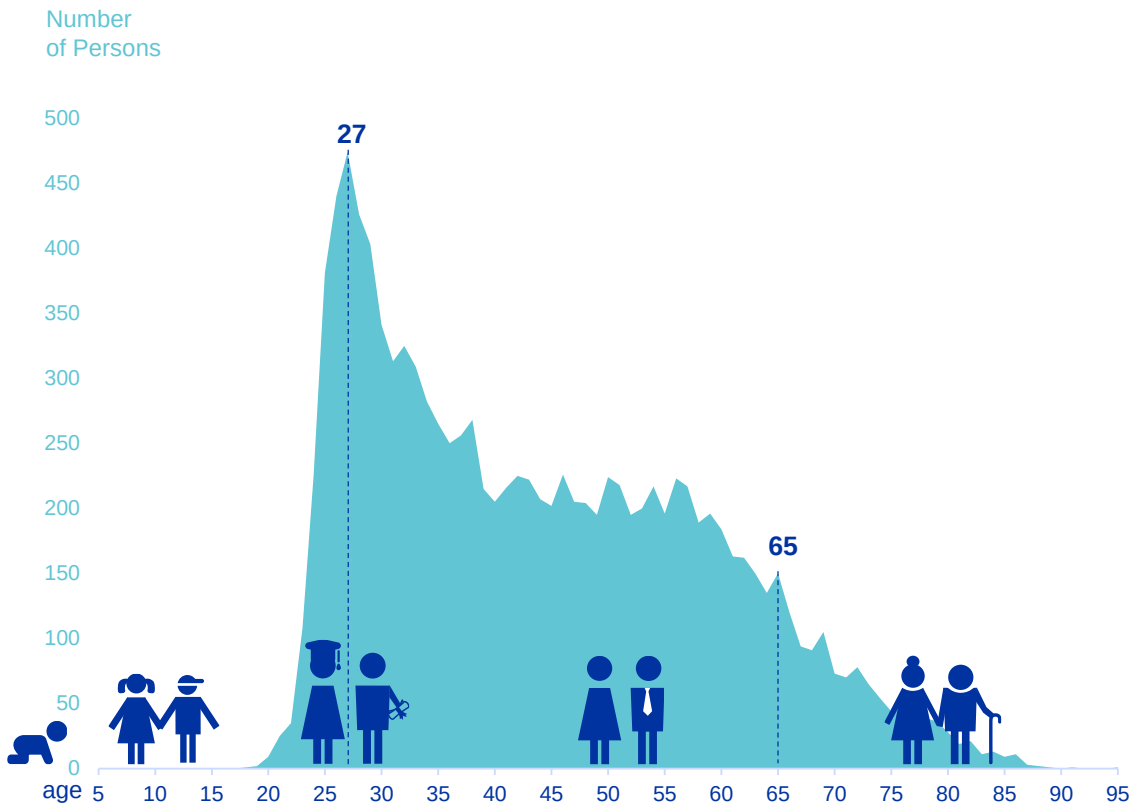
Accelerator technologies are applied in cancer radiotherapy with protons, ions and electrons.



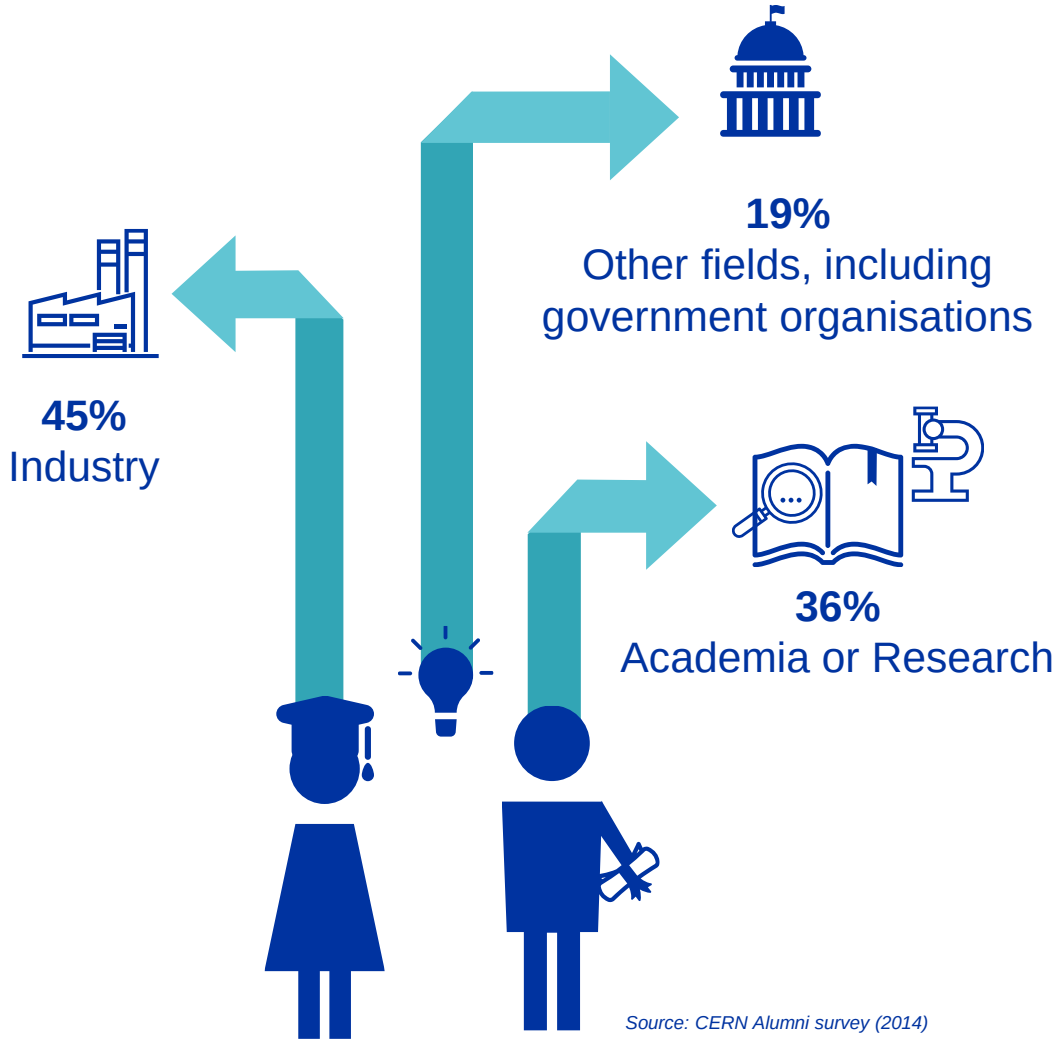
Pixel detector technologies are used for high resolution 3D colour X-ray imaging.

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 UK

18 summer students during 2022
1372 teachers in Teacher Programmes since 1998
122 teams in BL4S competition since 2014
3623 students participating in S'Cool LAB since 2015
11 855 UK visitors 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.

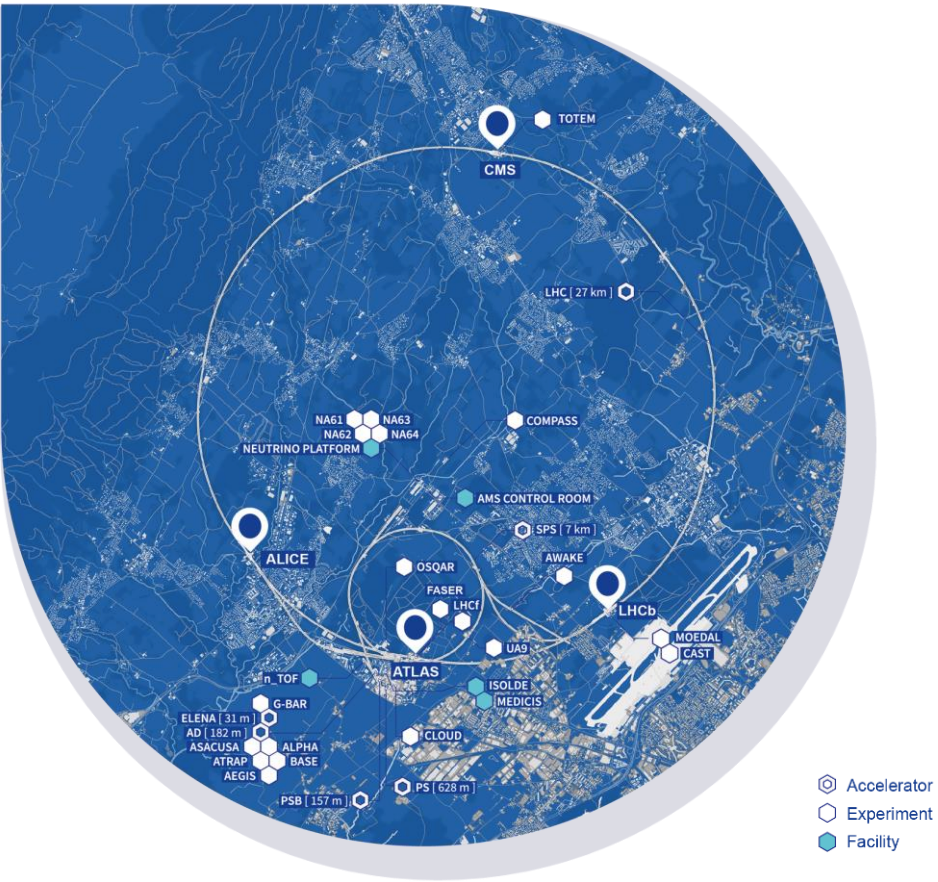
The United Kingdom plays a leading role in setting CERN's experimental agenda

Mr George William Freeman, MP Parliamentary Under Secretary of State, Minister for Science, Research and Innovation, United Kingdom of Great Britain and Northern Ireland.

- **Founding member of CERN (1954)**
- **Peter Higgs** awarded the 2013 **Nobel Prize in Physics**
- Well represented in CERN top management
- STFC CERN Business Incubation Centre at Sci-Tech Daresbury and at Harwell
- Leading role in public outreach: 460 UK schools involved and 20 000 students have taken part in experiments using CERN Medipix technology

CERN is the UK's national lab for particle physics

The UK has a strong involvement across CERN experiments



LHC EXPERIMENTS:

ALICE 4 Institutes, 31 Participants
ATLAS 15 Institutes, 549 Participants
CMS 8 Institutes, 163 Participants
LHCb 12 Institutes, 240 Participants

OTHER LHC EXPERIMENTS

FASER 2 Institutes, 5 Participants
MoEDAL 2 Institutes, 3 Participants
SND 1 Institute, 3 Participants

FIXED TARGET EXPERIMENTS

- **AWAKE**
- **NA62**
- **n_TOF**
- **NeutrinoPlatform**

18 Institutes, 199 Participants

ISOLDE

13 Institutes, 106 Participants

ANTIPROTON EXPERIMENTS

- **ALPHA**
- **G-BAR**

2 Institutes,
20 Participants

Major contribution to the LHC Grid computing via a Tier 1 site at STFC Rutherford Appleton Laboratory (RAL) and several Tier 2 sites.

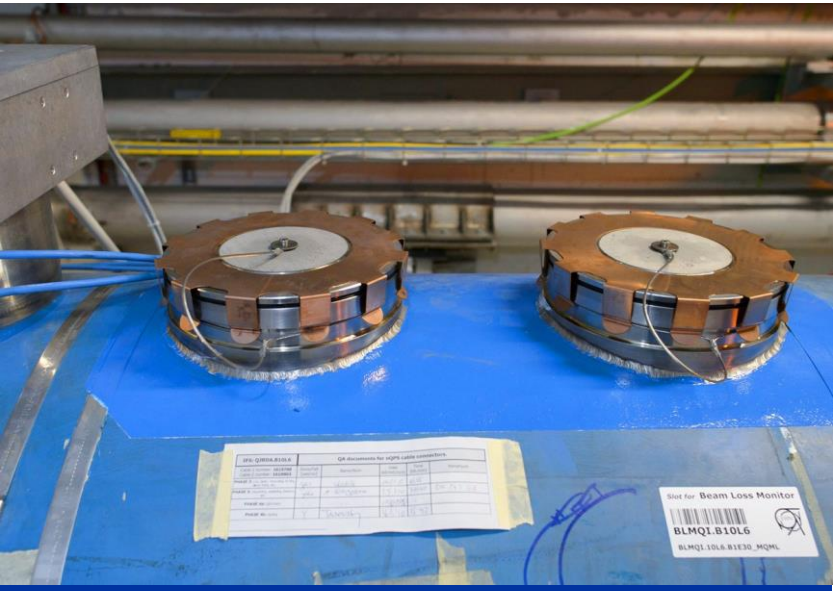
Strong Collaboration in International Projects, Studies & R&D

- HL-UK2, a collaboration for the UK to provide in-kind contributions to the HL-LHC project in collaboration with UK industry (worth £26M) (8 Universities, STFC – Daresbury and RAL)

- The UK has a strong involvement in CERN's Neutrino Platform (18 institutes)
- Significant contribution to studies for future energy frontier machines: CLIC and FCC (13 institutes)

- Accelerator R&D – close links with Cockcroft, & John Adams institutes as well as RAL and Daresbury laboratories
- The UK is strongly supporting AWAKE (3 institutes)
- Innovative technologies developed

Opportunities for UK industry

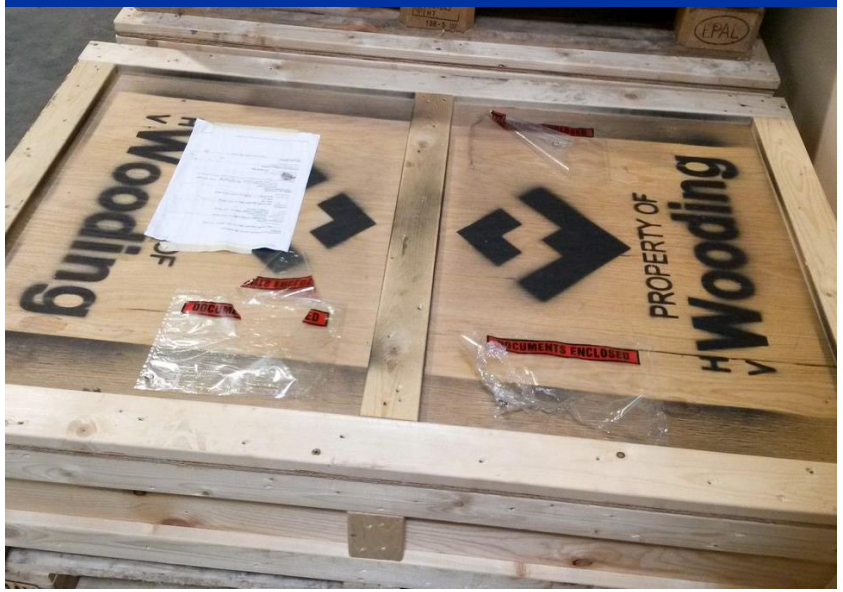


Supply goods and services

- Specialist components and everyday items
- Infrastructure upgrades and new builds
- Consultancy services e.g. Crisis planning and resilience

Collaborate

- Working closely with CERN can open up new market e.g. HV Wooding Ltd
- Supply other science facilities



Exploit CERN IP

- Open Hardware licences offer access to CERN IP
- Radiation resistant lighting design has opened up new markets

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.

IdeaSquare

The Innovation Space at CERN

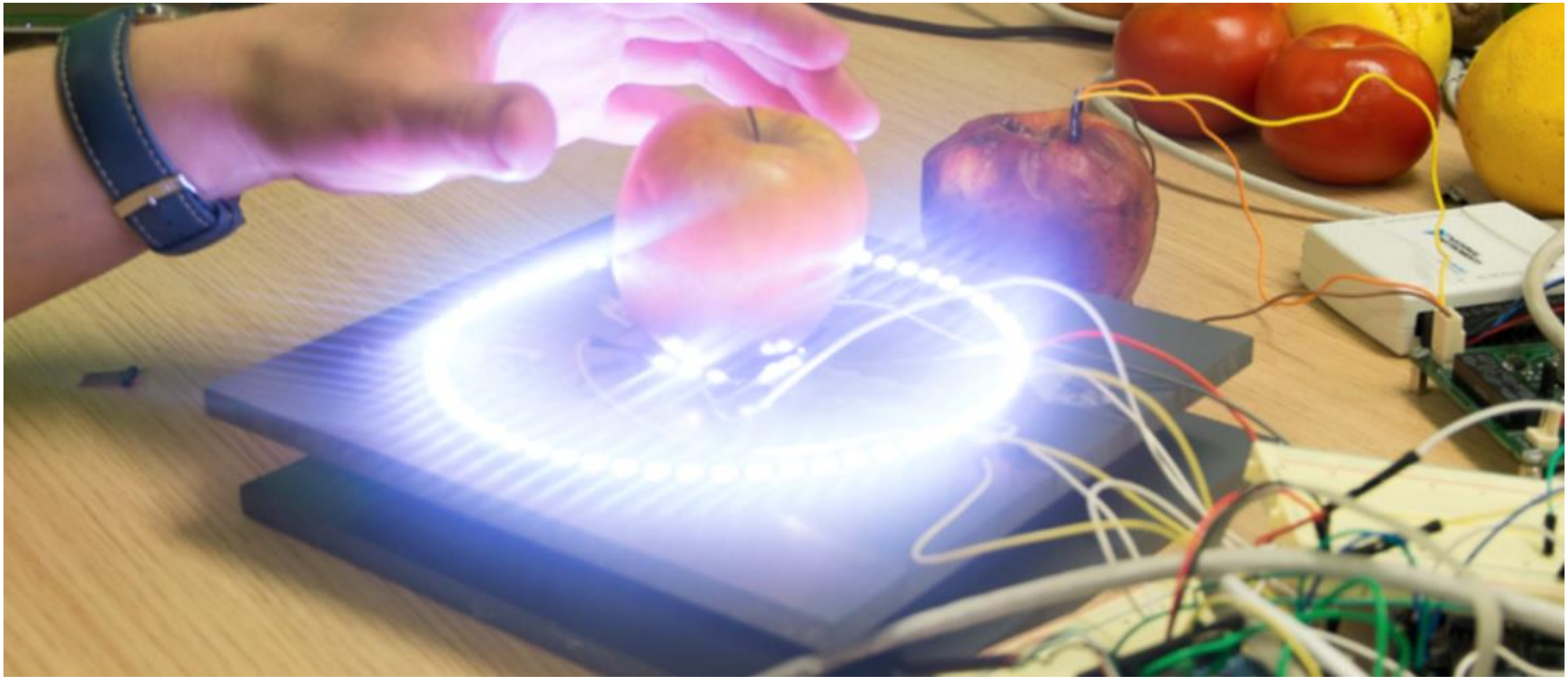
IdeaSquare is the innovation space at CERN, that uses collaborative methodologies, access to CERN expertise and cross-connectivity to ideate solutions for the future of humankind. A place where people have the licence to dream.

Challenge Based Innovation (CBI) and Innovation for Change

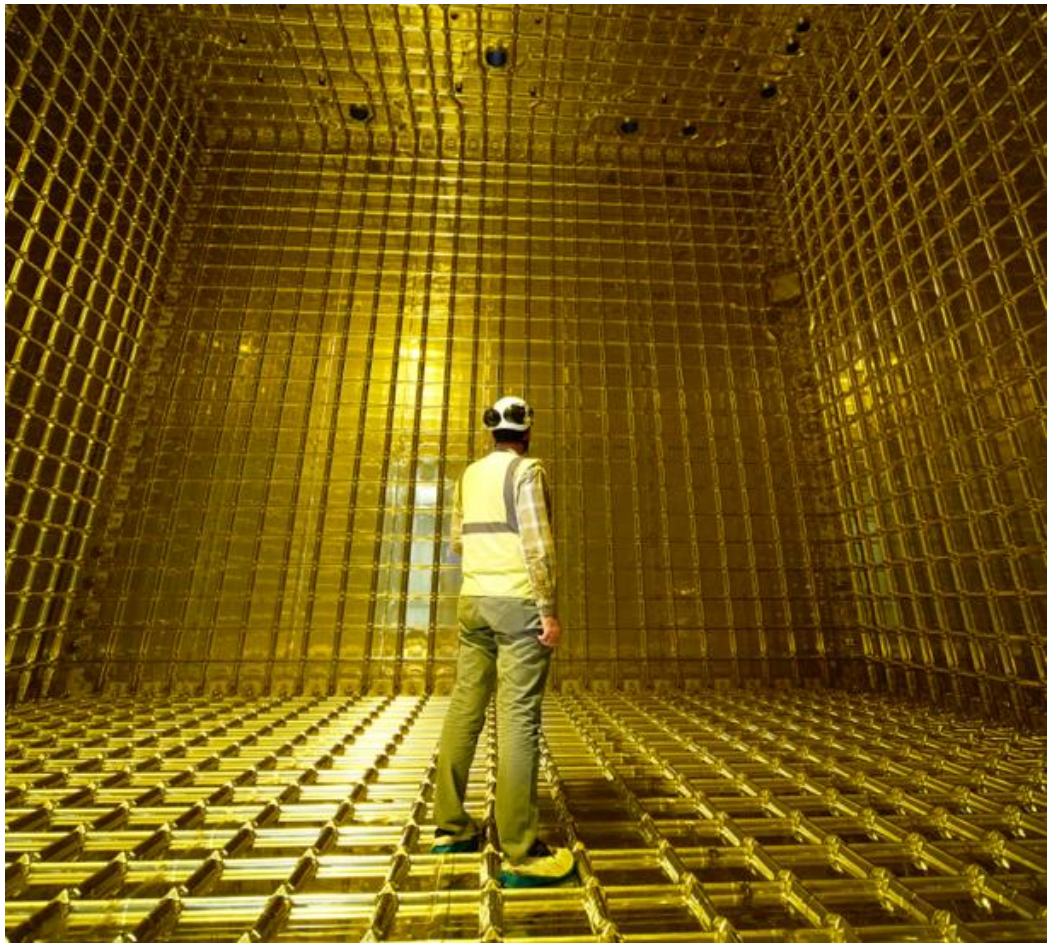
- 4 - 6 months MSc-level specialization courses for product and service development, run by participating universities from all around the world
- Over 1700 students have participated with more than 300 conceptual prototypes produced at IdeaSquare, contributing to UN Sustainable Development Goals
- Our main partner in the UK: Royal College of Art (over 800 students in London), also IC, contacts with Brunel
- In the course, multidisciplinary student teams learn how to apply Design Thinking – process for new product/service development; engaging with CERN researchers who act as technological coaches in the process
- “Work extremely hard, learn and have fun!” AND “Fail fast and often to succeed sooner”

Students prototyping to a TEDxCERN installation


Intelligent Electricity
Electrique is a modular, extendable, plug-n-play and intelligent grid solution that optimizes electricity distribution in refugee camps.
SEE IT NOW



Neutrino Platform

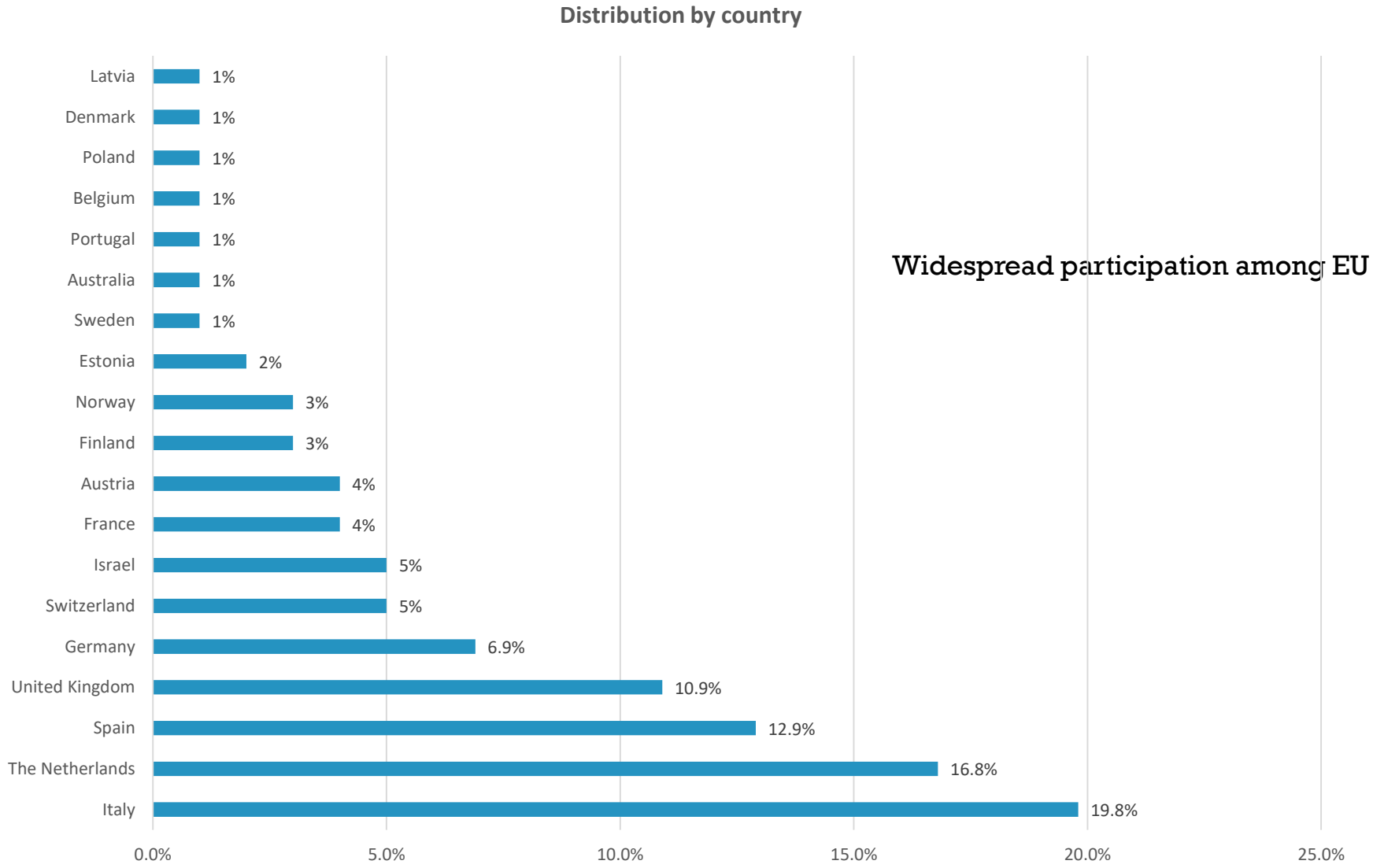


- Neutrino Platform (CENF) fosters fundamental research in the field of Neutrino Accelerator Physics
- CENF supports generic detector, neutrino beams R&D and large detector prototypes or demonstrators. It gives technical, financial and logistics support to approved projects
- Currently includes seven projects, including significant involvement in (Proto) Dune
- Strong UK involvement
- CERN & IdeaSquare provides a facility for R&D on future technologies (HW and SW) and partner in several neutrino research programs

#ATTRACT EU Project

- ATTRACT funds breakthrough projects in Detection & Imaging
- Provides funding for developing early-stage ideas and prototypes
- Focuses on high innovation with potential outside research
- Engages with MSc-level, cross-disciplinary student activities, seeking for unforeseen entrepreneurial opportunities for the young
- Strong collaboration with partners in most European countries
- Purpose is to create a new innovation ecosystem in Europe
- ATTRACT is coordinated by CERN (IdeaSquare)

ATTRACT Phase 2: 18 R&D&I funded projects; 28M Euros



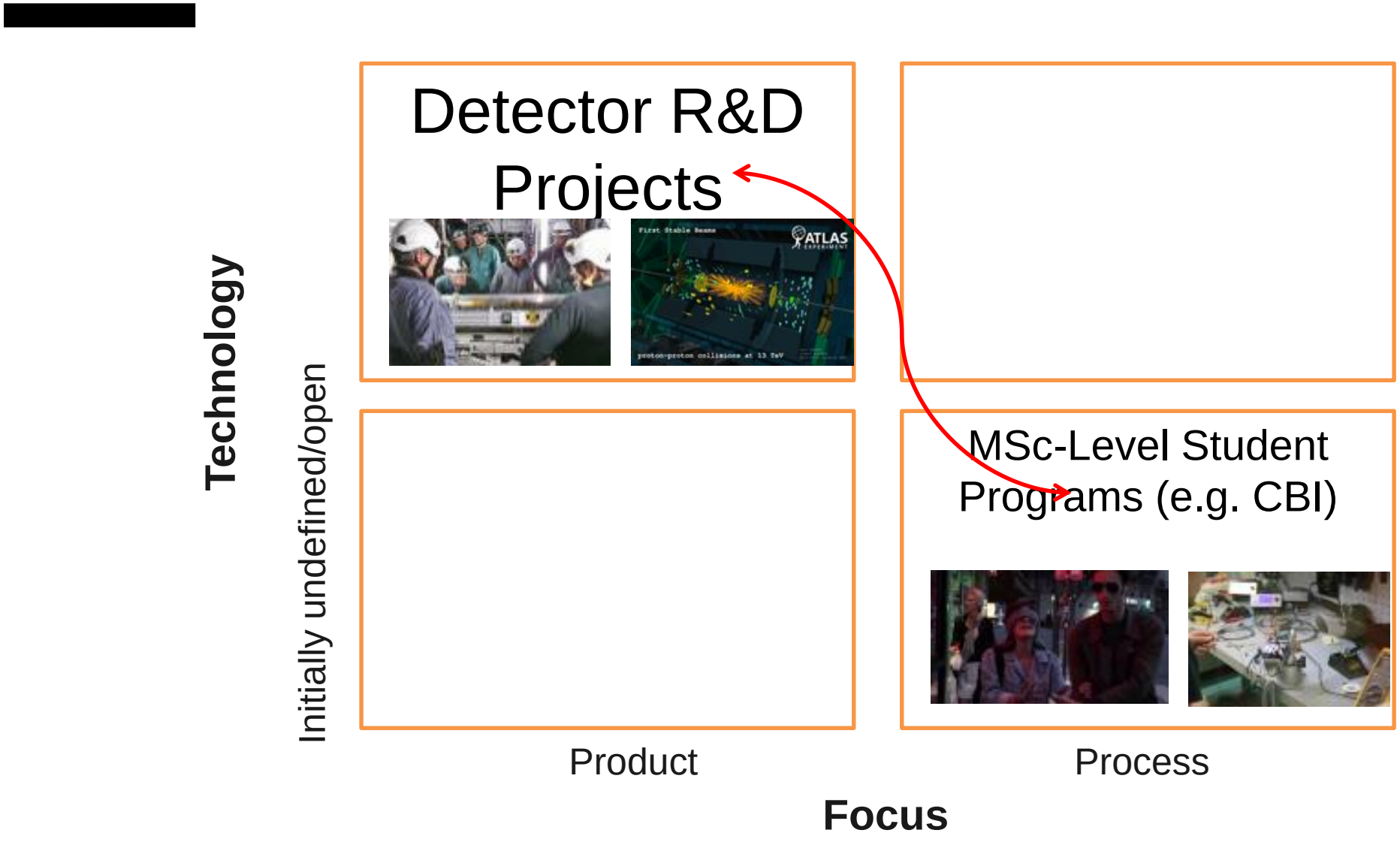
Widespread participation among EU MS and AC

Events, workshops and hackatons

When the building is not in full use, Ideasquare can offer access to its open work areas, rapid prototyping facilities and its meeting rooms for short, deadline driven Challenge Events, such as :

- Innovation Events,
- Workshops (e.g. Science Fiction Days)
- Hackathons (an event compressed into a short number of days where participants work towards a concept prototype).

IdeaSquare Open Doors event 2018


Technology
Initially undefined/open
Detector R&D Projects
First Stable Beams
ATLAS EXPERIMENT
proton-proton collisions at 13 TeV
MSc-Level Student Programs (e.g. CBI)
Product
Process
Focus