



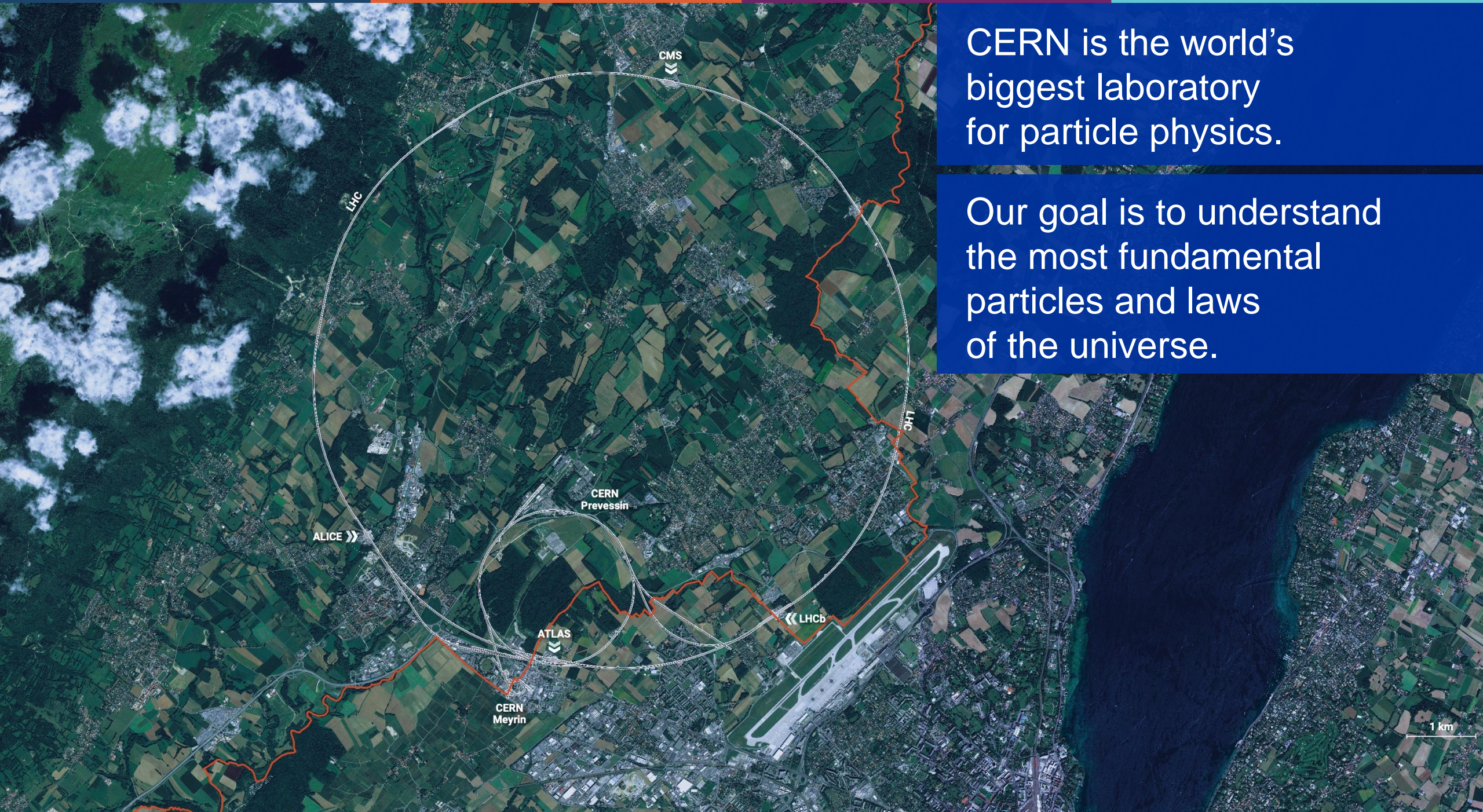
Introduction to CERN

Germany@CERN 2021

Joachim Mnich
Director for Research and Computing
April 28-30, 2021

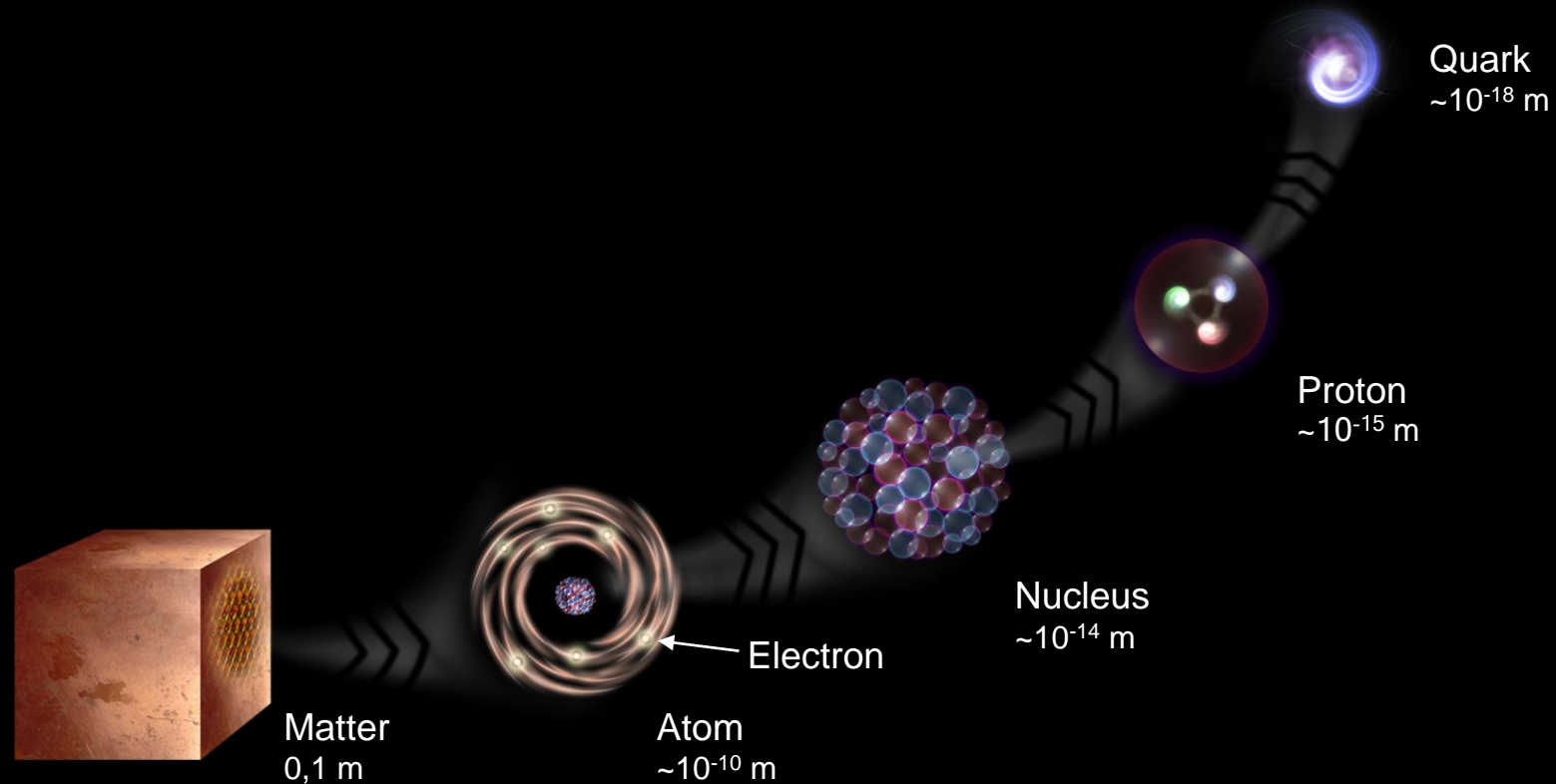
CERN is the world's biggest laboratory for particle physics.

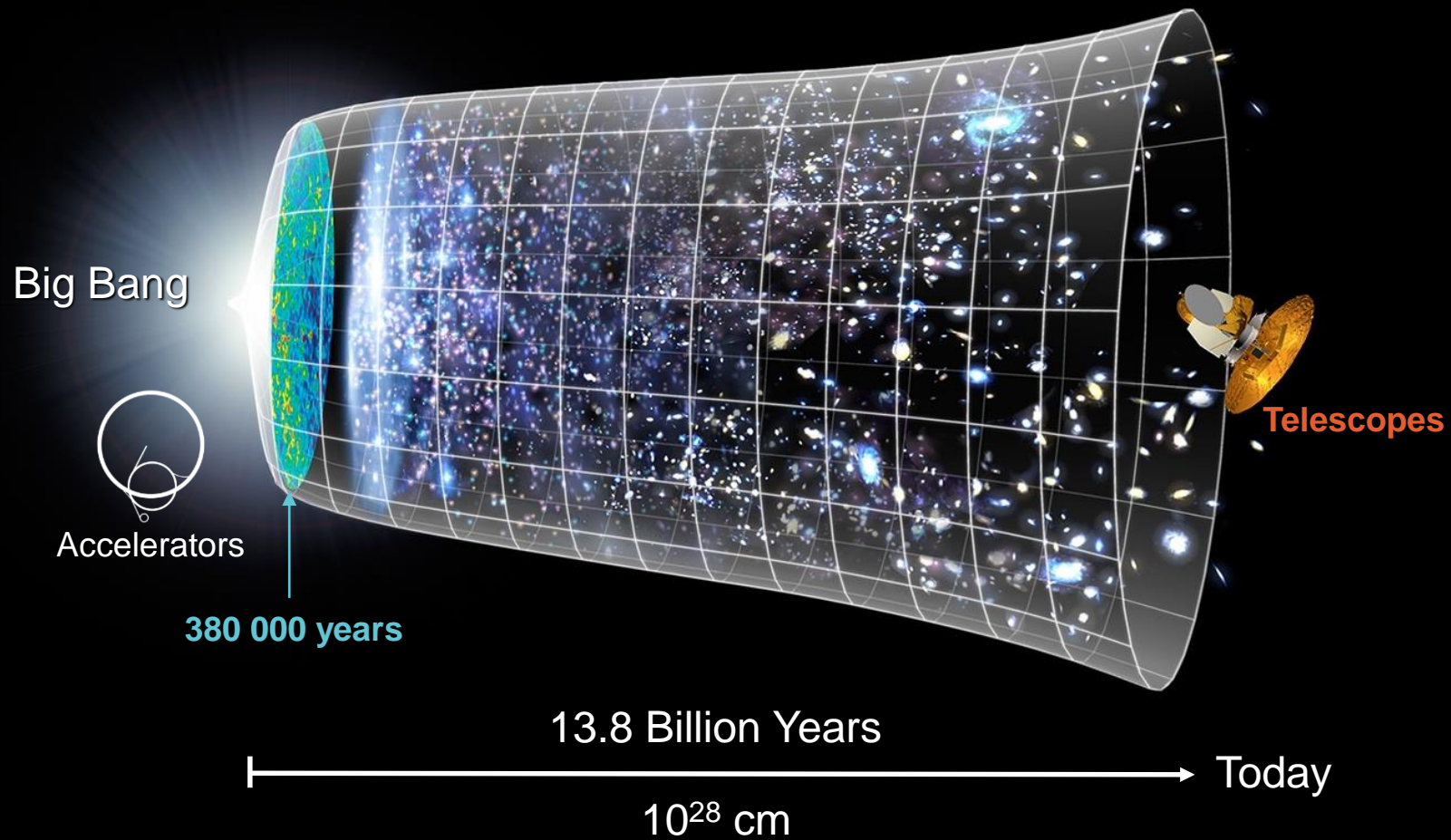
Our goal is to understand the most fundamental particles and laws of the universe.



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.

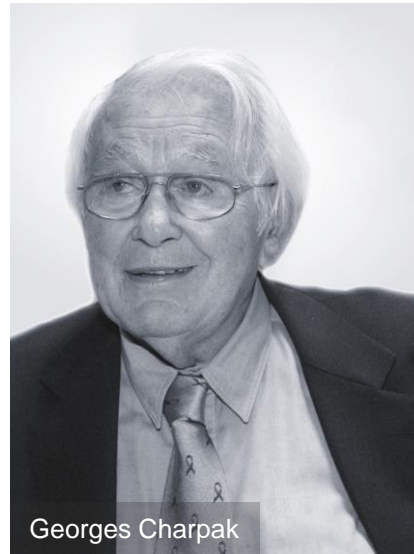
At CERN we help to answer these questions



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.



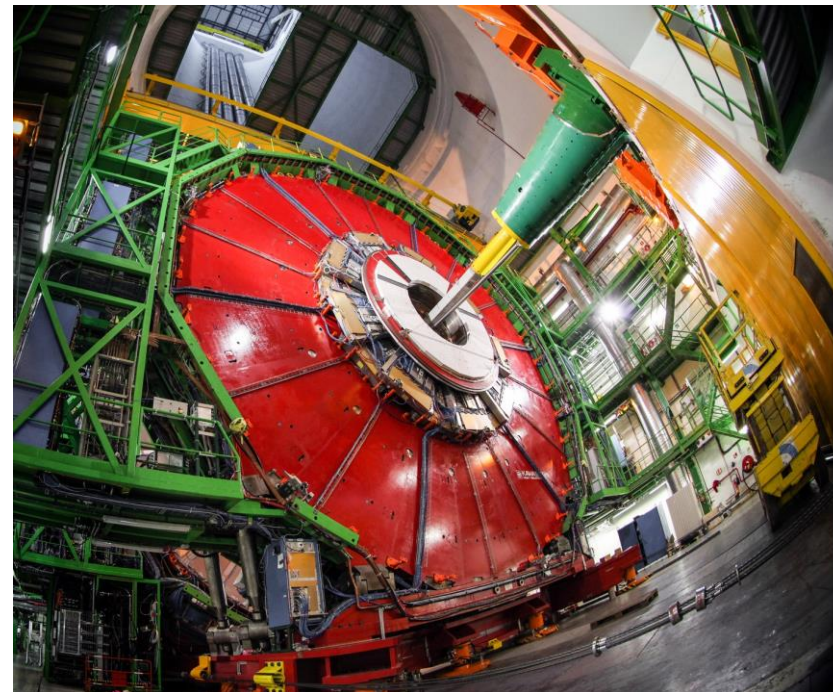
François Englert and Peter Higgs

How do we do it?

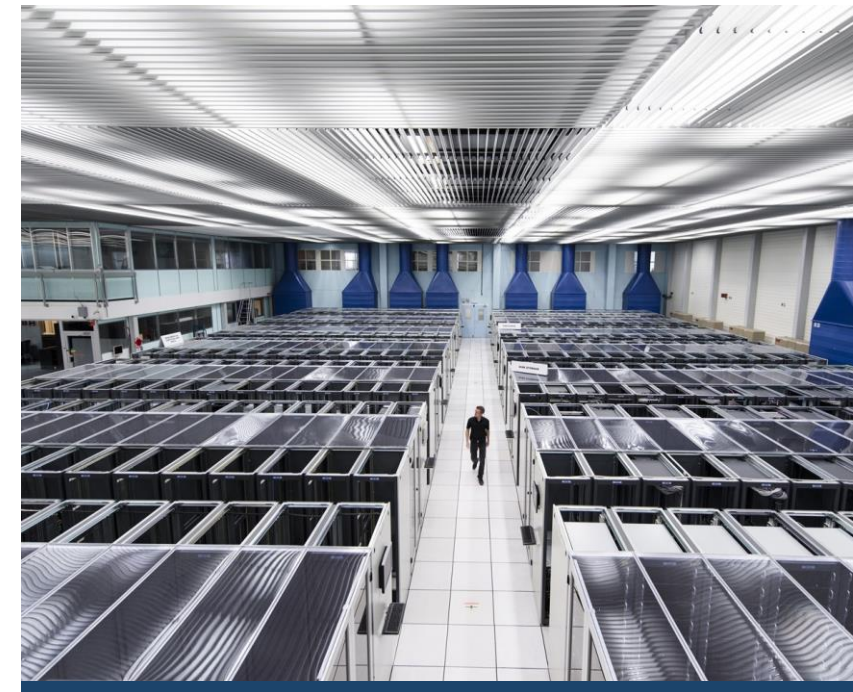
- We build the largest machines to study the smallest particles in the universe
- We develop technology to advance the limits of what is possible



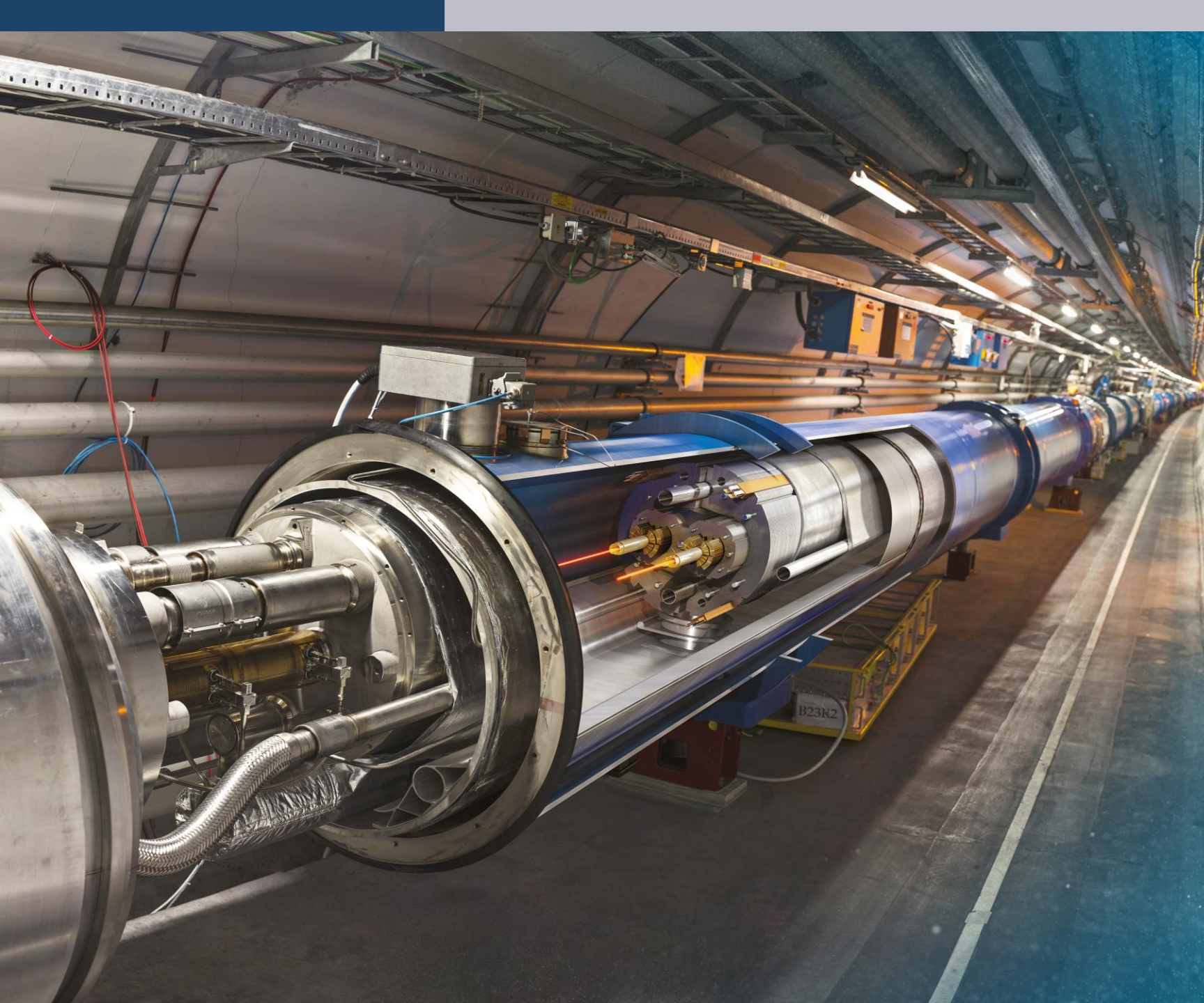
ACCELERATORS



DETECTORS



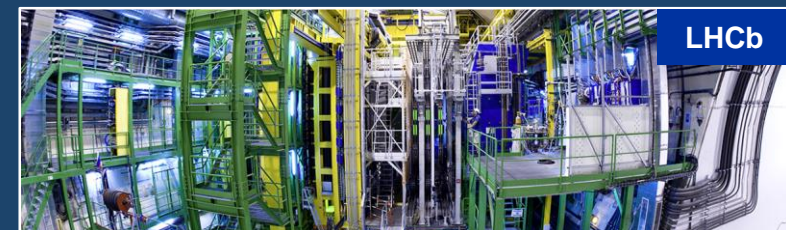
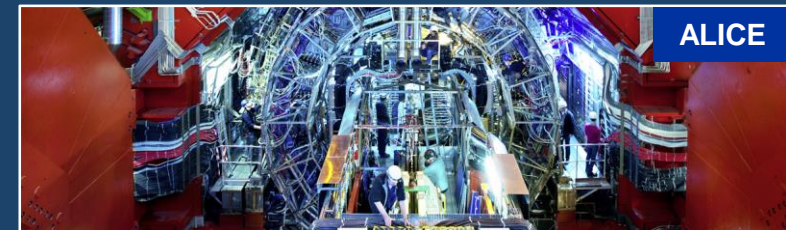
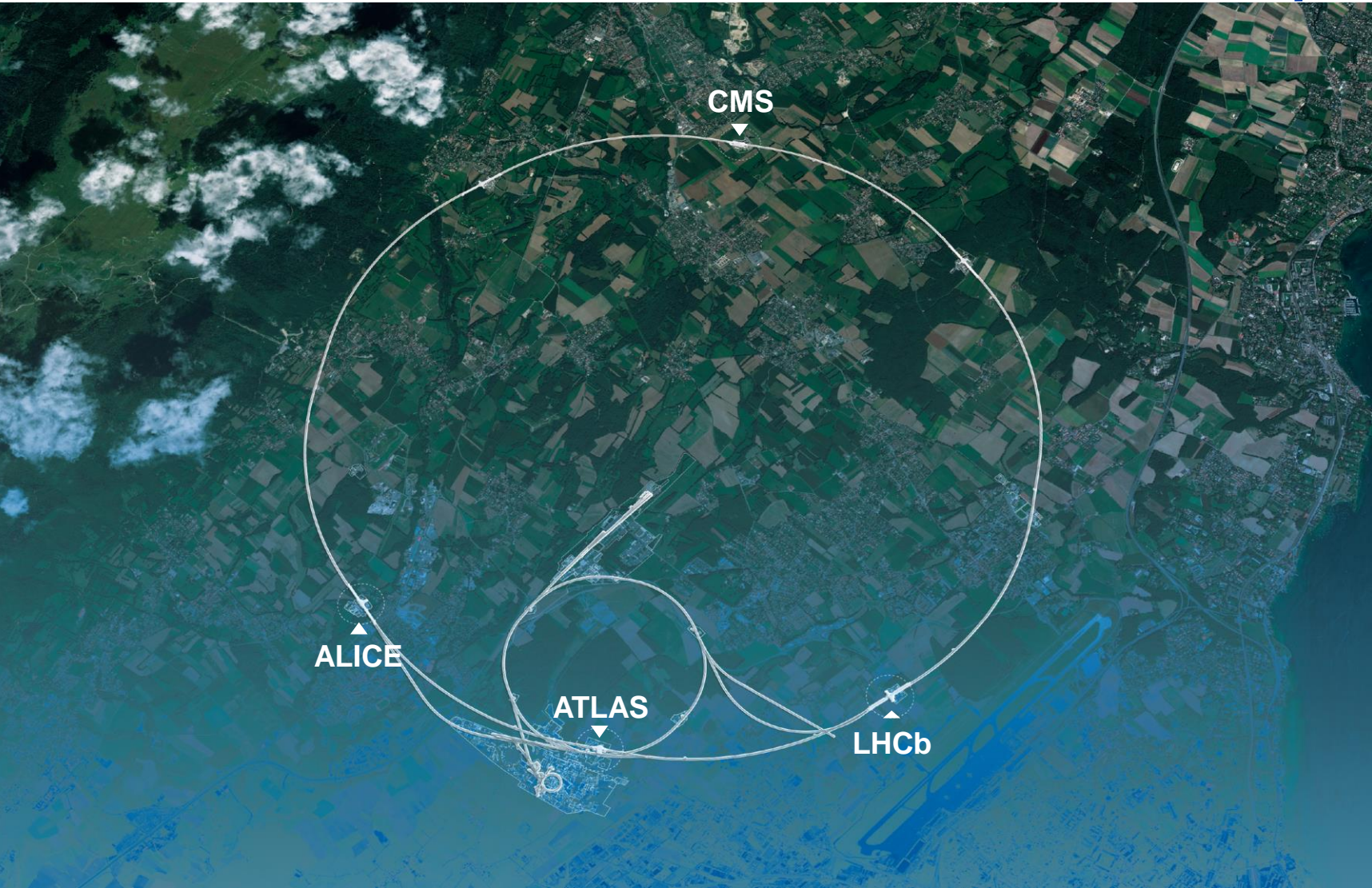
COMPUTING



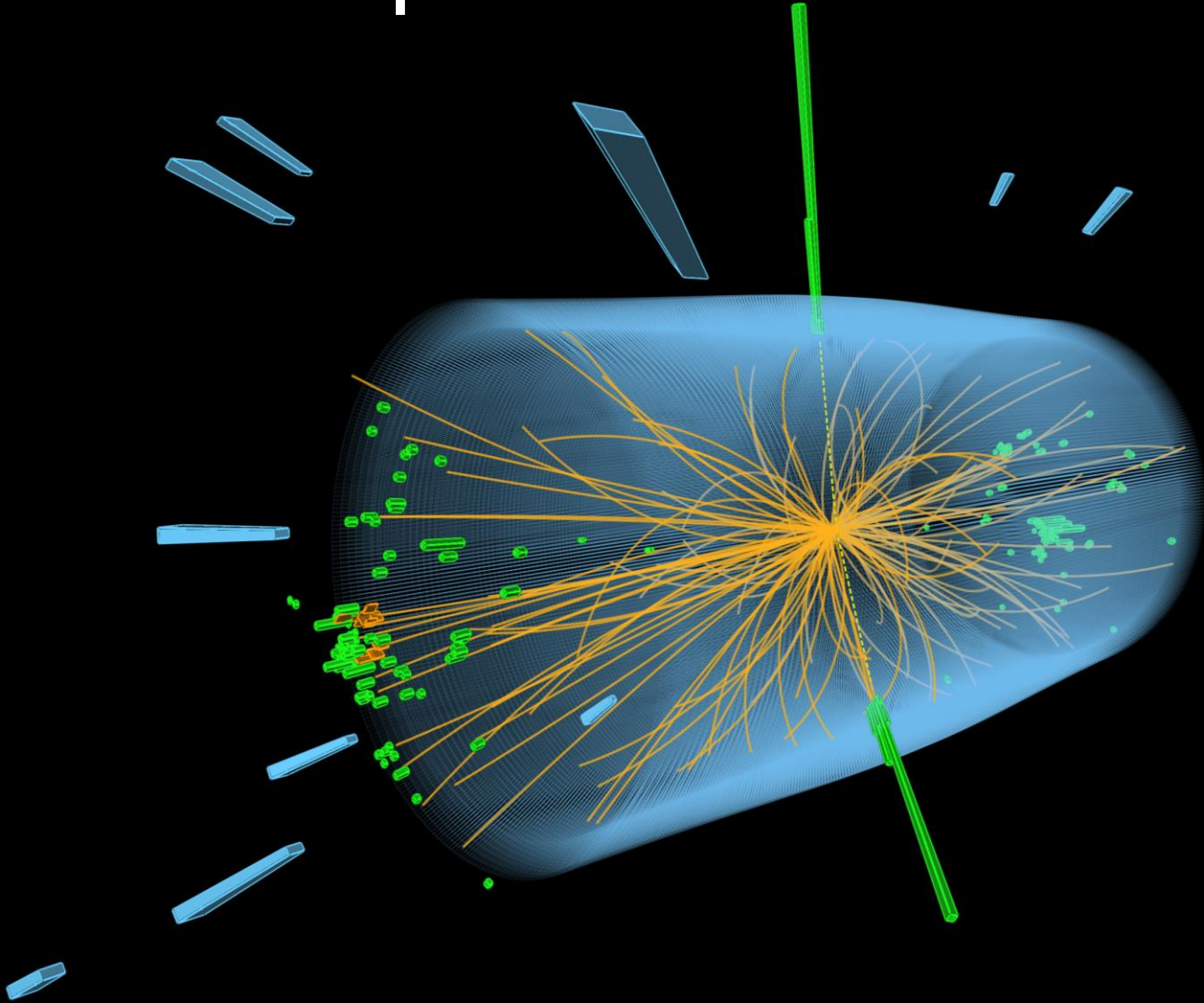
Large Hadron Collider (LHC)

- 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

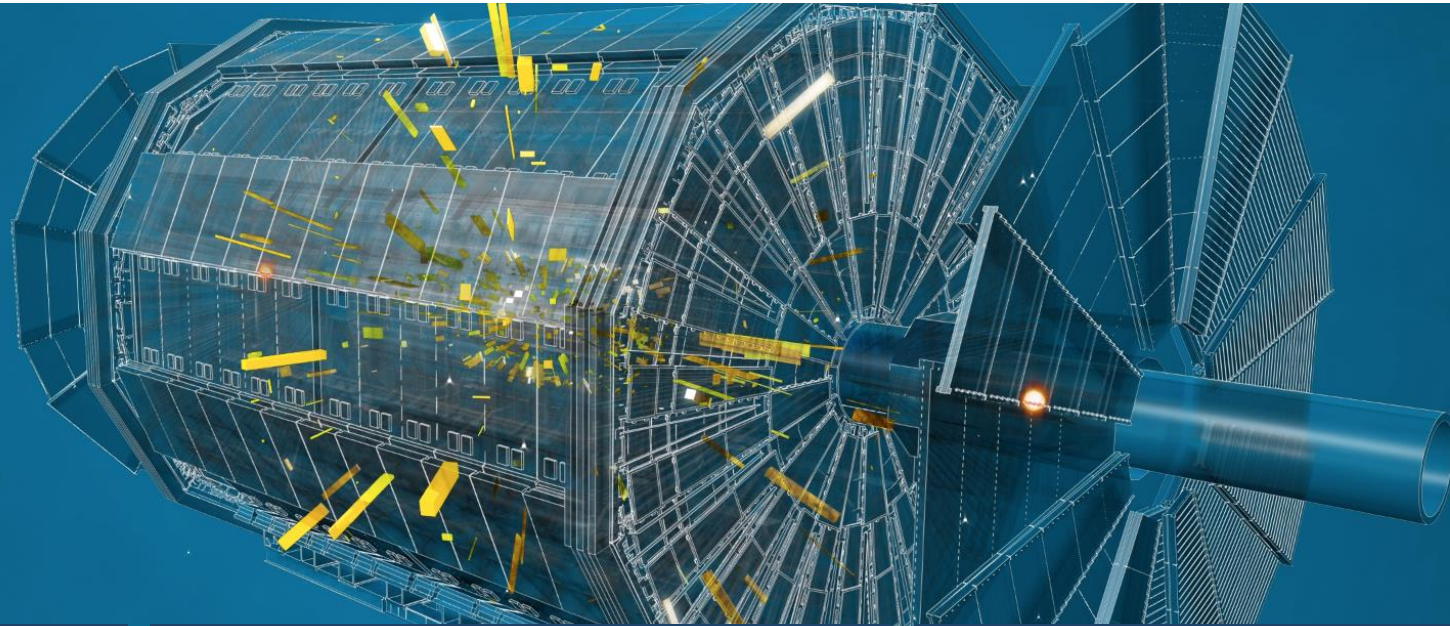


The LHC produces more than 1 billion particle collisions per second



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.

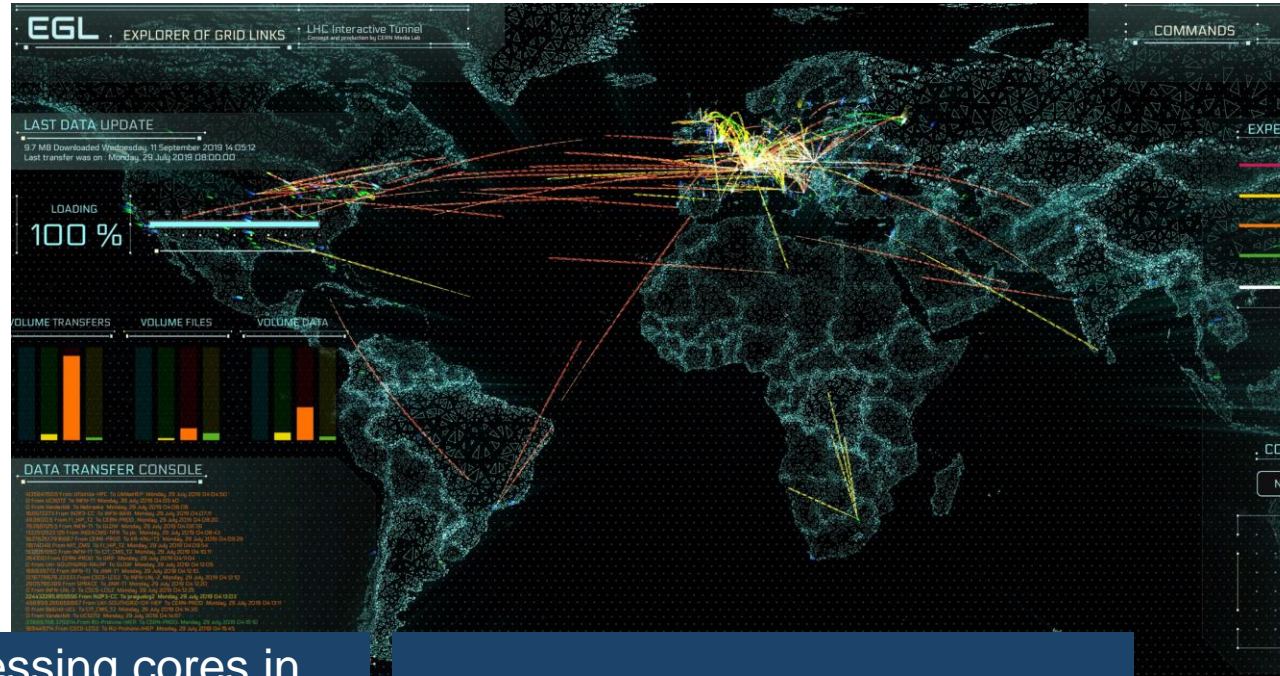


They take 40 million pictures a second. Only 1000 are recorded and stored.



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 160 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

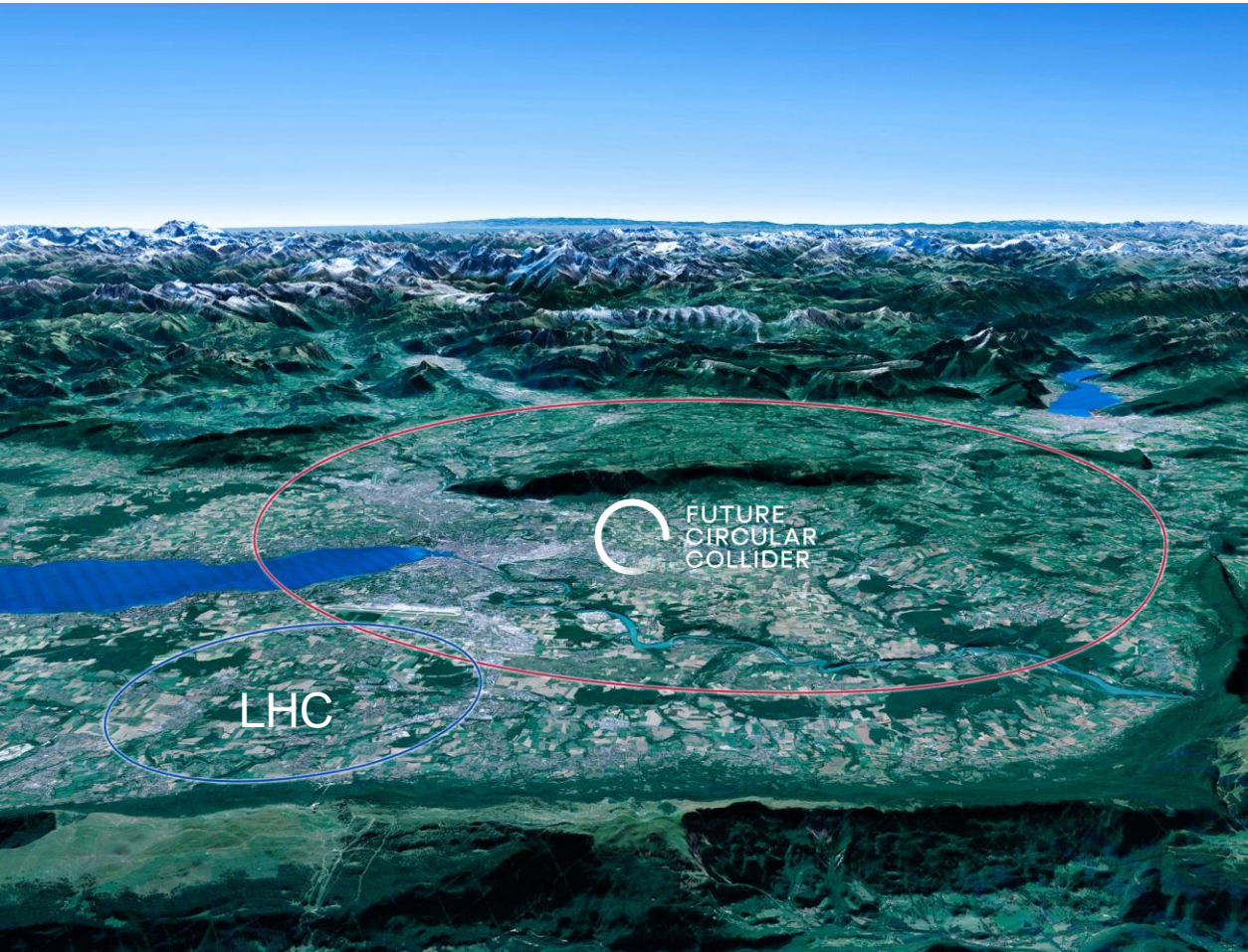
- The HL-LHC will use new technologies to provide 10 times more collisions than the LHC.
- It will provide greater precision and discovery potential.
- It will start operating in 2027, and run until 2040.



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



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

6 Associate Member States

Croatia – India – Lithuania – Pakistan – Turkey – Ukraine

6 Observers

Japan – Russia – USA
European Union – JINR – UNESCO

35 Non-Member States with Co-operation agreements with CERN

Albania – Algeria – Argentina – Armenia – Australia – Azerbaijan – Bangladesh – Belarus – Bolivia
Bosnia and Herzegovina – Brazil – Canada – Chile – China – Colombia – Costa Rica – Ecuador – Egypt
North Macedonia – Georgia – Iceland – Iran – Jordan – Korea – Malta – Mexico – Mongolia – Montenegro
Morocco – New Zealand – Peru – Saudi Arabia – South Africa – United Arab Emirates – Vietnam

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

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

Numbers for Germany

- Personnel by nationality as of 31 December 2020
 - **1107 users**
 - **175 staff**
 - **53 fellows**

Other countries **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's technological innovations have applications in many fields

CERN is the birthplace of the World Wide Web

And there are many more examples

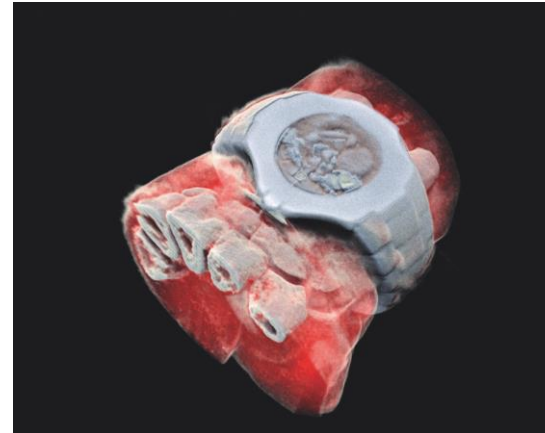
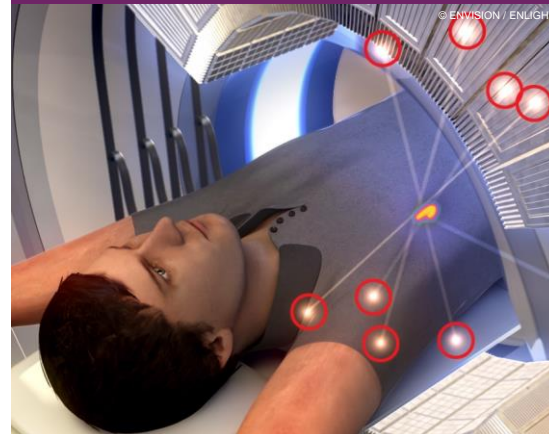
Medical imaging, cancer therapy, material science, cultural heritage, aerospace, automotive, environment, health & safety, industrial processes.

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.



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.

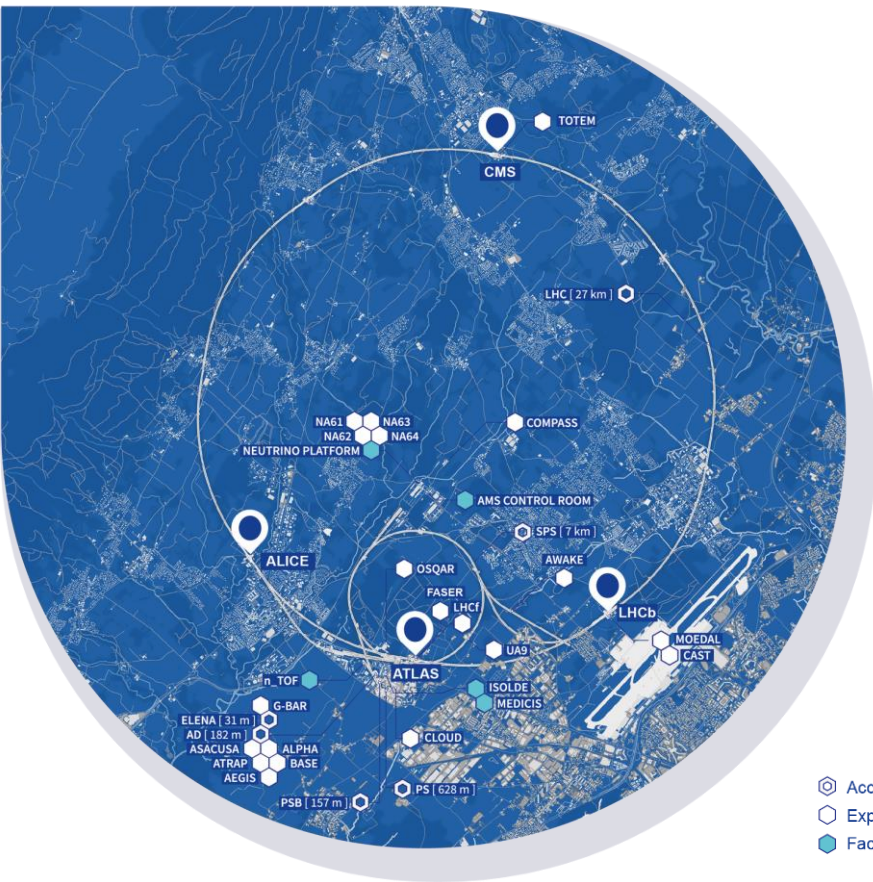
Germany plays a leading role in setting CERN's experimental agenda



2 April 2014 - H. E. Mr Joachim Gauck, President of the Federal Republic of Germany with Director-General R. Heuer.

- **Founding member of CERN (1954)**
- **Always well-represented in CERN top management**
- **Special PhD programme with a technical orientation. Funded by BMBF and organized through DESY**
- **Strong collaboration between CERN and German national labs**

Germany has a strong involvement across the whole of the CERN experimental programme



LHC EXPERIMENTS:

- ALICE** 11 Institutes
- ATLAS** 17 Institutes
- CMS** 6 Institutes
- LHCb** 6 Institutes

- ## OTHER LHC EXPERIMENTS:
- FASER** 2 Institutes

FIXED TARGET EXPERIMENTS

- **AWAKE**
- **CLOUD**
- **COMPASS**
- **nToF**
- **NA61**
- **NA62**
- **NA64**
- **Neutrino Platform**
26 institutes

ISOLDE
39 institutes

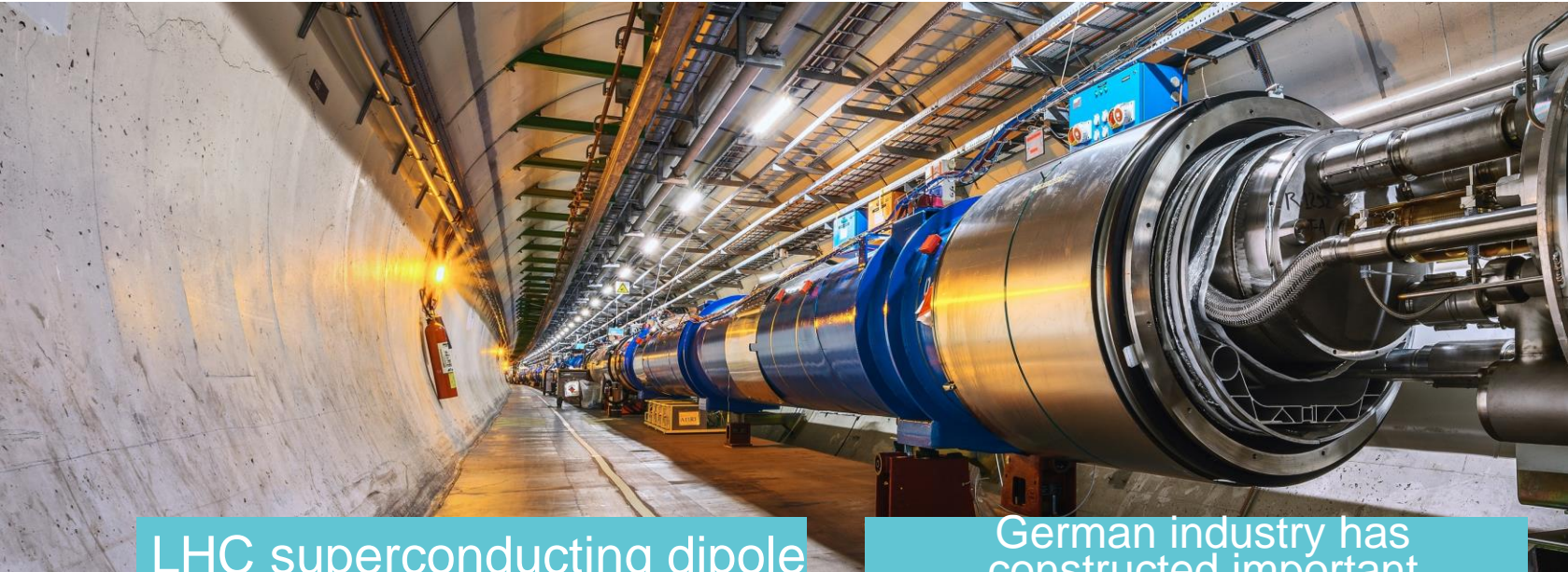
ANTIPROTON EXPERIMENTS

- **ATRAP**
- **ASACUSA**
- **AEGIS**
- **BASE**
- **GBAR**
9 institutes

High performance computing centre GridKa (Tier-1) operated by KIT Karlsruhe as well as several Tier-2 centres

German Industry and CERN

Example LHC accelerator and detectors



LHC superconducting dipole magnets (1/3 of total production) manufactured by Babcock Noell in Zeitz (Sachsen-Anhalt)

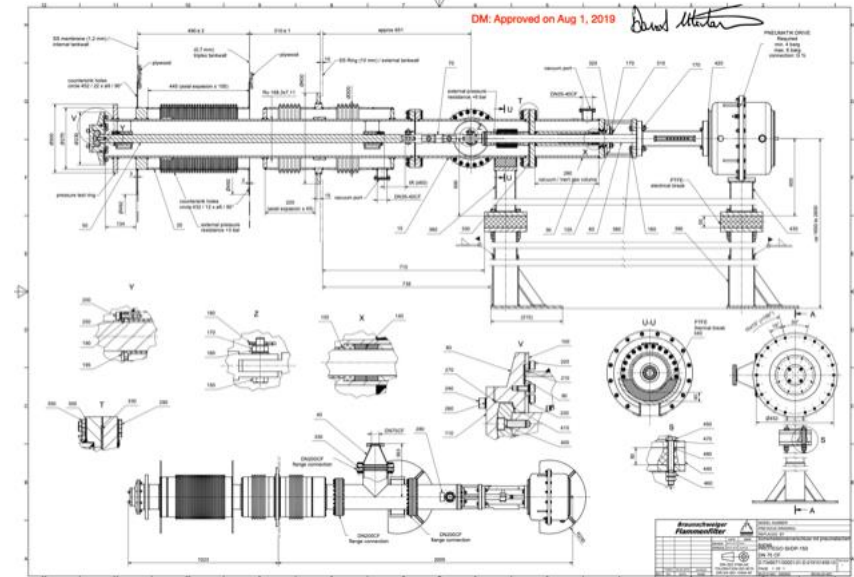
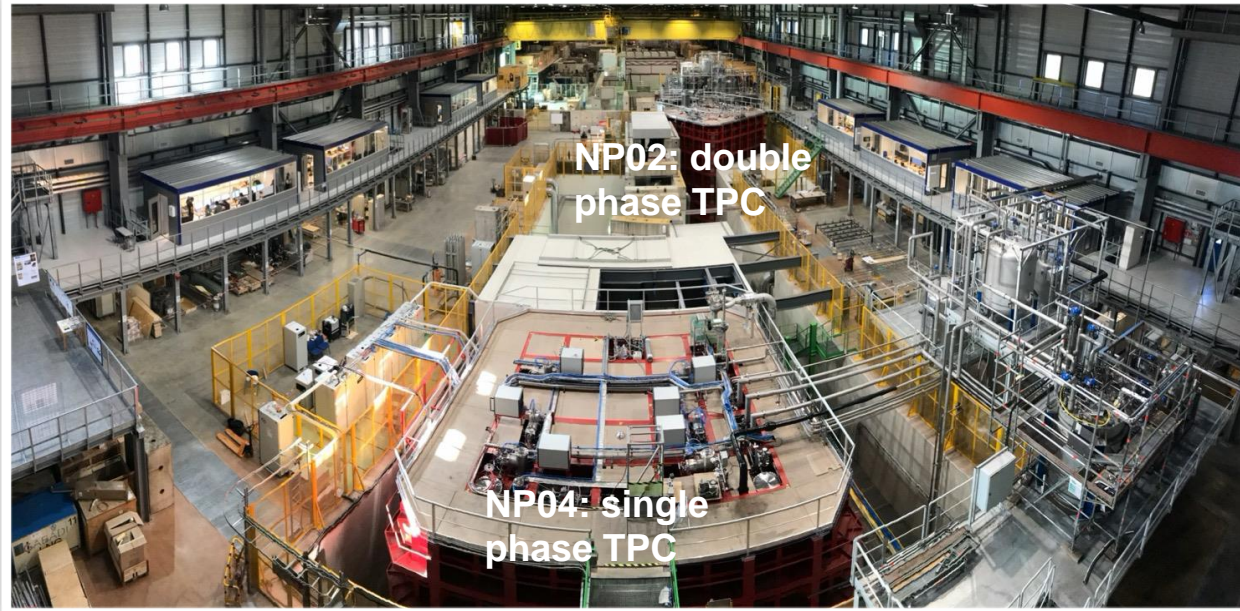
German industry has constructed important components for the LHC project, using advanced technologies. Total industrial return: 600 Million € shared between 400 companies



Iron yokes of CMS magnet manufactured by MAN Deggendorfer Werft

German Industry and CERN

Example Neutrino Platform to prepare large experiments in the USA



Two large cryostats for
Liquid Argon based neutrino
detectors

300 kV High Voltage supply
Heinzinger Electronic GmbH
FuG Elektronik GmbH

Protego Valve on the
bottom of the cryostat to
recirculate the liquid



There are many unanswered questions
in fundamental physics

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