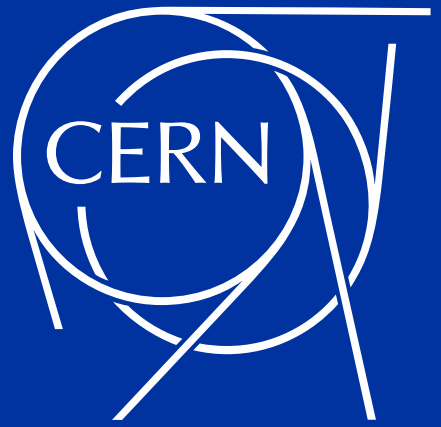


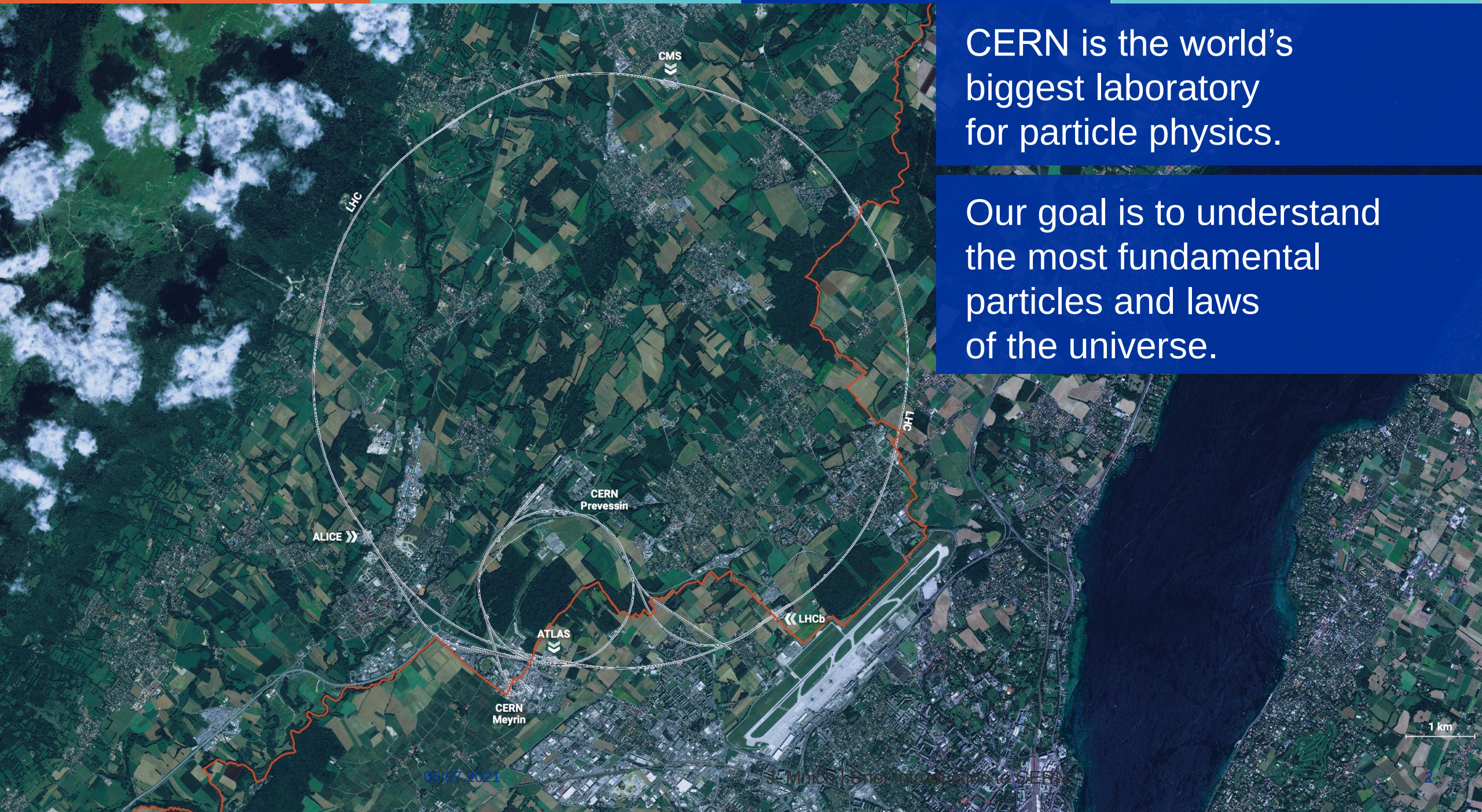
Brief Introduction to CERN

Welcome to 2021 Summer Students

Joachim Mnich

Director for Research and Computing

July 5th, 2021

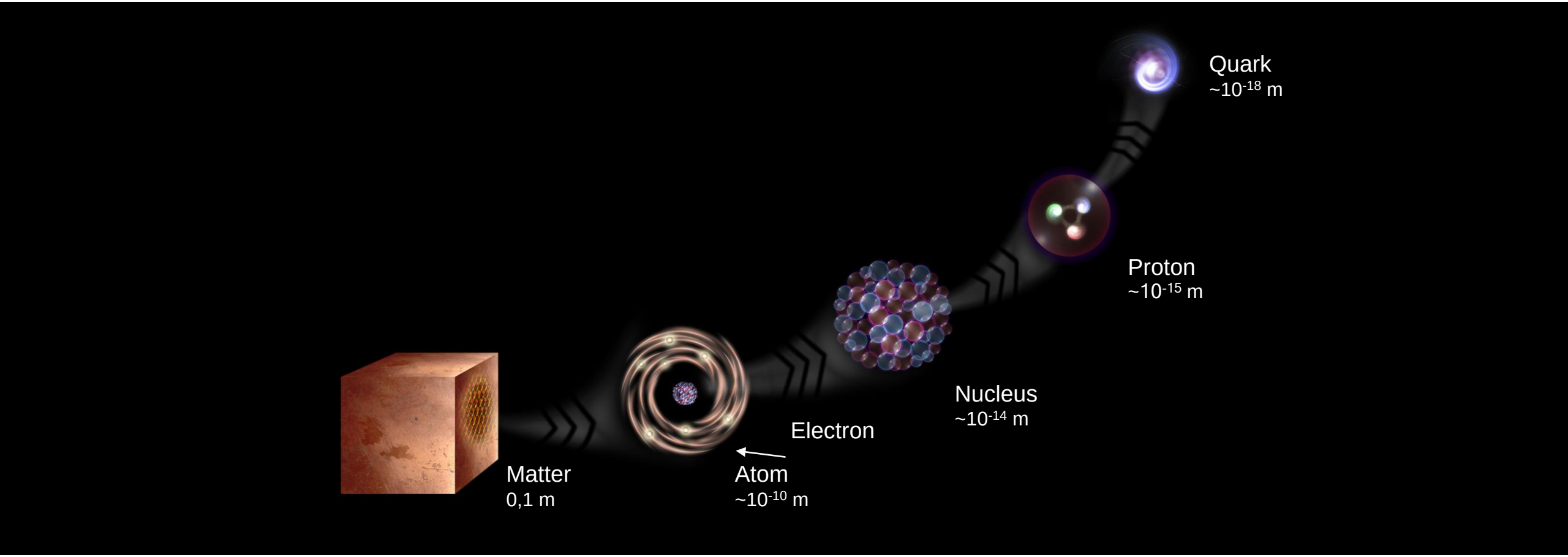


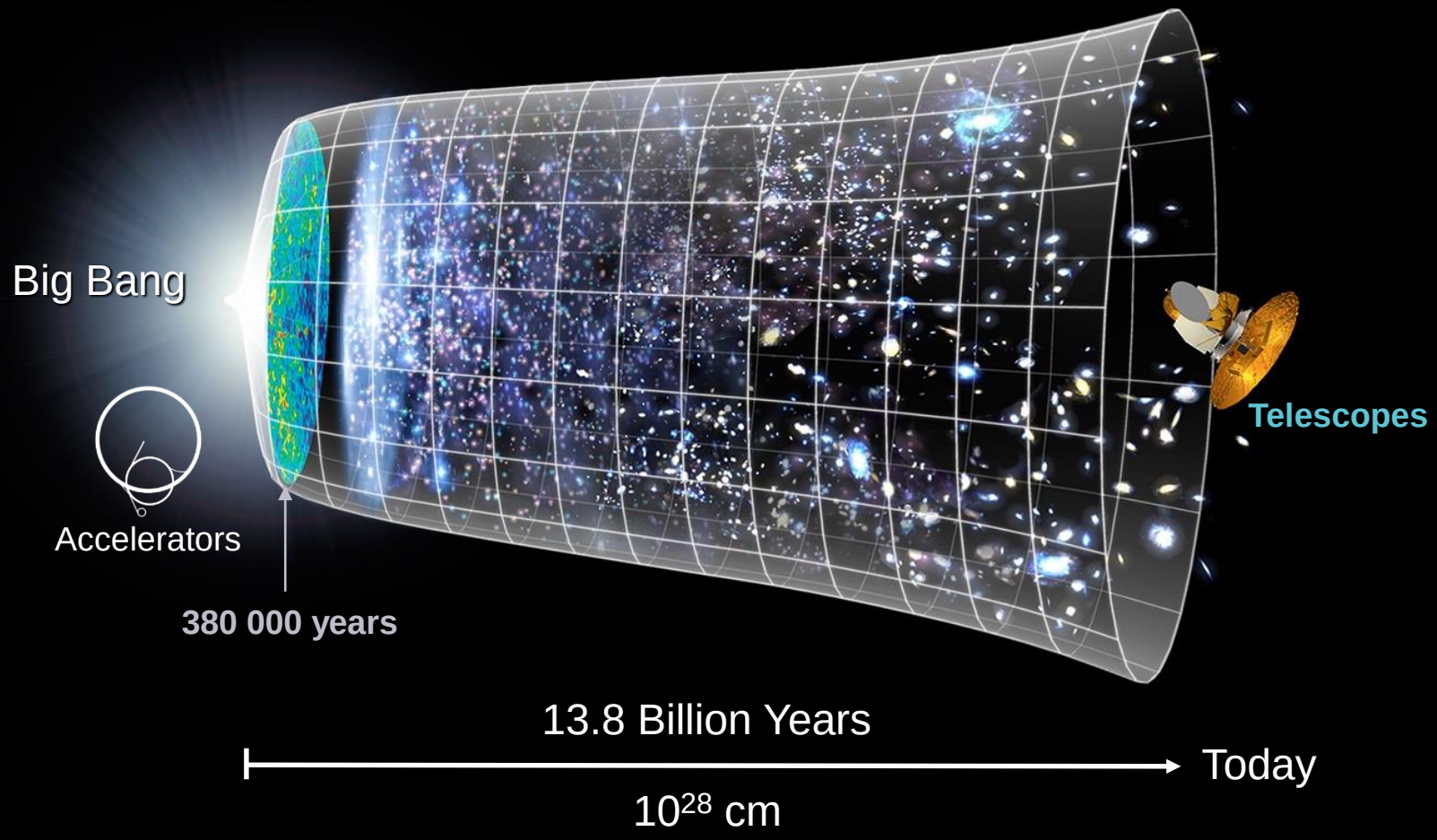
CERN is the world's biggest laboratory for particle physics.

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





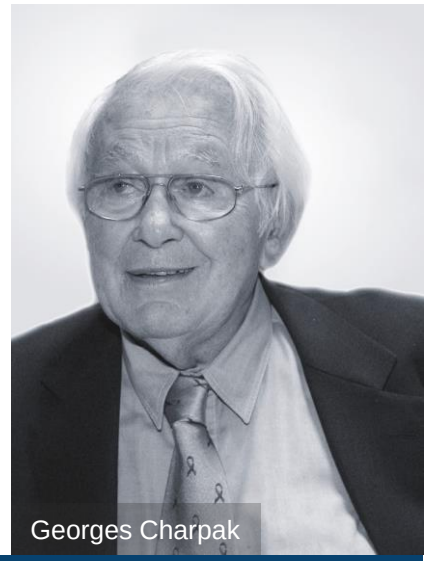
How did the universe begin?

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.

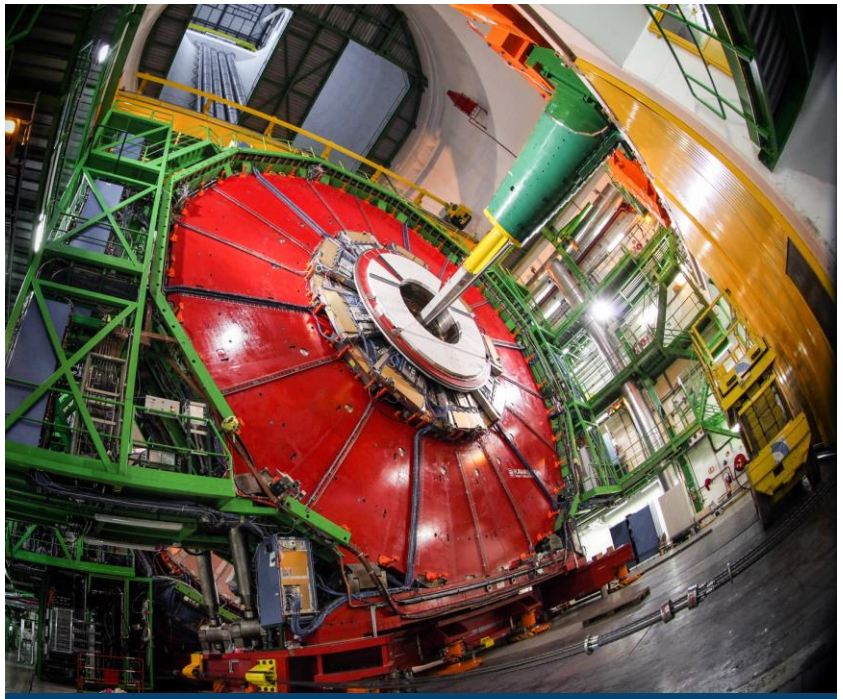
The Higgs boson was discovered in 2012; without it fundamental particles would be massless and atoms could not form.


François Englert and Peter Higgs

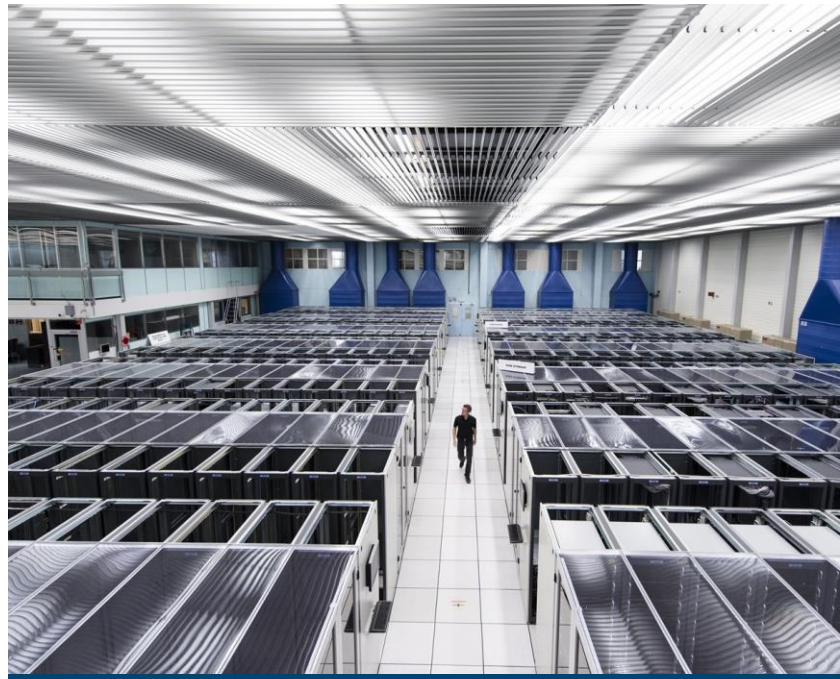
How do we do it?

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

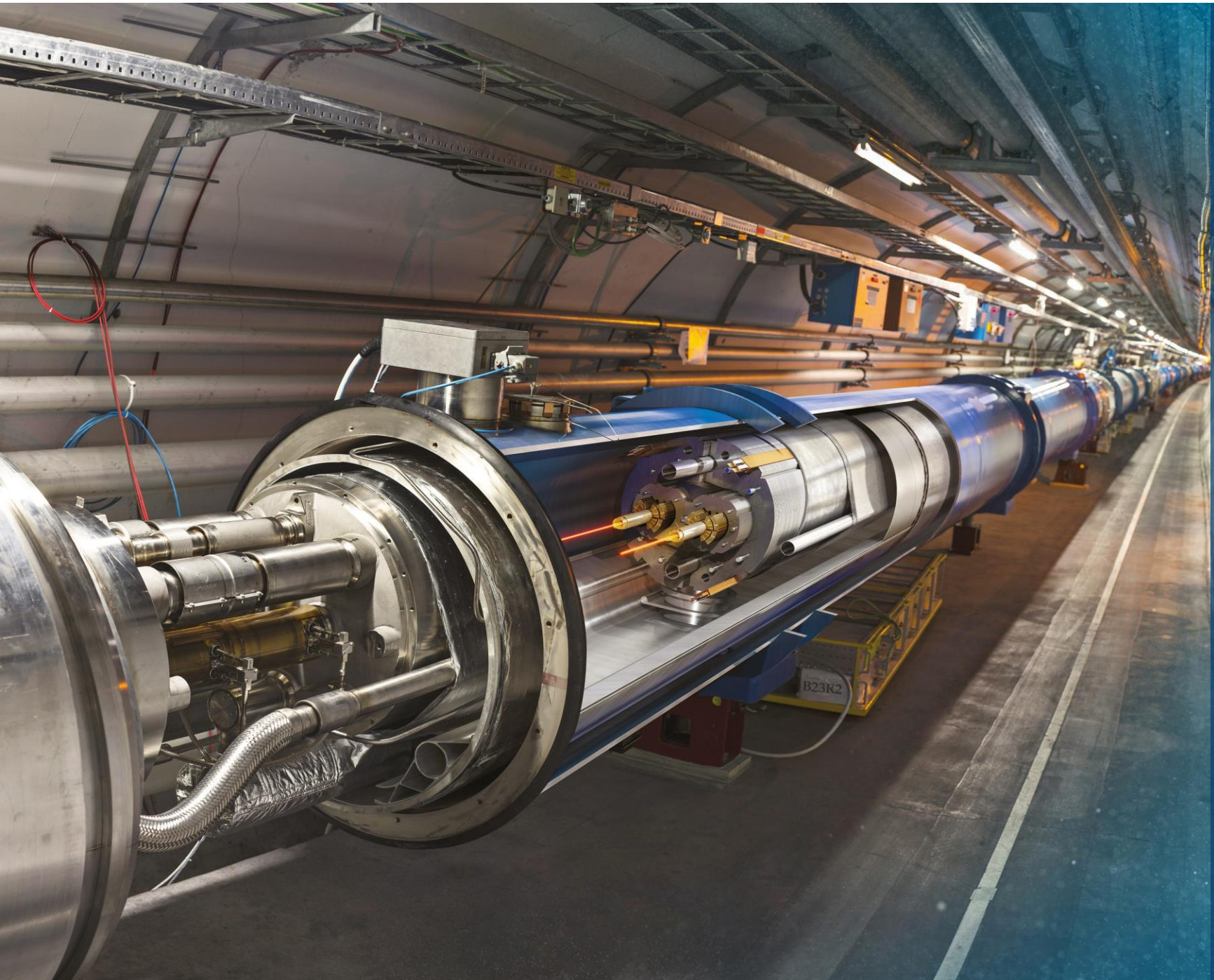
ACCELERATORS



DETECTORS



COMPUTING



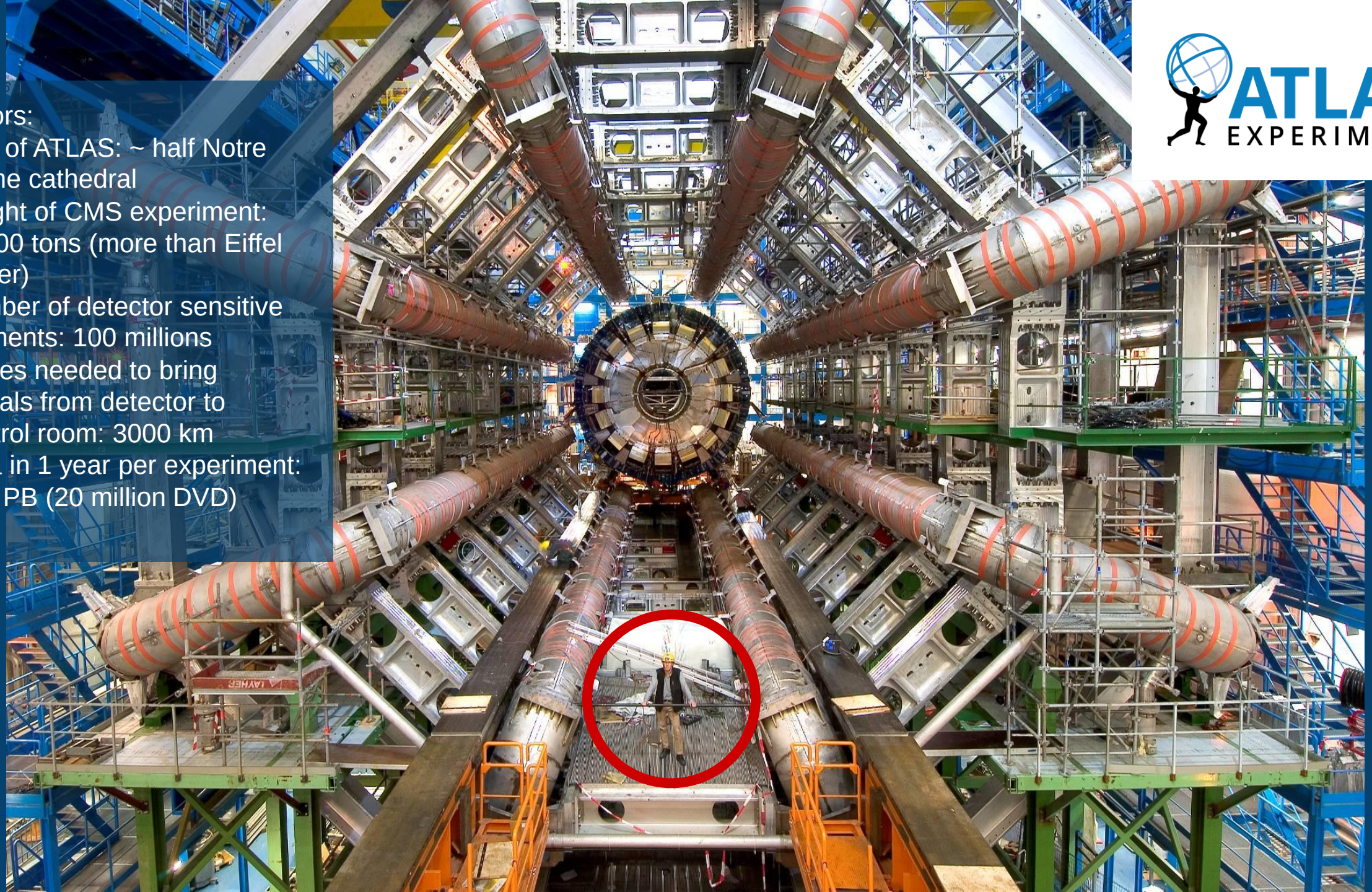
Large Hadron Collider (LHC)

- 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

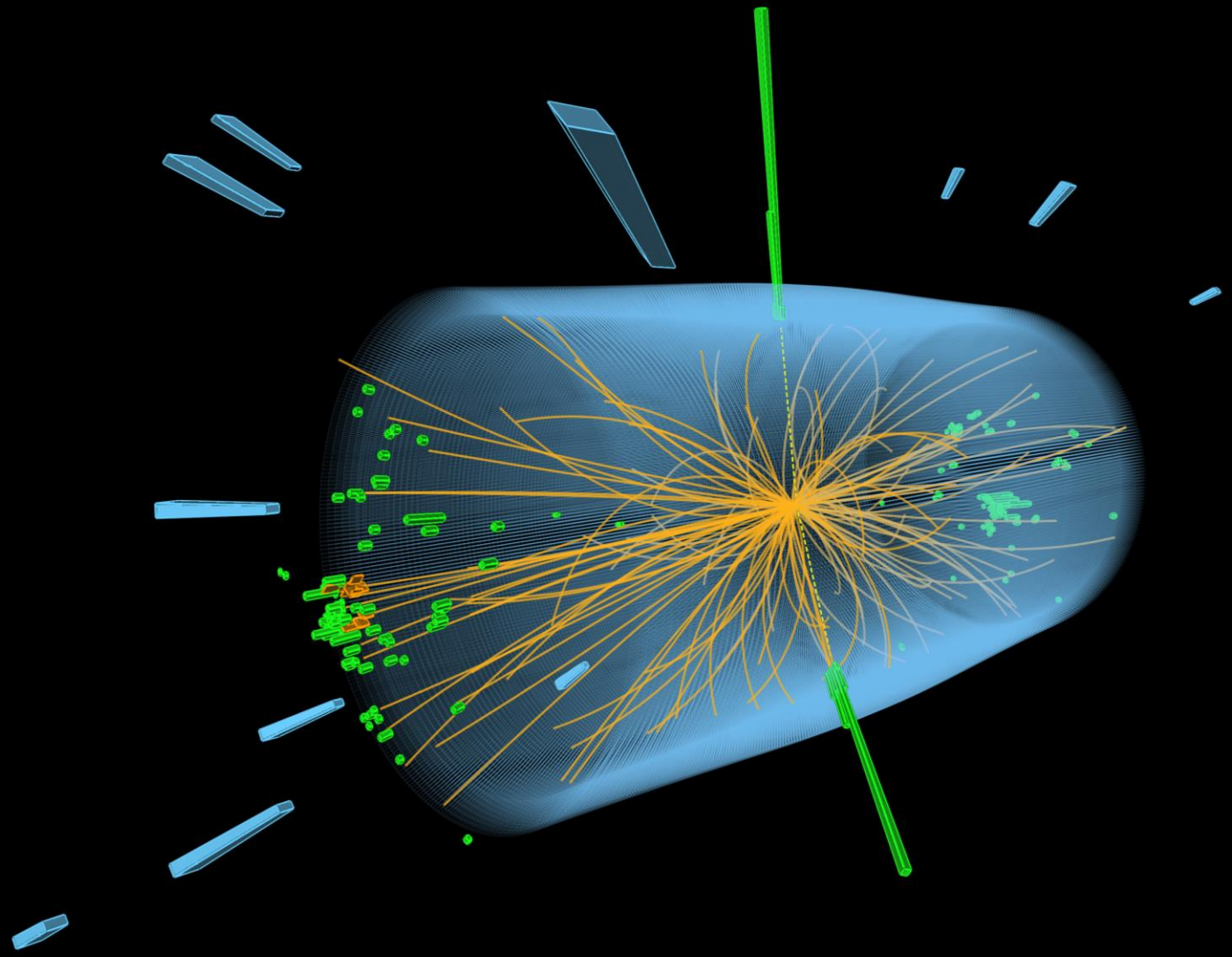
Detectors:

- size of ATLAS: ~ half Notre Dame cathedral
- weight of CMS experiment: 13000 tons (more than Eiffel Tower)
- number of detector sensitive elements: 100 millions
- cables needed to bring signals from detector to control room: 3000 km
- data in 1 year per experiment: ~10 PB (20 million DVD)



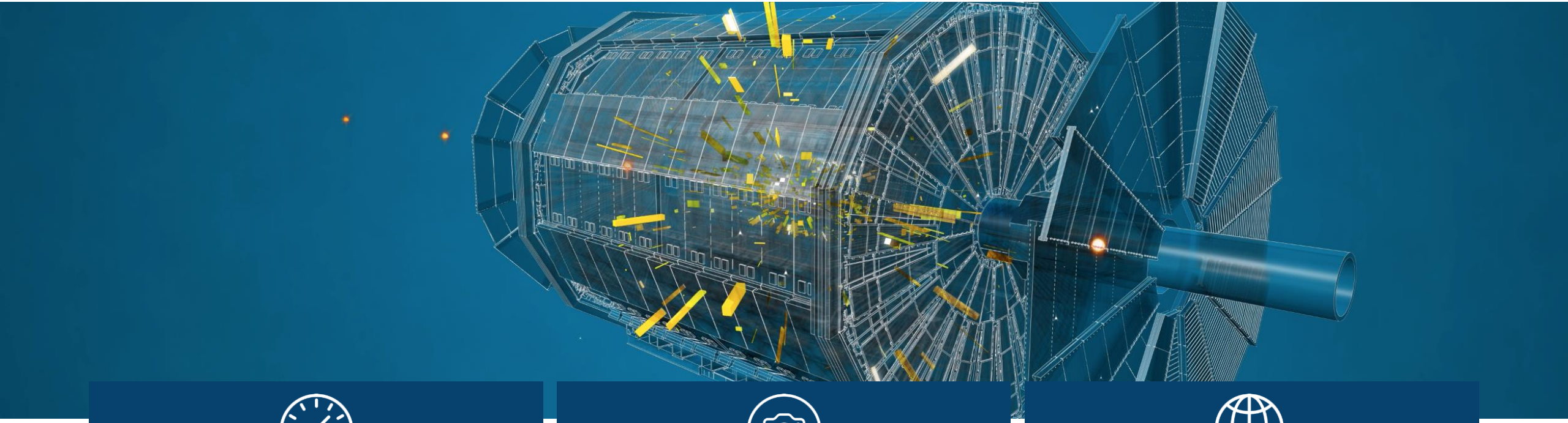
ATLAS EXPERIMENT

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

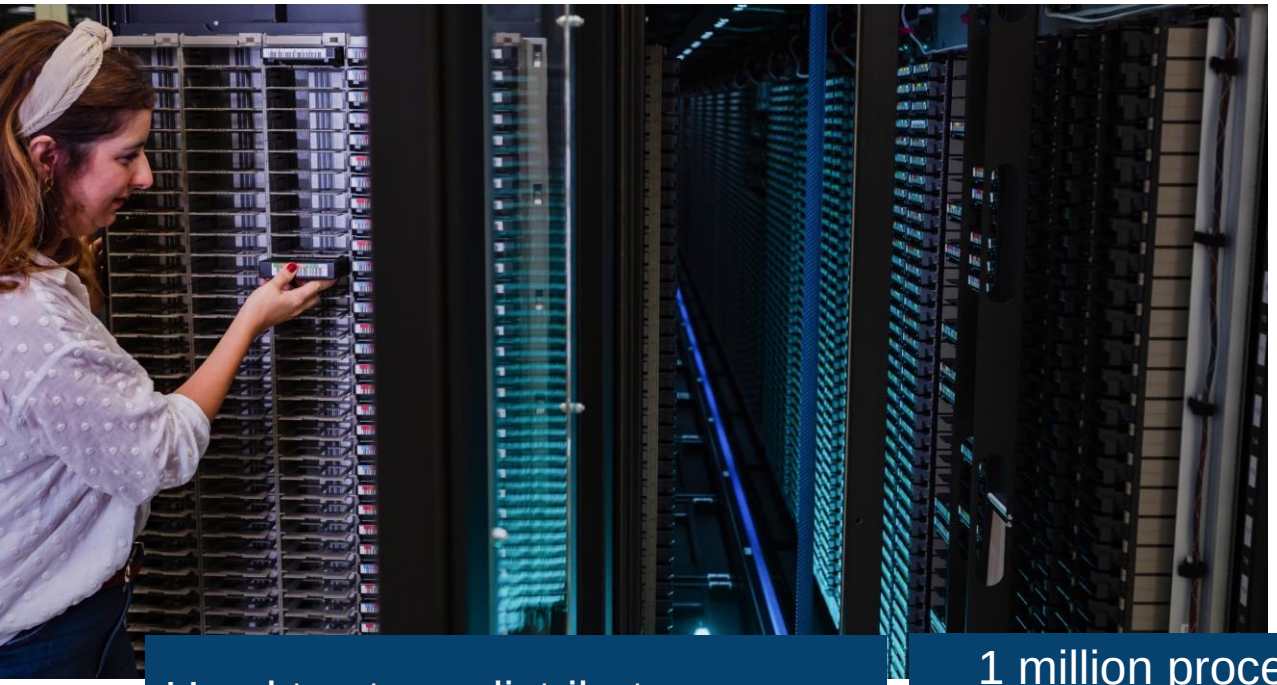


The detectors measure the energy, direction and charge of new particles formed.

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.

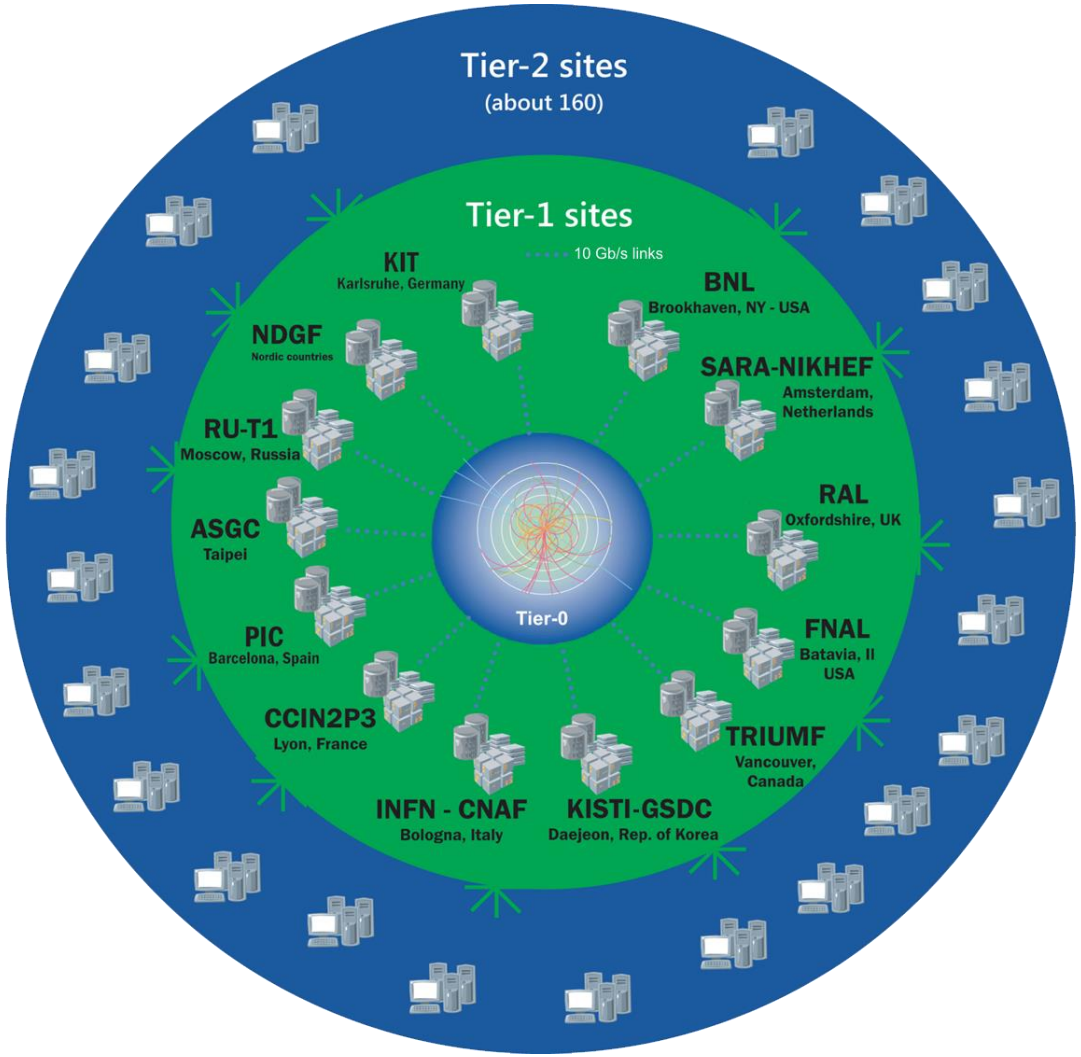
1 million processing cores in about 160 data centres and 42 countries.

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

The Worldwide LHC Computing Grid (WLCG)

An international collaboration to distribute and analyse LHC data

Integrates computer centres worldwide that provide computing and storage resource into a single infrastructure accessible by all LHC physicists



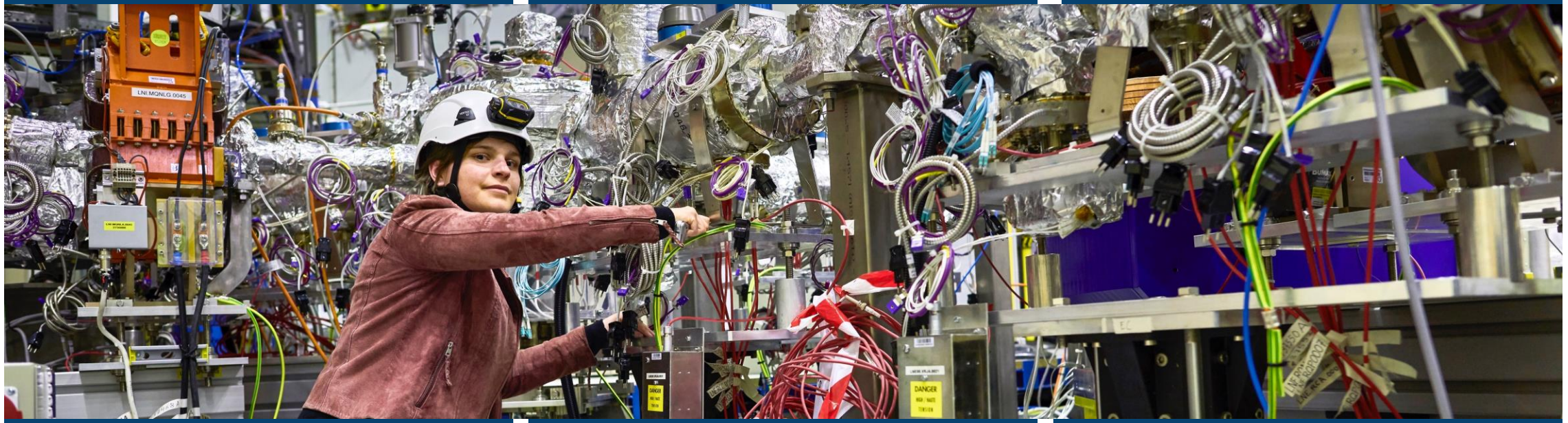
Tier-0
data recording, reconstruction and distribution

Tier-1:
permanent storage,
reprocessing,
analysis

Tier-2:
simulation,
end-user analysis

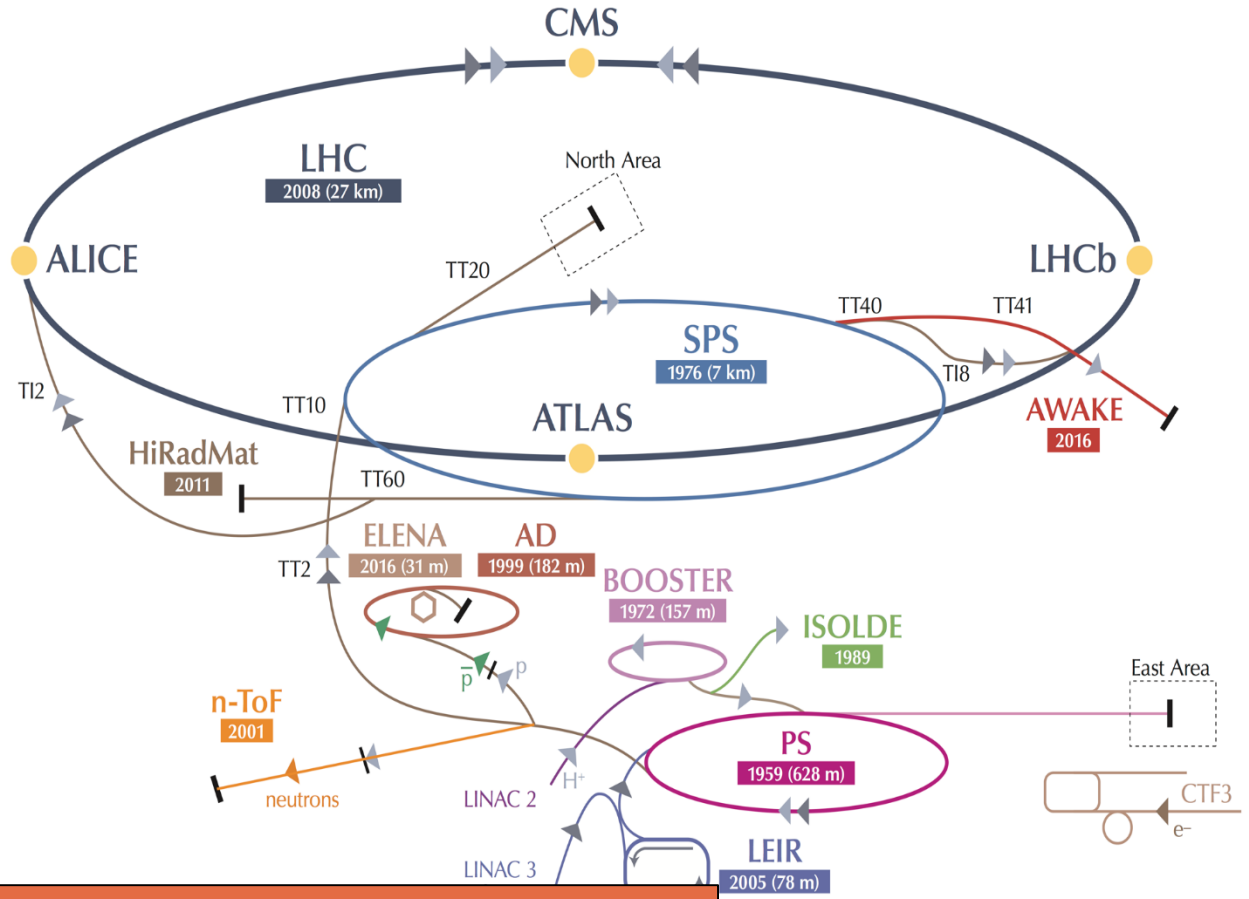
CERN has a diverse scientific programme

Theoretical Particle Physics	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)

CERN scientific programme



exploits unique capabilities of CERN's accelerator complex; complementary to other efforts in the world.

~20 projects other than LHC with > 1200 physicists

AD: Antiproton Decelerator for antimatter studies

AWAKE: proton-induced plasma wakefield acceleration

CAST, OSQAR: axions

CLOUD: impact of cosmic rays on aeorosols and clouds → implications on climate

COMPASS: hadron structure and spectroscopy

ISOLDE: radioactive nuclei facility

LHC

NA61/Shine: ions and neutrino targets

NA62: rare kaon decays

NA63: radiation processes in strong EM fields

NA64: search for dark photons

Neutrino Platform: ν detector R&D for experiments in US,Japan

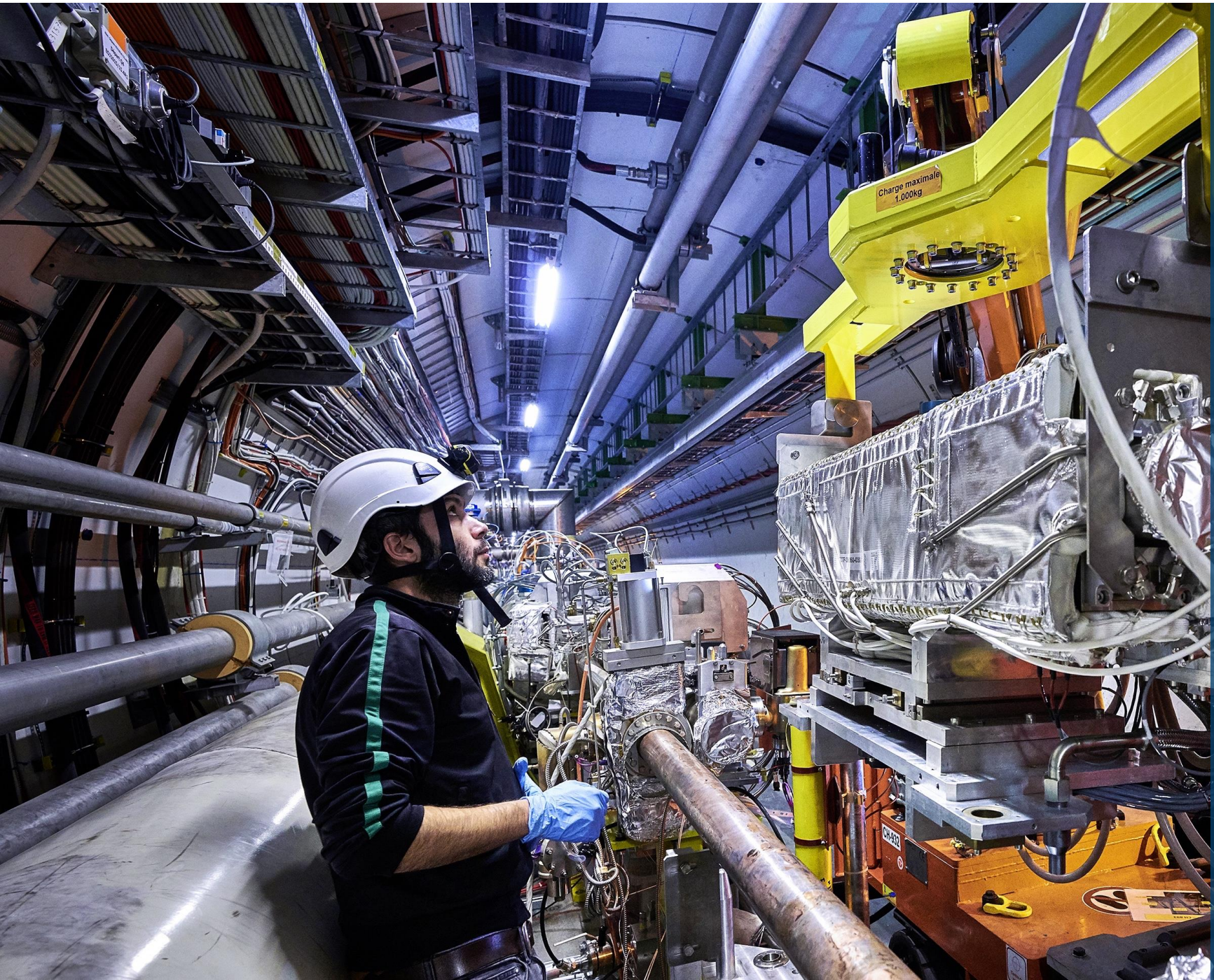
n-TOF: n-induced cross-sections

UA9: crystal collimation

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

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

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

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

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 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.

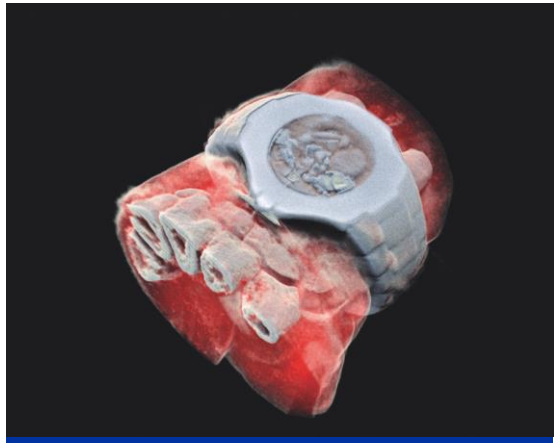
CERN’s technological innovations have applications in many fields

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.

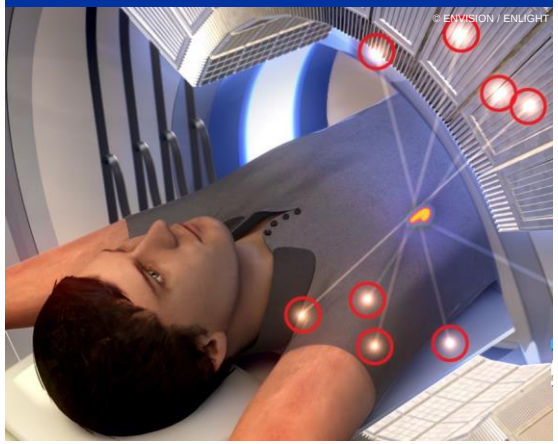
CERN’s technological innovations have important applications in medicine and healthcare

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.

CERN openlab Summer Student Projects

Machine Learning for Fast Physics Simulation

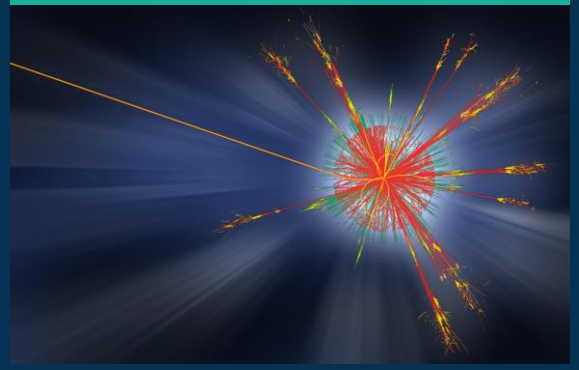
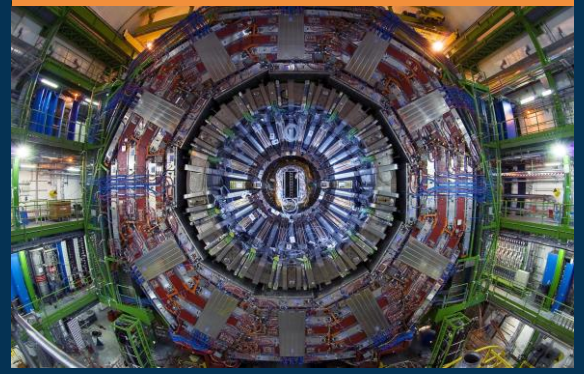
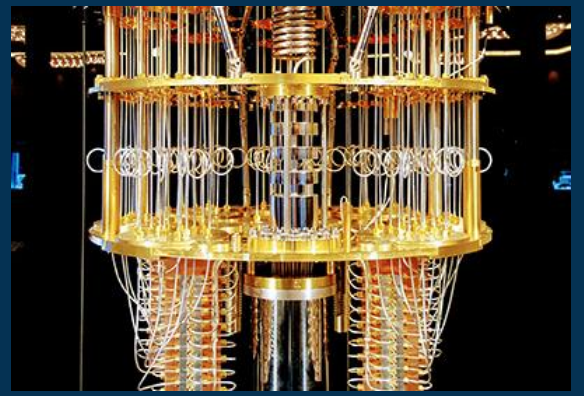


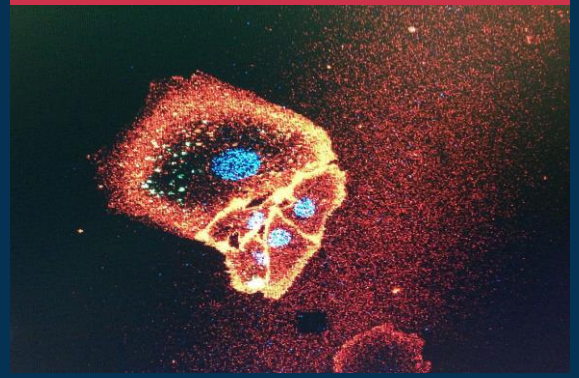
Image Processing for Track Reconstruction



Quantum Computing for Physics Analysis

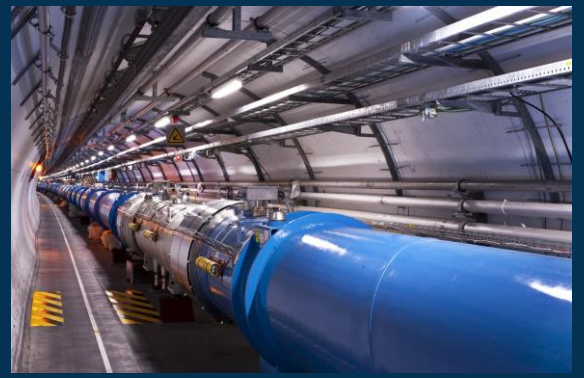


Biology Development Simulation in the Cloud



Secure Computing, Privacy-Preserving Data Analysis

Internet of Things for Smart Control Systems in the LHC



CERN openlab Research Activities

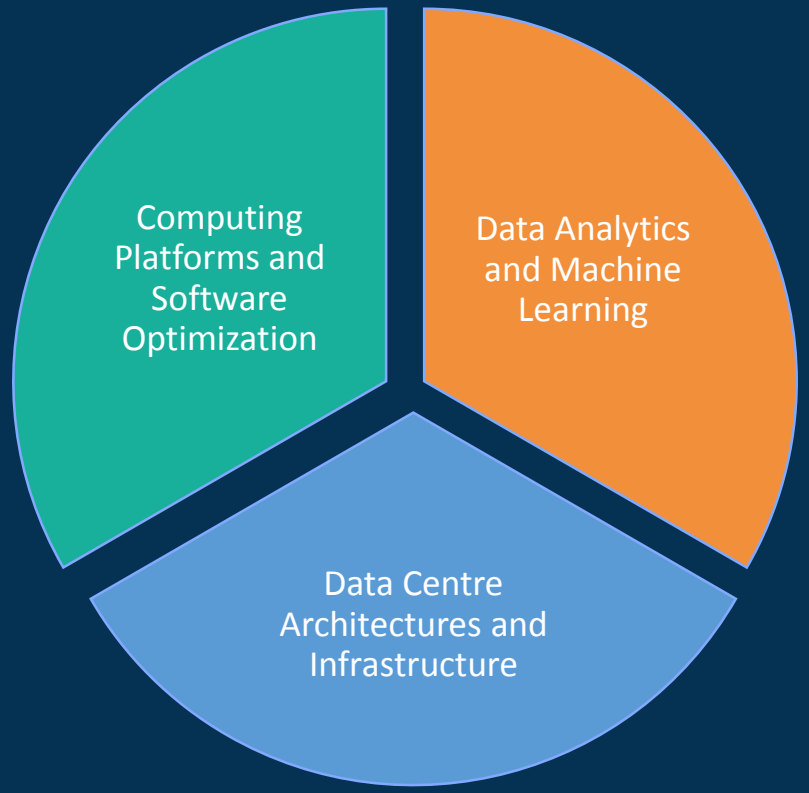
Accelerated computing platforms for data acquisition and filtering (GPUs, FPGA, High-Capacity-High-Bandwidth Memory)

Specialized platforms for Machine Learning applications

New computing architectures (Neuromorphic and Quantum Computing)

High Performance Computing

Parallelized Simulation Software (Physics and Medical Research)



Anomaly Detection (Data Quality and Engineering Systems)

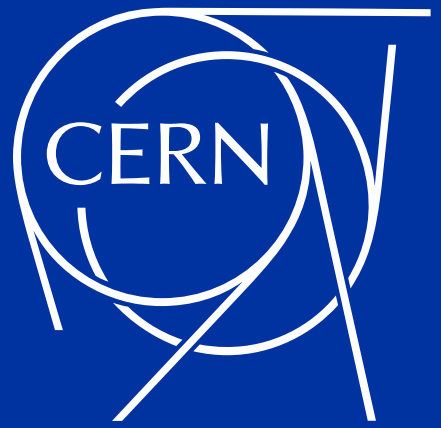
Cloud-based Data Training
Fast Inference for Triggers,
Big Data Reduction

Image Processing (Track Reconstruction, Medical Applications, Maps)

Quantum Machine Learning
Quantum Field Theory modelling and simulation

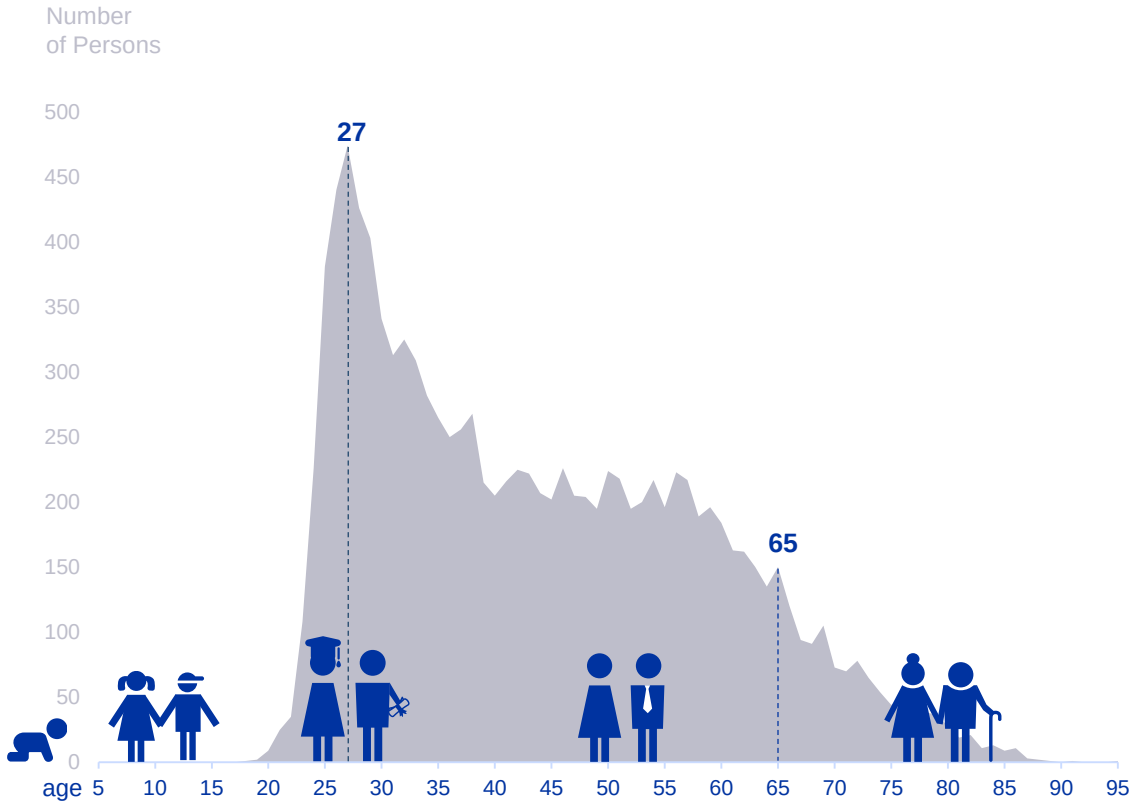
Software Defined Networks (SDN), IoT Infrastructures, Sensor Networks,
High-Speed Fiber Links

Software Defined Infrastructure (SDI)
Scalable Hybrid Clouds,
File Systems as a Service, In-Memory Databases

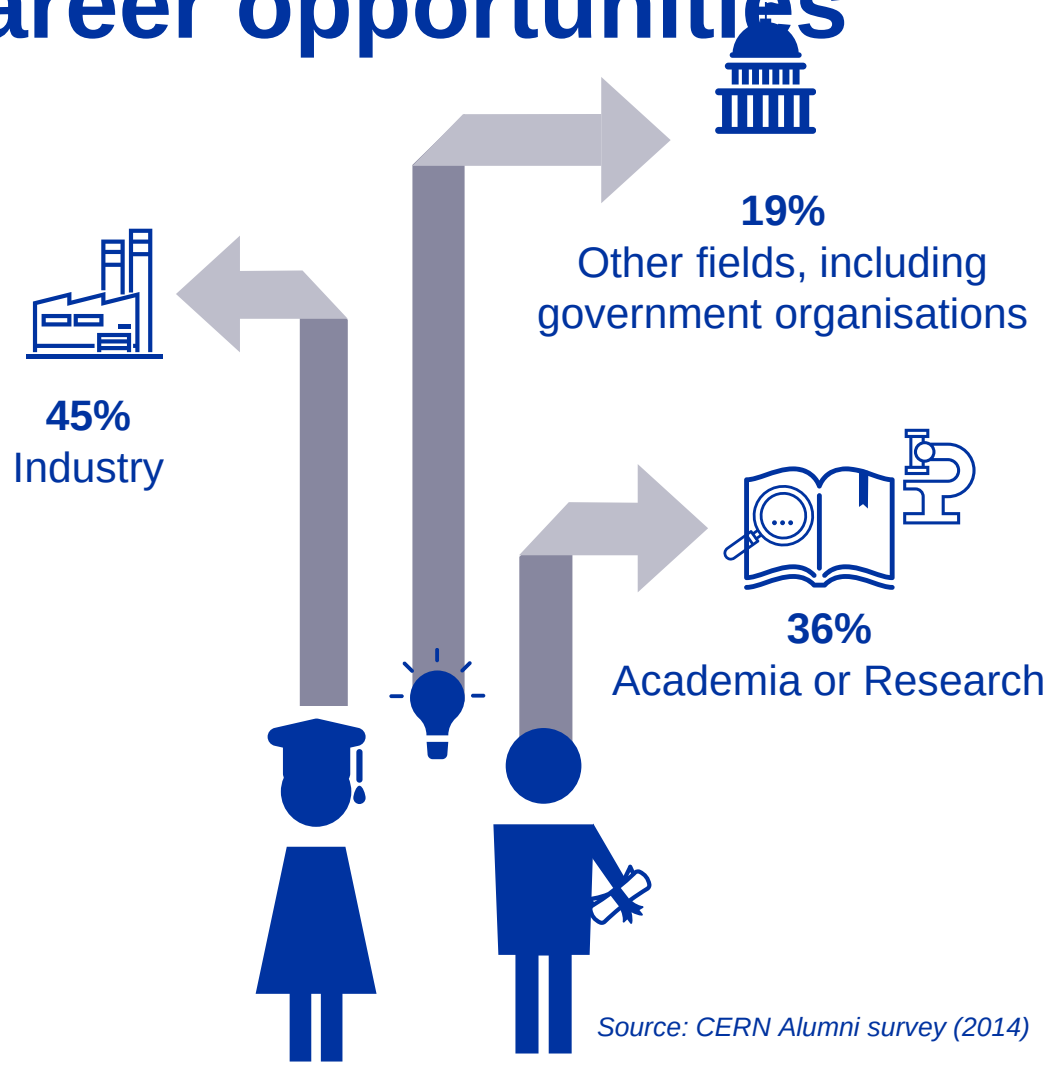


Thank you very much for your attention!

CERN opens a world of career opportunities



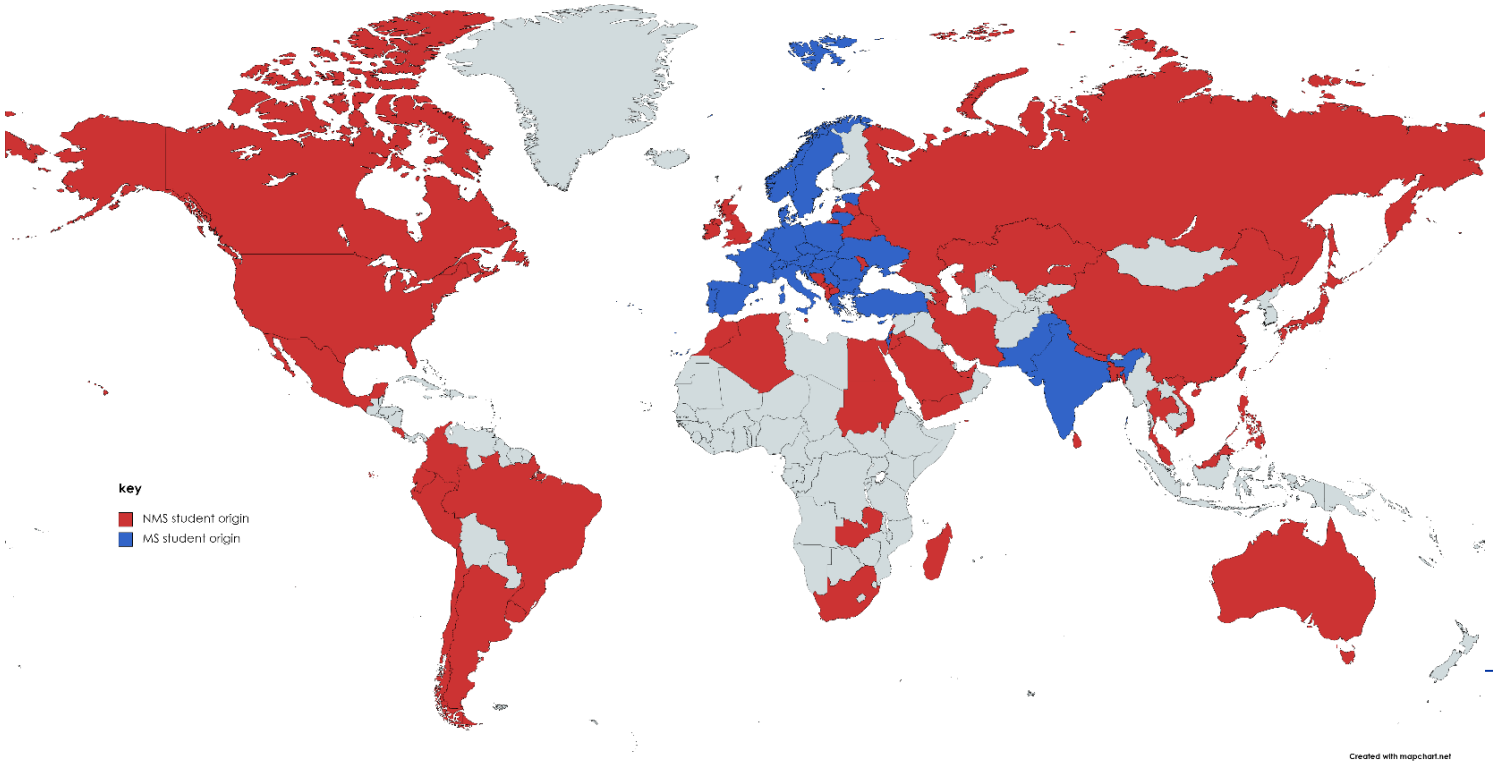
Age Distribution of Scientists working at CERN



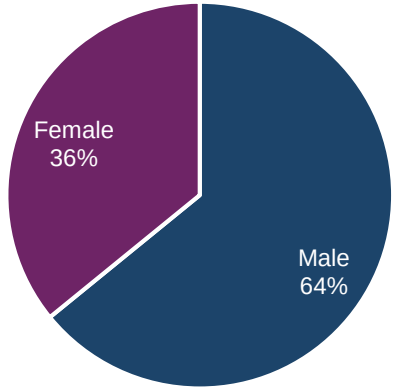
PhD and Technical students leaving CERN

Summer Student Program 2021

- There are a total of 291 summer students coming from 84 different countries
- With 132 MS students, 132 NMS students and 27 Openlab students
- Students come from a diverse background of studies, with the majority studying physics



Gender Breakdown 2021



SUMMER STUDENTS EDUCATION BACKGROUND