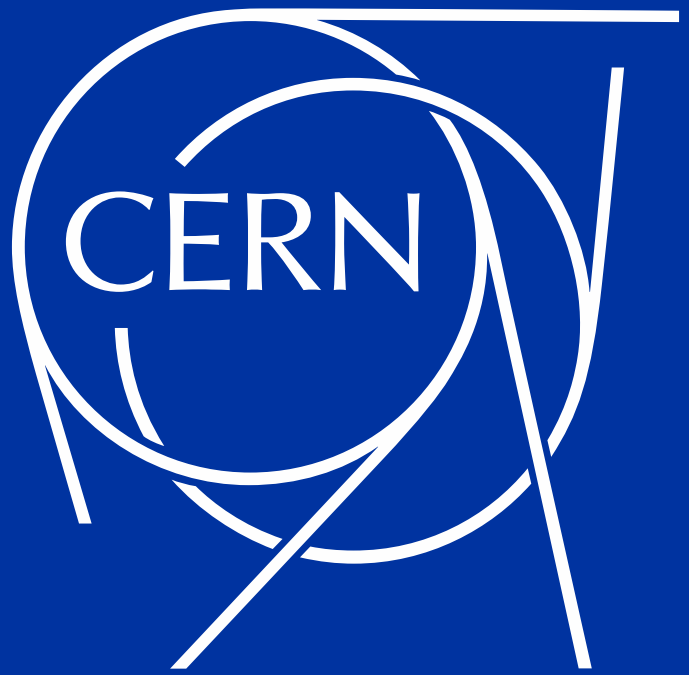
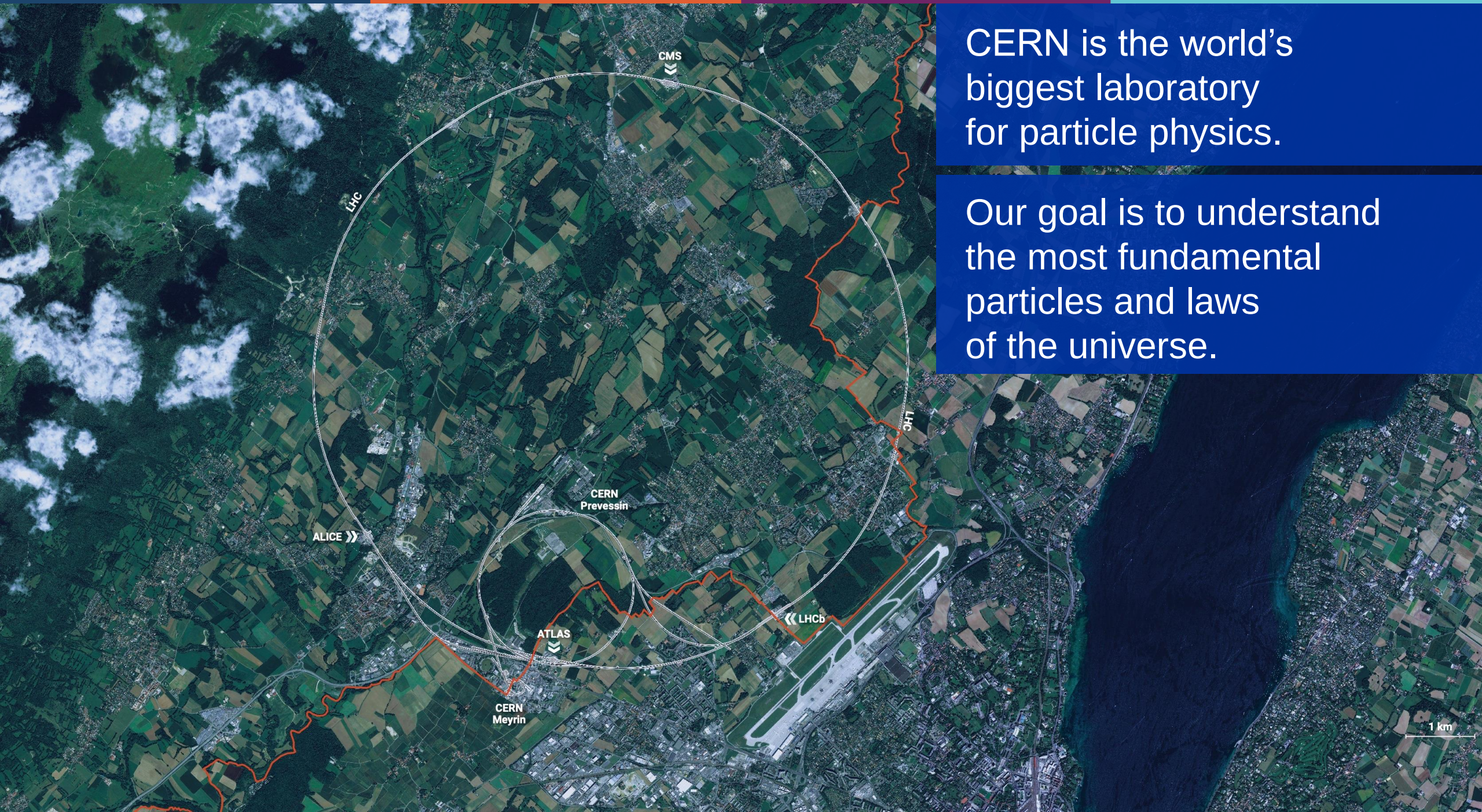

CERN

WELCOME TO CERN

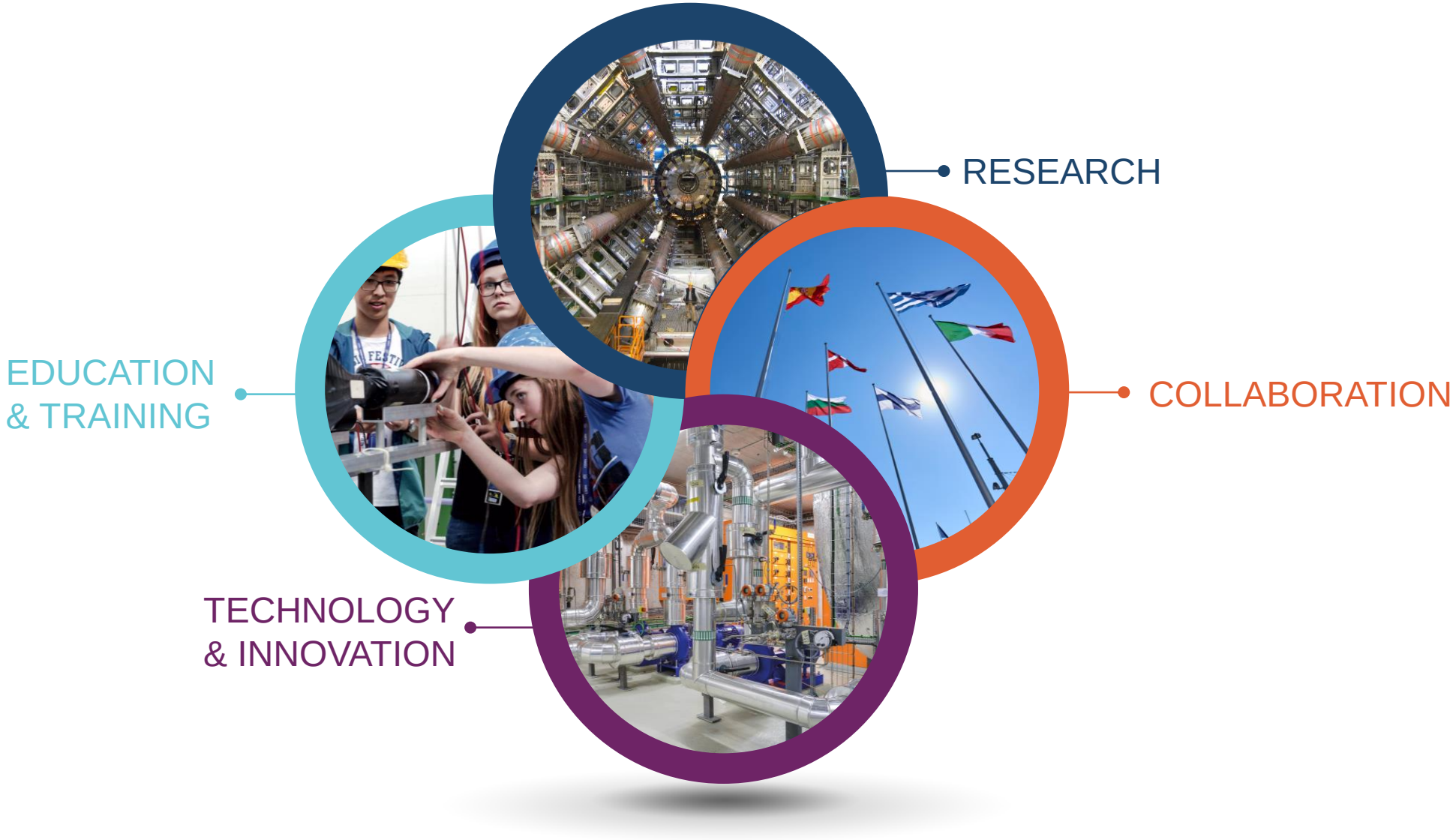
GIM Workshop, January 19, 2023

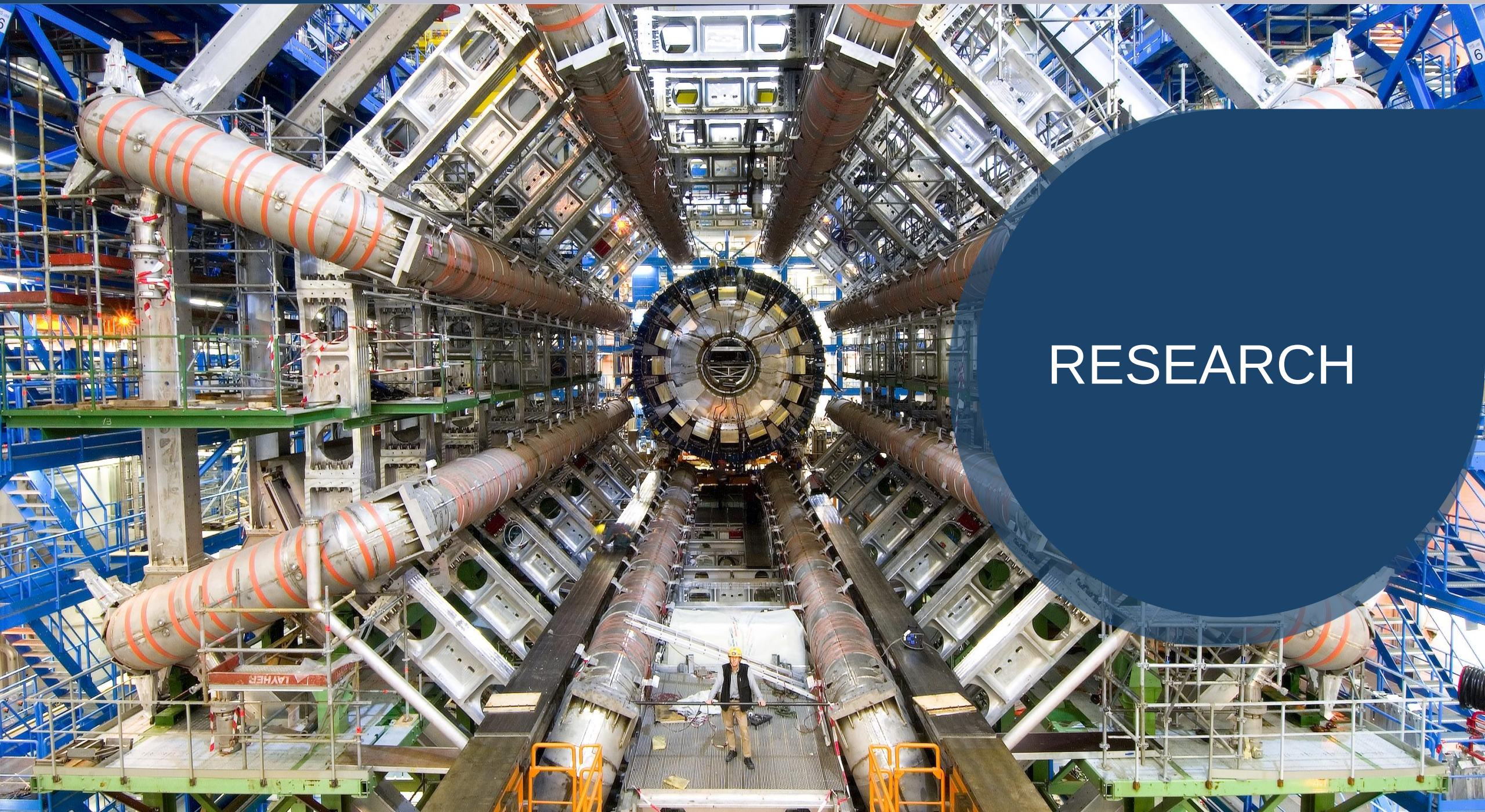


CERN is the world's biggest laboratory for particle physics.

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

Four pillars underpin CERN's mission



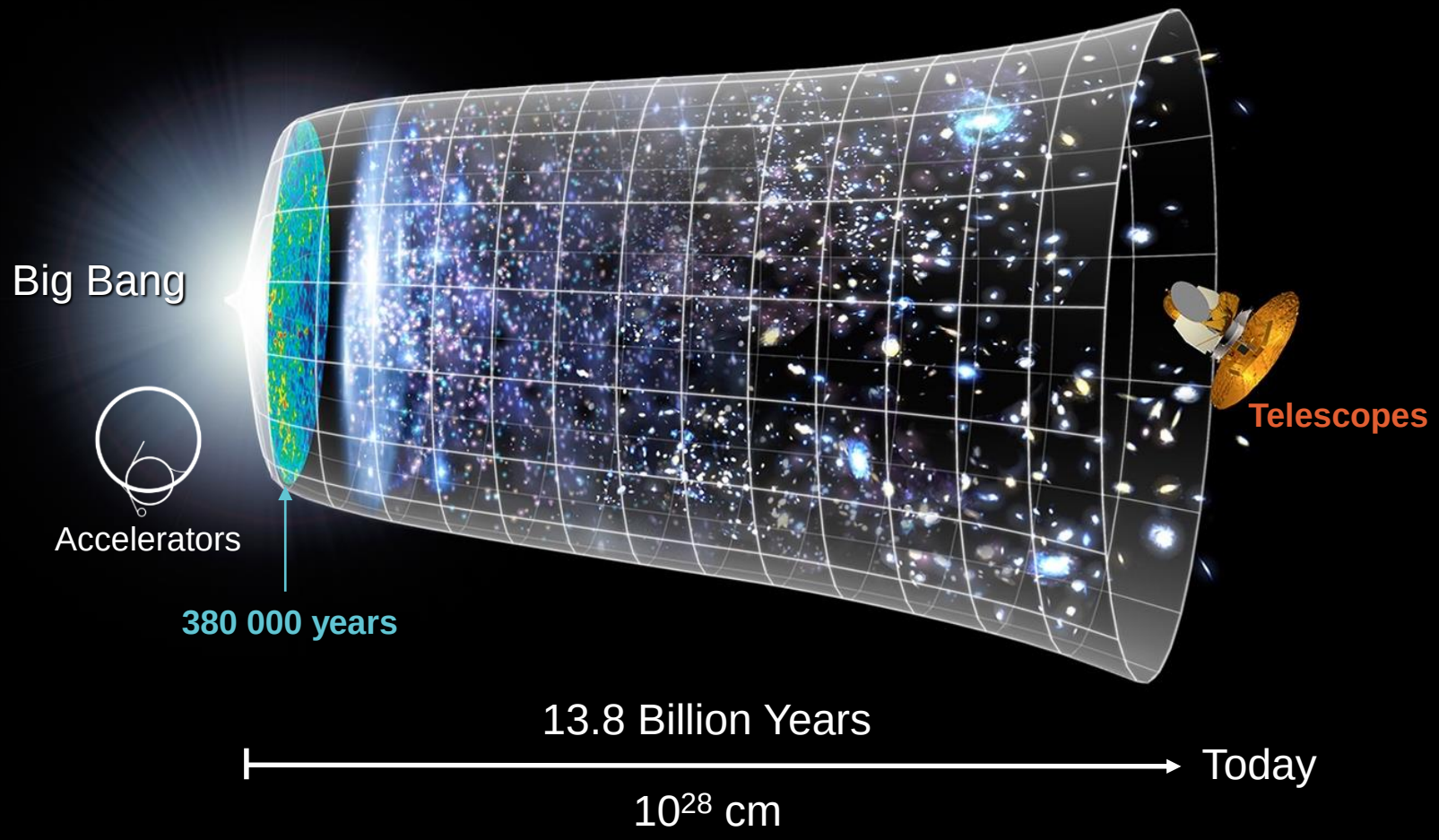


RESEARCH

There are many unanswered questions in fundamental physics

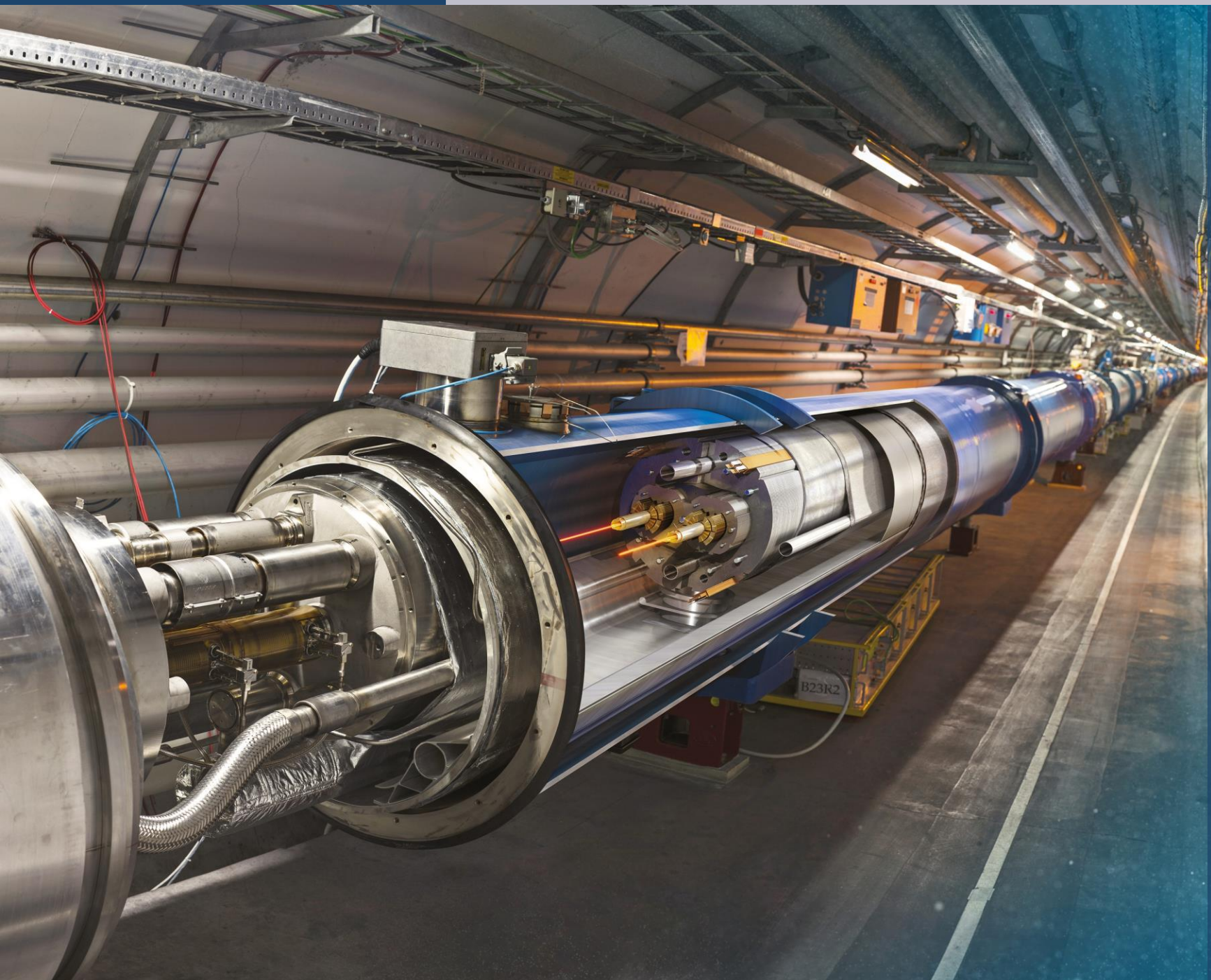
Including

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?

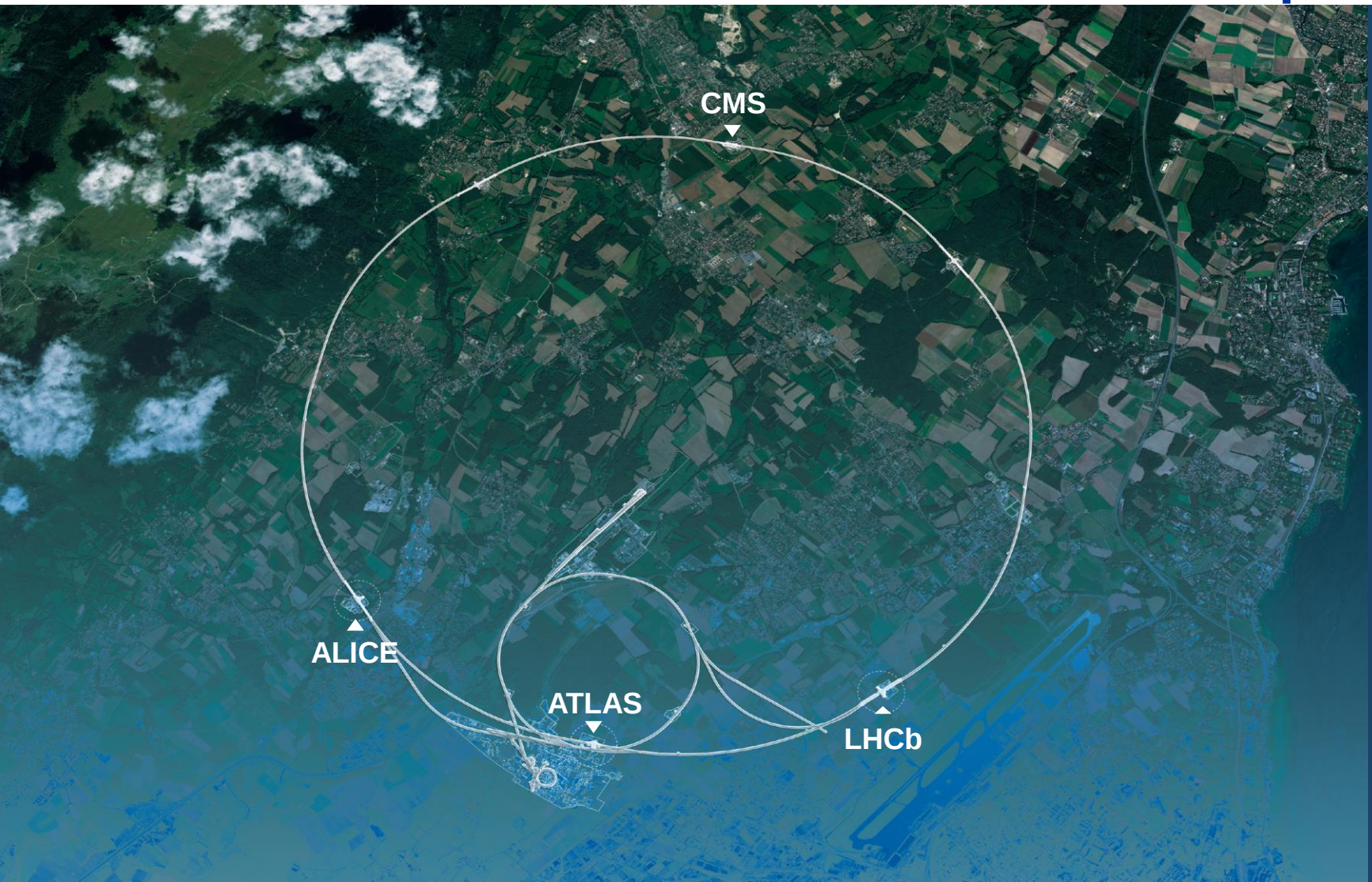
We reproduce the conditions a fraction of a second after the Big Bang, to gain insight into the structure and evolution of the universe.

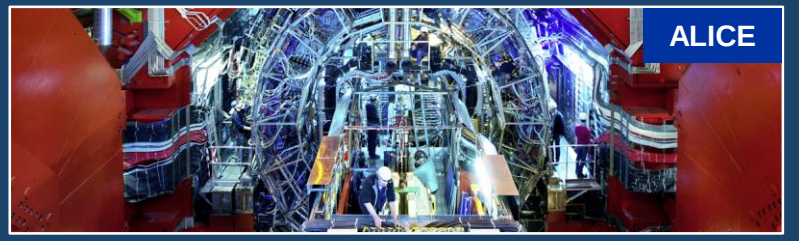


Large Hadron Collider (LHC)

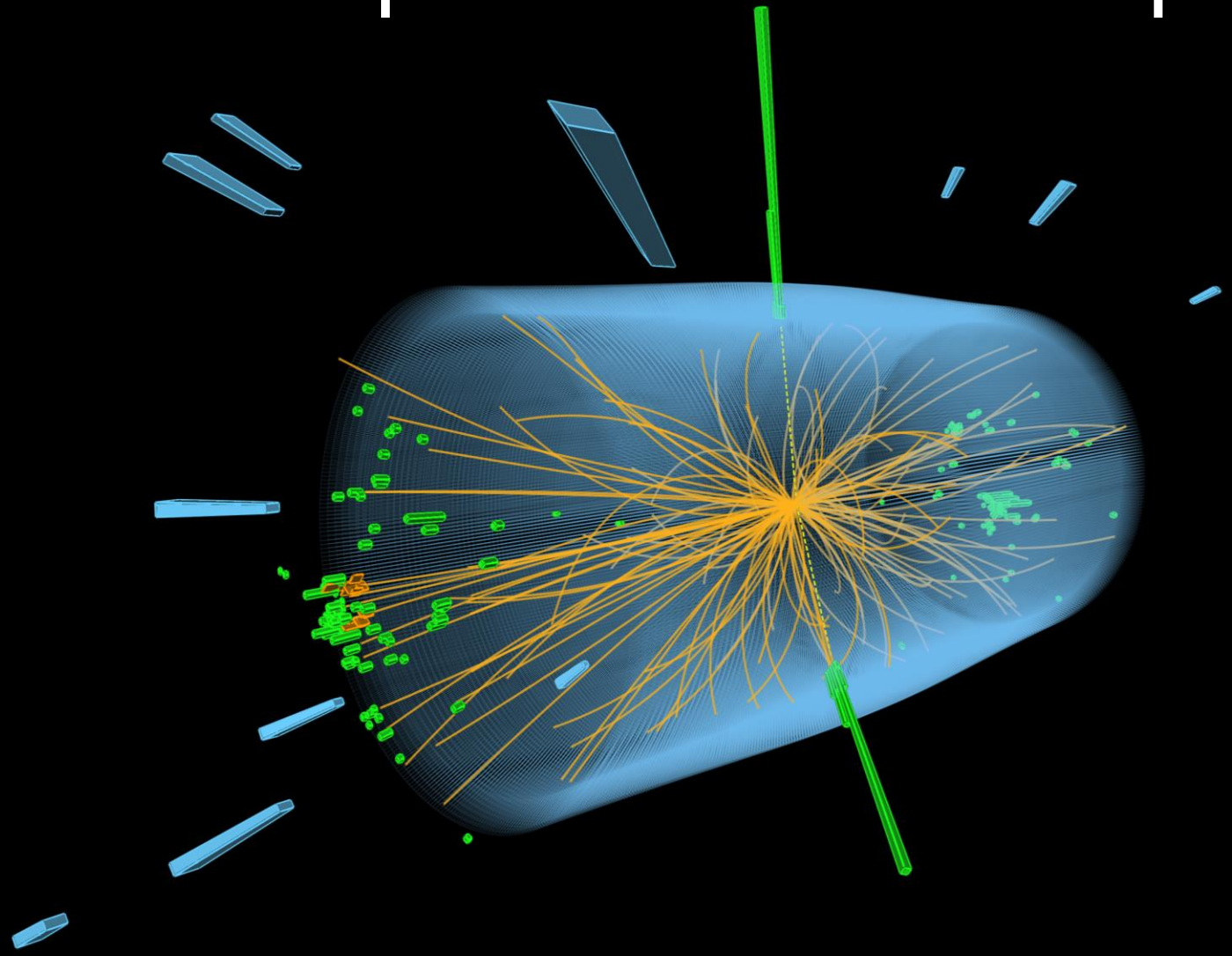
- 27 km in circumference
- About 100 m underground
- Superconducting magnets steer the particles around the ring
- Particles are accelerated to close to the speed of light

Giant detectors record the particles formed at the four collision points



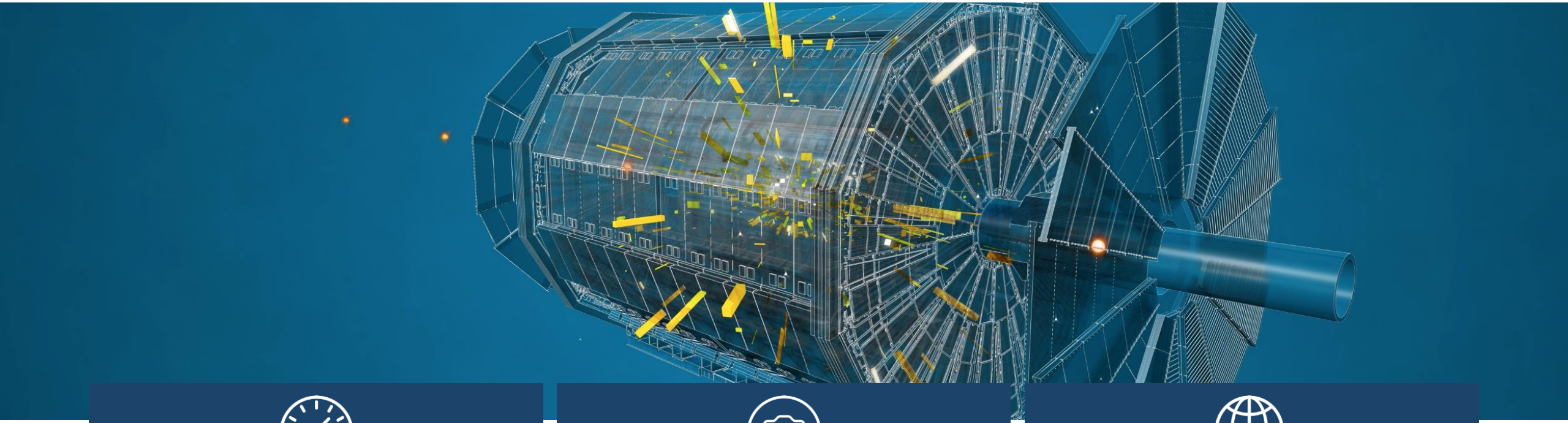


The LHC produces more than 1 billion particle collisions per second



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

The LHC detectors are analogous to 3D cameras

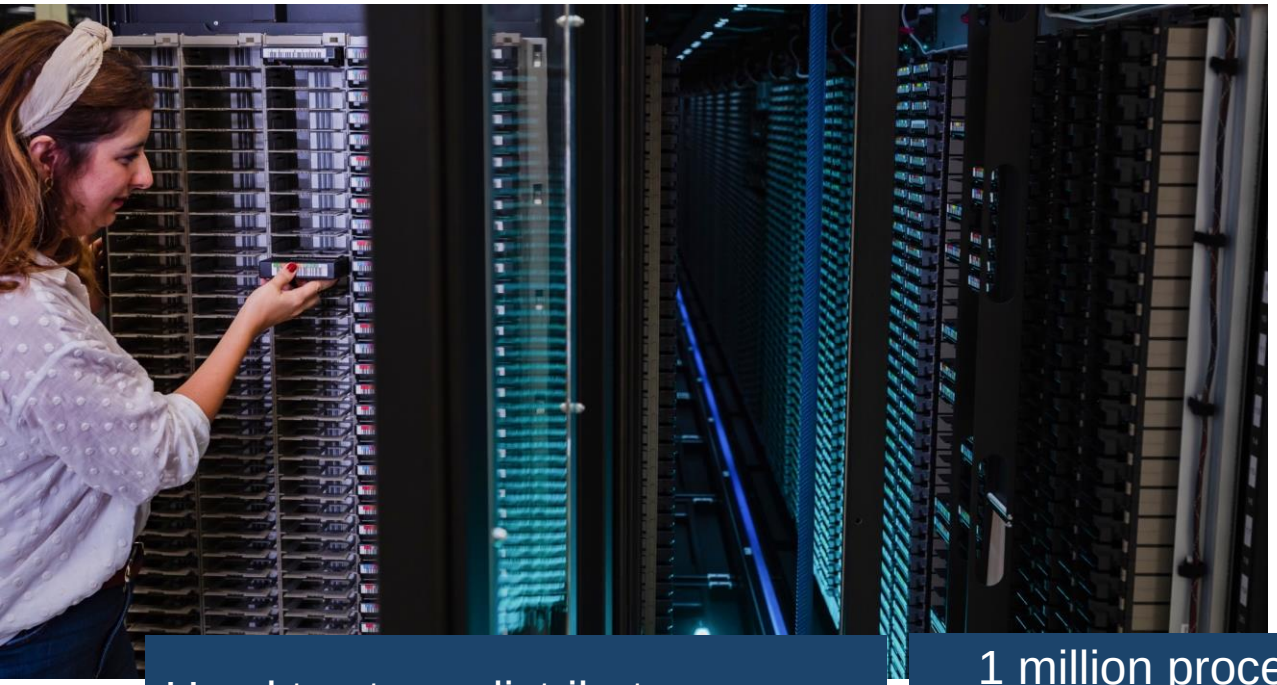


The detectors measure the energy, direction and charge of new particles formed.

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

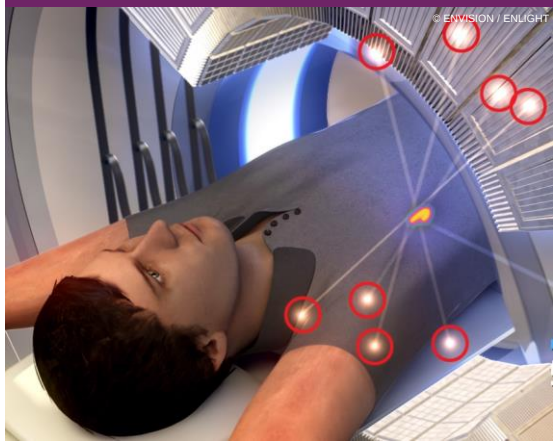
Albania – Algeria – Argentina – Armenia – Australia – Azerbaijan – Bangladesh – Belarus – Bolivia
Bosnia and Herzegovina – Brazil – Canada – Chile – Colombia – Costa Rica – Ecuador – Egypt – Georgia – Honduras
Iceland – Iran – Jordan – Kazakhstan – Lebanon – Malta – Mexico – Mongolia – Montenegro – Morocco – 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

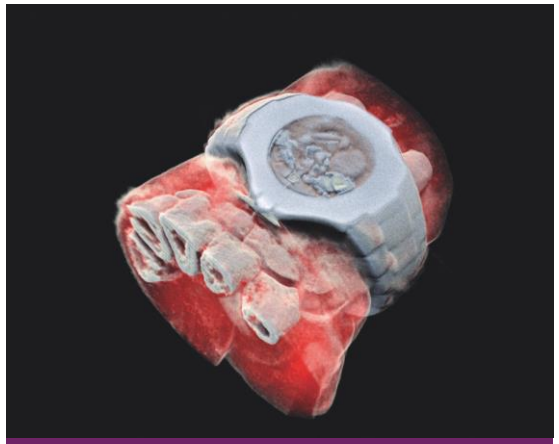
TECHNOLOGY & INNOVATION

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.



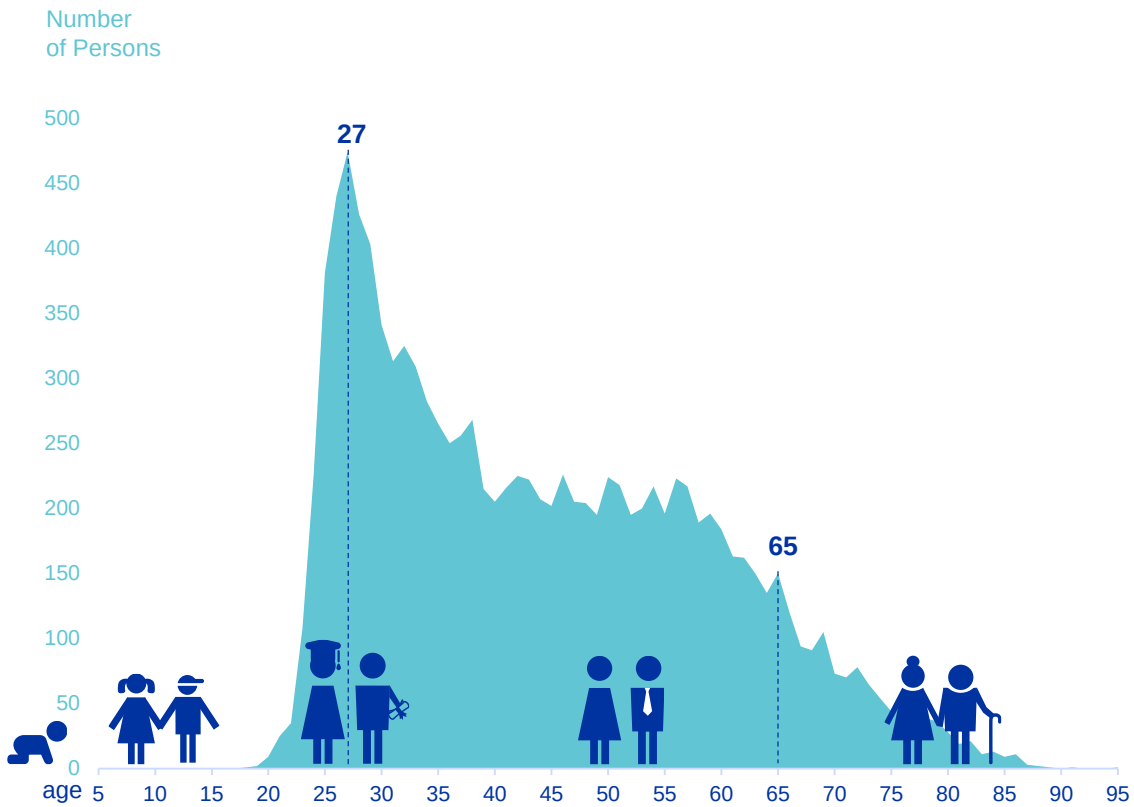


Pixel detector technologies are used for high resolution 3D colour X-ray imaging.

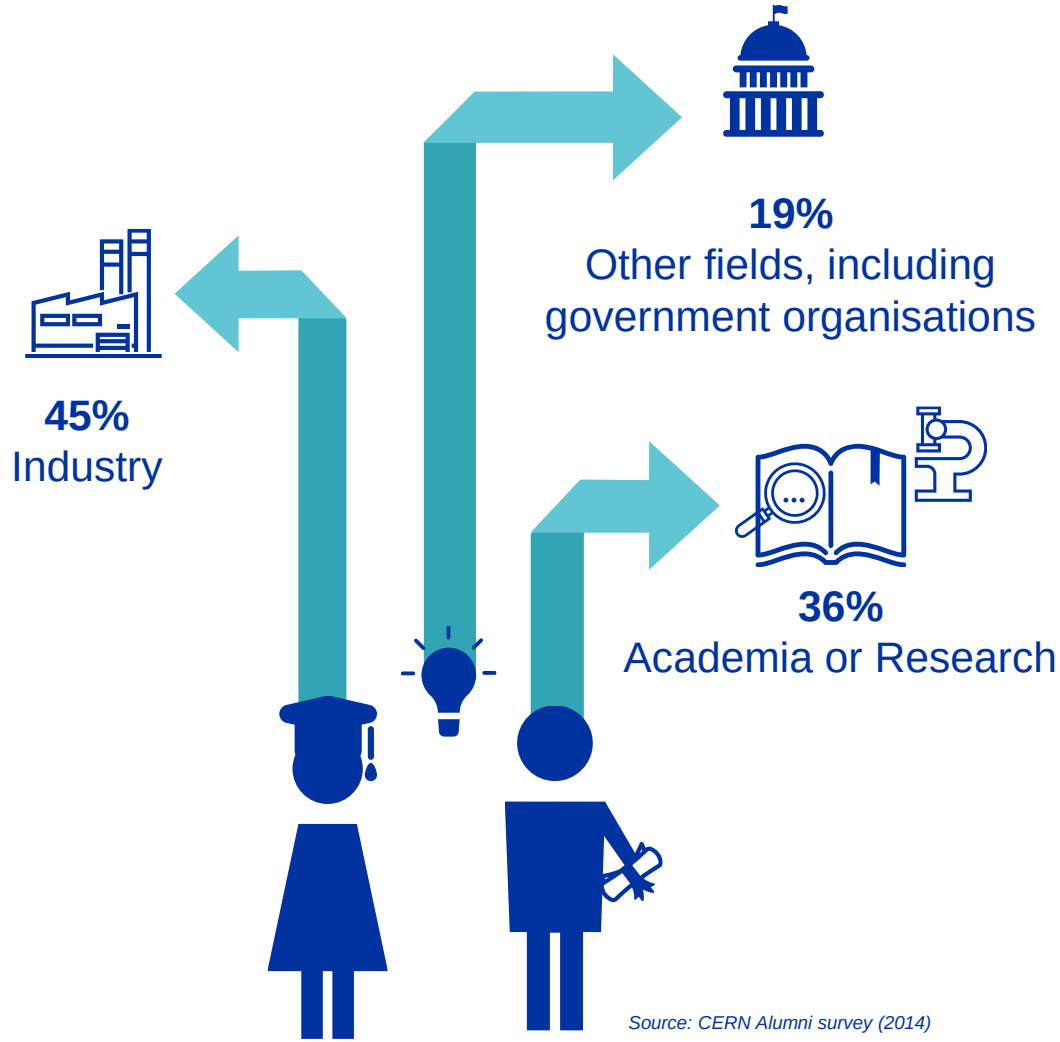
CERN produces innovative radioisotopes for nuclear medicine research.

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

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 Italy

14 summer students during 2019
1066 teachers in Teacher Programmes since 1998
146 teams in BL4S competition since 2014
1765 students participating in S'Cool LAB since 2015
18 531 Italian 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.

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

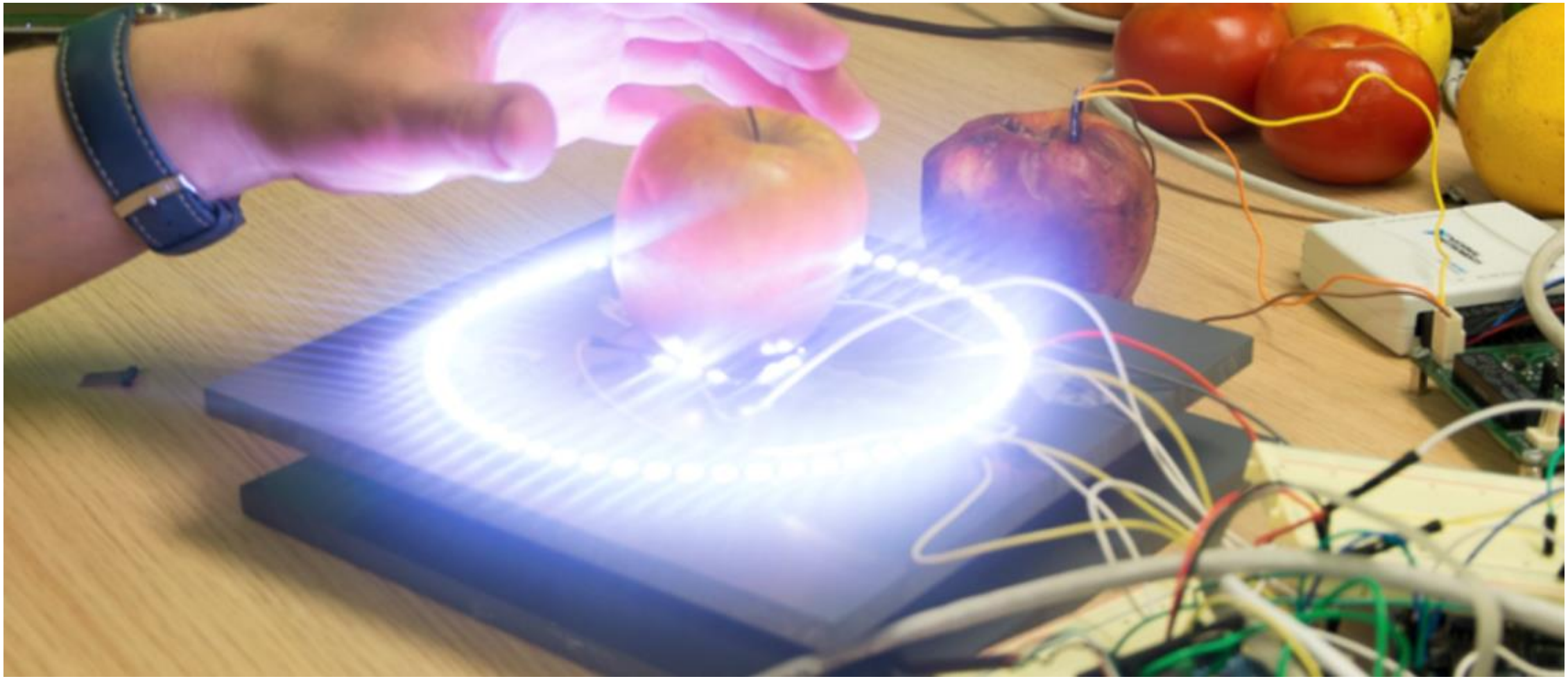
IdeaSquare is the innovation space at CERN, that uses collaborative methodologies, access to CERN expertise and cross-connectivity to ideate solutions for the future of humankind. A place where people have the licence to dream.

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
- 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



#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)

Events, workshops and hackatons

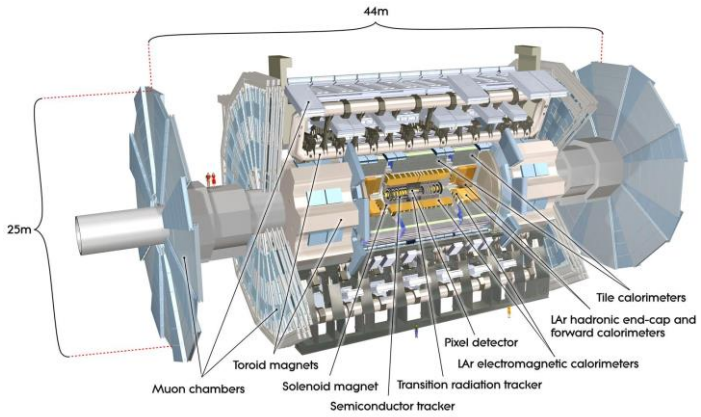
When the building is not in full use, Ideasquare can offer access to its open work areas, rapid prototyping facilities and its meeting rooms for short, deadline driven Challenge Events, such as :

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

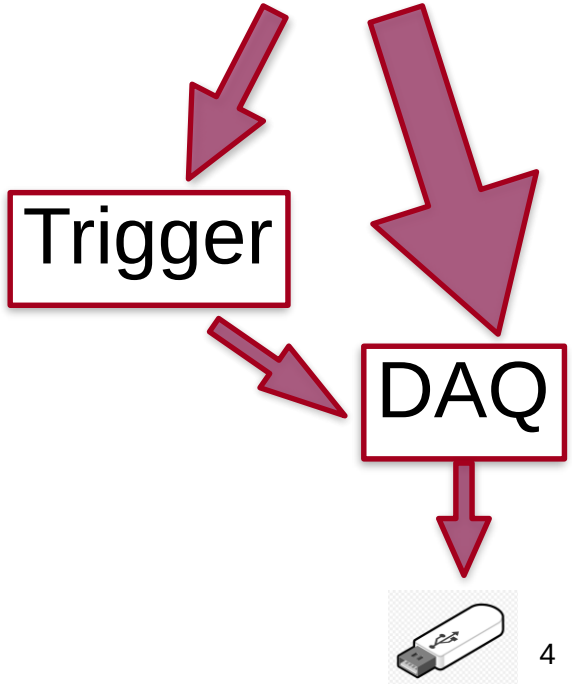
IdeaSquare Open Doors event 2018

ATLAS Trigger & Data Acquisition (TDAQ) System

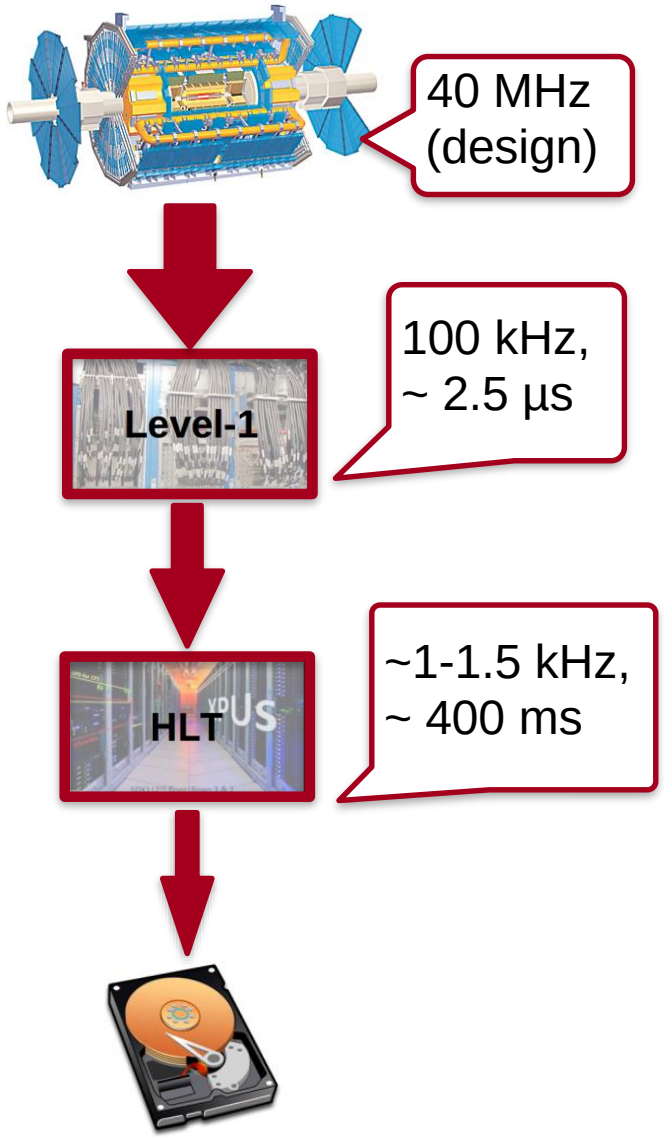
- Recording the interesting physics is a challenge
  - **ATLAS detector is BIG**
    - ~100 million channels
    - Up to 2.2 MB of RAW data per event (dependent on running and recording conditions)
  - **Rate of delivered collisions is high**
    - In 2018 ~30 MHz measurement rate



- **Data Acquisition (DAQ)** is responsible for
  - collecting data from detector systems (detector read-out),
  - digital conversion and
  - recording them to mass storage for offline analysis (data flow)
- **Trigger** is responsible for **real-time (online) selection** of the subset of events to be recorded

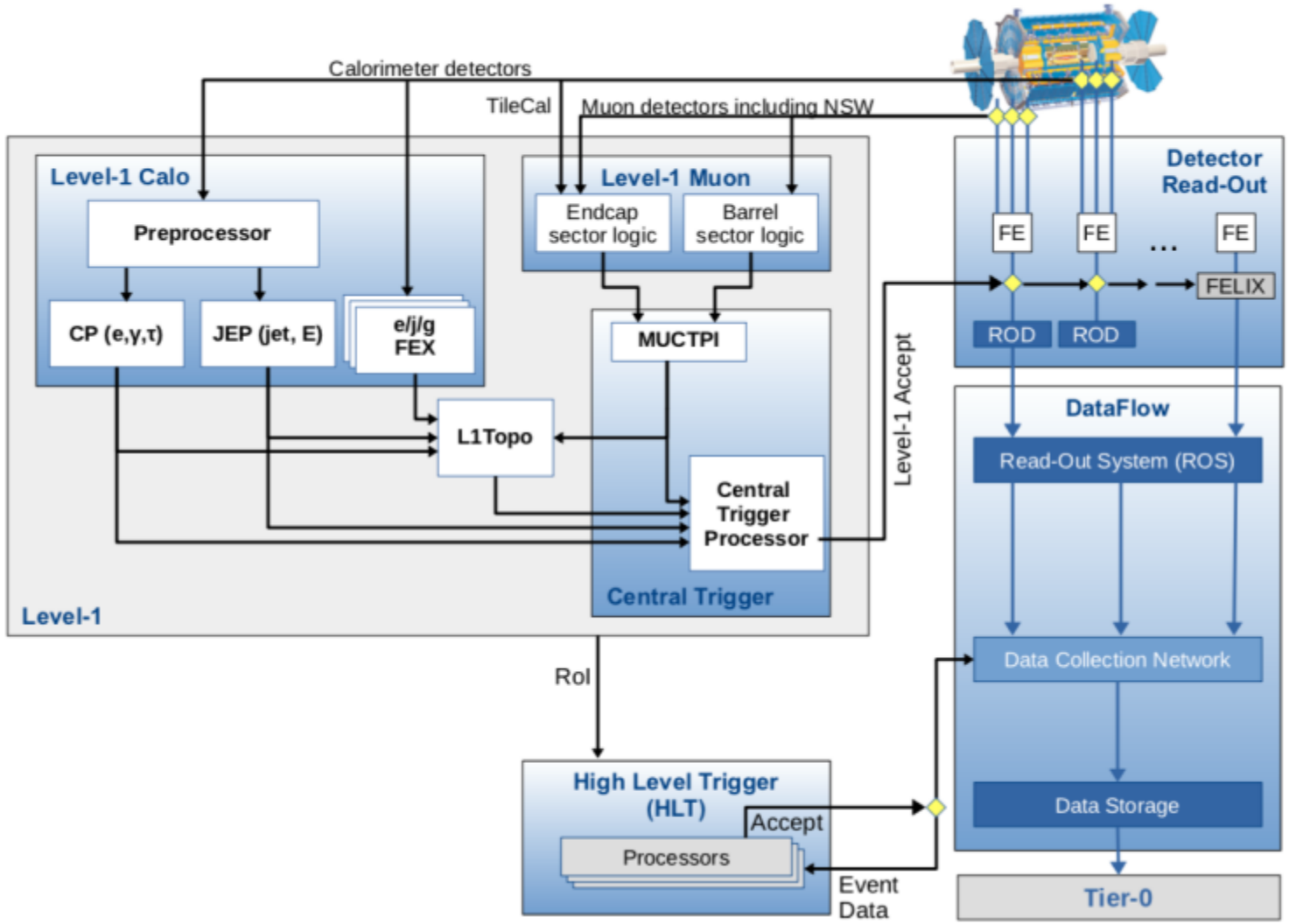


The ATLAS Trigger System

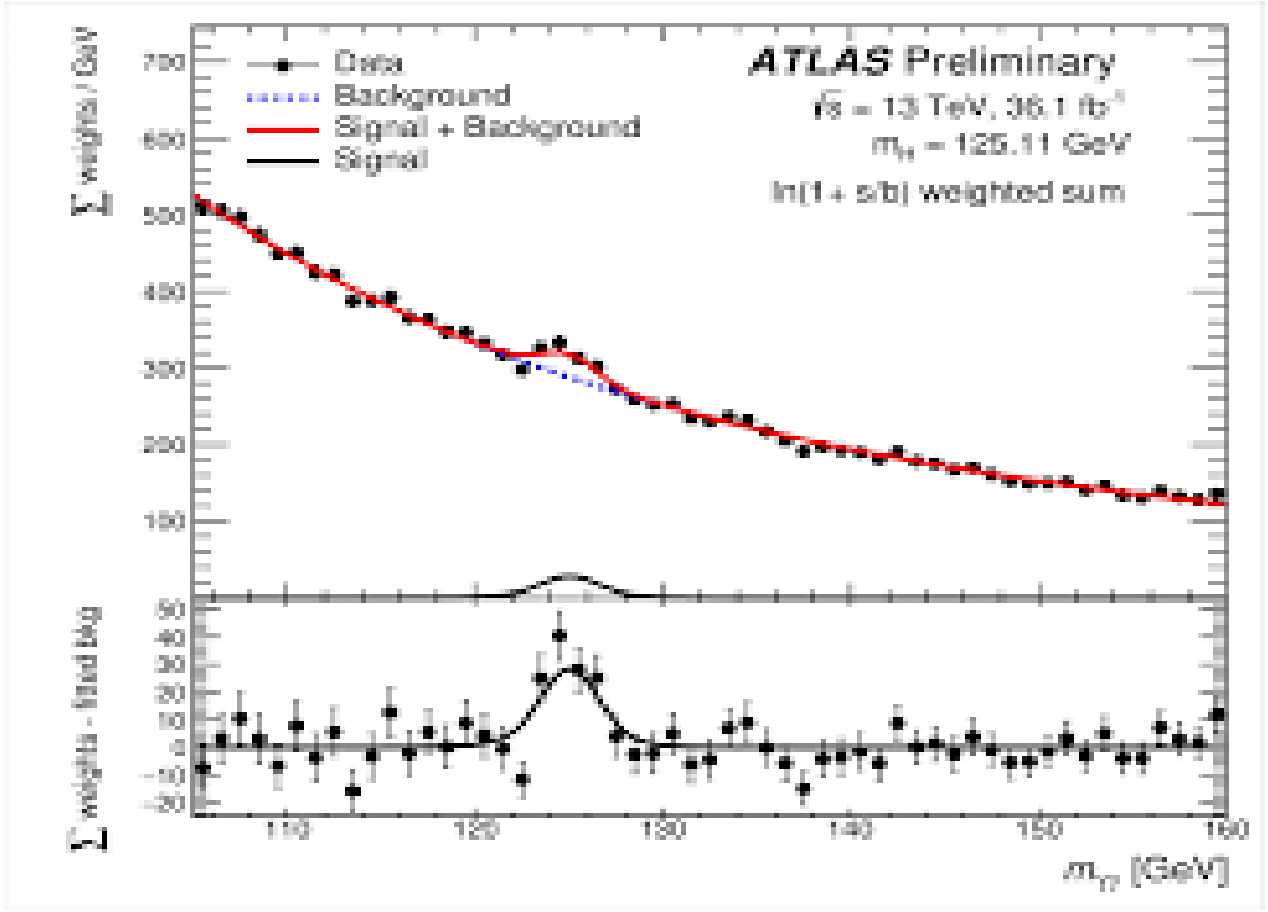


- **Level-1 (L1)**
  - Hardware-based
  - Coarse selection based on limited input from calorimeter & muon systems
  - Rate and latency limit set by detector & trigger hardware
- **High-Level Trigger (HLT):**
  - Software-based
  - Average processing time limited by HLT farm size
    - Commodity hardware; ~40k processing applications
  - Networking based on commercial technologies (Ethernet)

Run-3 ATLAS TDAQ System



Looking for Variations from the Background



Using Arduino as a «proxy» to TDAQ System

Table 1. Summary correspondence between ATLAS/TDAQ and the Arduino systems.

Sequence	**ATLAS Detector system**	**Arduino system**
1 (hardware)	Detector (calibration). I/O determined by the hardware	Initial system calibration
2 (hardware & software)	Trigger	Signal-to-noise (S/N) definition
3 (software, computing)	Data Acquisition (DAQ). Data format (packaging, transfer)	Software & structure
4 (computing)	Data storage	Data distribution, copying
5 (computing)	Analysis (off-line)	Data reconstruction
6 (computing)	Results (physics plots)	Result (alarm/no alarm, LED lights)