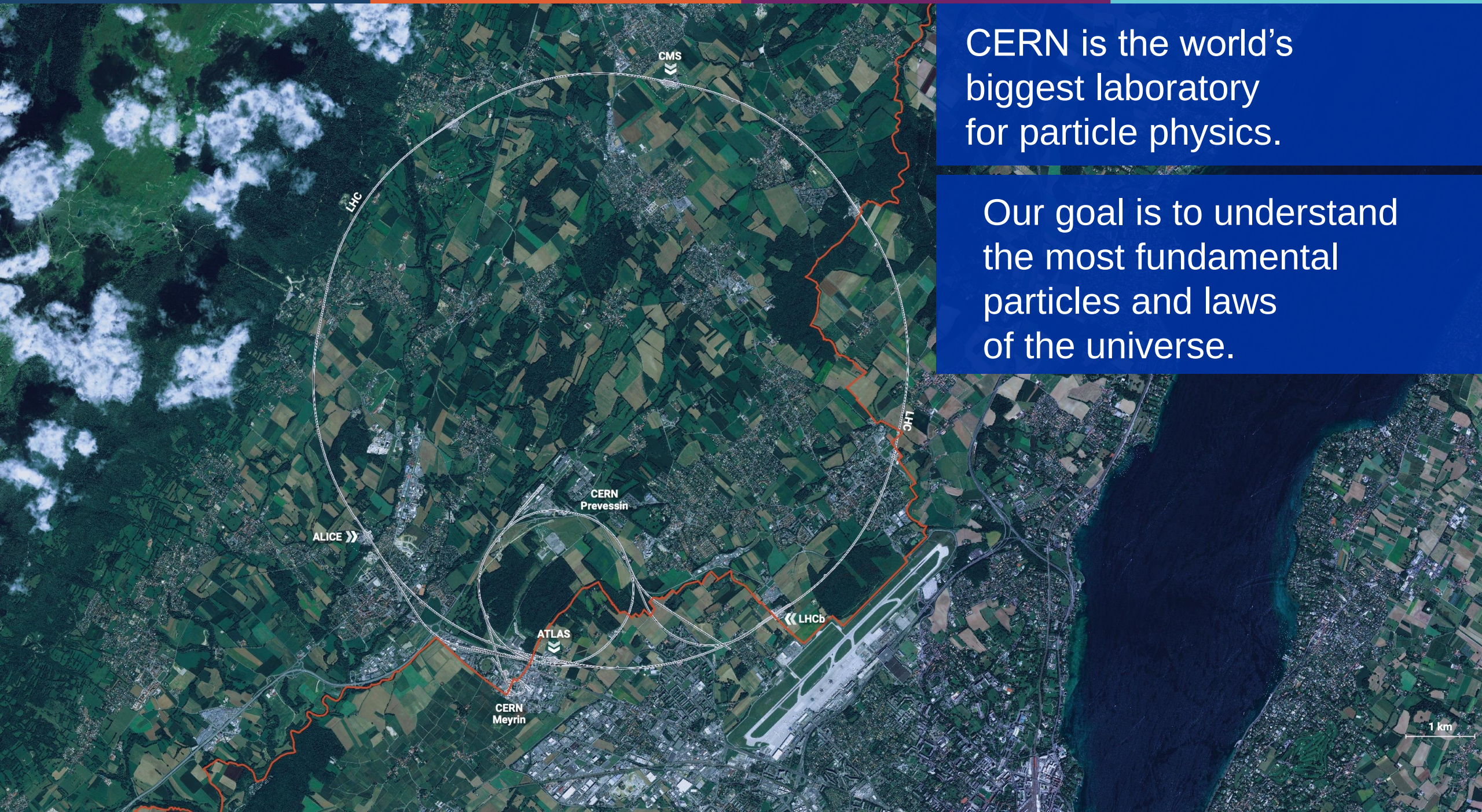
Brazilian National Confederation of Industry
3 December 2021

Entrepreneurial Mobilisation for Innovation (MEI)

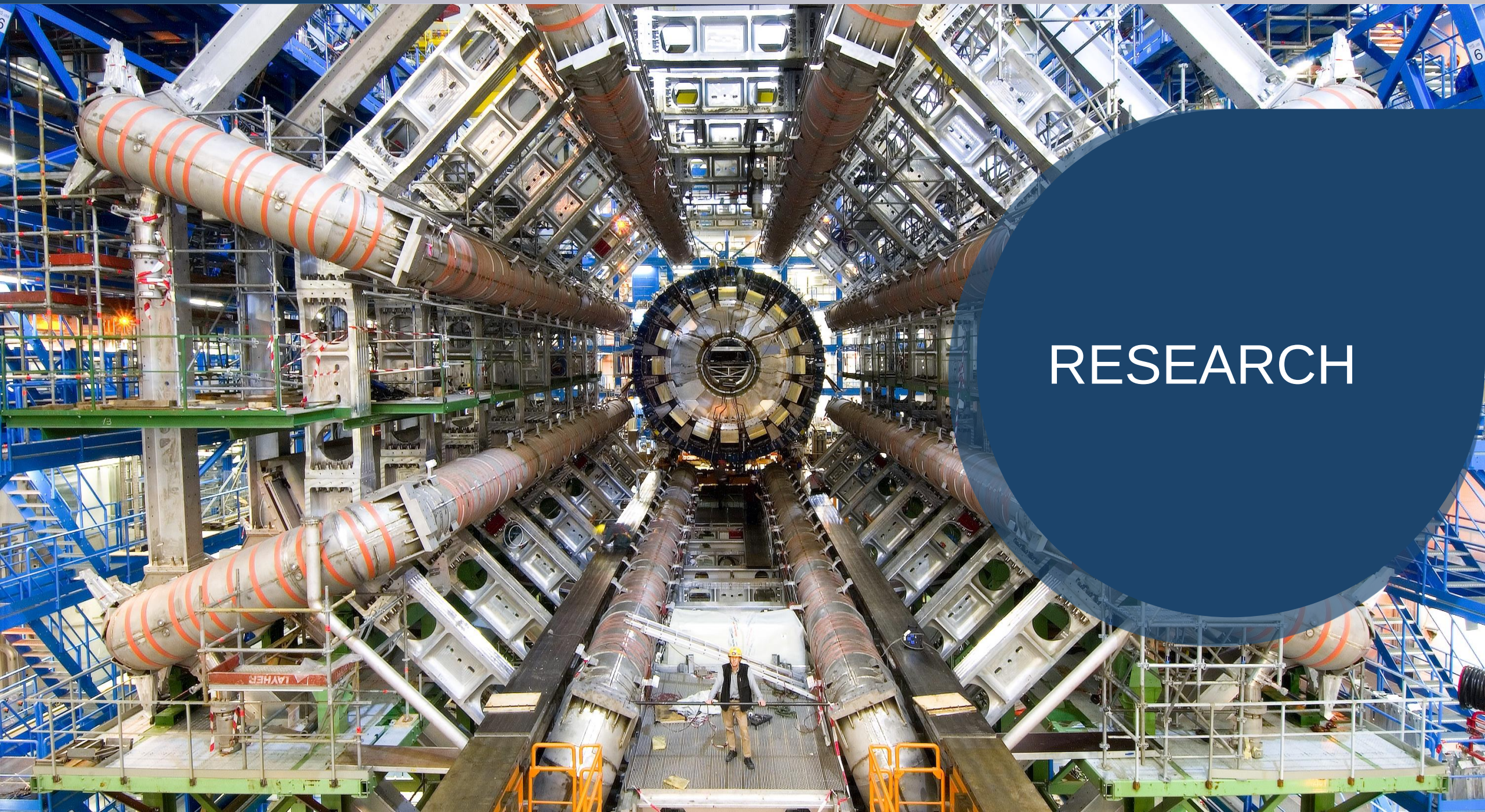
Raphaël BELLO, CERN Director for Finance and Human Resources



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

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

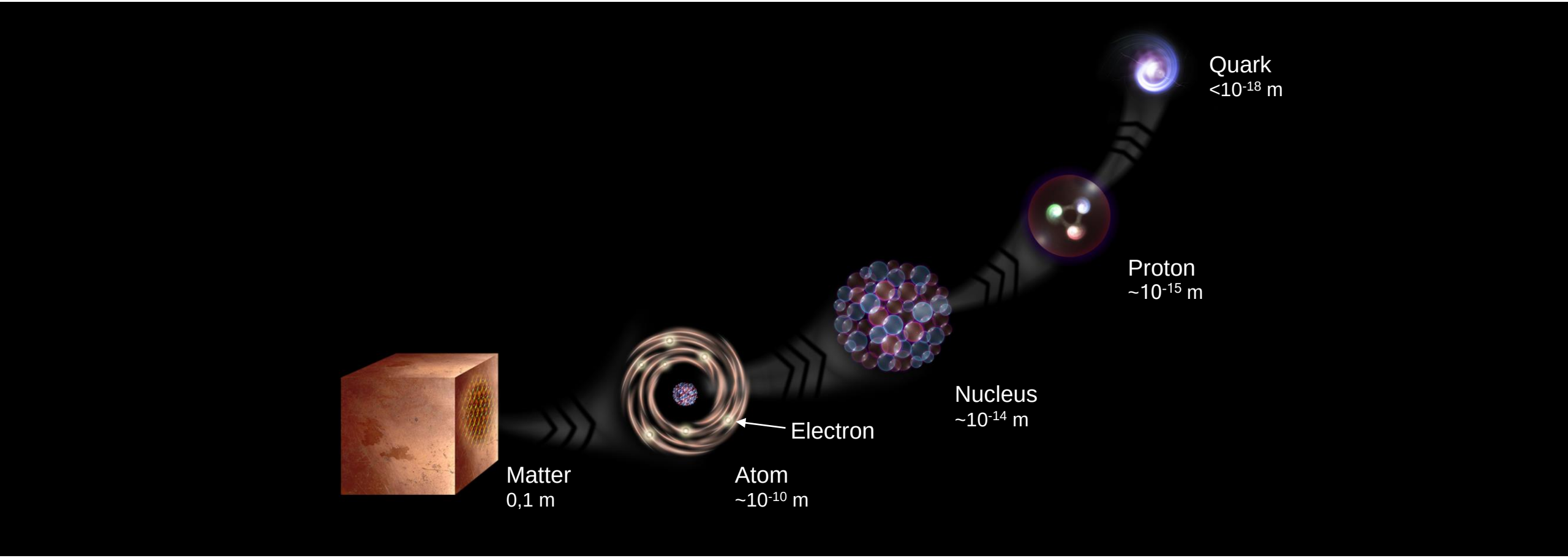
Four pillars underpin CERN's mission



RESEARCH

What is the universe made of?

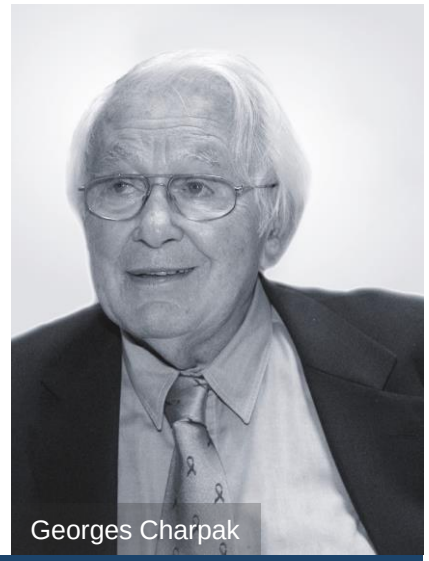
We study the elementary building blocks of matter and the forces that control their behaviour



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.

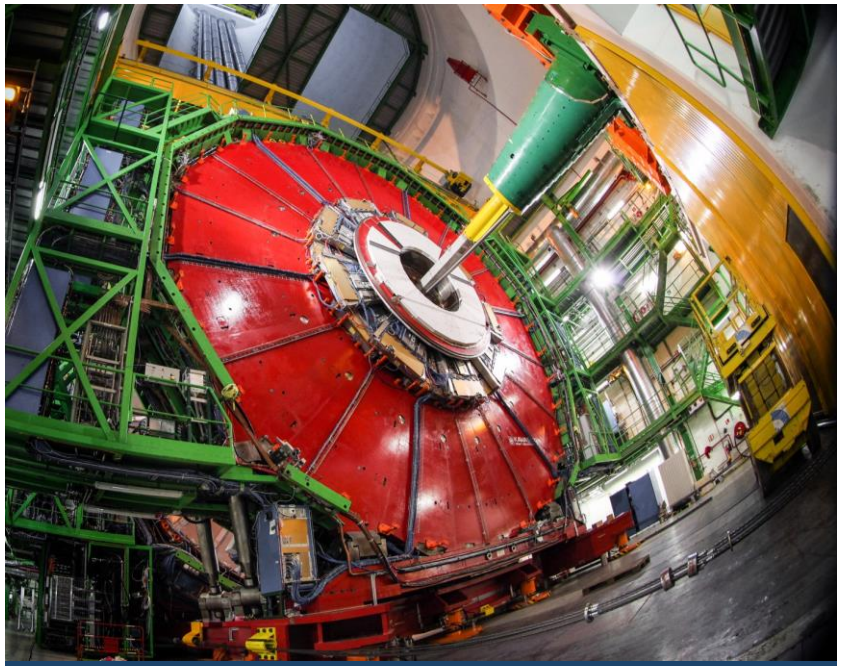
The Higgs boson was discovered in 2012; without it fundamental particles would be massless and atoms could not form.


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

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

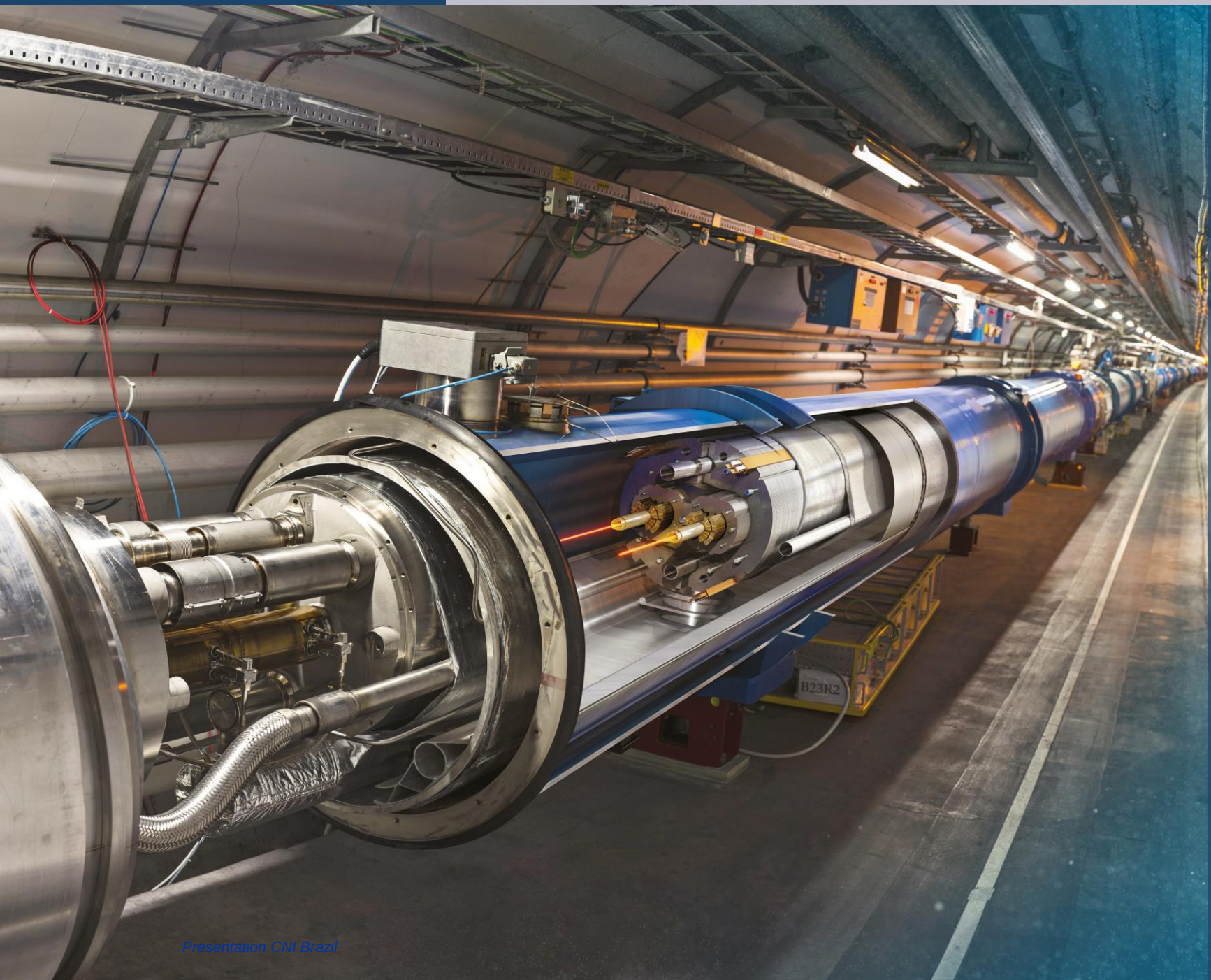
- We build the largest machines to study the smallest particles in the universe
- We develop technology to advance the limits of what is possible
- We perform world-class research in theoretical and experimental particle physics

ACCELERATORS



DETECTORS

COMPUTING

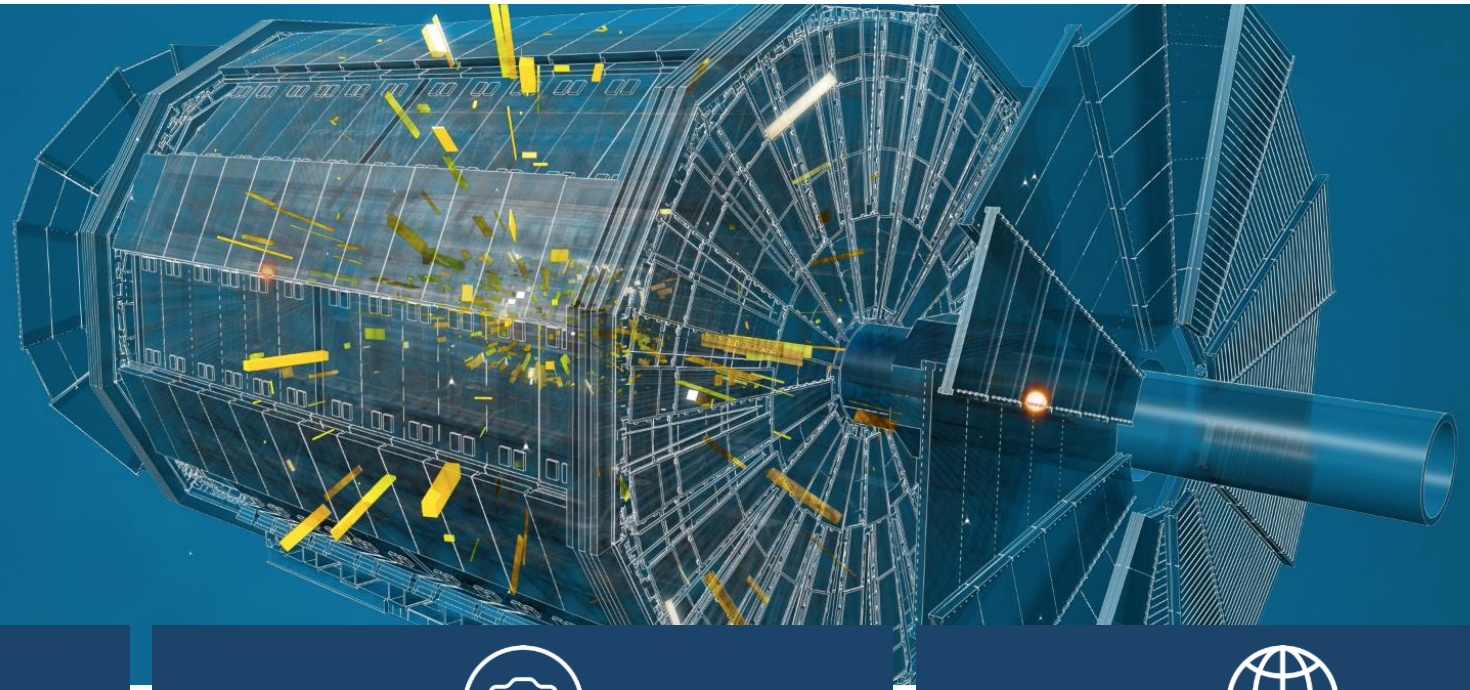


Large Hadron Collider (LHC)

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

Four detectors observe the collisions:

3D cameras with 100’000+ sensors the size of a 5-story building

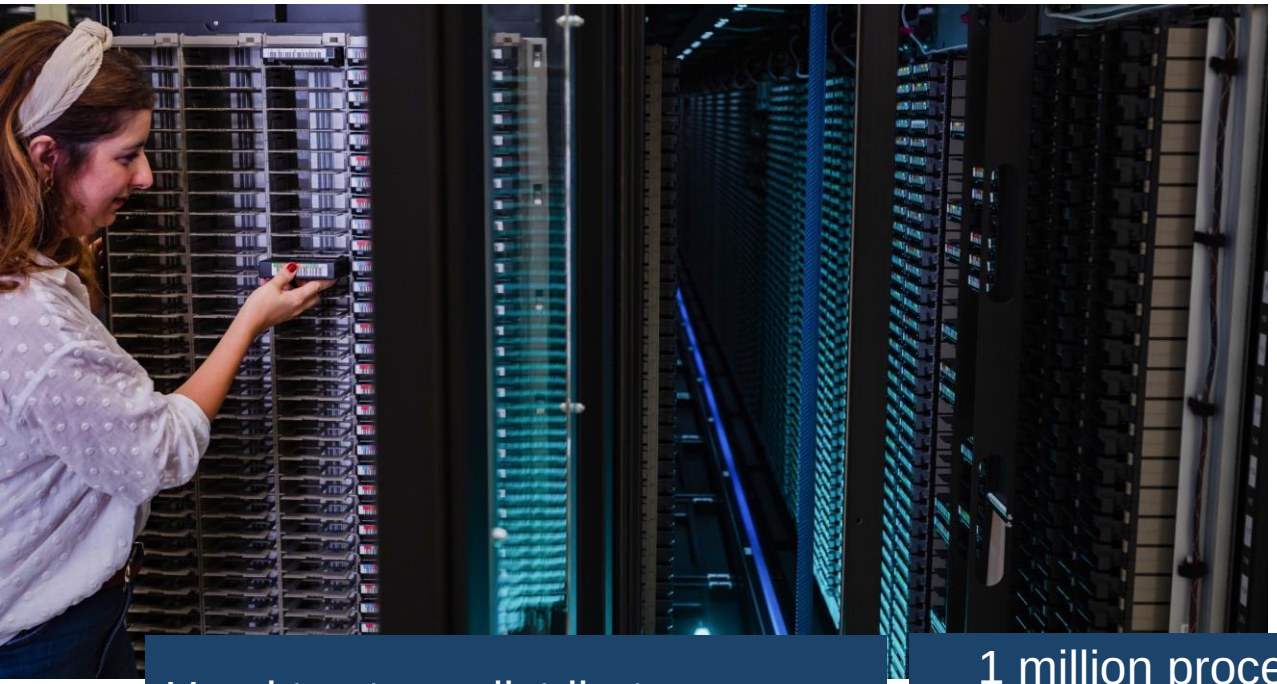


The detectors measure the energy, direction and charge of new particles formed.

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.

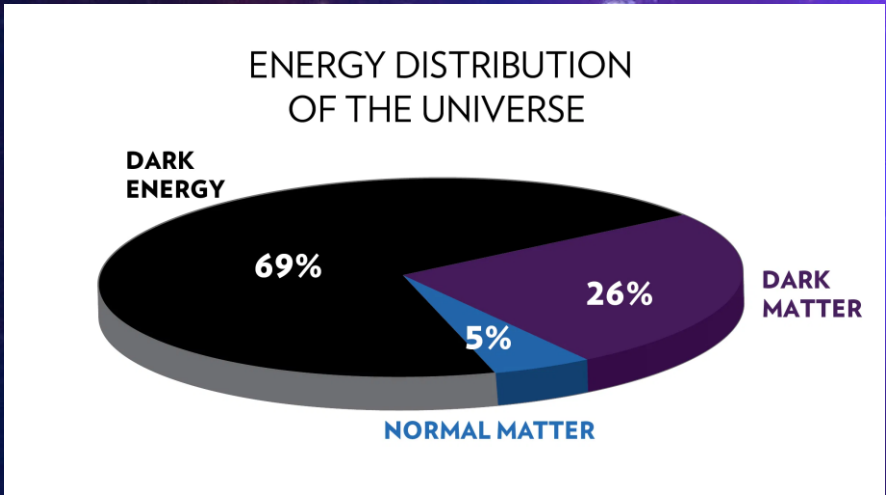
1 million processing cores in about 170 data centres and 42 countries.

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

New opportunity from transatlantic BELLA data cable between Europe and Brazil.

There are many unanswered questions in fundamental physics

Including

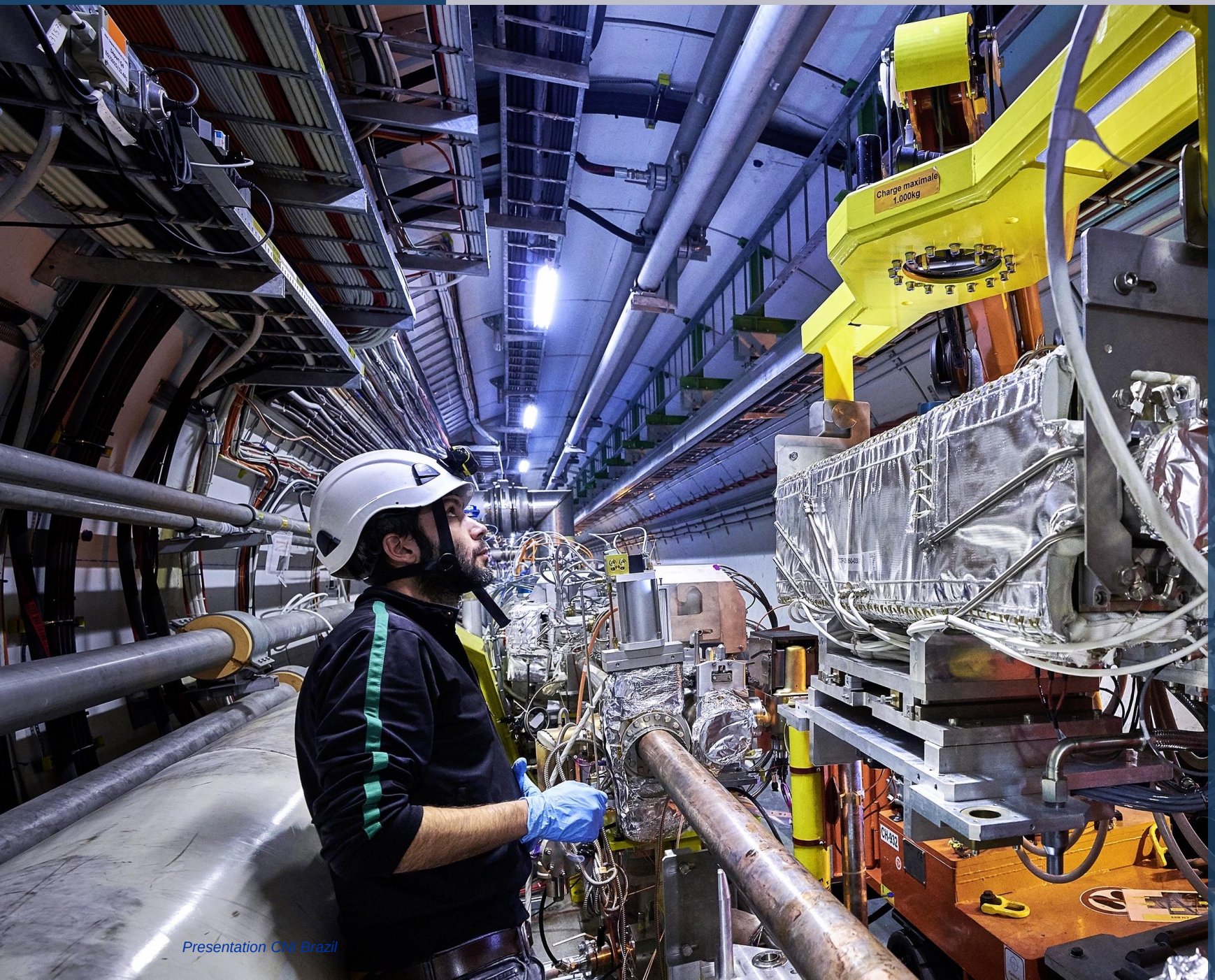


95% of the mass and energy of the universe is unknown.

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 give access to rare phenomena, greater precision and discovery potential.

It will start operating in 2027 until 2040.

Nb3Sn magnets have been designed and built for the upgrade of the LHC.

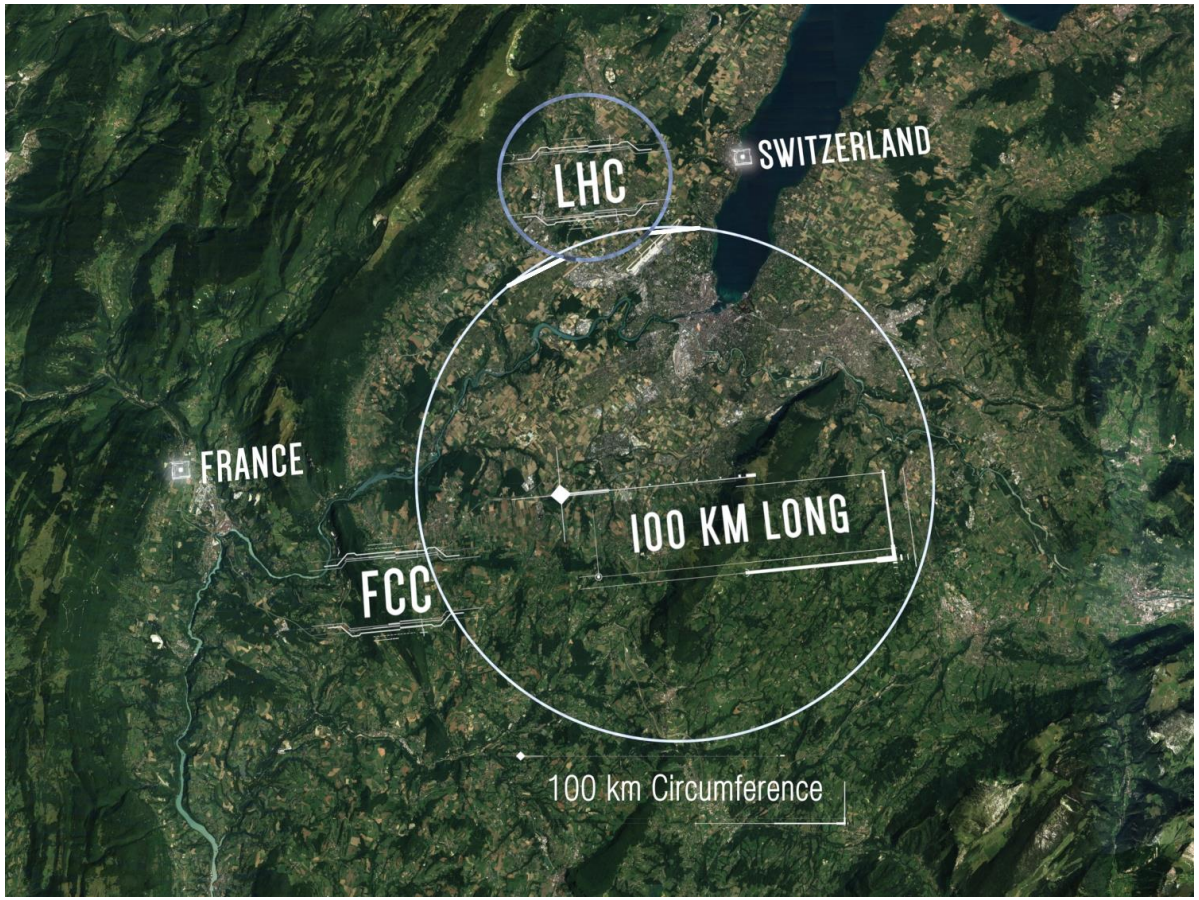
Detectors' upgrades: Radiation-hard silicon detectors, precision timing detectors, fast and radiation-hard electronics, ASIC, machine learning software

Scientific priorities for the future

European particle physics community has recommended to assess the long-term technical/financial feasibility of a Future Circular Collider: FCC

FCC: Future Circular Collider: ~100 km ring

- Technologically very ambitious → innovation driver with global partners
- Cost: ~11 BCHF for first stage
  (LHC: ~5 BCHF - tunnel was already there)
- Tentative timescale: project approval **~2028**, first-stage operation **2045-2060**, second-stage operation **2070-2090++**
- Strong support from the US, historical partnership of reciprocal contributions
- Competition with China, which is considering a similar project
- Cost-drivers: Civil engineering, Warm magnets (1st stage), High-field Niobium superconducting magnets (2nd stage)



COLLABORATION

Science for peace

CERN was founded in 1954 with 12 European Member States

23 Member States
(+3 since 2010)
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
(since 2010)
Cyprus – Estonia – Slovenia

7 Associate Member States
(since 2010)
Croatia – India – Latvia – Lithuania – Pakistan
Turkey – Ukraine

6 Observers
Japan – Russia – USA
European Union – JINR – UNESCO

CERN's annual budget
is 1200 MCHF (7200 MBRL)
(equivalent to a medium-sized
European university)

As of 31 December 2020
Employees:
2635 staff
- 45% Engineers, applied scientists
- 32% Technicians

756 fellows
- Early-career professionals

Associates:
11 399 users, **1687** others

More than 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 – 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
Shared research infrastructure, extending national ones

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

- 10 Brazilian institutes participate to the scientific programme
- 108 Brazilian researchers regularly visiting CERN before 2020

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

Yearly Budget (contributions 2021) in CHF
Brazil's future contribution ~12 MCHF = ~72 MBRL

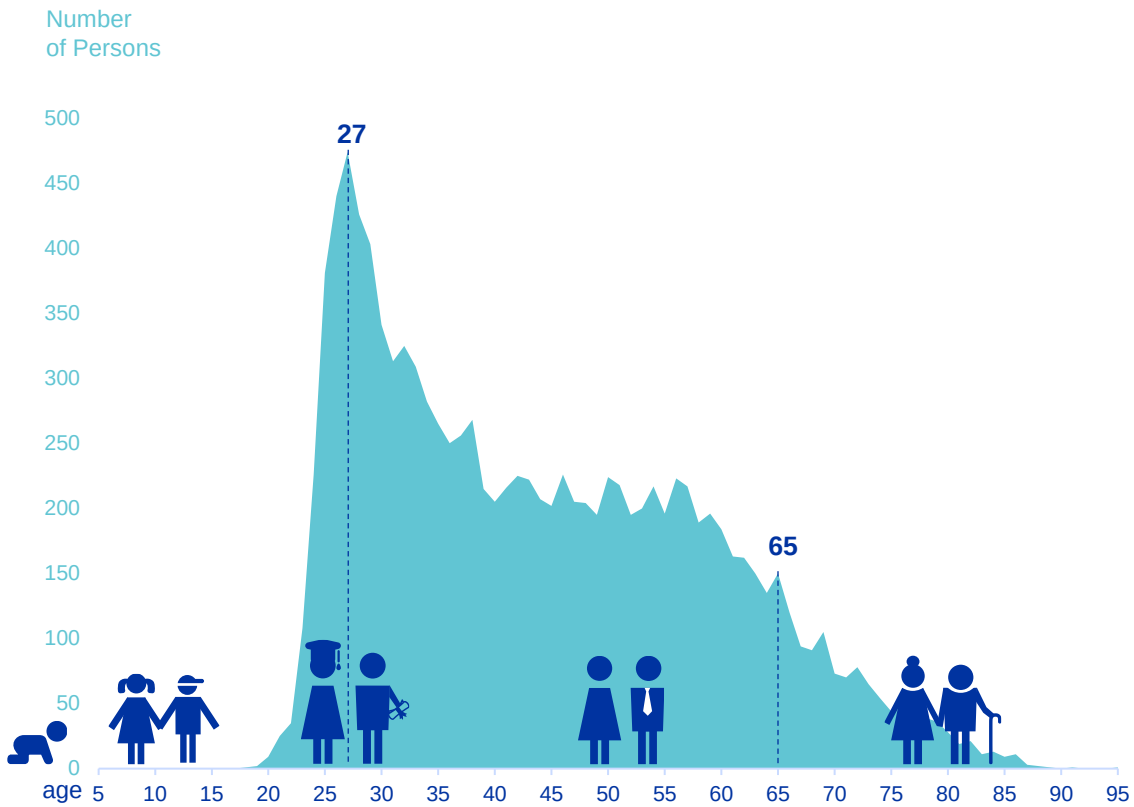
Country	In CHF, 2021 prices	%
Germany	243,978,500	20.4%
United Kingdom	173,742,400	14.5%
France	162,651,400	13.6%
Italy	122,471,350	10.2%
Spain	86,327,950	7.2%
Netherlands	54,493,050	4.5%
Switzerland	45,973,250	3.8%
Poland	33,135,900	2.8%
Belgium	32,398,200	2.7%
Sweden	30,272,750	2.5%
Norway	26,893,400	2.2%
Austria	25,773,200	2.1%
Israel	22,390,950	1.9%
Denmark	21,020,250	1.8%
India*	16,211,900	1.4%
Finland	15,669,300	1.3%
Romania	13,586,400	1.1%

Country	In CHF, 2021 prices	%
Portugal	12,942,750	1.1%
Czech Republic	12,274,400	1.0%
Greece	12,232,750	1.0%
Hungary	8,029,550	0.7%
Slovakia	6,010,500	0.5%
Turkey*	5,349,000	0.4%
Bulgaria	3,788,250	0.3%
Serbia	2,865,800	0.2%
Pakistan*	1,898,100	0.2%
Slovenia*	1,410,200	0.1%
Estonia*	1,020,000	0.1%
Cyprus*	1,000,000	0.1%
Croatia*	1,000,000	0.1%
Lithuania*	1,000,000	0.1%
Ukraine*	1,000,000	0.1%
TOTAL	**1,198,811,450**	**100.0%**

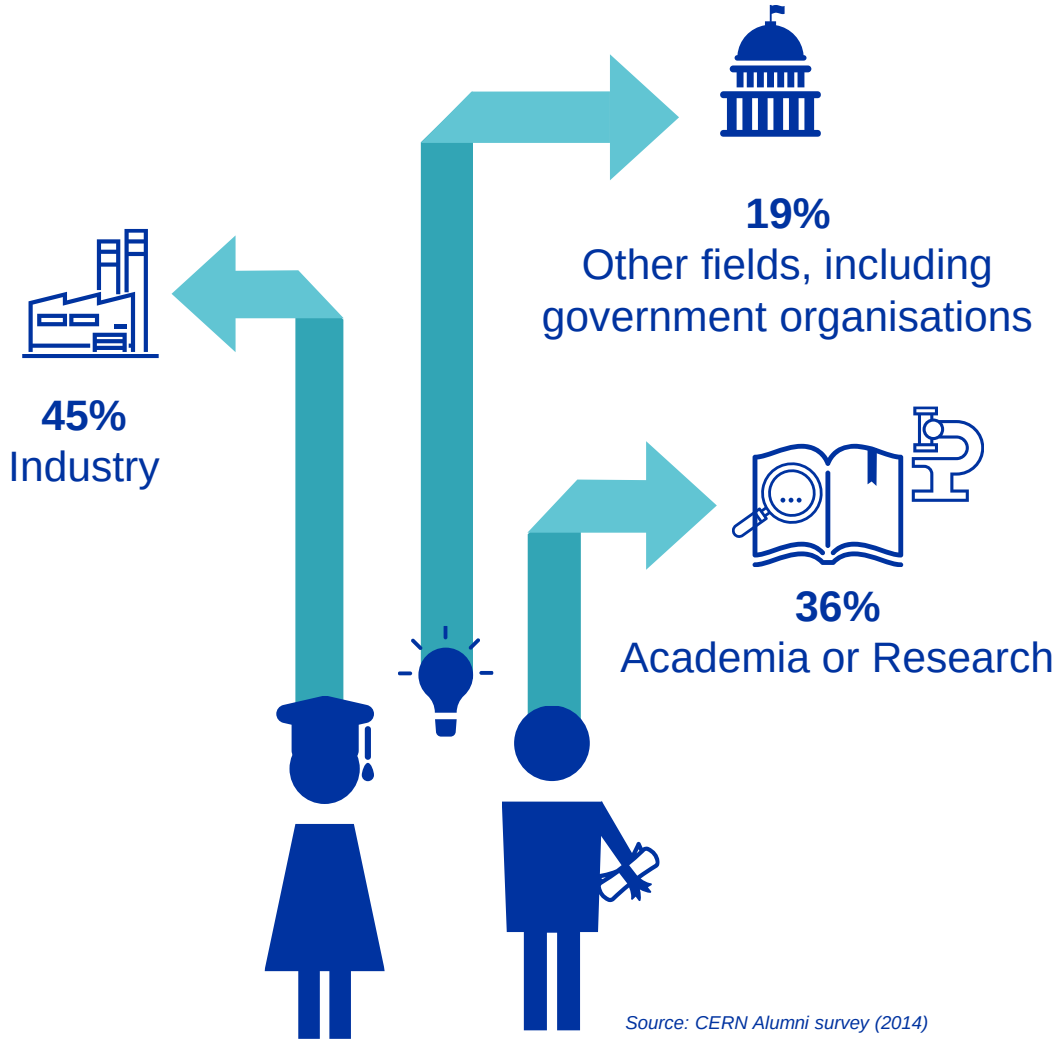
(*) Associate Member states pay 10% of their 'theoretical' contribution as full Member States with a minimum of 1MCHF. Industrial and personnel returns are capped to their contribution

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.

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.

I'm from an engineering background so it's amazing to see the real knowledge and technologies being applied here. I feel more motivated and looking forward to bringing this knowledge back to Brazil.

Henrique, Brazil

Undergraduate participants to CERN 8-weeks summer internship

TECHNOLOGY & INNOVATION

CERN and CNPEM/SIRIUS cooperation in accelerator technology

1-year cooperation agreement signed in December 2020, just renewed through 2022

Joint design of components to upgrade SIRIUS performance

Superconductive technology, Niobium components, to be prototyped in Campinas

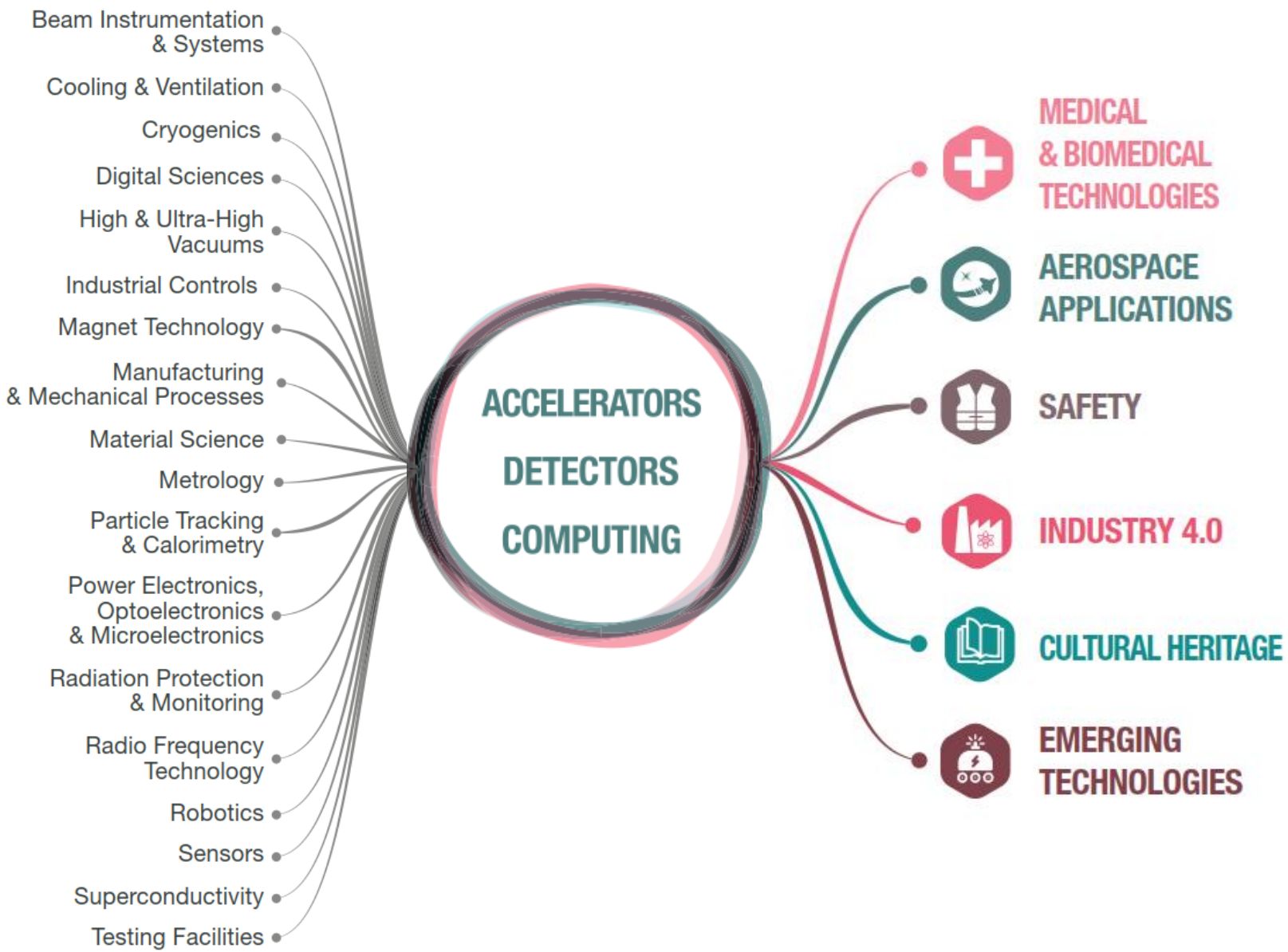
Training of Brazilian physicists and engineers in Campinas

CERN’s technological innovations have applications in many fields

CERN is the birthplace of the World Wide Web

And there are many more examples

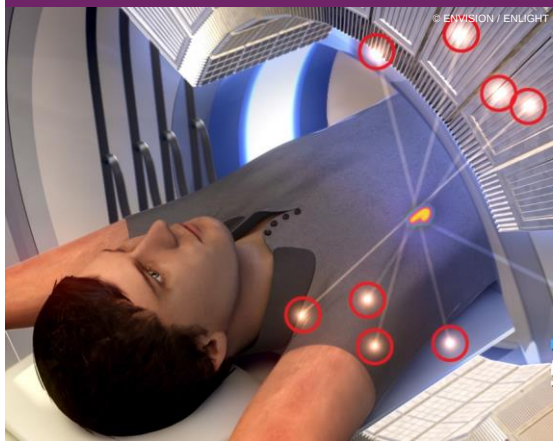
Medical imaging, cancer therapy, material science, cultural heritage, aerospace, automotive, environment, health & safety, industrial processes.

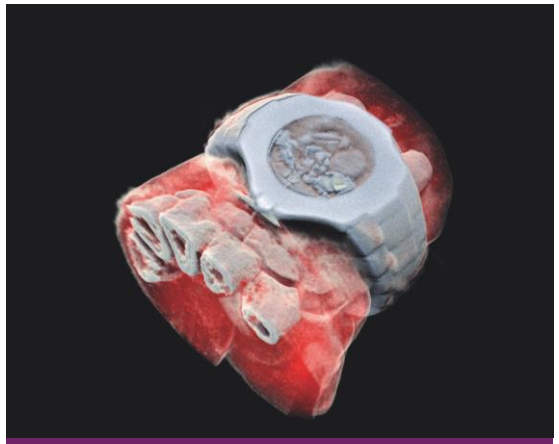

Beam Instrumentation & Systems
Cooling & Ventilation
Cryogenics
Digital Sciences
High & Ultra-High Vacuums
Industrial Controls
Magnet Technology
Manufacturing & Mechanical Processes
Material Science
Metrology
Particle Tracking & Calorimetry
Power Electronics, Optoelectronics & Microelectronics
Radiation Protection & Monitoring
Radio Frequency Technology
Robotics
Sensors
Superconductivity
Testing Facilities
ACCELERATORS
DETECTORS
COMPUTING
MEDICAL & BIOMEDICAL TECHNOLOGIES
AEROSPACE APPLICATIONS
SAFETY
INDUSTRY 4.0
CULTURAL HERITAGE
EMERGING TECHNOLOGIES

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.

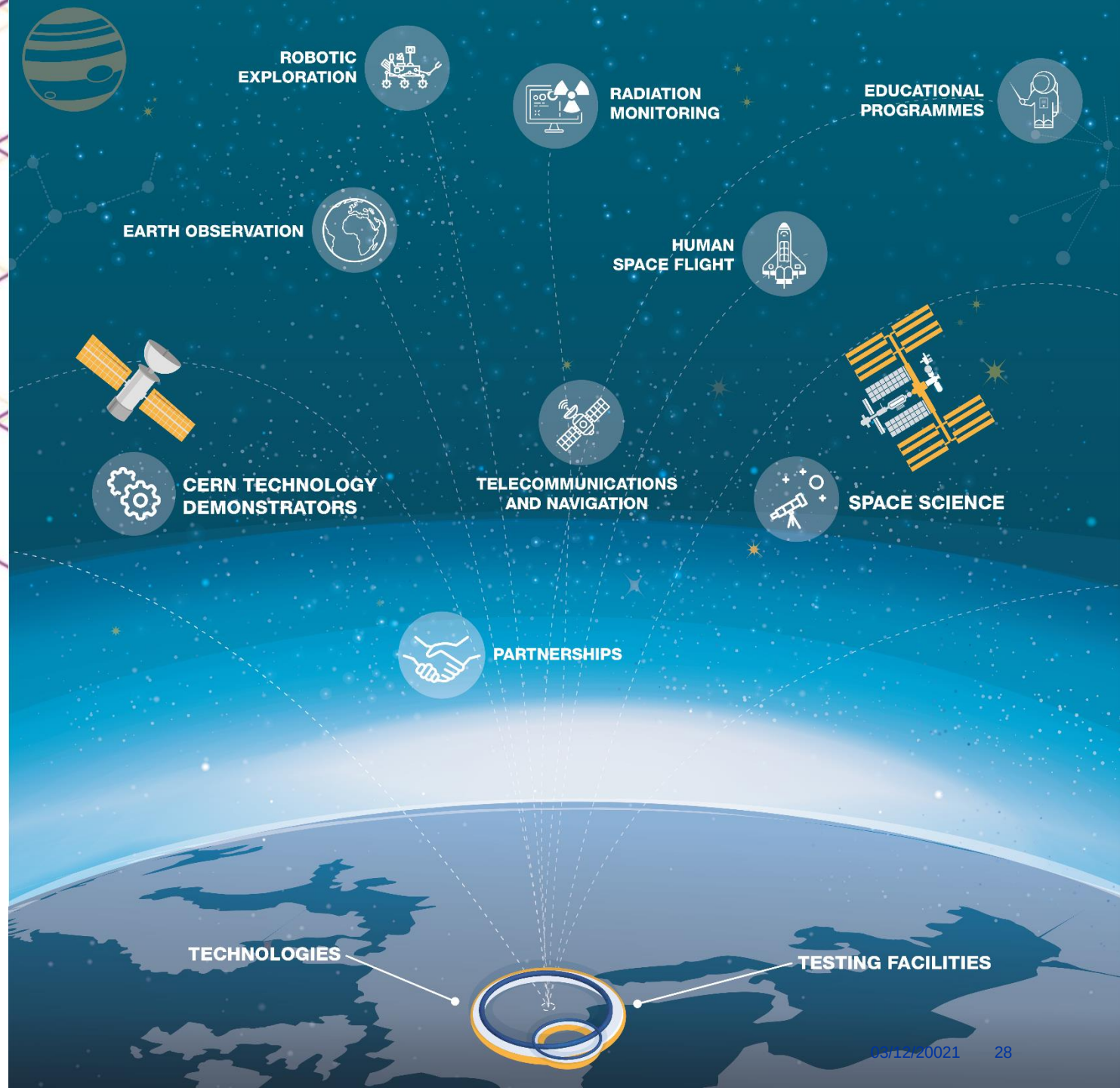
Knowledge Transfer Channels

Dedicated actions to **foster the transfer of technologies and know-how** to other fields than particle physics
(very often with the involvement of industry)

Technology-intensive **procurement contracts**

People
(very hard to quantify but extremely impactful for particle physics)

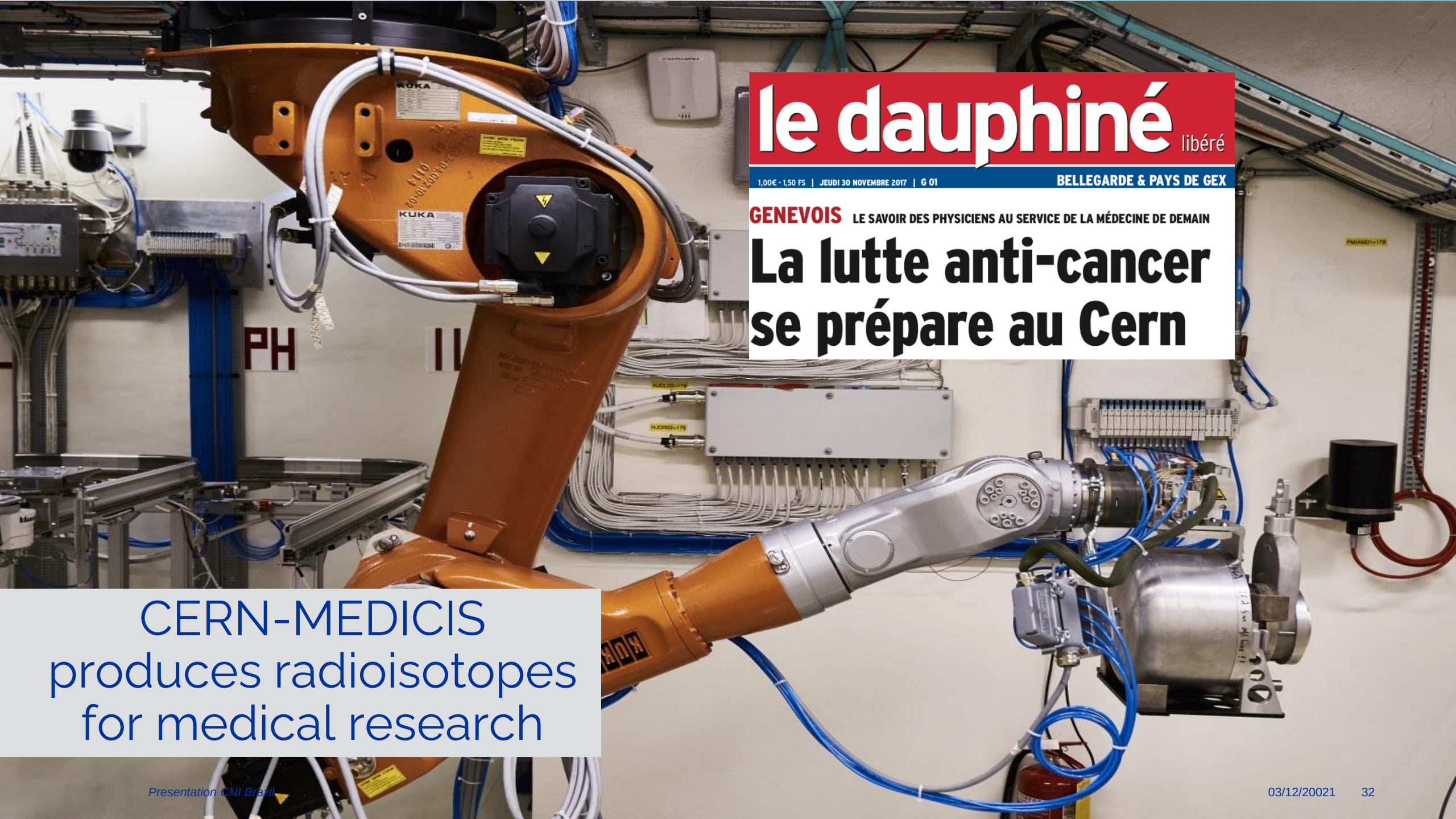
Aerospace Applications



CERN tech used for monitoring radiation levels in space missions (courtesy of NASA ISS)

CERN's Controls middleware software for worldwide factory automation at LG.

Machine learning to improve vaccine production at Sanofi.



CERN-MEDICIS produces radioisotopes for medical research

MedAustron started cancer treatments in December 2016 and is using CERN technology for its proton acceleration

Designing smaller accelerators for production of medical radioisotopes and/or cancer therapy

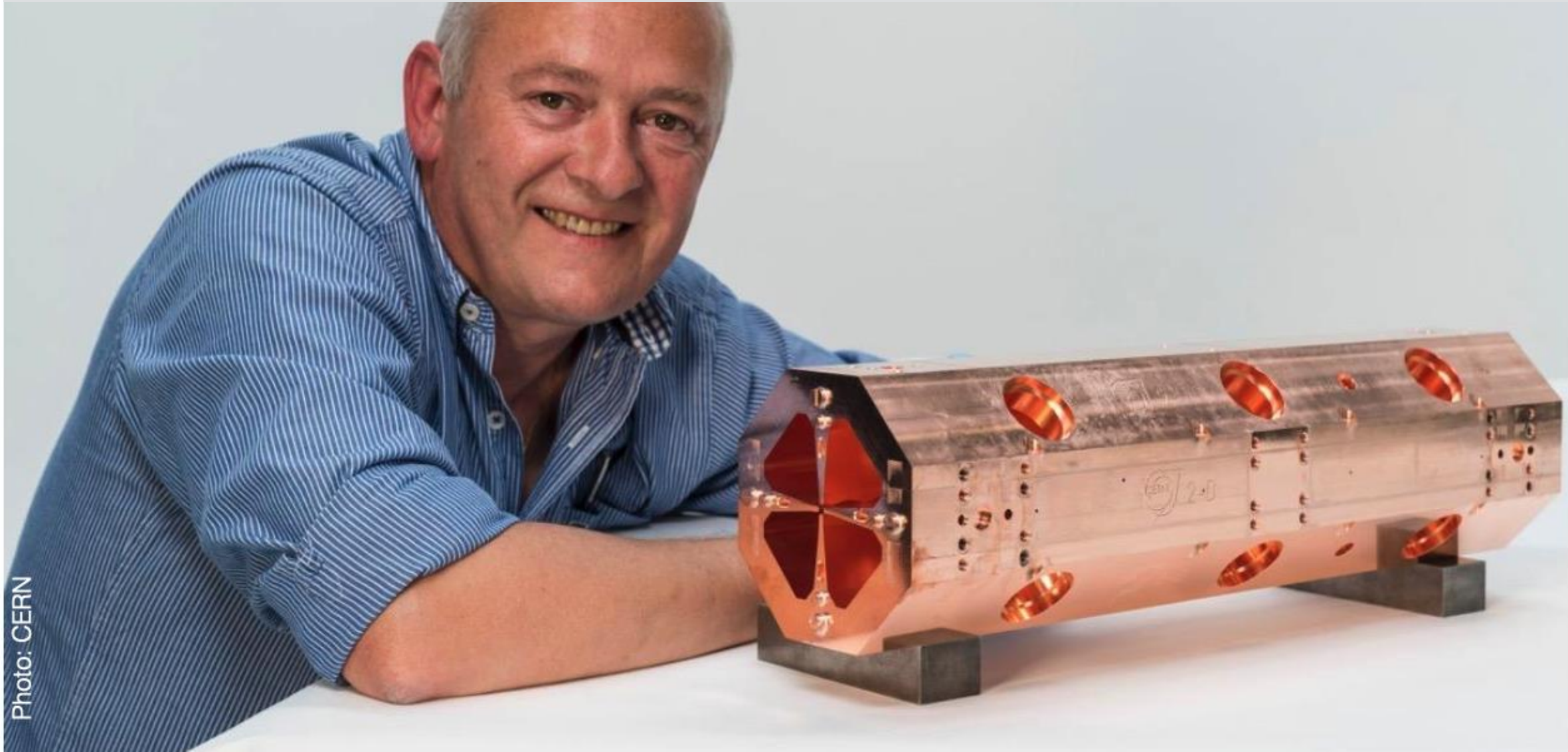
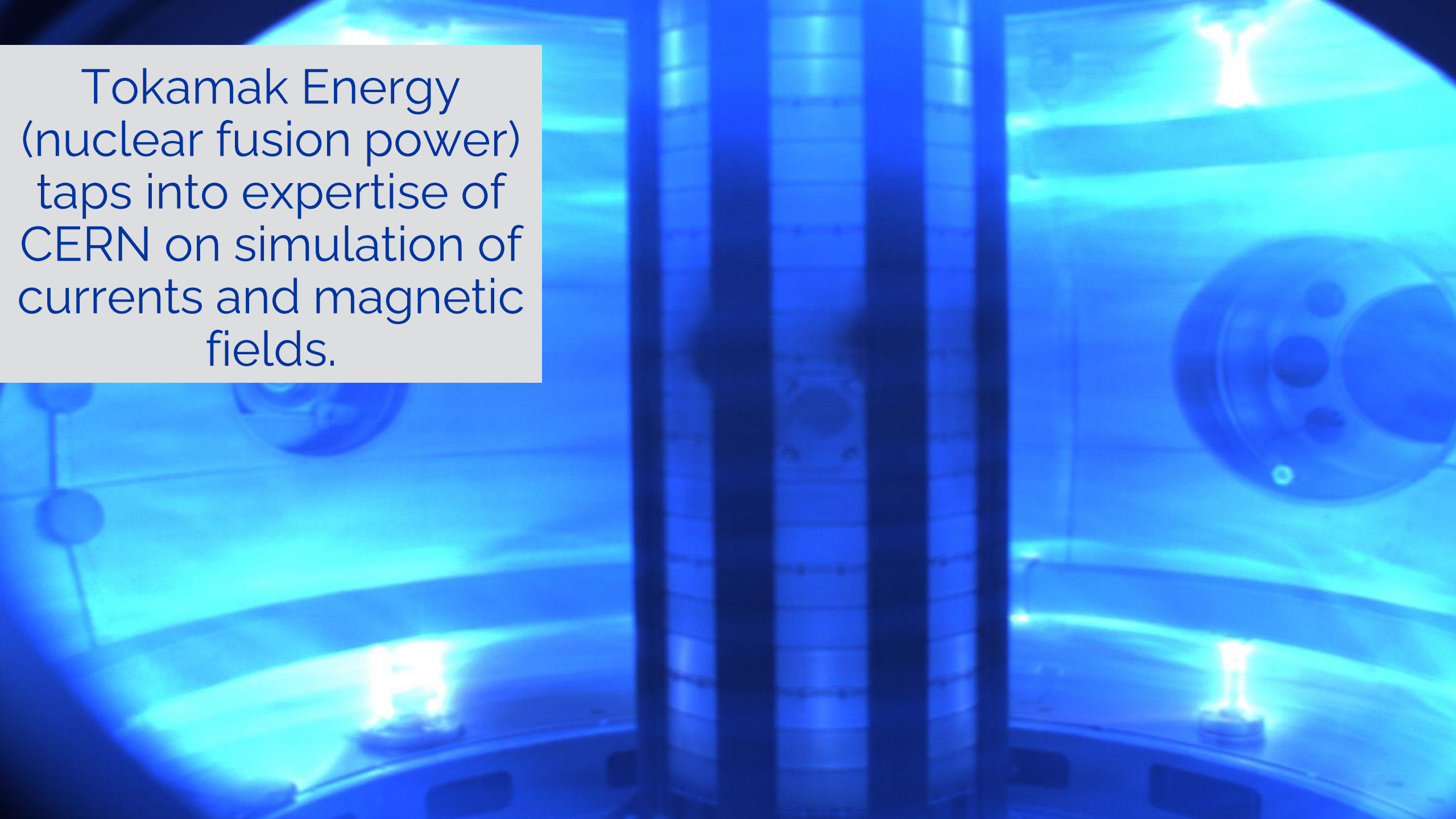


Photo: CERN

Bundesdruckerei (Berlin) works with CERN on next generation ideas for identity management and cryptography



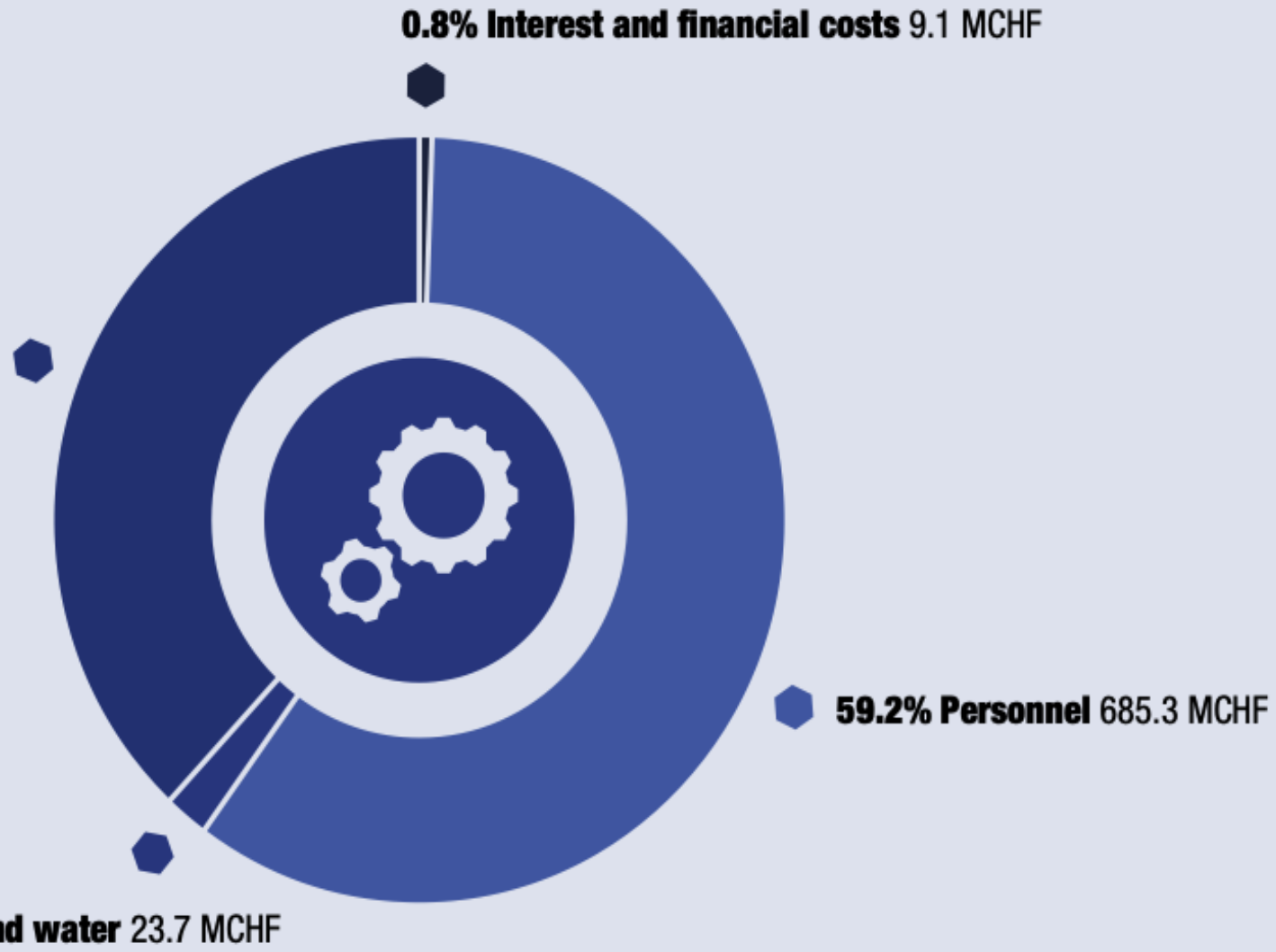
Tokamak Energy (nuclear fusion power) taps into expertise of CERN on simulation of currents and magnetic fields.

Zenuity (Volvo Cars / Veoneer) teams up with CERN on fast machine learning.

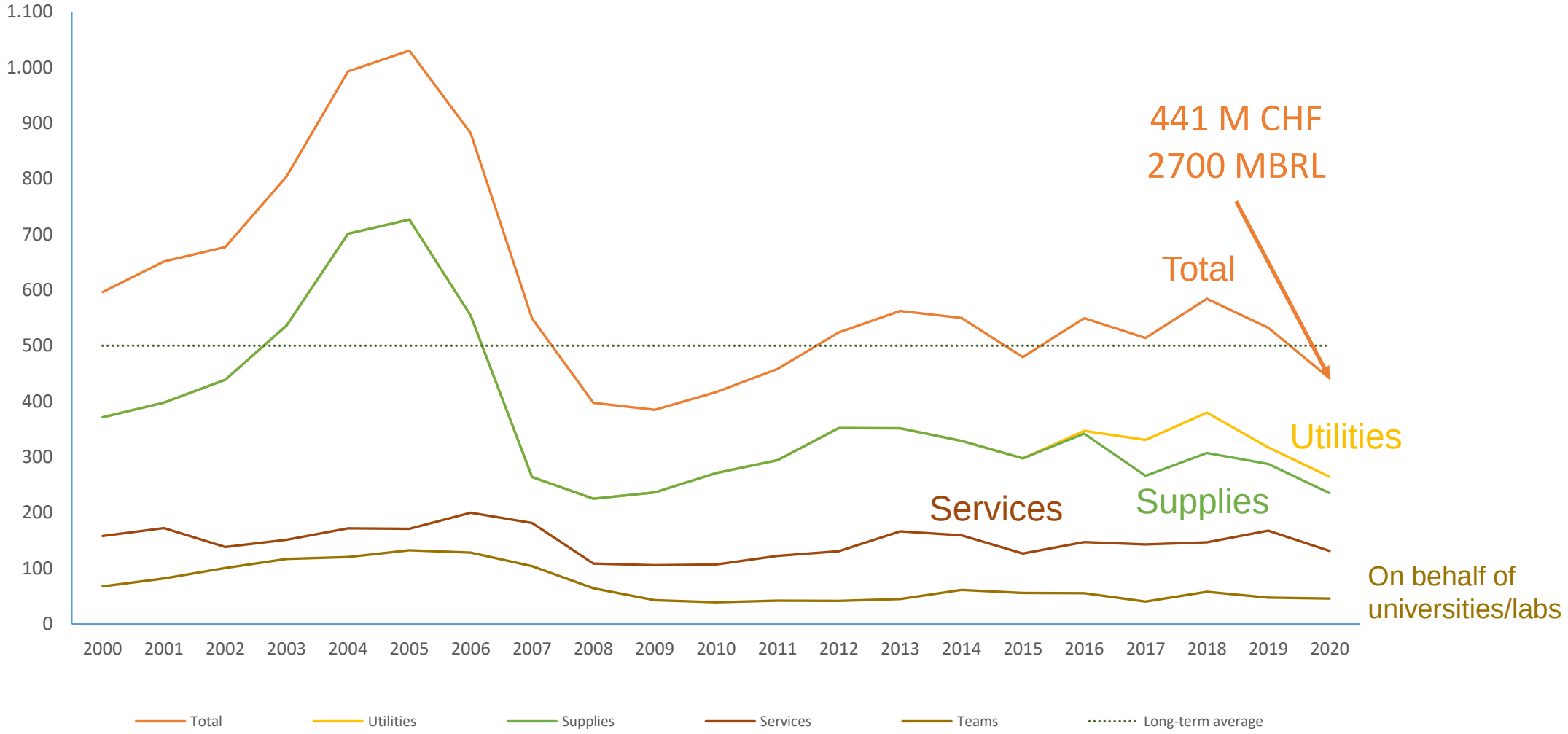
Procurement and knowledge transfer opportunities

CERN EXPENSES

Total expenses: 1157.4 MCHF



Procurement Expenditure (MCHF)



What do we buy ?

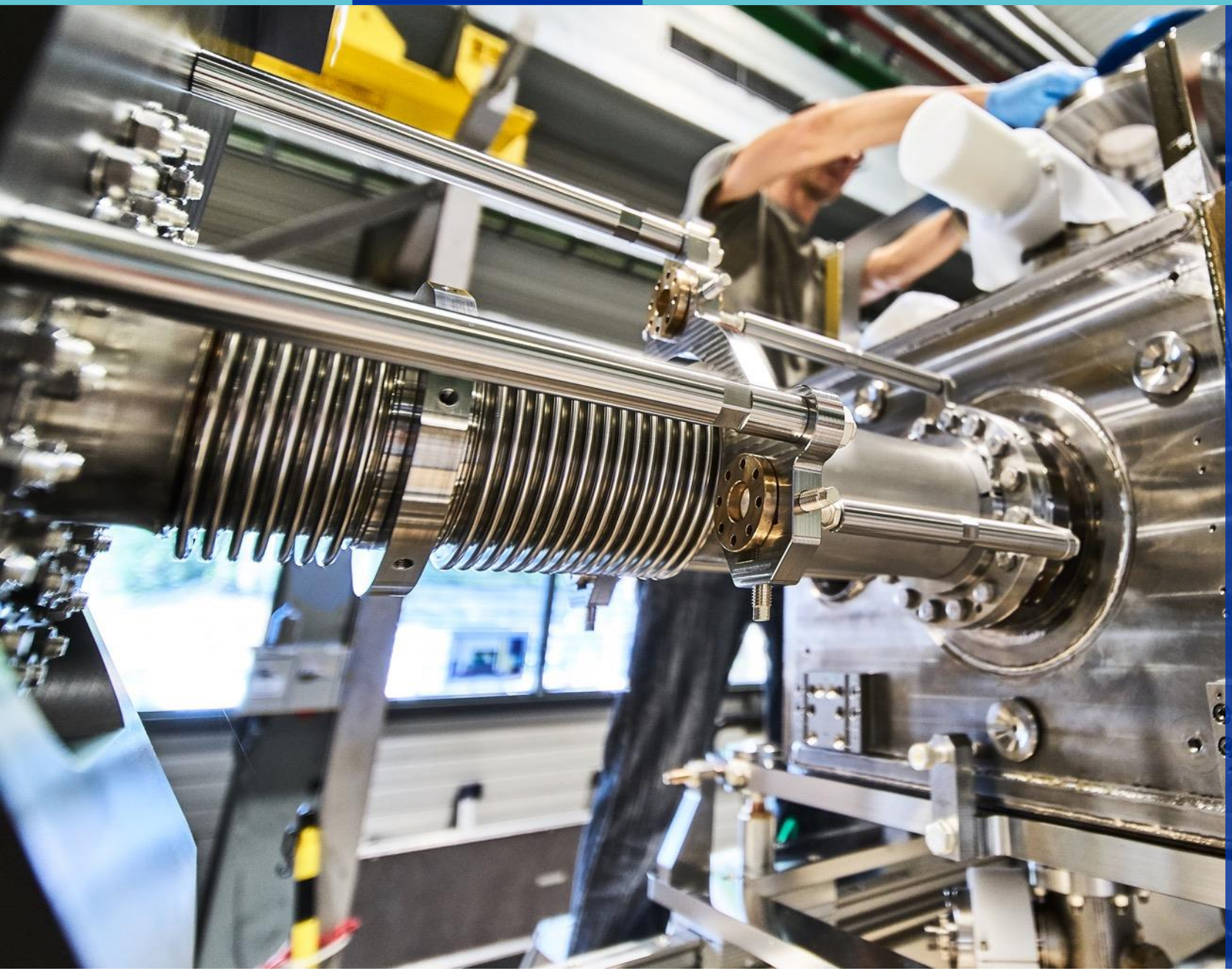
- Civil engineering:
  - Construction
  - Renovation of buildings
  - Metallic structures
  - Earthworks
  - Roads
- Cooling and ventilation equipment

What do we buy ?

- Electrical engineering and magnets
  - Transformers
  - Switchboards and switchgear
  - Cables
  - Automation
  - Power supplies
  - Magnets

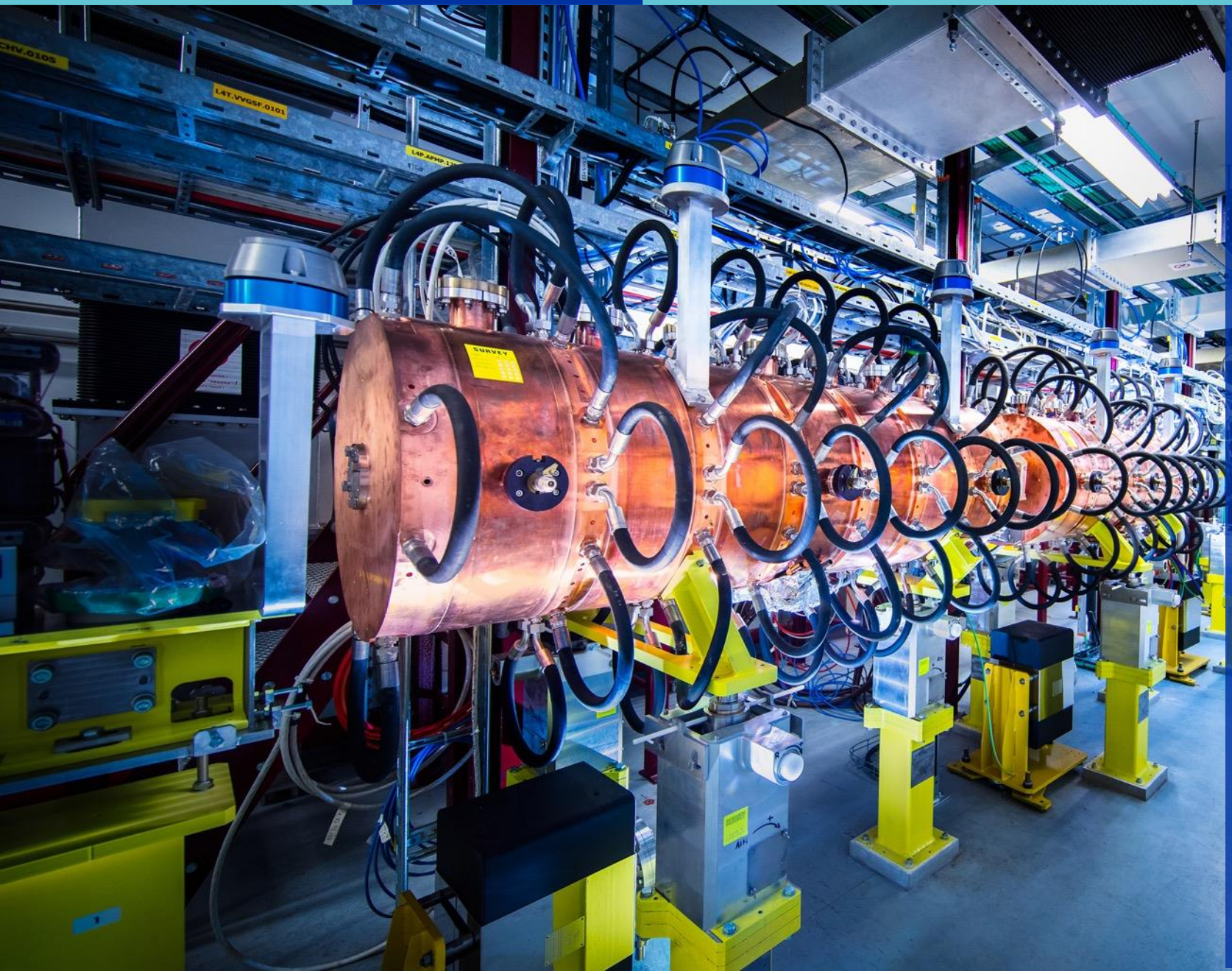
What do we buy ?

- Information Technology
  - Computing systems
  - Servers
  - Software
  - Network equipment
  - Personal computer equipment



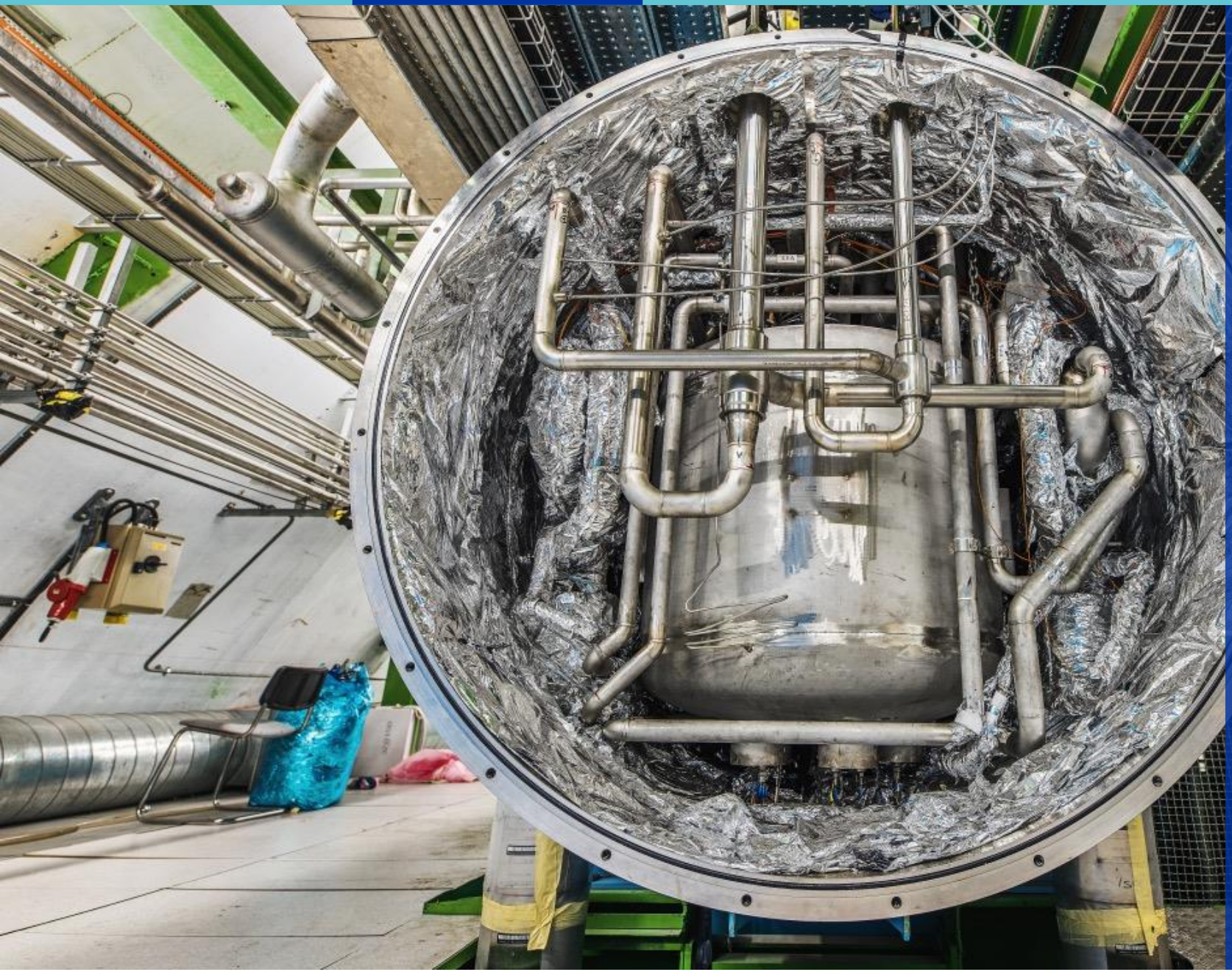
What do we buy ?

- Mechanical engineering and raw materials:
  - Machining
  - Sheet metal work and arc welding
  - Special fabrication techniques
  - Raw materials, finished and semi-finished products (plates, pipes, etc.)
  - Offsite engineering and testing



What do we buy ?

- Electronics and radiofrequency:
  - Electronic components (active, passive)
  - PCBs and assembled boards
  - LV and HV power supplies
  - Radiofrequency plants
  - Amplifiers



What do we buy ?

- Cryogenic and vacuum equipment
- Optics and photonics
- Particle and photon detectors
- Health and safety equipment,
- Transport and handling equipment
- Office supply, furniture
- Industrial services on the CERN site

Knowledge Transfer Tools

How to collaborate with CERN

Start a company based on CERN technology or know-how

Service & Consultancy

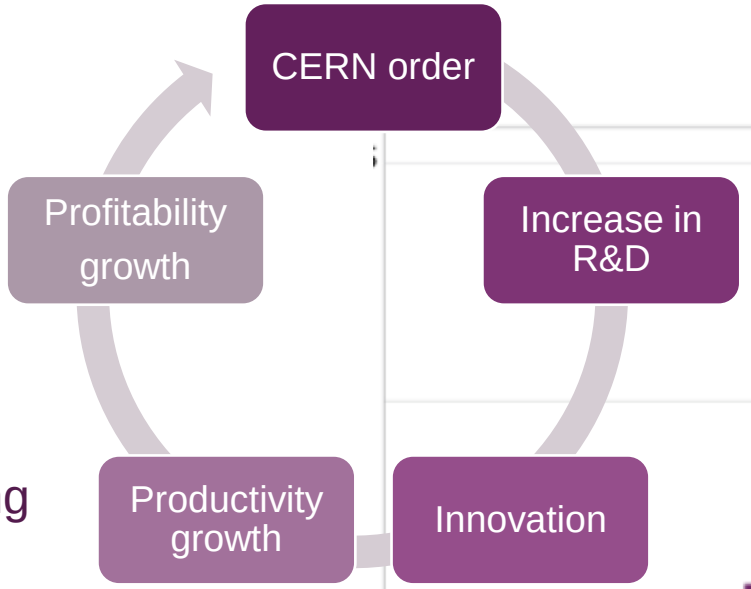
Licensing

R&D Collaborations

Find out more at kt.cern/collaborate

Castelnovo et al.: analysis of '95-'08 financial data on 365 CERN suppliers.

After working with CERN, high-tech suppliers out-perform peers



Out of 700 companies working with CERN

- 55% improved technical knowledge
- 48% improved products
- 42% developed new products
- 18% found new markets

High-tech suppliers outperform peers in patents 5-8 years after working with CERN

From the CERN Council Evaluation of Brazil's application as Associate Member State

Important criterion:
Existence of a sufficiently developed industry within the applicant State to enable it to tender for contracts with CERN with a reasonable chance of success

- Brazil has a vast industrial sector, with leading companies in areas relevant to CERN such as **electronics, mechanics, power distribution and control, cooling and gas systems**, in addition to companies extracting and transforming relevant metals.
- Construction of the Sirius light source (85% of contracts awarded to local companies - 350 MCHF) demonstrates **capacities in the automotive, metallurgic, precision mechanics and microelectronic sectors**; the largest **niobium producer** in the world is now partnering with CNPEM, Sirius' host laboratory, for the development and characterisation of superconductive materials.
- With appropriate national coordination and leveraging of existing national platforms and connections, **Brazilian industry has proven potential for CERN industrial partnerships and procurement**.

Very valuable advice and support of CNI since 2018 => *thank you!*

Brazil as a CERN Associate Member State

- Discussions started in 2009, formal application in 2012, process paused in 2013
- Process restarted in 2019, vigorous lead by MCTI, strong support of MFA
- Renewed application in 2021 with support of Head of State and Casa Civil
- CERN Council (all Member States) approved Brazil association in September 2021 !
- Now looking forward to official signature (within 3 months) and…
- …completion of ratification in Congress (within 12 months)

- Hopefuly by 2023 access for Brazilian nationals and companies to:
  - Employment (capacity-building in engineering, technology, physics, administration)
  - Procurement opportunity (deep-tech, supplies, materials, and services)
  - Knowledge transfer through people, procurement, partnerships

Looking forward to achieving the ratification process

Conclusion

The love story between CERN and Brazil still goes on…

We have to write the next episodes of this partnership altogether : CERN Member States, CERN management, Brazilian authorities and Brazilian private sector !

CERN is looking forward to developing commercial relationships with Brazilian companies. We have confidence in their expertise, innovation and competitiveness !