

When infinitely large meets infinitely small

Giovanni Porcellana
Nuclear Engineer

- Conference will start shortly
- Switch off camera and microphone
- Open the *chat* tool (down-right)



Your virtual conference

Format

- Presentation (40 minutes in total)
- Questions and answers (20 minutes in total)

During presentation

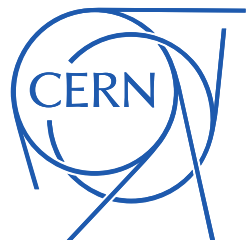
- Ask questions using the chat
- Use microphone or camera only if needed

After presentation

- Please fill out survey on Indico page
- Material and links available on Indico page



**POLITECNICO
DI TORINO**



Knowledge Transfer
Accelerating Innovation

An Italian
Nuclear Engineer
at CERN?
Tell me more...



CERN

What is it?





What does *CERN* stand for?

Conseil
Européen pour la
Recherche
Nucléaire

European
Council for
Nuclear
Research

1953

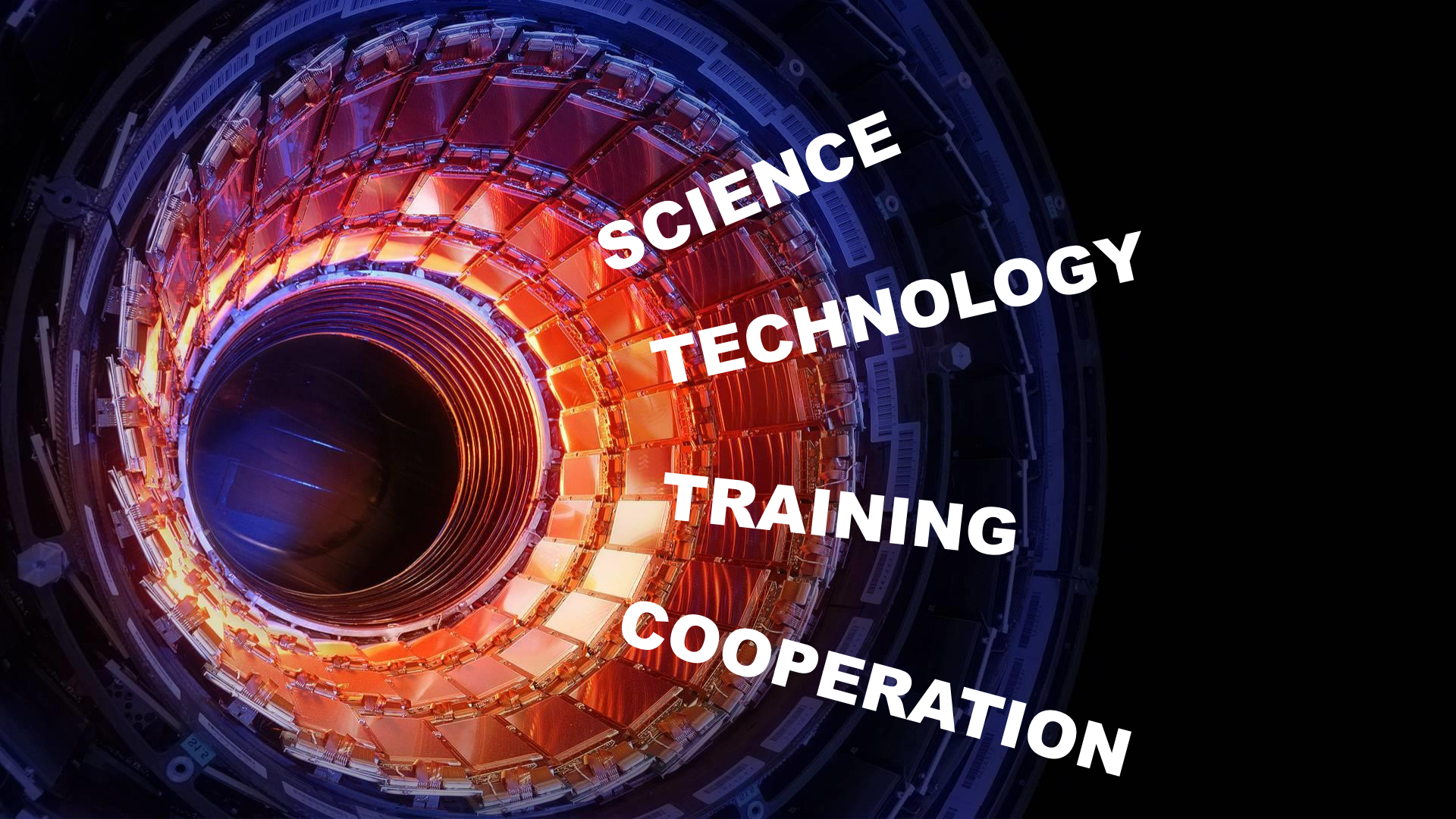
What does *CERN* stand for?

Organisation

Européenne pour la
Recherche
Nucléaire

European
Organization for
Nuclear
Research

1954



SCIENCE

TECHNOLOGY

TRAINING

COOPERATION

CERN

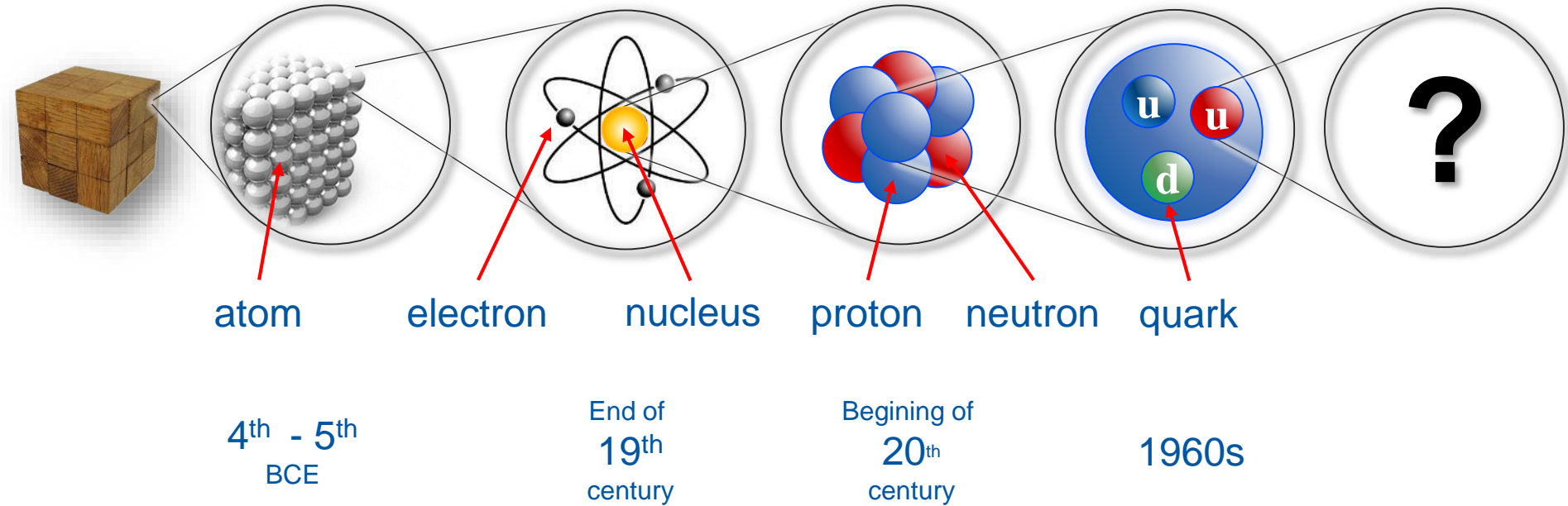
Science and Technology



Fundamental research ?



What is the matter made of



Checking theories

$$-dx^2 - dy^2 - dz^2$$

$$\left(\frac{m}{\sqrt{1-u^2}}, \frac{m u_i}{\sqrt{1-u^2}} \right) \quad \left| \quad \frac{m u_i}{\sqrt{1-u^2}} \text{ Impuls} \right.$$

$$\left(m + \frac{1}{2} m u^2, m u_i \right) \quad \left| \quad m \left(\frac{1}{\sqrt{1-u^2}} - 1 \right) \text{ Kin Energy} \right.$$

$$= \frac{t' + v x'}{\sqrt{1-v^2}} \quad \left| \quad x = \frac{x' + v t'}{\sqrt{1-v^2}} \quad y = y' \quad z = z' \right.$$

$$\sum \frac{1}{\sqrt{1-u^2}} = \frac{2}{\sqrt{1-u^2} \sqrt{1-v^2}}$$

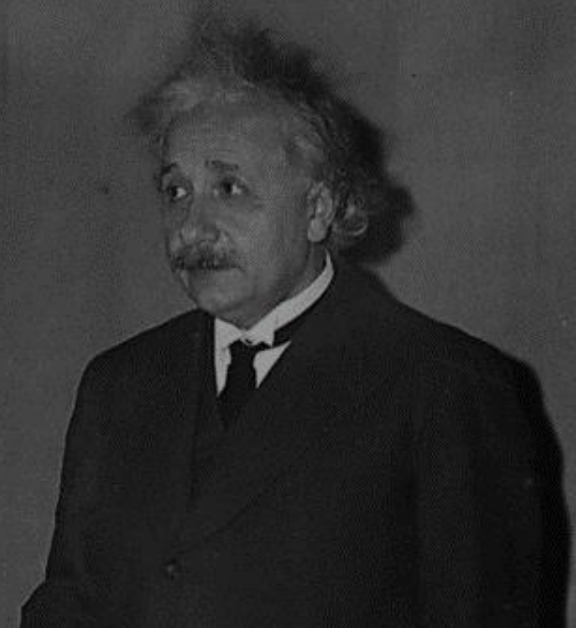
$$\sum \frac{u_i}{\sqrt{1-u^2}} = \frac{2v}{\sqrt{1-u^2} \sqrt{1-v^2}}$$

$$\text{Hyp. } \sum \vec{p}_i = \sum \vec{p}_i \text{ (relativistic)}$$

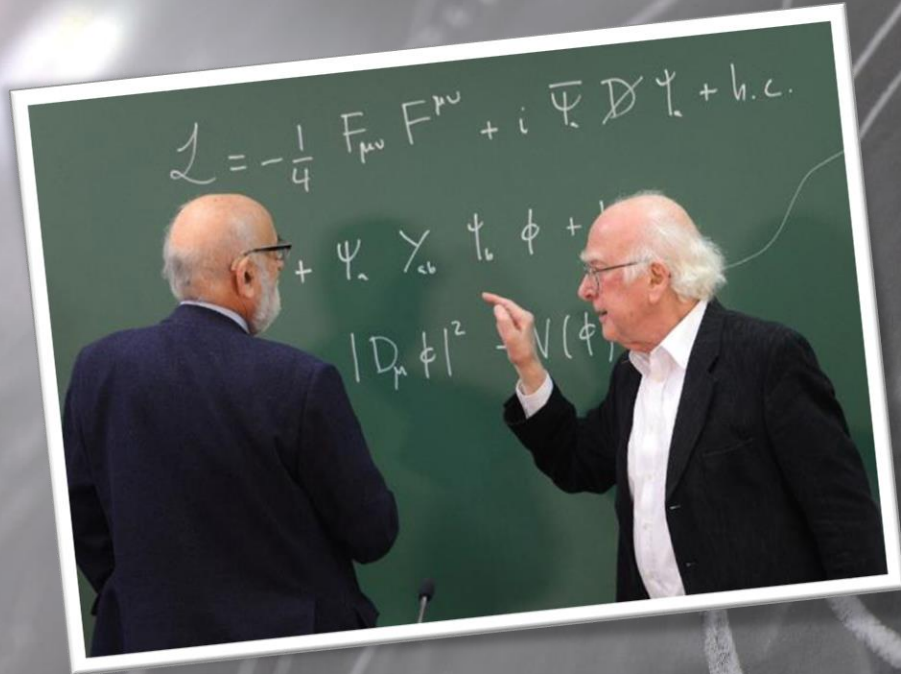
$$\sum \vec{E}_i = \sum \vec{E}_i \text{ (relativistic)}$$

$$\vec{p}_i = \vec{p}_i + m \vec{v}_i$$

$$\vec{E}_i = \vec{E}_i + m \gamma_i$$



Answering questions...



Higgs

Higgs?

Answering questions...



Antimatter?

Answering questions...

Dark matter?

CERN

How does it work?



$$-\frac{\hbar^2}{2m} \frac{d^2\psi}{dx^2} + V\psi = E\psi$$

$$U_{ef} = \frac{U_m}{E = \hbar\omega}$$

$$\vec{B} = \mu_0 \frac{NI\sqrt{2}}{2\pi r}$$

$$k = \frac{p^2}{2m}$$

$$\lambda = \frac{h}{m_0 v}$$

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{g}{l}}$$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 \iint_S \vec{J} \cdot d\vec{S}$$

$$v_k = \sqrt{\frac{3kT}{m_0}} = \sqrt{\frac{3kTN_A}{M_m}} = \sqrt{\frac{3R_m T}{M_r \cdot 10^{-3}}}$$

$$\Phi_e = \frac{L}{\Delta t} \int \frac{1}{2\pi} = \frac{\lambda_1}{4\pi \epsilon_0 \epsilon_r} \frac{\lambda_2}{2} = \frac{\lambda_1 \lambda_2}{8\pi \epsilon_0 \epsilon_r}$$

$$X_L = \frac{U_m}{I_m} = \omega L = 2\pi f L$$

$$T = \frac{4n_1 n_2}{(n_2 + n_1)^2}$$

$$E = \frac{E_c}{a} \int_{-a/L}^{+a/L} \sin(\omega t + \phi) dy$$

$$R_m = \frac{C}{T} k = \pm \sqrt{\frac{2m}{\hbar^2} (E - V_0)}$$

$$\omega = 2\pi f$$

$$\frac{\sin\alpha}{\sin\beta} = \frac{v_1}{v_2} = \frac{\omega_2}{\omega_1}$$

$$v = \frac{1}{\sqrt{\epsilon \cdot \mu}} = \frac{c}{\sqrt{\epsilon_r \cdot \mu_r}}$$

$$F_x = \frac{1}{2} C_x \rho \beta^2$$

$$\frac{\Delta I_B}{X} + \frac{\omega_2}{X'} = \frac{\omega_2 - \omega_1}{v}$$

$$E_k = \frac{\hbar^2}{8mL^2}$$

$$\oint \vec{J} \cdot d\vec{S} = Q^*$$

$$E = mc^2$$

$$\vec{S} = \frac{1}{\mu_0} (\vec{E} \times \vec{B})$$

$$E = \hbar k^2 \cdot 1 \text{ pc} = \frac{1 \text{ AU}}{c}$$



$$-\frac{\hbar^2}{2m} \frac{d^2\psi}{dx^2} + V\psi = E\psi$$

$$U_{ef} = \frac{U_m}{E = \hbar\omega}$$

$$\vec{B} = \mu \frac{NI\sqrt{2}}{2\pi r}$$

$$k = \frac{p^2}{2m}$$

$$\lambda = \frac{h}{m_0 v}$$

$$\lambda = \frac{h}{\sqrt{2eUm_e}}$$

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{g}{l}}$$

$$\oint \vec{B} \cdot d\vec{l} = \mu \iint_S \vec{J} \cdot d\vec{S}$$

$$v_k = \sqrt{\frac{3kT}{m_0}} = \sqrt{\frac{3kTN_A}{M_m}} = \sqrt{\frac{3R_m T}{M_A \cdot 10^{-3}}}$$

$$\Phi_e = \frac{L}{\Delta t} \int_{2\pi} = \frac{\lambda_1}{4\pi \epsilon_0 \epsilon_r} \frac{q_1 q_2}{r_{12}}$$

$$X_L = \frac{U_m}{I_m} = \omega L = 2\pi f L$$

$$T = \frac{4n_1 n_2}{(n_2 + n_1)^2}$$

$$E = \frac{E_c}{a} \int_{-a/L}^{+a/L} \sin(\omega t + \phi) dy$$

$$I = \frac{U_e}{R + R_i}$$

$$\sin(\beta) = \frac{v_1}{v_2} = \frac{\omega_2}{\omega_1}$$

$$\frac{\Delta I_C}{\Delta t} \phi_e = \frac{\Delta E}{\Delta t}$$

$$\oint \vec{D} \cdot d\vec{S} = Q^*$$

$$E = \frac{1}{2} \hbar \sqrt{k/m}$$

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

$$E_k = \frac{h^2}{8mL^2}$$

$$E = \hbar k^2$$

$$1 \text{ PC} = \frac{1 \text{ AU}}{c}$$

$$F_m = \vec{B} I l = \frac{\mu I_1 I_2}{2\pi d} l$$

$$g = \frac{m_1 m_2}{r^2}$$

$$R_m = \frac{c}{T}$$

$$k = \pm \sqrt{\frac{2m}{\hbar^2} (E - V_0)}$$

$$\omega = 2\pi f$$

$$v = \frac{1}{\sqrt{\epsilon_r \mu_r}} = \frac{c}{\sqrt{\epsilon_r \mu_r}}$$

$$F_x = \frac{1}{2} C \exp(\beta^2)$$

$$\frac{\omega_1}{x} + \frac{\omega_2}{x'} = \frac{\omega_2 - \omega_1}{v}$$

E = mc²



Accelerating and colliding



Incredible levels of energy

7 TeV

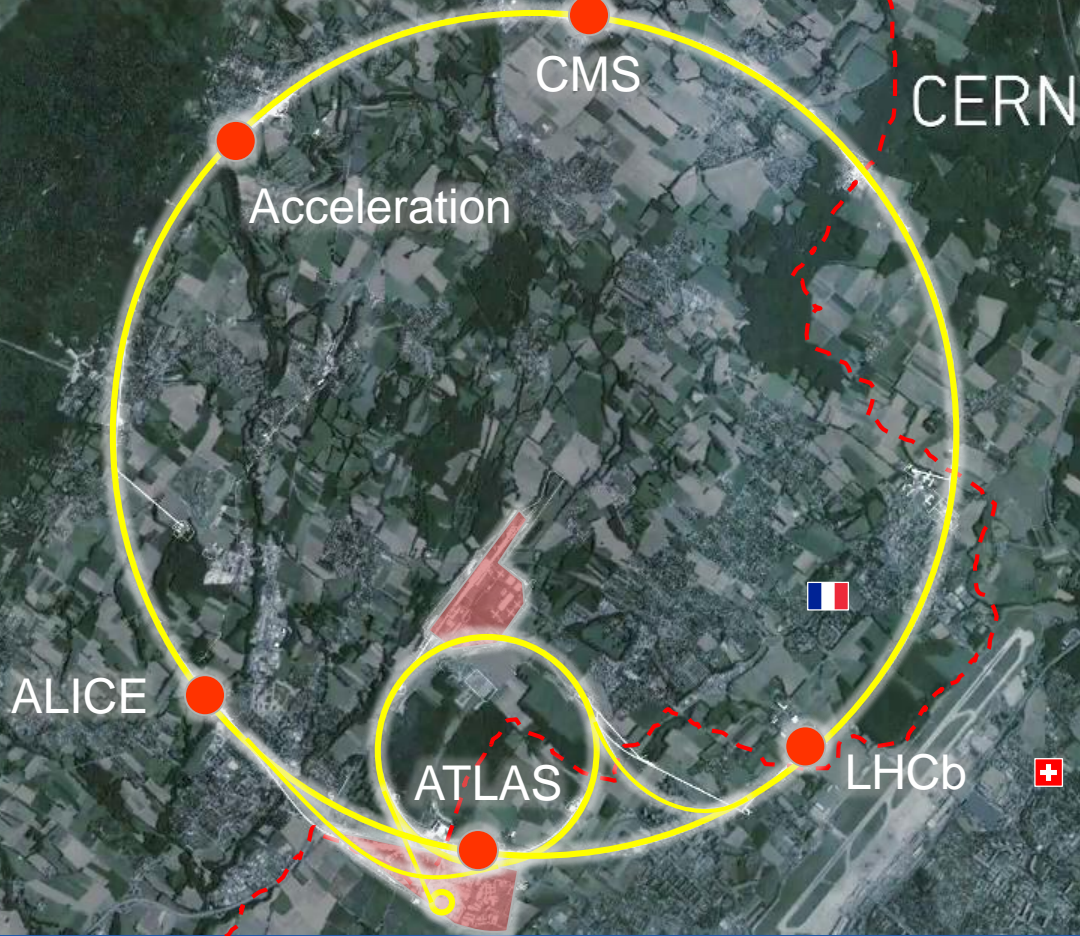



The equivalent energy of
100'000'000'000'000'000'000'000'000 protons
into one of them

Our accelerator is a bit like a beltway...



Largest machine on Earth





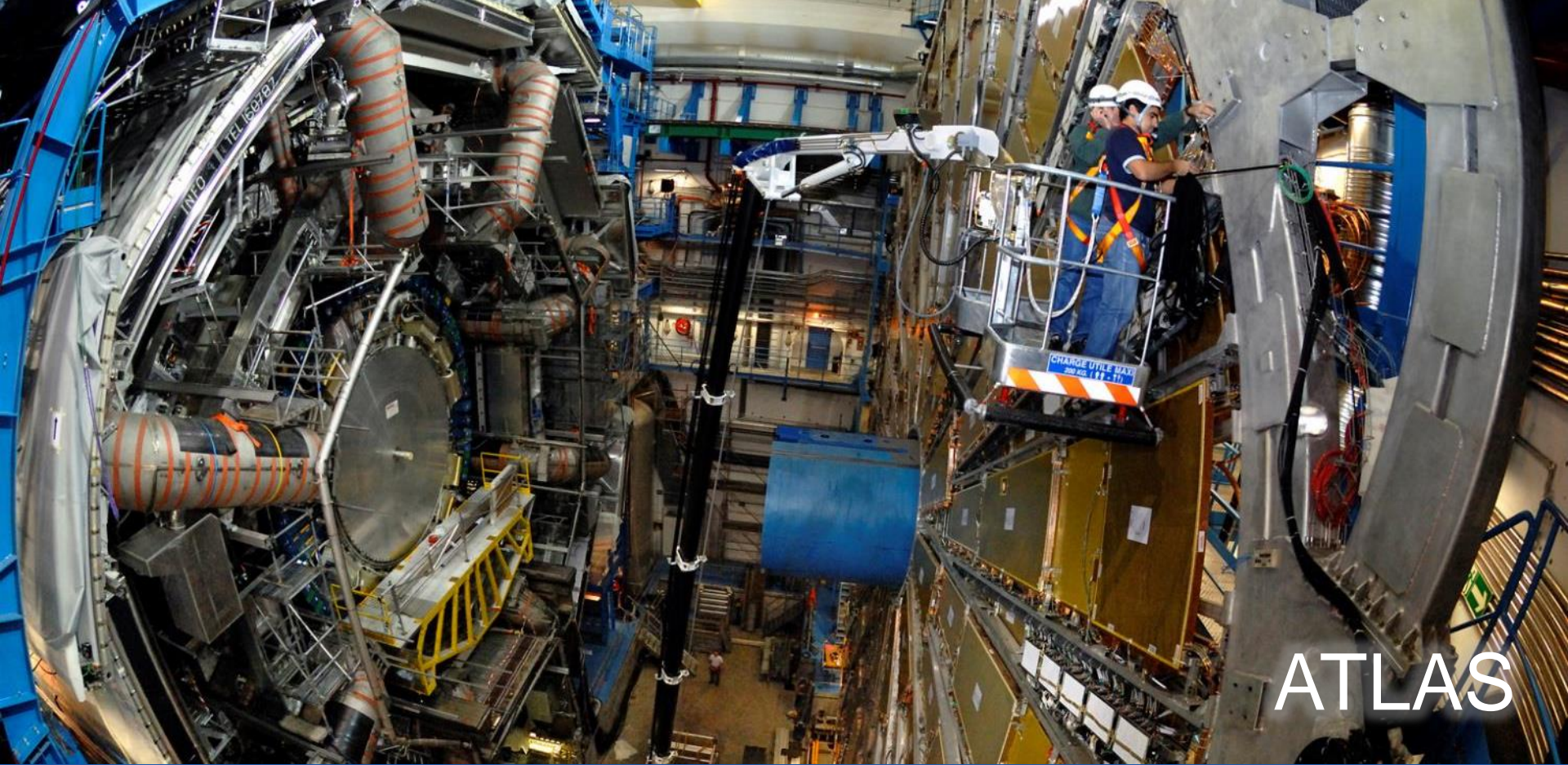
The most
powerful
magnets



The coldest
temperatures

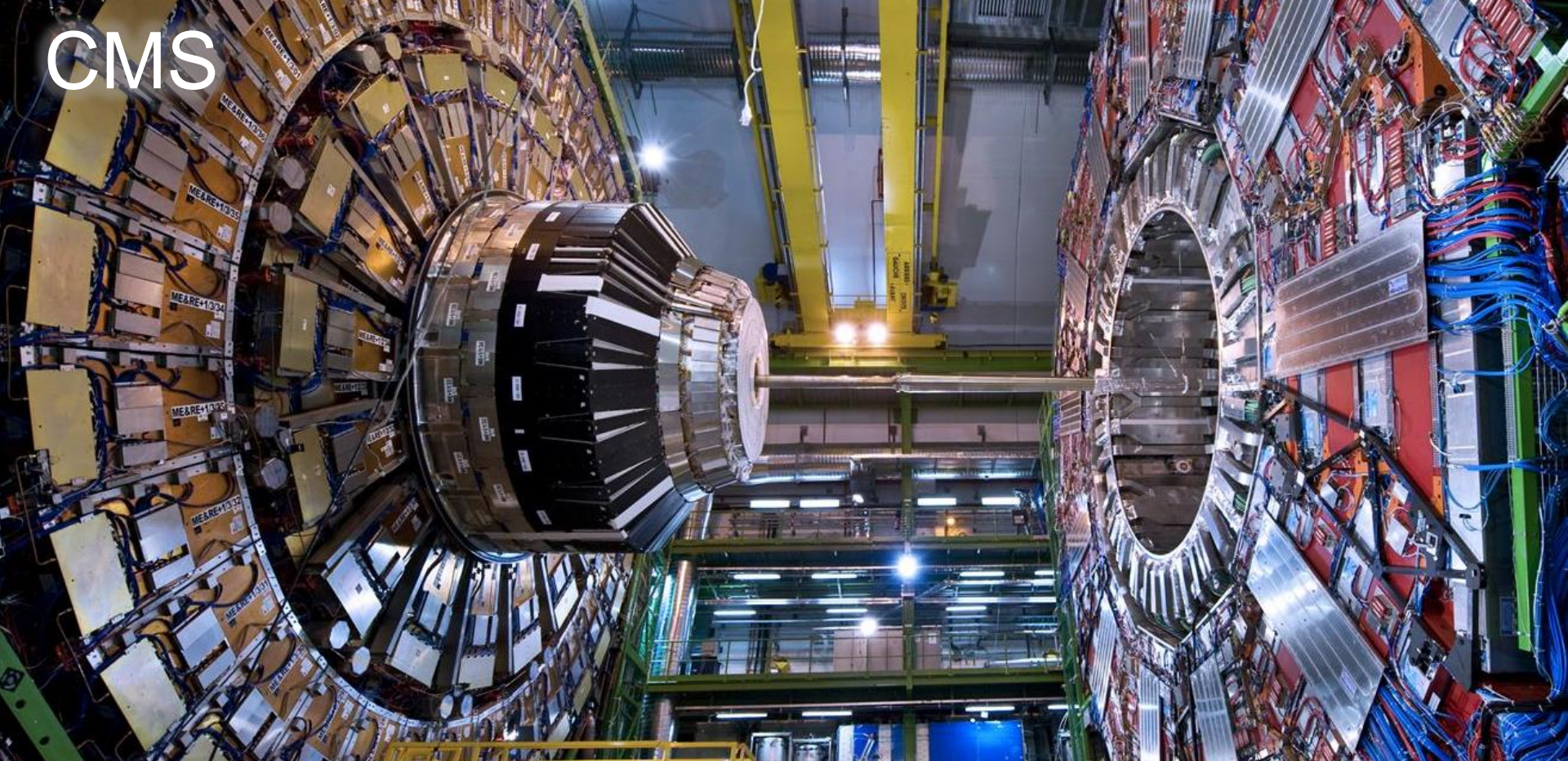


The highest vacuum

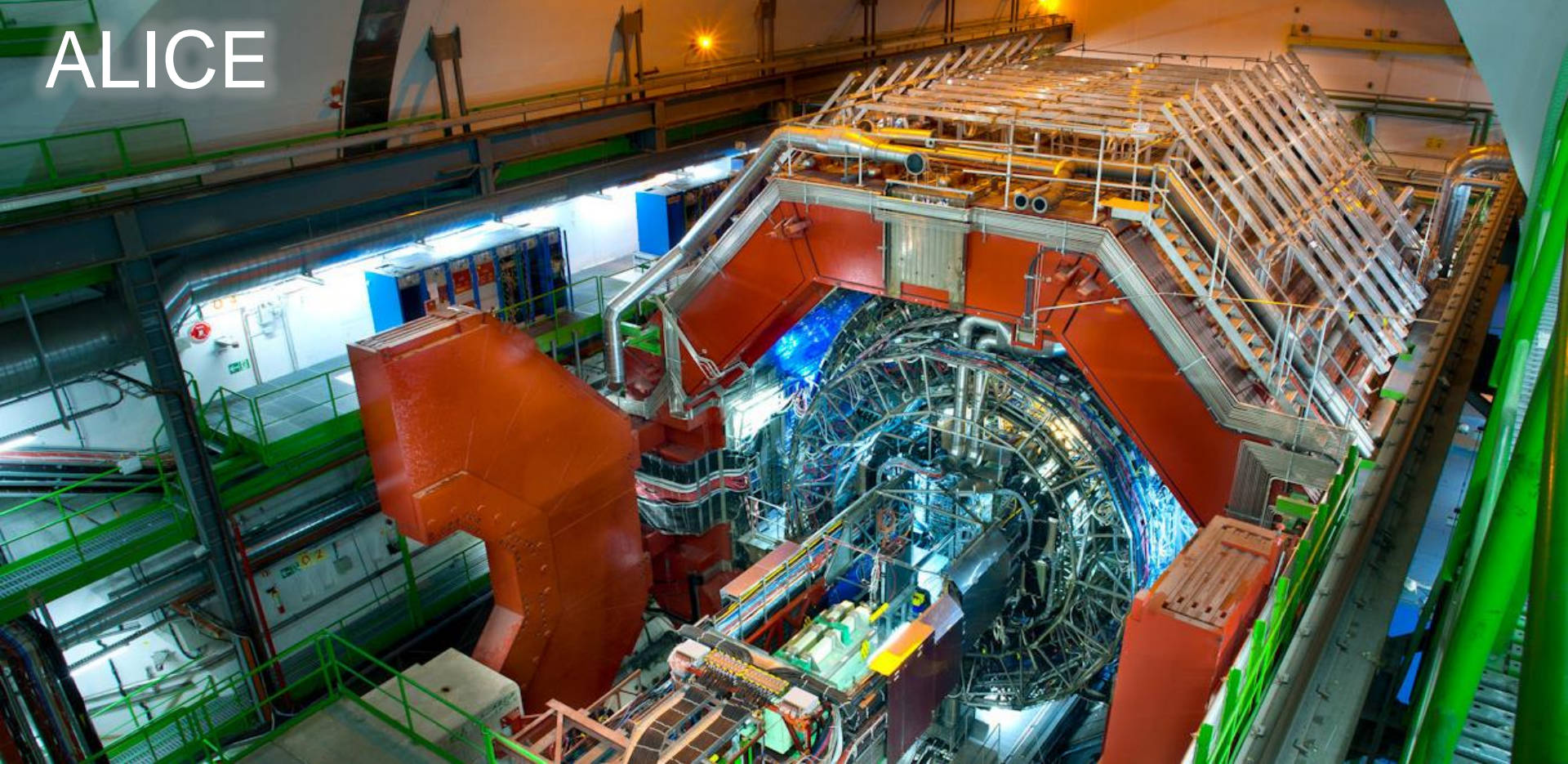


ATLAS

CMS



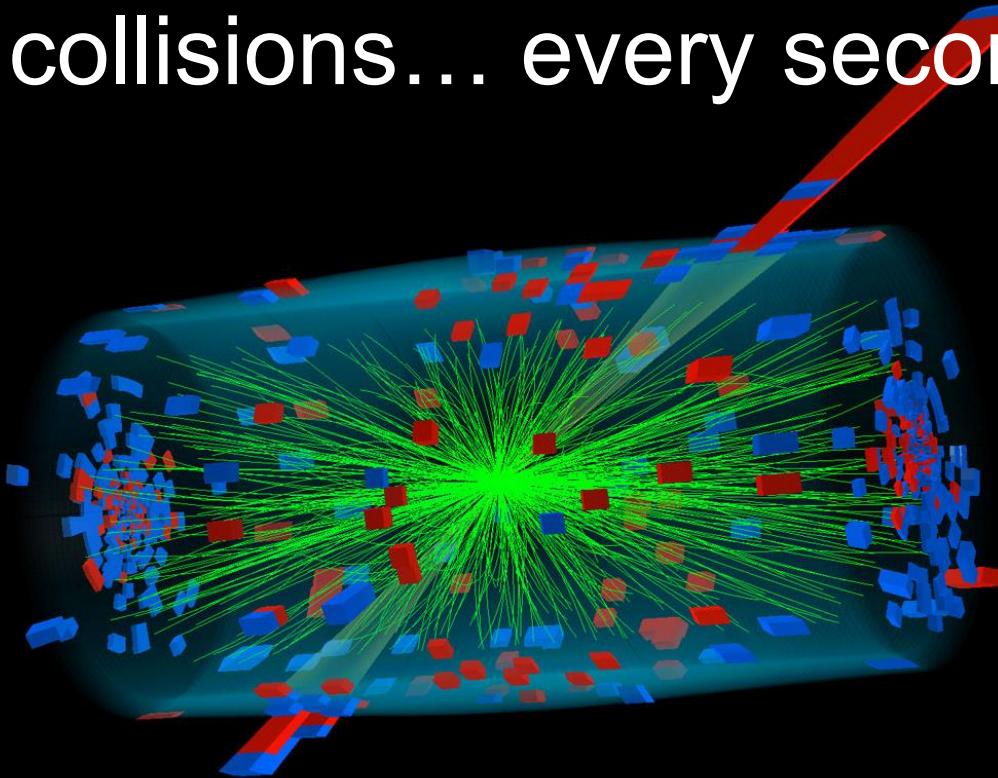
ALICE



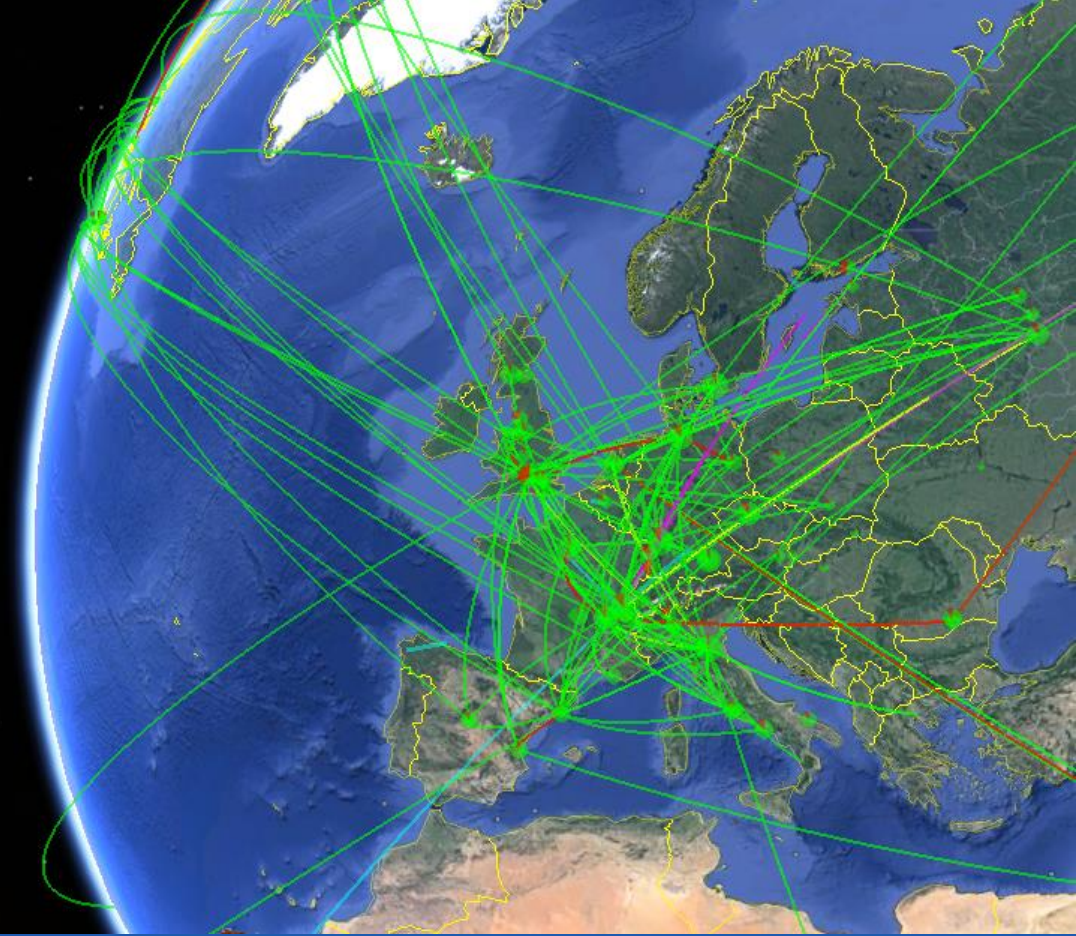


LHCb

Million of collisions... every second!



The largest computing grid



CERN

Training of the scientists and engineers of tomorrow, and not only!







M—E—D



T—E—C—H



H—A—C—K

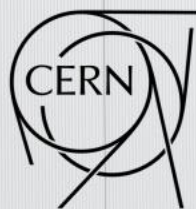
AN INNOVATION COMPETITION WHERE TEAMS CAN SOLVE MEDTECH PROBLEMS PITCHED BY HEALTHCARE ORGANISATIONS AND INDUSTRY.

#CERNMEDTECHHACK

AWARD FEST, FIND OUT MORE AT:
[INDICO.CERN.CH/E/MEDTECHHACK18](https://indico.cern.ch/e/medtechhack18)



M-E-D
|| || ||
T-E-C-H
|| || ||
H-A-C-K



Idea^s
THINK. DO. COLLABORATE.



CERN

International Collaboration



23 Member States

Budget (2020)
 1.168 billion CHF
 1.10 billion EURO
 0.970 billion GBP



LHC

-  Austria (1959)
-  Belgium (1953)
-  Bulgaria (1999)
-  Czech Republic (1993)
-  Denmark (1953)
-  Finland (1991)
-  France (1953)
-  Germany (1953)
-  Greece (1953)
-  Hungary (1992)
-  Israel (2014)
-  Italy (1953)
-  Netherlands (1953)
-  Norway (1953)
-  Poland (1991)
-  Portugal (1986)
-  Romania (2016)
-  Serbia (2019)
-  Slovakia (1993)
-  Spain (1961-1968, 1983-)

-  Sweden (1953)
 -  Switzerland (1953)
 -  United Kingdom (1953)
- ## 8 Associated
-  Croatia (2019)
 -  Cyprus (2016)
 -  India (2017)
 -  Lithuania (2018)
 -  Pakistan (2015)
 -  Slovenia (2017)
 -  Turkey (2015)
 -  Ukraine (2016)



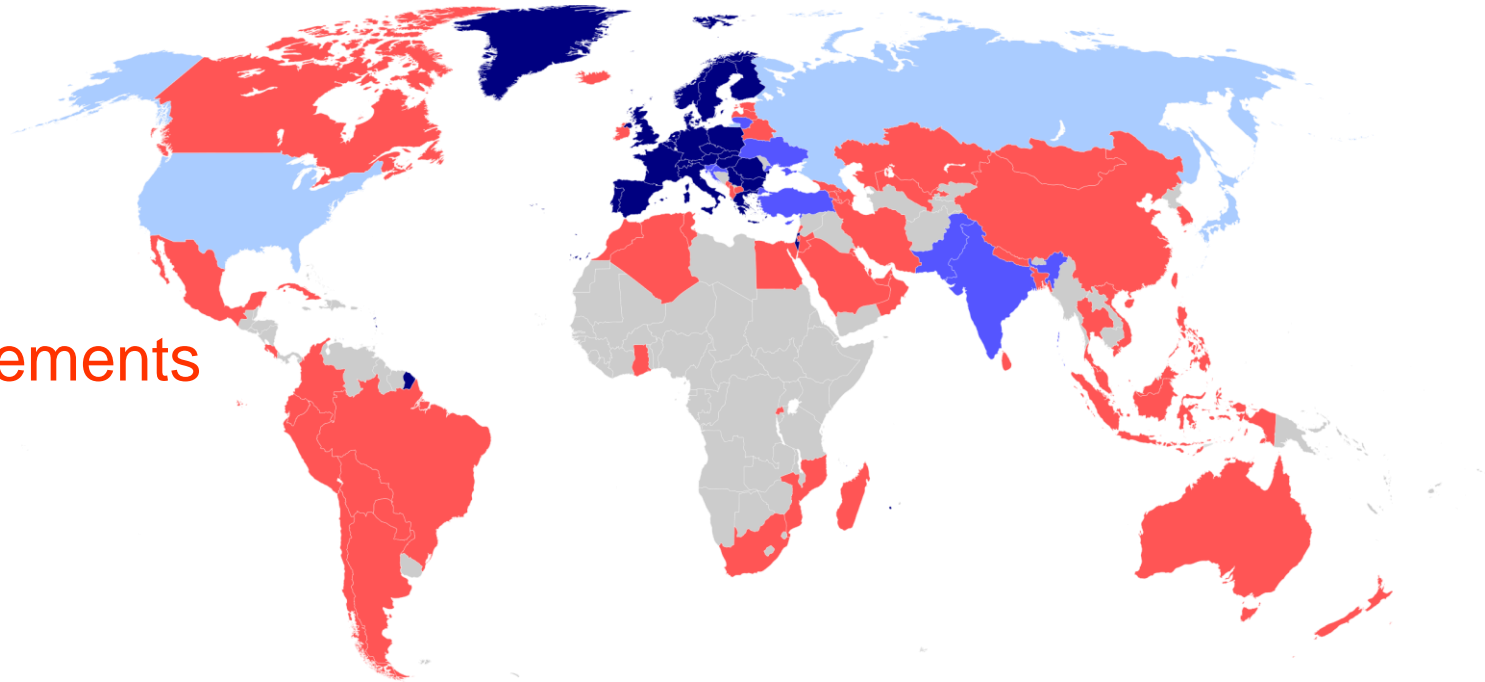
A world collaboration

23 members

8 associated

3 observers

61 with agreements



How many persons?

20 000!



2 600 staff

800 fellows
apprentices

550 students

15 000 users

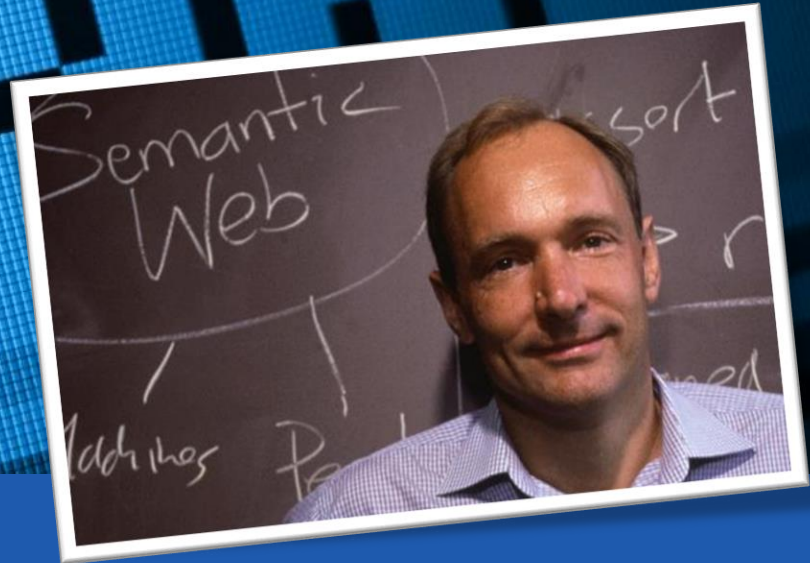
2 000 external
companies

CERN

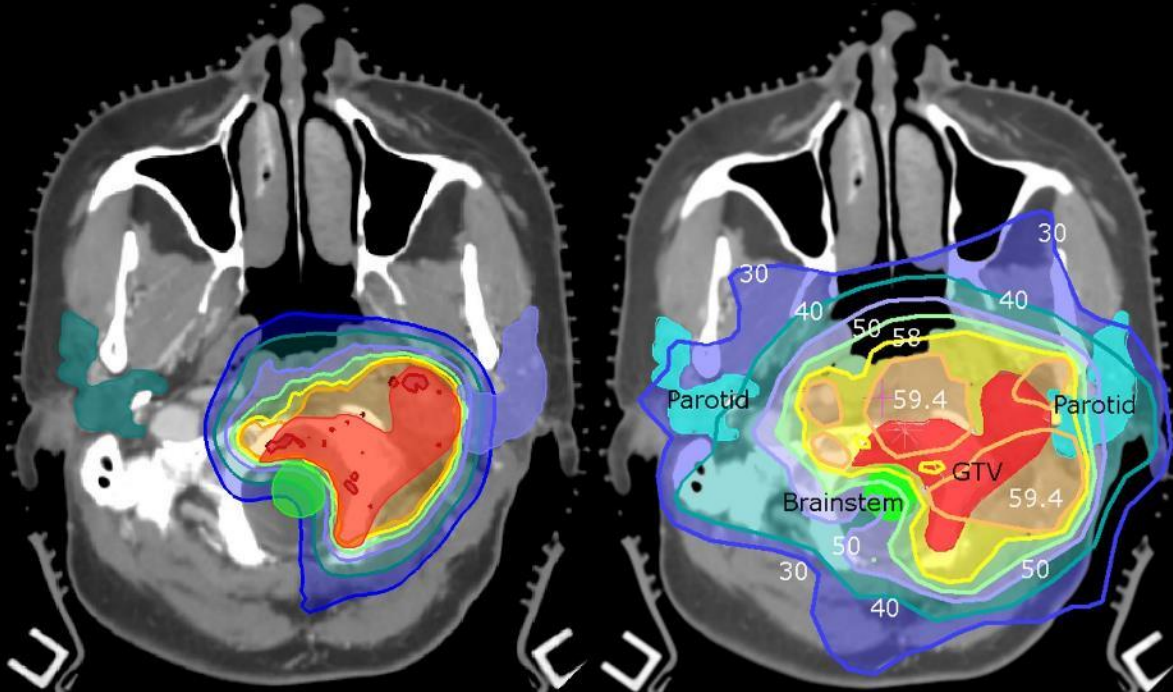
So what?

World Wide Web

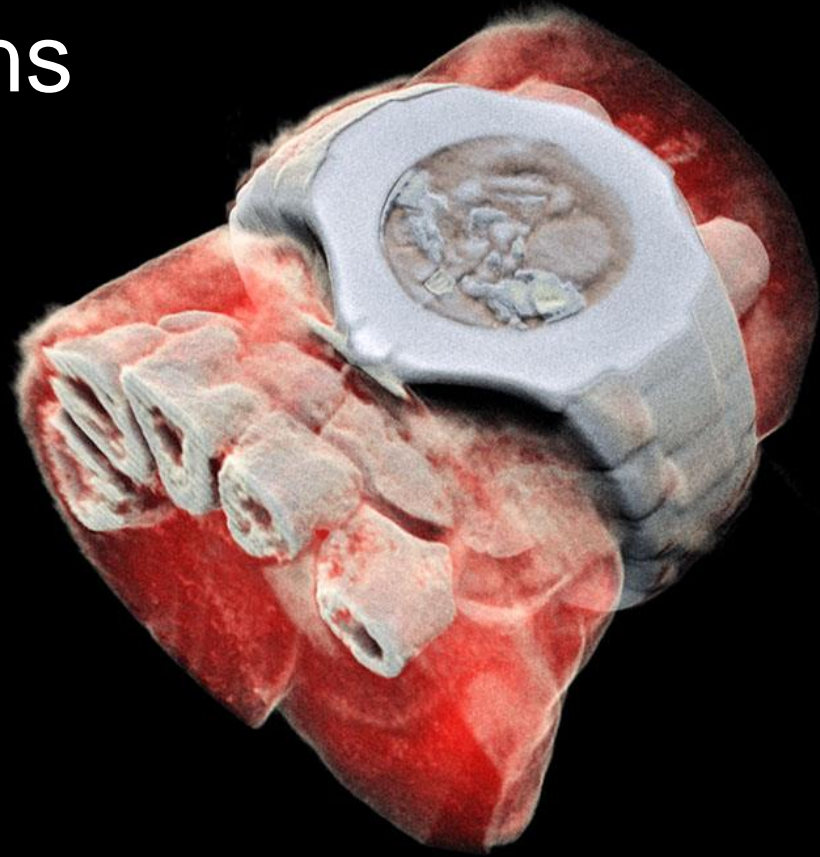
WWW



Medical applications



Medical applications



See inset for close-up view of affected roads around the Baradim Stadium in Mukalla City

Possible landslide caused by floods

HADRAMAUT

ALMUKALLA

Humanitarian missions

PRE - IMAGE 24 OCTOBER 2015



POST - IMAGE 4 NOVEMBER 2015

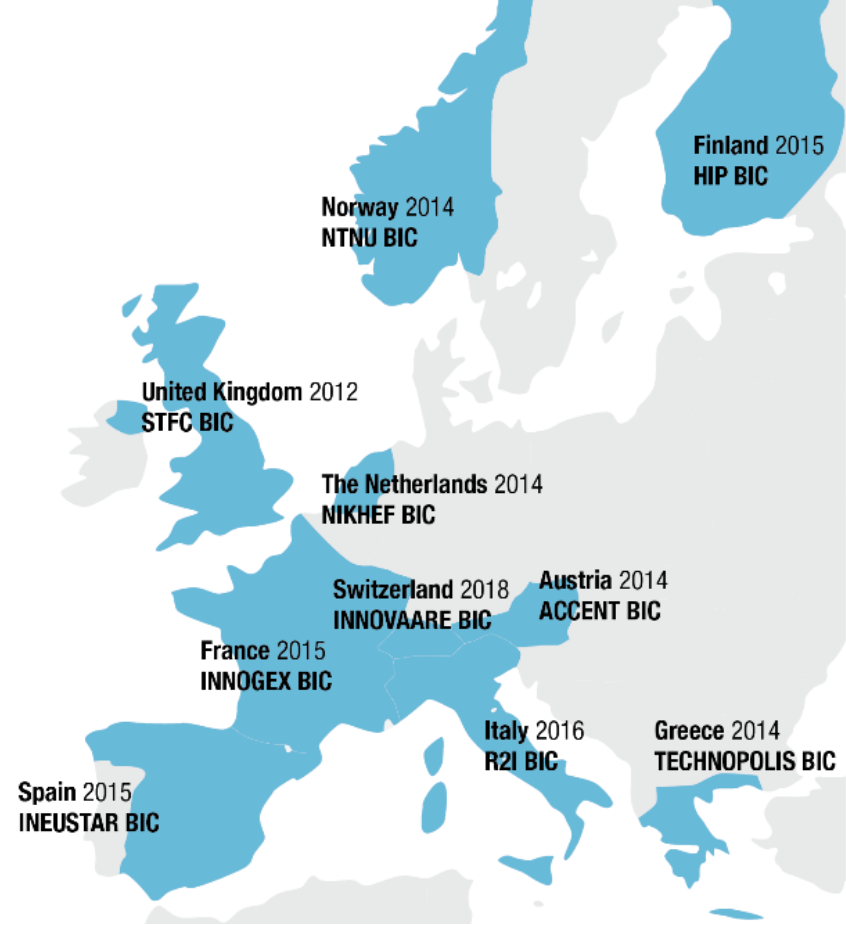


Entrepreneurship

Support to CERN spin-offs and start-ups in the Member States with dedicated programmes.

And much more!

Visit: kt.cern/entrepreneurship



In a nutshell...

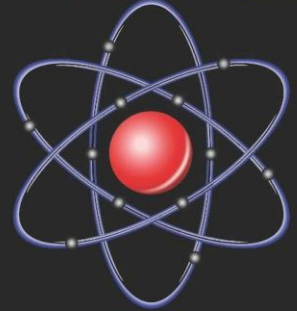


Thanks for your attention!

To learn further:

- home.cern
- visit.cern
- careers.cern

Think like a
Proton



and stay
Positive



Thanks for filling up the survey!

And to learn even further (1/3):

- Discover CERN online: <https://visit.cern/discover-cern-online>
- Voyage in the world of atoms:
https://www.youtube.com/watch?v=7WhRJV_bAiE
- The Standard Model explained simply:
<https://iopscience.iop.org/article/10.1088/1361-6552/aa5b25>
- Little quiz: which particle are you?
<https://scoollab.web.cern.ch/sites/scoollab.web.cern.ch/files/ParticleGame/>
- The Higgs Discovery Explained:
<https://www.youtube.com/watch?v=so2nCu2Jkbc>

And to learn even further (2/3):

- LHC: the path of the protons: <https://www.youtube.com/watch?v=pQhbhpU9Wrg>
- Accelerators: <https://home.cern/science/accelerators>
- Superconductivity: <https://home.cern/science/engineering/superconductivity>
- Little game on detecting particle: connecting the dots: <https://connectdots.web.cern.ch/>
- The Worldwide LHC Computing Grid: <https://wlcg-public.web.cern.ch/>
- CERN Summer Student Programme: <https://home.cern/summer-student-programme>
- CERN Teachers Programme: <https://teacher-programmes.web.cern.ch/home>

And to learn even further (3/3):

- Students Opportunities at CERN: <https://careers.cern/students>
- Knowledge Transfer at CERN: <http://kt.cern/>
- Medical Applications: <https://kt.cern/medtech>
- UNOSAT at CERN: <https://unitar.org/unosat>