

Welcome to CERN!

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

19.09.2020

Despina Hatzifotiadou

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

Despina Hatzifotiadou

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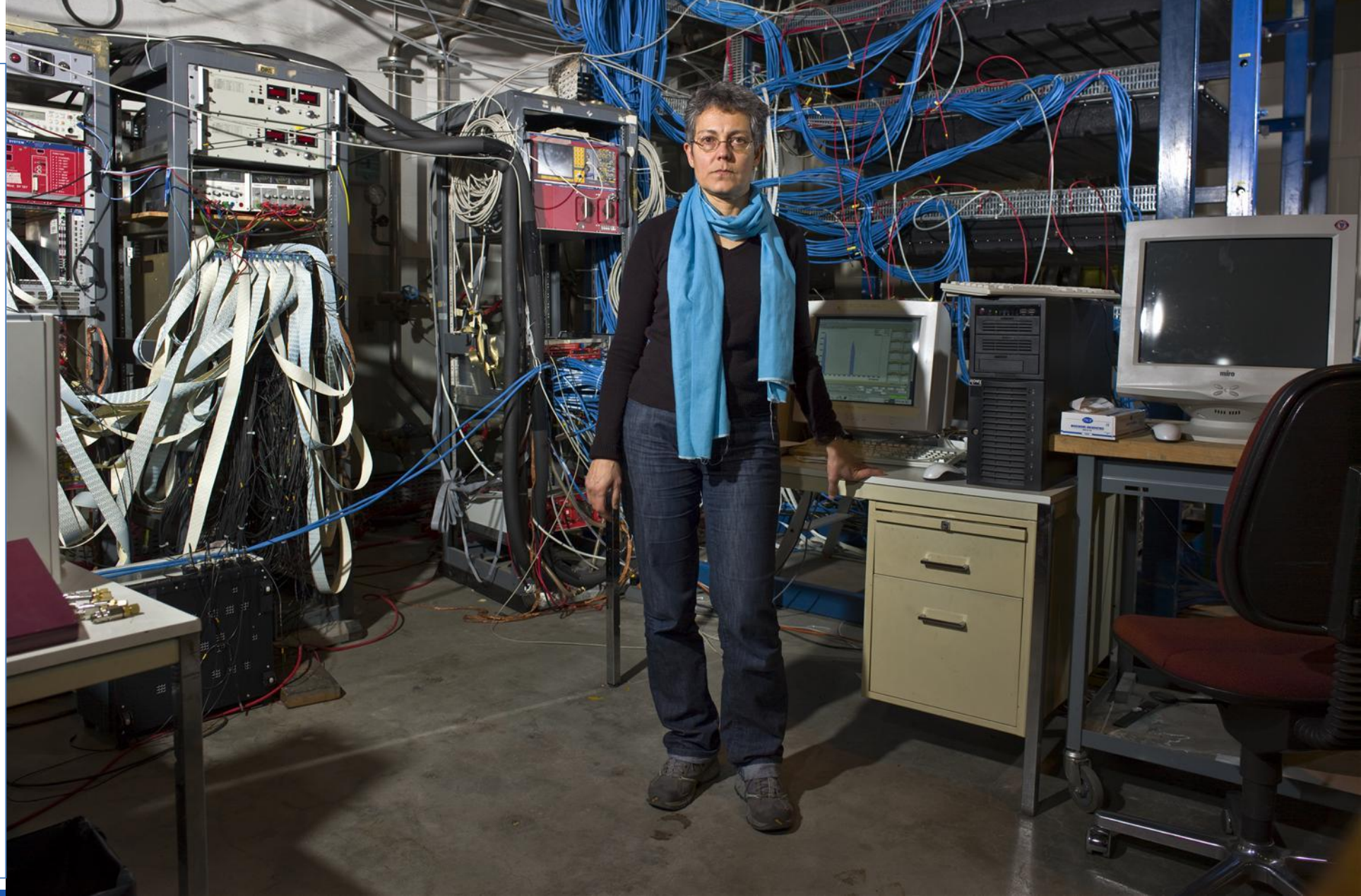
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PhD at AUTH (PS182
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What does *CERN* stand for ?

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

Nuclear?



European laboratory for particle physics

Member States

Budget (2020)
 1,168 billion CHF
 0,970 billion GBP
 1,210 billion USD



-  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-)

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



Collaborations



The ALICE Collaboration consists of

- 39 countries
- 174 institutes
- 1927 members

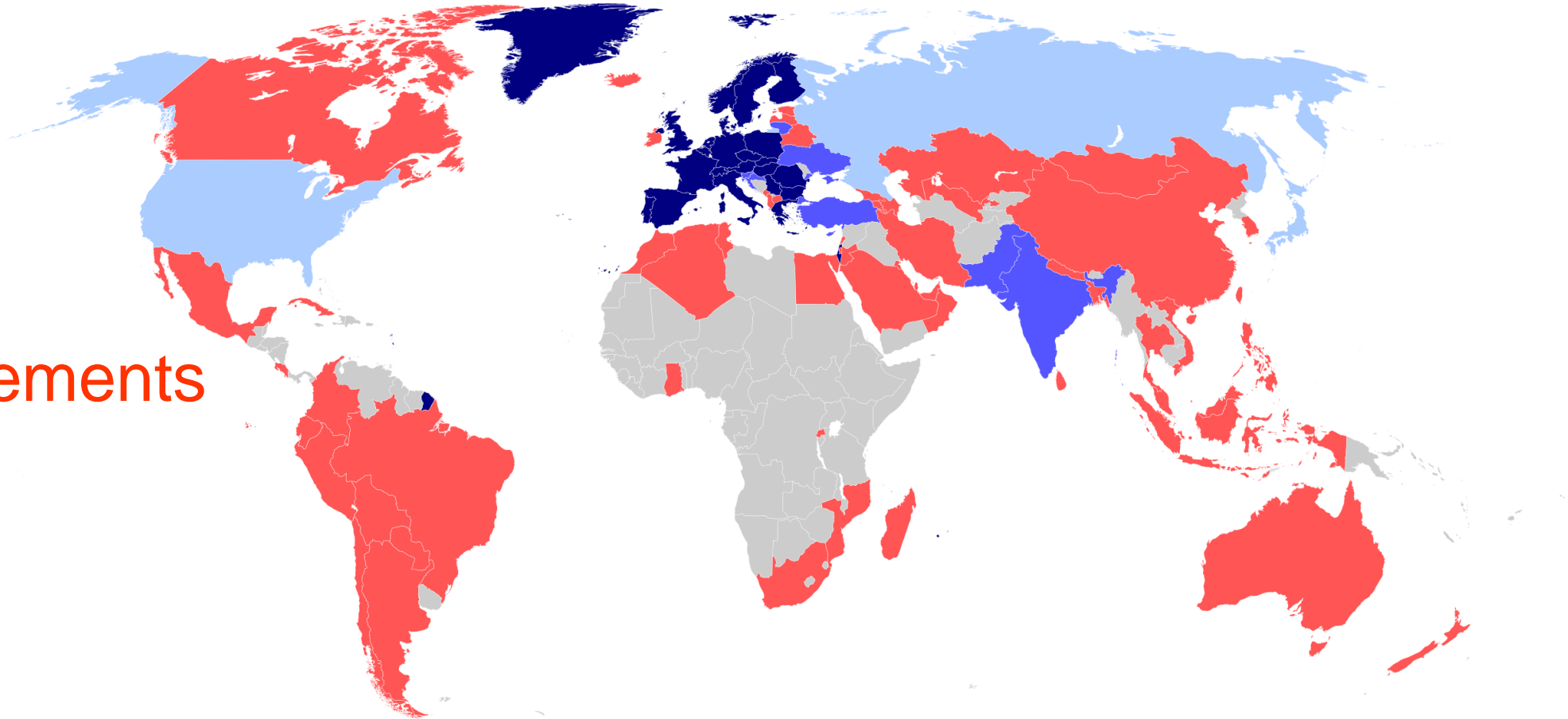
A world collaboration

23 members

8 associated

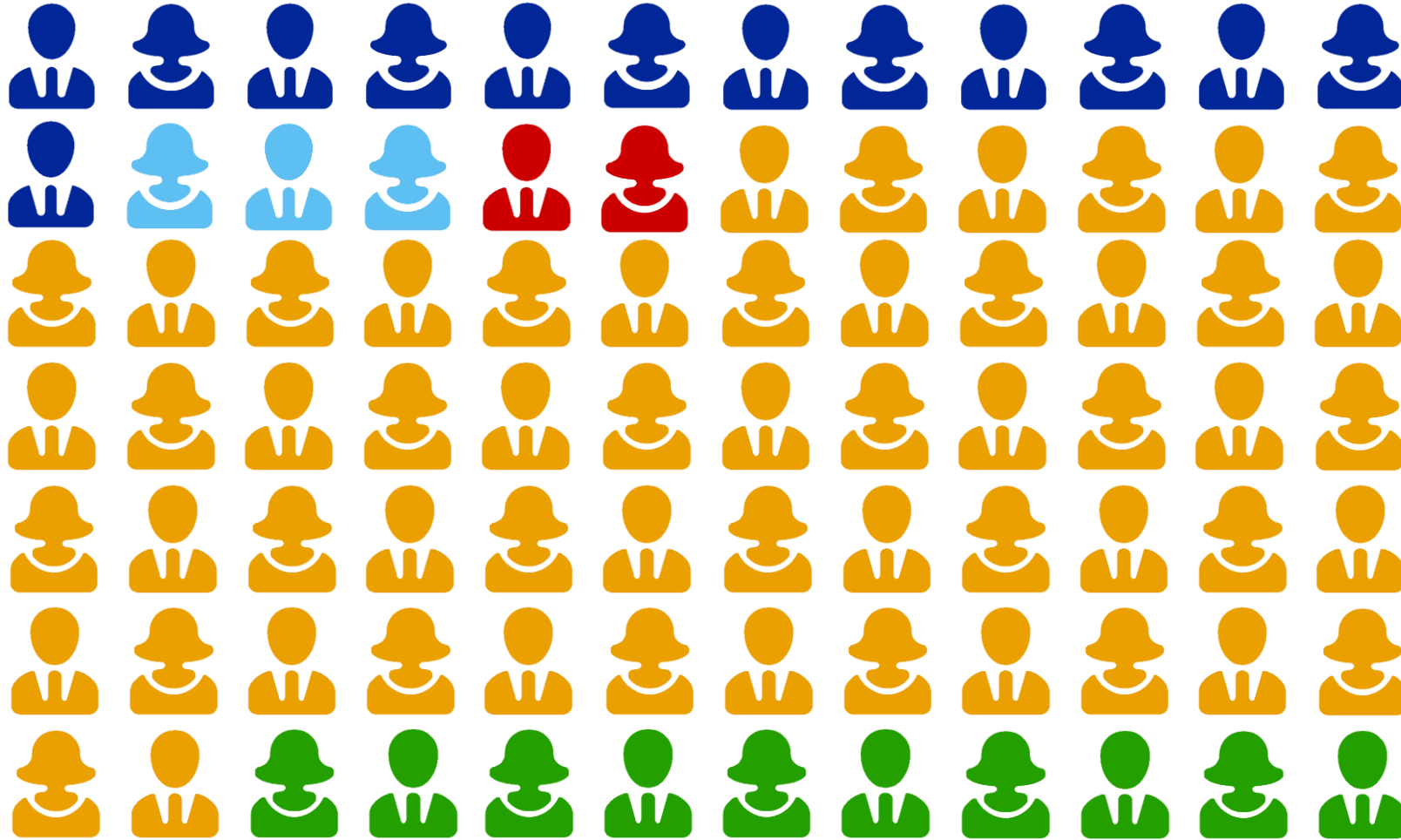
3 observers

61 with agreements



How many persons?

20 000!



2 600 staff

800 fellows
apprentices

550 students

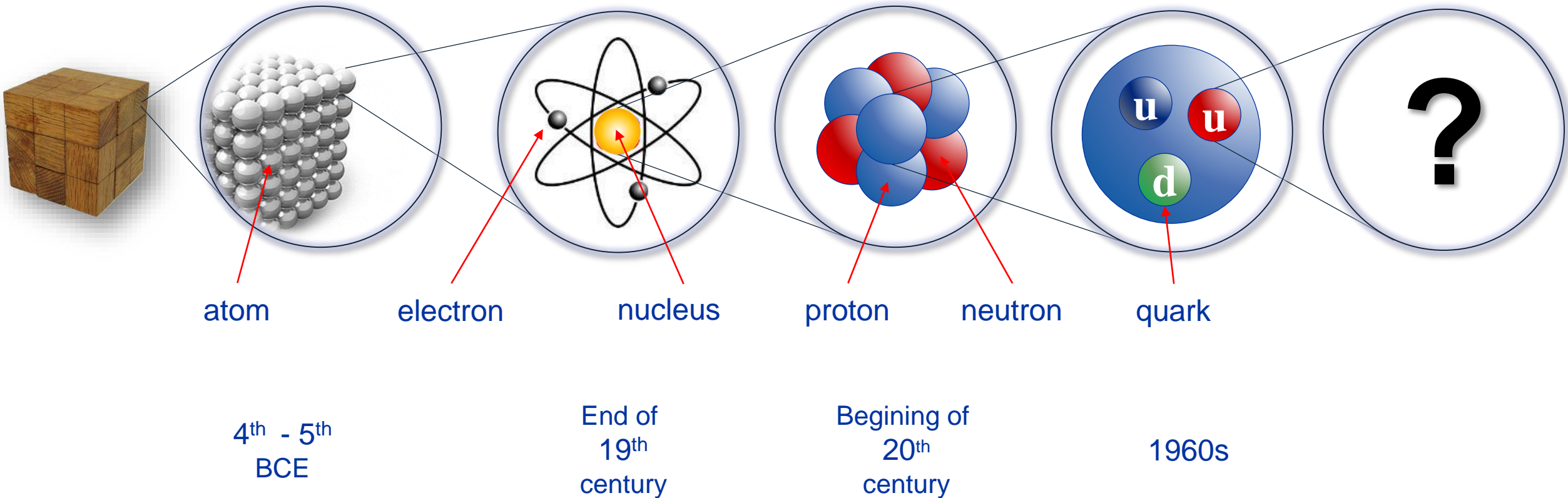
15 000 users

2 000 external
companies

Fundamental research











What is matter made of



Standard model

Images:
www.particlezoo.net

Ordinary matter

LEPTONS				QUARKS			
ELECTRON		ELECTRON NEUTRINO		UP		DOWN	
MUON		MUON NEUTRINO		CHARM		STRANGE	
TAU		TAU NEUTRINO		TOP		BOTTOM	



GLUONS	PHOTONS	HIGGS	BOSONS	GRAVITONS
				
Strong force	Electromagnetic force		Weak force	Gravity

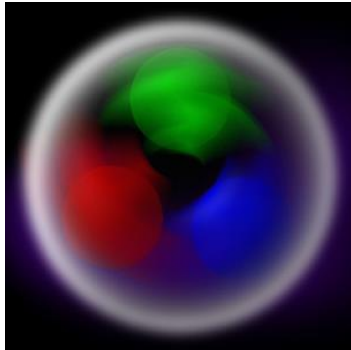
4 forces



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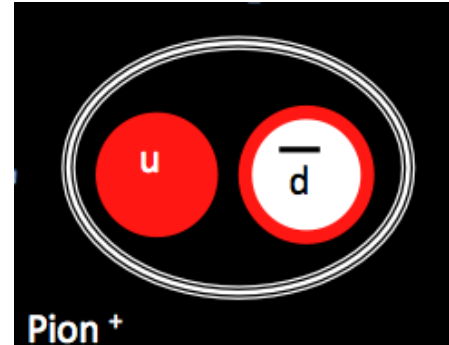
Despina Hatzifotiadou

Quark Confinement : Quarks can not exist free. We find them confined inside hadrons



Baryons

Made of 3 quarks



Mesons

Made of a quark-antiquark pair

Baryons qqq and Antibaryons $\bar{q}\bar{q}\bar{q}$

Baryons are fermionic hadrons.

These are a few of the many types of baryons.

Symbol	Name	Quark content	Electric charge	Mass GeV/c^2	Spin
\mathbf{p}	proton	\mathbf{uud}	1	0.938	1/2
$\bar{\mathbf{p}}$	antiproton	$\bar{\mathbf{u}}\bar{\mathbf{u}}\bar{\mathbf{d}}$	-1	0.938	1/2
\mathbf{n}	neutron	\mathbf{udd}	0	0.940	1/2
Λ	lambda	\mathbf{uds}	0	1.116	1/2
Ω^-	omega	\mathbf{sss}	-1	1.672	3/2

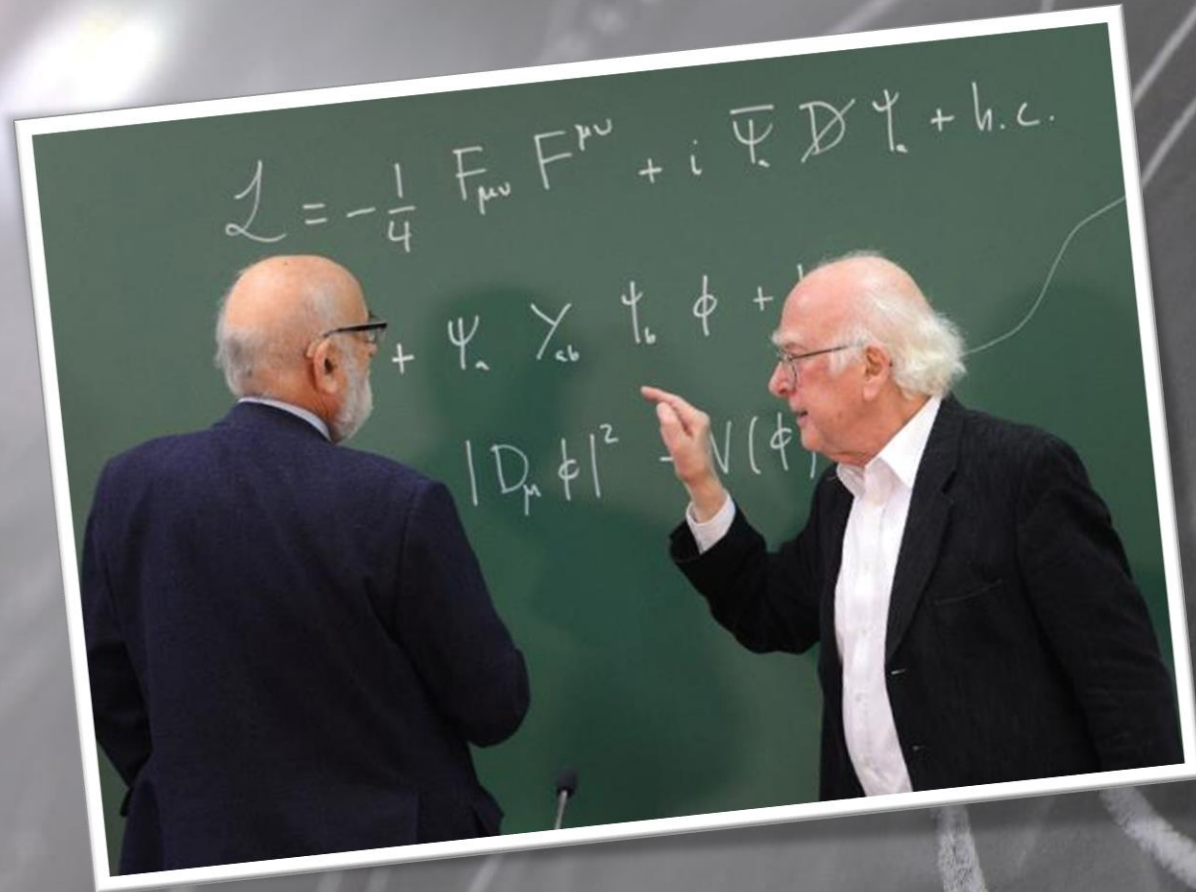
Mesons $q\bar{q}$

Mesons are bosonic hadrons

These are a few of the many types of mesons.

Symbol	Name	Quark content	Electric charge	Mass GeV/c^2	Spin
π^+	pion	$\mathbf{u}\bar{\mathbf{d}}$	+1	0.140	0
\mathbf{K}^-	kaon	$\mathbf{s}\bar{\mathbf{u}}$	-1	0.494	0
ρ^+	rho	$\mathbf{u}\bar{\mathbf{d}}$	+1	0.776	1
\mathbf{B}^0	B-zero	$\mathbf{d}\bar{\mathbf{b}}$	0	5.279	0
η_c	eta-c	$\mathbf{c}\bar{\mathbf{c}}$	0	2.980	0

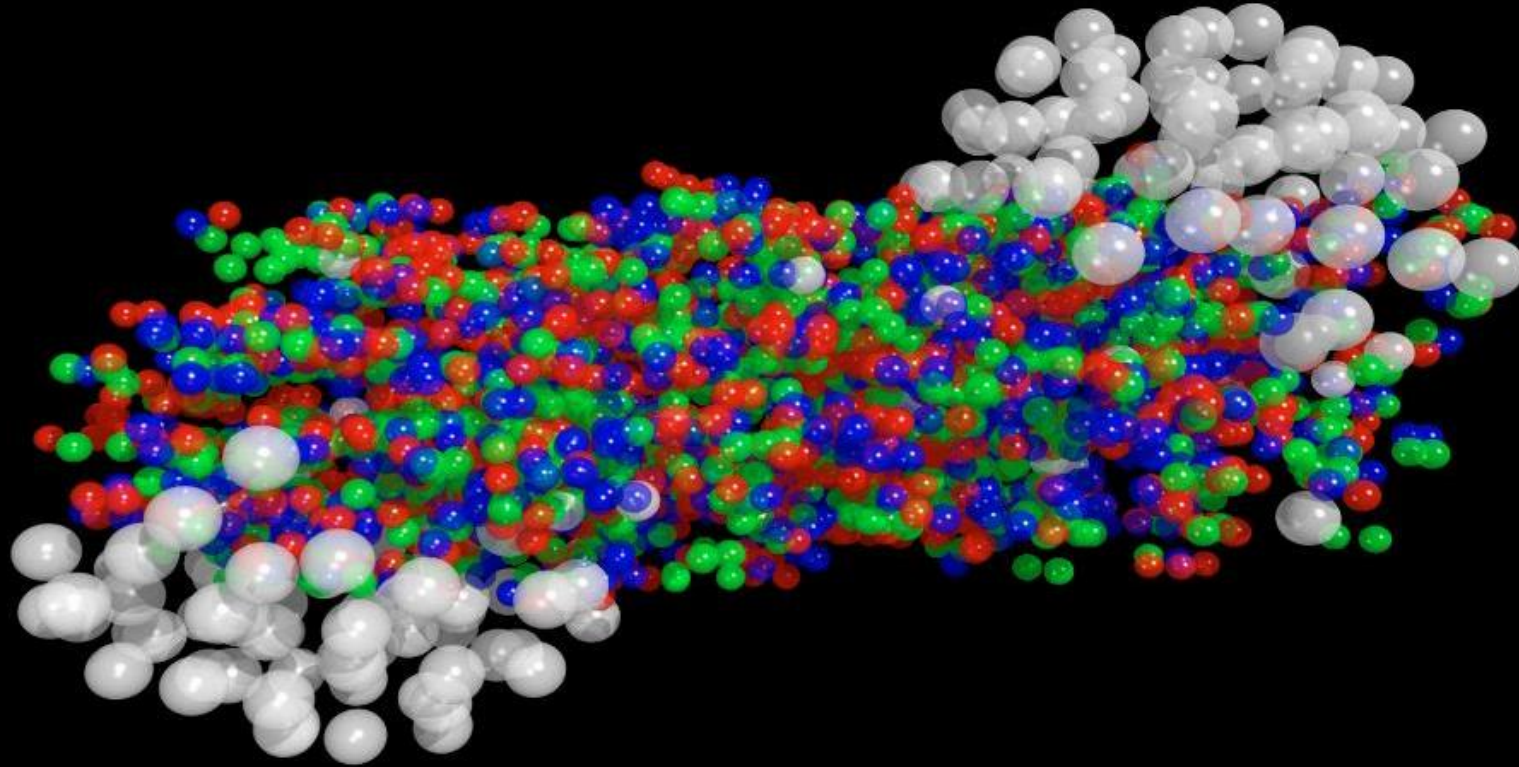
Answering questions...



Higgs

The Higgs boson

Answering questions ...



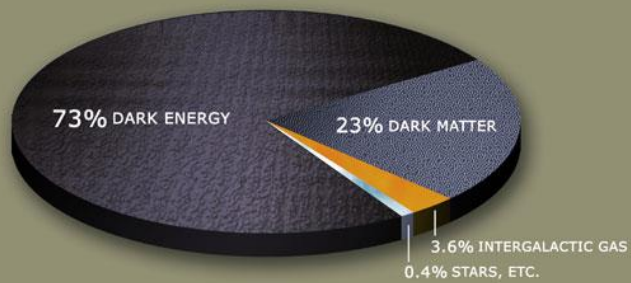
Quark gluon plasma?

Answering questions...



Antimatter ?

Answering questions...



4% is visible matter

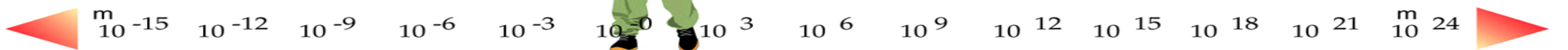
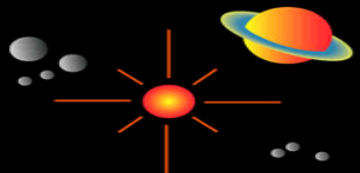
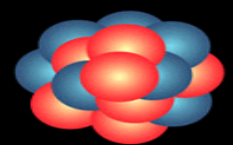
Dark matter?

La physique des particules étudie la matière dans ses dimensions les plus petites.

Particle physics looks at matter in its smallest dimensions.

L'astrophysique étudie la matière dans ses dimensions les plus grandes.

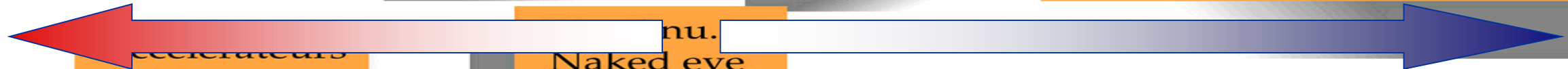
Astrophysics looks at matter in its largest dimensions.



Microscopes
Microscopes

Jumelles
Binoculars

Telescopes optiques & radio
Optical & radio telescopes

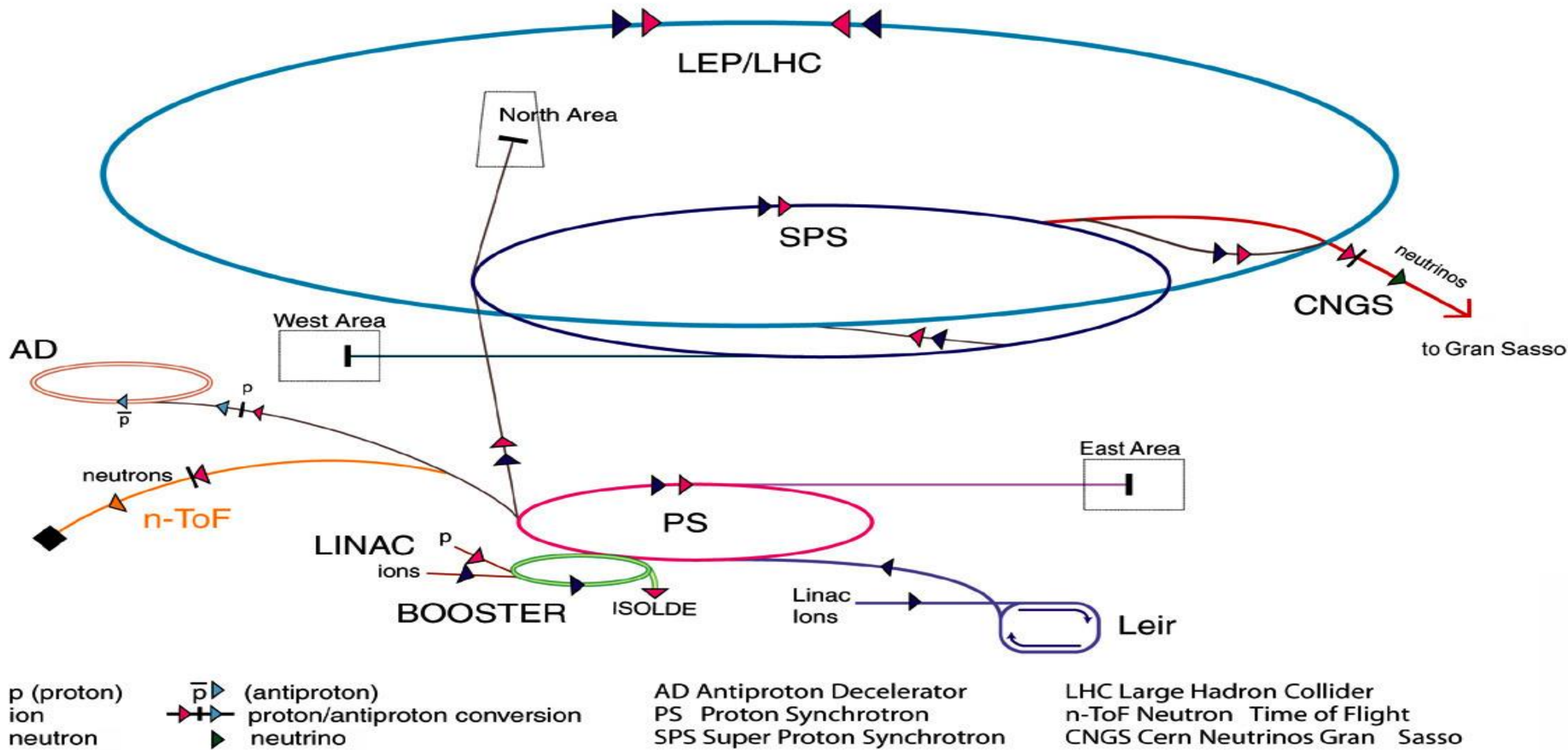


Accélérateurs
et détecteurs
Accelerators
and detectors

nu.
Naked eye

THE TWO FRONTIERS OF PHYSICS

LES DEUX FRONTIÈRES DE LA PHYSIQUE

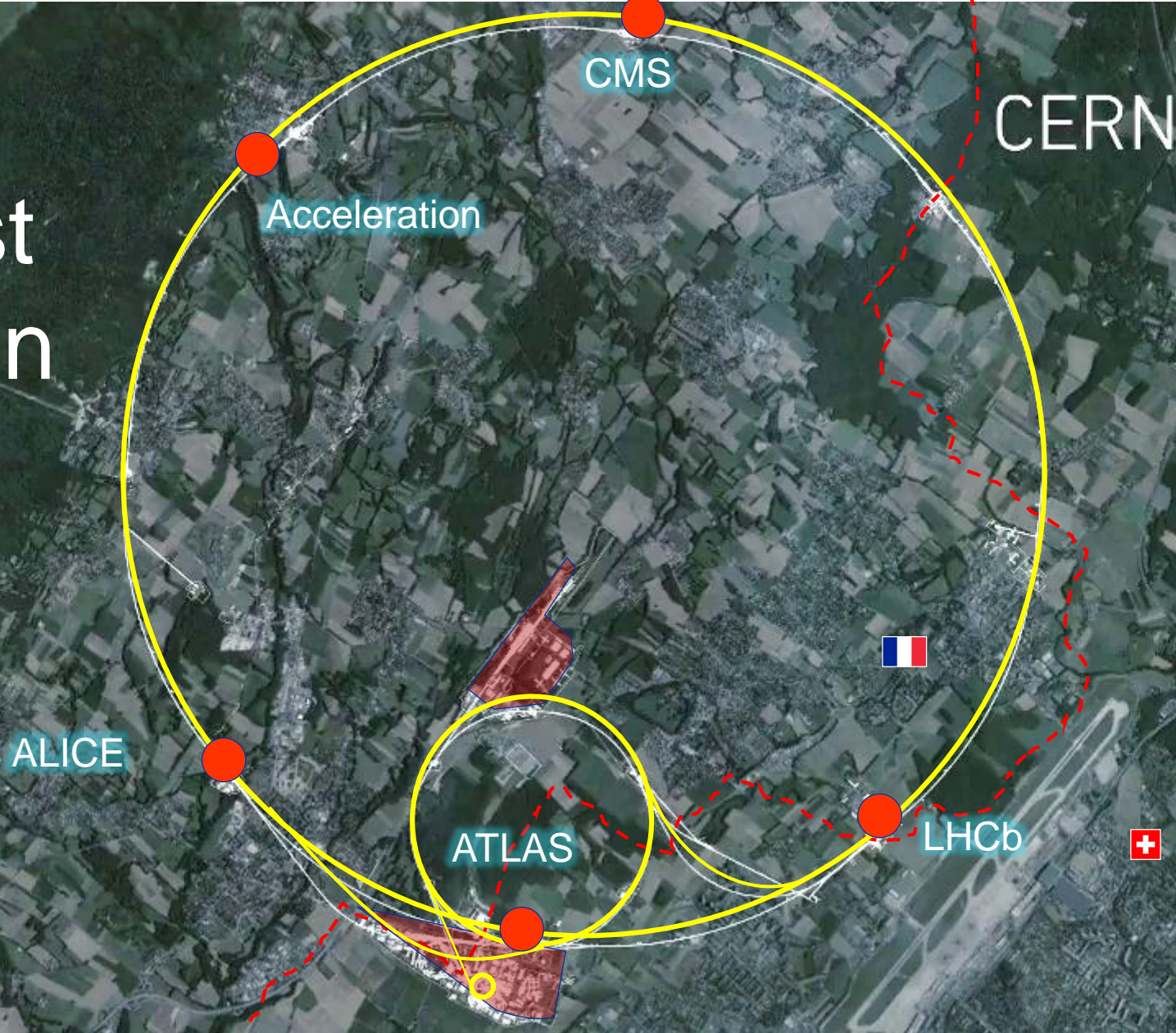


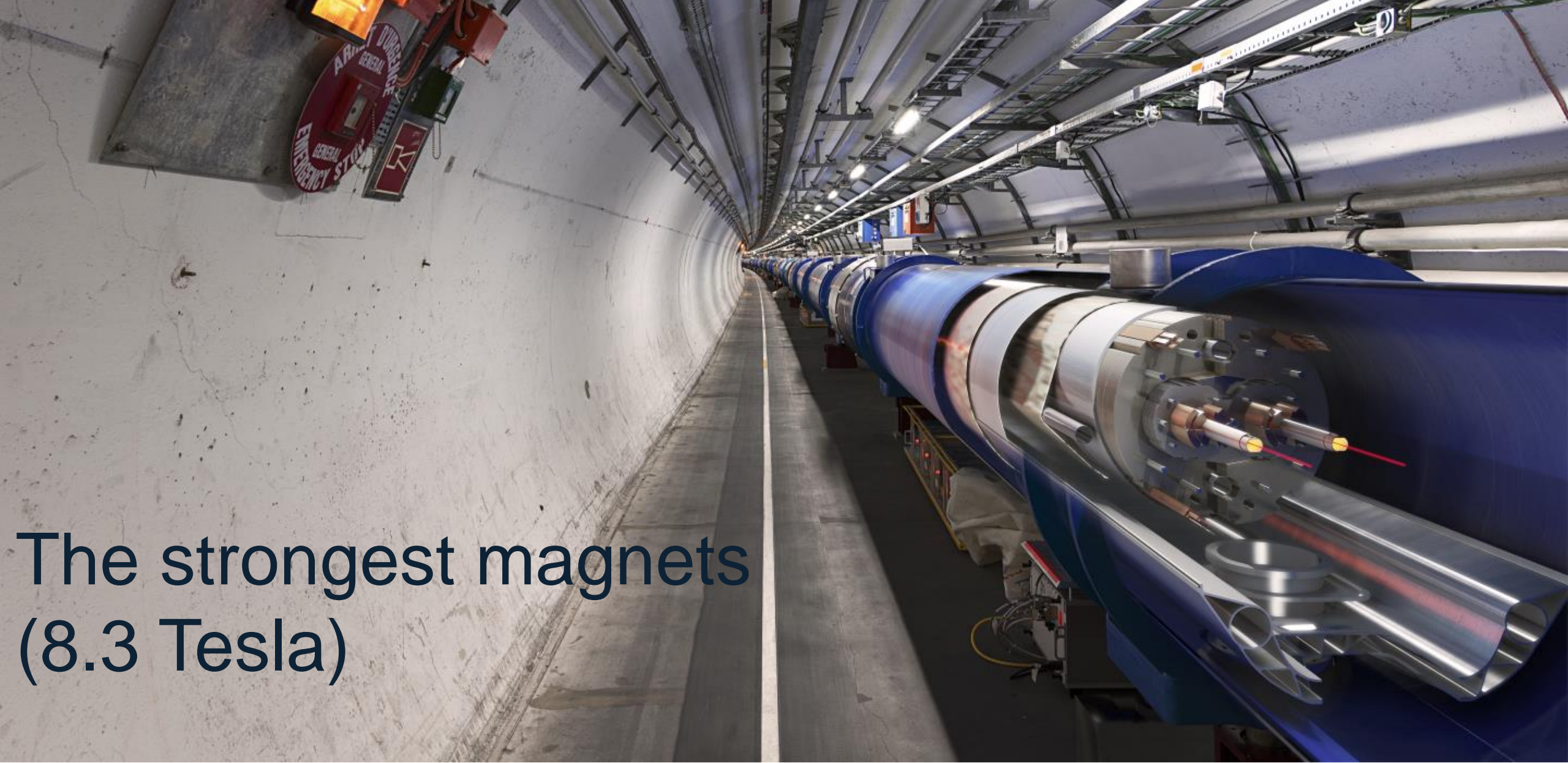
Background filled with various physics formulas:

- $-\frac{\hbar^2}{2m} \frac{d^2\psi}{dx^2} + V\psi = E\psi$
- $E = \hbar\omega$
- $U_{ef} = \frac{U_m}{\sqrt{2}}$
- $\vec{B} = \mu_0 \frac{NI\sqrt{2}}{2\pi r}$
- $k = \frac{p}{\hbar} = \frac{2\pi}{\lambda}$
- $\lambda = \frac{h}{p}$
- $\sqrt{2eUm_e}$
- $f_0 = \frac{1}{2\pi} \sqrt{\frac{g}{l}}$
- $\oint \vec{B} \cdot d\vec{l} = \mu_0 \iint_S \vec{J} \cdot d\vec{S}$
- $\vec{S} = \frac{1}{\mu_0} (\vec{E} \times \vec{B})$
- $v_{rms} = \sqrt{\frac{3kT}{m_0}} = \sqrt{\frac{3kTN_A}{M_m}} = \sqrt{\frac{3R_m T}{M_r \cdot 10^{-3}}}$
- $E = \hbar k^2 \cdot 1 \text{ pc} = \frac{1 \text{ AU}}{1 \text{ pc}}$
- $\Phi_e = \frac{L}{2\pi} \int \frac{1}{r^2} = \frac{L}{2\pi r^2}$
- $X_L = \frac{U_m}{I_m} = \omega L = 2\pi f L$
- $F_g = \frac{m_1 m_2}{r^2}$
- $R_m = \frac{C}{T}$
- $\omega = 2\pi f$
- $\frac{\sin \alpha}{\sin \beta} = \frac{v_1}{v_2} = \frac{m_2}{m_1}$
- $\phi_e = \frac{\Delta E}{\Delta t}$
- $\oint \vec{D} \cdot d\vec{S} = Q^*$

E = mc²

LHC the largest machine on Earth





The strongest magnets (8.3 Tesla)

Υπεραγώγιμοι μαγνήτες (μηδενική αντίσταση) σε πολύ χαμηλή θερμοκρασία (καλώδιο από Νιόβιο – Τιτάνιο)



The lowest temperature
1.9 K (-271° C)

Η ψύξη γίνεται με υγρό ήλιο

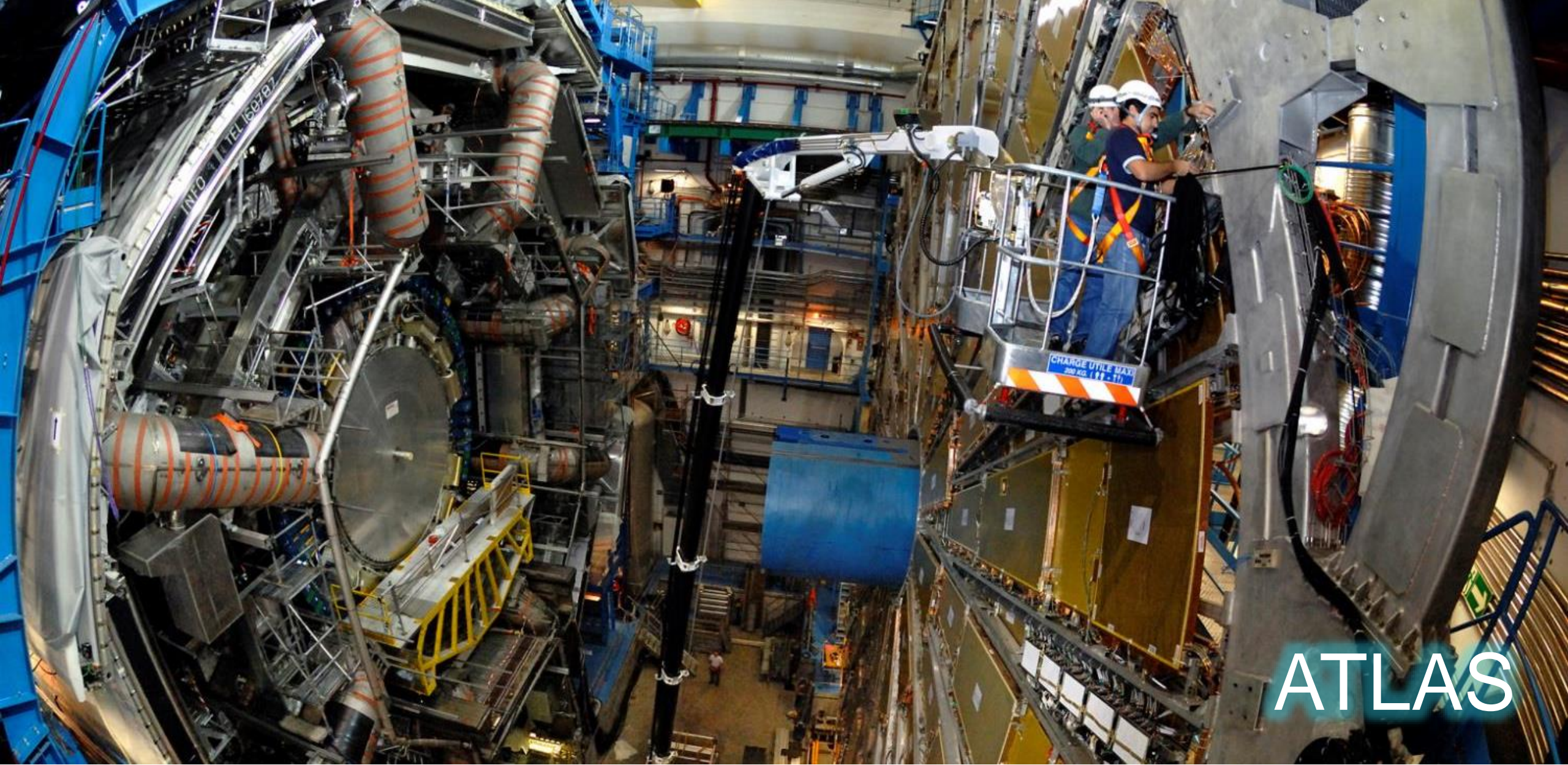


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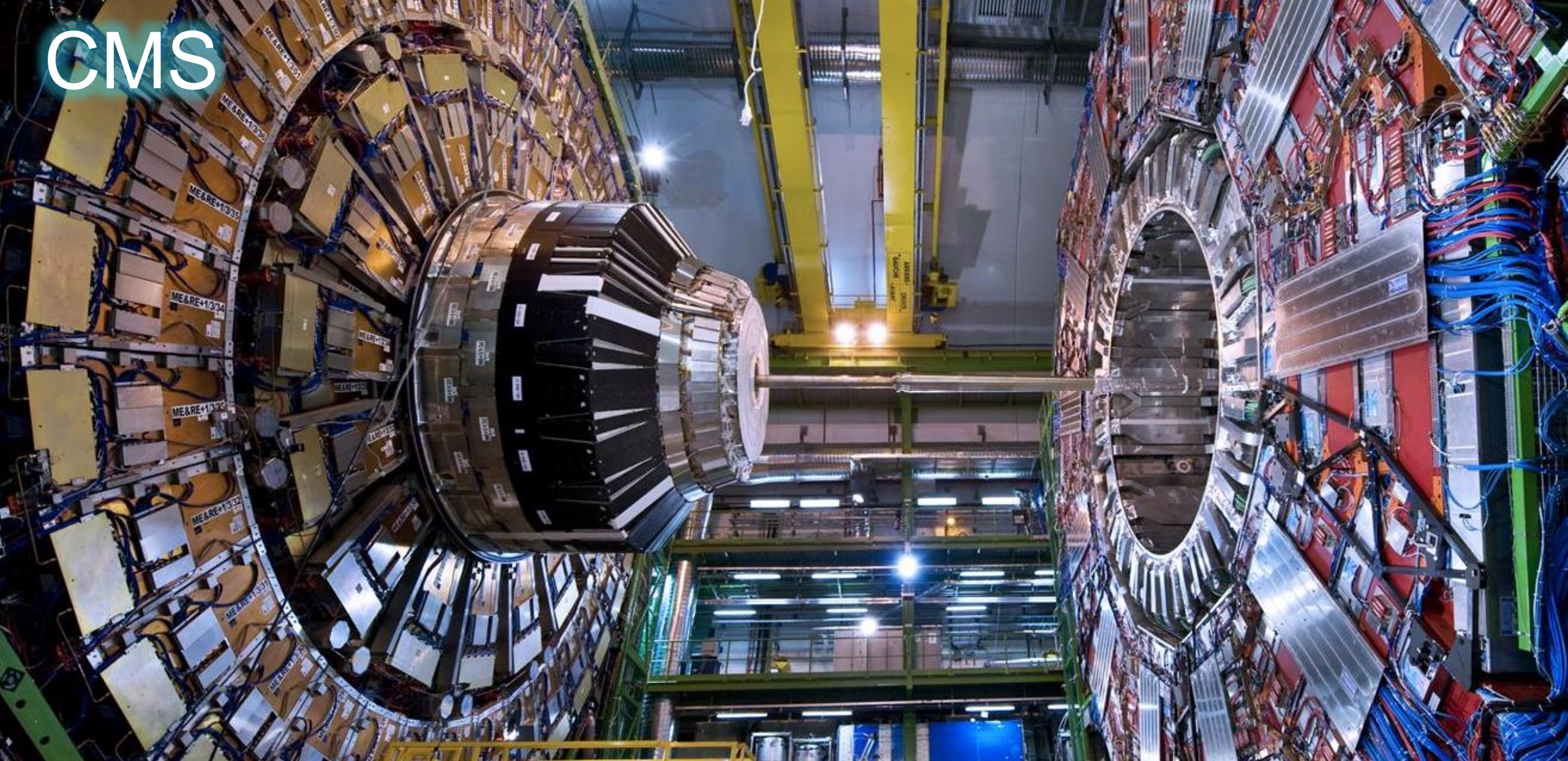


The highest vacuum 10^{-13} atm



ATLAS

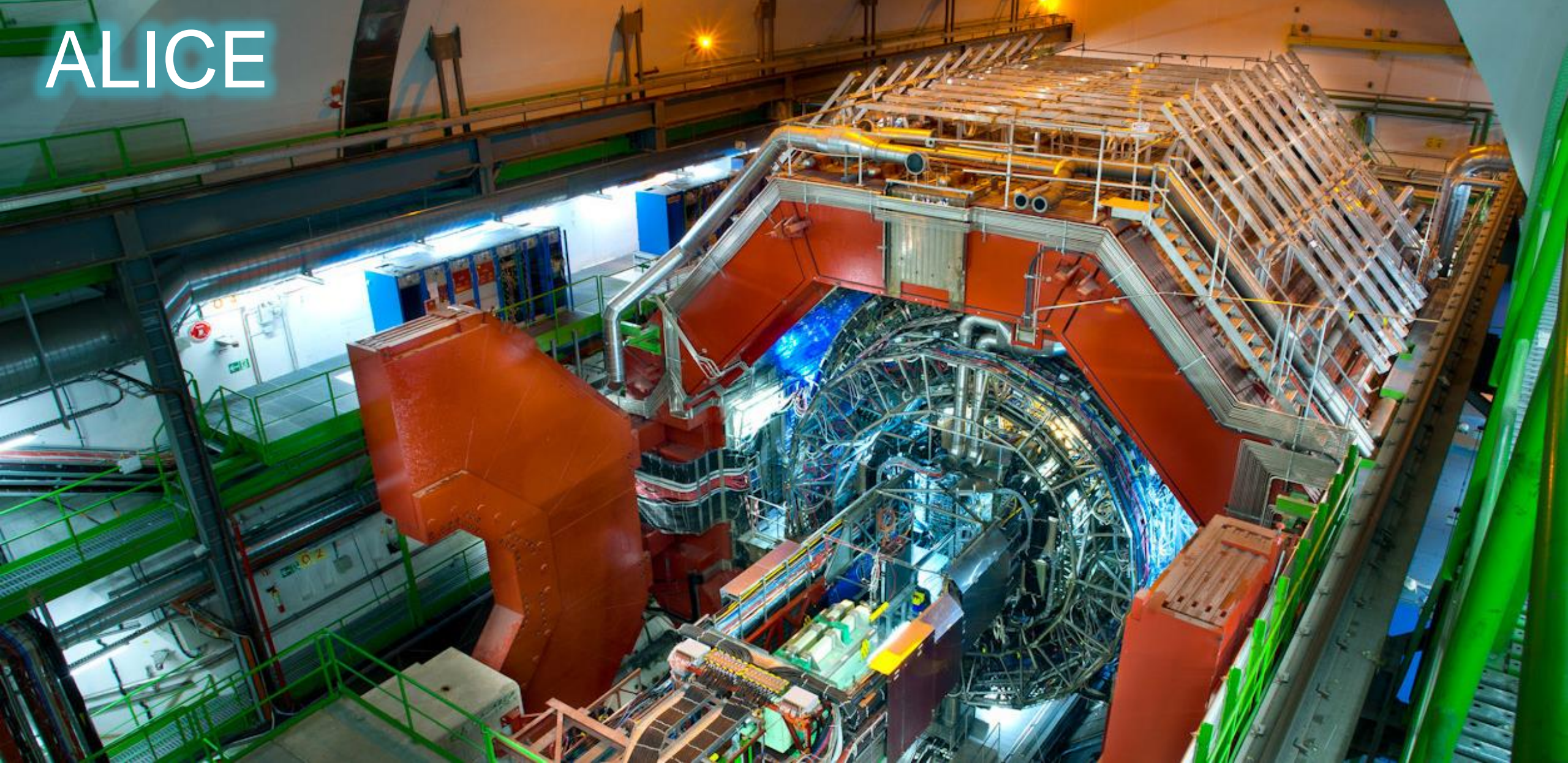
CMS



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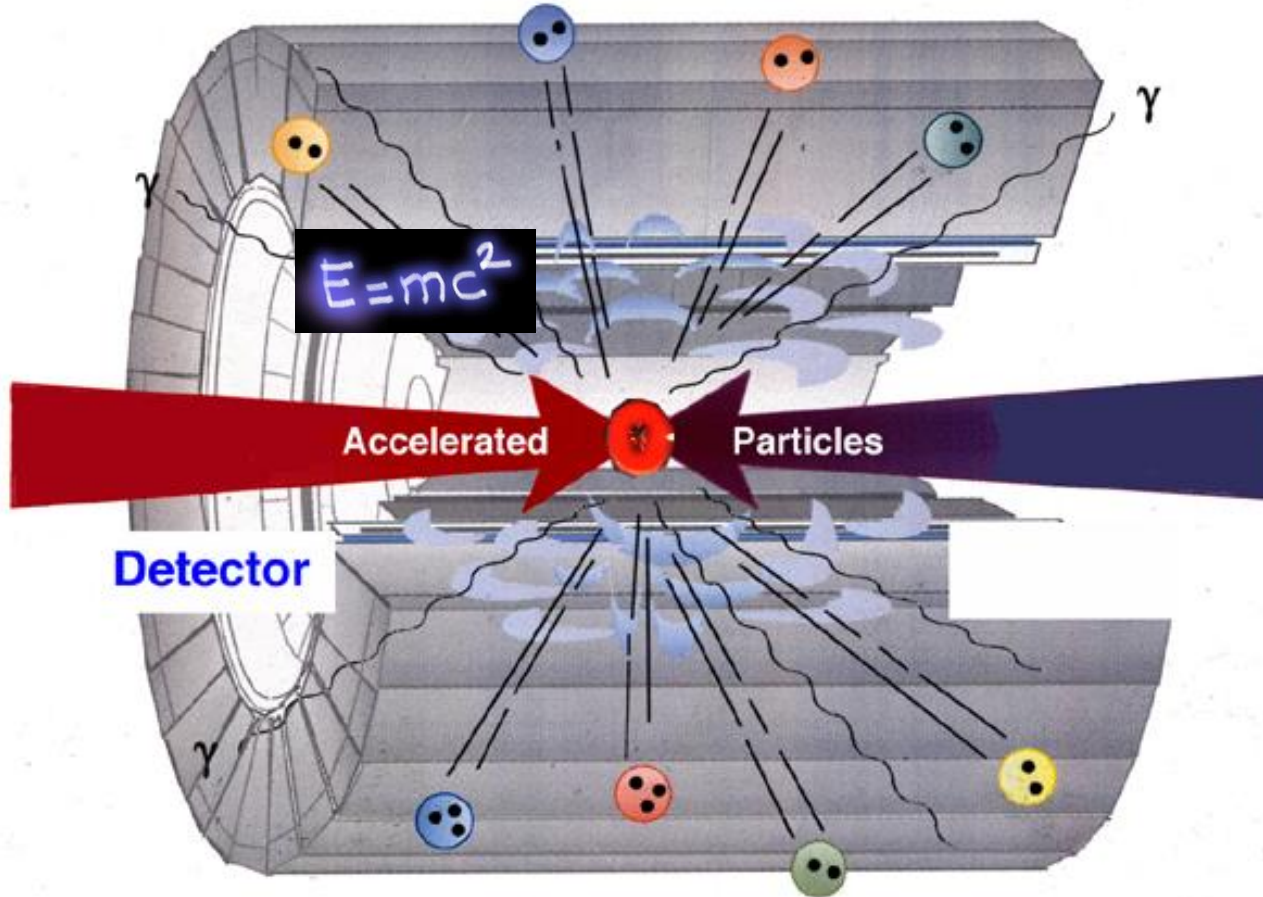
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ALICE





LHCb



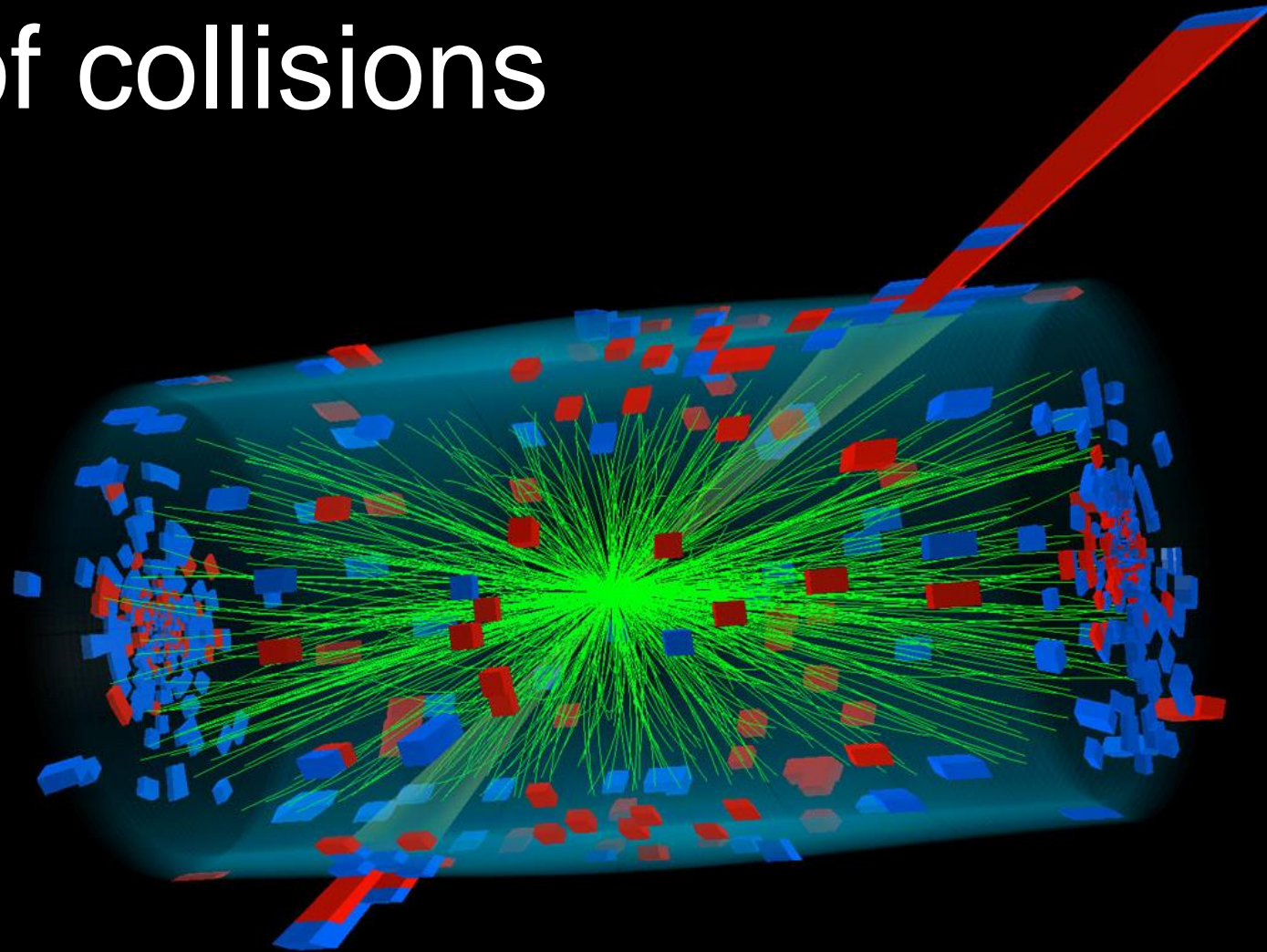
1) By accelerating protons we concentrate energy on them

2) The protons collide – their energy is released at the point of collision

3) Energy is transformed into mass : new particles are produced

4) Detectors “see” these new particles, measure their characteristics (momentum, energy, charge) and identify them

Millions of collisions



- Protons are injected into the LHC in bunches (100 billion protons) every 25 ns;
- They are accelerated from 450 GeV to 7 TeV
- They reach 99.9999991% of the velocity of light
- Protons go around the LHC 11245 times/s
- 40 million times/s bunches pass each collision point
- 31.2 MHz crossing rate
- 20 collisions expected from (100 on 100 billion p)
- 600 million particle collisions per second
- After filtering, 100-100 collisions of interest per second
- A Megabyte of data digitised for each collision
- recording rate of 0.1 Gigabytes/sec
- 10^{10} collisions recorded each year
= 10 Petabytes/year of data

1 Megabyte (1MB)

A digital photo

1 Gigabyte (1GB) = 1000MB

A DVD movie

1 Terabyte (1TB) = 1000GB

World annual book
production

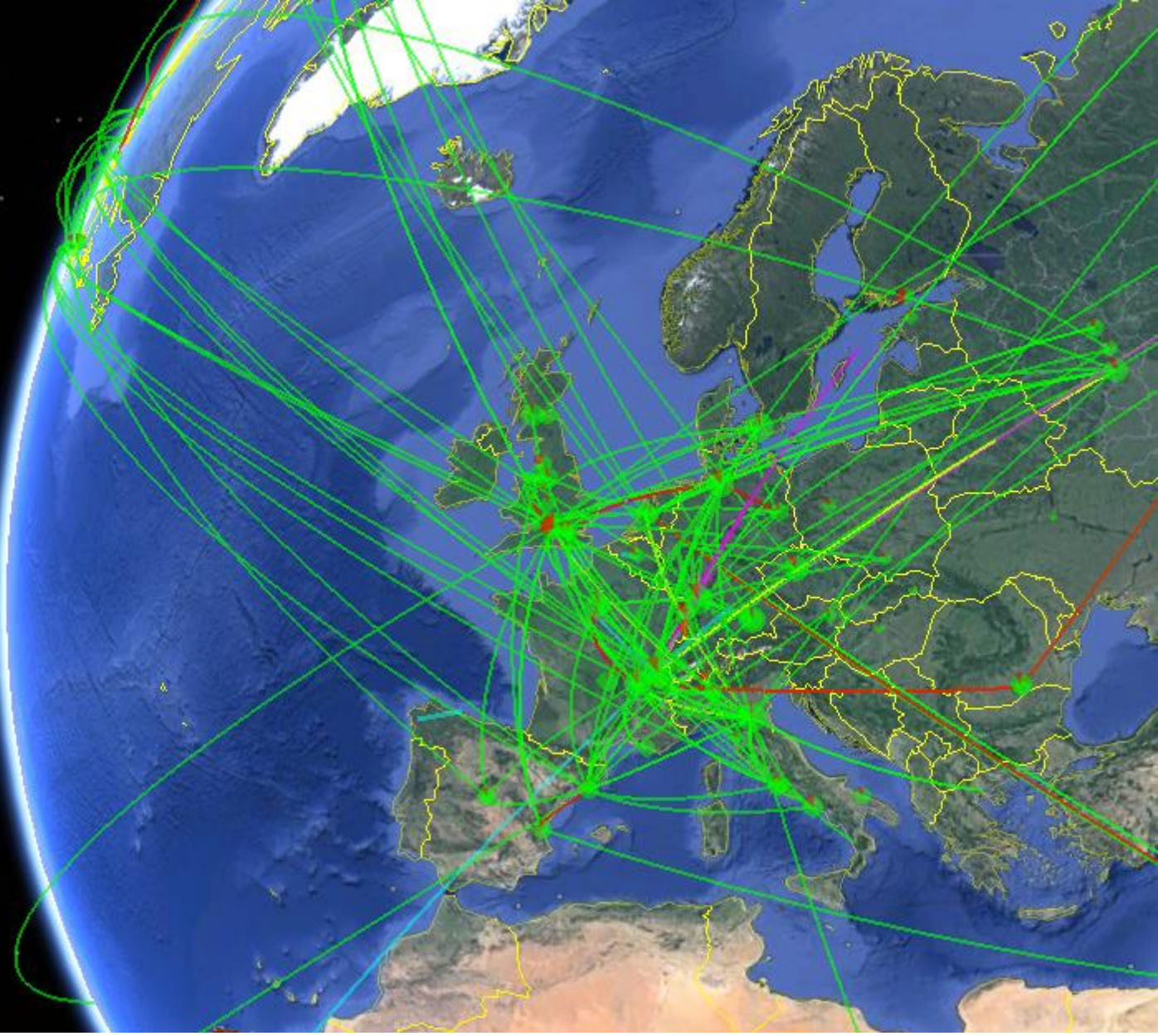
1 Petabyte (1PB) = 1000TB

Annual production of one
LHC experiment

1 Exabyte (1EB) = 1000 PB

World annual information
production

The largest computing grid



CERN spin-offs

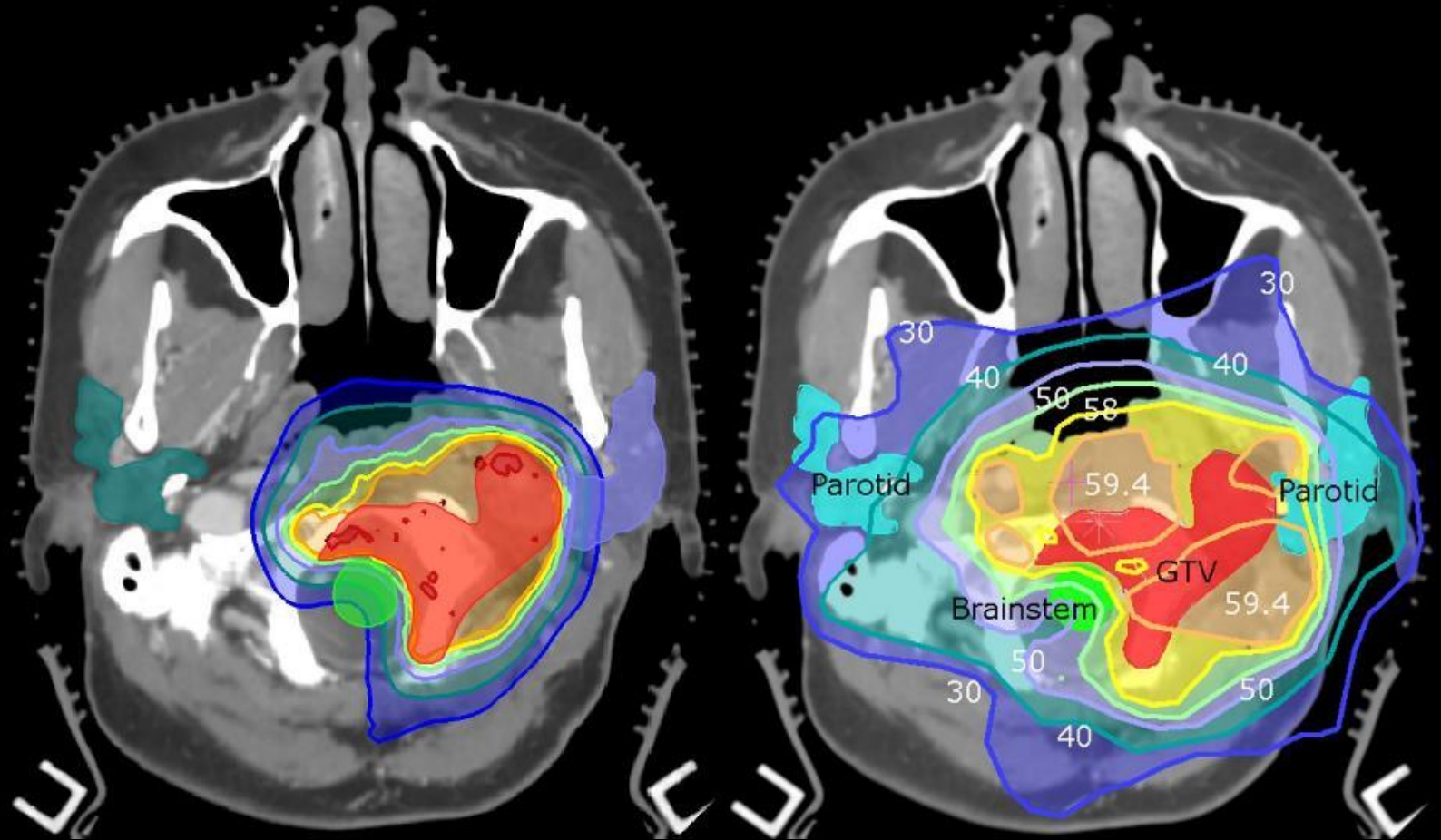
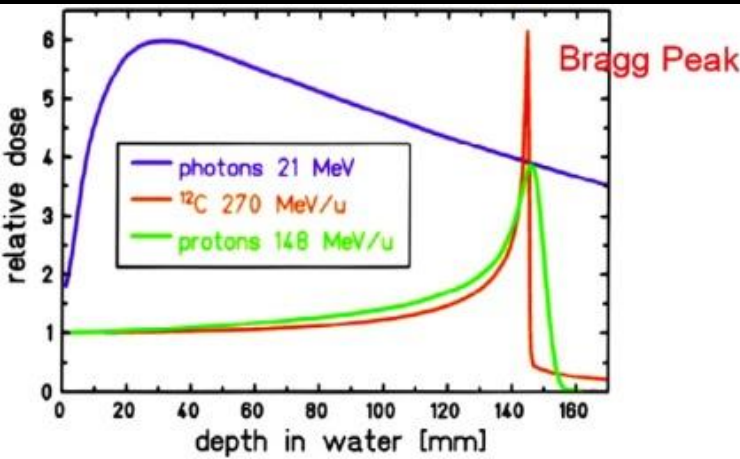
What are the benefits for us?

World Wide Web

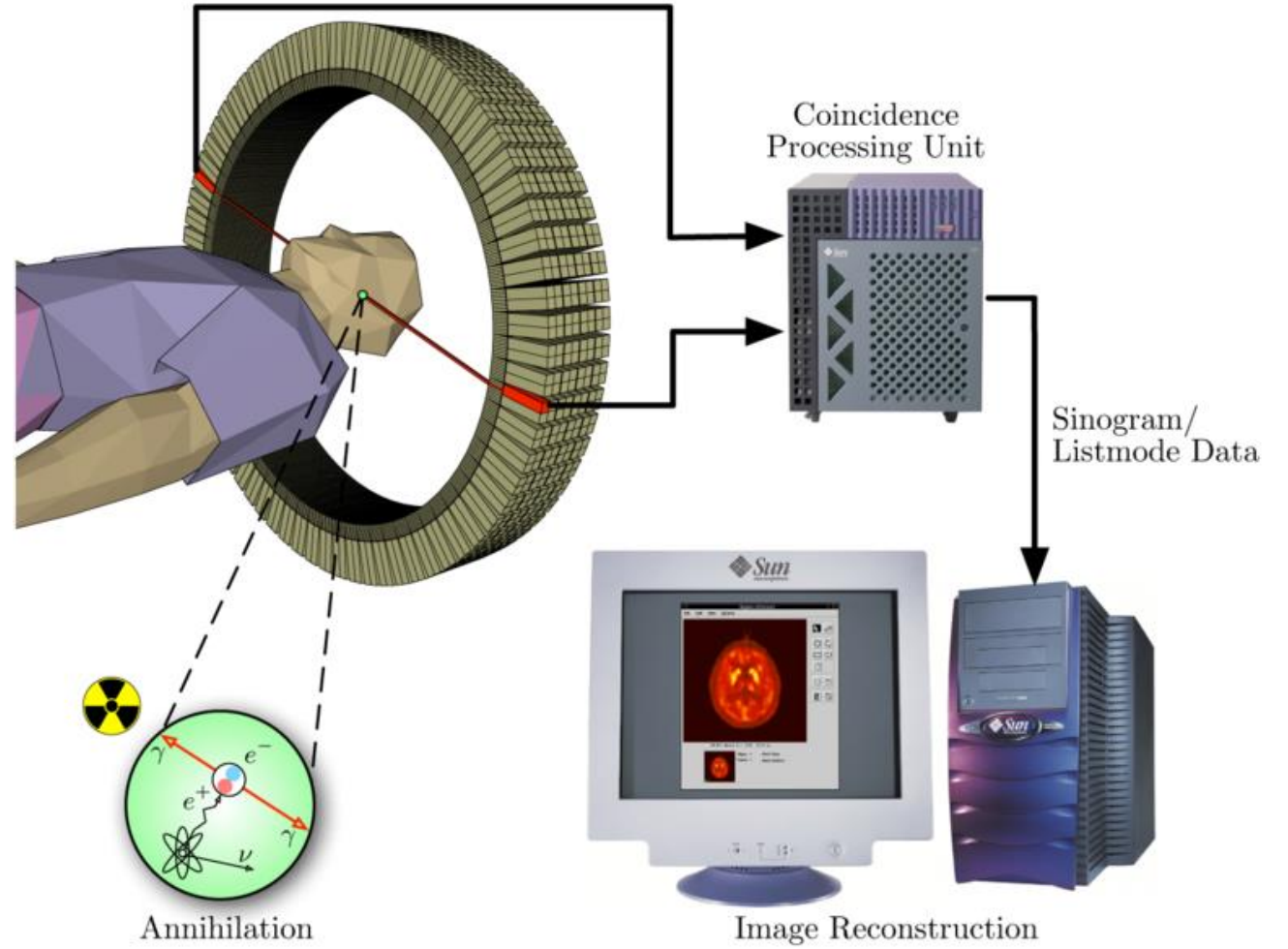
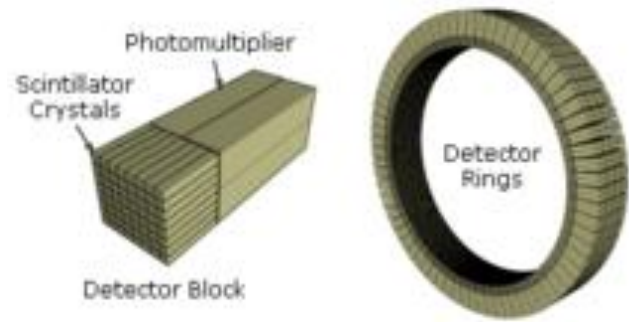
HTTP



Medical applications: hadron therapy



Medical applications: Positron Emission Tomography (PET)



In a nutshell...



Thanks for your attention!

Thanks for filling
up the survey!

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- despina.hatzifotiadou@cern.ch