

# Quand l'infiniment grand rencontre l'infiniment petit

François Briard

Visites et organisation des événements

Ingénieur en informatique UNamur (1993)

La conférence commence bientôt



# Votre conférence virtuelle

## **Format**

- Présentation (environ 40 minutes au total)
- Questions-Réponses (environ 20 minutes au total)

## **Pendant la présentation**

- Posez des questions via le Q&A

## **Après la présentation**

- Merci de répondre à l'enquête sur la page Indico
- Présentation et liens disponibles sur la page Indico



Que fait un informaticien  
(*allergique à la physique*)  
au CERN ?

# Le CERN

*C'est quoi ?*

Que signifie « CERN » ?

Conseil  
Européen pour la  
Recherche  
Nucléaire

1953



Que signifie « CERN » ?

Organisation

Européenne pour la  
Recherche  
Nucléaire

1954



# Nucléaire?



Laboratoire européen pour la physique des particules

# Le CERN

*C'est qui ?*



# Etats membres

Budget (2020)  
 1,168 milliard CHF  
 1,108 milliard EUR



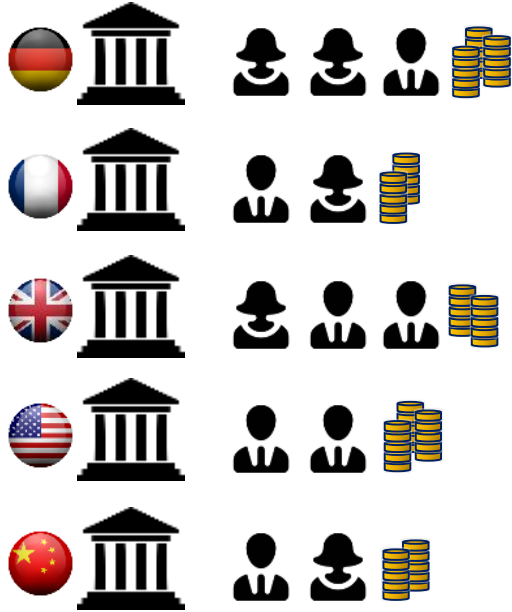
LHC

-  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-)

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



# Collaborations



En réalité, ATLAS compte

- 44 pays
- 261 instituts
- 8442 participants

et il y a 261 collaborations actives en 2020

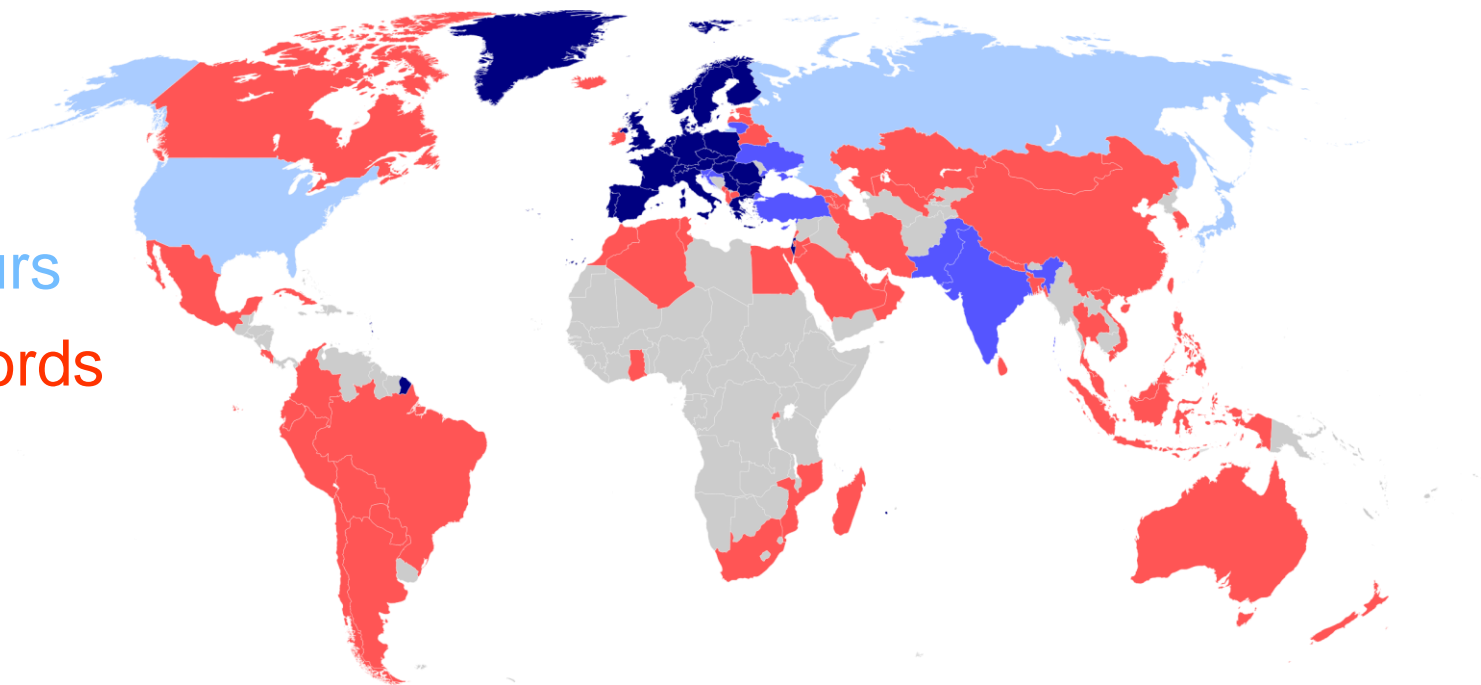
# Une collaboration mondiale

23 membres

8 associés

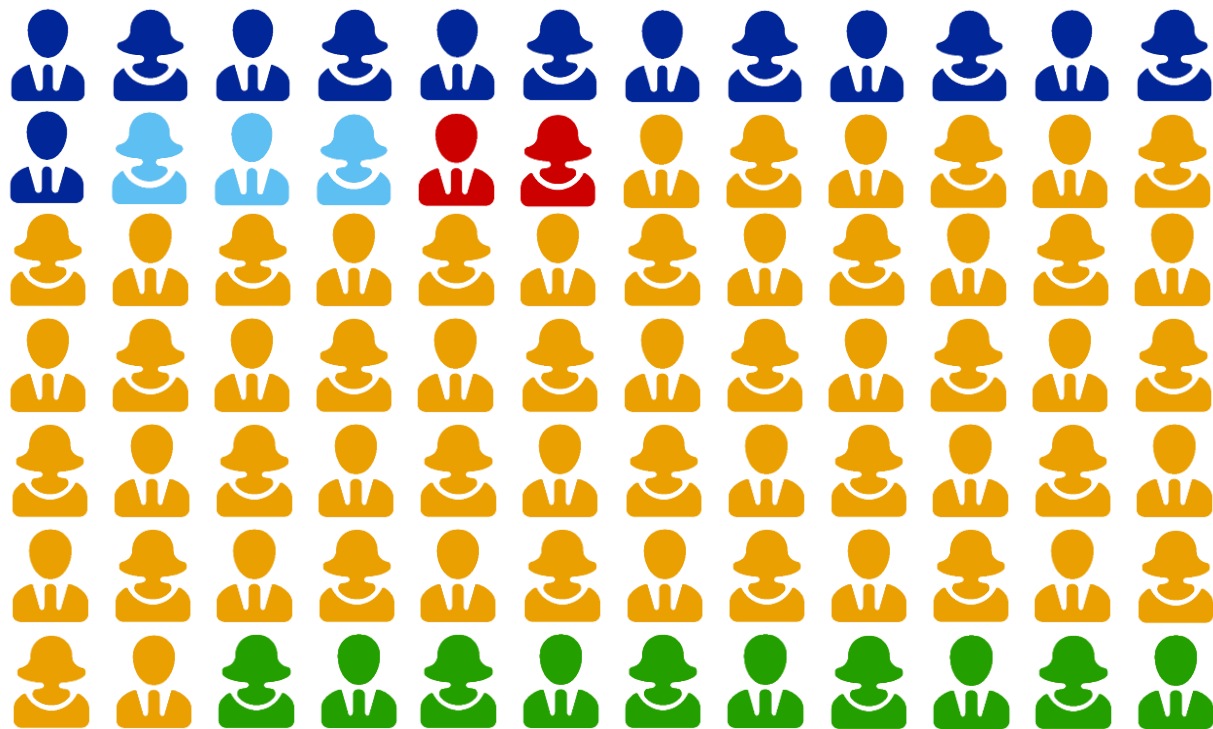
3 observateurs

61 avec accords



# Combien de personnes?

20 000!



2 600 titulaires

800 boursiers  
& apprentis

550 étudiants

15 000 utilisateurs

2 000 entreprises  
extérieures

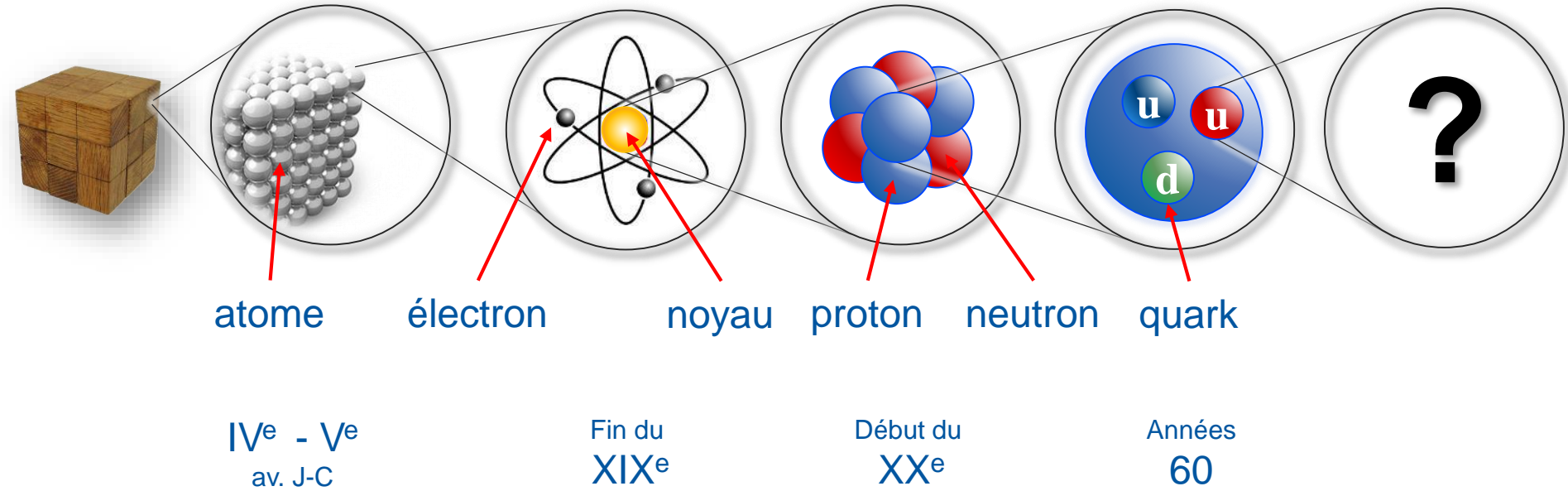
# Le CERN

*A quoi ça sert ?*

# Recherche fondamentale



# De quoi est composée la matière ?



# Vérifier des théories

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

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

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

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

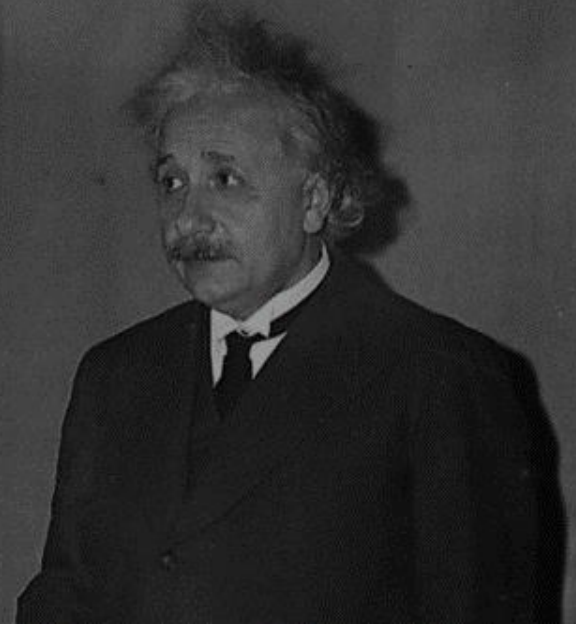
$$\sum \frac{u_i}{\sqrt{1-u^2}} = \frac{2v}{\sqrt{1-u^2} \sqrt{1-v^2}}$$

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

$$\sum \mathcal{E}_i = \sum \mathcal{E}_i \text{ (conserved)}$$

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

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



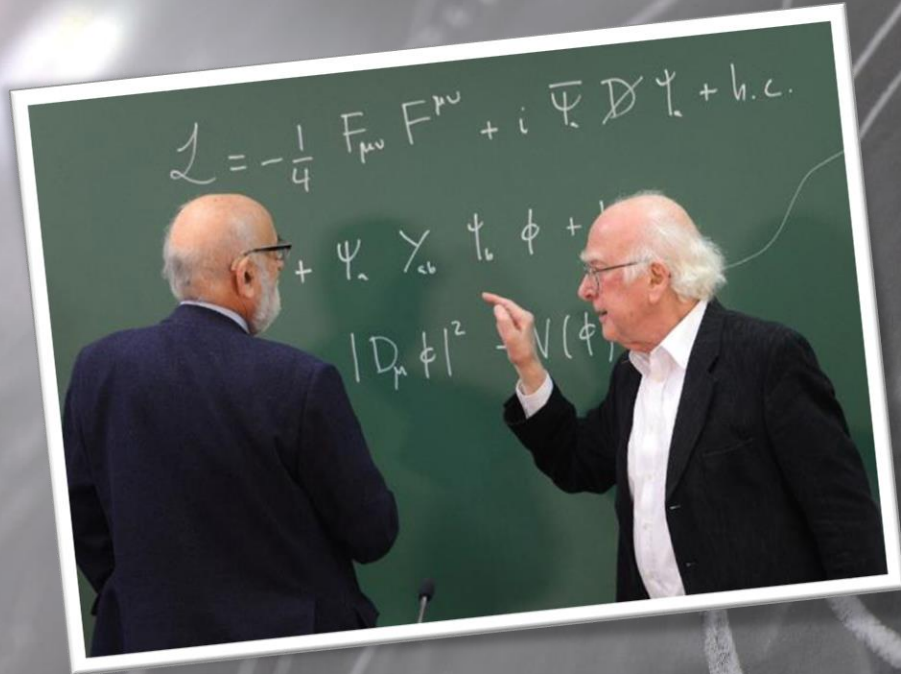


# Le modèle standard

Images:  
[www.particlezoo.net](http://www.particlezoo.net)



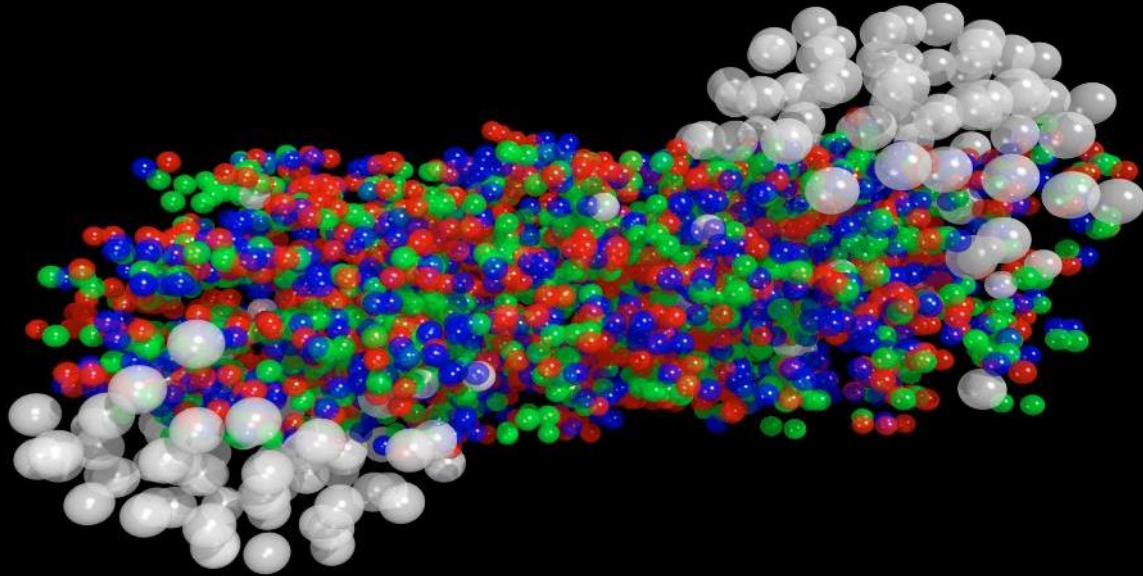
# Répondre à des questions...



Higgs

*Higgs ?*

# Répondre à des questions...



*Le plasma quark-gluon ?*

Répondre à des questions...



*Antimatière ?*

Répondre à des questions...

*Matière noire ?*

Le CERN

*Comment ça marche ?*



# Accélérer, faire entrer en collision



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

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

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

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

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

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

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

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

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

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

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

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

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

$$\omega = 2\pi f$$

$$\frac{\sin\alpha}{\sin\beta} = \frac{v_1}{v_2} = \frac{w_2}{w_1}$$

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

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

$$\frac{\Delta I_B}{X} + \frac{w_2}{X'} = \frac{w_2 - w_1}{v}$$

$$\phi = \frac{2\pi \sin^2 \theta}{\lambda}$$

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

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

$$E = \hbar k^2$$

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

$$U = \frac{W_{AB}}{|E_{PA} - E_{PB}|} = |\varphi_A - \varphi_B|$$

$$\varphi_E = \frac{E_c}{\rho_0} = k \frac{Q}{r^2} \varphi$$

$$m = N \cdot m_0 = \frac{Q}{v_e} \frac{M_m}{N_A}$$

$$l_t = l_0(1 + d \Delta t)$$

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

$$E = m c^2$$

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

$$E = \hbar k^2$$

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





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

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

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

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

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

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

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

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

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

$$\Phi_e = \frac{L}{\Delta t} = \frac{L}{\frac{\Delta t'}{\sqrt{1-\frac{v^2}{c^2}}}}$$

$$4\pi r^2$$

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

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

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

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

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

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

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

$$k = \frac{\lambda_1}{4\pi \epsilon_0 \epsilon_r \lambda^2}$$

$$v_k = \sqrt{\frac{M_m}{R_m}}$$

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

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

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

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

$$\omega = 2\pi f$$

$$\frac{\sin \alpha}{\sin \beta} = \frac{v_1}{v_2} = \frac{w_2}{w_1}$$

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

$$F_x = \frac{1}{2} \epsilon_0 \rho \sigma^2$$

$$\frac{w_1}{x} + \frac{w_2}{x'} = \frac{w_2 - w_1}{v}$$

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

$$R = \frac{U}{I}$$

$$W_2 = U_e I t$$

# E = mc<sup>2</sup>



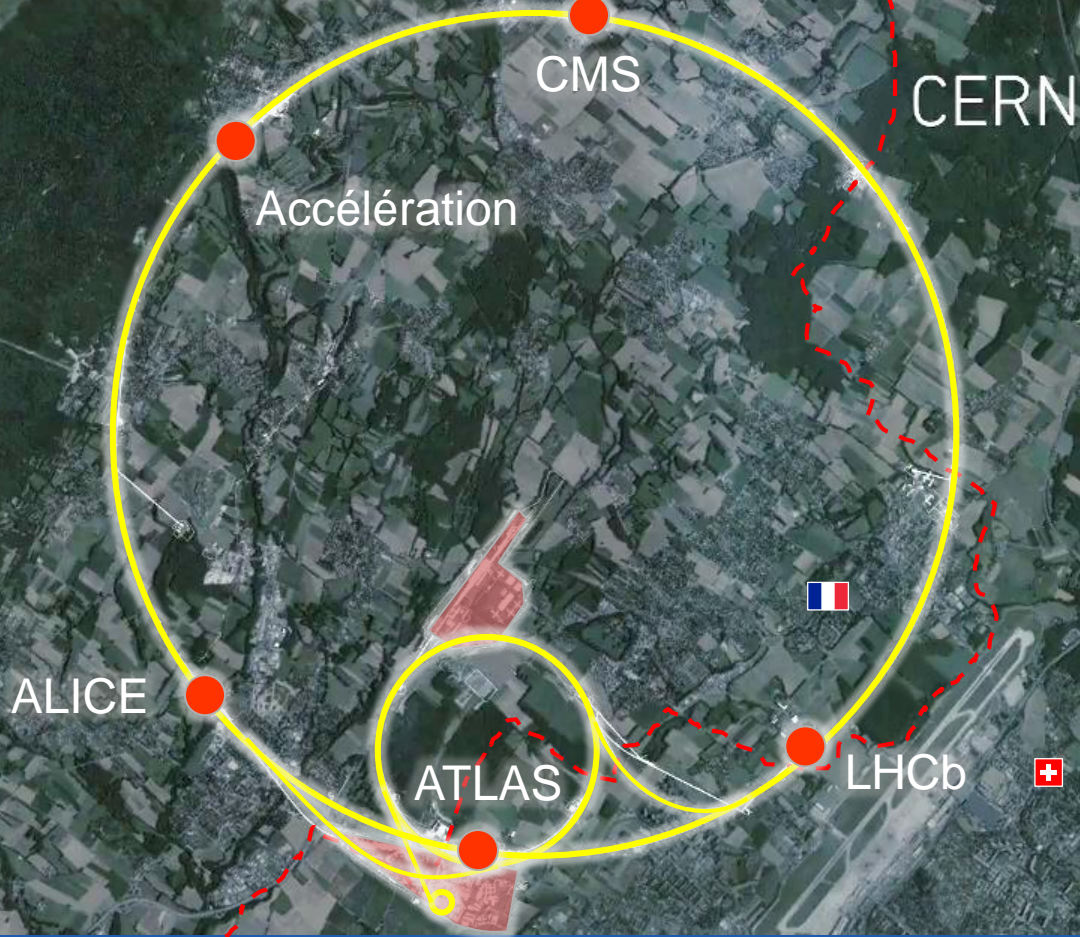
# Une énergie incroyable

7 TeV



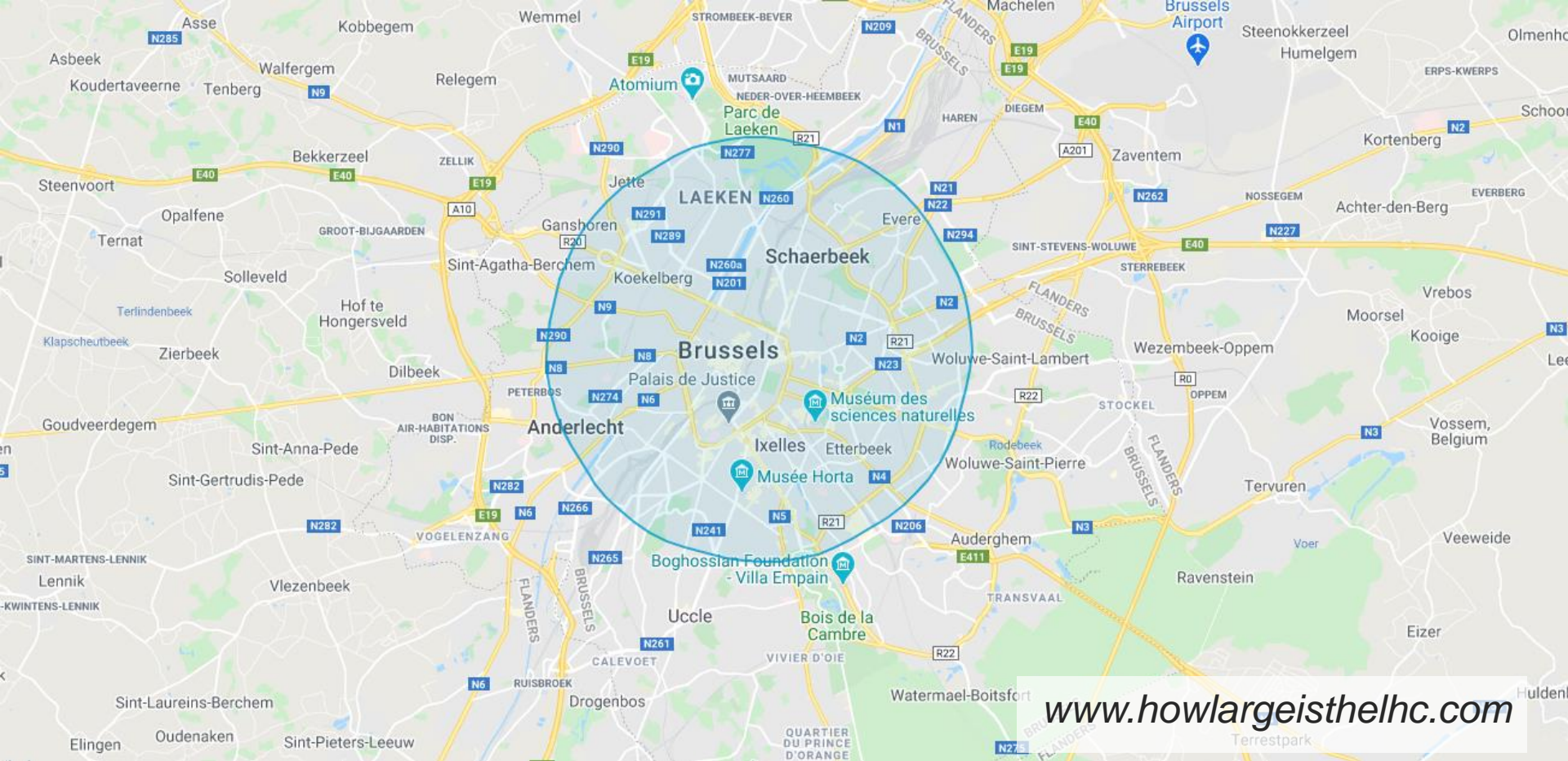
L'énergie de  
100'000'000'000'000'000'000'000 de protons  
dans un seul proton

# La plus grande machine sur Terre



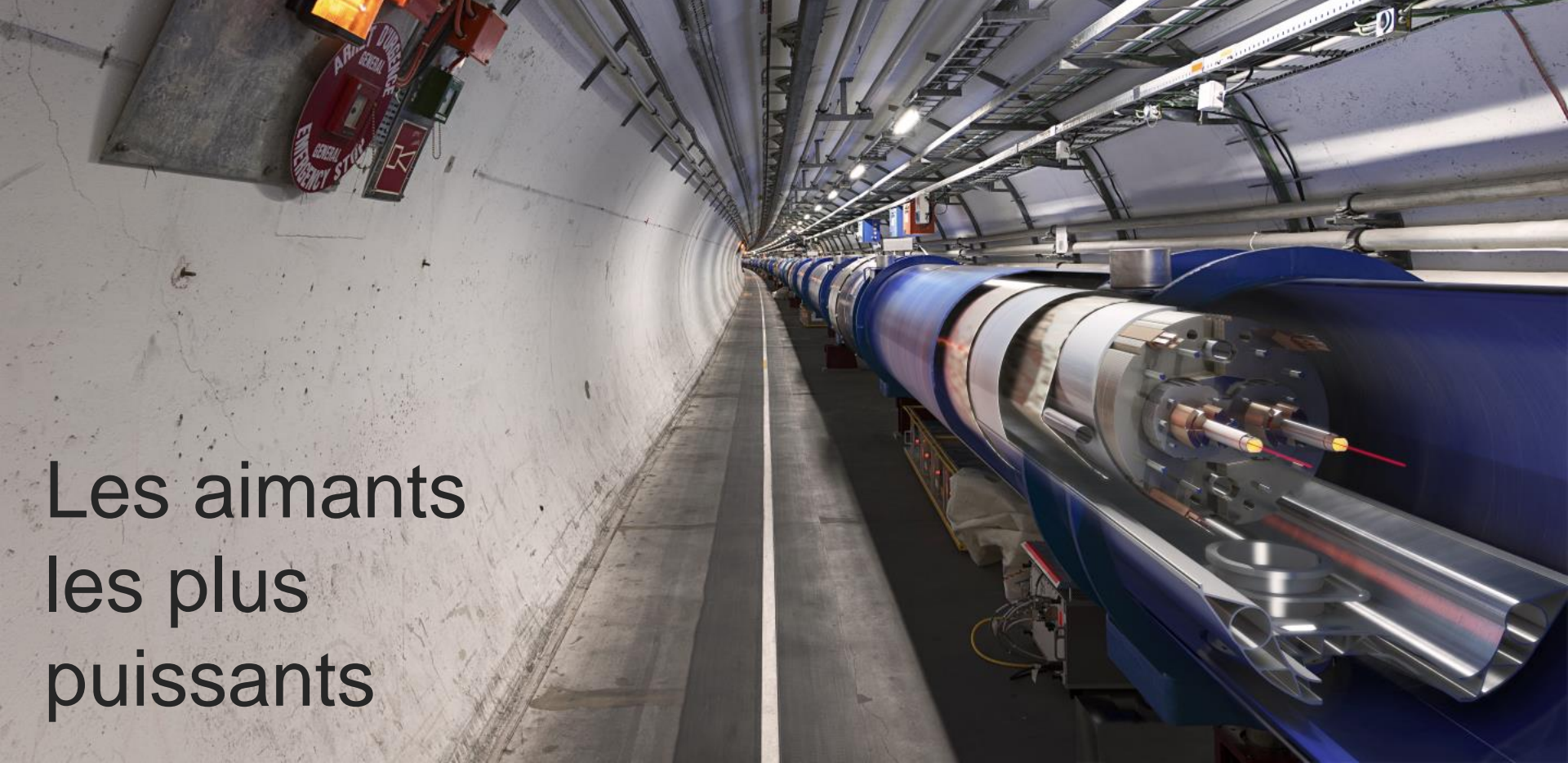
Le LHC, c'est un peu comme le périph...





[www.howlargeisthelhc.com](http://www.howlargeisthelhc.com)





# Les aimants les plus puissants

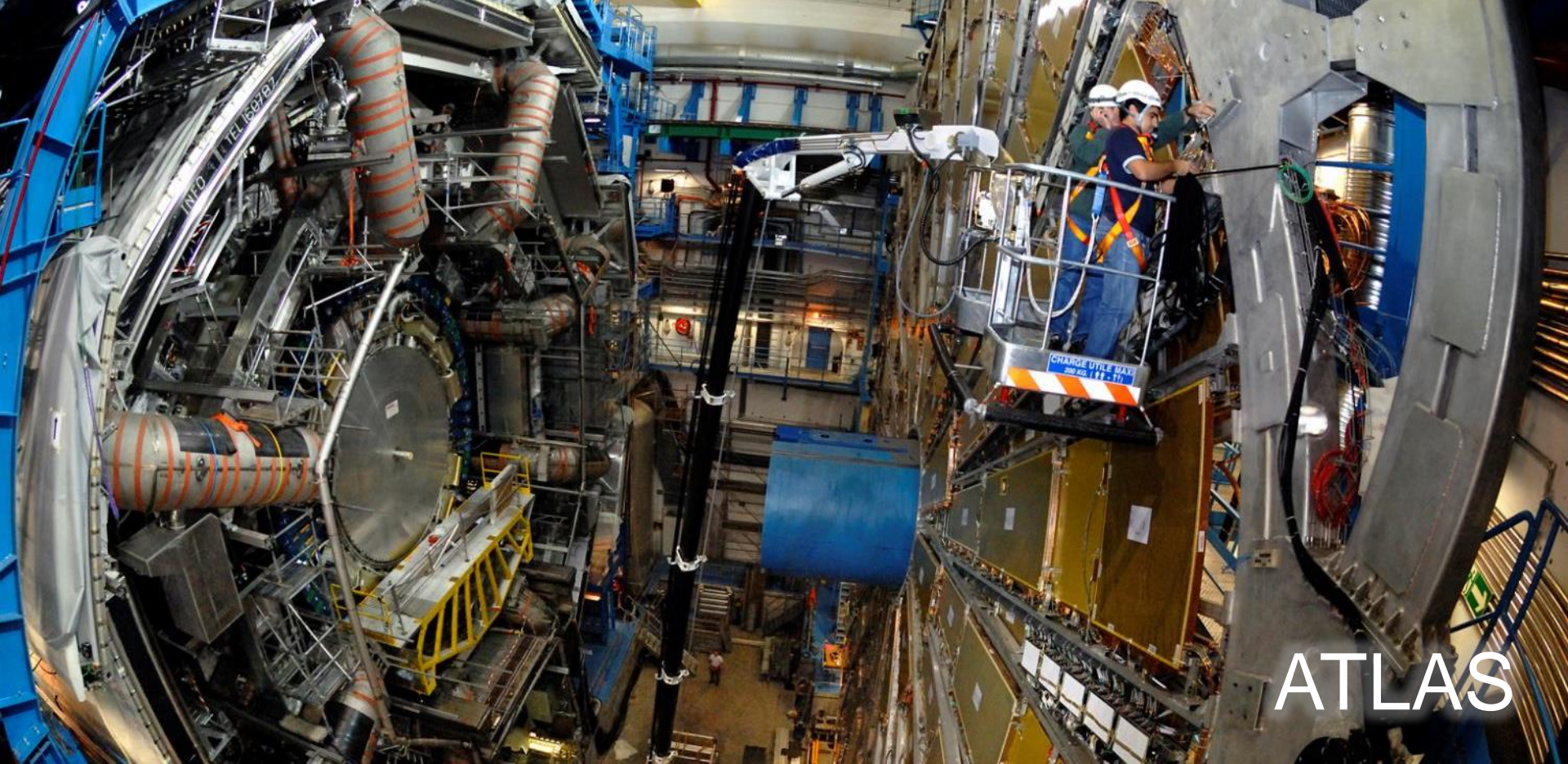


# Le vide le plus extrême



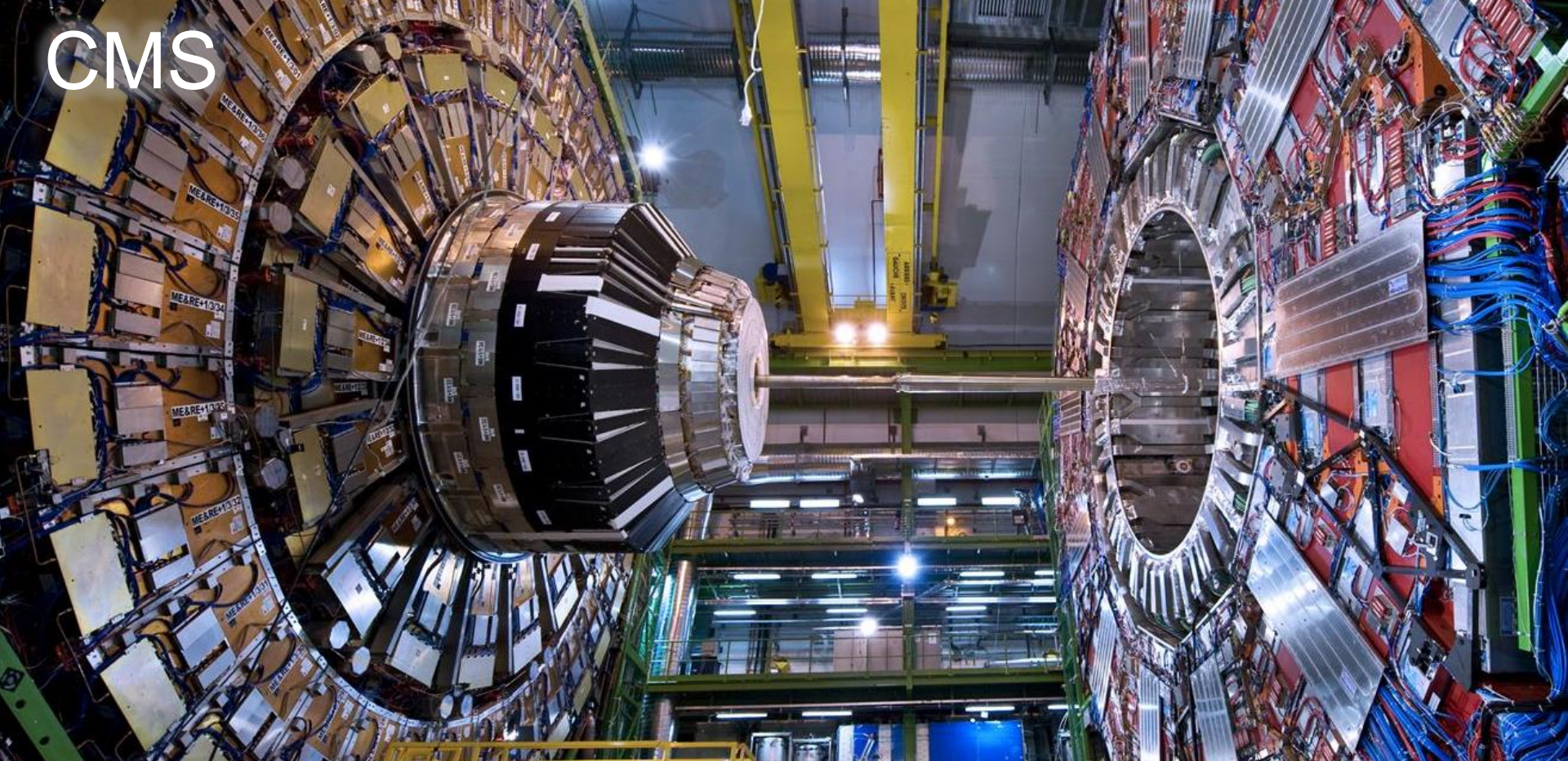
Le froid  
le plus glacial



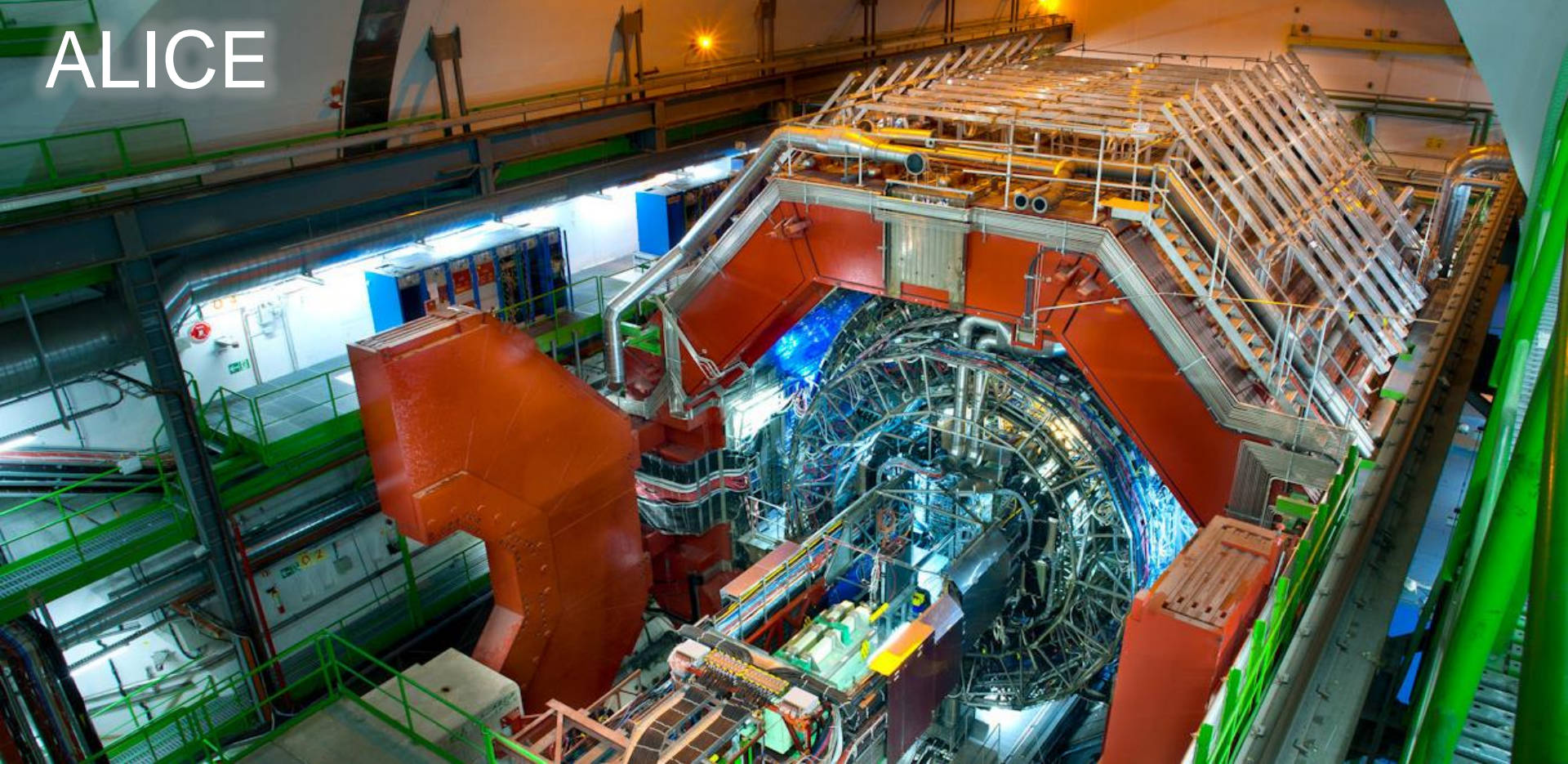


ATLAS

# CMS



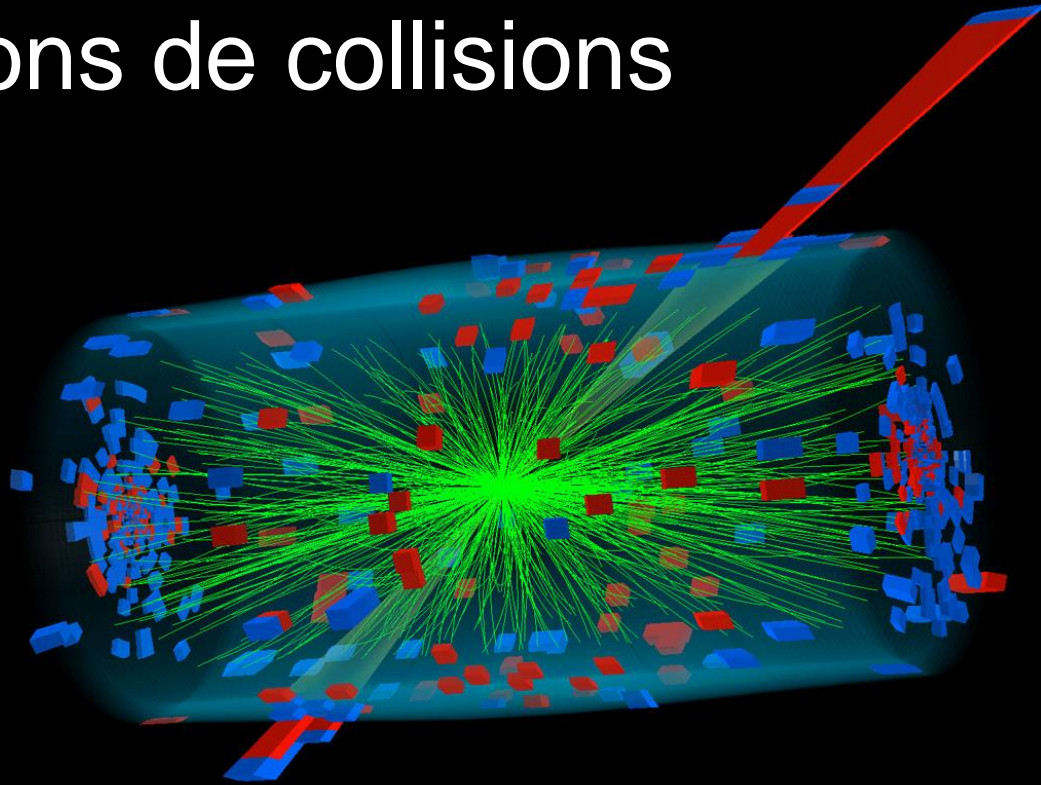
# ALICE



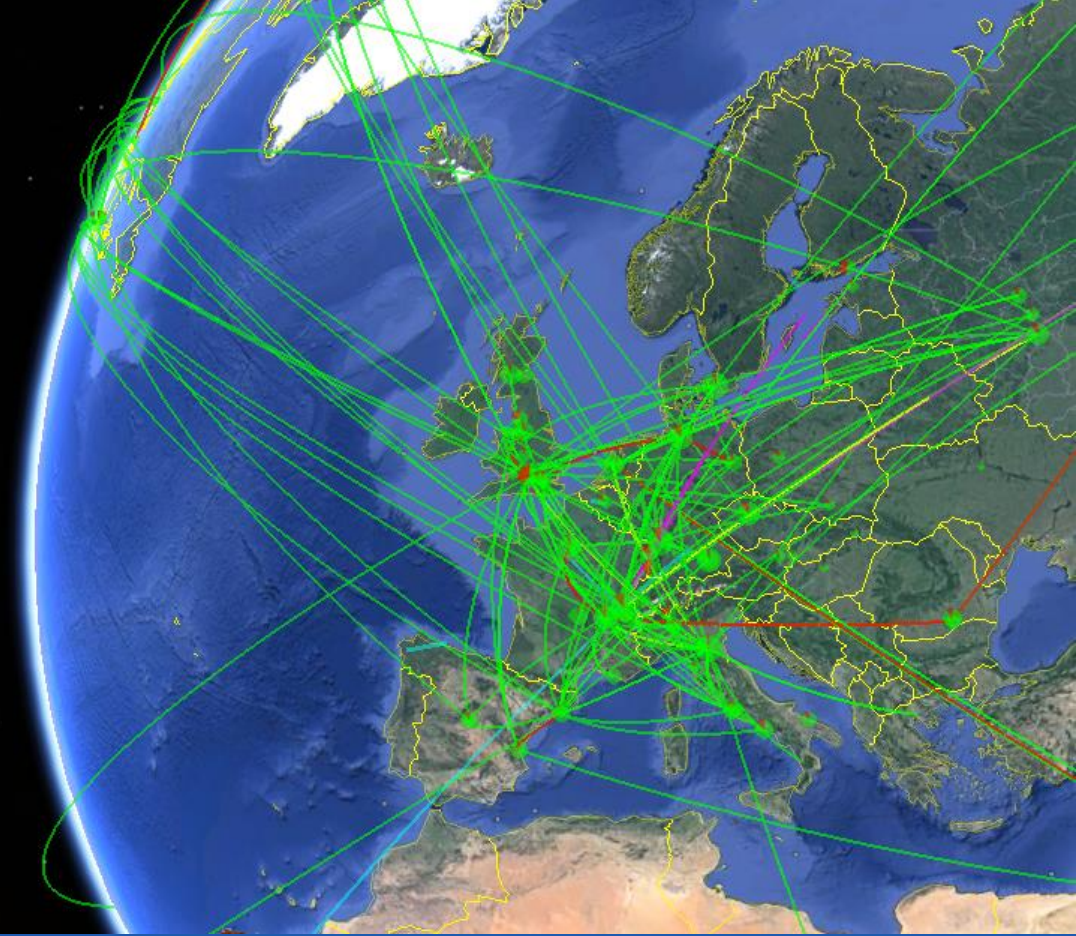


LHCb

# Des millions de collisions



# La plus grande grille de calcul



Le CERN

*Ça change quoi pour moi ?*



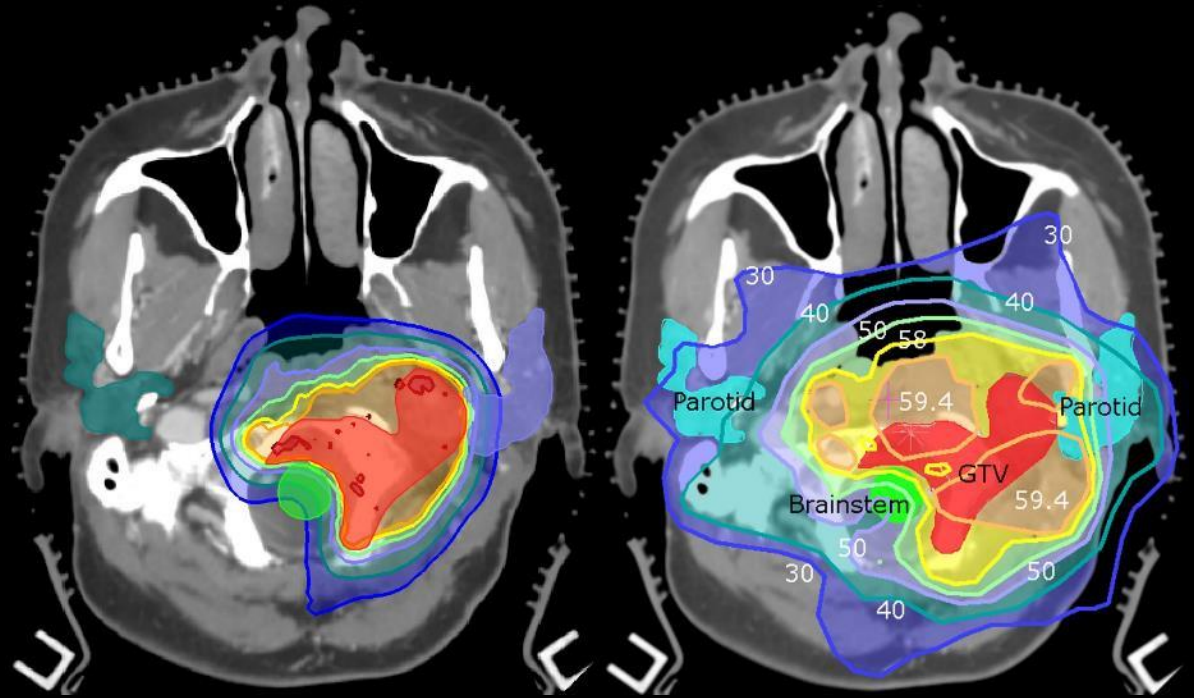
# World Wide Web

WWW





# Applications médicales



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

Possible landslide caused by floods

HADRAMAUT

ALMUKALLA

Missions  
humanitaires

PRE - IMAGE 24 OCTOBER 2015



POST - IMAGE 4 NOVEMBER 2015



# En un mot...



# Visites virtuelles



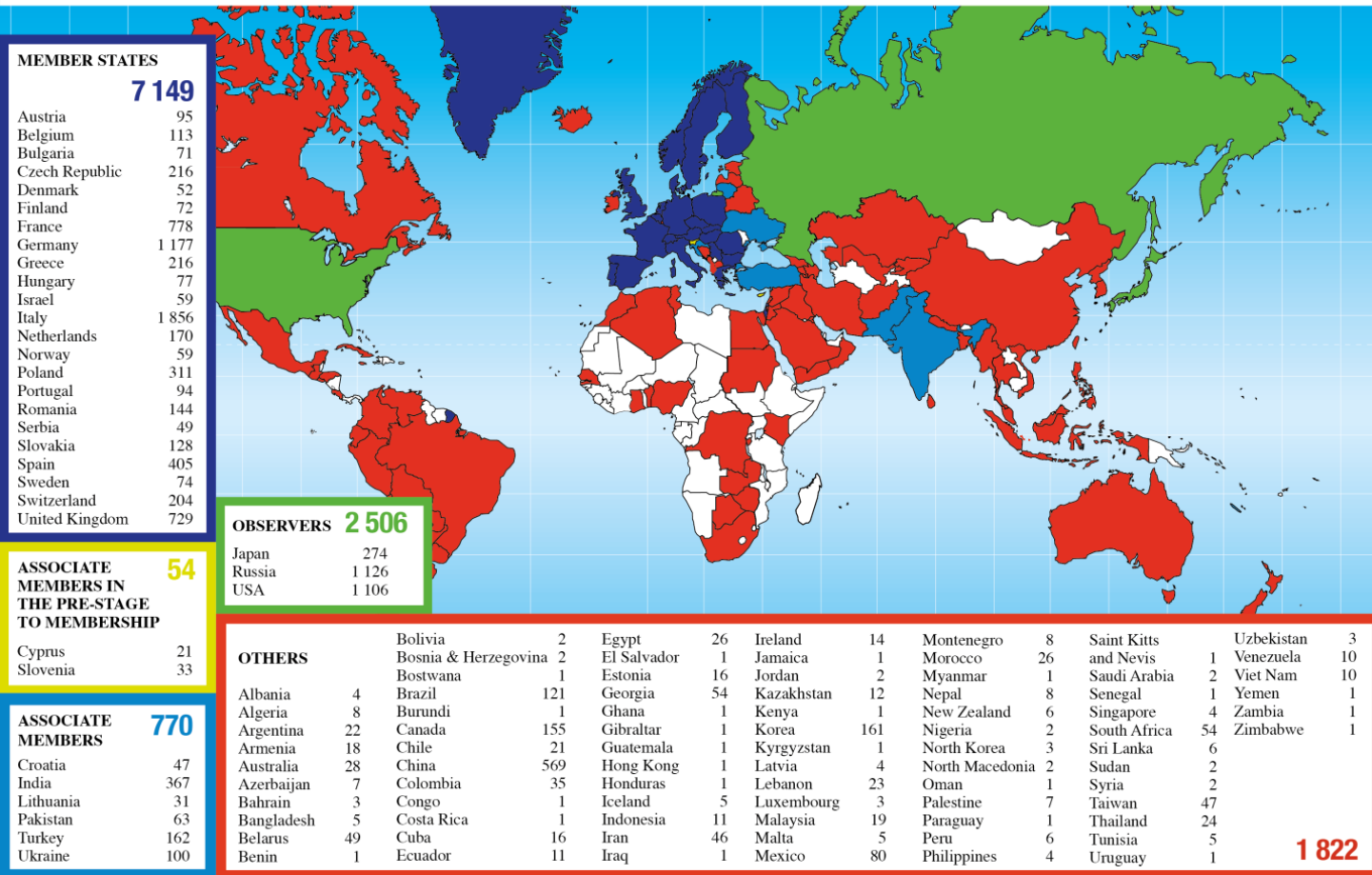
# Merci de votre attention !

## Pour aller plus loin...

- [home.cern](http://home.cern)
- [visit.cern](http://visit.cern)
- [careers.cern](http://careers.cern)
- [francois.briard@cern.ch](mailto:francois.briard@cern.ch)

Merci de remplir  
l'enquête !

# Distribution of All CERN Users by Nationality on 27 January 2020



**MEMBER STATES**

**7 149**

Austria	95
Belgium	113
Bulgaria	71
Czech Republic	216
Denmark	52
Finland	72
France	778
Germany	1 177
Greece	216
Hungary	77
Israel	59
Italy	1 856
Netherlands	170
Norway	59
Poland	311
Portugal	94
Romania	144
Serbia	49
Slovakia	128
Spain	405
Sweden	74
Switzerland	204
United Kingdom	729

**OBSERVERS**

**2 506**

Japan	274
Russia	1 126
USA	1 106

**ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP**

**54**

Cyprus	21
Slovenia	33

**ASSOCIATE MEMBERS**

**770**

Croatia	47
India	367
Lithuania	31
Pakistan	63
Turkey	162
Ukraine	100

**OTHERS**

Albania	4	Bolivia	2	Egypt	26	Ireland	14	Montenegro	8	Saint Kitts and Nevis	1	Uzbekistan	3
Algeria	8	Bosnia & Herzegovina	2	El Salvador	1	Jamaica	1	Morocco	26	Venezuela	10		
Argentina	22	Bostwana	1	Estonia	16	Jordan	2	Myanmar	1	Viet Nam	10		
Armenia	18	Brazil	121	Georgia	54	Kazakhstan	12	Nepal	8	Yemen	1		
Australia	28	Burundi	1	Ghana	1	Kenya	1	New Zealand	6	Zambia	1		
Azerbaijan	7	Canada	155	Gibraltar	1	Korea	161	Nigeria	2	Zimbabwe	1		
Bahrain	3	Chile	21	Guatemala	1	Kyrgyzstan	1	North Korea	3				
Bangladesh	5	China	569	Hong Kong	1	Latvia	4	North Macedonia	2				
Belarus	49	Colombia	35	Honduras	1	Lebanon	23	Oman	1				
Benin	1	Congo	1	Iceland	5	Luxembourg	3	Palestine	7				
		Costa Rica	1	Indonesia	11	Malaysia	19	Paraguay	1				
		Cuba	16	Iran	46	Malta	5	Peru	6				
		Ecuador	11	Iraq	1	Mexico	80	Philippines	4				

**1 822**

