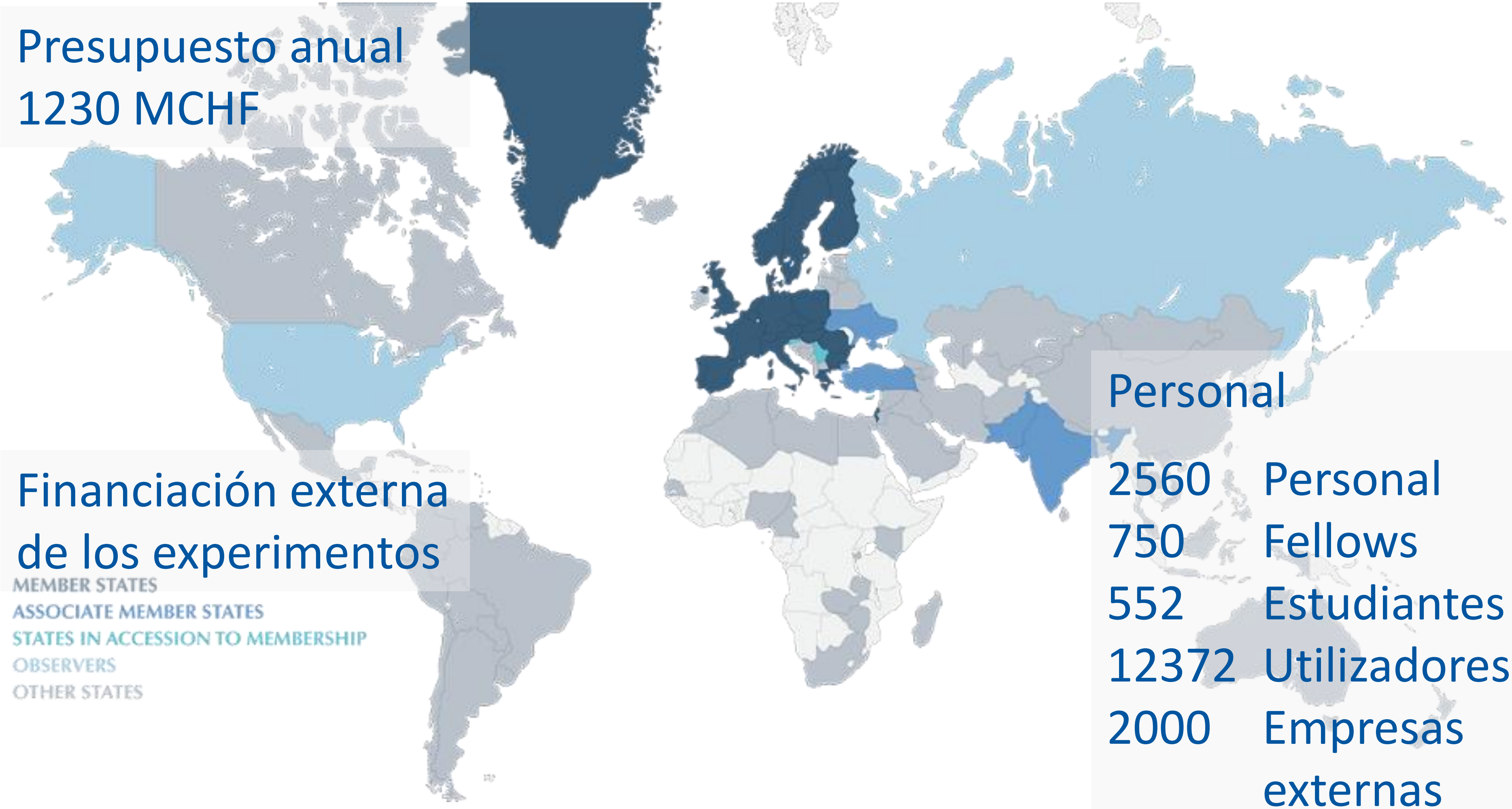
CERN

CERN: Acelerando Ciencia e Innovación

El laboratorio en física de partículas más grande del mundo

Presupuesto anual
1230 MCHF

Financiación externa de los experimentos



Personal

2560	Personal
750	Fellows
552	Estudiantes
12372	Utilizadores
2000	Empresas externas

Distribution of All CERN Users by Nationality on 12 January 2016

MEMBER STATES	7319
Austria	106
Belgium	125
Bulgaria	88
Czech Republic	217
Denmark	56
Finland	102
France	858
Germany	1267
Greece	216
Hungary	79
Israel	63
Italy	1974
Netherlands	164
Norway	63
Poland	302
Portugal	113
Slovakia	111
Spain	399
Sweden	90
Switzerland	220
United Kingdom	706

ASSOCIATE MEMBERS	224
Pakistan	58
Turkey	166

OBSERVERS	2775
India	284
Japan	316
Russia	1071
USA	1104

STATES IN ACCESSION TO MEMBERSHIP	195
Cyprus	19
Romania	131
Serbia	45

OTHERS	1803
Albania	4
Algeria	8
Argentina	24
Armenia	27
Australia	31
Azerbaijan	11
Bangladesh	7
Belarus	50
Bolivia	2
Bosnia & Herzegovina	1
Brazil	135
Cameroon	2
Canada	154
Central African Rep.	1
Chile	20
China	421
Colombia	38
Costa Rica	1
Croatia	38
Cuba	13
Ecuador	4
Egypt	24
El Salvador	1
Estonia	15
Georgia	44
Iceland	4
Indonesia	10
Iran	54
Iraq	1
Ireland	20
Jordan	8
Kazakhstan	1
Kenya	2
Korea, D.P.R.	4
Korea Rep.	151
Latvia	1
Lebanon	12
Libya	1
Lithuania	30
Luxembourg	2
Madagascar	4
Malaysia	18
Malta	5
Mauritius	[illegible]
Mexico	84
Montenegro	2
Mo[illegible]	13
Nepal	7
New Zealand	6
Oman	1
Palestine (O.T.)	7
Peru	6
Philippines	4
Qatar	1
San Marino	1
Saudi Arabia	1
Senegal	1
Singapore	3
Sint Maarten	1
Slovenia	27
South Africa	31
Sri Lanka	3
Syria	1
Taiwan	56
Thailand	20
T.F.Y.R.O.M.	2
Tunisia	3
Ukraine	88
Uzbekistan	5
Venezuela	11
Viet Nam	8
Zimbabwe	5

Universidad Autónoma de Puebla
Universidad Nacional Autónoma
Universidad Autónoma de San Luis de potosí
Universidad Autónoma de Sinaloa
Universidad Iberoamericana


Formación
Investigación &
Descubrimientos
Colaboración
Tecnología

Innovación

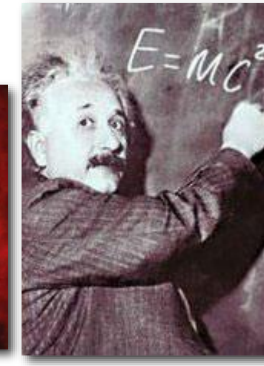
Educación

CERN

uniendo pueblos

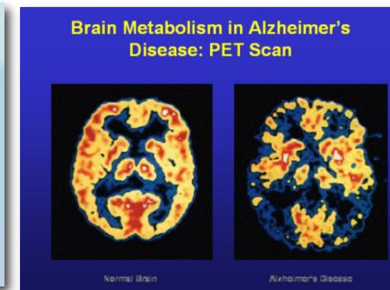
Investigación

Las Misiones del CERN



- **Empujar** las fronteras del conocimiento

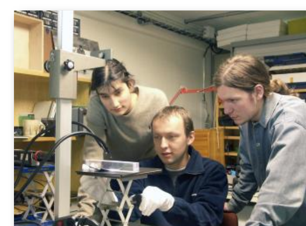
  Ej.: los secretos del Big Bang …¿como era la materia durante los primeros momentos de existencia del Universo?



- **Desarrollar** nuevas tecnologías en aceleradores y detectores

  Tecnología de la Información - la Web y la GRID

  Medicina - diagnosis y terapia



- **Entrenar** los científicos e ingenieros del mañana

- **Unir** gentes de países y culturas diferentes

Investigación & Descubrimientos

From **individual** theoretical physicist **idea**….

…to **collective innovation**

Volume 13, Number 16 PHYSICAL REVIEW LETTERS 19 October 1964

BROKEN SYMMETRIES AND THE MASSES OF GAUGE BOSONS

Peter W. Higgs

Tait Institute of Mathematical Physics, University of Edinburgh, Edinburgh, Scotland

(Received 31 August 1964)

Volume 13, Number 9 PHYSICAL REVIEW LETTERS 31 August 1964

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[1]R. Feynman and M. Gell-Mann, Phys. Rev. 109, 13 (1958).

[2]T. D. Lee and C. N. Yang, Phys. Rev. 119, 1410 (1960); S. B. Treiman, Nuovo Cimento 15, 916 (1960).

[3]S. Okubo and R. E. Marshak, Nuovo Cimento 28, 56 (1963); Y. Ne'eman, Nuovo Cimento 27, 922 (1963).

[4]Estimates of the rate for $K^+ \to \pi^+ + e^+ + e^-$ due to induced neutral currents have been calculated by several authors. For a list of previous references see Mirza A. Baqi Bég, Phys. Rev. 132, 426 (1963).

[5]M. Baker and S. Glashow, Nuovo Cimento 25, 857 (1962). They predict a branching ratio for decay mode (1) of $\sim 10^{-6}$.

[6]N. P. Samios, Phys. Rev. 121, 275 (1961).

[7]The best previously reported estimate comes from the limit on $K_2^0 \to \mu^+ + \mu^-$. The 90% confidence level is $|g_{\mu\mu}|^2 < 10^{-3}|g_{\mu\nu}|^2$: M. Barton, K. Lande, L. M. Lederman, and William Chinowsky, Ann. Phys. (N.Y.) 5, 156 (1958). The absence of the decay mode $\mu^+ \to e^+ + e^+ + e^-$ is not a good test for the existence of neutral currents since this decay mode may be absolutely forbidden by conservation of muon number: G. Feinberg and L. M. Lederman, Ann. Rev. Nucl. Sci. 13, 465 (1963).

[8]S. N. Biswas and S. K. Bose, Phys. Rev. Letters 12, 176 (1964).

BROKEN SYMMETRY AND THE MASS OF GAUGE VECTOR MESONS*

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(Received 26 June 1964)

It is of interest to inquire whether gauge vector mesons acquire mass through interaction[1]; by a gauge vector meson we mean a Yang-Mills field[2] associated with the extension of a Lie group from global to local symmetry. The importance of this problem resides in the possibility that strong-interaction physics originates from massive gauge fields related to a system of conserved currents.[3] In this note, we shall show that in certain cases vector mesons do indeed acquire mass when the vacuum is degenerate with respect to a compact Lie group.

Theories with degenerate vacuum (broken symmetry) have been the subject of intensive study since their inception by Nambu.[4-6] A characteristic feature of such theories is the possible existence of zero-mass bosons which tend to restore the symmetry.[7,8] We shall show that it is precisely these singularities which maintain the gauge invariance of the theory, despite the fact that the vector meson acquires mass.

We shall first treat the case where the original fields are a set of bosons φ_A which transform as a basis for a representation of a compact Lie group. This example should be considered as a rather general phenomenological model. As such, we shall not study the particular mechanism by which the symmetry is broken but simply assume that such a mechanism exists. A calculation performed in lowest order perturbation theory indicates that those vector mesons which are coupled to currents that "rotate" the original vacuum are the ones which acquire mass [see Eq. (6)].

We shall then examine a particular model based on chirality invariance which may have a more fundamental significance. Here we begin with a chirality-invariant Lagrangian and introduce both vector and pseudovector gauge fields, thereby guaranteeing invariance under both local phase and local γ_5-phase transformations. In this model the gauge fields themselves may break the γ_5 invariance leading to a mass for the original Fermi field. We shall show in this case that the pseudovector field acquires mass.

In the last paragraph we sketch a simple argument which renders these results reasonable.

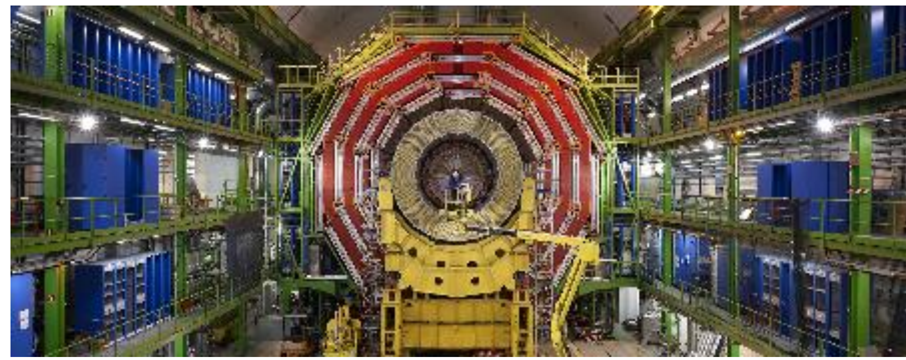
(1) Lest the simplicity of the argument be shrouded in a cloud of indices, we first consider a one-parameter Abelian group, representing, for example, the phase transformation of a charged boson; we then present the generalization to an arbitrary compact Lie group.

The interaction between the φ and the A_μ fields is

$$H_{int} = ieA_\mu \varphi^* \overleftrightarrow{\partial}_\mu \varphi - e^2 \varphi^* \varphi A_\mu A_\mu, \quad (1)$$

where $\varphi = (\varphi_1 + i\varphi_2)/\sqrt{2}$. We shall break the symmetry by fixing $\langle\varphi\rangle \neq 0$ in the vacuum, with the phase chosen for convenience such that $\langle\varphi\rangle = \langle\varphi^*\rangle = \langle\varphi_1\rangle/\sqrt{2}$.

We shall assume that the application of the



1964

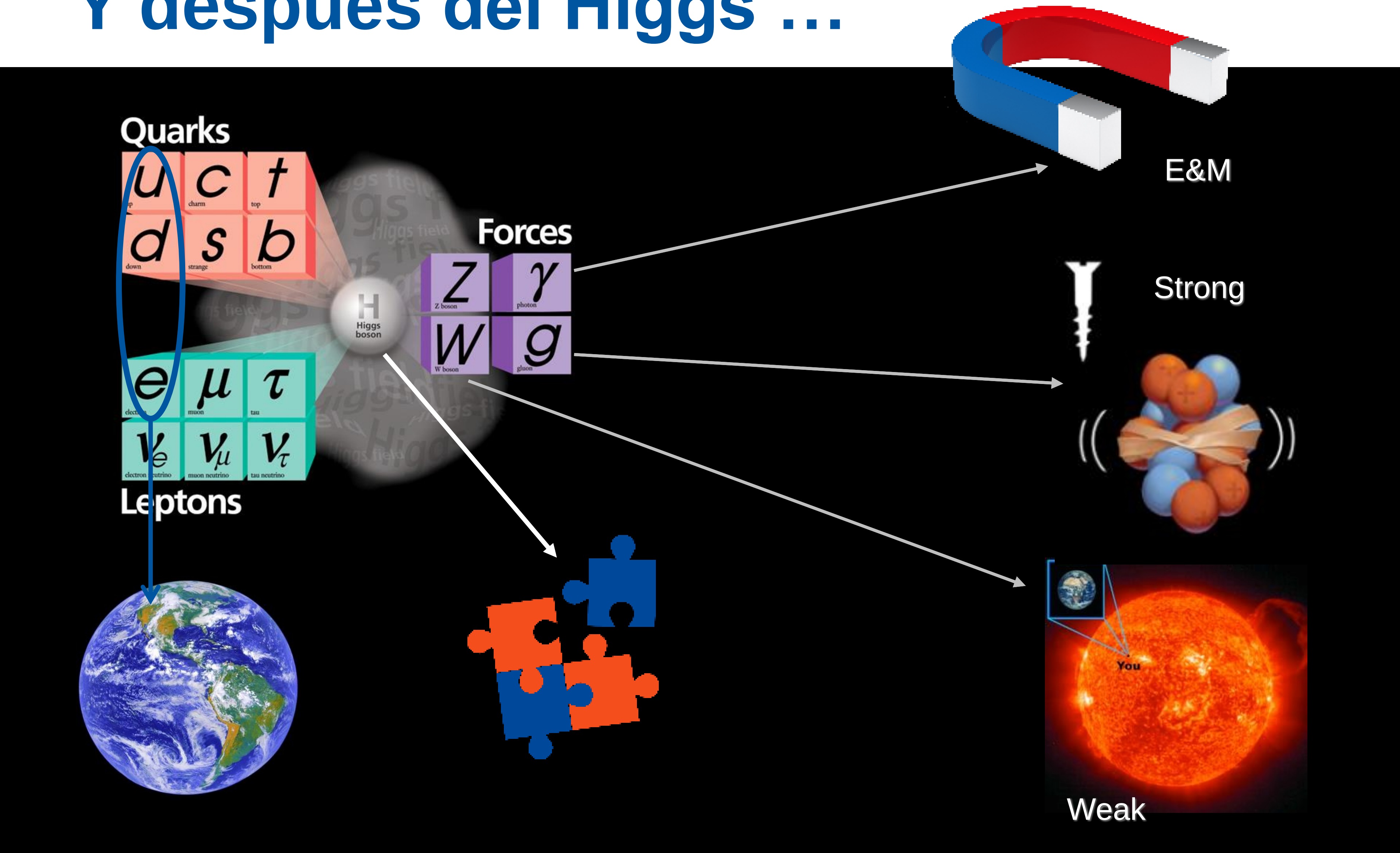
1964-2012

Discovery 2012, Nobel Prize in Physics 2013

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was **confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".**

Y el Premio Principe de Asturias

Y despues del Higgs …



Standard Model

Only **4%**

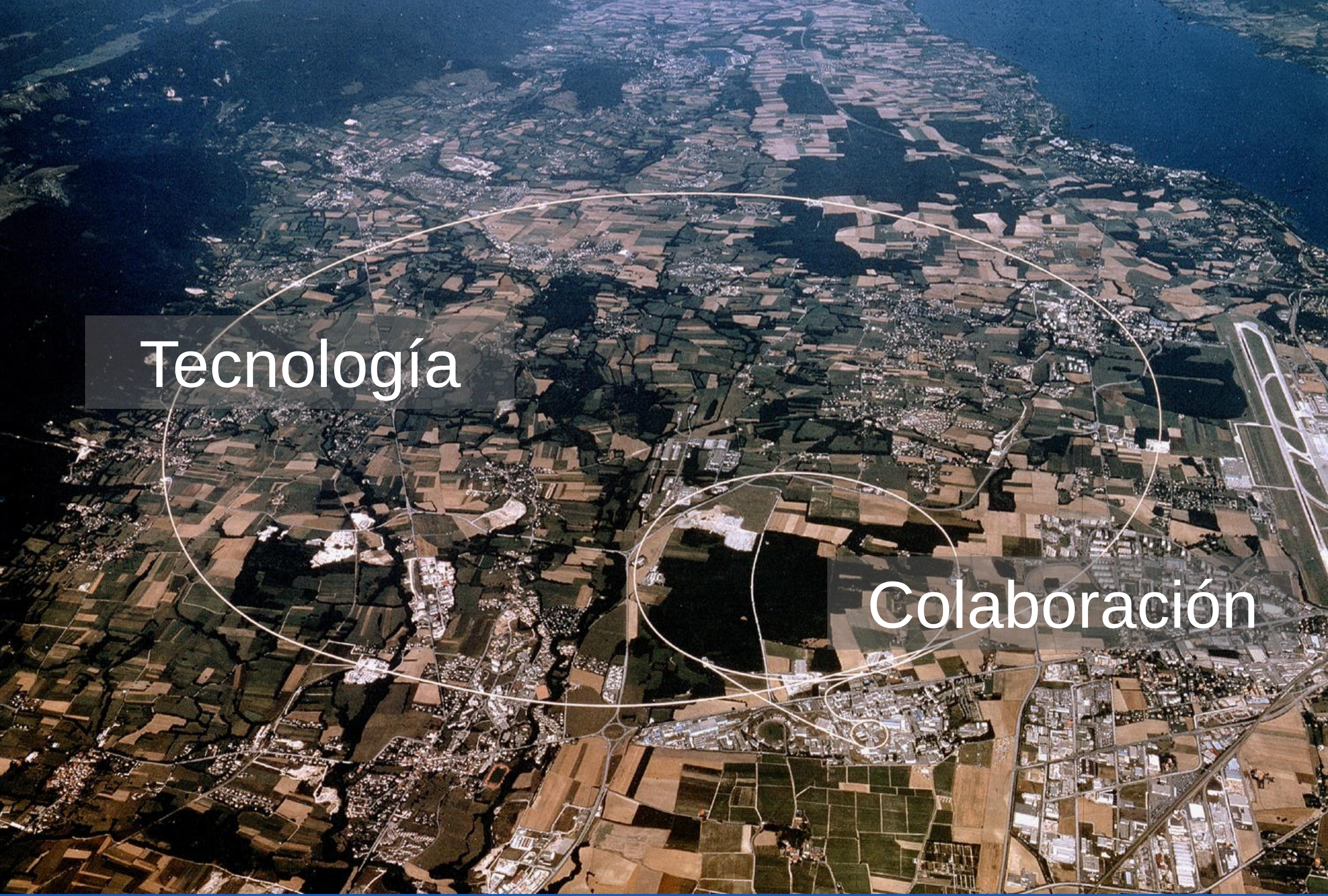
is ordinary (visible) matter

The DARK Universe

96%

- 73% Dark Energy
- 23% Dark Matter

DARK …. MATTERS !



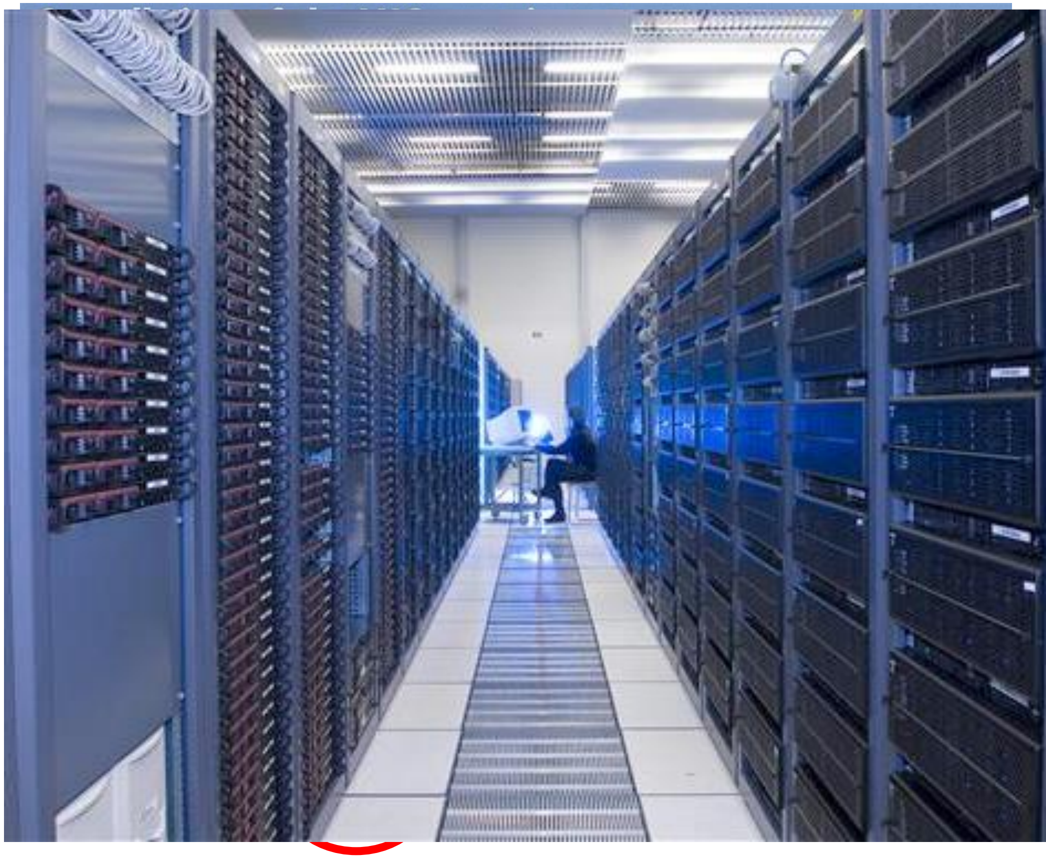
CERN

Las Herramientas

1. Aceleradores: Máquinas capaces de acelerar partículas a energías extremadamente altas y hacerlas colisionar

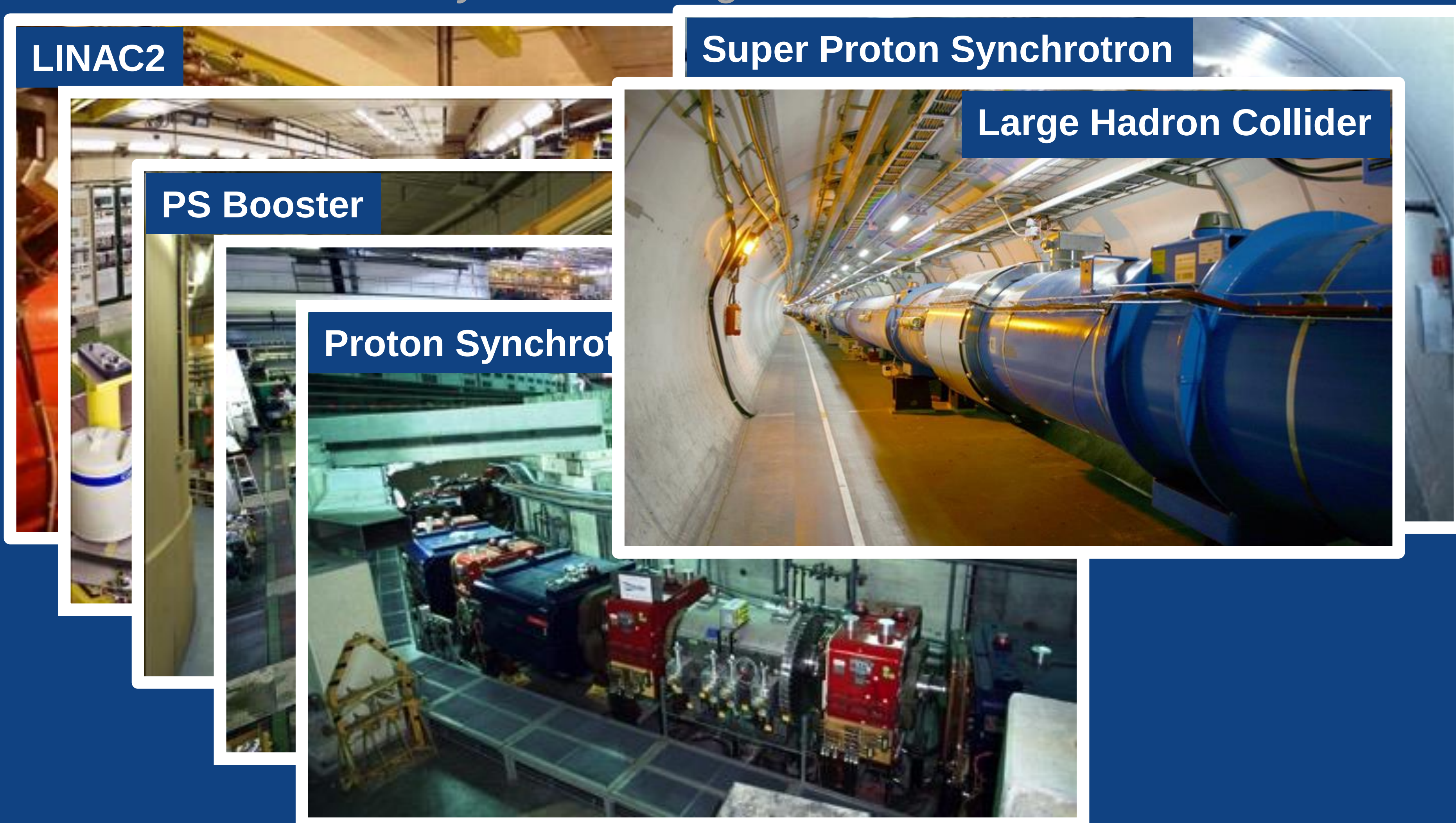
2. Detectores : Instrumentos gigantes que graban las trazas de las partículas

3. Ordenadores : Recogen, almacenan, distribuyen y analizan enormes cantidades de datos producidos por los detectores



A worldwide success?

With a wide diversity in technologies!



LHC: el acelerador más grande del mundo

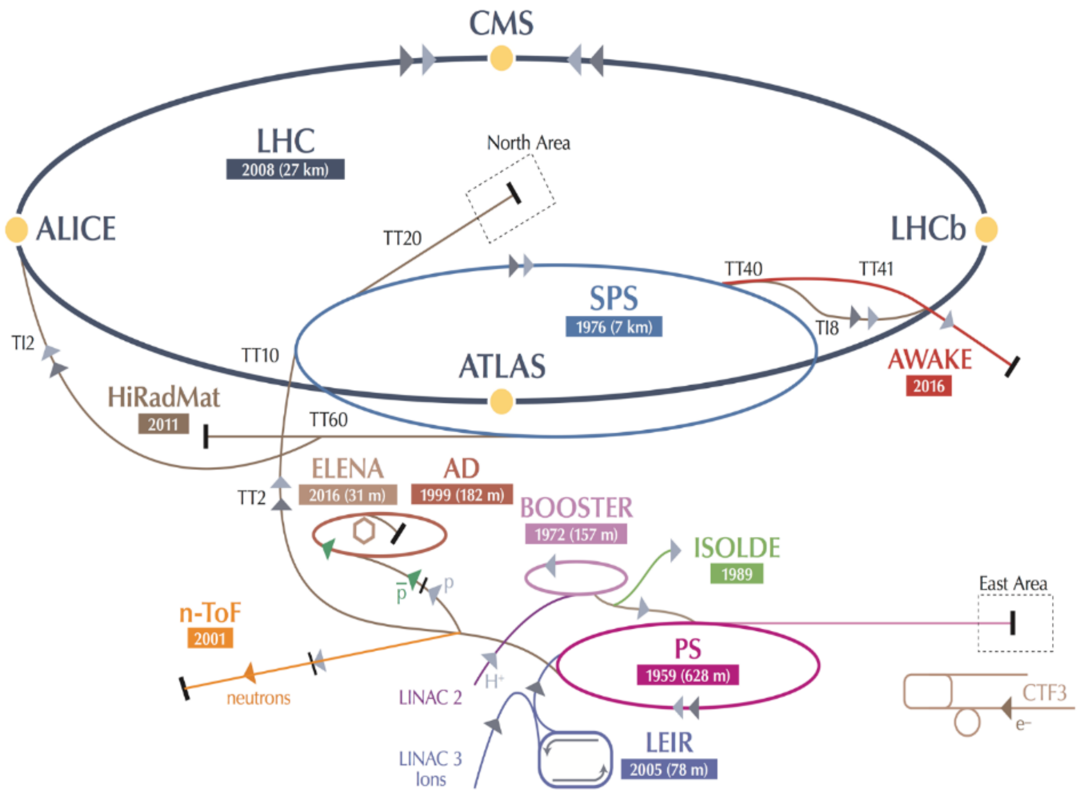
27km de túnel 100 bajo tierra

Miles de imanes superconductores (1.8×10^9 km de filamentos superconductores)

Ultra vacío:
10x más vacío que en la Luna

El lugar más frío del Universo:
-271° C

CERN's accelerators
CERN's scientific diversity programme



~20 experiments,
> 1200 physicists

AD: Antiproton Decelerator for antimatter studies

AWAKE: proton-induced plasma wakefield acceleration

CAST, OSQAR: axions

CLOUD: impact of cosmic rays on aeorosols and clouds → implications on climate

COMPASS: hadron structure and spectroscopy

ISOLDE: radioactive nuclei facility

NA61/Shine: heavy ions and neutrino targets

NA62: rare kaon decays

NA63: radiation processes in strong EM fields

NA64: search for dark photons

Neutrino Platform: **ν** detectors R&D for experiments in US, Japan

n-TOF: n-induced cross-sections

UA9: crystal collimation

Los detectores más grandes y más sofisticados

$E = mc^2$

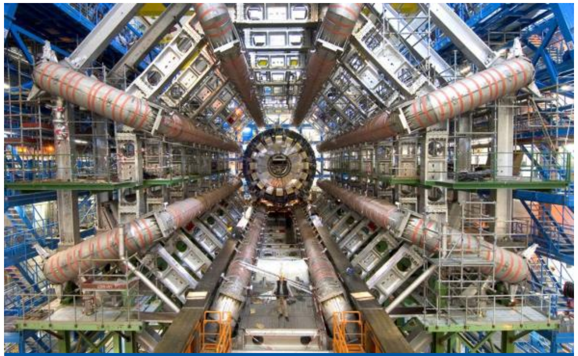
Catedrales de la ciencia
100m bajo tierra

600 millones de colisiones/s detectadas
Por cientos de millones de sensores

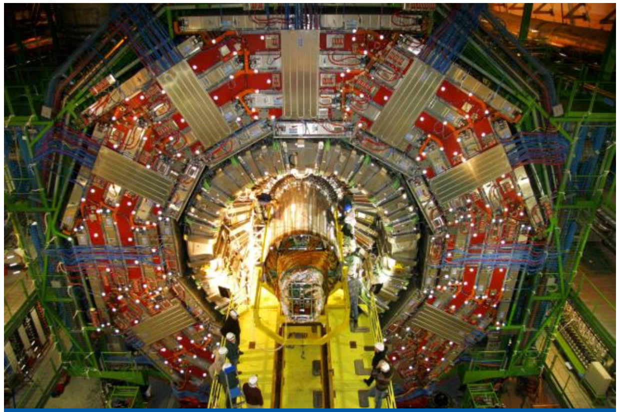
Miles de colaboradores

Cuatro Experimentos: the coopetition

LHCB Collaboration:
15 Countries, 54 Institutes and 754 members



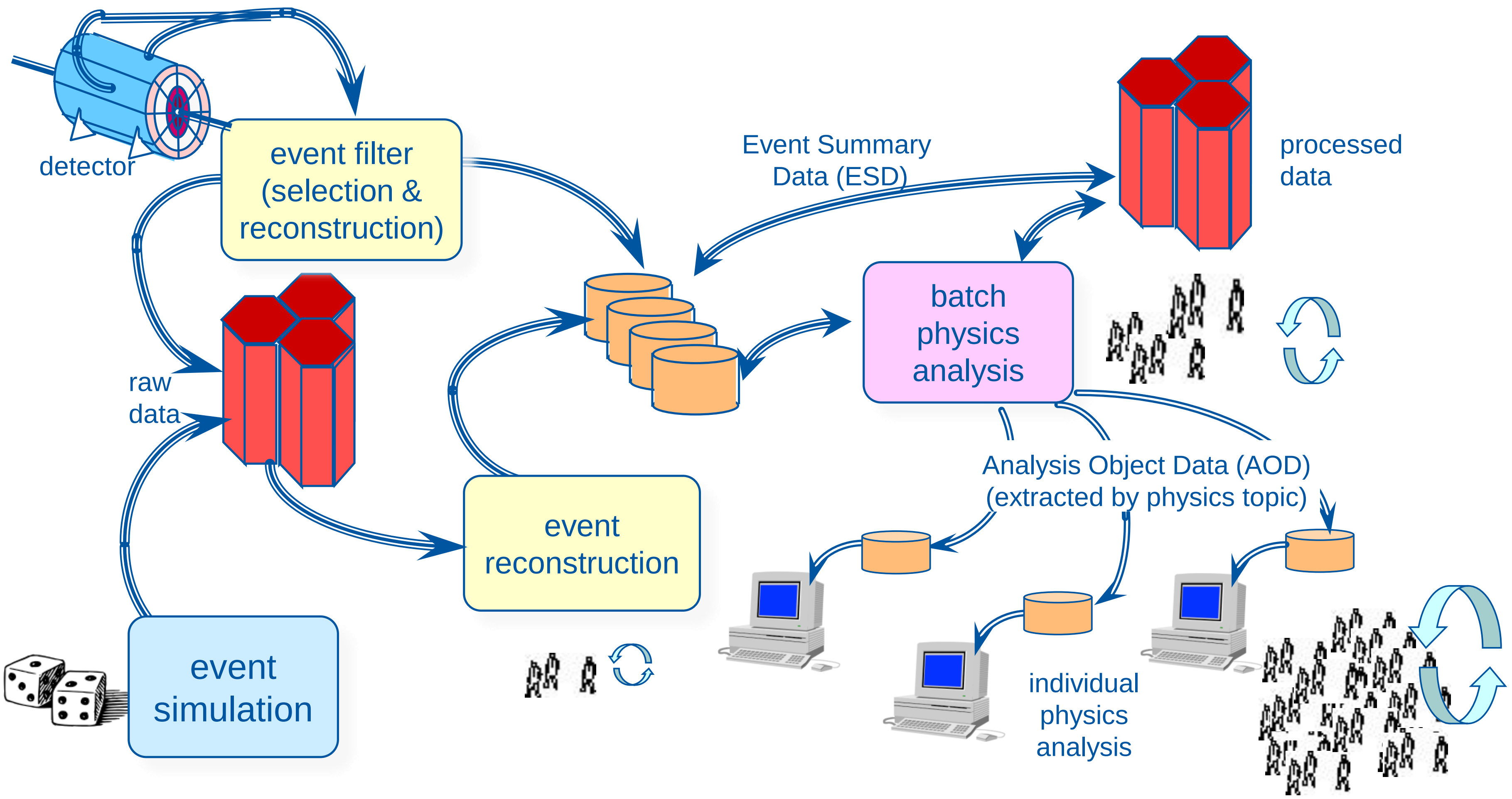
ATLAS Collaboration:
38 Countries, 174 Institutes and 3000 members



CMS Collaboration:
39 Countries, 169 Institutes and 3170 members

ALICE Collaboration:
33 Countries, 116 Institutes and over 1000 members

Análisis de Datos



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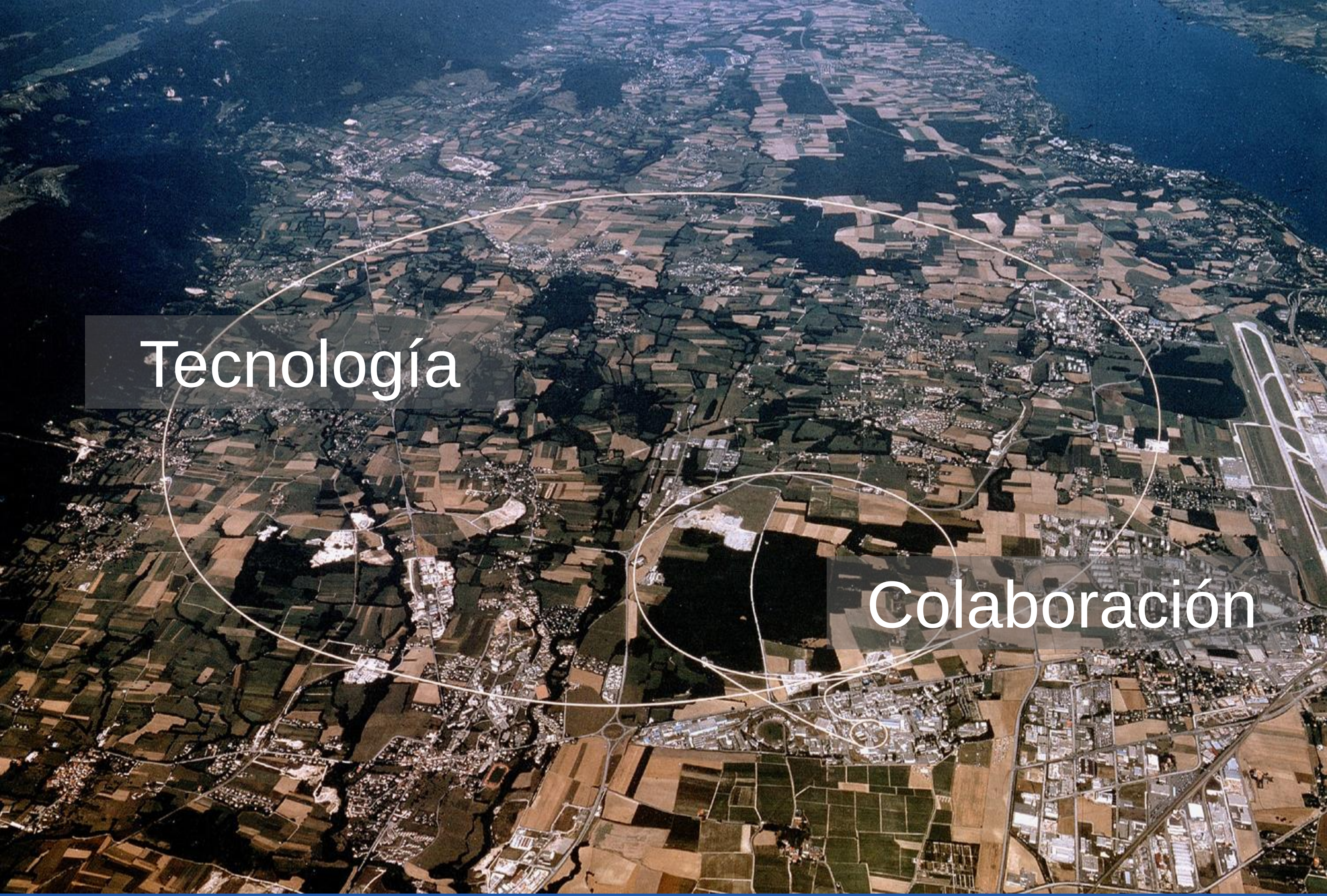


Mirando al futuro

Construyendo el LHC

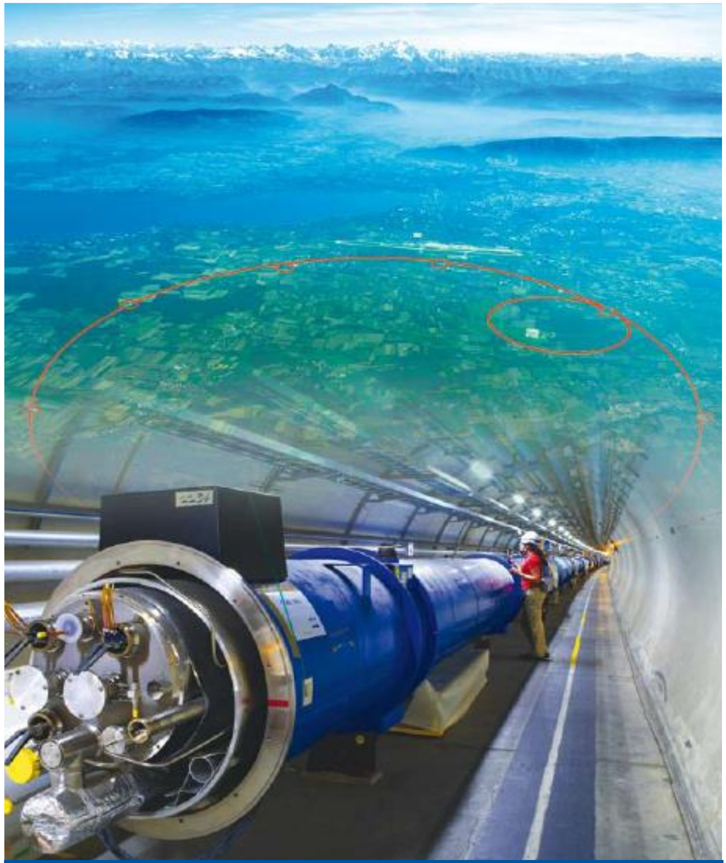
14 TeV proton-proton accelerator-collider built in the LEP tunnel

1983	First studies for the LHC project
1988	First magnet model (feasibility)
1989	Approval of the LHC by the CERN Council
1996-1999	Series production industrialisation
1998	Declaration of Public Utility & Start of civil engineering
1998-2000	Placement of the main production contracts
2004	Start of the LHC installation
2005-2007	Magnets Installation in the tunnel
2006-2008	Hardware commissioning
2008-2009	Beam commissioning and repair

2010-2035…   Physics exploitation

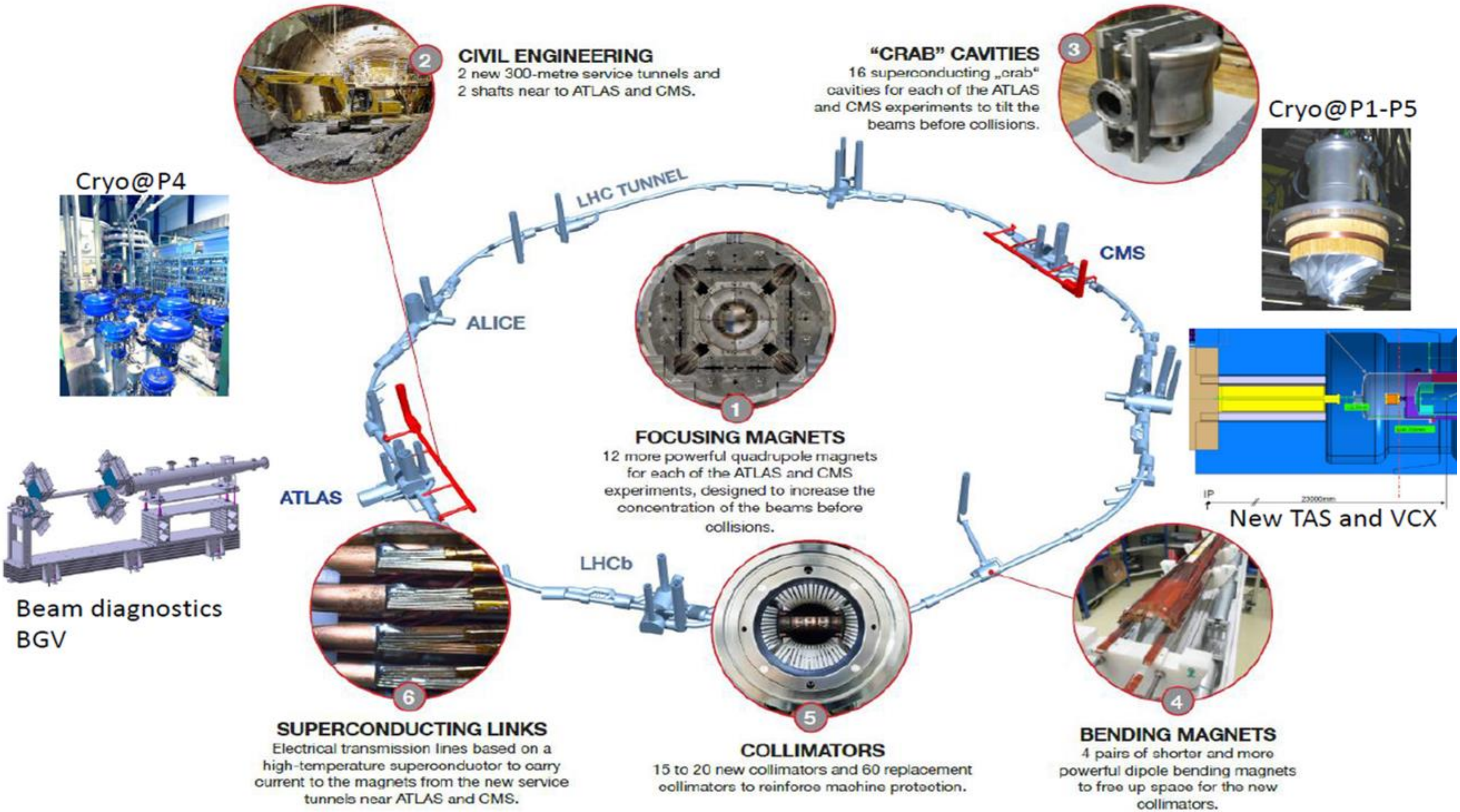
2010 – 2012	Run 1 ;7 and 8 TeV
2015 – 2018	*Run 2 ; 13 TeV*
2021 – 2023	Run 3 (14 TeV)
2024 – 2026	HL-LHC installation
2026 – 2035…	HL-LHC operation

HiLumi HL-LHC PROJECT



A 27 km circumference collider…

HL-LHC:Vector de tecnología!



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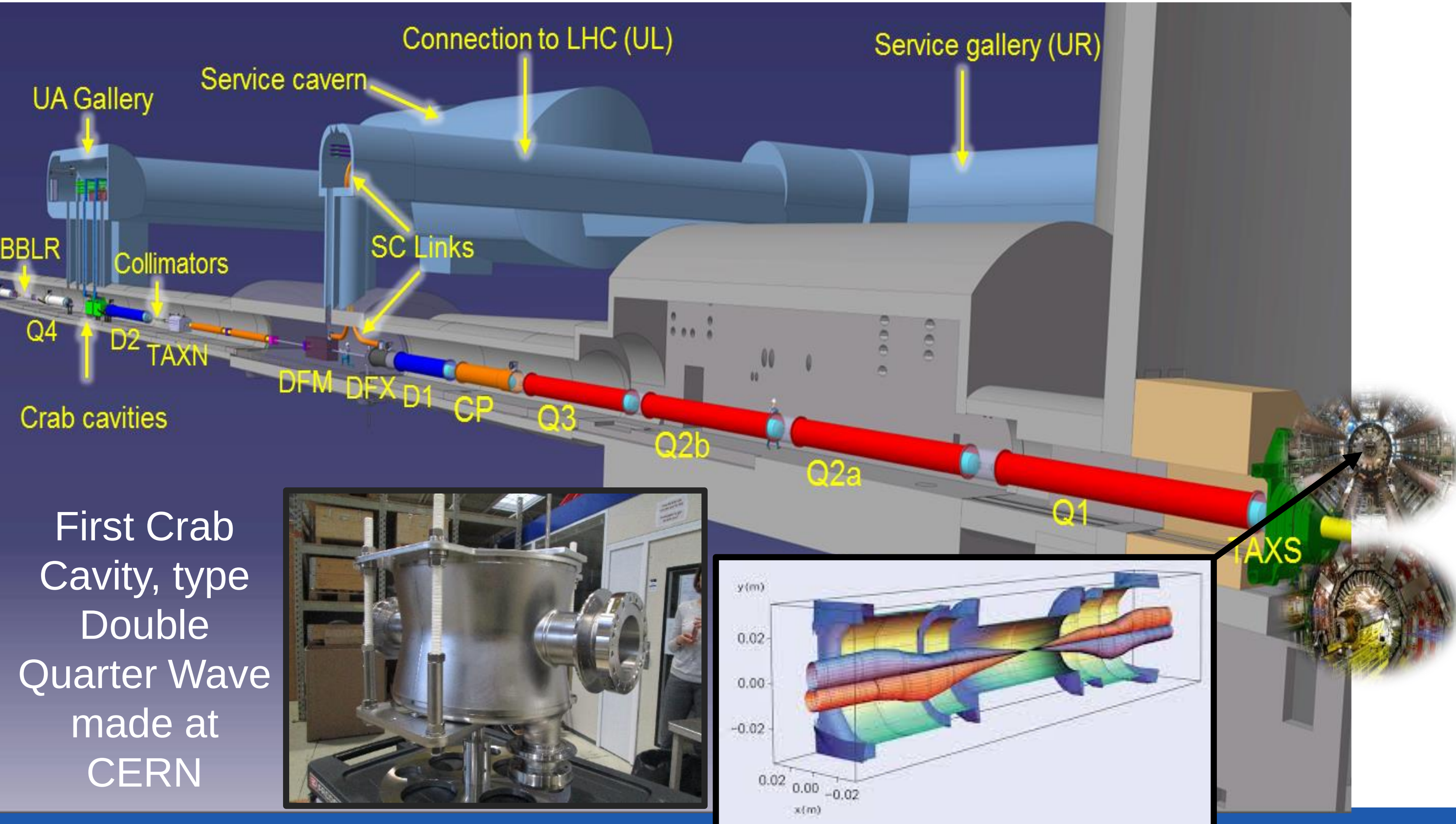
HL-LHC: more than an HEP Project?

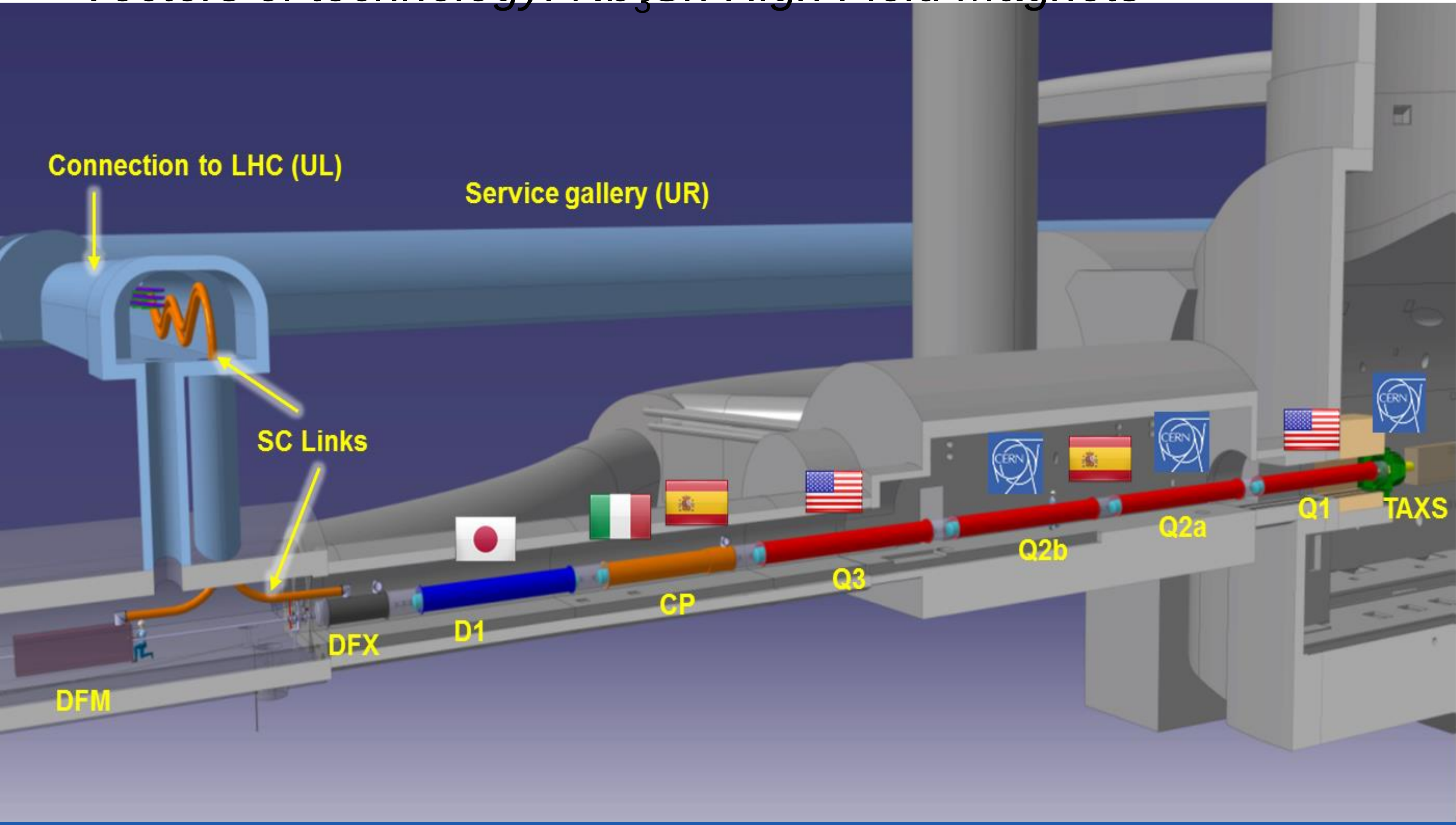
Vectors of technology! Engineering around while operating…



First Crab Cavity, type Double Quarter Wave made at CERN

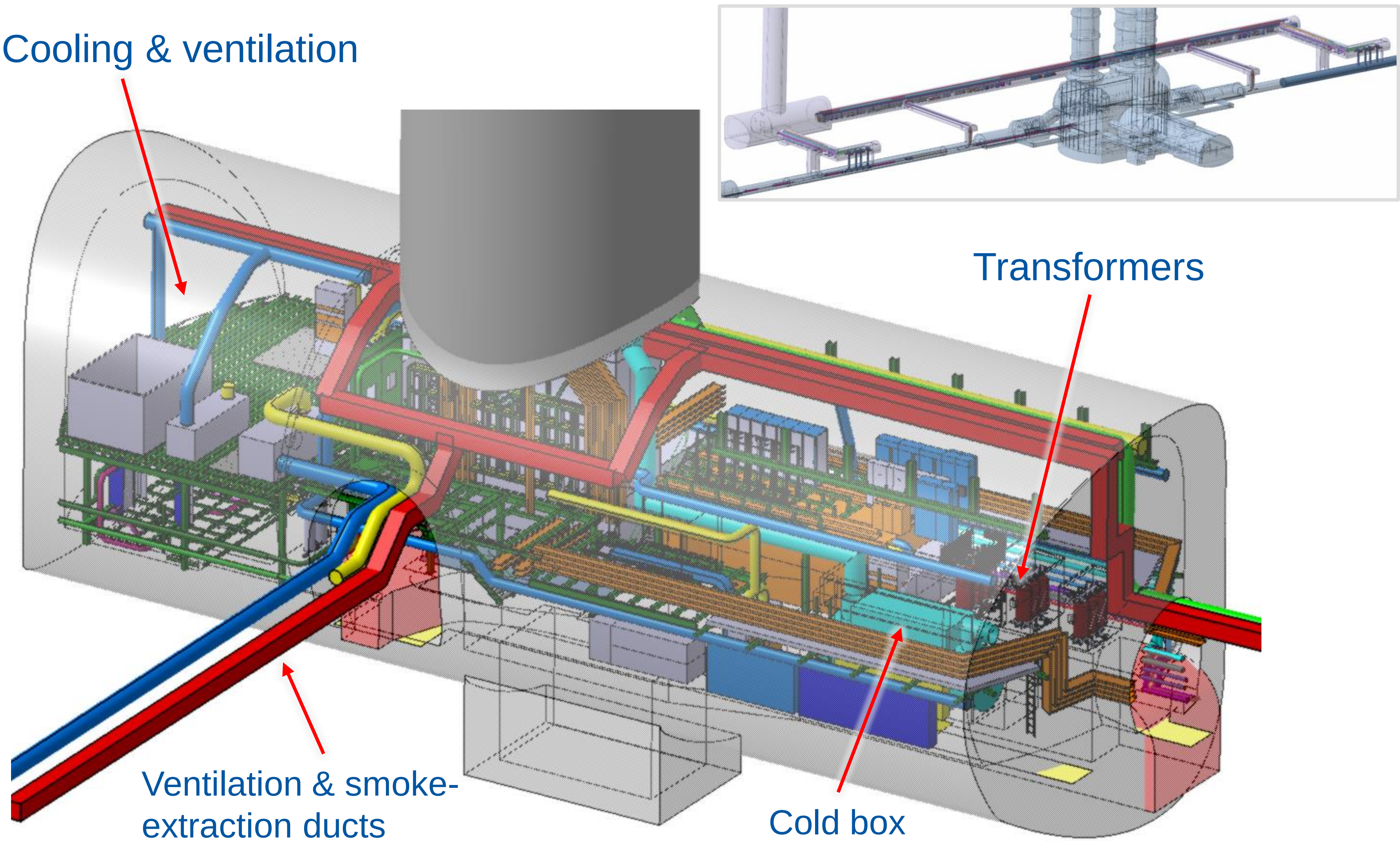
HL-LHC: more than an HEP Project?

Vectors of technology! Nb_3Sn High Field Magnets



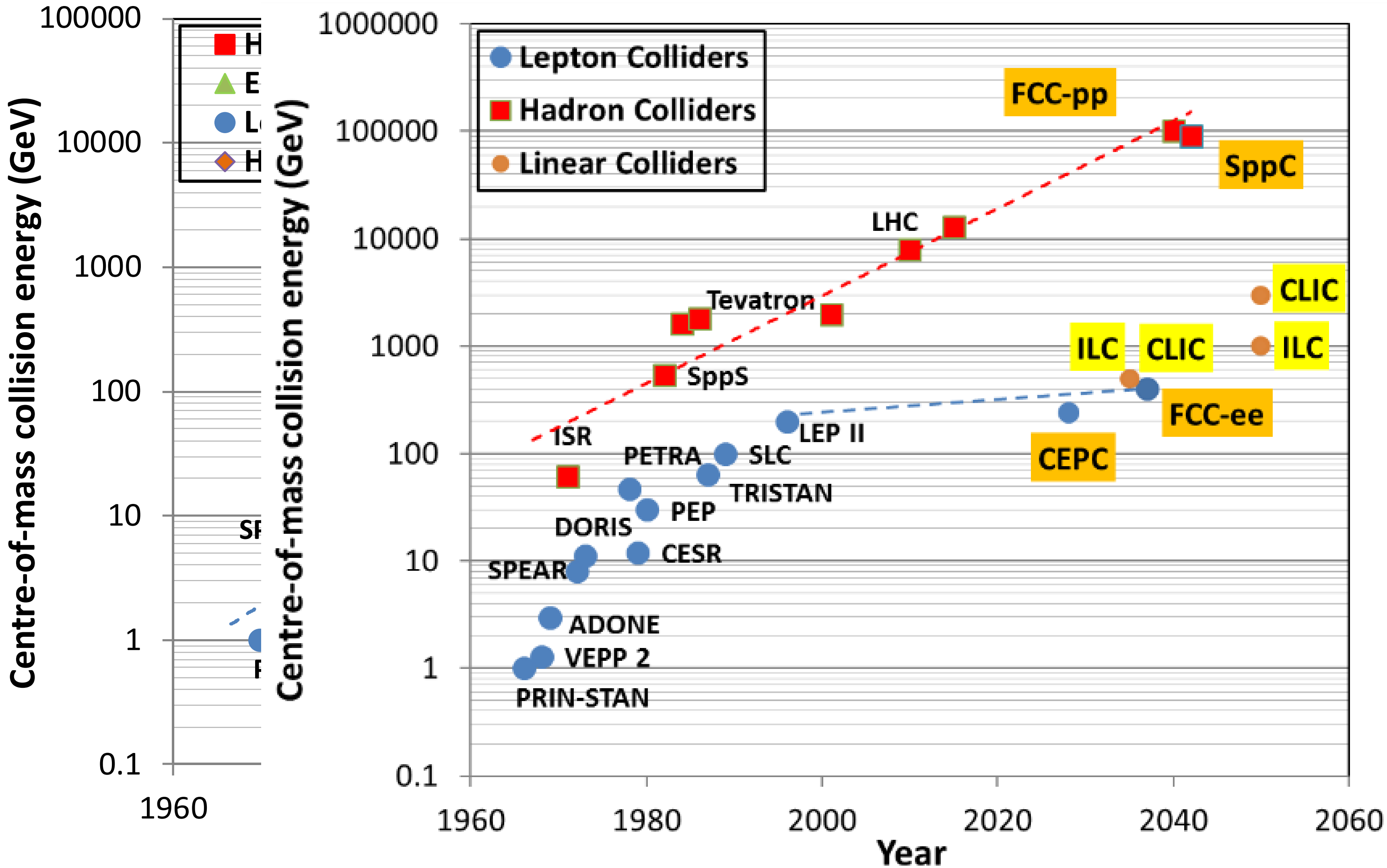
A vibrant R&D on breakthrough technologies!

Vectors of technology! Novel approaches against radiation…



A vibrant R&D on breakthrough technologies!

Fundamental role of Colliders



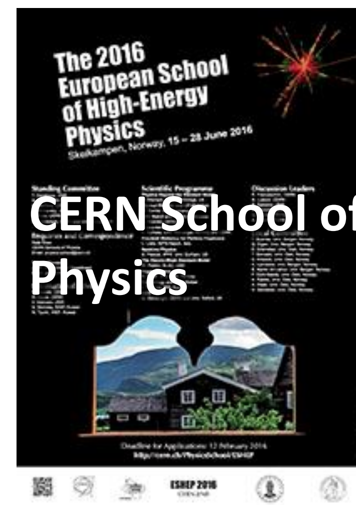
Formación

Actividades educativas del CERN

Científicos en el CERN
Programa de enseñanza académica

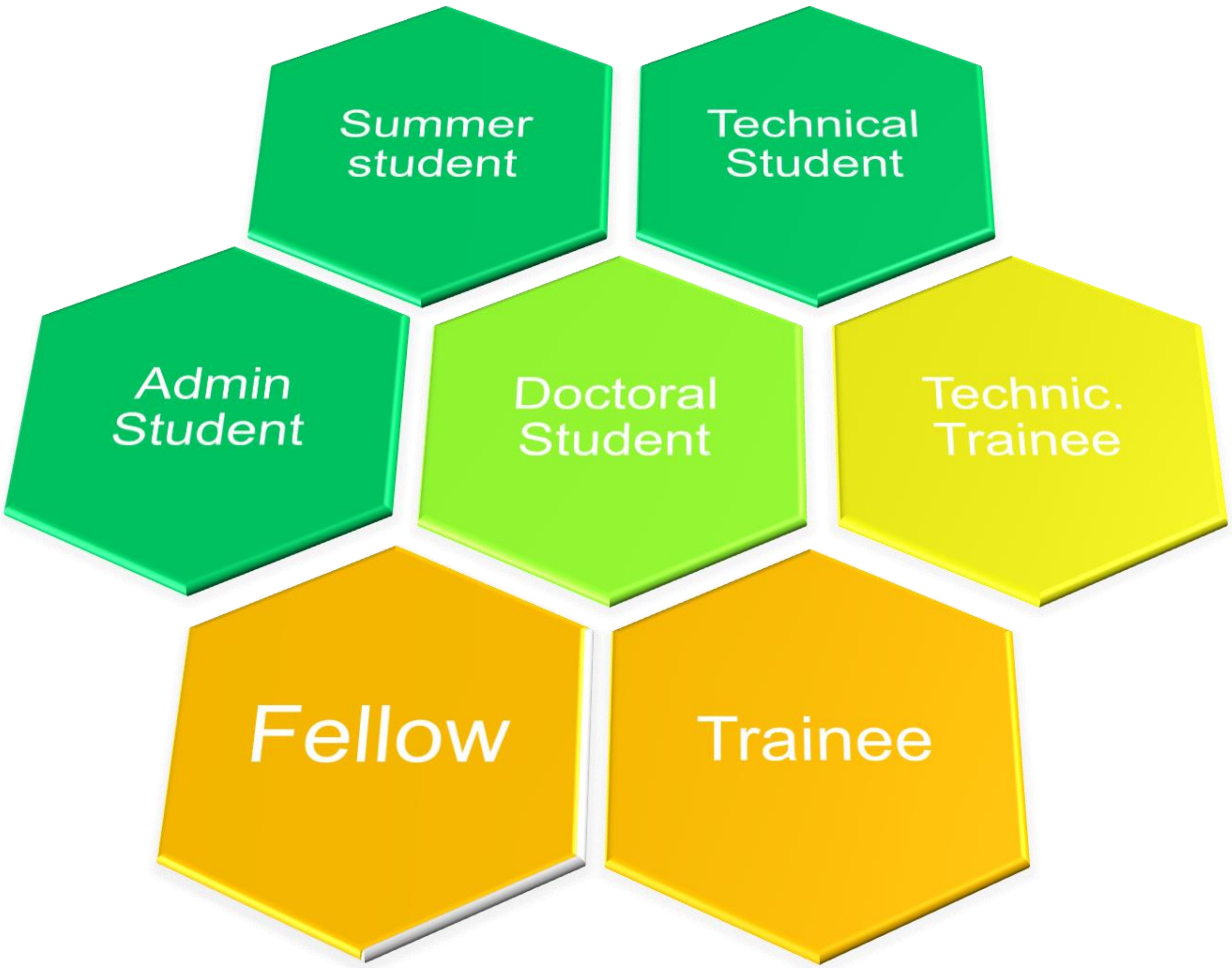
Jóvenes investigadores
Escuelas de física de altas energías
Escuela de computación
Escuela de aceleradores

Escuelas para profesores EM
Programas internacionales y nacionales



Estudiantes de física
Programa de estudiantes de verano

Actividades formativas del CERN



Bienvenidos al CERN

Esta es una presentación colectiva con contribuciones de decenas de personas.
Cooperando hasta lo imposible se consigue