

An aerial photograph of a rural landscape with green fields and small towns. Superimposed on the image is a large, thin red oval line, representing the path of the Large Hadron Collider (LHC) ring. In the background, a range of mountains with snow-capped peaks is visible under a clear blue sky.

CERN: Acelerando Ciencia e Innovación



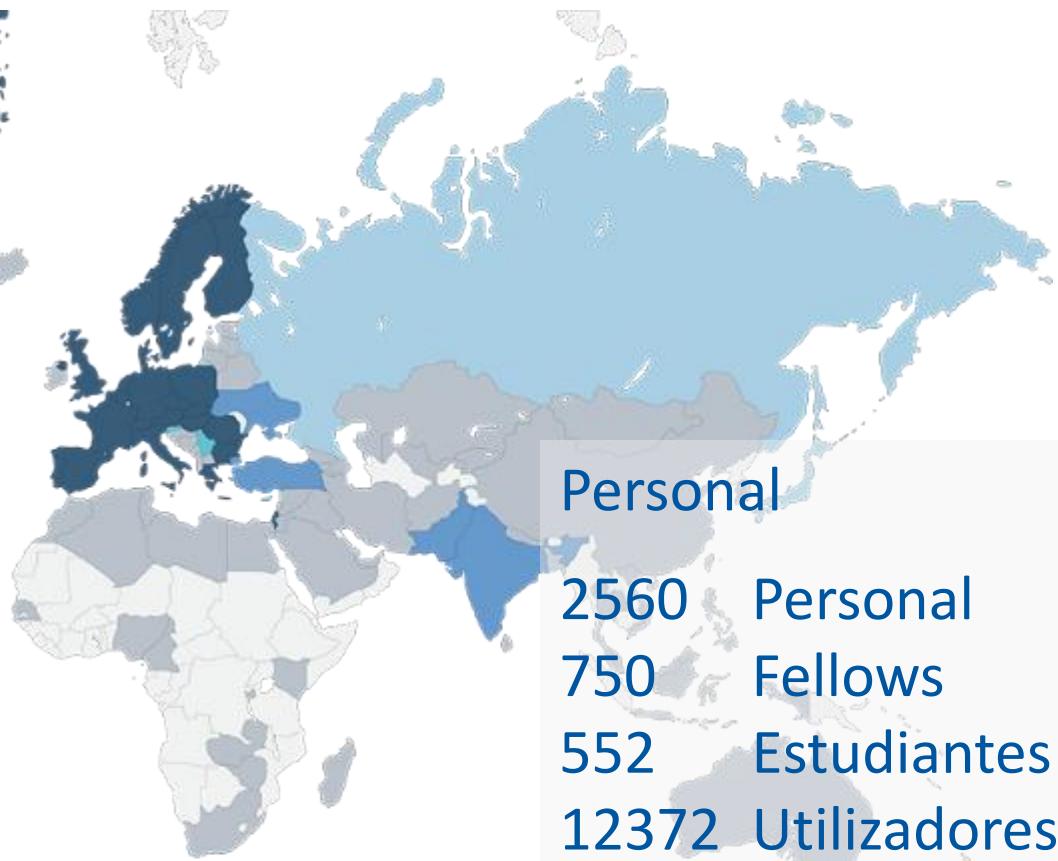
Spanish Teacher Programme 2018

El laboratorio en física de partículas más grande del mundo

Presupuesto anual
1230 MCHF

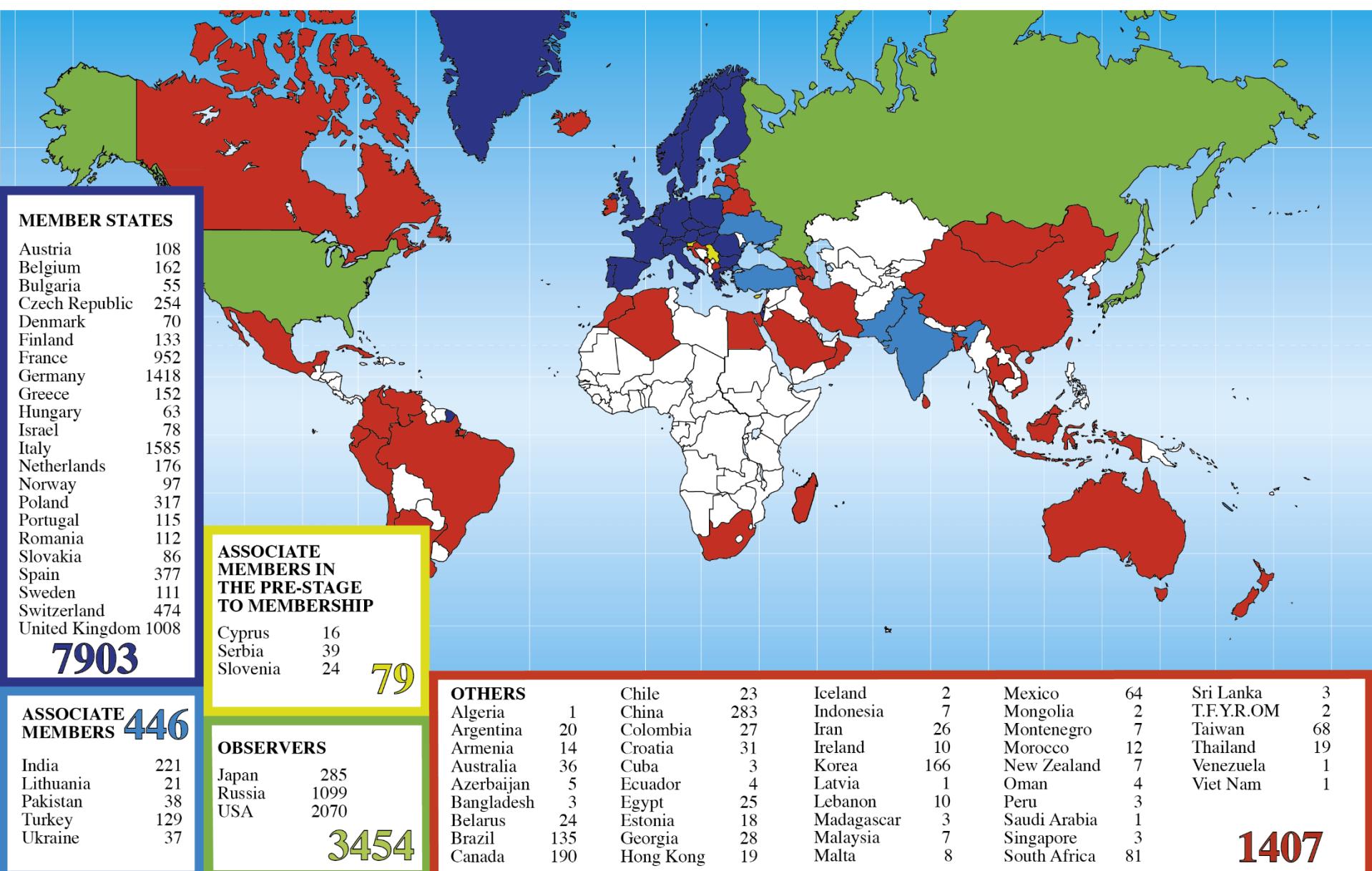


Financiación externa
de los experimentos



Personal
2560 Personal
750 Fellows
552 Estudiantes
12372 Utilizadores
2000 Empresas
externas

Distribution of All CERN Users by Location of Institute on 24 January 2018



The background image shows an aerial view of the CERN particle accelerator complex in a rural area of France. The complex consists of several large circular structures, primarily the Large Hadron Collider (LHC) ring, which is the largest and most prominent feature. The surrounding landscape is a mix of green fields, some small towns, and roads.

Formación

Investigación &
Descubrimientos

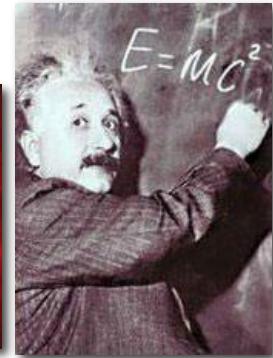
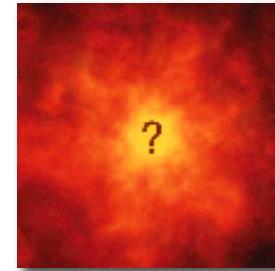
Colaboración
Tecnología



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?



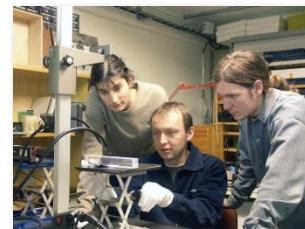
- **Desarrollar nuevas tecnologías en aceleradores y detectores**

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**



An aerial photograph of the CERN particle accelerator complex in Geneva, Switzerland. The image shows a dense network of roads, buildings, and agricultural fields. Superimposed on the image is a large, thin white circle representing the LHC ring, which cuts through the landscape. A smaller white circle highlights a specific area near the center of the ring.

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)

In a recent note¹ it was shown that theories in which massless symmetries under an internal group contain zero-mass particles the conserved currents of the internal group are coupled to the gauge fields. As a consequence of the present note it is shown that the mass of some of the gauge bosons, the longitudinal degrees of freedom of the gauge particles (which would be at zero) go over into the Go coupling tends to zero. The results apply to the theory to which Anderson² has shown that the scalar zero-mass conducting neutral Fermi field plasma modes of finite temperature exist.

The simplest theory which is a gauge-invariant theory used by Goldstone³ himself uses fields ψ_1, ψ_2 and a real v through the Lagrangian \mathcal{L}

$$\mathcal{L} = -\frac{1}{2}(\nabla\psi_1)^2 - \frac{1}{2}(\nabla\psi_2)^2 - V(\psi_1^2)$$

where

$$\nabla_\mu\psi_1 = \partial_\mu\psi_1$$

$$\nabla_\mu\psi_2 = \partial_\mu\psi_2$$

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

v is a dimensionless constant is taken as $-++-$, simultaneous gauge transformation $\psi_1 \rightarrow i\psi_1$ and $A_\mu \rightarrow A_\mu + v\partial_\mu$. Let us suppose that $V(\psi)$ spontaneous breakdown. Consider the equations of motion governing the propagation

508

*Work supported in part by the U. S. Atomic Energy Commission and in part by the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

¹G. F自然而 M. Gell-Mann, Phys. Rev. **120**, 13 (1959).

²D. Lee and C. N. Yang, Phys. Rev. **119**, 1419 (1960).

³J. Goldstone, Nuovo Cimento **19**, 918 (1960).

⁴J. Gubat and R. E. Shrock, Nuovo Cimento **64**, 96 (1963); Y. Ne'eman, Nuovo Cimento **27**, 923 (1963).

⁵E. P. Segré, Phys. Rev. **133**, 456 (1964).

⁶S. Adler, S. Glashow, Nuovo Cimento **25**, 857 (1964).

VOLUME 13, NUMBER 9 PHYSICAL REVIEW LETTERS 31 AUGUST 1964

BROKEN SYMMETRY AND THE MASS OF GAUGE VECTOR MESONS*

F. Englert and R. Brout
Faculté des Sciences, Université Libre de Bruxelles, Bruxelles, Belgium
(Received 26 June 1964)

It is of interest to inquire whether gauge vector mesons acquire mass through interaction with a gauge vector meson we mean a Yang-Mills field¹ associated with the extension of a local symmetry group to local symmetry. The importance of this problem lies in the possibility that strong interactions originates from massive gauge fields related to a system of conserved currents.² 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.^{3,4} A characteristic feature of such theories is the possible existence of zero-mass bosons which tend to restore the symmetry.^{5,6} We shall show that it is precisely these singularities which violate the gauge invariance of the theory, complete 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, in such a situation not studied in particular mention to what extent the symmetry is broken but simply assume that such a mechanism exists. A calculation performed in lowest order perturbation theory indicates that

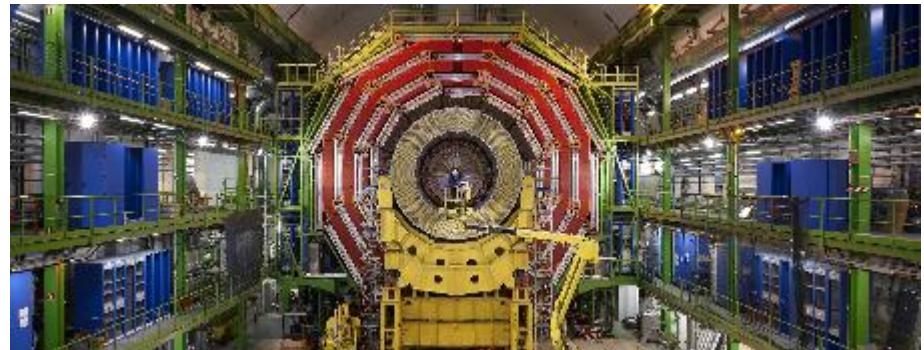
*Work supported in part by the U. S. Atomic Energy Commission and in part by the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

¹N. P. Salter, Phys. Rev. **111**, 275 (1959).

²The most generally reported estimate comes from the limit on $K_F^2 - \mu^2 - v^2$. The 90% confidence level is $|g_{\mu\mu}| < 10^{-3}|g_{ee}|$, M. Barton, K. Lando, L. M. Lederman, and William Chlomsky, Ann. Phys. (N.Y.) **5**, 156 (1959).

³The analysis of the decay mode $\pi^+ \rightarrow e^+ + e^-$ is not yet available for the case of neutral currents since this decay mode may be absolutely forbidden by conservation of muon number: G. F自然而 M. Gell-Mann, Ann. Rev. Nucl. Sci. **12**, 445 (1962).

⁴S. N. Blasius and S. K. Bose, Phys. Rev. Letters **12**, 176 (1964).



1964

1964-2012



Discovery 2012, Nobel Prize in Physics 2013

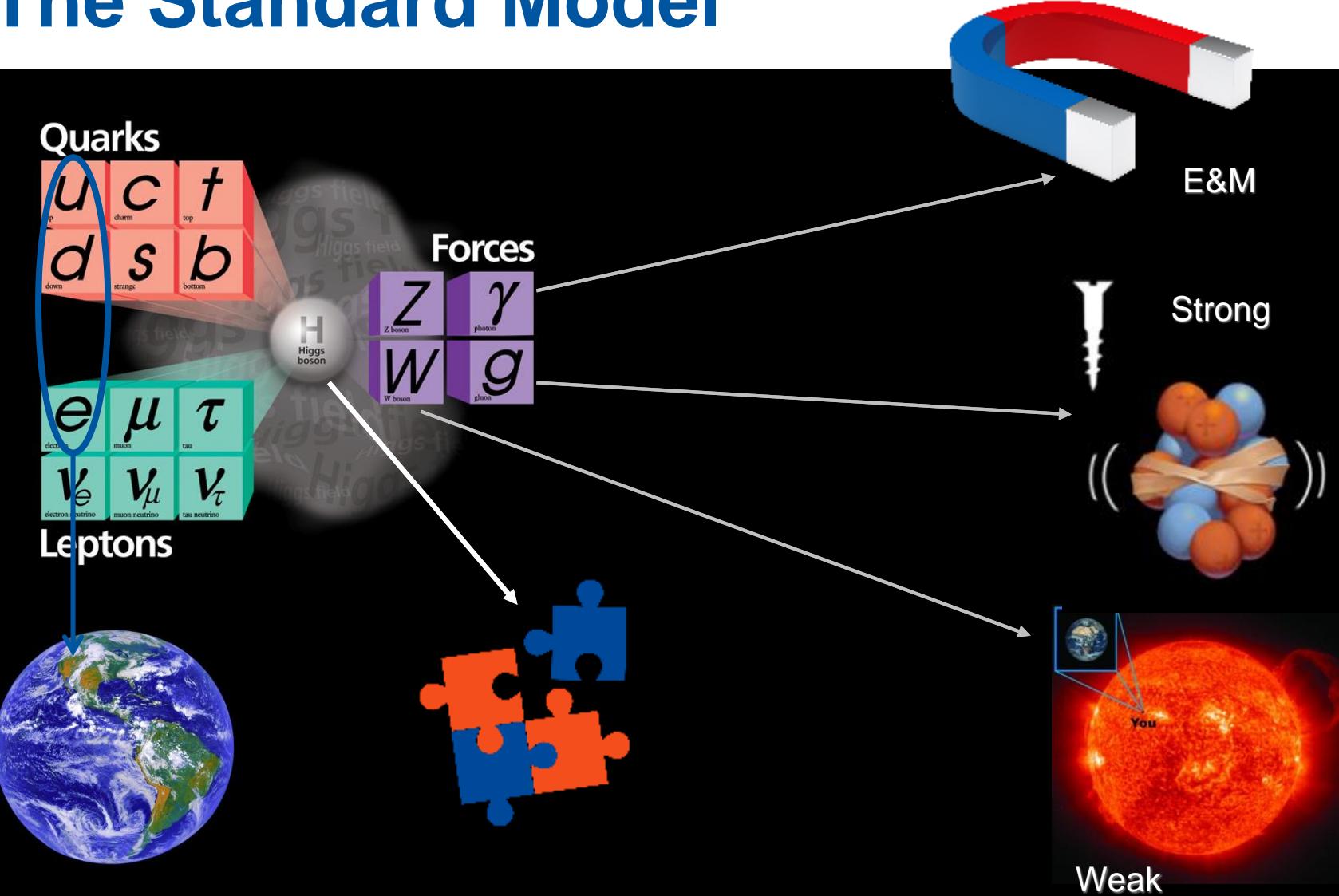


The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental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

Y nuestro Premio Príncipe de Asturias



The Standard Model



Standard Model

Only **4%**

is ordinary (visible) matter

The DARK Universe

96%

- 73% Dark Energy
- 23% Dark Matter

DARK MATTERS !

An aerial photograph of the CERN particle accelerator complex in Geneva, Switzerland. The image shows a vast, green, agricultural landscape with numerous fields and small settlements. Superimposed on the image is a large, thin white circle representing the LHC ring. Inside this ring, there are several smaller white circles and lines forming a complex geometric pattern, representing the interaction points and beam lines of the accelerator.

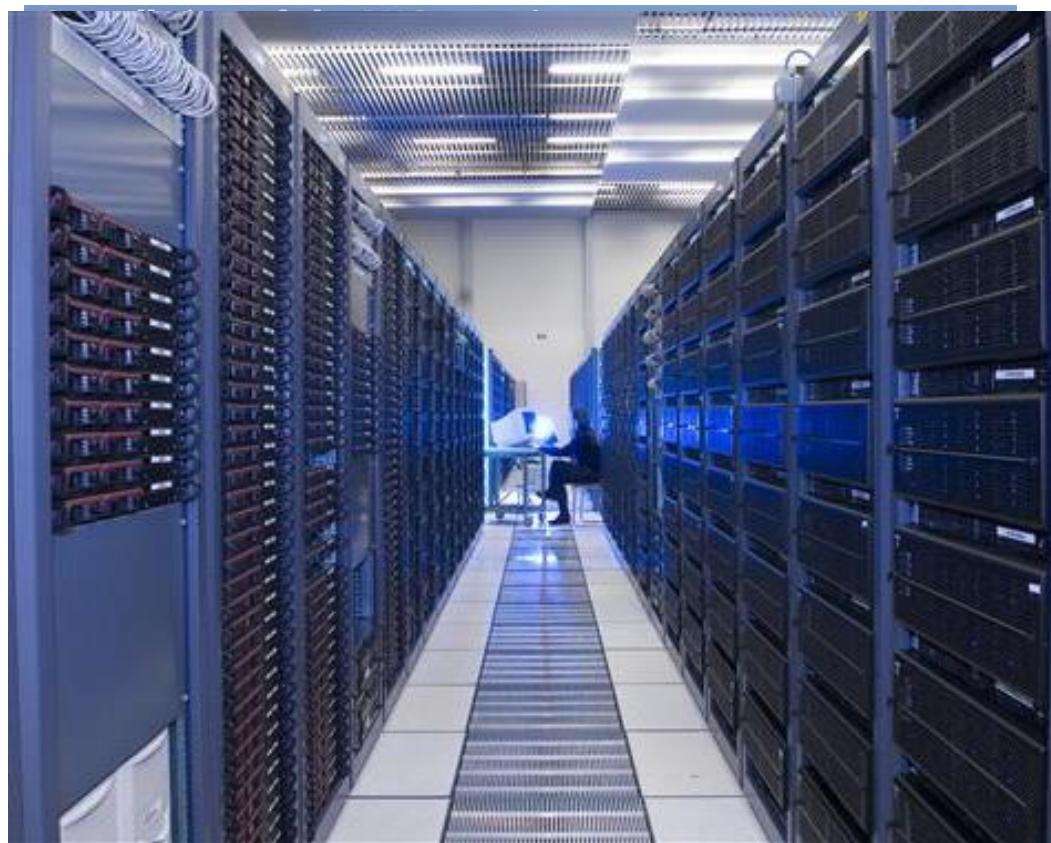
Tecnología

Las Herramientas

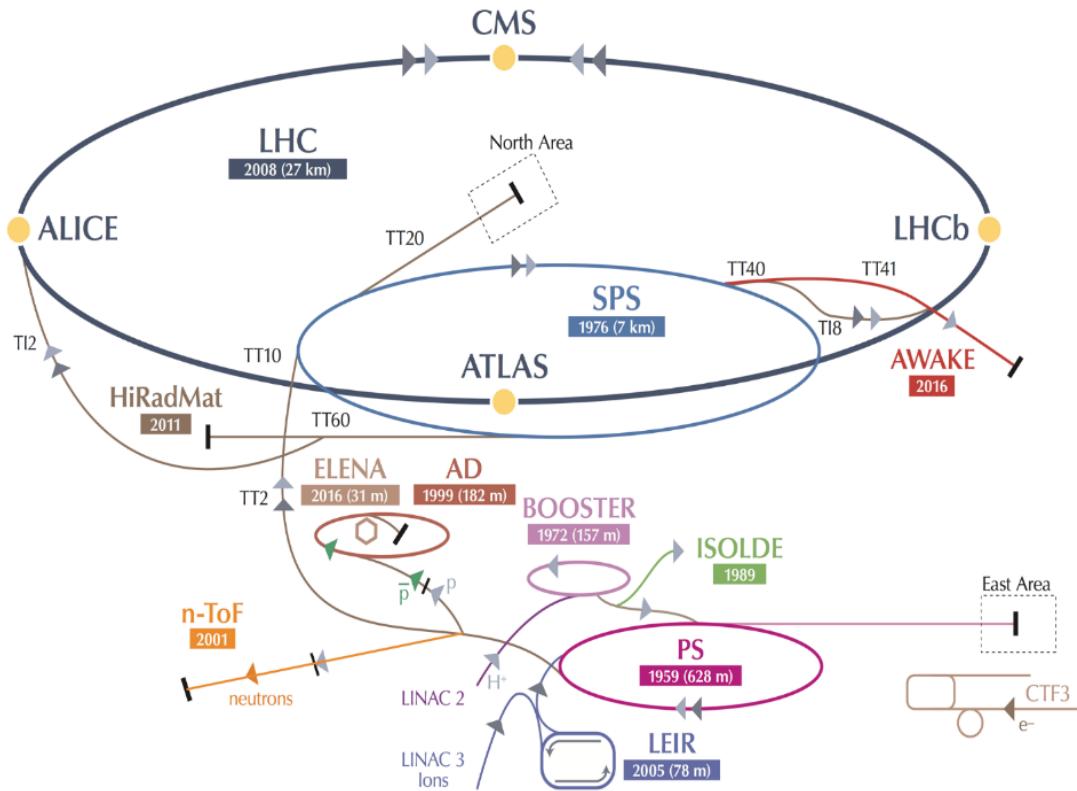
1. Aceleradores: Máquinas capaces de acelerar partículas a energías extremadamente altas y hacerlas colisionar

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



CERN's accelerator 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 aerosols 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

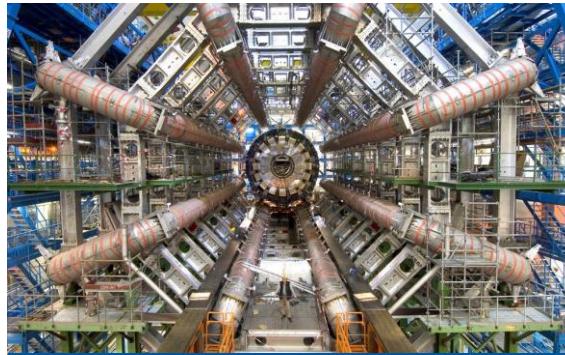
n-TOF: n-induced cross-sections

UA9: crystal collimation

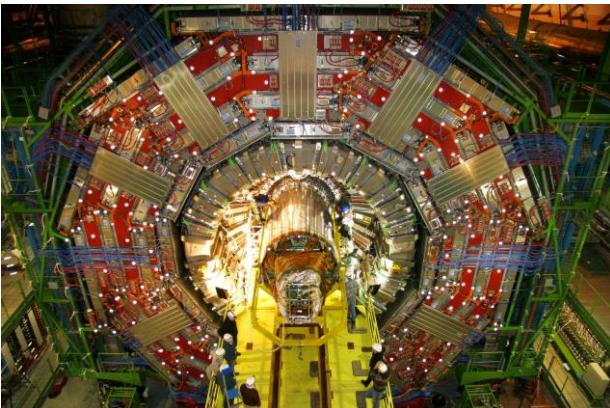
Quatro Experimentos: the coopetition



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

A worldwide success?

With a wide diversity in technologies!

LINAC2



Super Proton Synchrotron

Large Hadron Collider

PS Booster



LHC straight section

LHC Magnet Coil



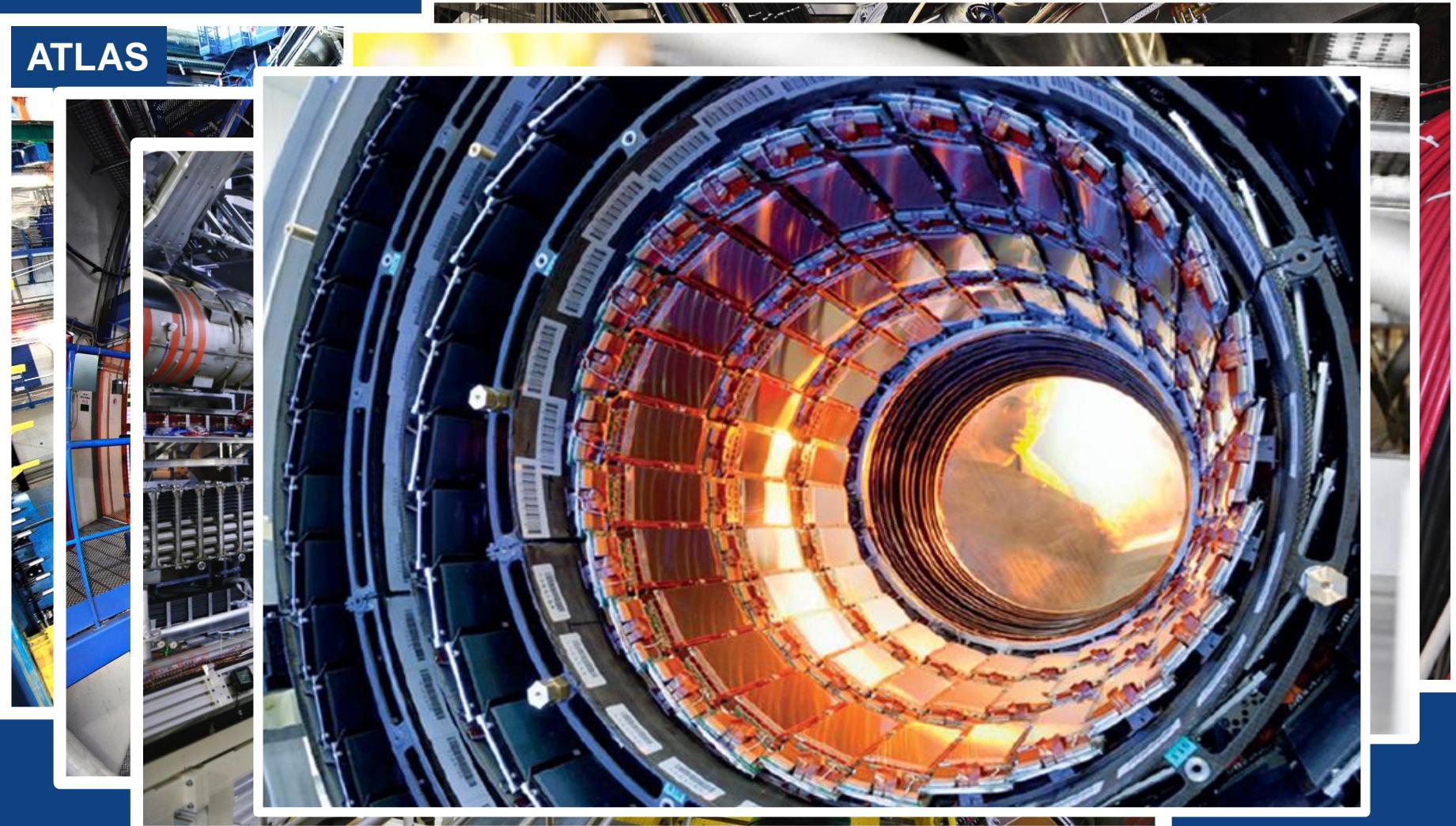
Superconductor strand



A worldwide success?

And detectors amonast major instruments of Humanity!

ATLAS



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

Los detectores más grandes y más sofisticados

$$E = mc^2$$

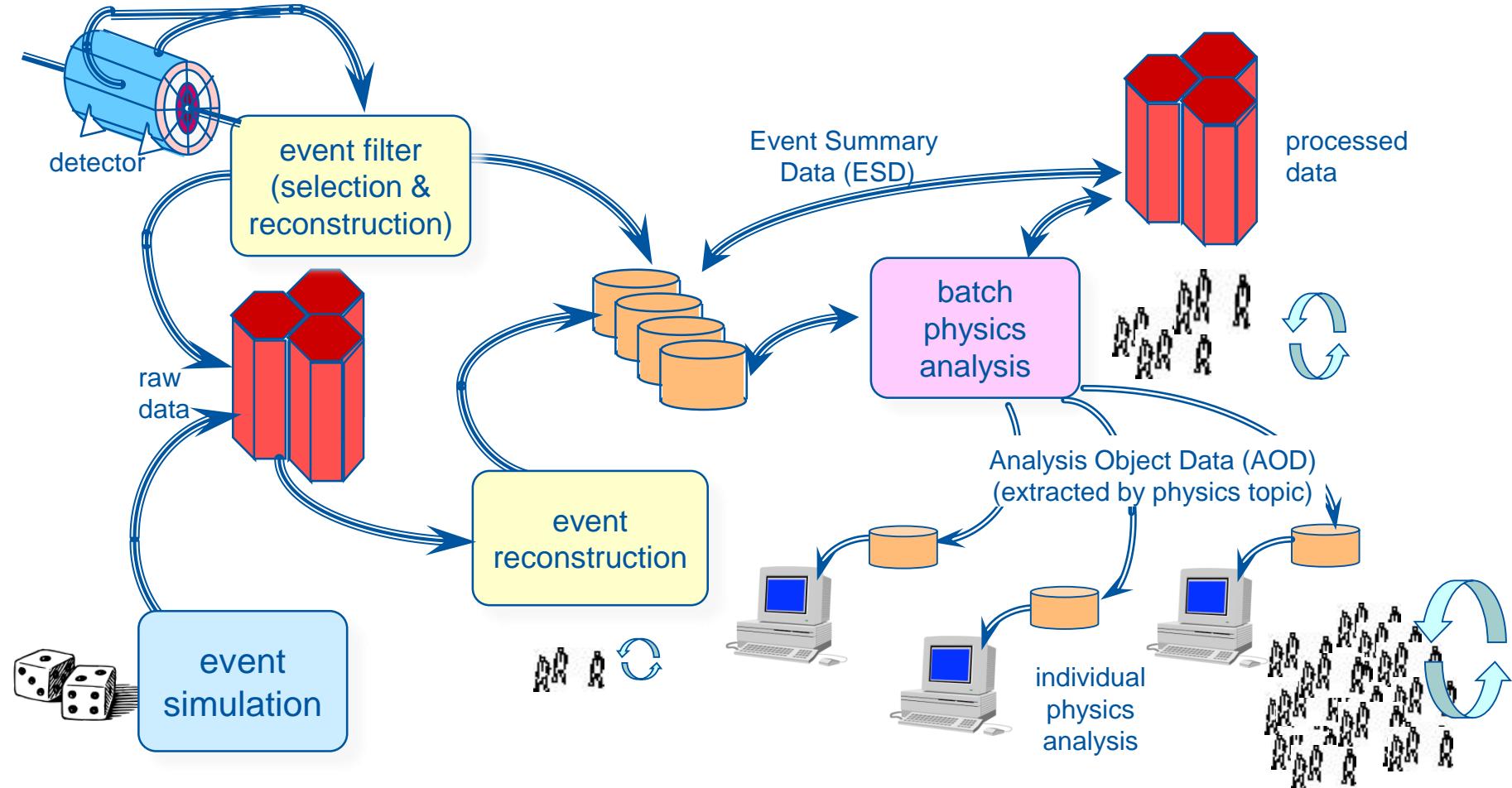
Catedrales de la ciencia
100m bajo tierra

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

Miles de colaboradores



Análisis de Datos



LHC (Large Hadron Collider)

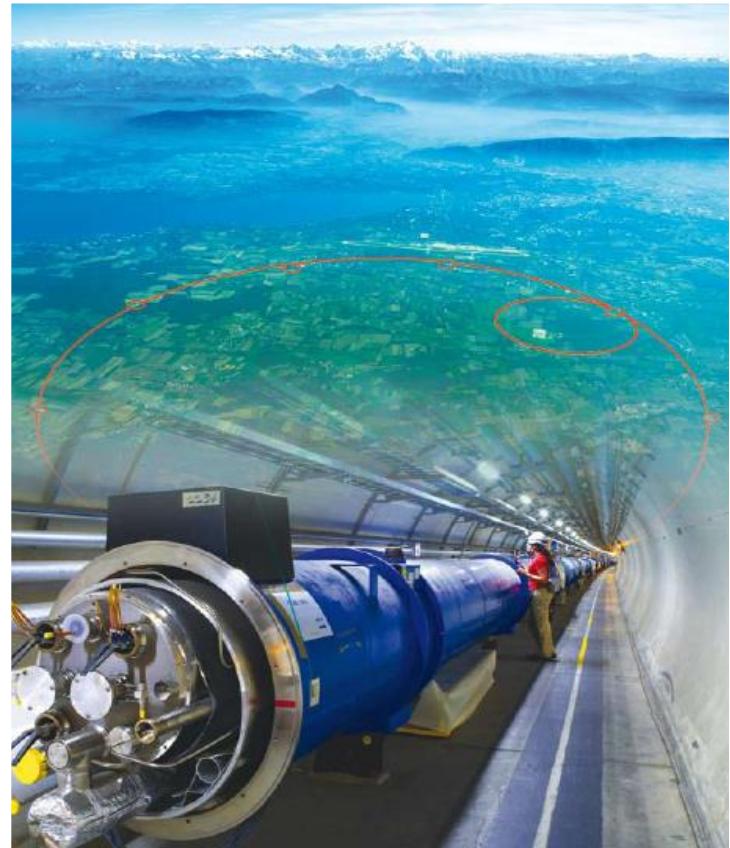
14 TeV proton-proton accelerator-collider built in the LEP tunnel

Lead-Lead (Lead-proton) collisions

- 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

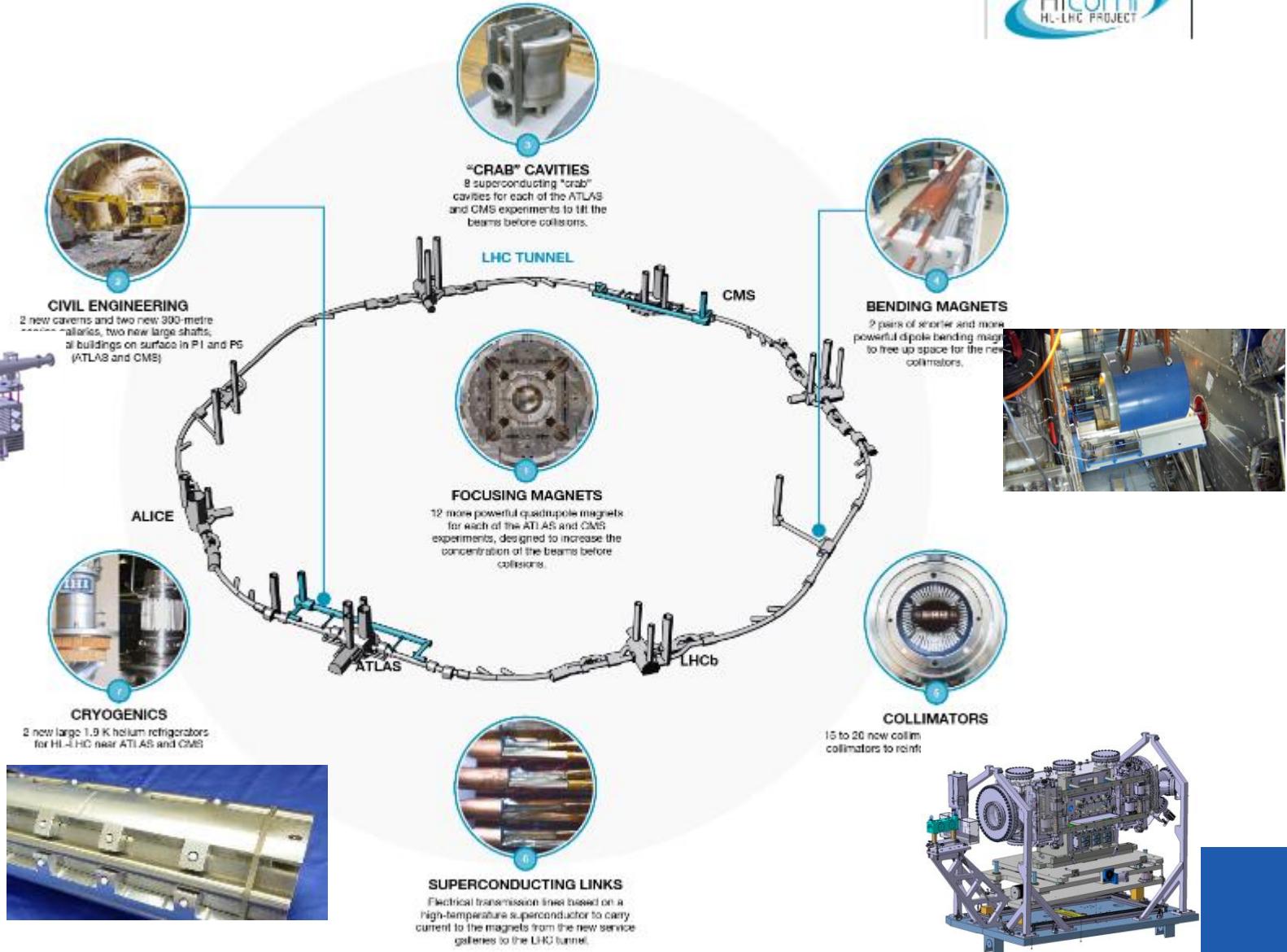
- 2010 – 2012 Run 1 ; 7 and 8 TeV
- 2015 – 2018 Run 2 ; 13 TeV
- 2021 – 2023 Run 3 (14 TeV)
- 2024 – 2025 HL-LHC installation**
- 2026 – 2035... HL-LHC operation



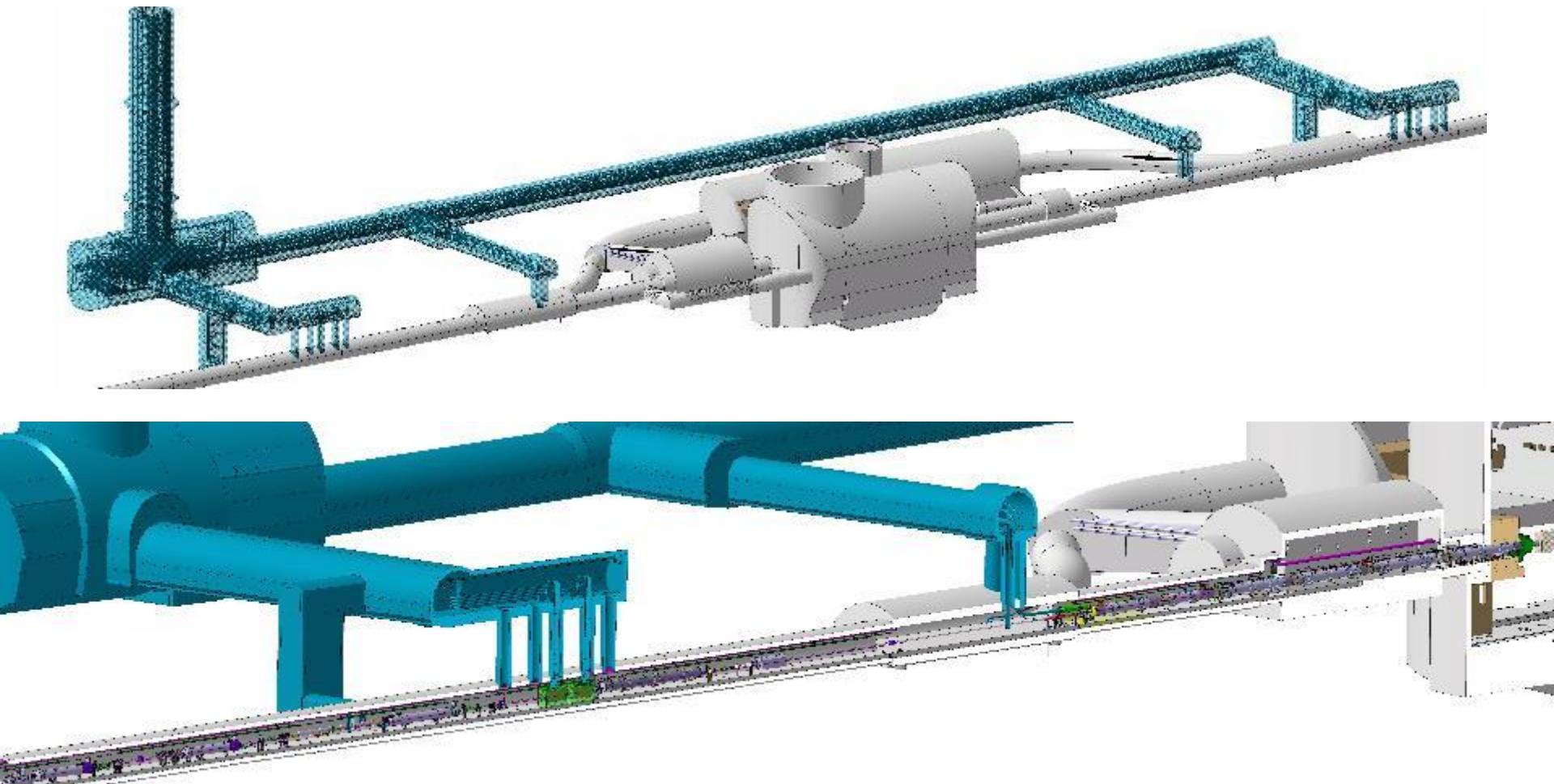
A 27 km circumference collider...



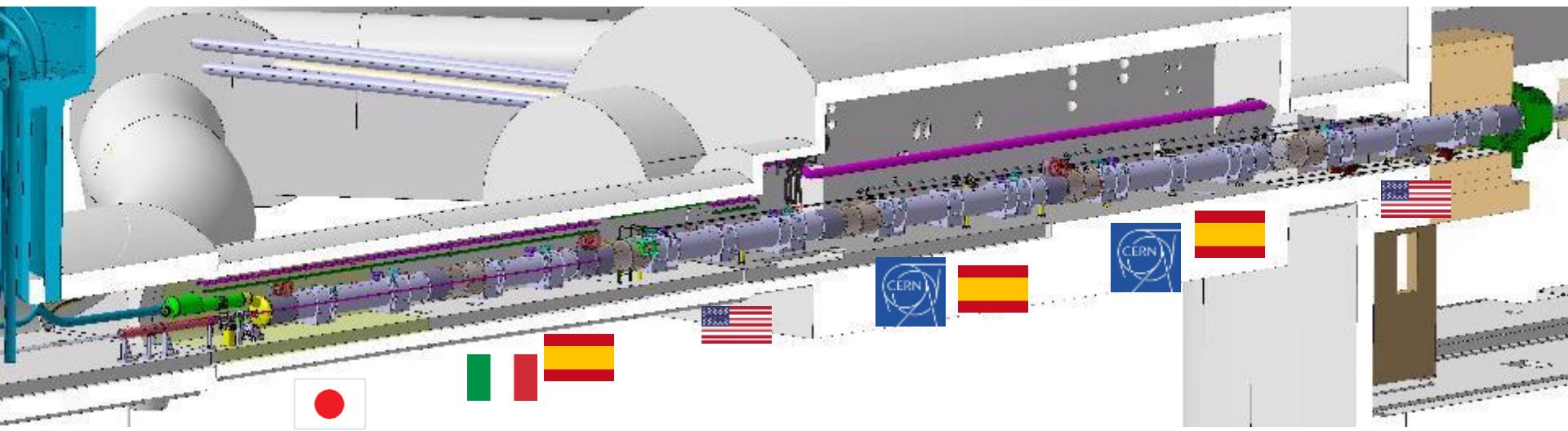
HL-LHC: Pushing the technology!



2024–2026 Long shutdown (LS3)

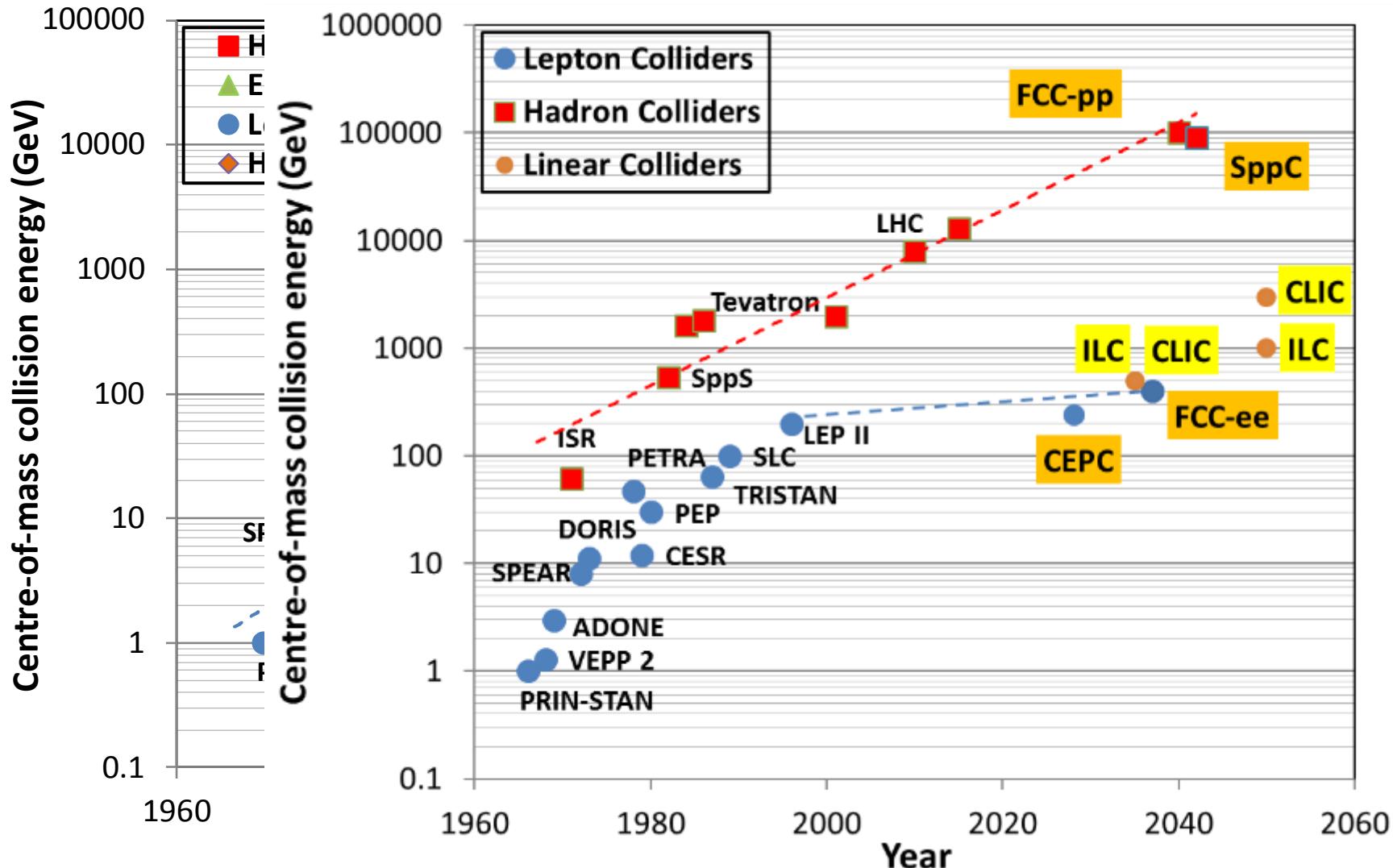


2024–2026 Long shutdown (LS3)



A vibrant R&D on breakthrough technologies!

Fundamental role of Colliders





The background image shows an aerial view of the CERN particle accelerator complex in a rural area of France and Switzerland. The complex consists of several large circular structures, primarily the Large Hadron Collider (LHC) ring, which is the largest and most prominent feature. The surrounding landscape is a mix of agricultural fields, some small towns, and the Seine River. The image is taken from a high altitude, providing a comprehensive view of the facility and its surroundings.

Formación

Actividades educativas del CERN

Científicos en el CERN

Programa de enseñanza académica

Jóvenes investigadores

Escuelas de física de altas energías

Escuela de computación

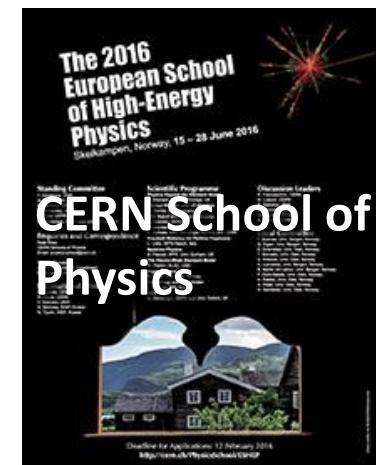
Escuela de aceleradores

Escuelas para profesores EM

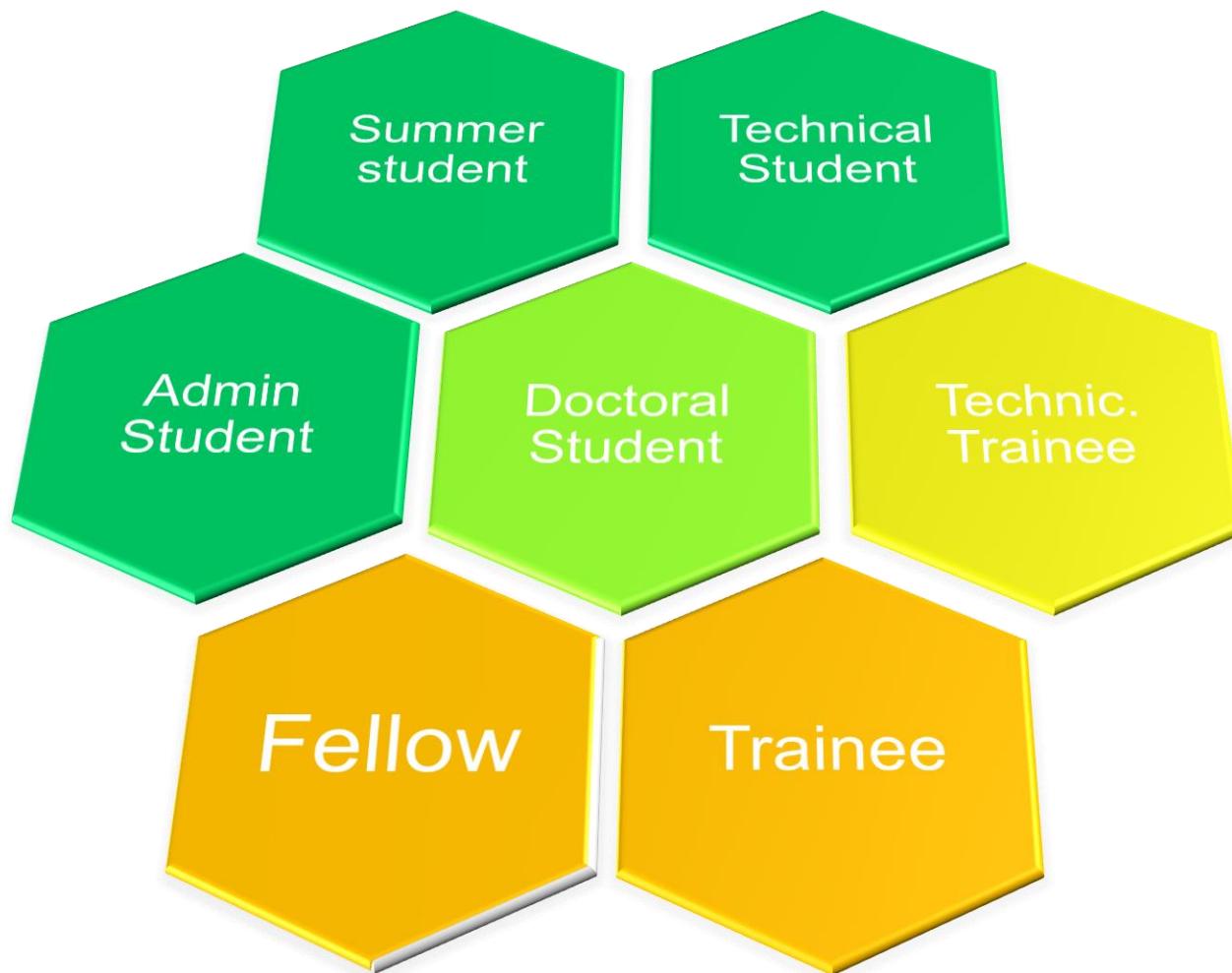
Programas internacionales y nacionales

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

