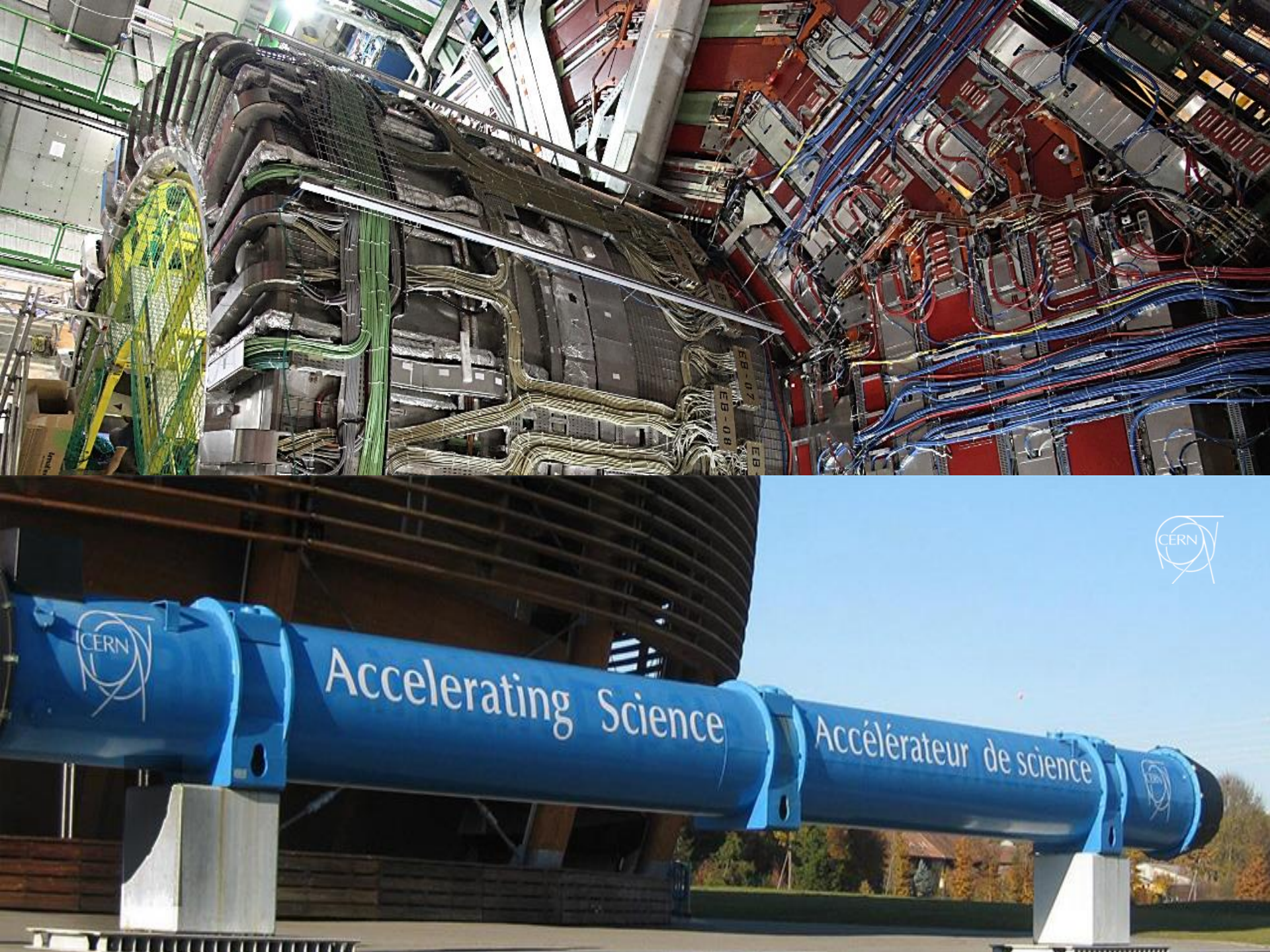

CERN
Accelerating Science
Accélérateur de science
CERN

Welcome – Bienvenidos

Ministro Pedro Duque

Ministerio de Ciencia, Innovación
y Universidades

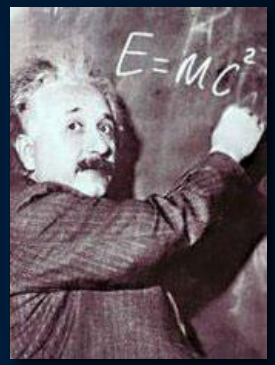
Kingdom of Spain

to Accelerating Science and Innovation

The Mission of CERN

- **Push back** the frontiers of knowledge

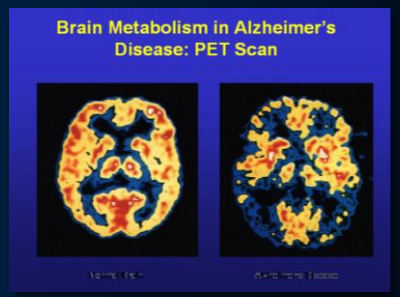
  E.g. the secrets of the Big Bang …what was the matter like within the first moments of the Universe's existence?



- **Develop** new technologies for accelerators and detectors

  Information technology - the Web and the GRID

  Medicine - diagnosis and therapy



- **Train** scientists and engineers of tomorrow

- **Unite** people from different countries and cultures

CERN: founded in 1954: 12 European States
"Science for Peace"
Today: 22 Member States

~ 2500 staff
~ 1800 other paid personnel
~ 13000 scientific users

Budget (2018) ~ 1150 MCHF

Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Sweden, Switzerland and United Kingdom

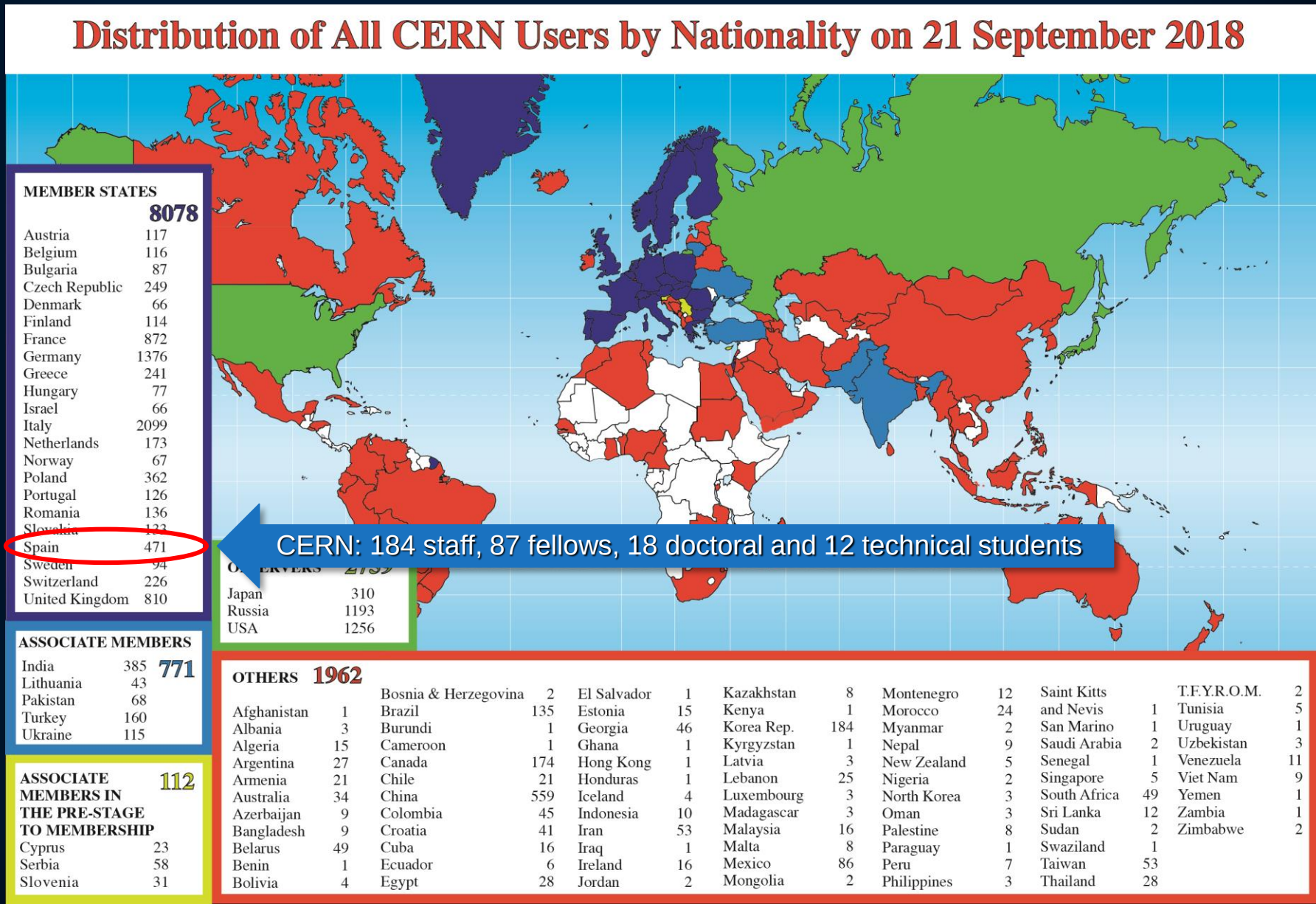
Associate Members in the Pre-Stage to Membership: Cyprus, Serbia, Slovenia

Associate Member States: India, Lithuania, Pakistan, Turkey, Ukraine

Applications for Membership or Associate Membership: Brazil, Croatia, Estonia

Observers to Council: Japan, Russia, United States of America; European Union, JINR and UNESCO

Science is getting more and more global



Spain and CERN

España @ CERN
Personnel

- Contribution 2018: ~79 MCHF
  7.04%
- 165 Staff and 19 bi-nationals

  Very satisfactory situation ~7.7% (including bi-nationals)
- Continuous increase of Students and Fellows, remaining above returns
- Improvement in the number of Doctoral Students, several Collaboration agreements signed with Universities

Personnel return and contribution by primary nationality

01.11.2018

Country	Staff members		Fellows		Doctoral students		Technical students		Admin. students		Normalized contribution
	hc	%	hc	%	hc	%	hc	%	hc	%	%
AT	56	2.10	11	1.31	23	10.04	5	2.96			2.10
BE	104	3.90	7	0.83							2.65
BG	17	0.64	7	0.83			1	0.59			0.29
CH	205	7.69	27	3.21	6	2.62			3	10.34	3.94
CY	2	0.08	3	0.36	1	0.44					0.09
CZ	5	0.19	10	1.19			1	0.59			0.91
DE	179	6.71	67	7.98	50	21.83	22	13.02	1	3.45	20.10
DK	19	0.71	3	0.36							1.76
ES	165	6.19	87	10.36	18	7.86	10	5.92	2	6.90	6.89
FI	27	1.01	11	1.31			2	1.18			1.50
FR	999	37.47	112	13.33	15	6.55	3	1.78	1	3.45	13.81
GB	220	8.25	48	5.71	8	3.49	4	2.37			15.49
GR	45	1.69	57	6.79	13	5.68	35	20.71	8	27.59	1.09
HU	15	0.56	11	1.31	3	1.31	4	2.37	1	3.45	0.60
IL	3	0.11									1.58
IN	2	0.08	11	1.31	1	0.44	5	2.96			1.07
IT	312	11.70	156	18.57	41	17.90	21	12.43	1	3.45	10.20
LT			1	0.12			1	0.59			0.09
NL	68	2.55	11	1.31	7	3.06	1	0.59			4.51
NO	17	0.64	20	2.38	3	1.31	6	3.55	1	3.45	2.65
PK	1	0.04	1	0.12	3	1.31	5	2.96	1	3.45	0.13
PL	73	2.74	68	8.10	15	6.55	21	12.43	3	10.34	2.76
PT	61	2.29	21	2.50	4	1.75	1	0.59			1.08
RO	18	0.68	11	1.31			3	1.78	2	6.90	1.00
RS	5	0.19	1	0.12			3	1.78	2	6.90	0.17
SE	26	0.98	8	0.95	4	1.75	4	2.37	1	3.45	2.63
SI					1	0.44					0.09
SK	13	0.49	7	0.83	2	0.87	3	1.78			0.48
TR			2	0.24	2	0.87	2	1.18	1	3.45	0.49
UA	1	0.04	3	0.36	2	0.87	3	1.78	1	3.45	0.09
NMS	8	0.30	58	6.90	7	3.06	3	1.78			
Total	**2,666**		**840**		**229**		**169**		**29**		

Spain and CERN

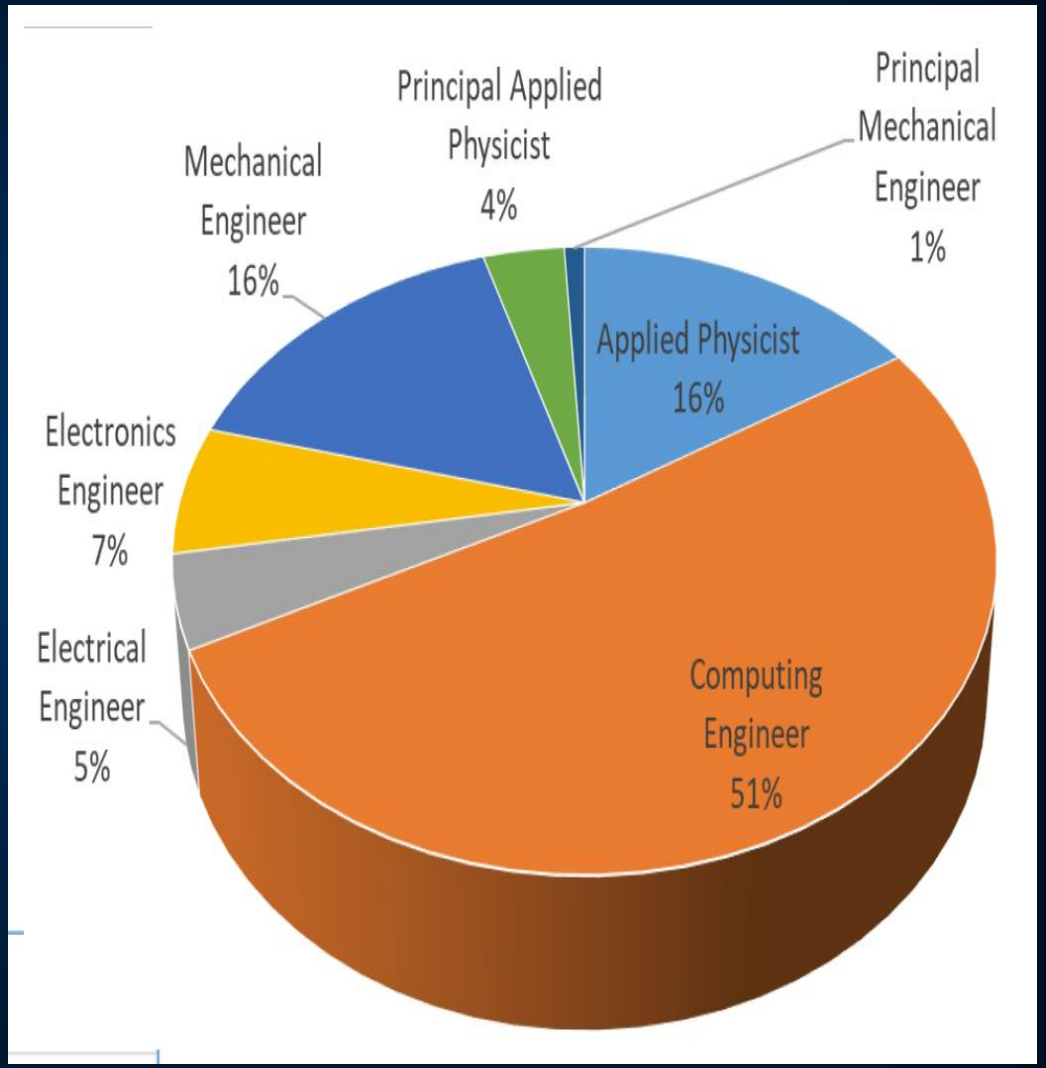
España @ CERN
Personnel

1170 Spanish working @ CERN

- Staff, Fellows, Students and Associates
  - **Staff** **165**

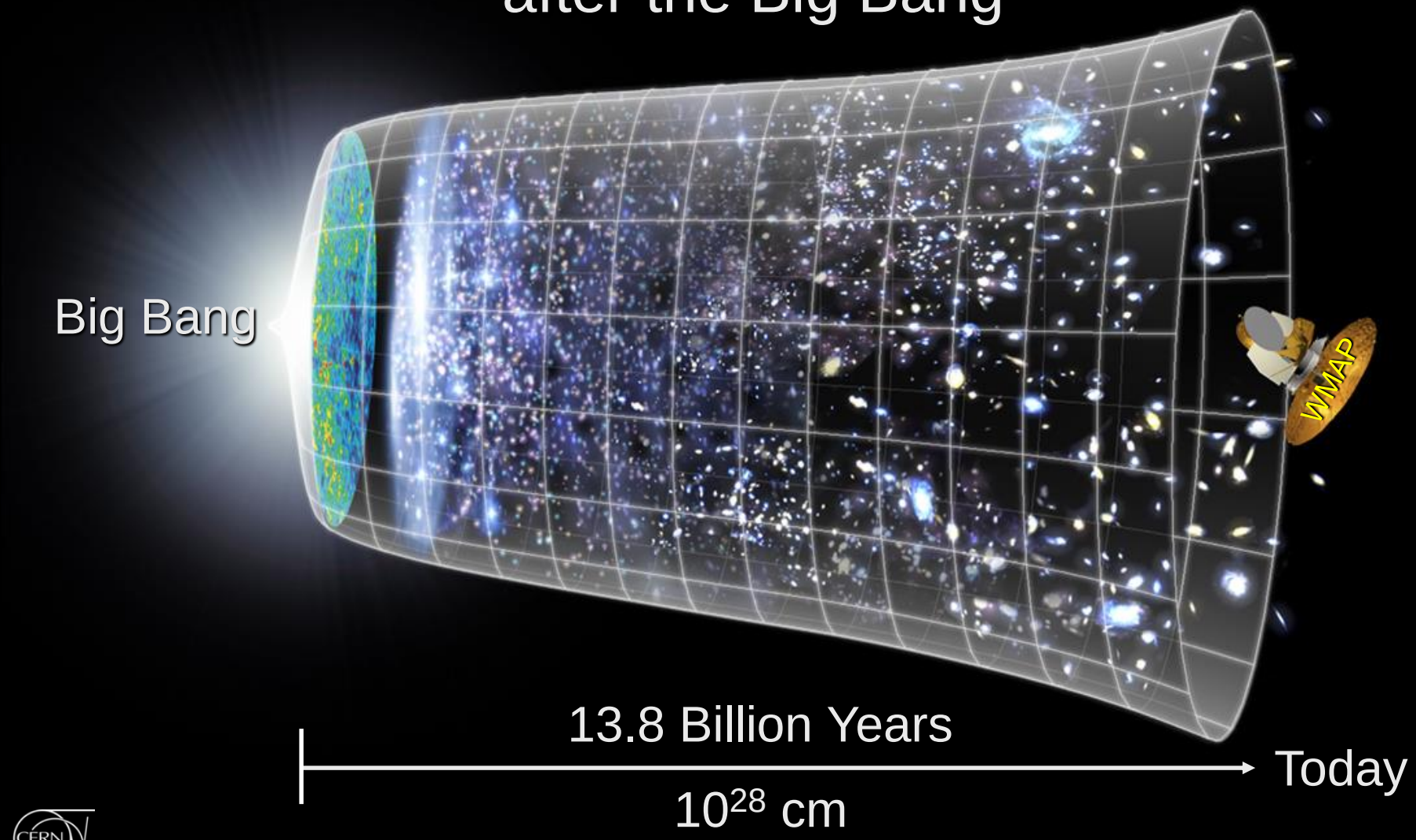
    63% of Staff has an academic profile (Engineers or Doctors)

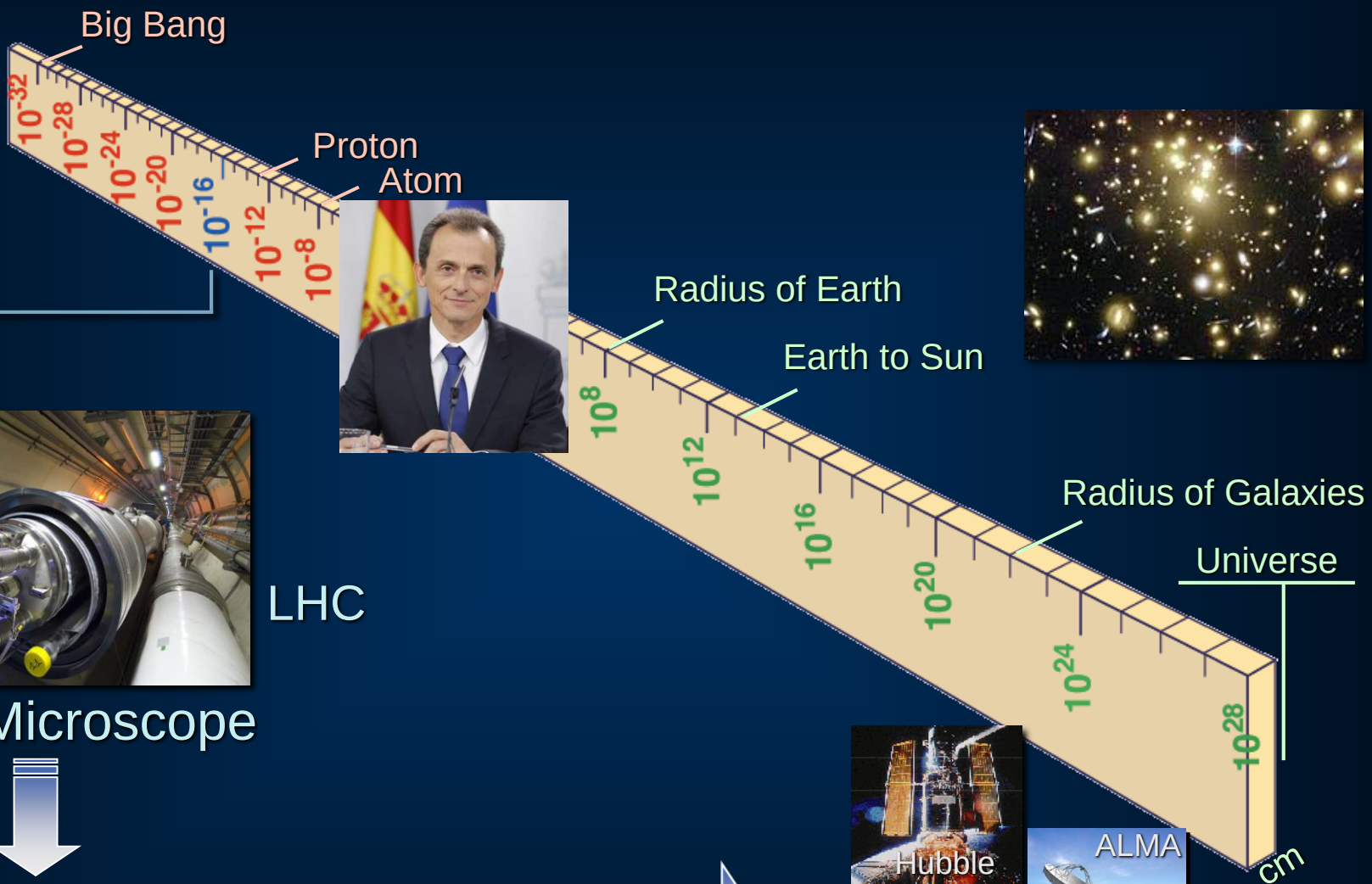
    51% hold Indefinite (Staff) Contracts
  - Fellows 87
  - Students 78
  - Associates 133
- Companies 238
- Users 471

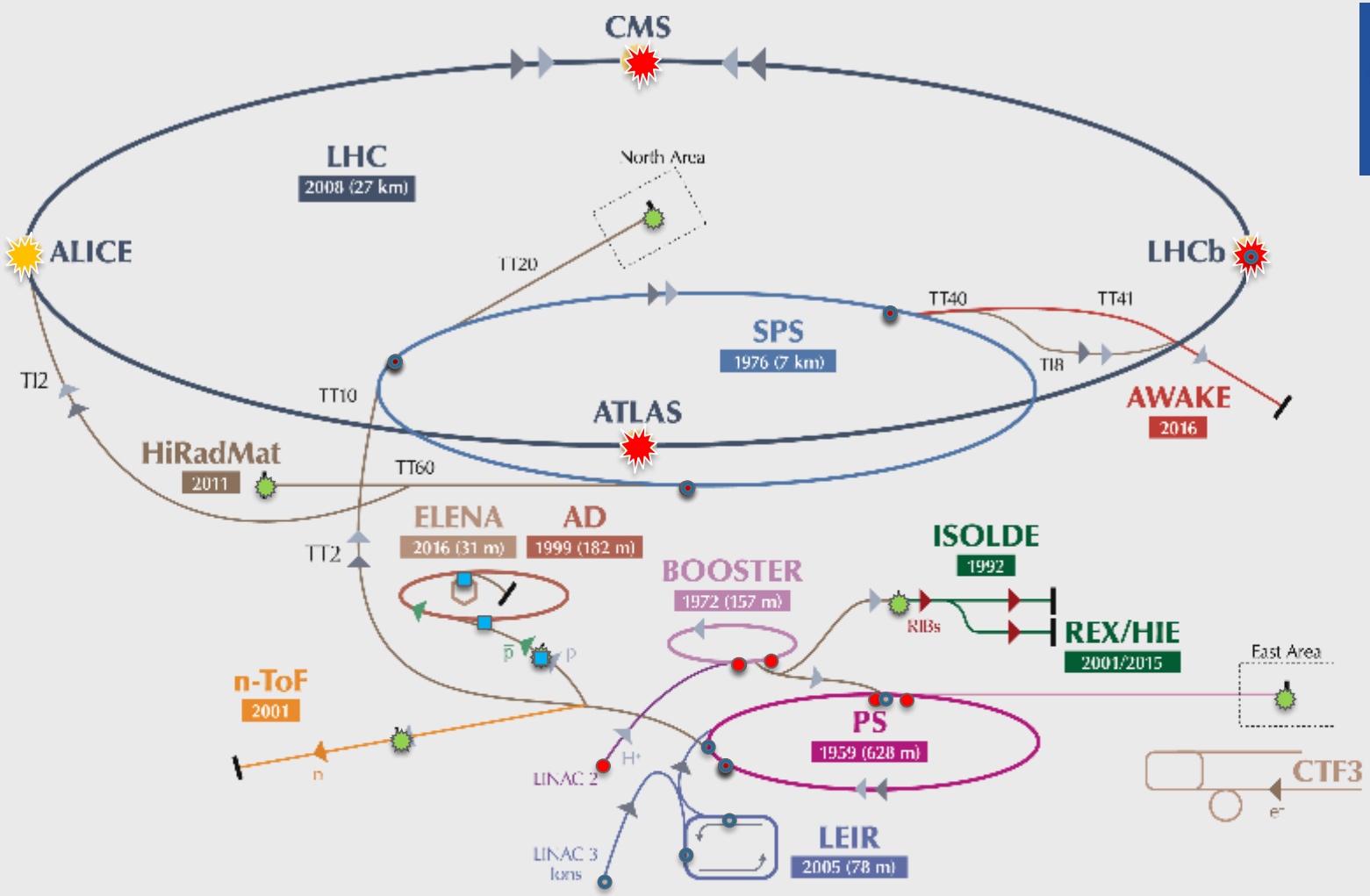


Next Scientific Challenge:

to understand the very first moments of our Universe after the Big Bang




Big Bang
Proton
Atom
Radius of Earth
Earth to Sun
Radius of Galaxies
Universe
cm
LHC
Super-Microscope
Reproducing conditions
Looking back
Hubble
ALMA
AMS
VLT



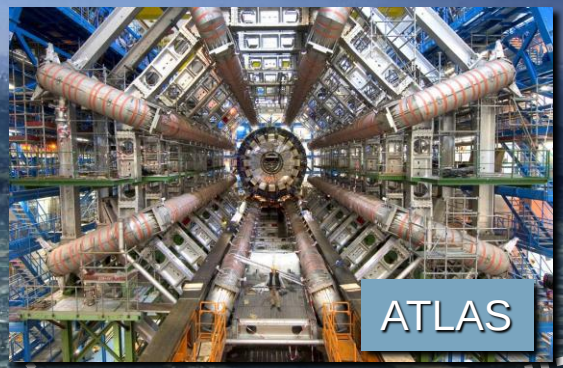
p (protons) ions RIBs (Radioactive Ion Beams) n (neutrons) $\bar{p}$ (antiprotons) e^- (electrons) proton/antiproton conversion proton/RIB conversion

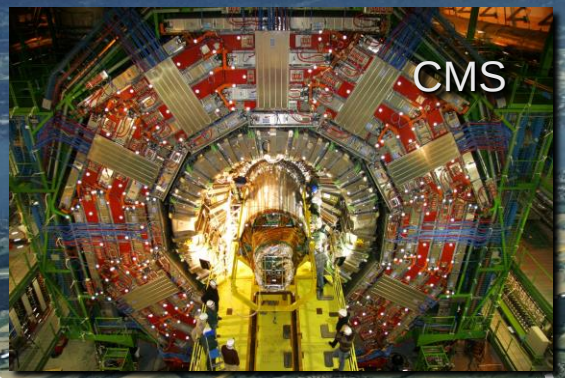
LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron AD Antiproton Decelerator CTF3 Clic Test Facility

AWAKE Advanced WAKefield Experiment ISOLDE Isotope Separator OnLine REX/HIE Radioactive EXperiment/High Intensity and Energy ISOLDE

LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight HiRadMat High-Radiation to Materials

2010: a New Era in Fundamental Science

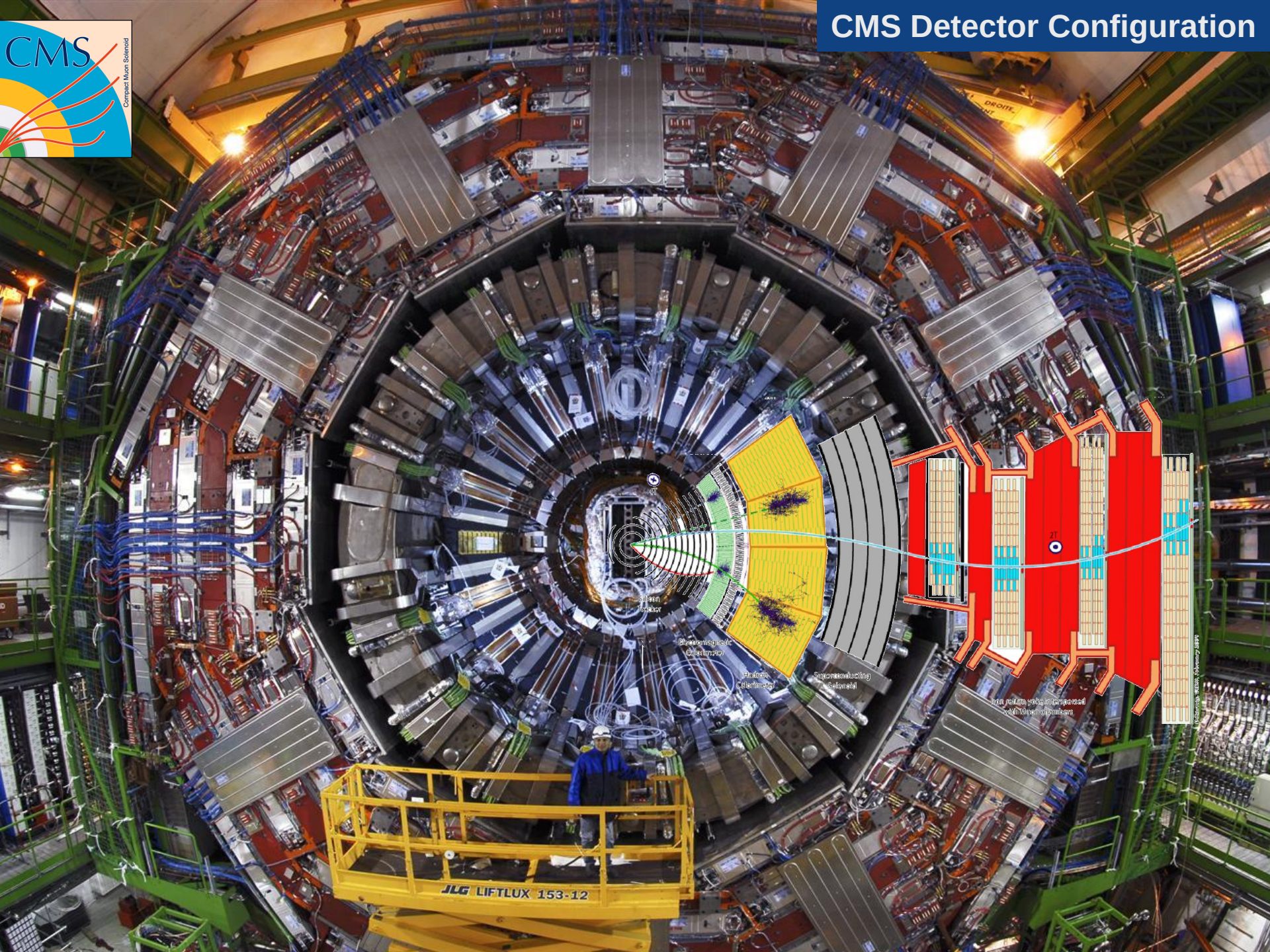




Exploration of a new energy frontier
in p-p and Pb-Pb collisions

CERN

CMS Detector Configuration



A Scientific Strategy in response to its leading role in High Energy Physics*

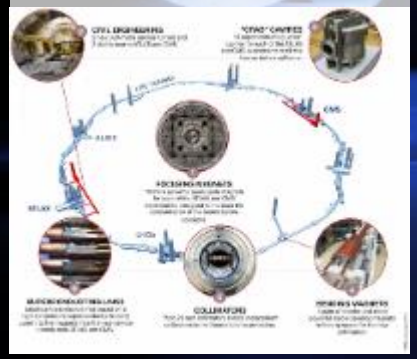
- **Full exploitation** of the LHC:
  - Successful Run 2, LS2, and Run 3 start-up.
  - Upgrade of LHC Injectors; on-track construction of HL-LHC.
- **Scientific diversity** programme serving a broad community:
  - ongoing experiments and facilities at Booster, PS, SPS and their upgrades.
  - participation in accelerator-based neutrino through CERN Neutrino Platform.
- Preparation of **CERN future**:
  - Vibrant accelerator R&D programme exploiting CERN strengths and uniqueness.
  - Design studies for future accelerators: CLIC, FCC (includes HE-LHC).
  - Future opportunities of diversity programme: “Physics Beyond Colliders”.

*update of the European Strategy for Particle Physics in 2019-2020.

Futures Accelerators: 3 vectors of R&D!

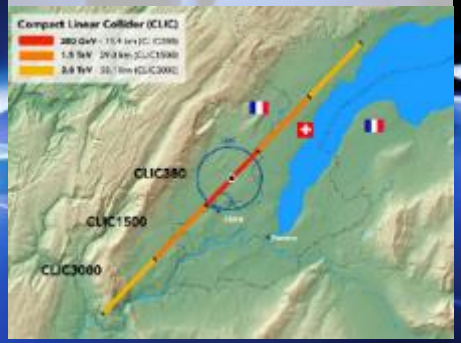
CERN
responds to the
European Strategy

High Luminosity
HL-LHC



High Energy
FCC and
HE-LHC, as
technology
demonstrator

High Energy and
Precision Physics
CLIC

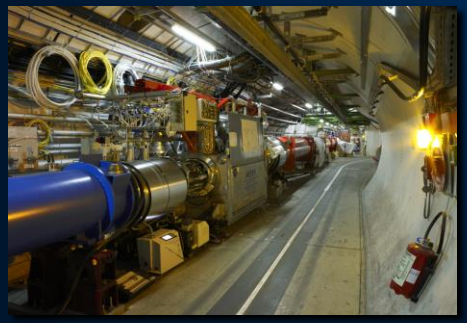


Innovation
Education
CERN
uniting people
Research

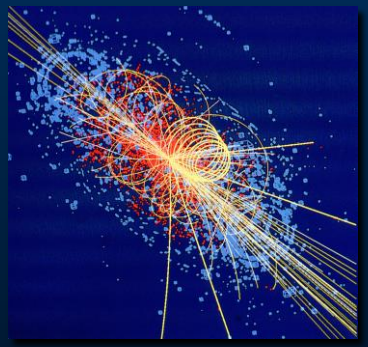
CERN: Particle Physics and Innovation

- Interfacing between fundamental science and key technological developments

- CERN Technologies and Innovation



Accelerating particle beams



Detecting particles

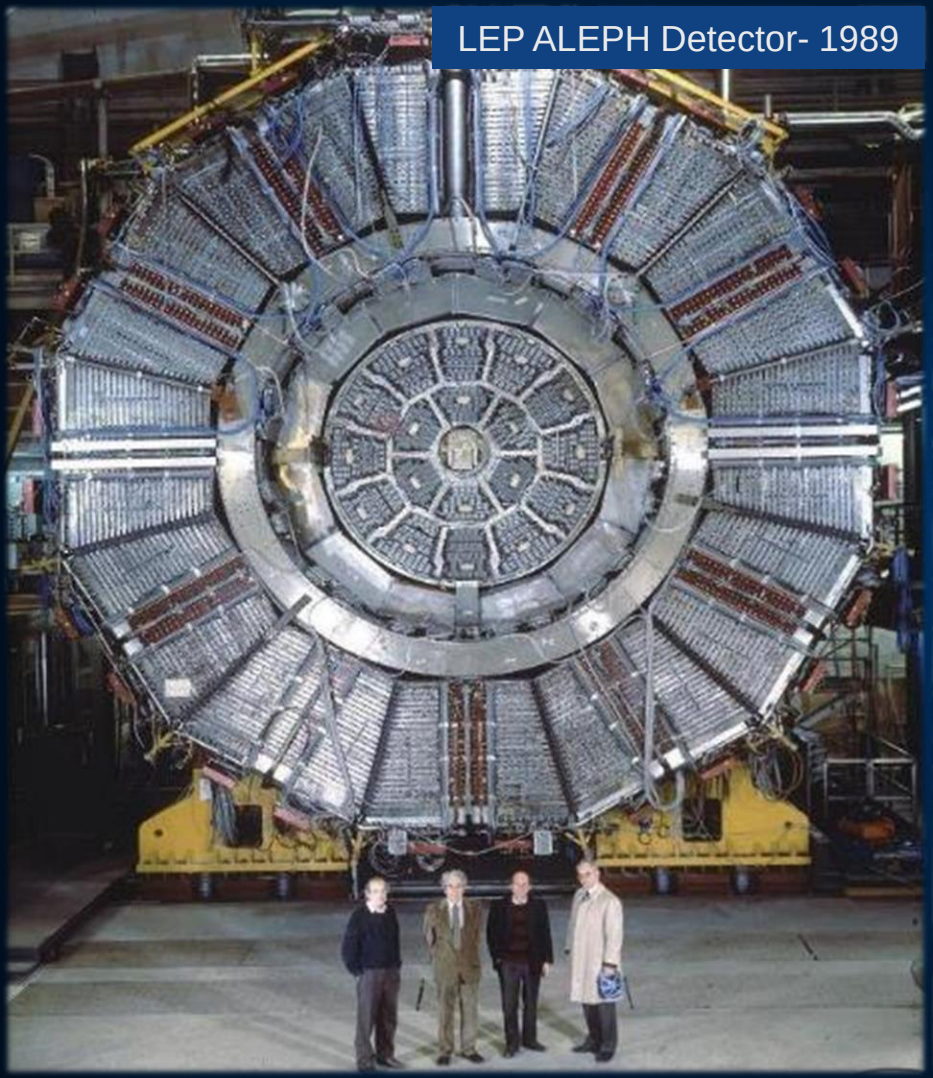
Large-scale computing (Grid)

CERN

Accelerating Science and Innovation

Pushing Technology breakthroughs!

Accelerating Science and Innovation



Pushing Technology breakthroughs!

Accelerating Science and Innovation

Pushing Technology breakthroughs!

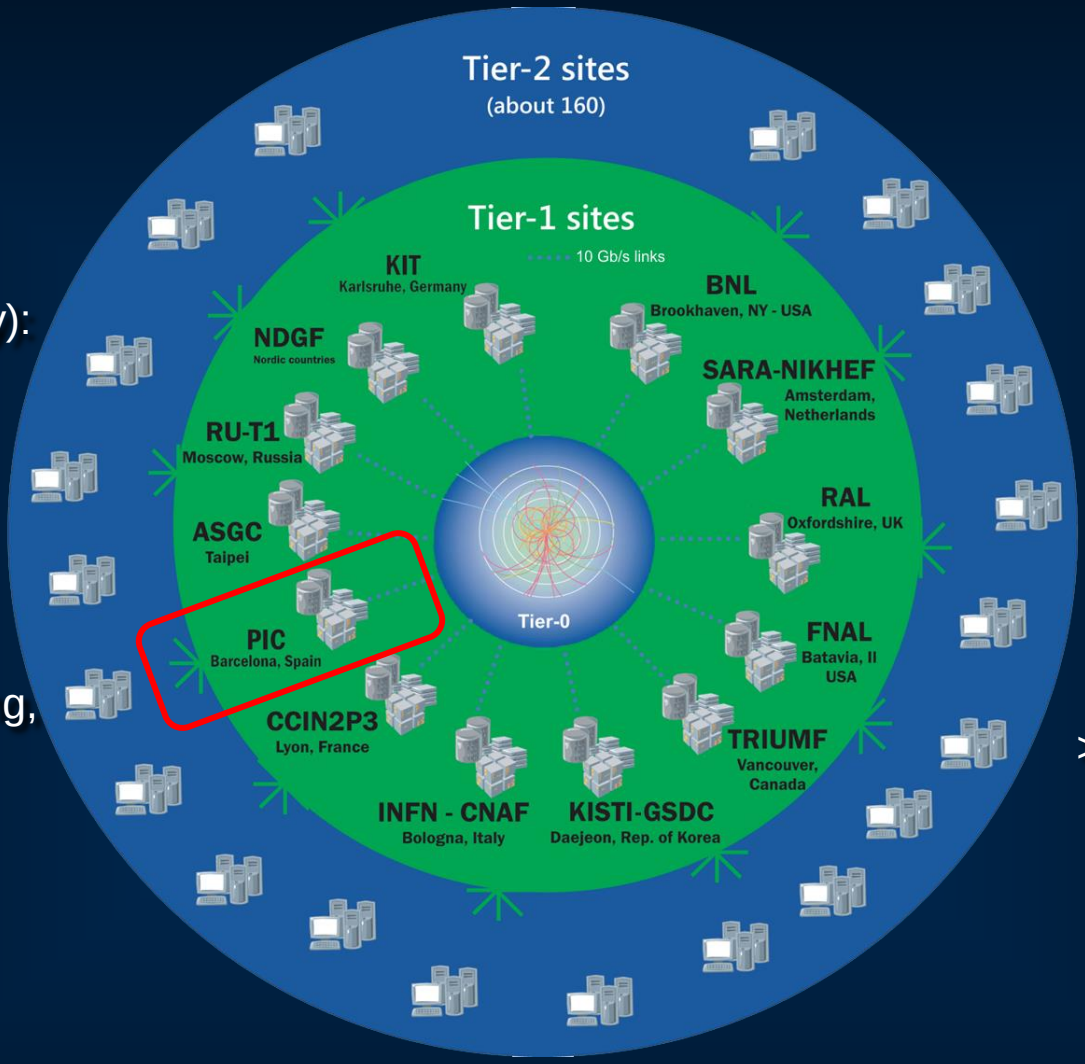
Consolidating workshop uniqueness!

The Worldwide LHC Computing Grid

Tier-0
(CERN and Hungary):
data recording,
reconstruction and
distribution

Tier-1: permanent
storage, reprocessing,
analysis

Tier-2: simulation,
end-user analysis



>170 sites in,
42 countries

750k CPU cores

800 PB of storage

> 2 million jobs/day

35 GB/s global
transfers

WLCG:
An International collaboration to distribute and analyse LHC data

Integrates computer centres worldwide that provide computing and storage resource into a single infrastructure accessible by all LHC physicists

CERN Education Activities

Scientists at CERN
Academic Training Programme

Young Researchers
CERN School of High Energy Physics
CERN School of Computing
CERN Accelerator School

Undergraduates
Summer Students Programme

12 Spanish Students/year

Public visitors
120 thousand per year

CERN Teacher Schools
International and National Programmes

531 Spanish teachers trained!

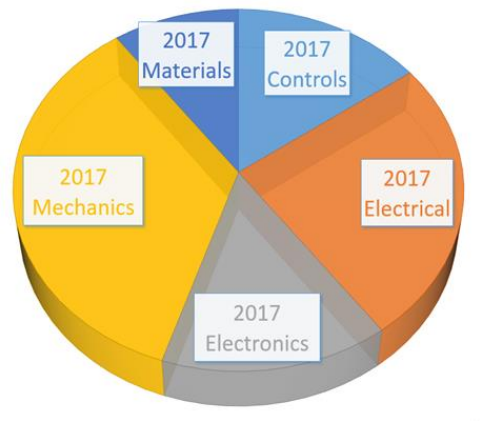
Spanish Traineeship Programme

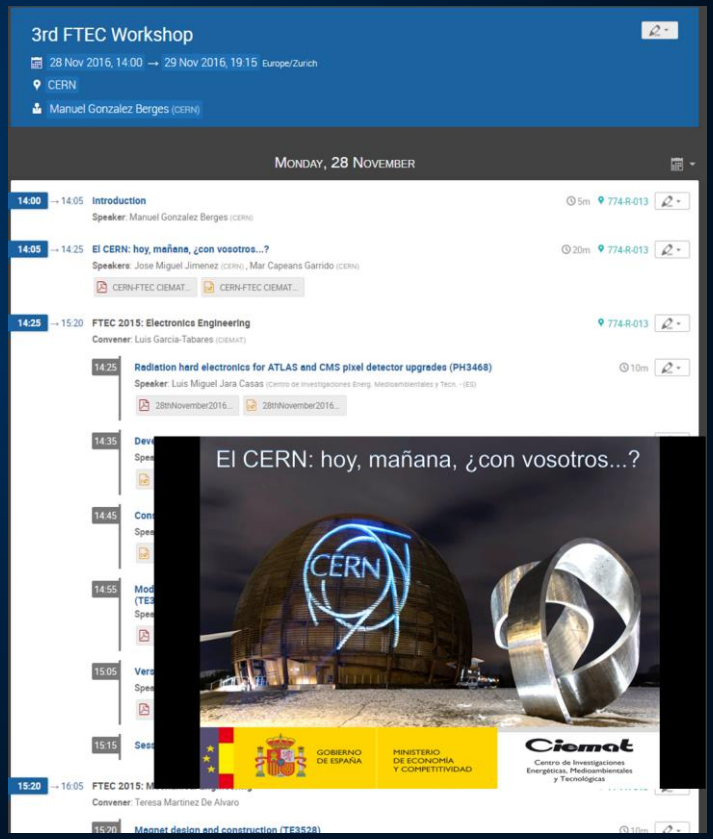
FTEC (Formación en las TEcnología del CERN)

Offering young engineers and physicists to develop a specialization in technologies of accelerators, detectors and associated infrastructures, in fields such:

- Superconducting and resistive magnets,
- Power converters and their associated electronics,
- Cryogenics and vacuum technologies,
- Electronics for detectors, including radiation tolerance.

2015	267 candidates for 20 hired.
2016	317 candidates for 15 hired.
2017	215 candidates for 18 hired.
2018	Call launched recently.





Spain and CERN

Scientists in Spain have made very important contributions to the advance of Particle Physics in general and have maintained a strong involvement in CERN

Strong participation in the LHC experimental programme ATLAS, CMS, LHCb and ALICE

ALICE

1 Institutions
- CIEMAT

ATLAS

4 Institutions
-IFAE
- IFIC
- - Univ. Autónoma de Madrid
- Instituto de Microelectronica de Barcelona

CMS

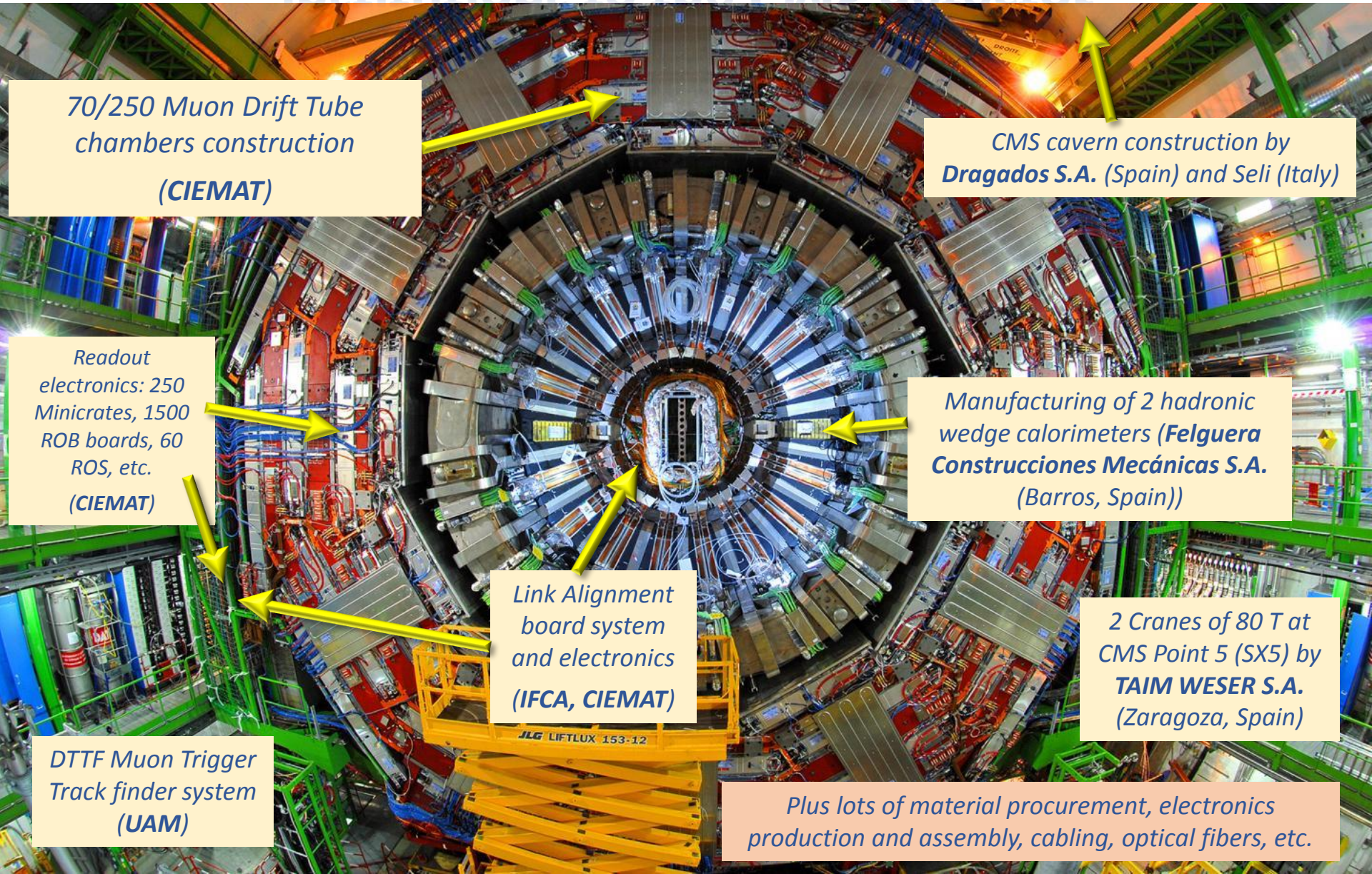
5 Institutions
- CIEMAT
- Univ. Autónoma Madrid
- Univ. Oviedo
- Univ. Cantabria
- Grupo de Ingenieria Electronica (Universidad de Sevilla)

LHCb

3 Institutions
- Univ. Barcelona
- Univ. Santiago de Compostela
- IFIC

Spain also actively participates in most European Grid activities and hosts the PIC, one of the leading European centres in Barcelona (Tier-1 for ATLAS, CMS and LHCb, 3 distributed TIER-2 centres)

Historical Contribution from Spanish companies and institutions to the CMS detector



70/250 Muon Drift Tube chambers construction

(CIEMAT)

CMS cavern construction by ***Dragados S.A.*** *(Spain) and Seli (Italy)*

Readout electronics: 250 Minicrates, 1500 ROB boards, 60 ROS, etc.

(CIEMAT)

*Manufacturing of 2 hadronic wedge calorimeters (****Felguera Construcciones Mecánicas S.A.*** *(Barros, Spain))*

Link Alignment board system and electronics

(IFCA, CIEMAT)

2 Cranes of 80 T at CMS Point 5 (SX5) by ***TAIM WESER S.A.*** *(Zaragoza, Spain)*

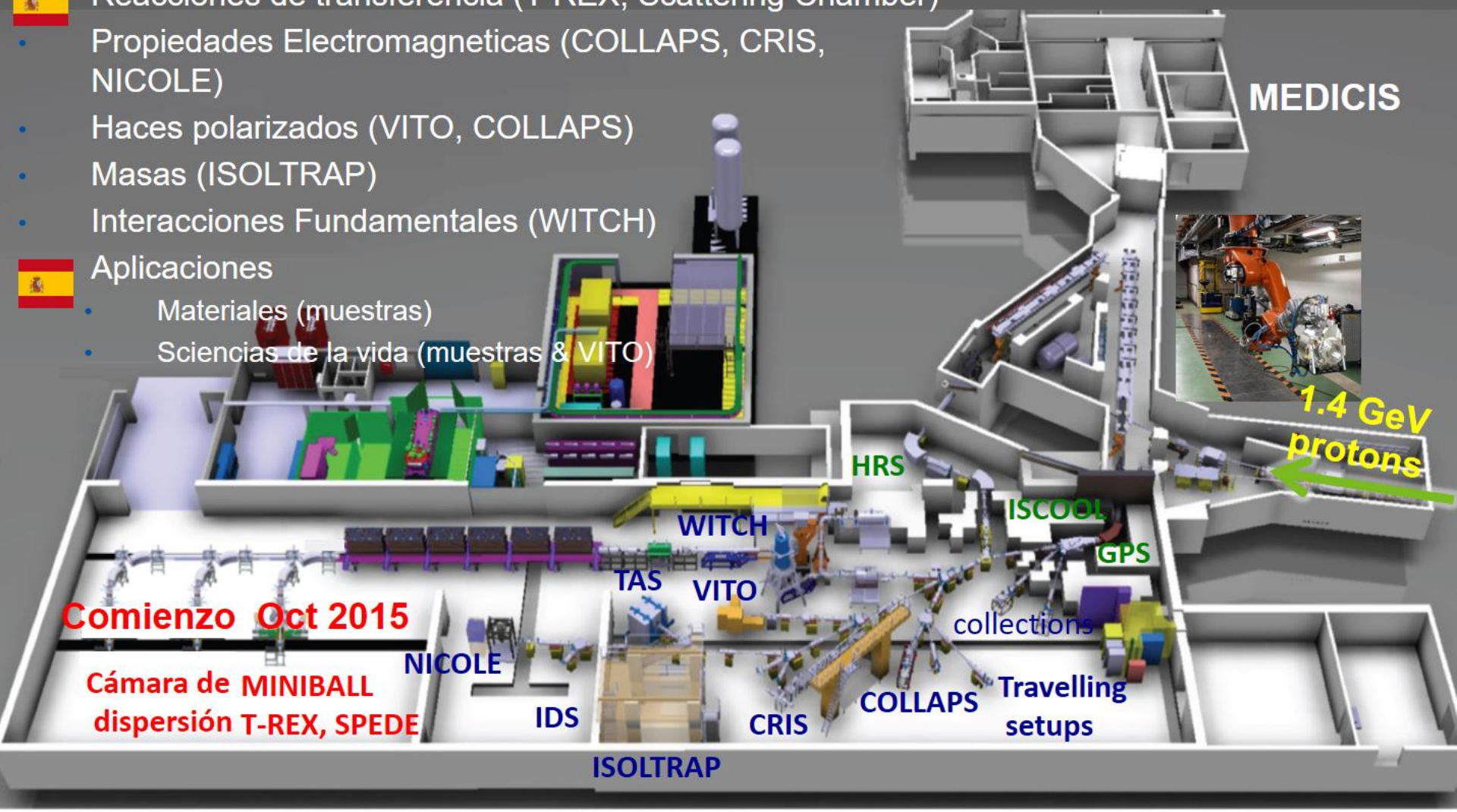
DTTF Muon Trigger Track finder system

(UAM)

Plus lots of material procurement, electronics production and assembly, cabling, optical fibers, etc.

ISOLDE

- Desintegración beta (IDS, TAS,..)
- Excitacion Coulombiana (MINIBALL+ CD + SPEDE)
- Reacciones de transferencia (T-REX, Scattering Chamber)
- Propiedades Electromagneticas (COLLAPS, CRIS, NICOLE)
- Haces polarizados (VITO, COLLAPS)
- Masas (ISOLTRAP)
- Interacciones Fundamentales (WITCH)
- Aplicaciones
  - Materiales (muestras)
  - Sciencias de la vida (muestras & VITO)

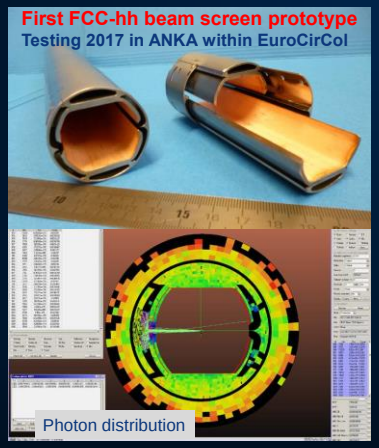


Haces Post-acelerados (5.5 MeV/u) — Exp. de baja energía (30-60kV) — Maquina

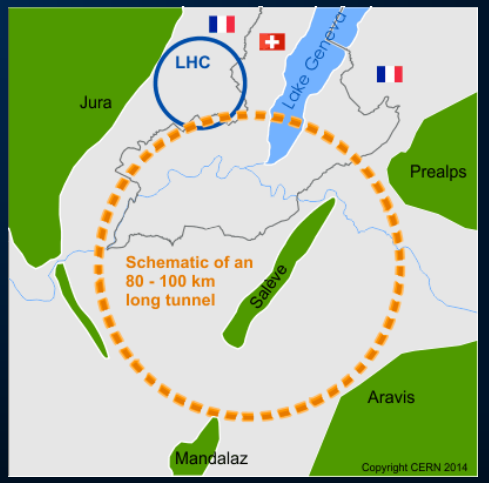
Spain and CERN

Generation of vigorous R&D activities in forefront technologies with the objectives of creating breakthrough and returns to industry.

- CELLS, Coordination of the EuroCirCol WP4 **Cryogenic beam vacuum system** conception (CELLS, CERN, CIEMAT, INFN, KIT, STFC) and Study **beam-induced vacuum effects**.
- CIEMAT, participation on EuroCirCol WP4/5: conceptual design for cryogenic beam vacuum system; study accelerator dipole magnet design options. **Common coil magnet design**, key performance indicators, dipole magnet cost model.
- Consortium Project association between ICMAB, IFAE and CELLS : evaluate the use of **high temperature superconducting coated conductors tapes for the beam screens** (low surface impedance and high superconducting properties).

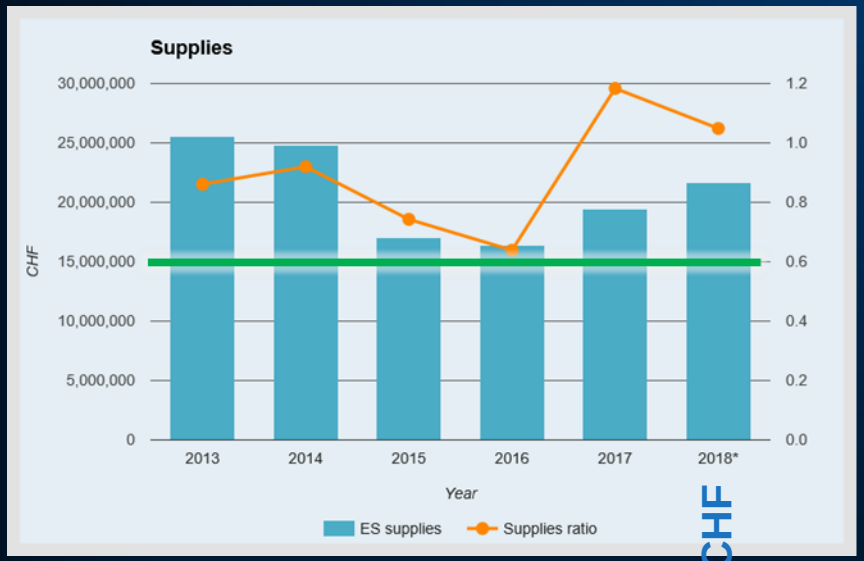



CERN RMC

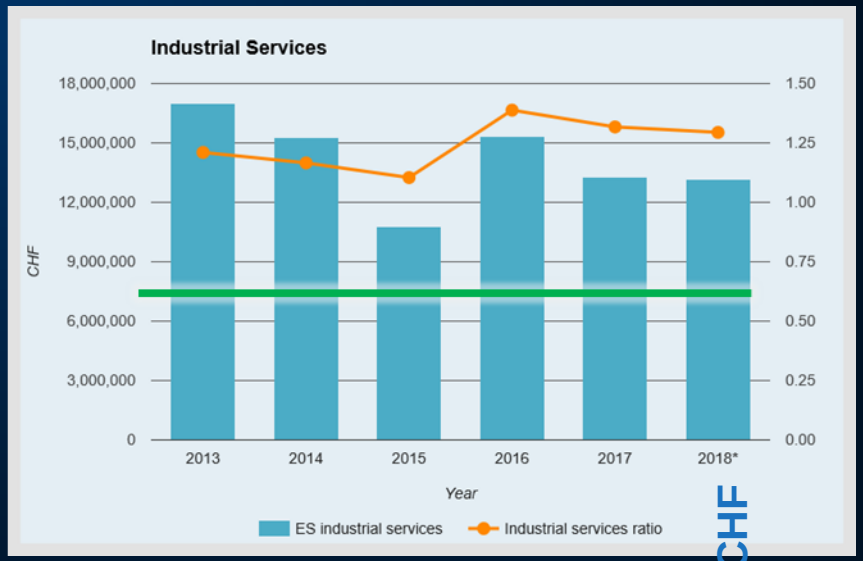


Spain and CERN

- **The Industrial Returns evolution is strongly linked with the on going Projects at CERN and therefore varies between years.**
- **Figures below show respectively the expenditures in Spain and the Return Ratios for Supplies and Industrial Services.**
- **Spain has been above optimum returns in the last 6 years for Industrial Services and for the Supplies.**



23.9 MCHF



14.5 MCHF

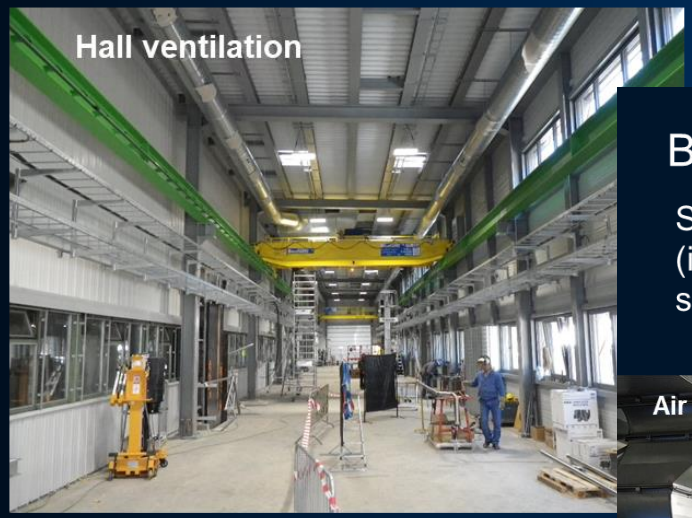
38.4 MCHF in 2018

Spain and CERN

HVAC Systems

SM18 EXTENSION - ARCECLIMA

Scope: **supply, installation, testing and commissioning** of the HVAC, the hot distribution network and the smoke extraction systems.



B107 Project – SADES S.A.

Scope: **supply, installation, testing and commissioning** of the HVAC system (including air treatment and heat recovery of polluted air), the chilled/hot water system, the hot/cold domestic water system and the smoke extraction system.

Spain and CERN

HVAC Systems

The B311 PROJECT - ARCECLIMA

Scope: **supply, installation, testing and commissioning** of the HVAC, the chilled water, the hot and superheated water, the compressed air, hot/cold domestic water, the firefighting and the cooling systems.

Hall ventilation

BAF3 Ventilation SADES S.A.

Scope: **supply, installation, testing and commissioning** of the HVAC, the chilled water and the smoke extraction systems.

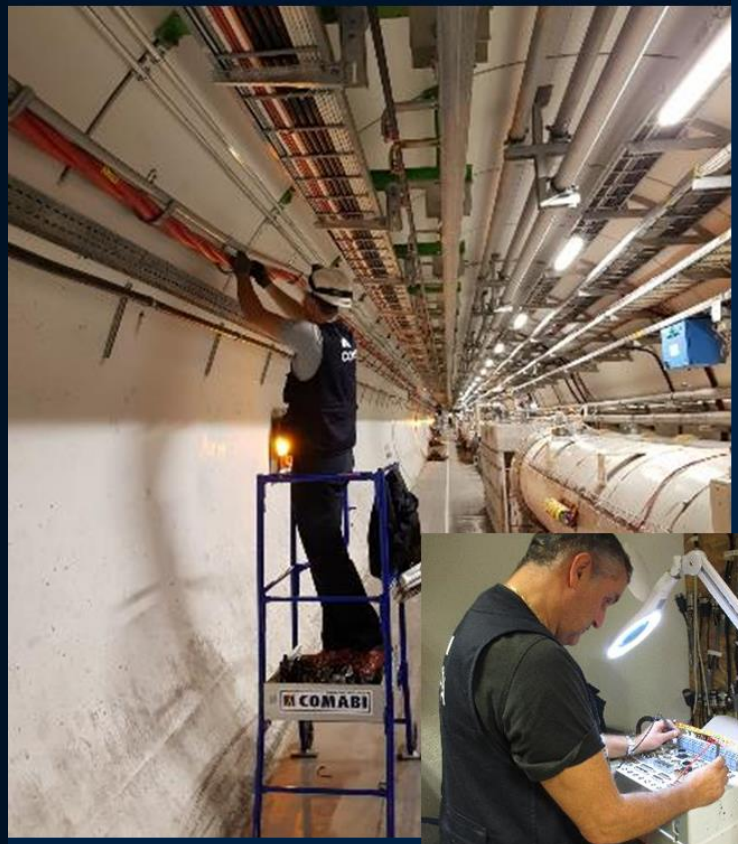
Ventilation plant

Air diffusers

Spain and CERN

Electrical Sytems

Electrical and cabling installation contract



Electrical maintenance contract

Spain and CERN

Electrical Sytems

B771 – Electrical installations (2017)

Consultant: COMSA

Spain and CERN

Security Systems

Spain and CERN

Infrastructures & Civil Engineering

New LHCb Control Room (TOP PROYECTOS)

Spain and CERN

Infrastructures & Civil Engineering

LHCb Assembly Hall (2017)

Contrac

Offices and Laboratories (2015)

Contractor: Various spanish companies

Spain and CERN

Superconducting Magnets

ELYTT

ANTEC

Spain and CERN

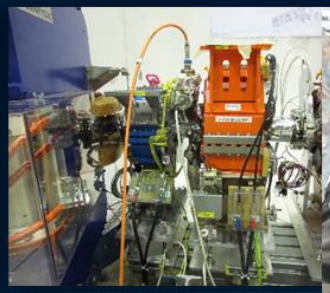
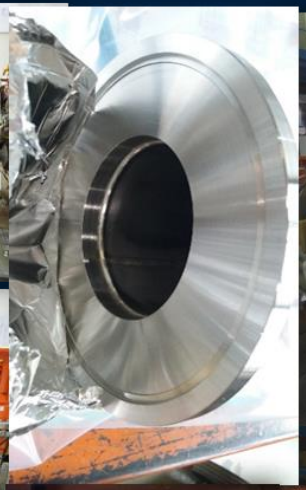
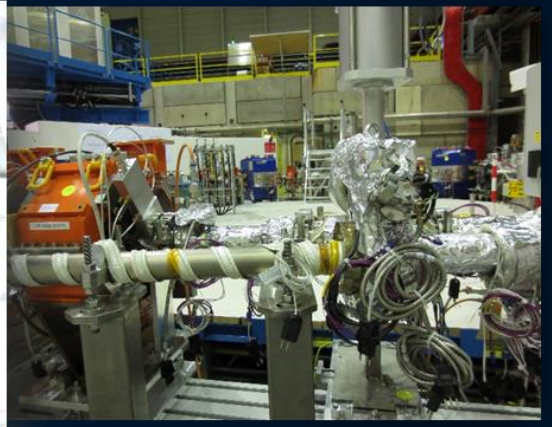
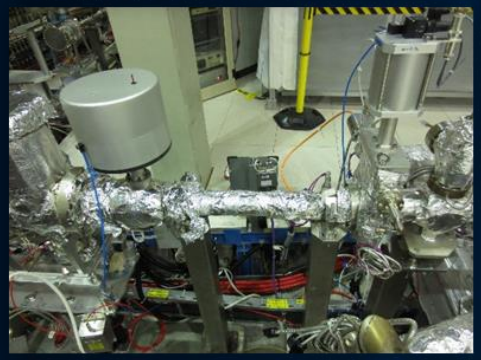
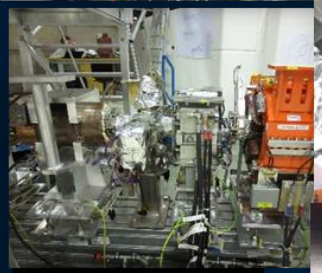
Normal conducting Magnets

PS Booster magnet bores (NORTEMECANICA S.A)

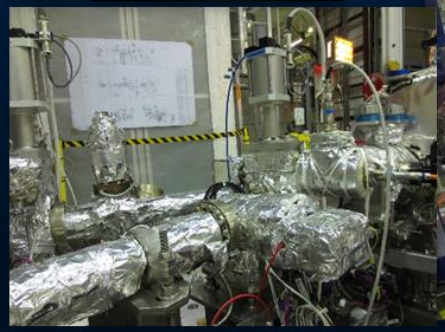
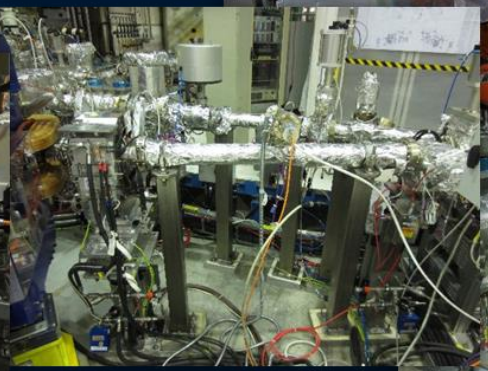
PS Booster magnet coils (ELYTT ENERGY)

Spain and CERN

Vacuum Technology

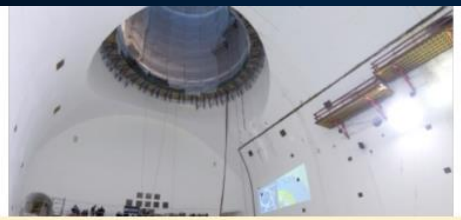









Spain and CERN

Detector Technologies

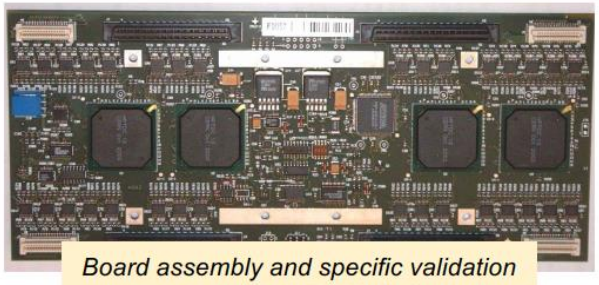


CMS cavern construction by Dragados S. A. (Spain) and Seli (Italy)

Manufacturing of 2 hadronic wedge calorimeters for CMS Detector (Felguera Construcciones Mecánicas S. A. (Barros, Spain))

Custom cables assembly SINTERSA S. A.

2 Cranes of 80 T at CMS Point 5 (SX5) by TAIM WESER S. A. (Zaragoza, Spain)



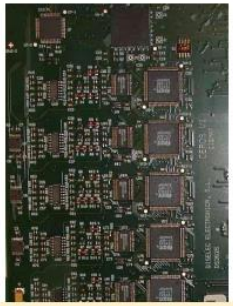
Board assembly and specific validation tests at IMPELEC S. A.

Moreover, material procurement for:

- Muon Drift Tube chambers,
- Mechanics material, welding and assembly,
- Electronics components purchasing
- Cabling, optical fibers
- Large variety of instrumentation

PCB fabrication at LABCIRCUITS S. A.

Custom MTP splitter FIBERCO S. A.



Board layout at DISELEC S. A.

Closing remarks

Spanish participation has **increased over years to unprecedented levels:**

- With more than 470 Spanish citizens in the payroll, 470 Physicists using CERN Experiments and a total of 1170 Spanish collaborating with CERN.

Spain is positioned to **make the best use of its position of 5th Contributor:**

- With an extensive use of all CERN training programs complemented by the benefits of the Spanish Trainee program (FTEC), an example of “on-the-job” training.

Leading roles of National Institutes in CERN Study programs allow **Spain to be present in the earlier stages**, occupying position towards the future, **a clear competitive advance for its Industry of Science**.

Collaborating with CERN has lot of advantages for Industry, in terms of image as **being associated to the scientific and technological excellence** but also in terms of **technological opportunities**.

- And Industrial Returns which amounts to 38.5 MCHF in 2018!

Thank You!
¡Gracias por su atención!

Accelerating Science and Innovation