



[www.cern.ch](http://www.cern.ch)

***CERN TE-VSC meeting with University of Minho  
5-5-2017***

# What is CERN?

The twenty two  
Member States of CERN

Founded in 1954, the CERN laboratory sits astride the French-Swiss border near Geneva.

Member States (date of accession)

2400 staff members  
1000 associate members of personnel  
12000 users from 70 countries  
Budget (2017) ~ 1100MCHF  
Contribution  $\propto$  GDP (PT ~1.1%)

CERN council :  
1 political + 1 scientific  
representative / member state

General Director:  
Dr. Fabiola Giannotti in 2016-2020

 France (1953)	 Romania (20)
 Germany (1953)	 Slovakia (19)
 Greece (1953)	 Spain (1961)
 Hungary (1992)	 Sweden (19)
 Israel (2014)	 Switzerland
 Italy (1953)	 United King
 Netherlands (1953)	
 Norway (1953)	
 Poland (1991)	
 Portugal (1986)	

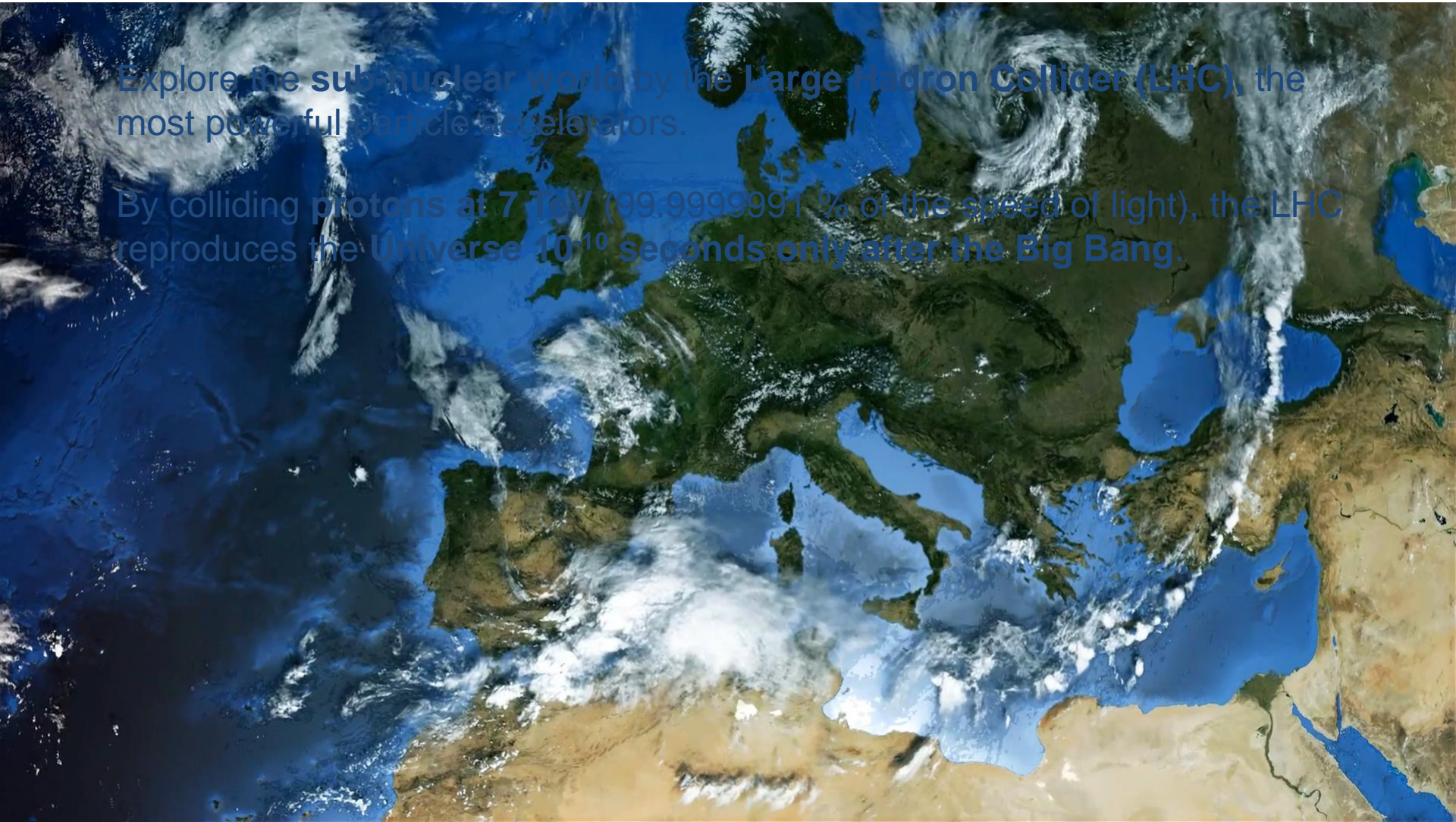


Cost per year and per Member-State inhabitant

# The main goal of CERN: fundamental research by particle accelerators

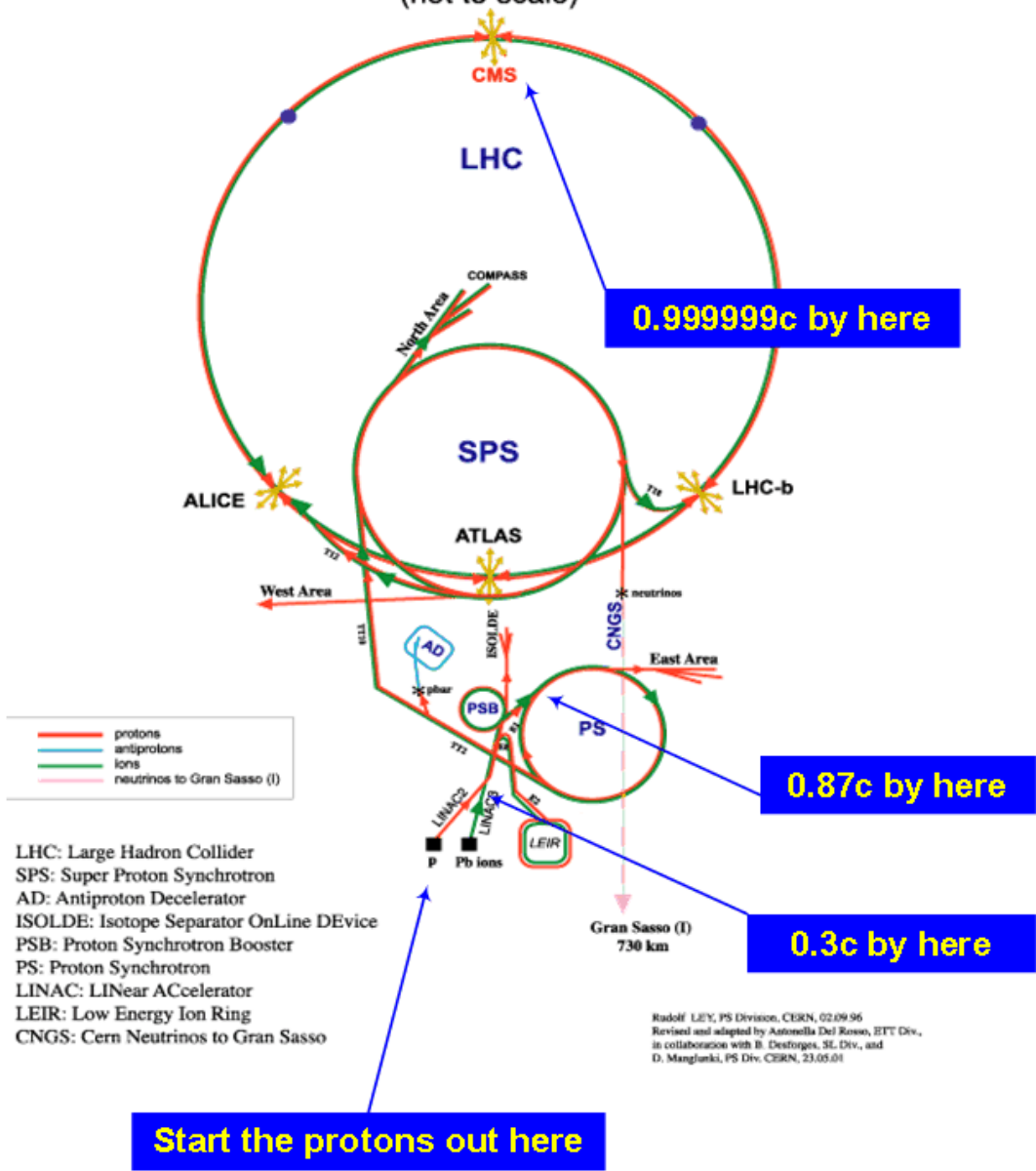
Explore the sub-nuclear world by the **Large Hadron Collider (LHC)**, the most powerful particle accelerators.

By colliding protons at **7 TeV** (99.9999991 % of the speed of light), the LHC reproduces the **Universe  $10^{-10}$  seconds only after the Big Bang**.





# CERN Accelerators (not to scale)



## Energies:

Linac 50 MeV

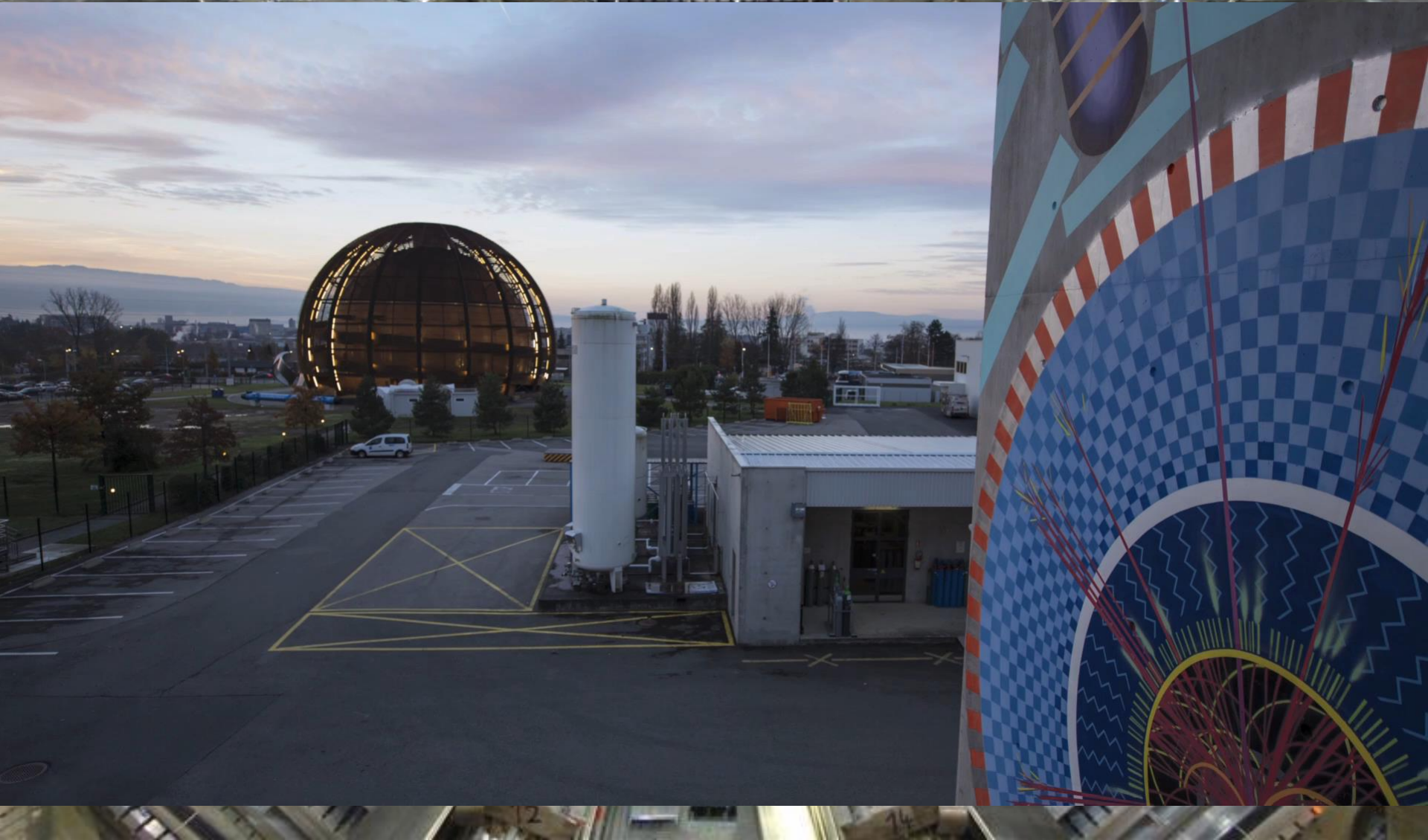
PSB 1.4 GeV

PS 28 GeV

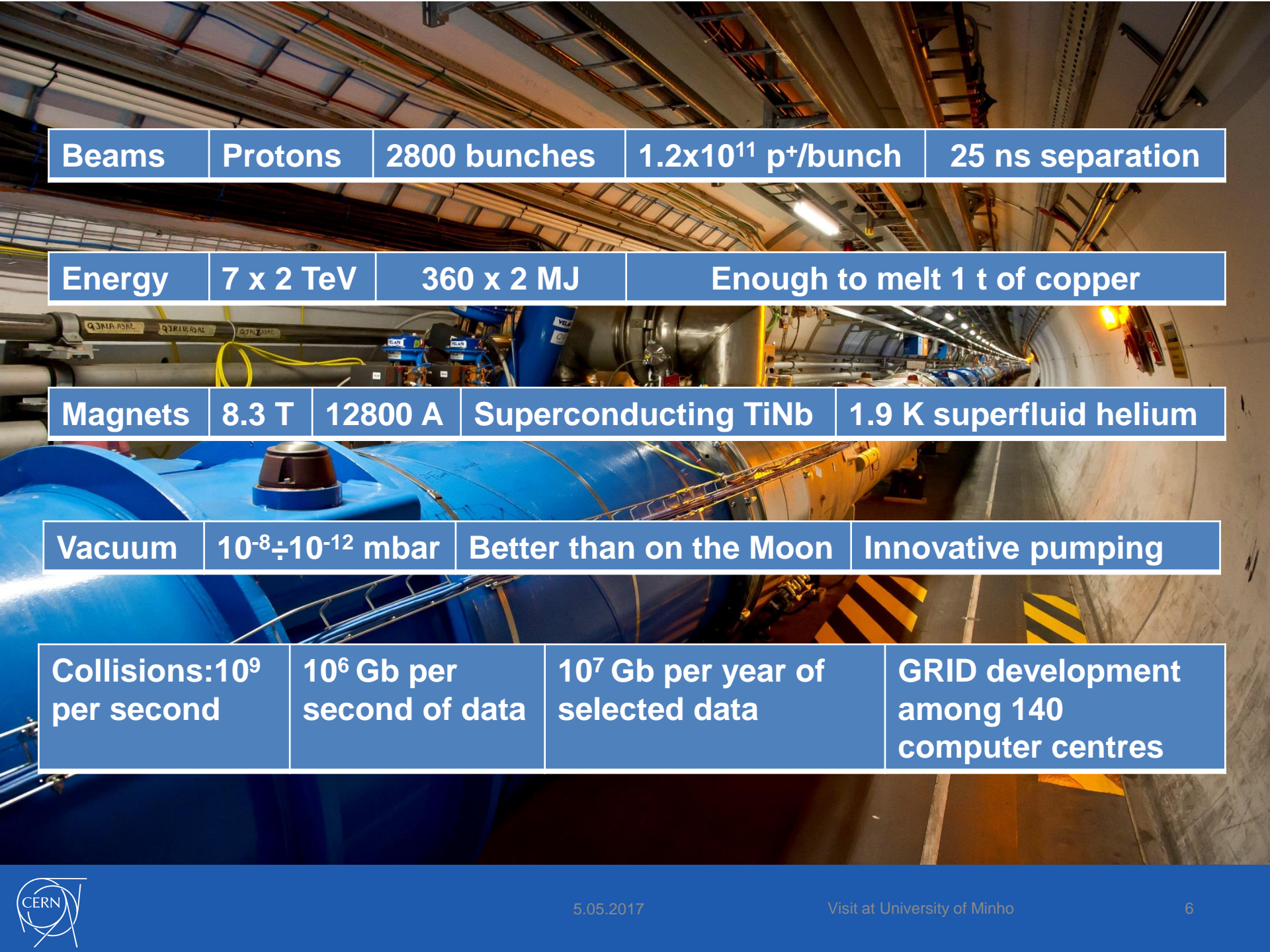
SPS 450 GeV

LHC 7 TeV

# The main goal of CERN: fundamental research by particle accelerators







<b>Beams</b>	<b>Protons</b>	<b>2800 bunches</b>	<b><math>1.2 \times 10^{11}</math> p<sup>+</sup>/bunch</b>	<b>25 ns separation</b>
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<b>Energy</b>	<b>7 x 2 TeV</b>	<b>360 x 2 MJ</b>	<b>Enough to melt 1 t of copper</b>	
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<b>Magnets</b>	<b>8.3 T</b>	<b>12800 A</b>	<b>Superconducting TiNb</b>	<b>1.9 K superfluid helium</b>
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<b>Vacuum</b>	<b><math>10^{-8} \div 10^{-12}</math> mbar</b>	<b>Better than on the Moon</b>	<b>Innovative pumping</b>	
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<b>Collisions: <math>10^9</math> per second</b>	<b><math>10^6</math> Gb per second of data</b>	<b><math>10^7</math> Gb per year of selected data</b>	<b>GRID development among 140 computer centres</b>	
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# CERN core technical competences

## *Accelerators, detectors and computing*

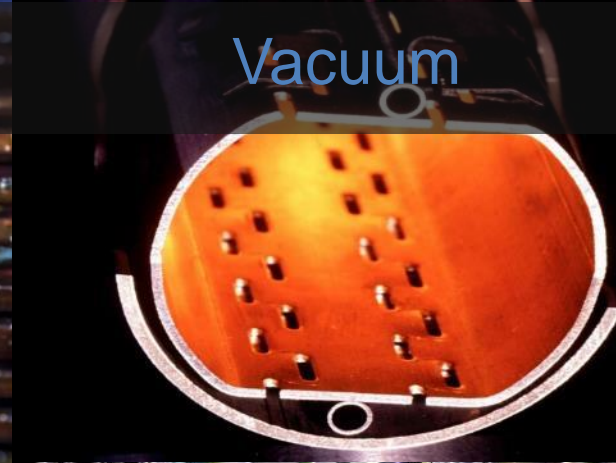
Cryogenics



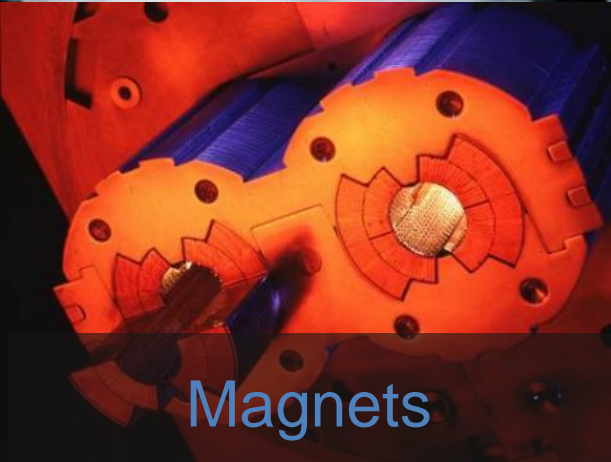
Superconductivity



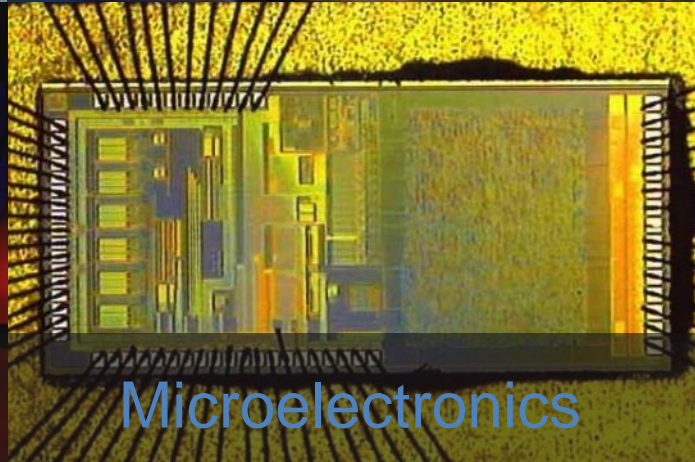
Vacuum



Magnets



Microelectronics



Data Processing





## CERN Priorities





# CERN Vision & Strategy

## Three main scientific pillars

Courtesy of José Miguel Jimenez

- **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's future:**
  - vibrant accelerator R&D programme exploiting CERN's strengths and uniqueness.
  - design studies for future accelerators: CLIC, FCC (includes HE-LHC).
  - future opportunities of diversity programme: "Physics Beyond Colliders".

Important milestone: update of the European Strategy for Particle Physics (ESPP) in **2019-2020**.

Our DG  
Fabiola Giannotti



Our Director  
F. Bordry



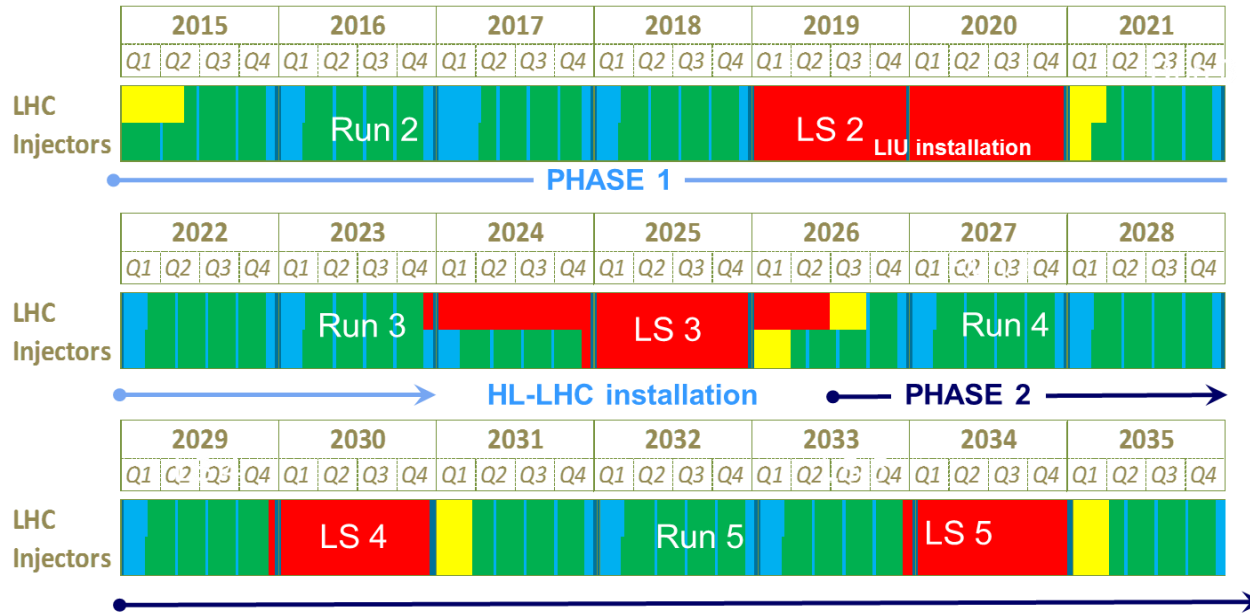
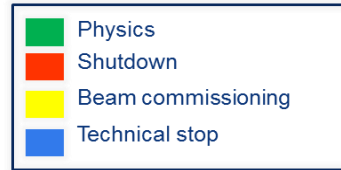
Our Dep. Head  
J. M. Jimenez



# CERN Vision & Strategy

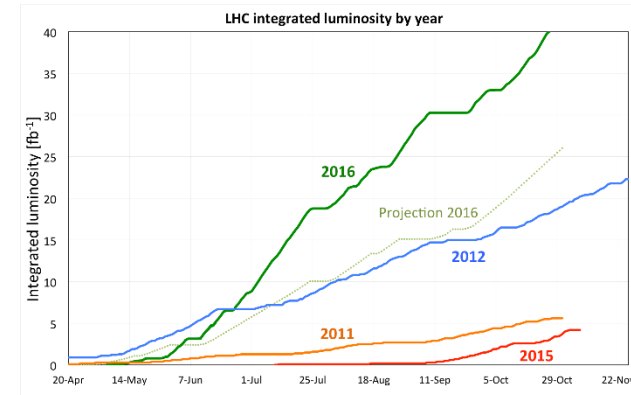
## LHC Roadmap

- \* LS2 starting in 2019 => 24 months + 3 months BC
- LS3 LHC: starting in 2024 => 30 months + 3 months BC
- Injectors: in 2025 => 13 months + 3 months BC



**Objective for Run 2:**

**100 fb<sup>-1</sup> of high-quality data**



\*LS = Long Shutdown



# Vacuum, Surfaces and Coatings group's mandates

- Provide CERN's accelerators with the **required degree of vacuum**.
- **Exploit the CERN's production facilities** for surface treatments, including thin film coatings.
- Provide high-energy physics community with **expertise in vacuum technology** (from design to operation) and beam-surface interactions.
- Ensure **characterization measurements** in the field of analytical chemistry, surface analysis, and performance of vacuum material.
- Develop simulation, materials, instrumentation, and production technologies in the framework of **CERN's projects and studies**.

# CERN's vacuum beamlines

Machine	Type	Year	Energy	Bakeout	Pressure (Pa)	Length	Particles	
<b>Linac, Booster, ISOLDE, PS, n-TOF and AD Complex</b>						<b>2.6 km !</b>		
LINAC 2	linac	1978	50 MeV	Ion pumps	$10^{-7}$	40 m	p	
ISOLDE	electrostatic	1992	60 keV	-	$10^{-4}$	150 m	ions: 700 isotopes and 70 (92) elements	
REX-ISOLDE	linac	2001	3 MeV/u	partly	$10^{-5} - 10^{-10}$	20 m		
LINAC 3	linac	1994	4.2 MeV/u	Ion pumps	$10^{-7}$	30 m	ions	
LEIR	accumulator	1982/2005	72 MeV/u	complete	$10^{-10}$	78 m	pbar, ions	
PSB	synchrotron	1972	1-1.4 GeV	Ion pumps	$10^{-7}$	157 m	P, ions	
PS	synchrotron	1959	28 GeV	Ion pumps	$10^{-7}$	628 m	P, ions	
AD	decelerator	?	100 MeV	complete	$10^{-8}$	188 m	pbar	
CTF3 complex	linac/ring	2004-09		partly	$10^{-8}$	300 m	e	
PS to SPS TL	Transfer line	1976	26 GeV	-	$10^{-6}$	~1.3 km	P, ions	
<b>SPS Complex</b>						<b>15.7 km !</b>		
SPS	synchrotron	1976	450 GeV	Extractions	$10^{-7}$	7 km	p, ions	
SPS North Area	Transfer line	1976		-	$10^{-6} - 10^{-7}$	~1.2 km		
SPS West Area	Transfer line	1976				~ 1.4 km		
SPS to LHC TI2/8 Line	Transfer line	2004/2006				2 x 2.7 km		
CNGS Proton Line	Transfer line	2005				~730 m		
<b>LHC Accelerator</b>						<b>~109 km !</b>		
LHC Arcs (Beam x2, Magnets & QRL insul.)	collider	2007	2 x 7 TeV	-	$< 10^{-8}$	2 x (2 x 25 km)	p, ions	
LSS RT separated beams				complete		2 x 3.2 km		
LSS RT recombination						~ 570 m		
Experimental areas						~ 180 m		
Beam Dump Lines TD62/68	Transfer line	2006	7 TeV	-	$10^{-6}$	2 x 720 m		
						<b>High Vacuum</b>	~20 km	<b>~128 km !</b>
						<b>UHV w/wo NEG</b>	~ 57.5 km	
						<b>Insulation vacuum</b>	~ 50 km	





# Vacuum, Surfaces



P. Chigiato  
Group Leader



P. Cruikshank  
Deputy Group Leader

# & Coatings group



D. Letant  
Detached HDO  
Group



P. Clerc  
Group Secretary



G. Riddone  
Group Coordinator



L. Ludvig  
Admin Student  
31.08.2017

## Vacuum Studies and Measurements



V. Baglin  
Section Leader



S. Calatroni



B. Henrist



B. Jenninger



D. Calegari



G. Cattenoz



J. Chauré



R. Kersevan



P. Lancon



S. Meunier



C. Coliomb P.



P. Demarest



J.A. Ferreira S.



I. Wevers



J. Finelle



A. Harrison



J. Korttesmaa



P. Lepeule



G. Merino F.



A. Michet



E. Page



C. Pasquino



J. Sestak



A. Sinturel



N. Thaus



C. Yin Vallgren



N. Zelko

## Beam Vacuum Operation



G. Bregliozzi  
Section Leader

## Design, Logistics & Methods



C. Garion  
Section Leader

## Interlocks, Controls & Monitoring



P. Gomes  
Section Leader

## Surface, Chemistry Coatings



M. Taborelli  
Section Leader



C. Duclos



J. Hansen



H. Kos



N. Kos



W. Maan



L. Mourier



J. Perez Espinos



H. Rambeau



M. Sitko



A. Vidal



J.R. Alvelos Ferreira



S. Blanchard



J.-P. Bovin



N. Chatzigeorgiou



F. Daligault



J. De La Gama S.



A. Gutierrez



A. Paiva E Rocha



G. Pigny



H. Vestergard



A. Bentivenga



J. Carosone



J. Cavé



C. Charvet



P. Costa Pinto



L. Ferreira



F. Fesquet



S. Forel



P. Garritty



L. Leggiero



P. Maurin



A. Monzelluzzo



H. Neupert



G. Rosaz



A. Sapountzis



A. Sublet



B. Teissandier



M. Thiebert



L. Viezzi



W. Vollenberg

Staff Members

Operation budget: 4.6 CHF  
Project budget: 10 MCHF

# Students & Collaborators



A.L. Lamure

FELL-> 31.12.2017



R. Salemmé

FELL->31.08.2017



Y. Delaup

FELL -> 31.08.2017



J. Gomes

PJAS -> 30.09.2017



J. Gargiulo

FELL-> 31.01.2018



Q. Deliege

FELL-> 31.12.2017



G. Minuzzo

FELL -> 28.02.2017



P. Prieto

FELL-> 31.07.2017



M. Van Gompel

FELL - 30.09.2017 / 31.03.2017 / 31.01.2018



B. Holliger



S. Fiotakis



C. Vazquez Pelaez

FELL-> 31.05.2017



M. Ady

FELL -> 31.05.2018



J. Hellstrom

TECH -> 31.08.2017



A. Kukolava

TECH -> 28.02.2017



C. Guyenet

FELL-> 31.07.2017



R. Nelen

FELL-> 31.01.2018



J. Gonzalez Arias

TRNE -> 31.08.2017



P. Krakowski

FELL -> 31.10.2017



V. Nistor

FELL -> 31.01.2017 / 31.10.2017 / 30.09.2017



K. Ilyina



H. Fjaerli



B. Antoine

FELL ->31.03.2018



I. Aichinger

DOCT->31.03.2017



P. Gebolis

TECH -> 28.02.2017



S. Callegari

FELL -> 31.12.2018



M. Morrone

DOCT-> 31.03.2017



F. Niccoli

DOCT -> 31.03.2017



J. Fraga

FELL-> 30.06.2018



M. Quero Corrales

TECH-> 28.02.2017



P. Demolon

FELL -> 28.02.2018 / 31.03.2018



T. Sinkovits



E. Kepes

TECH ->31.03.2017



P. Santos Diaz

TRNE VI -> 31.01.2018



L. Krzempek

PJAS-> 31.12.2017



M. Gil Costa

PJAS-> 30.06.2018



C. Pequeno Dias

TRNE -> 30.09.2017



G. Gkioka

TECH-> 31.08.2017



T. Richard

DOCT- 30.06.2017 / 30.09.2017 / 30.04.2017



L. Lain Amador



V. Petit



B. Trzpil

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L. Gonzalez Gomez

PJAS -> 31.01.2018



P. Gach

PJAS -> 31.12.2017



J. Fernandez Topham

PJAS-> 31.07.2017



M. Van Winden

TECH-> 30.09.2017



A. Baldanza

TECH - 31.03.2017 / 31.03.2017



P. Massuti Ballester



E. Garcia-Tabares

PJAS 30.06.2018



R. Fernandez Gomez

PJAS-> 31.12.2017



L. Baudin

TRNE VIA -31.01.2017



A. Perez Rodriguez

TRNE 21.12.2016 / 31.05.2017 / 31.08.2017



E. Felizardo



A. Bellissimo

COAS 30.04.2017



A. Awais

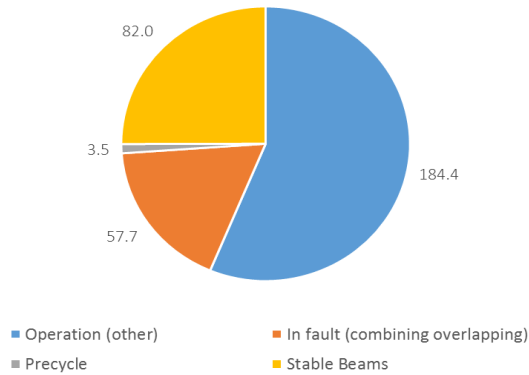
VIST 31.12.2017



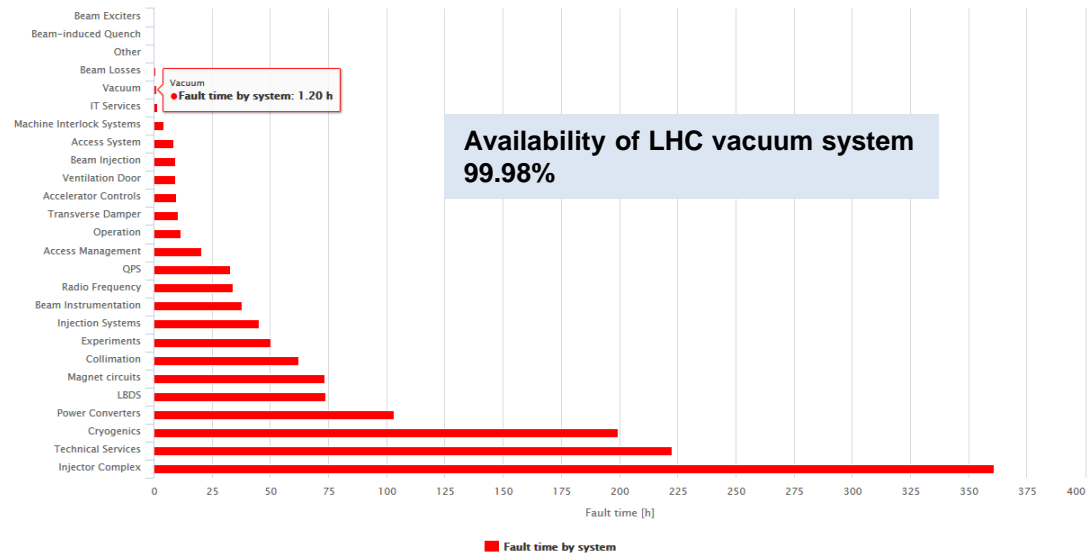
# CERN priorities: Full exploitation of the LHC

VSC contribution: **extremely low operational faults**

LHC operation availability 2016  
Values in days



LHC Impact Fault Times by System



Availability of LHC vacuum system  
**99.98%**

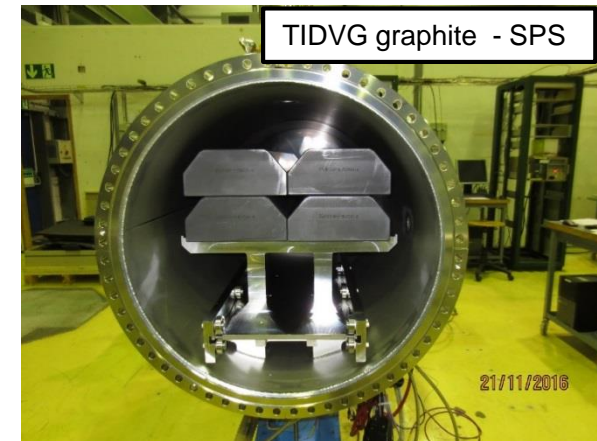
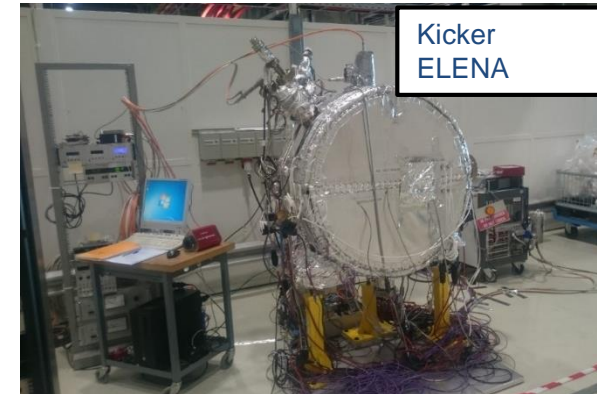
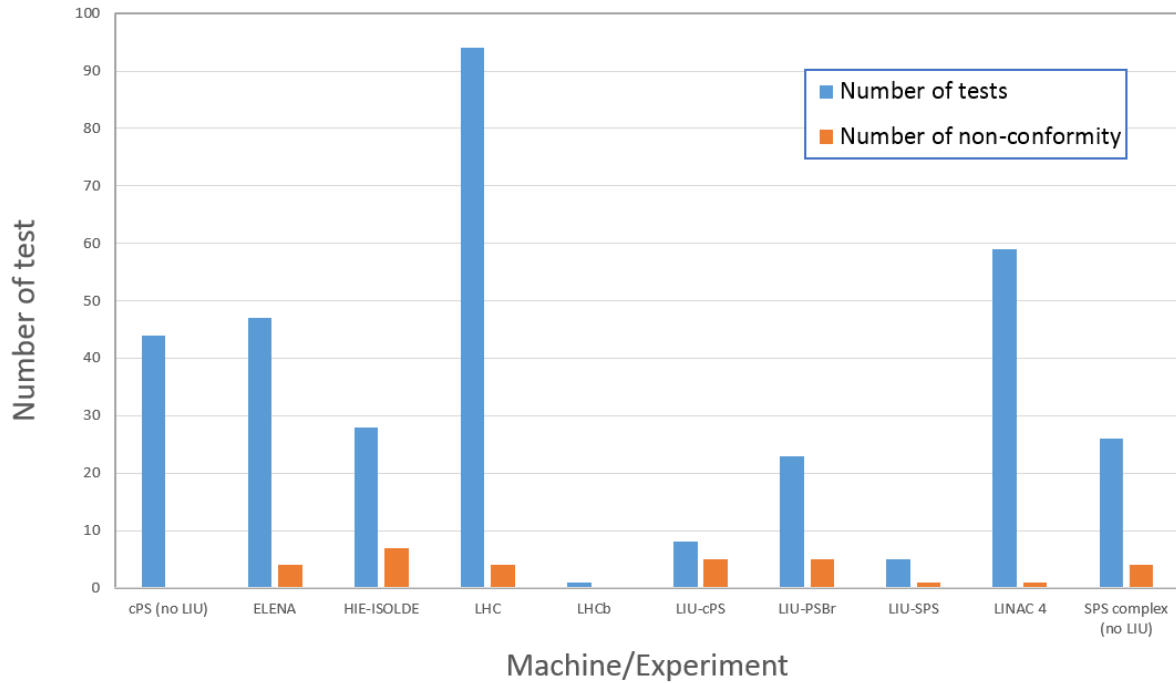
Parent / Child issue	Issue count	Total duration [hh:mm]	Beam dump
Parent	2	01:22	0
Child	0	NA	NA

*Based on data from LHC  
Cardiogram and  
BVO OP tracking*

# CERN priorities: Full exploitation of the LHC

VSC contribution: **issue prevention**

**No test = No installation in beam vacuum**



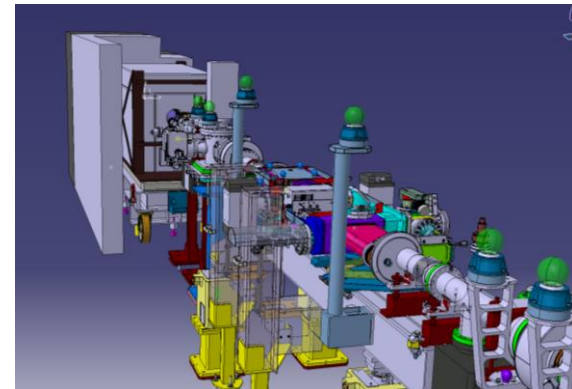
# CERN priorities: Upgrade of LHC injectors

## VSC contribution: LINAC 4 installation

- ❑ Validation and installation of RF cavities
- ❑ Acceptance test of components
- ❑ Installation and commissioning of transfer line



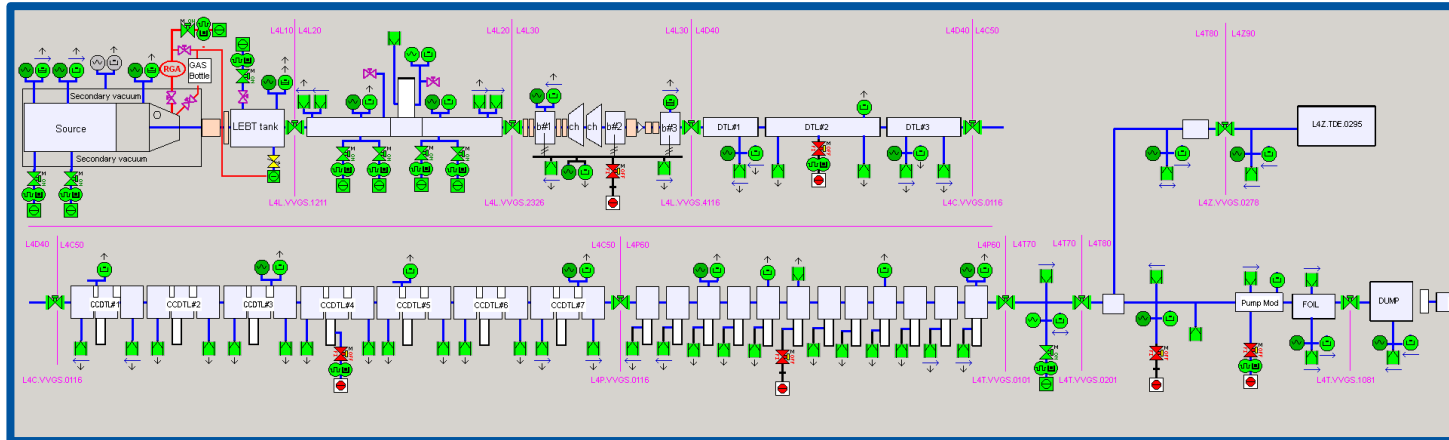
160 MeV commissioning





# CERN priorities: Upgrade of LHC injectors

## VSC contribution: LINAC 4 installation



### 3 MeV (Nov-13)

✓ Source, RFQ, Chopper

### 50 MeV (Jul-15)

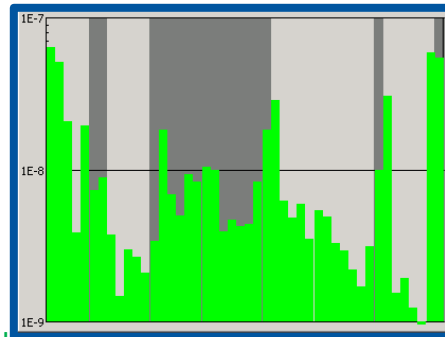
✓ DTL, BIS

### 100 MeV (Jul-16)

✓ CCDTL, BIS

### 160 MeV (Oct-16)

✓ PIMS, HST, dump line, BIS

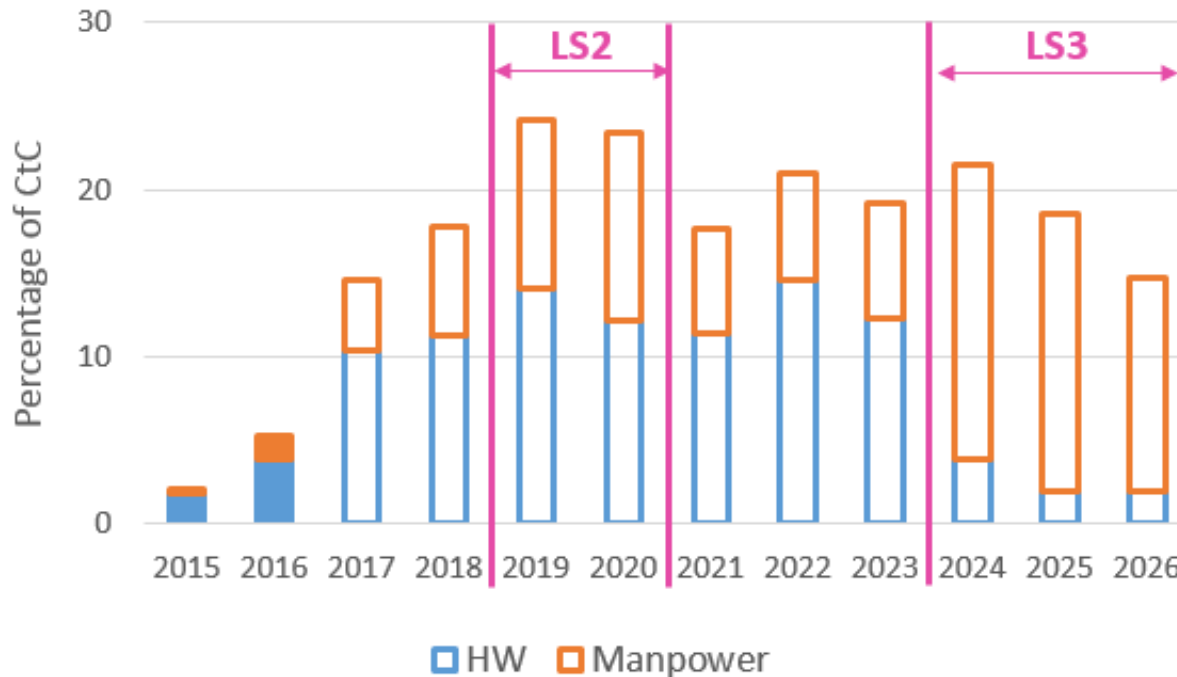


VGR+P	VGF	VPG	VPI	TOTAL
29+22	12	15	46	124



# CERN priorities: on-track construction of HL-LHC

## VSC contribution: impressive involvement



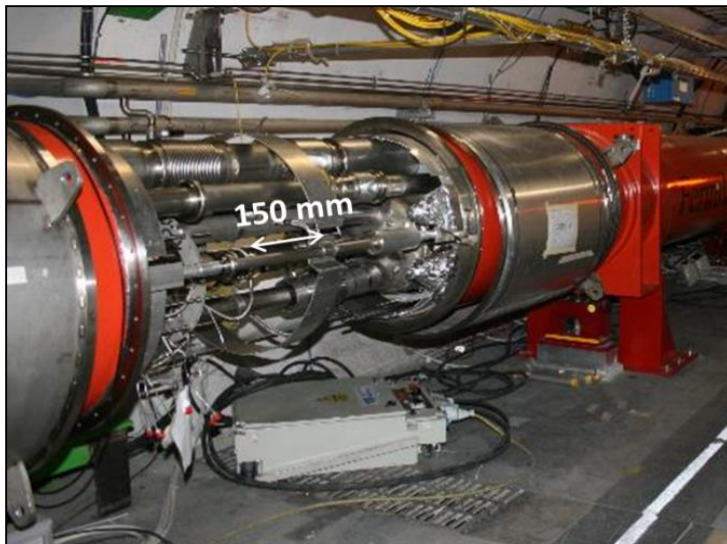
Two most critical actions for TE-VSC:

- Mitigation of e-cloud in P2 and P8
- Production of new beam screens

# CERN priorities: on-track construction of HL-LHC

## VSC contribution: in-situ coating of LHC-b and ALICE IT areas

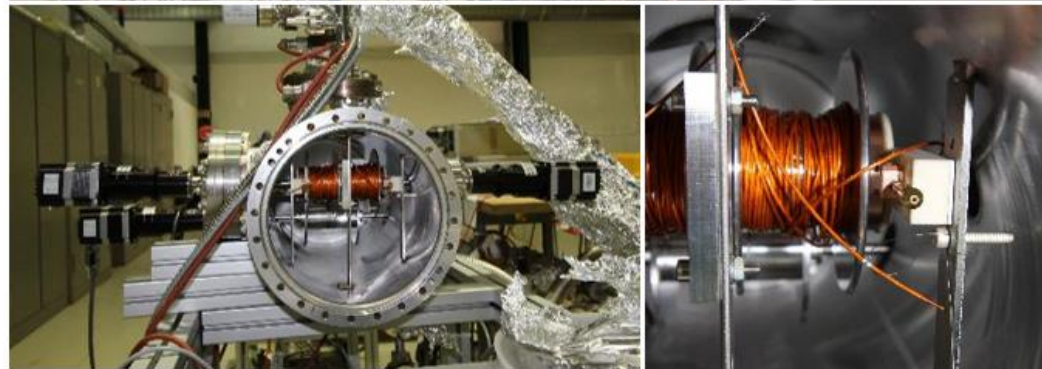
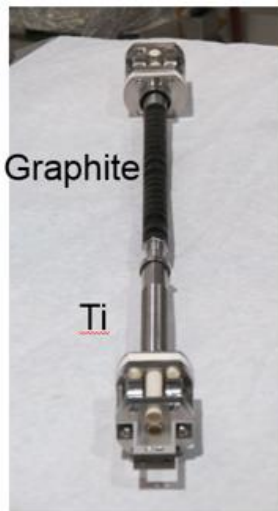
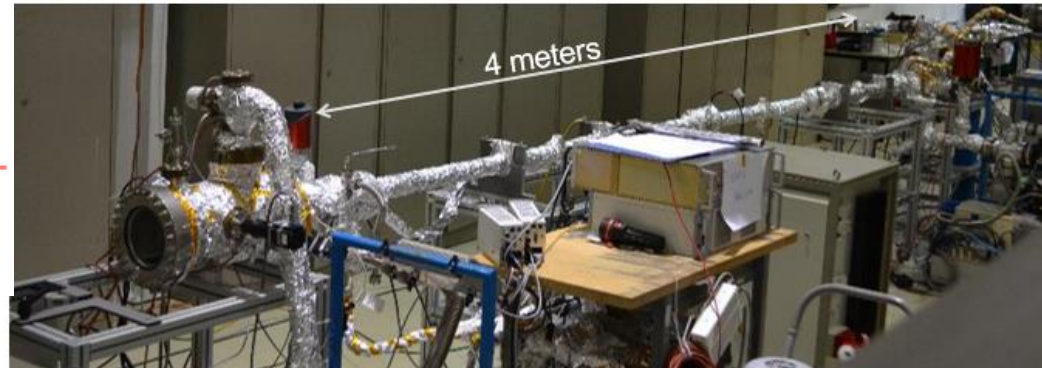
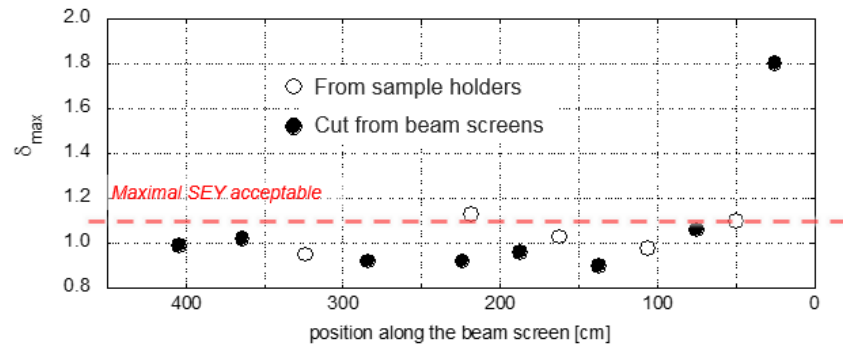
Length to be *in-situ* coated: ~45 meters per “string” (Q1, Q2, Q3, DFBX & D1) of LSS2 and LSS8.  
Development of a “**modular sputtering source**” that can be inserted in a 150 mm slot and pulled by cables along D1 and the triplets.





# CERN priorities: on-track construction of HL-LHC

## VSC contribution: in-situ coating of LHC-b and ALICE IT areas

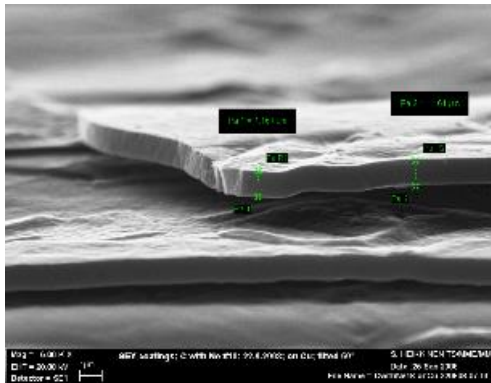


# CERN priorities: on-track construction of HL-LHC

VSC contribution: in-situ coating of LHC-b and ALICE IT areas

Baseline

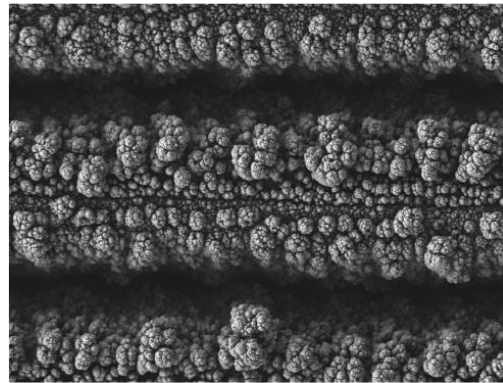
Carbon coatings



Low SEY based on the electronic properties of the material

Alternative solution

Laser Engineered Surface Structure  
LESS



Low SEY based on morphological effects

Agreement achieved in October.  
Feasibility study just started.  
Main deliverable: 2-m long LESS treated beam screen in mid-2018.

University of Dundee Study About Student Life Research

University News

Contact Press

Research News

Archive News from 2015

Archive News from 2014

Archive News from 2013

2016

January

February

Laser technology to help take Large Hadron Collider to next level

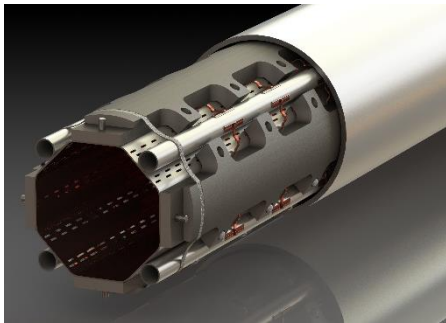
Published On Tue 29 Nov 2016 by Roddy Isles

Pioneering laser technology could boost the performance of the Large Hadron Collider (LHC) at CERN to new levels of efficiency, helping unlock some of science's greatest mysteries going back to the 'Big Bang'.

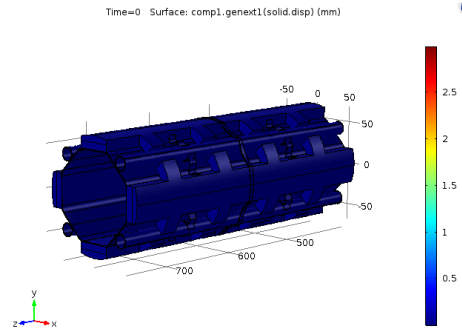
# CERN priorities: on-track construction of HL-LHC

## VSC contribution: new beam screen and interconnections

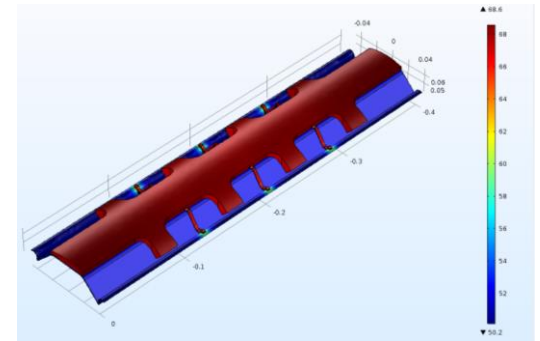
### Triplet area beam screen



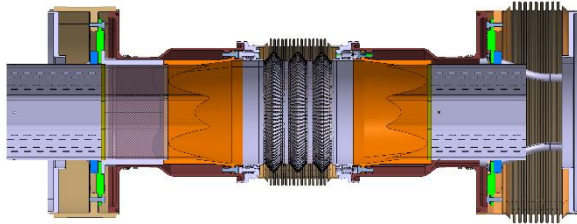
Beam screen / cold bore assembly



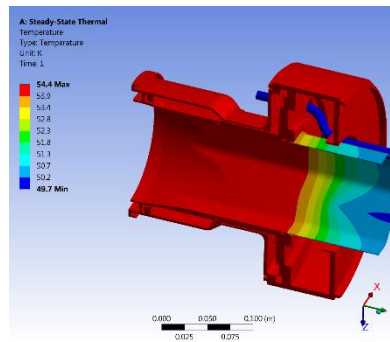
Mechanical behaviour during a quench



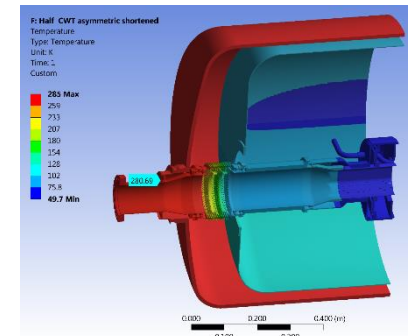
Heat transfer from the tungsten absorbers to the cryogenic cooling tube



Mechanical design of vacuum line interconnection



Temperature field in the interconnection

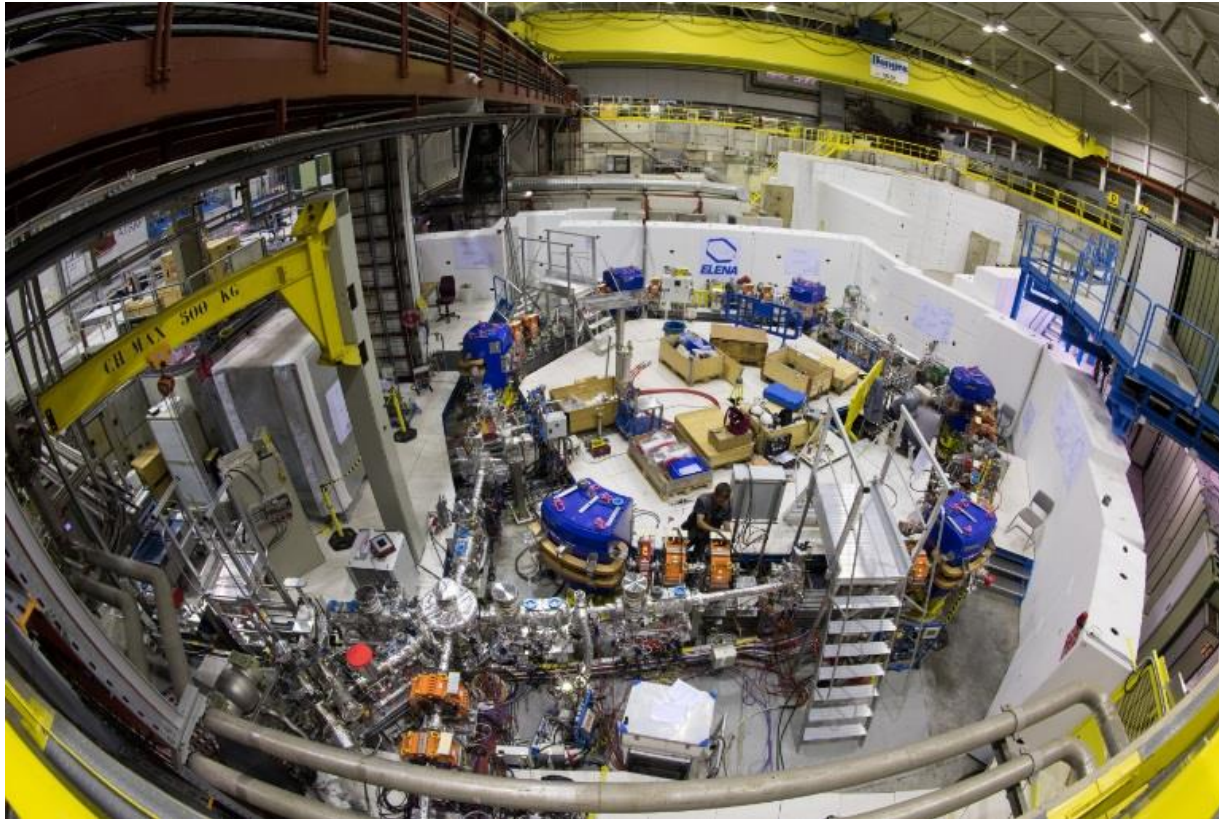


Design and thermal simulations of the cold/warm transition in Q1



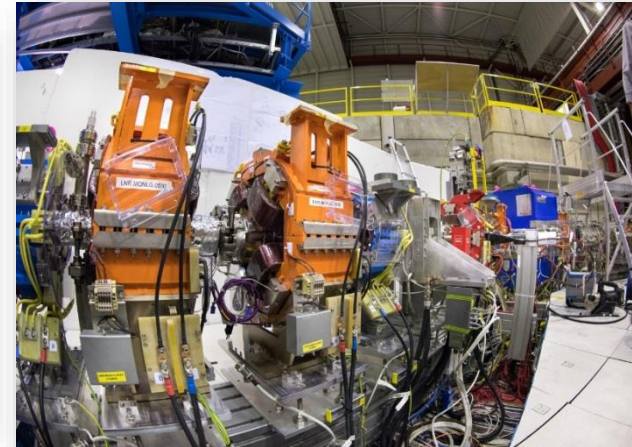
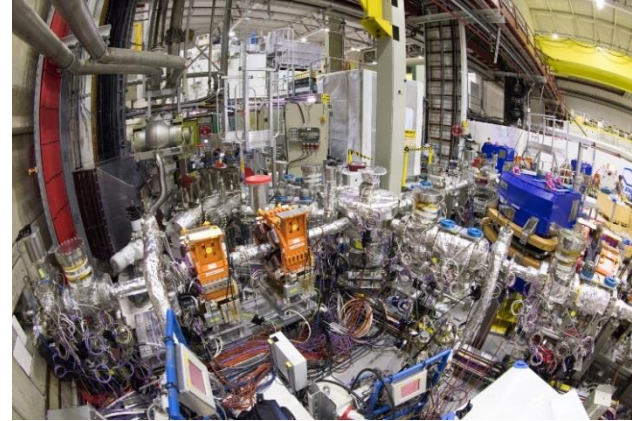
# CERN priorities: Scientific diversity programme

## VSC contribution: ELENA



# CERN priorities: Scientific diversity programme

## VSC contribution: HIE-ISOLDE





# CERN priorities: Scientific diversity programme

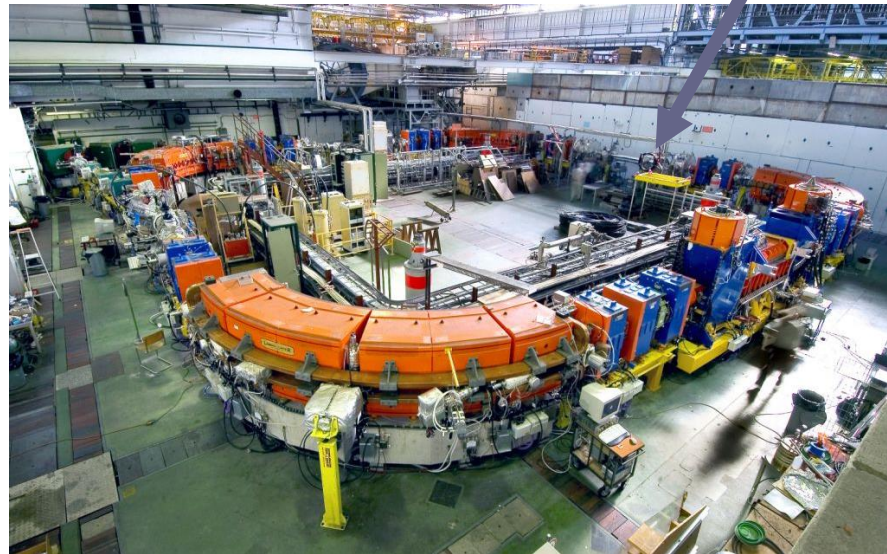
## VSC contribution: other potential projects

**HIE-ISOLDE phase 3:** not yet approved

**SHIP:** not yet formally approved

**OPENMED:** not yet approved

Suitable for  
hadrontherapy  
studies



Proposed extraction line



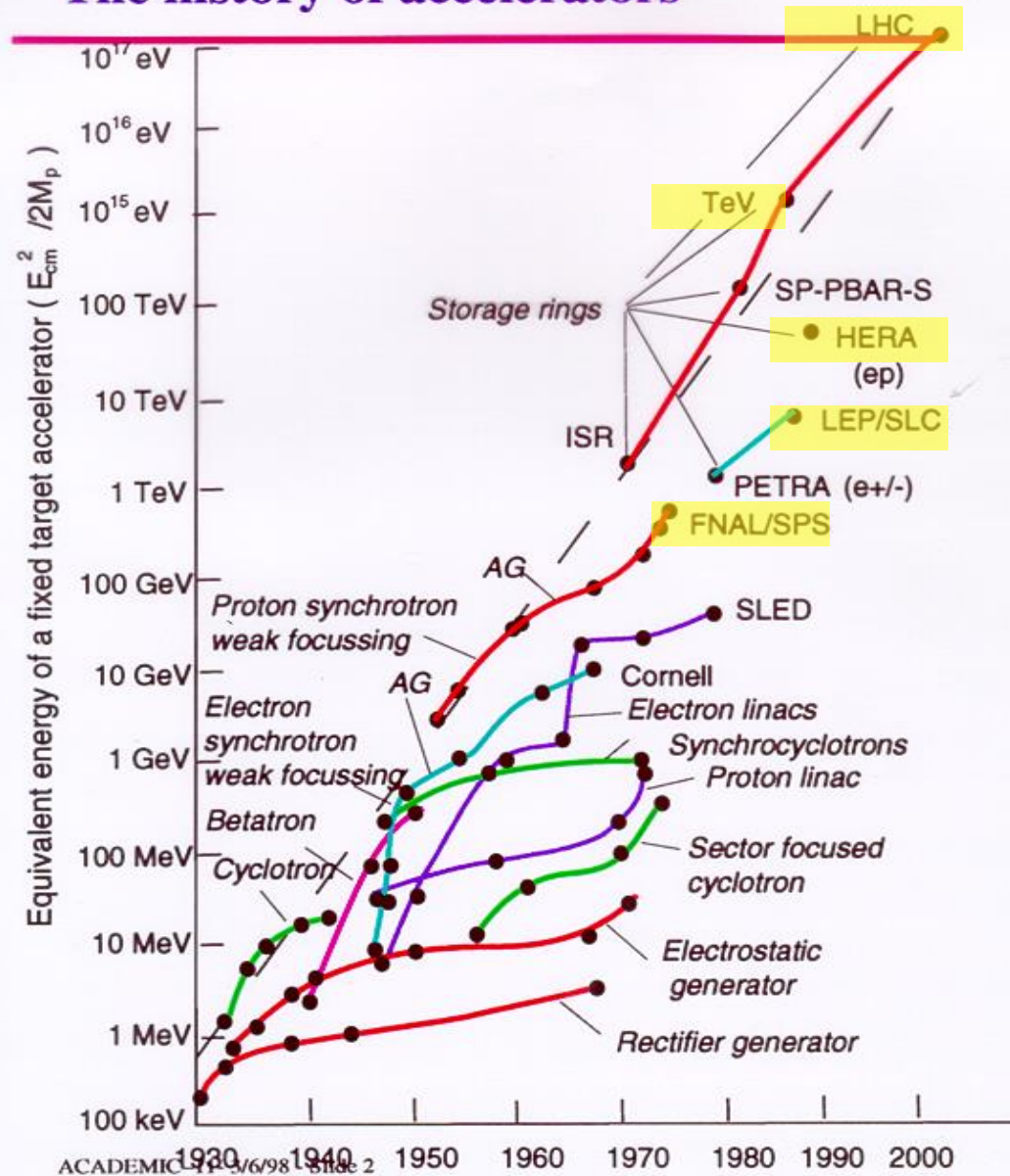
# How have we contributed to the CERN priorities?

- **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's future:**
  - vibrant accelerator R&D programme exploiting CERN's strengths and uniqueness.
  - design studies for future accelerators: CLIC, FCC (includes HE-LHC).
  - future opportunities of diversity programme: "Physics Beyond Colliders".

# Brief look at history

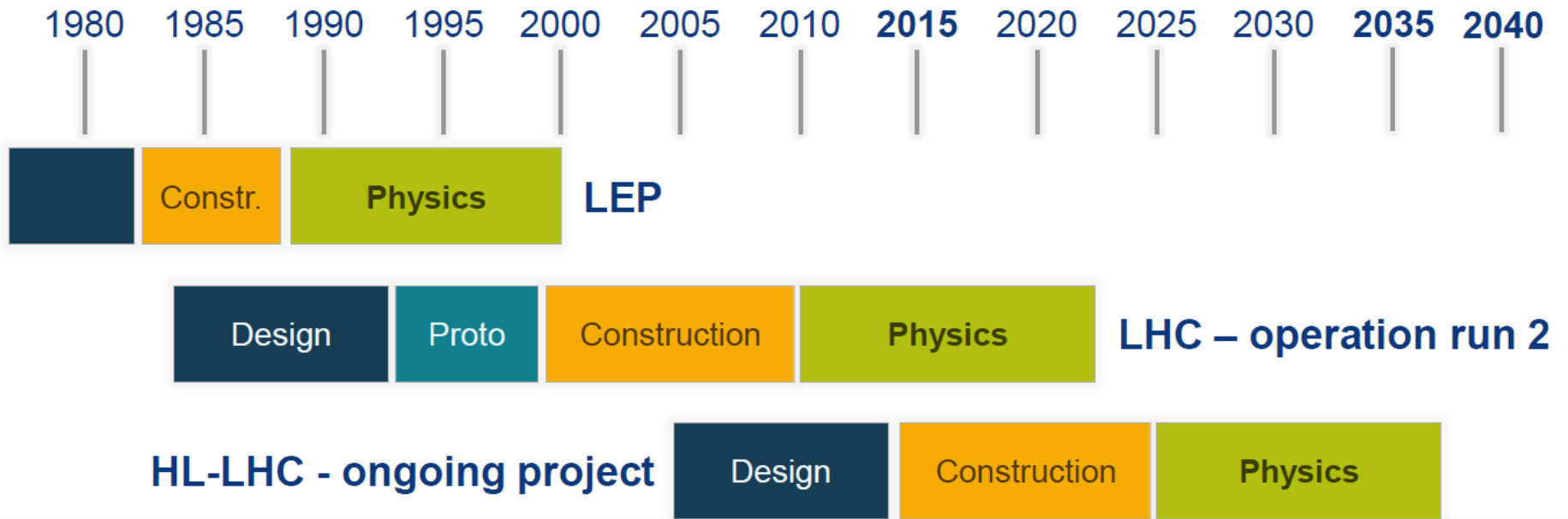
- Fundamental discoveries made with “beams” from radioactive sources (Rutherford) trigger the demand for higher energies
- **New concepts** allow sustained exponential development for more than 80 years and progress achieved through repeated jumps from saturating to new technologies
- From early 80’s, more **technology driven** progresses: superconductivity key technology of high-energy machines (RF and magnets)

## The history of accelerators



ACADEMIC 19/06/98 Slide 2

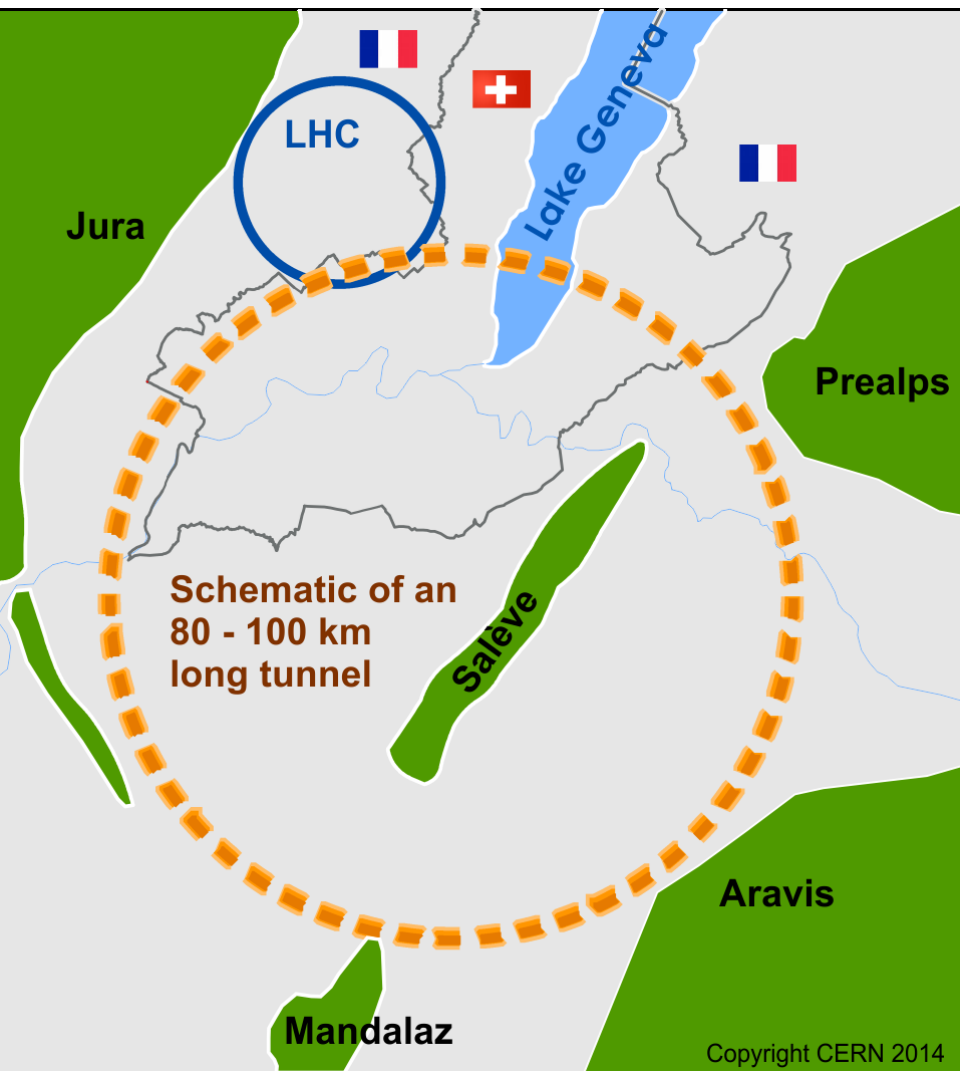
# Future Circular Collider Study





# Future Circular Collider Study

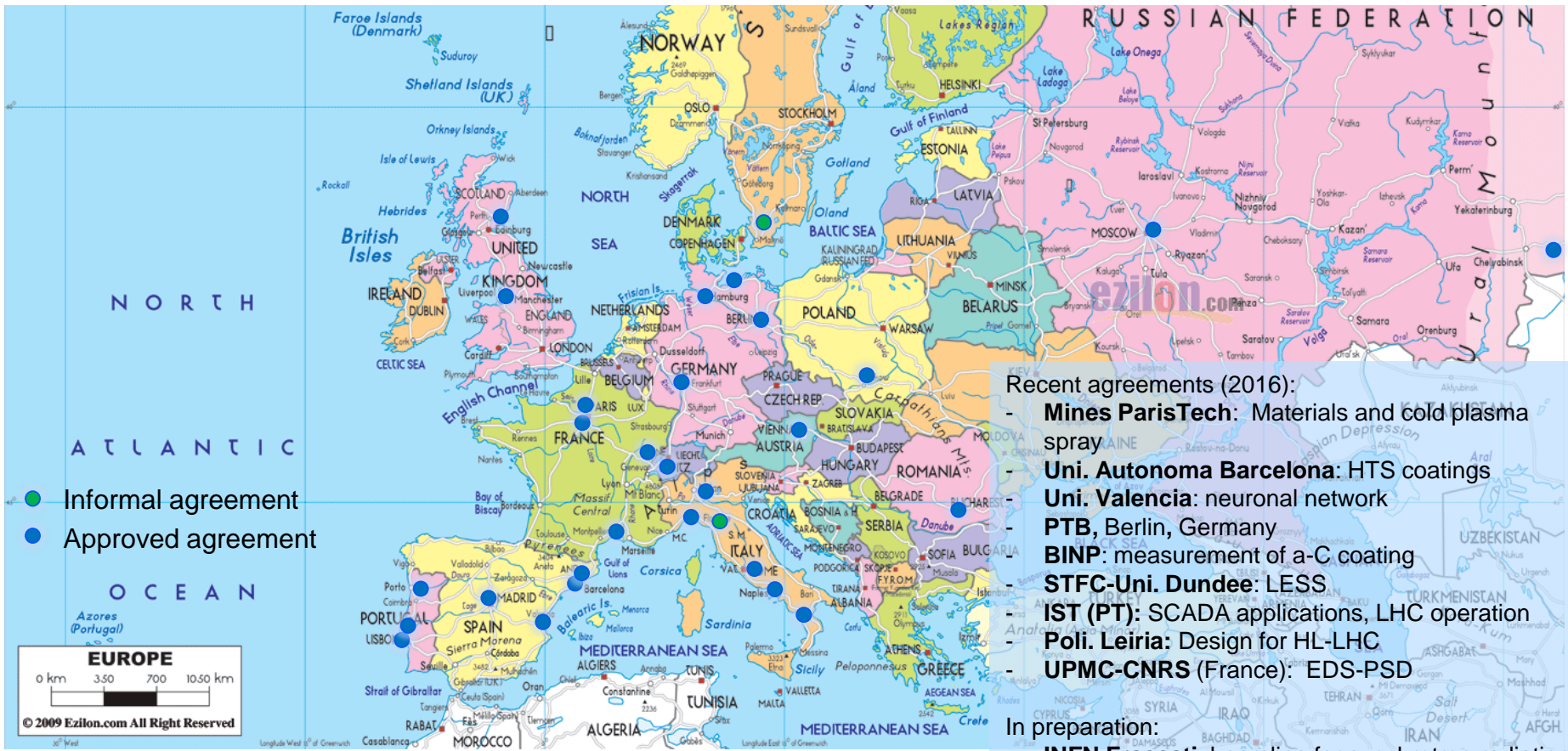
Goal: CDR For the European Strategy Update 2019



International FCC collaboration  
(CERN as host lab) to study:

- **$pp$ -collider (*FCC-hh*)**  
→ main emphasis, defining infrastructure requirements  
**16 T → 100 TeV  $pp$  in 100 km**
- **80-100 km tunnel infrastructure** in Geneva area, site specific
- **$e^+e^-$  collider (*FCC-ee*)**, as potential first step
- **$p-e$  (*FCC-he*) option**, integration one IP, FCC-hh & ERL
- HE-LHC with FCC-hh technology

# Collaborations



Recent agreements (2016):

- **Mines ParisTech**: Materials and cold plasma spray
- **Uni. Autònoma Barcelona**: HTS coatings
- **Uni. Valencia**: neuronal network
- **PTB, Berlin, Germany**
- **BINP**: measurement of a-C coating
- **STFC-Uni. Dundee**: LESS
- **IST (PT)**: SCADA applications, LHC operation
- **Poli. Leiria**: Design for HL-LHC
- **UPMC-CNRS (France)**: EDS-PSD

In preparation:

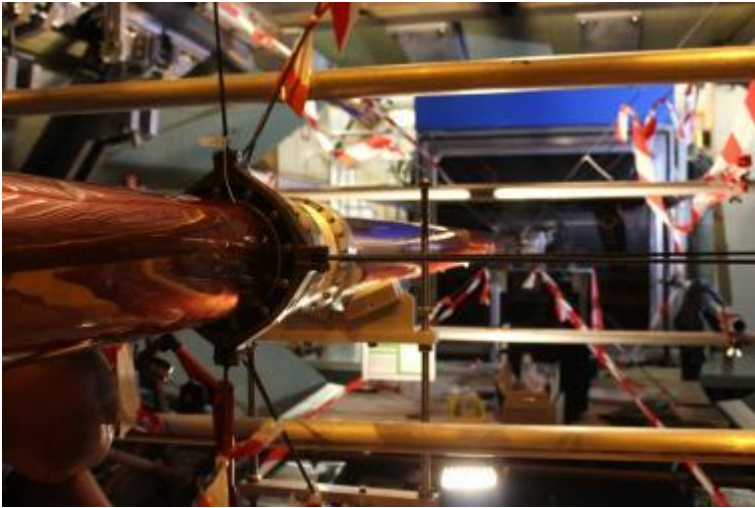
- **INFN Frascati**: beamline for synchrotron radiation studies
- **Max-Planck-Institute + EPFL**: Helicon plasma cell





- Argonne National Laboratories
- University of Florida
- LNLS, Campinas, São Paulo
- KEK, Photon Factory, Tsukuba

## Examples of installation





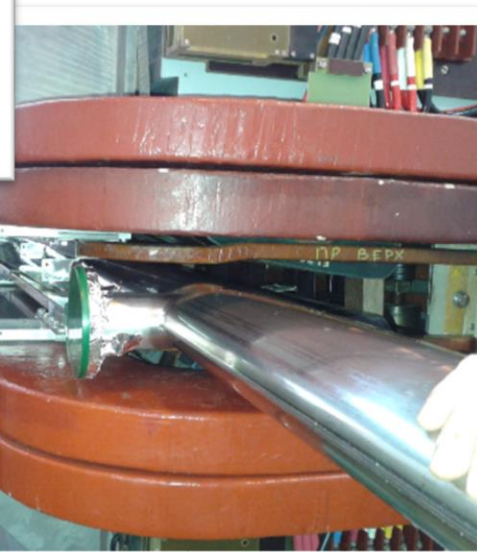
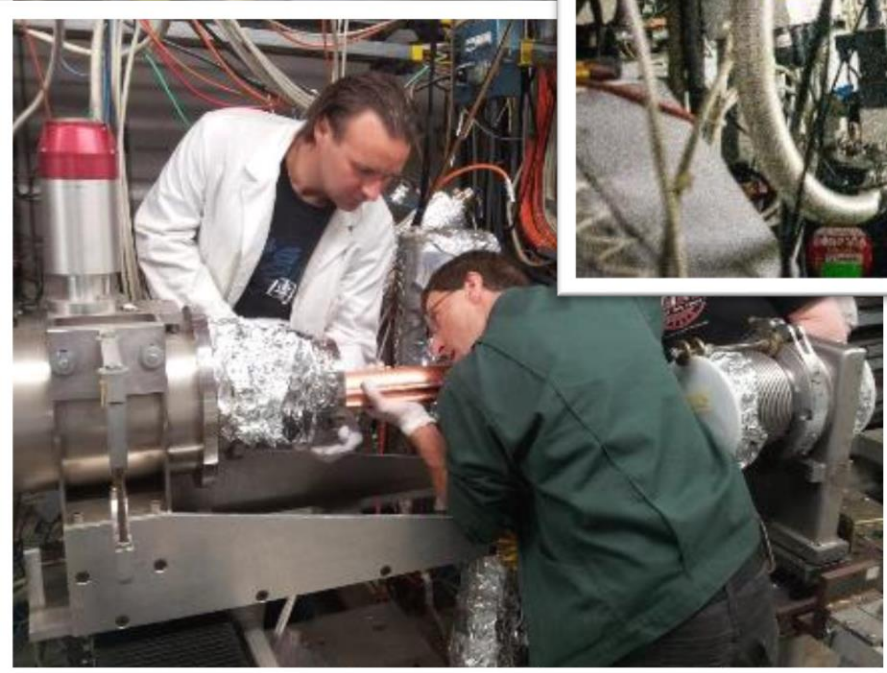
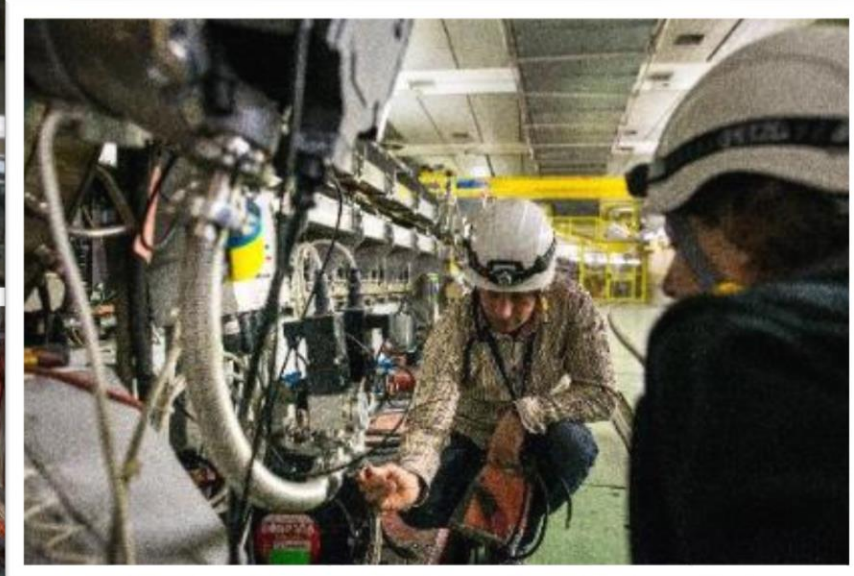
# Examples of installation





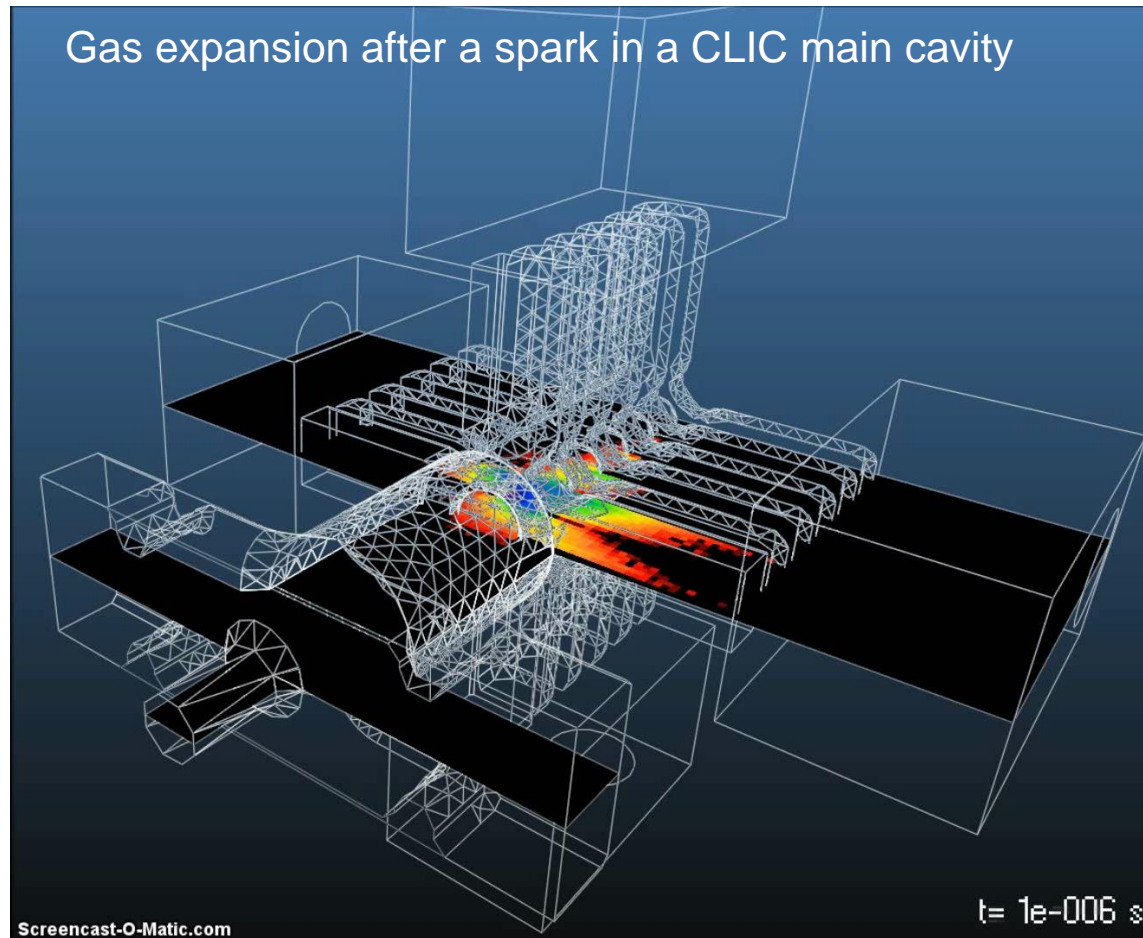






## Simulations

- Molflow+, a Monte Carlo code, is now a standard for vacuum simulation.
- Recent developments have introduced time dependence of pressure profile.
- Synchrotron radiation is integrated in the code.







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