www.cern.ch

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

What is CERN?

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

2400 staff members
1000 associate members of personnel
12000 users from 70 countries

Budget (2017) ~ 1100MCHF

Contribution ∝ GDP (PT ~1.1%)

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

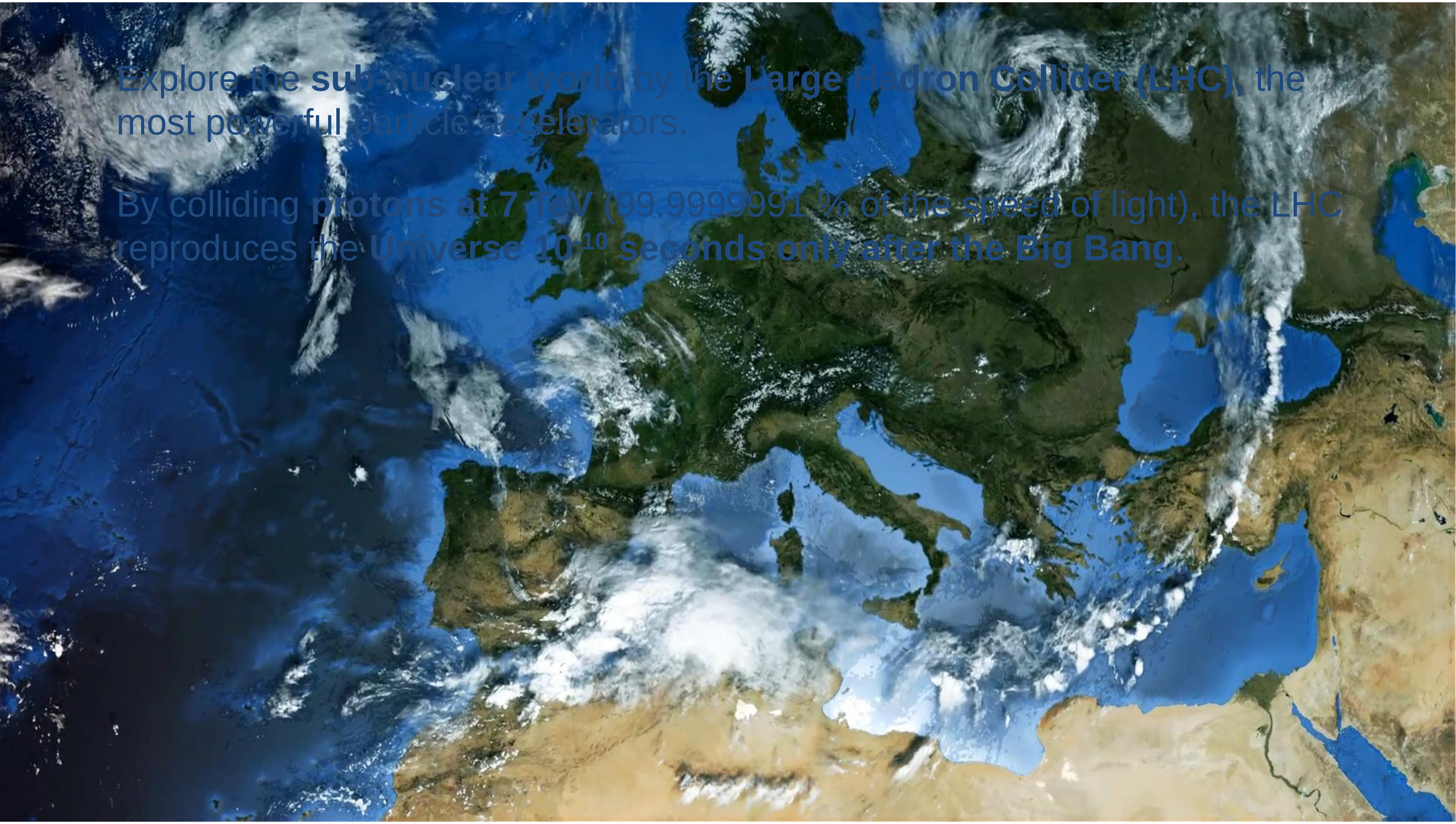
General Director:
Dr. Fabiola Giannotti in 2016-2020

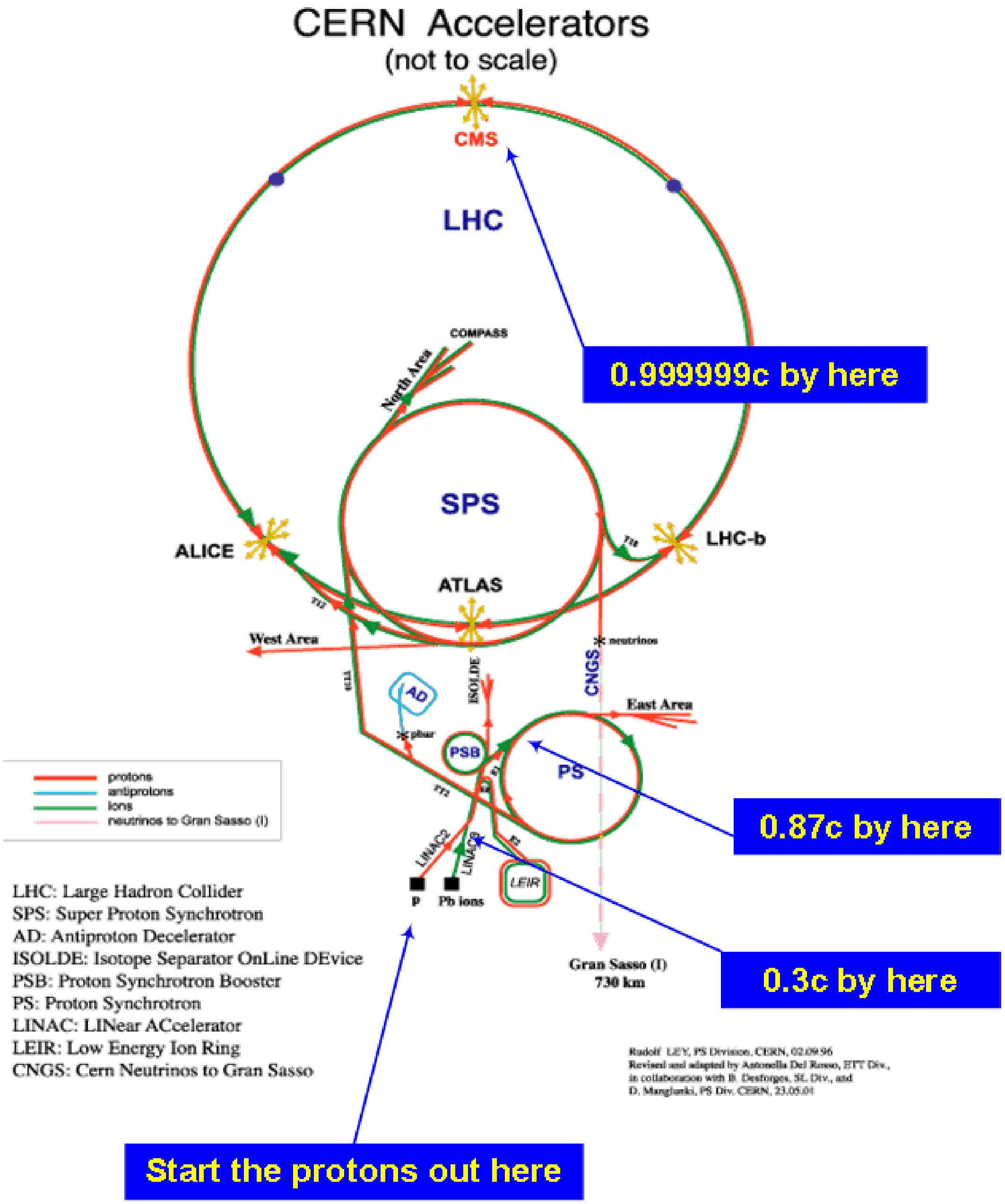
Cost per year and per Member-State inhabitant

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**.

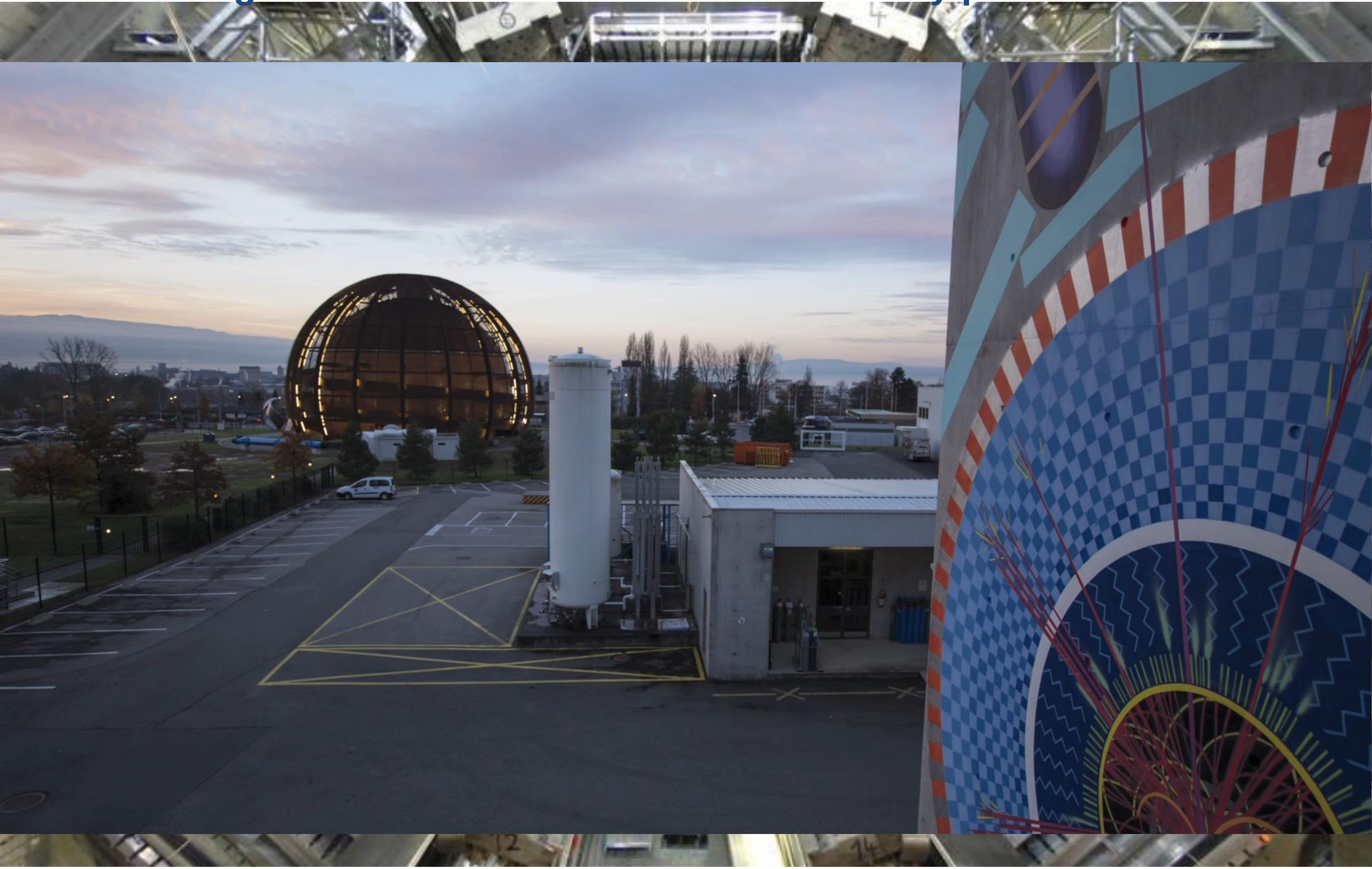


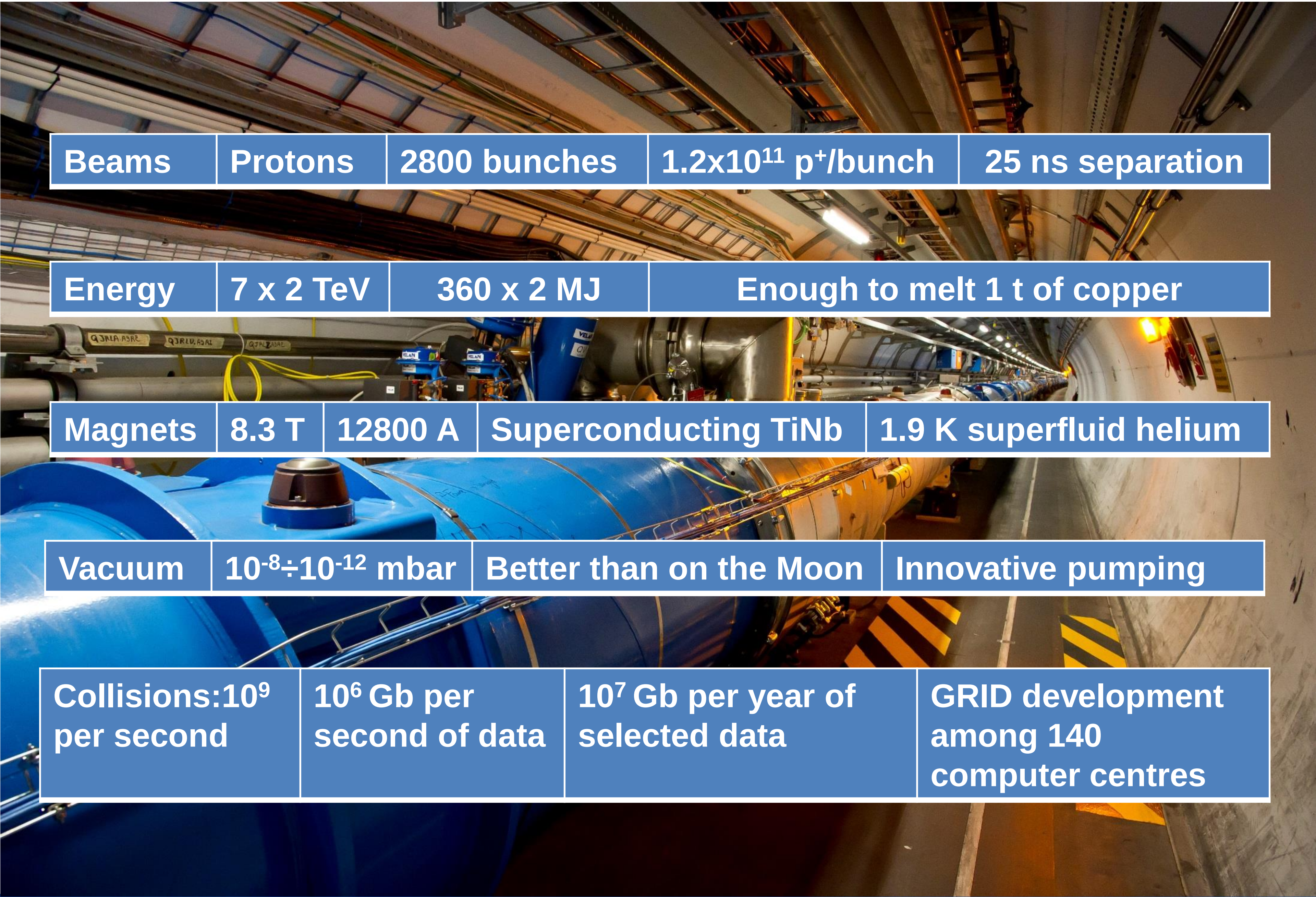


Energies:

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

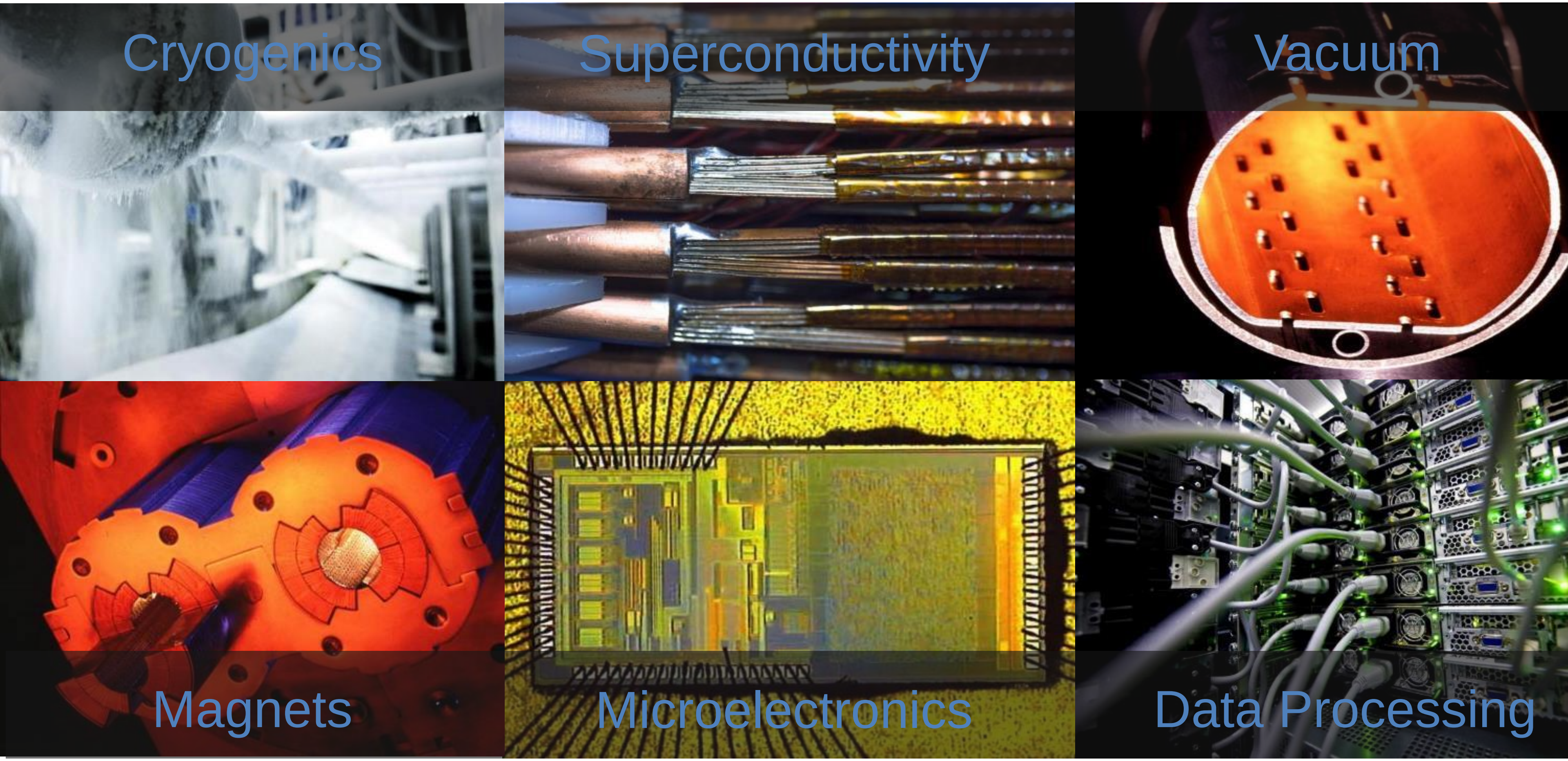




Beams	Protons	2800 bunches	1.2×10^{11} p^+/bunch	25 ns separation
Energy	7 x 2 TeV	360 x 2 MJ	Enough to melt 1 t of copper	
Magnets	8.3 T	12800 A	Superconducting TiNb	1.9 K superfluid helium
Vacuum	$10^{-8} \div 10^{-12}$ mbar	Better than on the Moon	Innovative pumping	
Collisions: 10^9 per second	10^6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

CERN core technical competences

Accelerators, detectors and computing



CERN Priorities

CERN Vision & Strategy

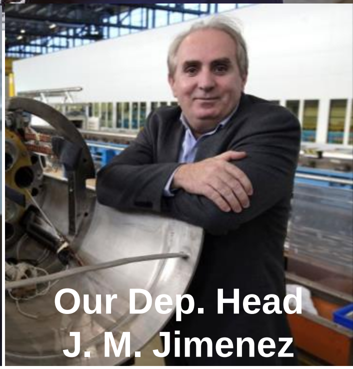
Three main scientific pillars

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 Director
F. Bordry

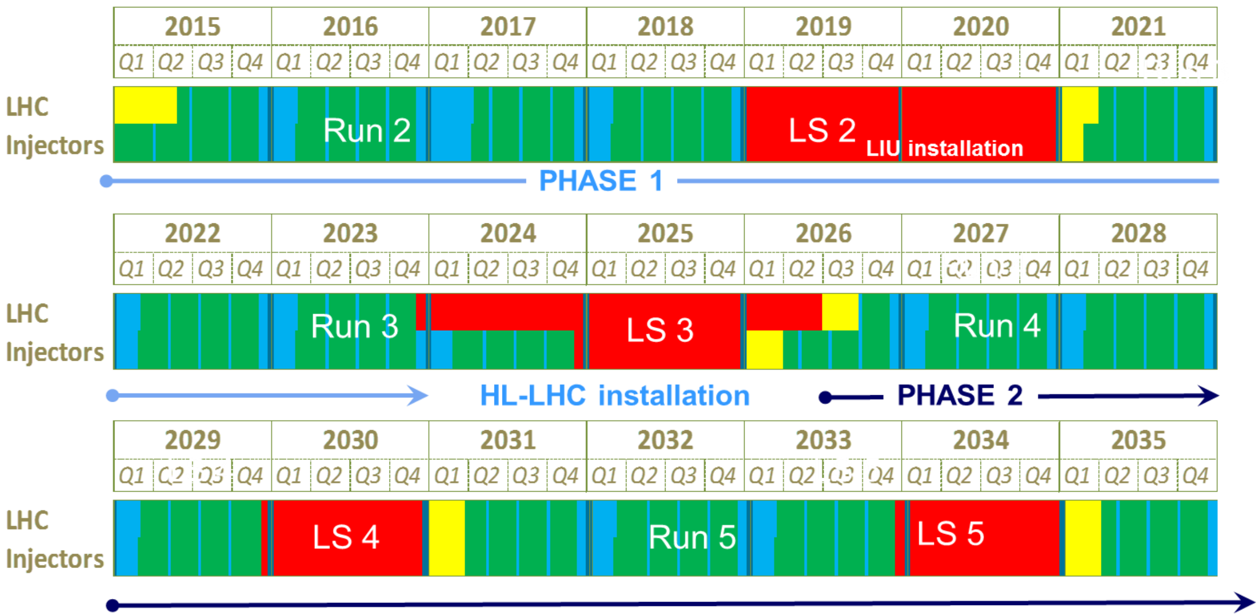


CERN Vision & Strategy

LHC Roadmap

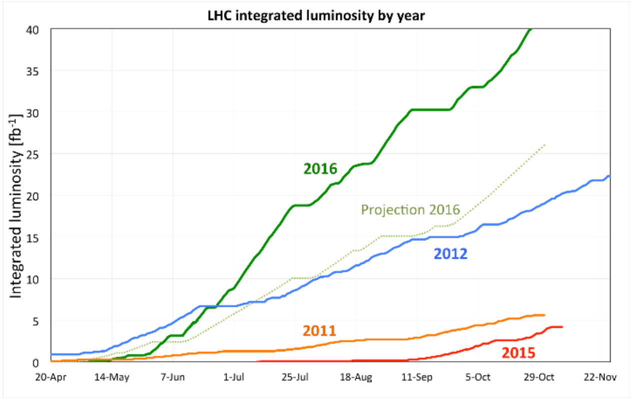
*LS2 starting in 2019 => 24 months + 3 months BC
LS3 LHC: starting in 2024 => 30 months + 3 months BC
Injectors: in 2025 => 13 months + 3 months BC

Physics
Shutdown
Beam commissioning
Technical stop



Objective for Run 2:

100 fb^{-1} of high-quality data



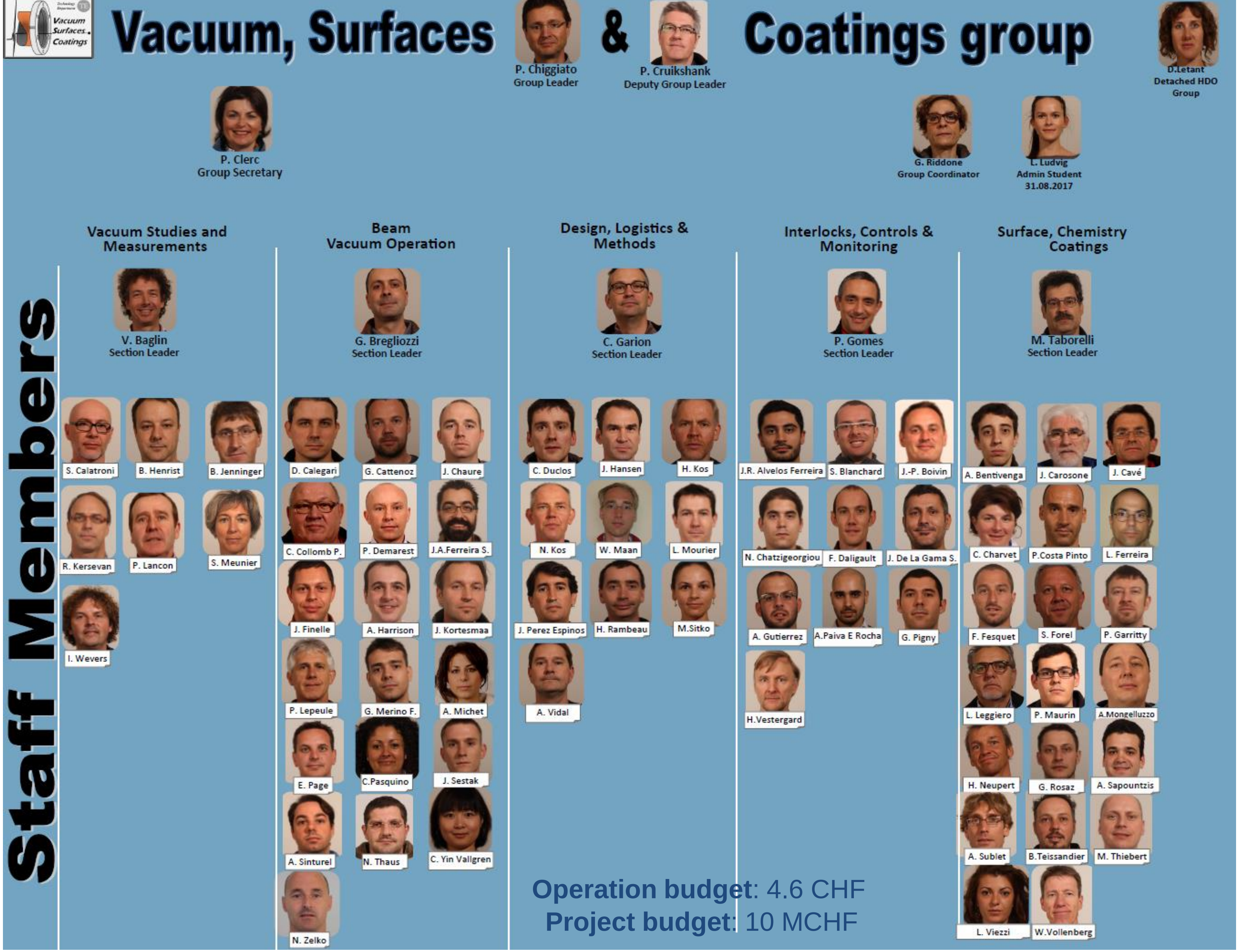
***LS** = Long Shutdown

Vacuum, Surfaces and Coatings group’s mandates

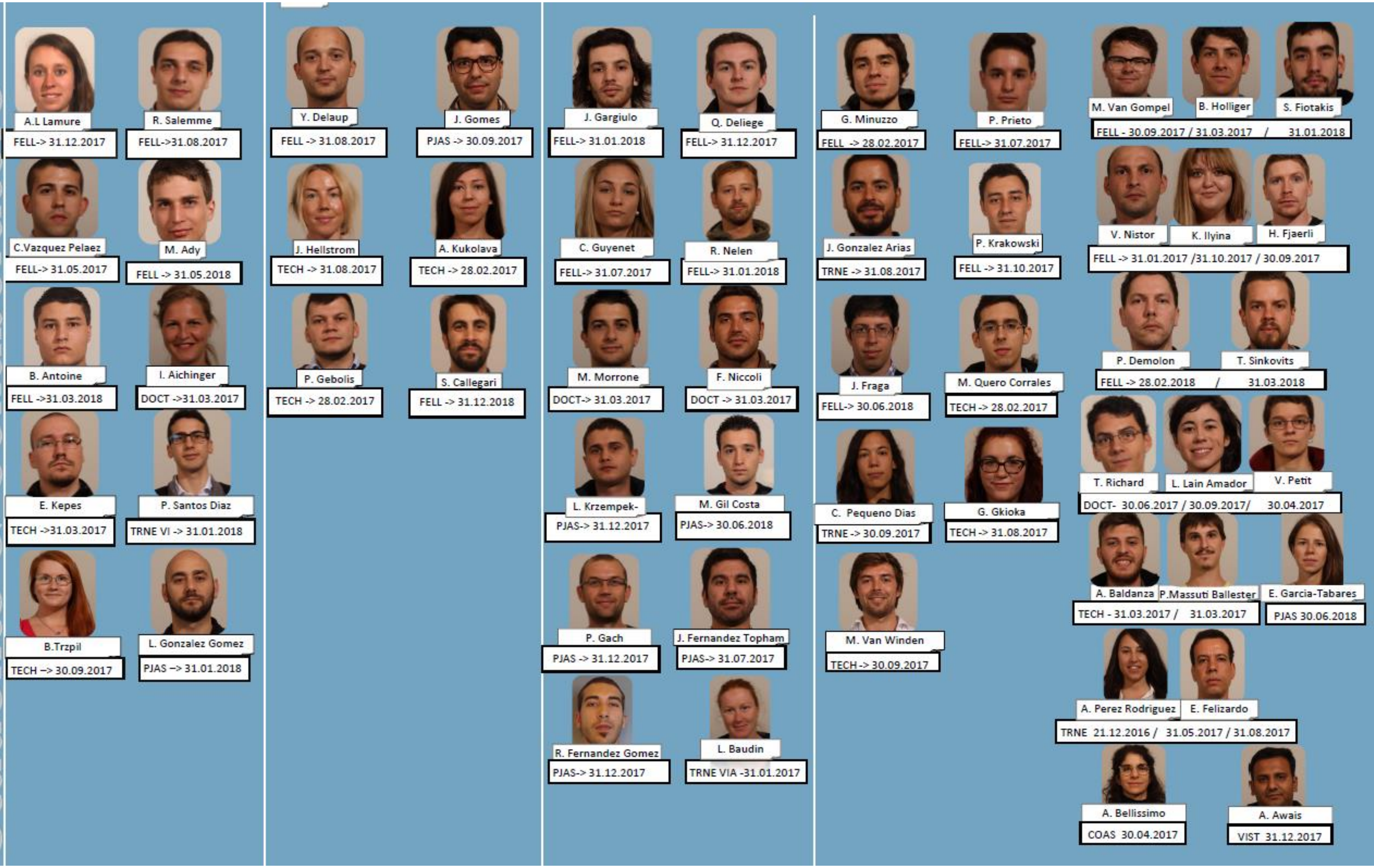
- Provide CERN’s accelerators with the **required degree of vacuum**.
- **Exploit the CERN’s production facilities** for surface treatments, including thin film coatings.
- Provide high-energy physics community with **expertise in vacuum technology** (from design to operation) and beam-surface interactions.
- 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
Linac, Booster, ISOLDE, PS, n-TOF and AD Complex						**2.6 km !**	
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
SPS Complex						**15.7 km !**	
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	
LHC Accelerator						***~109 km !***	
LHC Arcs (Beam x2, Magnets & QRL insul.)	collider	2007	2 × 7 TeV	-	< 10^{-8}	2 x (2 x 25 km)	p, ions
LSS RT separated beams				complete		2 × 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 × 720 m	
				High Vacuum		~20 km	**~128 km !**
				UHV w/wo NEG		~ 57.5 km	
				Insulation vacuum		~ 50 km	

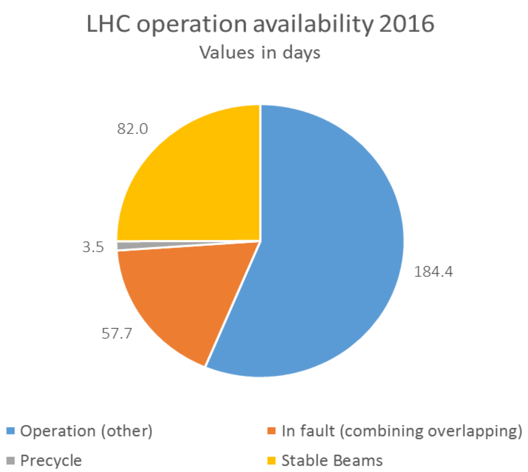

Vacuum, Surfaces & Coatings group
Vacuum Surfaces Coatings
P. Chiggiato
Group Leader
P. Cruikshank
Deputy Group Leader
D.Letant
Detached HDO Group
P. Clerc
Group Secretary
G. Riddone
Group Coordinator
L. Ludvig
Admin Student
31.08.2017
Staff Members
Vacuum Studies and Measurements
V. Baglin
Section Leader
S. Calatroni
B. Henrist
B. Jenninger
R. Kersevan
P. Lancon
S. Meunier
I. Wevers
Beam Vacuum Operation
G. Bregliozzi
Section Leader
D. Calegari
G. Cattenoz
J. Chaure
C. Collomb P.
P. Demarest
J.A.Ferreira S.
J. Finelle
A. Harrison
J. Kortesmaa
P. Lepeule
G. Merino F.
A. Michet
E. Page
C.Pasquino
J. Sestak
A. Sinturel
N. Thaus
C. Yin Vallgren
N. Zelko
Design, Logistics & Methods
C. Garion
Section Leader
C. Duclos
J. Hansen
H. Kos
N. Kos
W. Maan
L. Mourier
J. Perez Espinos
H. Rambeau
M.Sitko
A. Vidal
Interlocks, Controls & Monitoring
P. Gomes
Section Leader
J.R. Alvelos Ferreira
S. Blanchard
J.-P. Boivin
N. Chatzigeorgiou
F. Daligault
J. De La Gama S.
A. Gutierrez
A.Paiva E Rocha
G. Pigny
H.Vestergard
Surface, Chemistry Coatings
M. Taborelli
Section Leader
A. Bentivenga
J. Carosone
J. Cavé
C. Charvet
P.Costa Pinto
L. Ferreira
F. Fesquet
S. Forel
P. Garritty
L. Leggiero
P. Maurin
A.Mongelluzzo
H. Neupert
G. Rosaz
A. Sapountzis
A. Sublet
B.Teissandier
M. Thiebert
L. Viezzi
W.Vollenberg
Operation budget: 4.6 CHF
Project budget: 10 MCHF

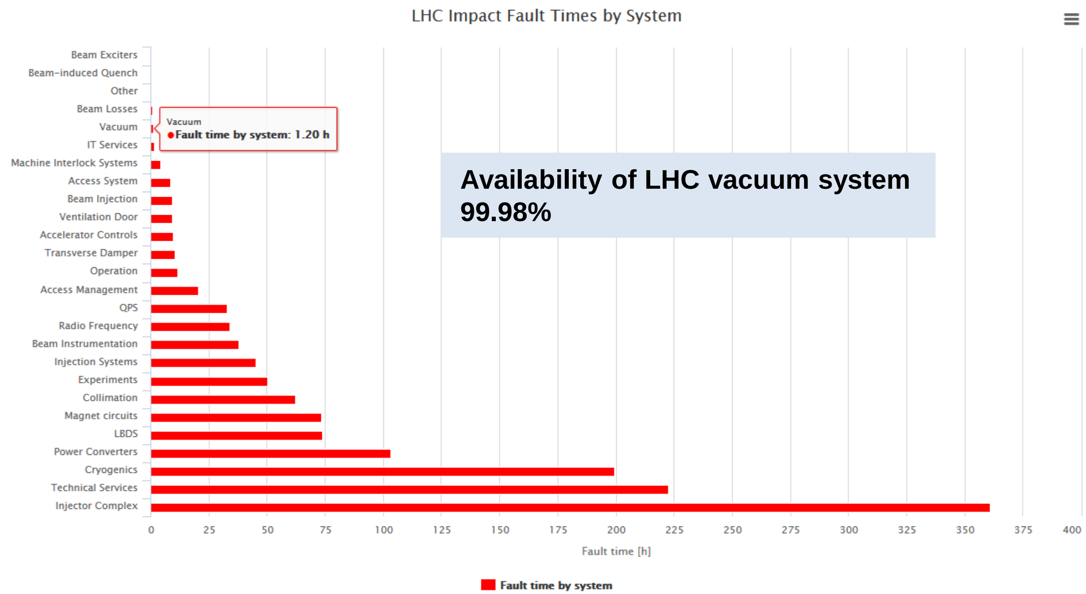
Students & Collaborators



CERN priorities: Full exploitation of the LHC

VSC contribution: extremely low operational faults





Availability of LHC vacuum system 99.98%

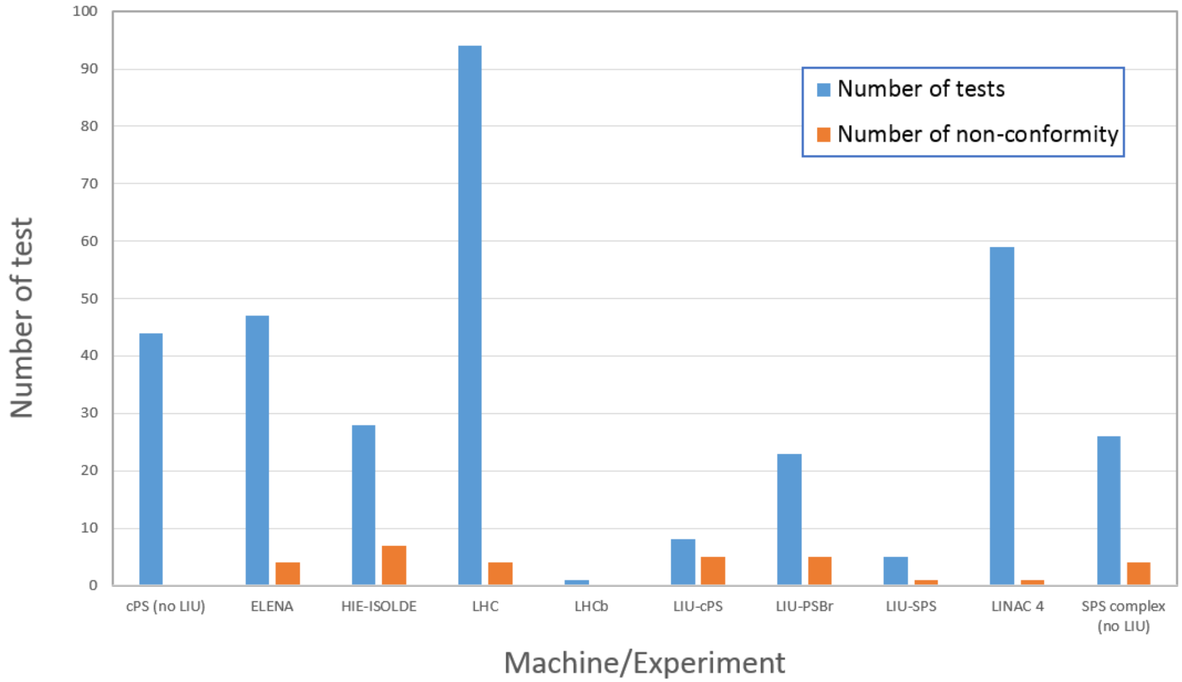
Parent / Child issue	Issue count	Total duration [hh:mm]	Beam dump
Parent	2	**01:22**	**0**
Child	0	**NA**	**NA**

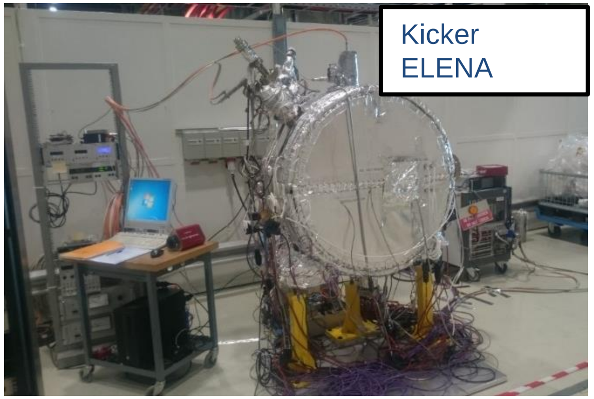
Based on data from LHC Cardiogram and BVO OP tracking

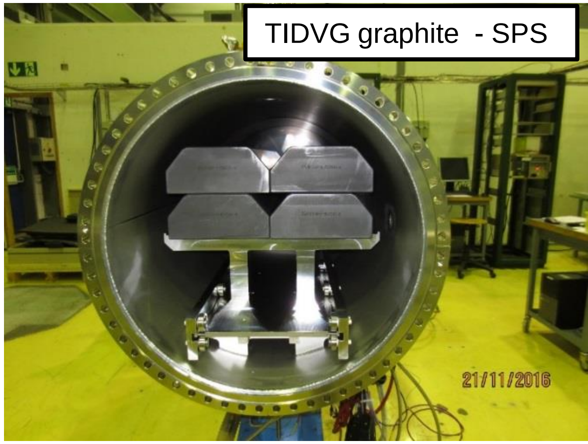
CERN priorities: Full exploitation of the LHC

VSC contribution: issue prevention

No test = No installation in beam vacuum





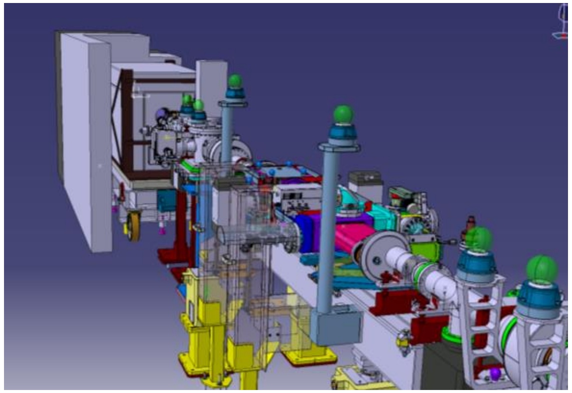


CERN priorities: Upgrade of LHC injectors

VSC contribution: LINAC 4 installation

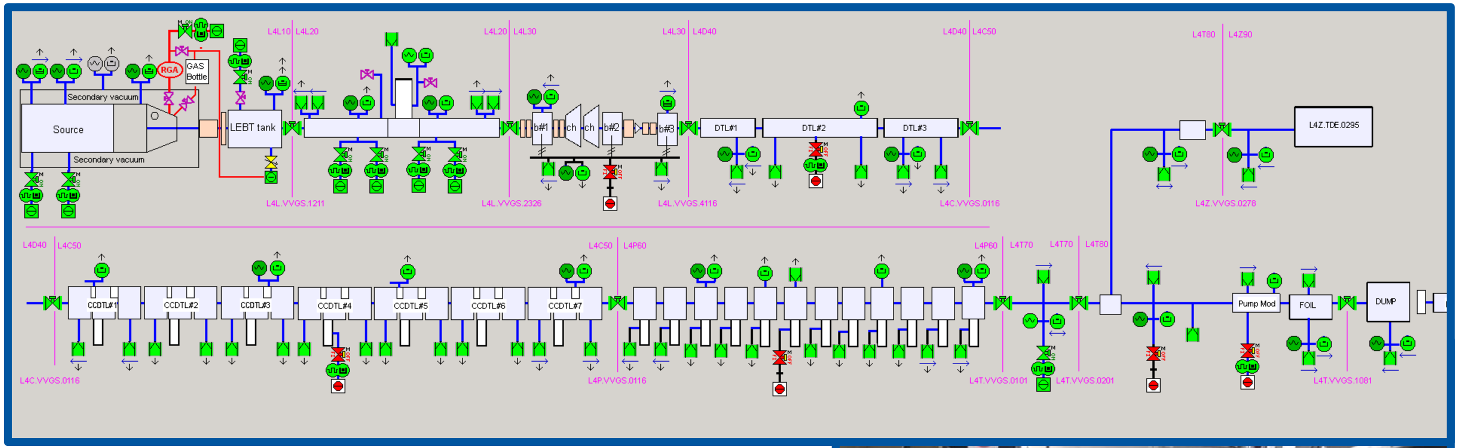
- ❑ Validation and installation of RF cavities
- ❑ Acceptance test of components
- ❑ Installation and commissioning of transfer line

160 MeV commissioning



CERN priorities: Upgrade of LHC injectors

VSC contribution: LINAC 4 installation

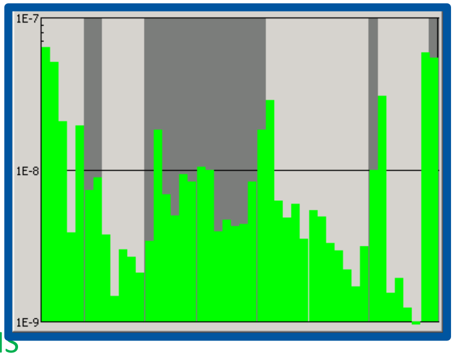


3 MeV (Nov-13)
✓ Source, RFQ, Chopper

50 MeV (Jul-15)
✓ DTL, BIS

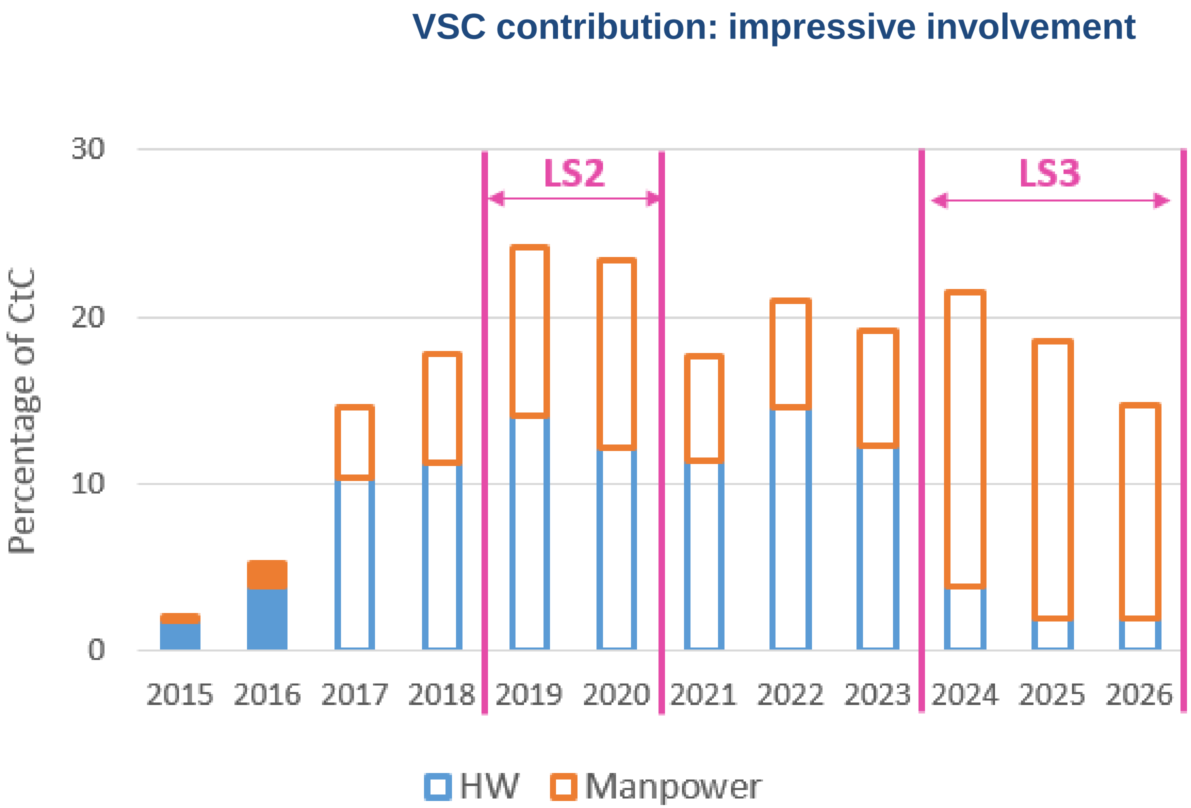
100 MeV (Jul-16)
✓ CCDTL, BIS

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



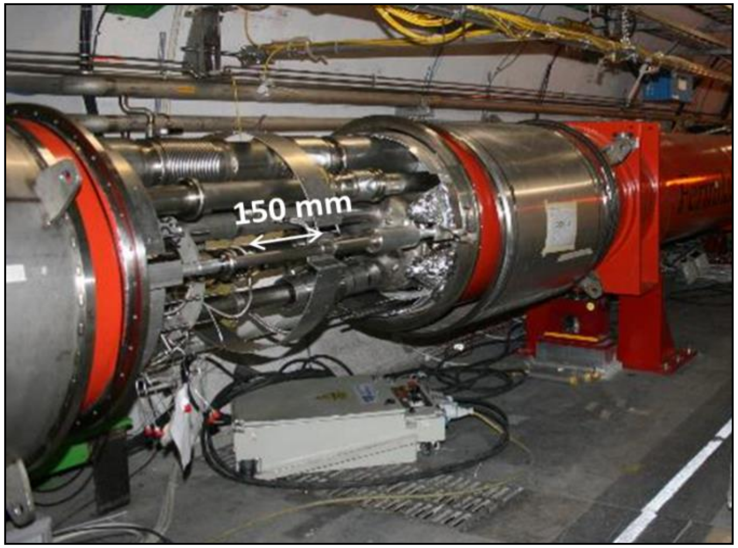
Two most critical actions for TE-VSC:

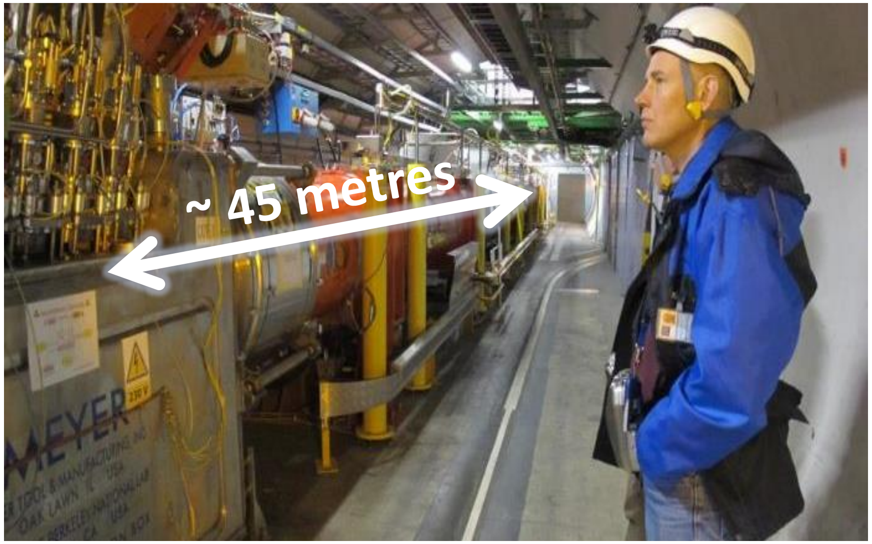
- Mitigation of e-cloud in P2 and P8
- Production of new beam screens

CERN priorities: on-track construction of HL-LHC

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

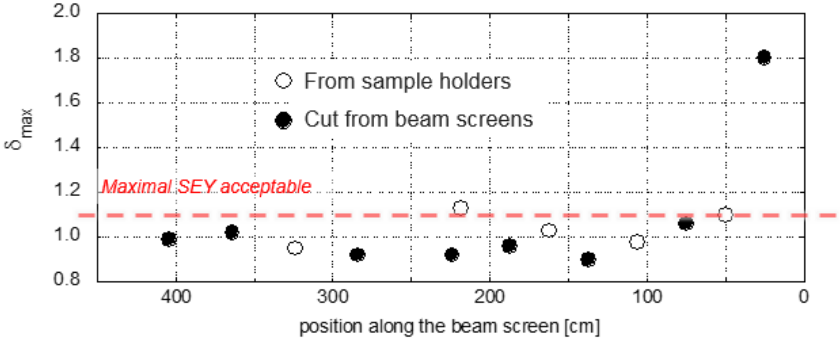
Length to be *in-situ* coated: ~45 meters per “string” (Q1, Q2, Q3, DFBX & D1) of LSS2 and LSS8.
Development of a “**modular sputtering source**” that can be inserted in a 150 mm slot and pulled by cables along D1 and the triplets.

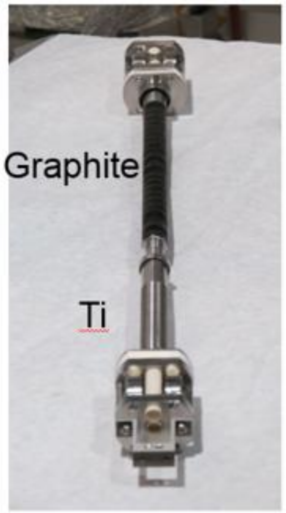


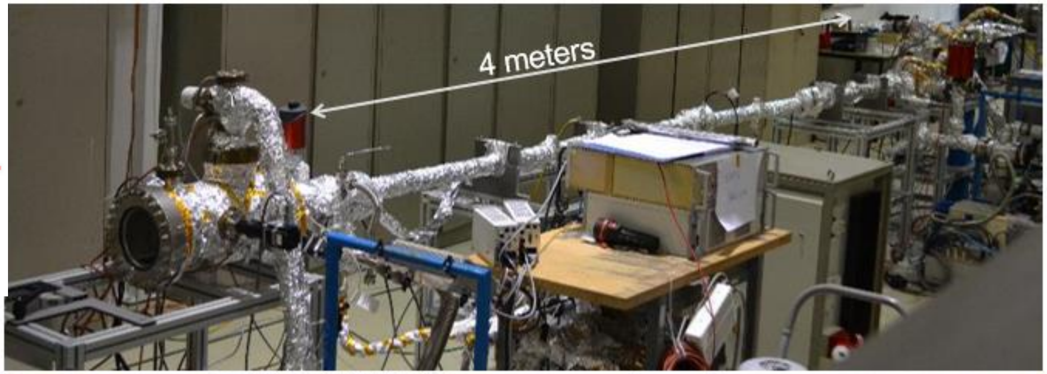


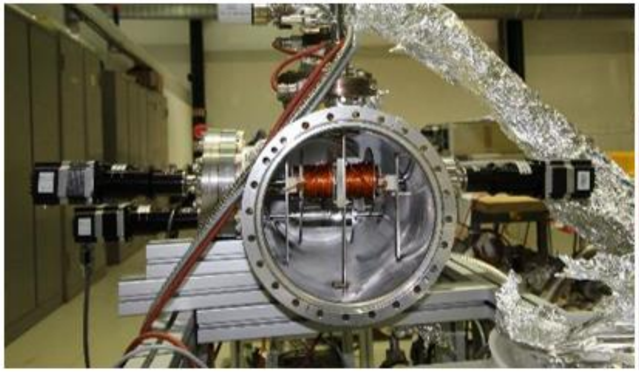
CERN priorities: on-track construction of HL-LHC

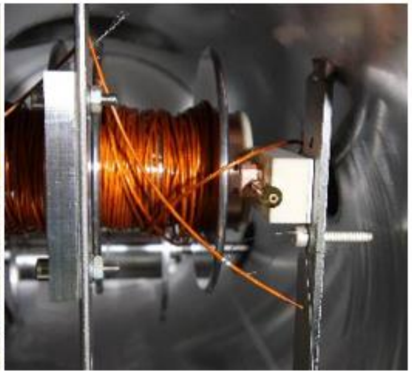
VSC contribution: in-situ coating of LHC-b and ALICE IT areas









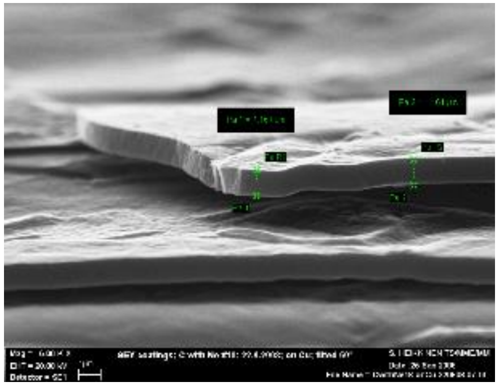


CERN priorities: on-track construction of HL-LHC

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

Baseline

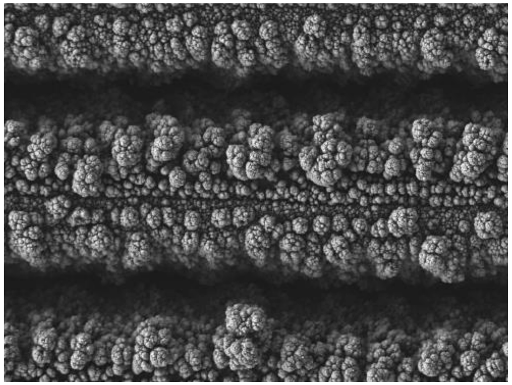
Carbon coatings



Low SEY based on the electronic properties of the material

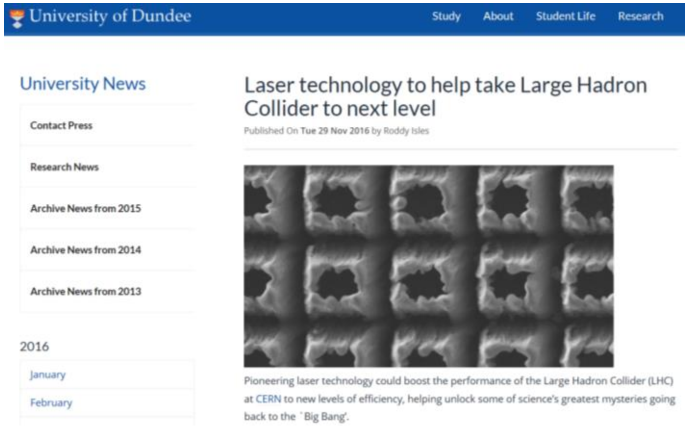
Alternative solution

Laser Engineered Surface Structure LESS



Low SEY based on morphological effects

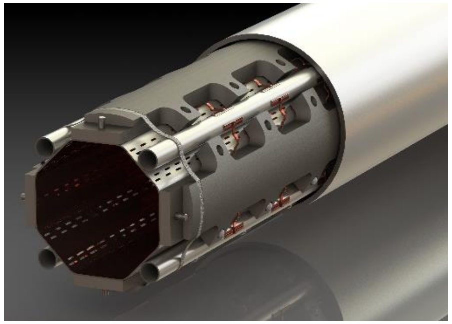
Agreement achieved in October.
Feasibility study just started.
Main deliverable: 2-m long LESS treated beam screen in mid-2018.



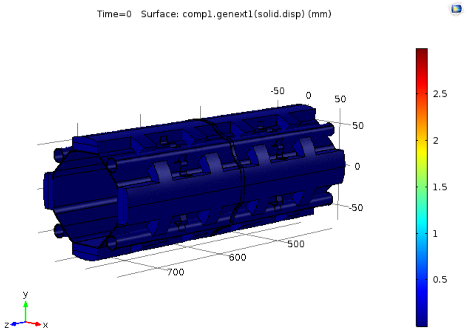
CERN priorities: on-track construction of HL-LHC

VSC contribution: new beam screen and interconnections

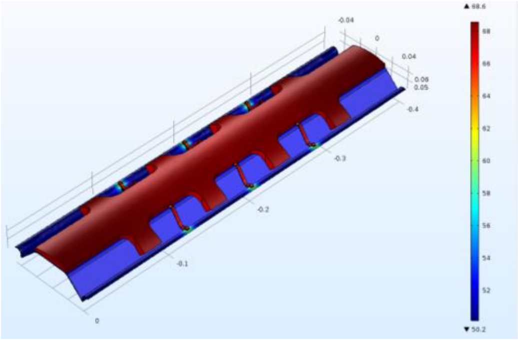
Triplet area beam screen



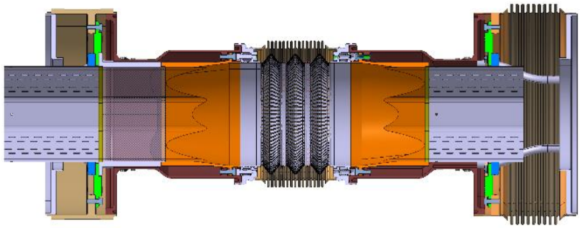
Beam screen / cold bore assembly



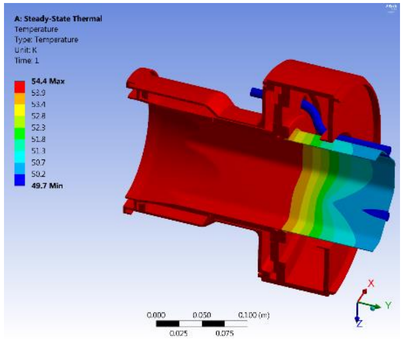
Mechanical behaviour during a quench



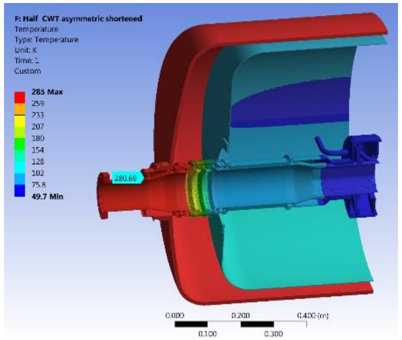
Heat transfer from the tungsten absorbers to the cryogenic cooling tube



Mechanical design of vacuum line interconnection



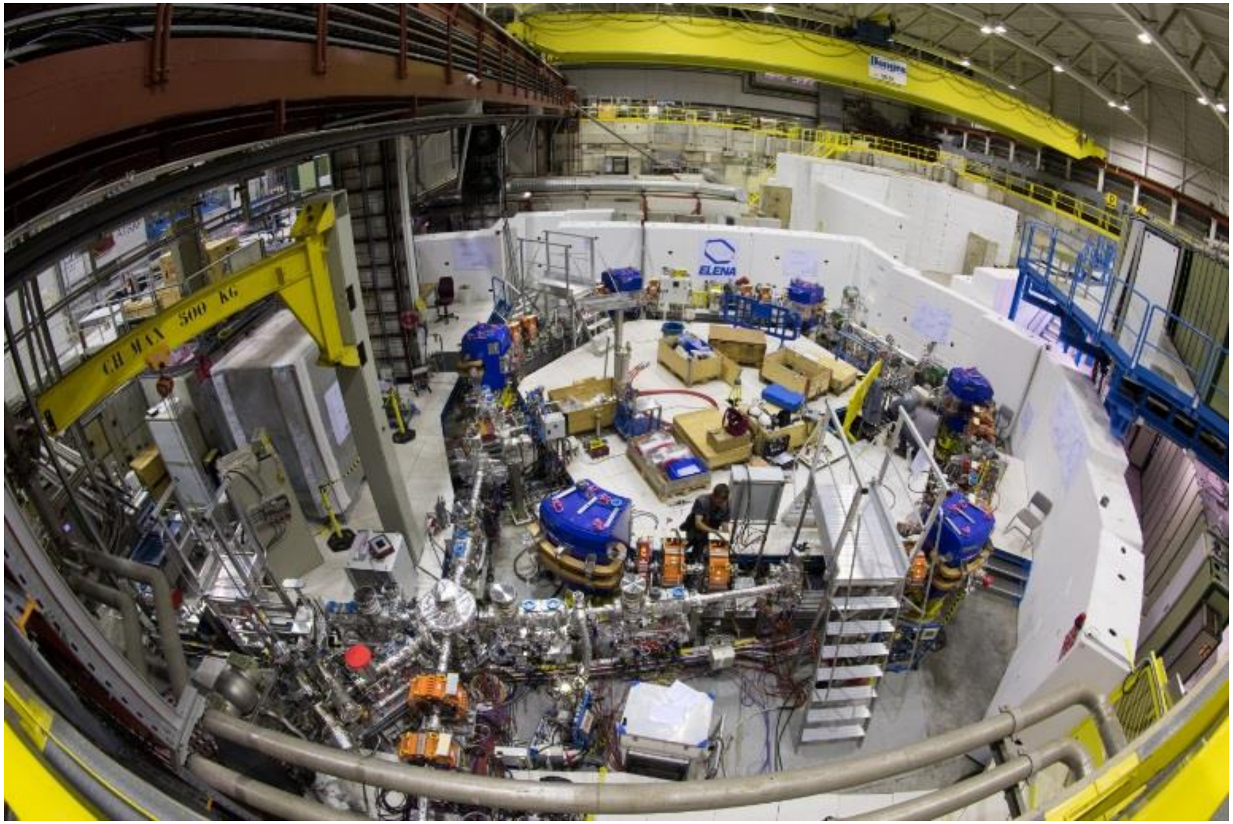
Temperature field in the interconnection



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

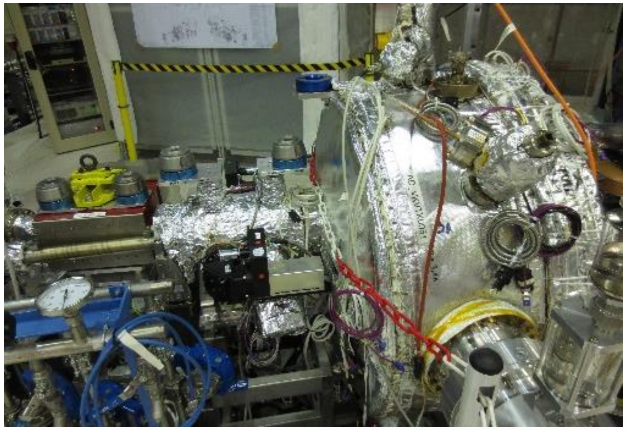
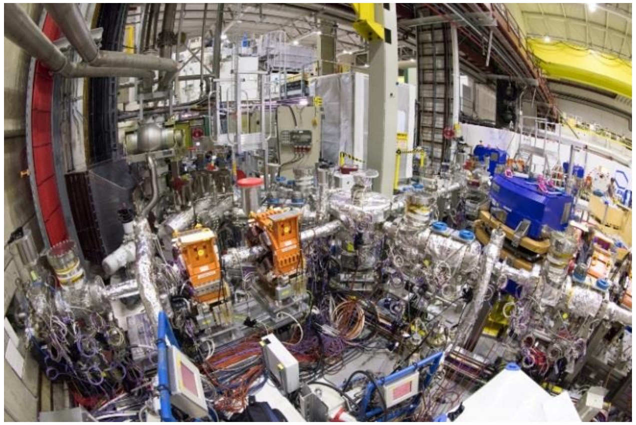
CERN priorities: Scientific diversity programme

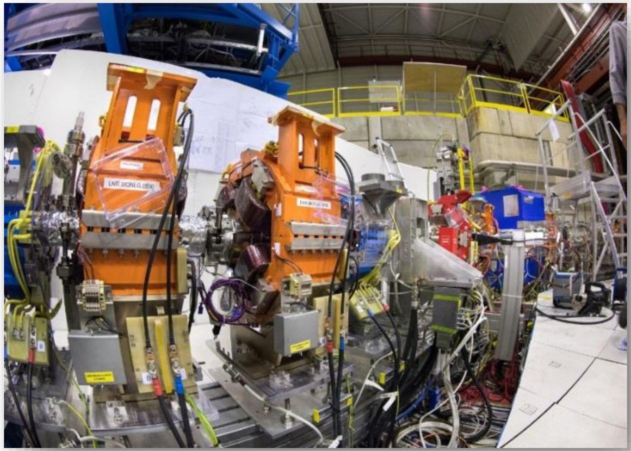
VSC contribution: ELENA



CERN priorities: Scientific diversity programme

VSC contribution: HIE-ISOLDE



CERN priorities: Scientific diversity programme

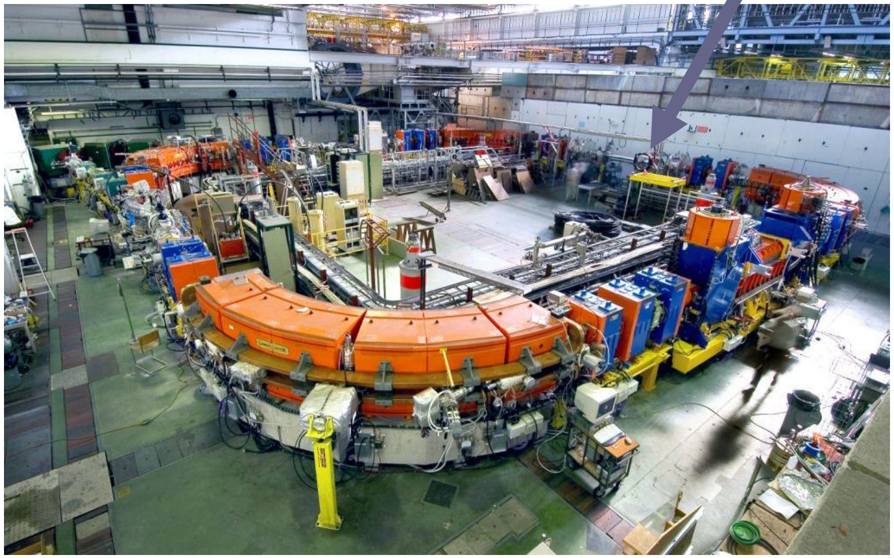
VSC contribution: other potential projects

HIE-ISOLDE phase 3: not yet approved

SHIP: not yet formally approved

OPENMED: not yet approved

Proposed extraction line



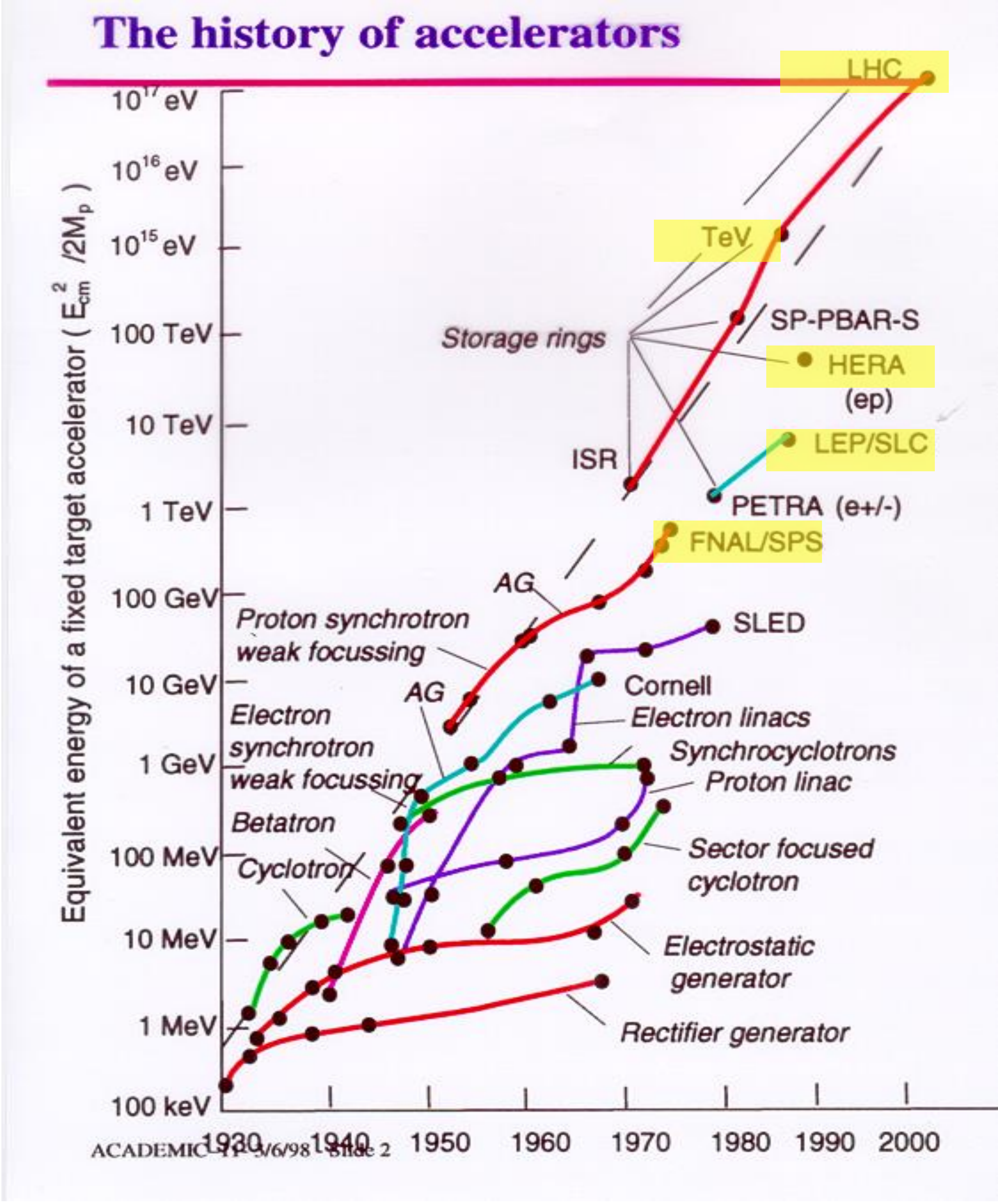
Suitable for hadrontherapy studies

How have we contributed to the CERN priorities?

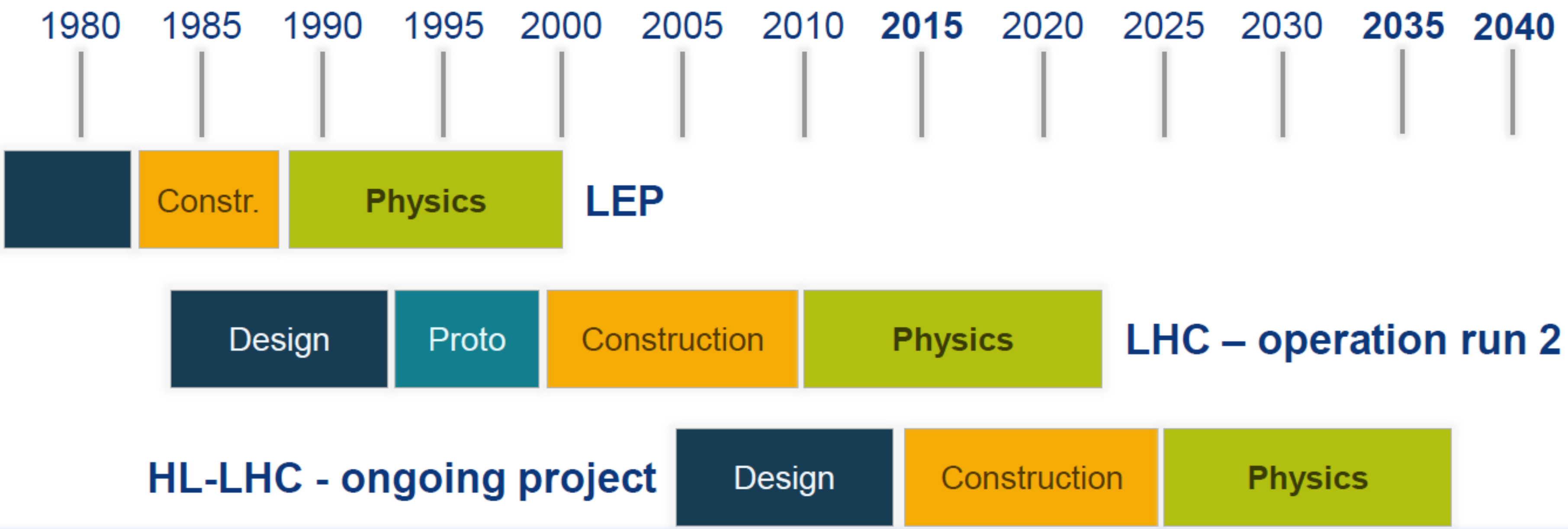
- **Full exploitation of the LHC**:
  - Successful Run 2, LS2, and Run 3 start-up.
  - Upgrade of LHC Injectors; on-track construction of HL-LHC.
- **Scientific diversity programme** serving a broad community:
  - ongoing experiments and facilities at Booster, PS, SPS and their upgrades.
  - participation 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)

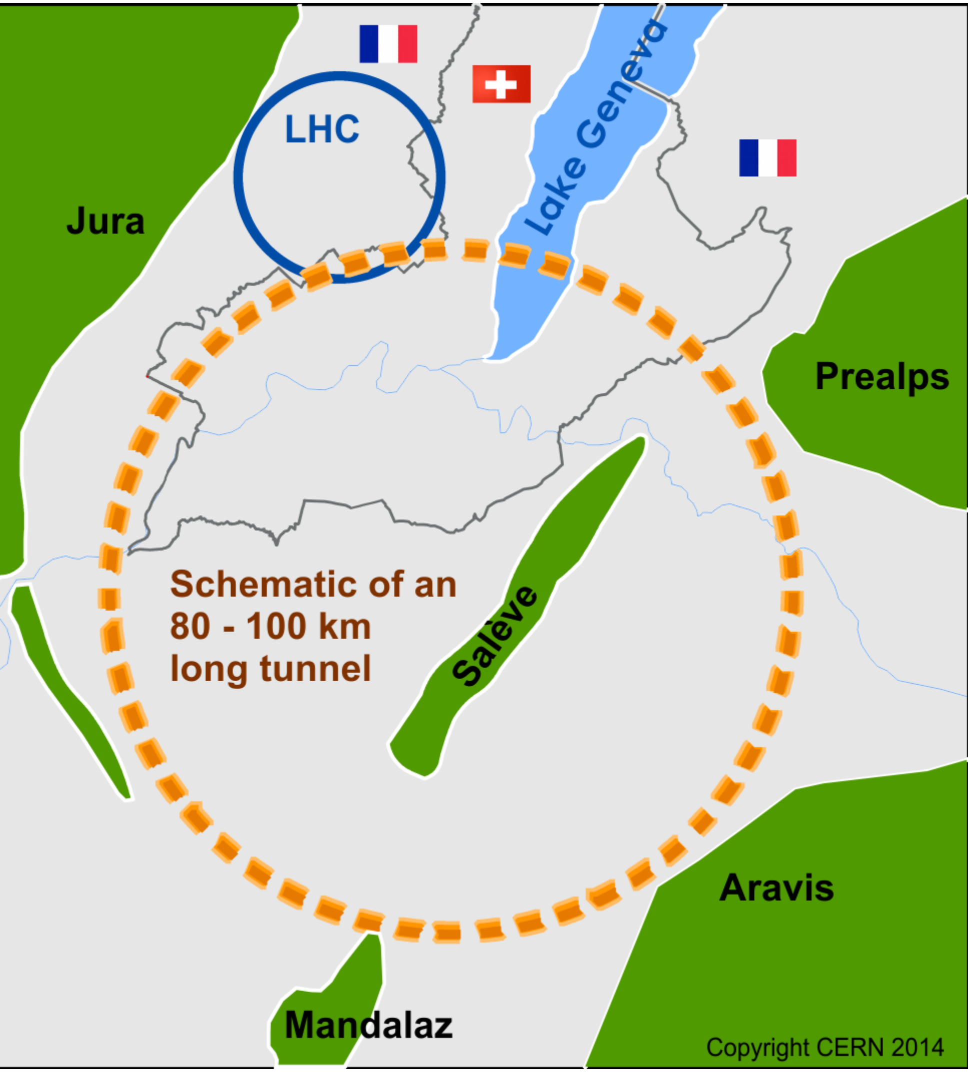


Future Circular Collider Study



Future Circular Collider Study

Goal: CDR For the European Strategy Update 2019



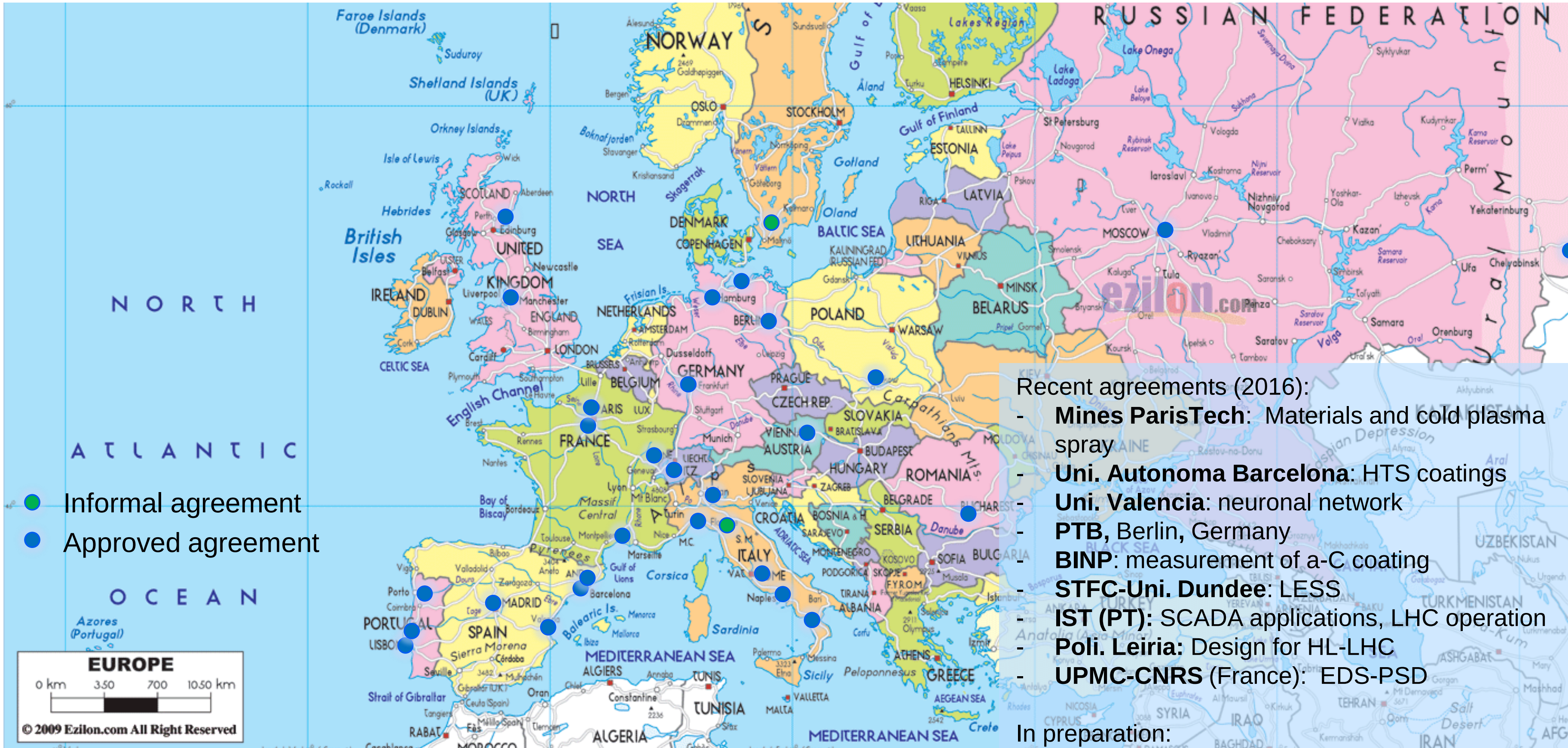
International FCC collaboration (CERN as host lab) to study:

- ***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):

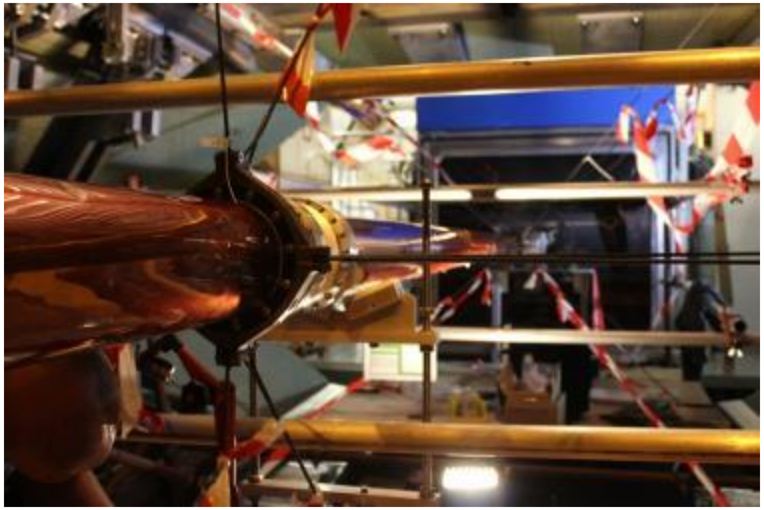
- **Mines ParisTech**: Materials and cold plasma spray
- **Uni. Autonoma Barcelona**: HTS coatings
- **Uni. Valencia**: neuronal network
- **PTB,** Berlin, Germany
- **BINP**: measurement of a-C coating
- **STFC-Uni. Dundee**: LESS
- **IST (PT):** SCADA applications, LHC operation
- **Poli. Leiria:**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

In preparation:

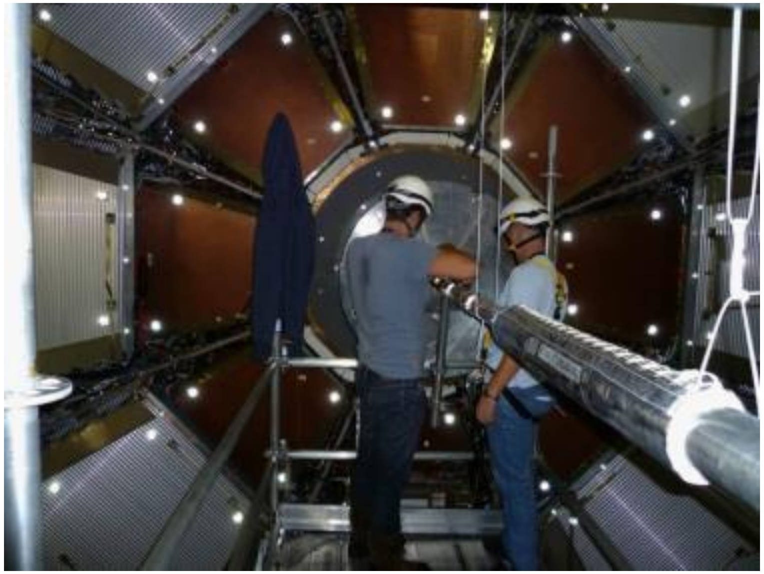
- **INFN Frascati**: beamline for synchrotron radiation studies
- **Max-Planck-Institute + EPFL** : Helicon plasma cell

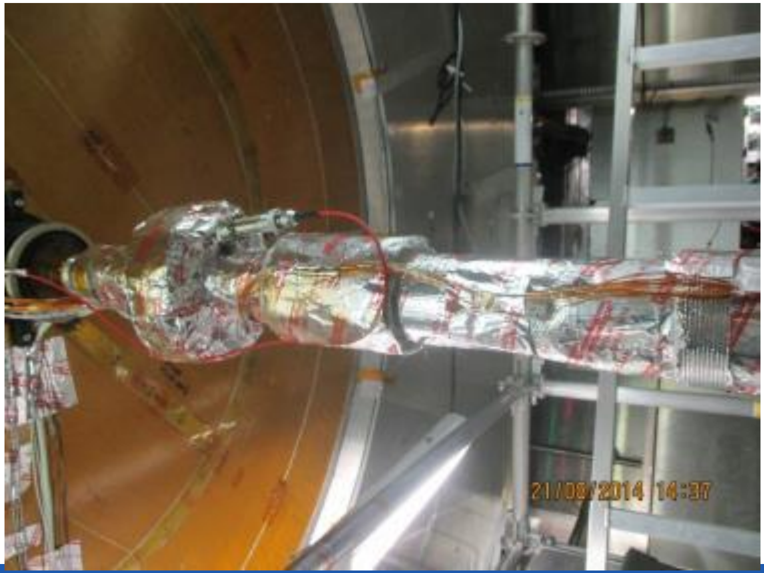
- Argonne National Laboratories
- University of Florida
- LNLS, Campinas, São Paolo
- KEK, Photon Factory, Tsukuba

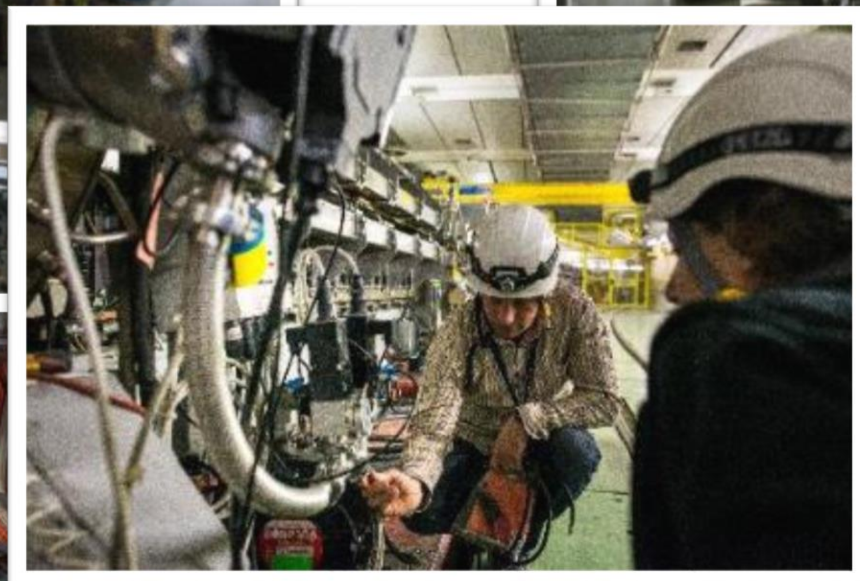
Examples of installation

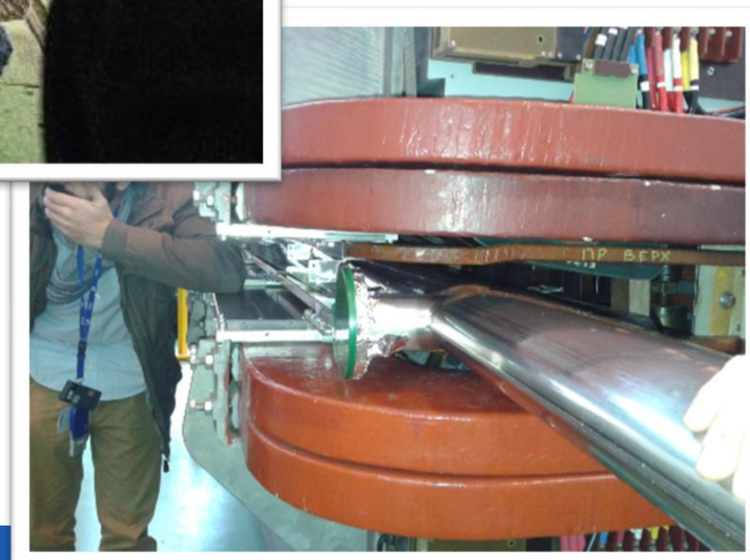


Examples of installation








ПР ВЕРХ

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.