Where Science meets Engineering:
The lifecyle of the CERN's accelerator complex

Jean-Philippe TOCK / EN-HDO
LS3 Programme Coordinator
Engineering Department Deputy Head
2026-10-29

Reference EDMS: 3538995

Not my first visit …

Visit to MTA ATOMKI –Debrecen
Institute for Nuclear Research, Hungarian Academy of Sciences
CERN General introduction

Outline

1. CERN in general
2. The magnet group (TE-MSC)
3. The LHC : present and future (HighLumi)
4. A flavour of the post LHC era

17th of March 2016

J.Ph. Tock, TE-MSC

Report of Activities

done at CERN

by Daniel Turi (MTA Atomki)

from 2016-11-01 to 2018-10-31

according to

Addendum No.1, KE3257/TE

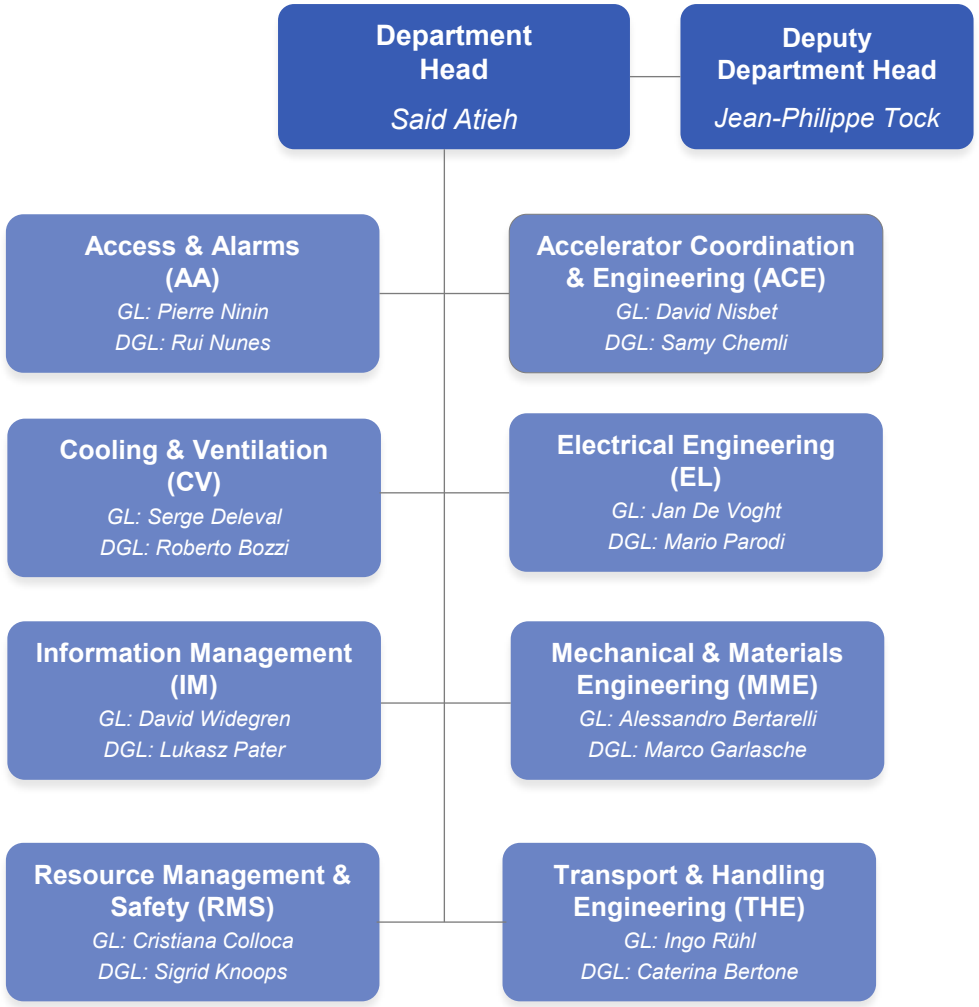
of

Framework Collaboration Agreement, KN3137

Outline

- The CERN Engineering Department
- The CERN Accelerator Complex lifecycle
- The 3rd Long Shutdown of the CERN Acc. Complex (LS3)
- Some LS3 projects
- What after the LHC era ?

The CERN Engineering Department



Department Head
Said ATIEH

Deputy Department Head
Jean-Philippe Tock

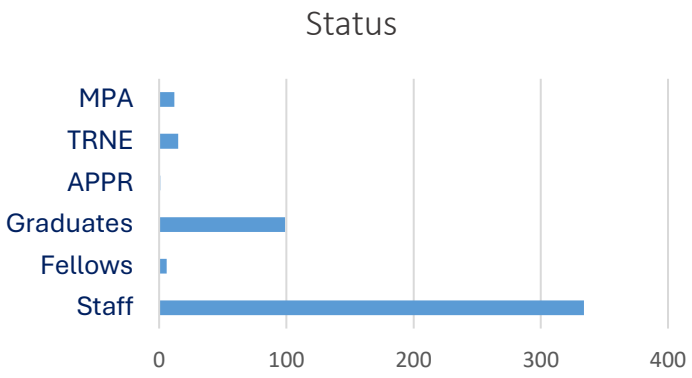
The Engineering Department is responsible for:

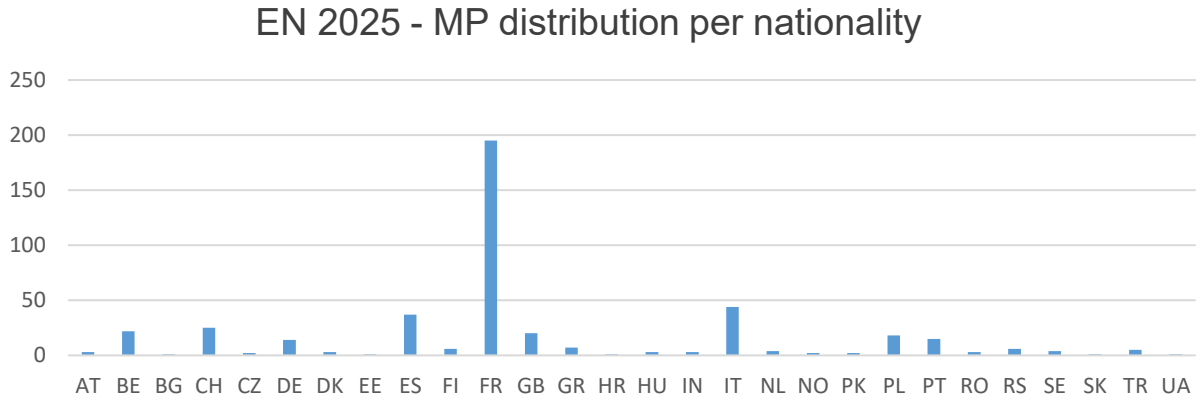
- Operation
  - Infrastructure
  - Accelerators
- Projects
  - Consolidation
  - Upgrades
  - New facilities
  - Design & Manufacturing
- Studies

https://en.web.cern.ch/

The CERN Engineering Department

467
Members of Personnel



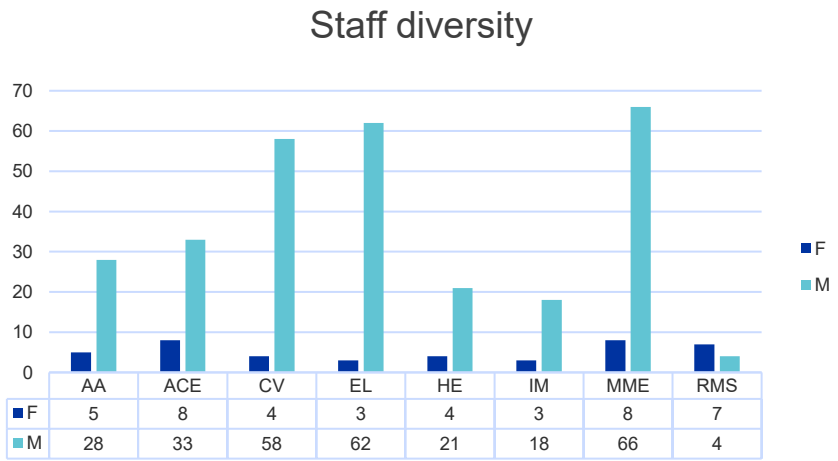


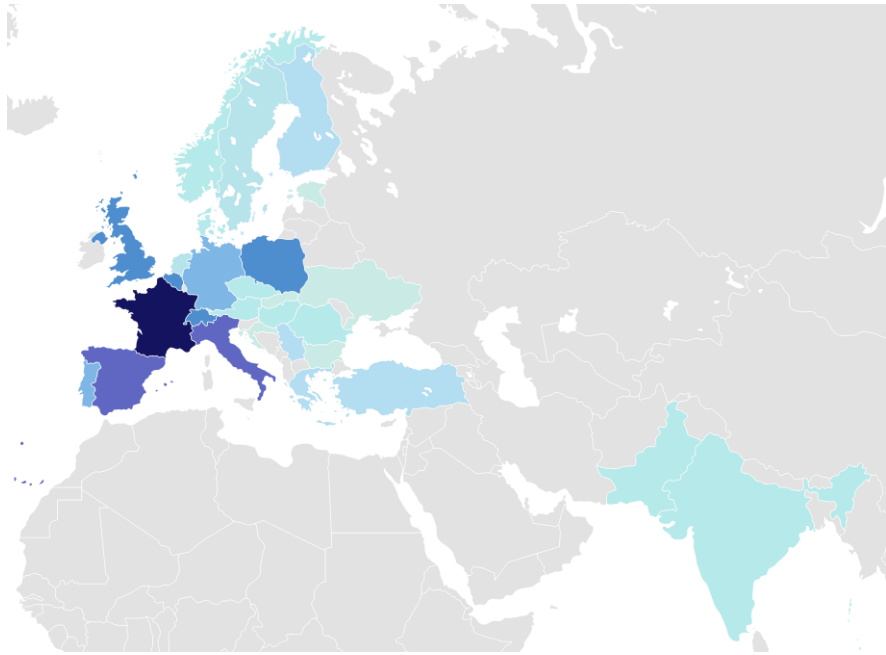
PROFESSIONAL CATEGORIES

17 (4%) OFFICE & ADMINISTRATIVE FIELD

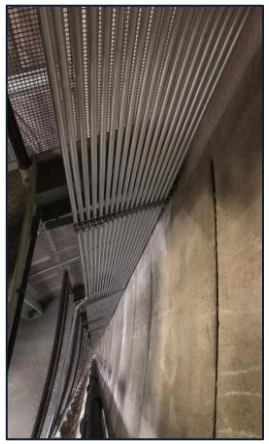
206 (44%) TECHNICAL FIELD

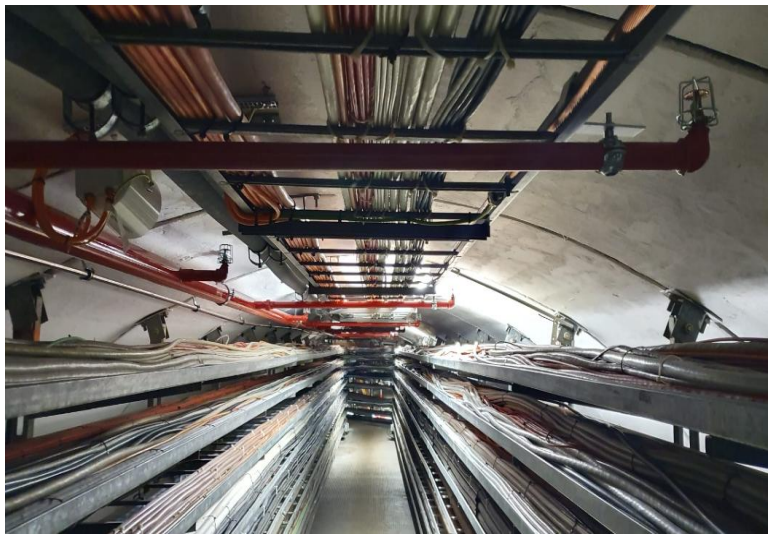
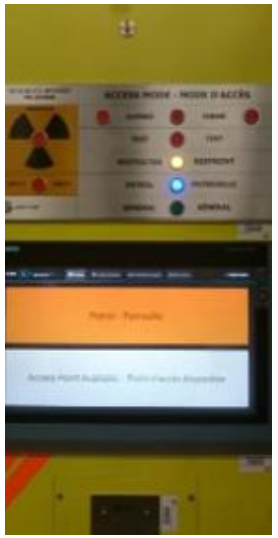
244 (52%) SCIENTIFIC & ENGINEERING FIELD





The Eng. Dpt.: Access & Alarms (AA)



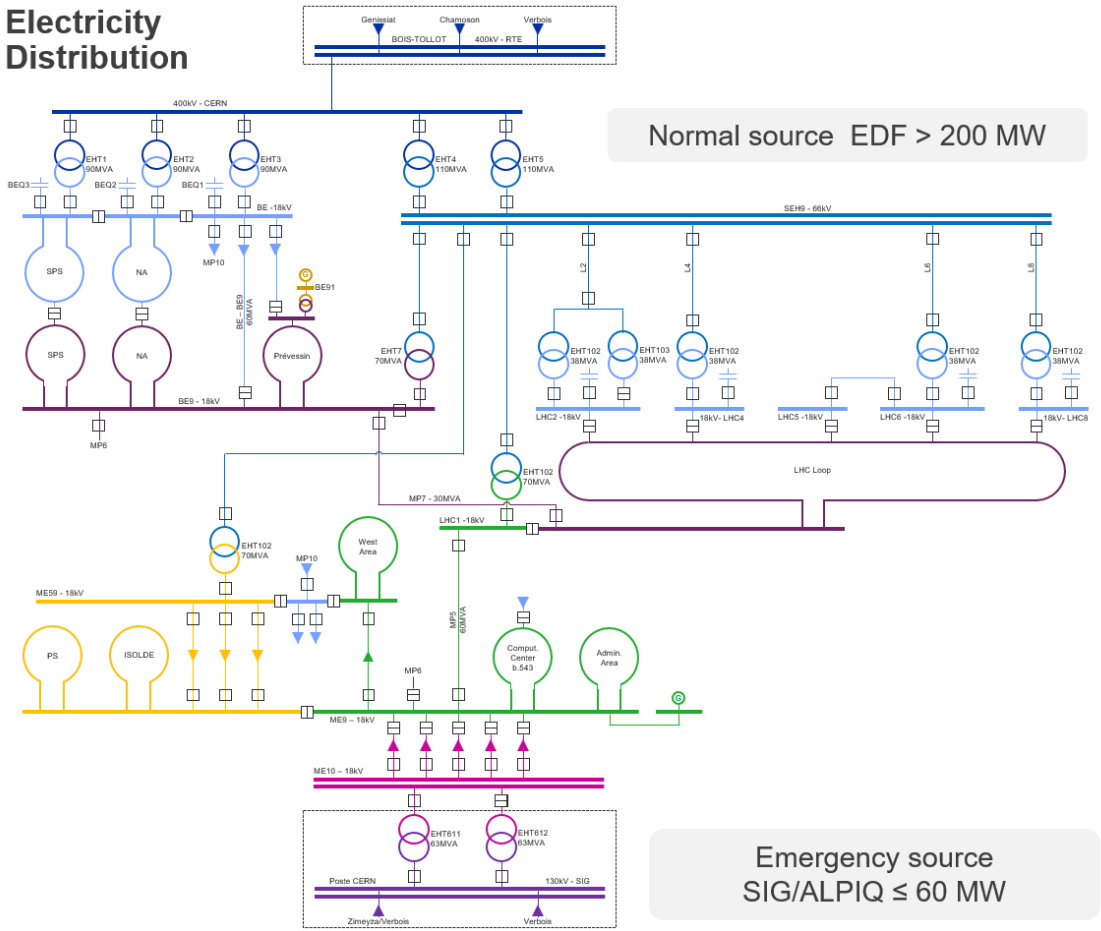
Systems that ensure the safety of the CERN Personnel, Users and visitors

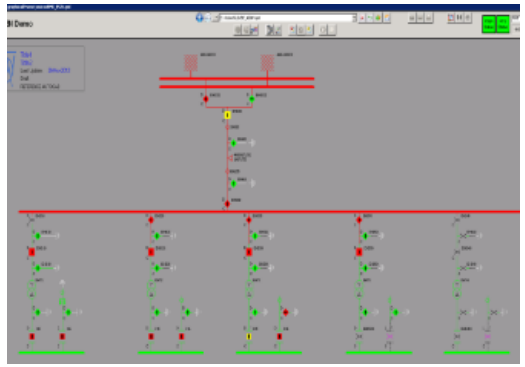
- Fire and Gas/ODH detection
- Emergency phones
- Evacuation
- Alarms
- Interlocks
- Access control
- Video surveillance, protection and intrusion
- …

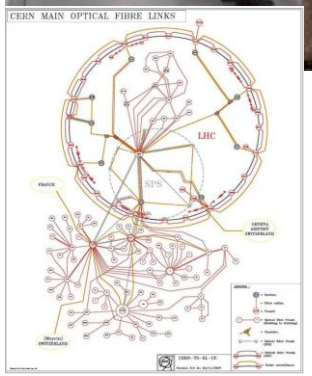
The Eng. Dpt.: Cooling & Ventilation (CV)

- 150 Cooling plants
- 800 km pipelines
- 800 hydrants points
- 24 Cooling towers (450 MW)
- 35 Chilled water plants (73 MW)
- Water network
  - 7 398 m^3/h
  - 2 800 000 m^3 annual consumption
- HVAC
  - > 1 500 untis
  - 2 000 to 120 000 m^3/h each
- Compressed air
  - 14 stations
  - 200 km network

The Eng. Dpt.: Electrical Engineering (EL)







- 400 kV to 400/230 V
- 1.3 TWh annual consumption
- Cabling activities

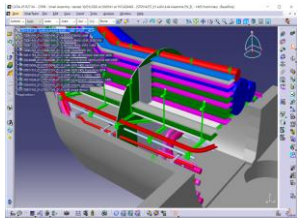
The Eng. Dpt.: Transport & Handling Eng. (THE)

- Logistics
- Design
- Feasibility studies
- Integration

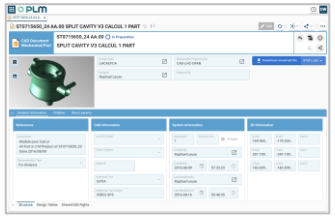
- 132 Lifts
  Personnel & goods
- 6 000 assets
- 700 surface buildings

The Eng. Dpt.: Information Management (IM)

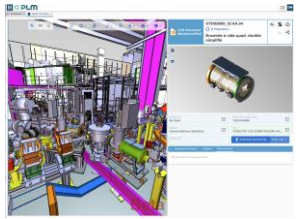
CAD
Mechanical 3D CAD



PLM
Product Lifecycle Management

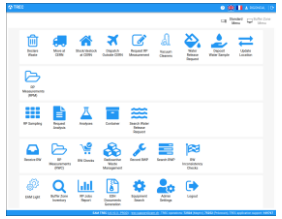


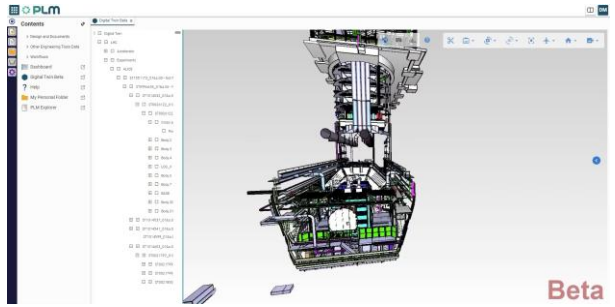
3D Digital Twins
Navigation / Visualization of Product Data



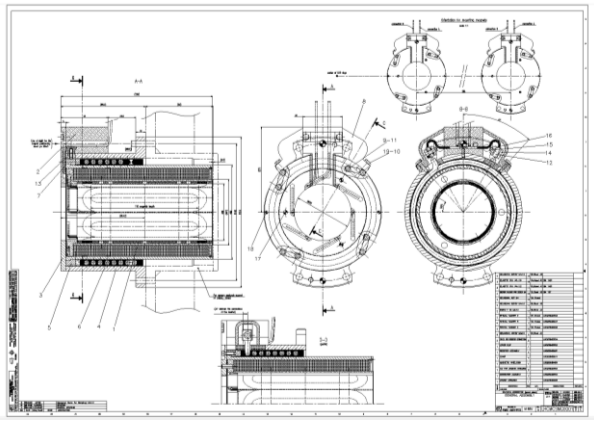
Track It
Activity Coordination

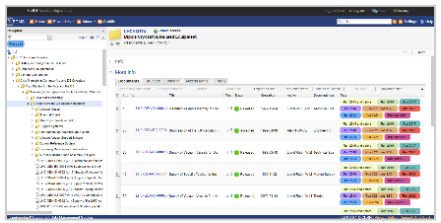
TREC
Radioactive Traceability





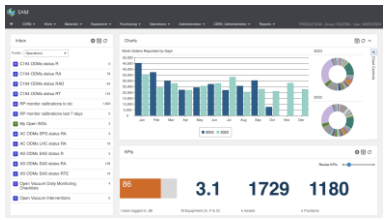
Specification & Requirements → Design → Manufacturing → Installation & Commissioning → Operation & Maintenance → Dismantling & Waste management





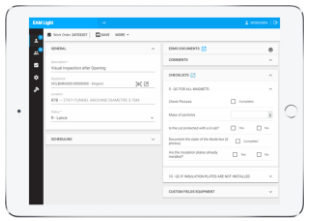
EDMS
Engineering Document Management

IMPACT
Work Permit Management

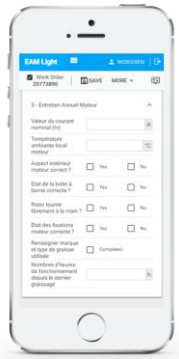


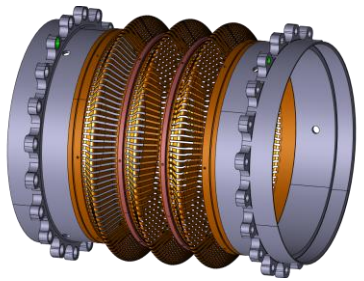
EAM
Enterprise Asset Management

EAM Store Kiosk
Spare Part Management



EAM Light
Simplified / Mobile EAM Interface





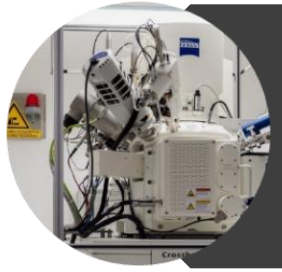
The Eng. Dpt.: Mechanical and Materials Eng. (MME)

DESIGN

- **Design Office** 50+ designers – CATIA v5, PLM, ISO-GPS standards
- **Engineering Unit** 20+ engineers – Ansys, LS-Dyna, COMSOL, Autodyn
- **Mechanical Measurements Laboratory** 10 engineers & technicians – Physical, mechanical, seismic measures. Digital Twins

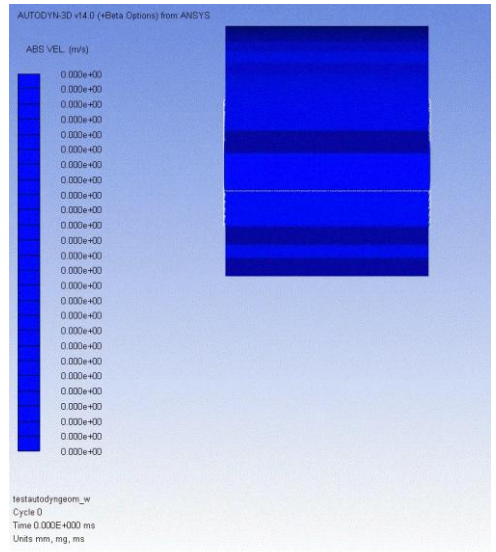
FABRICATION

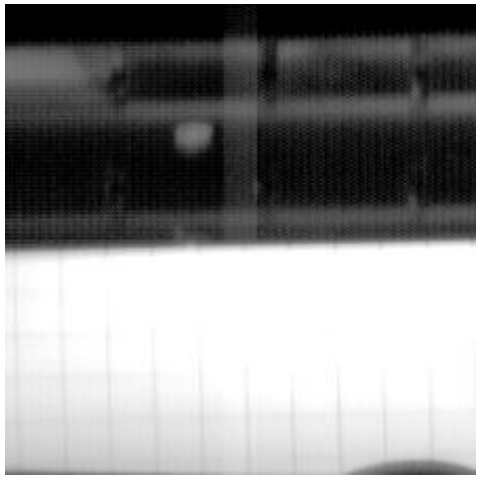
- **Mechanical workshop** 70+ technicians and 20+ engineers
  - CNC machining, Metal AM, Assembly & Metal forming
  - Welding (TIG, MIG, EBW, Laser), Vacuum Brazing
- **Technical Subcontracting unit**



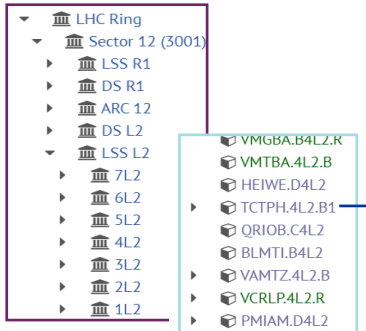
MATERIALS

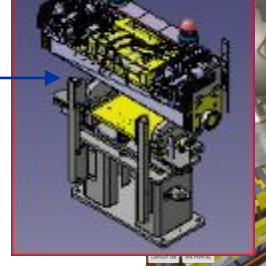
- **Materials science consultancy** 20+ Scientists/Engineers
  - Materialography, Microscopy, Diffraction, Mechanical testing)
  - NDT (UT, PT, Industrilal R-X, microtomography)
- **Dimensional Metrology** CMMs, CT, Portable devices

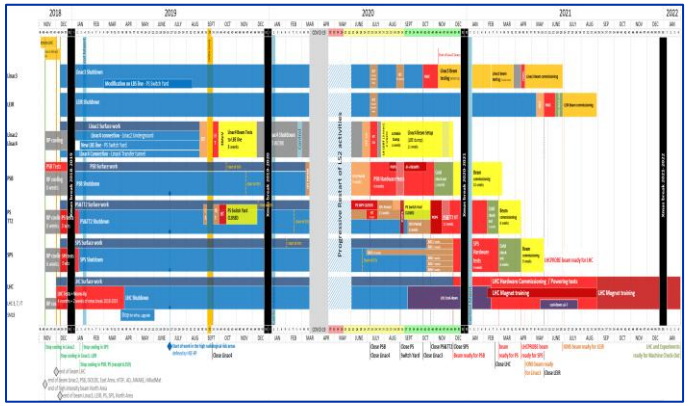


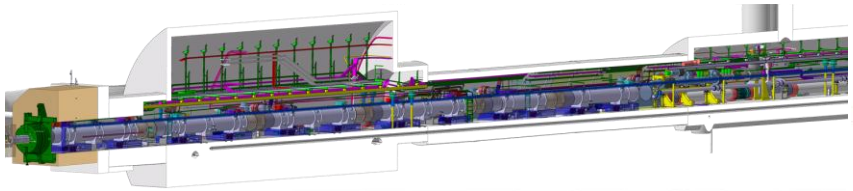


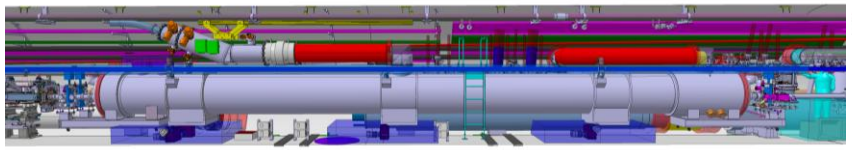
The Eng. Dpt.: Accelerator Coordination & Eng. (ACE)

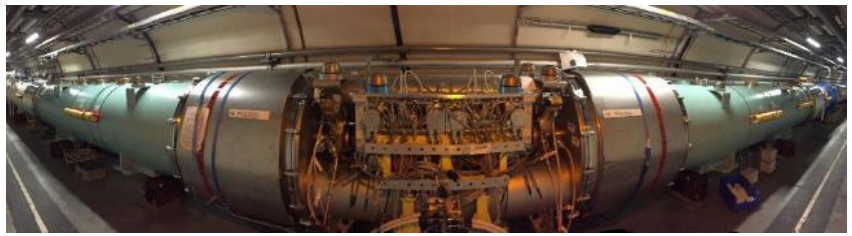


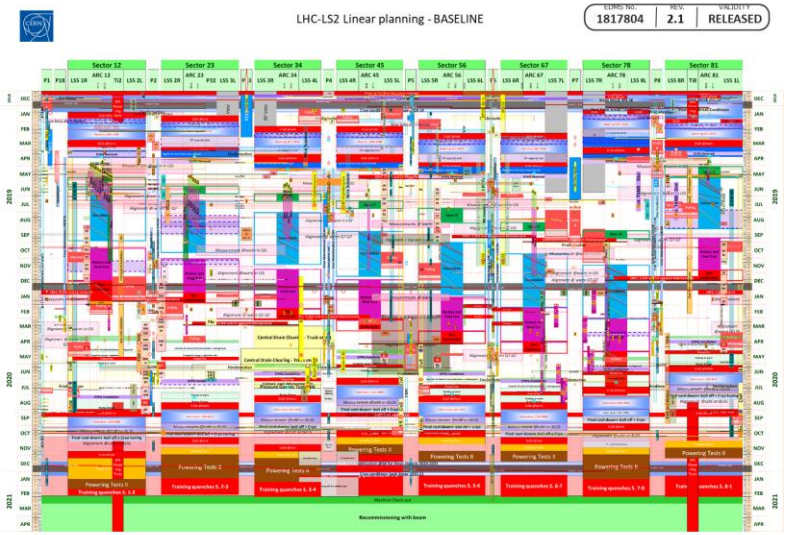






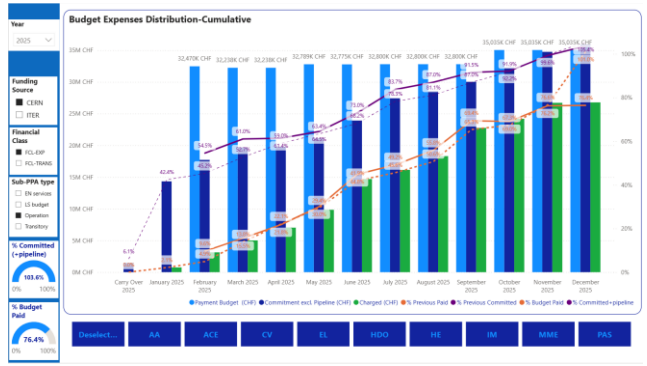


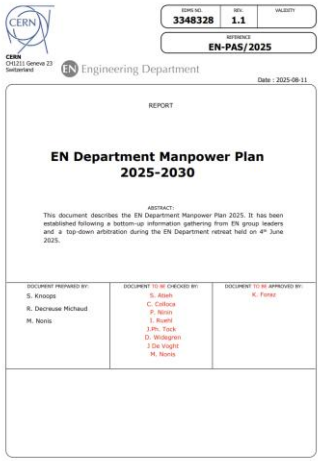


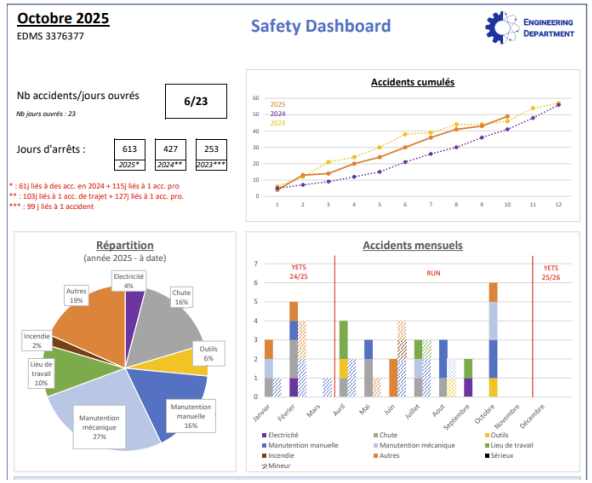


The Eng. Dpt.: Resources Management & Safety(RMS)

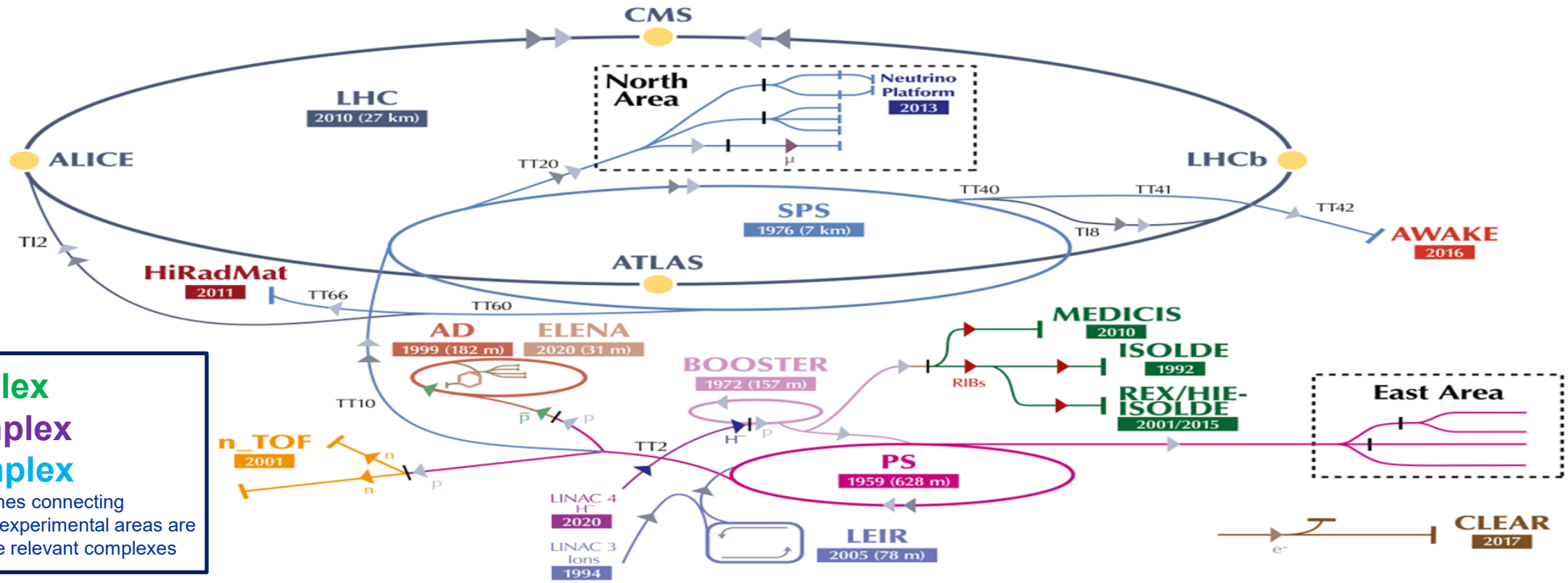
- Administration
- Budget
- People
- Quality
- Safety
- Special Projects







The CERN Accelerator Complex lifecycle



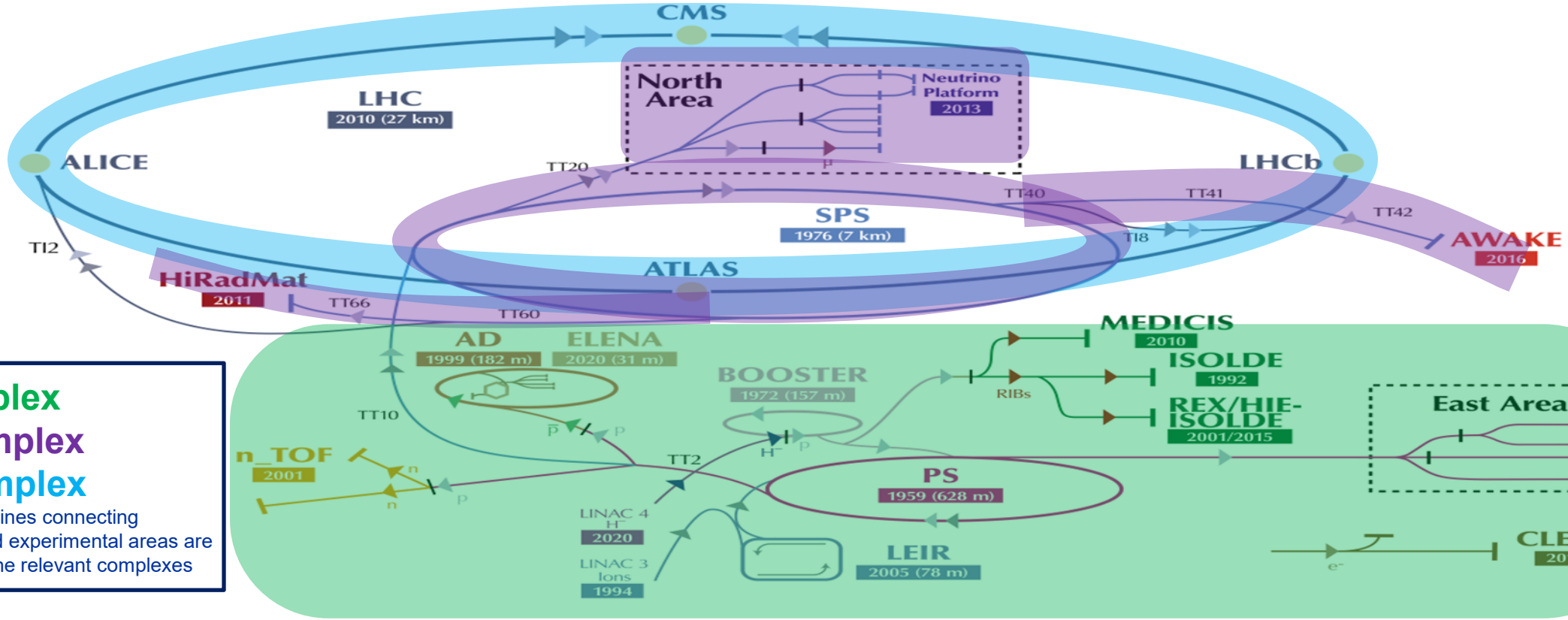
PS complex
SPS complex
LHC complex

(*) The transfer lines connecting accelerators and experimental areas are integrated into the relevant complexes

▶ H⁻ (hydrogen anions) ▶ p (protons) ▶ ions ▶ RIBs (Radioactive Ion Beams) ▶ n (neutrons) ▶ $\bar{p}$ (antiprotons) ▶ e⁻ (electrons) ▶ μ (muons)

LHC - Large Hadron Collider // SPS - Super Proton Synchrotron // PS - Proton Synchrotron // AD - Antiproton Decelerator // CLEAR - CERN Linear Electron Accelerator for Research // AWAKE - Advanced WAKefield Experiment // ISOLDE - Isotope Separator OnLine // REX/HIE-ISOLDE - Radioactive EXperiment/High Intensity and Energy ISOLDE // MEDICIS // LEIR - Low Energy Ion Ring // LINAC - LINear ACcelerator // n_TOF - Neutrons Time Of Flight // HiRadMat - High-Radiation to Materials // Neutrino Platform

The CERN Accelerator Complex lifecycle



PS complex
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The CERN Accelerator Complex lifecycle

Movie : CERN Accelerator complex cut

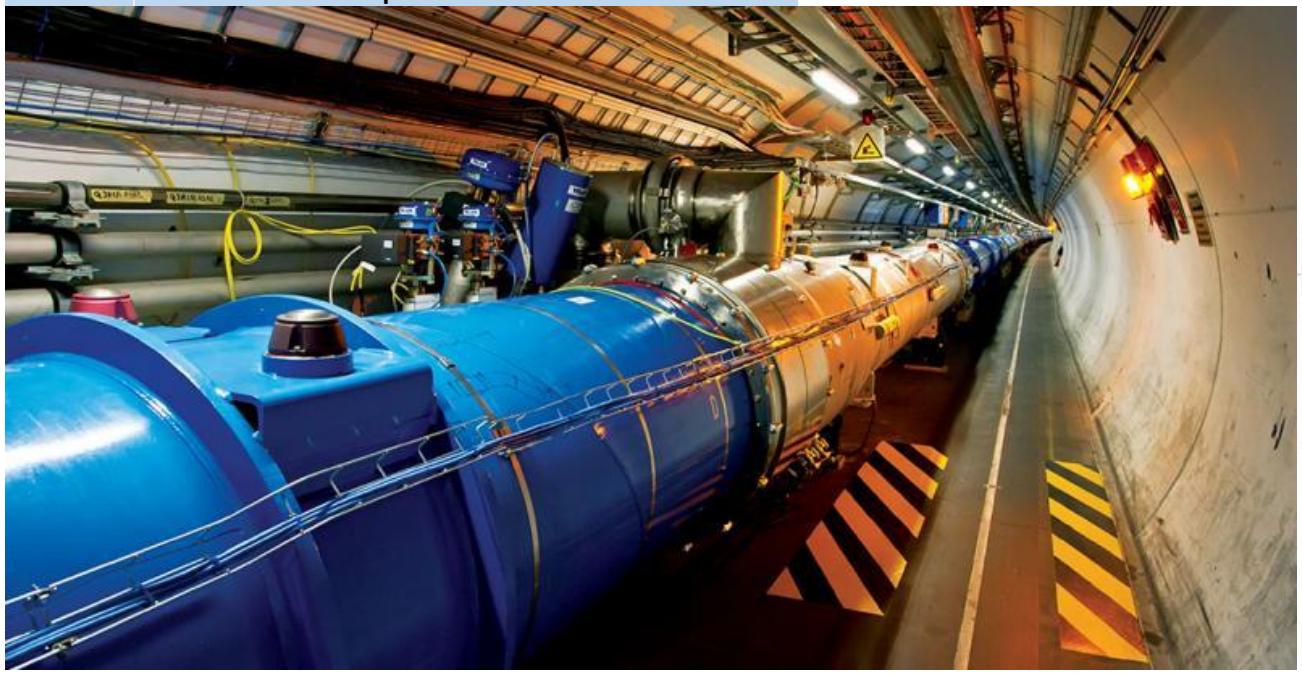
The CERN Accelerator Complex lifecycle

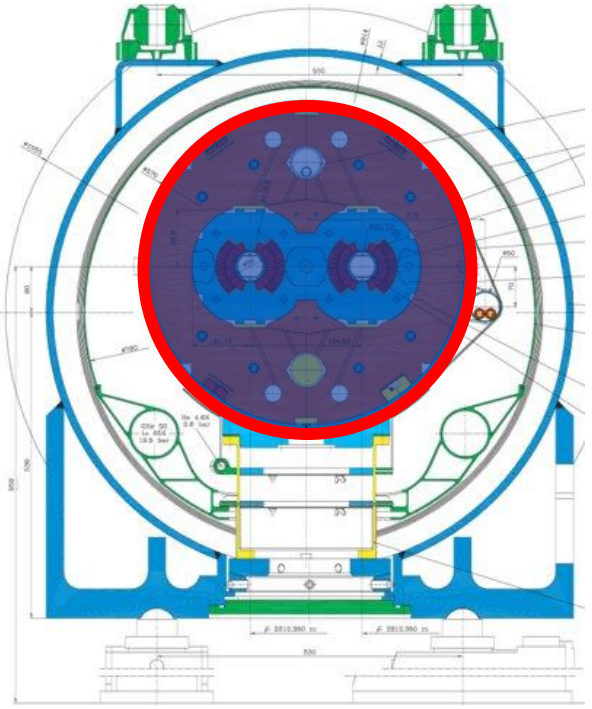
The LHC superconducting magnets

#	Description
1232	Main Bending dipoles
392	Main Lattice quadrupoles
18	Separation/Recombination Dipoles
142	Insertion Quadrupoles
1044	Dipole Correctors
512	Quadrupole Correctors
3232	Sextupole Correctors

> 1 700 main superconducting magnets

- 36 000 tonnes of cold mass to cool down to 1.9 (4.5) K. (-271 °C)



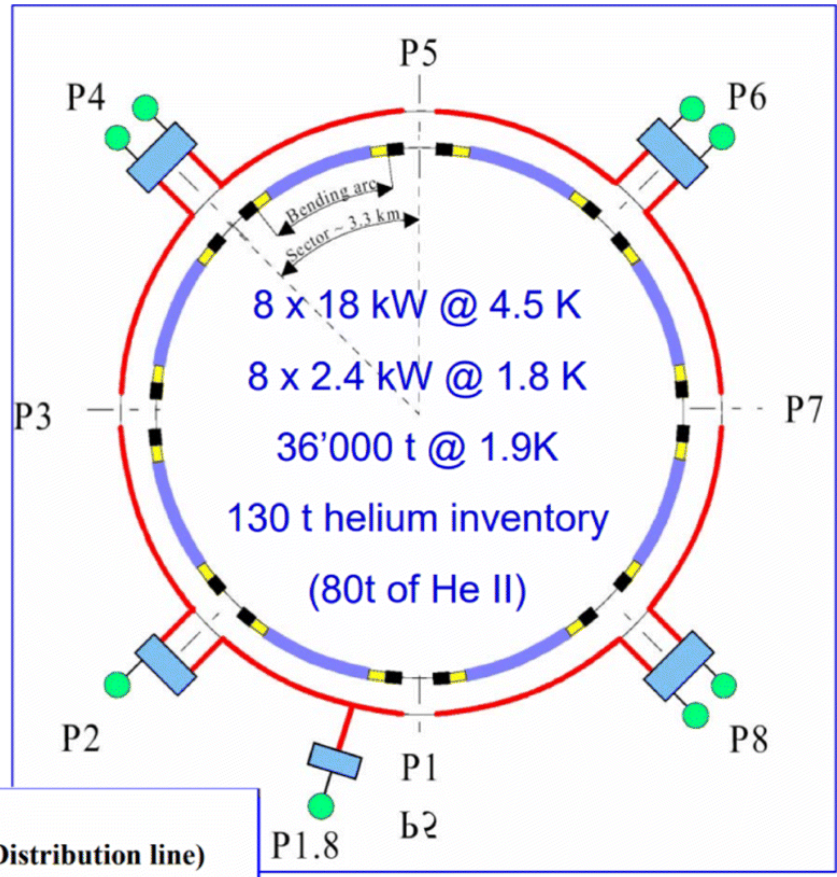


64 AIRBUS A380

https://www.airbus.com/

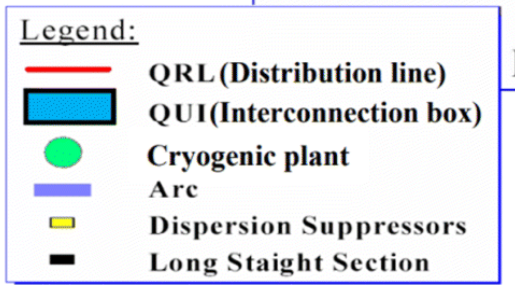
The CERN Accelerator Complex lifecycle

The LHC cryogenic system



- LHC is divided in 8 sectors
- Major overhaul after 40 000 hours of operation, ≈ 5 years is possible while maintaining the LHC at cryogenics temperature during long shutdowns (*) - *Never used so far during long shutdowns*

(*) Same applies to LHC experiments



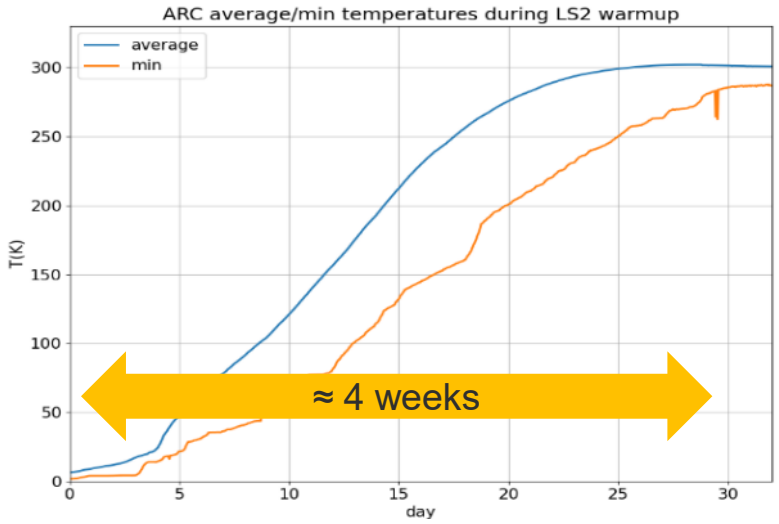
The CERN Accelerator Complex lifecycle

The LHC cool-down and warm-up cycles

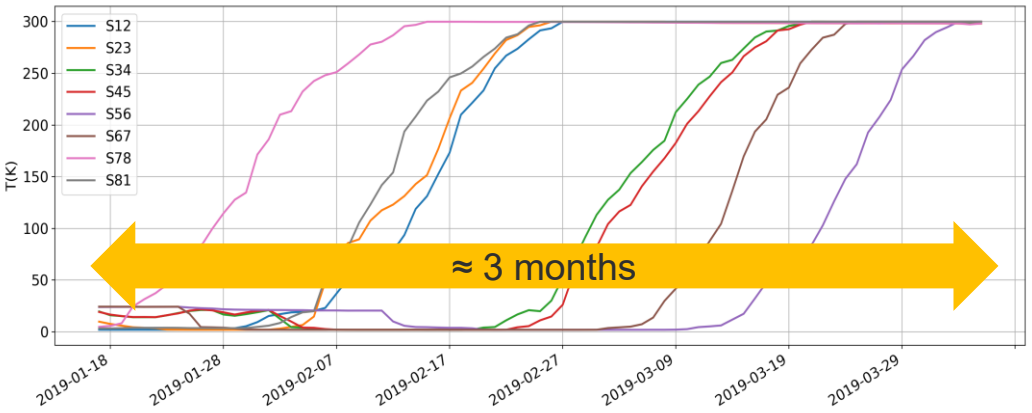
Warm-up
- ≈ 4 weeks per sector
- ≈ 3 months for the LHC

Cool-down
- ≈ 7 weeks per sector
- ≈ 5 months for the LHC

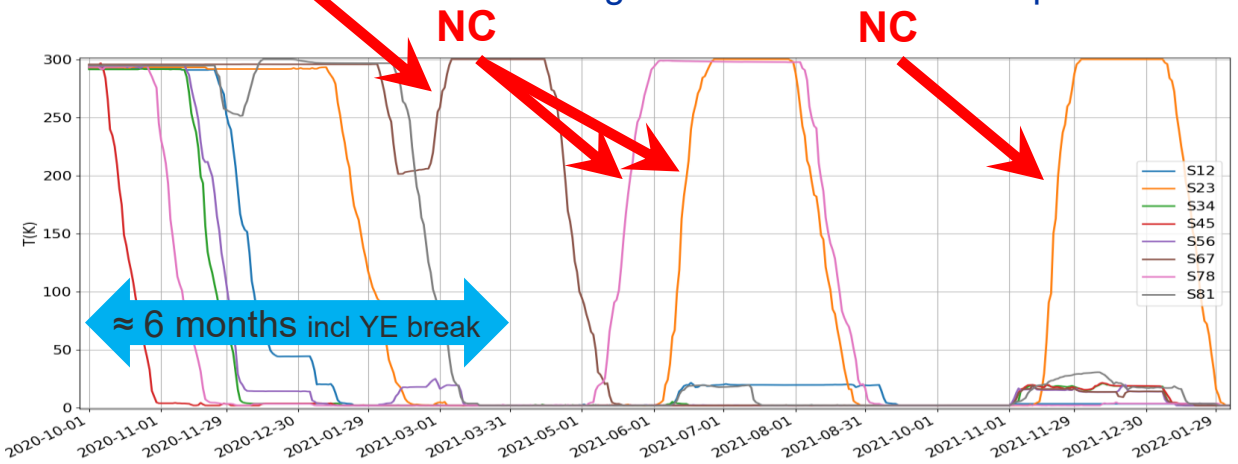
! Nonconformities (NC) identified during cool-down or at cold → thermal cycles to solve them !



LS2 « average sector » actual warm-up



LS2 actual warm-up

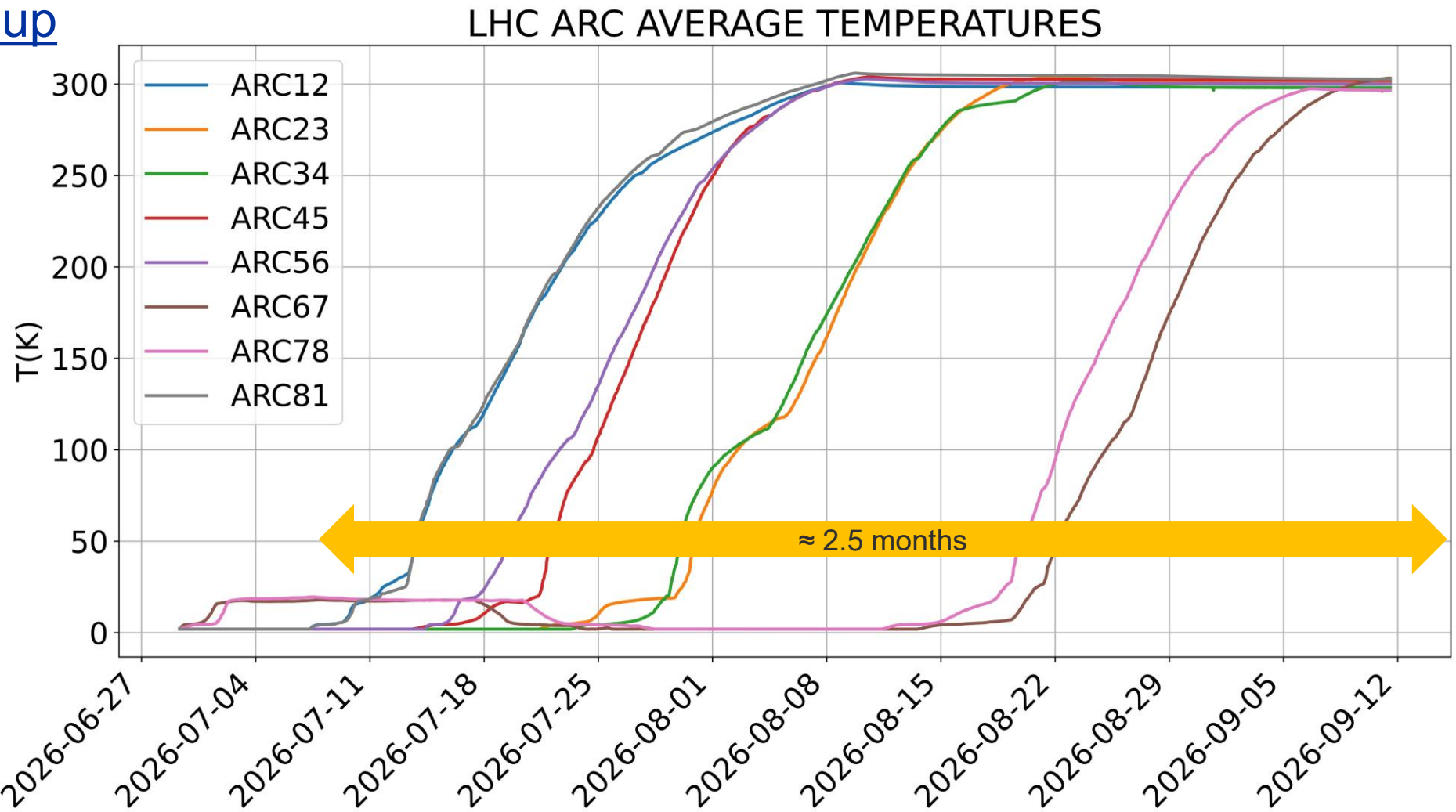


LS2 actual (re)cool-down

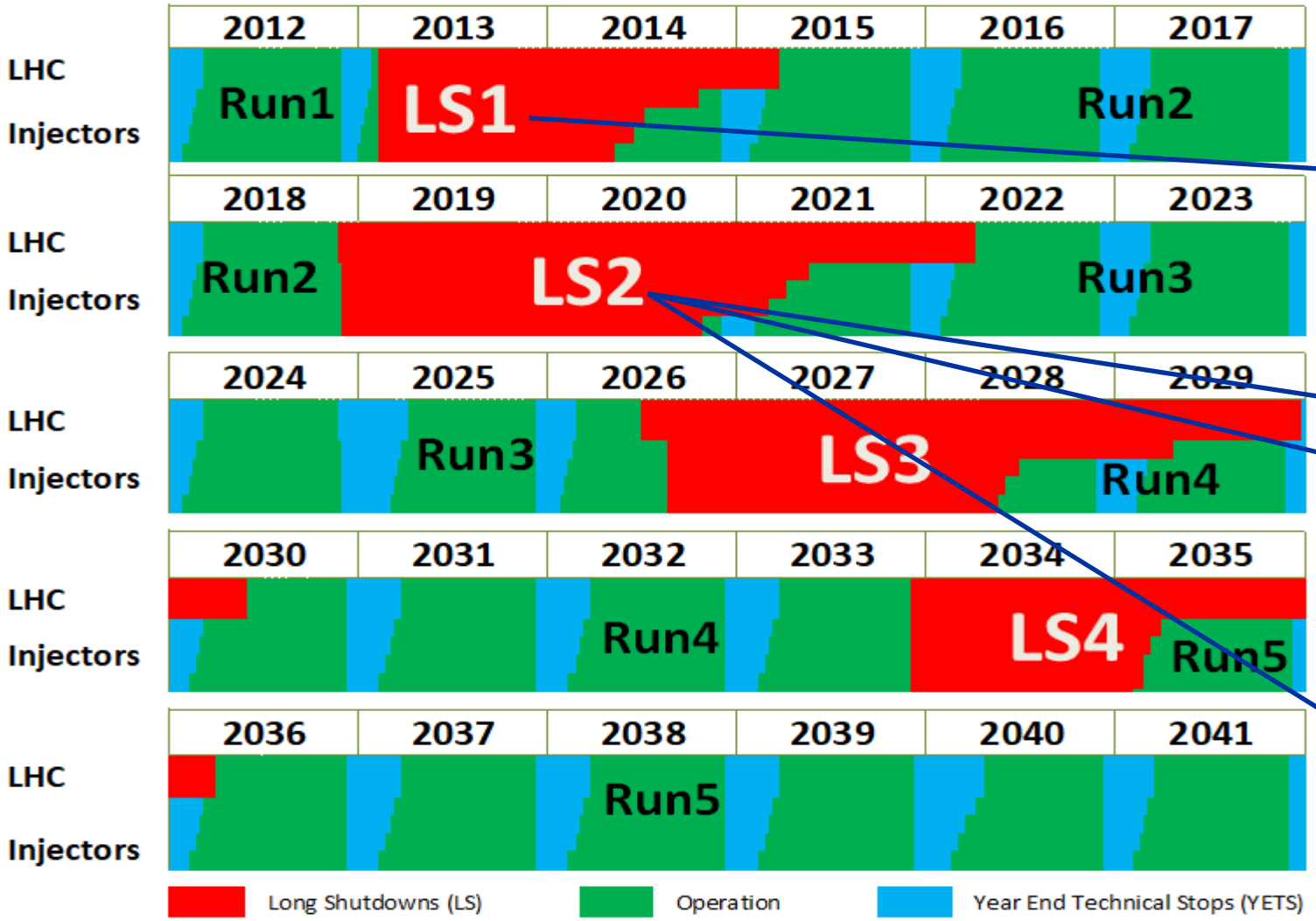
► Large interventions requiring warm-up are grouped in long shutdowns.

The CERN Accelerator Complex lifecycle

The LS3 LHC warmup



The CERN Accelerator Complex lifecycle

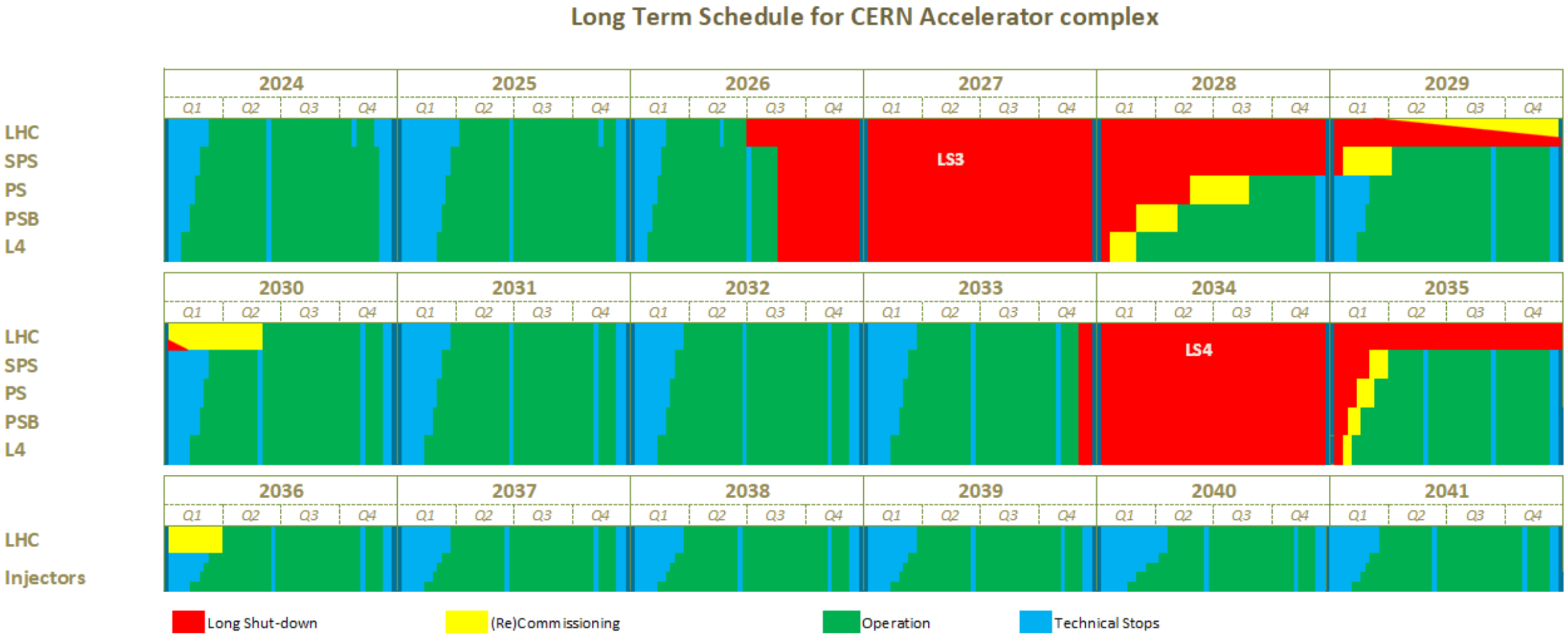


Simplified CERN long-term schedule

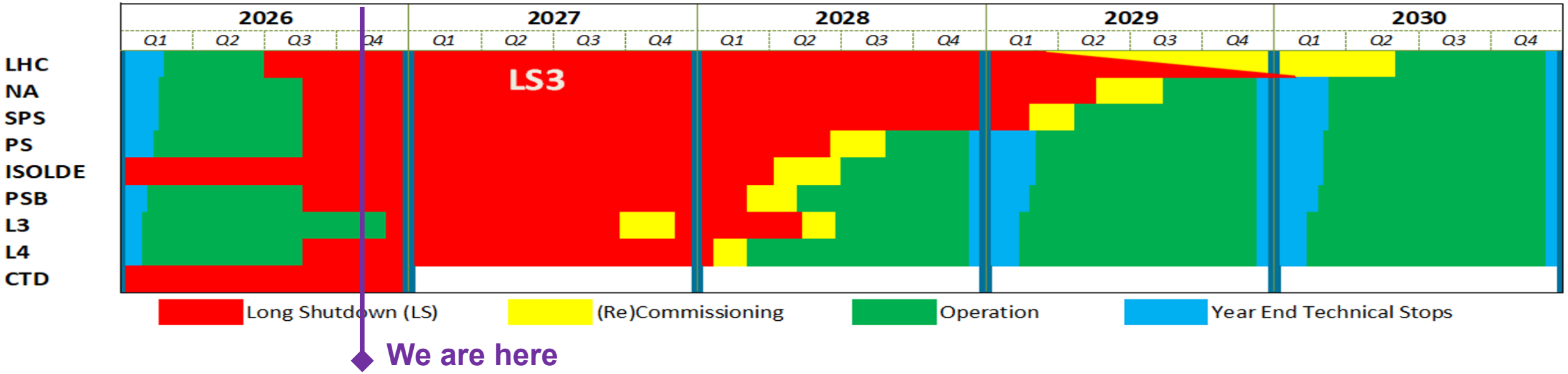
LHC Injectors Upgrade

New service tunnels for the high-luminosity LHC being excavated at Point 5 in July 2019. Credit: Z. Arenas

The CERN Accelerator Complex lifecycle



The third Long Shutdown (LS3) period



LS3 start

- CTD: 02.06.2025 ✓
- ISOLDE: 08.12.2025 ✓
- LHC: 29.06.2026 ✓
- Injectors: 31.08.2026 ✓
- L3: 30.11.2026

Injectors Operation restart

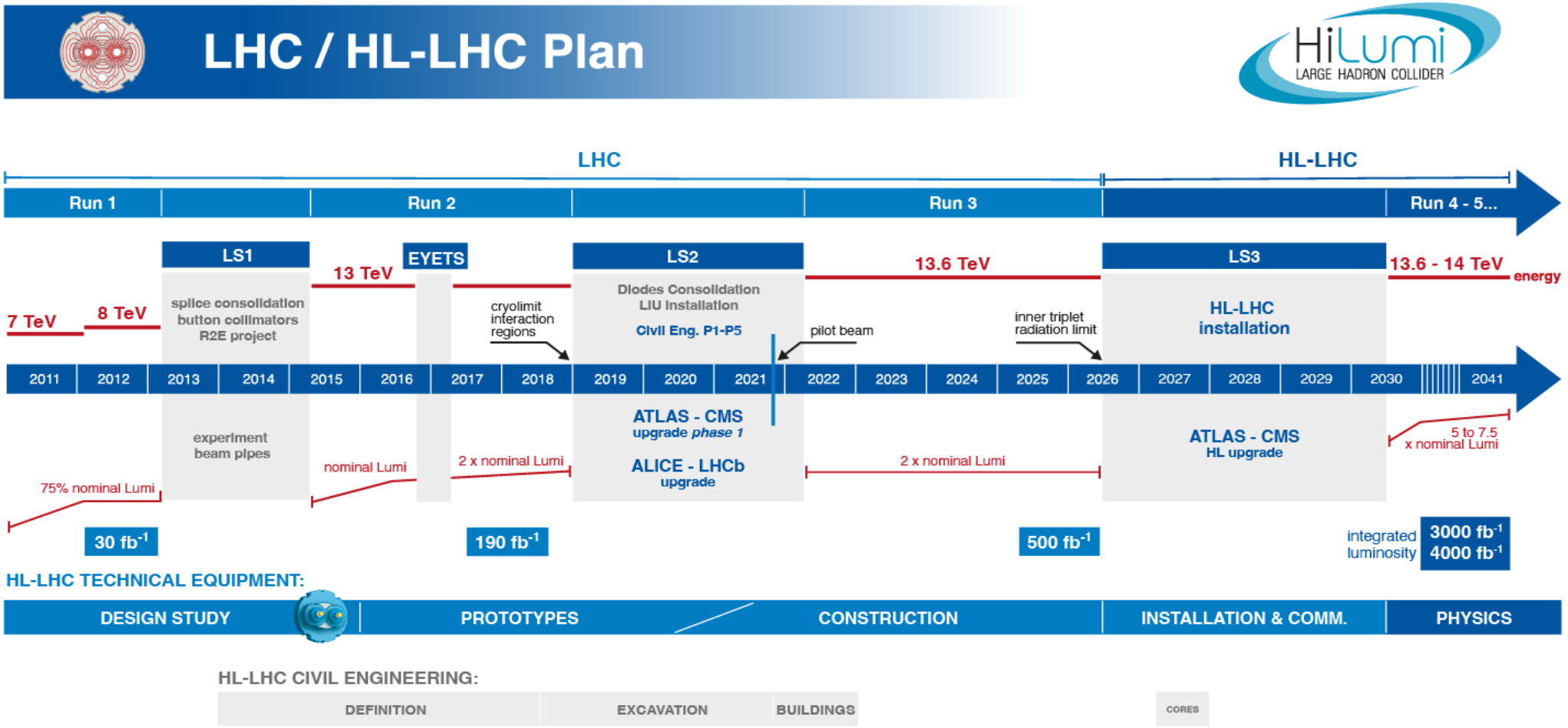
- L4: March 2028
- PSB: May 2028
- PS: Aug 2028
- SPS: April/May 2029

LHC restart

- 1st sectors cooldown: Early 2029
- Final HW Com (P1&5): January 2030
- Caverns closure: Mid May 2030
- Beam valves opening: End May 2030

NA stands for North Area, CTD for CNGS Target area Dismantling

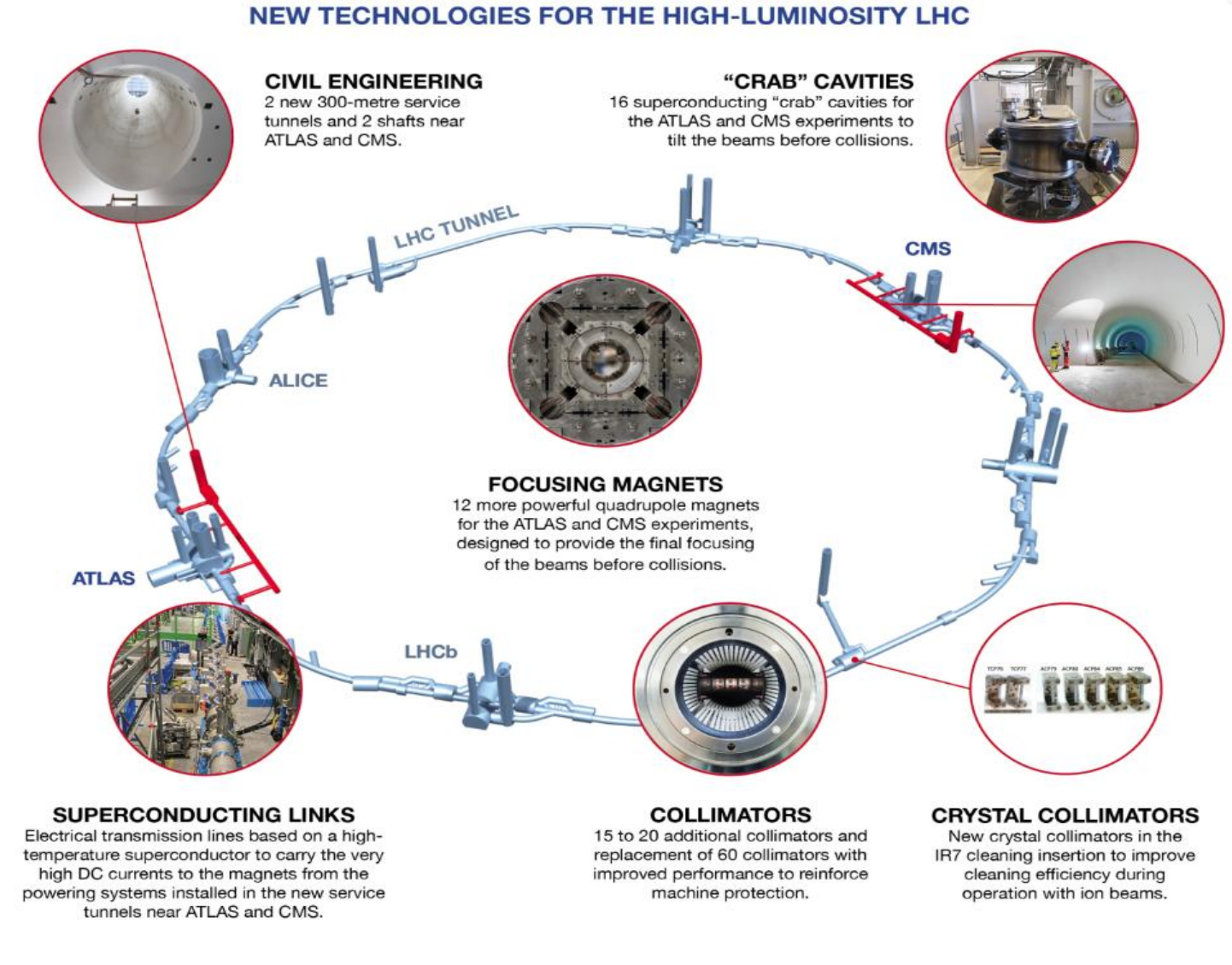
The third Long Shutdown (LS3) trigger:

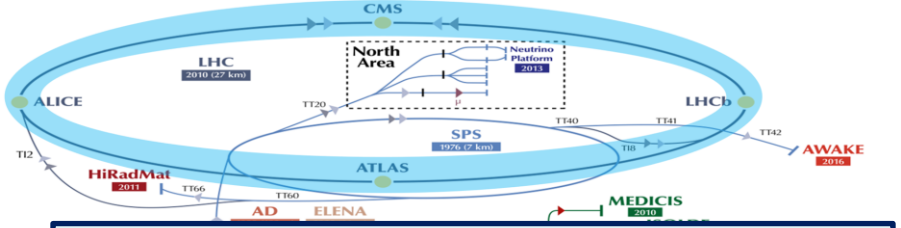


The LHC is depending on the injectors. Large interventions are also planned in the injectors complex during LHC shutdown to globally optimise the operation time

https://hilumilhc.web.cern.ch/content/hl-lhc-project

The third Long Shutdown (LS3)



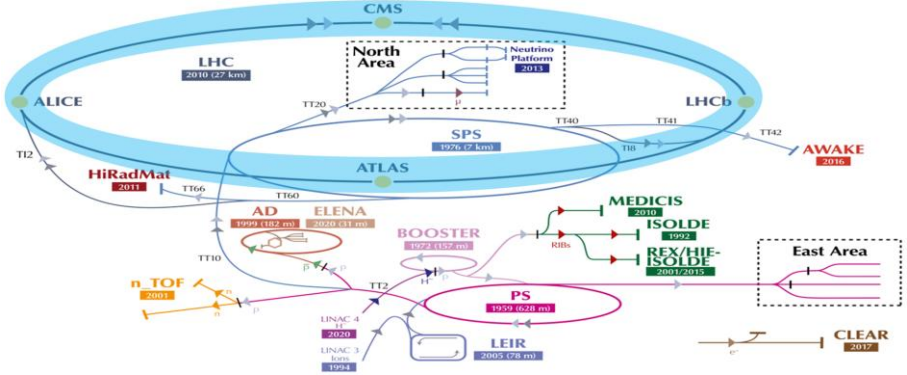


HL-LHC

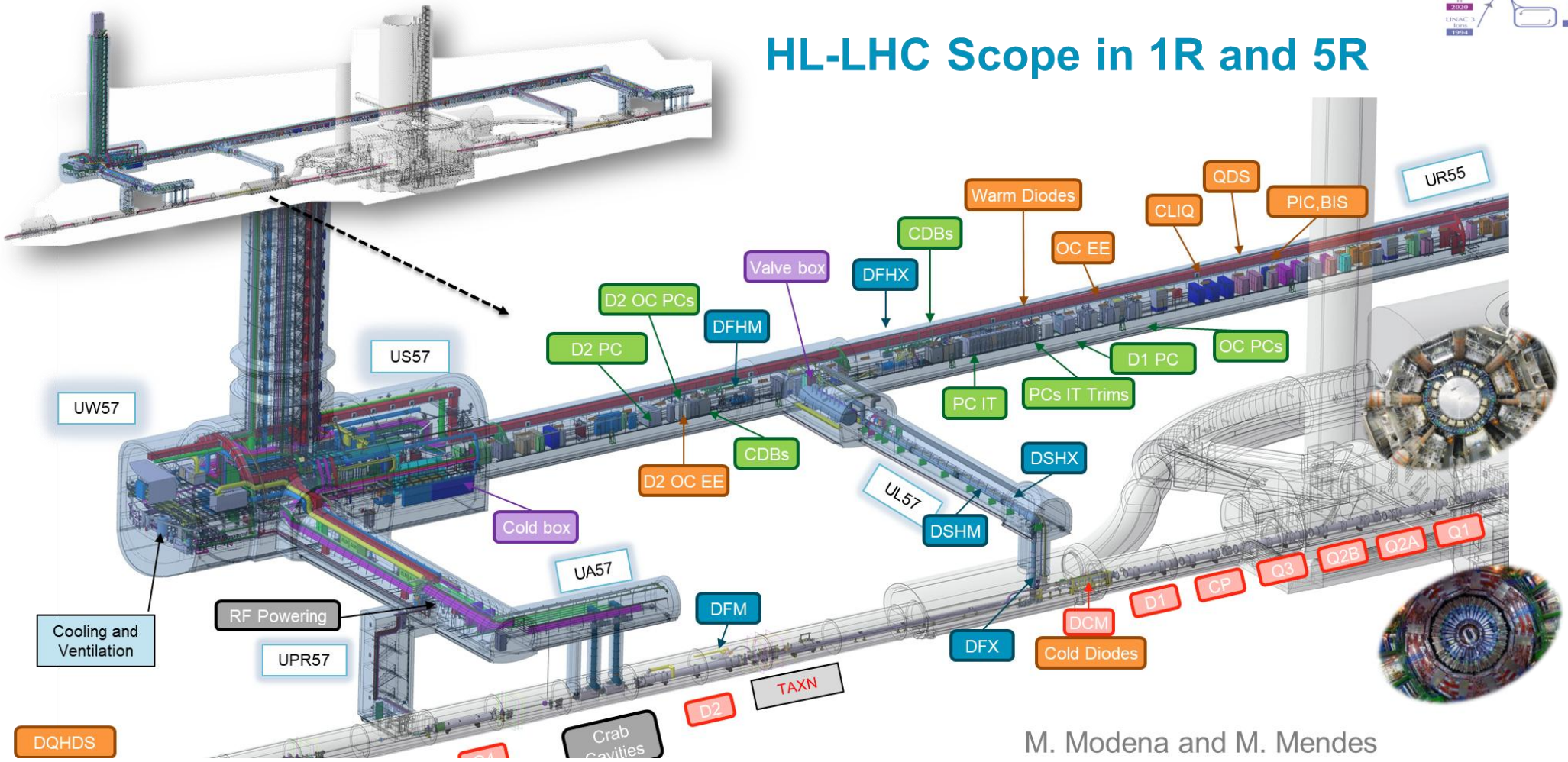
Increase of the LHC integrated design luminosity by an order of magnitude.

The third Long Shutdown (LS3)

HL-LHC : Civil Engineering – Underground and Surface



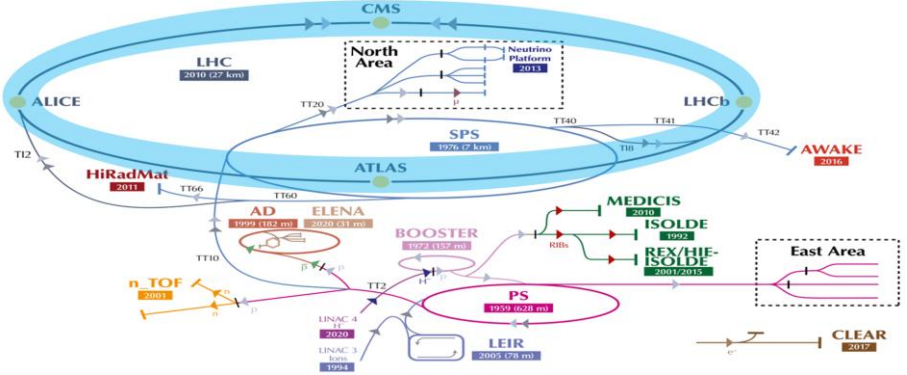
HL-LHC Scope in 1R and 5R



M. Modena and M. Mendes

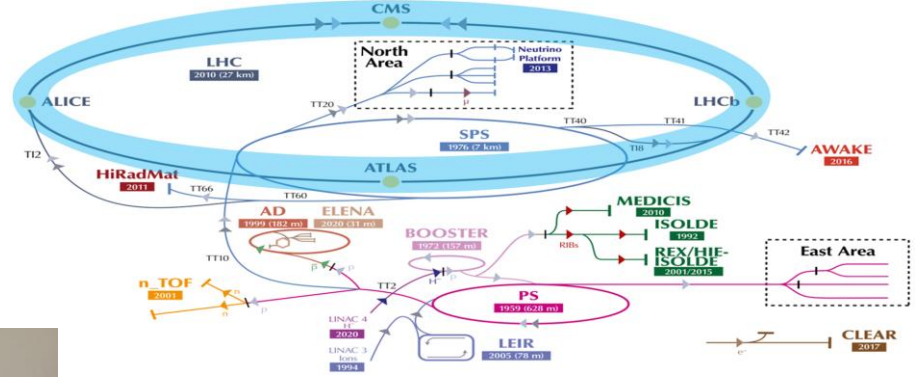
The third Long Shutdown (LS3)

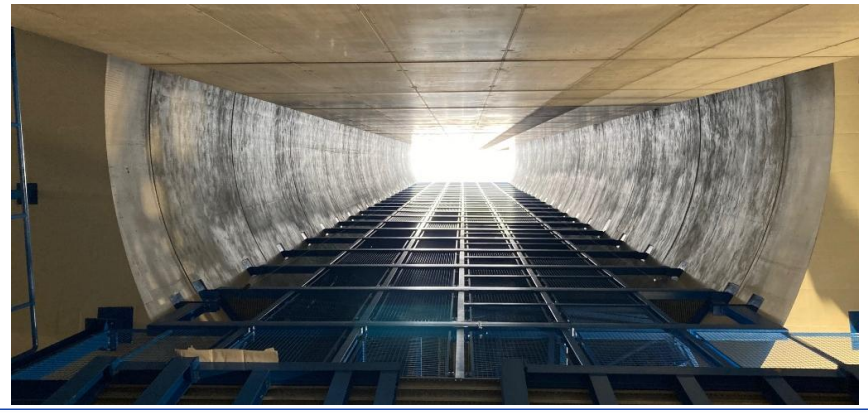
HL-LHC : Civil Engineering –Surface

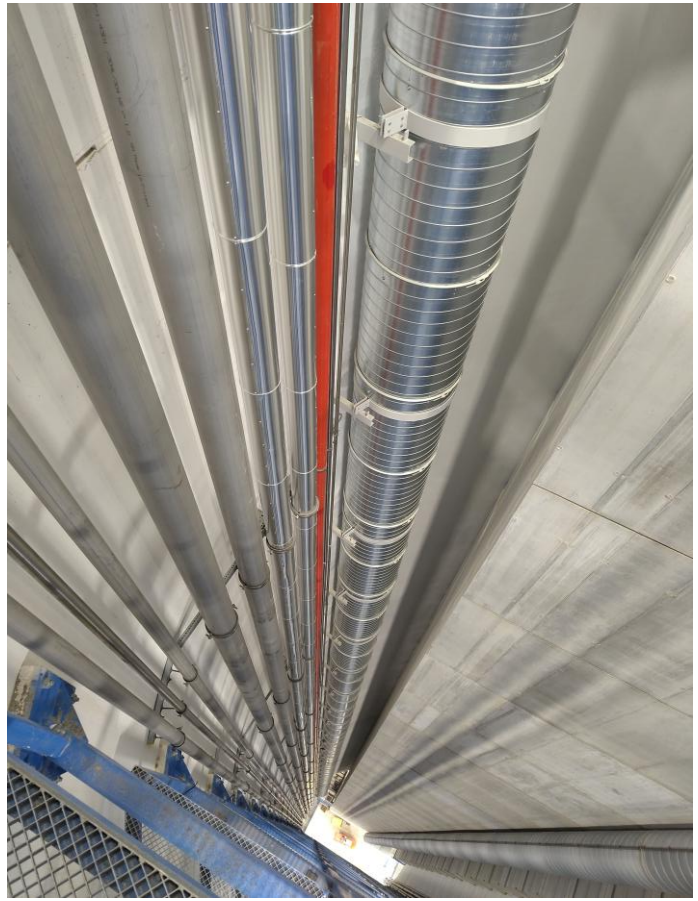


The third Long Shutdown (LS3)

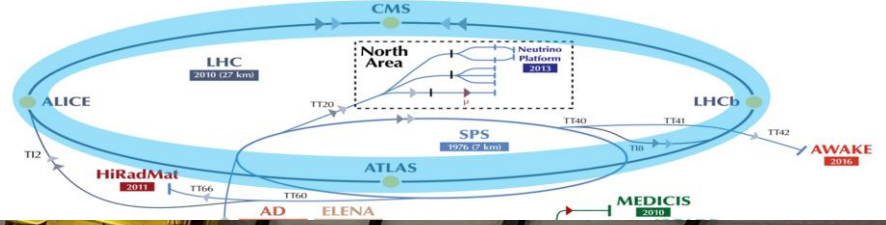
HL-LHC : Civil Engineering – Underground



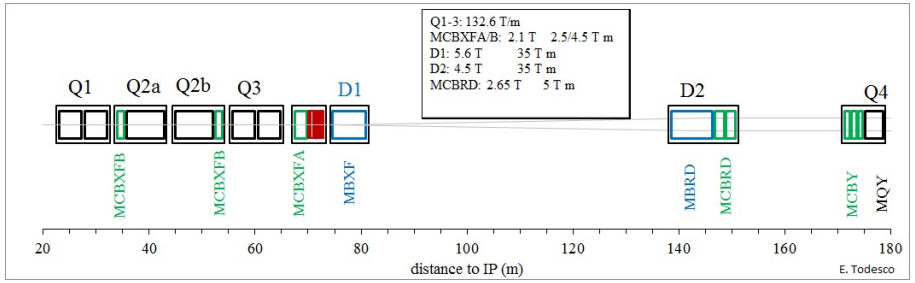


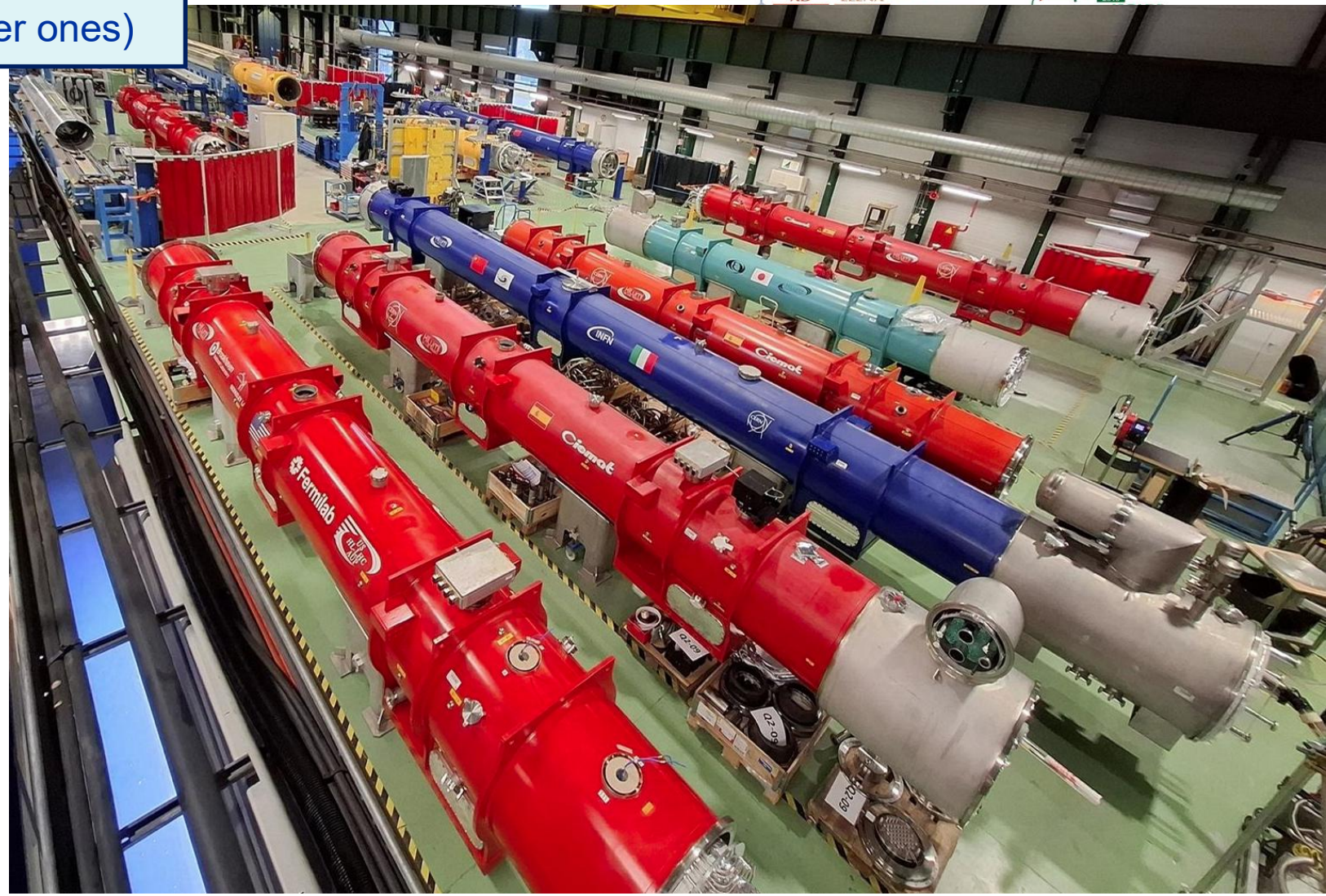


The third Long Shutdown (LS3)

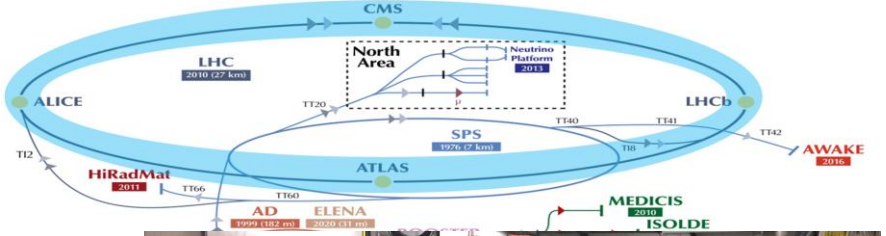


HL-LHC : Focusing Magnets (and other ones)

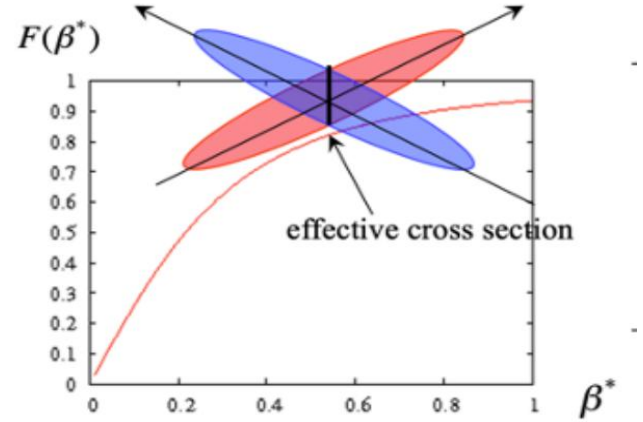


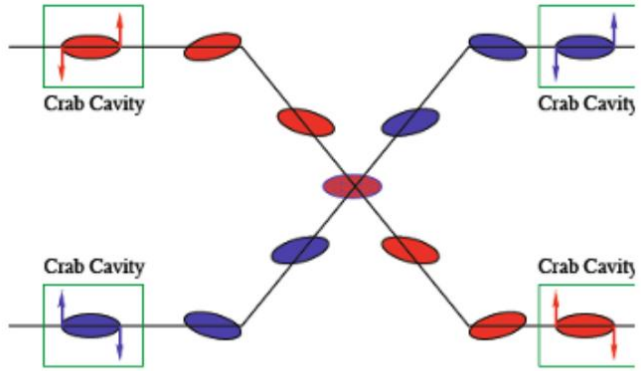


The third Long Shutdown (LS3)

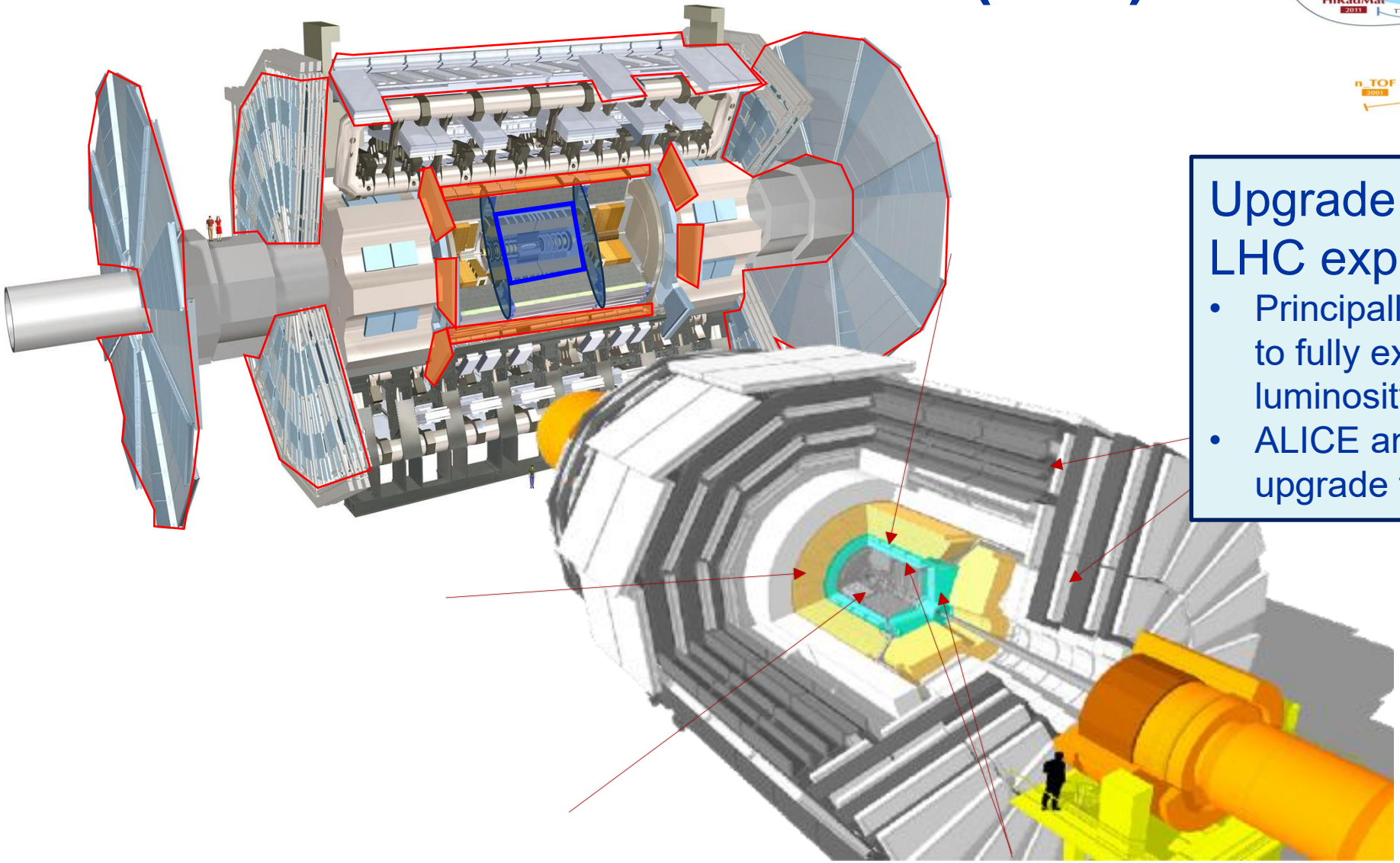


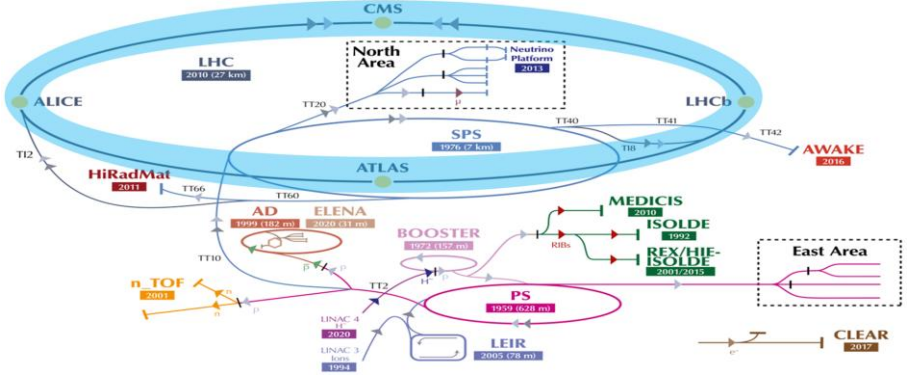
HL-LHC : Crab cavities





The third Long Shutdown (LS3)

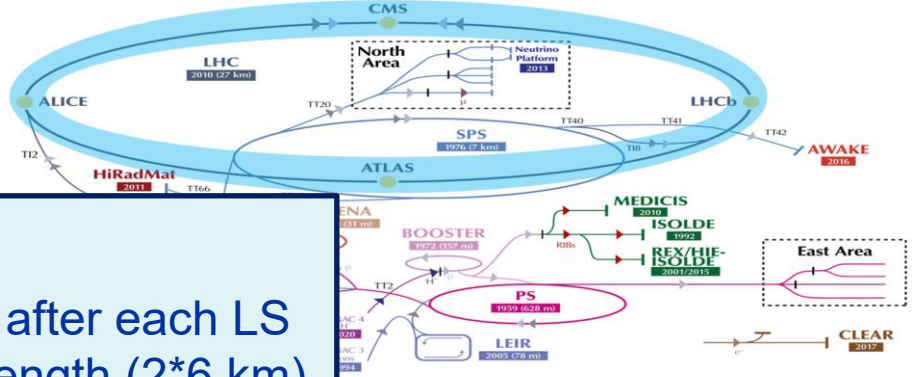




Upgrade and maintenance of the LHC experiments

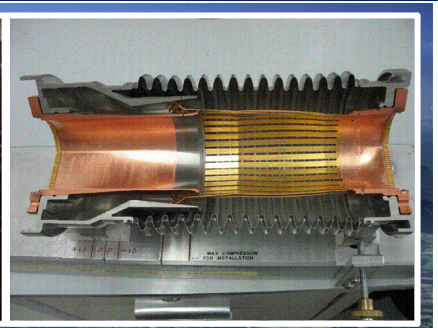
- Principally ATLAS and CMS during LS3 to fully exploit the increased LHC luminosity during Run4
- ALICE and LHCb are preparing major upgrade for LS4

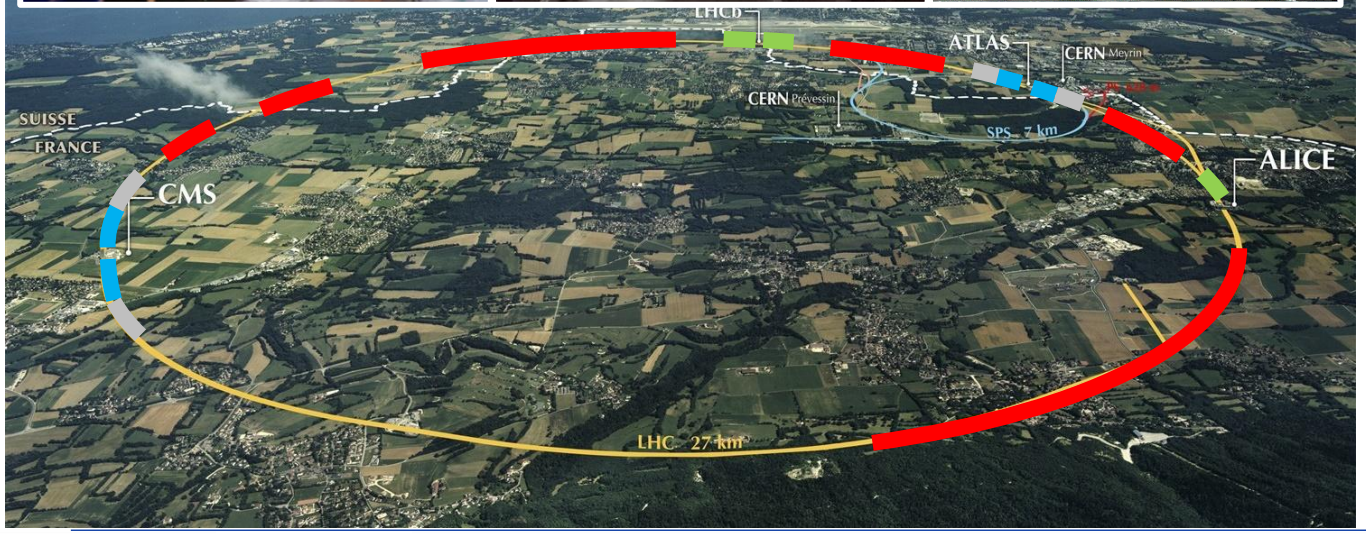
The third Long Shutdown (LS3)

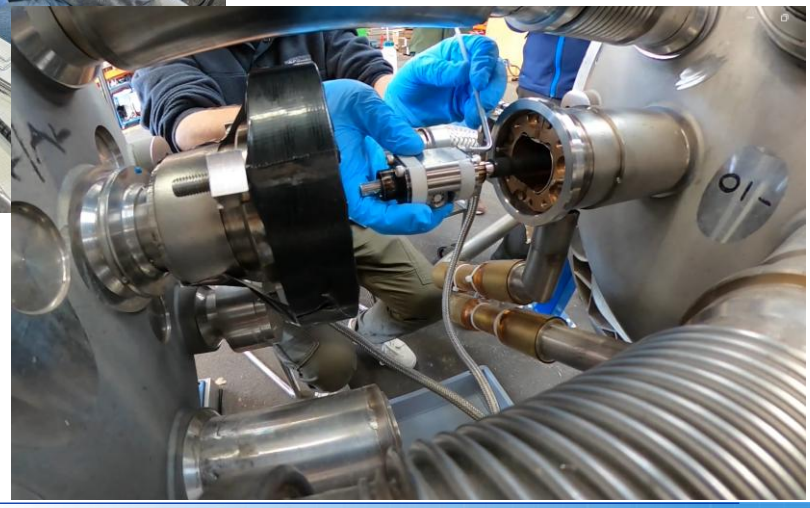


Beam Screen Treatment (BST)

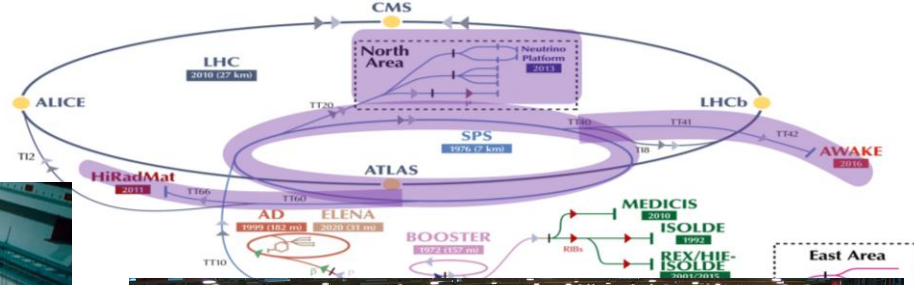
- To reduce beam induced heat loads and mitigate degradations observed after each LS
- By depositing a thin amorphous carbon layer on ≈ 30% of the LHC arcs length (2*6 km)
- And in the Long Straight Sections







The third Long Shutdown (LS3)



- Overall 60 000 m^2:
  - underground 16 600m^2,
  - experimental halls 31 000 m^2,
  - service buildings: 12 000 m^2
- 6 beam lines ~ 6.3 km cumulated

Experimental halls

Underground beam tunnels, caverns

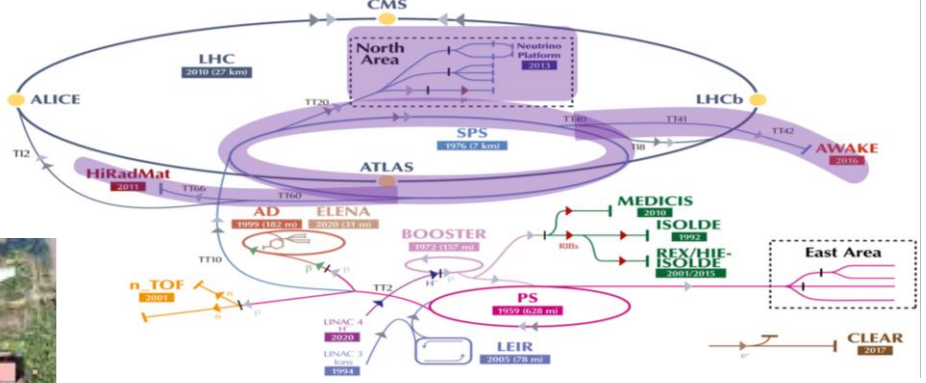
Underground technical galleries

Service buildings

NA-CONS : North Area Consolidation

Renovation the infrastructure and upgrade beam equipment to ensure high performance and availability during Run4

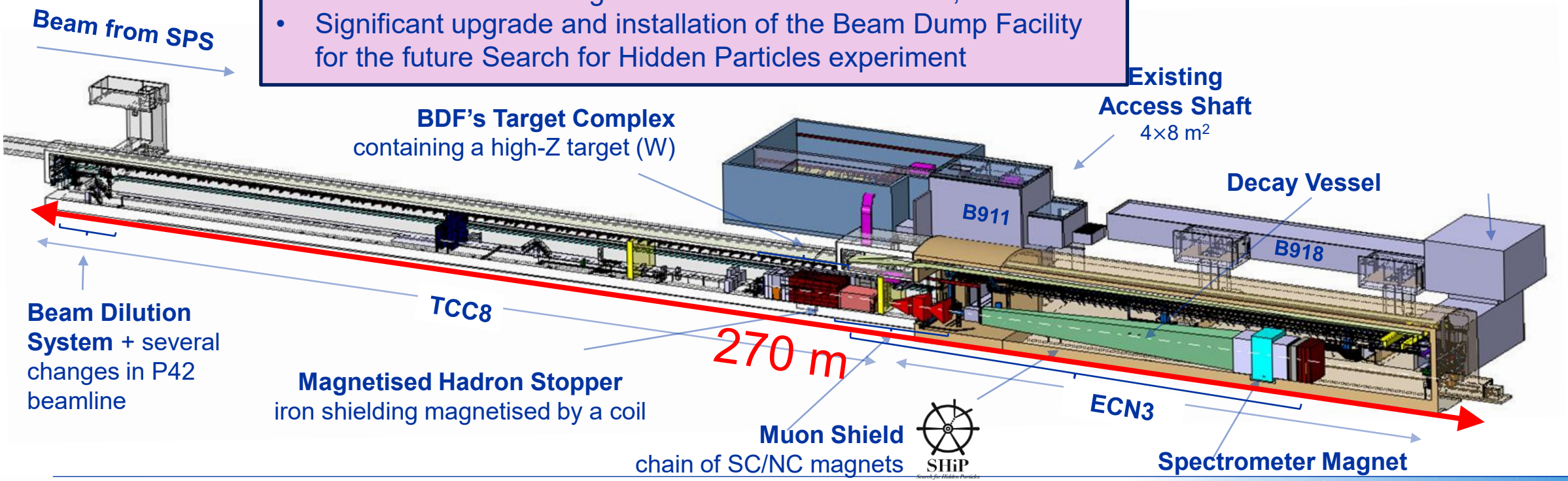
The third Long Shutdown (LS3)



HI-ECN3 (Experimental Cavern 3 in the North Area)

Comprehensive transformation ECN3

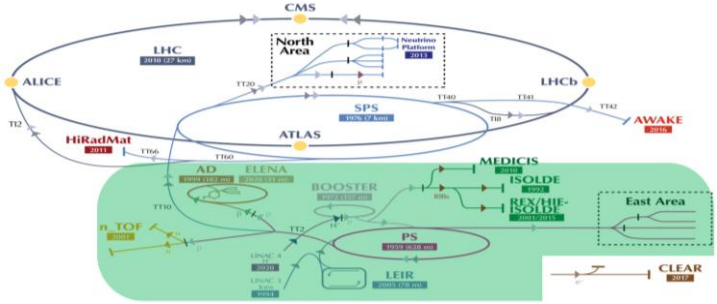
- Removal of the existing infrastructure and detectors,
- Significant upgrade and installation of the Beam Dump Facility for the future Search for Hidden Particles experiment

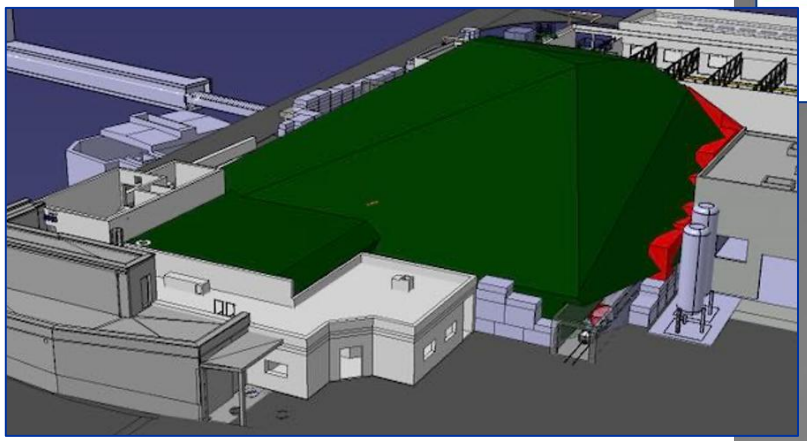


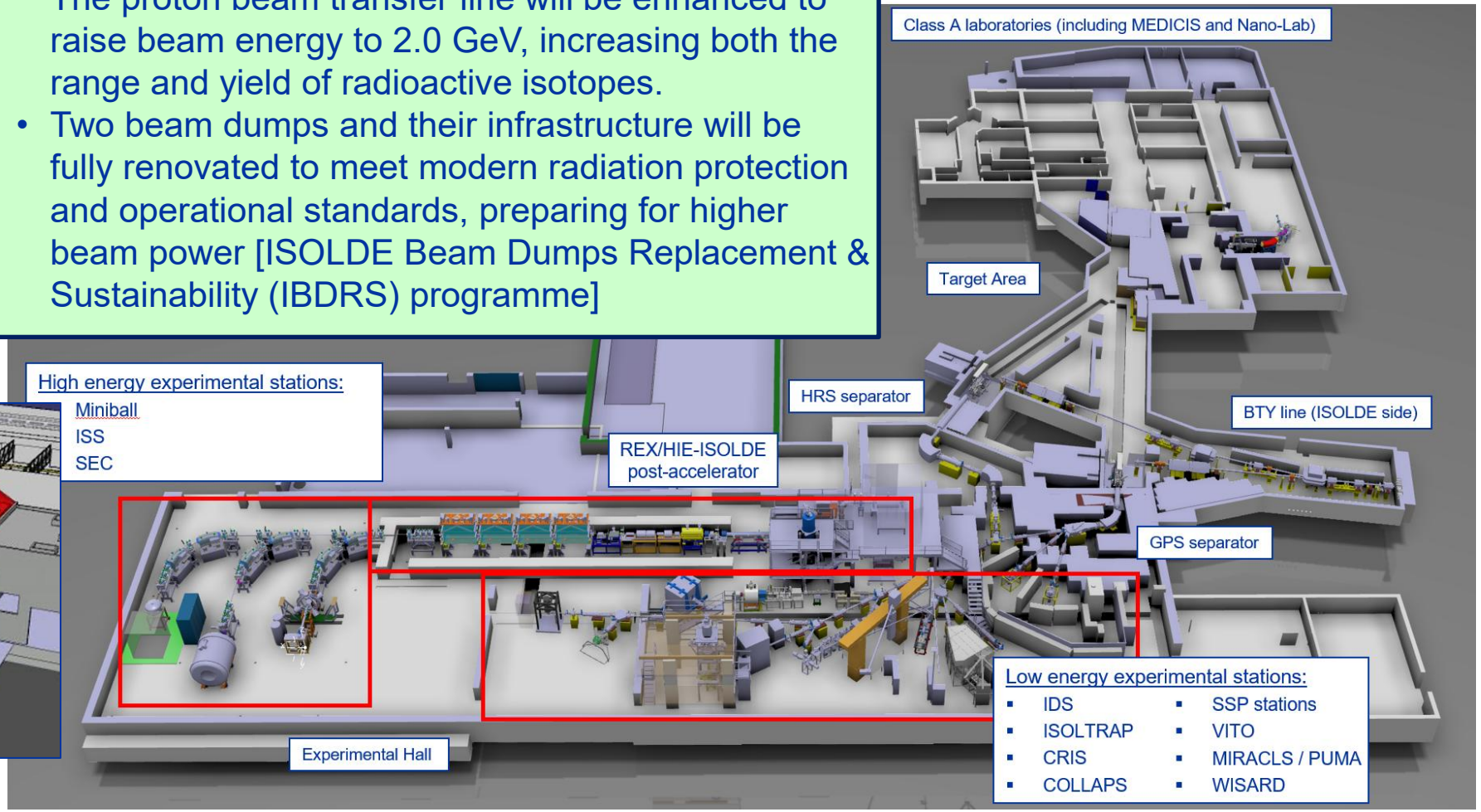
The third Long Shutdown (LS3)

ISOLDE (Isotope mass Separator On Line)

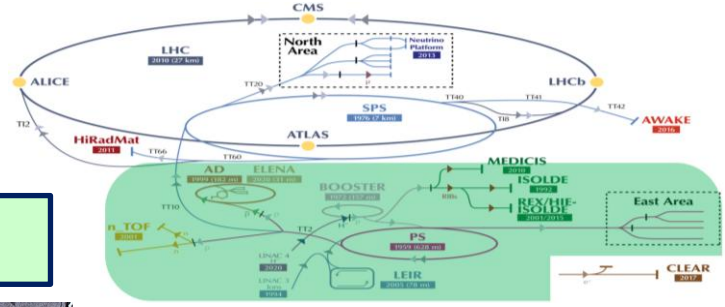
- The ISOLDE facility will undergo major upgrades. The proton beam transfer line will be enhanced to raise beam energy to 2.0 GeV, increasing both the range and yield of radioactive isotopes.
- Two beam dumps and their infrastructure will be fully renovated to meet modern radiation protection and operational standards, preparing for higher beam power [ISOLDE Beam Dumps Replacement & Sustainability (IBDRS) programme]





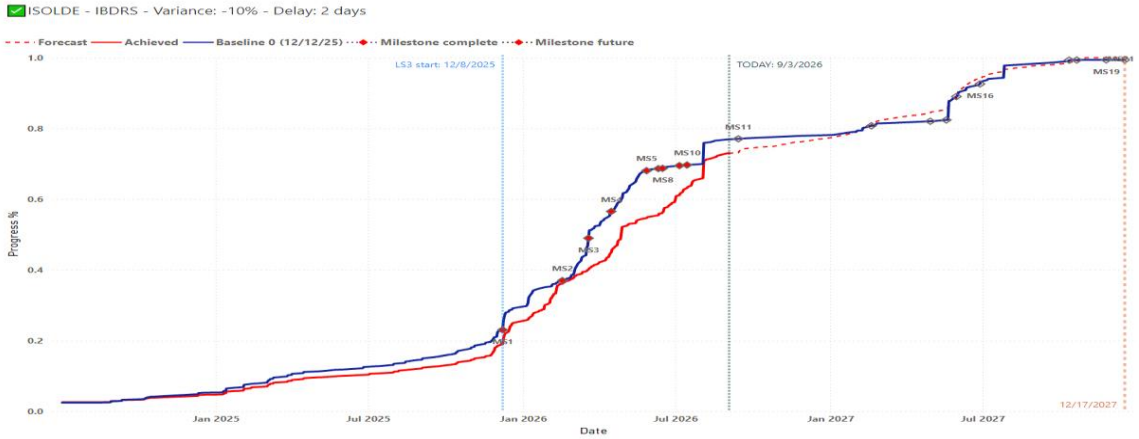


The third Long Shutdown (LS3)

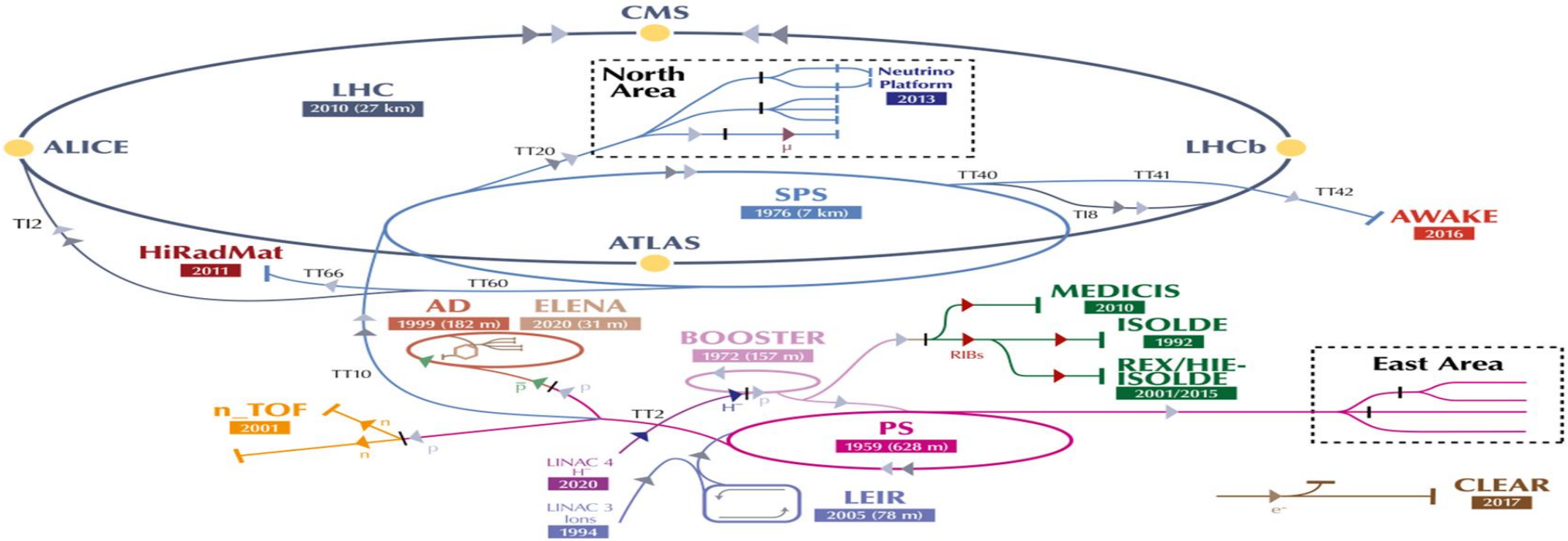


ISOLDE (Isotope mass Separator On Line)

HRS dump is dismantled



The third Long Shutdown (LS3)



- Consolidation of the Personnel Safety System (PSS-CONS)
- Consolidation of the electrical transmission and distribution networks (EL-CONS)
- Decabling and Cabling
- Construction of a building for processing and testing superconducting radio frequency cavities
- Consolidation of the Technical Galleries (TG-CONS)
- And large **maintenance** and **consolidation** of the infrastructure and equipment

The third Long Shutdown :

Movies :

- Hi Lumi LHC
- Travaux LS3

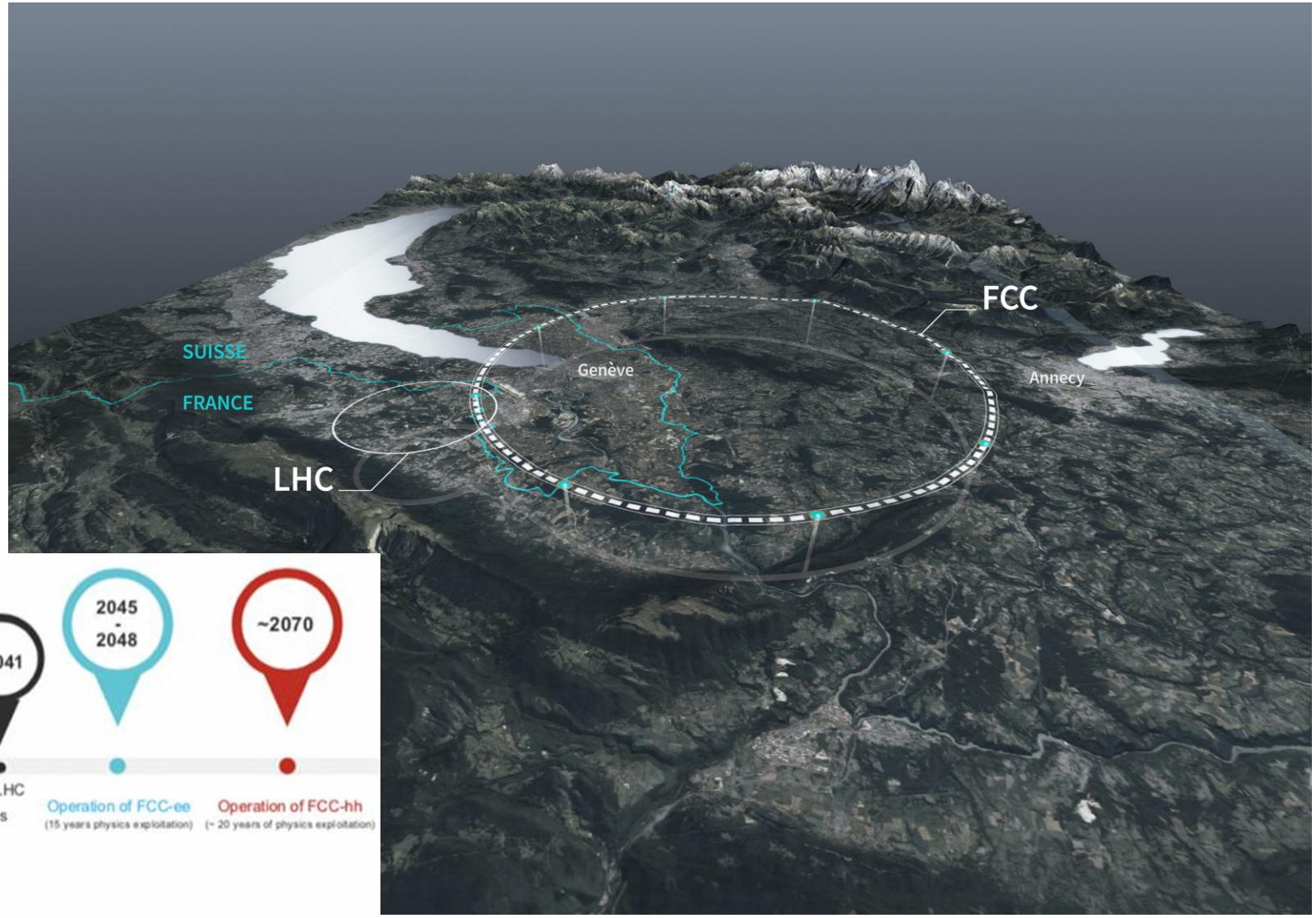
The third Long Shutdown (LS3)

A pivotal phase for CERN

- **Enables HL-LHC installation and commissioning**
- **Major ATLAS and CMS upgrades** to fully exploit Run 4 luminosity
- **Extensive consolidation, maintenance, and enhancements** across the accelerator complex
- **Largest and most diverse programme** since the LHC installation (> LS1/LS2)
- **Requires strong coordination** across all sectors and projects
- **Strategic opportunity** to:
  - Boost **performance**
  - Enhance **reliability**
  - Ensure long-term **availability**

What after the LHC era ?

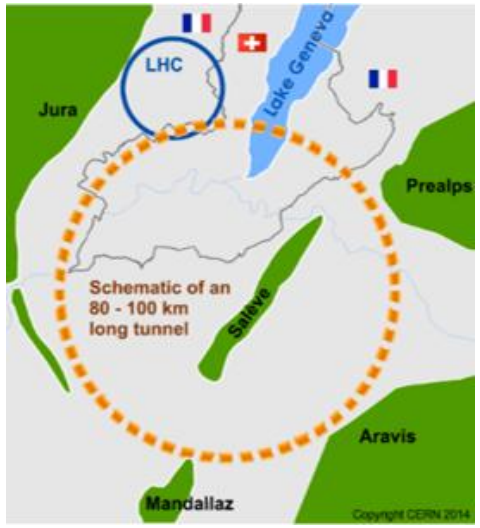
FCC-ee: Higgs factory, electroweak & top factory at highest luminosities

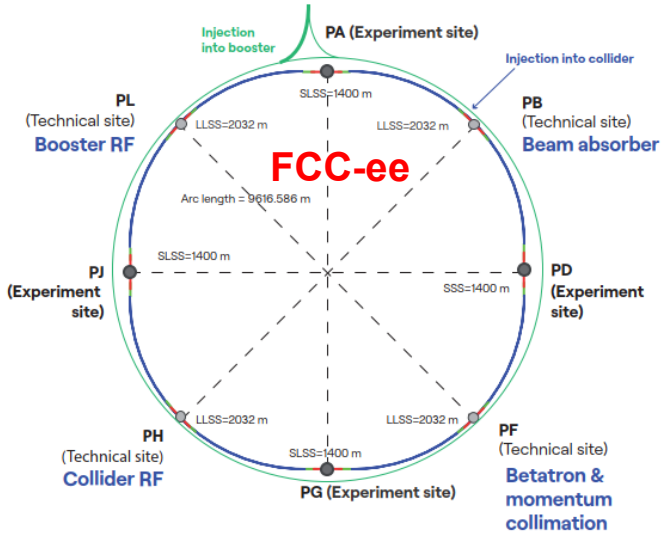


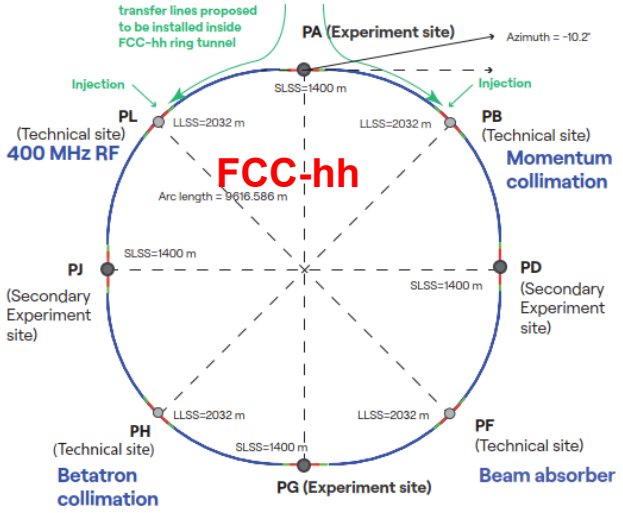
Courtesy M. Benedikt

What after the LHC era ?

- Focus on implementation of FCC-ee as first step ; possible pathway to FCC-hh to be decided later
- Common civil engineering and technical infrastructures, building on and reusing CERN's existing infrastructure
- Highly synergetic and complementary physics programme maximising the physics opportunities
- FCC-ee project would allow the start of a new, major facility at CERN within a few years of the end of HL-LHC

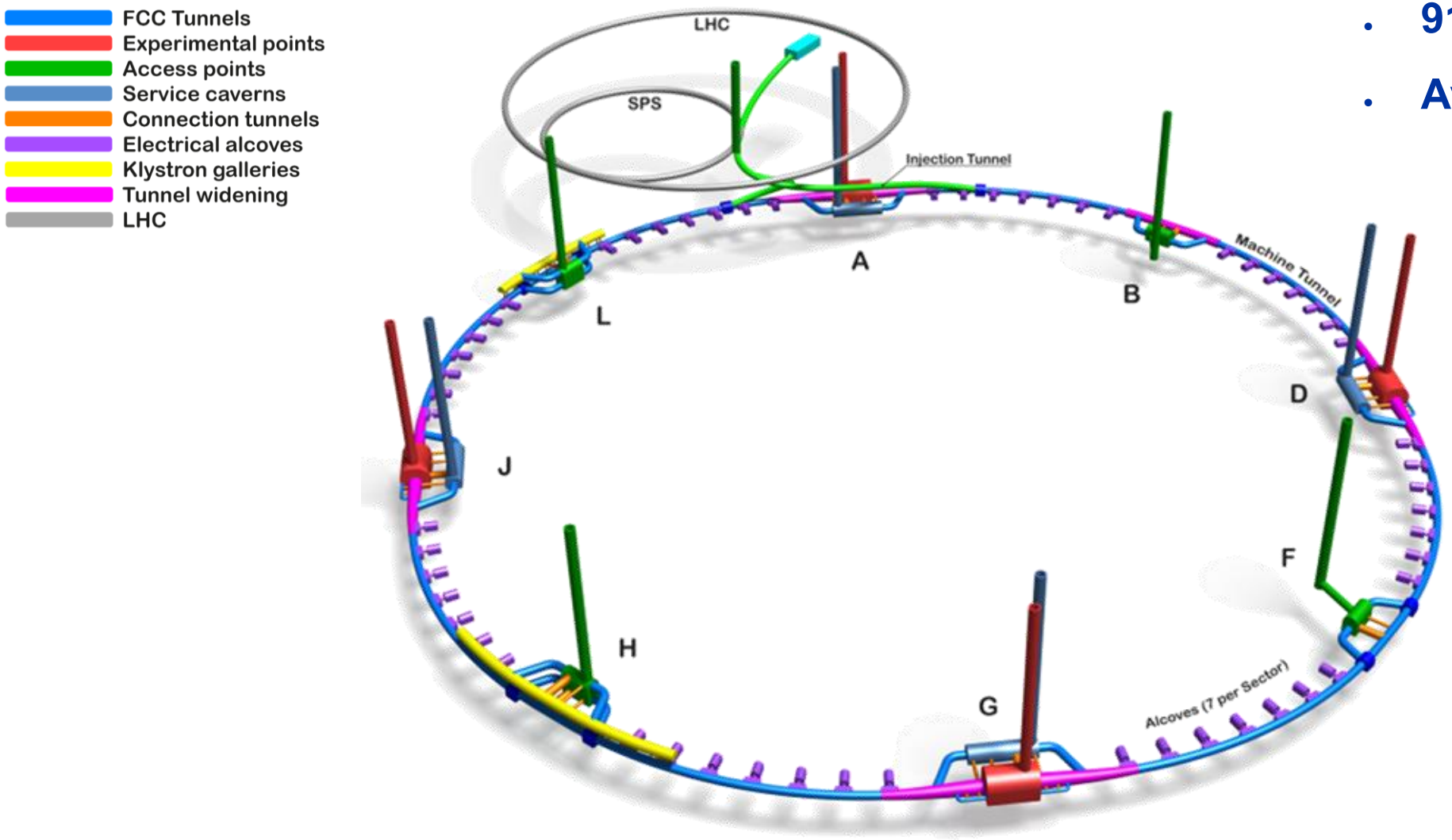






Courtesy M. Benedikt

What after the LHC era ?

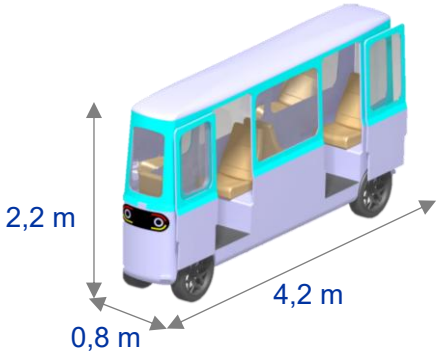


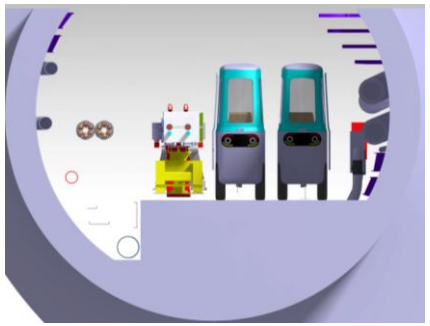
- **91 km tunnel**
- **Average depth : 200 m.**

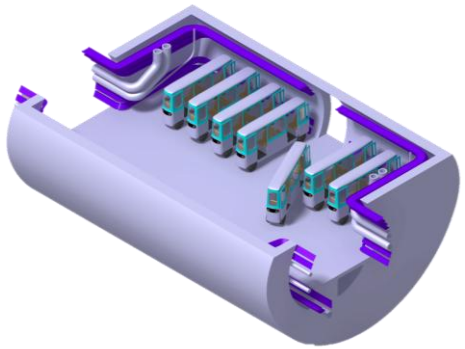
Schematic
Not to scale
Not final version

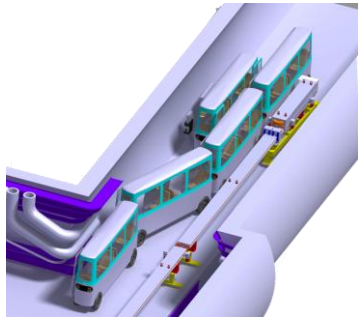
Some EN contributions to FCC(-ee)

Horizontal transport – vehicles for personnel



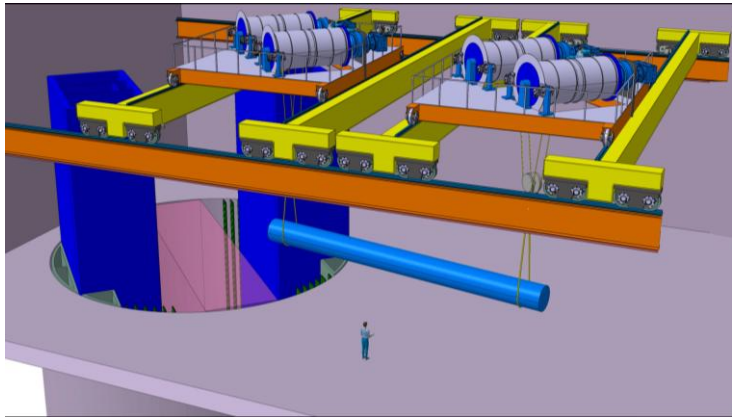


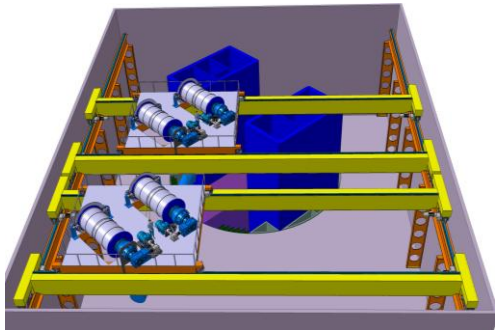


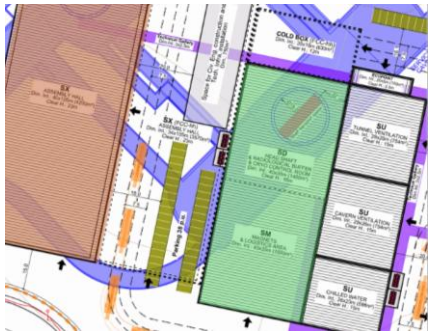


Courtesy Frederic Veit, Fraunhofer Institute for Materials and Logistics IML (vehicles)

Surface-to-underground : Shaft crane

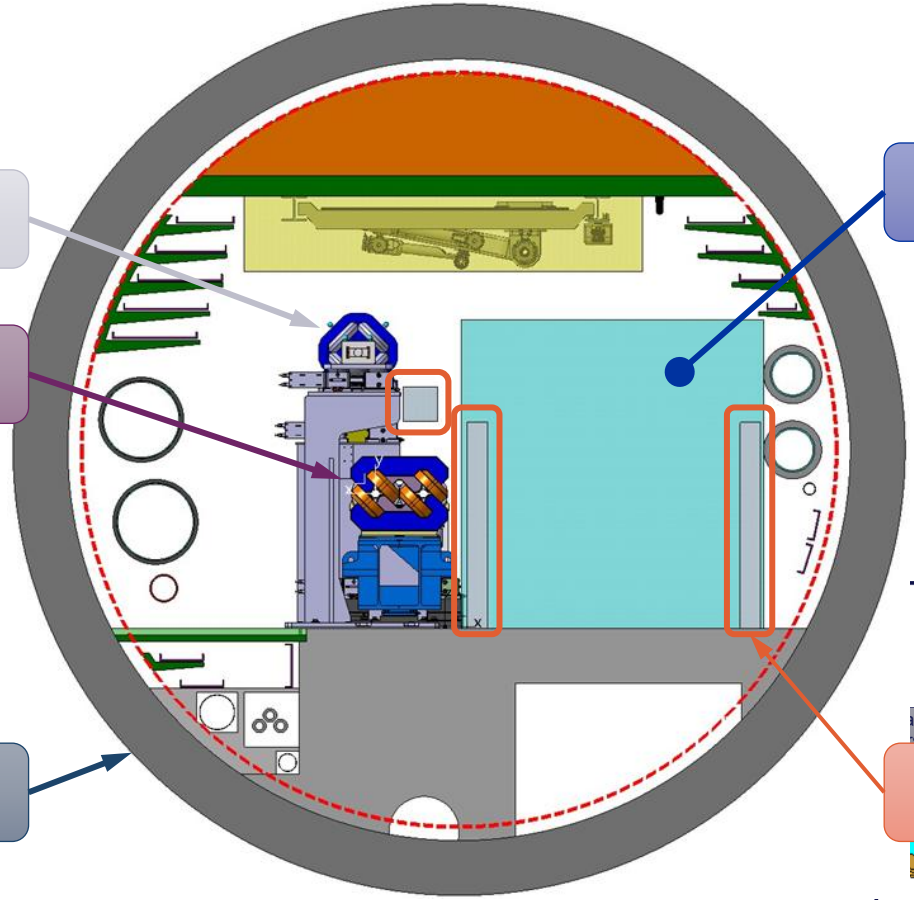




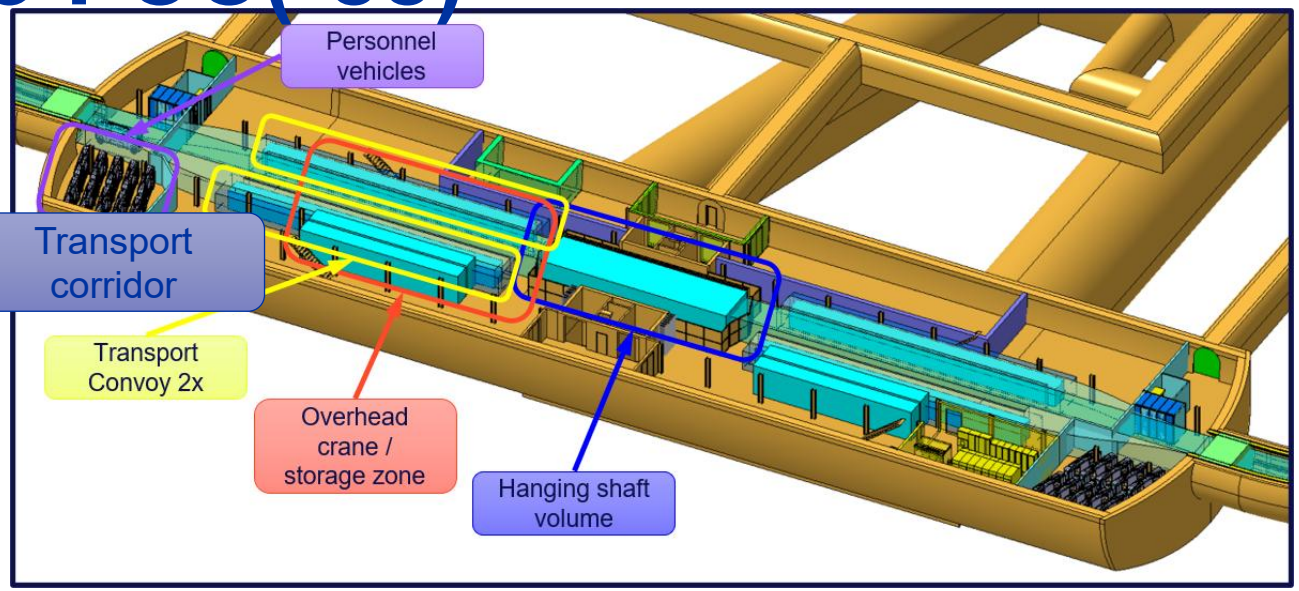


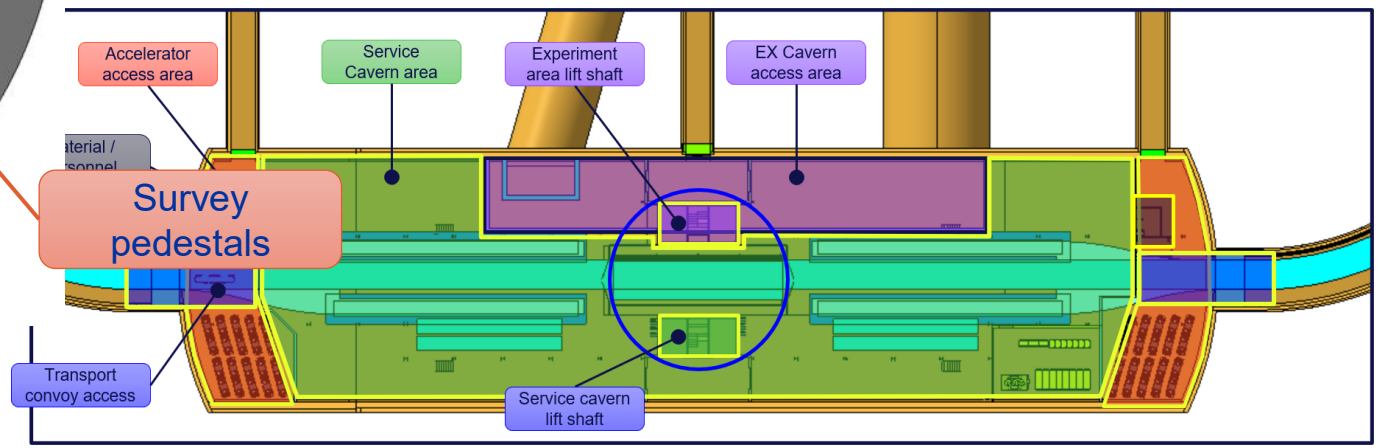
FCC head-shaft crane updated concept.
Courtesy Gilles Villiger

Some EN contributions to FCC(-ee)



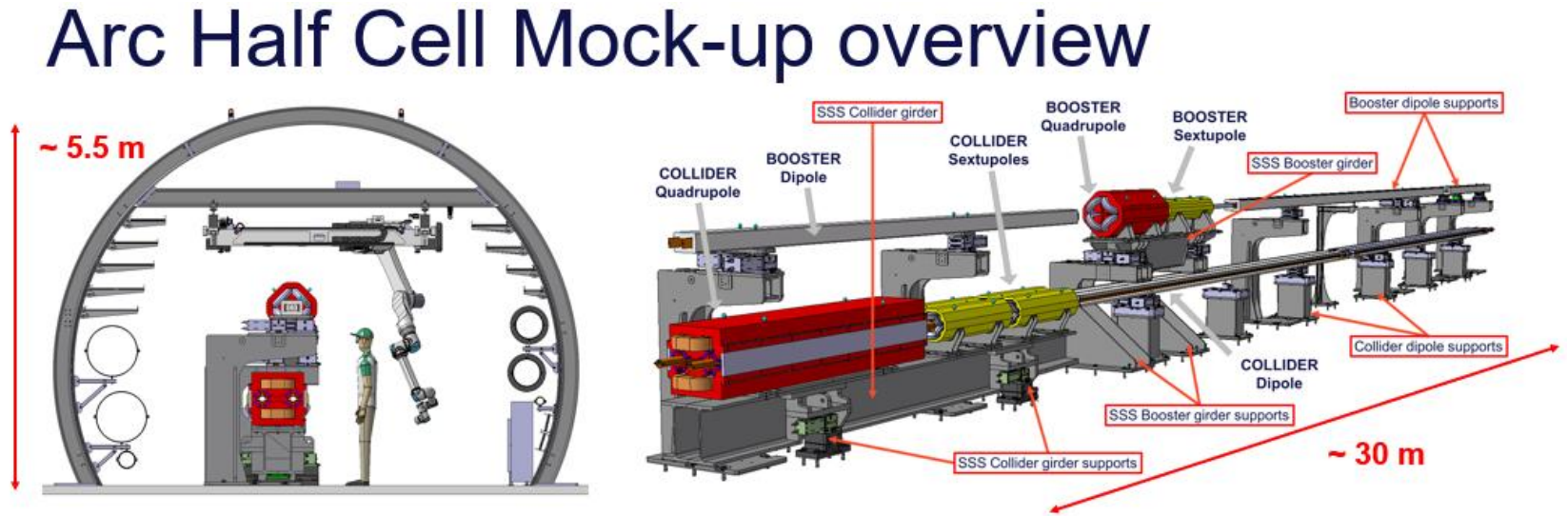
Updated Arc cross-section





Courtesy D. Harvey

Some EN contributions to FCC(-ee)



Courtesy Y. Grislain and his team, M. Rouchouse

Courtesy A.Piccini

What after the LHC era ?

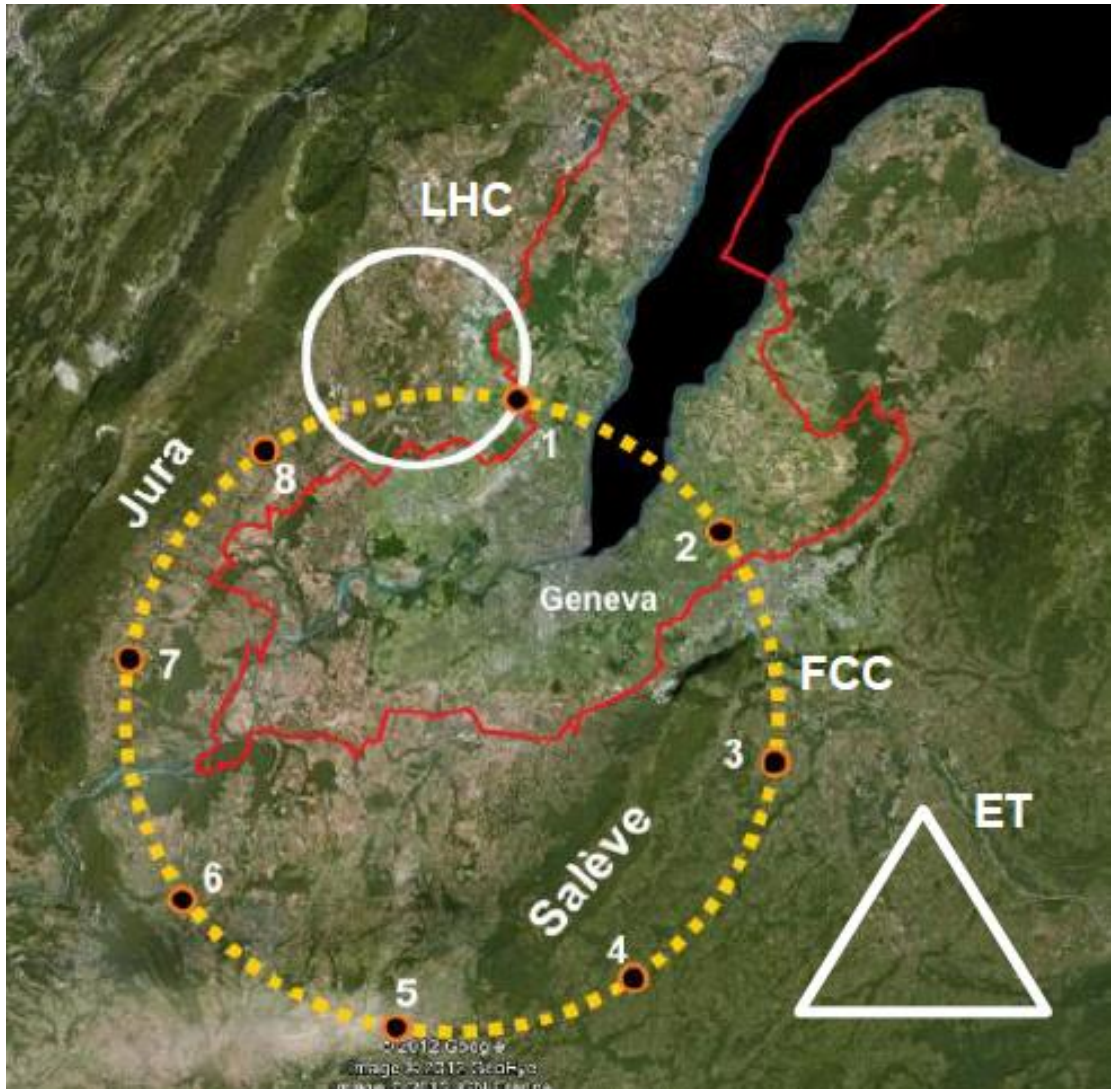
FCC-ee Progress

There is also a lot of technical progress

- The goal is to baseline the **FCC-ee** design by the end of 2026
  - at that point the design comes under formal change control
- Progress in many areas
- In addition, I would like to highlight the arc-cell mock-up in B355
  - Validate the concept + an opportunity to highlight FCC to visitors to CERN

The Einstein Telescope

- CERN collaborate on the ET activities for ***safety and engineering studies*** of the ET in collaboration with other relevant ET Partners. CERN's interest in contributing in these fields aligns with its expertise, mission, and ongoing work on the Future Circular Collider (FCC). Given that the challenges and solutions developed for the ET directly overlap with those of the FCC, this project will enable a mutually beneficial exchange of knowledge, expertise, and innovation.
- Site independent

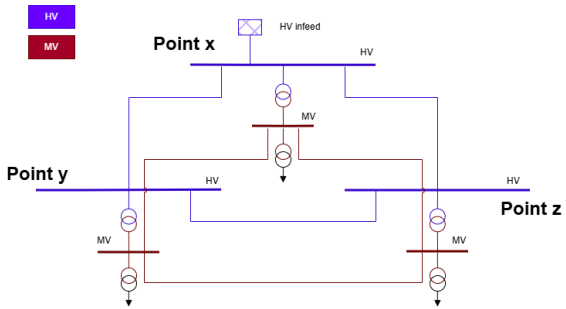


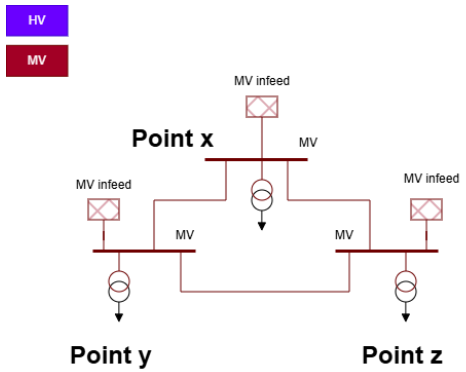
Note : ET became a recognised CERN experiment in March 2022

(considered to be of importance to High Energy Physics, recognition status by the Research Board, can benefit to a limited extent from CERN's infrastructure and service)

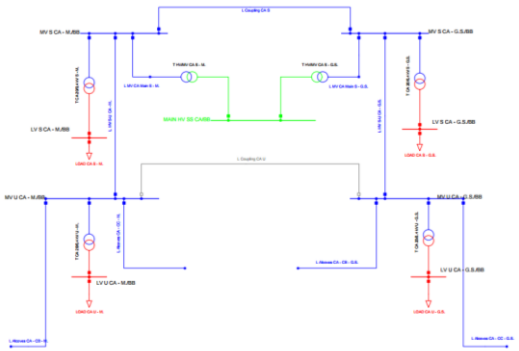
The Einstein Telescope

Grid backbone proposals





MV-LV network of corner station



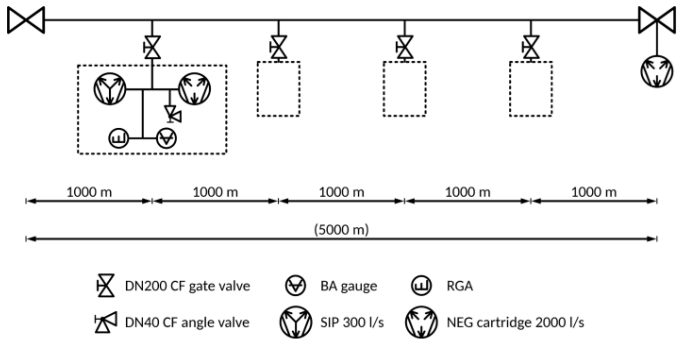
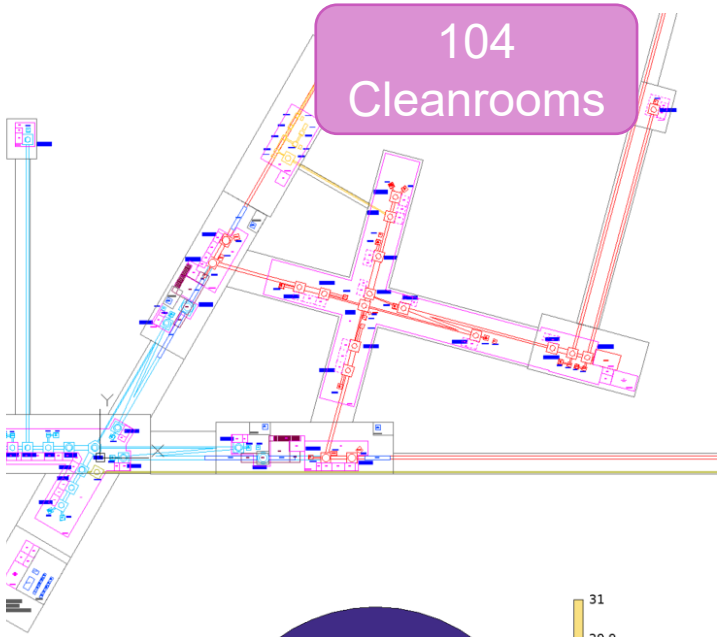


Fig. 21 - *UHV vacuum layout*

104 Cleanrooms



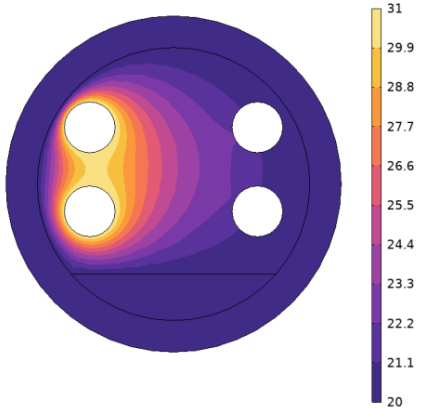
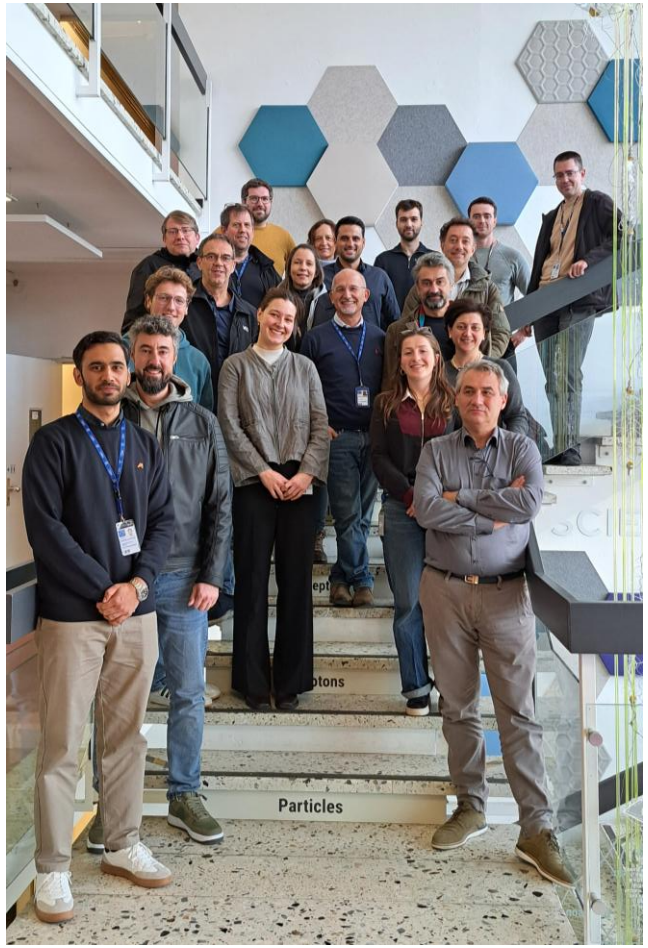


Fig. 25 - *CFD simulated temperature distribution after 7 days of simultaneous bakeout at 150°C of two ET vacuum sectors. The average temperature in the tunnel is 23°C, (tunnel's walls at 20°C).*

The workforce

10 young graduates
(7 Engineering / 3 EN/HSE)
All at CERN
Supervised by experienced CERN staff



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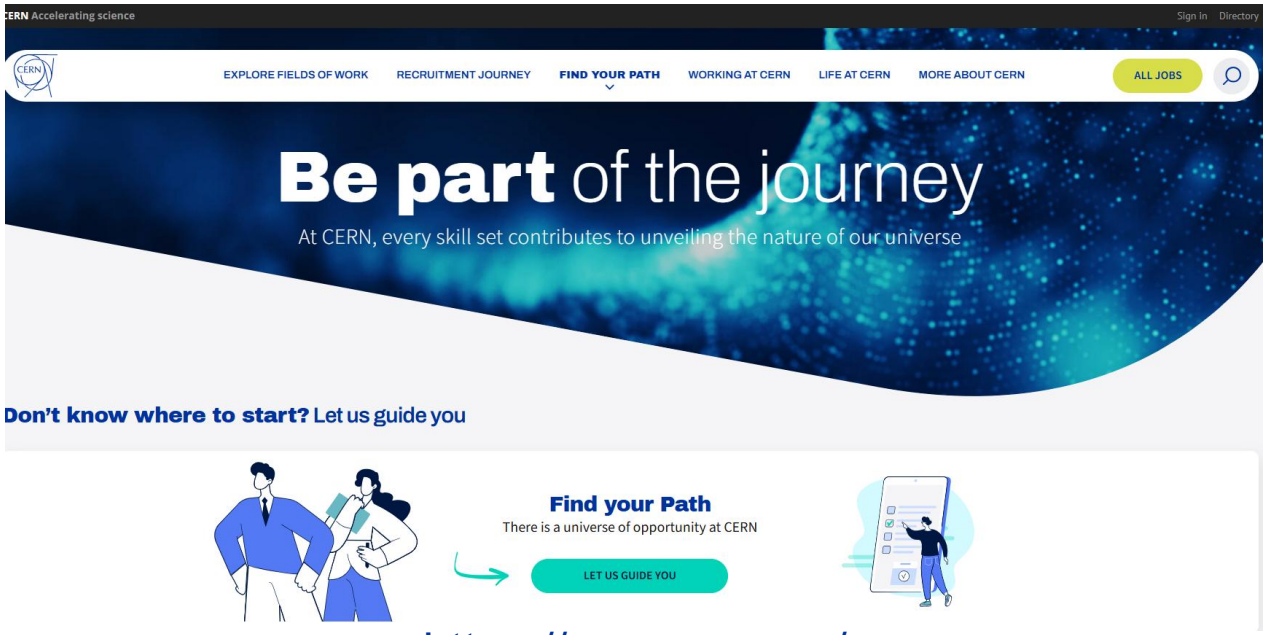
Plan your visit

Tour the accelerator complex



https://careers.cern/

Thank you for your attention

Highlights 2026 movie

Thank you for your attention

Highlights 2026 movie

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