Cryogenics storage and distribution

3rd HiLumi Industry Day
22 – 23 May 2017, Warrington, UK

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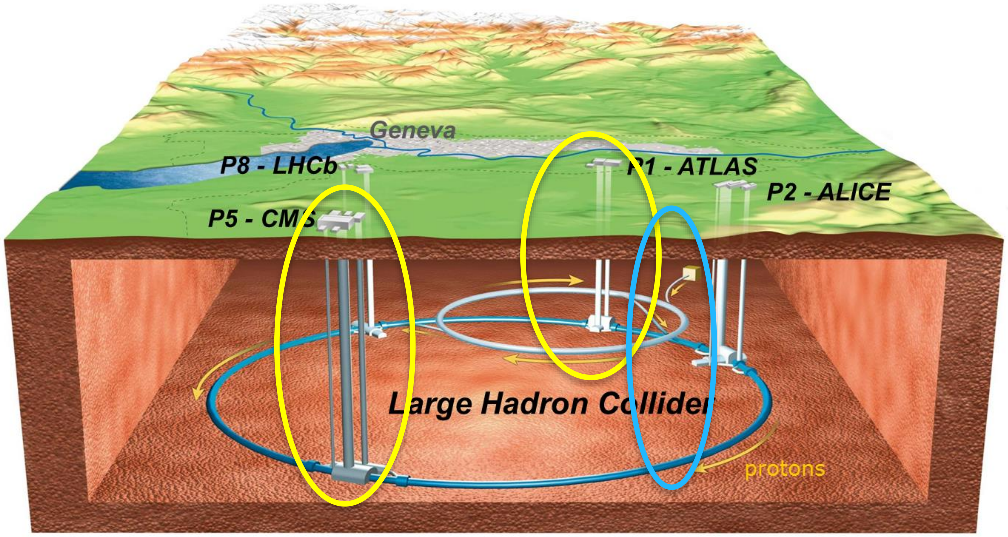
on behalf of involved team

OUTLOOK

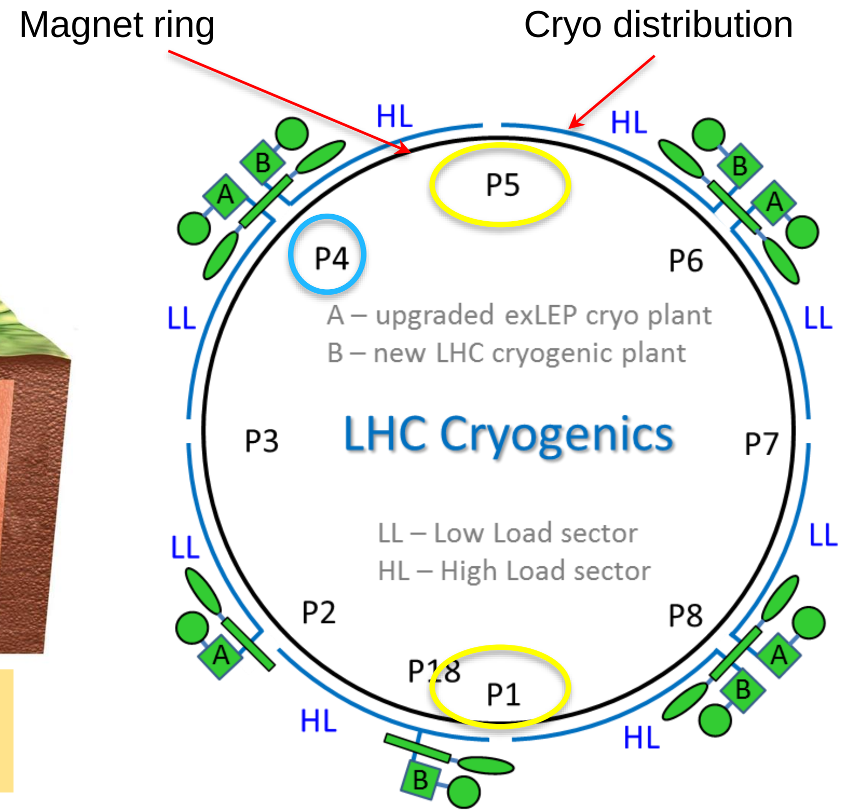
- Introduction
- LHC Cryogenics HiLumi upgrade
  - Distribution
  - Storage
- Concluding remarks

Introduction

LHC cryogenics:
8 x 18 kW @ 4.5 K
1800 sc magnets
24 km & 20 kW @ 1.8 K
37 000 tons @ 1.9 K
135 tons of helium inventory



- **circumference ➔ ~ 27 km,**
- **constructed at ~ 100 m underground,**

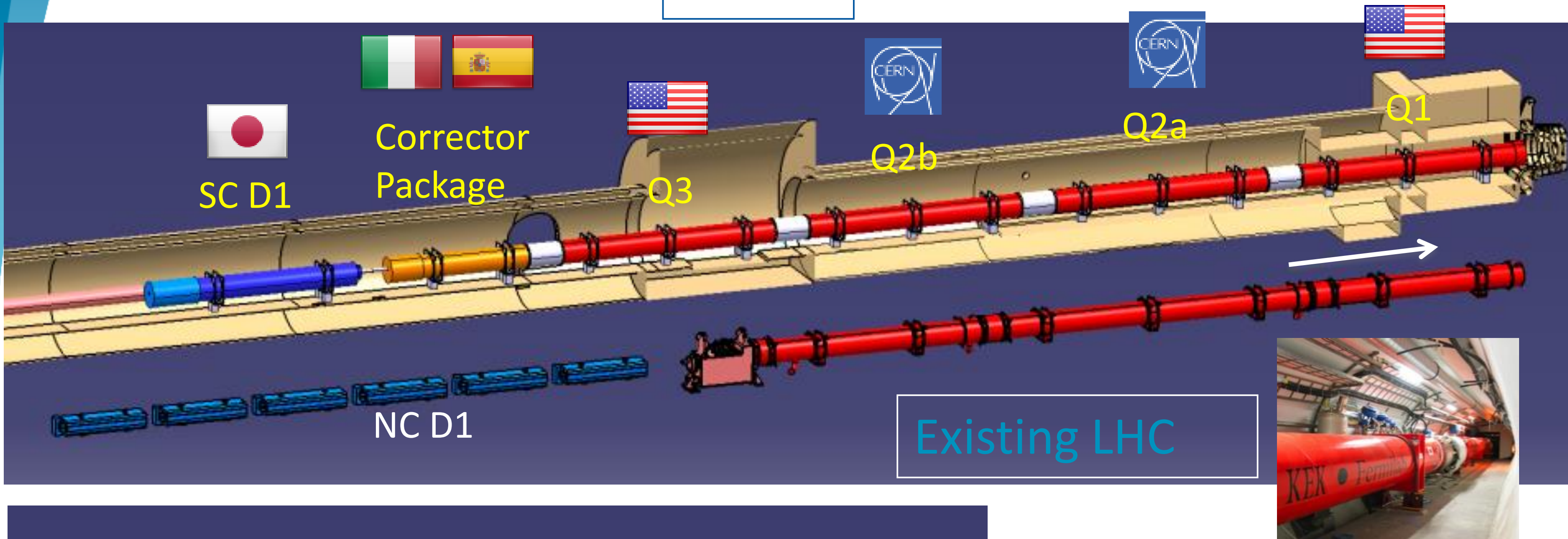


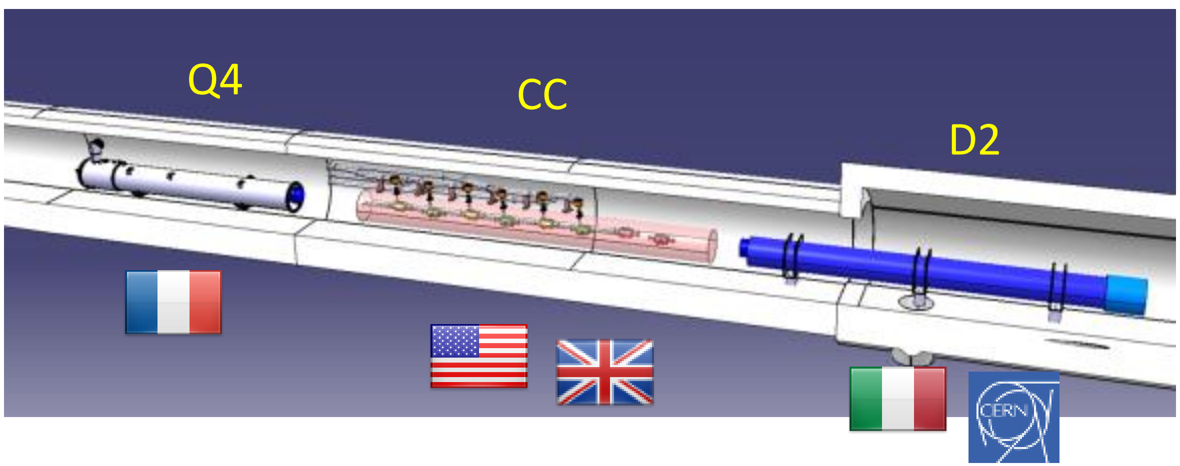
Main HiLumi cryogenics upgrade will affect P1 and P5 for cooling of LHC matching sections and P4 for cooling of RF accelerating system.

Compressor station
4.5 K refrigerator
Interconnection box
1.8 K pumping unit (cold compressor)

HL-LHC configuration

HL-LHC





HL-LHC systems are entering detailed integration phase

New baseline adopted to increase operating margins (Nb3Sn quadrupoles)

In-kind contribution and Collaborations for HW design and prototypes

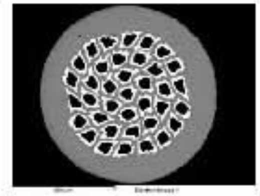
Cold Powering System HTS links

- Design and construction of test station with 20 m long SC Link cryostat (CERN)
- Development of MgB_2 round wire (CERN with Columbus – Genova)
- Development of high-current (20 kA) MgB_2 cables (CERN)
- Launched procurement of 80 km of MgB_2 round wire - which will be delivered as from April 2015

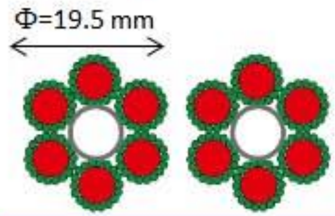
Excellent results obtained for elementary part of the cable

MgB_2 Wire

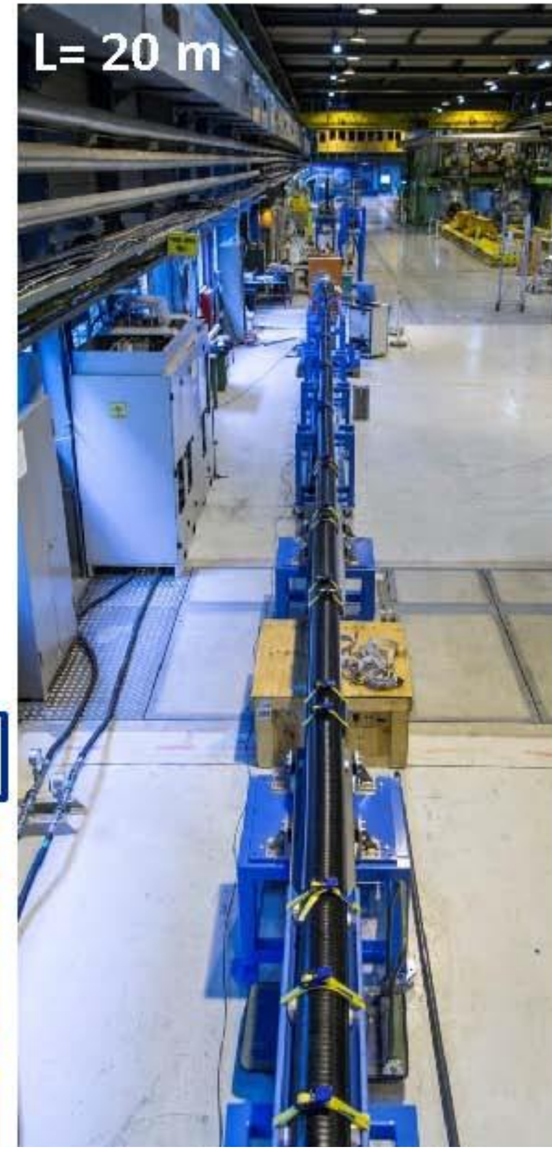
(Φ = 0.9 mm)



MgB_2 Cables



I=20 kA @ 24 K

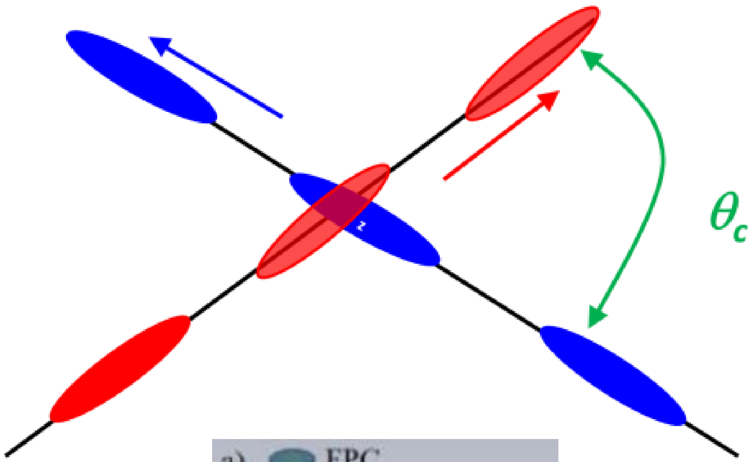


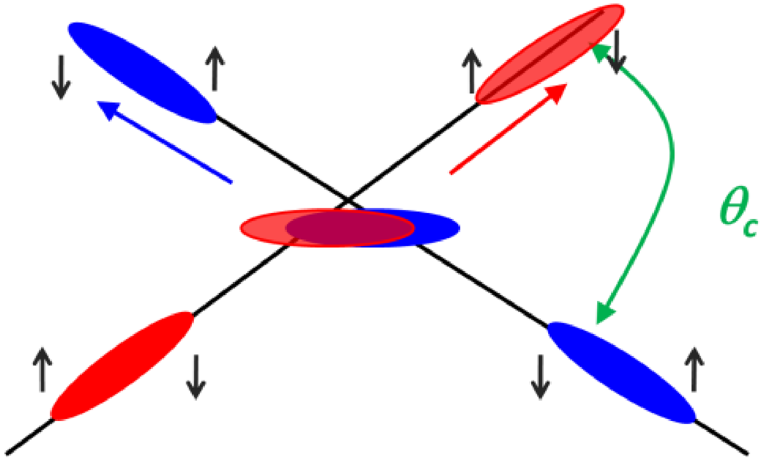
Global engineering (termination boxes, supporting) under study

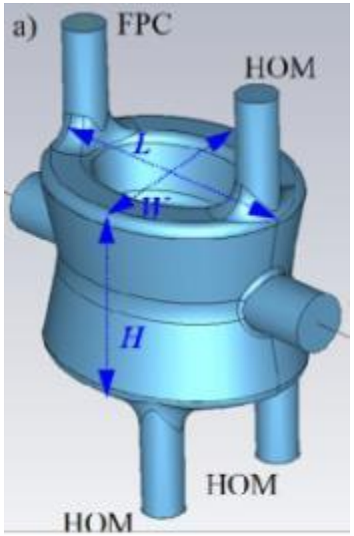
A. Ballarino

Effect of the crab-cavities

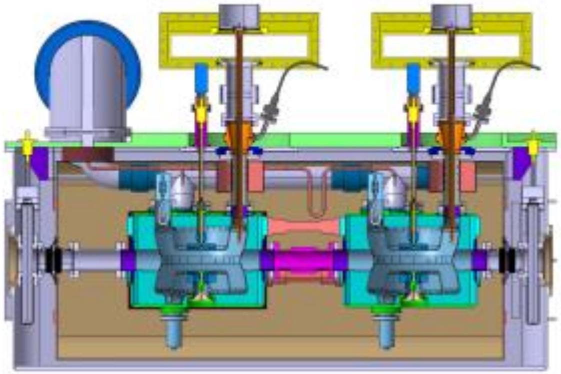
To increase interaction overlap





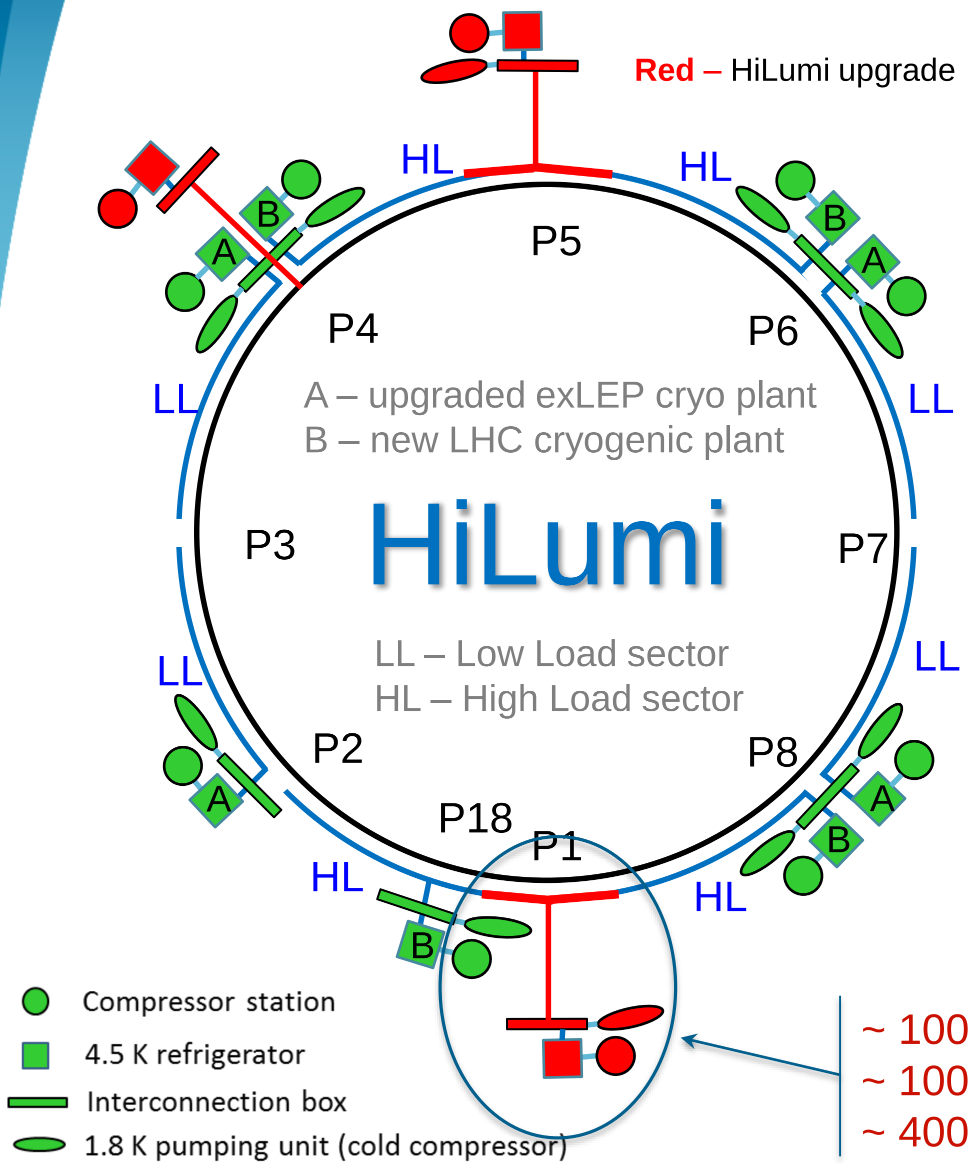


Double ¼-wave:
Coaxial couplers with
hook-type antenna



Operated at 2 K using superfluid helium

Cryogenic distribution



HiLumi cryo updgrade will consist:

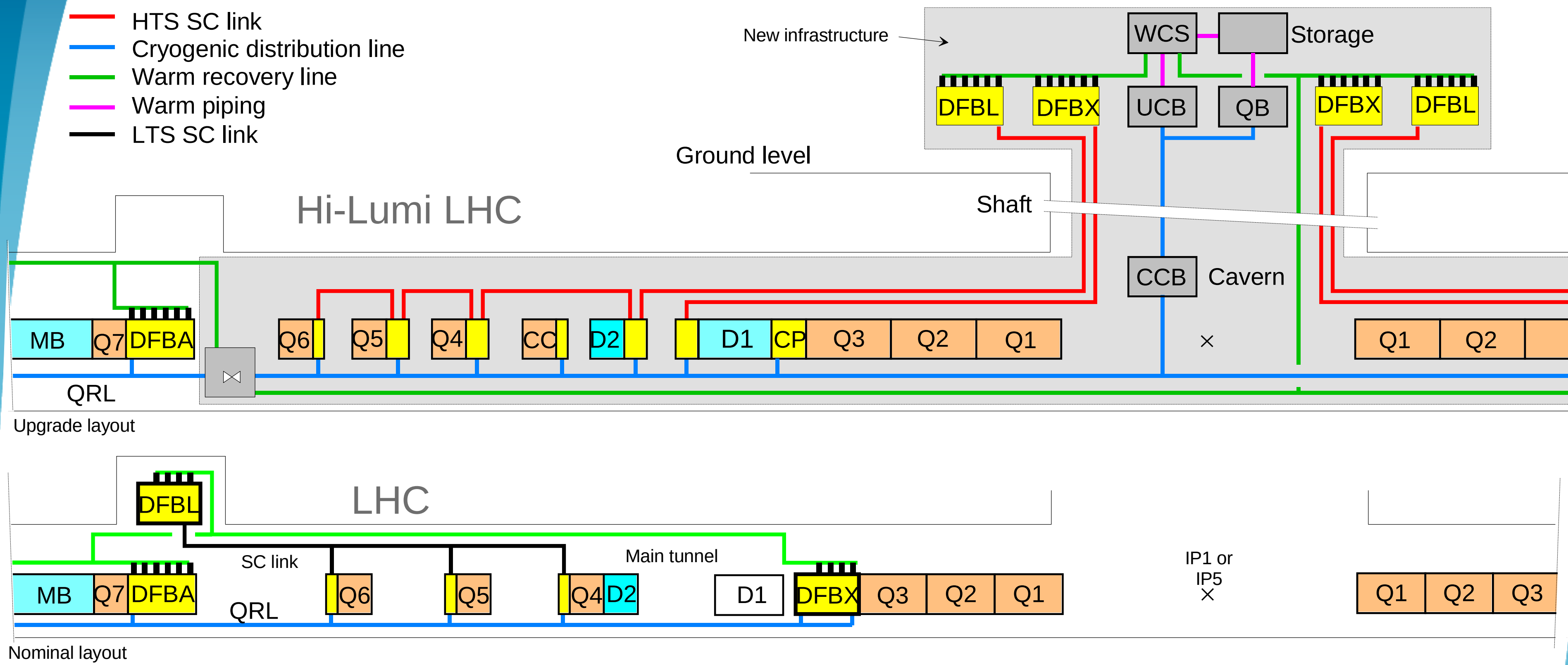
- 2 new cryoplants (~18 kW @ 4.5 K incl. ~3 kW @ 1.8 K) at P1 and P5 for high-luminosity insertions

- 1 new cryoplant (~4 kW @ 4.5 K) at P4 for SRF cryomodules. (Alternative under study: upgrade of 1 existing LHC cryoplant)

- Completely new helium cryogenic distribution between the production plants and client interfaces.

~ 100 m of warm distribution on the surface
~ 100 m of vertical cryogenic distribution
~ 400 m of cryo transfer line in the tunnel

New insertions at P1 & P5



- Cryogenics for new cryo-assemblies (Crab cavities (CC), insertion cryomagnets, DFBs, HTS links…)
- 1 warm compressor station (WCS) in noise insulated surface building
- 1 upper cold box (UCB) in surface building
- 1 cold quench buffer (QV) in surface
- 1 or 2 cold compressor boxes (CCB) in underground cavern
- 2 main cryogenic distribution lines
- 2 interconnection valve boxes with existing QRL (partial redundancy)

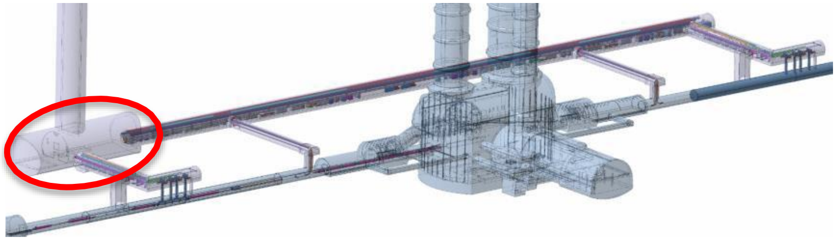
18kW@4.5K incl. 3kW@1.8K
(integrated - mixed cycle)

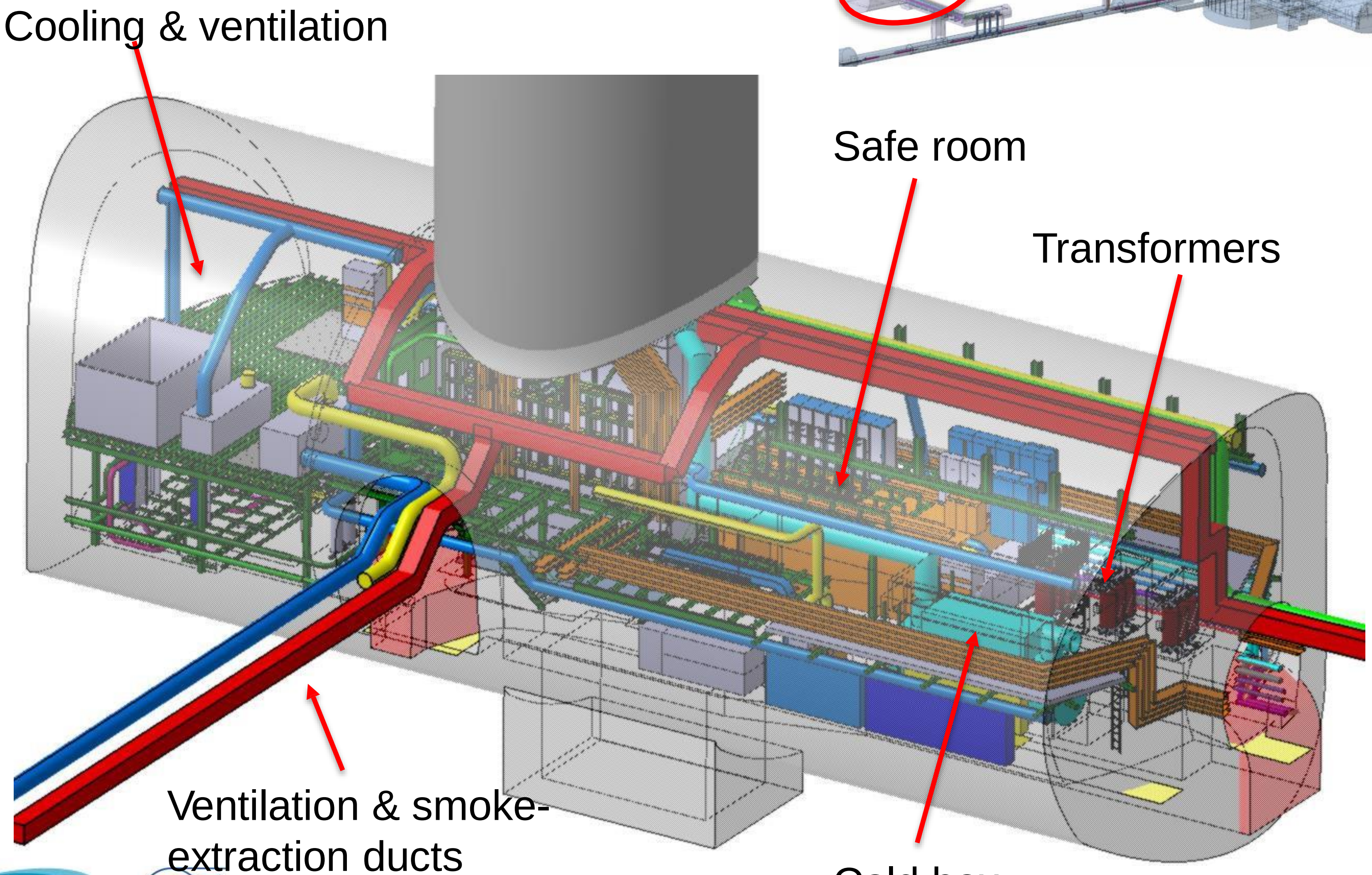
And lines, vessels, …

LHC cryo distribution in 2006 (photos)

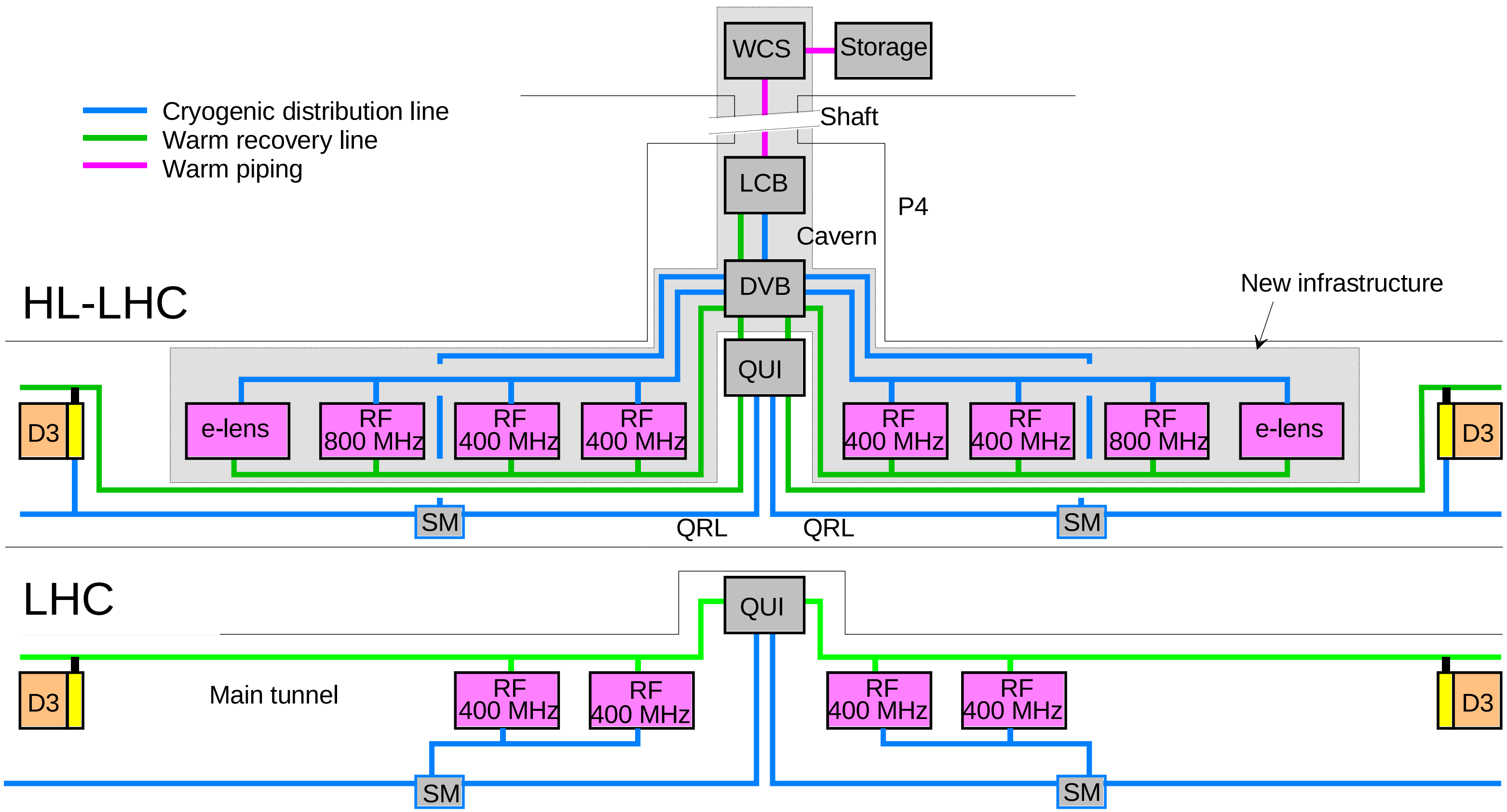
Size of underground structures (e.g. US/UW cavern)

Size defined by integration and transport studies of similar equipment existing at CERN



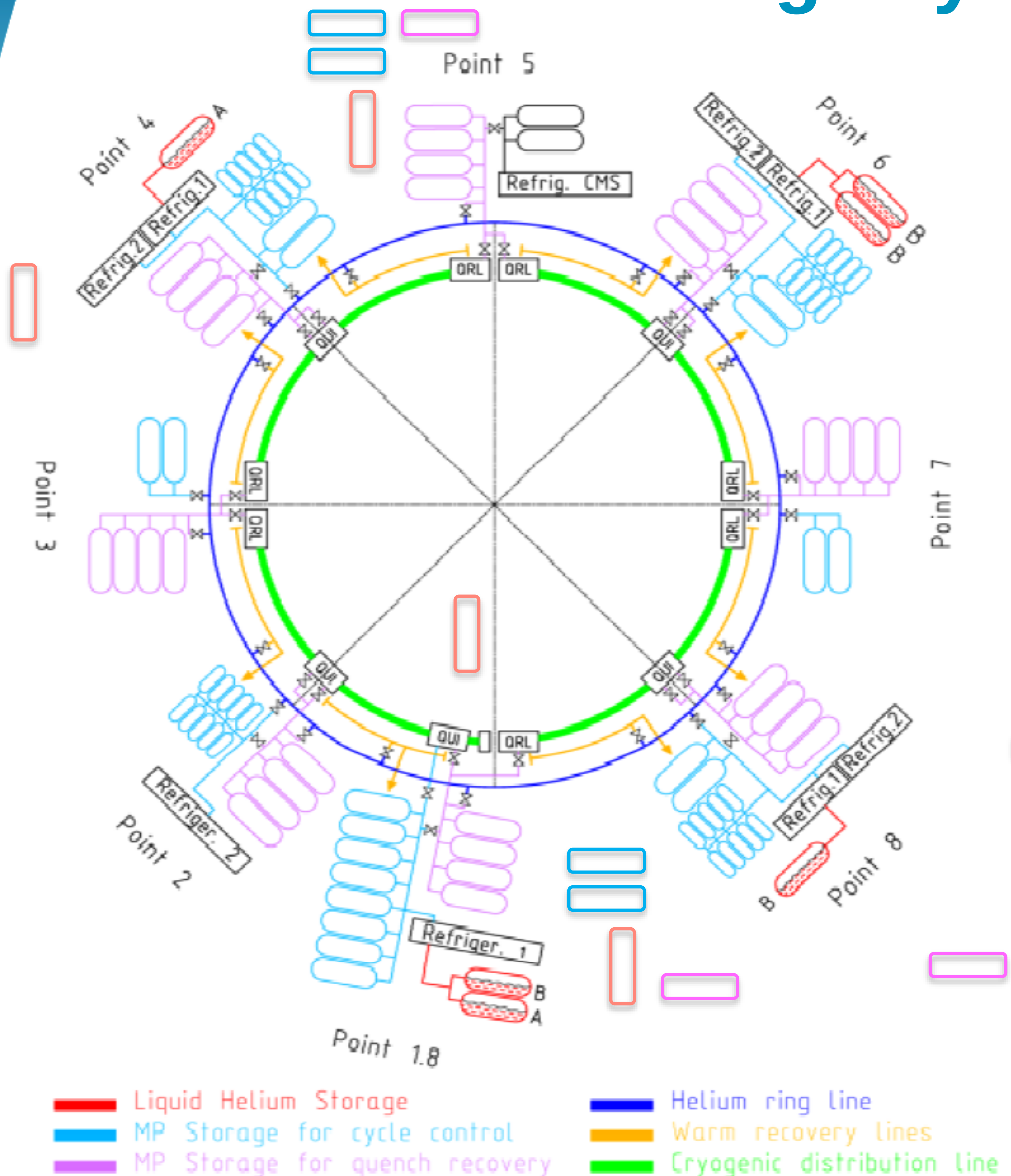


New insertion at P4



- Cryogenics for 800 MHz SRF cryomodules and e-lenses
- 1 warm compressor station (WCS) in noise insulated surface building
- 1 lower cold box (LCB) in UX45 cavern
- 1 valve box in UX45 cavern
- 2 main cryogenic distribution lines
- 2 interconnection lines with existing QRL service modules (redundancy by sector cryoplants)

Storage system



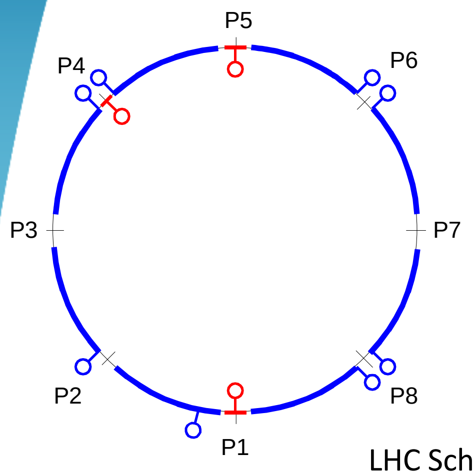
2 x 6 GHe 250 m3 tanks

LN_2: 2017 – BA6, 20m^3, PN6
LN_2: 2019/20 – P4, 20m^3, PN6
(4 tanks)

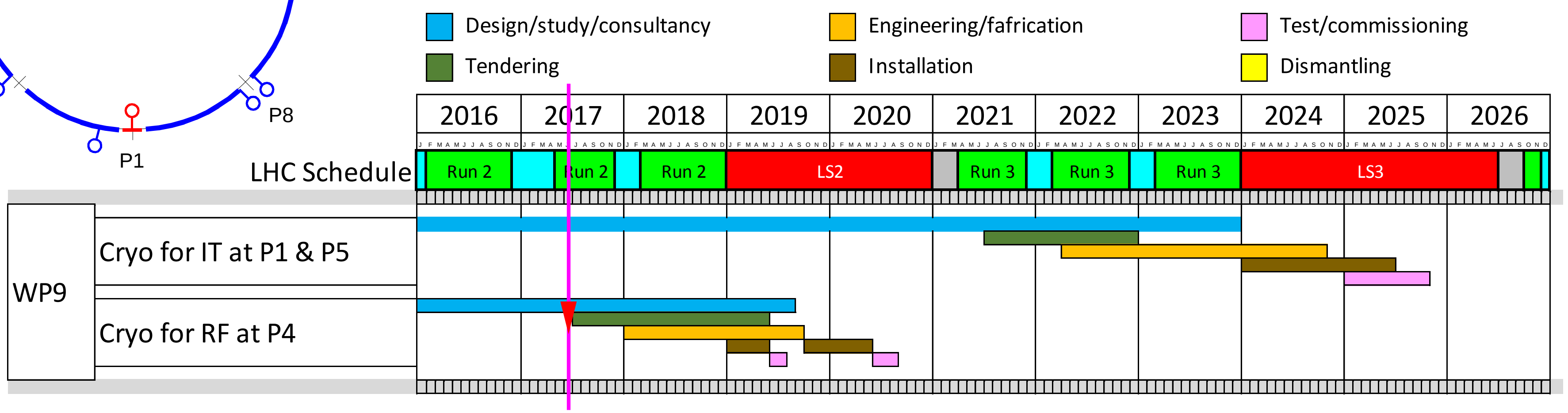
GHe operational storage:
2024 – P1 and P5, 250m^3, 25bar
(4 tanks)

Open option (tbc)
GHe quench storage with LN_2 screen:
2024 – P1 and P5, 50m^3, 25bar
(2 tanks)

HL-LHC Cryogenics Master Schedule



Major HL-LHC Cryo activities



P4-RF:

=> specification work during 2017, for contracts by end'2017 (mid 2018)

P1/P5:

=> 4-5 years to complete design, clarify interfaces and prepare for tendering

Concluding remarks

- The High-Luminosity LHC is a worldwide funded project corresponding to a 1.2 km new accelerator (advanced Nb3Sn, Crab cavities, HTS links) progressively switching to construction, with European institutes and industry heavily involved
- Series of qualification and testing of components foreseen in the coming years
- Now, civil works and global lay-out has been decided, with project fully approved. Precise evaluation of heat-loads and cryogenic architecture are being refined prior to future call for tenders.
- 4 contracts from cryogenics were signed with industry in 2016 with 4 different countries (SPS refrigerator – CH, cryogenic service module – UK, cryogenic valve boxes and 80 m distribution line – I, adaptation valve box for SM18 – F).
  Large part of the HiLumi project is done with industry and not framework collaboration between different institutions.

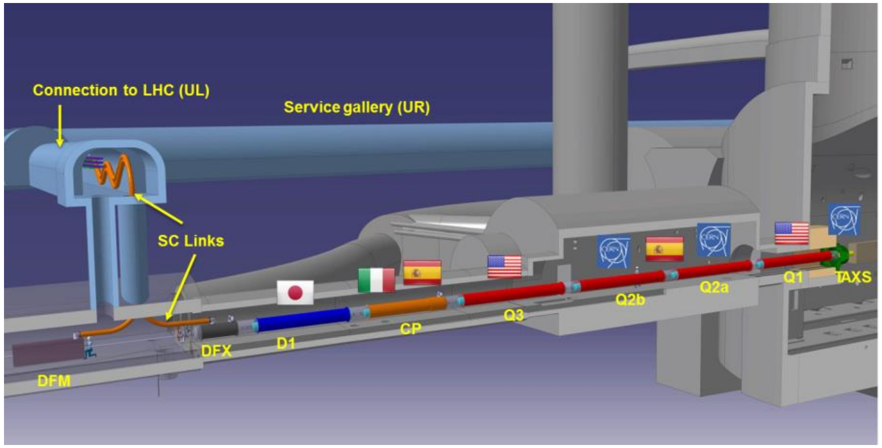
⇒ We will need new Helium/Nitrogen storage, new refrigerators, valve boxes and hundreds meters of the distribution system… and we are here to help you selecting what could be adapted to your abilities !

Thank you for your attention

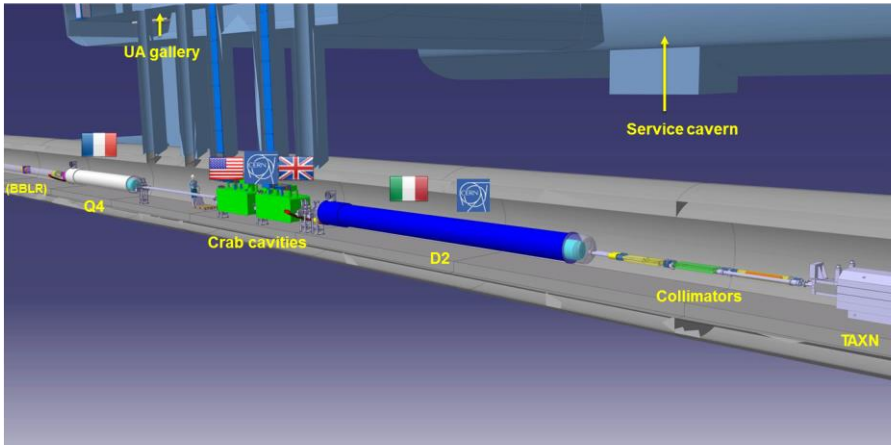
Spare Slides

HL-LHC configuration

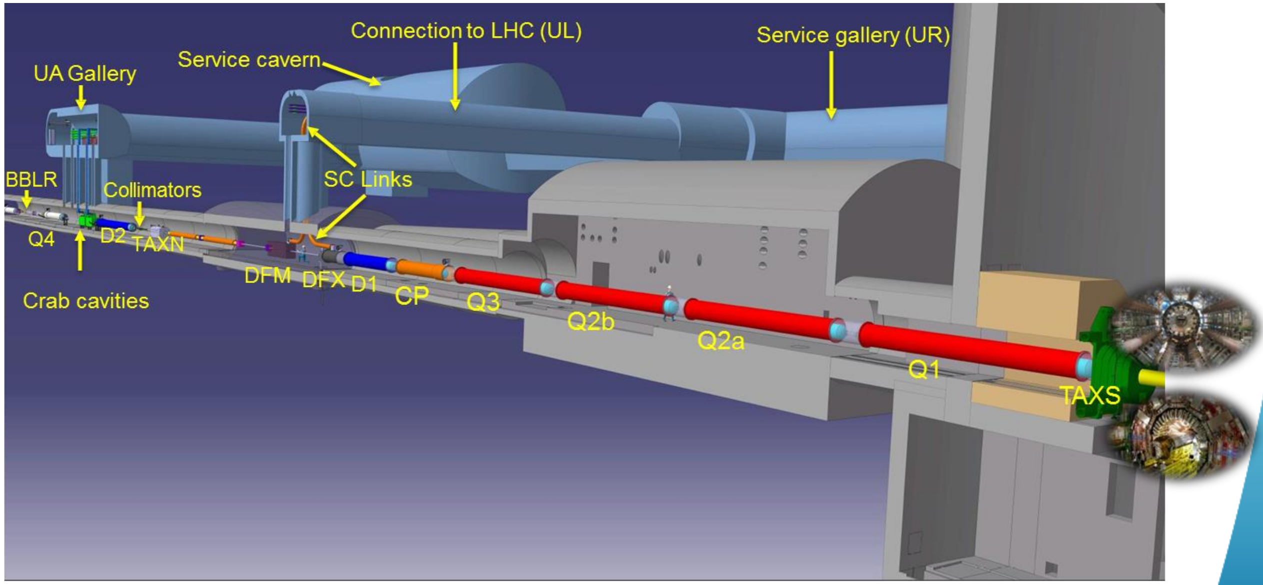
The Inner Triplet region with in-kinds



The MS regions with in-kinds



The Insertion Region (till Q4)

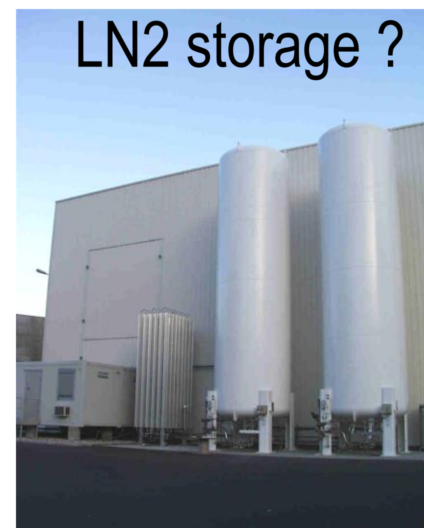


What it would look like: Surface

Helium Vessels

New surface buildings, shafts and caverns to be constructed, to accommodate for new Hardware to be installed

One cold box

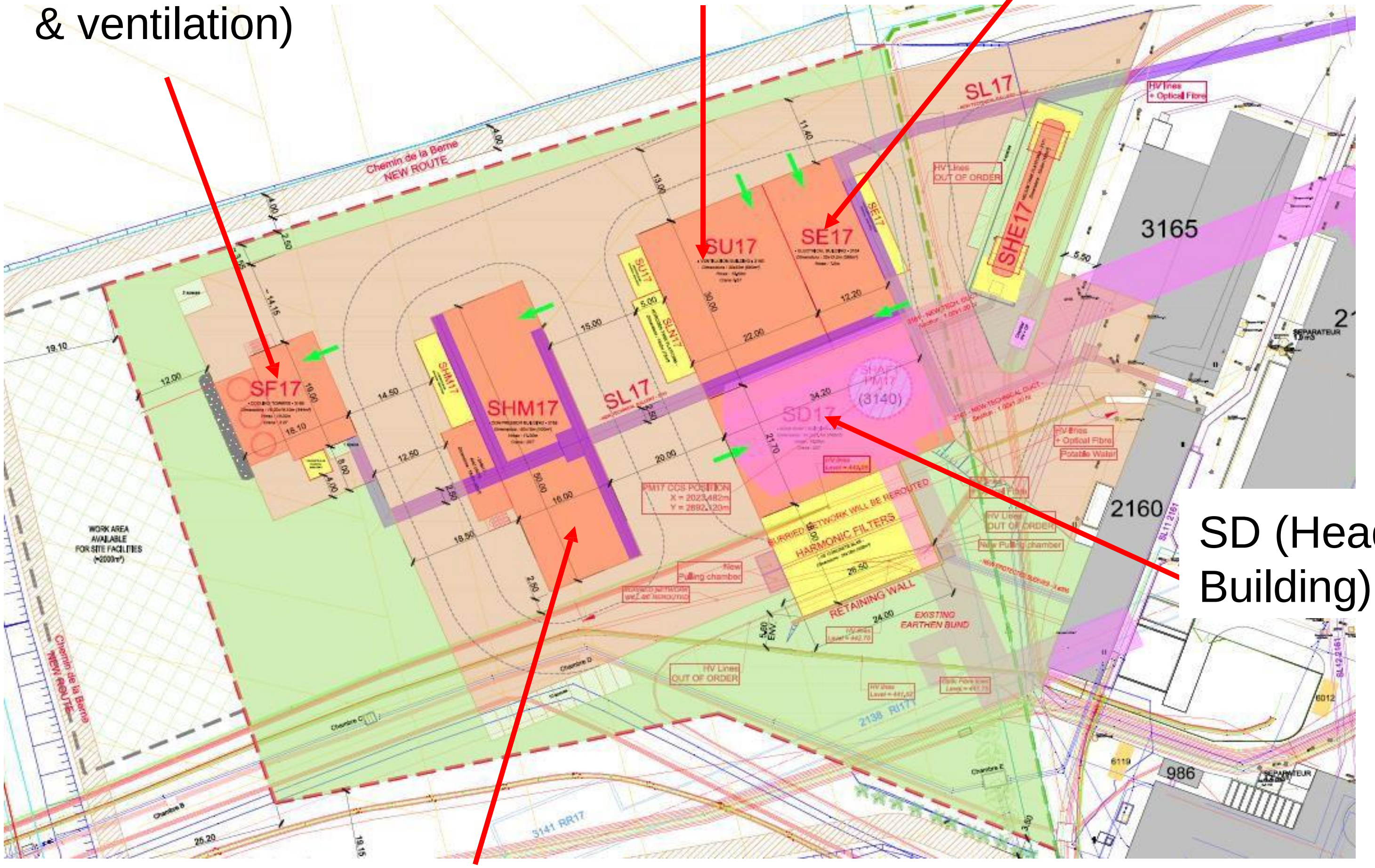


New HL-LHC surface buildings at P1

SF (Cooling & ventilation)

SU (Cooling & ventilation)

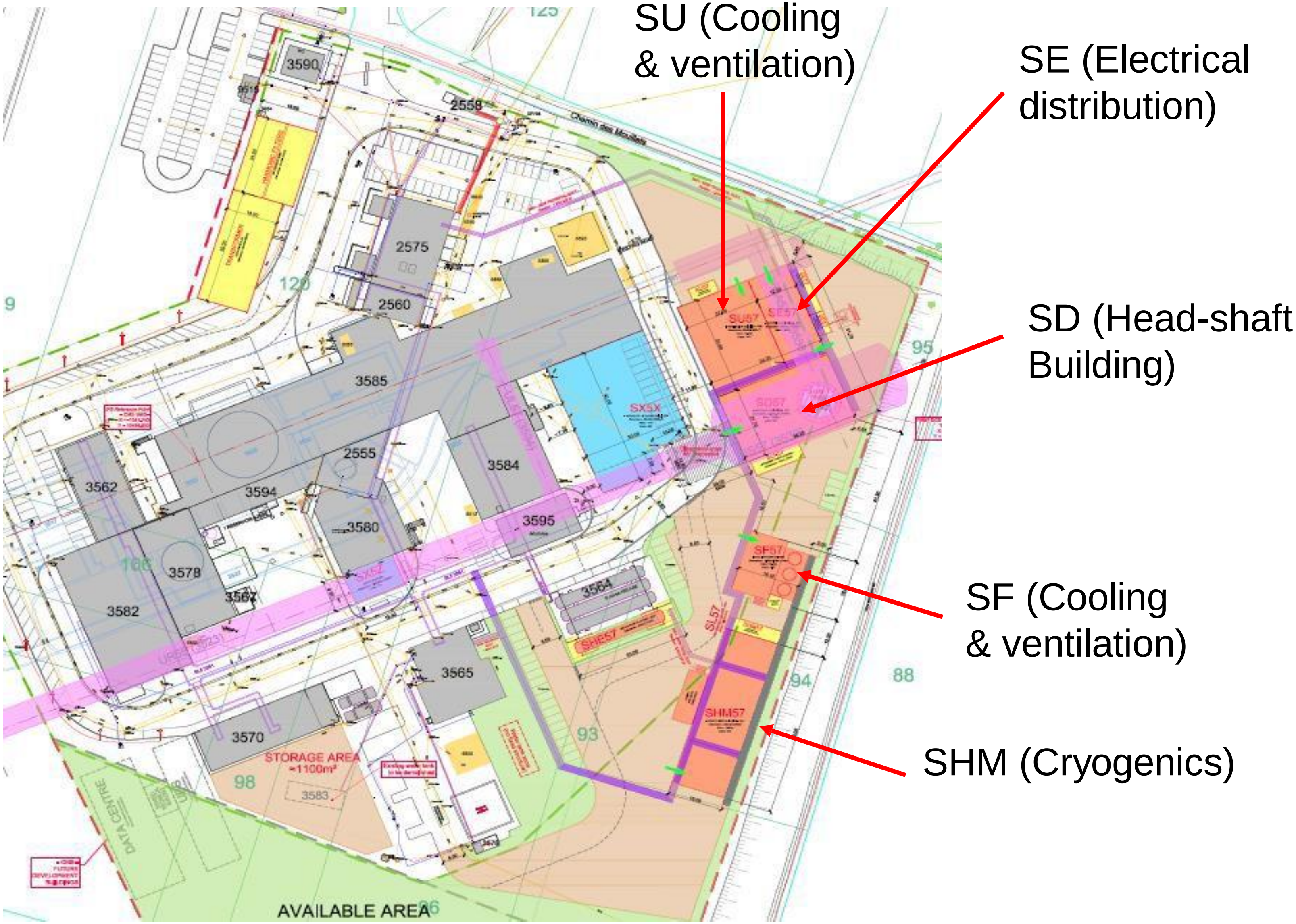
SE (Electrical distribution)



SD (Head-shaft Building)

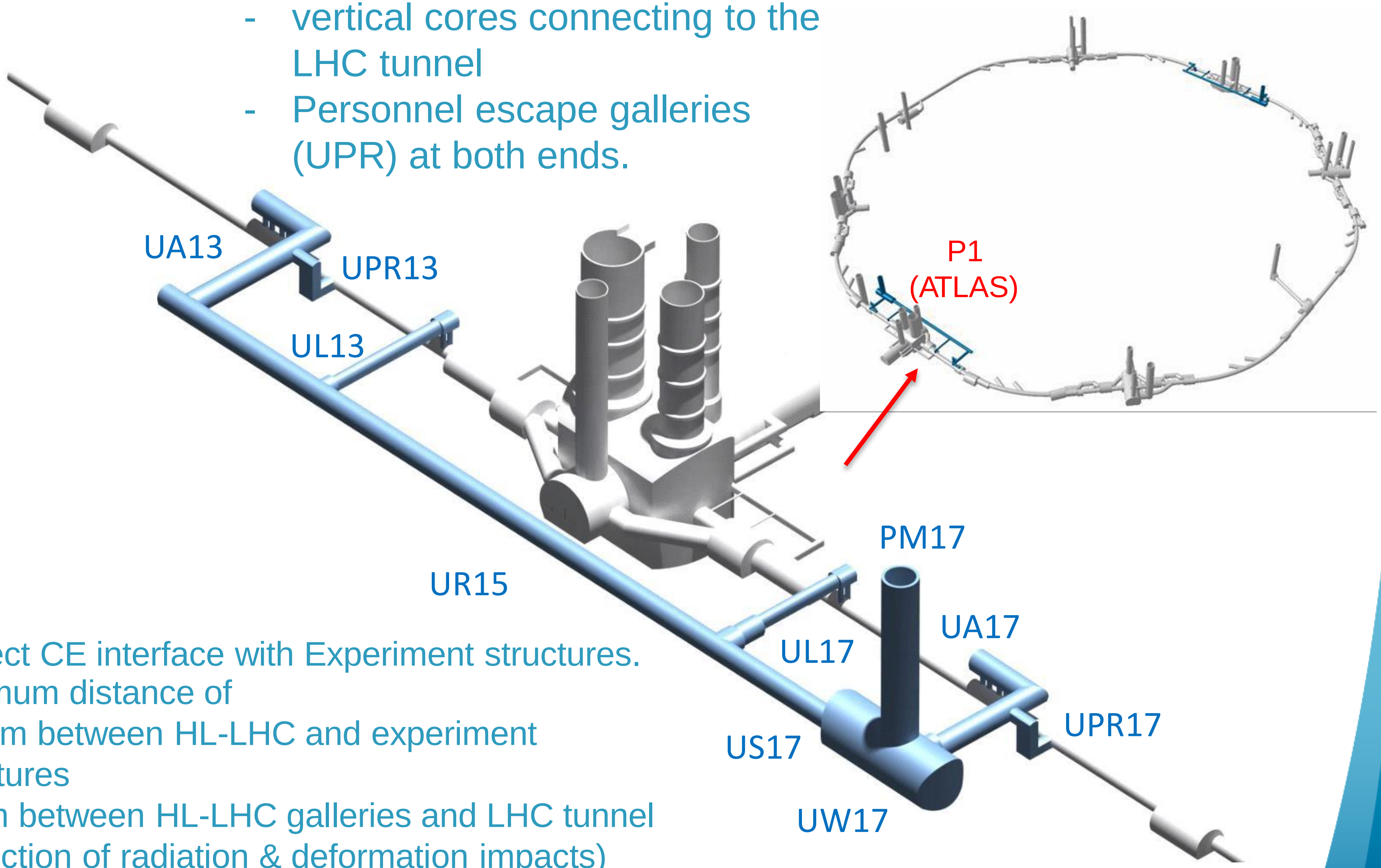
SHM (Cryogenics)

New HL-LHC surface buildings at P5



HL-LHC underground structures at P1

Based on double-decker with:
- vertical cores connecting to the LHC tunnel
- Personnel escape galleries (UPR) at both ends.



- No direct CE interface with Experiment structures.
- Minimum distance of
  ~ 15 m between HL-LHC and experiment structures
  ~ 7 m between HL-LHC galleries and LHC tunnel (reduction of radiation & deformation impacts)

HL-LHC underground structures at P5