Associated Cryogenics for HL-LHC project

2nd HiLumi Industry Day – October 31st 2016

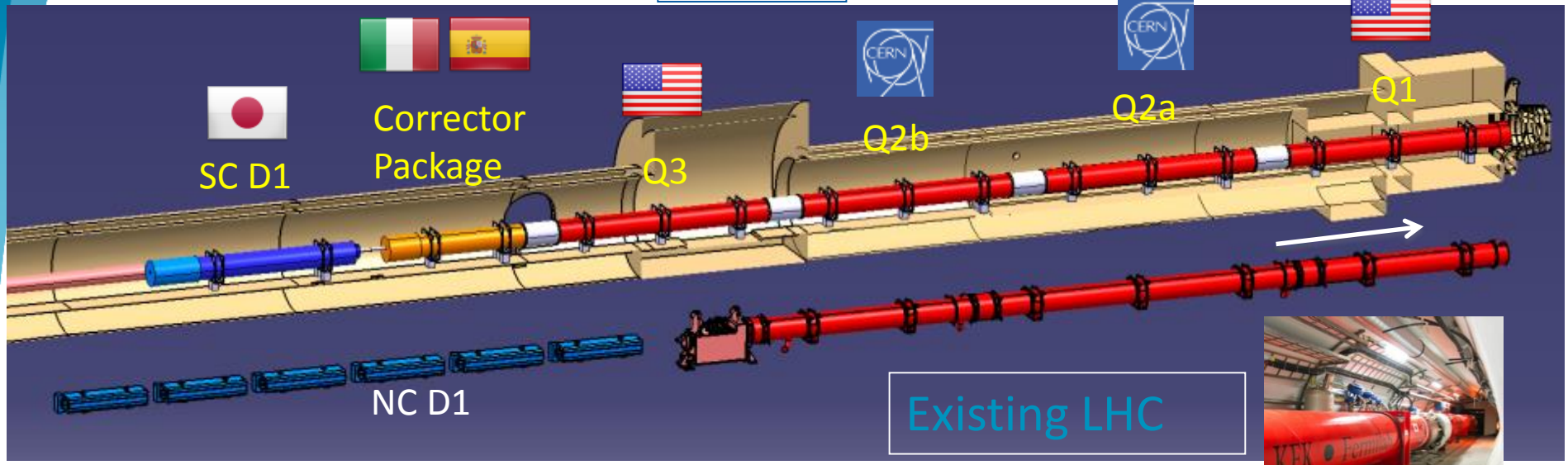
Laurent Delprat – CERN

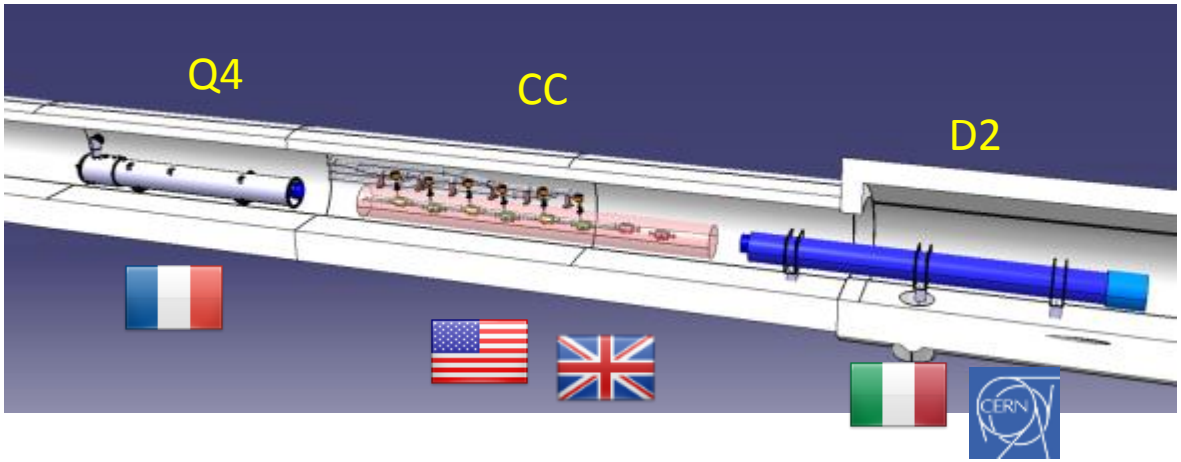
OUTLOOK

- Main sub-systems concerned (to be cooled)
- The Cryogenic part of it
- Concluding remarks

HL-LHC configuration

HL-LHC





HL-LHC systems are entering detailed integration phase

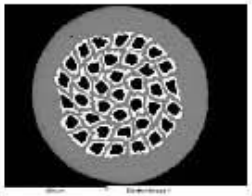
New baseline adopted to increase operating margins (Nb3Sn quadrupoles)

In-kind contribution and Collaborations for HW design and prototypes

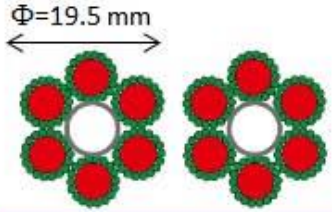
Cold Powering System HTS links

- 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

MgB_2 Wire
(Φ = 0.9 mm)



MgB_2 Cables



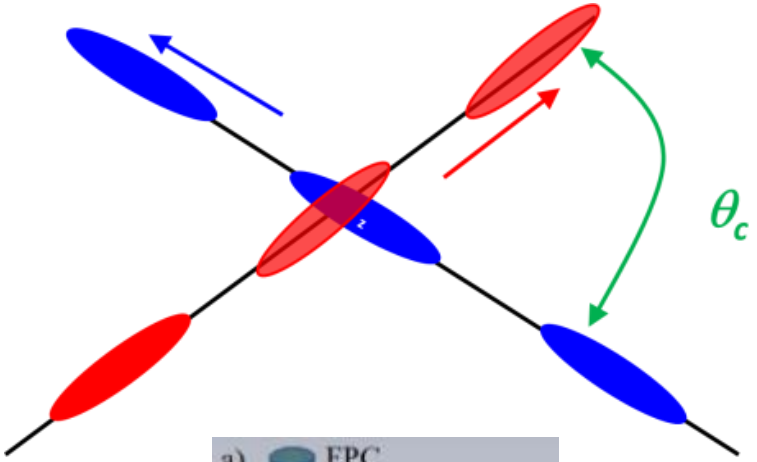
I=20 kA @ 24 K

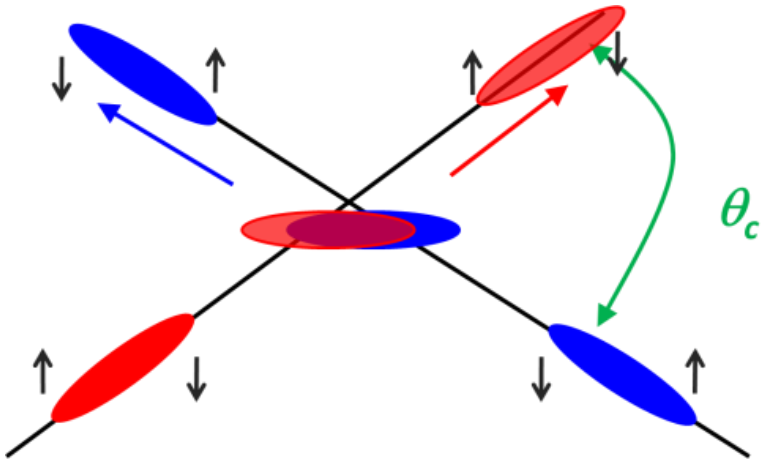
Excellent results obtained for elementary part of the cable

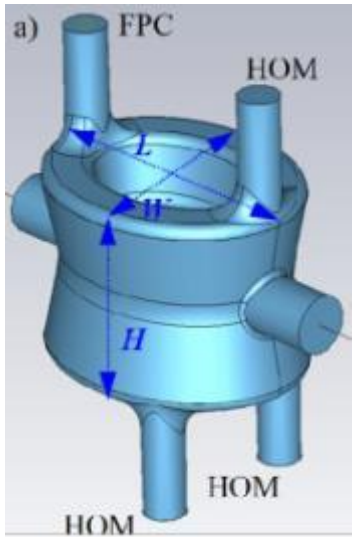
Global engineering (termination boxes, supporting) under study

Effect of the crab-cavities

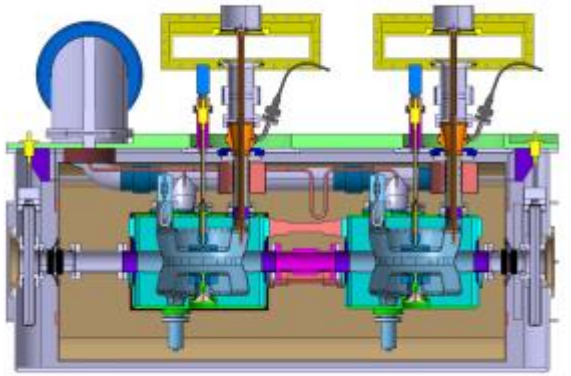
To compensate for the larger crossing angle







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



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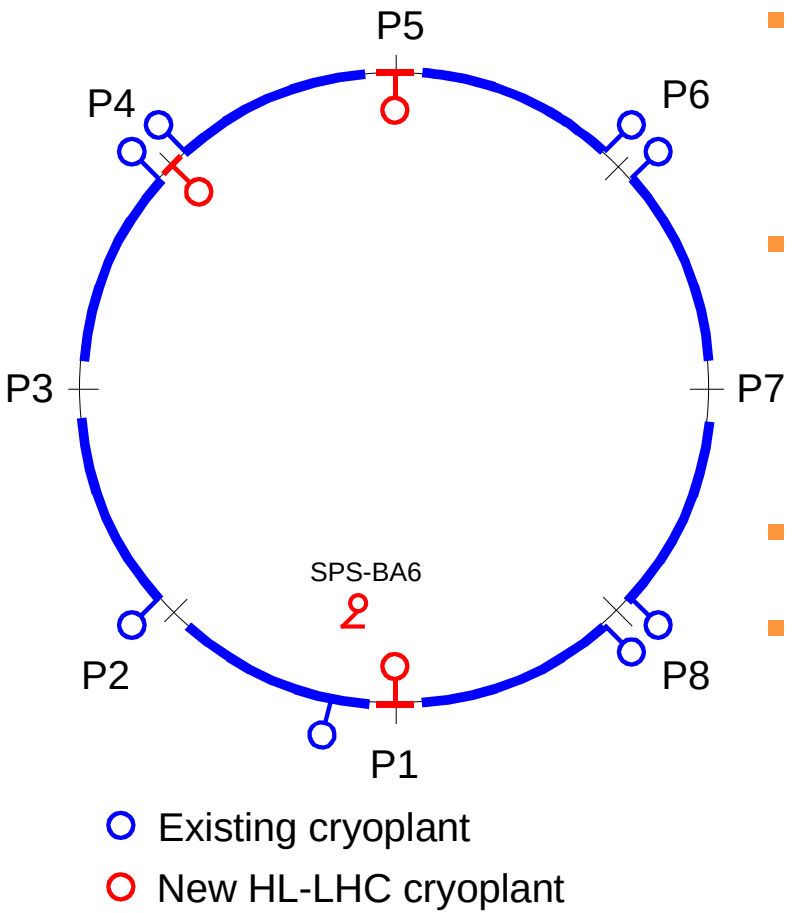
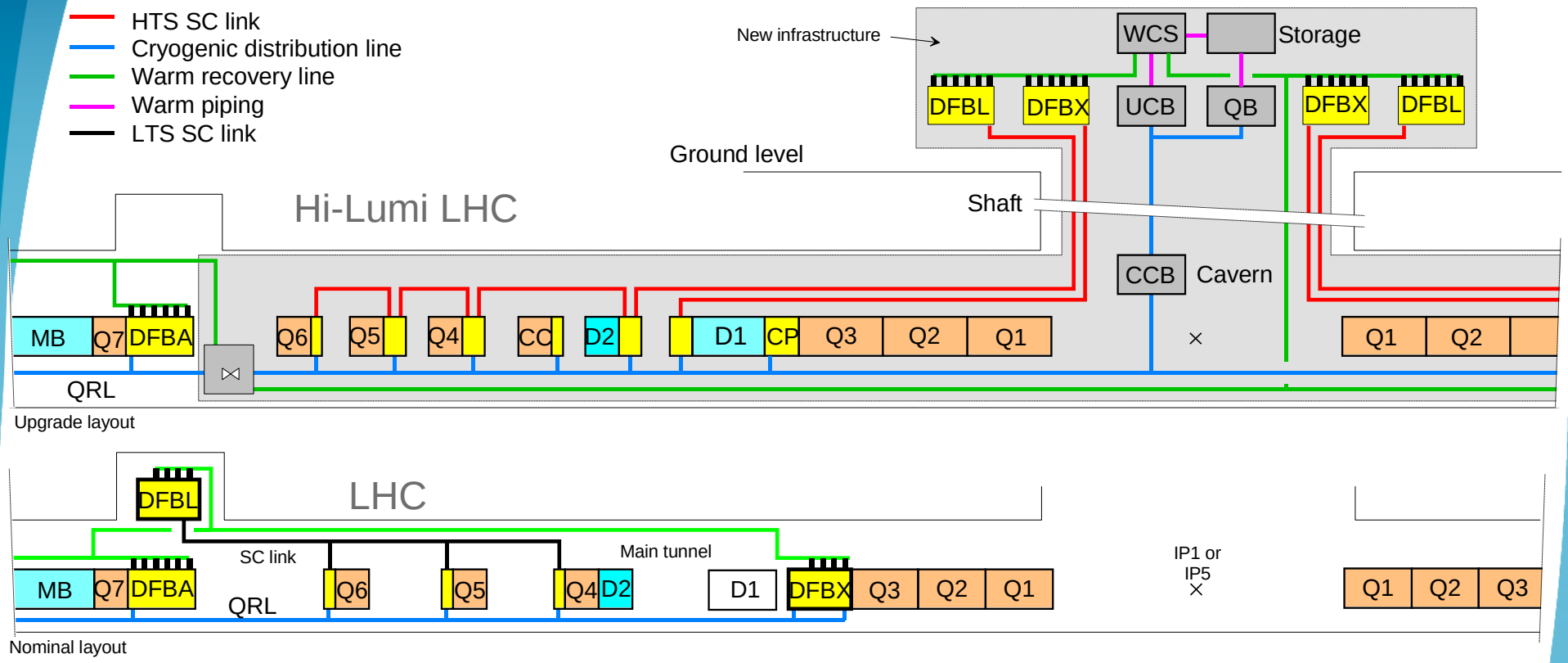
HL-LHC Cryo Upgrade



- 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 and distribution)
- 11T + Q5@P6
- SRF test facility with beam at SPS-BA6 primarily for Crab-Cavities

SM18 related activities not reported here

New insertions at P1 & P5



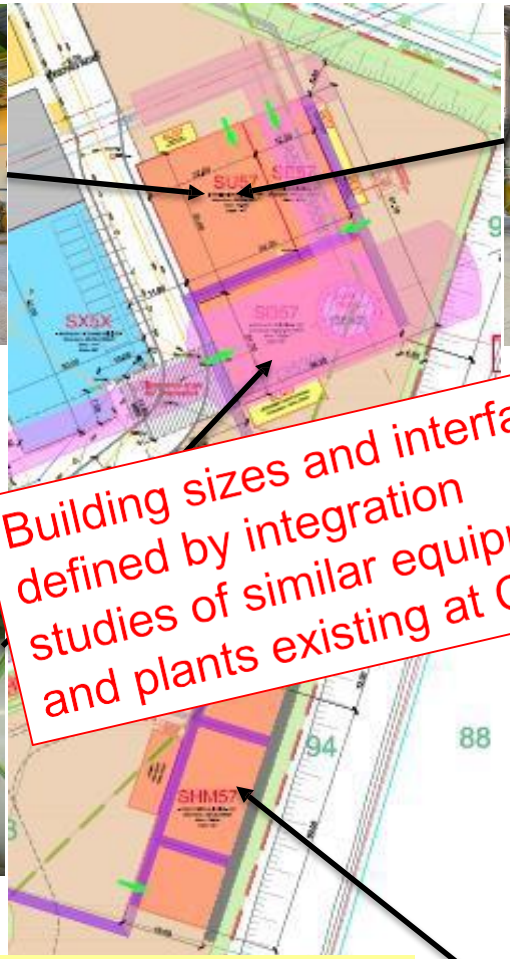
- Cryogenics for new cryo-assemblies (Crab cavities (CC), insertion cryomagnets, DFBs, HTS links…)
- 1 warm compressor station (WCS) in noise insulated surface building
- 1 upper cold box (UCB) in surface building
- 1 cold quench buffer (QV) in surface
- 1 or 2 cold compressor boxes (CCB) in underground 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, …

Technical Infrastructures at P5

SU Ventilation units



SU chillers & pumping stations

Building sizes and interfaces defined by integration studies of similar equipment and plants existing at CERN

SD He refrigerator

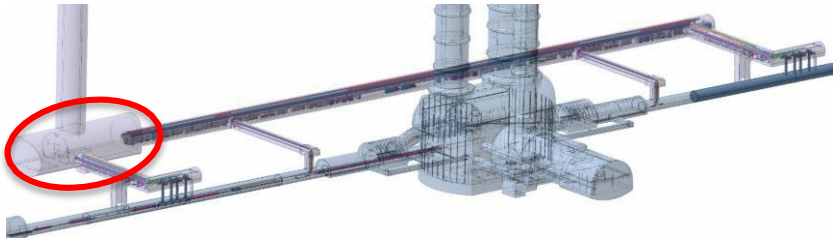
SF cooling towers

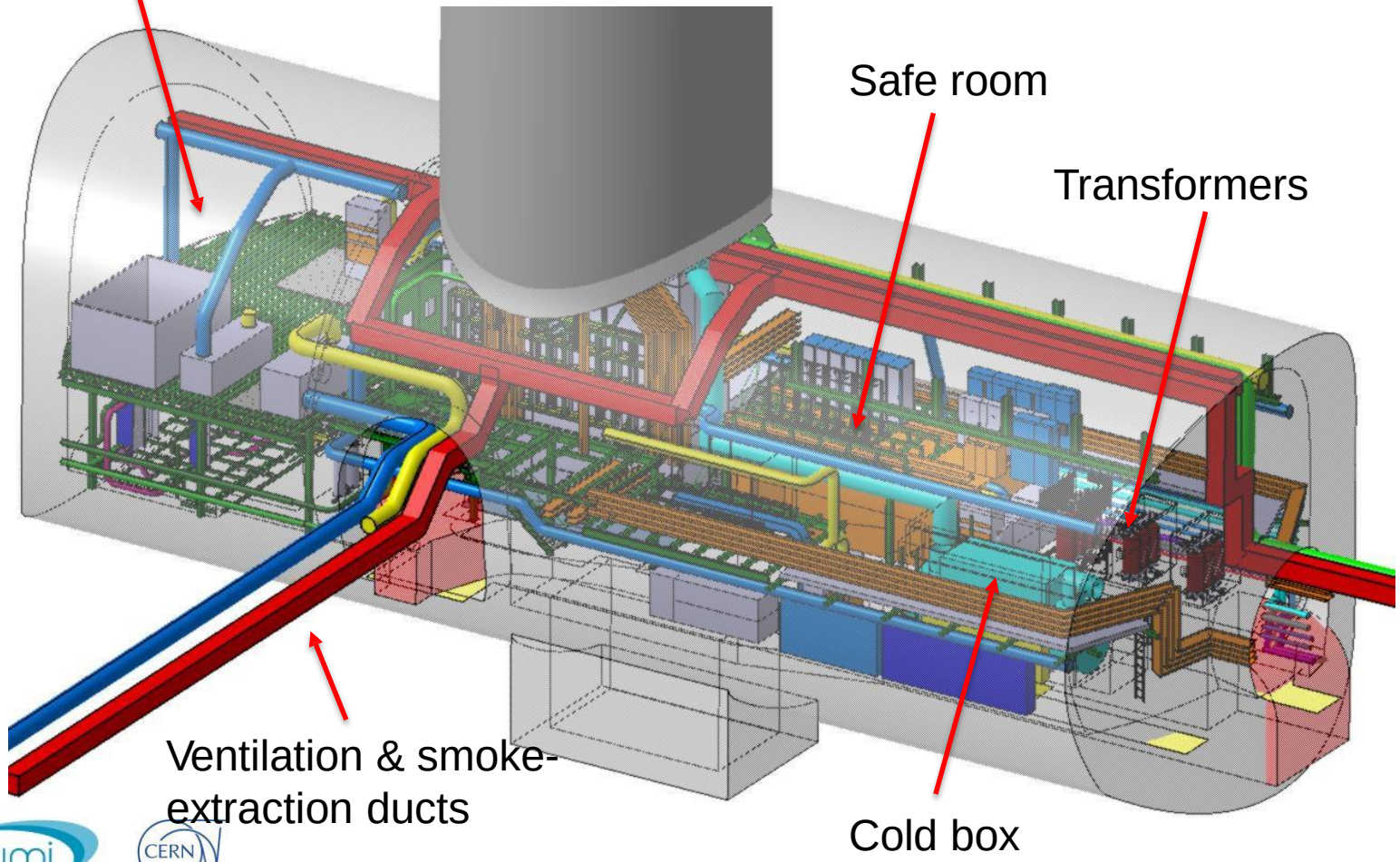
SHM Helium compressor station

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

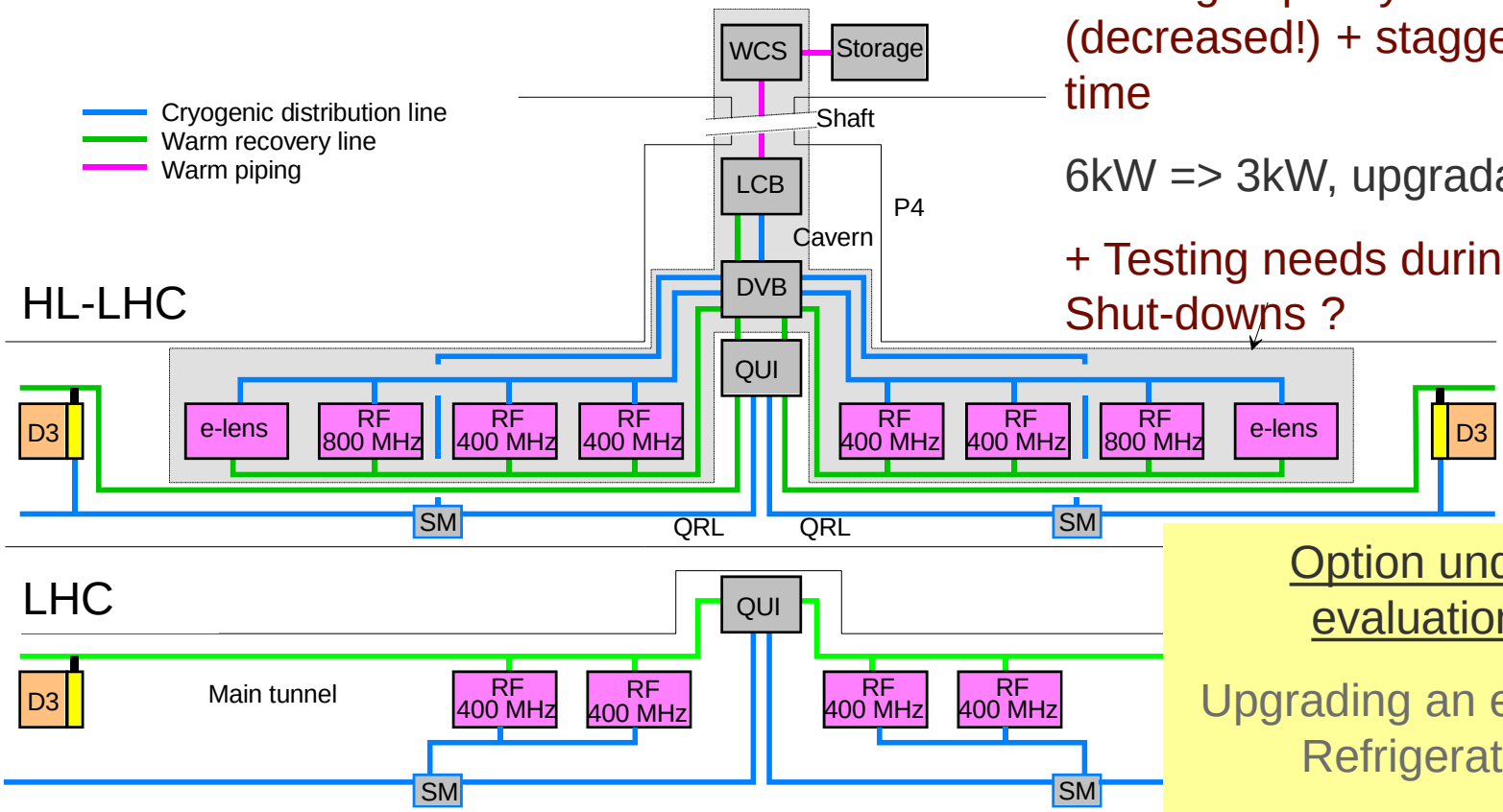
Size of underground structures (e.g. US/UW cavern)

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





New insertion at P4



Cooling capacity revised (decreased!) + staggered in time

6kW => 3kW, upgradable?

+ Testing needs during Long Shut-downs ?

Option under evaluation:

Upgrading an existing Refrigerator

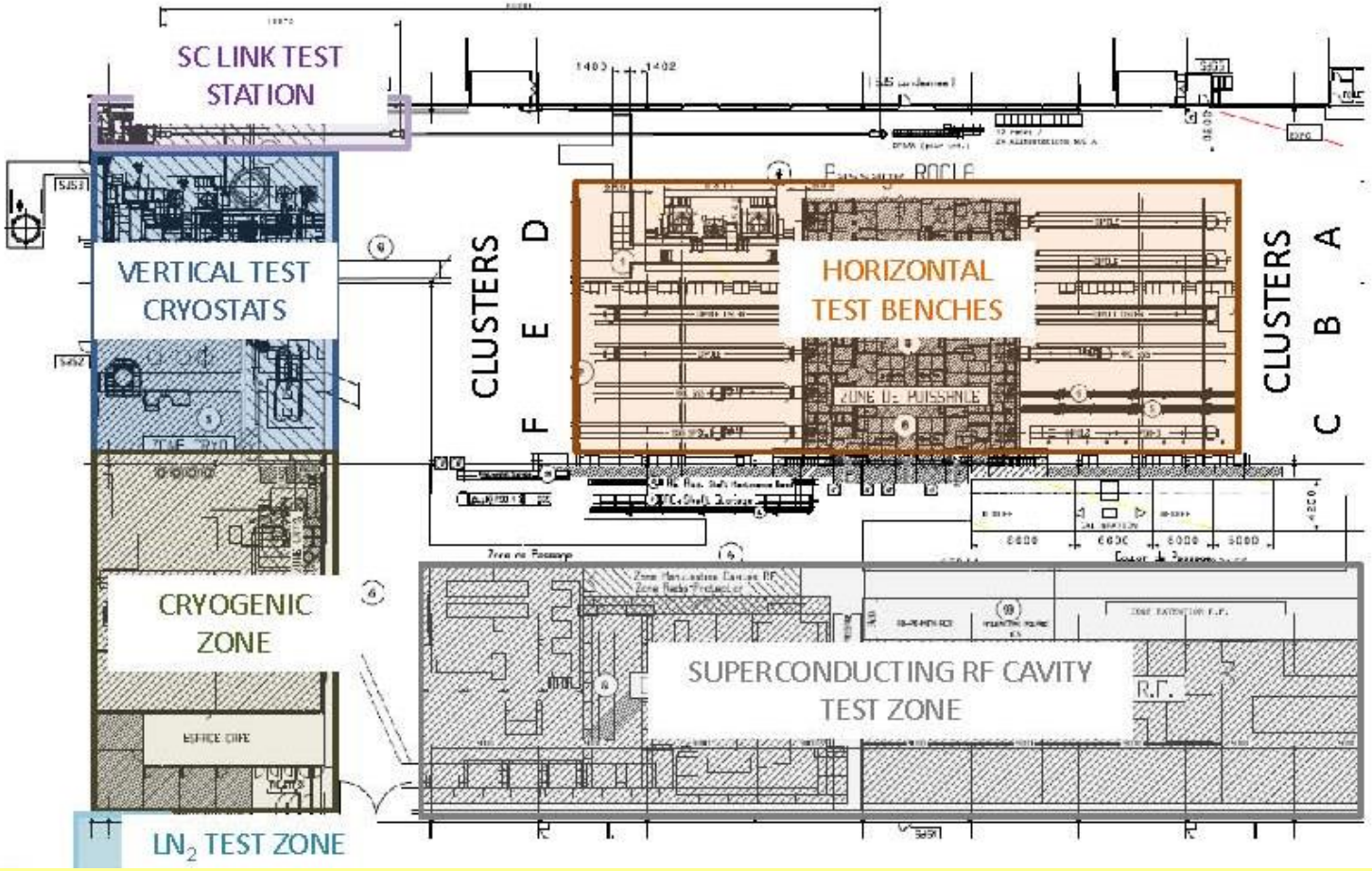
+ dedicated 700W refrigerator for LS

- Cryogenics for 800 MHz SRF cryomodules and e-lenses
- 1 warm compressor station (WCS) in noise insulated surface build
- 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)

Test & Qualification

THE ZONES in the Building 2173

SM18 building, 100m x 80m, 6kW@4.5K

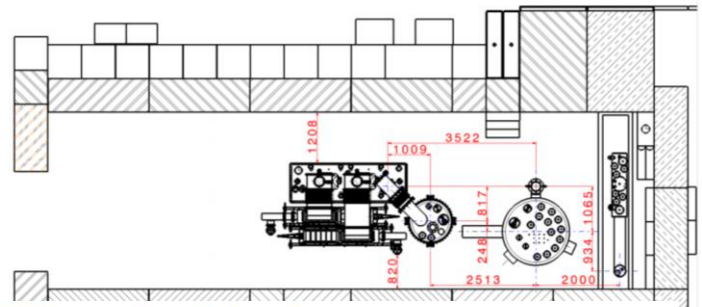


A serious transformation of this test station and cryogenic hardware has started and is to be continued to validate all the HL-LHC superconducting sub-systems

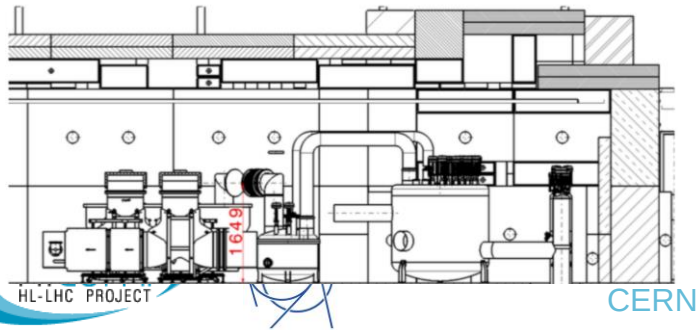
SM18 – RF M7 Bunker upgrade

Ready **DO 30148** **DO 30000**

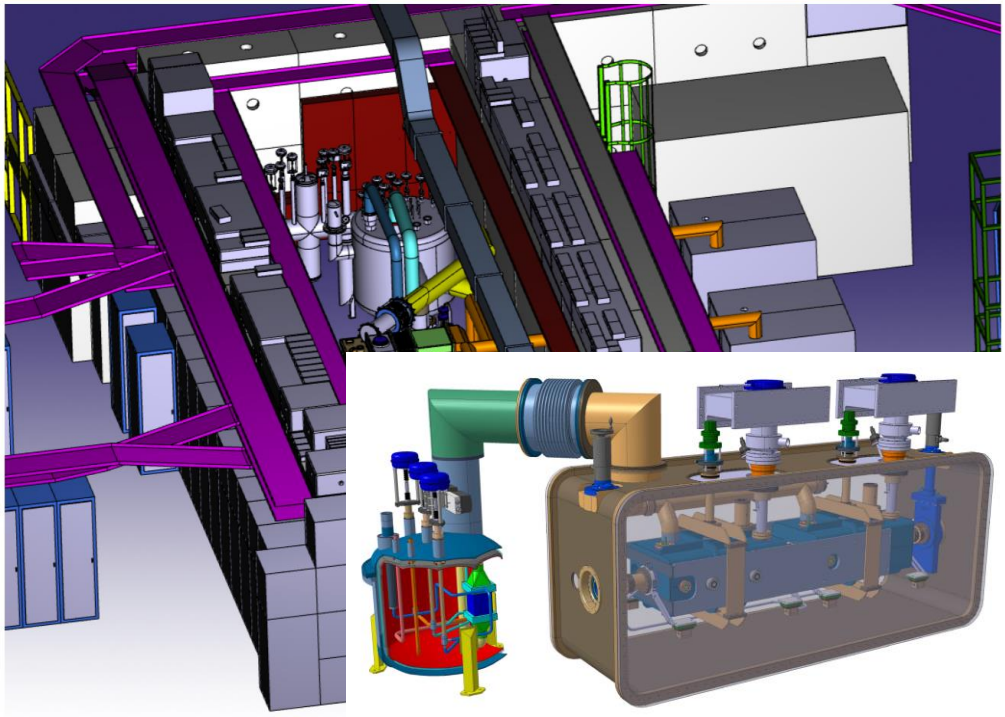
M7 layout - top view



M7 layout - side view

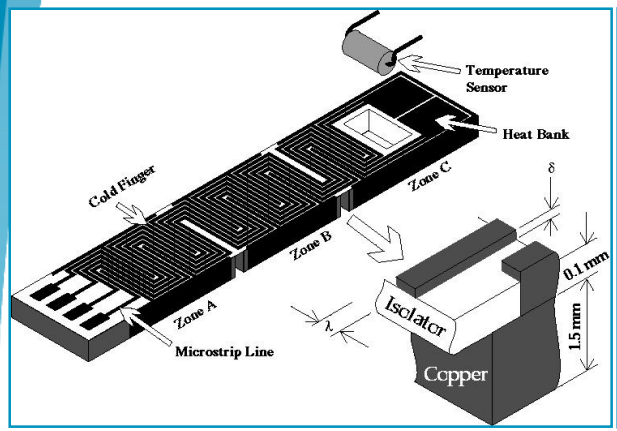


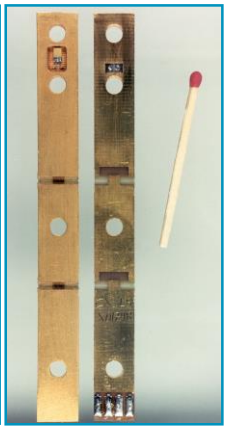
M7 Bunker Layout

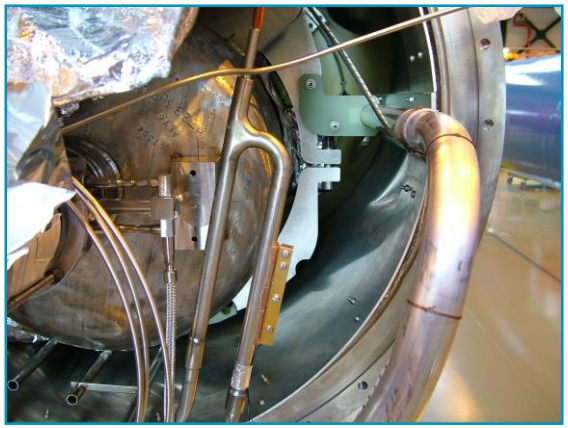


Thermometry

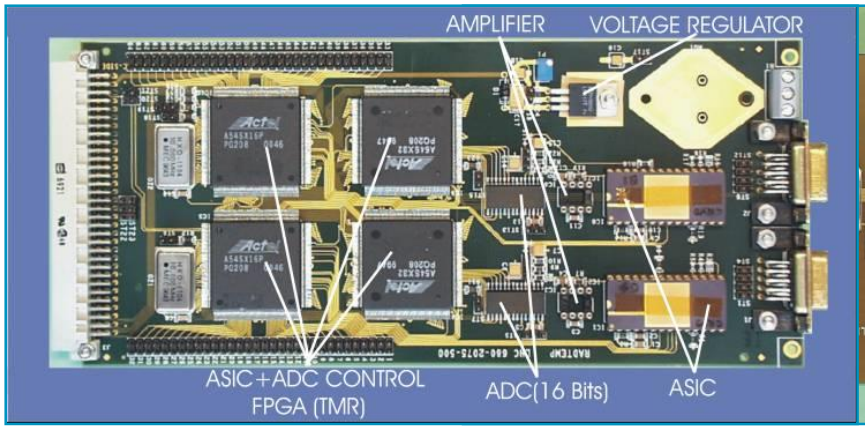
6’000 units, +/- 10 mK @ 2K in LHC radiation conditions

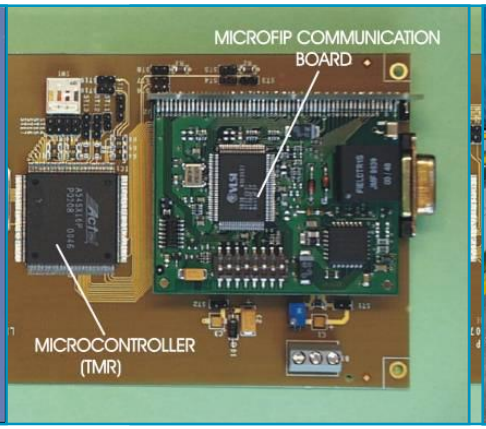


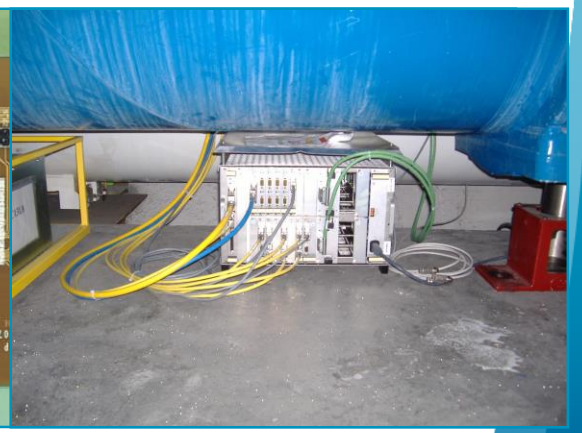




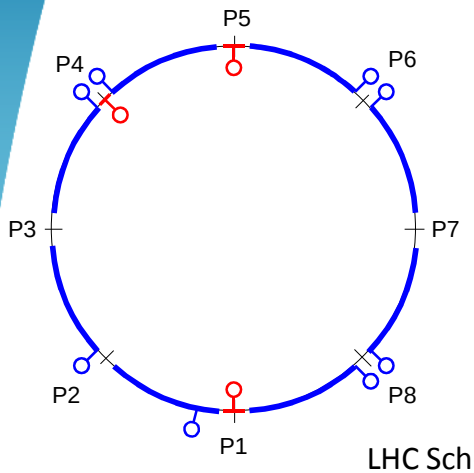
From ‘sensor’ to ‘thermometer’ with signal processing





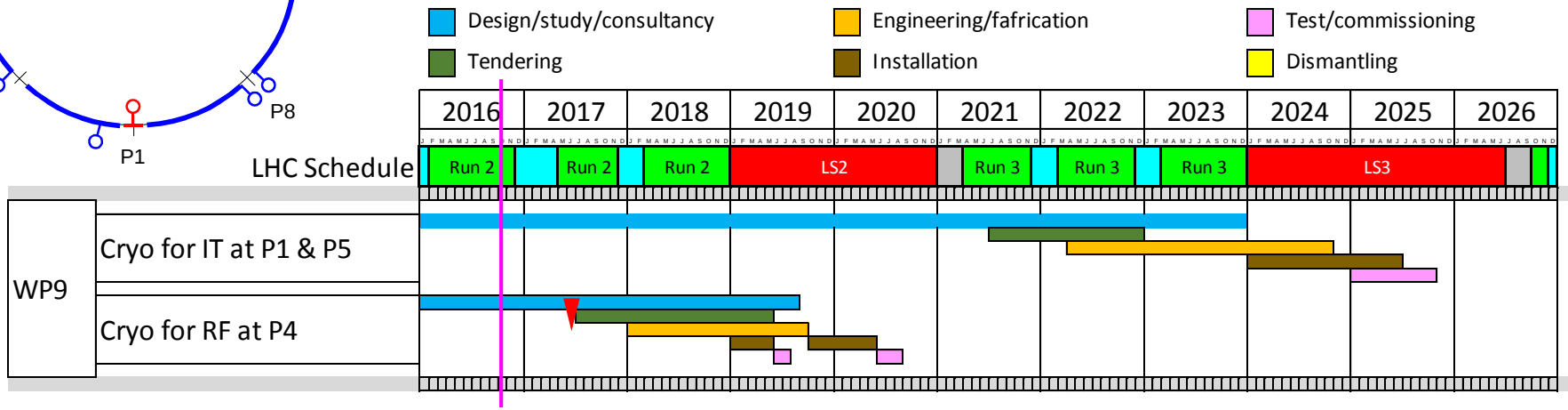


HL-LHC Cryogenics Master Schedule



Major HL-LHC Cryo activities

(SPS-BA6 on tracks, in parallel with SM18 activities)



P4-RF:

=> Decision baseline/alternative by end of 2016 for work @LS2

=> Then specification work during 2017, for contracts by end'2017

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 1.2km 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.

⇒ We will need new refrigerators, valve boxes, cryo-lines, vessels … and we are here to help you selecting what could be adapted to your abilities !

HiLumi
HL-LHC PROJECT

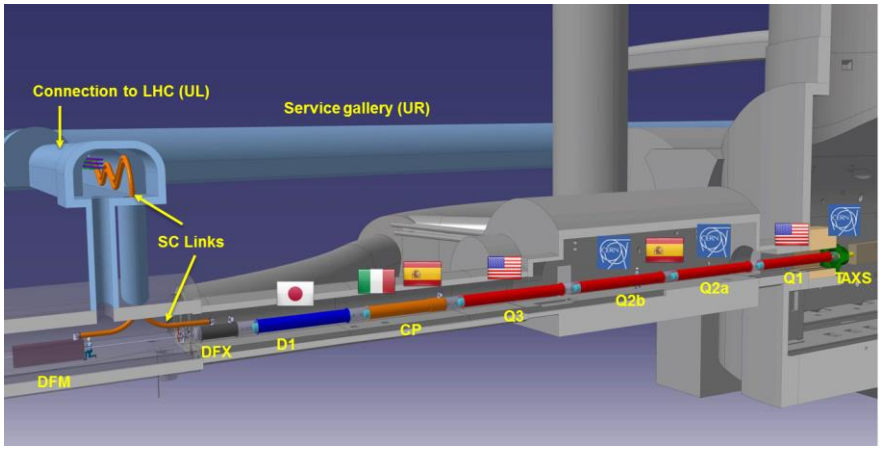
Thank you for your attention

CERN

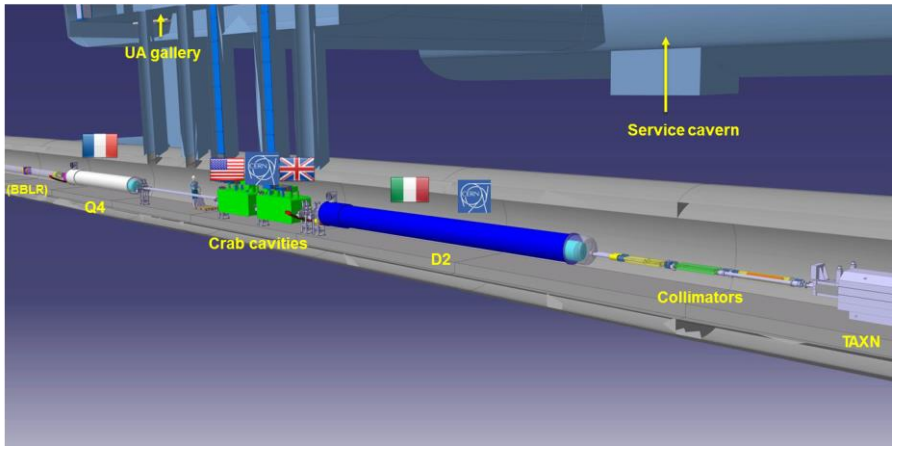
Spare Slides

HL-LHC configuration

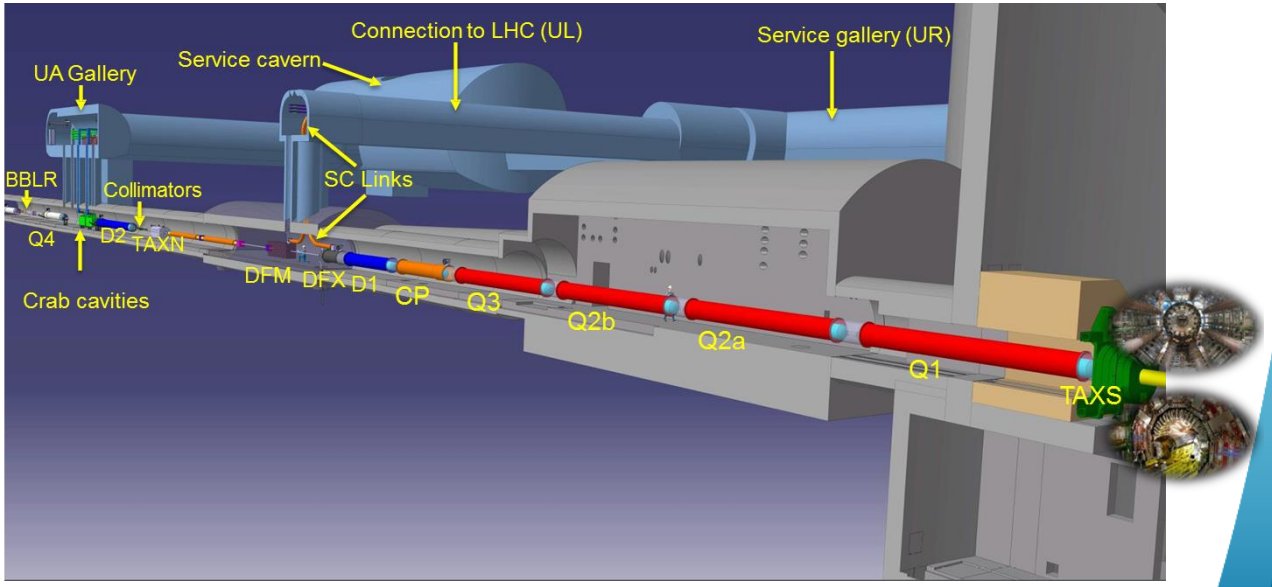
The Inner Triplet region with in-kinds



The MS regions with in-kinds



The Insertion Region (till Q4)

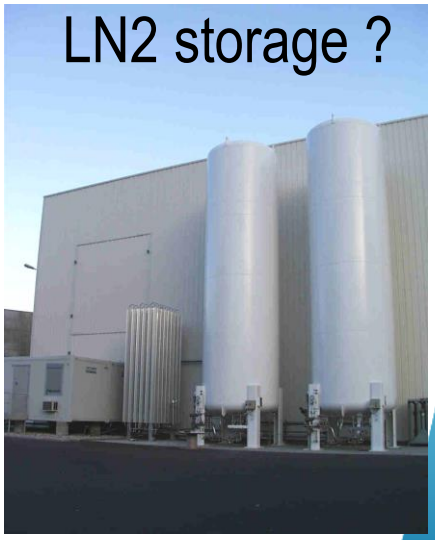


What it would look like: Surface

Helium Vessels

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

One cold box

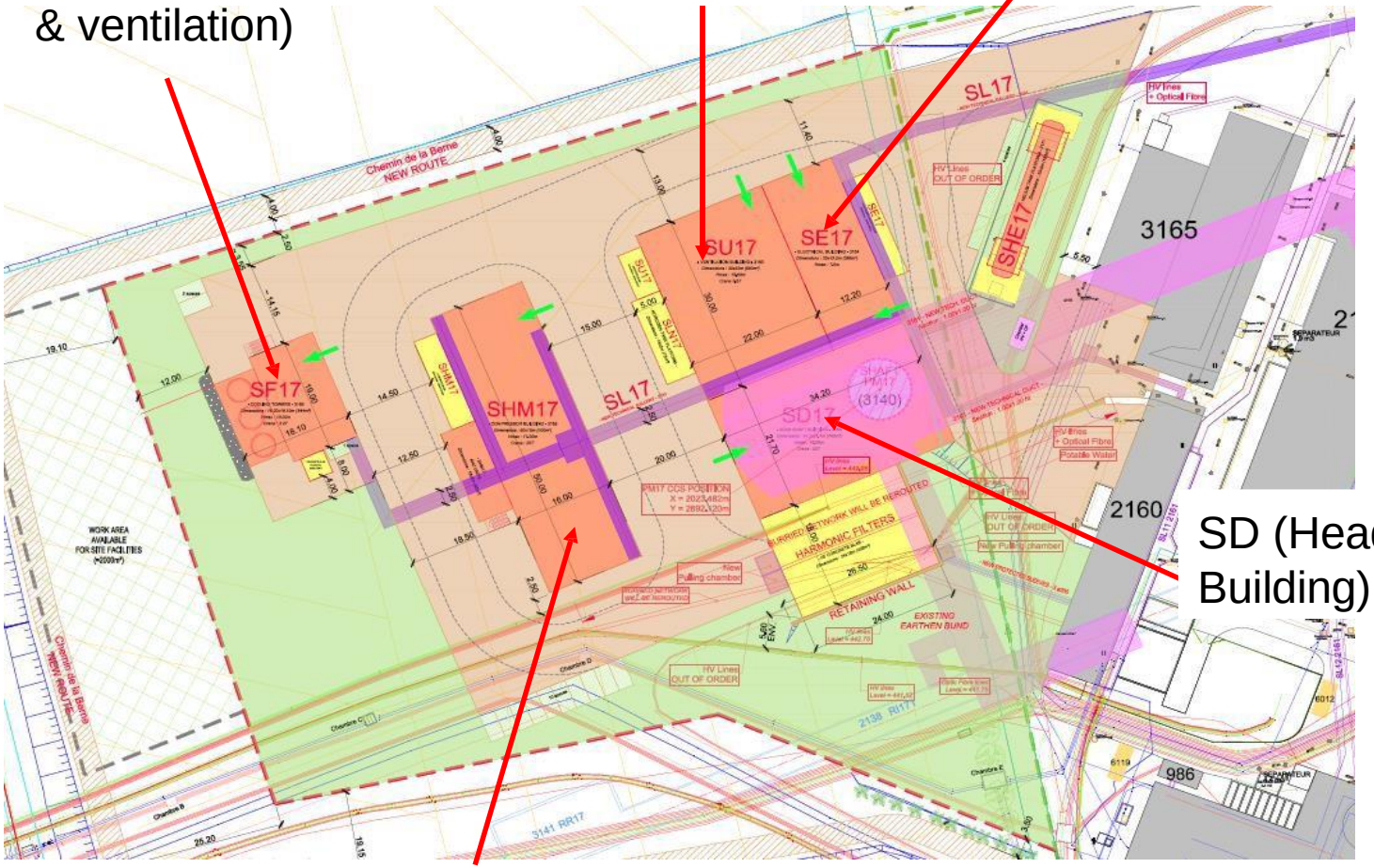


New HL-LHC surface buildings at P1

SF (Cooling & ventilation)

SU (Cooling & ventilation)

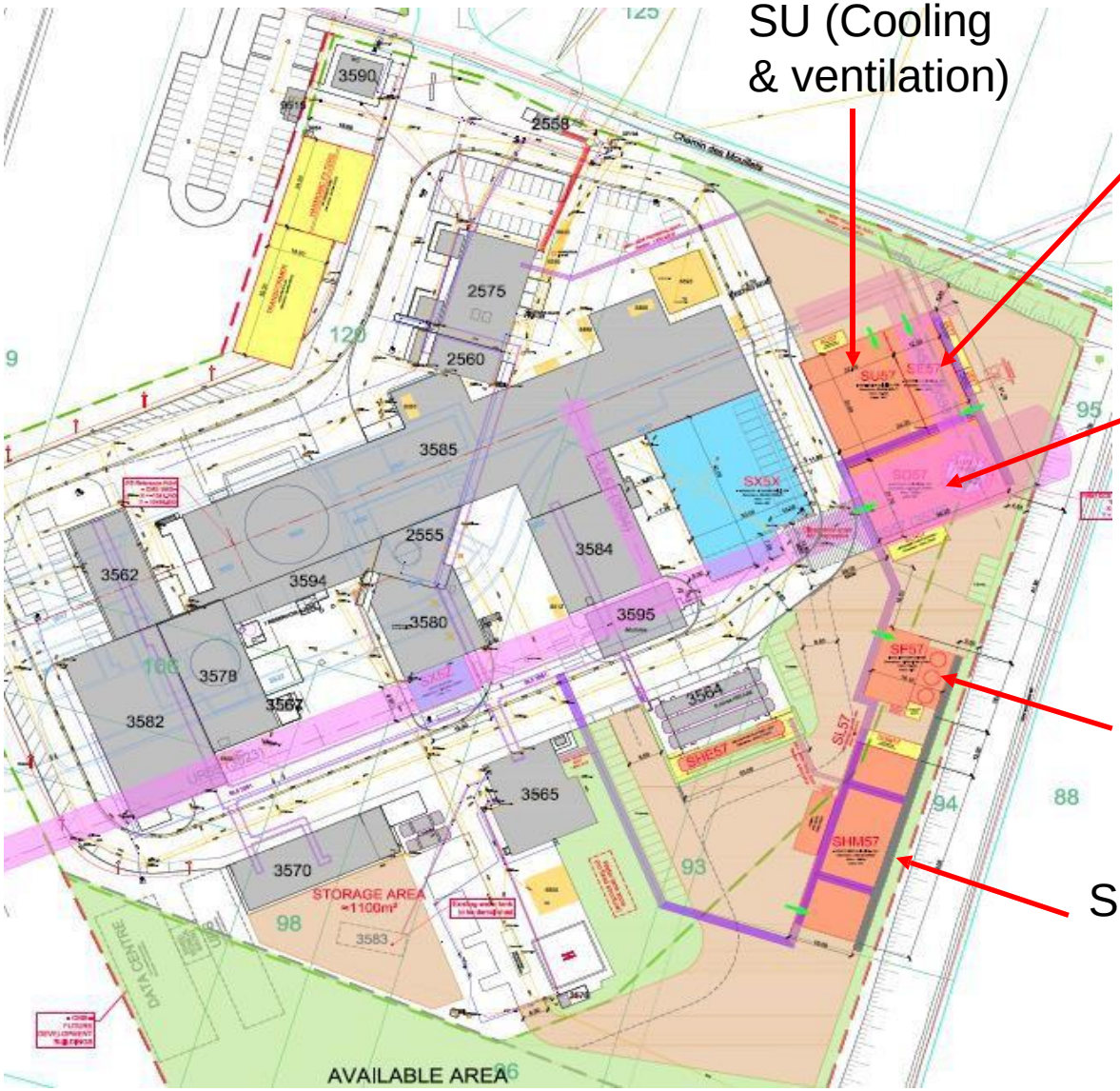
SE (Electrical distribution)



SD (Head-shaft Building)

SHM (Cryogenics)

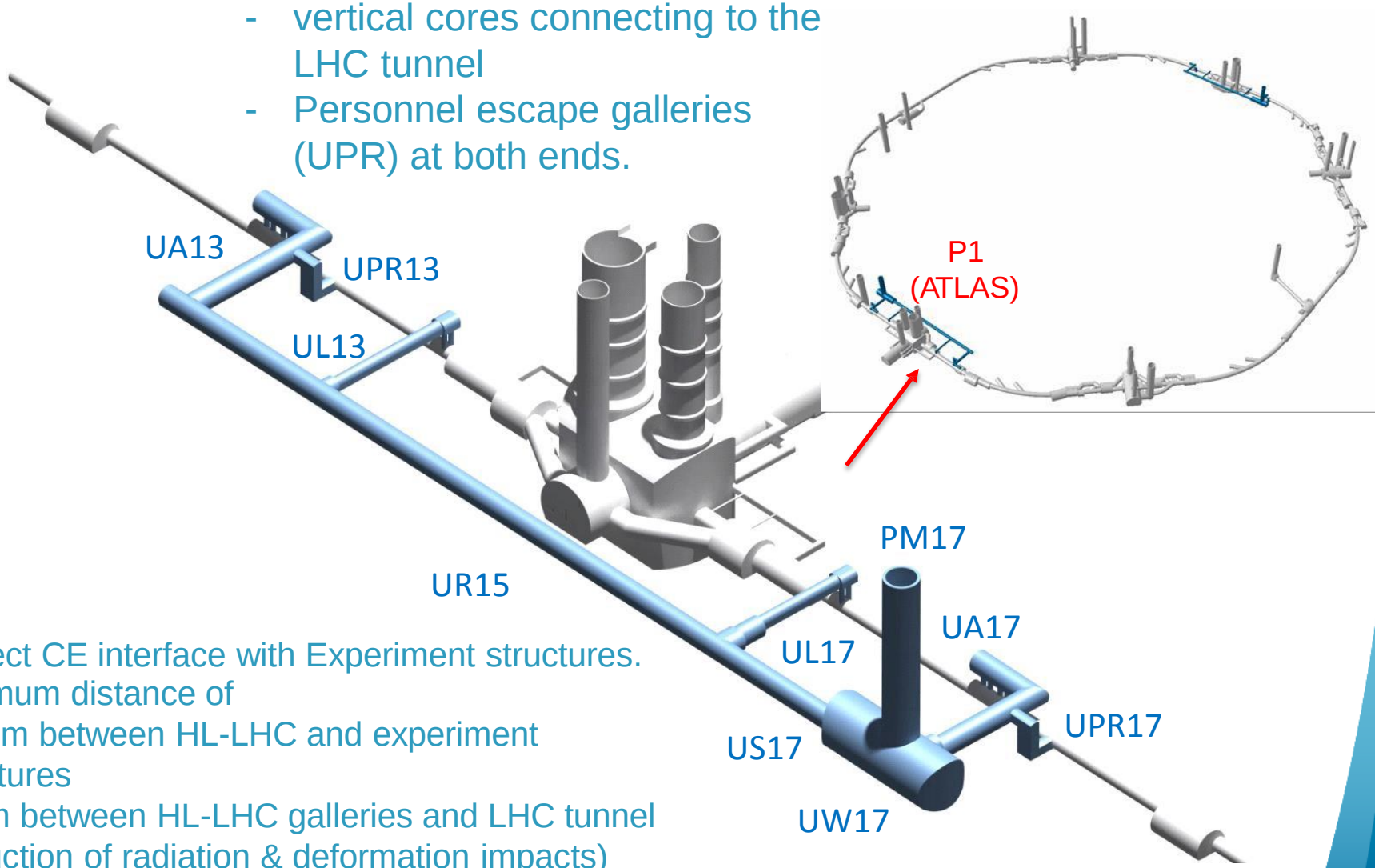
New HL-LHC surface buildings at P5



HL-LHC underground structures at P1

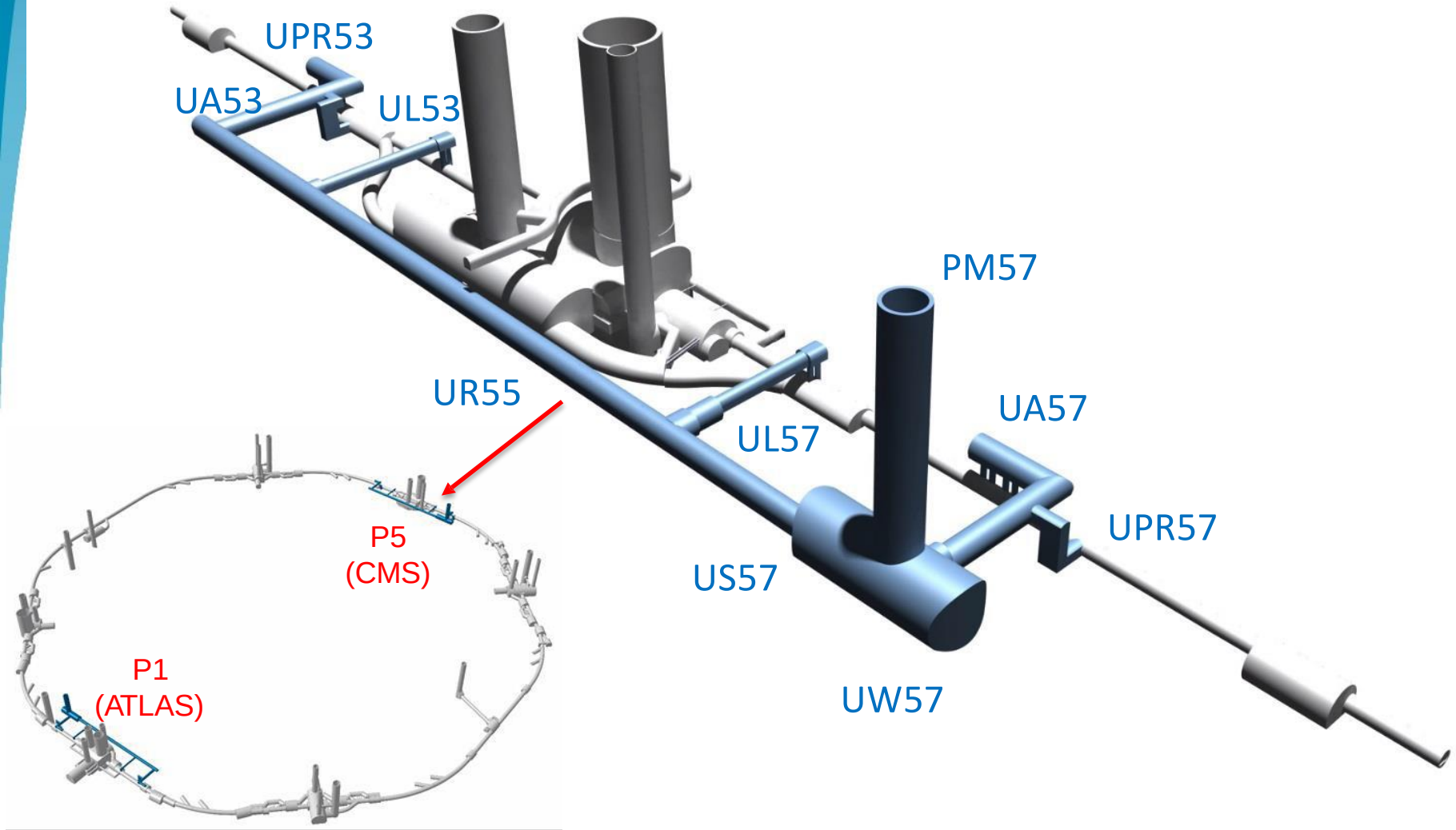
Based on double-decker with:

- vertical cores connecting to the LHC tunnel
- Personnel escape galleries (UPR) at both ends.

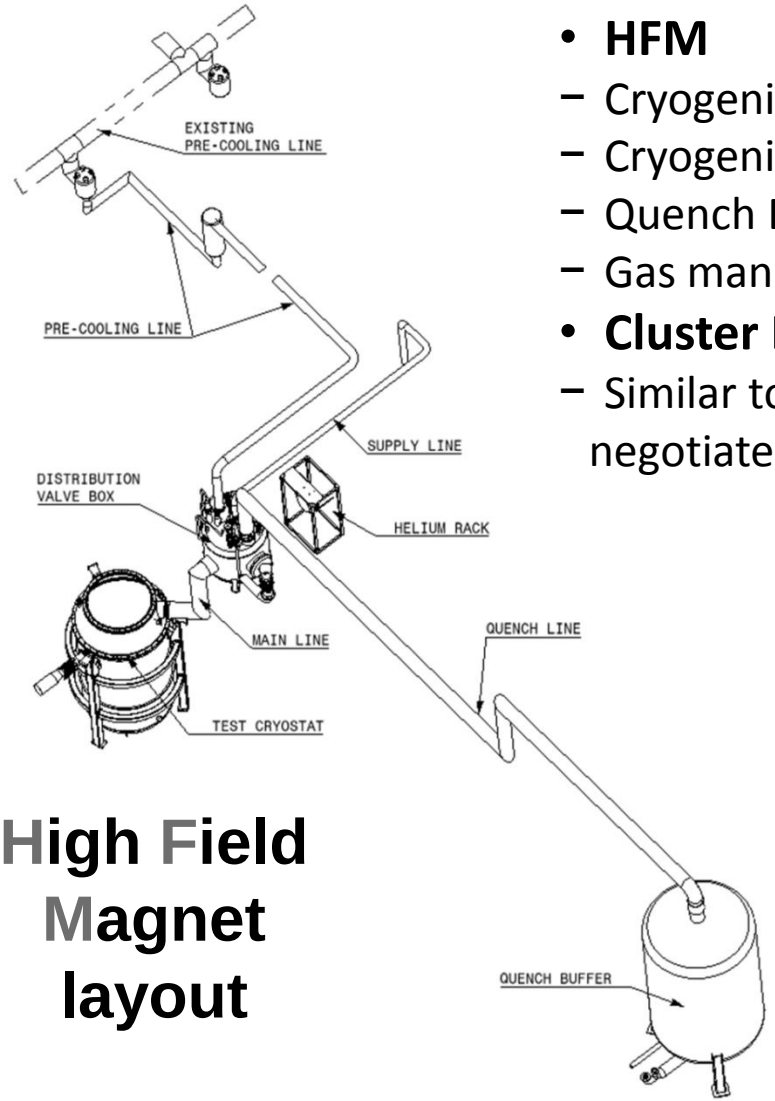


- No direct CE interface with Experiment structures.
- Minimum distance of
  ~ 15 m between HL-LHC and experiment structures
  ~ 7 m between HL-LHC galleries and LHC tunnel (reduction of radiation & deformation impacts)

HL-LHC underground structures at P5

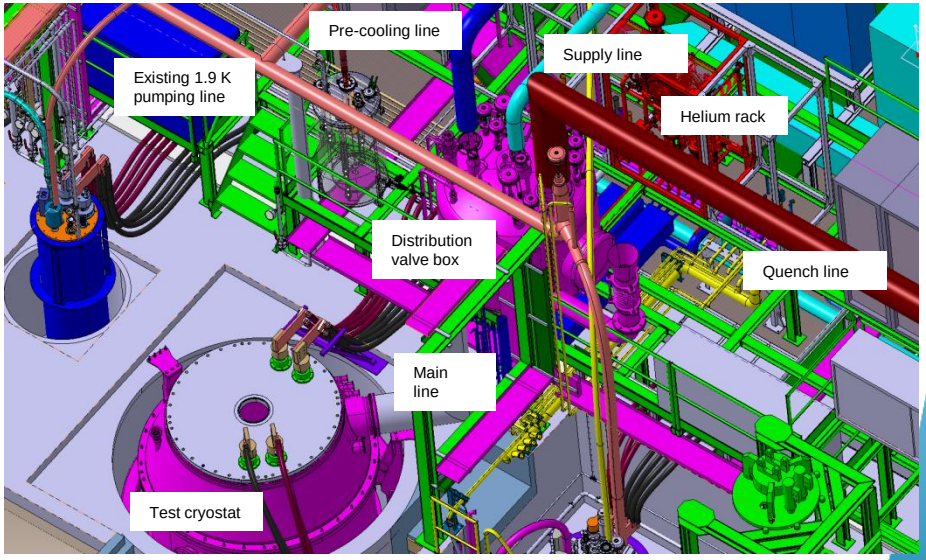


HFM & Cluster D: procurement breakdown

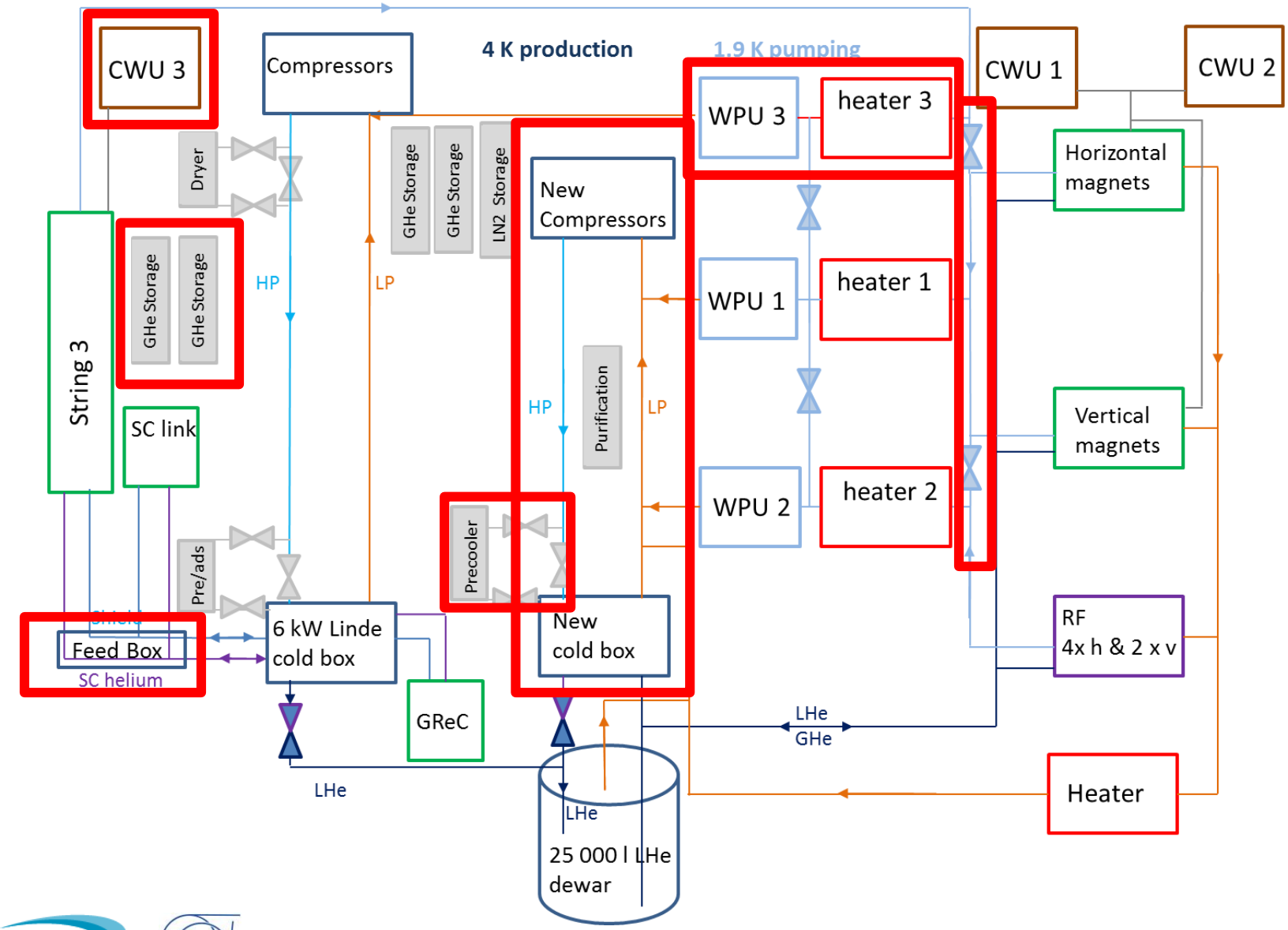


High Field Magnet layout

- **HFM**
  - Cryogenic valves : DO-28760
  - Cryogenic Distribution System : IT-3944
  - Quench Buffer : DO-28932
  - Gas management panel, warm pipework : CERN
- **Cluster D**
  - Similar to HFM -> procurement w/o tendering, negotiated with companies in charge of HFM contracts



SM18 Upgrade: baseline concept



Technology validation of Crab Cavities

Service module to CC cryo module interface:
-Welded internal lines, equipped with flexible hoses
-Bolted external bellow with vacuum sealing

Cryogenic part studied and designed in collaboration between CRG and MME