HL-LHC Integration, status and changes from November 2015

With input from all the HL WPs

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Civil engineering: P. Mattelaer, M. Manfredi, L. A. Lopez-Hernandez and the rest of WP17.1 team

Vibration study: BE-ABP: G. Arduini, M. Fitterer. BE-OP: J. Wenninger, EN-MME team: responsible M. Guinchard. SMB: P. Mattelaer, J. A. Osborne, M. Poehler

Presented by P. Fessia

Outline

- Impact on integration from the June 2016 re-baseline
- Update on the machine lay-out
- Update on the underground integration of services IP 1 and IP 5
- CE induced vibrations impact on the LHC operation: where we are
- Update on the integration for the 11 T at Point 7
- Dealt with in other contributions
  - mini-TAN integration at Point 8 (presentation WP8, F. Sanchez Galan)

Main impacts on integration of the HL-LHC June 2016 re-baseline

Reduction of the crab cavity system, but with possibility of future complete installation

Change of powering strategy for Q4,Q5,Q6

Change of Q4 composition in terms of magnet types

New cryogenics: decoupling of the cooling and sectorization function in 2 units (valve + cold box)

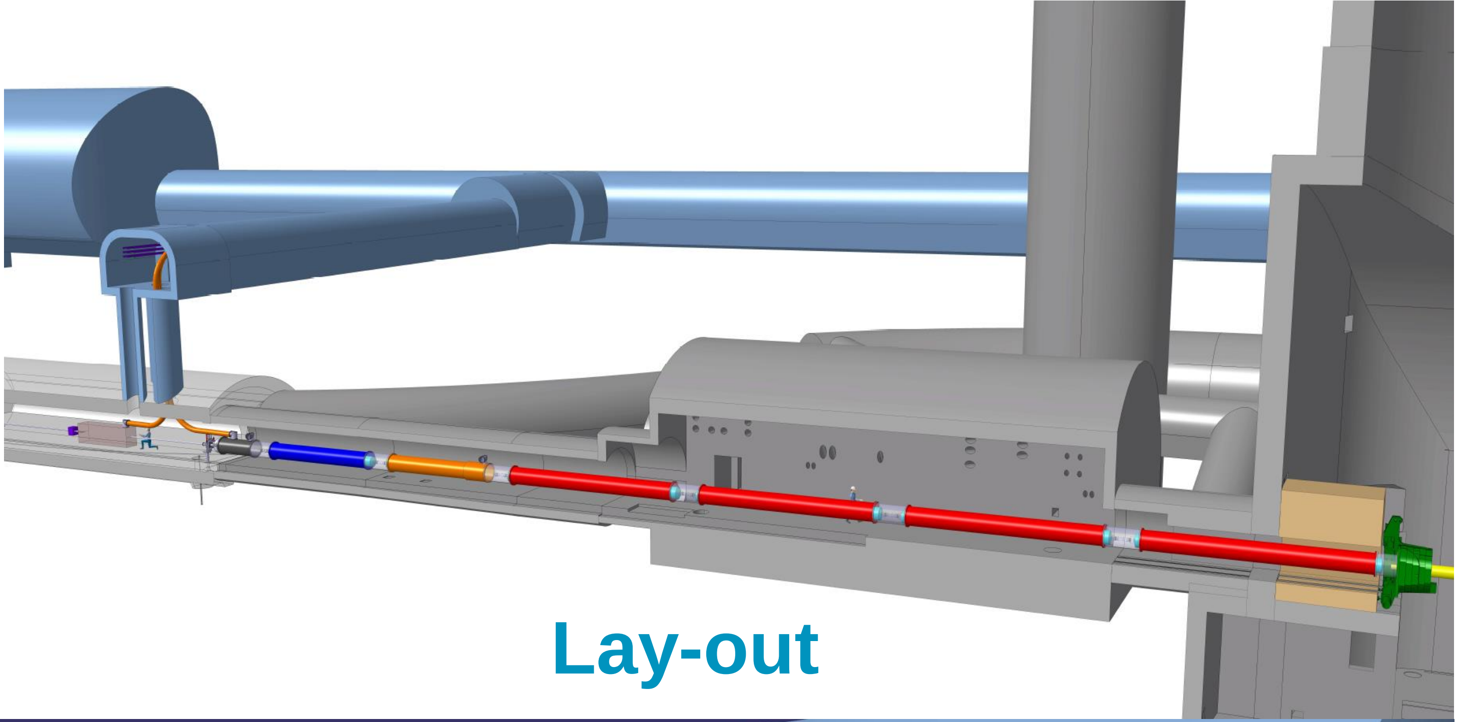
Reduction to 2 11T units

New integration in the new underground structures

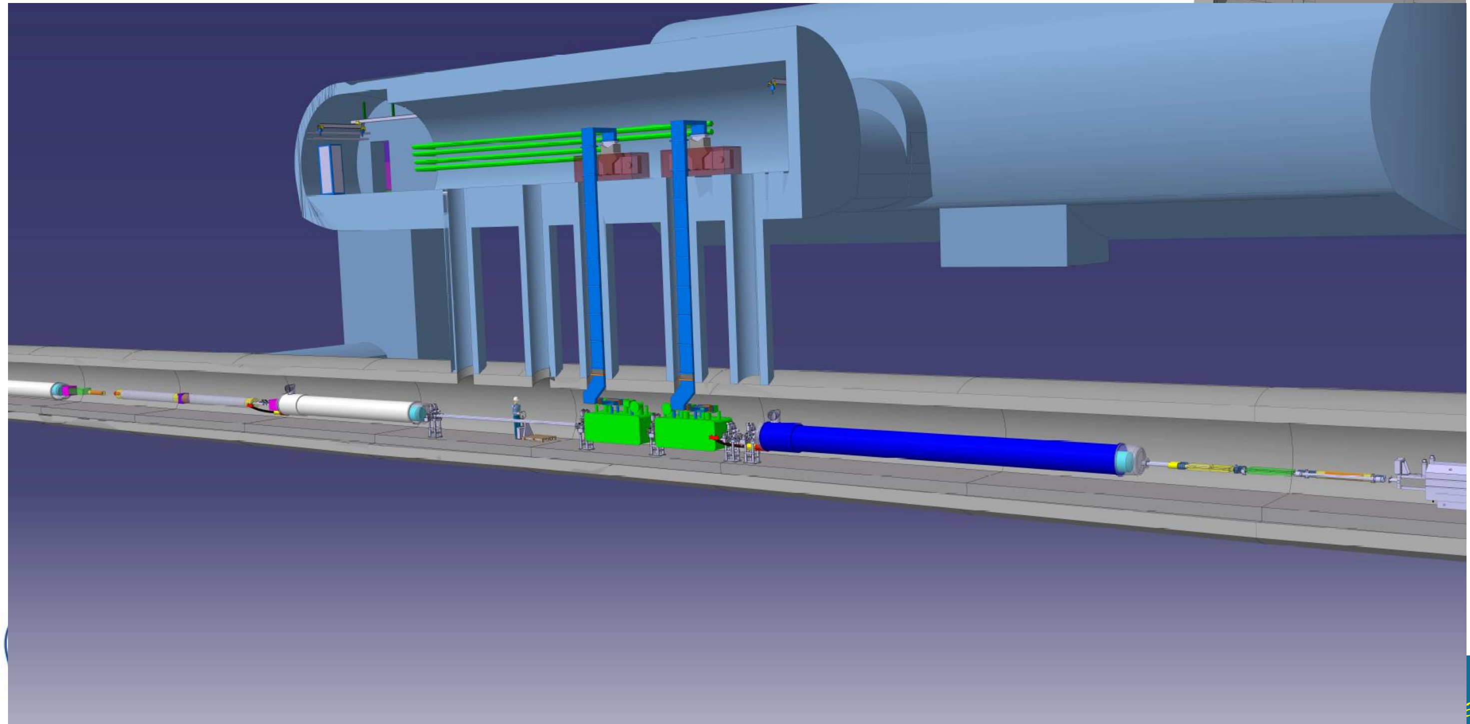
New integration in the present LHC RR alcoves

New integration of services in the LHC tunnel

New machine lay-out



Lay-out

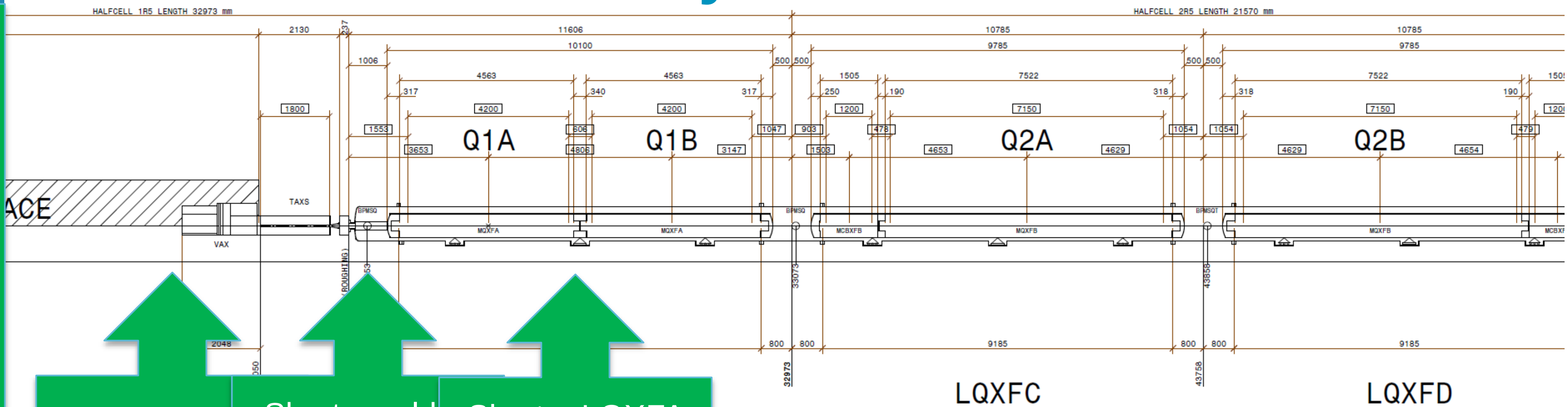


Status of lay-out and lay-out drawings

- The HL lay-out version 1.3 and drawings (drawings are undergoing QA approval process) have been completed for
  - 5R
  - 5L
  - 1R
  - 1L
- The matching updated lay-out and drawings for IP 7, IP 2, IP 8 and IP to 4 will be the next
- In the next slides the comparison of main changes between 5R present version 1.3 and Nov 2015 approved version
- Remark: valid drawings are the ones approved and available in CDD. Other versions are development ones.
- To stay tuned the HL-LHC WP15 integration webpage
  https://espace.cern.ch/HiLumi/WP15/default.aspx
- On web page you can also find
  - Topics and agenda of the integration activities
  - Update of the underground integration with drawings, schemes and temporary EXCEL database for equipment to be installed
  - And much more

Lay out I

V 1. 3

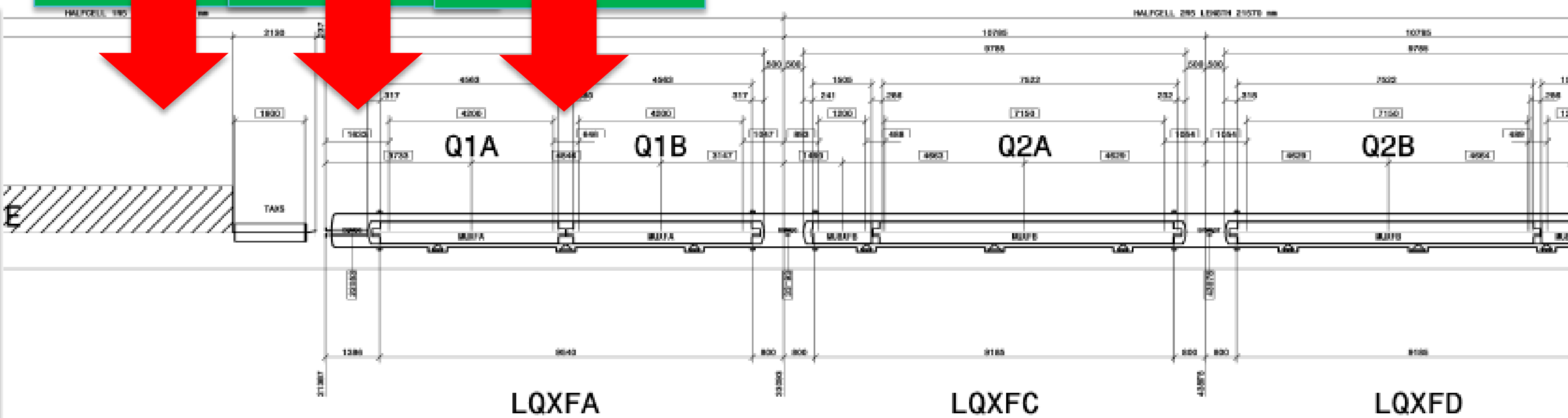


VAX in exp. a

Shorter cold warm transiti Reduction l BPM good ar

Shorter LQXFA for BPM Q1-Q2A into good area

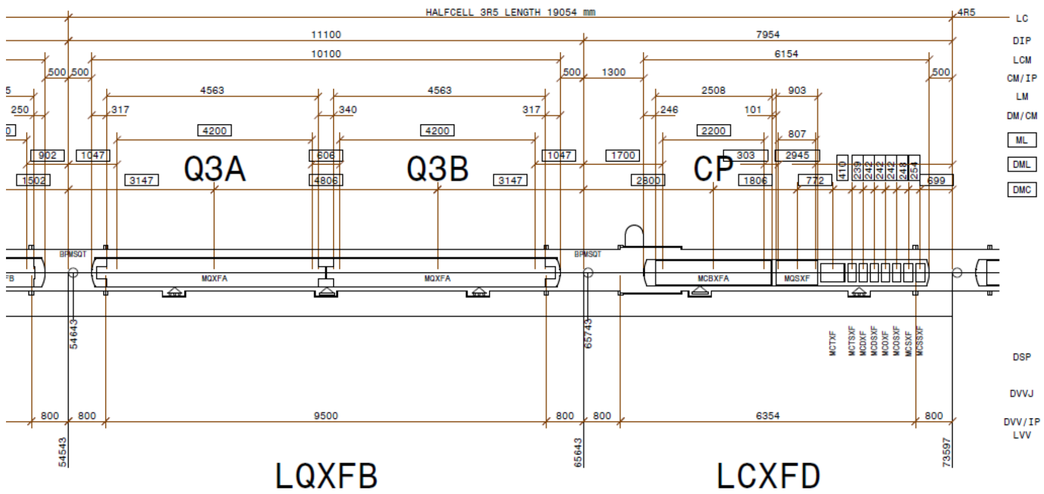
V 1. 1



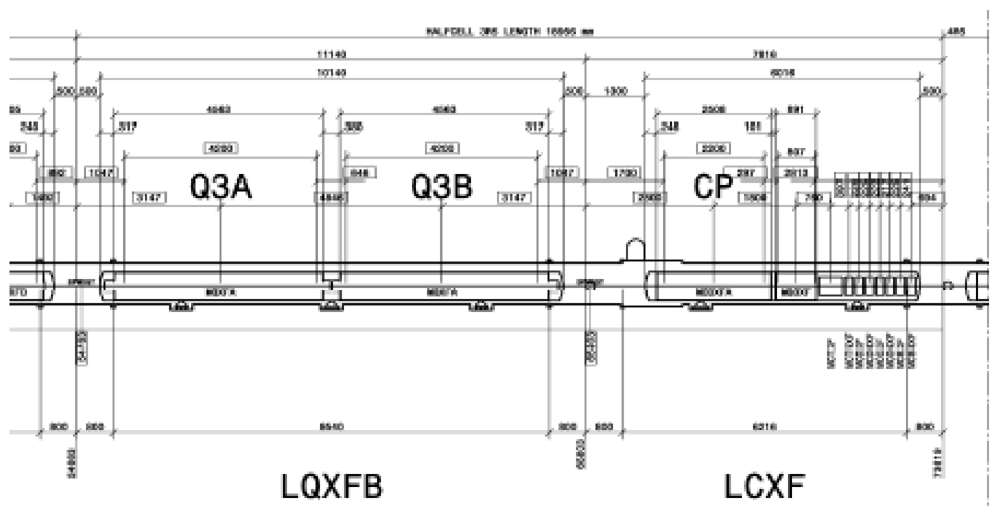
HL – LHC integration team: dreams that shape the reality

Lay out II

V 1.3

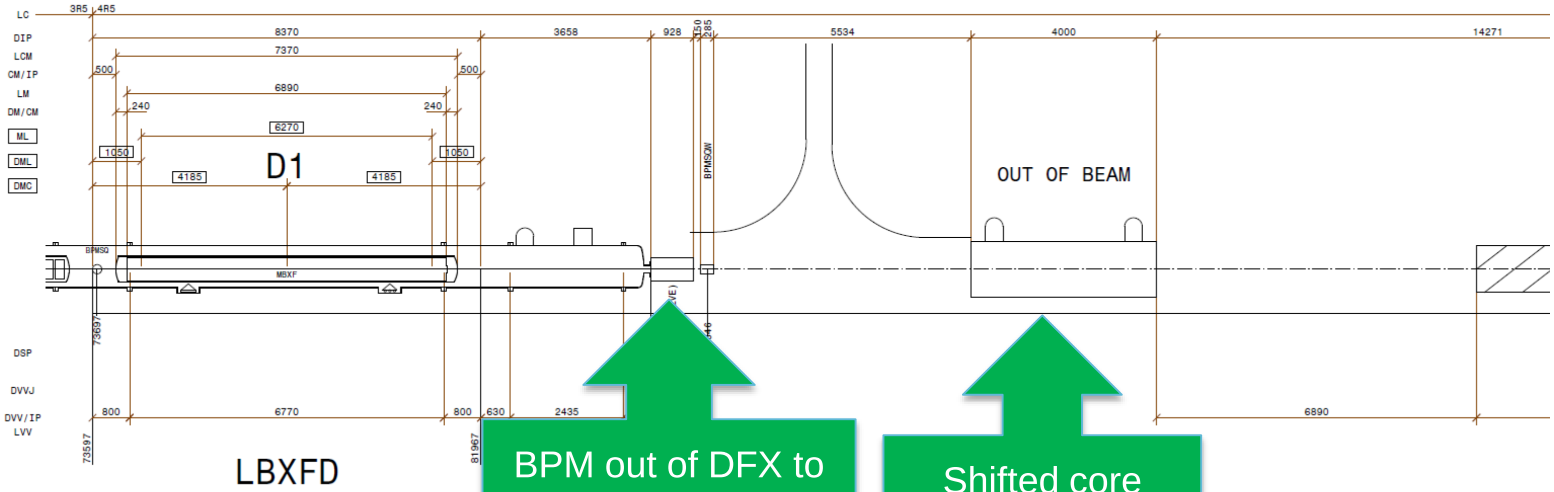


V 1.1



Lay out III

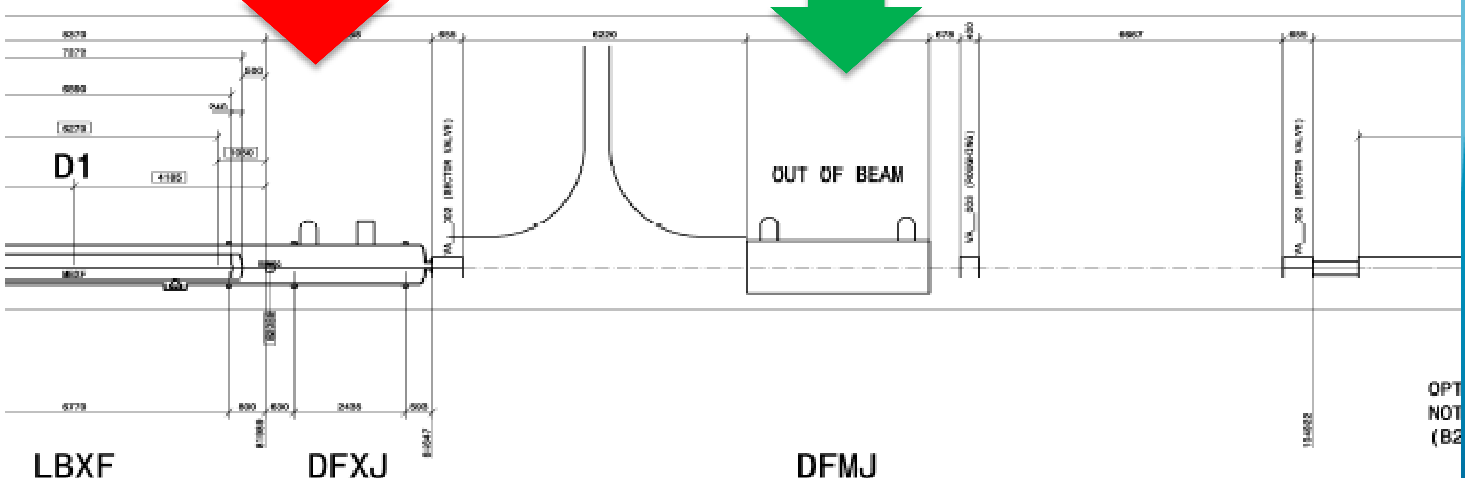
V 1.3



BPM out of DFX to simplify DFX design and decouple BPM and DFX designs

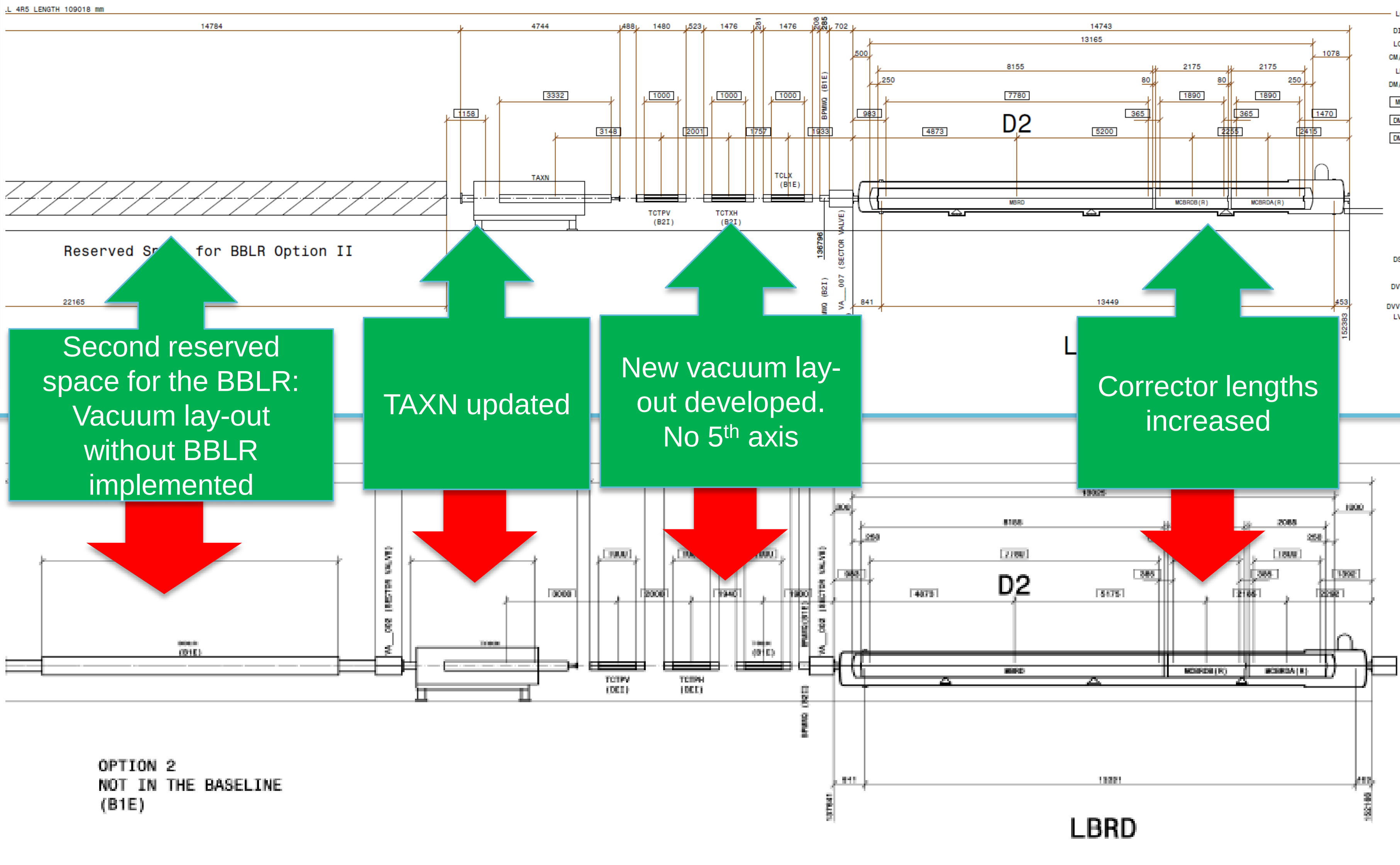
Shifted core positon to gain margin for SC link routing

V 1.1



Lay out IV

V 1.3



Second reserved space for the BBLR: Vacuum lay-out without BBLR implemented

TAXN updated

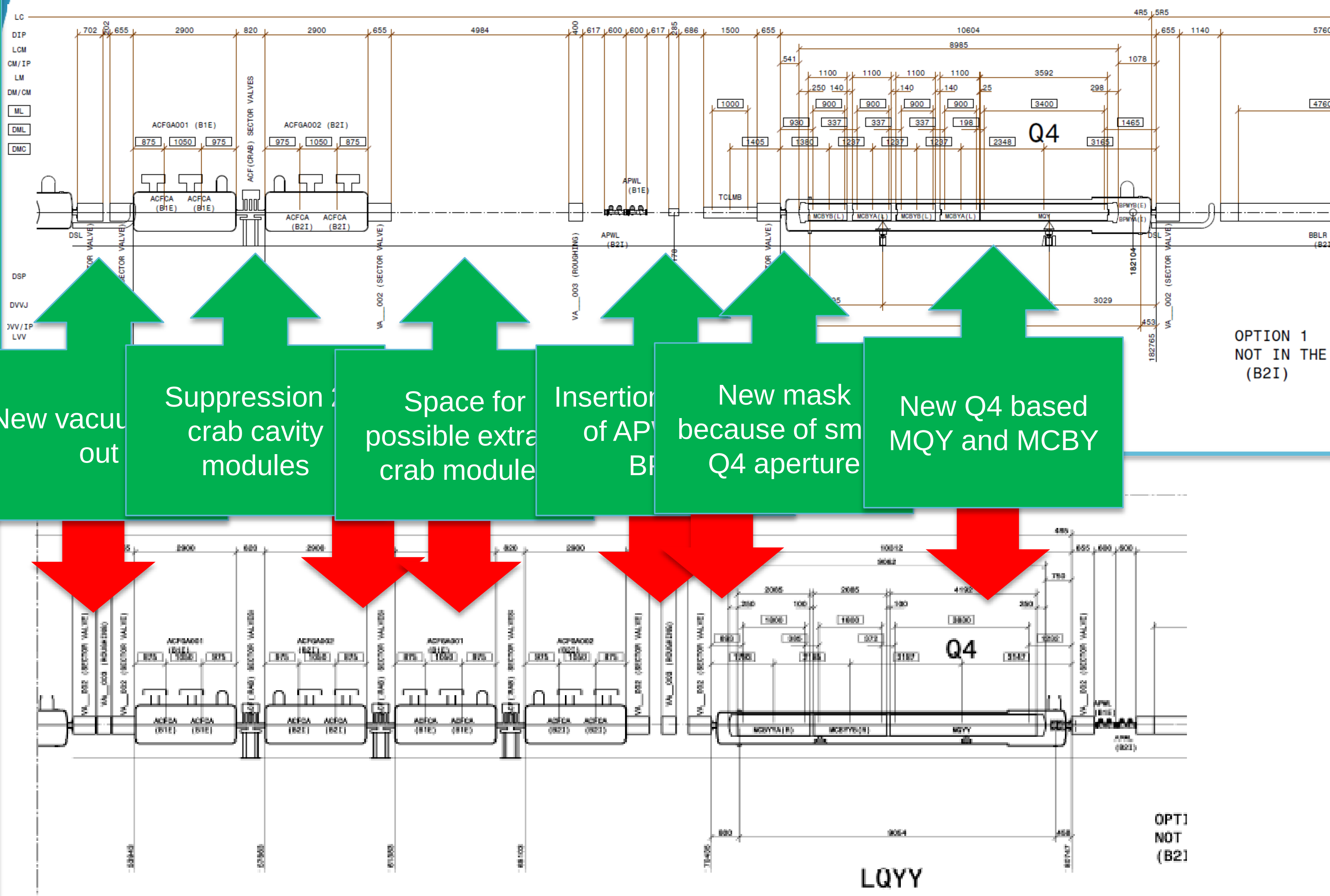
New vacuum lay-out developed. No 5th axis

Corrector lengths increased

V 1.1

Lay out V

V 1.3



New vacuu
out

Suppression
crab cavity
modules

Space for
possible extra
crab module

Insertion
of AP
B

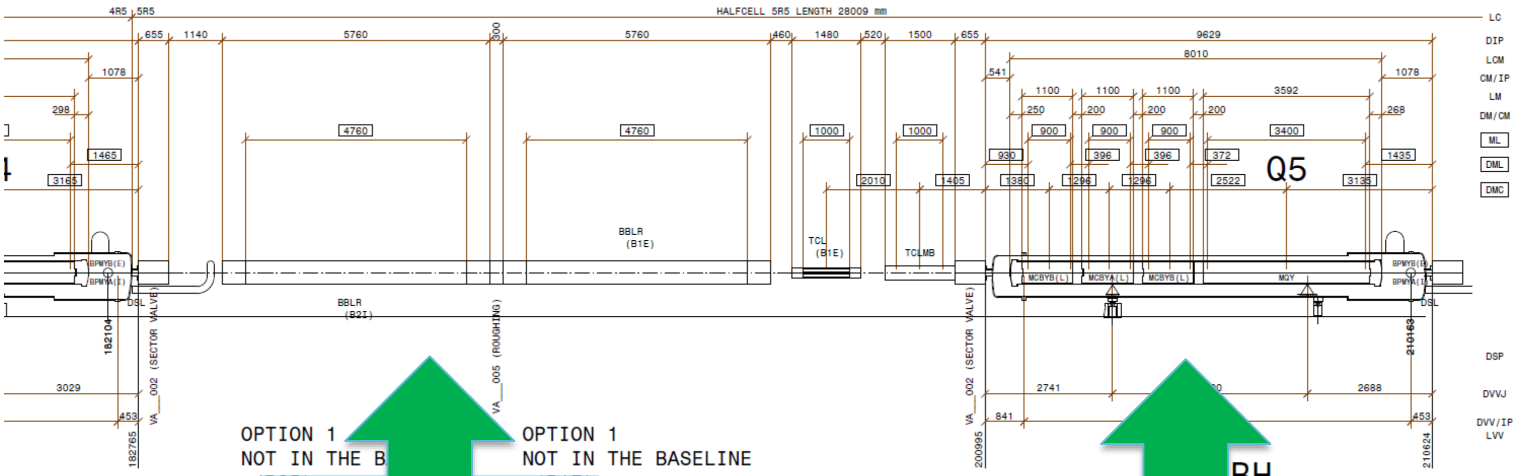
New mask
because of sm
Q4 aperture

New Q4 based
MQY and MCBY

V 1.1

Lay out VI

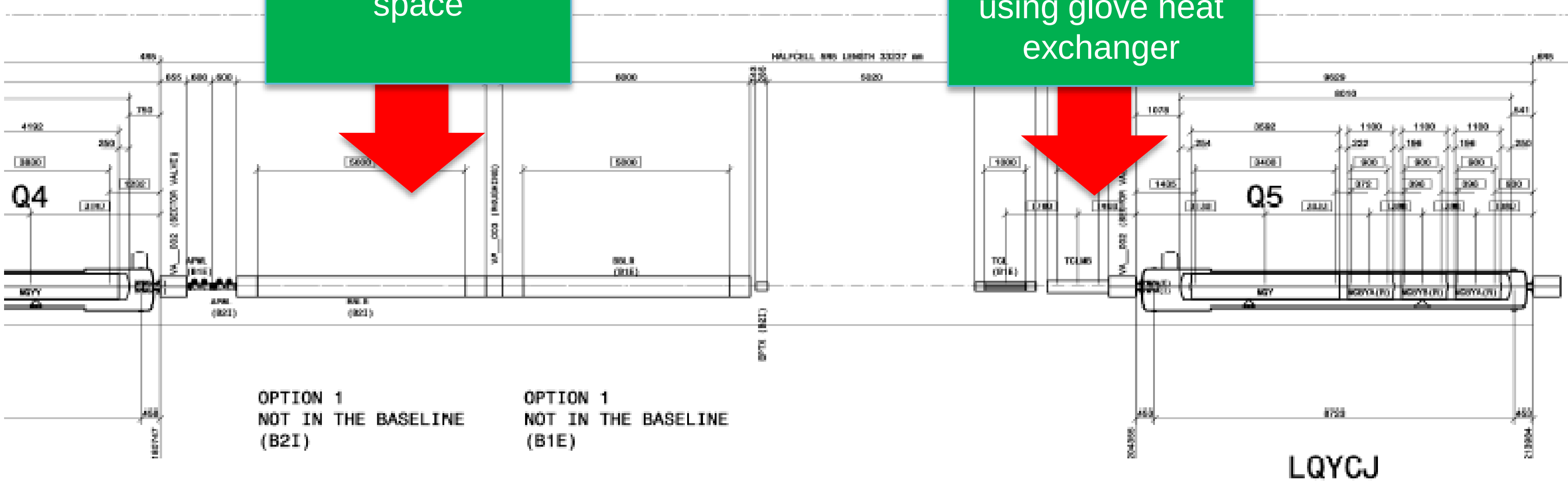
V 1. 3



Shortened BBLR space

Q5 symmetric respect to IP using glove heat exchanger

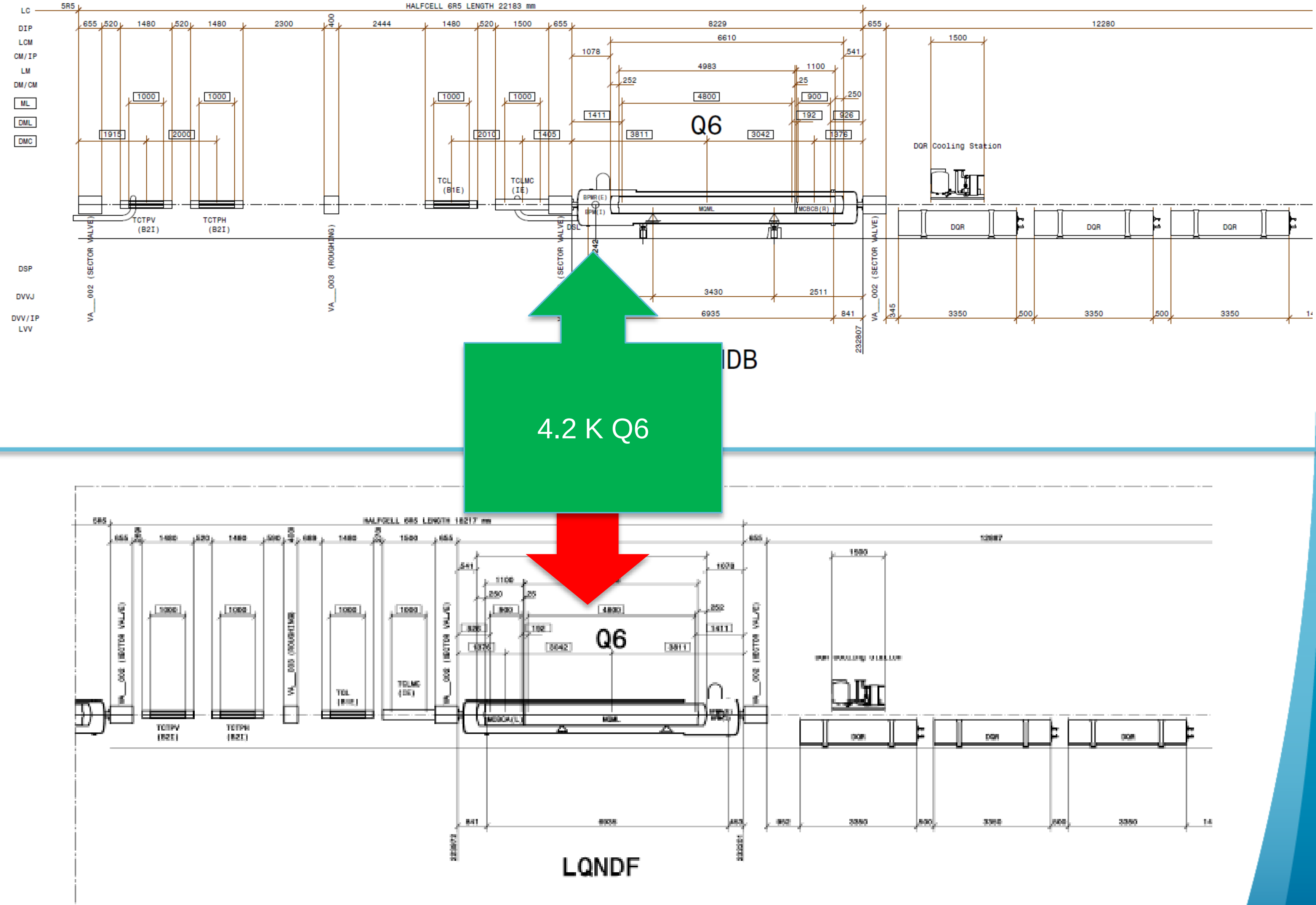
V 1. 1

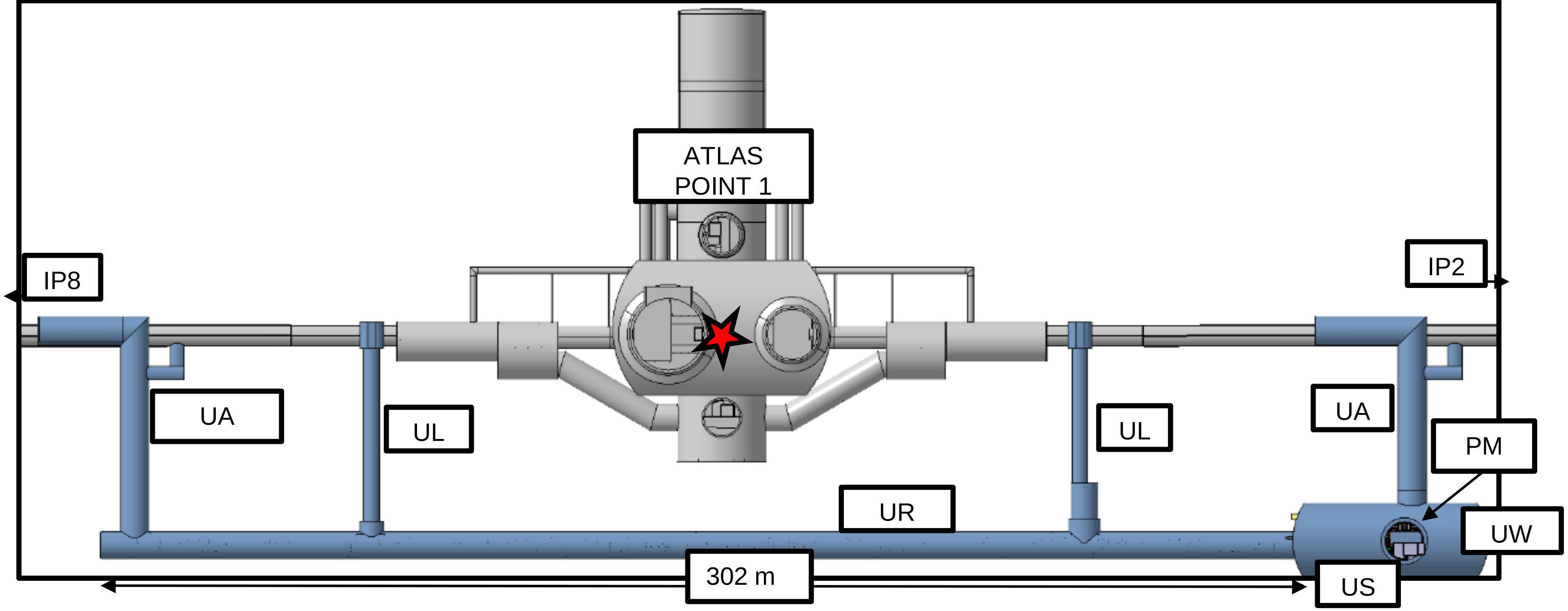


Lay out VII

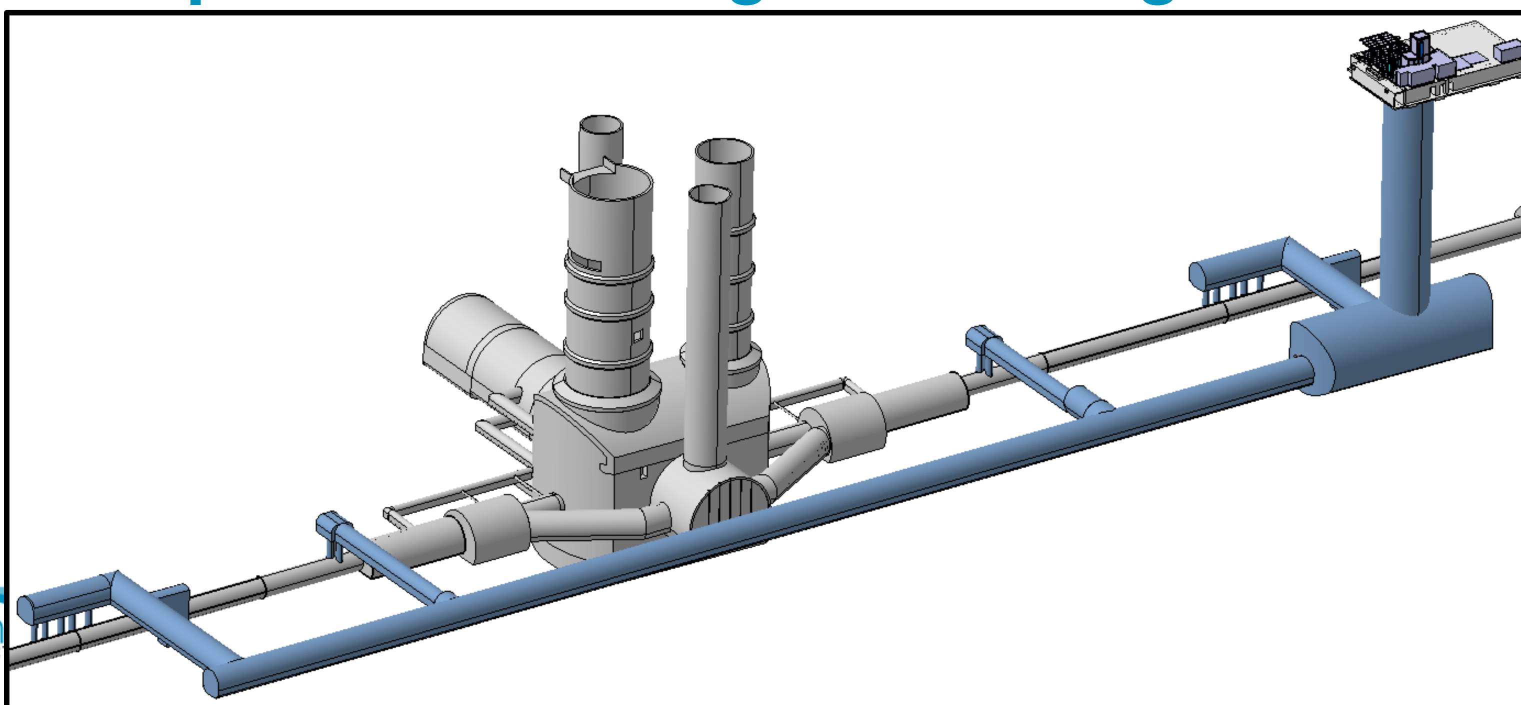
V 1.3

V 1.1



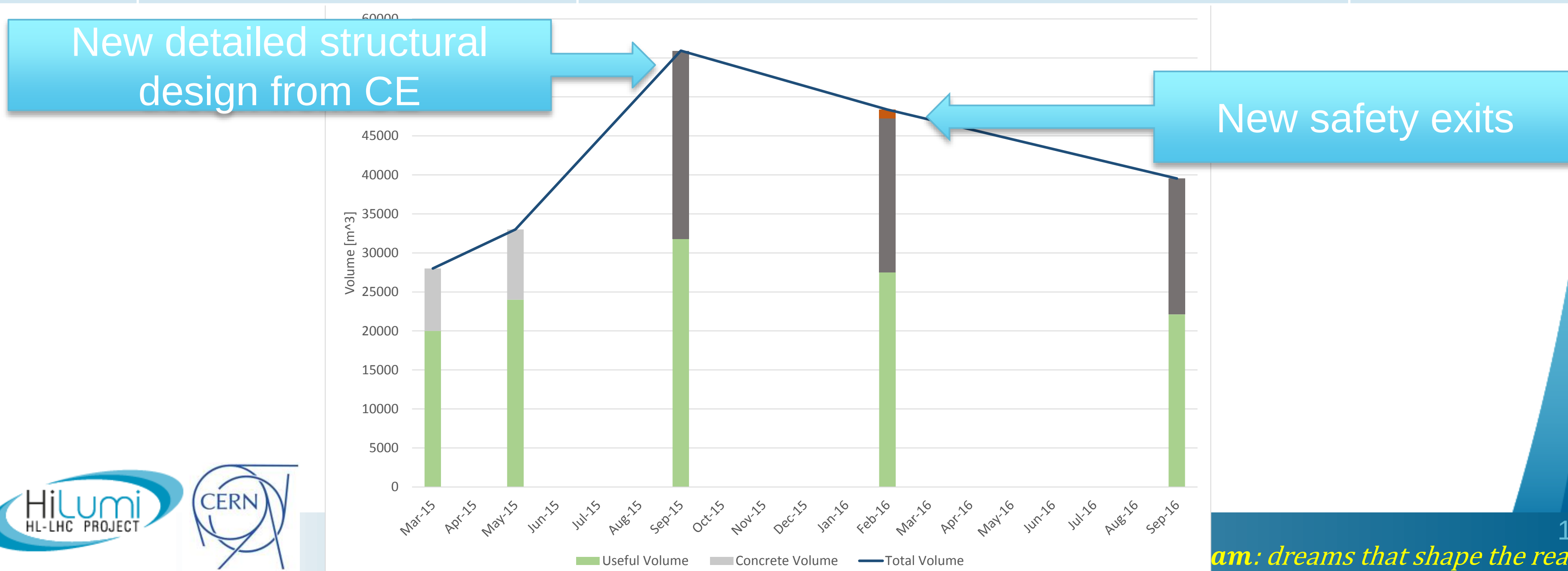


Update on underground integration

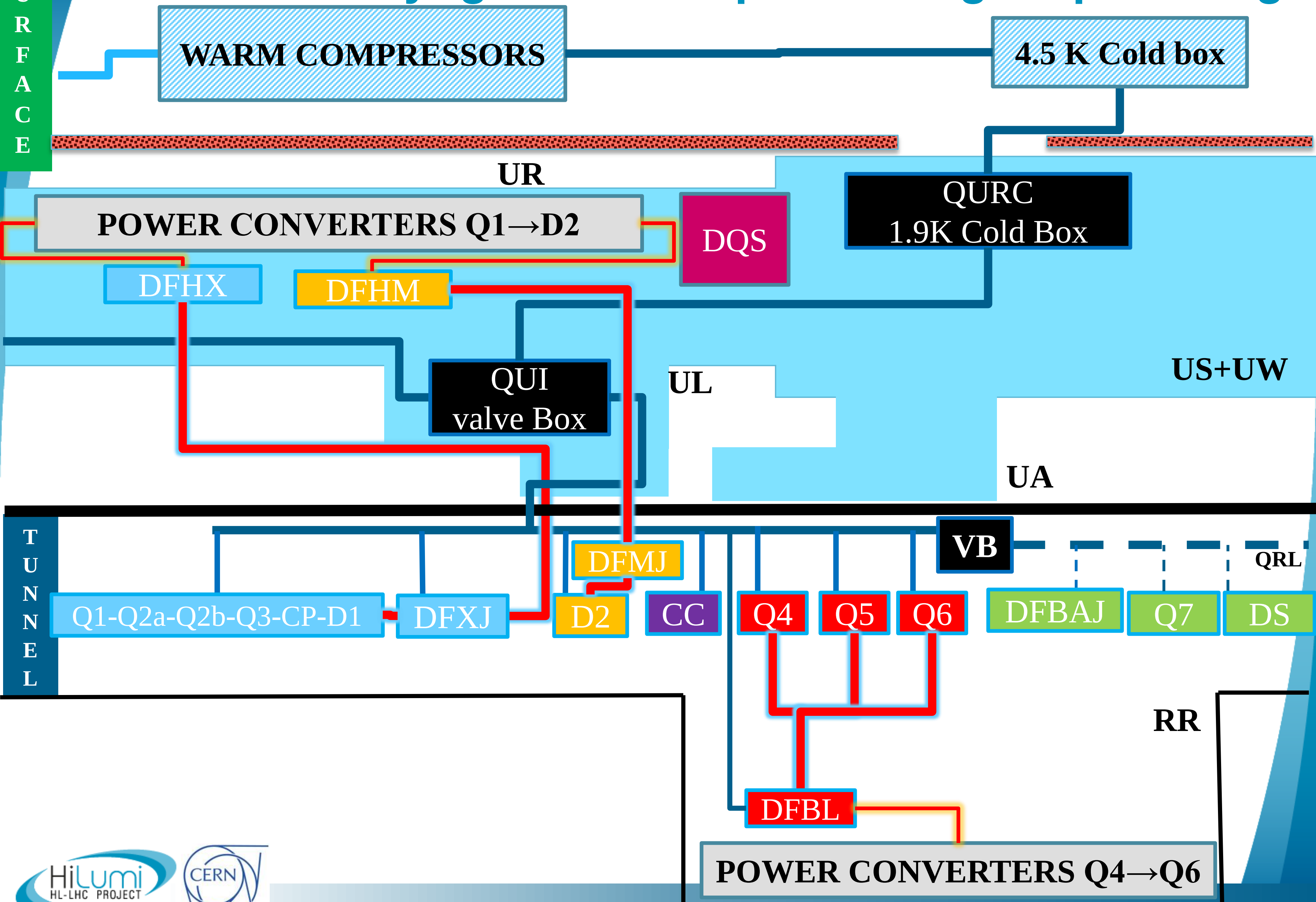


Underground Volume evolution and revolution

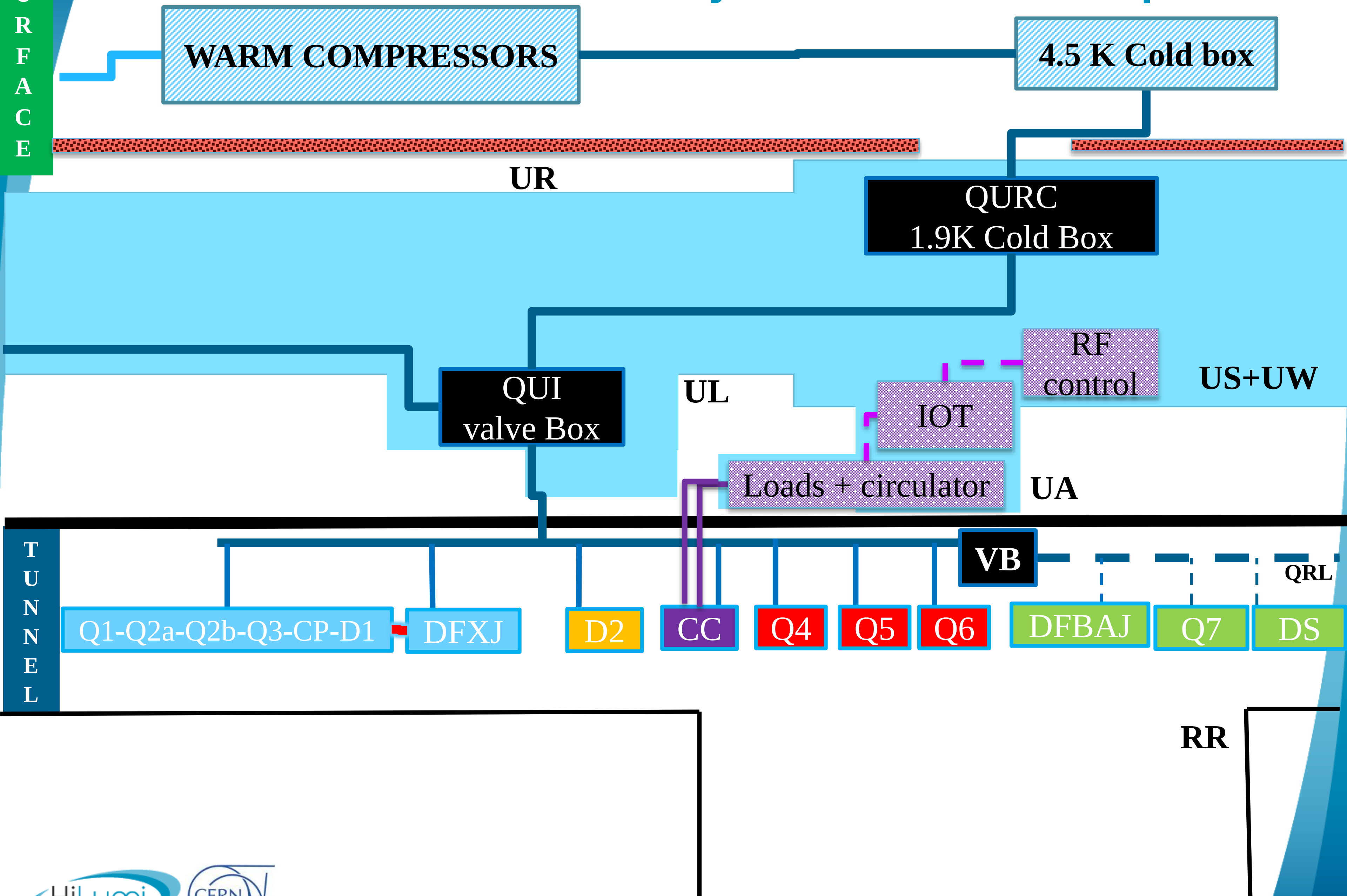
Date	Milestone	Changes/status	Volume m^3
03/2015	Cost and Schedule review I	First model of underground galleries. Working on differences between surface and underground options	**28000**
06/2015	HL-LHC approves Double Decker as baseline	Change of baseline. Approval double decker. Initial structural design with SMB	**33000**
09/2015	Freezing model end of general integration	Completion of review of all the needs. New wall thicknesses from detailed structural design by CE	**56000**
02/2016	Freezing model end of optimisation	Optimisation of integration looking for space occupancy optimisation also via cabling reduction → CV requirement. Reduction of shaft diameter, **new safety exit**	**48500**
09/2016	Freezing model end of re-baseline	Integration accounting all decisions for the new baseline	**39600**



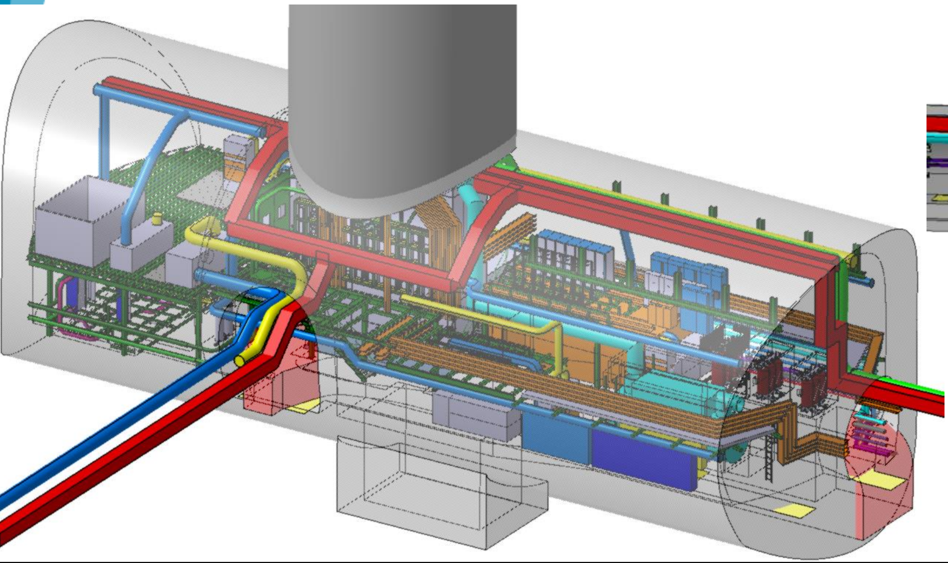
Pt1 & Pt 5: cryogenic concept and magnet powering

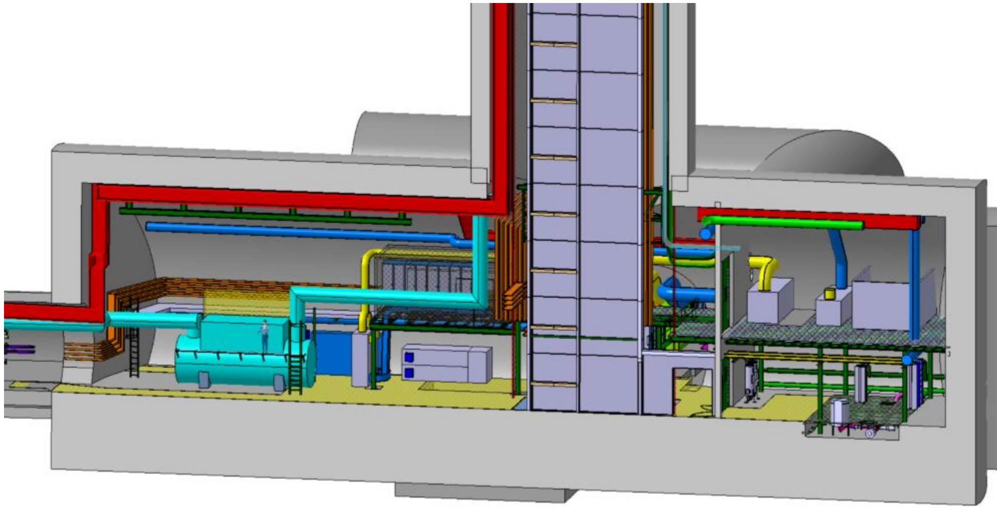


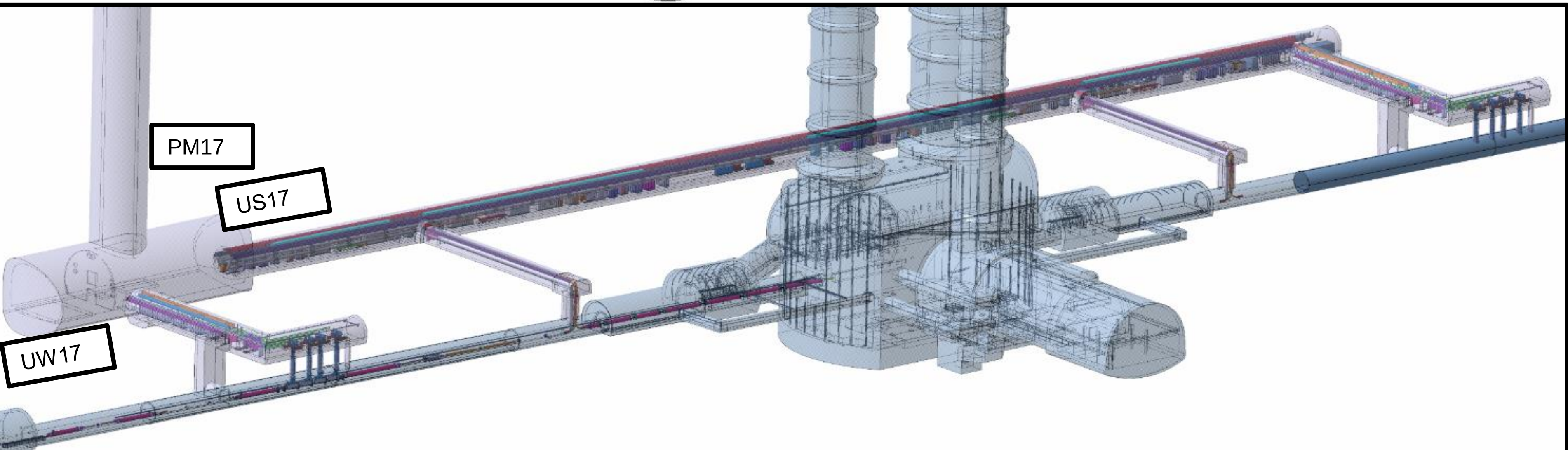
Pt1 & Pt 5: crab cavity RF services concept



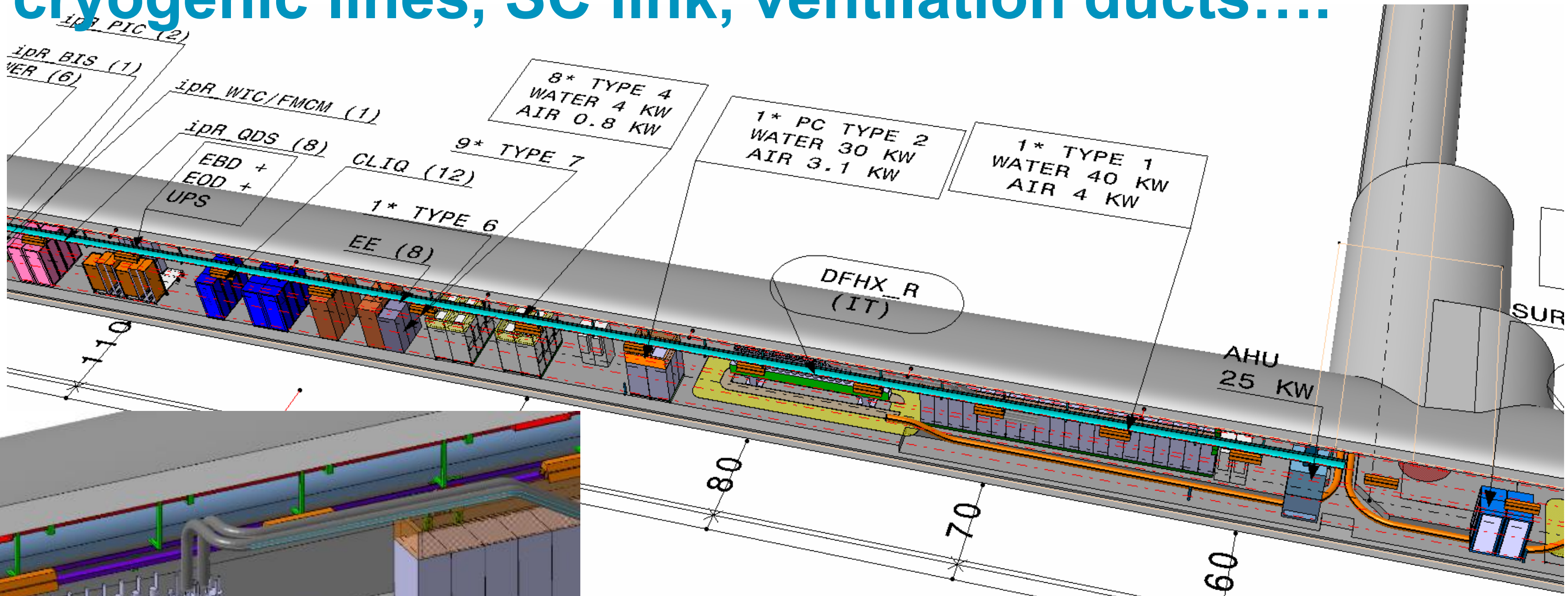
US-UW: Cryogenic cold box, shaft access, transformers, safety elements, cooling and air treatment, RF Faraday cage

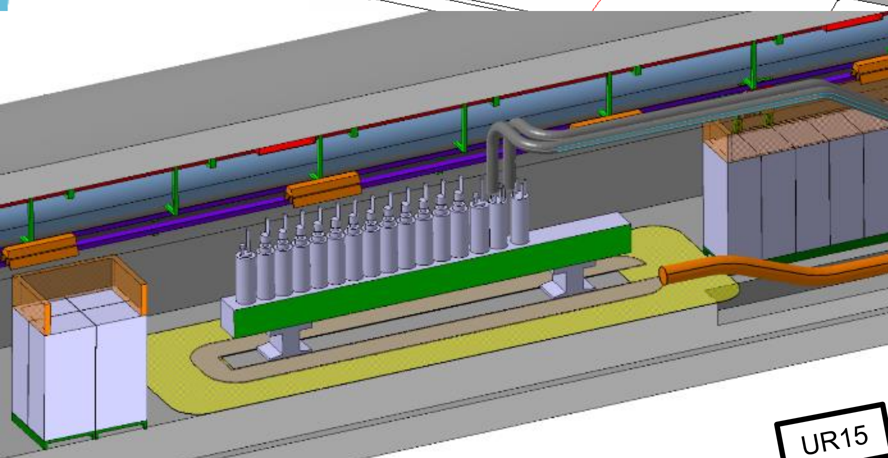


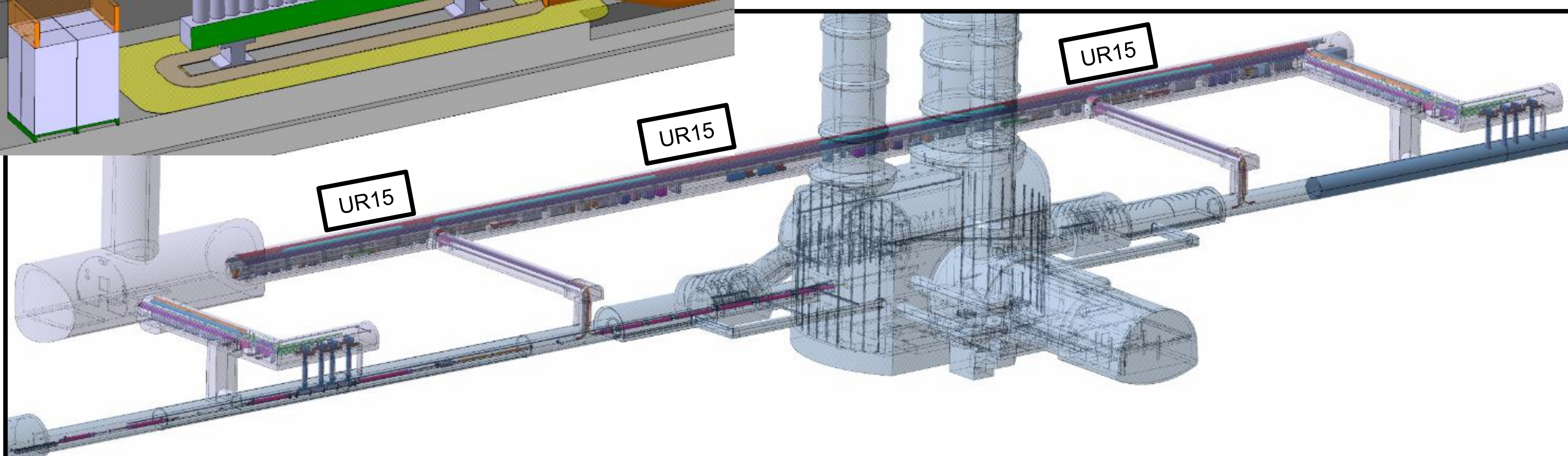




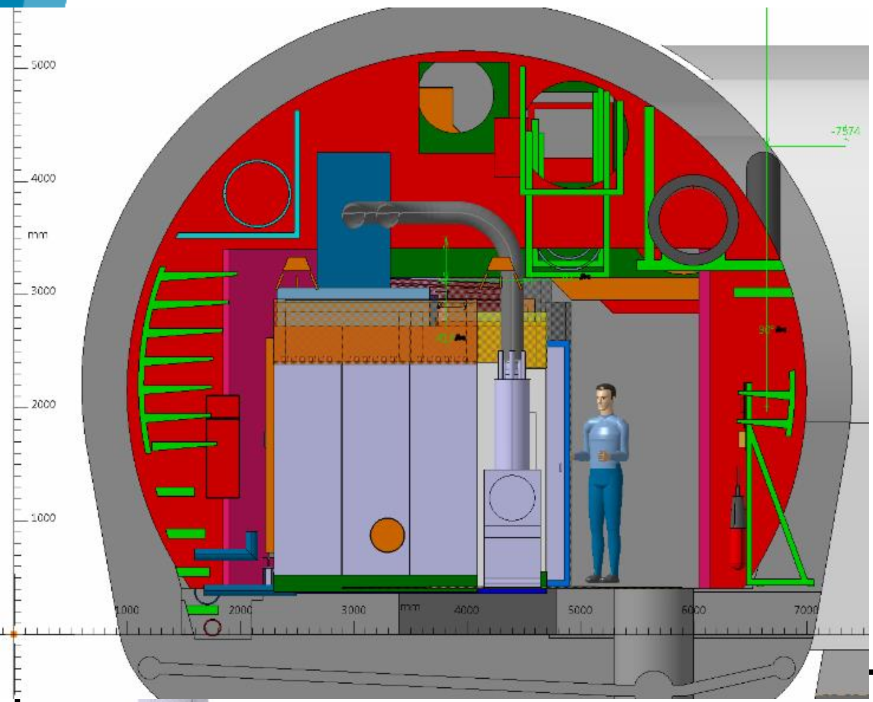
UR: power converters, quench detection system, transformers, air handling units, distribution feed boxes, cryogenic lines, SC link, ventilation ducts….

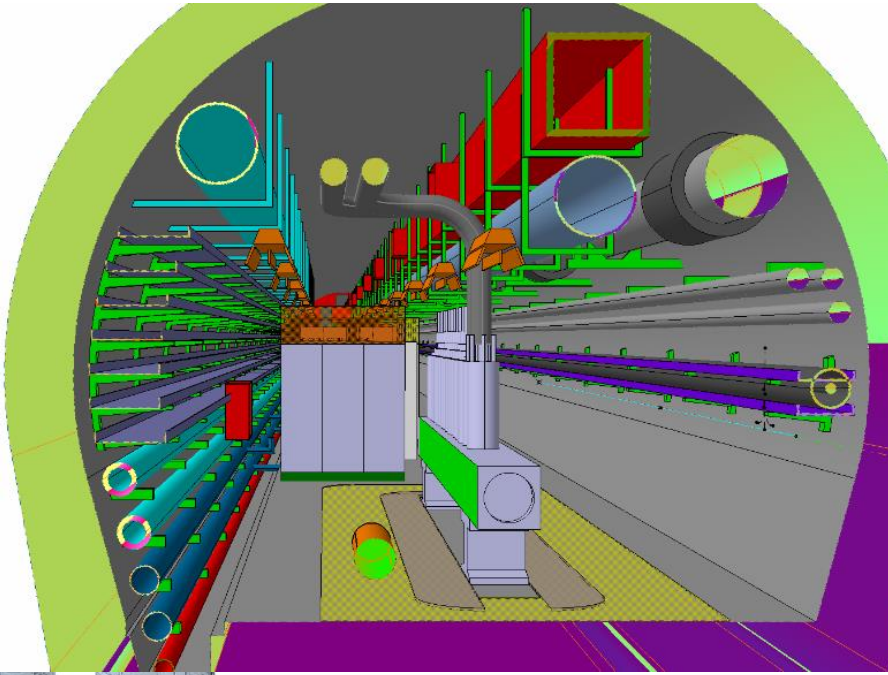


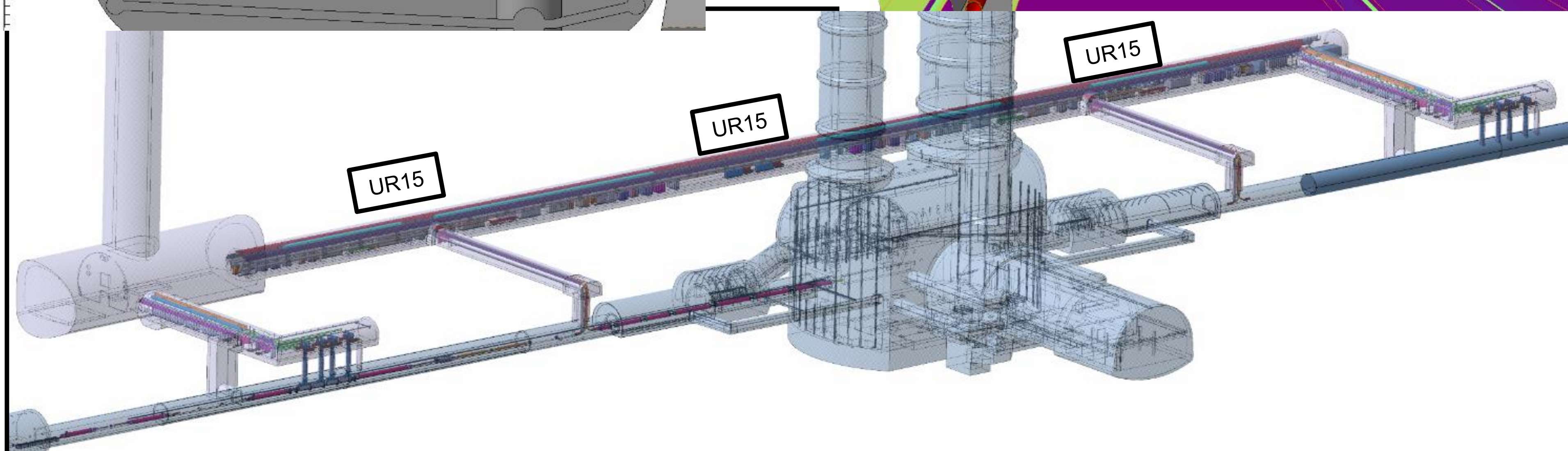




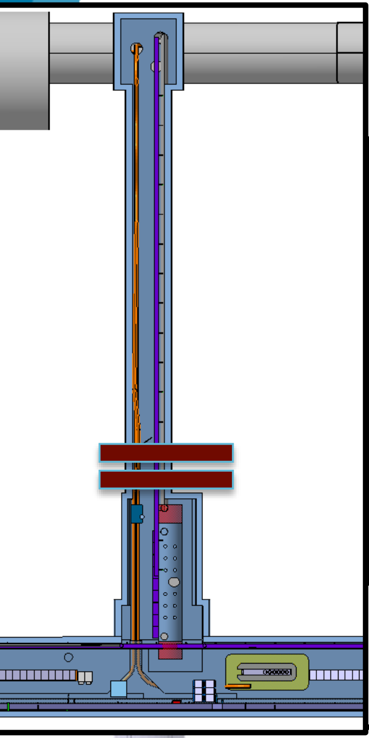
UR: power converters, quench detection system, transformers, air handling units, distribution feed boxes, cryogenic lines, SC link, ventilation ducts….

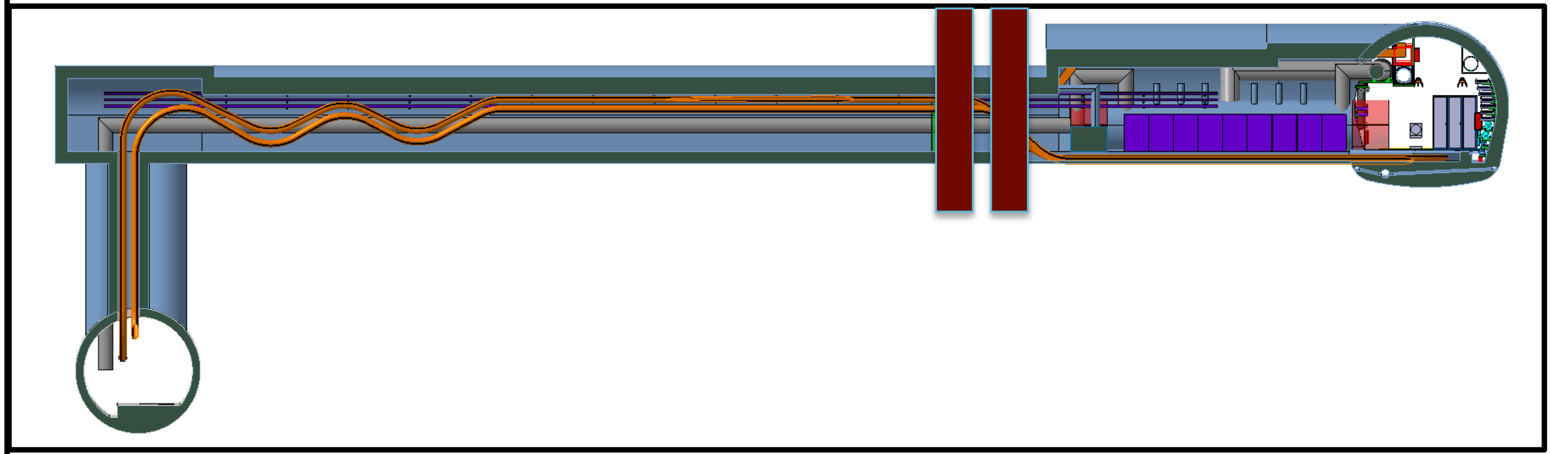


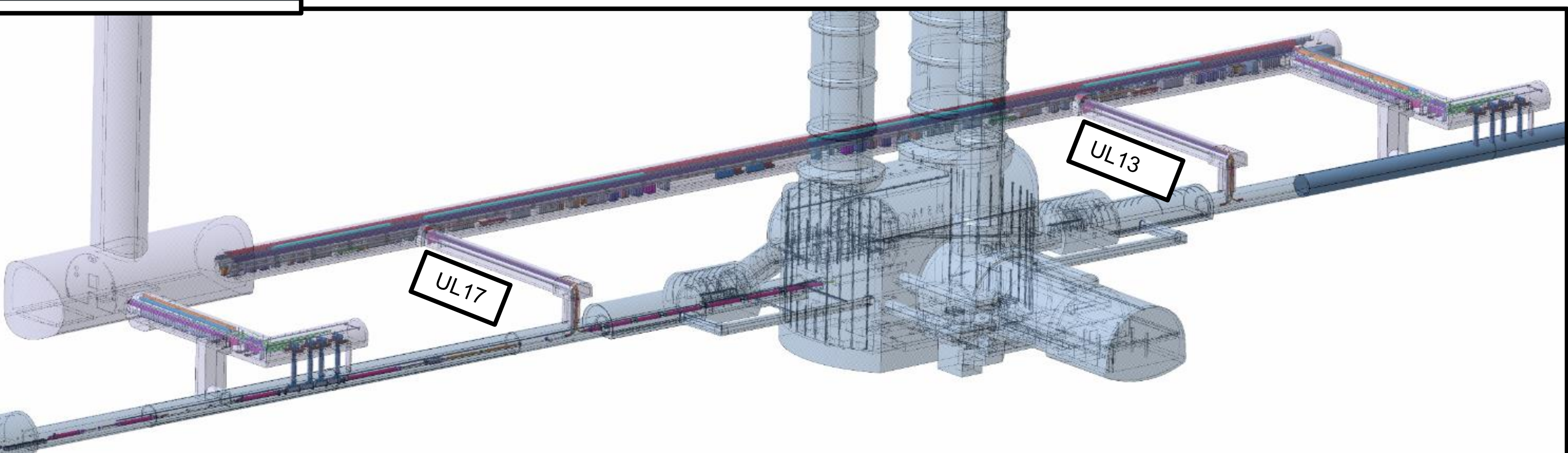




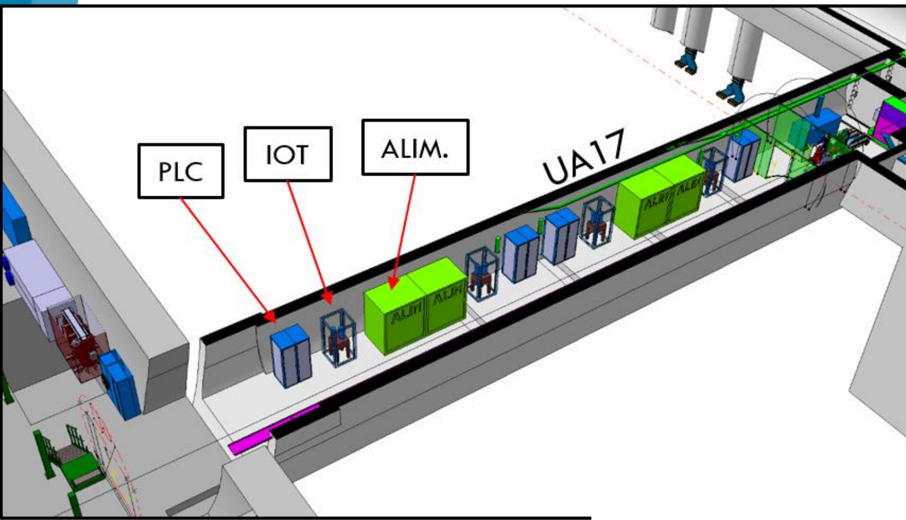
UL: Cryogenic valve box (only UL17), Cryogenic line, SC link. Closed to access for the largest part of length, not active equipment

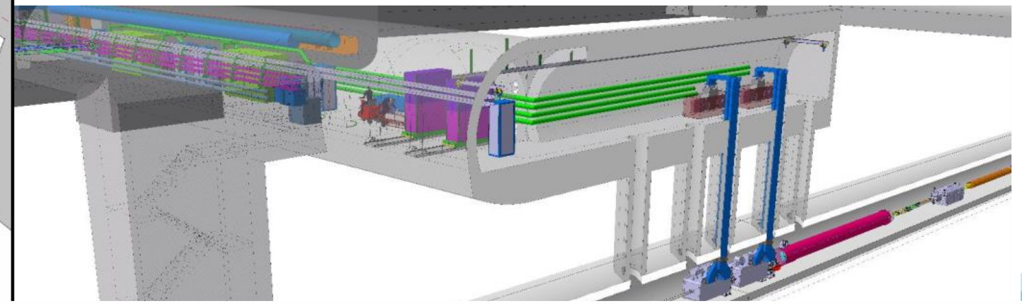


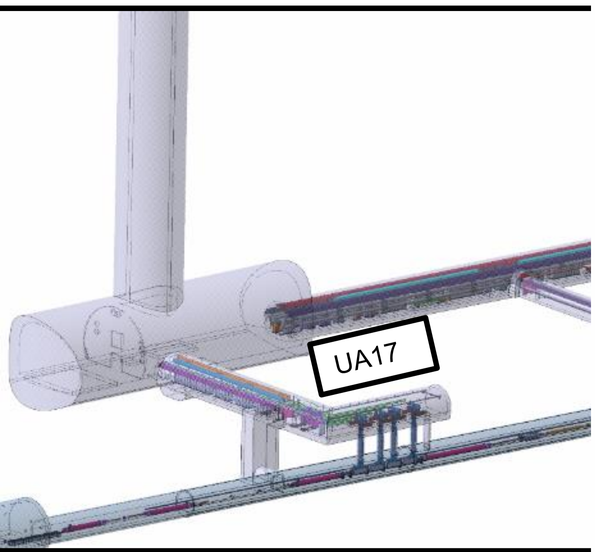


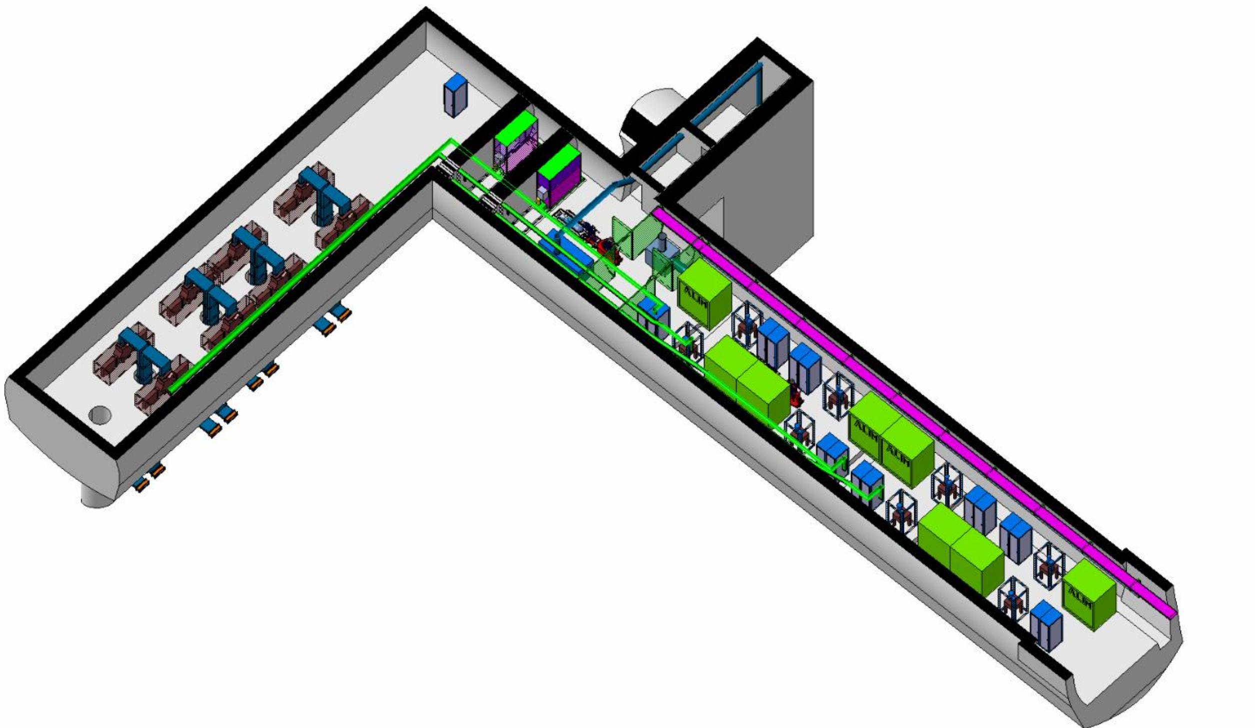


UA: RF control, RF powering, survey proximity rack, RF Faraday Cage and RF ventilation (last two only in UA13)



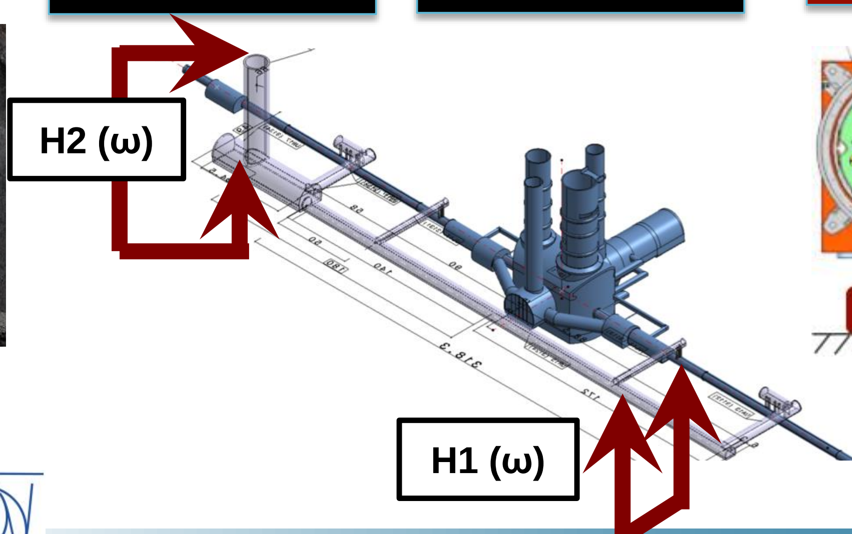


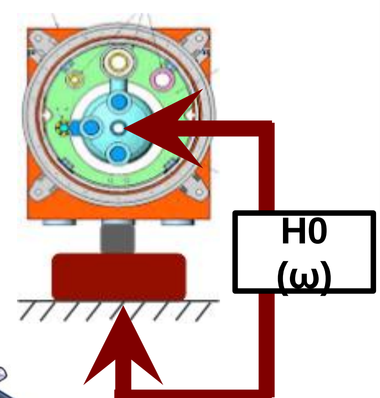


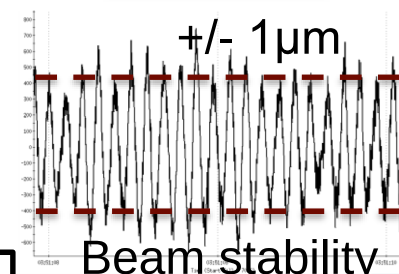


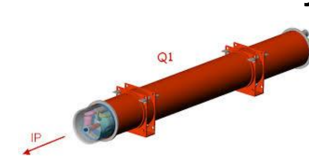
Dividing the problem in smaller contribution

Source term: the excavation technique	Transmission term: Vertical through the rock layers	Transmission term: Horizontal through rock	Transmission term: From the floor to the magnetic axis	Sensitivity: The beam stability
In (ω)	**H_2 (ω)**	**H_1 (ω)**	**H_0 (ω)**	**Out (ω)**

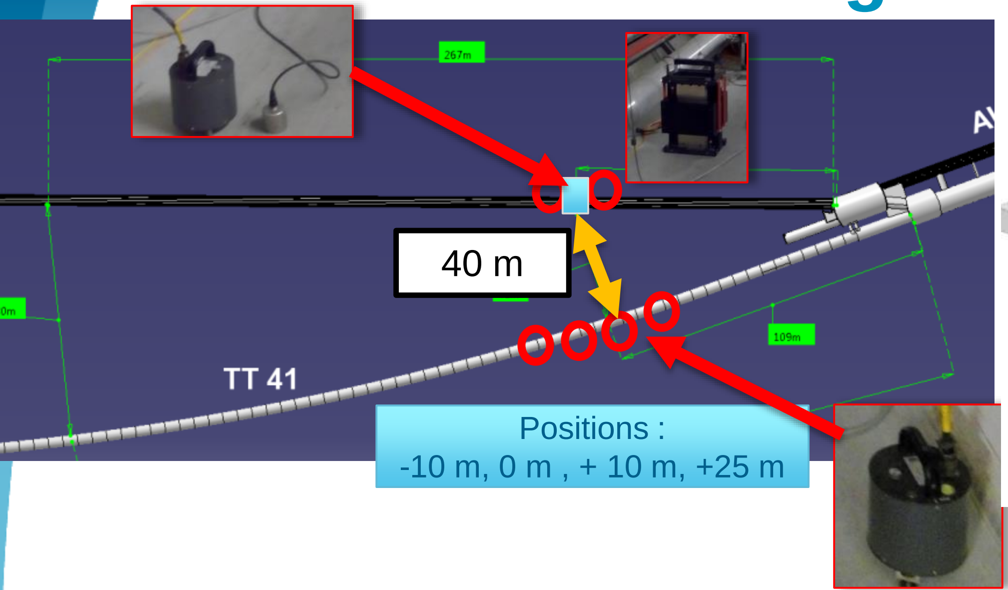


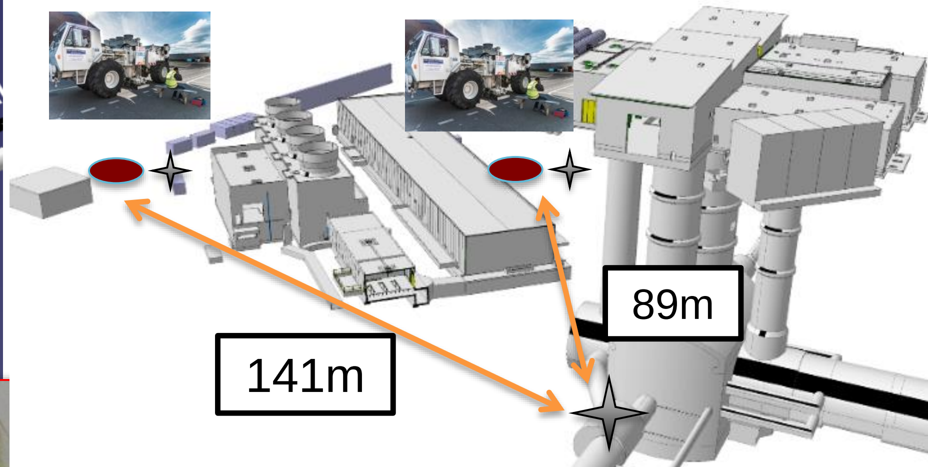




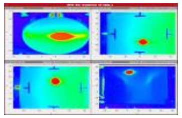


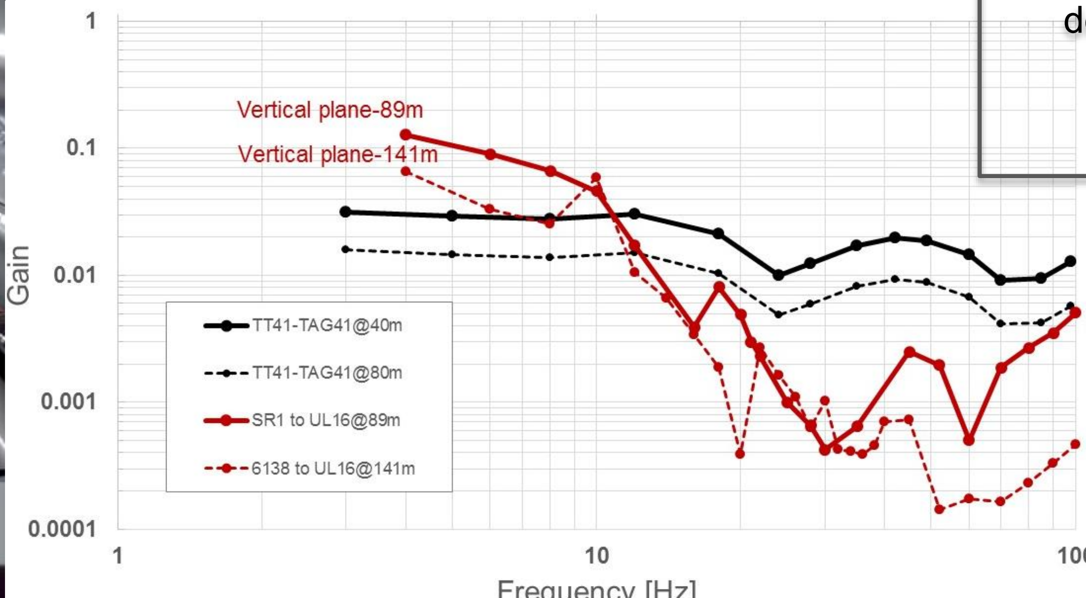
Estimating H1 (ω)+H2 (ω)



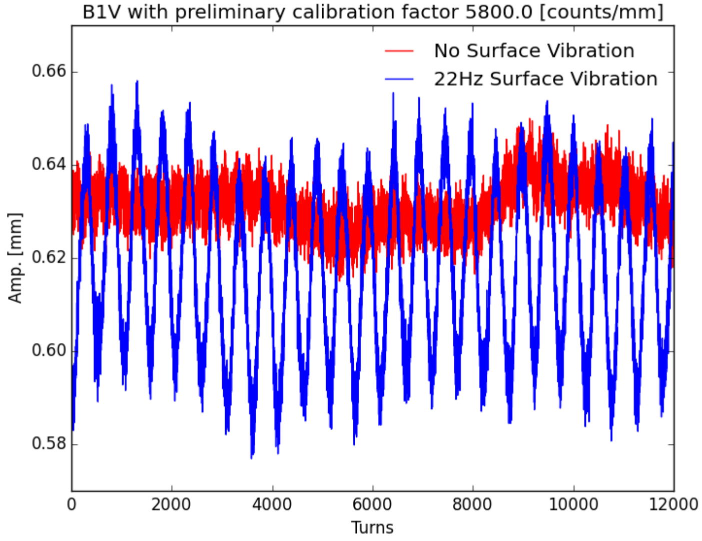


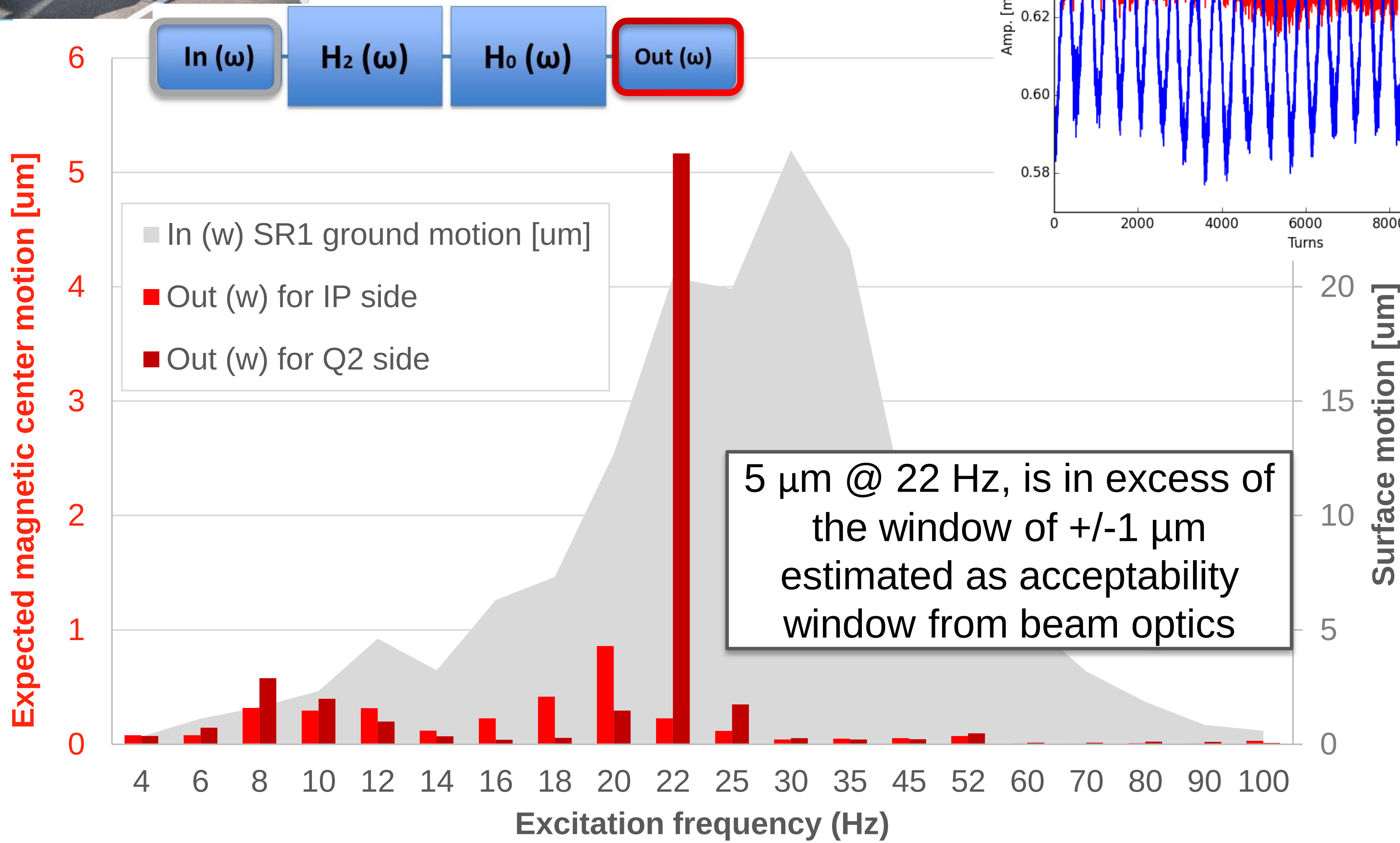
Beams stability measurements done in // by OP's team





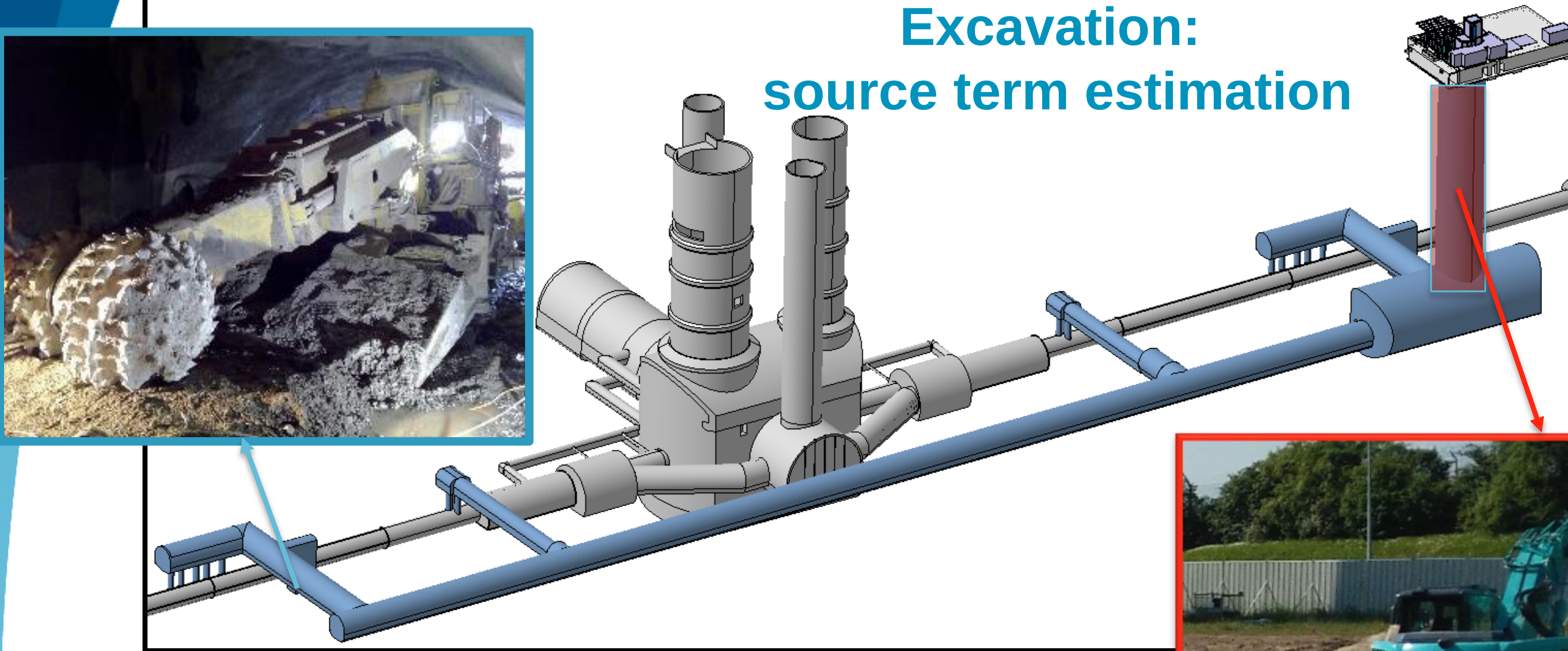
Measurement, expected movement and effect on beam at 22 Hz resonance



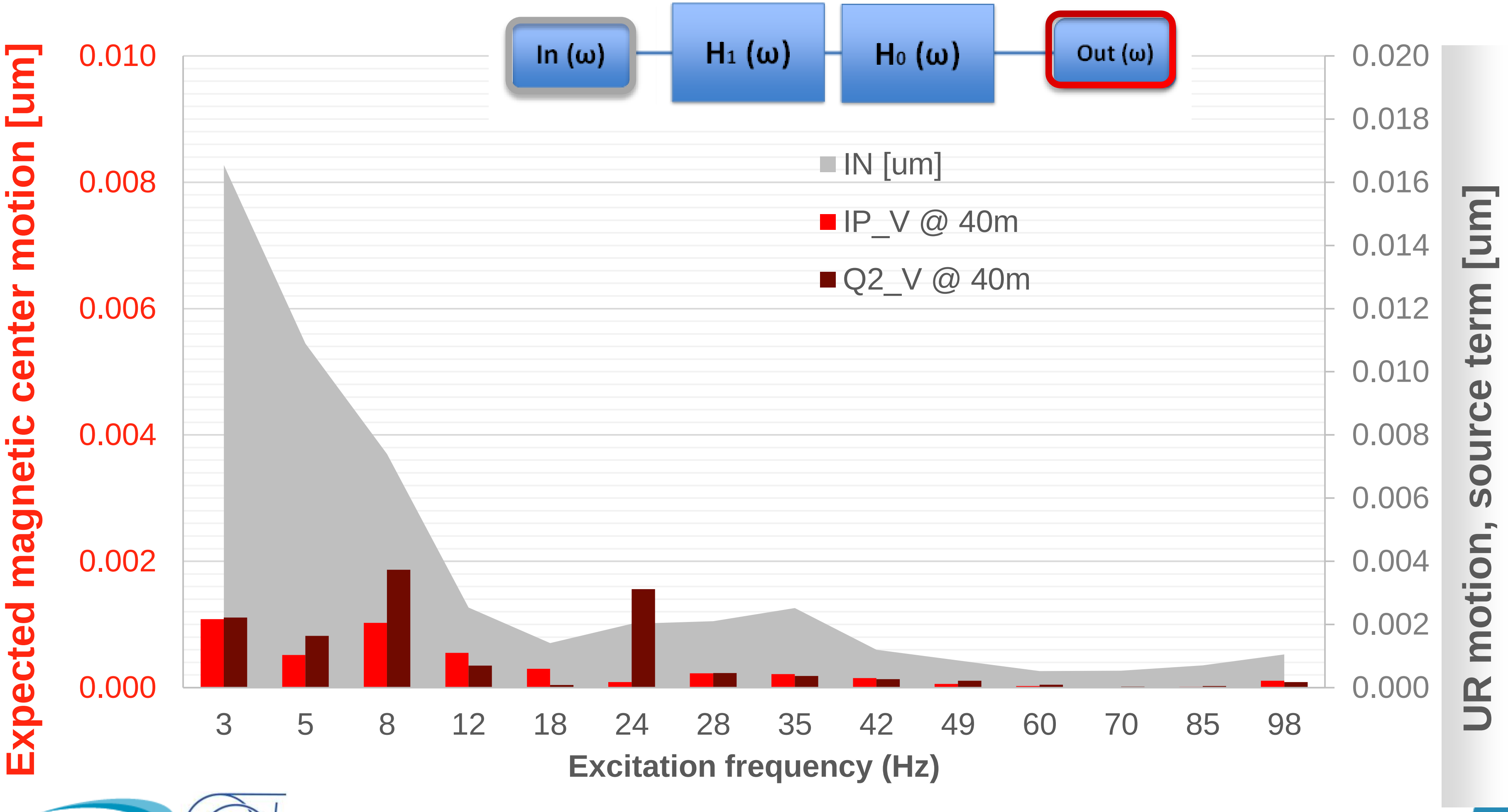


5 µm @ 22 Hz, is in excess of the window of +/-1 µm estimated as acceptability window from beam optics

Excavation: source term estimation

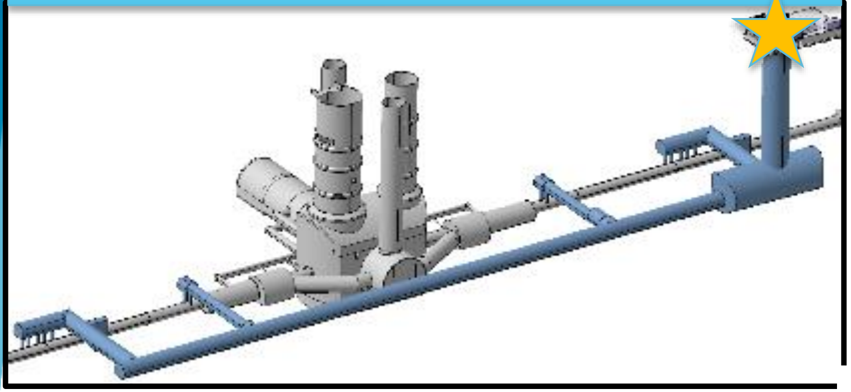


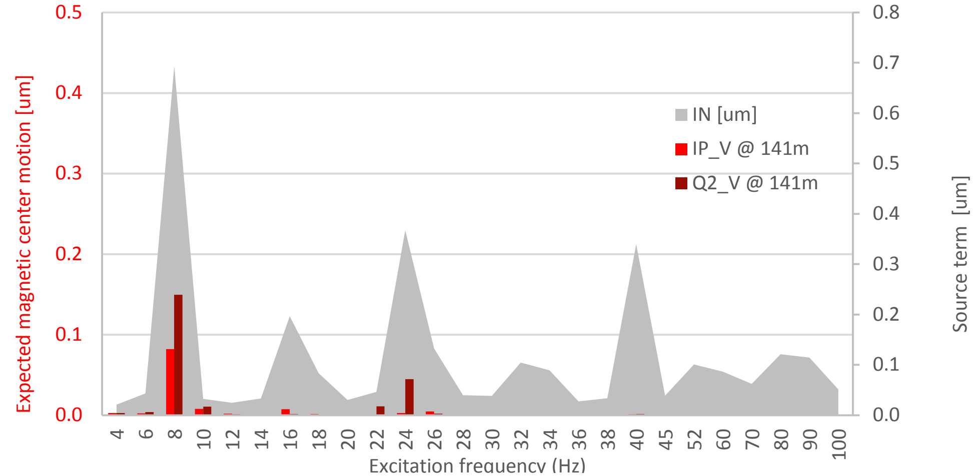
Roadheader simulations for the UR excavation: 40 m distance



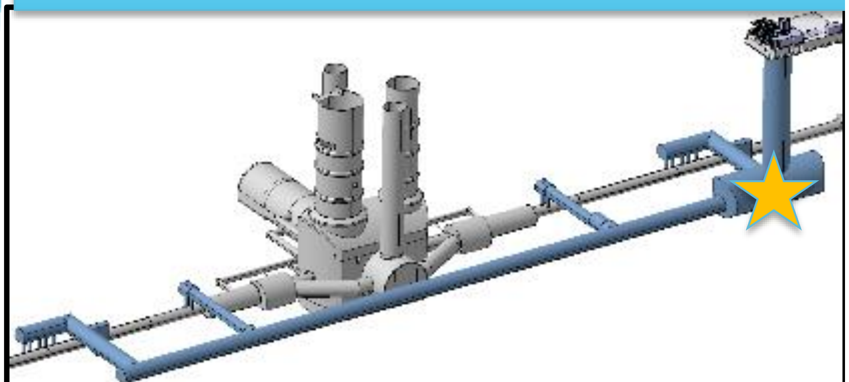
Shaft excavation

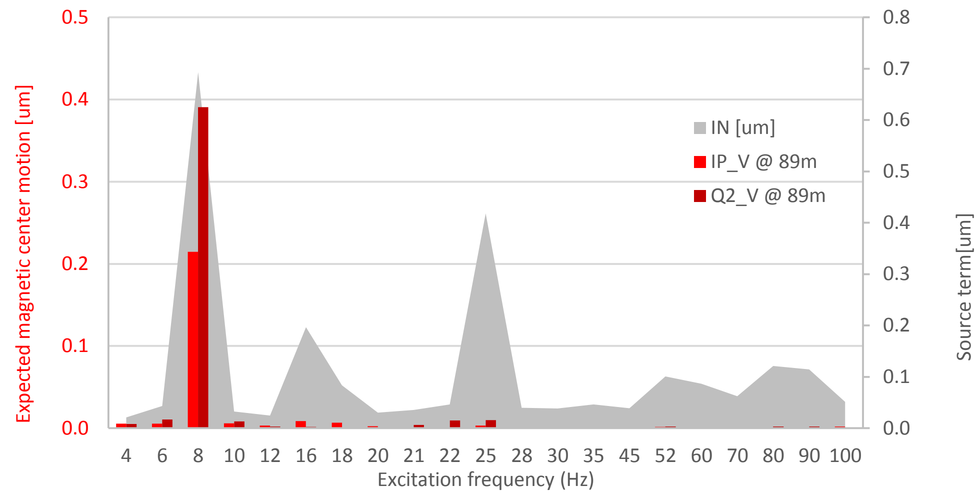
Start point hydraulic hammer



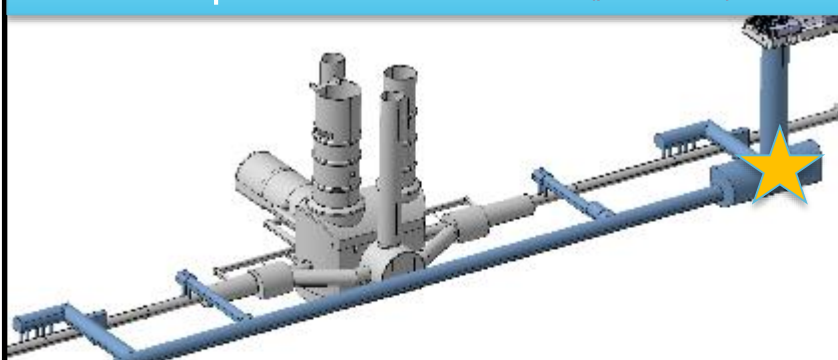


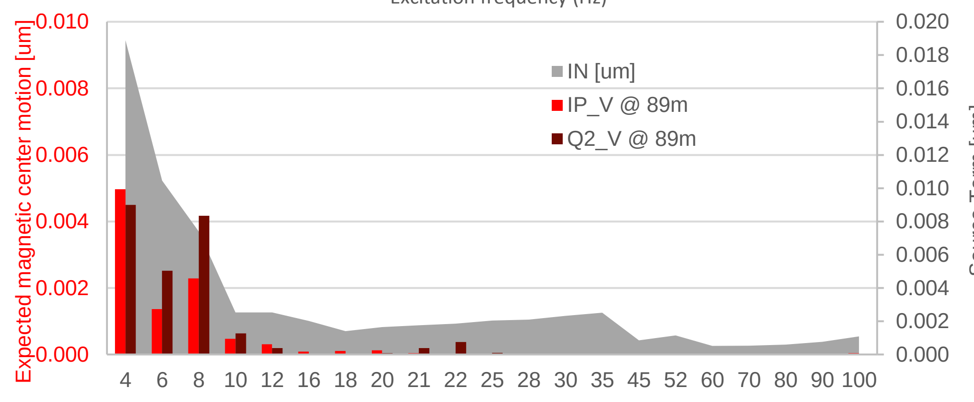
End point hydraulic hammer (pessimistic)





End point roadheader (pessimistic)





Conclusions of the vibrational analysis

HL-LHC project is confident today to have a comprehensive strategy to manage the possible impact of the vibration on the LHC operation

PLANNING:

The civil engineering activities have been anticipated in order to overlap the LS2. Activities that are outside that period are

- The shaft excavation: take place during the final part of the Run 2
- The concrete and tunnel finishing: take place during the machine restart in Run 3

EXCAVATION TOOLING:

Following lengthy and complex measurement:

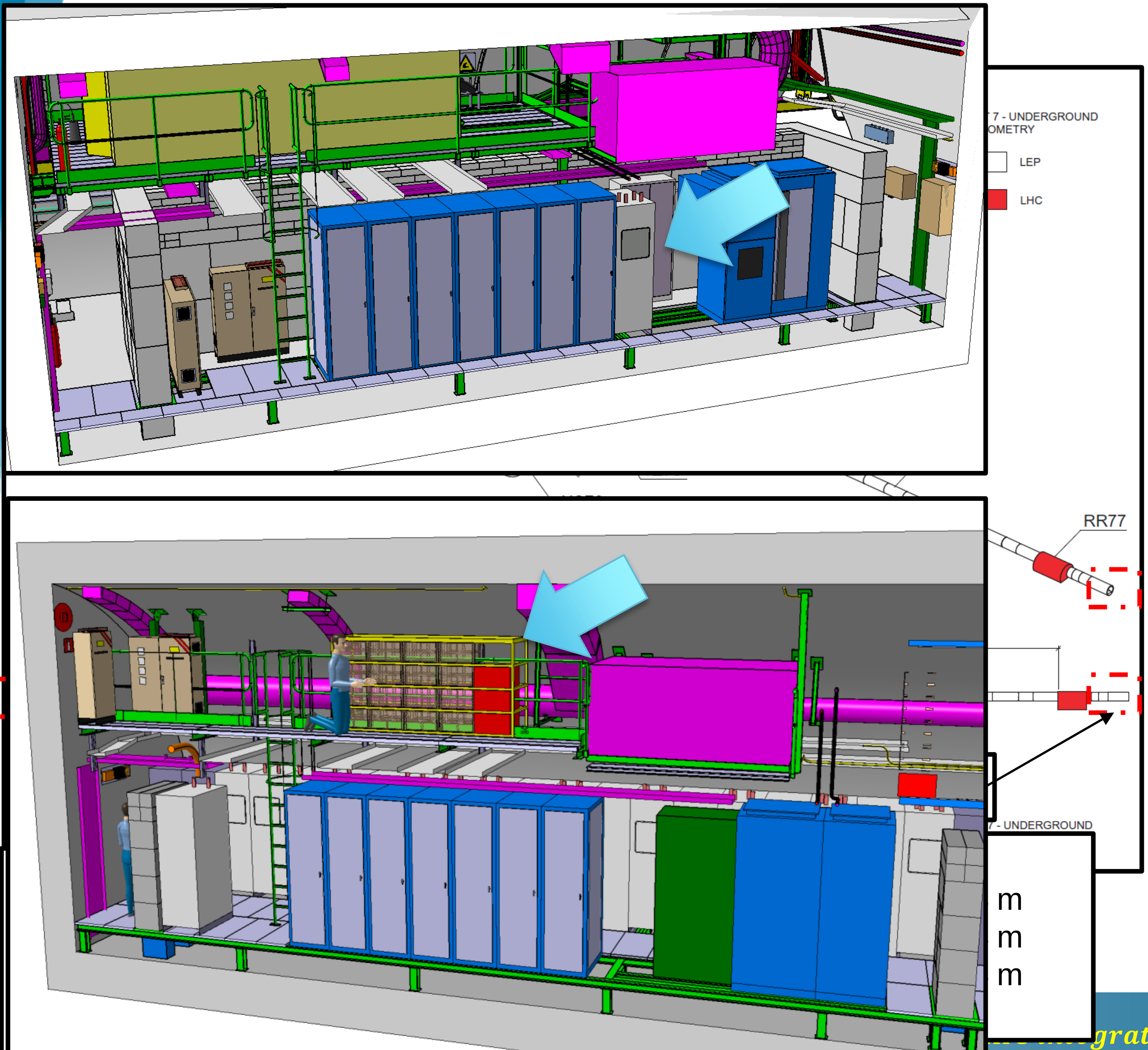
- The roadheader looks to be compatible with the horizontal structure excavation, but being these tunnels the longest and the nearest to the LHC, they have been placed in parallel to the LS2
- The hydraulic hammer look to be marginal for the shaft excavation, but the use of roadheader could be applied in case of problems (impact on planning and cost being assessed). Possible modified hydraulic hammer could be evaluated.

Design:

The double decker has allowed to redesign the new infrastructure in order to increase as much as possible the distance of the largest excavation to the most sensitive area (final focus magnets)

HiLumi HL-LHC PROJECT

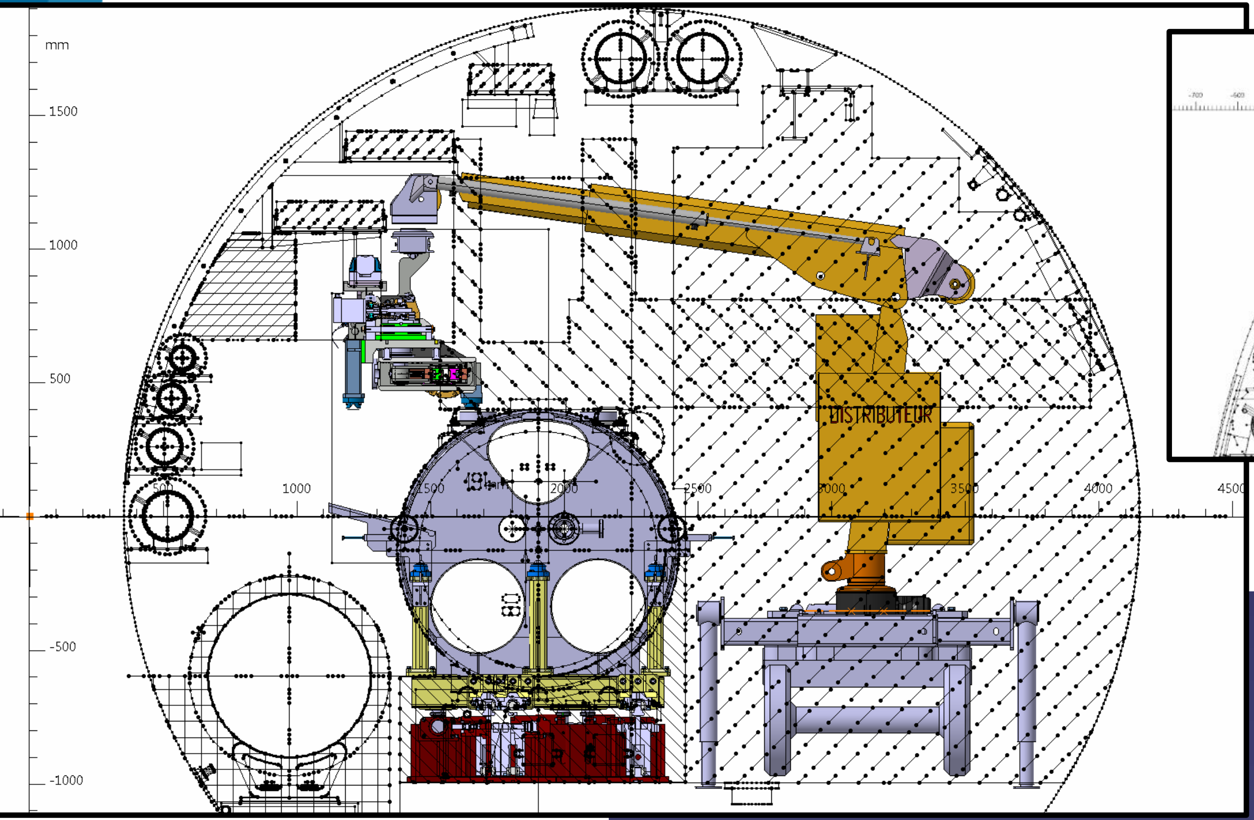
11T and TCLD integration work

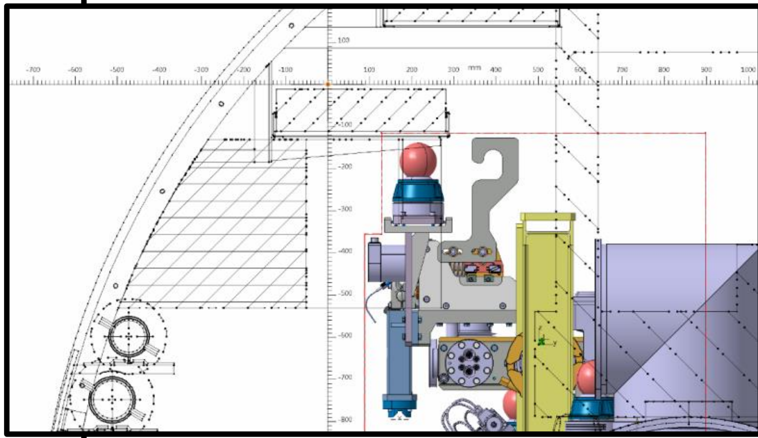


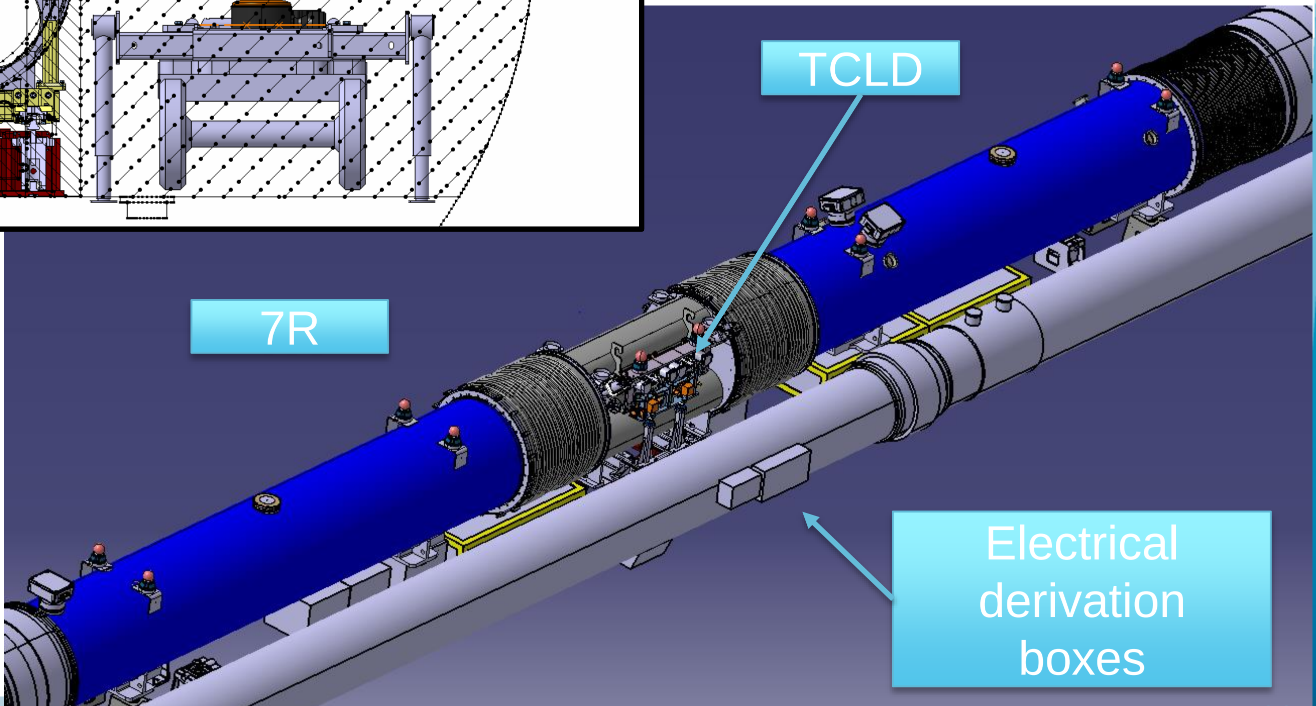
Integration of the following equipment ongoing:

- QDS
- QH power supply
- PC for trim
- Cable for trim circuit

11T and TCLD integration work







Courtesy F. Delsaux, M. Czech and L. Gentini

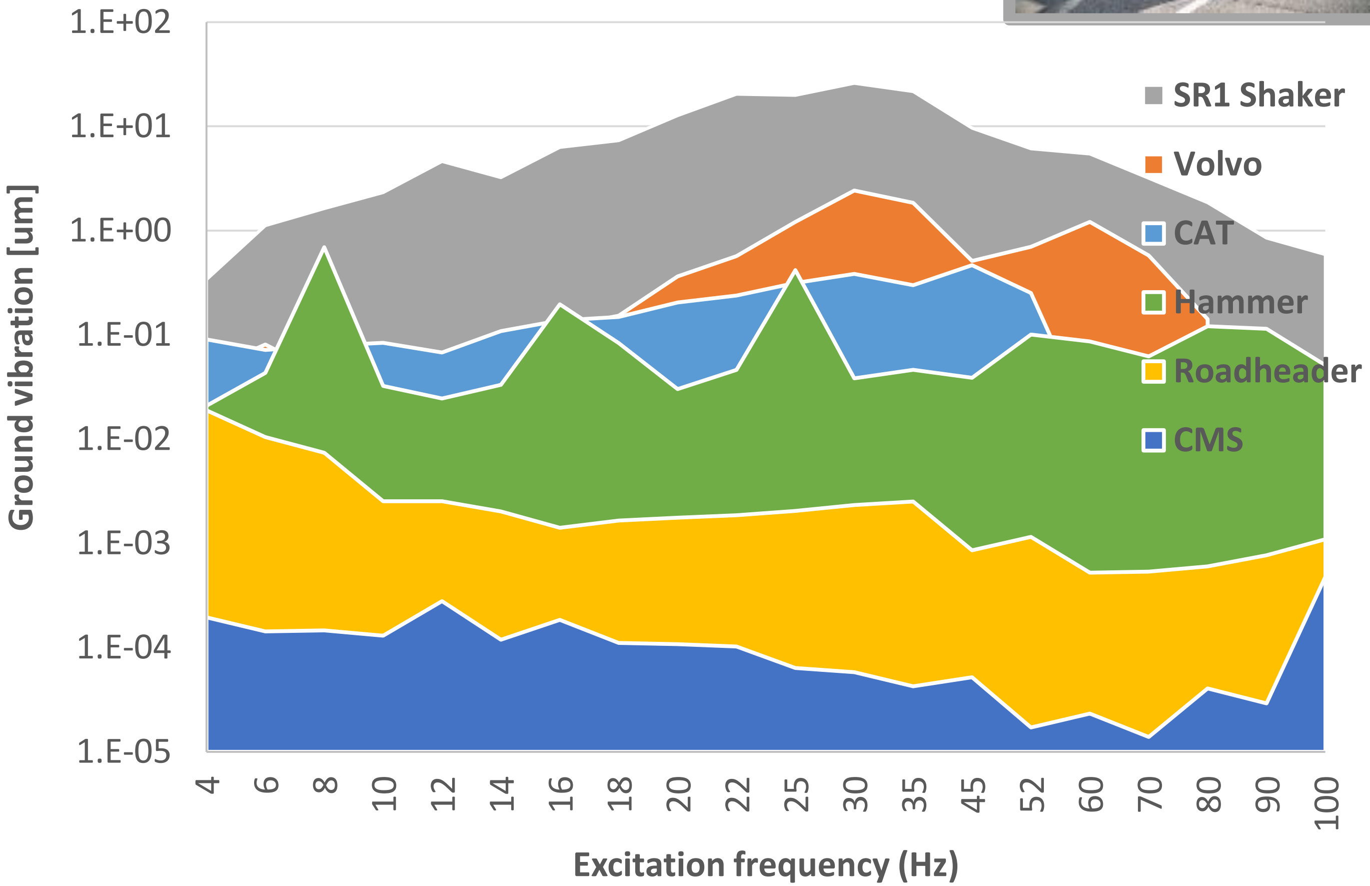
Conclusions and look in the short term future

- The Lay-out 1.3 for the IP 1 and IP 5 is completed and drawings being approved, integrating the June 2016 project re-baseline
- The other HL-LHC relevant lay-out will be dealt with in the next months
- The underground integration in the new CE infrastructures has been updated according to June 2016 decisions
- The vibration analysis concerning LHC exploitation during the LHC operation has well advanced and a solid action baseline has been set
- Detailed study for equipment installation are starting from LS2 objects (11T, TCLD, new TAN in point 8) which are well advanced
- A strict collaboration with R2E team is being setting up. We are setting up common documentation in order to have explicit R2E stamps and qualification reported in the integration documents
- De-installation and installation, phasings, sequences and related budget will be the main subject of work in the next 12 months together with the lay-out of the other point with particular regard to the IP4

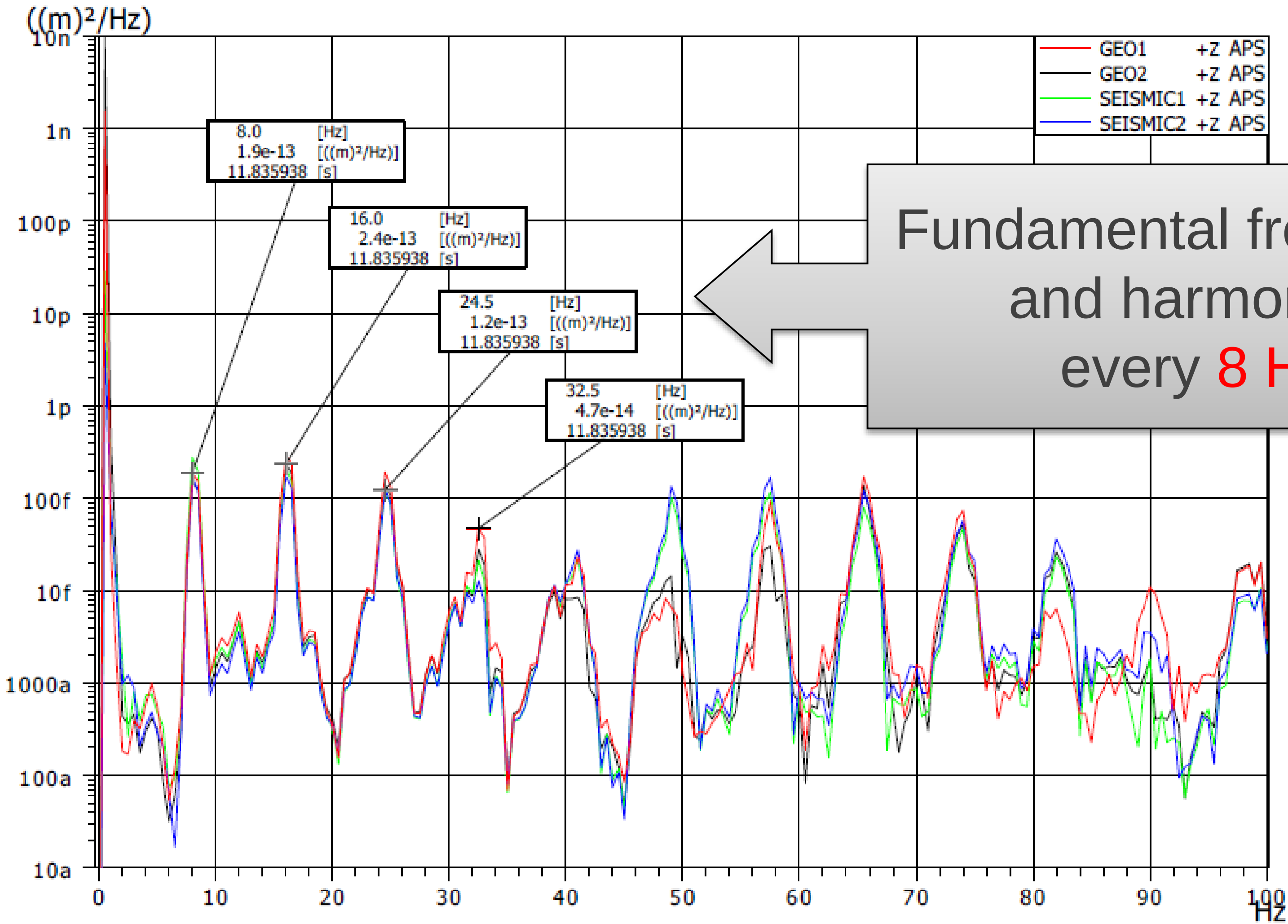
Extra slides

Source characterization

- Vibration level for several civil engineering tools

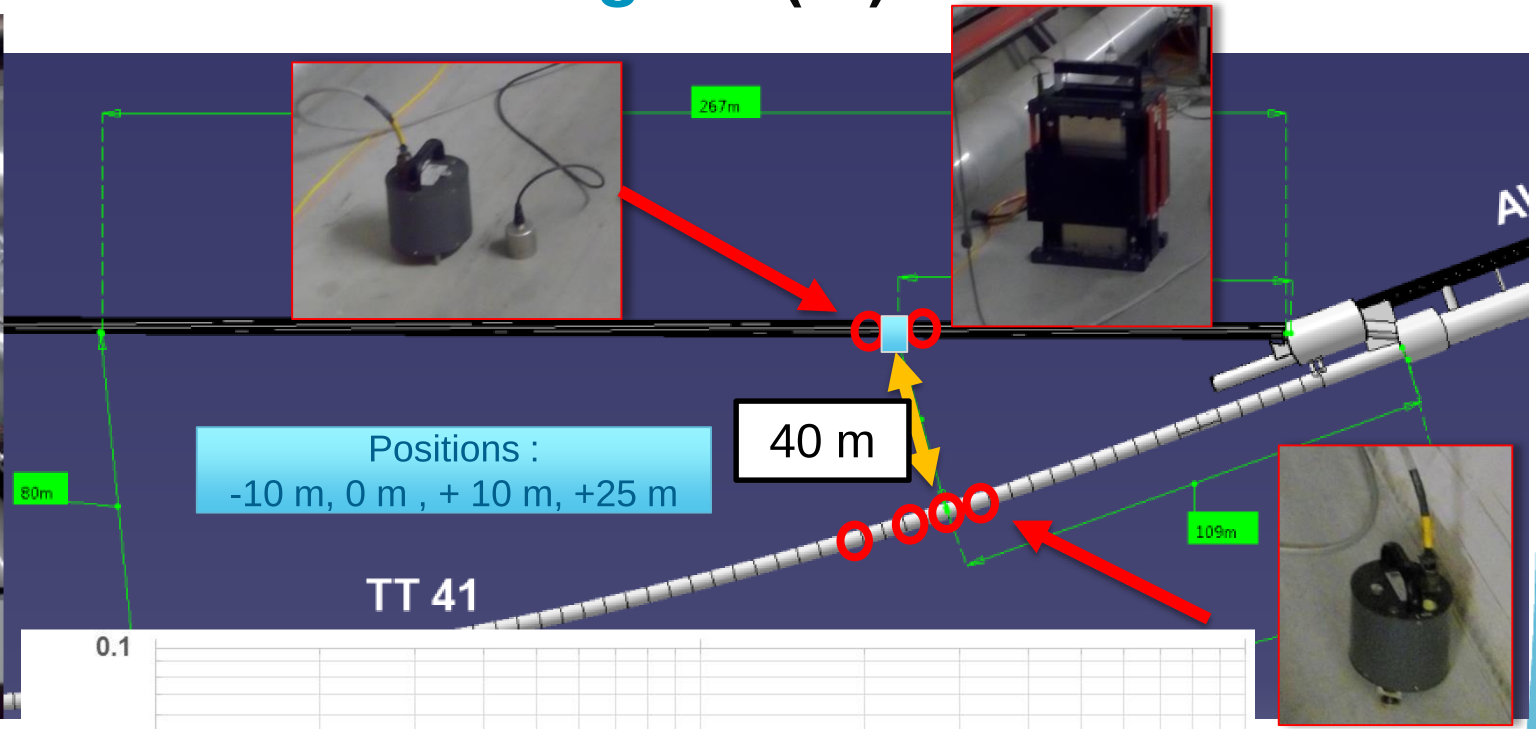


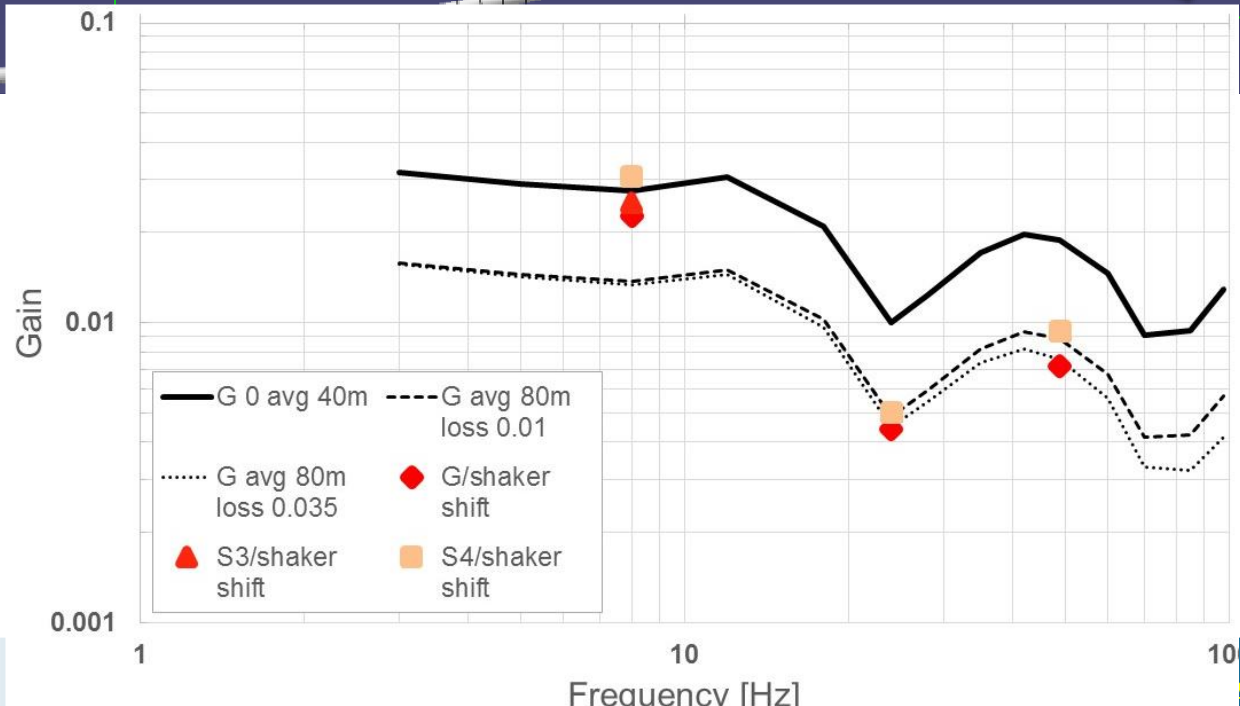
Shaft excavation: hydraulic hammer power spectral density



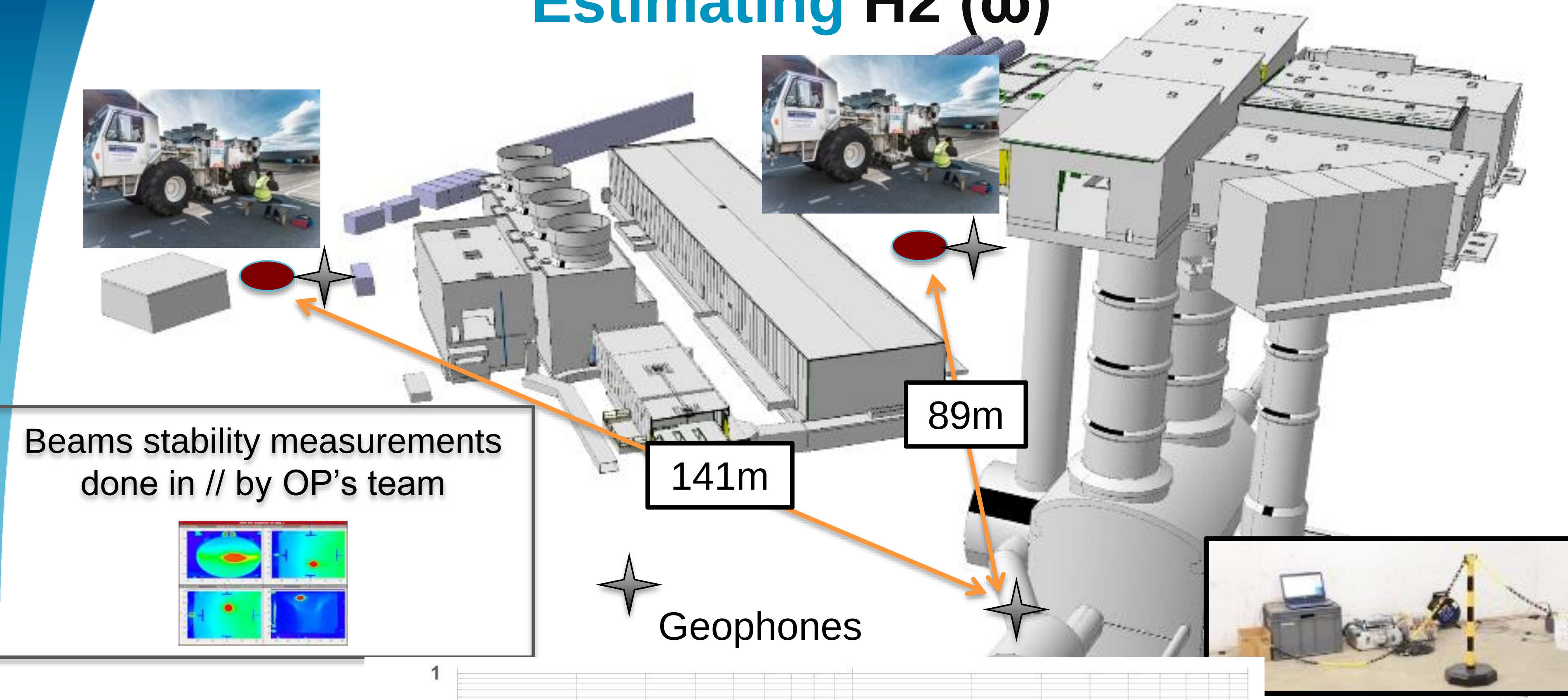
Fundamental frequency and harmonics every 8 Hz

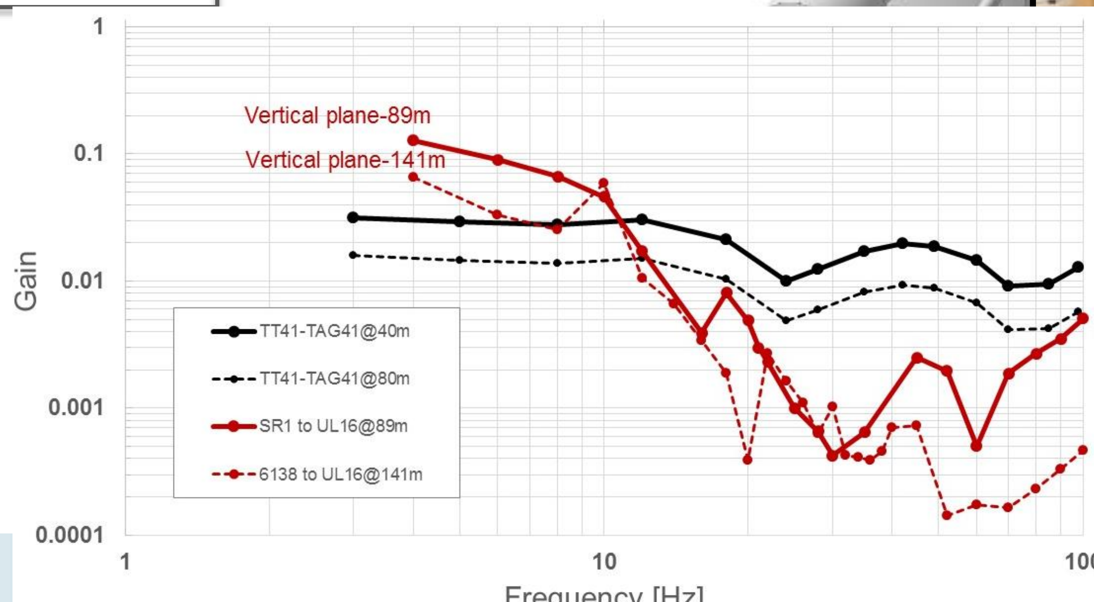
Estimating H1 (ω)





Estimating H2 (ω)

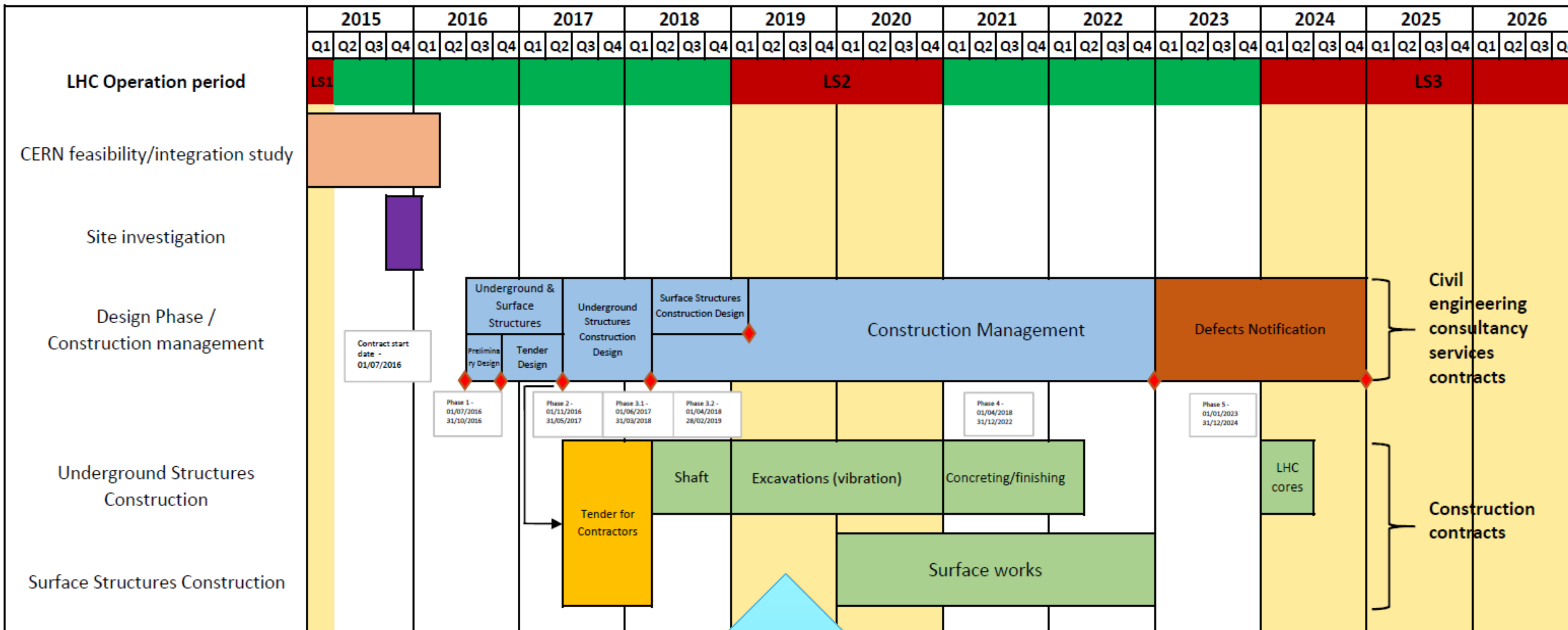




Minimize risk with appropriate planning approach.

Conceptual see the WP17.1 for detailed

APPENDIX L - Programme DATE: 13/05/2016 REVISION: 2



NOTE: Staged Handovers for the underground and ...ructures is envisaged. The timing of these handovers will be agreed during Phases 1 & 2.

Maximum quantity of work out of beam time
Work in beam the furthest from critical point

That for loss on collimators and now what about emittance growth? Low frequency noise MD

(analysis ongoing very preliminary results)

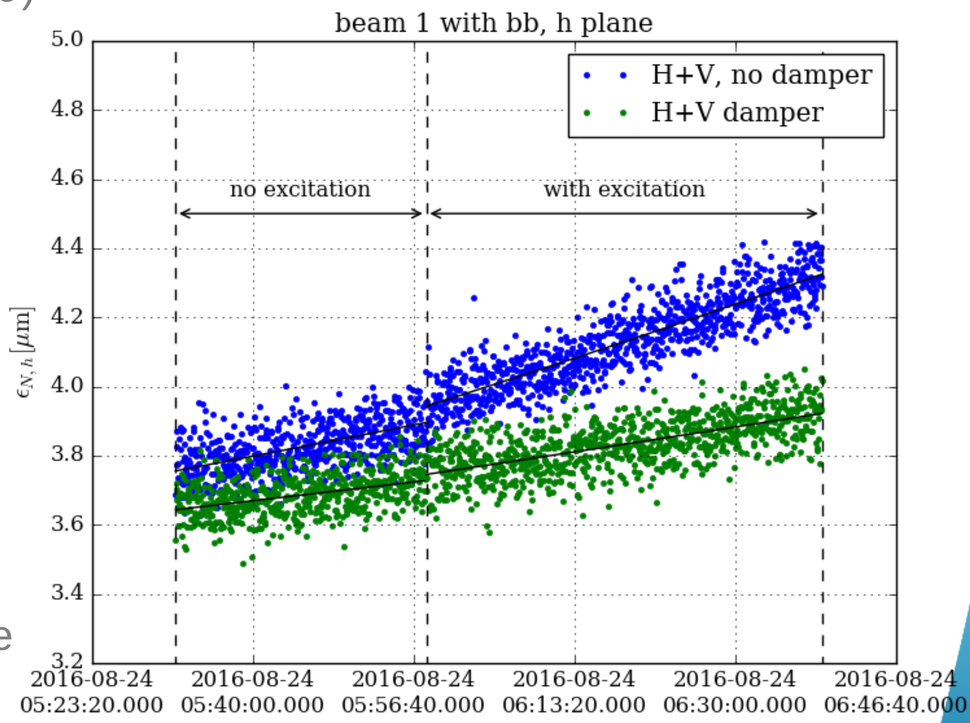
2 experiments (experiment 1, experiment 2, both at injection):

- sinusoidal low frequency dipole excitation with inner triplet eigen-frequencies ($f_{hor.}$=11.245Hz, $f_{vert.}$=20.49Hz, rounded as multiples of the revolution frequencies)
- colliding and non-colliding bunches, with and without damper
- excitation amplitude approx. x10 higher than expected from ±1 µm displacement of inner triplet in worst case scenario (excitation amplitude @ transverse damper = ±2 µrad, displacement at IP up to 62 µm = 0.25 σ)
- excitation switched on/off

Main observations (to be confirmed by detailed analysis):

- emittance growth due to excitation without transverse damper (up to 10%)
- no emittance growth with transverse damper (as in physics operation)
- increased losses mainly in vertical plane due to excitation (orbit movement at collimators, increased diffusion)

=> Effect on emittance likely to be negligible



Measurements H0 (ω) on spare LHC Q1

Q1-Q2

Q1-IP