Option to feed the Corrector Package correctors with Water cooled cable following TCC 01/11/2018

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Short summary

- TCC endorse the removal of the 120 A and 200 A SC wires from the SC link
- The connection of the CP (where the related magnet are connected) to the PC and the PC location itself is still pending
- The following options were discussed
  - Case A: use to standard warm cable leaving the PC on the HL UR. The cables would run through the HL ULs and SC link core. This had to be reviewed because the core modification to allow the warm copped cable to cool in air and the CV installation in the UL had not been foreseen
  - Case A': the update version of the Case A
  - Case B: installation of the PC in the LHC service galleries around the IPs
- On the 01/11/2018 following the presentation it was asked to analyze the Water Cool Cable option Case A"

	CASE A	CASE A'	CASE B
WP3	- 40 kCHF + 95 kCHF	- 40 kCHF + 95 kCHF	- 40 kCHF + 95 kCHF
WP6a	- 450 kCHF	- 450 kCHF	- 450 kCHF
WP6a		+3 m SC link for 90 T	
WP6b	No extra cost	No extra cost	+ 75 KCHF
WP7	- 25 kCHF	- 25 kCHF	No extra cost
WP9	- 60 kCHF	- 60 kCHF	- 60 kCHF
WP15	Minor impact	Minor impact	+ 100 kCHF
WP17.1		+128 kCHF core mod	
WP17.2	+ 330 kCHF	+ 286 kCHF + vertical core inst cost	+ 62 kCHF
WP17.3		+200 kCHF UL cooling	
Total saving	- 575 kCHF	- 575 kCHF	- 550 kCHF
Total cost	425 kCHF	709 kCHF	232 kCHF
Net	- 150 kCHF	134 kCHF	- 318 kCHF **(-218 kCHF)**

TCC 01/11/2018

Plus saving in magnet test (not quantified)

Op. cost electricity between 15 to 45 kCHF over 10 years (depending from kWh cost). Indicative evaluation WP6b

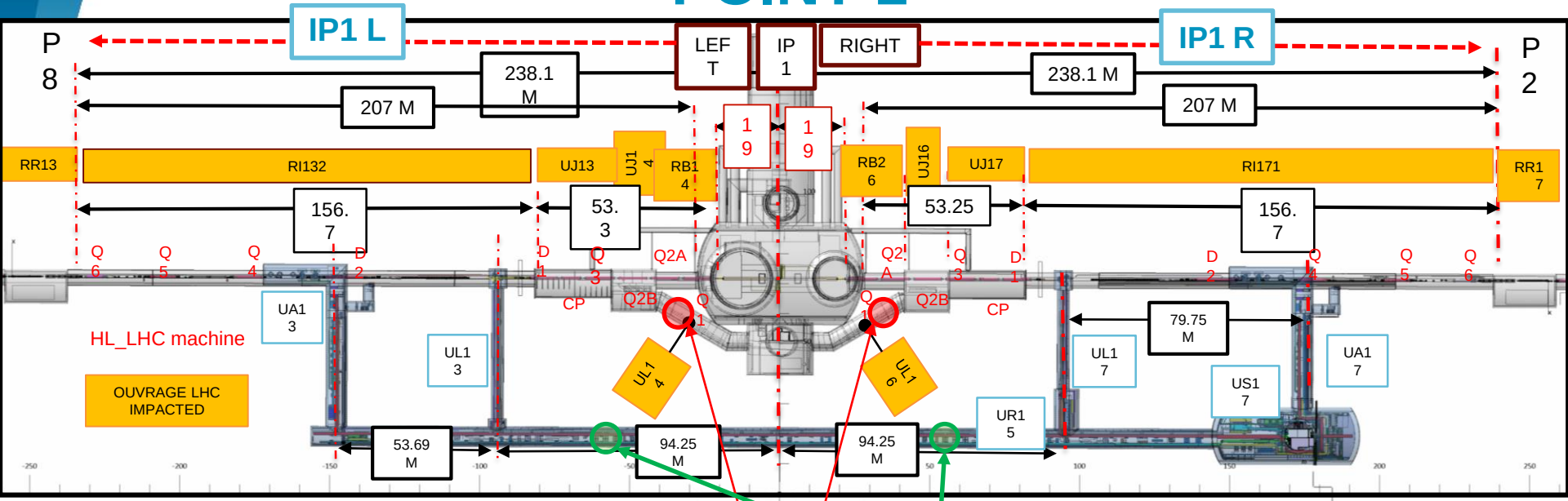
Op. cost + 80 kCHF

Provision in case of need

(38 kCHF already in baseline)

Option 2 :

POINT 1



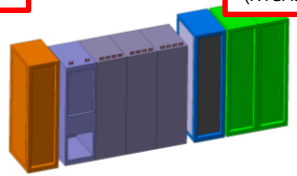
3 racks PC 120 A (R2E design) , (8 pc).

1 rack spare contrôle (RYSC01)

1 rack PC 200 A (R2E-LHC600A-10V)

2 racks spare modules (RYSA01-RYSA02)

½ rack energie extraction for 200A → 1 rack



Baseline location (140 m cables)

Location to place PC @LHC zone

IP1 R

8 racks It's possible !

HL_LHC STUDY

F

QH : 14 racks

UJ16

UL16

TYCFL01
SPARE 2
SPARE 3
BY01

QYC01
QYC02
TYCFL01
RYSA01
RYSA02

Debitmetre DFBX

EXISTING LHC Interlock rack CYCIP01

2 racks spare modules (RYSA01-RYSA02)

GEOPHONE

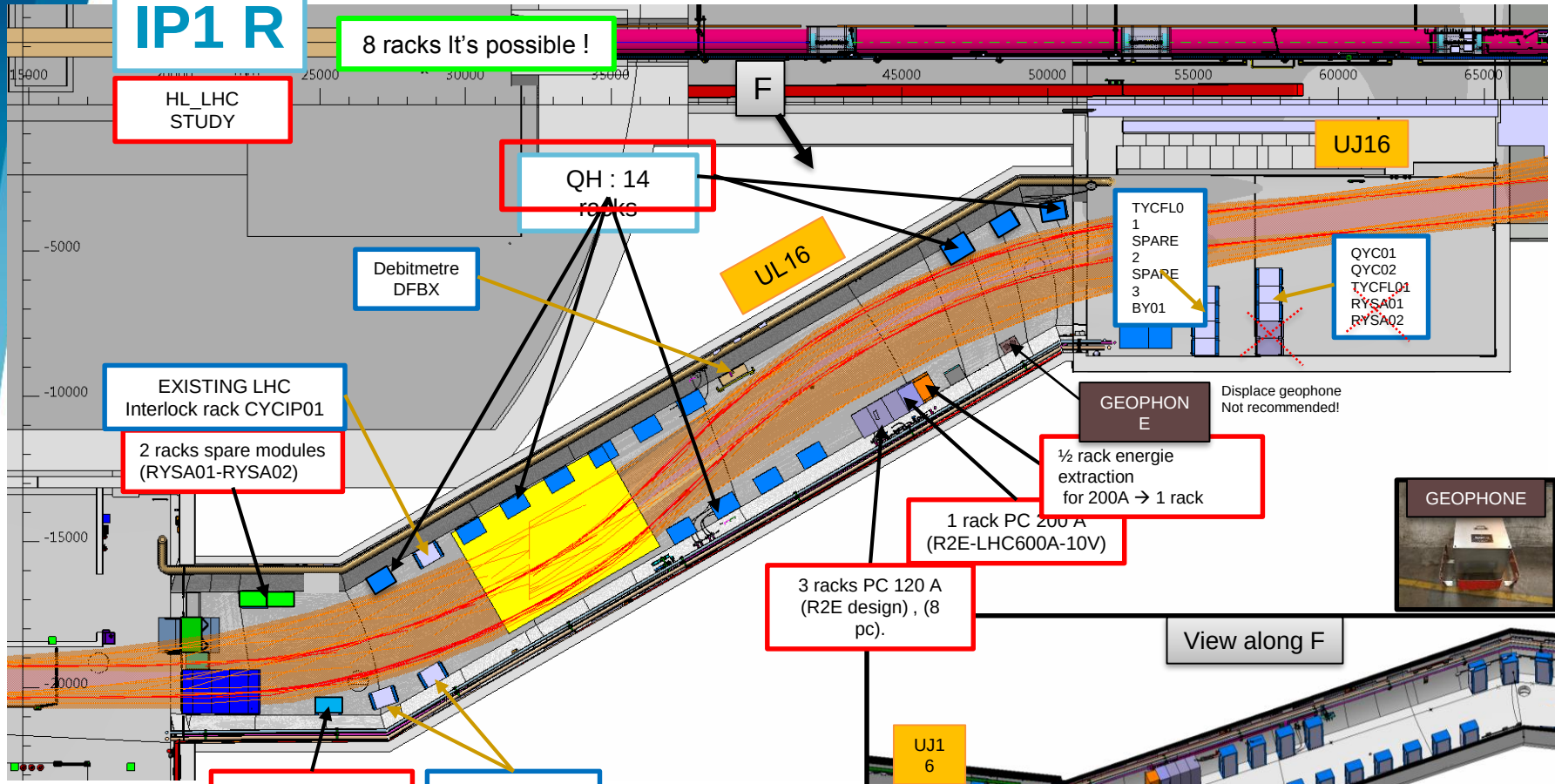
Displace geophone
Not recommended!

½ rack energie extraction for 200A → 1 rack

1 rack PC 200 A (R2E-LHC600A-10V)

3 racks PC 120 A (R2E design) , (8 pc).

GEOPHONE



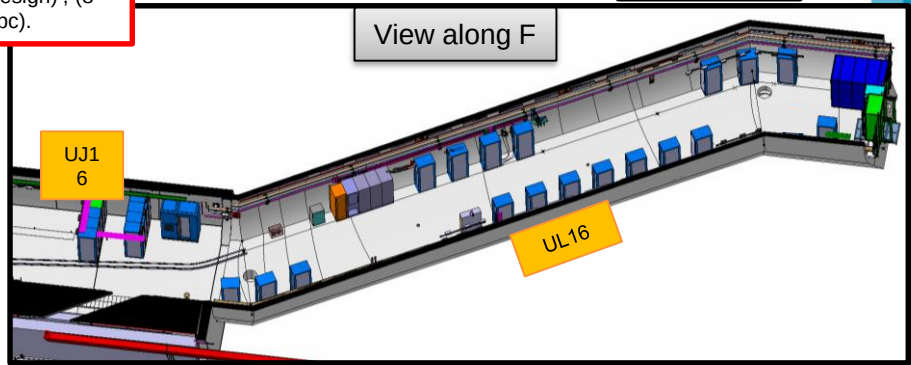
1 rack spare contrôle (RYSC01)

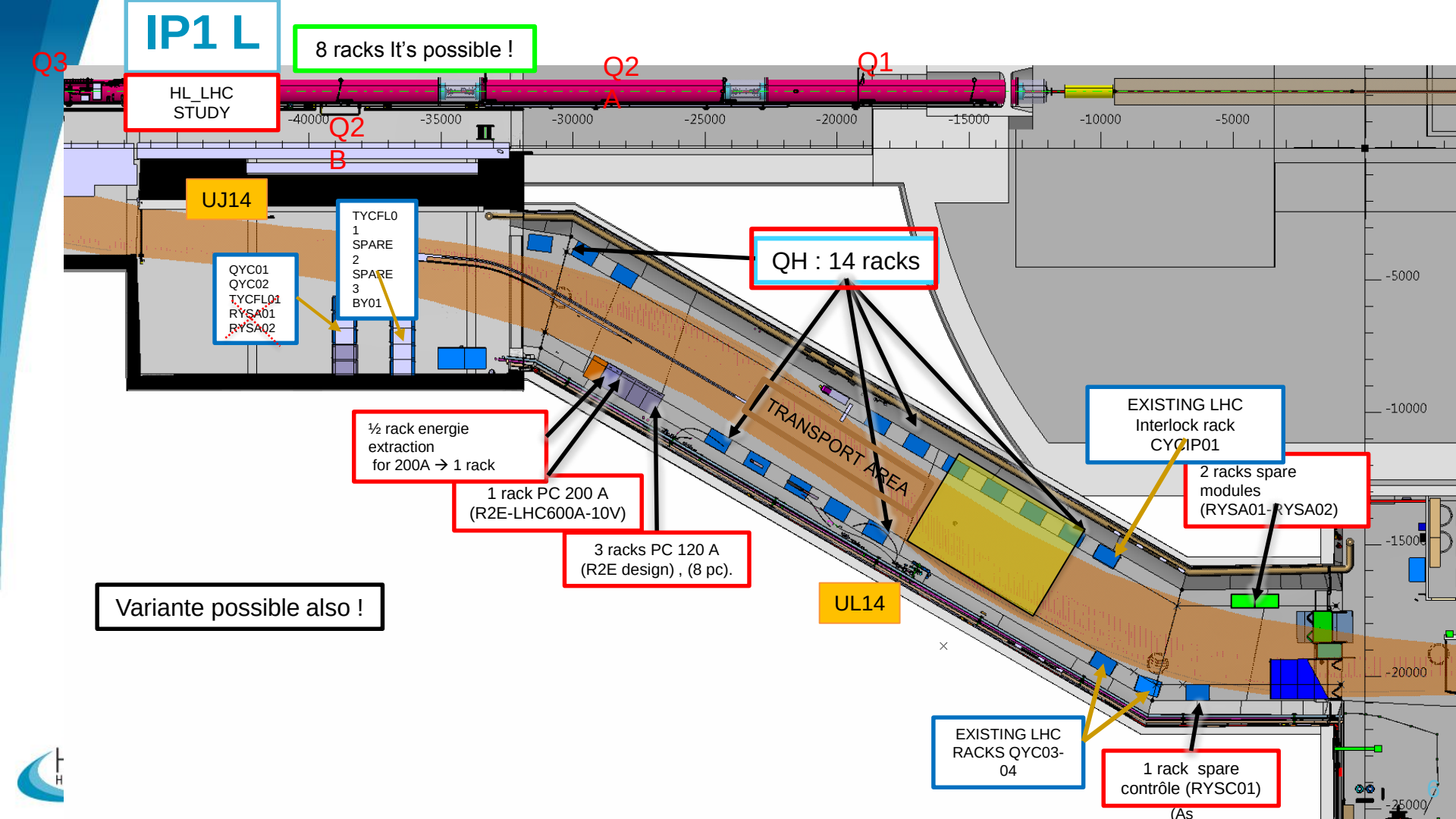
(As now)

EXISTING LHC RACKS QYC03-04

QH : Quench heaters power supplies

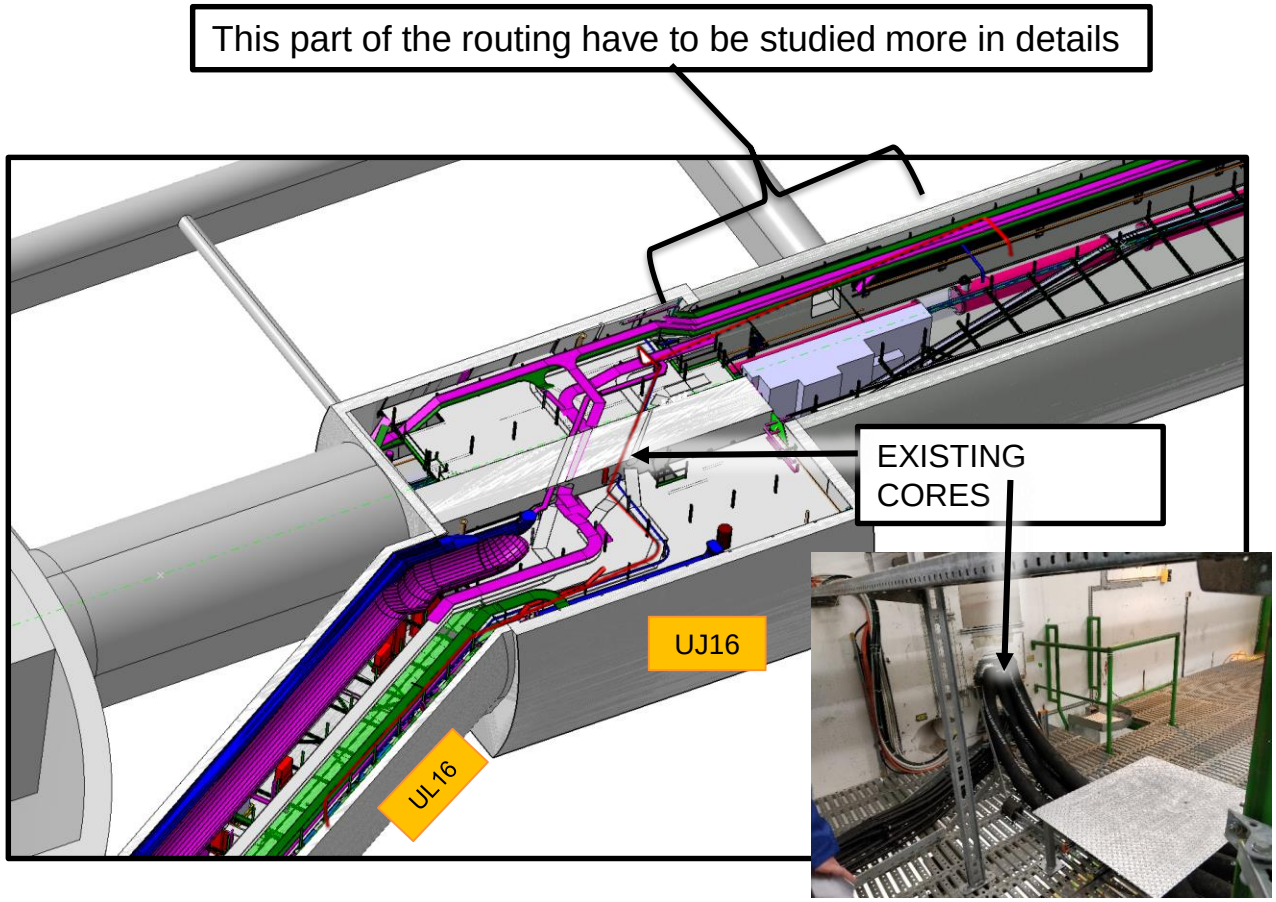
View along F



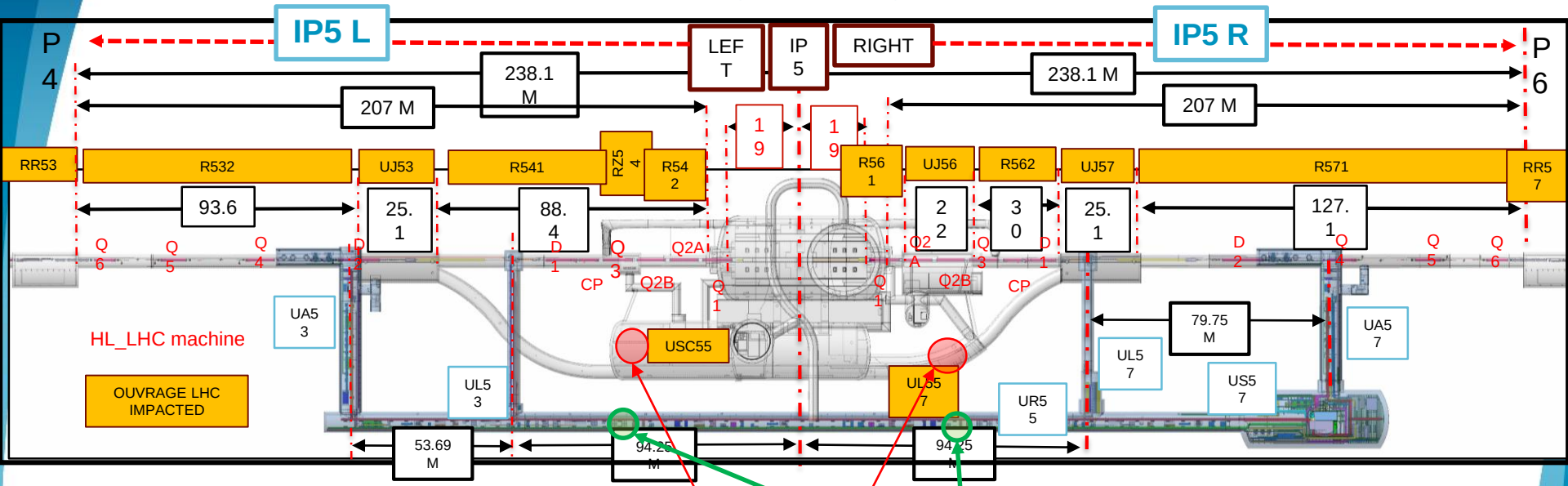

IP1 L
8 racks It's possible !
HL_LHC STUDY
Q3
Q2 A
Q1
Q2 B
-40000
-35000
-30000
-25000
-20000
-15000
-10000
-5000
UJ14
TYCFL01
1 SPARE
2 SPARE
3 BY01
QYC01
QYC02
TYCFL01
RYSA01
RYSA02
QH : 14 racks
TRANSPORT AREA
½ rack energie extraction for 200A → 1 rack
1 rack PC 200 A (R2E-LHC600A-10V)
3 racks PC 120 A (R2E design) , (8 pc).
EXISTING LHC Interlock rack CYCIP01
2 racks spare modules (RYSA01-RYSA02)
UL14
Variante possible also !
EXISTING LHC RACKS QYC03-04
1 rack spare contrôle (RYSC01)
(As
-5000
-10000
-15000
-20000
-25000

Power cables routing from PC to CP

IP1 R



Option 2 : POINT 5



Baseline location (140 m cables)

Location to place PC @LHC zone

Option 2 :

IP5 R

PLACE 14 QH racks in UJ56

8 racks It's possible !

1 rack PC 200 A (R2E-LHC600A-10V)

(R2E design) , (8 pc).

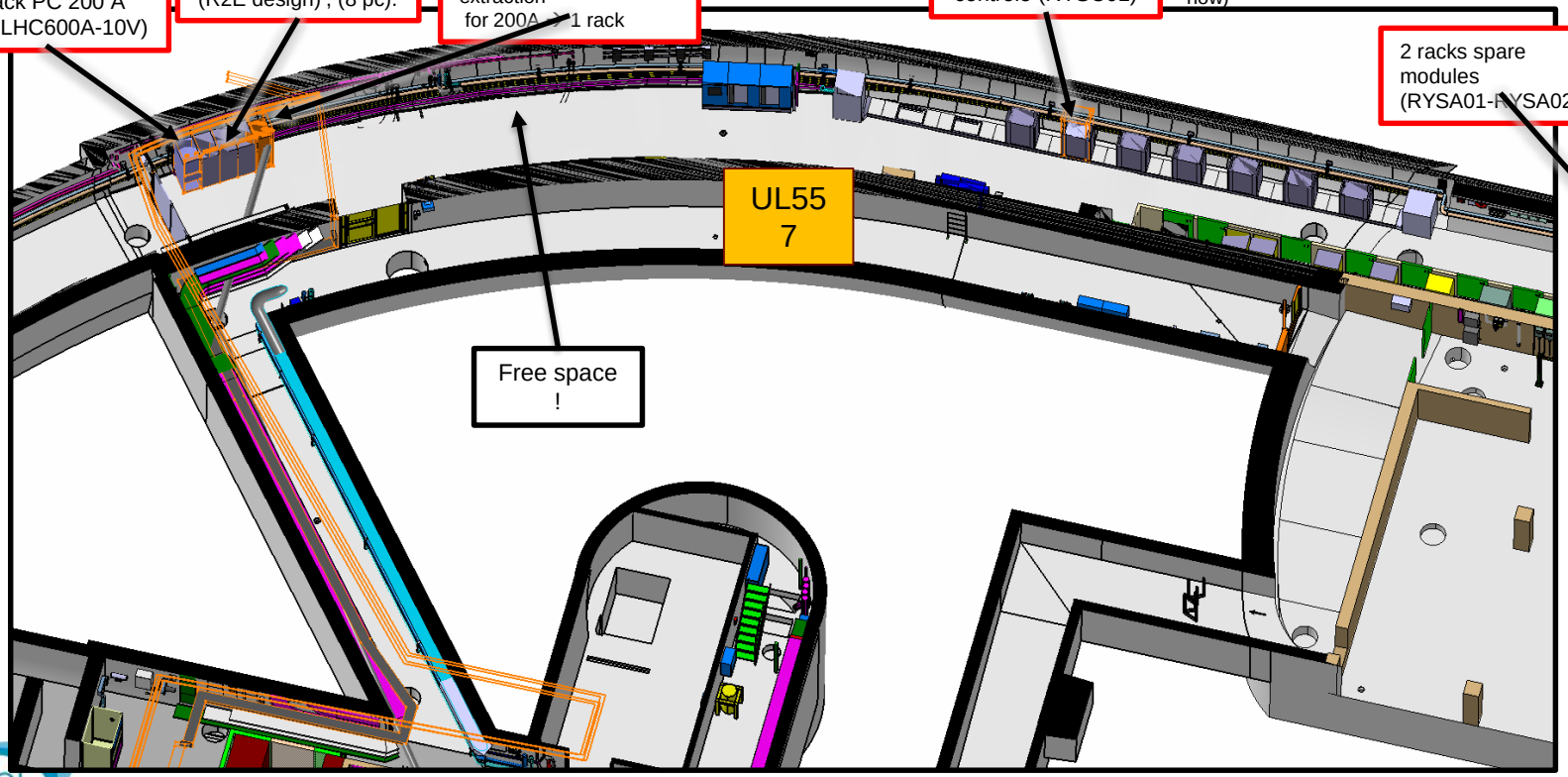
extraction for 200A – 1 rack

1 rack spare contrôle (RYSC01)

(As now)

2 racks spare modules (RYSA01-RYSA02)

(As now)

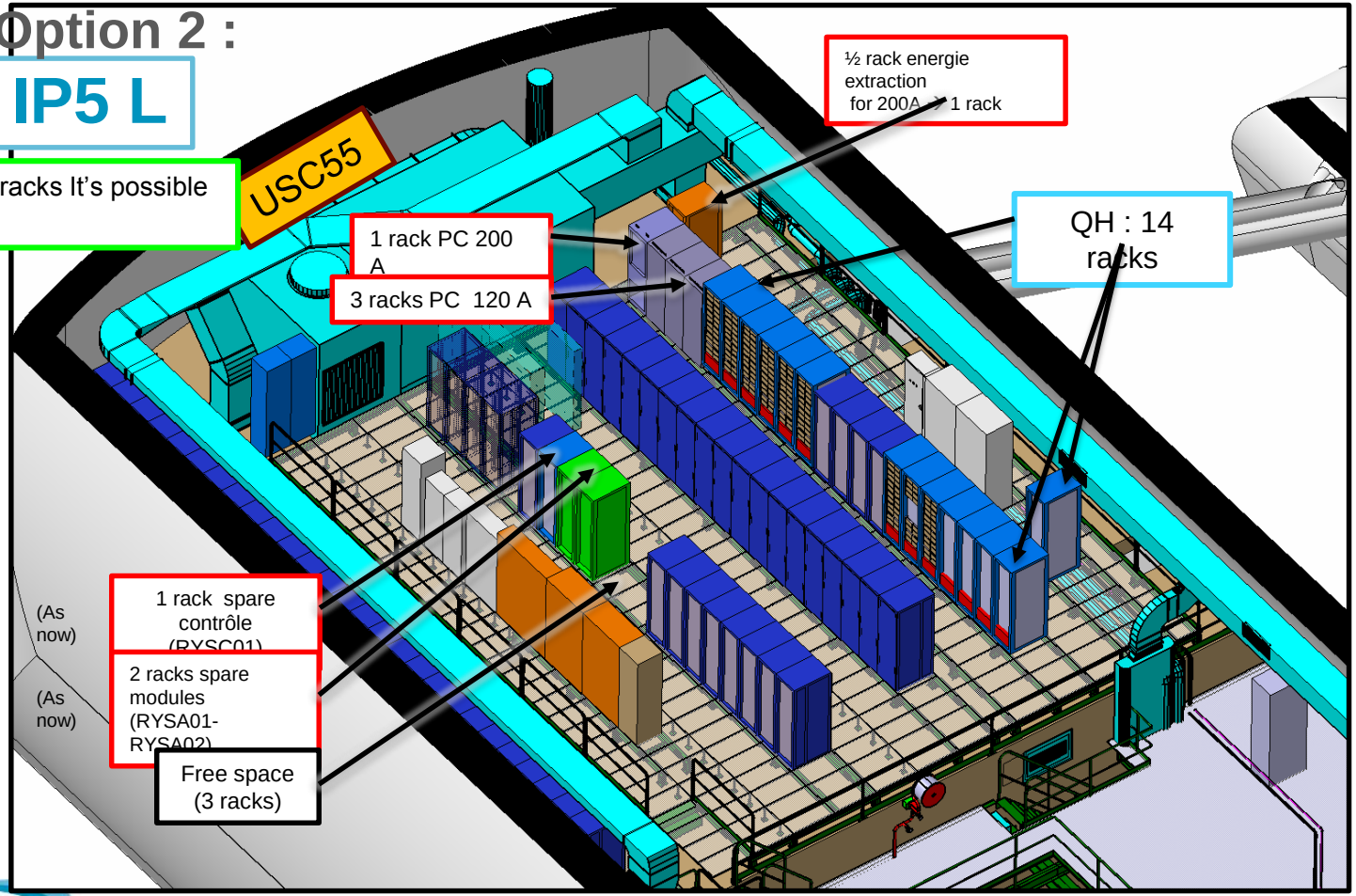


IP5 L

Option 2 :

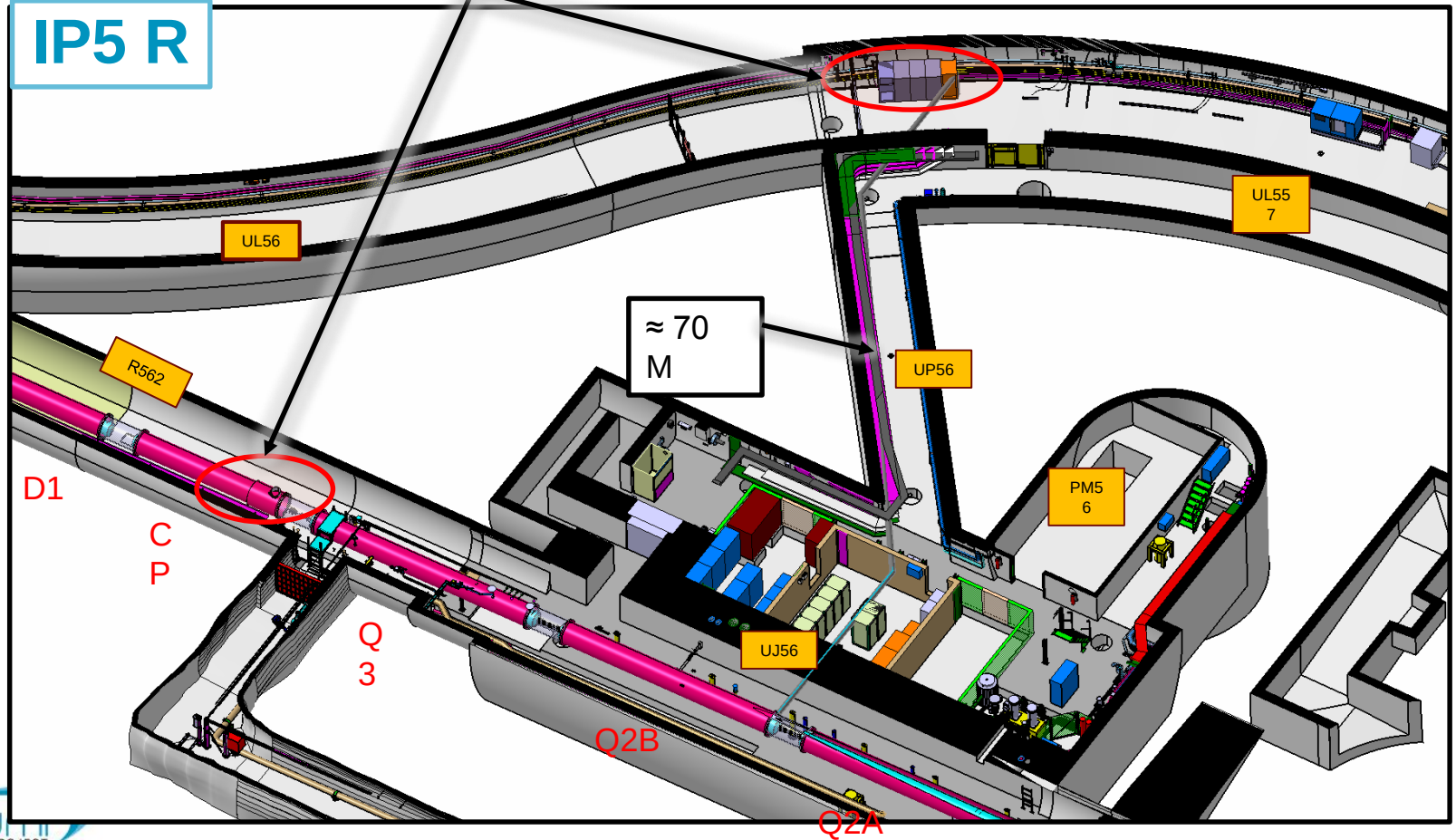
IP5 L

8 racks It's possible !



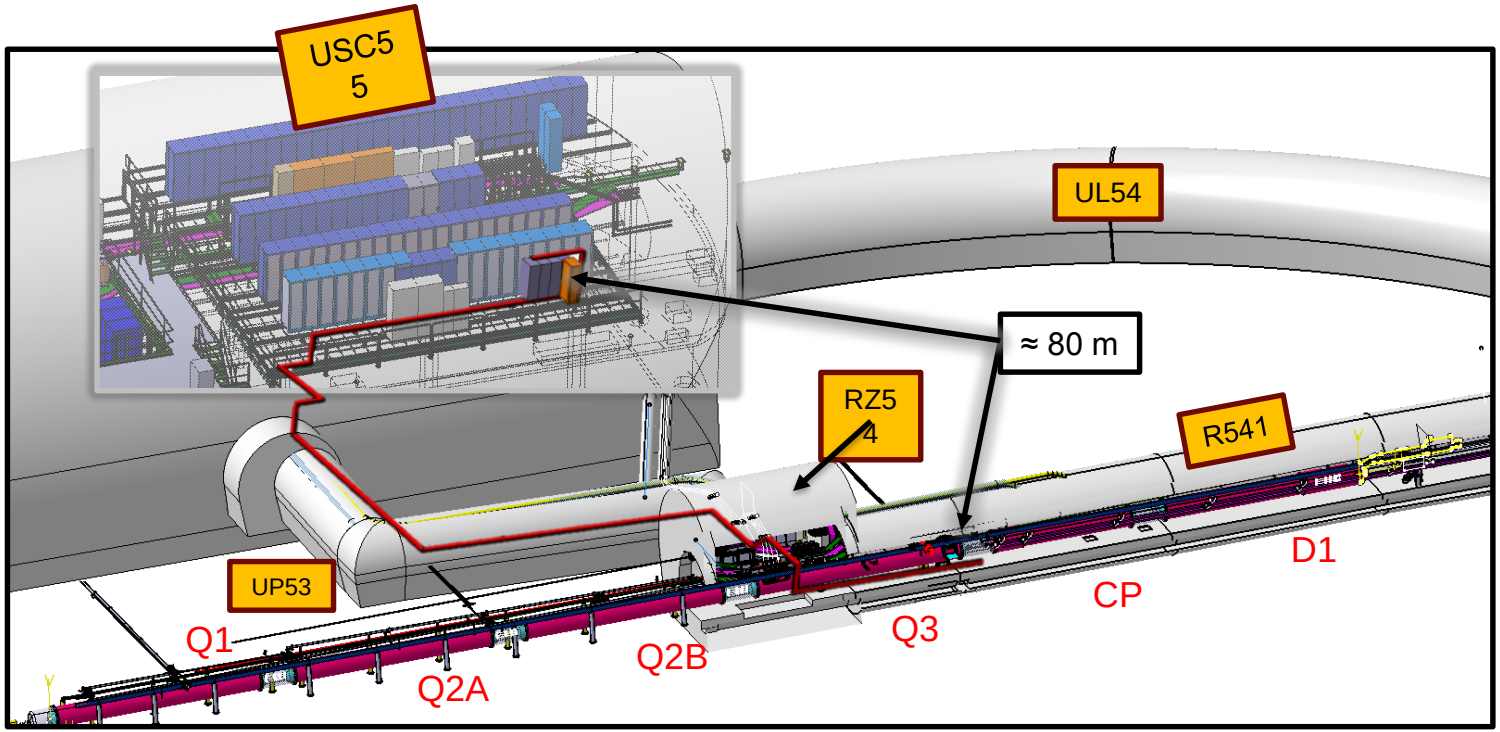
Power cables routing from PC to CP

IP5 R

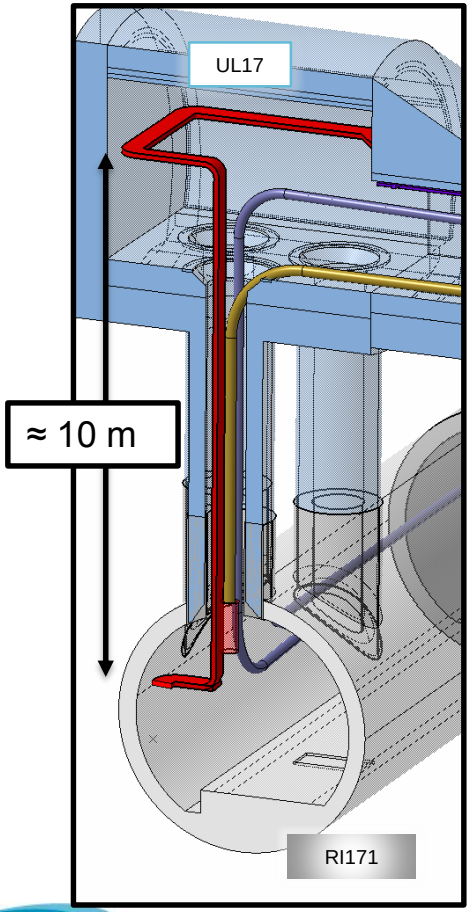


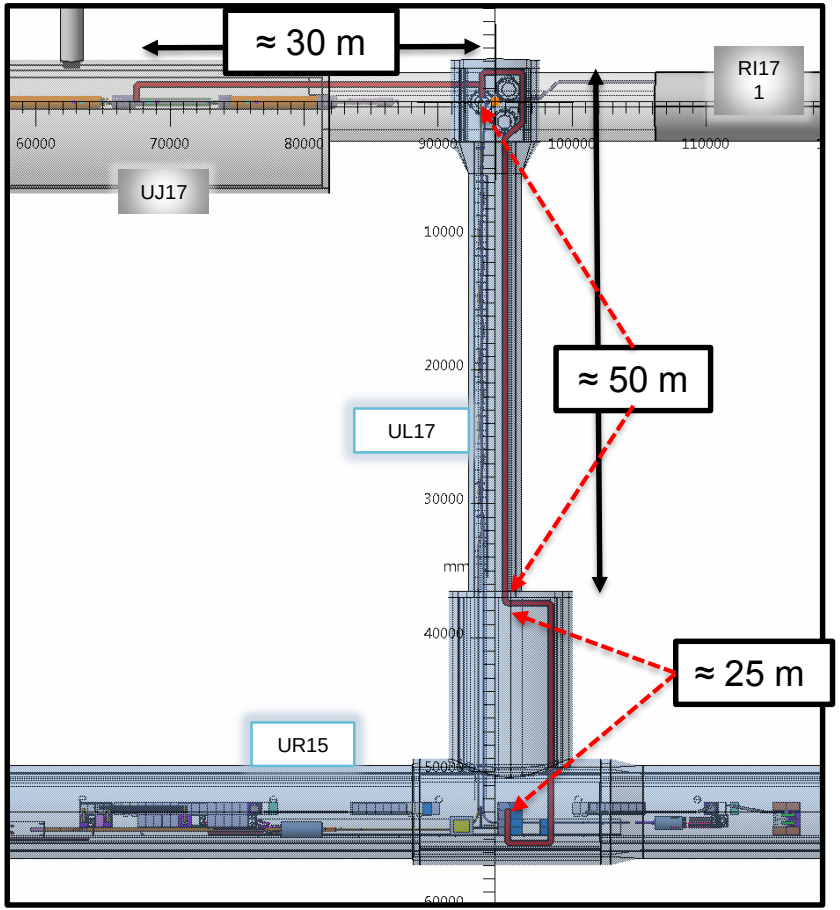
Power cables routing from PC to CP

IP5 L



WCC





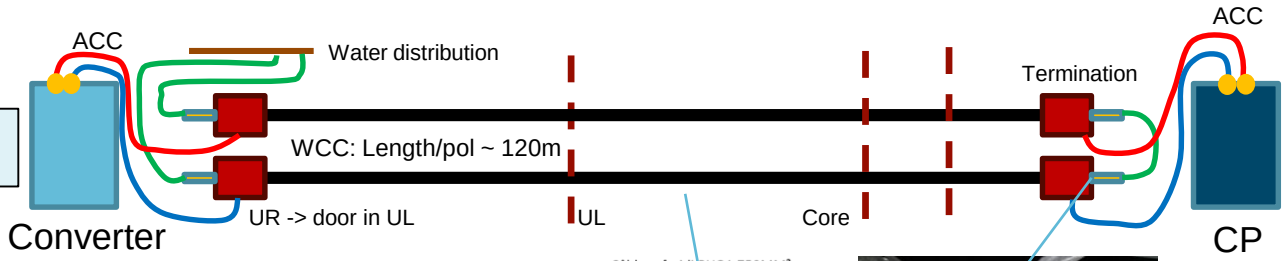
Max length of power cables ≈ 115 -120m

HiLumi HL-LHC PROJECT

For HL-LHC: DC water cooled lines 200 and 120A

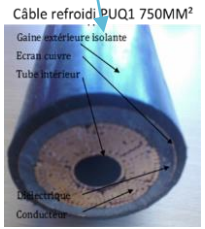
Technical solution:

ACC: Air cooled cables
WCC: Water cooled cables



(X 9 per half point
= 2160m/half point
=> total: 8640m)

Installation in cable trays



Exemple

Termination

Some consideration on ELQA and space

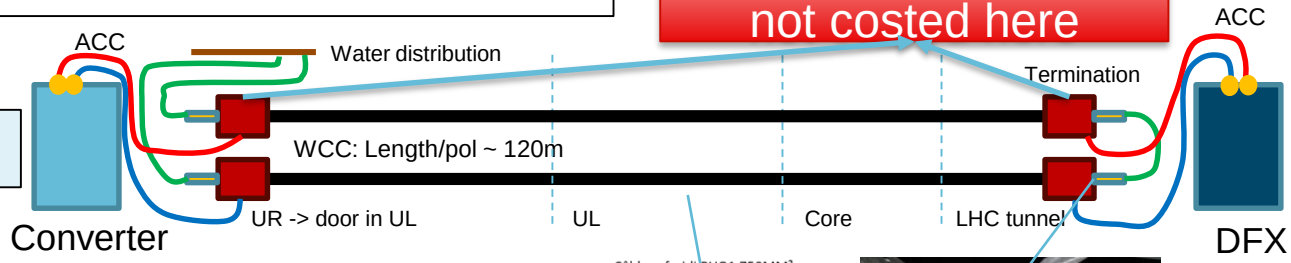
- We would have a WCC cable length per circuit between 200 m and 250 m
- This would lead to a leakage current > > 100 µA per circuit to be compared with the typical 5 µA that need to be measured *(1µA for MCBC circuits → 10µA for MCBY)*
- Human intervention in the LHC tunnel will be necessary to act on the junction box between the WCC and the standard cable that will be connected to the current leads on the CP
- The junction box will be near the D1, a complex area with not negligible radiation (much larger respect the UJs and ULs)

For HL-LHC: DC water cooled lines 200 and 120A

To be developed and not costed here

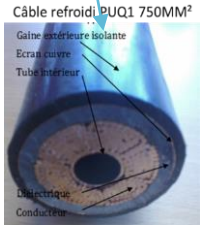
Technical solution:

ACC: Air cooled cables
WCC: Water cooled cables



(X 9 per half point
= 2160m/half point
=> total: 8640m)

Installation in cable trays



Exemple

Termination

Advantage: 0%->10% of thermal loads remaining in the UR, UL, cores and LHC tunnel.

Disadvantages: High bending radius for the cables, risk of crushing the cable during installation, special manufacture

need more place -> C. trays more larger.
Need of water -> risk of water leakage
-> Water interfaces
Need interlock cable to verify that the cable is correctly cooled.
Price: High level.

Ex: Pt 3 LHC: 800A; 3 lines DC 500mm2 WCC from UJ32 -> SS pt3: 4.5 km; price 0.9 MCHF @2005 ~ actually: 1.2 MCHF (260CHF/m)
For 200A: 36 lines 120mm2 (~100CHF/m) and 8.64km: -> **0.8 MCHF (very preliminary approach).**

	CASE A' Cu cable	CASE A" WCC	CASE B
WP3	- 40 kCHF + 95 kCHF	- 40 kCHF + 95 kCHF	- 40 kCHF + 95 kCHF
WP6a	- 450 kCHF	- 450 kCHF	- 450 kCHF
WP6a	+3 m SC link for PC int.	+3 m SC link for PC int.	
WP6b	No extra cost	No extra cost	+ 75 KCHF
WP7	- 25 kCHF	- 25 kCHF	No extra cost
WP9	- 60 kCHF	- 60 kCHF	- 60 kCHF
WP15	Minor impact	Study to be performed	+ 100 kCHF
WP17.1	+128 kCHF core mod		
WP17.2	+ 286 kCHF + vertical core inst cost	+ 760 kCHF + connection boxes	+ 62 kCHF
WP17.3	+200 kCHF UL cooling	Valve systems	
Total saving	- 575 kCHF	- 575 kCHF	- 550 kCHF
Total cost	709 kCHF	>855 kCHF (~1 MCHF)	232 kCHF
Net	134 kCHF	>280 kCHF (~450 kCHF)	- 318 kCHF (-218 kCHF)

Plus saving in magnet test (not quantified)

Op. cost electricity between 15 to 45 kCHF over 10 years (depending from kWh cost). Indicative evaluation WP6b

Op. cost + 80 kCHF

Provision in case of need

(38 kCHF already in baseline)

Previous presentation 01/11/2018

Necessary actions and impact evaluations to leave the 120 A and 200 A PC (correctors in the CP) in the HL-LHC UR gallery

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Cost evaluation

Amalia Ballarino et al.
TCC 20/09/2018

	CASE A	CASE B
WP3	- 40 kCHF	+ 95 kCHF
WP6a	- 450 kCHF	
WP6b	No extra cost	+ 75 KCHF
WP7	- 25 kCHF	No extra cost
WP9	- 60 kCHF	
WP15	Minor impact	**+ 100 kCHF**
WP17	+ 330 kCHF	+ 62 kCHF

Plus saving in magnet test (not quantified)

Operational cost + 80 kCHF

Provision in case of need

Total saving CASE A: 575 kCHF
CASE B: 550 kCHF

Total extra-cost CASE A: 425 kCHF
CASE B: 232 kCHF

Net saving CASE A: 150 kCHF
CASE B: 318 kCHF

HiLumi HL-LHC PROJECT

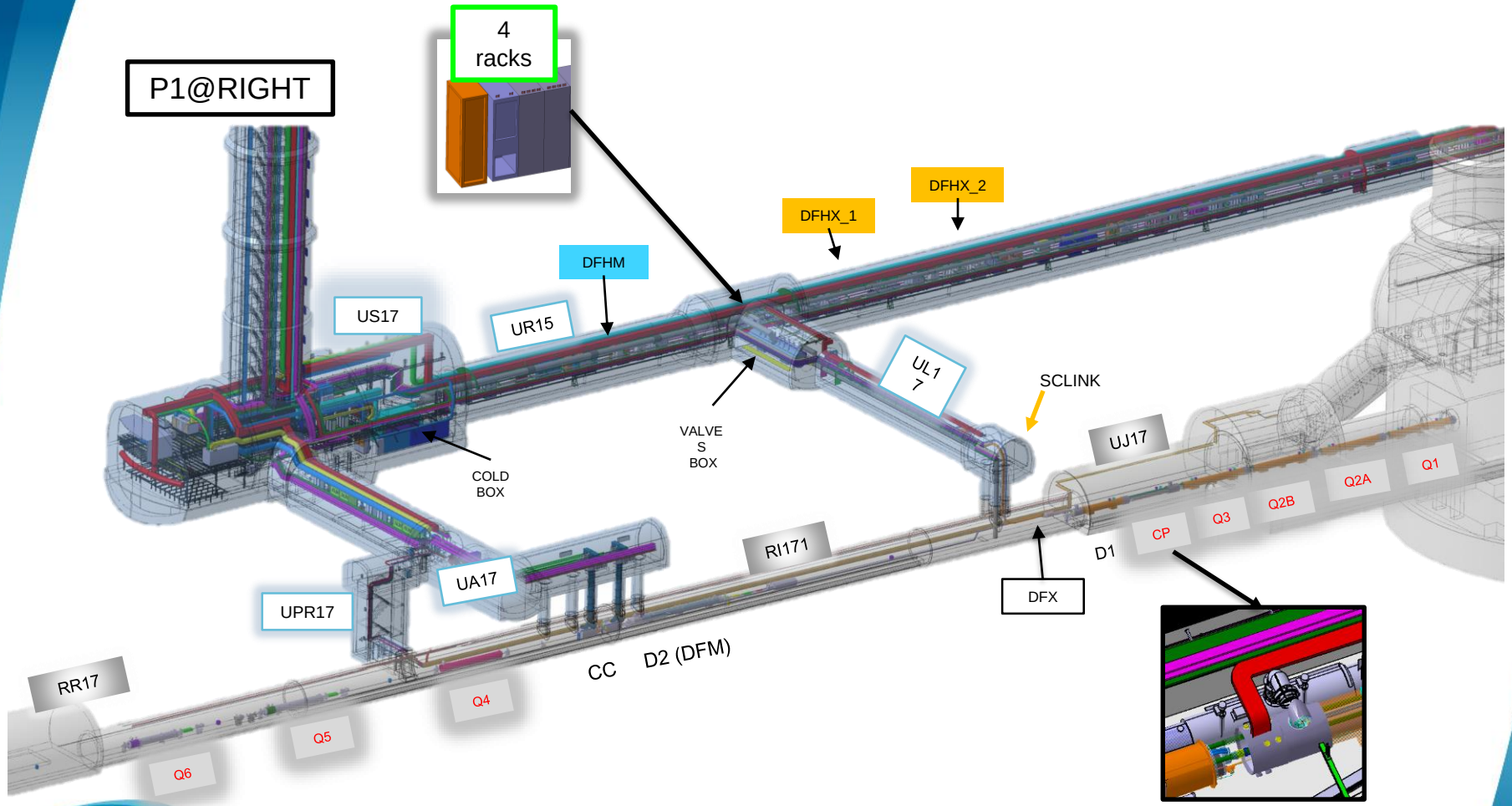
Case definition

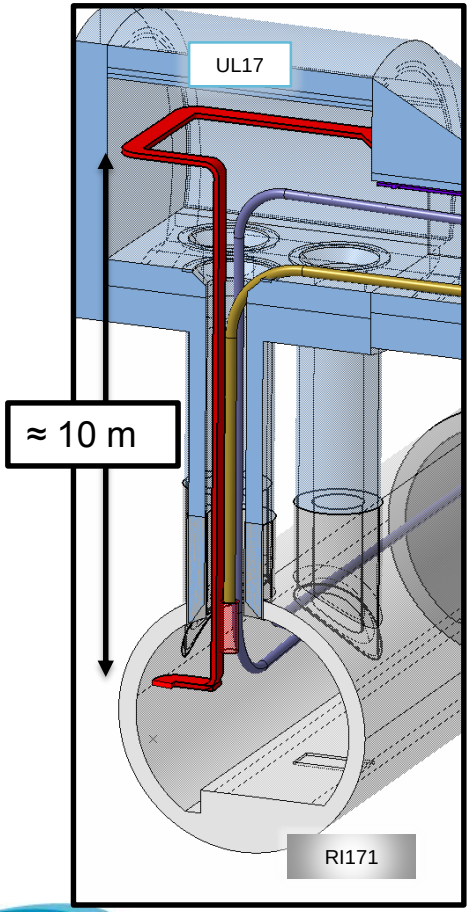
- CASE A:
  - PC installed in the HL UR
  - Connection to the CP via copper cables in the HL UL via vertical cores
  - No solution for cooling of the cable in the cores
- CASE B:
  - PC installed in the LHC Point 1 and Point 5 bypasses as the present IT PC (LHC ULs)
  - Connection following similar path as the present cables for the DFX
- CASE A':
  - Refined CASE A with solution for the cooling of the cables in the cores

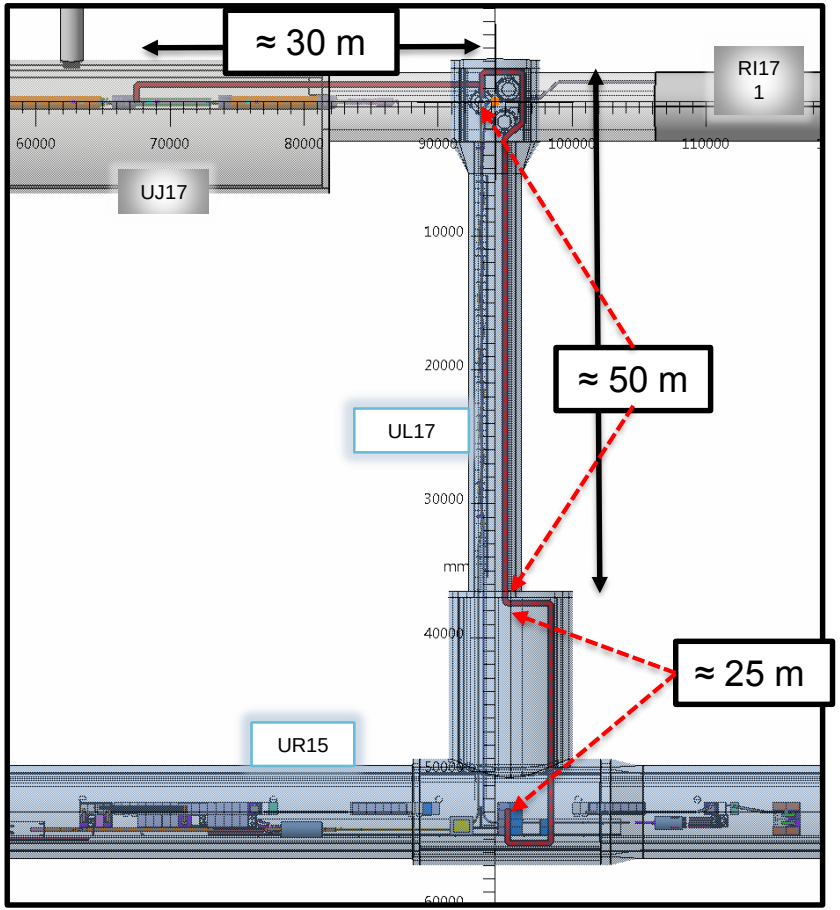
Actions to make feasible the installation of the 120A and 200 A in the UR linking them to the CP with copper cable

- Find solution to provide cooling to the cables installed in the vertical cores
- Optimize PC position to reduce the cable length and reduce integration problems in the UR
- Check that introduced resistance is acceptable for the circuit
- Ensure that the dissipated heat power can be evacuated

Review of the Case A with more details and associated Cost. Here as Case A’

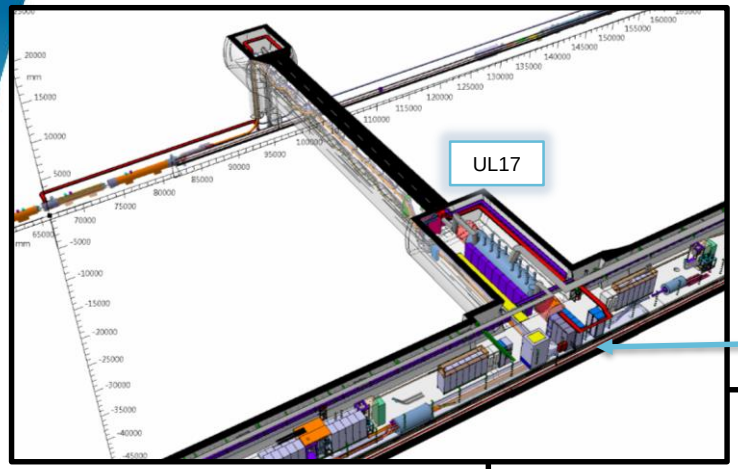

P1@RIGHT
4 racks
DFHX_2
DFHX_1
DFHM
US17
UR15
UL17
SCLINK
VALVE S BOX
COLD BOX
UJ17
Q1
Q2A
Q2B
Q3
CP
D1
DFX
RI171
UA17
UPR17
RR17
CC
D2 (DFM)
Q4
Q5
Q6



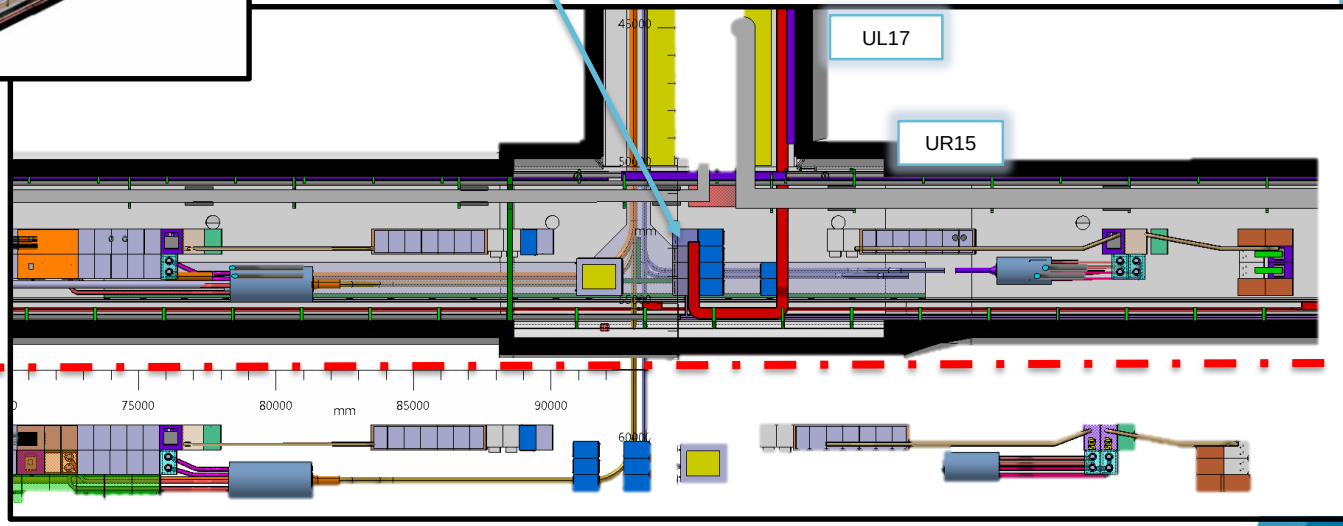


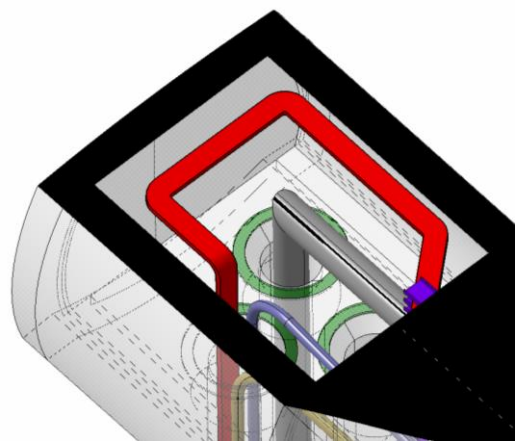
Max length of power cables ≈ 115 -120m

HiLumi HL-LHC PROJECT

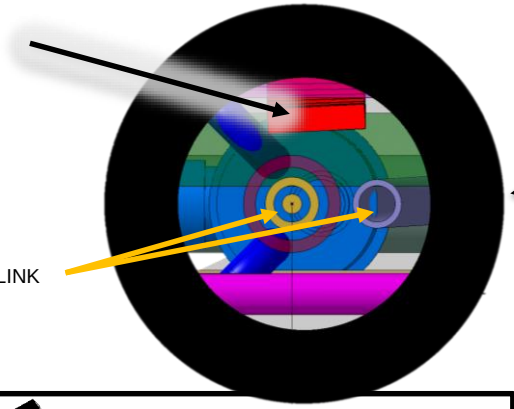


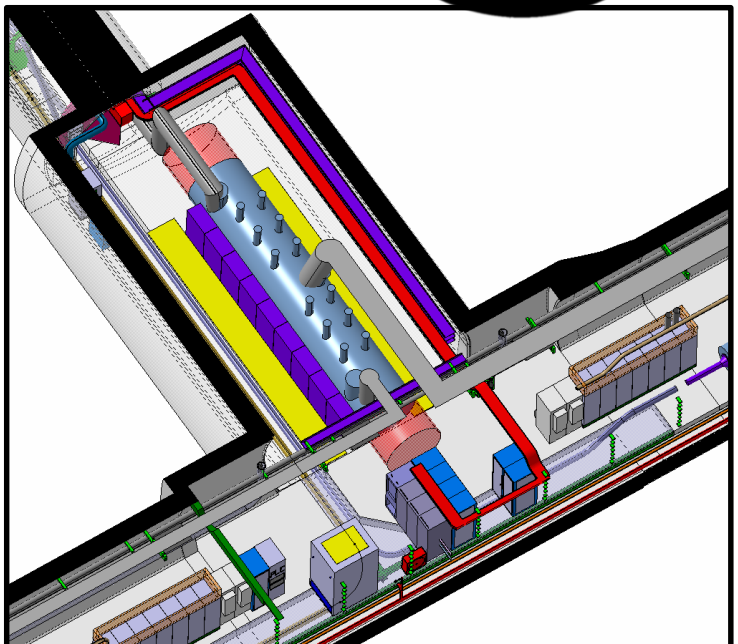
Pc 120 A / 200A

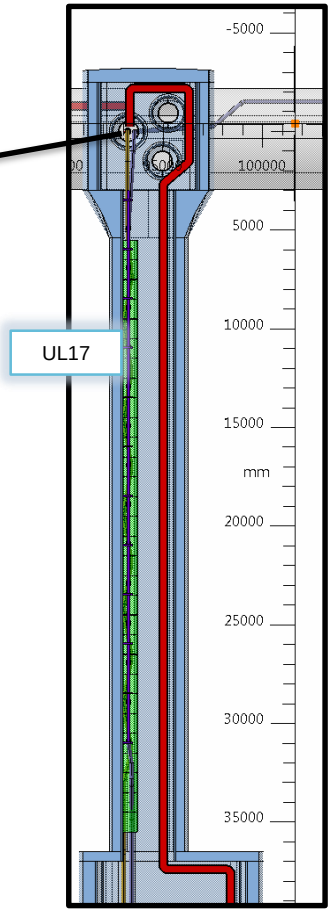


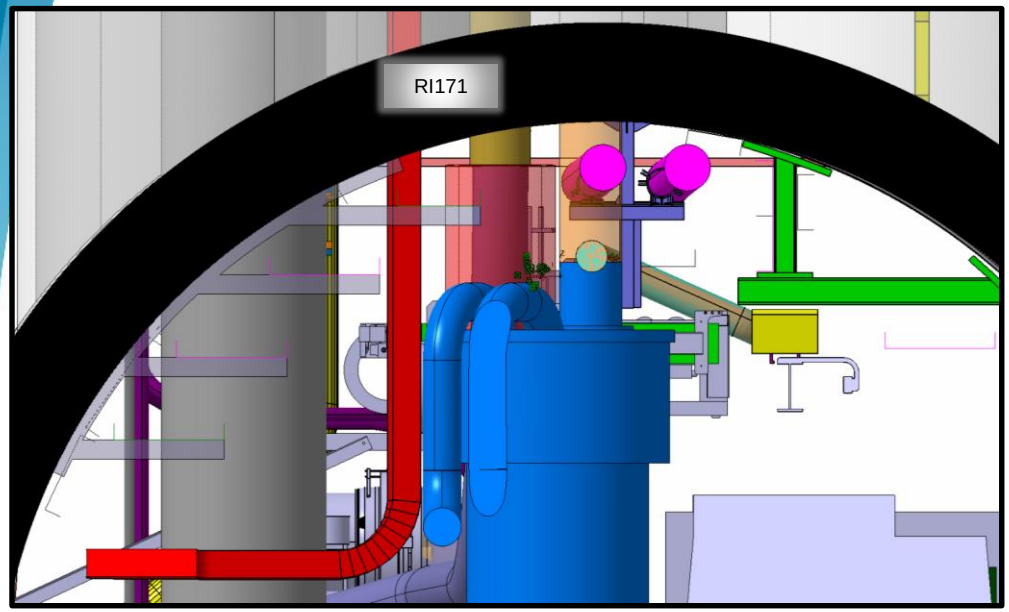


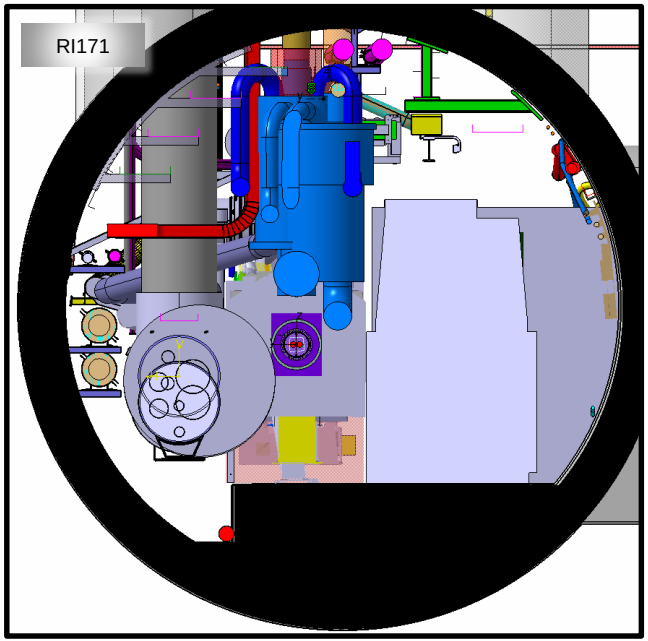
400
x100

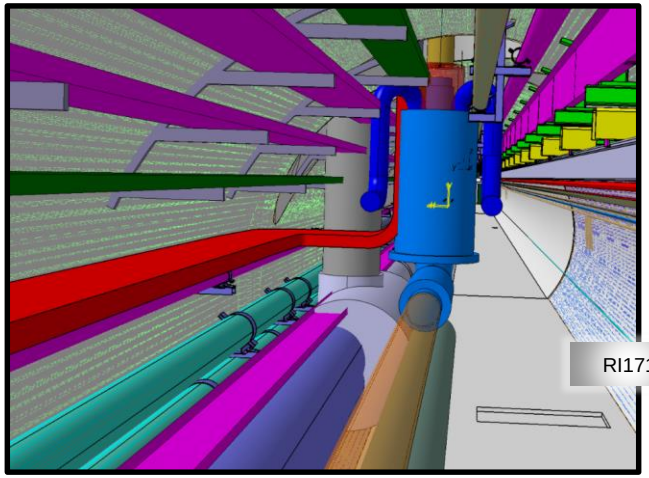

SCLINK




-5000
100000
5000
10000
15000
mm
20000
25000
30000
35000
UL17


RI171


RI171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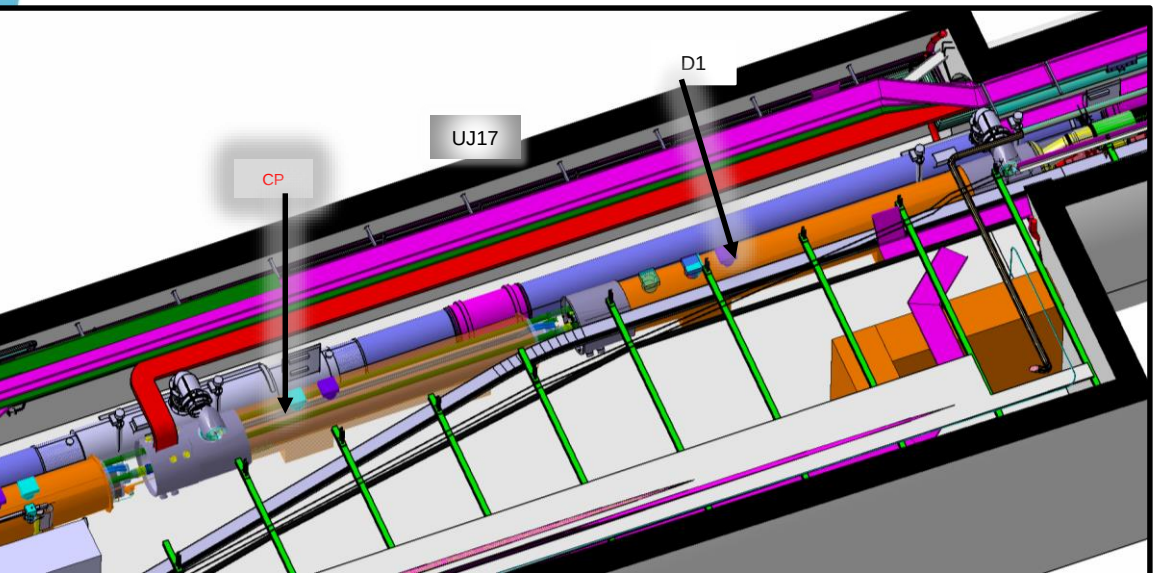
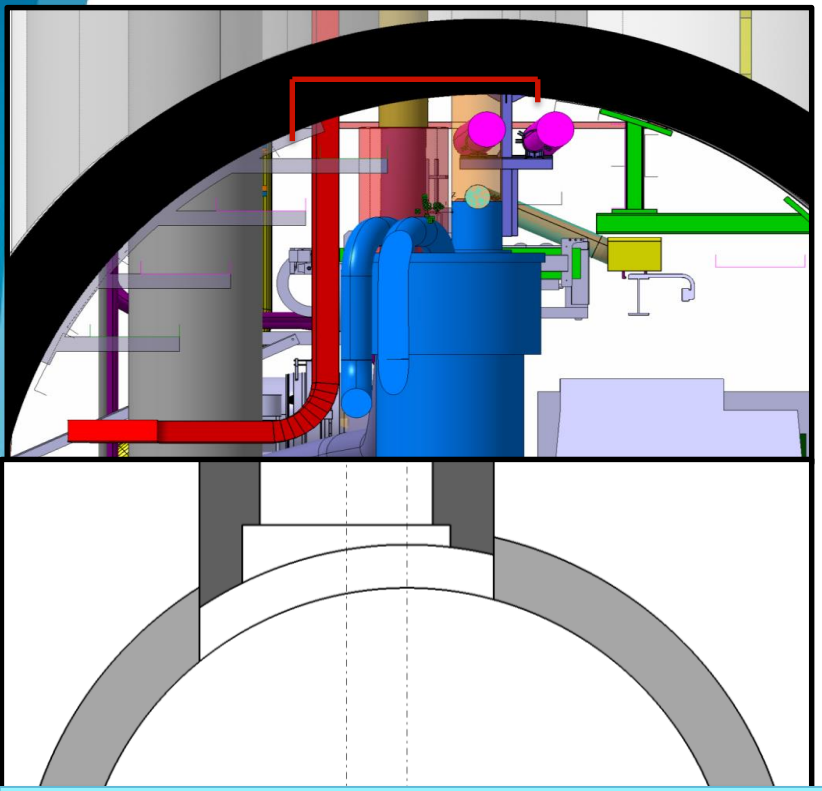

D1
UJ17
CP

Moving surface for air leak tightens from UL to LHC tunnel



The proposed solution satisfies EL requirement
Modifying 4 cores (1 each IP Side).
WP17.1
estimated cost
32 kCHF/core
Total
128 kCHF

Images shown here on the left are purely conceptual and have been prepared by WP15. They are not representative of th possible solution to be proposed by WP17.1

Remark the flat enlargement at the bottom of the core would help the installation of the new DFX

WP6B position

- There is no technical showstopper to keep the PCs in the URs. The supplement with respect to the baseline (120 A and 200 A in the sc link) will + 0 CHF for URs vs + 75 KCHF for ULs/USC55 .

- WP6B has communicated the requested minimum cable sections to EL (for 120A and 200A circuits) that respect the power converters limitation of 10V. This takes into account the ramp rate requirements given to us by WP2 and an estimate of the cables length (140 m per polarity). The new increased inductance value of the Quad Corrector (1505 mH vs. 1247 mH before) remains in the margin that has been taken.

- The margin taken on the voltage is 20 % and accounts for inductance variation in function of circuit current, possible mutual inductances between circuits, possible inductance evolution from magnet design perspective, etc.

- The indicative cable cross-sections provided by EL to satisfy the WP6B requirements are are:
  - **200A : 240 mm2/polarity**
  - **120A : 120 mm2/polarity**

WP 17.2: cabling

- With the previous sections and 120 m the budgeted cable cost is 81 kCHF/IP side
- Total 324 kCHF
- Possible cost increase for installation in the cores

WP17.3: cooling and ventilation

- With the maximum current the following power shall be dissipated
  - Vertical cores: 0.4 kW
  - UL ventilation door to core: 1.9 kW
  - UR:1.1 kW
- It is needed to install 2 water cooled

Fan-Coil in each UL (1+1 redundant). No water drain was foreseen in the ULs.

Small risk in case if water leak: costs

40 kCHF/UL fan coil

10 kCHF/UL collectors (partial compensatory measure)

TOTAL 200 kCHF

The 2 DN20 pipes to feed the Fan-Coil shall be integrated in the same trench with the SC link

Power to be extracted matching full power max current

2.3 kW UL