Local Powering of the Corrector Package in the Inner Triplet

A Ballarino, F Menendez Camara, F Rodriguez Mateos, S Yammine

With many valuable contributions from E. Todesco, D. Ramos, V. Parma, H. Prin, L. Bottura, M. Martino, S. Maridor, D. Wollmann, S. Claudet, P. Fessia, J. C. Guillaume.

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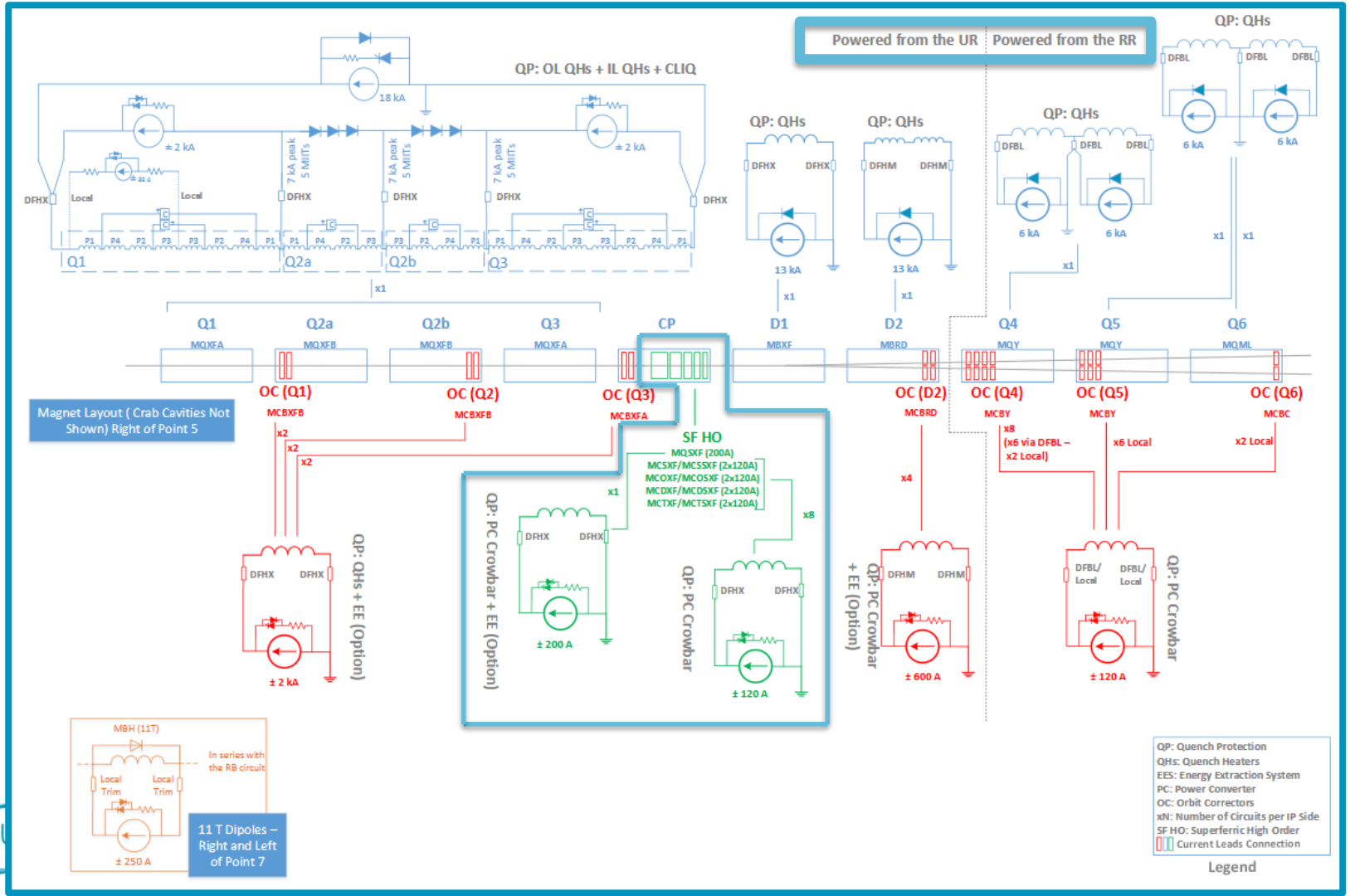
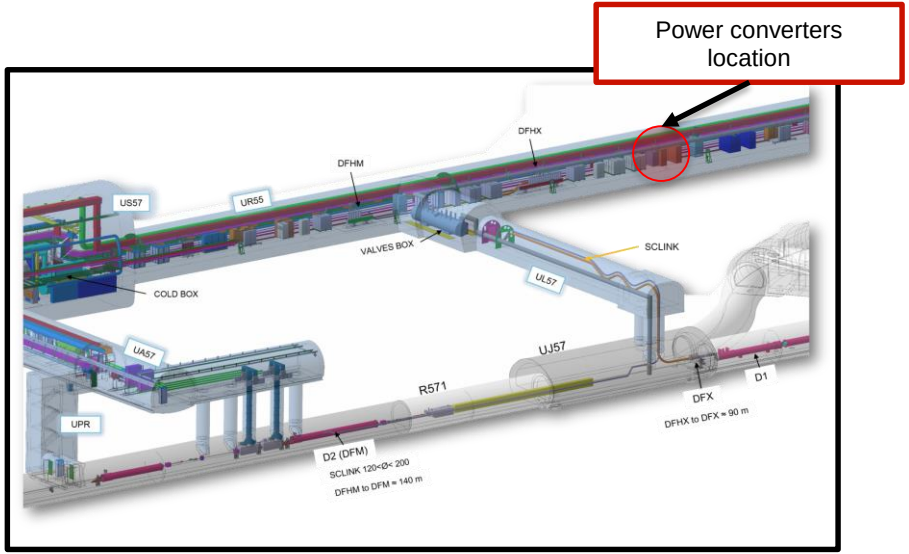

Powered from the UR
Powered from the RR
QP: OL QHs + IL QHs + CLIQ
18 kA
± 2 kA
7 kA peak 5 MJITs
DFHX
Local
Q1
Q2a
Q2b
Q3
x1
QP: QHs
DFHX
DFHM
13 kA
DFBL
6 kA
Q1
Q2a
Q2b
Q3
CP
D1
D2
Q4
Q5
Q6
MQXFA
MQXFB
MBXF
MBRD
MQY
MQML
OC (Q1)
OC (Q2)
OC (Q3)
OC (D2)
OC (Q4)
OC (Q5)
OC (Q6)
MCBXFB
MCBXFA
MCBRD
MCBY
MCBC
x2
x8
(x6 via DFBL – x2 Local)
x6 Local
x2 Local
x4
SF HO
MQSXF (200A)
MCSXF/MCSSXF (2x120A)
MCOXF/MCOSXF (2x120A)
MCDXF/MCDSXF (2x120A)
MCTXF/MCTSXF (2x120A)
QP: QHs + EE (Option)
QP: PC Crowbar + EE (Option)
QP: PC Crowbar
± 2 kA
± 200 A
± 120 A
± 600 A
Magnet Layout (Crab Cavities Not Shown) Right of Point 5
MBH (11T)
In series with the RB circuit
Local Trim
± 250 A
11 T Dipoles – Right and Left of Point 7
QP: Quench Protection
QHs: Quench Heaters
EES: Energy Extraction System
PC: Power Converter
OC: Orbit Correctors
xN: Number of Circuits per IP Side
SF HO: Superferric High Order
Current Leads Connection
Legend

The HL-LHC Cold Powering baseline envisaged powering the Inner Triplet Corrector Package (CP) circuits rated at 200 A and below via the MgB_2 Superconducting Link and associated cryo-electrical equipment.

An ECR presented to HL-LHC TCC on September 20 2018 proposes to remove the cold powering equipment related to these circuits replacing them by warm cabling from the converters location to LHC-type conduction-cooled current leads integrated in the CP magnet cryostat.



Reasons for the ECR (WP6a)

- **Simplification** of the HL-LHC Cold Powering
- Adopting for HL-LHC the **same strategy as for LHC**, where low-current (60 A and 120 A) corrector circuits are fed via conduction-cooled current leads integrated in the magnet cryostats

The **main advantages** of the proposed change with respect to the present Cold Powering baseline are the following:

- ***Elimination of the about 100 m long electrically insulated MgB_2 cables**, rated for DC currents of 200 A or 120 A, housed inside the superconducting link (18 cables per Triplet);*
- ***Elimination of the cabling process related** to the assembly of the 200 A/120 A MgB_2 cables in the final MgB_2 cable assembly developed for feeding the magnets in the Triplets;*
- ***Elimination of the 200 A/120 A gas cooled High Temperature Superconducting (HTS)** current leads located in the UR – replaced by conduction-cooled current leads;*
- ***Elimination of the control valves and warm recovery lines** associated with gas-cooled current leads;*
- ***Elimination of the protection equipment** needed for the superconducting part of the circuit, i.e. for the MgB_2 cables and for the HTS part of the leads (each requiring dedicated protection with different voltage thresholds);*
- ***Reduction of the number of the electrical splices in the Cold Powering System**, i.e. elimination - per Triplet- of eighteen HTS to MgB_2 splices in the DFH cryostat and eigtheen MgB_2 to Nb-Ti splices in the DFX cryostat;*
- ***Simplification of DFH cryostat** by reduction of number of HTS cables routed out of it and number of splices it shall host .*

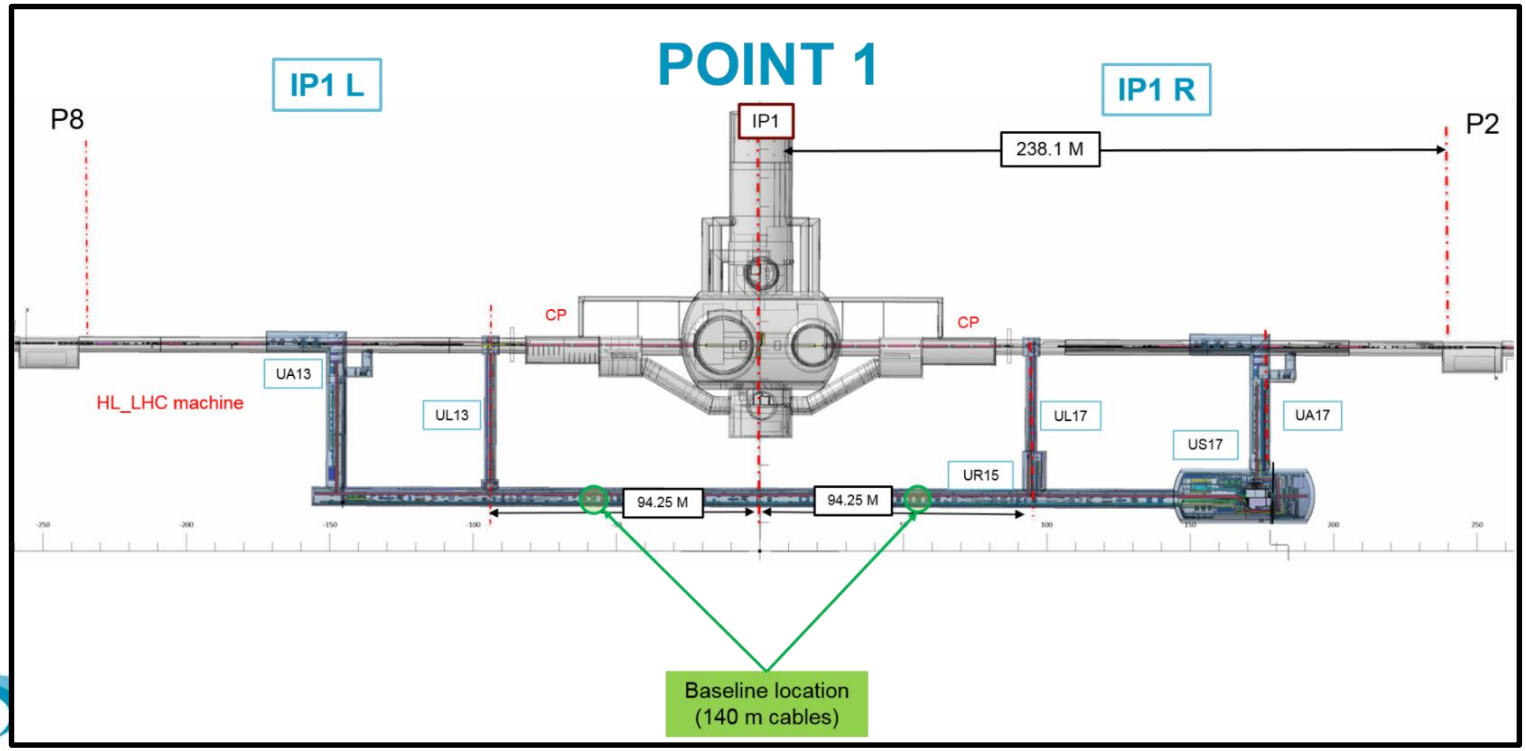
“Local” powering of the corrector circuits can be achieved by

- *either leaving the concerned power converters in the present baseline location, i.e. in the UR (case A),*
- *or by re-locating the power converters in the LHC’s UL14, UL16, UL557 and USC55 (case B).*

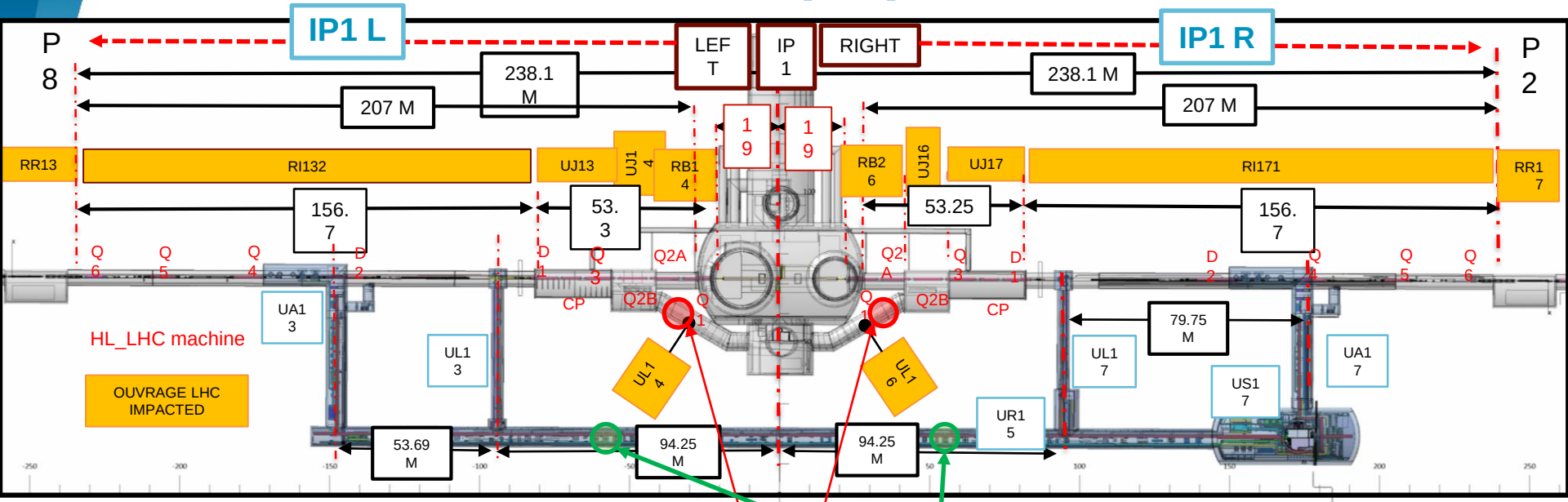
2 Options

Case A

- add new power cables trays routing in the ULs , and use the vertical shaft



Case B (P1)



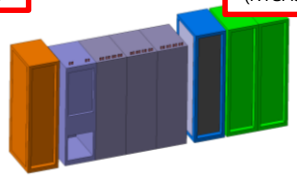
3 racks PC 120 A (R2E design) , (8 pc).

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

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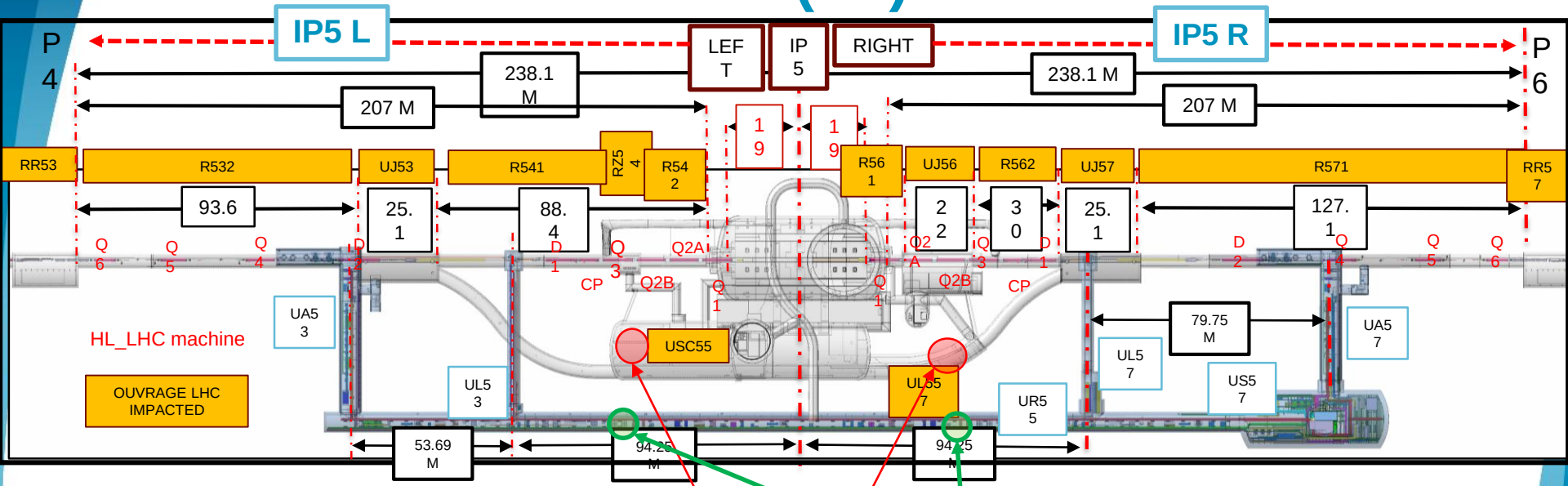
Case B (P5)



Baseline location (140 m cables)

Location to place PC @LHC zone

P Fessia, S Maridor

TECHNICAL EVALUATION PER WP

Work-package	CASE A	CASE B
WP3	• Saving the work associated with the interconnection of the Nb-Ti bus - in the line N - in the LHC tunnel • Reduction of the number of cool-downs and reconnections work in different test configurations - reduction by a factor of three with respect to the present baseline • **Integration of the conduction-cooled leads in the CP cryostat can be achieved**	
WP6b	• The cross-section of the cables needs to be chosen to fit available voltage compliance	• UL14 and UL16 → **Power Converters radiation tolerant** • 120A and 200A Power Converters to be controlled by FGCLite. Two configurations cannot co-exist in the same Gateway. • **Access**!
WP7	• Remove the need of dedicated quench detection equipment • MQSXF monitoring and protection of the conduction cooled leads will be ensured by two uQDS units	• MQSXF protection equipment to be placed next to the PCs. • Adding an extra complexity in the de-installation and installation planning • Additional signal cables (PCs, EE)
WP9	• Elimination of the control valves and associated thermometers and piping needed for operation of gas cooled current leads • Operational cost would give an increase of cost over 10 years	
WP15	• Technical challenge in the removal of the **heat generated from the copper cables in the vertical sections** • Addition of an extra element in the planning	• 3 **different integrations** and the preparation of the installation in 4 different areas leading to an increase in complexity in integration and installation • Adding extra complexity in the de-installation and installation planning
WP17	• DC cables power dissipation in the vertical shaft to be verified • Cross section of cables to be increased	• Partial re-use of existing infrastructure and cable trays

Summary of TCC and follow up

- To **decouple the decision on the sc link from location of power converters**
  - Approve the changes in the link
  - Study on going to keep converters in UR
- Only **Option A has no implication on radiation issues** and thereby fits to the HL-LHC upgrade goal of providing accessibility for the new hardware.
- WP15 is verifying with Civil Engineering the possibility of **displacing the radiation shield** to the bottom of the shaft
- First indications from WP15 say that there is **no issue concerning the cooling/ventilation** in the shaft for case A

Thanks

Questions?