Q6 at P1/P5
Alternatives 1.9K - 4.5K

Following HL-LHC TC #29
https://indico.cern.ch/event/373550/

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HL-TCC, 03Dec'15

Basic considerations

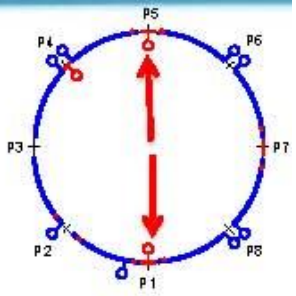
- Q6 is part of the baseline for new LSS @ P1/P5
- Cold mass of existing Q6(4.5K) to be re-used

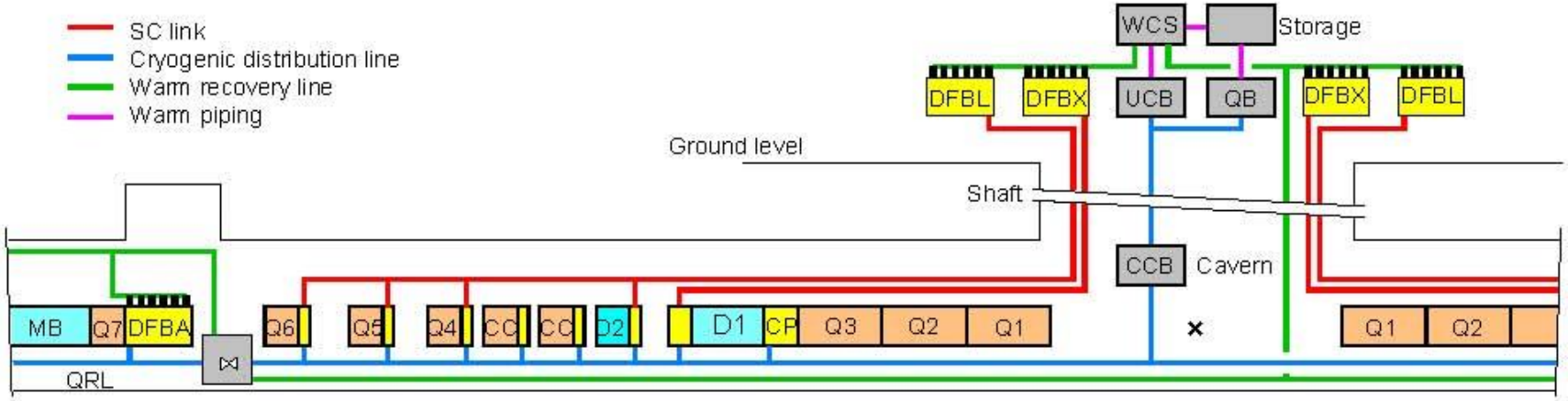
- Would optics require to go to 1.9K ?
- Would optics require to move Q6 ?

- What are the alternatives or concerns for others:
  Cryogenics, vacuum, powering (cold mass presented TC#29)
- Is there a clear show-stopper or optimum?

New cryogenic infrastructure at P1 and P5

L. Tavian, Daresbury, Nov'13



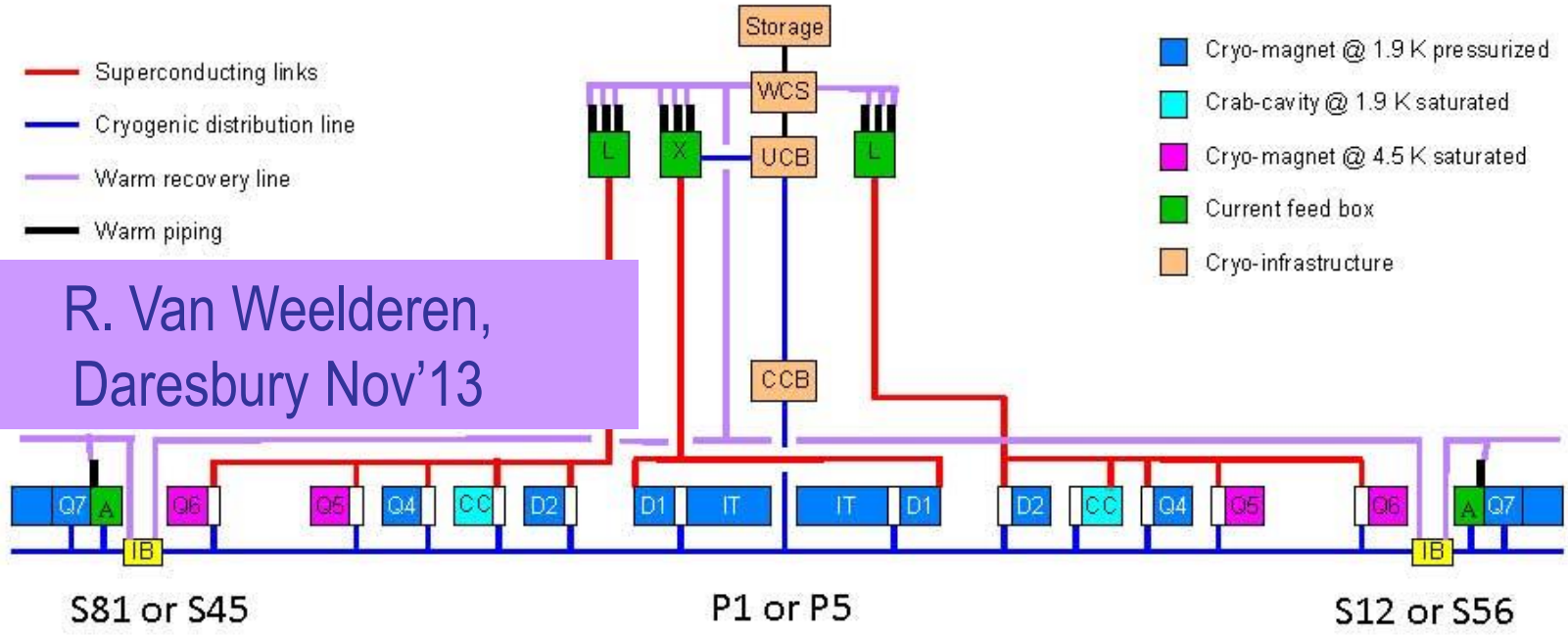


- 1 warm compressor station (WCS) in noise i… …ce building
- 1 upper cold ba…
- … cavern
- … distribution lines
- 2 interconnection valve boxes with existing QRL

No specific info on magnet temperature, could be all at 1.9K looking at heat load tables

Critical integration issue

Baseline for P1 & P5 layout: Matching section cooled with inner triplet cryoplants (4/4)



R. Van Weelderen, Daresbury Nov'13

Notes:

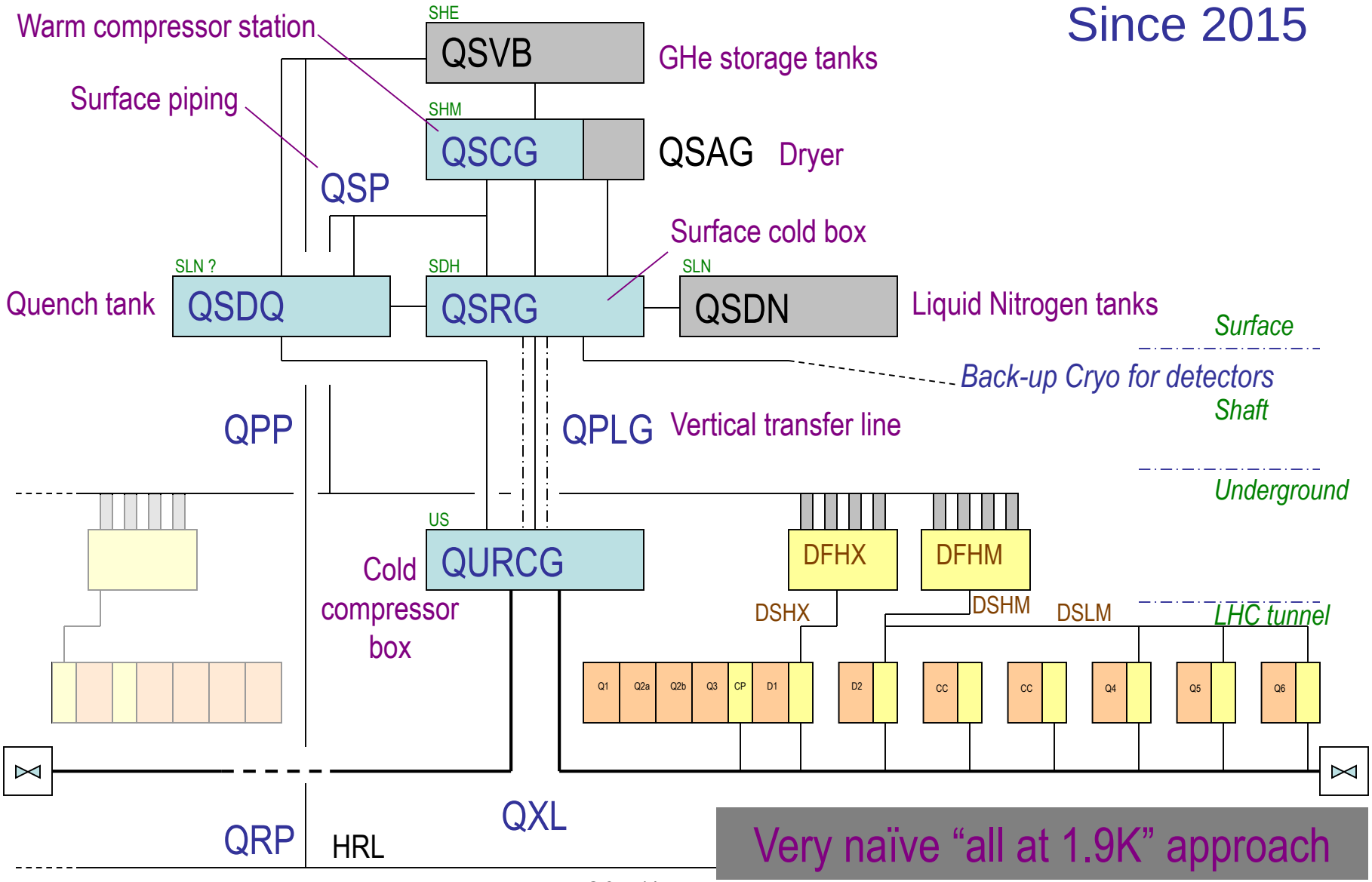
- Q5, Q6 at **4.5 K**,
- DFBA ...
- ...
- ...

Q5 probably next on the list !

Q5 and Q6 at 4.5K,

Not yet clear indication for beam screens

HL-LHC Cryogenic architecture

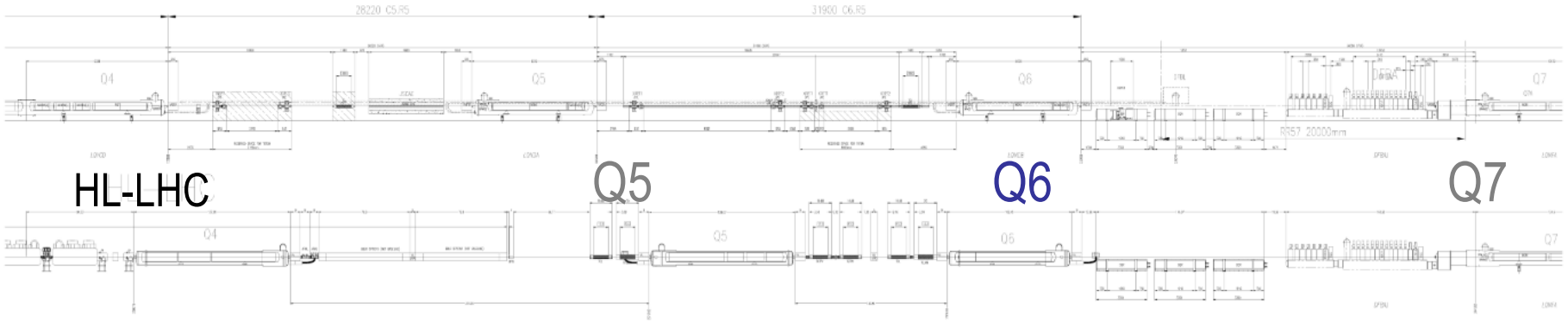


Lay-out and optics requirements

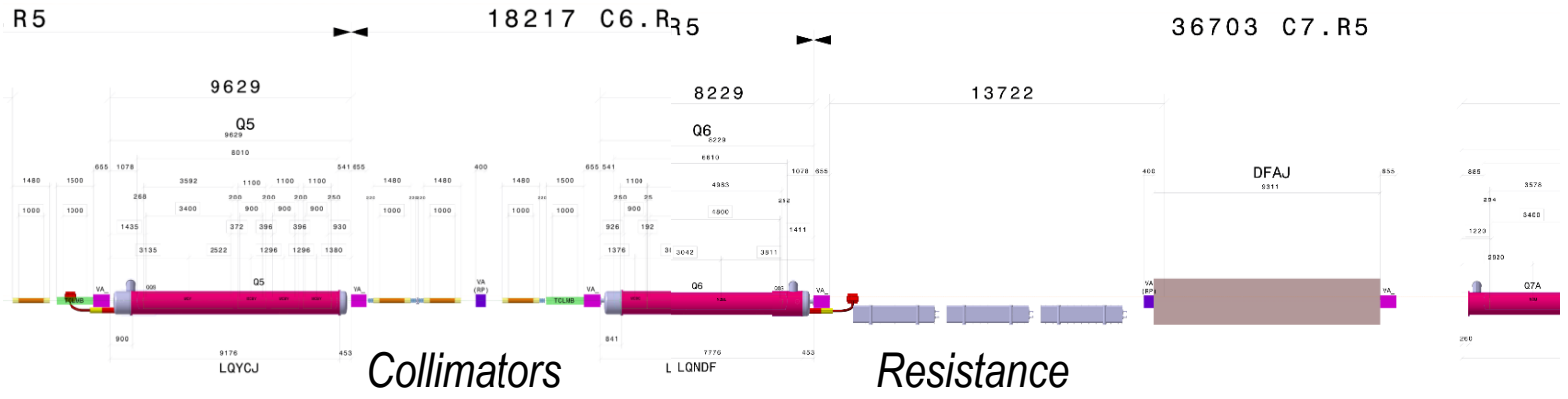
Present LHC Vs HL integration (Q4 to Q7)

LHC

Q6: no need for higher currents nor for displacement *

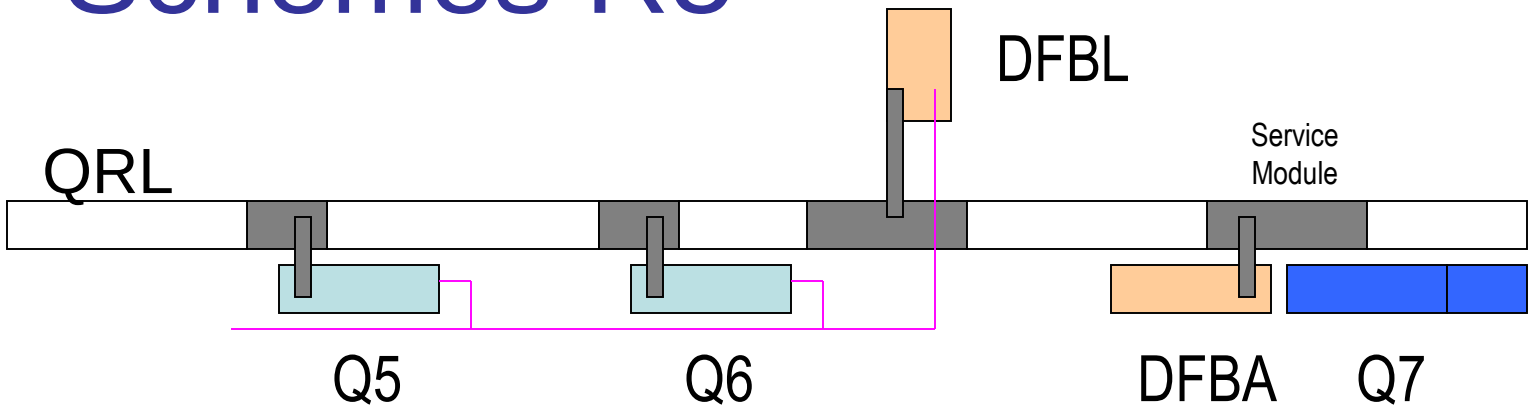


**: ramp-down of Q6 is a limiting factor for Combined Ramp & Squeeze, enough room to be made available in RR in case Power Converters to be changed (1Q to 2Q)*

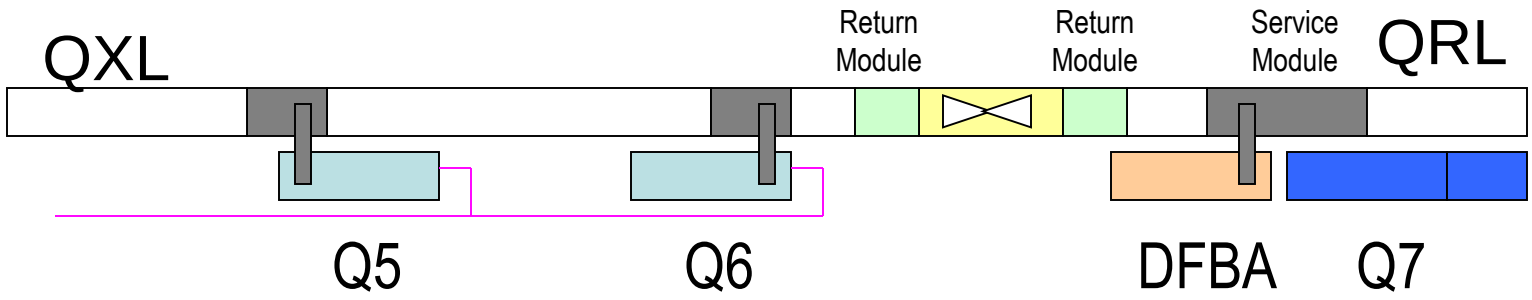


Schemes R5

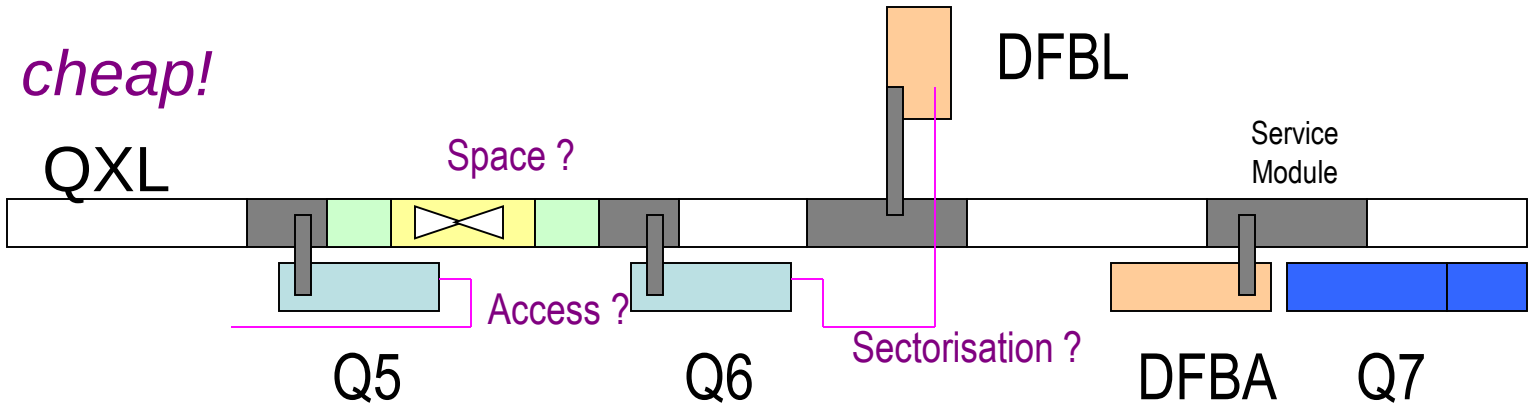
LHC



HL-LHC

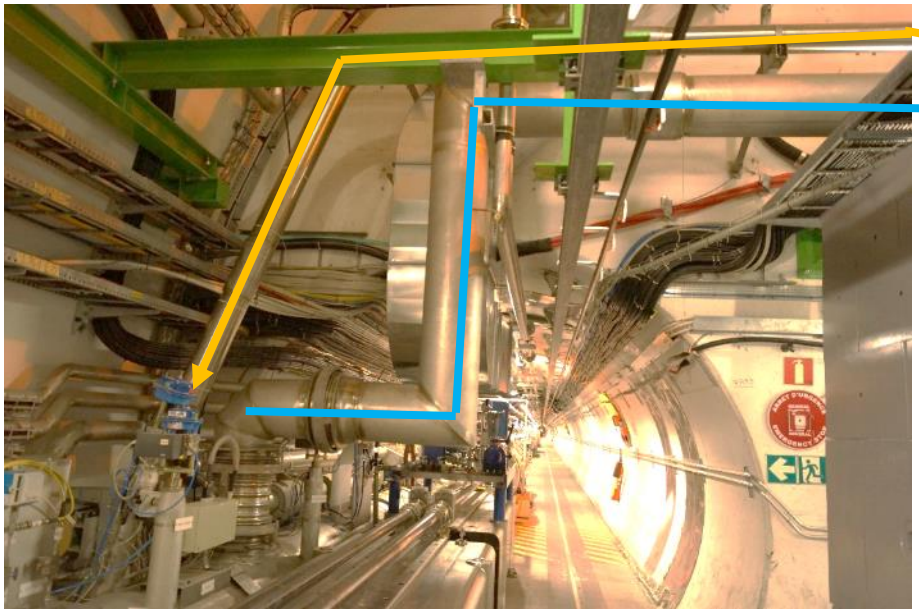


HL-LHC, *cheap!*



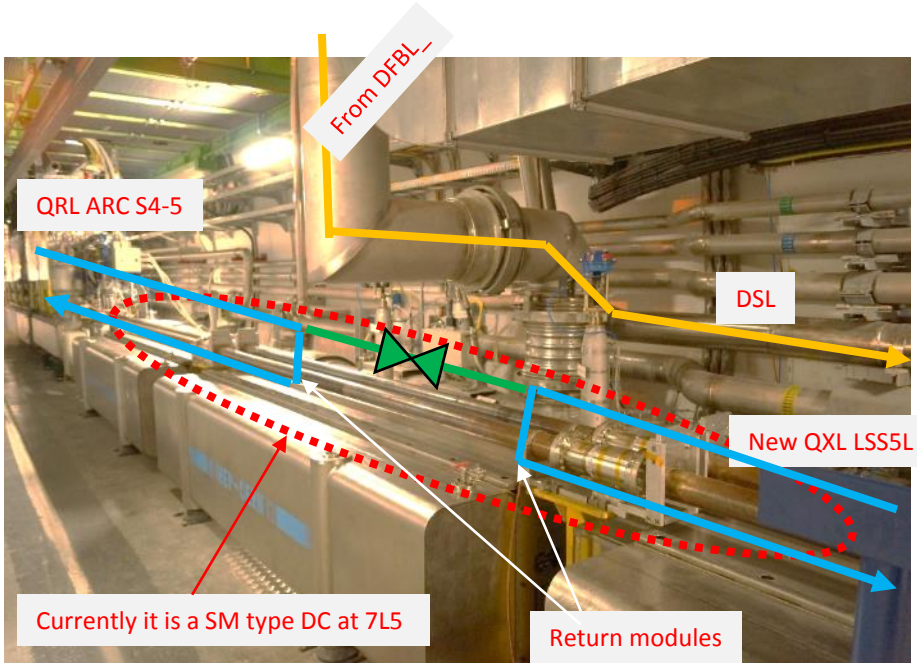
LHC sector 45, DFBL for Q6-Q5-Q4/D2

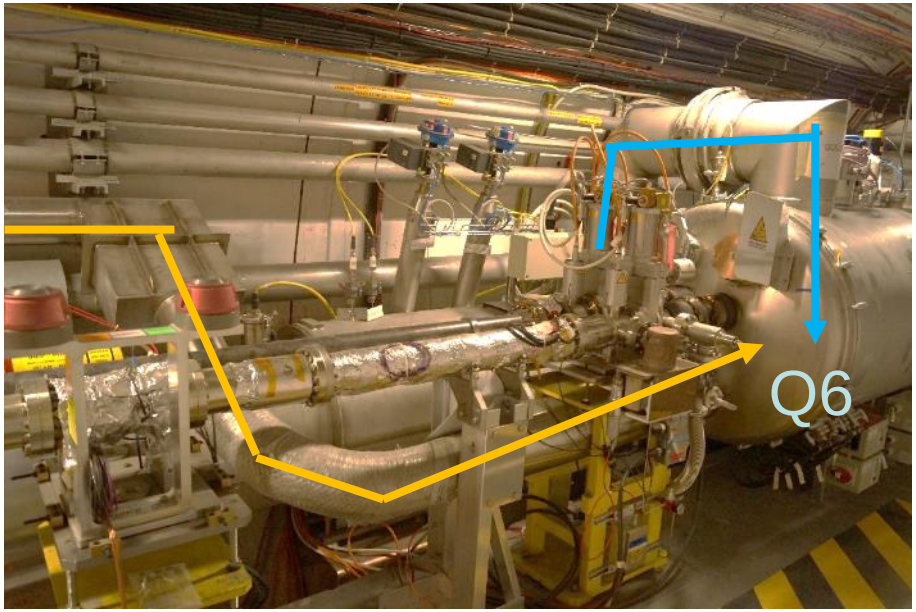
RR



- QRL supply DFBL with cold He (blue)
- DFBLD supplies current leads over DSL (orange)
- HL-LHC-DFBs will be on the new service tunnel and will have DSLs to the SAMs
- On the HL-LHC, the direction of the He flow to cool the current leads will be different:
  - LHC: QRL-DFBL-DSL-Magnet
  - HL-LHC: Magnet-DSL-DFH-WarmRecovery

LHC sector 45, DFBL for Q6-Q5-Q4/D2





- Currently SM (at 7L5) receives current leads from DFBLD and delivers DSL. **This will be <u>removed</u>.** The DFBL and DSL will be routed diferently.
- The new available space will be used for a special ServiceModule (at 7L5). It will be a kind of „QUIC“ to connect QRL S4-5 and QXL S5 (in other words Refr4-5 and Refr5) in case of need.

- DSL coming from DFBLD and connected to Q4L5-D2L5 (orange)
- SM cools the magnets independently from the current leads coming from the DSL (blue)

From Vacuum Perspectives

Vincent Baglin

- Perforation on the beam screen provides pumping speed
- Operating the cold bore at 1.9 K provides H_2 capacity
- A cold bore operating at 4.5 K do not provides H_2 capacity: a cryosorber is needed
- Actual (known) cryosorber can operate in the range 5-20 K but cannot operate above ~ 40 K
- Finding a cryosorber operating above 40 K is one of the main challenge for the FCC study !
- Evidencing such a cryosorber in the HL-LHC time frame seems unrealistic

If cold-mass @ 4.5K, beam screens to be at 4.5-20K,
Beam screens @40-60K only possible if magnet @ 1.9K

Confirmed during the meeting

⇒ Q1 to D1 @1.9K => BS @40-60K *or equivalent*

⇒ D2 to Q6 @1.9K(Q6@4.5K?) => BS @4.5K-20K

Summary (H. PRIN, HL-LHC TC#29)

- *To operate Q6 in IR1&5 at 1.9K, we have to **adapt the existing cryo-assemblies** (lack of spare magnets and major components). The job has to be performed during LS3 **in parallel** with the **HL-LHC installation upgrade** and other consolidation activities in the tunnel. The cost estimation for the four Q6 modification is about **800kCHF**. It requires **2.5FTE** from the MSC group over **68 weeks**.*
- *An operation at 4.5K requires a displacement of the present Q6 by few meters. In case of **1.9K cryo-assemblies** have to be stored and modified on **surface**. The ones **from IR1** might be **installed in IR5** and vice versa (to inverse the service module side and respect the beam screen orientation associated to the focalisation plane and orbit corrector orientation).*
- ***Risks** during **handling** and **execution** of the work are not excluded and have to be **considered**.*
- *The passage through **ALICE** cavern has **to be scheduled** for the removal and reinstallation. This has to be done at least for the Q4 that will become Q5.*
- *Operating the magnet at 1.9K offers more flexibility from the **cryogenics** point of view but there is **no strong argument** for such a change.*
- *The **base line** for beam screen operation temperature [illegible] nets (D2-Q5-Q6) stays **5-20K**. No modification [illegible] and this level.*
- *The **vacuum** [illegible] presence of the **cryosorbers** [illegible] operation **at 1.9K**. But in case of a **carbon coating** up to [illegible], the **compatibility** has to be **verified** and in case of an operation at 4.5K, the activity in situ must be established.*

If at 4.5K, beam screens to be at 4.5-20K,
BS@40-60K only possible if Q6@1.9K

From Cryo perspective

- Heat loads: not an issue (marginal impact)
- Configuration: easyer @1.9K if part of the LSS, not a blocking point
- If Q6 kept @4.5K and to minimise additional work/cost, could be powered by DFBL and existing sc link, not foreseen yet but could be envisaged, *with additional complexity to perform work in the area with existing sc-link in place*
- Configuration and integration of return module and coupling between QRL & QXL might be a decisive criteria (space available, collimators between Q5 & Q6)
- Even if at 4.5K and same place, might be wise to consider cooling and powering from P1/P5 (QXL + new sc links)
- A 1.9K cooling alternative to longitudinal bayonet heat exchanger could reduce MSC work and provide a viable solution for all

From powering perspective

- Powering Q6 from new DSL is considered as baseline
- Clear difference in the approach between "refurbished DFBL+sc_link" or "all new" (with 2ndary LTS link DFM-Q6)
  - Keeping existing powering line (DFBL+sc-link) does not allow to move Q6
  - However, the new design of the Cold Powering System enables individual powering of Q6 – via a compact and optimized DFH+DSH (Current Leads + Superconducting Line) system, with tolerance for some years on Q6 position
- In case keeping existing DFBL + sc-link would be of interest:
  - Having Q6 as part of the arc is already the case in L8 & R2 at least.
    Could induce constraints for sectorisation; a concern for someone?
  - Space in RR will be made available for any Power Converter configuration that might be required

Summary

- No compulsory requirement to go to 1.9K for time being
- No objection to have Q6@4.5K as part of the new LSS
- If magnet @4.5K, beam screens to be at 4.5-20K, Beam-screens @40-60K only possible if magnet @1.9K
- Cooling and powering possible for all cases
- The interconnection between QRL & QXL seems to be more adapted between Q7/DFBA and Q6
- Cooling scheme for HL-LHC Stand-alone magnets (short) probably to be revisited (no bayonet, HeII conduction)

  This could apply as well for Q5-P1/P5 and Q5-P6
- One would need a complete integration of the area (machine, QXL, links) to make a decision with all elements properly studied