Circuit Disconnector Boxes for HL-LHC

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technical content extensively covered in Samer Yammine presentations:

53rd TCC 2018-07-12

8th Annual Meeting 2018-10-16 & 2018-10-18 (plenary)

Summary of Circuit Disconnector Boxes : Why?

- A functional & safety equipment that was overlooked in LHC design
  - First pre-study/proposal by WP7 in 2016 (MCF no.6)
  - WP6B adopted the idea in 2017 as already familiar with similar equipment at CERN
- An elegant solution for highly optimized warm-cold transition in HL-LHC
  - "Current leads, located as near as possible to the power converters…" TDR V.0.1
    - Ideally zero cable resistance : virtually no losses!
    - Except for 13 kA circuits, D1 and D2, where 1Q Power Converters will require a minimum resistance for ramp-down
  - ElQA driven requirements to ensure galvanic insulation
    - 3 kV withstand level between poles and to ground with <1 µA leakage current
  - Reduce risks of damaging current leads
    - Due to mechanical strain (incorrect manipulation)
    - Due to hydraulic shocks (water hammer effect) when water is turned on/off
  - Maintain current leads contact quality without additional intervention
  - Reduce intervention time

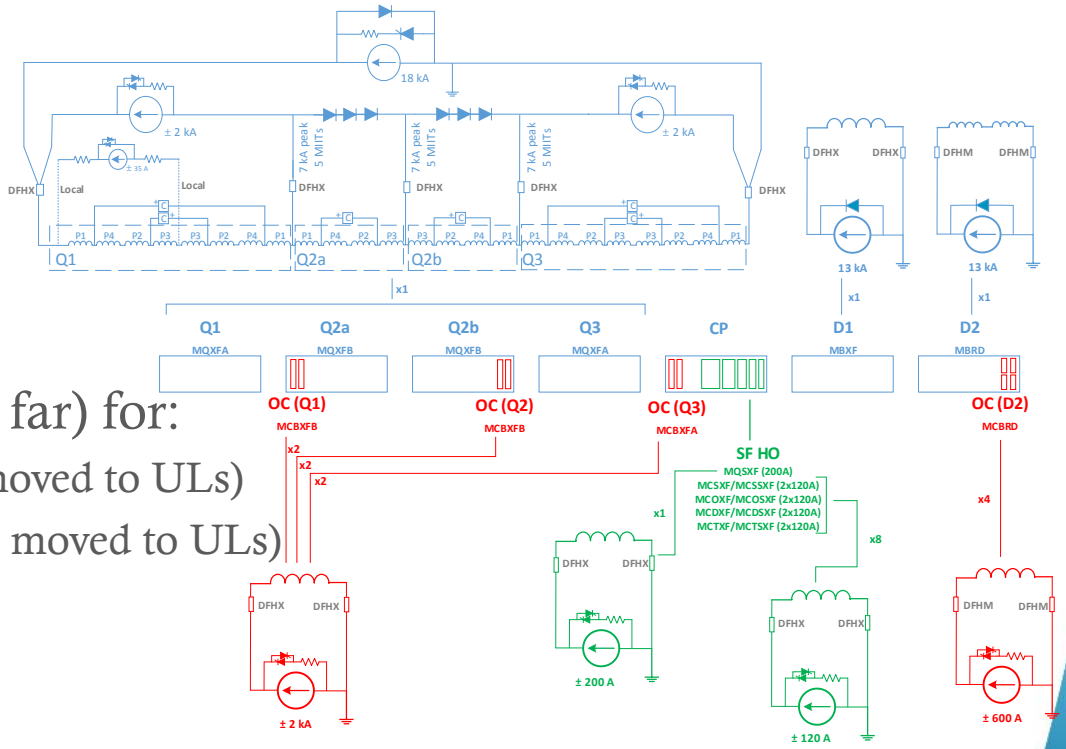
} Functional Features

- Electrically protected equipment (IP2X) to allow access during normal operation
- Short circuit and grounding connections to maximize safety during intervention

{ Safety Features

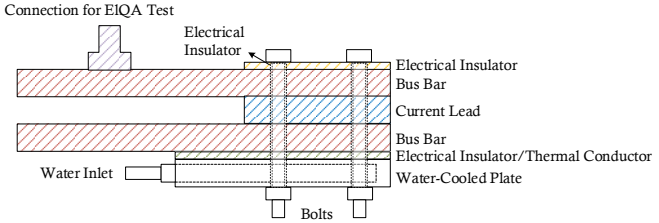
Summary of Circuit Disconnector Boxes : What?

- CDBs for circuits in the URs
  - 1x18 kA Circuit
  - 2x13 kA Circuits
  - 8x2 kA Circuits
  - 4x0.6 kA Circuits
  - 1x0.035 kA Circuit
- CDBs are not considered (so far) for:
  - 1x0.2 kA Circuit (as could be moved to ULs)
  - 8x0.12 kA Circuits (as could be moved to ULs)



Summary of Circuit Disconnector Boxes : How?

- A new solution based on solid experience
  - TE-EPC already own and operate several motorized “disconnectors”
    - Switchable fingers type for 18 kA & 13 kA circuits
    - Rotative position type for ≤ 2 kA circuits
  - PLC + Panel key will ensure both:
    - CDBs proper diagnostics (zero current detection etc.)
    - CDBs safe manipulation both for machine and for people
  - Optimal thermo-dynamics conditions for warm-to-cold transition
    - Main technical issue to overcome is to guarantee proper temperature and humidity conditions for the very high currents 18 kA and 13 kA warm-to-cold transitions
    - Proposal of using water-cooled plates with electrical insulators/thermal conductors interfaces
      - It will need to be fully developed and experimentally proven
      - It will still need water cooling but far from being as bulky and cumbersome as WCCs



Summary of Circuit Disconnector Boxes : How much?

- Material costs : 2 MCHF (5 x locations: 4 x IP sides + 1 x IT String → operational Spare)

Circuits	Number of CDBs per IP side	Cost per IP side	Cost for 4 IP sides + IT String (HL-LHC Spare)
IT Main Circuit	1 x 18 kA + 2 x 2kA + 1 x 35 A + 1 x Warm Diodes	100 kCHF	500 kCHF
D1 and D2	2 x 13 kA	120 kCHF	600 kCHF
2 kA Orbit Correctors	6 x 2 kA	140 kCHF	700 kCHF
0.6 kA Orbit Correctors	4 x 0.6 kA	40 kCHF	200 kCHF
Complete System			2 MCHF (comprehensive budget)

- Manpower costs : 0.5 MCHF (additional resources to be granted to WP6B)
  - MPAs:
    - 1 FELL 2 ½ years (or equivalent PJAS if possible) ~ 250 kCHF
    - 1 TTE 2 years ~ 140 kCHF
  - Mechanical Design/Integration:
    - Jobs to be provided by EN/MME up to ~ 100 kCHF (1 FTE equivalent)
- CDBs were not thought as cost saving options but they could be

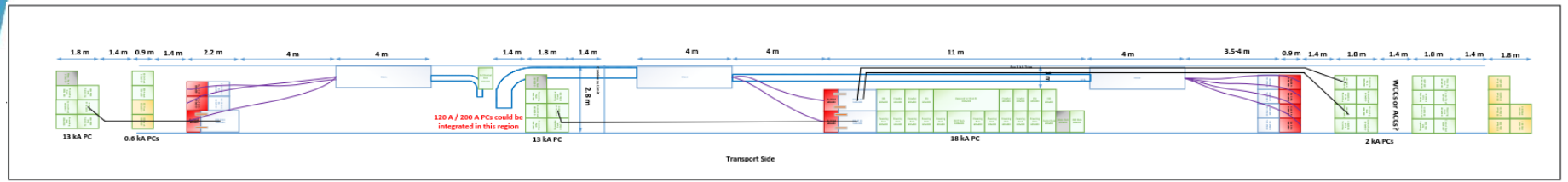
Latest news

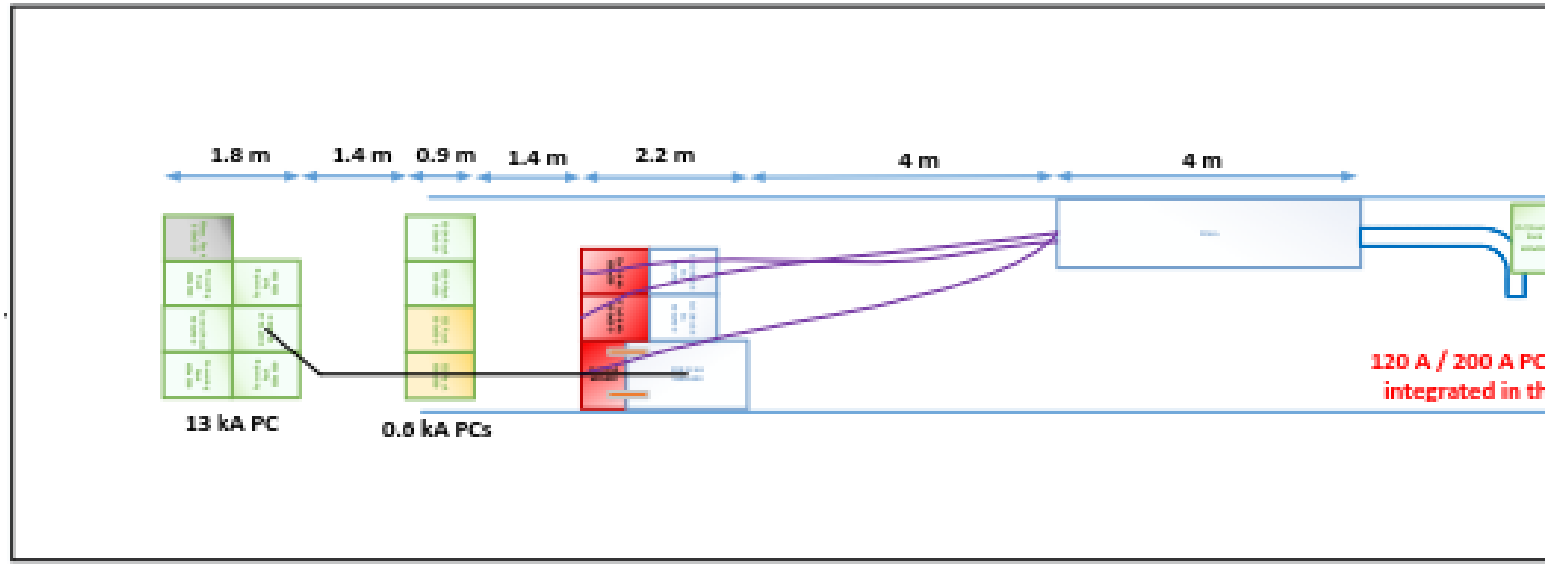
- It seems SC link cannot really reach Power Converters
  - WCCs need for 18 kA and 2kA circuits is likely to remain substantial
    - quite some savings in WP17 can still be expected though
  - Less elegant solution but still achieving all functional & safety objectives
  - For D1/D2 a minimum ohmic resistance was needed anyway so nothing really changes
- For ≤ 2 kA circuits two Circuit Disconnectors are now foreseen x "Box"
  - Optimized solution for integration "mirroring" current leads arrangement
  - Operational & maintainability aspects of the new configuration to be fully analyzed
- Configuration with some IT circuits/terminals connected to DFHx1 and some connected to DFHx2 to be avoided for EMC reasons!!!
  - This issue has been "just" spotted on December 11th , it will need reconfiguration of DFHx1 and DFHx2 and it will require further Integration iterations!

Thank you for your attention

Backup Slides

Latest Integration “iteration”





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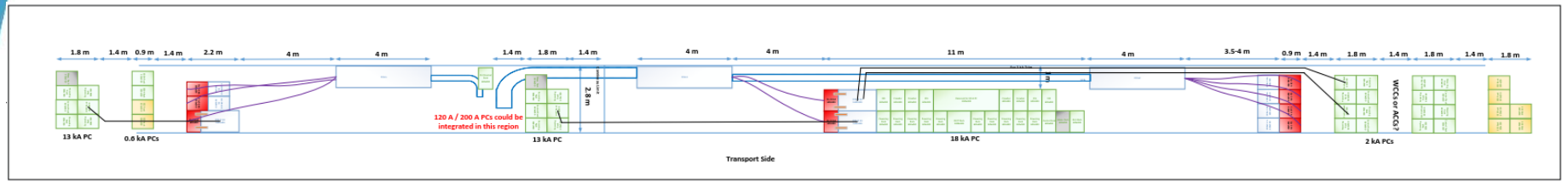
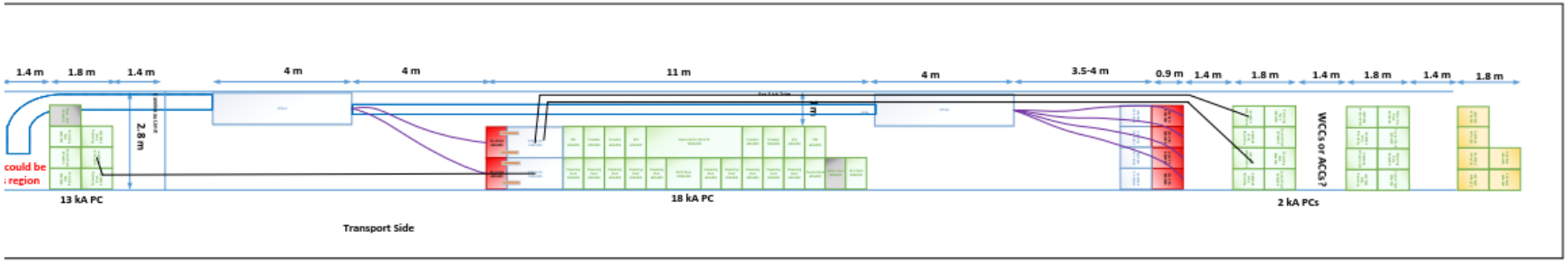
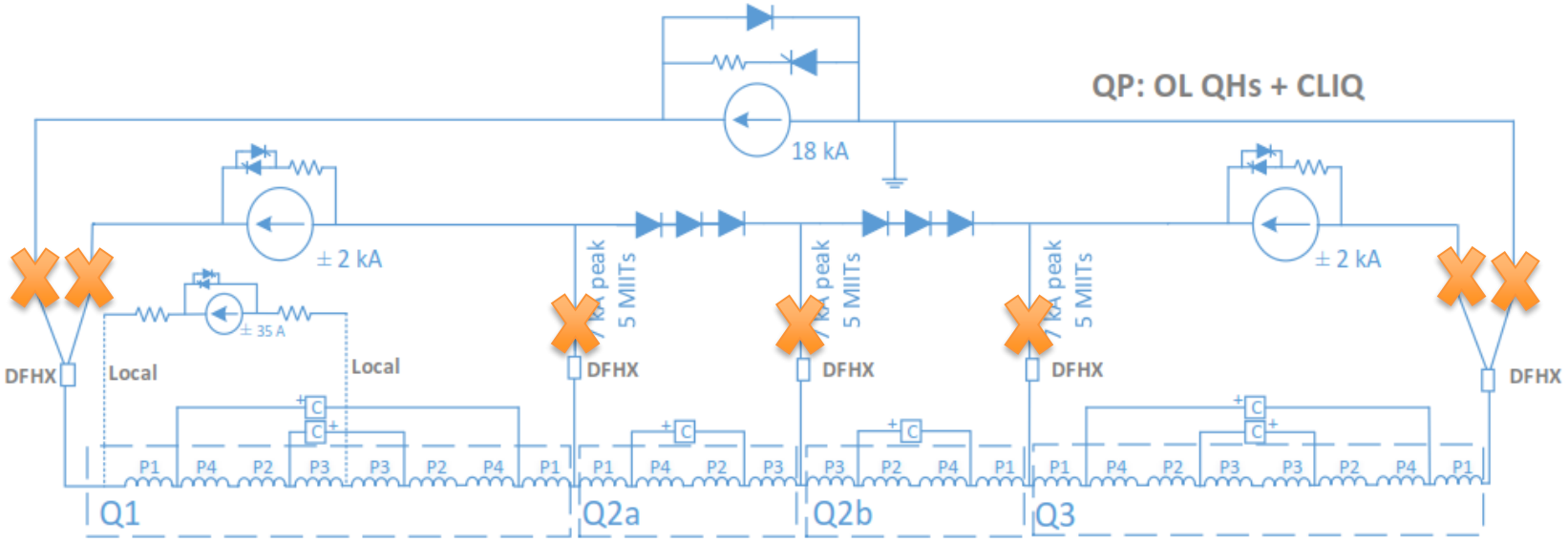


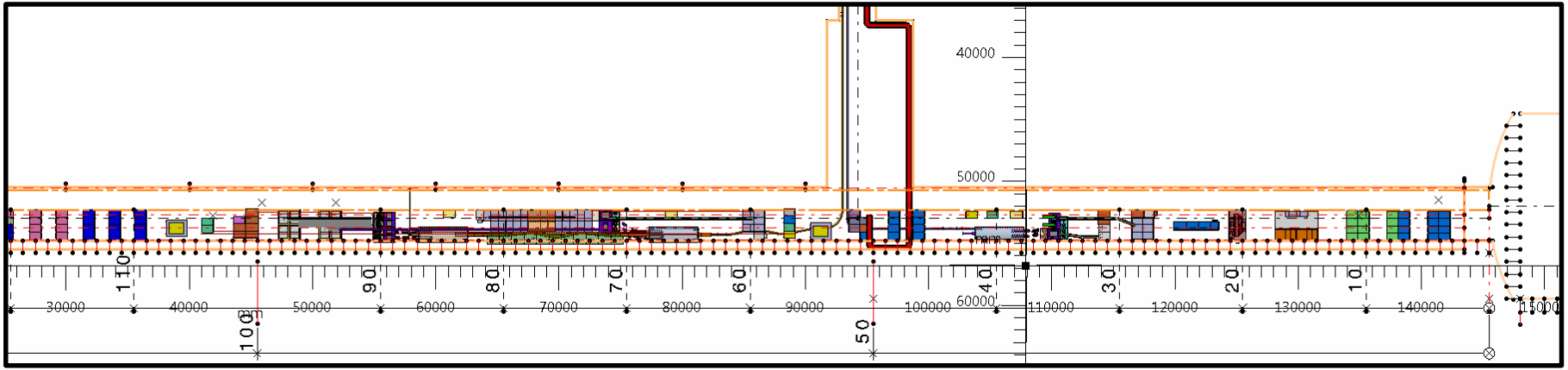


EMC Issue



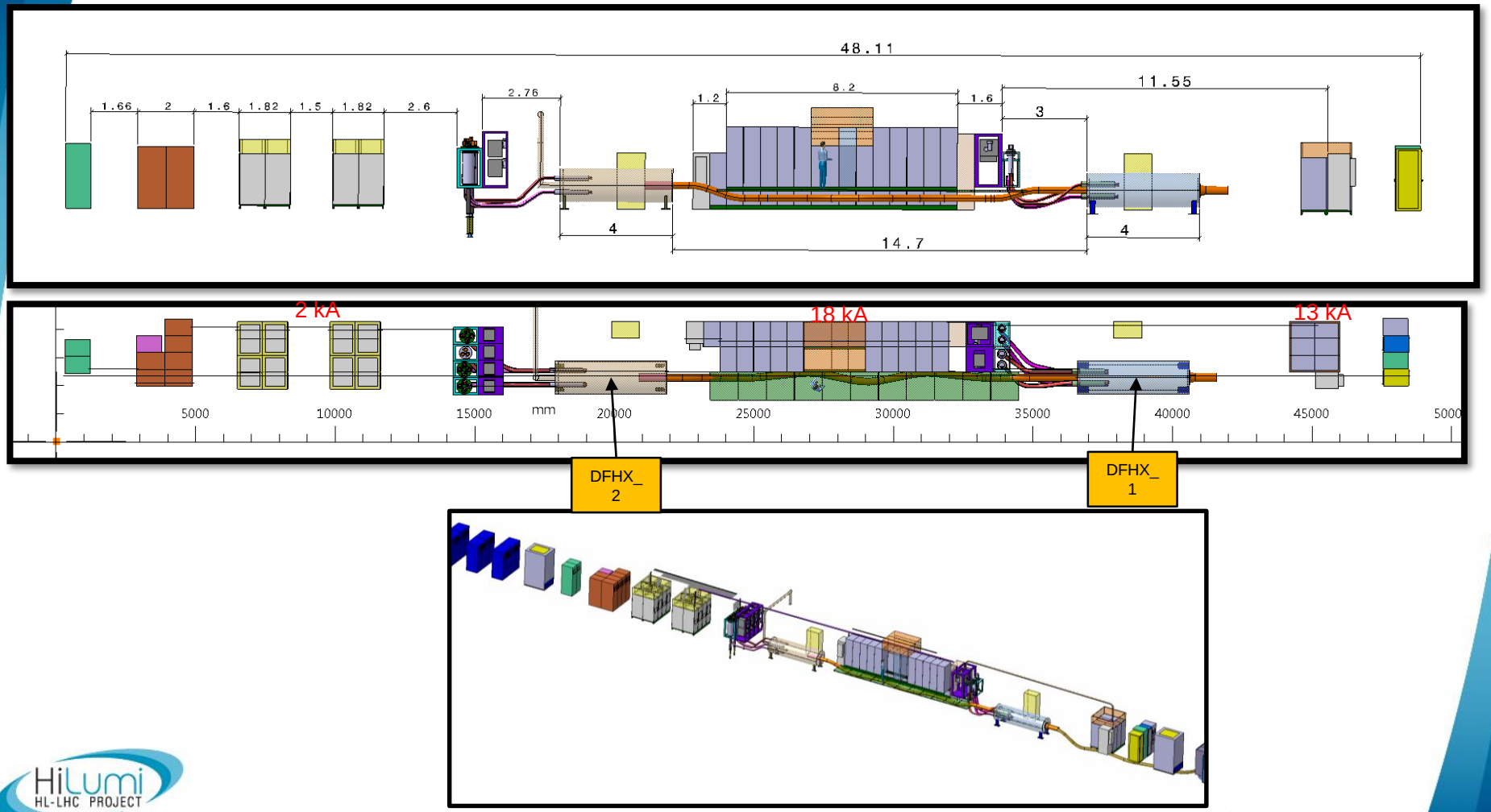
All these “conductors” must be connected to the same DFHx!
Forward and backward current paths must run as close as possible!

Latest Integration “iteration”



Machine protection	Powering inner triplet	Powering D2

Courtesy of Stephane Maridor



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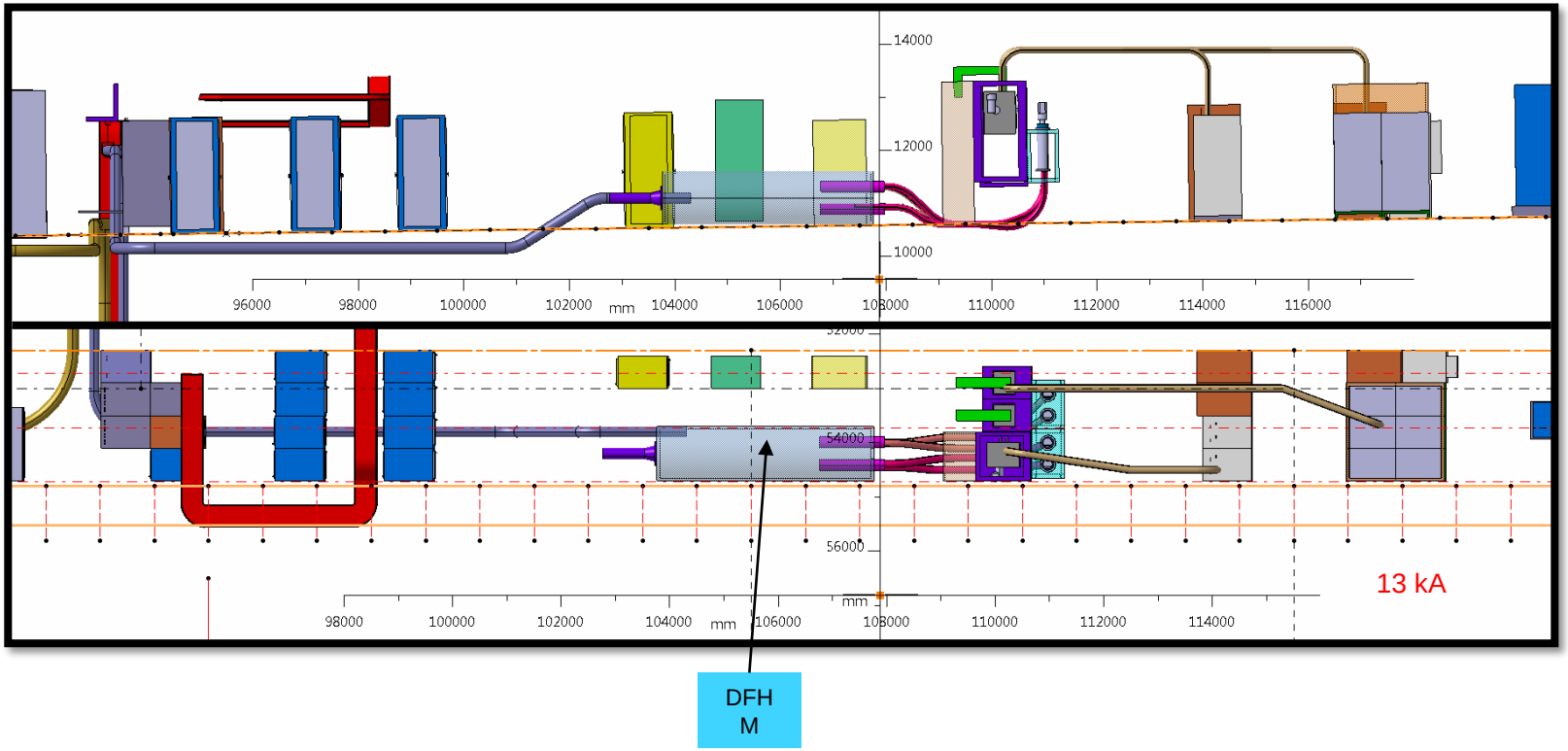

Courtesy of Stephane Maridor

Conceptual Solution for the IT Main Circuit