# DECOUPLING OF ADJACENT CRYOGENIC SECTORS

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*Abstract*

The LHC sectors are coupled two by two via interconnection boxes allowing cryoplant cooling redundancy and efficient stand-by or low-beam-intensity operation. The present LHC cryogenic sectorization allows to performed mechanical interventions on the magnet cold-mass circuit of a sector, like diode or interconnection splice repairs while the adjacent sector remain in nominal cryogenic operation. However this sectorization does not allow exchanging a magnet or a QRL service module in a sector while keeping the adjacent sector in nominal cryogenic operation and the cooling redundancy ability. This presentation will describe, based on different scenarios, hardware update proposals allowing a complete separation of the two adjacent sectors.

## INTRODUCTION

This paper and associated presentation is the result of 3 years of operation of LHC cryogenic system.

## PRESENT CONFIGURATION

### *Nominal scheme*

The nominal scheme for the cryogenic distribution system is one helium refrigeration plant (18 kW/4.5K) associated with one 1.8K unit used to feed one sector. (See Figure 1)

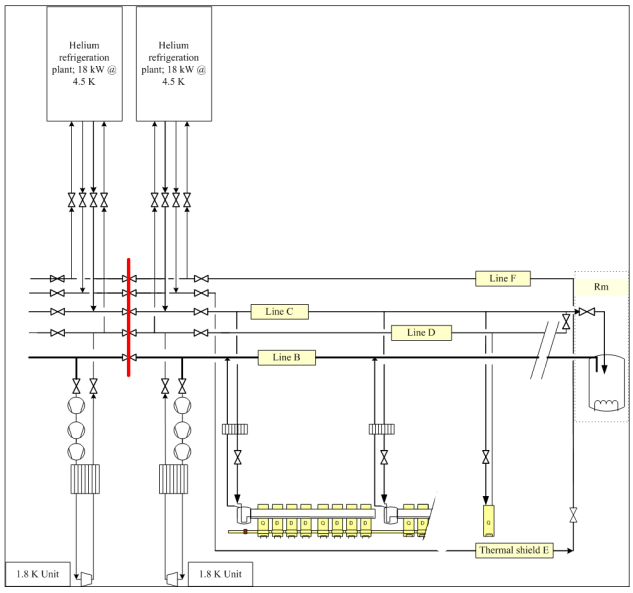


Figure 1: Nominal scheme.

### *Low-intensity or stand-by scheme*

The low-intensity or stand-by scheme for the cryogenic distribution system consist to join the two sectors with one helium refrigeration plant (18 kW/4.5K) associated with one 1.8K unit used to feed one sector. (See Figure 2). This scheme is foreseen during 2010/2011 run for sectors S56 & S67 in Point 6 and at point 8 for sectors S78 & S81.

## OVERALL CONFIGURATION DURING INTERVENTION ON ONE SECTOR

### *Safety*

The sector must be “consigned” from pressure and gas flow.

### *Cryogenic operation*

Cold valves must be protected from air and moisture condensation and icing.

### *Configuration adopted for each affected circuit*

Two valves locally consigned with helium gas buffer in between, at room temperature and atmospheric pressure. The pressure is constantly monitored. Figure 3 show the actual status during intervention on one sector with the adjacent sector cold.

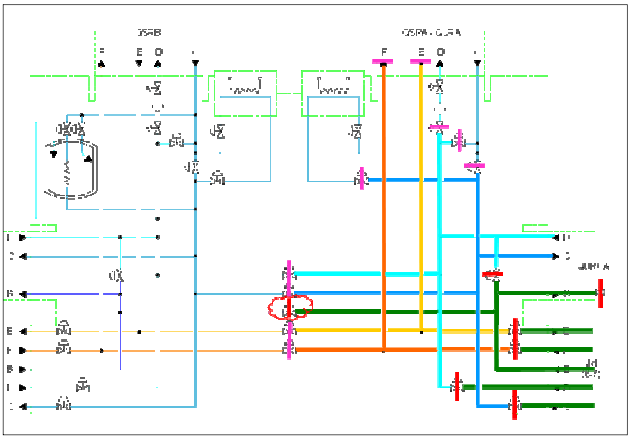

Figure 3: Actual status during intervention for one sector while the other sector remains cold.

All headers are protected with a gas buffer (2 closed valves in serial with He gas in between) except header B (low pressure header used to pump saturated helium at 15 mbar) which should be equipped with a temporary tool to guaranty helium gas buffer. By virtue of his design, this temporary tool does not perfectly stop air and moisture condensation. Figure 4 shows this temporary tool.

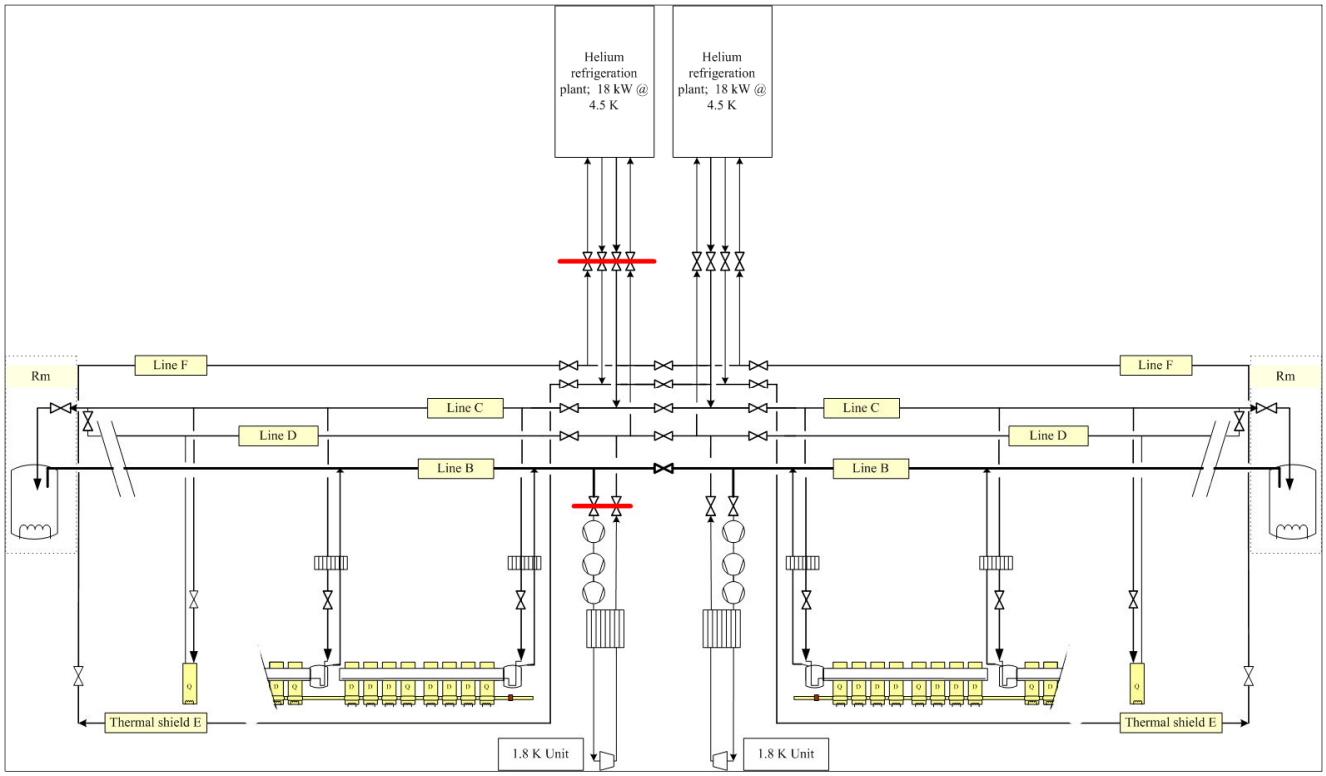


Figure 2: Low-intensity or stand-by scheme

As partial conclusion, exchanging a magnet or a QRL service module in a sector while keeping the adjacent sector in nominal cryogenic operation is not possible without important risk for long term cryo-stability (important risk of pollution and icing of the temporary tool).

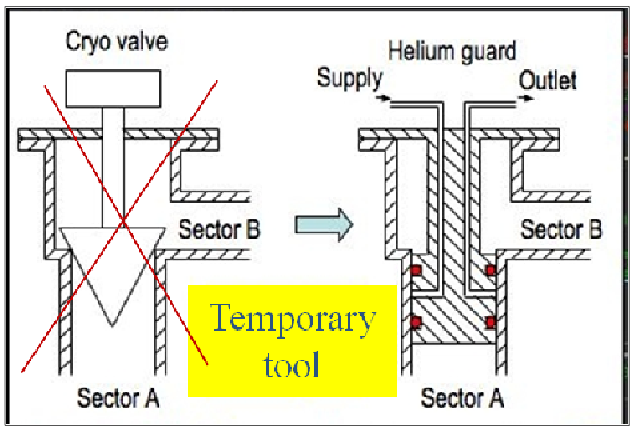


Figure 4: Temporary tool used to protect header B from pressure and air in leak

## SCENARIOS PROPOSED FOR FUTURE INTERVENTION

### *One sector cooled by **normal** cryoplant, One sector under intervention.*

The problem of pollution and icing of the valve on header B should be solved by adding a new valve on header B. This solution fixes the pollution problem and upgrades the interconnection of Header B to the same configuration than all the other headers of the sector. Figure 5 shows the new added valve on header B

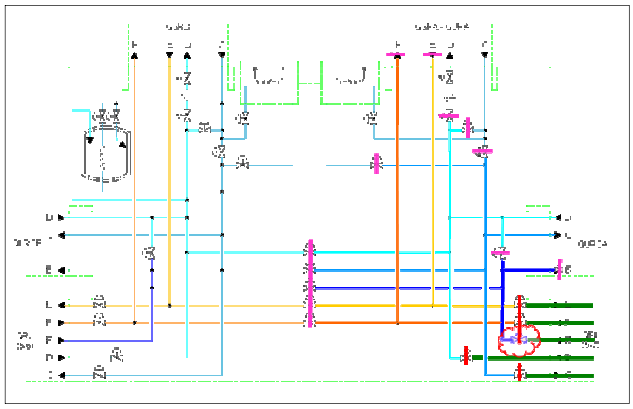

Figure 5: New added valve on header B to warranty Helium gas buffer.

The solution described above needs a design validation for the 5 valves boxes. In particular, free space in QUI valve boxes must be carefully checked in point 18 and point 2. Rough cost estimation gives a budget cost of 120 to 150 kCHF/sector included design, materiel, installation, pressure & X-ray tests. The estimated duration of the works is 3 to 4 weeks. Figure 6 show a picture of internal piping for one QUI.

Figure 6: QUI internal piping

Figure 7 shows a first study done in 2006 (G. Riddone, N. Veillet) showing a possible integration of the added valve.

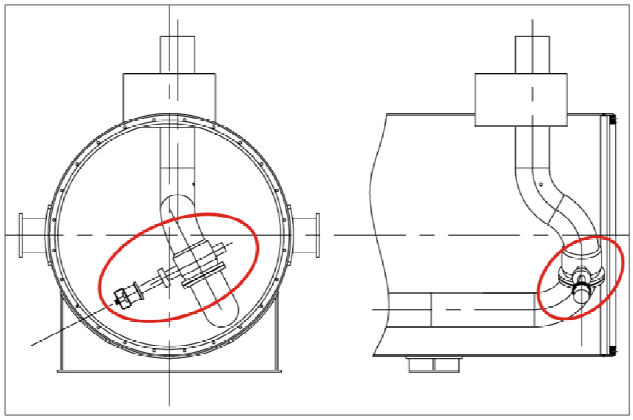

Figure 7: Integration of the added valve, first study, 2006

Figure 8 shows internal piping of a QUI valve box installed in point 4,6 or 8.

As partial summary, this solution to add a DN 250 valve on header B gives the following advantages:

- Gas flow safety guaranteed during mechanical intervention.
- Air and moisture condensation/icing prevented.
- Warm-up and De-icing of the cold compressor filter much more easier.
- Restore the possibility of leak-tight insulation between header B and QURC and allows the repair of the inlet valve of the cold compressor.

Disadvantages are:

- Installation possible only if the two sectors are at room temperature.
- The time schedule impact is at least 4 weeks.

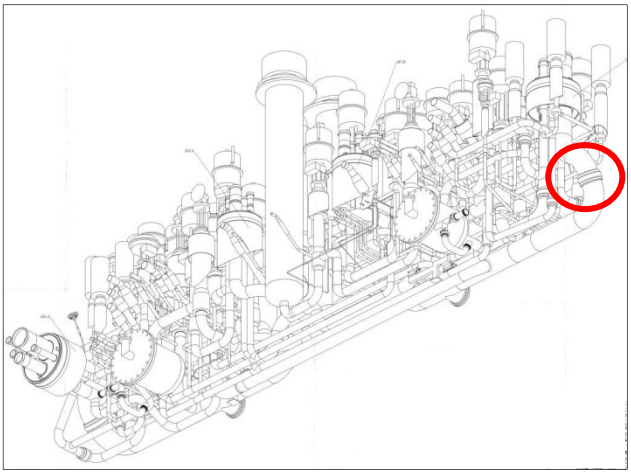

Figure 8: QUI internal piping

### *One sector cooled by **redundant** cryoplant, One sector under intervention.*

The second scenario proposed consists to fully disconnect the sector under intervention of the other sector under normal cryogenic operation. By this method the running sector will have all functionality to remains operational, included cryoplant redundancy. To achieve this scenario, a new valve-box must be added on the junction region of each sector. Figure 9 shows the added valve-box and shows the cold sector cooled by the redundant helium refrigerator plant.

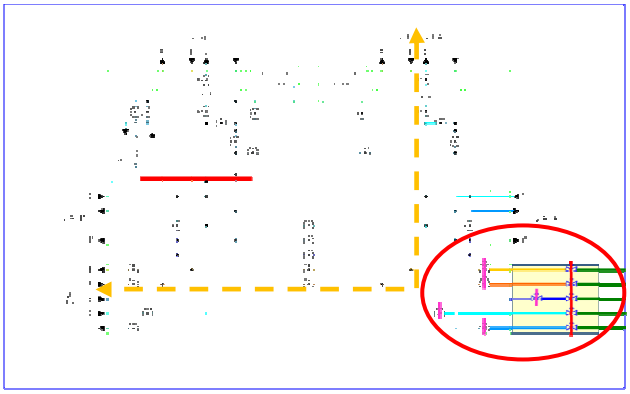

Figure 9: Valve-box added on junction region

The impact on the design of the junction region must be carefully studied for the 8 junction-regions. Figure 10 shows example of junction region for sector S81. Preliminary cost estimation gives a budget of 300 to 350 kCHF per sector, for a time schedule impact of 4 to 6 weeks. The impact on proximity piping and safety valves must be carefully checked.

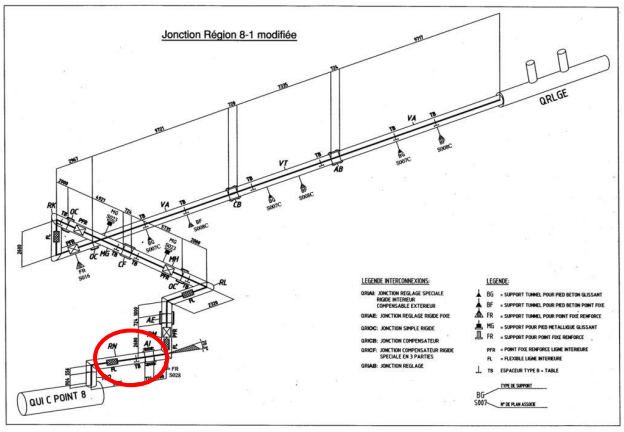


Figure 10: Valve-box added on junction region S81

As partial summary the solution to add a new valve box gives the following advantages:

- Same than previous solution plus redundancy of cryoplant guaranteed.

Disadvantages of the added valve solution are:

- Integration design to be checked and validated. See figure 11 showing stress simulation for junction region, sector S81.
- Installation possible only if the two sectors are at room temperature.
- Time schedule duration and cost.

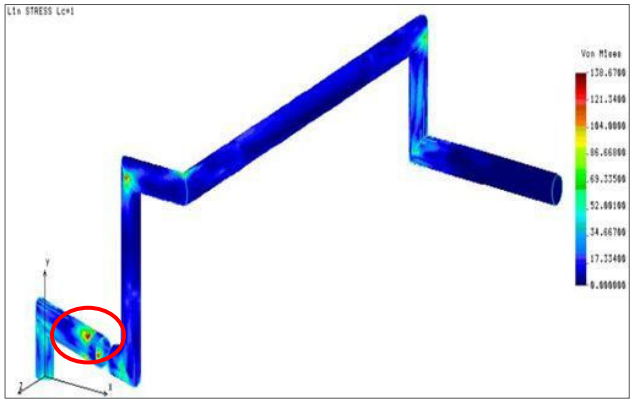


Figure 11: Stress simulation, junction region S81

## *Other points not detailed in this document.*

To fulfil the main topic of this document "Decoupling of adjacent cryogenic sectors" some other subjects must be studied.

- Some Helium Ring Line (HRL) sectorisation valves must be remotely driven.
- In the QUI area, by pass of the Warm Helium Line (WRL) must be installed.
- The QUI purge panel must be separate in two half parts to prevent possible gas communication from one sector to the other one.

## CONCLUSION

Heavy intervention, such as exchanging magnet or a QRL service module, while keeping the adjacent sector in nominal cryogenic operation will be possible only by upgrading the gas buffer system on header B. This new valve will also restore leak-tight insulation and gas buffer system between sector and Cold Compressor unit during intervention.

If the cryoplant redundancy is mandatory during this heavy intervention, a valve box must be added on the junction region, to completely separate the QUI from the sector.