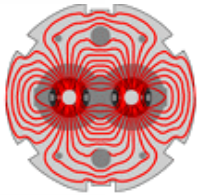
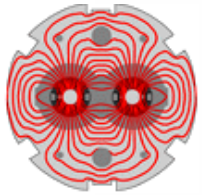


CRAB CAVITY INTEGRATION

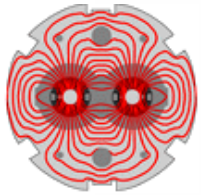
CRYOGENICS INSTALLATION

Bruno Vullierme



Crab Cavities Phase I, stated issues

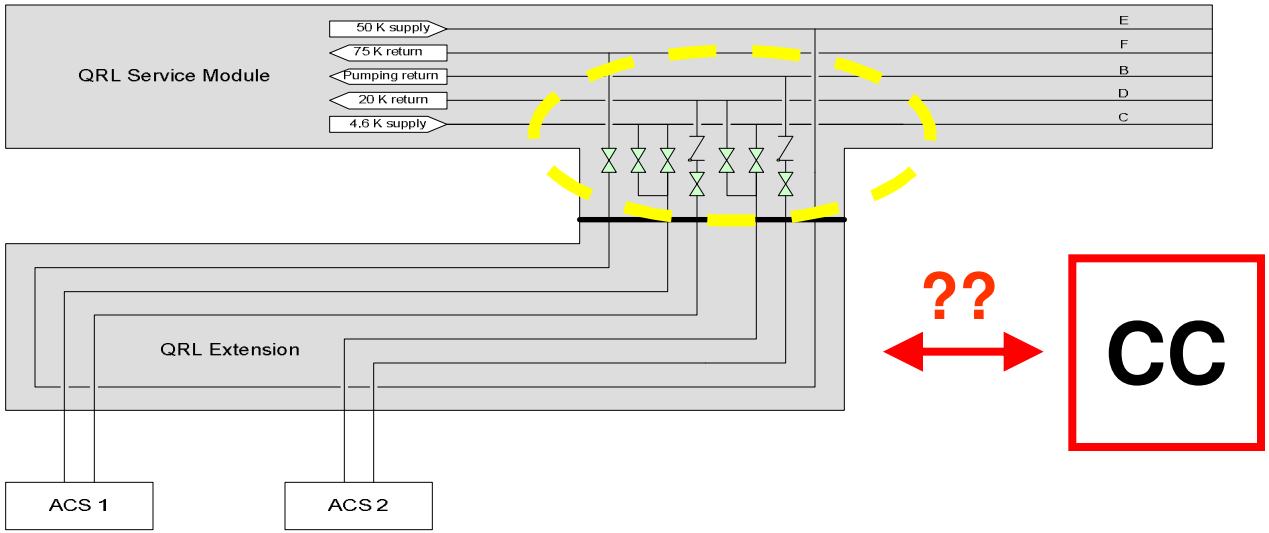
- Extension of main RF *vs.* specific cryogenic lines
- Operating temperature, pressure
- Heat loads
- Cryogenic circuits and controls
- Safety valves and protection
- Overall installation effort and time line
- Impact on the LHC during prototype tests and regular operation



Crab cavities Phase I, context

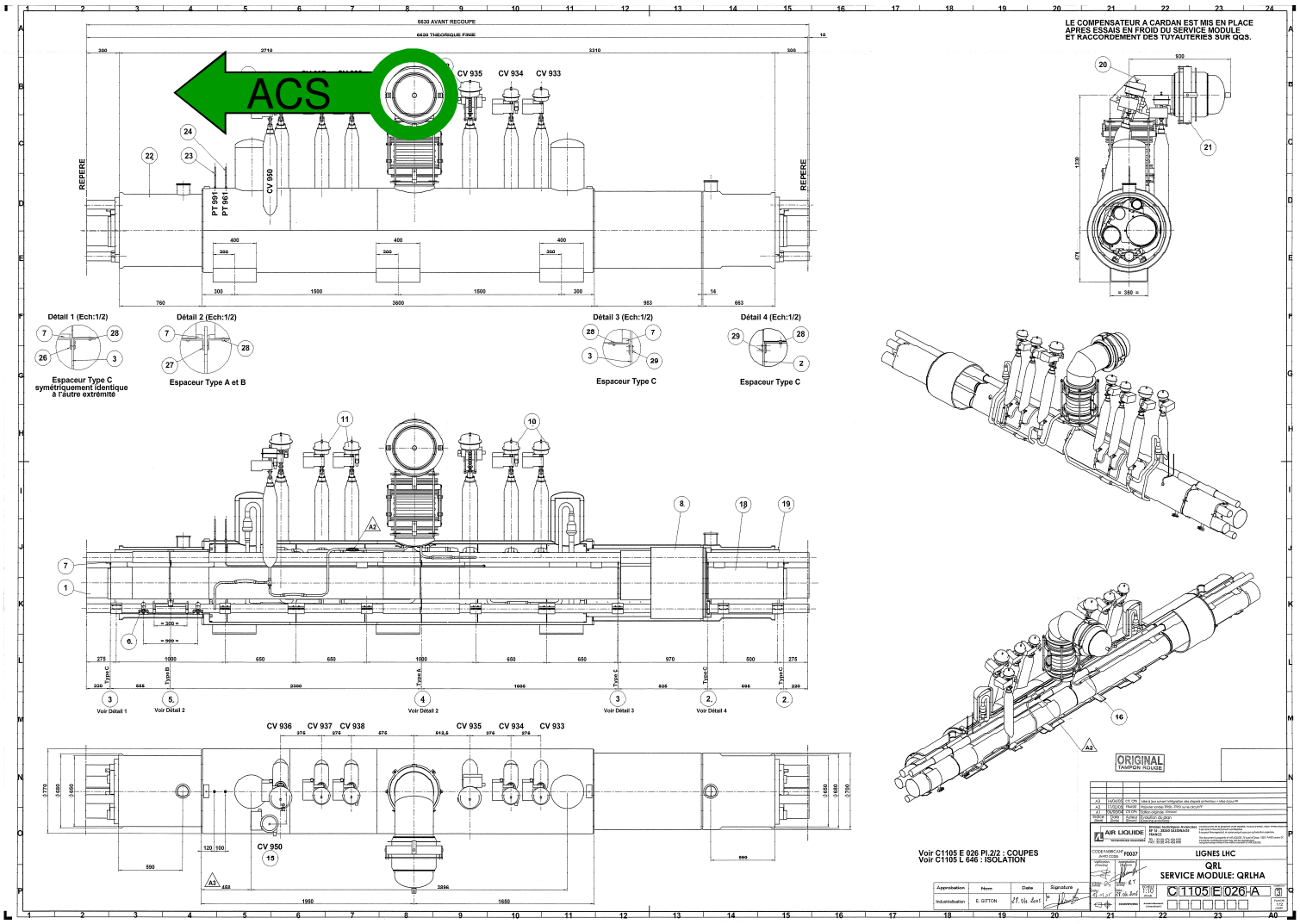
- The operating temperature of 2 K is preferred for 800 MHz superconducting cavity.
- However, the physical constraints and the availability of the 2 K @ ~30 mbar may limit the operating temperature to 4.6 K.
- Cavity Losses 50 W @ 2 K or 250-500W @ 4.6 K
- Helium volume 35-50 litre

Extension of main RF lines for CC ?

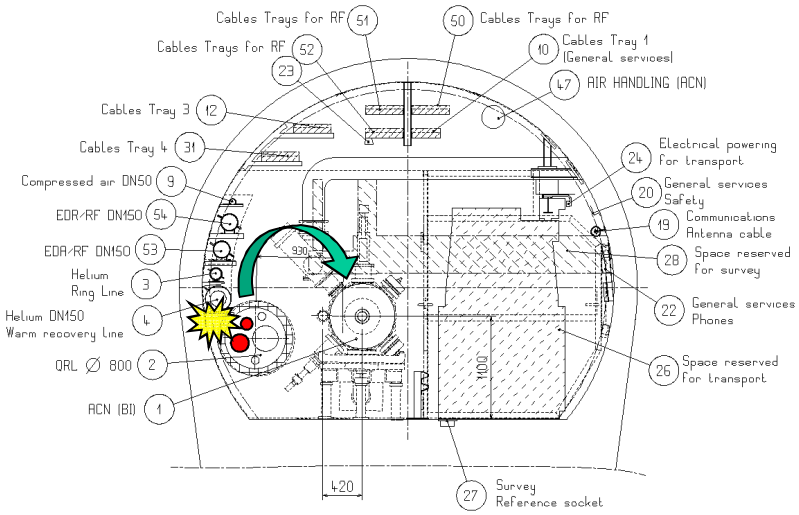


- *First guess*: it is not possible to simply extend the existing line feeding the ACS RF system in order to independently supply the Crab Cavity (CC) cryostat with helium @ 4.6 K: all the control valves required for the level and pressure control of ACS cryomodules are located on a dedicated *Cryogenic Ring Line (so-called QRL) Service Module*.

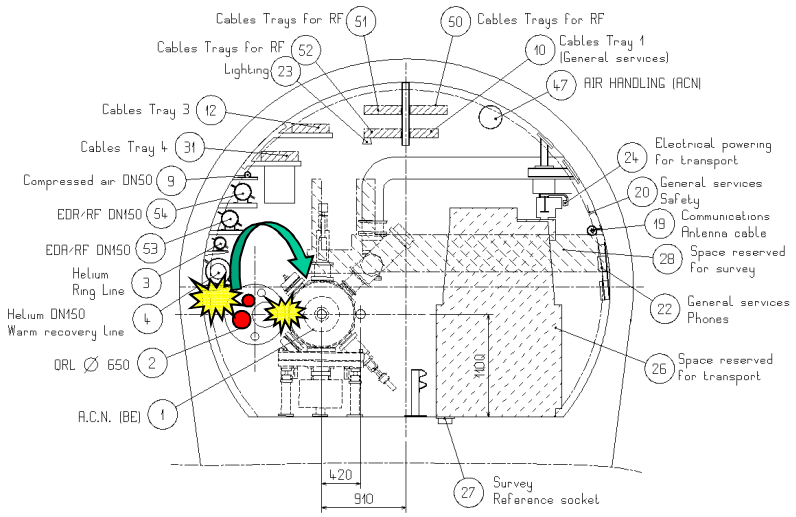
Present *QRL Service Module*



Specific cryo-lines to *QRL pipe elements* ?

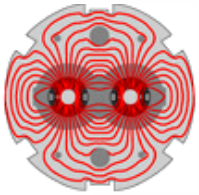


Section RB44



Section RB46

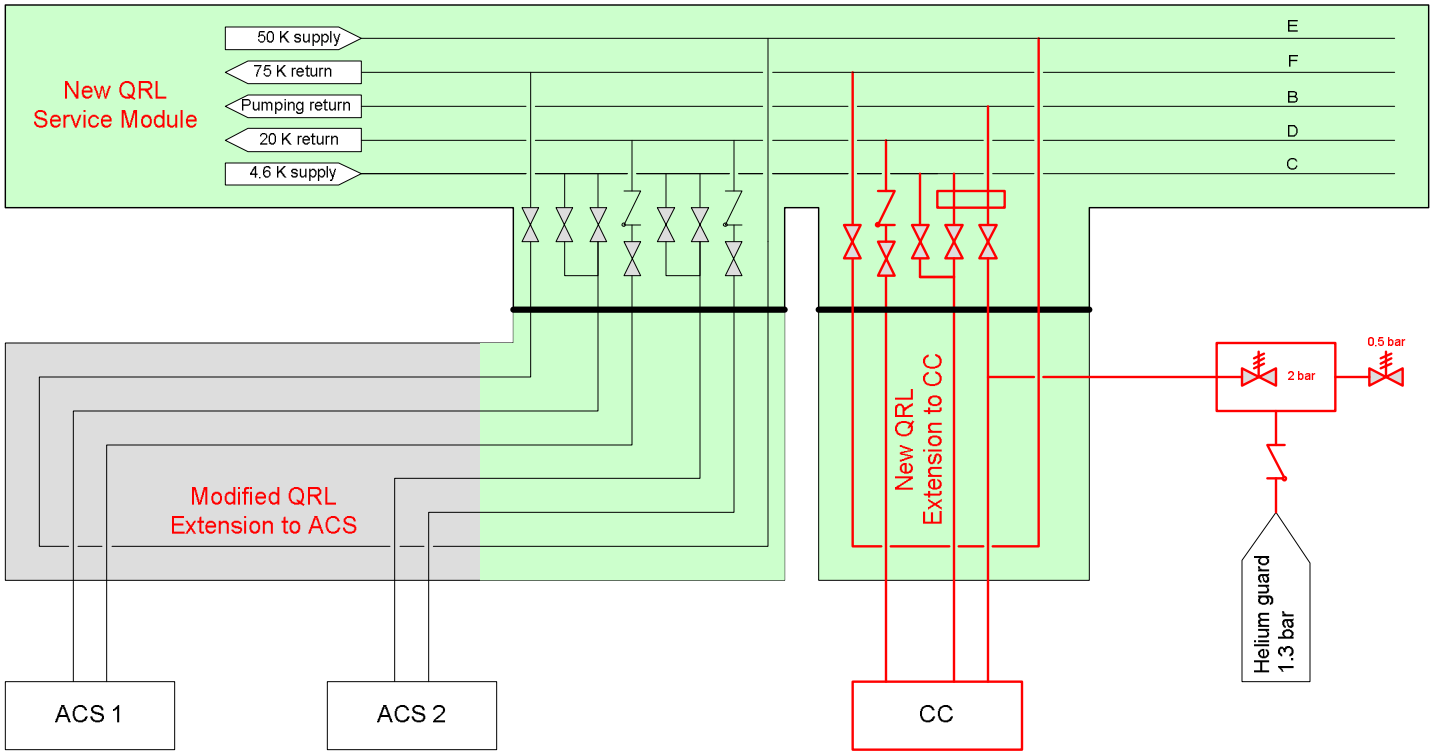
- The preliminary study shows that there is not enough space to install additional standard (∅ 800 mm) *QRL service modules* (integration problems due to space with respect to vault, to CC cryostat, position of possible slots).
- Special QRL interface to CC cryostat is not considered .



OPTION 1 – New QRL Service Modules

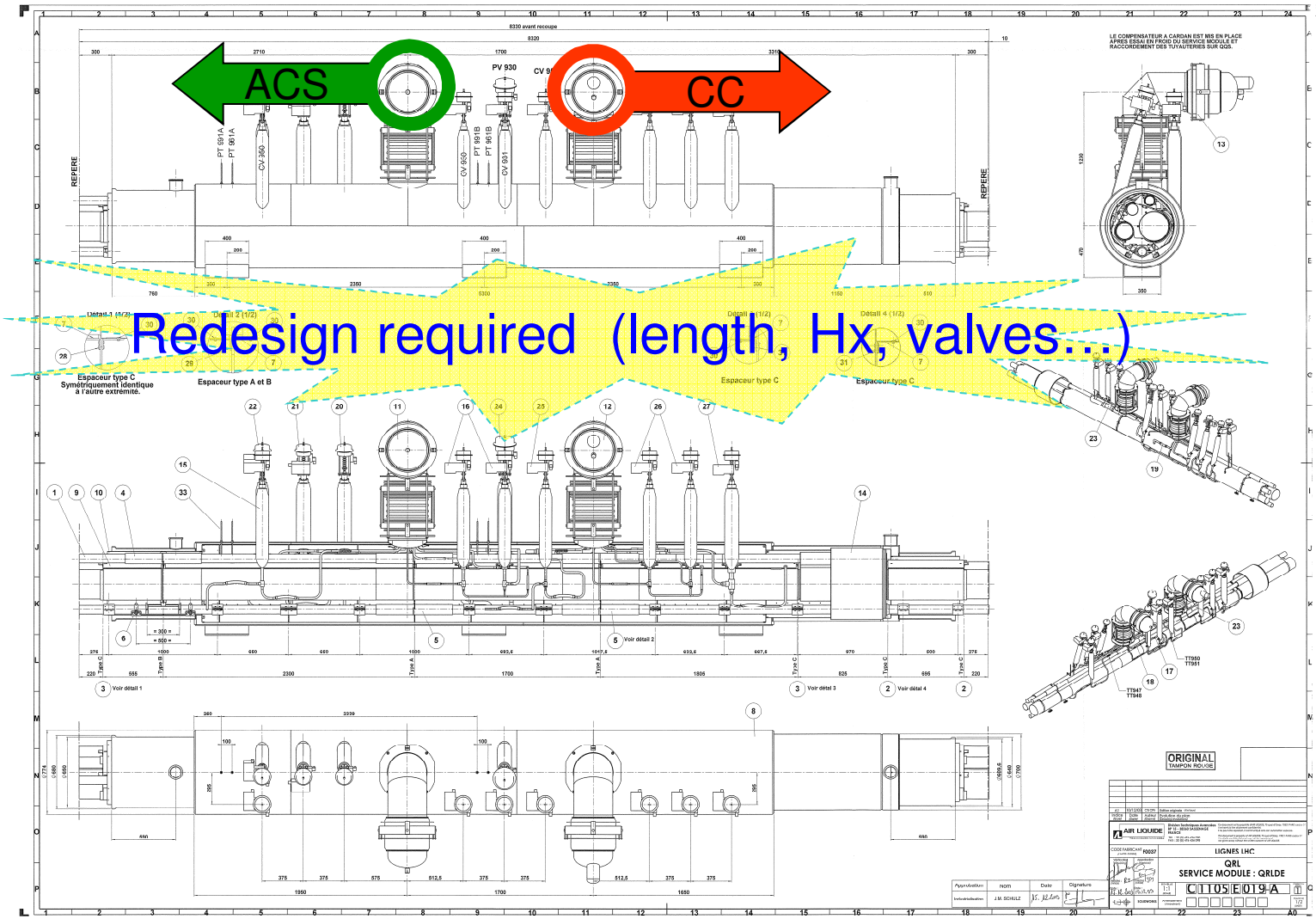
- The first option would be to replace both present *QRL service modules* for the RF system at P4 – and to modify both present *QRL extensions* to ACS RF system –
- The required *QRL service modules* would be of new design, possibly with a double jumper, with a heat exchanger and 5 additional valves. The length excepted, no major design nor integration problem is expected.
- The replacement of the 2 *QRL service modules* requires:
  - Removal and reinstallation of neighboring ACS cryomodules
  - 20 critical cuts and welds on the 5 QRL headers
  - 5 to 6 weeks for dismantling/installation (cryo only)
  - Nearly global pressure tests for both 3-4 and 4-5 LHC sectors
- Cost for such QRL modifications : > 1 MCHF

OPTION 1 – QRL Modification for CC @ 2 K



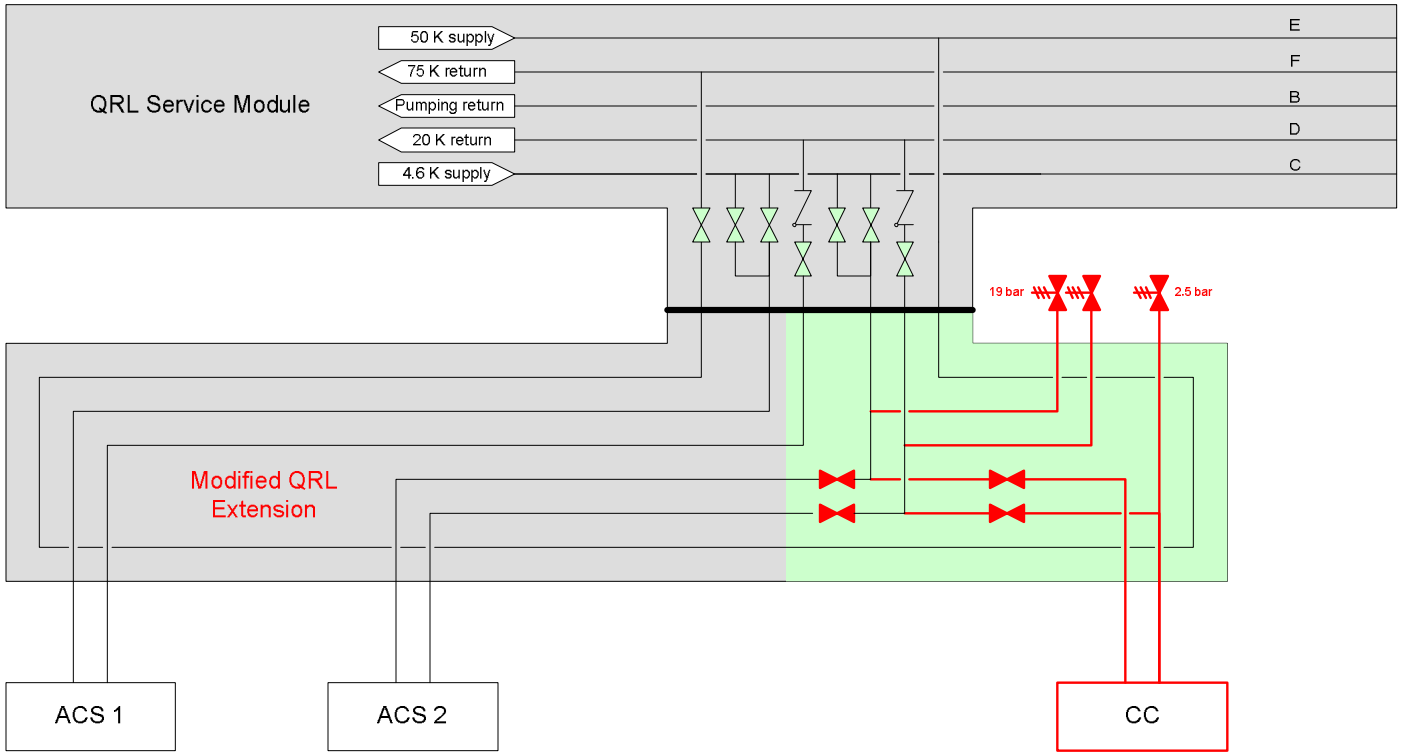
- CC design pressure: 3.5 bar
- CC operating pressure: saturated helium @ 2 K
- Helium guard required on CC safety (sub-atmospheric) circuits
- Additional cooling power of 50 W @ 2 K is available for CC

New type of *QRL Service Module*

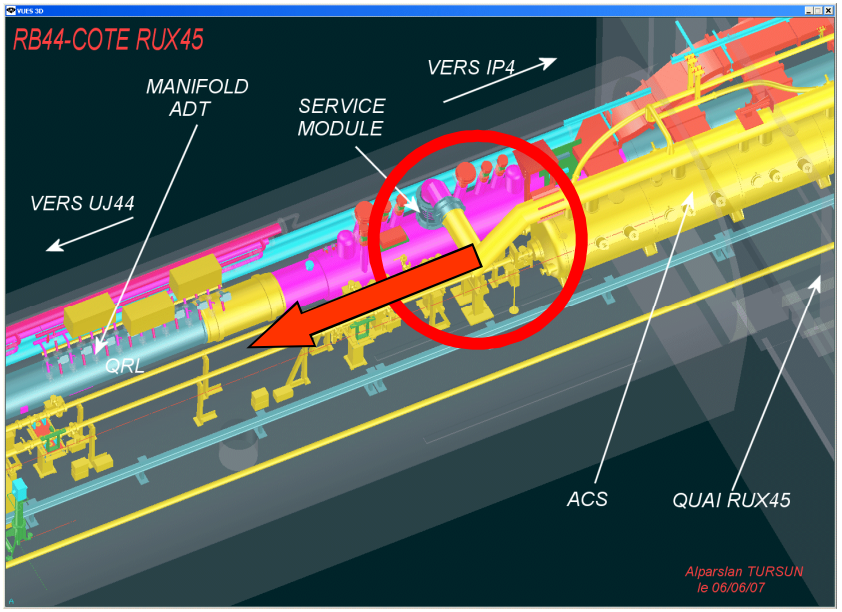


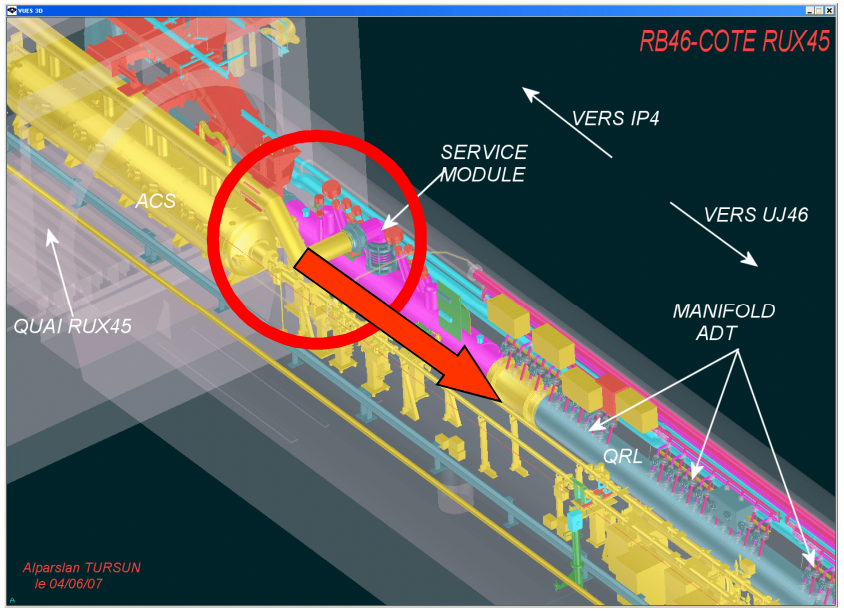
OPTION 2 – CC @ 4.6 K

- The straightforward solution is to finally modify the supply and return lines of the *QRL extension* to one of the two ACS cryomodules, in order to connect the CC in parallel, via an additional set of valves.

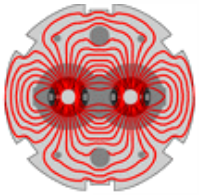


OPTION 2 – CC @ 4.6 K, integration



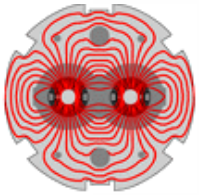


- The present elbow region of the *QRL extension* to the ACS can be cut and replaced by a T-shape part (+ 4 control valves, + safety circuits, + 2 cryogenic lines with bayonets to CC cryostat)
- Installation: ~ 1 week, local pressure and leak tests only, not critical



OPTION 2 – CC @ 4.6 K, main features

- Design pressure of CC helium vessel: 3.5 bar
- CC helium pressure, temperature: 1. 35 bar, ~ 4.6 K
- The CC required flow rate of 15-30 g/s of helium at 4.6 K from QRL header “C “ should be available.
- The flow coefficient of the existing QRL supply and return control valves can be increased (ACS + CC He flow rates).
- Controls: liquid helium level and pressure controls with dedicated control (and shut-off) valves.
- Safety: non-return valves to QRL header “D”, possible pressure interlocks (QRL header “C”, QRL header “D”, ACS)
- Possibility of using an additional circuit for helium return to the Warm Recovery Line via an electrical heater, during magnet quenches (i.e. pressurization of QRL header “D”).



CC Phase I cryo-installation – Summary

	OPTION 1	OPTION 2
Saturated liquid helium temperature	2 K	4.6 K
Heat loads @ temperature	50 W	250-500 W
Removal/reinstallation of ACS cryomodules	Yes (time?)	None
QRL Service Module replacement	Yes, ~6 weeks	None
Installation of *QRL Extensions* to ACS and CC	~2 weeks	~1 week
Nearly global LHC sector pressure tests	Yes (2 x 1 week)	None
Impact on LHC during prototype tests	Marginal	Not critical
Impact on LHC during regular operation	Marginal	Not critical *
Total installation time (QRL cryogenics only)	~10 weeks	~1 week
Cost	> 1 MCHF	~ 150 kCHF