Cryogenic status of SM18, SPS and HL-LHC and challenges/open points

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on behalf of HL-LHC WP4 and WP9 working teams

2023.09.27_HiLumi Annual meeting, Vancouver, Canada

Outlook

- SM18 readiness status
- Overview on operation of SPS BA6 in 2023
  - Cool down phase and global feedback
  - Perspectives – preparation for RFD test
- Cryomodule design
  - Instrumentation and safety devices
  - fabrication
- HL-LHC – supply line design and integration
- Conclusions

SM18 – M7 readiness

New transfer line installed as interface to cryomodule jumper

Electrical rack for instrumentation

Test end cap to the crab cryomodule

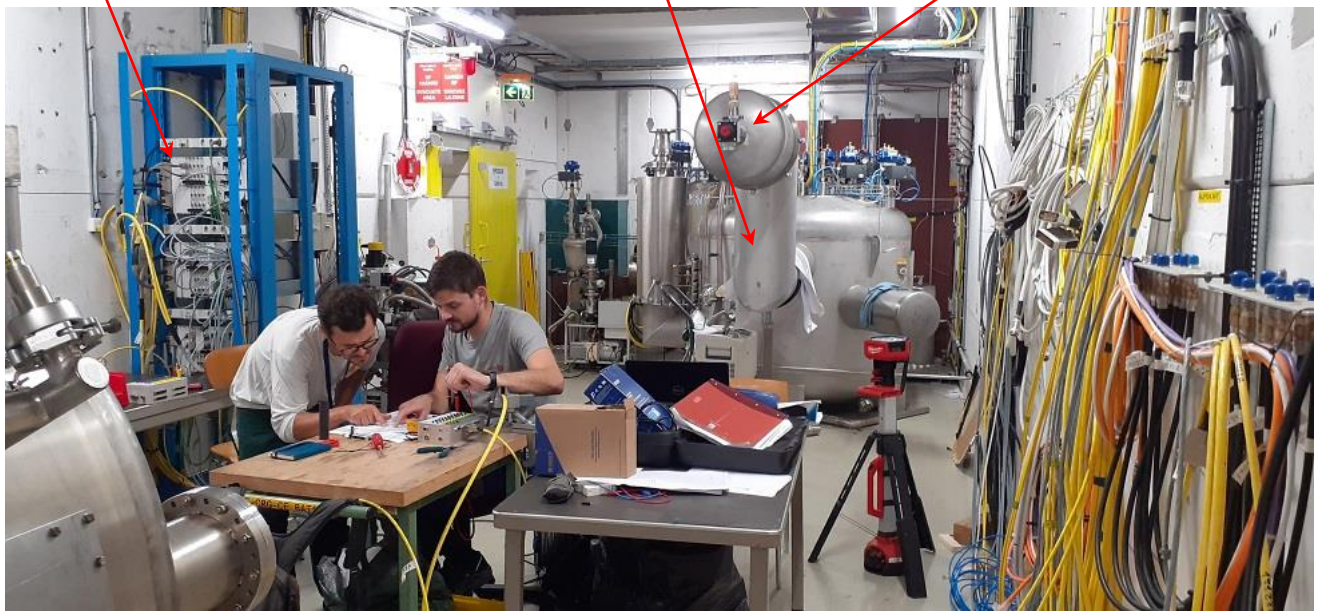
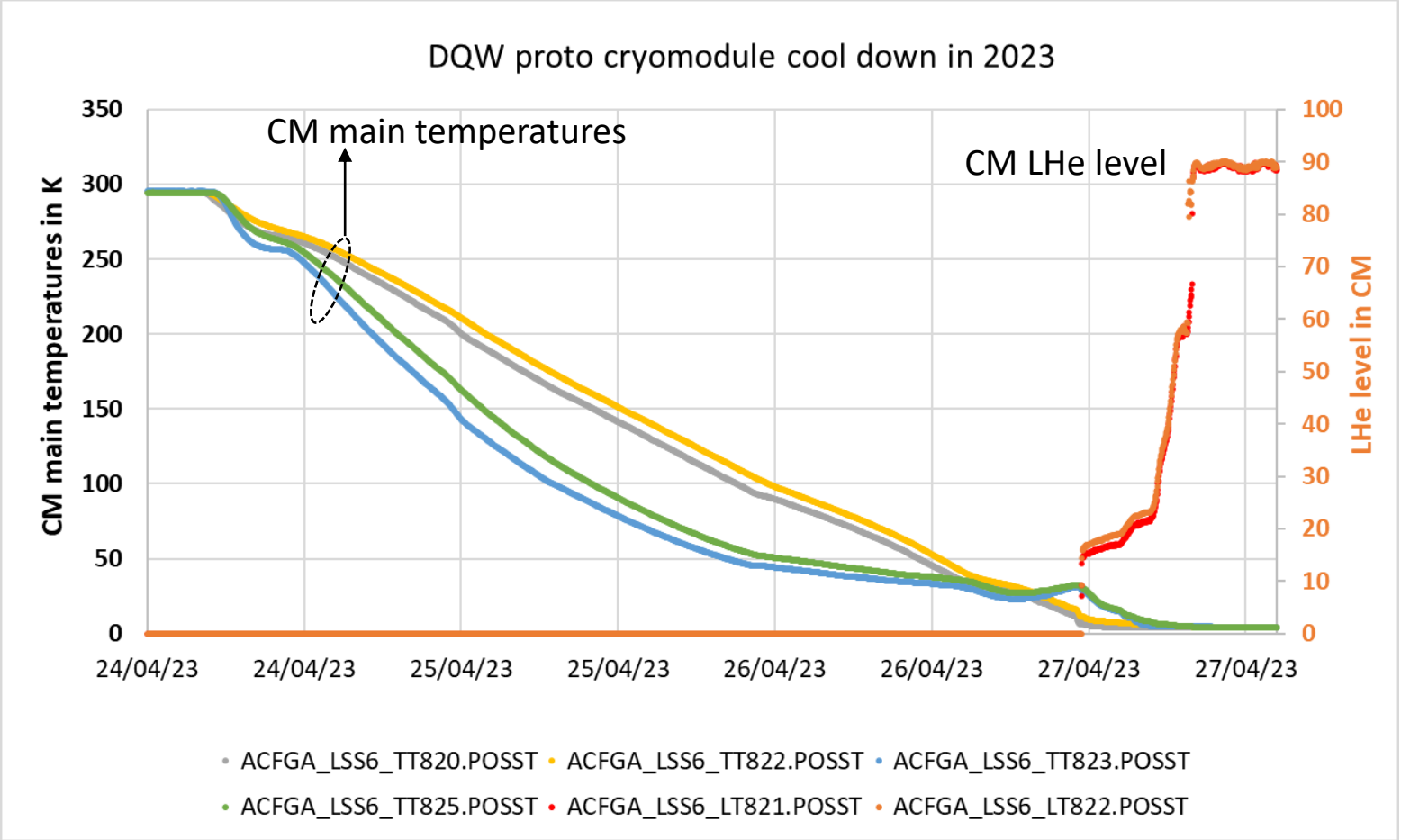


photo on 13.09.2023

Status:

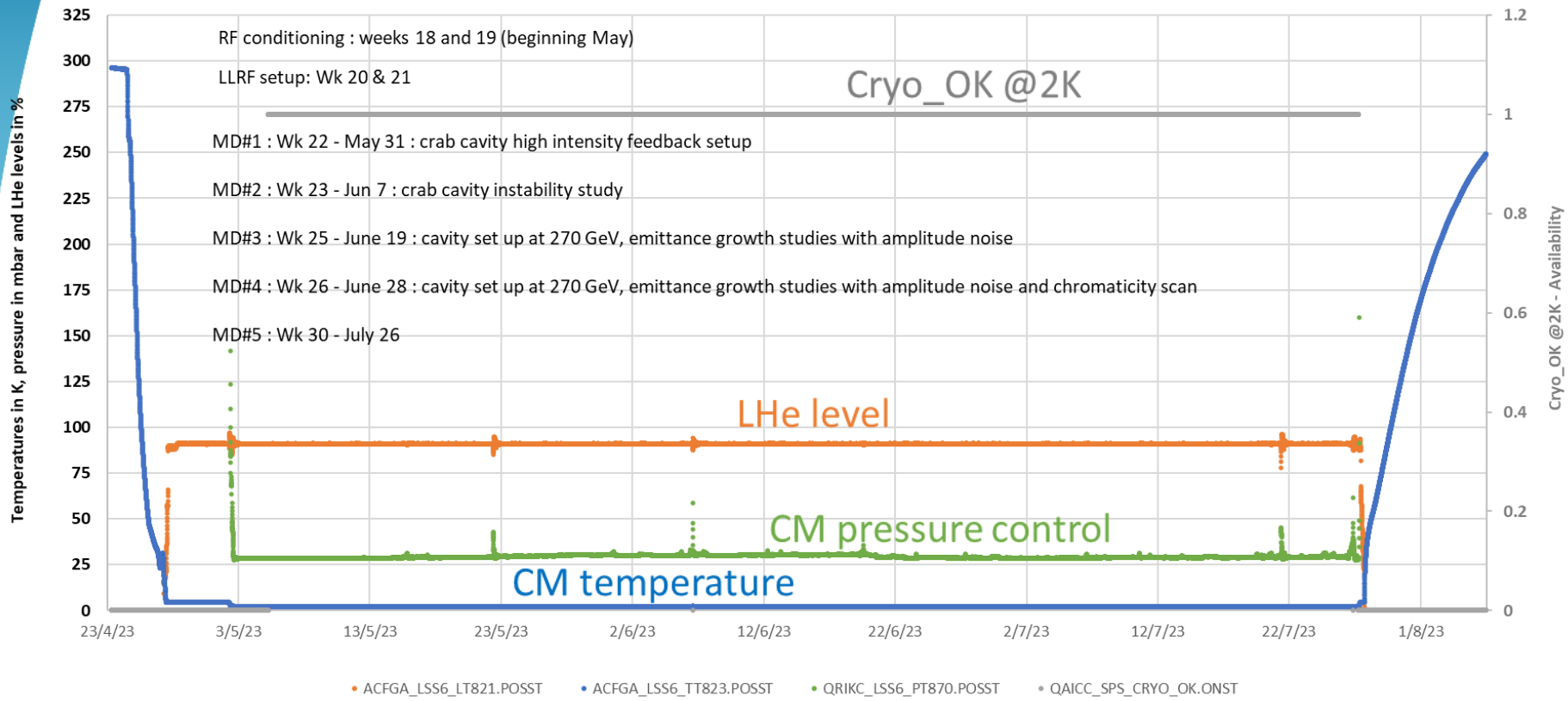
- Mechanical adaptation of the transfer lines is completed,
- Valve Box commissioning is completed (Autumn 2022),
- Instrumentation electrical chain is constructed (electrical racks ready, cabling prepared),
- M7 cryogenics mechanical and instrumentation interfaces are ready for cryomodule connection from now.

SPS – feedback from 2023



Operation is fully mastered with standard duration of ~3 days from cool down start @300K up to LHe regulation at 90%
(~1 hour needed to transit from stable 4.5 K to 2 K)

SPS – feedback from 2023



List of operational issues (not critical – just a real life):

2023 annual availability : 99.9%

- TSH731 issue, August 02, beep acknowledged
- Cryo OK loss, July 26, due to pressure increase on WPU system. Origin was a too high RF power
- 400V electrical cut, June 27
- WPU output flowmeter issue, June 19. Repaired during the shutdown.
- CM Peak pressure with cryo OK loss, June 6, due to RF activities. Then return to nominal.
- Pressure sensor default for WPU (with indication of 0 mbar), May 3, control support intervention

SPS – perspectives

Regarding future operation there is one consolidation and two modification to be done in SPS:

1. After first year of operation we noticed failure of the main helium flowmeter, caused by non-sufficient oil separation in the pumping system. In order to avoid migration of oil from the pump into other part of the system, additional separation device shall be installed close to flowmeter area. The equipment is present at CERN (ex-CMS coalescing filter), manpower and integration to be planned ➔ Action TE-CRG (LS)

2. Jumper interface between the Service Box and the cryomodule must be redesigned and adapted for next modules ➔ Action EN-MME and TE-CRG
(applicable for next module RFD going to the SPS)

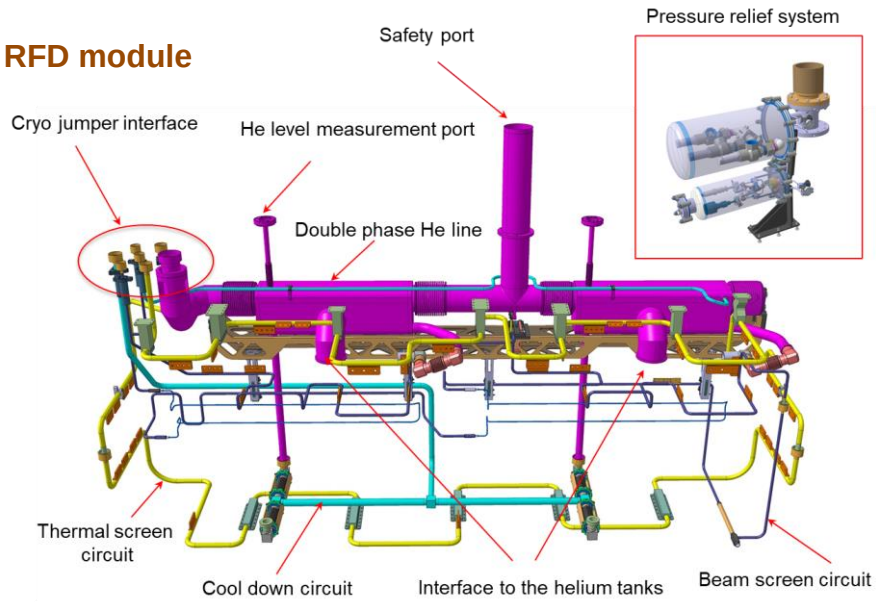
3. For replacement DQW → RFD adaptation of instrumentation treatment chain is required (RFD has much more instrumentation than DQW) ➔ Action TE-CRG-IC
(this action is being handled, no showstopper for swap of modules)

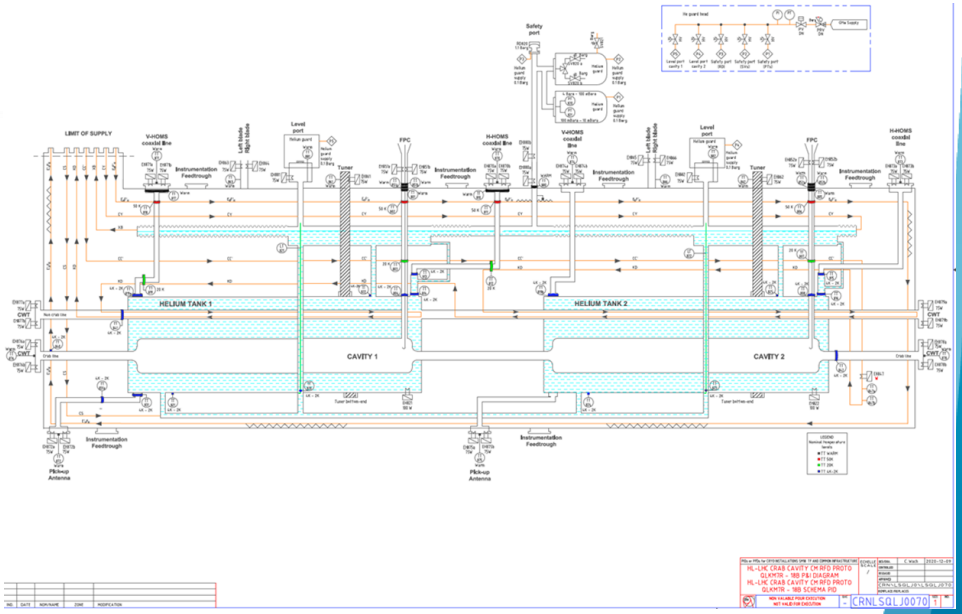
However, extremely tight planning for SPS RFD connection!

Notice: Added to the system Beam Screen cooling loop can be tested in SM18 M7 but cannot be operated in SPS.

Cryomodule design – cryogenic circuits

- Instrumentation list for all types of the cryomodules (proto and series for DQW and RFD) was defined and validated between MME and CRG
- Flow schemes for both types of the cryomodules were prepared and are validated and available





Focus on instrumentation – status

RFD prototype:

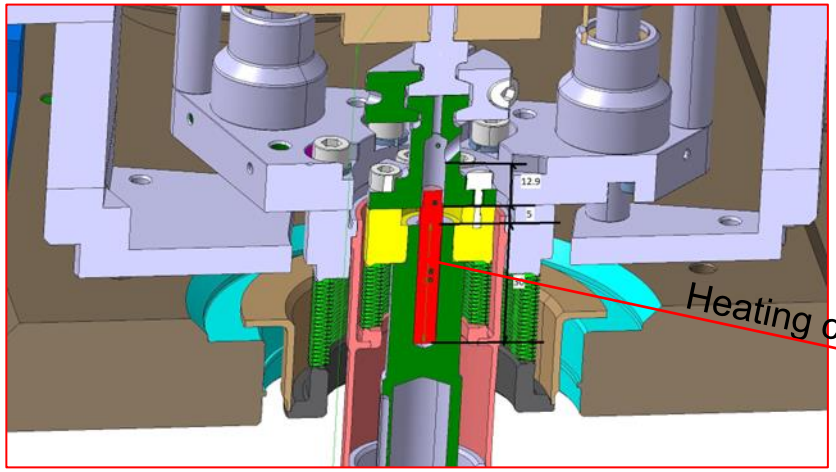
All instrumentation for RFD prototype was supplied to the builder for the installation. Dedicated installation training for CERNOX was done by TE-CRG in Daresbury on 24th May 2023.

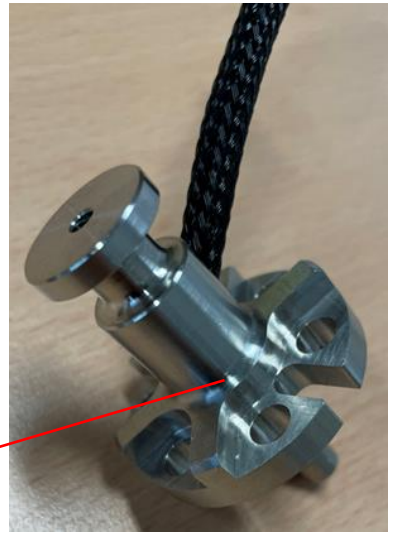
Focus on instrumentation – status

Tuner heaters:

following problems on first DQW prototype during SPS run 2018 when we have lost both tuner heaters, the new concept of integration was developed by MME and CRG with dedicated assembly allowing for effective heating and optimized integration of the heating cartridges – see pictures below.

This solution will be tested on RFD prototype module.



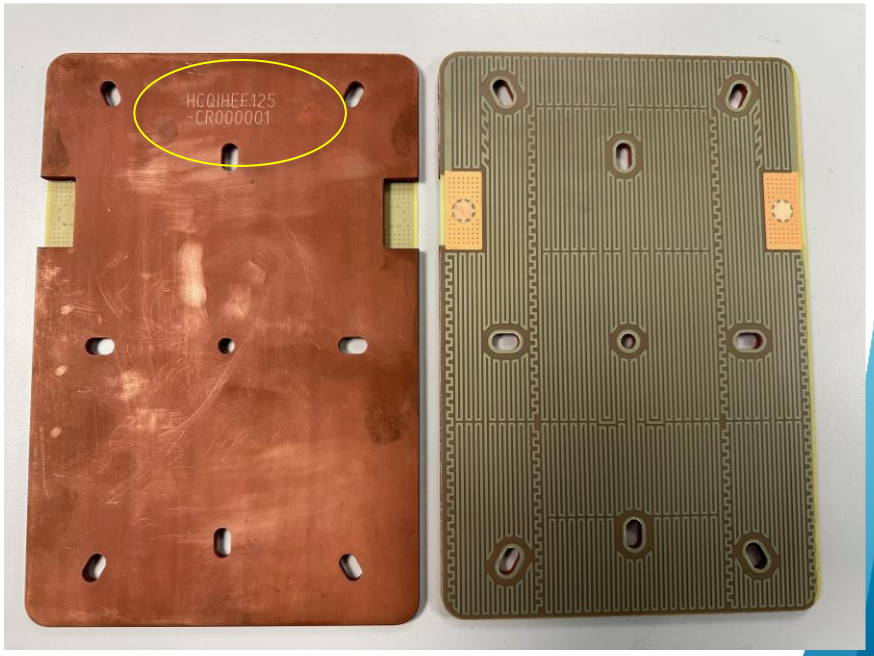


Focus on instrumentation – status

RFD and DQW series modules:

- All sensitive items (long delivery CERNOX) are available at CERN
- Beam screen heaters: available at CERN
- Helium tank heaters: produced and available at CERN
- Level gauges: to be ordered
- Pressure transducers: to be ordered
- External heaters: to be ordered

All foil heaters were transferred (glued) on copper support and identified for QA plan.



Safety devices

Both safety devices for RFD prototype: safety valves and rupture disc were supplied for installation

Series modules:

- Rupture discs produced by two suppliers from UK and D (10 + 10 pieces), still to be tested at max. allowable working pressure for acceptance. One of the supplier out of specification – clarification for acceptance is underway.
- SV – specified and to be ordered

Nota: Safety valves and rupture discs for series will be the same as for RFD prototype

Safety valve

Rupture disc

Fabrication of the cryomodules

General remark:

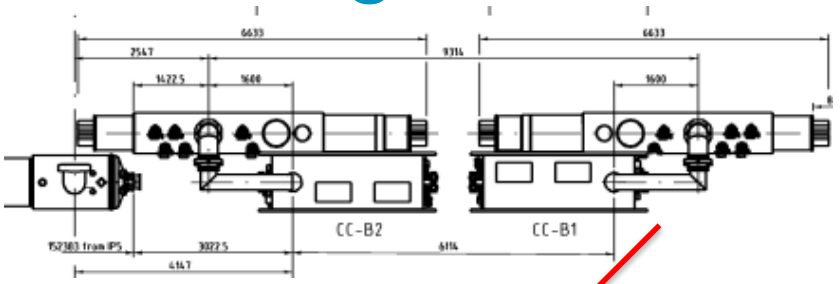
Concerning the fabrication process (RFD in UK) we did not experienced direct difficulties on the interface between Daresbury and CRG (only very few interactions). Some consultation for cryo aspects were done mainly via MME. The visit for instrumentation installation training was done.

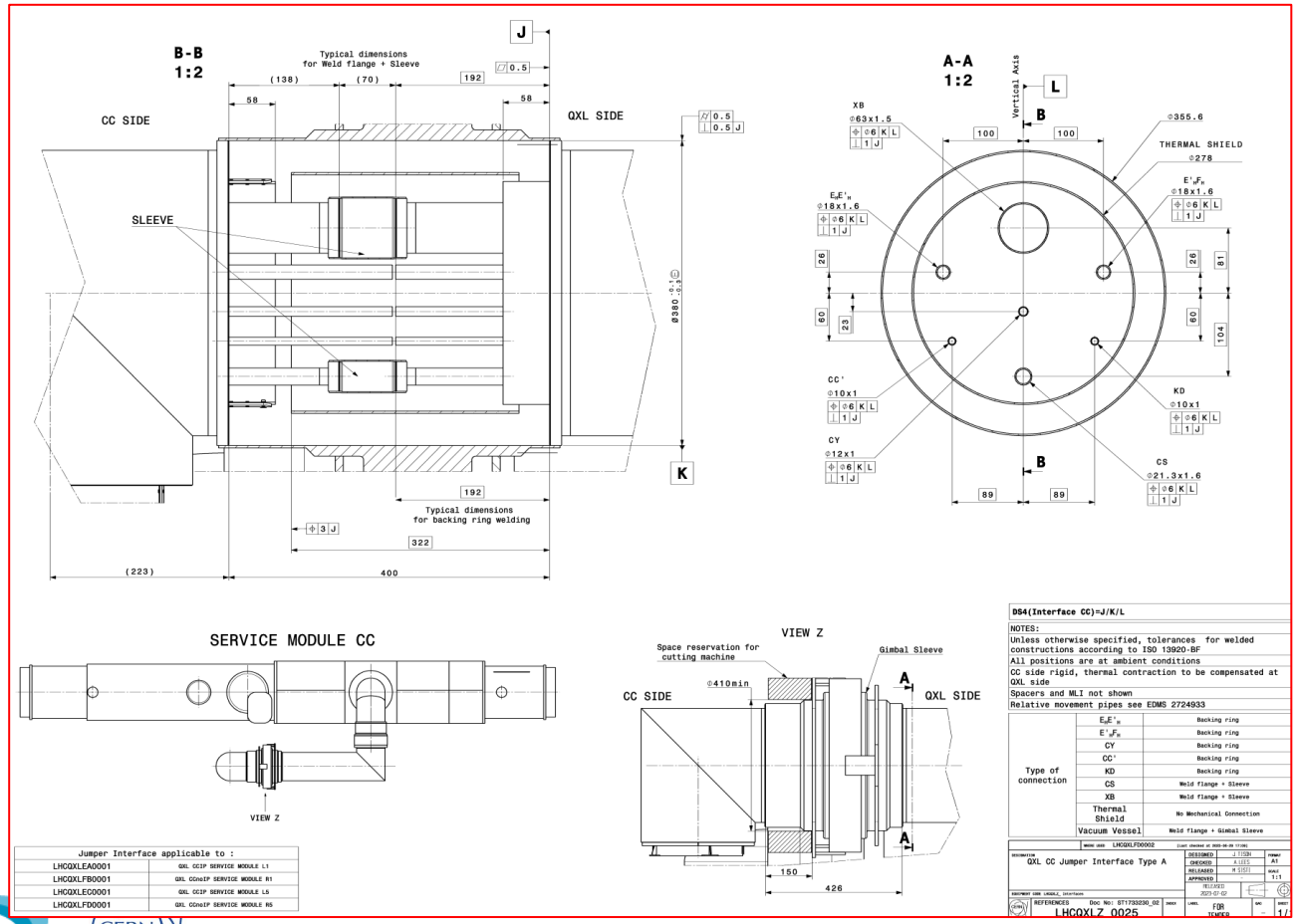
A few comments:

- Instrumentation installation training was largely postponed – but very good collaboration during the visit with Daresbury personnel for RFD proto module – Thanks!
- Be very careful to respect geometry of the internal cryo system/lines. The module is crowded inside and geometrical deviations may lead to additional, not expected mechanical stresses during thermal cycling and higher heat load in case of contact between parts with different temperatures.
- Do not hesitate to contact us in case of needs

HL-LHC – design and integration

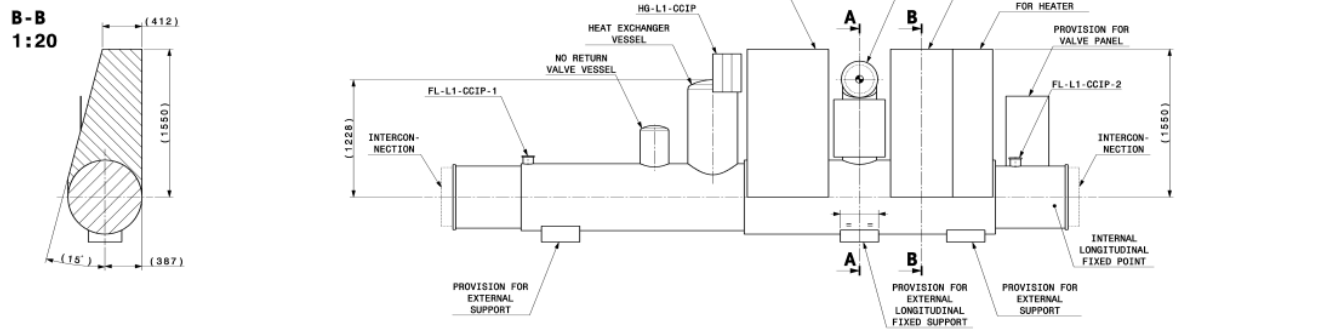
Contract for the distribution line QXL is signed and design work progressing. Requirements for the jumper interfaces for all crab cavity modules are defined.

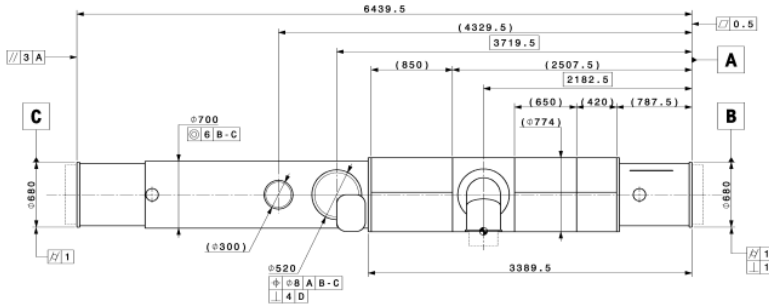


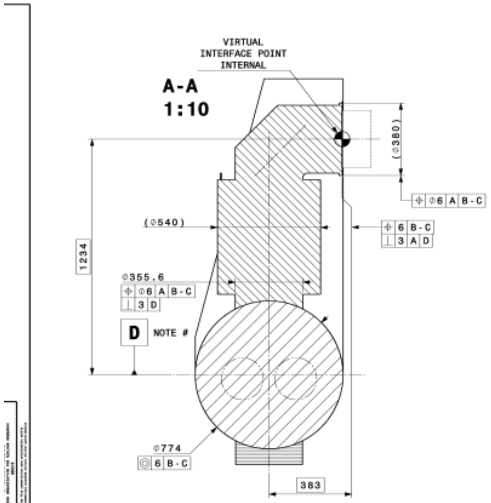


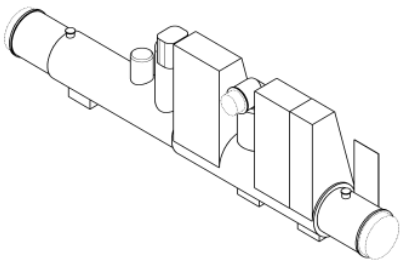
HL-LHC – design and integration

The service module space occupation with functional requirements are defined and design work started.









DS1(Service module)=A/B-C/D

NOTES:

(#): Datum D is built on the orientation of main QXL headers at the service module internal longitudinal fixed support.

Unless otherwise specified, tolerances for welded constructions according to ISO 13920-BF.
General tolerances ISO 22081, linear sizes: ±5

Technical Specification:	LHC-QXL-CI-0001 EDMS 2436668
Service Module Assembly:	LHCQXLEA0002
P&ID:	LHCLSQRG0003
Interconnection:	LHCQXL_0093
HG: Helium guard	
FL: Flange	

HL-LHC QXL - CCIP SERVICE MODULE
L1

REFERENCES LHCQXLEA0001

Conclusions

- SM18 M7 for RFD: cryogenically (mechanical and instrumentation aspects) ready to receive the module

- Test facility at BA6: operated reliably for last a few years, ready for RFD adaptation during YETS,
- SPS consolidations: oil separation system to be improved (LS), adaptation of interface for RFD and series to be done (YETS),

- Cryomodule design is progressing well: all flow schemes are available, internal instrumentation for series modules is available, safety system is in final validation stage, externally installed instrumentation – to be ordered.

- HL-LHC: integration and functionality of the infrastructure is defined: contract for QXL signed, design of distribution system is underway.

Great thanks to design team from EN-MME and SY-RF
for smooth and efficient collaboration !

Thank you for your attention!
Questions?

Great thanks to all people involved in HiLumi adventure!