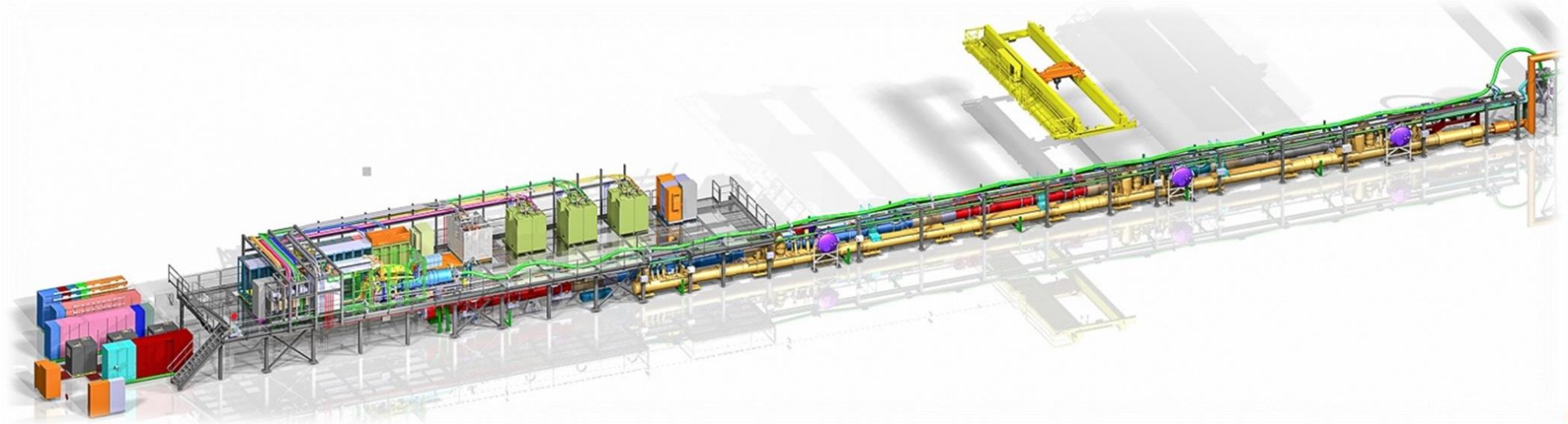
Lessons learned on IT String relevant for HL-LHC installation #3

HL-LHC Integration Meeting, Friday 13th of December

D. Bozzini from TE-MPE-SF, on behalf of WP16 and IT String contributors



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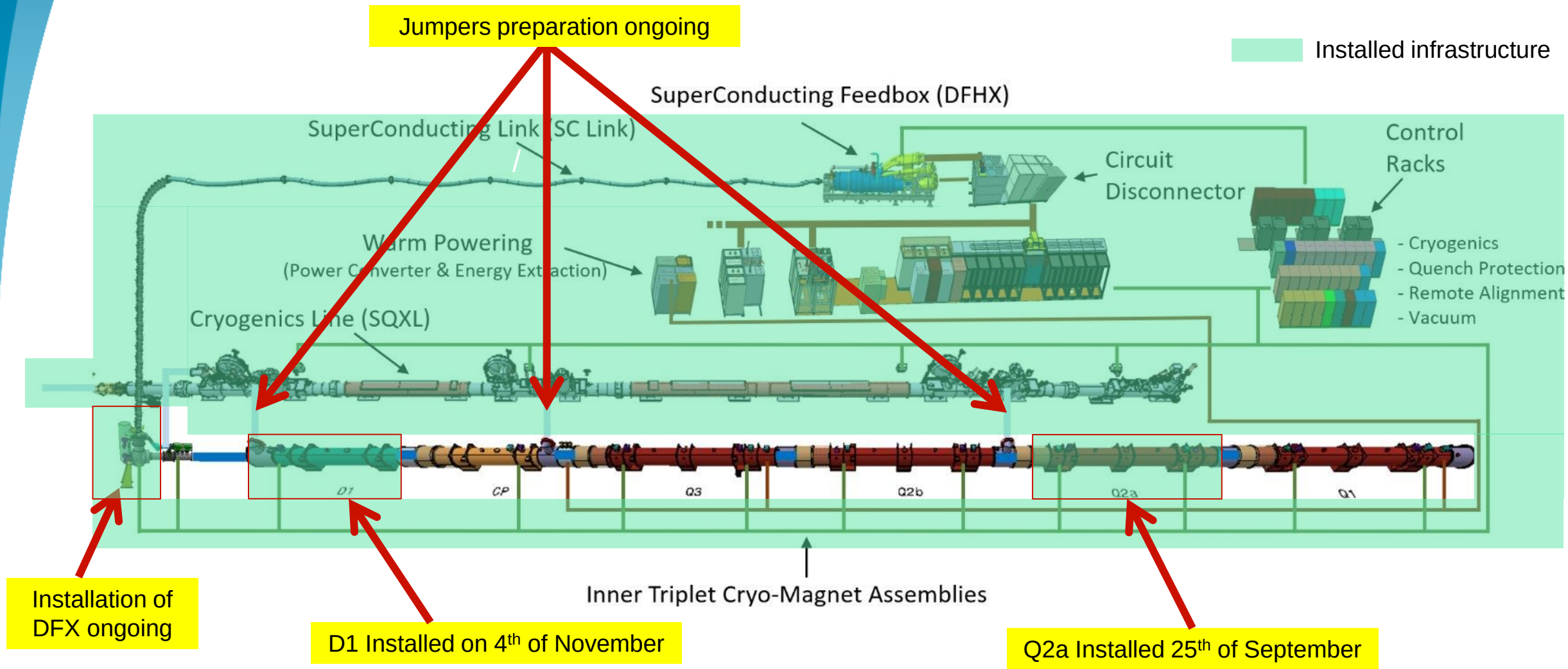
Foreword

- This is the third round of lessons learned. It follows the ones given on 31st of May and 13th of September
- The goal of these talks is to report on lessons learned we consider useful for WP15 and the integration / installation of the HL-LHC in the machine
- Several talks and meetings on specific lessons learned have already been given by WP16 to stakeholders and concerned bodies such as TCC and MCF
  - Lessons learned on IT String relevant for HL-LHC installation #1, HL-LHC Integration Meeting, 31st May 2024
  - Lessons learned on IT String relevant for HL-LHC installation #2, HL-LHC Integration Meeting, 13th September 2024
  - Progress report on IT String coordination, installation, and commissioning, 195th TCC, 23rd May 2024
  - IT String Lessons learned for warm powering, 15th February 2024
  - IT String Lessons learned for EN-EL contribution, 1st December 2023
- Generic nonconformities are duly documented in EDMS. Here what we would like to share with you are relevant lessons learned which will not be systematically documented

Main equipment installation – Status as of 13st of December 2024



Conflict during Q2a installation

Observation

- An instrumentation pick-up flange on the SQXL that was not part of the 3D model

Description of the non-conformity

- (EDMS 3075007) - **Resolved**
- Luckily, there is no mechanical conflict between the SQXL and the Q2a is in its final position
- However, it is is impossible to connect the two instrumentation cables which are necessary for the operation of the SQXL

Resolution

- TE-CRG has moved the position of the instrumentation pick-up to a more suitable place
- This change has imposed to breack the insulation vacuum on the entire SQXL which has been vented to dry air

Lesson learned

- As-built model shall be provided by equipment manufacturers (in this case SQXL) and implemented in the 3D model
- Surpassing of reserved envelope shall be quickly announced to evaluate impact on neighbouring equipment and overall integration
- The distance between the cryo-magnet and the pick-up reached couple of mm during the installation and alignment. The envelope in the 3D model shall include sufficient margin necessary for the installation manoeuvres which can be more restrictive compared to the envelope once installed

Conflicts during D1 installation

Observation

- Distance between SQXL and D1 end cover goes out of specified 3D volume
- Impossibility to install the D1 without removing two clamps of the D1 end cover

Description of the non-conformity

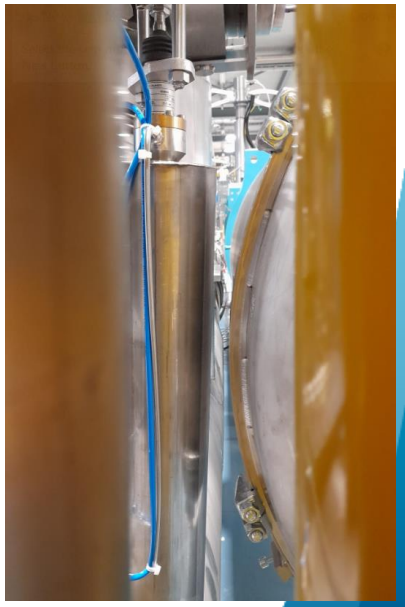
- (EDMS 3075007) - **Resolved**
- Luckily, there is no mechanical conflict between the SQXL and the D1 when it is in its final position

Resolution

- Removal of two clamps during installation of D1
- The removal of the two clamps might have impacted the tightness of the D1 end cover

Lesson learned

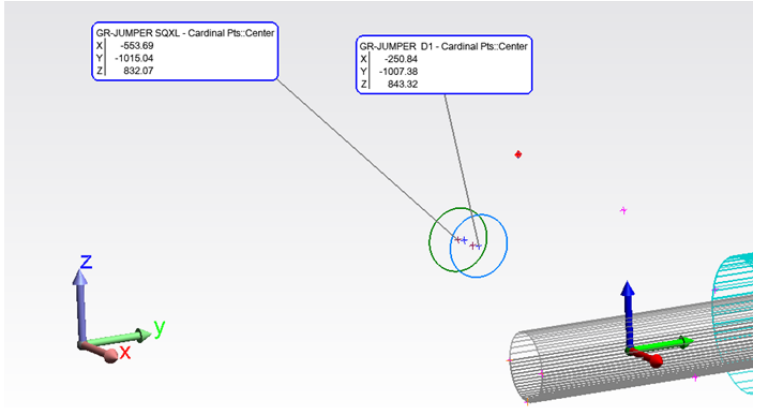
- Clamps volume are not integrated in the 3D model
- Precision of the SQXL is not within the 3D model volumes
- The distance between the D1 end cover and the SQXL reached couple of mm during the cryo-magnet installation and alignment. The envelopes in the model shall include margins necessary for the installation which can be more restrictive compared to the envelopes once installed



Jumpers

Observation

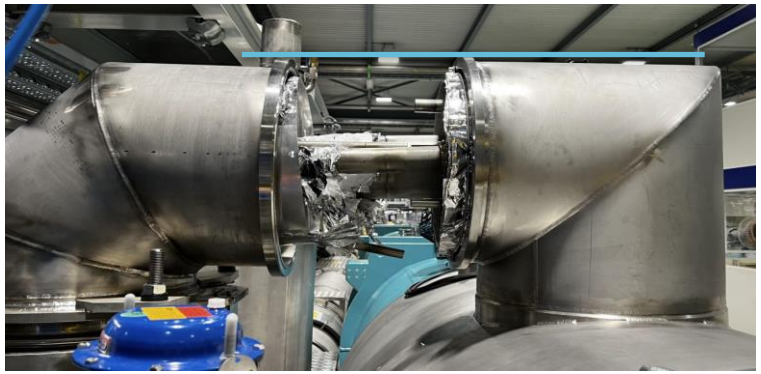
- Real position of D1 jumper interfaces on both sides out of specified tolerances
- Sequence and methodology of gimbal installation not clearly defined
- Complex interface between two entities, TE-CRG on SQXL side and TE-MSC on D1 side
- Two valid but different approaches by TE-CRG and TE-MSC on mechanical assembly methods and specifically on welding techniques



Point Name	X [mm]	Y [mm]	Z [mm]
Jumper D1	-250.84	-1007.38	843.32
Jumper SQXL	-553.69	-1015.04	832.07
Δ		**-7.66**	**-11.25**

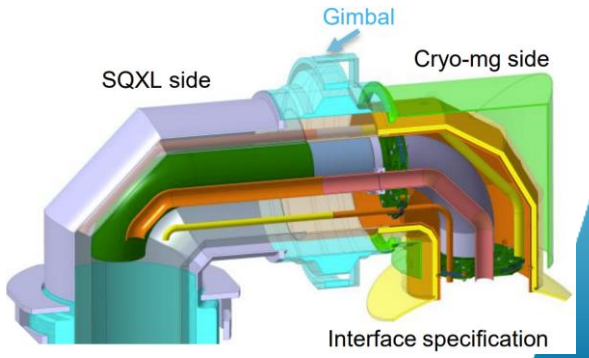
Description of the non-conformity

- (EDMS 3075007) - **Resolved**
- A dimensional non-conformity on the D1 jumper position of – 7.66 mm on Y direction
- An installation non-conformity on the SQXL jumper position of -11.25 mm on Z direction



Resolution

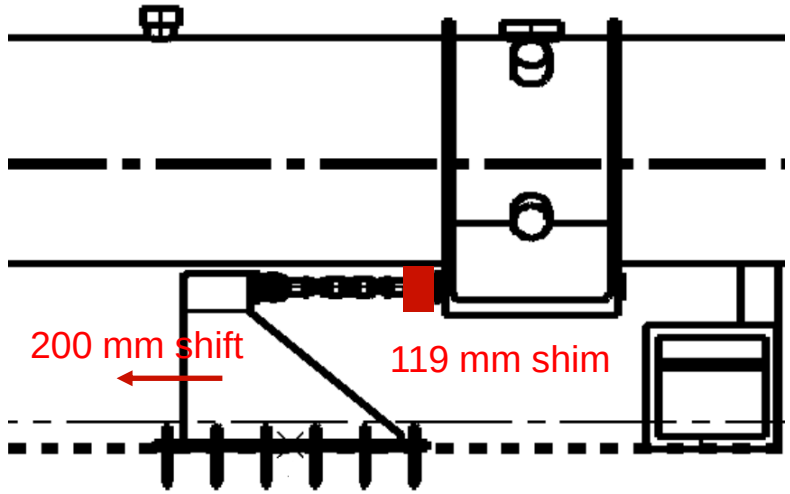
- Adaptation of the gimbal to best fit the real situation
- Common approval of installation sequence and responsibilities between TE-CRG and TE-MSC



Lesson learned

- Different approaches of designing and working might create blocking points where there are mechanical interfaces
- Get the concerned stakeholders working together already at design phases to find the best possible solution to cope with the possible non-conformities or deviations

Cryo-magnets anchoring

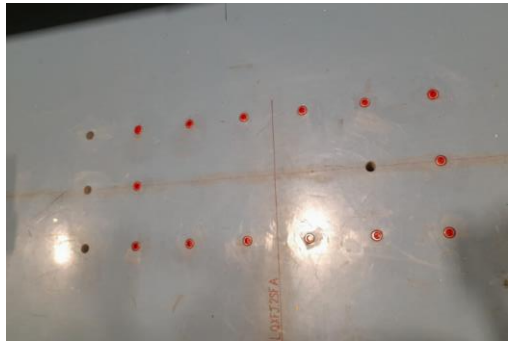


Observation

- Drawing for drilling holes approved but found to have wrong quotes
- Discrepancy between installation and manufacturing of the anchor tie rods length with 600 mm for the installation drawing and 681 mm for the manufacturing drawing

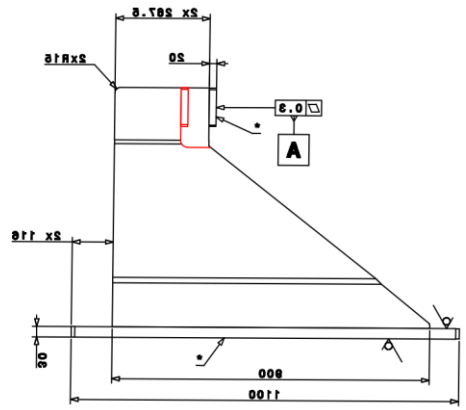
Description of the non-conformity

- (EDMS 3075007) - **Resolved**
- All holes in the concrete have been drilled according to the installation drawing
- Procured 681 mm long tie rods cannot be installed



Resolution

- For all cryo-magnets except Q2a already in place. Drilling of four additional holes to shift the anchoring position of 200 mm. Manufacturing of an additional shim of 119 mm to be interleaved between the cryo-magnet and the tie rod extremity
- For the already installed Q2a cryo-magnet the anchoring frame will be machined to shift by 81 mm the interface with the tie rod.



Lesson learned

- Changes on installation or manufacturing drawings shall be disseminated and concerned drawings updated accordingly
- Name and version of manufacturing drawings shall be noted in the installation drawings

DCM support

Observation

- The fixing roods for one of the three DCM frame supports are falling on a silicone joint of the SM18 floor

Description of the non-conformity

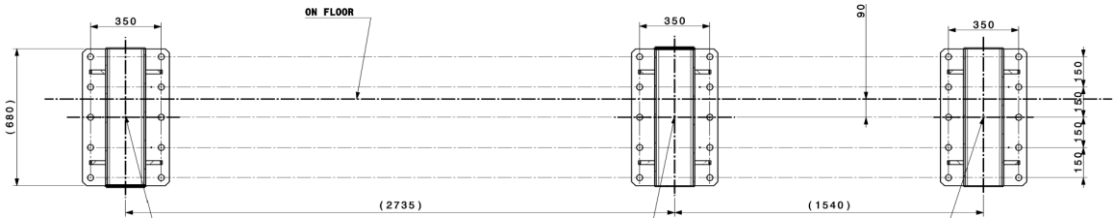
- (EDMS 3075007) - **Resolved**
- 5 out of the 10 fixing rods cannot be used as specified

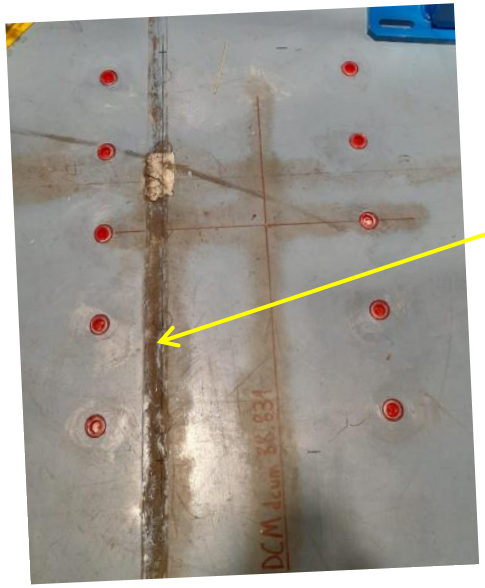
Resolution

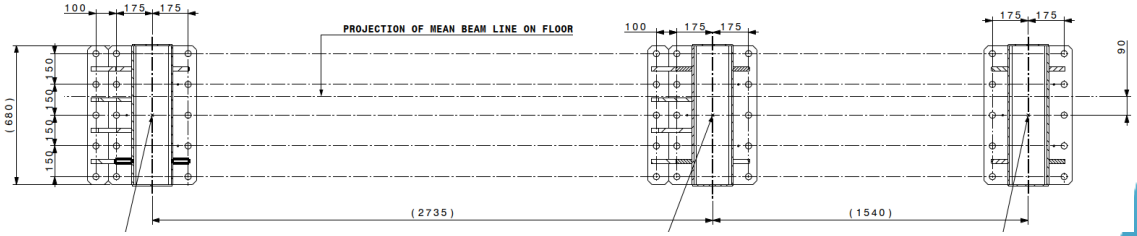
- Change the design of the concerned support by adding an extension plate
- Drill 5 additional holes at the due place

Lesson learned

- The real environment might impede the installation of an equipment as designed
- Checks on site of all boundaries will anticipate the identification of discrepancies







Control Cabling

Status of cabling campaign

- A quality issue characterized by 40 % non-conform cables among 22 cables samples requested by TE-MPE has been observed
- EN-EL did necessary continuity checks on the last cable campaign #3 followed by a second check by TE-MPE team. The detailed report is available here EDMS 3192477
- EN-EL will intervene in week 49 to resolve the reported issues
- An additional non-conformity has been detected when starting the ELQA on installed magnets. 5 out of 6 Harting connectors hoses are mounted wrongly and need to be modified
- After installation and testing, cables will remain unplugged and laid on the floor for multiple months with a high risk to having them damaged

Lessons learned

- Quality of assembly is still a concern. In particular for the recessed pins that might have major functional implications
- Mounting of nonsymmetric connectors shall be reviewed and the required mounting orientation shall be specified in the DIC by the cable requestor
- WP16 recommends to put protecting covers on connectors at least on machine side (as it was done for the LHC)

4 SUMMARY OF TEST FINDINGS

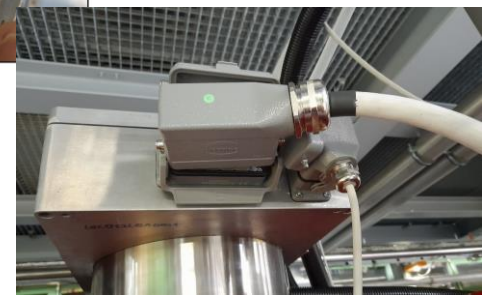
To briefly summarise the test results

- **All cable shielding and continuity (connector wiring) is conformal.**

However, several non-conformities have still been observed:

- 14 connectors with visibly recessed (unseated) pins (male and female types) (See appendix - 7.1).
- 1 missing cable ID label.
- 19 cables with one wire whose resistance deviates from the average significantly (>3σ)
- 4 minor functional positioning errors (excluding DFHX cables not yet routed to the mezzanine).

Figure 2 – Examples of recessed (unseated) pin



Readiness of equipment

Observations

- Q2a has been delivered to IT String with the conductors not adjusted to length and the N cable segment not installed

- D1 has been delivered without the two spares seal joints of the end cover. The tightness of the end cover has not been checked and the feasibility to exchange the sealing joint is not verified by design

Corrective actions

- Q2a extremities have been prepared on site ~ 5 days
- D1 joints will be installed on site before installation of DCM
- A feasibility check of a sealing join replacement will be conducted during the test assembly of the DCM

Lessons learned

- For upcoming cryo-magnets deliveries an assessment of the readiness for installation will be done with the participation of WP16, WP3 and the cryo-magnet coordinator
- Delivery of each cryo-assembly will be subject to the termination of all associated tasks (see punch list example for the CP)

Punch list for CP readiness for installation

- Drilling of anchoring holes including the 5 additional holes **(EN-ACE)** **Done**
- Installation of the flange and preparation of internal lines on the SQXL to CP jumper **(TE-MSC)** **Ongoing**
- Pre-alignment (best possible fitting) and measurement of real position of SQXL jumper side **(TE-CRG, BE-GM)**
- Measurement of real position of CP jumper side **(TE-MSC, BE-GM)**
- Pre-alignment of the three CP jacks and injection of concrete **(BE-GM, EN-ACE)**
- Availability of the gimbal (and all ancillary pieces) required prior to final positioning of the CP **(TE-MSC)**
- Availability and positioning of W bellow (plus spare joints) to be installed between D1 and CP **(TE-MSC)**
- Completion of preparatory works on CP extremities prior to installation **(TE-MSC)**
- Final electrical qualification (**TE-MSC**)
- Submittal to WP16 of the CP ID card **(MAB)**
- Submittal to WP16 of the list of CP non-conformities and their status **(TE-MSC)**
- OK for transport to IT String (**cryomagnet coordinator**)

Duration of planned activities

Goal

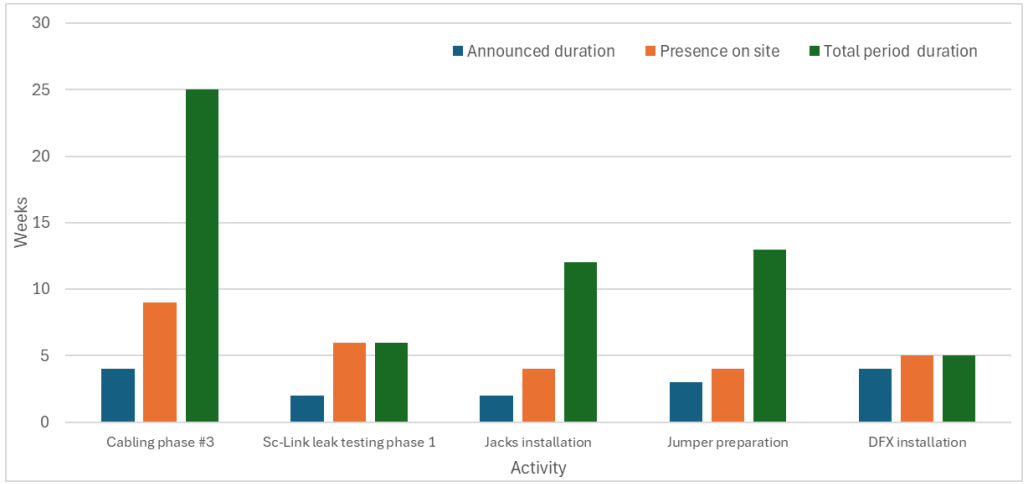
- Quantify and compare the announced duration of planned activities versus the real presence on site and the total period duration
- 5 activities have been considered

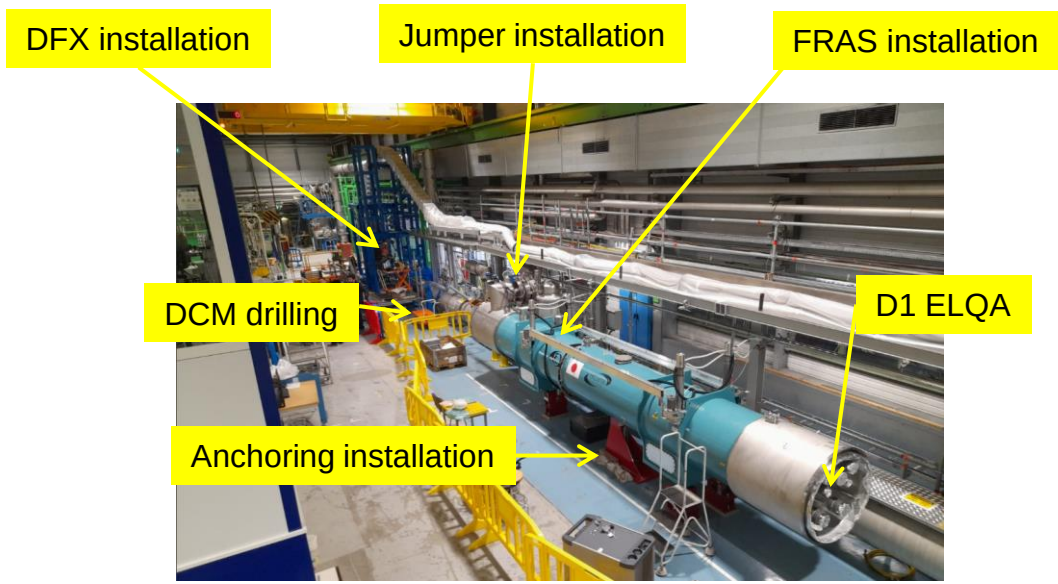
Key facts

- The presence on site to execute the work is systematically longer compared to the announced duration which is used to define the master plan
- The total period duration might be:
  - up to 2.5 times the presence on site and
  - up to 6 times the announced duration

Lessons learned

- There are opportunities to profit from the difference hereafter referred as ‘’dead-time’’ between the presence on site of a team and the total period of duration of the associated activity by managing multiple intervening teams and co-activities at a given time





Leak testing of Sc-Link

Observation

- Leak testing on the Sc-Link took longer than initially planned

Key facts

- Design of equipment might impact the duration to reach a good level of vacuum due to low conductance
- Acceptance criteria between equipment owner and vacuum team might not be sufficiently clear to consider a test acceptable
- Vacuum team also require time slots to gain experience on the testing methodology to enhance processes for the later use in the HL-LHC
- Resolution of non-conformities goes on top of announced durations

Lessons learned

- For phase 2 (after assembly of the DFX) WP16 and VSC will commonly agree on test duration which will include the pumping, the leak detection and the gain of experience periods
- The leak detection activities shall be planned in the background of other activities
- Measures shall be identified to allow the necessary time for leak testing while continuing with other assembly activities in the neighboring areas

Concluding remarks

- First experience acquired for the installation of cryo-magnets Q2a and D1. **The readiness checks prior to delivery deserves to be enhanced** to avoid finalization works on site
- **Several near miss mechanical conflicts identified** for which solutions could be implemented. The precision of the 3D integration does not allow to point out punctual possible conflicts. The IT String integration is extremely dense and deserves particular attention before starting the installation of cryo-magnets
- **Compliance checks of installation drawings with respect of manufacturing drawing** and the on-site environment will contribute to the early identification of discrepancies
- Mechanical interfaces of the jumper D1 are out of specification. **We observed different approaches at design level** which created many constructive discussion between equipment owners to solve the problem out
- **Cabling still has some margin of improvement** on execution, quality and control aspects
- Duration of activities are systematically longer than estimated. **There is a margin to profit from the dead times** (difference between global duration and presence on site) to accommodate other intervening teams by managing the co-activities
- **Leak detection tests require an adequate and sufficient time** to qualify the equipment tested and gain sufficient experience for the HL-LHC. These tests should be organised in a way that other activities can be carried out in parallel

Thank you for your attention