



# **VSC contribution to WP16; Vacuum Systems “Insulation Vacuum readiness and lessons learned”**

Wim Maan



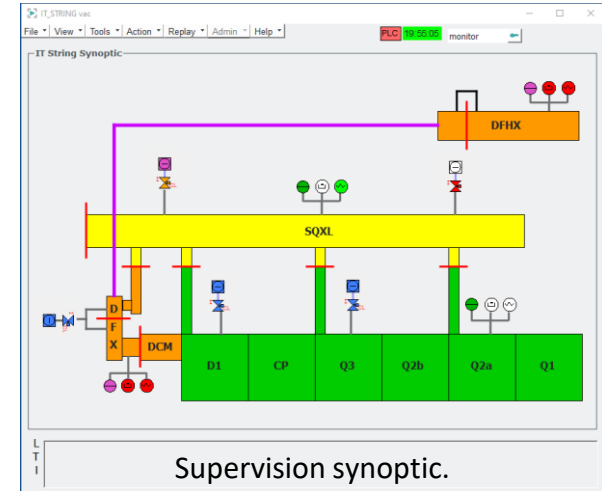
HL-LHC IT String Day IV

September 27<sup>th</sup>, 2024

# Contents

- Vacuum leak tests and validation programs executed;
  - SQXL.
  - DFHX-DSH-DFX.
- Lessons learned during commissioning of SQXL and Cold Powering System.
- Installation and interconnection leak test tooling preparations.
- Upcoming activities.
- *Baseline, Resources / Planning.*
- *Conclusion.*

IT-String Insulation Vacuum Systems and instruments.



# Reminder

- Each system is tested following two programs;
  - Verification program 1; helium to insulation vacuum, qualification criteria  $< 1 \cdot 10^{-9}$  mbar·l/s
  - Verification program 2; air to insulation vacuum, qualification criteria  $< 1 \cdot 10^{-8}$  mbar·l/s

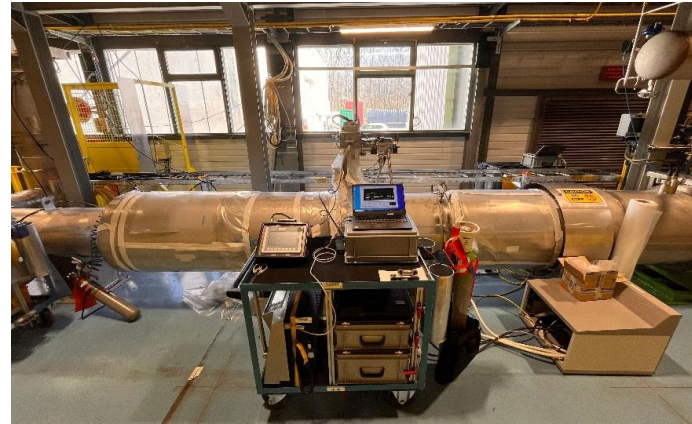
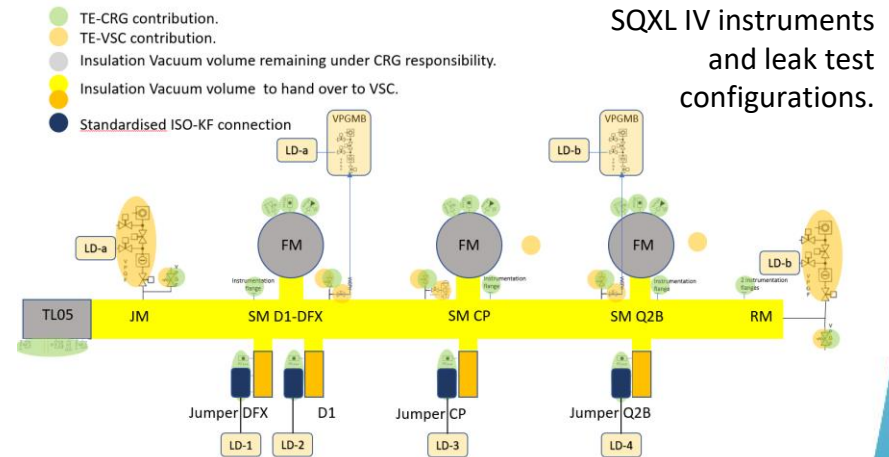


Photo M. Knoch

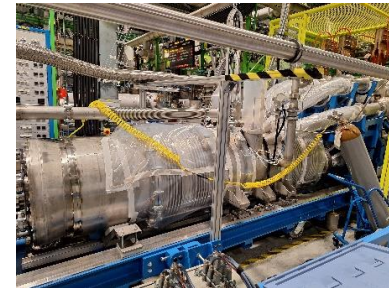
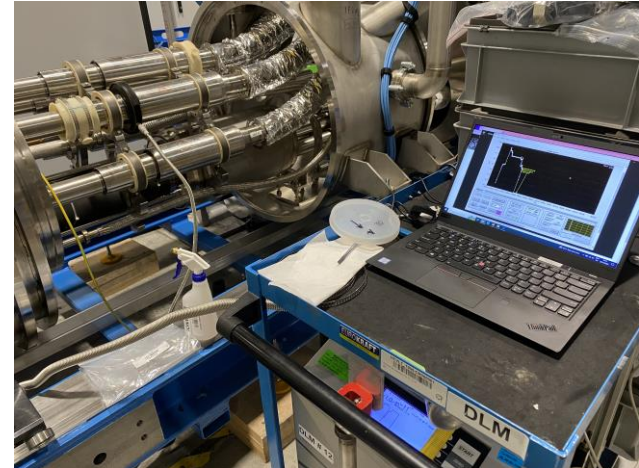
# Vacuum leak tests and validation programs executed; SQXL

- Both verification programs 1 & 2 have been repeatedly executed.
- The insulation vacuum system of the SQXL main volume and jumper volumes are validated for cold operation.



# Vacuum leak tests and validation programs executed; DFHX-DSHX-DFX the Cold Powering System

- The Cold Powering leak tightness validation programs are part of a two-stage activity:
  - First stage; the DFHX-DSHX surface, manufacturing and assembly leak tightness validation programs.
  - Second stage; the DSHX-DFX in-situ manufacturing and assembly leak tightness validation programs.
- Only the first stage has been executed at the cluster F. Both verification programs 1 and 2 were made.
- The DFHX-DSHX has been validated leak tight and, ready for installation.
- Preparations for the second stage, at the IT-String test facility, are on-going.

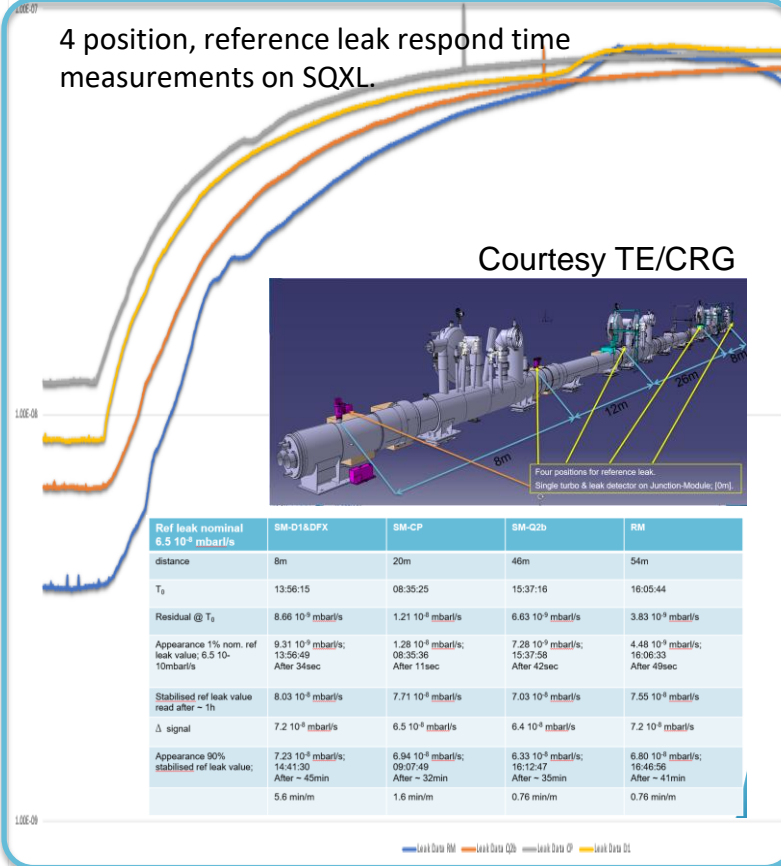


Photo's G. Barlow

# Lessons learned during commissioning of SQXL

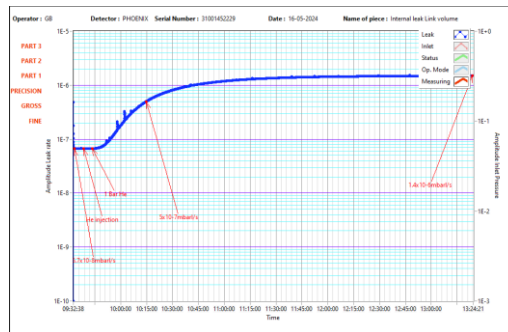
- We expected and approached the SQXL as an LHC QRL subsector. Don't take things for granted until you measure it.
  - Longitudinal conductance is significantly smaller than LHC-QRL.
  - Significant increases in verification program time.
  - Is there any change to achieve with TE/CRG a higher longitudinal conductance of the QXL? This would help reducing the test duration.
- Baseline contribution was a limited and idealistic approach.
  - Additional support and contributions have been requested.
  - Verification program 1 gave a validated system following the first test made. It was repeated after each cold cycle.
  - Verification program 2 theoretically starts with the elimination of the biggest leaks. Smaller leaks are hidden behind. Repeated execution will result in a higher validation quality.
  - Time estimates for planning purposes should therefore become longer.

4 position, reference leak response time measurements on SQXL.

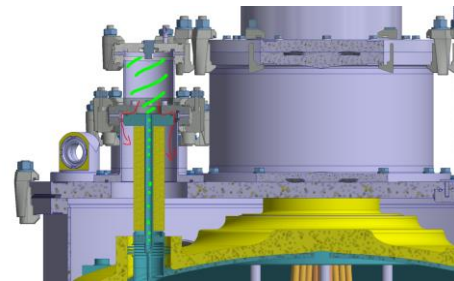


# Lessons learned during commissioning of Cold Powering System

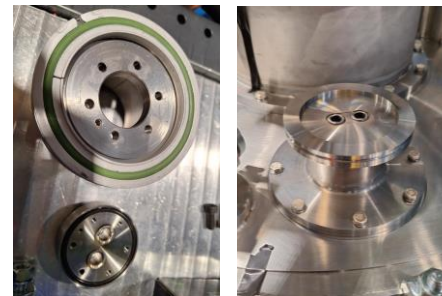
- The sub-volumes should remain separated during initial validation stages. This will speed up the process when complications are encountered.
- Test bench tooling, such as the DFX and cluster F connections, should follow the same concepts, leak tests and validations logics as the machine systems (DFHX-DSHX) under test.
  - The first stage validation program results were delayed by the common volume (DFHX-DSHX-DFX&Cluster F connections) shared by the systems under test.



Leak signal observed during verification program 1, inside the common insulation vacuum of the Cold Powering System at the Cluster F.



Courtesy of TE/MSC WP6A



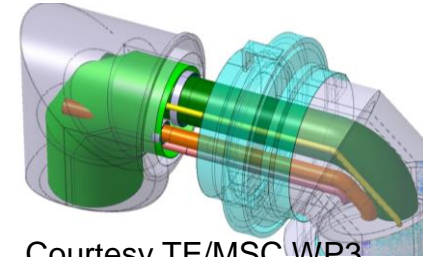
Elastomer O-ring seal between helium circuit and insulation vacuum.

September 27<sup>th</sup>, 2024

# Installation and interconnection leak test tooling preparations.

- Machine interconnection clamshells are almost complete. Only few dimensions are still under development or in production.
- Jumper interconnections are particular to the IT-String and SQXL. Butt welds or lip welds with flanges are needed due to the limited access. Detailed models and drawings will be communicated shortly by TE/MSC WP3 & WP6A.
- Manufacturing and installation clamshells for cold powering system are available and already used at Cluster F.
- Some 40 different IT-String clamshells have been prepared.

Access for clamshells is under review.



Courtesy TE/MSC WP3

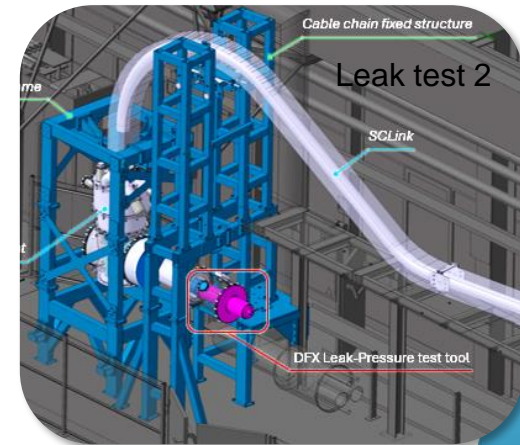
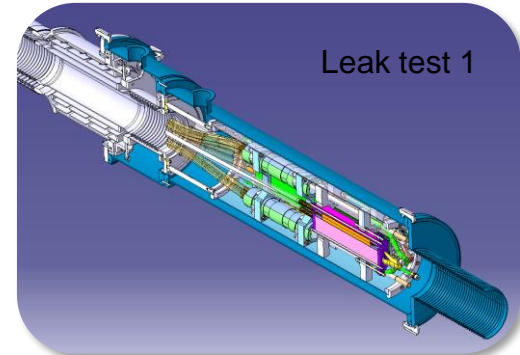
Photo's by M. Knoch





# Upcoming activities

- Cold Powering System installation and interconnecting leak tests & validations.
  - First stage (leak test 1); validates DFHX-DSHX following transportations and handlings
    - Verification program 1. (Local purge pump and helium supply)
    - Verification program 2.
  - Second stage (leak test 2); validates DSHX-DFX following handling and installation
    - Verification program 1. (Local purge pump and helium supply on two circuits; CD and EF)
    - Verification program 2.
  - Following the arrival of the DCM, installation and local leak tests on DCM interconnections, both on DFX and on D1 side.



Courtesy of TE/MSW WP6A

# Upcoming activities

- The leak testing strategy of the magnets follows the LHC machine engineering specification (edms 228665).
- Magnet manufacturing leak tests & validations are under the TE/MSC WP3 responsibility.
  - All magnet cryostat assemblies, including all circuits crossing the same magnet cryostat assembly, shall be validated leak tight.
  - Magnet test bench leak tightness information is important. A thermal cycle could induce changes and leaks.
  - Pressure & leak test data and reports shall be available, consulted and validated by TE/VSC, before transfer to the IT-String. TE/MSC will make the information available in due time.

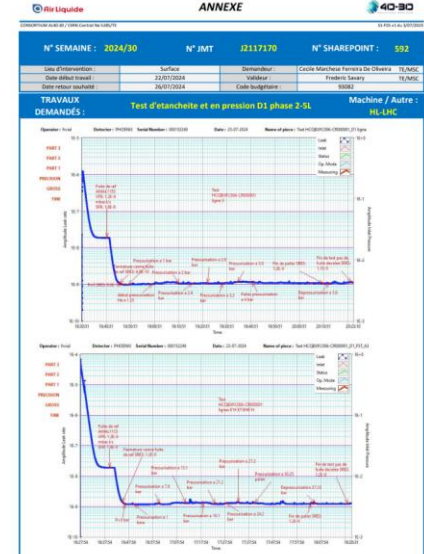
Courtesy AL40-30 TE/MSC WP3

PHOTOS

N° SEMAINE : 2024/30 N° JMT : J2117370 N° SHAREPOINT : 992

Date d'intervention:	Surface	Demandeur:	Cecile Marchese Ferraris De Oliveira	TE/MSC
Date de fin travail:	23/07/2024	Validé par:	Andreas Senz	TE/MSC
Date de fin maintenance:	24/07/2024	Code budgetaire:	99992	

TRAVAUX DEMANDÉS : Test d'étanchéité et en pression D1 phase 2-5L Machine / Autre : HL LHC



Photo's CERN-Courier

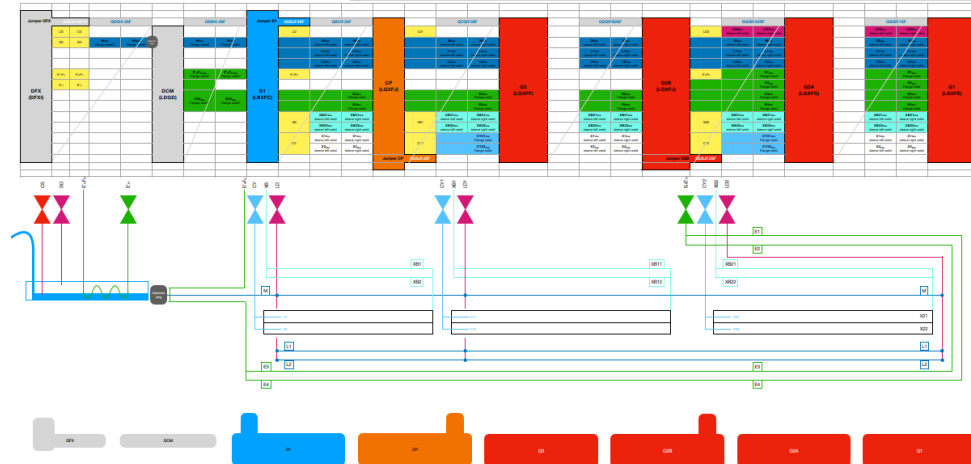
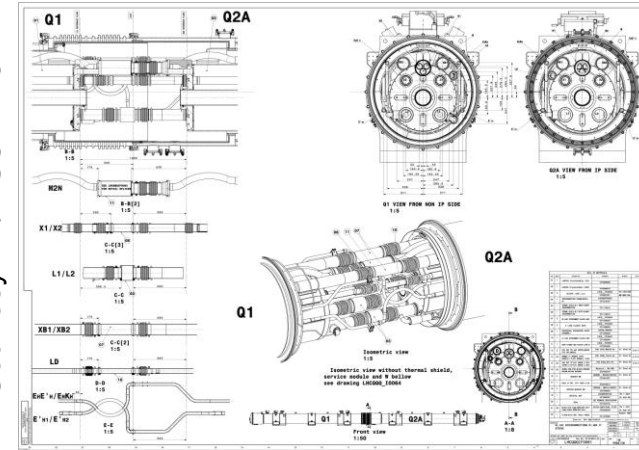


September 27<sup>th</sup>, 2024

# Upcoming activities

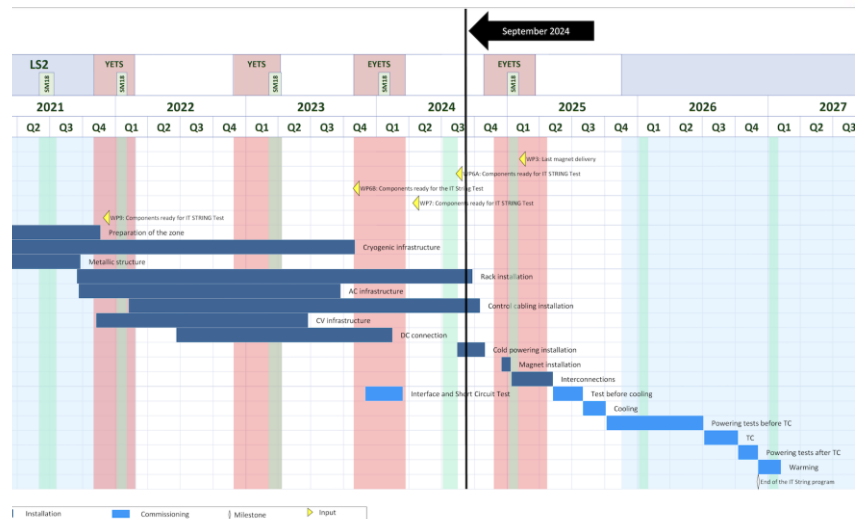
- IT String Interconnection, SQXL, Cold Powering and Magnet to Magnet local leak testing and global leak testing.
  - Following the purge pump and helium back fill through the SQXL of all magnet and cold powering circuits, the local clamshell testing campaign will start.
  - This test campaign is an excellent opportunity to familiarise our technicians with the complexity of helium circuits and lines.
  - IC-drawings with understandable line nomenclature are needed and available.

Courtesy TE/MS/WP3



# Baseline, Resources / Planning

- Based on LHC knowledge.
- Local leak tests; all lines and circuits purge pumped and backfilled with 100% Helium at atmospheric pressure through SQXL.
  - 1 team (2 persons) per IC's.
  - 8 clamshell tests per day per team.
  - ~ 150 tests estimated; ~4 weeks to validate welds before "W" closures.
  - Availability subcontractor teams is compromised during YETS and TS's.
- Commissioning and conditioning insulation vacuum; 1 team ~ 4 weeks
- Envelope leak test; 1 team ~2 days.
- Global leak test, including all quality assurance programs, needs 2 teams (TE-CRG and TE-VSC) for 1 day providing no complications occur.
- These are all new components, tooling's and systems. Unexpected events could occur.



# Conclusion

- SQXL main volume and jumper volumes validated and ready for operational responsibilities.
- Longitudinal conductance performance is important especially in the tunnel operational configuration of the HiLumi-QXL.
- Cold Powering System, first stage validation is passed. Second stage validation programs have started and will continue to the interconnection of the DCM.
- Magnet interconnecting tooling is ready to be used on the interconnection welds.
- IT-String generates top level curiosity and excitement.
- Ready to execute our validation programs and establish the conforming insulation vacuum for cold operation.
- TE/VSC is proud to contribute to this unique installation and to become trained for LS3.

Thank you for your attention