



HL-LHC IT String Quality Assurance & Control

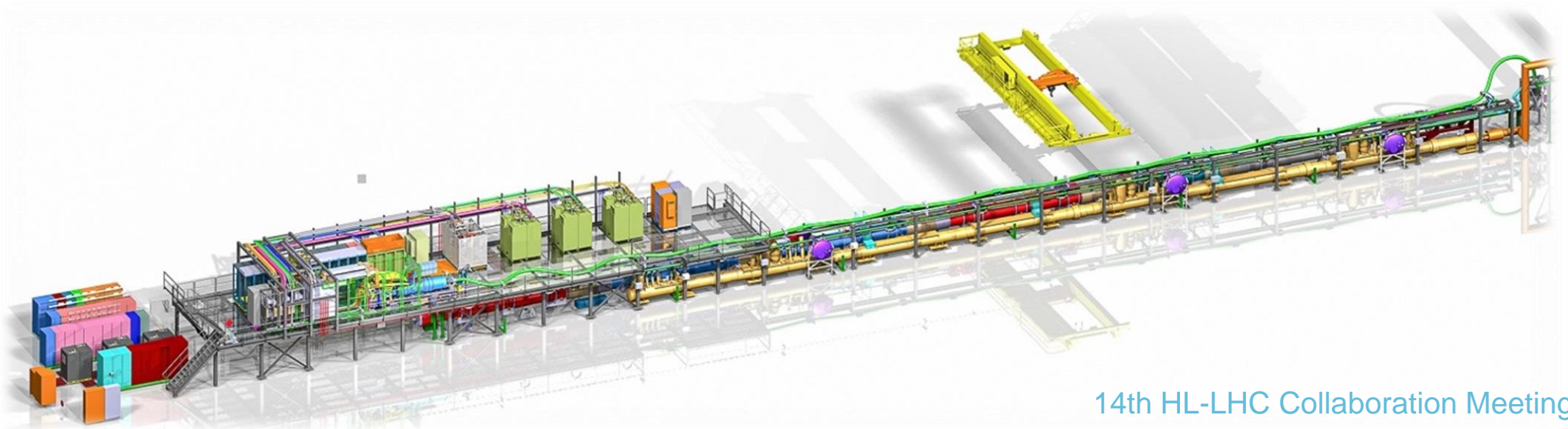
N. Heredia García (TE-MPE-SF)
On behalf of WP16

[14th HL-LHC Collaboration Meeting, Genoa, 7-10 October 2024](#)



Scope of the talk

- Introduction
- Quality design
- Quality assurance
- Quality control
- Non-conformities
- Lessons learned
- Conclusions



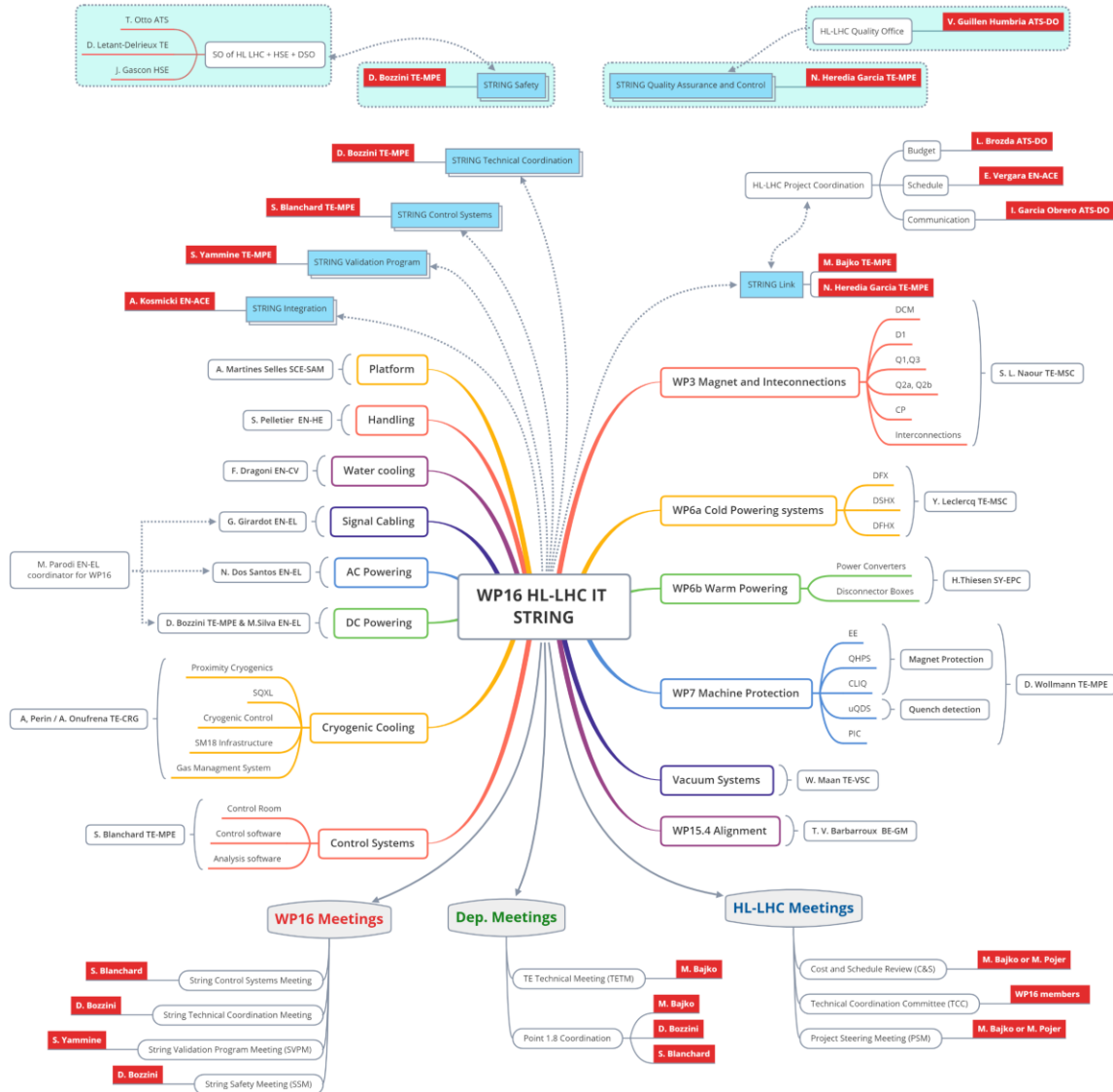
Introduction

- Careful consideration of quality management driven by the diverse components, constraints and required stakeholders.
- Three phases of quality management have been considered, defined by PMI.
- the IT String follows the quality standards and processes established for the HL-LHC project within the [quality plan](#).

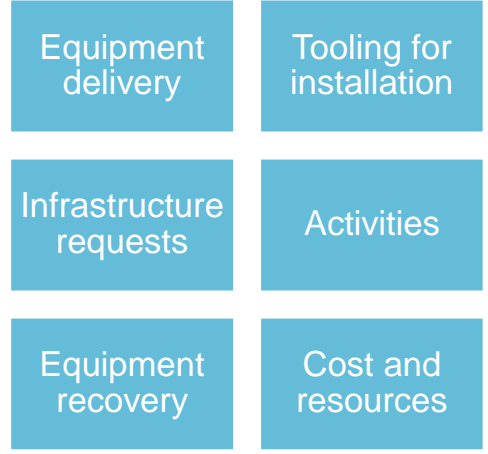
Phase	Goal	Description
Quality design	Plan quality management	Understand the specific needs and requirements of the project. It involves the definition of processes, tools and performance metrics.
Quality assurance	Manage quality	Ensure that the project meets the defined quality standards and requirements. It involves regular reviews, and continuous improvement.
Quality control	Monitor, record and control quality	Validation of the system to ensure a qualified output. It involves testing and corrective actions.

Quality design: Requirements & Expectations

Project organization chart



Scope baseline



CONTRIBUTION DOCUMENT		
WP16: HL-LHC IT STRING & HARDWARE COMMISSIONING		
SUMMARY OF TE-MSC CONTRIBUTION (MAGNETS) TO WP16 – IT STRING		
Abstract		
This document summarises the contribution of TE-MSC group for the HL-LHC IT String. In relation to magnets, it describes the scope of the contribution in terms of hardware to be provided, activities to be performed and specific needs requested by the contributor. Furthermore, it gives an overview of the activity procedures as well as the associated timeline for their execution. Finally, it clarifies the needs of resources and the budget to finance the contribution.		
TRACEABILITY		
Prepared by: S. La Rosa, N. Heredia Garcia	Date: 2024-05-16	
Verified by: N. Pico, N. Bourry, D. Duarte Ramos, E. Todesco and A. Balzano	Date: 2024-05-22	
Approved by: A. Mirano, J. Sathorn and M. Bako	Date: 2024-05-23	
Distribution: All HL-LHC EP members, M. Zentgraf		
Rev. No.	Date	Description of Changes (major changes only, minor changes in EDMS)
0.1	2023-05-16	First issue
0.2	2023-08-02	Update of the document
0.3	2023-12-10	Update of engineer responsible for the DCM

Safety analysis

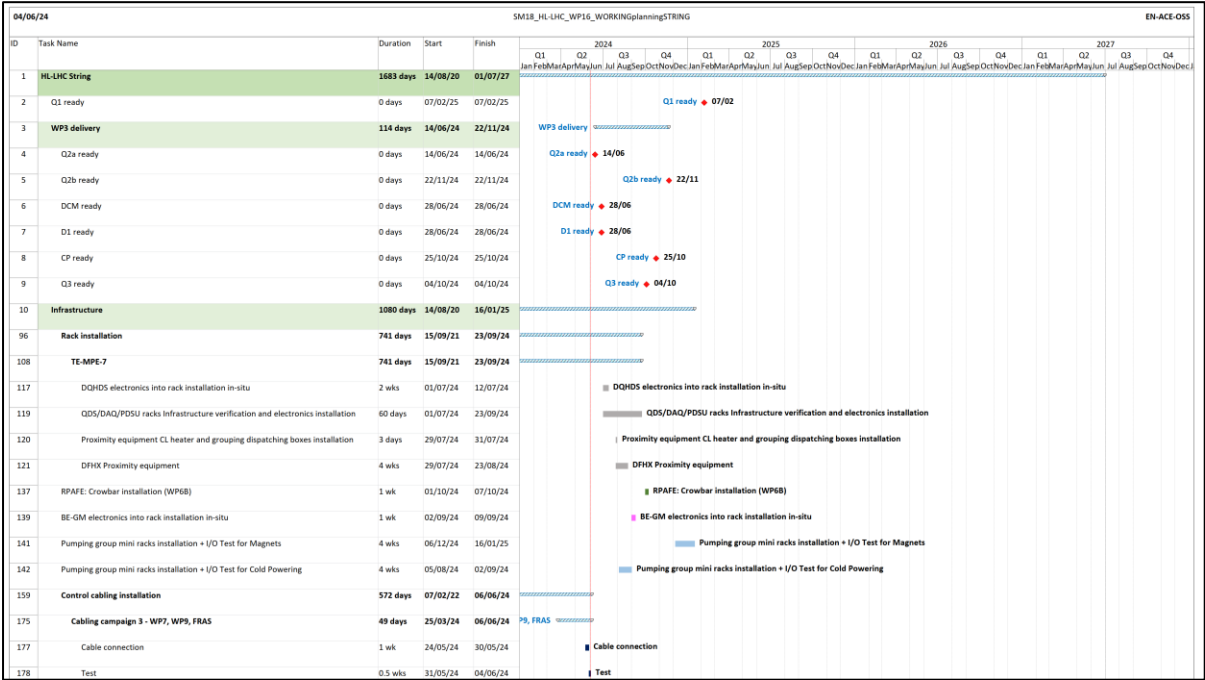
SAFETY DOCUMENT	
FMEA applied to test facility HL LHC IT STRING	
Failure Modes and Effects Analysis (FMEA) Test Stand HL LHC IT STRING	
Summary	
This document is a Failure Modes and Effects Analysis - Safety (FMEA - Safety) of the various functions of the "HL LHC IT STRING" test bench located in building 1273 (SM18). The study focuses on the detailed identification of all undesirable effects within the defined limits of the system under analysis. It also defines the measures to be implemented in order to improve the reliability and safety of the system. The present study is conducted by a working group involving a safety engineer and various individuals who worked on the design of the "HL LHC IT STRING". This method is applied to ensure the safety of personnel present at SM18 during the operational phases of the test bench.	
Participants in the study:	Safety engineer
• Emmanuel Bigot	
• Marta Bajko	Section leader
• Christian Gilmore	Engineer (Section MSC-TE)
• Nora Girard	HL-LHC Safety Support Officer
• Thomas Otto	DSO (Departmental Safety Officer)
• Samir Yammine	Warm powering system (EPC)
• Fahim Dhalla;	Cryogenic System (TE-CRG)
• Gabriela Rolando;	Cryogenic System (TE-CRG)
• Michele Sisti;	Cryogenic System (TE-CRG)
• Alain Antoine	Powering Interlocks (PIC)
• Yann Leclercq	Magnets Cryostats & Connections (MSC)
• Faïza, Jerome	Magnets Cryostats & Connections (MSC)
• De Luca Davide;	Water Cooled Cables (EN EL)

Test plan

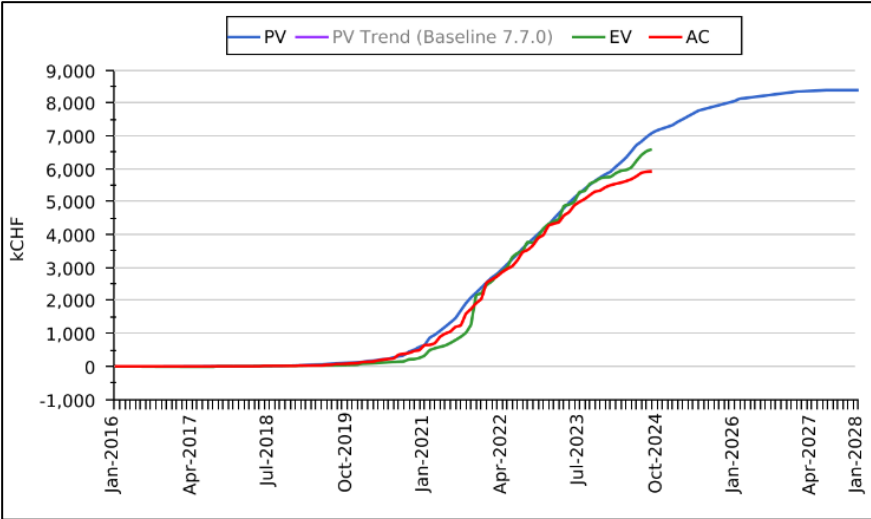
TEST PLAN		
HL-LHC INNER TRIPLET STRING HL-LHC IT STRING VALIDATION PROGRAM		
Abstract		
The HL-LHC Inner Triplet (IT) String is a test stand, whose goal is to validate the collective behaviour of the cooling, powering and protection of the IT magnets and circuits in conditions as similar as possible to their later operation in the LHC. This document will be concerned with classifying the tests requested by the defined WPs involved in the HL-LHC IT String. It will also show a proposed test sequence, as well as a time estimation of the different tests that make up the HL-LHC IT String Validation Program (SVP).		
TRACEABILITY		
Prepared by: M. Bajko, N. Heredia Garcia, M. Pajon and S. Yammine	Date: 2022-03-05	
Verified by: M. Boharik, S. Blanchard, D. Borlin, G. D'Angelo, G. Danilak, L. De Marco, B. Horta, J. Horta, D. Girard, M. Garcia Garcia, M. Gilmore, R. Gilmore, M. Harty, S. Koutoukos, W. Mann, M. Mirano, A. Pavia, E. Rausari, G. Roberts, S. Santilli, S. Santilli, G. Santilli, S. Thomas, A. Terasaki and J. Zentgraf	Date: 2022-02-21	
Approved by: V. Baglini, O. Spring, M. Salvo, A. Balzano, F. Chigiolini, S. Cusack, A. Devereux, P. Ferras, B. Gaudenzi, J. Gilmore, B. Gilmore, D. Hertz, M. Mirano, A. Mirano, V. Mirano, T. Ochi, M. Pajon, F. Rodriguez Martinez, J. Santilli, A. Santilli, J. Terasaki, E. Todesco, B. Terasaki, S. Yammine, S. Yammine, S. Yammine and M. Zentgraf	Date: 2022-04-05	
Distribution: A. Ferras, S. Yammine and HL-LHC SVP members		
Rev. No.	Date	Description of Changes (major changes only, minor changes in EDMS)
1.0	2022-04-27	Document released

Quality design: Tools

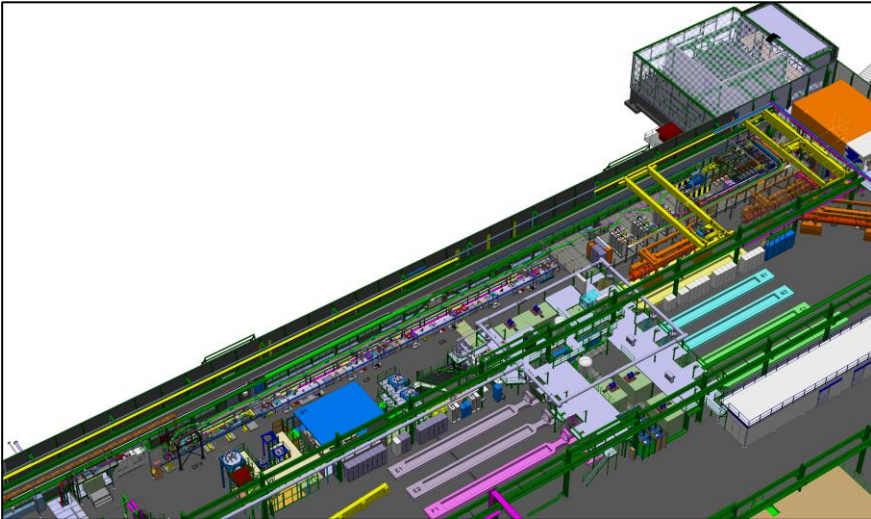
Project planning



Cost tracking



Integration model

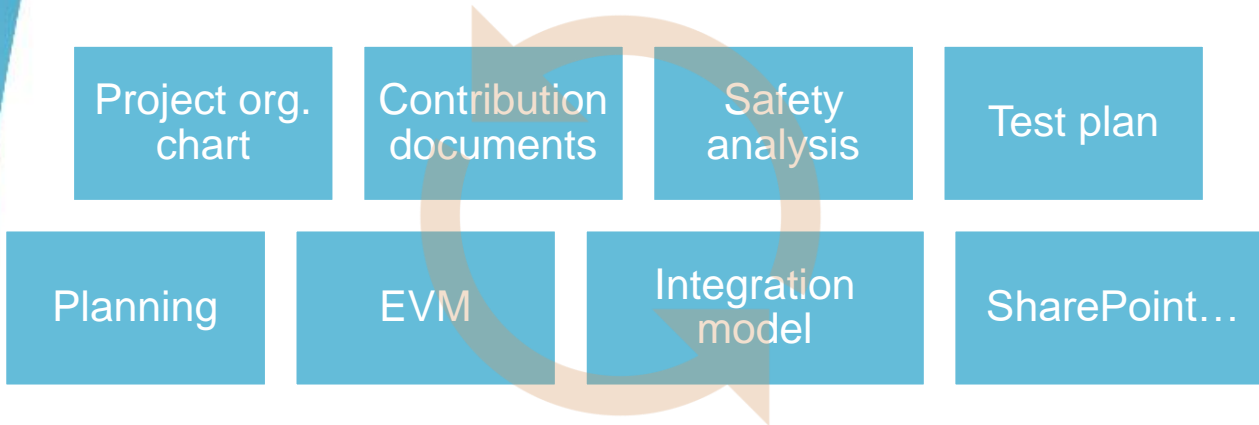


Other tools



Quality Assurance: Process

- The tools developed during the quality design phase have been continually updated.



- The IT String coordination team has organized/participated in multiple meetings to present project updates, discuss next steps, address non-conformities, provide lessons learned...

String Technical Coordination Meeting

String Validation Program Meeting

String Controls Meeting

String Quality Meeting

String Day

Project Steering Meeting

Technical Coordination Committee

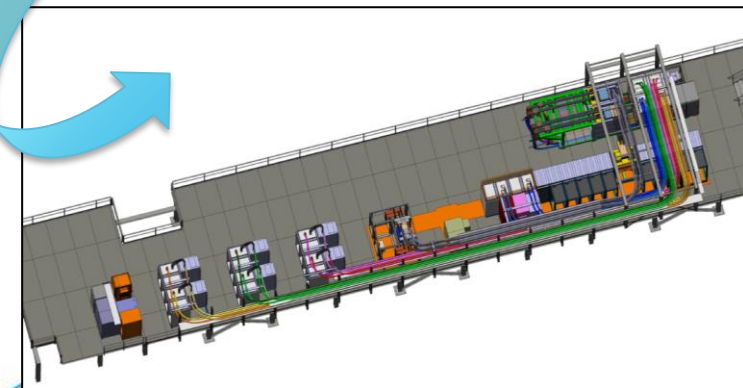
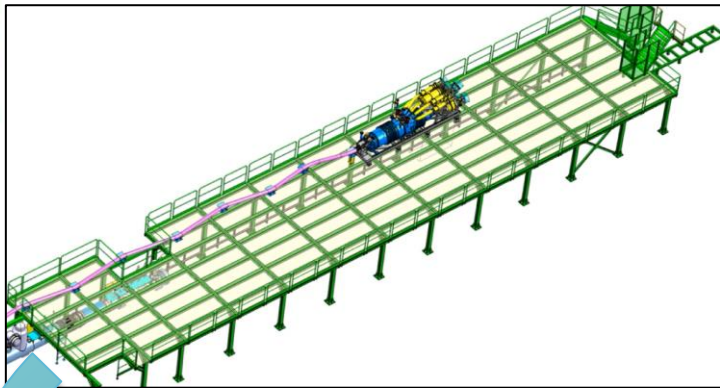
Cost & Schedule Review

HL-LHC Annual Meeting

Quality Assurance: Examples

- To enhance project execution, various changes, measures, and tools have been implemented, reflecting engagement to continuous improvement:

Installation sequence

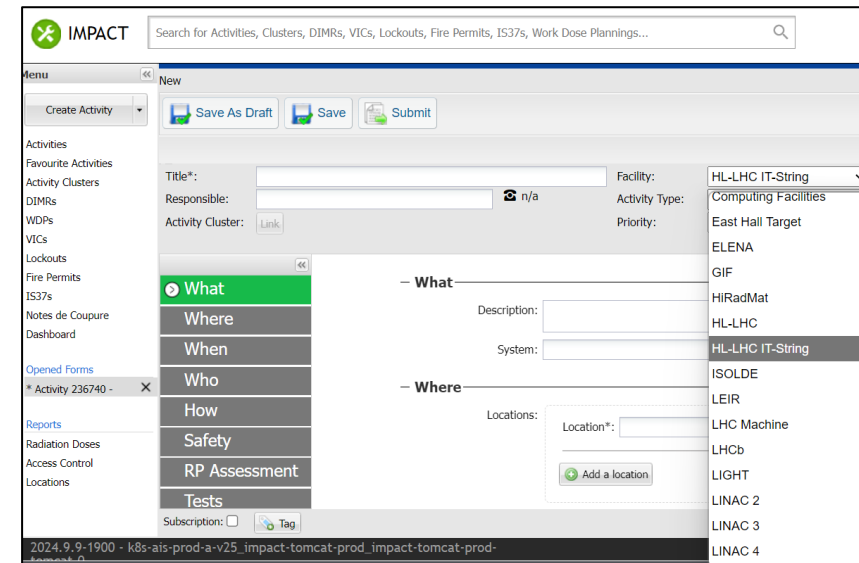


Coordination

Sep-24 IT-STRING

	GROUND FLOOR AREA										MEZZANINE AREA				CR					
	RACKS	Q1	Q2a	Q2b	Q3	CP	D1	DCM	SOXL	DFX	DSH	DFHX	18 kA	14 kA	2 kA	EE	SF-HO	INT	EXT	
35																				
36																				
37																				
38																				
39																				

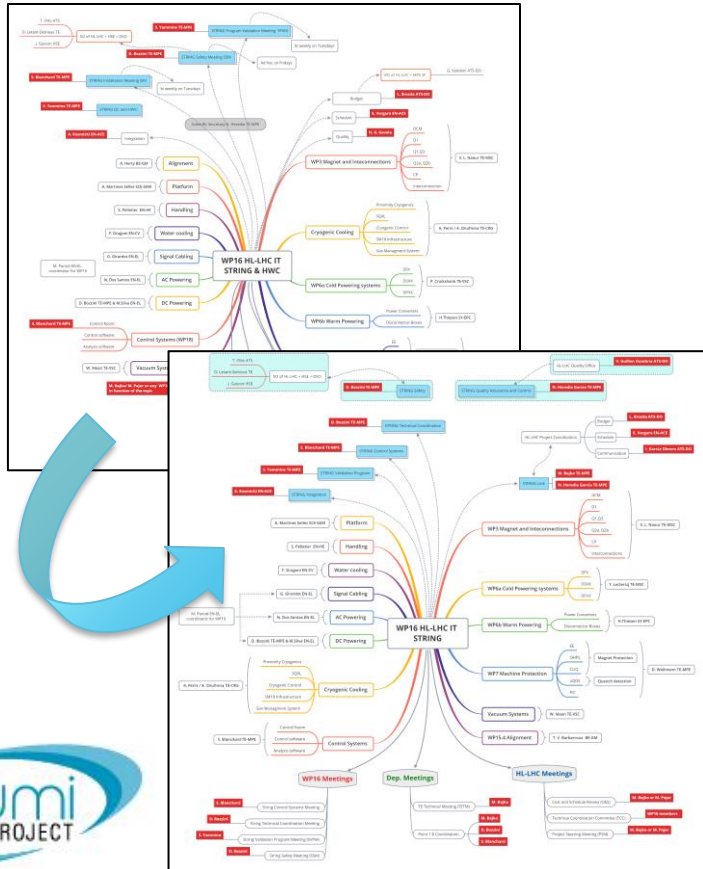
Access



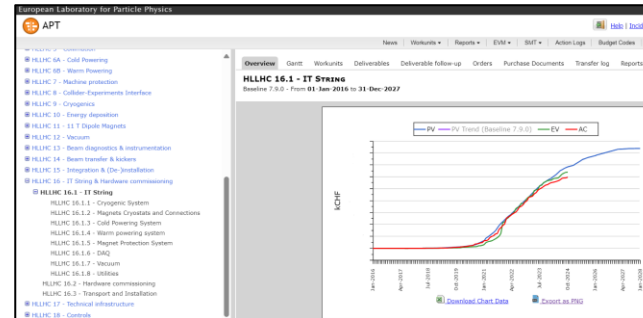
Quality Assurance: Examples

- To enhance project execution, various changes, measures, and tools have been implemented, reflecting engagement to continuous improvement:

Roles and responsibilities

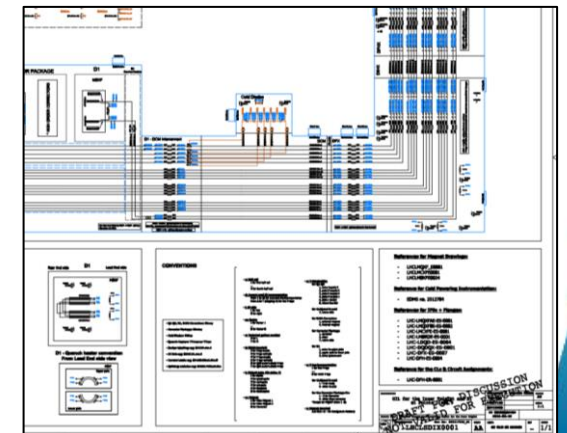
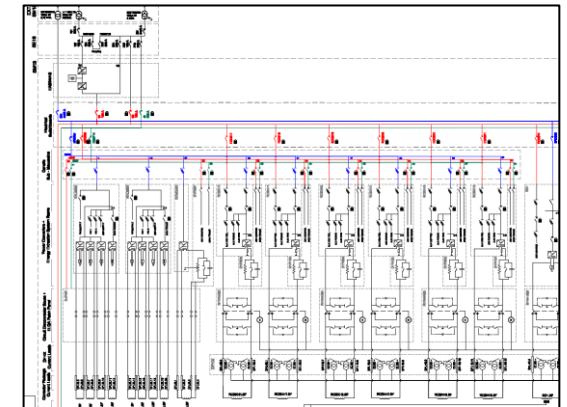


Cost monitoring



The screenshot shows the 'CET Desktop' web application interface. At the top, it displays the user's name 'JONSSON, Per Gunnar Mr.' and the date '01.04.2009'. Below this, there are navigation tabs for 'Welcome', 'Contracts', 'Transactions and Orders', 'Summaries and Totals', 'CFUtk', 'Info and Misc', and 'My Stuff'. A 'Welcome to the CET Desktop' message is displayed, along with a note that the old CET menu and reports are available for a limited time. A 'Common Reports' section lists various reports such as 'Transactions By Cost Centre', 'Team Transactions', 'Contract List', 'Contract Overview', 'Summaries/Pivot', 'Totals by Cost Centre', 'Monthly Totals', and 'Totals for Teams'. The interface is designed for project management and financial reporting.

Operational drawings



Quality Assurance: Examples

- To enhance project execution, various changes, measures, and tools have been implemented, reflecting engagement to continuous improvement:

Communication strategy



Accelerating NEWS HOME PAST ISSUES ALL NEWS ABOUT

HL-LHC IT String advancements and challenges for 2024

The commissioning of key equipment on the metallic platform is now completed.

3 MAY, 2024 | By WP16 HL-LHC IT STRING team

Figure 1: Part of the teams that made possible the execution of Short Circuit Tests in the HL-LHC IT String. (Credit: CERN/ M. Cavazza)

The operation of the HL-LHC IT String will mark a significant milestone for the High-Luminosity LHC (HL-LHC) project, as many state-of-the-art technologies developed for the HL-LHC will work collectively for the first time.

In the last episode of the HL-LHC IT String, featured in [Accelerating News](#), we highlighted the completion of infrastructure installations for the test stand and the readiness of some equipment to be commissioned.

NEWS CATEGORIES

- Particle Accelerators
- High-Luminosity LHC
- Compact Linear Collider
- Future Circular Collider
- Communication & Outreach

ARIES

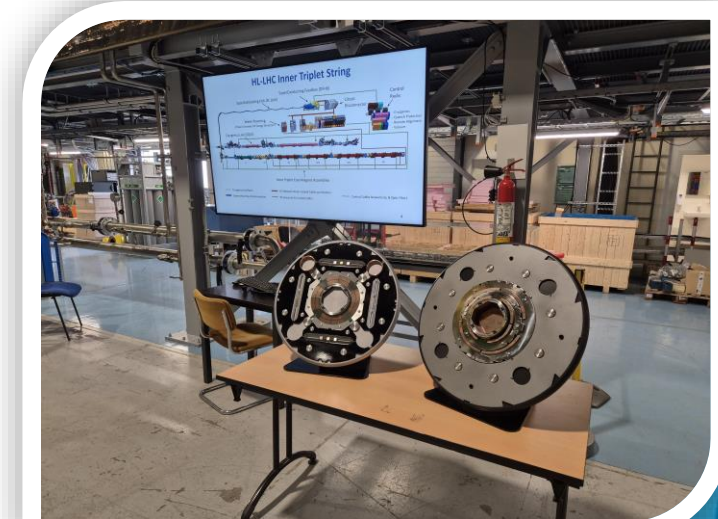
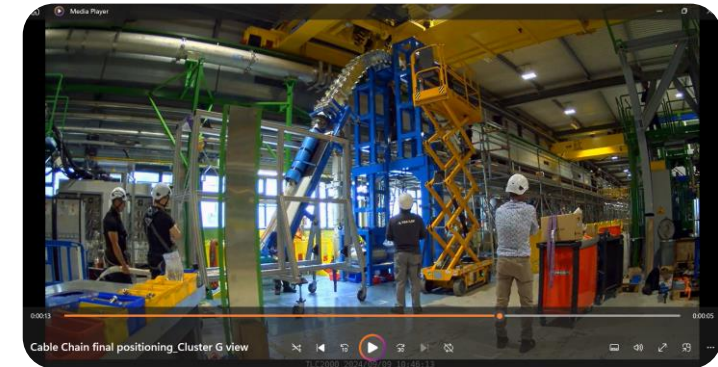
IFAST

EuPRAXIA

EASITrain

Knowledge Transfer

€1M innovation fund for sustainable accelerat...
IFAST (IFA)



Quality Assurance: Examples

- To enhance project execution, various changes, measures, and tools have been implemented, reflecting engagement to continuous improvement:

Communication strategy

IPAC 21

IT STRING: DESIGN AND PLANNING

THE IT STRING GOAL
In the HL-LHC upgrade, the inner triplet region will be fully replaced. The replacement will be completely different from the previous design. The main goal of the IT string is to improve the reliability of the inner triplet region in the HL-LHC. The various operational modes for the IT string will be studied and validated in different equipment and systems compatibility before installation in the HL-LHC.

SAFETY
The IT string will be fully replaced. The replacement will be completely different from the previous design. The main goal of the IT string is to improve the reliability of the inner triplet region in the HL-LHC. The various operational modes for the IT string will be studied and validated in different equipment and systems compatibility before installation in the HL-LHC.

ALIGNMENT SYSTEM
An innovative concept alignment system has been developed for the HL-LHC. It will be used for the alignment of the IT string. The system will be used for the alignment of the IT string. The system will be used for the alignment of the IT string.

THE STRING VALIDATION PROGRAM
The string validation program is a key element of the IT string. It will be used for the validation of the IT string. The program will be used for the validation of the IT string.

CRYSOGENIC COOLING
The cryogenic cooling system is a key element of the IT string. It will be used for the cooling of the IT string. The system will be used for the cooling of the IT string.

CONCLUSION
The IT string is a key element of the HL-LHC. It will be used for the HL-LHC. The IT string is a key element of the HL-LHC.

MT 28 (2023)

HL-LHC IT STRING status and perspectives

THE IT STRING GOAL
In the HL-LHC upgrade, the inner triplet region will be fully replaced. The replacement will be completely different from the previous design. The main goal of the IT string is to improve the reliability of the inner triplet region in the HL-LHC. The various operational modes for the IT string will be studied and validated in different equipment and systems compatibility before installation in the HL-LHC.

STATUS
The cryogenic cooling system is a key element of the IT string. It will be used for the cooling of the IT string. The system will be used for the cooling of the IT string.

PERSPECTIVES
The string validation program is a key element of the IT string. It will be used for the validation of the IT string. The program will be used for the validation of the IT string.

CONCLUSION
The IT string is a key element of the HL-LHC. It will be used for the HL-LHC. The IT string is a key element of the HL-LHC.

IPAC 24

Hardware Commissioning of the HL-LHC Inner Triplet String Facility at CERN: Individual System and Short Circuit Tests

HL-LHC INNER TRIPLET STRING AT CERN

CRYOGENIC SYSTEM TESTS
The cryogenic system is a key element of the IT string. It will be used for the cooling of the IT string. The system will be used for the cooling of the IT string.

INDIVIDUAL TESTS OF THE WARM POWERING SYSTEMS AND SHORT CIRCUIT TESTS
The warm powering system is a key element of the IT string. It will be used for the powering of the IT string. The system will be used for the powering of the IT string.

CONCLUSION
The IT string is a key element of the HL-LHC. It will be used for the HL-LHC. The IT string is a key element of the HL-LHC.

ASC 24

TRANSFORMING CONCEPT INTO REALITY: OVERCOMING CHALLENGES IN THE HL-LHC IT STRING TEST STAND IMPLEMENTATION

M. Bajko, S. Blanchard, D. Bozzini, O. Bruning, N. Heredia Garcia, M. Zerlauth and S. Yammine

Quality Assurance & Control in the HL-LHC IT String

QUALITY MANAGEMENT
Plan quality management (processes, measurement tools)
Monitor quality (equipment, constraints, stakeholders)
Monitor, record and control quality

QUALITY ASSURANCE
Track updates, CPM techniques
Monitor quality (equipment, constraints, stakeholders)
Monitor project performance
Monitor project performance

QUALITY CONTROL
Checklist
Preventive, test results, non-conformities
Report non-conformities



Quality Assurance: HL-LHC

- The IT String has adhered to HL-LHC processes for requesting and documenting deviations and/or changes with regards to the baseline scenario during project execution, including:

ECR

EDMS NO. 2102130 REV. 1.0 VALIDITY VALUO
REFERENCE: LHC-XMS-EC-0002

HL - LHC Engineering Change Request EXCLUSION OF THE BEAM SCREEN IN THE IT STRING

ECR DESCRIPTION

WP Originator	WPSE	Process	Engineering, Integration
Equipment	LHCXMS	Baseline affected	Scope, Schedule, Cost
Drawing	Drawing(s) concerned	Date of issue	2022-02-03
Document	Document(s) concerned	CI responsible	M. Bujko
WP Affected	WP1, WP2, WP3	Reference Document	TDR Version 1.0

Detailed Description

The cryosystems composing the HL-LHC IT STRING are D1, D2, Q1, Q2, Q3, and Q4. Additionally, an electrical feed box (EFB) acting as an interface towards the superconducting line (SC line) will be attached at the D1 side. In principle the magnets can be prototypes or first of the series, being fully representative for the HL-LHC IT string. The IT STRING will reproduce the configuration of the left side of point 3 (P3). The powering will be done through the SC Link system and joints or previous HL-LHC prior commission (except for the CP), as well as the quench detection and protection will follow the baseline design of the project. Although the cryogenic cooling will target the 1.9 K temperature, the system ensuring the cooling and the total capacity for pumping will not be the one of the HL-LHC. Nevertheless the dedicated system will be installed and operated in the SM18 test facility where the STRING will be working. A major difference between the configuration of the IT zone on HL and the HL-LHC IT STRING will be the absence of the beam screen in the HL-LHC IT STRING, apart from the fact that the slope of the tunnel will not be reproduced.

The original baseline considered the use of the beam screen in all the magnets where they are the first of the series or prototypes. Due to the delivery schedule, and the decision to use of at least 3 prototypes, the installation of the beam screens implied a non-negligible extra cost for WP16 and WP12. In addition, from technical discussions, it turned out that the recovery of the beam screens as spare parts after dismantling the STRING experiment, would affect the stock of the spare beam screens because the beam screens are not easily dismountable.

In the HL-LHC STRING data, a review organized by the HL-LHC project and the TE Department was an occasion to see the proposed configurations and associated test plan at an early stage of the project. From those discussions and presentations, it was decided not to implement the beam screen in any of the magnets, but to test the beam screen performance in separate tests on model magnets (in MQPS4 in SM18 vertical cryostat for the Q1 type beam screen) and dedicated tests stand already installed in the cryo lab. The common vacuum system between cold bore and insulation was also considered as a complementary optimisation.

Reasons for change

The reason of the change is the optimisation of the configuration, budget, and planning of the two main affected WPs, WP16 and WP12. Following that process, the beam screen presence in the STRING resulted not to be critical considering that the tests of the beam screens are being done on individual magnets and off line. As an example, the beam screen of the Q1 type magnets has been tested in the cryo lab for its thermal behaviour and in the model magnet (MQPS4) in a vertical cryostat for its thermo-mechanical behaviour in the presence and use of the QLD protection system.

In this optimisation process, a common vacuum between beam tube and insulation is also considered as a good compromise. The results of the optimisation efforts and the different configurations has been presented at the 'TCC 66%', and are approved in February 2019.

Impact on Cost, Schedule & Performance

Page 1 of 3 Template EDMS No.: 1202829

Ex: [EDMS 2102130](#)

SCR

EDMS NO. 2799934 REV. 1.0 VALIDITY VALUO
REFERENCE: LHC-XMS-EC-0003

HL - LHC Schedule Change Request Shift of Milestones in the HL-LHC IT String

SCR DESCRIPTION

WP Originator	WP16	Baseline affected	Schedule
Equipment	IT String	Date of issue	2022-11-23
Drawing	-	CI responsible	M. Bujko
Document	WP16 planning	Reference Document	EDMS No. 2283817
WP Affected	WP1, WP6A, WP6B, WP7, WP13A, TE-CRG, EN-EL, TE-VSC, TE-MSC, TE-MFE and EN-HE	-	-

Detailed Description

The milestones of the HL-LHC IT String concerning its installation and operation are largely determined by the delivery of the major HL-LHC components by the different Work Packages. The critical path is today defined by the arrival of the last magnet, the interconnection process and the operational phase, all of which have to be executed sequentially. The subcritical item as of today is the delivery of the SC Link system for installation in the IT String. Table 1 summarises the major shifts in the HL-LHC IT String milestones occurred since the CBS Review 2021.

Table 1. HL-LHC IT String milestones comparison between CBS review baselines

Milestone	Baseline 2 CBS Rev. 2021	Baseline 4 CBS Rev. 2022	Δt (months)
1. End of cryogenics commissioning without magnets	20/02/2023	31/10/2023	+ 8
2. End of power converters installation (including electronics)	12/05/2023	26/05/2023	+ 0.5
3. End of WP7 racks installation (including electronics)	26/05/2023	26/05/2023	+ 0
4. Delivery of SC Link system including (DFX and DFHX)	03/11/2022	03/07/2023	+ 8
5. Delivery of the last cryomagnet	05/05/2023	15/12/2023	+ 7.5
6. End of interconnections closure	14/09/2023	21/05/2024	+ 8
7. Start of first cool-down	24/11/2023	13/08/2024	+ 8.5
8. End of IT String program (start of the warming up)	30/03/2025	04/12/2025	+ 8.5

Reasons for the request

The main reasons inducing the changes exposed in Table 1 are provided hereafter:

- The end of the cryogenics commissioning without magnets is postponed by 8 months, to the end of October 2023. This is explained by the shift of the SM18 cryogenic shutdown. The CCU (Cold Compressor Unit) is to be installed in the shadow of the maintenance shutdown, as well as the handover of the SQB insulation vacuum from TE-CRG to TE-VSC. The cold test can only start once the shutdown is finished. Beginning of May 2023, as an estimated start date for this activity remains to be fully confirmed.

Page 1 of 5 Template EDMS No.: 1202775

Ex: [EDMS 2799934](#)

DMR

EDMS NO. 2717815 REV. 1.0 VALIDITY VALUO
REFERENCE: LHC-XMS-ED-0011

HL-LHC: Decision Management APPROVAL OF AN ADDITIONAL THERMAL CYCLE WITH FULL POWERING TESTS IN THE HL-LHC IT STRING VALIDATION PROGRAM

Decision Description

WP/Dep.	WP16, TE Department	Date of issue	2022-03-16
---------	---------------------	---------------	------------

This document formalises the decision on the inclusion of an additional thermal cycle (TC) and an optimised powering test into the HL-LHC IT String Validation Program. The decision considers the cost-benefit analysis performed for this purpose and presented at the LHC Performance (Chamonix) Workshop on the 27th of January 2022 and at the 214th PSM of the HL-LHC regarding the WP16 held on the 8th of February 2022.

Facts

The IT String Validation Program (SVP) can be initiated once verifications and measurements are possible on fully operational circuits. This implies that all the equipment has been inter-connected and as such do not represent individual components anymore but have become parts of the aforementioned circuits.

The HL-LHC IT String Validation Program is composed of 5 distinct phases that are to be completed in a sequential order:

1. Tests before cooling and 1st cool-down to LHe temperature
2. Powering tests before TC
3. TC 1st warm-up to 300 K followed by a 2nd cool-down to 1.9 K
4. Powering tests after TC
5. 2nd warm-up, final tests at room temperature and dismantling

These phases are performed at different steady state temperatures (Fig. 1). The time for transitioning from one phase to the next is also considered.

Figure 1. Temperature vs time diagram of the SVP phases

Page 1 of 5 Template EDMS No.: 1202710

Ex: [EDMS 2717815](#)

NCR

EDMS NO. 3025021 REV. 1.0 VALIDITY VALUO
REFERENCE: LHC-XMS-EN-0002

Nonconformity Report Cables trays for IT String WCC

NC Description

Work Package	WP16	Equipment	Water Cooled Cables (WCC)
Collaboration Contact	EN-EL	Process	Visual Inspection
Team		Inspector	D. Bozzini, N. Heredia

Introduction:

The IT String includes 24 Water Cooled Cables (WCC) that connects electrically the power converters to the circuit disconnection breakers. The WCC are installed partially on metallic beams and on standard cable trays. The 3D isometric shows the position and routing of the WCC. Five Cable trays are necessary to support each four WCCs [1].

Non-conformity:

During the installation of the WCC on the cable trays it has been detected that in several points the cables trays where collaging. Visual inspections showed that the way of fixing the cables trays to the vertical beams of the metallic structure was plastically deformed. In some points the bolts and washers used to fix the cable tray to the vertical beam overstepped the U shaped metallic profile. Figures 1 to 5 shows some of the non-conformity proofs.

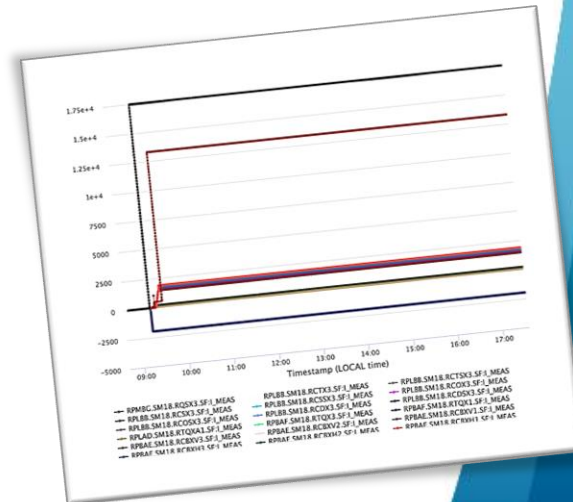
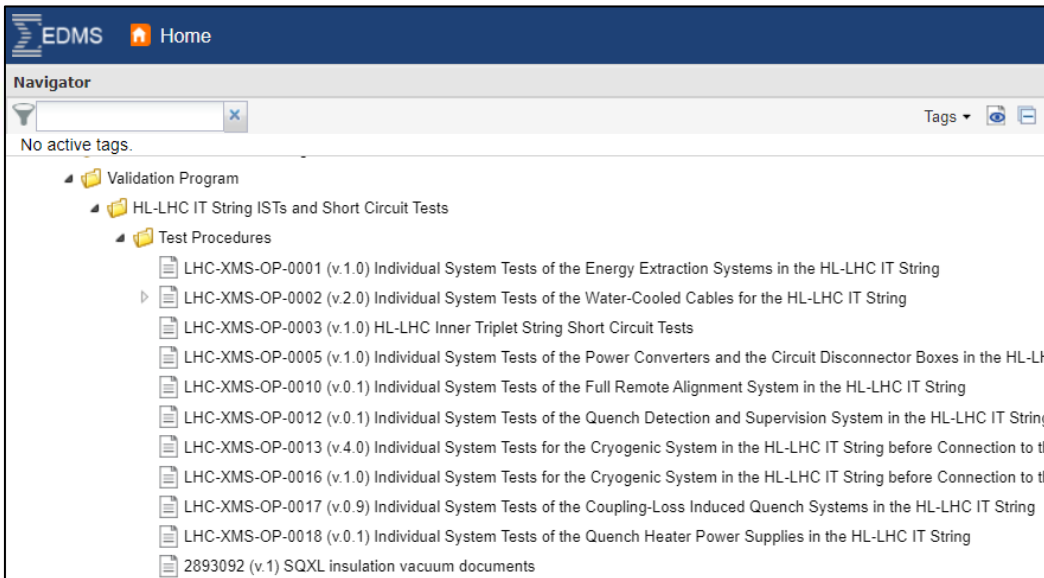
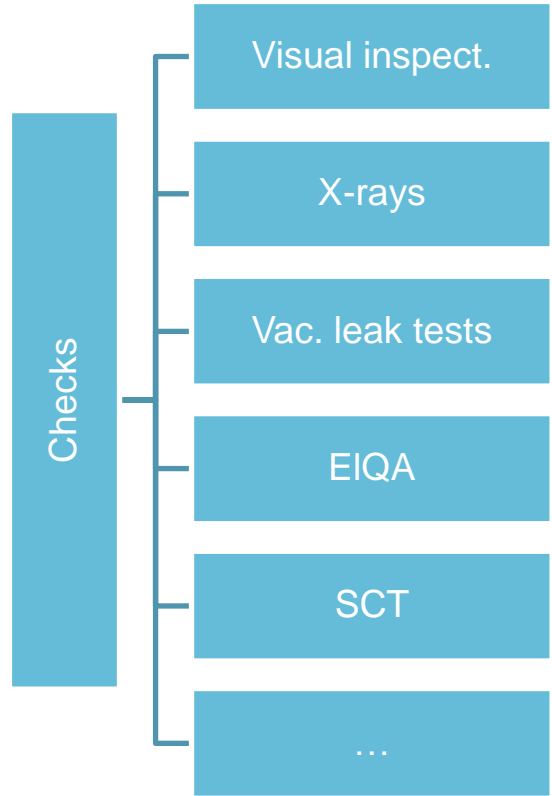
Figure 1: Cable tray sinking
Figure 2: Washer overstepping the U shape
Figures 3 to 5: Cable tray fixing non-conformities

Page 1 of 3 Template EDMS No.: 1202109

Ex: [EDMS 3025021](#)

Quality Control: Process

- Quality control tests are managed by the equipment owner.
- The String coordination team:
 - Ensure proper conditions for the execution of the tests.
 - Follow up the activities on-site.
 - Check that the test results are documented.
- Tests procedures are defined as part of the String Validation Program.



Quality control: MTF

- For the follow up of the quality checks WP16 proposed a MTF structure that was agreed with the HL-LHC Quality Office.
- The Manufacturing and Test Folder (MTF) is used at CERN to register manufacturing and quality control steps, it is imbricated in EDMS.
- The structure is divided in several systems, and steps are defined for each of them.
- Steps are extracted from test procedures.

EDMS Home Favourites Inbox Caddie

Navigator

- IT String MTF Systems
 - IT String
 - Cold Powering System
 - Circuits
 - RQX.SF
 - RD1.SF
 - RCBXH1.SF
 - RCBXV1.SF
 - RCBXH2.SF
 - RCBXV2.SF
 - RCBXH3.SF
 - RCBXV3.SF
 - RQSX3.SF
 - RCSX3.SF
 - RCSSX3.SF
 - RCOX3.SF
 - RCOSX3.SF
 - RCDX3.SF
 - RCDSX3.SF
 - RCTX3.SF
 - RCTSX3.SF
 - Cryogenic System
 - Magnets, Interconnections and FRAS

System Identifier: RCBXH1.SF
Other Identifier: None
Description: RCBXH1.SF

Main System data Installation & Commissioning Operation History Documents

Actions: Create Job

Job Id	IR/E	Status	Res.	Description	Started	Ended	INC
32863974	Done	Ok		00-IST WCC-Pressure test of hydraulic circuitry (*)	2023-05-03	2023-06-14	
32863975	Done	Ok		02-IST WCC - Dielectrical & insulation resistance test (*)	2023-06-14	2023-06-30	
32863976	Done	Ok		04-IST ACC - Dielectrical & insulation resistance test (*)	2023-10-10	2023-10-24	
32863977	Done	Ok		06-IST CDB (RSWMA.SM18.RCBXH1.SF) - Dielectrical & insulation resistance test	2024-02-06	2024-03-22	
32863984	Accepted	Ok		08-IST EE (DQAMS.SM18.RCBXH1.SF) - Voltage withstand tests (*)	2023-12-07	2023-12-07	
32863985	Done	Ok		10-IST EE (DQAMS.SM18.RCBXH1.SF) - Functional tests (*)	2023-12-07	2023-12-07	
32863986	Done	Ok		12-IST EE (DQAMS.SM18.RCBXH1.SF) - Readiness check for powering (*)	2023-12-07	2023-12-07	
32863979	Accepted	Ok		14-IST PC (RPBAA.SM18.RCBXH1.SF) - Pressure test of hydraulic circuit (*)	2023-12-01	2023-12-01	
32863978	Done	Ok		16-IST PC (RPBAA.SM18.RCBXH1.SF) - Verif. connection to grid (*)	2023-11-16	2023-11-16	
32863980	Done	Ok		18-IST PC (RPBAA.SM18.RCBXH1.SF)-Verif. earth fault, water loss & EPC an. tools	2023-11-27	2024-01-23	
32863981	Done	Ok		20-IST CDB (RSWMA.SM18.RCBXH1.SF) - Verif. PLC comm, funct. manuev. & water flow	2024-02-06	2024-03-22	
32863982	Accepted	Ok		22-IST PC (RPBAA.SM18.RCBXH1.SF) - Test and calibration of DCCTs (*)	2023-12-01	2023-12-01	
32863983	Done	Ok		24-IST PC (RPBAA.SM18.RCBXH1.SF) - Interlock tests btw PC & CDB with PLC check	2023-11-27	2024-01-23	
32863988	Done	Ok		26-SCT - PC control loop tuning for short circuit powering	2023-11-27	2024-01-23	
32863987	Done	Ok		28-SCT - Interlock tests (water loss, earth fault, PC-EE, PIC-PC/AUG/UPS loops)	2023-11-27	2024-01-23	
32863989	Done	Ok		30-SCT - Gradual discharges with EES	2023-11-27	2024-01-23	
32863990	Done	Ok		32-SCT - 1 hour pre-validation run (*)	2024-01-25	2024-01-25	
32863991	Done	Ok		34-SCT - 8-12 hour run	2024-01-24	2024-01-25	



Non-conformities: Process

- HL-LHC process in place (<https://edms.cern.ch/document/1499015>):



Detection
(QC)

Technical
discussions

Decision

Actions
ongoing

Closure



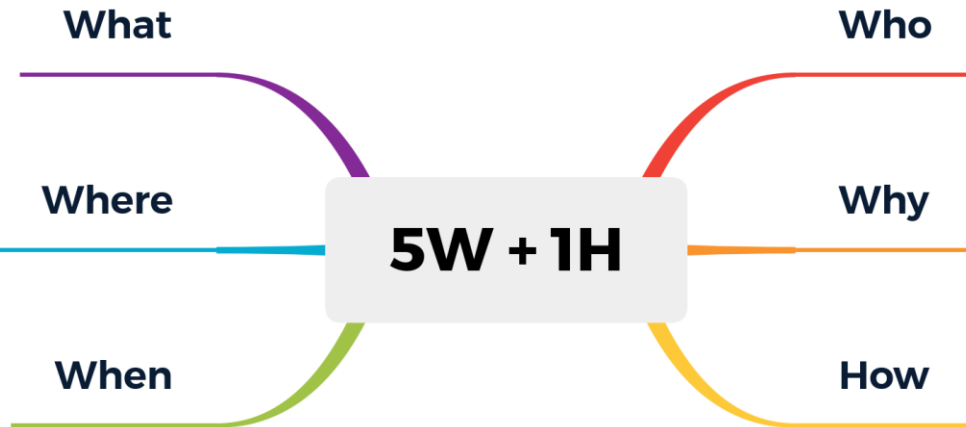
Document
Draft

EDMS
Evaluation

Review
STCM

Non-conformities: Template

- Information included in the non-conformity:



HL-LHC Nonconformity Report

Functional Range of Water Flow Switches for the Water-Cooled Cables in the 2kA Circuits

NC Description	
Work Package	WP16
Equipment	Water flow switches, 2 kA water-cooled cables and 2 kA power converters
Collaboration Teams	EN-CV, EN-EL and 5Y-EPC
Process	IST & SCT
Inspectors	D. Bozzini, N. Heredia, S. Yammine

Introduction:
The hydraulic circuit of the IT String integrates an Elettta flow meter/switch for each hydraulic branch feeding the Water-Cooled Cables (WCC). These flow switches are hardwired to the power converters (PCs) leading to a power abort when the water flow rate is beneath the defined threshold value.

In the current IT String configuration of the hydraulic network [1], the WCC of the RCBXH1 and RCBXV1 circuits are hydraulically connected in series, demanding a nominal flow rate of 12 l/min of demineralized water [2] (keeping the temperature increase of the cooling water traversing the WCC beneath 10 °C). The remaining 2 kA circuits (i.e. RCBXH2, RCBXV2, RCBXH3, RCBXV3, RTQX1, and RTQX3) currently form individual hydraulic branches with the two WCC connected in series, requiring nominal flow rates between 4 – 6 l/min of demineralized water [2].






Figure 1: Flow meter installed in the IT String for WCC in the RCBXH1 and RCBXV1 circuits where the 4 WCC are hydraulically connected in series

Figure 2: Flow meter installed in the IT String for WCC powering RCBXV2 circuit where only 2 WCC are hydraulically connected in series

EDMS NO.	REV.	VALIDITY
3025021	1.1	VALID

REFERENCE : LHC-XMSAH-QN-0001

HL-LHC Nonconformity Report

Functional Range of Water Flow Switches for the Water-Cooled Cables in the 2kA Circuits

NC Description	
Work Package	WP16
Equipment	Water flow switches, 2 kA water-cooled cables and 2 kA power converters
Collaboration Teams	EN-CV, EN-EL and 5Y-EPC
Process	IST & SCT
Inspectors	D. Bozzini, N. Heredia, S. Yammine

Introduction:
The hydraulic circuit of the IT String integrates an Elettta flow meter/switch for each hydraulic branch feeding the Water-Cooled Cables (WCC). These flow switches are hardwired to the power converters (PCs) leading to a power abort when the water flow rate is beneath the defined threshold value.

In the current IT String configuration of the hydraulic network [1], the WCC of the RCBXH1 and RCBXV1 circuits are hydraulically connected in series, demanding a nominal flow rate of 12 l/min of demineralized water [2] (keeping the temperature increase of the cooling water traversing the WCC beneath 10 °C). The remaining 2 kA circuits (i.e. RCBXH2, RCBXV2, RCBXH3, RCBXV3, RTQX1, and RTQX3) currently form individual hydraulic branches with the two WCC connected in series, requiring nominal flow rates between 4 – 6 l/min of demineralized water [2].

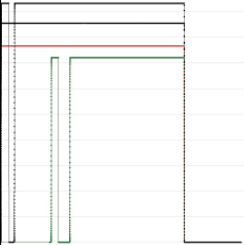


Figure 3: Current measurements registered in number for OC circuits H1 and V1 during Heat Run tests in the IT String [3]

EDMS NO.	REV.	VALIDITY
3025021	1.1	VALID

REFERENCE : LHC-XMSAH-QN-0001

two WCC in series, the nominal flow rate (4 – 6 l/min) is close to the installed Elettta flow meters. This specific condition has switch to the power converter (PC), primarily due to fluctuations SM18 (underlying reason needs to be checked with EN-CV), if the powering during the Heat Run tests conducted on the 25th of February 2024 is depicted in Figure 3.

all the flowmeters installed in the IT String, despite the configuration of the hydraulic circuits while adjusting the nominal flow rate of 8 l/min. This adjustment is deemed to have lower impact on series configuration.

to better align with the nominal flow rate of the cooling water for the 2 kA circuits, given their configuration in the IT String [4]. Nevertheless, it is advisable to consider the various hydraulic circuits to be implemented.

assignments for operation [EDMS 2882278](#). The HL-LHC IT String [EDMS 2744521](#).

ables cooling scheme [EDMS 2953127](#).

nt, F. Dragoni, J. Emonds-Ait, H. Garcia Gavela, V. and M. Zerlauth.

-Critical (Impact 1,2 or 3)

<input type="checkbox"/>	Return	<input type="checkbox"/>	Concession	<input checked="" type="checkbox"/>
	Date			2024-02-05

re

g the identification of the non-conformity. The test

<input checked="" type="checkbox"/>	No	<input type="checkbox"/>
	Date Closure	2024-02-05
	Collaboration manager/WPE/WPL/PL	M. Bajko, TE-MPE-SF

HL-LHC Nonconformity Report

Functional Range of Water Flow Switches for the Water-Cooled Cables in the 2kA Circuits

NC Description	
Work Package	WP16
Equipment	Water flow switches, 2 kA water-cooled cables and 2 kA power converters
Collaboration Teams	EN-CV, EN-EL and 5Y-EPC
Process	IST & SCT
Inspectors	D. Bozzini, N. Heredia, S. Yammine

Introduction:
The hydraulic circuit of the IT String integrates an Elettta flow meter/switch for each hydraulic branch feeding the Water-Cooled Cables (WCC). These flow switches are hardwired to the power converters (PCs) leading to a power abort when the water flow rate is beneath the defined threshold value.

In the current IT String configuration of the hydraulic network [1], the WCC of the RCBXH1 and RCBXV1 circuits are hydraulically connected in series, demanding a nominal flow rate of 12 l/min of demineralized water [2] (keeping the temperature increase of the cooling water traversing the WCC beneath 10 °C). The remaining 2 kA circuits (i.e. RCBXH2, RCBXV2, RCBXH3, RCBXV3, RTQX1, and RTQX3) currently form individual hydraulic branches with the two WCC connected in series, requiring nominal flow rates between 4 – 6 l/min of demineralized water [2].

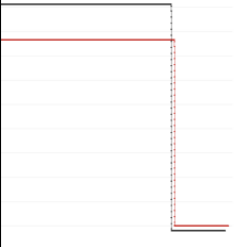


Figure 4: Current measurements registered in number for OC circuits H1 and V1 during Heat Run tests in the IT String [3]

EDMS NO.	REV.	VALIDITY
3025021	1.1	VALID

REFERENCE : LHC-XMSAH-QN-0001

those WCC are connected in series and necessitate a flow rate of 4 – 6 l/min of demineralized water [2]. This specific condition has led to faulty trips during the Heat Run tests as depicted in Figure 4.

Non-conformities: Table

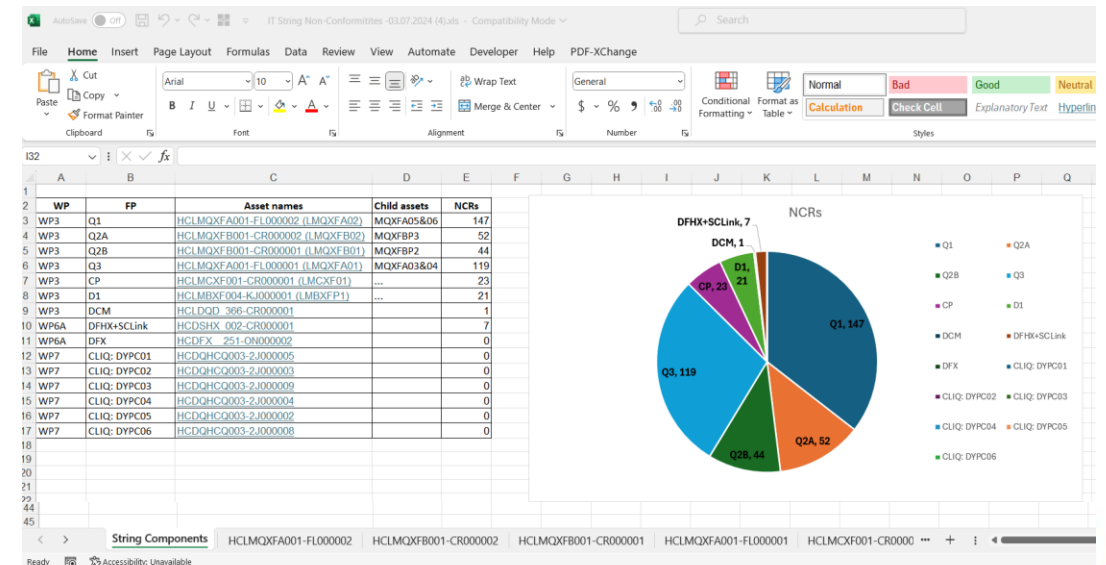
- Table of non-conformities to keep track of documentation status. Reviewed at the String Technical Coordination Meeting.

Ref.	NCR Description	Status	Ap. Date	EDMS	Criticality	Decision	Manag. team	Equipment	Detect. phase	Det. Year	Class
	NCR of TL02	1. To be Opened	TBD	TBD	Non-Critical	Repair	WP16	Cryogenics	Commissioning	2024	Mechanical
LHC-XMSAD-QN-0003	NCR of water-cooling plates for busbars	2. In Work	TBD	3162382	Non-Critical	Repair	WP16	Warm powering	Commissioning	2024	Manufacturing
LHC-XMSA-QN-0002	NCR - Integration conflict between alignment system and SQXL	2. In Work	TBD	3153667	Non-Critical	Repair	WP16	FRAS	Integration	2024	Integration
LHC-XMSAH-QN-0003	NCR - Acceptance criteria for WCC High Voltage Tests in the HL-LHC IT String	2. In Work	TBD	3045592	Non-Critical	Concession	WP16	Electrical infrastructure	Commissioning	2023	Electrical
LHC-XMSAA-QN-0001	NCR - Excessive Heat Load Detected in Line C within TL01	2. In Work	TBD	3044384	Non-Critical	Repair	WP16	Cryogenics	Operation	2023	Mechanical
LHC-XMSAA-QN-0005	NCR - Leak tightness of the SQXL main volume envelope	2. In Work	TBD	3075007	Non-Critical	Repair	WP16	Cryogenics	Commissioning	2024	Vacuum
LHC-XMSAH-QN-0004	NCR - WCC weight distribution plates at the extremities of the cable trays	4. Closed	15/07/2024	3117788	Non-Critical	Repair	WP16	Electrical infrastructure	Installation	2024	Mechanical
LHC-XMSAH-QN-0002	Non-conformity of cables trays supporting system for WCC	4. Closed with Warnings	15/07/2024	2804269	Non-Critical	Repair	WP16	Electrical infrastructure	Operation	2022	Mechanical
LHC-XMSA-QN-0001	NCR - Conflict between cable trays and ROCLA in the racks zone	4. Closed	07/06/2024	3093233	Non-Critical	Repair	WP16	Electrical infrastructure	Operation	2024	Transport
LHC-XMSAC-QN-0001	Flexible busbars manufacturing for the IT String	4. Closed	13/05/2024	3045423	Non-Critical	Repair	WP16	Cold powering	Installation	2023	Manufact. & instal.
LHC-XMSAD-QN-0001	Cable convention for connecting water flow switches to 14 and 18 kA PC	4. Closed	29/04/2024	3018444	Non-Critical	Repair	WP16	Water distribution system	Commissioning	2024	Electrical
LHC-XMSAH-QN-0001	NCR - Water Flow Switches Functional Range for the Water-Cooled Cables on the 2kA Circuits	4. Closed	29/04/2024	3025021	Non-Critical	Concession	WP16	Water distribution system	Operation	2024	Other
LHC-XMSAA-QN-0002	IT STRING - NCR - SQXL - Shape of service modules	4. Closed	22/03/2024	2961669	Non-Critical	Concession	WP16	Cryogenics	Installation	2022	Mechanical
LHC-XMSAA-QN-0003	IT STRING - NCR - SQXL - Pipe element vacuum vessel reinforcement	4. Closed	22/03/2024	2961672	Non-Critical	Repair	WP16	Cryogenics	Installation	2023	Mechanical
LHC-XMSAA-QN-0004	IT STRING - NCR - SQXL - DN100 Instrumentation Feedthroughs	4. Closed	22/03/2024	2961678	Non-Critical	Repair	WP16	Cryogenics	Commissioning	2023	Manufact. & instal.
LHC-XMS-QN-0001	Non-conformity SM18 floor for jack shims Q3	4. Closed	02/04/2024	2872779	Non-Critical	Concession	WP16	FRAS	Integration	2023	Integration

Non-conformities: Quality Meetings

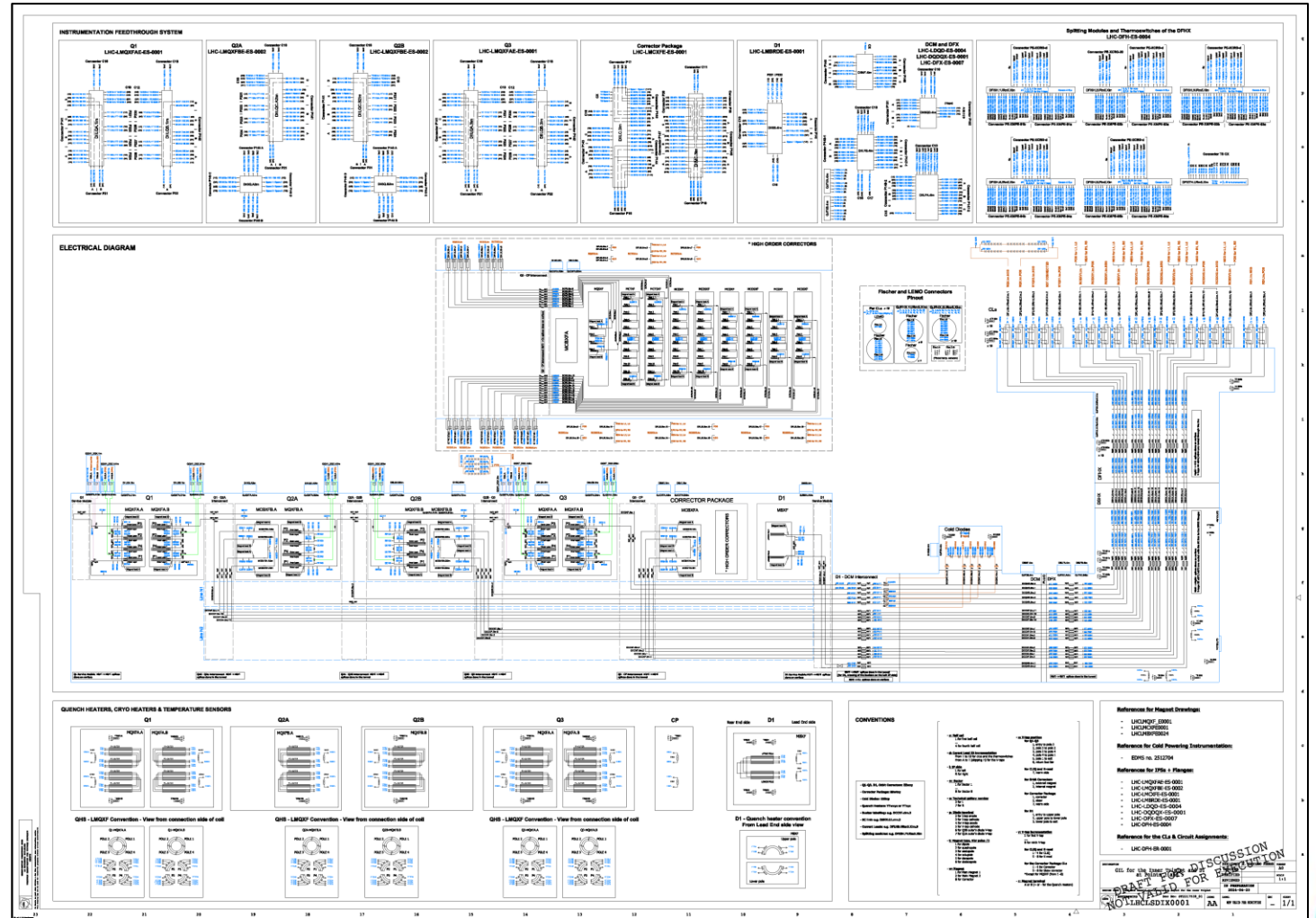
- A series of meeting have been launched with the HL-LHC Quality Office. Assets codes of the equipment coming to the IT String are been identified.
- Using the asset codes, non-conformities have been extracted using Pentaho tool and some of them reviewed. Also, assets will be attached to the String MTF structure to have full traceability of their installation.

- On a weekly basis, the HL-LHC Quality Office informs WP16 via email about the status of open non-conformities in the HL-LHC project.



Non-conformities: Quality Meetings

- For the equipment non-conformities tagged as “electrical”, an exercise is being initiated in the coordination team to integrate them as part of the general instrumentation layout drawing.
- Deviations from the baseline will also be signaled in this “As-built” drawing.
- This drawing will help to analyse the test results.



Lessons Learned

- Lessons learned have been transmitted to the HL-LHC project in different forums (WP15 integration meeting, TCC, String Day).
- Non-conformity reports contain a chapter dedicated to lessons learned.
- Working meetings have been organised with the intervening teams after completing an installation to discuss areas of improvement.
- A document of lessons learned will be drafted to gather all the feedback communicated.

HL-LHC Integration Meeting: Follow-up on "Lessons learned on IT String relevant for HL-LHC installation #1", Lessons learned on IT String relevant for HL-LHC installation #2, HL-LHC upload of equipment to the Layout Database: UR15 UR55

Friday Sep 13, 2024, 10:55 AM → 12:30 PM Europe/Zurich
CERN

EDMS for presente...

Videoconference HL-LHC Friday Integration meeting

10:55 AM → 11:25 AM Follow-up on "Lessons learned on IT String relevant for HL-LHC installation #1" 30m
Speakers: Miguel Navarro Baeza (CERN), Darshana Kumari Ramrekha
Follow-up on Lesso... Follow-up on Lesso...

11:30 AM → 12:15 PM Lessons learned on IT String relevant for HL-LHC installation #2 45m
Speakers: Davide Bozzini (CERN), Marta Bajko (CERN), Samer Yammine (CERN)
Lessons_Learned... Lessons_Learned...

12:15 PM → 12:30 PM HL-LHC upload of equipment to the Layout Database: UR15 UR55 15m
Speaker: Miguel Navarro Baeza (CERN)
HL-LHC_ApprovalLi... HL-LHC_ApprovalLi...

192nd HL-LHC TCC

Thursday Mar 14, 2024, 3:30 PM → 5:30 PM Europe/Zurich
30/7-010 (CERN)

Minutes 192nd Tec...

Videoconference 192nd HL-LHC TCC

3:30 PM → 3:35 PM HL-LHC Project announcements
Speakers: Markus Zerlauth (CERN), Oliver Bruning (CERN)

3:35 PM → 3:55 PM Edge welded bellows – lessons learned and follow-up
Speaker: Antonio Perillo Marccone (CERN)
Slides

4:05 PM → 4:25 PM Position vs magnetic axis measurement for MQXFs
Speakers: Dr Carlo Petrone (CERN), Vivien Rude (CERN)
Slides

4:35 PM → 4:55 PM Summary of the of the warm powering IST and SCT campaign In the IT String
Speaker: Samer Yammine (CERN)
Slides

HL-LHC IT String Day IV

Friday Sep 27, 2024, 8:30 AM → 5:35 PM Europe/Zurich
30/7-018 - Kjell Johnsen Auditorium (CERN)
Markus Zerlauth (CERN)

10:40 AM → 12:20 PM Status / Lessons learned / Upcoming activities

10:40 AM Cryogenic cooling system (WP16/TE-CRG) 20m
The presentation will address the following topics:
• Overview of cryogenic system commissioning without magnets
• Status of the cryogenic system
• Outcomes of commissioning and lessons learnt
• Upcoming activities for preparation of commissioning with magnets
Speaker: Aleksandra Onufrena (CERN)

11:05 AM Vacuum system (WP16/TE-VSC) 20m
The presentation will address the following topics:
• Vacuum leak tests and validation programs executed
• Lessons learned during commissioning of SQXL and Cold Powering System.
• Installation and interconnecting leak test tooling preparations.
• Upcoming activities.
Speaker: Willemjan Maan (CERN)

11:30 AM Warm powering system (WP6B/SY-EPC) 20m
The presentation will address the following topics:
• Lessons learned from installation and commissioning.
• Upcoming activities.
Speaker: Hugues Thiesen (CERN)

11:55 AM Cold powering system (WP6A/TE-MS) 20m
The presentation will address the following topics:
• Performance of the Prototype Cold Powering system
• Completed installation activities and lessons learnt
• Upcoming activities and interfaces
Speaker: Yann Leclercq (CERN)

Conclusions

- Sound quality processes are in place in the IT String, with improvements in various aspects.
- Effective collaboration and support from the HL-LHC quality office to deal with quality subjects.
- Intervening teams are committed to quality, and they count with experience in quality assurance/control methods.
- WP16 discovered non-conformities up to now are not critical and corrective measurement have been successfully implemented.
- A meeting dedicated to quality is launched to review, among others, equipment non-conformities potentially affecting the IT String.
- Lessons learned from the IT String experience have been gathered and communicated.



Thank you for your attention