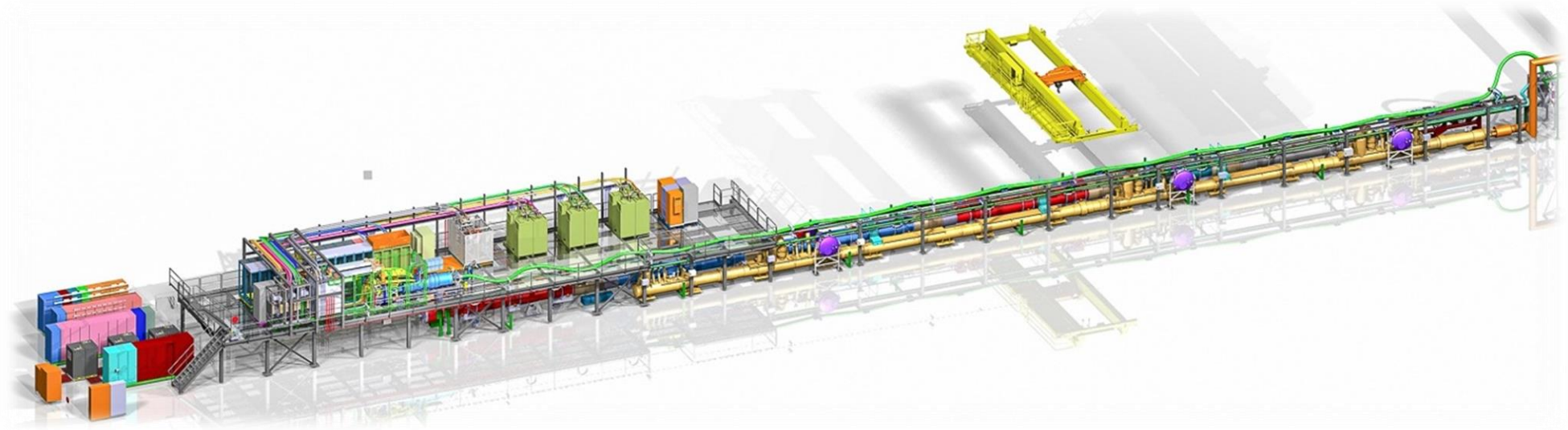
HL-LHC IT String Quality Assurance & Control

N. Heredia García (TE-MPE-SF)

On behalf of WP16

Scope of the talk

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



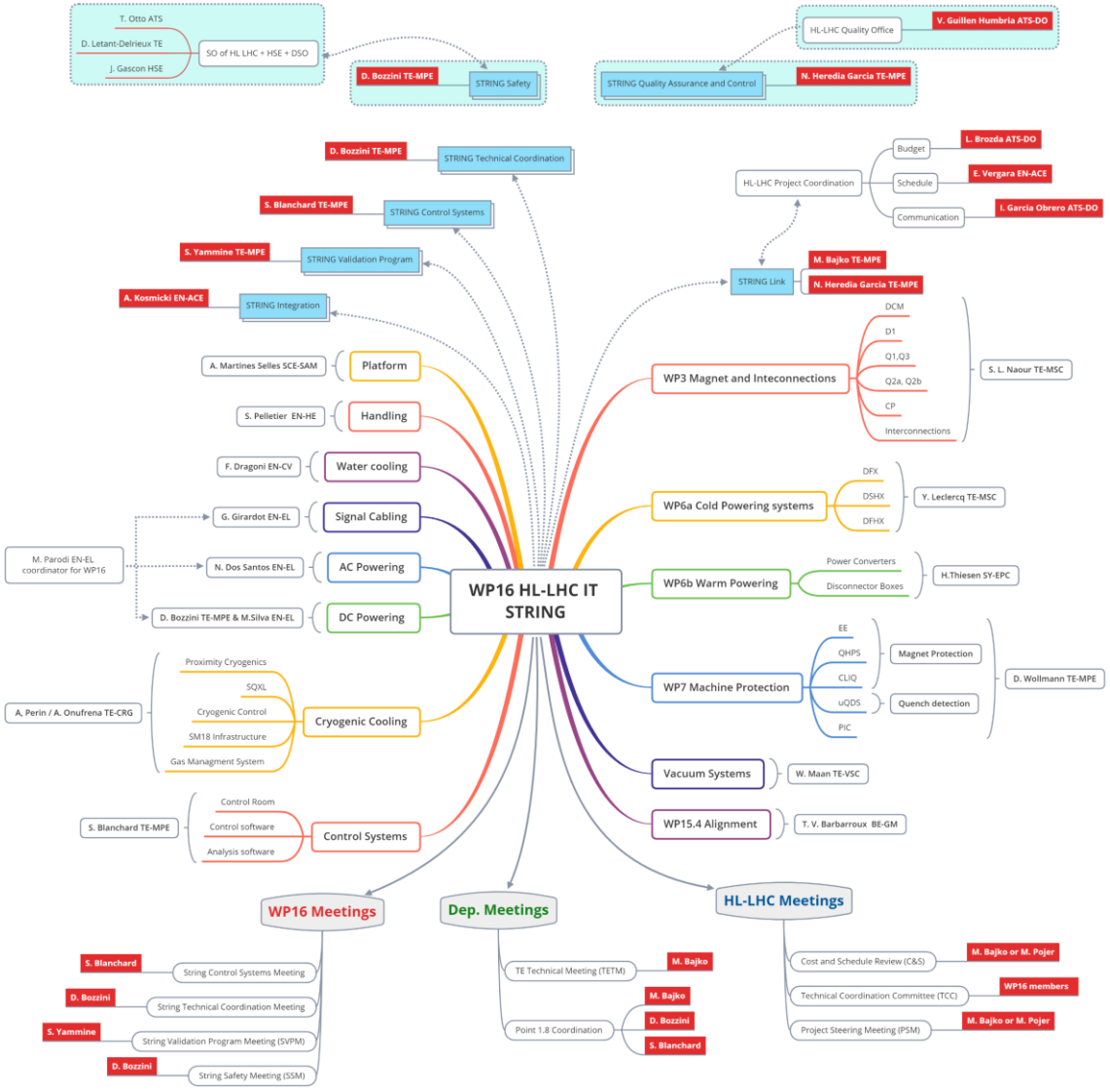
Introduction

- 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.

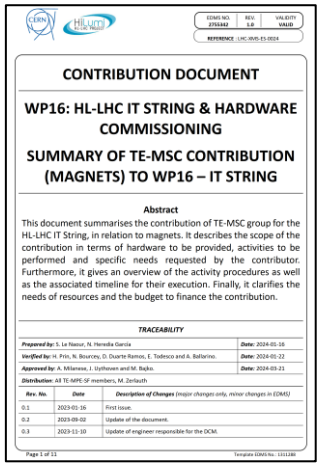
Phase	Goal	Description
Quality design	Plan quality management	Understand the specific needs and requirements of the project. It involves the definition of processes, tools and performance metrics.
Quality assurance	Manage quality	Ensure that the project meets the defined quality standards and requirements. 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

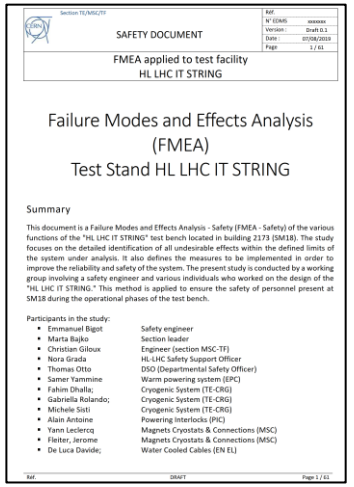
This document summarises the contribution of TE-MSC group for the HL-LHC IT String, in relation to magnets. It describes the scope of the contribution in terms of hardware to be provided, activities to be performed and specific needs requested by the contributor. Furthermore, it gives an overview of 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

Rev. No.	Date	Description of Changes (major changes only, minor changes in EDMS)
0.1	2023-01-16	First issue.
0.2	2023-09-02	Update of the document.
0.3	2023-11-10	Update of engineer responsible for the DCM.

- Equipment delivery
- Tooling for installation
- Infrastructure requests
- Activities
- Equipment recovery
- Cost and resources

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

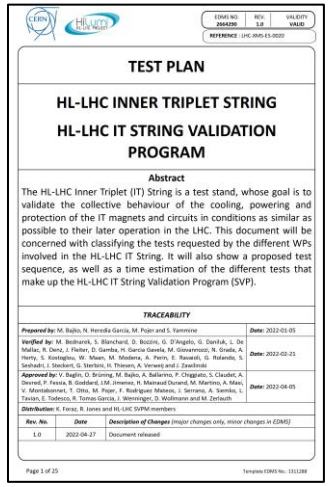
Summary

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 2173 (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:

- Emmanuel Bigot — Safety engineer
- Marta Bajko — Section leader
- Christian Giloux — Engineer (section MSC-TF)
- Nora Grada — HL-LHC Safety Support Officer
- Thomas Otto — DSO (Departmental Safety Officer)
- Samer Yammine — Warm powering system (EPC)
- Fahim Dhalla; — Cryogenic System (TE-CRG)
- Gabriella Rolando; — Cryogenic System (TE-CRG)
- Michele Sisti — Cryogenic System (TE-CRG)
- Alain Antoine — Powering Interlocks (PIC)
- Yann Leclercq — Magnets Cryostats & Connections (MSC)
- Fleiter, 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

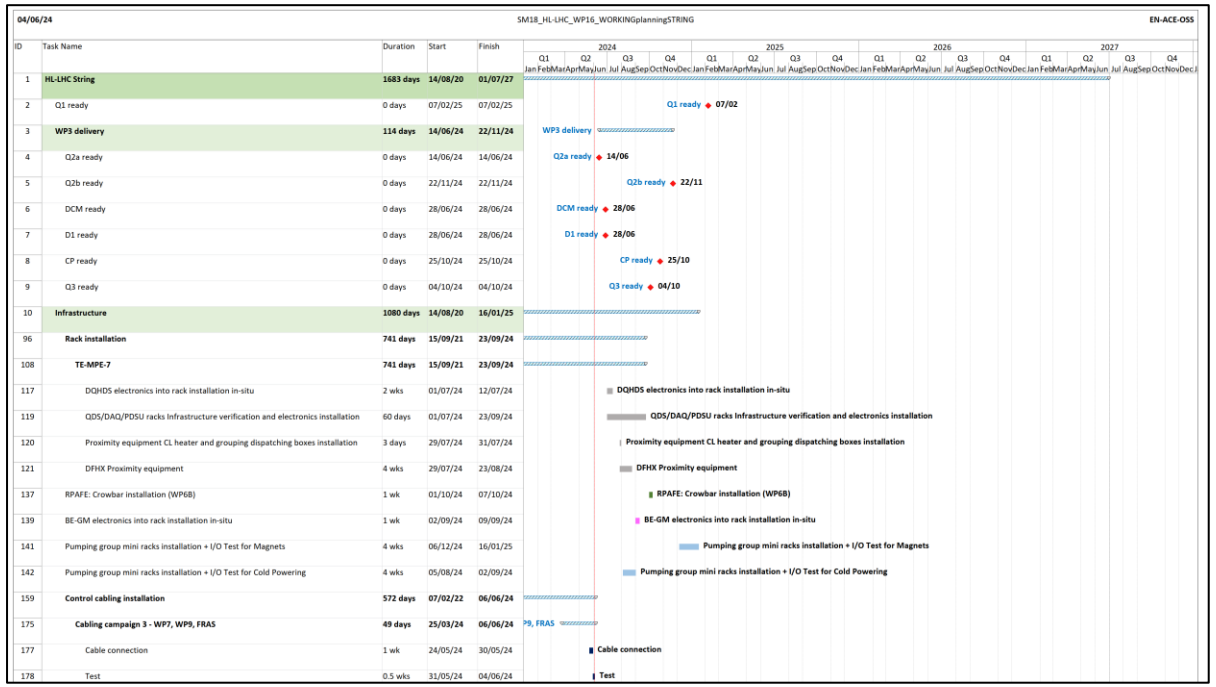
The HL-LHC Inner Triplet (IT) String is a test stand, whose goal is to validate the collective behaviour of the cooling, powering and protection of the IT magnets and circuits in conditions as similar as possible to their later operation in the LHC. This document will be concerned with classifying the tests requested by the different 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

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



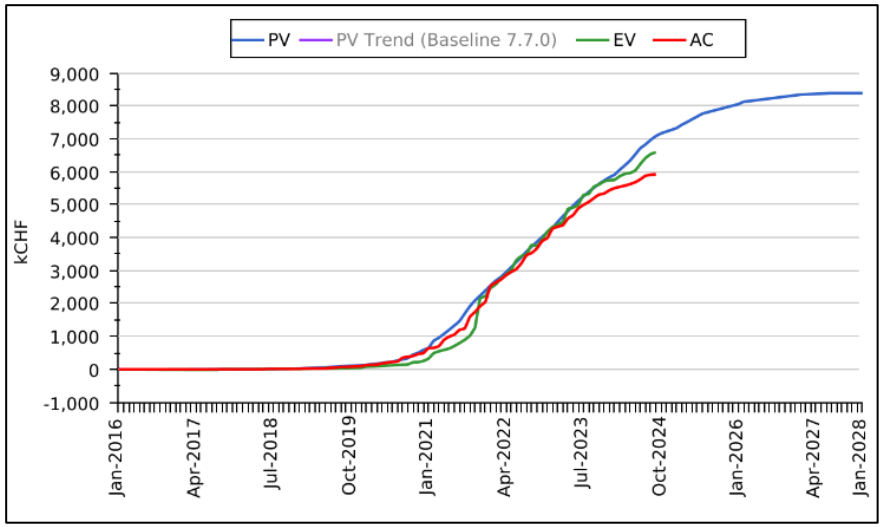
04/06/24 — SM18_HL-LHC_WP16_WORKINGplanningSTRING — EN-ACE-OSS

ID	Task Name	Duration	Start	Finish
1	**HL-LHC String**	**1683 days**	**14/08/20**	**01/07/27**
2	Q1 ready	0 days	07/02/25	07/02/25
3	**WP3 delivery**	**114 days**	**14/06/24**	**22/11/24**
4	Q2a ready	0 days	14/06/24	14/06/24
5	Q2b ready	0 days	22/11/24	22/11/24
6	DCM ready	0 days	28/06/24	28/06/24
7	D1 ready	0 days	28/06/24	28/06/24
8	CP ready	0 days	25/10/24	25/10/24
9	Q3 ready	0 days	04/10/24	04/10/24
10	**Infrastructure**	**1080 days**	**14/08/20**	**16/01/25**
96	**Rack installation**	**741 days**	**15/09/21**	**23/09/24**
108	**TE-MPE-7**	**741 days**	**15/09/21**	**23/09/24**
117	DQHDS electronics into rack installation in-situ	2 wks	01/07/24	12/07/24
119	QDS/DAQ/PDSU racks Infrastructure verification and electronics installation	60 days	01/07/24	23/09/24
120	Proximity equipment CL heater and grouping dispatching boxes installation	3 days	29/07/24	31/07/24
121	DFHX Proximity equipment	4 wks	29/07/24	23/08/24
137	RPAFE: Crowbar installation (WP6B)	1 wk	01/10/24	07/10/24
139	BE-GM electronics into rack installation in-situ	1 wk	02/09/24	09/09/24
141	Pumping group mini racks installation + I/O Test for Magnets	4 wks	06/12/24	16/01/25
142	Pumping group mini racks installation + I/O Test for Cold Powering	4 wks	05/08/24	02/09/24
159	**Control cabling installation**	**572 days**	**07/02/22**	**06/06/24**
175	**Cabling campaign 3 - WP7, WP9, FRAS**	**49 days**	**25/03/24**	**06/06/24**
177	Cable connection	1 wk	24/05/24	30/05/24
178	Test	0.5 wks	31/05/24	04/06/24

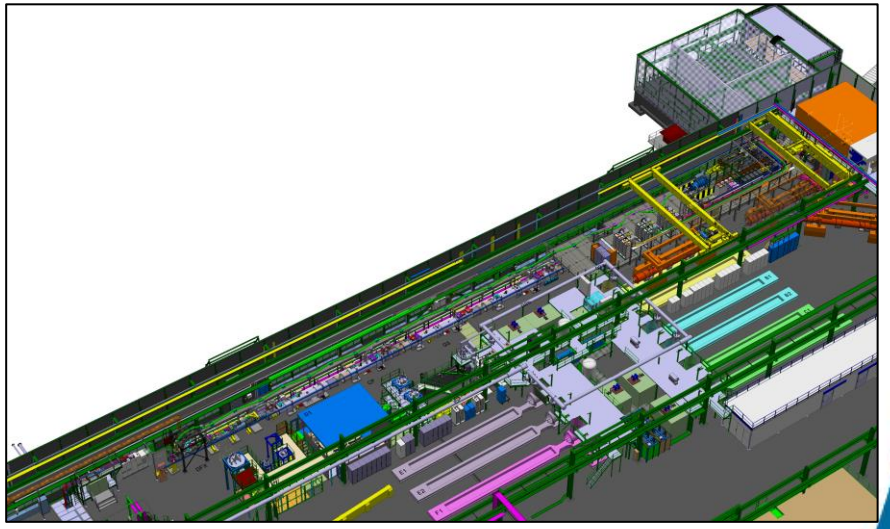
2024 2025 2026 2027 — Q1 Q2 Q3 Q4 — Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Q1 ready 07/02 · WP3 delivery · Q2a ready 14/06 · Q2b ready 22/11 · DCM ready 28/06 · D1 ready 28/06 · CP ready 25/10 · Q3 ready 04/10 · P9, FRAS · DQHDS electronics into rack installation in-situ · QDS/DAQ/PDSU racks Infrastructure verification and electronics installation · Proximity equipment CL heater and grouping dispatching boxes installation · DFHX Proximity equipment · RPAFE: Crowbar installation (WP6B) · BE-GM electronics into rack installation in-situ · Pumping group mini racks installation + I/O Test for Magnets · Pumping group mini racks installation + I/O Test for Cold Powering · Cable connection · Test

Cost tracking



Integration model

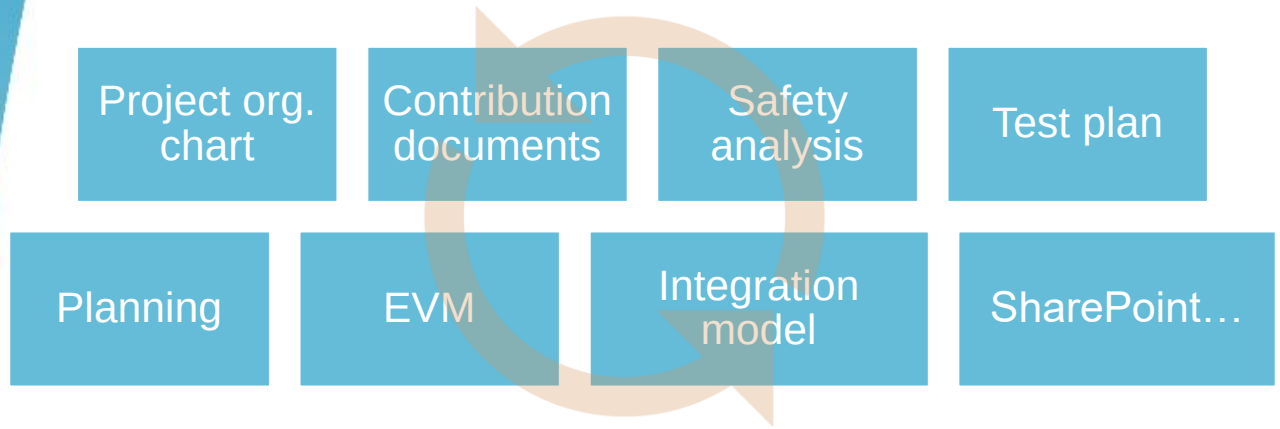


Other tools

EDMS

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

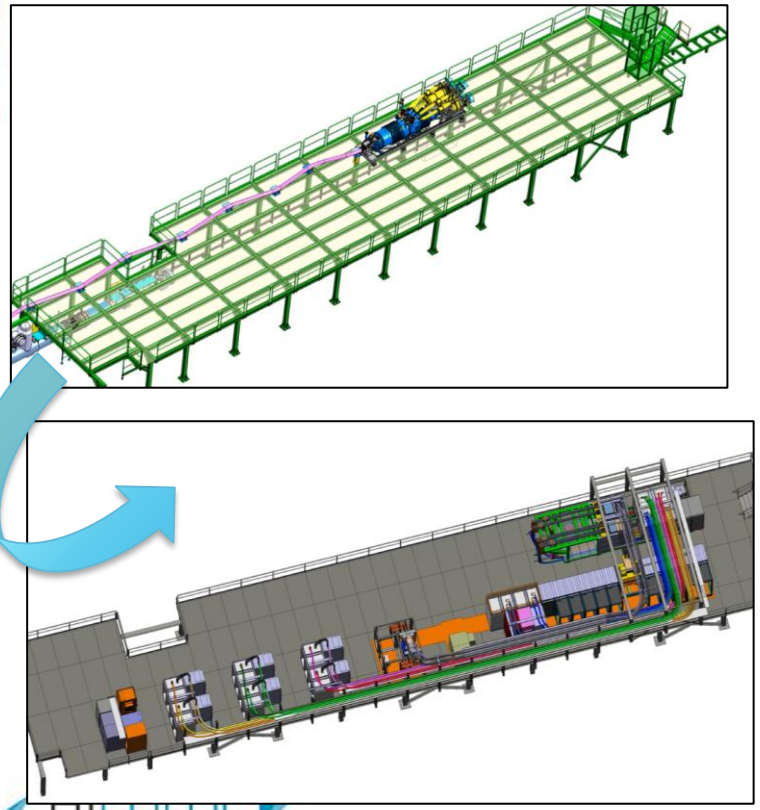
Cost & Schedule Review

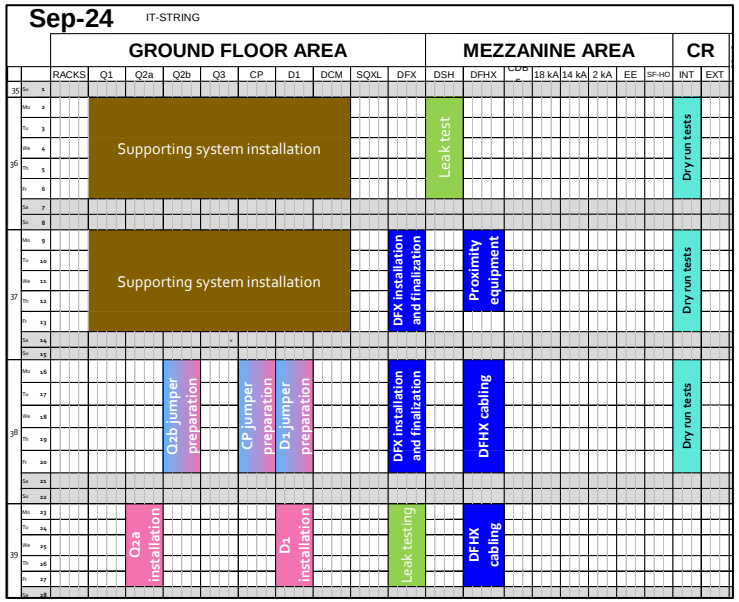
HL-LHC Annual Meeting

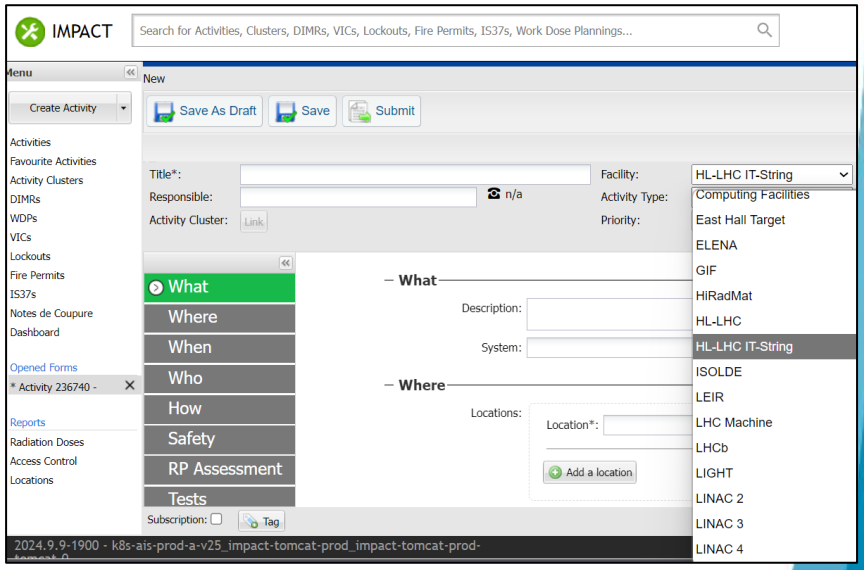
Quality Assurance: Examples

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

Installation sequence	Coordination	Access





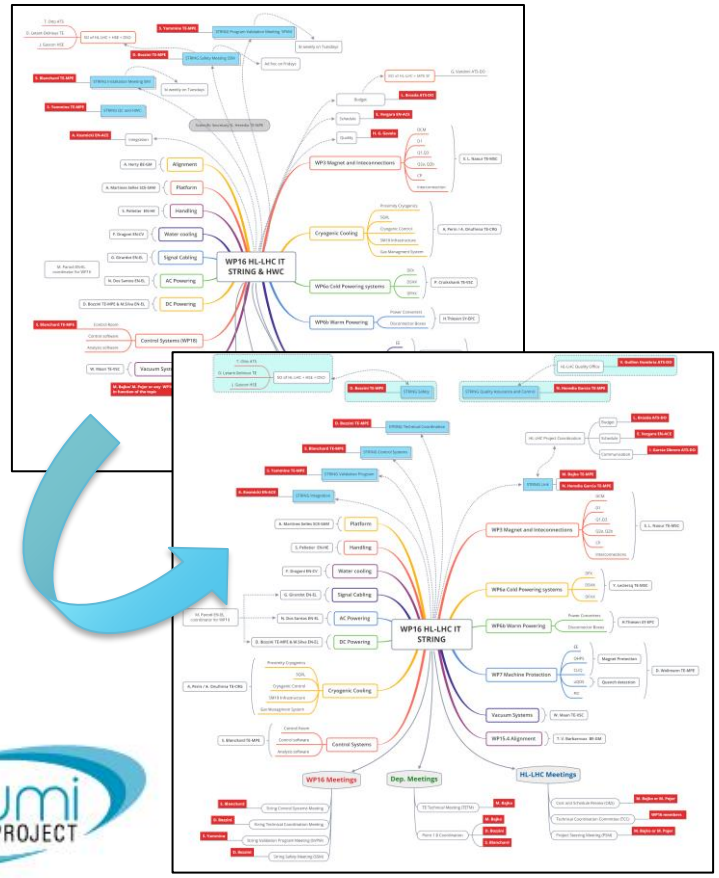


More info in “HL-LHC IT String Technical Coordination & Safety” by D. Bozzini

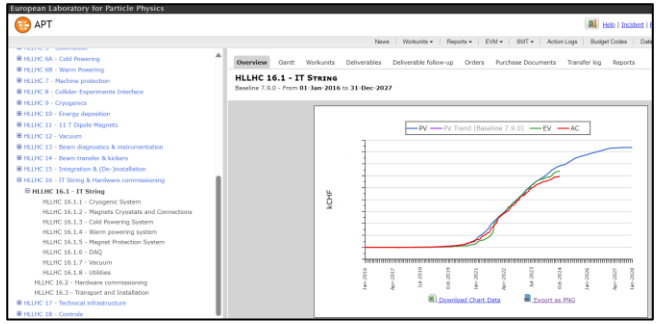
Quality Assurance: Examples

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

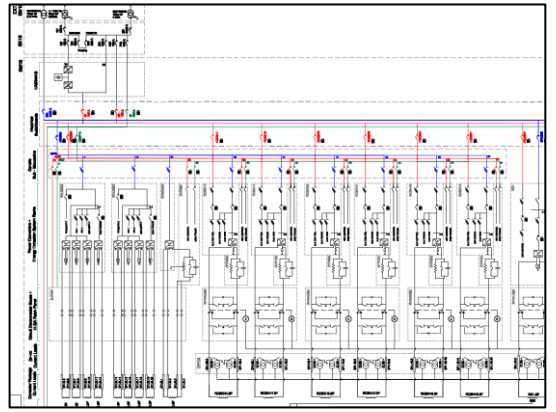
Roles and responsibilities

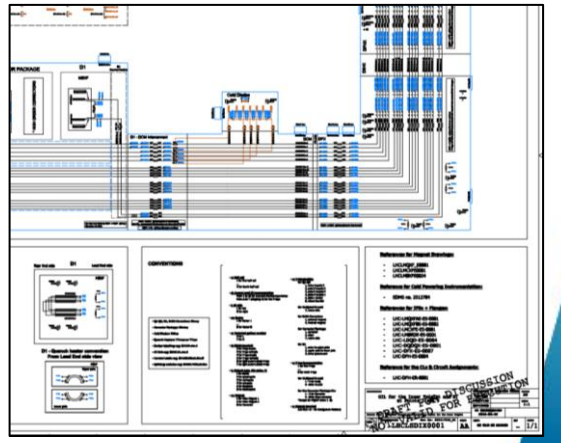


Cost monitoring



Operational drawings

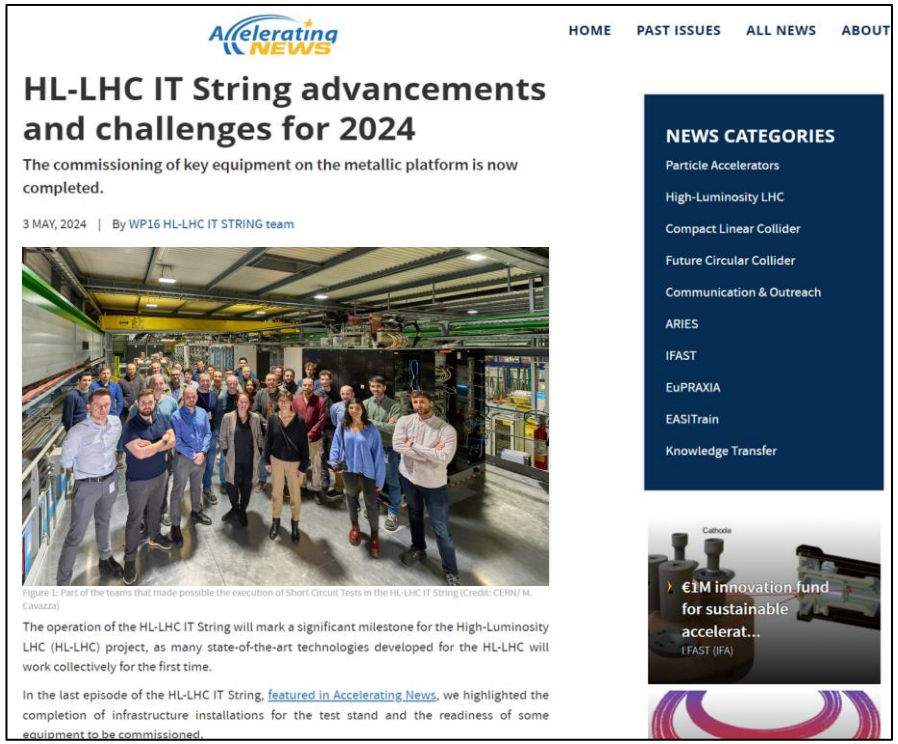


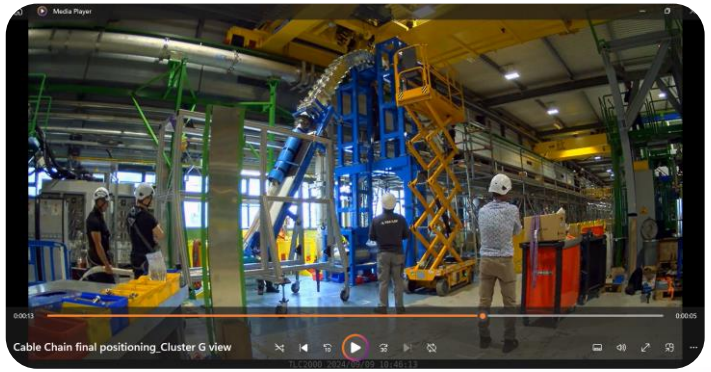


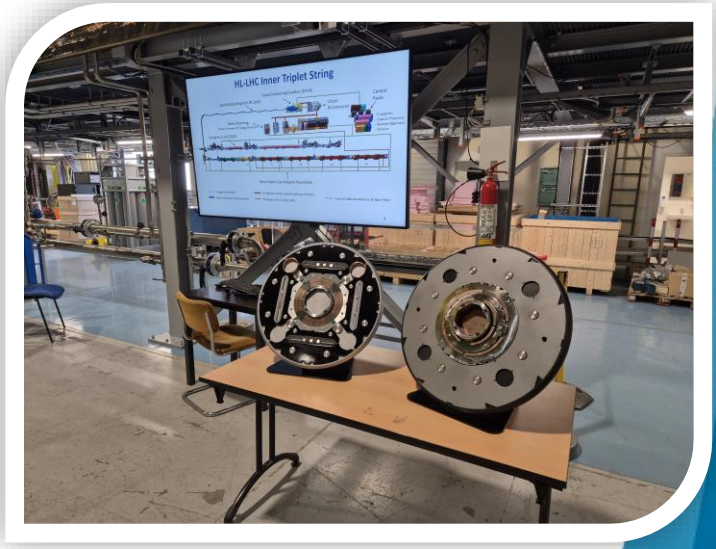
Quality Assurance: Examples

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

Communication strategy





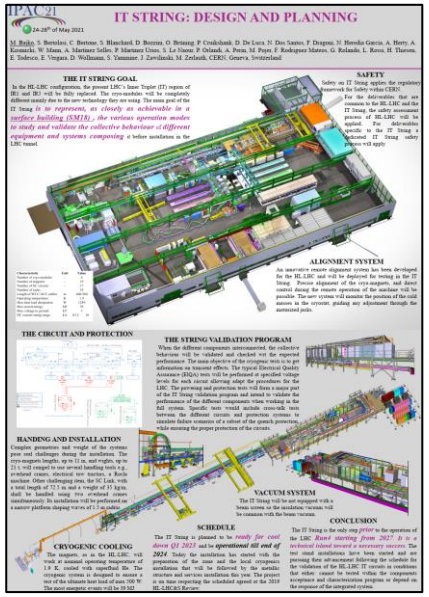


Quality Assurance: Examples

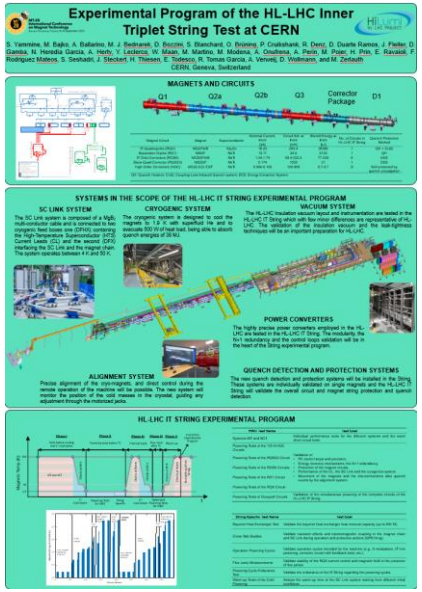
- To enhance project execution, various changes, measures, and tools have been implemented, reflecting engagement to continuous improvement:

Communication strategy

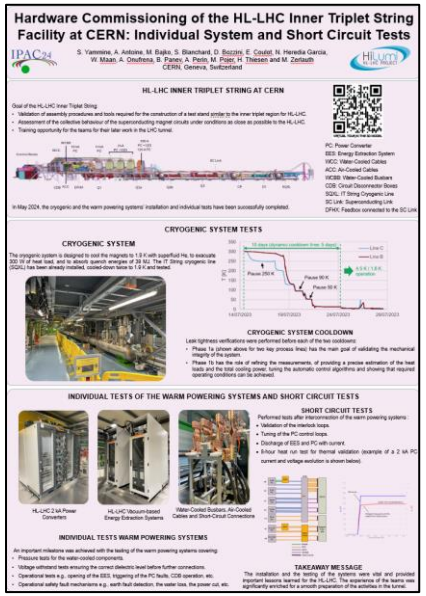
IPAC 21



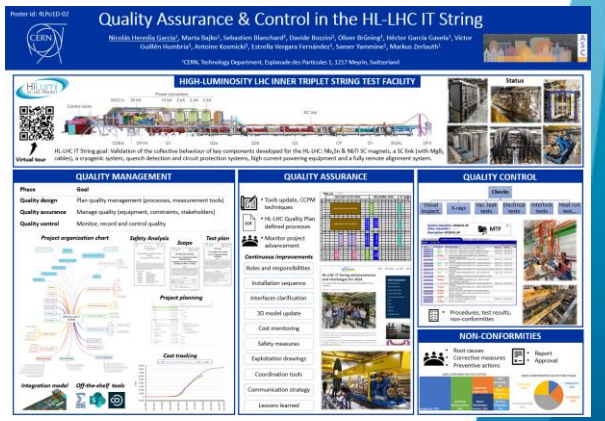
MT 28 (2023)



IPAC 24



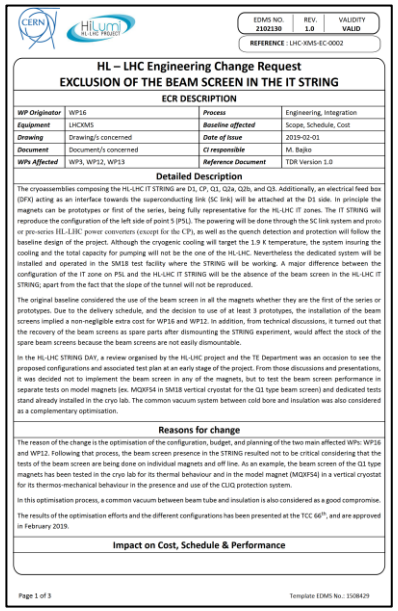
ASC 24



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



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

ECR DESCRIPTION

WP Originator	WP16	Process	Engineering, Integration
Equipment	LHCXMS	Baseline affected	Scope, Schedule, Cost
Drawing	Drawing/s concerned	Date of Issue	2019-02-01
Document	Document/s concerned	CI responsible	M. Bajko
WPs Affected	WP3, WP12, WP13	Reference Document	TDR Version 1.0

Detailed Description

The cryoassemblies composing the HL-LHC IT STRING are D1, CP, Q1, Q2a, Q2b, and Q3. Additionally, an electrical feed box (DFX) acting as an interface towards the superconducting link (SC link) 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 zones. The IT STRING will reproduce the configuration of the left side of point 5 (P5L). The powering will be done through the SC link system and proto or pre-series HL-LHC power converters (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 insuring 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 P5L 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 whether 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 dismounting 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 DAY, a review organised 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 (ex. MQXFS4 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 screen 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 (MQXFS4) in a vertical cryostat for its thermos-mechanical behaviour in the presence and use of the CLIQ protection system.

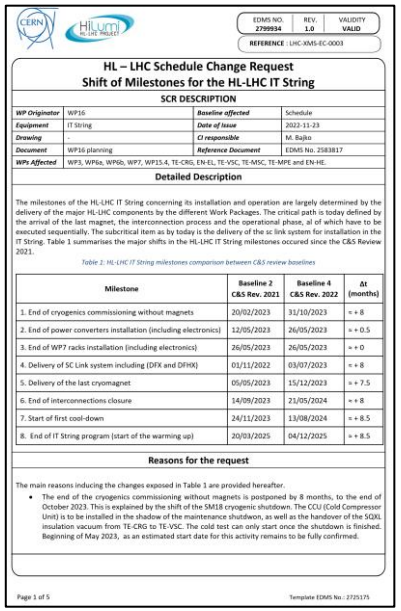
In this optimisation process, a common vacuum between beam tube and insulation is also considered as a good compromise.

The results of the optimisation efforts and the different configurations has been presented at the TCC 66th, and are approved in February 2019.

Impact on Cost, Schedule & Performance

Ex: EDMS 2102130

SCR



HL – LHC Schedule Change Request
Shift of Milestones for 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. Bajko
Document	WP16 planning	Reference Document	EDMS No. 2583817
WPs Affected	WP3, WP6a, WP6b, WP7, WP15.4, TE-CRG, EN-EL, TE-VSC, TE-MSC, TE-MPE 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, al of which have to be executed sequentially. The subcritical item as by 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 occured since the C&S Review 2021.

Table 1: HL-LHC IT String milestones comparison between C&S review baselines

Milestone	Baseline 2 C&S Rev. 2021	Baseline 4 C&S 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)	01/11/2022	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)	20/03/2025	04/12/2025	+ + 8.5

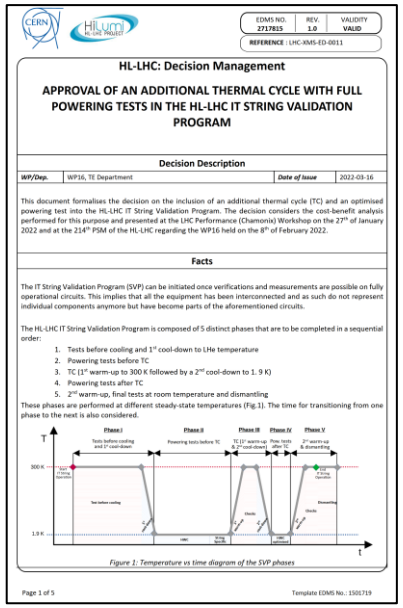
Reasons for the request

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 shutdwon, as well as the handover of the SQXL 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.

Ex: EDMS 2799934

DMR



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 interconnected 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:

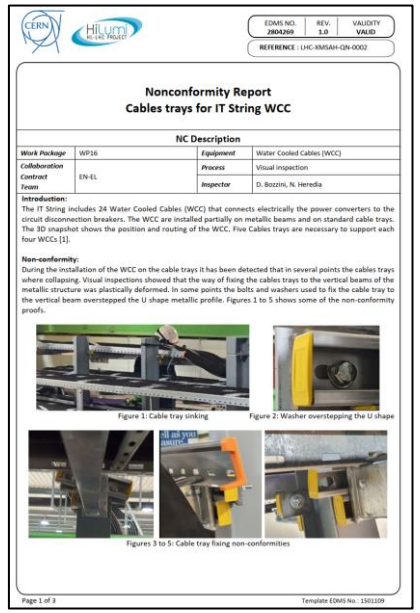
1. Tests before cooling and 1st cool-down to LHe temperature
2. Powering tests before TC
3. TC (1st warm-up to 300 K followed by a 2nd cool-down to 1. 9 K)
4. Powering tests after TC
5. 2nd warm-up, final tests at room temperature and dismantling

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

Ex: EDMS 2717815

NCR



Nonconformity Report
Cables trays for IT String WCC

NC Description

Work Package	WP16	Equipment	Water Cooled Cables (WCC)
Collaboration Contract Team	EN-EL	Process	Visual inspection
		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 snapshot shows the position and routing of the WCC. Five Cables 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 collapsing. 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 shape metallic profile. Figures 1 to 5 shows some of the non-conformity proofs.

Figure 1: Cable tray sinking

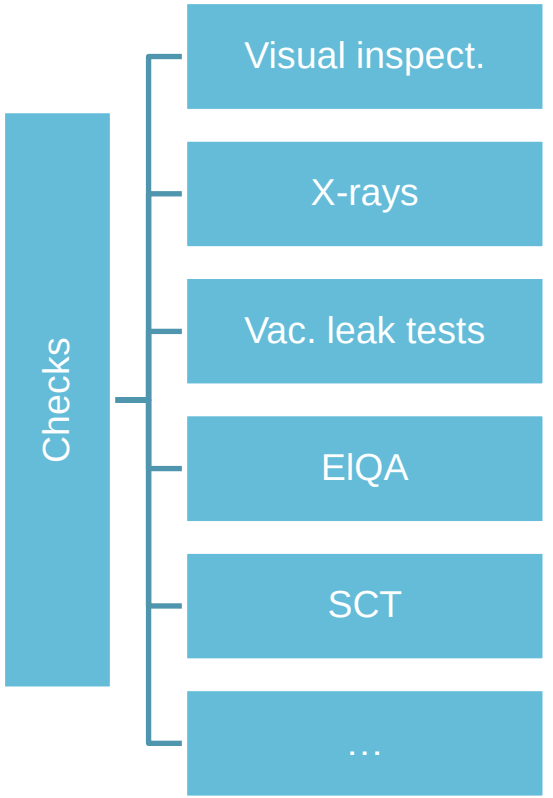
Figure 2: Washer overstepping the U shape

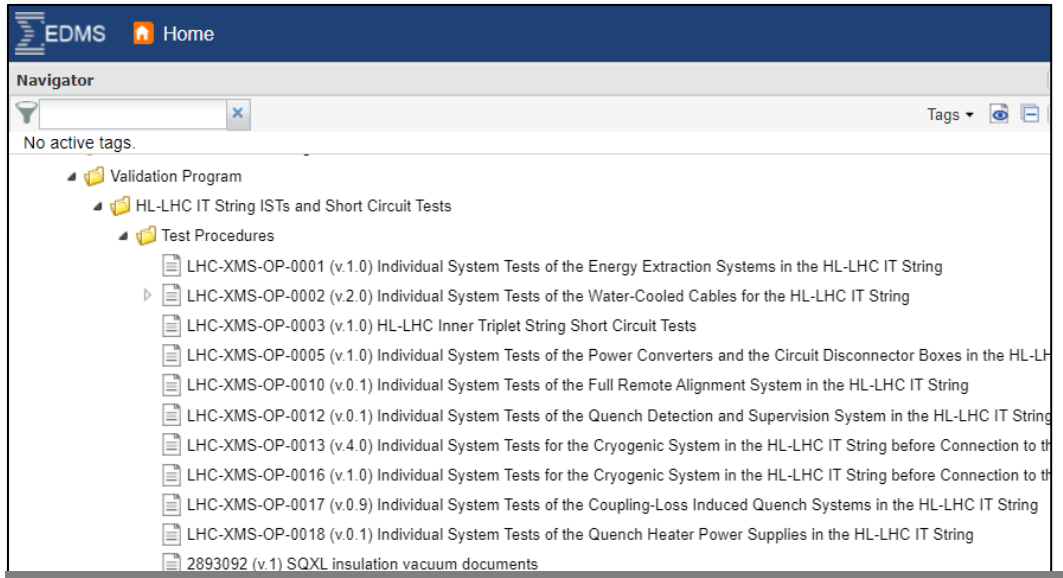
Figures 3 to 5: Cable tray fixing non-conformities

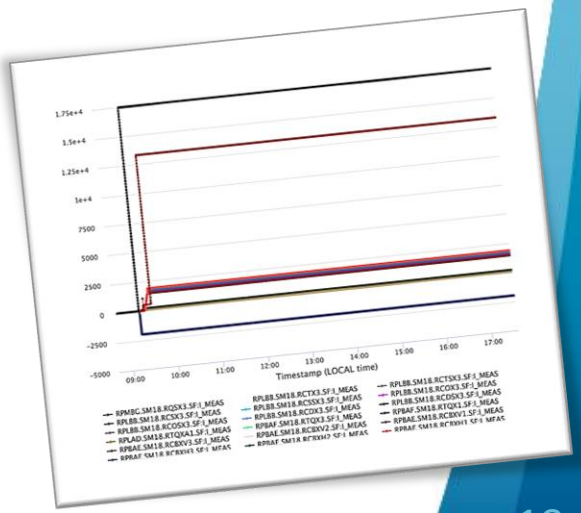
Ex: EDMS 3025021

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.



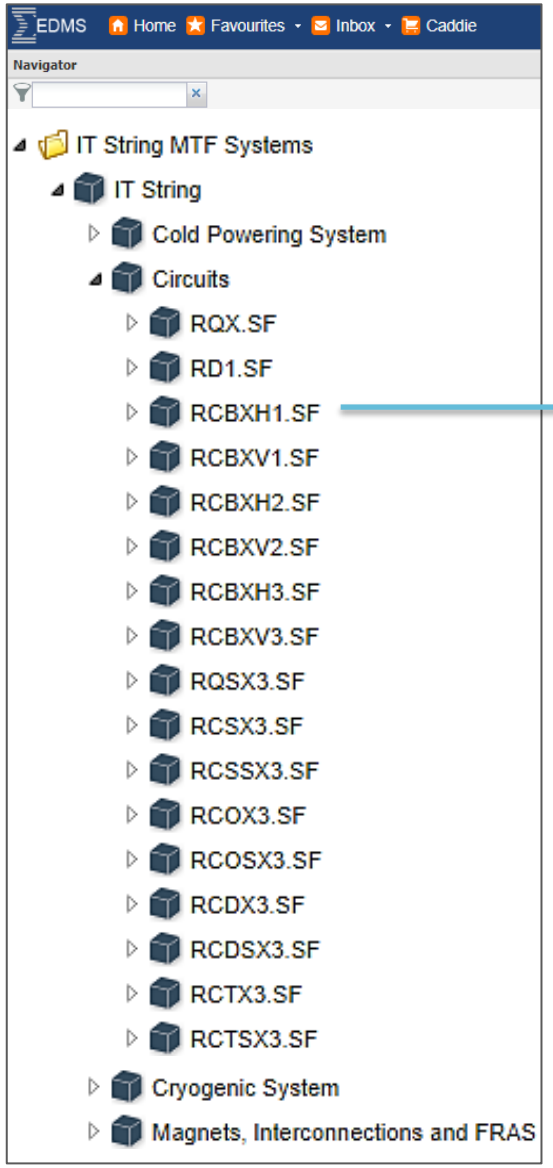


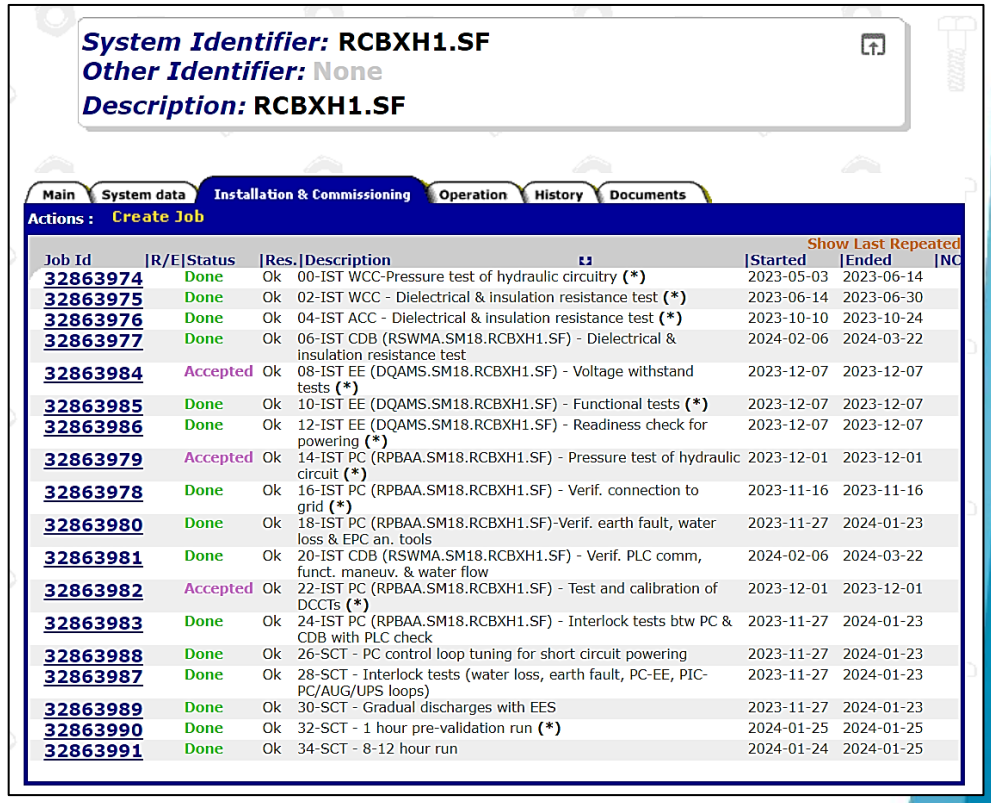


More info in “IST, SCT and Powering Test for the HWC of the HL-LHC IT String” by S. Yammine

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 structure is divided in several systems, and steps are defined for each of them.
- Steps are extracted from commissioning and operation procedures.





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

Main | System data | Installation & Commissioning | Operation | History | Documents

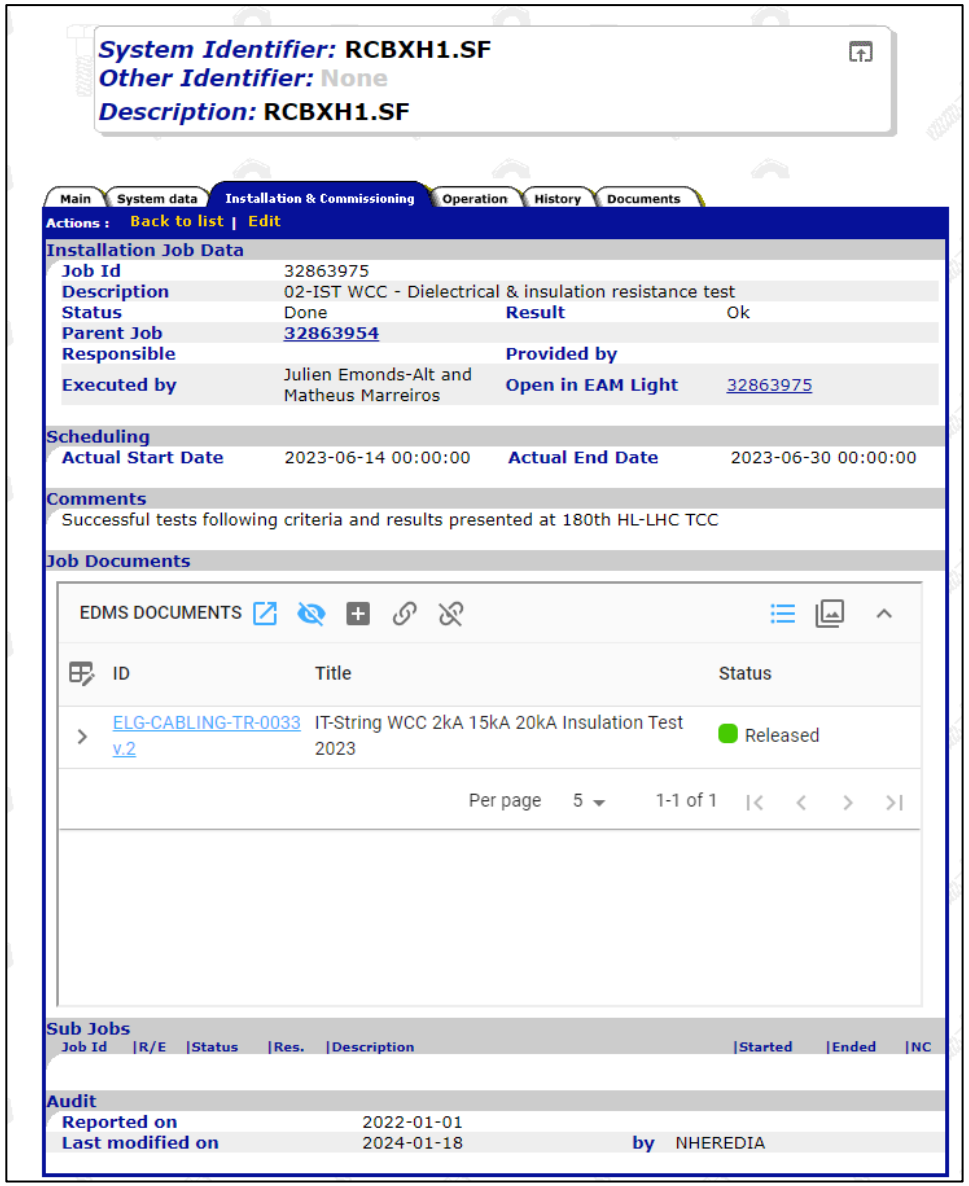
Actions : Create Job

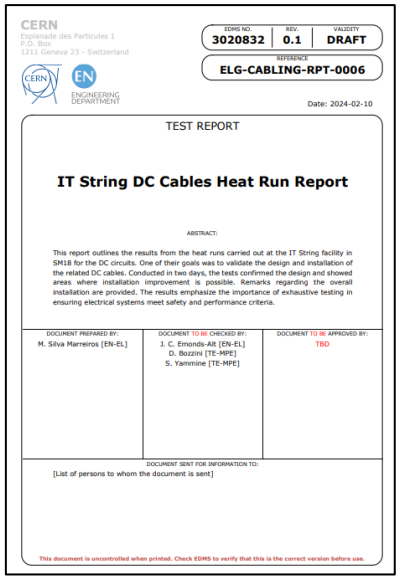
Show Last Repeated

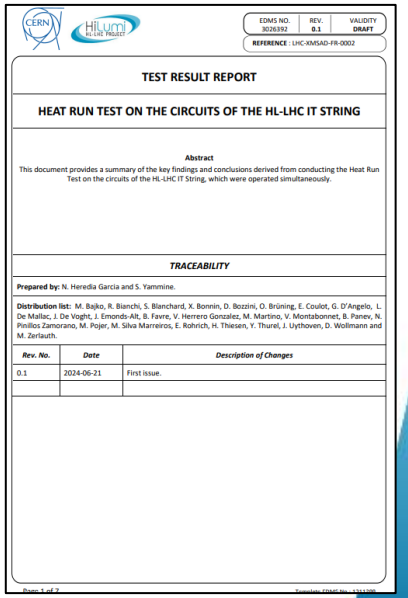
Job Id	R/E	Status	Res.	Description	Started	Ended	NC
32863974		Done	Ok	00-IST WCC-Pressure test of hydraulic circuitry (*)	2023-05-03	2023-06-14	
32863975		Done	Ok	02-IST WCC - Dielectrical & insulation resistance test (*)	2023-06-14	2023-06-30	
32863976		Done	Ok	04-IST ACC - Dielectrical & insulation 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. maneuv. & 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	

Quality control: Steps

- Information included in a MTF step:
  - Description
  - Status
  - Executor
  - Activity start date
  - Activity end date
  - EDMS docs.: Test result reports, confirmation emails, non-conformities







Non-conformities: Process

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

Detection (QC) → Technical discussions → Decision → Actions ongoing → Closure

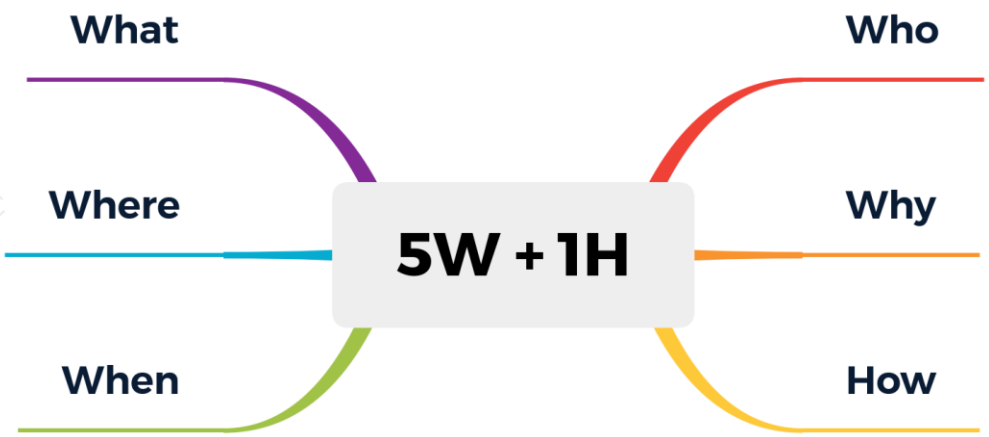
Document Draft → EDMS Evaluation → Review STCM → Closure

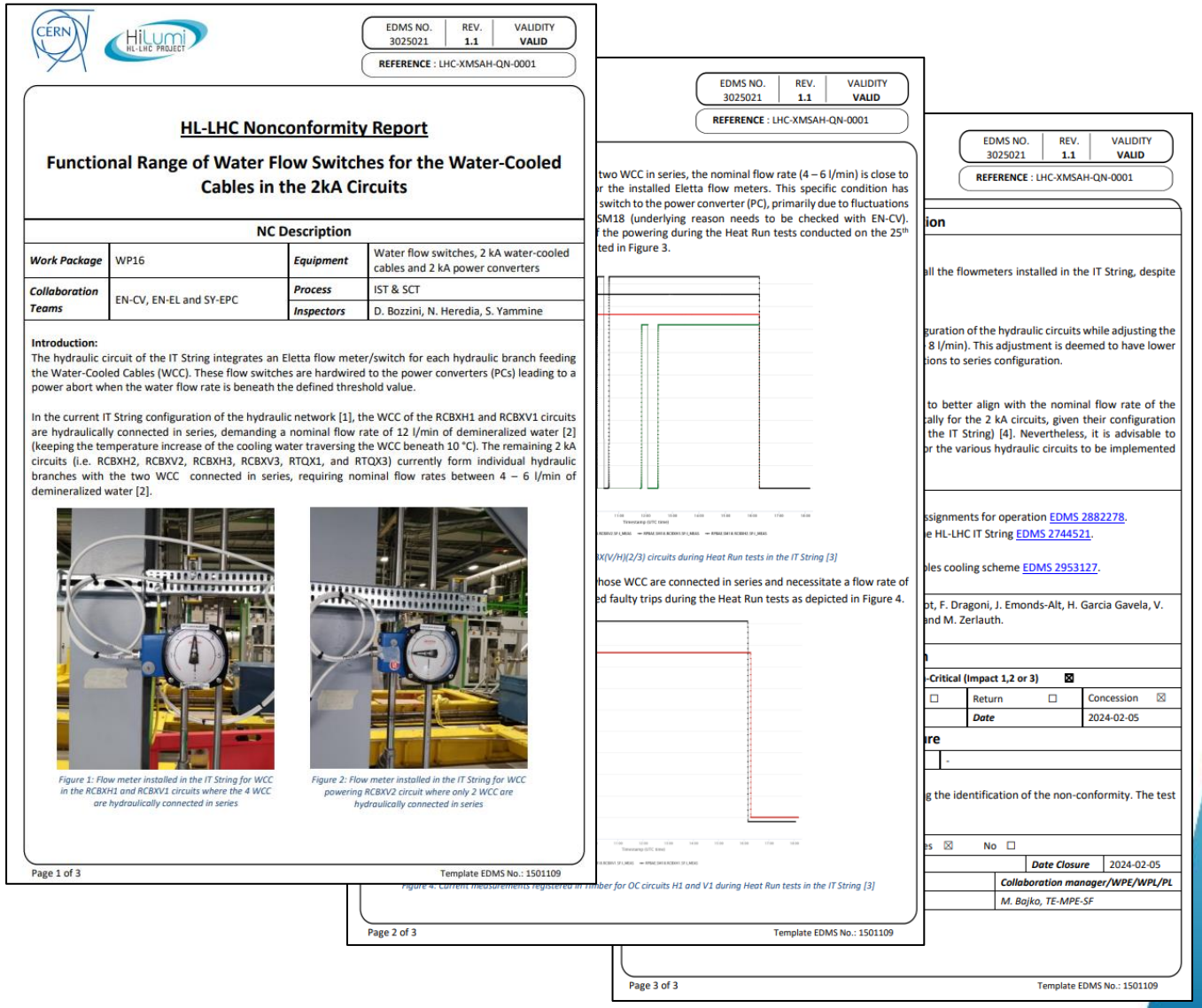
Feedback from IT String Day III:

- Addressing non-conformities: It's imperative to document these instances comprehensively, to prevent their recurrence in the HL-LHC tunnel installation ensuring a meticulous follow-up by the entire IT-String / HL-LHC project teams.

Non-conformities: Template

- Information included in the non-conformity:





EDMS NO. 3025021 | REV. 1.1 | VALIDITY 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 SY-EPC	***Process***	IST & SCT
		Inspectors	D. Bozzini, N. Heredia, S. Yammine

Introduction:
The hydraulic circuit of the IT String integrates an Eletta 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

Page 1 of 3 — Template EDMS No.: 1501109

Page 2 of 3 — Template EDMS No.: 1501109

Page 3 of 3 — Template EDMS No.: 1501109

Non-conformities: Table

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

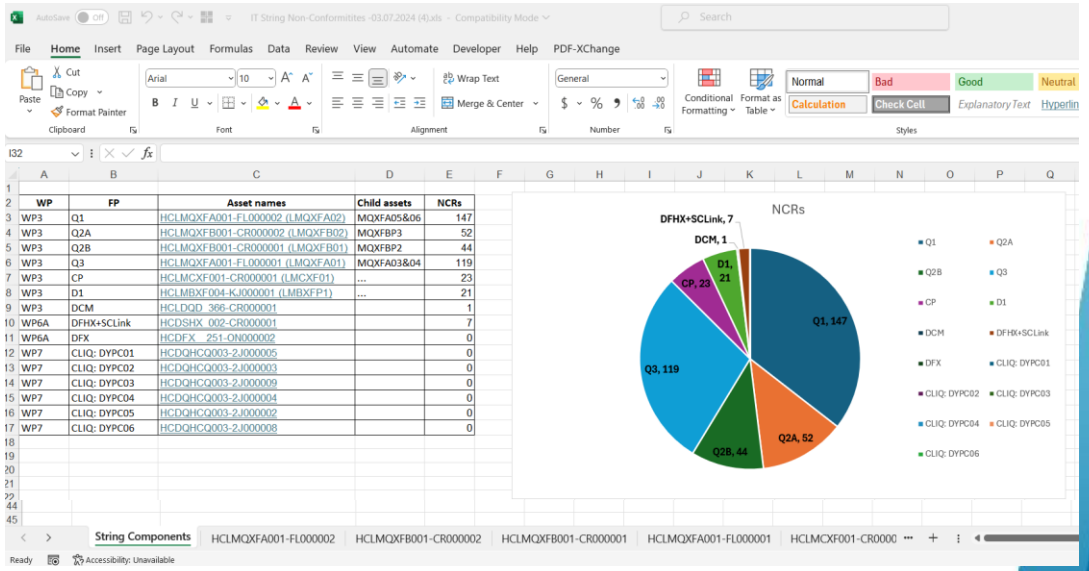
Ref.	NCR Description	Status	Ap. Date	EDMS	Criticality	Decision	Manag. team	Equipment	Detect. phase	Det. Year	Class
	NCR of TL02	1. To be Opened	TBD	TBD	Non-Critical	Repair	WP16	Cryogenics	Commissioning	2024	Mechanical
LHC-XMSAD-QN-0003	NCR of water-cooling plates for busbars	2. In Work	TBD	3162382	Non-Critical	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.

Feedback from IT String Day III:

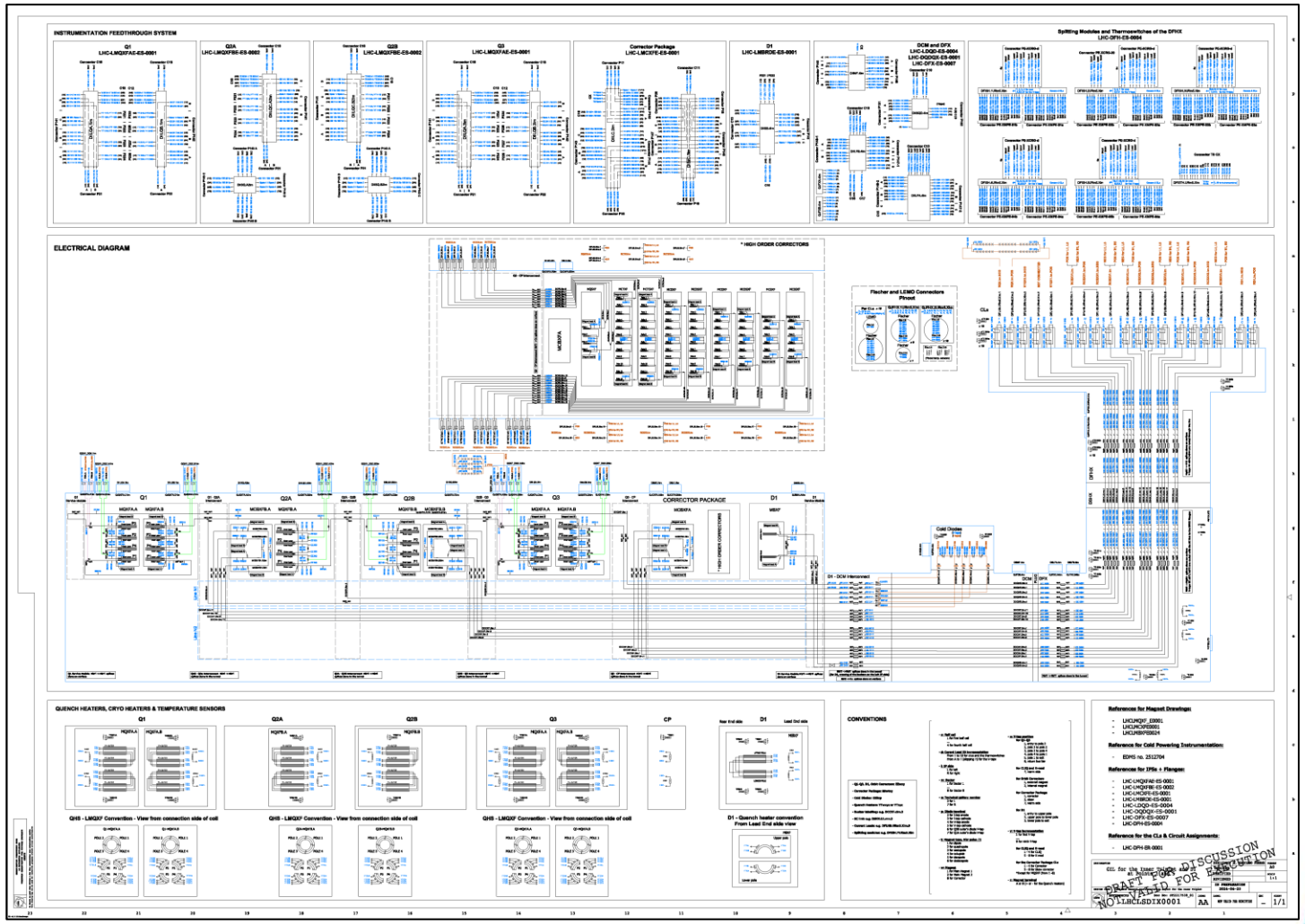
- Handling Non-Conformities: Identifying non-conformities for the String (out of all non-conformities traced across the project), crucial for HL-LHC, presents a challenge. Discussions focused on methods like tagging these issues in databases or Excel sheets. The focus is on comprehensive documentation and ensuring easy accessibility of these records for future reference is crucial.



WP	FP	Asset names	Child assets	NCRs
WP3	Q1	HCLMQXFA001-FL000002 (LMQXFA02)	MQXFA05&06	147
WP3	Q2A	HCLMQXFB001-CR000002 (LMQXFB02)	MQXFBP3	52
WP3	Q2B	HCLMQXFB001-CR000001 (LMQXFB01)	MQXFBP2	44
WP3	Q3	HCLMQXFA001-FL000001 (LMQXFA01)	MQXFA03&04	119
WP3	CP	HCLMCXF001-CR000001 (LMCXF01)	...	23
WP3	D1	HCLMBXF004-KJ000001 (LMBXFP1)	...	21
WP3	DCM	HCLDQD_366-CR000001		1
WP6A	DFHX+SCLink	HCDSHX_002-CR000001		7
WP6A	DFX	HCDFX_251-ON000002		0
WP7	CLIQ: DYPC01	HCDQHCQ003-2J000005		0
WP7	CLIQ: DYPC02	HCDQHCQ003-2J000003		0
WP7	CLIQ: DYPC03	HCDQHCQ003-2J000009		0
WP7	CLIQ: DYPC04	HCDQHCQ003-2J000004		0
WP7	CLIQ: DYPC05	HCDQHCQ003-2J000002		0
WP7	CLIQ: DYPC06	HCDQHCQ003-2J000008		0

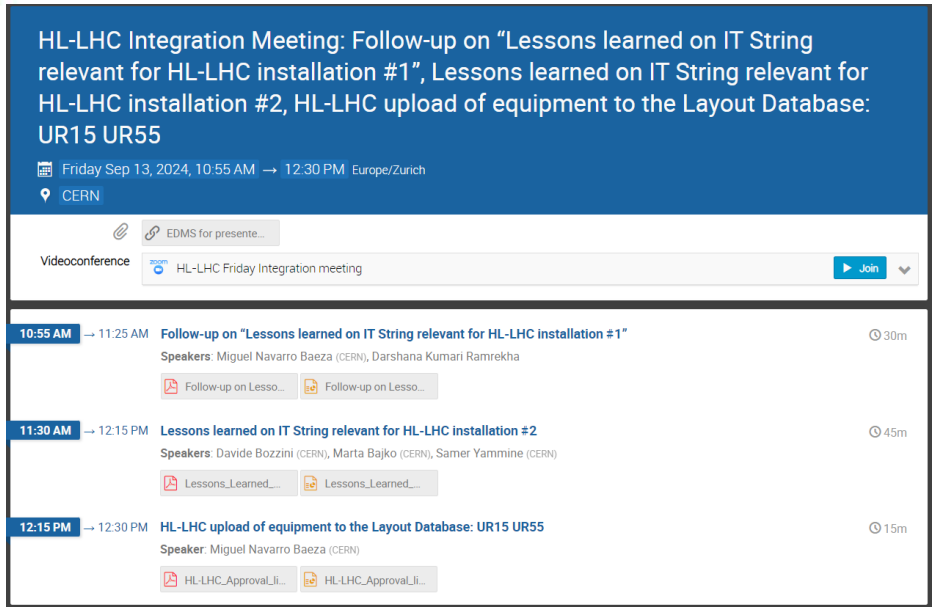
Non-conformities: Quality Meetings

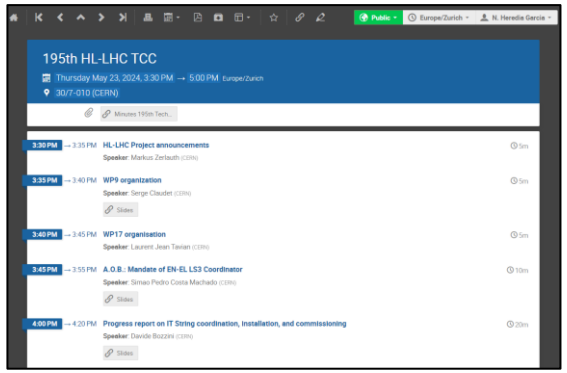
- For the equipment non-conformities tagged as “electrical”, an exercise is being initiated in the coordination team to integrate them as part of the general instrumentation layout drawing.
- Deviations from the baseline will also be signaled in this “As-built” drawing.
- This drawing will help to analyse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

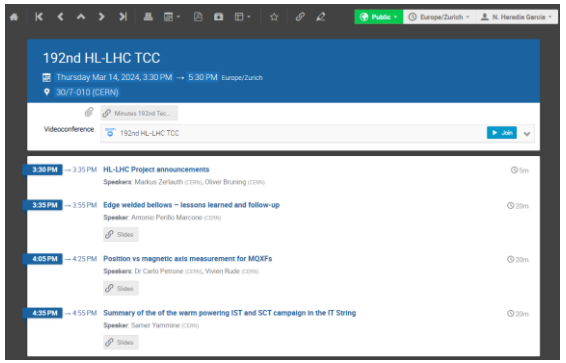


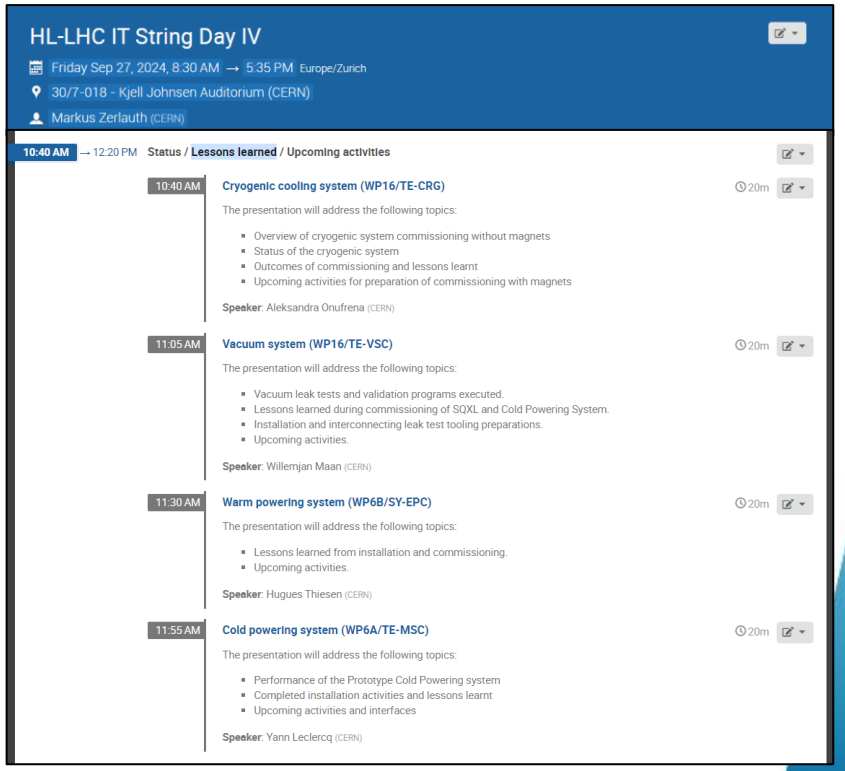
Lessons Learned

- 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.









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

Special thanks to all the collaborators for their efforts