HL-LHC IT String
General Status Budget and Schedule

M. Bajko TE-MPE-SF/HL-LHC WP16
On behalf of the SF section and WP16 team

HL-LHC IT STRING days IV the 27th of September 2024

OUTLINE

- RECALL OF THE ORGANISATION (2024 vs 2023)
- STATUS OF ACTIVITIES (2024 vs 2023)
- IMPACT OF THE DELAYS ON THE SCHEDULE
- RESOURCES DURING LS3
- UPCOMING ACTIVITIES
- PLANS for STRING OPERATION
- BUDGET
- SUMMARY
- LESSONS LEARNED

WP16
HL-LHC IT STRING and HL-LHC HWC

Marta Bajko

Mirko Pojer

Extract from the Mandate of the WP16

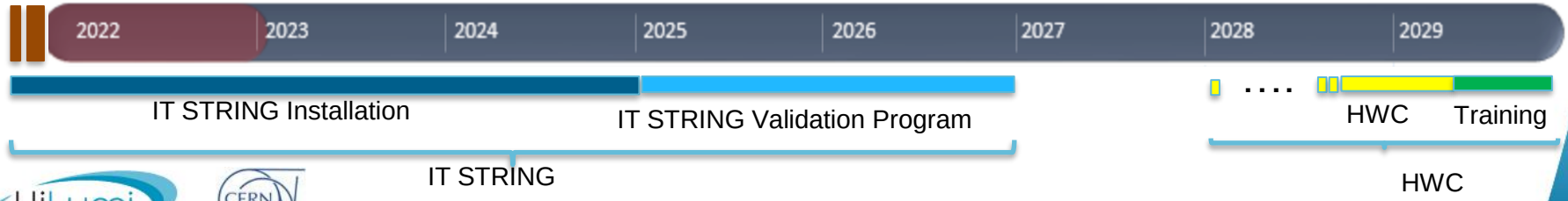
The **HL-LHC IT STRING** will serve as a test bed [….]. The HL-LHC IT STRING should therefore validate operational modes […] in view of the hardware commissioning and operation periods in the HL-LHC era. […]

The present reporting is essentially done in this part

The **HARDWARE COMMISSIONING** phase should extend its activity to all equipment that will be installed in the insertion regions [..]. The hardware commissioning (HWC) activity will focus on the preparation and execution of detailed procedures […] including their *individual system tests* and a *short circuit test campaign*, […] consolidated operational tools obtaining the final *validation of the superconducting circuits*.

But …IST, SCT, HWC Procedures, Software and Control is not STRING specifique, but HL

The IT STRING test will ensure a successful and efficient HWC of the HL-LHC!



IT STRING –Increasing ACTIVITIES and SAFETY

REFERENCE | EDMS NO. 3072722 | REV. 1.0 | VAL

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3. Type of visits

3.1 Professional visit for CERN members

Professional visits are only for CERN personnel already involved on the IT String construction, commissioning, and operation. Technical visits aim at checking on the field status of the facility without execution of work. VICs or preparatory inspections prior subcontractor's interventions are two examples of a technical visit.

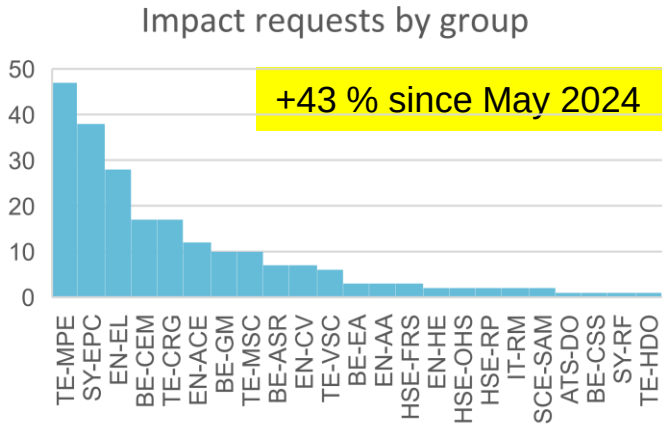
The conditions to access for a technical visit are a valid SM-18 Access and safety training, an approved Impact request and the PPEs. Before accessing the facility, the escort shall pass by the control room to announce him/her-self and for verifying specific conditions.

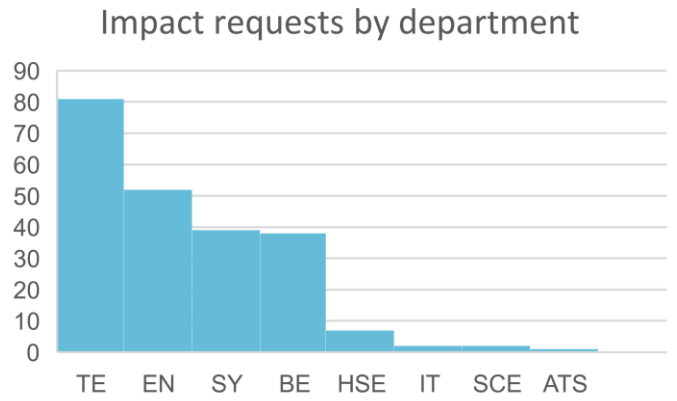
3.2 Professional visit with external participants

Today visist's IMPACT 236876

Professional visit with external participants includes professional personnel accessing punctually the IT String not having a valid SM-18 Access and safety training. External participants are accompanied by the visit organizer and by an IT String team member. Examples of external visits includes personnel and professional involved on equipment supply, equipment transport, engineering studies, safety audits.

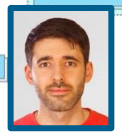
The conditions to access for a visit with external participants are an approved Impact request created by a CERN member of personnel qualified to organize technical visits, the wearing of PPEs.





See talk of D. Bozzini

HL-LHC IT STRING organization 2023-2024



WP16 responsibility (Infrastructure)

Other WPs' Reponsability (Componenets)

TE-MPE-SF

EN-ACE

HL-LHC PO

https://cern.sharepoint.com/sites/HL-LHC/WP16/SitePages/WP16-Key-Roles.aspx

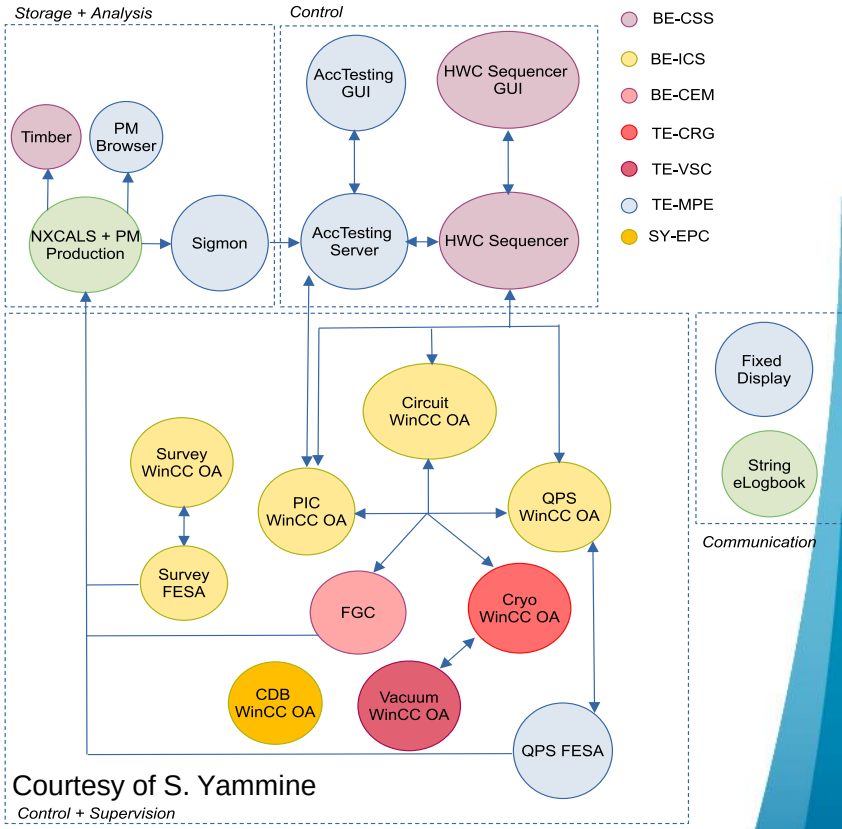
CONTROL AND SOFTWARE FOR IT STRING

- RoadMap---set up done by S. Yammine
- Interface---mapped by S. Blanchard

S. Blanchard , TE-MPE-SF

Coordinate the work of the Control and Software (new role)

S. Yammine will stay very active in the follow up as part of the SVPM



Courtesy of S. Yammine

The IT STRING DAY III outcome justifies also this choice

See talk of S. Blanchard

Control, Analysis and Supervision Software for the HL-LHC IT String HWC Powering Tests

TECHNICAL COORDINATOR of the IT STRING (new role)

D. Bozzini TE-MPE-SF

In case of absence

S. Yammine TE-MPE-SF

Define and implement access and control monitoring procedures.	Plan and coordinate of operational maneuvers.	Issue all necessary authorizations, including access authorizations.
Identify the person responsible for lockout/tagout procedures.	Monitor the operations carried out and their progress.	Monitor and plan the maintenance of the facility

See talk of D. Bozzini

QUALITY FOR THE HL-LHC IT STRING

N. Heredia Garcia ,TE-MPE-SF dedicated new role

Communication channels update

Setup structure

Extraction of test steps from procedures

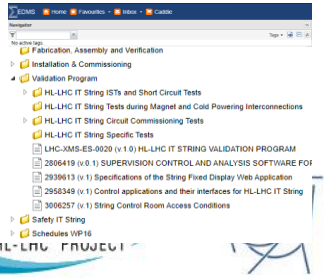
Attachment of test reports to MTF

Update of test steps status

Check test results values wrt procedures

MTF

Register of procedures in EDMS



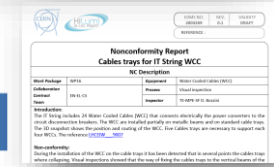
Quality role attributions

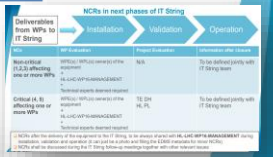
Contribution documents update

Non-conformities documentation

Link for non-conformities of other WPs

Lessons learned compilation



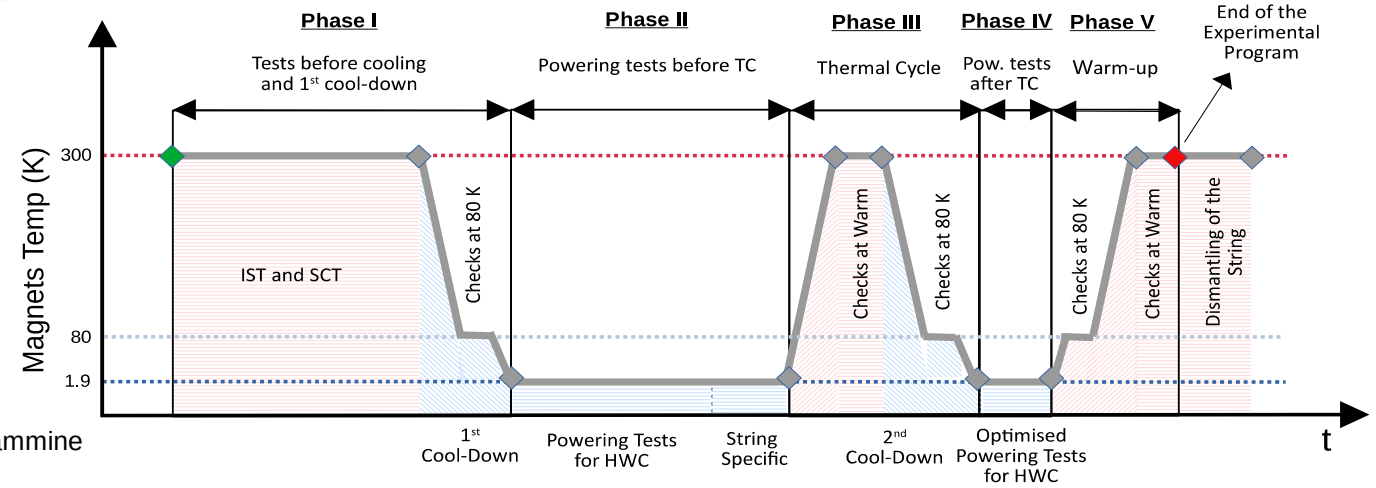


See talk of N. Heredia

STRING VALIDATION PROGRAM

S. Yammine, TE-MPE –SF SVP Responsible (existing role)

No change in the communication and working methods.



Courtesy of S. Yammine

To be remarked that all documents (IST, SCT, HWC procedures) are prepared for the HL-LHC and will be tested in the IT STRING. As such this work is fully on the WP16 HWC part.

See talk of S. Yammine

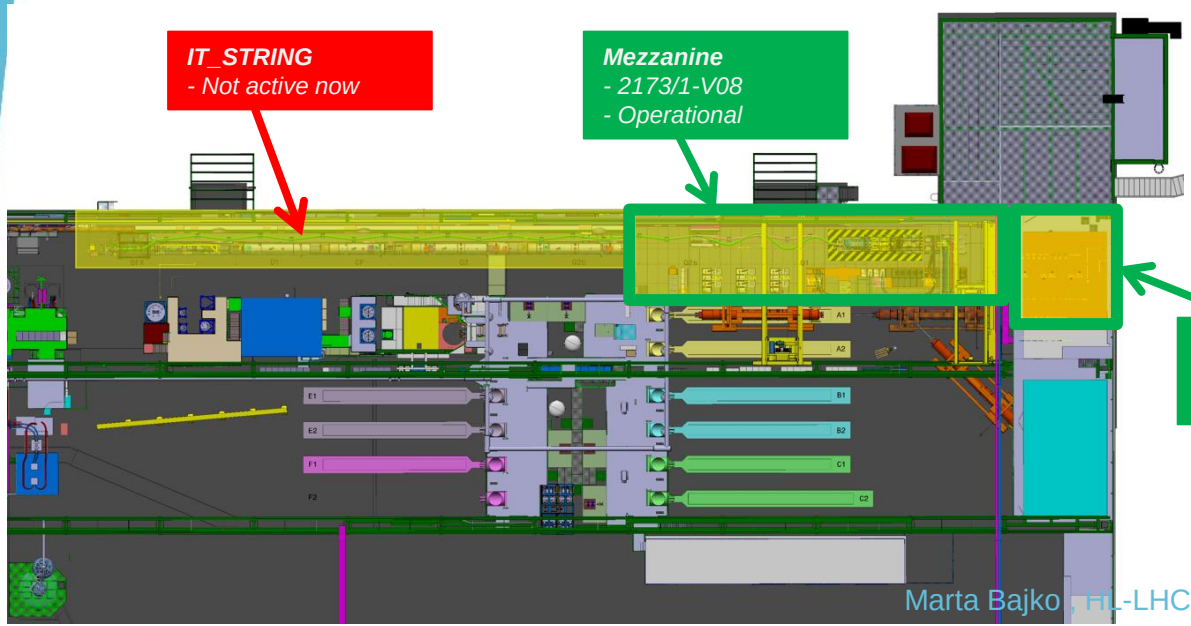
STRING SAFETY (TSO)

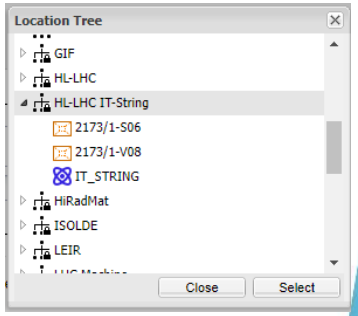
D. Bozzini, TE-MPE –SF SSM Responsible (existing role!)

No change in the communication and working methods.

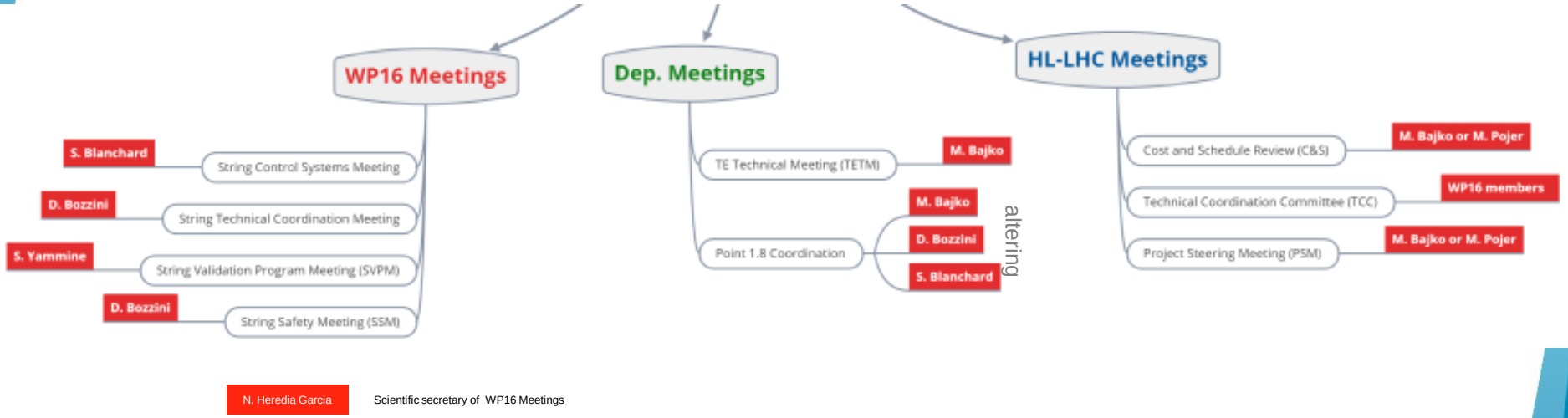
- Same approach as in the accelerators
- Three areas, two are operational
- Traceability of interventions and associated safety risks
- Train personnel that will work in HL-LHC

SM18					
Building				Surface / Underground	Facility
Num	Floor	Area / Room	Name		
2173	R	IT_STRING	IT-String area	Surface	HL-LHC IT-String
2173	1	1-S06	Control room	Surface	HL-LHC IT-String
2173	1	1-V08	Mezzanine	Surface	HL-LHC IT-String



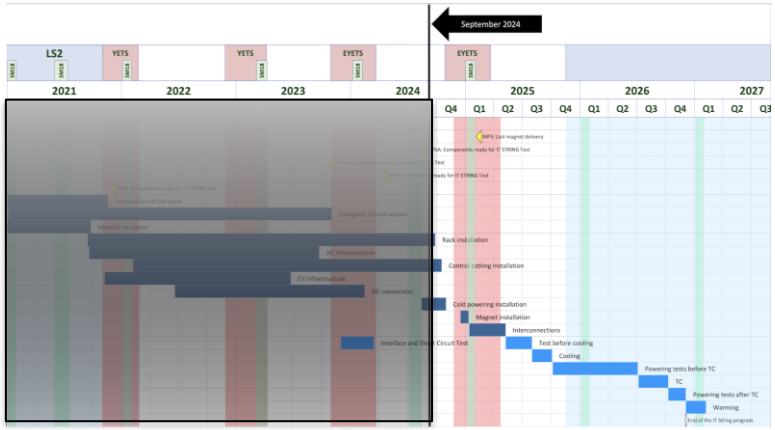


HL-LHC IT STRING organization 2024
REPORTING

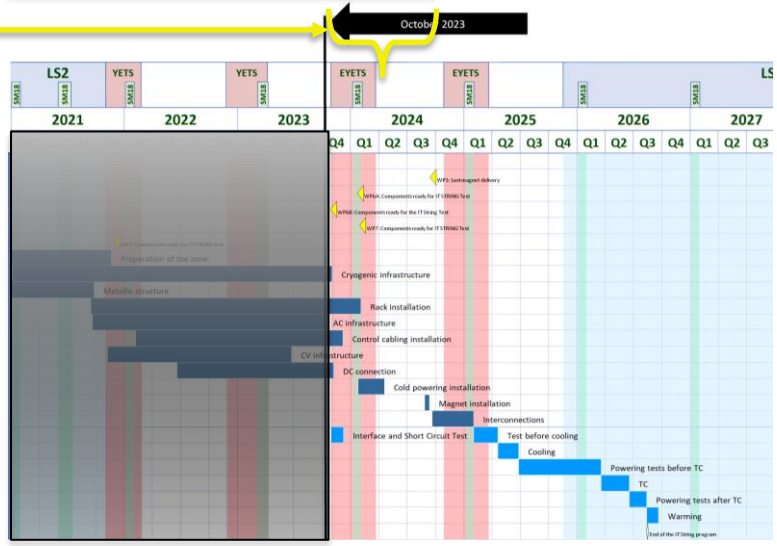


https://cern.sharepoint.com/sites/HL-LHC/WP16/SitePages/WP16-Key-Roles.aspx

STATUS REPORT
IN THIS TALK



2024



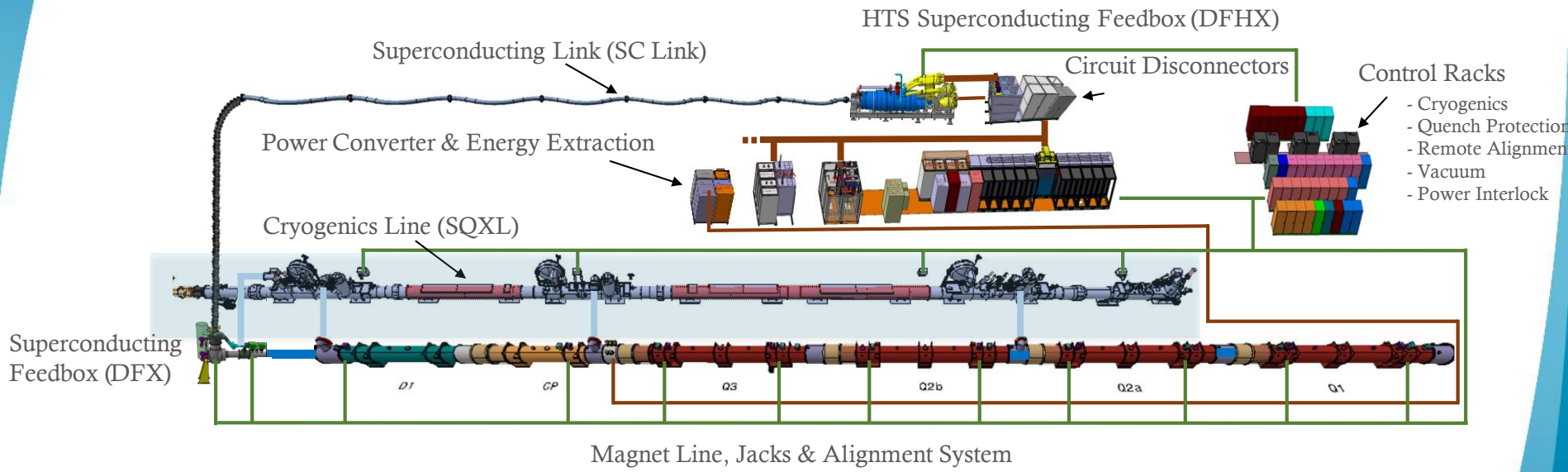
2023

A slide from 2023 STRING DAY III

UPCOMING ACTIVITIES

Remaining activities of the infrastructure
Short Circuit Test
SC Link installation
Cryo magnet installation

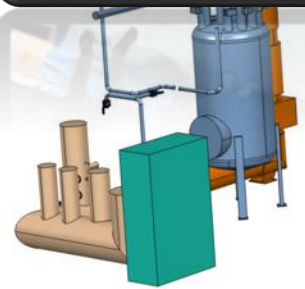
CRYOGENIC INFRASTRUCTURE



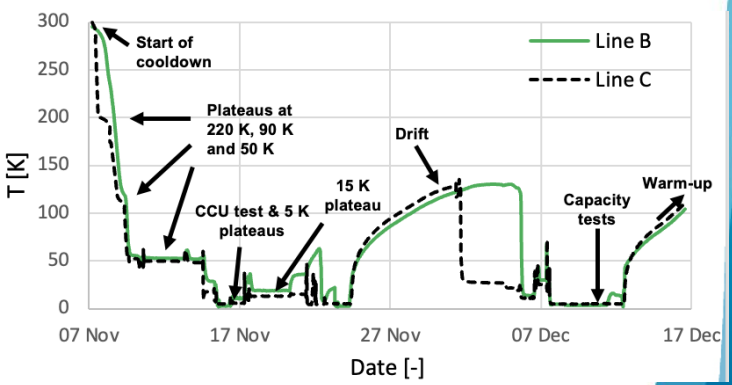
CRYOGENIC EQUIPMENT and VSC activity

PCDS, SQXL and associated CONTROL installation including the Cold Compressor COMPLETED;
HWC phase 1 (IST at cold) **COMPLETED**

CRG delivery (WP9)

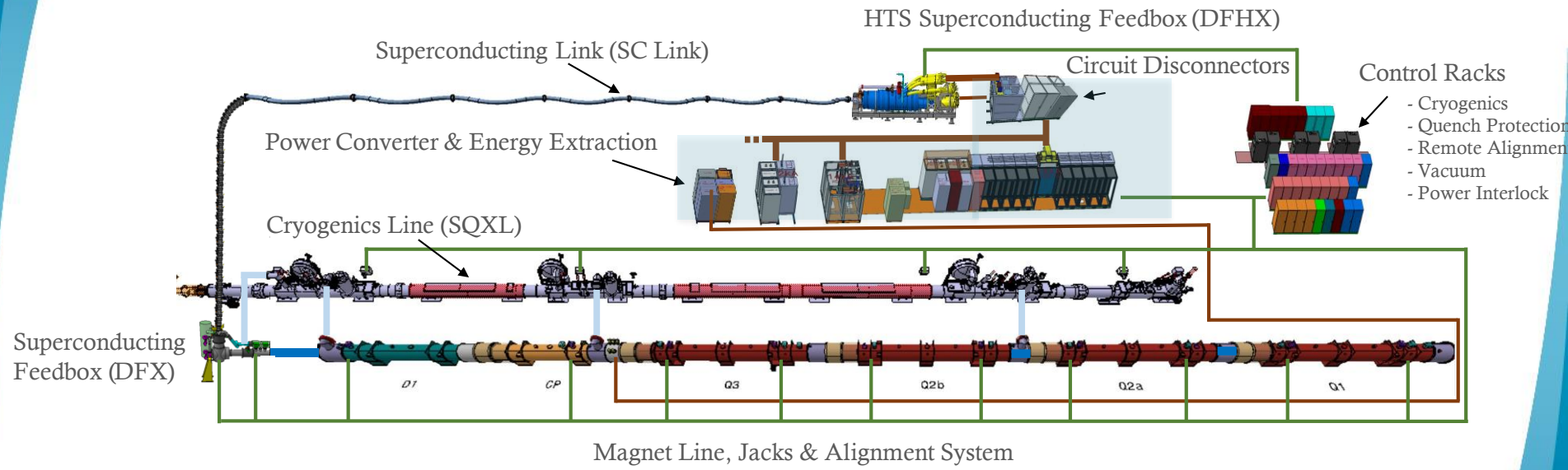


Phase 1: commissioning **without magnets** (1a controlled cooldown and mechanical integrity validation, 1b further validation and studies (e.g. heat load measurements, refined control sequences), 1c additional opportunity to validate CCU logic (nominal and fast transients), mechanical consolidations (TL01 repair) and system tests



See presentation A. Onufrena (CRG) and W. Maan (VSC)

SHORT CIRCUIT TEST



SHORT CIRCUIT TEST: COMPONENTS

COMPLETED

W6b, WP7, WP16 delivery


Rapport de vérification initiale

N° E3678430230 1R001

IAD ELEC N° 050 2023

CERN
2173
SM18 HALL D'ASSEMBLAGE DES AIMANTS
SE18
01630 PREVESSIN

2173
LH-LHC IT-STRING

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FINANCE AND ADMINISTRATIVE PROCESSES D
Accounts Payable/Bureau des factures
(A-3-017)
1211 GENEVE 23
SUISSE

CERN
2173
SM18 HALL D'ASSEMBLAGE DES AIMANTS
SE18
01630 PREVESSIN

19/11/2023

LEULLIETTE DAVID

Schéma E3678430230 1R001

Observation(s) constatée(s)

19/11/2023

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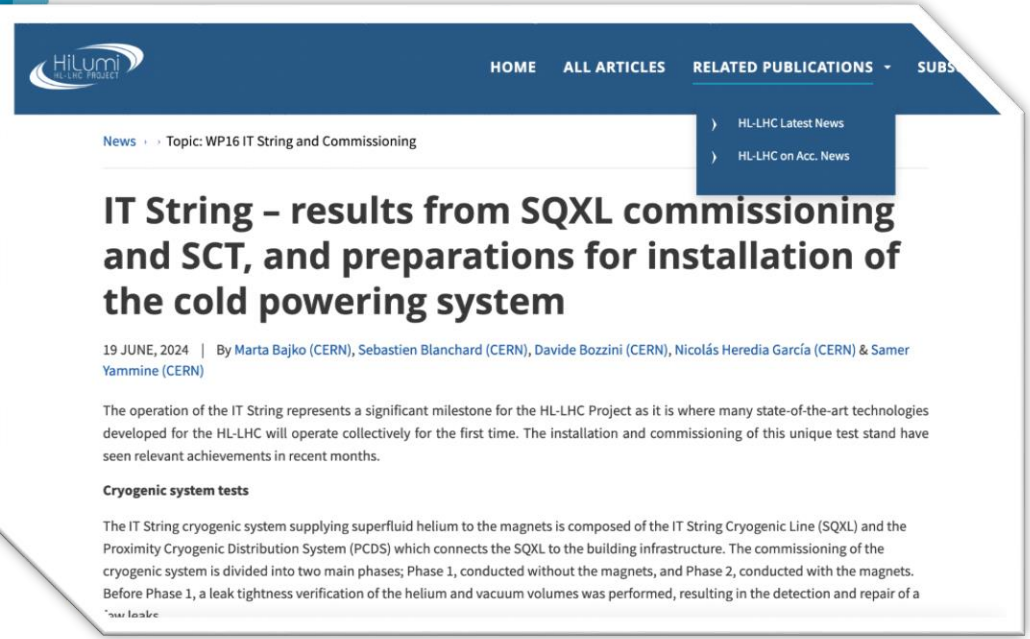
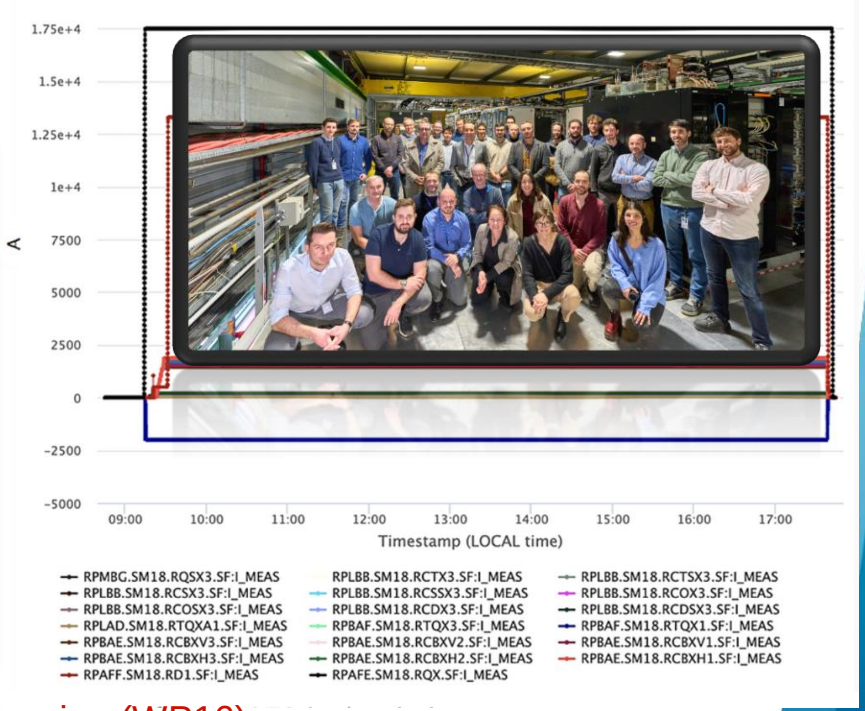
SHORT CIRCUIT TEST

The steps executed during short-circuit tests included the validation of interlocks, the tuning of control loops, the discharge of the energy extraction system and power converter, and the 8-hour heat run test for thermal validation. This last test required the simultaneous powering of all circuits at ultimate current for 8 hours.

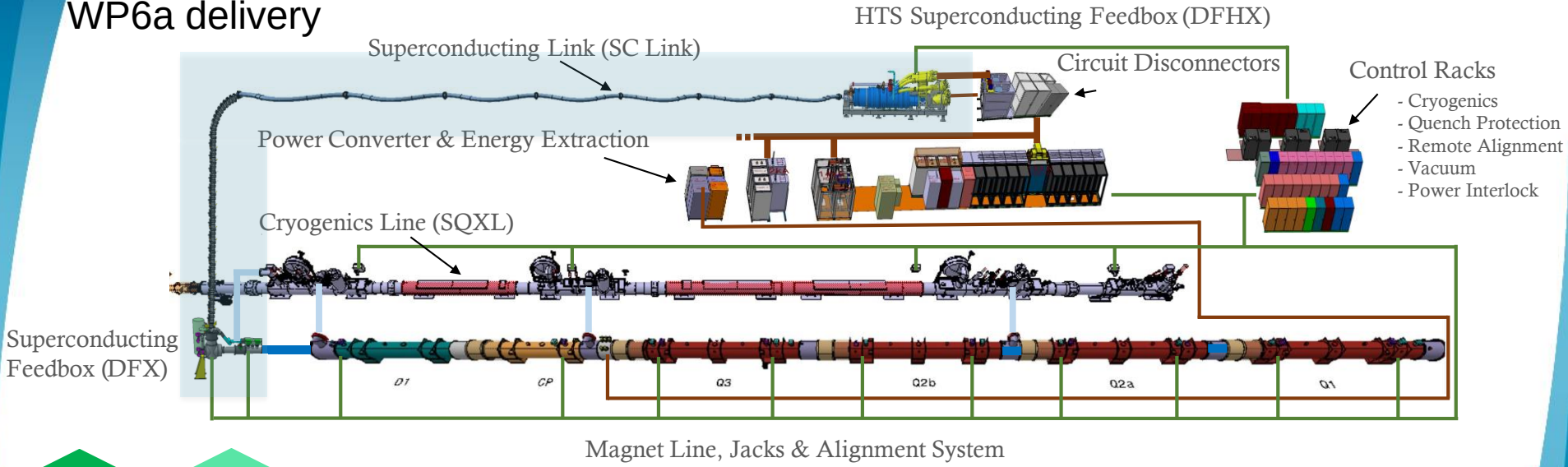


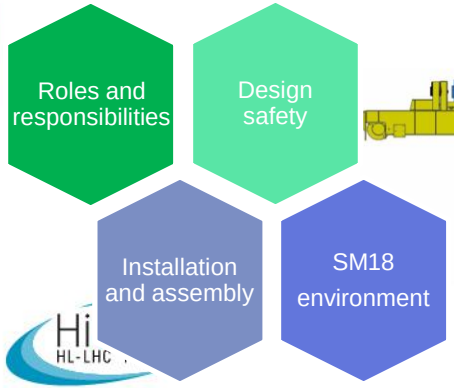


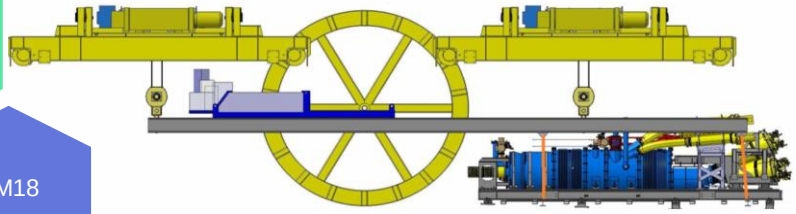
See presentation of H. Thiesen (WP6b), S. Yammine (WP16)

SC Link Installation

WP6a delivery







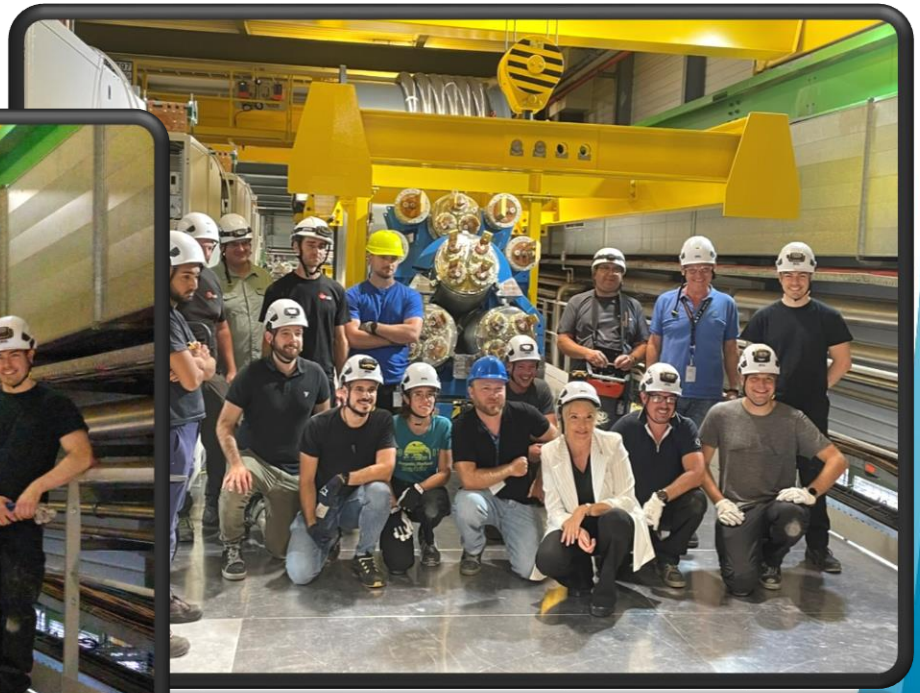
[…] unique set of challenges, primarily centered around the handling of the SC link connected to the DFHX and its positioning on the platform.

See presentation of Y . Leclerc (WP6a)

Sc Link INSTALLATION IN THE IT STRING

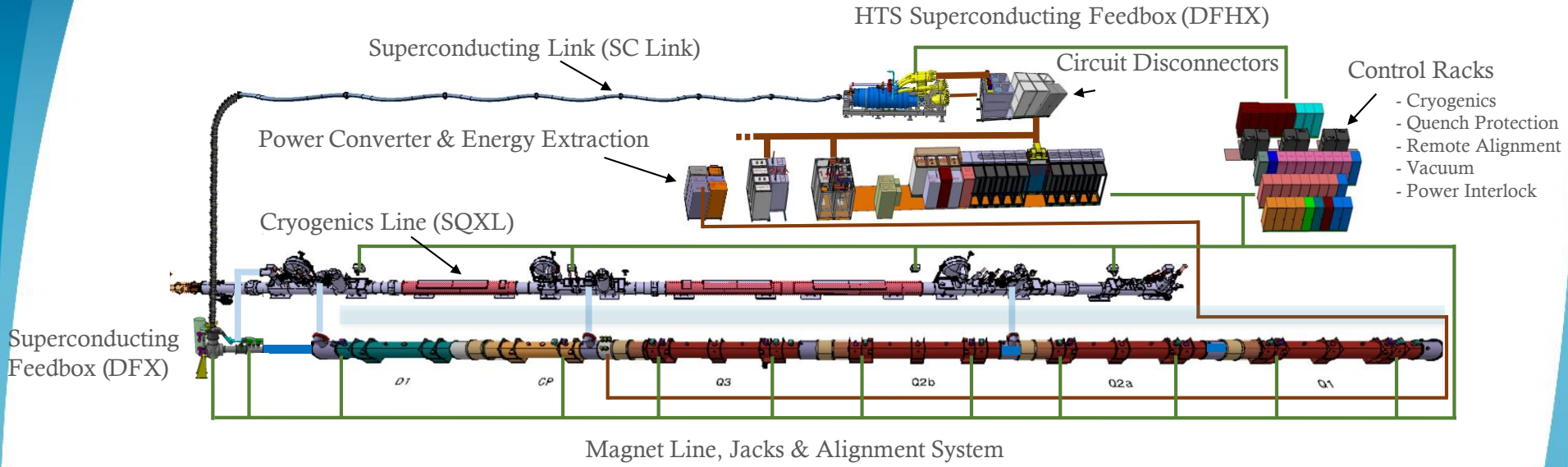
COLLABORATIVE EFFORTS of WP16, WP6a with the key actors of EN-HH

WP6a + WP16 team



WP6a team

ALIGNMENT EQUIPMENT INSTALLATION

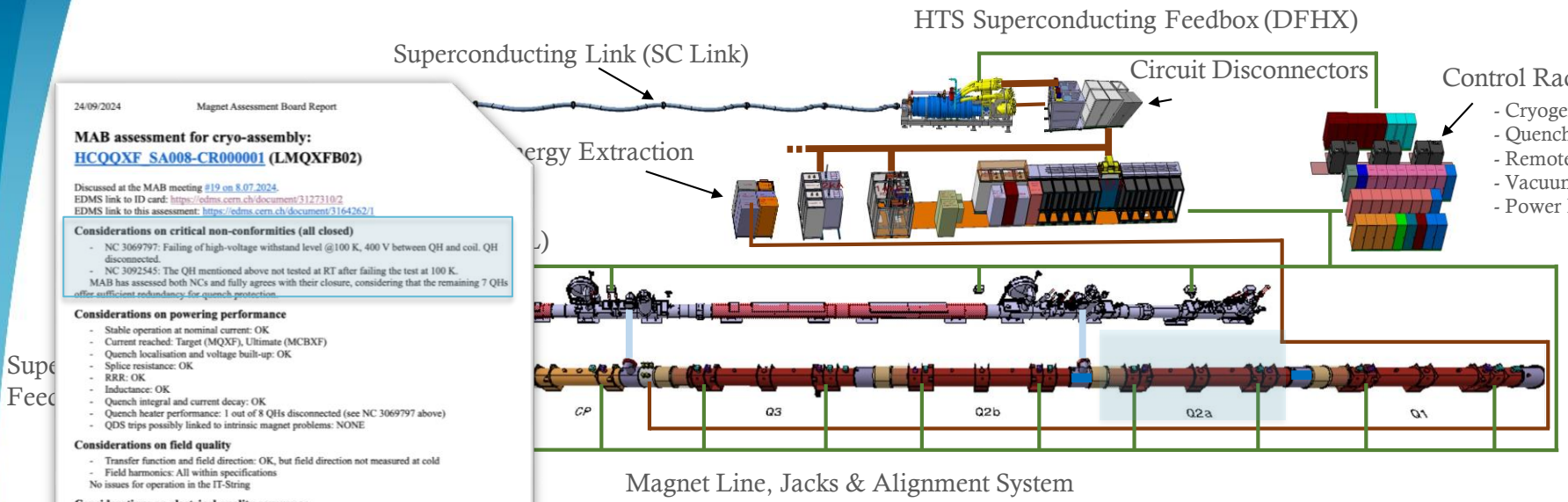


Installation started

WP19 delivery

See presentation of H. Mainaud Duarte

CRYO COLD MASS Installation



Magnet Line, Jacks & Alignment System

24/09/2024 Magnet Assessment Board Report

MAB assessment for cryo-assembly:
HCQQXF_SA008-CR000001 (LMQXFB02)

Discussed at the MAB meeting #19 on 8.07.2024.
EDMS link to ID card: https://edms.cern.ch/document/3127310/2
EDMS link to this assessment: https://edms.cern.ch/document/3164262/1

Considerations on critical non-conformities (all closed)
- NC 3069797: Failing of high-voltage withstand level @100 K, 400 V between QH and coil. QH disconnected.
- NC 3092545: The QH mentioned above not tested at RT after failing the test at 100 K.

MAB has assessed both NCs and fully agrees with their closure, considering that the remaining 7 QHs offer sufficient redundancy for quench protection.

Considerations on powering performance
- Stable operation at nominal current: OK
- Current reached: Target (MQXF), Ultimate (MCBXF)
- Quench localisation and voltage built-up: OK
- Splice resistance: OK
- RRR: OK
- Inductance: OK
- Quench integral and current decay: OK
- Quench heater performance: 1 out of 8 QHs disconnected (see NC 3069797 above)
- QDS trips possibly linked to intrinsic magnet problems: NONE

Considerations on field quality
- Transfer function and field direction: OK, but field direction not measured at cold
- Field harmonics: All within specifications

No issues for operation in the IT-String

Considerations on electrical quality assurance
- Instrumentation integrity: OK
- Quench heater and coil impedances: OK
- High-voltage insulation tests: OK, except NC given above

Considerations on geometry
- Cold-bore shape with unexplained peaks at the extremities

No issues for operation in the IT-String

Miscellaneous considerations
- None

…l assessment

… considers the cryo-assembly suitable for use in the IT-String. Slot number: Q2A
…ment will be made for possible use in the LHC, also considering the future test results of the …n the IT-String.

Installation started:

A. Jack installation,
B. Jumper preparation
C. First Cold Mass Installed

WP3 delivery

See presentation of S. Le Naour

Q2a cold mass installation

COLLABORATIVE EFFORTS of WP16 , WP3 with the key actors of EN-HH

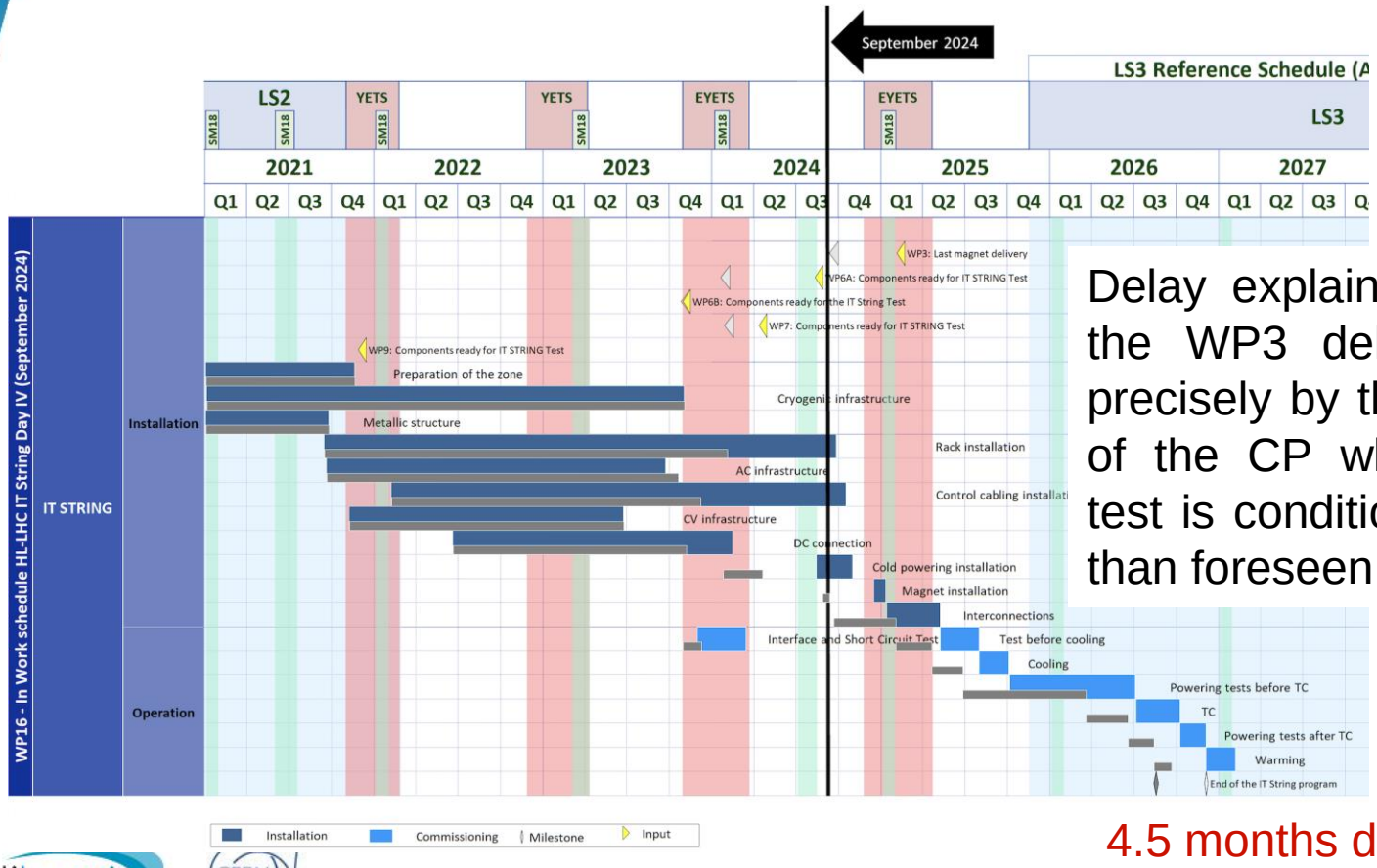
WP3 + WP16 team

WP3 team

UPCOMING ACTIVITIES

Cryo Magnet Installation
SC link and Cryo Cold masses interconnection
Control and software dry runs
QC (leak detections and elqa tests)
Cool down
IT STRING cold circuit powering test

EVOLUTION of the SCHEDULE wrt the STRING day III

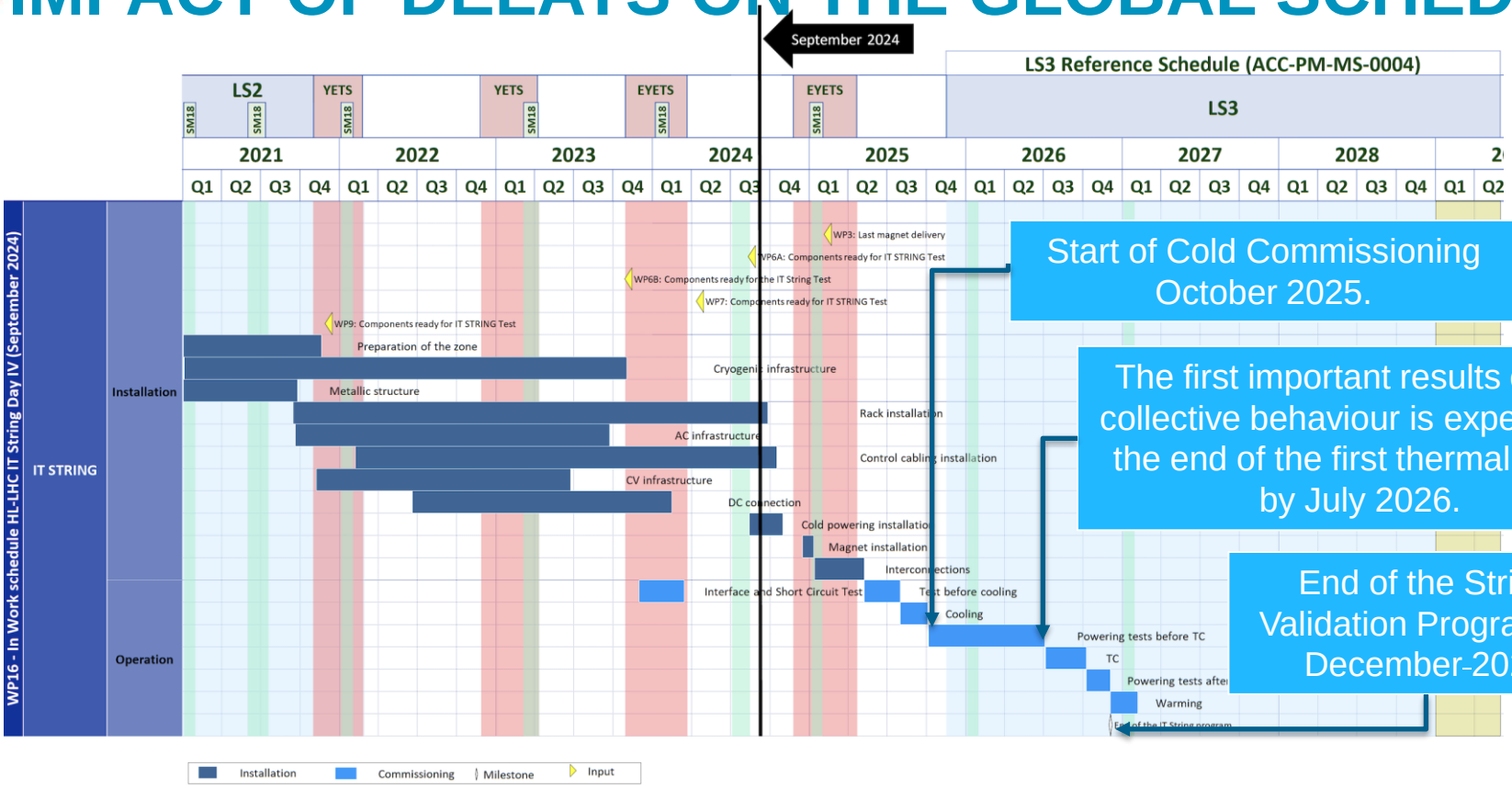


Delay explained by the shift of the WP3 deliveries and more precisely by the Q1 magnet and of the CP where its horizontal test is conditioned by the longer than foreseen testing of the Q3.

4.5 months delay

HL-LHC IT String Day III Baseline in grey

IMPACT OF DELAYS ON THE GLOBAL SCHEDULE



Start of Cold Commissioning October 2025.

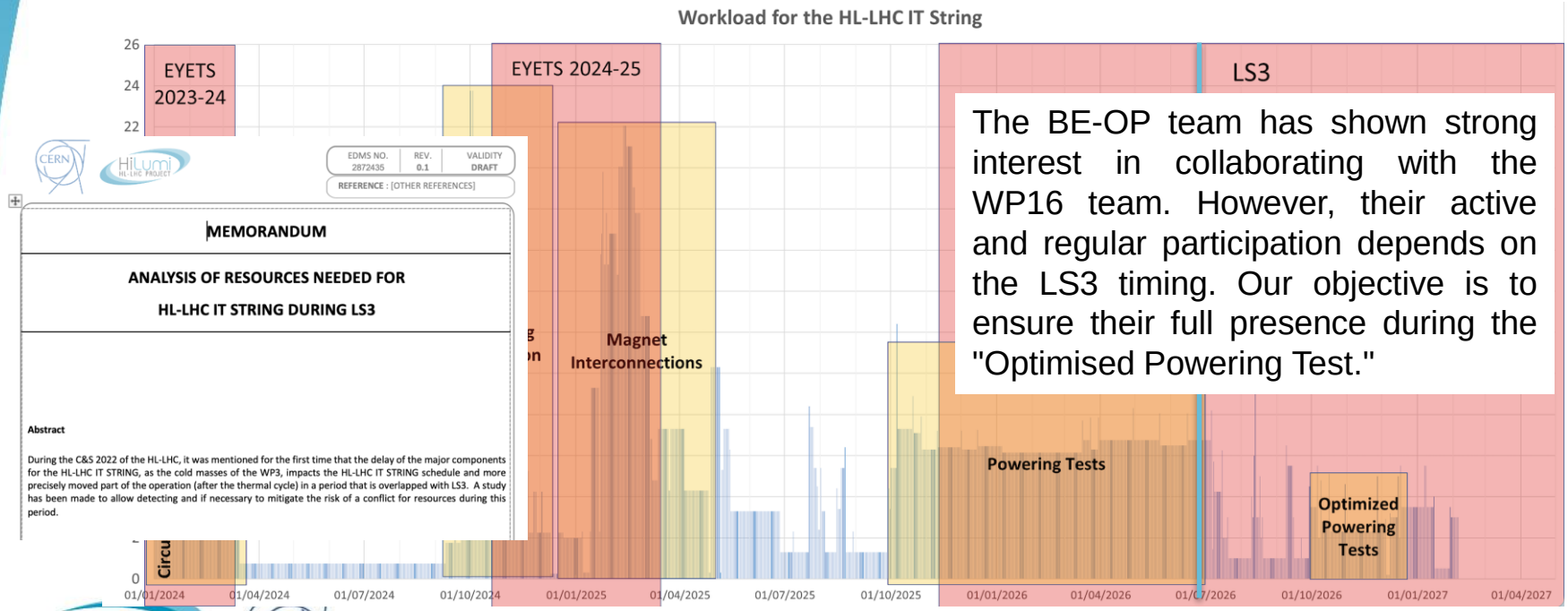
The first important results on the collective behaviour is expected at the end of the first thermal cycle: by July 2026.

End of the String Validation Program by December-2026

This planning does not integrate the annual SM18 shut down period for 2025/2026, and is conditioned by the delivery of the Q1

IMPACT OF the SCHEDULE on RESOURCES for LS3

The overlap with **LS3 may potentially** bring us **to conflicts** . A study is done (and is updated at every baseline change) , showing the needs of STRING . The document can be circulated at each baseline change within the concerned GL at CERN.



The BE-OP team has shown strong interest in collaborating with the WP16 team. However, their active and regular participation depends on the LS3 timing. Our objective is to ensure their full presence during the "Optimised Powering Test."

See talk of N. Heredia, S. Blanchard

STRING VALIDATION PROGRAM

The ***scope*** of the IT STRING is to represent, the various operation modes, to **STUDY and VALIDATE the COLLECTIVE BEHAVIOUR** of the different systems of the HL-LHC's IT zone

We will be working with magnets that are not fully conforming, subject to limitations on:

a. maximum current
b. protection aspects

This performance has been reviewed by a team of experts (MAB).

We have a comprehensive document detailing the circuit parameters and the proposed operational approach within the String.

Cour

for HWC

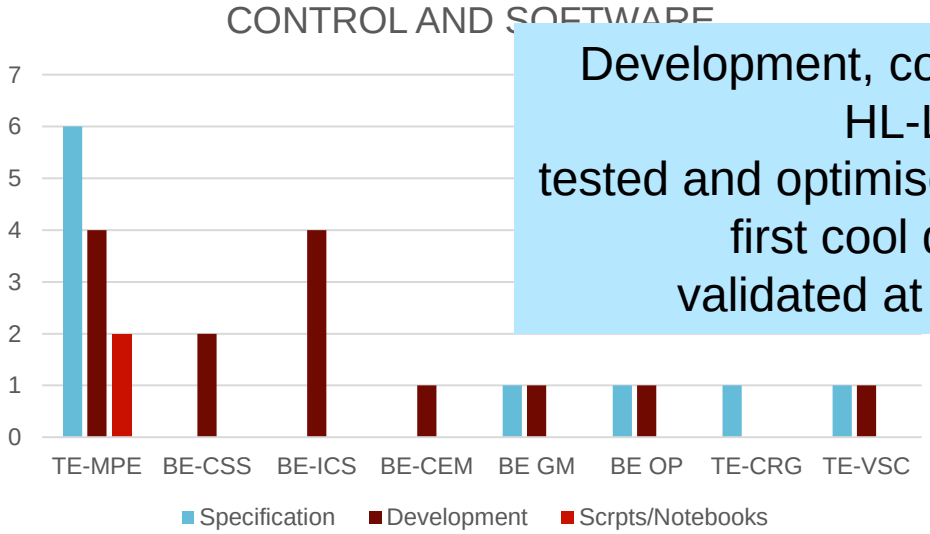
	IST	SCT	HWC
nr of documents	9	1	8

See presentation of S. Yammine

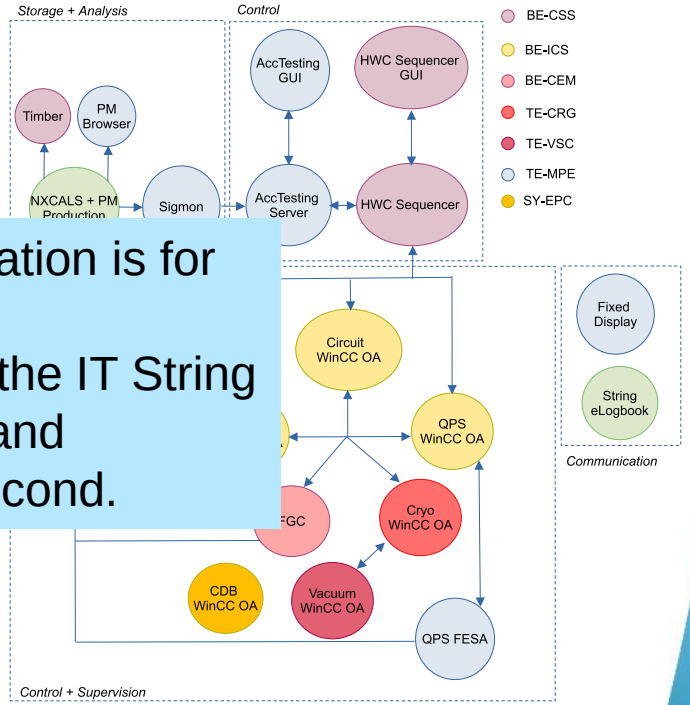
CONTROL AND SOFTWARE FOR IT STRING

DEPARTMENTS	3
GROUPS	9

Specification	5
Develeopment	7
Scripts/Notebook	1



Development, configuration is for HL-LHC
tested and optimised on the IT String
first cool down and
validated at the second.



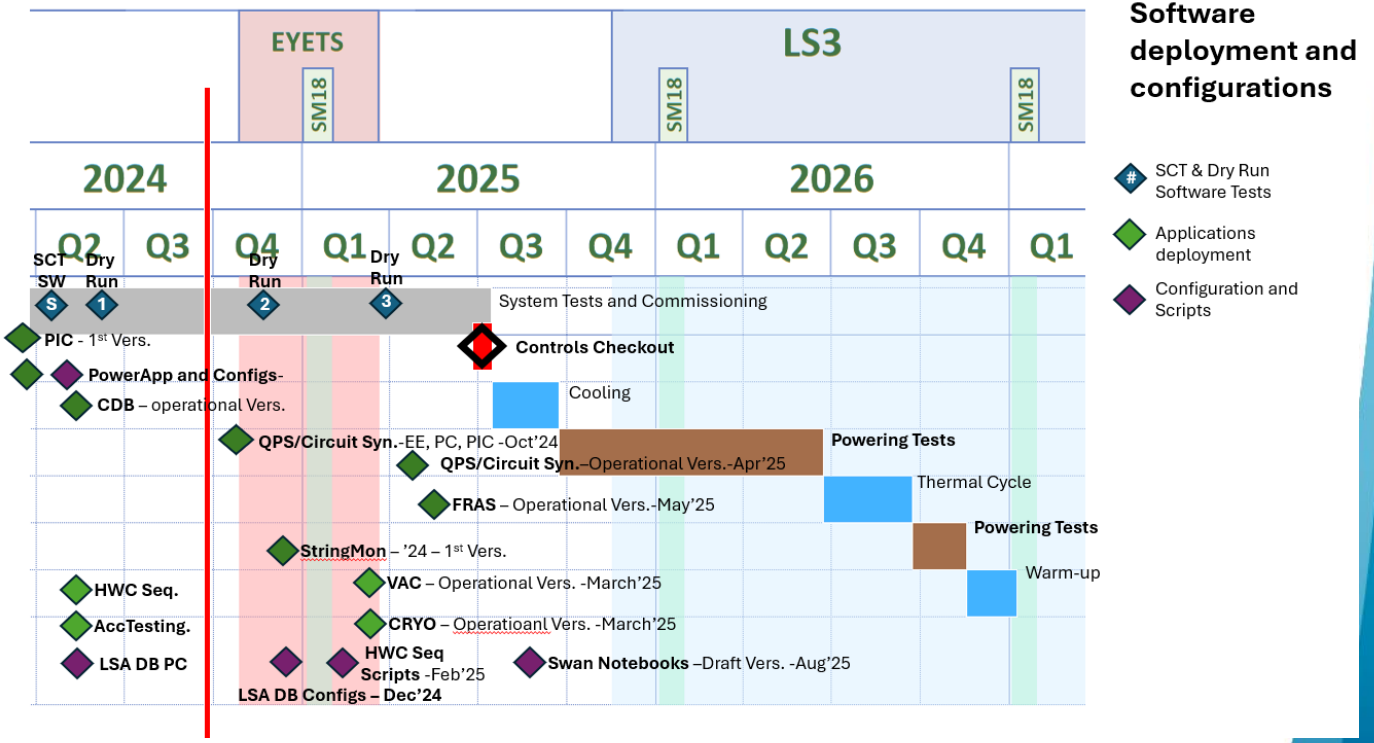
Courtesy of S. Yammine

See presentation of S. Blanchard

CONTROL AND SOFTWARE MILESTONES

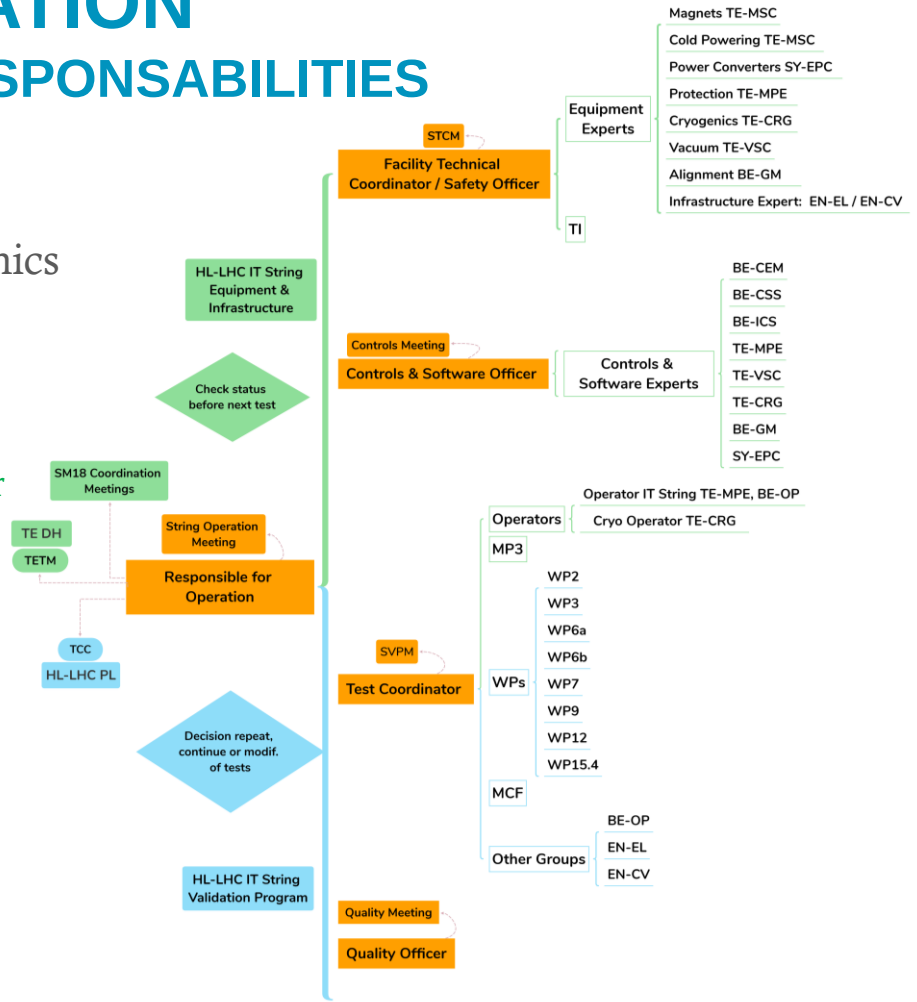
This schedule would insure the readiness of the Control and Software for the start of the String HWC.

Dry runs during SCT was helpful; the next runs are mandatory . Delayed test may bring us to the critical path.

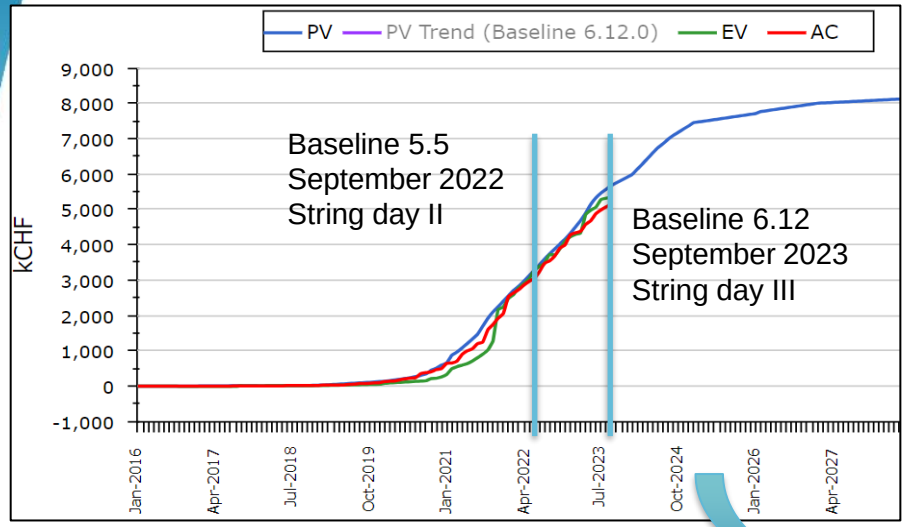


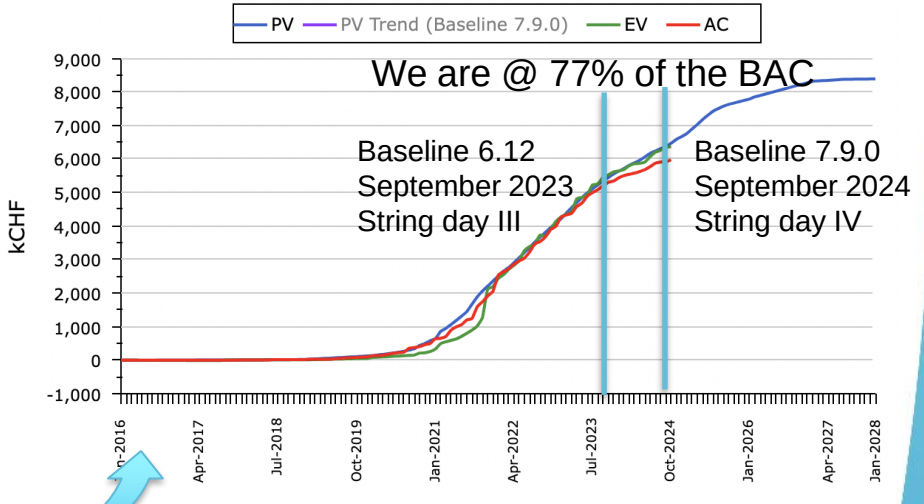
STRING OPERATION
STRUCTURE, ROLES AND RESPONSABILITIES

- Proposal already tested during cryogenics commissioning, IST and SCT
- 5 core roles proposed:
  - Responsible for operation
  - Facility technical coordinator and safety officer
  - Controls and software officer
  - Test coordinator
  - Quality officer



COST, BUDGET





Increase of the BAC from Baseline 6.12 to 7.9.0 is **< 1** % wrt the last year report of 7.7 %

The presently allocated budget for the HL-LHC IT STRING (WP16) is **8.384 MCHF –** only 0.72 % of the total cost of the HL-LHC project.

Metrics on the 24-Sep-2024

PV (kCHF)	EV (kCHF)	AC (kCHF)	BAC (kCHF)	PV Trend (Baseline 7.9.0) (kCHF)	SV (kCHF)	SPI (%)	CV (kCHF)	CPI (%)	SV(t) (months)
6,447	6,365	5,971	8,383	6,447	-82	99	394	107	-0.81

SUMMARY

- **STRING Integration and Installation**
  - Major infrastructure is in place and commissioned. The goal 2023 to perform the SCT achieved. Major component delivery : SC link and the first magnets in place.
- **STRING Validation Program- Control and Software**
  - Work advanced on the HL-LHC HWC procedures, together with the HL-LHC like software and control layers in 2024. Dry runs planned. Coordination of the Control and software is challenging but so far so good.
- **STRING Safety**
  - Safety is closely followed. On the activity/coactivity side is to remark that ~~67~~ 222 IMPACT request from 22 different groups are processed or in process. The most challenging activity the installation of the Sc link system is behind us. Nomination of a technical coordinator done.
- **STRING Operation and Resources**
  - The Operation structure, roles and responsibilities has been defined and documented. Today is ~~under~~ approved (`recommendation). Tested during IST and SCT. It is closely linked to the safety. BE-OP presence in the STRING is conditioned by the LS3 timing. Budget for a graduate is secured in WP16 to complete the existing but reduced WP16 team. No conflict between HL-LHC IT STRING and LS3 regarding resources
- **Schedule**
  - The start of the cold commissioning is foreseen by ~~June~~ October 2025. First important results on the collective behaviour is expected at the end of the first thermal cycle: by ~~May~~ July 2026. End of the String Validation Program is planned by ~~August~~ December 2026. All these is conditioned by the delivery of the Q1..
- **Budget**
  - WP16 cost stays within the allocated Budget of 0.79 % of HL-LHC. The increase of BAC from last year is ~~7.7~~ < 1 %. 380 kCHF saving is reported today.

Lessons Learned:
Integration vs Installation

LEARNING: Despite having highly detailed 3D integration drawings, we remain vulnerable in several areas: tolerance management, verification of the 'as-built' state, and undeclared modifications. Given the dense nature of the HL-LHC installations, it is crucial to continue refining our quality control processes and tools.

FEED BACK : We have invested in a system that enables easy identification of design divergences directly in the field. While this is a promising option for conflict tracking, we still need to establish acceptable tolerances, define the granularity of the measurements (scanners), and clarify what exactly we are measuring and how

Lessons Learned:
Design and Tools for installation

LEARNING: During the STRING phase, we have identified technical solutions that could be optimized—such as water cooling, cabling, interfaces, and tools for progressing while awaiting final equipment—for the final HL-LHC implementation.

FEED BACK: In some cases, discussions were initiated with us directly (e.g. water cooling, air-cooled cables, cabling quality), while in other cases, they were based solely on documents left behind. Personally, I believe that direct involvement in the optimization process of the HL-LHC leads to better outcomes, rather than simply following messages presented in slides.

Lessons Learned:
CONTROL AND SOFTWARE

LEARNING: The control systems and software are typically specified by the equipment owner but often developed by specialized groups. Some of these groups may place us on the critical path if all dry runs and integrated system tests (IST) are not completed on time.

FEED BACK: Coordination is crucial, and part of its role is to drive progress forward (with the STRING project being ahead of HL-LHC). It's essential to ensure that for all systems, the IST and associated software are tested as early as reasonably possible. We hope that our work on the STRING project will contribute positively to this effort.

Lessons Learned: Schedule

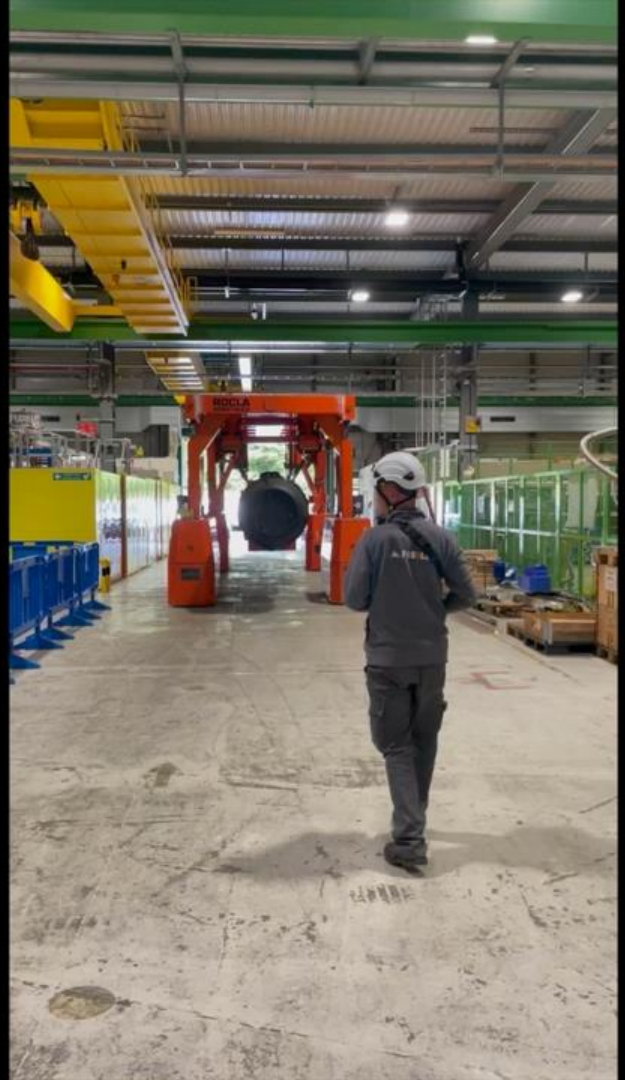
LEARNING: Some activities took three times longer and cost three times more than initially planned. This wasn’t due to a single team or reason. Delays in the delivery of major equipment, which is often the case in the 'high-tech' sector and still in the prototyping phase, fully justify the overall timeline extensions. However, alongside these delays, even less technologically complex items experienced significant setbacks. Trials and dry runs are essential for success. Safety measures, while adding cost and time, ensure the necessary conditions for progress, though they were sometimes underestimated.

FEED BACK: It’s difficult to extrapolate directly to the HL-LHC, as we are likely paying the price of being a 'first-of-a-kind' project. While communicating delays doesn't eliminate their impact, it has always helped by allowing us to reorganize and continue progressing. It's crucial to extract insights from this experience, particularly regarding the actual time spent on installation and IST, to better plan for the HL-LHC. Prioritizing dry runs and safety measures in advance will reduce risks, minimize extra costs, and help prevent delays in the schedule.

Lessons Learned: Accounting

LEARNING: I find it very challenging to track the budget and costs with the current tools. Monitoring expenses requires parallel accounting systems, and even then, it’s difficult to gain a clear overview. I’ve done my best to provide a transparent declaration of all additional costs to facilitate post-mortem analysis, which explains the growing BAC alongside the resulting savings. The budget distribution across various sections (with WP16 not owning all budget codes) has led to a situation where spending transparency depends largely on whether the responsible link person chooses to provide it.

FEED BACK: A Work Package Leader (WPL) cannot be held responsible for expenditures that they have not personally approved. Some adjustments are needed to align the approval routing with CERN's rules, while also adapting it to the specific structure of the project.


ROCLA