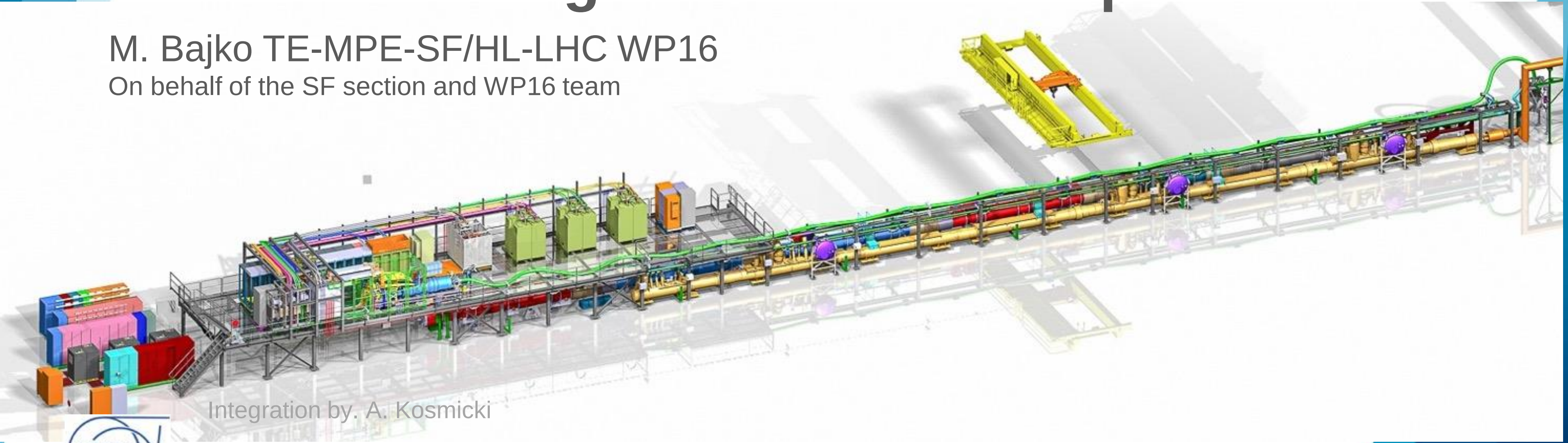
HL-LHC IT String :Status and Perspectives

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



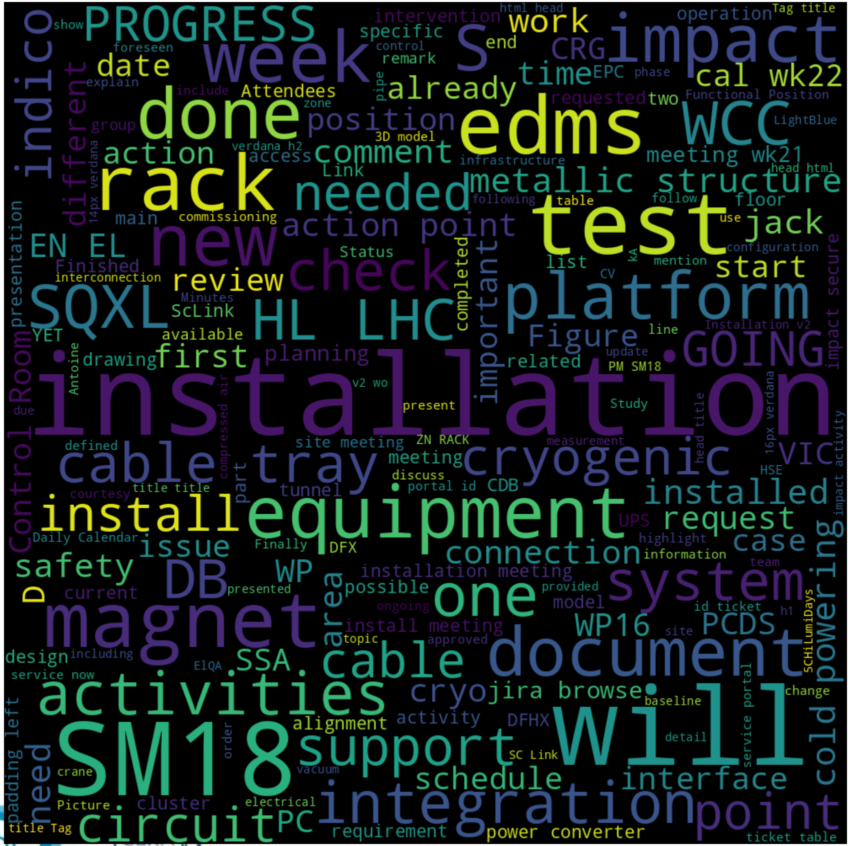
Integration by. A. Kosmicki

13th HL-LHC Collaboration Meeting meeting, Vancouver 25-28th September 2023

OUTLINE

- STATUS- PERSPECTIVES
  - Word Cloud of the IT STRING web site
  - STRING Integration and Installation
  - STRING Validation Program
  - STRING Safety
- STRING OPERATION
- Schedule and Resources
- Summary

STRING ACTIVITY WORLD COULD



some word increases size, such as **INSTALLATION** and **PROGRESS**, **DONE** while some others reduces : ex. **WILL** wrt the last time, in February 2023 in Chamonix, when I showed the image.

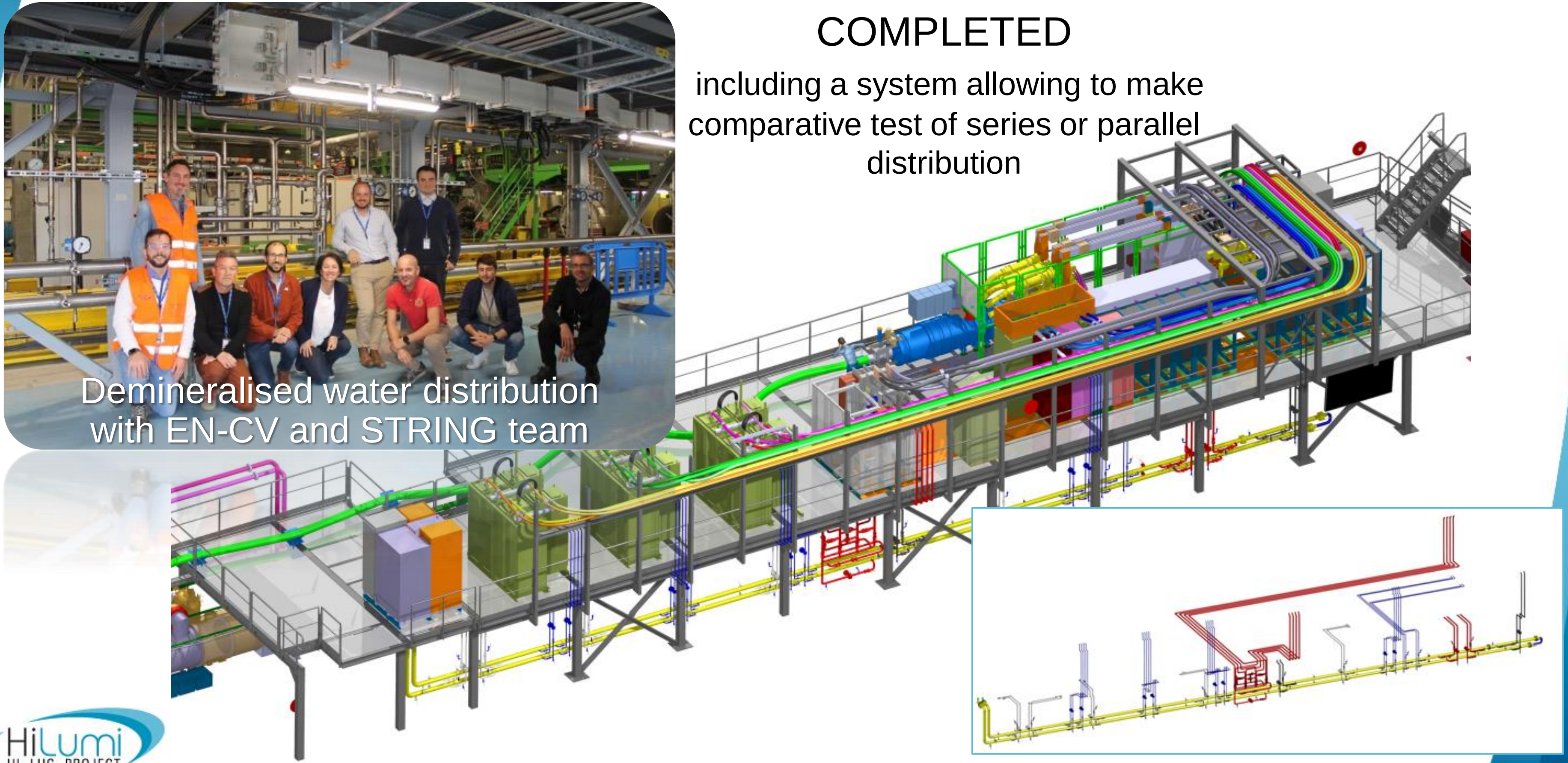
Courtesy of S. Blanchard

CRYOGENIC EQUIPMENT

PCDS and SQXL installation
COMPLETED

SQXL with TE-CRG ,
KrioSystem and String team

DEMINERALISED WATER


Demineralised water distribution with EN-CV and STRING team

COMPLETED

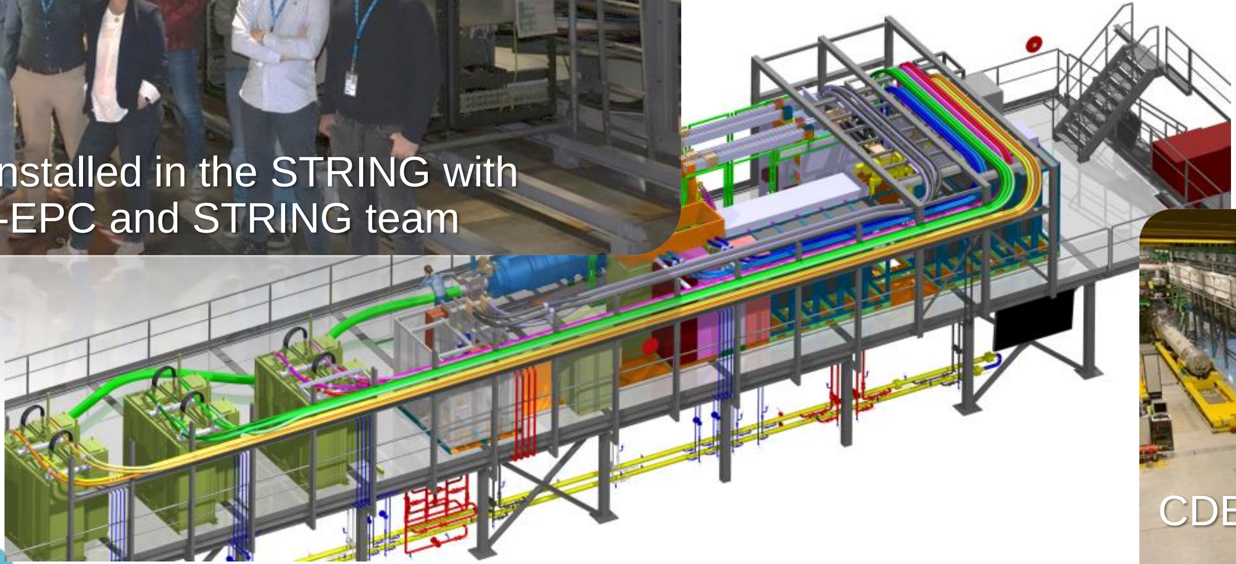
including a system allowing to make comparative test of series or parallel distribution

CIRCUIT DISCONNECTOR BOXES

CDB installed in the STRING with SY-EPC and STRING team

COMPLETED

the CDBs were the first equipment belonging to a HL-LHC WP (the WP6b) installed into the STRING

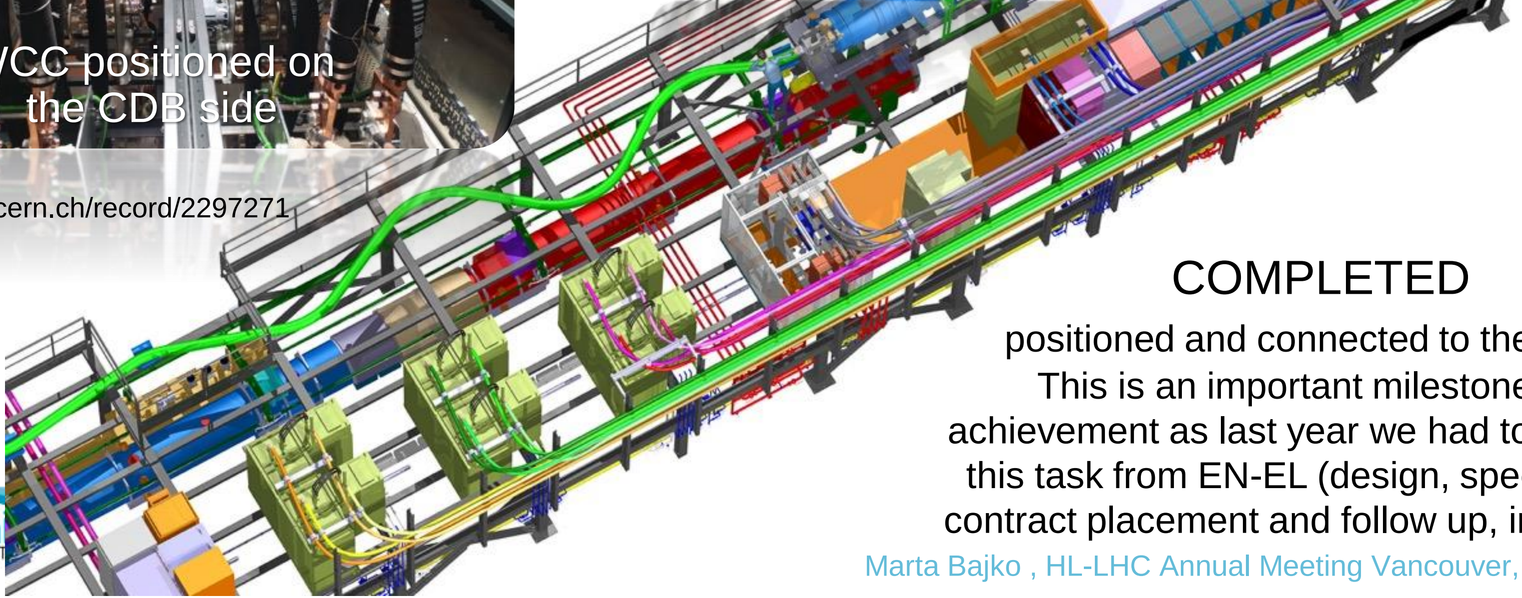


CDBs at reception

WATER COOLED CABLES

WCC positioned on the CDB side

https://videos.cern.ch/record/2297271



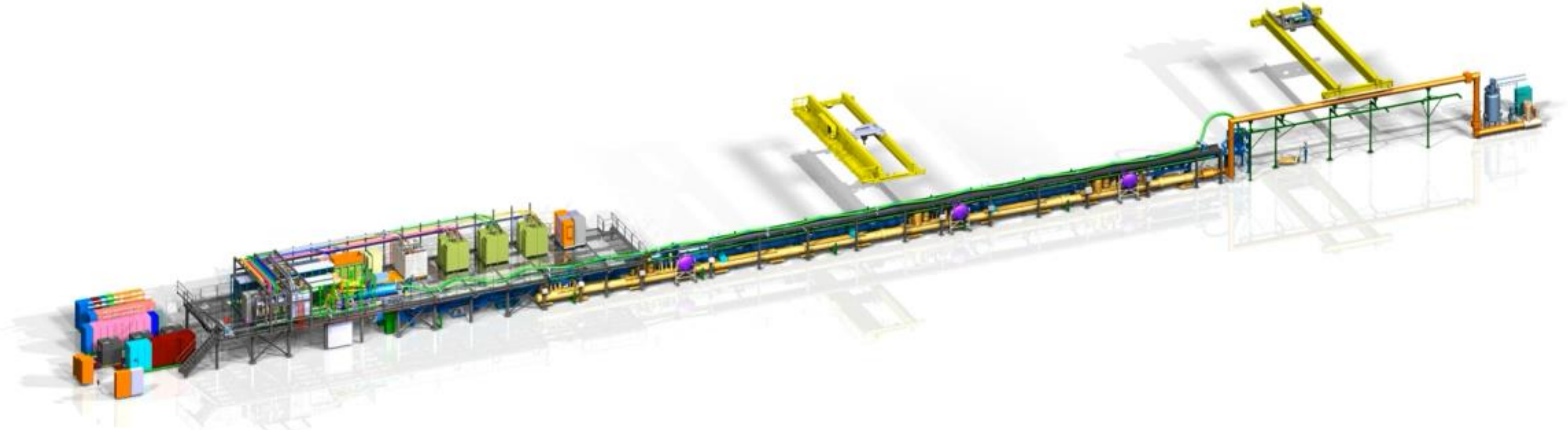
COMPLETED

positioned and connected to the CDBs.
This is an important milestone and achievement as last year we had to take over this task from EN-EL (design, specification, contract placement and follow up, installation)

HL-LHC PROJECT

IT STRING

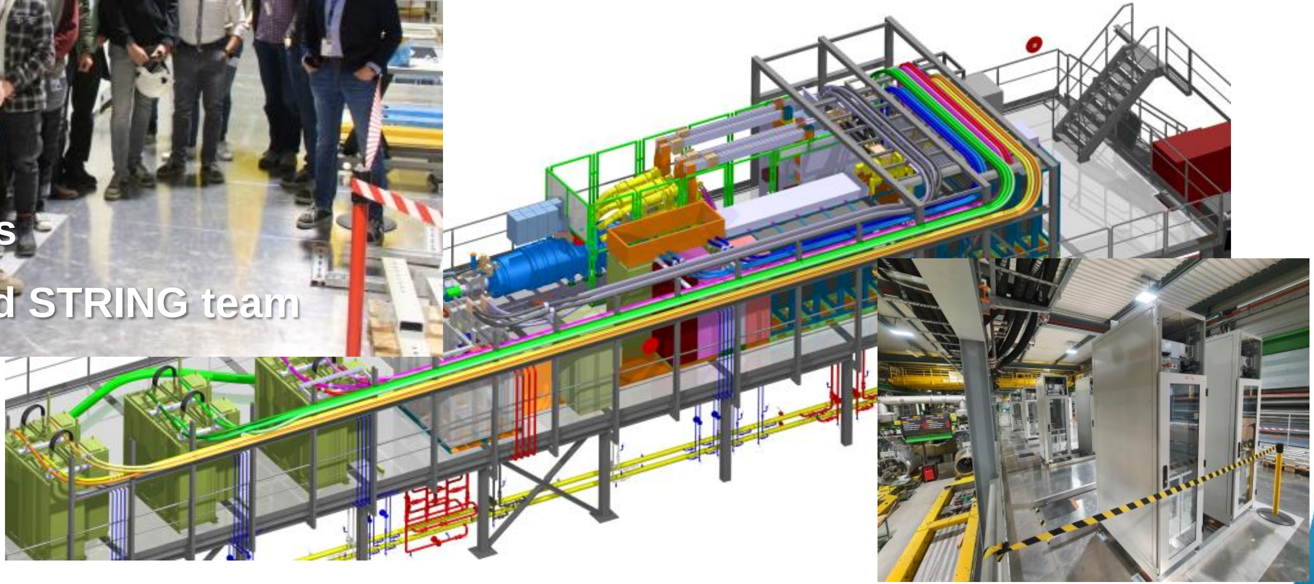
Water-Cooled Cables Installation



ENERGY EXTRACTION AND POWERING INTERLOCK

COMPLETED

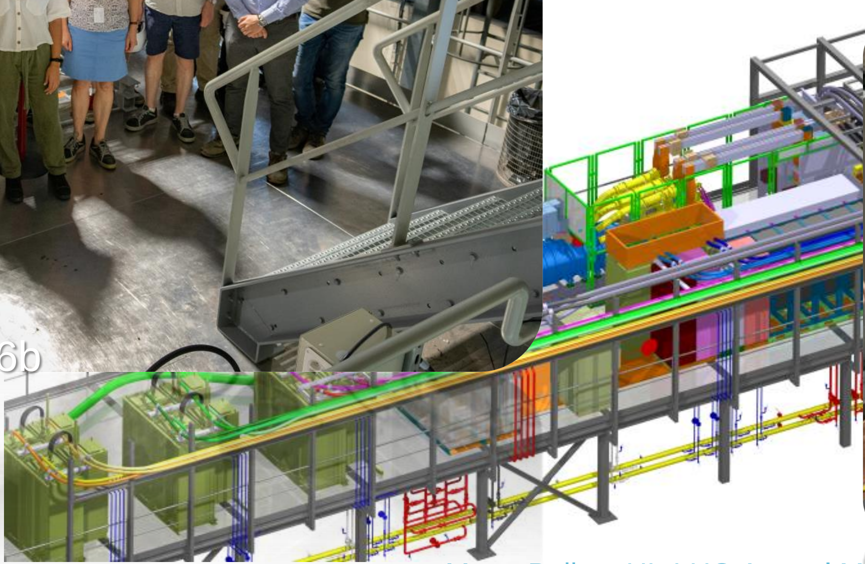
The EE and PIC belonging to WP7 are installed on the platform



POWER CONVERTERS

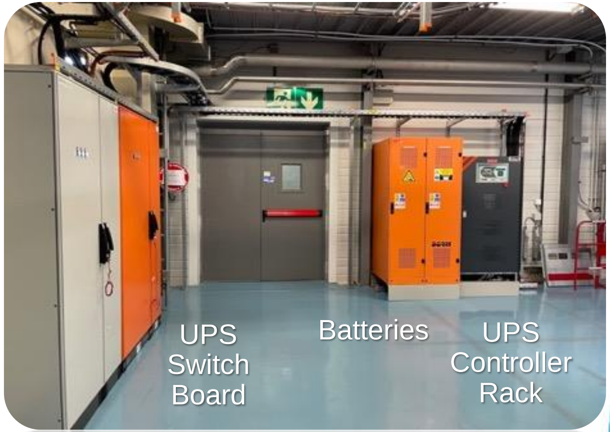
PC racks installed in the STRING with SY-EPC, WP6b

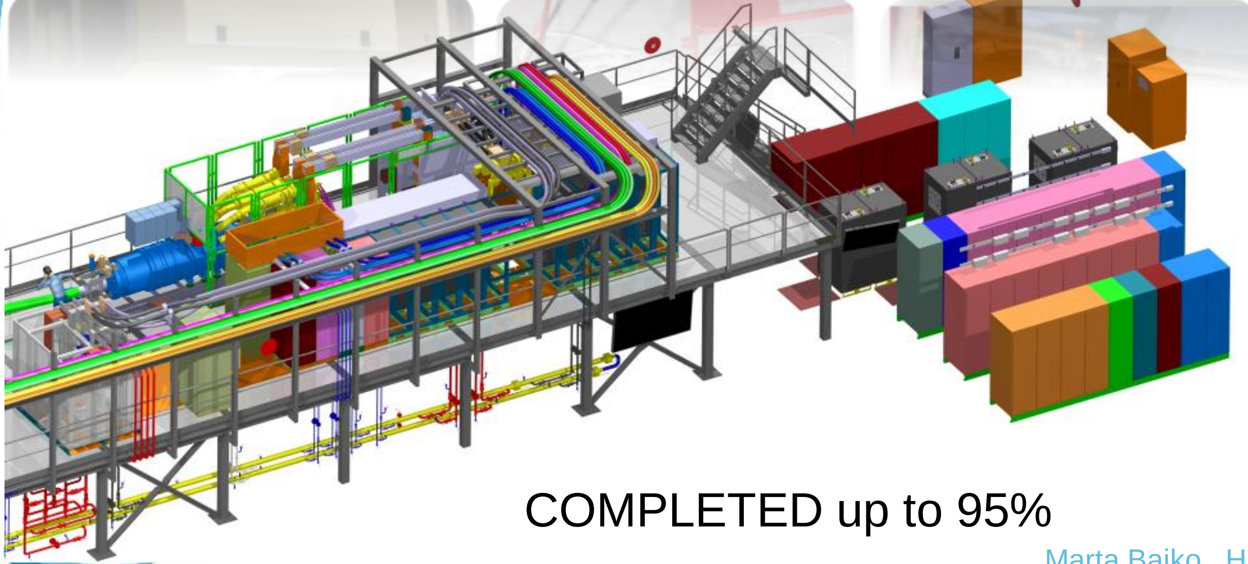
All Power Converter racks are installed



https://www.youtube.com/watch?v=hnXyvxRCMGw

OTHER INFRASTRUCTURES



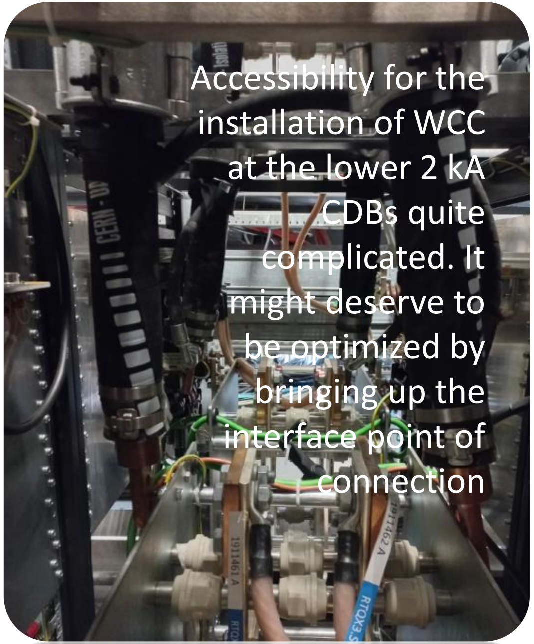


COMPLETED up to 95%

LESSONS LEARNED: few examples

See rapport given at the

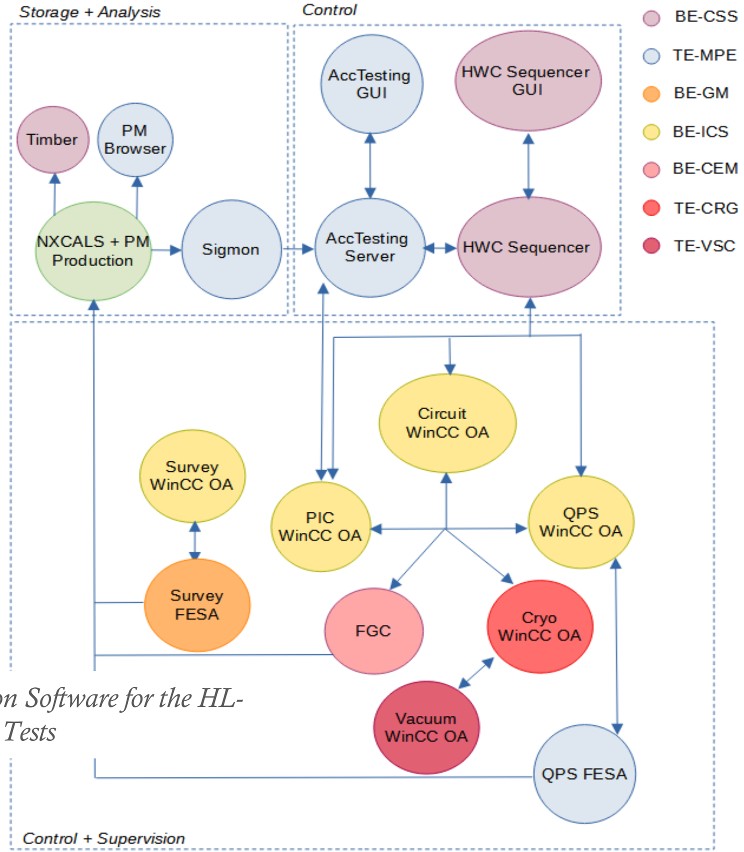
184TH HL-LHC Technical Coordination Committee (TCC) By D. Bozzini



CONTROL AND SOFTWARE FOR IT STRING

RoadMap

- Control, supervision and analysis software for the HL-LHC IT String defined in line with the software for the LHC
- Responsibilities of the software development have been defined for the HL-LHC IT String
- In 2023, monthly meetings are proposed to follow-up the software progress within the series of the String Validation Program (SVP) meetings

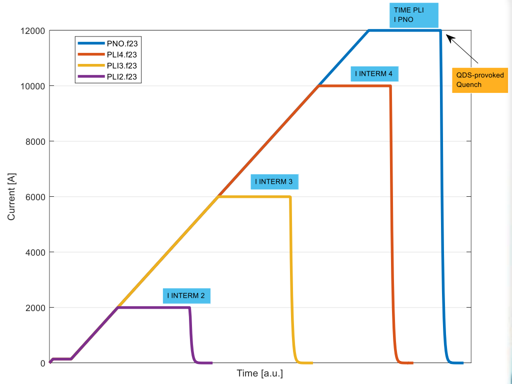


Control, Analysis and Supervision Software for the HL-LHC IT String HWC Powering Tests

Courtesy of S. Yammine

HWC Powering Procedures and Acceptance Criteria for HL-LHC

Step	Current level	Test description
PCC.23	I_PCC	Power converter configuration
PIC2	I_MIN_OP	Power interlock controller check
PLI1.c23	I_INTERM_1	Fast power abort via PIC at intermediate current 1
PLI2.d23	I_INTERM_2	Powering failure at intermediate current 2
PLI2.f23	I_INTERM_2	QDS provoked quench at intermediate current 2
PLI3.e23	I_INTERM_3	Slow power abort via PIC at intermediate current 3
PLI3.c23	I_INTERM_3	Powering failure at intermediate current 3
PLI3.f23	I_INTERM_3	QDS provoked quench at intermediate current 3
PLI4.s23	I_INTERM_4	Splice mapping till intermediate current 4
PLI4.d23	I_INTERM_4	Powering failure at intermediate current 4
PLI4.f23	I_INTERM_4	QDS provoked quench at intermediate current 4
PNO.c23	I_PNO+I_DELTA	Fast power abort after a current plateau at I_PNO+I_DELTA
PNO.f23	I_PNO	QDS provoked quench at I_PNO
PNO.a23	I_PNO	Current cycle to I_PNO with splice measurement



Example : Steps for RD1 Circuit

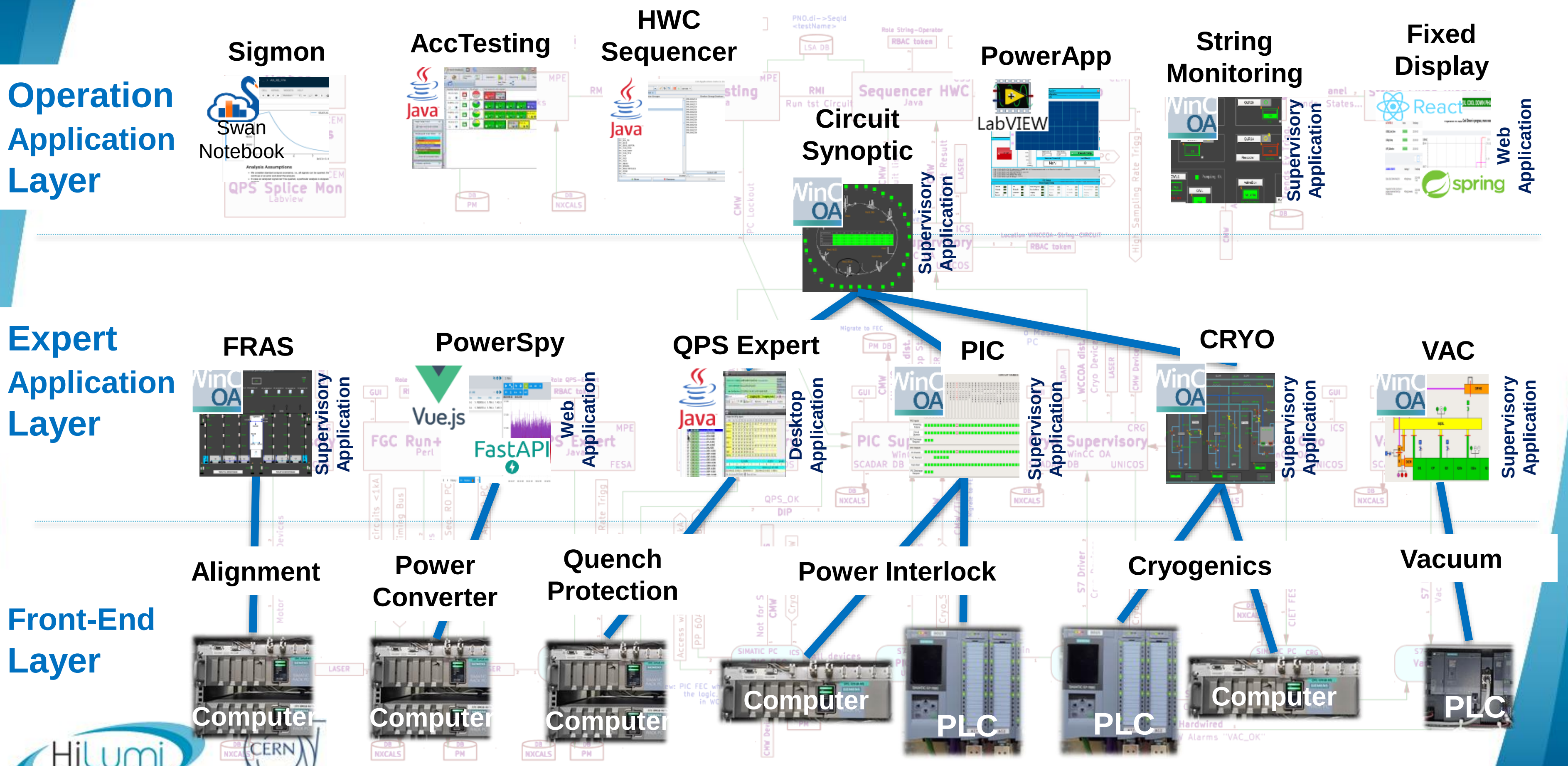
HL-LHC Test Procedure and Acceptance Criteria Document	EDMS no.	Status
Inner Triplet (RQX)	2771115	In Preparation
Separation Dipole (RD1)	2771114	Eng. Check
IT Orbit Correctors (RCBX)	2771111	Eng. Check
200 A Circuit (RQSX3)	2922509	In Preparation
High Order Corrector (120 A) Circuits	2922510	In Preparation
Parameters for the HL-LHC Circuit Powering Tests	2771118	In Preparation
Test of Grouped Circuits	To be created	In Preparation

Work already started with a collaboration between MCF with MP3

Applicable to HL-LHC and String

Courtesy of S. Yammine

STRING CONTROLS ARCHITECTURE



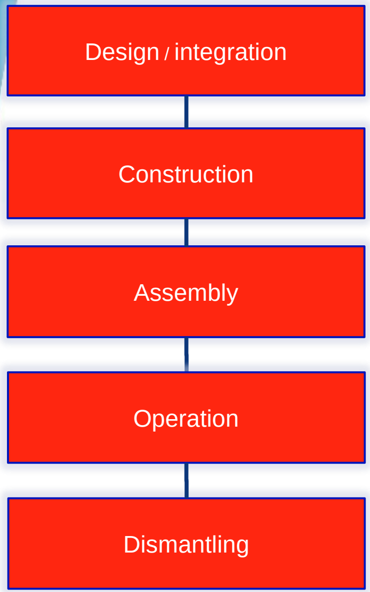
Last animation

Courtesy of S. Blanchard

IT STRING – SAFETY

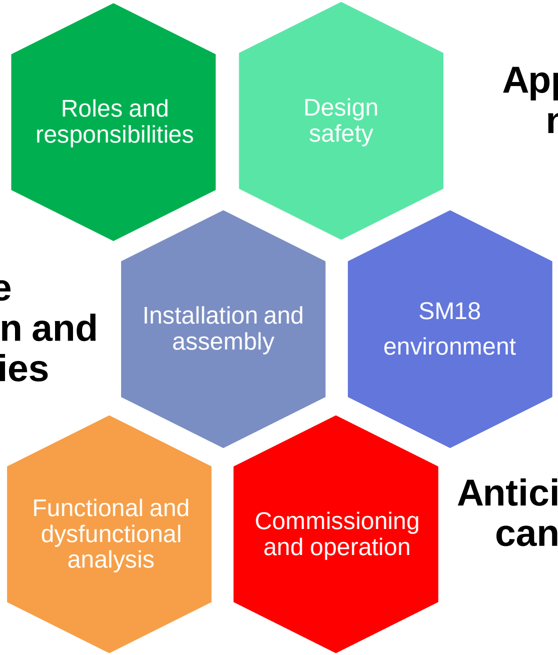
We consider six main safety sections covering the entire IT String life cycle

IT String life cycle



Applicable standards, norms, rules and regulations

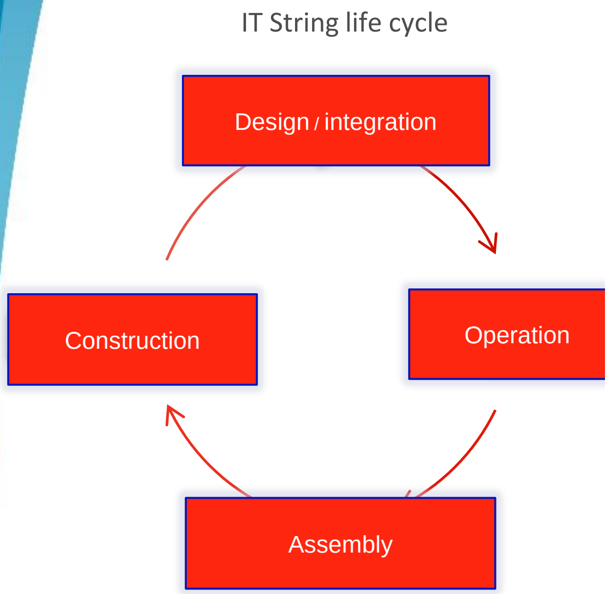
On-site construction and coactivities

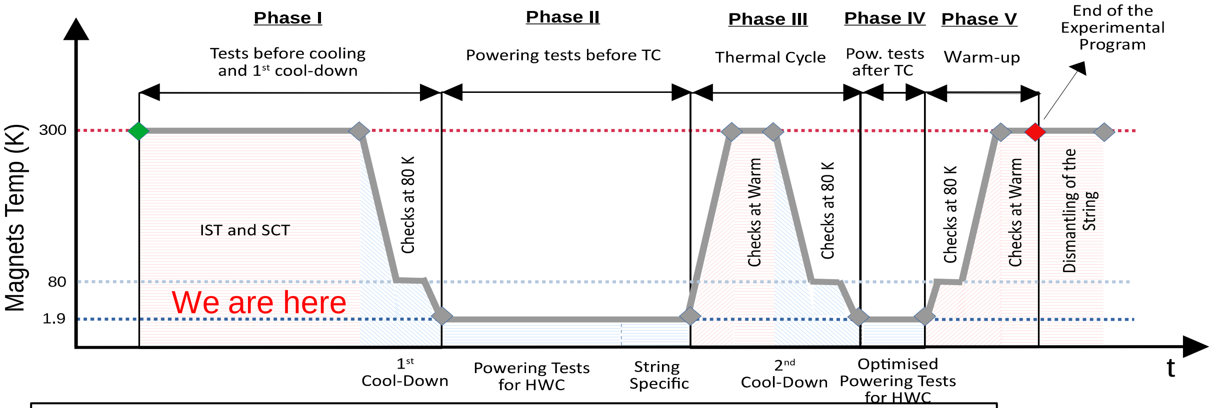


Anticipate/identify what can go wrong. Safe operation

Courtesy of D. Bozzini

SAFETY CHALLANGES

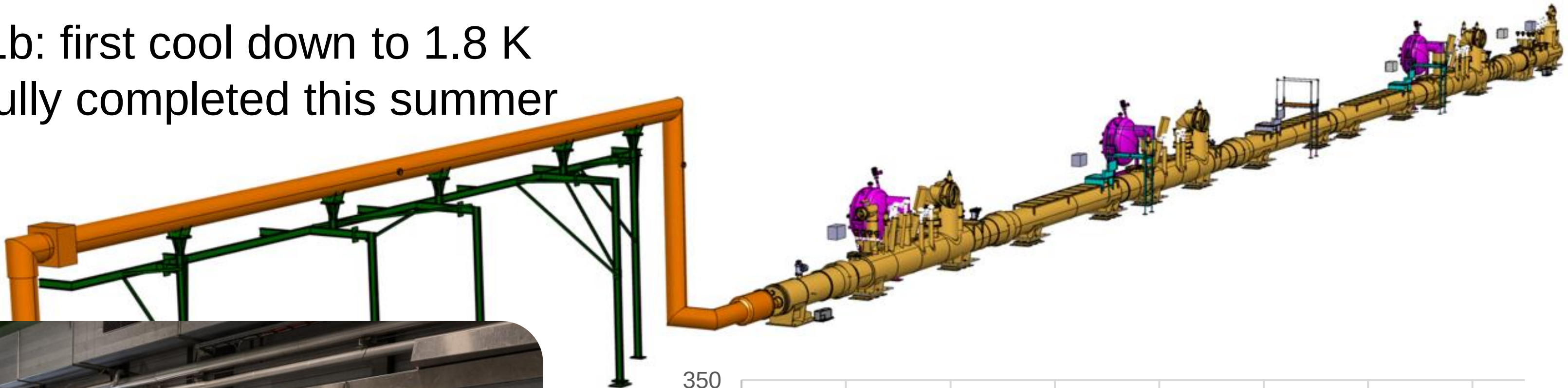


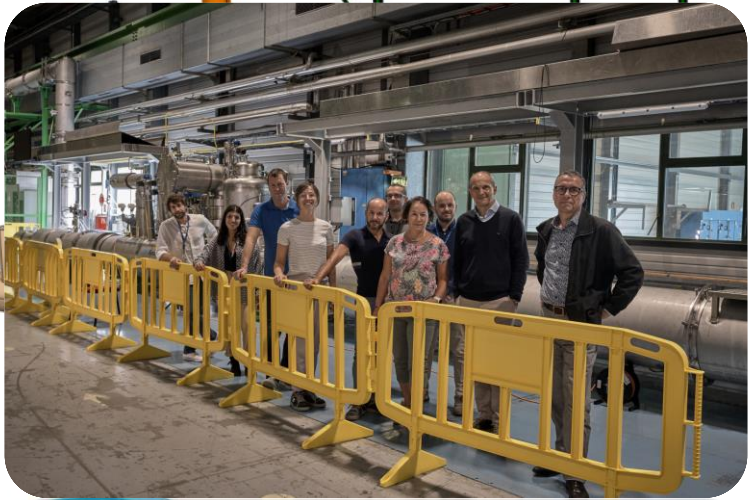


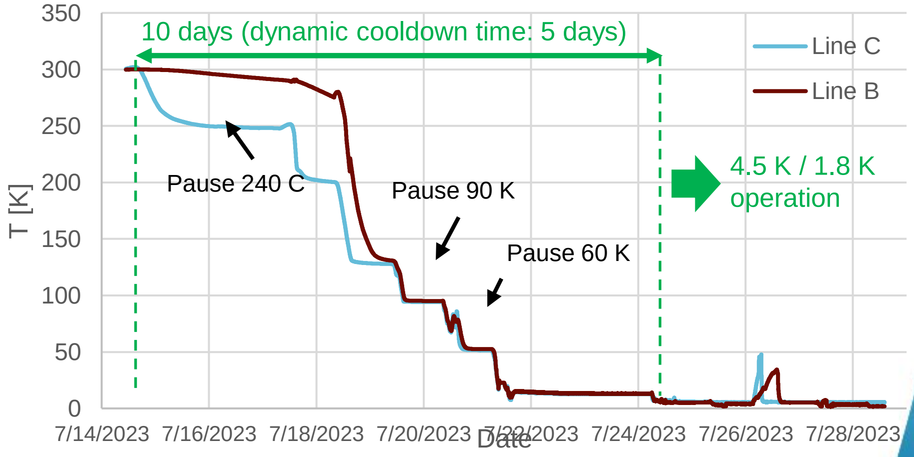
IST – Phase 1a for Cryogenic System done (see next slides)
IST – Phase 1b planned before end of 2023
IST – Warm powering to be finalized in October 2023 (as PC are arriving)
SCT planned to start before end of 2023

INDIVIDUAL SYSTEM TEST: CRYOGENICS

Phase 1b: first cool down to 1.8 K successfully completed this summer

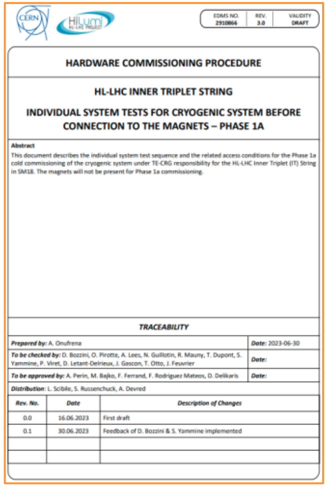






IT STRING – SAFETY: CRYO IST HWC PHASE 1A

Coordinated with WP16 team, SM18 team and TE-DSO to define access zones, procedures, communication. During the first cooldown, a managed-access area were defined around the IT String.


HARDWARE COMMISSIONING PROCEDURE

HL-LHC INNER TRIPLET STRING

INDIVIDUAL SYSTEM TESTS FOR CRYOGENIC SYSTEM BEFORE CONNECTION TO THE MAGNETS – PHASE 1A

EDMS NO.	REV.	VALIDITY
2910866	3.0	DRAFT

Abstract

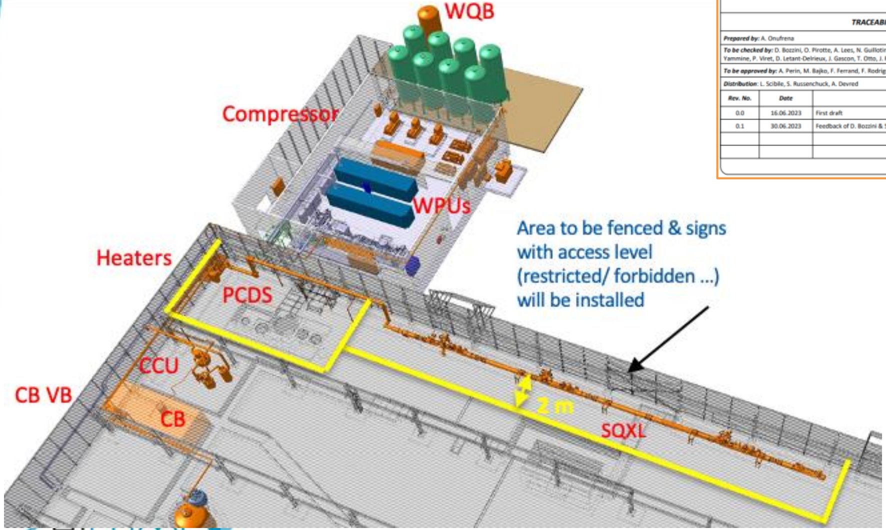
This document describes the individual system test sequence and the related access conditions for the Phase 1a cold commissioning of the cryogenic system under TE-CRG responsibility for the HL-LHC Inner Triplet (IT) String in SM18. The magnets will not be present for Phase 1a commissioning.

TRACEABILITY

Prepared by: A. Onufrena	***Date:*** 2023-06-30
To be checked by: D. Bozzini, O. Pirotte, A. Lees, N. Guillotin, R. Mauny, T. Dupont, S. Yammine, P. Viret, D. Letant-Delrieux, J. Gascon, T. Otto, J. Feuvrier	***Date:***
To be approved by: A. Perin, M. Bajko, F. Ferrand, F. Rodriguez Mateos, D. Delikaris	***Date:***
Distribution: L. Scibile, S. Russenchuck, A. Devred	

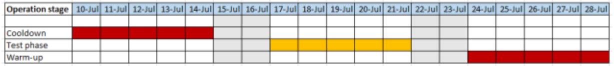
Rev. No.	Date	Description of Changes
0.0	16.06.2023	First draft
0.1	30.06.2023	Feedback of D. Bozzini & S. Yammine implemented

Step	Stage description	Temperature	Timeframe	Access
1	Activities at warm	RT	2 weeks	Controlled
2	Cooldown CD1	300 K – 223 K	8 hrs	Access forbidden
3	Stop at -50 C	223 K	2 hrs	Restricted access
4	Cooldown CD2	223 K – 93 K	8 hrs	Access forbidden
5	Stop at 93 K	93 K	2 hrs	Restricted access
6	Cooldown CD3	93 K – 62 K	8 hrs	Access forbidden
7	Stop at 62 K	62 K	2 hrs	Restricted access
8	Cooldown CD4	62 K – 52 K	3 hrs	Access forbidden
9	Cooldown CD5	52 K – 18 K	5 hrs	Access forbidden
10	Cooldown CD6	18 K – 4.5 K	0.5 hrs	Access forbidden
11	Cooldown CD7	4.5 K – 1.8 K	2.1 hrs	Access forbidden
12	Tests at 4.5 K and 1.8 K	4.5 K & 1.8 K	5 days (total)	Restricted access
13	Warm-up	1.8 K – 300 K	5 days	Access forbidden



SM18 environment

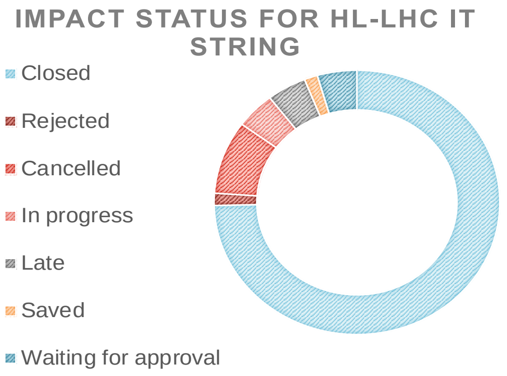
Commissioning and operation



Courtesy of D. Bozzini

IT STRING – SAFETY

We consider six main safety sections covering the entire IT String life cycle

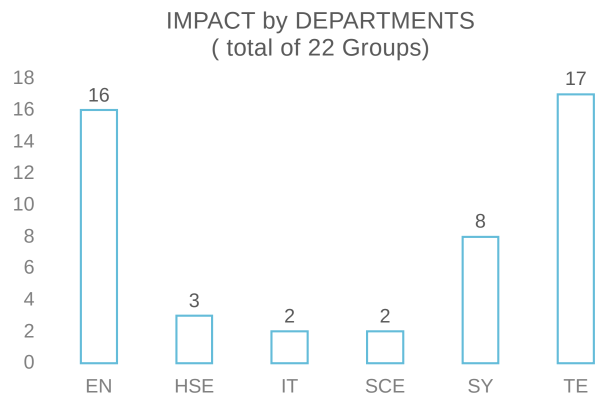


67 request has been created since the STRING area has been declared in the IMPACT (Intervention Management Planning And CoordinationTool).

Roles and responsibilities

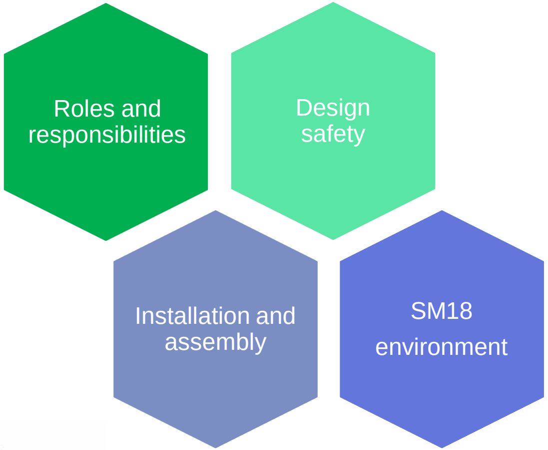
Installation and assembly

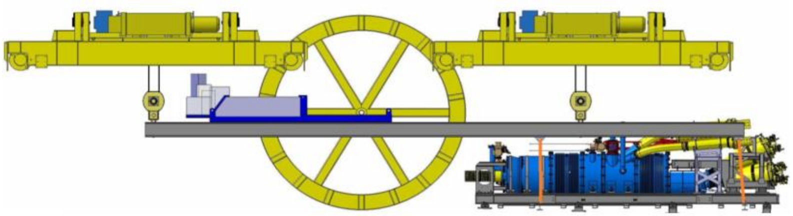
SM18 environment



SAFETY SC LINK SYSTEM INSTALLATION

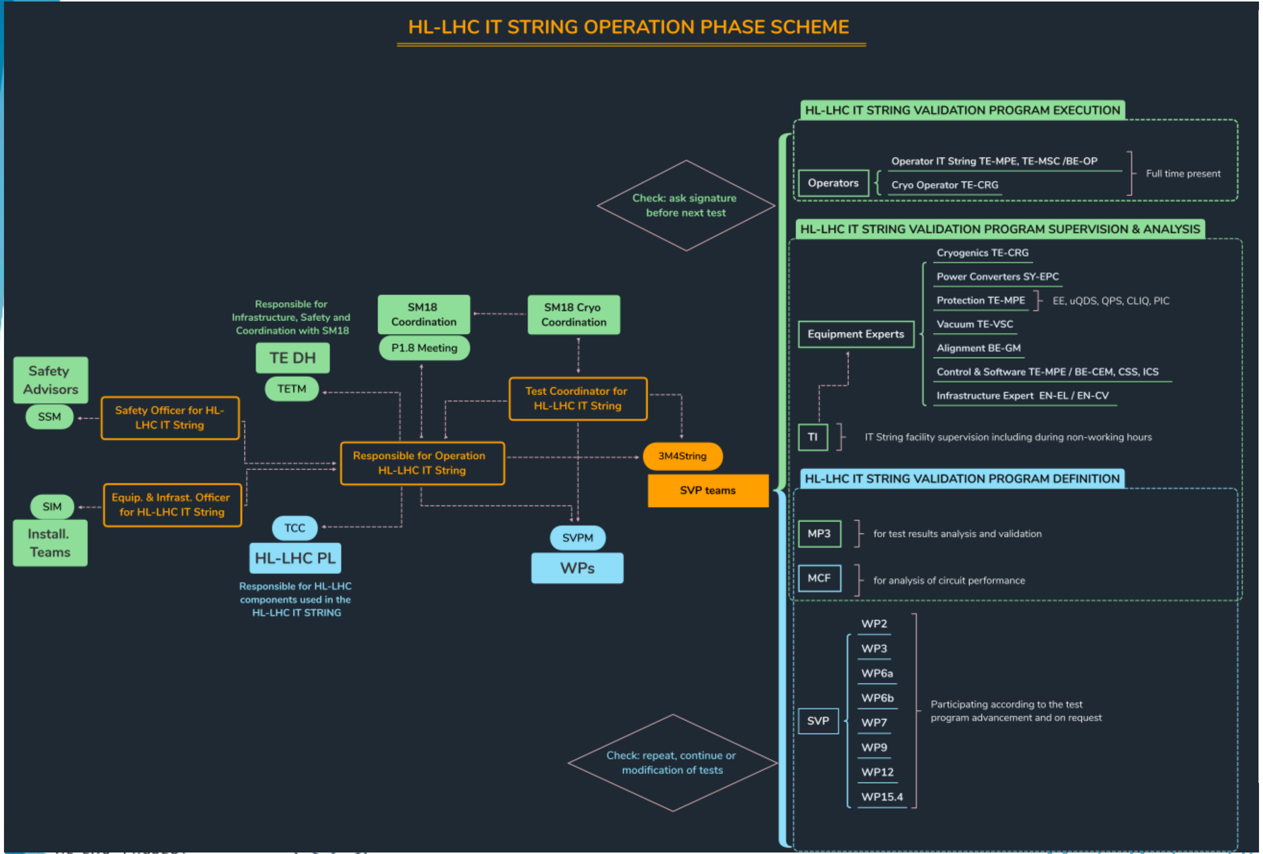
The most formidable task ahead of us, slated for the 1st quarter of 2024, is the installation of the cold powering system. This undertaking presents a unique set of challenges, primarily centered around the handling of the SC link connected to the DFHX and its positioning on the platform. This unique challenge requires the simultaneous use of two overhead cranes.





STRING OPERATION

STRUCTURE, ROLES AND RESPONSABILITIES



HL-LHC IT String Operation

M. Bajko

CERN, TE Department, Genève 23, CH-1211, Switzerland

The HL-LHC IT String is the test stand to validate the collective behavior of the Inner Triplet (IT) magnets and circuits in conditions as near as possible to the operational ones. This document describes the modus operandi of the hardware commissioning and the operation of the HL-LHC IT String.

1. Introduction

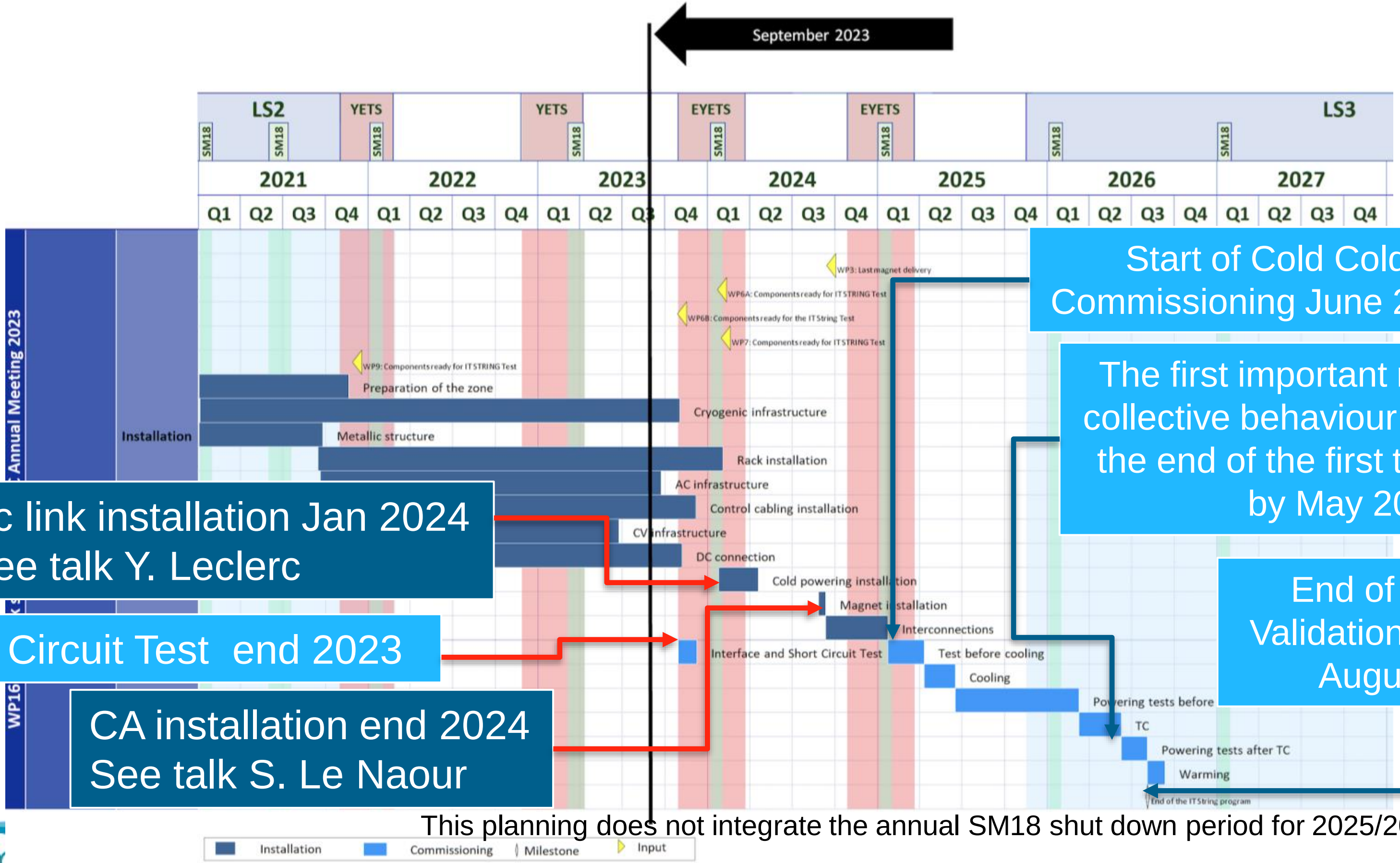
The goal of the HL-LHC project is to upgrade the existing LHC machine by incorporating new technologies that enable it to achieve its objectives [1]. The individual component tests do not fully capture their behavior when integrated into the HL-LHC, where several components are interconnected through a common electrical and cooling circuit. The HL-LHC IT String test stand allows for the comprehensive validation and testing of an entire Inner Triplet (IT) region of the HL-LHC under normal operational conditions, providing insight into the collective behavior of its components [2]. The HL-LHC IT String represents a significant intermediate milestone for the HL-LHC project, enabling system integration verification and smooth hardware commissioning of the final machine.

2. Description of the HL-LHC IT String

The HL-LHC IT String is installed in a surface building and functions as a representative model of the Inner Triplet (IT) region located on the left side of the HL-LHC at Point 5 as shown in Fig.1. However, the HL-LHC IT String setup does not replicate the tunnel inclination, does not include the modified matching section region and exclude the beam screen from the setup.

EDMS 2956328 Under approval

STRING SCHEDULE



Start of Cold Cold Commissioning June 2025.

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

End of the String Validation Program by August 2026.

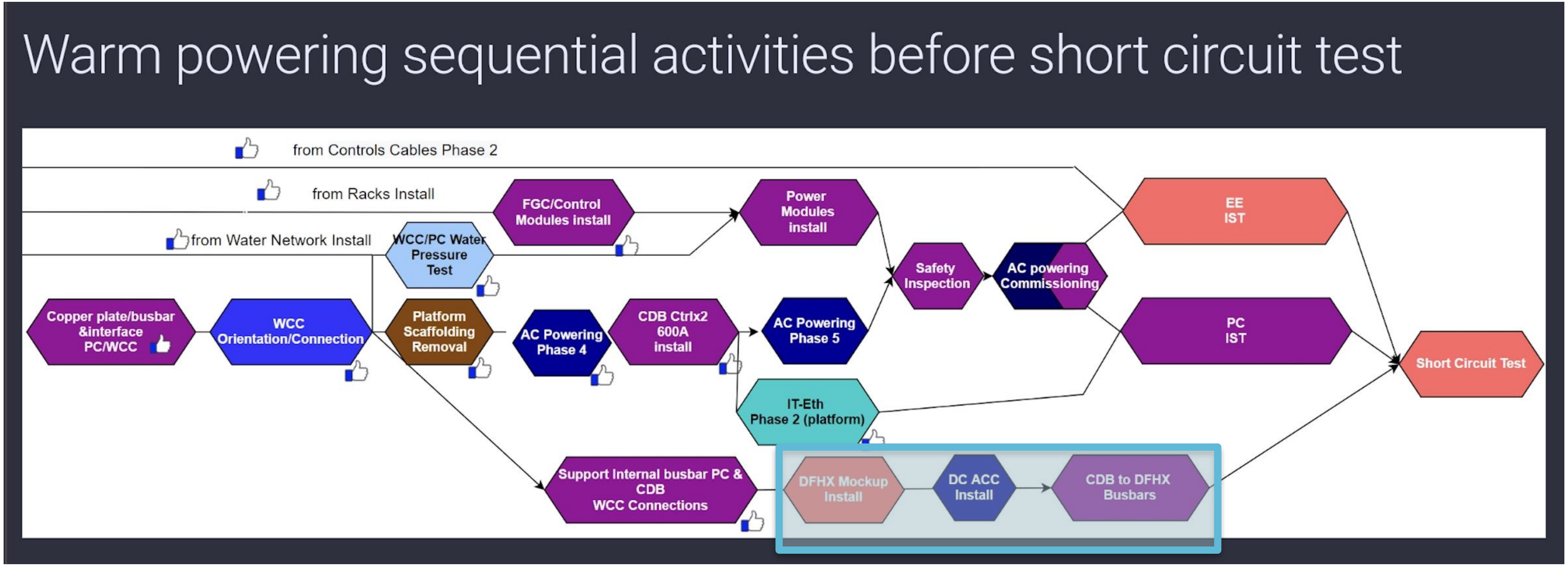
Sc link installation Jan 2024
See talk Y. Leclerc

Short Circuit Test end 2023

CA installation end 2024
See talk S. Le Naour

This planning does not integrate the annual SM18 shut down period for 2025/2026

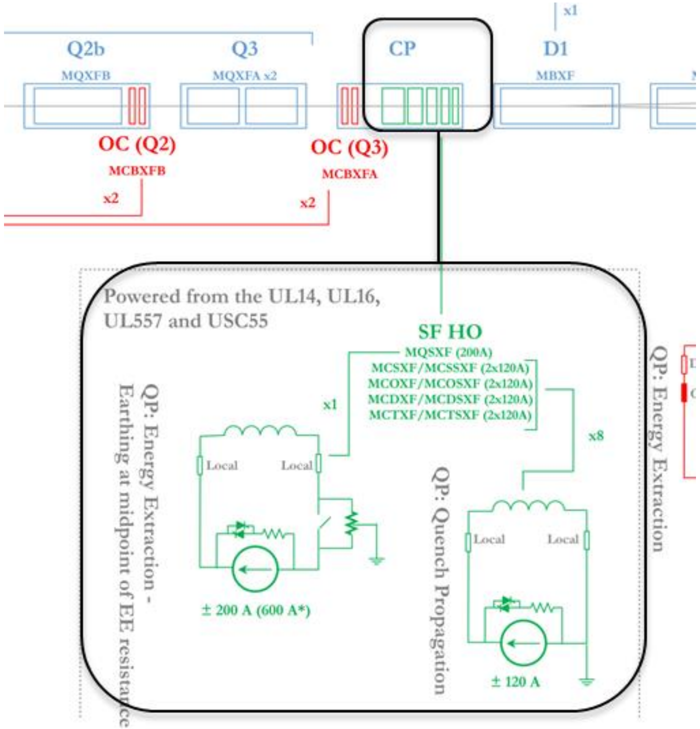
SHORT CIRCUIT TEST (SCT) by end 2023

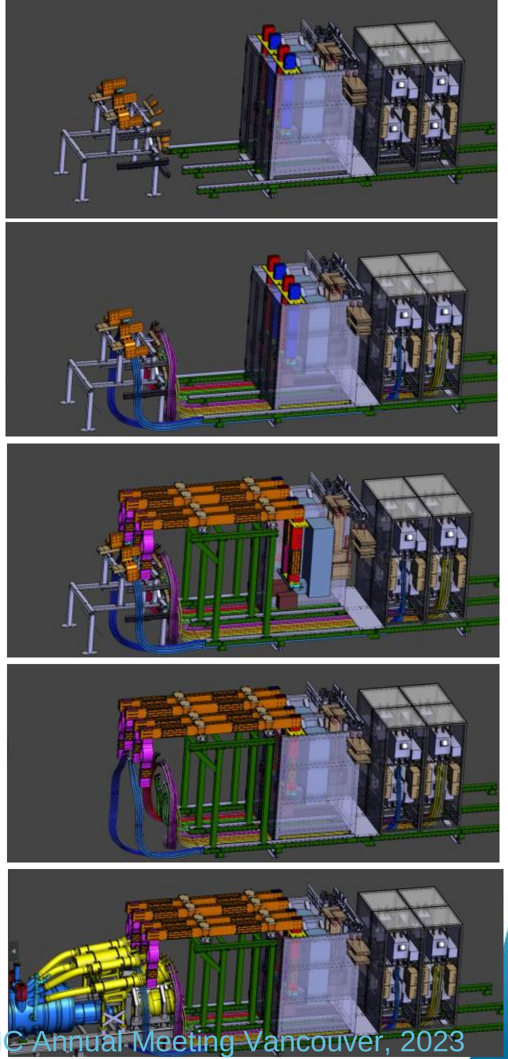


Courtesy of S. Blanchard

MAJOR STEPS towards SCT

ex. ACC cabling and Bus-Bars – Readiness

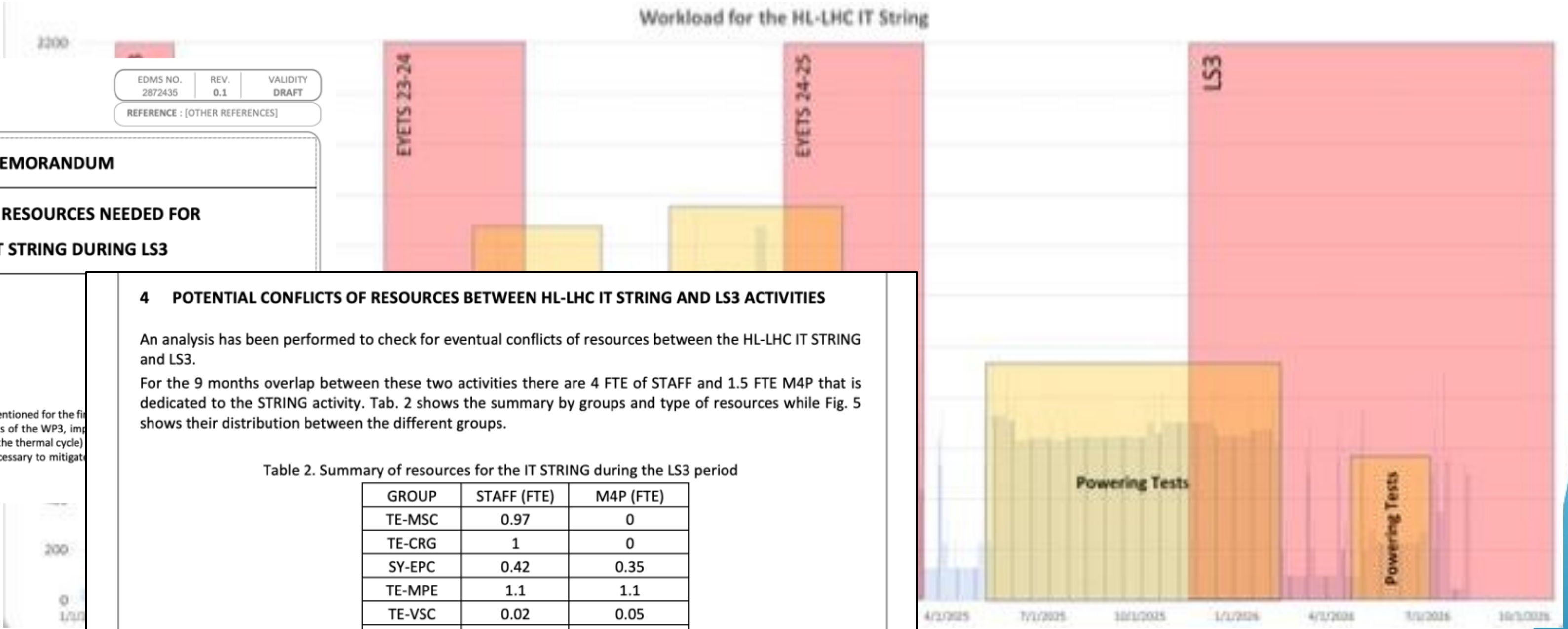




DFHX current leads connections model

STRING RESOURCES

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 is circulated at baseline change within the concerned GL at CERN.



EDMS NO. 2872435 | REV. 0.1 | VALIDITY DRAFT

REFERENCE : [OTHER REFERENCES]

MEMORANDUM

ANALYSIS OF RESOURCES NEEDED FOR HL-LHC IT STRING DURING LS3

Abstract

During the C&S 2022 of the HL-LHC, it was mentioned for the fi… for the HL-LHC IT STRING, as the cold masses of the WP3, imp… precisely moved part of the operation (after the thermal cycle) … has been made to allow detecting and if necessary to mitigat… period.

4 POTENTIAL CONFLICTS OF RESOURCES BETWEEN HL-LHC IT STRING AND LS3 ACTIVITIES

An analysis has been performed to check for eventual conflicts of resources between the HL-LHC IT STRING and LS3.

For the 9 months overlap between these two activities there are 4 FTE of STAFF and 1.5 FTE M4P that is dedicated to the STRING activity. Tab. 2 shows the summary by groups and type of resources while Fig. 5 shows their distribution between the different groups.

Table 2. Summary of resources for the IT STRING during the LS3 period

GROUP	STAFF (FTE)	M4P (FTE)
TE-MSC	0.97	0
TE-CRG	1	0
SY-EPC	0.42	0.35
TE-MPE	1.1	1.1
TE-VSC	0.02	0.05
BE-GM	0.48	0

SUMMARY

- STRING Integration and Installation
  - Infrastructure advanced following the schedule. The 2023 perspectives as presented last year have been achieved or no show stoppers seen till the end of the year (goal SCT).
- STRING Validation Program
  - Work advanced on the HL-LHC HWC procedures (as part of the WP16 mandate) , starting with the circuits used in the HL-LHC IT STRING, to be finalised together with the HL-LHC like software and control layers in 2023. Responsibilities and road map for software and control layers defined.
- STRING Safety
  - Responsibilities defined, safety is followed following the different subjects (6 legs). 67 IMPACT request from all departments, 22 groups are processed or in process. 1st IST at cold by the cryo system has been successfully completed following the well established procedures. The most challenging activity (installation of the Sc link system in January 2024) is on front of us.
- STRING Operation
  - The Operation structure, roles and responsibilities has been defined and documented. Today is under approval (String II days recommendation).
- Schedule and Resources
  - The start of the cold commissioning is foreseen by June 2025. First important results on the collective behaviour is expected at the end of the first thermal cycle: by May 2026. End of the String Validation Program is planned by August 2026.

HL-LHC IT String Infrastructure team

General Integration: Antoine Kosmicki, Alparslan Tursun (EN-ACE), Philippe Orlandi (EN-EL)
Civil Engineering: Alejandro Martinez Selles, Wolfgang Bastien (SCE)
AC Powering: Nuno Dos Santos, Mathieu Rigollet (EN-EL)
Control Cables: Gael Girardot (EN-EL)
DC Cables: Matheus Silva (EN-EL)
IT Infrastructure: Maryse Da Costa (IT-CS)
CV infrastructure: Francesco Dragoni, Dominique Piednoir (EN-CV)
Cryogenic infrastructure: Gabriella Rolando, Jeremy Mouleyre, Jos Metselaar, Andrew Lees, Luis Fernandez, Benoit D'Hulster (TE-CRG)
Transport: Serge Pelletier, Erik Richards, Antonio Jorge-Costa (EN-HE)
Design and drawing: Robin Betemps, Oussama Id Bahmane, Hector Perez (EN-MME)
Alignment: Andreas Herty, Jean-Frederic Fuchs, Kacper Widuch (BE-GM)
Mechanical works: Jordi Bossy, Pascal Catherine (EN-ACE)
Control HW infrastructure: Benjamin Ninet (BE-CEM), Enzo Genuardi (BE-CSS)
…

HL-LHC IT String Validation Program team

Work Packages	WP Leader	DWP Leader	GL	SVPM Members
WP2/BE-ABP	Rogelio Tomas Garcia	Elias Metral	Yannis Papaphilippou	Davide Gamba
WP3/TE-MSC	Ezio Todesco	Delio Duarte Ramos	Arnaud Devred	Ezio Todesco and Sandrine Le Naour
WP6a/TE-MSC	Amalia Ballarino	Paul Cruikshank	Arnaud Devred	Amalia Ballarino, Paul Cruikshank and Jerome Fleiter
WP6b/SY-EPC	Michele Martino	Valerie Montabonnet	Valerie Montabonnet	Louis de Mallac, Hugues Thiesen and Shruti Seshadri
WP7/TE-MPE	Daniel Wollmann	Reiner Denz	Felix Rodriguez Mateos	Daniel Wollmann and Jens Steckert
WP9/TE-CRG	Serge Claudet	Antonio Perin	Dimitri Delikaris	Antonio Perin and Gabriella Rolando
WP12/TE-VSC	Vincent Baglin	Giuseppe Bregliozzi	Paolo Chiggiato	Willemjan Maan
WP15/BE-GM	Paolo Fessia	Michele Modena	Helene Mainaud Durand	Michele Modena and Andreas Herty
WP16 (HWC)	Marta Bajko - Mirko Pojer		Felix Rodriguez Mateos	Marta Bajko and Mirko Pojer
WP18	Javier Serrano	Greg Daniluk	Alessandro Masi	Greg Daniluk and Odd Oyvind Andreassen

- A. Verweij, E. Ravaioli for MP3
- M. Giovannozzi, Riccardo De Maria for WGA
- M. Zerlauth for the Project Office
- S. Blanchard for IT String Installation
- D. Bozzini for IT String Safety Coordinator
- J. Zawilinski for IT String Tools Coordinator

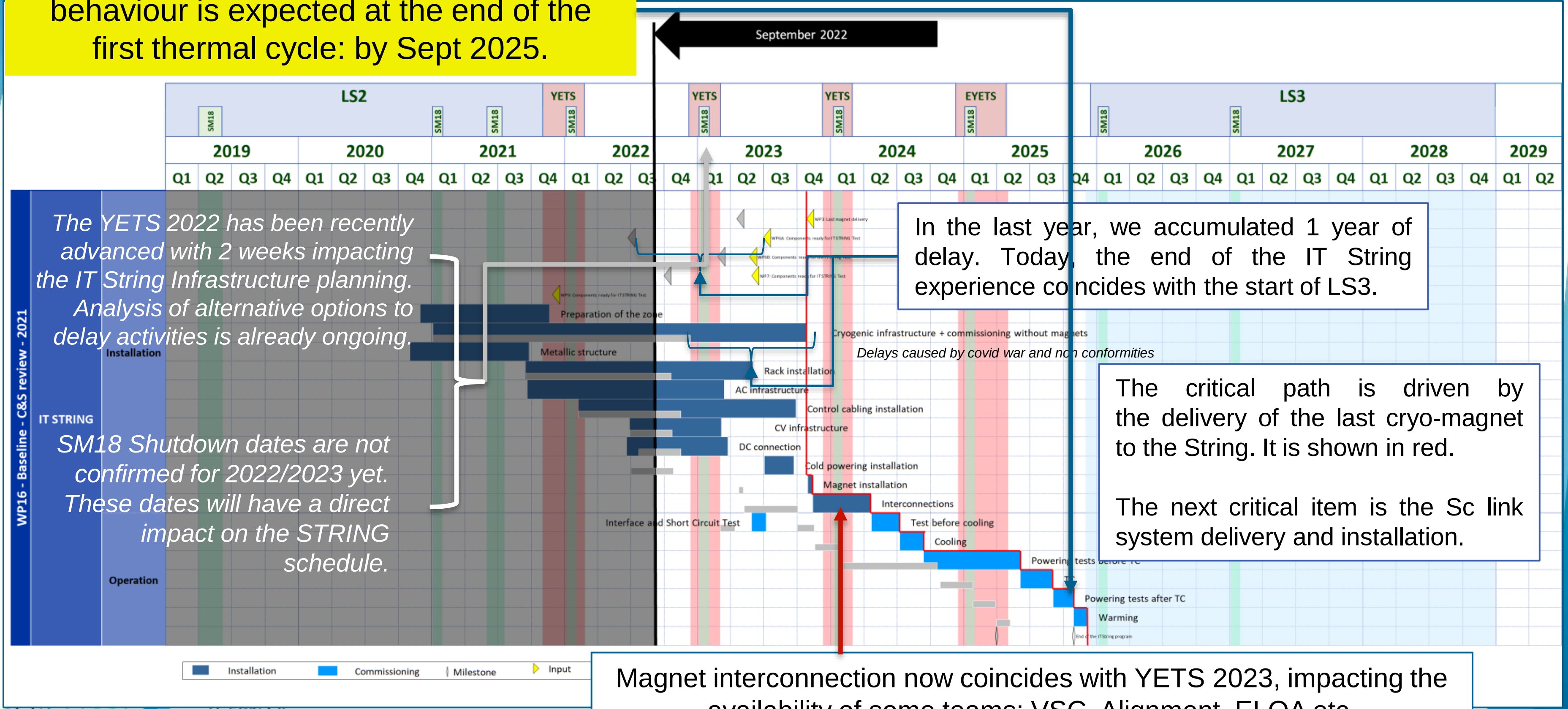
- M. Guinchard for Mechanical TF Measurements
- M. Jakub Bednarek for ElQA tests
- S. Yammine (Chair)
- N. Heredia Garcia (Scientific Secretary)
- Others for specific topics (software, control layers, protection equipment, etc.)

Schedule as presented 2022

The first important results on the collective behaviour is expected at the end of the first thermal cycle: by Sept 2025.

The YETS 2022 has been recently advanced with 2 weeks impacting the IT String Infrastructure planning. Analysis of alternative options to delay activities is already ongoing.

SM18 Shutdown dates are not confirmed for 2022/2023 yet. These dates will have a direct impact on the STRING schedule.



In the last year, we accumulated 1 year of delay. Today, the end of the IT String experience coincides with the start of LS3.

The critical path is driven by the delivery of the last cryo-magnet to the String. It is shown in red.

The next critical item is the Sc link system delivery and installation.

Magnet interconnection now coincides with YETS 2023, impacting the availability of some teams: VSC, Alignment, ELQA etc.