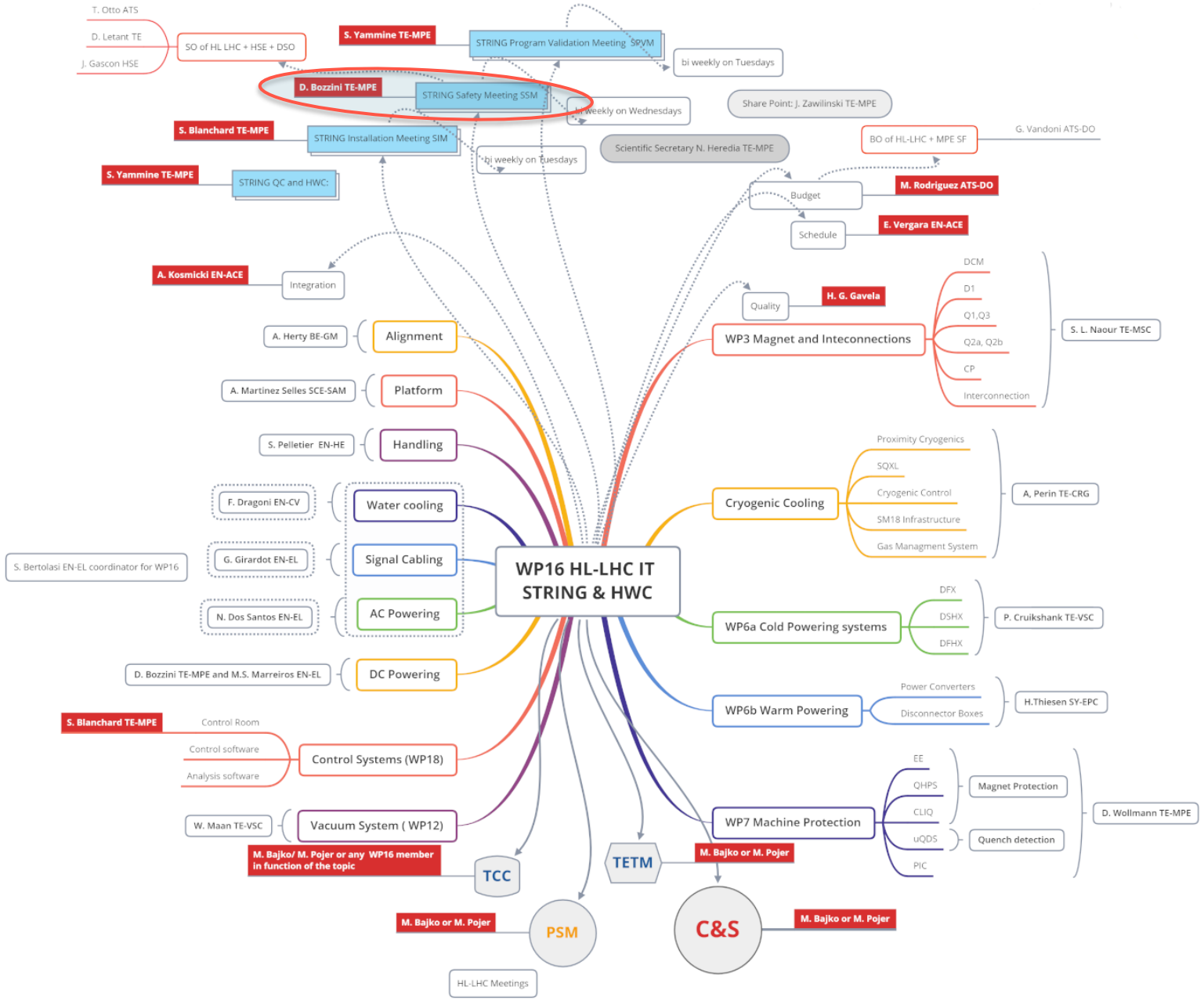
[12th HL-LHC Collaboration Meeting – Uppsala – Sweden – September 20th 2022]

Safety coordination for the HL-LHC IT String

D. Bozzini - CERN on behalf of WP16

WP16 structure and stakeholders



Safety @ IT String

Introduction

Organization

Responsibilities

SM18 environment

Installation and assembly

Commissioning and operation

HL-LHC IT String Day II

HL-LHC IT String Day II

Thursday Sep 15, 2022, 8:30 AM → 5:30 PM Europe/Zurich

30/7-018 - Kjell Johnsen Auditorium (CERN)

Markus Zerlauth (CERN)

Description **Scope**

After the first HL-LHC IT String Day in 2018 (https://indico.cern.ch/event/741801) where the HL-LHC IT String baseline configuration and the motivation of the associated test program were reviewed, the **HL-LHC IT String Day II** has as main objectives the assessment of:

a. The readiness of the HL-LHC IT String equipment intended for the installation in the facility.

b. The installation strategy, sequence and procedures.

c. The test program for the HL-LHC IT String Hardware Commissioning and the HL-LHC IT String Specific tests.

d. The safety during the installation and operation period of the HL-LHC IT String within the SM18 building.

- Held last Thursday 15th of September
- A session dedicated to safety
- Three talks addressing safety @ HL-LHC IT-String
- WP16 is thankful to the speakers Th. Otto (HL-LHC PSO) and J. Gacon (HSE correspondant) for the high quality of the talks and to the participants, for the fruitful discussion related to IT String safety

2:50 PM → 3:40 PM **HL-LHC IT String Safety**

2:50 PM **Safety for the HL-LHC IT String Installation and Validation Program (WP16 / TE-MPE)** 20m

The HL-LHC IT String safety strategy including the responsibilities is presented. The safety aspects during installation and during operation are detailed. The difference between the safety aspects in the HL-LHC IT String and those in the machine will be highlighted. The mitigation of the associated risks and the required installations to ensure safety are described.

Speaker: Davide Bozzini (CERN)

HL-LHC_IT-String_D... HL-LHC_IT-String_D...

3:10 PM **Safety Documentation of the HL-LHC Components (WP1)** 15m

This presentation describes the structure, content, responsibilities and deadlines of the safety documentation and gives a few examples. The safety hazards, risks and mitigations of individual HL-LHC components to be installed in the HL-LHC IT String are documented in System Safety Assessments (SSA), under the responsibility of the HL-LHC Safety Office. The risks of complete systems, for example the cryogenic and electrical hazards of IT String operation, are described in more extensive Safety Reports, together with proposals for mitigation, worked out among equipment owners and safety experts (DSO, TSO, HSE, PSO).

Speaker: Thomas Otto (CERN)

WP_16_String_Day_... WP_16_String_Day_...

3:25 PM **HSE Actions for Safety in the HL-LHC IT String (HSE)** 15m

HSE Unit provide to HL-LHC project a dedicated support that helps them fulfil their roles and responsibilities with respect to safety. HSE guide project safety stake holders in the implementation of the Safety Rules and regulations applicable at CERN, tailoring safety requirements for the project based on the identified hazards. Where standard Safety approaches are impossible for the project, HSE formalize the Safety approach to be taken to ensure an equivalent level of Safety. The presentation will show the involvement of HSE and the safety tasks within the HL-LHC IT String.

Speaker: Jose Gascon (CERN)

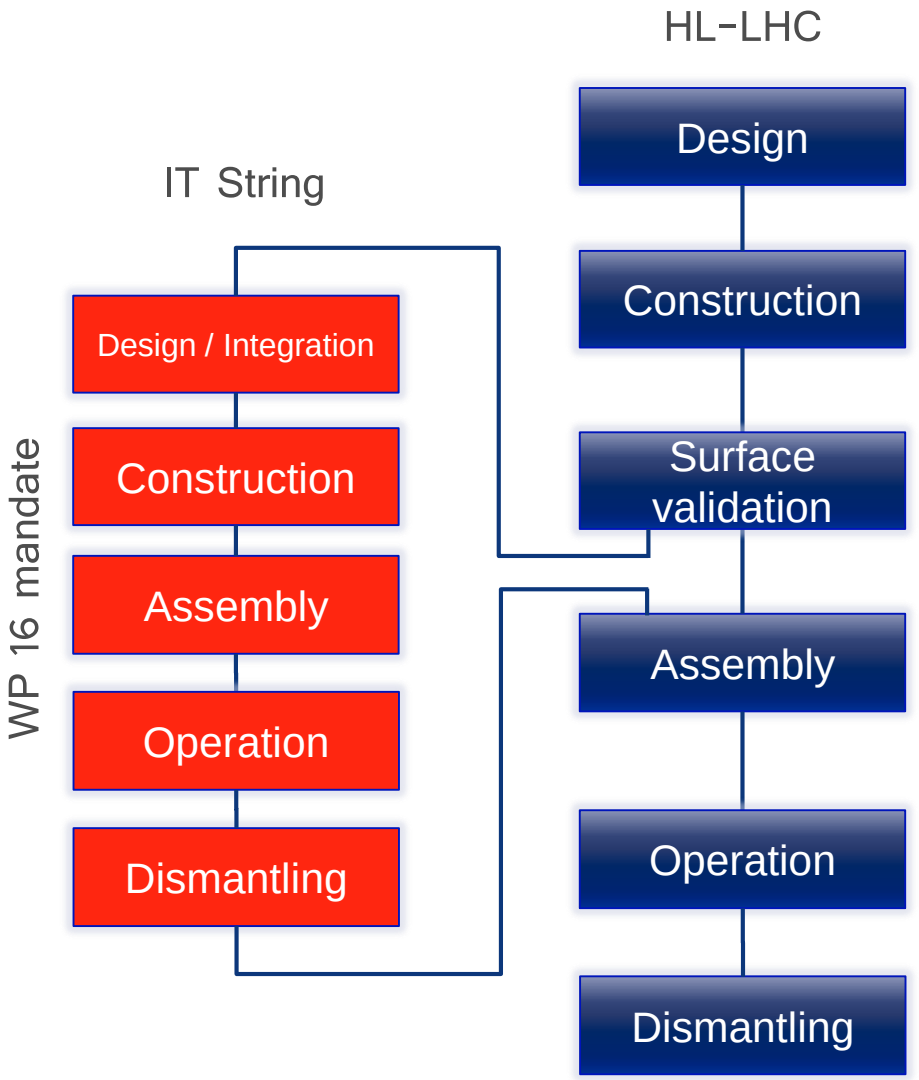
HL-LHC String day - ... HL-LHC String day - ...

IT String – Life cycle

A full-scale (1 fifth of HL-LHC IT) project, within the HL-LHC project, which requires safety coordination

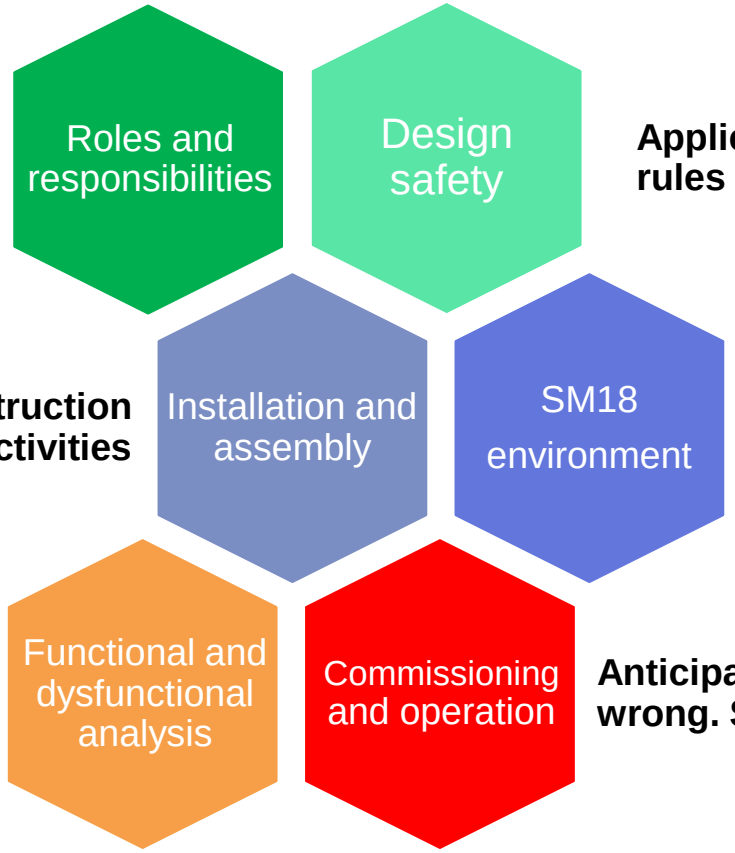
IT String boundaries

- Equivalent configuration as in HL-LHC 5L
- No beam
- No activation
- Surface building SM18
- Coactivities
- Cooperation
- Reuse of equipment



IT String – Safety content sections

Six main safety sections covering the entire IT String life cycle

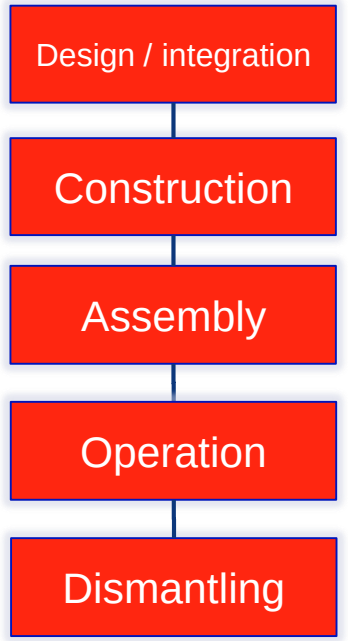


Applicable standards, norms, rules and regulations

On-site construction and coactivities

Anticipate/identify what can go wrong. Safe operation

IT String life cycle



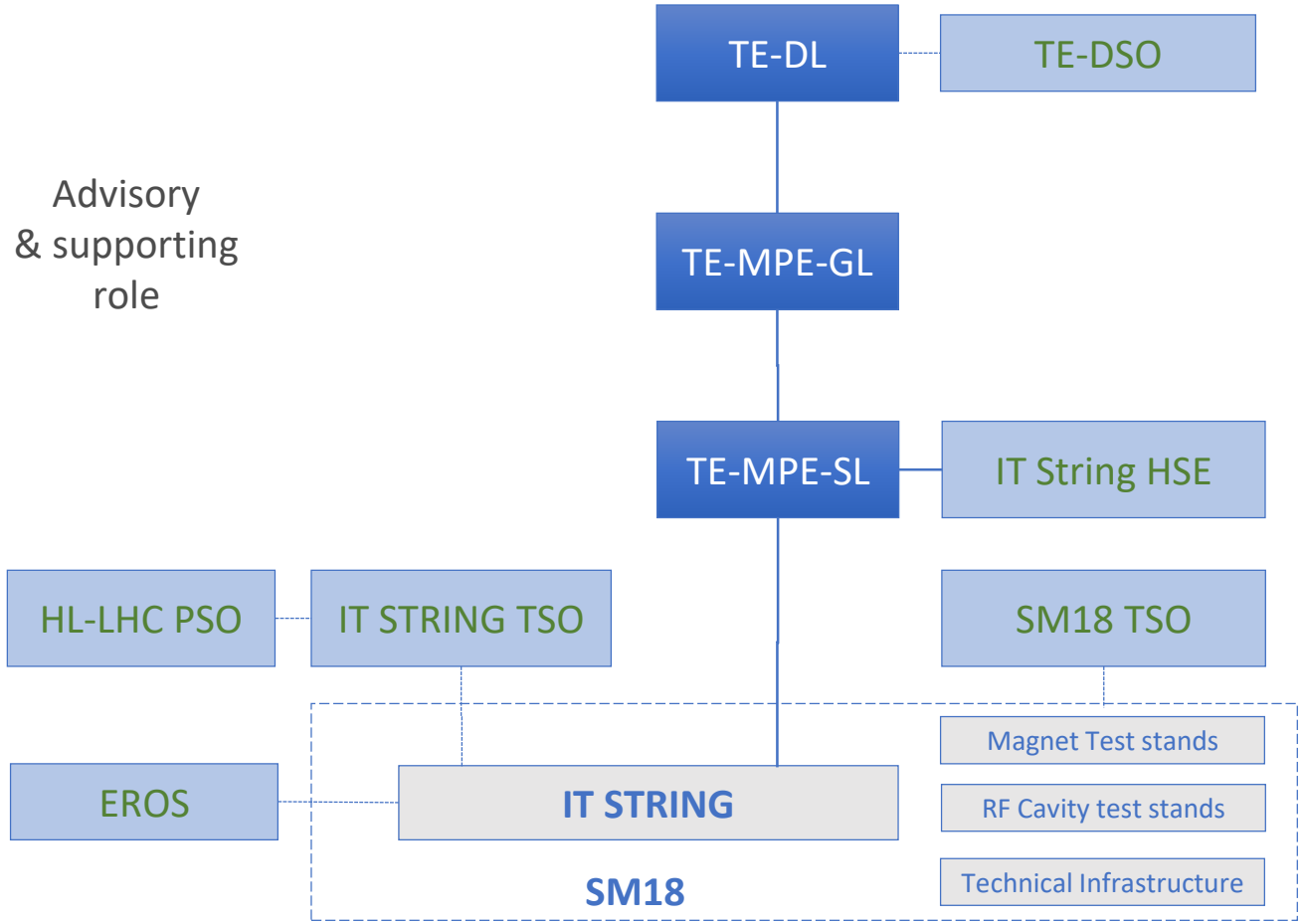
IT String Safety – Roles and responsibilities*

TE-DL	Miguel Jimenez
TE-MPE-GL	Felix Rodriguez Mateos
TE-MPE-SL	Marta Bajko

Line Management Responsibility role

TE DSO	Delphine Delrieux-Letant
IT String TSO	Davide Bozzini
SM18 TSO	Patrick Viret
HL-LHC PSO	Thomas Otto
IT String HSE	Carlos Gascon
EROS	Emanuel Paulat

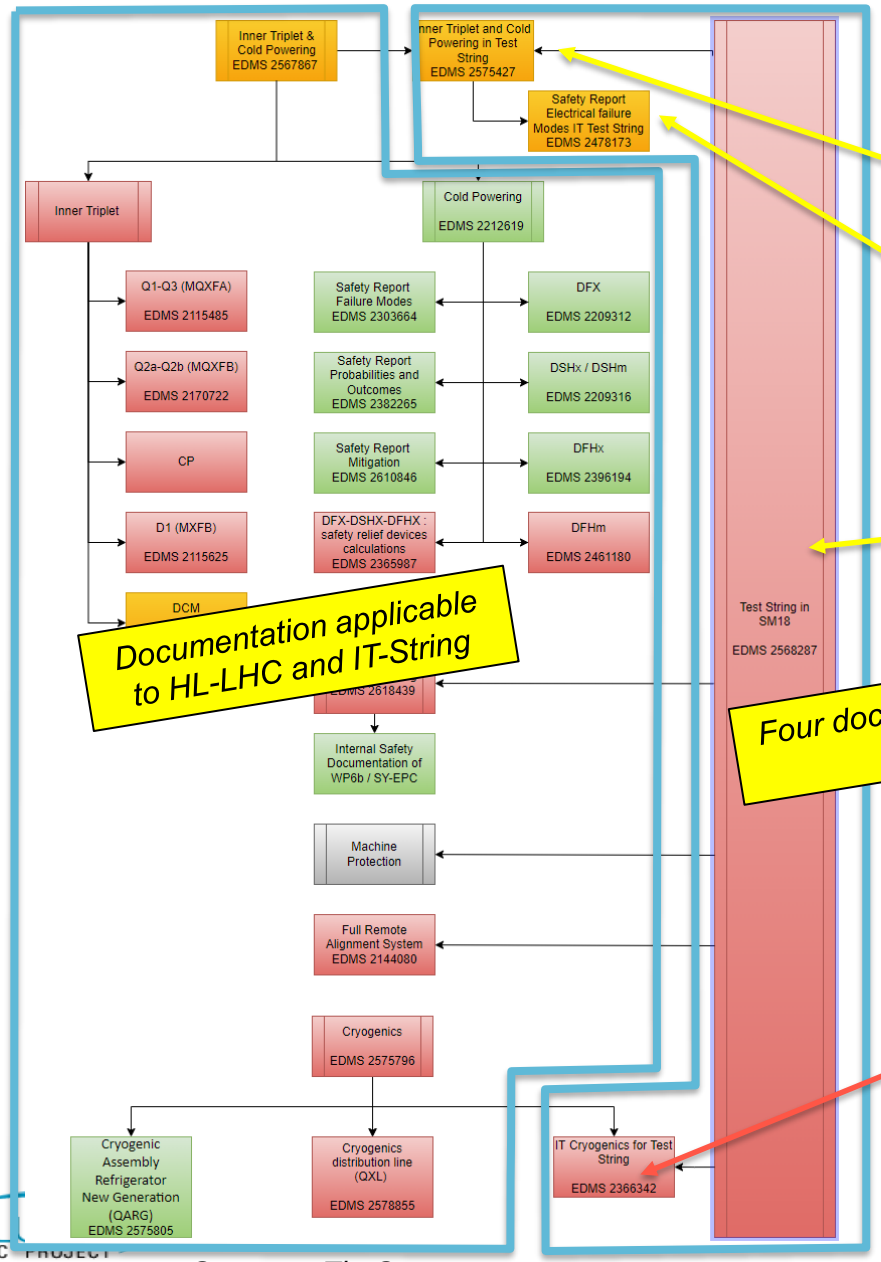
Advisory & supporting role



DH	Department Head
GL	Group Leader
PL	Project Leader
DSO	Departmental Safety Officer
TSO	Territorial Safety Officer
PSO	Project Safety Officer
HSE	Health, Safety & Environmental
EROS	Engineering Referent for Operational Safety
TC	Technical Coordinator

* According to SR-SO ''Responsibilities and organizational structure in matters of safety at CERN''

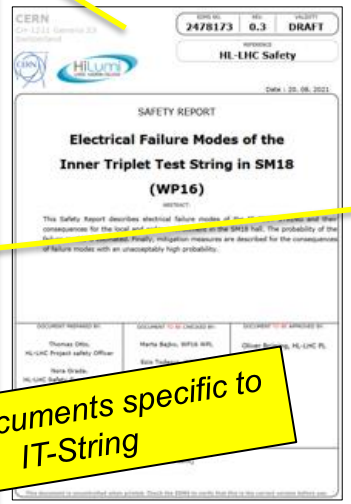
Design safety – Contribution from HL-LHC Safety office



Documentation applicable to HL-LHC and IT-String

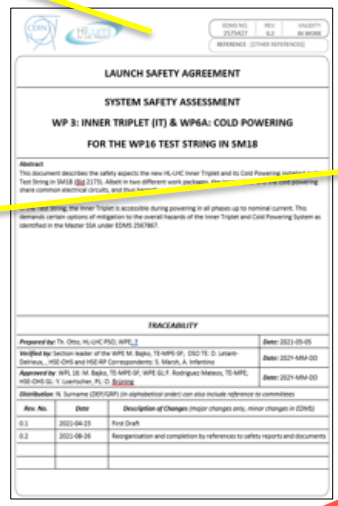
Four documents specific to IT-String

- Edited according Safety Organisation for the HL-LHC as presented by C. Gaignant talk Safety for HL-LHC



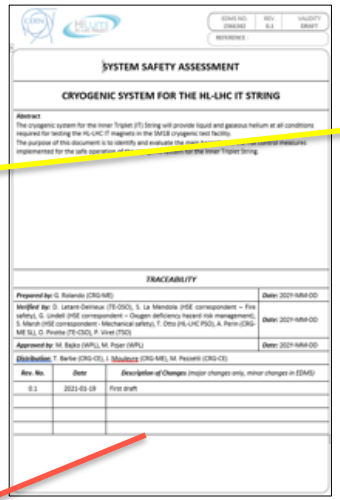
HL Engineering Check

November 2022



HL Engineering Check

November 2022



In Work

December 2022

In Work

February 2023

Expected release dates

Good overall progression, but availability of individual equipment SSAs to be carefully followed-up

Courtesy: Th. Otto

Design safety – Contribution from HSE

- HSE Follows-up IT String project closely attending safety and technical meetings
- Assisting HL-LHC IT string project team on safety issues raised during works advancement
  - ✓ Earthing & electrical issues, platform mechanical structure, crane operations
  - ✓ Emergency: AUG, lighting, fire extinguishers, evacuation paths
  - ✓ Worksite safety: VICs, site discussions, coactivity
- Processing SSAs submitted
  - ✓ Mainly systems standalone
  - ✓ Classifying mSI (major Safety Implications)
  - ✓ Establishing memo Safety checks
- SRFs demanded by HL-LHC IT String team
  - ✓ AUG strategy on UPS already implemented - EDMS no 2691128
  - ✓ Defined evacuation paths in IT String area - EDMS no 2675718
  - ✓ Validation calculation report for IT String platform - EDMS no 2591988
  - ✓ Validation calculation report for DN100 pipes supports - EDMS no 2659207

❑ Master SSA for installation is needed

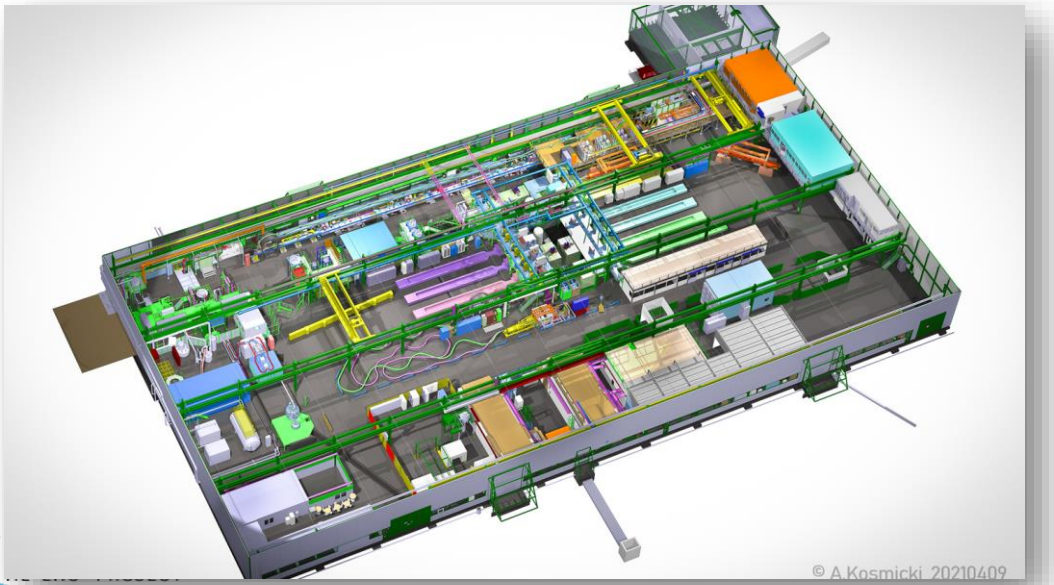
- ✓ All standalone SSA from system to be integrated in works
- ✓ Installation analysis (in advance) will identify problematic interfaces in works phases
- ✓ Coactivity needs to be assessed in advance

Courtesy: C. Gascon

SM18 environment - Boundaries

IT String boundaries in SM18

- Equivalent configuration as in HL-LHC 5L
- No beam ✓
- No activation ✓
- Surface building SM18
- Coactivities
- Cooperation
- Reuse of equipment/systems



Safety-related points (non-exhaustive)

- Different layout and two floors (dedicate mezzanine)
- Implementation of dedicated metallic structure
- Accessibility

- Presence of personnel
- Adaptation and share of AUGs
- Share of infrastructure (EL, CV, cryo,…)
- Adaptation of evacuation paths

- Knowledge and assessment of neighbouring risks during works
- Sharing/understanding of risks introduced by the IT String and the identification of mitigation actions

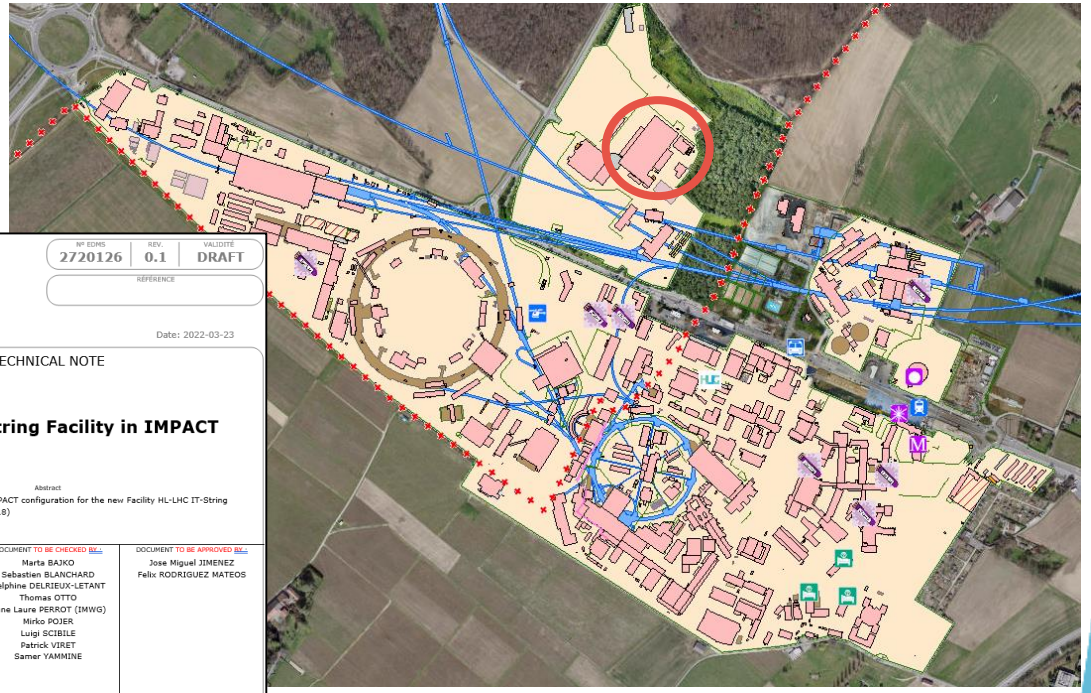
- Cumulative risks
- Crosstalk and dependencies between testing areas

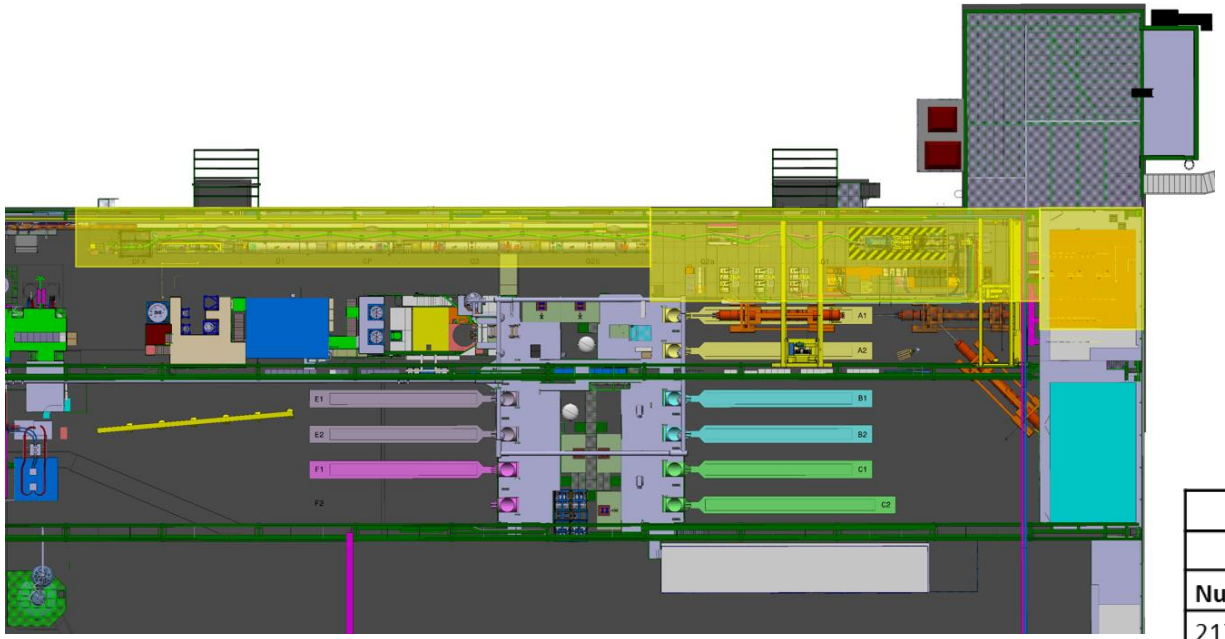
- Confirm return of equipment to owners
- Traceability of changes

SM18 readiness to host IT String - IMPACT

SM18 environment

- Same approach as in the accelerators
- Multifunctional test hall – coactivity management
- Traceability of interventions and associated safety risks
- Train personnel that will work in HL-LHC
- Three IT String areas declared
- Fully operational





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2720126	0.1	DRAFT

REFERENCE

CERN TE TECHNOLOGY DEPARTMENT

Date: 2022-03-23

TECHNICAL NOTE

HL-LHC IT-String Facility in IMPACT

Abstract

This document describes the IMPACT configuration for the new Facility HL-LHC IT-String to be built in building 2173 (SM18)

DOCUMENT PREPARED BY:	DOCUMENT TO BE CHECKED BY:	DOCUMENT TO BE APPROVED BY:
Davide BOZZINI (TE-MPE)	Marta BAJKO Sebastien BLANCHARD Delphine DELRIEUX-LETANT Thomas OTTO Anne Laure PERROT (IMWG) Mirko POJER Luigi SCIBILE Patrick VIRET Samer YAMMINE	Jose Miguel JIMENEZ Felix RODRIGUEZ MATEOS

DOCUMENT SENT FOR INFORMATION TO:

Jean-Philippe TOCK, Oliver BRUNING, Emmanuel PAULAT, Estrella VERGARA FERNANDEZ

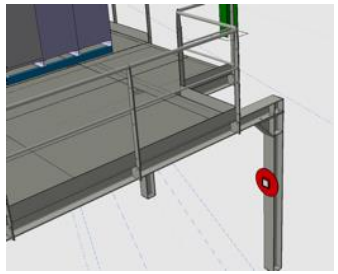
Dès qu'imprimé, la validité de ce document est non contrôlée. Vérifier sa validité sur l'EDMS avant de l'utiliser.

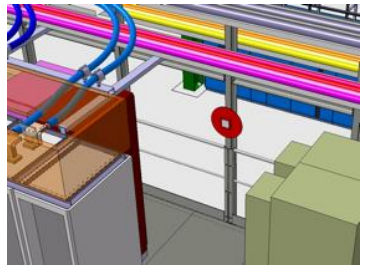
SM18					
Building				Surface / Underground	Facility
Num	Floor	Area / Room	Name		
2173	R	IT_STRING	IT-String area	Surface	HL-LHC IT-String
2173	1	1-S06	Control room	Surface	HL-LHC IT-String
2173	1	1-V08	Mezzanine	Surface	HL-LHC IT-String

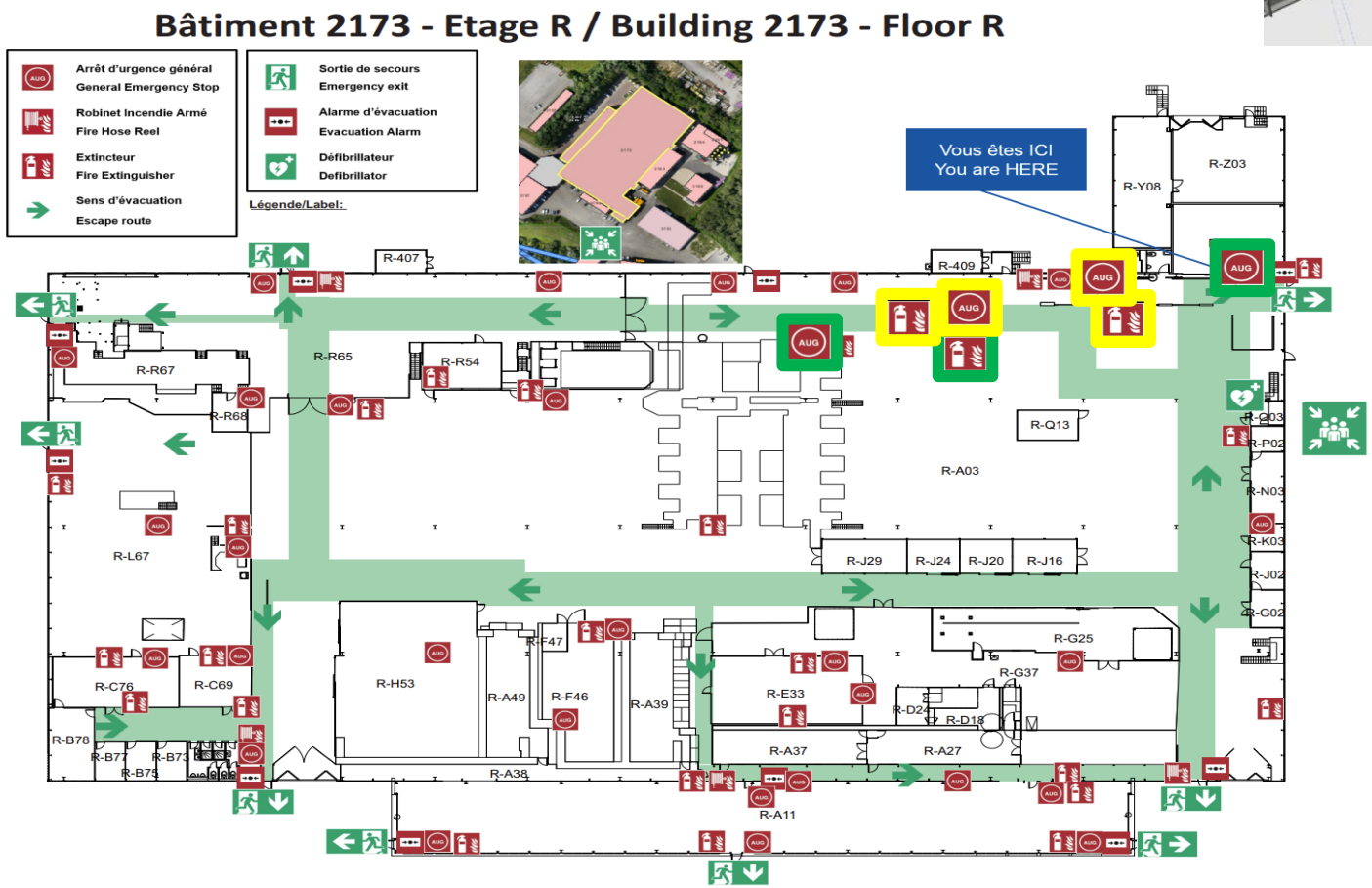
HiLumi HL-LHC PROJECT

SM18 readiness to host IT String – Safety equipment

- AUG and fire extinguisher locations defined considering CERN fire brigade, SM18 coordination, DSO and IT String requirements
- All installed and operational







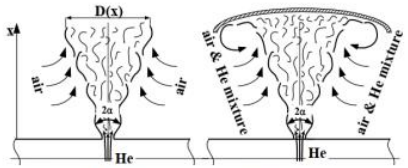
EDMS : 1208004

SM18 readiness to host IT String – Oxigen deficiency hazard

- Risks assessment done by HL-LHC PSO
- Comparative assessment between HL-LHC underground and IT-String in surface buiding SM18
- Outcome: No oxygen deficiency hazard in SM18 in case of major leak on the IT String
- Fencing around IT String recommended

SM18 vs. LHC Tunnel

- In the LHC tunnel, a helium release rate of 1 kg/s reduces O_2 concentration < 18 % over sizeable distance from leakage
- → No access during Powering Phases Ib and II



SM18 Tunnel

- Large volume of SM18: no OD Hazard
- Relief disk orientation gives helium release an upward momentum, at T_{He}> 40 K, buoyancy.
- Safety fence around IT string prevent getting too close to release point.

Courtesy: Th. Otto

SM18 readiness to host IT String – Evacuation and fencing

Evacuation

- Evacuation plan of SM18 updated according to IT String installation and operation boundaries

Fencing during installation

- During installation and construction work use of mobile fencing in concerned areas
- Mobile fencing and adequate panels are installed when impacting non IT String areas

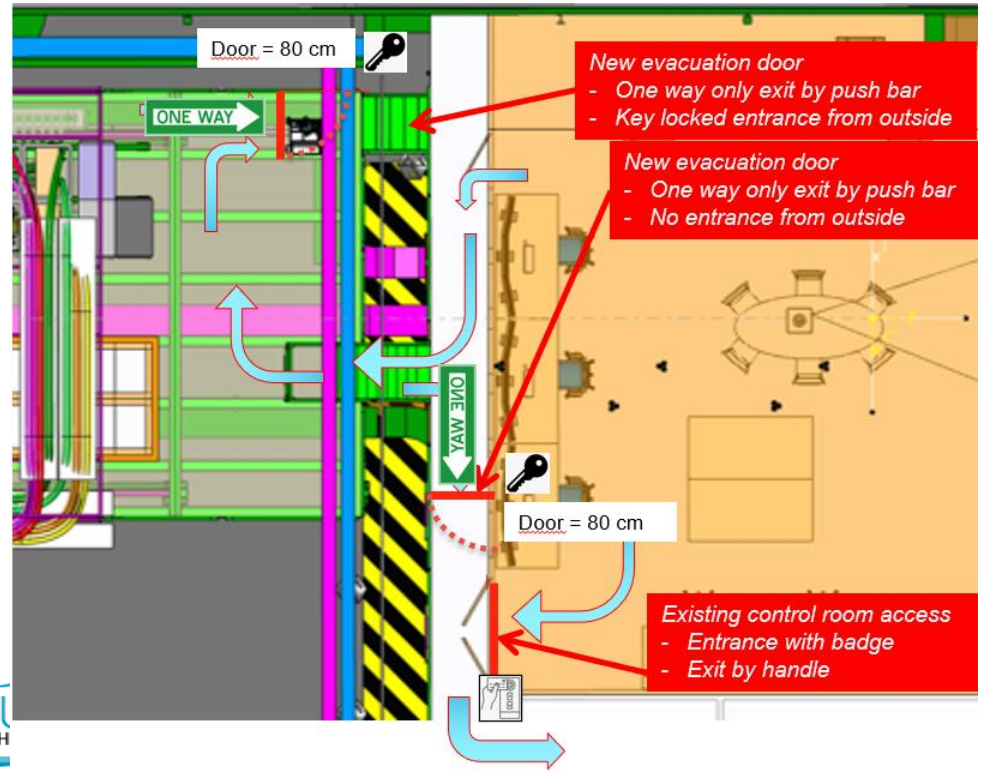
Fencing during commissioning and operation (see next slides)

- Fix fencing around string of magnets
- Controlled access to string of magnets fenced area, to mezzanine and to control room
- Installation of evacuation doors to comply with evacuation plan

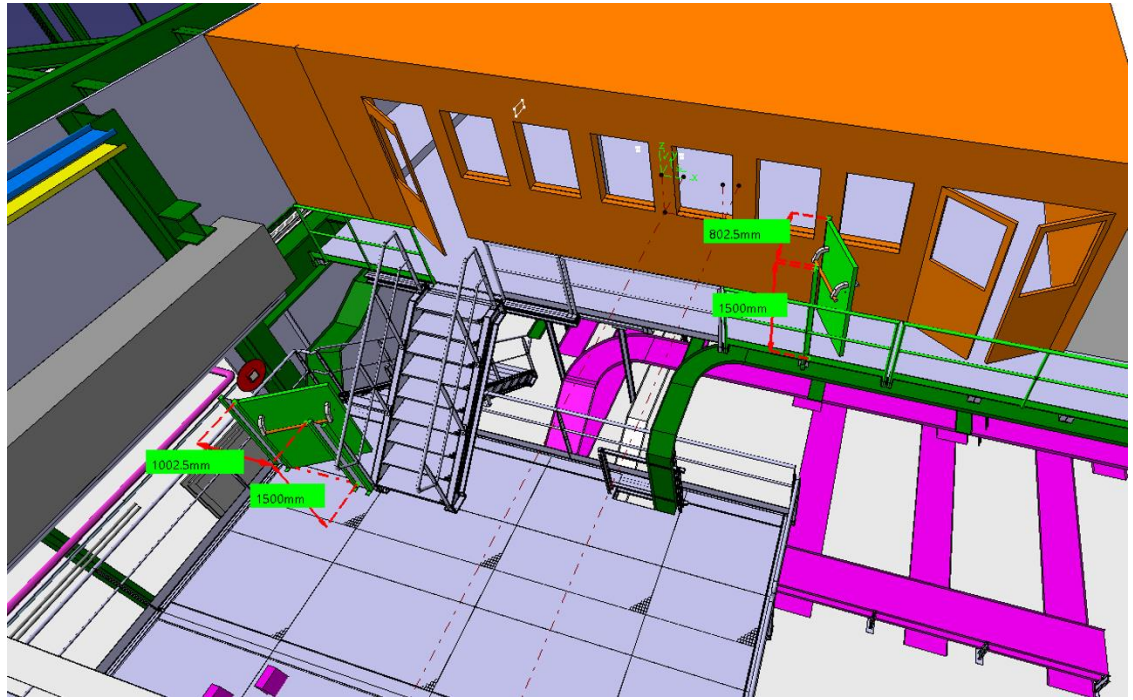
SM18 readiness to host IT String – Fix fencing proposal

- Technical feasibility has been confirmed
- 3D integration proposal available
- Technical note is ongoing
- Submittal of proposal for approval: November 2022

Evacuation path from control room and mezzanine



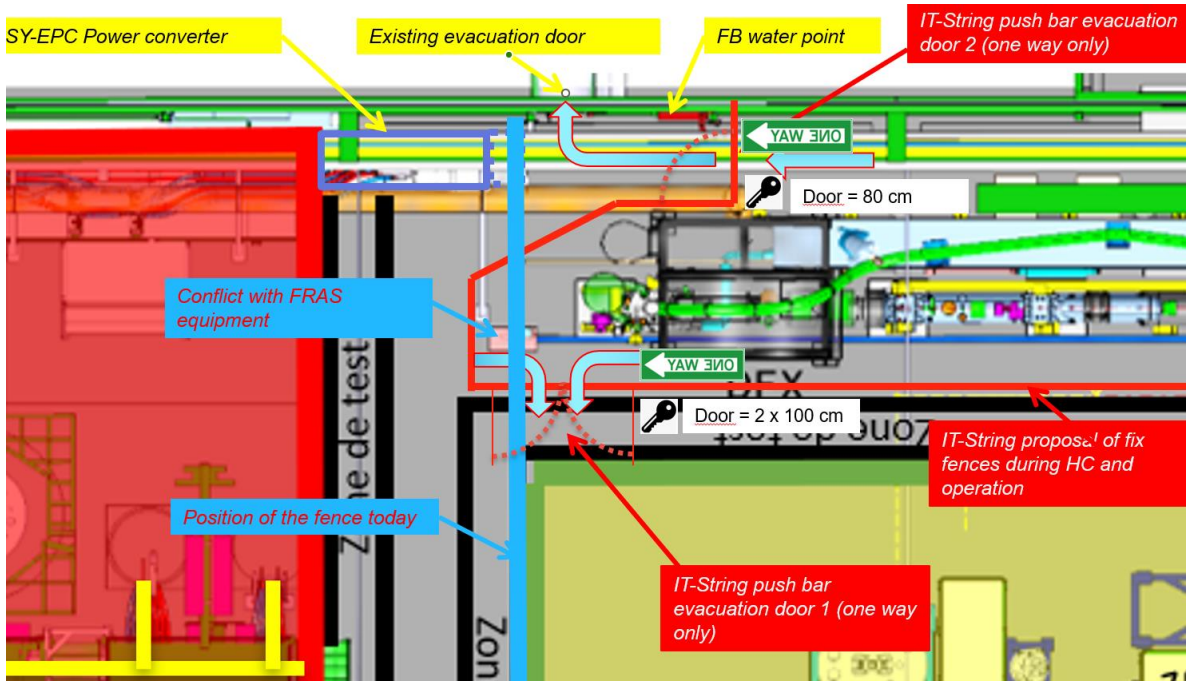
Doors for access and evacuation from control room and mezzanine



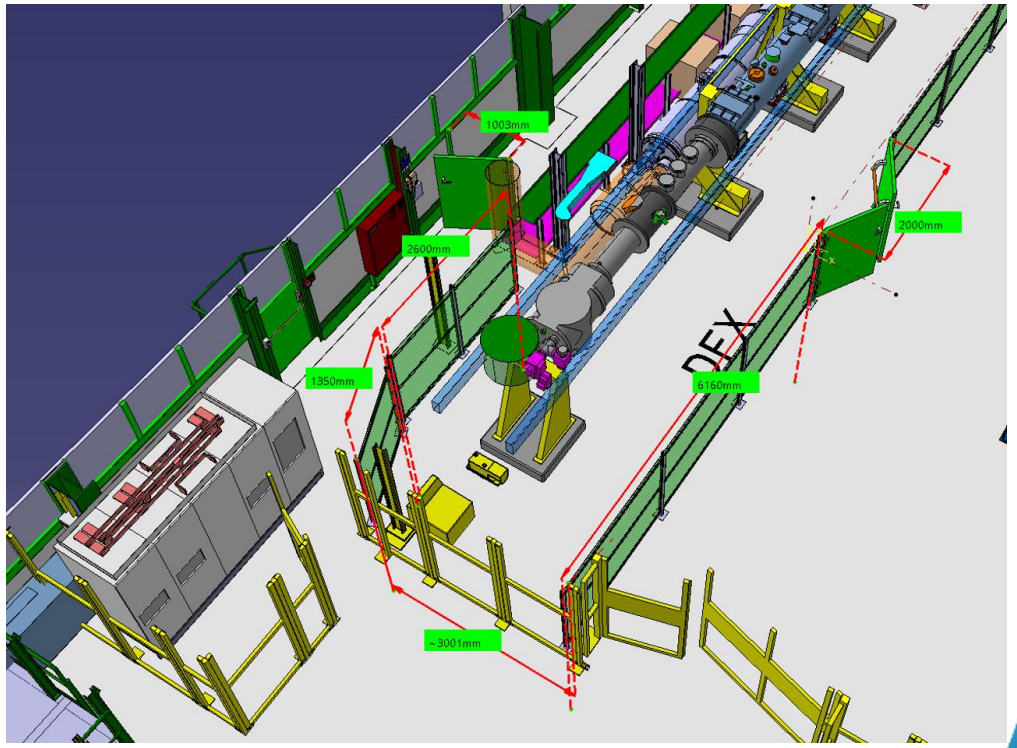
SM18 readiness to host IT String – Fix fencing proposal

- Conflicts between existing cluster G-H fix fencing and IT String identified
- Proposal considering all requirements (evacuation, fencing of clusters G-H, fencing of IT String) is available

Clusters G-H and IT String equipment and fences conflicts



Proposal of fix fencing for clusters G-H and IT String

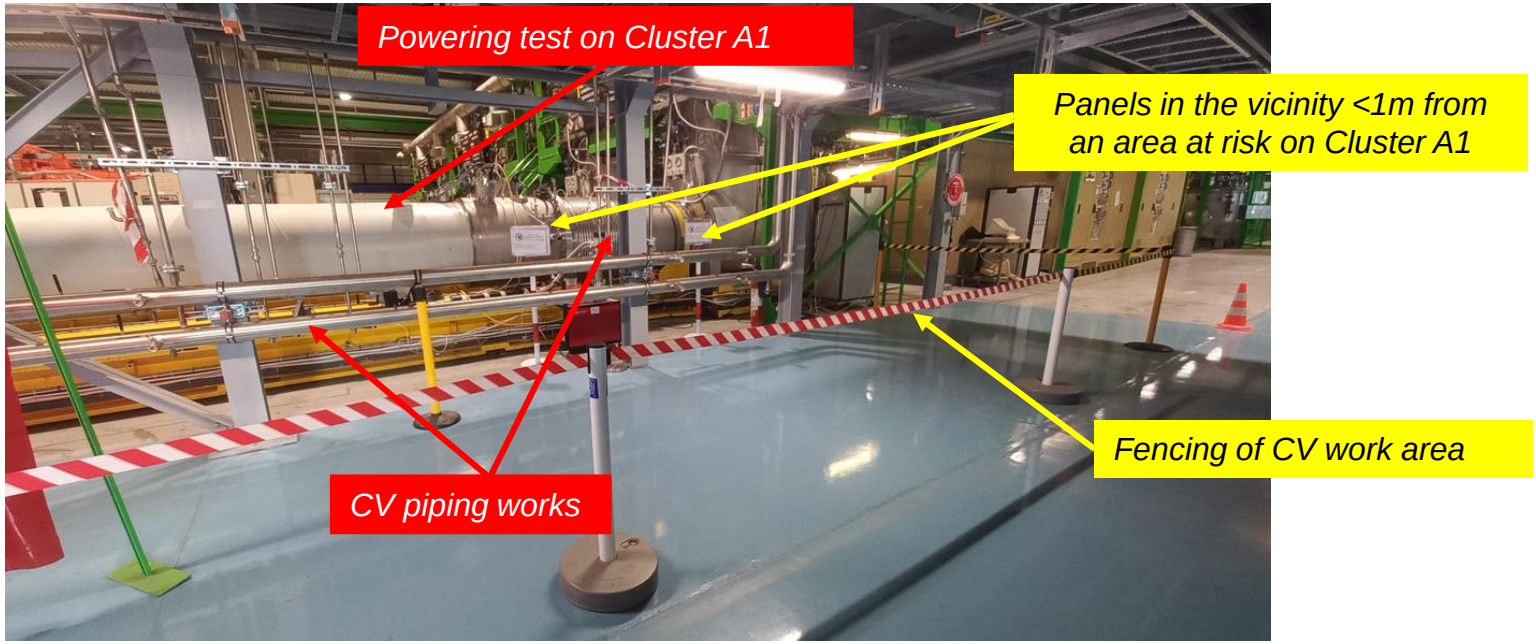


Installation & assembly – Safety on the field

Works done so far and related safety aspects

- 50 VICs successfully organised or planned
- Incidents, accidents, near miss …. **None so far**
- Multidisciplinary exercise (heavy handling, electricity, mechanics, cabling, soldering, X-ray)
- Proactive collaboration / contribution from stakeholders, service providers and contractors

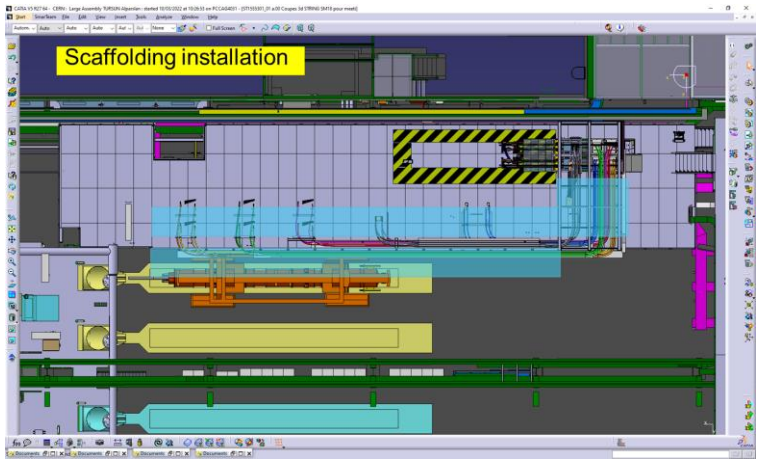
Example of two-levels safety awareness and fencing during coactivity between CV piping work and powering tests on Cluster A1

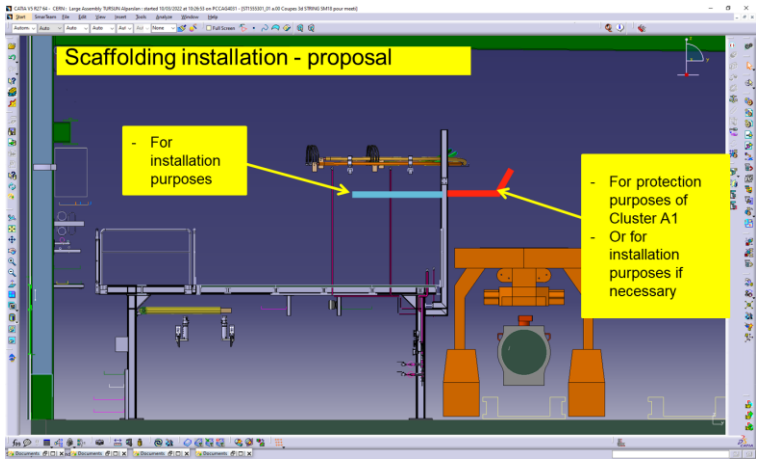


Installation & assembly – coactivities

SM18 – Operational aspects ad coactivates with Cluster A

- Early installation of scaffolding over the A1 test bench has proved to be a smart decision
- Safe workplace at height that allows coactivities between the IT String and Cluster A1
- Daily follow-up required to rapidly adapt to activities and tests program evolution





Functional and dysfunctional analysis

Functional analysis

- Details the way in which the system will operate in all its phases of its life, as well as the other systems with which it will be able to interact

Dysfunctional analysis

- Aims to imagine all possible failures that can occur anywhere in the system, alone or in combination, and to analyse the impact of these failures and/or implement mitigation actions

IT String

- Boundaries are different from HL-LHC environment
- Four real examples will be given (see next slides)
- Implemented measures and lessons learned are documented and will contribute to HL-LHC

Functional and dysfunctional analysis – CASE 1: UPS supply and AUG action

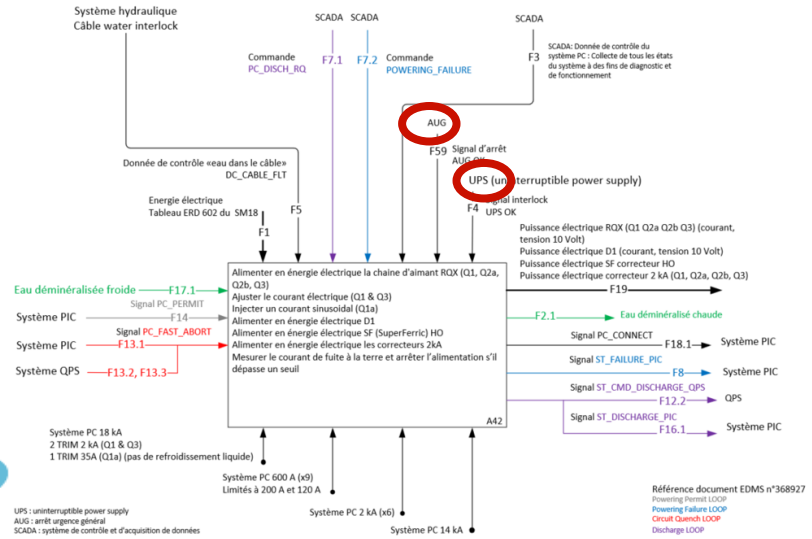
Options available

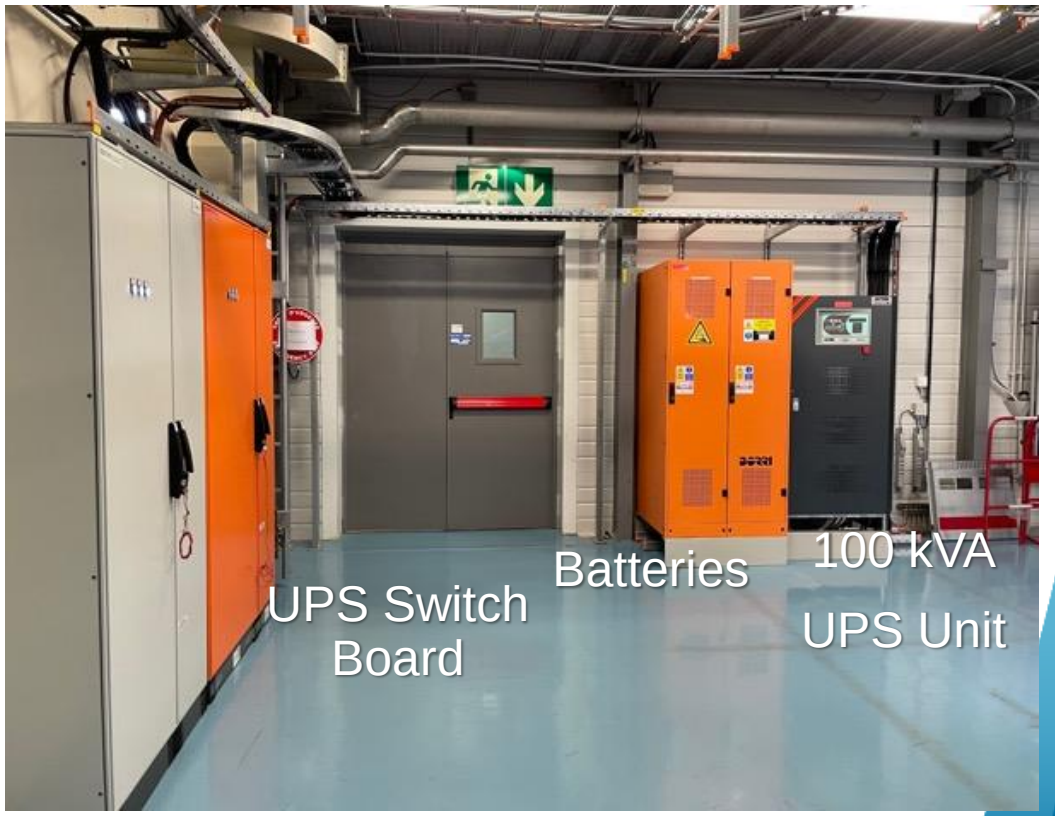
1. Review of UPS and AUG dependencies on SM18's main uninterruptable supply network and remove dependencies
2. Design and implement a dedicated IT String UPS network without dependencies on existing AUG system

Implemented and operational

Retained option → 2

- A dedicated and independent UPS network for the IT String is under study
- AUG trip will not cut UPS loads, allowing IT String to be safely protected during discharge





Functional and dysfunctional analysis – CASE 2: Water flow in WCC

Functional analysis

- Absence of water circulation through a water-cooled cable segment shall be supervised and an interlock signal shall act in the event of water circulation loss

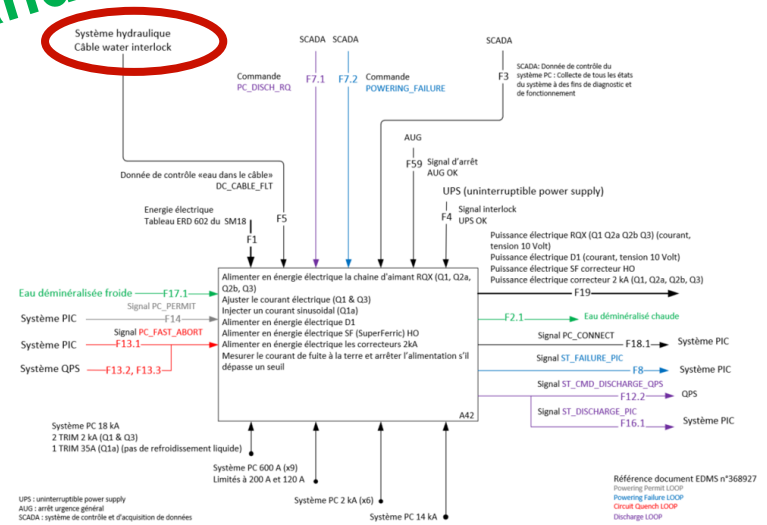
Dysfunctional analysis

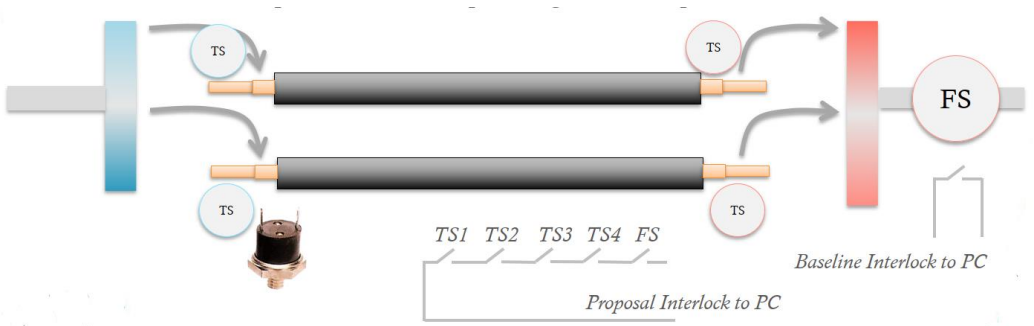
- Technical review with concerned stakeholders (EL and CV) pointed out that interlock signals from WCC flowmeters to power converters were not planned
- Missing interlock redundancy

Mitigation actions taken

- Concerned stakeholders will design and order the cabling for the required interlock signals
- Review of WCC circuitry P&I and interlock scheme in the framework of the HL-LHC Magnet circuit Forum

Issue resolved and to be implemented





Interlock redundancy elements, courtesy of S. Yammine

Functional and dysfunctional analysis – CASE 3: Use of crane VISAN

Functional analysis

- Possibility to operate the VISAN crane for Cluster A activities during the construction and commissioning of the IT String

Dysfunctional analysis

- Risks have been identified when the crane shall be used in the IT String area, in particular when transiting over the mezzanine
- Aerial collisions during manoeuvres
- Risks of injuries for personnel working at high

Mitigation actions under study

- Seeking from HSE: derogation on crane use without having the recommended 50 cm of clearance
- Defining detailed operational procedures considering SM18 environment
- Implementation of exclusive non-use areas for the crane, according to the IT String's status (construction, operation)
- Implementation of switches to limit the zone of use and modality of operation (slow mode, double button)

Actions under study

Functional and dysfunctional analysis – CASE 4: FRAS

Functional analysis

- Possibility to operate FRAS from remote imply having moving active parts in the IT String

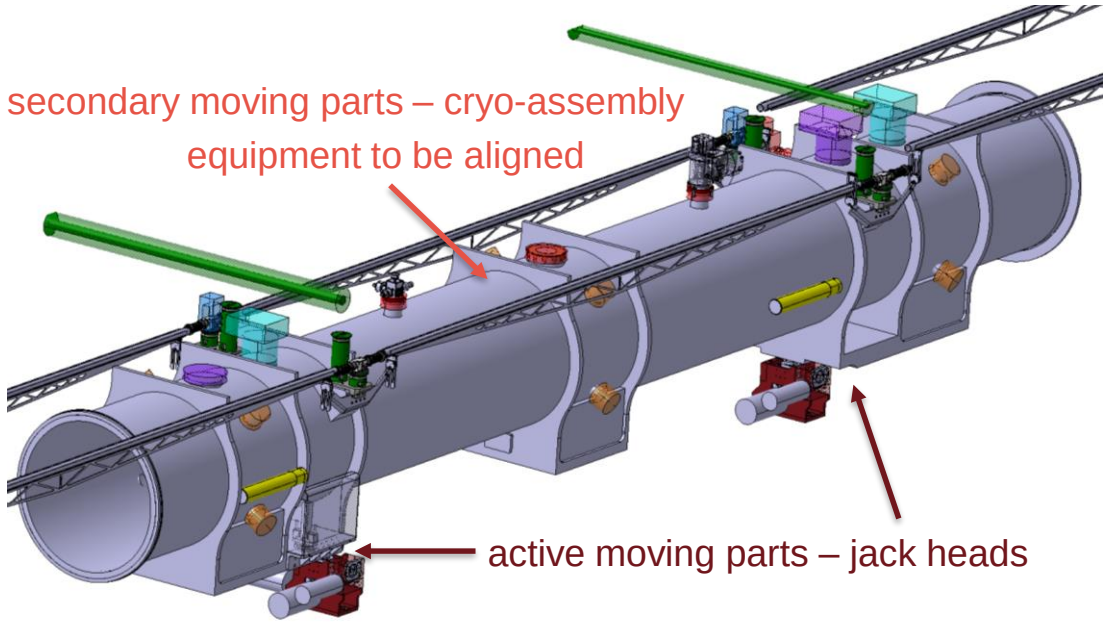
Dysfunctional analysis (EDMS LHC- -SR-0001)

- Risks have been identified when the FRAS is used remotely and personnel might be in the vicinity of the moving/moved components
- Risks of injuries for personnel not from movement, but from possible equipment damage and Helium release

Mitigation actions under study

- Implement a key lock system for the interlock of FRAS
- Operation of FRAS from IT-String control room or in local expert mode (only BE-GM personnel in the vicinity)
- Implementation of fix fences to prevent involuntary access and to prevent involuntary collisions with FRAS components

actions specified – implementation under study



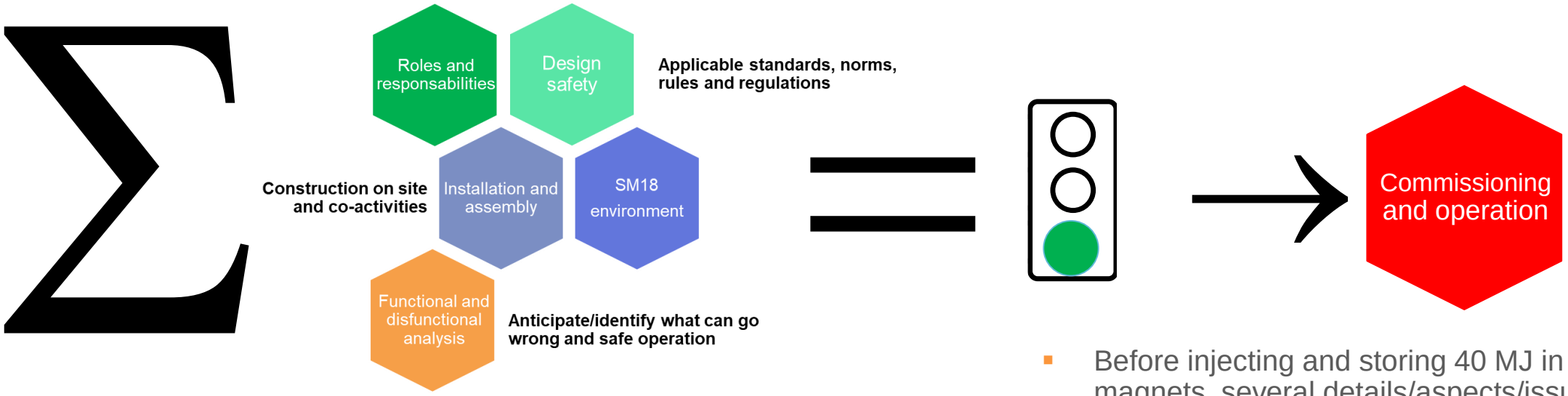
movement steps ≤ 500 µm
movement speed ≤ 20 µm/s

FRAS hardware snapshot, courtesy of A. Herty

Commissioning and operation - Content

Time to put power on infrastructure and current through the magnets

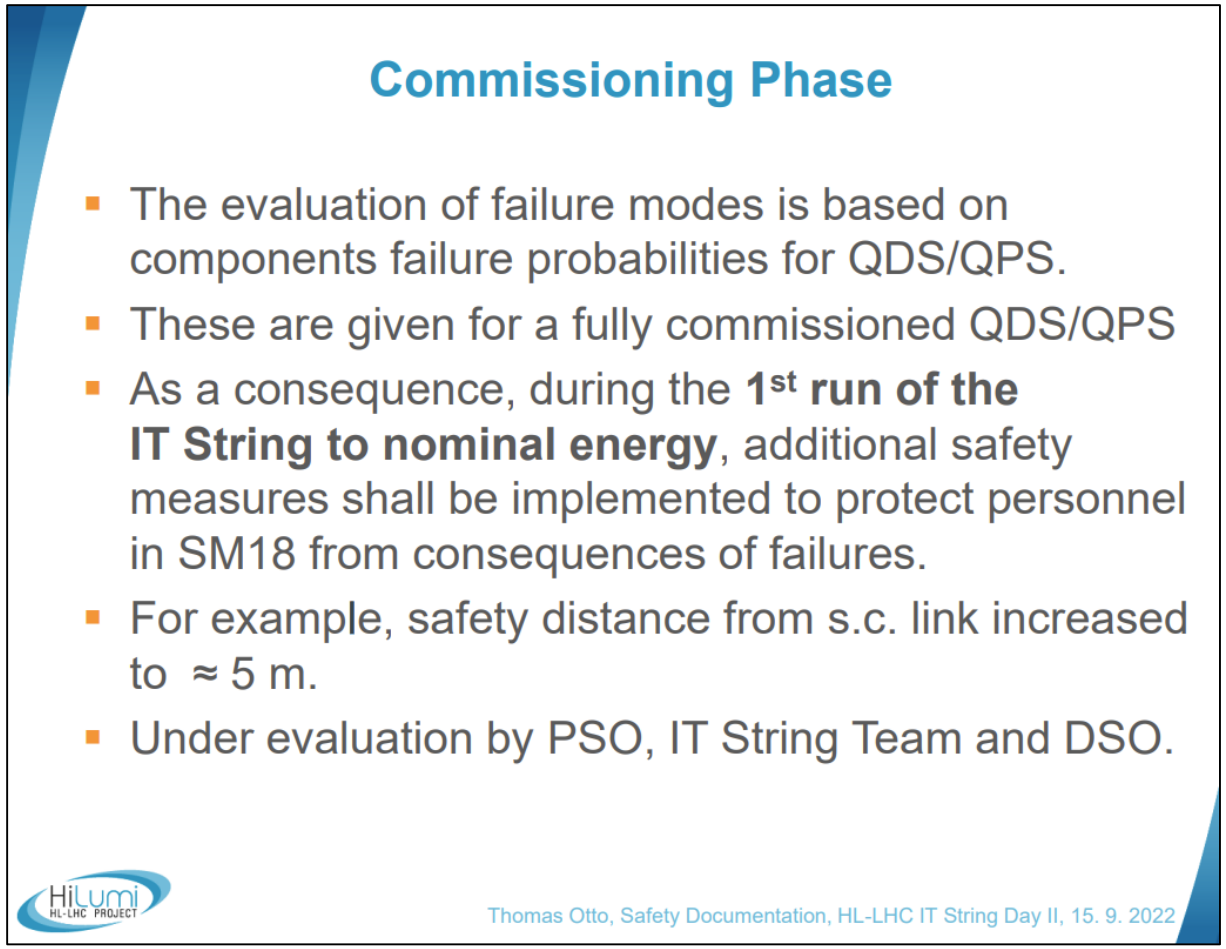
- Safe commissioning and operation of the IT String will depend on how the previous five safety sections will be executed, validated and applied



- Before injecting and storing 40 MJ in the magnets, several details/aspects/issues shall be finalized
- This work started in 2022 by WP16, HL-LHC PSO, MCF and concerned stakeholders
- Next slides will report on progress

Commissioning and operation - Accessibility

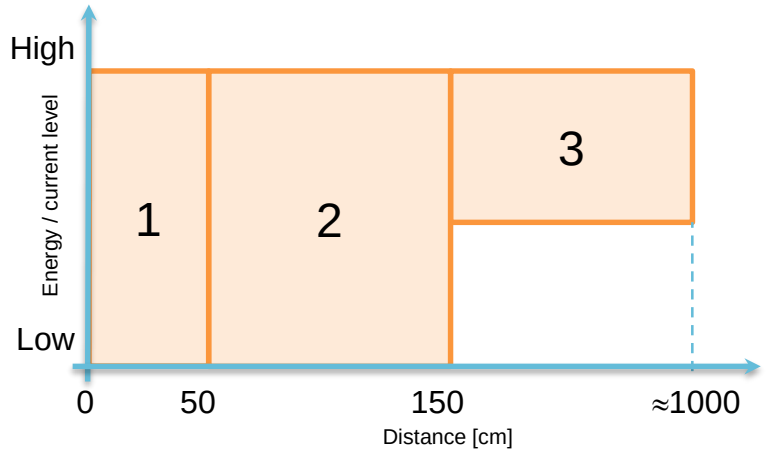
- The goal is to safely work in SM18 areas considering the IT String commissioning phases, type of test and level of stored energy
- Risks assessment done in collaboration with HL-LHC PSO
- Specific measures to be implemented considering the boundaries of SM18 environment (workload of benches, presence of personnel,..)
- Proposal: Extended and punctual extended safety area during first commissioning of systems with powering at high energy



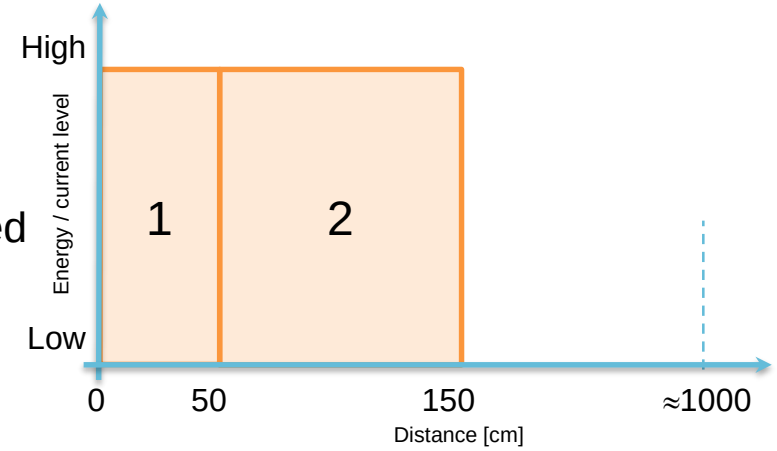
Courtesy: Th. Otto

Commissioning and operation - Accessibility

Individual system commissioning and first powering



Test program once all systems are commissioned



1 – Forbidden area
- According to recommendations of ‘’Electrical failure modes of the Inner Triplet in SM18’’ – EDMS 2575427’’

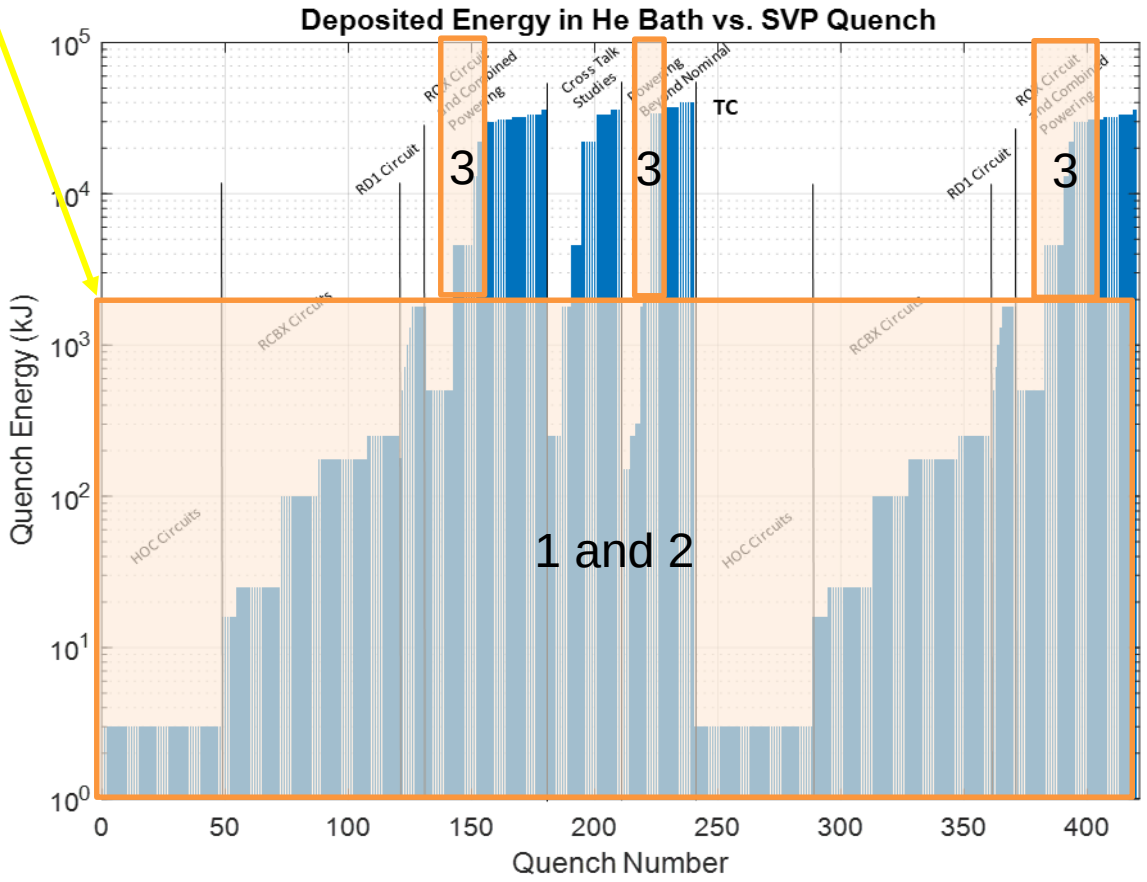
2 – Controlled area
- Fenced and access-controlled
- Distantiatiate from release valves opening
- Safe remote use of alignment system
- Safe high-voltage tests during ELQA
- Facilitate activities in the neighbouring areas

3 – Extended area
- Including clusters A, D, G, H and transit areas
- To grant safety during first high-energy powering tests and quenches
- Energy thresholds and types of tests to be determined

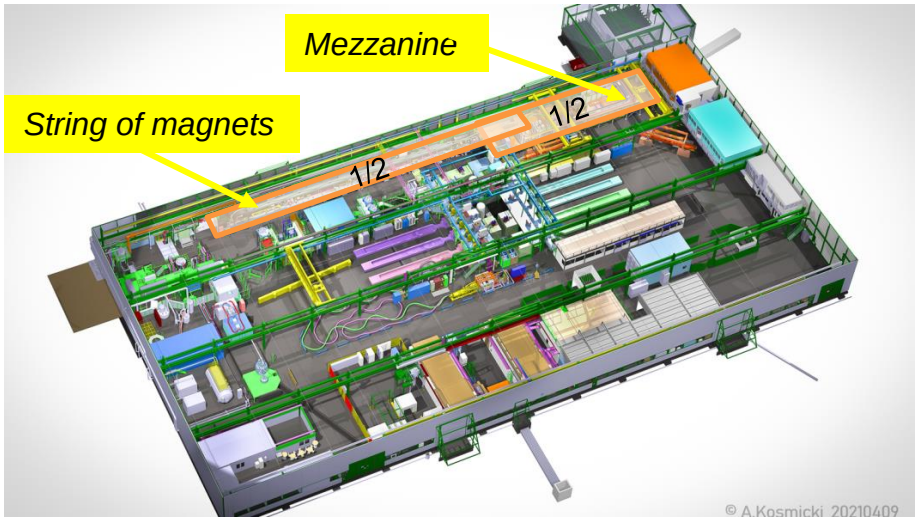
Whenever and wherever needed (under study)
- Patrolling before powering
- CCTV in IT String control room
- Powering tests performed outside normal working hours
- Interlocks

Commissioning and operation - Accessibility

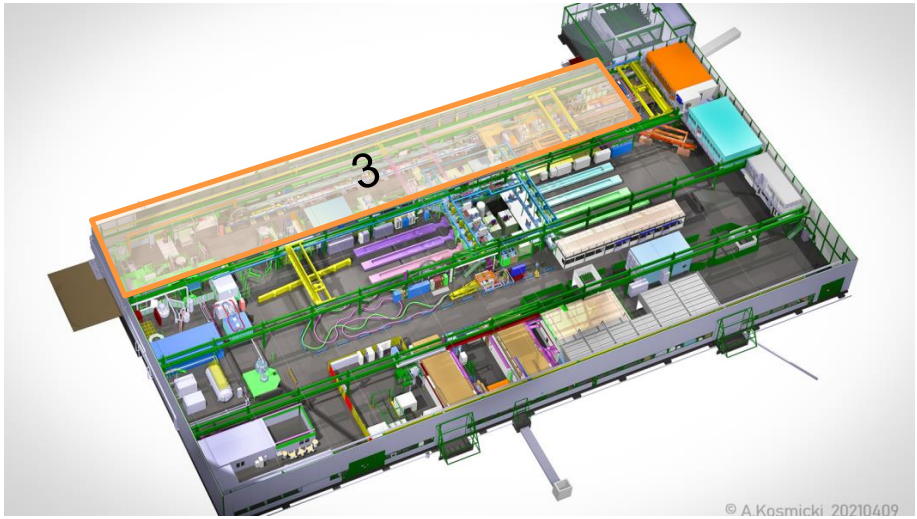
Threshold to be determined



1 & 2 forbidden and controlled areas



3 Extended area (proposal)



Commissioning and operation – Safety rules

IST procedures

- Each procedure for IST will include a dedicated chapter for safety aspects

Operational procedures

- A dedicated safety document will be edited including the generic safety aspects that apply during the operation of the IT String
- Specific procedures (such as FRAS operation and ELQA tests) will include a dedicated chapter for the specific safety consideration

ELQA during the IT String assembly

	SLC	MIC-W	IT-PAQ	ITIV	ITIC
HVQ	✓	✓	✓	✓	✓
TFM	✓	✓		✓	
IRC	✓	✓		✓	
ICC	✓	✓	✓	✓	
TDR	✓	✓			✓
COC	✓			✓	✓
QHR		✓			
DVC		✓			
TSQ	✓	✓			

HVQ – High Voltage Qualification
TFM – Transfer Function Measurement
IRC – Instrumentation Resistance Check
ICC – Instrumentation Configuration Check
TDR – Time Domain Reflectometry
COC – Continuity of Conductor check
QHR – Quench Heater Resistance measurement
DVC – Diode opening Voltage Check
TSQ – Temperature Sensor Qualification

SLC – Superconducting Link Check
MIC-W – Magnet Instrumentation Check
IT-PAQ – Inner Triplet Partial Assembly Qualification
ITIV – Inner Triplet Interconnection Verification
ITIC – Inner Triplet Instrumentation Check

ELQA during the IT String commissioning

	TP4-A	MIC-W	TP4-B	TP4-C	TP4-D +MIC-D	MIC-C	TP4-E
	At warm	At warm	After flushing	During cool-down/ warm-up	At 80 K	At cold	At cold
HVQ		✓	✓	✓	optional	✓	✓
TFM	✓	✓			optional	✓	✓
IRC	✓	✓			optional	✓	✓
ICC	✓	✓			optional	✓	✓
TDR		✓			optional	✓	
QHR		✓			optional	✓	
DVC		✓				✓	
TSQ	✓	✓			optional	✓	✓

TP4-A – Test Procedure 4 type A
MIC-W – Magnet Instrumentation Check at warm
TP4-B – Test Procedure 4 type B
TP4-C – Test Procedure 4 type C
TP4-D – Test Procedure 4 type D
MIC-D – Magnet Instrumentation Check at 80 K
MIC-C – Magnet Instrumentation Check at cold
TP4-E – Test Procedure 4 type E

HVQ – High Voltage Qualification
TFM – Transfer Function Measurement
IRC – Instrumentation Resistance Check
ICC – Instrumentation Configuration Check
TDR – Time Domain Reflectometry
QHR – Quench Heater Resistance measurement
DVC – Diode opening Voltage Check
TSQ – Temperature Sensor Qualification

Courtesy: M. Bednarek

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PROCEDURE

ELQA QUALIFICATION OF SUPERCONDUCTING CIRCUITS IN THE HL-LHC IT STRING

Abstract

This document defines the sequence of qualification tests, technical requirements, organisational aspects and safety rules for the successful ELectrical Quality Assurance (ELQA) of superconducting circuits in the HL-LHC IT string facility in SM-18 during assembly and commissioning phases.

5 SPECIFIC ELQA SAFETY CONSIDERATIONS

The personnel executing the qualification tests as mentioned in this document, must have followed the electrical safety courses according to the UTE C 18-510 [3] and be in possession of a B1 or B2 certification. The teams are led by a "chargé de travaux" in possession of a B2 certification.

The areas where the tests will be done and all the areas where circuits or elements directly connected to them are energized or could be energized due to a fault shall be duly signalized and specific protection shall be put in place.

According to the UTE C 18-510 rules [3], all power converters powering the IT string facility under test have to be locked-out. All quench heater power supplies in the IT string facility have to be switched off. Any other electrical test or electrical intervention are forbidden on an IT string facility where ELQA tests are carried out.

Before starting the tests the ELQA engineer in charge will verify that all the preparatory works and restrictions are in place.

Qualification tests are always executed by a minimum of 2 ELQA team members. If the energized areas are multiple, the necessary personnel for the control will be provided by the ELQA team.

During the execution of the tests any person requiring an access to the area shall contact the ELQA engineer in charge and ask the permission for entering or crossing the area under test.

After the tests all circuits will be discharged and will be left grounded.

Take-away message

Safety @ IT String

- Safety is WP16's top priority
- Good progress on each of the 6 safety sections. In line with the IT String requirements and progress
- Safety during construction and installation phases is duly applied by all contributors
- Functional and dysfunctional analysis continues to yield results, with solutions being identified
- Definition of safety aspects to apply during the operation phase is in work
- Excellent collaboration between the WP16 core team, HL-LHC safety office, the SM18 users and all stakeholders concerned by safety
- Looking forward to actively contribute with feedback and lessons learned to the safety organization for the HL-LHC

Thank you to the participants and collaborators for all their efforts

Thank you for your attention