Safe intervention during operation on the electrical circuits of the HL-LHC IT String

D. Bozzini from TE-MPE-SF, on behalf of WP16 and IT String contributors

14th HL-LHC Collaboration Meeting, 7-10 October 2024

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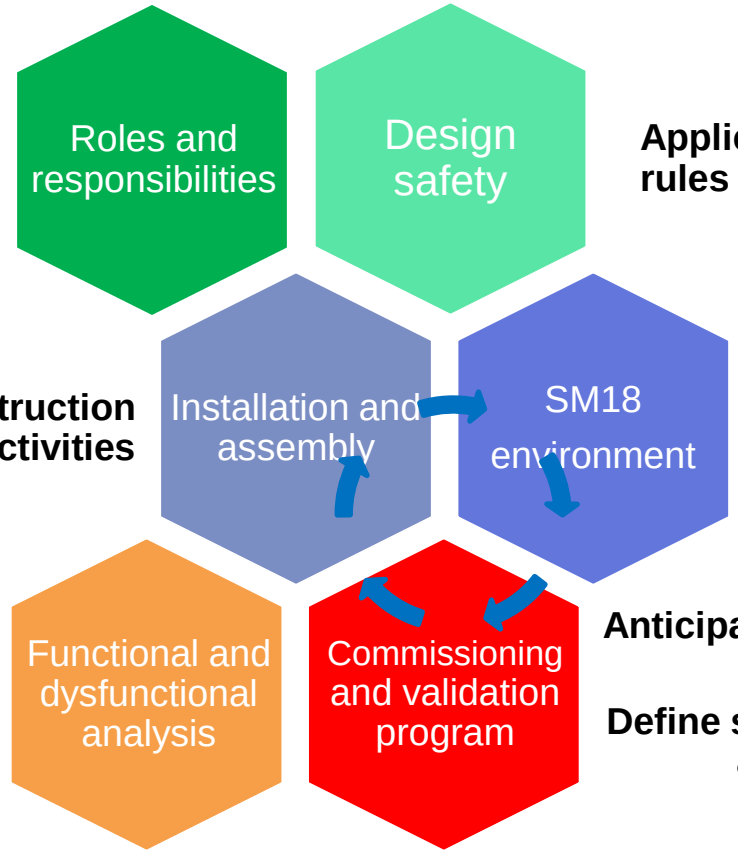
IT String Safety Framework

IT String – Safety Coordination Methodology

Six main safety sections covering the entire IT String life cycle



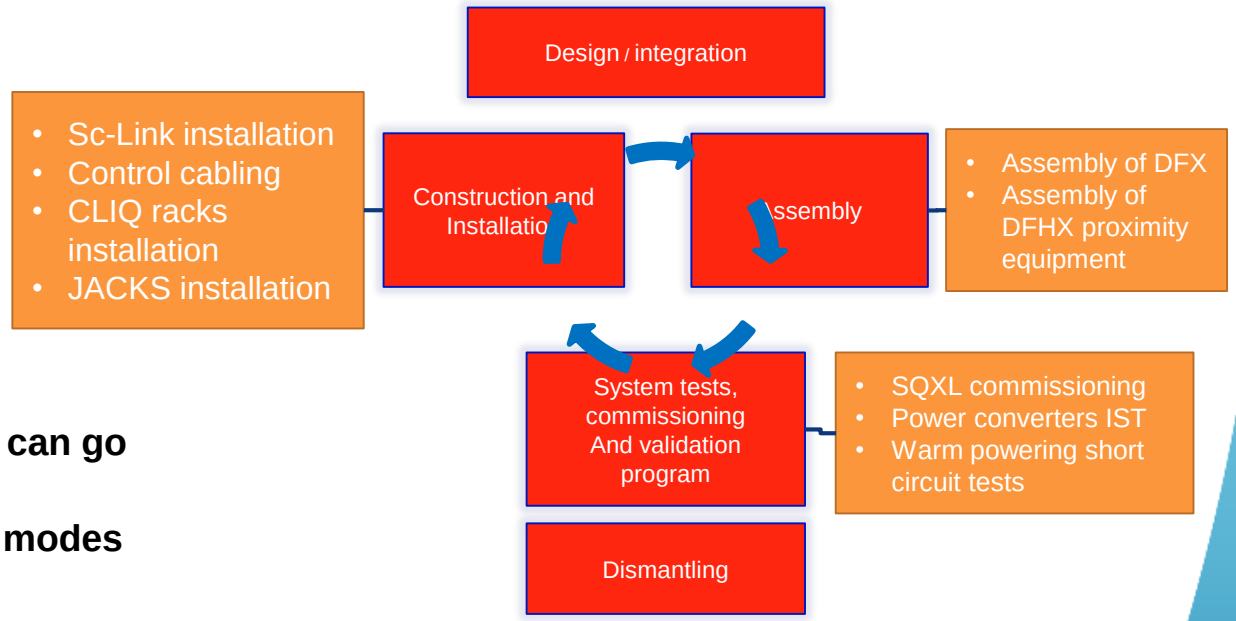
Applicable standards, norms, rules and regulations

On-site construction and coactivities

Anticipate/identify what can go wrong.

Define safe operational modes and procedures

Today we are here



Design safety - Status of Safety Assessment Documentation for IT String

Progress on System Safety Assessment (SSA) release schedule from HL-LHC Project safety officer

SSAs are required for systems and equipment identified as having significant safety implications

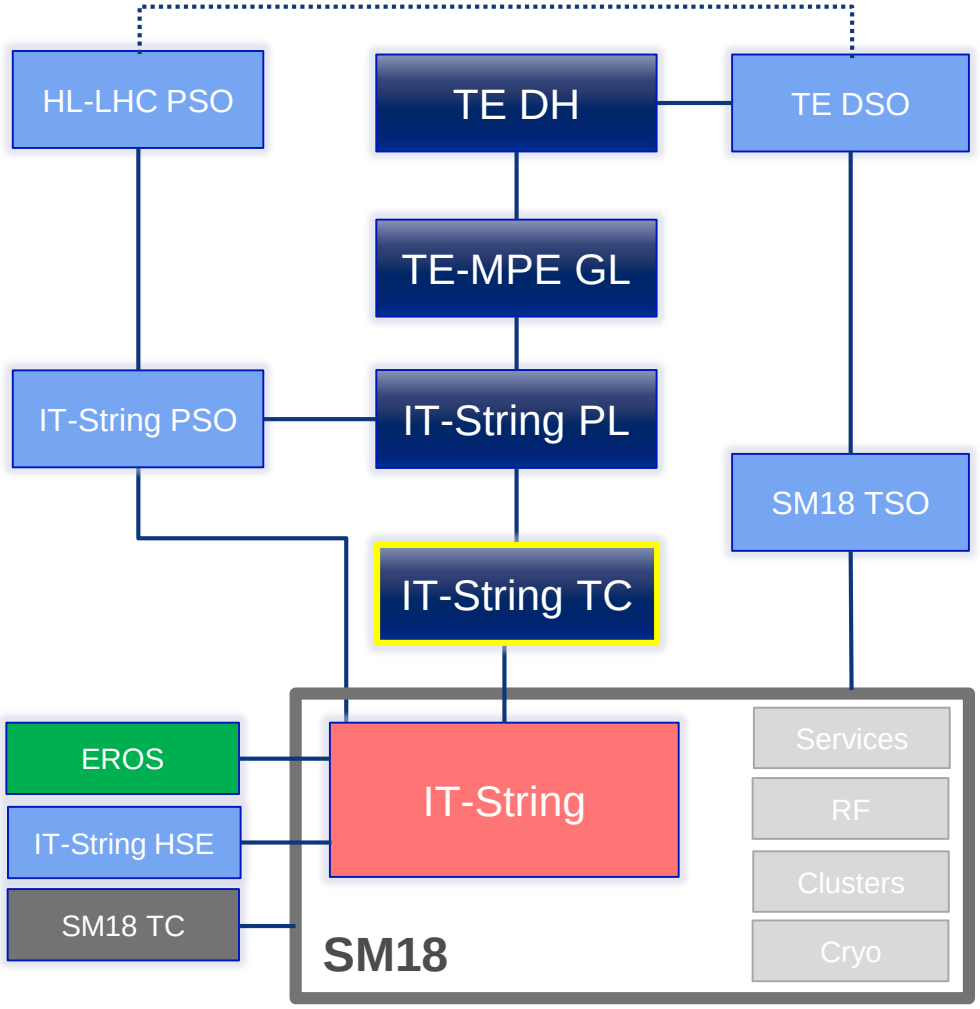
WP	Equipment/ Activity	Doctype	EDMS	Ver.	Q4 2023	Q1 - Q3 2024	Oct.2024	Nov.2024	Dec.2024
16	Test String in SM18	Master SSA	2568287	0.2	In Work	In Work	Eng Check	Under Approval	Released
16	Inner Triplet and Cold Powering in Test String	SSA	2575427	0.3	In Work	In Work	Eng Check	Under Approval	Released
16	Electrical Failure Modes of the Inner String Test Assembly in SM18	Risk Analysis	2478173	1.0	Released				
3	Inner triplet and cold powering	Master SSA	2567867	1.0	Released				
3	Inner Triplet Master	Master SSA	2575617	1.0	Released				
3	Q1-Q3 MQXFA	SSA	2115485	2.0	Released				
3	Q2a-Q2b (MQXFB)	SSA	2170722	1.0	Released				
3	D1 (MBXF)	SSA	2115625	1.0	Released				
3	Corrector Package CP	SSA	2575620	1.0	Released				
3	DCM D1-DFX Connection Module	SSA	2464501	1.0	Under Approval	Released			
6a	Cold Powering	Master SSA	2212619	1.2	Released				
6b	Safety of Power Converters (PC)	Master SSA	2618439	0.4	In Work	In Work	Eng Check	Under Approval	Released
9	IT Cryogenics for Test String	SSA	2366342	1.0	Released				
15.4	Full Remote Alignment System (FRAS)	SSA	2144080	1.0	Released				

Courtesy of T. Otto

Roles and Responsibilities* - IT String @ SM18 buiding

TE DH	**Miguel Jimenez**	Line Management Responsibility role
TE-MPE GL	**Jan Uythoven**	
IT-String PL	**Marta Bajko**	
IT-String TC	**Davide Bozzini**	
TE DSO	Delphine Delrieux-Letant	Advisory & supporting role
SM18 TSO	Patrick Viret	
IT-String PSO	Davide Bozzini	
HL-LHC PSO	Thomas Otto	
IT-String HSE	Carlos Gascon	
EROS	Emanuel Paulat	Referent role
SM18-TC	Luigi Scibile	

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

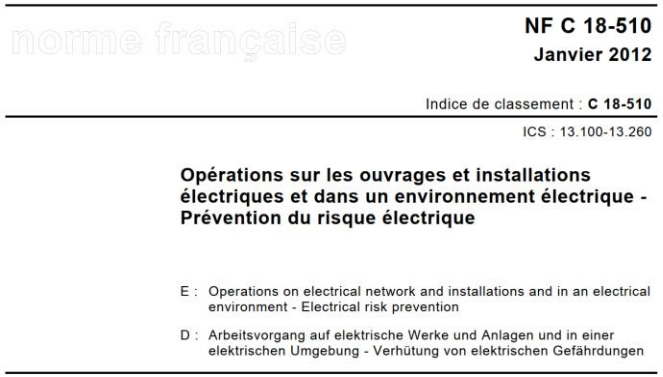


* According to SR-SO ''Responsibilities and organizational structure in matters of safety at CERN''

Electrical Operational Safety – Norms and Roles

Roles and responsibilities

- **The norm NF C 18-510** is a French standard that deals with the prevention of electrical risks. It is mainly used for defining safety rules for electrical operations and for establishing the necessary qualifications for personnel working on or around electrical installations.



norme française

NF C 18-510
Janvier 2012

Indice de classement : **C 18-510**
ICS : 13.100-13.260

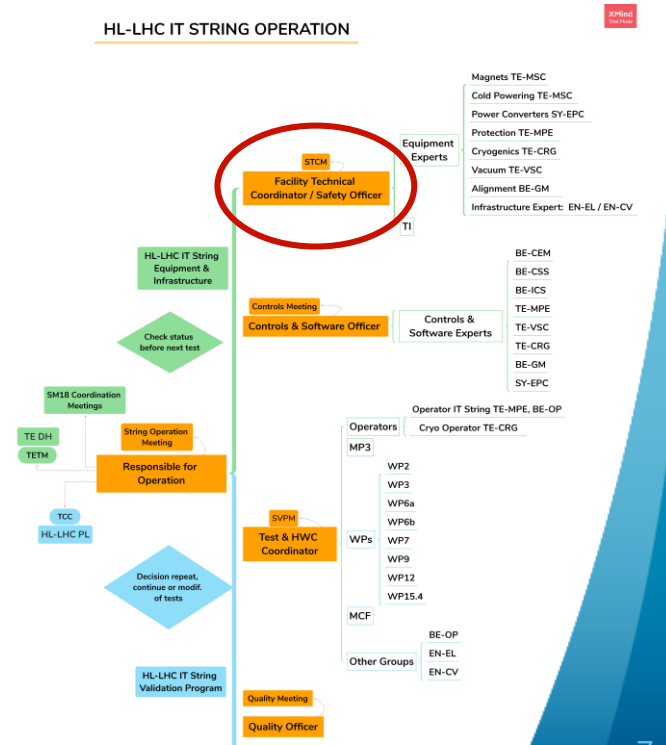
Opérations sur les ouvrages et installations électriques et dans un environnement électrique - Prévention du risque électrique

E : Operations on electrical network and installations and in an electrical environment - Electrical risk prevention

D : Arbeitsvorgang auf elektrische Werke und Anlagen und in einer elektrischen Umgebung - Verhütung von elektrischen Gefährdungen

- In January 2024, the IT String implemented the role of '**Facility Technical Coordinator**" a.k.a ''Chargé d'Exploitation'' as defined in the NF C 18-510.

- The **Facility Technical Coordinator** is responsible for managing and overseeing the operation and maintenance of the IT String electrical installations. It ensures that work is performed safely and that the installations are properly managed according to established procedures, ensuring compliance with safety regulations and protocols.

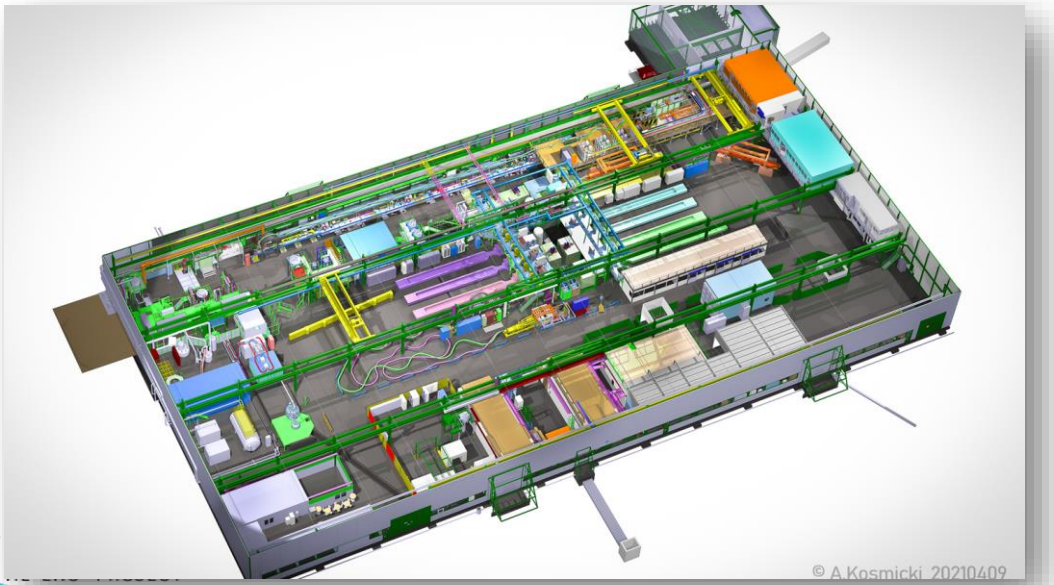


IT String environment – The SM18 buiding

SM18 environment

IT String boundaries in SM18

- Equivalent configuration as in HL-LHC 5L
- No beam ✓
- No activation ✓
- Surface building SM18
- Co-activities
- Co-operation
- Re-use of equipment/systems



Safety related points (non-exhaustive)

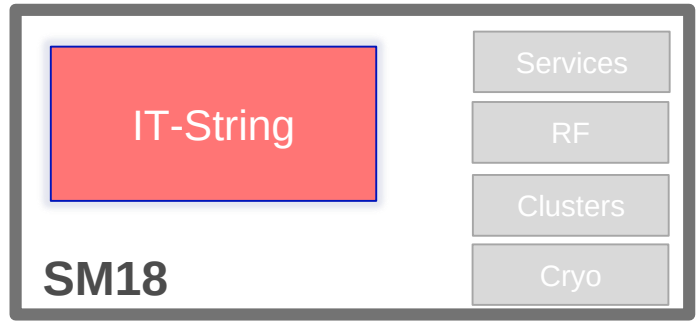
- Different layout and two floors (dedicate mezzanine)
- Implementation of dedicated metallic structure
- Accessibility

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

- Knowledge and assessment of neighbouring risks during works
- Share/understanding of risks induced by IT String and identification of mitigation actions

- Cumulative risks
- Crosstalk and dependencies between testing areas

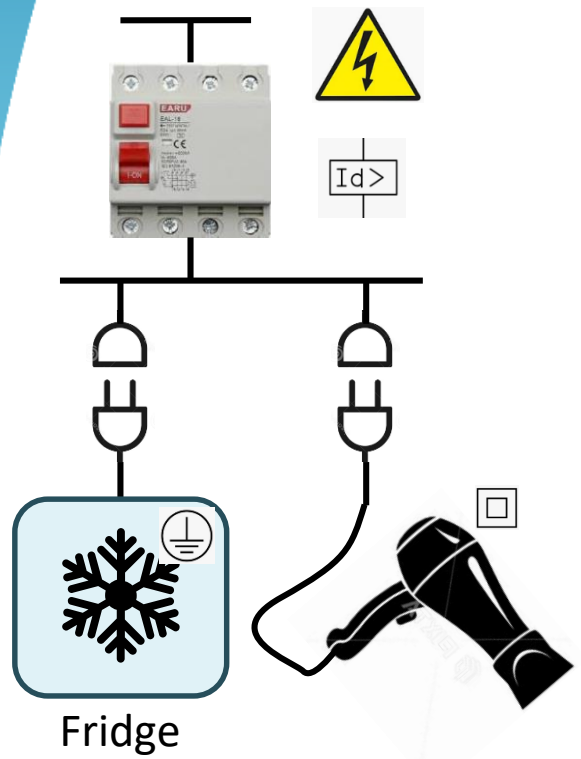
- Conform return of equipment of owners
- Traceability of changes



Electrical Operational Safety Aspects

IT String Electrical Infrastructure - From an Electrical Risk Perspective

AT HOME

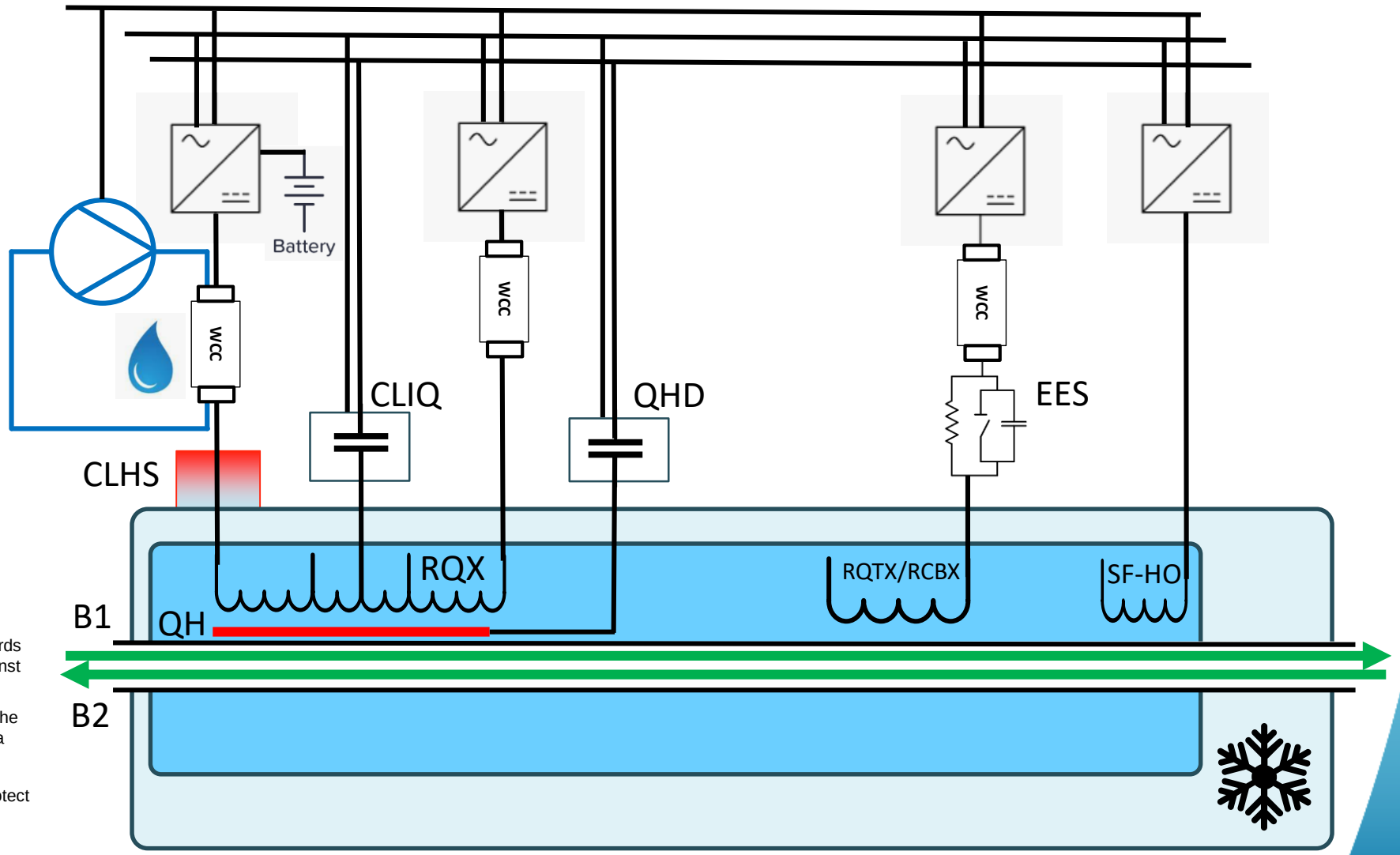


Double electrical insulation Equipment meets safety standards for electrical insulation and provides additional protection against electric shock, even if a single insulation layer fails

Grounding ensures that the excess electricity flows safely to the ground. Without grounding, the electricity could pass through a person, causing a dangerous shock

Differential Protection is a safety mechanism designed to protect people from electrical shock

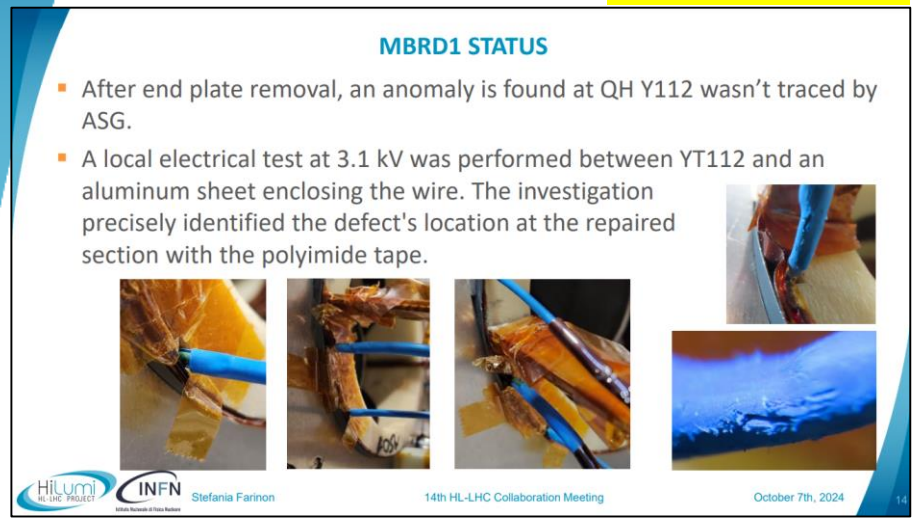
IT STRING



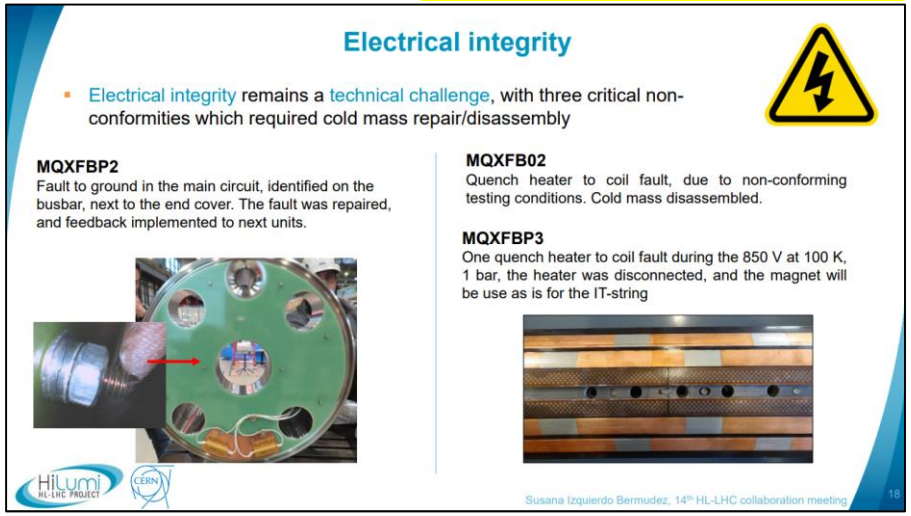
AAAA+ Hi-performance fridge – Cryogenic infrastructure

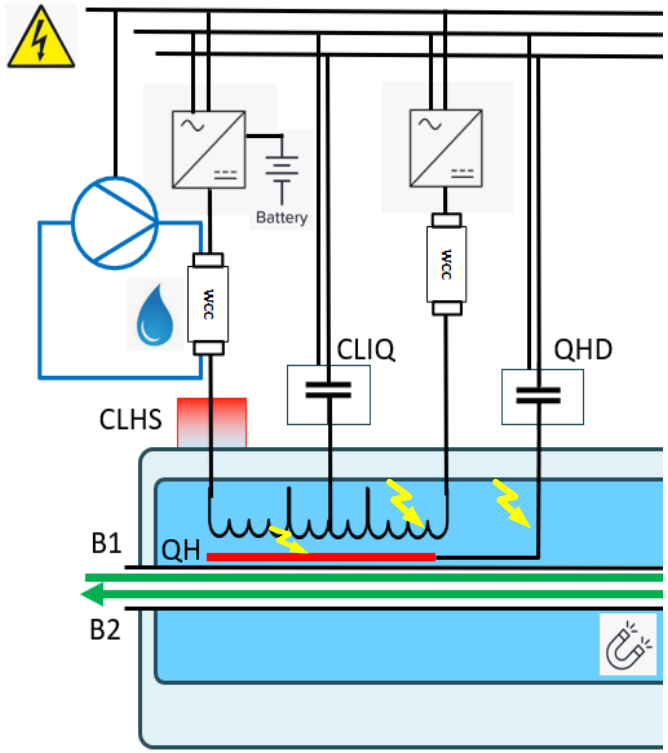
IT String Electrical Infrastructure – What Can go Wrong

Courtesy S. Farinon



Courtesy S. Izquierdo Bermudez





- Operational safety for diagnostic (ELQA) and repair of similar faults appearing in the IT String deserves a high level of preparedness and clear procedures due to the complexity of the electrical infrastructure

IT String Electrical Infrastructure – Operational Safety Requirements

Purpose

- The primary aim of the operational safety is to prevent electrical risks and accidents during installation, construction, hardware commissioning and validation program as well as testing and diagnostic interventions

Requirements

- A detailed and duly documented understanding and of the electrical infrastructure to be operated
- The identification and definition of the operational modes
- The identification and validation of the operational procedures

Main stakeholders

- Chargé exploitation`(Technical Coordinator @ IT String)
- Trained and certified personnel according to the nature of the intervention

Operational Drawing of Electrical Circuits

Observation

- There are many drawings available, but “the glue’’ between all of them for a detailed global view of the electrical circuitry is missing.

Goal

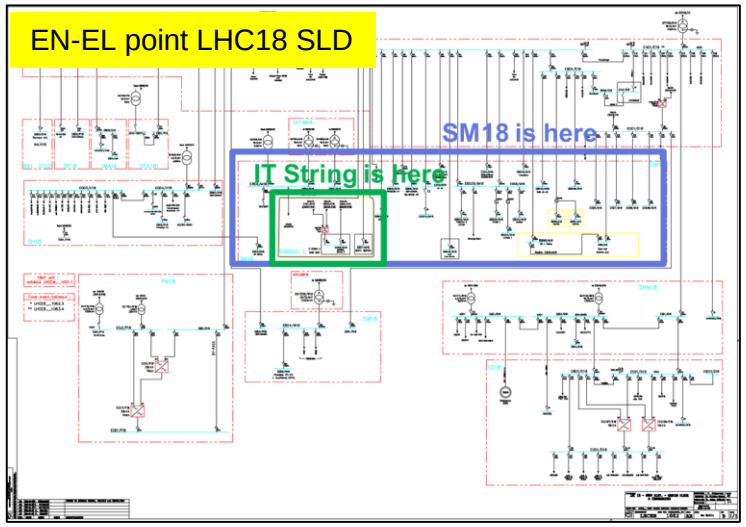
- Represent all electrical AC and DC circuits, internal energy sources in a way that allows a safe electrical operation and a safe and efficient coordination of the interventions.

Methodology

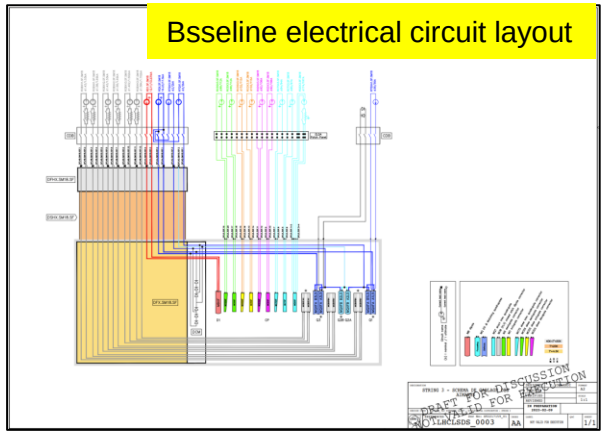
- Grouping of the different source and nature of electrical information into a single drawing/document.
- Define layers that allow identifying relationships between electrical components and associated electrical sources.
- Facilitate the identification of circuits that shall be lock-out according to the nature of the electrical intervention.

This initiative also contributes to the ESP project.

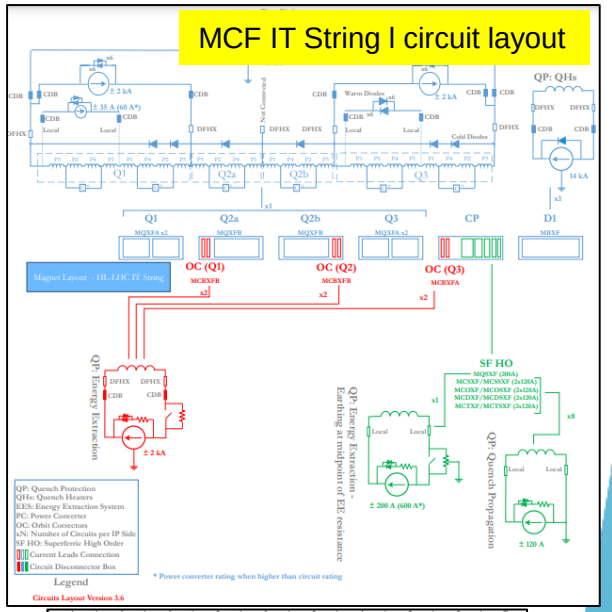
EN-EL point LHC18 SLD



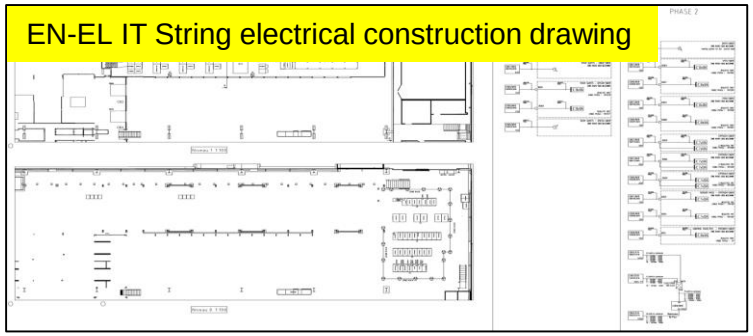
Bsseline electrical circuit layout



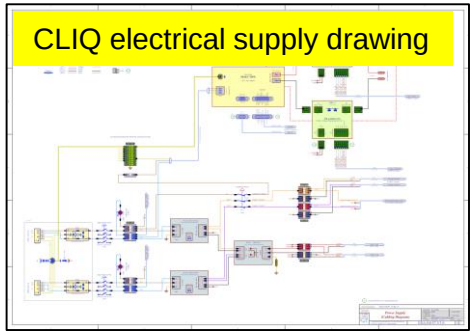
MCF IT String I circuit layout



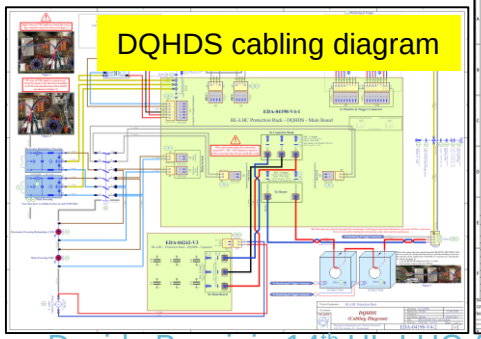
EN-EL IT String electrical construction drawing



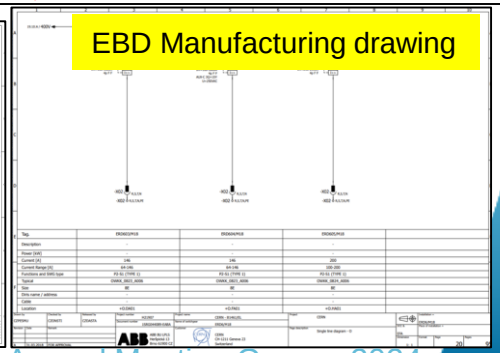
CLIQ electrical supply drawing



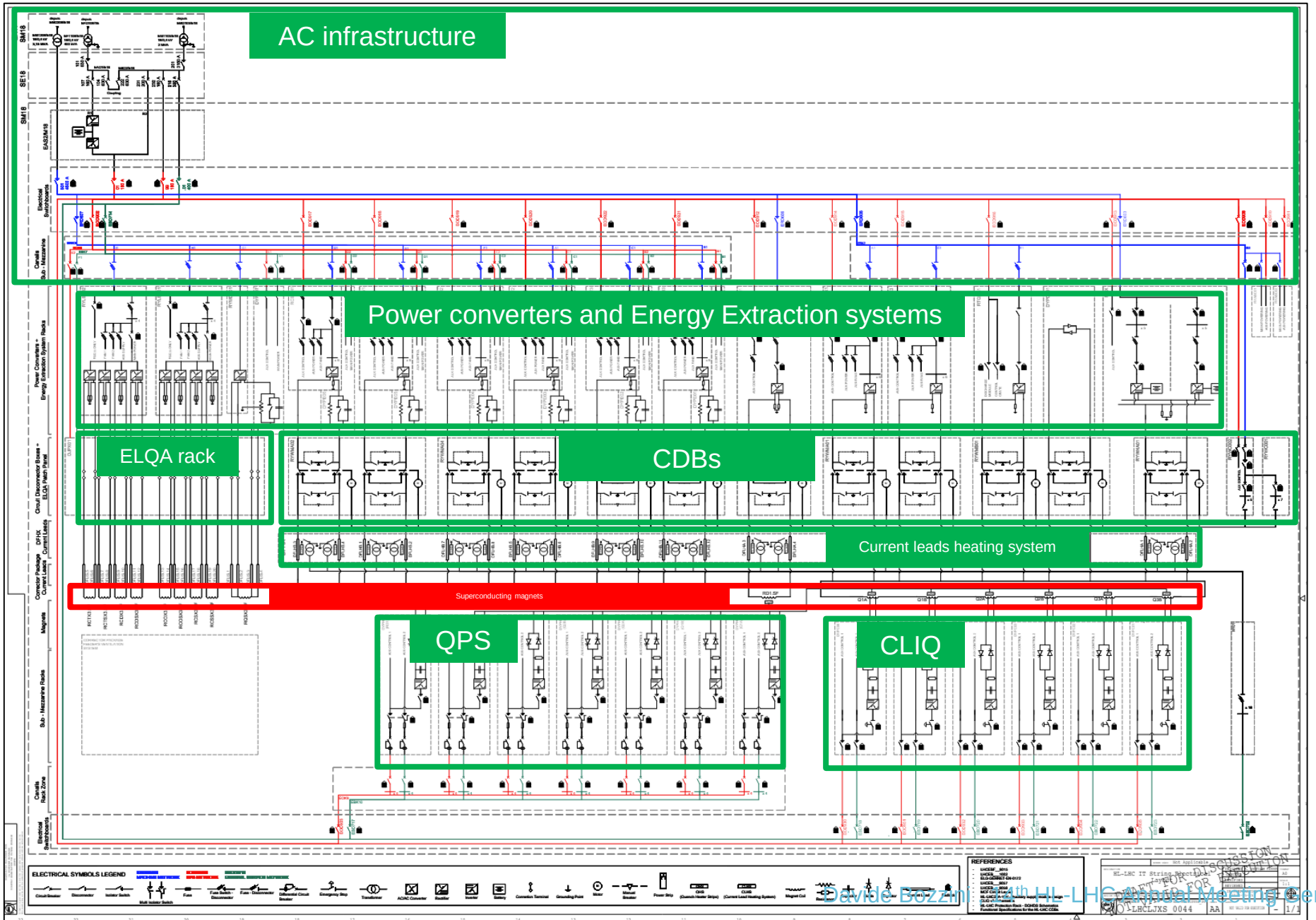
DQHDS cabling diagram



EBD Manufacturing drawing



Operational Drawing of Electrical Circuits



Operational Modes

- Electrical operational modes for the HL-LHC magnet circuits have been defined in the framework of MCF
- Four modes have been identified covering operation, testing and maintenance interventions
- Electrical operation procedures describing how to move between modes are under definition

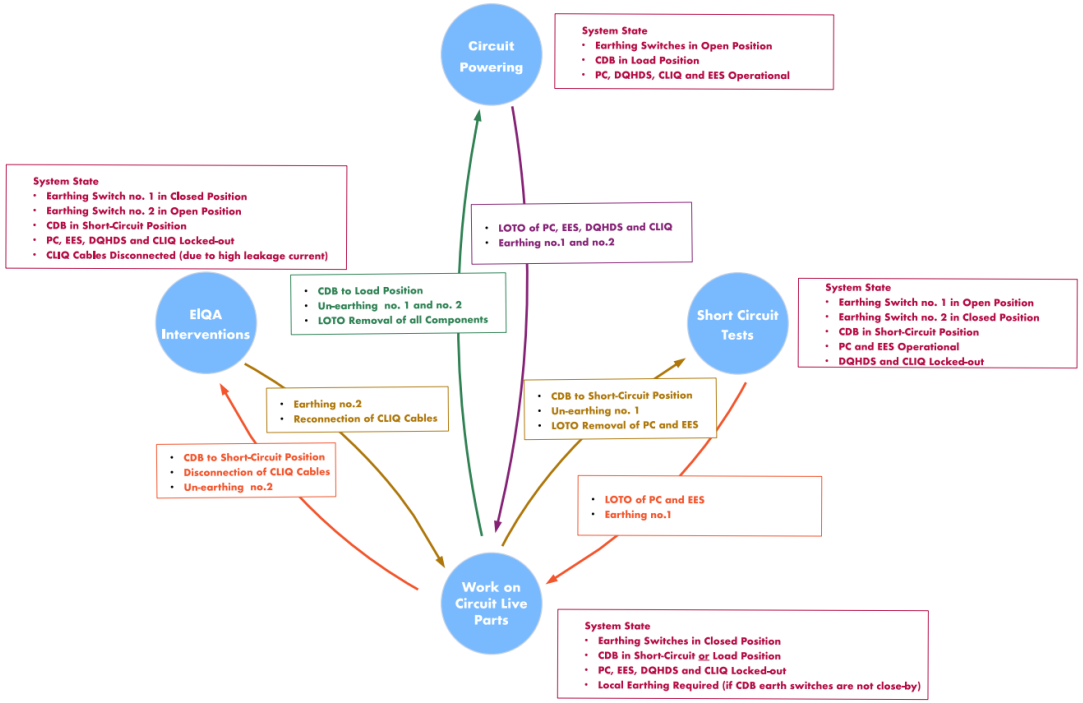


Figure 7 – Procedure overview of modification of the operation modes

EDMS NO. 3138092 | REV. 0.1 | VALIDITY DRAFT
REFERENCE : LHC-MPP-ES-0004

ENGINEERING SPECIFICATIONS

HL-LHC MAGNET CIRCUIT FORUM

ELECTRICAL OPERATION MODES OF THE HL-LHC MAGNET CIRCUITS

Abstract

The present document details the electrical operation modes of the HL-LHC magnet circuits in view of their operation, testing and maintenance/interventions in the HL-LHC and in the HL-LHC IT String facility. The electrical sources that must be considered for a safe operation of the circuits are identified and localised in the LHC and HL-LHC technical galleries and the tunnel for HL-LHC and in SM18 for the HL-LHC IT String test facility. The operation and the role of the Circuit Disconnector Boxes (CDB) that are new elements introduced to the HL-LHC magnet circuits for DC galvanic separation are described in this document. Finally, this document defines the set of rules to respect to ensure electrical safety for the different electrical operation modes and during the transition between them.

EDMS no. 3138092

HL Engineering Check

TRACEABILITY

Prepared by: S. Yammine and H. Thiesen	***Date:*** 2024-07-15
Verified by: C. Barth, M. Bednarek, X. Bonin, D. Bozzini, D. Carrillo, E. Coulot, G. D'Angelo, R. Denz, J. Emonds-Alt, S. Le Naour, E. Nowak, B. Panev, M. Parodi, T. Otto, M. Pojer, F. Rodriguez Mateos, A. Verweij and M. Solfaroli Camillocci	***Date:*** 2024-MM-DD
Approved by: A. Ballarino, M. Bajko, O. Brüning, J. De Vogt, M. Martino, A. Milanese, V. Montabonnet, E. Todesco, J. Uythoven, D. Wollmann and M. Zerlauth	***Date:*** 2024-MM-DD
Distribution: A.L. Perrot, C. Mugnier, MCF members and for info lists and HL-LHC PO	

Rev. No.	***Date***	***Description of Changes*** *(major changes only, minor changes in EDMS)*
0.1	2024-07-28	First version for Eng. Check

Operational Procedures

- The procedures will be part of a catalogue that will evolve according to the nature of the intervention and the certification of the intervening personnel

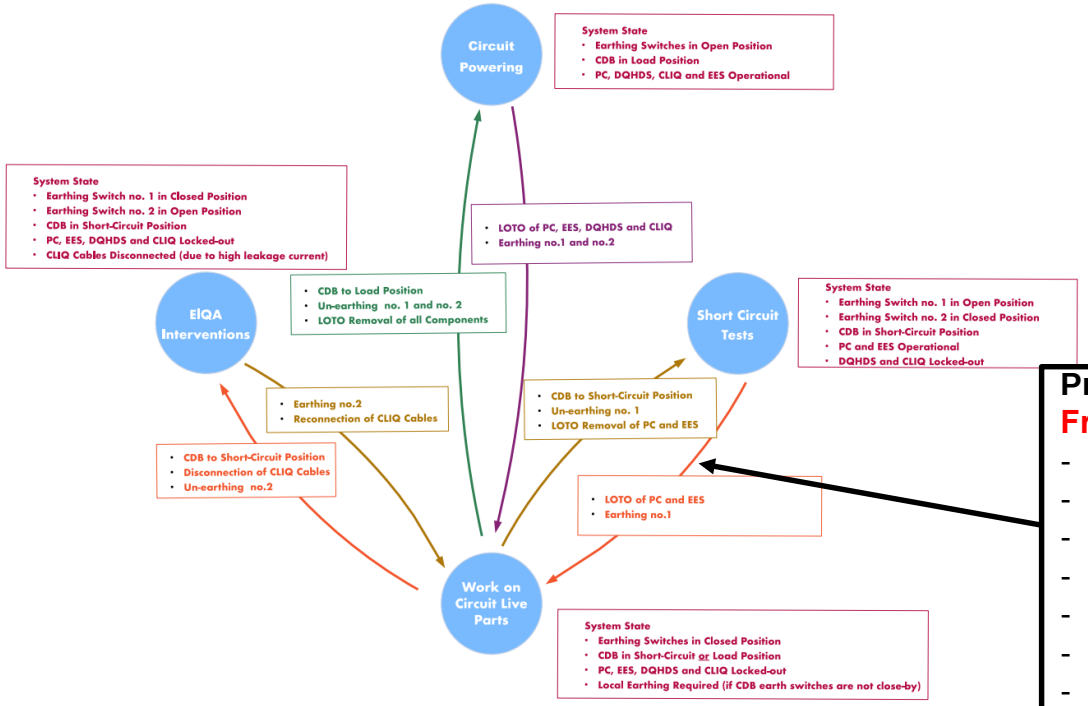


Figure 7 – Procedure overview of modification of the operation modes

Procedure nr. X

From ‘’SCT” to ‘’work on circuit live part”

- Nature of intervention
- Risk assessment
- Concerned circuit
- Concerned equipment
- Lock-outs points
- Who does what
- Work(s) authorization(s)
- Specific safety measures
- …..

EDMS NO. 3165863 | REV. 0.1 | VALIDITY DRAFT

REFERENCE : LHC-MPP-ES-XXXX

ENGINEERING SPECIFICATIONS

HL-LHC IT STRING

ELECTRICAL OPERATION PROCEDURES OF THE HL-LHC IT STRING MAGNET CIRCUITS AND ELECTRICAL INFRASTUCTURE

Abstract

The present document details the electrical operation procedures of the HL-LHC IT String magnet circuits and electrical infrastructure in view of their operation, testing and maintenance interventions. The document first recalls the applicable standards in terms of electrical operational safety. Then it provides a catalogue of procedures each detailing the way to follow according to the identified transitions between operational modes as specified in the document ”Electrical Operation Modes of the HL-LHC Magnet Circuits” EDMS 3138092.

The catalogue of procedures is meant to be updated and completed according to the operational safety experience we will gather during the life cycle of the HL-LHC IT String.

EDMS no. 3165863

In Work

TRACEABILITY

Prepared by: D. Bozzini and S. Yamine	***Date:*** 2024-09-15
Verified by: C. Barth, M. Bednarek, S. Bertolasi, X. Bonin, D. Bozzini, D. Carrillo, E. Coulot, Emonds-Alt, S. Le Naour, E. Nowak, B. Panev, M. Parodi, T. Otto, lateos, A. Verweij and M. Solfaroli Camillocci	***Date:*** 2024-MM-DD
o, M. Bajko, O. Brüning, J. De Vogt, M. Martino, A. Milanese, V. o, J. Uythoven, D. Wollmann and M. Zerlauth	***Date:*** 2024-MM-DD
, C. Mugnier, MCF members and for info lists and HL-LHC PO	

e	***Description of Changes*** *(major changes only, minor changes in EDMS)*

Electrical Safety During Construction

Construction Example 1 – Electrical Intervention

Intervention description

- Hardware change required after lessons learned from DFHX test on F2 cluster
- Partial replacement of air-cooled cables from class 5 to class 6
- Activity to be planned after successful IST and SCT of the warm powering

Operational safety actions

- Change of mode from: ''Short circuit tests'' to ''Work on circuit live parts''
- Three lock-out (LOTO) requested to concerned equipment owner
- One work permit released

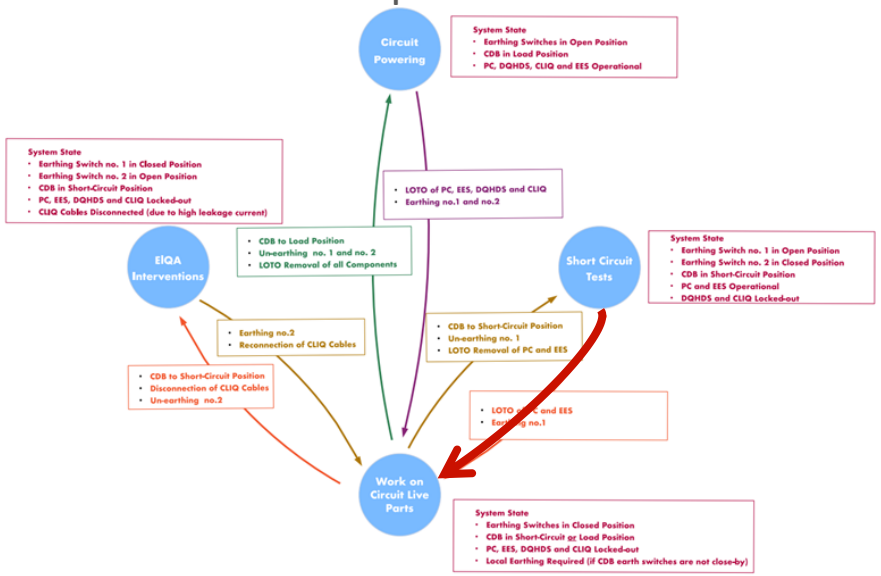
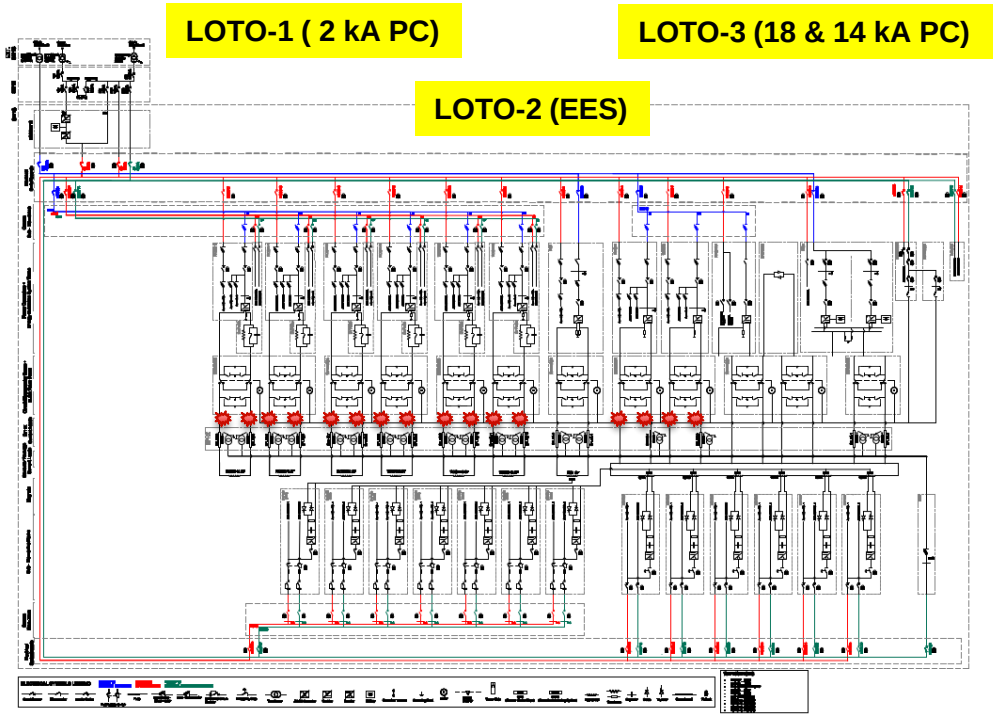
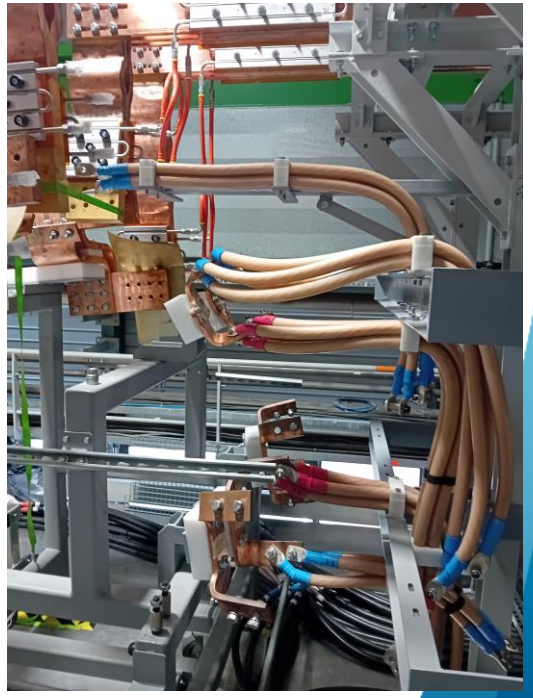


Figure 7 – Procedure overview of modification of the operation modes



Semi-rigid class 5 cables

Ultra-flexible class 6 cables



Construction Example 2 – Non-Electrical Intervention

Intervention description

- Installation of the helium gas recovery line
- Non-electrical intervention
- Extreme vicinity with AUG safety alarm level 3 of SM18 buiding

Analysis

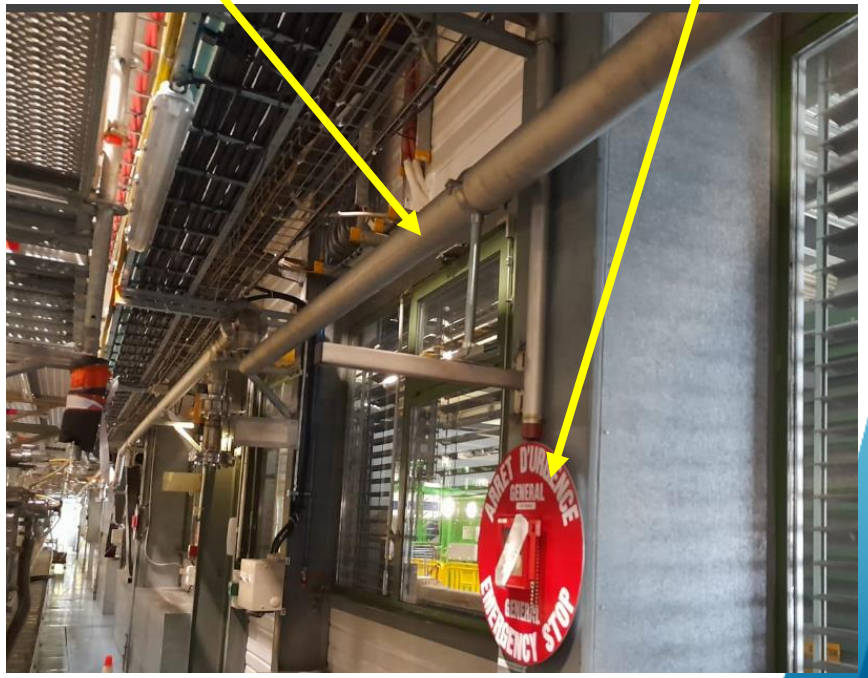
- The work supervisor might not know all safety implications of the concerned working area
- Unvoluntary trip of AUG will cut all electrical energy supply to SM18 infrastructure
- Major implication on SM18 activities

Operational safety actions

- Preventive inhibition of (2) concerned AUG points is required
- Safety instruction IS37 to be filed-in to informed concerned bodies
- Limit as much as achievable the duration of the intervention

AUG Inhibited

Gas recovery line and associated supports as successfully installed

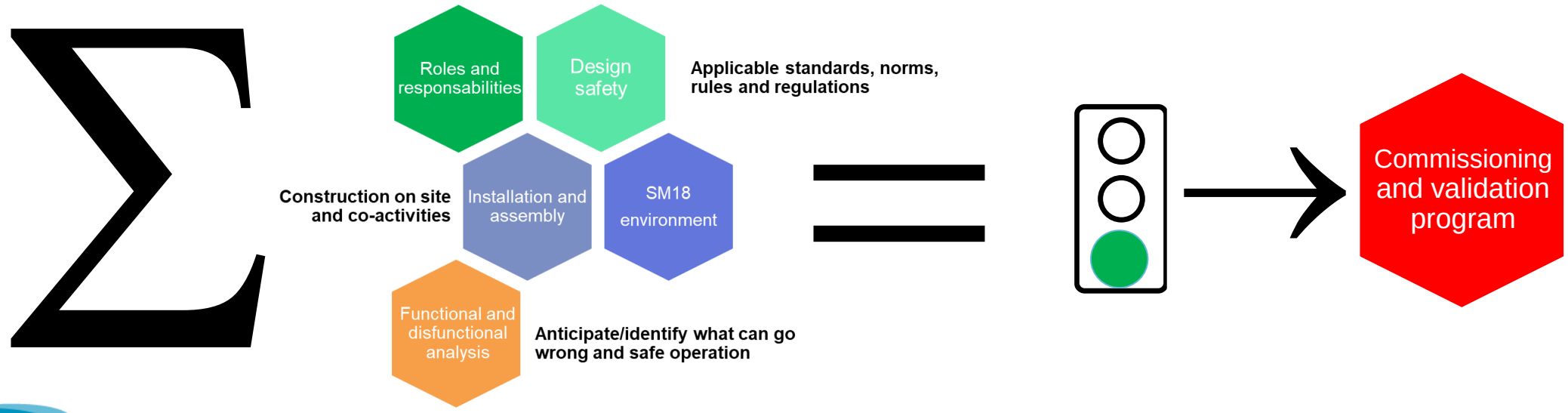


Electrical Safety During Commissioning and Validation Program

Operational Safety During Commissioning and Validation Program

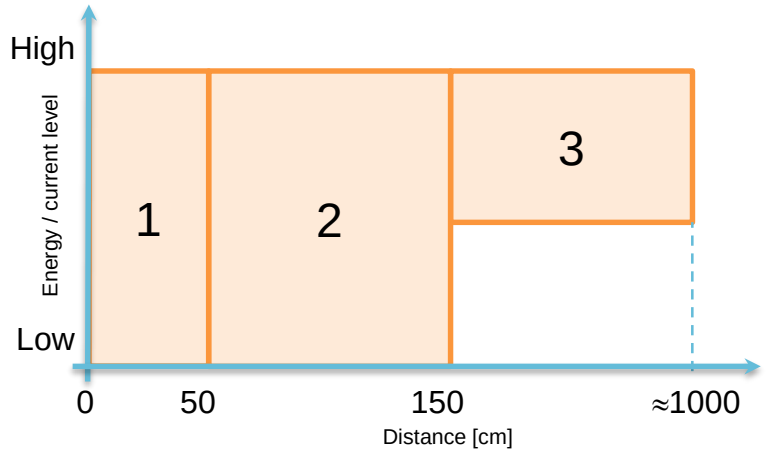
Time to put power through the magnet circuits

- Before injecting and storing up to 40 MJ in the magnets, several details/aspects/issues have been finalized
- Safe commissioning and operation of the IT String will depend on how the previous five safety sections are executed, validated and applied
- Access control and distancing from energized equipment are two of the main concerns to be addressed

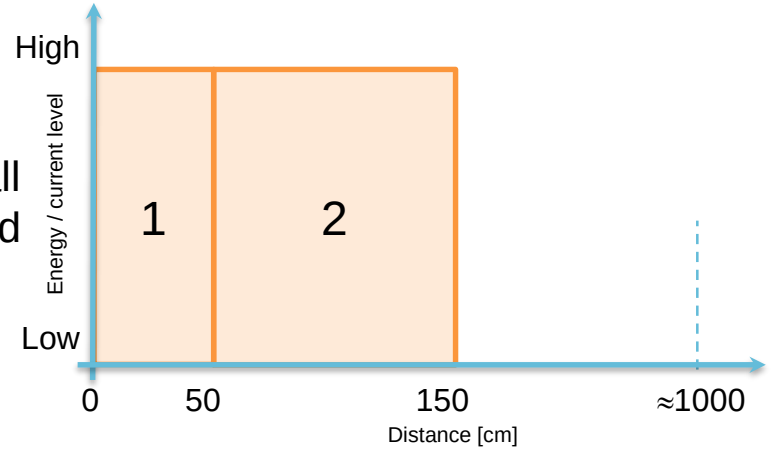


Operational Safety During Commissioning and Validation Program

Individual system commissioning and first powering



Validation program once all systems are commissioned



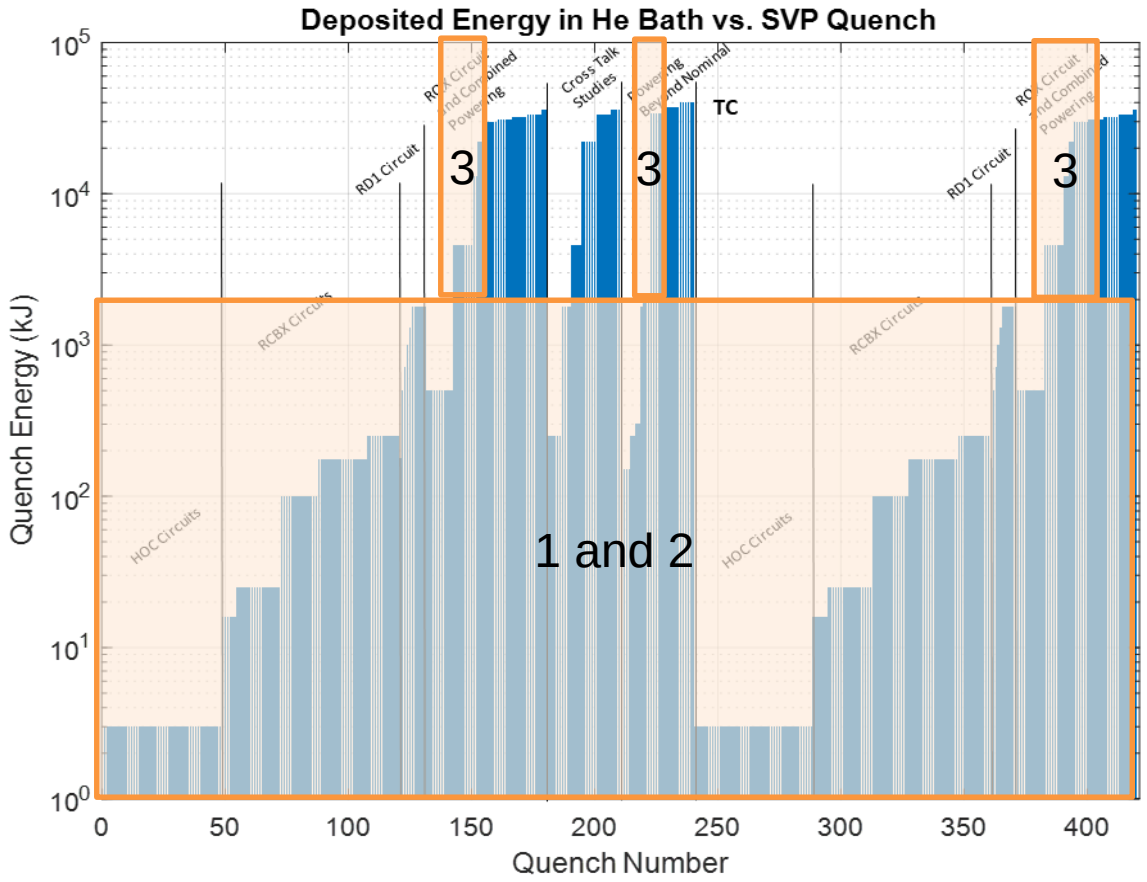
1 – Forbidden area
- According to recommendations of ‘’Electrical failure modes of the Inner Triplet in SM18’’ – EDMS 2575427’’

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

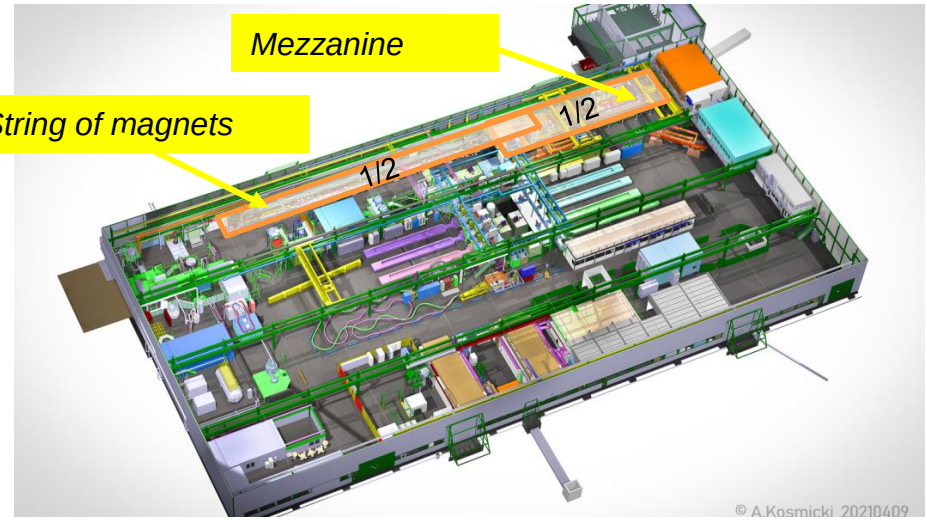
3 – Extended area
- Including clusters A, D, G, H and transit areas
- To grant safety during first high-energy powering tests and quenches
- Energy thresholds and types of tests to be determined

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

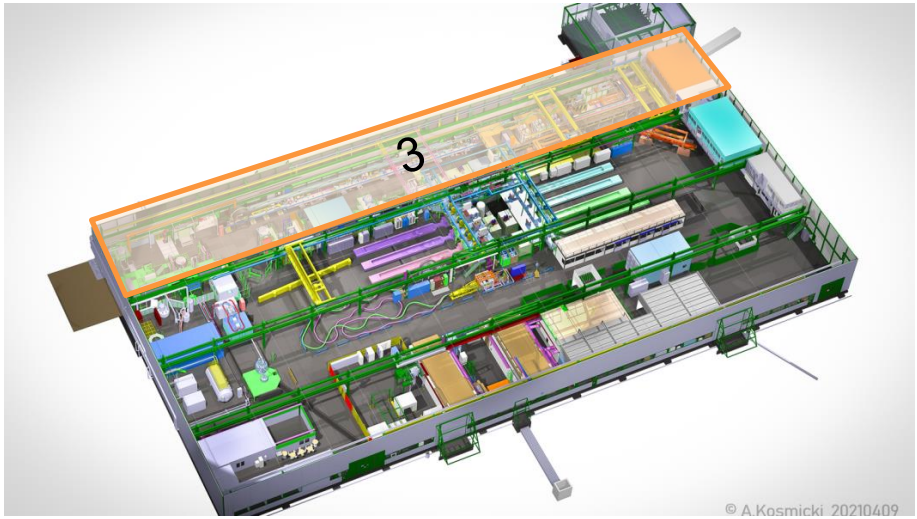
Operational Safety During Commissioning and Validation Program



1 & 2 forbidden and controlled areas



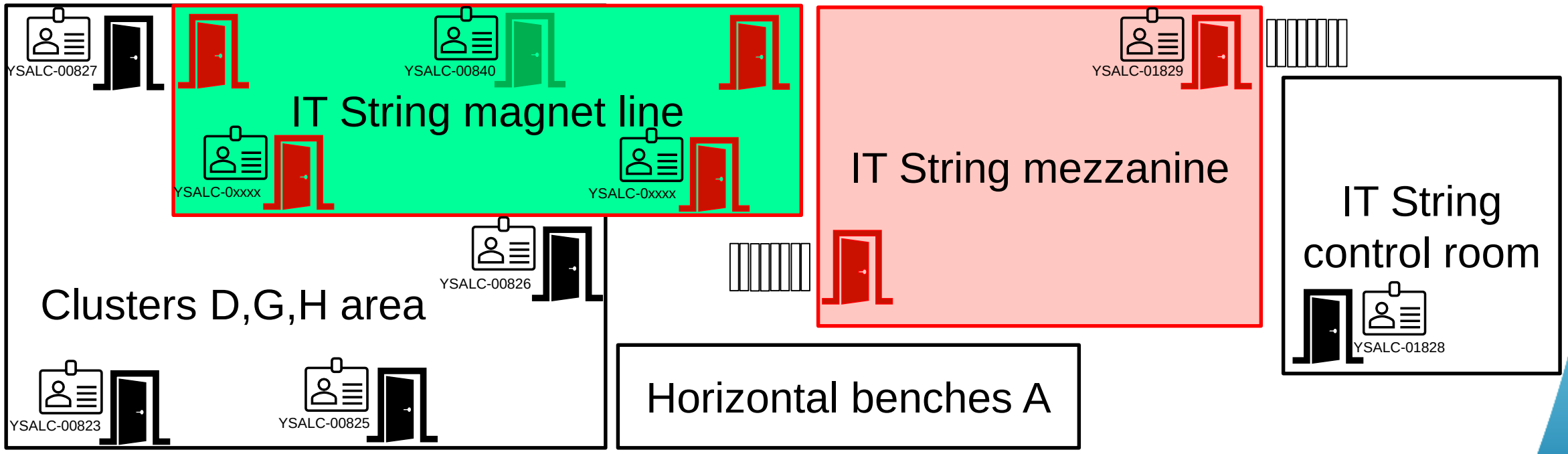
3 Extended area (proposal)



Operational Safety During Commissioning and Validation Program

A supervised access system is under deployment according to the construction progress

- The access to each area can be granted or removed through CERN IMPACT tool
- The supervision allows a real time remote monitoring of the access status to the concerned areas
- The remote acknowledgment of any access break through is implemented



Take Away Message

- Roles and responsibilities have been identified and people nominated accordingly
- Internal energy sources and locally stored energy in the triplet increased compared to LHC. The electrical infrastructure of the IT String and HL-LHC is the most complex all around LHC and probably at CERN
- An operational drawing showing the relationships and dependencies between all electrical equipment and systems has been released
- The electrical operation modes of the HL-LHC circuits have been defined by MCF
- The associated electrical operation procedures are under preparation for the IT String keeping in mind to use them for HL-LHC as well
- Operational safety is daily applied since the first electrical equipment installed and we are ready to safely operate the TI String during commissioning and validation program

Thank you for your attention