HL-LHC IT STRING and Series test of SC link

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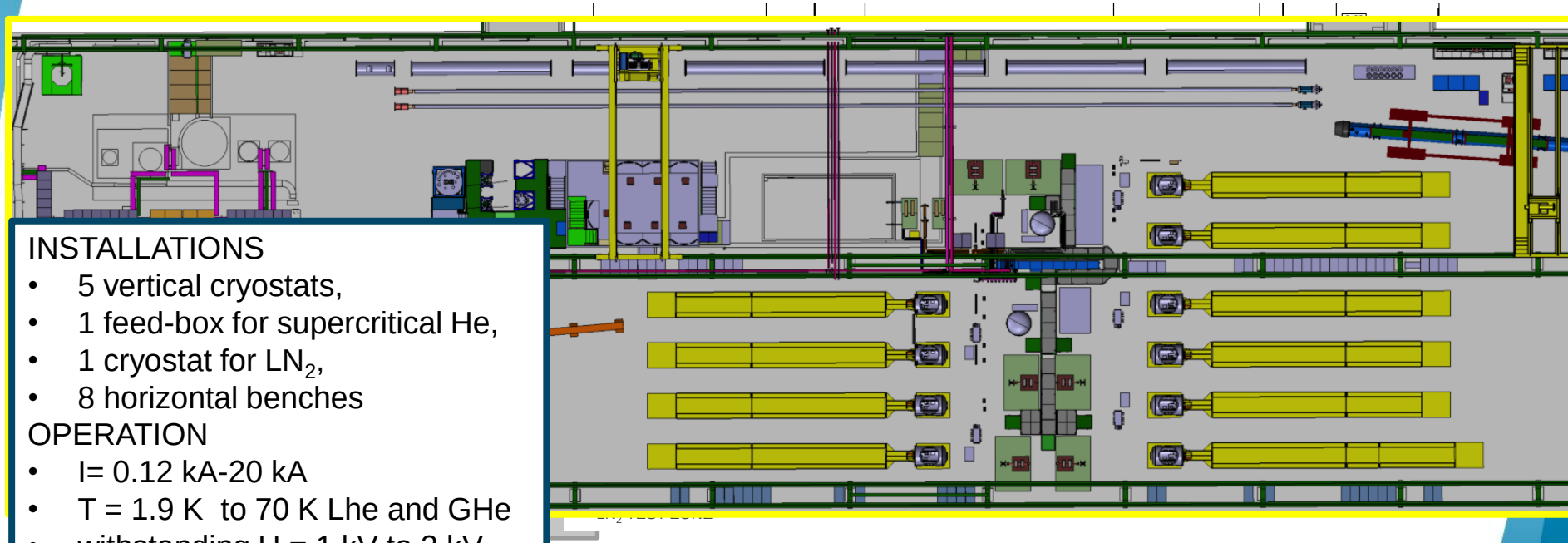
International Review of the Conceptual Design of the Cold Powering System for the HL-LHC Superconducting Magnets

Outline of the presentation

- Test stands today in Sm18
- Infrastructure upgrade for tests in SM18
- Conflict between test stands
- Proposal for the SC LINK test
- Proposal for the STRING test
- Status of the work

Magnet test stands layout @ CERN

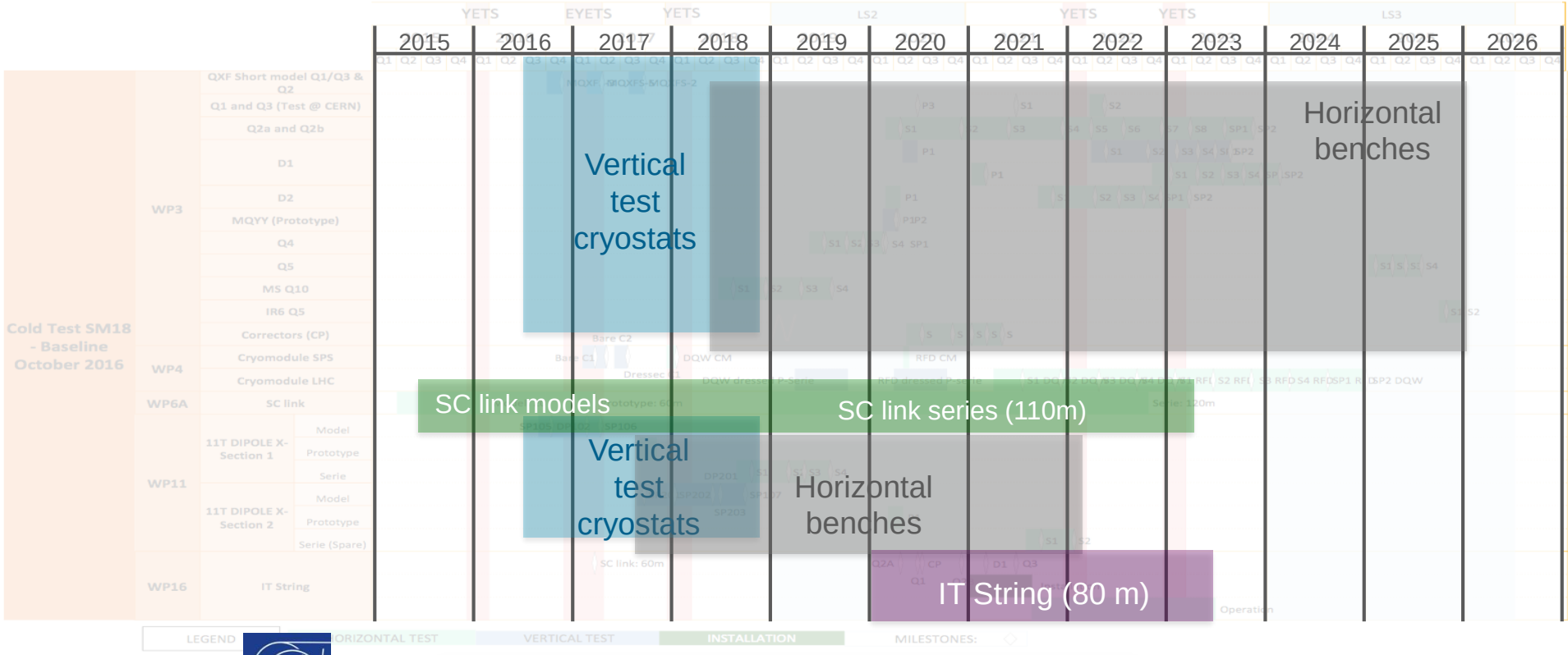
THE SUPERCONDUCTING MAGNET TEST STAND AT CERN in SM18



INSTALLATIONS
- 5 vertical cryostats,
- 1 feed-box for supercritical He,
- 1 cryostat for LN_2,
- 8 horizontal benches

OPERATION
- I= 0.12 kA-20 kA
- T = 1.9 K to 70 K Lhe and GHe
- withstanding U = 1 kV to 3 kV

Conflict between test stands?



Infrastructure upgrade for test in SM18

UPGRADE DRIVEN BY The recommendation enabling to carry out the full test programme with no constraints

CRYOGENIC COOLING PRODUCTION: **+ 35 g/s LHe** For 2019

Needs essentially for HL-LHC IT STRING run in parallel with magnet testing

DEMINERALISED WATER PRODUCTION: **+ 150 m^3/h** Operational

Needs for demineralised water entirely coming from magnet operation

HANDLING: **25 t and longer rope**

Needs for overhead crane entirely coming from magnet operation Operational

nCONTROL ROOM

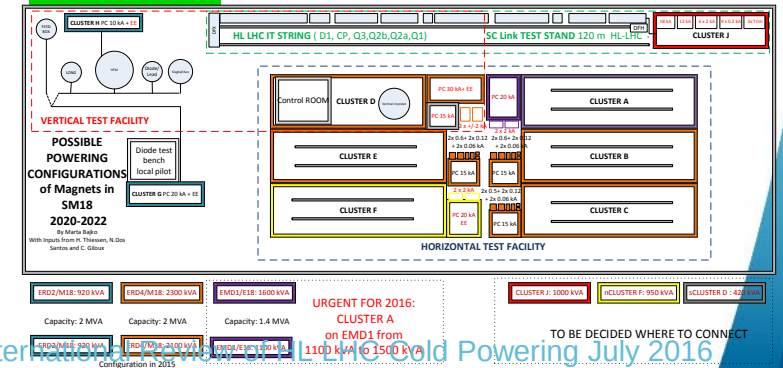
Needs to extend the small control room of the vertical . Test facility to be used also for horizontal benches and Sc link

Operational

POWERING CAPACITY FROM THE NETWORK

Extra powering of 3 MVA to allow connection of nCluster F and J

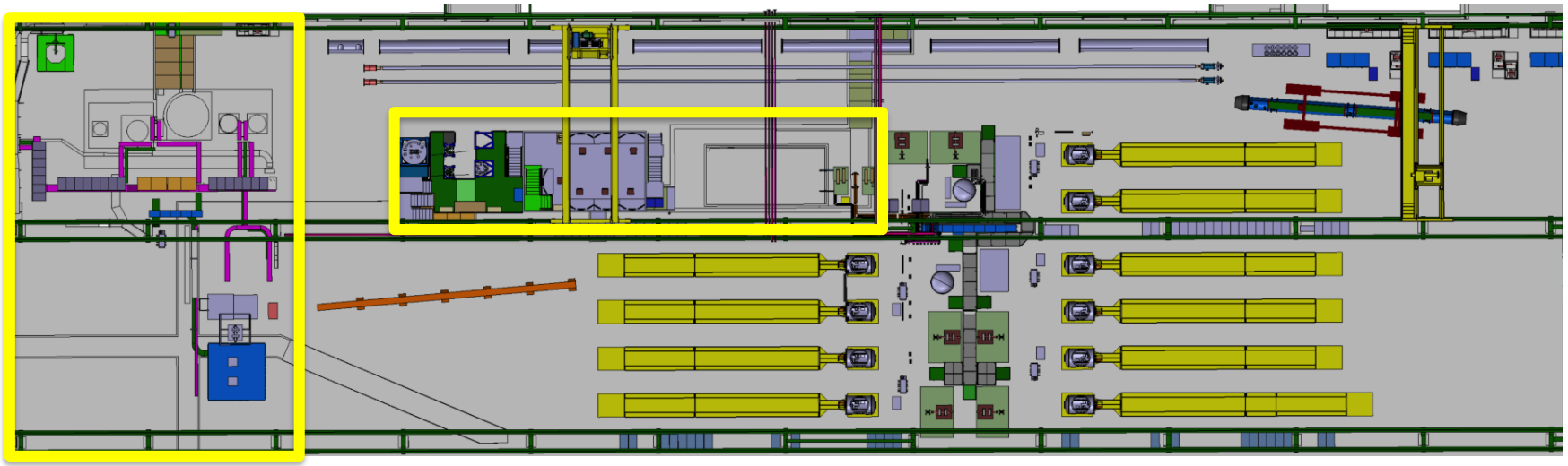
For 2019



Vertical test stands for (WP3 WP11 and LHC) magnets

Cluster G

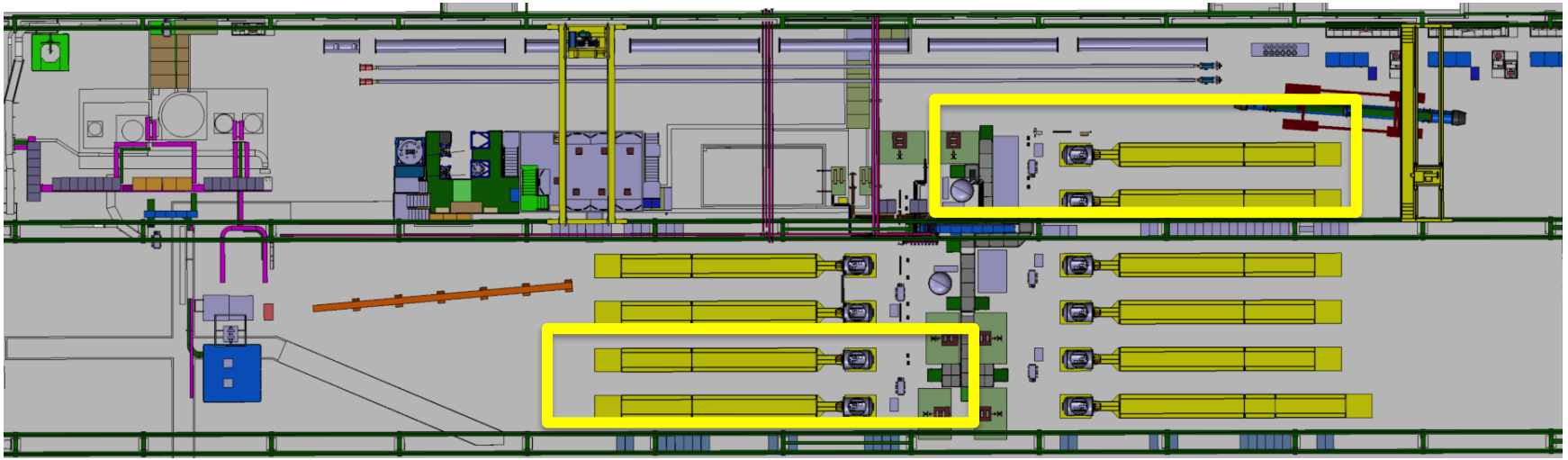
Cluster D



The vertical cryostats zone, called Cluster G is about 400 m^2 . It is mainly dedicated to model magnets but also series up to a length of max 5 m.

Horizontal test benches for magnets (WP3, WP11 and LHC)

Cluster A

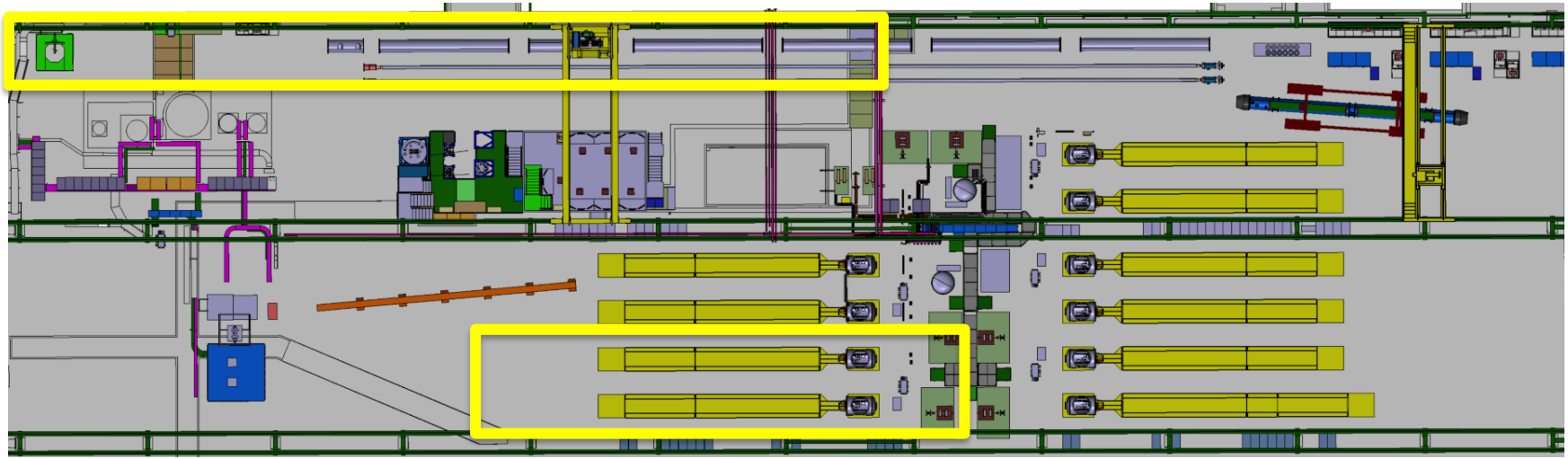


Cluster F

The horizontal test zone covering the Cluster A to F is foreseen for the high current testes as the Q2a and Q2b aswell as for some of the Q1 and Q3 cold masses. Cluster A is operational till 20 kA and a secondary circuit of 2 x 2 kA is going to be implemented in 2018. Cluster F will be equipped in the same way in 2020. All the other clusters are equipped with powering circuits till 15 kA with secondary circuits of 600 or/and 120 A.

Test Stands for SC link (WP6A)

Cluster G

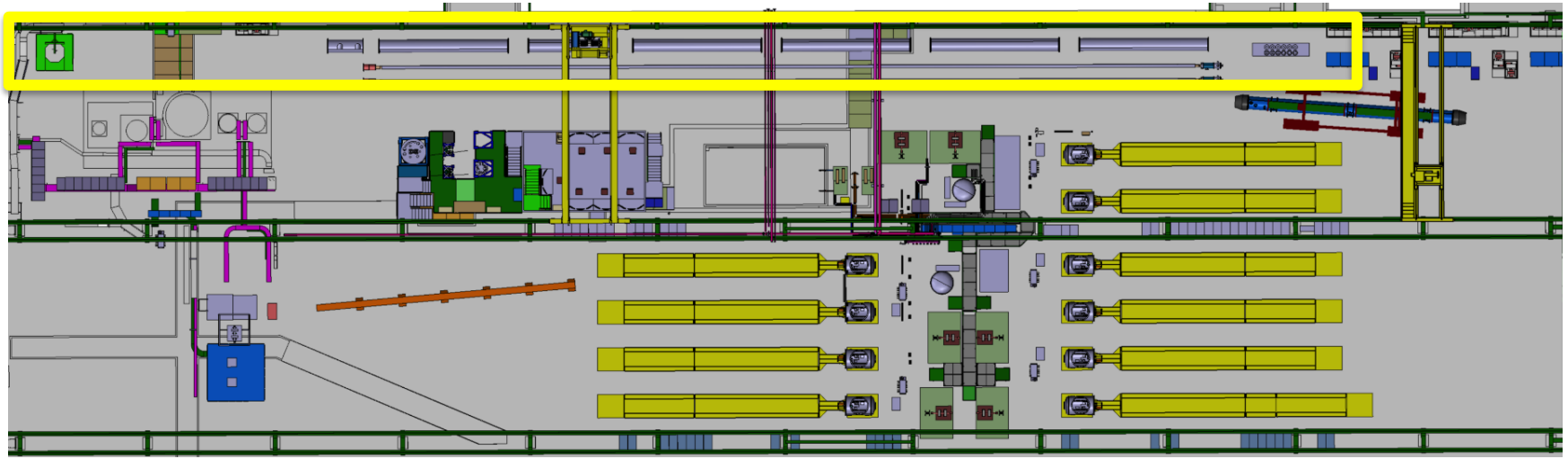


Cluster F

The Cluster G is equipped with a feed box allowing powering up to 20 kA in a single, main circuit. This test stand will allow the testing of the model, demonstrator and prototypes up to 60 m length. Extra converters of 2 kA are needed for the prototype test.

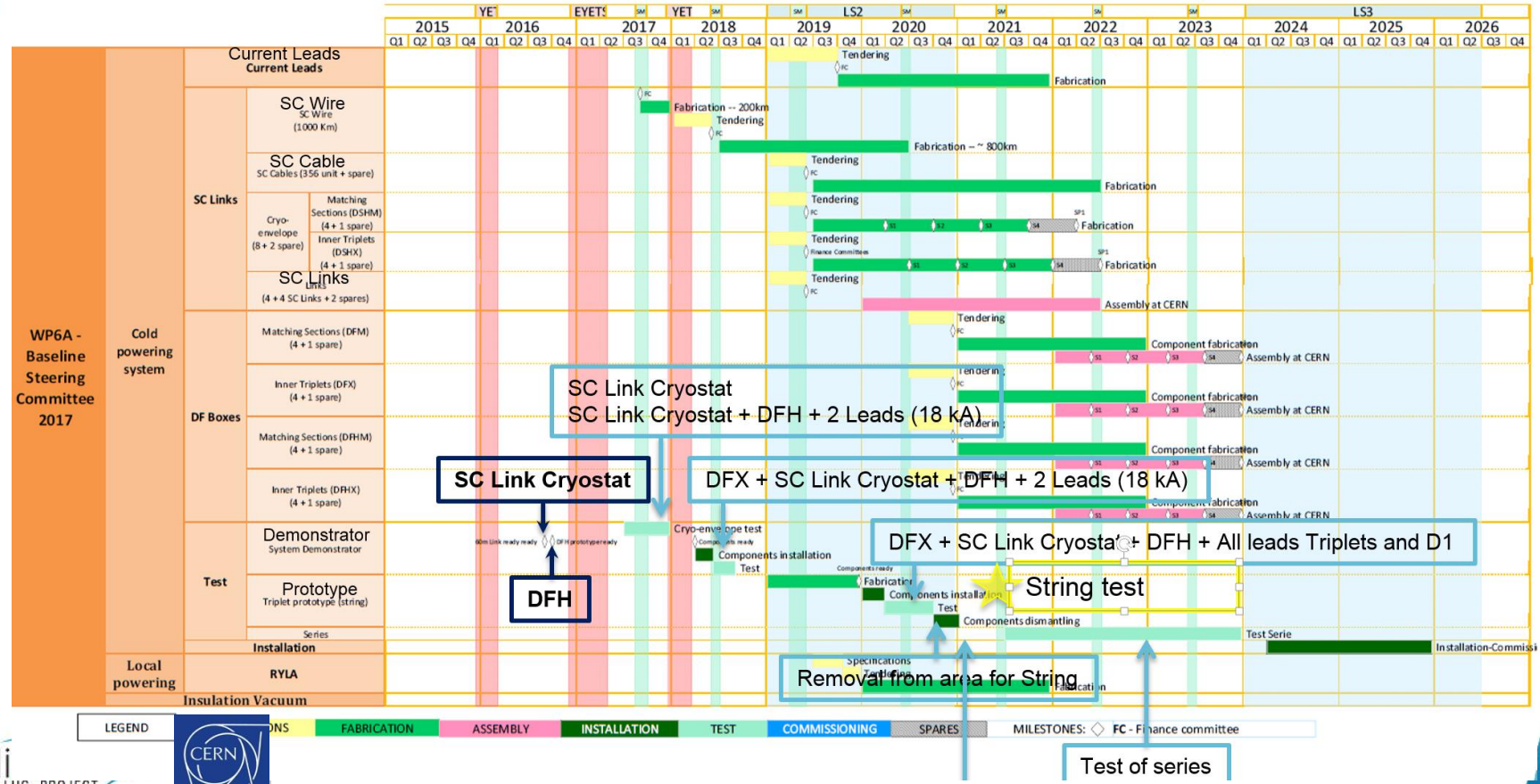
HL-LHC STRING TEST (WP16)

Cluster J



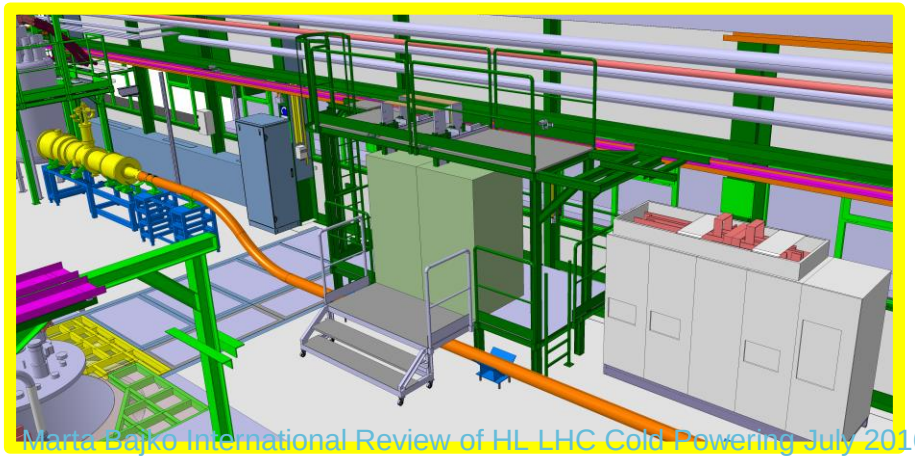
The HL-LHC TRING test stand is foreseen to be places on the so called cluster J with all powering circuits of the Inner Triplet and will use a Sc link prototype.

SC LINK test stands: planning of WP6A



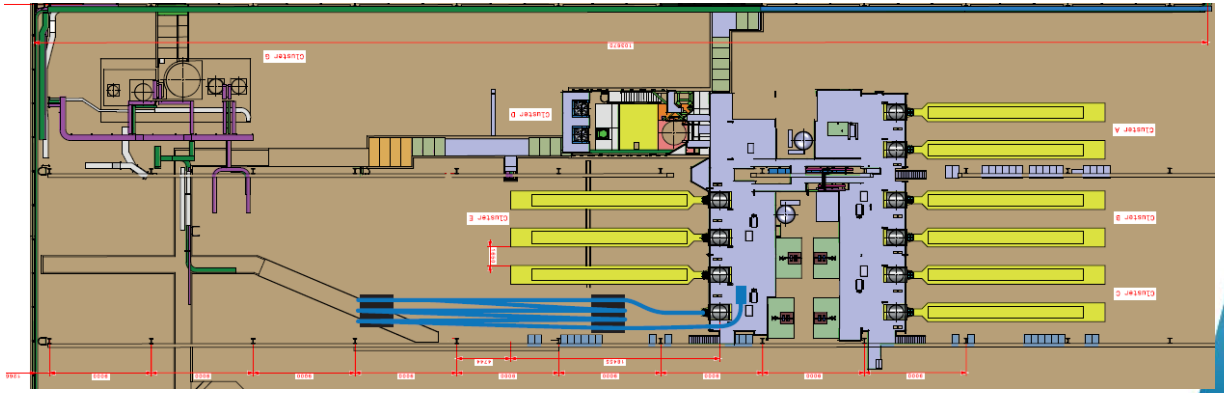
ID Card of SC LINK (demonstrator) test stand

- Test Facility name: HL-LHC SC LINK
- Test Facility location: SM18 (b. 2173) Cluster G
- Test date: 2016-2020
- Operational temperature: 1.9 – 50 K
- Magnets: none
- Cold powering: SC link 60 m + (DFL, DFH and DFX only at the latest stages)
- Warm powering: 1 x 20 kA xx x 0.6 kA, xx x 2 kA
- Water cooled cables for 20 kA
- Protection: Interlocked



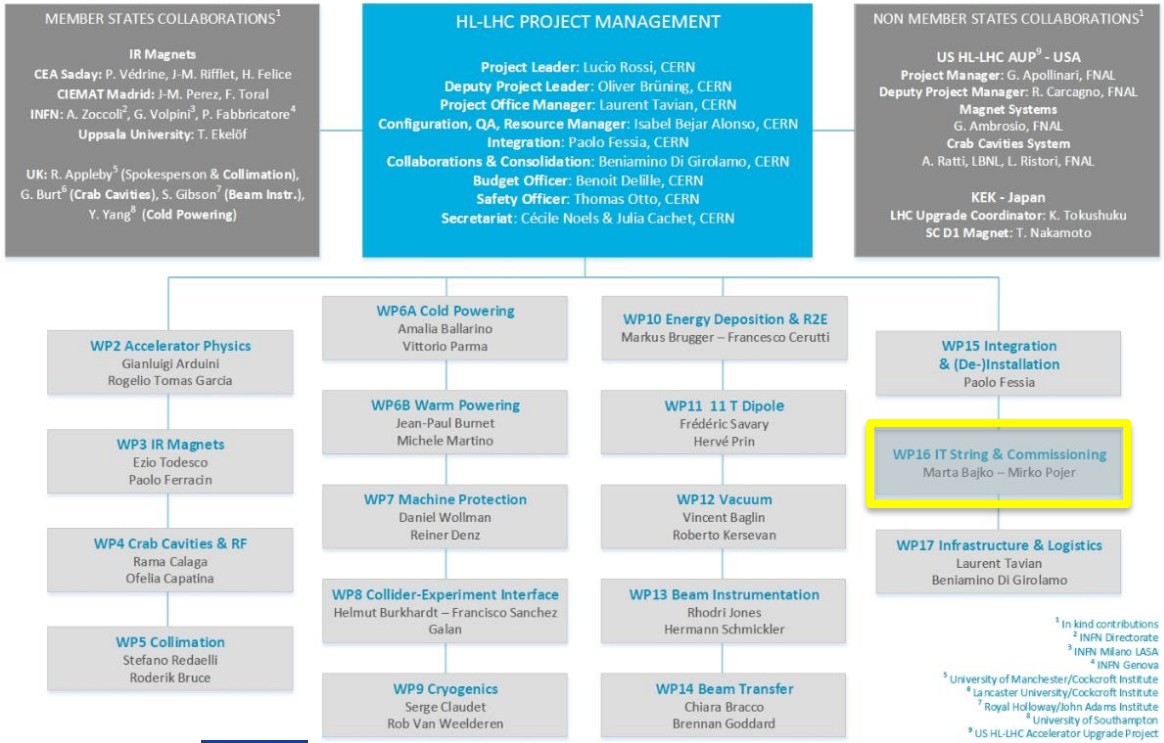
ID Card of SC LINK (series) test stand

- Test Facility name: HL-LHC SC LINK
- Test Facility location: SM18 (b. 2173) Cluster F
- Test date: 2021-2023
- Operational temperature: 1.9 – 50 K
- Magnets: none
- Cold powering: SC link 120 m + DFL, DFH and DFX
- Warm powering: 1 x 20 kA , 1x 13 kA, 2 x 2 kA, 2- 4 x 0.6 kA
- Water cooled cables
- Protection: interlocked



The HL-LHC IT STRING in the organigram

High Luminosity LHC Project



[…] **THE WP16** covers the coordination of the commissioning of the HL-LHC equipment as part of the accelerator system. […] The first important **system test** will be the Inner Triplet (IT) STRING test.

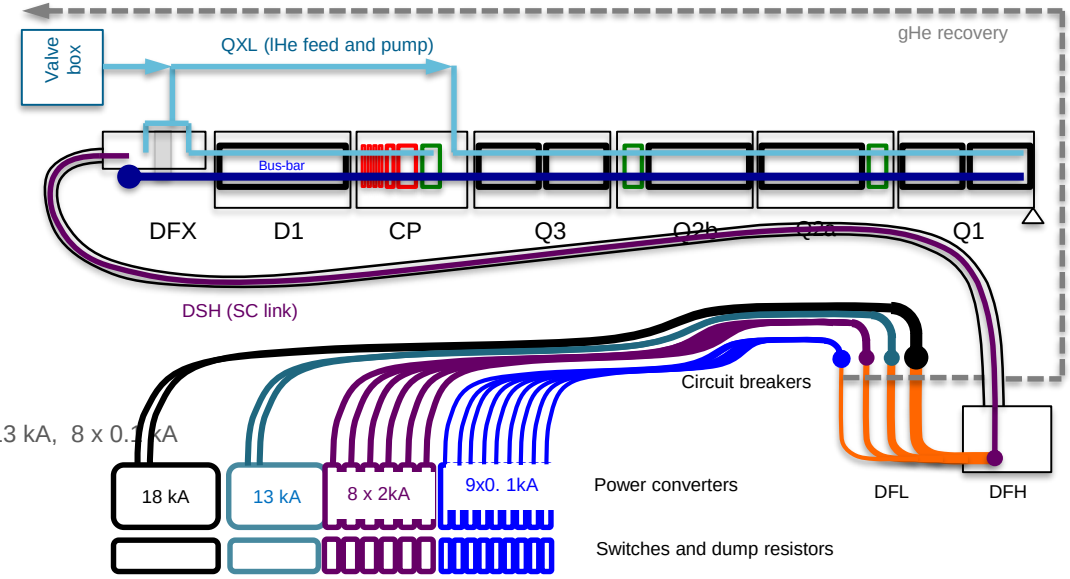
The **IT STRING** should comprises all magnets with their cold and warm powering and associated cryogenics systems from Q1 to D1 magnets including DFX. […] The IT STRING will have conditions as similar as possible to the operational ones and will constitute an integration and system test of the most critical part of the upgrade.

Ref. HL_WP16 Conceptual specification : https://edms.cern.ch/document/1586706/1

Ref. HL_WP16 IT STRING Mandate: https://edms.cern.ch/document/1513780/1

ID Card of HL-LHC IT-String

- Test Facility name: HL-LHC IT STRING
- Test Facility location: SM18 (b. 2173)
- Test date: 2021-2023
- Operational temperature: 1.9 K
- Magnets: Q1, Q2a, Q2b, Q3, CP, D1
- Cold powering:
  - SC link (60 m or 110 m) DFL, DFH and DFX,
- Warm powering:
  - 1 x PC 18 kA , 2 x 2 kA Trim Q1-Q3, 6 x 2 kA , 1 x 13 kA, 8 x 0.1 kA
- Water cooled cables, Circuit breakers
- Protection: CLIQ , QH and EE



[…] a **FULL INTEGRAL TEST** of the equipment from **Q1 till D1** including the **DFX** is foreseen in the HL-LHC project, in CONDITION AS SIMILAR AS POSSIBLE to the operational one.

The IT STRING of the HL-LHC will be composed by systems previously tested individually at least in nominal operational conditions.

HL_WP16 Conceptual specification : https://edms.cern.ch/document/1586706/1

Relevance for the HL-LHC IT STRING

The HL-LHC IT-String can provide relevant experience (same object as in the LHC), validation ("first time" test) and advanced operation information on:

- Magnet positioning, alignment, interconnection procedures (do not under-estimate)
- Mechanical behavior of the IT continuous cryostat (Q1 to DFX) and other components (DSH, DFH) under pressure, vacuum, cool-down, operation and warm-up
- Cryogenic behavior and operation under static and dynamic conditions
- Insulation and beam vacuum static (and dynamic) behavior
- ***Powering behavior of the system with SC links, dynamic response, interaction of circuits (electrical and cryogenic)***
- ***Cross talk between magnets in operation and during a quench, detection, propagation and protection of the complete superconducting circuit***

These aspects, especially the **collective behavior**, can only be tested in a representative test, a so-called STRING

GOALS in parallel: **Develop methods, techniques**
Develop tooling
Develop procedures

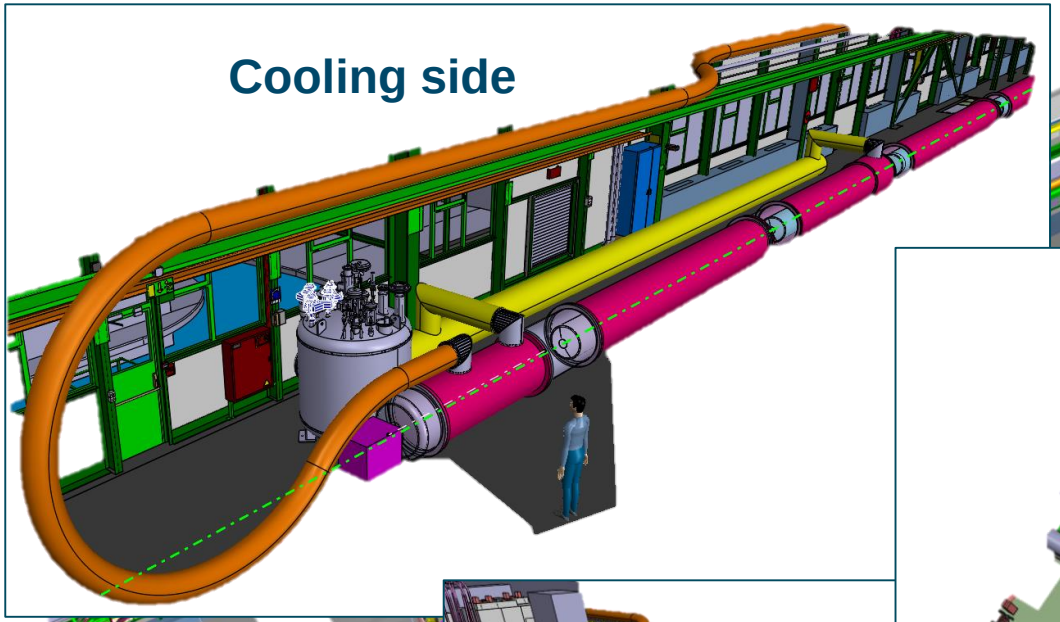
for definition of

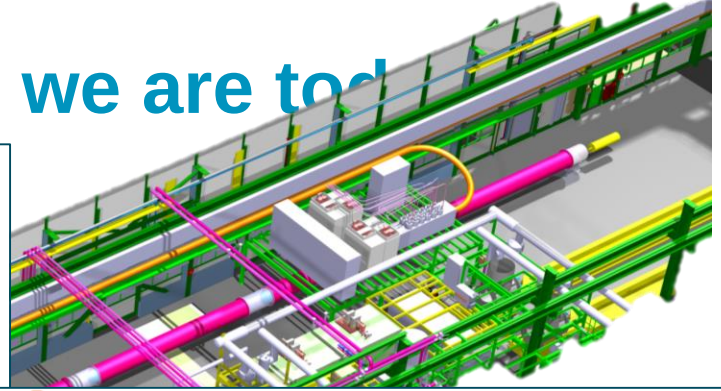
Installations
Test
Operation

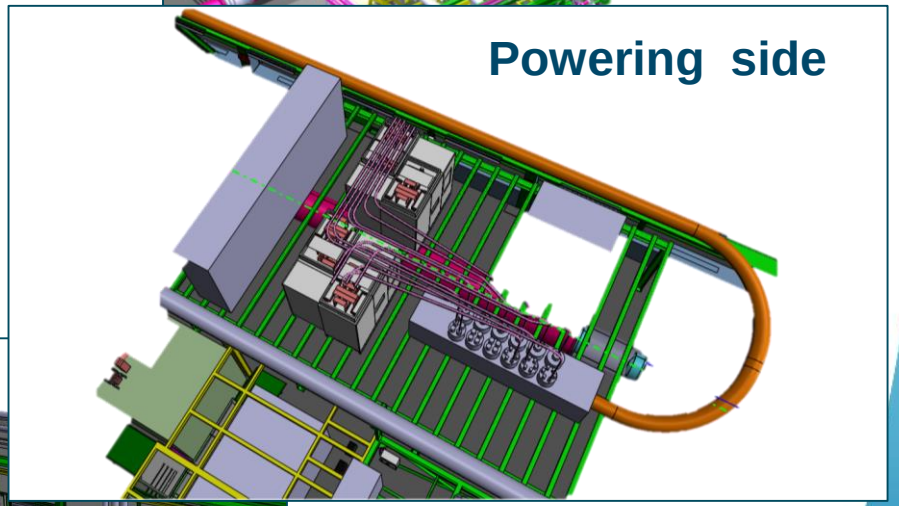
to support

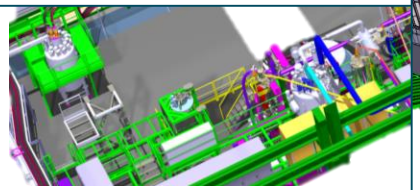
HWC and OP of HL-LHC

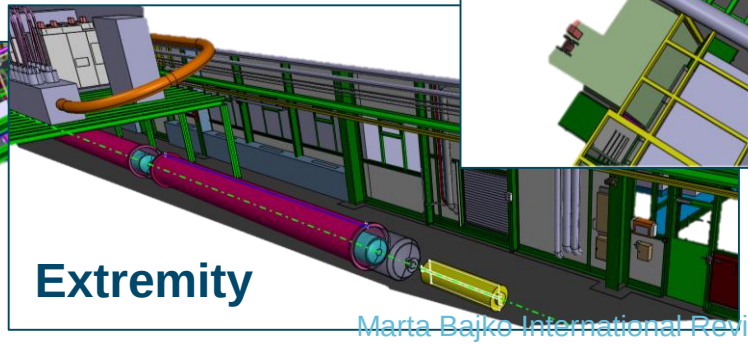
Options in space: where we are tod

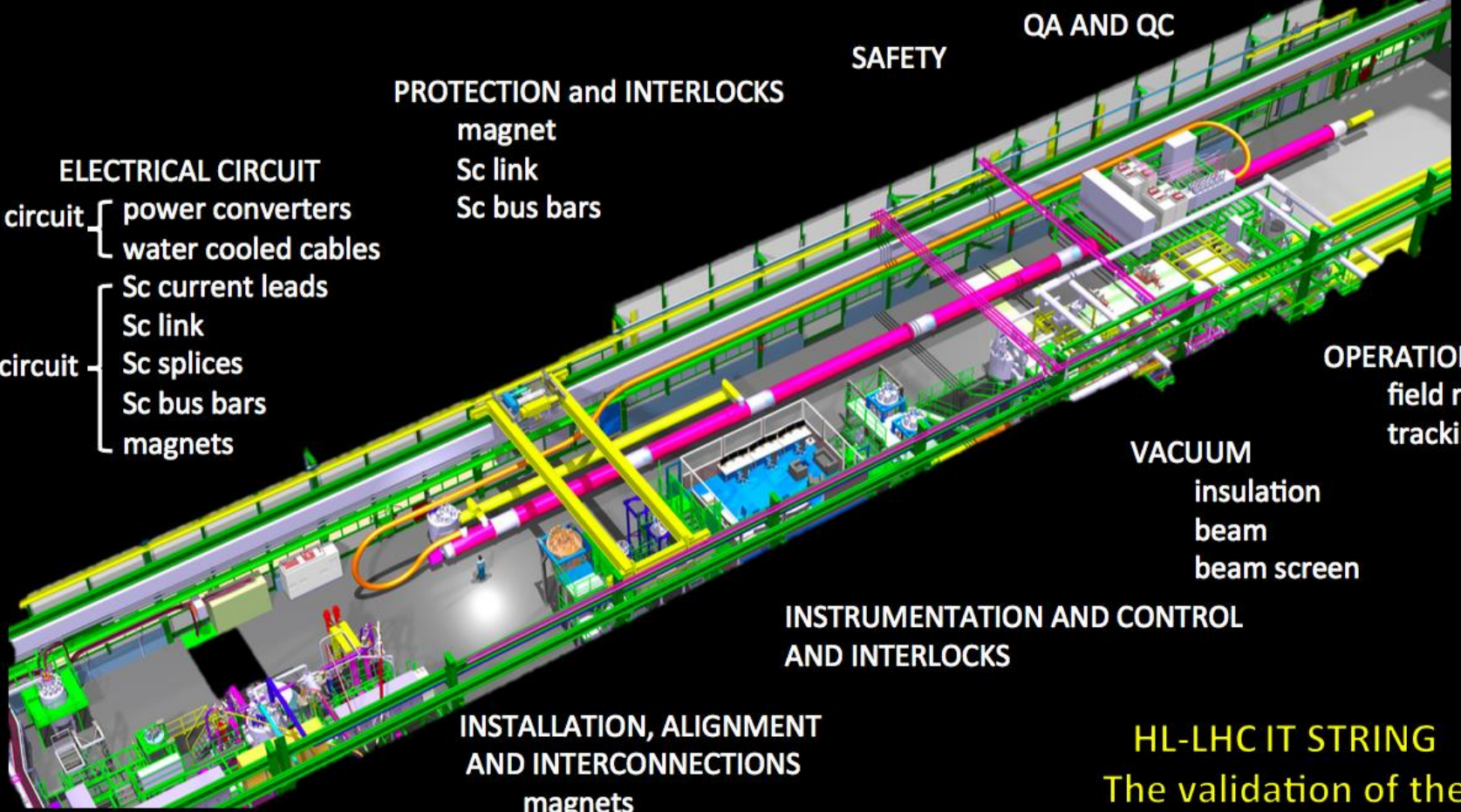












QA AND QC

SAFETY

PROTECTION and INTERLOCKS
- magnet
- Sc link
- Sc bus bars

ELECTRICAL CIRCUIT
- warm circuit
  - power converters
  - water cooled cables
- cold circuit
  - Sc current leads
  - Sc link
  - Sc splices
  - Sc bus bars
  - magnets

OPERATION
- field reference
- tracking

VACUUM
- insulation
- beam
- beam screen

INSTRUMENTATION AND CONTROL AND INTERLOCKS

INSTALLATION, ALIGNMENT AND INTERCONNECTIONS
- magnets
- sc link
- vacuum
- cryogenics

HL-LHC IT STRING

The validation of the

collective behavior

of the system components

SM18 2021-2023