Thematic industry days
19-20 September 2022

Cabling, assembly and industrialization of electrical cabinets/switchboards for cryogenic application at CERN

CERN - TE department - CRG group
TE-CRG-Instrumentation and Control Section
Dr Marco Pezzetti
19 September 2022

Outline

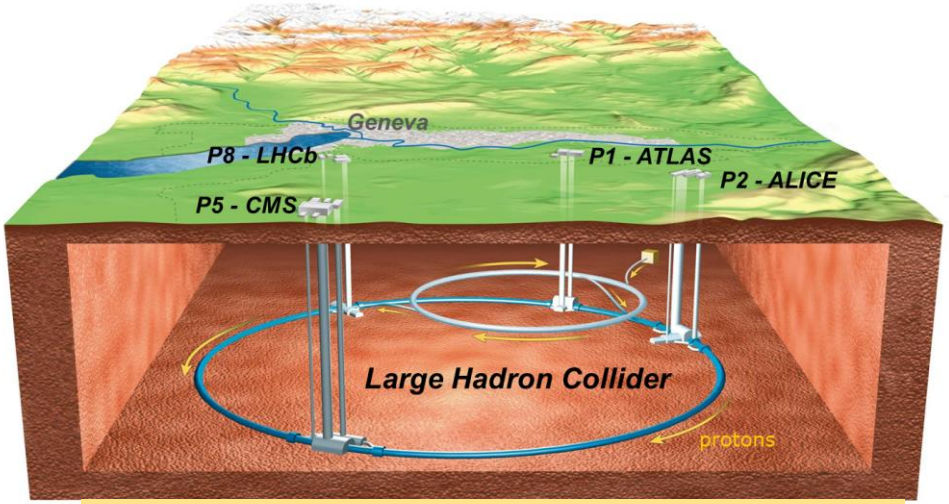
Introduction.

LHC cryogenic system and technology.

Cryogenic electrical control systems.

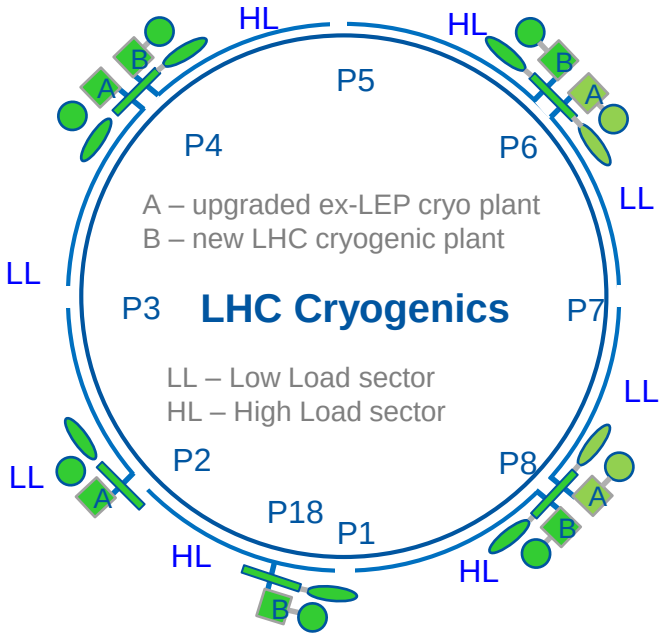
Supply of cryogenic electrical control cabinets manufacturing, assembly needs.

CERN LHC Cryogenic System

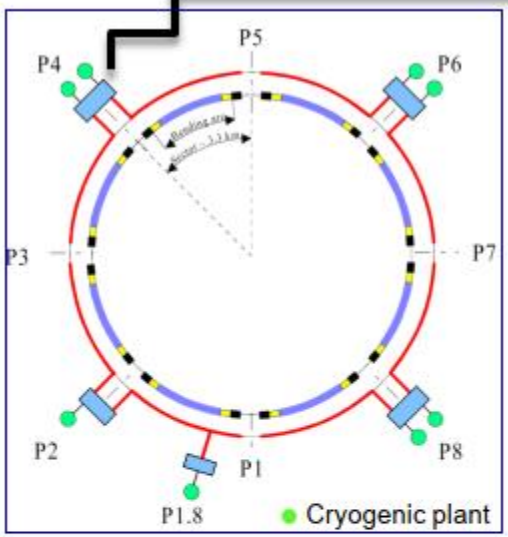


- **circumference ➔ ~ 27 km,**
- **constructed at ~ 100 m underground,**
- **the accelerator ring inclination is 1.4 %**

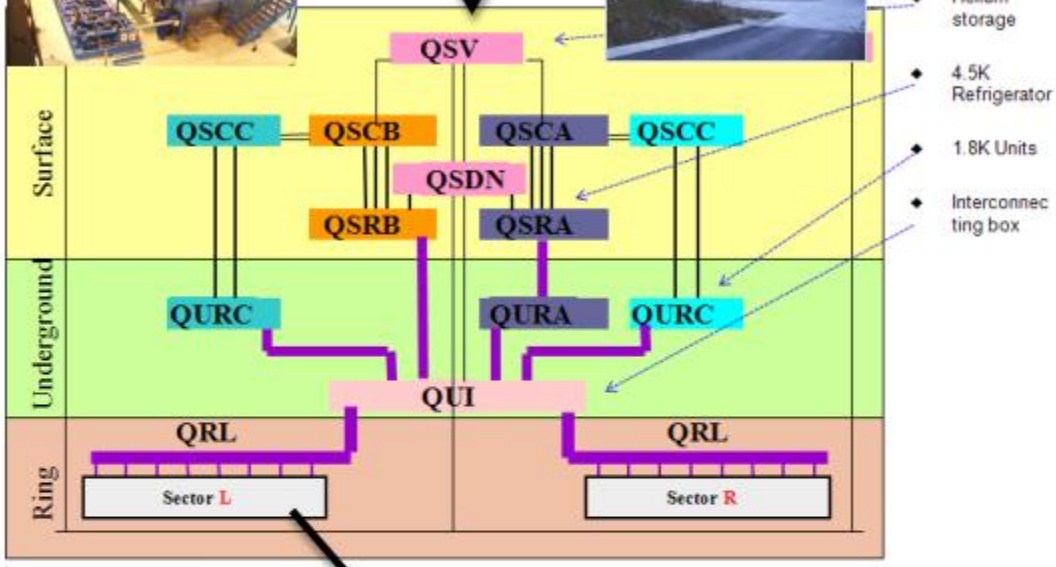
CERN LHC cryogenics:
1800 sc magnets
8 x 18 kW @ 4.5 K
8 & 20 kW @ 1.8 K
130 tons of helium inventory



CERN LHC Cryogenic System

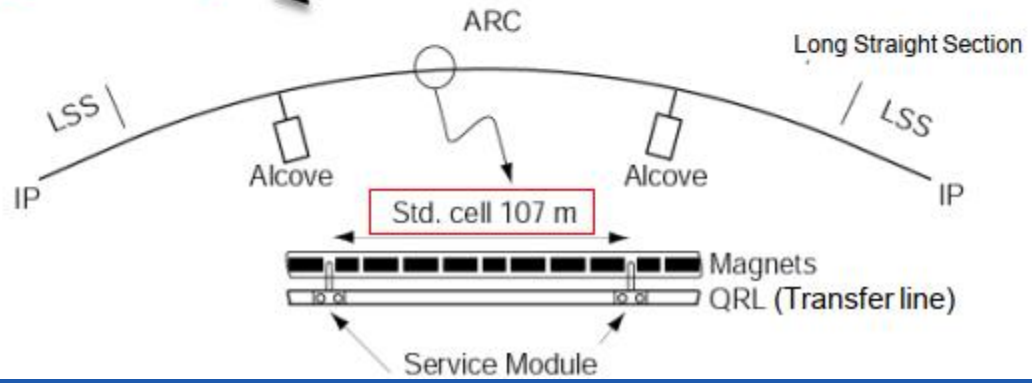


Cryogenic point

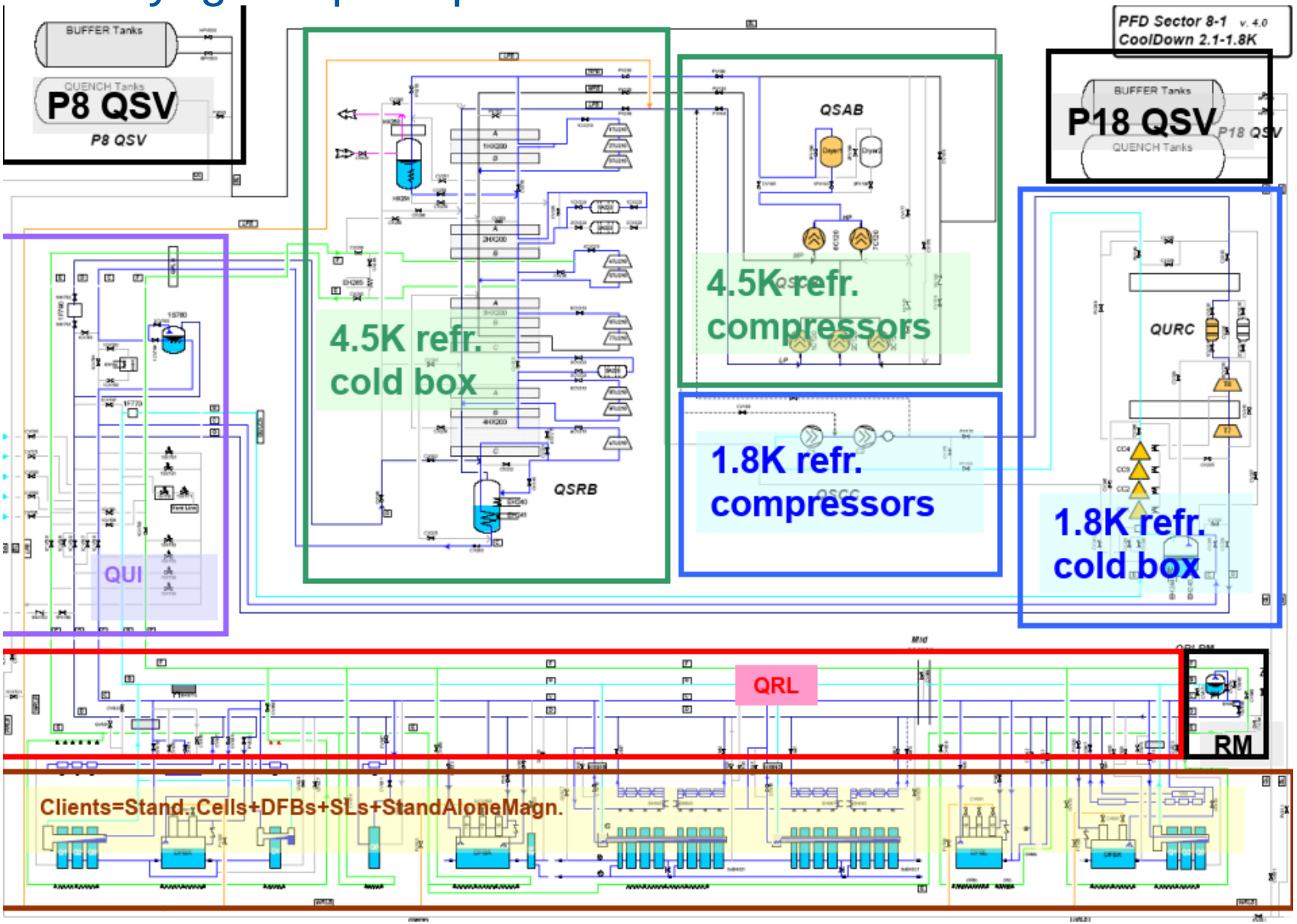


LHC tunnel (27 km)

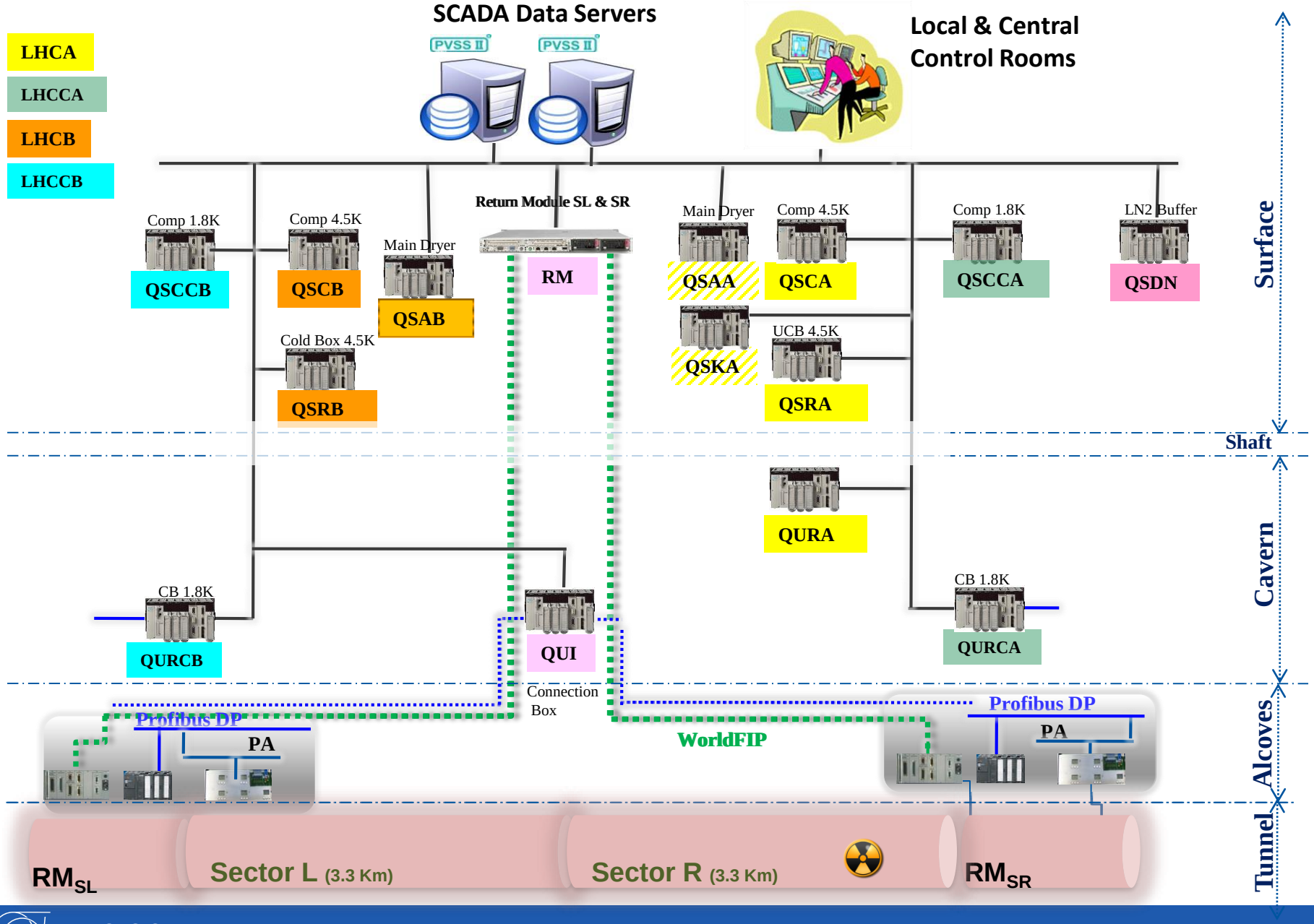
3.3 km



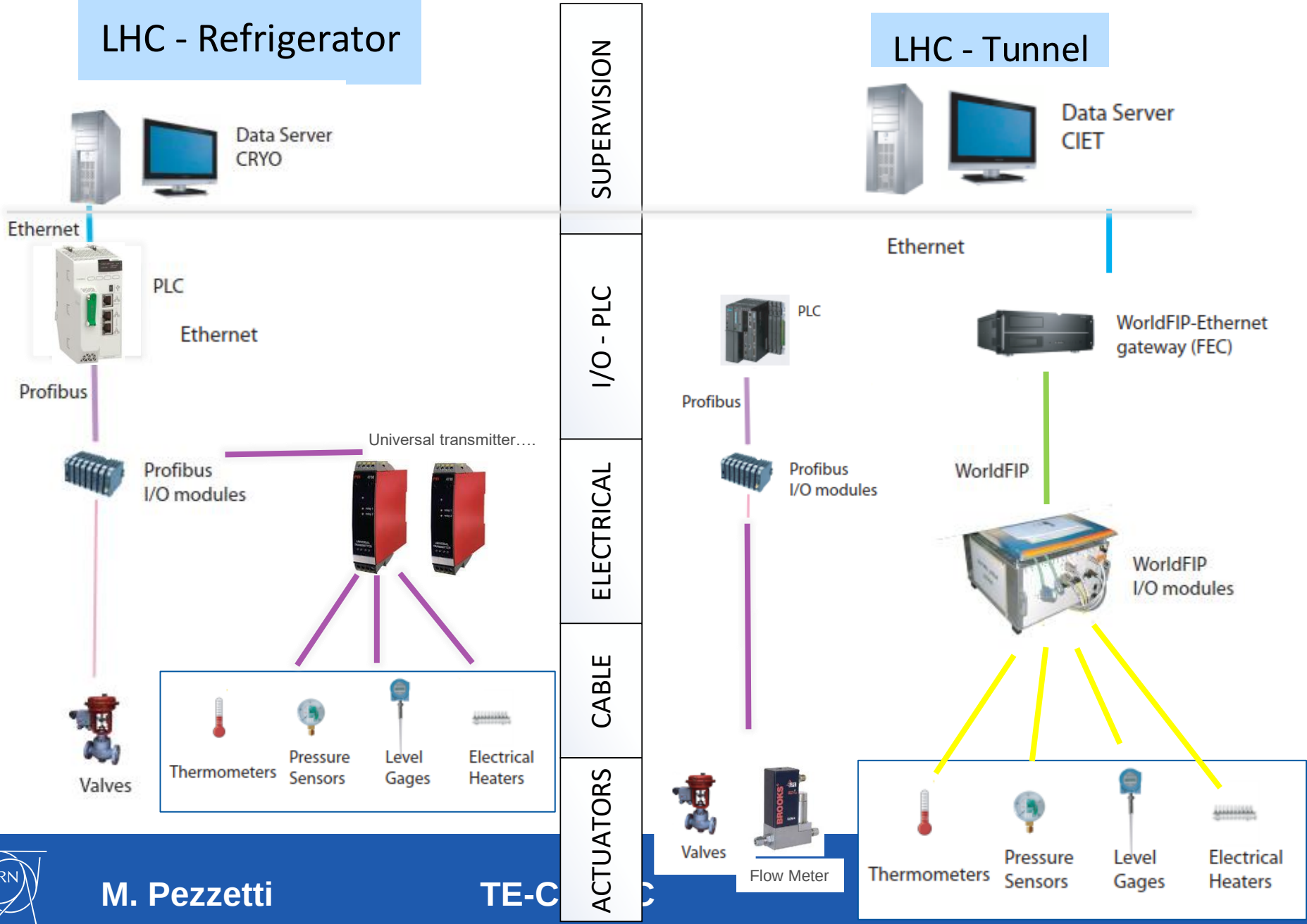
LHC Cryogenic plant process architecture



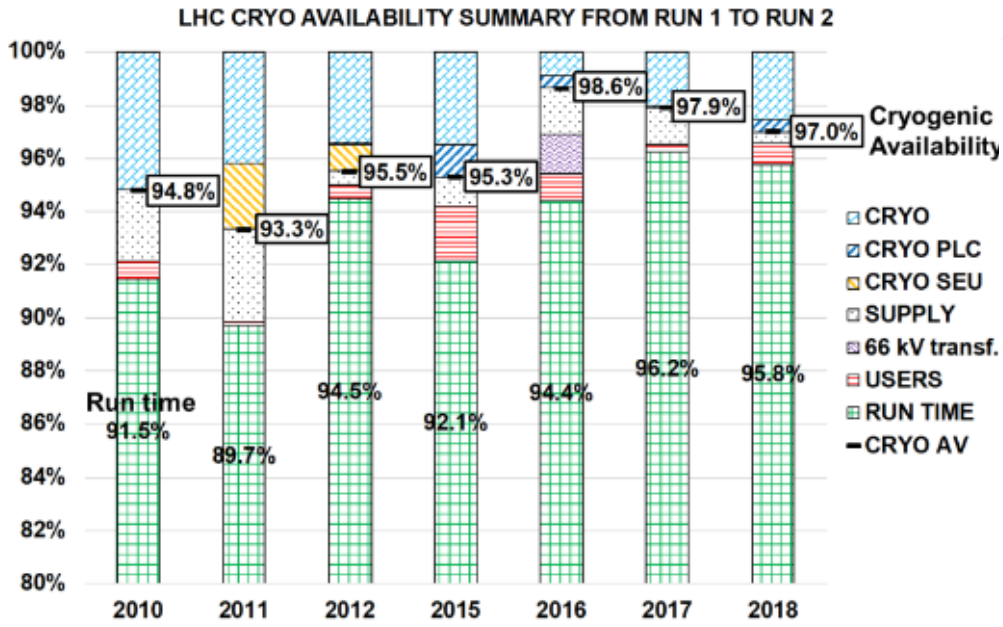
LHC Cryogenics Control System Refrigerators Architecture (Px)

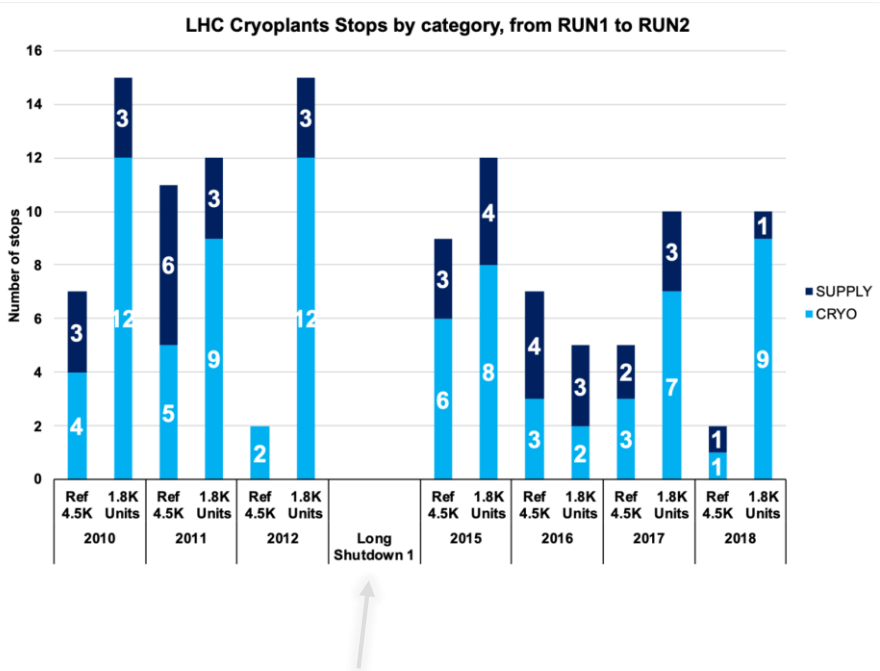


Cryogenic process control system typical architecture



LHC cryogenic availability Run1 & Run2



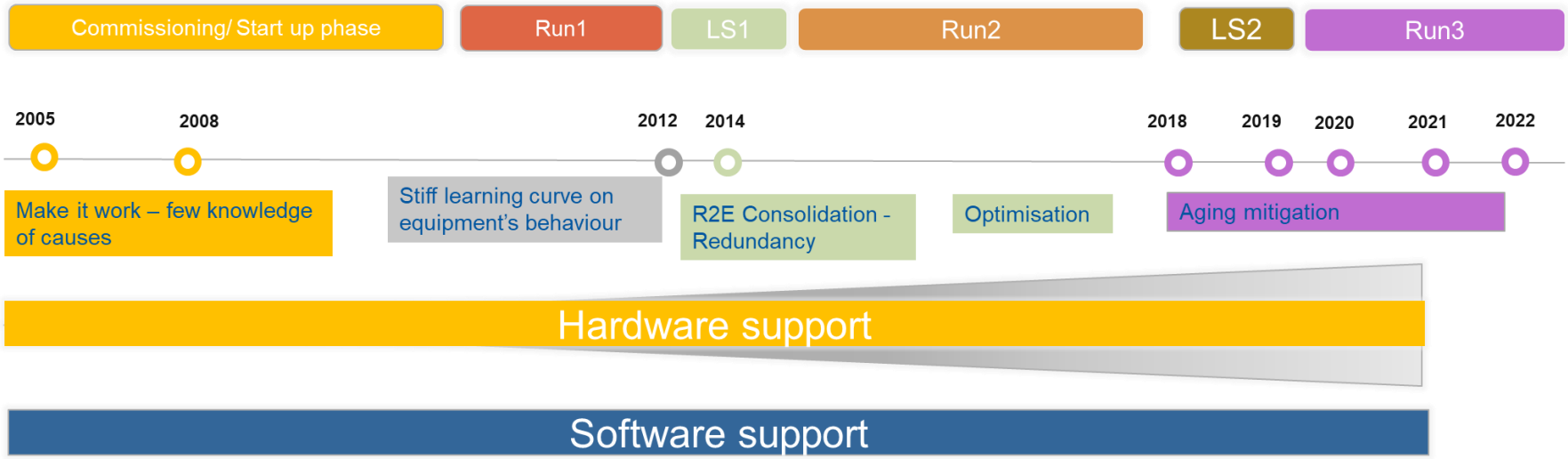


LS consolidation activities!

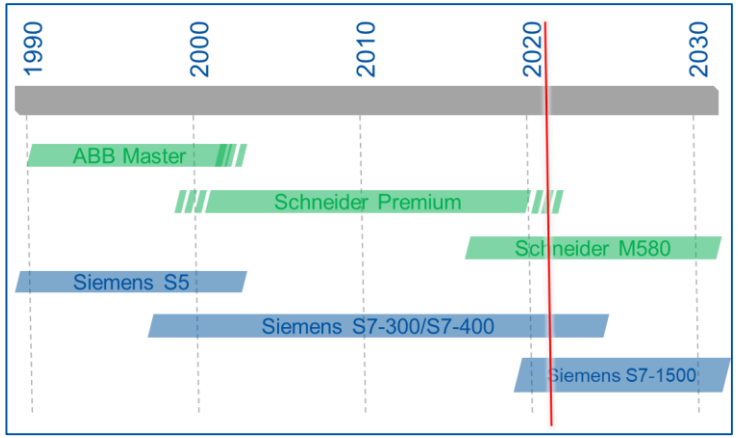
CRYOGENICS EXPERIENCE DURING RUN2 AND IMPACT OF LS2 ON NEXT RUN.

G Ferlin, L Delprat, B Bradu, K Brodzinski, M Pezzetti “Cryogenics experience during Run2 and impact of LS2 on next run”, in Proc. 9th CERN LHC Operations Evian Workshop, Evian, France, 30-1 January-February 2019.

CERN cryogenic control system “lifetime” challenge!



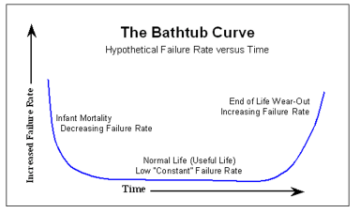
EDMS-1888489 “Cryo control LifeTime”
Control PLC “EoL” = 15/20y
Electrical cabinet “EoL”= 25y



Electrical system lifetime expectation.

By the first HL-HLC beam, most of the equipment of the ex-LEP cryo-plants would have passed EoL.

Typical lifetime	[y]
Cables	30-40
Plastic electricity	25-30
Instrumentations	20-25
Protections	20-25
Control PLC – IO	15-20

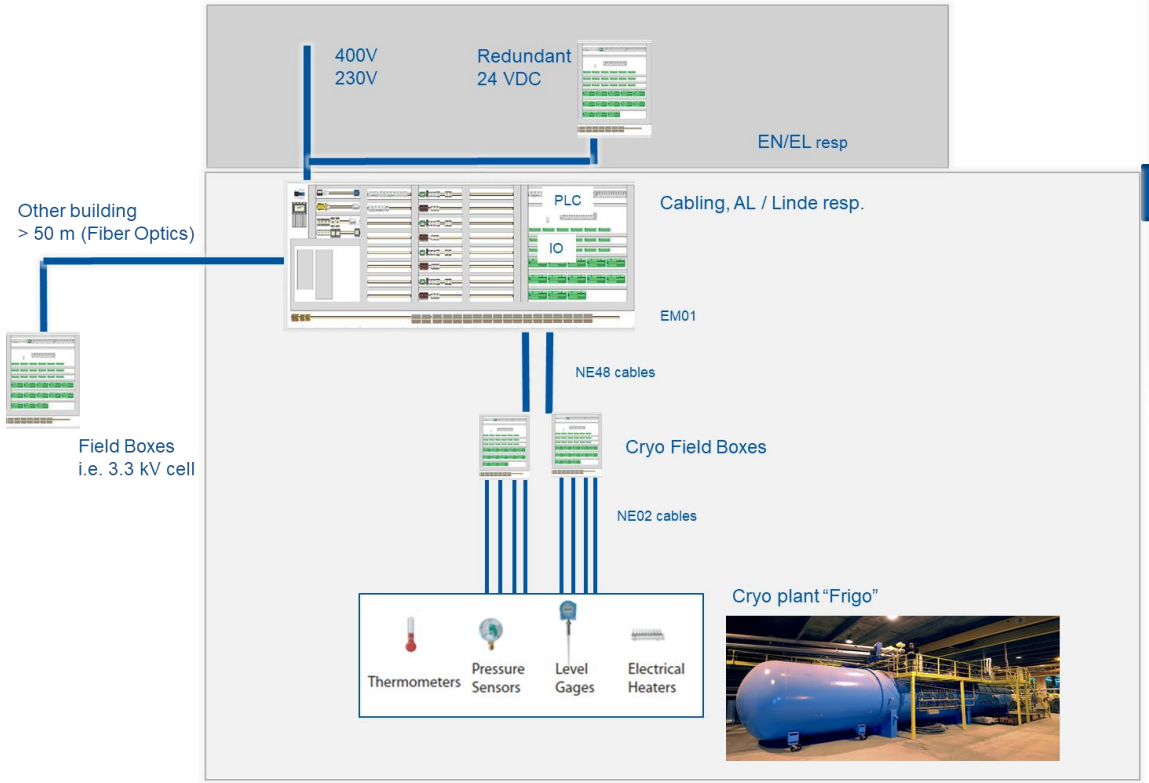


- Obsolescence – EoL replacement strategy in progress…;
- Degradation (cabling – electrical equipment);
- Safety (Local PLC, test de rotation, SIL1 push button);

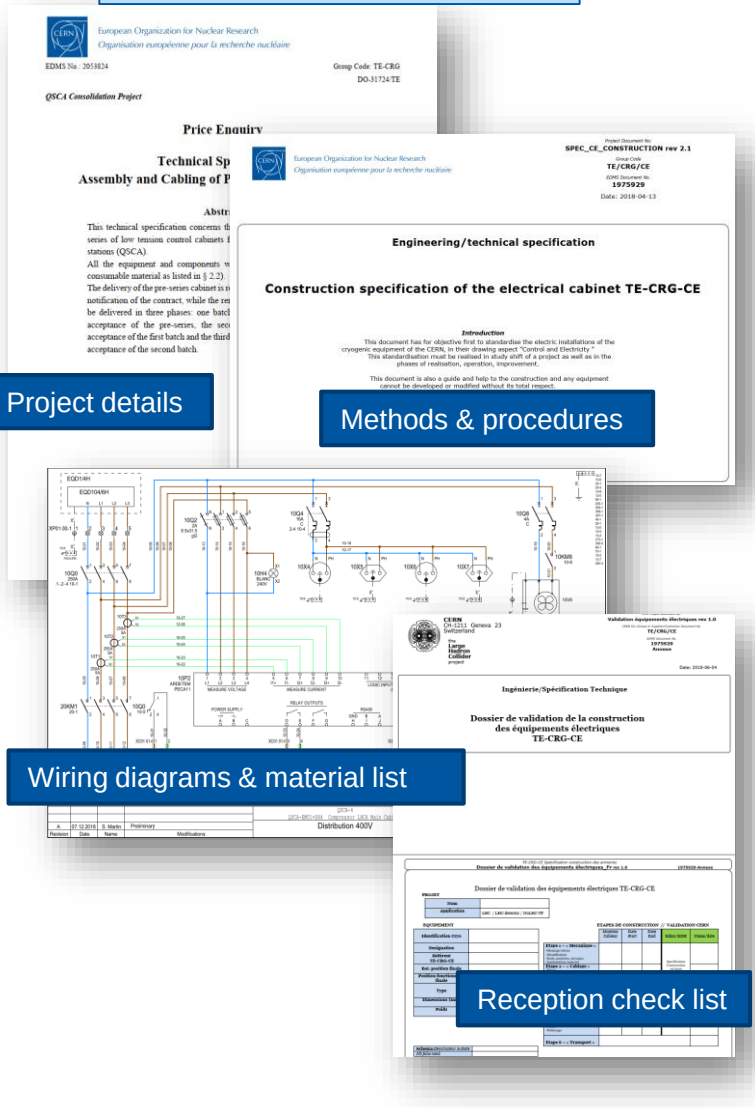
Priority :
- P4
- P6
- P8
- P2*

Upgrade is an evolving process all along the LHC accelerator lifetime ….

CERN Cryogenics Electrical System Methodology



CERN Methodology



Cryogenic electrical system

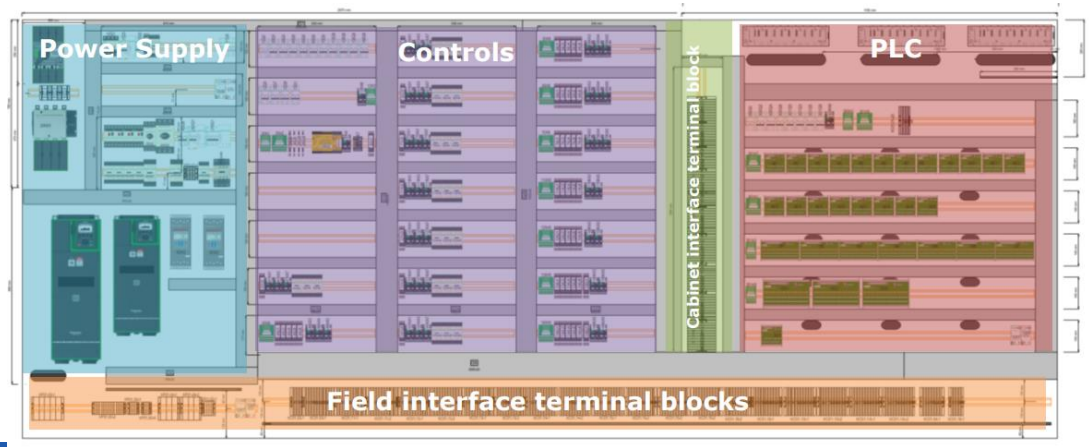
Global review of all **electrical** Specification and Standard

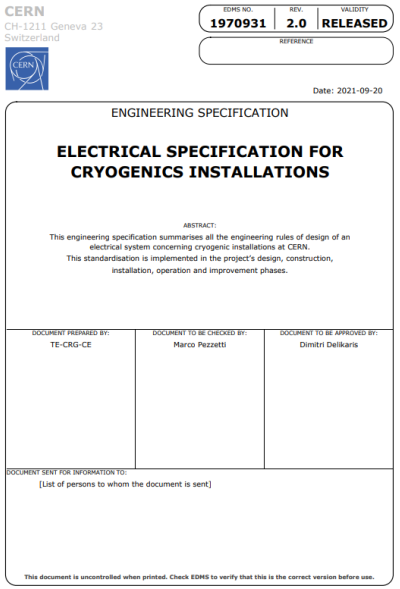
"Fault diagnostic model" -> "Preventive Maintenance" -> "Electrical functionality"

Maximize the plants **availabilities**;
Reduce the number of **components;**
Optimise (minimise) the **maintenance frequency;**
Improve the **flexibility** during operation.

Effort on Clarity & Simplicity for **Operation / Reliability / Maintenance**

- Main **Electrical Specification for Cryogenics installations** – EDMS 1970931;
- Set of instructions to create electrical drawing, manufacture cabinet and installation:
  - Instruction **for wiring Diagram Design** – EDMS 1769454;
  - Instruction for Electrical **cabinet manufacturing** – EDMS 1975929;
  - Instruction for **on site installation** – EDMS 1977146.




CERN
CH-1211 Geneva 23
Switzerland

EDMS NO. 1970931 | REV. 2.0 | VALIDITY RELEASED
REFERENCE

Date: 2021-09-20

ENGINEERING SPECIFICATION

ELECTRICAL SPECIFICATION FOR CRYOGENICS INSTALLATIONS

ABSTRACT:
This engineering specification summarises all the engineering rules of design of an electrical system concerning cryogenic installations at CERN.
This standardisation is implemented in the project's design, construction, installation, operation and improvement phases.

DOCUMENT PREPARED BY:	DOCUMENT TO BE CHECKED BY:	DOCUMENT TO BE APPROVED BY:
TE-CRG-CE	Marco Pezzetti	Dimitri Delikaris

DOCUMENT SENT FOR INFORMATION TO:
[List of persons to whom the document is sent]

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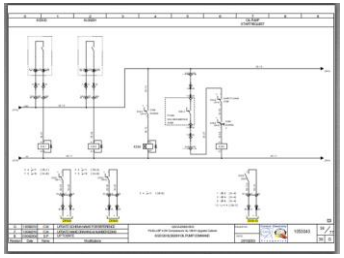
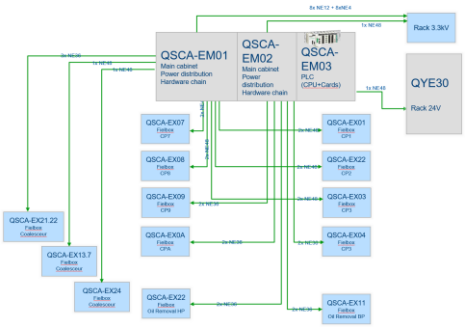
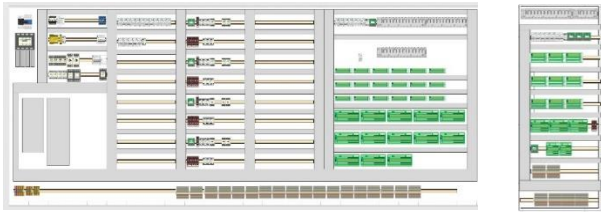
Supply of cryogenic electrical control cabinets manufacturing, assembly.

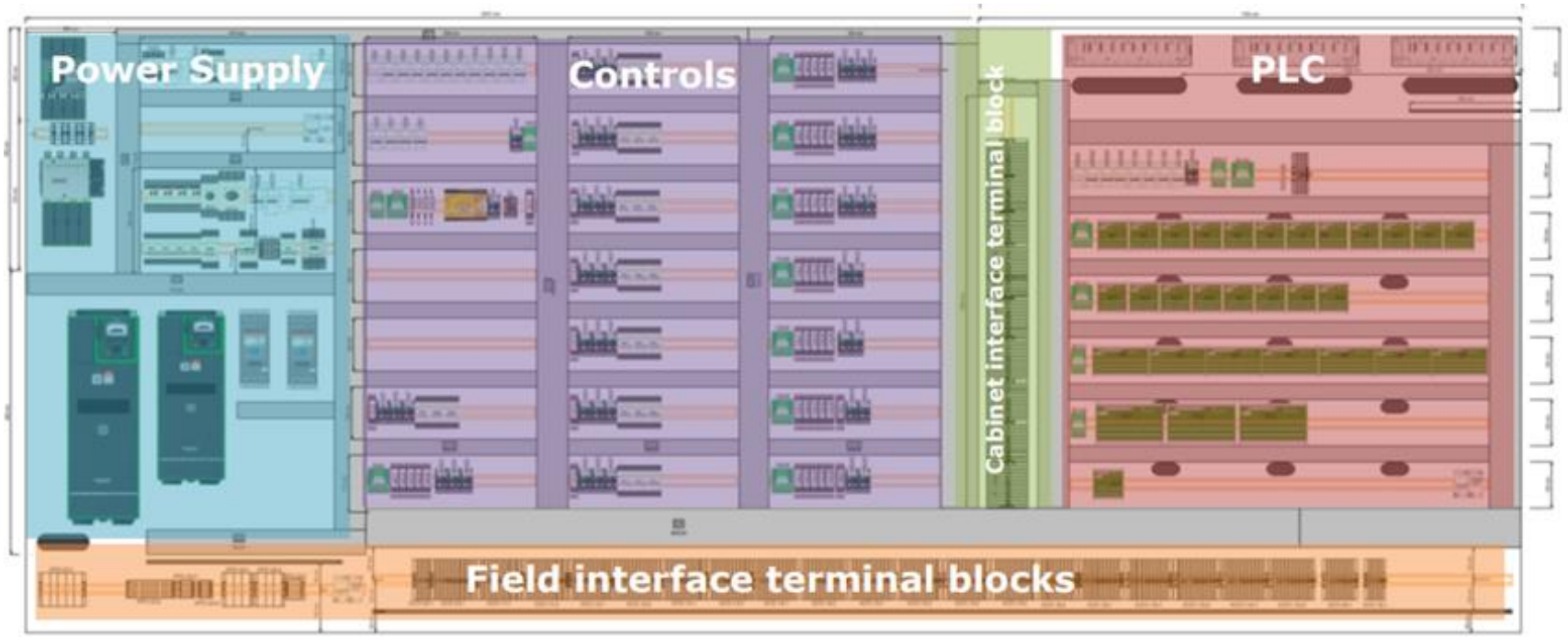
- Electrical cabinets manufacturing (built-to-print):
- Typical contract duration is 5 years (+2 option)
- Approximate quantities are 15 to 20 systems / 5years
- The cabinet voltage level is 24VDC
- Typically integrated in industrial cabinet (<5 doors per system)
- Contractors provide
  - the procurement of off-the-shelf parts
  - manufacturing or purchase of enclosures (cabinets)
  - assembly, cabling, testing of subassemblies and entire cabinets
  - Quality control and tests of complete cabinets
  - storage and delivery
- Outsourcing is not permitted
- Strict following of CERN technical specification







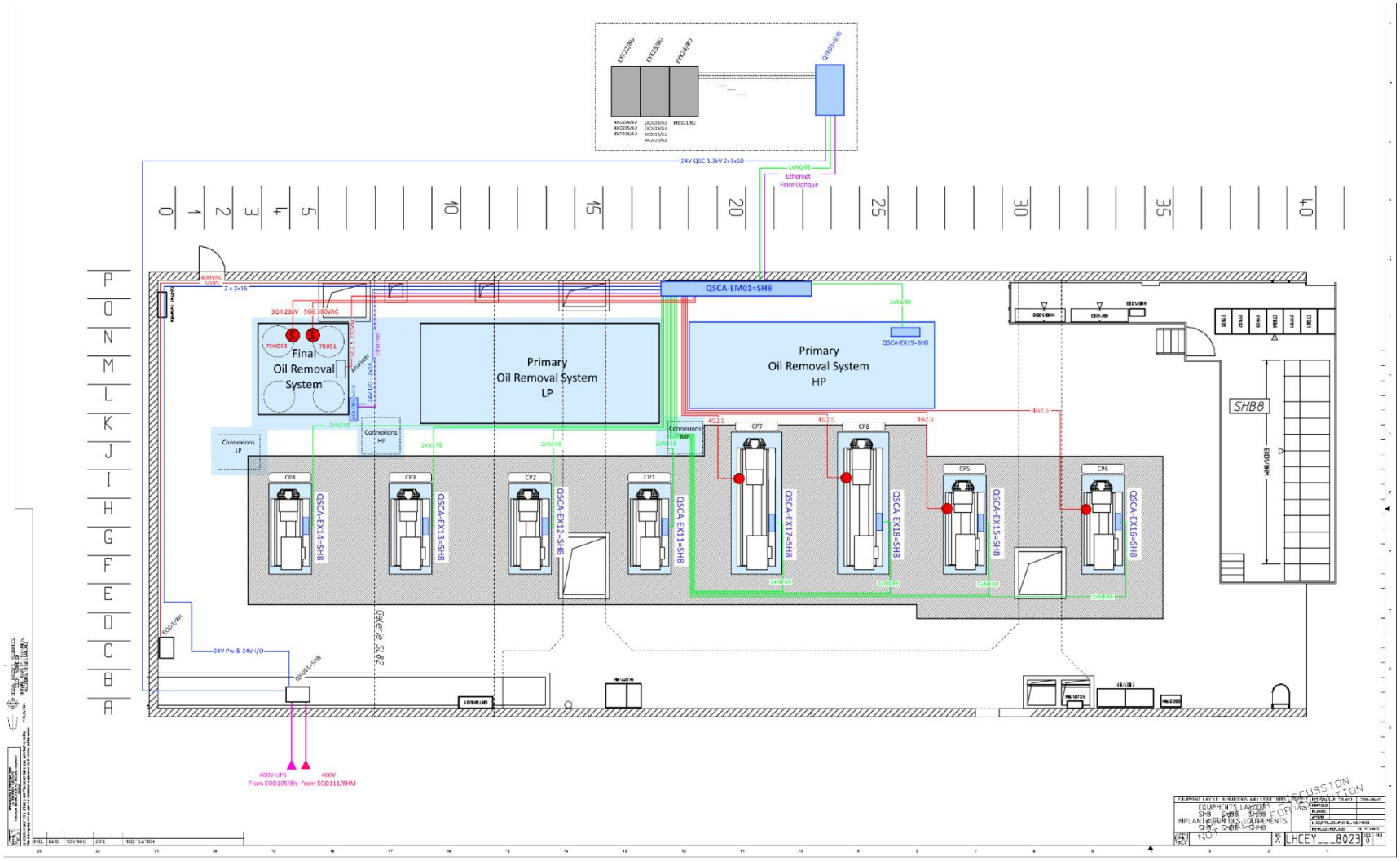
Typical cryo electrical cabinet



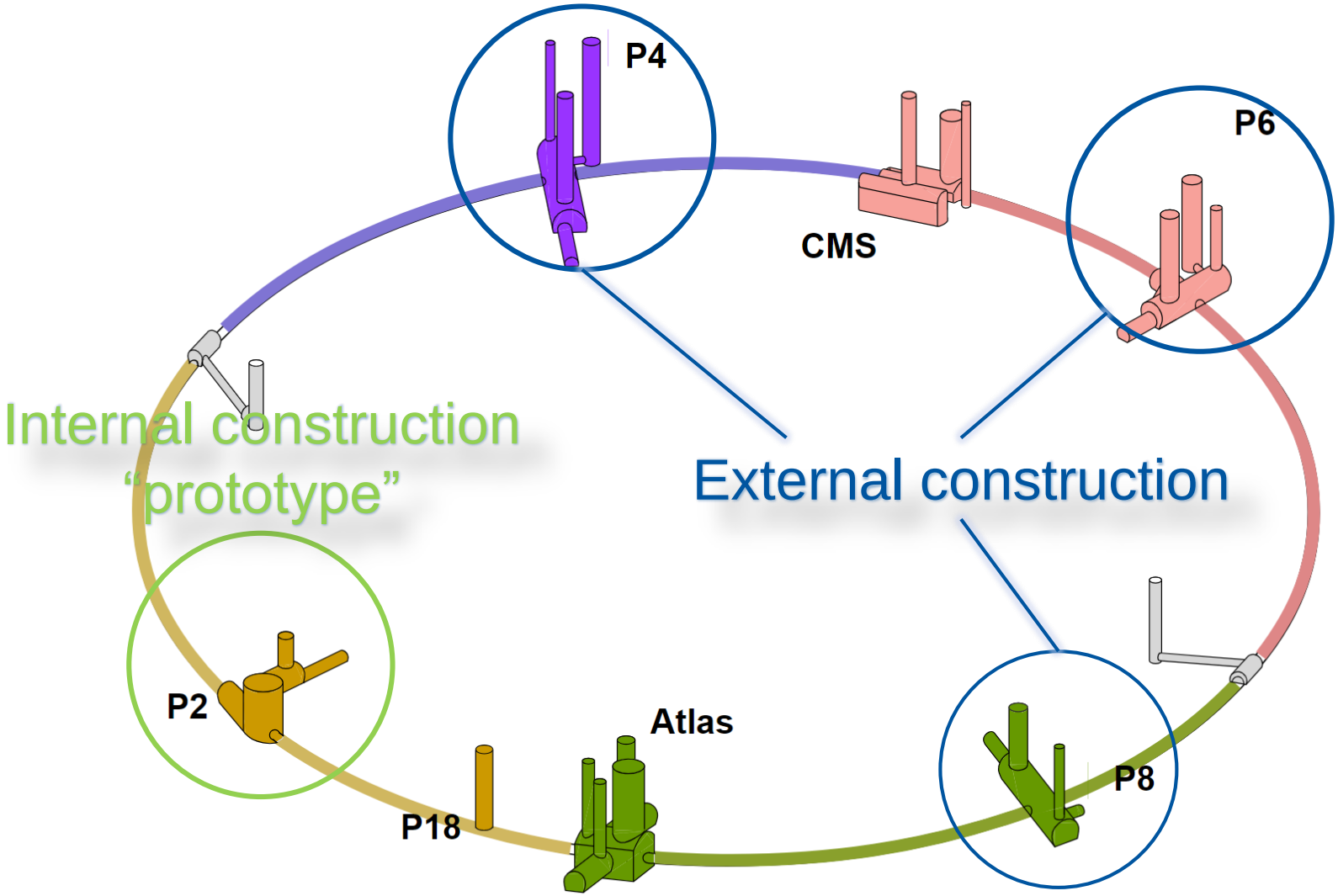
Case 1: consolidation activity example

CERN LHC cryogenic : warm helium compressor set

Onsite Implantation:

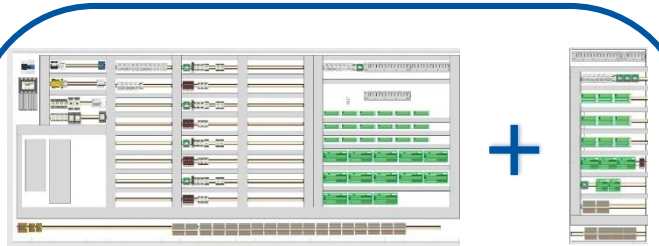


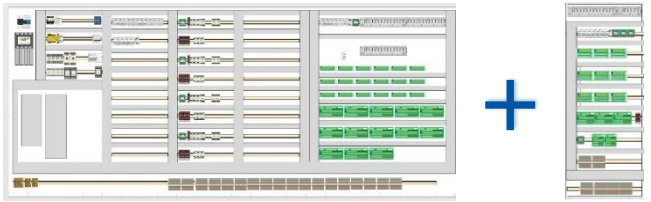
Cryogenic Electrical Cabinets construction strategy



Cryogenic Electrical Cabinets construction strategy

Internal material procurement
Internal construction





Internal material procurement
External construction

Best way to homogenize the supply with the workload & delay constraints

Challenging plan inside LS2!

P2 (8 weeks)
→100% of cabling
→100% Tests Synchro
→Air distributor for PV to be change and test. Purge panel to be cabled and test,
Soft starter for new oil pumps to be done Week 3&4

P4 (8 weeks)
→100% of cabling
→95% Tests Synchro
→ Tests synchro 3.3kV and soft starter for new oil pumps to be done Week 3

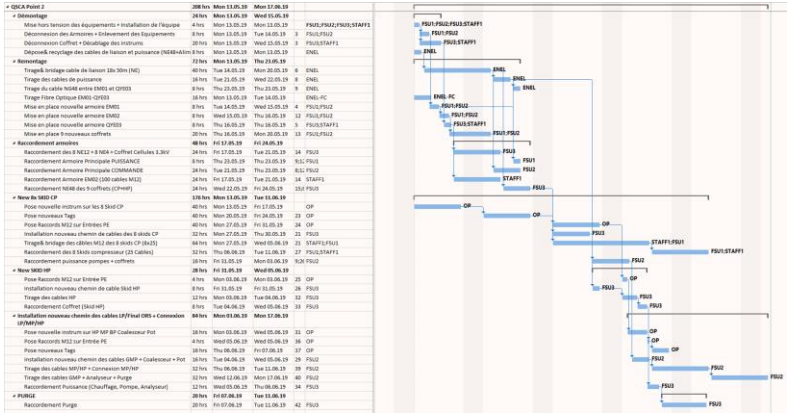
P8 (8 weeks)
→100% of cabling
→95% Tests Synchro
→Tests synchro 3.3kV to be done after SkID work
→ Soft starter for new oil pumps to be done Week 3

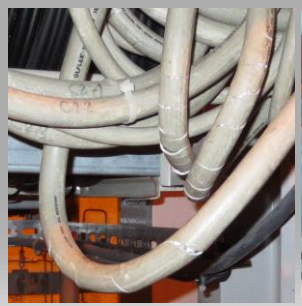
P6 (8 weeks)
→ Cabinet ready @ CERN
Onsite work scheduled for week 5

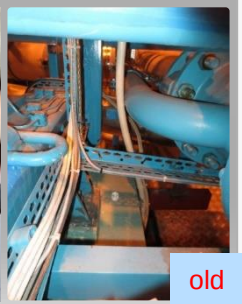
Commissioning
Hardware safety and protection chain tests
Synchro tests
Interlock tests
Commissioning

→ P4 Early in April
→ P8 Middle of April
→ P6 Early in May
→ P2 Early in July

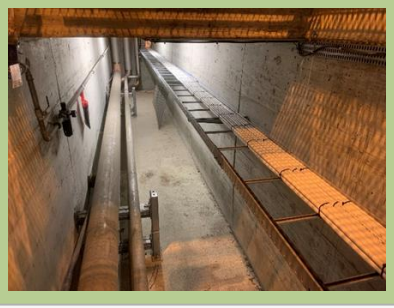
2019
End of April
Middle of July
End of September
Beginning of the year
2020
Early in April
End of July





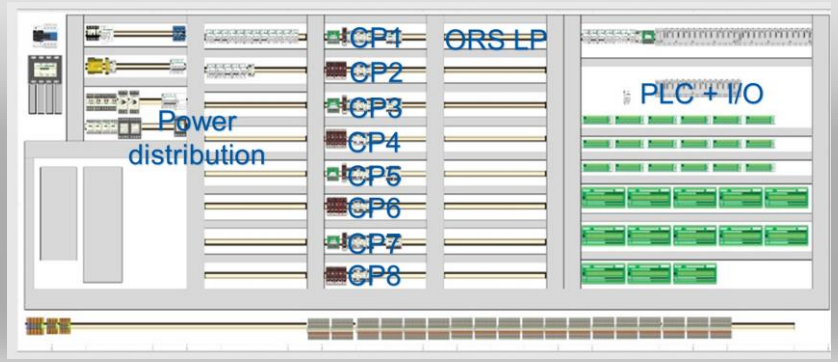


old



new

CERN Cryogenic Electrical Cabinets



new!!

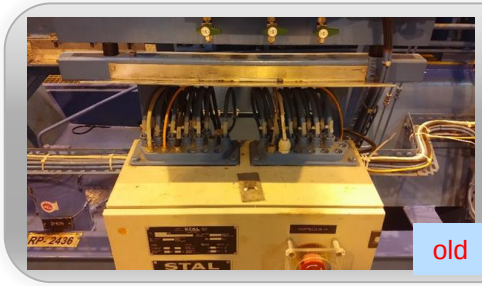
old

new

- Completed Machine Protection re-designed.
- Ergonomic electrical solution re-design operation-maintenance oriented!
- Technical solution bringing highest solution in term of reliability/ operability and minimal maintenance (30% reduction in term of instrumentation maintaining the same operation functionality).
- European industry assembly with logistical challenge
- Minimal cost for scaling production!

old

new



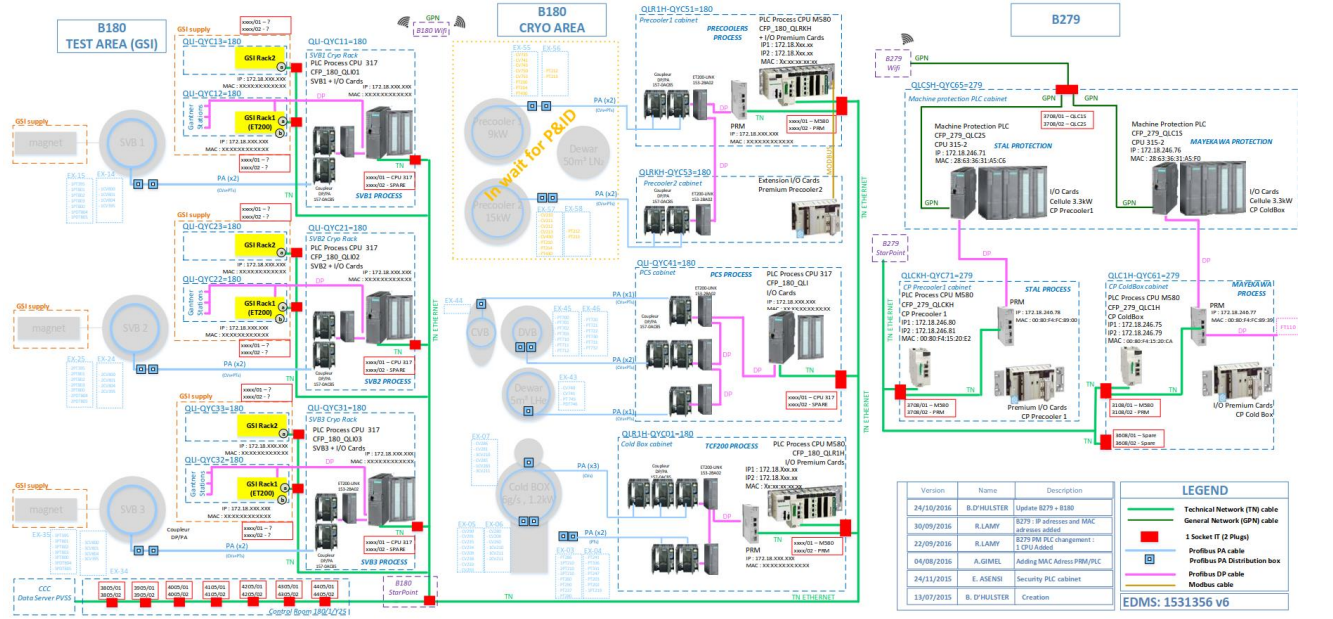
old

new

Case 2 : projects activities examples

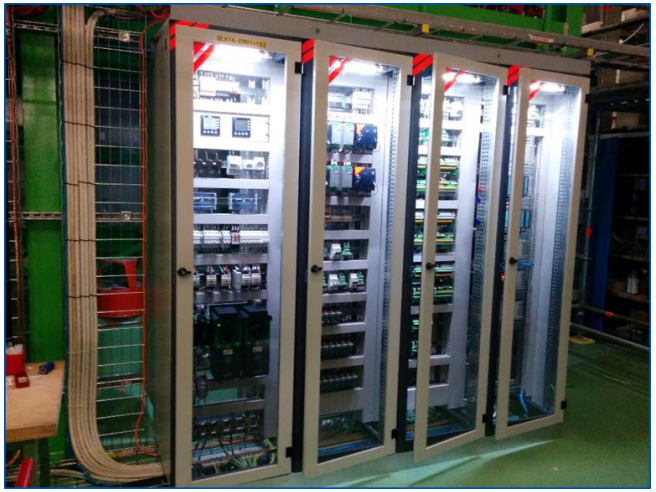
CERN WAT cryogenic control

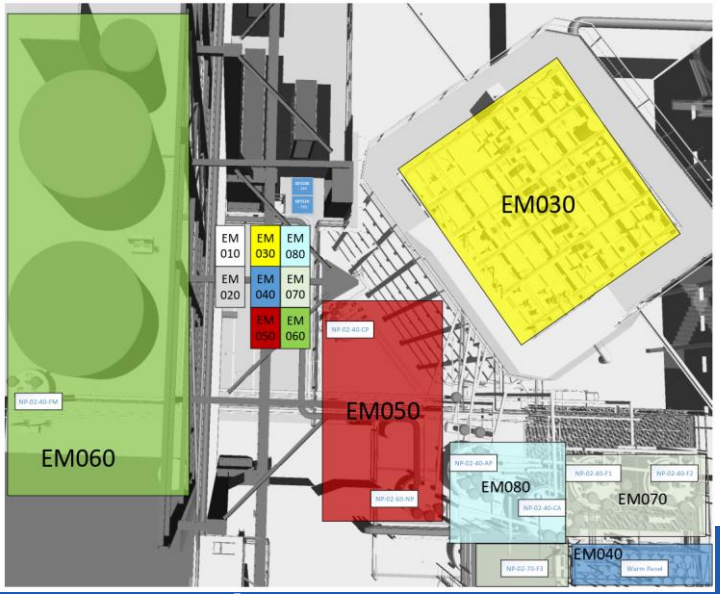
15 units of electrical cabinets design, constructed, installed...

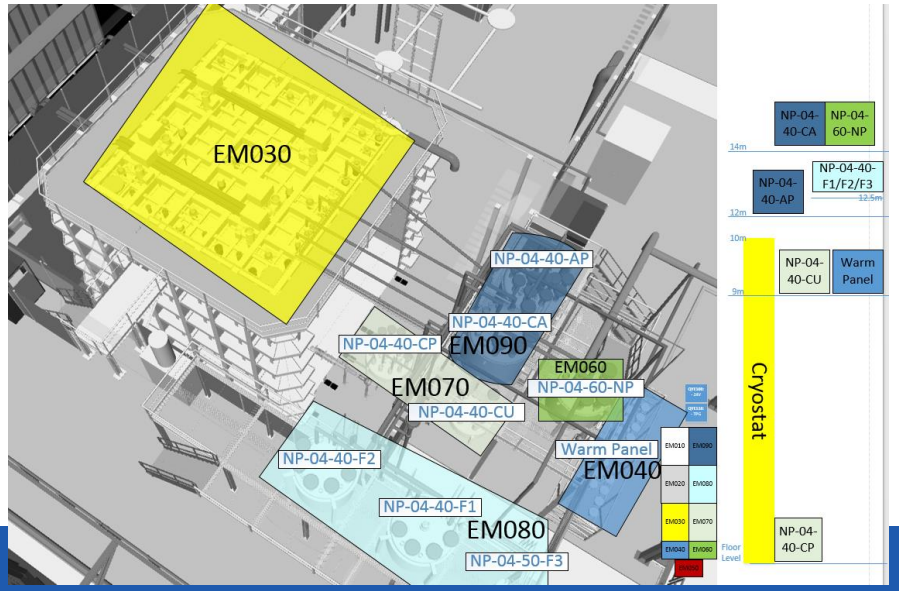


CERN Neutrino Platform NP02 & NP04

21 electrical cabinets/racks design, constructed, installed.







End