

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

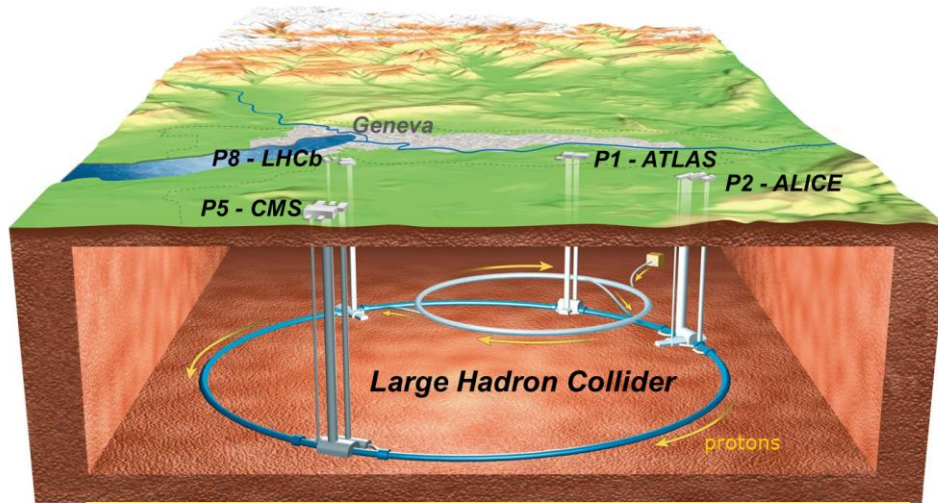
Introduction.

LHC cryogenic system and technology.

Cryogenic electrical control systems.

Supply of cryogenic electrical control cabinets manufacturing, assembly needs.

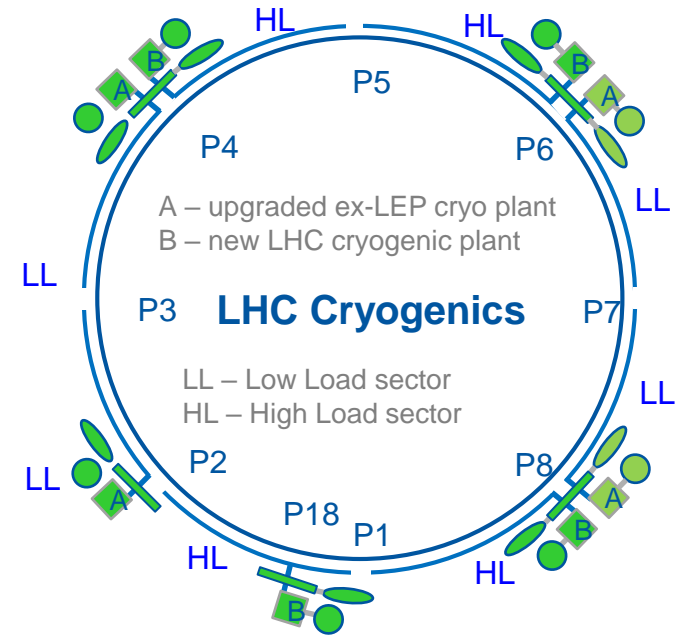
CERN LHC Cryogenic System



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

CERN LHC cryogenics:

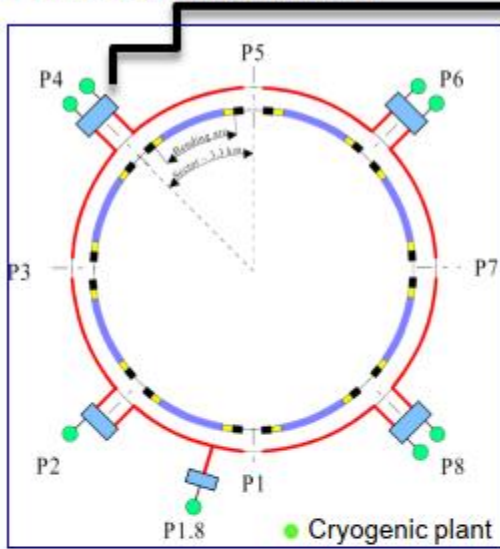
- 1800 sc magnets
- 8 x 18 kW @ 4.5 K
- 8 & 20 kW @ 1.8 K
- 130 tons of helium inventory



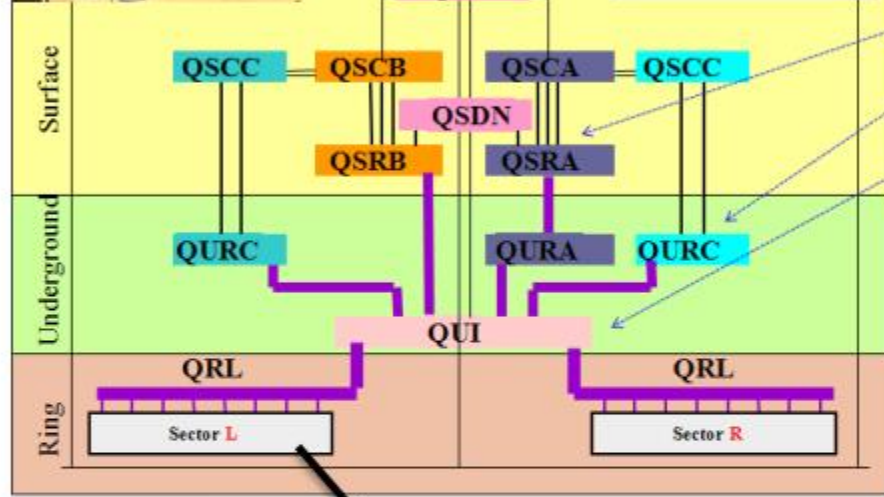
- Compressor station
- 4.5 K refrigerator
- ▬ Interconnection box
- ◌ 1.8 K pumping unit (cold compressor)

CERN LHC Cryogenic System

LHC cryogenics overview



Cryogenic point

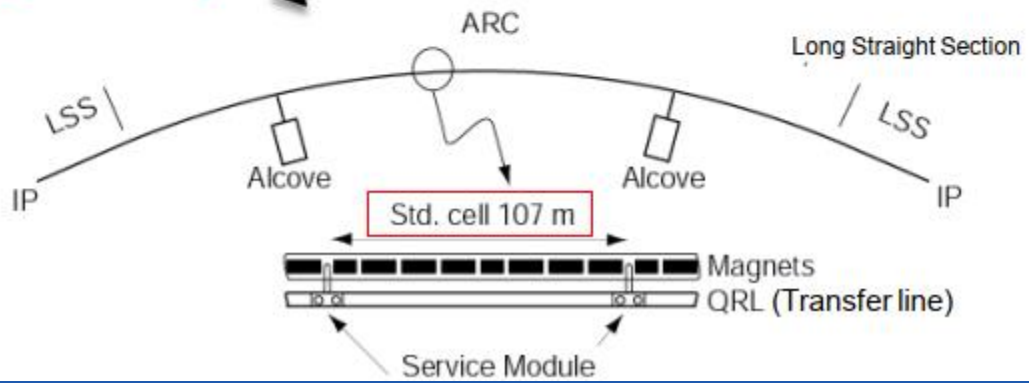


- Helium storage
- 4.5K Refrigerator
- 1.8K Units
- Interconnecting box

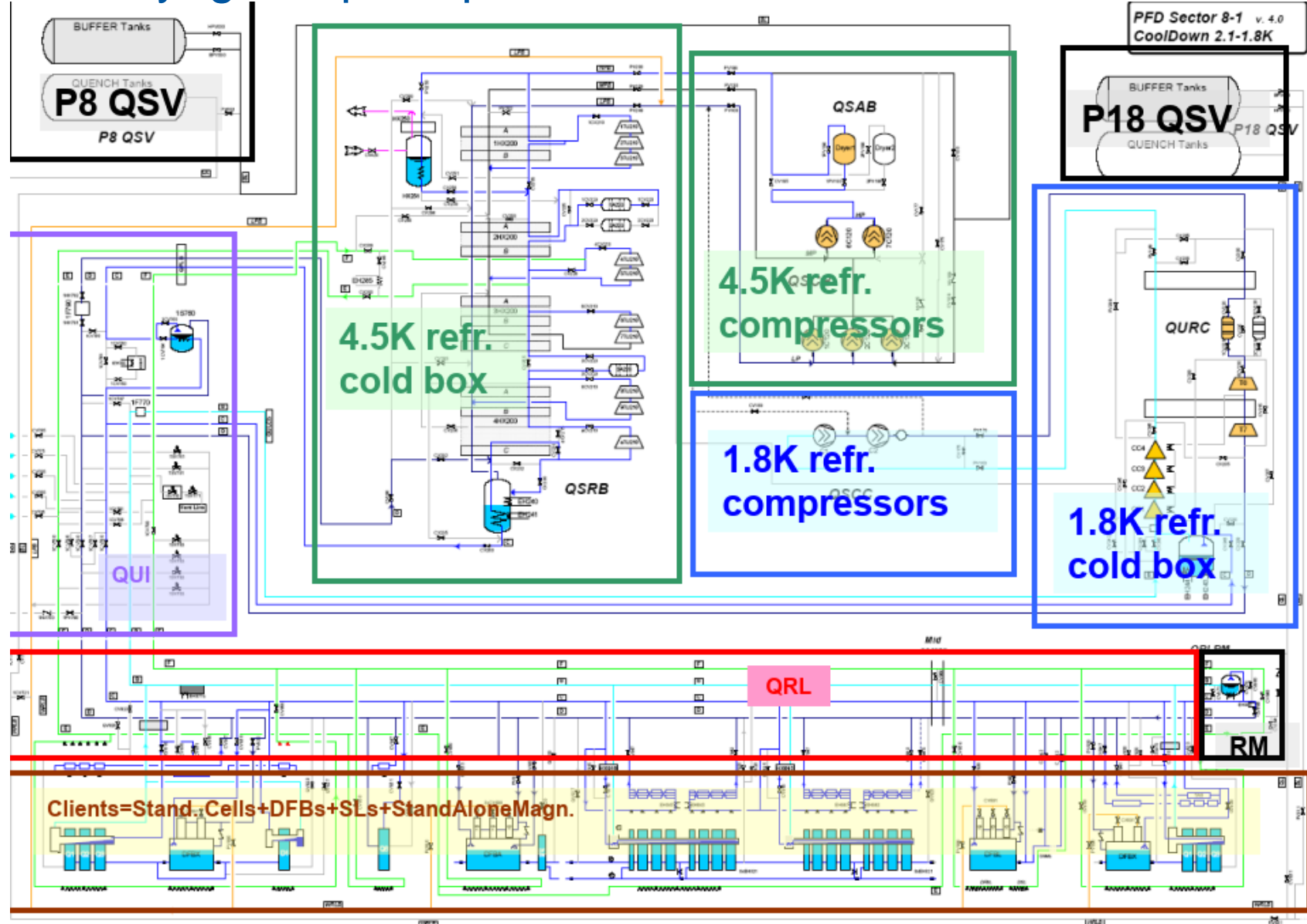


LHC tunnel (27 km)

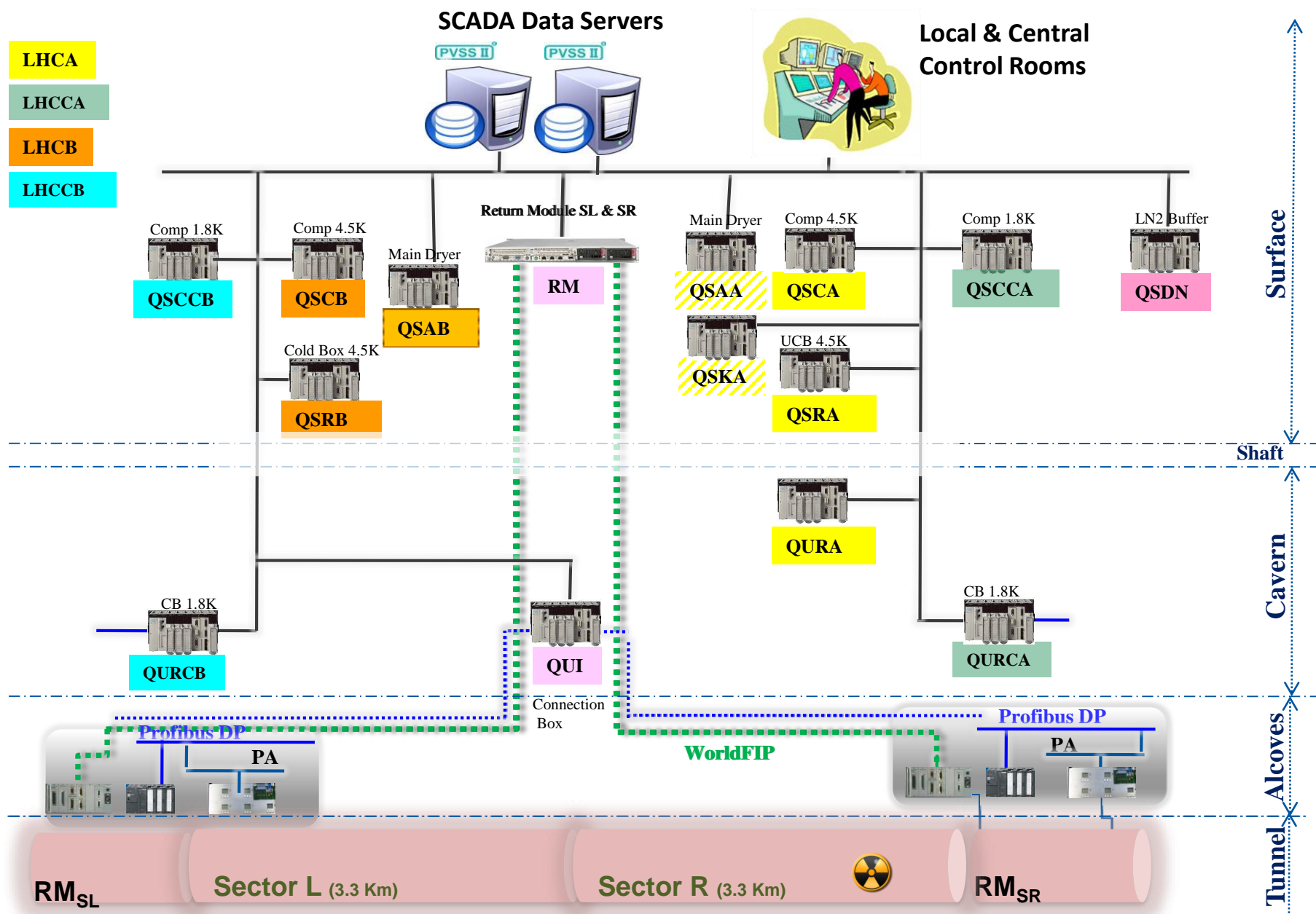
3.3 km



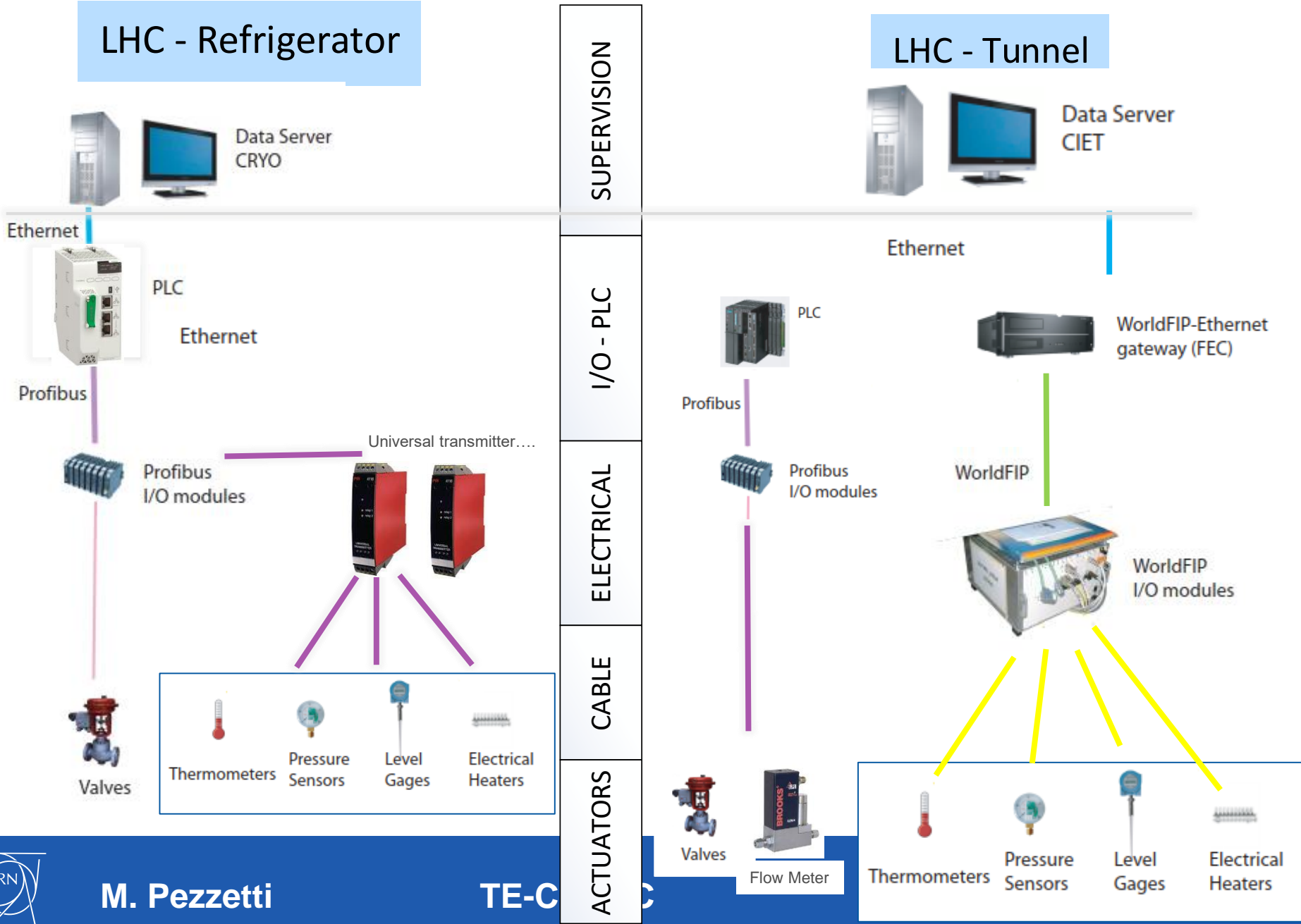
LHC Cryogenic plant process architecture



LHC Cryogenics Control System Refrigerators Architecture (Px)

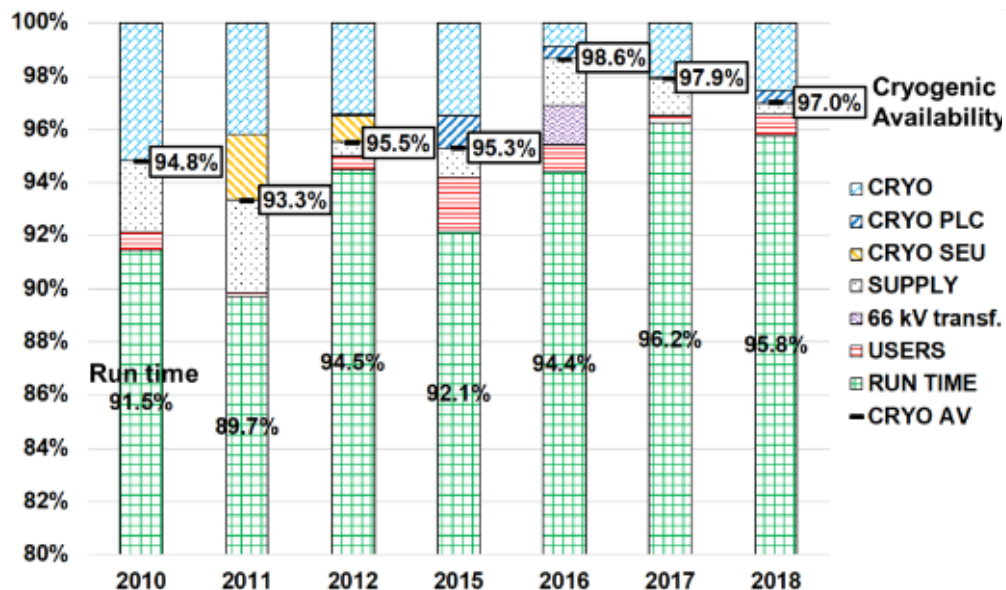


Cryogenic process control system typical architecture

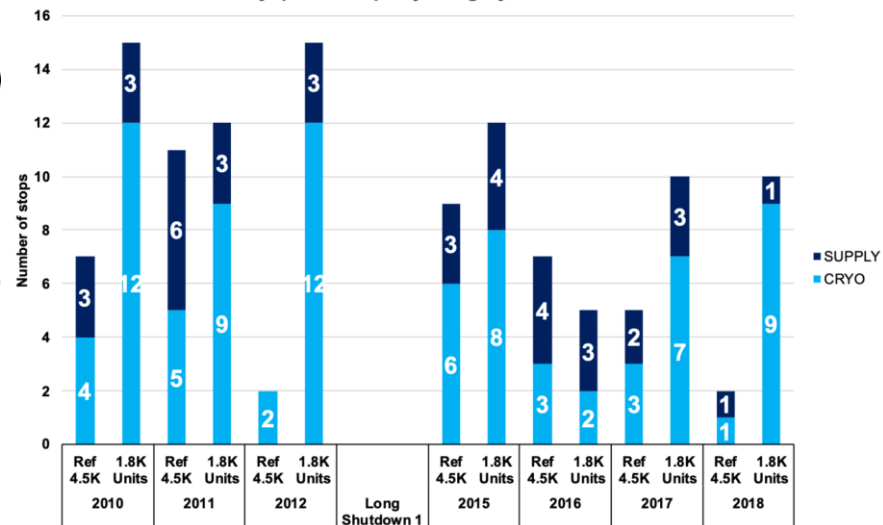


LHC cryogenic availability Run1 & Run2

LHC CRYO AVAILABILITY SUMMARY FROM RUN 1 TO RUN 2



LHC Cryoplants Stops by category, from RUN1 to RUN2

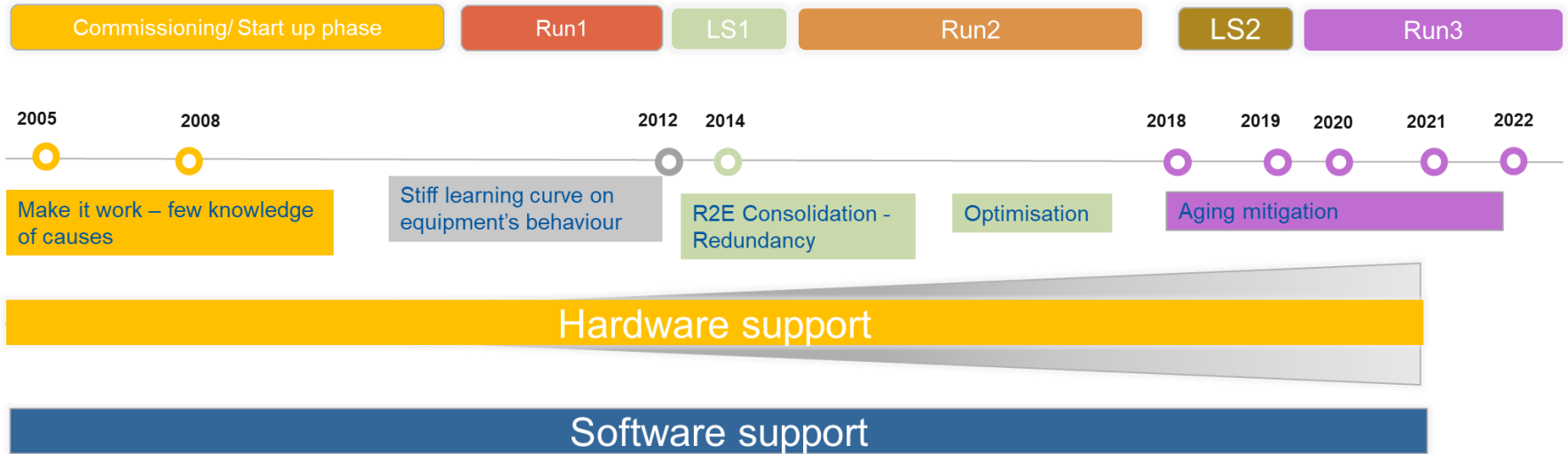


LS consolidation activities!

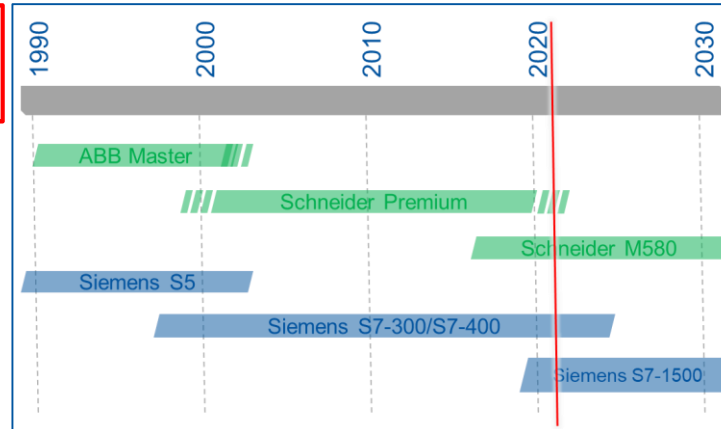
CRYOGENICS EXPERIENCE DURING RUN2 AND IMPACT OF LS2 ON NEXT RUN.

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!



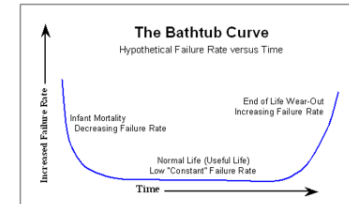
EDMS-1888489 “Cryo control LifeTime”
Control PLC “EoL” = 15/20y
Electrical cabinet “EoL”= 25y



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

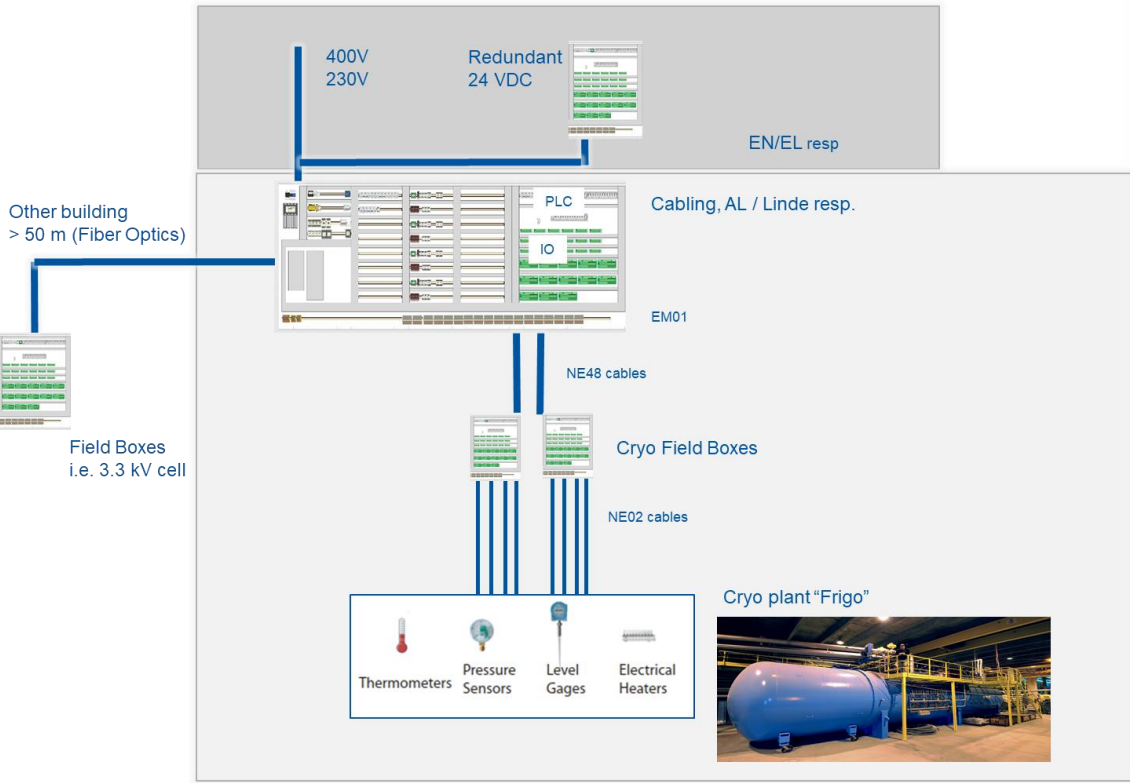


- Obsolescence – EoL replacement strategy in progress...;
- Degradation (cabling – electrical equipment);
- Safety (Local PLC, test de rotation, SIL1 push button);

Priority :
- P4
- P6
- P8
- P2*

Upgrade is an evolving process all along the LHC accelerator lifetime

CERN Methodology



Technical Specification
 European Organization for Nuclear Research
 Organisation européenne pour la recherche nucléaire
 EDM No. 1053824
 Group Code: TE-CRG
 DO-31724TE
 QSCA Consultation Project
Price Enquiry
Technical Sp Assembly and Cabling of P
Abstract
 This technical specification concerns 6 series of low tension control cabinets (stations) (QSCA). All the equipment and components with consumable material as listed in § 2.2.3). The delivery of the pre-series cabinet is in notification of the contract, while the rest are delivered in three phases: one batch acceptance of the pre-series, the rest acceptance of the first batch and the third acceptance of the second batch.

Engineering/technical specification
Construction specification of the electrical cabinet TE-CRG-CE
Introduction
 This document has for objective first to standardize the electric installations of the cryogenic equipment of the CERN, in their drawing aspect "Control and Electricity". This standardization must be realized in every part of a project as well as in the phases of realization, operation, improvement.
 This document is also a guide and help to the construction and any equipment cannot be developed or modified without its total respect.

Project details

Methods & procedures

Wiring diagrams & material list

Reception check list

Inspection/Specification Technique
Dossier de validation de la construction des équipements électriques TE-CRG-CE

Reception check list

Cryogenic electrical system

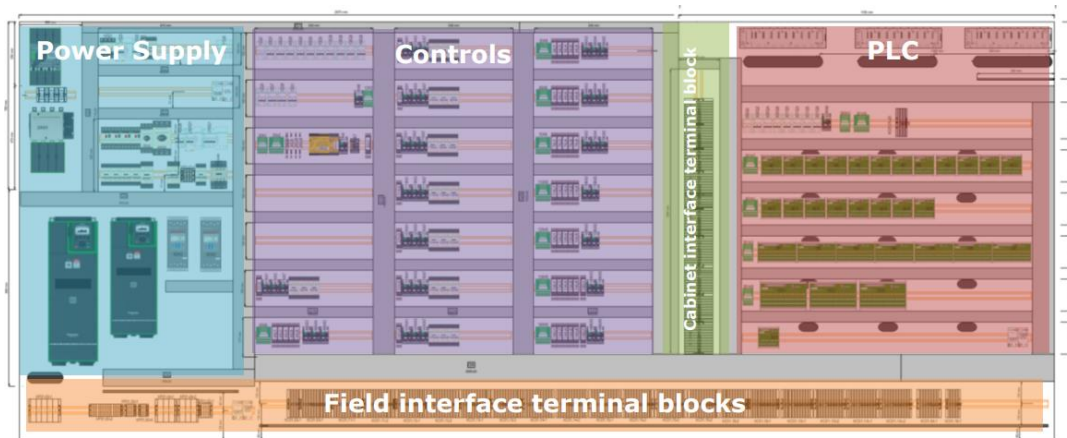
Global review of all **electrical** Specification and Standard

“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.



EDMS NO.	REV.	VALIDITY
1970931	2.0	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

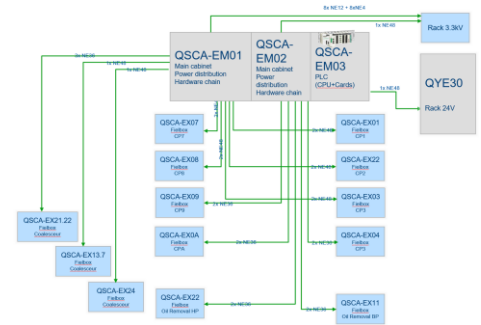
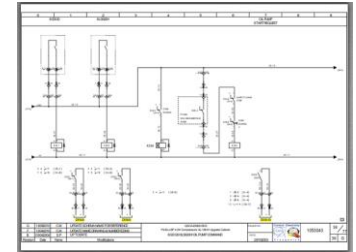
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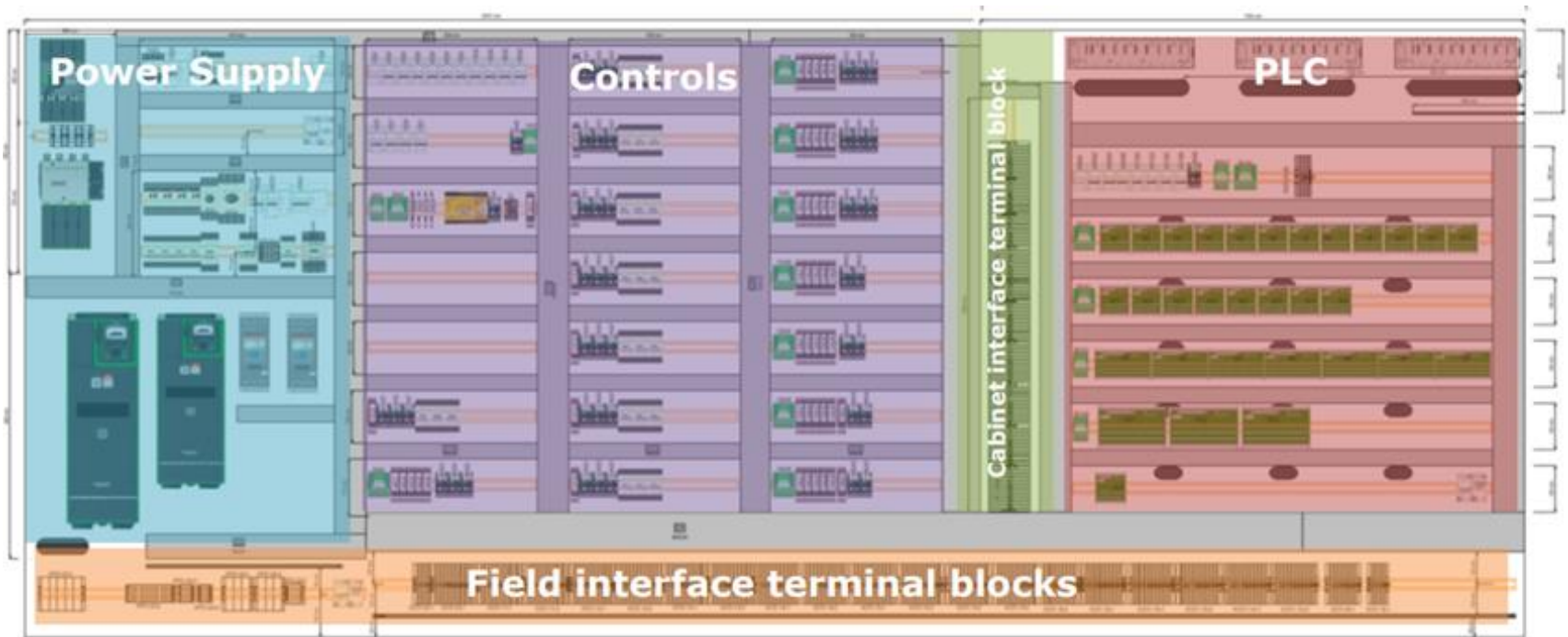


Supply of cryogenic electrical control cabinets manufacturing, assembly.

- ➔ 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

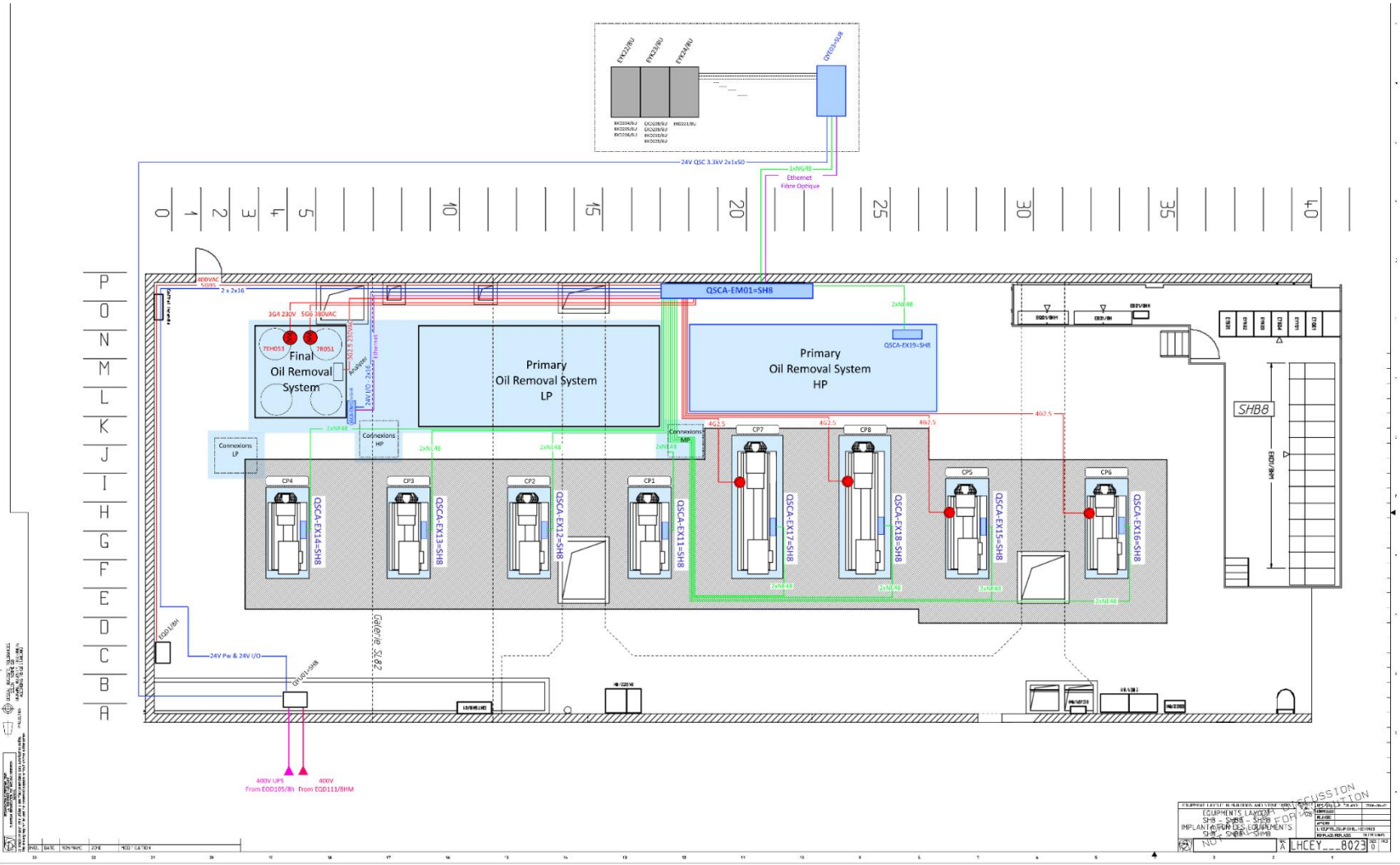


Case 1: consolidation activity example

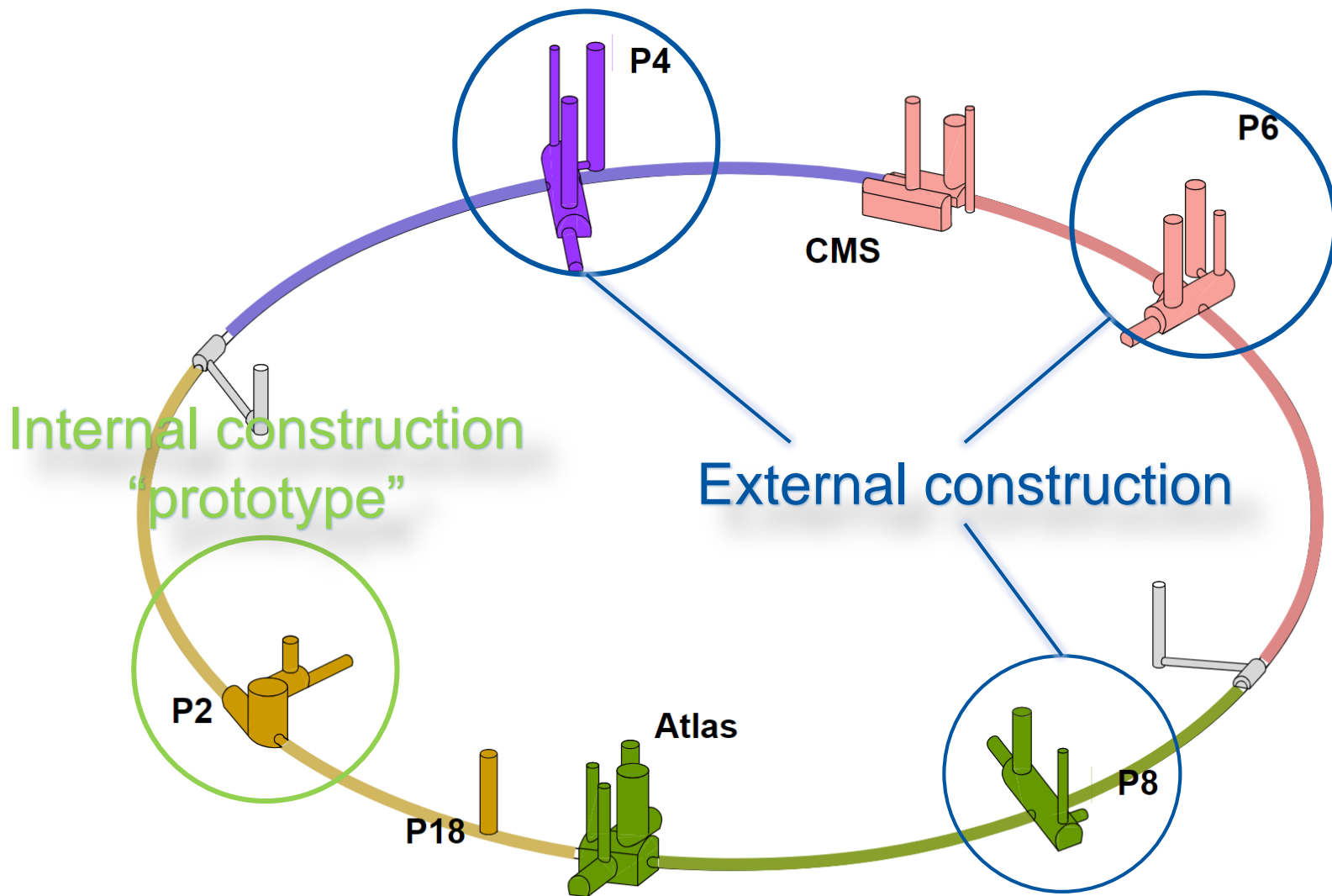
CERN LHC cryogenic : warm helium compressor set



Onsite Implantation:



Cryogenic Electrical Cabinets construction strategy



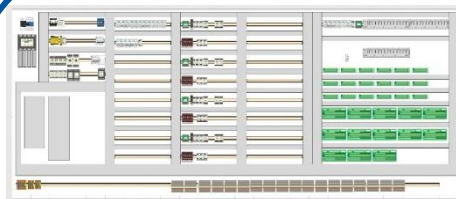
Cryogenic Electrical Cabinets construction strategy



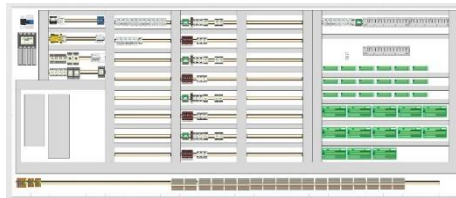
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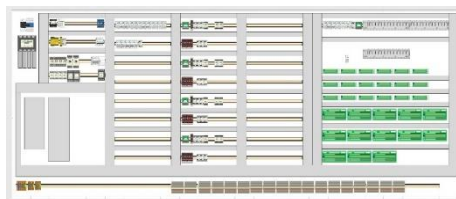
Internal material procurement
Internal construction



+



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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 distribution for P4 in the change and test! Pump panels to be cabled and test,
 Soft starter for new oil pumps to be done Week 3!

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 04-22 week
 → Soft starter for new oil pumps to be done Week 3

P6 (8 weeks)

→ Cabinet ready @ CERN
 Onsite work scheduled for week 5

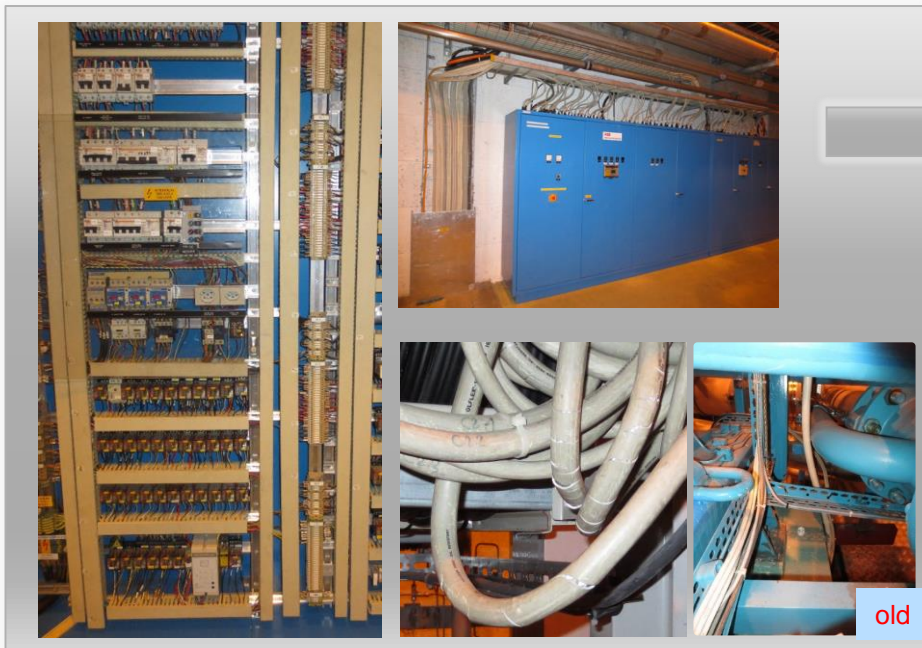
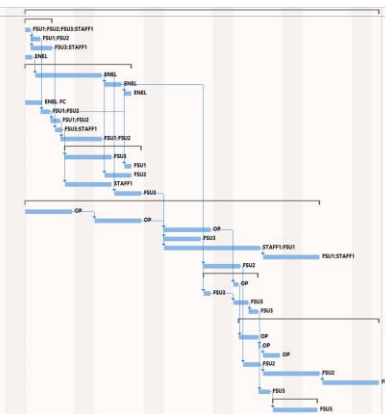
Commissioning

Hardware safety and protection chain tests
 Synchro tests
 Interlock tests
 Commissioning

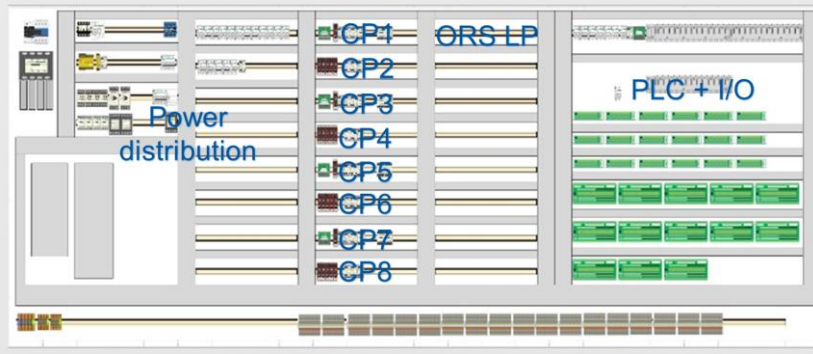
→ P4 Early in April
 → P8 Middle of April
 → P6 Early in May
 → P2 Early in July



CDCA Point 2	2019	Mon 13.06.19	Mon 17.06.19	
Séminaire	28 Juil	Mon 13.06.19	Mon 17.06.19	PSU1/PSU2/PSU1/STAFF1
Mise au service des équipements - Installation de l'équipement	47 Juil	Mer 22.06.19	Mer 26.06.19	PSU1/PSU2
Démontage des Armoires - Célébration des Equipements	8 Juil	Mer 13.06.19	Tue 14.05.19	PSU1/STAFF1
Démontage Coffret - Démontage des instruments	28 Juil	Mer 13.06.19	Wed 13.06.19	PSU1/STAFF1
Démontage montage des câbles de liaison et puissance (NID-430-3)	40 Juil	Mer 13.06.19	Mer 13.06.19	ENEL
Réception	72 Juil	Mer 13.06.19	Thu 20.06.19	
Tirage et montage des câbles de liaison 33kV (NID)	40 Juil	Mer 13.06.19	Mer 20.06.19	ENEL
Tirage des câbles de puissance	14 Juil	Thu 21.06.19	Wed 22.06.19	ENEL
Tirage de câbles NID-430-3 (NID) et ODESS	8 Juil	Thu 21.06.19	Thu 21.06.19	ENEL
Tirage Fibre Optique (NID-430-3)	14 Juil	Mer 13.06.19	Tue 14.05.19	ENEL-PC
Mise en place nouvelle armoire ENEL	8 Juil	Thu 14.05.19	Wed 13.06.19	PSU1/PSU2
Mise en place nouvelle armoire ENEL	8 Juil	Mer 13.06.19	Thu 14.05.19	PSU1/PSU2
Mise en place nouvelle armoire ODESS	8 Juil	Thu 14.05.19	Thu 14.05.19	PSU1/STAFF1
Mise en place 3 transformateurs coffrets	20 Juil	Thu 14.05.19	Mer 20.06.19	PSU1/PSU2
Raccourcement armatures	48 Juil	Mer 13.06.19	Mer 13.06.19	PSU1
Raccourcement des 3 NED - 3 NED - 3 Coffret Cellules 3.3kV	14 Juil	Mer 13.06.19	Thu 14.05.19	PSU1
Raccourcement Armature Protection PULSANCE	8 Juil	Thu 21.06.19	Thu 21.06.19	PSU1/PSU2
Raccourcement Armature Protection ODESS/ENEL	24 Juil	Thu 21.06.19	Thu 21.06.19	PSU1/PSU2
Raccourcement Armature ENEL (200 câbles M2)	14 Juil	Mer 13.06.19	Tue 13.06.19	STAFF1/PSU1
Raccourcement NID des coffrets (CP-HP)	14 Juil	Wed 22.06.19	Mer 22.06.19	STAFF1/PSU1
New Air M2 CP	17 Juil	Mer 13.06.19	Thu 14.06.19	CP
Pose nouvelle structure sur les 3 NED CP	40 Juil	Mer 13.06.19	Mer 13.06.19	CP
Pose nouvelle Tag	40 Juil	Mer 27.06.19	Mer 27.06.19	CP
Pose Rack/MS M2 sur Encluse PE	22 Juil	Mer 27.06.19	Thu 28.06.19	PSU1
Installation nouveau chemin de câbles de liaison CP	14 Juil	Mer 27.06.19	Thu 28.06.19	STAFF1/PSU1
Tirage et montage des câbles M2 (200 câbles CP (NED))	14 Juil	Mer 27.06.19	Wed 06.06.19	STAFF1/PSU1
Raccourcement des 3 NED compresseur (3 Câbles)	14 Juil	Mer 27.06.19	Tue 13.06.19	PSU1/STAFF1
Raccourcement puissance pompes + coffrets	14 Juil	Mer 27.06.19	Mer 27.06.19	STAFF1/PSU1
New MS2 HP	8 Juil	Mer 13.06.19	Wed 06.06.19	CP
Pose Rack/MS M2 sur Encluse PE	8 Juil	Mer 13.06.19	Mer 13.06.19	CP
Installation nouveau chemin de câbles MS2 HP	8 Juil	Mer 13.06.19	Mer 13.06.19	PSU1
Tirage des câbles HP	22 Juil	Mer 27.06.19	Tue 14.06.19	PSU1
Raccourcement Coffret (300 câbles)	8 Juil	Tue 04.06.19	Wed 05.06.19	PSU1
Installation nouveau chemin des câbles CP/Encluse + Commission ODESS/HP	8 Juil	Mer 13.06.19	Mon 17.06.19	
Pose nouvelle structure sur HP HP-CP Compresseur Puit	14 Juil	Mer 27.06.19	Wed 05.06.19	CP
Pose Rack/MS M2 sur Encluse PE	8 Juil	Wed 05.06.19	Wed 05.06.19	CP
Pose nouvelle Tag	14 Juil	Mer 27.06.19	Mer 27.06.19	CP
Installation nouveau chemin des câbles ODESS + Compresseur + Puit	14 Juil	Mer 27.06.19	Mer 27.06.19	PSU1
Tirage des câbles MS2/HP + Commission MS2/HP	12 Juil	Thu 06.06.19	Tue 11.06.19	PSU1
Tirage des câbles ODESS + Analyseur de Puissance	12 Juil	Mer 27.06.19	Mer 27.06.19	PSU1
Raccourcement Pulsance (200 câbles, Analyseur)	12 Juil	Mer 27.06.19	Thu 06.06.19	PSU1
PULSANCE	28 Juil	Mer 27.06.19	Tue 11.06.19	
Raccourcement Purgé	28 Juil	Mer 27.06.19	Tue 11.06.19	PSU1



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

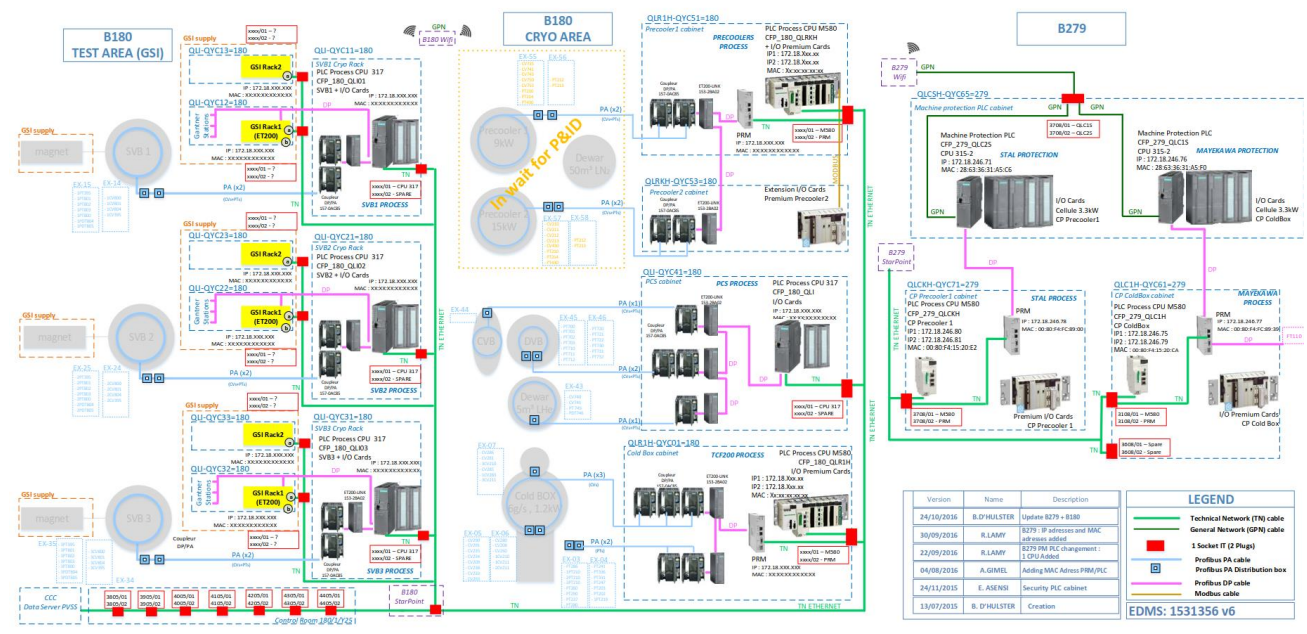


new

Case 2 : projects activities examples

CERN WAT cryogenic control

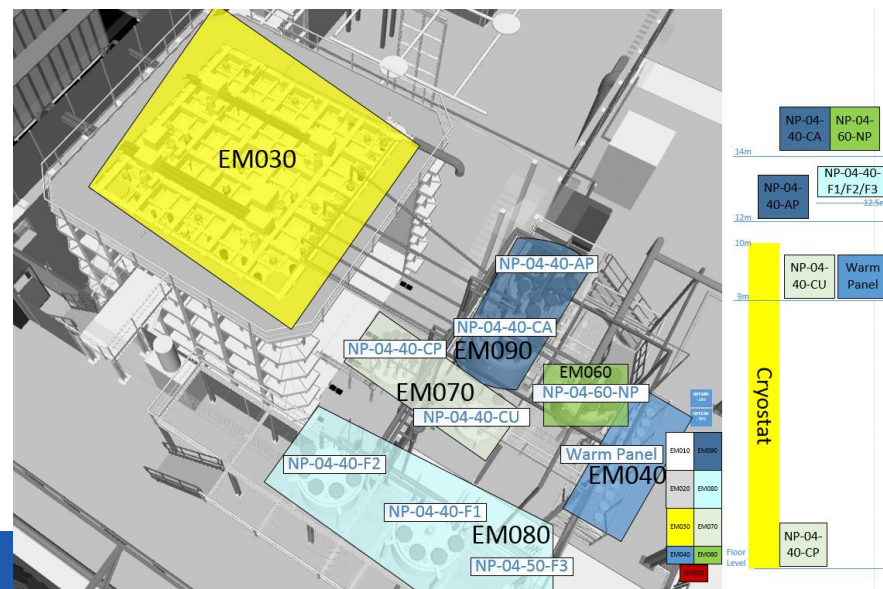
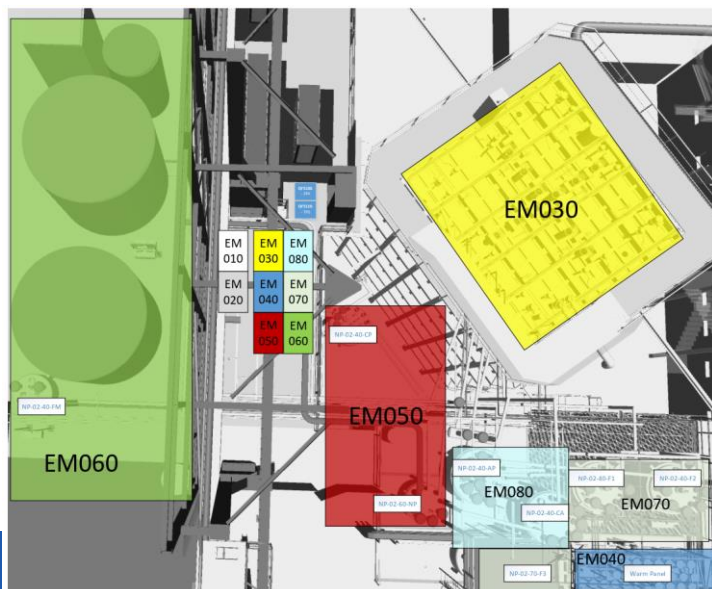
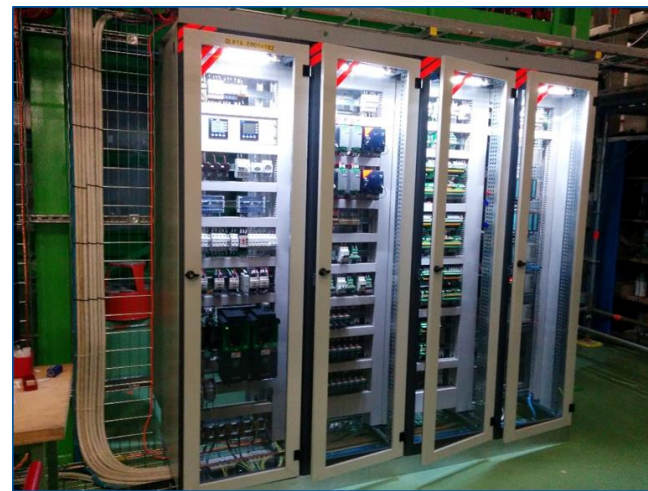
15 units of electrical cabinets design, constructed, installed...



2022

CERN Neutrino Platform NP02 & NP04

21 electrical cabinets/racks design, constructed, installed.



M. Pezzetti

TE-CRG-IC

2022

End

