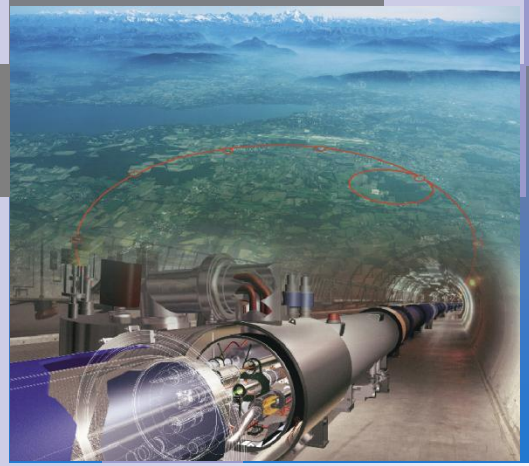


LHC Cryogenics Control

Enrique BLANCO

Industrial Controls Engineering Group

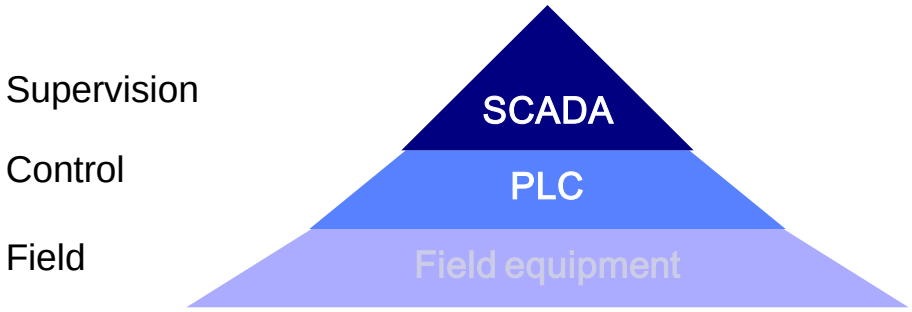
EN Engineering Department

Outline

1. Introduction
2. CERN
   1. Networking
   2. Controls Architecture
3. LHC Cryogenics
4. LHC Cryogenics Controls Architecture
   1. Production & Tunnel
   2. Communications view
   3. Frameworks: UNICOS & FESA
   4. Supervision: PVSS SCADA
   5. Interfaces: LHC Logging (long term archiving)
5. Shared responsibilities: EN/ICE – TE/CRG

1.- Introduction: Control systems

- Classical **industrial control systems** covers the three layers of the typical control pyramid



PVSS II by ETM

Schneider Electric

SIEMENS

  - ✓ The control layer may use not only PLCs but also special equipment like gateways (**FEC**s) running linux

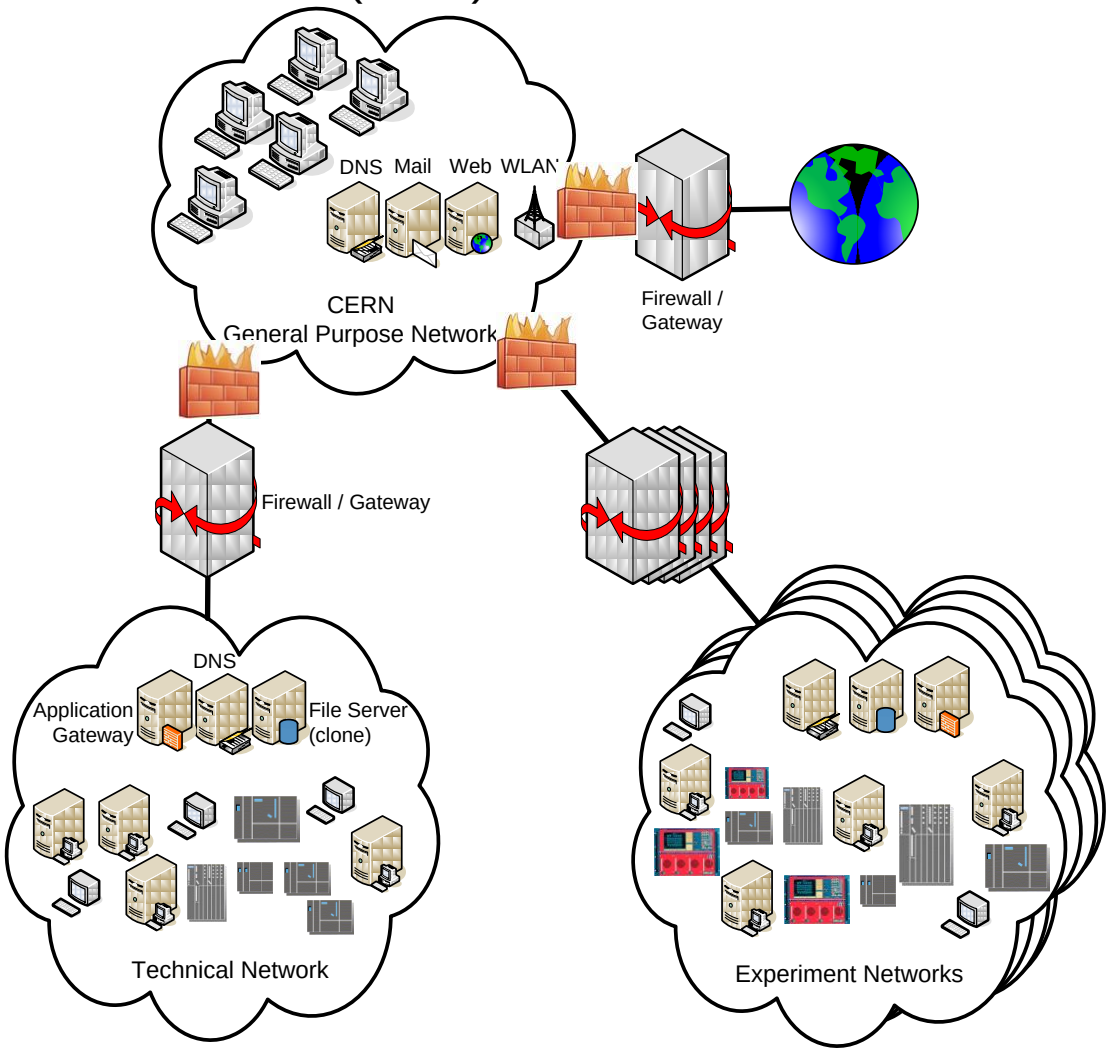
- **UNICOS** provides a **framework** and specialized **generation tools** to create automatically such industrial control systems both in the PLC and the SCADA.
  - ✓ Rapid startup of commissioning
  - ✓ Manual intervention is required for the control logic and HMI synoptics (process dependent)

- Talk goal: **To give the cryogenics operator an overview of the technologies and architectures deployed in the cryogenics control system**

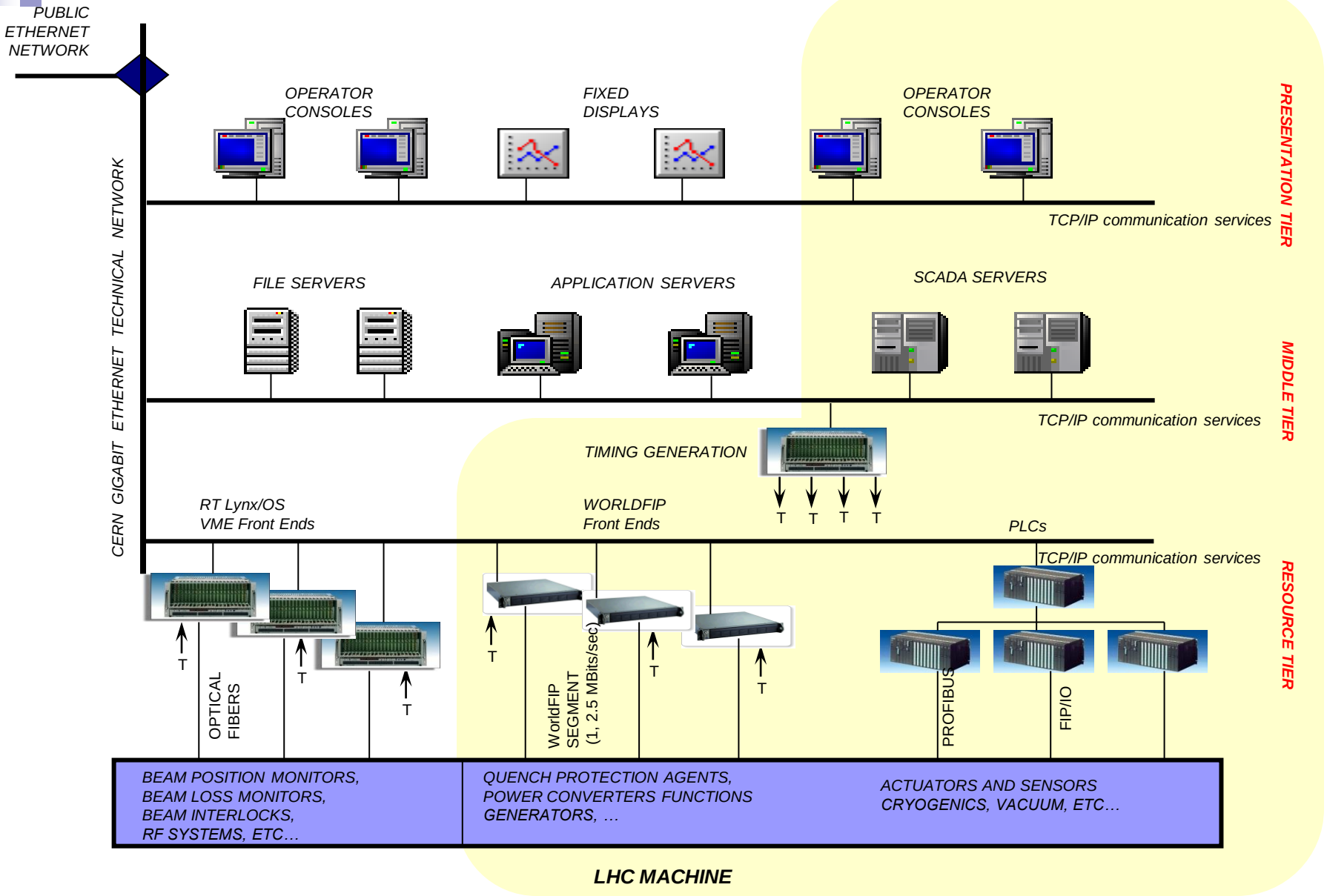
2.- CERN Architecture: networking

Desktop Computing (GPN) vs. Technical Network (TN)

Windows Terminal Servers (WTS)



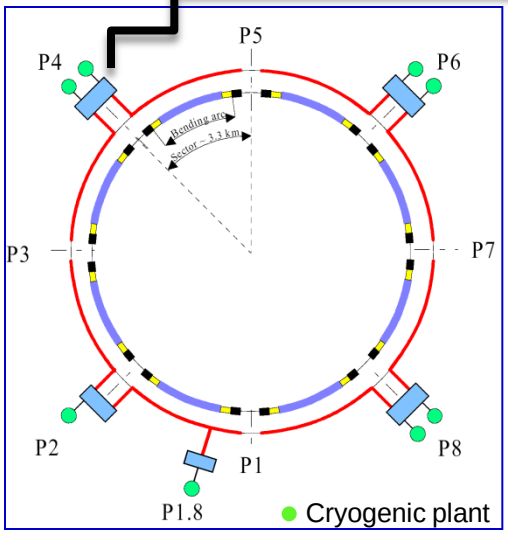
2.- CERN Architecture: Controls



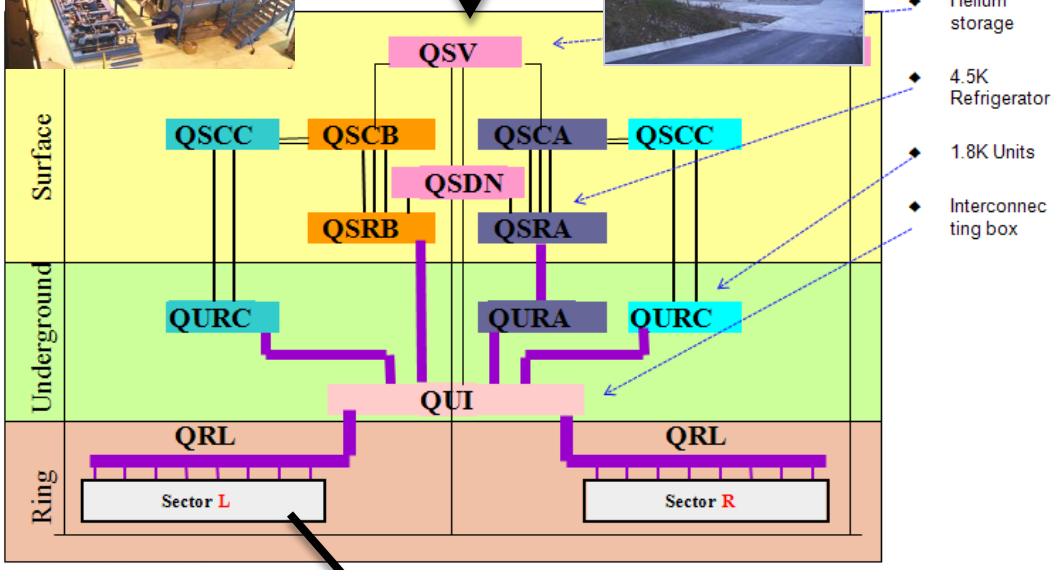
2.- LHC Cryogenics

Architecture

LHC cryogenics overview

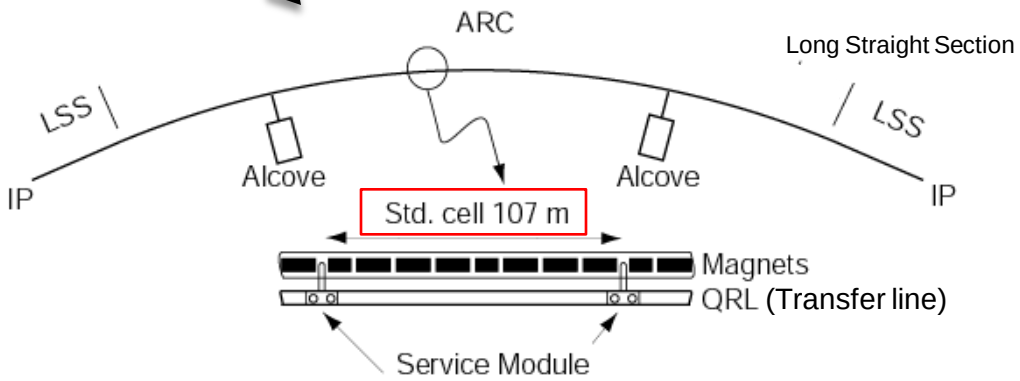


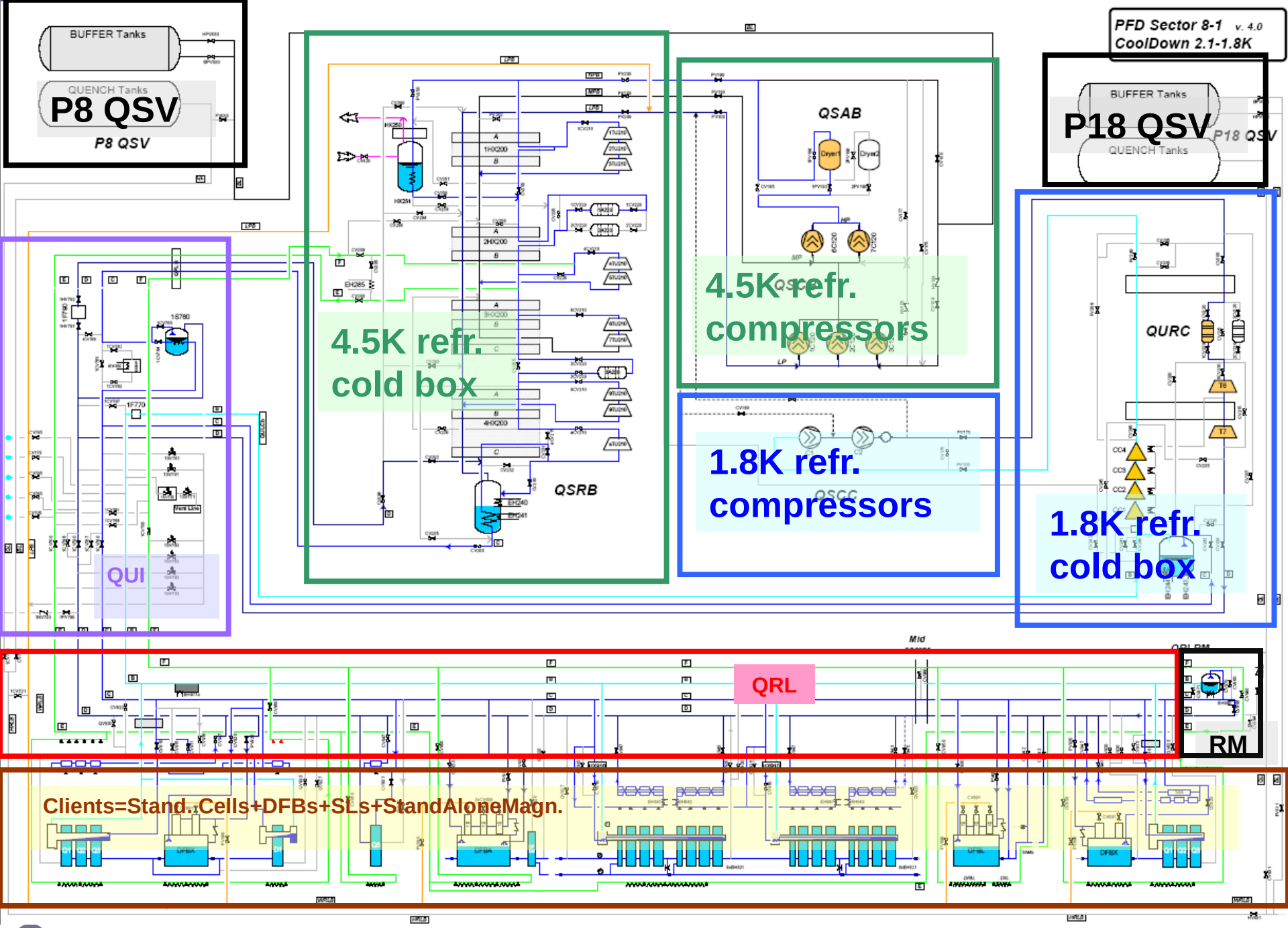
Cryogenic point



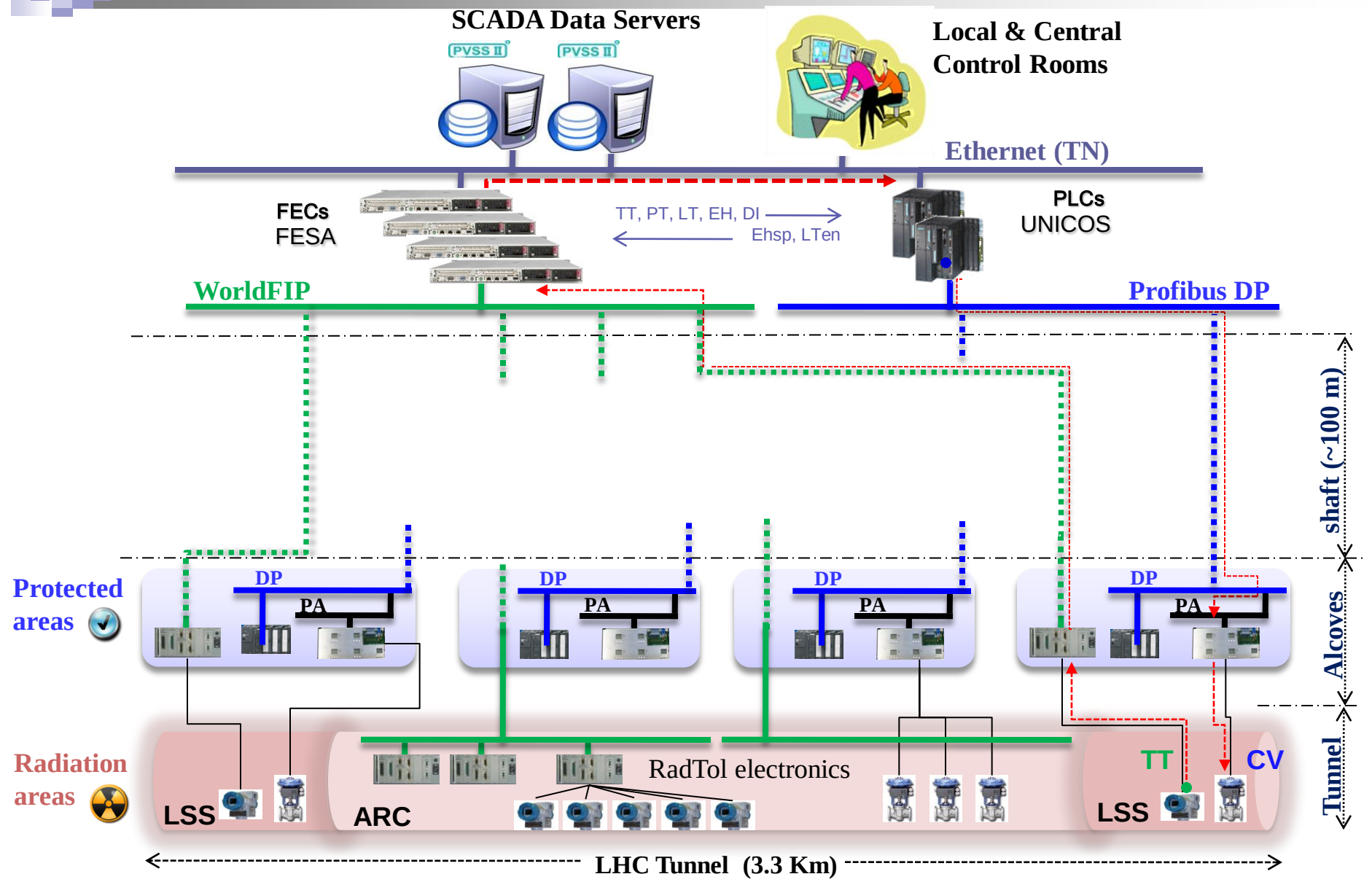
LHC tunnel (27 km)

3.3 km

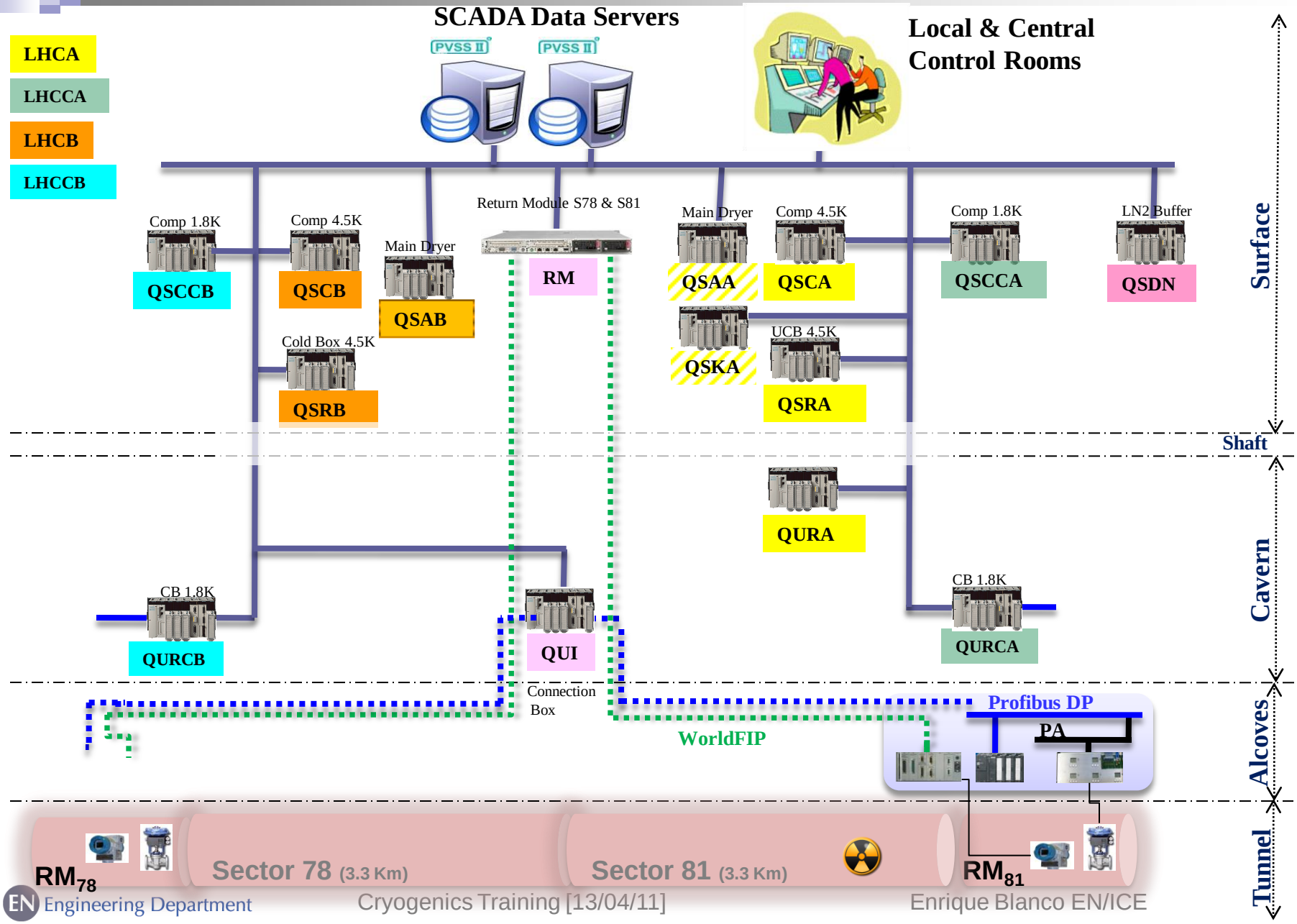



PFD Sector 8-1 v. 4.0
CoolDown 2.1-1.8K
BUFFER Tanks
QUENCH Tanks
P8 QSV
P8 QSV
BUFFER Tanks
P18 QSV
P18 QSV
QUENCH Tanks
QSAB
4.5K refr.
compressors
4.5K refr.
cold box
QSRB
1.8K refr.
compressors
QSCC
1.8K refr.
cold box
QURC
QUI
QRL
RM
Clients=Stand.Cells+DFBs+SLs+StandAloneMagn.

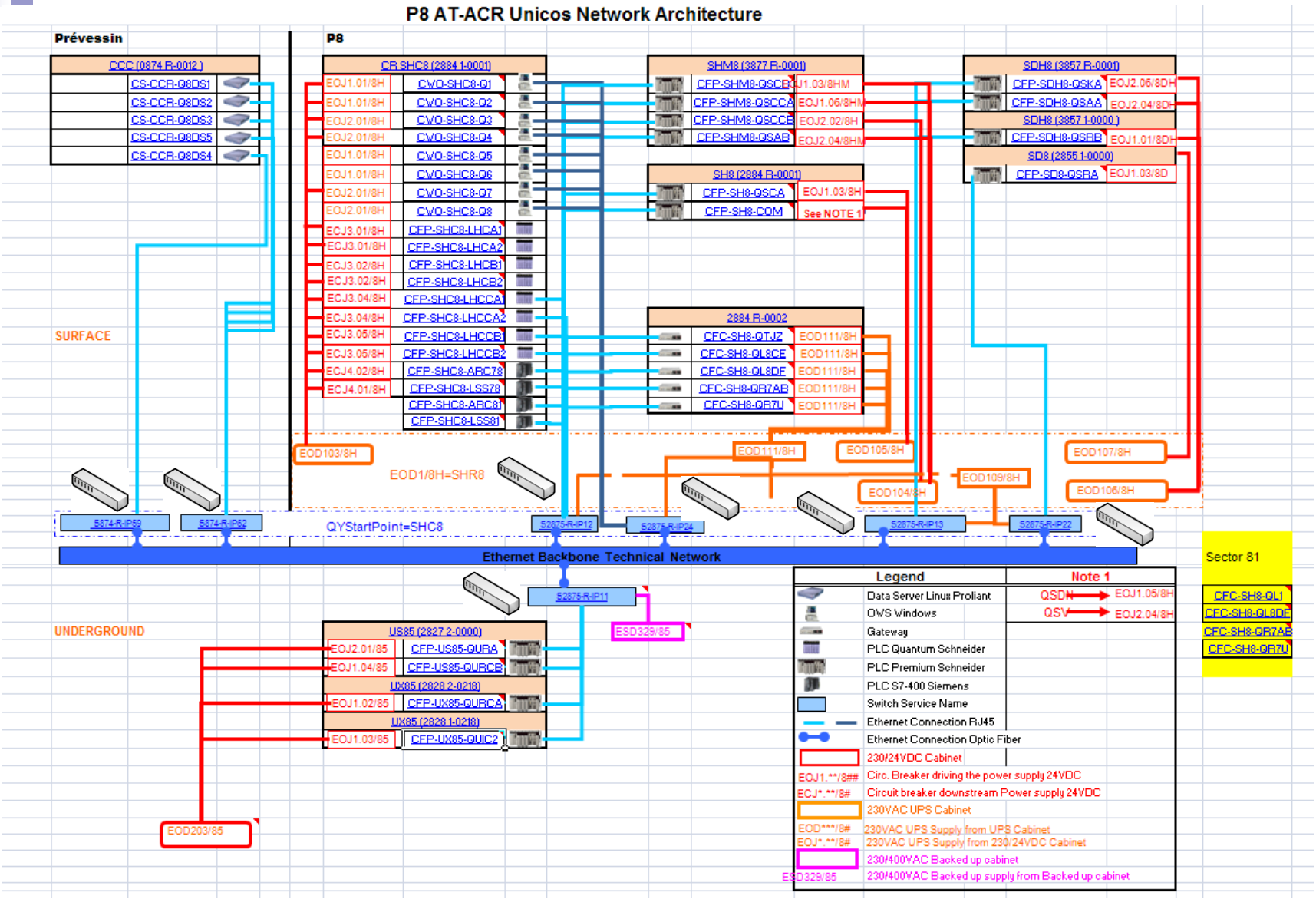
4.- Cryogenics Control System: Tunnel Architecture



4.- Cryogenics Control System: Refrigerators Architecture (P8)



4. Cryogenics Control System: Network components (P8)



4.- Cryogenics Control System: Industrial Communications

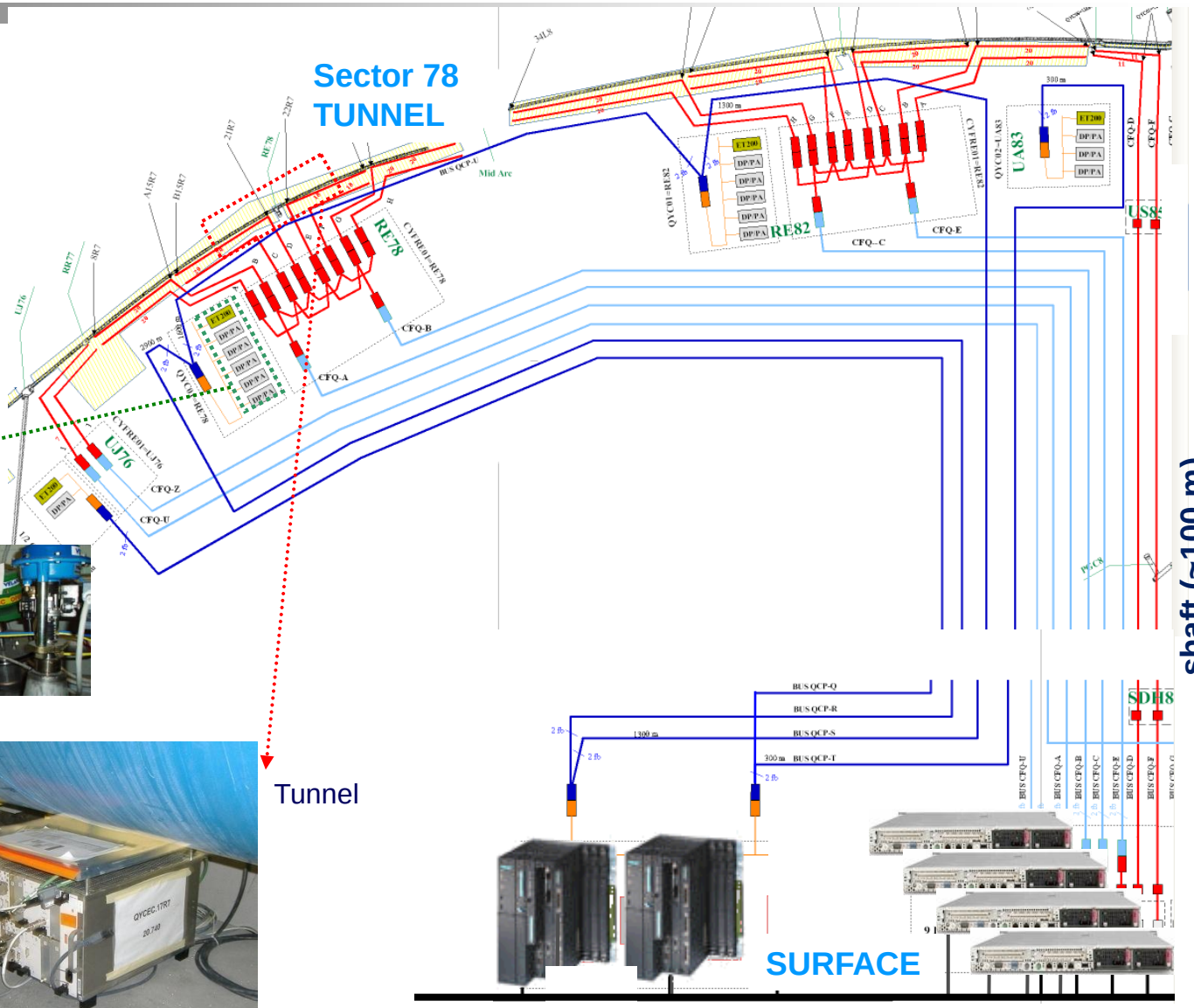
WorldFip Copper cable
WorldFip Fiber

Profibus DP Copper cable
Profibus Fiber

Ethernet UTP

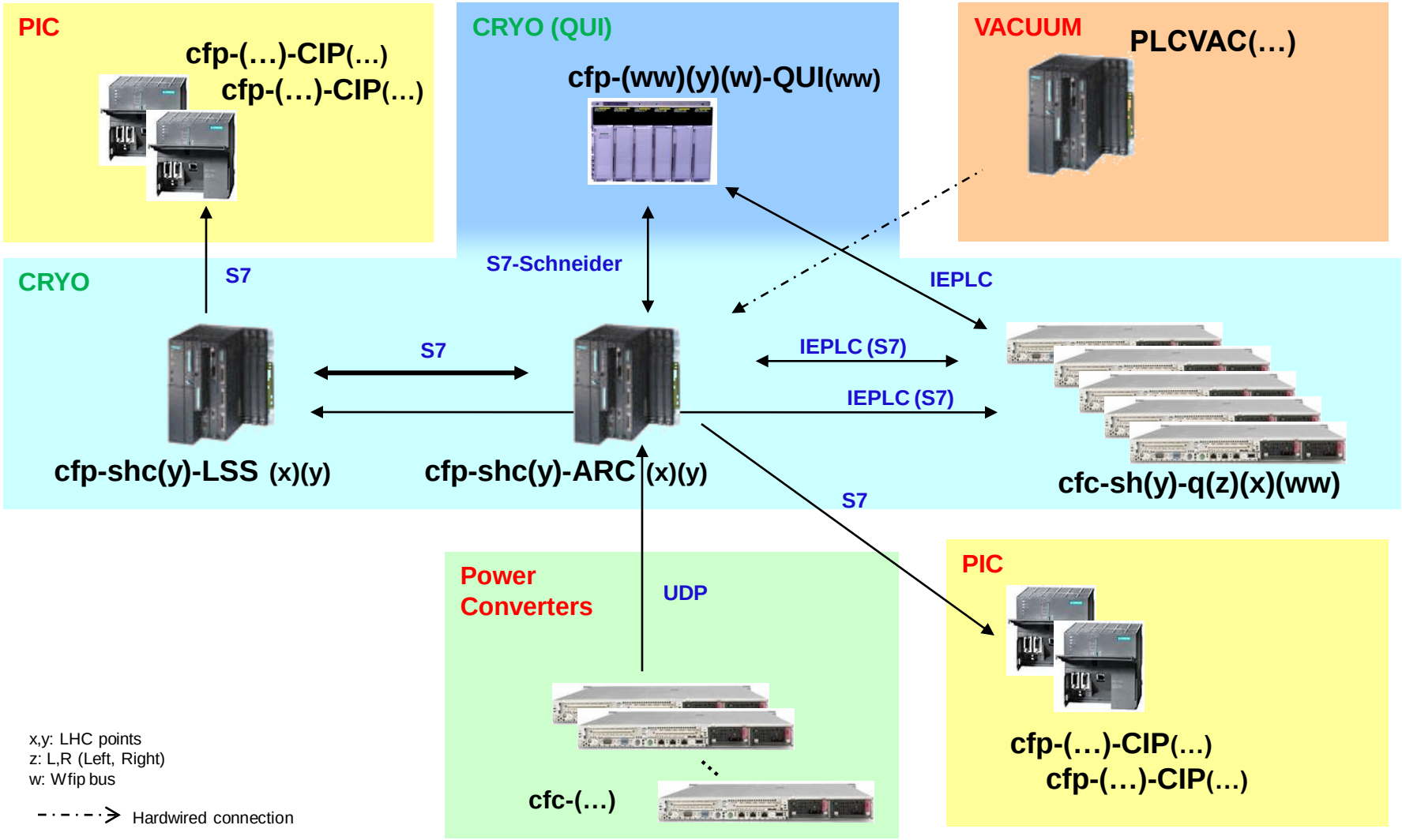
Alcoves

Tunnel

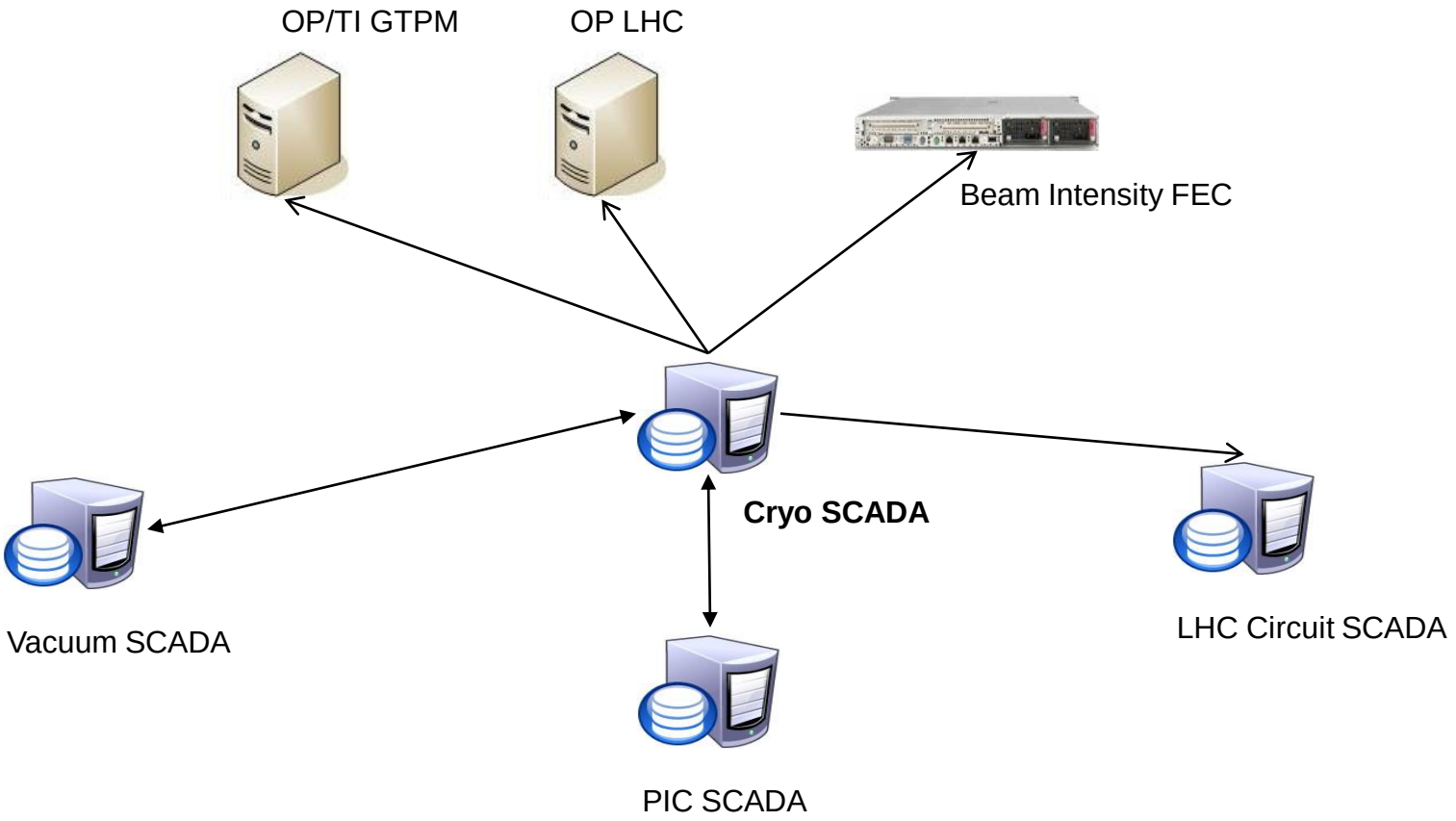


Ethernet: Protected technical network

4.- Cryogenics Control System: PLC tunnel communications



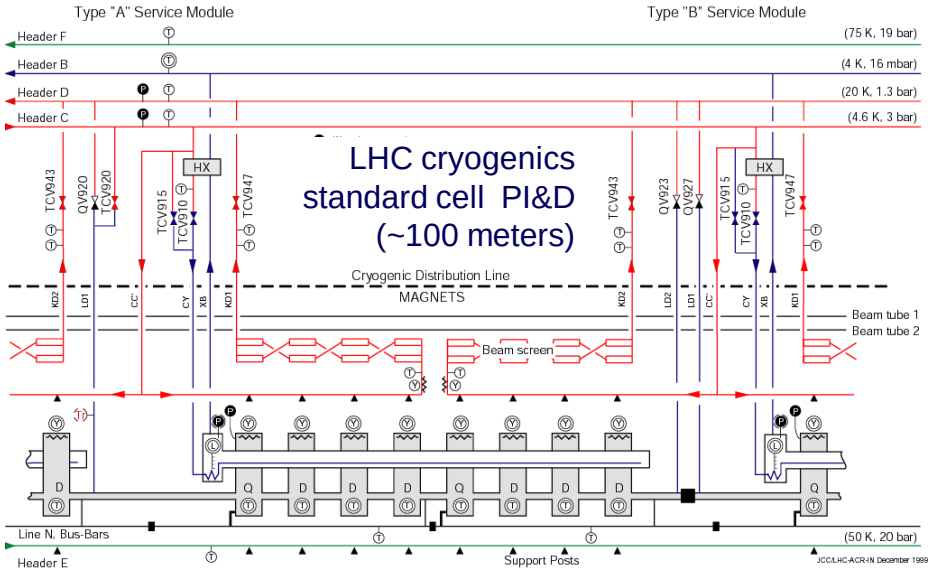
4.- Cryogenics Control System: SCADA communications



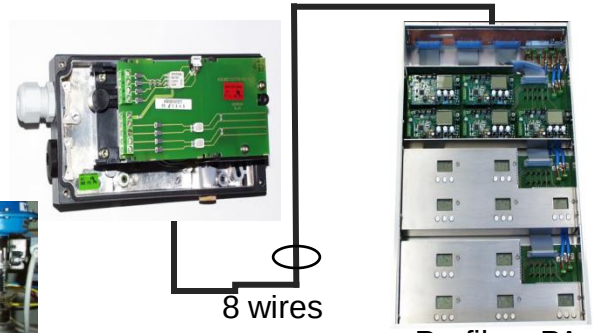
4.- Cryogenics Control System

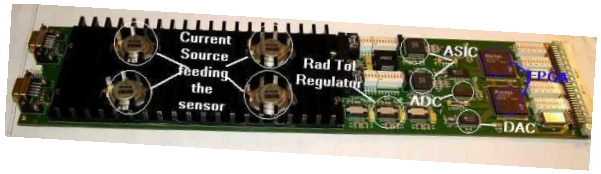
- Large number of sensors and actuators.

Instruments	Range	Total
TT (temperature)	1.6- 300K	9500
PT (pressure)	0-20 bar	2200
LT (level)	Various	540
EH (heaters)	Various	2500
CV (Control Valves)	0 - 100 %	3800
PV/QV (On Off Valves)	--	2000



- Tunnel instrumentation exposed to **radiation** (custom development to withstand the hostile environment)

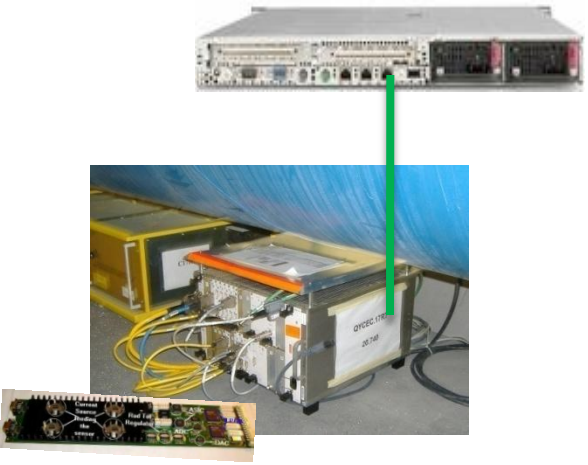


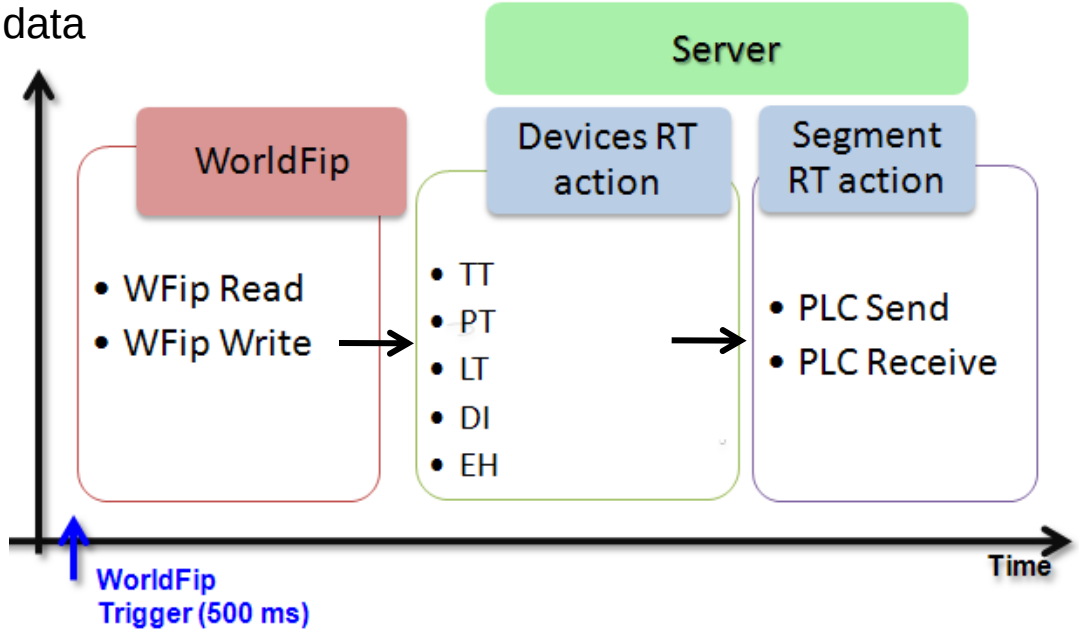


RadTol Signal Conditioners

4.- Cryogenics Control System: Frameworks FESA

- **F**ront-**E**nd **S**oftware **A**rchitecture*
  - ✓ CERN accelerator real-time software model
  - ✓ Deployed to **F**ront-**E**nd **C**omputers (**FEC**s) running Linux/LynxOS
- FEC processes
  - ✓ **WorldFip**: Read/Write Worldfip agents
  - ✓ **Real-Time** action
    - Device: Calculates devices data (Minimize electronics cards calculations)
    - Segment: Groups devices and communicates to the PLC
  - ✓ **Server:** CMW Exchange data





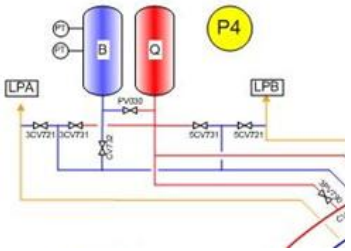
3.- Cryogenics Control System: Frameworks UNICOS

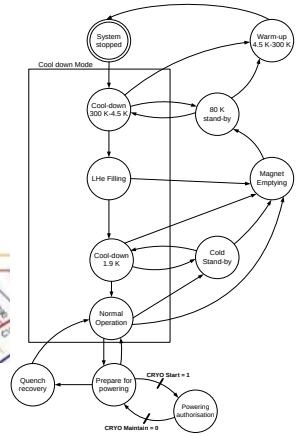
- **UN**ified **I**ndustrial **CO**ntrol **S**ystem

I/O Channels

Field Objects
(Valves, Heaters, …)

Process Control Objects
(Compressors, feedbox, …)





Specifications

UNICOS

PLC and SCADA Baseline

Generates PLC and SCADA Devices

Placeholders where the control engineer must write the process logic

Simplified HMI tool to create process synoptics (drag & drop)

Diagnostics tools

CMW interface
Long-Term archiving
LHC alarm system

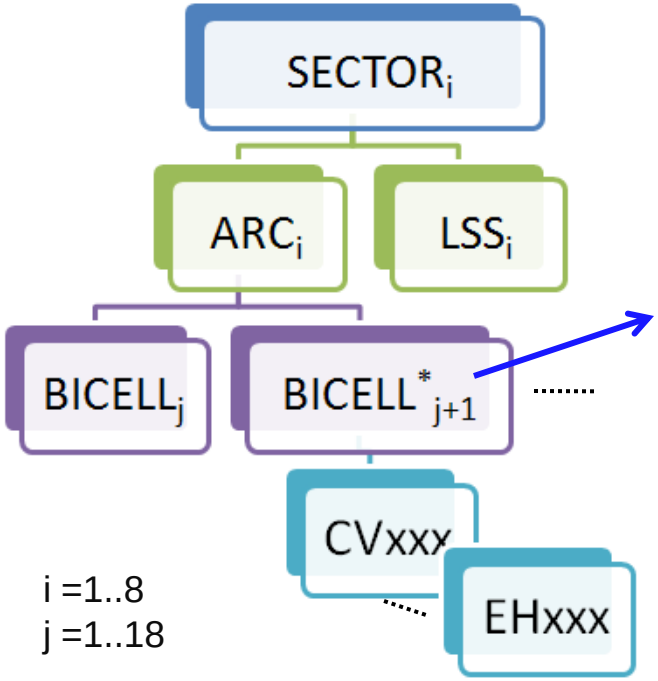
Operators

Process Engineer

Control Engineer

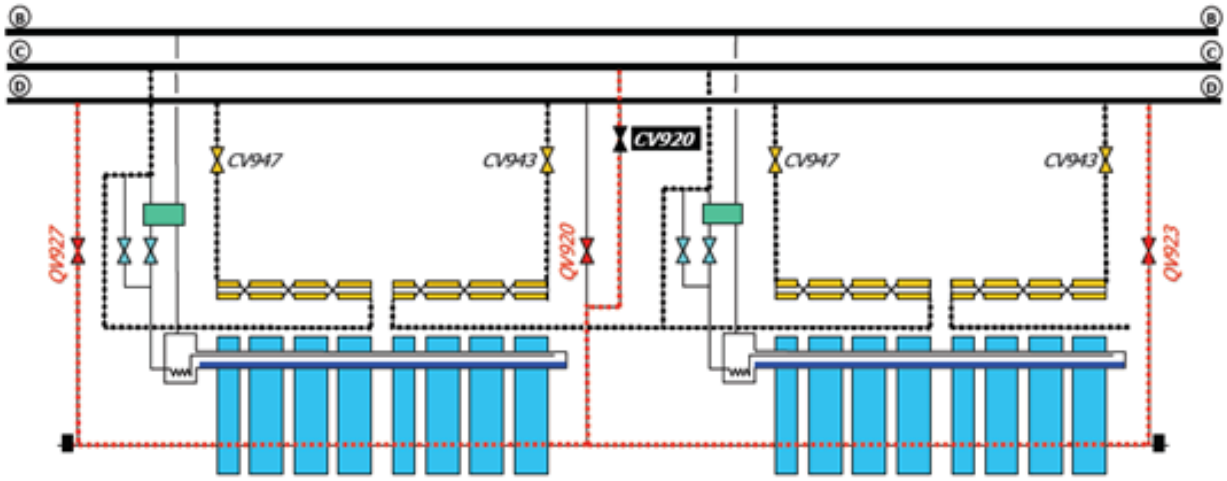
4.- Cryogenics Control System: i.e.: UNICOS Objects design

Sector Cryogenics Process Control Objects (PCO)



i =1..8
j =1..18

2 elementary cryogenics cells*



- **Process Decomposition** exercise (e.g.: Tunnel) :
  - Control a basic tunnel equipment (bi-cell)
  - Reduce the amount of logic to create by using a few templates which will be parameterized and generated automatically (e.g.: Controllers)

I/O objects + Controller (field objects)

Objects	Tunnel
Analog Inputs	12136
Analog Outputs	4856
Digital Inputs	4536
Digital Outputs	1568
Close Loop Controllers	3680

Process Decomposition: Controllers example

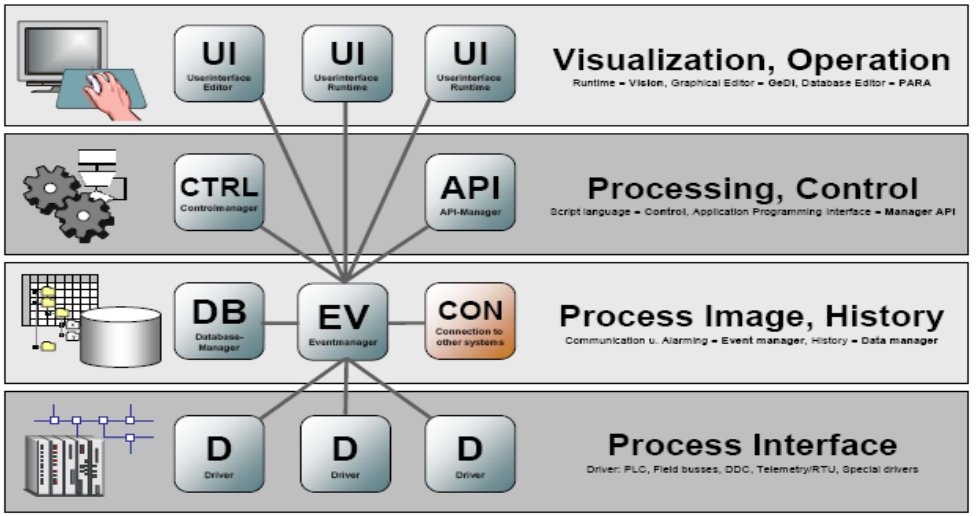
LHC	Sector	Arc	Bi-cell
3680	500	250	20

4 Cryogenics Control System: SCADA PVSS

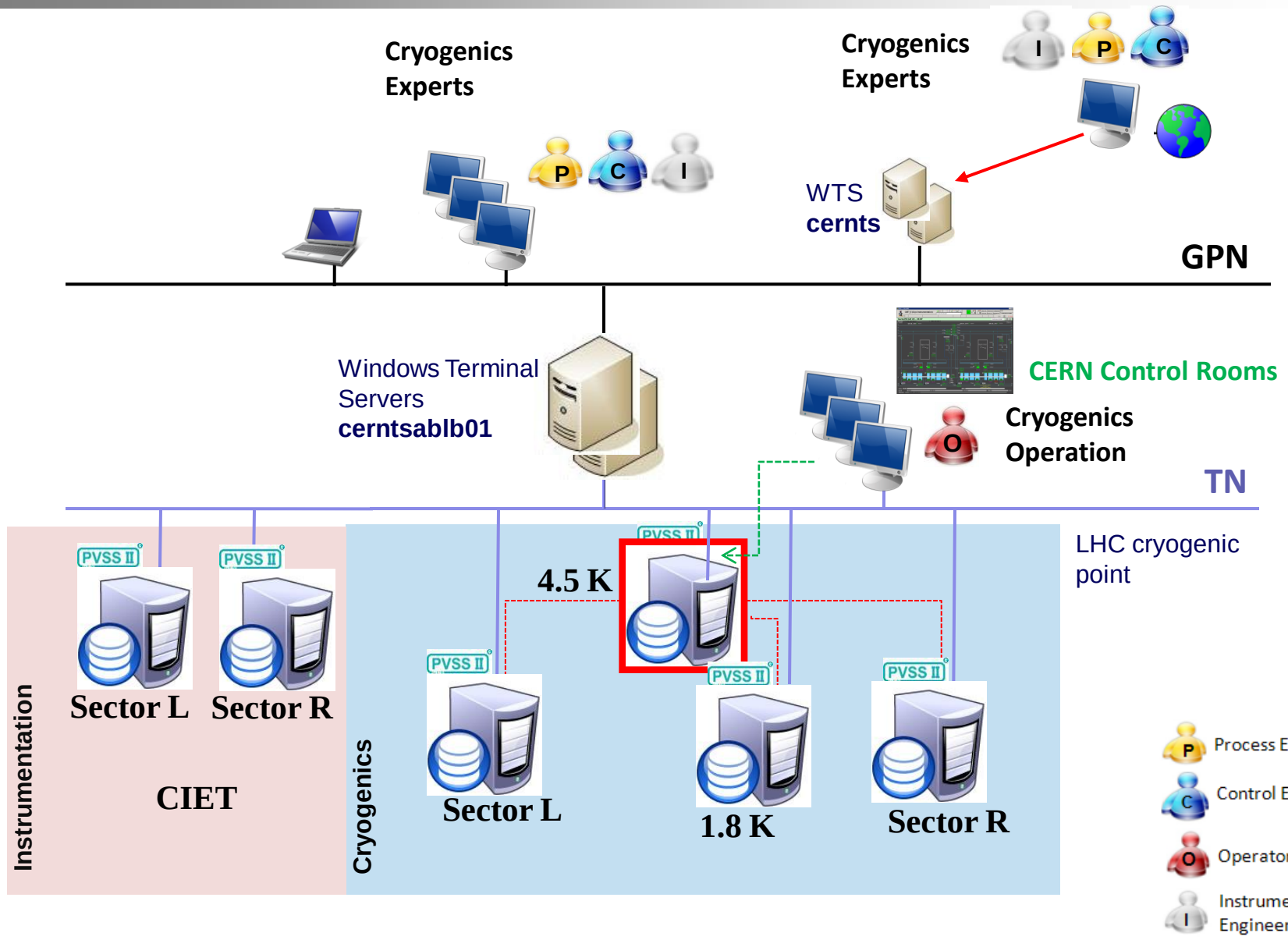
Modular architecture: **Managers**

- **Drivers (D)**: Process Interface (PLCs,…)
- Central processing: **Event manager (EV)** holds the current image of the process variables in memory
- **Data Manager** (DB) parameterization and archiving of value changes
- **User interface** (UI) : graphical display

Managers can run in different machines!

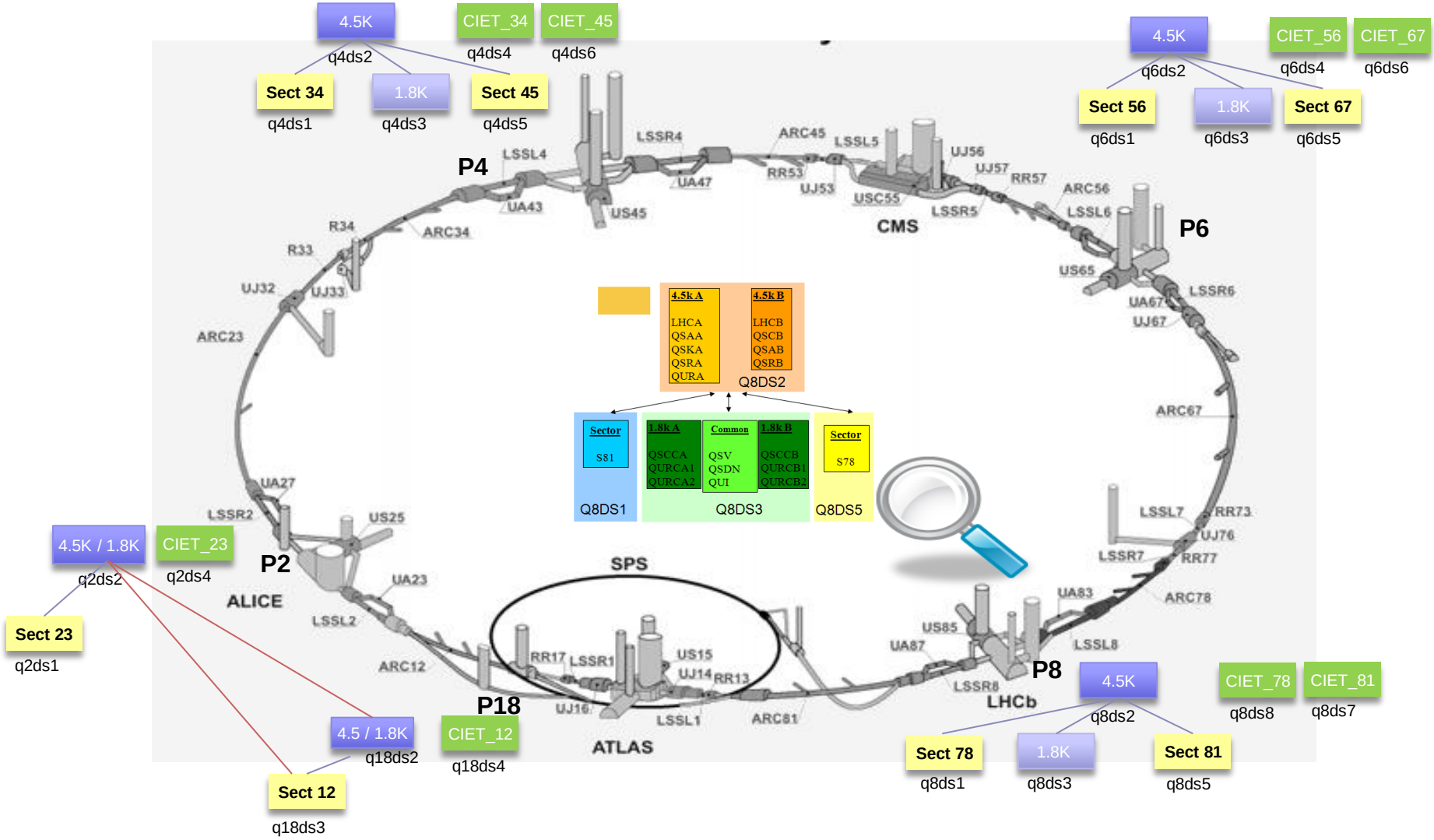


4.- Cryogenics Control System: SCADA Data Servers

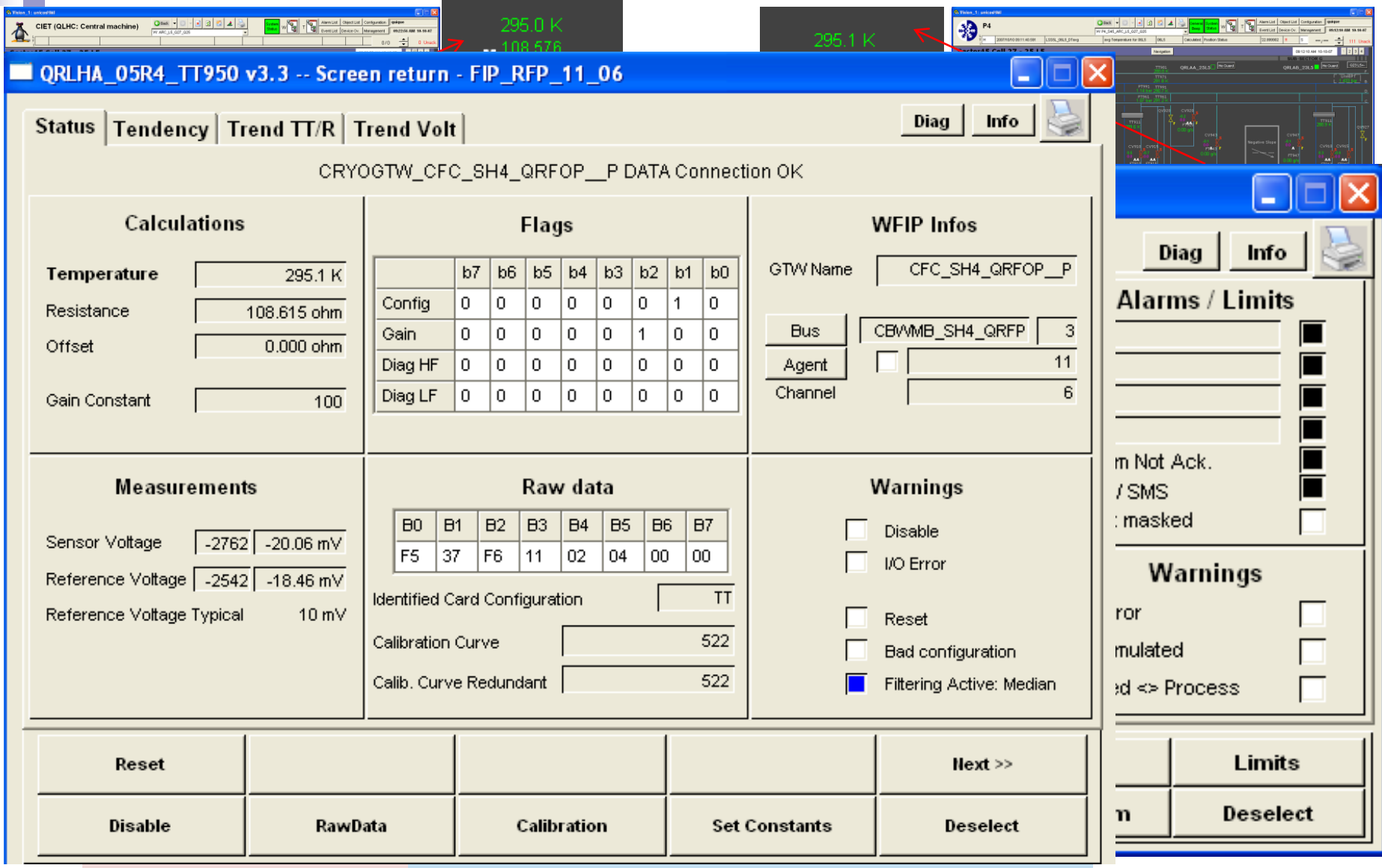


CIET: Cryogenics Instrumentation Expert Tool

4 Cryogenics Control System: SCADA architecture

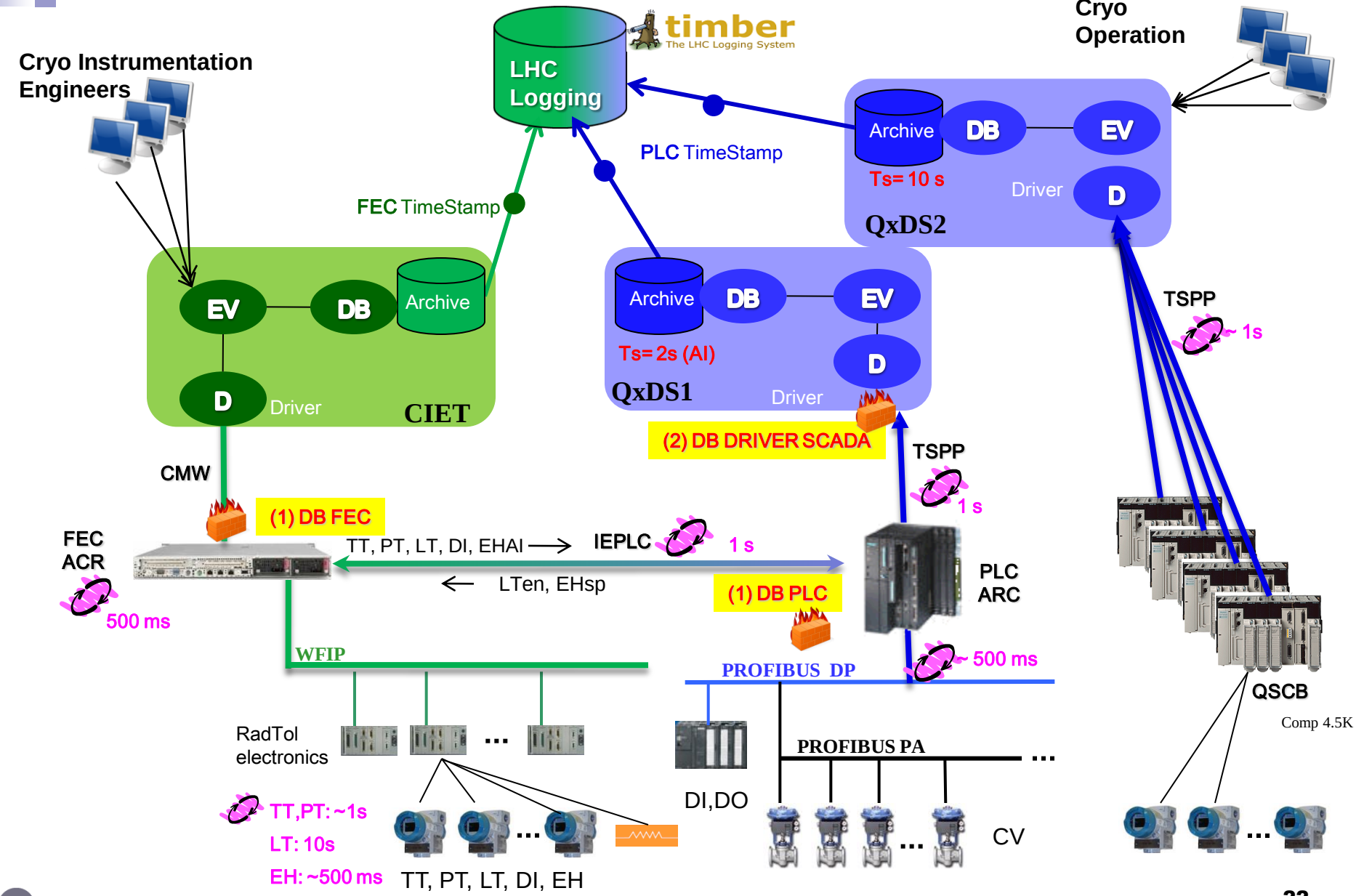


4.- Cryogenics Control System: SCADA Structure



CIET: Cryogenics Instrumentation Expert Tool

4.- Cryogenics Control System: Interfaces - LHC Logging



4.- Current shared responsibilities: EN/ICE vs TE/CRG

- Current assignations:
  - ✓ **Refrigerators**
    - SCADA & PLC
      - EN/ICE
  - ✓ **Tunnel**
    - SCADA
      - EN/ICE
    - FECs & WFip
      - EN/ICE
    - PLC & Instrumentation
      - TE/CRG
- Please contact support **EN/ICE** in case of problems with the refrigerators and **TE/CRG** in case of tunnel issues whenever the reason is not understood.
- Support GENERAL EN/ICE icecontrols.support@cern.ch
- Or alternatively: *cryocontrol.support@cern.ch*

Urgent interventions (Piquet service) Tlf: **164930**