WP2 Task 2.5

Control system development in a highly reliable accelerator context

ACS contribution on PLC cryogenic control

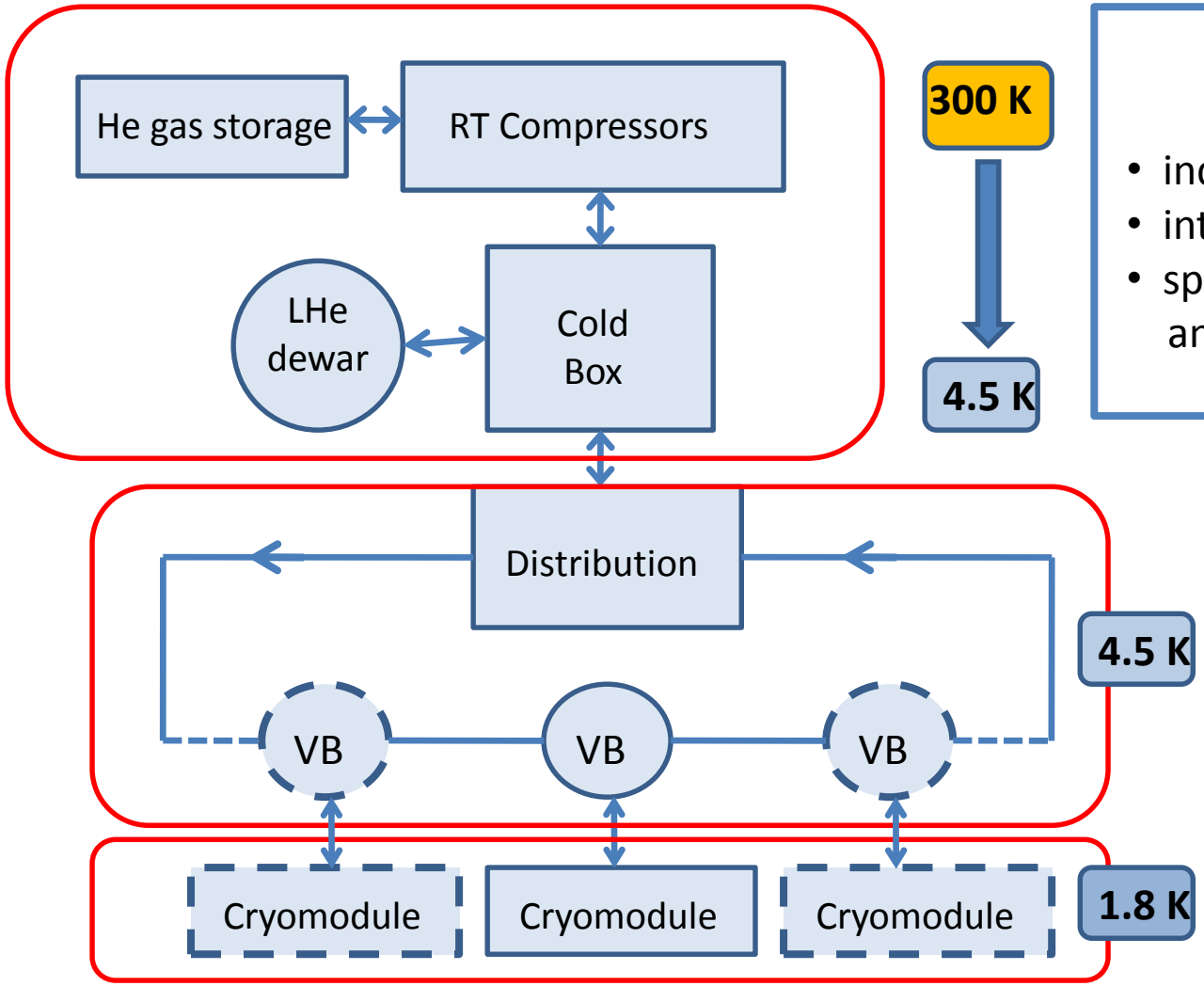
Initial ACS proposal for contribution to the Task 2.5:

→ **definition of automatons and PLCs**

Recent activities and proposal for Task 2.5 final report:

- Preliminary ideas and proposals for the C&C of cryogenic equipments (Cryomodules, distribution, refrigerator)
- Overview of Cryogenics C&C in similar SC Linac projects and new developments
- Eventual optimizations (reliability, stability, …) and role of C&C
- Actions that may be be implemented during the present R&D phase (Cryogenics C&C for the prototype cryomodule tests)

MYRRHA (Minerva) Cryogenic systems



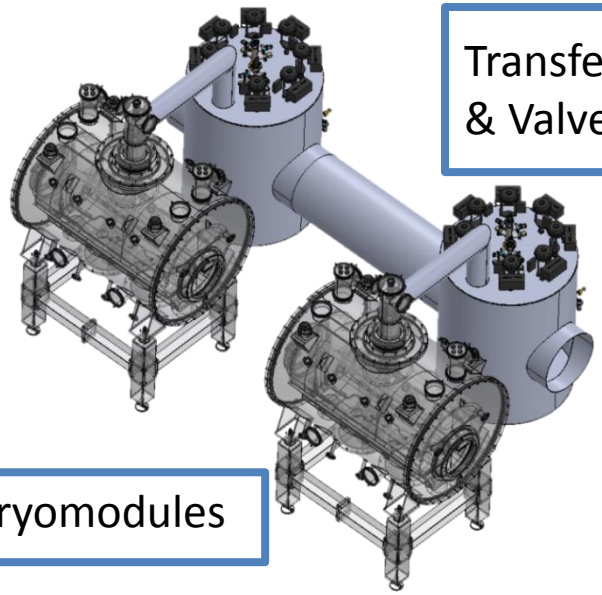
Refrigerator
4200 W (4.5 K)
- industrial development
- integrating **PLCs**
- special care for reliability and optimization

Distribution
- feed box
- transfer lines (100 m)
- 30 Valve Boxes

PLCs

SC Linac
- 30 cryomodules

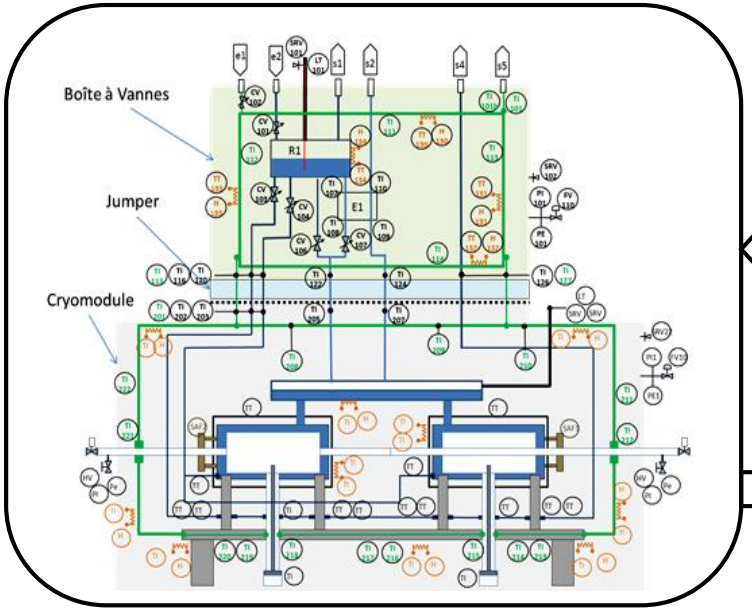
SC Linac Cryogenic systems



Transfer line
& Valve Boxes

Cryomodules

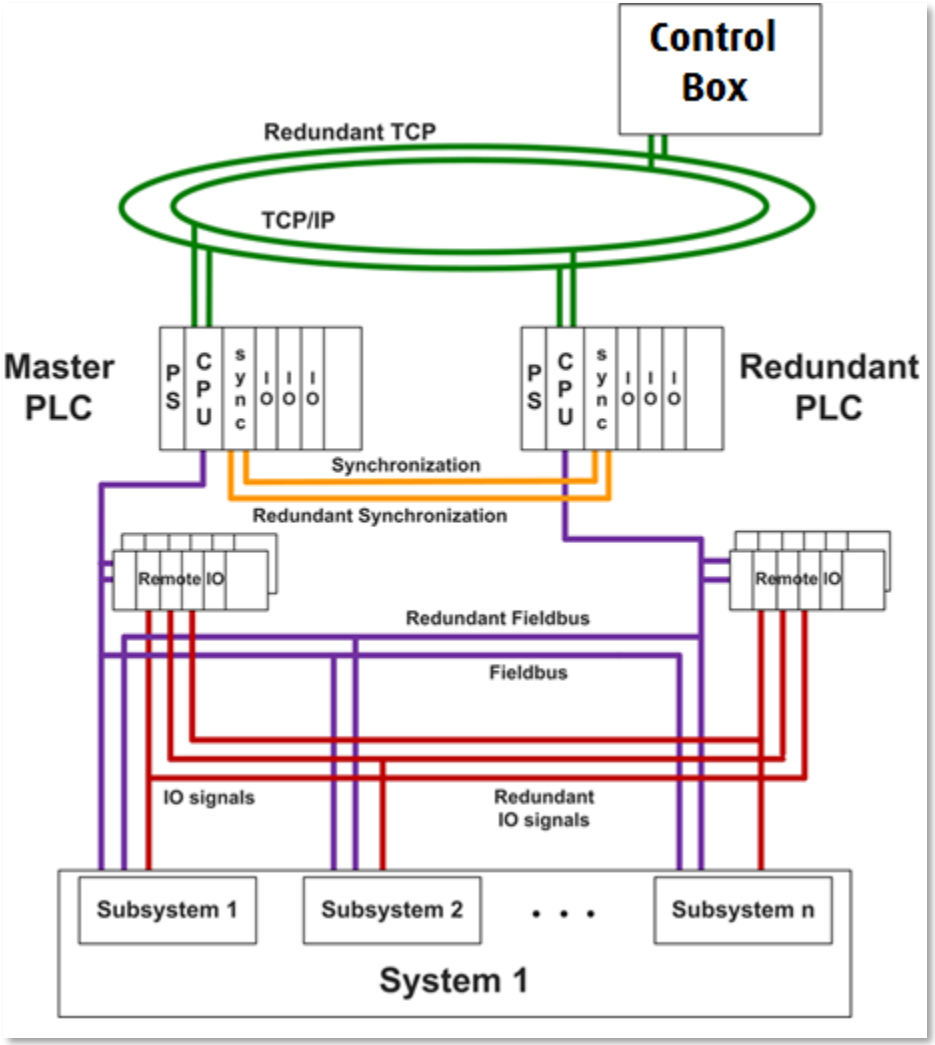
Cryomodule + Valve Box + Feeding Lines	
Actuators	
Cryo valves, vacuum	10
Heaters	30
Sensors	
Thermometers	100
Pressure	4
LHe level	2



Cryo Control Equipments

- PLC (Siemens, Step7, WinnCC, interface EPICS, network, …)
- Cryogenic measurements interfaces (temperature, pressure, LHe level)
- Cabinet, electrical terminals, …

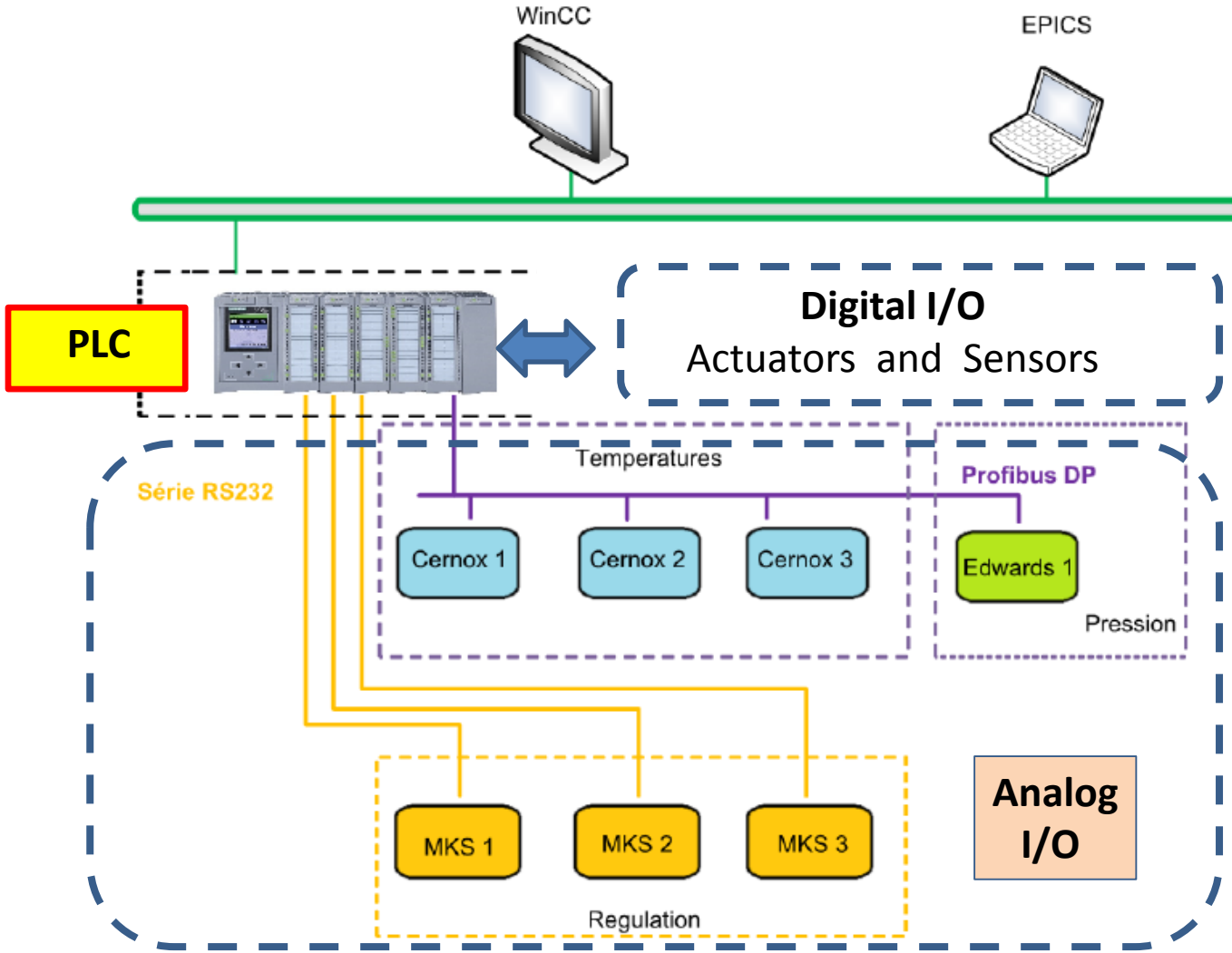
Initial proposals for MYRRHA (Minerva) PLC role on Control System



- Associated to the Control Boxes
- Hardware & Software platforms
- Specialized PLC network

Reliability and Availability goals need improvements:

- Redundant PLC architecture
- 2 PLCs:
  Master ↔ Redundant
- R&D phase must contribute to develop and test these architecture proposals



PLC Architecture for initial Cryomodule tests (R&D Phase)

PLC developments for the Minerva phases:
→ R&D - final requirements for series

R&D on MYRRHA Spoke Cryomodules (developed by CNRS-IN2P3)

- Main interest of PLC : process monitoring, check feasibility of control procedures, tests interfaces, test hardware, …
- Deliver interesting measurements : cryogenic temperature, He gas flow, pressure … to evalute SC Cavities performances (static and dynamic losses, sensitivity to perturbations, …)

Cryogenic Control studies (Valve Box operation):

- Tests of cryo operation procedures (cooling down, nominal operation, warm-up)
- Preparation of final Minerva SC Linac distribution specifications and test of general concepts for Minerva accelerator C&C

Interesting PLC developments in similar projects

CERN

- Intensive use of PLC for control of Cryogenic refrigeration, distribution and accelerator systems
- Work developed from 1990 … (LEP and LHC)
- Development of a framework UNICOS (UNified Industrial Control System) Object oriented software to handle PLC and Supervision operation
- Leading presently to develop automation of PLC software production (Continuous Integration and Cryo apps)
- Improvements: Reliability, software homogeneous development, reducing development time efforts, maintenance, easier update, …

→ Succesfully Tested in LHC Run 2 in 2016-2017.
Presently applied to other projects: Magnet Test facility, HIE ISOLDE …

ESS

- Development of a "PLC factory" to enhance reliability, reducing PLC deployment time (hundreds …)
- Associated to a database: CCDB (Control Configuration Data Base)
- Development of a specific programming language PLCF#