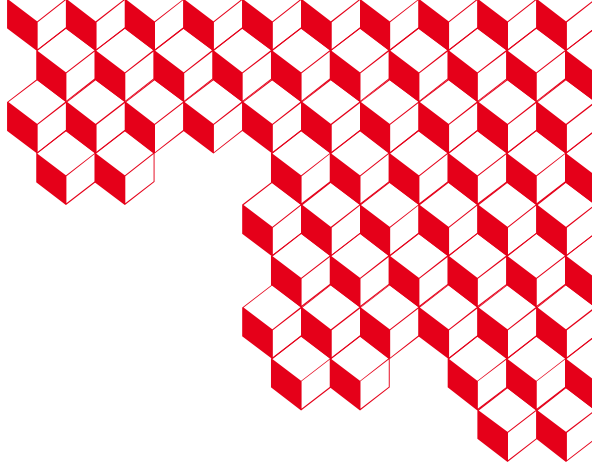


CEA Paris-Saclay
PLC based control systems

Tom Joannem

CEA

1 NATIONAL MISSION

- Defence and security

3 STRATEGIC AXES

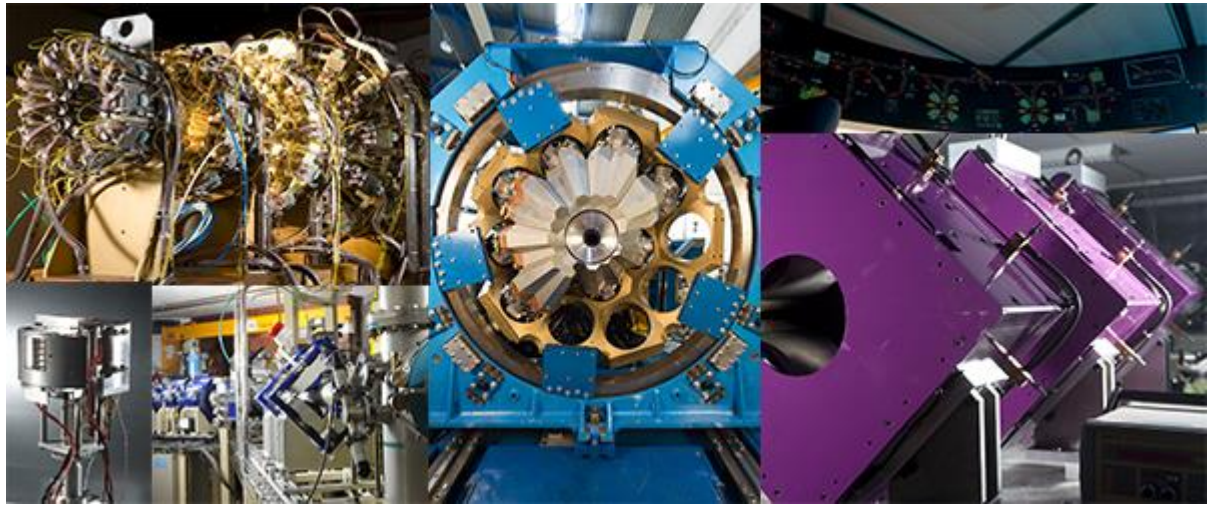
- Energy transition
- Numeric transition
- Next generation medecine technologies

1 BASE

- Fondamental research

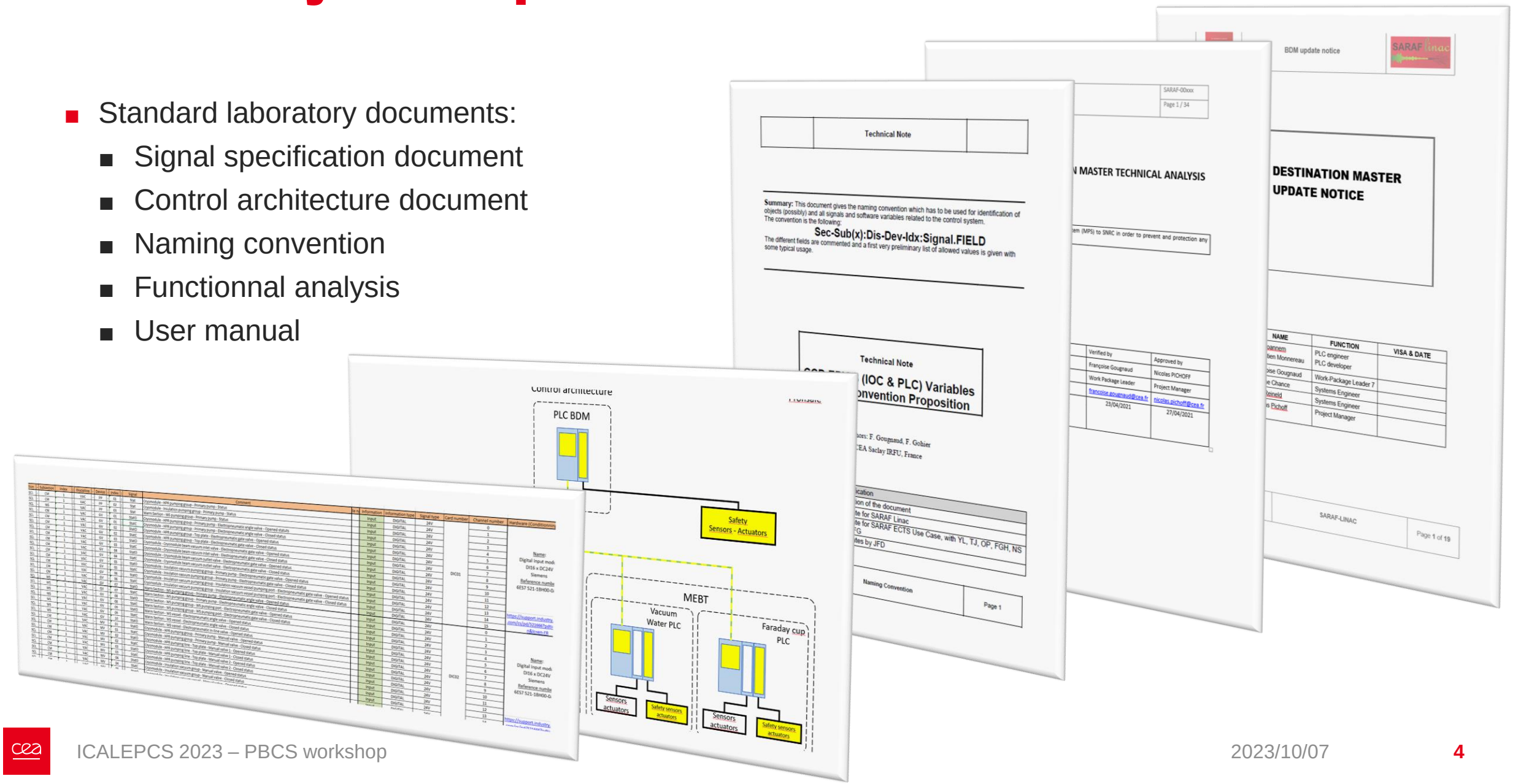
IRFU institute

- Research institute on the fundamental laws of the universe
  - Department of Accelerators, Cryogenics and Magnetism
  - Department of Astrophysics
  - Department of Detector Electronics and Computing for Physics
  - Department of Systems Engineering
  - Department of Nuclear Physics
  - Department of Particle Physics
  - GANIL particles accelerator



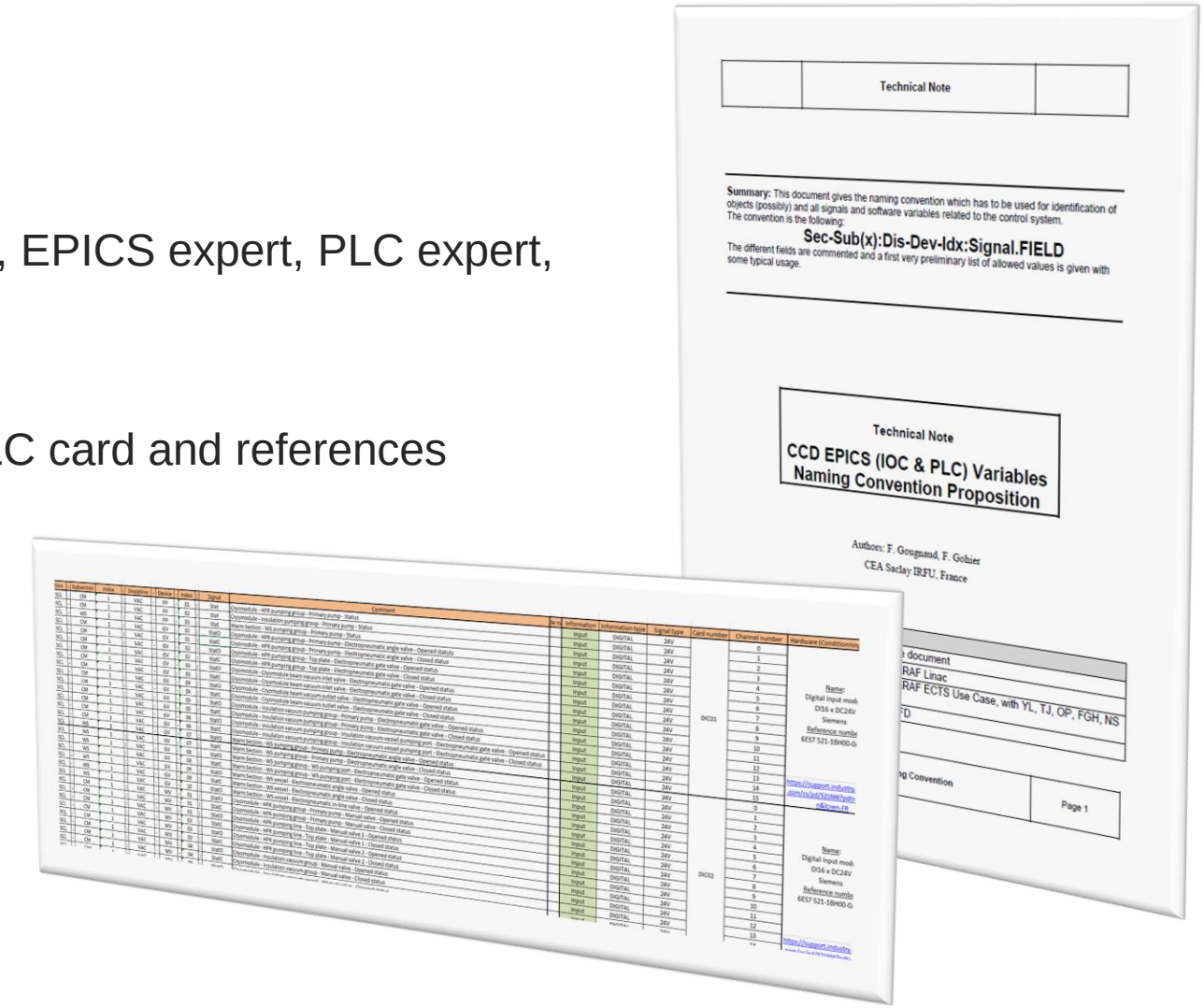
Control System Specification

- Standard laboratory documents:
  - Signal specification document
  - Control architecture document
  - Naming convention
  - Functionnal analysis
  - User manual



Control System Specification

- Standard laboratory documents:
  - Naming convention
    - EPICS name definition for electrical expert, EPICS expert, PLC expert, cryogeny and vacuum expert
  - Signal specification document
    - EPICS name, description, signal range, PLC card and references



Project development

- Standard laboratory hardware:
  - Siemens 1500 CPU and cards, MP format
  - Siemens 1500 CPU and cards, SP format
  - Siemens TouchPanels
- Standard laboratory software:
  - Siemens TIA Portal V16/V17
  - Siemens WINCC UA
  - EPICS Phoebus
  - Conversion tool from Autocad to EPICS
  - Conversion tool from PLC database to EPICS IOC (PLCParserTool)
- Standard laboratory function library:
  - Siemens TIA Portal V16 library
  - Signal conversion function
  - Specific and advanced functions

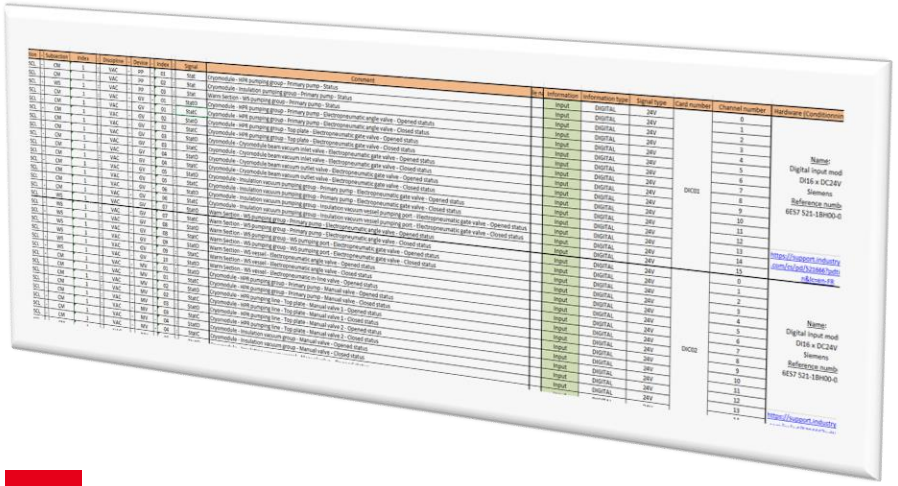
Project development

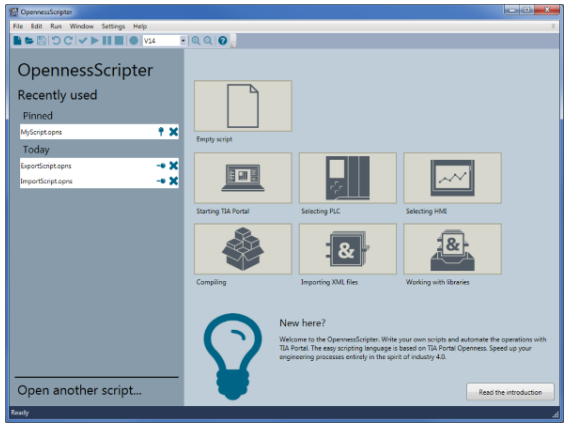
- Language choices:
  - SCL for signal conversion
  - SCL for communication management
  - Ladder for main purposes
  - Grafcet for automatic procedures

- Coding conventions:
  - Standard TIA Portal project
  - Project architecture
  - Laboratory function (EPICS server)
  - Internal data naming convention

Project development

- Automatic code generation (Possible R&D):
  - Analysis of signal specification document
  - Laboratory function library
  - Use TIA Portal Openness for TIA Portal project generation
  - Database generation, function integration and EPICS server parameters definition

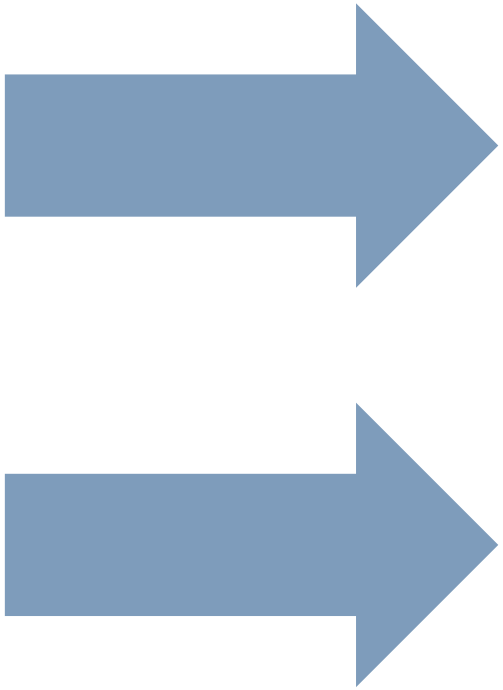


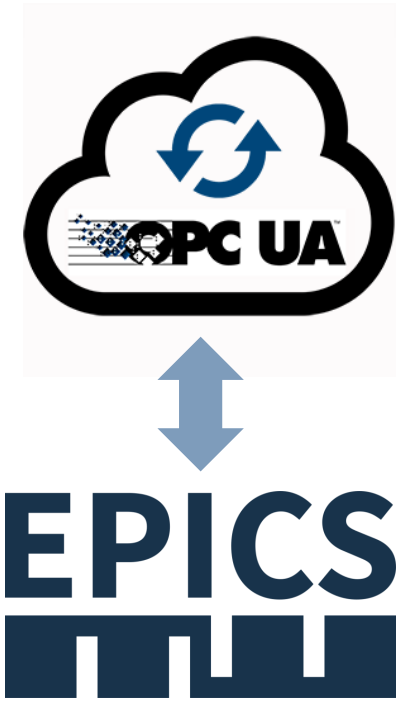


EPICS

Project development

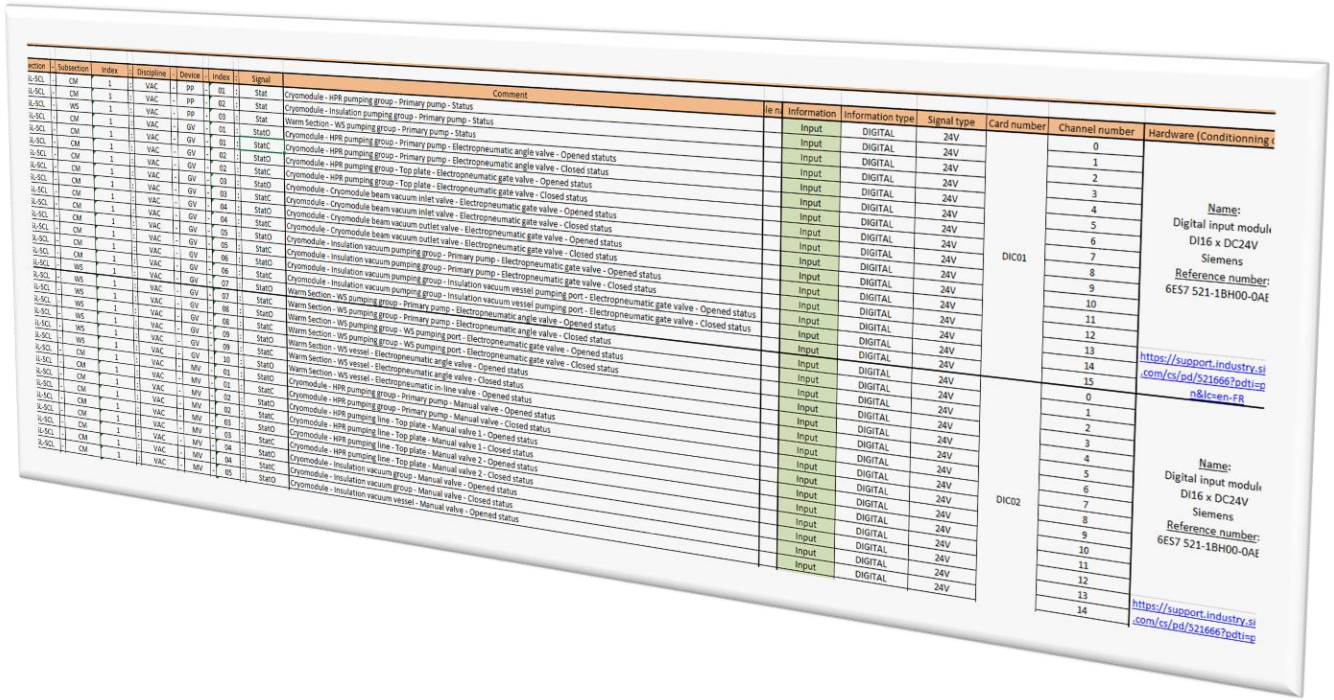
- OPC UA server with EPICS (R&D):
  - Simple OPC UA server configuration in PLC CPU
  - Simple OPC UA database generation to EPICS OPC UA driver
  - Secure communication with certificate
  - Tests of EPICS communauty drivers





Testing and verification

- Methodologies and tests (FAT, SAT)
  - Each channel is tested from PLC to cabinet interface connector (FAT)
  - Each channel is tested from PLC to sensor/actuator (SAT)
  - Each scenario is defined and tested (SAT)



Comment	Information	Information type	Signal type	Card number	Channel number	Hardware (Conditionning
Cryomodule - HPR pumping group - Primary pump - Status	Input	DIGITAL	24V	DIC01	0	Name: Digital input modul DI16 x DC24V Siemens Reference number: 6ES7 521-1BH00-0AE
Cryomodule - Insulation pumping group - Primary pump - Status	Input	DIGITAL	24V		1	
Warm Section - WS pumping group - Primary pump - Status	Input	DIGITAL	24V		2	
Cryomodule - HPR pumping group - Primary pump - Electropneumatic angle valve - Opened statuts	Input	DIGITAL	24V		3	
Cryomodule - HPR pumping group - Primary pump - Electropneumatic angle valve - Closed status	Input	DIGITAL	24V		4	
Cryomodule - HPR pumping group - Top plate - Electropneumatic gate valve - Opened status	Input	DIGITAL	24V		5	
Cryomodule - Cryomodule beam vacuum inlet valve - Electropneumatic gate valve - Closed status	Input	DIGITAL	24V		6	
Cryomodule - Cryomodule beam vacuum inlet valve - Electropneumatic gate valve - Opened status	Input	DIGITAL	24V		7	
Cryomodule - Cryomodule beam vacuum outlet valve - Electropneumatic gate valve - Closed status	Input	DIGITAL	24V		8	
Cryomodule - Cryomodule beam vacuum outlet valve - Electropneumatic gate valve - Opened status	Input	DIGITAL	24V		9	
Cryomodule - Insulation vacuum pumping group - Primary pump - Electropneumatic gate valve - Closed status	Input	DIGITAL	24V		10	
Cryomodule - Insulation vacuum pumping group - Primary pump - Electropneumatic gate valve - Opened status	Input	DIGITAL	24V		11	
Cryomodule - Insulation vacuum pumping group - Insulation vacuum vessel pumping port - Electropneumatic gate valve - Closed status	Input	DIGITAL	24V		12	
Warm Section - WS pumping group - Primary pump - Electropneumatic gate valve - Opened status	Input	DIGITAL	24V		13	https://support.industry.si .com/cs/pd/521666?pdti=p n&lc=en-FR
Warm Section - WS pumping group - Primary pump - Electropneumatic angle valve - Closed status	Input	DIGITAL	24V		14	
Warm Section - WS pumping group - Primary pump - Electropneumatic angle valve - Opened status	Input	DIGITAL	24V		15	
Warm Section - WS pumping group - WS pumping port - Electropneumatic gate valve - Closed status	Input	DIGITAL	24V	DIC02	0	Name: Digital input modul DI16 x DC24V Siemens Reference number: 6ES7 521-1BH00-0AE
Warm Section - WS pumping group - WS pumping port - Electropneumatic gate valve - Opened status	Input	DIGITAL	24V		1	
Warm Section - WS vessel - Electropneumatic gate valve - Opened status	Input	DIGITAL	24V		2	
Warm Section - WS vessel - Electropneumatic gate valve - Closed status	Input	DIGITAL	24V		3	
Warm Section - WS vessel - Electropneumatic angle valve - Opened status	Input	DIGITAL	24V		4	
Warm Section - WS vessel - Electropneumatic angle valve - Closed status	Input	DIGITAL	24V		5	
Cryomodule - HPR pumping group - Electropneumatic in-line valve - Opened status	Input	DIGITAL	24V		6	
Cryomodule - HPR pumping group - Primary pump - Manual valve - Opened status	Input	DIGITAL	24V		7	
Cryomodule - HPR pumping line - Top plate - Manual valve - Closed status	Input	DIGITAL	24V		8	
Cryomodule - HPR pumping line - Top plate - Manual valve 1 - Opened status	Input	DIGITAL	24V		9	
Cryomodule - HPR pumping line - Top plate - Manual valve 1 - Closed status	Input	DIGITAL	24V		10	
Cryomodule - HPR pumping line - Top plate - Manual valve 2 - Opened status	Input	DIGITAL	24V		11	
Cryomodule - HPR pumping line - Top plate - Manual valve 2 - Closed status	Input	DIGITAL	24V		12	
Cryomodule - Insulation vacuum group - Manual valve - Opened status	Input	DIGITAL	24V		13	https://support.industry.si .com/cs/pd/521666?pdti=p
Cryomodule - Insulation vacuum group - Manual valve - Closed status	Input	DIGITAL	24V		14	
Cryomodule - Insulation vacuum vessel - Manual valve - Opened status	Input	DIGITAL	24V			

Testing and verification

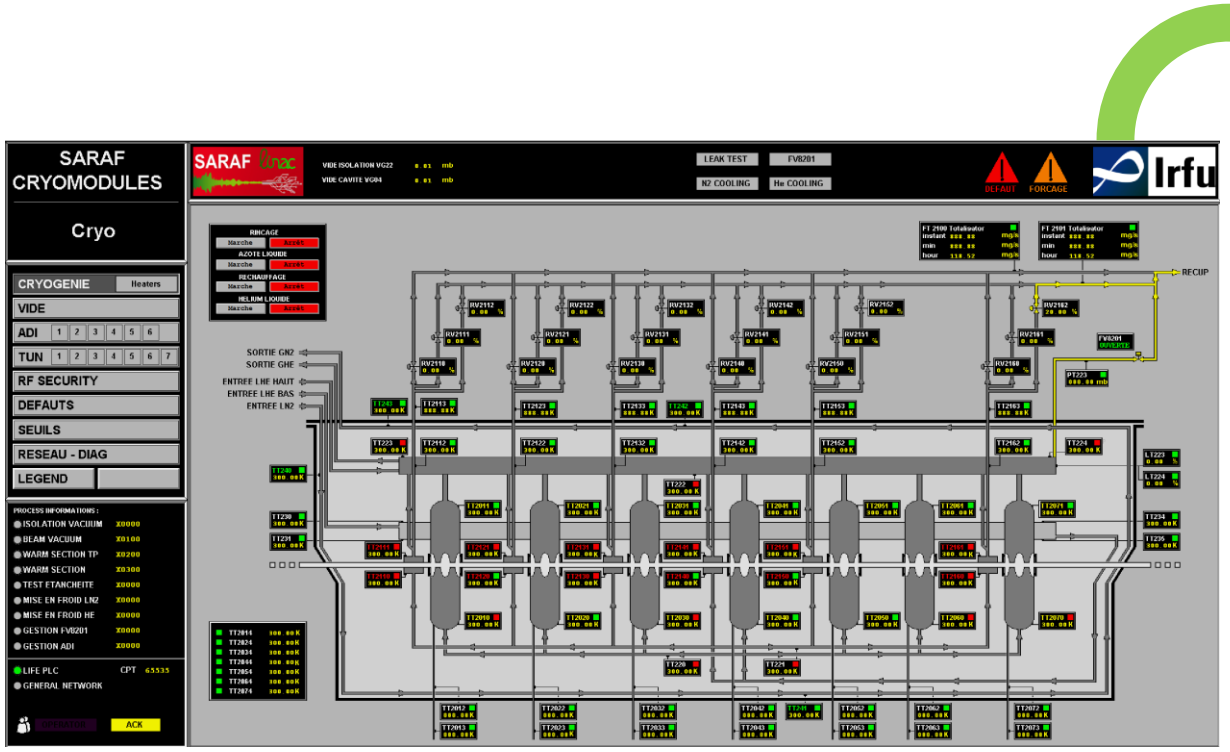
- Simulation, virtual commissioning
  - Simulation test bench is available in lab:
    - PLC
    - EPICS PC
    - Specific devices
  - Simulation mode can be activate in PLC
    - Physical reactions of actuators movement is apply to sensors
      - If a cryogenic valve is open, nearest temperature sensor decrease fast
      - If a cryogenic valve is open, farest temperature sensor decrease slow
      - Device error can be set
      - Automatic procedure can be test
      - Sensors and actuators managed (example):
        - Pressure sensor
        - Temperature sensor
        - Level sensor
        - Analog valve
        - Digital valve

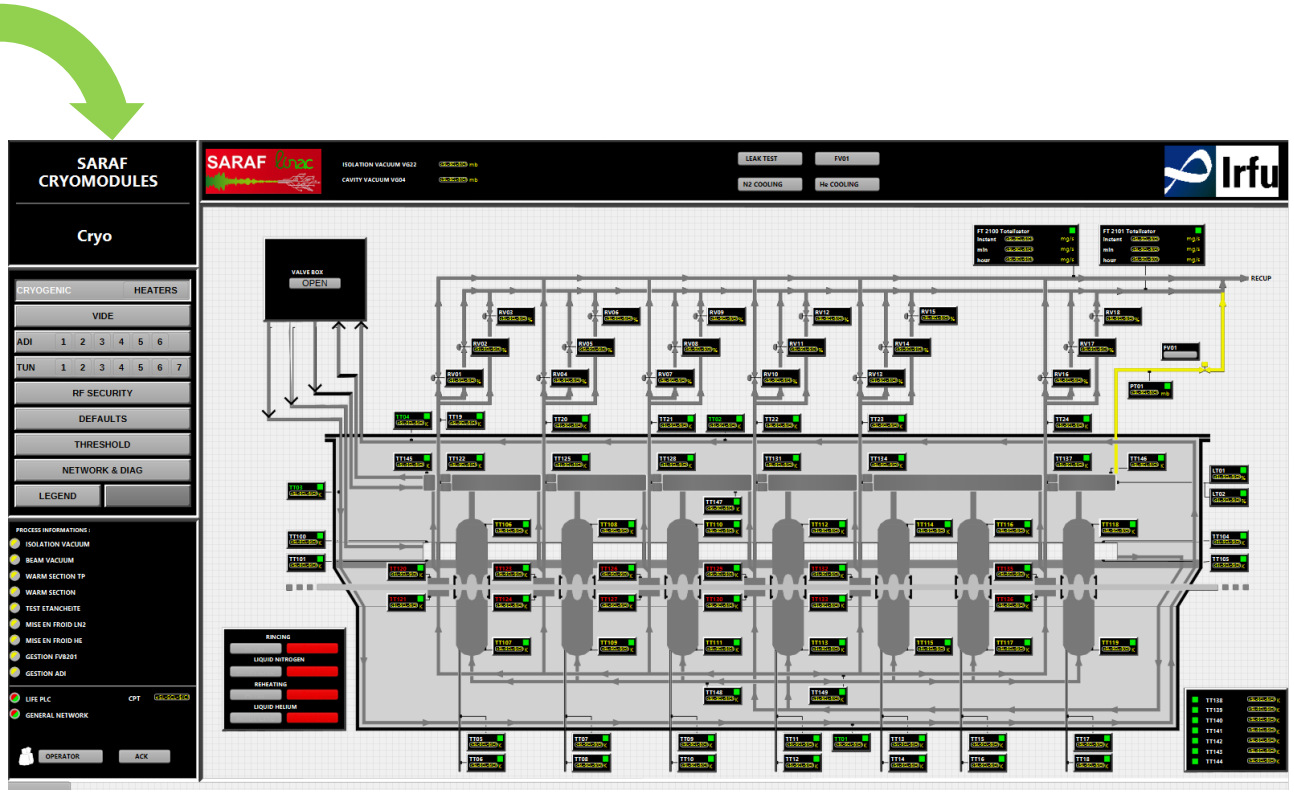
Application management

- Sharing code and builds
  - Current situation: PLC code archives are stored on a network disk
  - Looking to use TIA Portal Multi-User:
    - Possibility to work in collaboration
    - Single place to share and get last version of PLC code

Home made tools: GUI from Muscade to Phoebus

- GUI draws with Autocad because of cryogenic PID
- Previous SCADA: Muscade
- New SCADA: EPICS Phoebus,
- Conversion tool from Muscade to EPICS Phoebus





Home made tools: Generating EPICS code from DB description

- EPICS IOC database conversion tool from TIA Portal files: PLCParserTool
- TIA files managed: .sdf, .xlsx, .db, .awl
- EPICS IOC database generation for CSS and Phoebus
- PLC-EPICS communication: Modbus-TCP

.sdf
.xlsx
.db

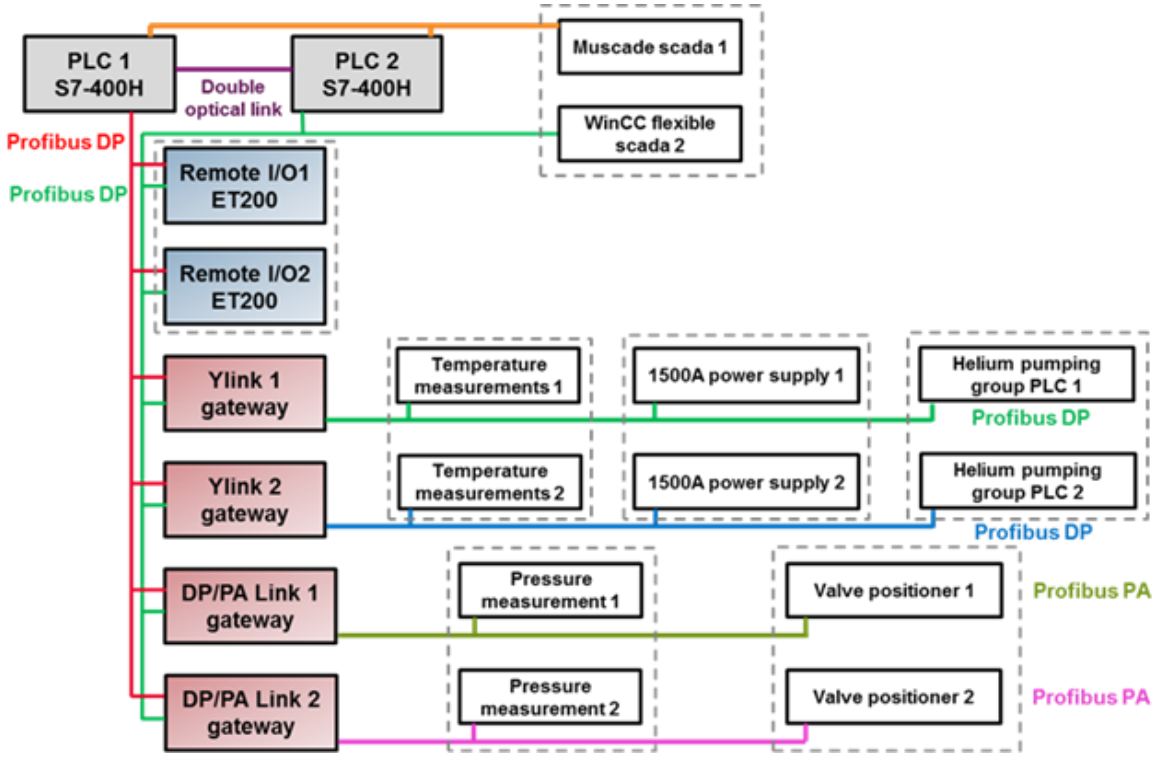
EPICS

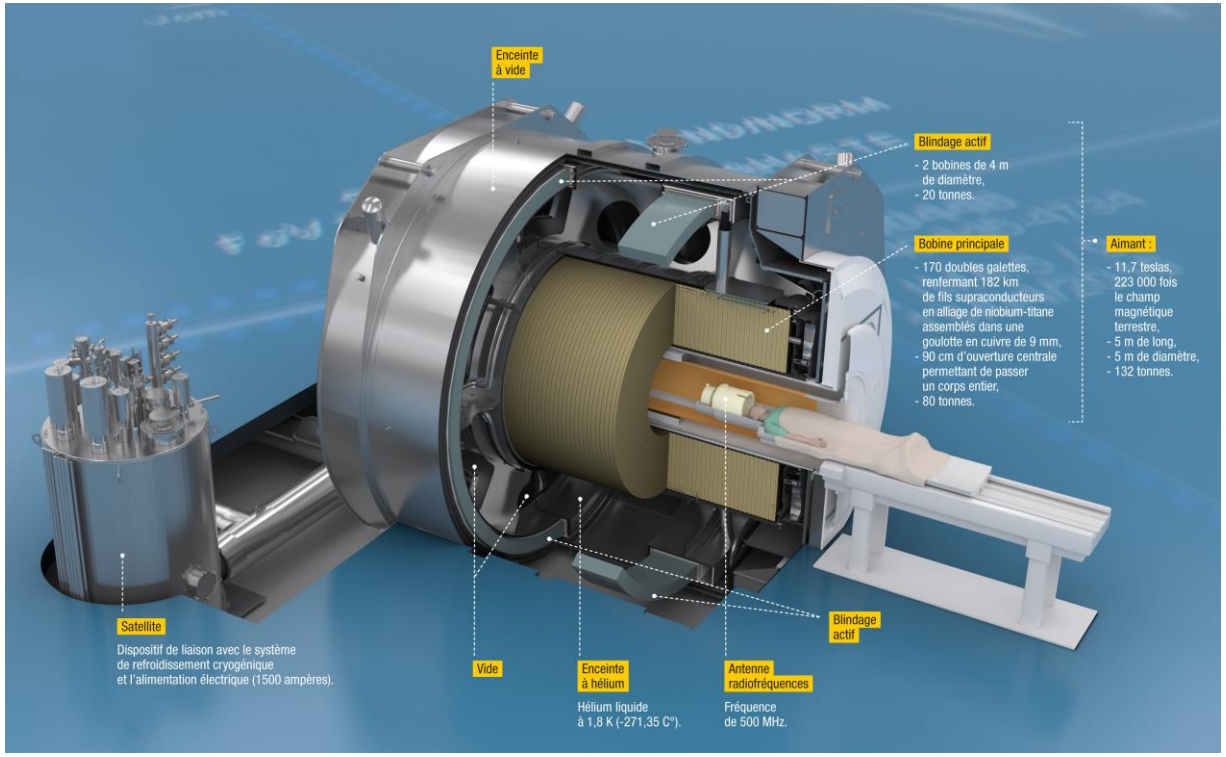
.db
.cmd
(IOC)

Thank you

Control architecture example

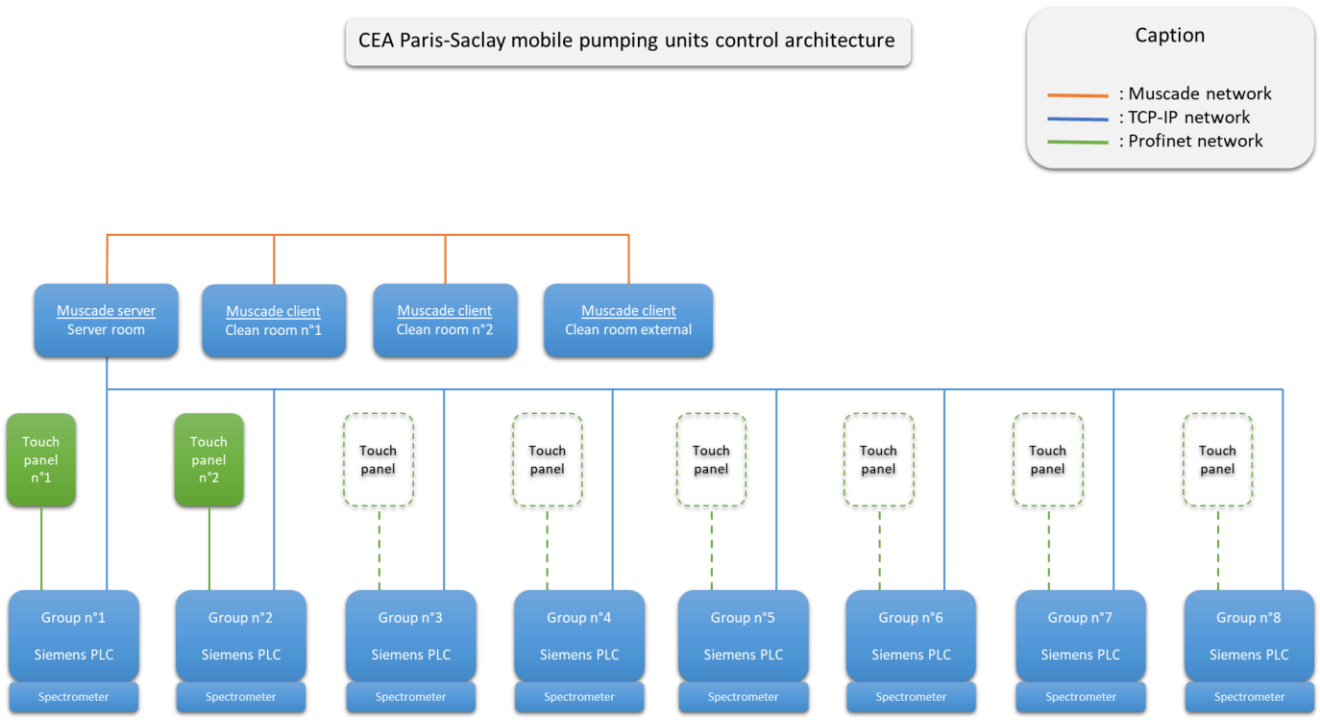
- Iseult: Most powerful MRI in the world for human purposes
  - Redundant cryogenic and electrical architecture





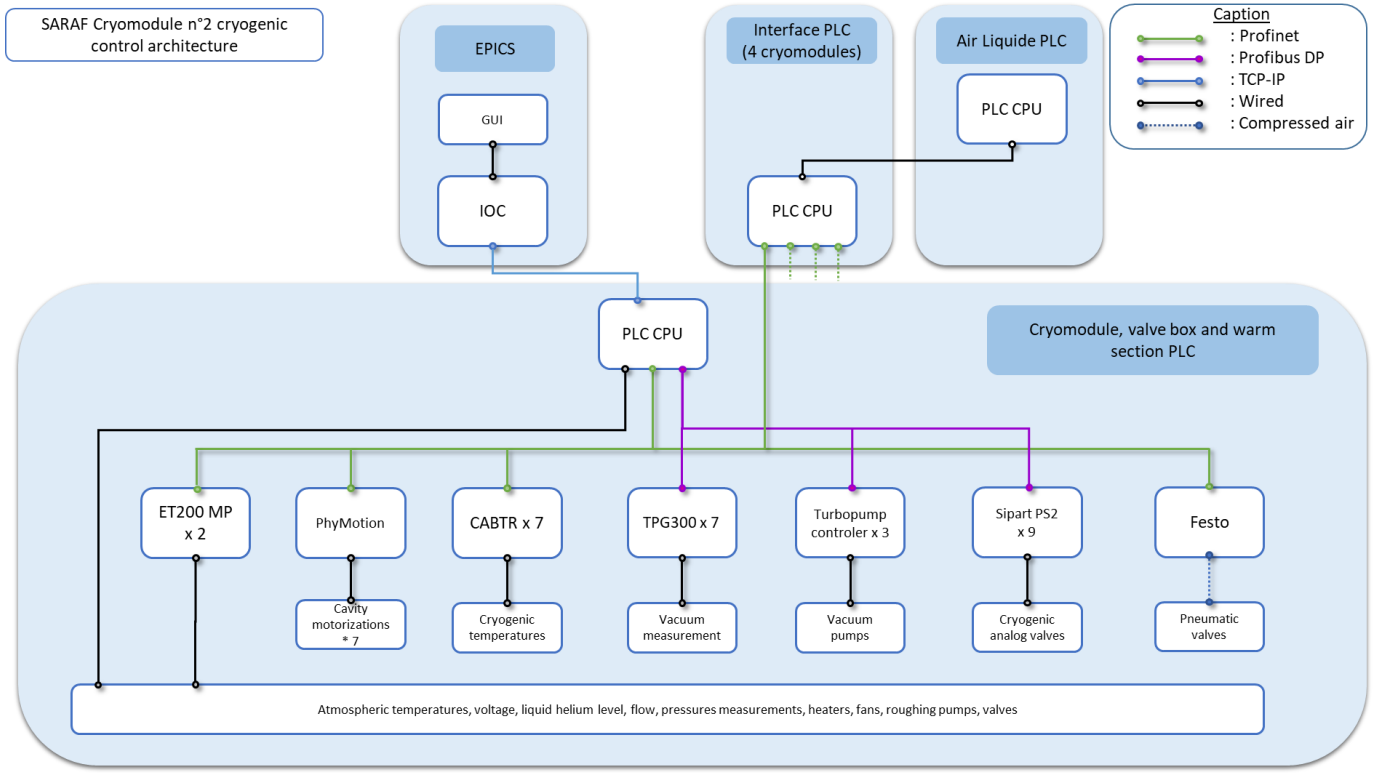
Control architecture example (Poster TUPDP009)

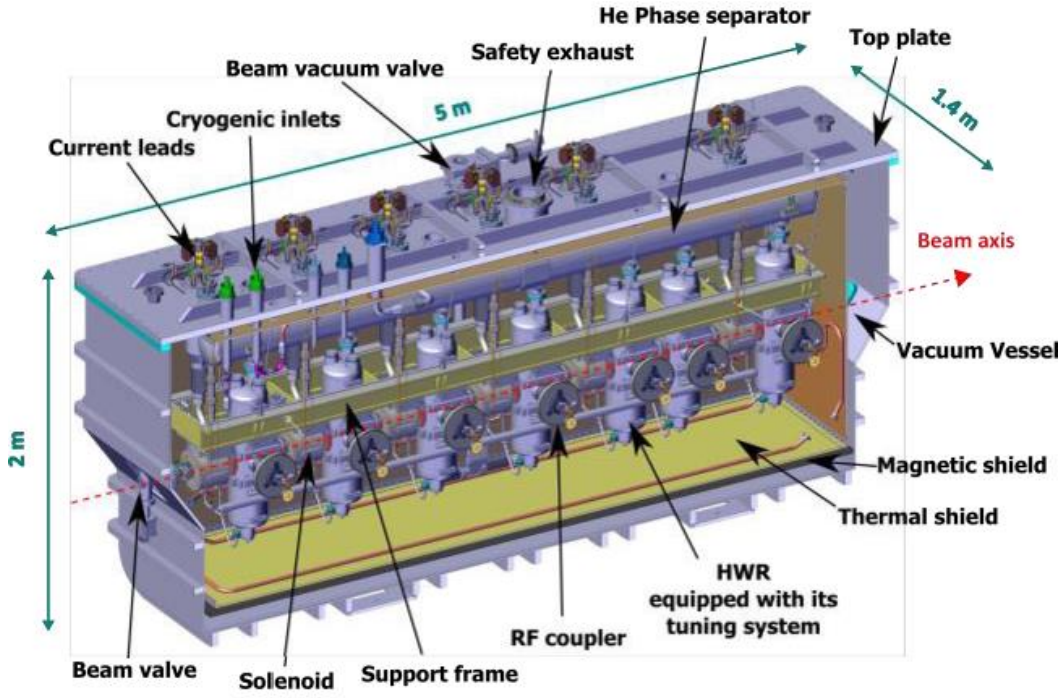
- Mobile pumping units: Vacuum pumping system for beam particle free
  - Embedded and reliable control system



Control architecture example (Poster ABCDE123)

- SARAF cryomodules: Linac elements of the SARF particles accelerator
  - Cryogenic, vacuum, cavities tuning and interlocks control architecture





Control architecture example (Poster ABCDE123)

- MPS: Machine protection system for SARF particles accelerator
  - Network control of remote device