

LHC Cryogenics Control: INTEGRATION OF THE INDUSTRIAL CONTROLS (UNICOS) AND FRONT-END SOFTWARE ARCHITECTURE (FESA) APPLICATIONS

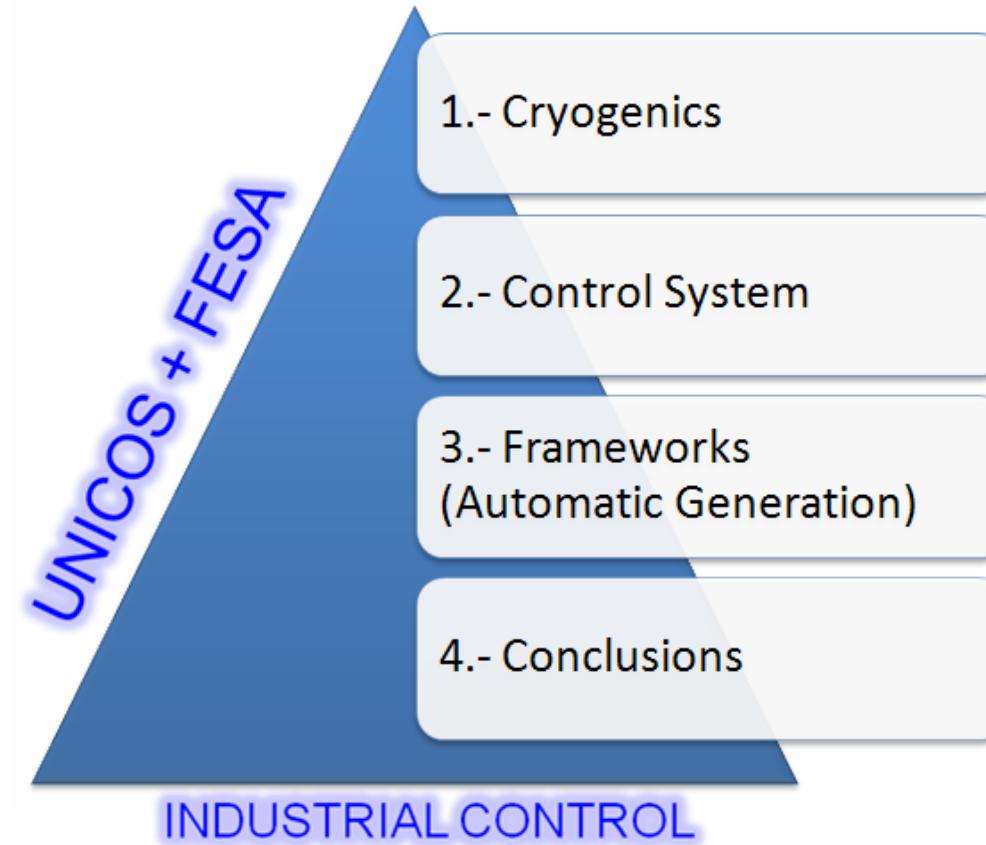
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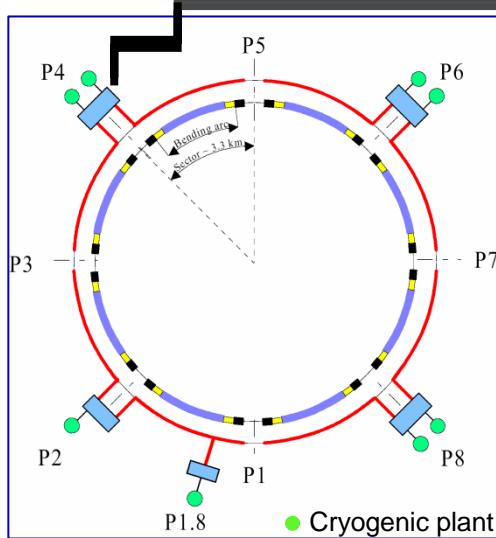
Industrial Systems



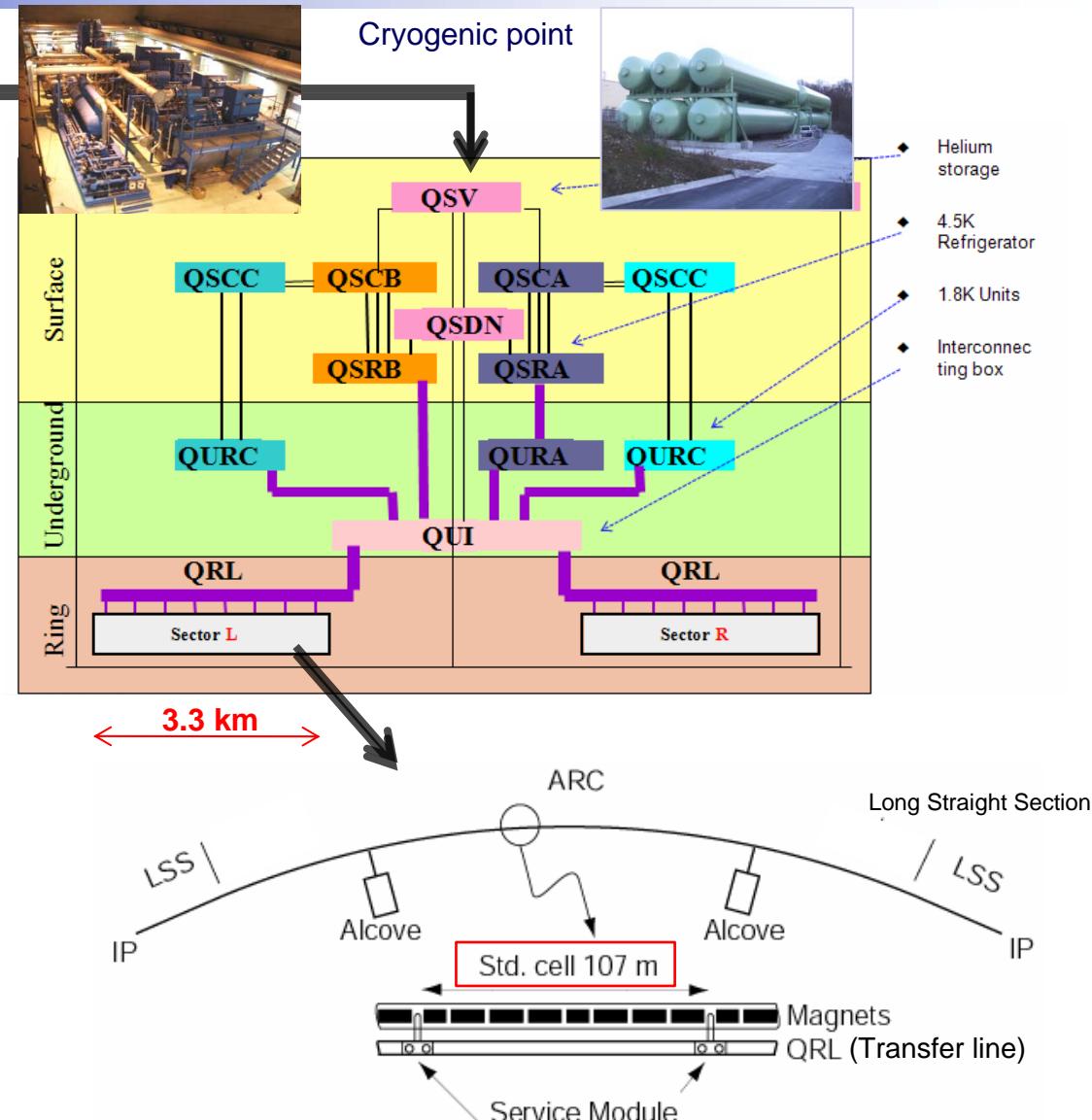
Outline



LHC cryogenics overview



LHC tunnel (27 km)

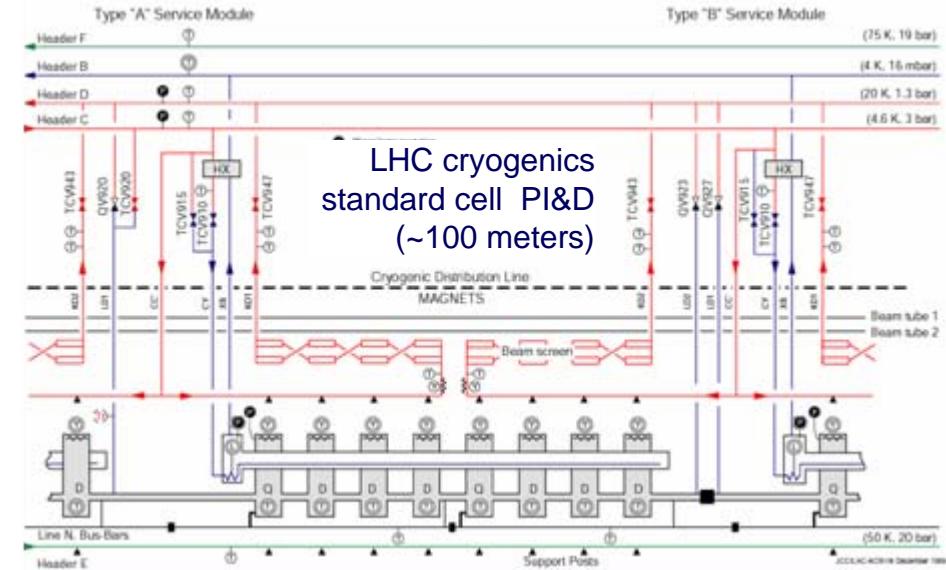


2.- Cryogenics Control System

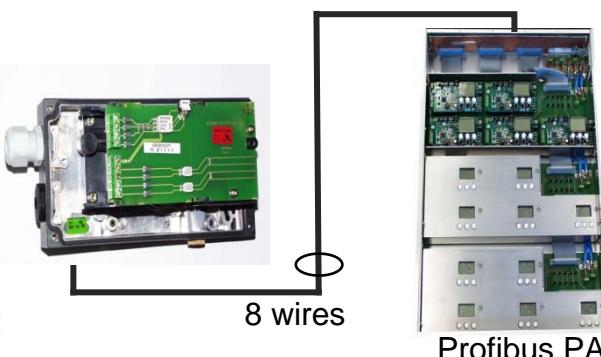
Instrumentation

- ✓ 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



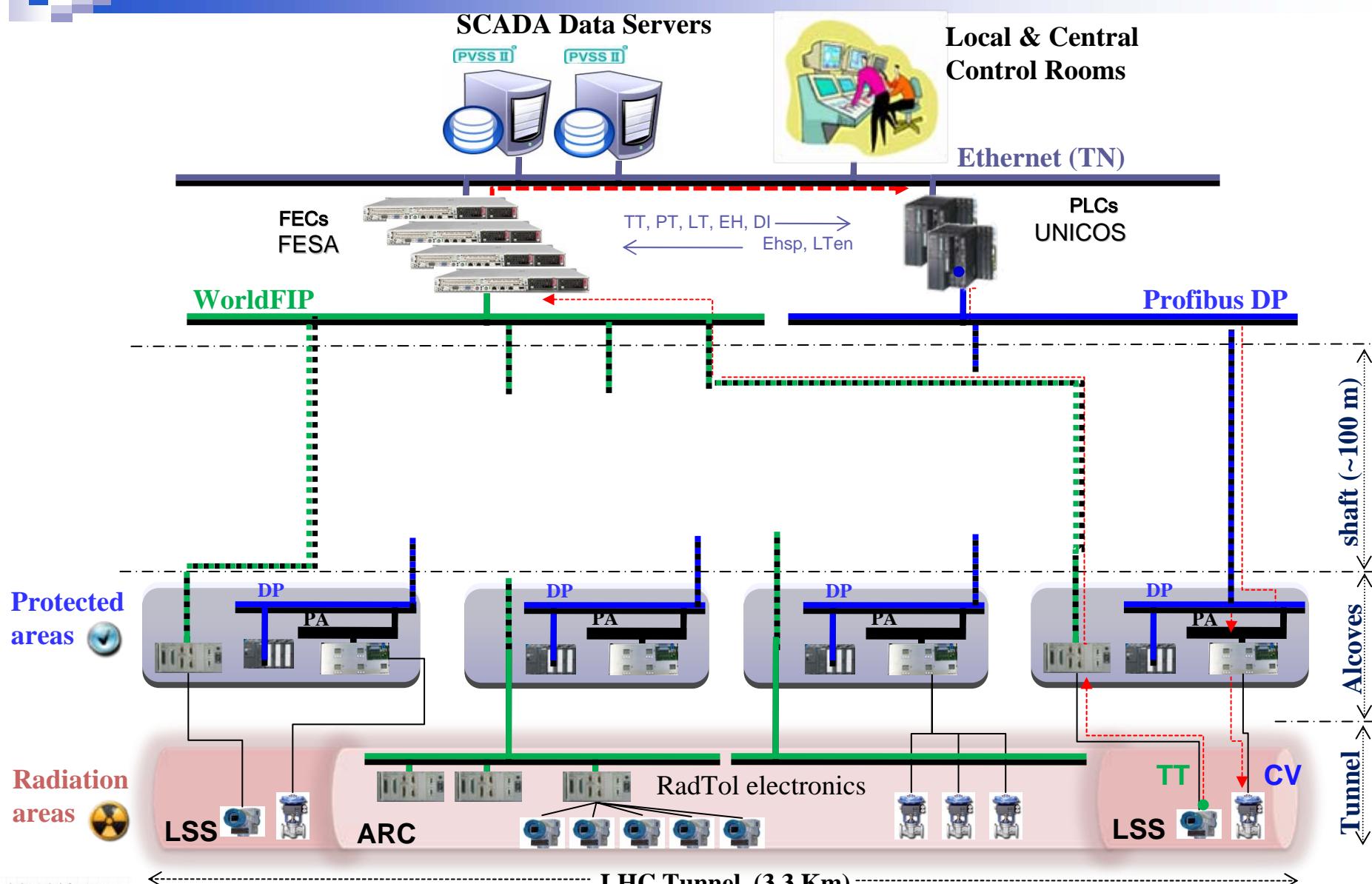
- ✓ Tunnel instrumentation exposed to **radiation** (custom development to withstand the hostile environment)



RadTol Signal Conditioners

2.- Cryogenics Control System

Tunnel Architecture



2.- Cryogenics Control System

Industrial Communications

— WorldFip Copper cable

— WorldFip Fiber

— Profibus DP Copper cable

— Profibus Fiber

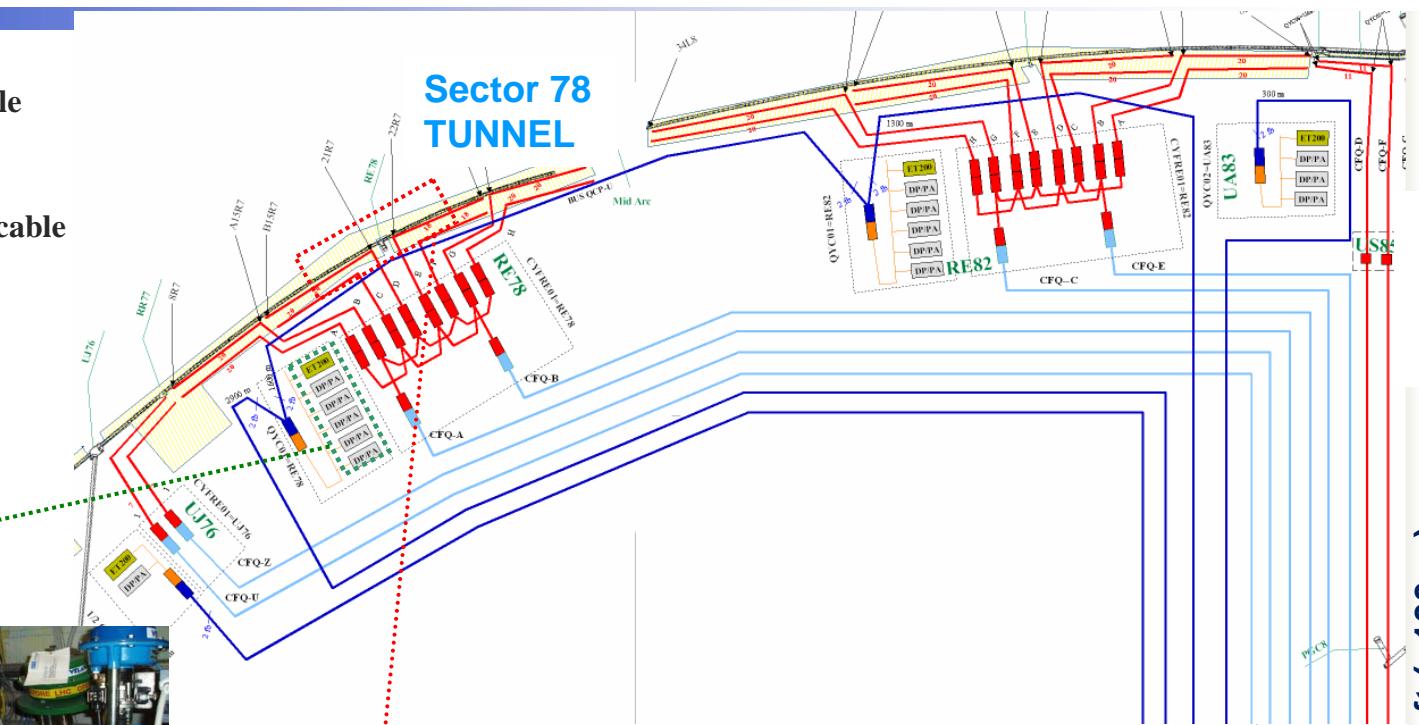
— Ethernet UTP



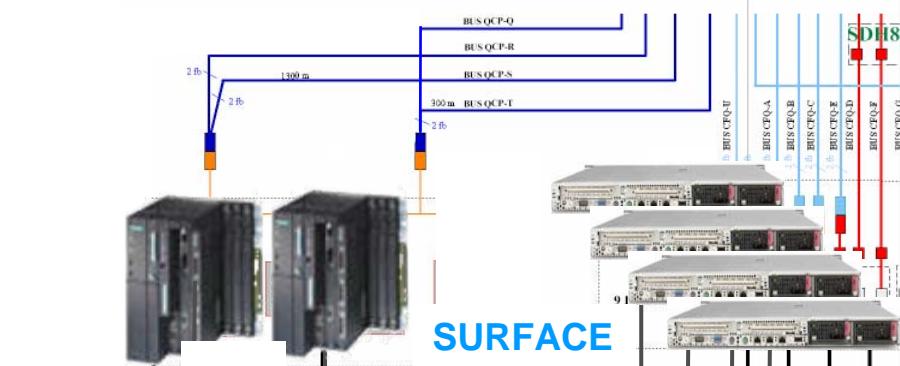
Alcoves



Sector 78 TUNNEL



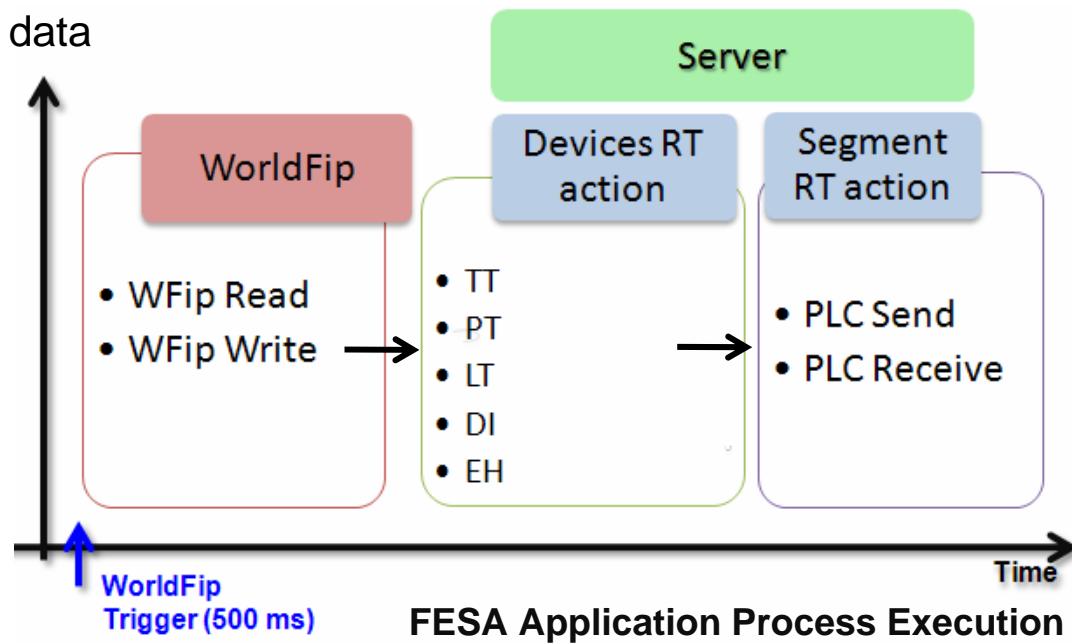
Tunnel



Ethernet: Protected technical network

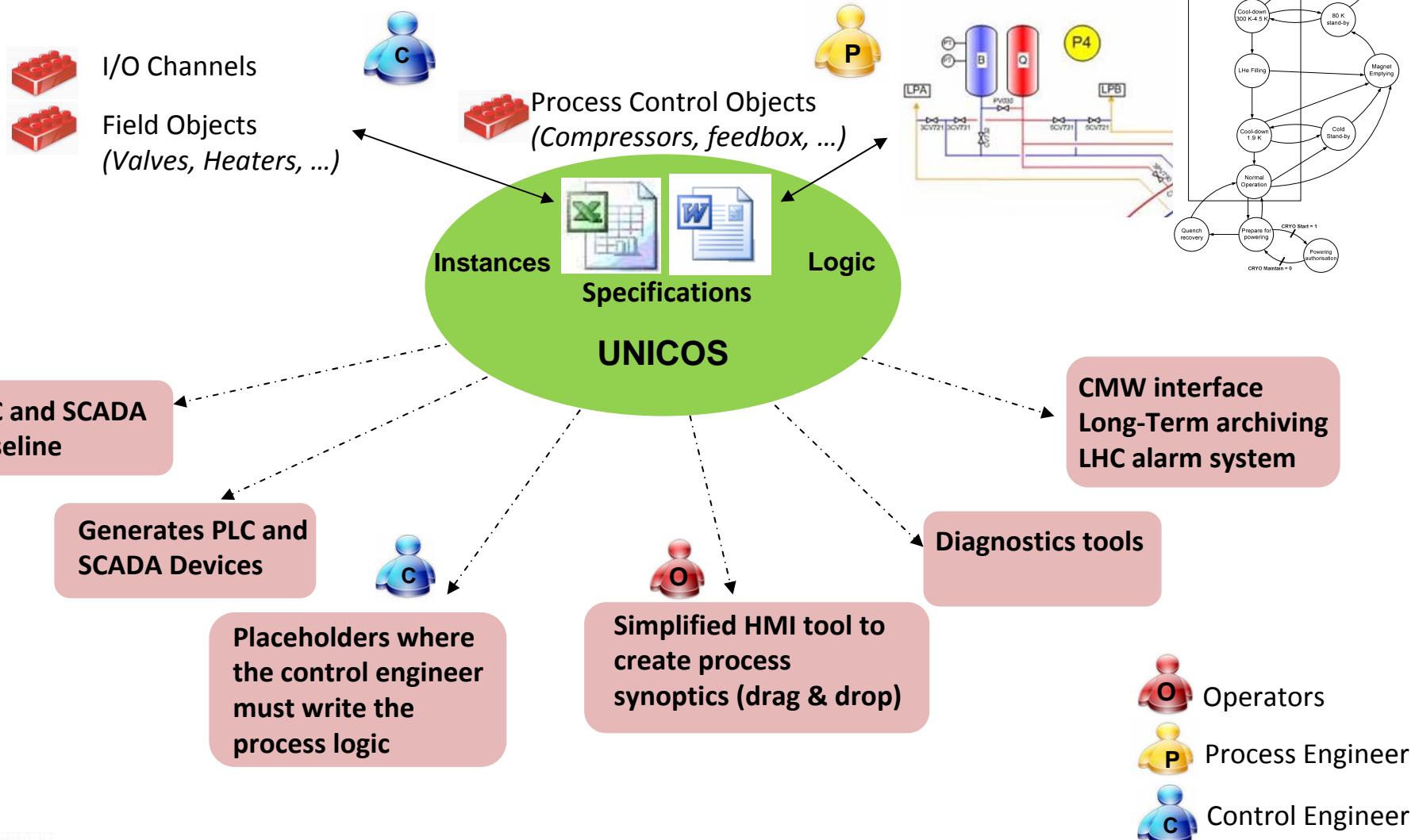
3.- Frameworks

- Front-End Software Architecture*
 - ✓ CERN accelerator real-time software model
 - ✓ Deployed to Front-End computers (FECs) running Linux/LynxOS
- Cryogenics application 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

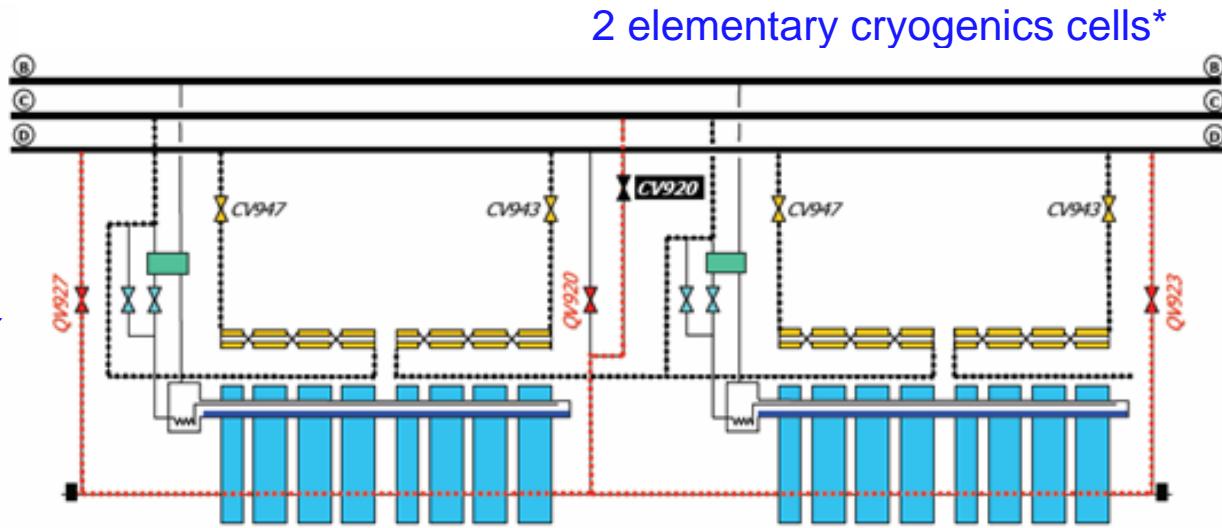
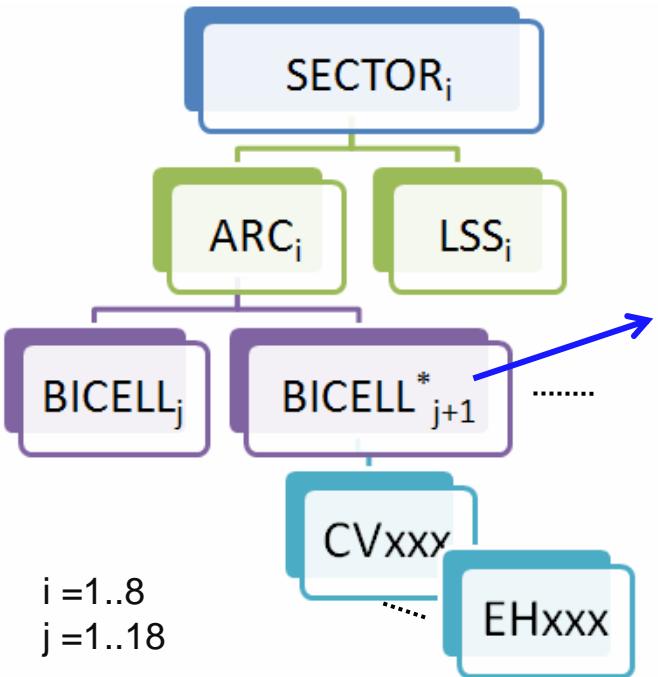


* Ref: "Front-End Software Architecture", M. Arruat, et all. (ICALEPCS 07)

■ UNified Industrial COntrOl System



Sector Cryogenics Process Control Objects



- **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)

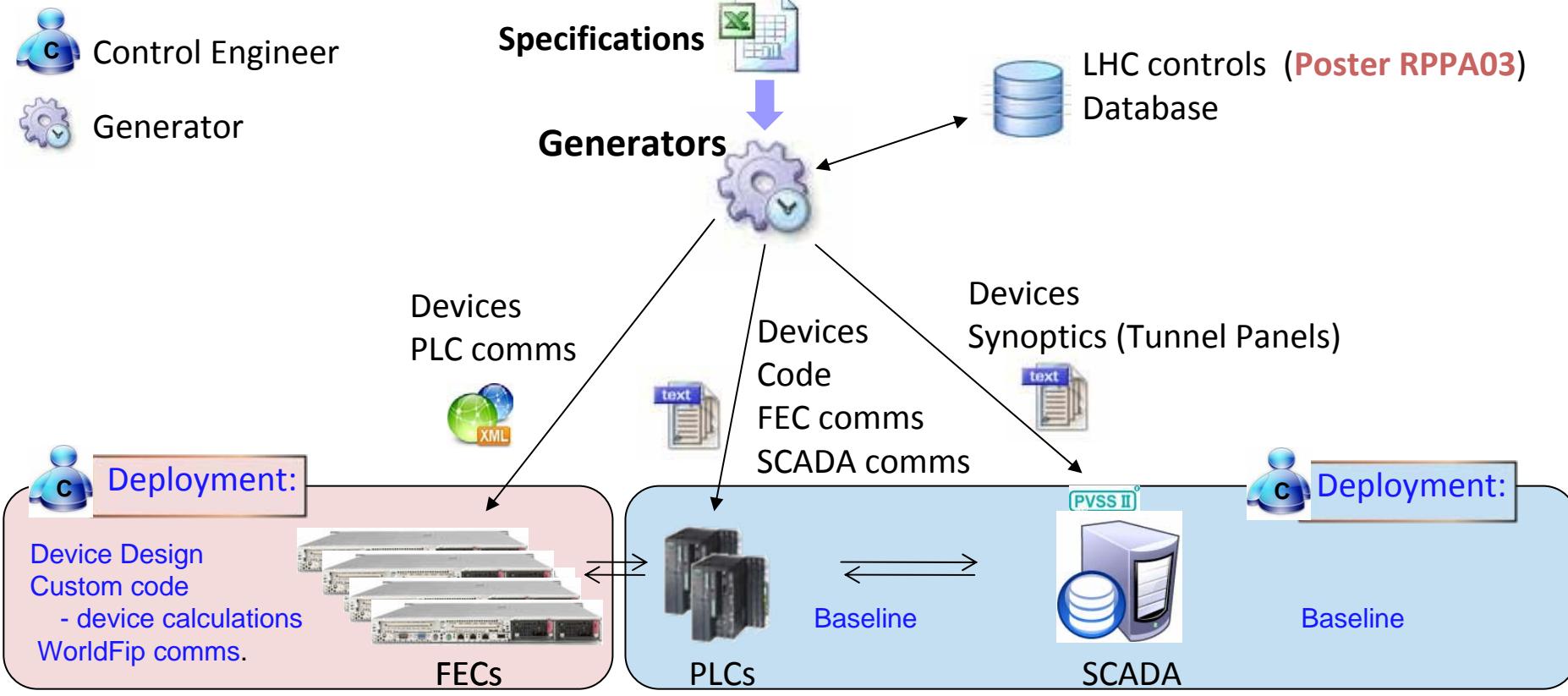
Objects	Tunnel
Analog Inputs	12136
Analog Outputs	4856
Digital Inputs	4536
Digital Outputs	1568
Close Loop Controllers	3680

Process Decomposition: Controllers example

LHC	Sector	Arc	Bi-cell
3680	500	250	20

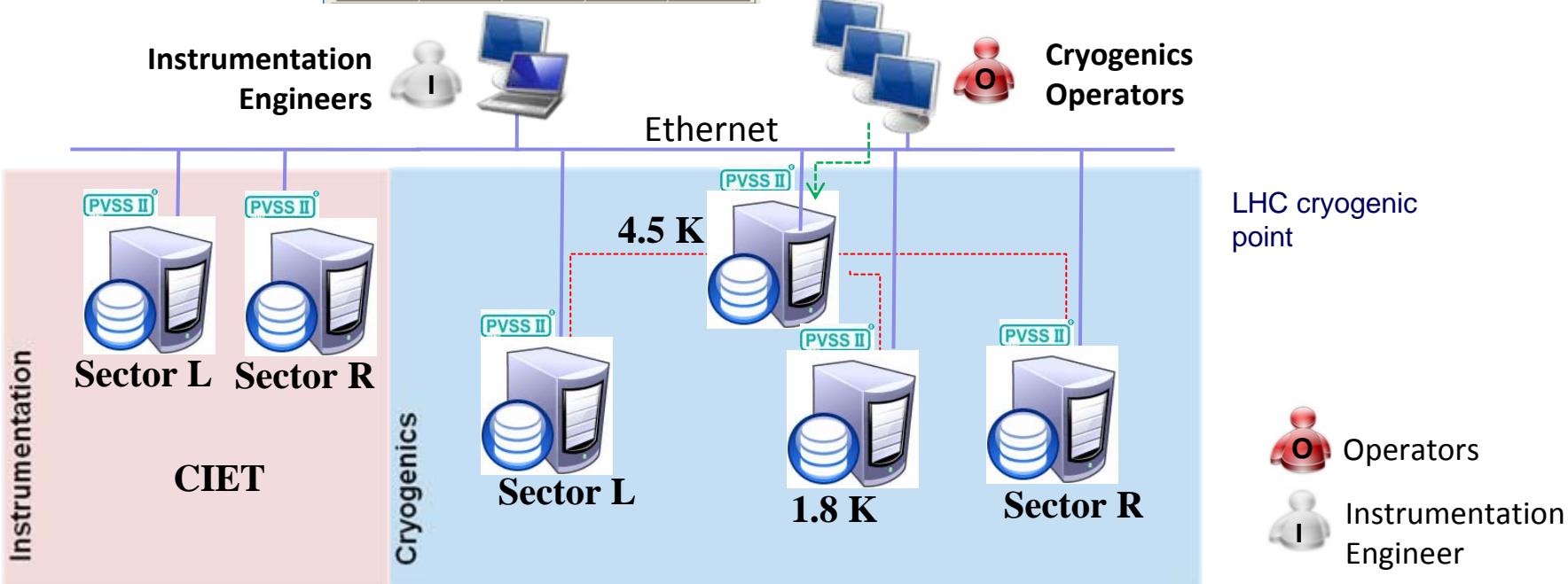
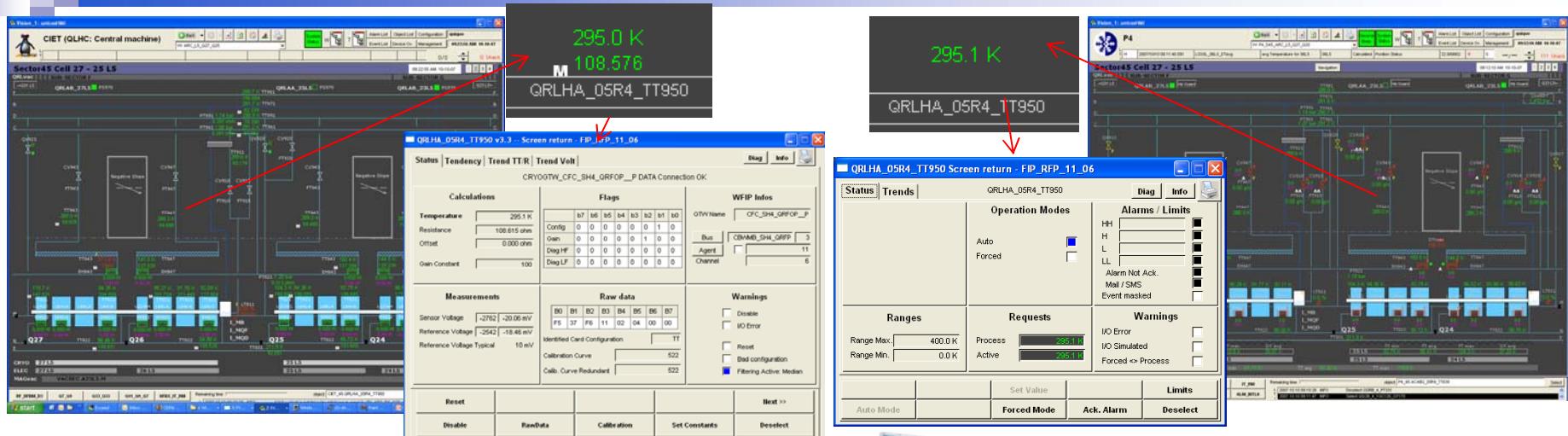
3.- Automatic generation Tools UNICOS & FESA integration

- ✓ Minimize hand code activities and focus on specific control logic
- ✓ Versioning mechanism to trace all the instances and allow different generation speeds
- ✓ Generation time of a complete LHC sector : ~ 1 day



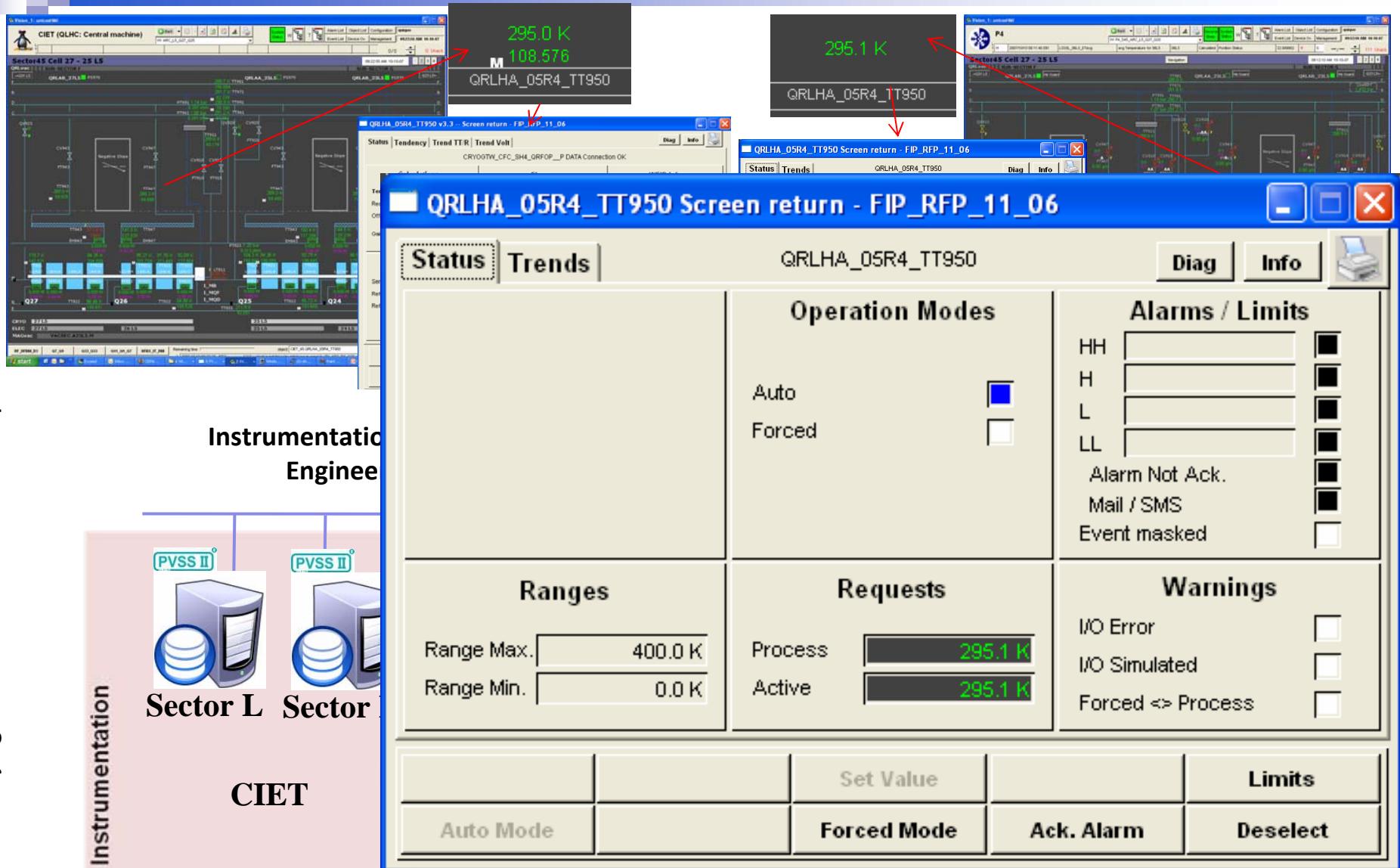
3.- Frameworks

UNICOS SCADA Structure



3.- Frameworks

UNICOS SCADA Structure



3.- Frameworks

UNICOS SCADA Structure

QRLHA_05R4_TT950 v3.3 -- Screen return - FIP_RFP_11_06

Status | Tendency | Trend TT/R | Trend Volt

CRYOGTW_CFC_SH4_QRFOP__P DATA Connection OK

Calculations		Flags								WFIP Infos	
Temperature	295.1 K	b7	b6	b5	b4	b3	b2	b1	b0	GTW Name	CFC_SH4_QRFOP__P
Resistance	108.615 ohm	Config	0	0	0	0	0	1	0	Bus	CBWMB_SH4_QRFP
Offset	0.000 ohm	Gain	0	0	0	0	1	0	0	Agent	3
Gain Constant	100	Diag HF	0	0	0	0	0	0	0	Channel	11
		Diag LF	0	0	0	0	0	0	0		6

Measurements		Raw data								Warnings	
Sensor Voltage	-2762	-20.06 mV	B0	B1	B2	B3	B4	B5	B6	B7	<input type="checkbox"/> Disable
Reference Voltage	-2542	-18.46 mV	F5	37	F6	11	02	04	00	00	<input type="checkbox"/> I/O Error
Reference Voltage Typical	10 mV	Identified Card Configuration								TT	<input type="checkbox"/> Reset
		Calibration Curve								522	<input type="checkbox"/> Bad configuration
		Calib. Curve Redundant								522	<input checked="" type="checkbox"/> Filtering Active: Median

Reset					Next >>
Disable	RawData	Calibration	Set Constants	Deselect	

Alarms / Limits

- m Not Ack.
- / SMS
- masked

Warnings

- ror
- mulated
- ed <> Process

Limits

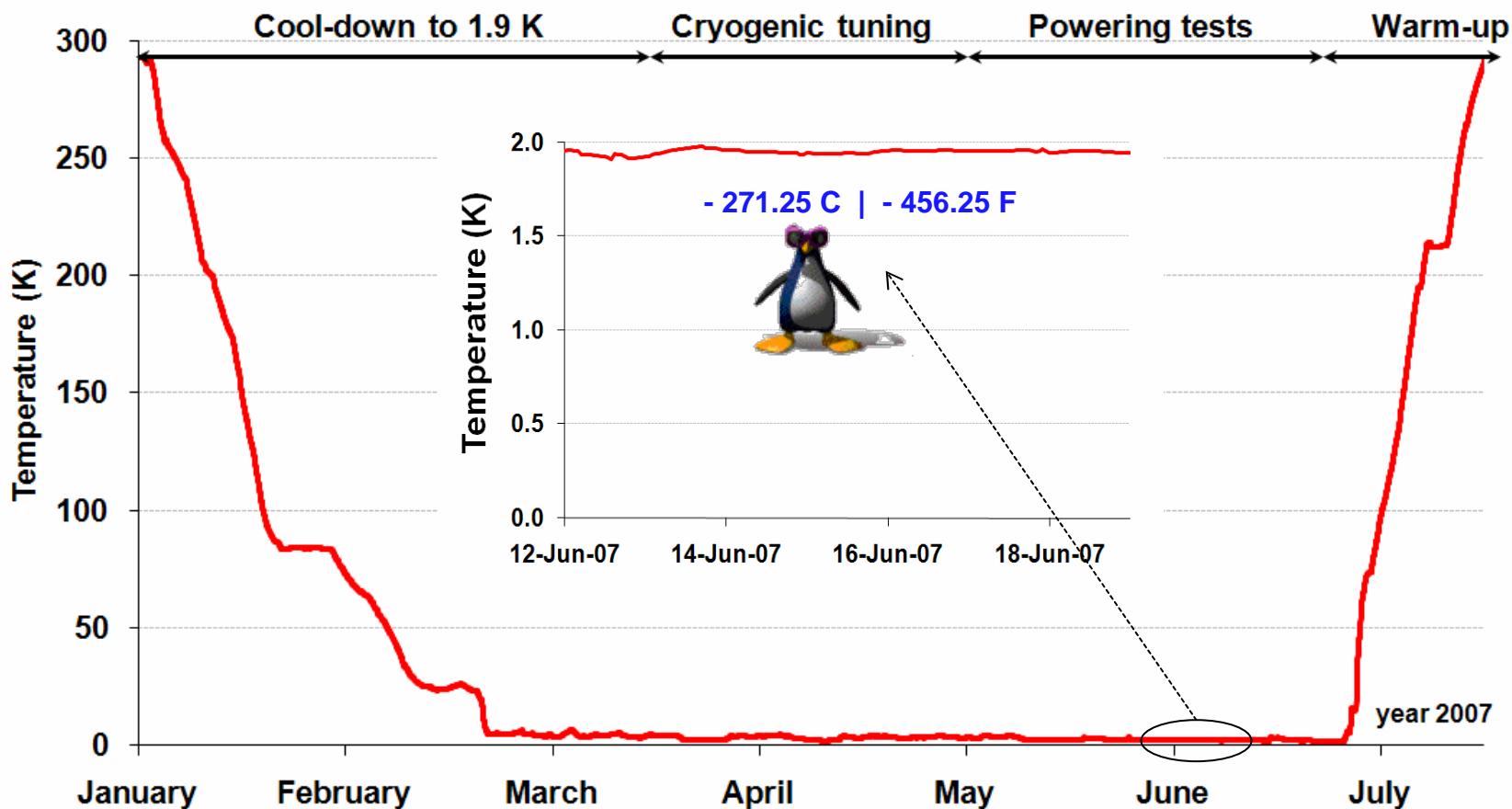
Deselect

4.- Conclusions



- Successful integration of UNICOS and FESA frameworks
 - ✓ Industrial approach
 - ✓ CERN accelerator software model
- Generation tools
 - ✓ Avoid synchronization tasks and concentrate on the specific control logic
 - ✓ Rapid prototyping & optimal regeneration mechanisms
- Cryogenics control system fully commissioned (LHC Sector) [1/8 machine]
 - ✓ Highly distributed and radiation environment
 - ✓ Heterogeneous control equipments
 - ✓ Scalability and openness (LHC services)
 - ✓ Currently in production giving entire satisfaction to cryogenics and hardware commissioning operators

World's largest superconducting installation cooled by helium !



- AB Controls Group (Industrial Systems Section)
- UNICOS
- FESA
- Cryogenics Group @ CERN
- LHC commissioning

<http://ab-dep-co-is.web.cern.ch/ab-dep-co-is/>
<http://ab-project-unicos.web.cern.ch/ab-project-unicos/>
<http://project-fesa.web.cern.ch/project-fesa/>
<http://at-div-acr.web.cern.ch/at-div-acr/>
<http://lhc.web.cern.ch/lhc/>

Thanks to all people involved in the project: CERN: **AB/CO, AT/ACR**