EN Engineering Department

PROCOS: a Real Time Process Simulator Coupled to the Control System

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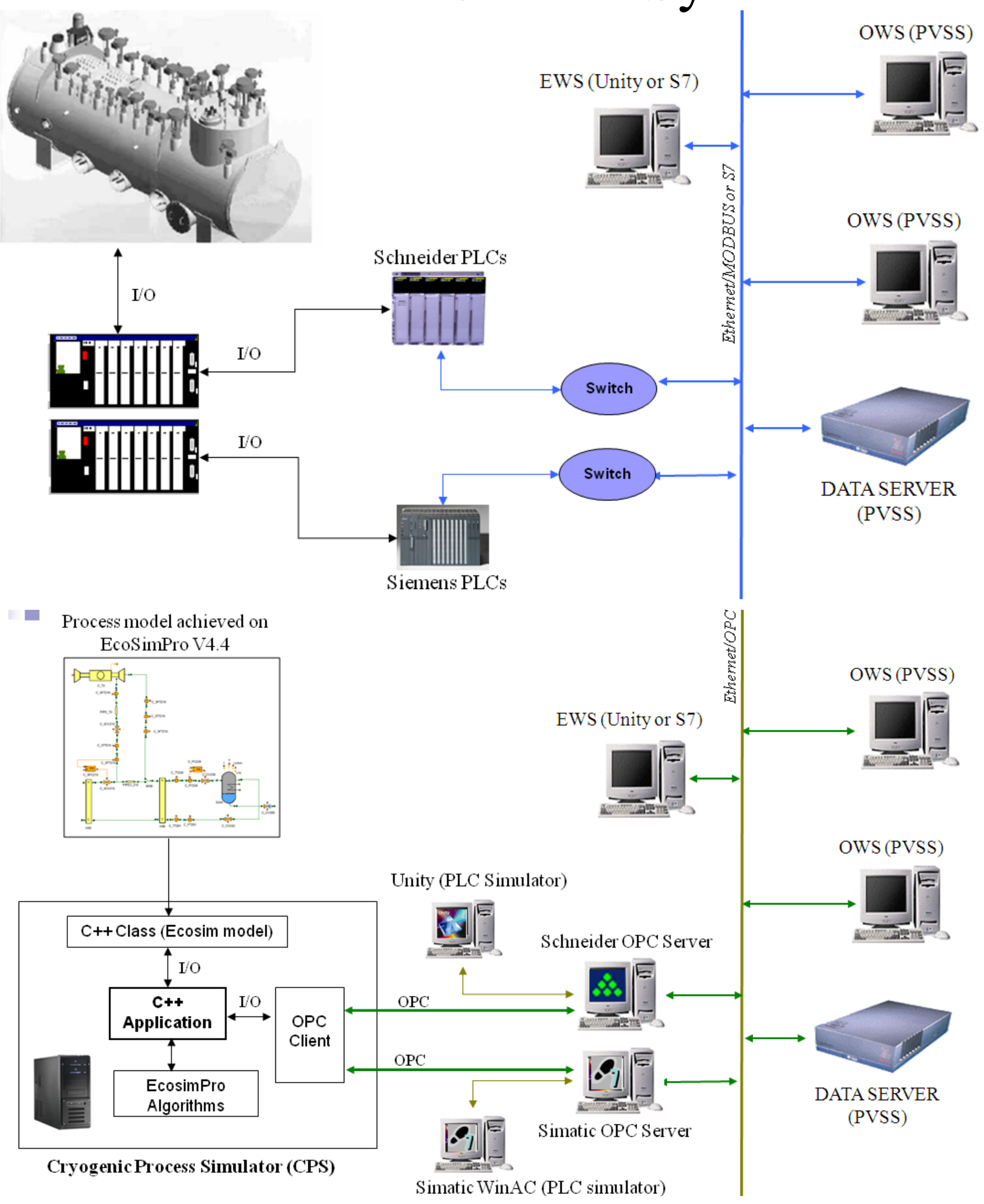
2009 ICALEPCS

Abstract

This poster presents the design of a simulator of a large-scale control system for the cryogenics of lhc and presents the results obtained. The simulator follows the real system architecture and is therefore made of a number of components sharing data through a standard protocol. The modeling of the process makes use of ecosimpro, the commercial simulation software for industrial systems. Each cryogenic component is represented by a set of differential-algebraic equations; helium properties are obtained from a specialized library. The control system is simulated with a plc-simulator running the process control logic implemented for the cryoplant. These are then connected to the same scada system used to operate the cryogenic plant.thus, both the actual control policy and the supervision systems are reused during simulation. The objectives of this work were threefold: first, to provide tools for operators training, second, to test new control strategies before their implementation.

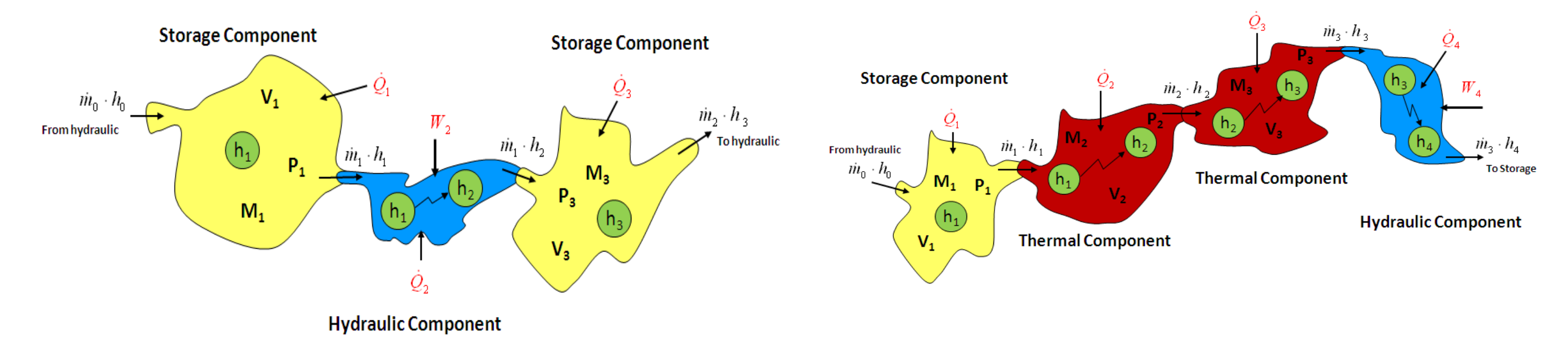
Simulator Architecture Similar to Installed Control System



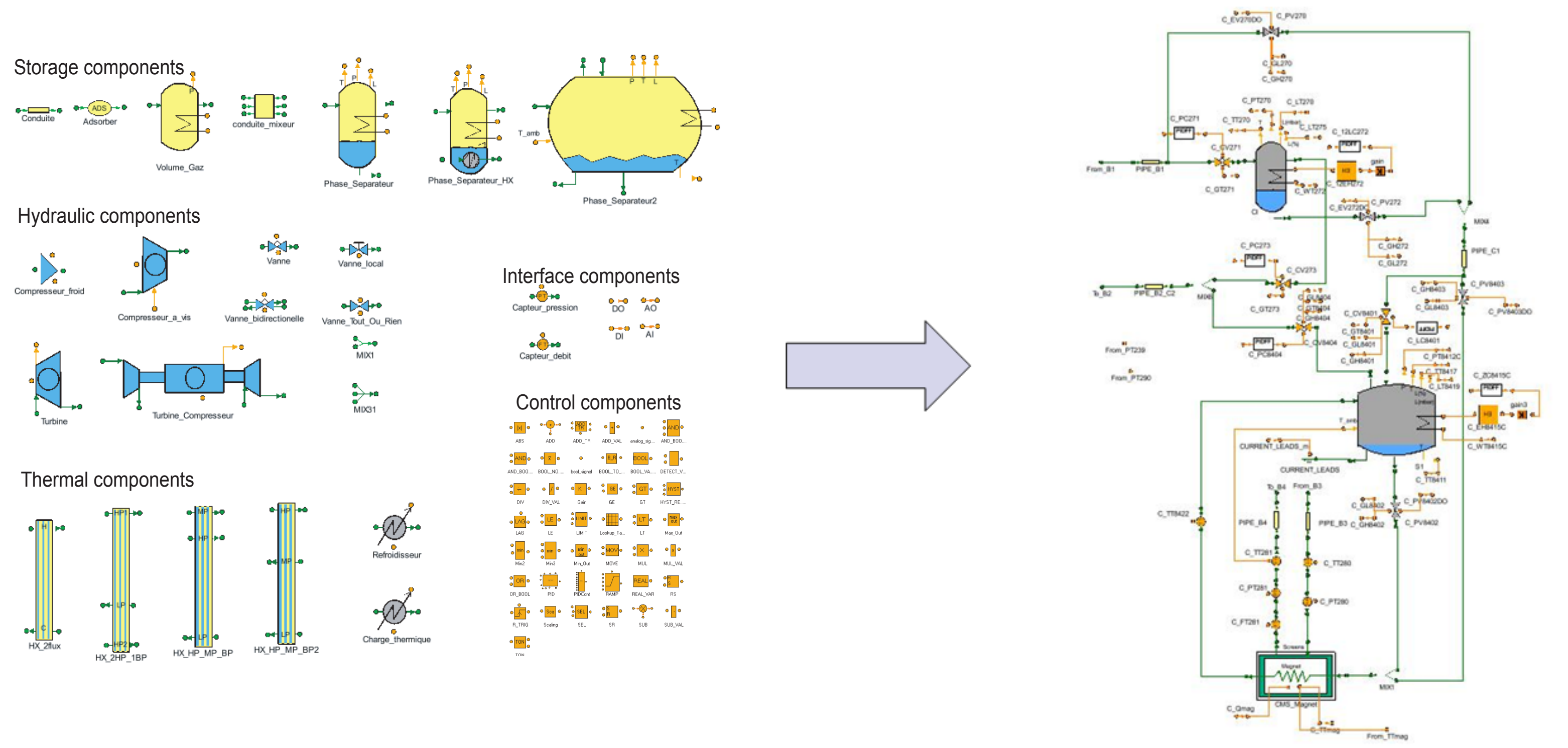
Complete Cryogenic and Control Simulation Suite

The developed simulation components library contains five main categories. All components have been validated independently :

- Storage components, such as ducts, phase separators, etc.
- Hydraulic components imposing a mass flow, such as valves, compressors, turbines, etc.
- Thermal components that can be composition of the two above with the addition of heat transfer, heat exchangers, heaters, etc.
- Interface components to connect the simulator to the control system.
- Control components to perform control action in the simulator.



Process Model component connections



Drag and drop graphical model construction
Including connection to PLC simulators

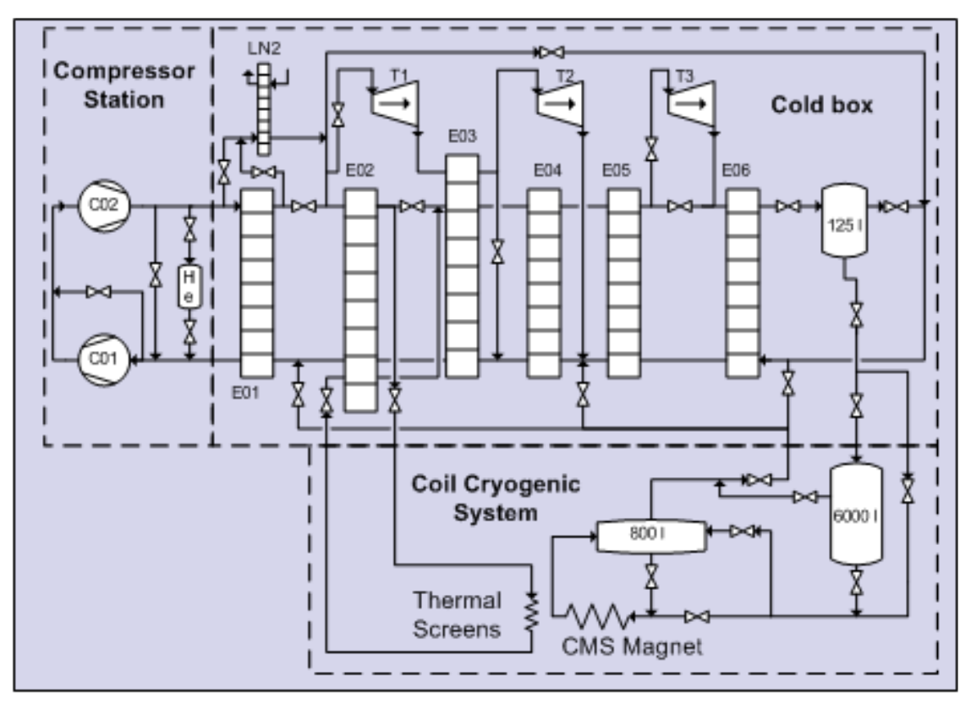
The simulator is generally faster than real time. Nevertheless, real-time is not reached for the 4.5 K refrigerators of the LHC sectors because of the large number of coupled equations generated by heat-exchangers.

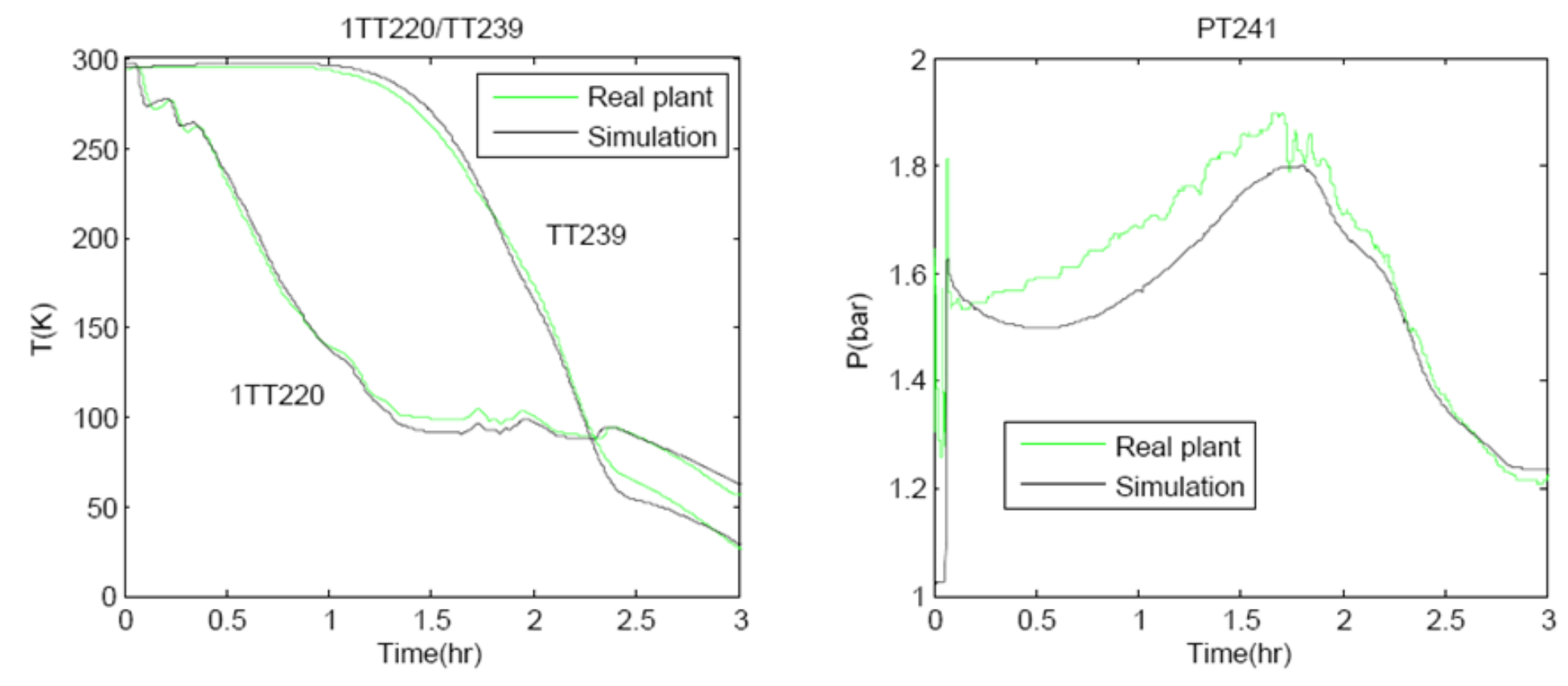
System	DAE	Derivative variables	Simulation Speed*
Central helium liquefier	2063	170	x18
Test benches refrigerator	2268	194	x15
CMS cryoplant	3334	296	x8
LHC 1.8 K cryoplant	3056	249	x83
LHC 4.5 K refrigerator	4677	392	x0.5

Performances

Outstanding Simulation Results

CMS Detector Cryoplant





Temperature before the 2nd HX and after the last HX

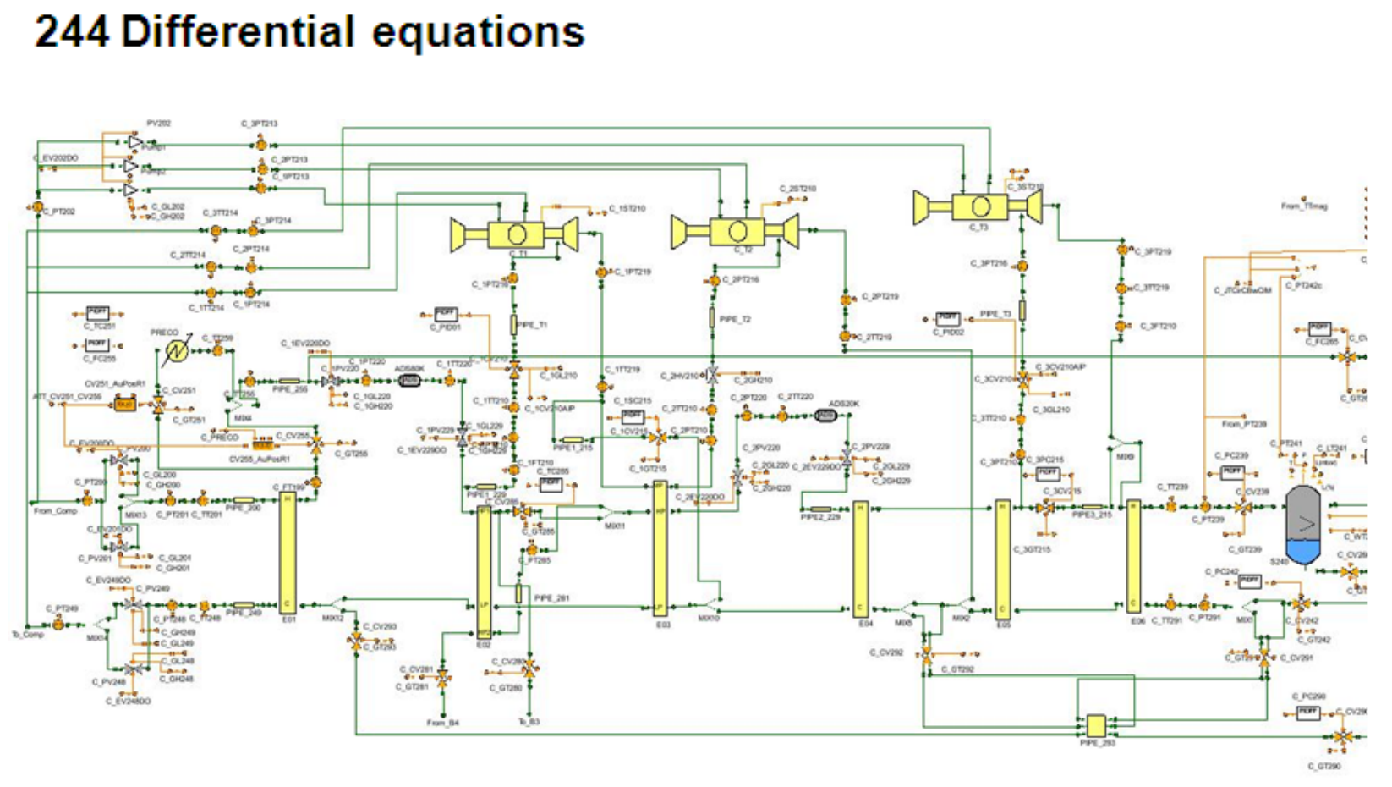
Pot Pressure

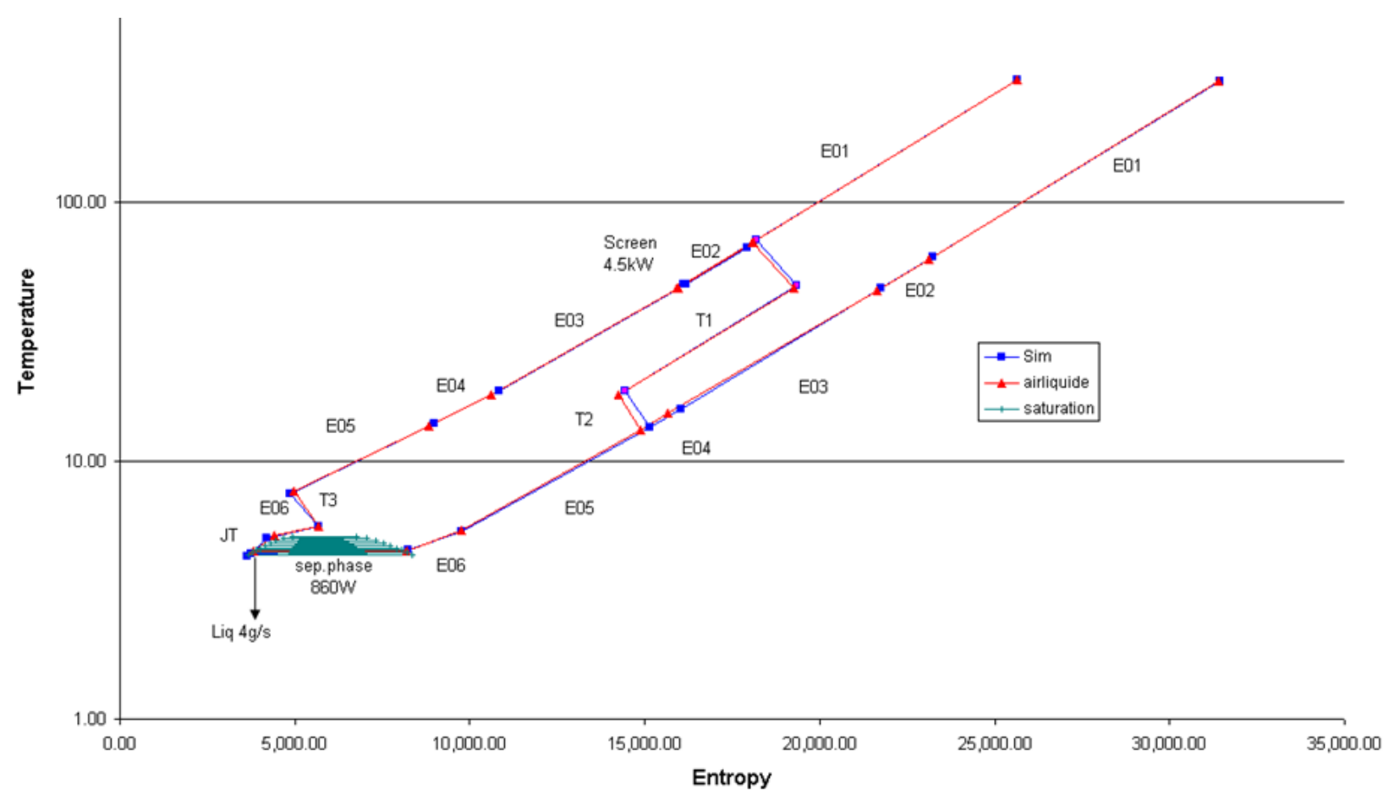
18 subsystems

3310 algebraic equations

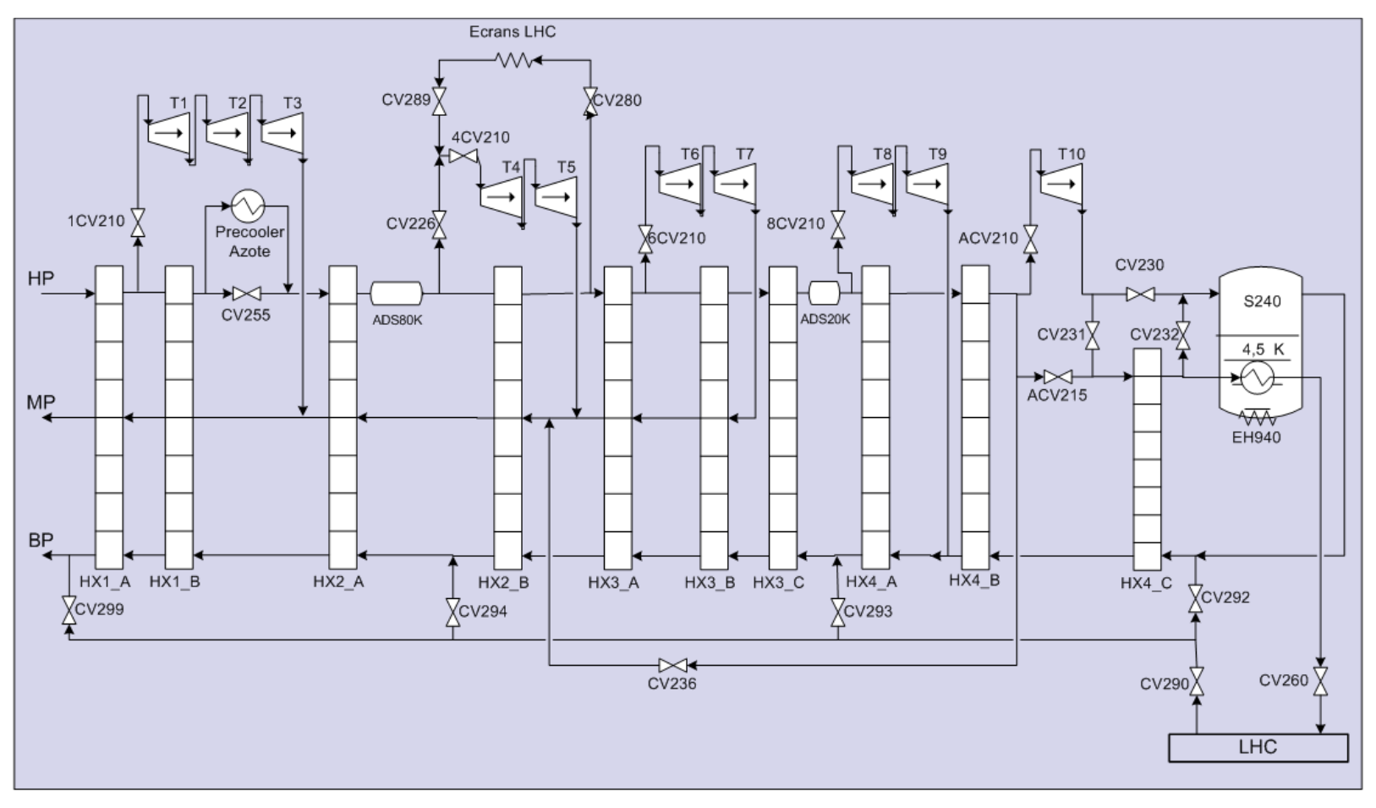
244 Differential equations

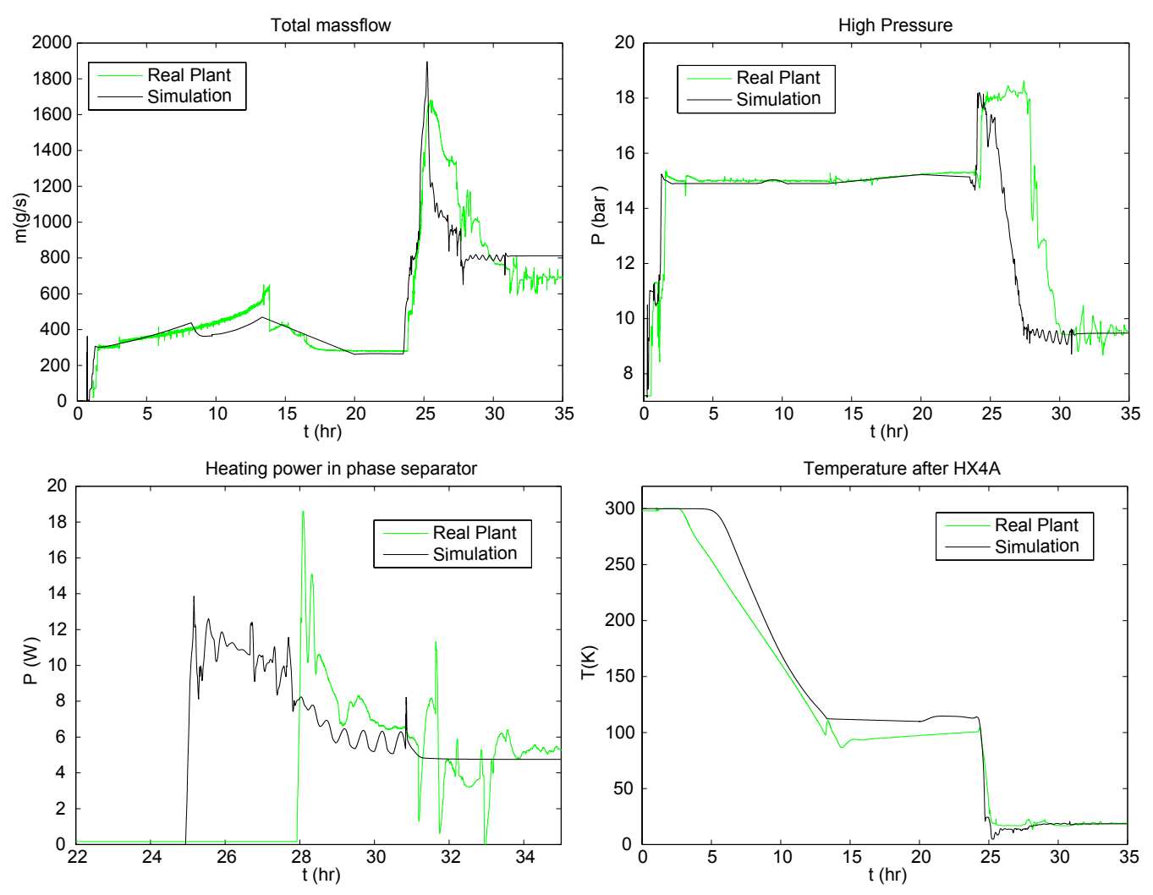
→ Simulations allow us to validate models and simulator





LHC 4.5K Refrigerator





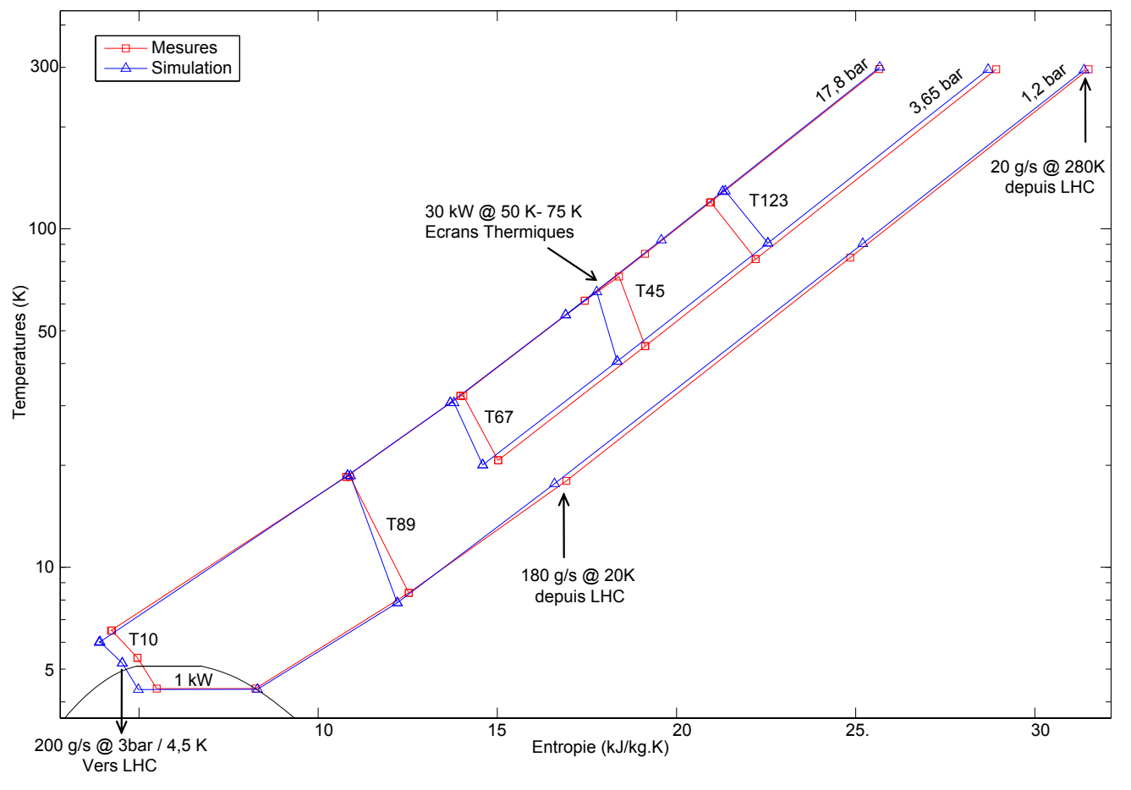
31 Subsystems

4677 Algebraic equations

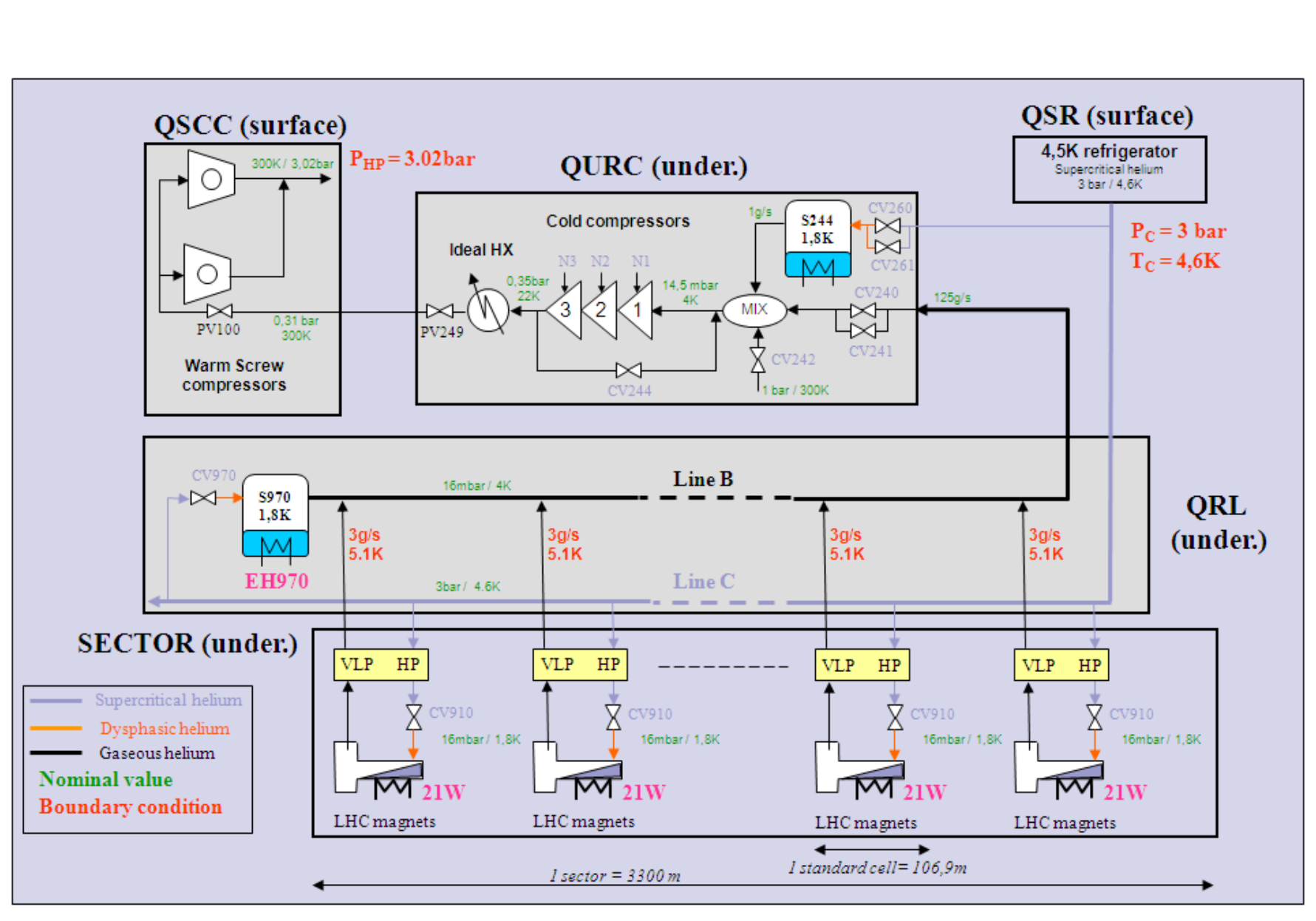
392 Differential equations

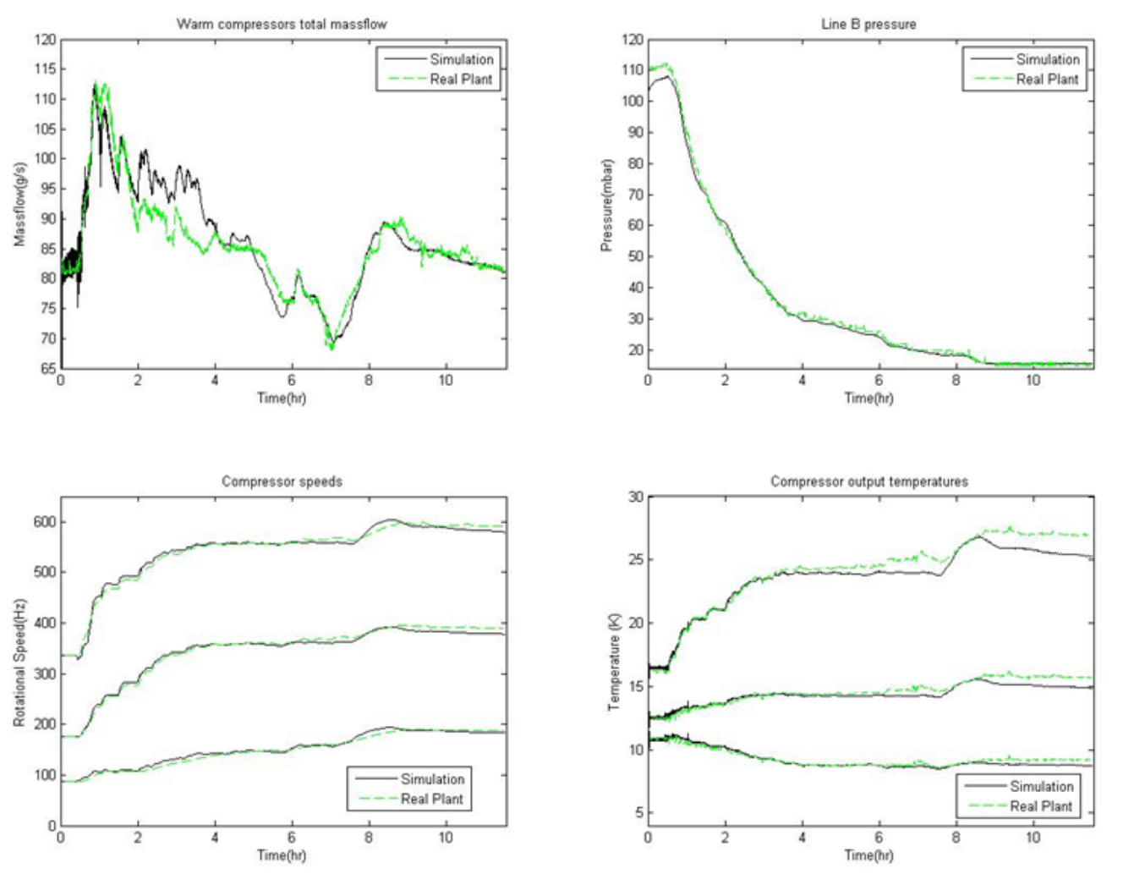
→New Internal Model Control for HP regulation.

→New Floating Pressure strategy to reduce power consumption



LHC 1.8K Refrigeration Unit



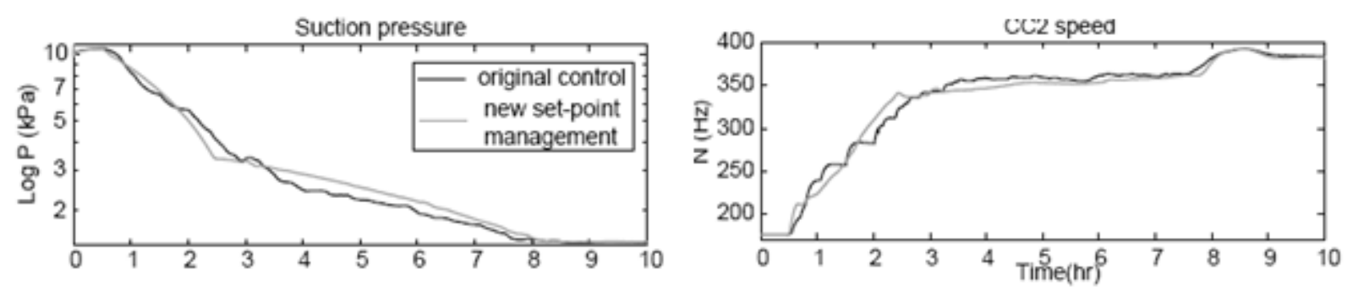


6 subsystems

2800 algebraic equations

210 Differential equations

→New set-point management for cold-compressors



CONCLUSION

The PROCOS components suite for cryogenic systems is now operational and has been used successfully to model optimize and commission several cryogenic systems at CERN. It will now be used to train the operation crews.

Two main challenges are still ahead of us:
- modelling developments must be made faster and easier
- for large systems, optimization are still necessary to reach acceptable simulation duration.

New feature will be introduced in the CERN generation tools to cope with this.New control system developments to other infrastructure system at CERN now justify the extension of the simulation capabilities of PROCOS to other types of continuous systems.