A Simulink Library of cryogenic components to generate control schemes for large refrigerators

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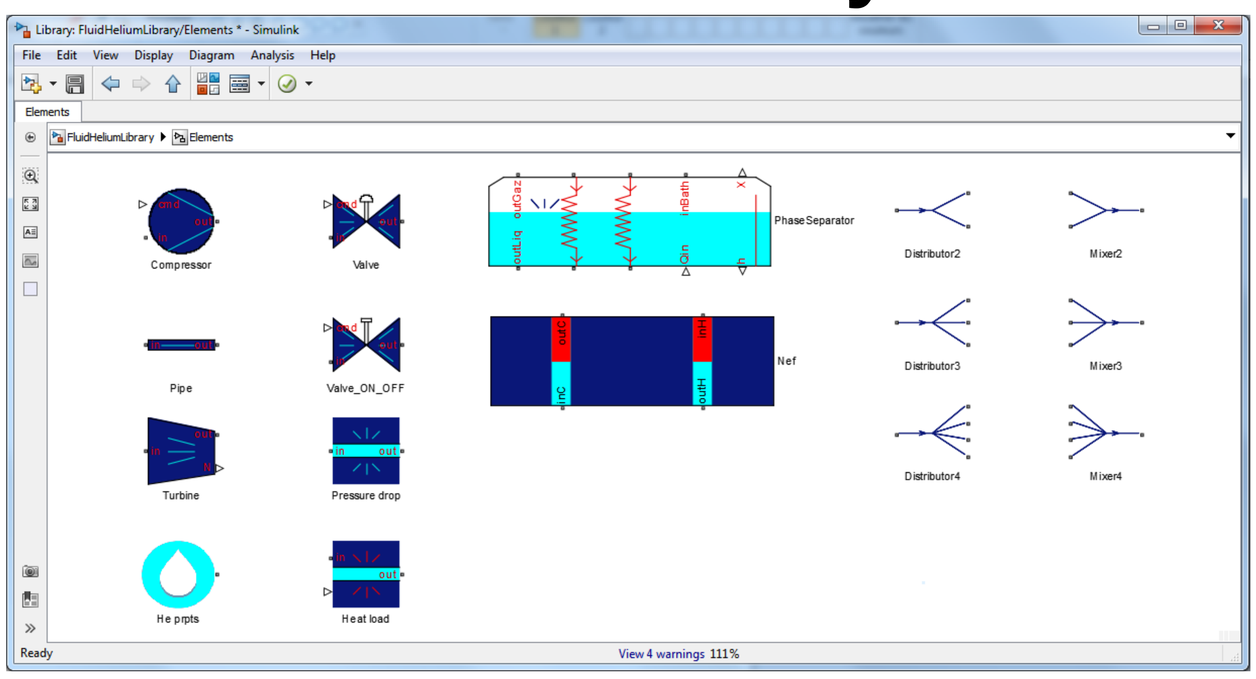
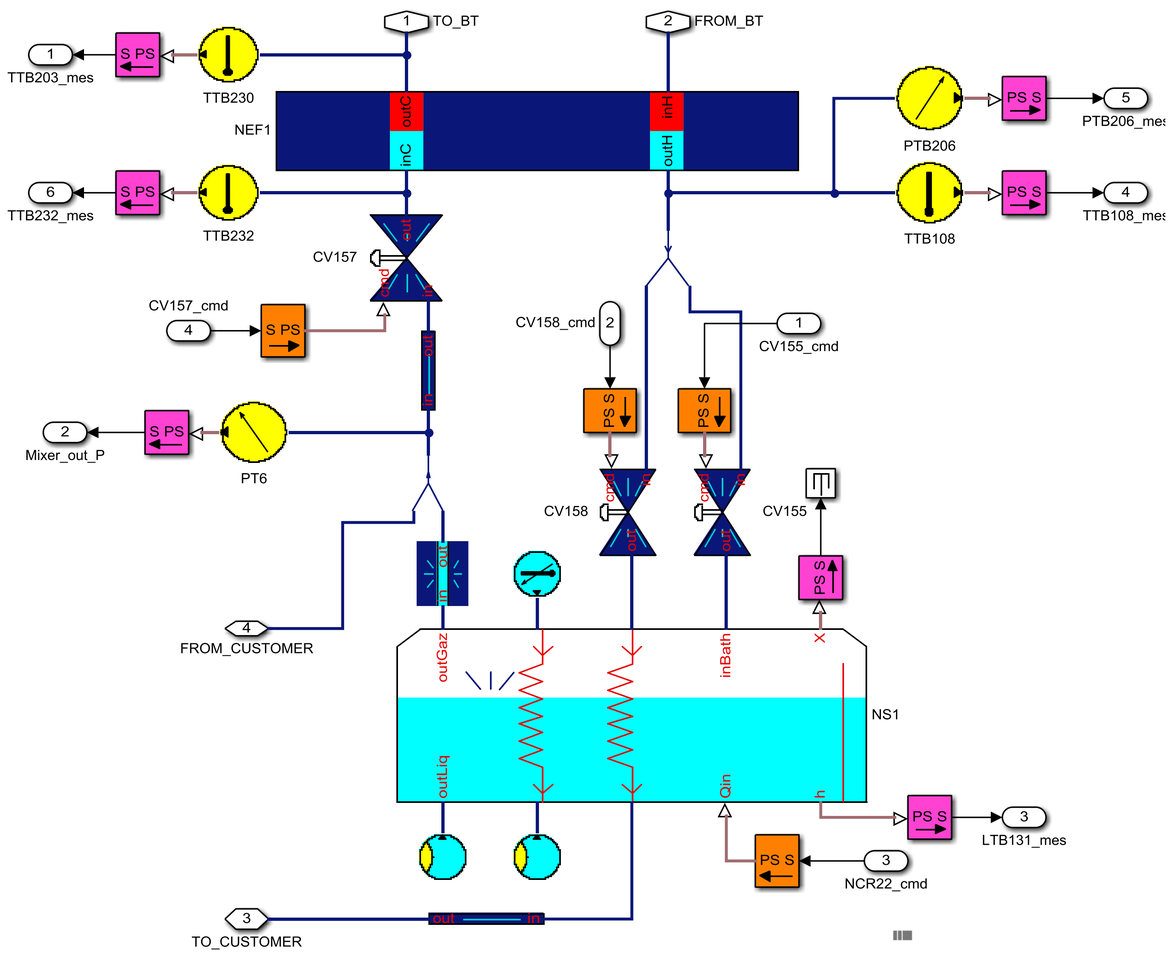
The aim of this work is to describe a generic methodology to model cryogenic plants and to synthesize control strategies for those witch are submitted to variable heat loads.

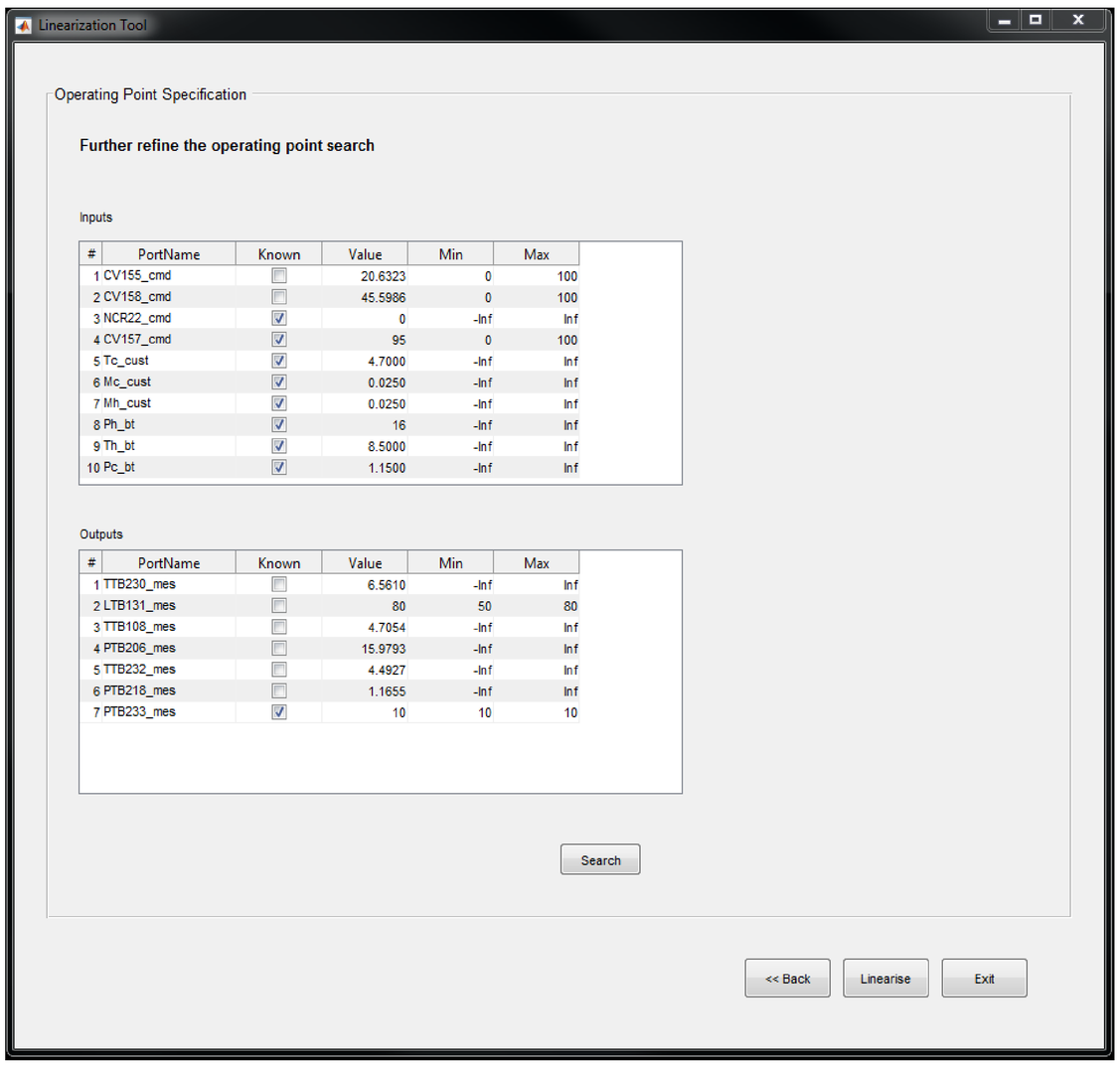
Simulink Library



Subsystem Construction



Operational point finder



JT cycle / SBT

Obtaining the model of the refrigerator for simulation and control purposes

$$\dot{x} = f(x, u, w)$$

x: state (temp., press., etc.)
u: manipulated variable (valve opening, …)
w: disturbances (boundary conditions)

Linear approximation

Obtaining the linear approximation of the model

$$\dot{x} = f(x, u, w) \Rightarrow \dot{x} = A\tilde{x} + B\tilde{u} + F\tilde{w}$$

Finding the constrained operating point of the machine

$$\frac{df(x, u, w)}{dt} = 0$$

$$A = \left.\frac{\partial f(x, u, w)}{\partial x}\right|_{\substack{x=x_0 \\ u=u_0 \\ w=w_0}}, B = \left.\frac{\partial f(x, u, w)}{\partial u}\right|_{\substack{x=x_0 \\ u=u_0 \\ w=w_0}}$$

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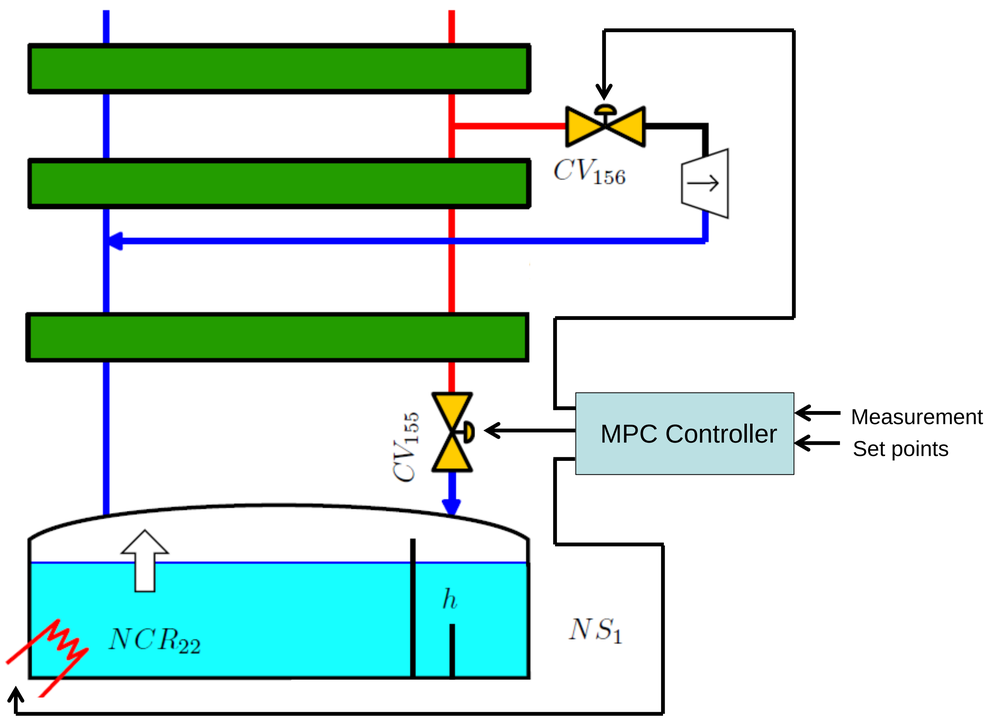
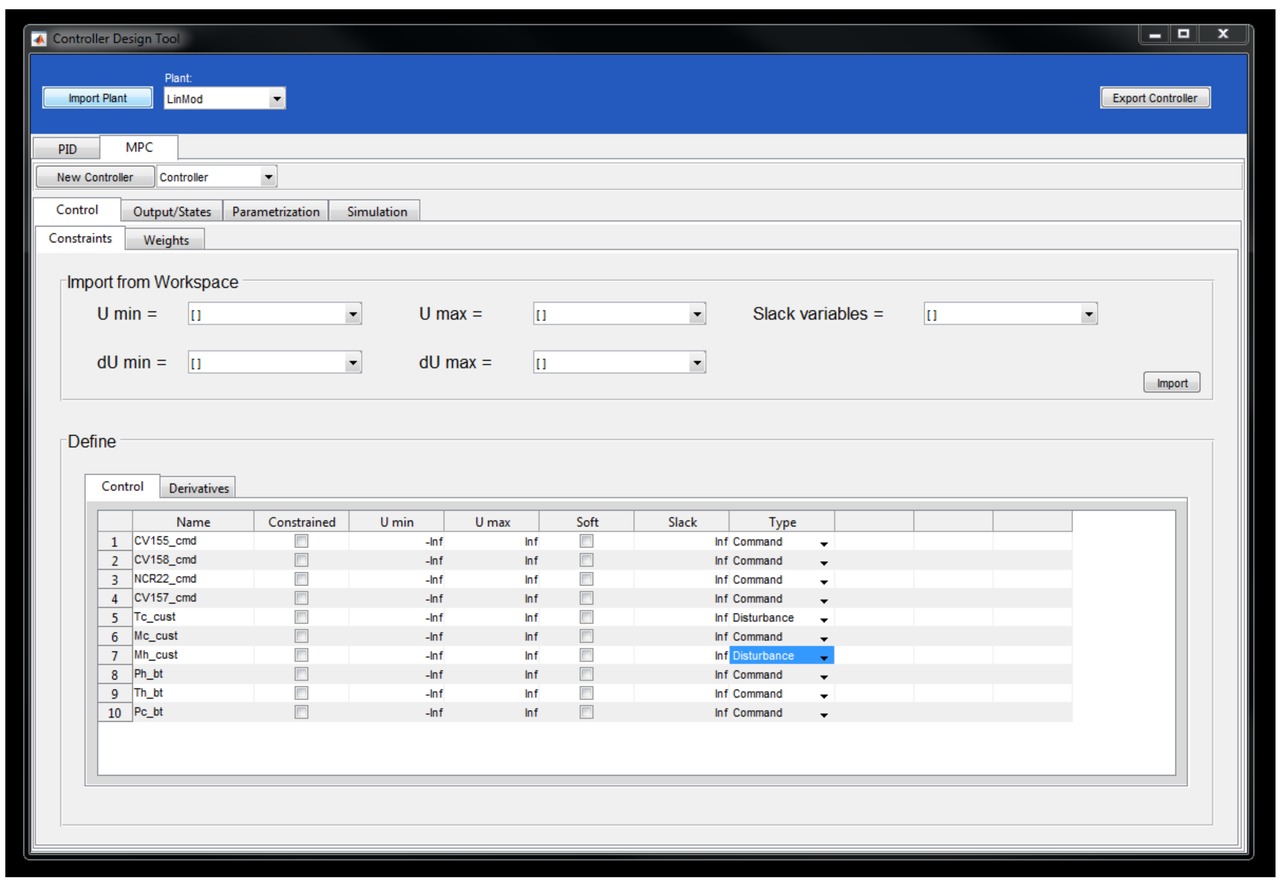
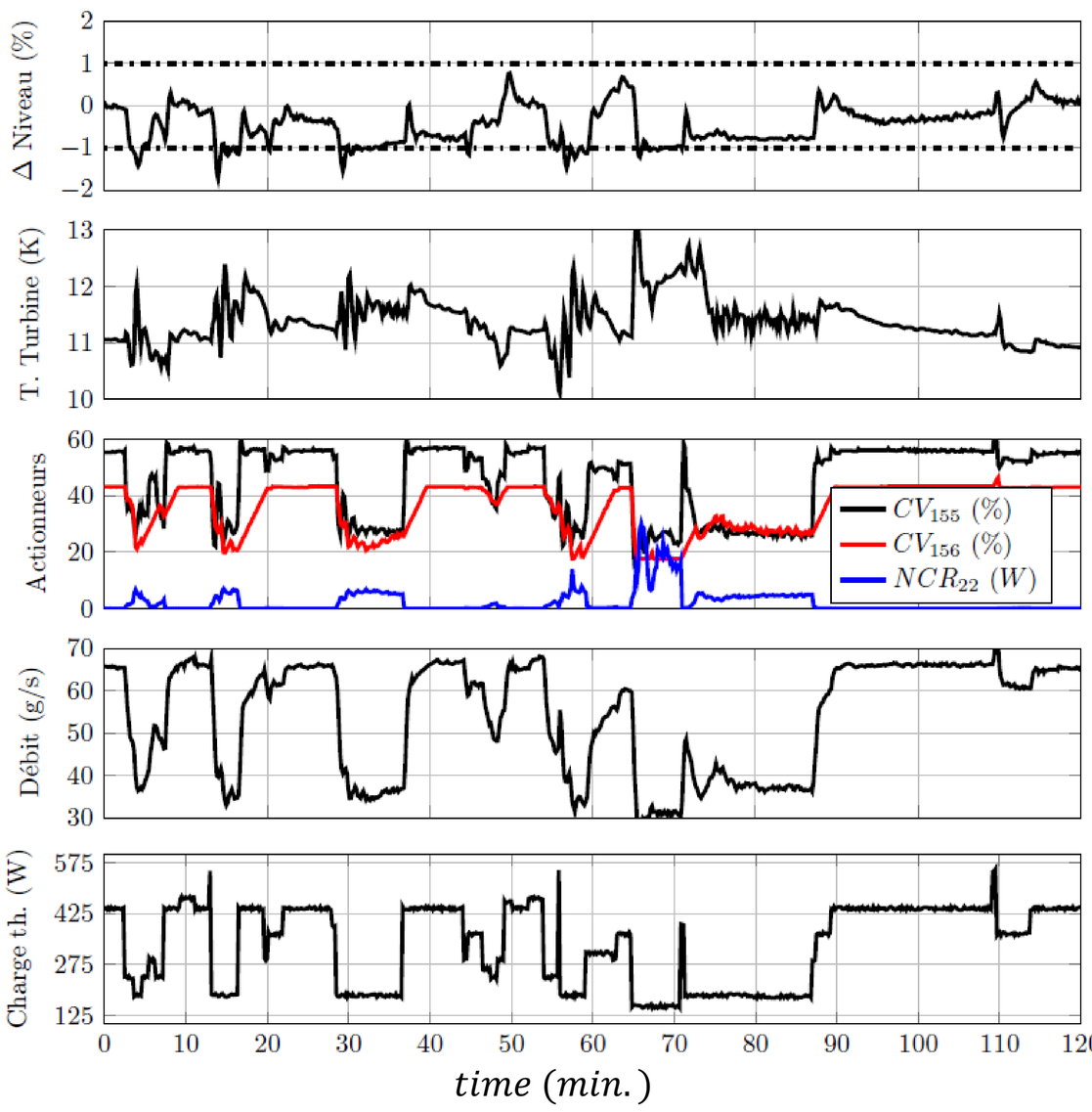
Software to generate:
- Advanced contrôle scheme
- PID controllers

Experimental results

SBT Cold Box



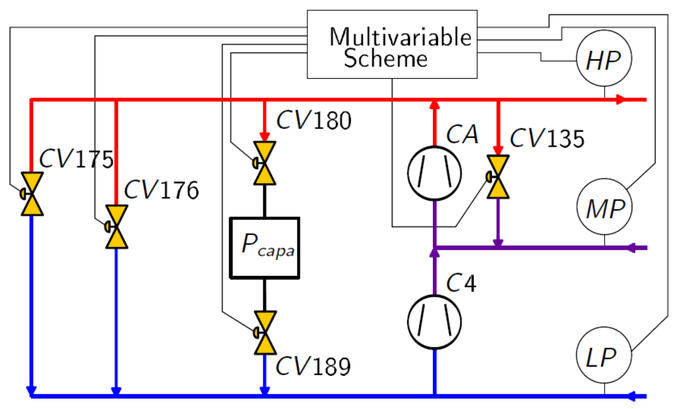


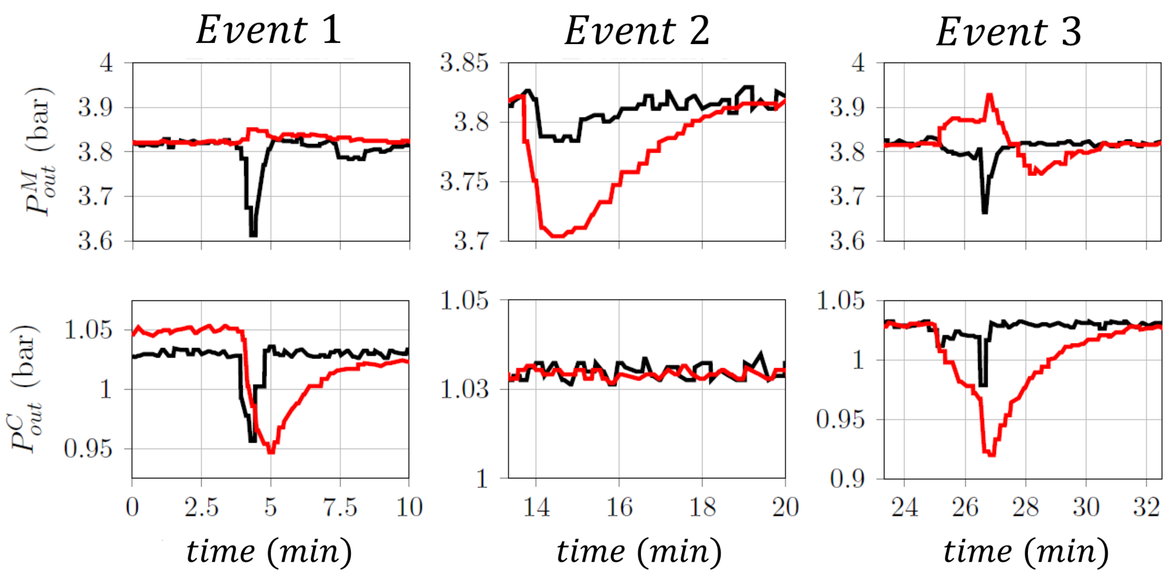


Measured variables are constrained as well as actuators : it provides operational safety

Absorbed flow-rate looks like the heat load
=>possible energy savings

CERN Warm Compression Station





--LQ
--PID

Low pressure is spending less time below atm pressure thanks to the advanced controller