Sub-system integration for the VBOX

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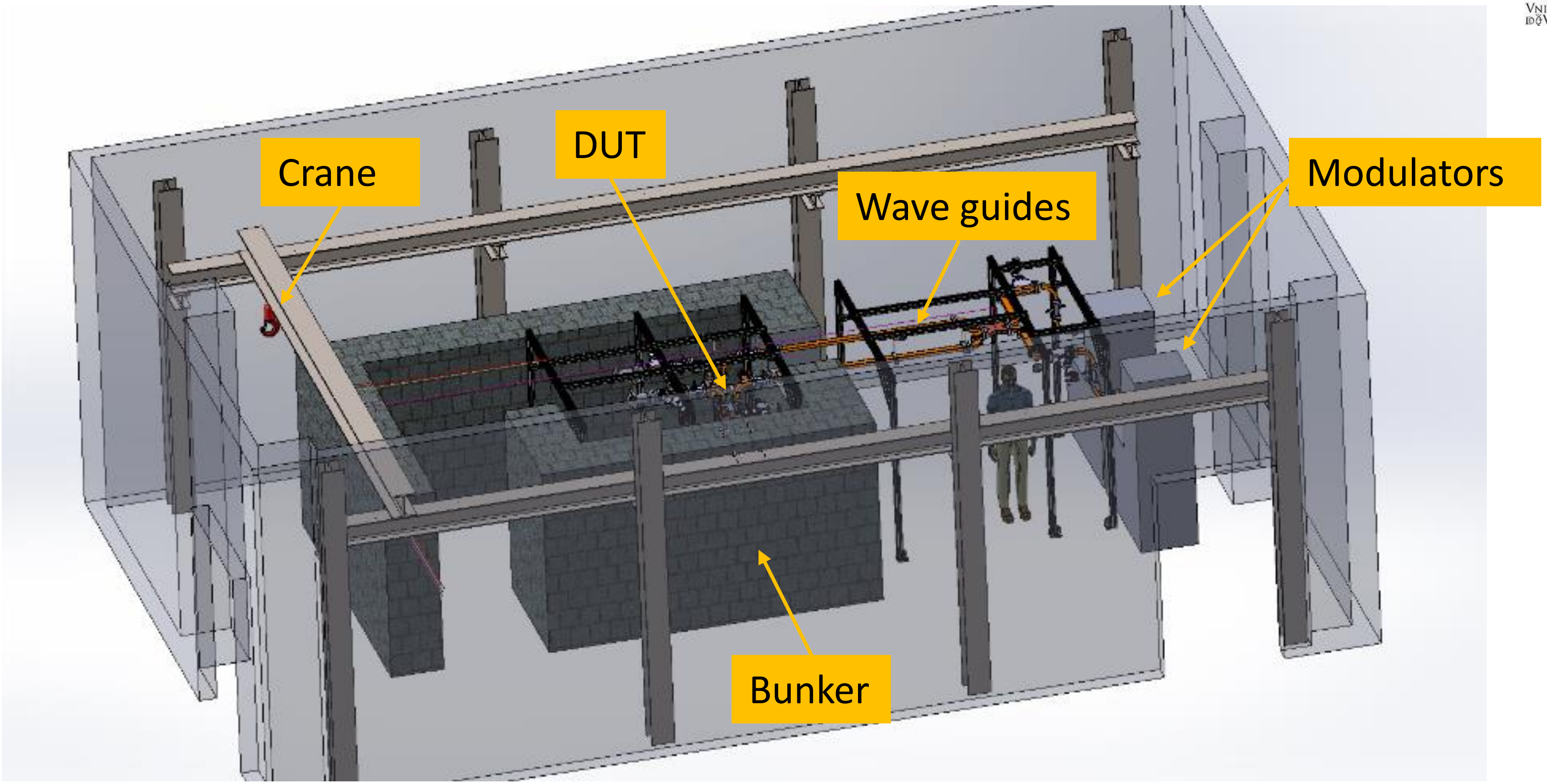
On behalf of the Group of Accelerator Physics (IFIC)

Outline

- Layout and integration
- Vacuum subsystem:
  - Vacuum equipment and system description
  - Vacuum simulations
  - Vacuum simulations: upgrade studies
- Cooling subsystem
  - Cooling plant
  - Demineralizer plant
  - Control system

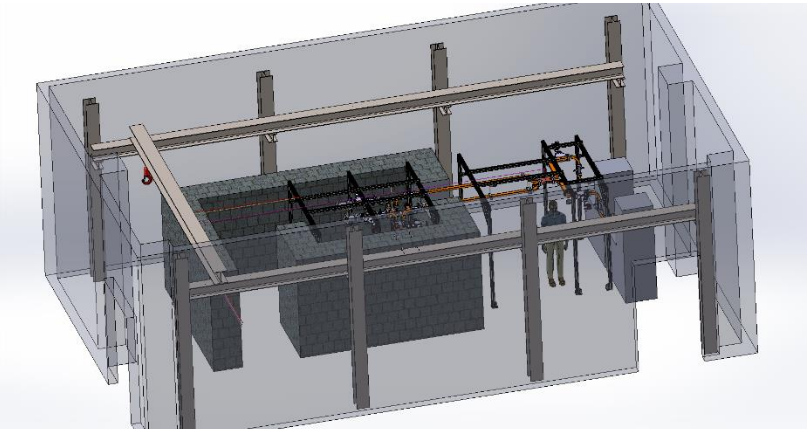
Layout and integration

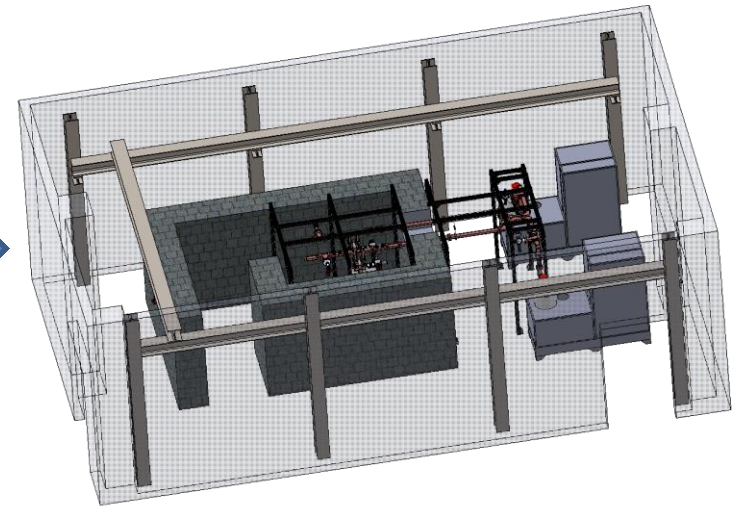
- 3D view of the VBOX lab

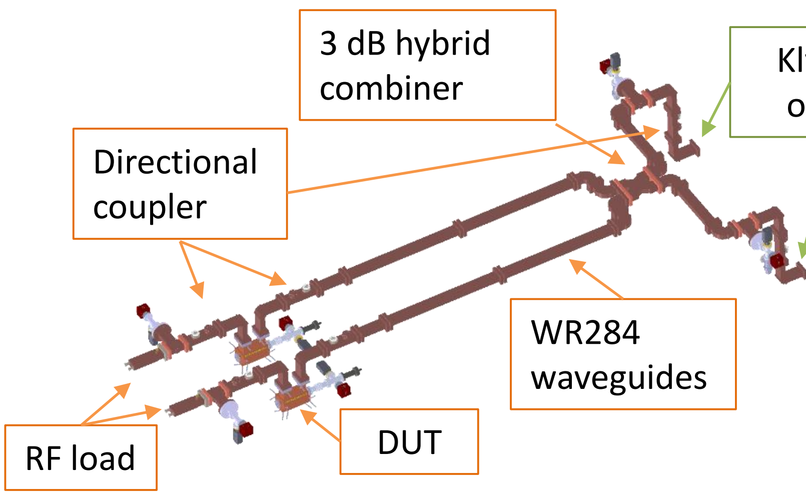


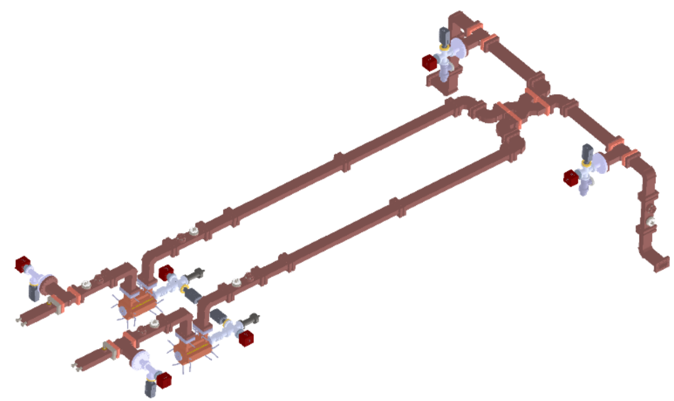
Layout and integration

- Changes in the dimensions of the modulators









Vacuum subsystem

- Ultra high vacuum system
  - Expected pressure ~ $5x10^{-8}$ mbar
- Turbo pumping group for primary pumping
  - Pfeiffer HiCube 80, Duo 3

Technical data

Backing pump	Duo 3
Cooling method, standard	Air
Flange (in)	DN 63 CF-F
Flange (out)	G 1/2"
Fore-vacuum safety valve	-
Mains requirement	230 V AC, 50/60 Hz
Pumping speed backing pump	2.5 m³/h
Pumping speed backing pump at 50 Hz	2.5 m³/h
Pumping speed for N_2	67 l/s
Turbopump	HiPace 80
Type	Turbo pumping station
Ultimate pressure	$< 5 \cdot 10^{-10}$ hPa | $< 3.75 \cdot 10^{-10}$ Torr | $< 5 \cdot 10^{-10}$ mbar
Weight	40.1 kg | 88.4 lb

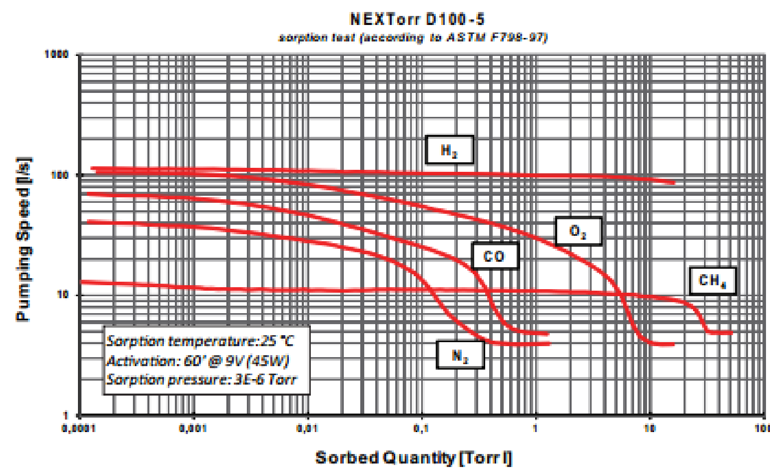
Pumping time does not contain run-up time and desorption.

  - Ready for gas (N_2) venting
  - Ready for leak detector connection

Vacuum subsystem

- Ultimate vacuum performed by ion pump + NEG cartridge
  - Nextorr D 100-5 pump
    - Extremely compact and light pump (2,2 Kg)
    - Ion pump and NEG cartridge in the same element
    - High pumping speed for all active gases
    - Pumping also noble gases and CH_4

Initial pumping speed (l/s)	Gas	NEG activated	NEG saturated
	O_2	100	4
	H_2	100	6
	CO	70	5
	N_2	40	4
	CH_4	15	5
	Argon[1]	6	6



Vacuum subsystem

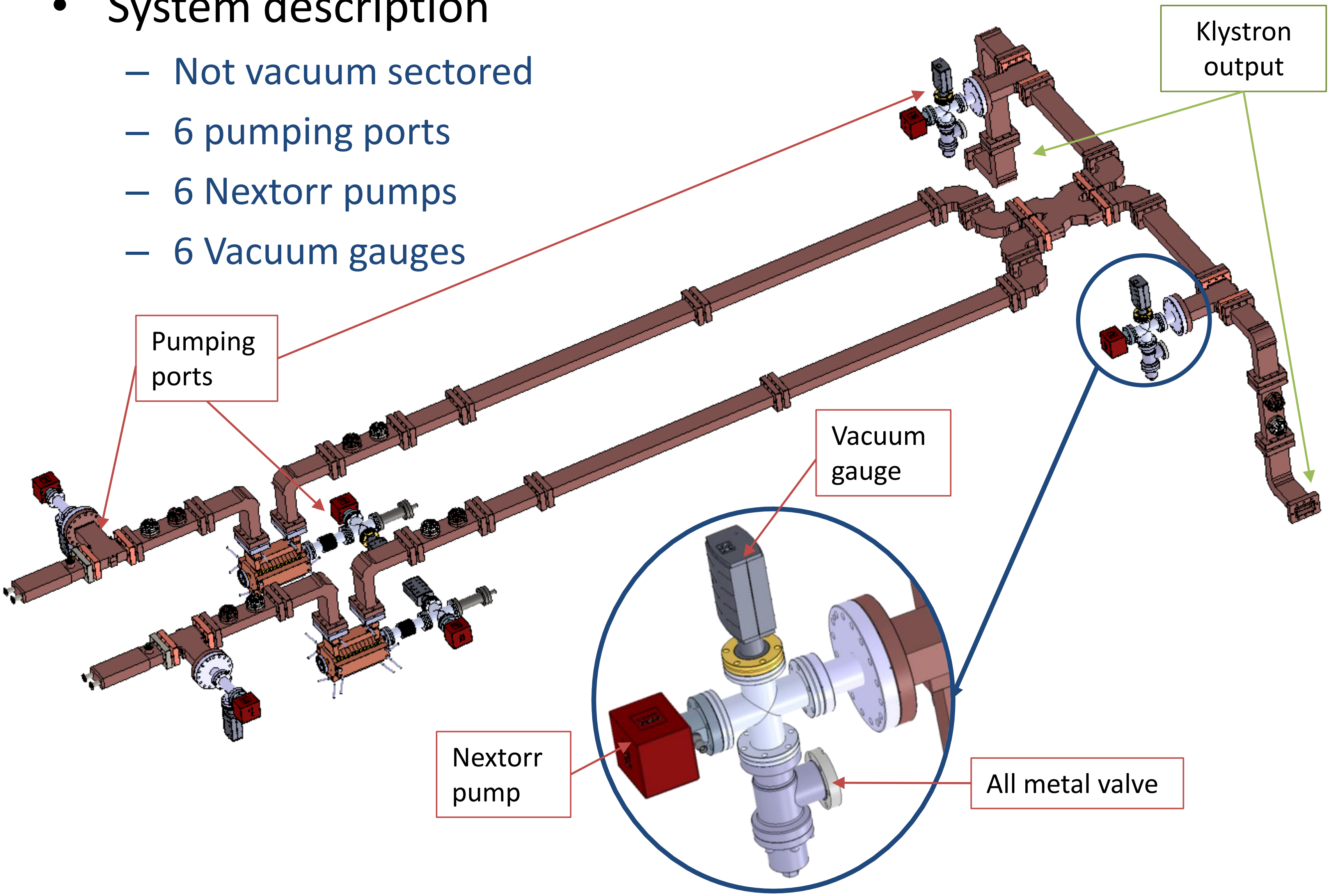
- Vacuum monitoring by ion pumps measurement and vacuum gauges
  - Full range Pirani/Bayard-Alpert gauges
  - From 1x10*^{3} down to 5x10^{-10} mbar
  - DN 40 CF flange

- All metal valves for pumping group connection

- He leak detector for vacuum leak tests
  - Minimum detectable leak rate 5x10^{-12} mbar*l/s
  - Backing pump capacity: 15 m^{3}/h
  - Pumping speed for He: 2,5 l/s
  - Possible to work standalone or connected to the turbo pumping group

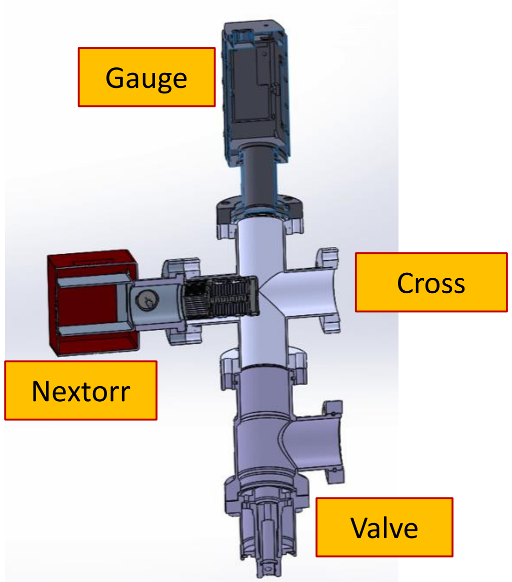
Vacuum subsystem

- System description
  - Not vacuum sectored
  - 6 pumping ports
  - 6 Nextorr pumps
  - 6 Vacuum gauges

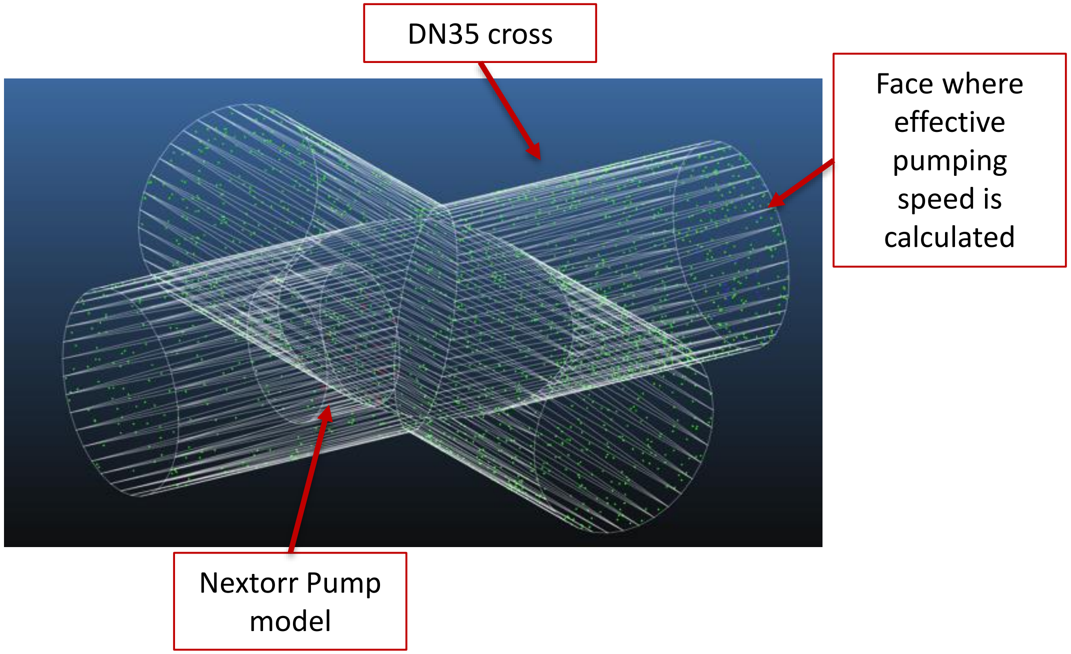


Vacuum subsystem

- Vacuum simulations
  - Monte-carlo simulations performed with Molflow software
  - Simulations of effective vacuum pumping speed in the pumping port for H_2(dominant gas) at molecular flow



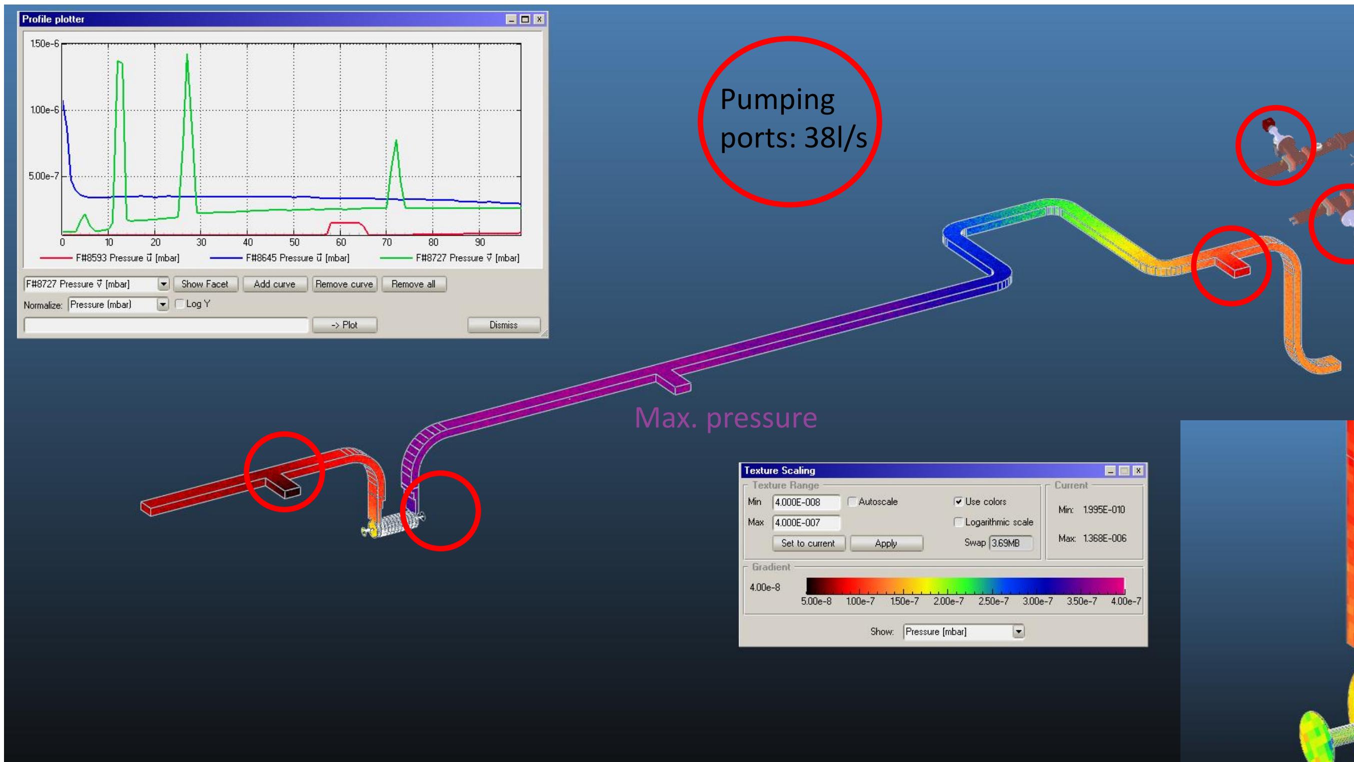
Pumping assembly cross-section

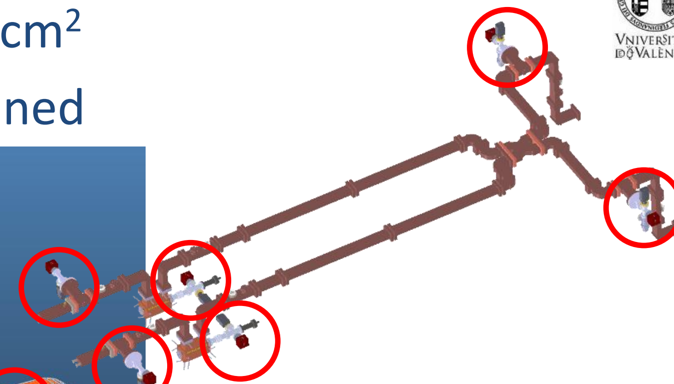


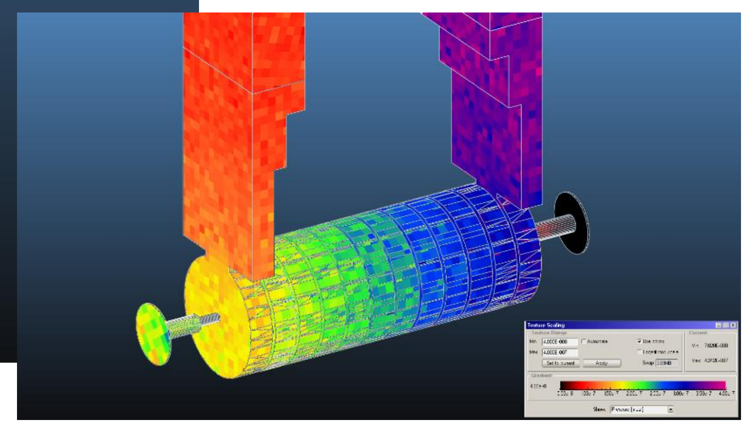
  - DN35 diameter cross
  - Effective pumping speed in pumping port : 38 l/s

Vacuum subsystem

- Vacuum simulations
  - Apply the obtained effective pumping speed into the pumping ports
  - Estimated outgassing rate: 3×10^{-10} mbar*l/s/cm^2
  - Pressure profile inside the wave guides obtained







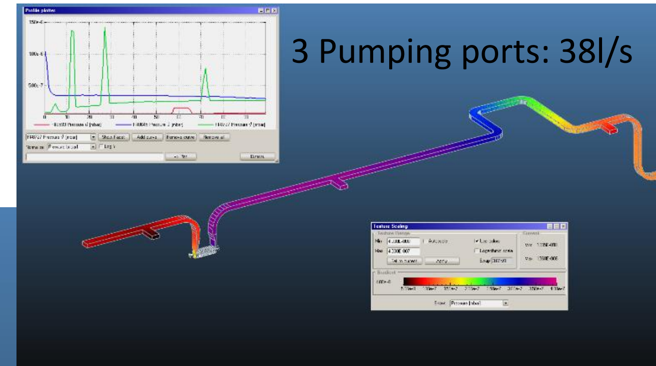
  - Max. pressure: 4×10^{-7} mbar
  - Min. pressure: 5×10^{-8} mbar

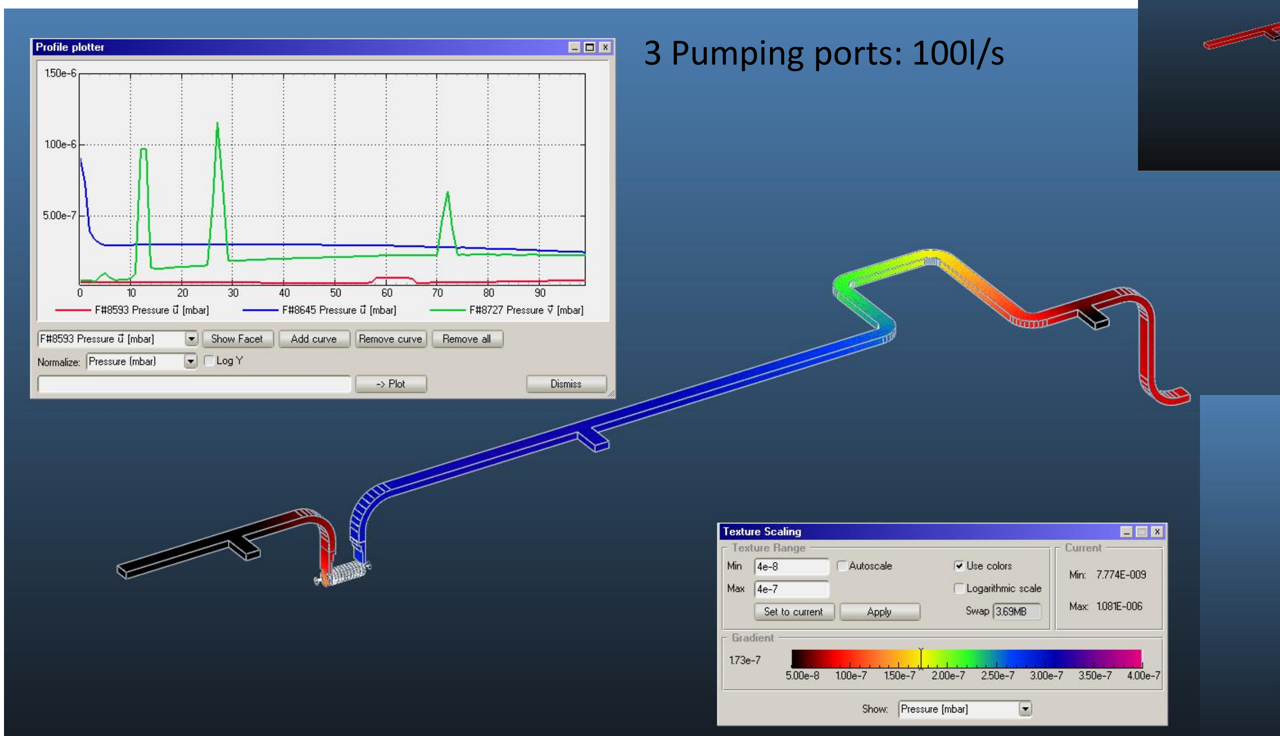
Vacuum subsystem

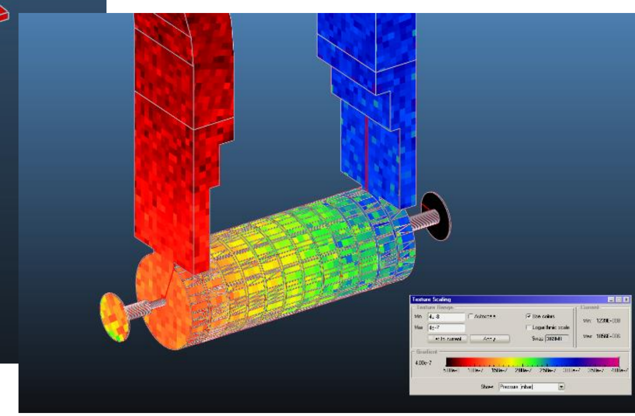
- Vacuum simulations
  - How can we get lower pressure if needed?
    - Adding pumps and therefore pumping ports (expensive)
    - Changing the current pumps for “bigger” ones (expensive)
    - Improving the effective pumping speed (“cheap”)
    - Reducing the outgassing (cleaner elements, bake-out, etc)

Vacuum subsystem

- Vacuum simulations – “Bigger” pumps
  - Higher pumping speed pumps would make the effective pumping speed to increase too (not linealy)
  - Effective pumping speed: 100 l/s



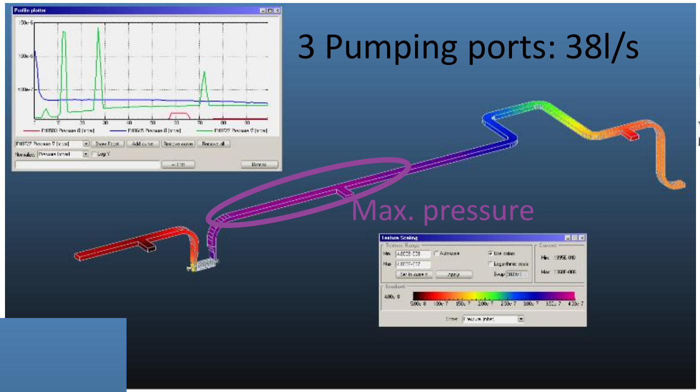


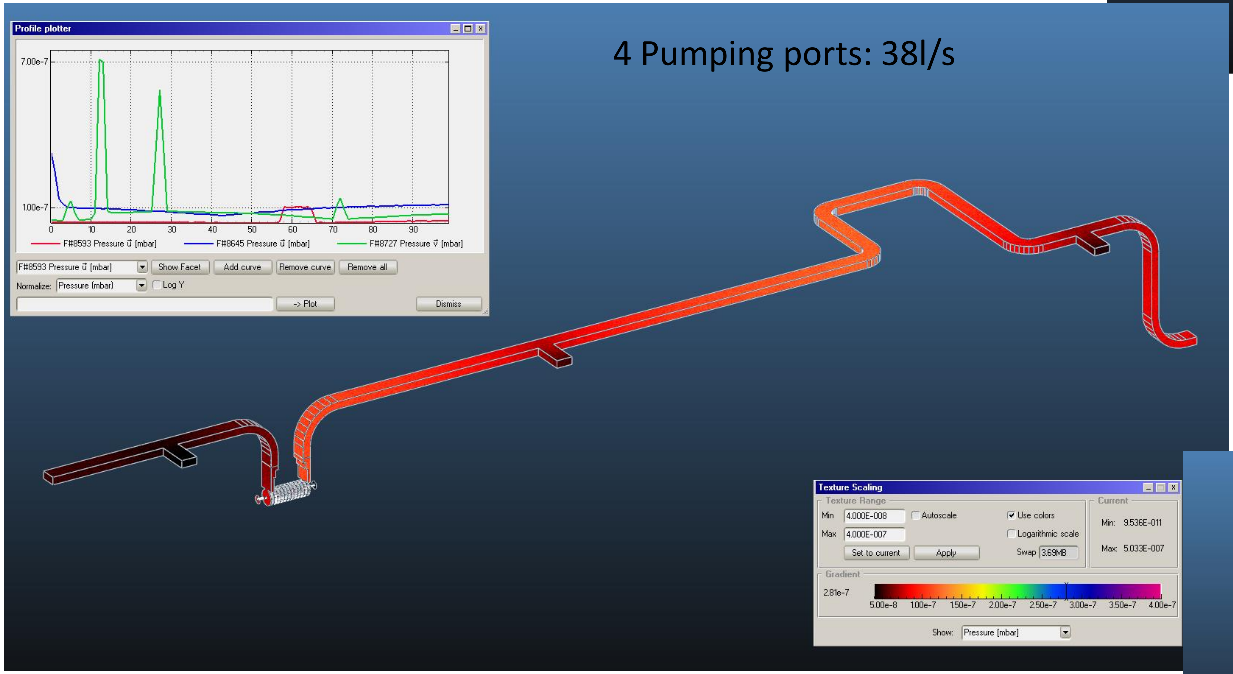


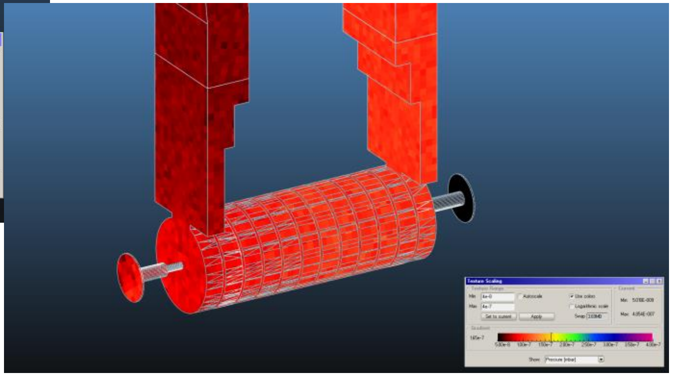
  - Some improvement in the vacuum level

Vacuum subsystem

- Vacuum simulations - Pumps addition
  - Where to add the pump? Where the pressure is higher
  - Higher improvement in the vacuum level than using bigger pumps

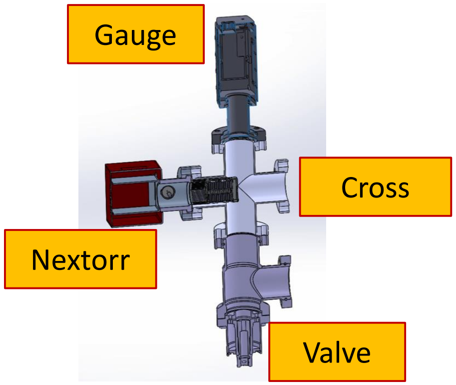




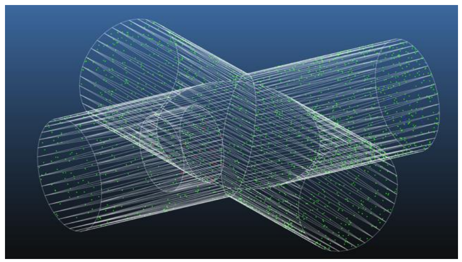


Vacuum subsystem

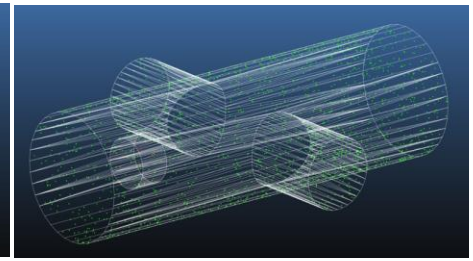
- Vacuum simulations – improving eff. Pumping speed
  - Increase Seff by increasing the volume of the chamber where the pump is and therefore the conductance



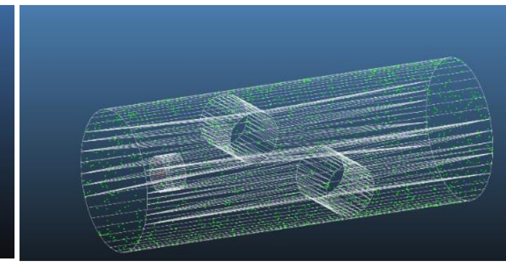
DN35 diameter cross

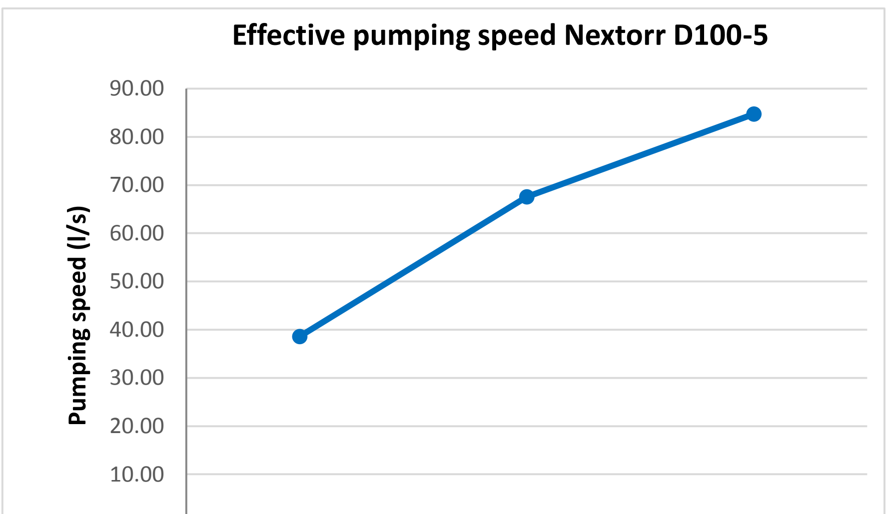


DN63 diameter cross



DN100 diameter cross



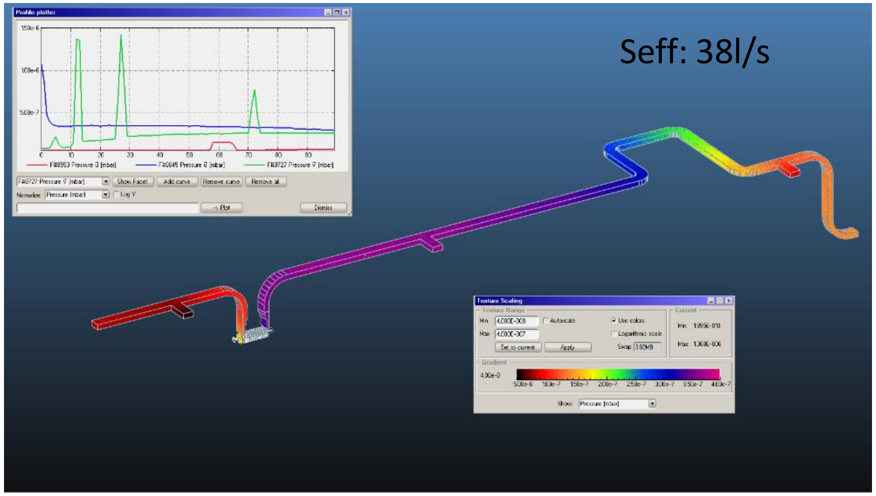


	CROSS DN35	CROSS DN63	CROSS DN100
Seff	38.61	67.57	84.75

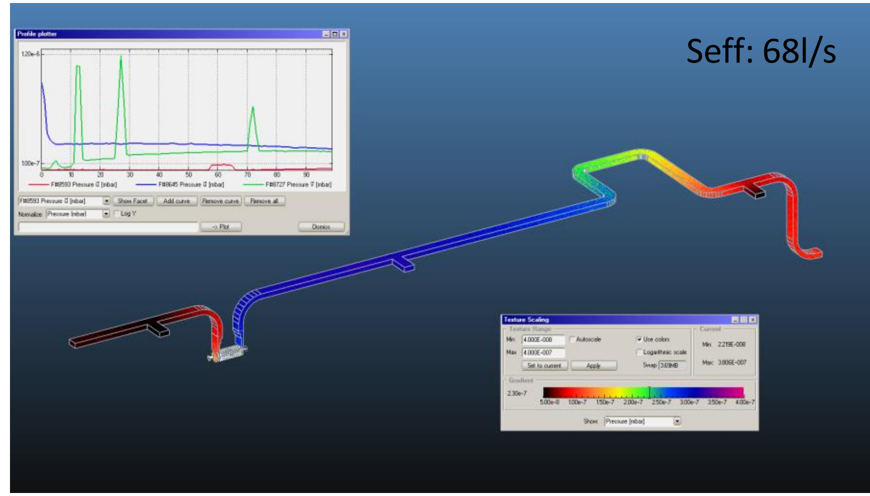
Vacuum subsystem

- Vacuum simulations – improving eff. Pumping speed

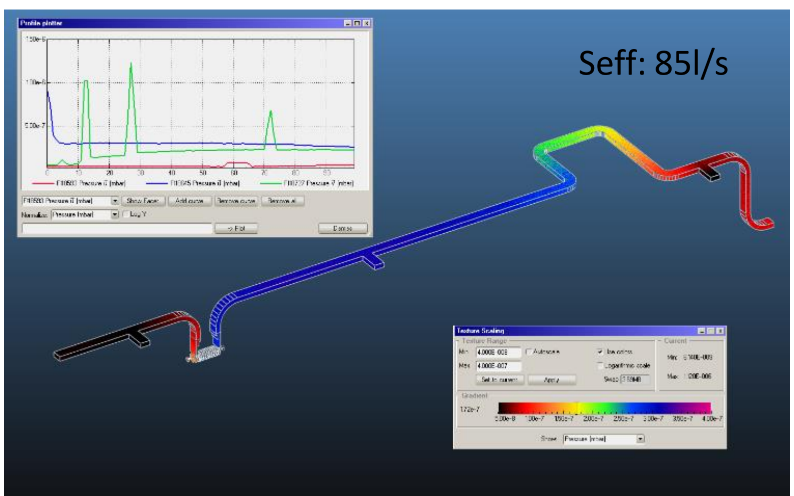
DN35 diameter cross.



DN63 diameter cross



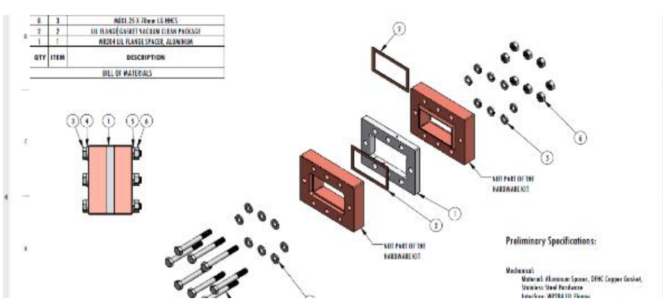
DN100 diameter cross

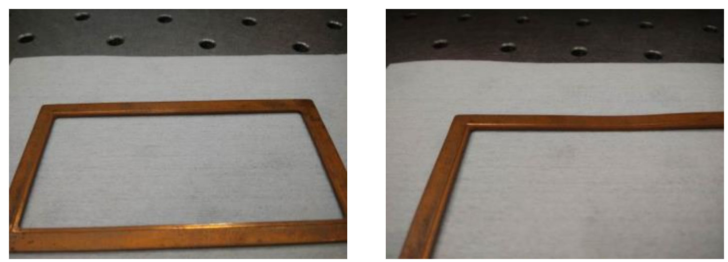


- Simulations show a lower final pressure when using DN63 instead of DN35
- Less improvement from DN63 to DN100

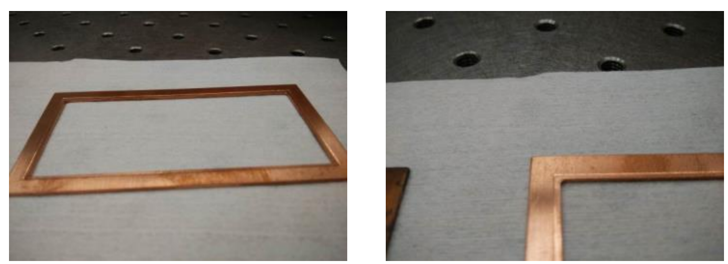
Vacuum subsystem

- Installation and vacuum tests
  - Installation in the lab already in progress
  - We found difficulties to leak tight the wave guides using the copper gaskets provided by Mega Industries
  - A later study showed us that the Mega gaskets are too hard and the flange cannot deform the gasket enough to make a good seal
  - A heat treatment (annealing) to the gaskets is missing
  - Mega Industries admitted the mistake during the production process and will provide us a new gaskets set with the annealing done





CERN gasket



Mega Industries gasket

Vacuum subsystem

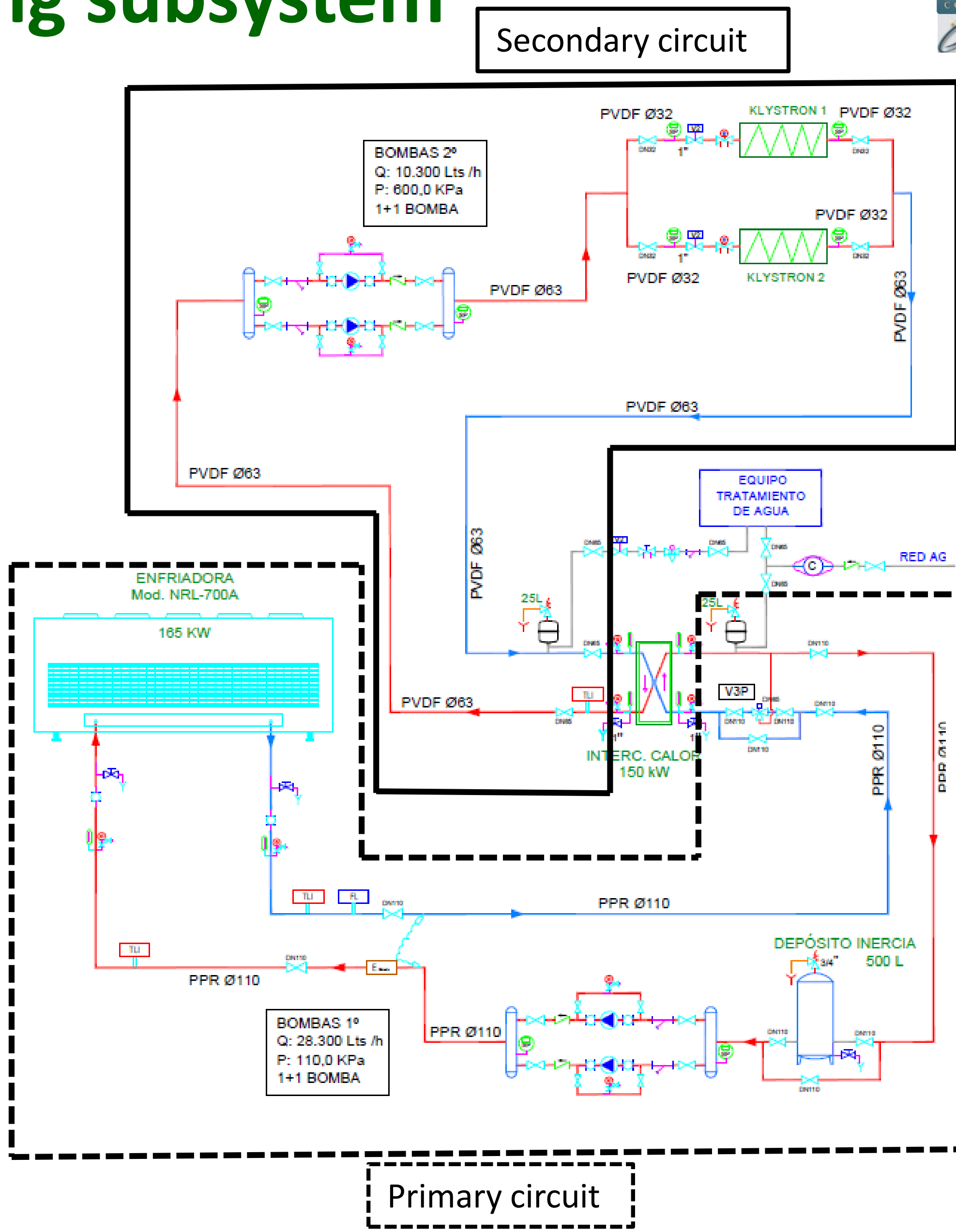
- Installation and vacuum tests
  - While waiting for the new gaskets a 1/3 of the waveguides line is already installed using old gaskets
  - Already under vacuum
  - Pressure ~5x10^{-8} mbar -> confirms the vacuum simulations

Vacuum subsystem

- Summary
  - Expected pressure ~ 10^{-8} mbar
  - Pressure profile obtained and the higher pressure zone was localized
  - Upgrade studies done in order to improve the vacuum level if needed
  - Changing the pumping cross size is a cheap way to get higher effective pumping speed and improve the vacuum
  - To change to bigger pumps doesn't seem to be the best option since the ratio price/improvement is not the best.
  - Adding a new pumping port makes the highest improvement but it is more expensive
  - We found a problem with the gaskets-> solution is on going
  - 1/3 of a waveguide line already installed and under vacuum confirms the simulations

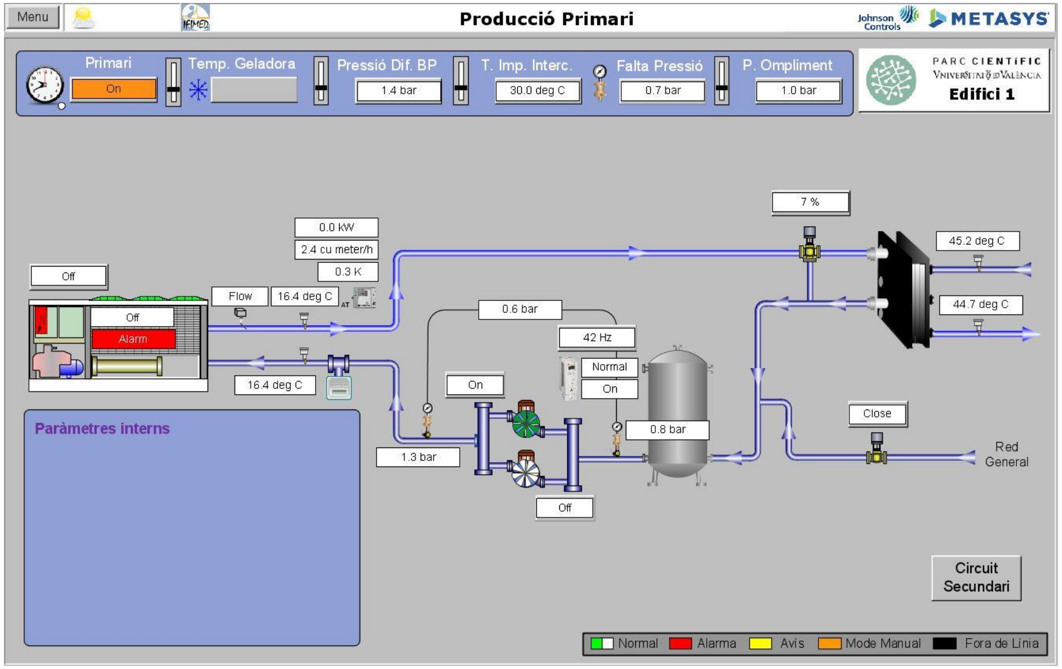
Cooling subsystem

- Used to cold down modulators, klystron and RF water loads
- Cooling plant + water demineralizer plant
- Cooling plant
  - 165 KW max. cooling power machine
  - 2 water closed circuits + heat exchanger



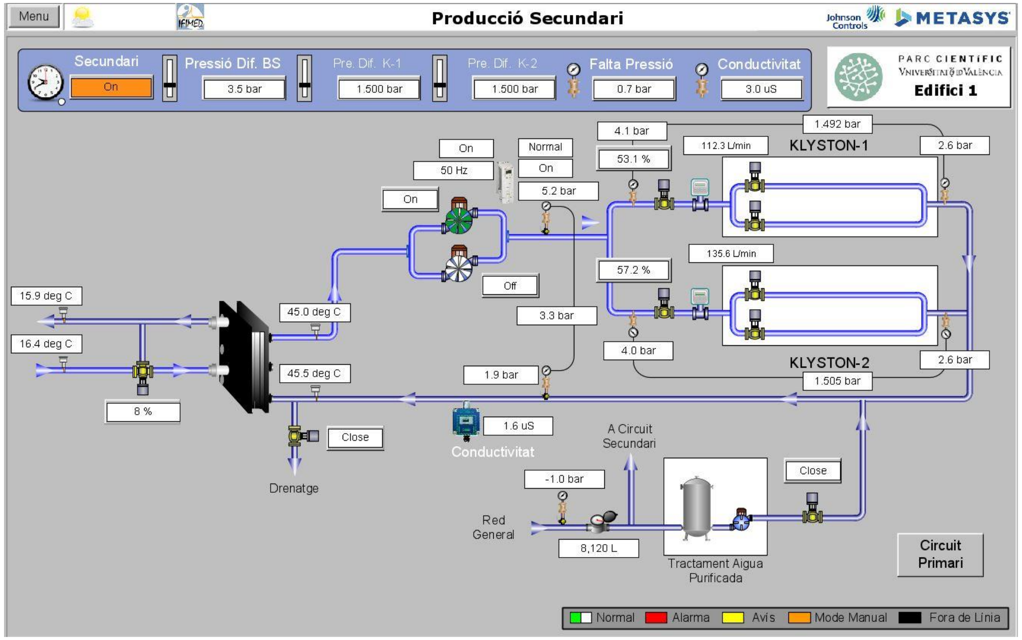
Cooling subsystem

- Cooling plant
  - Primary circuit
    - Cooling machine and pumps installed in the roof of the building
    - Chiller has 3 compression stages for better performance and power save.
    - Temperature range inlet-outlet in the cooling machine 12˚C / 7˚C
    - Runs normal network water
    - Temperatures and pressures monitored
    - Automated 3 ways valve to adjust the flow passing through the heat exchanger



Cooling subsystem

- Cooling plant
  - Secondary circuit
    - Feeds independently both modulators+klystrons and the RF loads
    - Pumps and heat exchanger installed in the basement of the building
    - Temperature range inlet-outlet in the heat exchanger 28˚C / 18˚C
    - Runs demineralizer water
    - Temperatures, pressures, flows and water conductivity monitored
    - Automated valves adjust independently the flow of each modulator

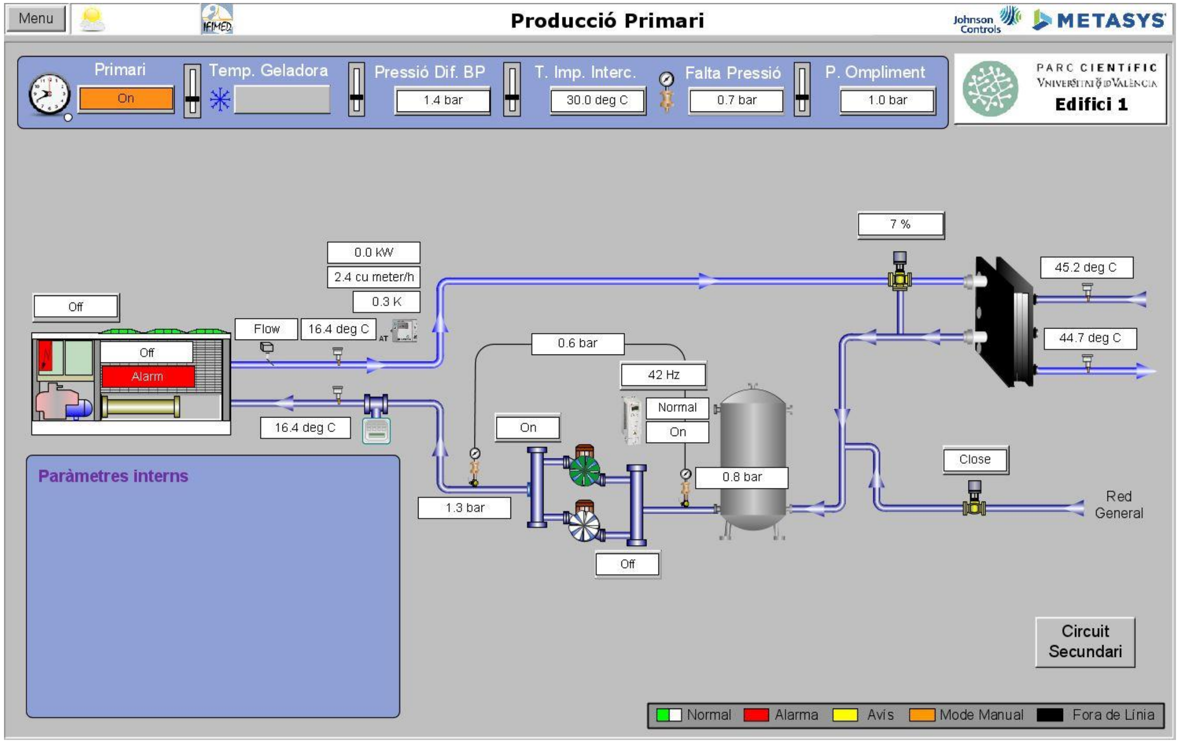


Cooling subsystem

- Cooling plant
  - Demineralizer plant
    - Integrated within the cooling system
    - Provides demineralized water to the secondary circuit
    - Klystrons need low conductivity water for cooling (0.1 – 1 µS/cm)
    - Water softener + reverse osmosis
    - Final ultra pure water with conductivity: 0.1 µS/cm

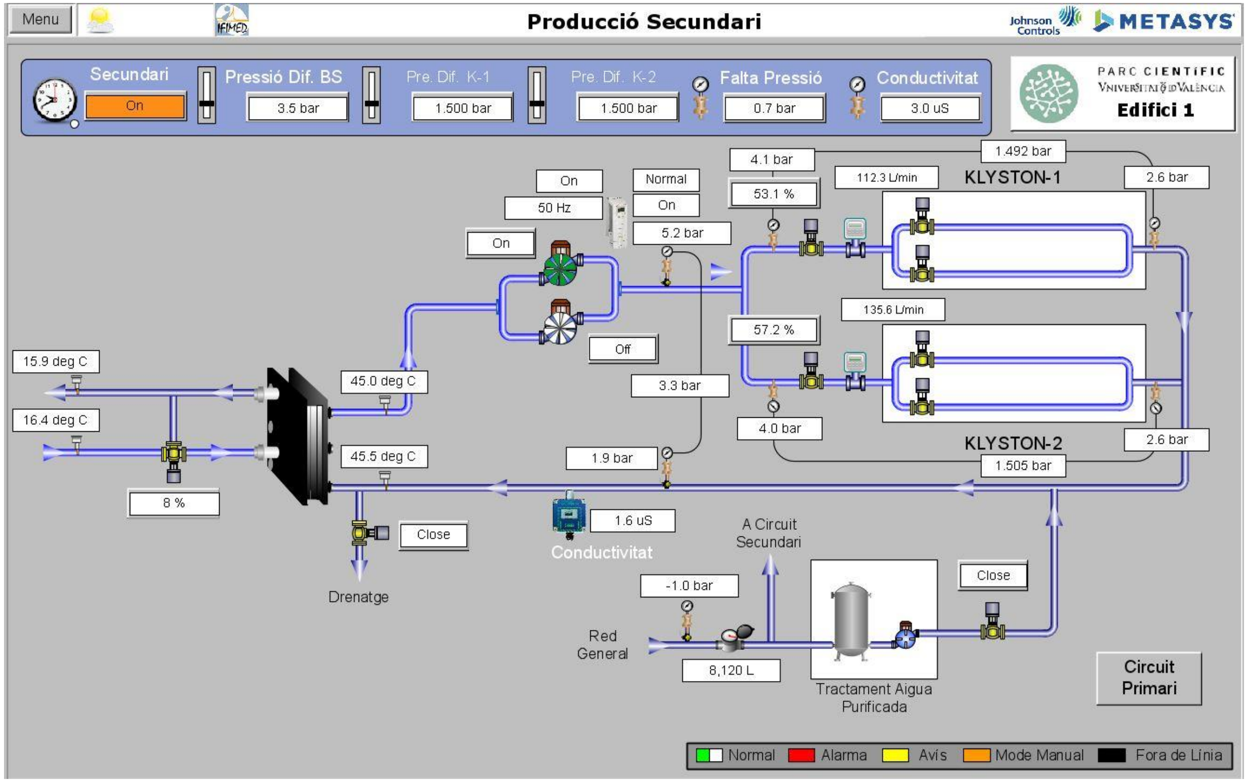
Cooling subsystem

- Control system and operation
  - PC interface
  - Integrates and control both cooling circuits and demineralizer plant
  - Allows to adjust diary working schedule to automatically start/stop the system
- Primary circuit control
  - Monitor the cooling machine
  - Automatically fill up the circuit if it is necessary
  - Allows to setup the pressures
  - Controls the 3 ways valve in order to get the water temperature set up in the secondary at the exit of the heat exchanger



Cooling subsystem

- Secondary circuit and demineralizer plant control
  - Monitor the water conductivity and recycle the water if it is over the limit
  - Automatically fill up the circuit if it is necessary
  - Controls the pump speed and allows to set up the modulators inlet pressure
  - Allows to set up independently the flow in each modulator
  - Monitor pressure and temperatures



Cooling subsystem

- Summary
  - 2 closed circuits + heat exchanger
  - Demineralizer plant providing water with 0.1 µS/cm
  - Allows to monitor, set up and control pressures, temperatures and flows in both circuits
  - Controls the demineralizer plant
  - System is under commissioning right now
  - Tested without modulators
  - Still need to do test with modulators

THANK YOU FOR YOUR ATTENTION