Vacuum Control Systems

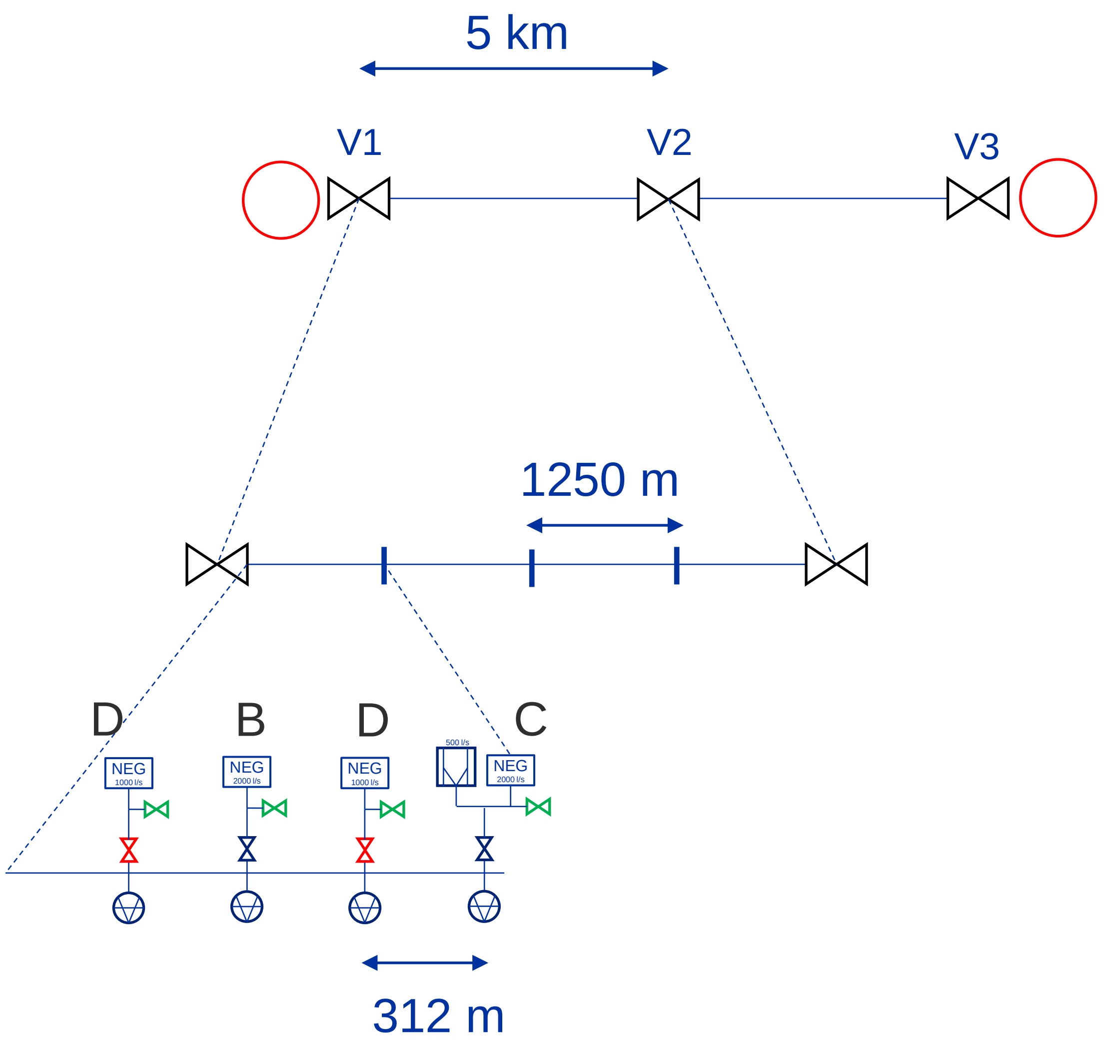
Gregory Pigny, TE/VSC, CERN

Outline

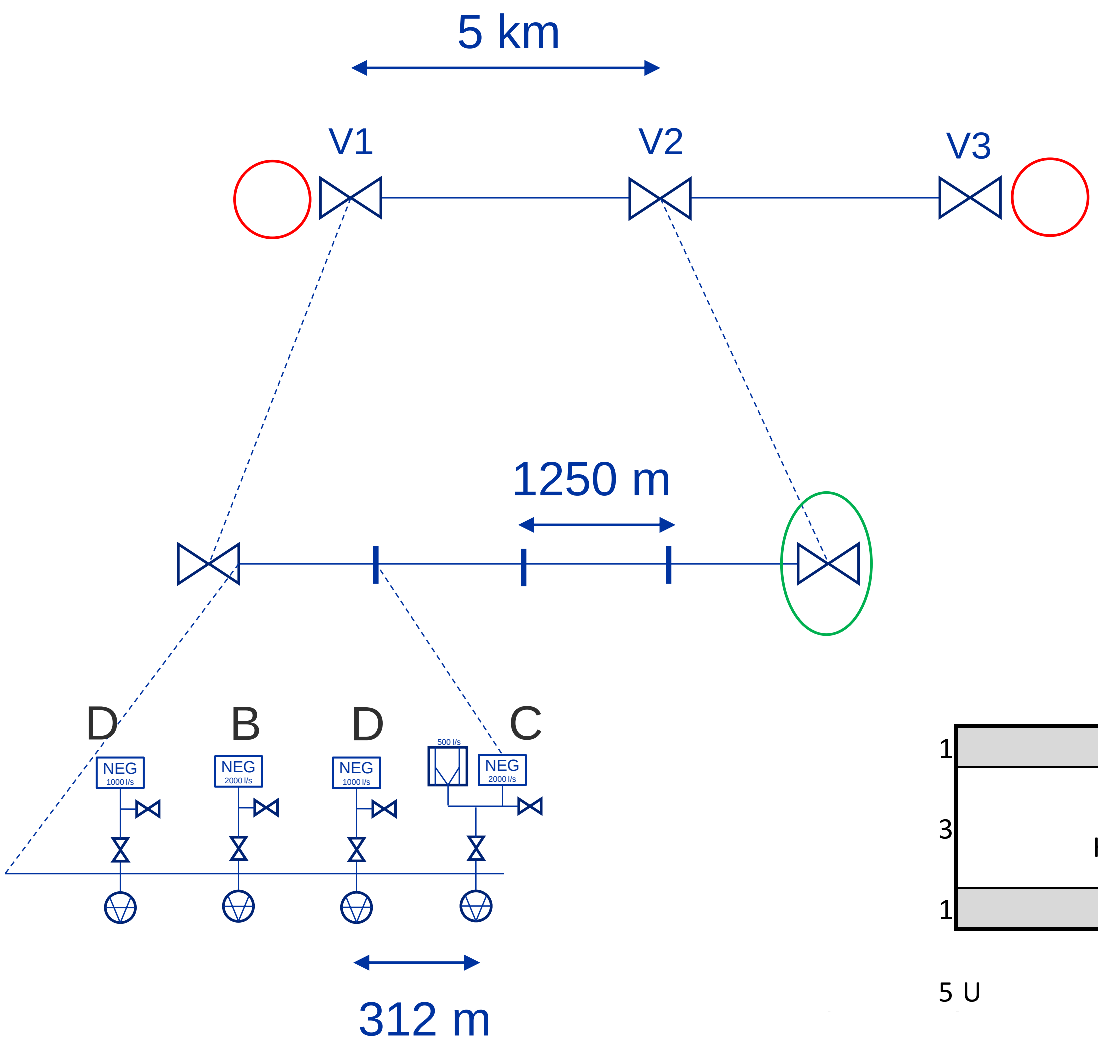
- Vacuum layout
- Racks and controllers
- Tunnel networking – CERN example
- Bake-out
- Control HW cost estimation
- Possible control architecture
- Supervision layer

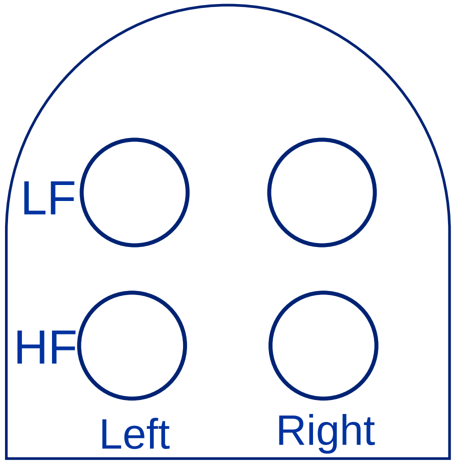
Vacuum layout

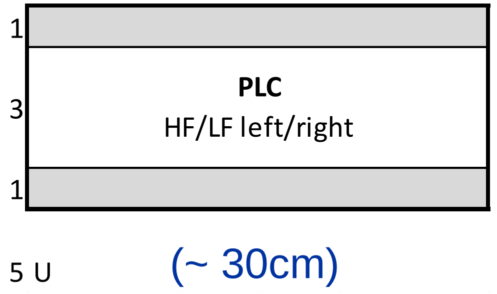
- **36** gate valves DN1250
- **216** gate valves DN150
- **168** gate valves DN100
- **384** angle valves DN40 (no control)
- **96** Sputter Ion Pumps (500 l/s)
- **384** NEG Pumps (1000 l/s and 2000 l/s)
  - Local activation of the NEG pumps during bakeout
- **384** Gauges (Bayard-Alpert)
- **36** Residual Gas Analyzer (RGA)



Racks and controllers

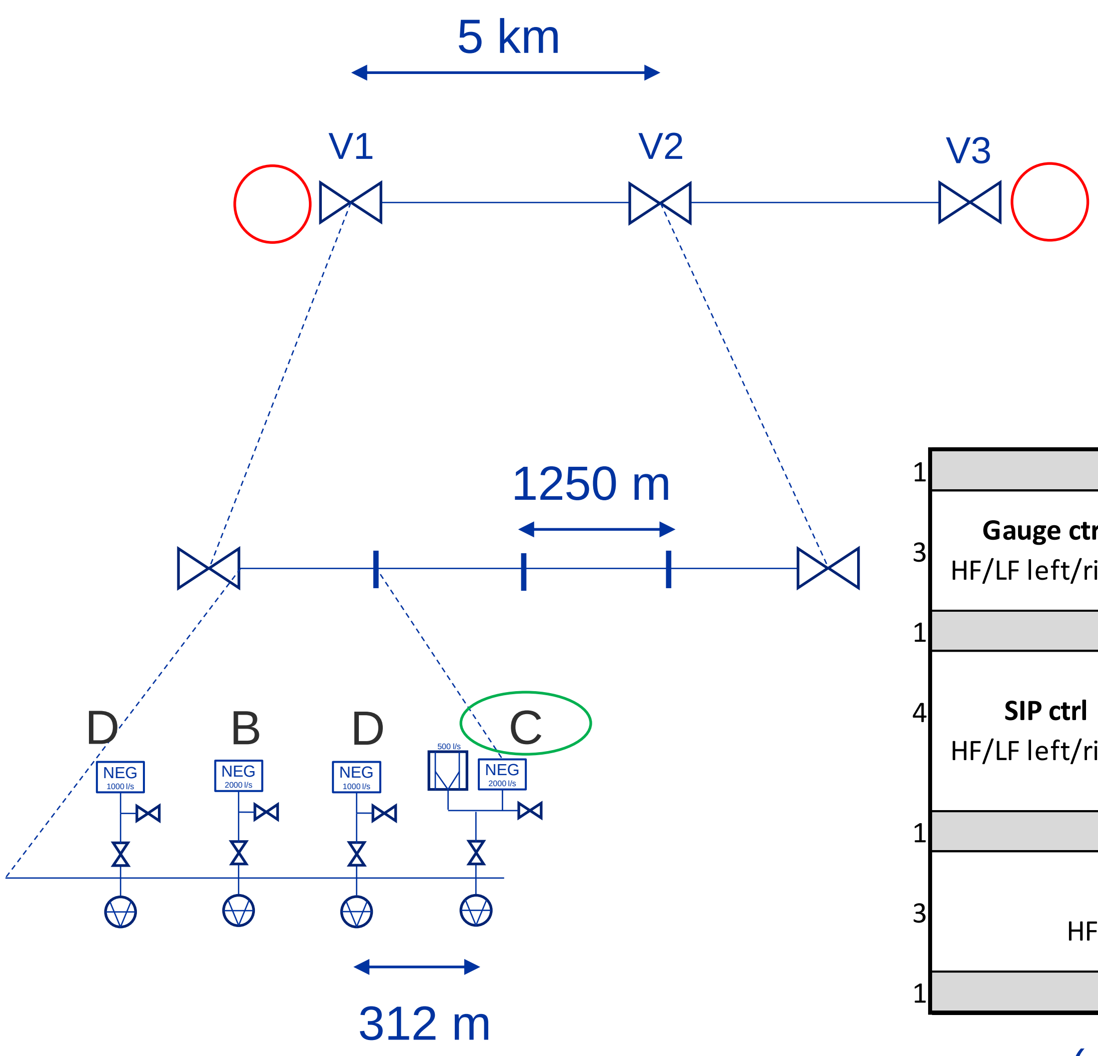


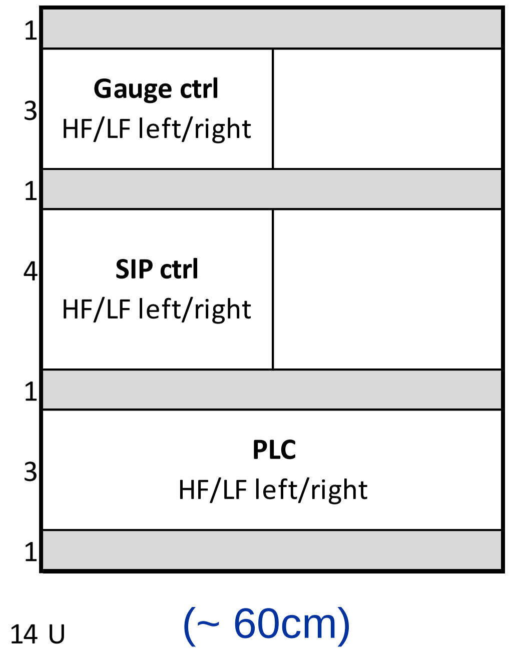


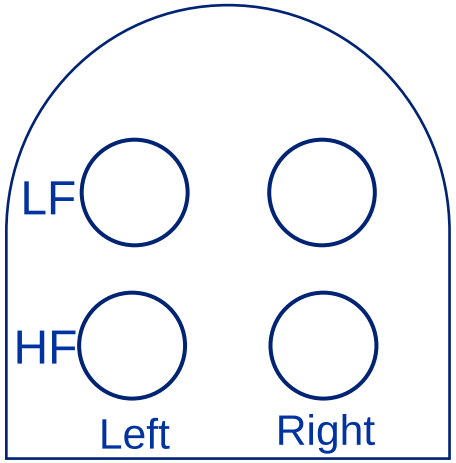


- One rack 5U at each sector valve position for all 4 lines
- 4 signal cables per rack (4 valves)
- Tot 3*4*3/4= **9** racks
  - **36** signal cables
- Mains 230VAC
  - 1x 10A for PLC
- Ethernet socket

Racks and controllers

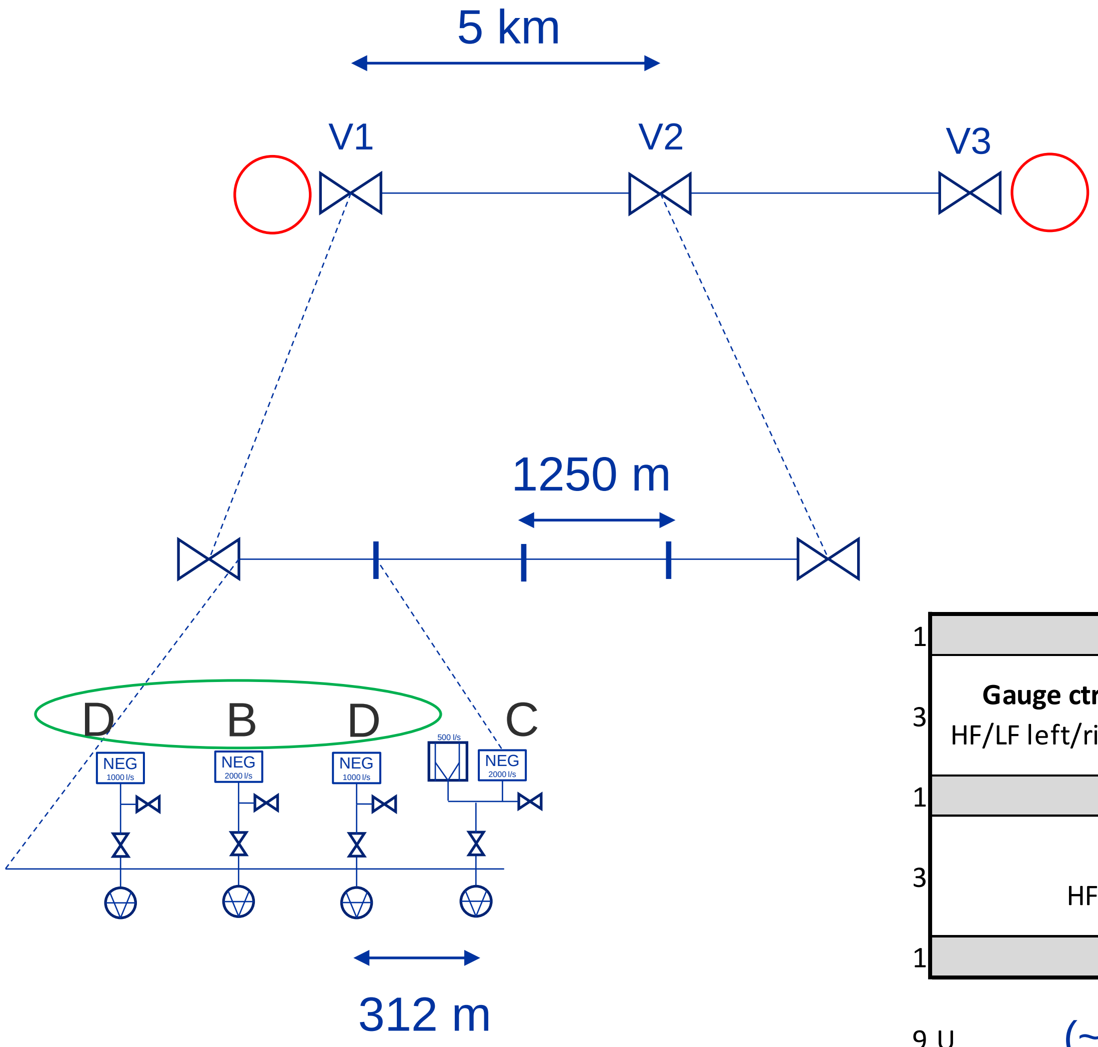


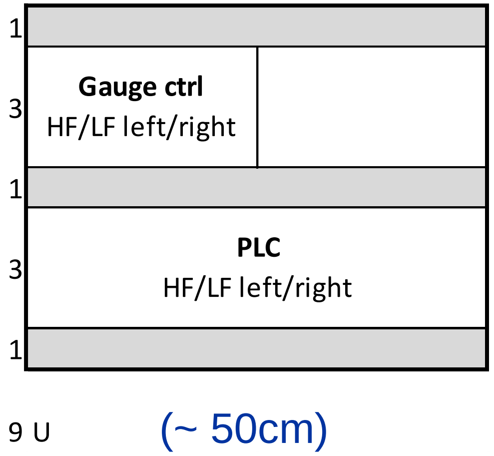


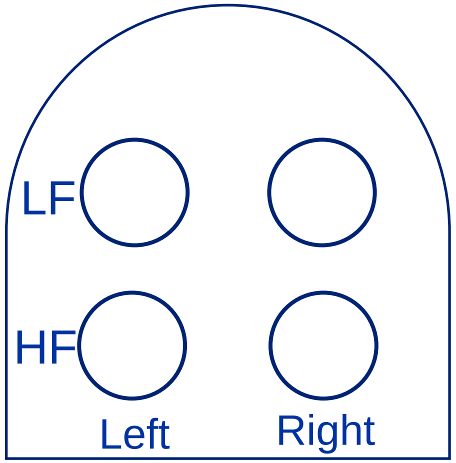


- One rack 14U at each pumping port type C for all 4 lines
- 12 cables per rack (4 gauges, 4 Ion pumps, 4 gate valves)
- Tot 4*4*3/4 = **12** racks
  - **144** signal cables
- Mains 230VAC
  - 1x 10A for the rack + controllers
  - 1x 16A for NEG
  - 1x 16A for mobile pumping group
- Ethernet socket

Racks and controllers





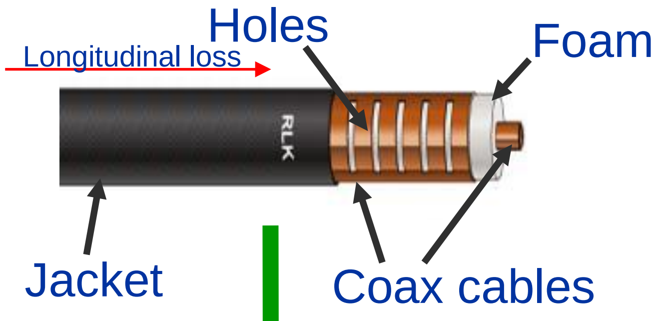


- One rack 9U at each pumping port type B or D for all 4 lines
- 8 signal cables per rack (4 gauges, 4 valves)
- Tot 4*4*3/4 = **36** racks
  - **288** signal cables
- Mains 230VAC
  - 1x 10A for the rack + controllers
  - 1x 16A for NEG
  - 1x 16A for Mobile pumping group
- Ethernet socket

Tunnel networking- CERN example

Radiating cable:

- Only means to have mobile communications in tunnels for the fire brigade and other users:
  - Safety: **TETRA** @400MHz (**TE**rrestrial **TR**unked **RA**dio)
  - Cellular : **LTE (4G)** @800MHz, **UMTS (3G)** @900MHz
    - Cell phones, Laptop
    - Remote inspection train on LHC monorail (TIM)
    - **Mobile vacuum equipment**



4G LTE

- Too high losses for Wi-Fi (2.4/5GHz) over long distances
- Recently used for LoraWan (Long range Wide area network) in the LHC
  - 867-870 MHz (in Europe)

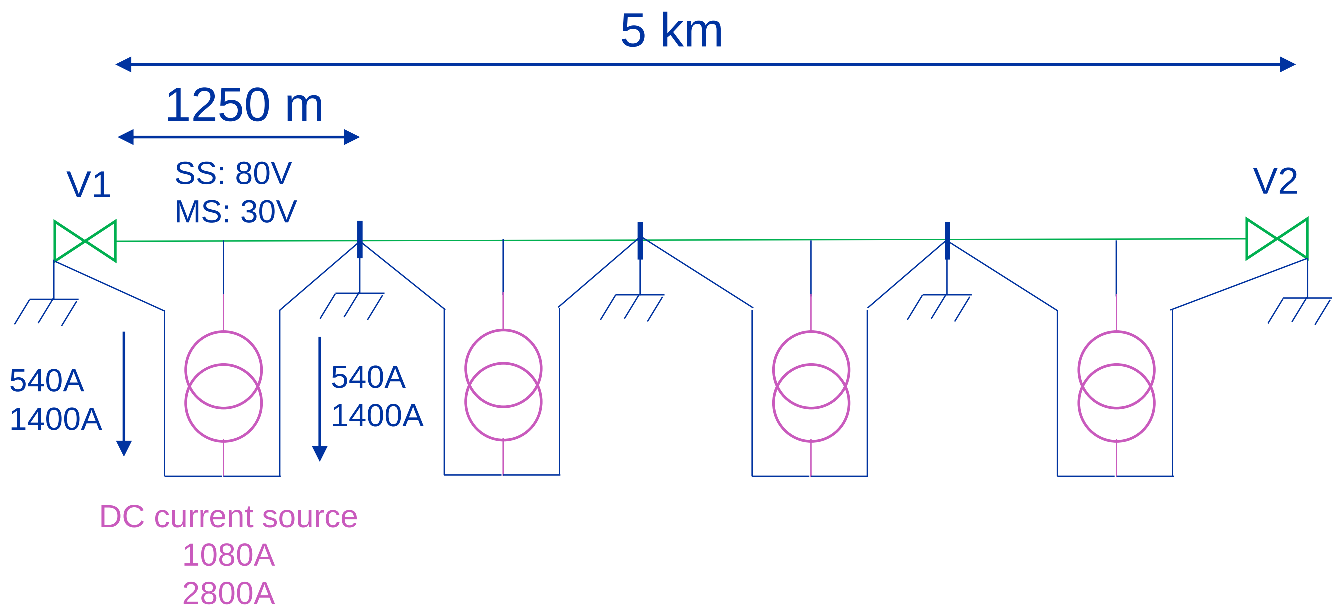
Bake-out

- **Stainless steel** (304L) 1.3mm thick corrugated tube 1.2m
- 15 cm thick thermal insulation based on PU/phenolic foam (λ ~ 0.025 $W.m^{-1}.K^{-1}$, Q ~ 72 W/m)
- R (ρ(**100°C**) ~ 8E-7 Ω.m) ~ 250 mΩ/km
- **Intensity ~ 540 A**
  - Smaller current and cross section
- **Voltage drop ~ 135 V/km**
  - Electrical hazard for circuit > 500m (> 60VDC)

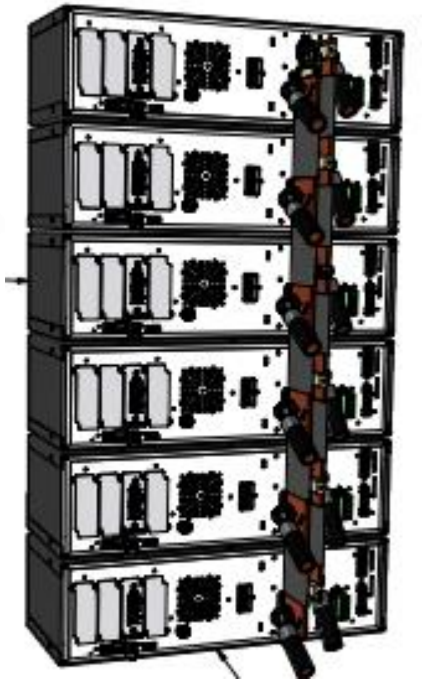
- **Mild steel** 3mm thick tube 1.2m
- 15 cm thick thermal insulation based on PU/phenolic foam (λ ~ 0.025 $W.m^{-1}.K^{-1}$, Q ~ 72 W/m)
- R (ρ(**100°C**) ~ 2.7E-7 Ω.m) ~ 34 mΩ/km
- **Intensity ~ 1400 A**
  - Higher current and cross section
- **Voltage drop ~ 50 V/km**
  - Electrically safe for circuit < 1km (< 60VDC)

For personnel safety, potential of the chamber must be < 60VDC

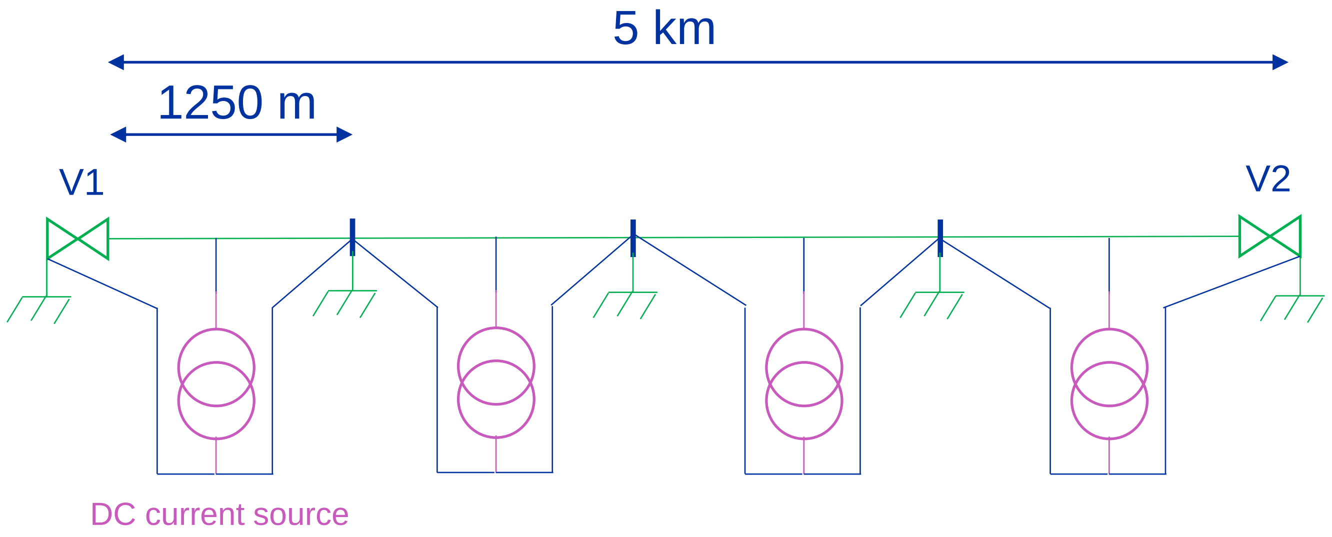
Bake-out

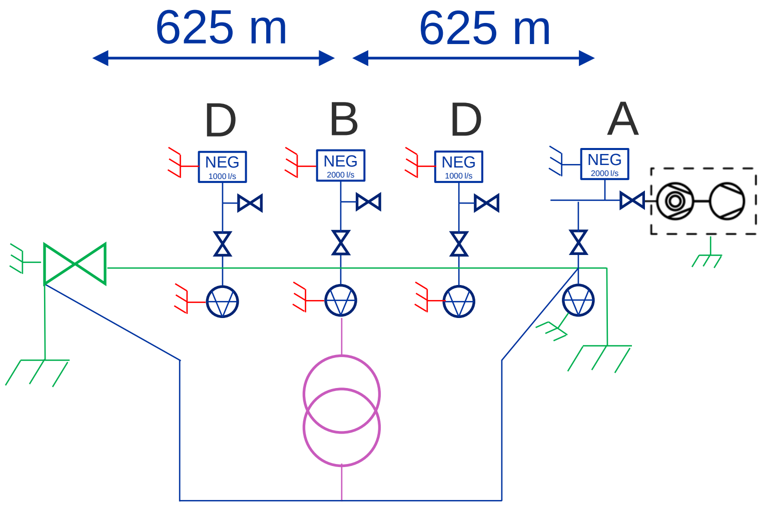


- Chamber connected to earth every 1250 m
- One current source every 1250m
- Current source: // connection of several smaller PS
- Temperature measurement: thermocouples (position? Qty?)
- Current source controlled by PLC: temperature regulation?
- Example of current source:
  - 6x SM70-CP-450 connected in // (2.8kA, 33V) in a mobile rack
  - Main power (max): 6x15kW = **90kW** per current source
  - 6x 3-phase sockets 32A / position
  - Tot. max power for one sector: 4x90kW = **360kW**



Bake-out





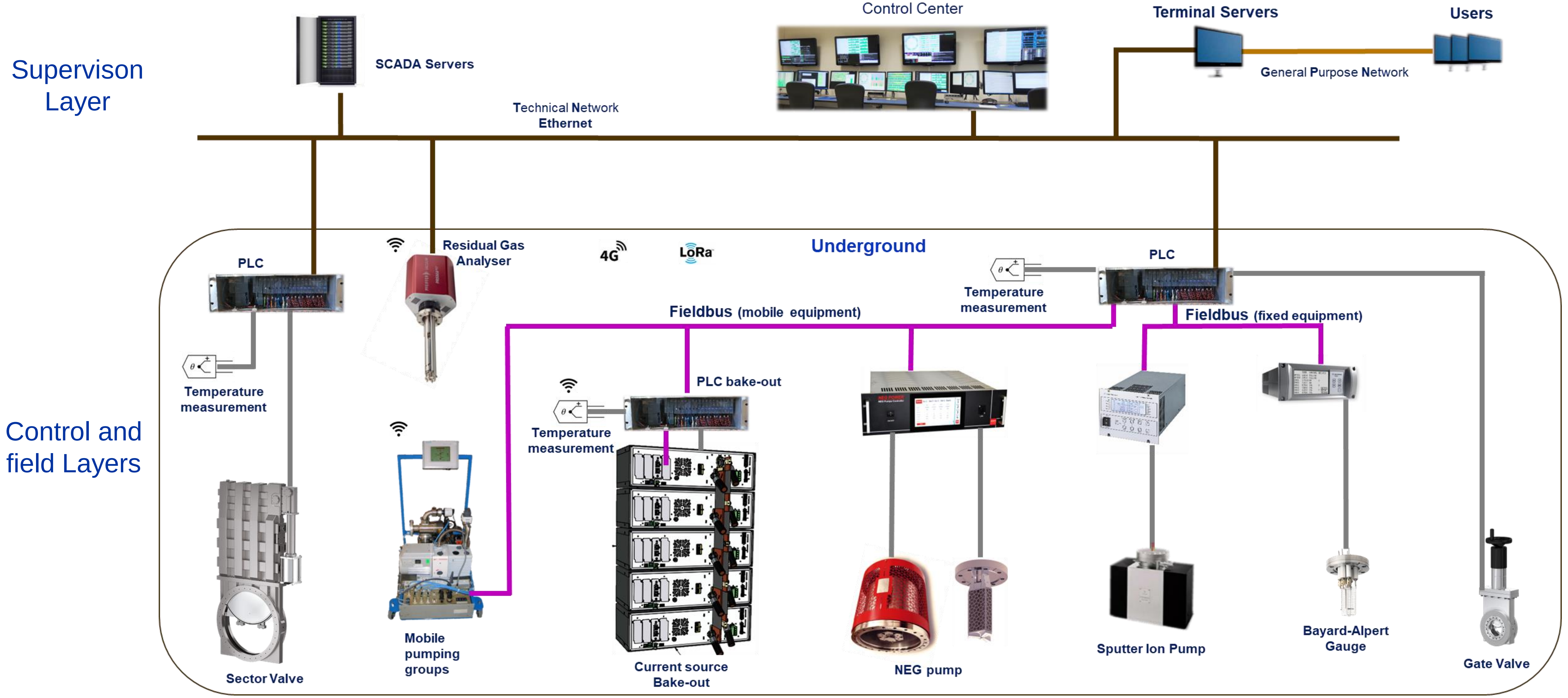
- All equipment and cables (D, B) must be isolated from earth during bakeout to avoid current deviation to earth through cable shielding or wires connected to earth through their controllers
  - NEG cartridges
  - Vacuum gauges
- Procedure and safety measures due to high current

Control hardware cost estimation

	Unit Price [EUR]	Qty	Tot Price [EUR]
BA Cable	500	384	192,000
BA controller	4,500	96	432,000
SIP controller	2,750	24	66,000
SIP HV cable	500	96	48,000
PLC rack 14/9 U	1,500	384	576,000
Cable valve DN100/150	100	384	38,400
PLC rack 5U	1,500	36	54,000
Cable valve DN1200	200	36	7,200
RGA	10,000	36	360,000
Rack 14U	1,000	12	12,000
Rack 9U	750	36	27,000
Rack 5U	500	9	4,500
Internal rack cables	500	57	28,500
SCADA Server	5,000	1	5,000
Mobile turbo ctrl	5,000	18	90,000
Mobile primary ctrl	3,000	3	9,000
Tot w/o spares			**1,949,600**
Spares (5%)			**97,480**
Tot			**2,047,080**

- Power and IT infrastructure not considered
- Bakeout control system not considered

Possible Control Architecture

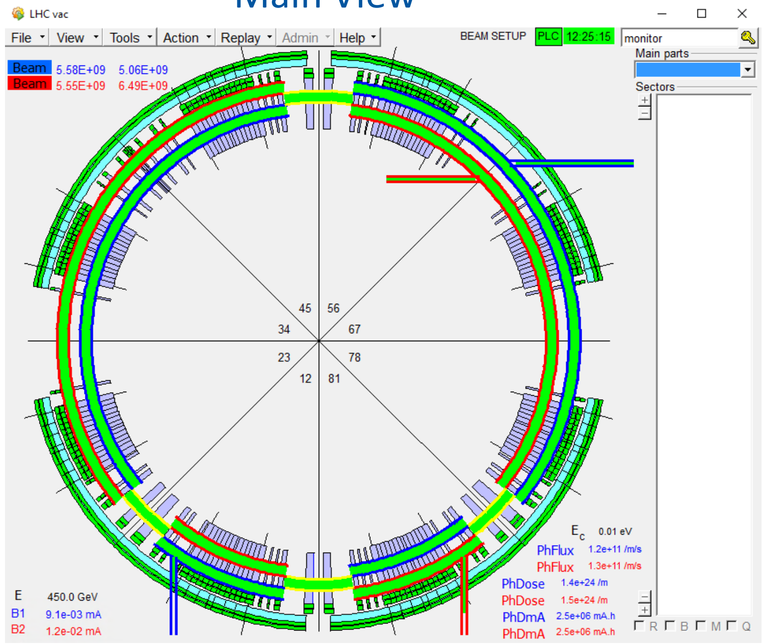


SCADA (Supervisory Control And Data Acquisition)

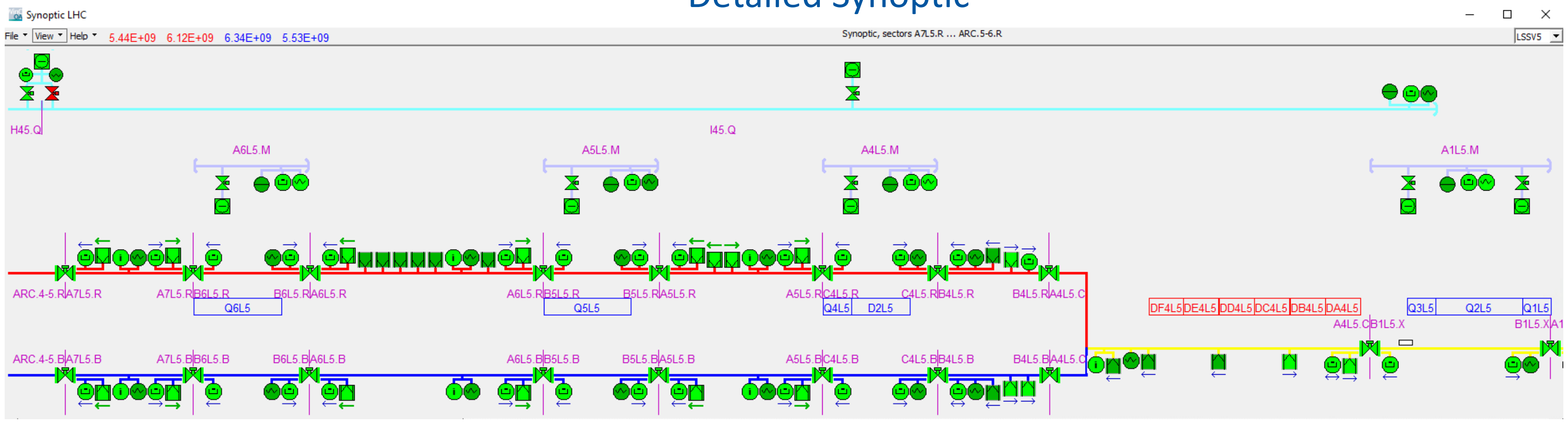
- Communicates in “real-time” with controllers running the vacuum process
- Present data to operators using a graphical user interface (GUI) in order to:
  - Check the process
  - React on alarms
  - Interact with devices
- Archives historical data
  - Operators can check what happened in the past
- CERN’s vacuum SCADA is based on WinCC-OA (Open Architecture) from Siemens
- Other SCADAs exist:
  - EPICS - Experimental Physics and Industrial Control System (www.aps.anl.gov/epics/)
  - TANGO - (http://www.tango-controls.org/)

Examples of Vacuum SCADA panels and functionalities

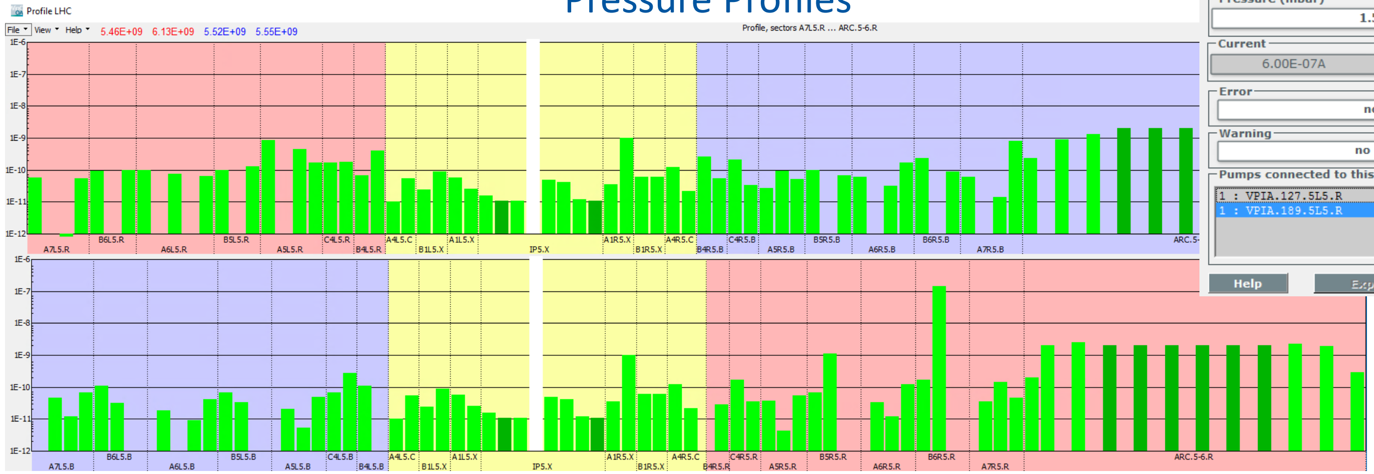
Main View



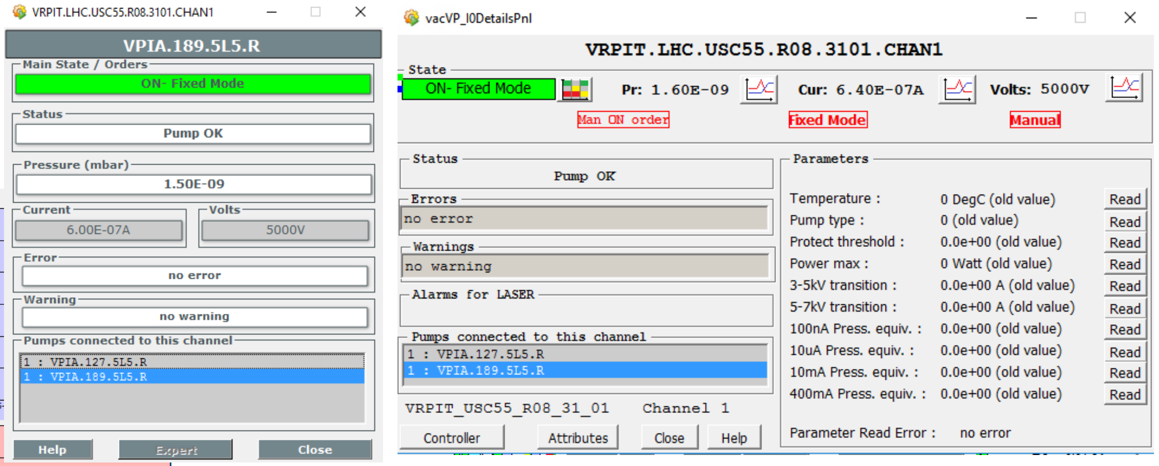
Detailed Synoptic



Pressure Profiles

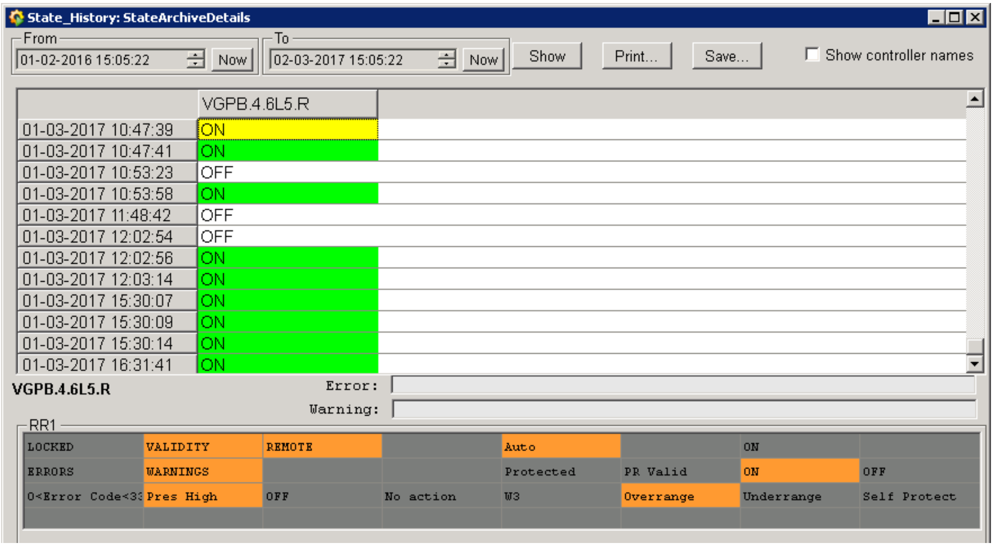


Controller Panels

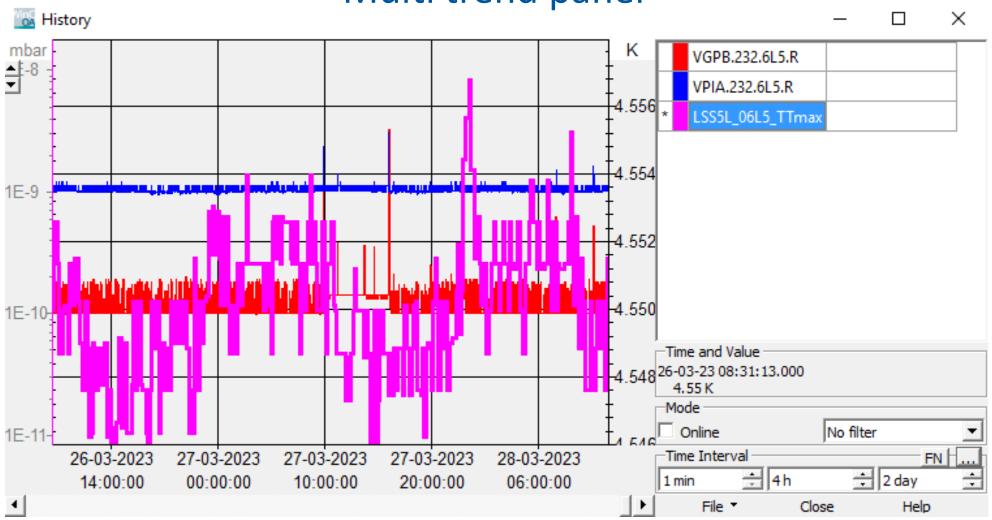


Examples of Vacuum SCADA panels and functionalities

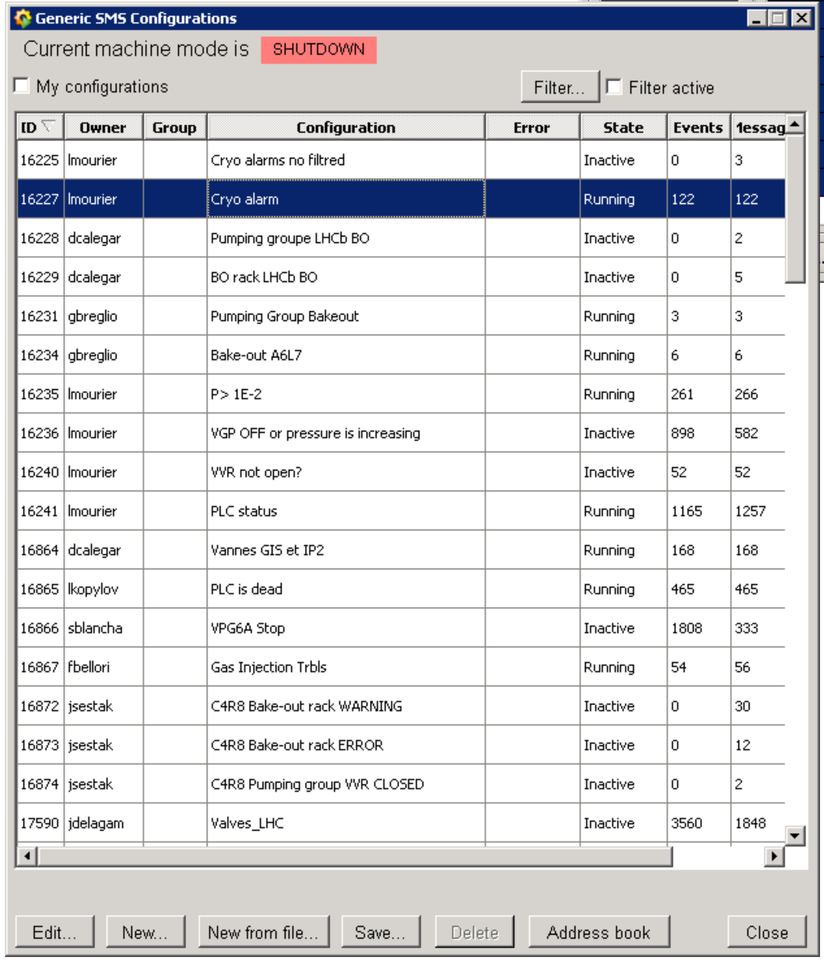
Equipment State History



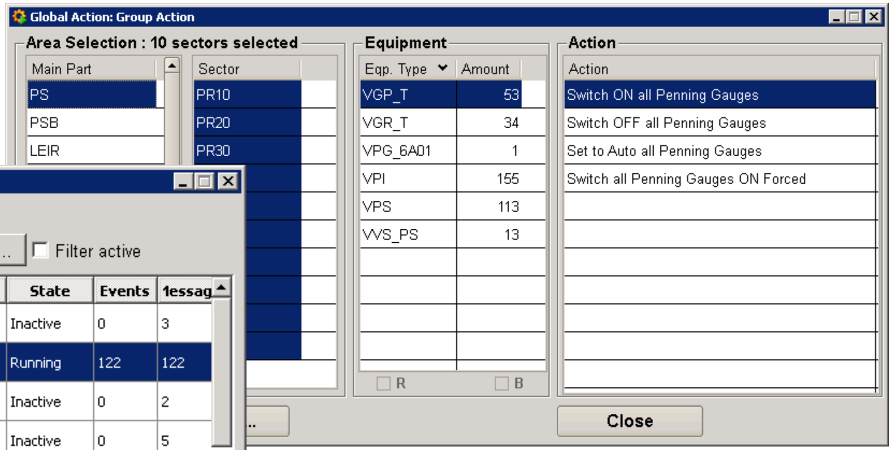
Multi trend panel



SMS Notifications



Global actions



Thank you for your attention