Automation of the accelerator vacuum system

Summer School (Third stage)
Joint institute of Nuclear Research (JINR University Centre)
Dubna, Moscow, Russia

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Outline

- Vacuum applications and uses
- First Project
- Main project
  - Manual phase
  - Automatic phase

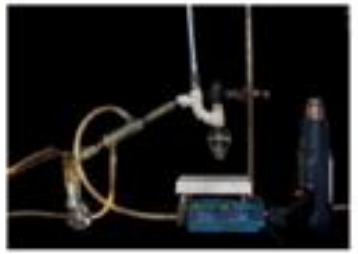
Vacuum applications

Electronics

Vacuum Engineering

Particle Physics

Metallurgy



Chemistry

Mechanic engineering

Medicine

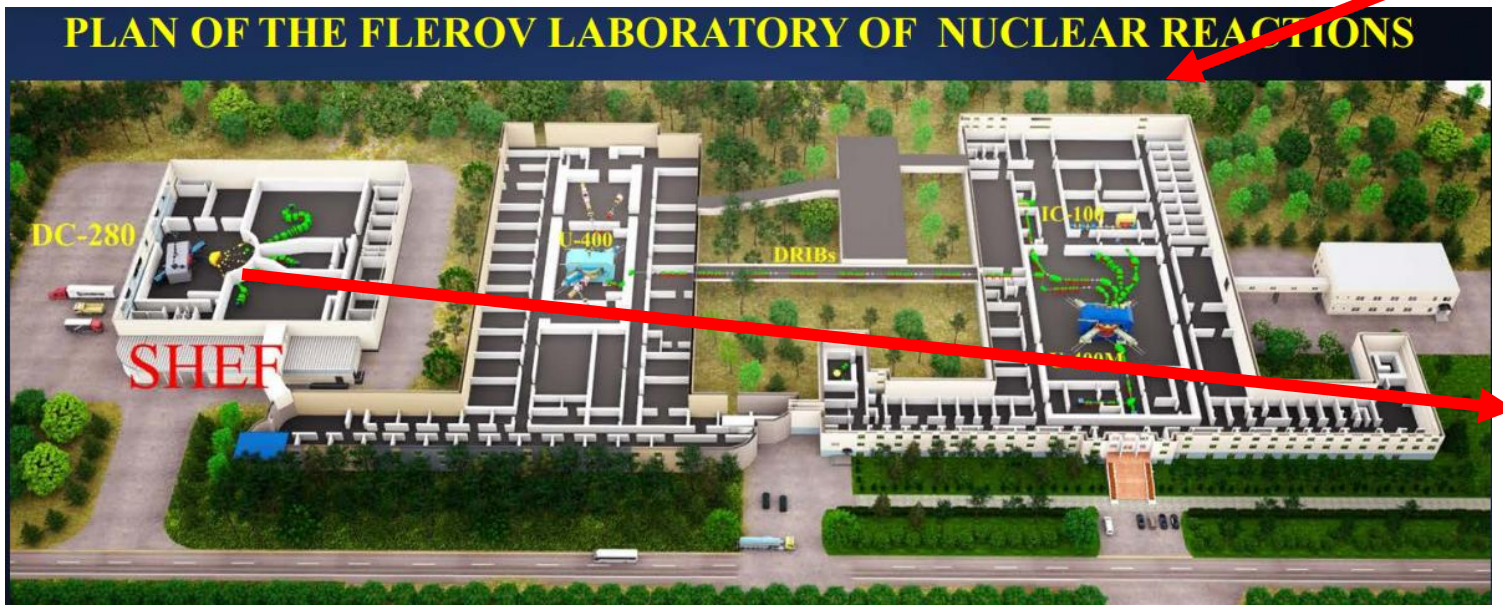
Vacuum

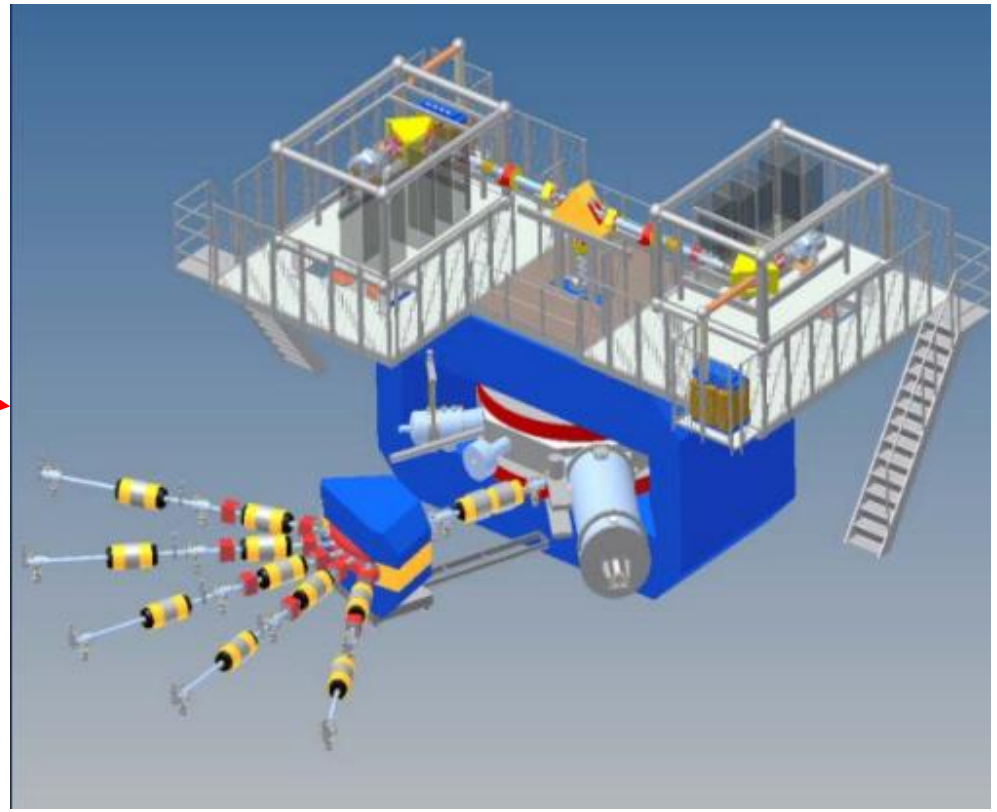
Optics

Food Industry

Where we can find vacuum system

- Vacuum is one of the main components of accelerator facilities.
- Residual gas scattering of the particle beam in accelerators leads to a deterioration in its quality.
- As an example (DC-280):



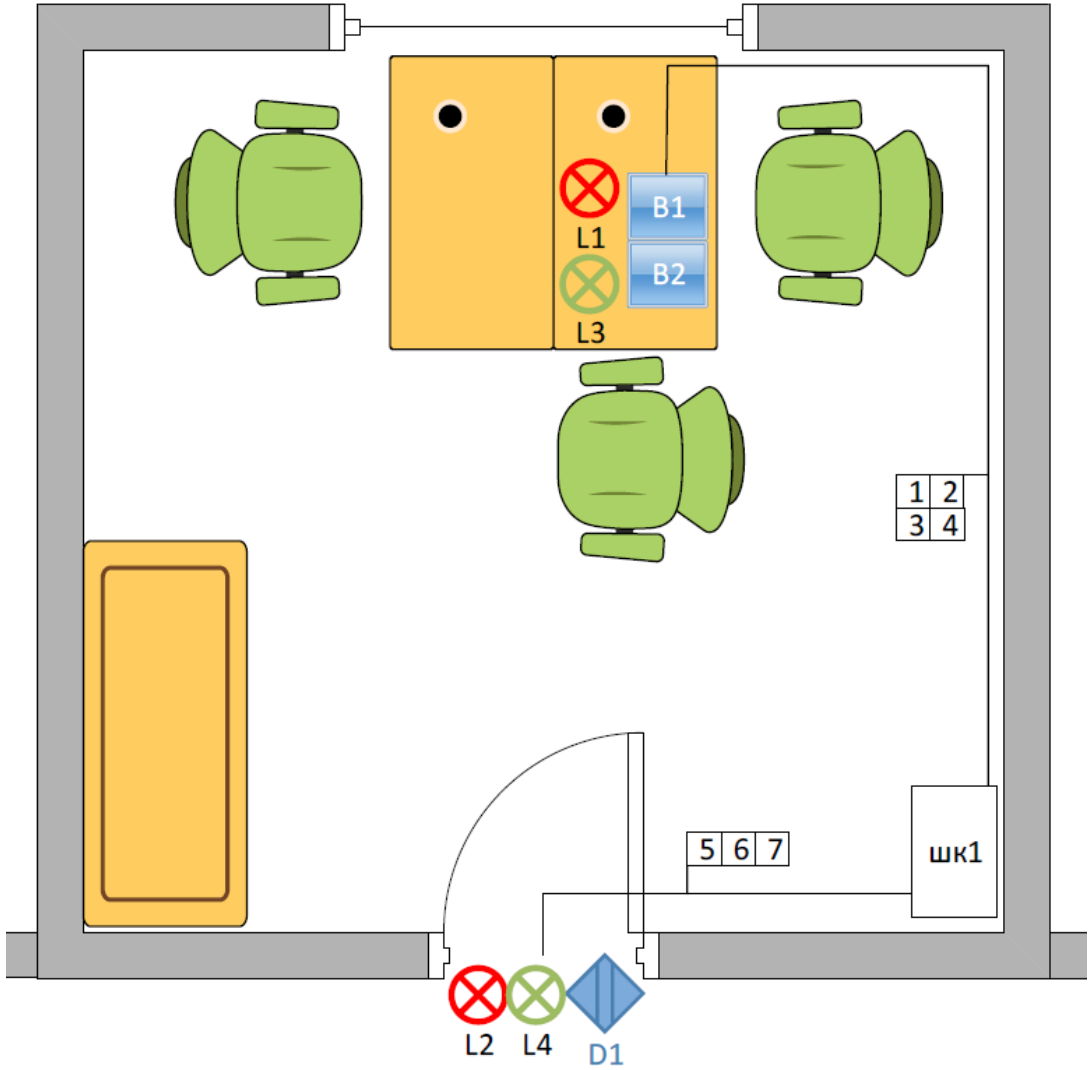


First Project: a clinic notification system

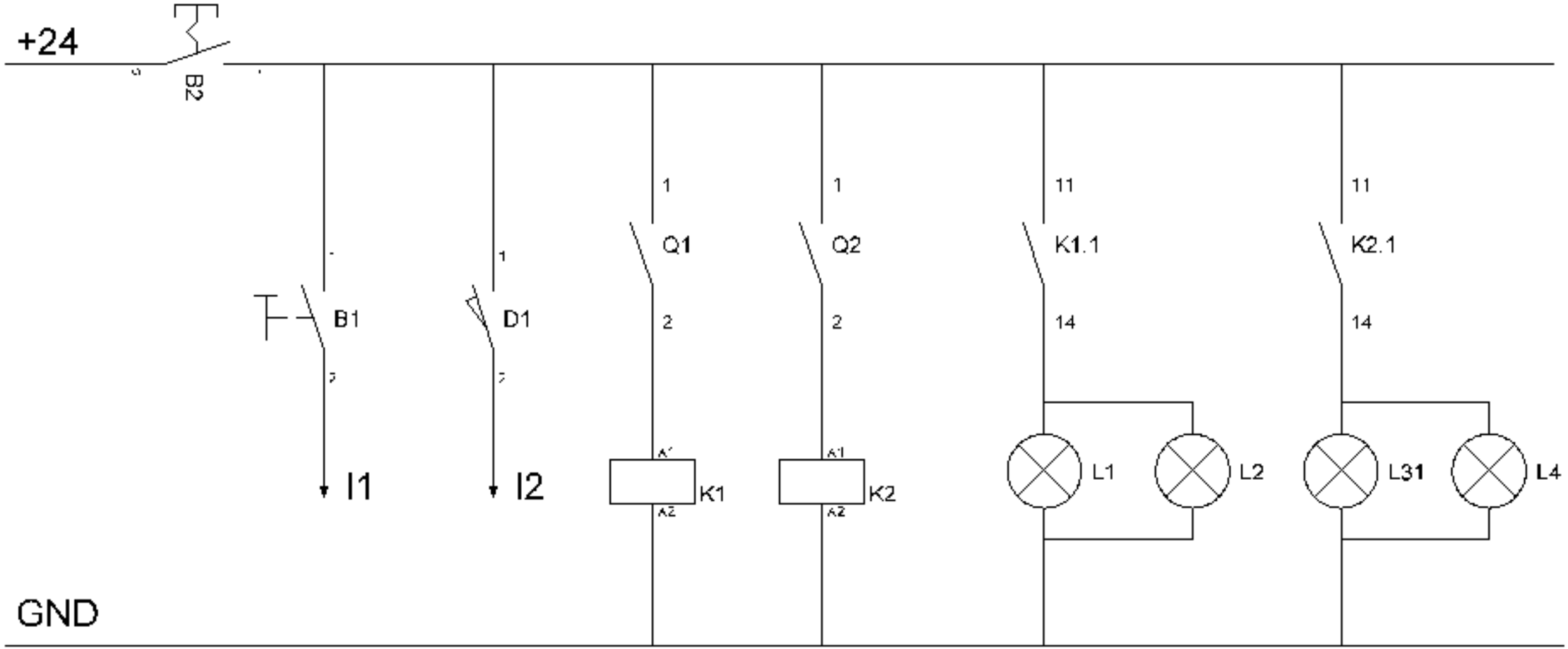
- A clinic receives large number of patients (more than 30 per room) every day.
- To maintain its performance, a visual notification system will be implemented.

Schematic diagram and system behavior

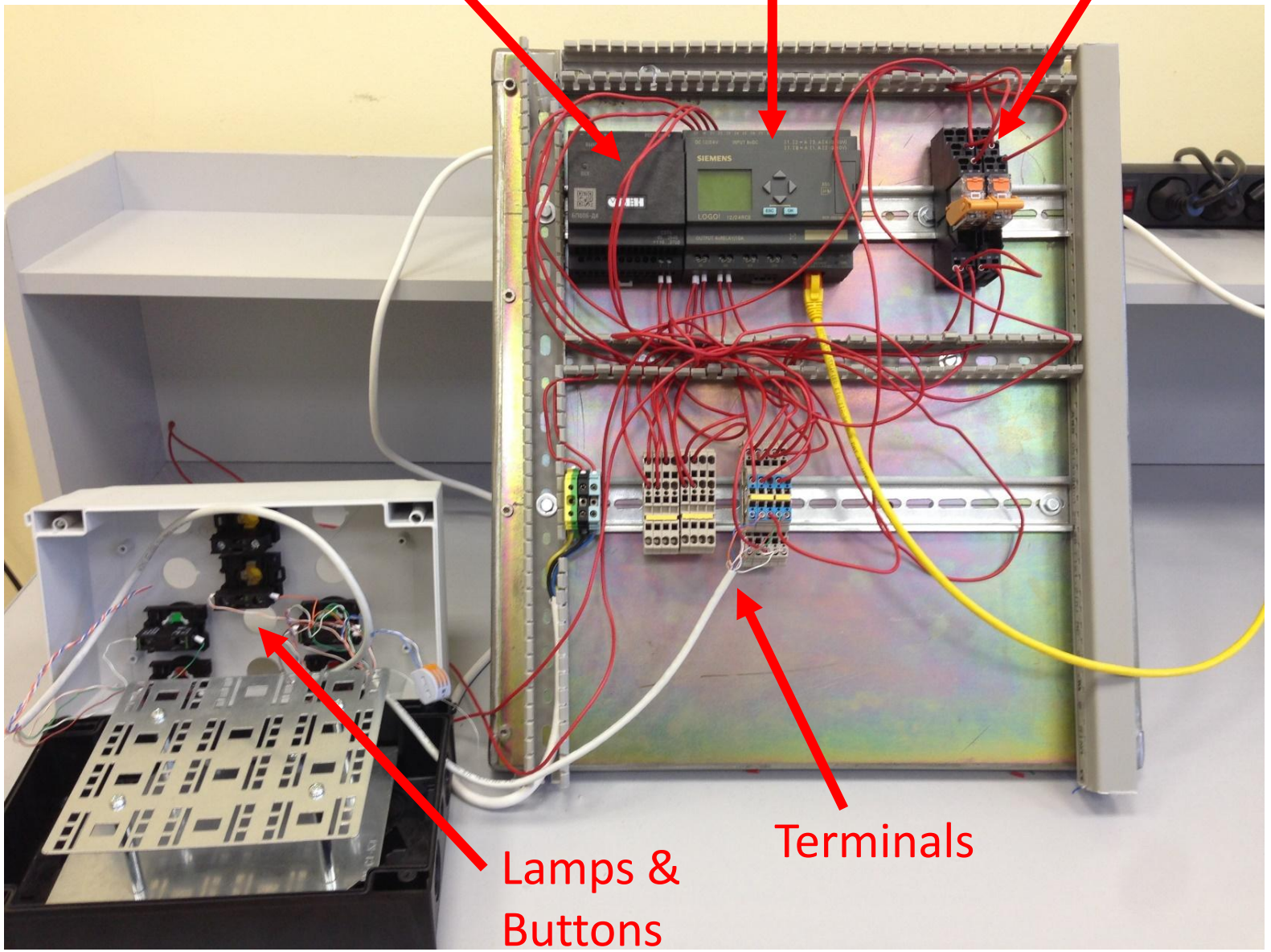
- Components:
  - B1: State triggering button
  - B2: Power button
  - D1: Door position sensor
  - L1&L2: Green lamps
  - L3&L4: Red lamps
- System behavior:
  - Pressing B2 for power on/off: Red lamps are on.
  - Pressing B1 turns on green lamps (free state).
  - Opening door or pressing again B1 turn on “occupied” state.



Electrical Circuit

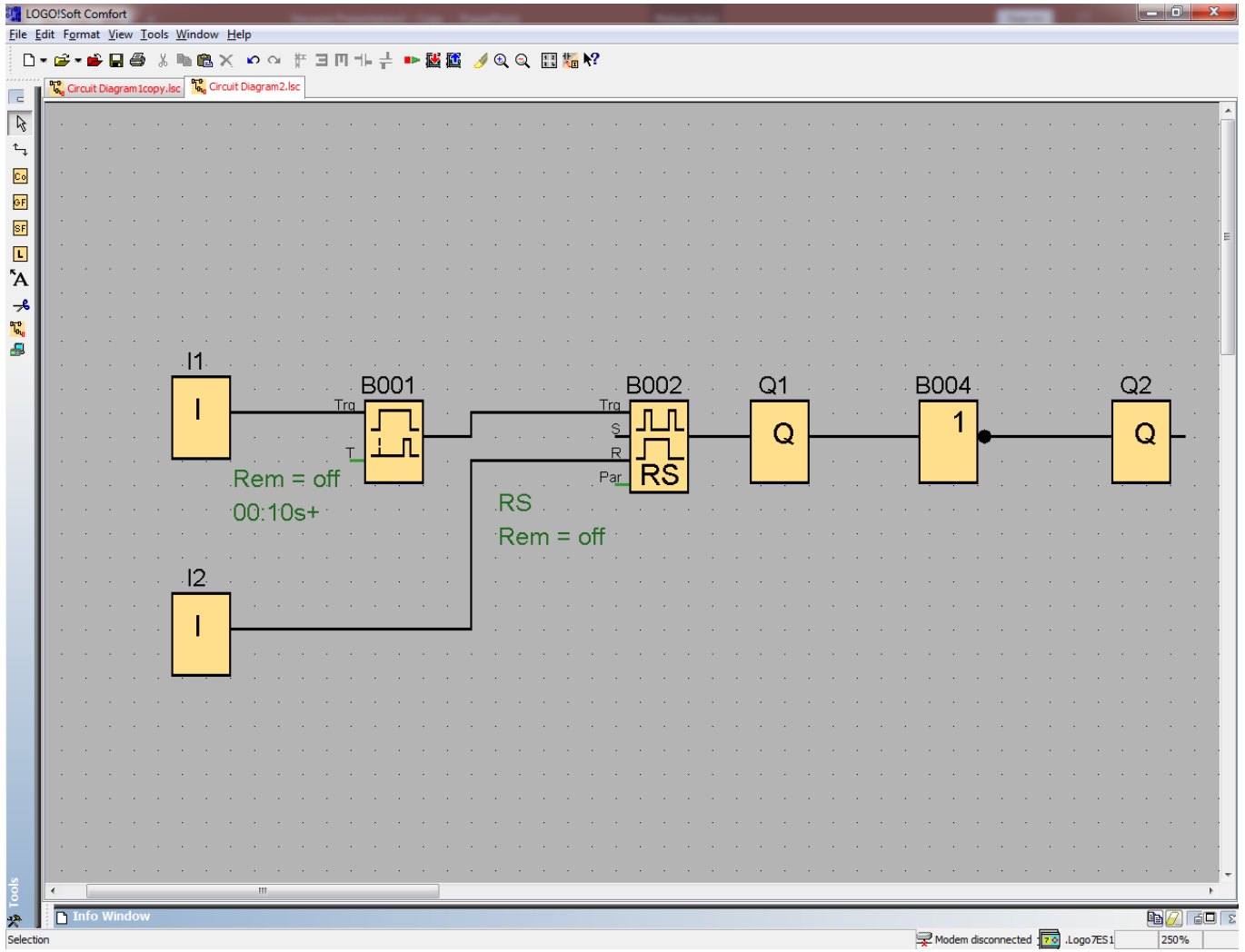


Equipment assembling

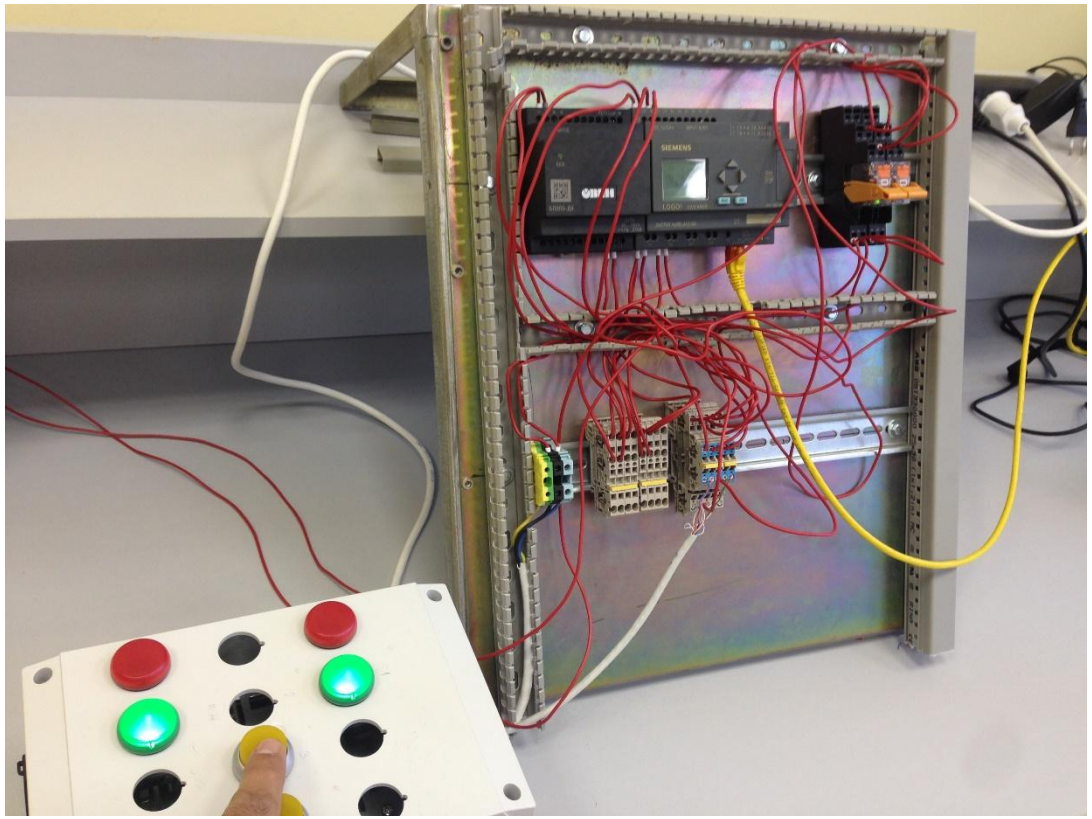


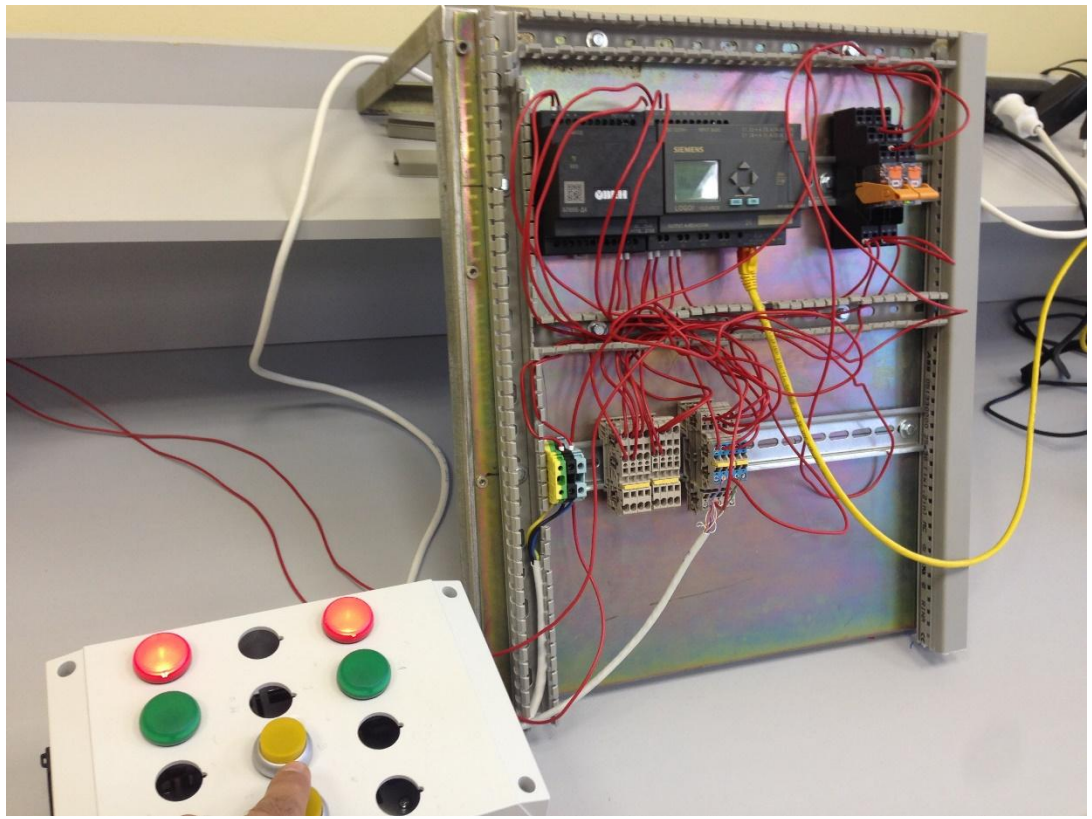
PLC program (using LOGO!Soft Comfort)

LOGO!Soft Comfort program allows to create programs and simulate projects using drag-and-drop functionality.



Test the project





Main Project (controlling a vacuum system)

System components

Pfeiffer Pascal 2010 SD :
oil rotary vane pump
Capacity 2,7 l/sec
Pmax 2×10^{-3} mbar

Edwards nXDS6i:
scroll pump
Capacity 1,9 l/sec
Pmax 5×10^{-2} mbar

Edwards nEXT300:
turbomolecular pump
Capacity 300 l/sec
Pmax 5×10^{-10} mbar

Gate valve: VAT Series 08

Angle valves
VAT Series 24
24428-KE01 CBVAC GD-J25

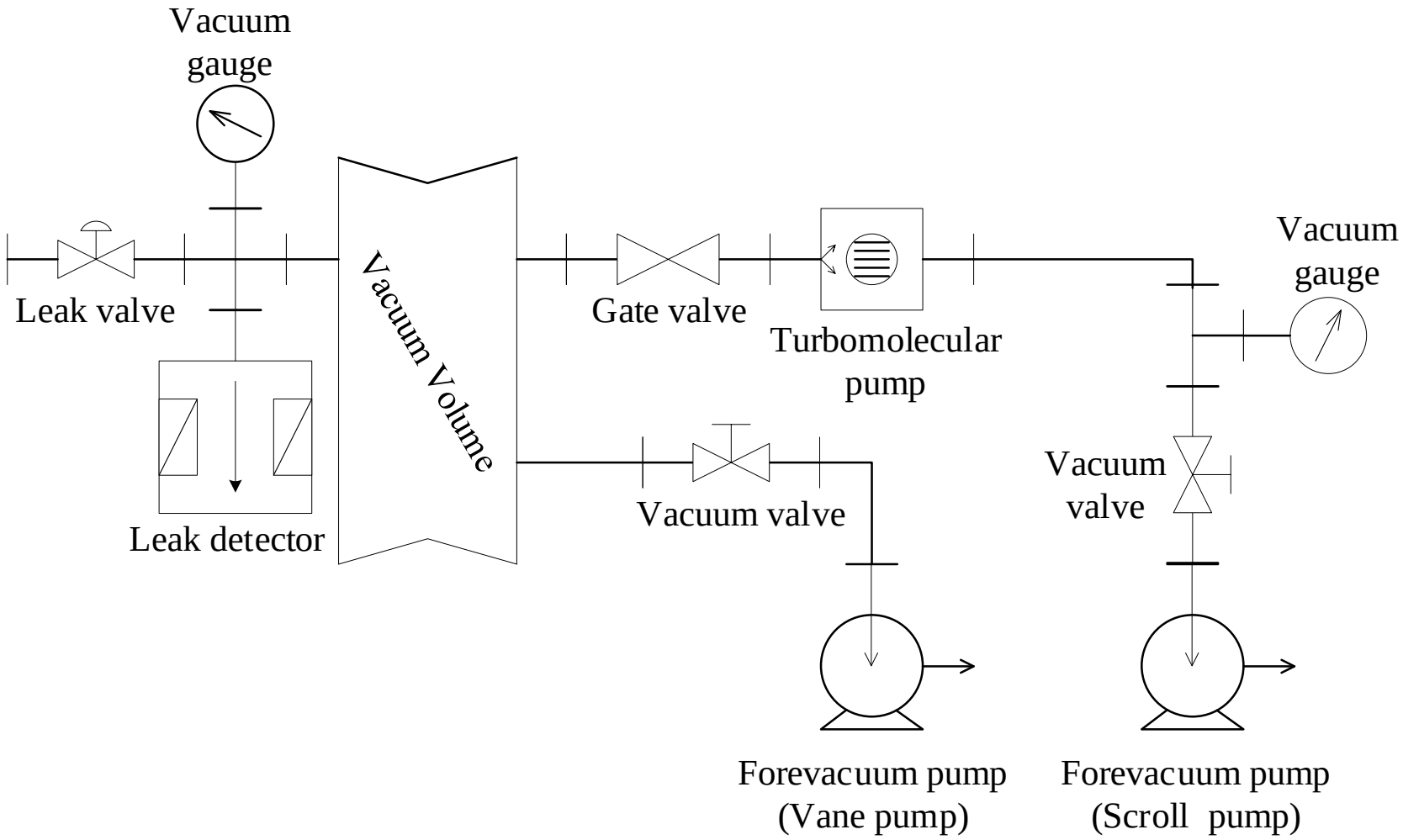
Edwards AGP 100

Edwards WRG

- Vacuum pumps
  - 2 Forevacuum pumps (oil rotary vane pump and scroll pump)
  - 1 High-vacuum (turbomolecular pump)
- Valves
  - 2 vacuum valves (manual and pneumatic)
  - 1 gate valve (manual and pneumatic)
  - Leak valve
- Measuring equipment
  - Pirani gauge (Atmosphere – 10^{-3} mbar)
  - Wide range vacuum gauge (Atmosphere – 10^{-9} mbar**)**
- Connection components
  - Flanges — stainless steel
  - Centering ring — stainless steel
  - Sealing— rubber

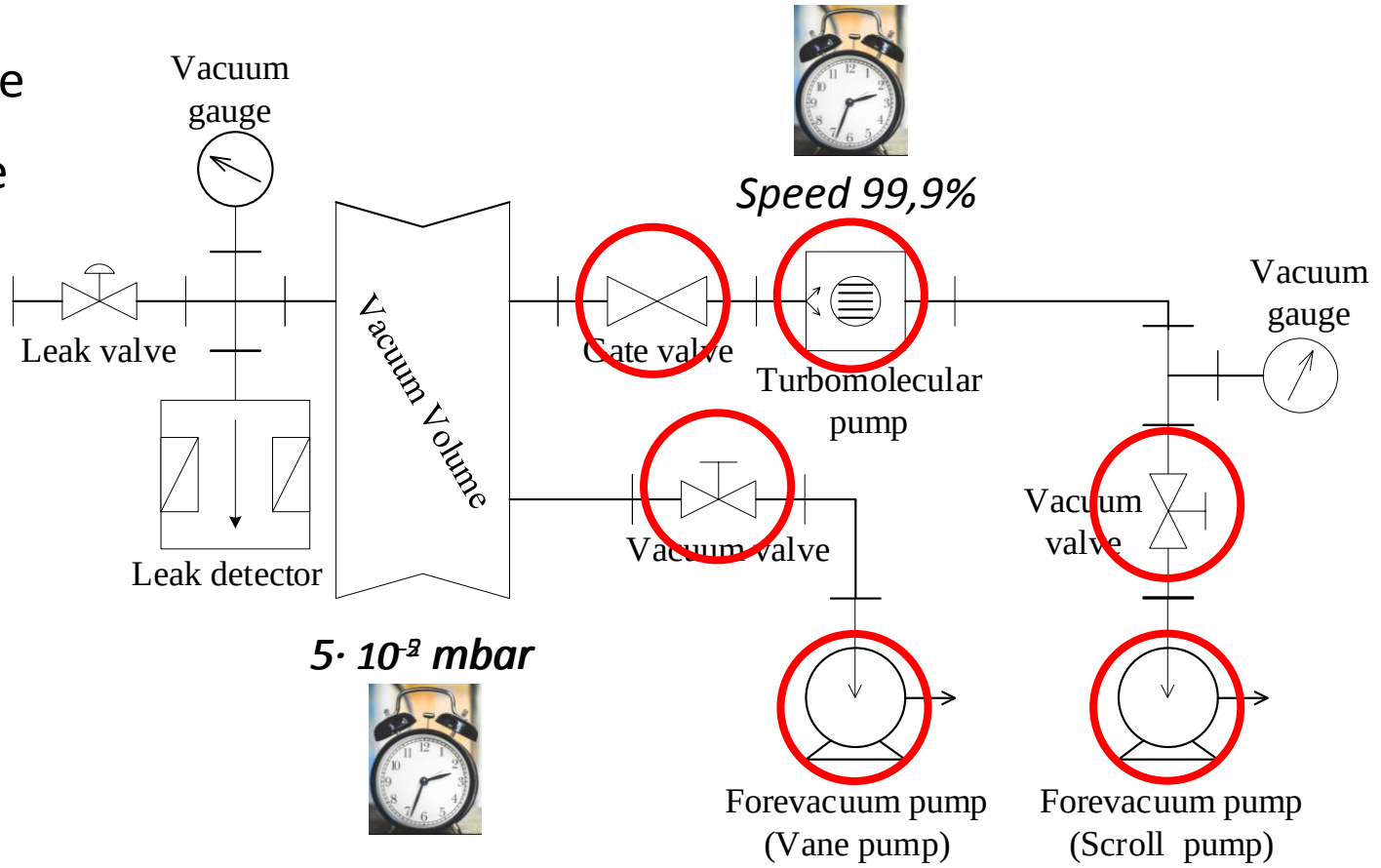
Vacuum System assembly (Manual phase)

Vacuum Manual Scheme (using Microsoft Visio)



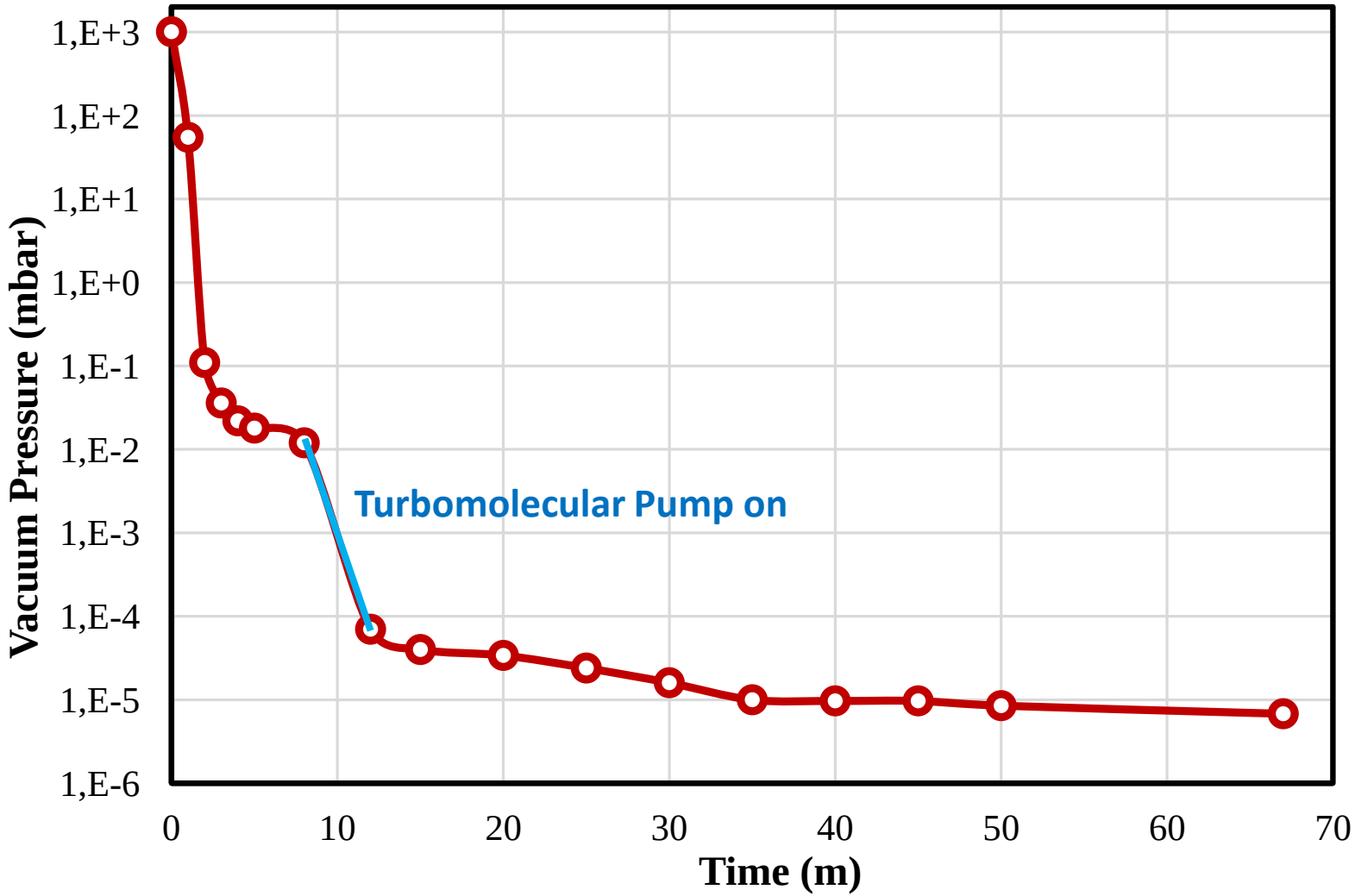
Operation Sequence

- Turn on vane pump and open its vacuum valve
- Wait until reach a pressure in vacuum volume of $5 \cdot 10^{-2}$ mbar.
- Turn on scroll pump and open its vacuum valve.
- Turn on Turbomolecular pump and wait until being ready (speed = 99,9%).
- Close vacuum valve and turn off vane pump.
- Open gat valve.
- Wait until reach vacuum around $5.\ 10^{-5}$ mbar.



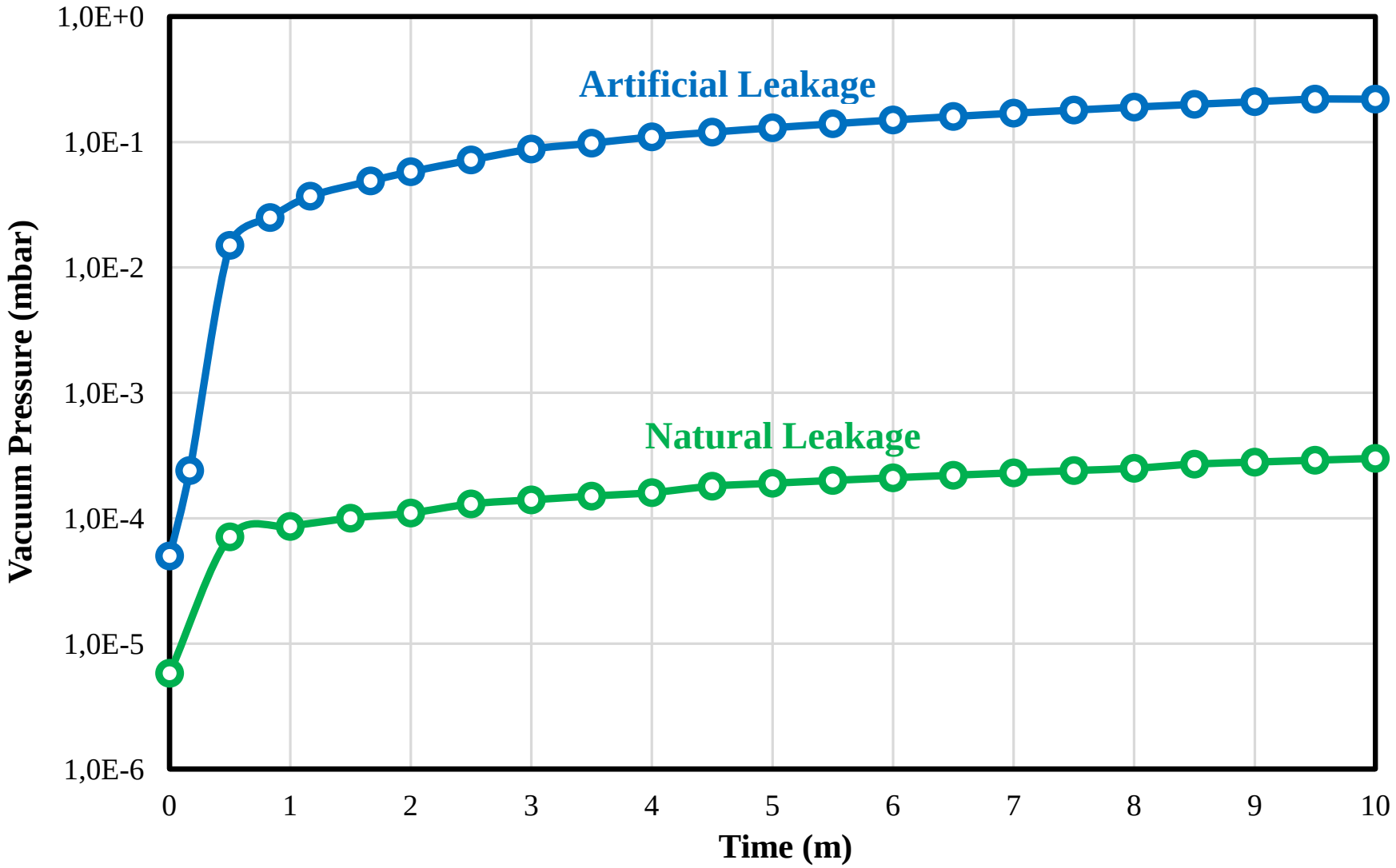
Pumping Curve of Vacuum System

By recording pressures measured during the time from starting until being stable at $1 \cdot 10^{-5}$ mbar, pumping curve is illustrated:



Leak detection (Natural and artificial)

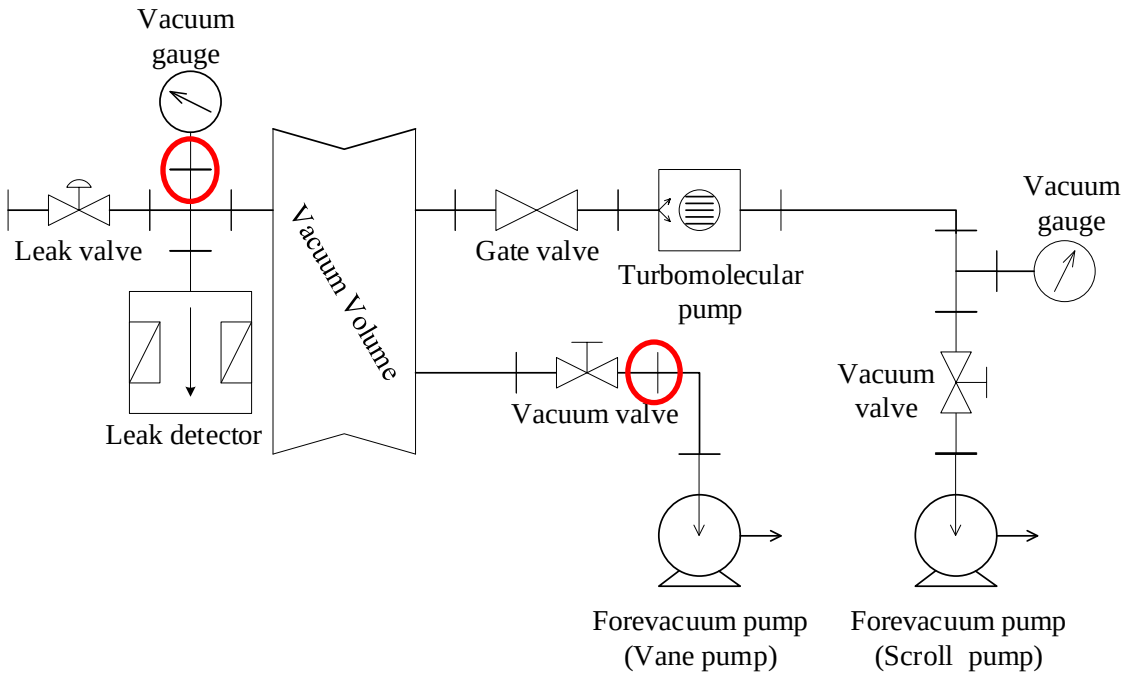
In natural leakage, I Just close gate valve and record the data while, in artificial one, I use leak valve



Leak detection

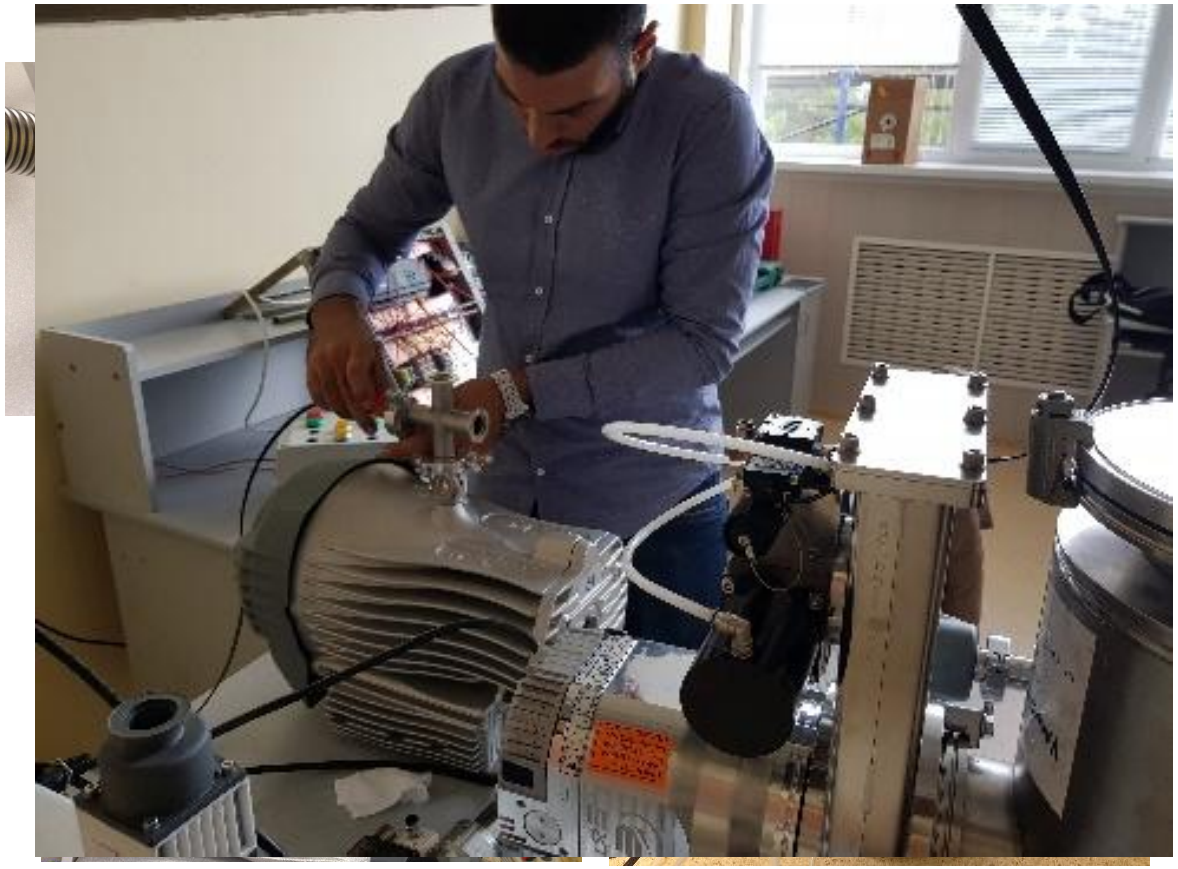
- Possible leaks sources:
  - Leaks in flange seals
  - Leaks in welds
  - Leaks in the equipment
- The device used is **Helium leak detector**: Helium cylinder, gas gun, and *leak detector device*.

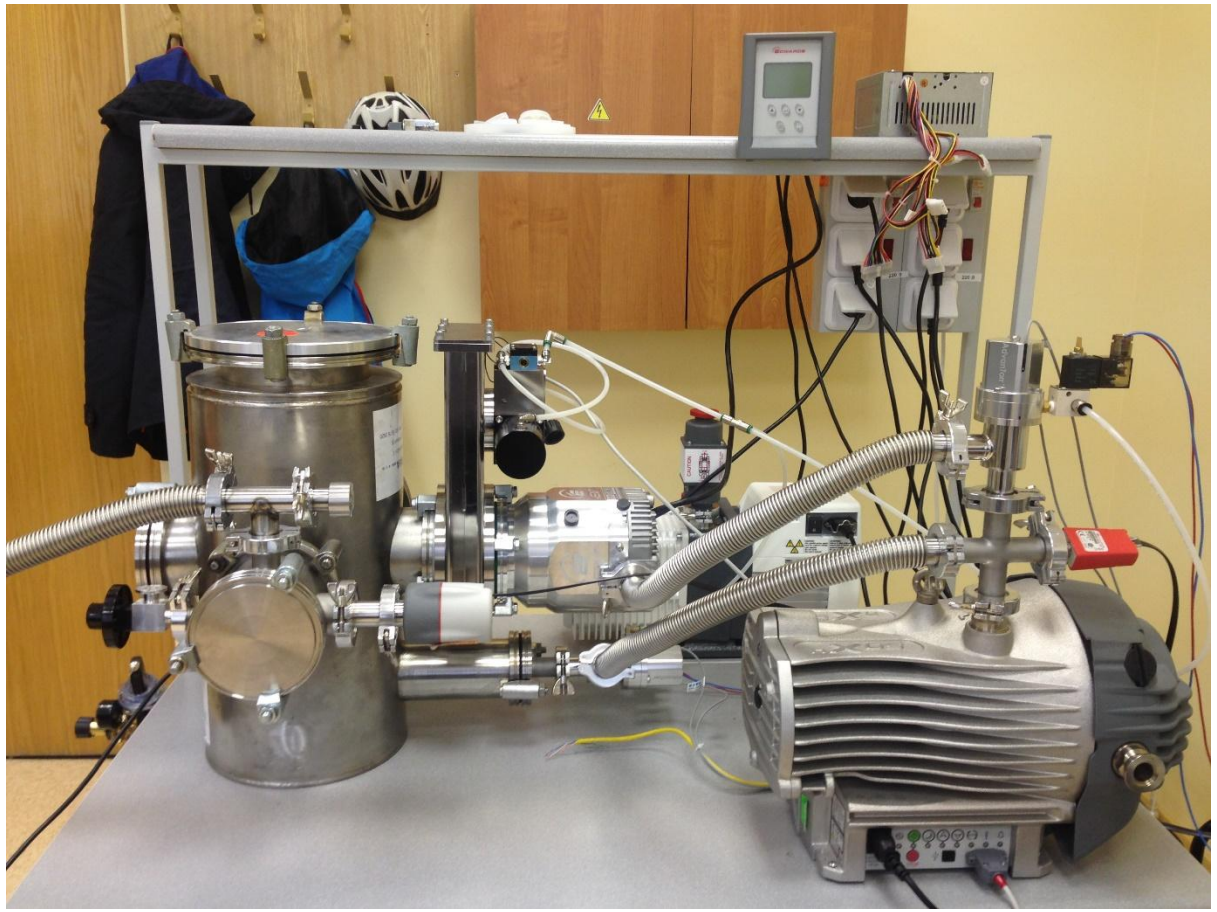
Leak detection and weak spots found



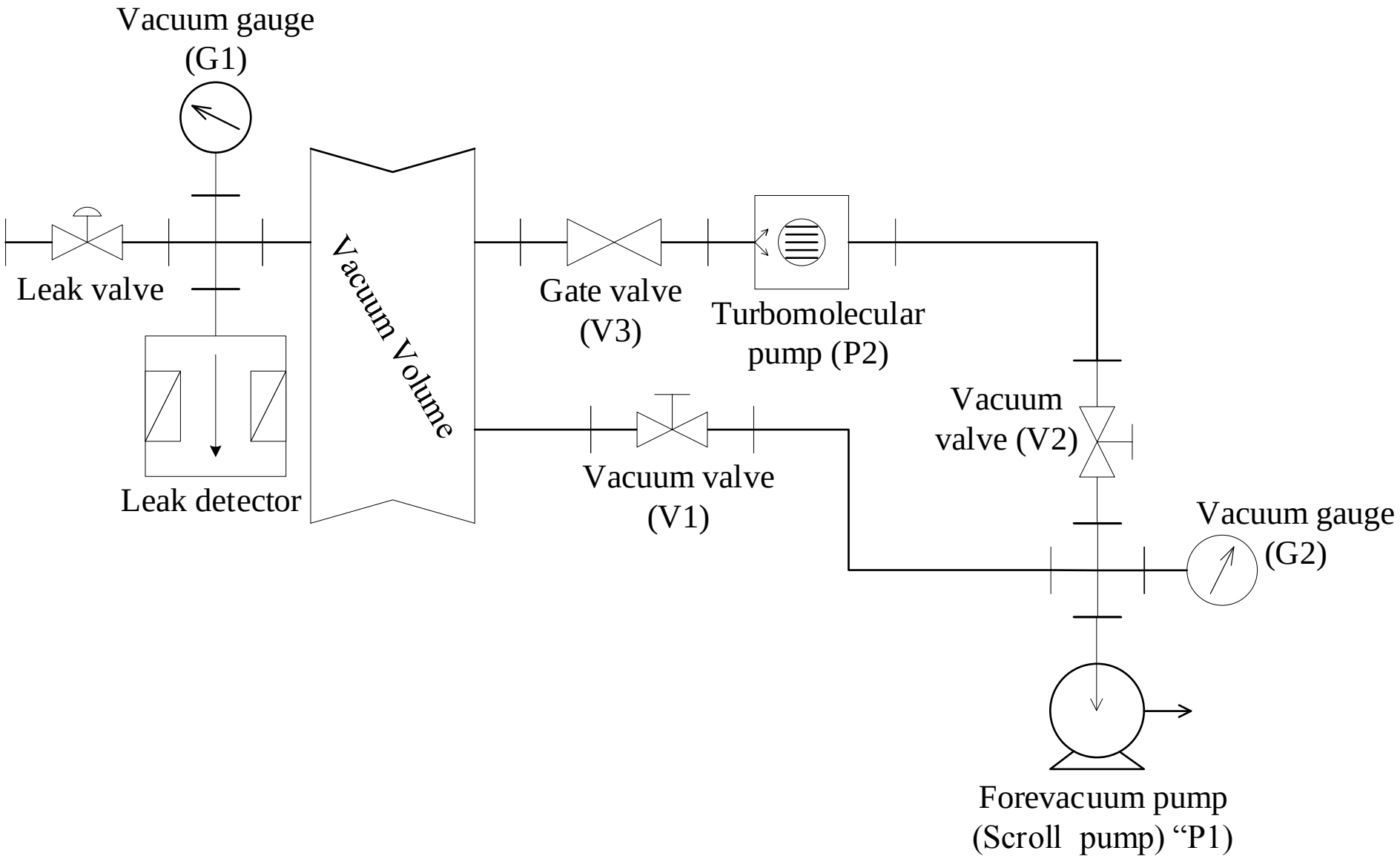
Reassembling the vacuum system (automatic phase)

- The manual three valves are **replaced** by pneumatic ones for control.
- Only two pumps are used (turbomolecular pump and scroll pump).
- Air compressor is used for actuating the valves pneumatically.

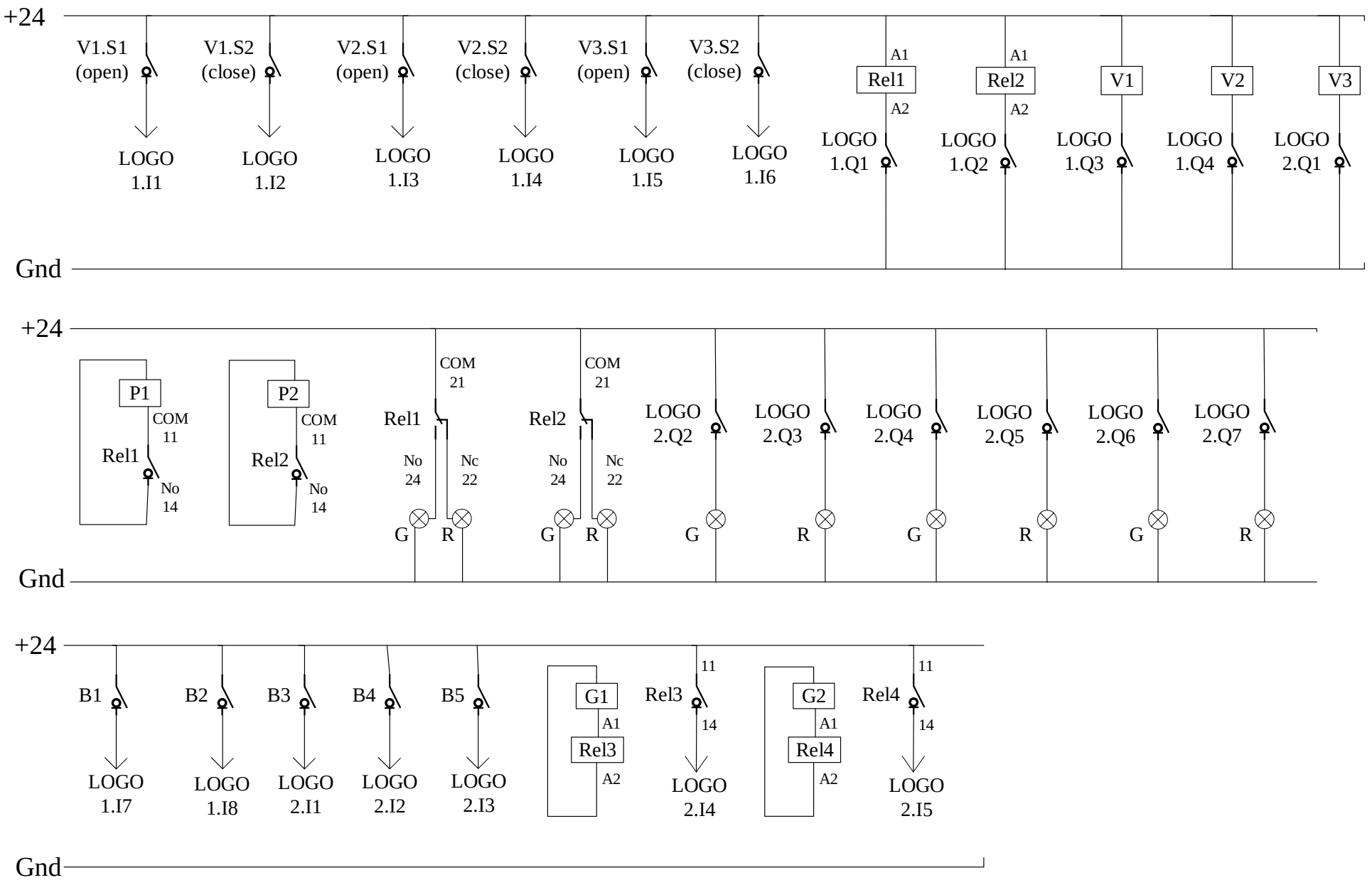




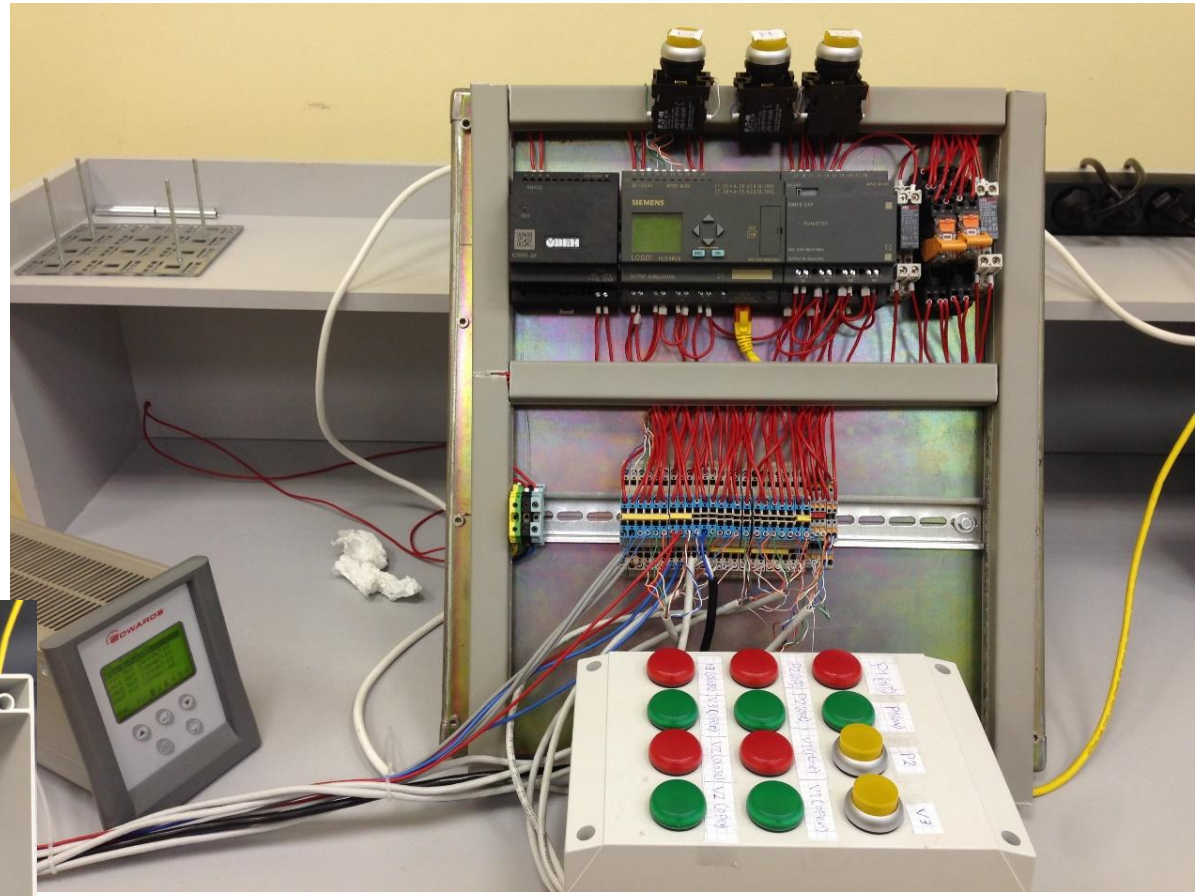
Vacuum Scheme (Automatic)



Electrical Circuit

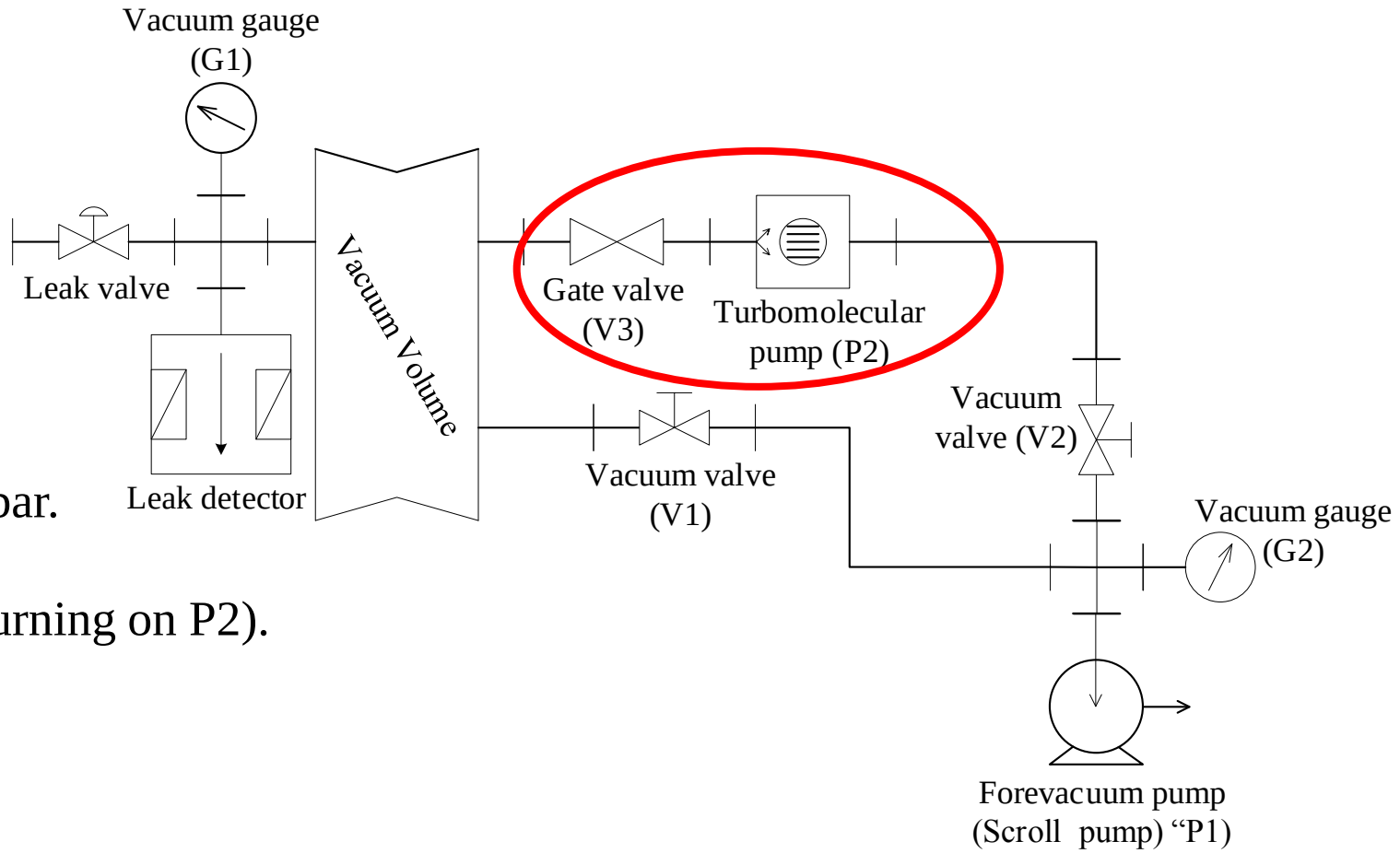


Assemble electrical scheme.



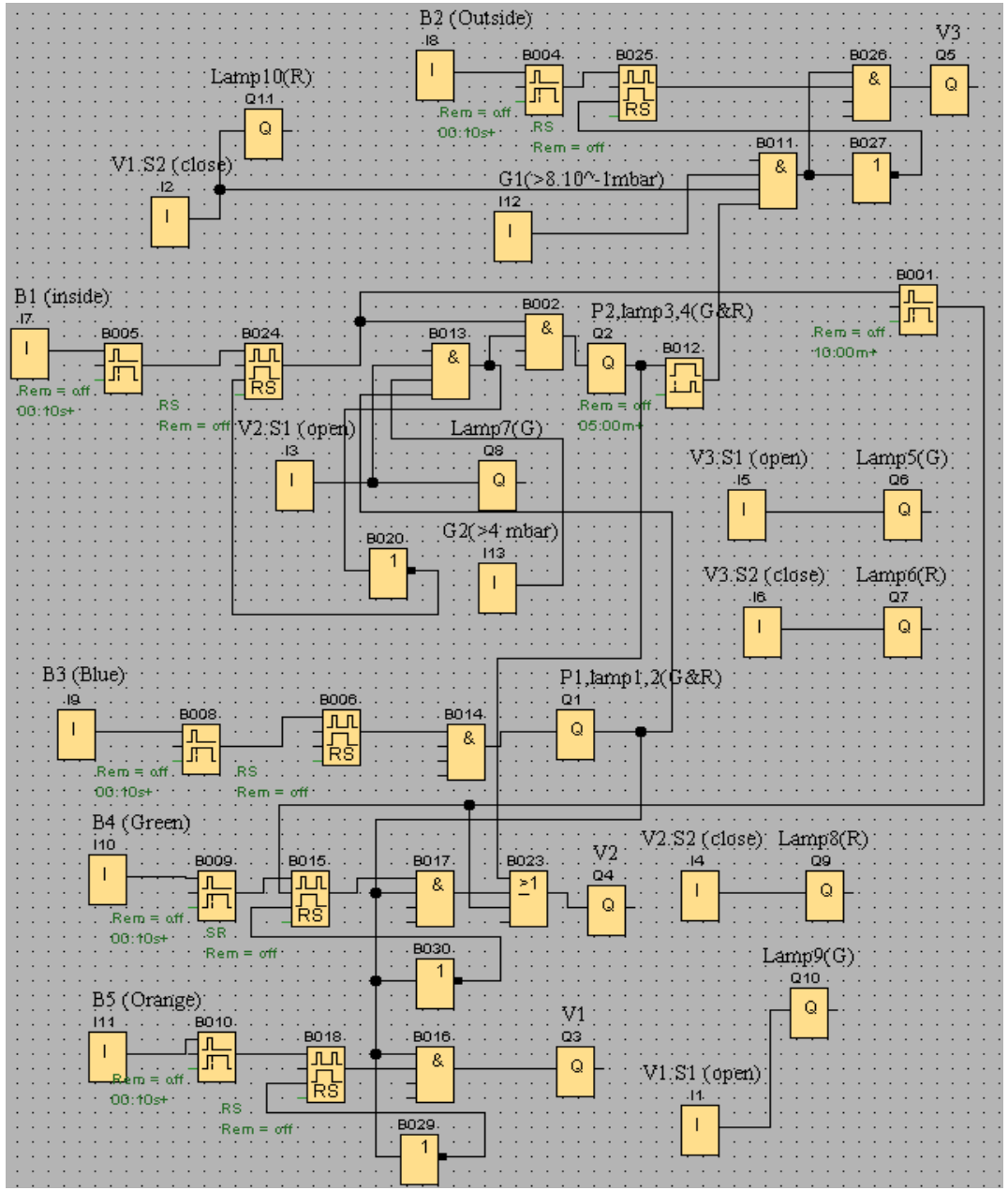
Interlock logic:

- P2 turns off if G2 indicates > 4 mbar.
- P2 turns on only if V2 is open.
- P2 turns on only if P1 is on.
- V3 opens only if G1 indicates < 8.10^-1 mbar.
- V3 opens only if P2 is ready (5 min. after turning on P2).
- V3 opens only if V1 is closed.
- V2 closes only if P2 is off.
- V2 closes only if P2 is fully off (10 min. after turning off P2).
- V1&V2 open only if P1 is off.

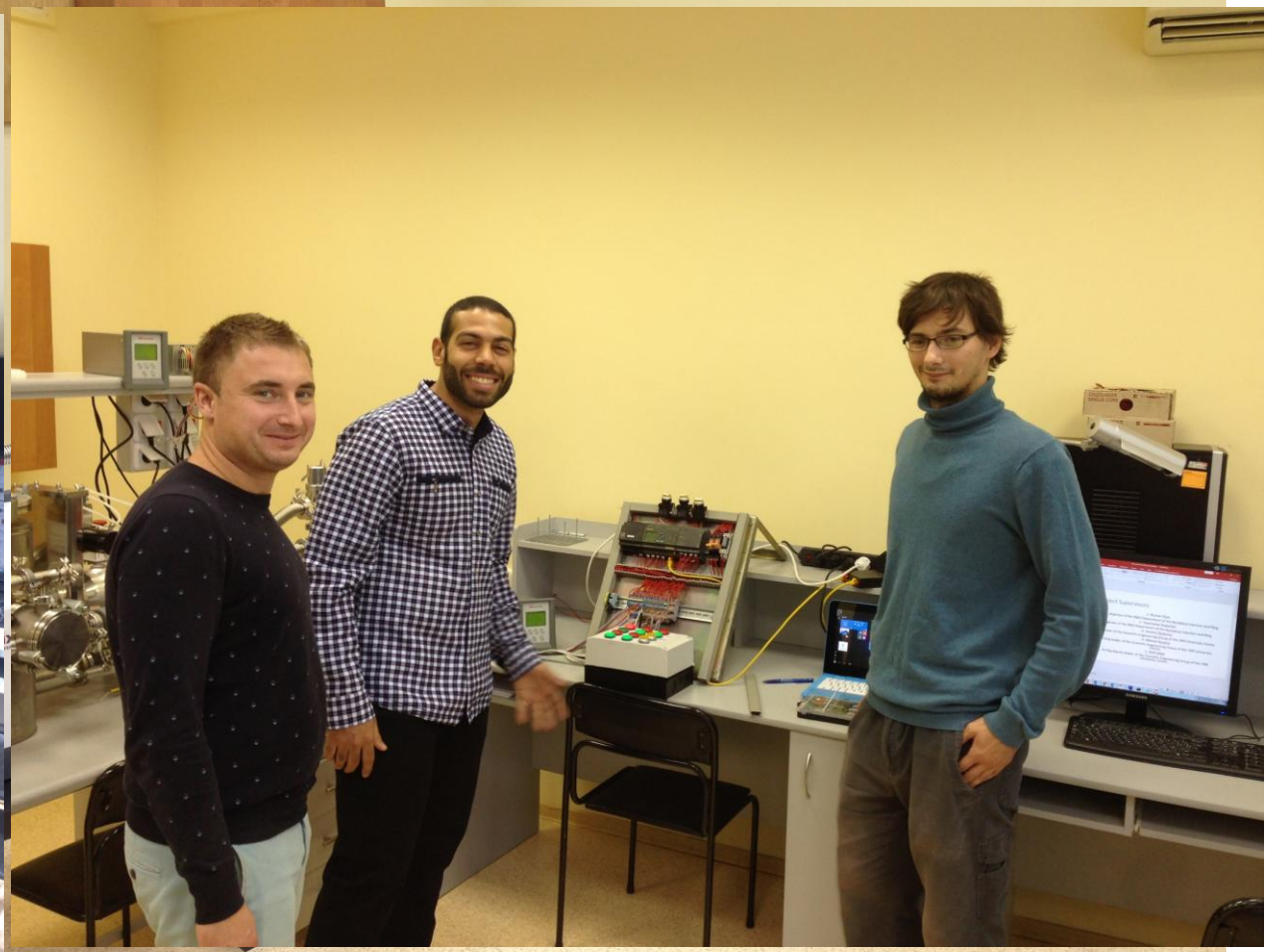


Implement the interlock logic and the automatic control system (PLC)

- Interlock logic, start-up and shut-down sequences are implemented using LOGO!Soft Comfort.



Final test of the system with a successful operation




Thank You!