Development of Gas System for Main TPC

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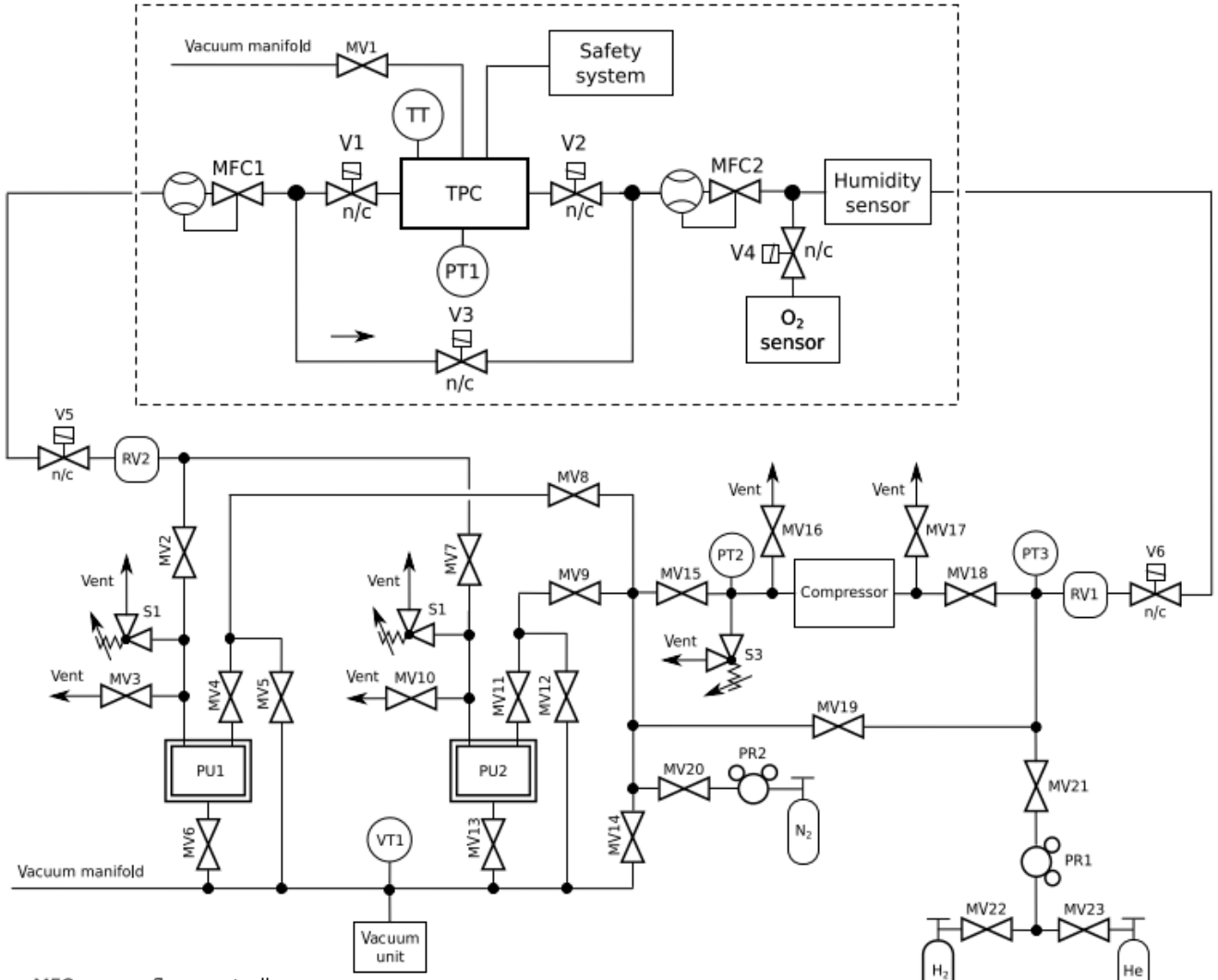
Current status

- Idea was presented at AMBER TB in November 2021
- Concept was developed and discussed within AMBER PRM group and the feedback is implemented
  - Couple of iteration

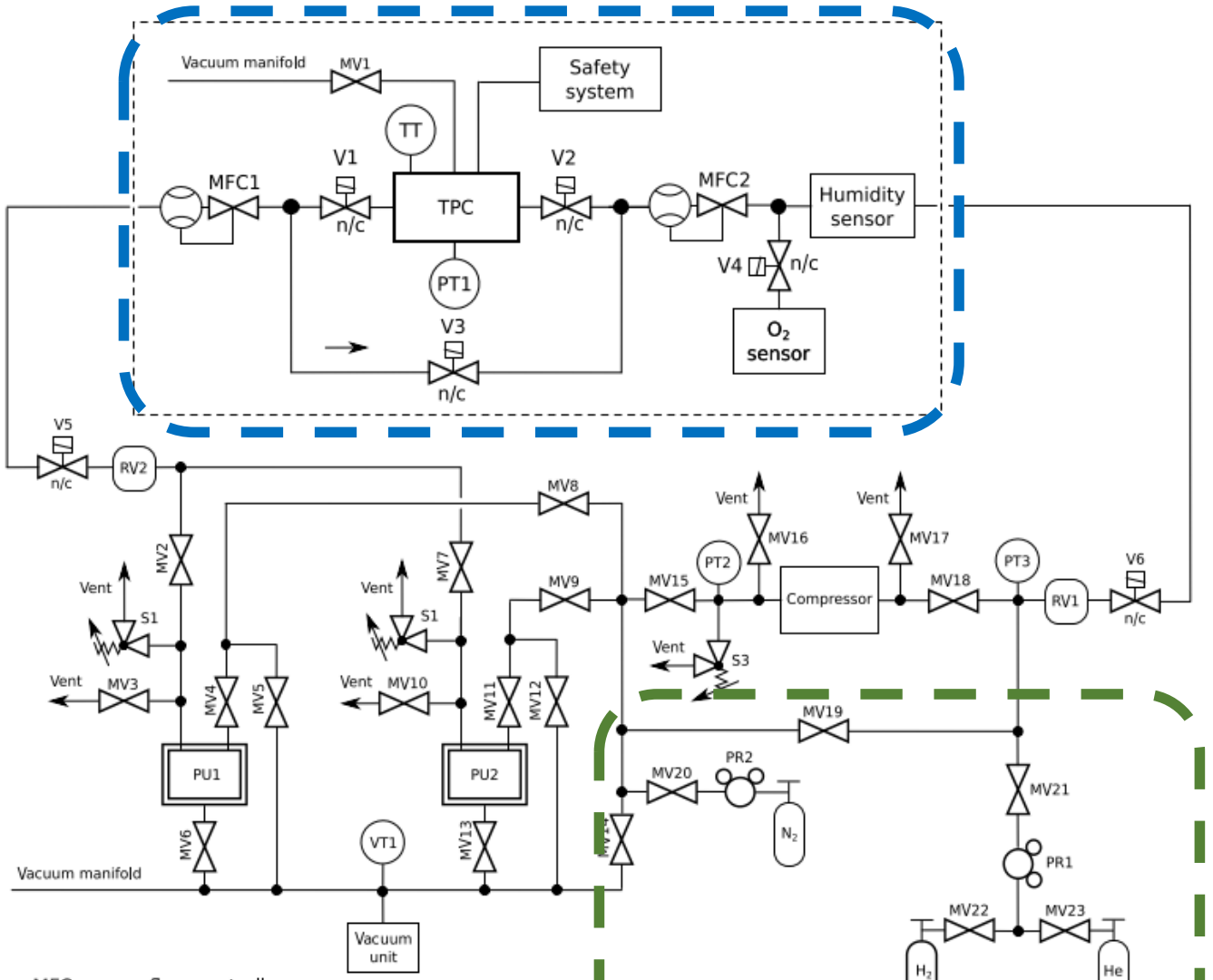
- In case of no showstoppers identified we will:
  - Estimate cost (in progress)
  - Need to specify information for discussion with safety



MFC - mass-flow controller
TT - temperature sensor (transmitter)
PT - pressure sensor (transmitter)
VT - vacuum sensor (transmitter)
RV - reserve volume (buffer)
V - operated valve (n/c - normally closed)
MV - manual valve
SV - safety valve
PU - purification unit
PR - pressure reducer

Operational conditions

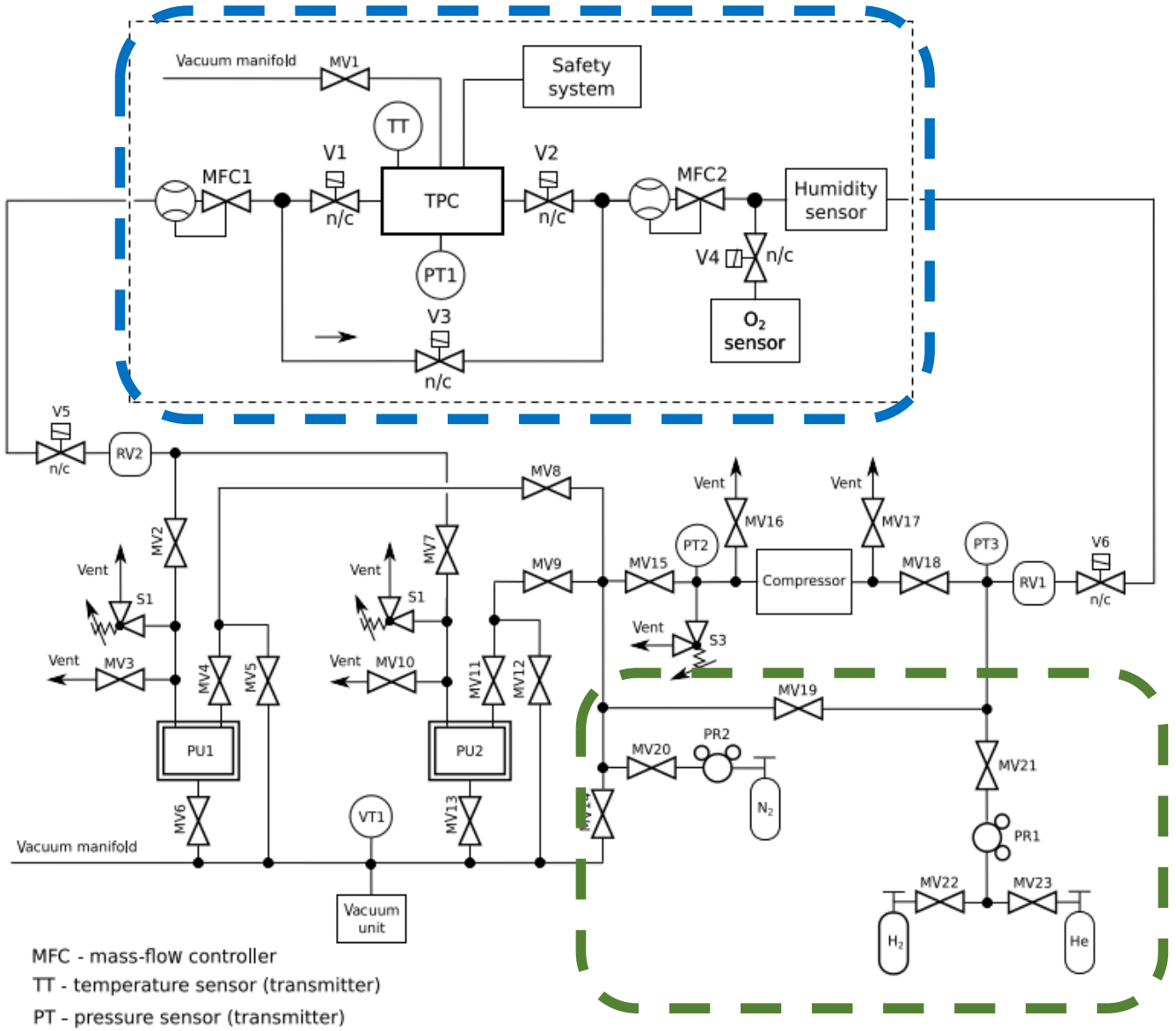
- **Gases:** Hydrogen, Helium, Nitrogen
- **Expected volume of TPC:** 2 m^3
- **Expected volume of rest of system:** 0.5 m^3
- **Operational pressure:** 0-20 bar
- **Maximal pressure: 30 (safety factor 1,43)**
- **Maximal flow:** 30 normal liters / minute
- **Standards:** Swagelok
- **Pipes:** stainless steel, inner radius of 4mm, outer radius of 6 mm
- **Initial gas:** H_2 mark 5, (10 ppm), stack of balloons
- **Starting time to achieve working conditions:** 1 week
- **Purification:** based on liquid N_2
- **Maintainable purification cells**



Proposed scheme

1. Detector house part (shown by dashed line, see requirements below);
2. Gas storage area (balloons, pressure reducer, MV10);
3. Gas barrack (compressor and purification units).

- Temperature stabilization with 0.1 K accuracy level
- Made of aluminum profiles and polycarbonate plates
- Hydrogen evacuation system on top (pipe to the roof)
- Will contain preamplifiers for TPC as well as HV inputs!
- **Sizes? Zoning (ATEX-2 → ATEX-1) ?**



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Detector house

- Operating valves are proposed to have pneumatic-based control
- V3 line is a by-pass
- V1-V3 are accompanied with a hand-controlled valves
- Humidity and oxygen sensors from the pilot run
- For TT it's proposed to use PT-100 sensors (current of 1 mA)
- Safety system as from Pilot run with minimal modification
- MFC – ATEX compatible
- Zoning issue

Alternative approaches to avoid TPC housing

- **Alternative 1**

- Density stabilization
  - Measure gas temperature and try to adjust hydrogen flow
  - There is a MuCup (PSI) experience (order of 0.001 precision)
- By knowing online and recording gas temperature and pressure we can always know how many molecules we have

- Several PT-100 inside TPC **(safety?)**

Alternative approaches to avoid TPC housing

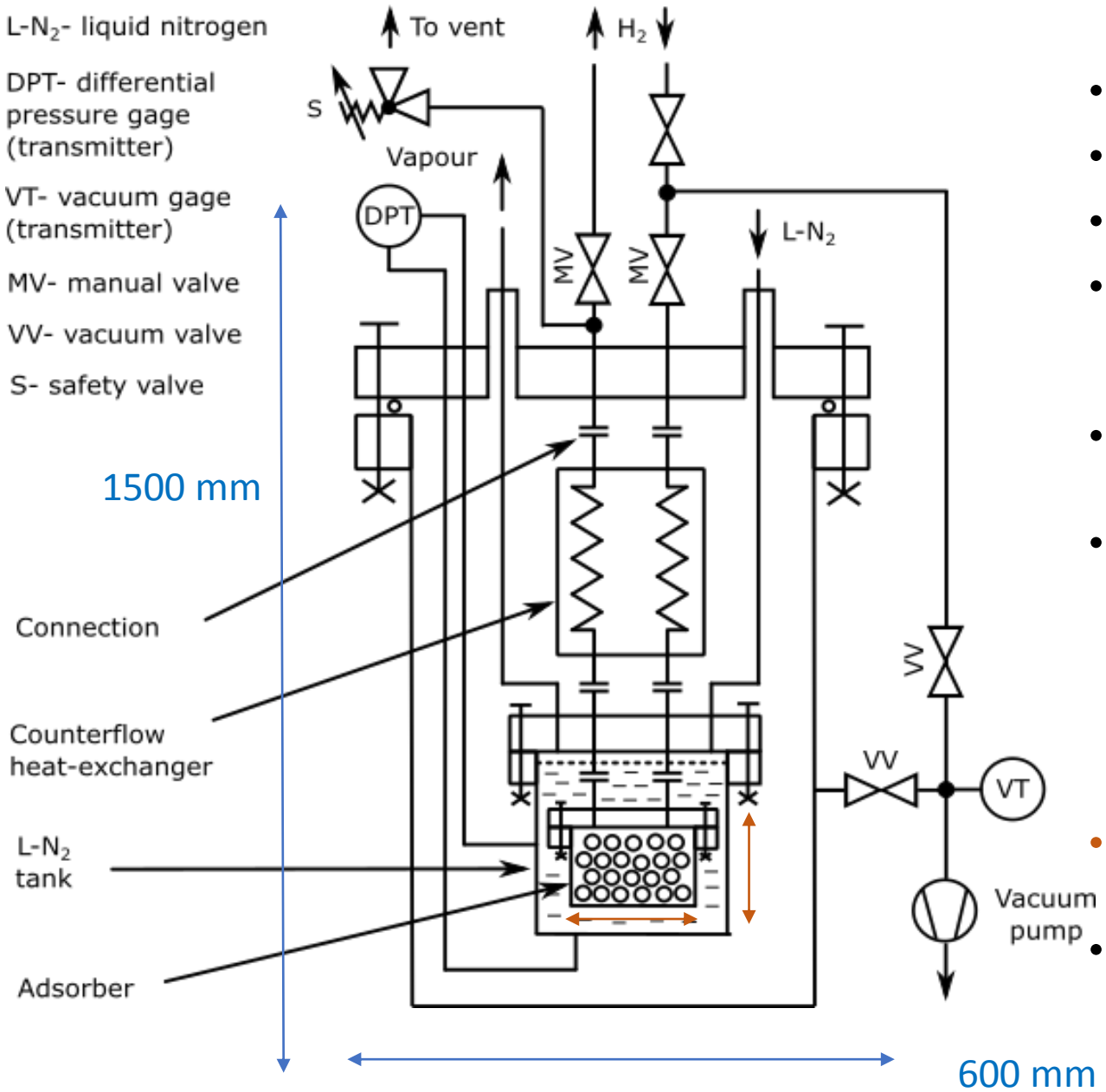
- **Alternative 2**

- Liquid thermostabilizing
  - Water, ethylene glycols
  - Under thermo-stabilization jacket

- *Tricky (many valves and feedthroughs) and 'dangerous' in a sense of HV present*

Both alternatives have to be investigated inside PRM WG.

Purification unit



- Work on liquid nitrogen to **clean H_2 and He.**
  - A tank of liquid N_2 has to be installed, not shown in the current main sketch.
  - Expected consumption of liquid nitrogen is 80 liters/day
- Switch between units will take 1-2 hours
- **No electric parts inside!**
- **VCR connection in liquid nitrogen (much more robust)**
- Besides line of working gas and nitrogen (input: liquid, output gas) a pumping from operational vacuum unit and differential monometer for control are foreseen.
- Evacuation of H_2 (in case of problems) through the N_2 vapor [should be safe by a default]
- Maintenance is done outside of installation area:
  - **Key point here is a demountable flange (copper coils gas isolation) allowed for PUs**
  - **Dismounting also means that a non-welding, but a Swagelok connection will be**
  - After mounting a helium test with helium detector at working temperature to control potential leaks.
- Pressure test-factor 1,43 is expected only for cartridge with adsorber.
- Vacuum unit consists of:
  - fore vacuum pump, turbo-molecular pump, valves control system

System outgassing before operation

Two fandoms exists:

- **“Heating and pumping”** – based on idea that admixtures placed on surfaces are released consuming energy from the surface.
- **“Flushing”** – admixtures can take an energy from the gas vis scattering. This procedure requires filling system, by working gas to 100 mbar pressure and when pumping it to 0.1 mbar level. Several (order of 5 iteration) are foreseen prior to any data taking if case system is considered to be dirty (due to innervations).

- The “Flushing” option is considered as the main one, as heating can deform plastic support elements inside the TPC and the large valve is required in order pumping to be efficient.
- To start data taking initial hydrogen has to be purified as well
  - 1 week of circulation at 1-2 bar pressure.
- When switching helium to hydrogen a PU, which was in use has to be detached from the system and regenerated.
  - Note, that PU can’t clean hydrogen out of helium admixtures.

Control of gas admixtures

- The expected admixtures to hydrogen are air components and water.
  - The main problem for less than ppm gas admixtures is the TPC signal degradation, which is caused by capture of electrons during their drift
- This will be controlled by water and oxygen sensors
- Water level is assumed to be a main benchmark, as other admixtures known to be less

- Chromatography can be optional solution for control, but elements, which are controlled should be known beforehand

Summary

- Compressor-based Gas System for main TPC
  - Detector housing (there are alternatives)
  - Maintainable purification units based on liquid-N_2

- The main question: "**From this glance is such concept possible to be accepted by safety?**"
- What else to be clarified?

- Cost evaluation is in progress.