C1Po2C-04: Development of a dual flow transfer system with a centrifugal pump for liquid helium

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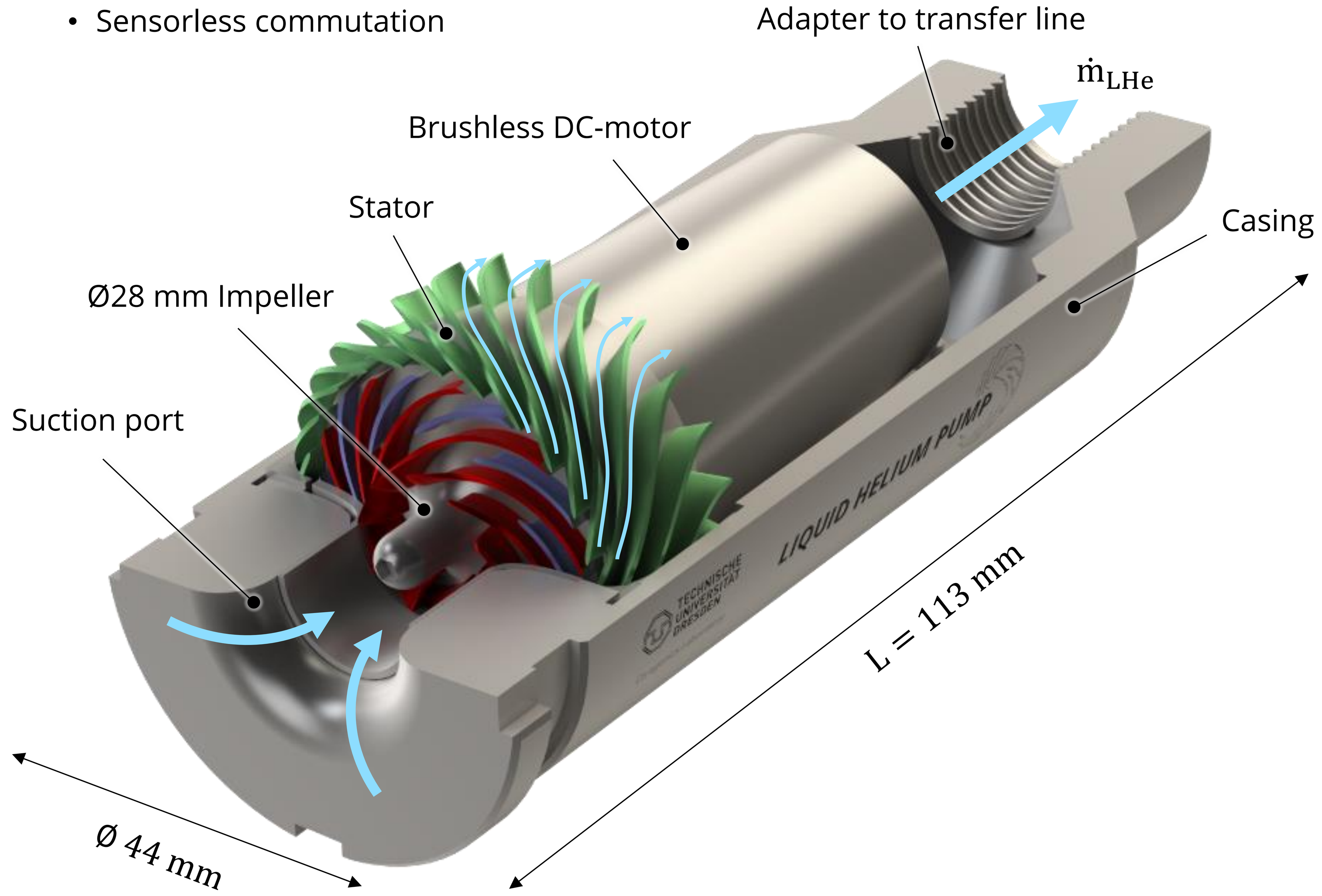
Motivation

- In liquid helium infrastructures the highest potential of efficiency optimization lies within the transfer process
- By use of conventional transfer lines up to 30% of transferred liquid evaporates
- Generated gas undergoes demanding recovery, purification and reliquefaction
- Using a pump in combination with a dual flow transfer system, transfer losses down to 2% or less are possible [1]

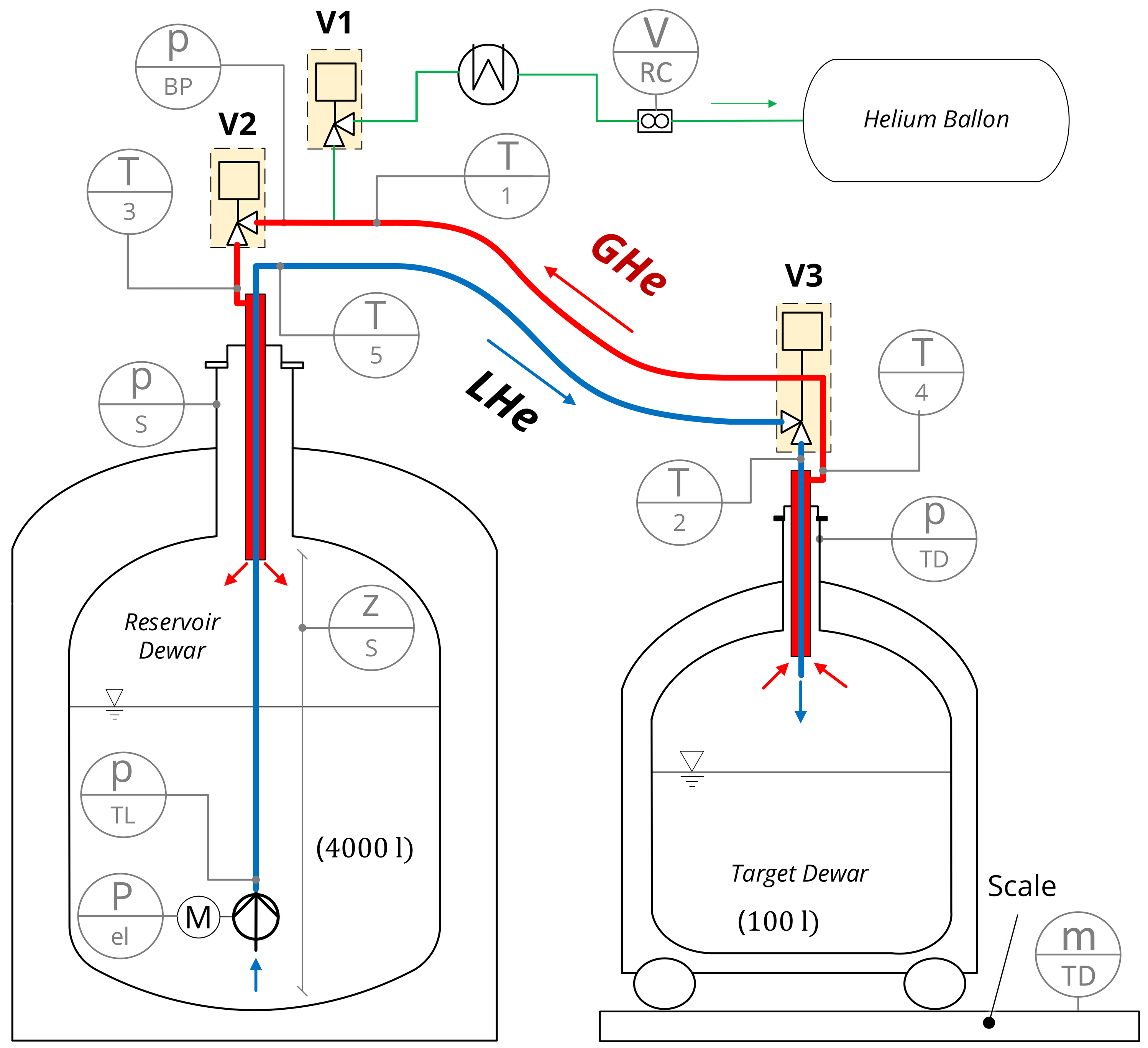
Goal: Development of a flexible transfer system with high-efficiency pump

Liquid helium pump

- Submersible centrifugal pump (design adapted from first TU Dresden prototype [2]):
  - Shrouded impeller with 18 blades (including 9 splitter blades)
  - Radial-axial stator with 22 blades
  - Impeller and stator additively fabricated (binder jetting method)
- Brushless three-phase DC-motor:
  - Dry running hybrid ball bearings
  - Sensorless commutation

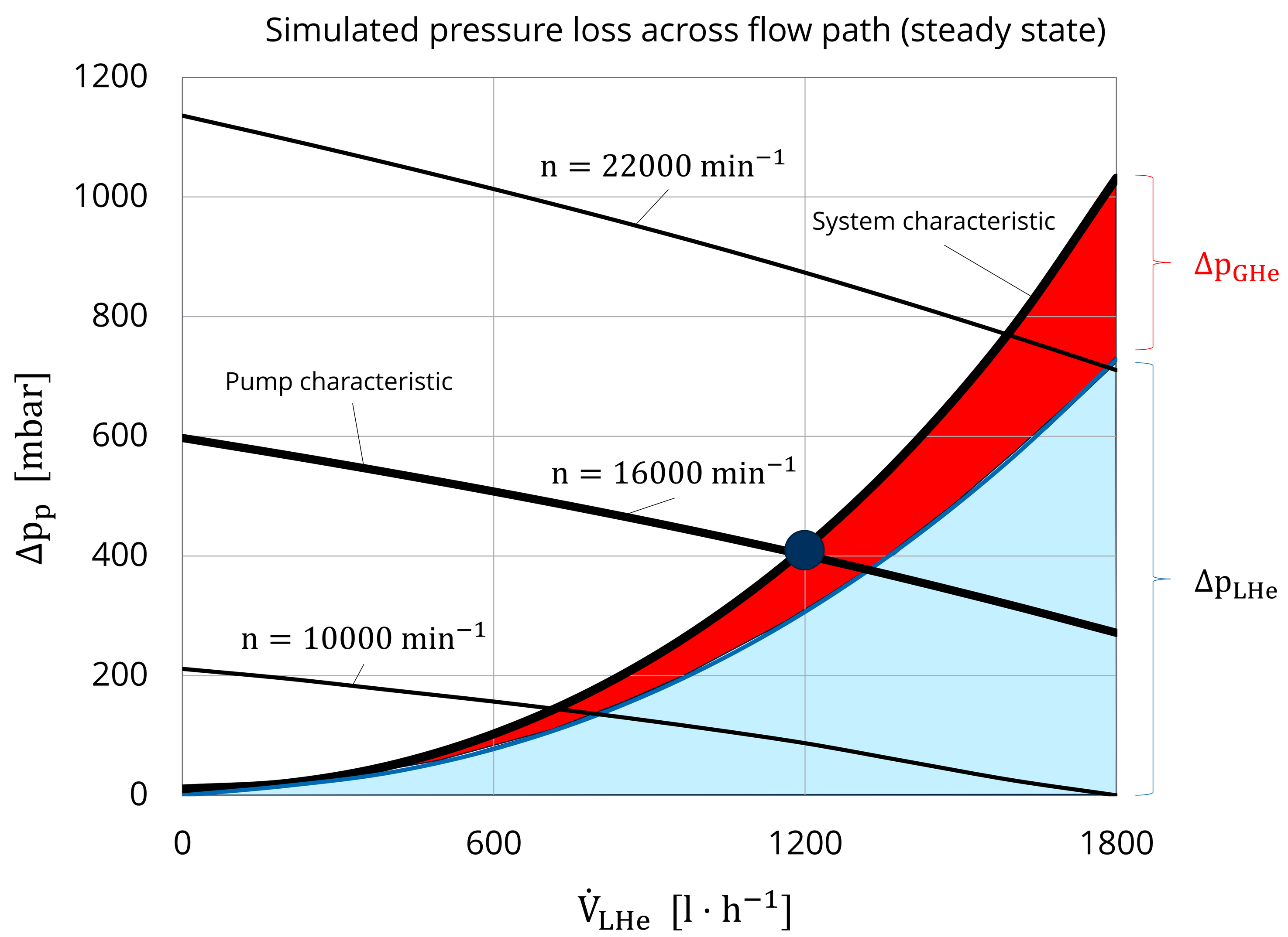


Concept of dual flow transfer system



- Pump transfers **liquid helium** from reservoir to target dewar through liquid line, in steady state: **cold gaseous helium** flows back in counterflow
- Cool down: **warm helium gas** is bypassed to recovery and warms up
- Flexible horizontal section (two corrugated tubes in parallel for more flexibility)
- Rigid vertical section (coaxial tubes at both sides)
- All tubes in one common vacuum
- Several layers MLI applied in horizontal section
- Aluminum tape applied in vertical sections to reduce radiation
- Use of PTFE spacers to fix internal tubes

System characteristics



- Pressure loss dominated by liquid line Δp_{LHe}
- Target dewar at medium pressure
- Assuming 7 W static heat leak, subcooled liquid enters target dewar at design flow rate of 1200 l/h
- Total evaporation loss depends on cool down losses (corresponding to cold mass)

Outlook

- Installation of the entire system at filling station
- Experimental testing of cool down and steady state operation
- Evaluation of system performance, especially evaporation losses and cavitation performance of the pump

Literature

[1] Berndt, H., Doll, R., Wiedemann, W., 1990. *Two Years' Experience in Liquid Helium Transfer with a Maintenance free Centrifugal Pump*. Advances in Cryogenic Engineering, Volume 35.

[2] Doll, J.; Klöppel, S.; Haberstroh, Ch., 2023. *Development and Characterization of a Centrifugal Pump for Low-loss Liquid Helium Transfer*. 17th Cryogenics 2023, IIR Conference (DOI: 10.18462/iir.cryo.2023.148).