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# CryoPHAEQTS – Cryogenic Phase Equilibria Test Stand

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Poster presented at the II. International Workshop on Cooling Systems for HTS Applications

## Motivation

- Cryogenic mixed refrigerant cascades (CMRCs) as efficient cooling method for applications below 63 K
- CMRC design requires fluid states (thermodynamic equation of state, surface tension) and transport properties to mass, momentum and energy equations

| Transport type | Transport coefficient |
|---|---|
| Mass | Diffusivity δ |
| Momentum | Viscosity η |
| Energy | Thermal conductivity λ |

## Phase equilibrium

Dynamic analytical method with vapor circulation

- Cell temperature control by pulse tube cryocooler
- Sampling VLLE phases by electromagnetically actuated valves allowing volumes in the µL range
- Analysis in gas chromatograph with molecular sieve type columns
- SLE measurement by calorimetric method and visual analysis

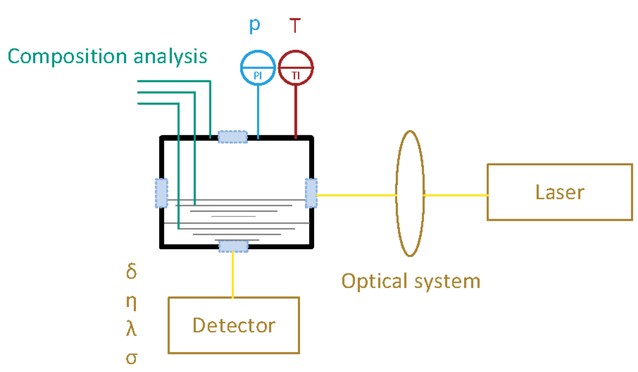



Fig. 1: Setup for parallel determination of fluid state and transport properties.

## Optical experiments

Detection of scattered light intensity decay by Photon Correlation Spectroscopy (PCS)

- Dynamic Light Scattering (DLS)
  - Laser light passes through bulk phase
  - Relaxation correlates with thermal conductivity, diffusion coefficient and sound attenuation
- Surface Light Scattering (SLS)
  - Laser light crosses the phase boundary in VLE
  - Damping factor of thermally induced surface waves correlates with kinematic viscosity and surface tension

## Process design

| Process parameters | |
|---|---|
| Temperature range | 15 K – 300 K |
| Pressure range | Up to 15 MPa |
| Cell volume | 100 mL |
| Fluids | Cryogenic mixtures, incl. flammable and oxidizing fluids (ATEX compliant) |

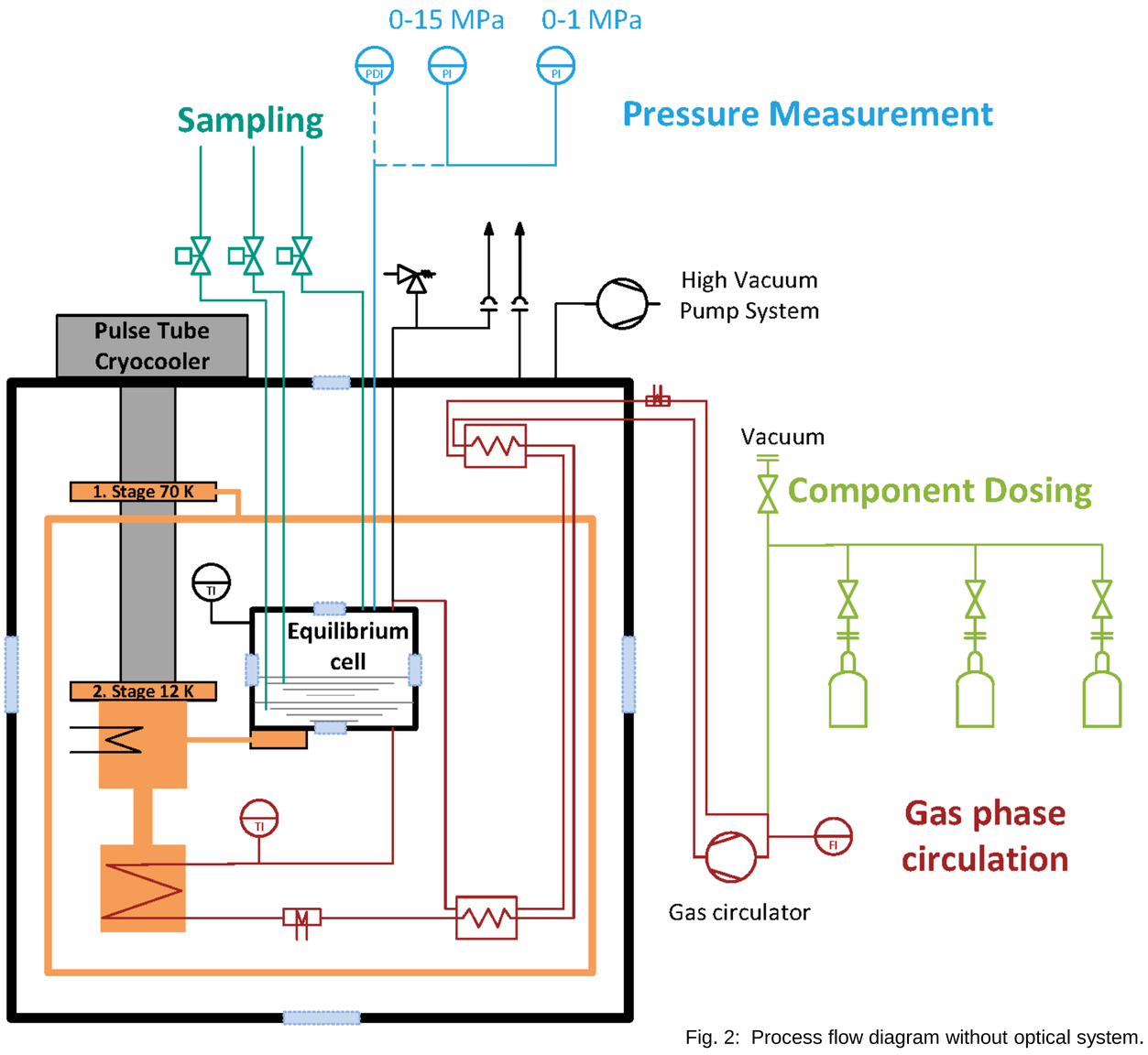
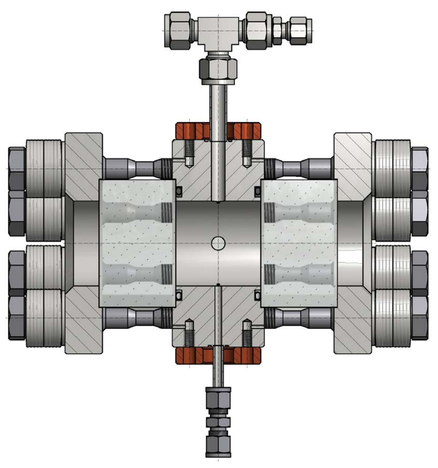



Fig. 2: Process flow diagram without optical system.

## Mechanical design

- Equilibrium cell consists of
  - 1.4571 austenitic stainless steel and quartz glass, allowing optical experiments up to 15 MPa
  - Helicoflex DELTA seals with disc springs
- Test stand safety ensured with pressure relief valves and rupture discs



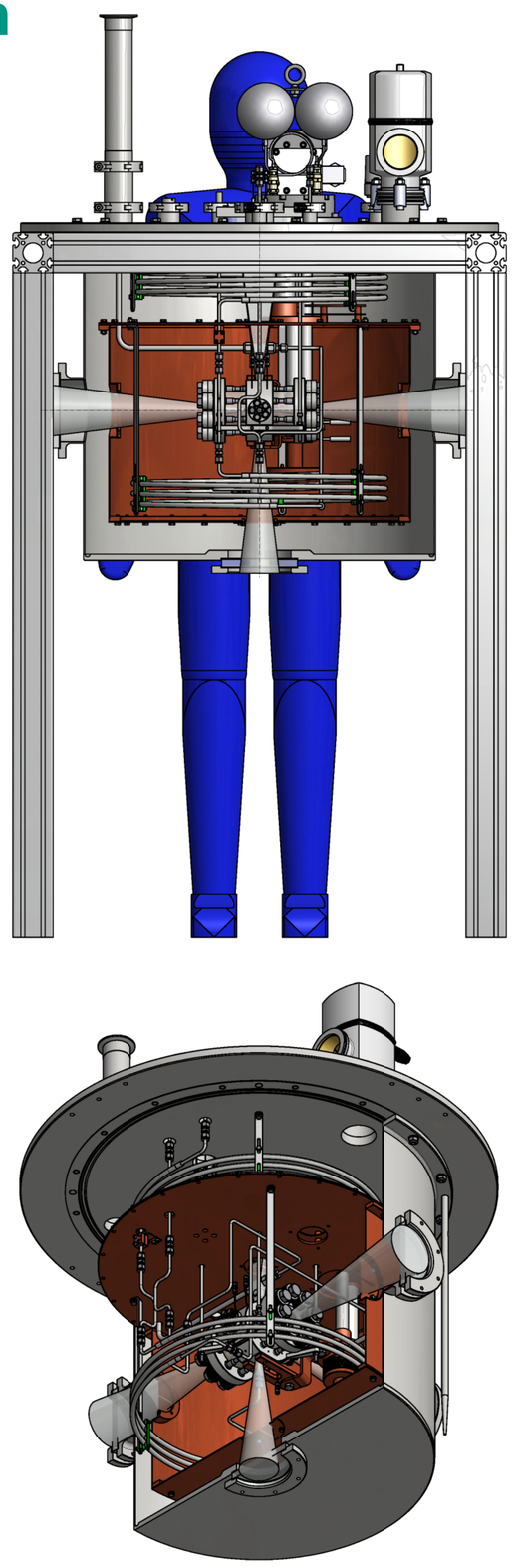


Fig. 3: Mechanical design visualization of the test stand cryostat interior.