Karlsruhe Institute of Technology

The KATRIN cryogenic system

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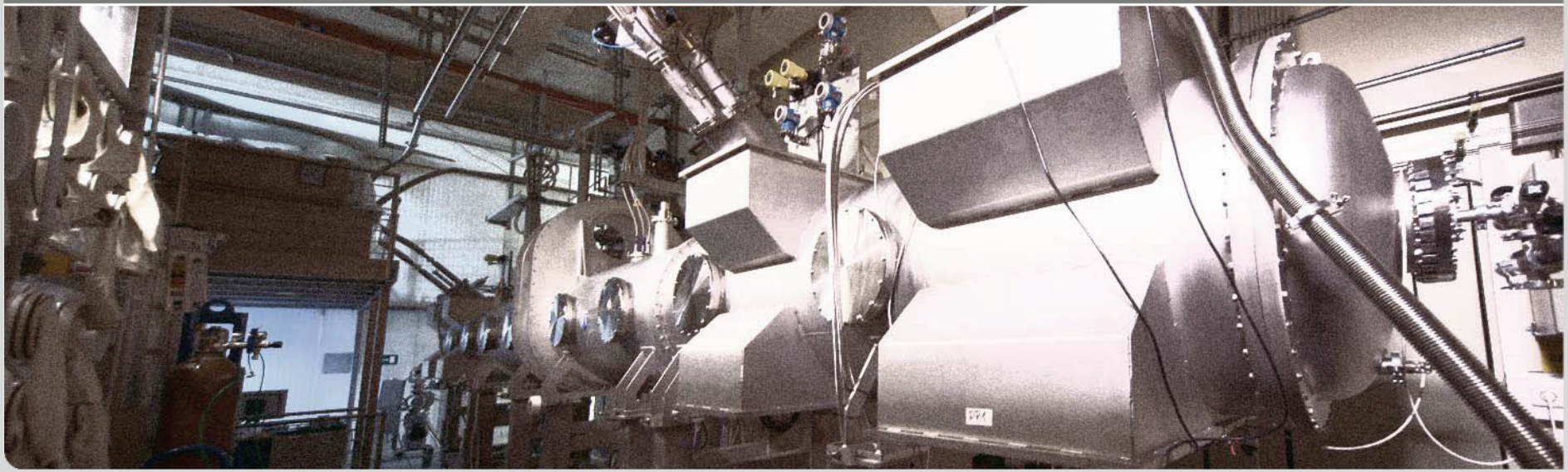
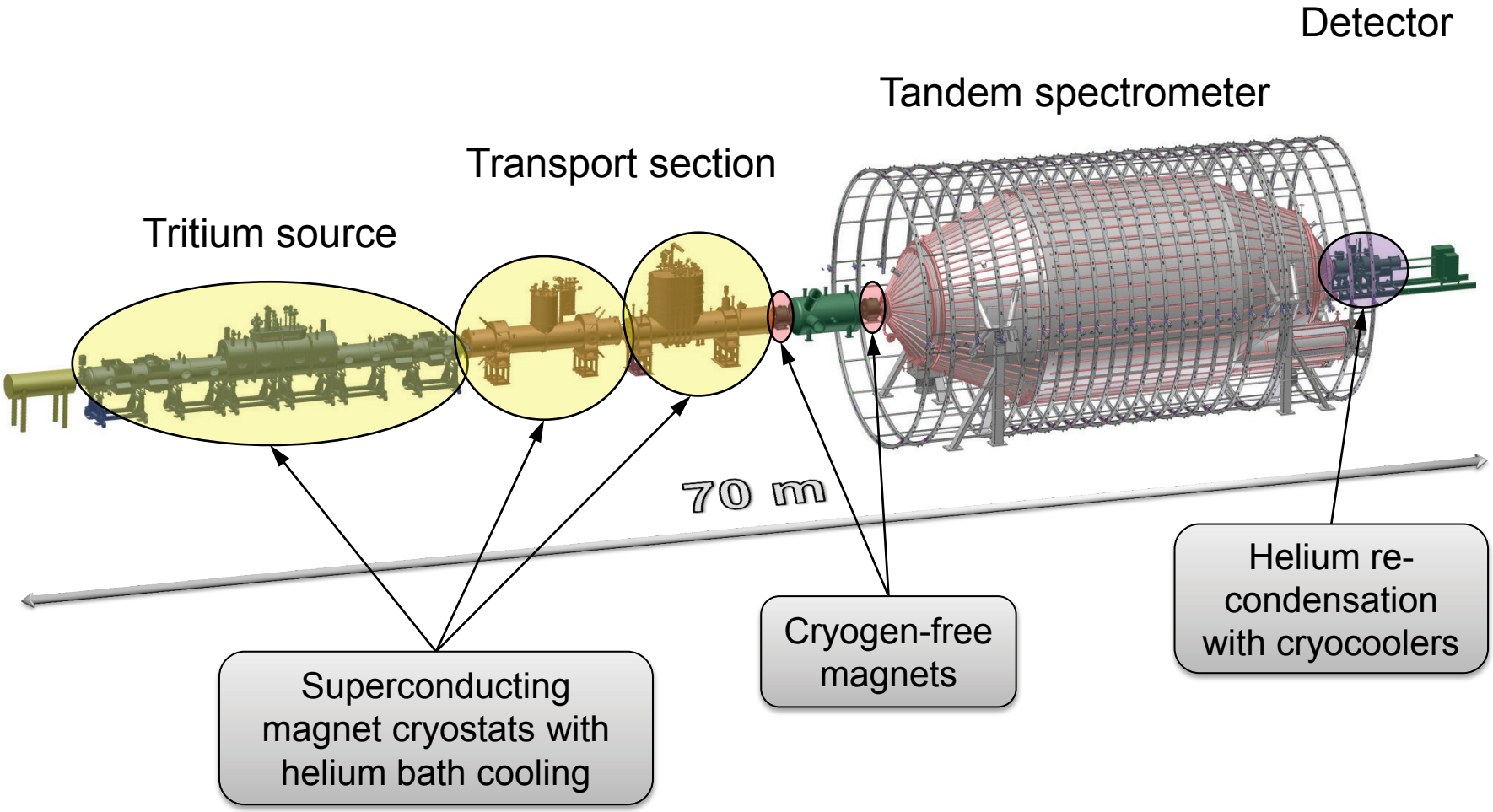
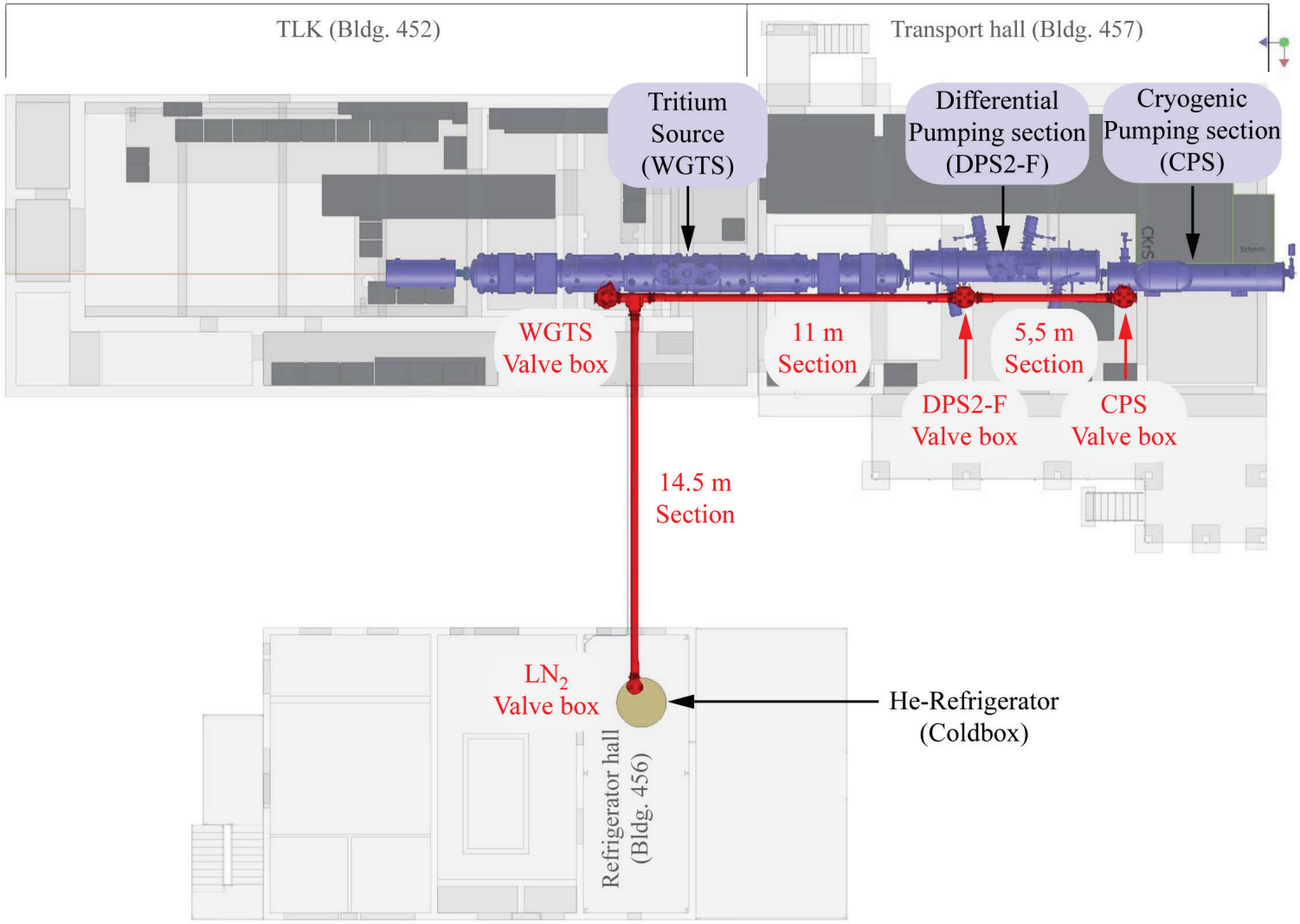
INSTITUTE FOR TECHNICAL PHYSICS (ITEP)



The beamline of KATRIN

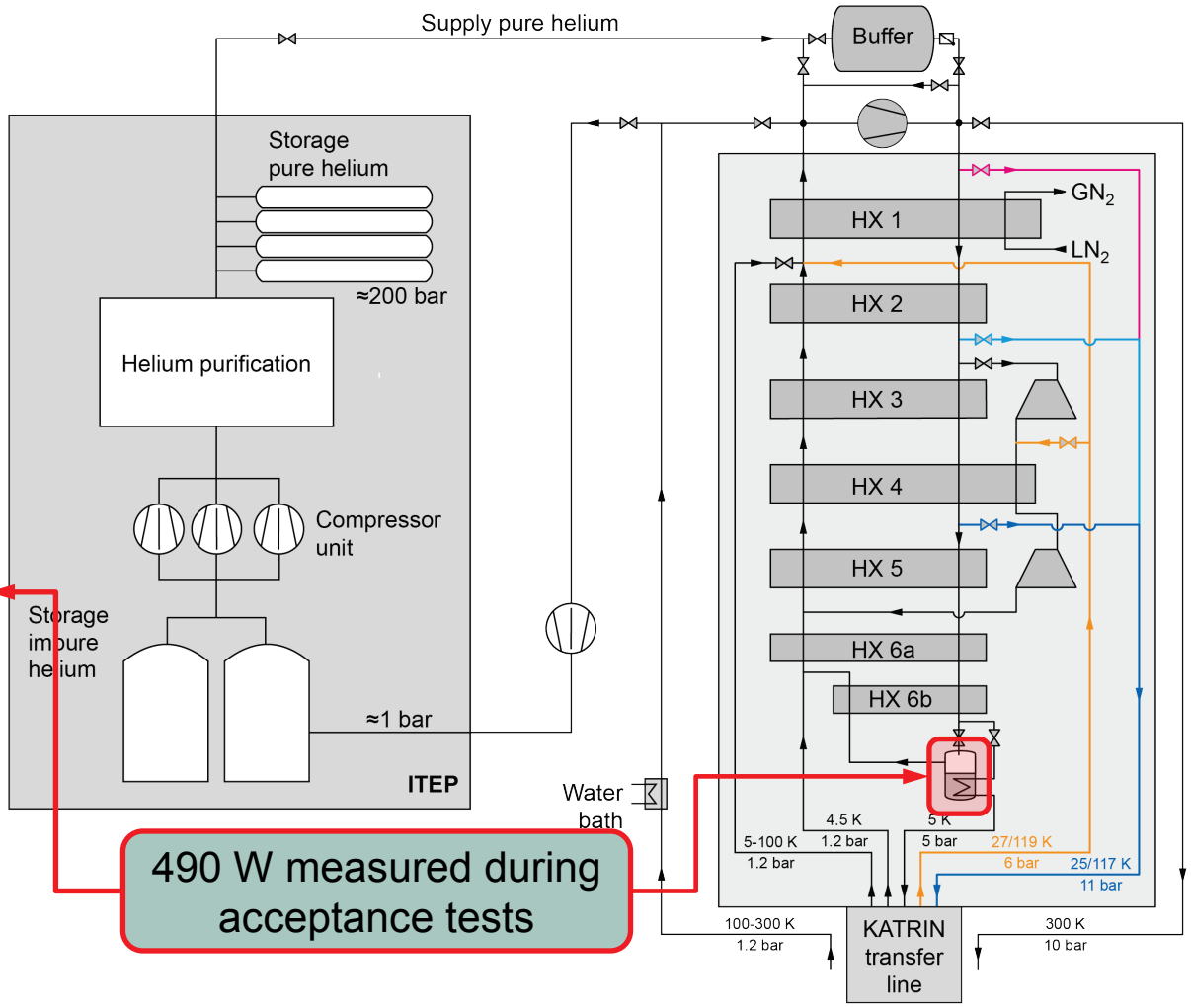


Overview of the KATRIN cryogenic system

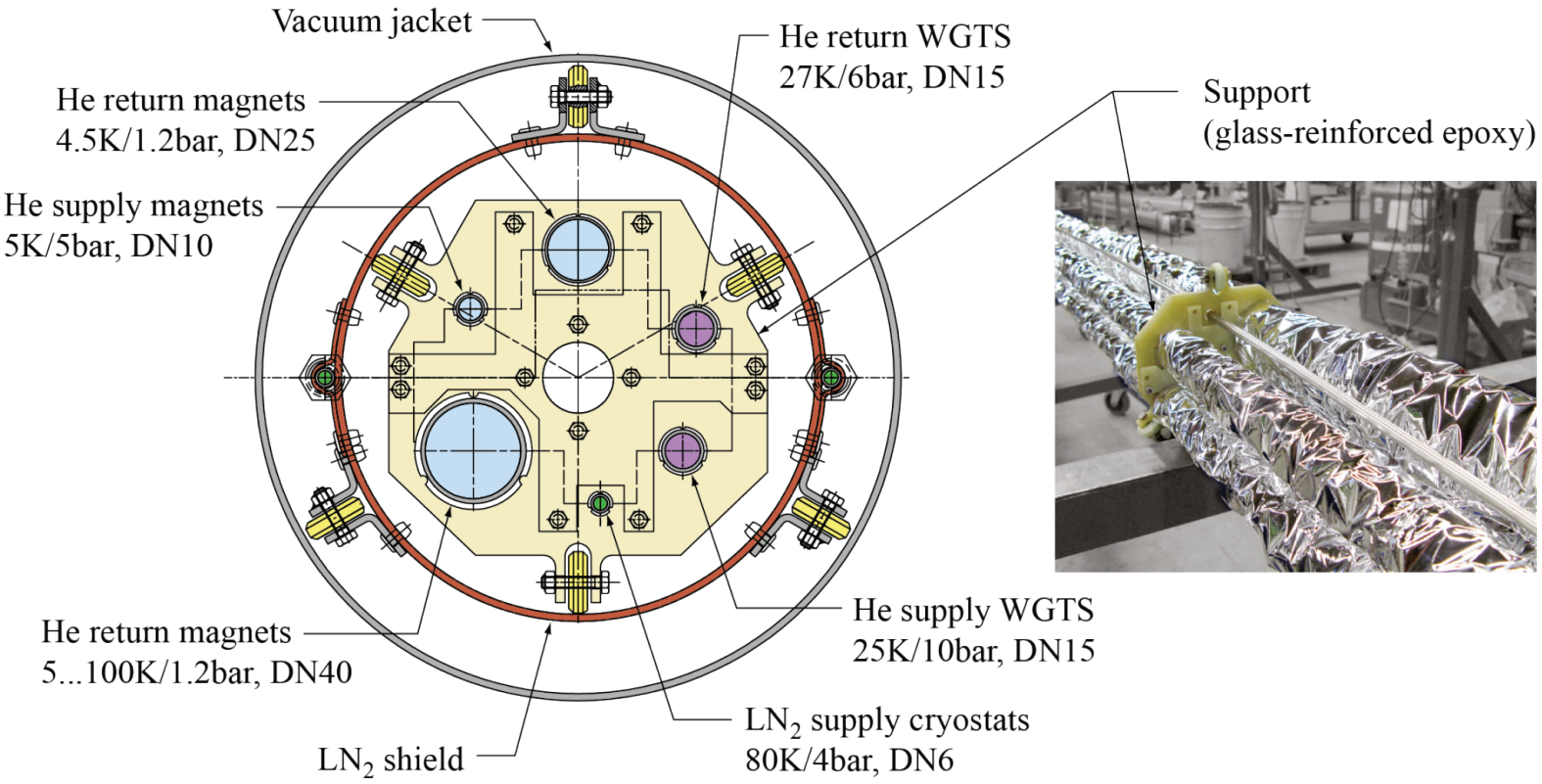


The KATRIN helium refrigerator

- Adapted standard refrigerator
  - *Linde TCF50*
  - Additional beam tube cooling circuit with 6 g/s He @ 25/117 K
- Cooling power
  - ~450 W @ 5 K / 5 bar
- Connection to existing helium purification plant



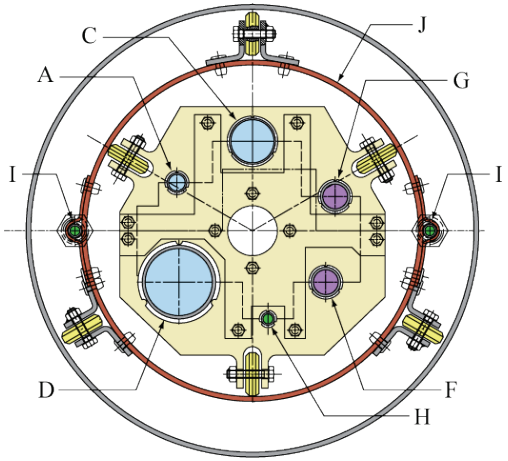
KATRIN cryogenic transfer line



- Mixing of 5 K and 300 K helium in the valve boxes for cool-down
  - ➢ Better operation with separate cool-down line from the refrigerator

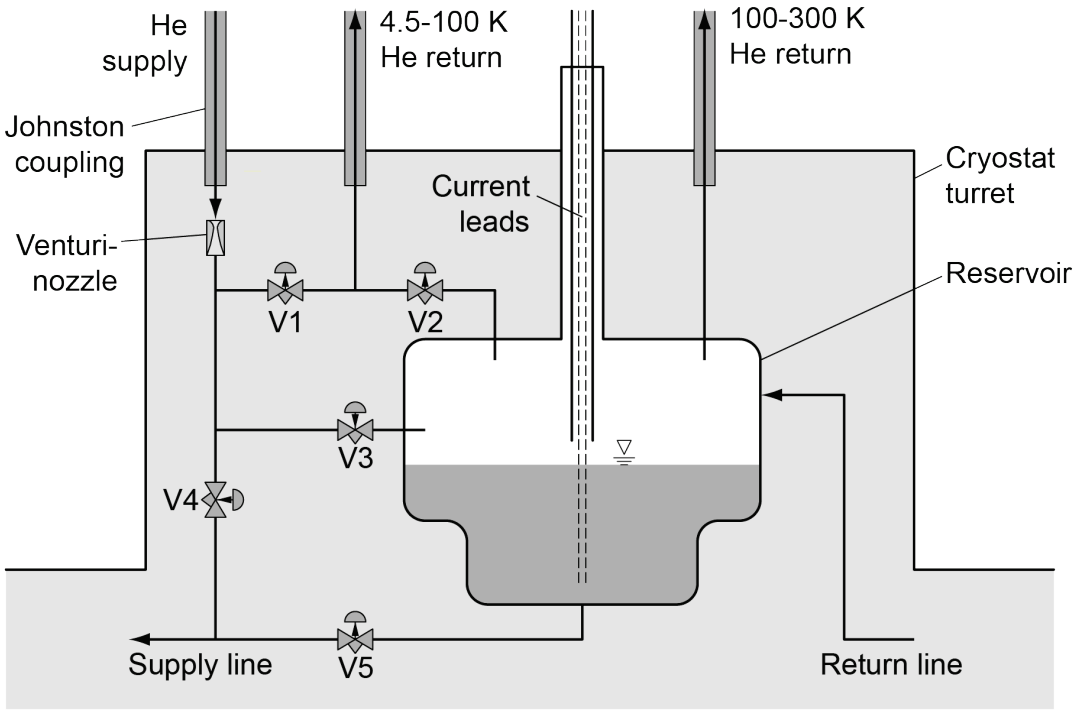
KATRIN cryogenic transfer line

- Process design/dimensioning by KIT
- User specification with geometric constraints, conceptual design
- Detailed design by supplier
- Design verification and manu-facturing release by customer
- Manufacturing, testing, installation, commissioning executed in the supplier's responsibility
  - Leak testing!
- Successful project completion within the planned schedule and cost frame

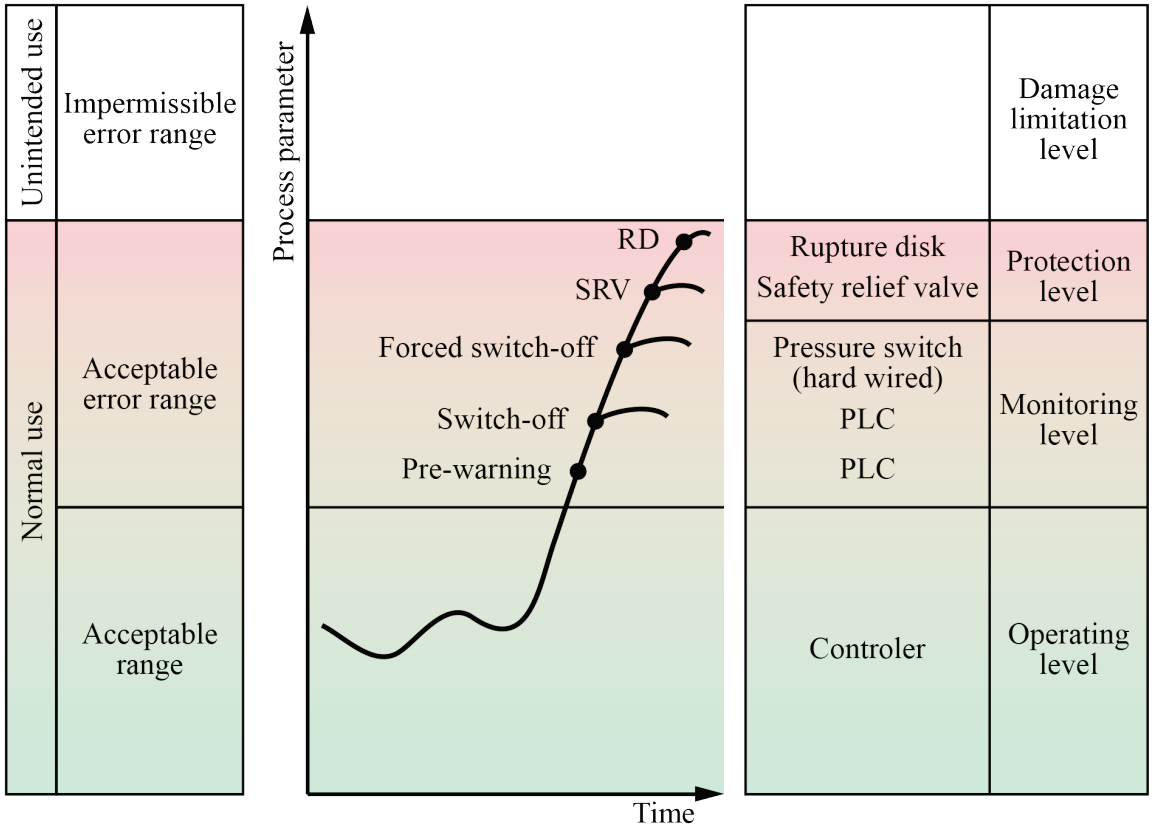


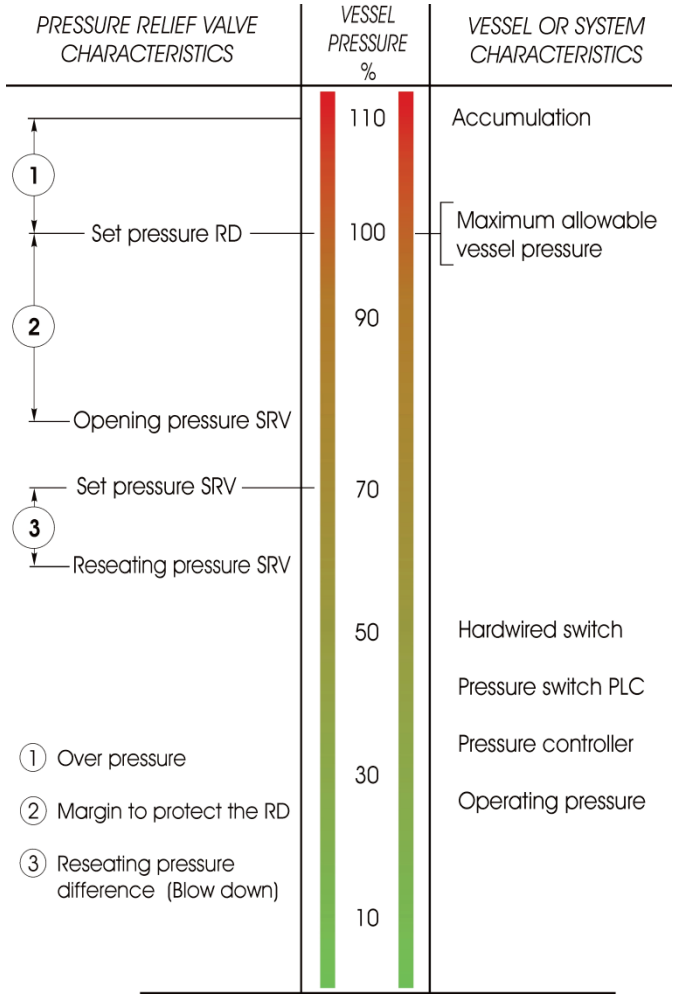
Principle of the helium bath cryostats

- Internal reservoir for standalone operation (48 h)
- Valve functions
  - V1: Bypass
  - V2: Return valve
  - V3: J-T valve
  - V4: Cool-down
  - V5: LHe supply
- Stationary operation
  - p_{Sat} = 1.3 bar
  - T_{Sat} = 4.5 K



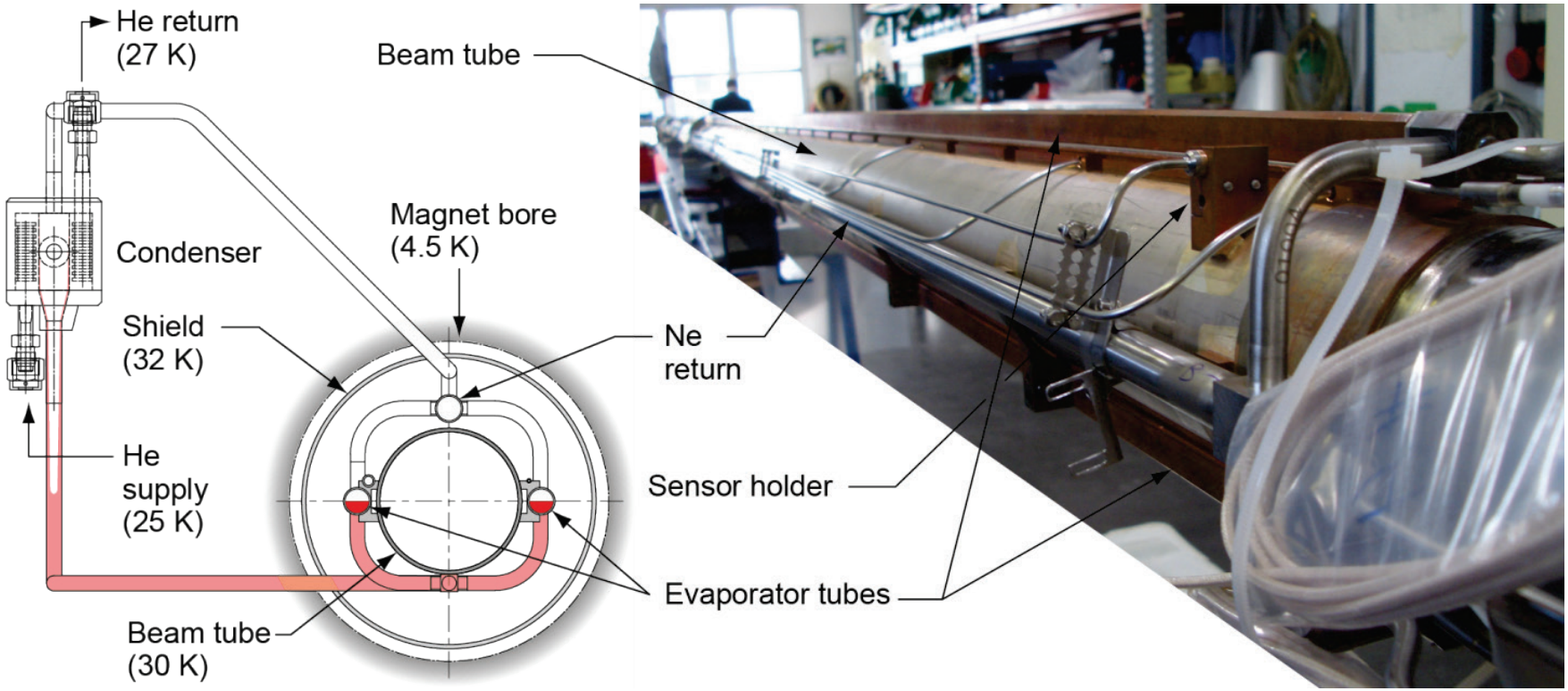
Safety concept for helium cryostats



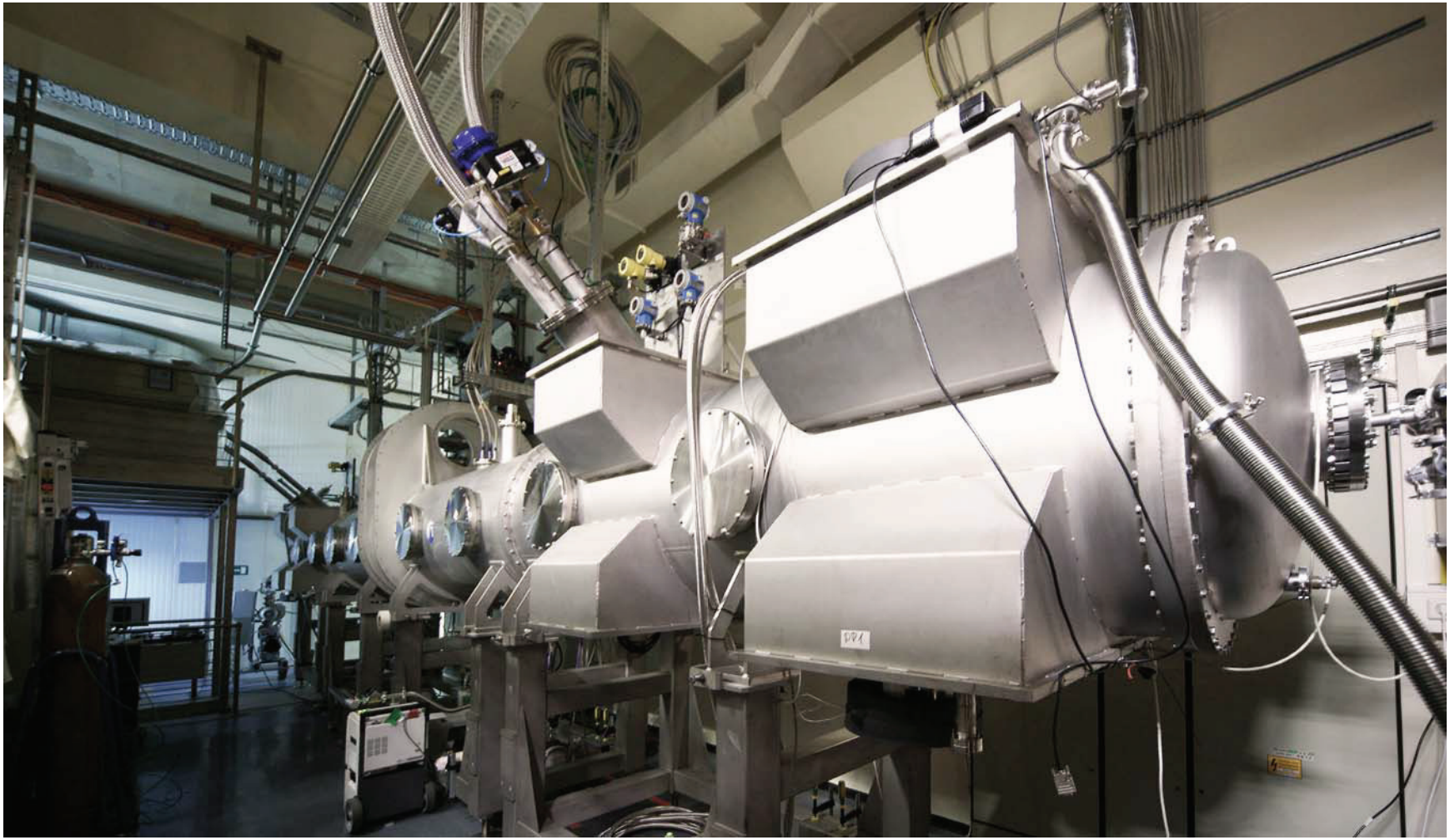


Cooling of the KATRIN tritium source

- Requirements for the 10 m beam tube
  - Temperature stability $30\ \mathrm{K} \pm 0.03\ \mathrm{K/h}$
  - Temperature homogeneity $30\ \mathrm{K} \pm 0.03\ \mathrm{K}$ over 95 % tube length

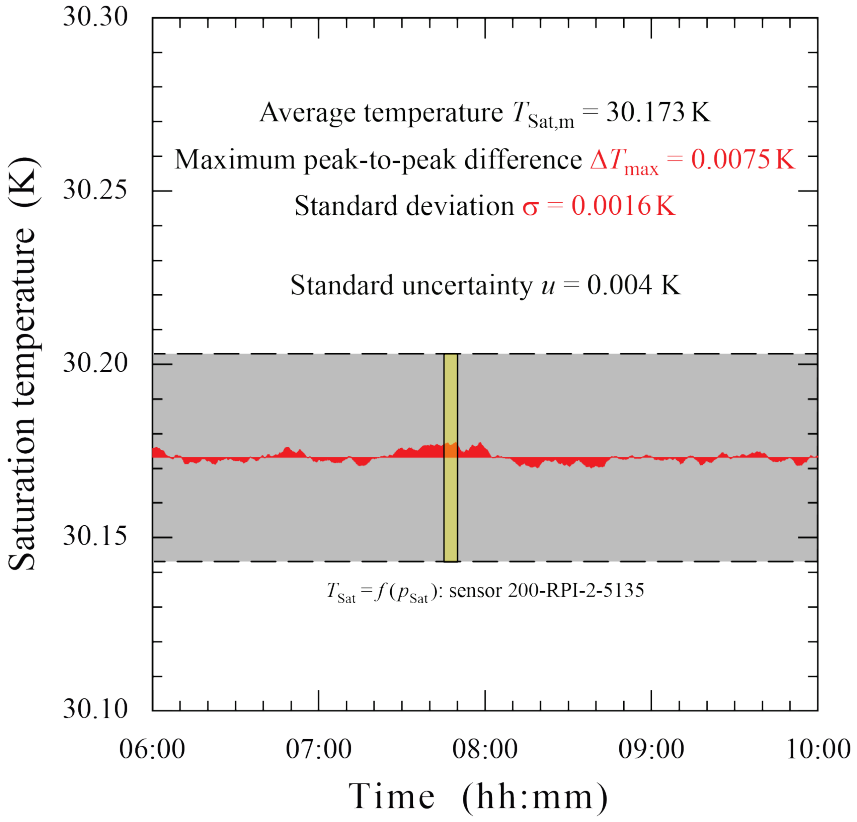


The KATRIN Demonstrator inside TLK

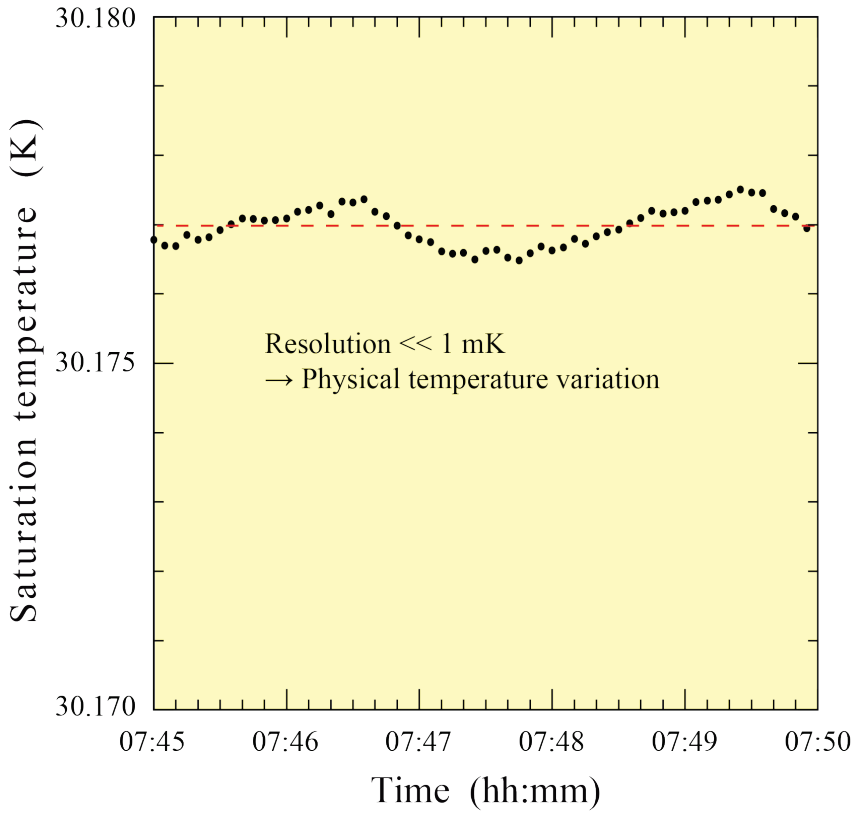


Measured temperature stability

Vapor pressure measurement



Resolution



Date of measurements: February 19, 2011

Recommendations / lessons learned

- **Refrigerator**
  - Project realization straightforward
    - Functional user specification
  - Commissioned long before required (→ warranty)
  - Plan separate cool-down line for magnet cryostats

- **Cryogenic transfer system**
  - Process engineering by customer, detailed design by supplier
    - Conceptual design part of user specification
  - Importance of project management and QA
    - Standards, documentation, testing → Round table
  - Project realization within schedules and cost frames

Recommendations / lessons learned

- **Cryostats**
  - Think carefully about the safety concept (pressure rating)!
  - Large LHe reservoirs inside the cryostats have increased the complexity of the cryostat design (space limitations)

  - Functional user specifications are problematic!
  - Long design phases with several iterations
  - Cryogenic know-how on the customer side is vital (process engineering)
  - Importance of project management and QA
    - Standards, documentation, testing → Round table
  - Large underestimation of efforts by both the project and the suppliers