TECHNISCHE
UNIVERSITÄT
DRESDEN

Faculty of Mechanical Science and Engineering Faculty of Mechanical Science and Engineering , Bitzer Chair of Refrigeration, Cryogenics and Compressor Technology

New measurements of multilayer insulation at variable cold temperature and elevated residual gas pressure

Th. Funke[1], Ch. Haberstroh[1]

[1] *Technische Universitaet Dresden, Dresden, Germany*

Motivation and Scope

Typically performance **measurements of MLI** insulations are carried out using bath calorimeter cryostats. Inherent to all these devices is a fixed cold temperature at the boiling point of the respective cryogenic liquid. Furthermore a current approach for cryogenic storage vessels for supercritical hydrogen is planned with an operating range between 20 K and ambient temperature. Thus, a new calorimeter cryostat has been designed at the TU Dresden to meet these requirements. Based on a flow cryostat working principle, it allows measurements of the thermal performance at **variable cold temperatures between 20 K and 300 K**. It can be operated in vertical as well as in horizontal orientation. The insulation material is wrapped around a nearly isothermal cylinder which is held at the desired temperature by a cooling fluid. Preferably LHe respectively helium cold gas is used.

New MLI measurements have been carried out. A specimen of 20 layer double side aluminized polyester film was tested. A cylindrical cold surface of 0.9 m² is held at the desired cold boundary temperature between approximately 30 K and 300 K.

Cryostat Design and Setup

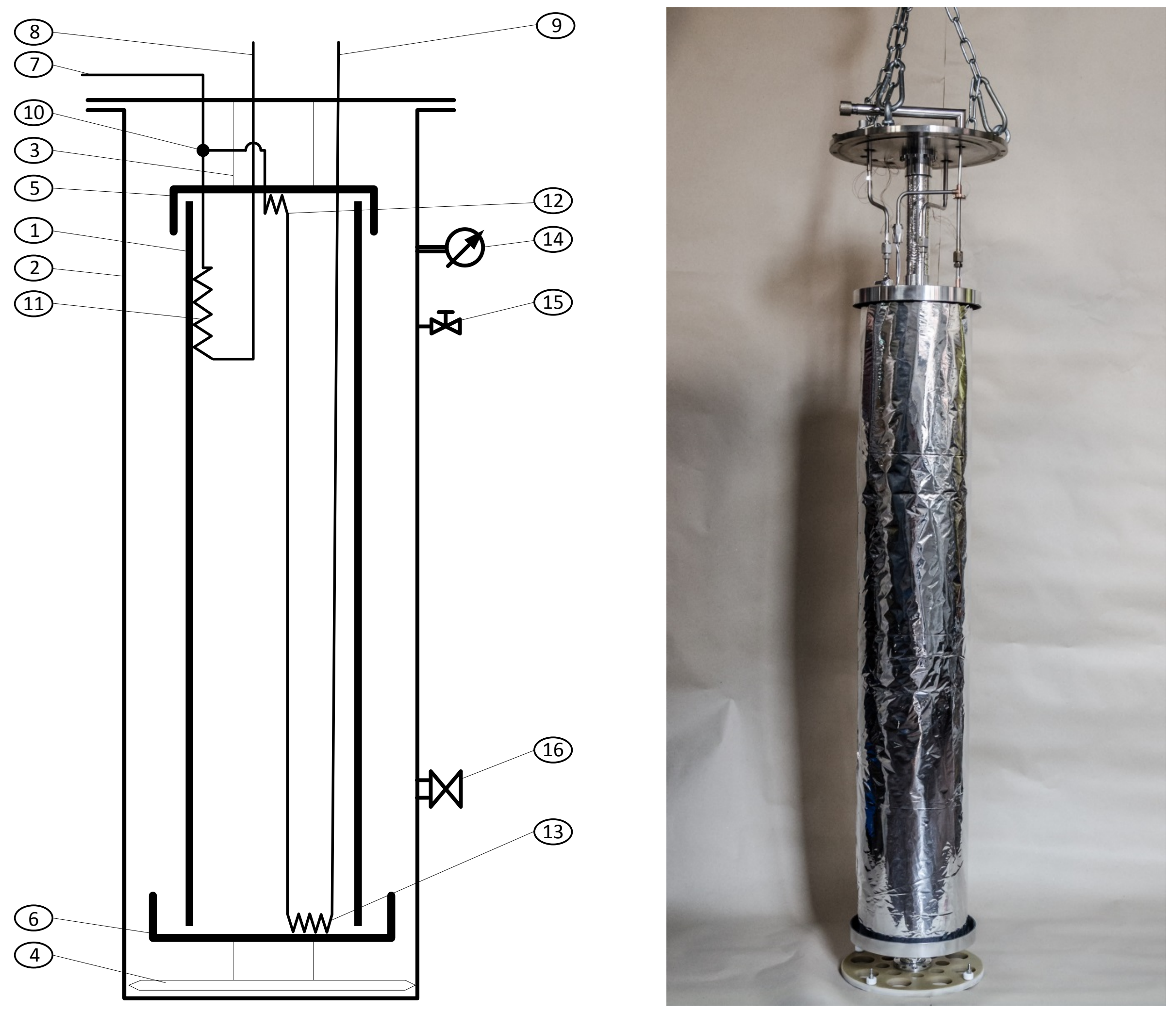

Figure 1. left Scheme of the calorimeter: 1- cold cylinder, 2 - warm cylinder, 3 - upper support rod, 4 - lower support rod, 5 - upper radiation shield, 6 - lower radiation shield, 7 - cooling fluid inlet, 8 - cooling fluid outlet test cylinder circuit, 9 - cooling fluid outlet shield, 10 - T-section of inlet line, 11 - heat exchanger test cylinder, 12 - 1st heat exchanger shield cooling, 13 - 2nd heat exchanger shield circuit, 14 - vacuum gauge, 15 - needle valve, 16 - vacuum port; **right** photo internal test section, mounted at the top flange with upper and lower radiation shield, MLI wrapped around the test cylinder

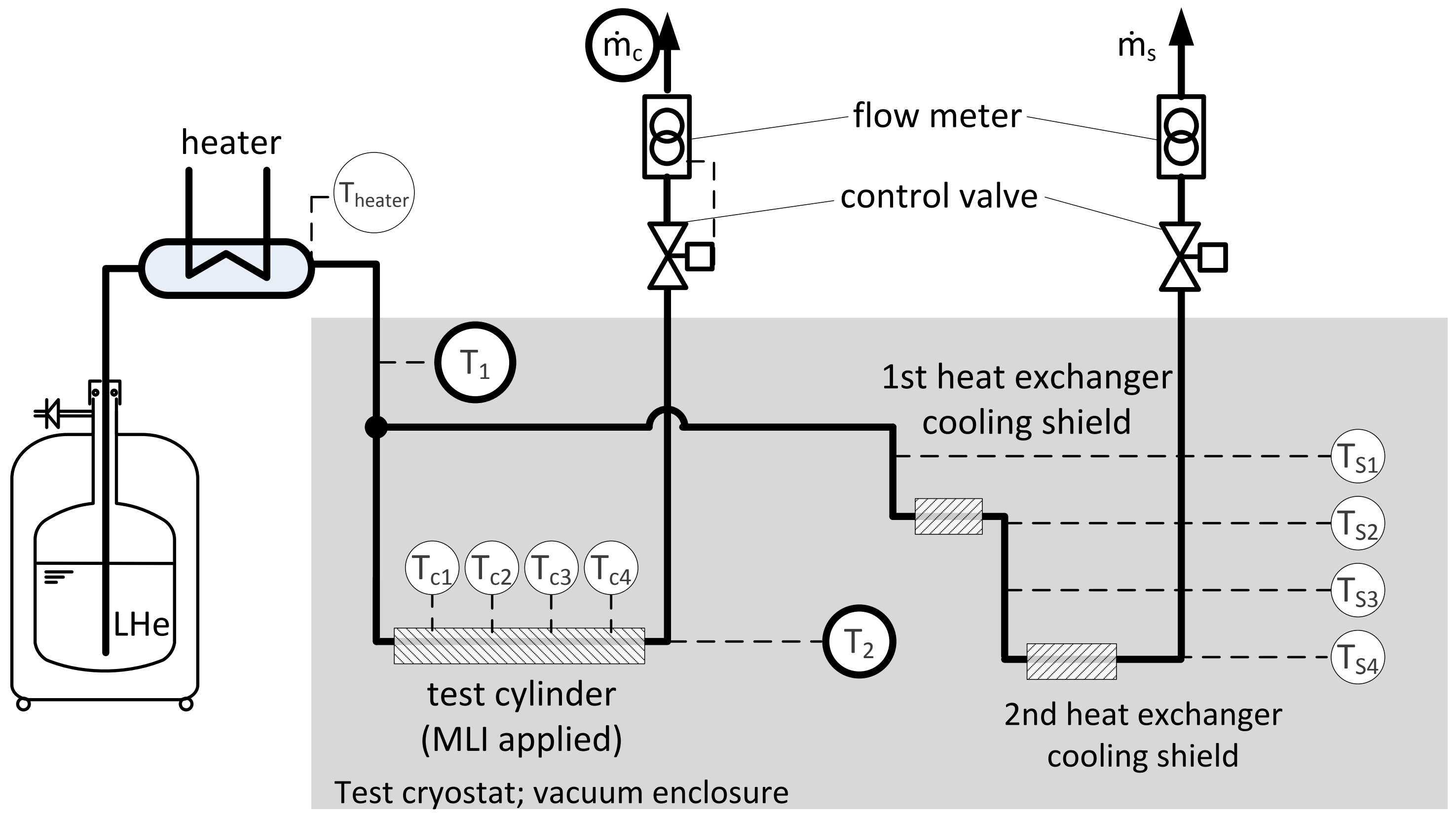

Figure 2. Flow diagram with LHe supply, external heater and the cryostat itself

Features:

- Vacuum vessel with all inner parts mounted at the top flange
- Operation at high vacuum conditions ($p < 10^{-5}$ mbar) or at defined elevated pressure ($p = 10^{-3}$ … 10^{-1} mbar); needle valve for controlled gas inlet (N_2, He)
- An isothermal cylindrical measuring surface ($A_{cold} = 0.9$ m²) is kept at T_2 by a cryogenic fluid flow
- Two separate cooling flows for the test cylinder and the shield cooling

Results

Figure 3 shows a typical test run at high vacuum conditions. The mass flow is changed during operation from 0.05 g/s to 0.033 g/s and the temperature T_1 is adapted to keep the test cylinder temperature constant. The total heat load is calculated at three discrete moments (see table 1) when steady state conditions are achieved.

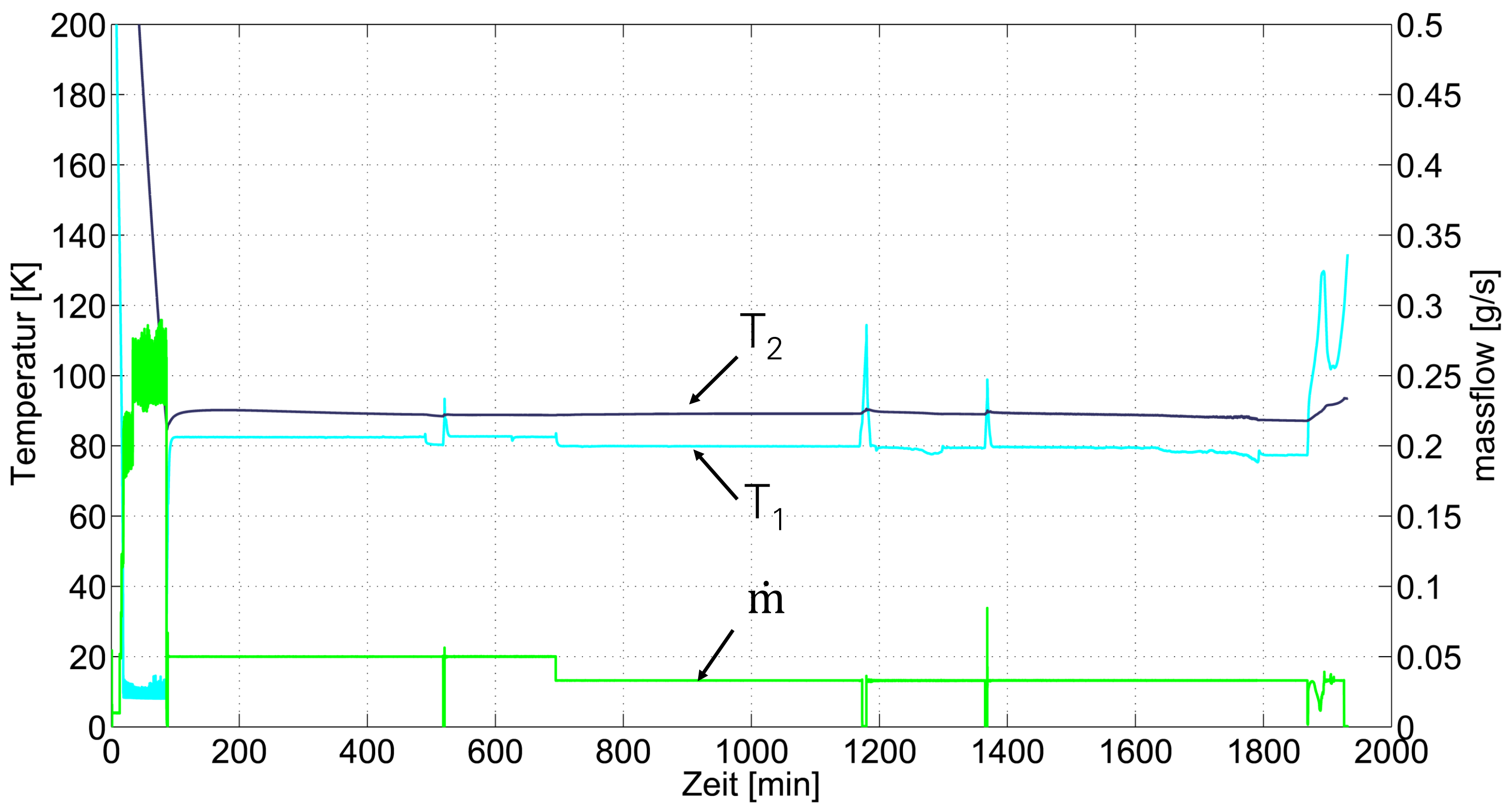

Figure 3. Test run at high vacuum conditions, temperature T_1, T_2 and He mass flow vs time

Table 1. Experimental data, 20 layer double side aluminized mylar MLI

T_1 [K]	T_2 [K]	ṁ [g/s]	Upper shield [K]	Lower shield [K]	Heat load [W]
82.7	88.8	0.05	94.4	104.8	**1.58**
82.6	88.7	0.05	92.5	101.8	**1.61**
79.9	89.2	0.033	89.1	101.3	**1.60**

Further experiments were carried out. These measurements are summarized in Figure 4. The diagram shows the total heat load onto the test cylinder vs the cold boundary temperature. The vacuum pressures are within a range of 10^{-7} mbar, 10^{-4} mbar, 10^{-3} mbar and 10^{-2} mbar. All heat loads are an average of multiple measurements, or averaged over a period of 10 min in steady state condition.

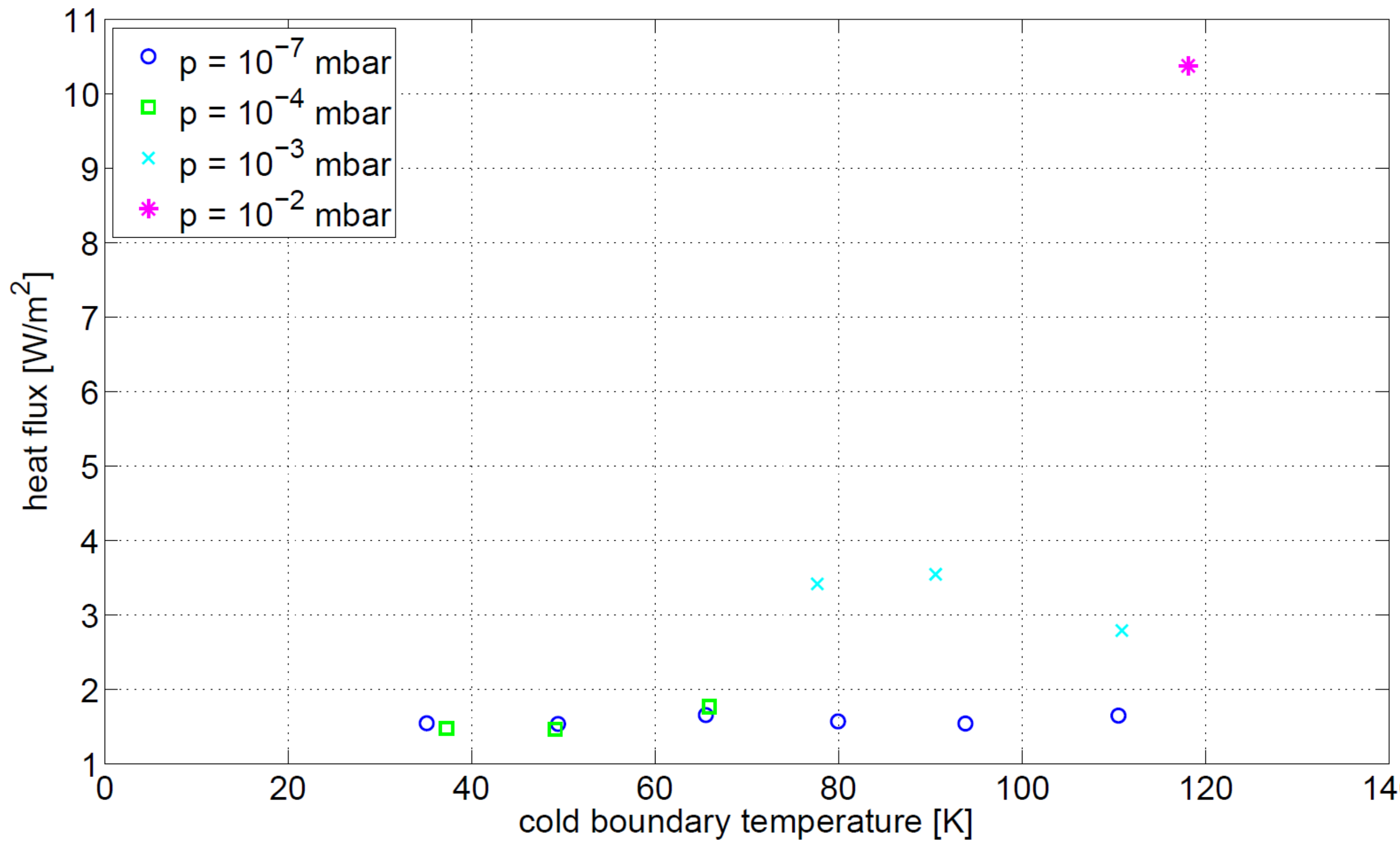

Figure 4. Measured heat flux through 20 layer MLI vs cold boundary temperature at vacuum pressure of 10^{-7} mbar, 10^{-4} mbar, 10^{-3} mbar and 10^{-2} mbar

Outlook

A number of measurements to characterize a 20 layer MLI at variable cold boundary temperature and elevated gas pressure were carried out. The test procedure and data analysis are widely standardized. A comparison of these results to existing correlations such as the Lockheed equation or the layer by layer model [4] is subject of the upcoming work.

The next task is to determine any gravimetric degradation in the thermal performance of the same MLI in horizontal orientation.

Contact details:
Technische Universität Dresden
Faculty of Mechanical Science and Engineering
Institute of Power Engineering
Bitzer Chair of Refrigeration, Cryogenics and Compressor Technology

Thomas Funke
thomas.funke@tu-dresden.de
+49 351 46339736

Christoph Haberstroh
christoph.haberstroh@tu-dresden.de
+49 351 46333406

CEC/ICMC 2015 – C1PoL-06 [38]