Linde Engineering Division

Phone : ++49 89 7445 0
Telefax : ++49 89 7445 4908
Email : info@linde-le.com
Internet : www.linde.com

The Linde Group

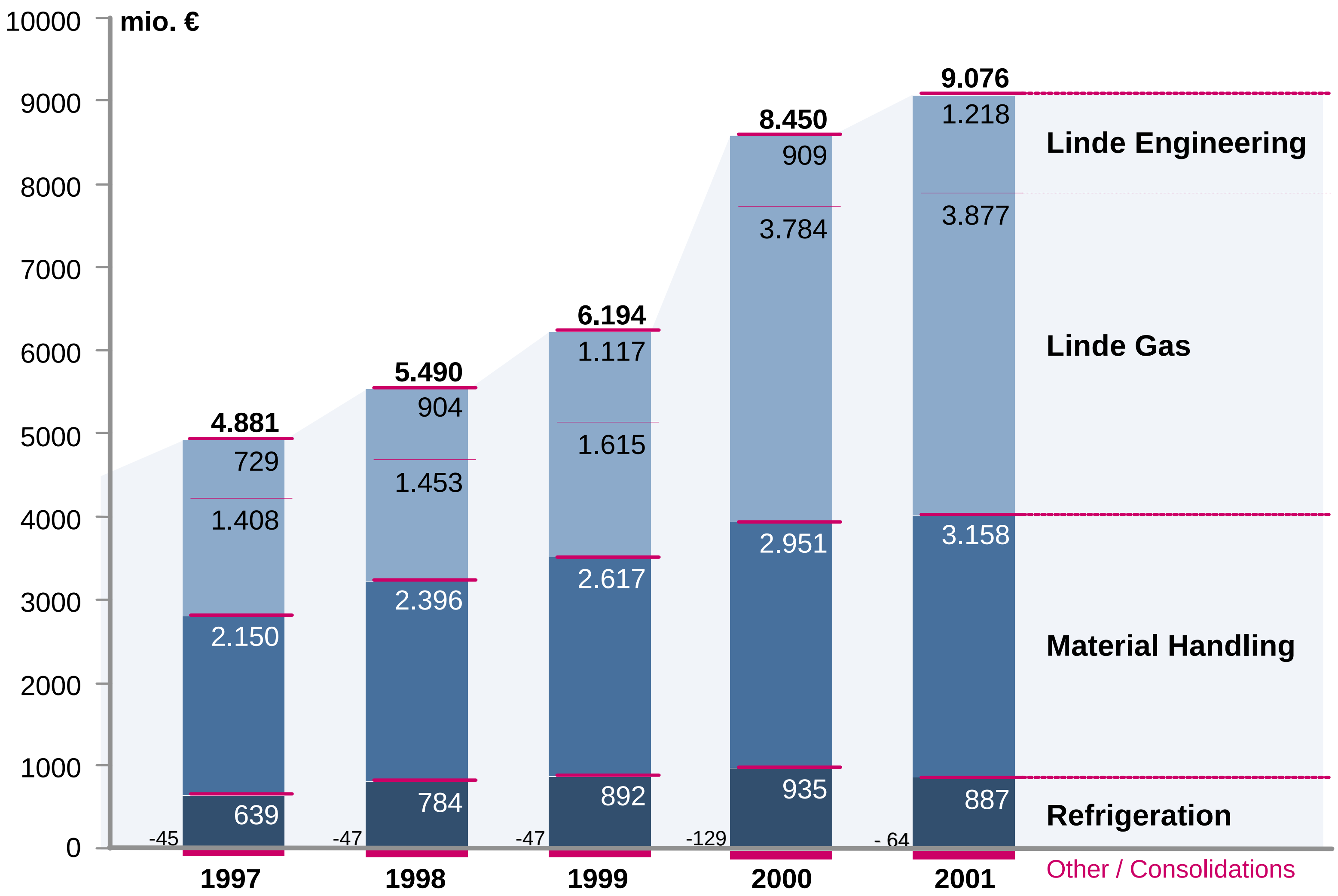
Linde Engineering

Linde Gas

Material Handling

Refrigeration

Linde Group Sales



Linde's Participation on Space Projects

1977 - 1980	GIRL	(German Infra-Red Laboratory)
1980 - 1995	ISO	(Infrared Space Observatory)
1994 - 2003	MELFI	(Minus eighty deg. Laboratory Freezer) for ISS
2001 -	AMS	(Alpha Magnetic Spectrometer) for ISS
2001 - 2007	HERSCHEL	(Far-Infrared and Submillimeter Telescope)

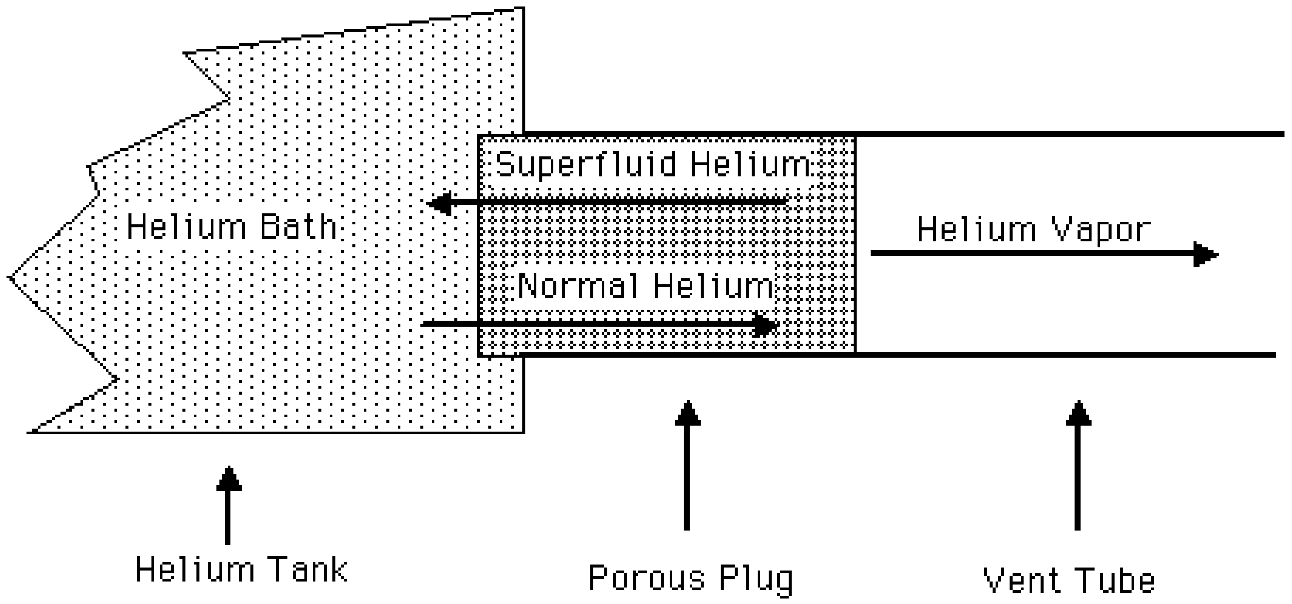
Cryogenic System, AMS

LINDE scope of delivery:

- Passive Phase Separator for superfluid Helium (Porous plug type)
- Mass Gauging Heater for the superfluid Helium tank
- Cold Safety Valve
- Cryogenic Consulting
- Vibration tests with a shaker proof cryostat at 4 K

Passive Phase Separator

Phase Separation



Passive Phase Separator

- Sintered stainless steel samples are thermally shrunk into a stainless steel housing

Passive Phase Separator

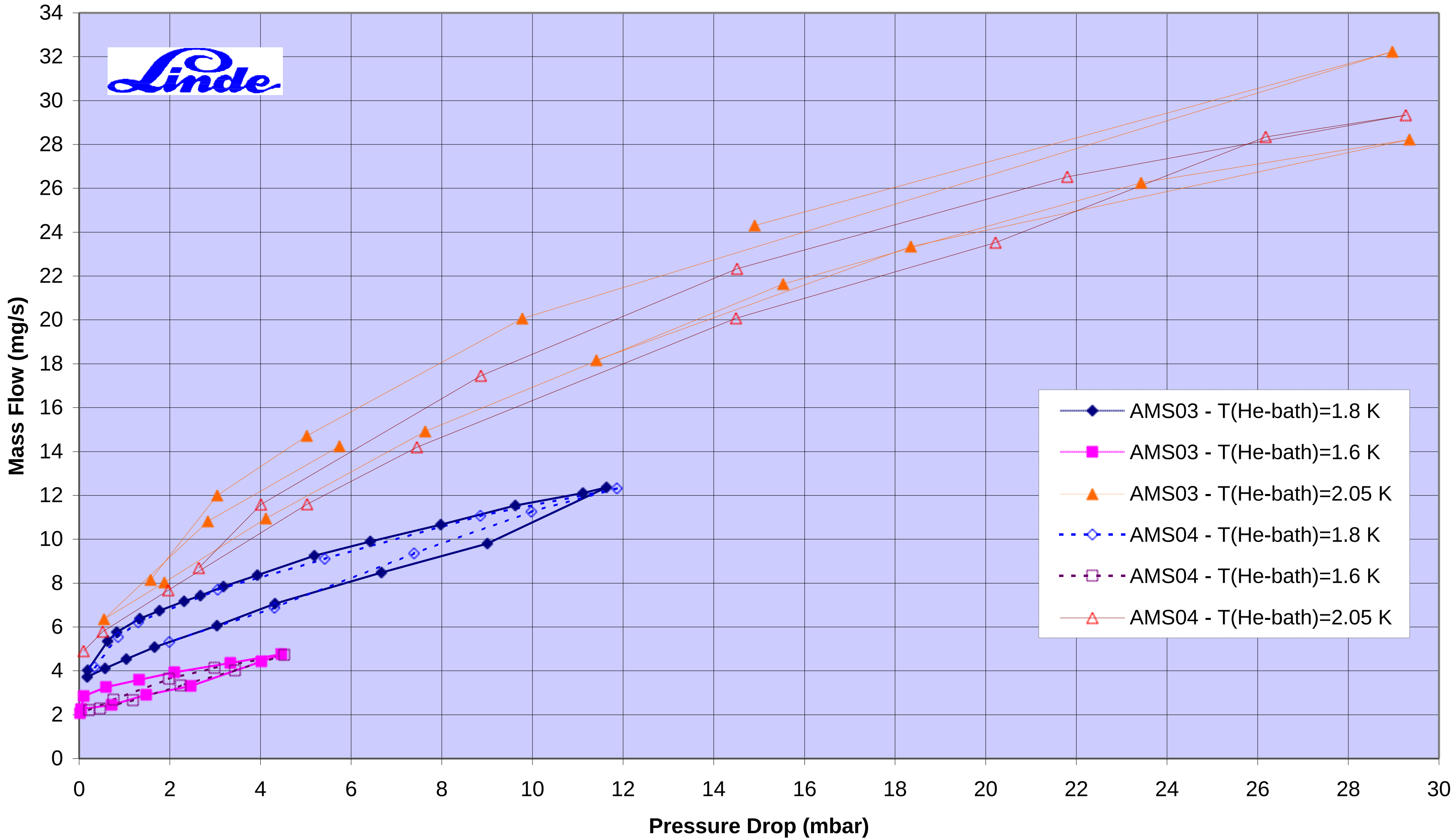
The porous plug sample holder

- He flow through the porous plug is from top to bottom
- By this arrangement any accumulation of liquid on the down-stream side is excluded
- Liquid breakthrough can easily be detected

Passive Phase Separator

Test Set-Up

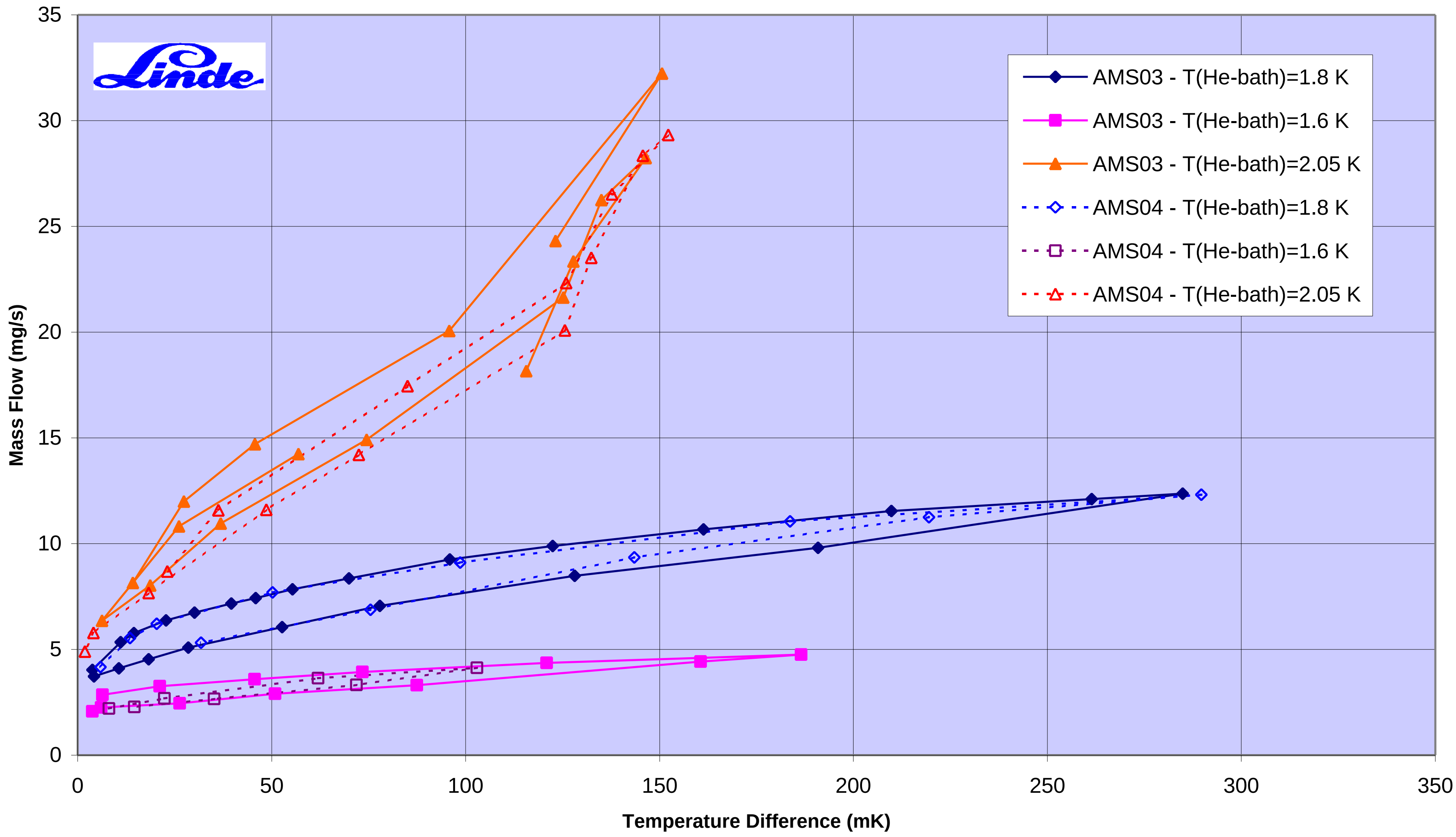
Charateristic mass flow as function of the pressure drop across the plug
PPS SIKA R0.5, Diameter 17 mm, Thickness 5,5 mm



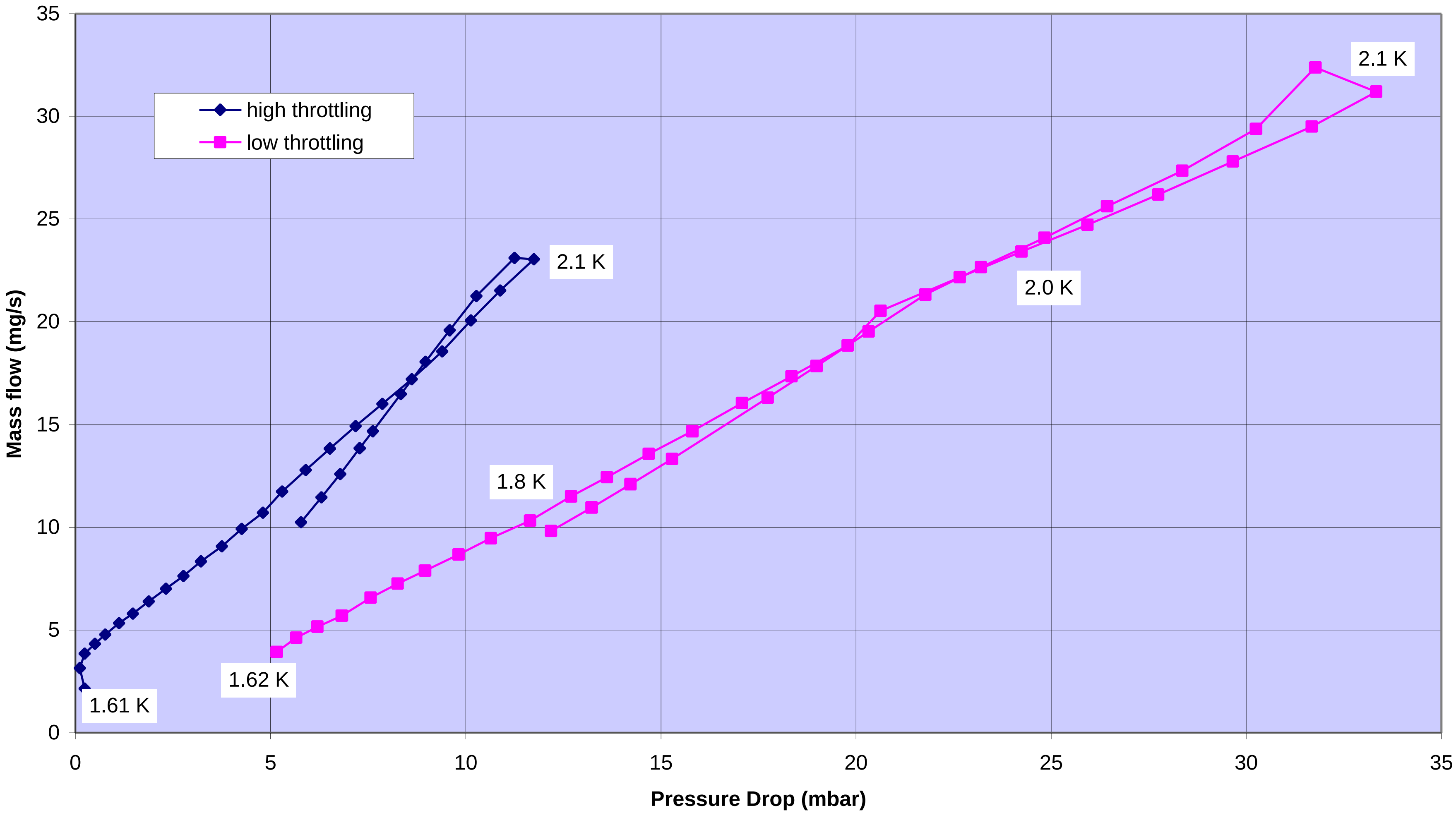
AMS Technical Interchange Meeting

Houston, October 28 - 31, 2002

Charateristic mass flow as function of the temperature difference across the plug
PPS SIKA R0.5, Diameter 17 mm, Thickness 5,5 mm



Charateristic mass flows as function of the pressure drop across the porous plug measured at two different constant positions of the vent valve



Passive Phase Separator

Theoretical Consideration (M. Murakami et al)

- Small Pressure and Temperature Region

$$\frac{d}{dt}m = A \cdot \frac{r \cdot S \cdot T \cdot Kp}{(L + S \cdot T) \cdot hn \cdot l} \cdot \Delta P$$

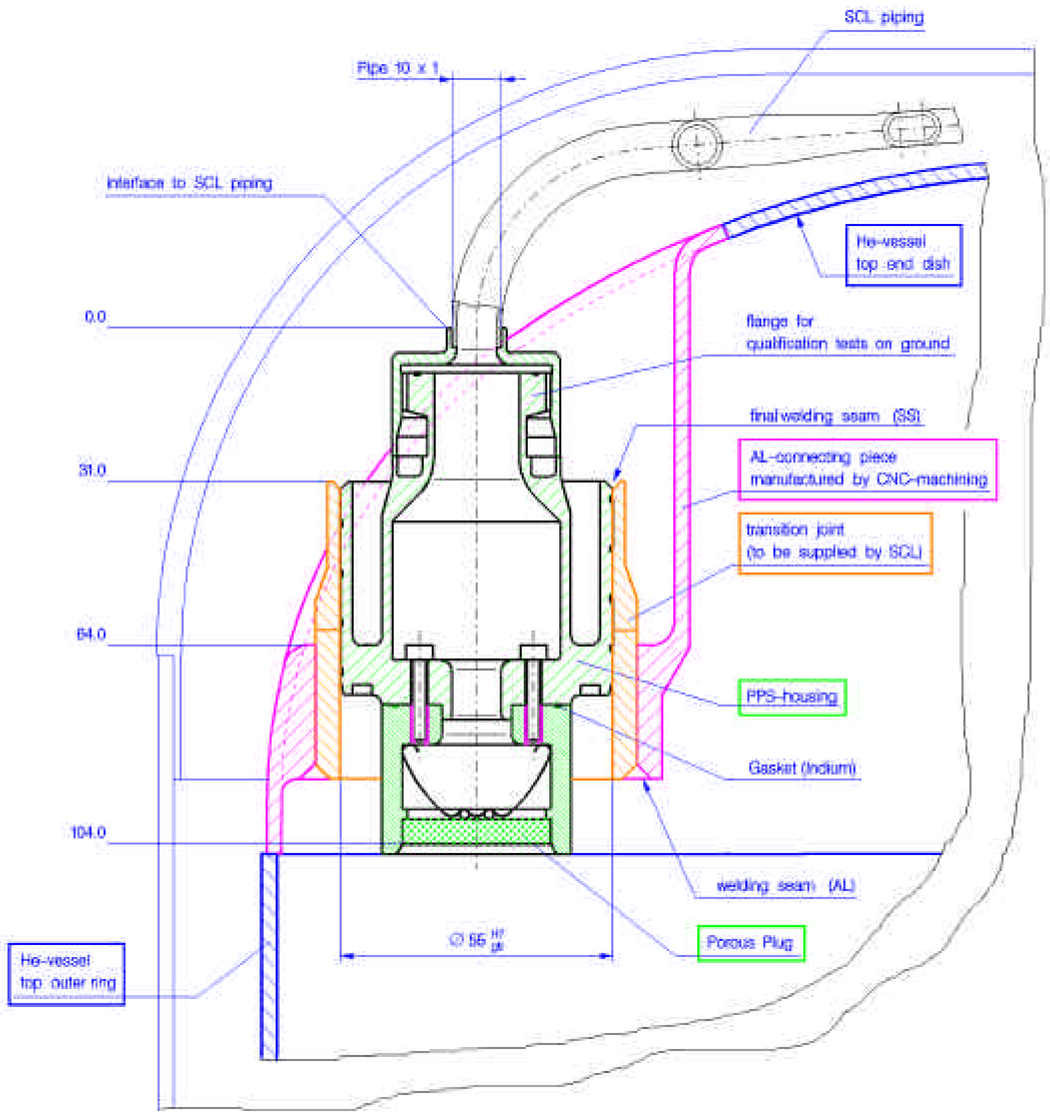
- Large Pressure and Temperature Region

$$\frac{d}{dt}m = A \cdot \frac{rv \cdot Kp}{hv \cdot l} \cdot \Delta P$$

Passive Phase Separator

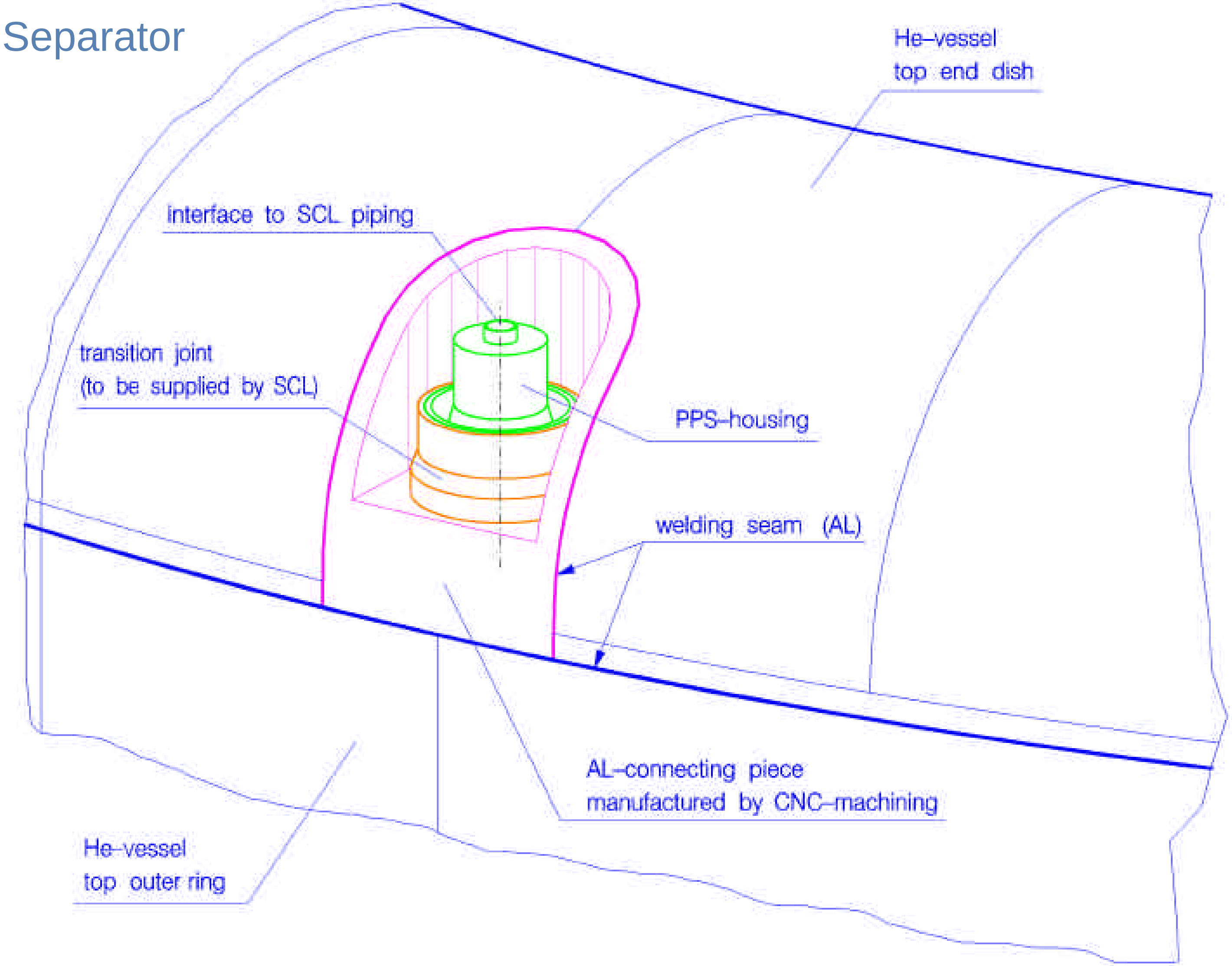
consisting of

- Sintered stainless steel porous plug
- Instrumentation (Thermometers)
- Housing
- Interface to piping



Passive Phase Separator

Integrated into
Helium Vessel



Passive Phase Separator

Conclusion

- The selected plug worked in normal phase separation mode without any leakage
- The specified mass flow range of 4 to 17 mg/s could be reached for the operational He II bath temperature range between 1.6 K and 2.0 K
- Detail design of the phase separator housing has has been started

Mass Gauging Heater

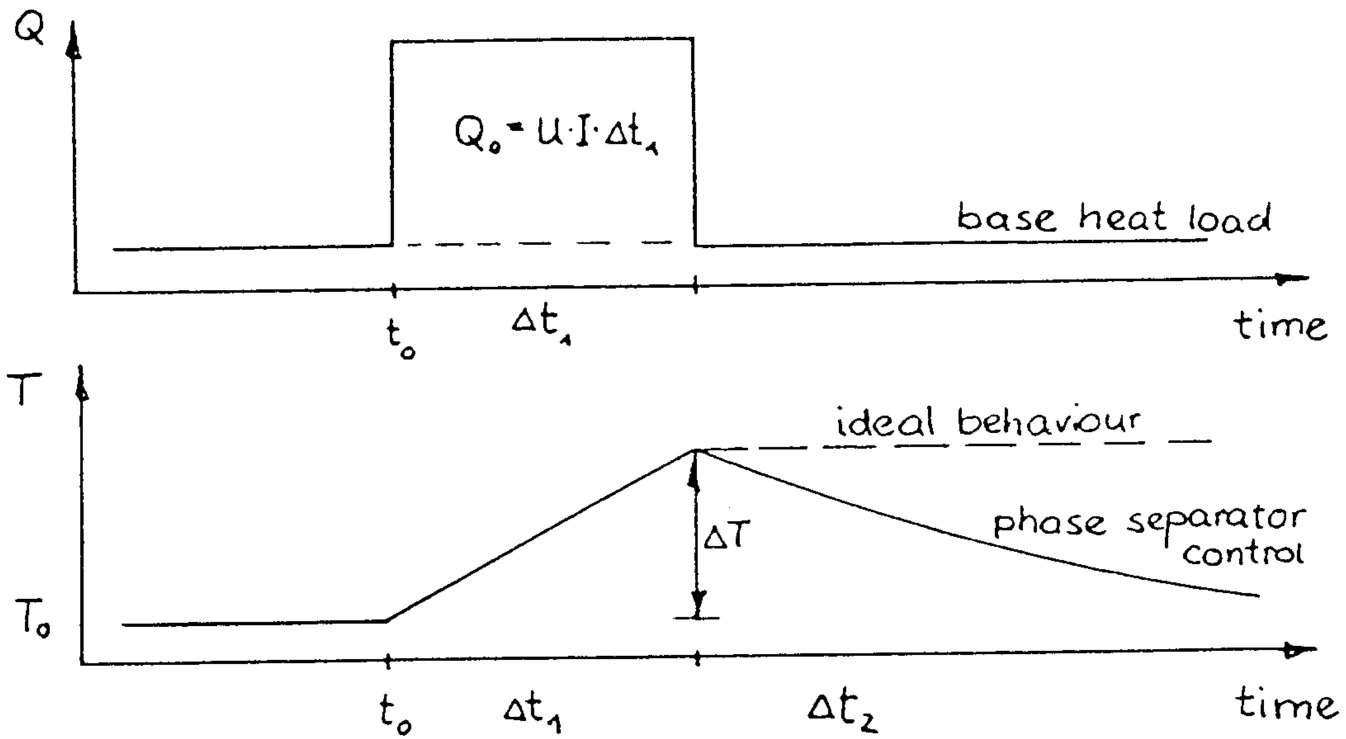
Principle: <u>Dissipated Power Method</u>

- A defined heat pulse Q applied to a LHe II bath for a time ?t immediately distributes throughout the liquid due to the excellent heat conductivity of LHe II

- By knowledge of the specific heat C_{svp} the liquid mass M_{He} can be deduced from the measurement of the temperature increase:

$$?T = Q * ?t / M_{He} * C_{svp}$$

Mass Gauging Heater



TYPICAL LOAD PROFILE AND TEMPERATURE RESPONSE FOR THE "HEAT PULSE" METHOD

Mass Gauging Heater

Heat pulse method works:

- under zero gravity
- even when the liquid volumes in the tank are not connected
- or if they are only connected by a superfluid film

The reason is:

- Helium is evaporated from the warm volume and nearly immediately recondensated on the cold volume, driven by the vapor pressure.

Neither gas heat conduction nor film flow along the walls can achieve a thermal equilibrium within short time

Mass Gauging Heater

Design Requirements

- The heat exchange area has to be sufficient for heat transfer to He II and to He I (depletion of tank)
- For retention of liquid in orbit the structure of the heater shall exhibit cavities
- For the purpose of depletion of the He tank the heater has to be located in the lower part of the tank.

Mass Gauging Heater

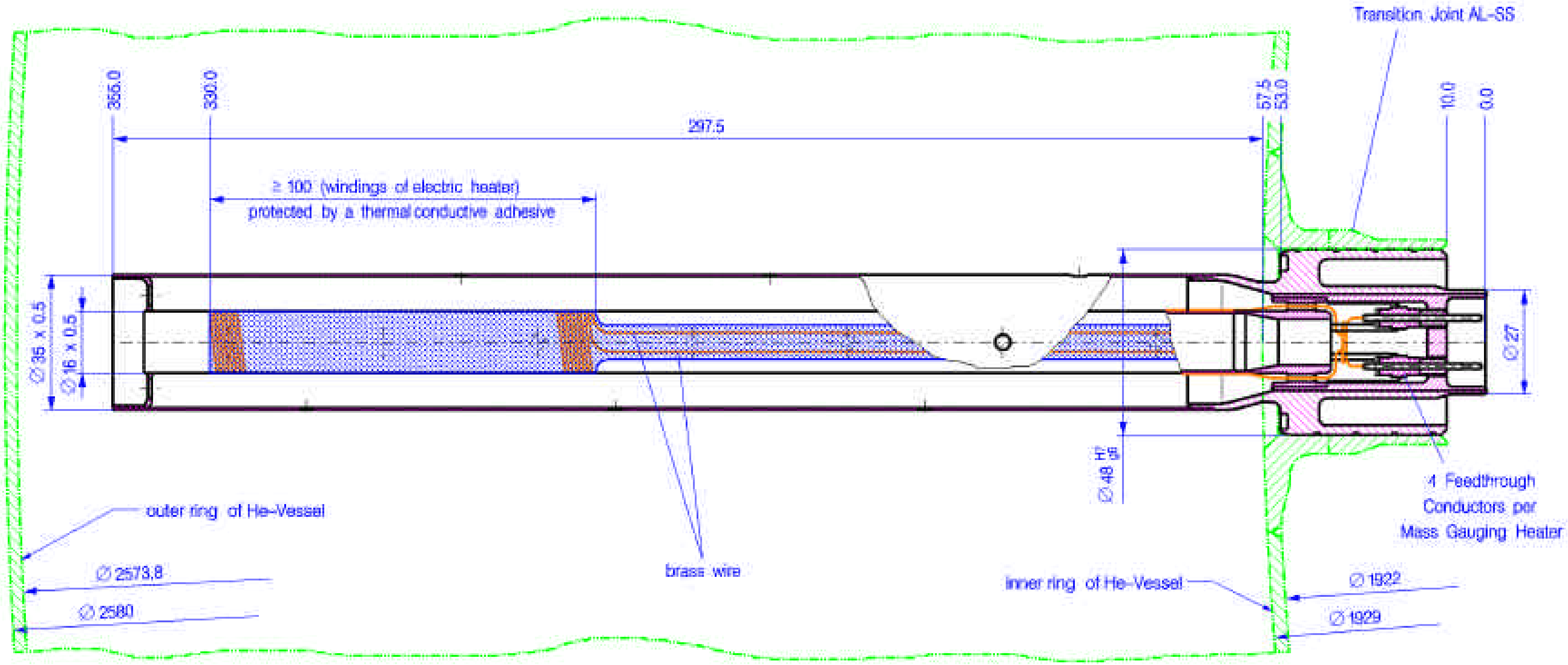
Heater Wire

- Coil wire type: brass, wire diameter 0,1 mm, varnished
- Wiring: 4-wire
- Resistance: nominally appr. 90 Ohm at 295 K
  nominally appr. 50 Ohm at LHe-Temperatures

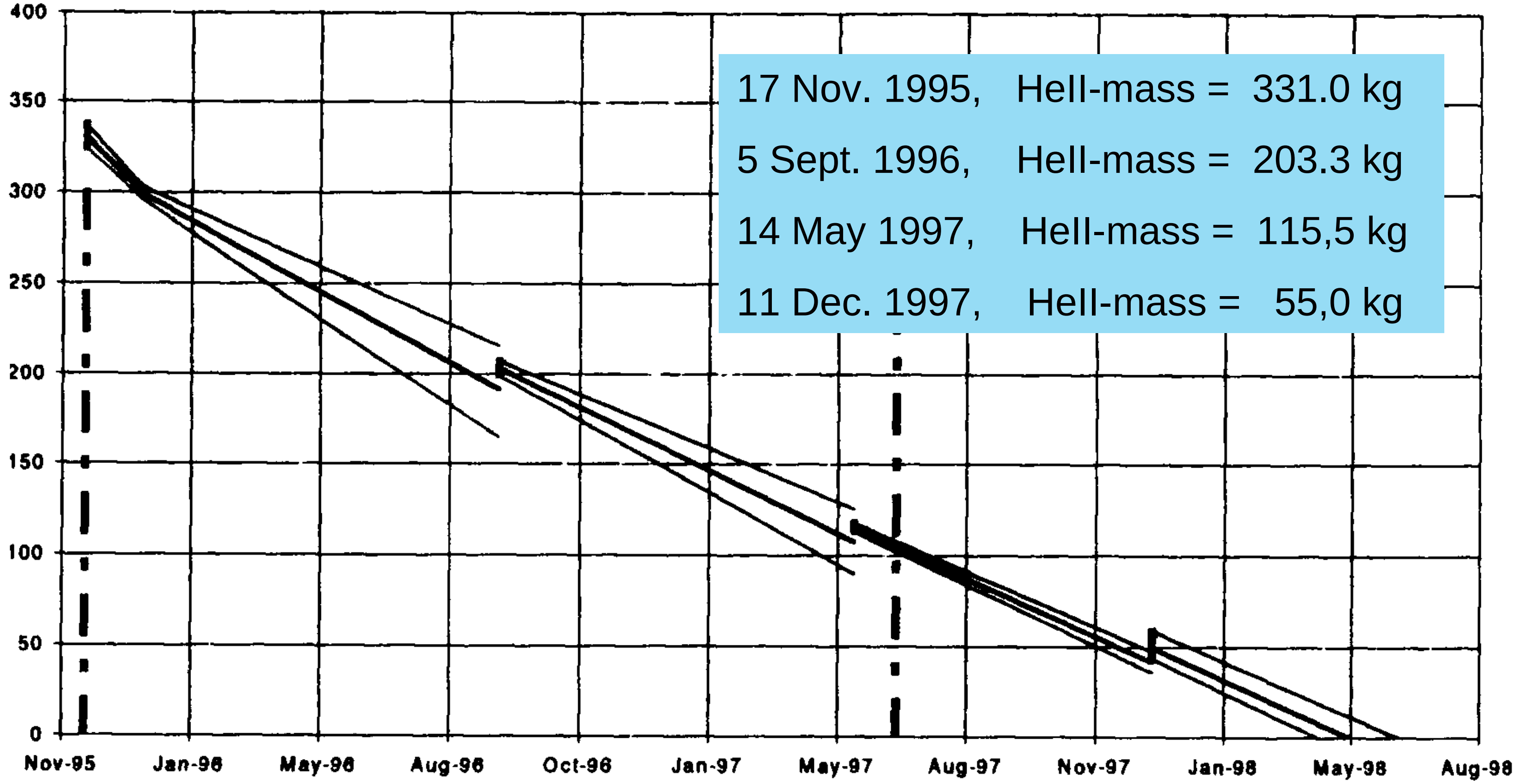
Proposed Heating Pulse Characteristics

- Power: 10 W
- Current: 0,45 A, constant
- Duration: depending on the remaining LHe II content, max. 200 sec

Mass Gauging Heater



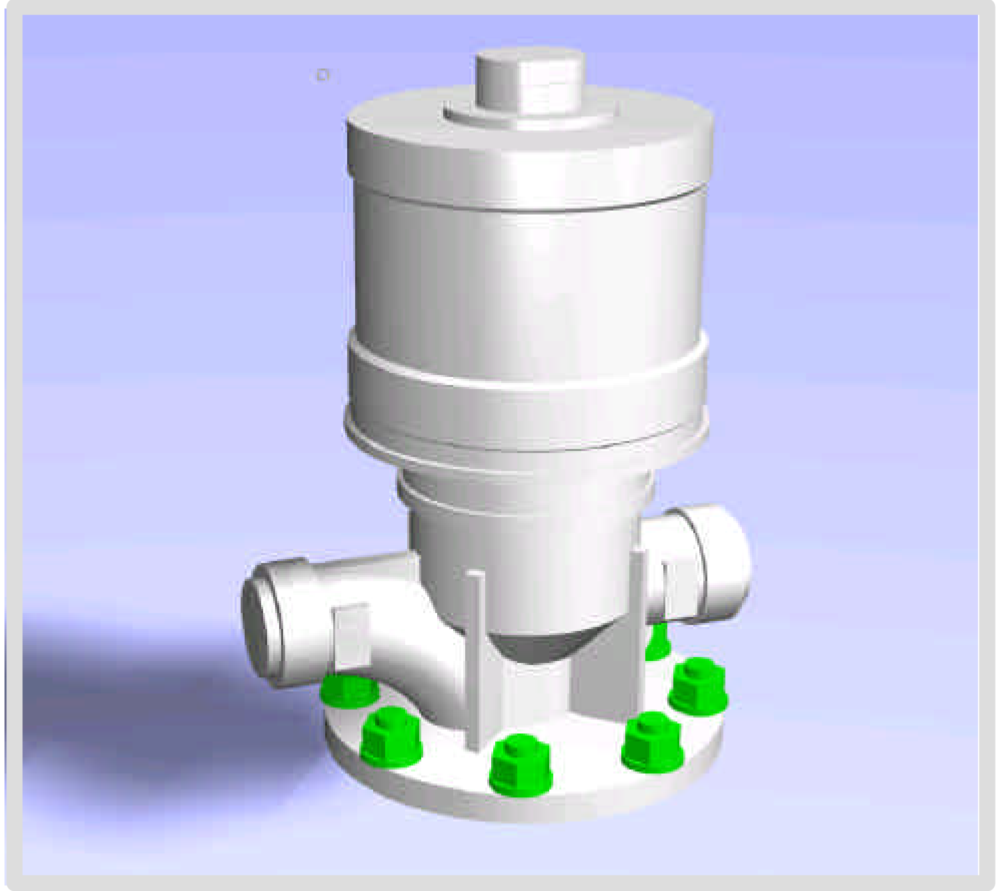
Mass Gauging Heater



He II-Mass Decrease (kg) During The Infrared Space Observatory (ISO) Mission

Cold Safety Valve RV 02

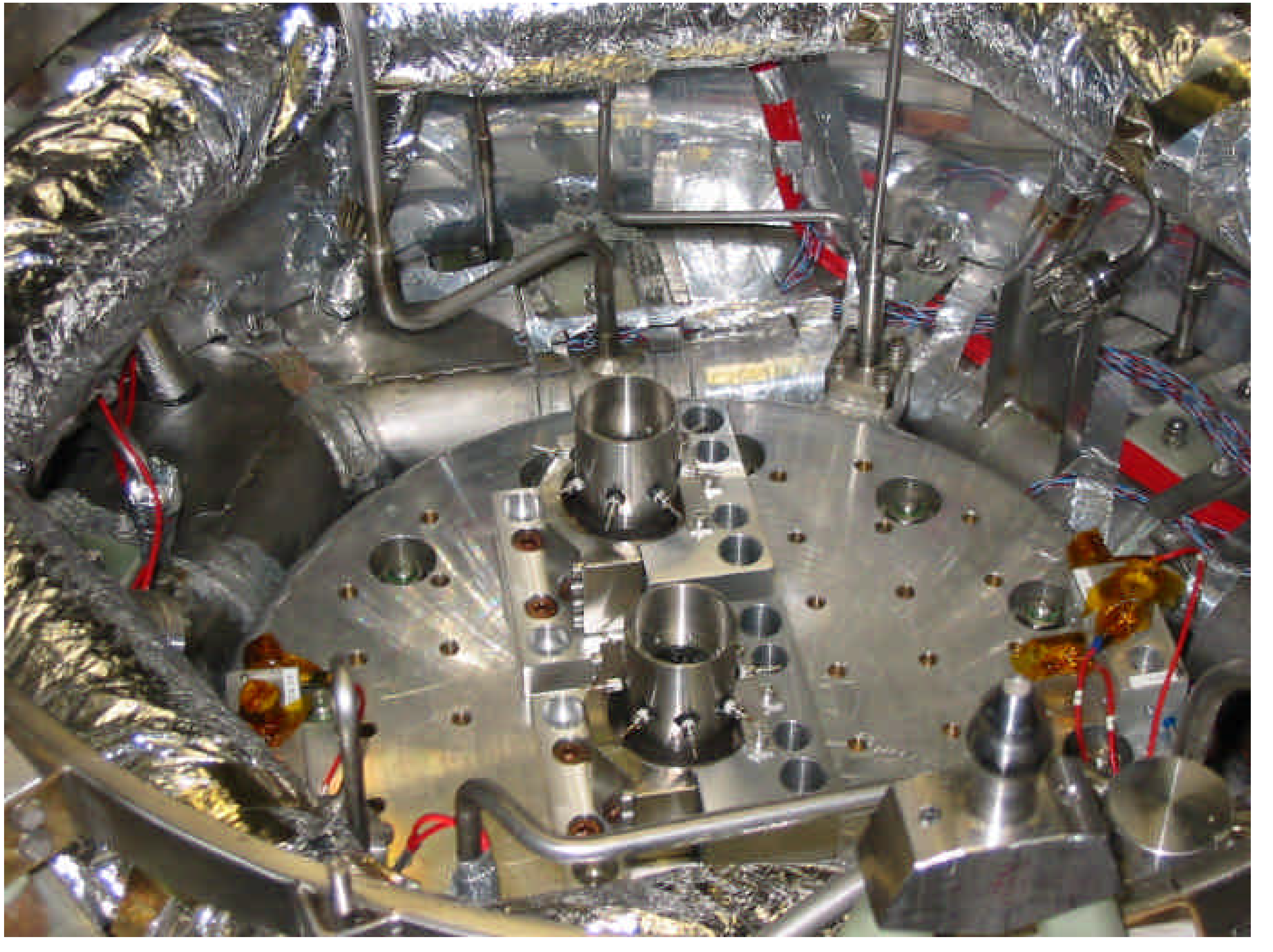
- Spring loaded safety device
- Part of the AMS safety system
- Protection of the AMS He II - Tank against overpressure



Cold Safety Valve RV 02

Operation Temperature:	1.8 K - 353 K
Opening Pressure:	1.6 bar ± 5 %
Fully open at:	1.76 bar
Maximum Mass Flow:	GHe 86 g/s at 4.9 K
Internal Leak Rate:	< 10^{-7} mbar l /sec at 300 K < 10^{-2} mbar l/sec at 1.8 K
External Leak Rate:	< 10^{-8} mbar l /sec

Shaker Proof Cryostat



Shaker Proof Cryostat