

# Local Cryogenics for the SIS100 at FAIR



GSI, Germany: T. Eisel, M. Kauschke,  
H. Kollmus, B. Streicher,

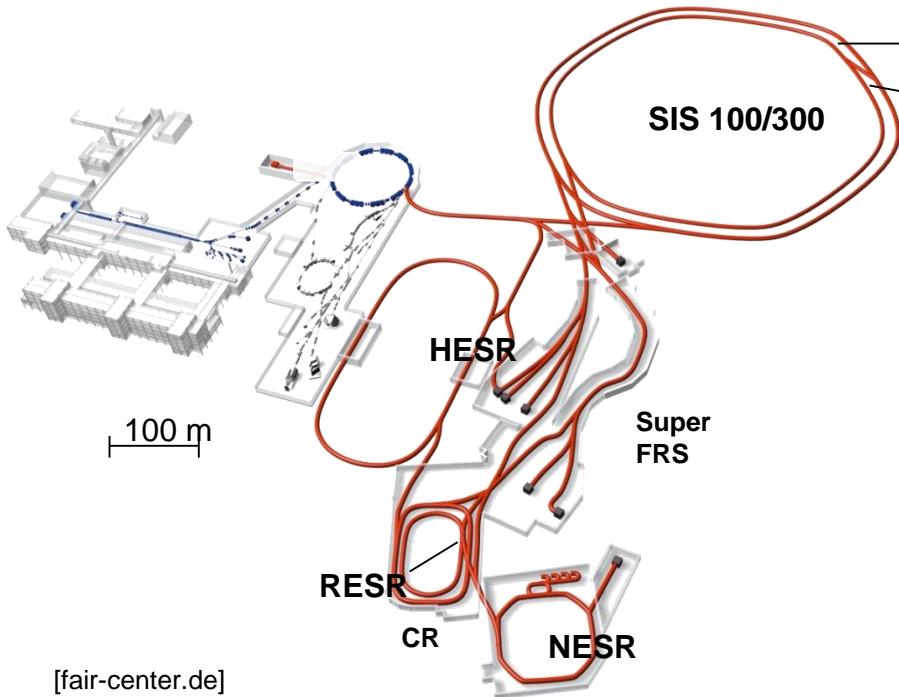
WrUT, Poland: M. Chorowski, A. Iluk,  
K. Malcher, J. Polinski

# Content

- *Introduction to FAIR and SIS100*
- *Magnet cooling*
  - Balancing parallel flows
  - Coping with changing dynamic loads
- *Polish In-kind*
  - By Pass Line (BPL)
  - Current Lead Box and Feed Box
- *Conclusion*

# Introduction

- FAIR: **Facility for Antiproton and Ion Research**
- SIS100: **Synchrotron 100 Tm**



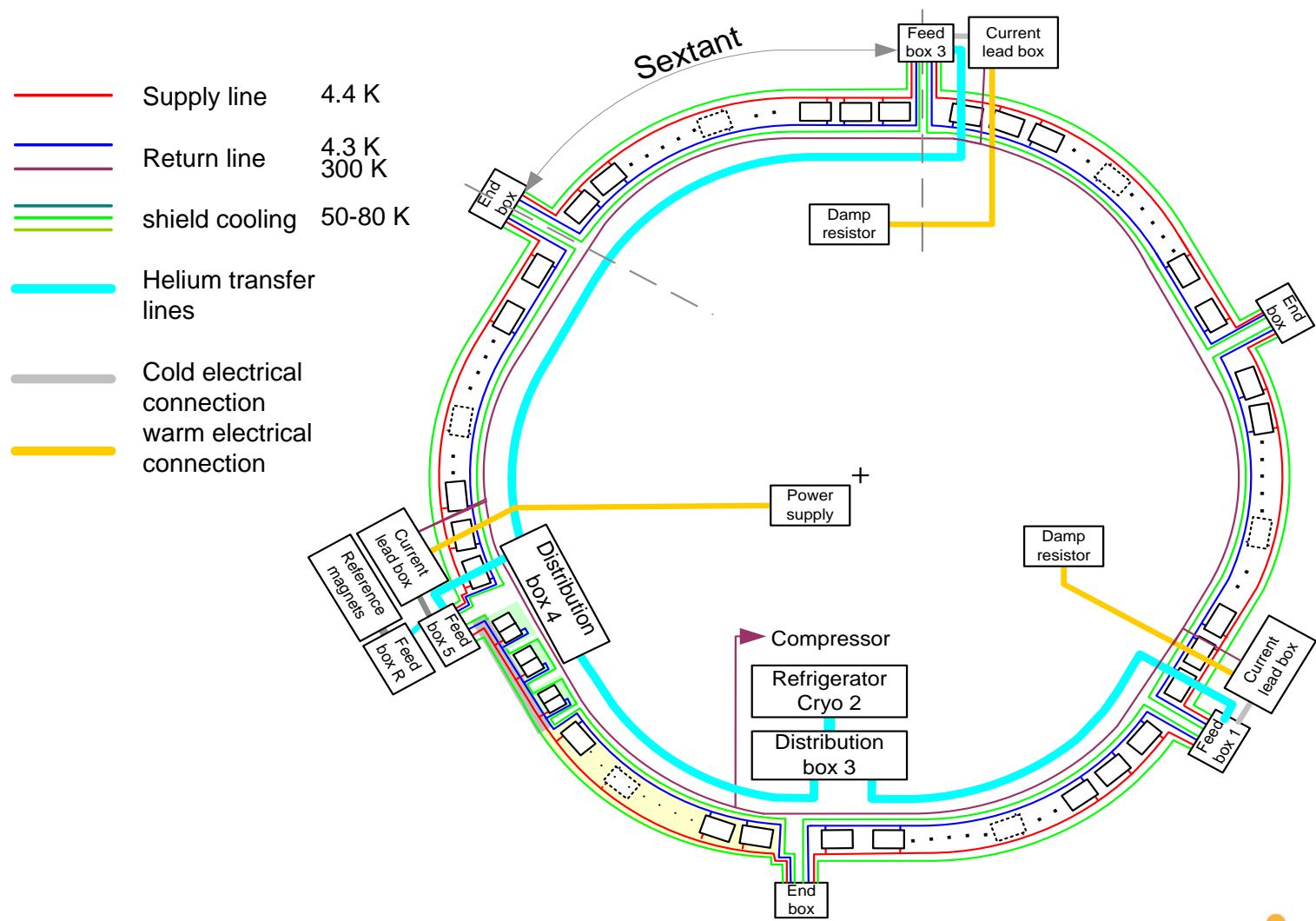
Deflecting magnets (Dipoles: DPs)  
Focusing magnets (Quadrupoles: QPs)

[google.de/maps]



- Synchrotron 1.083 km circ.
  - ❖ 108 Dipoles
  - ❖ 192 Quadrupole units

# Cryo distribution system

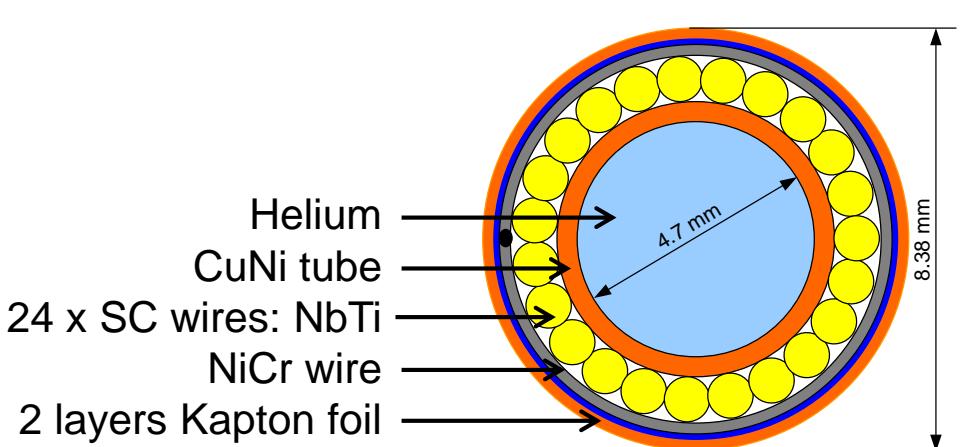
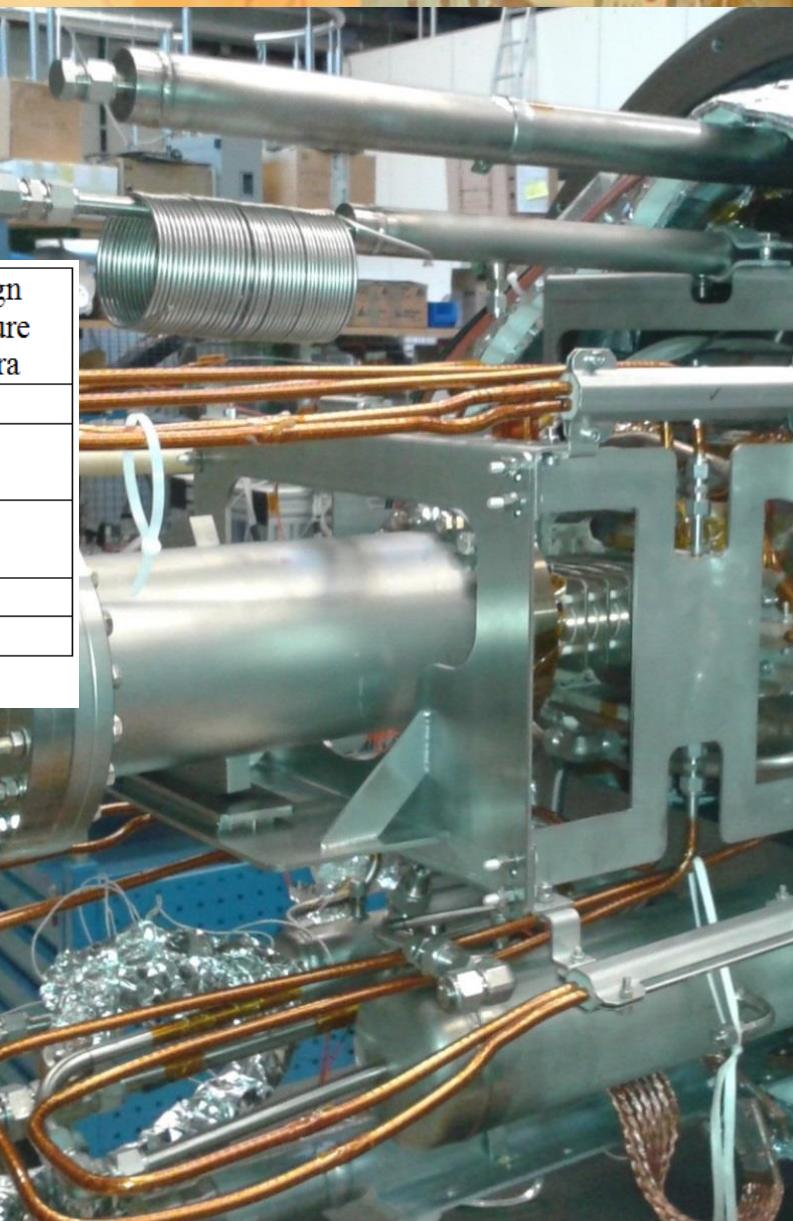


# Magnet cooling - general

## ➤ Process pipes

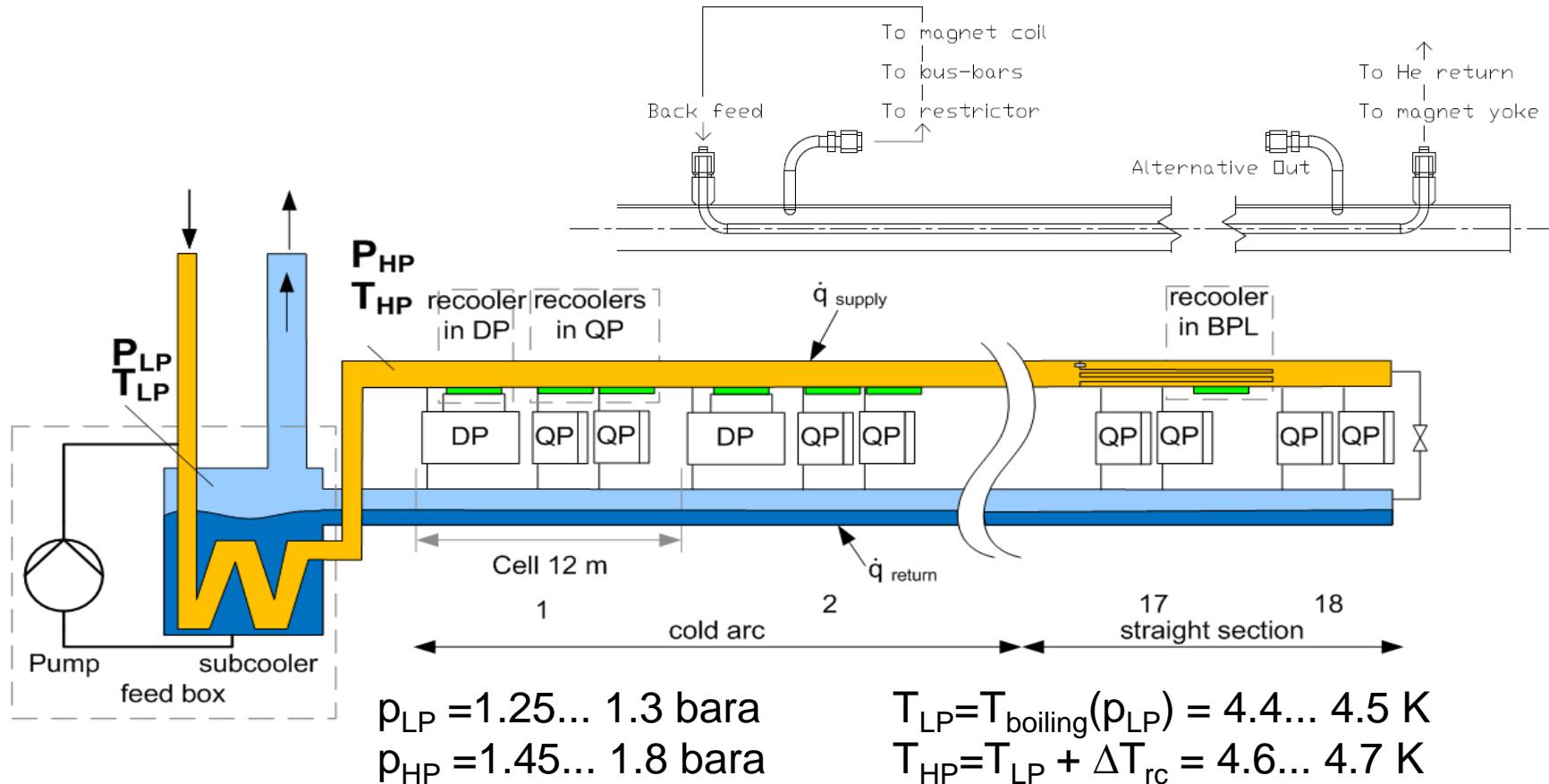
Process line	Outer Ø x thickness in mm	Operating temperature in K	Operating pressure in bara	Design pressure in bara
He supply magnets	54 x 2	4.5	1.8 *	20
He supply vacuum chamber	32 x 2	4.5	1.8 *	20
He return magnets + vacuum chamber	108 x 3	4.3	1.1 *	20
He supply shield	42.4 x 2	50	18	20
He return shield	42.4 x 2	80	17	20

\*The operation pressure during cool down is up to 18 bara.



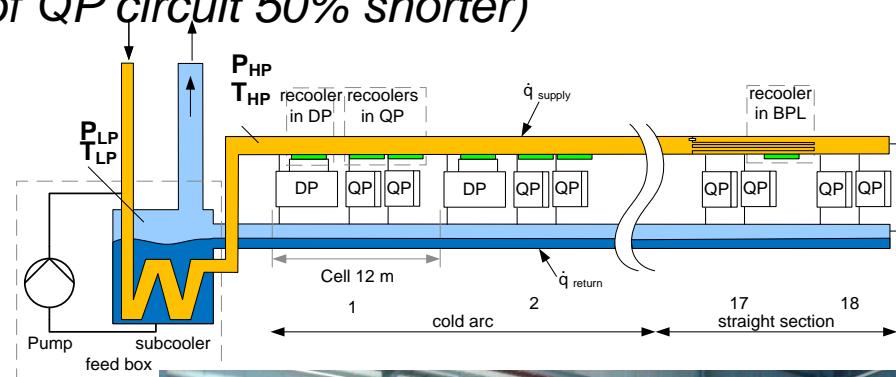
# Magnet cooling - general

## ➤ Parallel flow and recooling



# Magnet cooling – balancing parallel flows

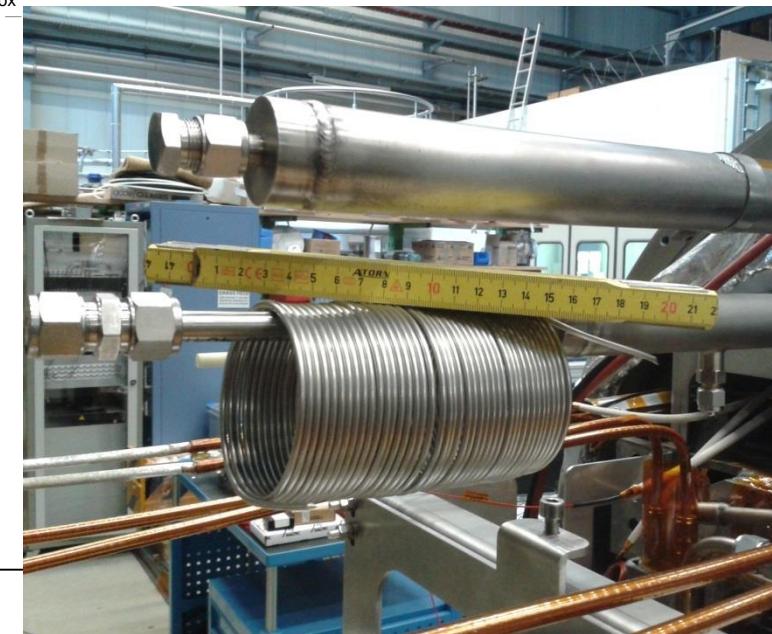
- DPs, QP units parallel arranged, having same supply and return
- Different dynamic heat load
- Different hydraulic impedance (length of QP circuit 50% shorter)



Without beam chamber	Static load [W]	Dynamic load [W]	
		Proton cycle	Triangular cycle
DP circuit	2	10	50 (measured)
QP circuits	3	5...7	25...35

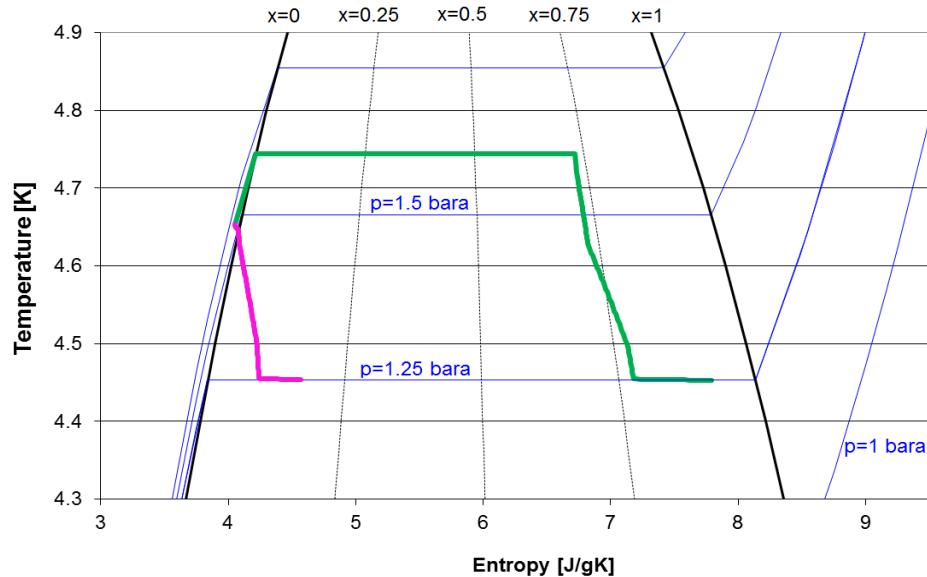
[A. Bleile]

- Restrictor in QP circuits (capillary with  $di=2\text{mm}$ , no mech. valve)



# Magnet cooling – coping with dynamic loads

- No mechanical valves planned for adjusting cooling to dynamic loads – heaters will be applied at the inlet of each cooling circuit
- 1) Machine's ramping cycles will change within seconds
  - Fast reacting heaters will simulate maximum dynamic load → constant load for refrigerator
- 2) Flooding of common return causes unstable operation



„static heat load“  
 $p_{in} = 1.6$  bara,  
 $x_{out} = 0.17$ ,  $m = 2.0$  g/s

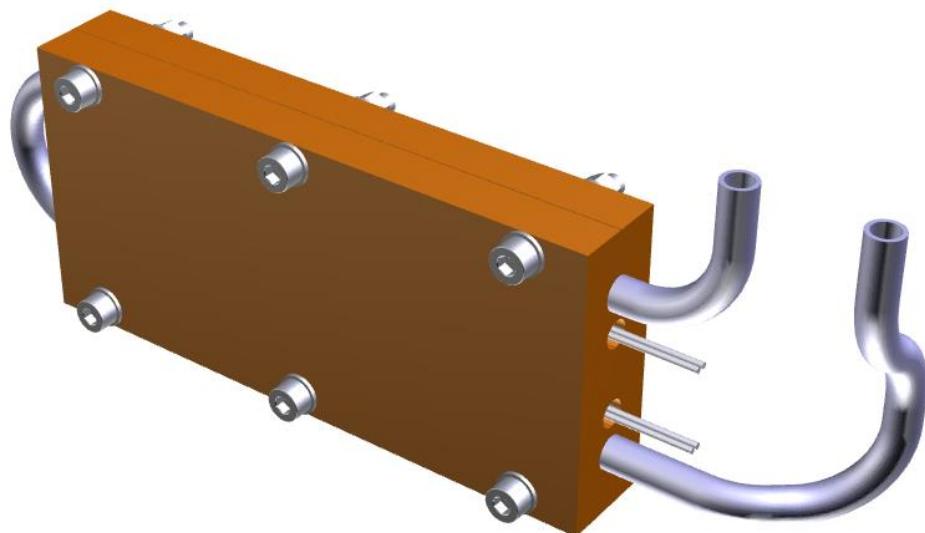
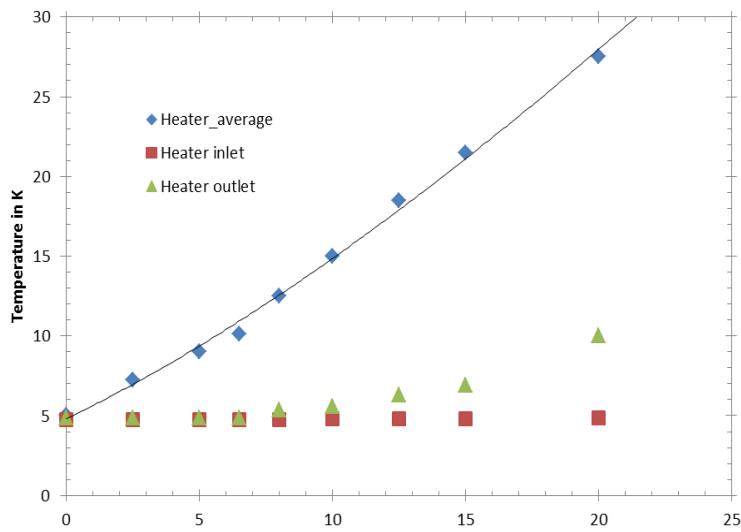
„static heat load + 14 W“  
 $x_{out} = 0.92$ ,  $m = 1.1$  g/s

- 3) Individual adjustment of cooling for each magnet is possible (functionality of balancing valve)
- Advantages of heaters (compared to mech. valves): failure safe, no pressure drop switched off, small heat in leak, no thermo acoustic oscillations, easy integration, inexpensive

# Magnet cooling – coping with dynamic loads

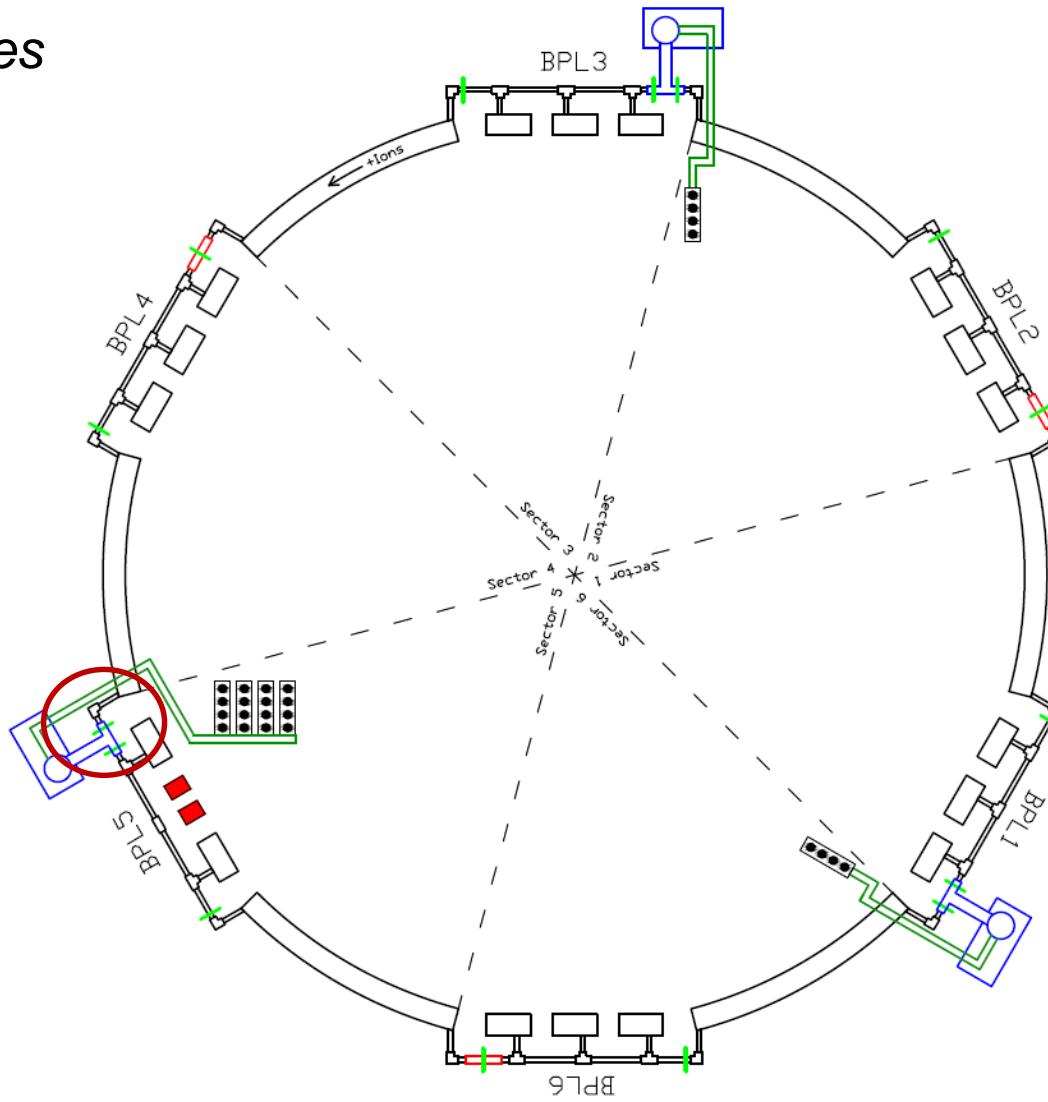
## ➤ Cartridge heaters

- Closed hydraulic circuit
- Redundancy: use of 2 heaters, each 10W, 0.28A, 35V  
PWM (if one is broken: 1 heater 20W, 0.4A, 48 V)
- Clamped with Apiezon® N
- Measurements performed
  - Thermal cycling, temperatures



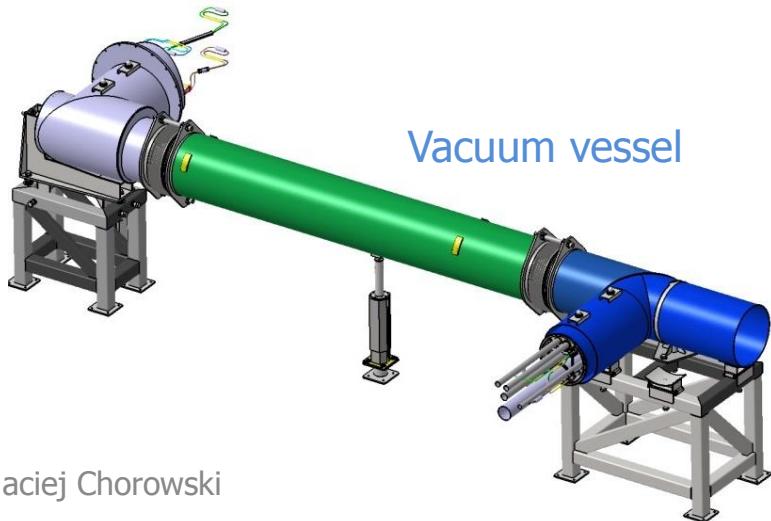
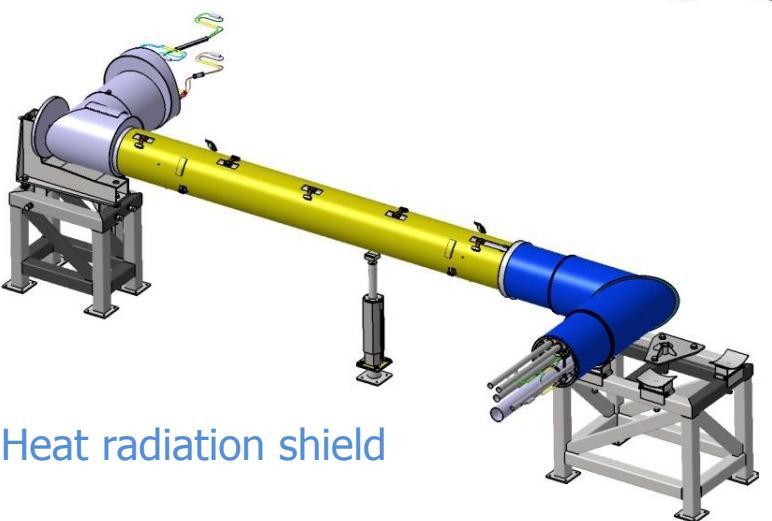
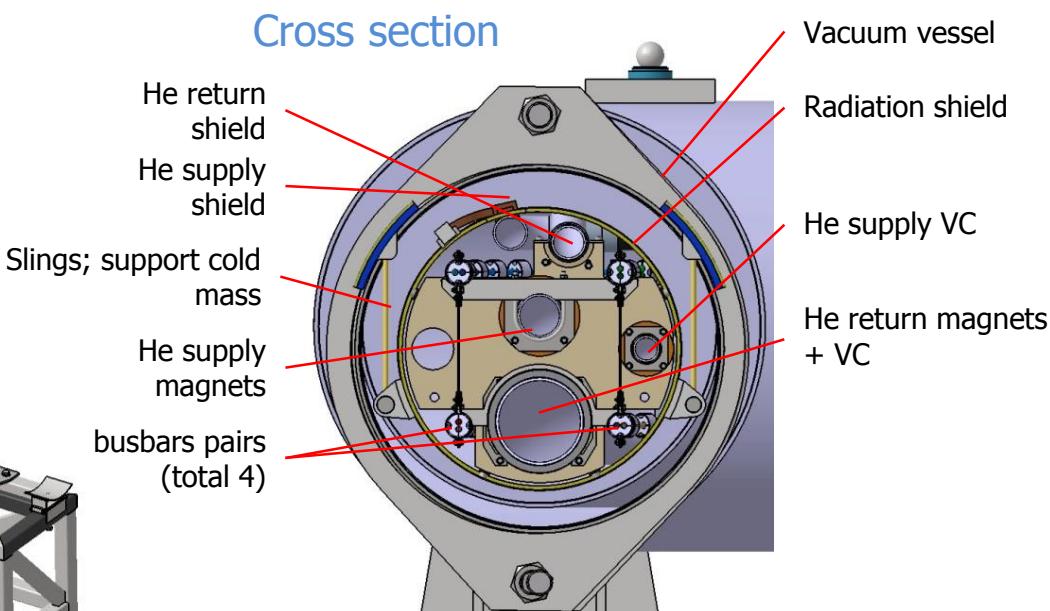
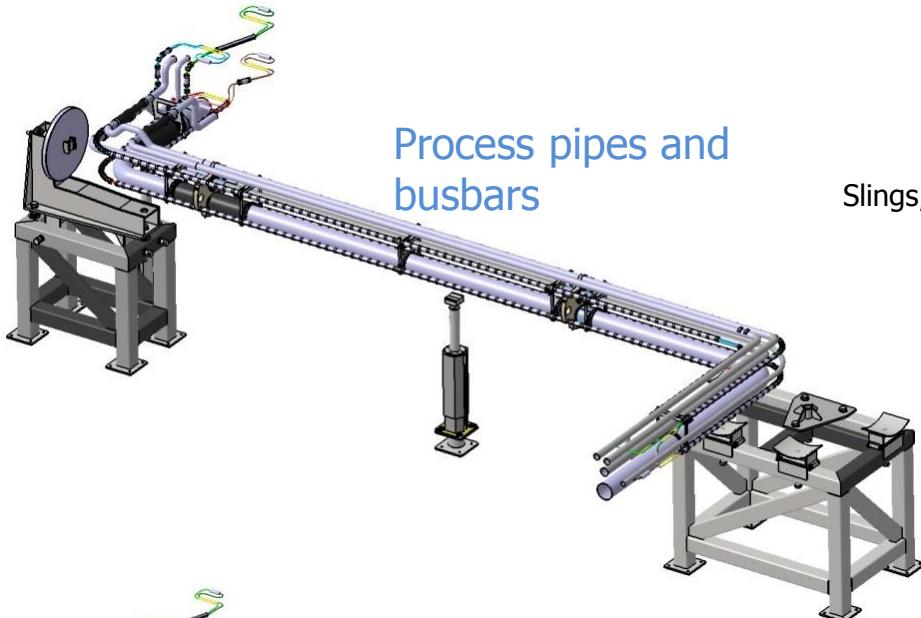
# Polish In-kind (WrUT – Wroclaw Uni Techn.)

- *By-pass lines*



# Polish In-kind

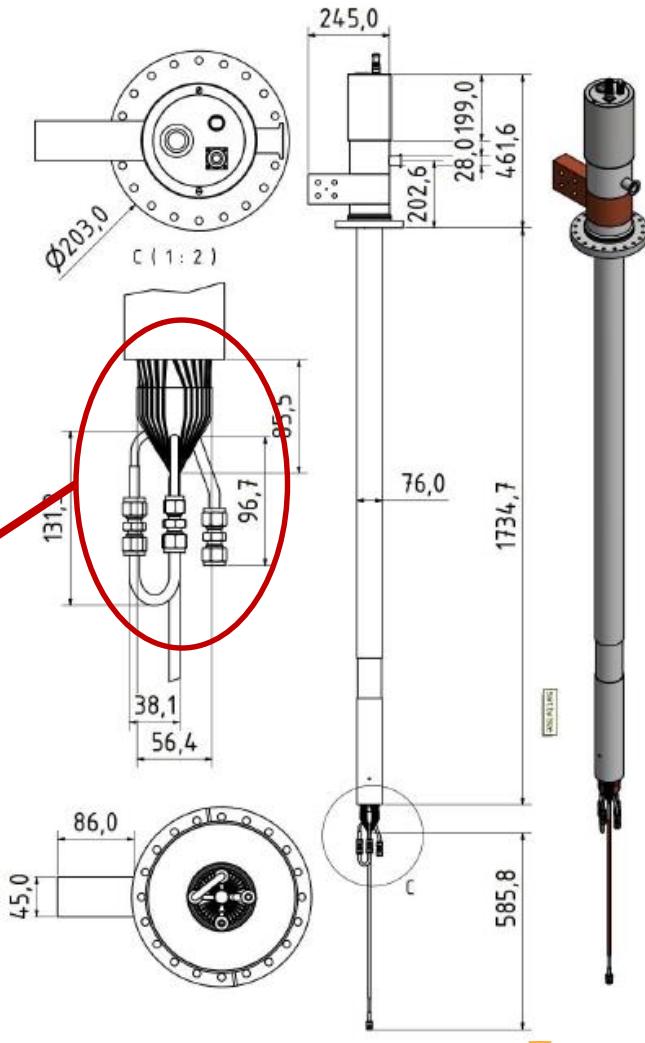
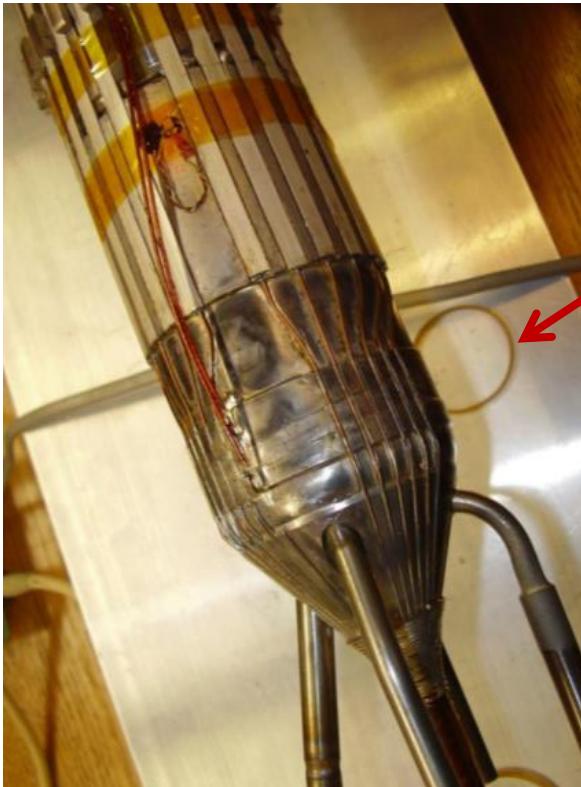
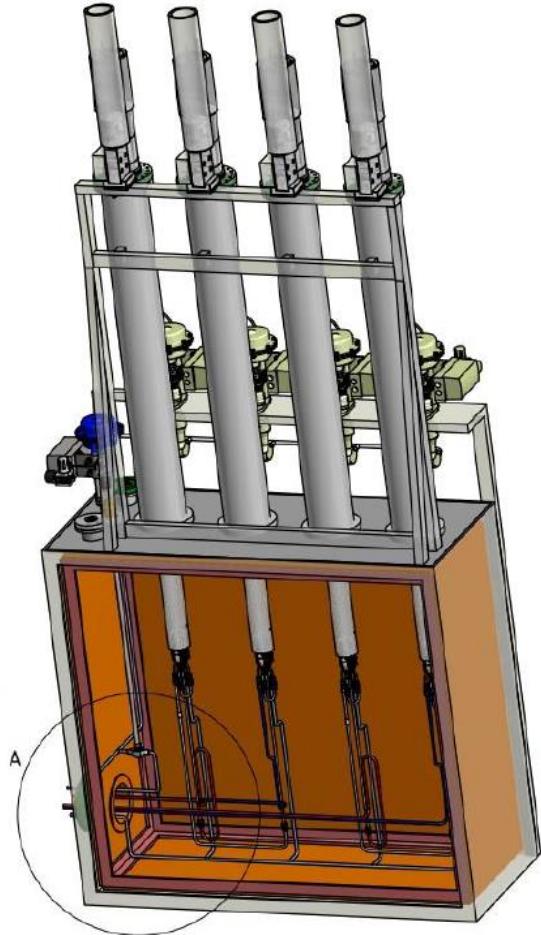
- *Design of first BPL piece*



Courtesy of Maciej Chorowski

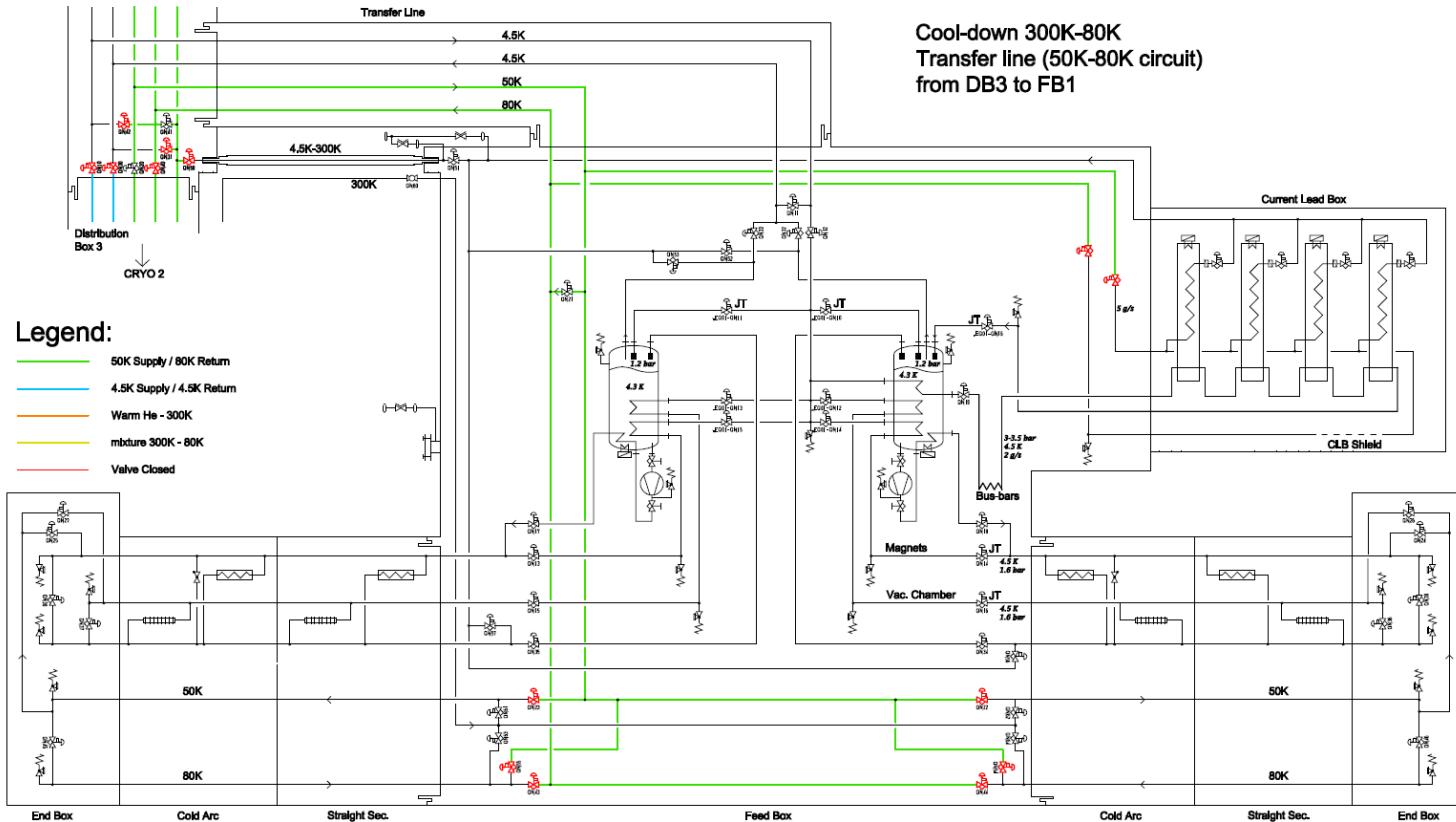
# Polish In-kind

- *Specifications of Current Lead Box*
  - contract with WrUT in work



# Polish In-kind

- *Specifications of Feed Box is in work*
- PID under discussion with Technical University Dresden (Ch. Haberstroh, H. Quack)



# Conclusion

- *Magnet cooling*
  - Balancing parallel flows
    - difference in dynamic load and hydraulic impedance
    - use of capillary tubes
  - Coping with dynamic loads
    - cartridge heaters at the inlet of each magnet cooling circuit
      - load simulation during fast ramping
      - no flooding of the common return line
      - cooling control of individual magnets
- *Polish In-kind*
  - Design of first BPL piece
  - Current Lead Box and Feed Box