Update on the cooling system of the luminosity detector

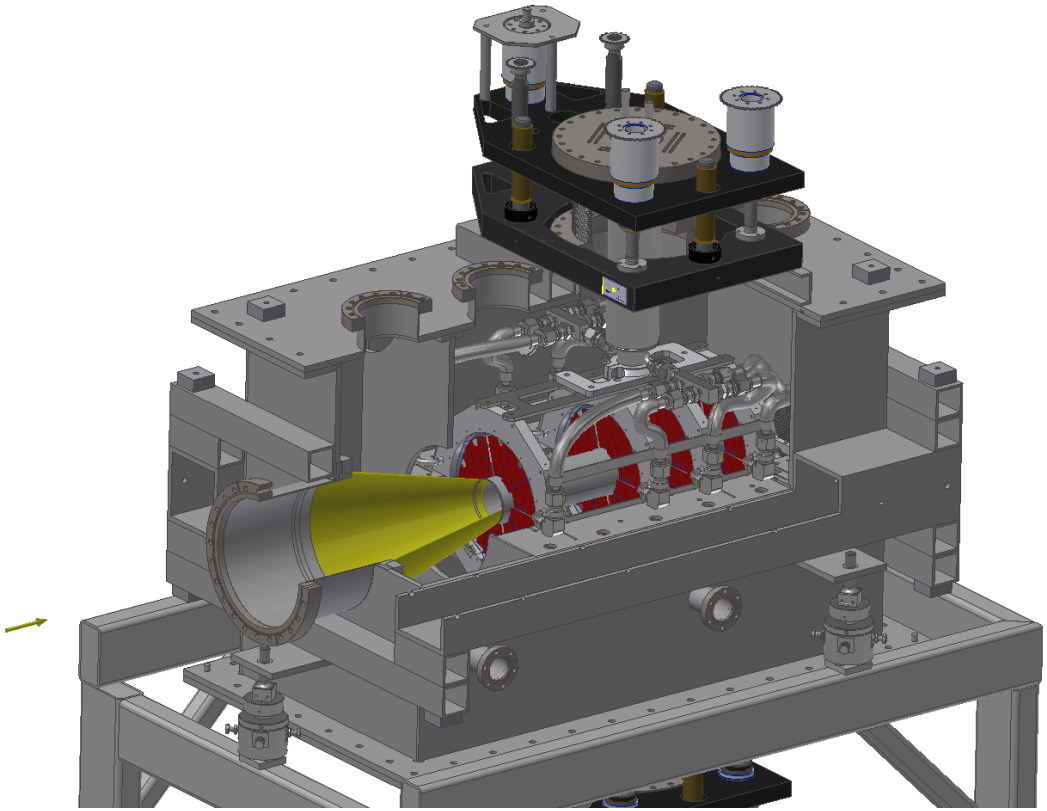
Heinrich Leithoff

Helmholtz Institut Mainz

PANDA-Collaboration-Meeting Darmstadt
November 5, 2019

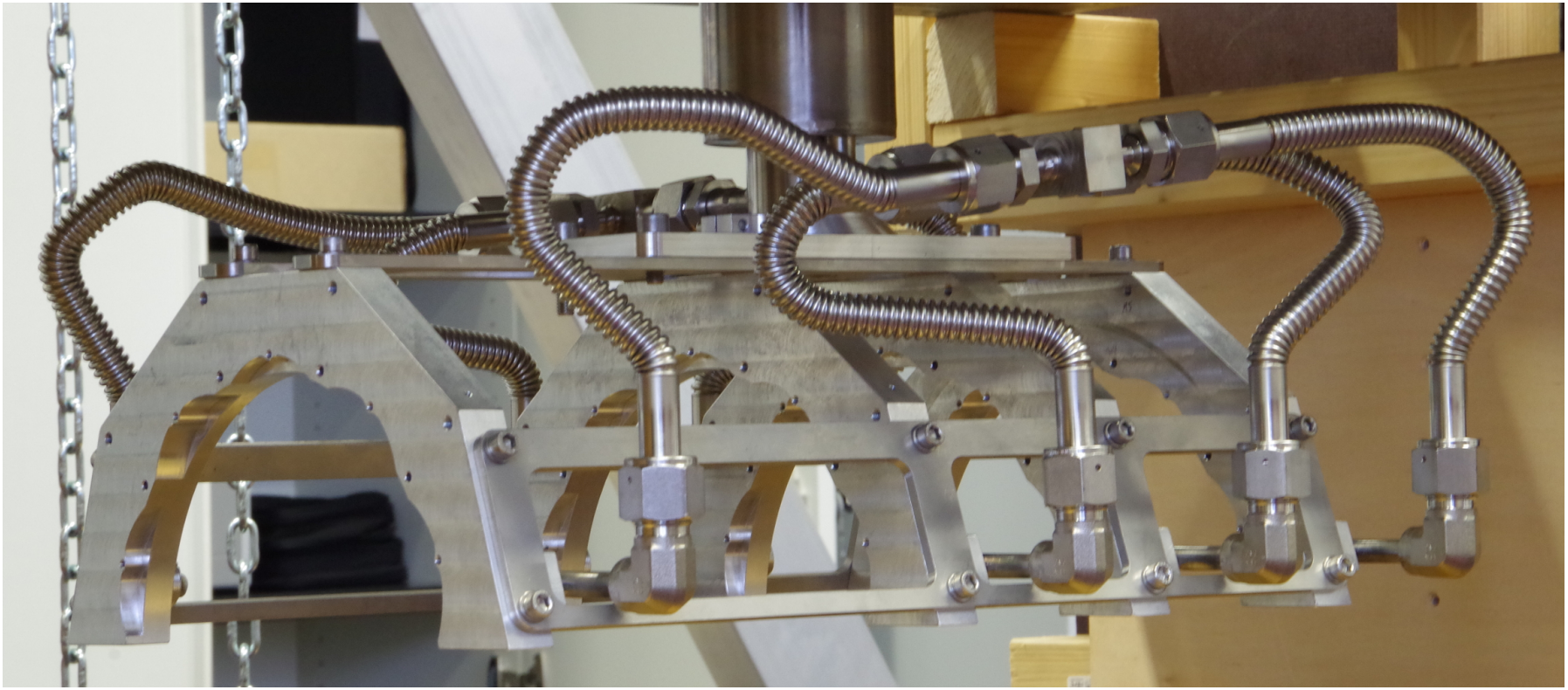
Helmholtz Institute Mainz

Overview



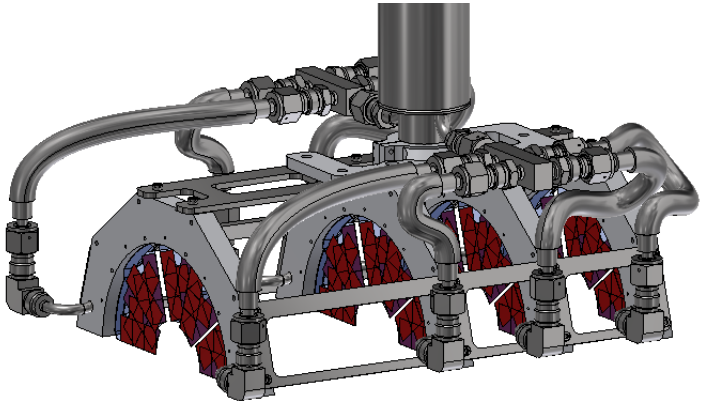
- status of the cooling system
- result of cycle test

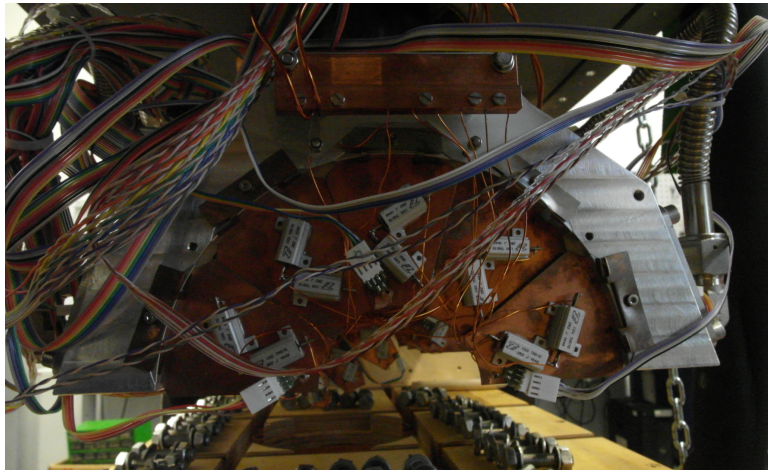
Half detector prototype



- production of halfplanes is finished
- Full half detector cooling test done
- Test in vacuum seems ok

Cooling system: General setup





	sensors	LDO Voltage regulator	resistance in flexcables	Multiplexer etc.
worst case	1040 W	320 W	160 W	∼100 W
likely case	380 W	120 W	20 W	∼100 W

- Total estimated heat load per half detector: 310 W to 810 W
- Worst case: 7 mW mm^{-2}, likely case: 2.5 mW mm^{-2}
- For cooling test: copper dummys and high power resistors

Cooling cycle test

Cooling cycle:

- Set bath temperature to $-20\,^{\circ}\mathrm{C}$
- When $-20\,^{\circ}\mathrm{C}$ is reached wait 10 min
- Switch on power supply and wait 15 min
- Switch off power supply and set bath temperature to $20\,^{\circ}\mathrm{C}$
- When $20\,^{\circ}\mathrm{C}$ is reached wait 10 min

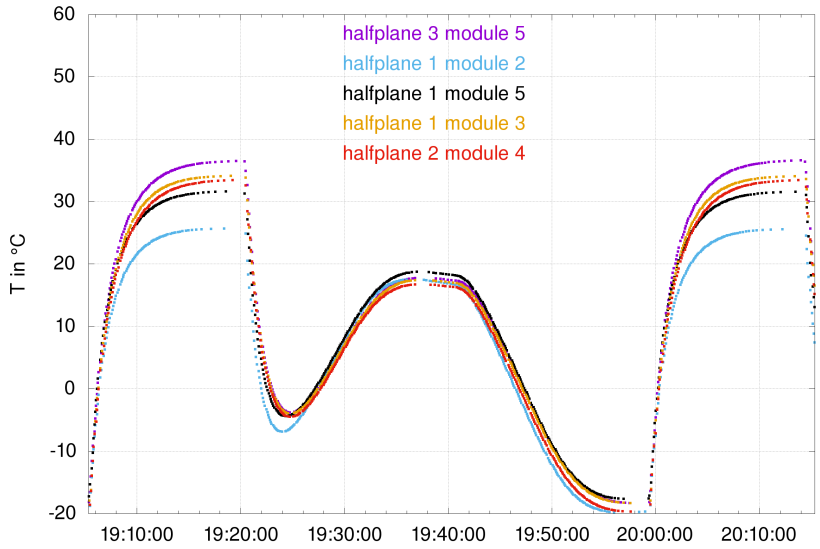
>500 cycles run with 340 W (14 W/module)

>500 cycles with 465 W (19 W/module)

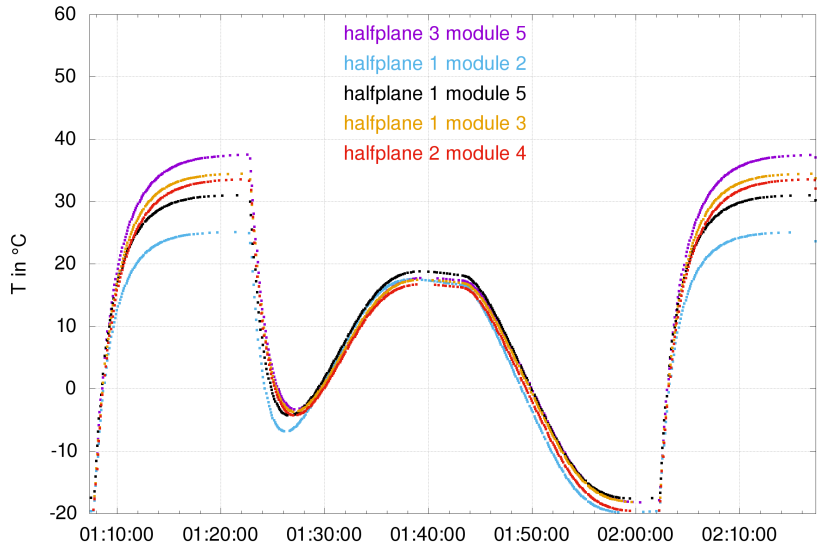
expected case: 10 W/module

Cooling cycle result I

First cycle:



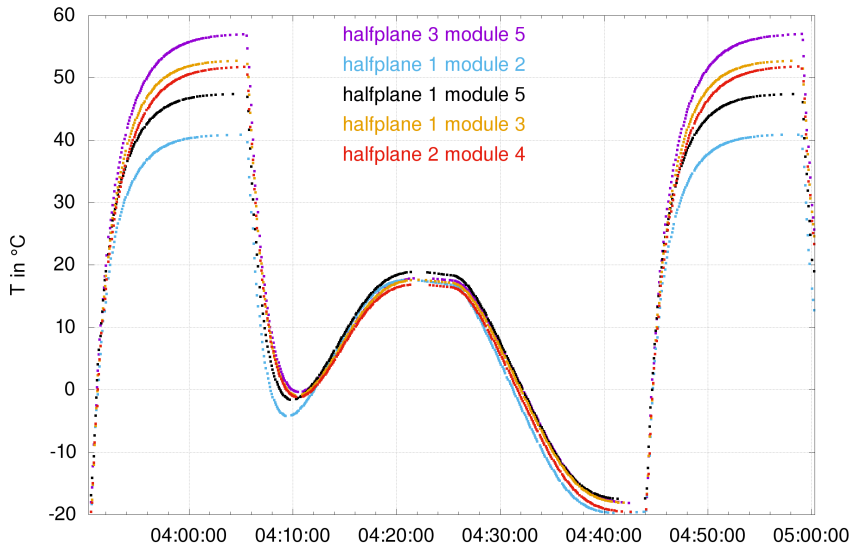
Last cycle:



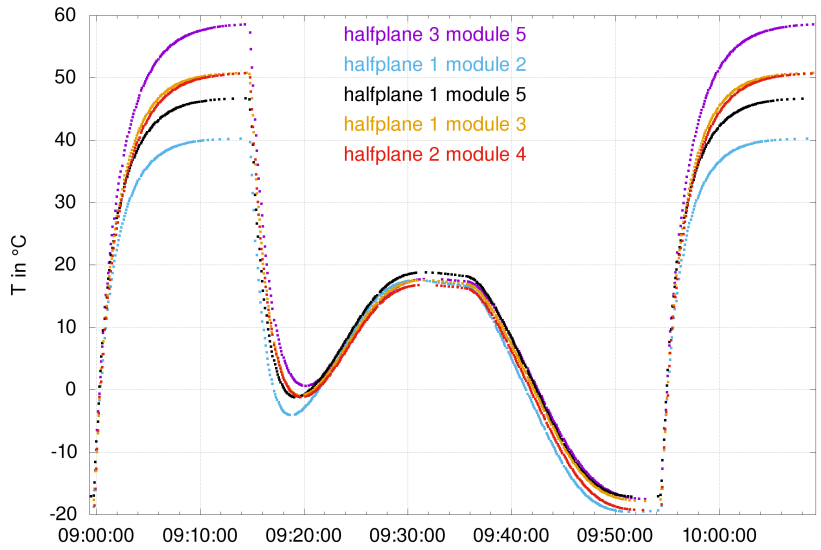
- No change in 500 cycles for 340 W
- Placement of modules difficult du to stiff copper cabling and heavy weight
- Well-placed modules show acceptable temperature under realistic conditions

Cooling cycle result II

First cycle:



Last cycle:



- Small changes after 500 cycles for 465 W
- Three copper dummies lost contact
- Well-placed modules still ok

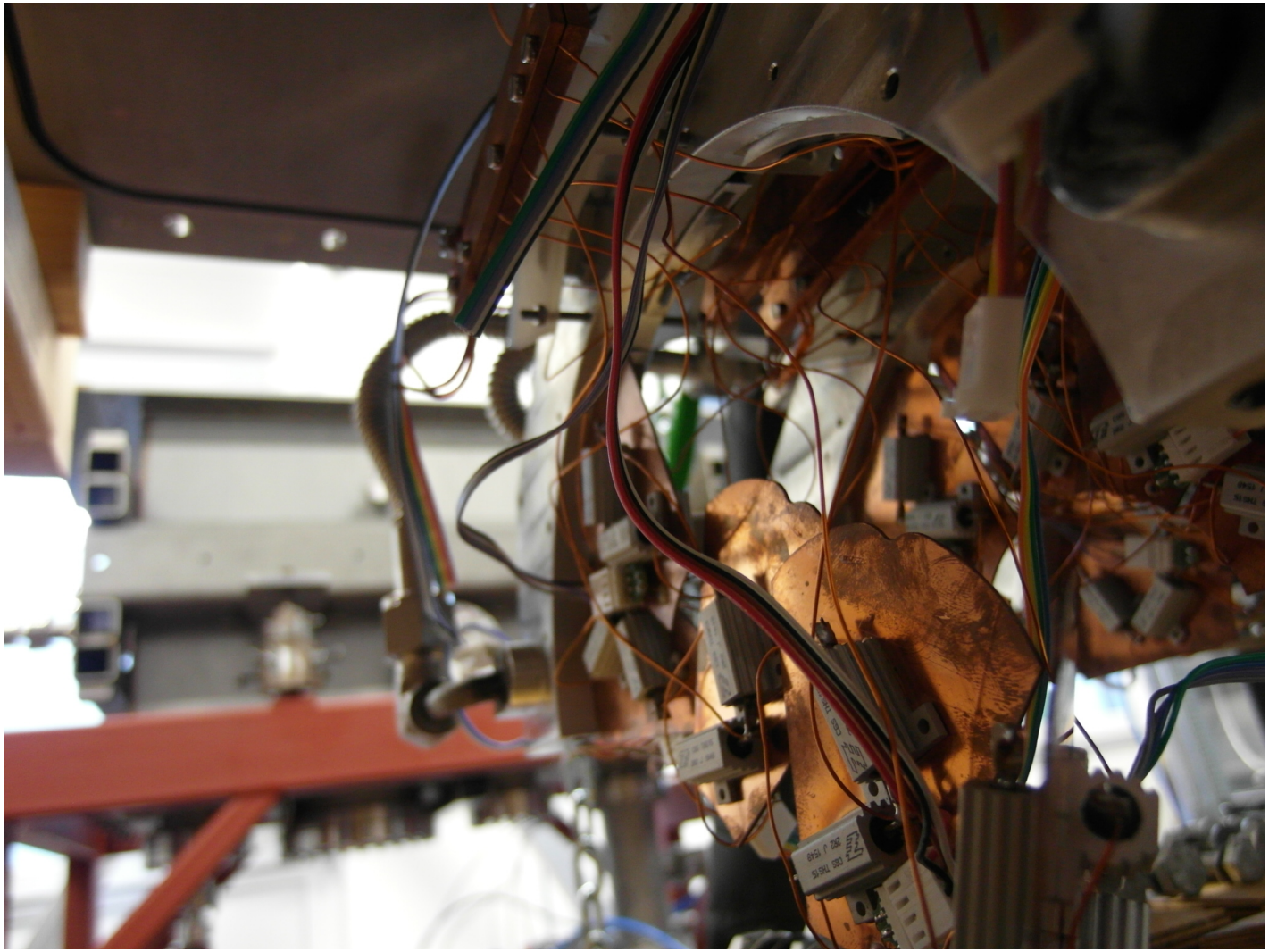
Summary and outlook

- production of half planes finished
- half detector prototype successfully tested
- new design vacuum box produced, first tests successful

What is next:

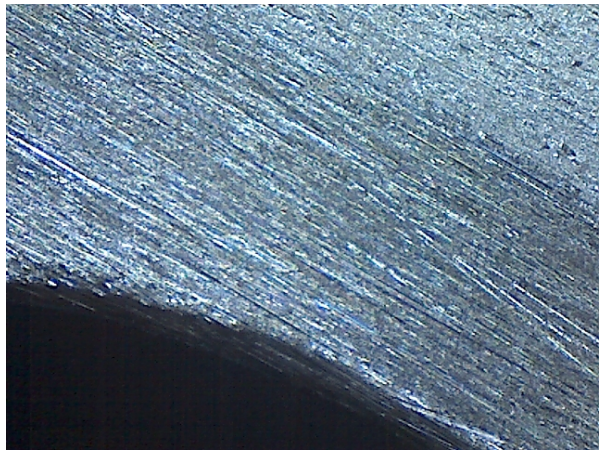
- extended test of new vacuum box
- production of half detector prototype with sensors
- production of final detector

Contact loss during cycle test

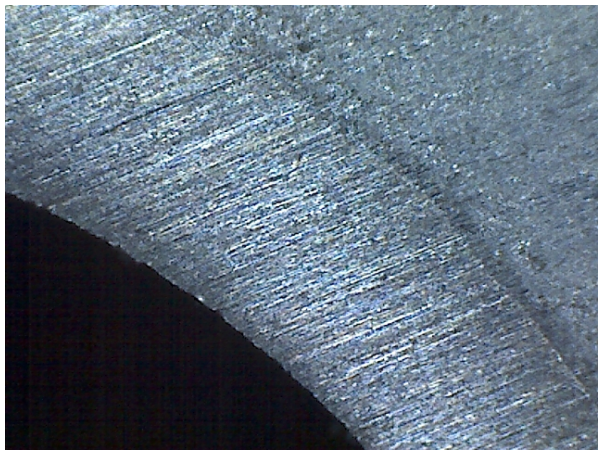
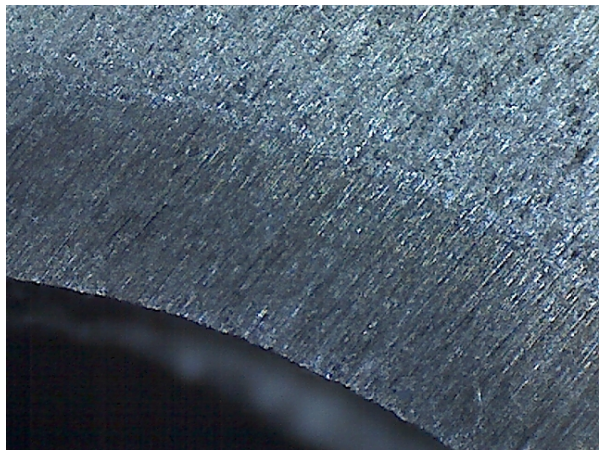


Aluminum steel contact after cooling

after cutting:

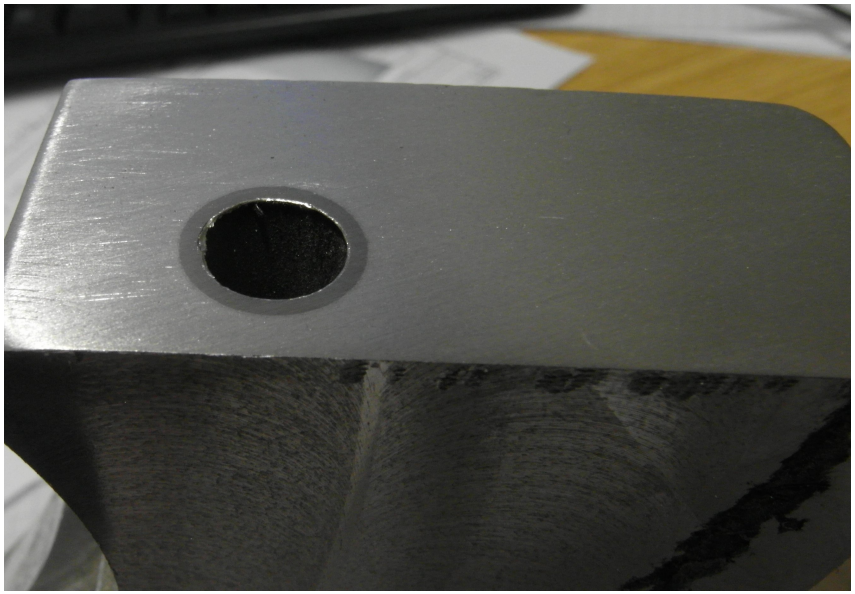



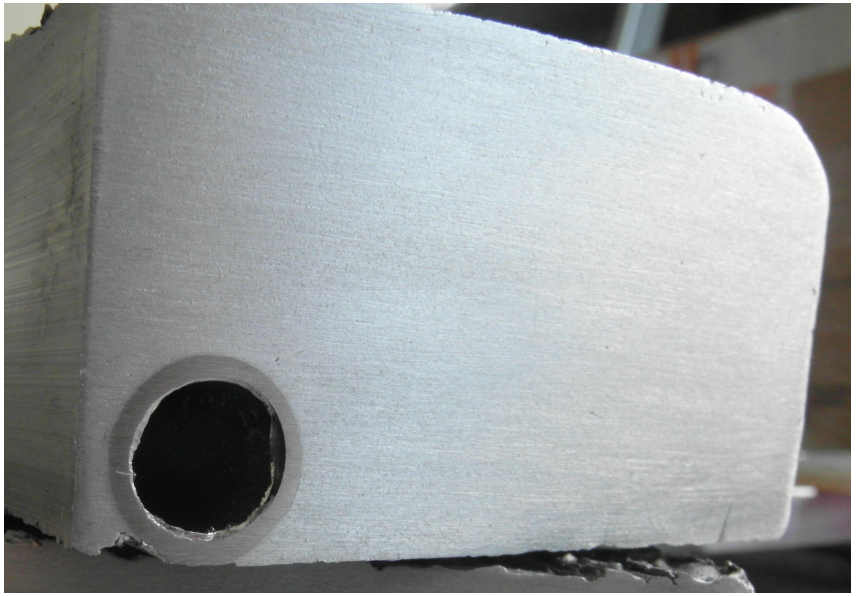
after cooling to -40°C:

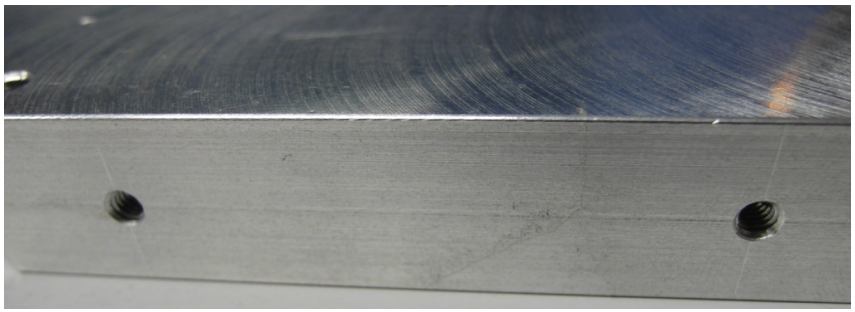



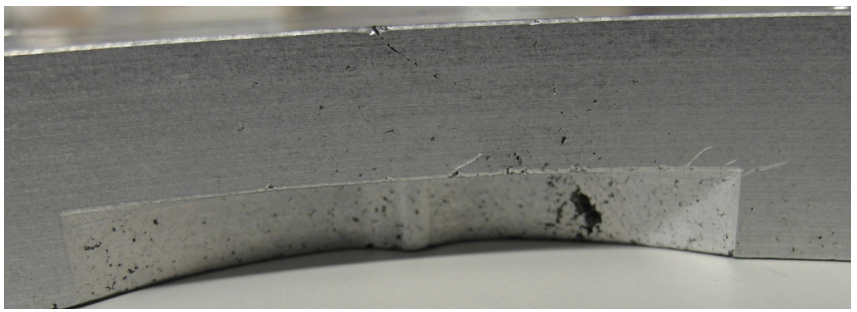
No gap between the materials, very good contact

Comparison of materials and processes

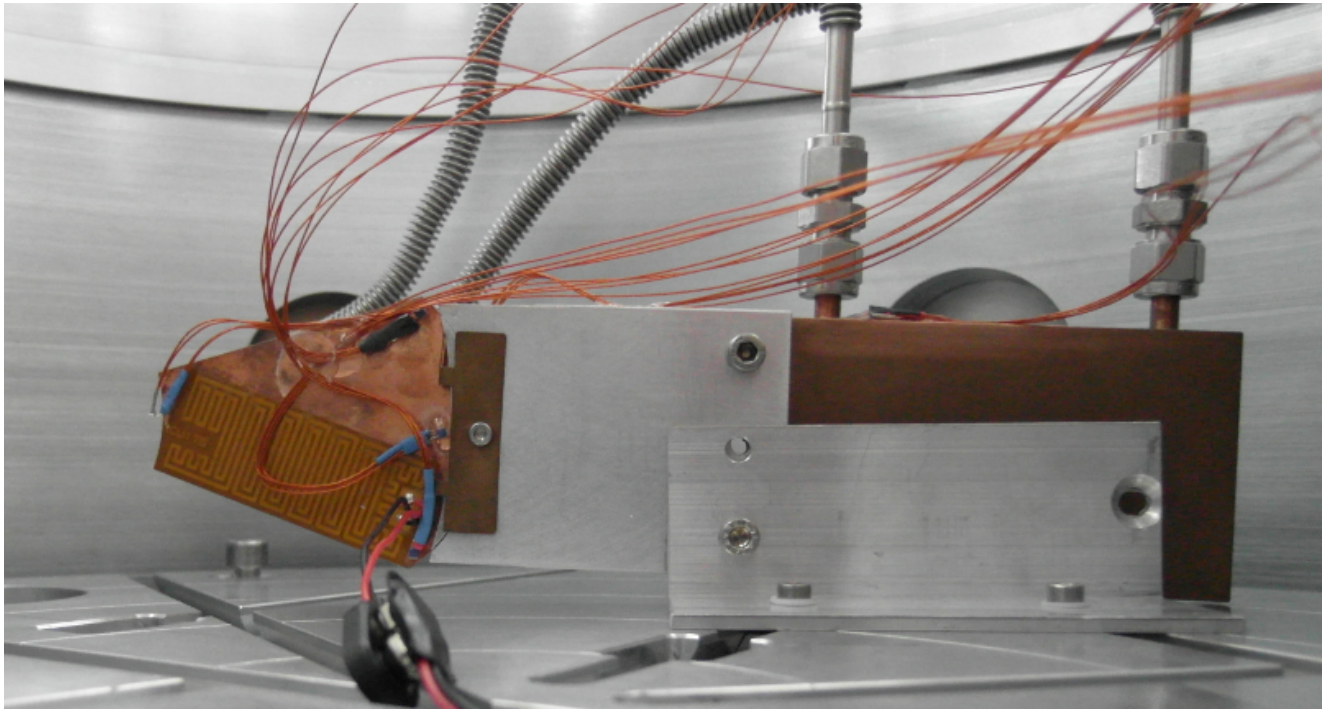






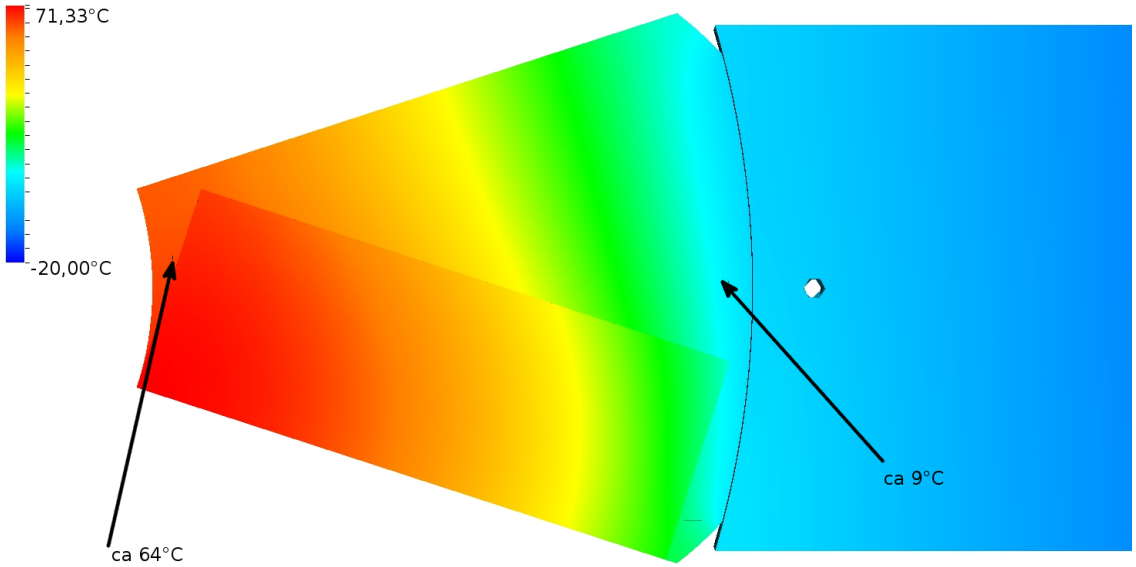


Test of the aluminum-diamond contact



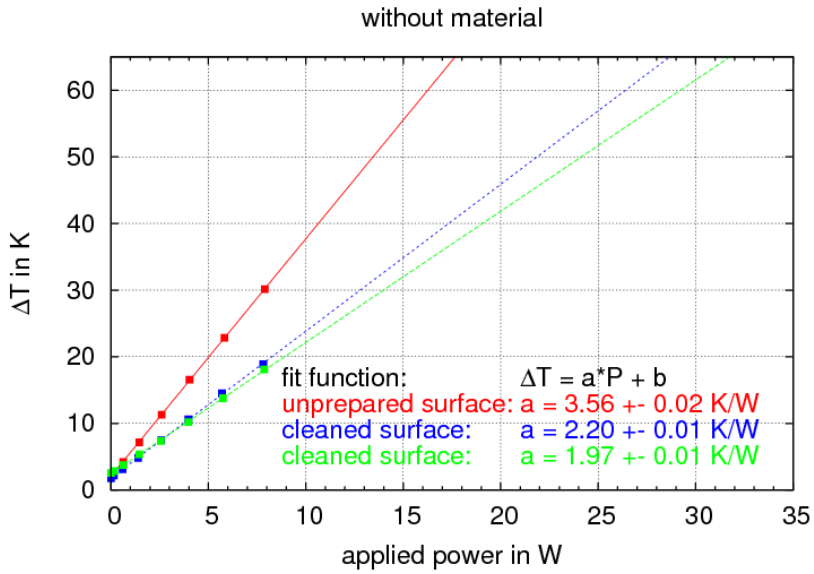
- Setup with copper dummy
- Comparison of FEM results with measurements
- Test and comparison of several contact materials

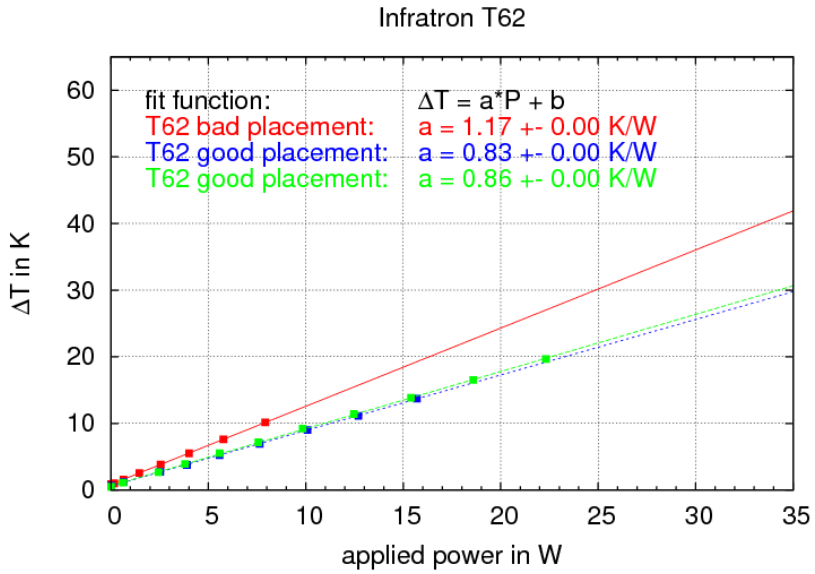
FEM-simulation and measurement

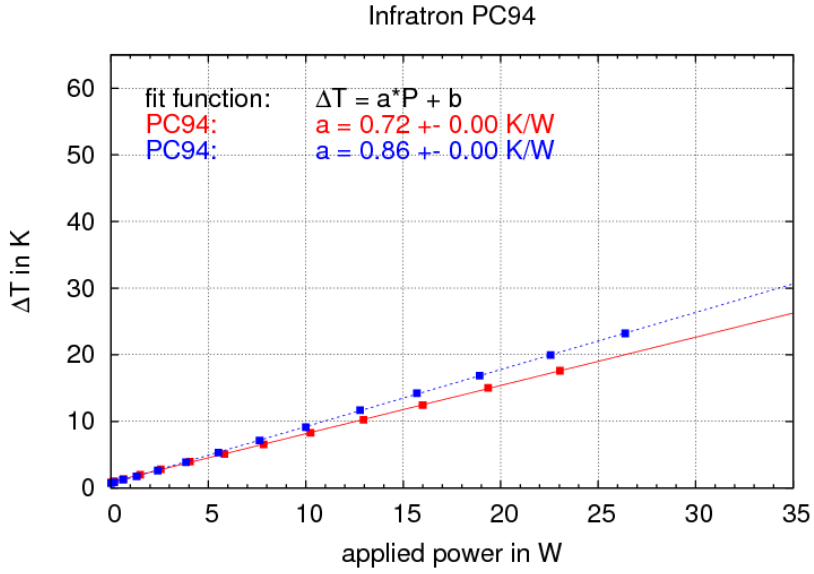


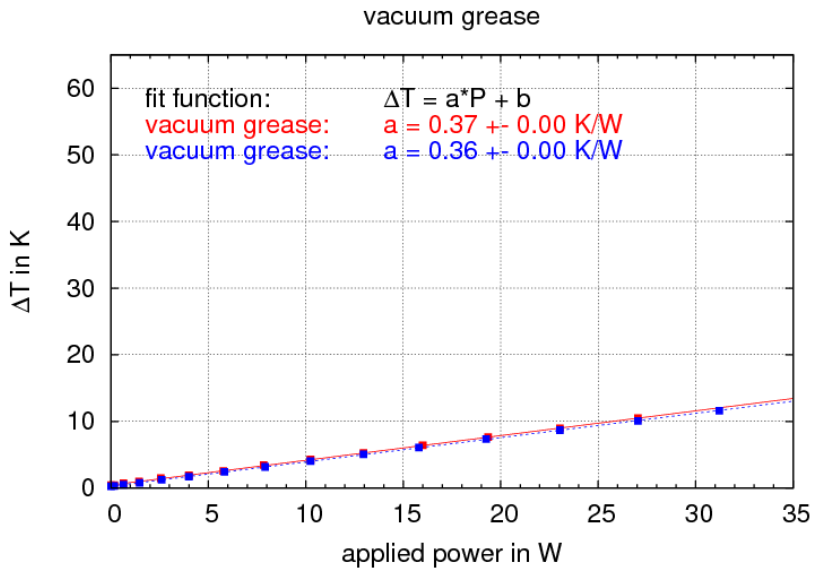
- Simulated temperature difference $\sim 55°C$
- Measured temperature difference (two Pt100): $50°C$
- High radial temperature gradient (up to $2\frac{K}{mm}$)

Contact materials

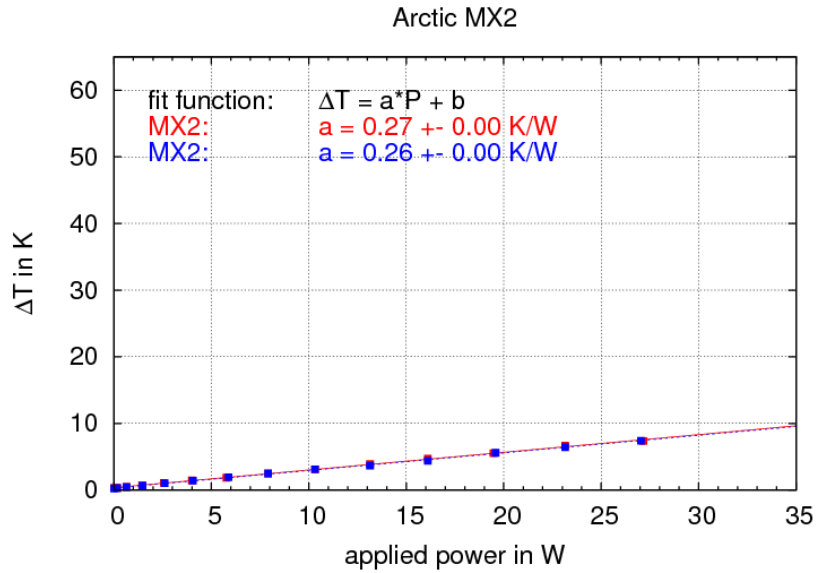








Contact materials 2

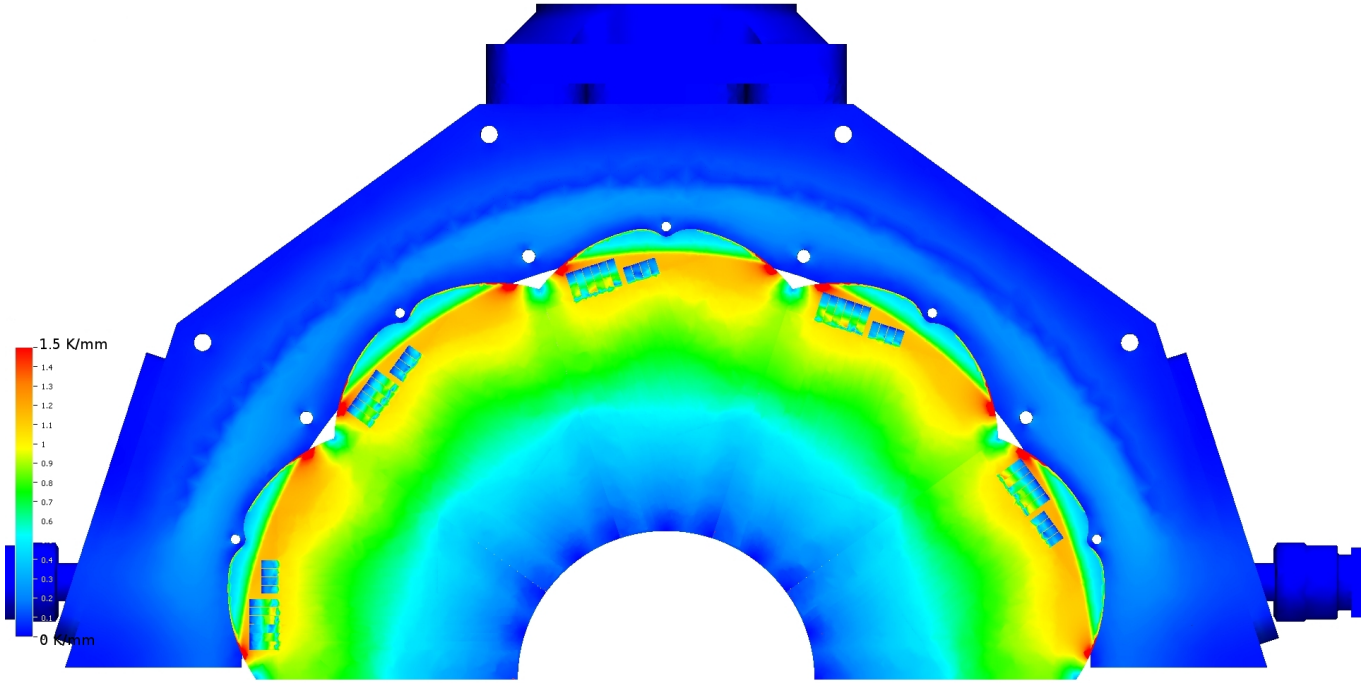


Upper limit for the material transition temperature rise:

no material	graphit foil	PC94	vacuum grease	MX2
$\sim 2,2\frac{^\circ C}{W}$	$\sim 0,86\frac{^\circ C}{W}$	$\sim 0,86\frac{^\circ C}{W}$	$\sim 0,37\frac{^\circ C}{W}$	$\sim 0,27\frac{^\circ C}{W}$

These contain $\sim 0,1\frac{^\circ C}{W}$ due to the measurement setup

Temperature Gradient



- Temperature gradient varies on the diamond
- High values near the cooling structure ($> 1.5\ \frac{K}{mm}$)
- interesting measurements are in region with $> 1\ \frac{K}{mm}$

Melting aluminum around stainless steel pipes

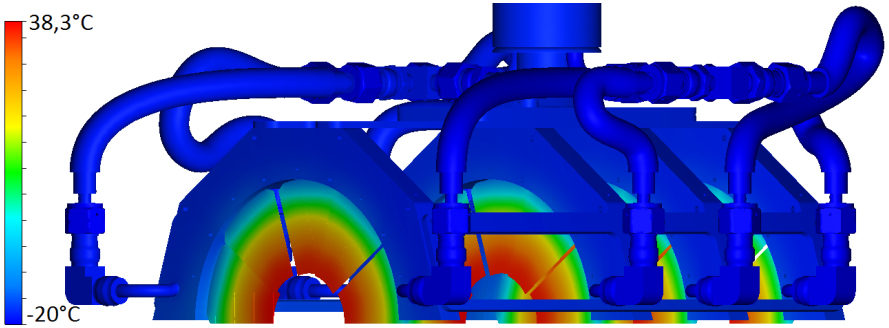
- Casting mould with stop off and cooling pipe
- The pipe can move in one direction to minimize internal stress

Casting mould after first melting process

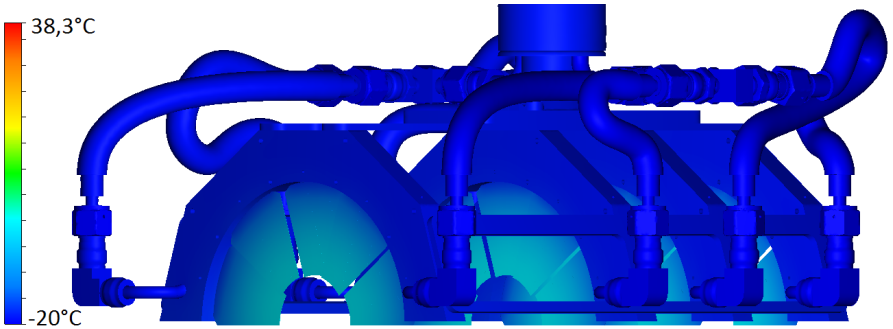
- First test done under vacuum
- good results, but the vacuum furnace gets really dirty

Simulation

worst case:



expected case:



- No transition or radiative effects
- Inlet temperature $-20\,^{\circ}\mathrm{C}$, pressure difference 1 bar
- diamond in nominal thickness
- maximum temperature:

  worst case: $\sim 39\,^{\circ}\mathrm{C}$

  ecpected case: $\sim 0\,^{\circ}\mathrm{C}$