The cooling system of the luminosity detector

Heinrich Leithoff

Helmholtz Institut Mainz

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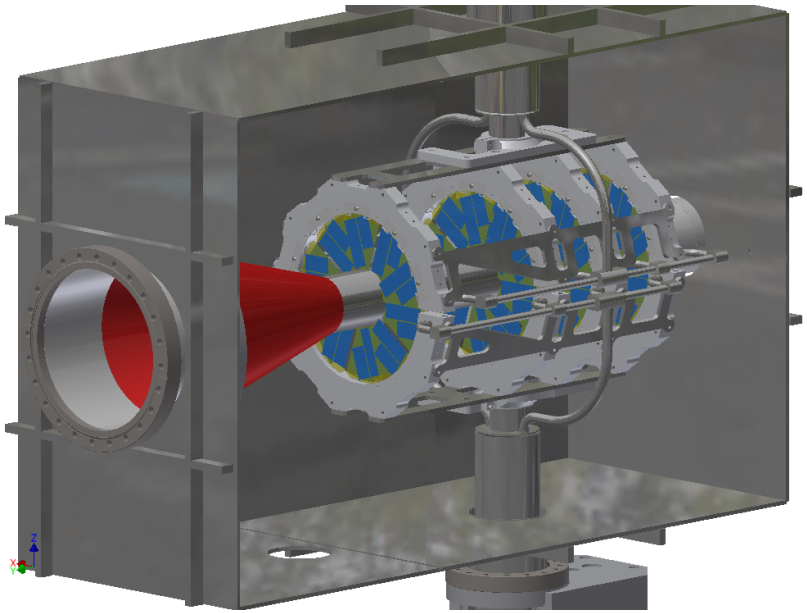
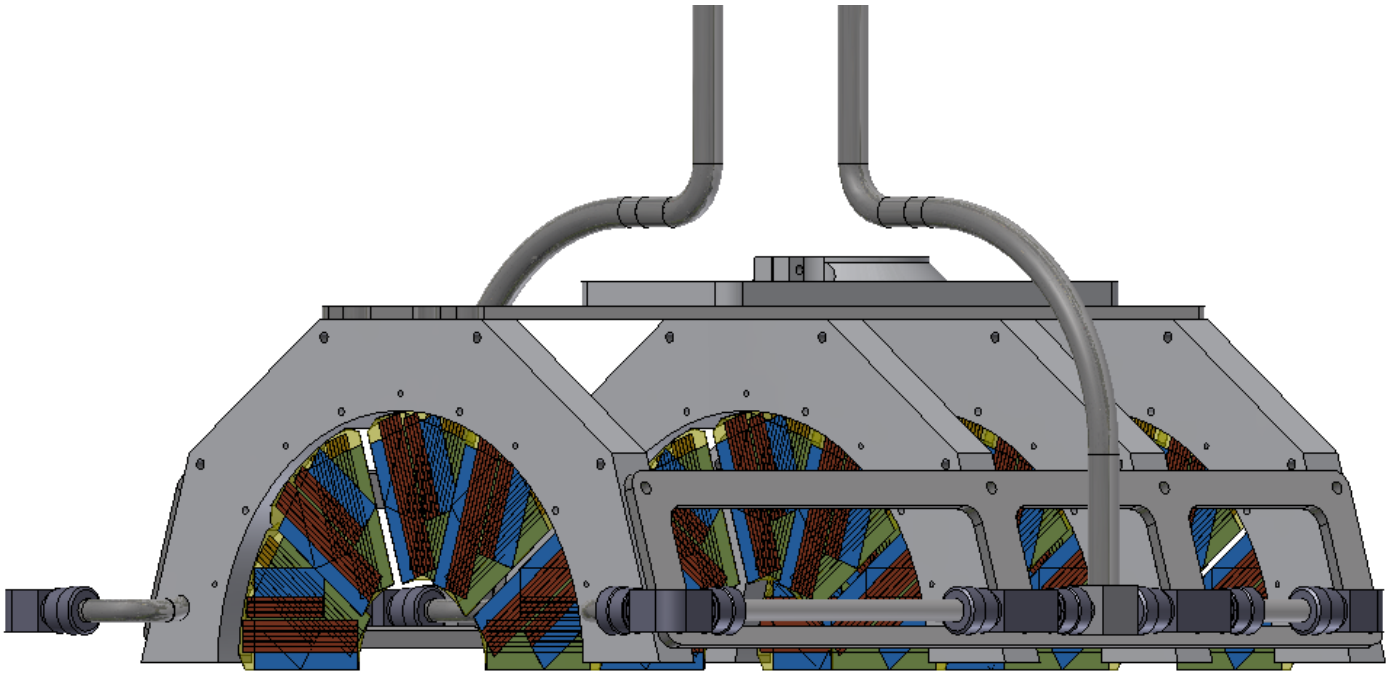
Overview



- Cooling of the luminosity detector
- Production of the cooling structure
- Comparison of heat distribution measurements to FEM simulations

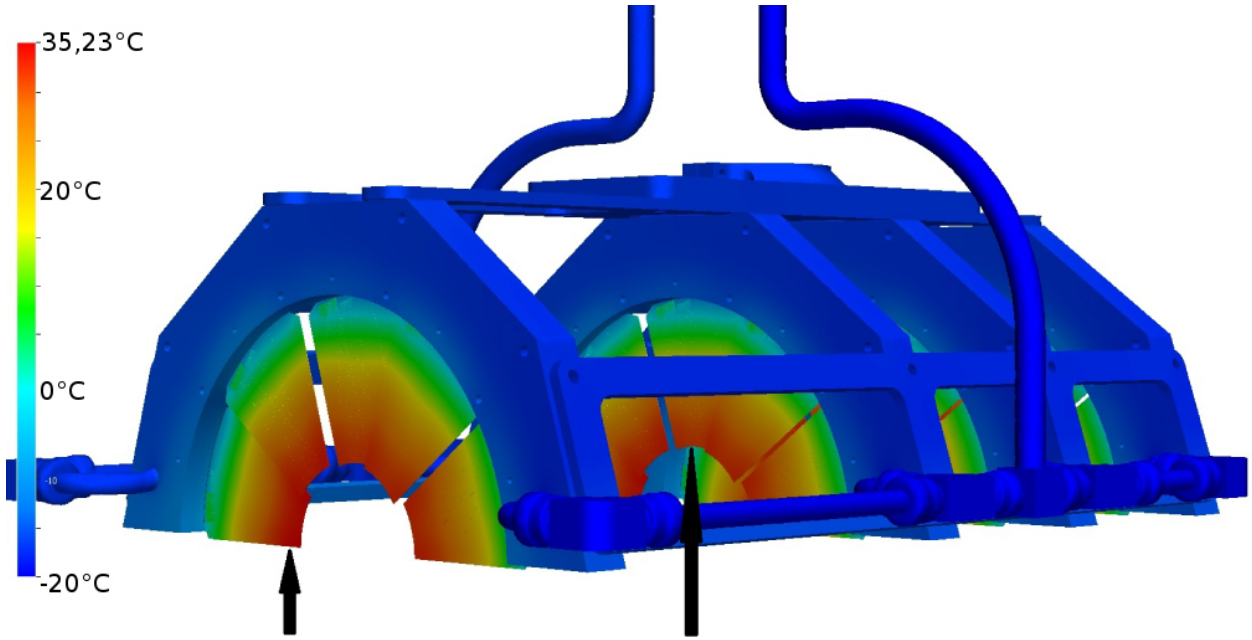
General setup



sensors	LDO Voltage regulator	resistance in flexcables	Multiplexer etc.
1120 W	320W	160W	∼100W

Total estimated heat load per half detector: ∼1 kW

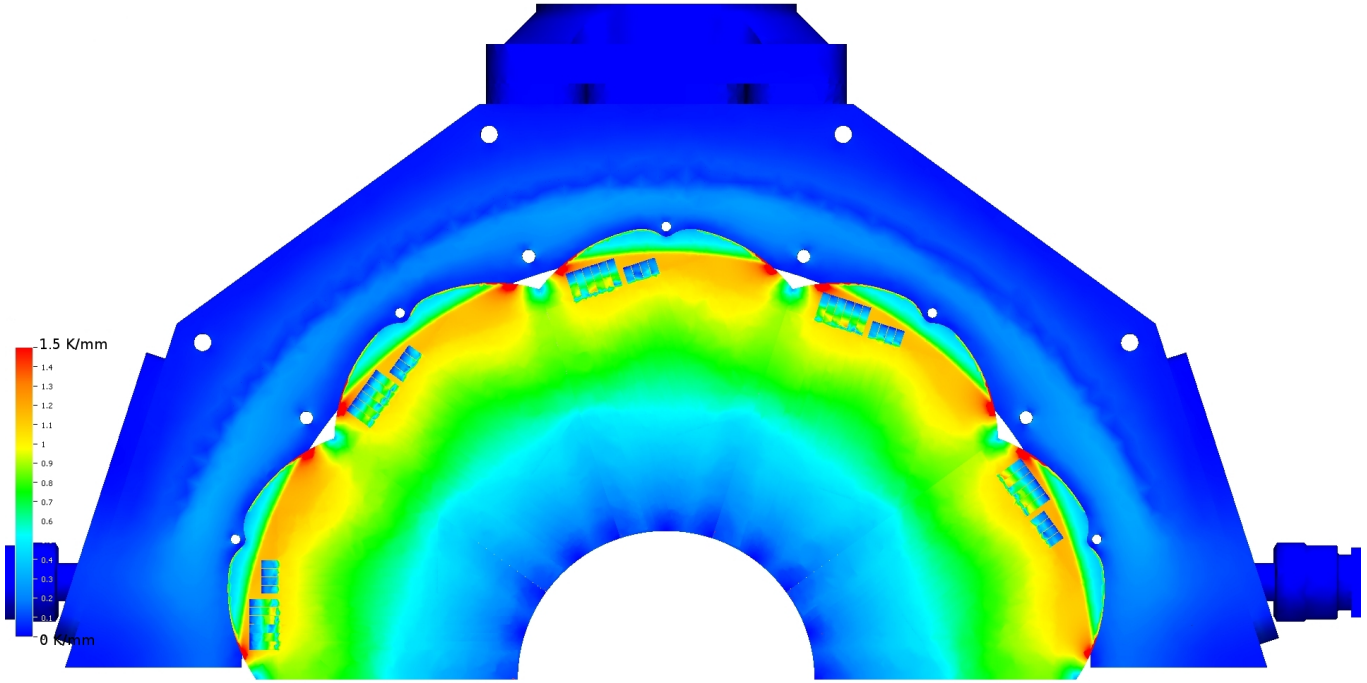
Temperature distribution



	warmest diamond	coldest diamond
$\frac{T_{min}}{^\circ C}$	-11.27	-13.89
$\frac{T_{max}}{^\circ C}$	35.23	32.03

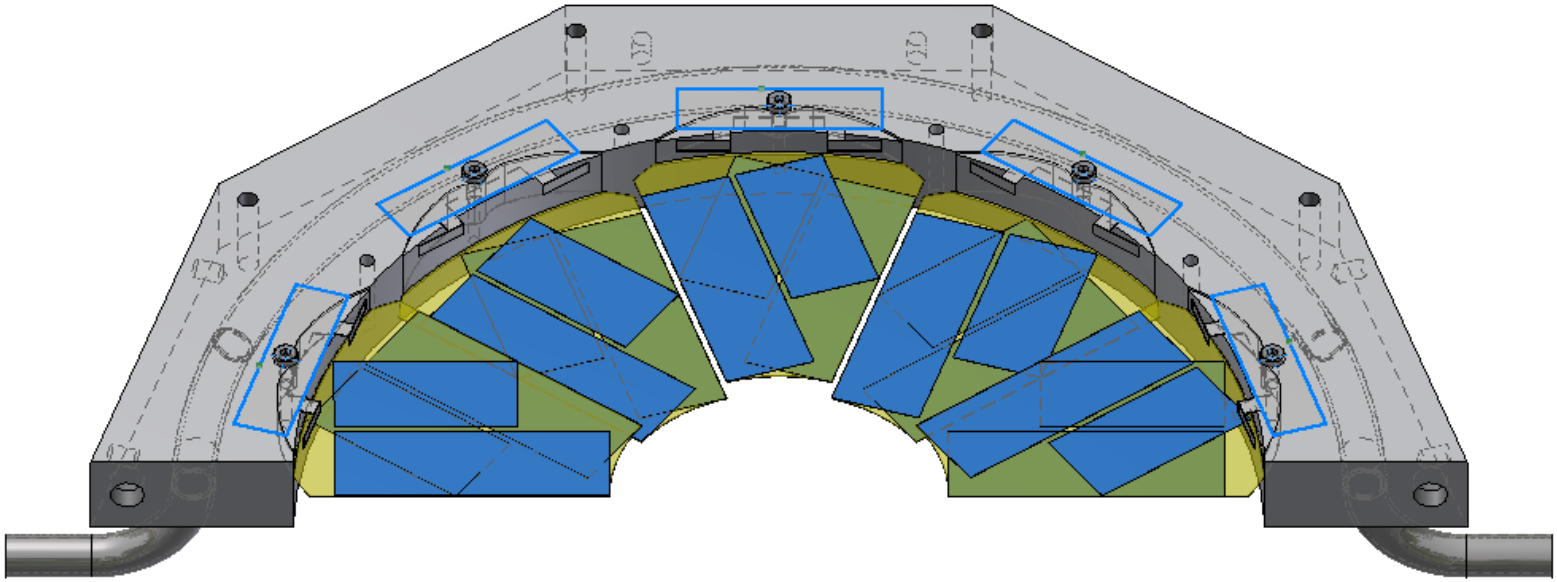
Temperature along tracks parallel to beam varies $\sim$1°C
FEM-simulation done with Autodesk Simulation CFD 2013

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 $> 1\ \frac{K}{mm}$

Cooling support with sensors



Requirement: Good thermal conducting contact between cooling pipe and aluminum

$\rightarrow$ Embedding the pipe in molten aluminum

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

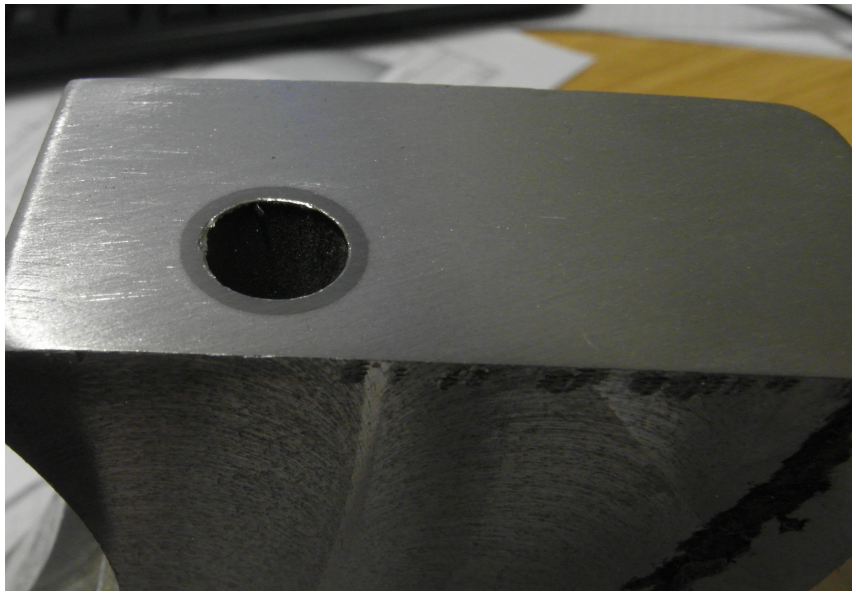
Casting mould after first melting process

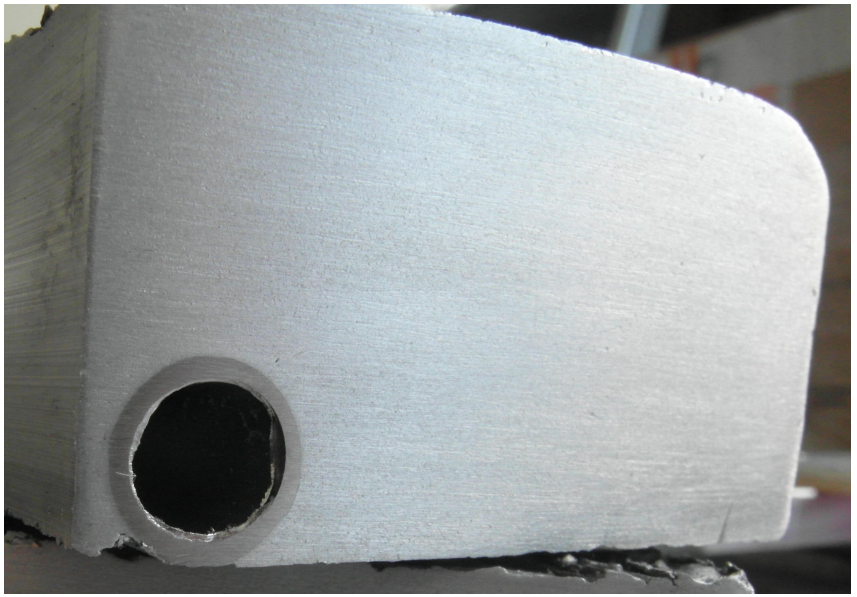
- First test done under vacuum
- good results, but the vacuum furnace gets really dirty

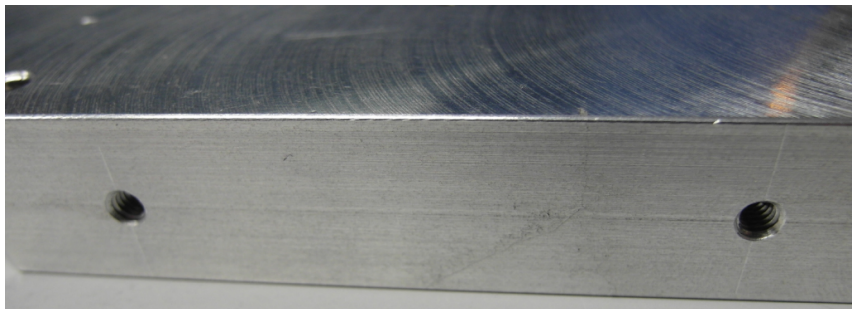
Comparison of processes and materials

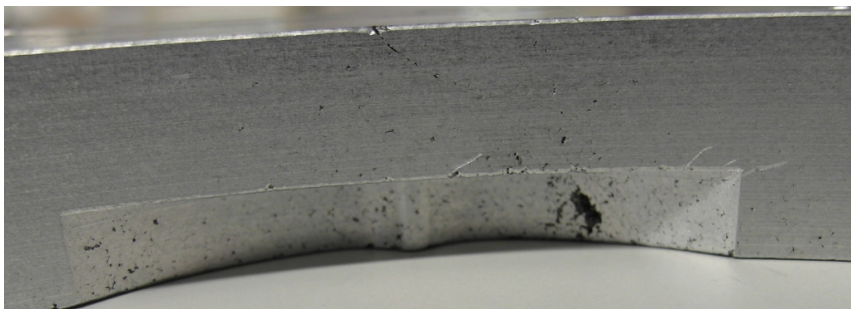
material	T	t	condition	machining and result
AlMg4.5Mn	750°C	60min	vacuum argon	Cutting: few bubbles, mostly near surface; good contact aluminum-steel
Al99.5	730°C	90min	argon argon	Cutting: almost no bubbles at all, good contact aluminum-steel
AlMg4.5Mn	730°C	90min	argon argon	CNC machining: few bubbles
AlCuMgPb	730°C	90min	argon argon	CNC machining: many bubbles, not really usable

Comparison of materials and processes



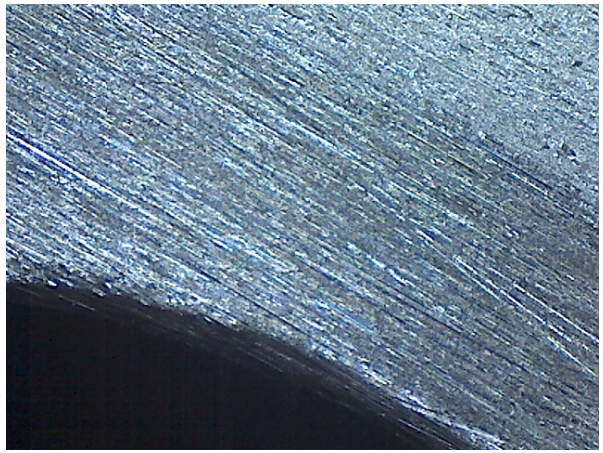




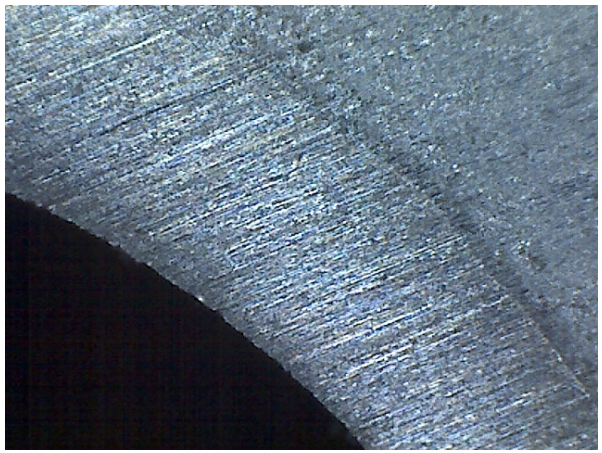
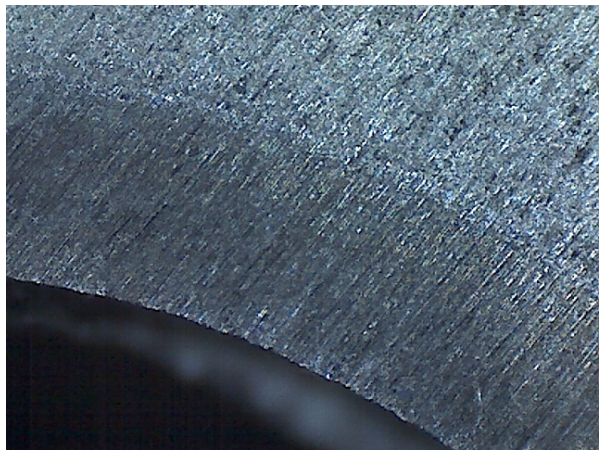


Aluminum steel contact after cooling

after cutting:

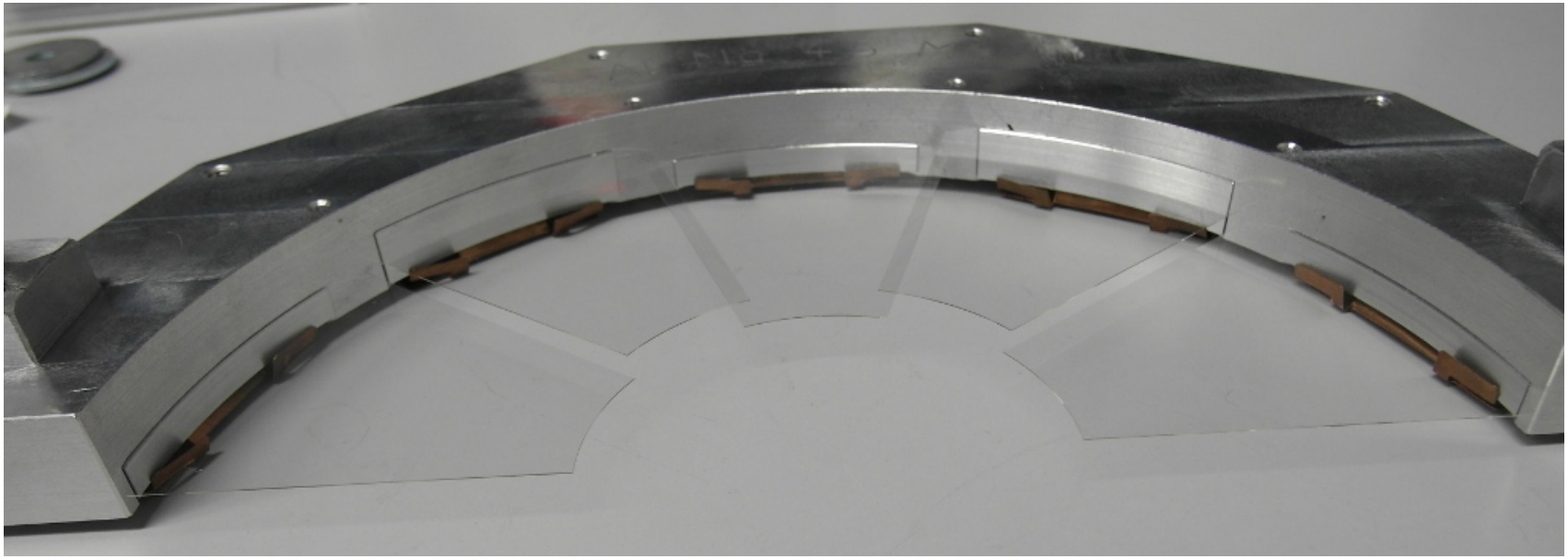



after cooling to -40°C:

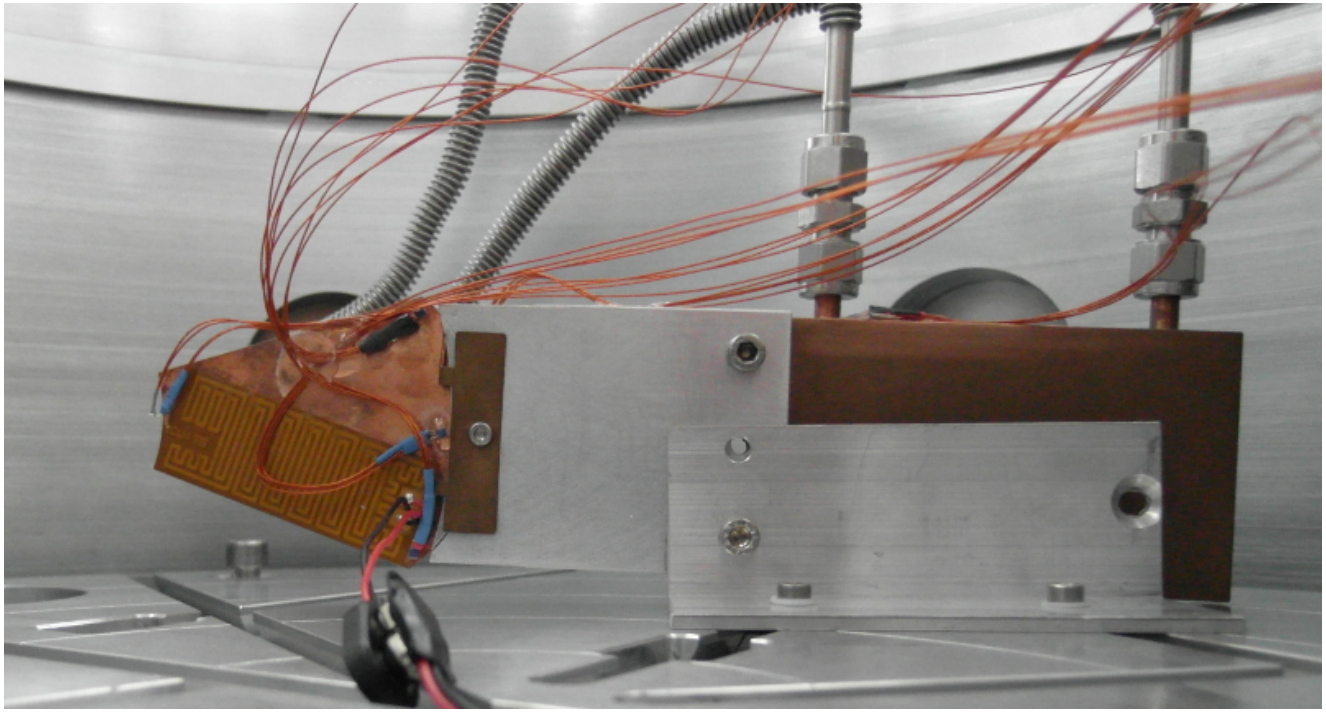
No gap between the materials, very good contact

Next steps



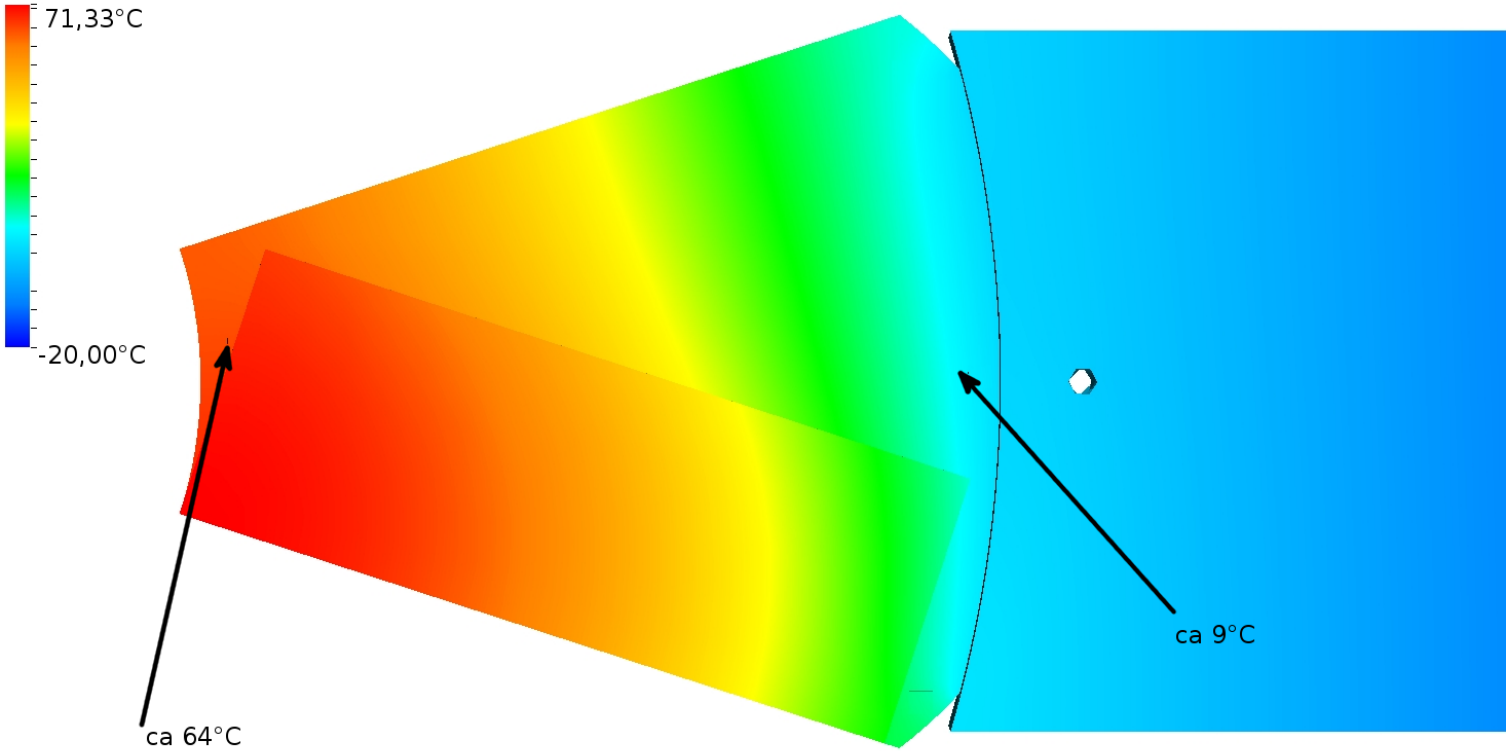
- Slight adjustment of process needed
- Production of halfplanes planned in Jülich

Test of the aluminum-diamond contact



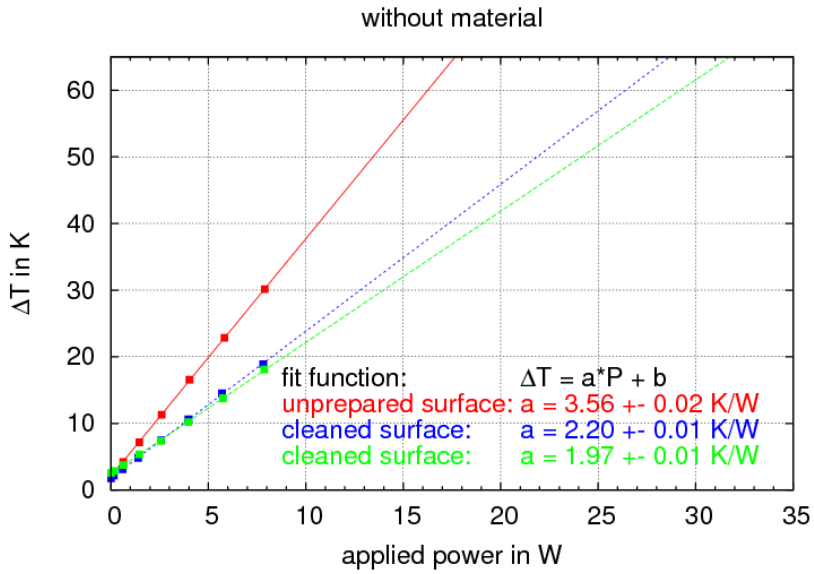
- Setup with copper dummy
- Comparison of FEM results with measurements
- Test and comparison of several contact materials

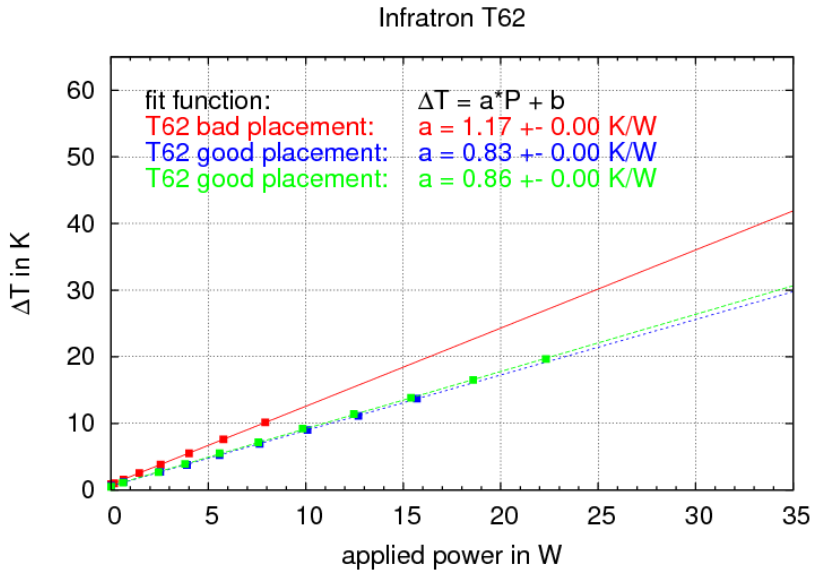
FEM-simulation and measurement

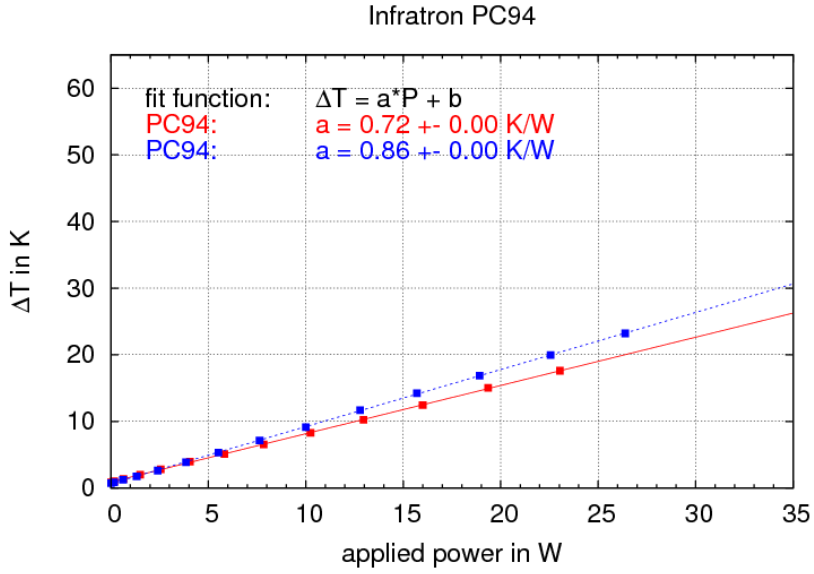


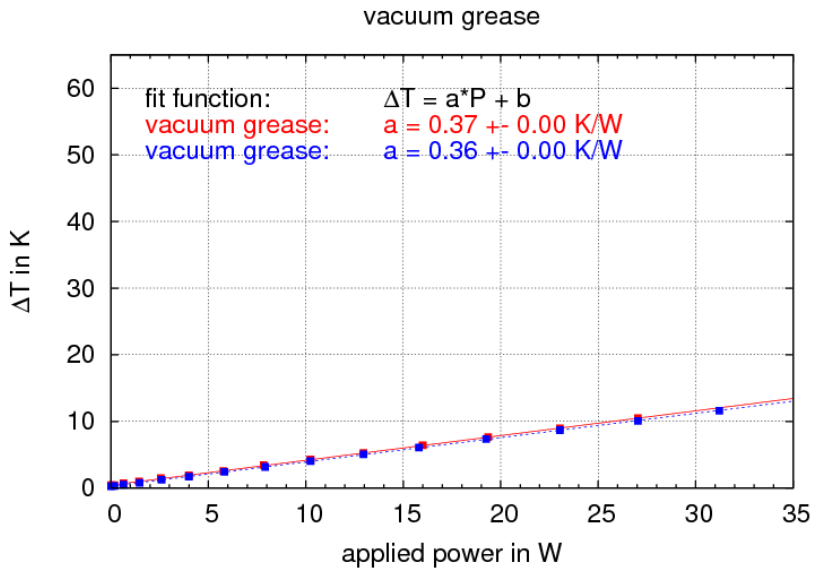
- Simulated temperature difference $\sim 55°C$
- Measured temperature difference (two Pt100): $50°C$
- High radial temperature gradient (up to $2\frac{K}{mm}$)

Contact materials

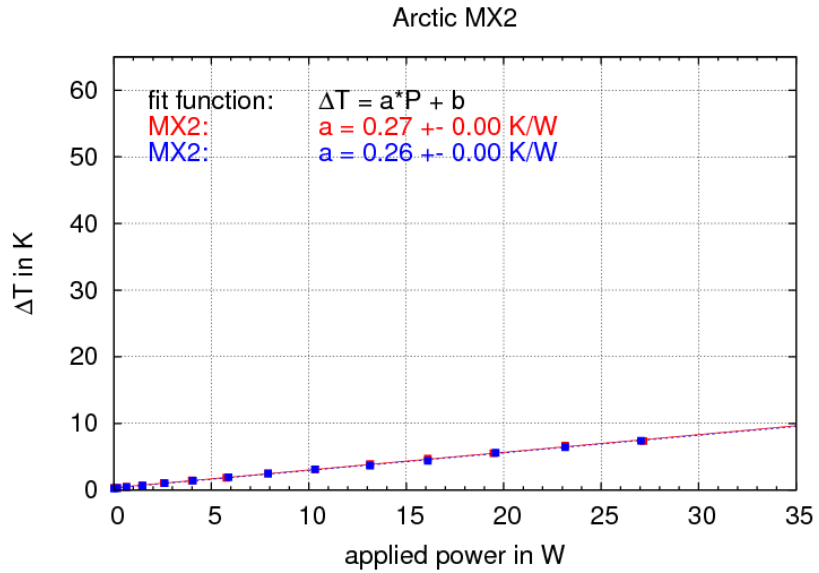








Contact materials 2



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

Summary and outlook

- Simulations of thermal behaviour promising
- Material transition effects solvable
- Cooling pipe – aluminum melting process working, production possible

What is next:

- Thermal behaviour of the diamond wafer
- Testing of one halfplane with full worst case heat load
- Gluing HV-MAPS on diamond