Update on cooling and mechanics of the luminosity detector

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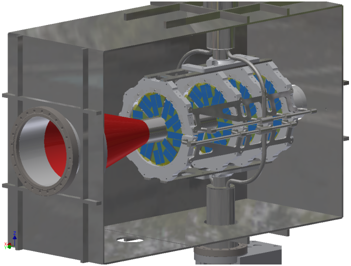
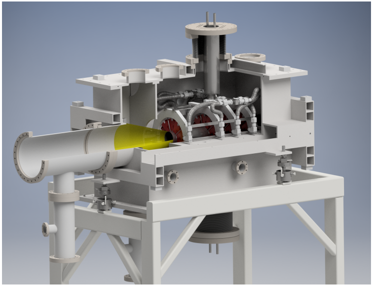
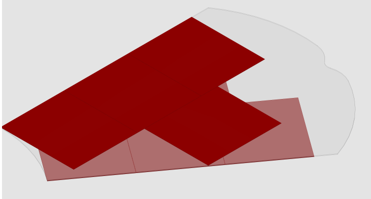
Overview

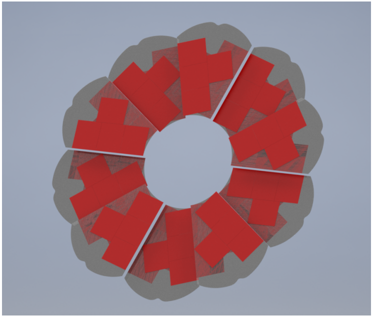




- 4 layers of active pixel sensors in vacuum
- cooling system of the luminosity detector
- mechanical structure

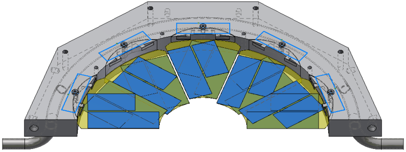
Modules

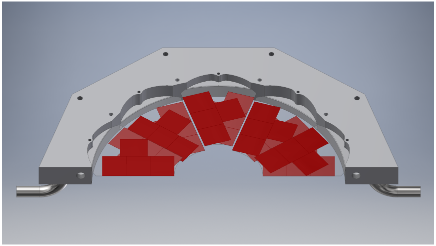




- Changes: Sensors are bigger ($20mm \times 23mm$ instead of $20mm \times 20mm$)
  $\longrightarrow$ only 8 sensors per diamond
- sensors glued to diamond wafer
- shown sensor positions worst case for cooling

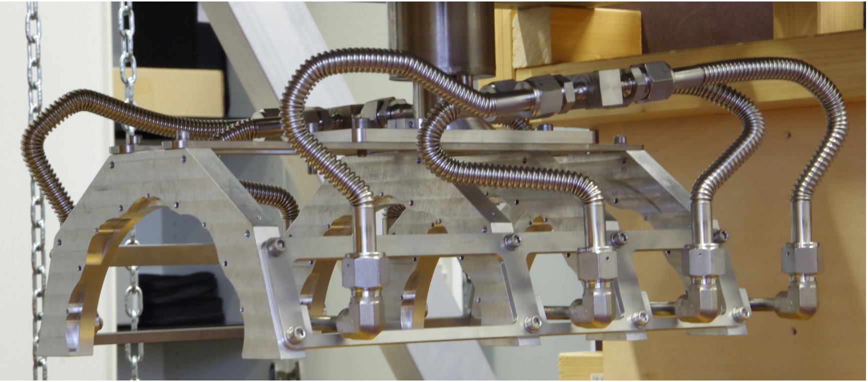
Cooling support with sensors





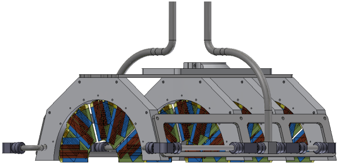
- diamond wafers clamped in cooling structure
- requirement: Good thermal conducting contact between cooling pipe and aluminum
  $\rightarrow$ Embedding the pipe in molten aluminum

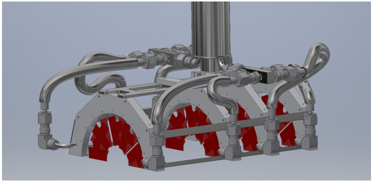
Half detector prototype



- production of halfplanes is finished
- First full half detector under preparation for testing

Cooling system: General setup

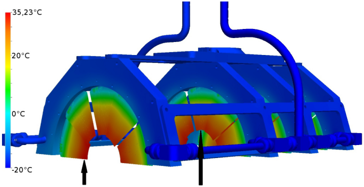


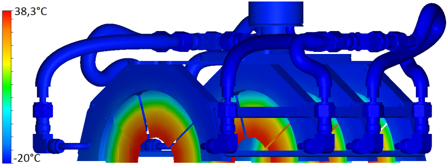


	sensors	LDO Voltage regulator	resistance in flexcables	Multiplexer etc.
worst case	1120 W	320W	160W	∼100W
likely case	370 W	110W	20W	∼100W

Total estimated heat load per half detector: ~~∼1 kW~~ ∼350 W
No huge changes between old and new design

Temperature distribution

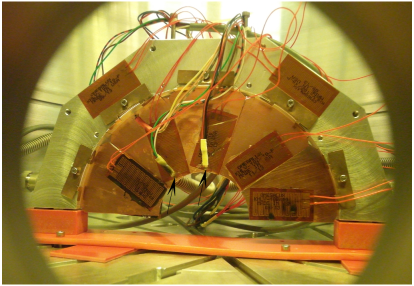


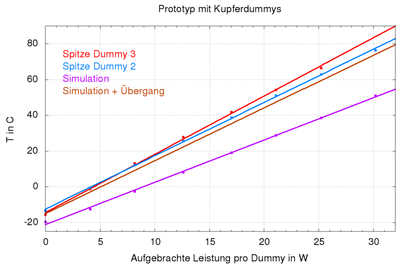


- heatload per diamond almost identical
- distribution very similar
- new design calculated for worst case sensor placement
- does not include transition effects from diamond to aluminium

Temperature along tracks parallel to beam varies $\sim 1^{\circ}$C
FEM-simulation done with Autodesk Simulation CFD 2013 and CFD 2017

Temperature measurements

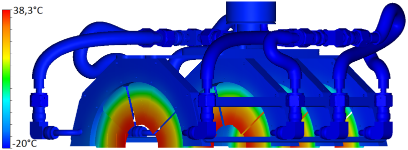




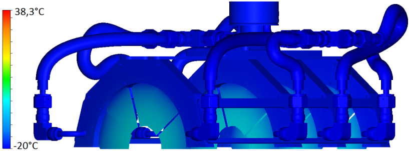
- measurement with half plane prototype
- measurement of transition effect on single module prototype
- good agreement between simulation and measurements

Temperature distribution 2

worst case:



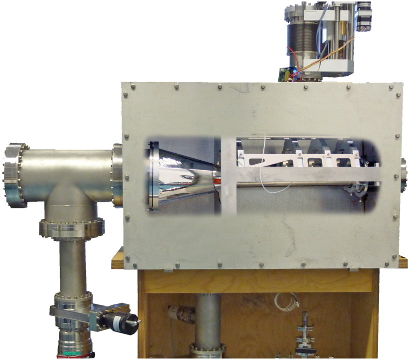
expected case:

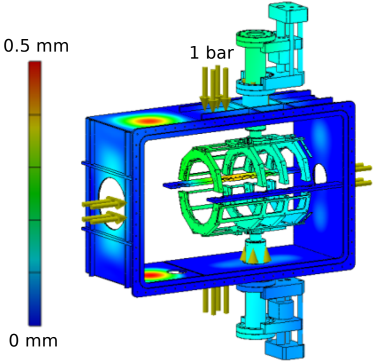


- expected case much colder
- adding expected transition effect gives $T_{max} \sim 50^\circ$C and $T_{max} \sim 5^\circ$C
- lower temperature possible if needed

FEM-simulation done with Autodesk Simulation CFD 2017

Mechanical setup old

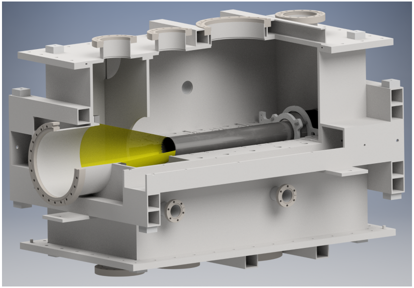




Old vacuum box with several problems:

- not stiff enough (displacement $\sim$ 1 mm by vacuum)
- inside too small (detector bigger than expected)
- mounting & connecting the detector in the box tricky (no space)

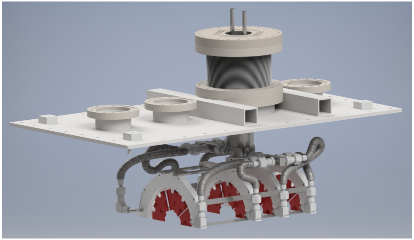
Mechanical setup new

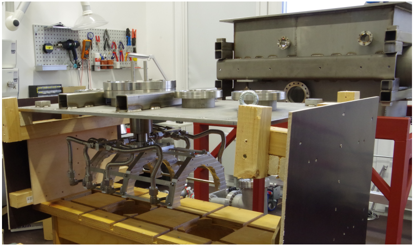


New design adresses these problems:

- much stiffer (displacement <0.2 mm by vacuum)
- more space inside
- symmetric design

Mechanical setup new





- mounting & connecting happens outside of box
  $\longrightarrow$ easier access to cables & connectors
- drawback: positioning relative to the box more challenging
- precise measurements needed

Summary and outlook

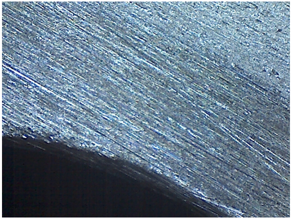
- production of half planes finished
- half plane prototype successfully tested
- new design vacuum box produced

What is next:

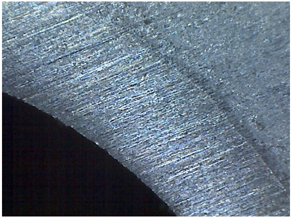
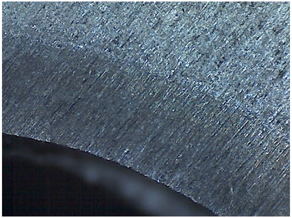
- extended test of new vacuum box
- test of half detector prototype
- cooling test starting in the next weeks
- production of final detector

Aluminum steel contact after cooling

after cutting:

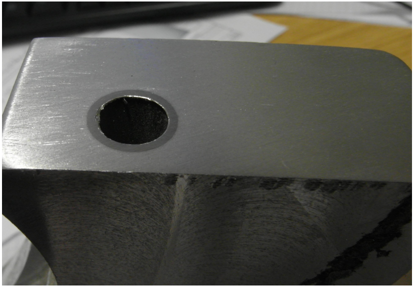
 

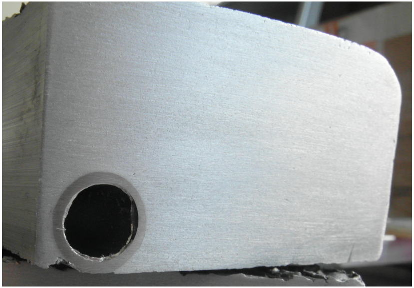
after cooling to -40°C:

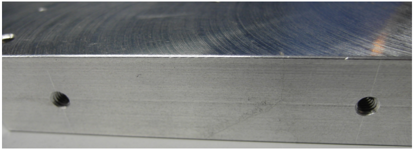
 

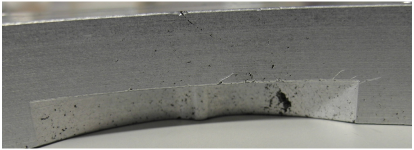
No gap between the materials, very good contact

Comparison of materials and processes

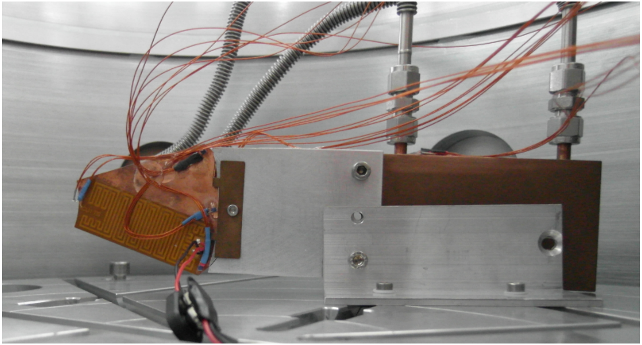






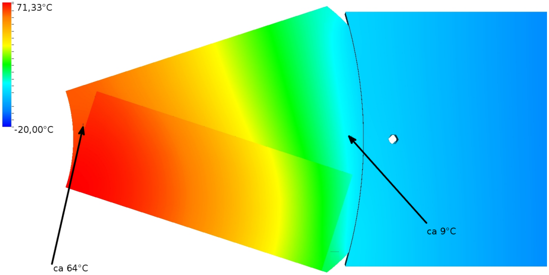


Test of the aluminum-diamond contact



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

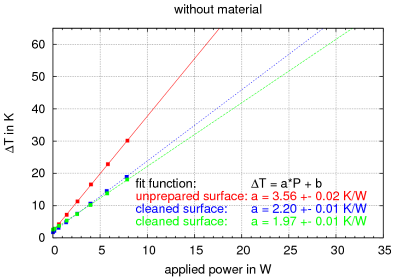
FEM-simulation and measurement

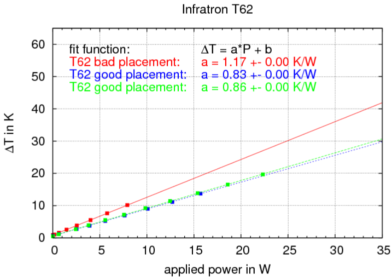


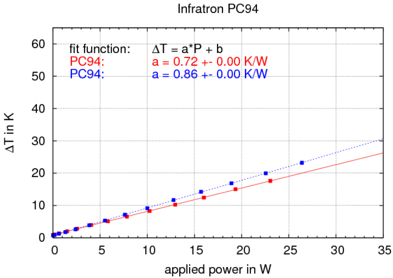
- Simulated temperature difference $\sim 55^{\circ}C$
- Measured temperature difference (two Pt100): $50^{\circ}C$
- High radial temperature gradient (up to $2\frac{K}{mm}$)

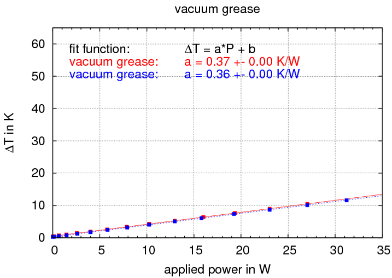
kein Material	Graphitfolie	PC93
$\sim 2,2\frac{^{\circ}C}{W}$	$\sim 0,88\frac{^{\circ}C}{W}$	$\sim 0,72\frac{^{\circ}C}{W}$

Contact materials

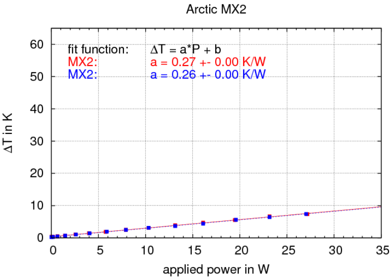








Contact materials 2

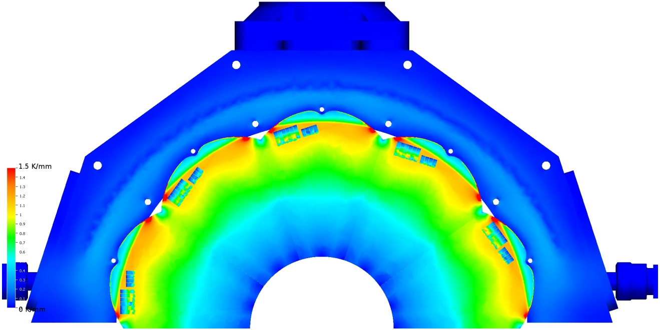


Upper limit for the material transition temperature rise:

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