Thermal Studies in Karlsruhe

Belle II PXD/DEPFET Meeting

Prague, 26th - 27th January 2010

Th. Weiler, O. Brovchenko, S. Heindl, H. J. Simonis

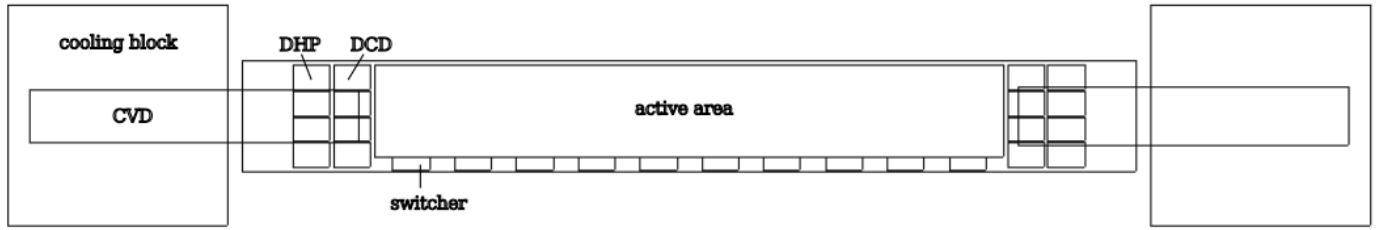
Institut für Experimentelle Kernphysik,

Karlsruher Institut für Technologie

Outline

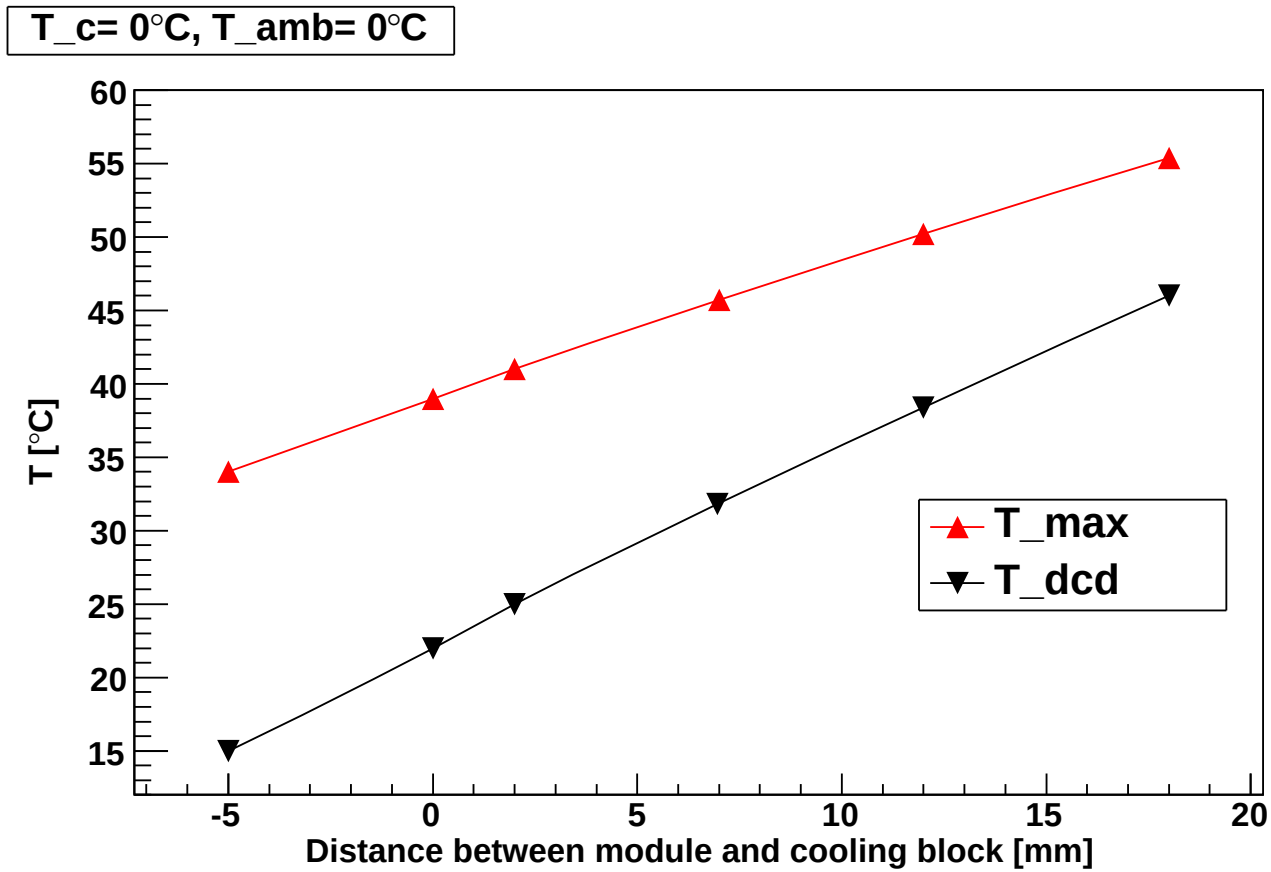
- Thermal simulations on a DEPFET module
  - dependence on heat-spreader length
  - dependence on cooling temperature
  - dependence on ambient temperature
- Measurements on a DEPFET module dummy
  - dependence on heat-spreader length
  - dependence on cooling temperature
  - dependence on ambient temperature
- Comparison: Simulation and Measurement
- Measurements on first support ring dummy

DEPFET Module



- DEPFET module $15\,\text{mm} \times 122.6\,\text{mm} \times 0.45\,\text{mm}$, active area not thinned for comparison with dummy module.
- CVD heat spreader $7\,\text{mm} \times 50\,\text{mm} \times 0.45\,\text{mm}$ (left side) and $8\,\text{mm} \times 50\,\text{mm} \times 0.45\,\text{mm}$ (right side).
- Power dissipation: $1.6\,\text{W}$ per DCD, $0.5\,\text{W}$ per DHP, $1\,\text{W}$ for all switcher chips and $1\,\text{W}$ at the active area, $18\,\text{W}$ in total.

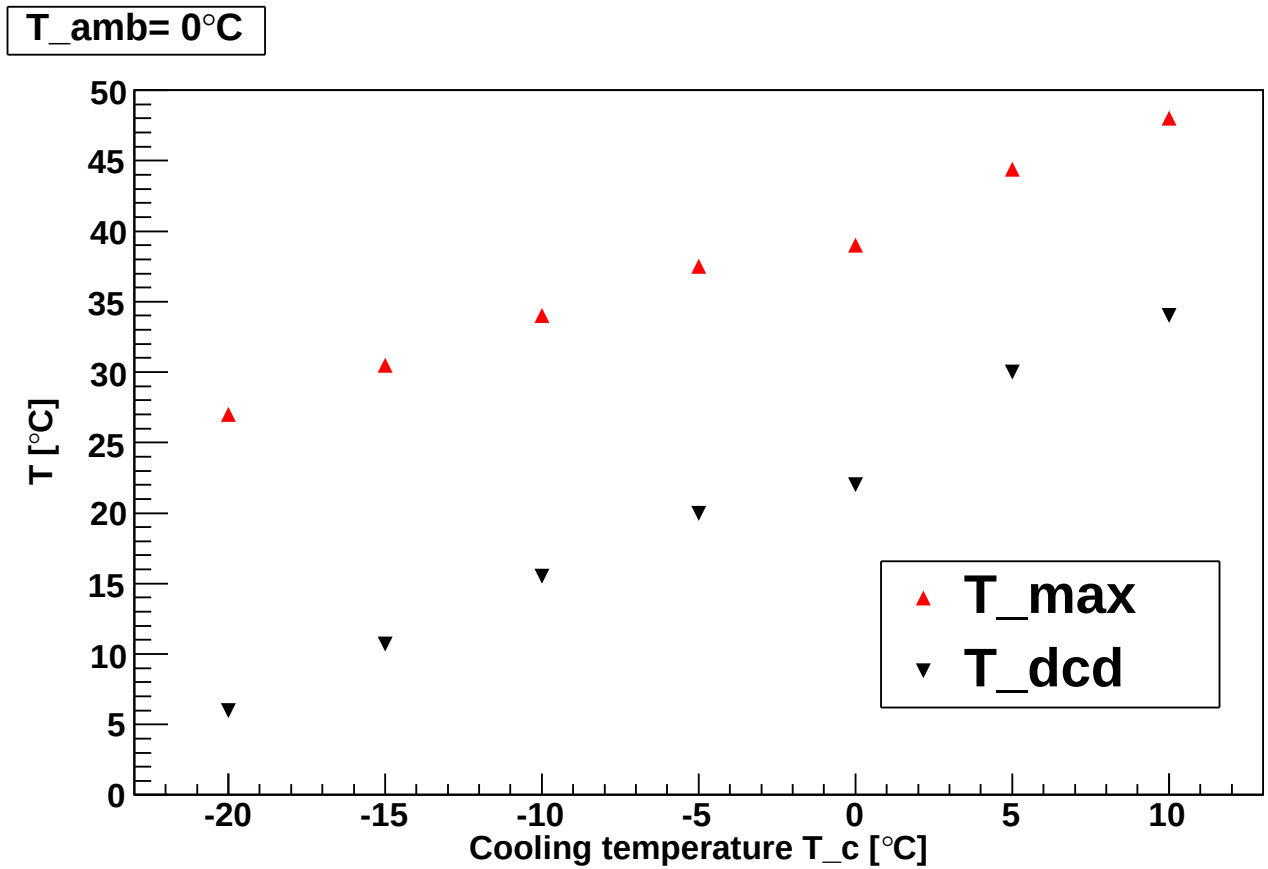
Simulation: Distance to Cooling Block



$\Rightarrow$ Temperature reduces with distance by $1.3\,°\mathrm{C}/\,\mathrm{mm}$ at DCD location and $0.95\,°\mathrm{C}/\,\mathrm{mm}$ in the middle of the module.

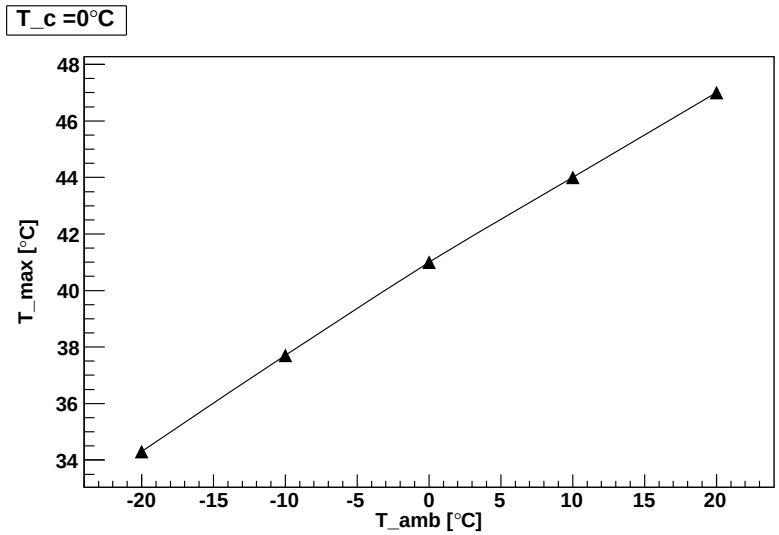
(remark: neg. distance -> cooling block overlaps silicon)

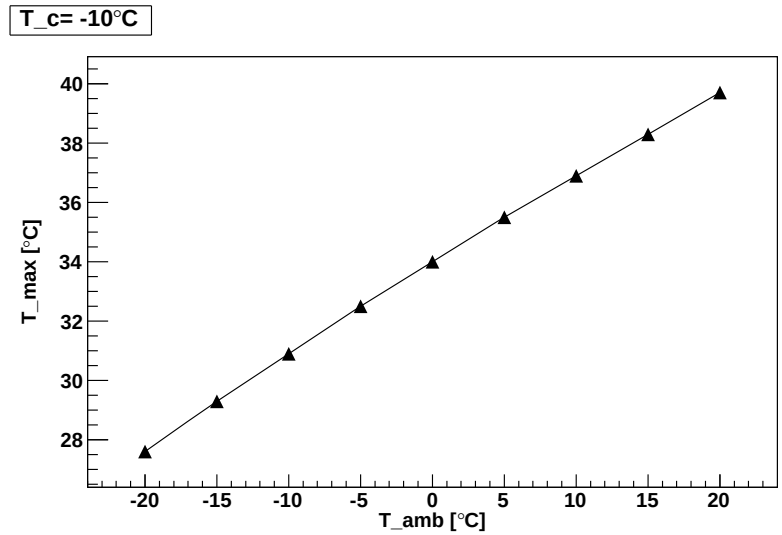
Simulation: Cooling Temperature



$\Rightarrow$ a $1\,°$C change in the cooling temperature changes module temperature by $0.91\,°$C at the DCD location and $0.68\,°$C at the middle of the module.

Simulation: Ambient Temperature

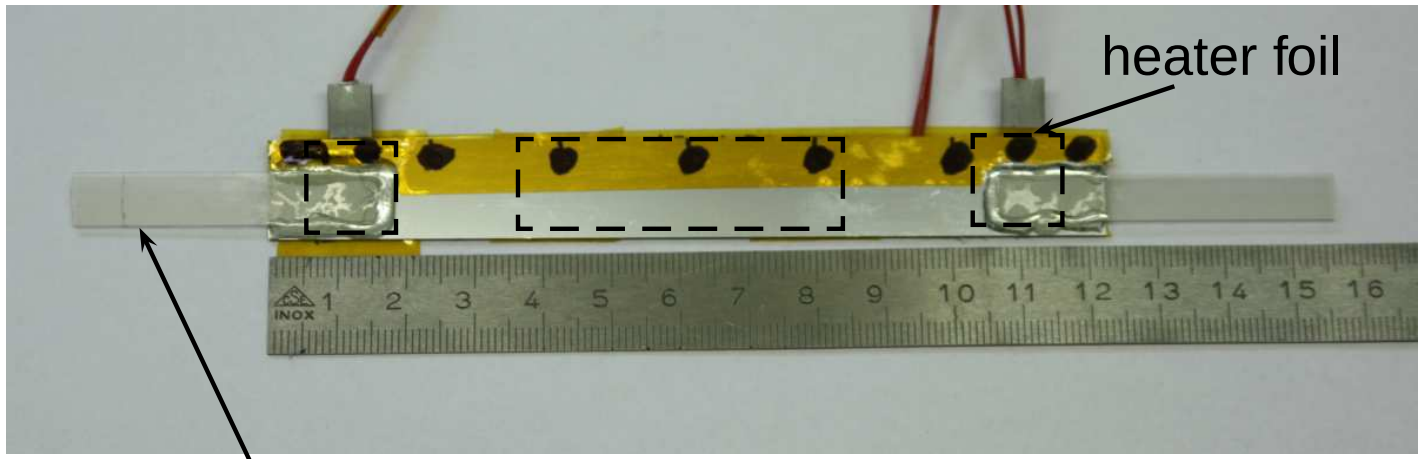




Further reduction on module temperature by reducing the ambient temperature $\Rightarrow 1\,°$C lower ambient temperature results in $0.3\,°$C lower module temperature.

Measurement Setup

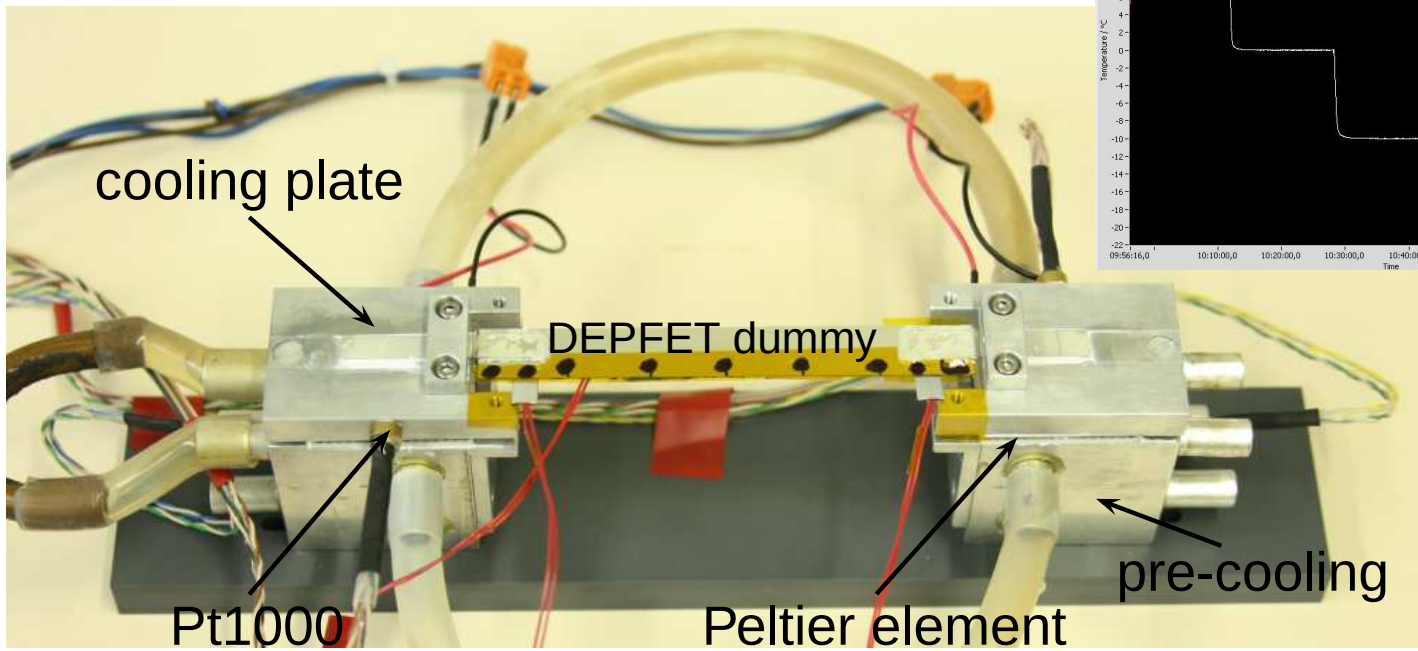
DEPFET dummy module:

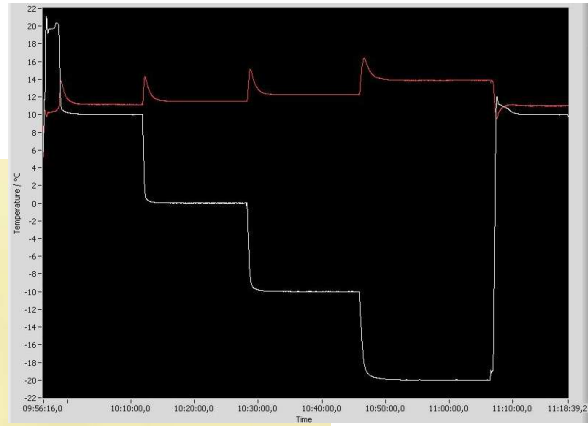


- Silicon dummy $15\,\text{mm} \times 122.6\,\text{mm} \times 0.45\,\text{mm}$
- Heater foils $12.7\,\text{mm} \times 12.7\,\text{mm}$ at DCD/DHP location and $12.7\,\text{mm} \times 50.8\,\text{mm}$ for switcher and active area.
- CVD heat-spreader $7\,\text{mm} \times 50\,\text{mm} \times 0.45\,\text{mm}$ (left side) and $8\,\text{mm} \times 50\,\text{mm} \times 0.45\,\text{mm}$ (right side)

Cooling Setup

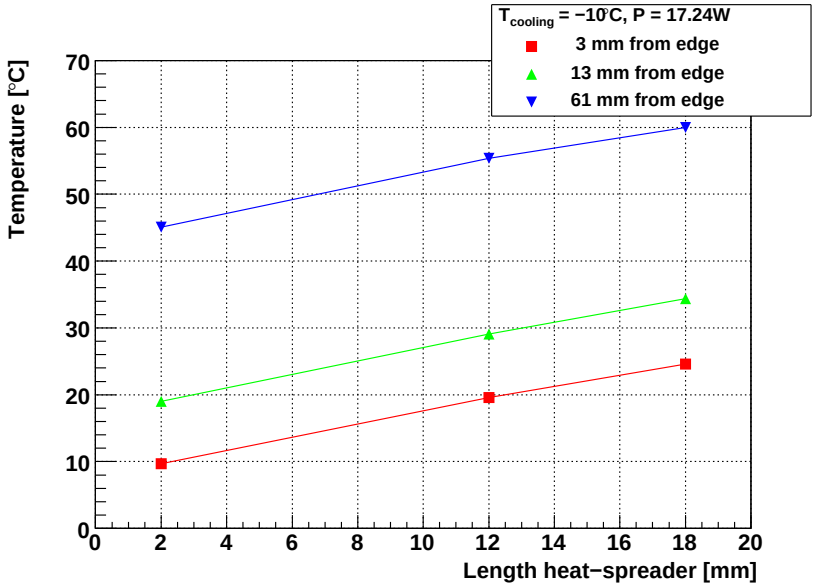
DEPFET dummy cooling setup:

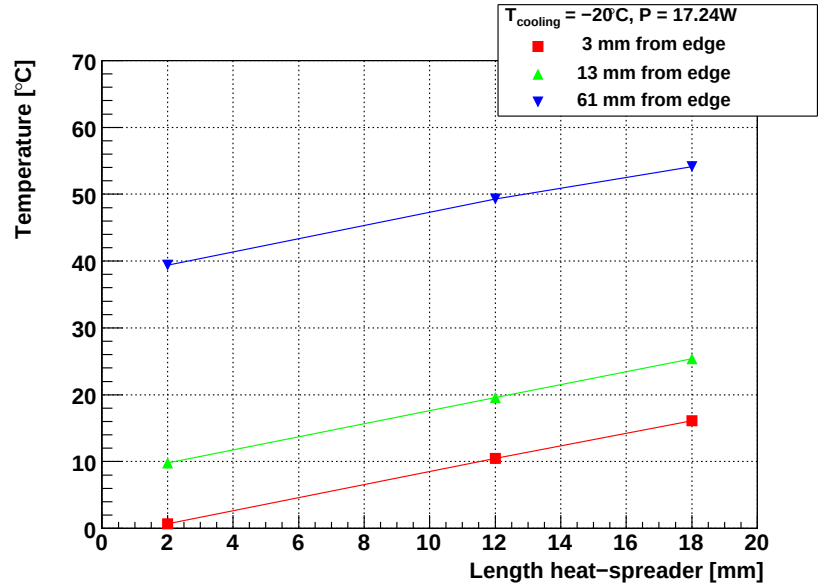




- Computer controlled setup with water/Antifrogen pre-cooling and Peltier elements below cooling plate, housed in Plexiglas box.
- Temperature measurement with PT1000 at cooling towers and infrared sensor across the DEPFET dummy (on opposite site of heater foils).

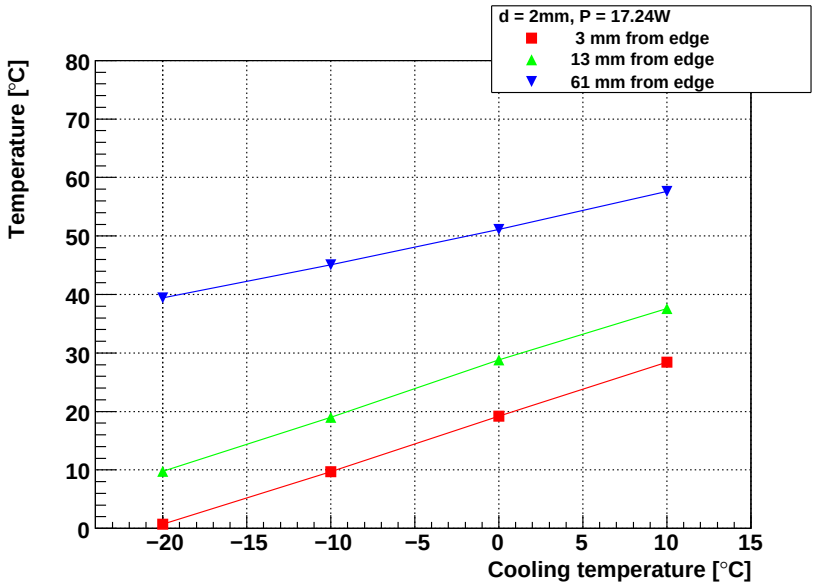
Distance to Cooling Block

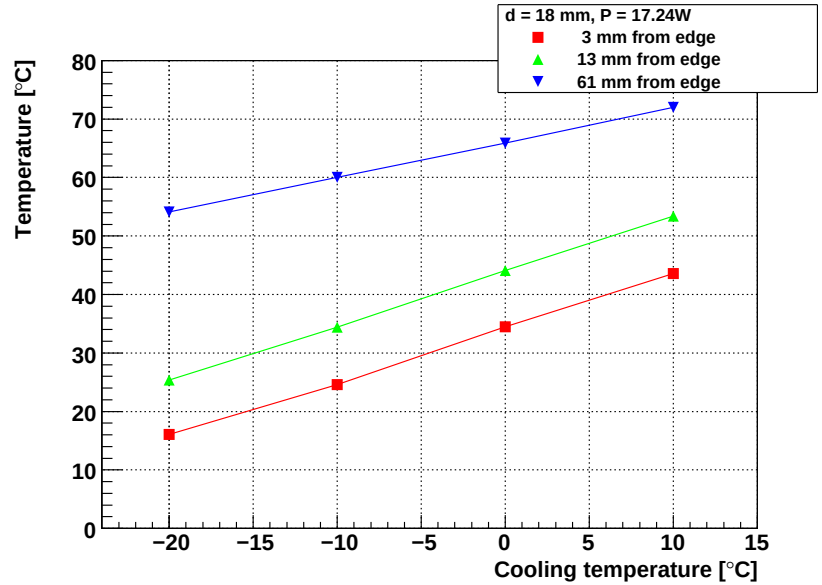




Reducing the distance between module and cooling block improves the module cooling by $0.95\,°\mathrm{C}/\,\mathrm{mm}$ at the location of the DCD and $0.92\,°\mathrm{C}/\,\mathrm{mm}$ in the middle of the module. (Simulation results: $1.3\,°\mathrm{C}$ and $0.95\,°\mathrm{C}$)

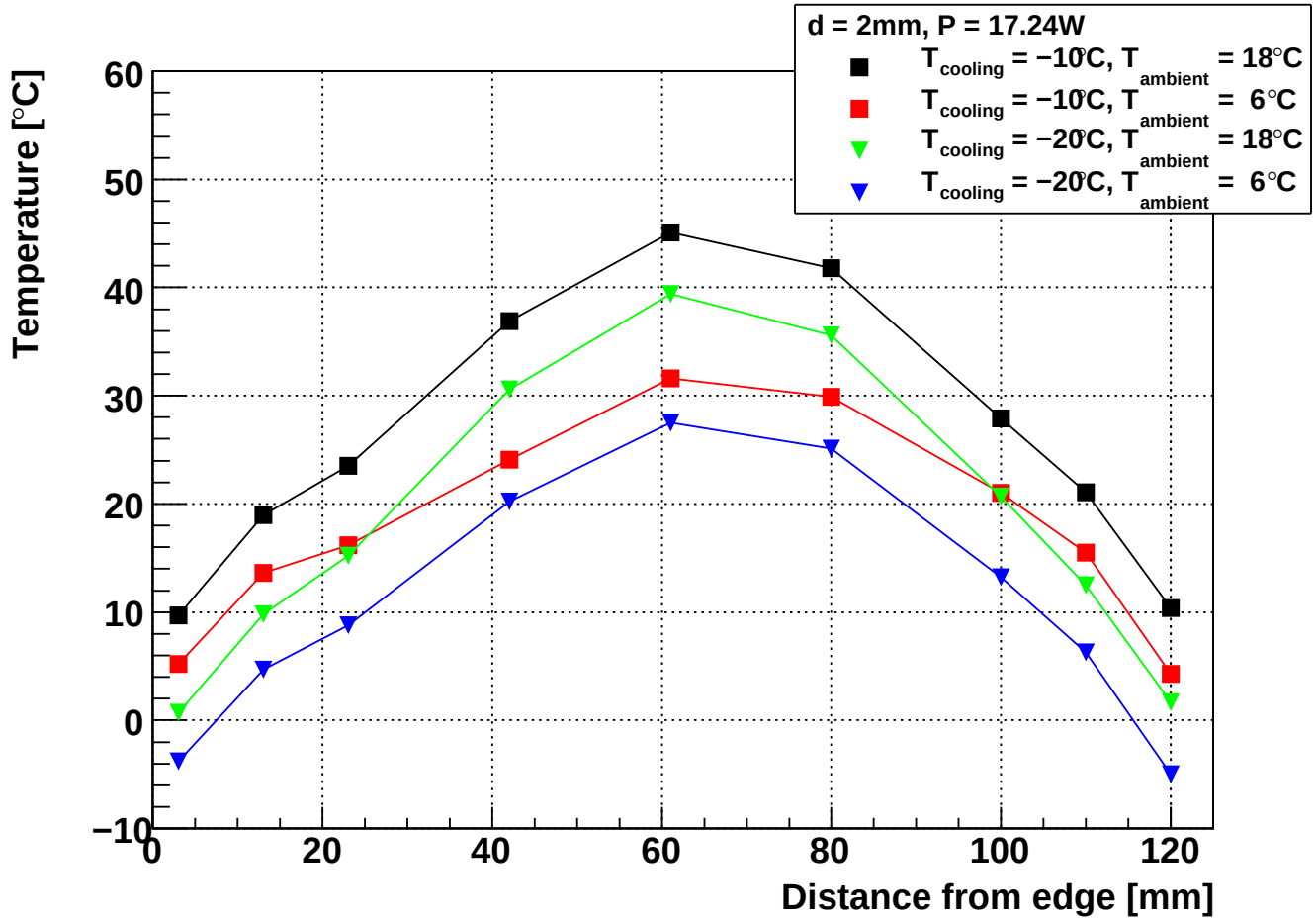
Cooling Temperature





Decreasing the cooling temperature by $1\,°$C reduces the temperature at the location of the DCD by $0.9\,°$C and in the middle of the module by $0.6\,°$C.
(Simulation results: $0.91\,°$C and $0.68\,°$C)

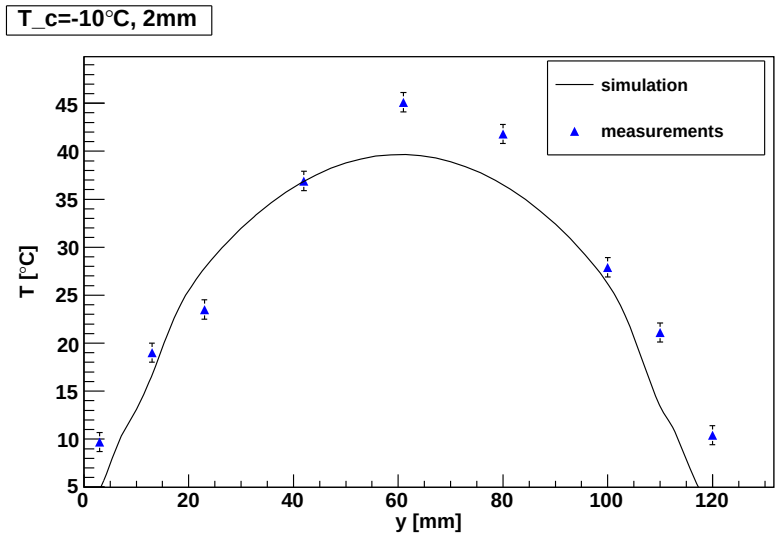
“Ambient” Temperature

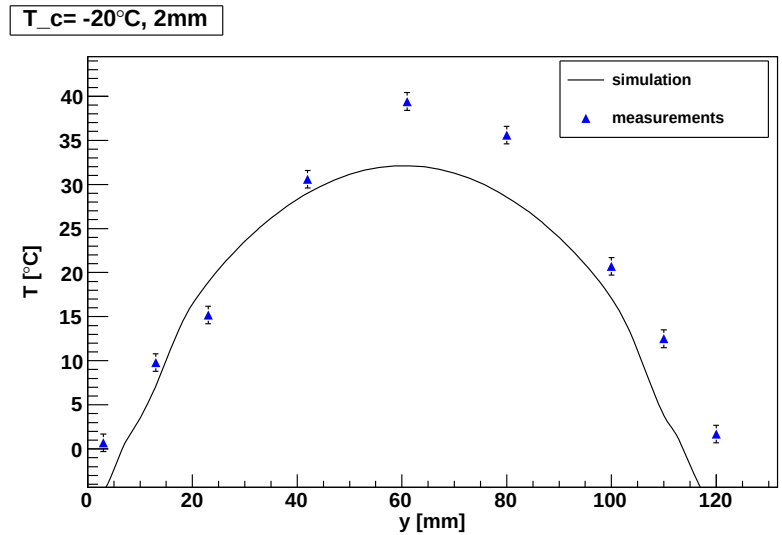


Setup flushed with pre-cooled air: $\Delta T_{DEPFET} \approx \Delta T_{ambient}$

(remark: forced convection could not be avoided with this setup)

Comparison

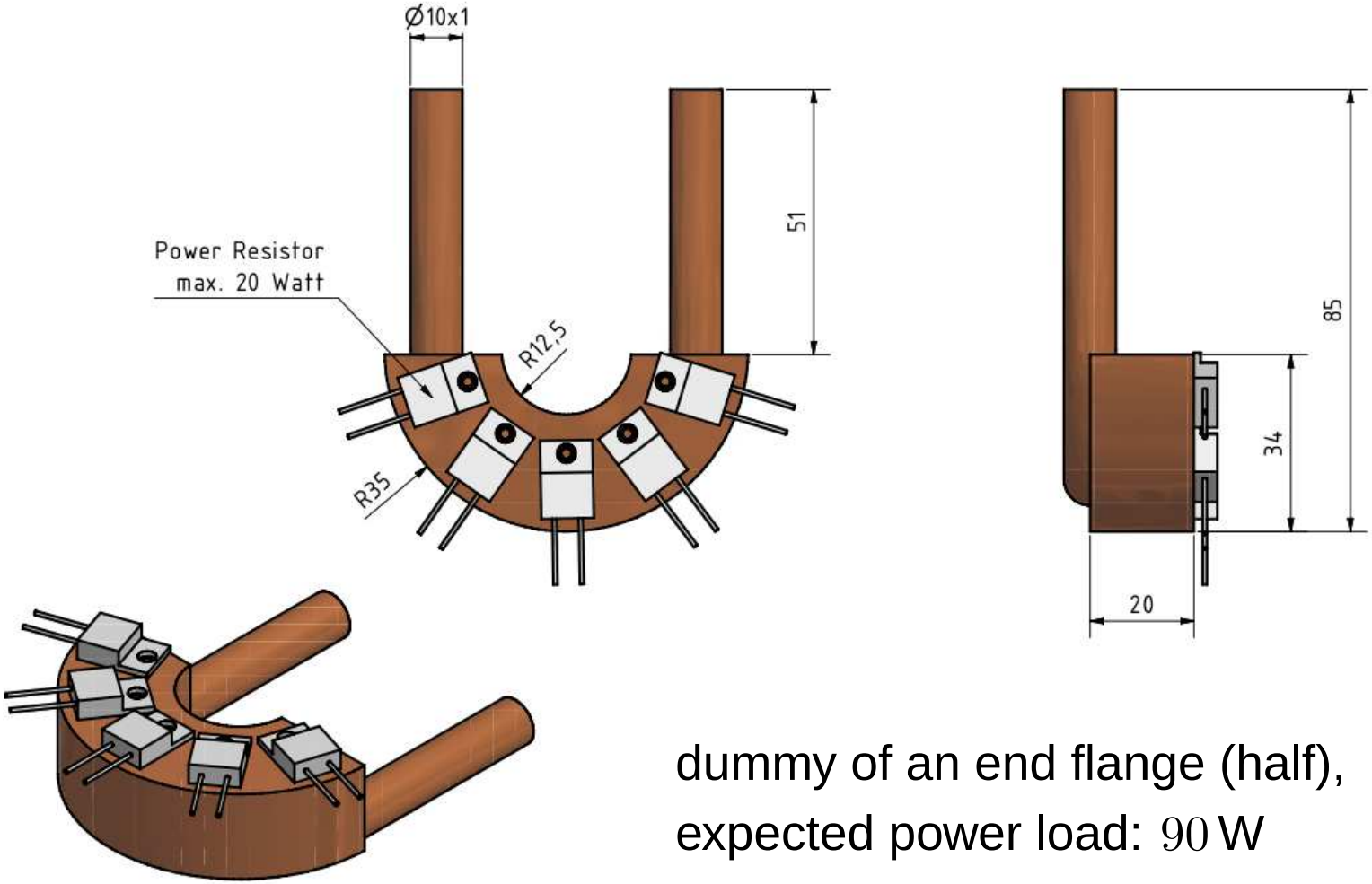




The comparison of simulation and measurement results shows good agreement.

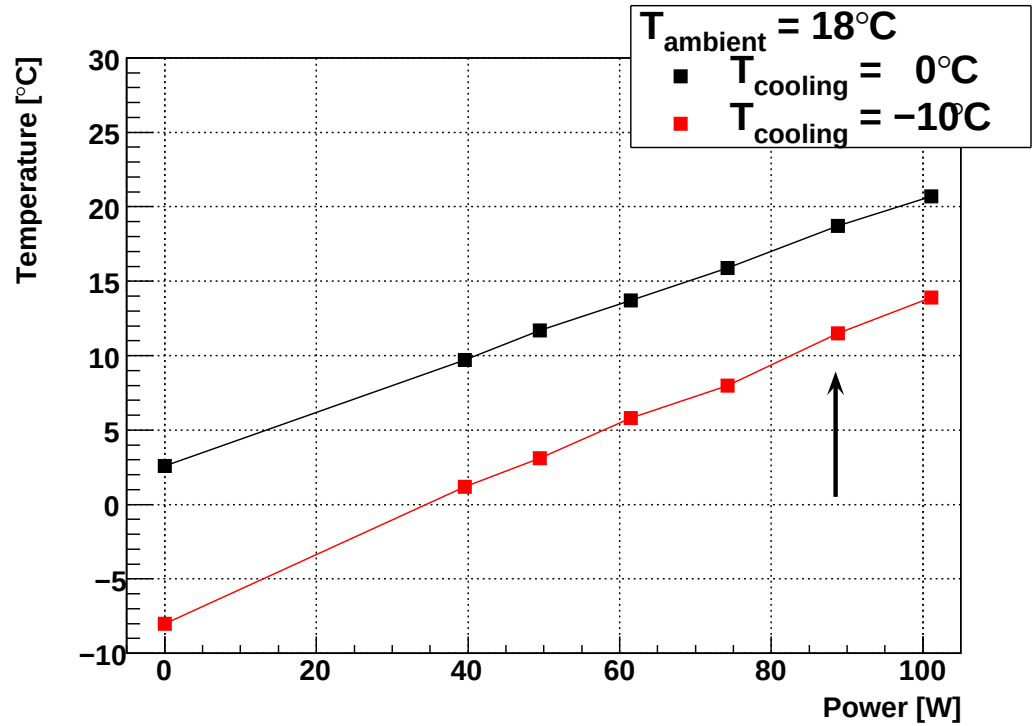
Diamond on right side has formed cracks due to multiple mounting procedures, overshoot in the middle is due to heater foil geometry.

First Studies on Support Ring Dummy



dummy of an end flange (half),
expected power load: $90\,\mathrm{W}$

Results from Support Ring Dummy



- First setup to get an idea of required cooling temperature at the support structure and to test capability of available chiller.
- According to these measurements, a temperature drop between $15\,^{\circ}$C and $20\,^{\circ}$C at $90\,$W has to be taken into account.

Summary

- Simulation performed for a single module on a wide range of parameters, e.g. dependence on ambient temperature, forced convection.
- Setup of a test bench for single modules, measured temperature distributions along a dummy module for different cooling temperatures, distances to cooling block; started study on ambient temperature.
- Results of simulations and measurements are in fairly good agreement.
- Started with measurements on support ring structures, first step towards a mock-up.