Karlsruhe Institute of Technology

Belle II Pixel Detector Endflange: Thermal Studies

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Institut für Experimentelle Kernphysik

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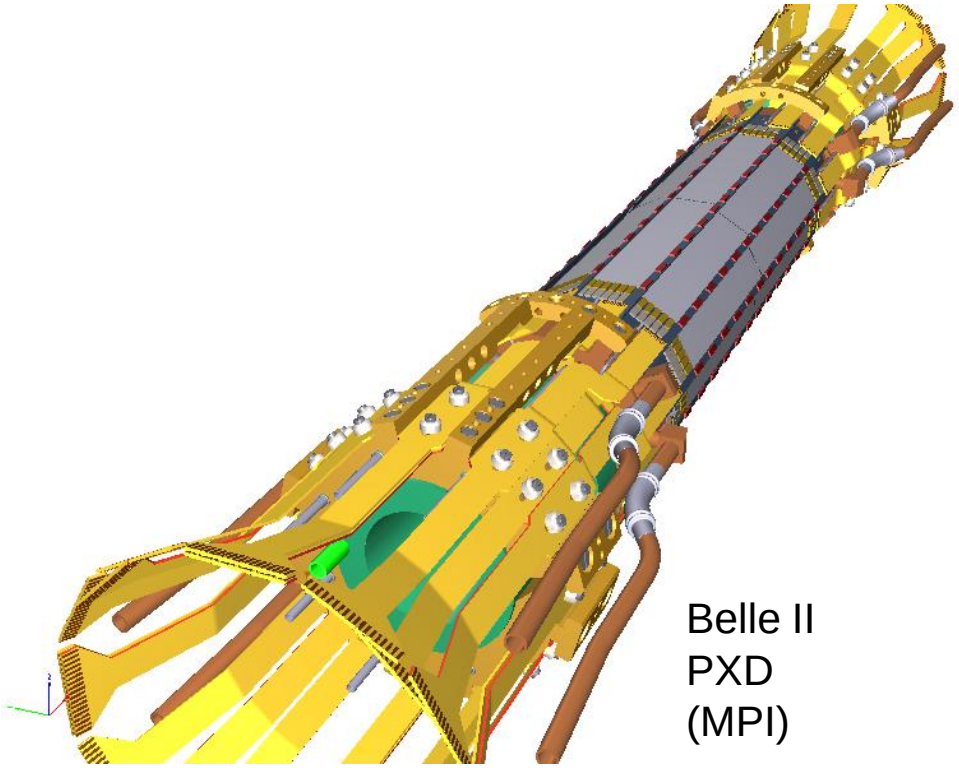
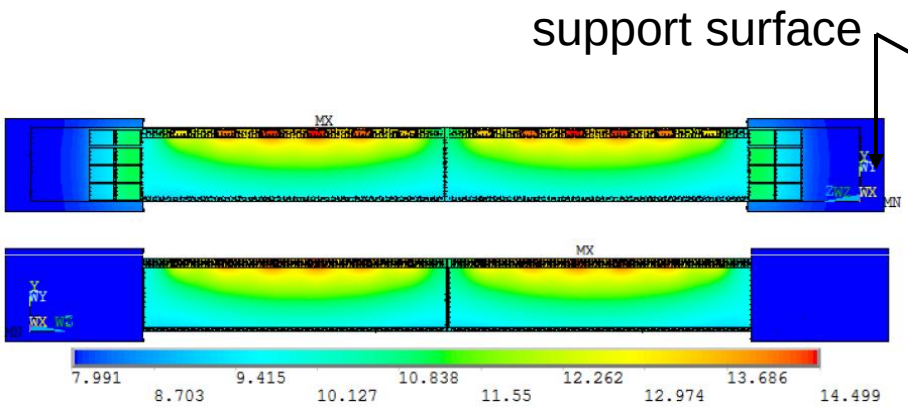


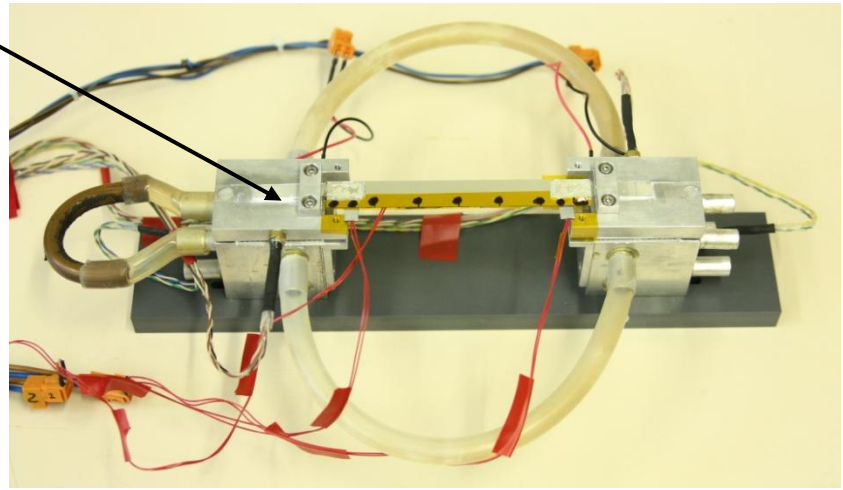
Belle II
PXD
(MPI)

1. Motivation

- simulations and measurements have shown that a temperature of **5°C** is needed on the support surface



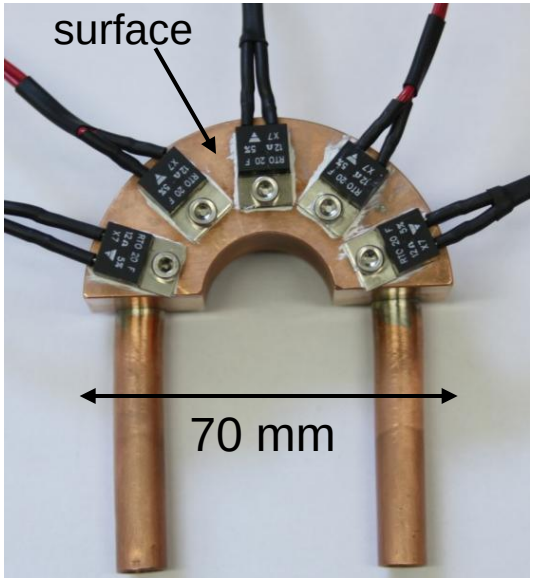
(C. Marinas)

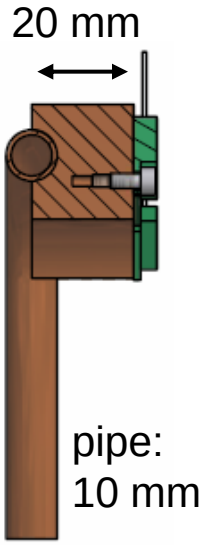


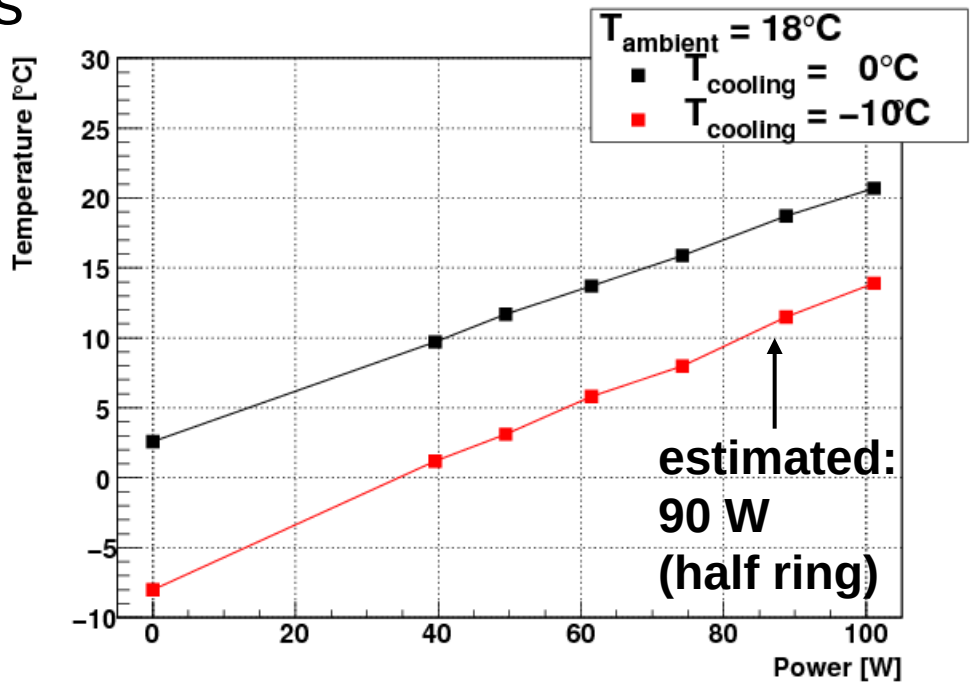
- now: go one step further → endflange
- question: temperature and type of coolant to reach required temperature on endflange surface?

2. Results shown in Prague

- first approach: very simple mockup of the endflange
- copper half ring, 5 resistors



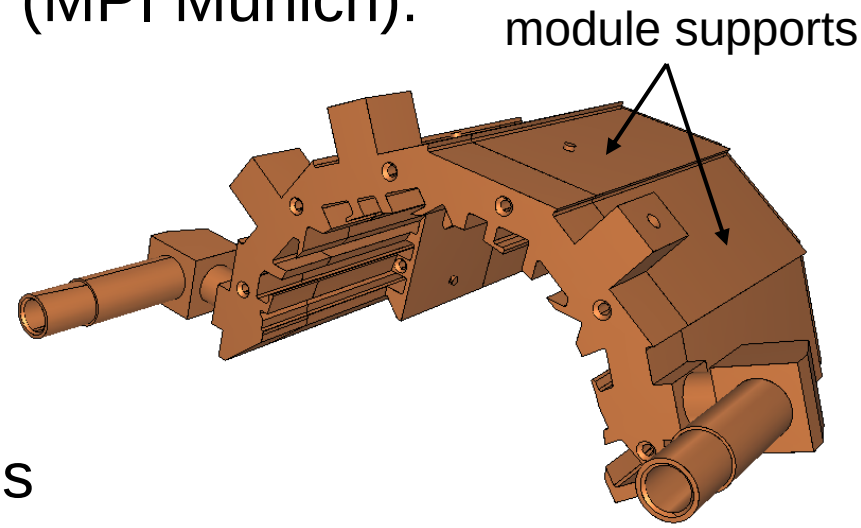




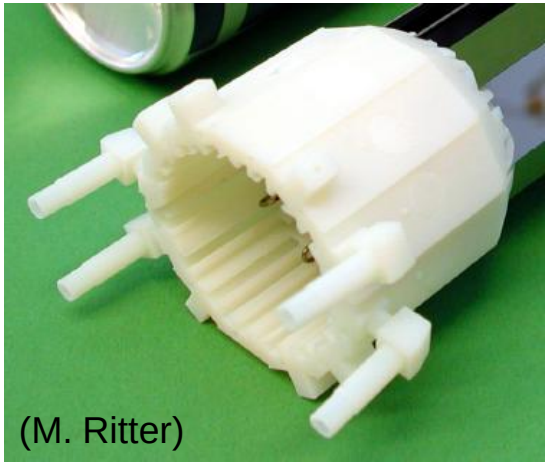
- temperature loss between surface and coolant about **22°C**
- more detailed mockup needed

3. Mockup construction

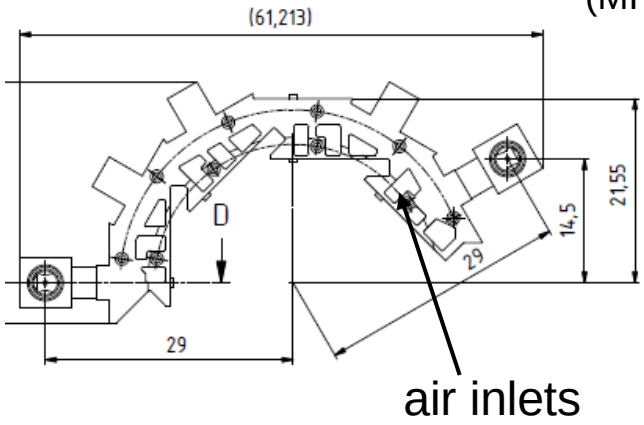
- new design of PXD endflange (MPI Munich):
  - modules placed directly on copper support
  - omission of CVD-diamond
- rapid prototyping:
  - plastic material
  - unsuitable for thermal studies



(MPI)



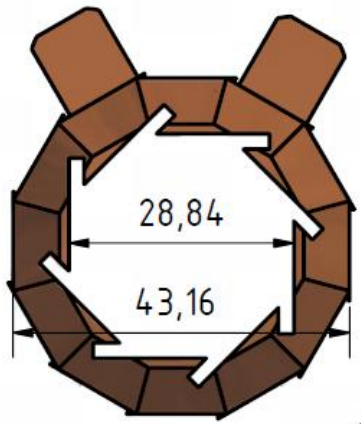
(M. Ritter)

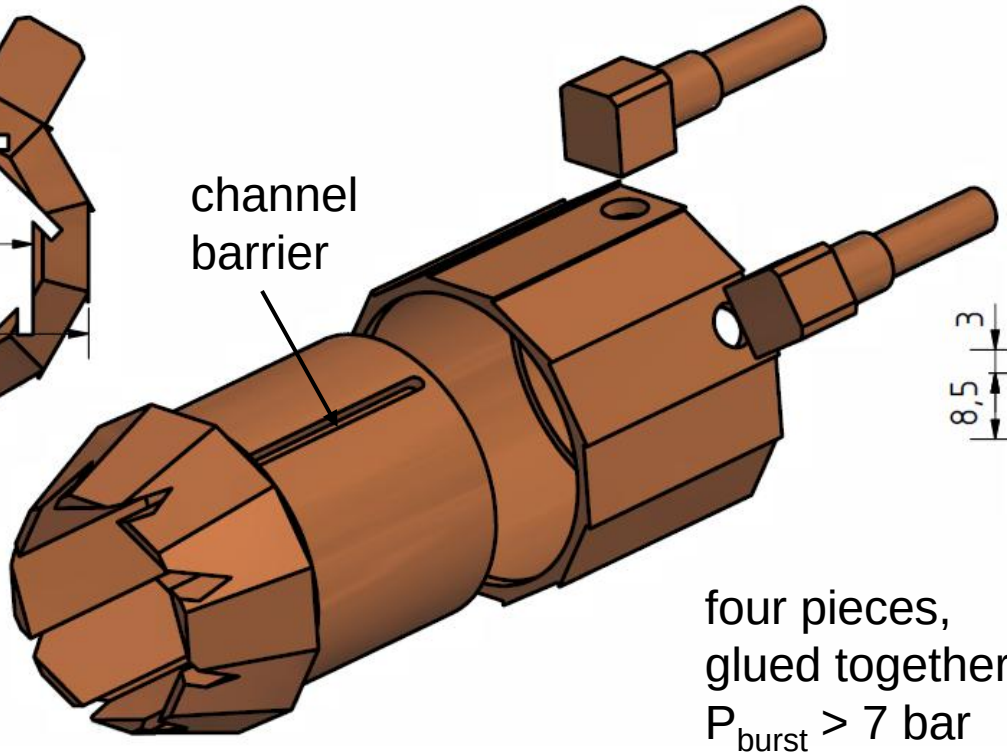


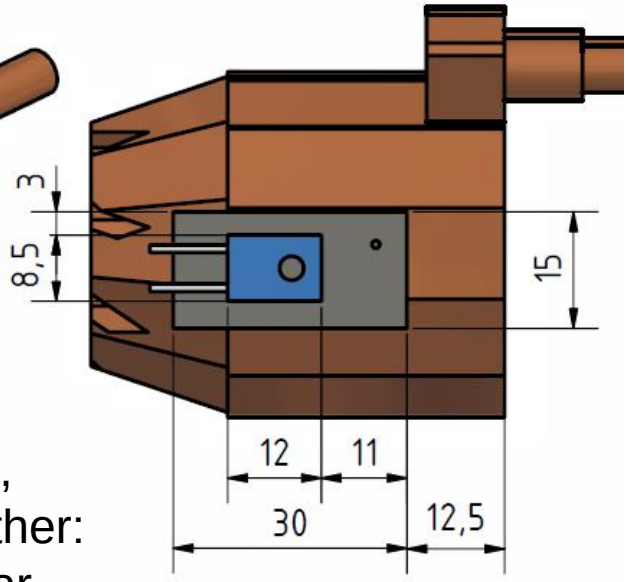
3. Mockup construction

dimensions according to MPI

- new design very complex, especially air inlets
- production not possible with normal machining
- solution: create a copper version **without air inlets**





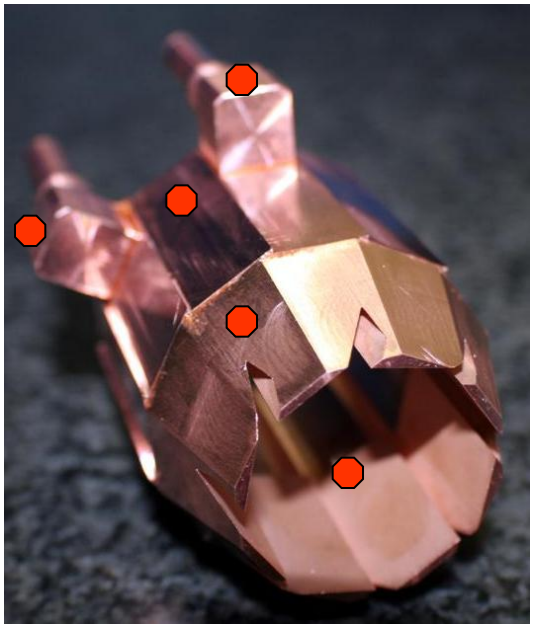


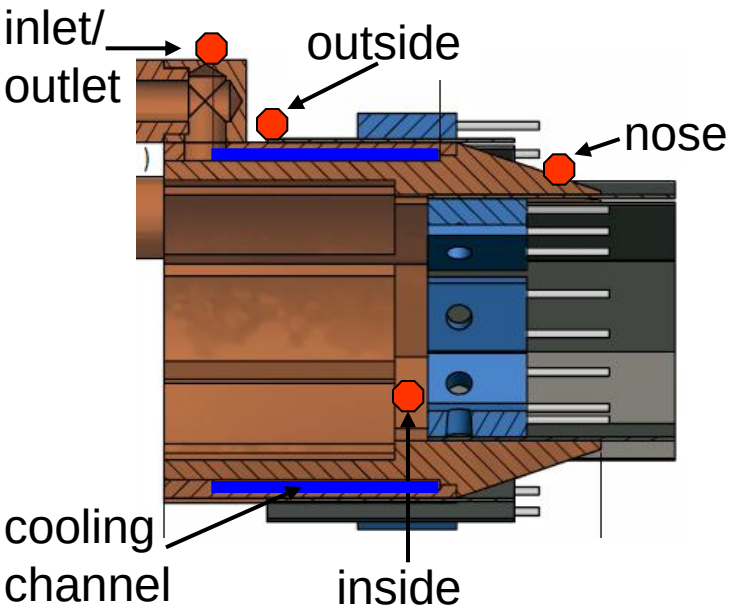
four pieces,
glued together:
P_{burst} > 7 bar

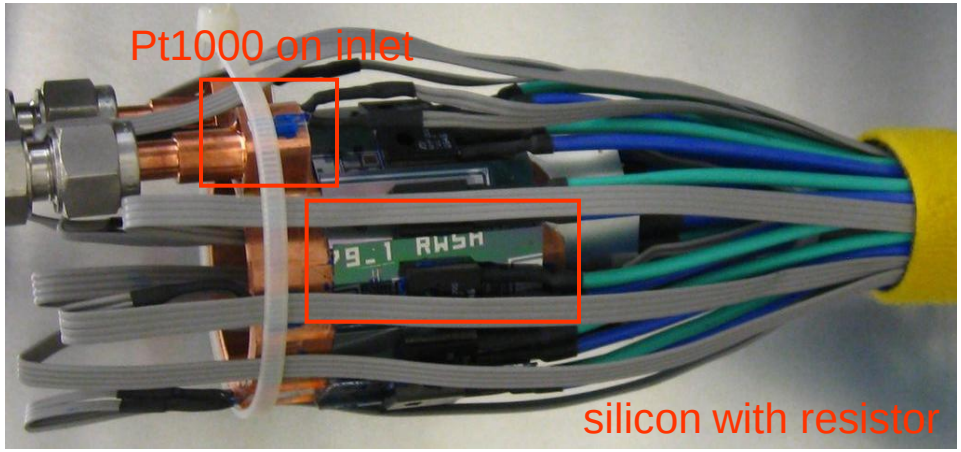
(T. Barvich)

4.1 Measurement setup: Flange

- machined endflange from our workshop:
- 20 silicon pieces with resistors as heat load
- 14 Pt1000 for temp. measurement





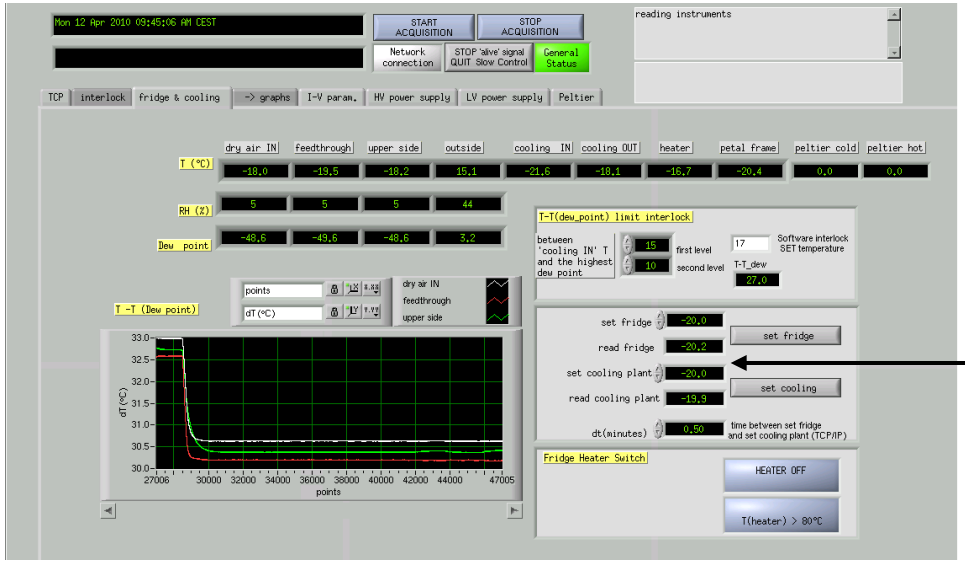


4.2 Measurement setup: Overview

- CMS Tracker petal cooling test setup:

4.3 Measurement setup: Cooling plant

- purpose-built cooling plant for CMS Tracker petal testing:
  - made by University of Louvain, Belgium
  - mono-phase, using FC-77
  - over pressure system, P = 2.8 bar
  - 350 W @ -20°C
- whole test setup computer-controlled:



temp. selector

4.4 Measurement setup: Coolant

- coolant in use: 3M “Fluorinert” FC-77 (C_8F_{18})
- German replacement for FC-72 (C_6F_{14}) used in CMS Tracker

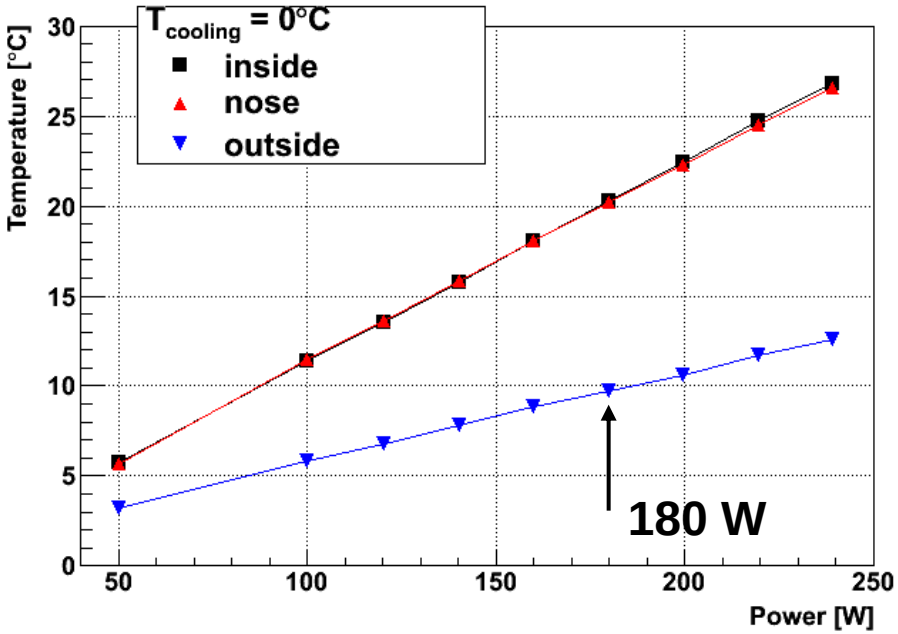
3M™ Fluorinert™ Electronic Liquids

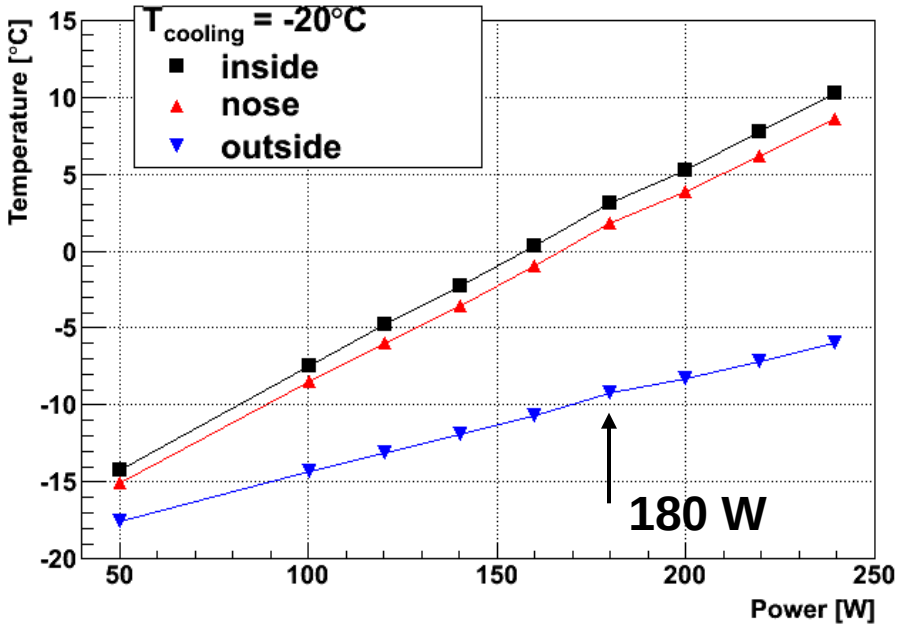
advantages:	**disadvantages:**
- thoroughly tested (rad. hard) - type of cooling system well understood and proven - high evaporation rate → leaks will not cause detector damage (current CMS leak rate: 8 kg/day or 0.4%!)	- larger pipes - over pressure required - high price: ~100 €/kg - increases global warming in the atmosphere

5. Results (1)

new results, not shown at KEK!

- power dependence:

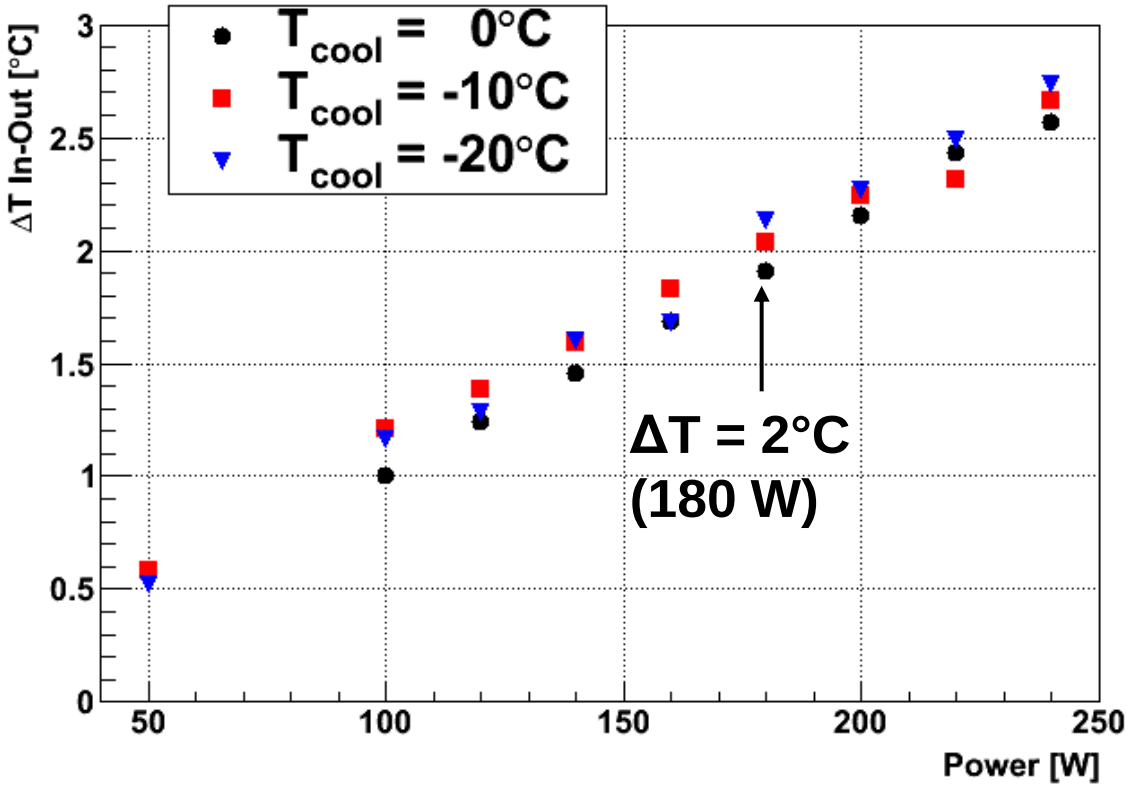




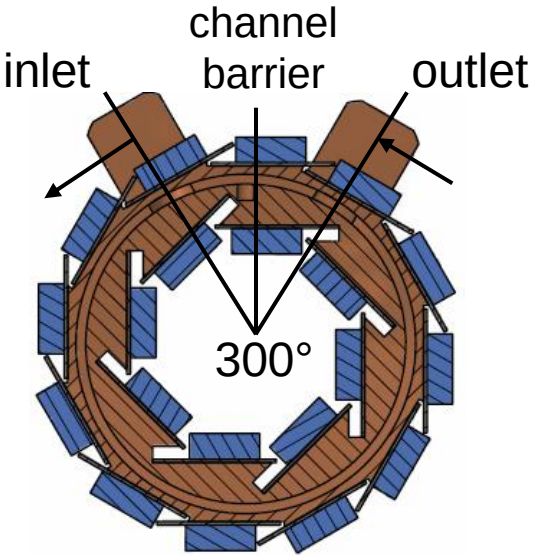
- maximum temperature loss about **23°C**
- reminder: **NO** air inlets!

5. Results (2)

- performance of cooling plant: ΔT between inlet and outlet



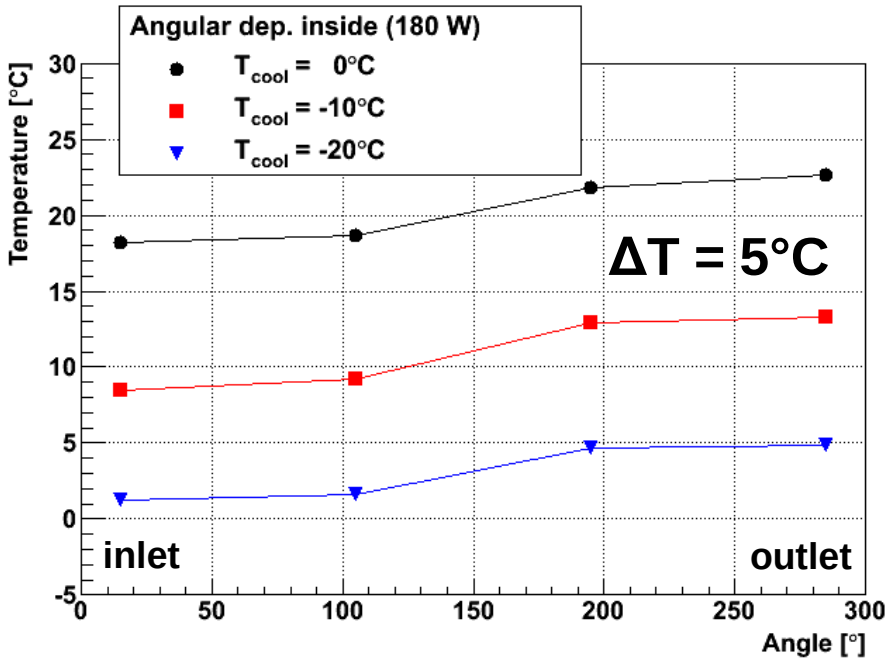
temperature difference not correlated to cooling temperature

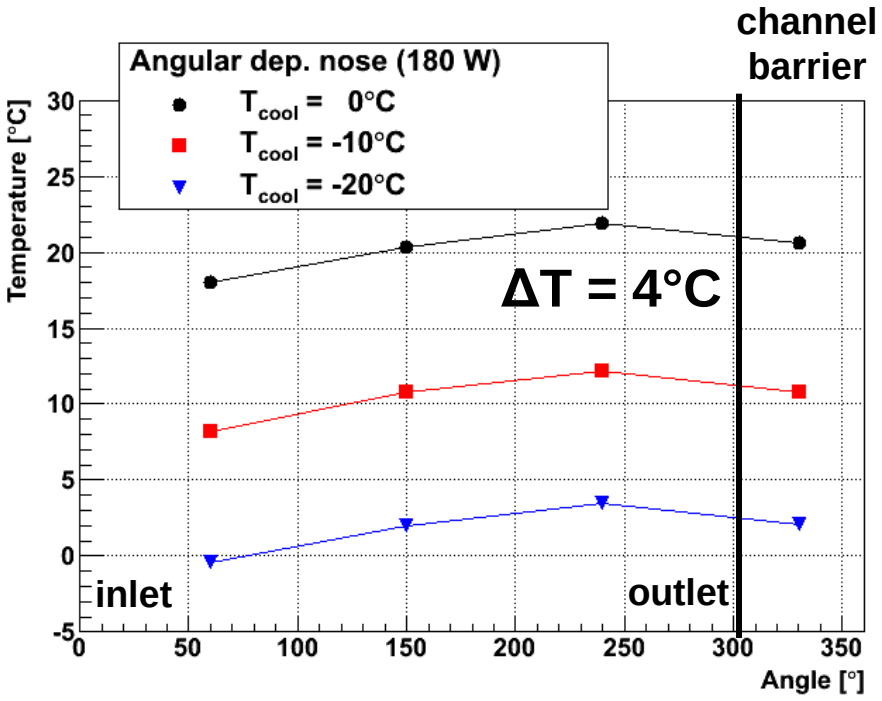


- performance is adequate to our needs

5. Results (3)

- angular dependence (power load 180 W):





- $\Delta T_{angular}$ (5°C) exceeds $\Delta T_{in\text{-}out}$ (2°C)
- heat transfer between copper and coolant is not ideal!

6. Summary

- temperature loss between coolant and surface **23°C**
- latest simulations by C. Marinas require a surface temperature of about **5°C**
- that translates into a coolant temperature of about **-20°C**
- -20°C is easily reachable with a mono-phase cooling system using special coolants

- leaking coolants like 3M “Fluorinert” will not damage the detector, especially not in a flushed volume

- only small margin towards lower coolant temperatures

Thank you…

Backup slides

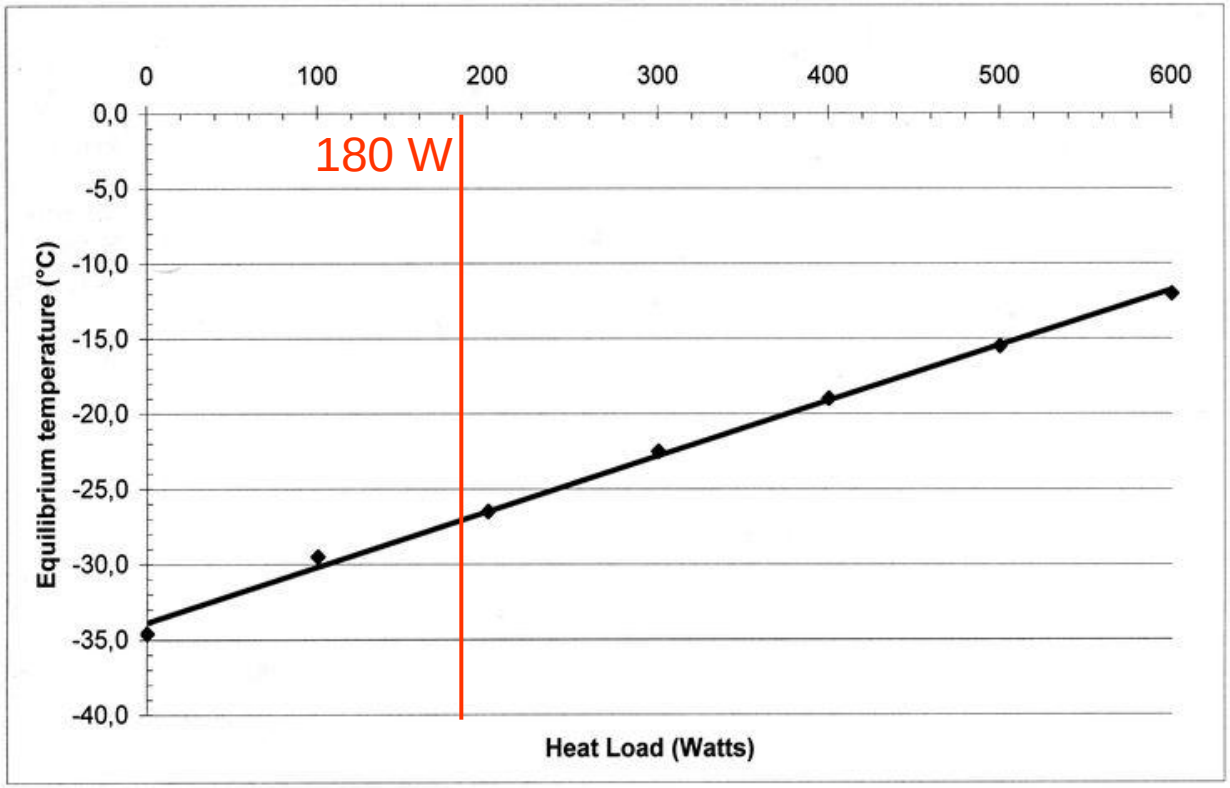
follow…

4.3a Measurement setup: Cooling plant

- performance chart of CMS Tracker petal cooling plant:

Cooling plant
Equilibrium temperature versus heat load

Heat load (Watts)	Equil. temp. (°C)
0	-34,6
100	-29,5
200	-26,5
300	-22,5
400	-19,0
500	-15,5
600	-12,0



(Univ. of Louvain)

5. Results (1a)

- power dependence for T = -10°C: