# A sample cooling system for the existing vertical warm bore magnet VM-5

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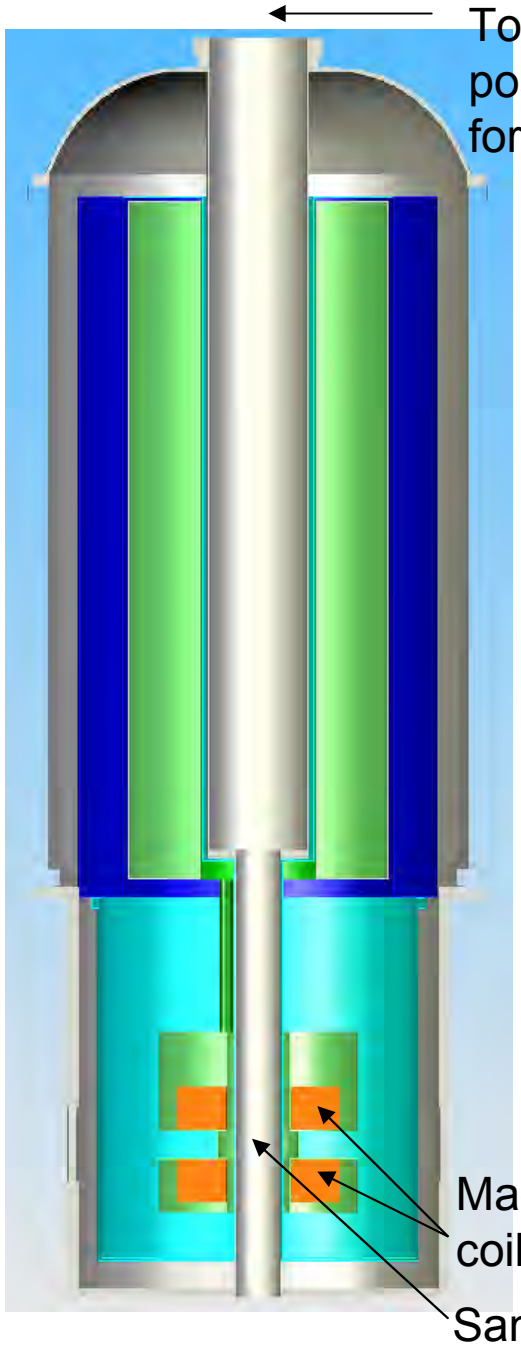
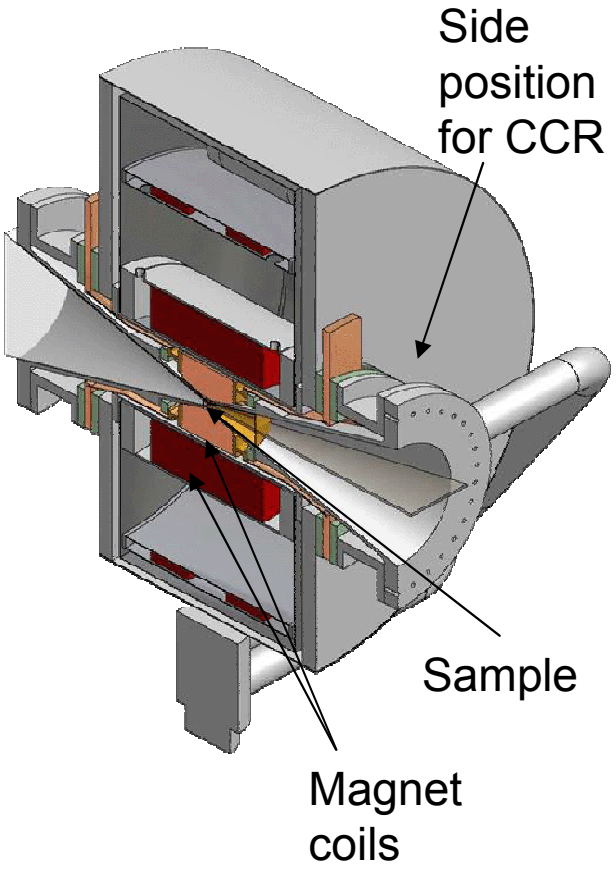
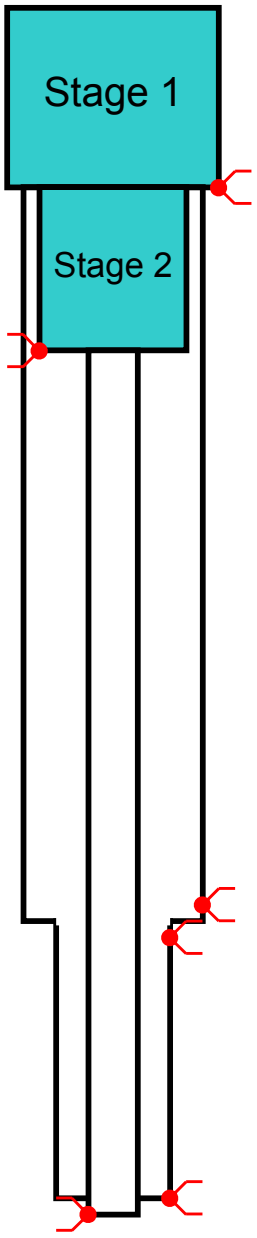
# Task description




- Replacement of a sample cooling insert ($LN_2$)
  - Large distance (~ 1.6 m)
  - Soft requirements in T (~ 50 K)
  - Using a given CCR
  - Unsophisticated approach
  - Consider an optional high temperature stage
- Establish computer simulations
  - COMSOL Multiphysics

**Goal: Trial & Learn**



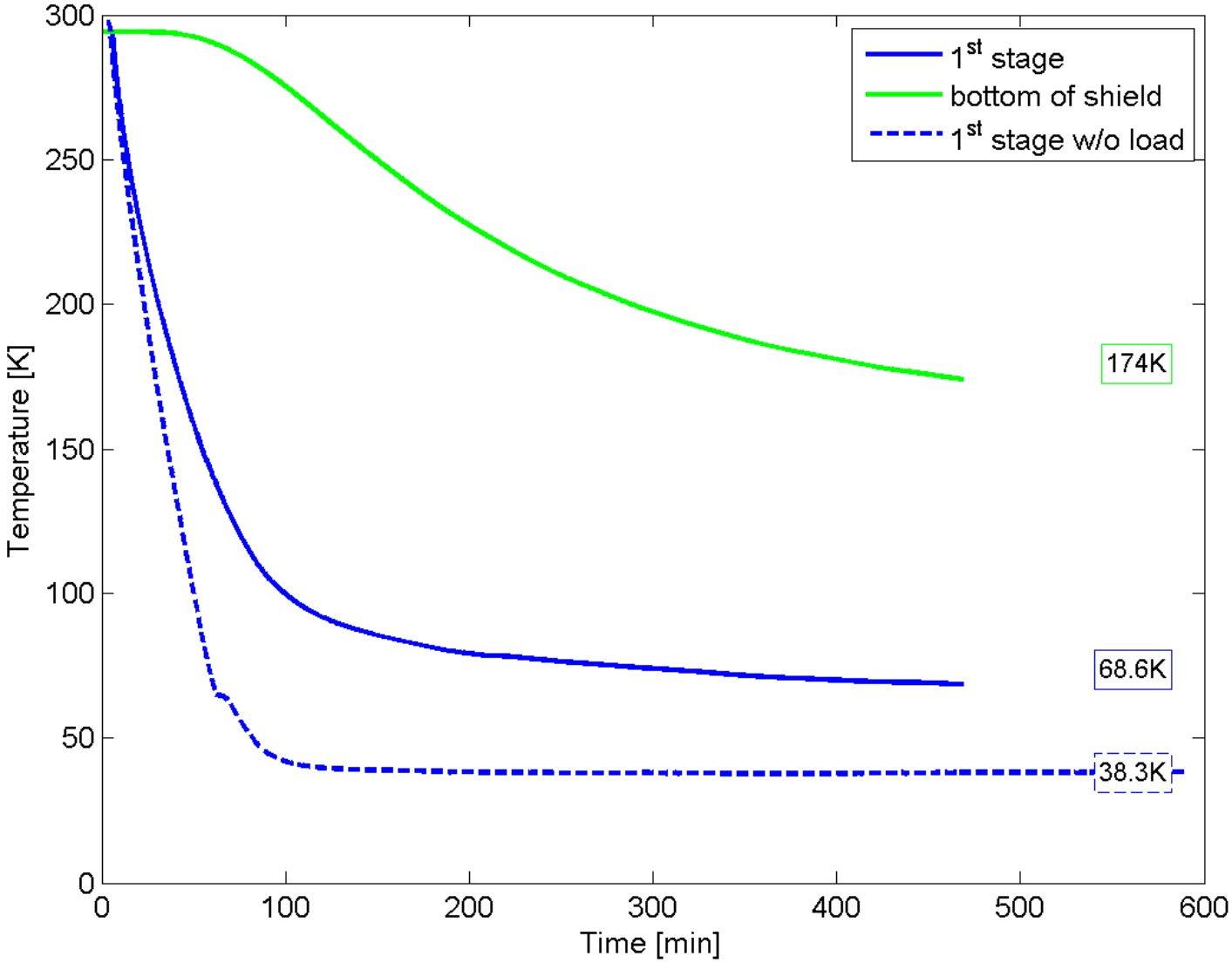

# Experimental setup – as simple as possible

- SHI RDK-205D with 10 W @ 65 K and 0.5 W @ 5.5 K
- Shield: pipes Ø70 x 2 mm, Ø30 x 2 mm of aluminum alloy
- Cold finger: pipe Ø12 x 2 mm of “pressure line copper”
- Thermometers at different positions
- Normal workshop materials

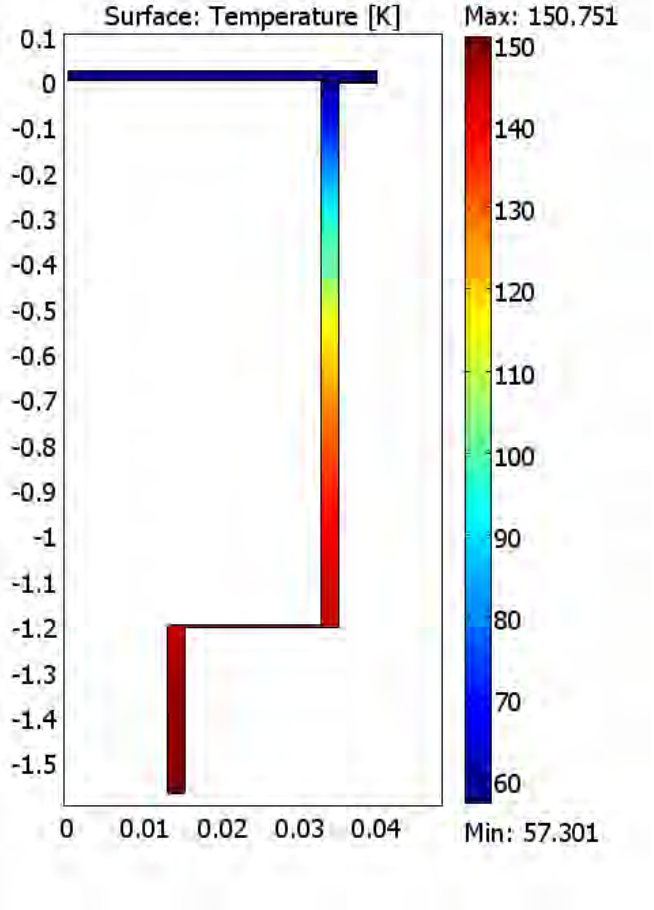
# Cool down 1st stage

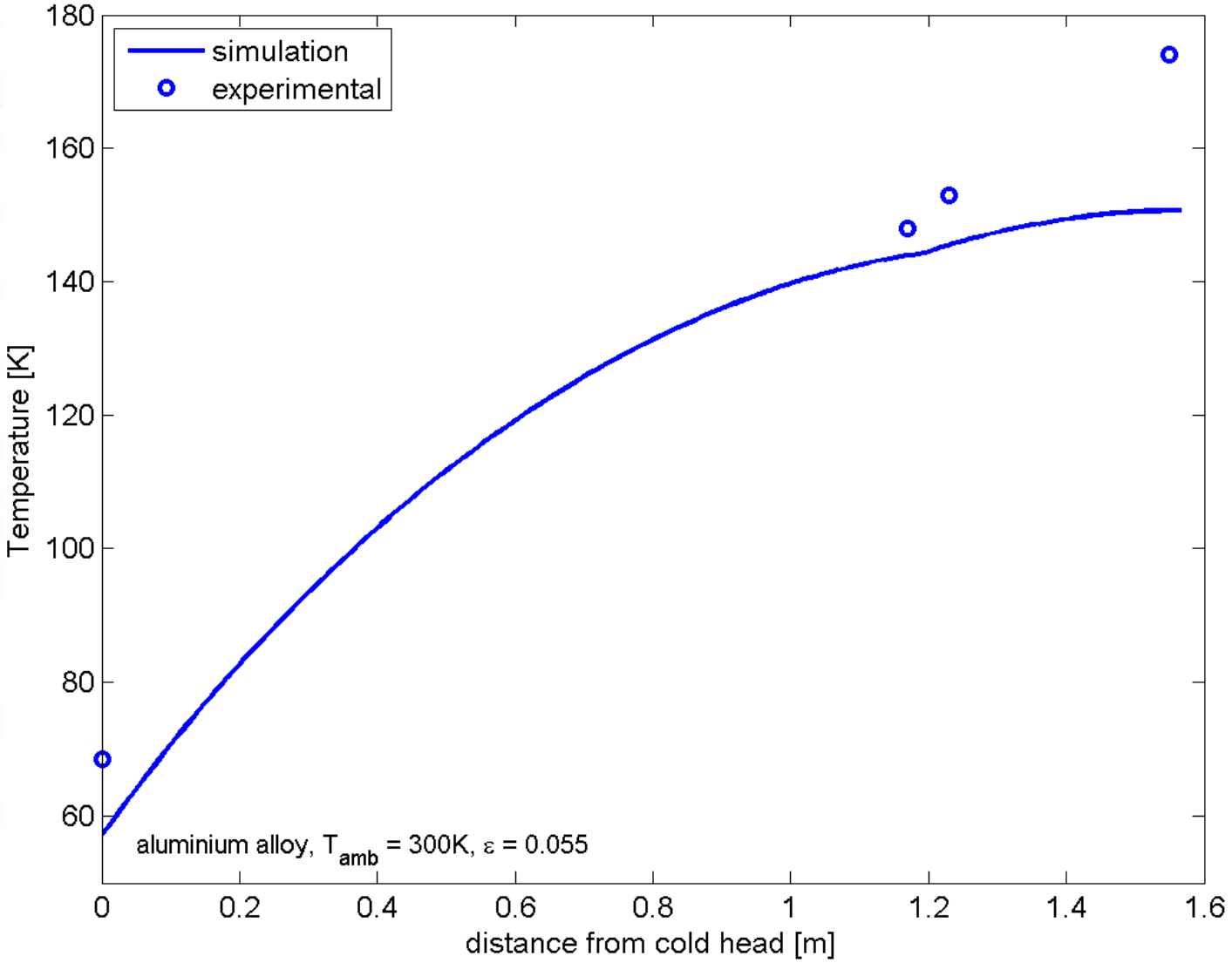
## Al shield

- length 1.6 m
- cold mass 1.75 kg



# Temperature curve along shield (1st stage)

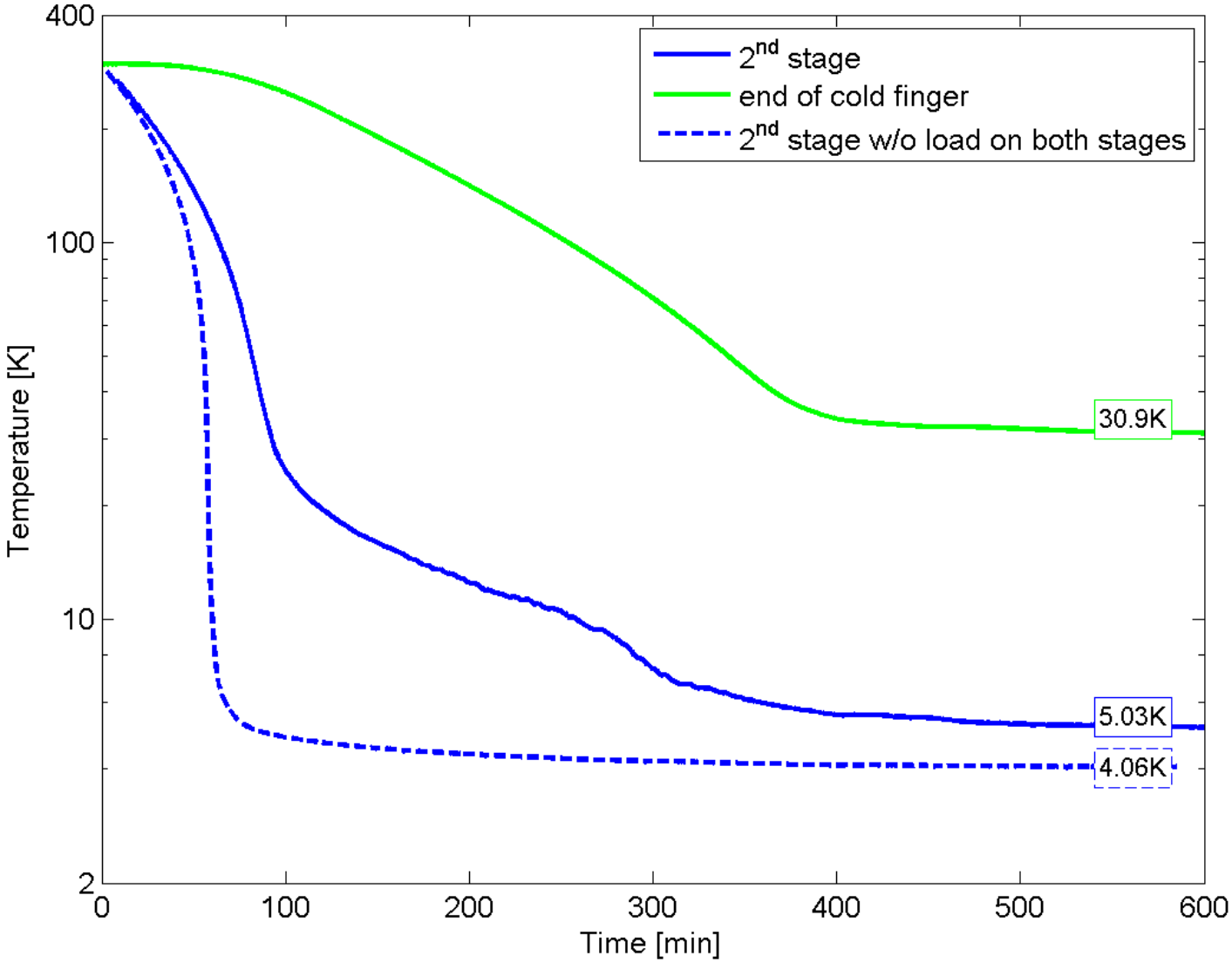


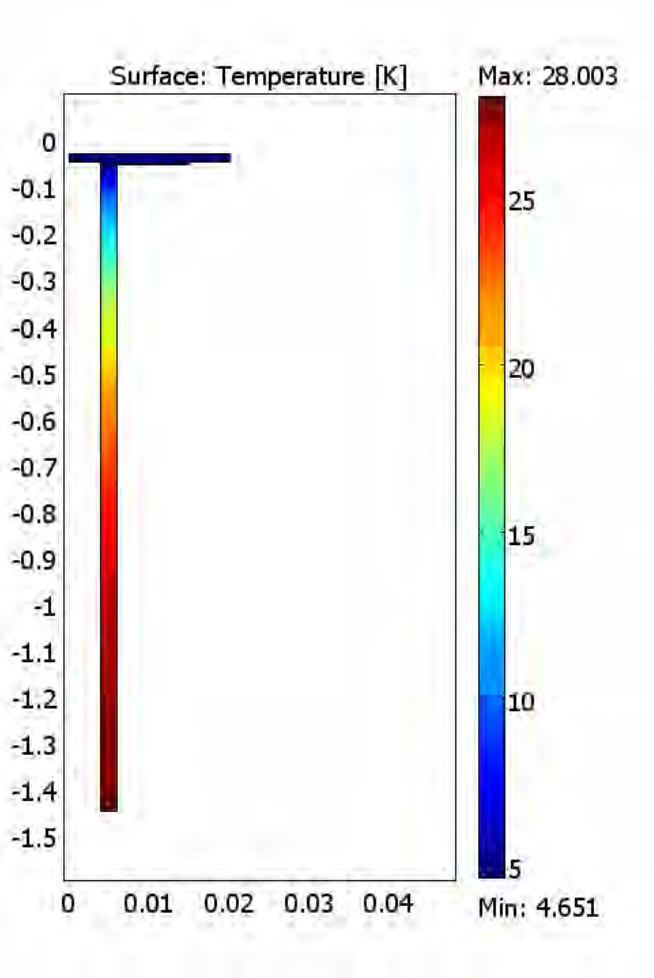
# Cool down 2nd stage

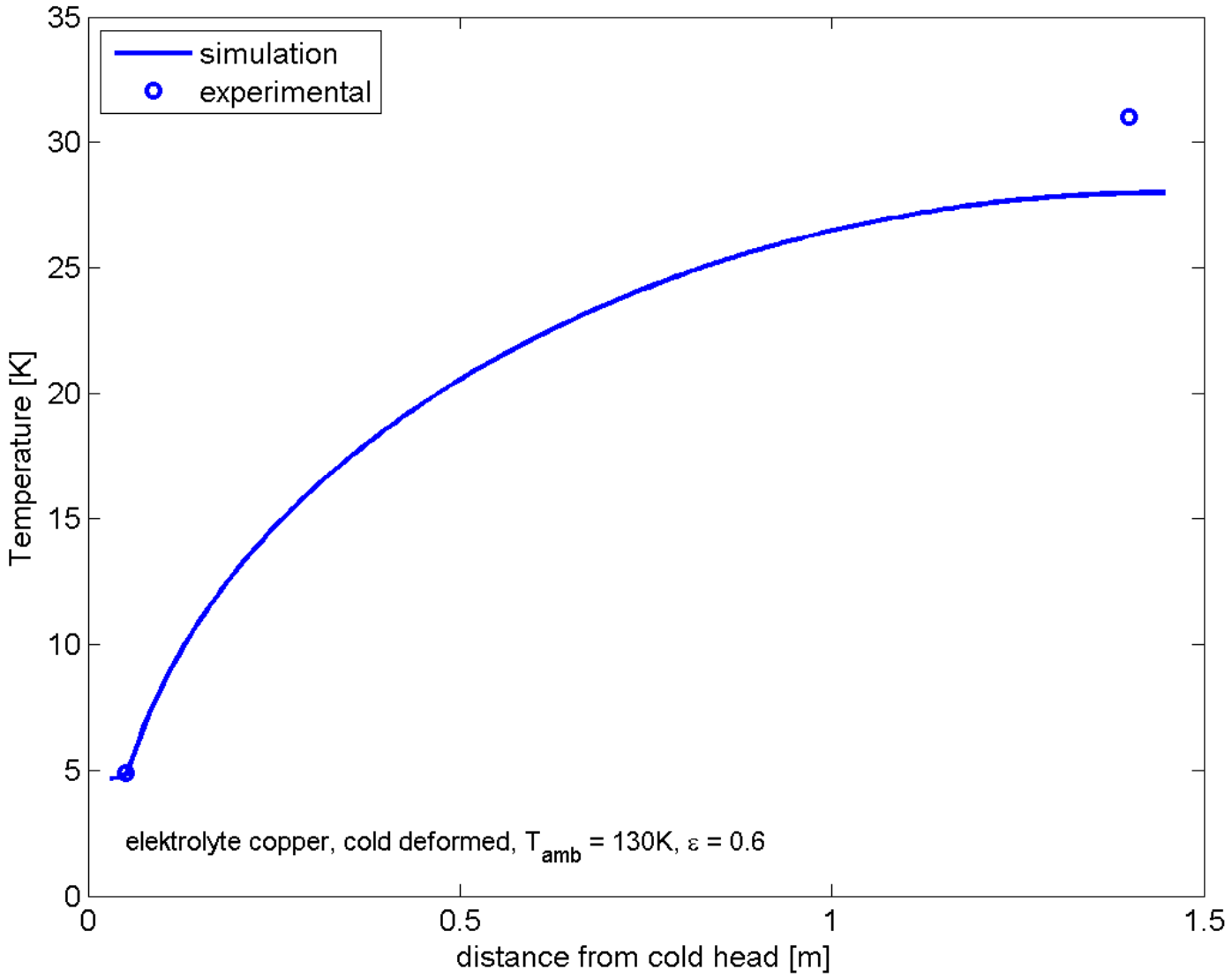
## Cu cold finger

- length 1.5 m
- cold mass 0.82 kg

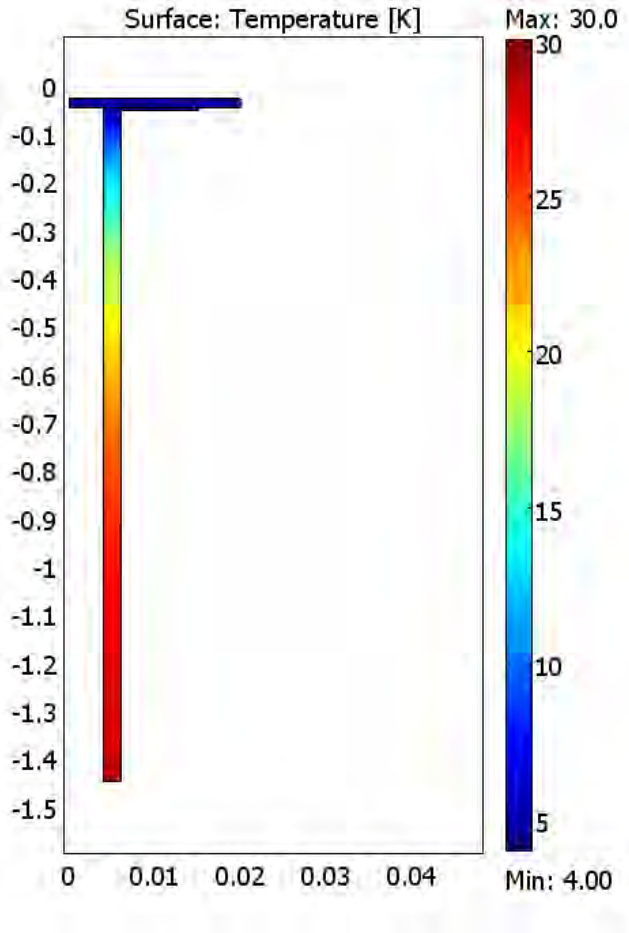


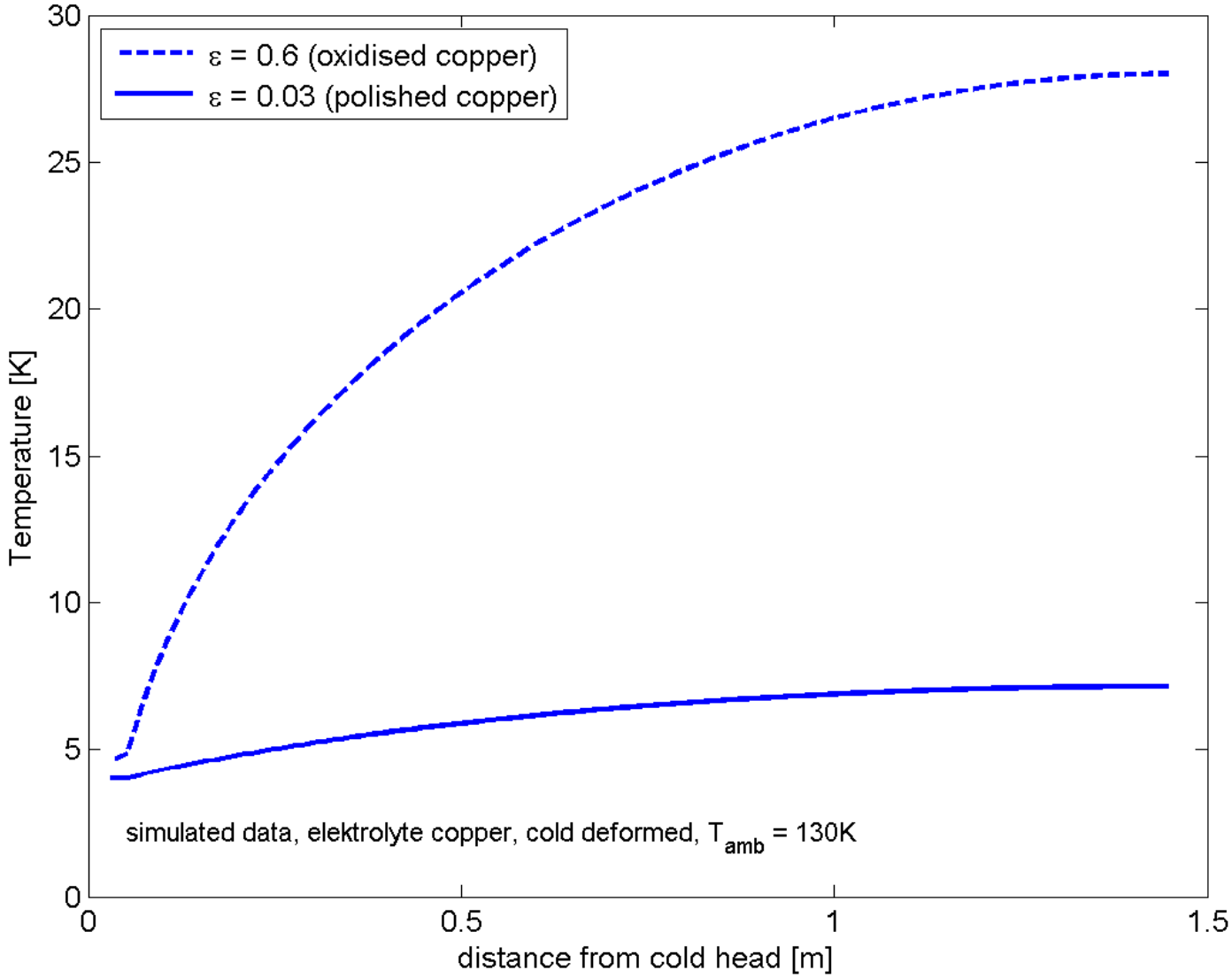
# Temperature curve along cold finger (2nd stage)



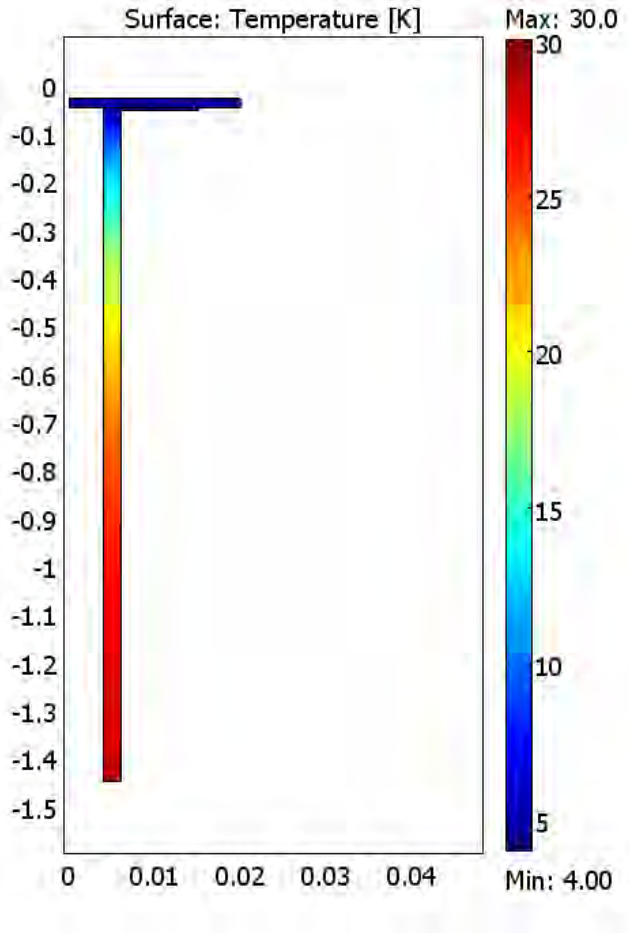



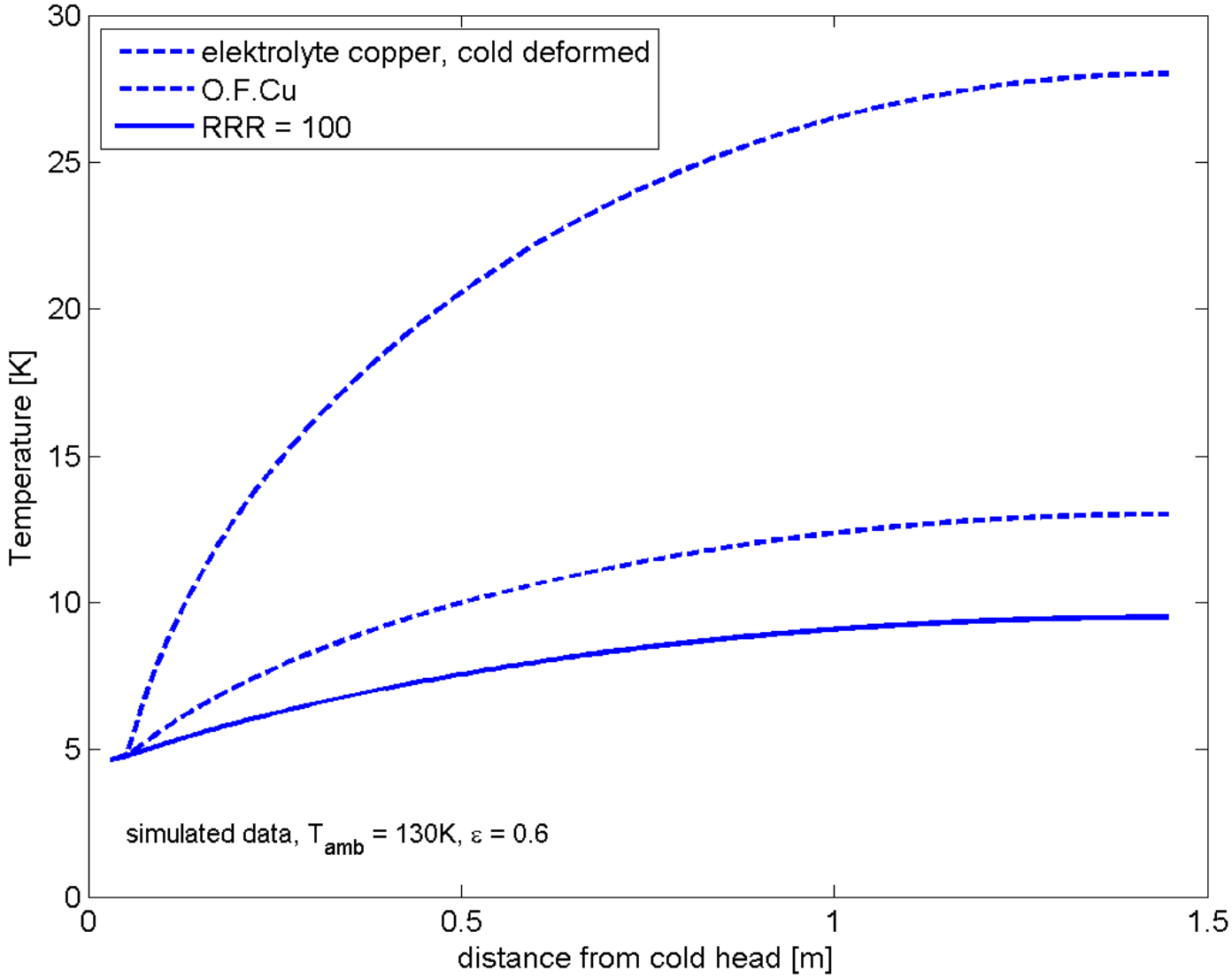
# Computer simulation example 1: Emissivity



# Computer simulation ex. 2: Thermal conductivity



# Learnings

- Computer simulations show relationships in a system and help to identify important parameters – at a minimum.
- Only if there is a firm base of material data and real material properties are known, computer simulations can predict a complete system.

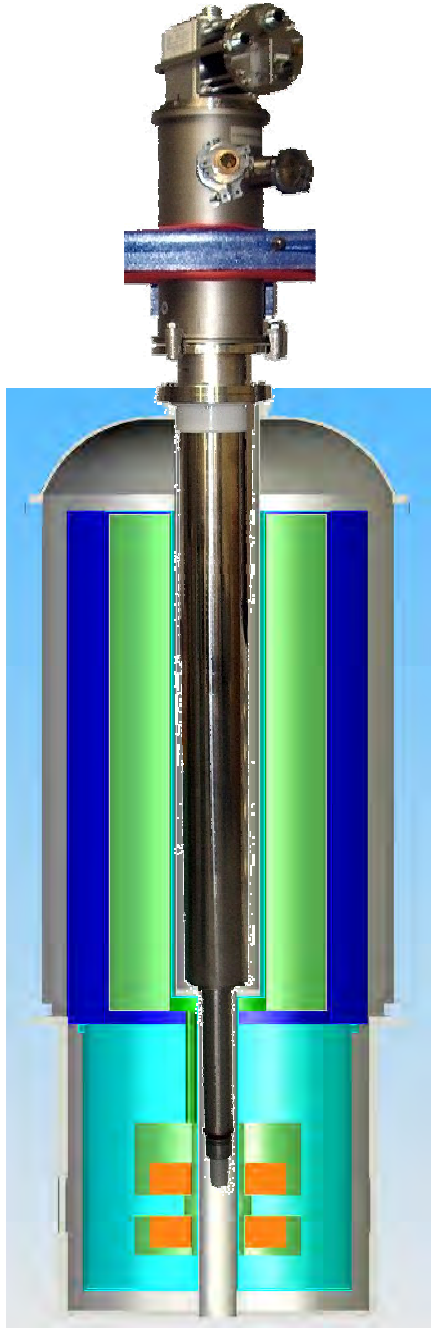
- Even when using a simple solid conduction setup one can transport cooling power over long distances – with moderate results if using poor materials.

# Outlook VM-5

- Use better copper material for the cold finger.

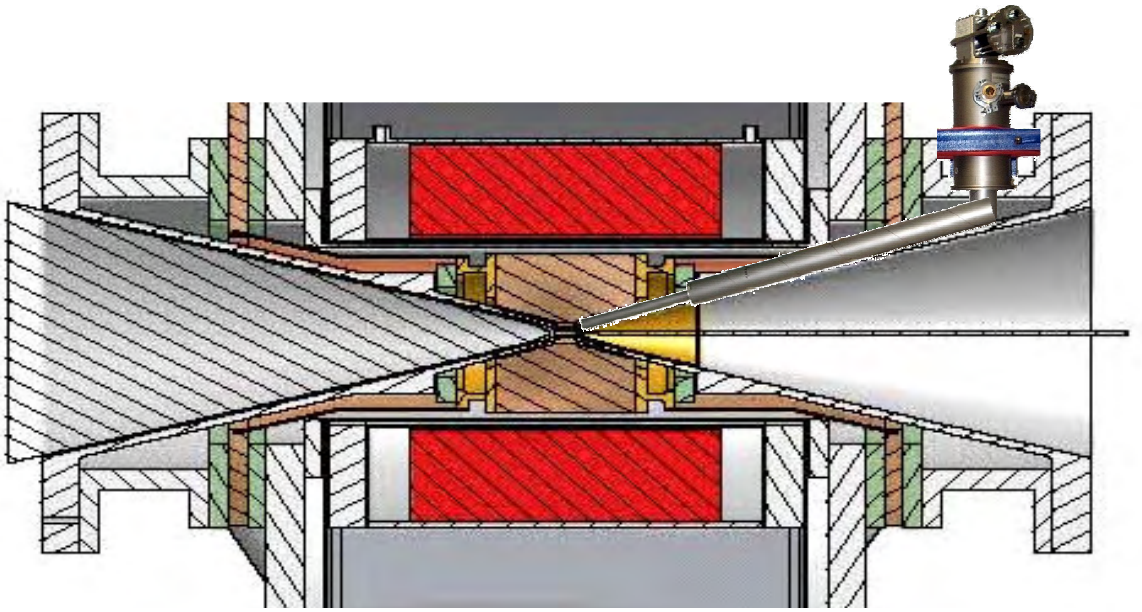
  → System will become faster and $T_{min}$ will decrease.
- Use an additional high temperature stage.

  → Temperatures in the range of 50K-800K are feasible.



# Outlook HFM

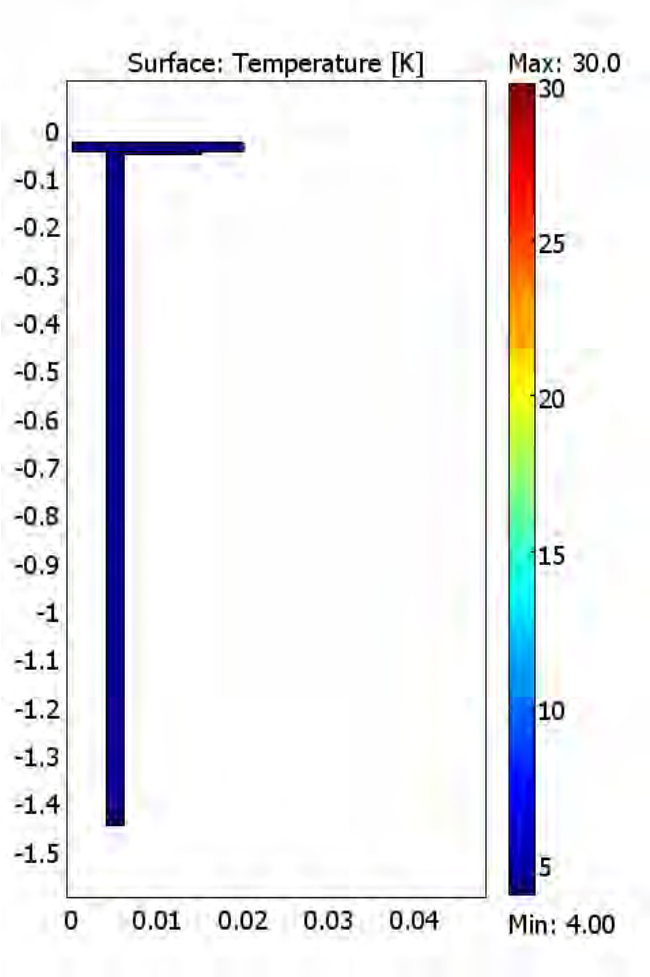
- $T_{min}$ below 10K seems to be achievable by solid conduction.
- If lower temperatures are requested, more sophisticated techniques like thermo siphon or 3rd stage must be used.

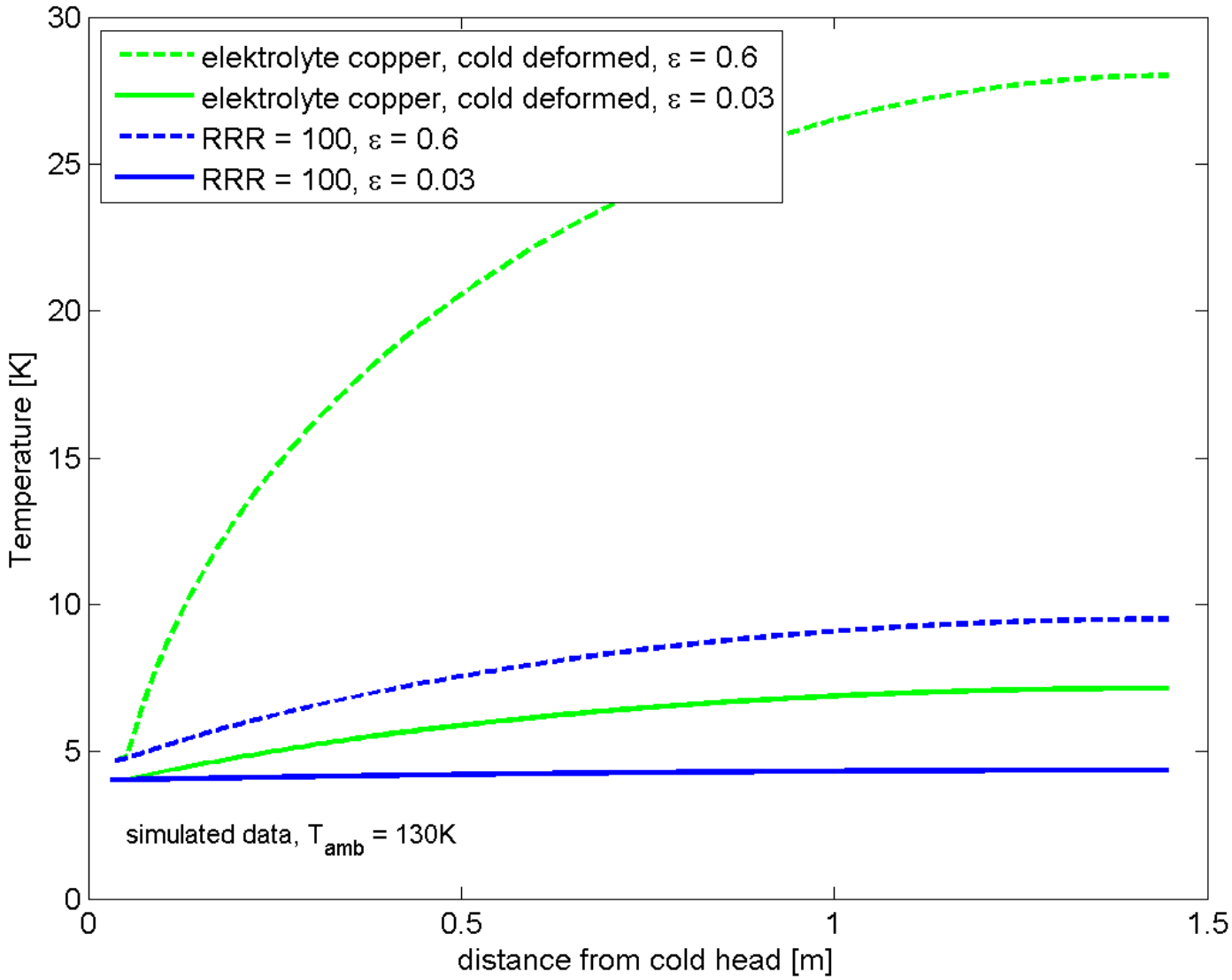


# Thank you for your attention!

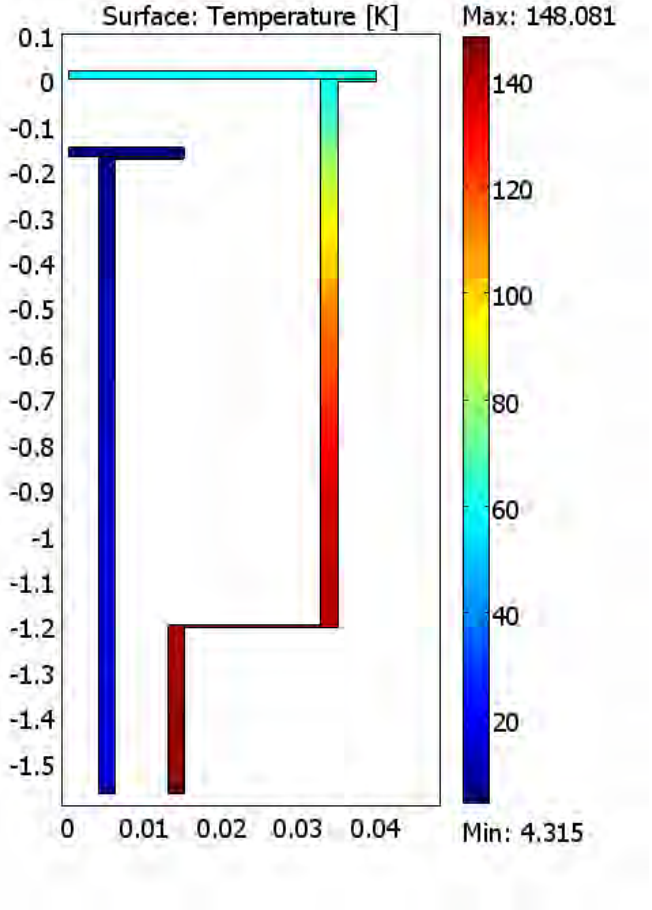
# some additional slides

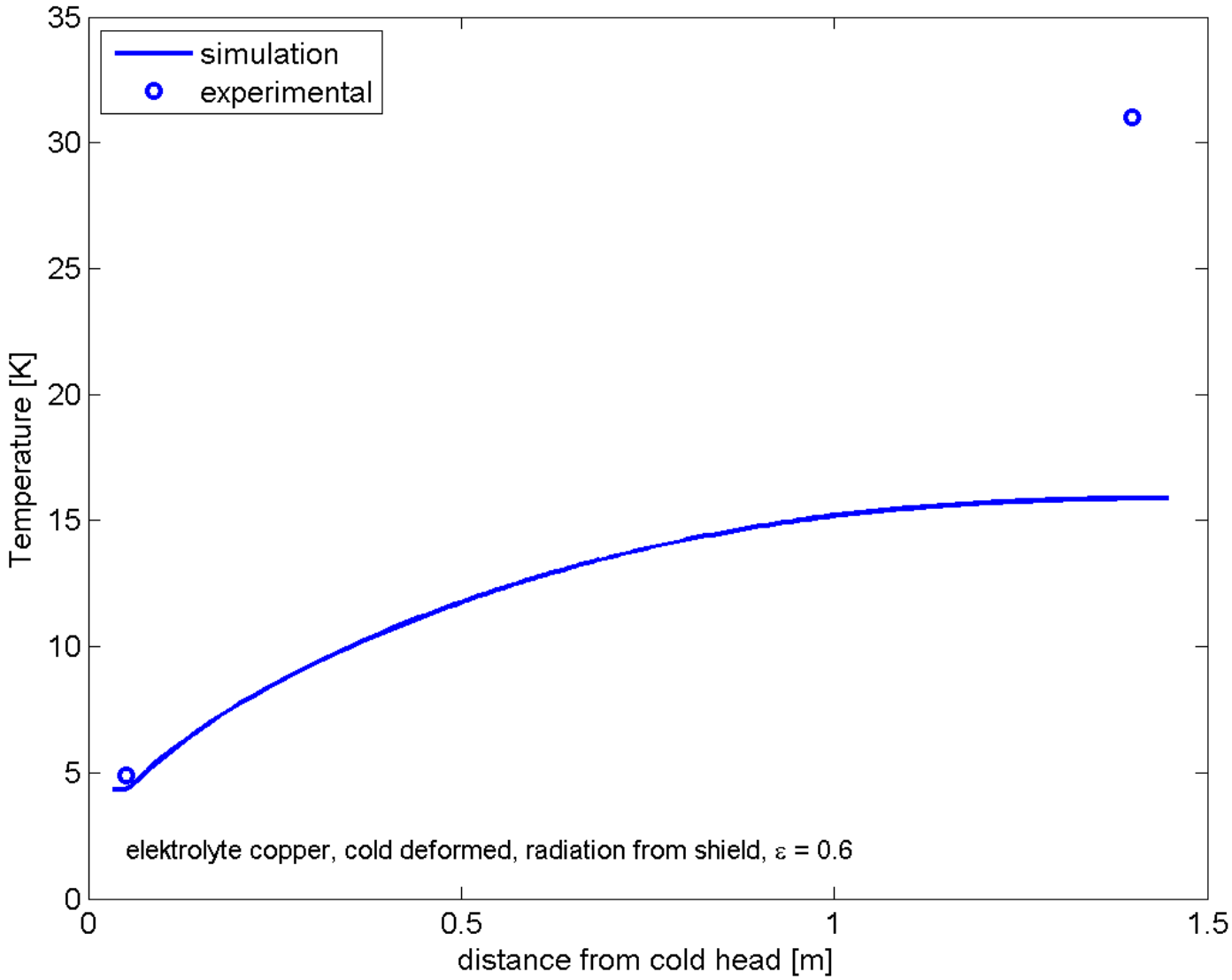
# Computer simulation: Emissivity and Material



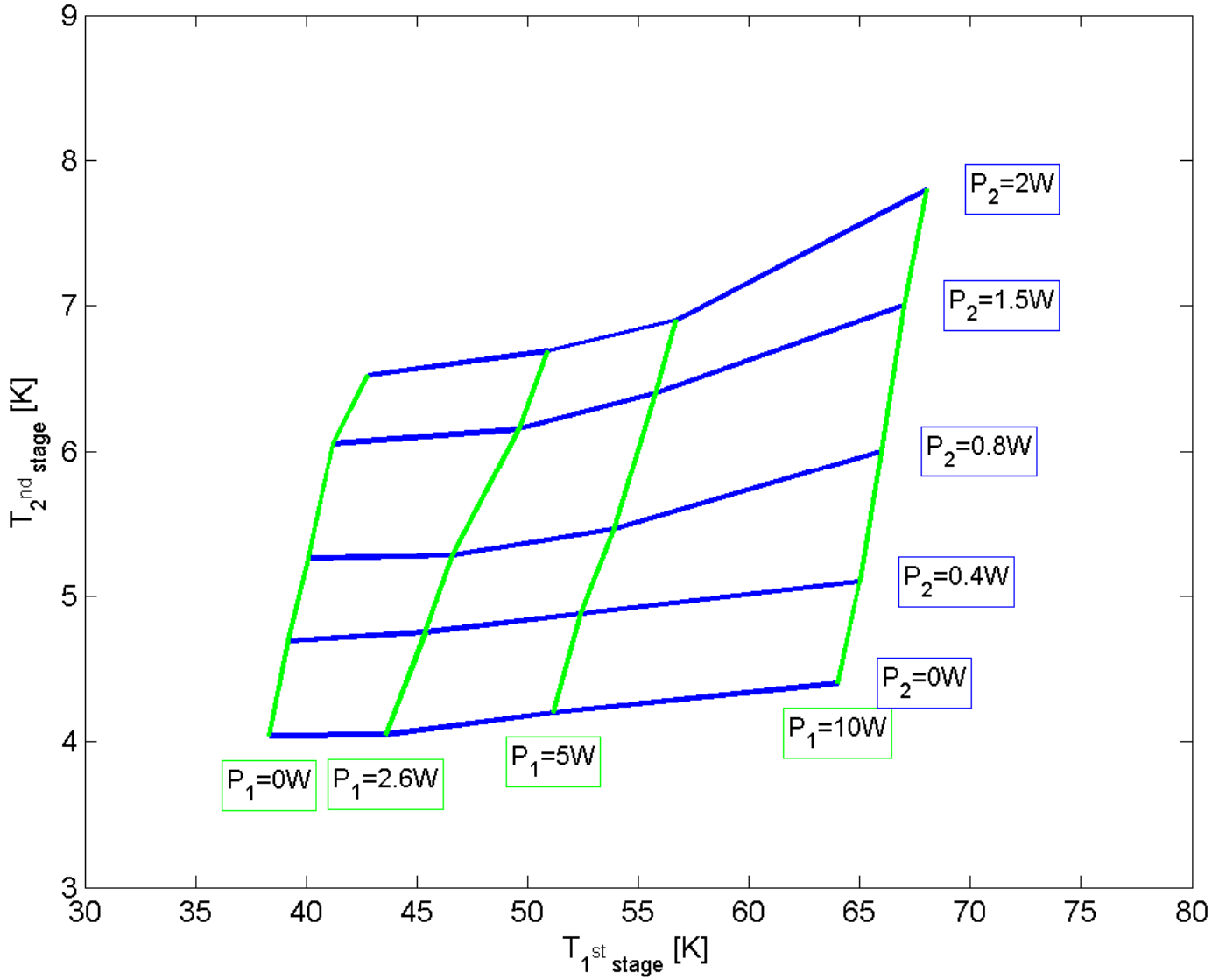
# Computer simulation: both parts



# Model of vacuum chamber

# Power plot


$P_2$=2W
$P_2$=1.5W
$P_2$=0.8W
$P_2$=0.4W
$P_2$=0W
$P_1$=10W
$P_1$=5W
$P_1$=2.6W
$P_1$=0W
$T_{2^{nd}\ stage}$ [K]
$T_{1^{st}\ stage}$ [K]
9
8
7
6
5
4
3
30
35
40
45
50
55
60
65
70
75
80