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Heat transfer at a sapphire – indium interface in the 30 mK – 300 mK temperature range

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Content

- Motivation – AEgIS
- Dilution Refrigerator
- Experimental setup
- Results
- Conclusions

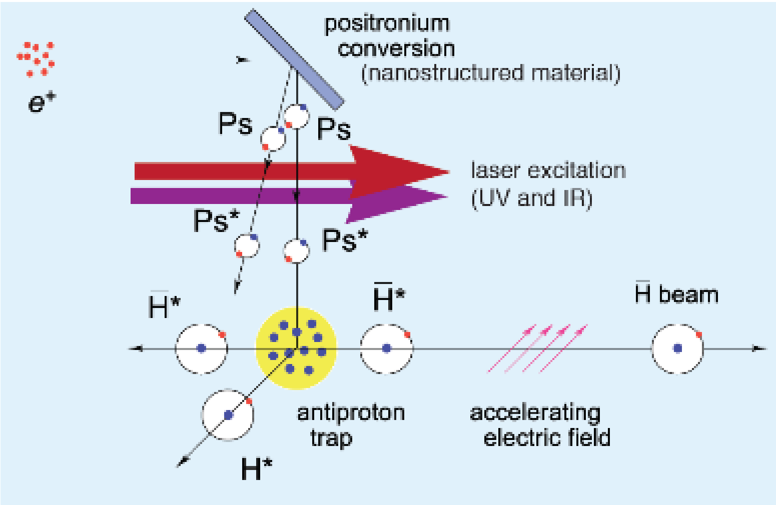
AEgIS:

Antimatter Experiment: Gravity, Interferometry, Spectroscopy

Goal:

direct measurement of the Earth's gravitational acceleration **g** on antihydrogen within 1% accuracy

Antihydrogen formation:



$$Ps^* + \bar{p} \longrightarrow \bar{H}^* + e^-$$

Galileo, Pisa, 1589

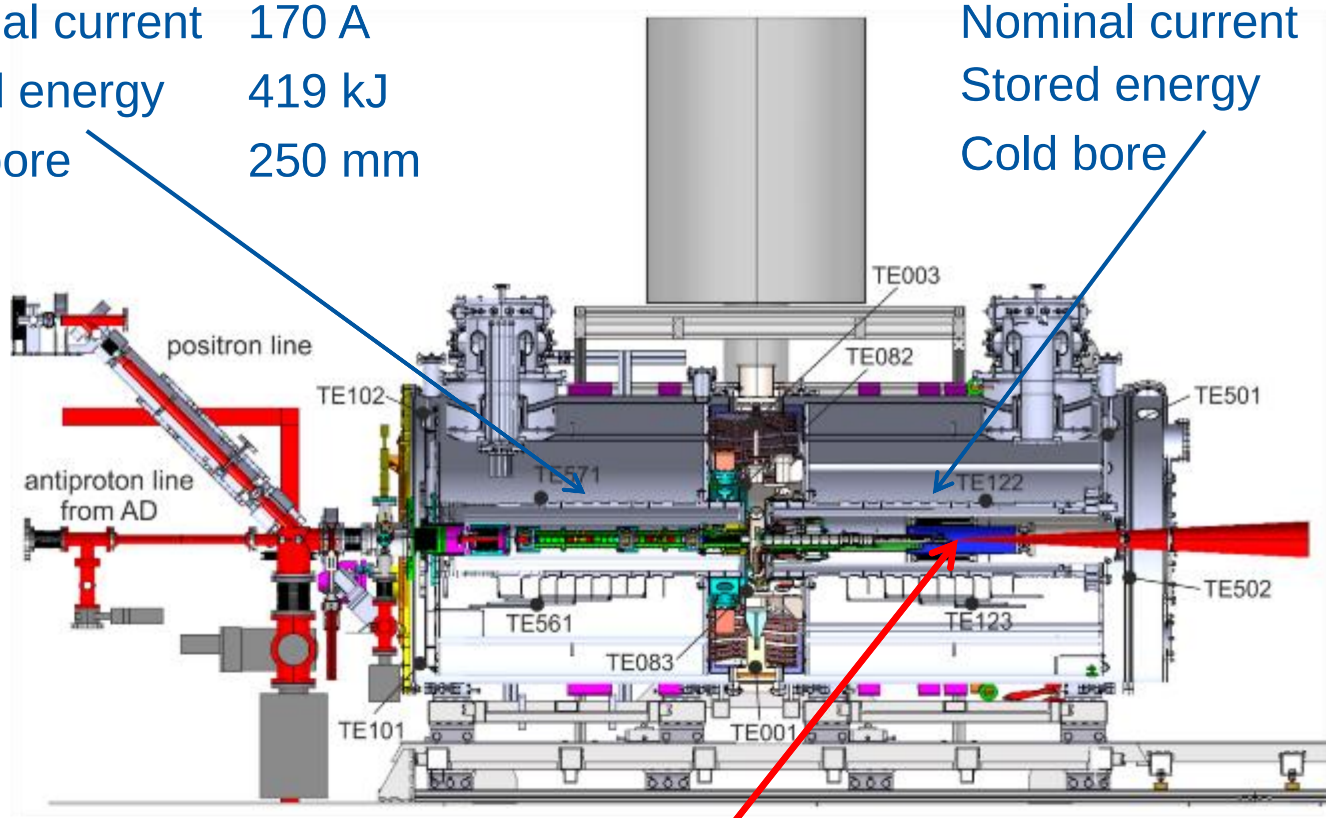
AEgIS apparatus lay-out

5T-magnet

Nominal current	170 A
Stored energy	419 kJ
Cold bore	250 mm

1T-magnet

Nominal current	85A
Stored energy	29 kJ
Cold bore	160 mm



Antihydrogen in a Penning trap below 100 mK

Ultra-Cold Electrodes

- 10 electrodes cooled to 100 mK
- Made of radiation hard materials
- Ultra-high vacuum (< 10^{-12} mbar)
- Electrical insulation for up to 1kV between neighbouring electrodes
- geometry with very high precision

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Sapphire as electrical insulator and good thermal conductor at low temprtature

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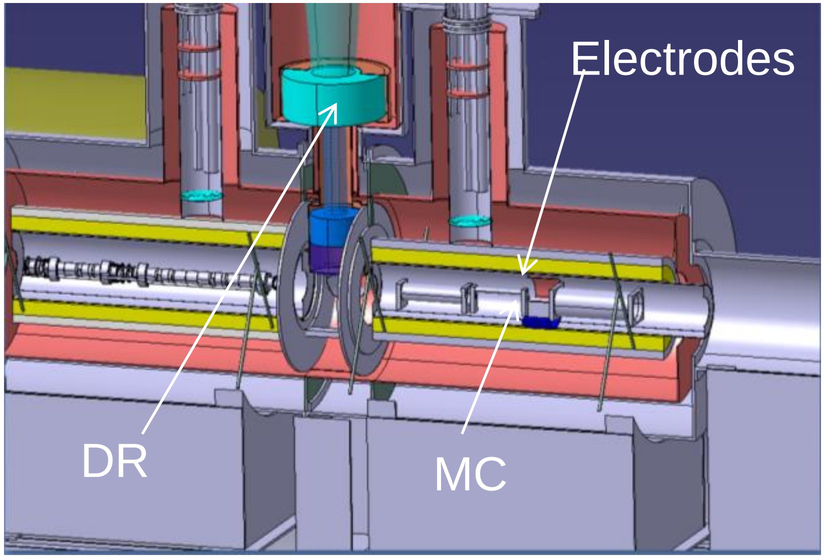
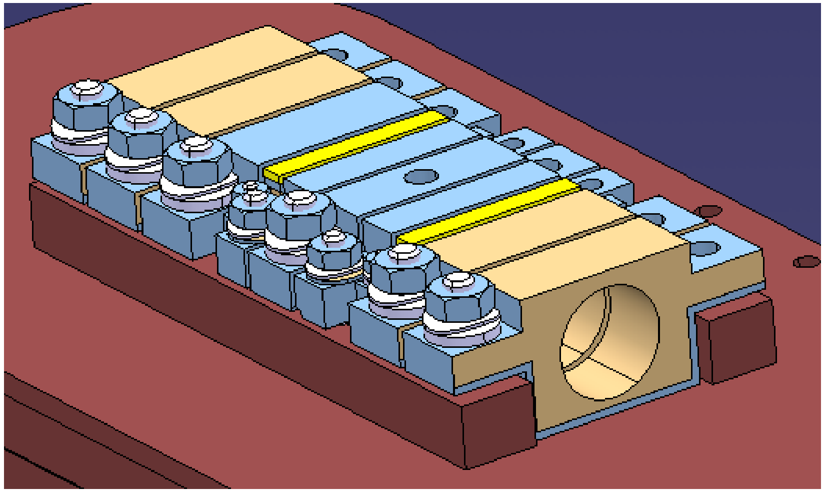
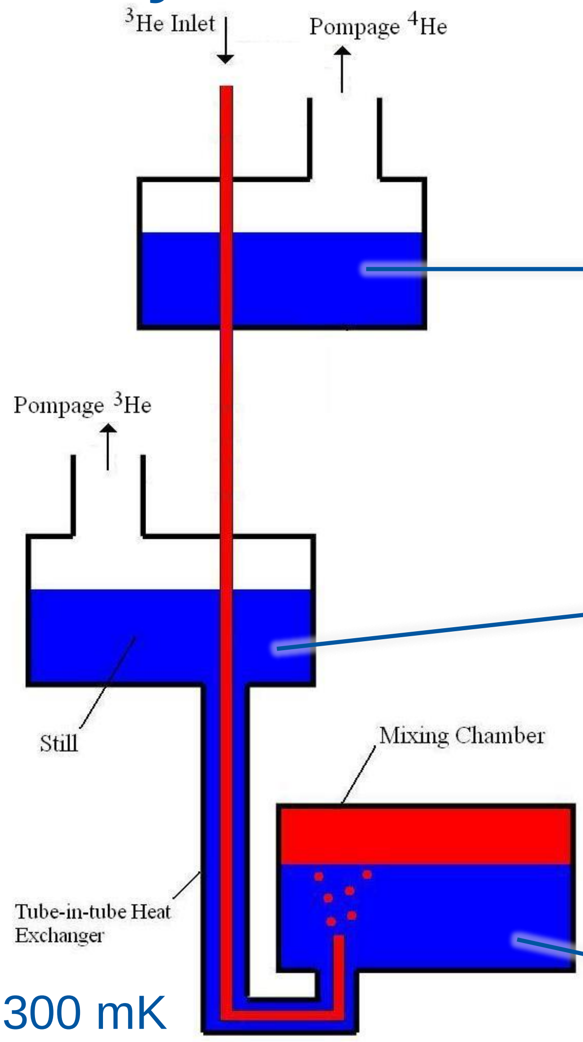
Thermal performance of a metal – dielectric Interface to be studied in 30 – 300 mK range





CERN Cryolab DR



T = 1.3 K

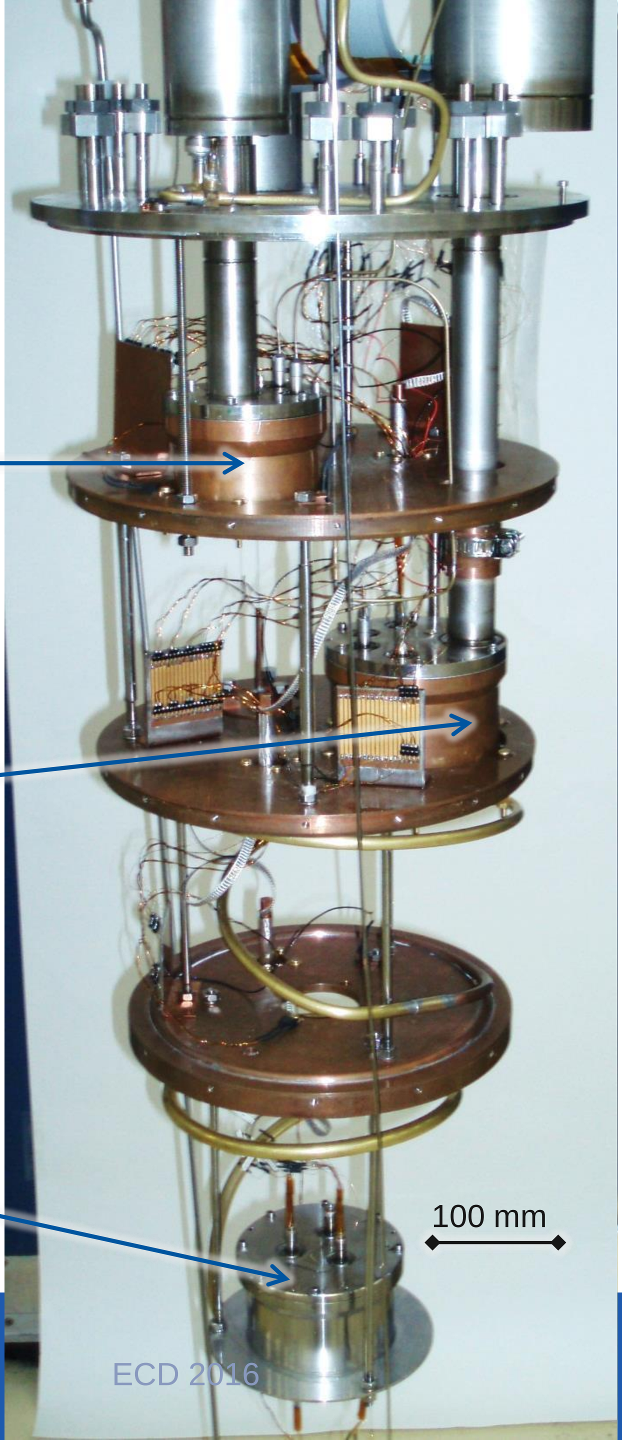
1 K pot

T = 0.6 K

Still

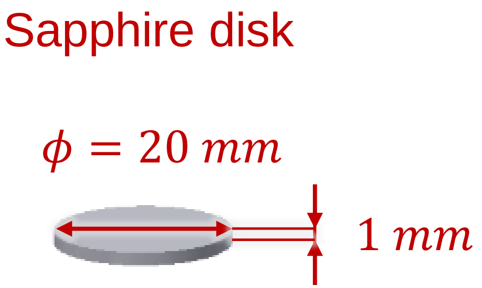
Mixing Chamber

20 mK < T < 300 mK

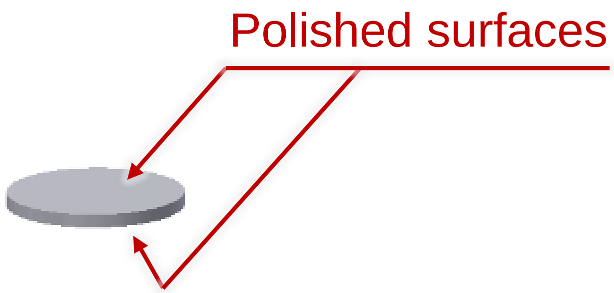


Pictures by Patrick Wikus

Experimental setup



Experimental setup



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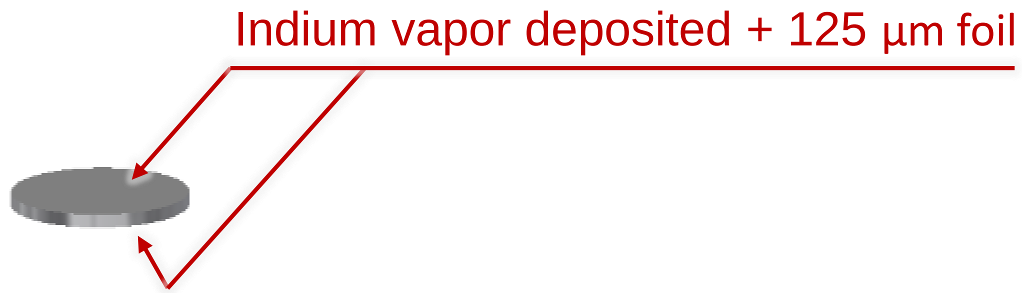

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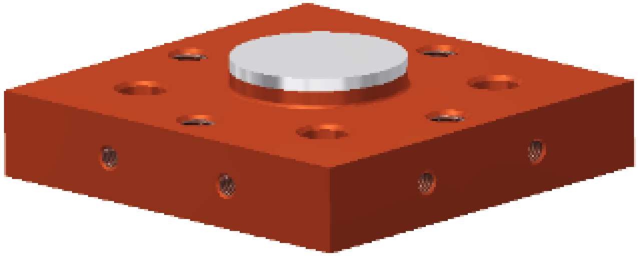
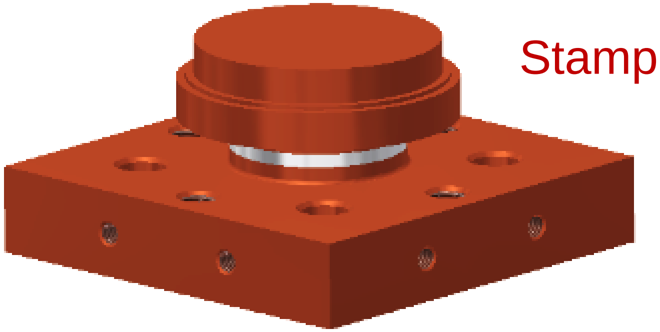
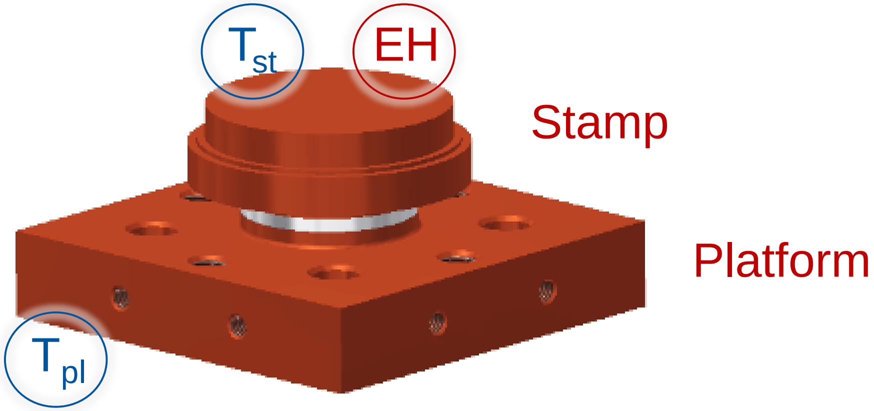


Platform

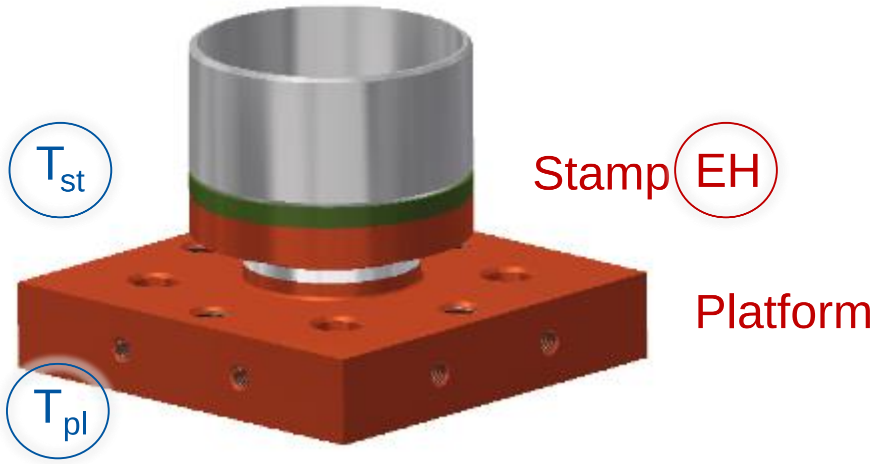
Experimental setup



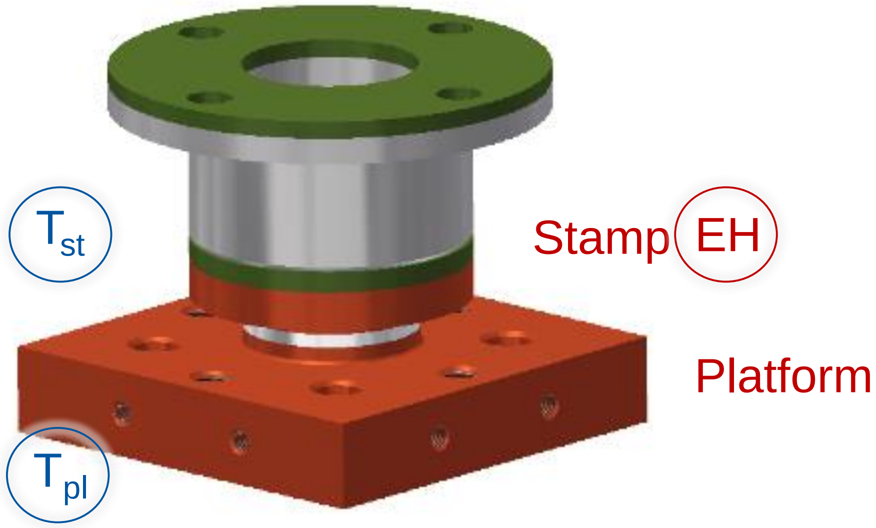
Experimental setup



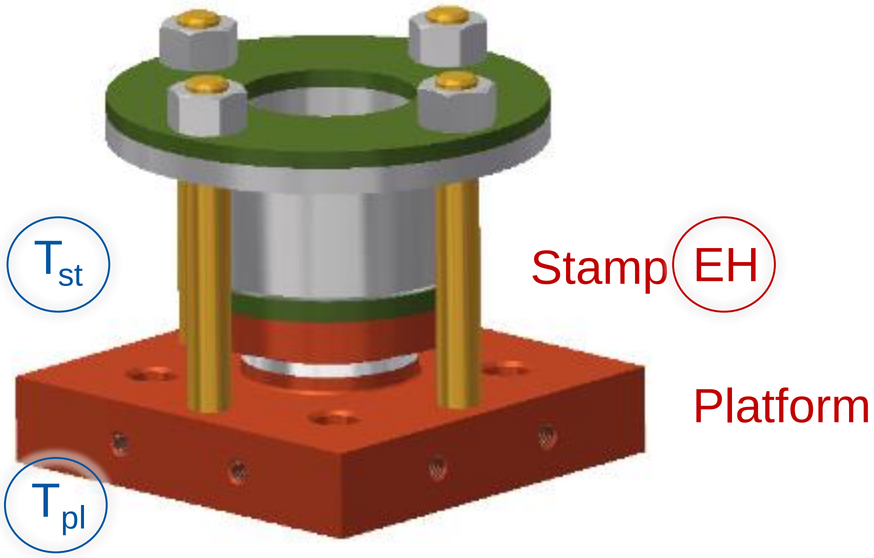
Experimental setup



Experimental setup



Experimental setup



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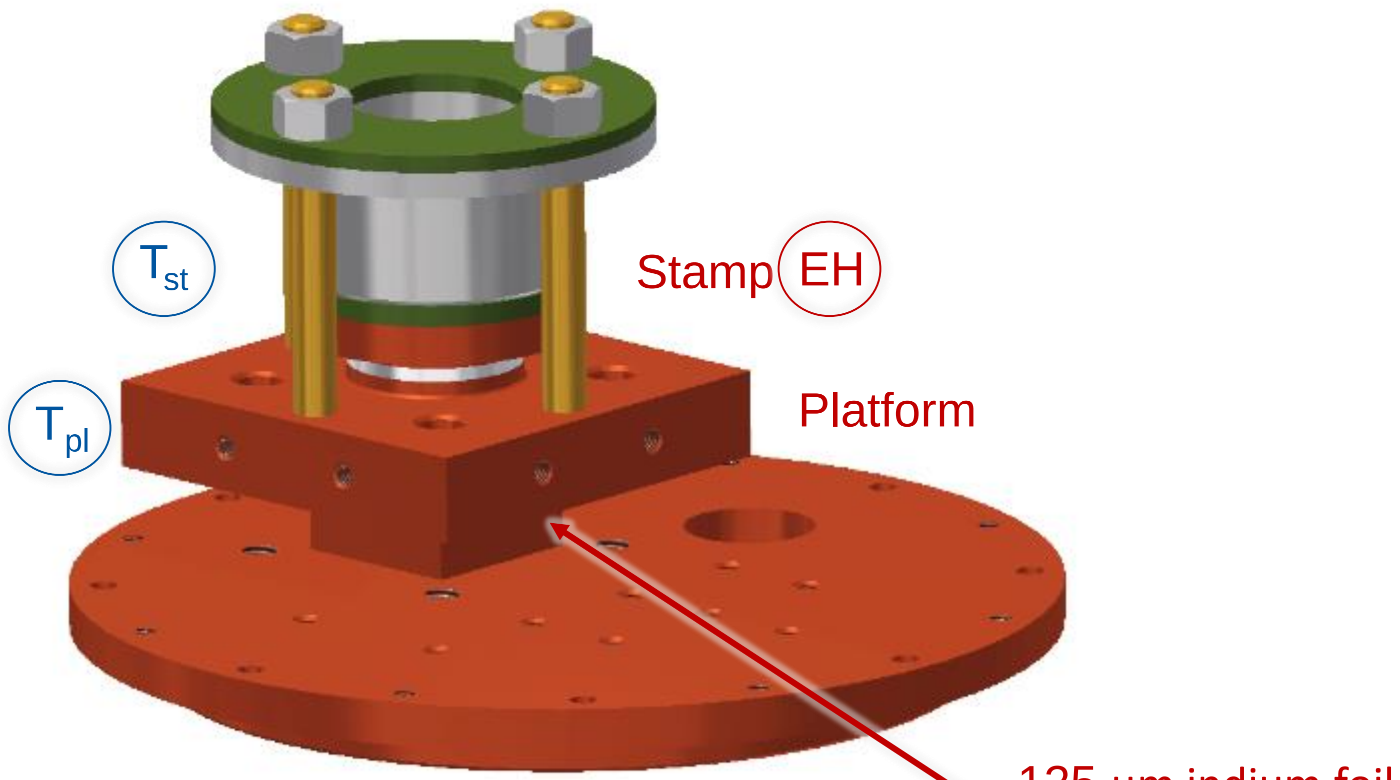

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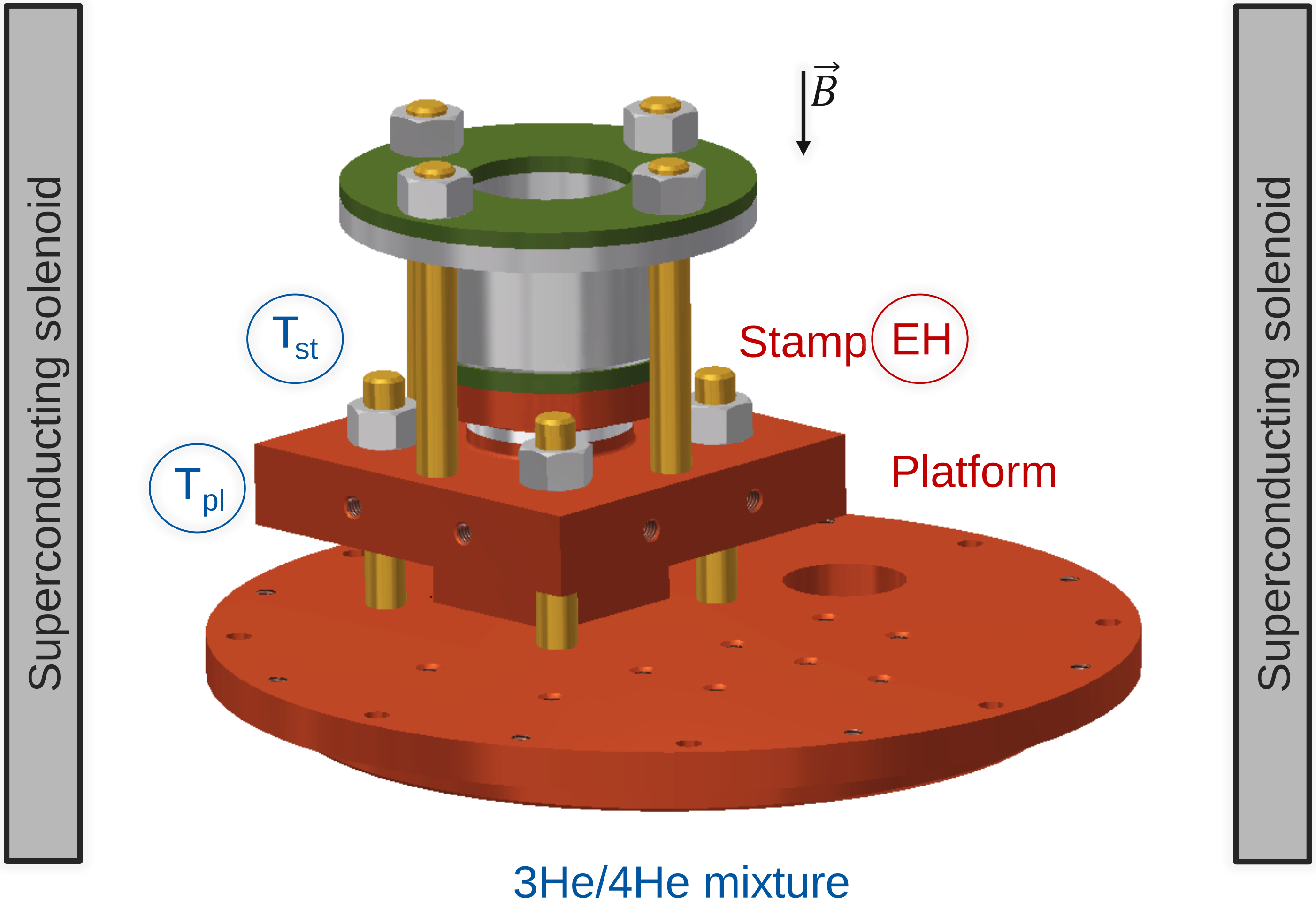
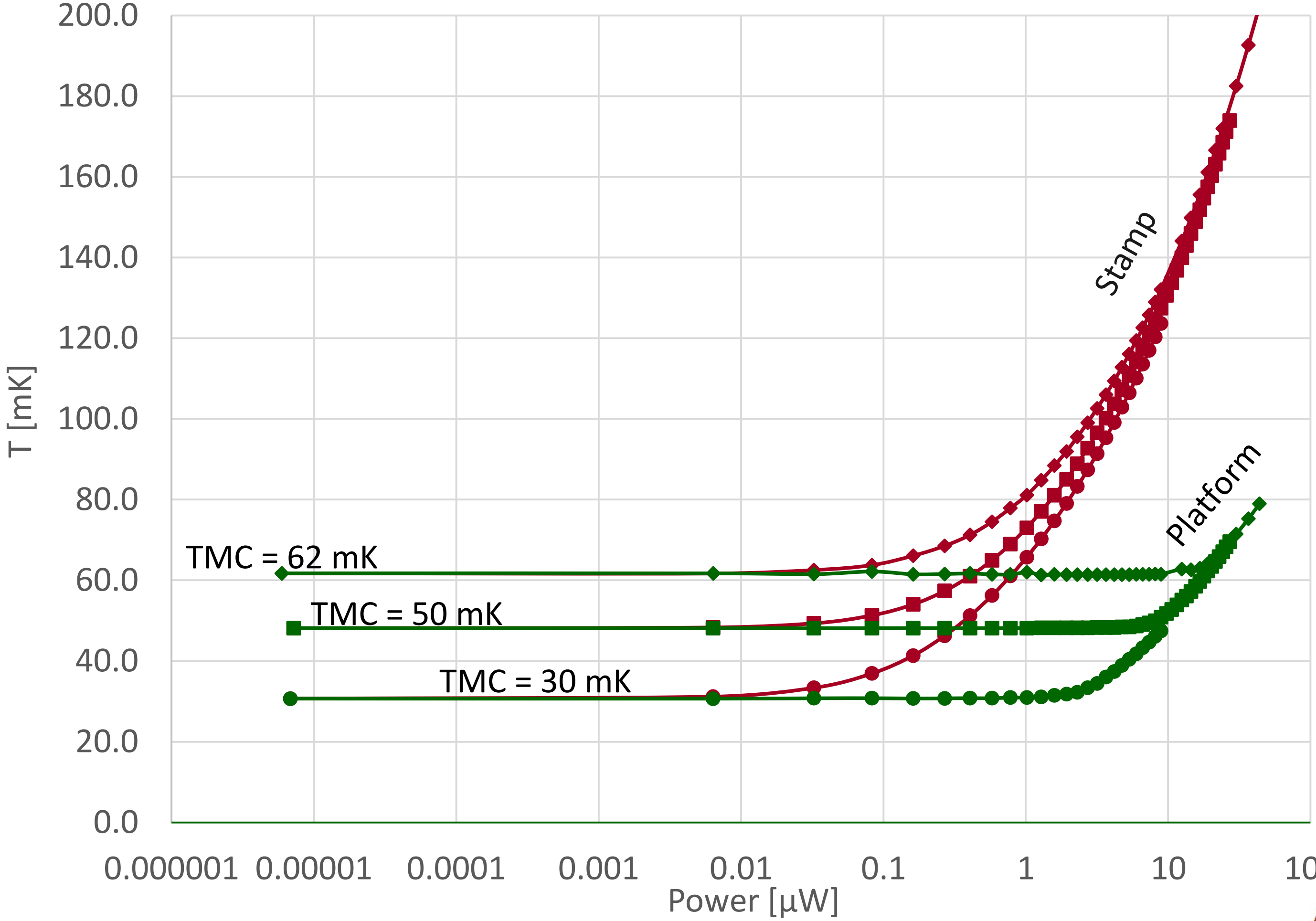
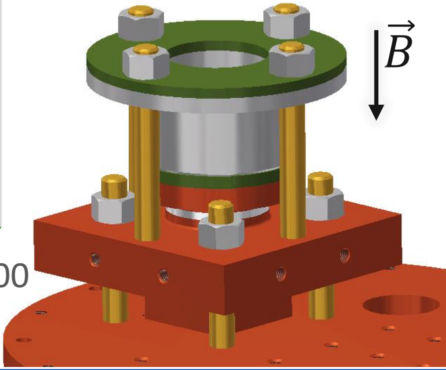
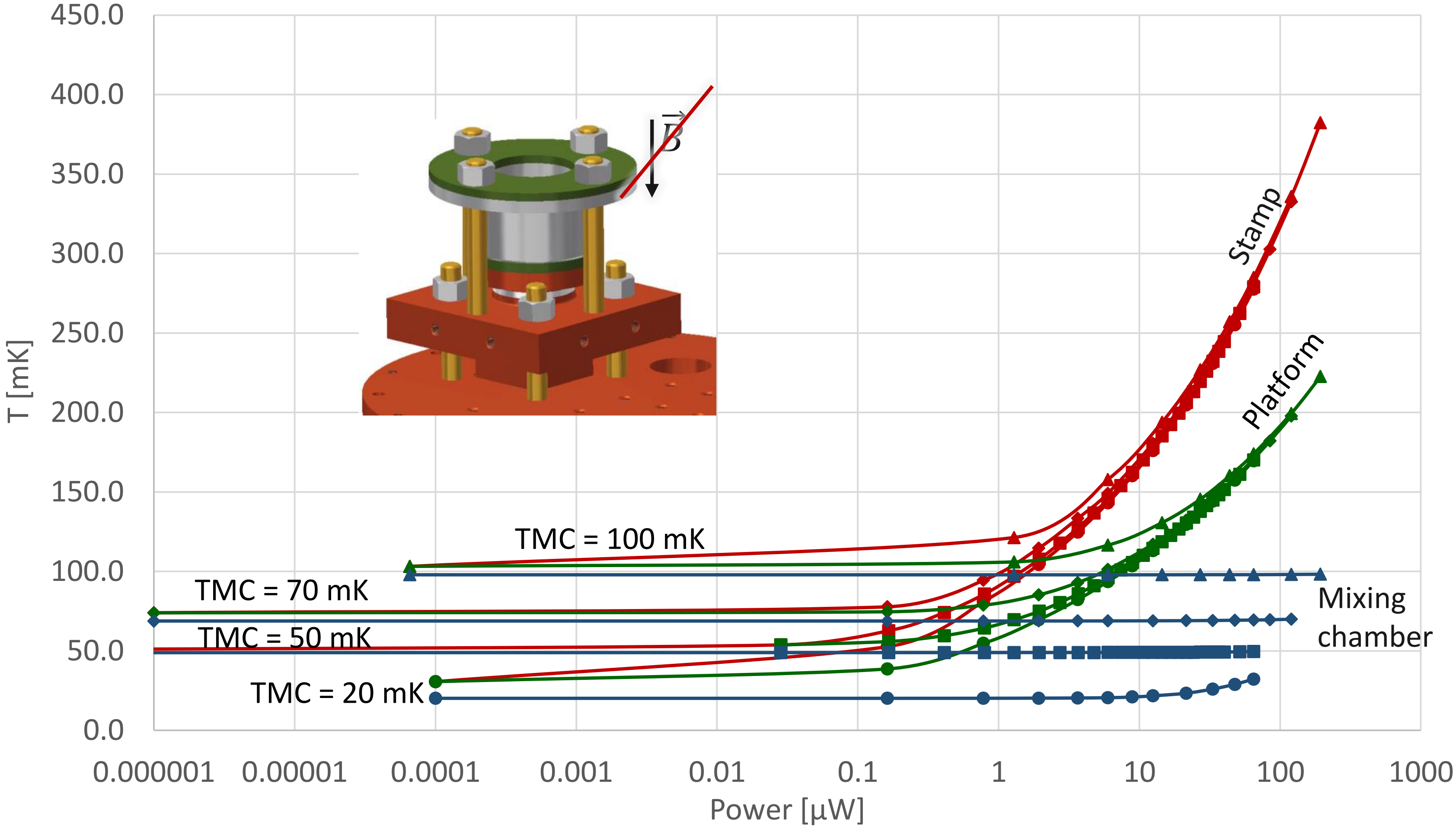


Temperature as a function of applied heat load, Indium in normal conducting state

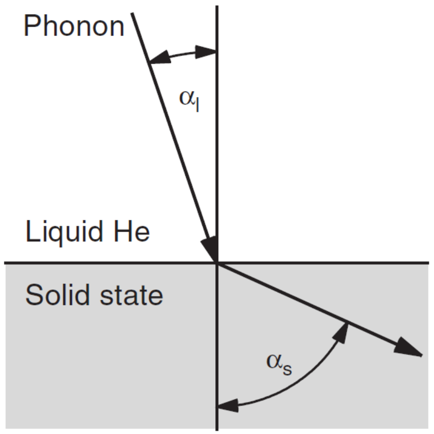




Temperature as a function of applied heat load, Indium in superconducting state



Kapitza resistance



Ch. Enss, S.Hunklinger – Low-Temperature Physics

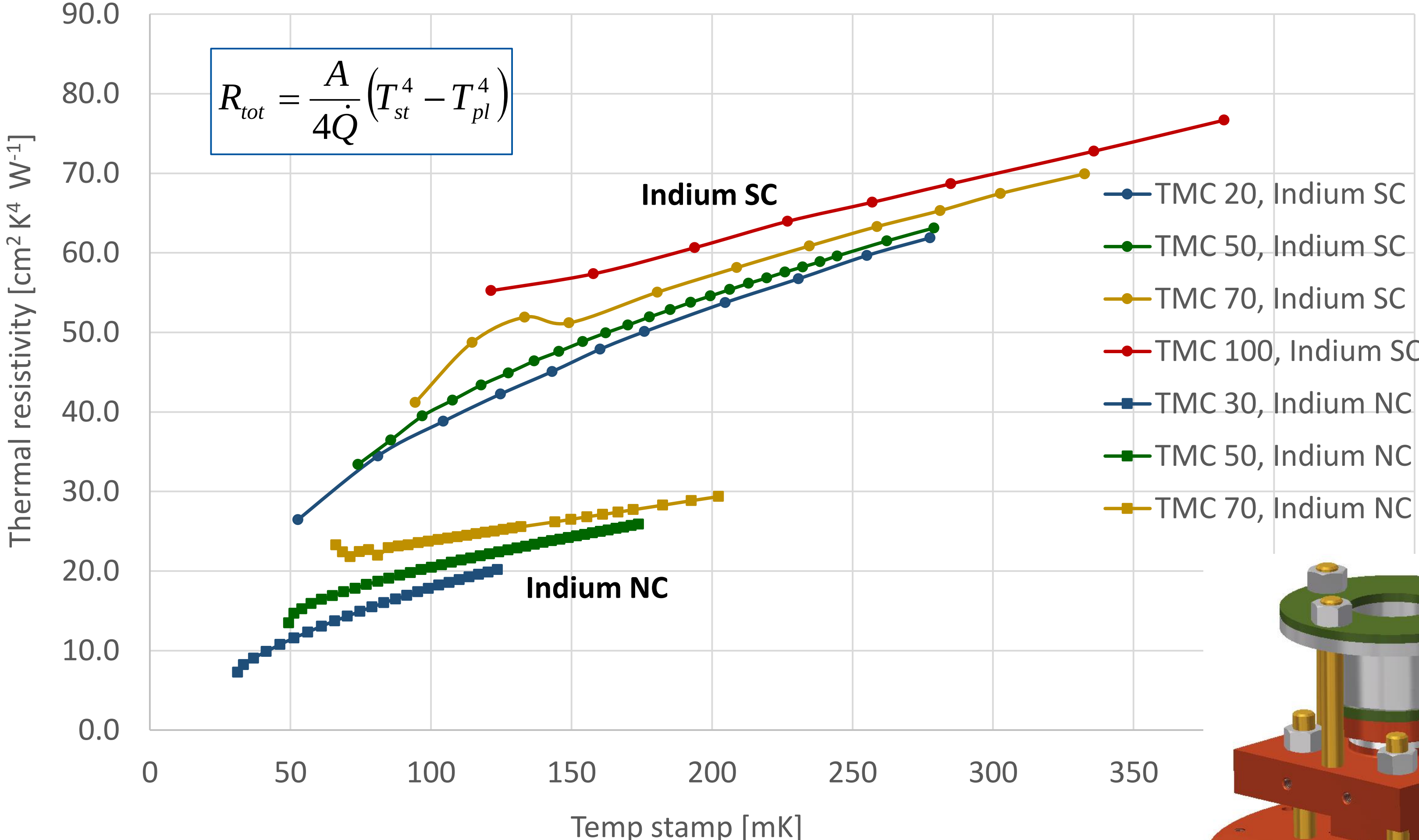
$$R_{tot} = \frac{A}{4\dot{Q}}\left(T_{st}^4 - T_{pl}^4\right)$$

$$\alpha = 4°$$

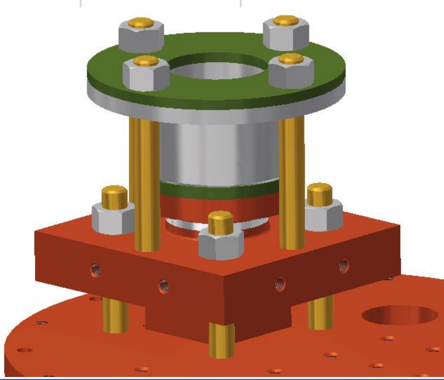
$$t = \frac{4Z_1Z_2}{(Z_1+Z_2)^2}$$

→ helium – copper
only 10^{-5}

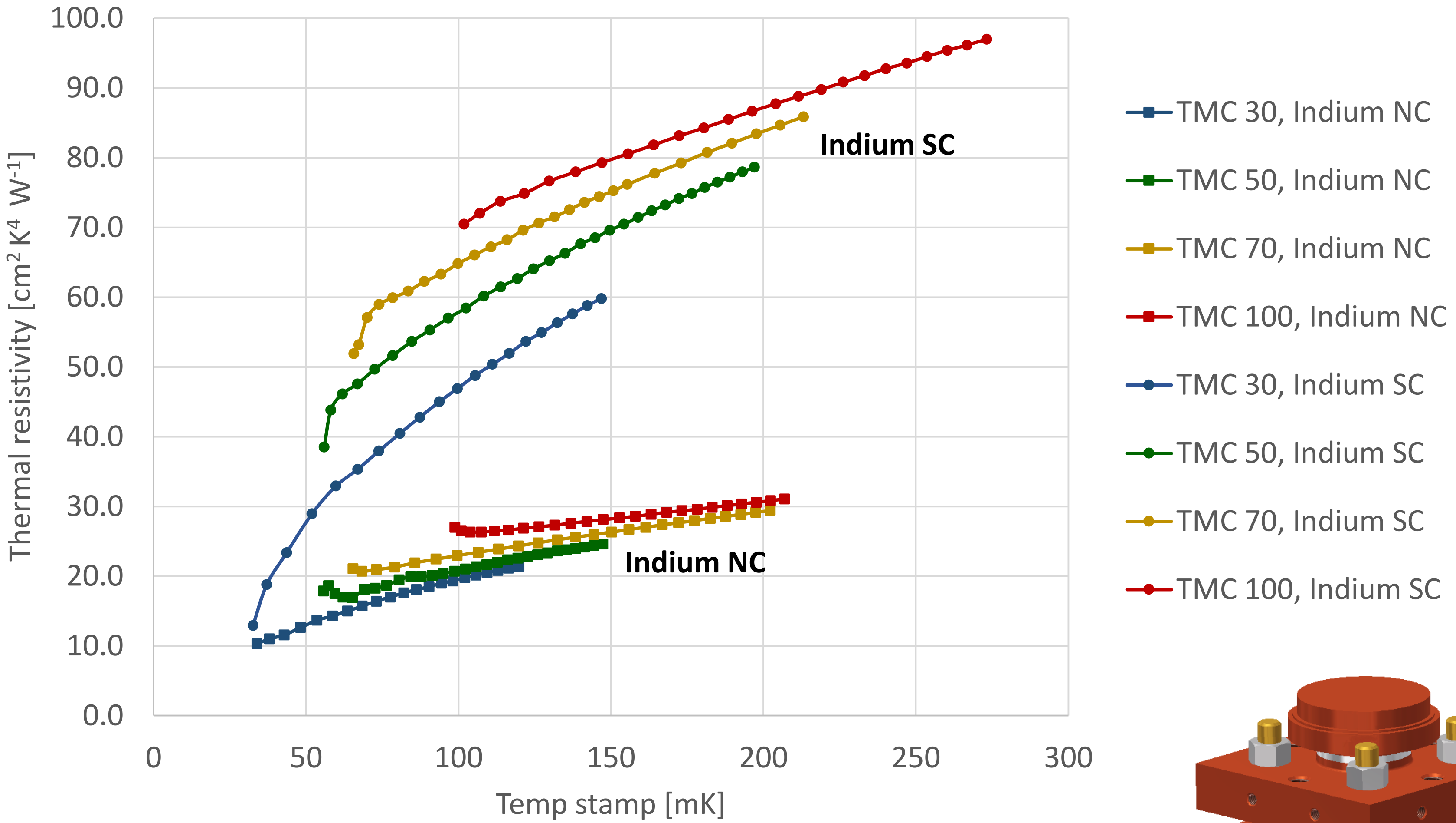
Thermal resistivity of the compressed setup

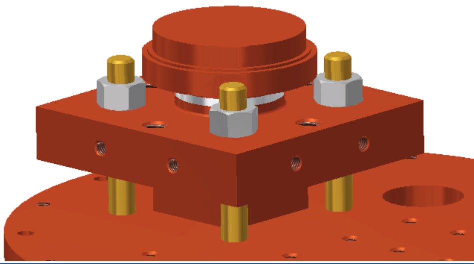


$$R_{tot} = \frac{A}{4\dot{Q}}\left(T_{st}^{4} - T_{pl}^{4}\right)$$

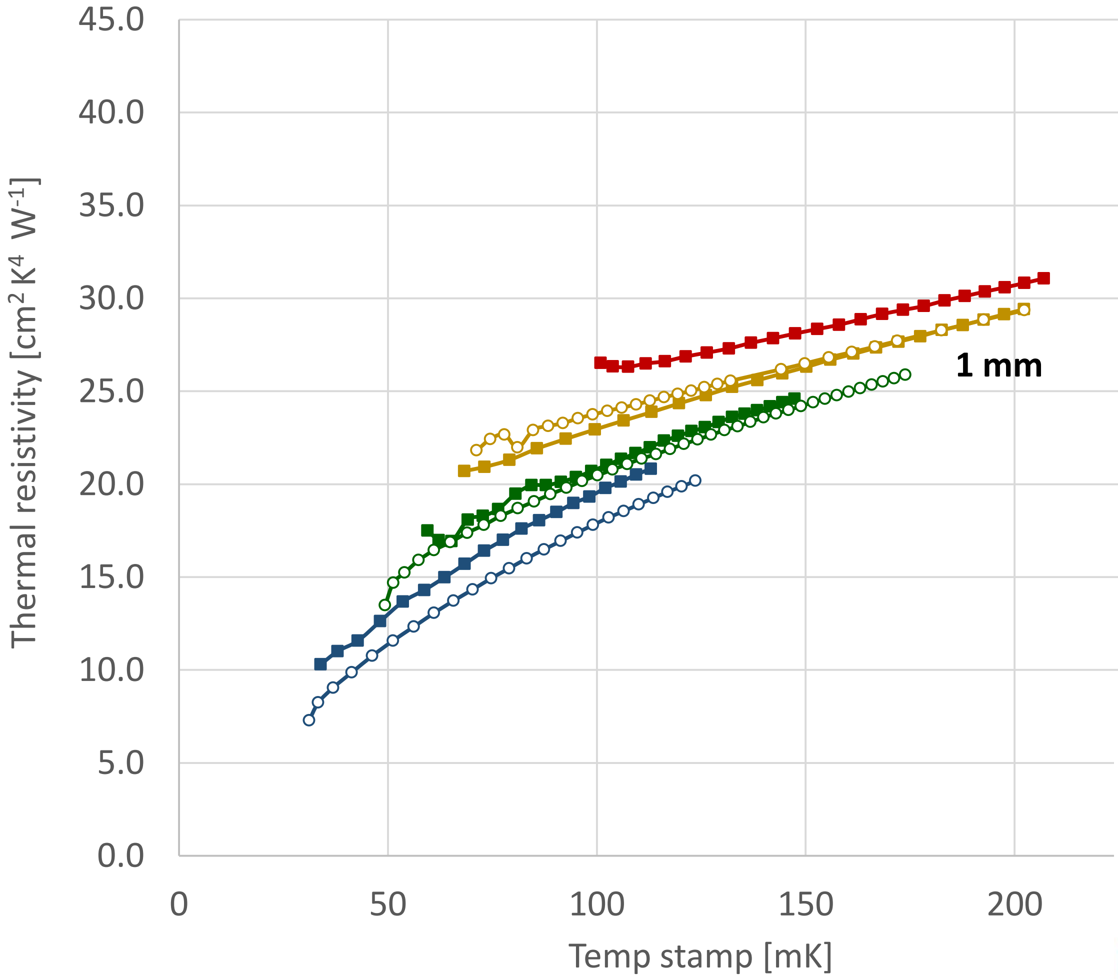


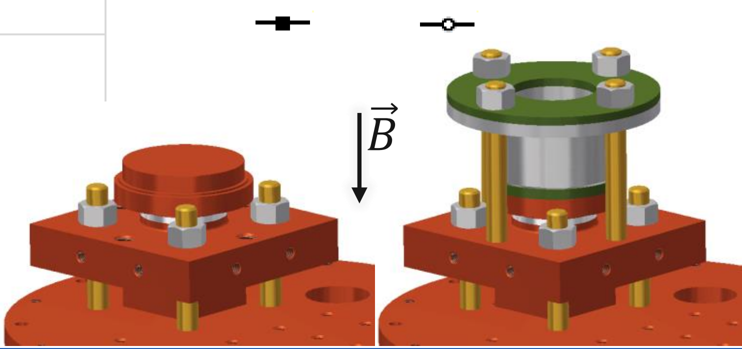
Thermal resistivity without compressing force



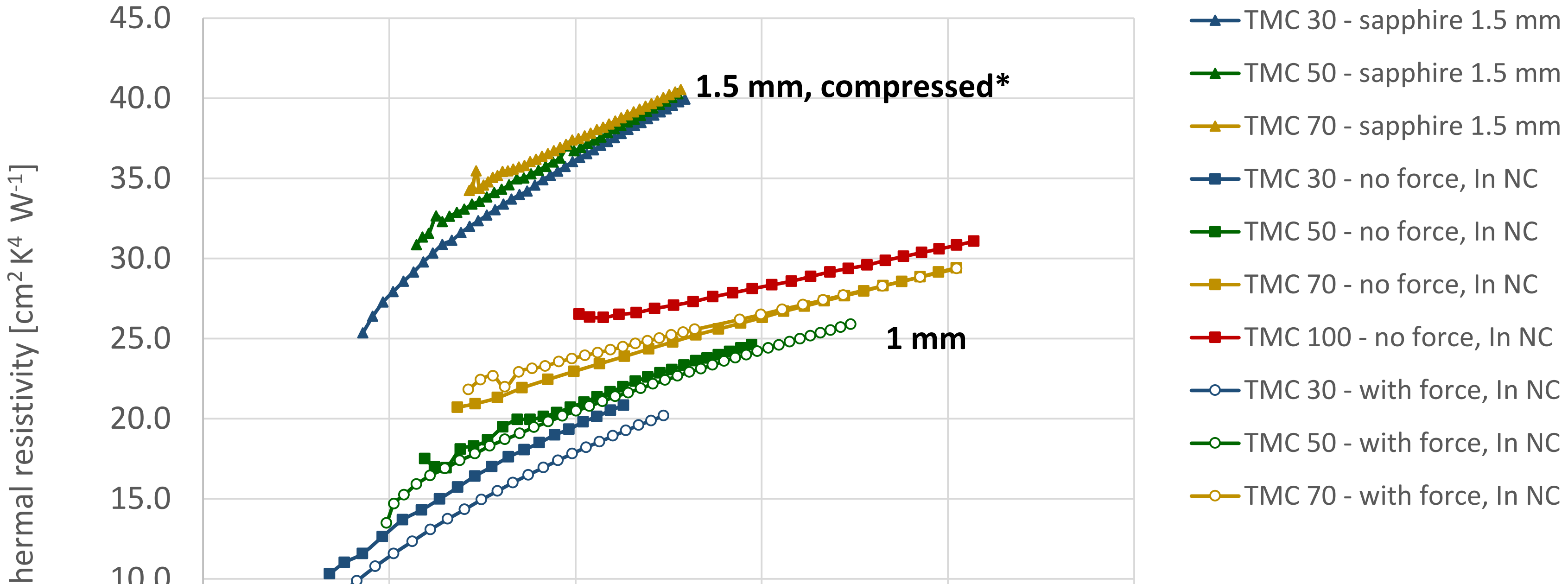


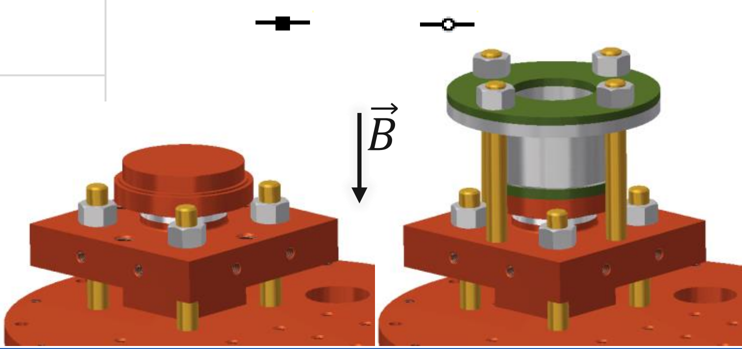
Thermal resisitivity with NC indium





Thermal resisitivity of the setup with 1 mm and 1.5 mm sapphire disk with NC indium





*Courtesy T. Eisel, PhD Thesis, CERN, Cryolab

Conclusions

- Surface preparation essential – polished surface with vapor deposited indium gives the best results
- The presence of the magnetic field shifts the dielectric – metallic interface and significantly changes the overall resistivity
- Compressing force doesn't influence the results with indium in normal conducting state
- The electrode mounting structure in AEgIS can be removed after a good connection is obtained

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