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DESY.

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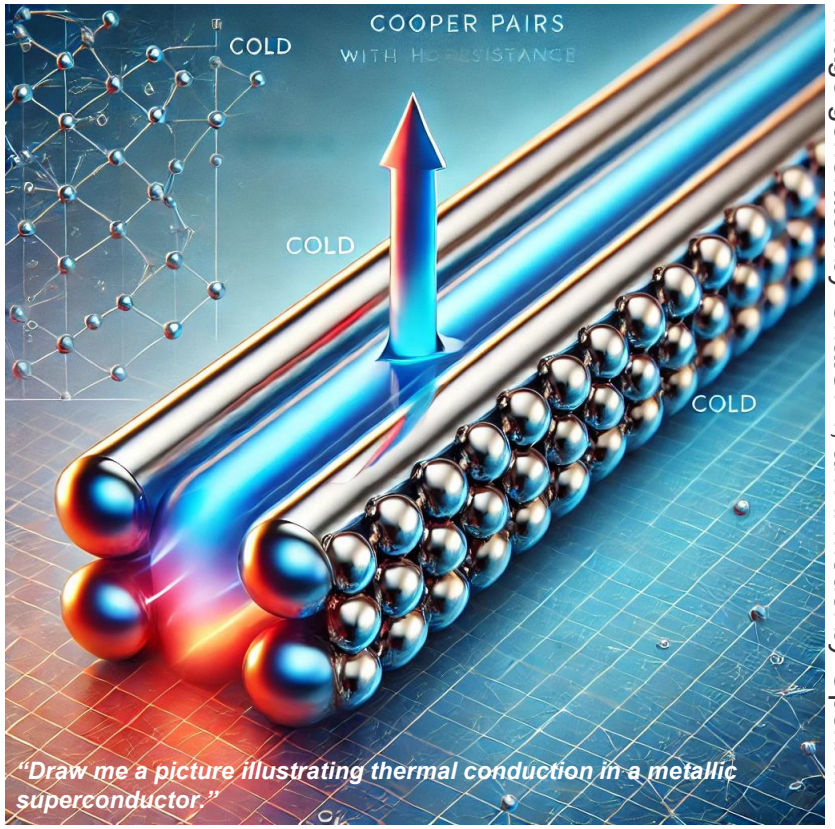

Image generated by ChatGPT, an AI model by OpenAI.

Thermal transmittance measurements of SIS & Nb_3Sn coated samples at cryogenic temperatures

19.09.2024

Marc Wenskat – on behalf SRF R&D Team
emphasis on Leon King, Anton Lorf, Cem Saribal

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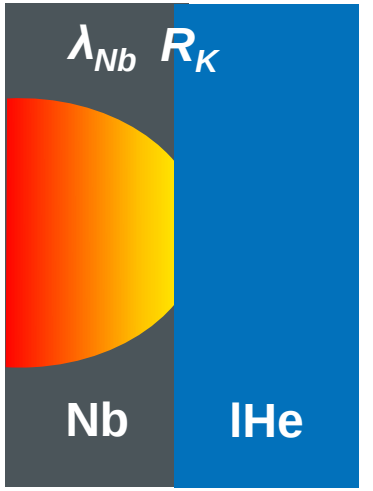

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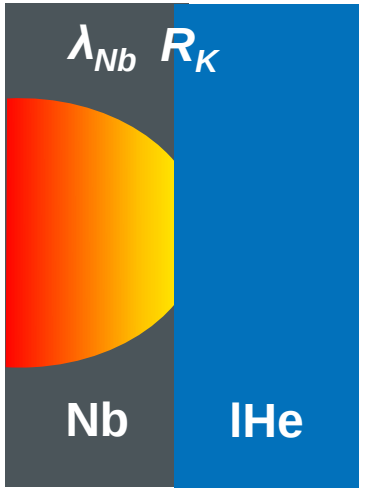

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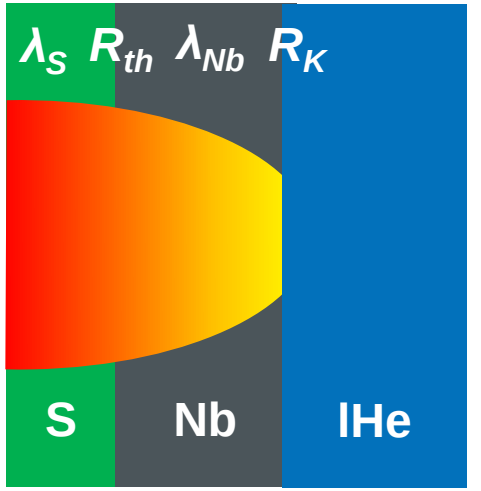
- Does overall thermal transmittance K deteriorate after coating of Nb?
  - Is the thermal conductivity λ the culprit?
  - The thermal interface resistance R_{th} between layer and substrate?
  - What about the Kapitza-Resistance R_K of the coated layer?



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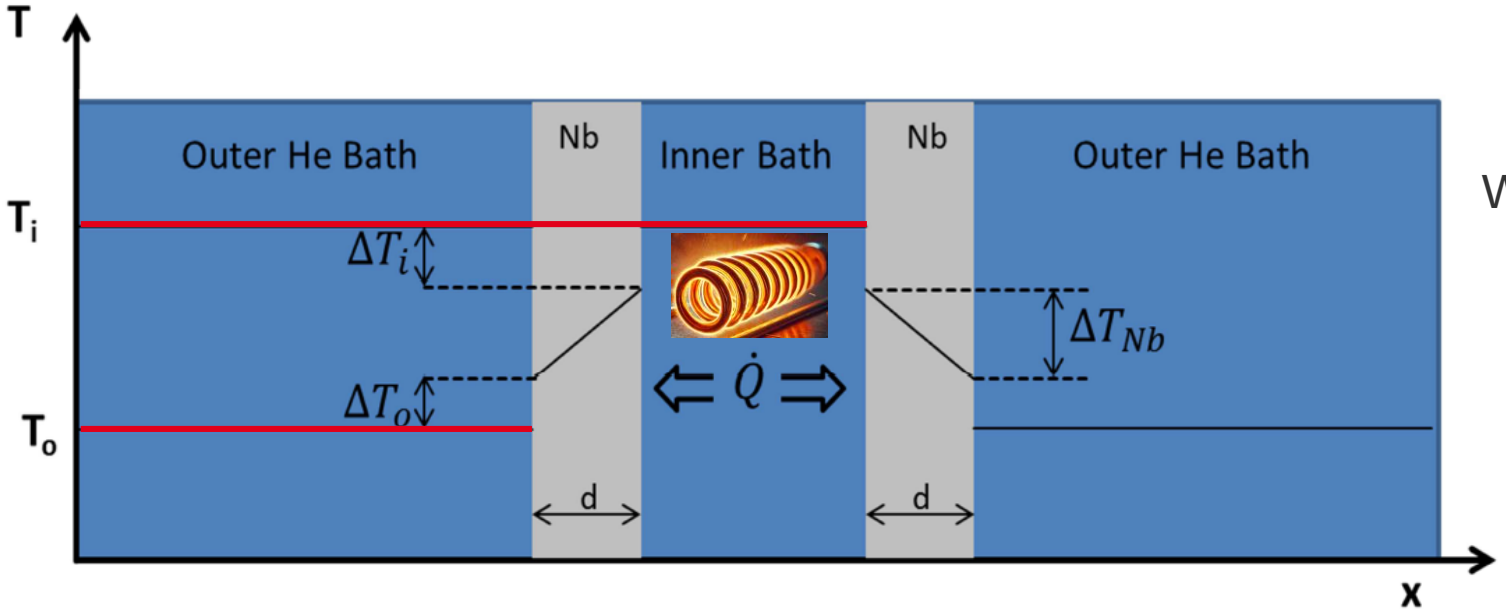
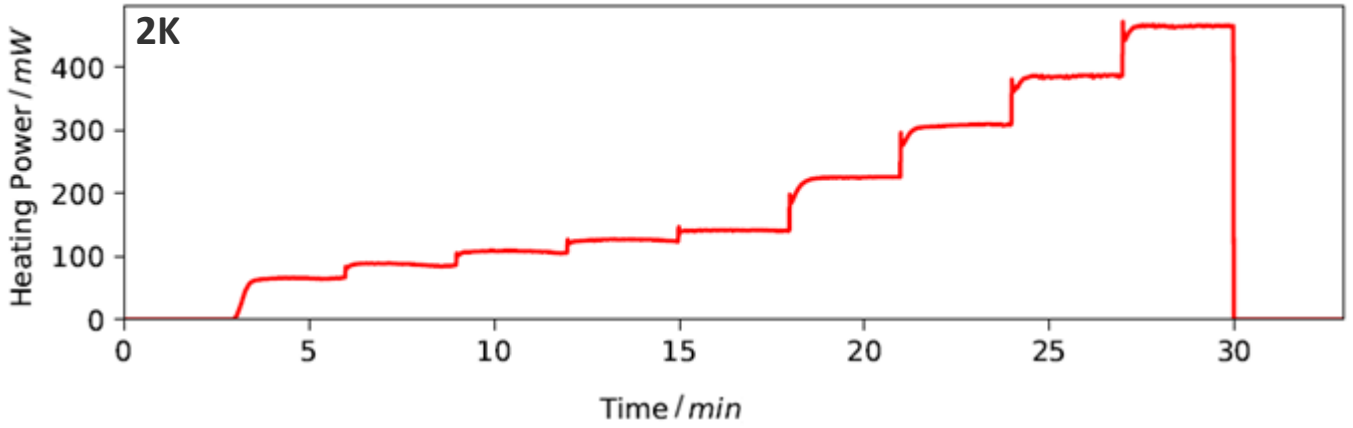


We know *A*, control $\dot{Q}$ and measure T_i and T_o

$$\underbrace{\left(\frac{d}{\lambda} + R_K\right)}_{1/K} \dot{Q} = A \cdot (T_i - T_o)$$

1/K → This is what we obtain

Measurement procedure



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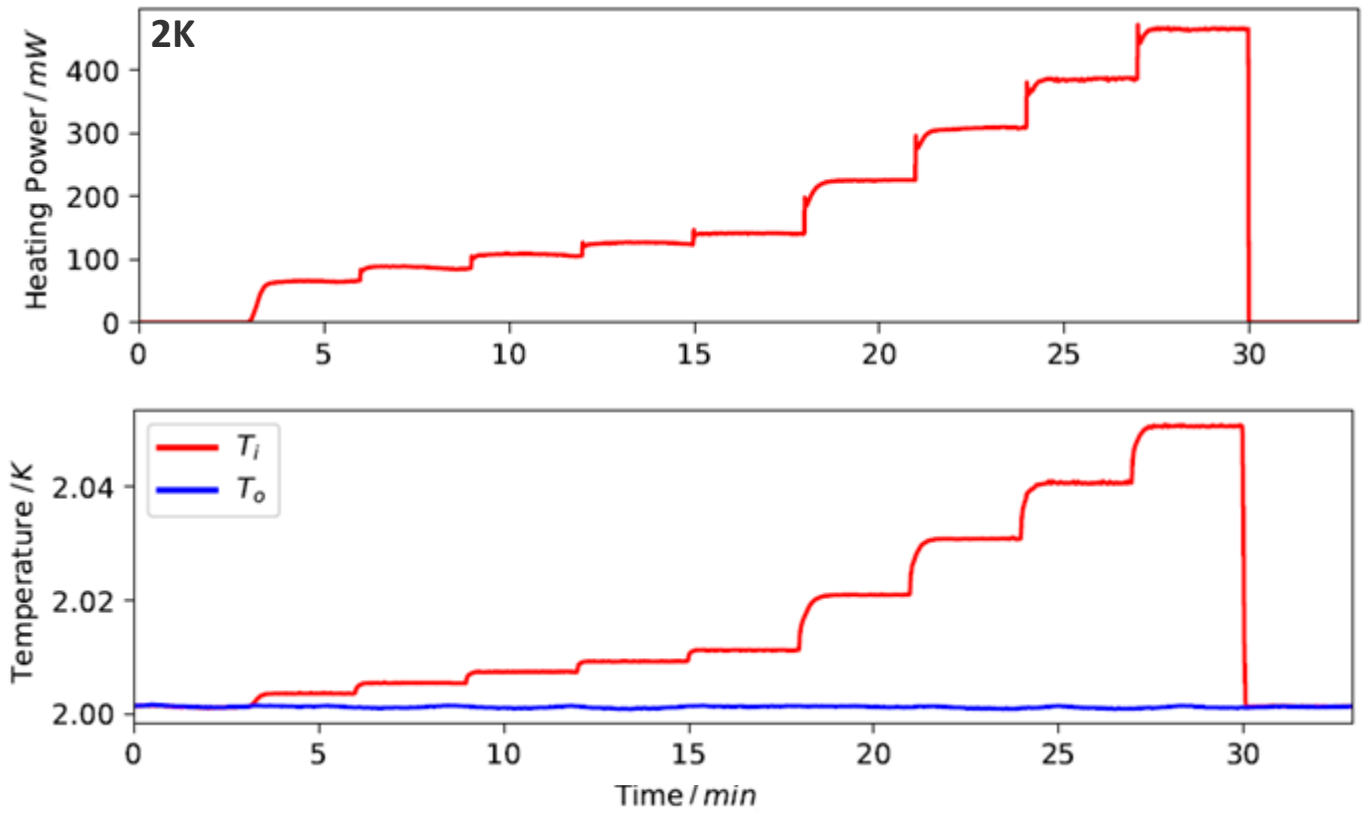

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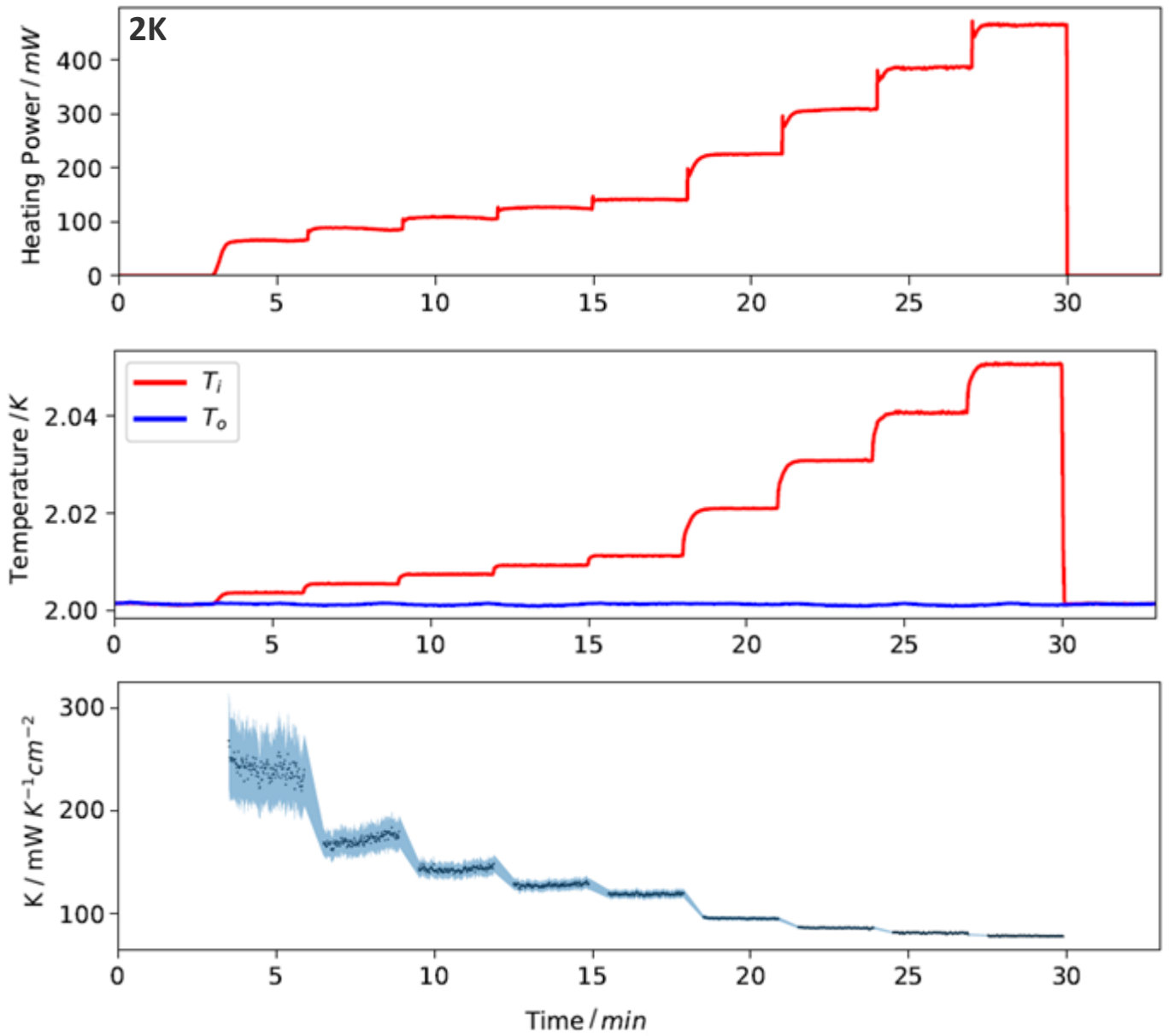

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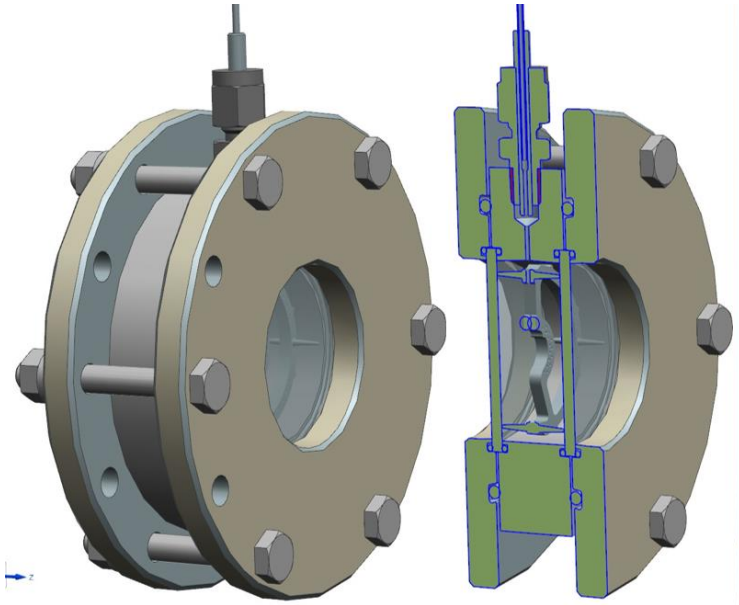

Cell Ø=106mm
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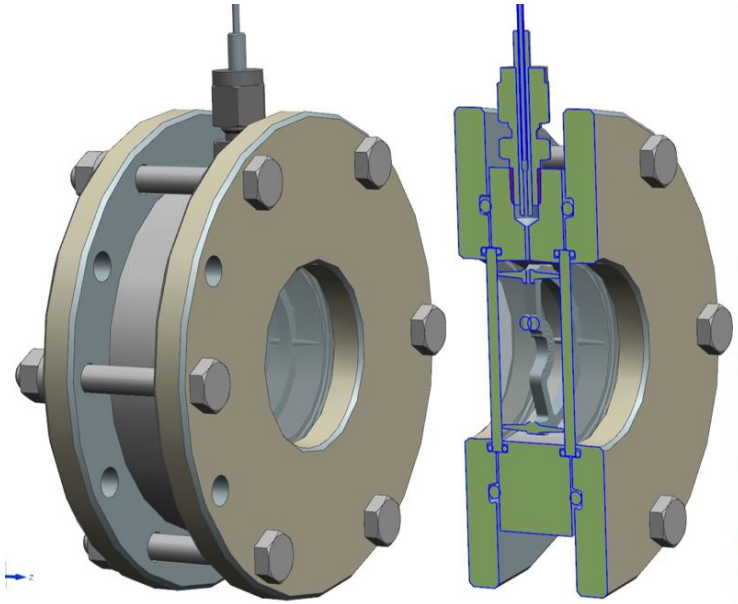

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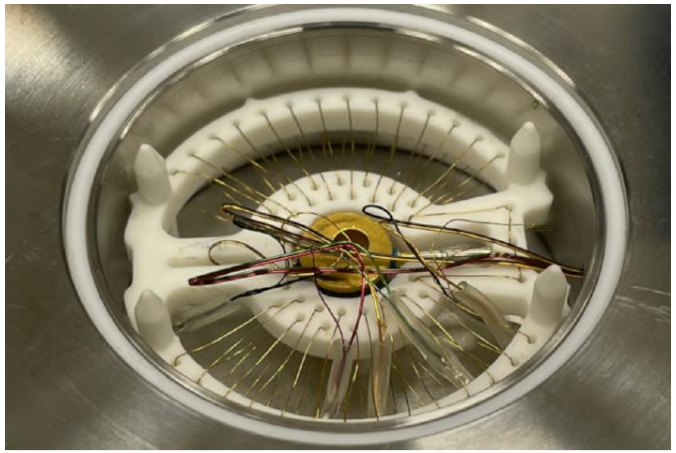
T-sensor inside & outside
Manganin heating wire inside



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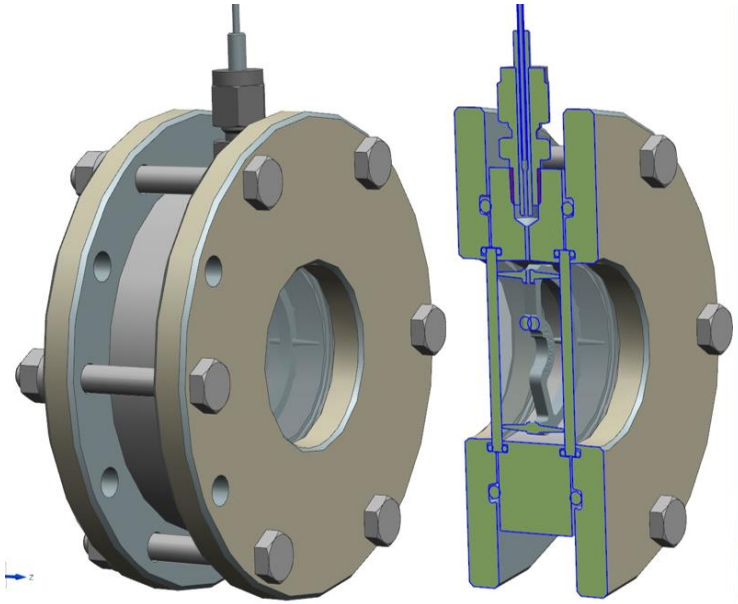

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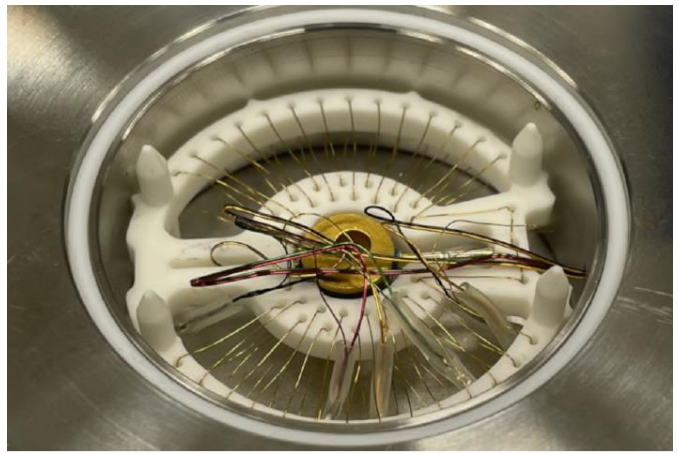

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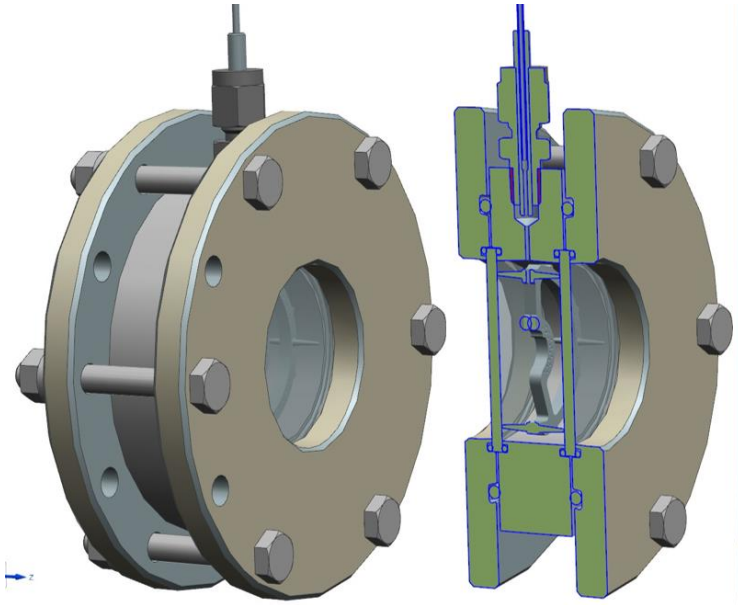

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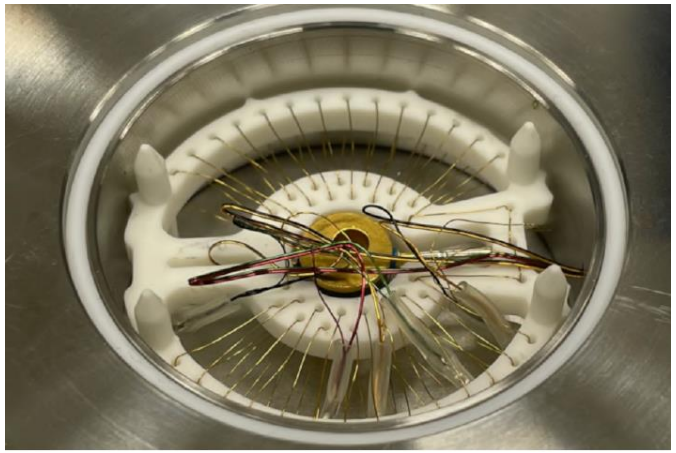
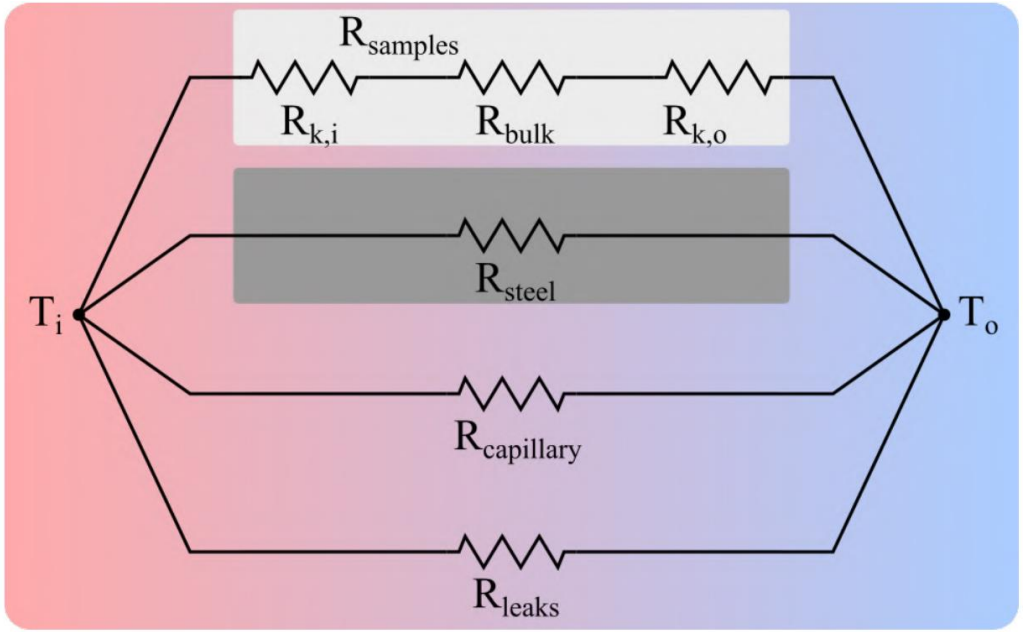


- Filling by 1m capillary with Ø=1mm to thermally decouple inside
- Electrical wires go through there (heater & T-sensor)
- Only glued / screwed → high chance of leaks

Systematic uncertainties?



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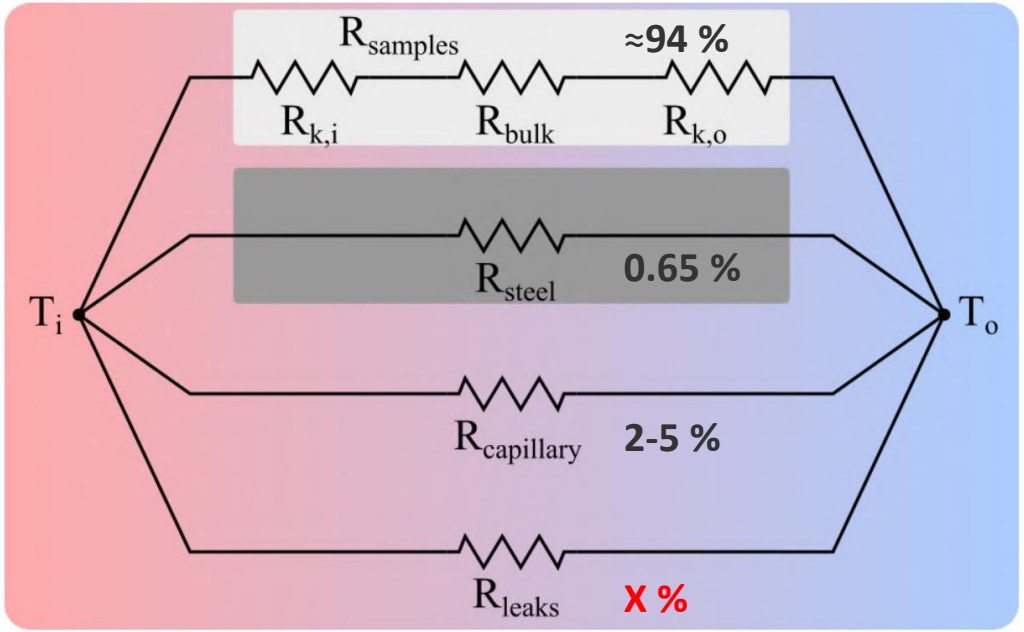

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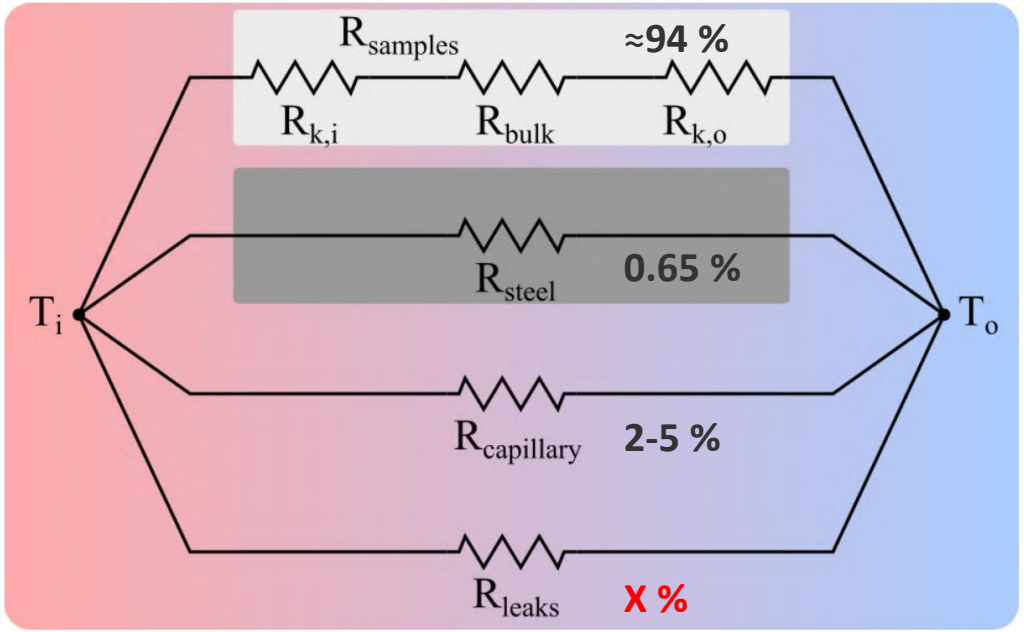

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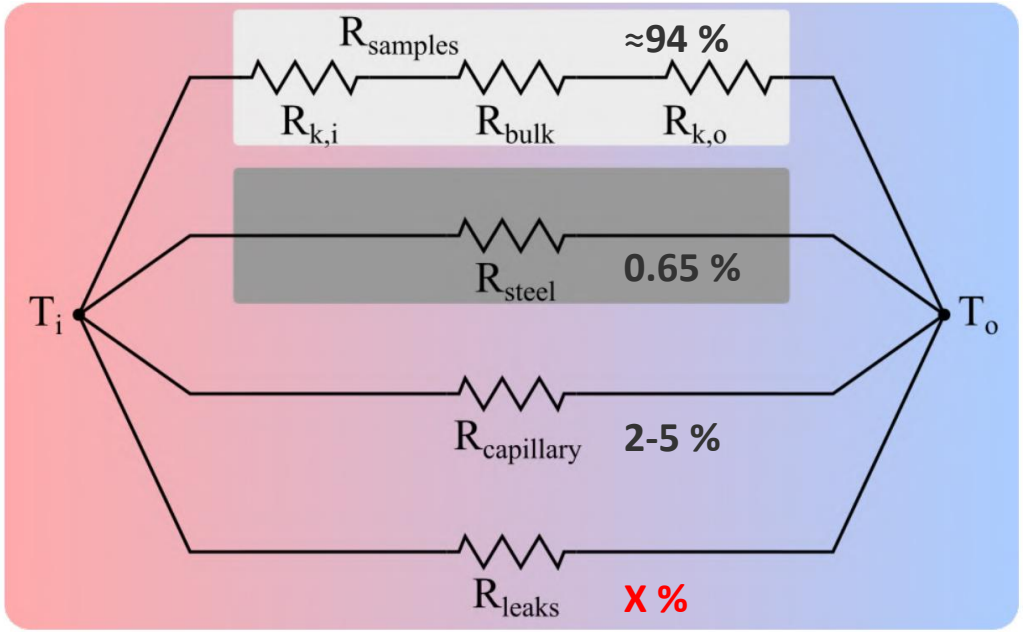

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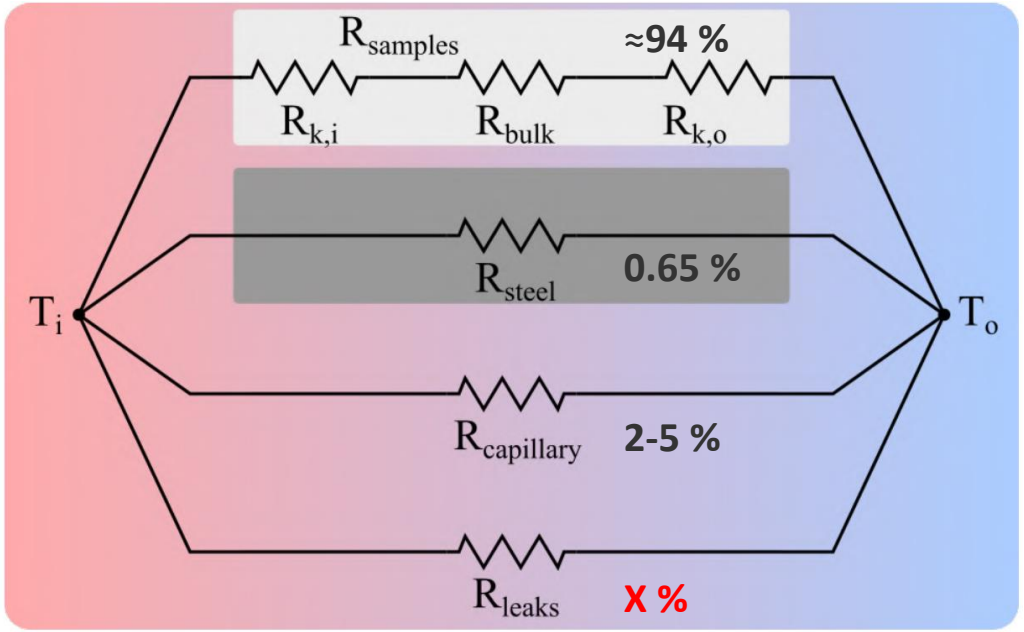

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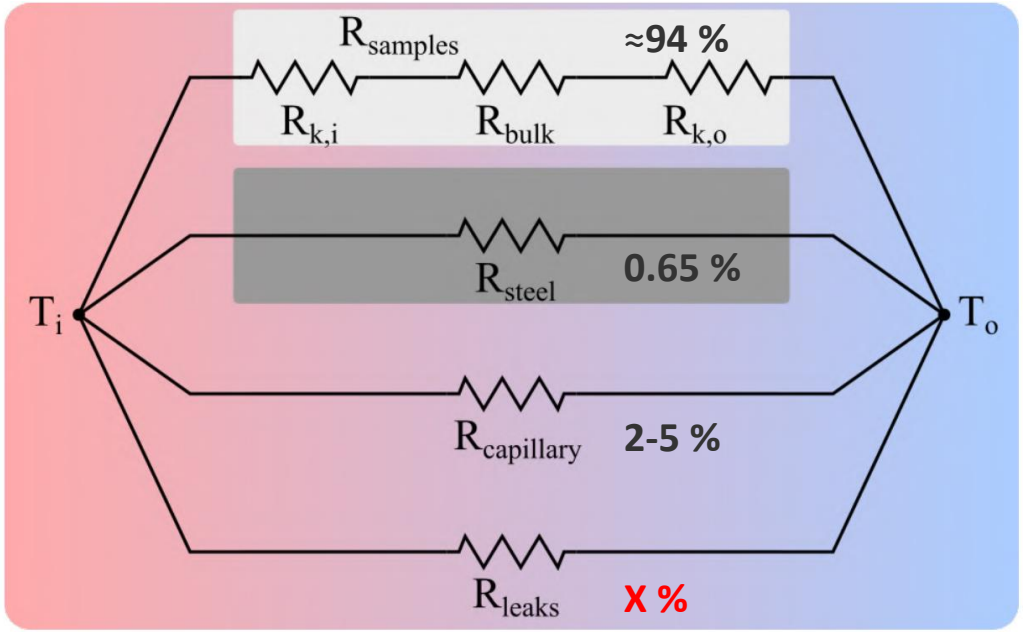

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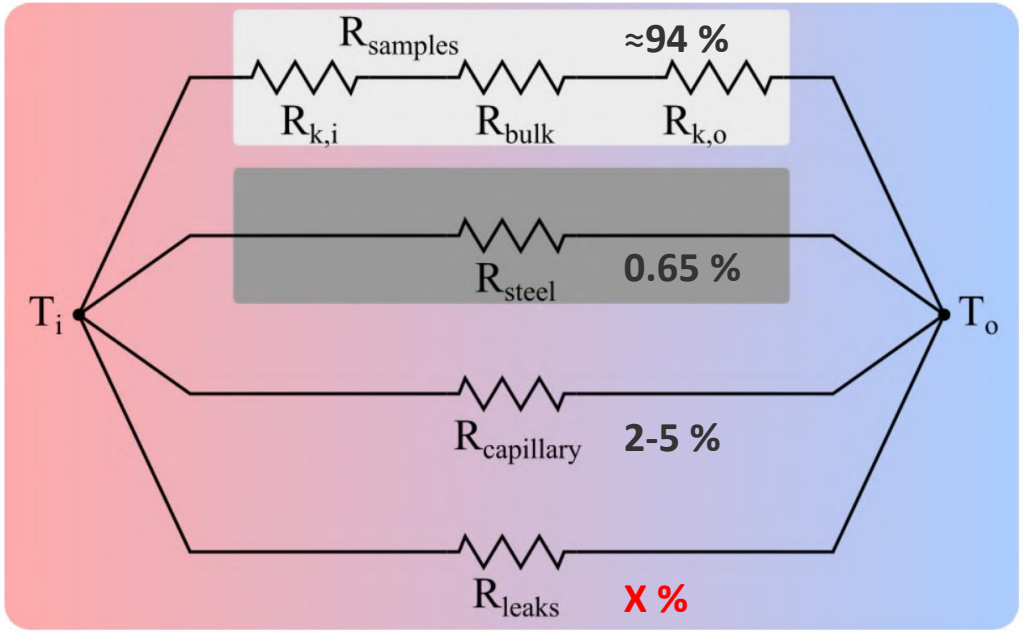

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$$K(\dot{Q}) = K_0 + a \cdot \left(\frac{\dot{Q}}{\dot{Q}_0}\right)^n$$

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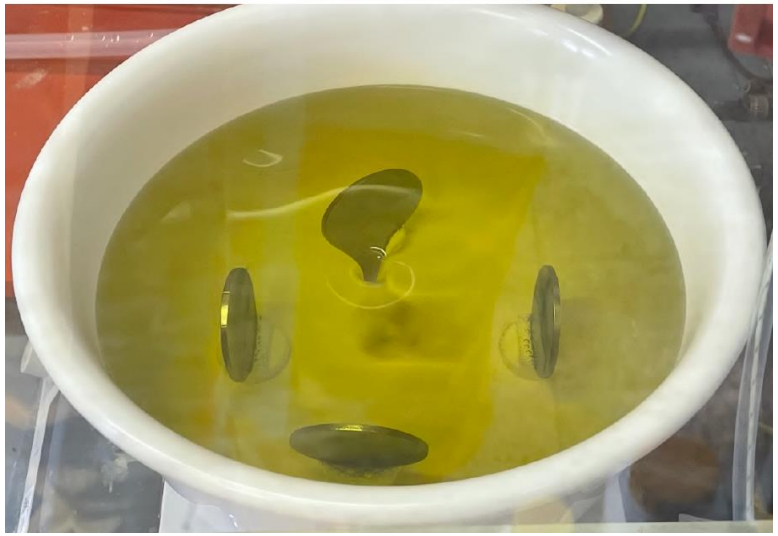

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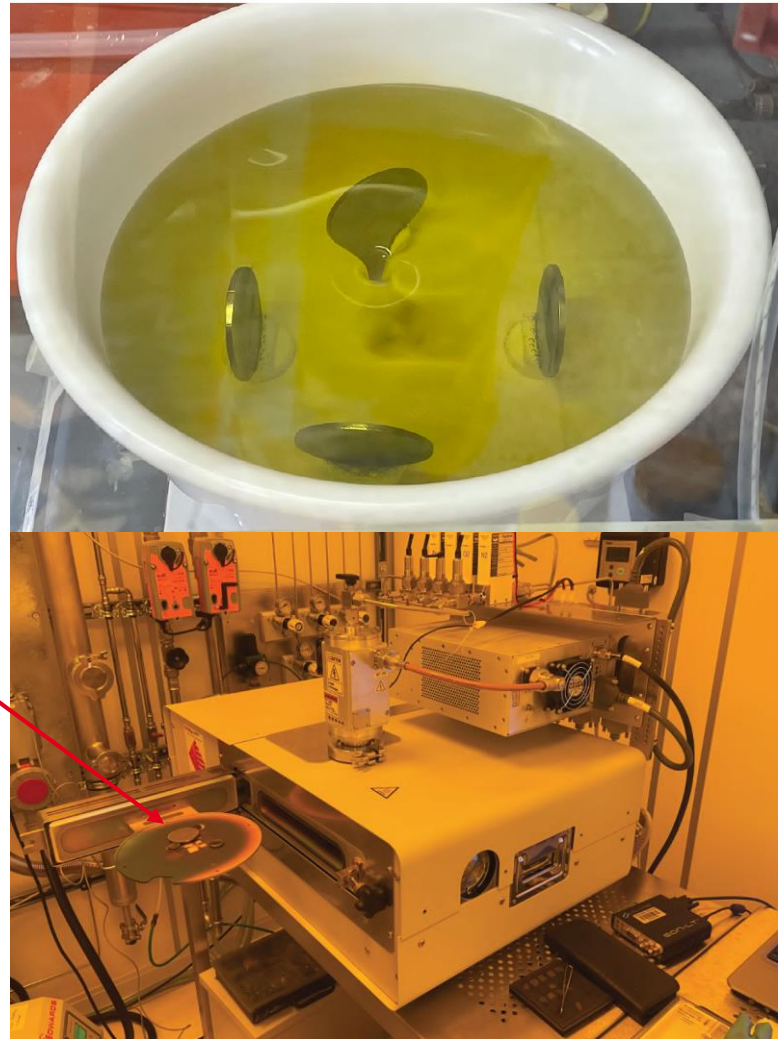

[1] González Díaz-Palacio, I., Wenskat, M., Deyu, G. K., Hillert, W., Blick, R. H., & Zierold, R. (2023). Thermal annealing of superconducting niobium titanium nitride thin films deposited by plasma-enhanced atomic layer deposition. Journal of Applied Physics, 134(3)

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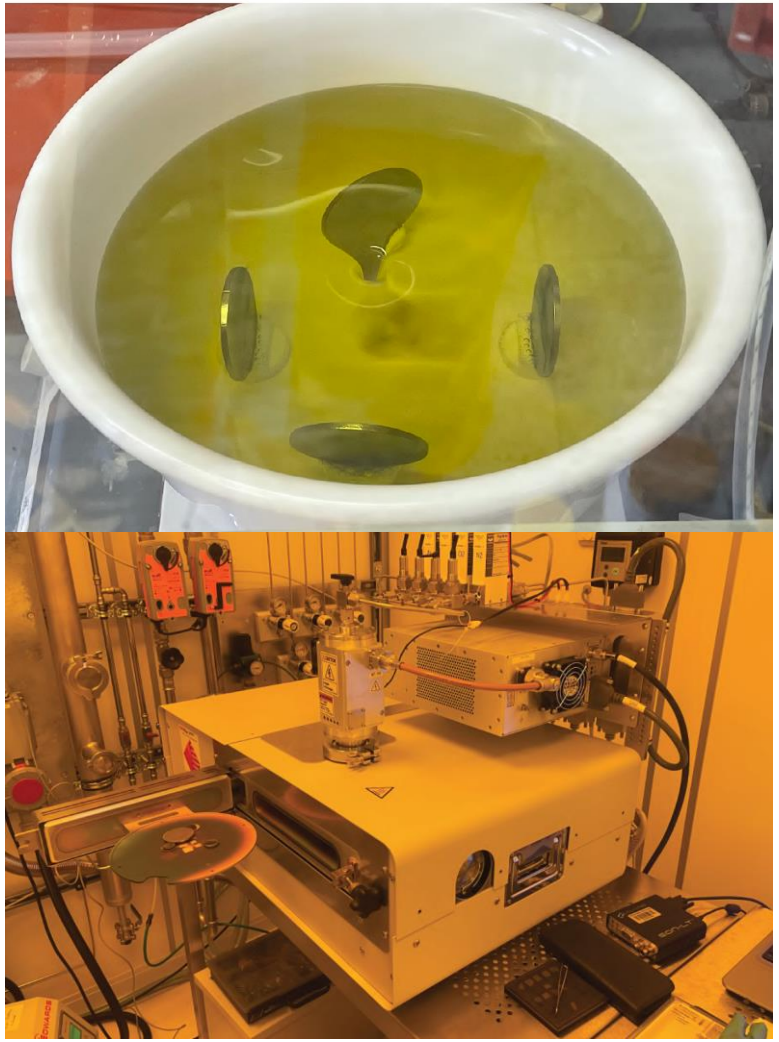

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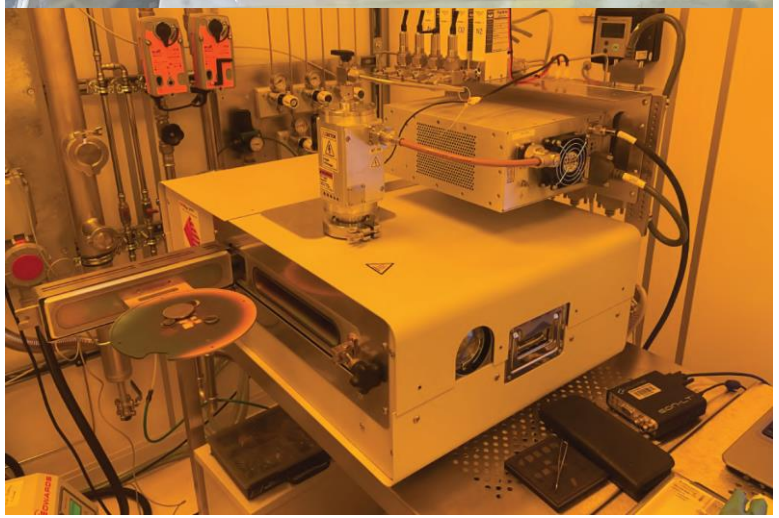

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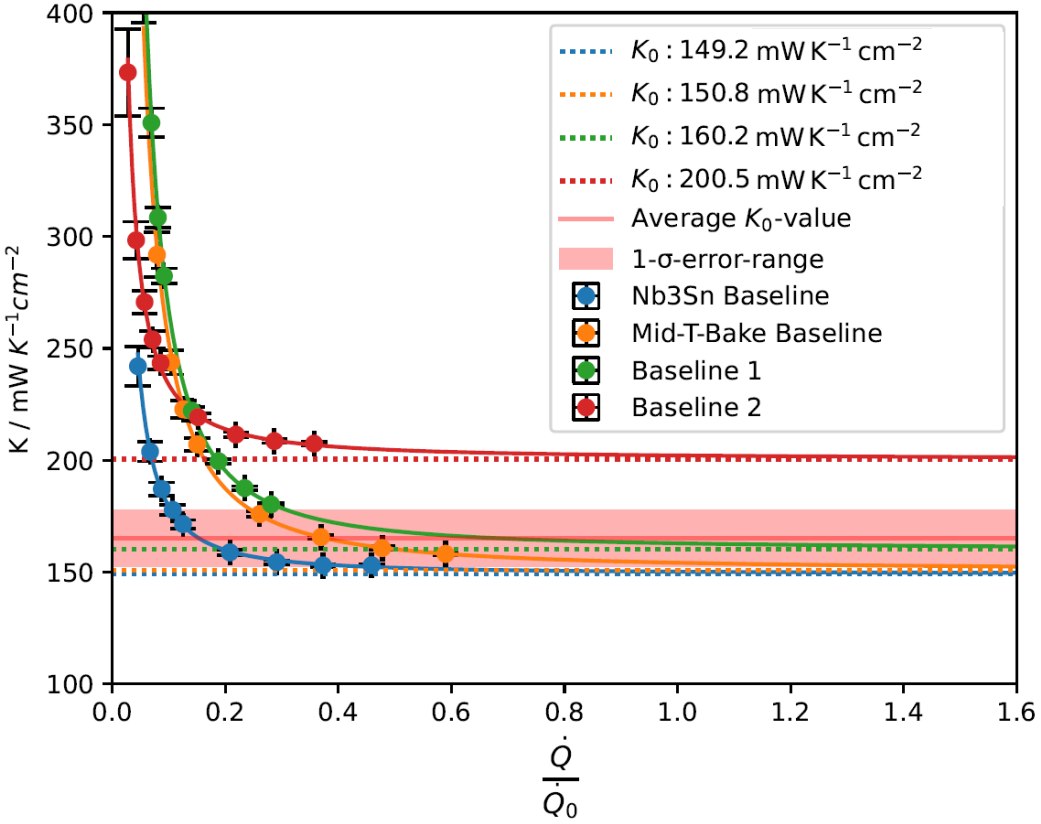

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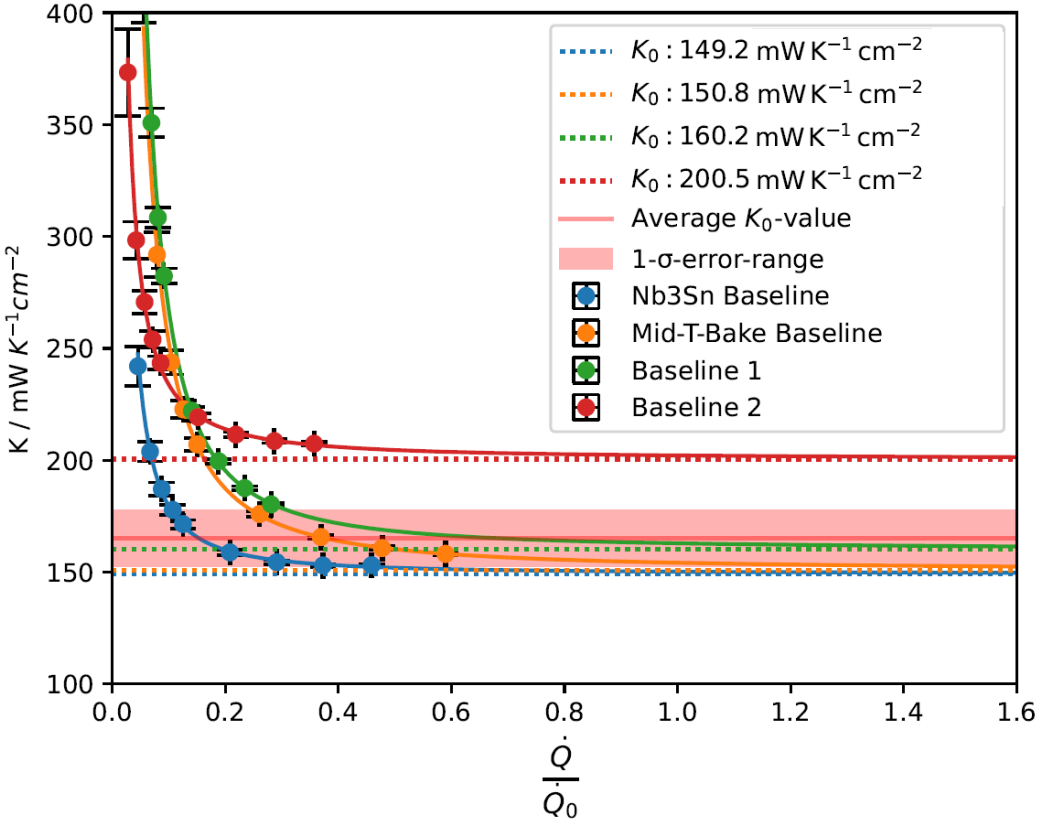

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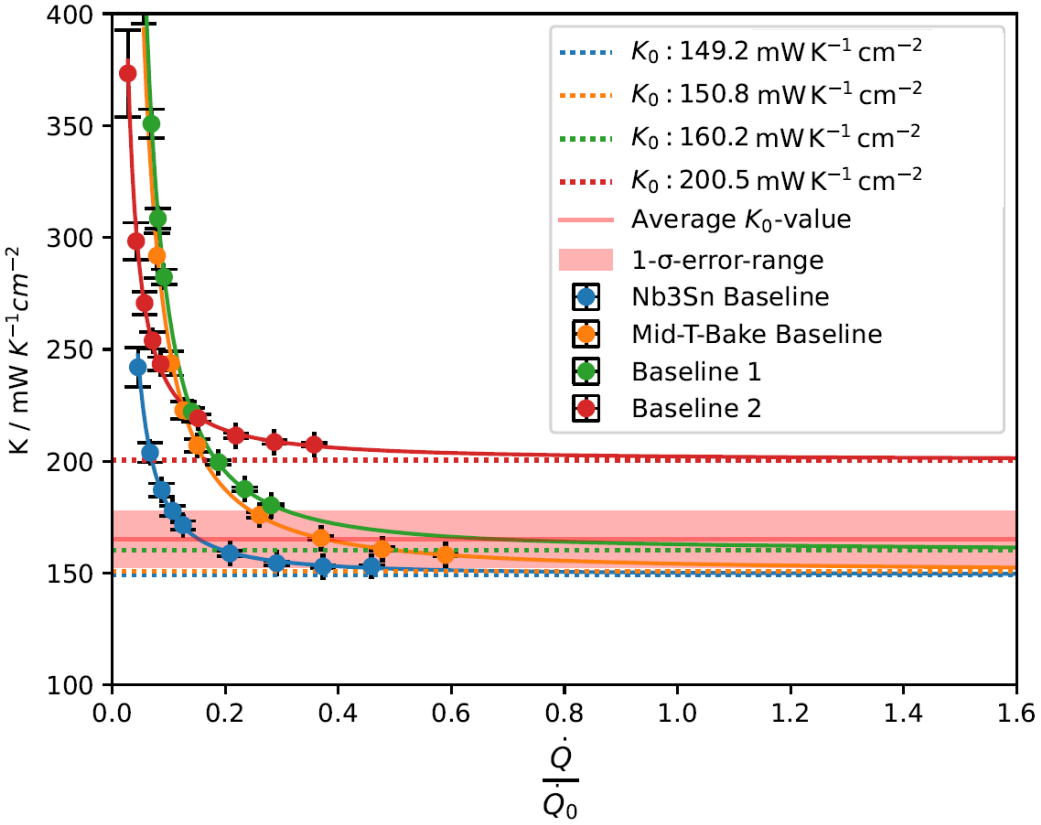

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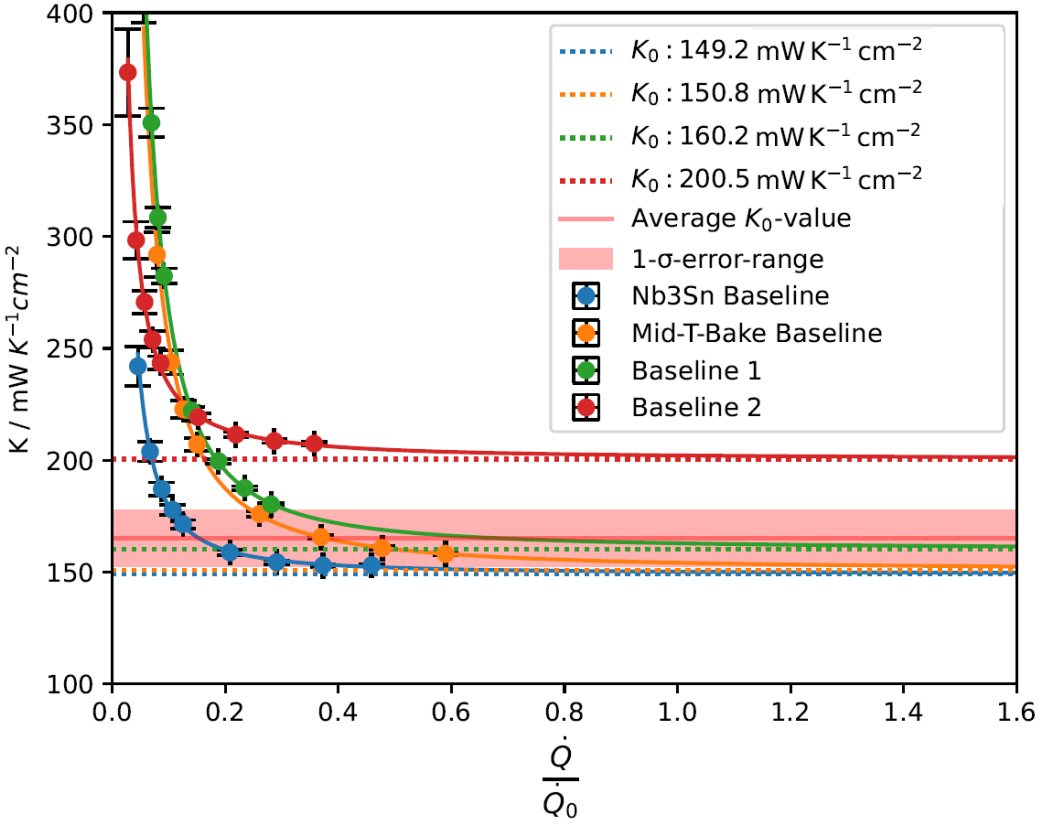

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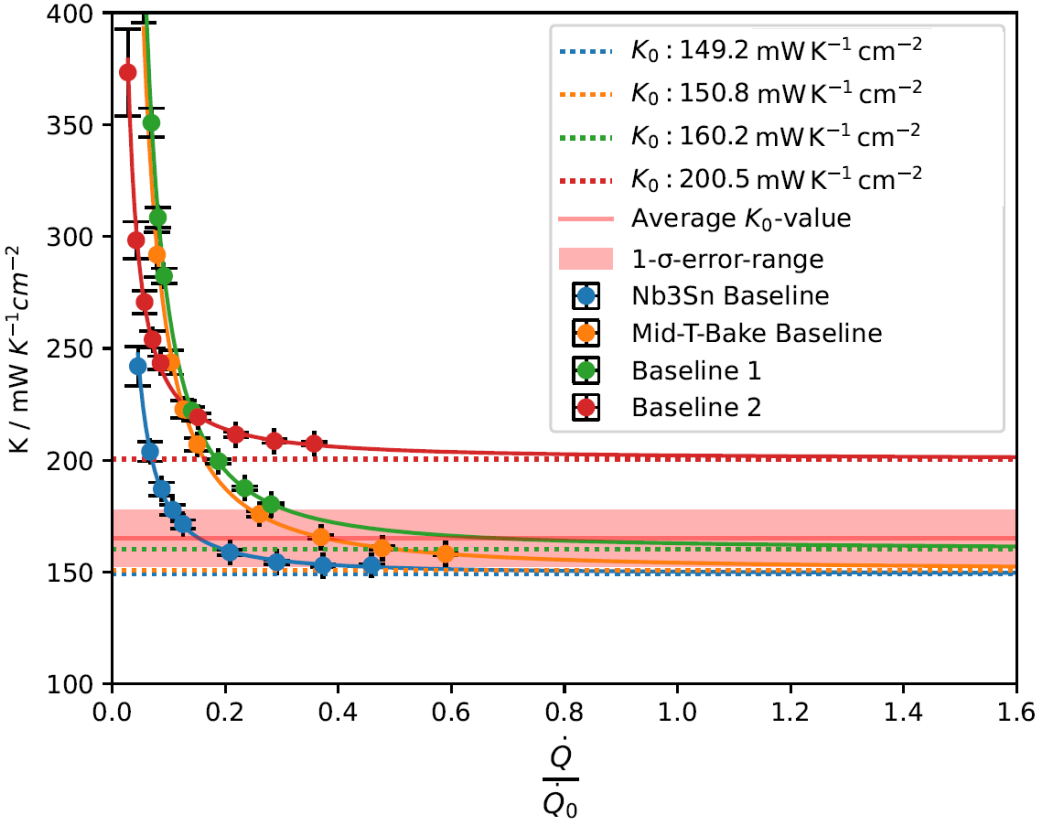
- Measured as-fabricated (only water-jet cutting)
  - K_0 = (307±46) mW cm^{-2} K^{-1}
  - K_0 = (332±31) mW cm^{-2} K^{-1}
- Higher K_0 also in agreement with literature

Can we trust the results? Yes, they are reasonable



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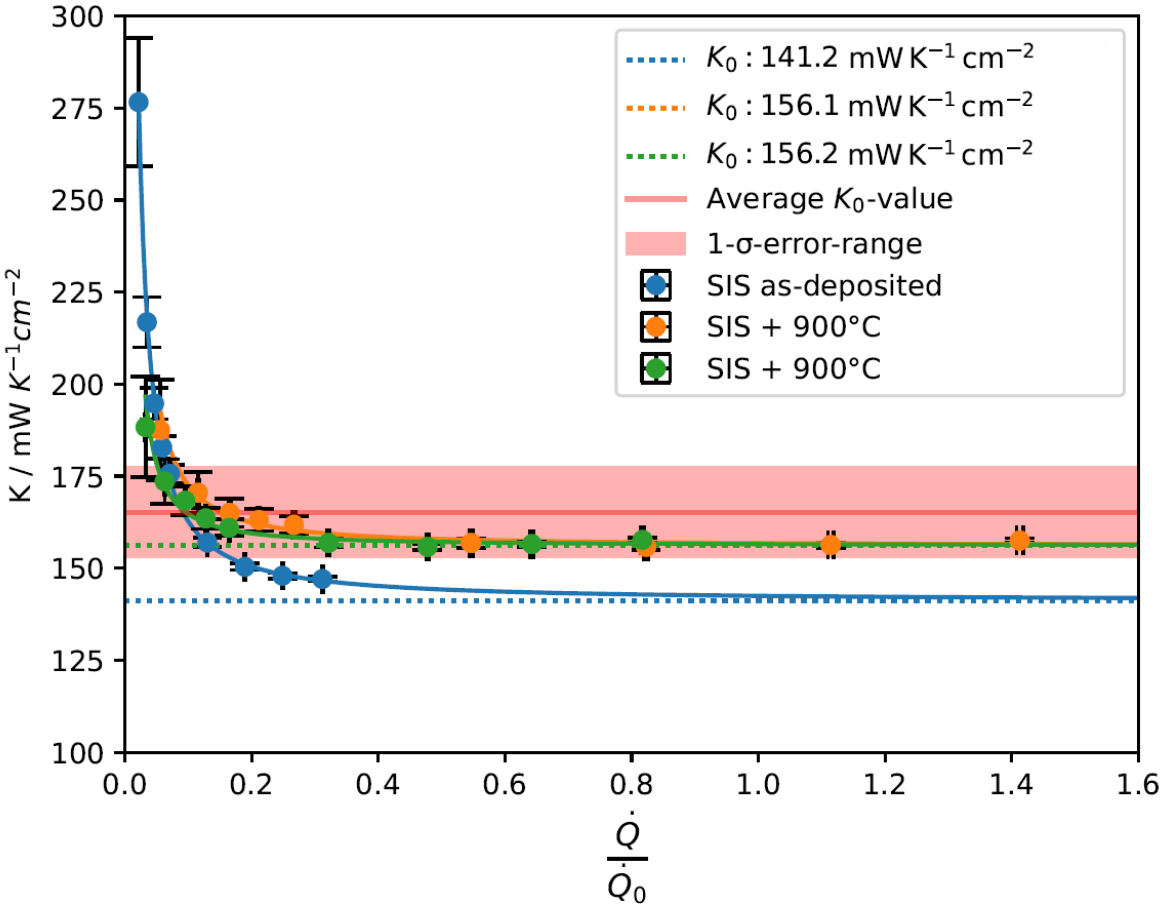
SIS does not reduce the thermal transmittance *K*



- As-deposited K_0 = (141±13) mW cm^{-2} K^{-1}
- After annealing K_0 = (156±10) mW cm^{-2} K^{-1}
- SIS on both sides → many interfaces

Well within the baseline Nb value!

Nb_3Sn coating shows an unexpected behavior

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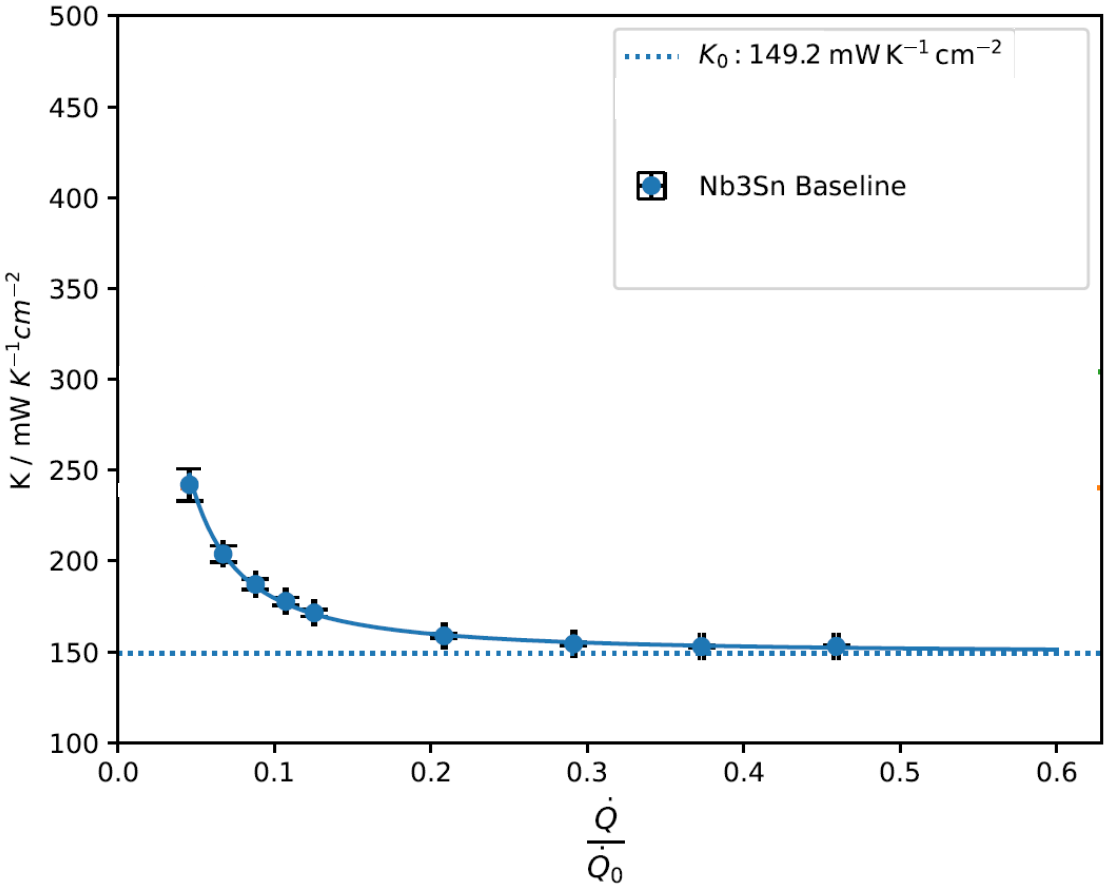

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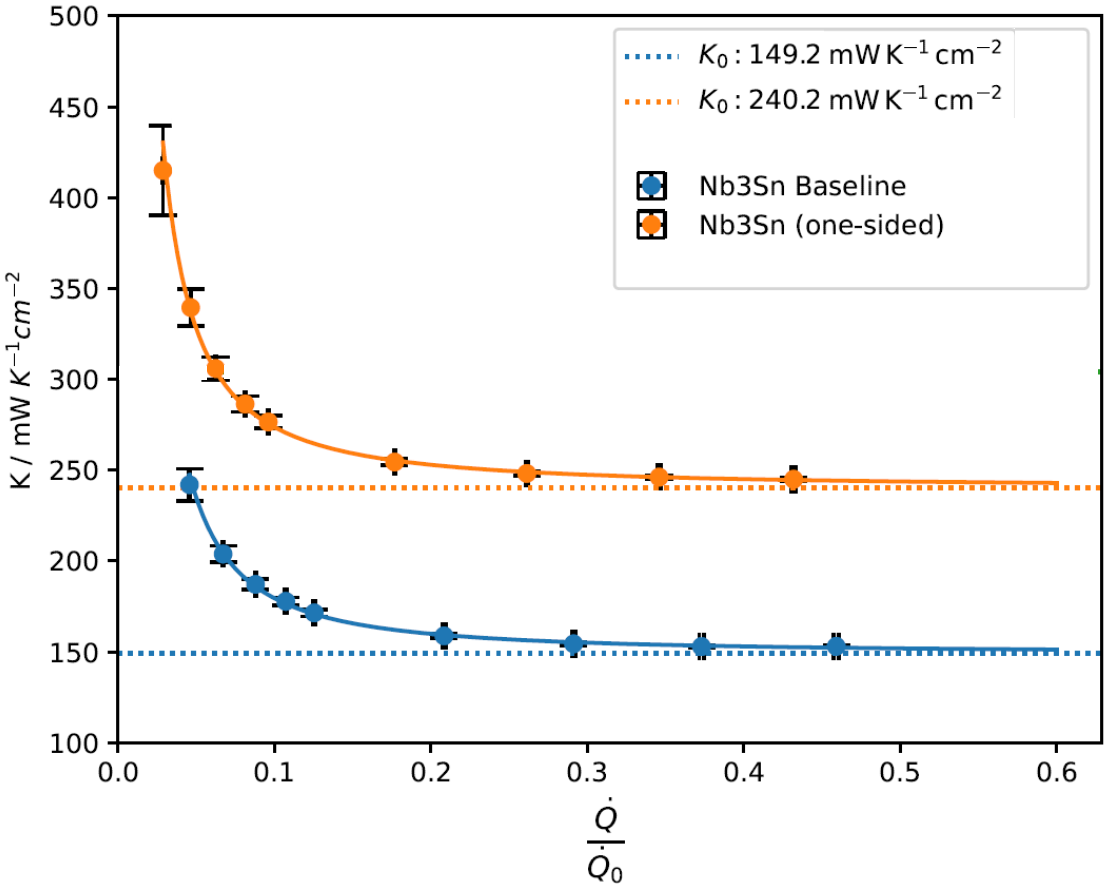

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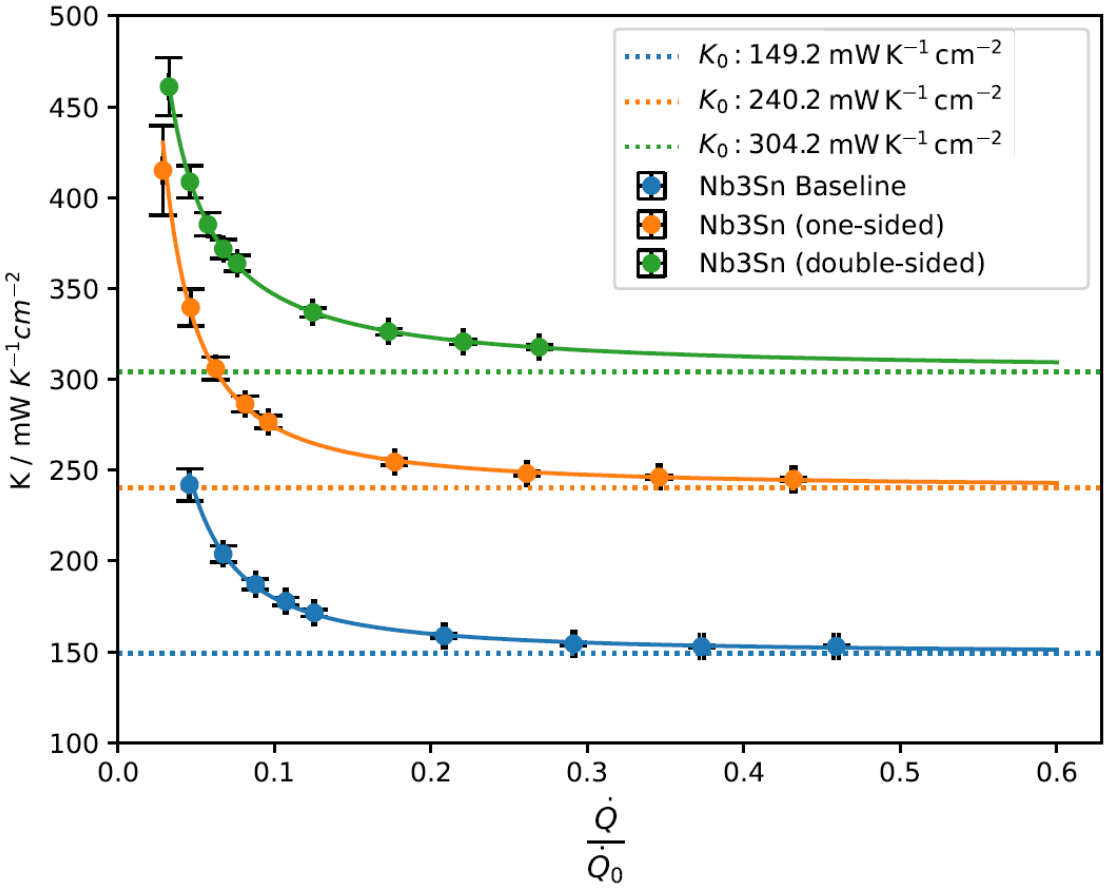

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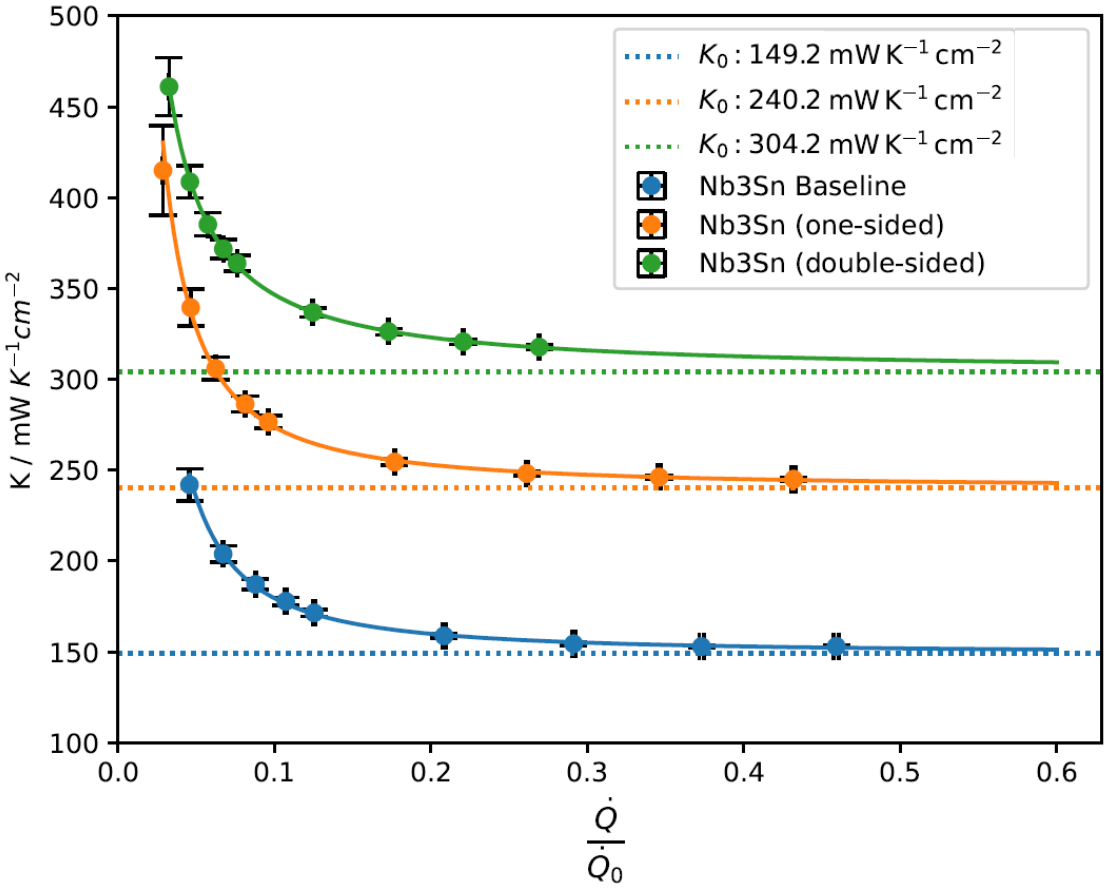

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- Further increase after coating other side as well
- It can‘t be thermal conductivity λ of Nb_3Sn

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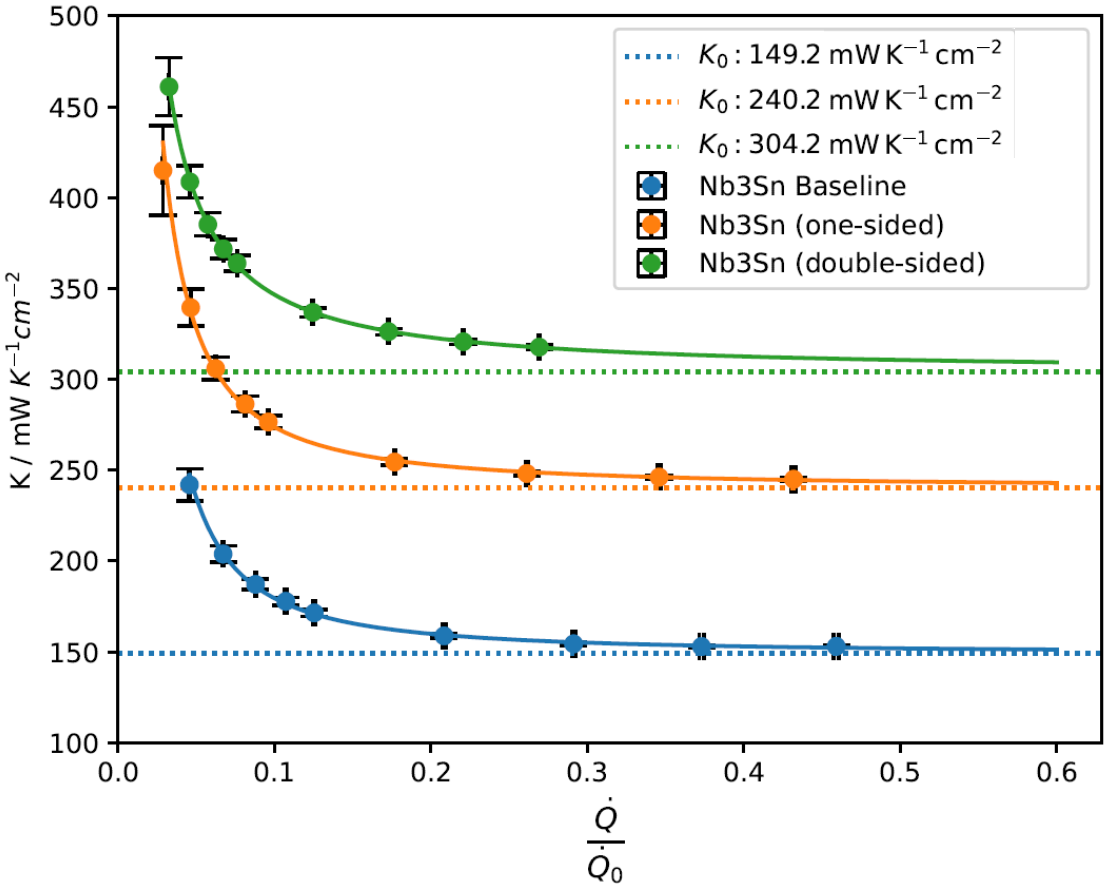

- Nb_3Sn shows increased K_0 after coating one side
- Further increase after coating other side as well
- It can‘t be thermal conductivity λ of Nb_3Sn
- What about the Kapitza-Resistance R_K?

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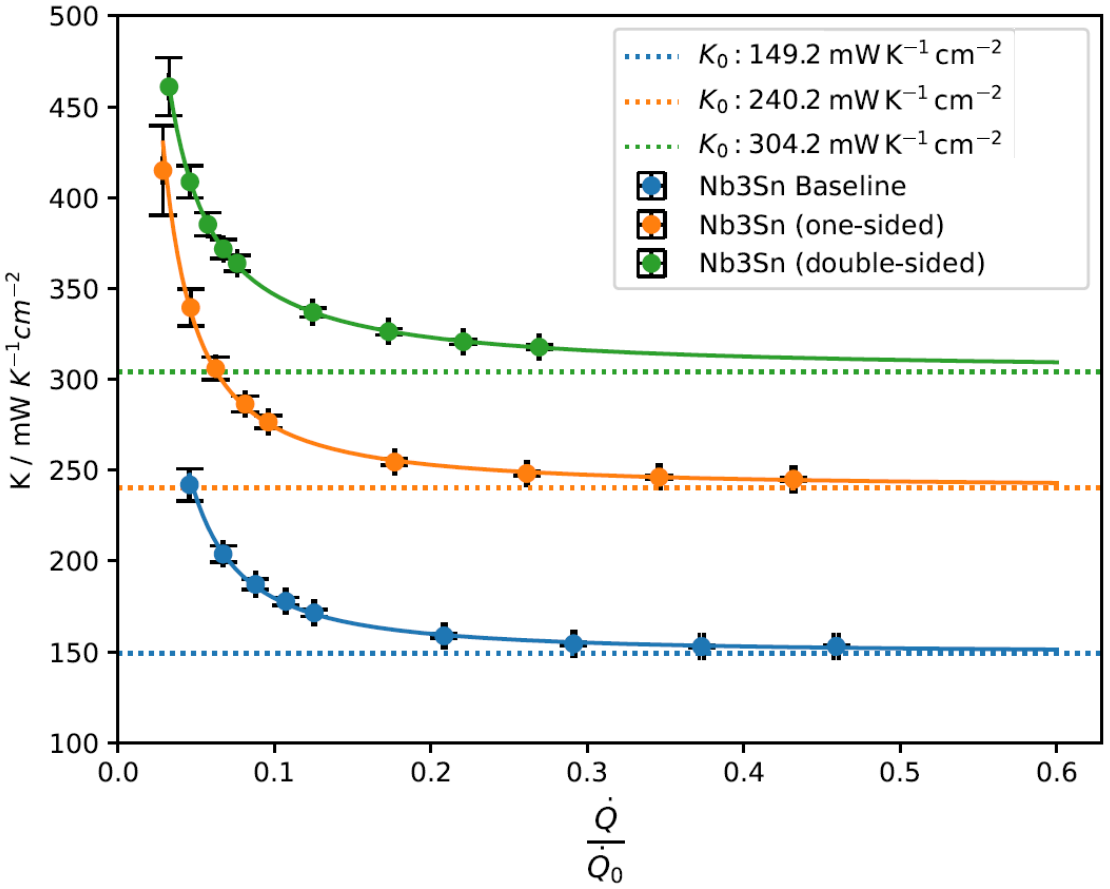

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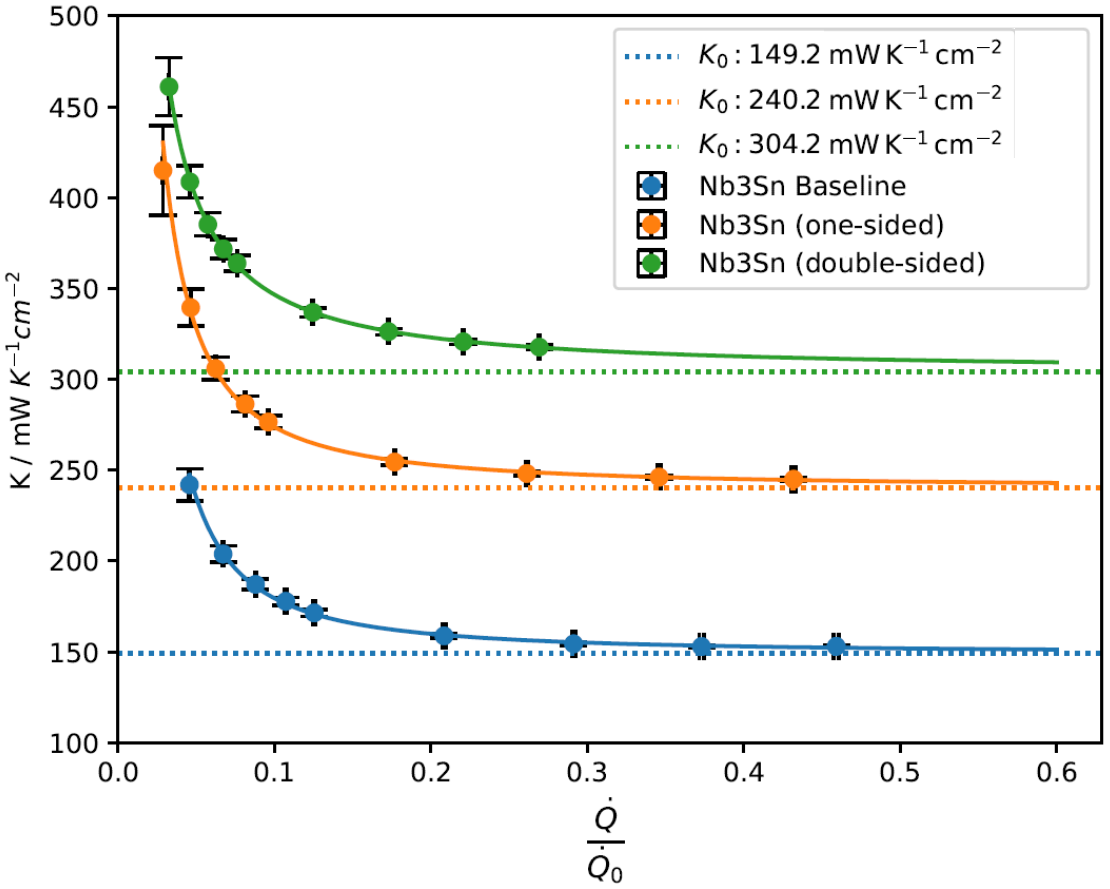

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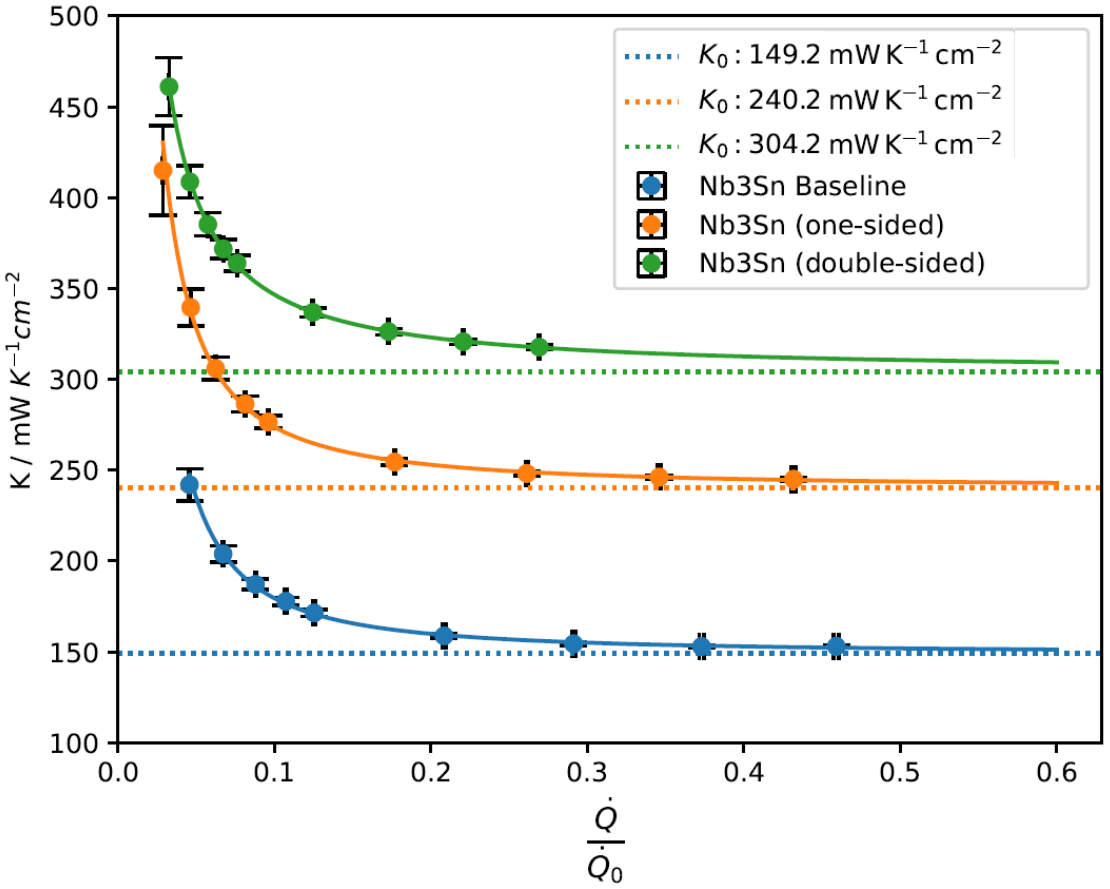

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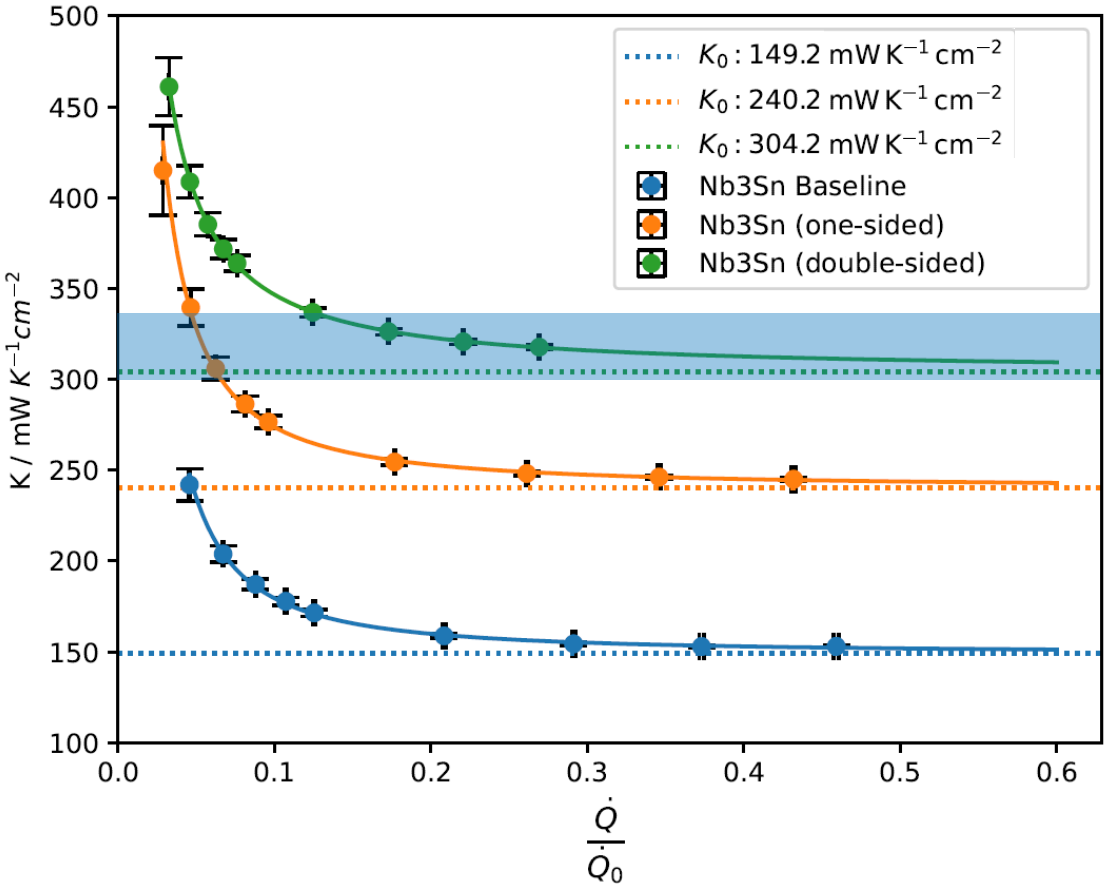

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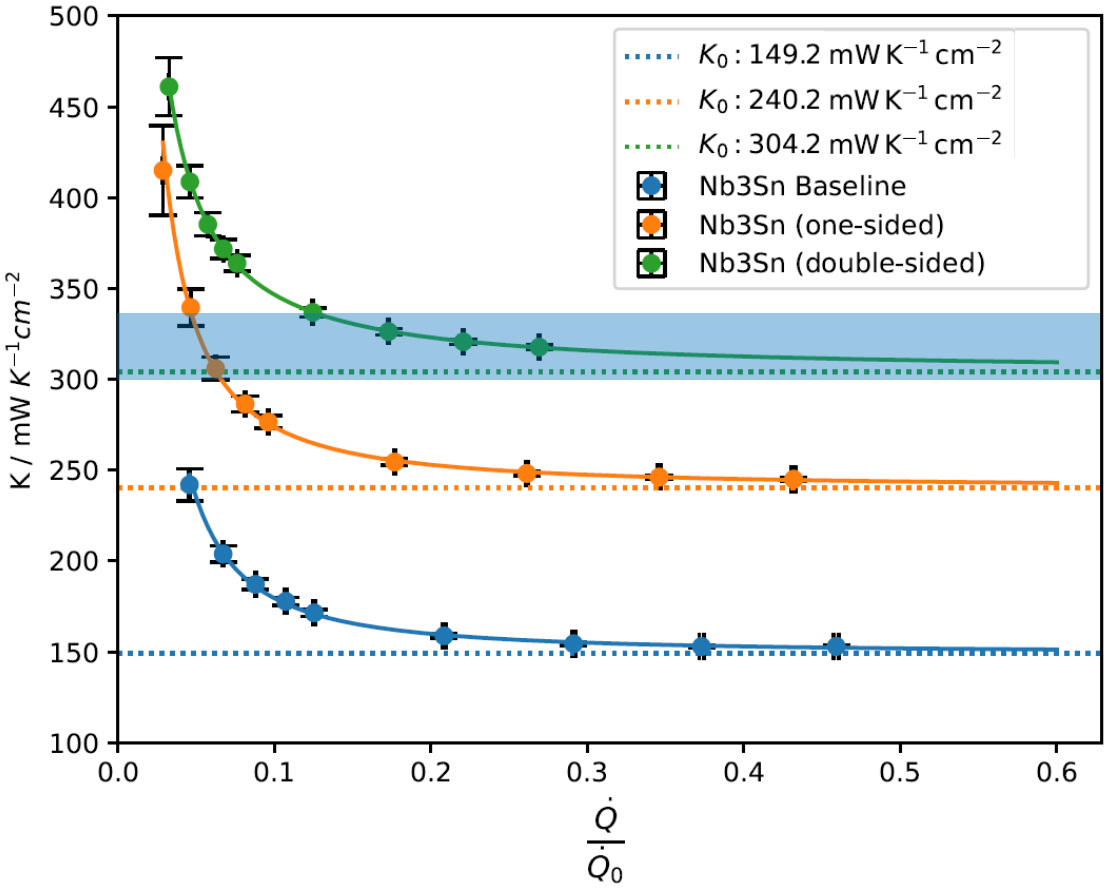

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- Next steps:
  - Coat second sample pair, measure K_0
  - Measure roughness before & after
  - Compare to as-fabricated roughness

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- Next-gen cell with soldered stainless steel capillary is currently fabricated

Thanks to…

- **you** for listening
- the **conveners** for the opportunity to present this work
- **DESY** for the measurement opportunities
- **BMBF** for funding

Questions?

Swartzwelder, J. (Writer), & Reardon, J. (Director). (1994, January 6). Homer the Vigilante (Season 5, Episode 11) [TV series episode]. In D. Mirkin, J. L. Brooks, M. Groening, & S. Simon (Executive Producers), *The Simpsons*. Gracie Films; Twentieth Century Fox Film Corporation.

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DESY.

Bundesministerium
für Bildung
und Forschung

Temperature Scan

- Started testing temperature scans while cooling down at QvT
- High power to be close to K_0
- Measurement starts at 2.1K