Karlsruhe Institute of Technology

Institute for Technical Thermodynamics and Refrigeration (ITTK)
Engler-Bunte-Ring 21, 76131 Karlsruhe, Germany, ttk.kit.edu

Signal-to-noise ratio of temperature measurement with Cernox™ sensors at various supply currents

A. Janzen[1,*], B. Burger[2], A. Ebersoldt[2], C. Heidt[3], O. Langhans[3], A. Reiner[3], S. Grohmann[1,3]

[1] Institute for Technical Thermodynamics and Refrigeration, [2] Institute for Data Processing and Electronics, [3] Institute for Technical Physics, * Email: andreas.janzen@kit.edu, Tel.: +49-721-608-42730

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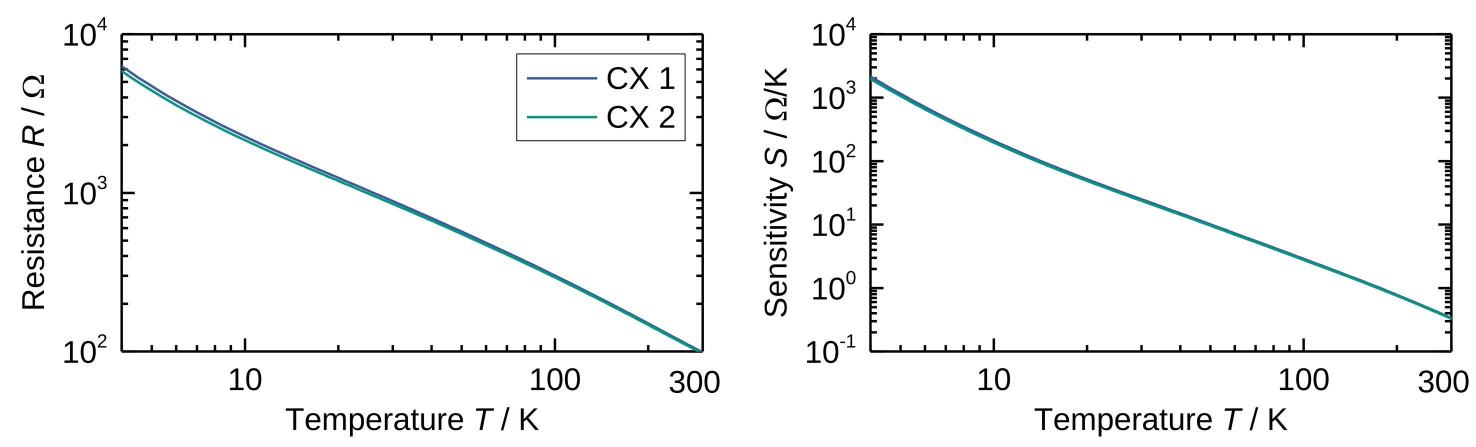
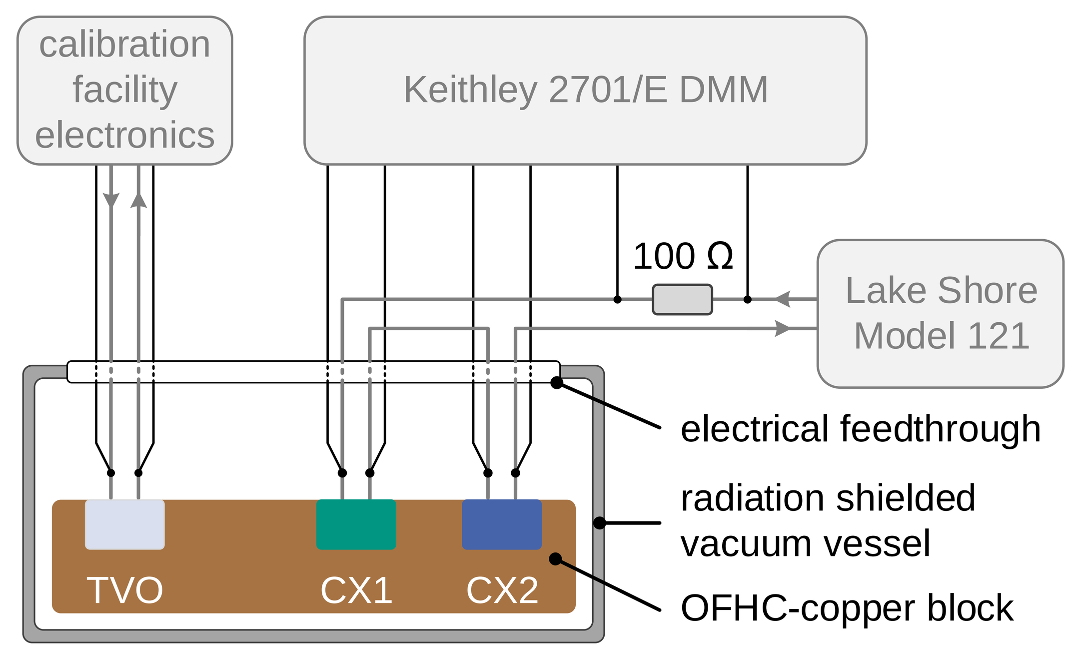
Motivation

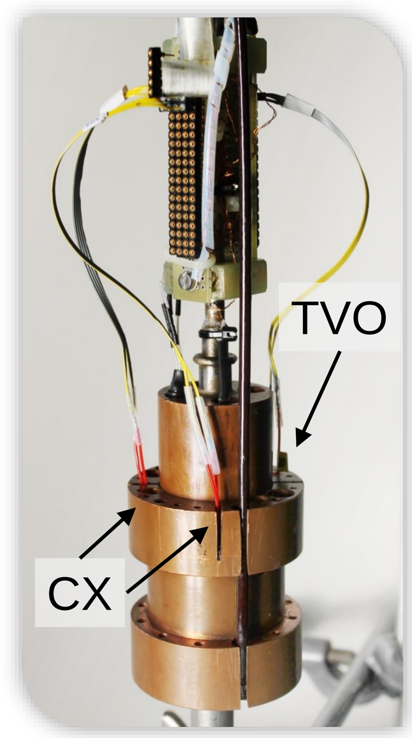
- Requirements for temperature measurement in a new cryogenic thermal mass flow meter
  - Small heat input on cryogenic fluid
  - High signal-to-noise ratio (SNR) and high temperature resolution
  - Temperature range: 4 to 300 K → Cernox™ type CX-1050-SD
  - ⇨ Performance investigation of 2 Cernox™
- Excitation voltage (*U*) variation from 10 to 100 mV to identify
  - Influence on SNR and temperature resolution
  - Influence on combined uncertainty
  - Electronics design parameters



Experimental setup

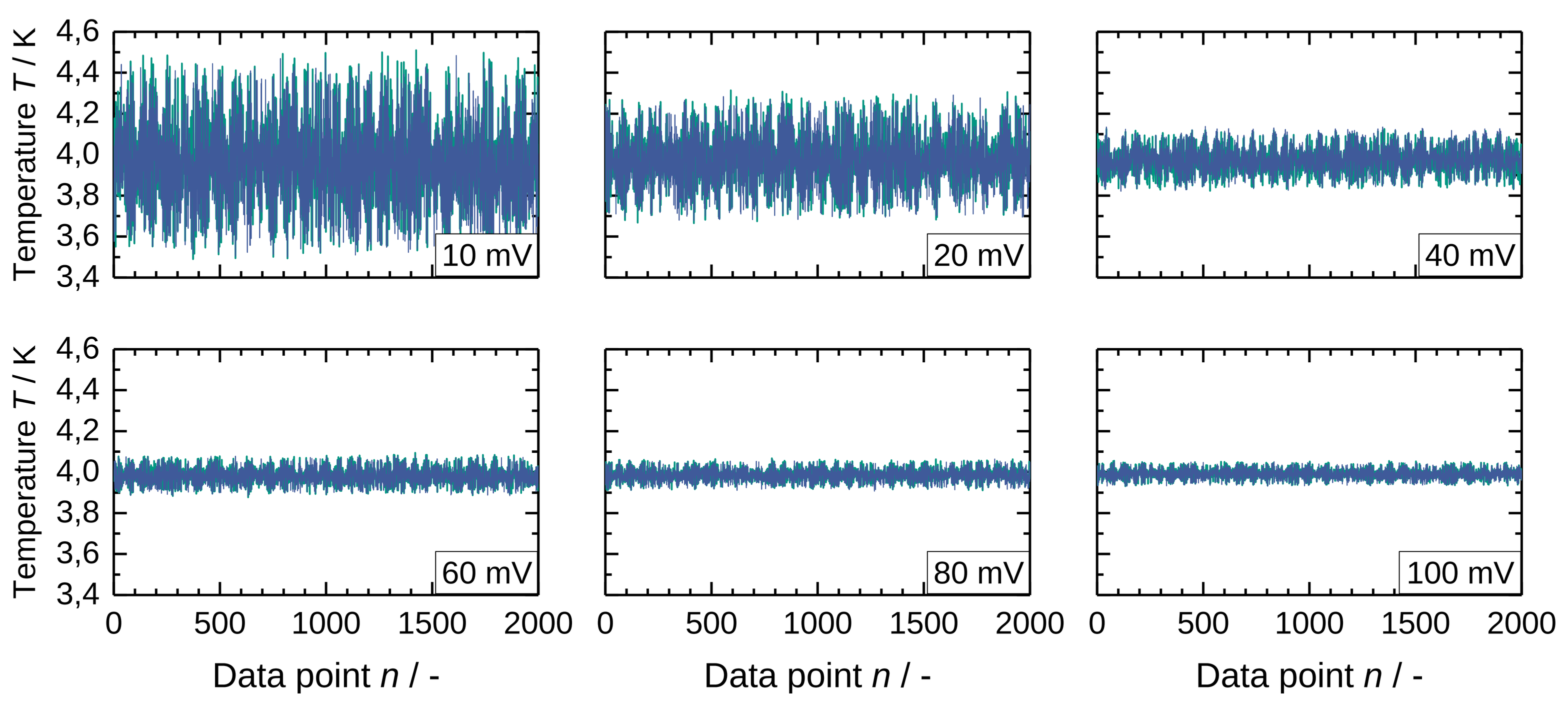
- Experimental investigation inside a helium operated calibration cryostat
  - Range of measurement: 4 to 296 K
  - TVO sensor for reference cryostat temperature measurement
- Cernox™ and TVO mounted into a OFHC-copper block
- Lake Shore current source and Keithley DMM for Cernox™

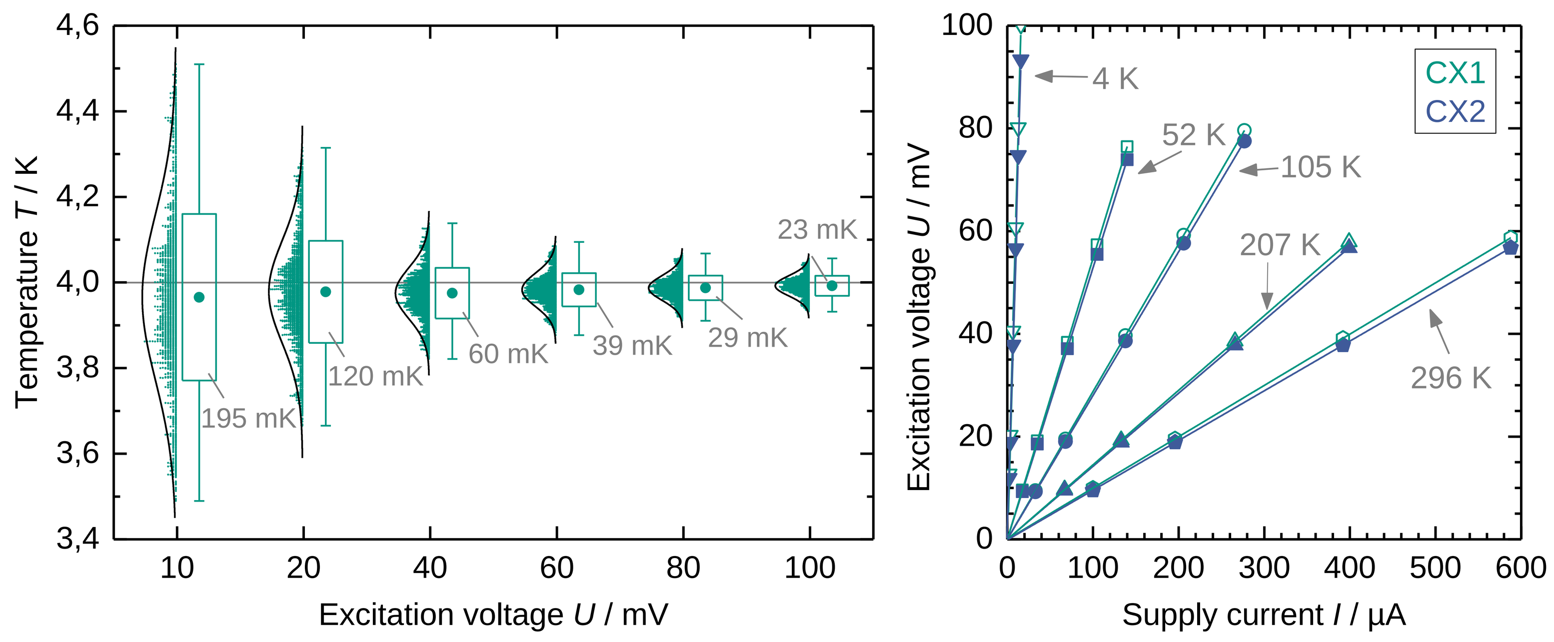




Experimental results

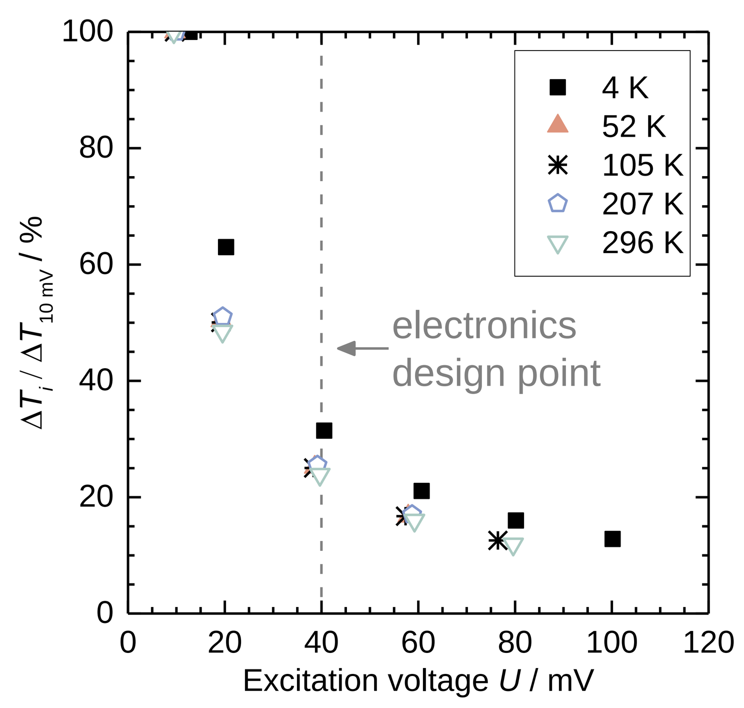
Standard deviation in temperature and self-heating





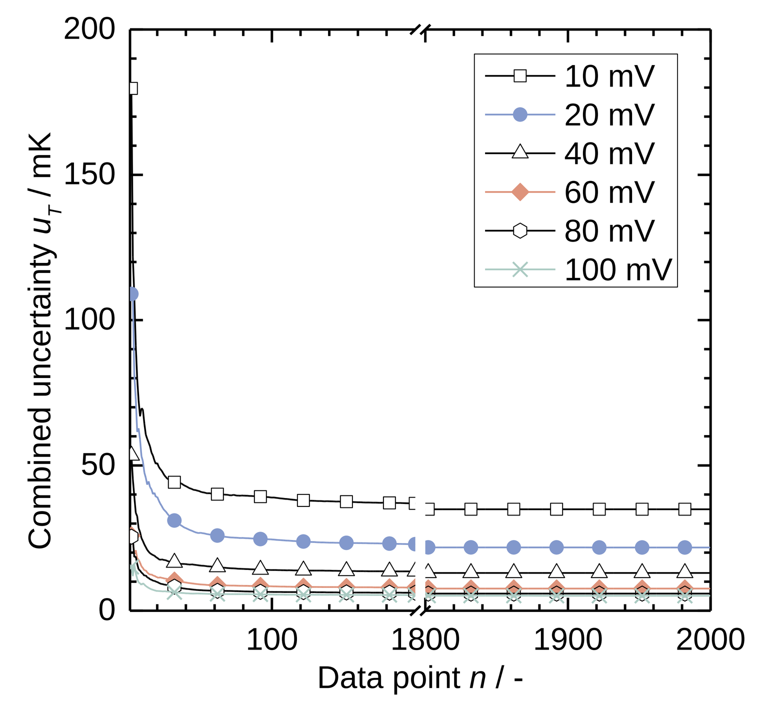
- 2000 data points for each temperature and excitation voltage setpoint
- Decrease in standard deviation and max-min difference with higher excitation voltages
- *U*-*I*-plots show perfectly proportional behavior for constant temperatures
- ⇨ No self-heating observed

Improvement in temperature resolution



- Enlargement in temperature resolution more distinct for low excitation voltages
- Risk of sensor overheating increases for higher excitation voltages
- ⇨ 40 mV as electronics design parameter

Combined uncertainty according to GUM



Property	Type
$U_{100\ \Omega\ \text{resistance}}$	A
U_{Cernox}	A
CX calibration	B
CX fit equation	B
Keithley DMM	B
T_{Croystat}	B

- Type A uncertainties decrease by $1/\sqrt{n}$
- Even for low signal-to-noise ratios type B uncertainties dominate for large *n*
- 60 – 80 data points enough to minimize type A influence