Excess Johnson noise in non-uniform TESs

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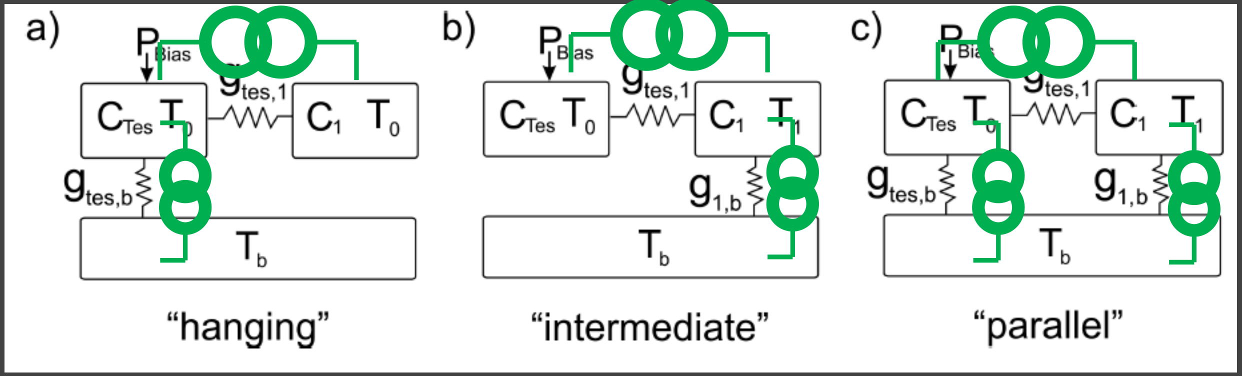
Overview

- Background
- Non-uniformity model
- Results
- Conclusions

Multi body models

In multi-body TES models it assumed that:

- There is a single body TES
- One or more temperature insensitive heat capacities
- Phonon noise across each thermal link



➢ Time constants can be measured with impedance measurements

Analytical expressions in: arXiv:1205.5693v2 (Maasilta)

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Definition M-factor noise

Noise which:

- cannot be explained by thermal (multi-body) models
- Cannot be explained by non-equilibrium Johnson noise
- Shows the spectral shape of Johnson noise

$$\sqrt{4k_b TR(1+2\beta)(1+M^2)}$$

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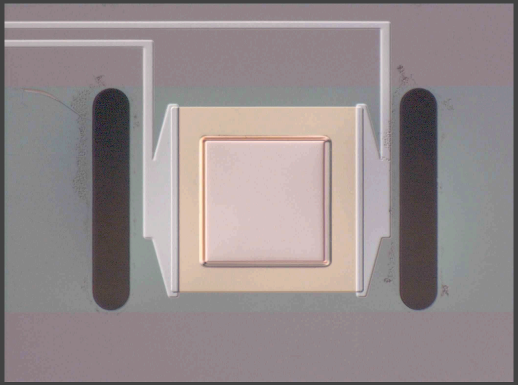
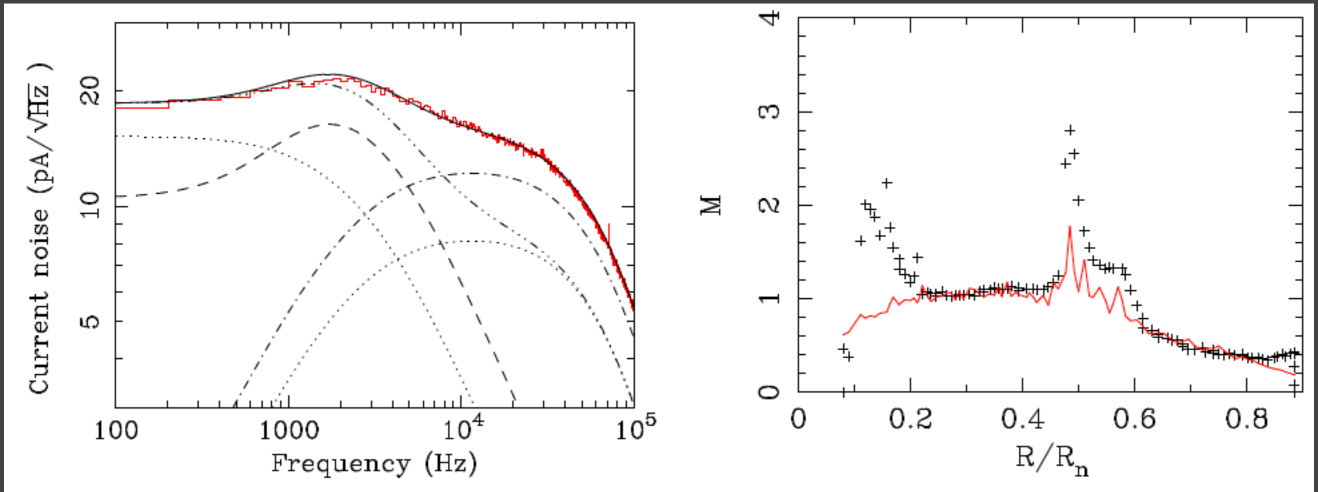
Observed M-factor SRON pixel (old design)

- Both multibody and M-factor noise present
- M-factor peaks at high-alpha regions





Y. Takei et al. JLTP 151 (2008)

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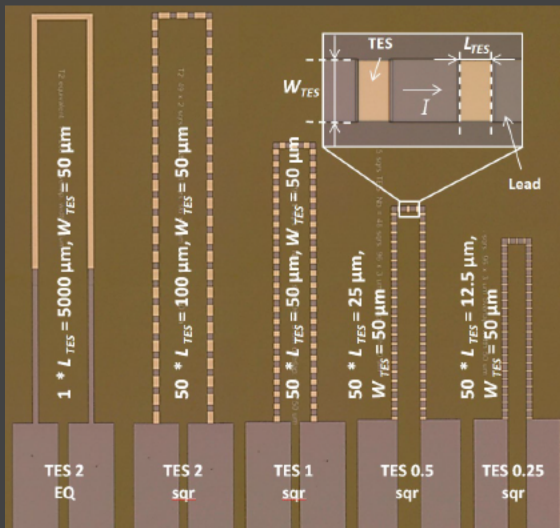
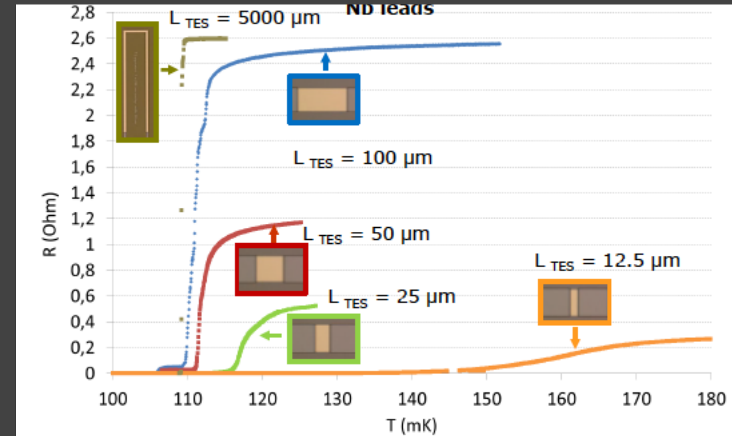
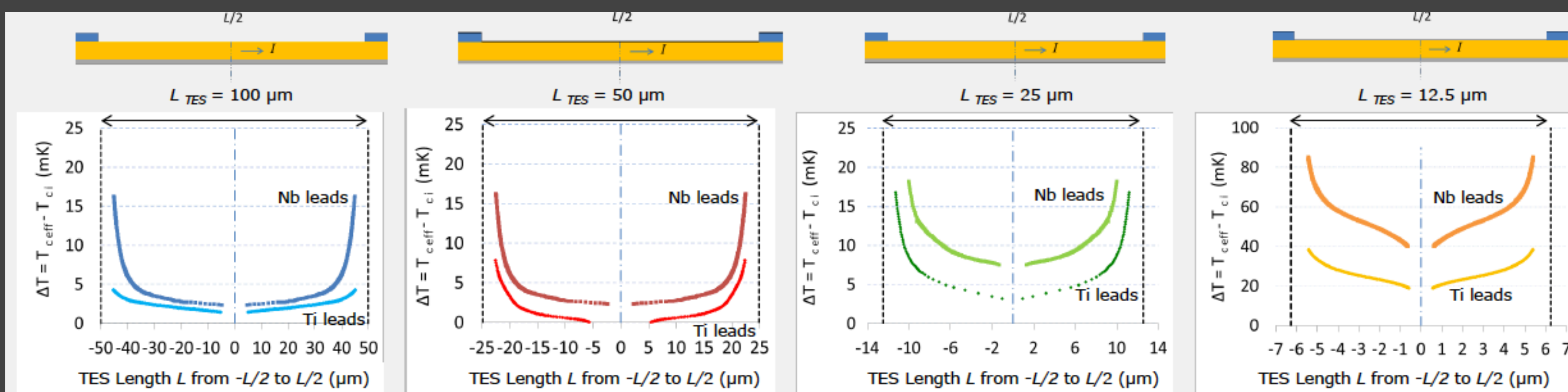
Tc gradients observed

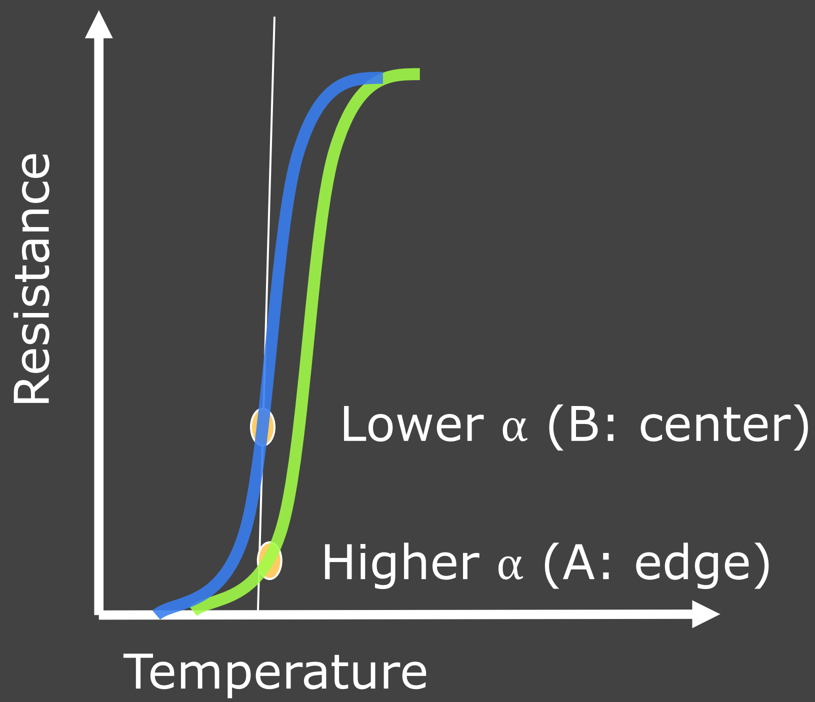


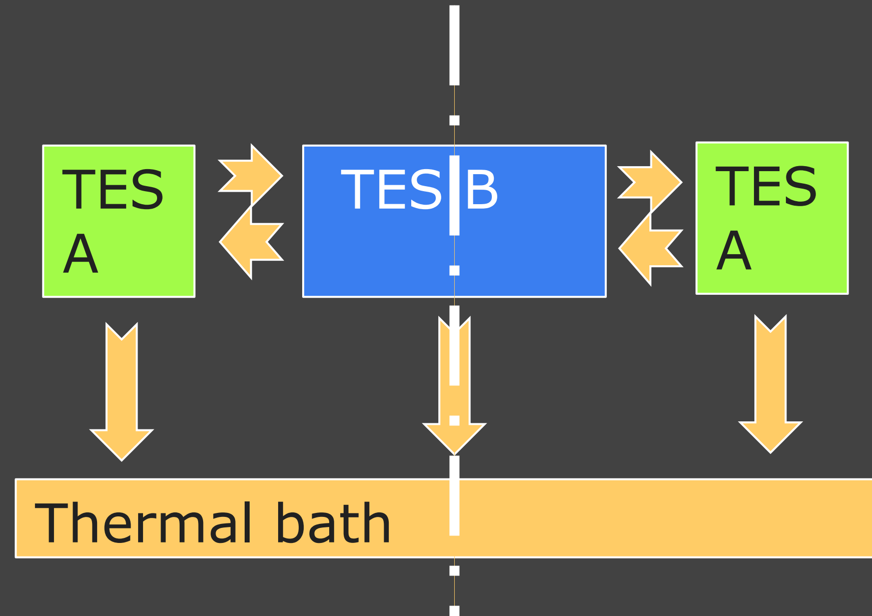


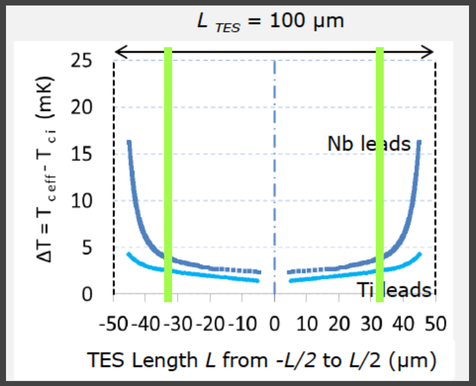


See poster M.Ridder (351)

Translation Tc gradient in 2-body TES model







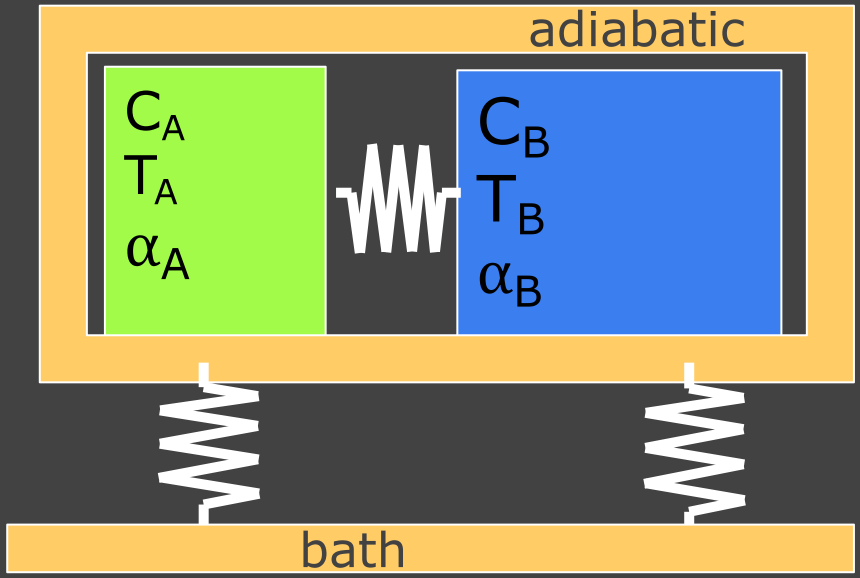
=> Net observed α:
resistance weighted average
of α of the different areas

Internal temperature fluctuations noise (ITFN) in a non-uniform TES

- Adiabatic condition:

$$C_A \Delta T_A + C_B \Delta T_B = 0$$

-> no observable resistance change in uniform TES as net resistance change equals zero



- Non-uniform TES:

$$\alpha_A \neq \alpha_B$$

=> observable ITFN when TES non-uniform

- Also: Positive internal ETF above thermal cutoff:

$$\Delta T \sim \sqrt{\frac{4\gamma k_b T^2}{G_{tes}} \frac{1}{1 - \frac{P\Delta\alpha}{GT}}}$$

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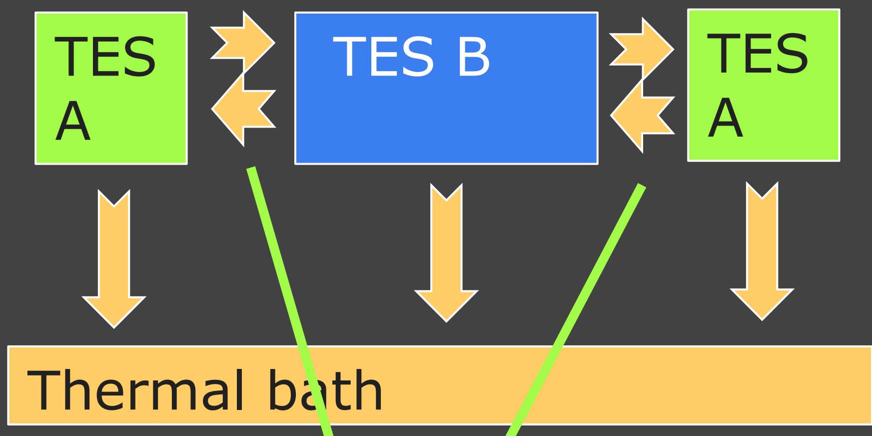
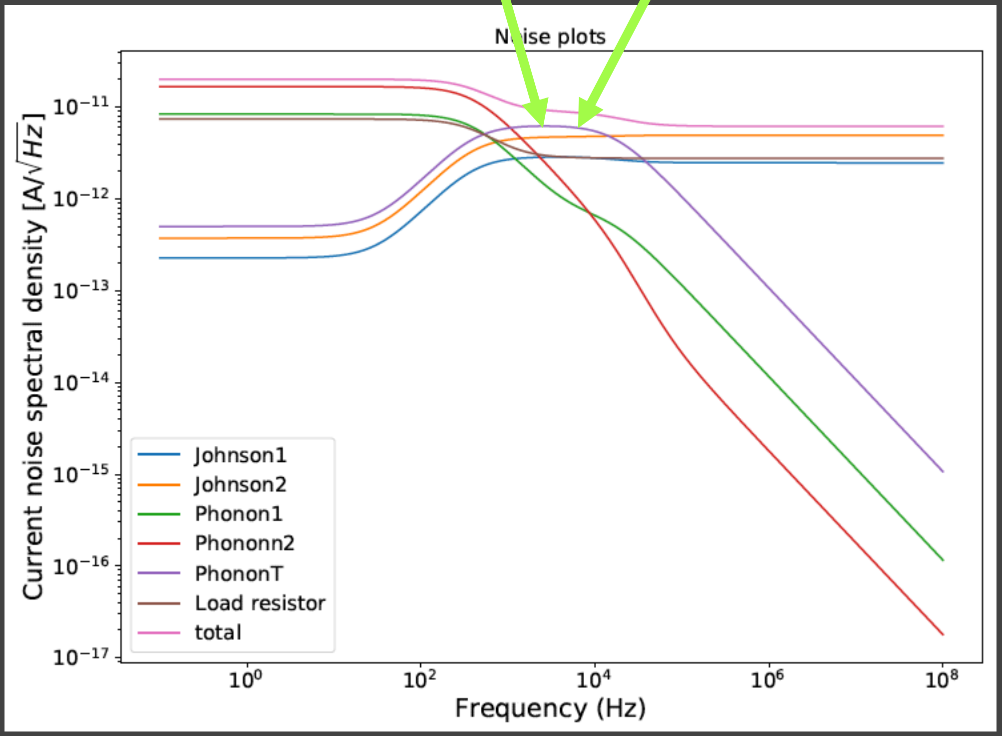
Model calculations



Assumptions:

- Two types of TES
- Adiabatic heat exchange between TES bodies
- Internal heat conductivity ~100 times conductivity to bath
- $\alpha_B \sim 0.4\ \alpha_A$
- $M \sim 1.6$
- Impedance deviates from semi circle, like in any 2-body model



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Observations/ consequences

- Further work is needed to test the model on experimental data
- The model provides an alternative mechanism to explain 2nd order impedance observations in absorber-less TESs
- Within a uniform TES internal fluctuations do not lead to observable ITFN
- Lowering the square resistance helps to spread the noise effects over a larger bandwidth
- Normal metal bars might function as thermal shorts
- Reducing the lateral proximity effect should help to reduce the TES non-uniformity

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Thank you

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