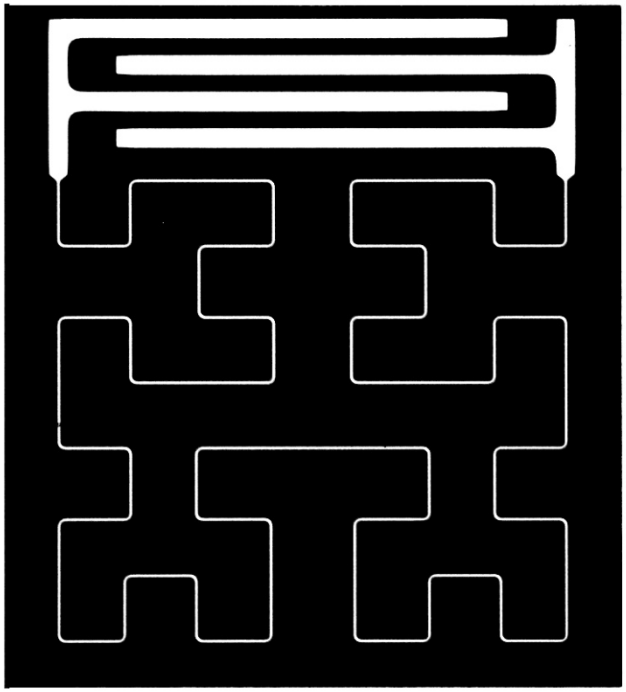
Interplay Between Kinetic Inductance, Nonlinearity, and Quasiparticle Dynamics in Granular Aluminum MKIDs

Francesco Valenti

Phys. Rev. Applied 11, 054087 (2019)

Karlsruher Institut für Technologie



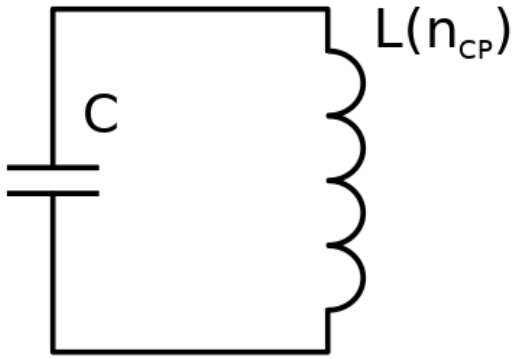
100 µm

institut

I. M. Pop's group

A. Monfardini's group

Microwave kinetic inductance detectors



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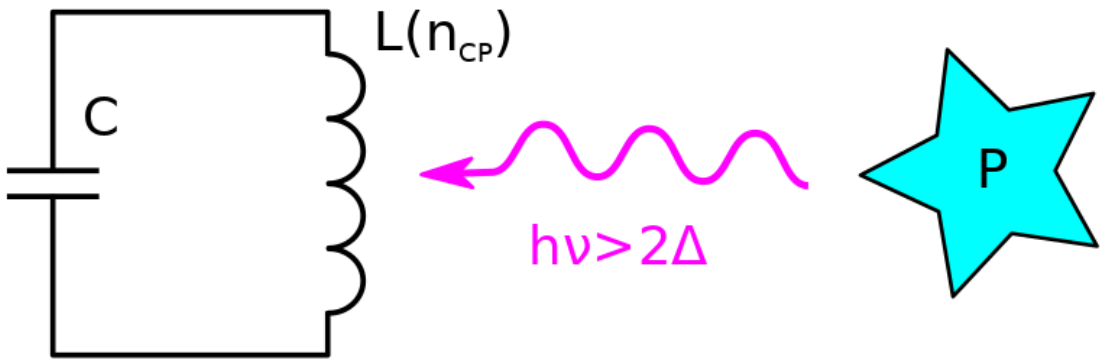

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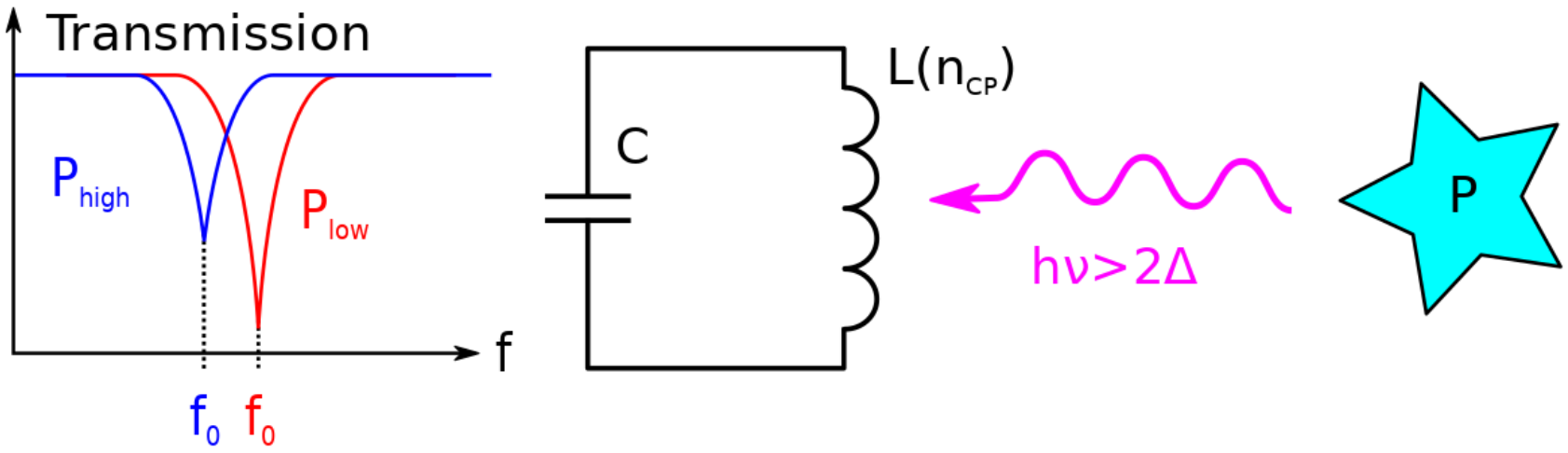

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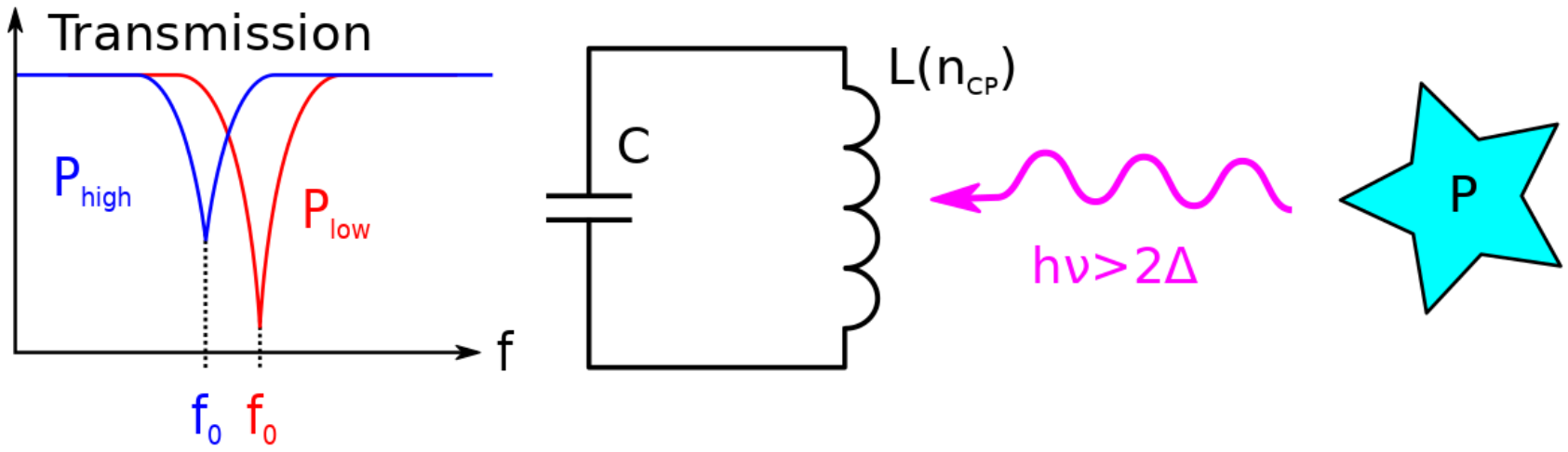

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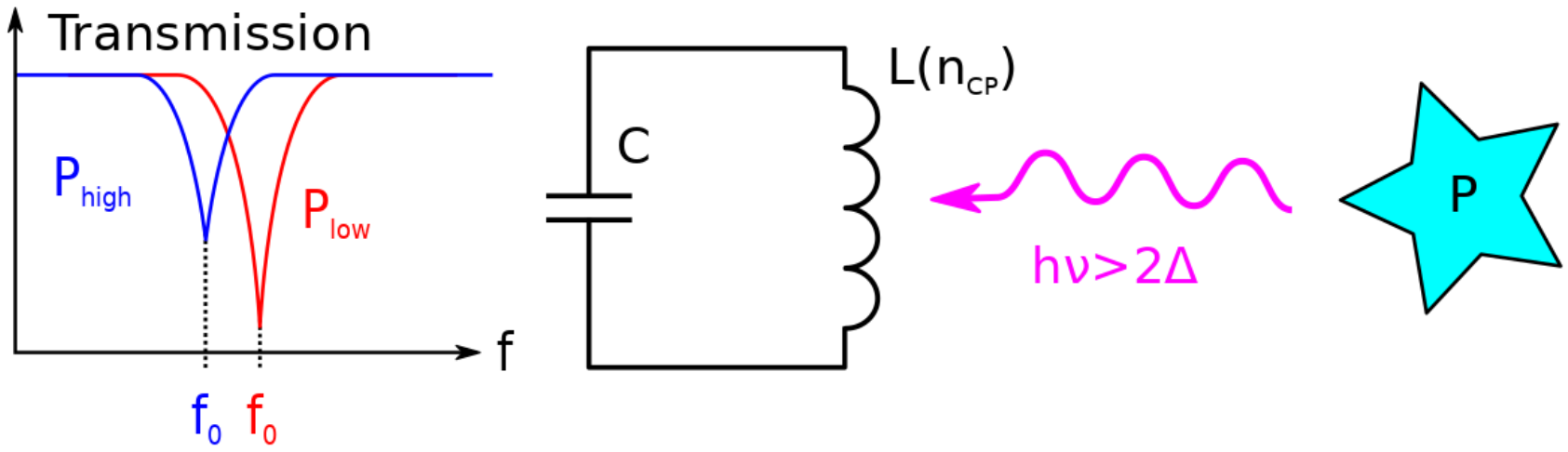
  ⇒ determines f_0

Microwave kinetic inductance detectors



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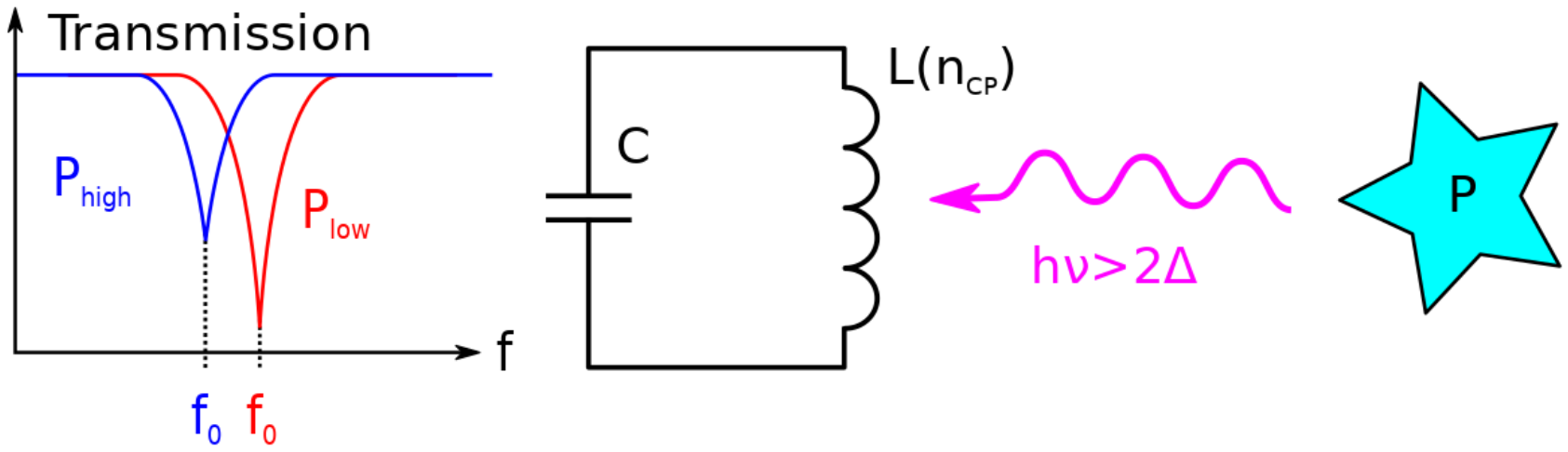

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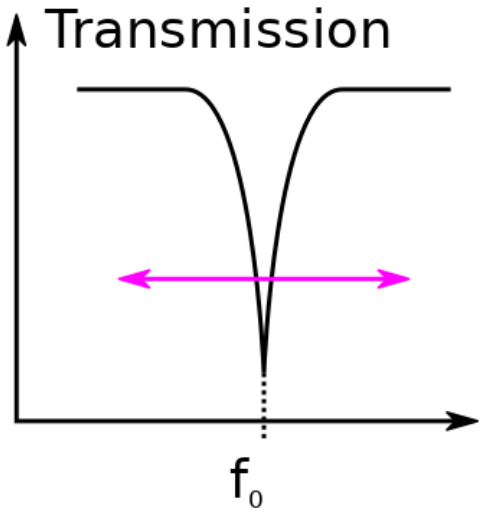
- Define the detector **responsivity:** $\Re = |\partial f_0| / \partial P$

MKIDs noise

- f_0 fluctuations in the absence of radiation = noise



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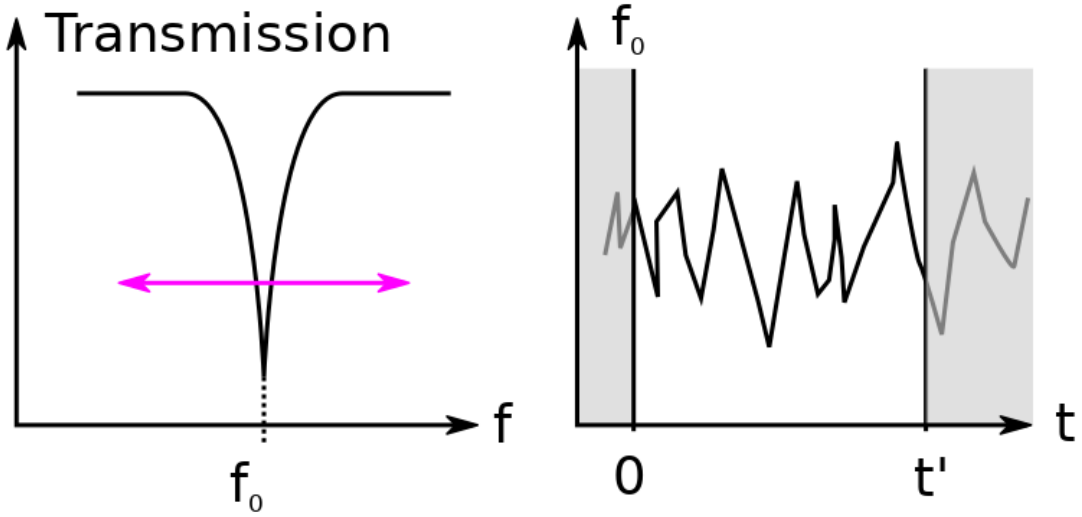

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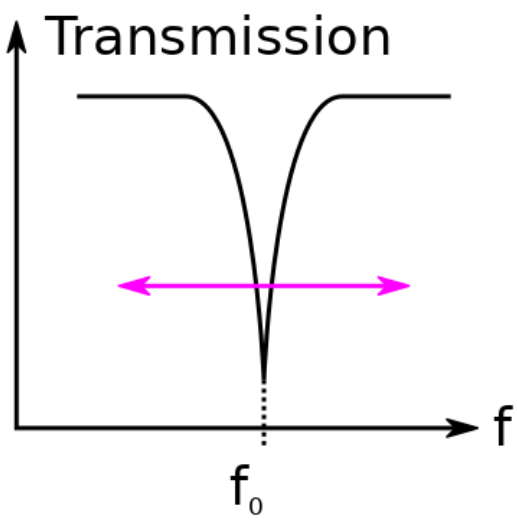

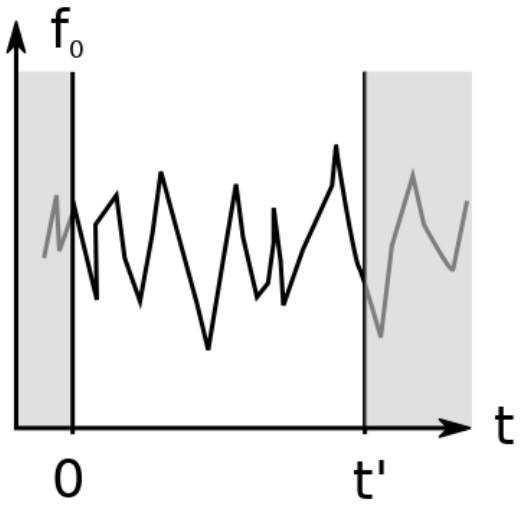

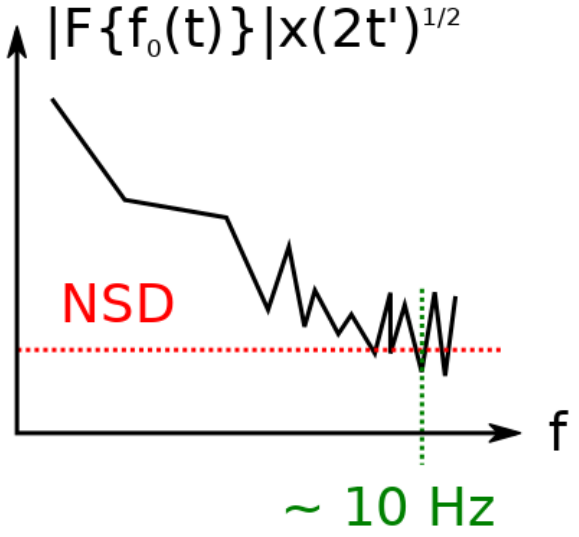

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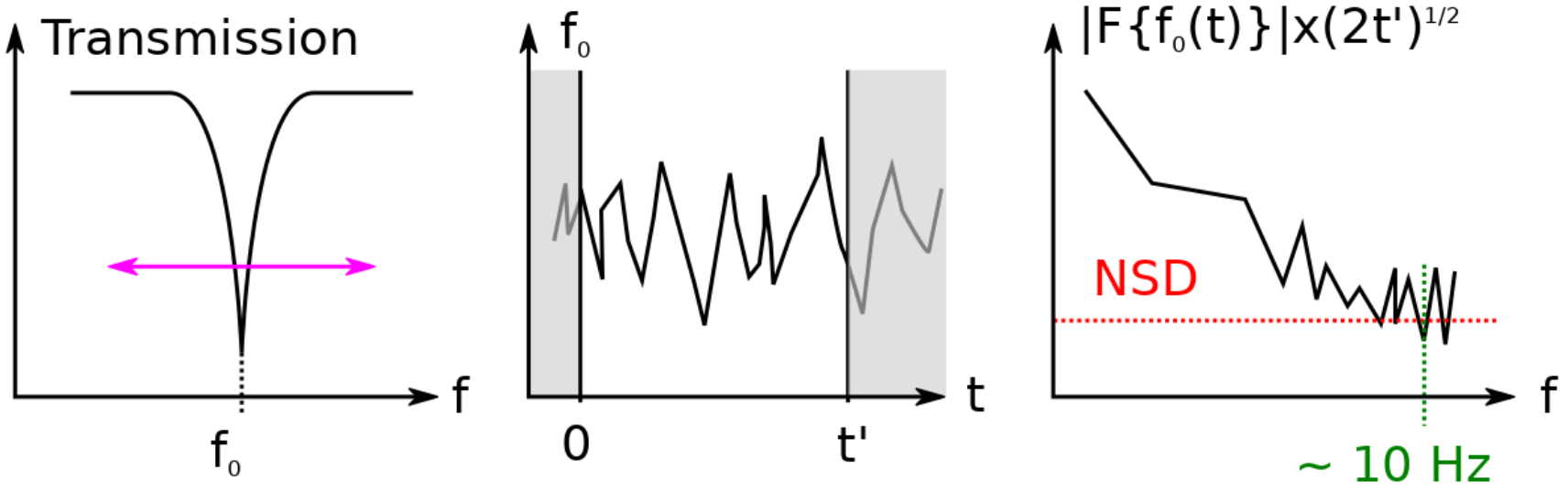

- Noise spectral density (NSD) quoted at noise floor

MKIDs performance

- Detector figure of merit:

  noise equivalent power (NEP)

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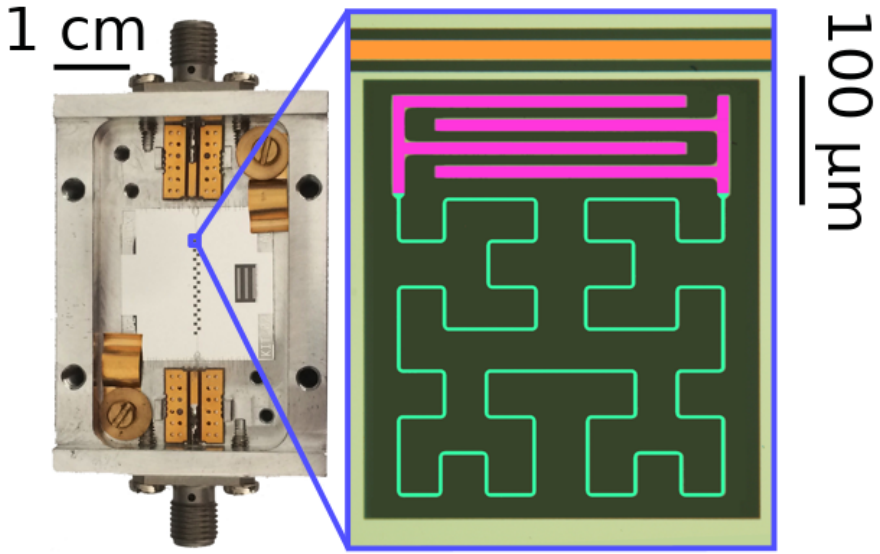
  - Increase $\Re$
  - Decrease NSD

MKIDs realization



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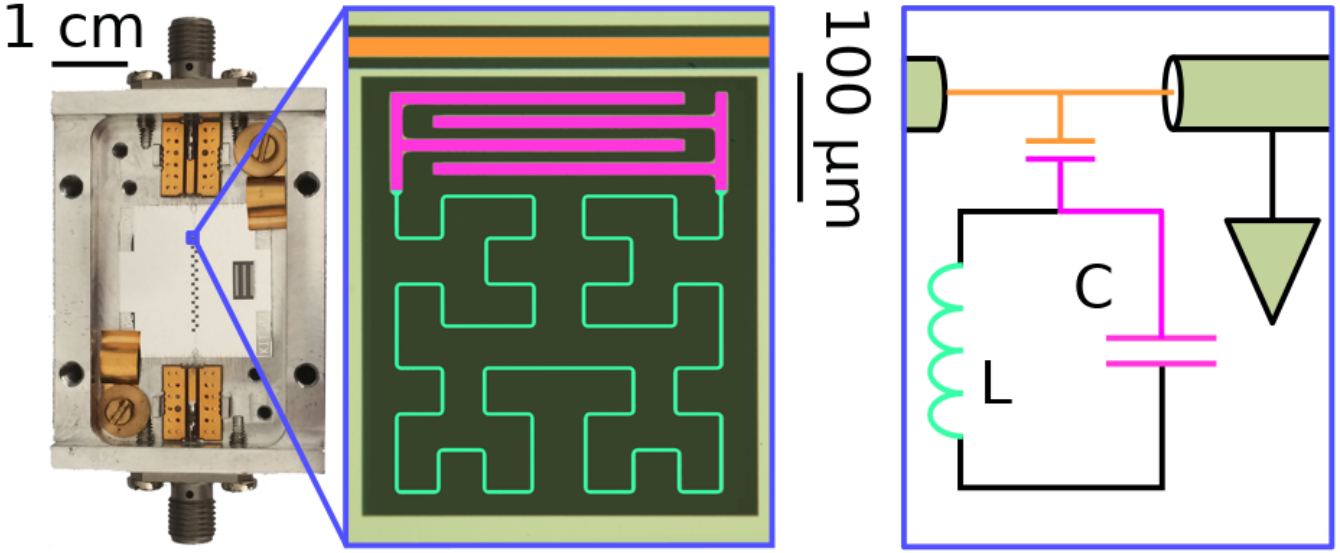

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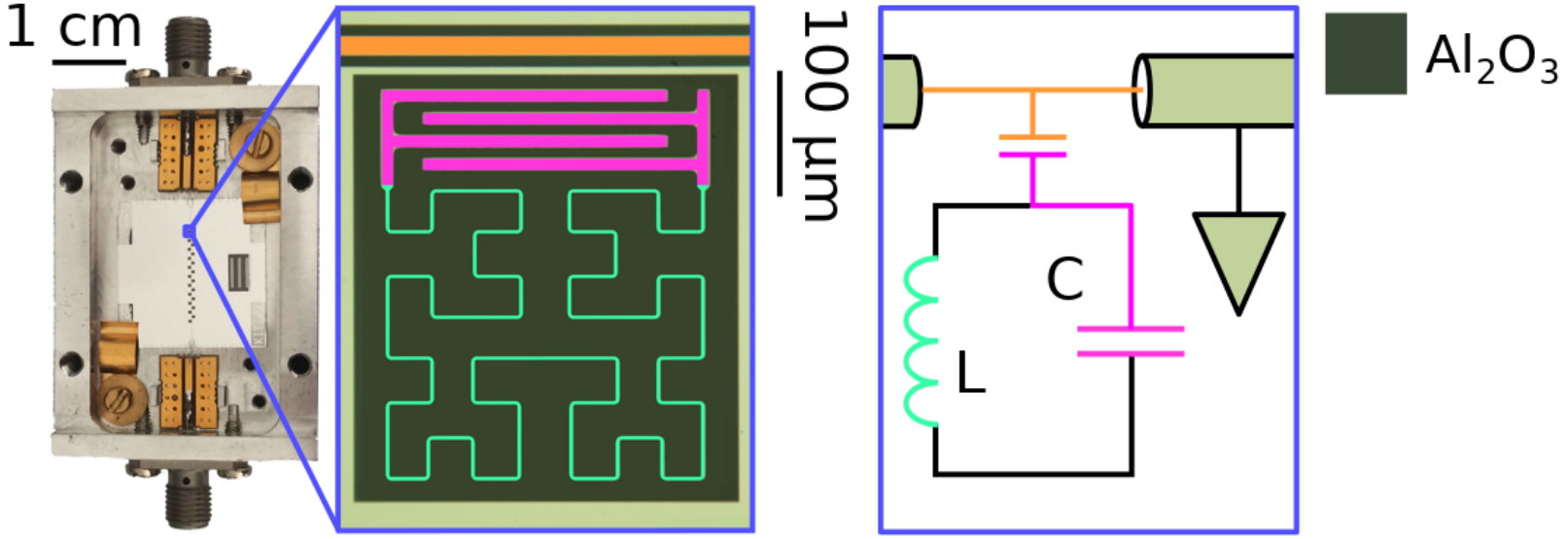

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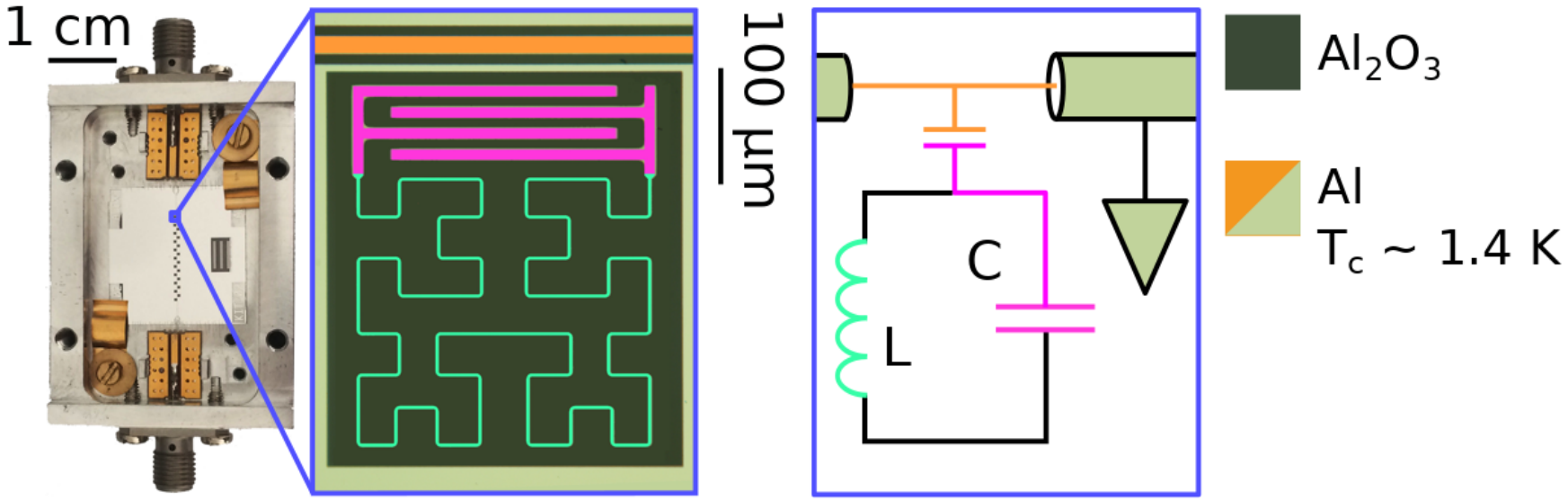

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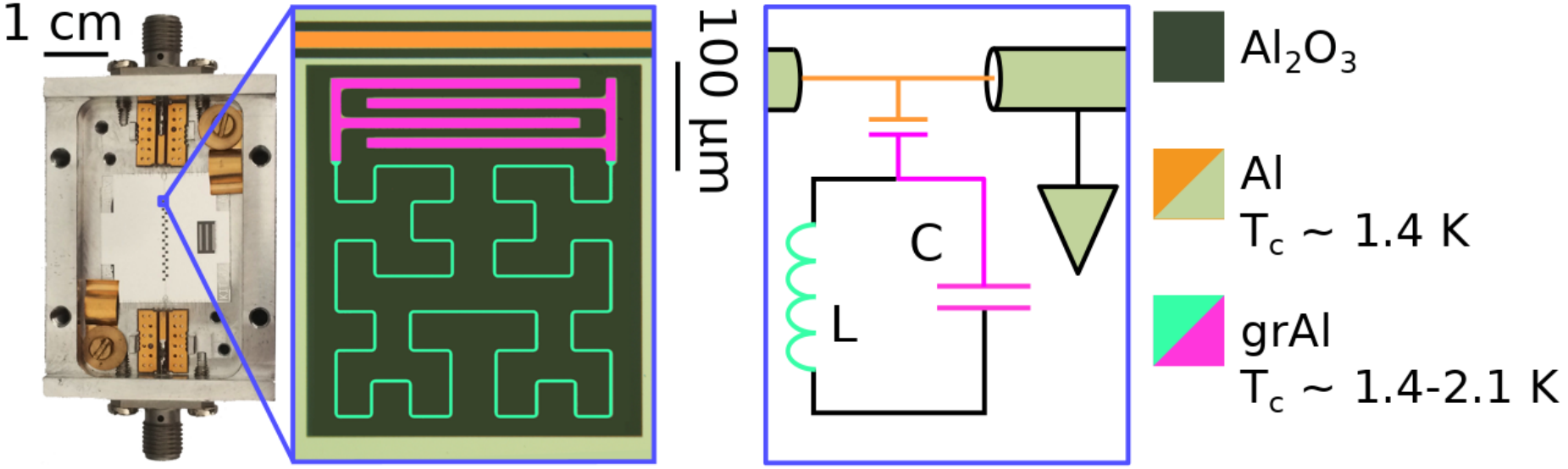

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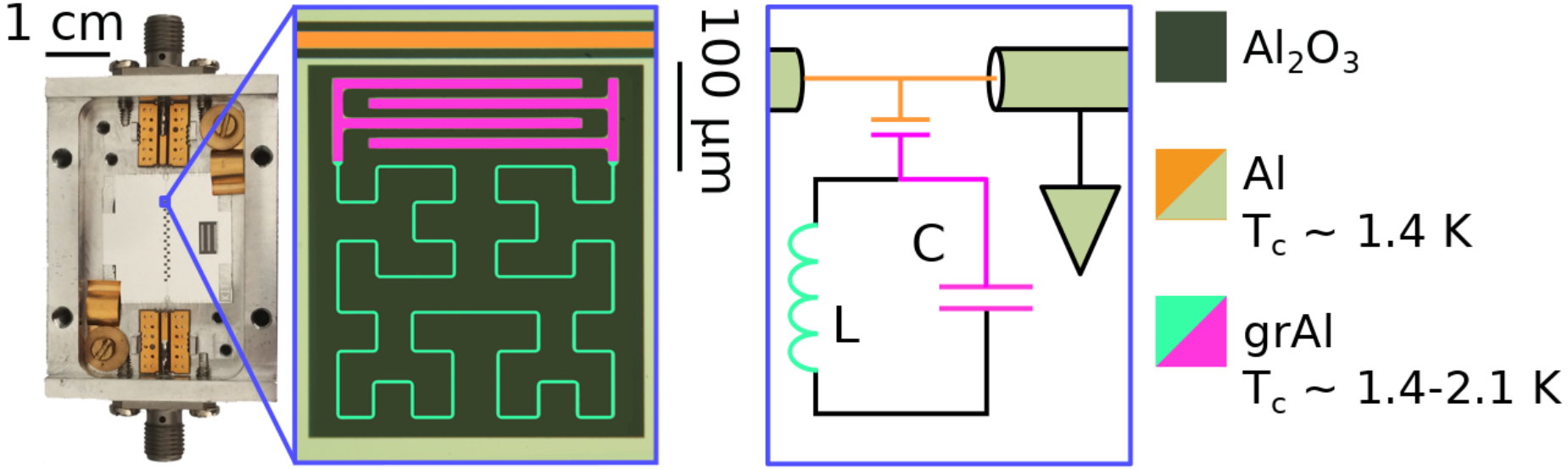

- Granular aluminum (grAl): a low-loss, gap-tunable composite material

Abeles *et. al.*, PRL 17,6532 (1966)

Deutscher *et. al.*, J. Vac. Sci. Technol. 10,697 (1973)

Pracht *et. al.*, Phys. Rev. B. 93, 100503(R) (2016)

Lévy-Bertand *et. al.*, Phys. Rev. B. 99, 094506 (2019)

Increase responsivity: an effective strategy?

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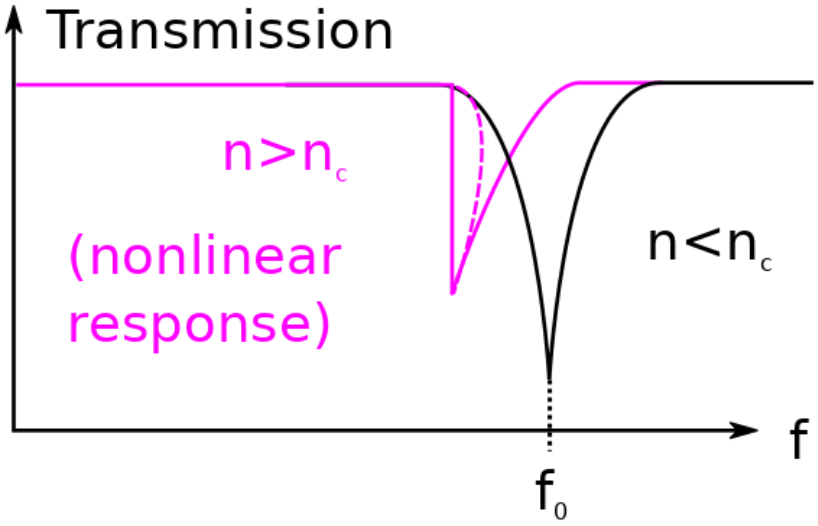
(Maleeva *et. al.*, Nat. Comm. 9:3889, 2018)



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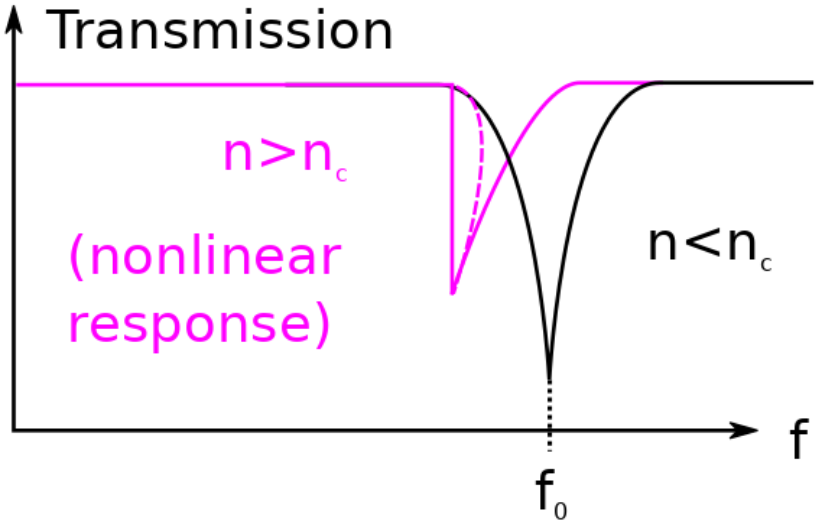

- Encode interplay in **voltage responsivity**:

$$\Re_V = \alpha \times n_c^{1/2}$$

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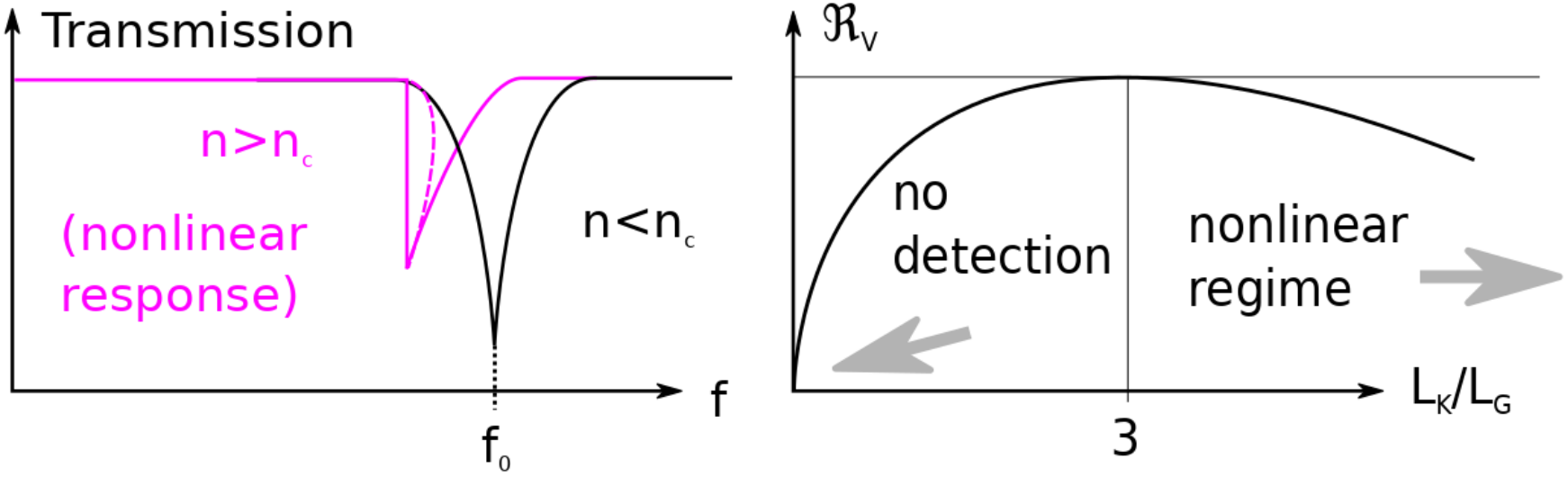

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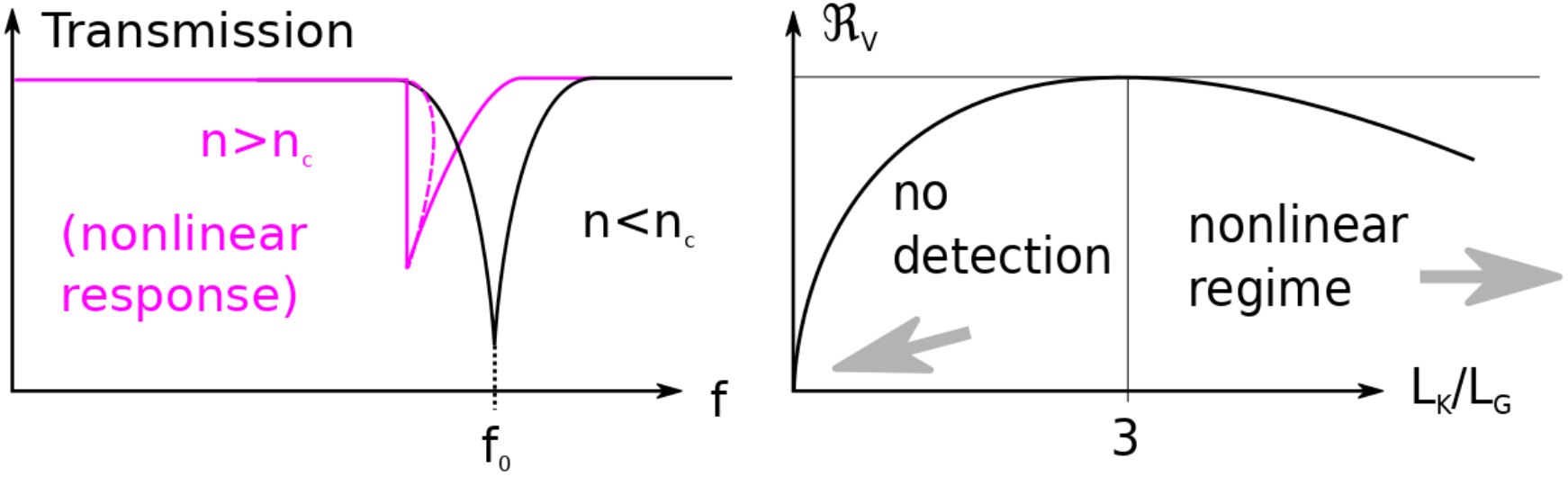

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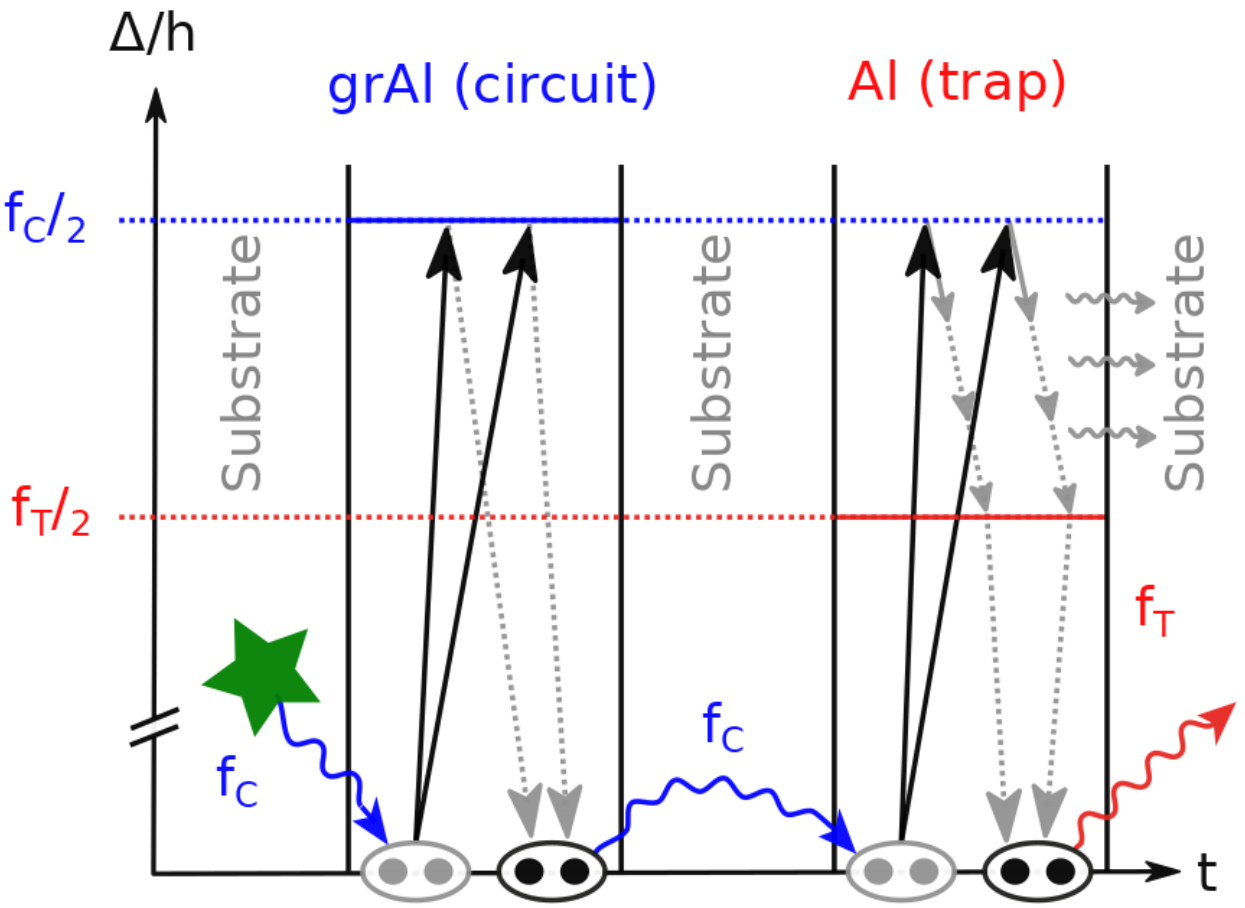
- Lower gapped ground plane (aluminum = trap) downconverts phonons

Karatsu *et. al.*, App. Phys. Letters 114, 032601 (2019)

Valenti *et. al.*, Phys. Rev. Applied 11, 054087 (2019)

Decrease noise: phonon trapping



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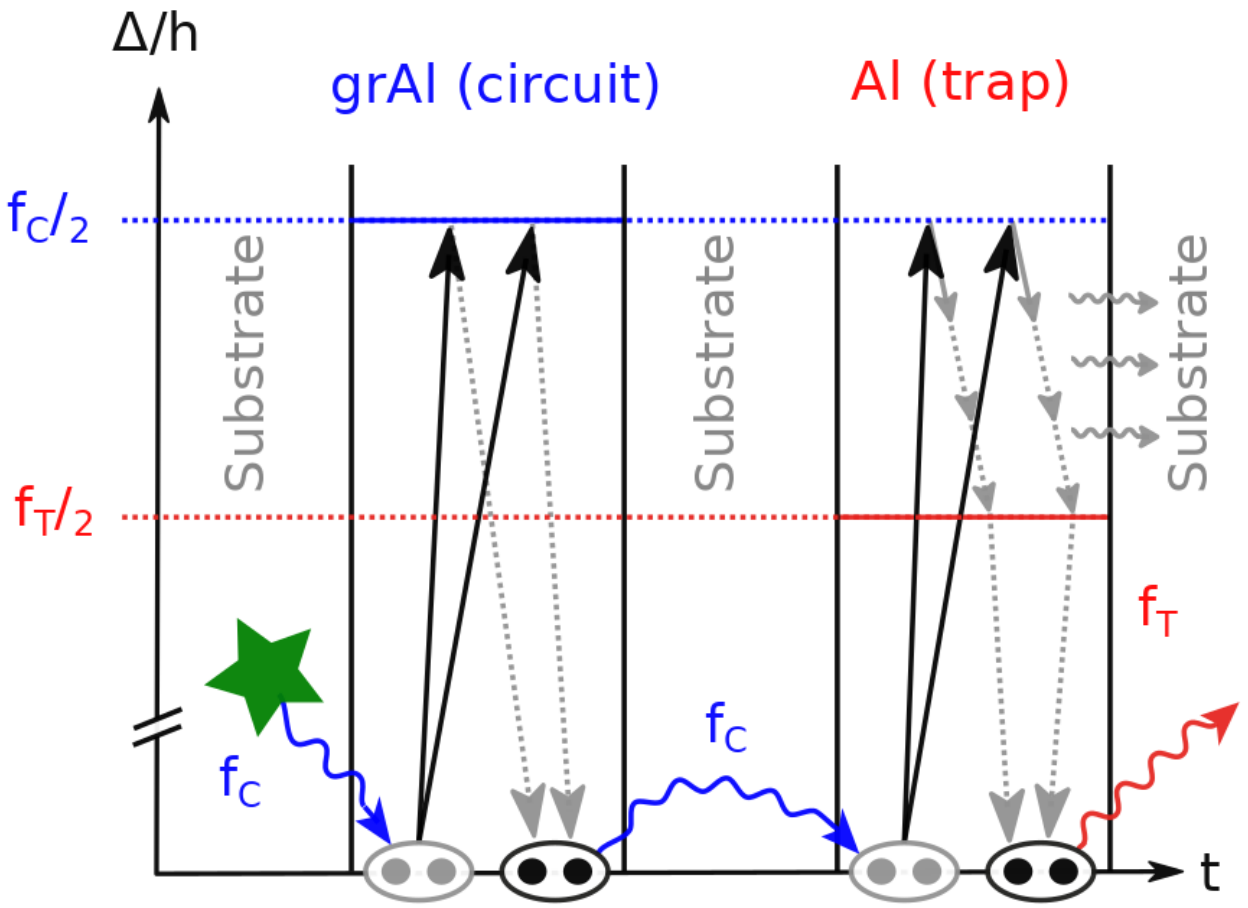

Increase $\Delta_{circuit}$ - Δ_{trap} ⇒ decrease NEP

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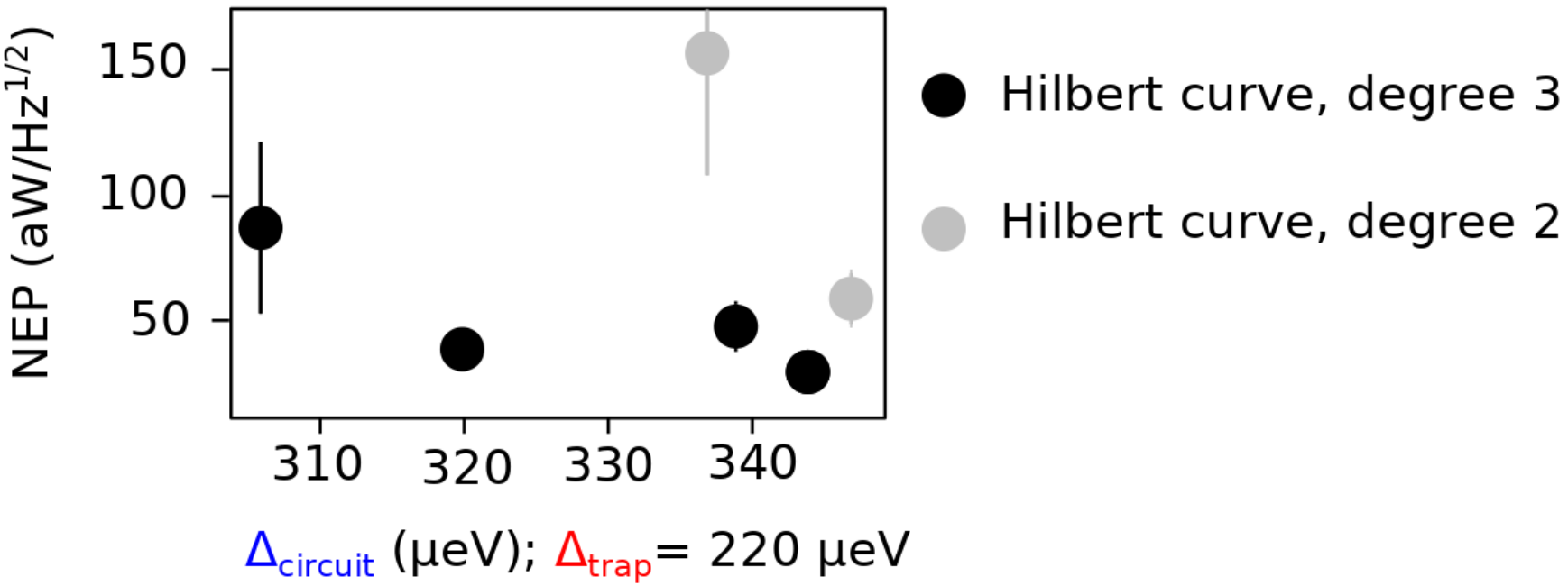

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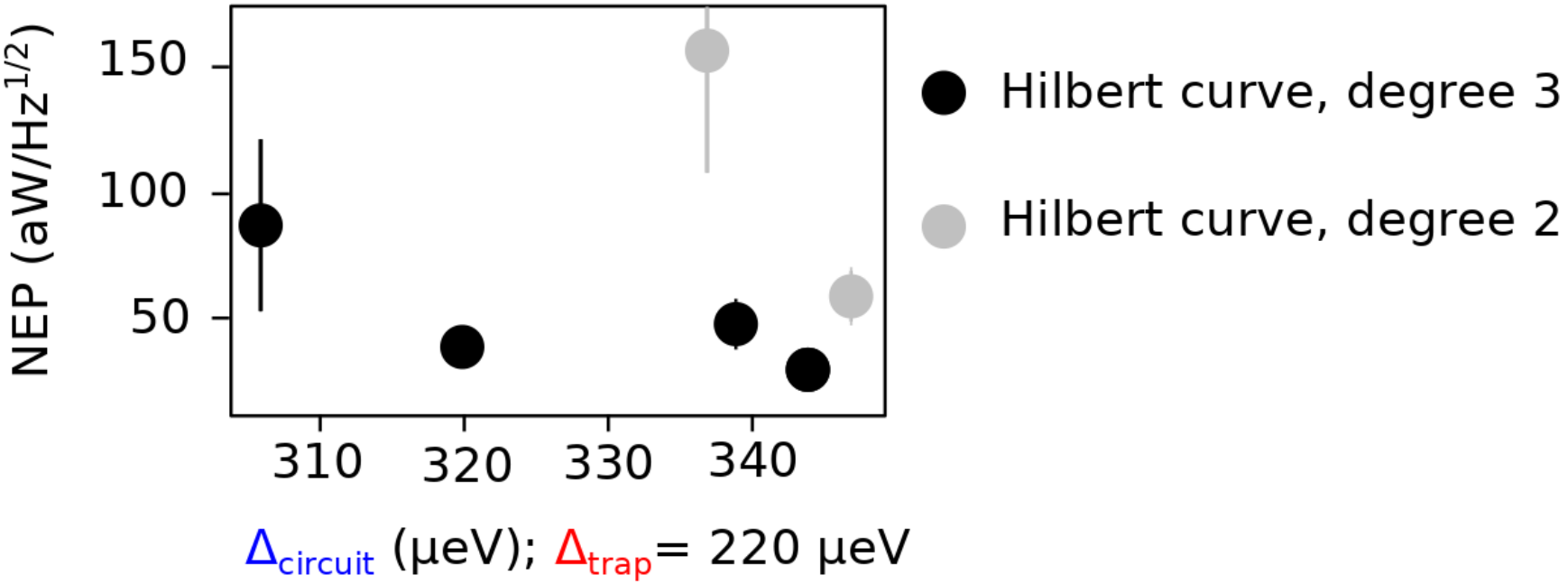

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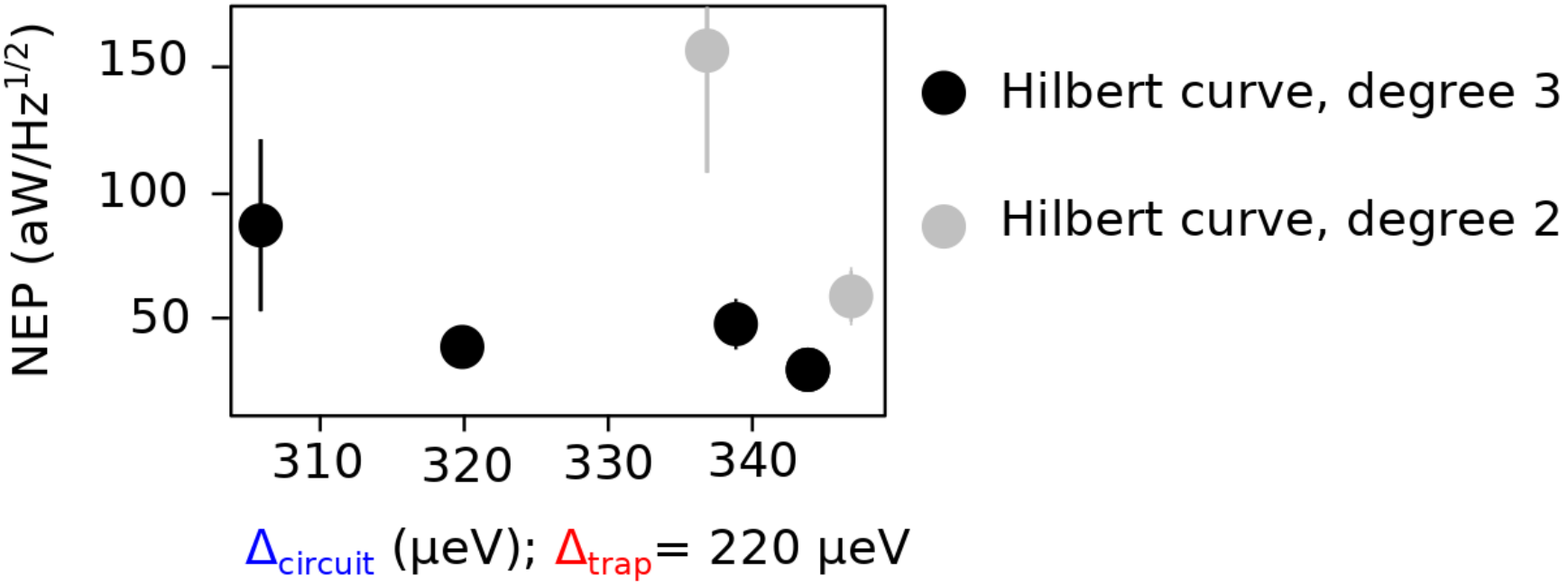

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- Phonon trapping is the winning strategy

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(Henriques, Valenti *et. al.*, in preparation)

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Thank you for your attention!