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Phonon traps and radiation shielding to reduce the quasiparticle density in superconducting circuits

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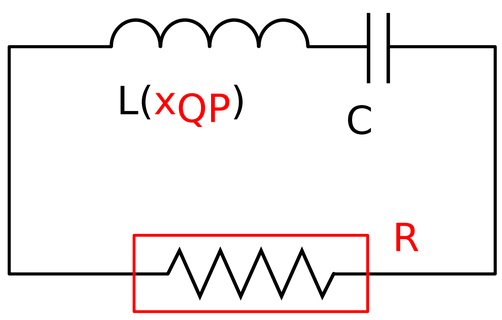
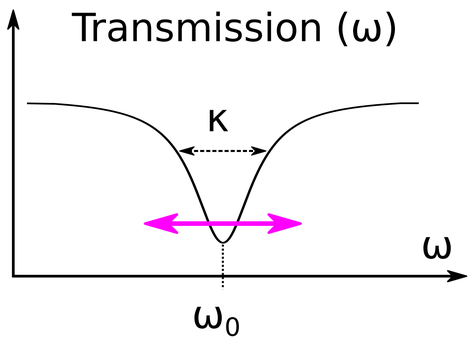
Quasiparticles (QPs) in high Z resonators

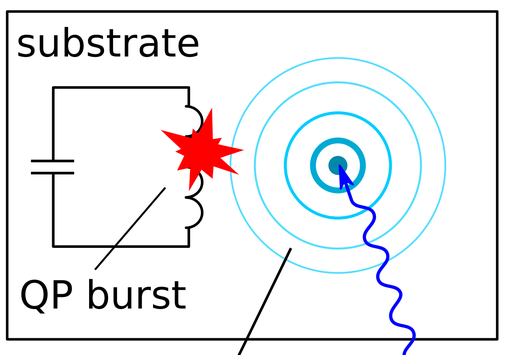
- Two-fluid model: quasiparticles = resistor

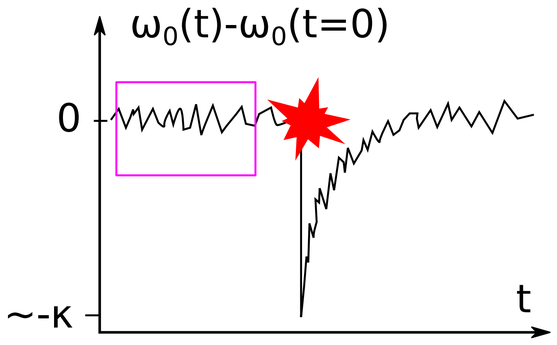
$Q_i^{-1} = \omega_0 RC$ $\quad \omega_0^{-2} = L(x_{QP})C$ $\quad$ QPs: loss, jitter





- One possible source: particle impacts

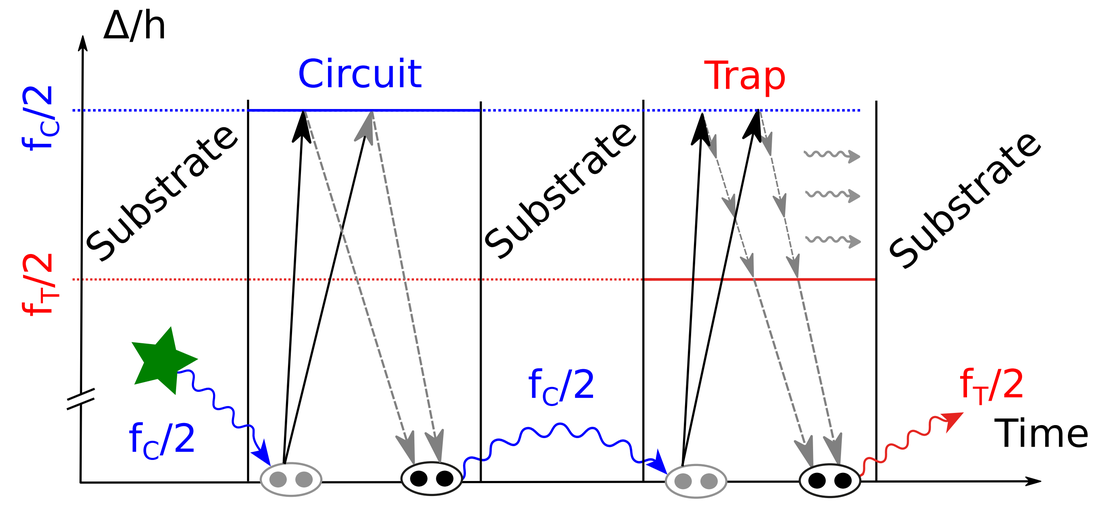




- Twofold approach: shield resonators from phonons and substrate from particle impacts

Phonon traps: proof of concept with grAl

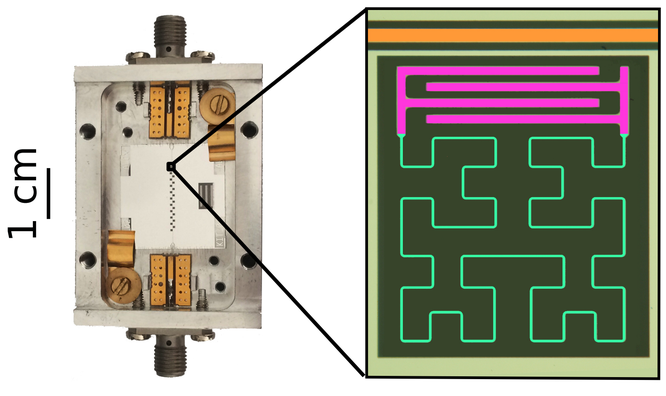
Valenti et al., PRApp 11, 054087 (2019)

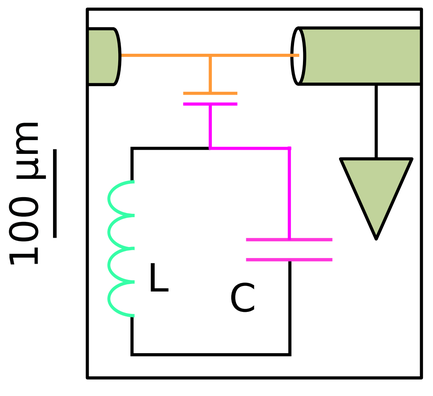


Al: lower gap ⇒ trap

granular aluminum (grAl): higher gap ⇒ circuit

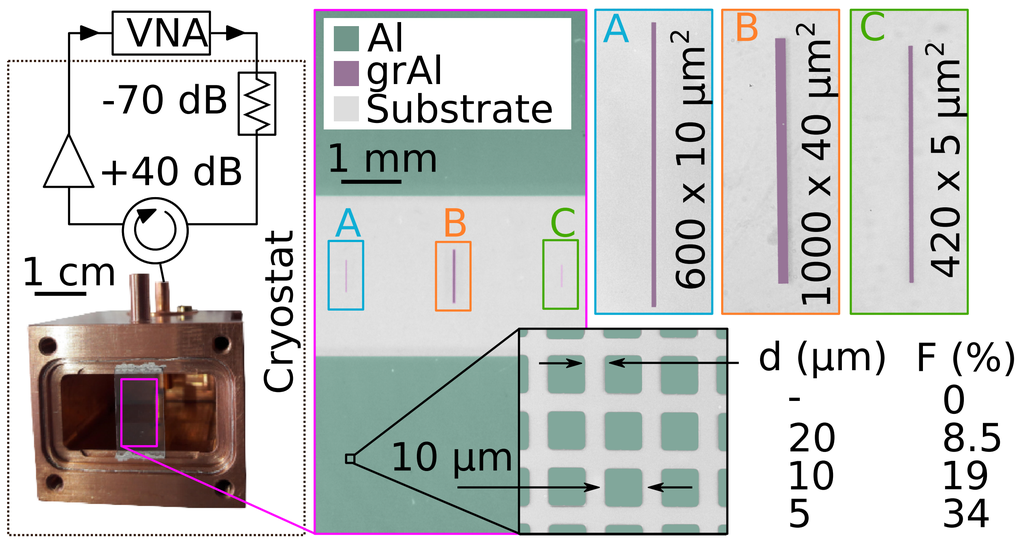
Al_2O_3

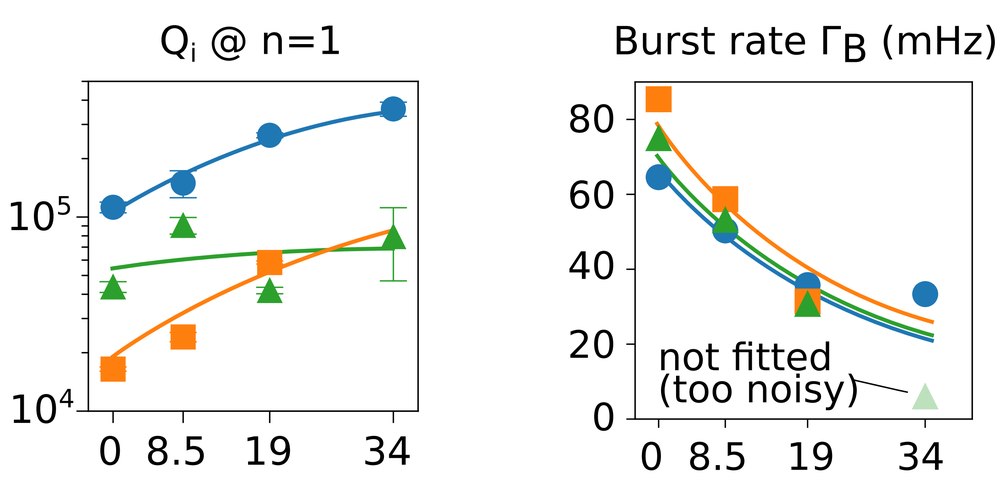




Phonon traps: a systematic study

Valenti, Henriques et al., APL **115**, 212601 (2019)





Radiation shielding: the DEMETRA project

Valenti, Cardani et al., Nat. Comm. **12**, 2733 (2021)

- Sample with no phonon traps
- Three cryogenics setups:

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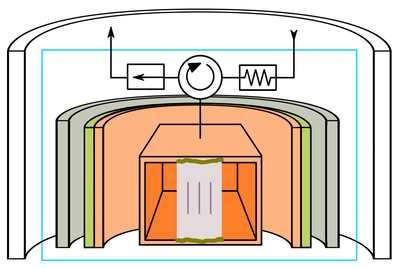
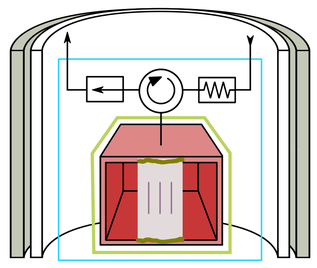
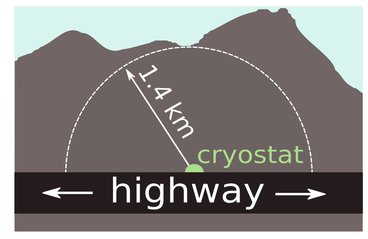
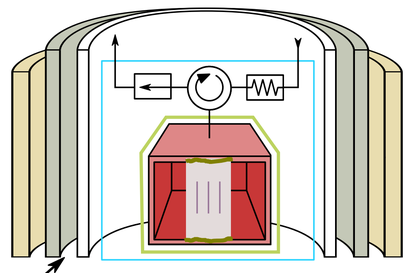


Rome



Gran Sasso





Cu μ-metal Cu (acid cleaned)

glue (Ag paste or vacuum grease)

Cryostat body (steel) Al

Granite Pb (bricks)

ThO_2 source (on/off)