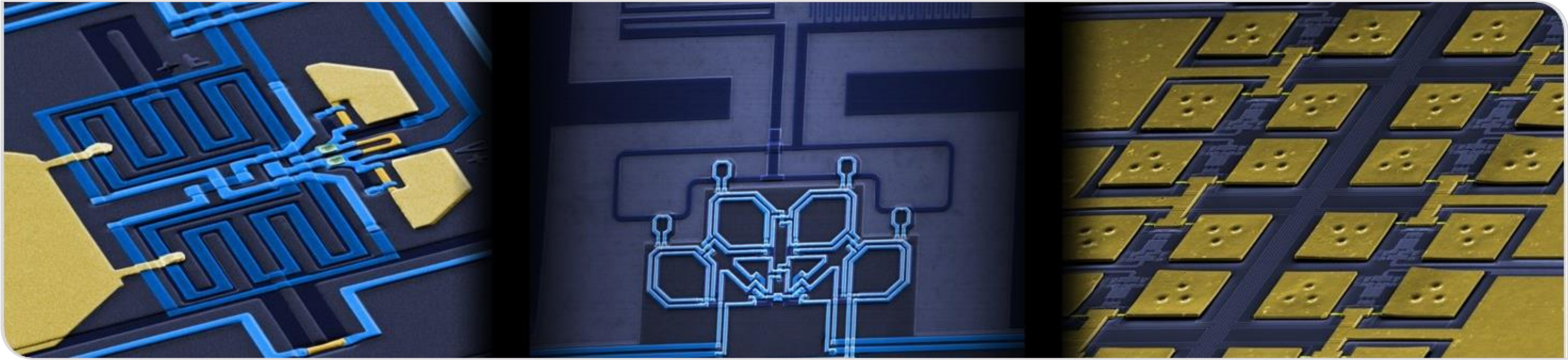
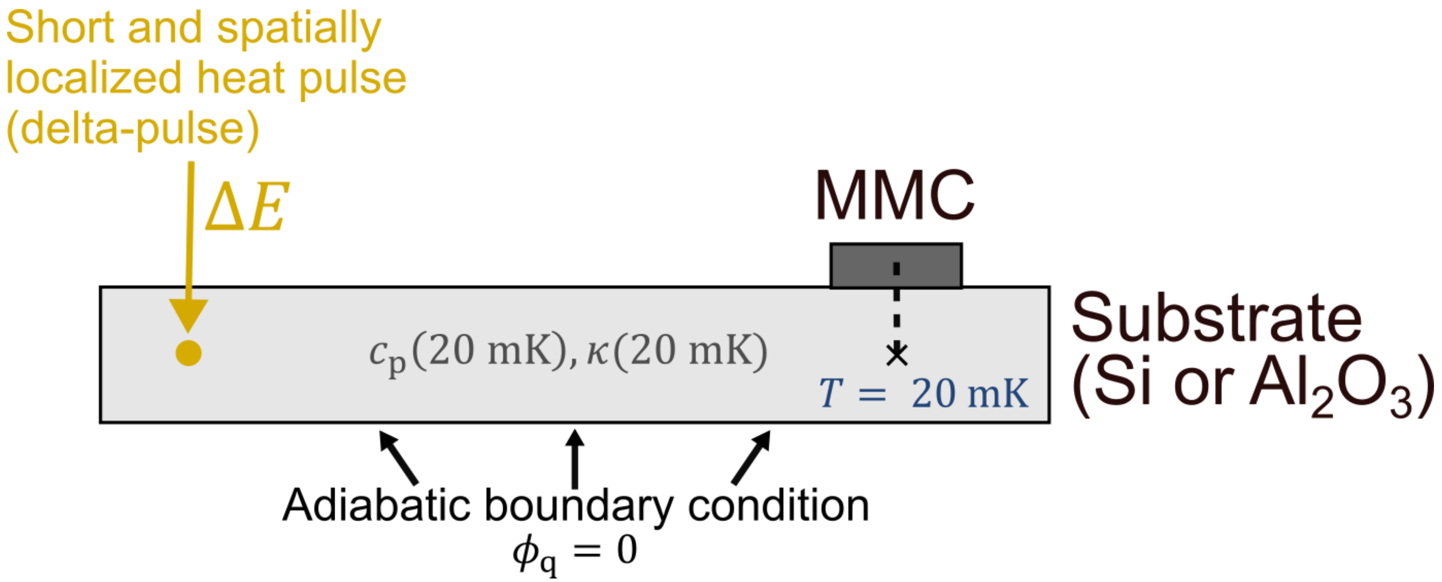
DELight Collaboration Meeting

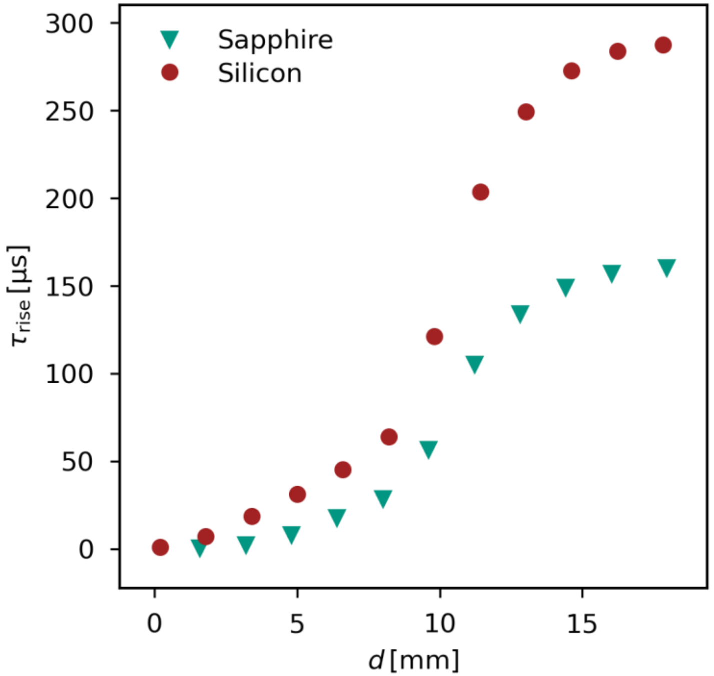
Lena Hauswald
Uni Freiburg, Freiburg, 18.06.25



Heat flow in dielectric substrates

- Worst case scenario: LAMCAL works as thermal, not athermal detector
- Finite-Elemente-Methode (FEM) simulation with Elmer to determine time resolution for worst-case scenario

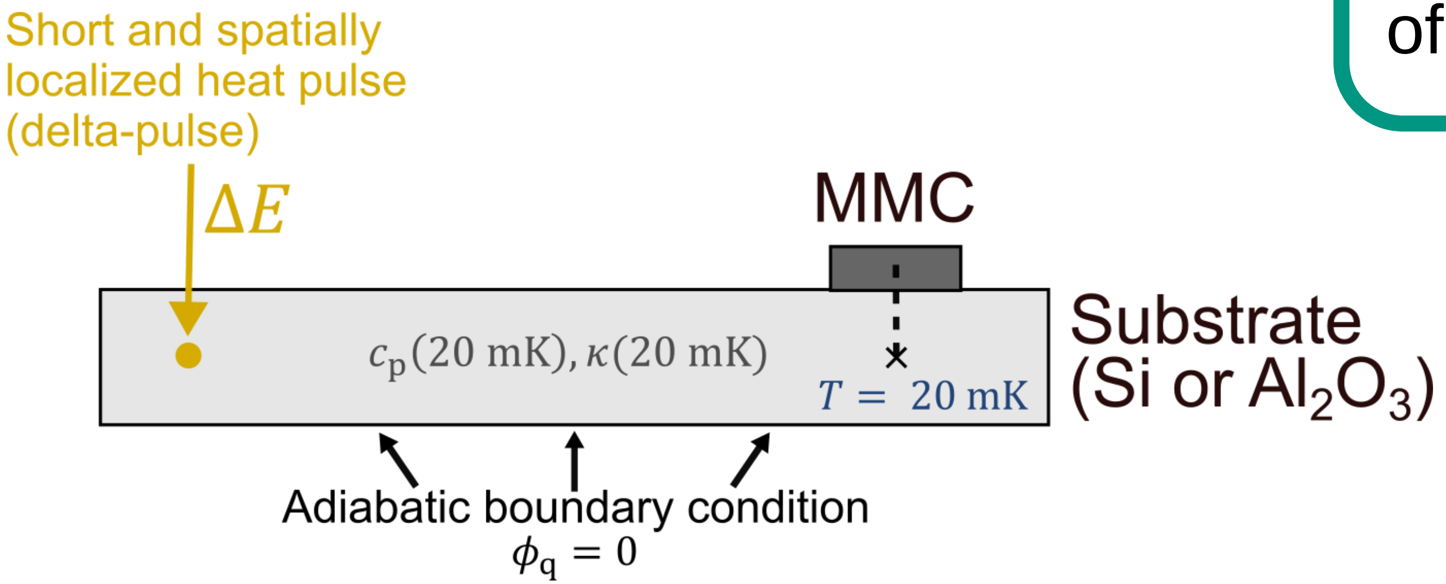


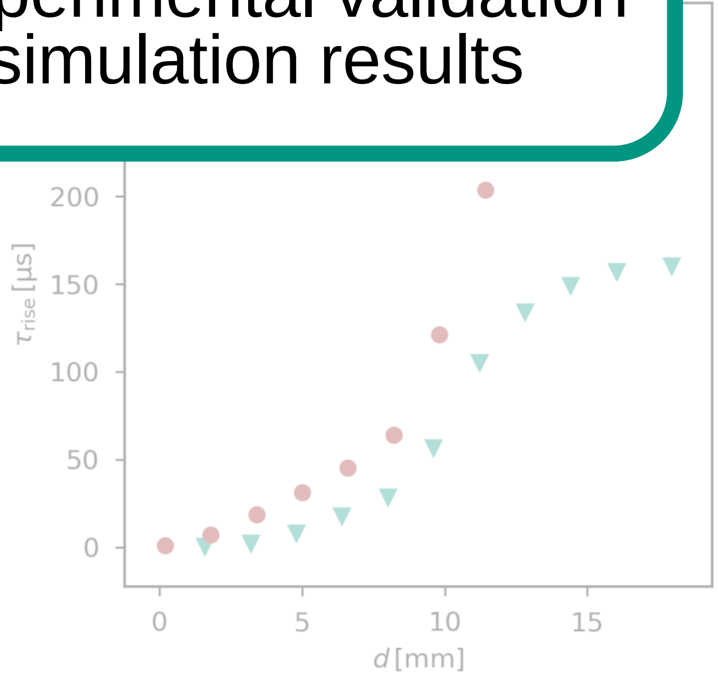


Heat flow in dielectric substrates

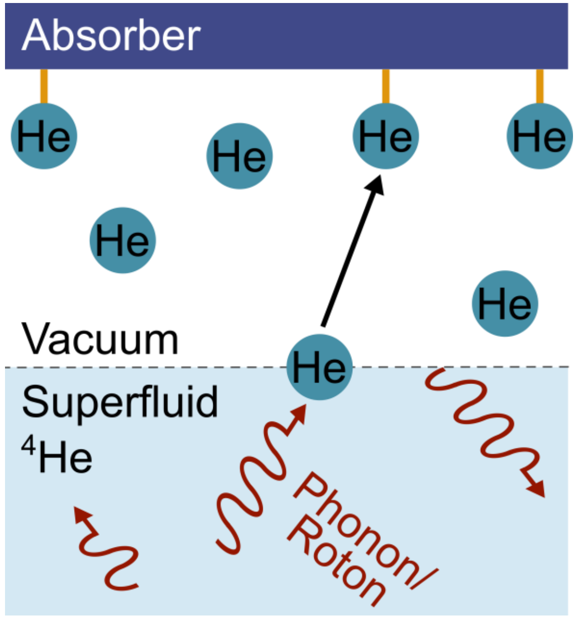
- Worst case scenario: LAMCAL works as thermal, not athermal detector
- Finite-Elemente-Methode (FEM) simulation … he resolution for worst-case scenario

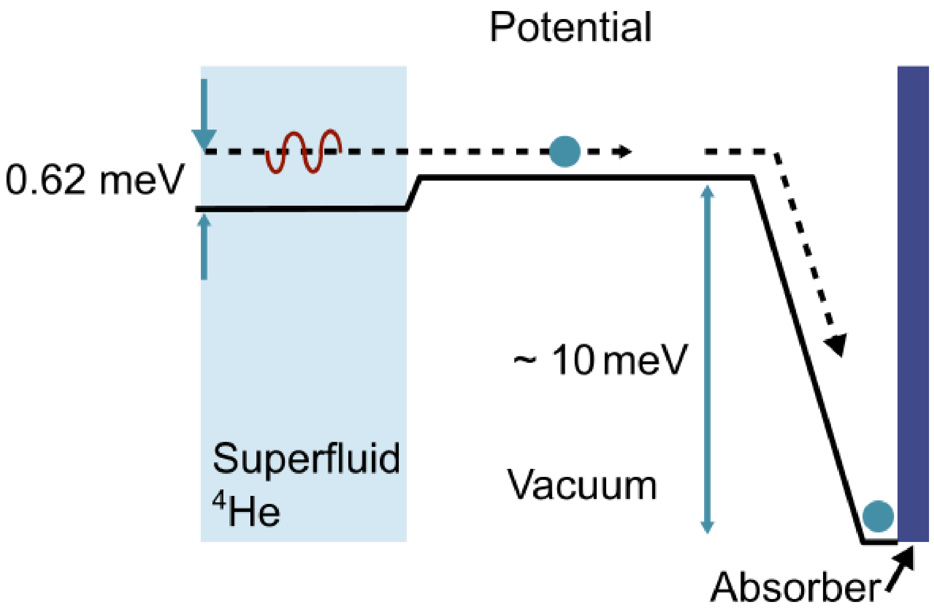
Ongoing master thesis:
Experimental validation of simulation results





Quasiparticle detection





- Typical QP energies $\geq 0.8\ \mathrm{meV}$
- Signal gain: Difference between evaporation and adsorption energy
- Dependent on absorber properties:
  - Silicon: ~ 10x;
  - Sapphire: ~ 20x

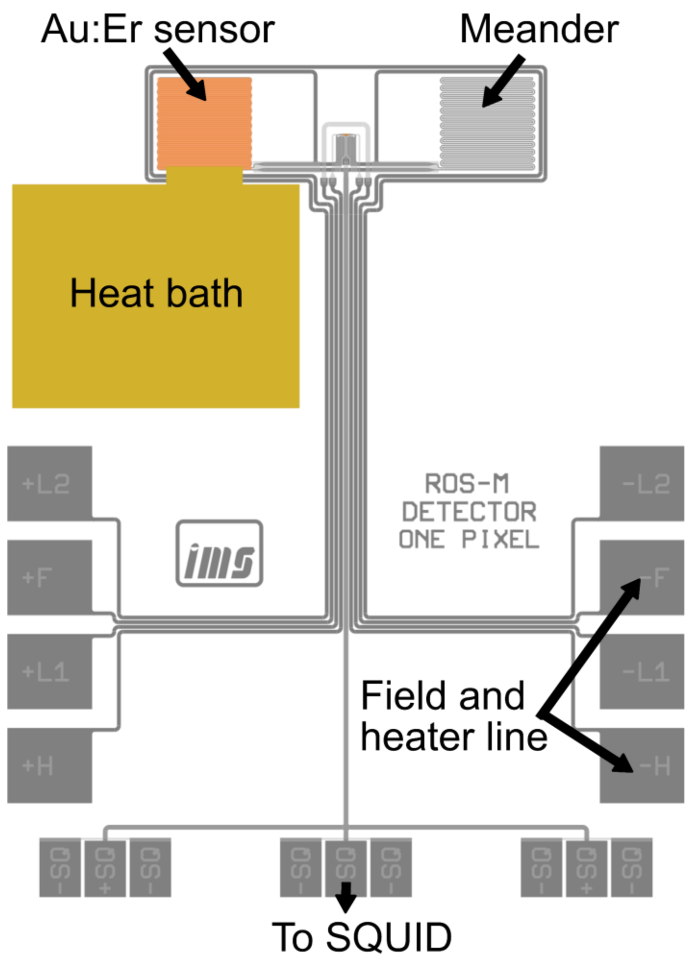
Magnetic calorimeters on sapphire substrate

Goal:

- First-time realization of a fully operational MMC on a sapphire substrate

Figures of merit validating full MMC functionality:

- Freezing of persistent current
- Agreement between magnetization measurement and theory expectation



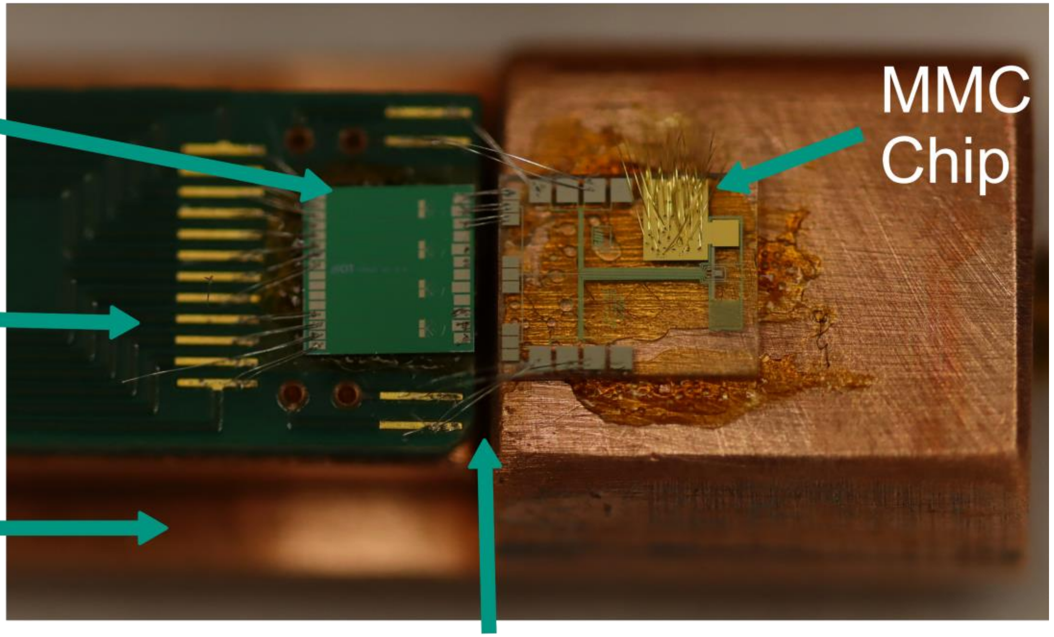
Magnetic calorimeters on sapphire substrate

Measurement setup

SQUID chip

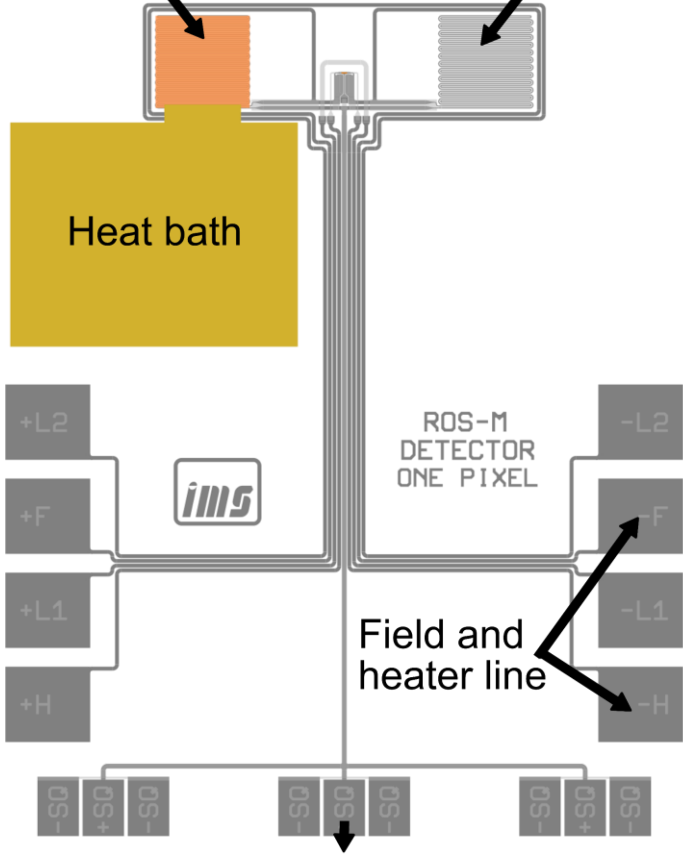
Circuit board

Copper holder



MMC Chip

Slit to themally decouple

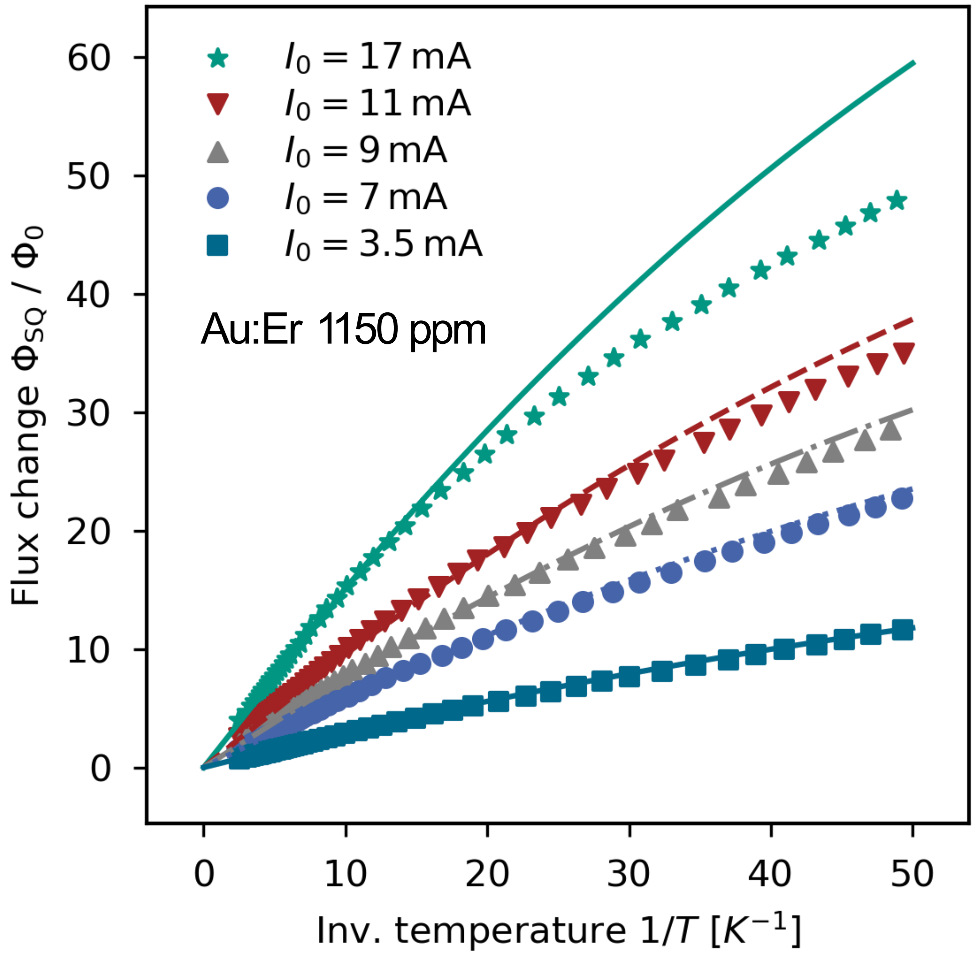


Magnetic calorimeters on sapphire substrate

Karlsruhe Institute of Technology

Results:

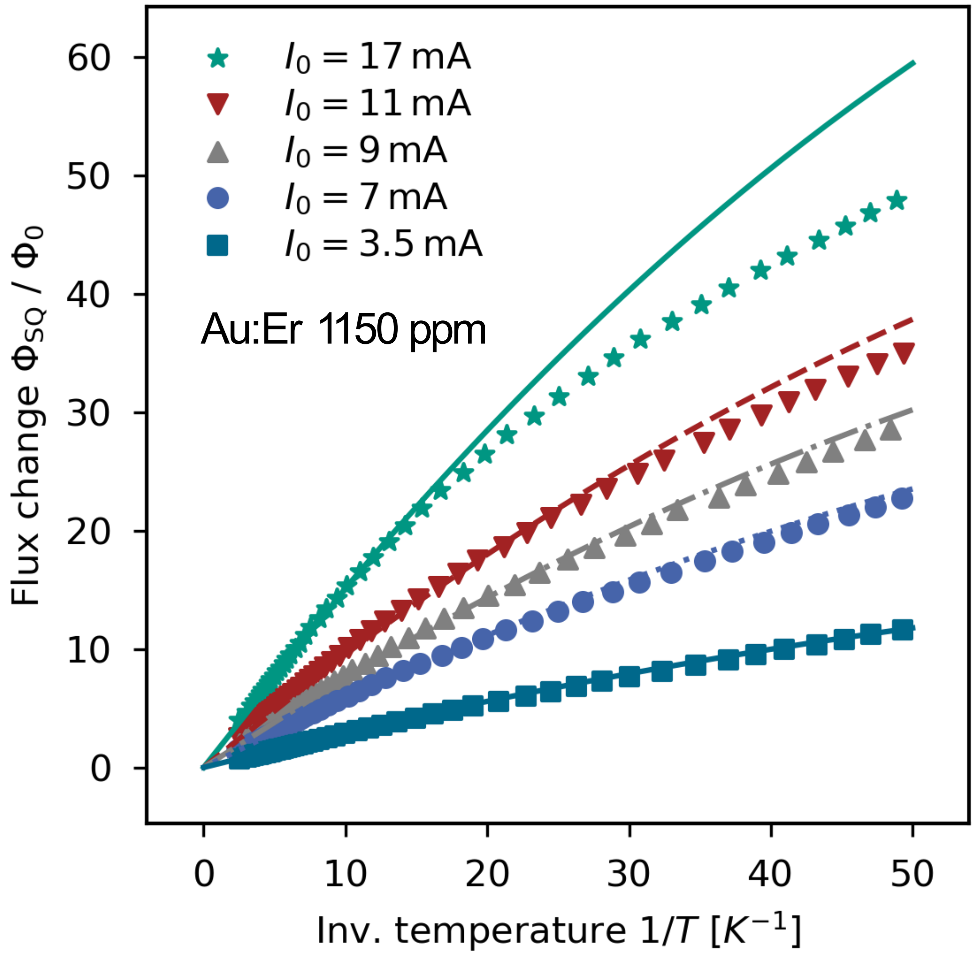
- First operating MMCs on sapphire
- Persistent current lower then anticipated
  - Dirty substrate, therfore poor Nb quality
- Rising deviation for higher currents and low temperatures
  - Au:Er concentration much higher than intended (Effect of spin-glass?)



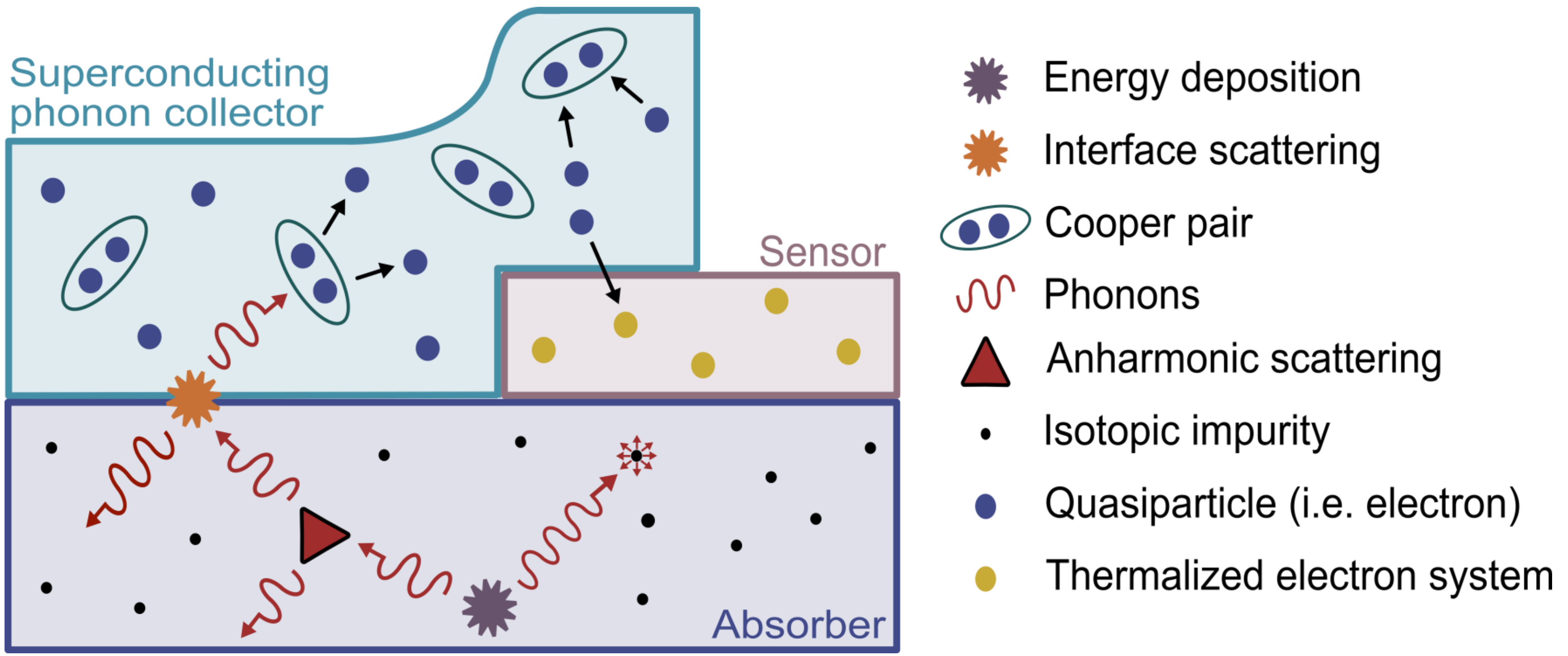
Magnetic calorimeters on sapphire substrate

Next to come:

- Fabrication of MMCs with reduced AuEr-Concentration and on clean substrates
- Optimization of parameters for improved freezing of persistent current
- Pulse measurements



Athermal phonon detector



Creation of athermal phonons → Cooper pair breaking; Quasiparticles (QPs) creation → (Diffusion) Thermalization through electron-electron interactions within temperature sensor

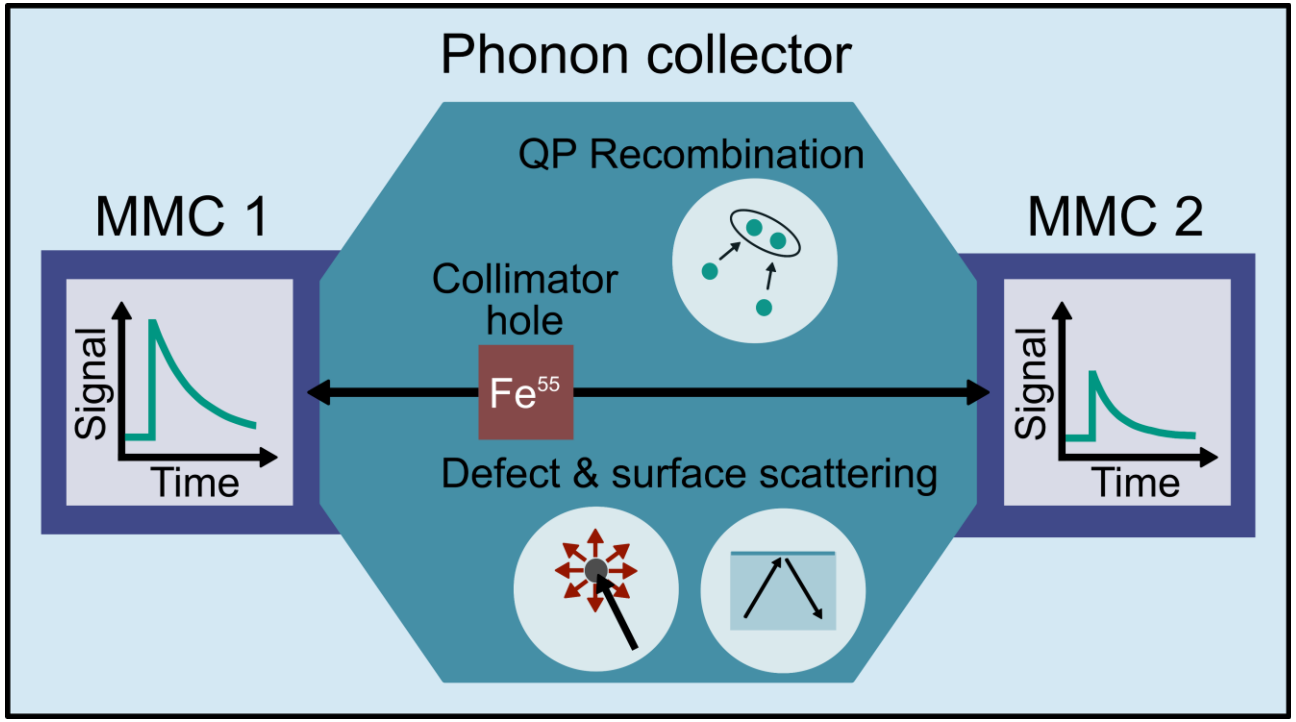
Quasiparticle lifetime experiment

Karlsruhe Institute of Technology

Experiment motivated by CRESST et al.

Angloher *et al.*, *J Low Temp Phys* 184, 323-329 (2016)

- Determination of diffusion length and quasiparticle lifetime
- Dependent on the choice of material and the quality of material
- Phonon collector geometry optimization

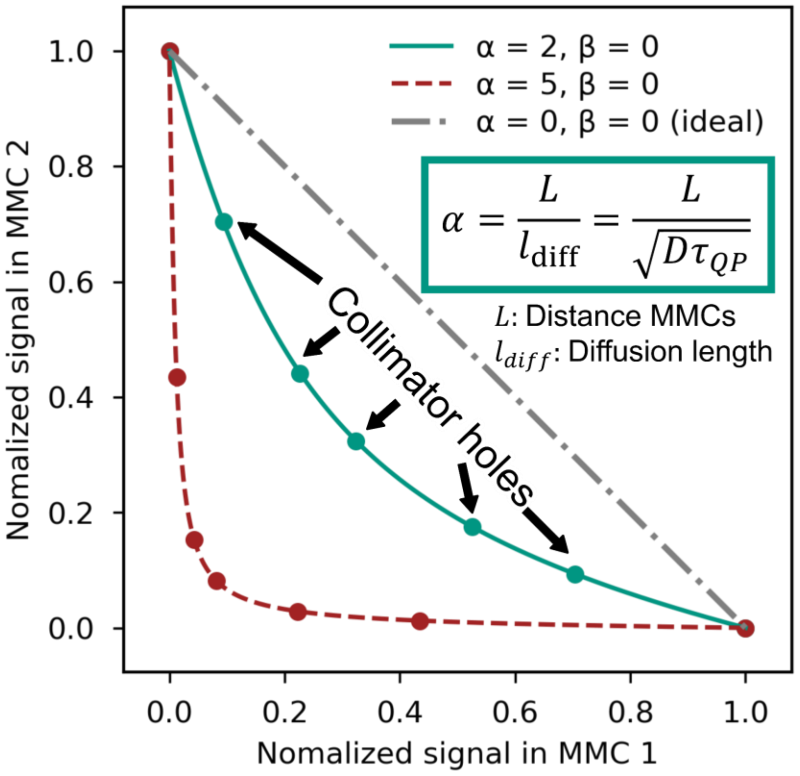


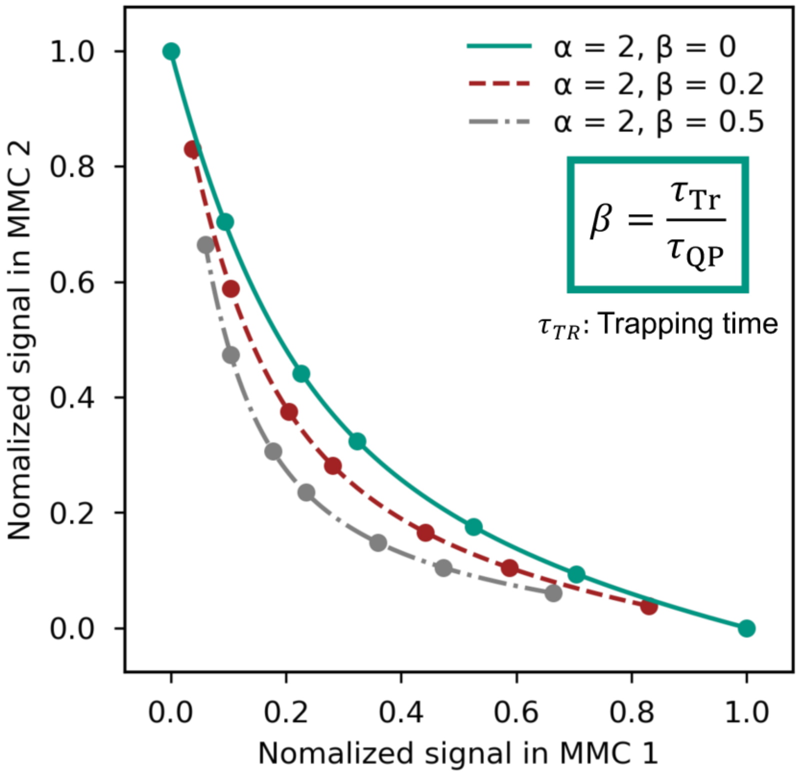
Quasiparticle lifetime experiment

1D Diffusion equation

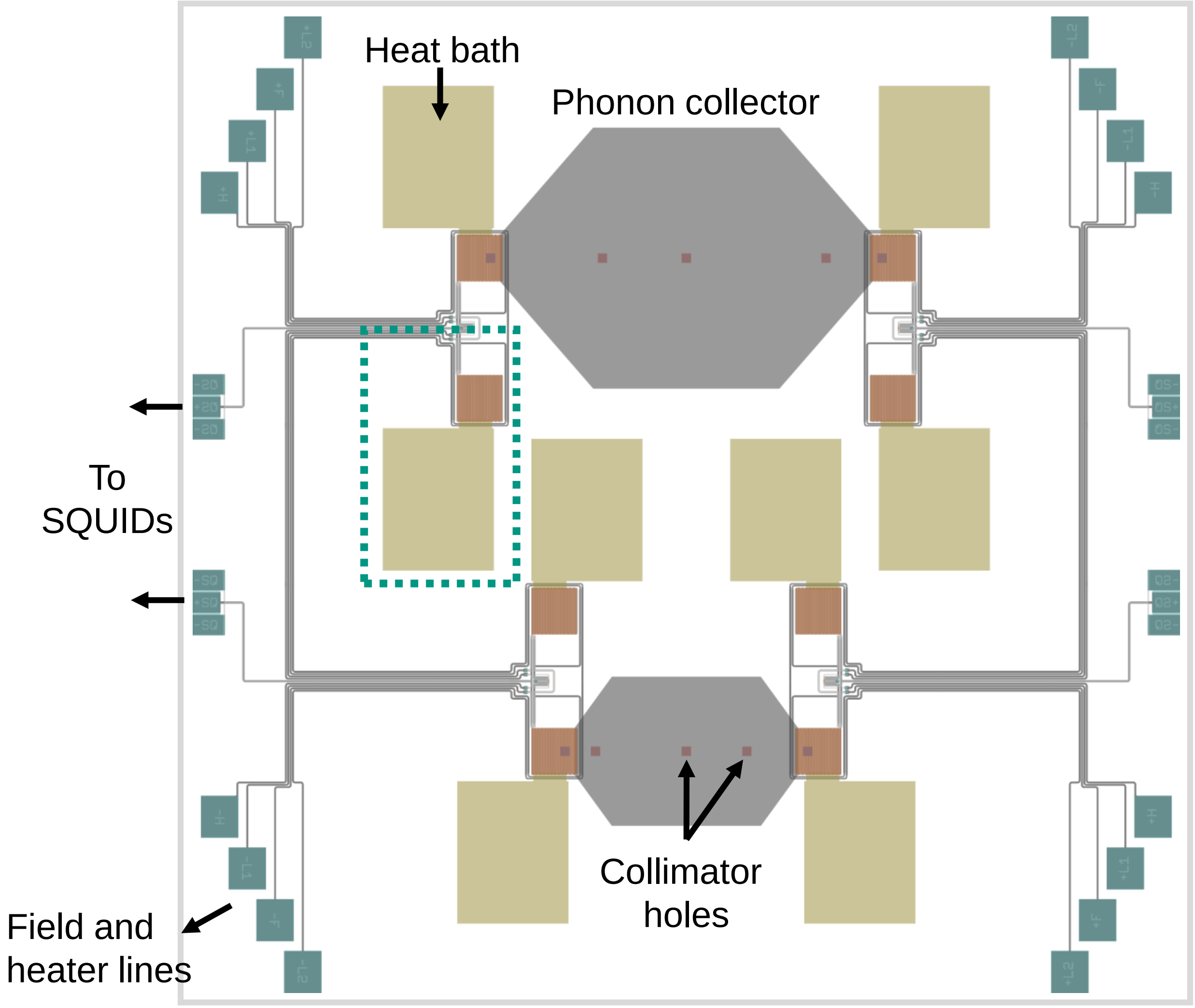
$$\boxed{\frac{\delta n}{\delta t} = D\frac{\delta^2 n}{\delta x^2} - \frac{n}{\tau_{\mathrm{QP}}}}$$

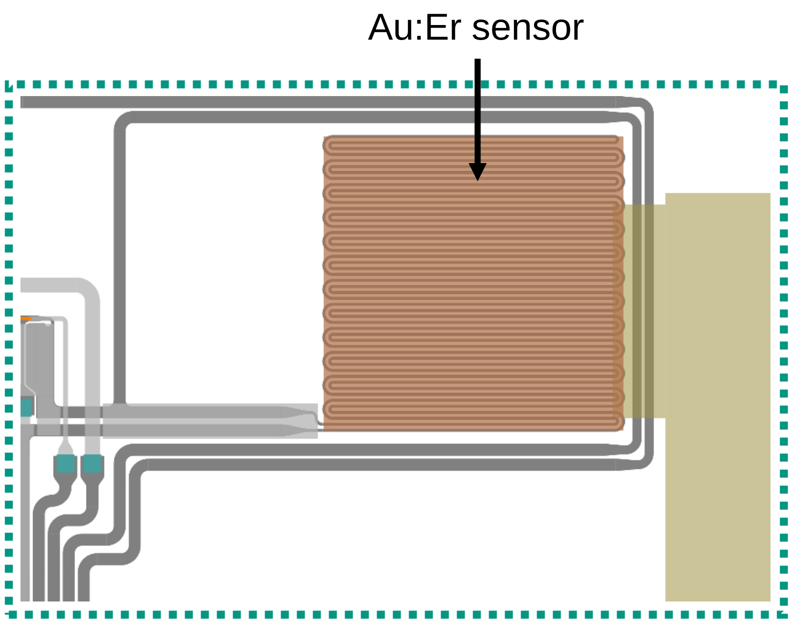
n: Number of QPs
D: Diffusion constant
τ_{QP}: QP lifetime



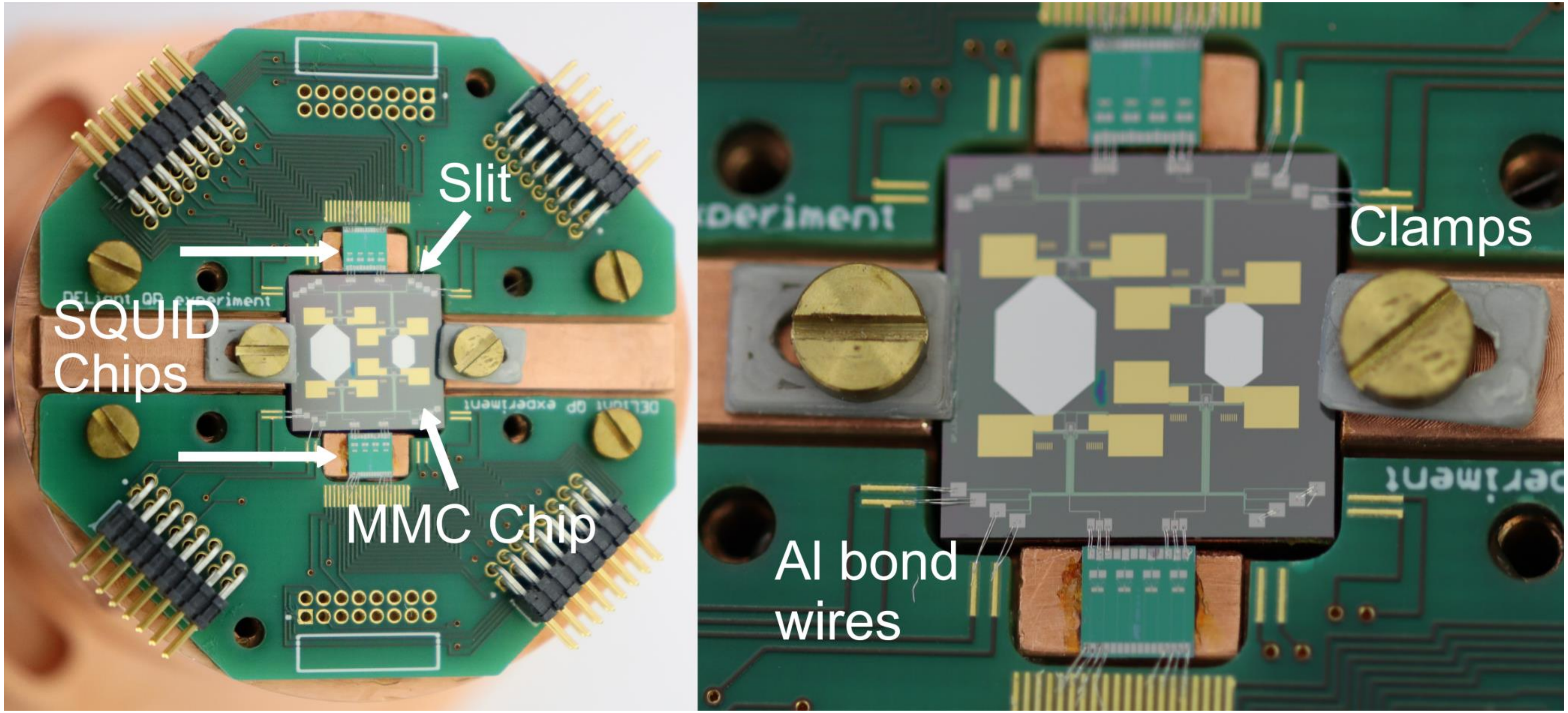


Quasiparticle lifetime experiment





Quasiparticle lifetime experiment



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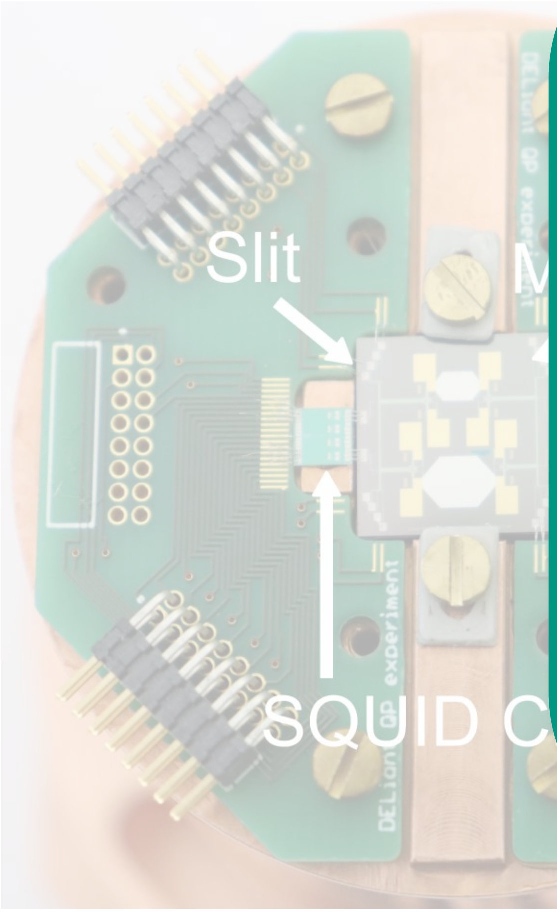
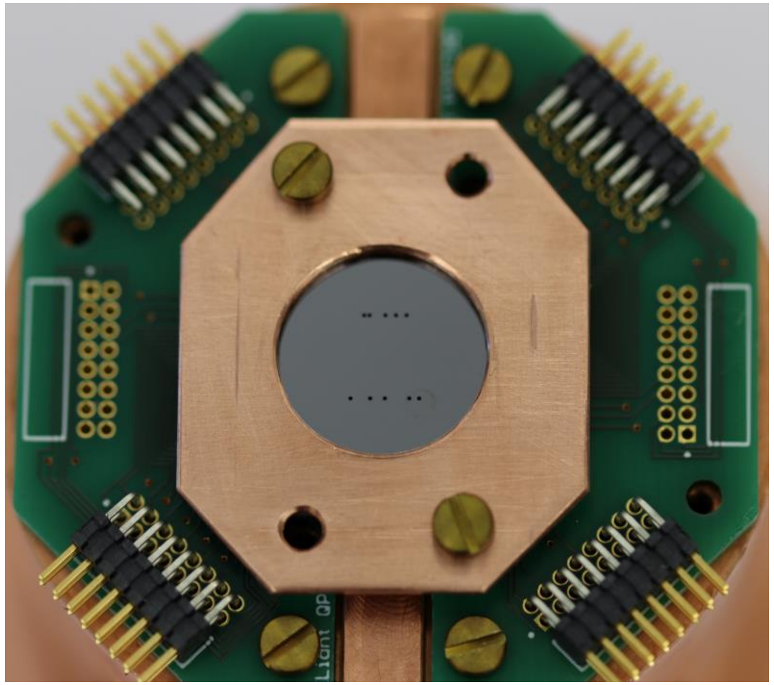
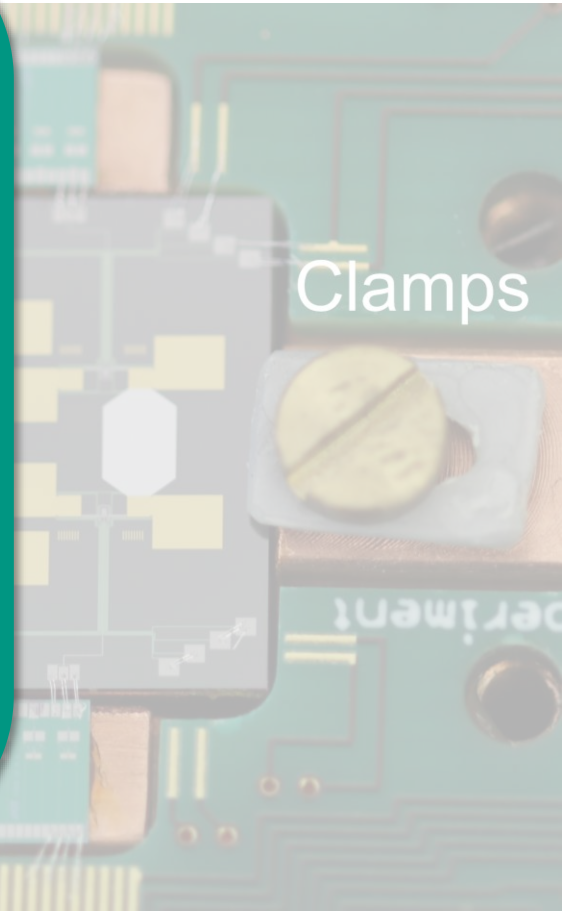


Collimator

150x150 μm^2 holes





Quasiparticle lifetime experiment

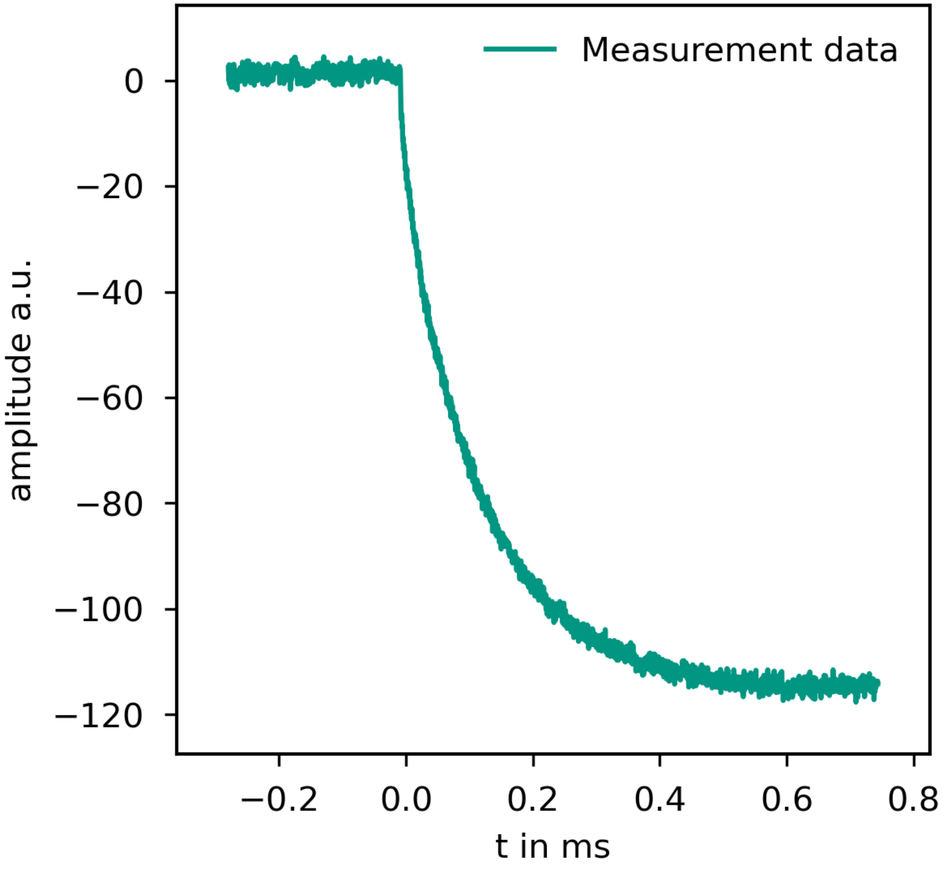
- First pulse measurements with Kr^{83m}-source
- Al foil to shield electrons

- Only one operating MMC
  - First pulse shape analysis

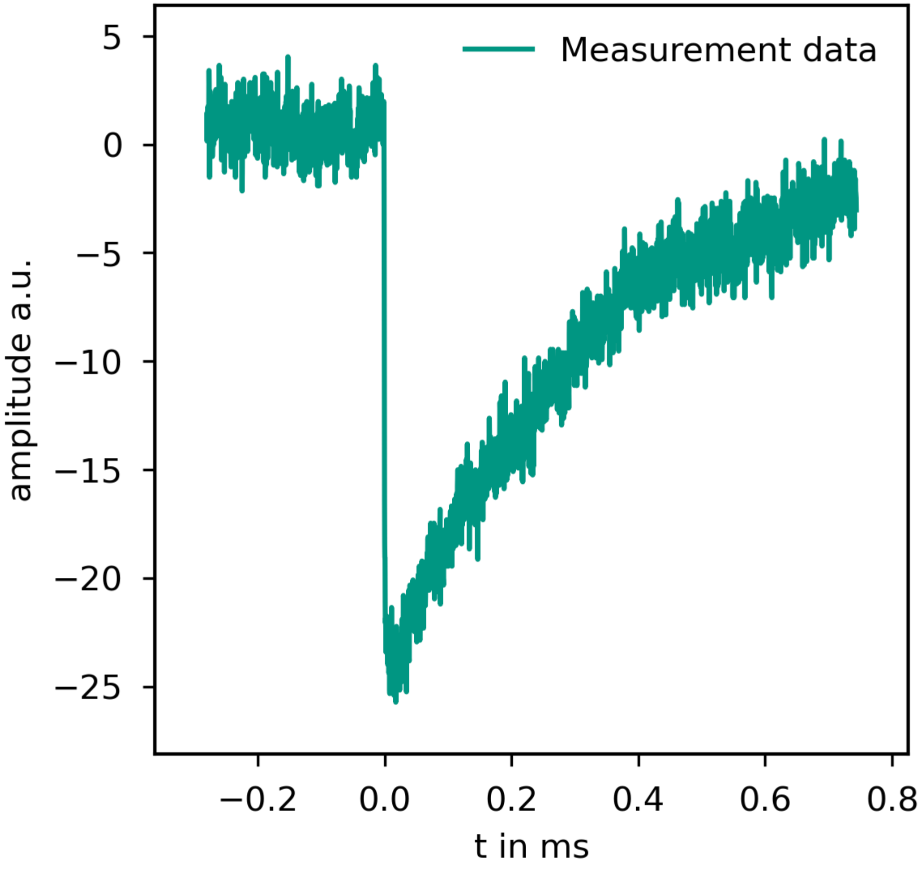
Preliminary results following

Quasiparticle lifetime experiment

Slow pulse



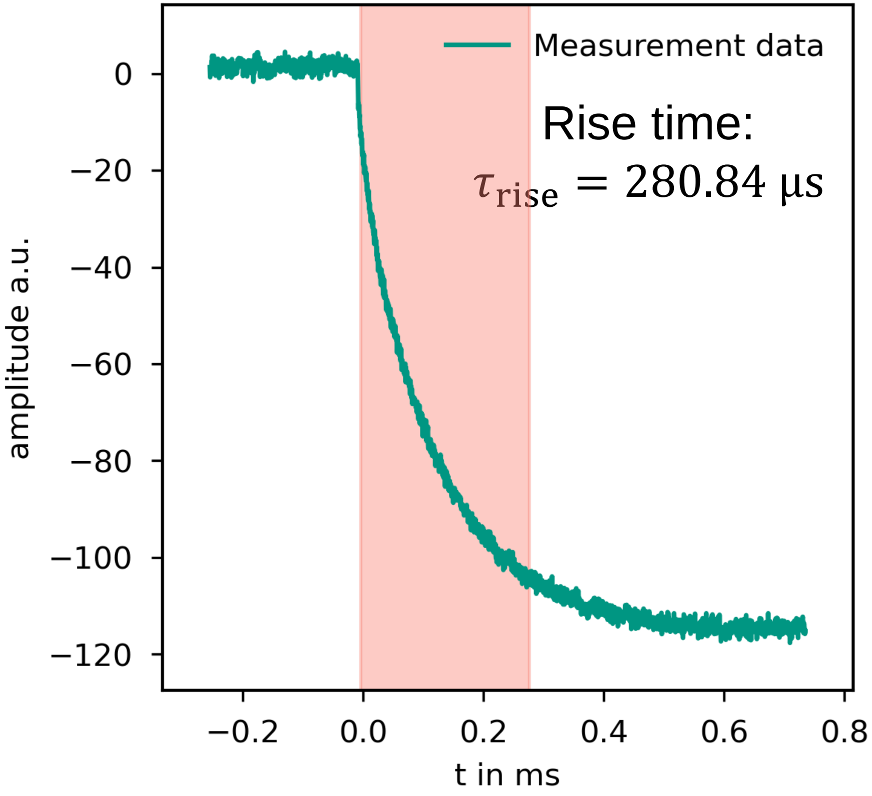
Fast pulse



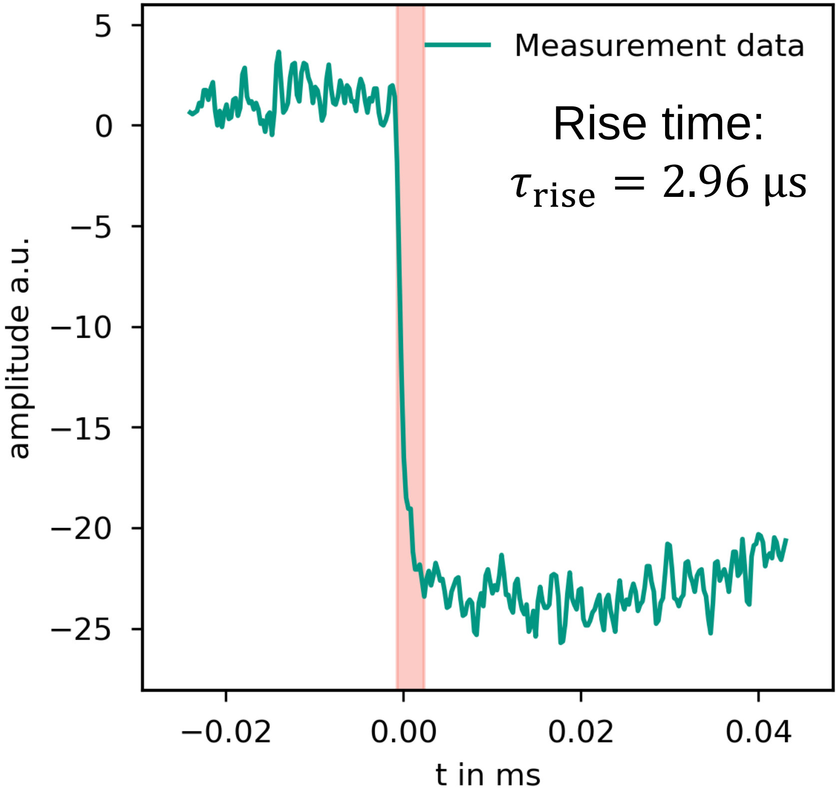
Quasiparticle lifetime experiment

- Rise time estimation (10 – 90 % of amplitude):

Slow pulse



Fast pulse



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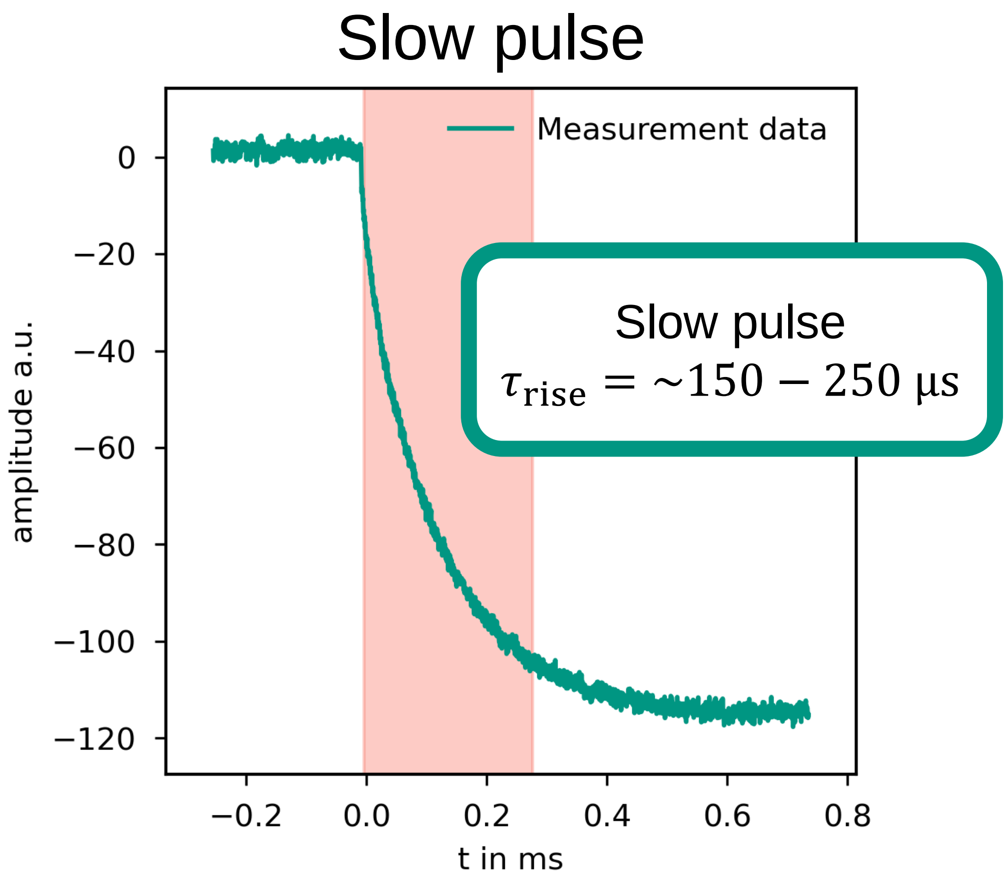
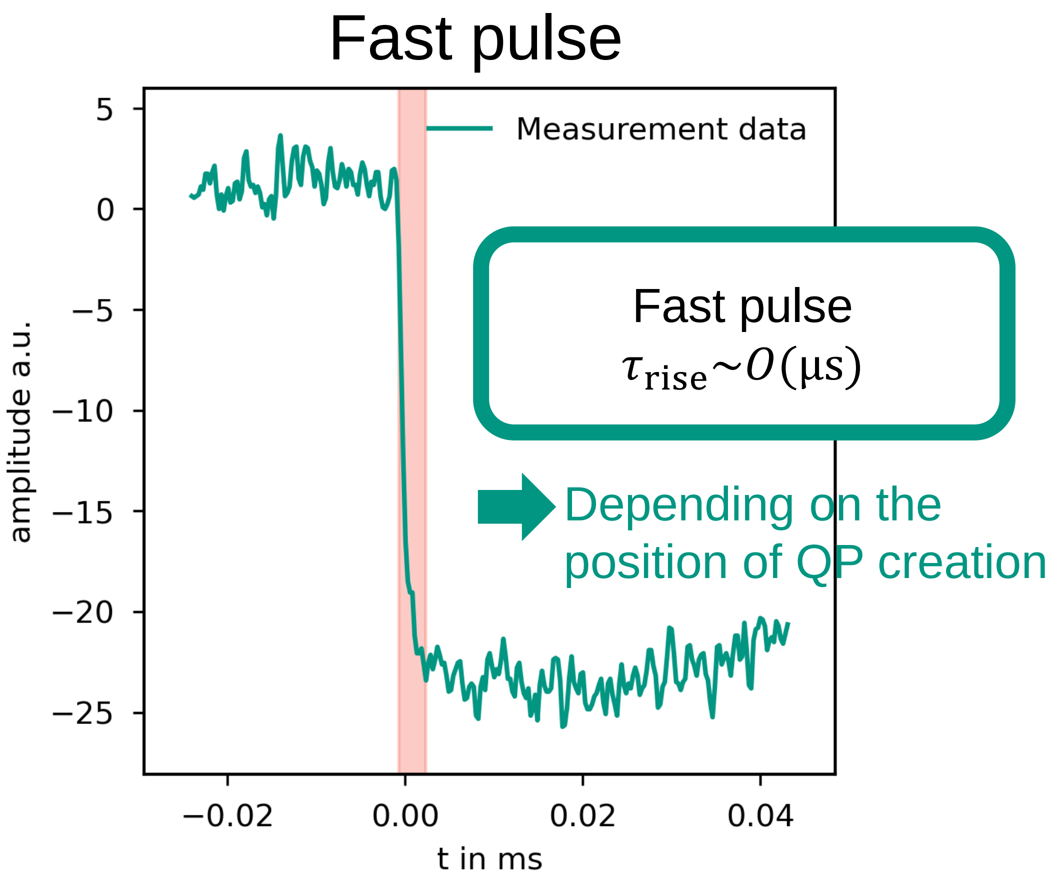
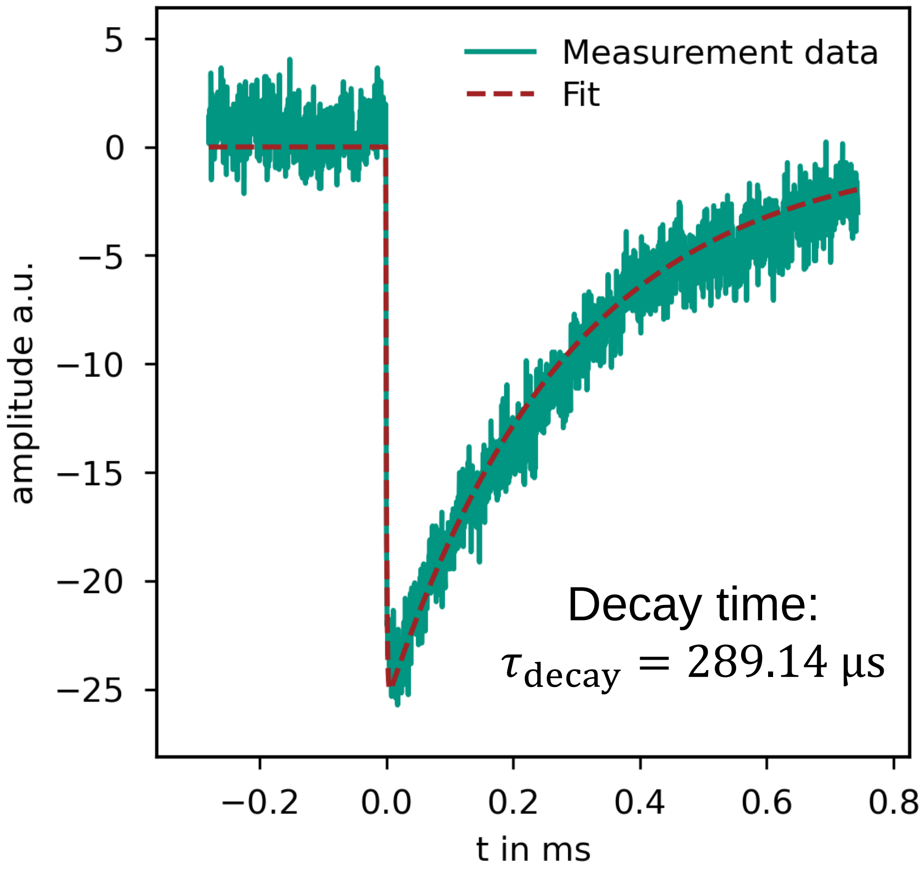




Quasiparticle lifetime experiment

- Decay time estimation through exponential fit:



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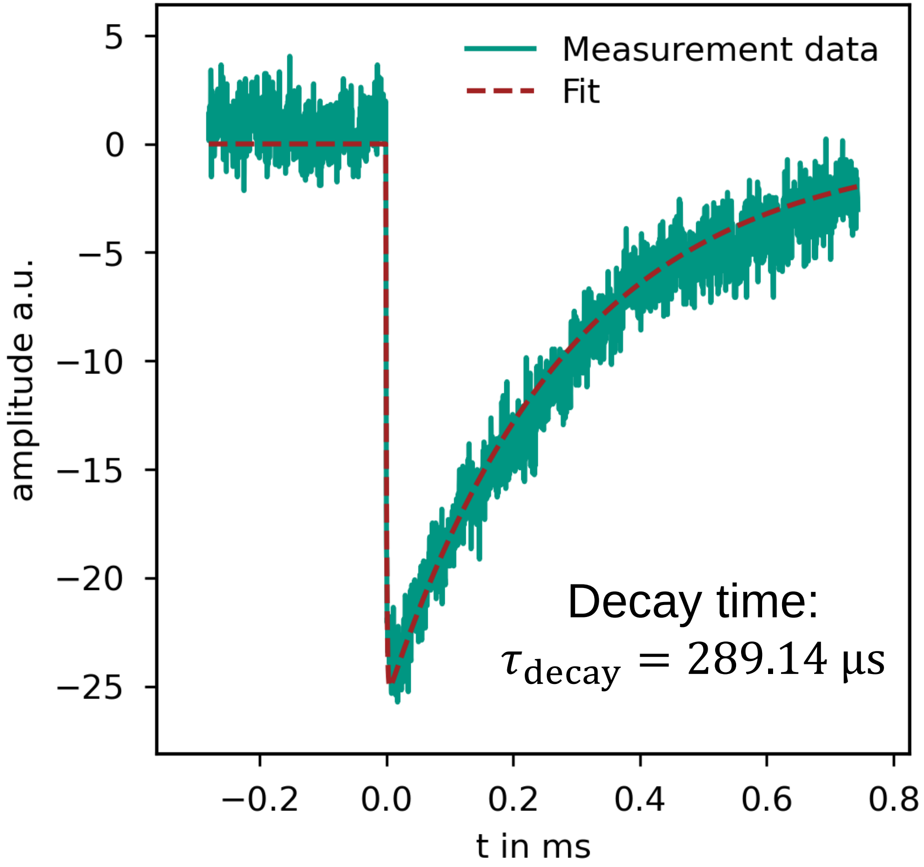

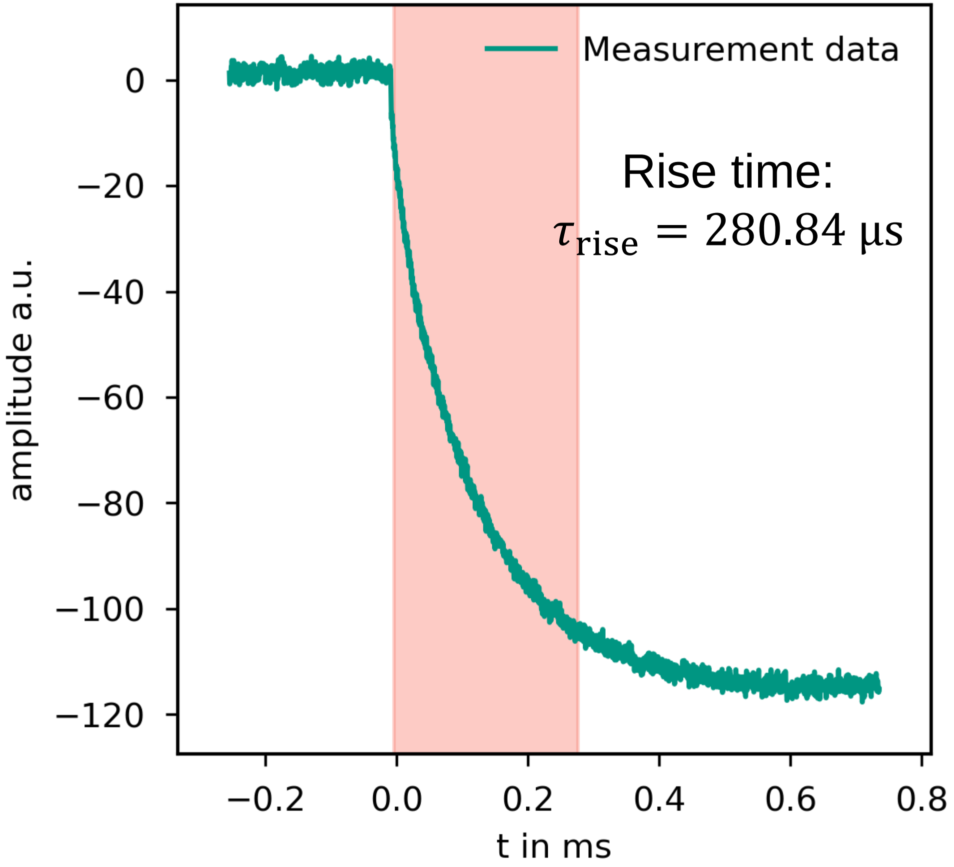

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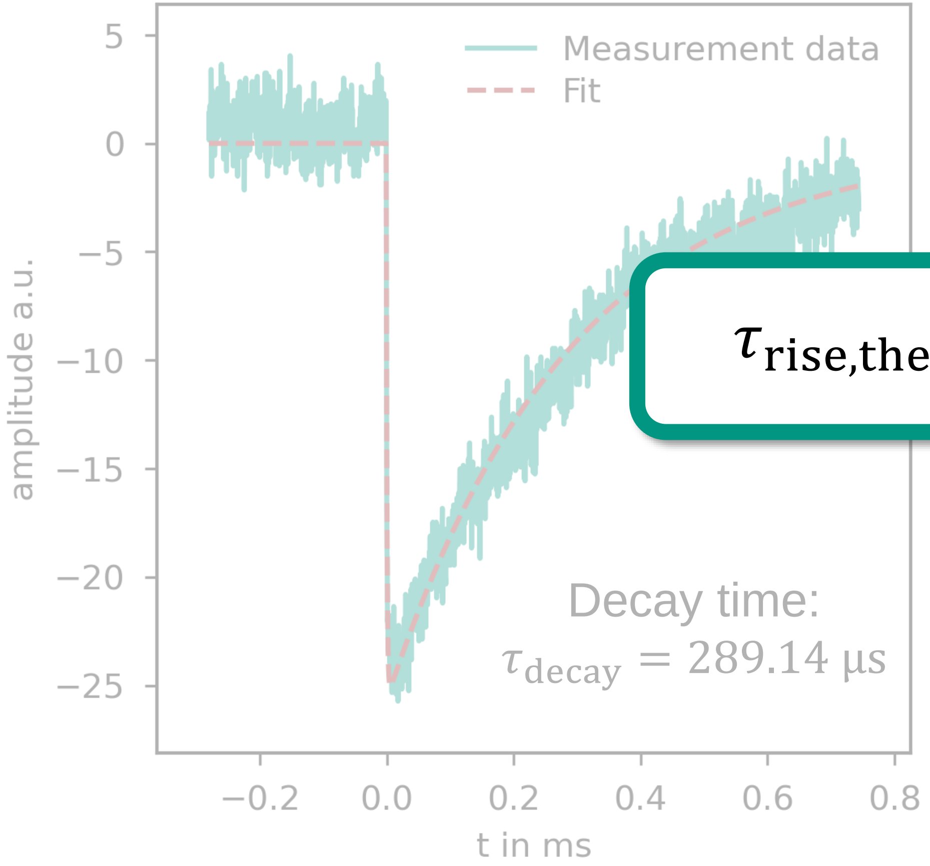

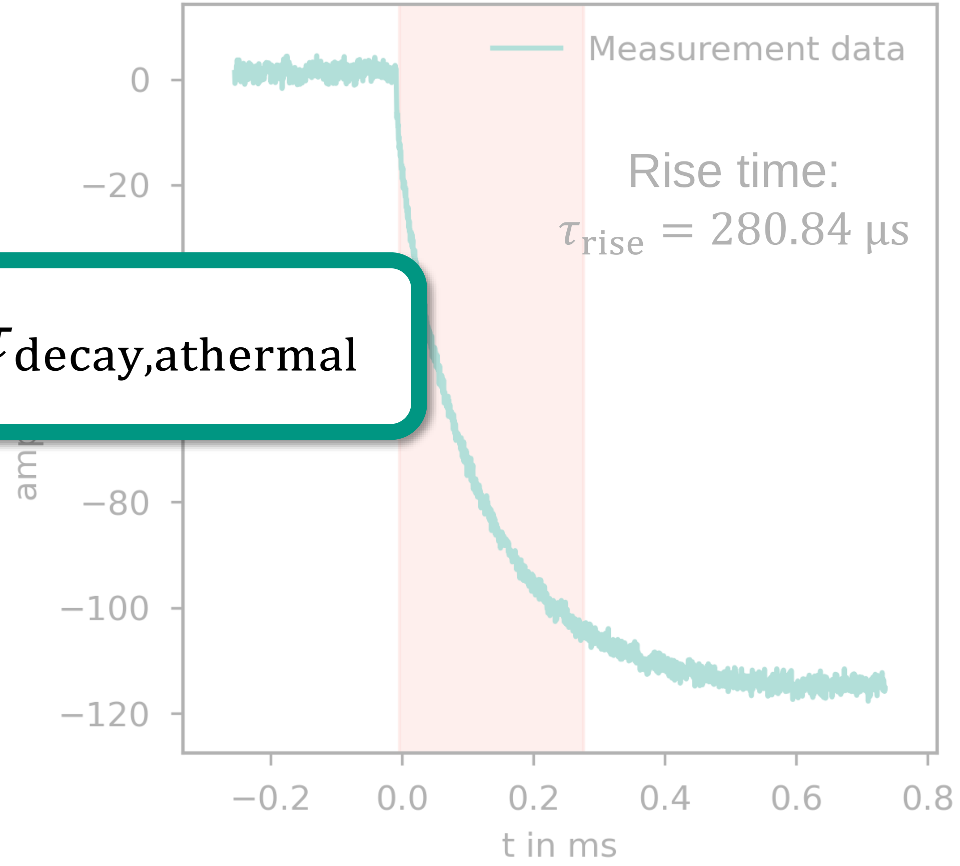

$$\tau_{\mathrm{rise,thermal}} \approx \tau_{\mathrm{decay,athermal}}$$