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Sensitivity to trapped flux in superconducting samples investigated via the quadrupole resonator

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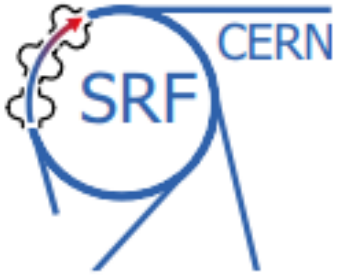
On behalf of FCC RF & WP 3

TTC Topical Workshop on Flux Trapping
CERN 8-9 November 2018



Can we use the QPR to test theoretical models?

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The importance of the electron mean free path for superconducting radio-frequency cavities

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Vortex dynamics and losses due to pinning: Dissipation from trapped magnetic flux in resonant superconducting radio-frequency cavities

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(Dated: August 7, 2018)

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Frequency dependence of trapped flux sensitivity in SRF cavities

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A simple model for the RF field amplitude dependence of the trapped flux sensitivity in SRF cavities

Authors

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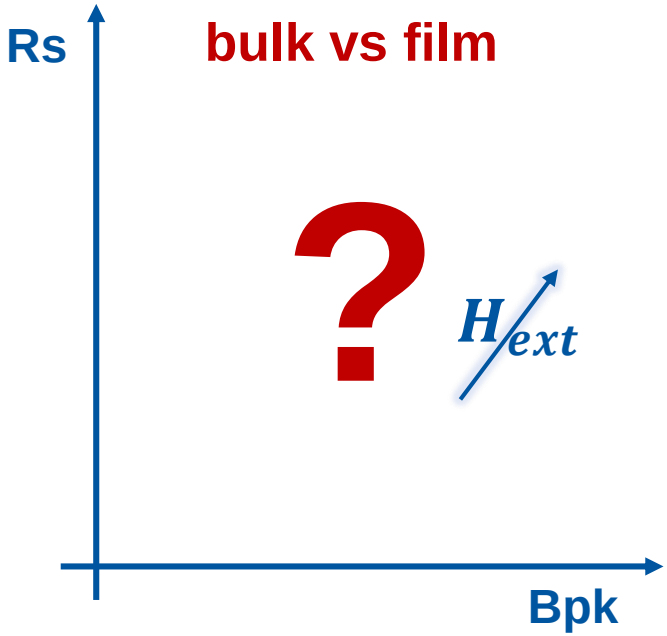
Yes, we can!

Outlines

Measurements

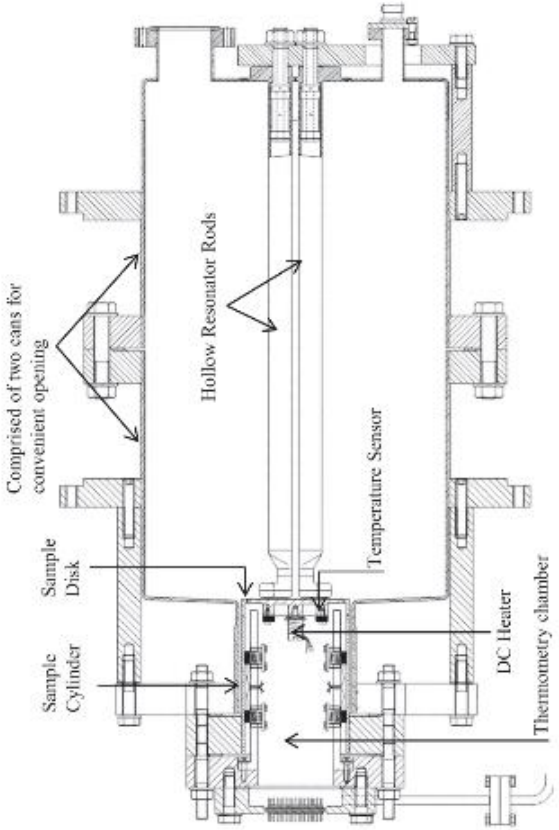
Pros&Cons



Results

QPR and measurement technique

RF performances characterized via a quadrupole resonator



Calorimetric technique

$$R_s = \frac{2\mu_0^2(P_{DC1} - P_{DC2})}{\int_{sample} |\overrightarrow{B}|^2 dS}$$

QPR pros&cons

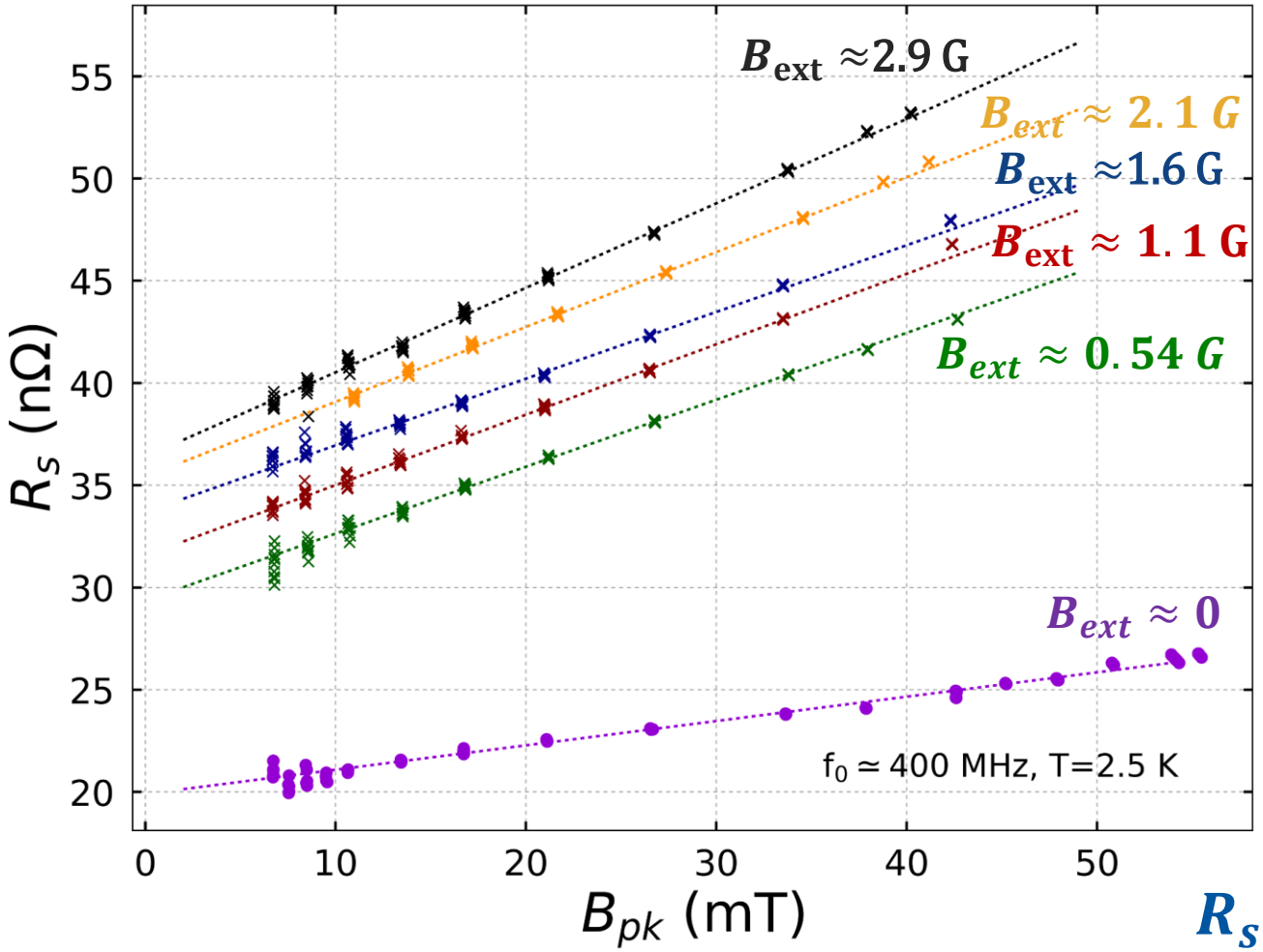
- Multi-frequency operation: ideal for basic studies
- Small samples are easily made and exchanged
- Samples are more cost effective than cavities
- Easy and quick thermal cycling

- Limited max RF field depending on the frequency mode
- Limitations on the minimum Rs measurable
- Microphonics

Results: bulk Nb sample

RRR≈300 – electro polished – water rinsing

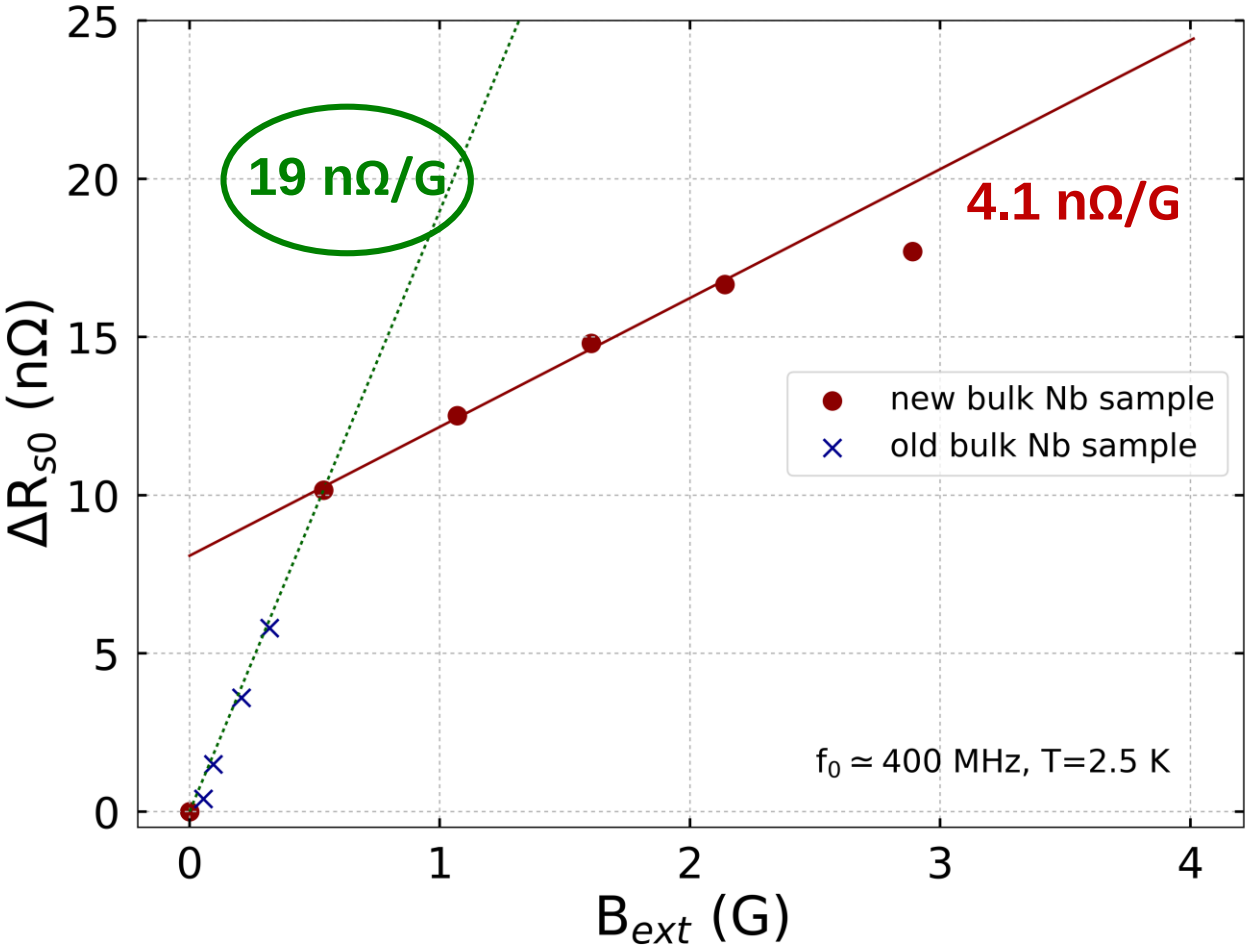
Linear dependence of Rs with the peak RF magnetic field



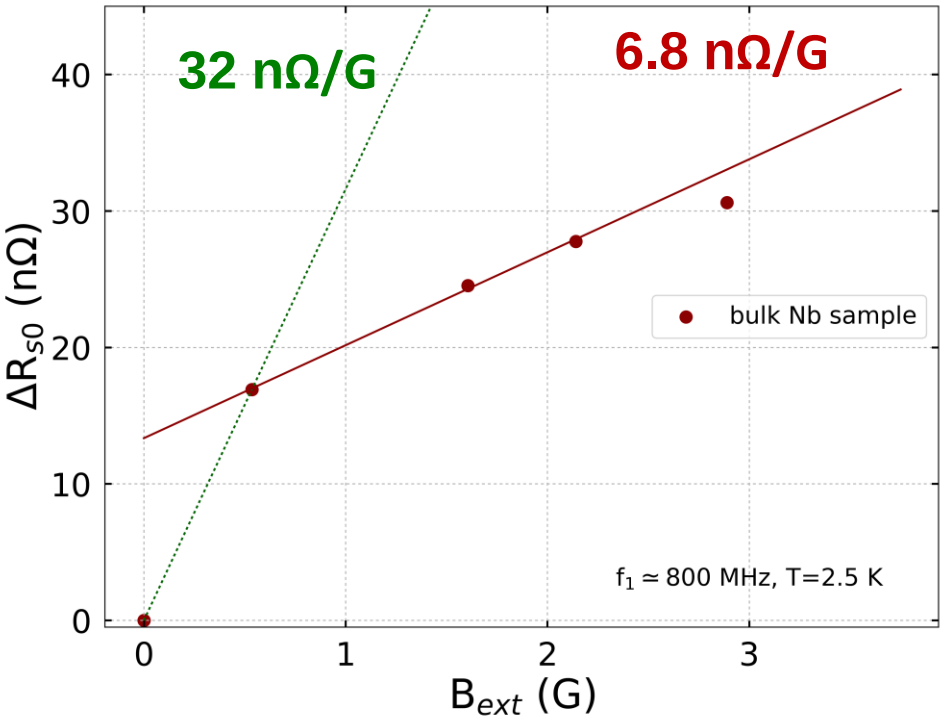
B_{ext}

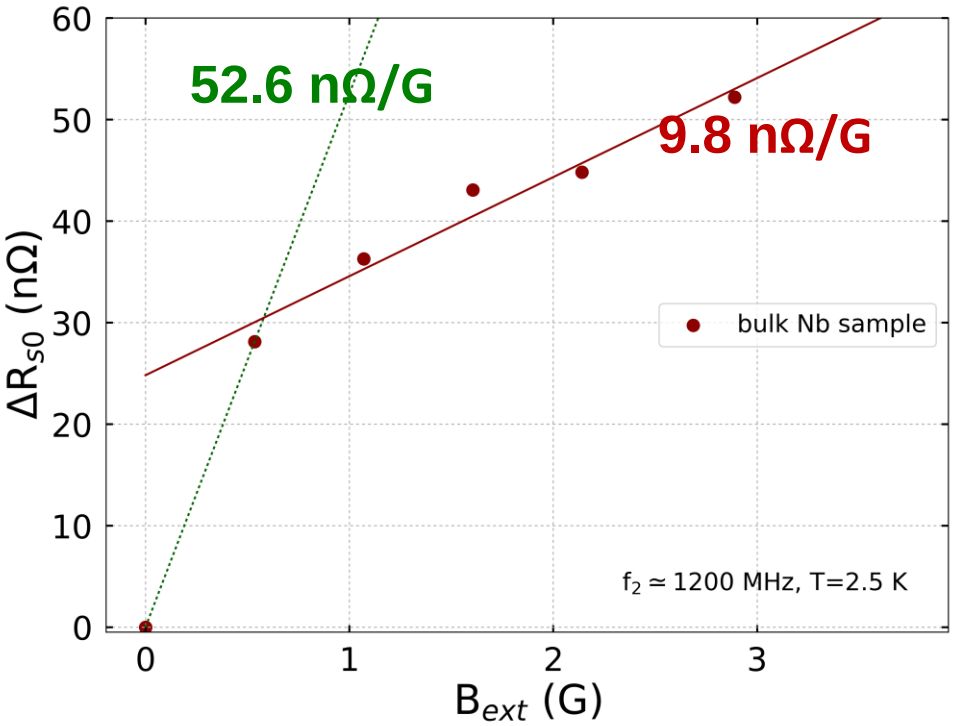
$$R_s = R_{s0} + R_{s1} * B_{pk}$$

Different sensitivity for different external field ranges



The same behaviour for the higher order modes





the sensitivity increases with the frequency

Two different possible scenarios

1. sensitivity saturation

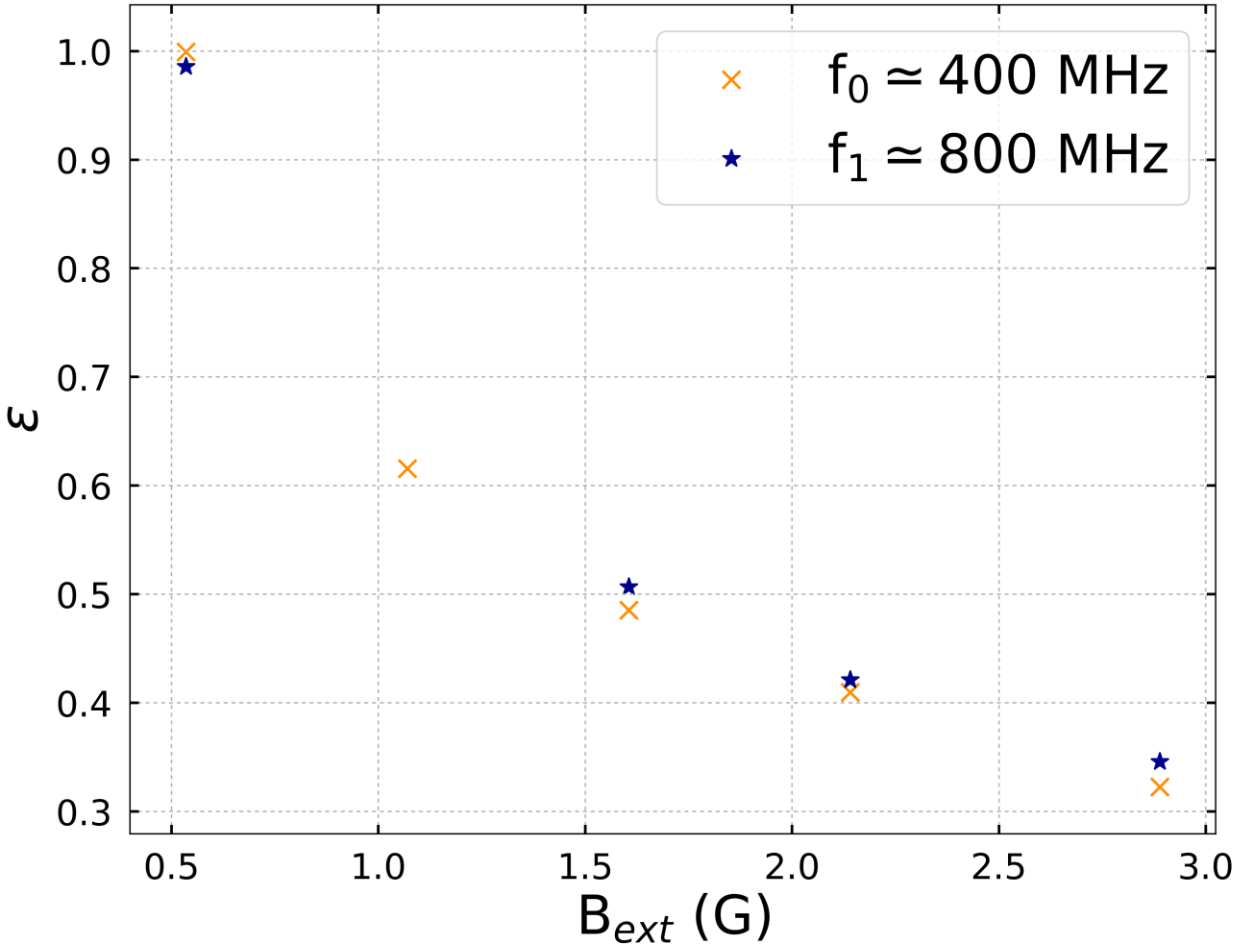
2. trapped flux saturation

Let's focus on scenario 2

1. sensitivity saturation

2. trapped flux saturation

Scenario 2: flux expulsion efficiency depends on external field

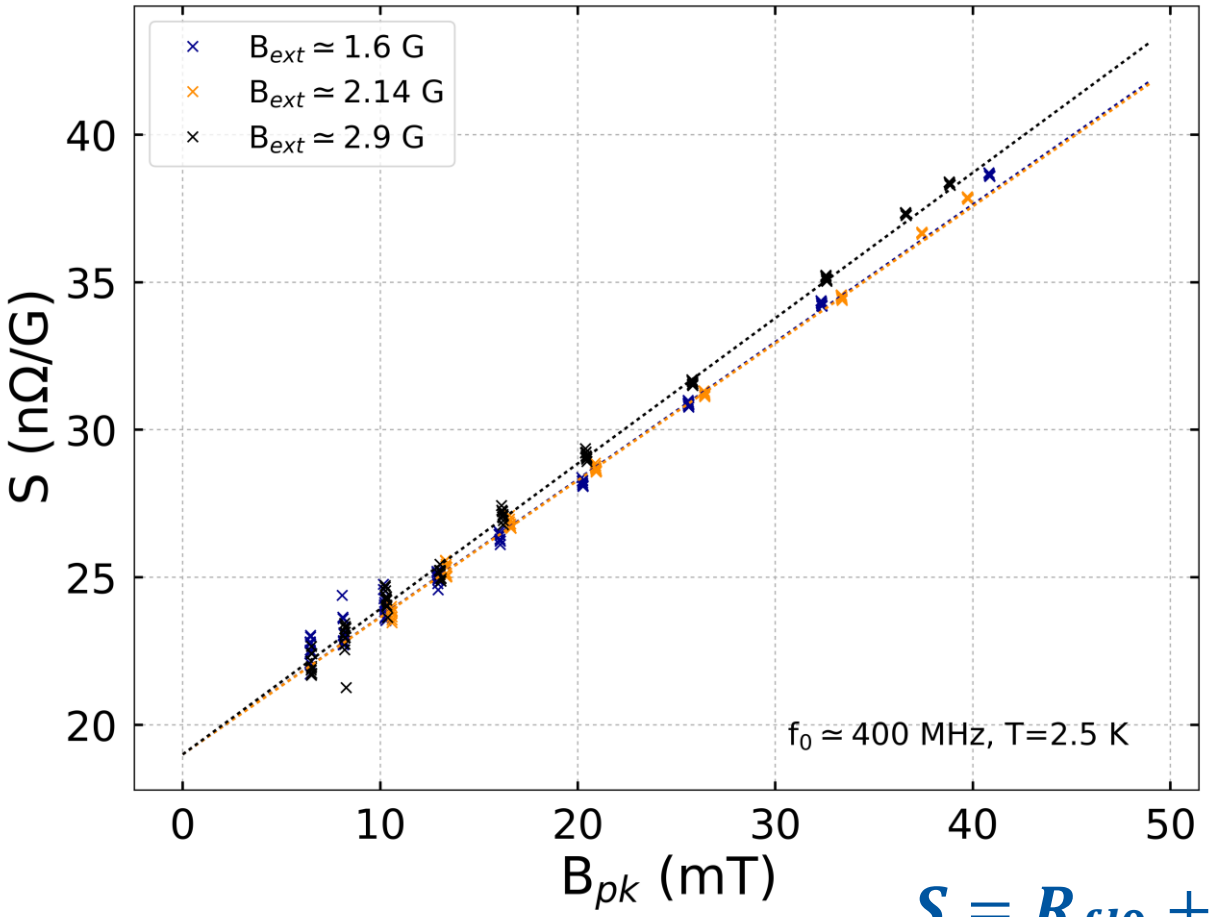


$$B_0 = \varepsilon B_{ext}$$

$$S = \frac{\Delta R_{s0}}{\varepsilon B_{ext}}$$

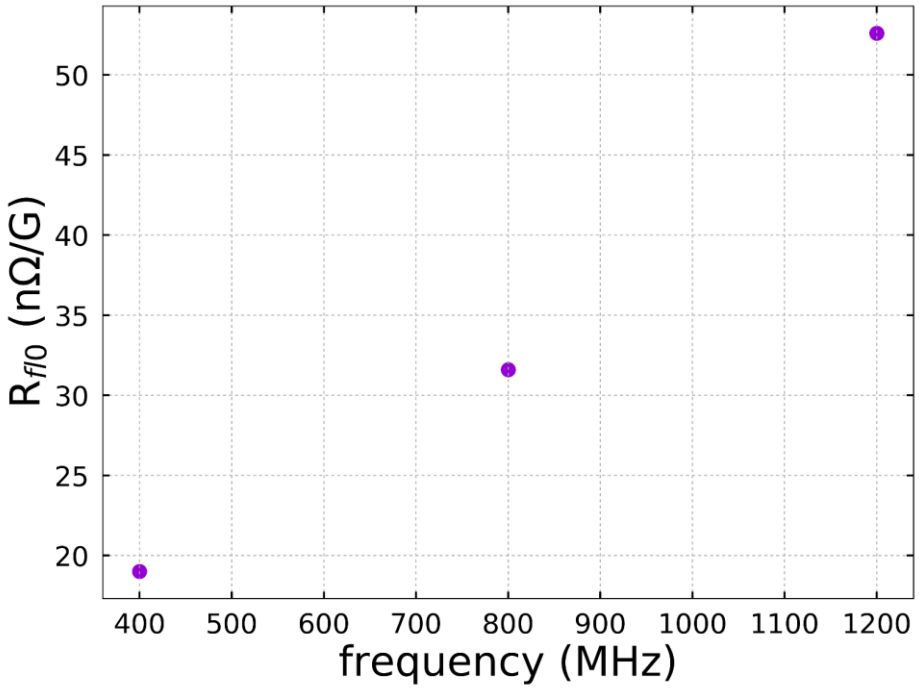
Here a fixed S at zero peak RF field is assumed

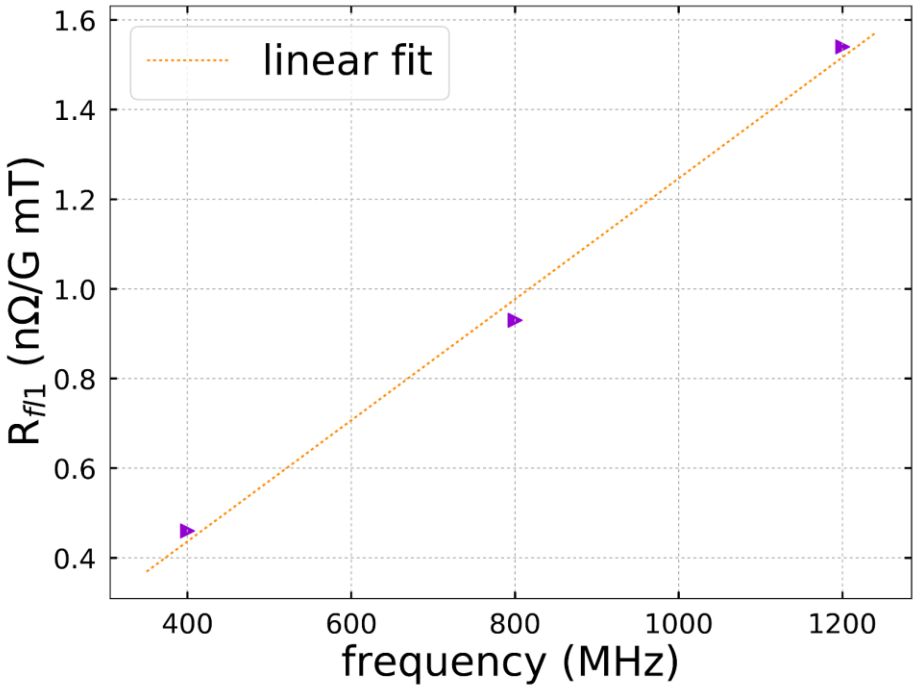
The sensitivity increases linearly with the peak RF field



$$S = R_{fl0} + R_{fl1} * B_{pk}$$

Both R_{fl0} and R_{fl1} increase with frequency

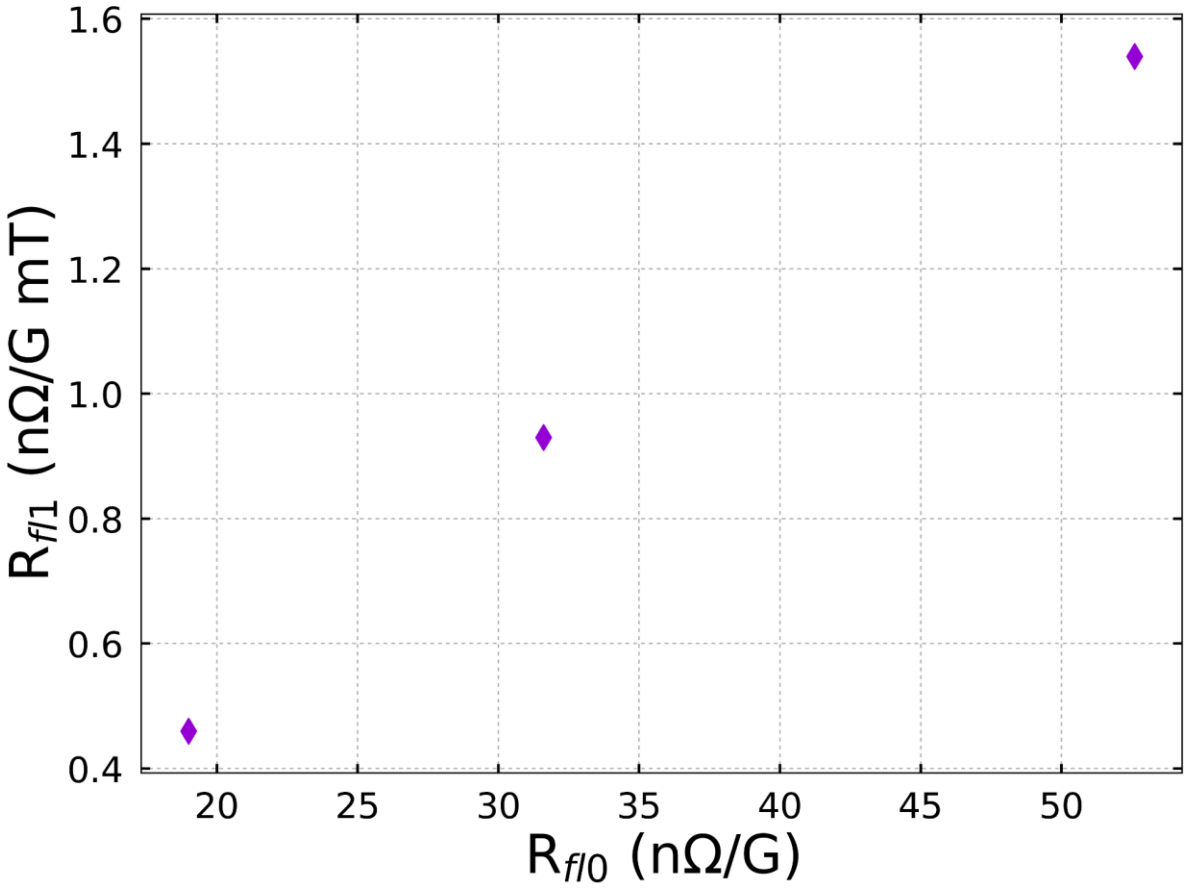




More data points are required for a proper model comparison

See R. Vaglio's talk

R_{fl1} increases with R_{fl0}

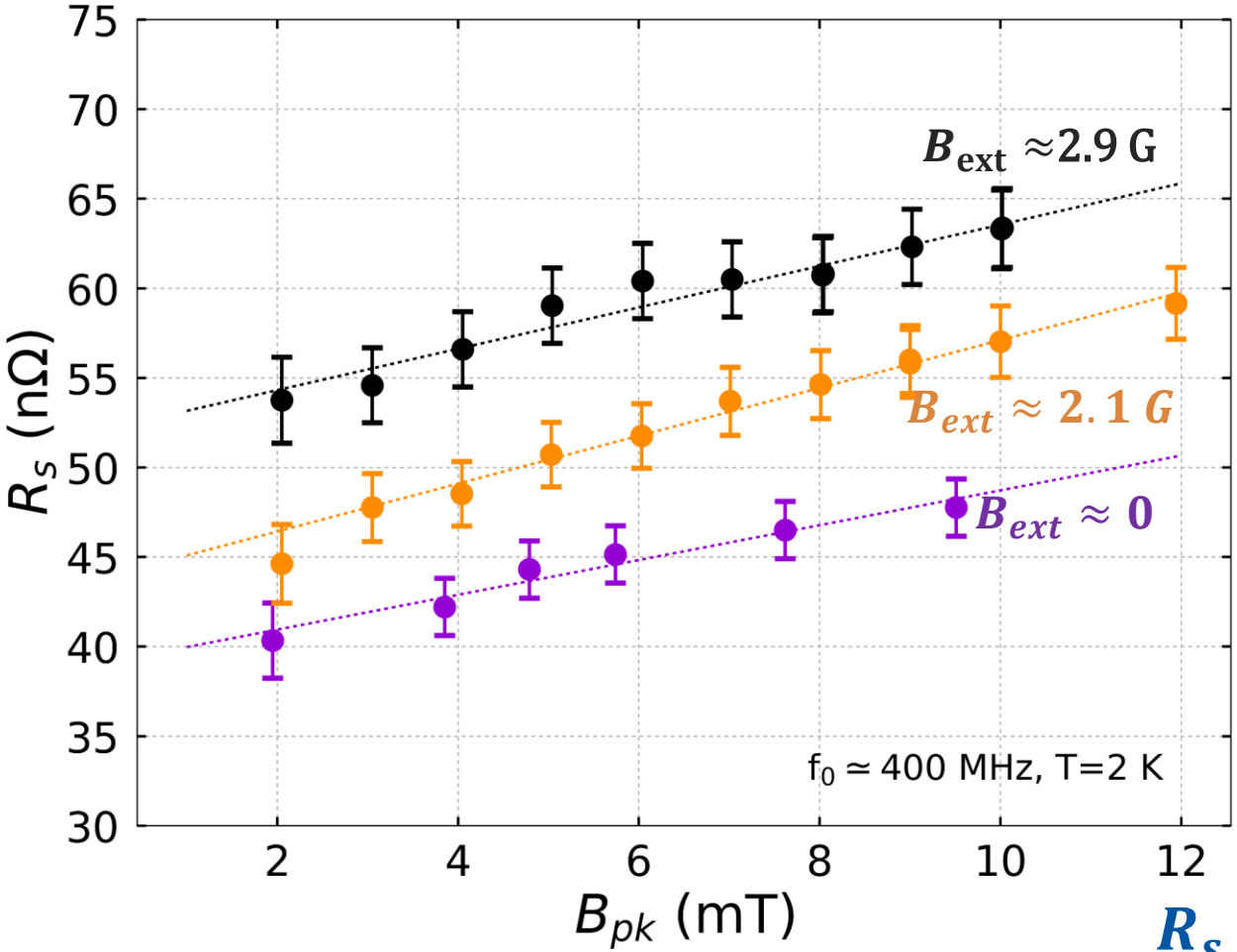


See R. Vaglio's talk

Results: Nb/Cu sample

Fine grain copper – ECR coating – water rinsing

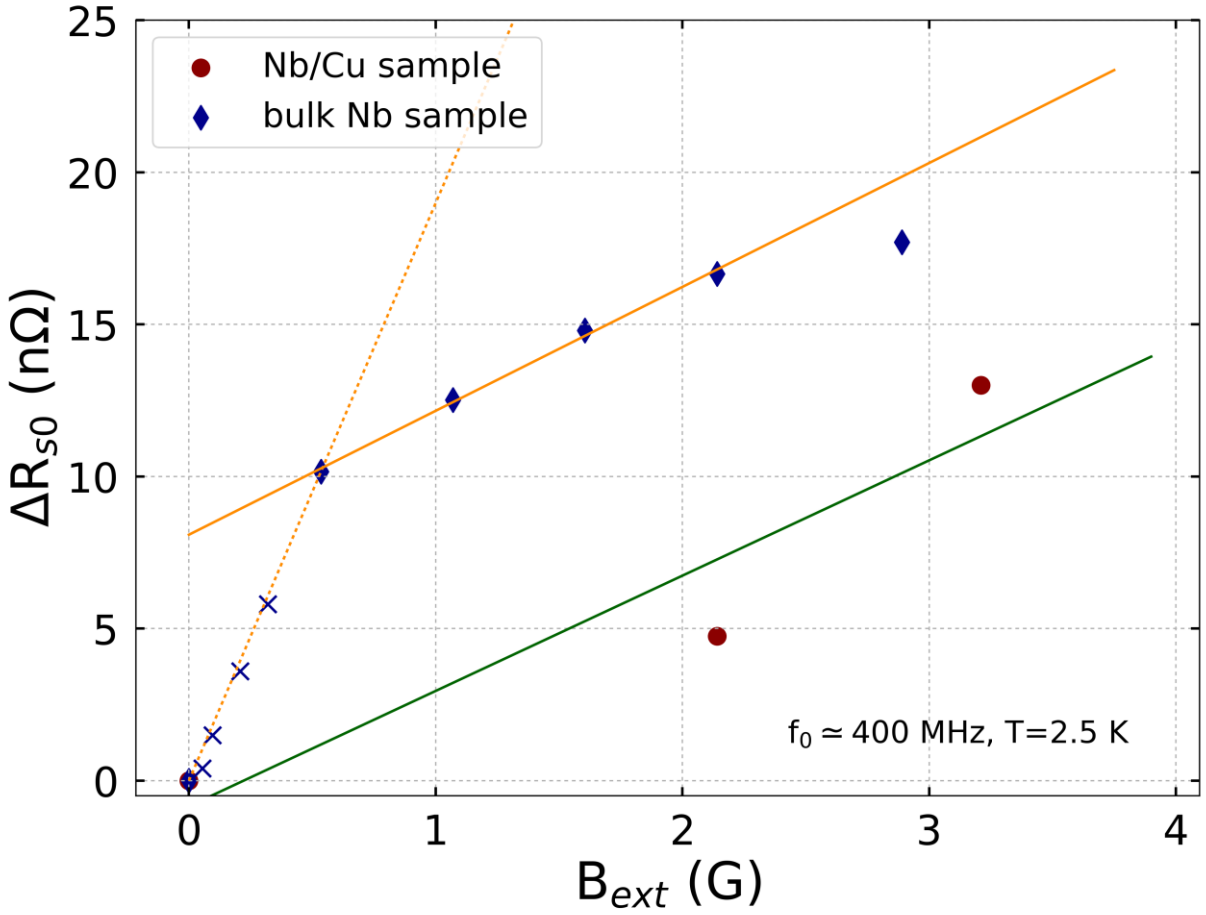
Linear dependence of Rs with the peak RF magnetic field



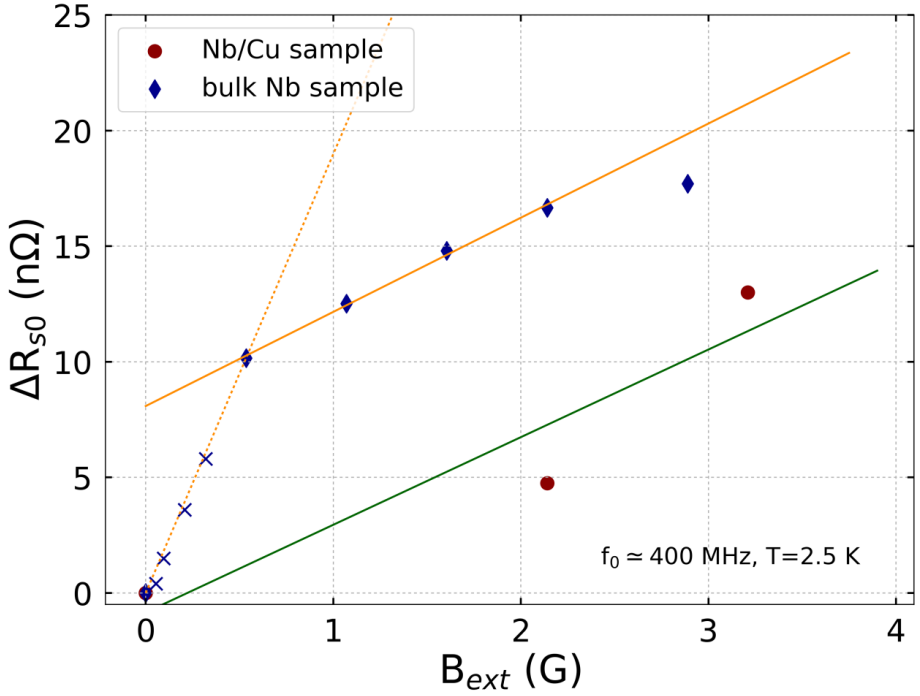
B_{ext}

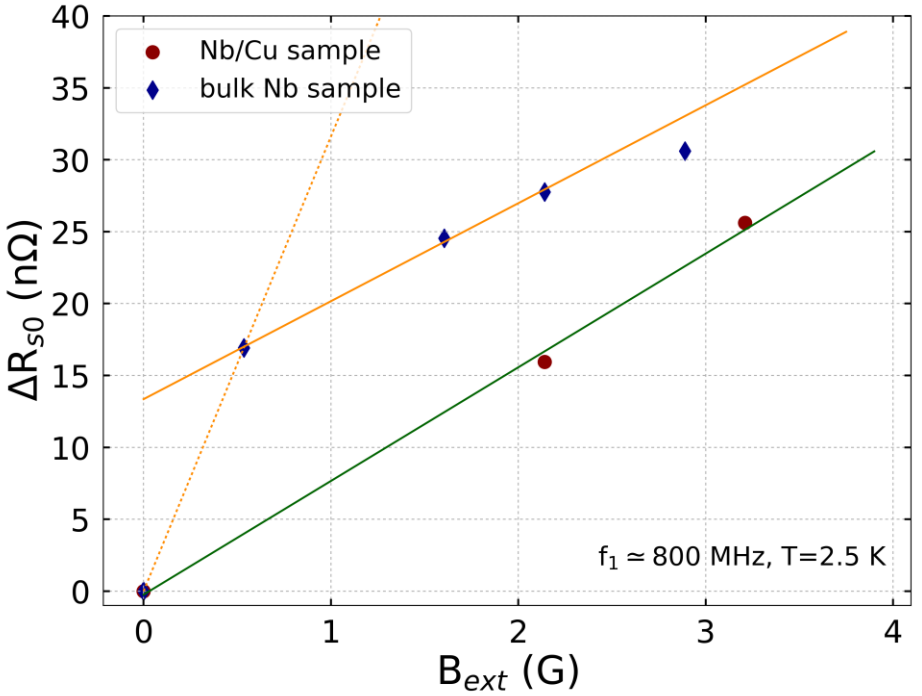
$$R_s = R_{s0} + R_{s1} * B_{pk}$$

No saturation observed for the Nb/Cu sample



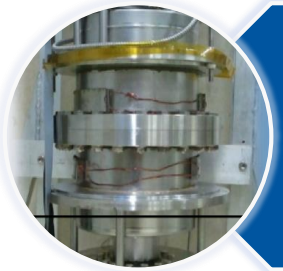
Nb/Cu samples are less sensitive to trapped flux



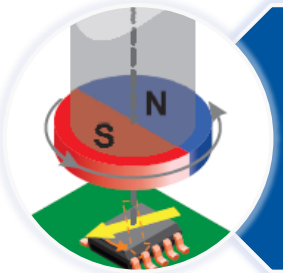


More data points are required

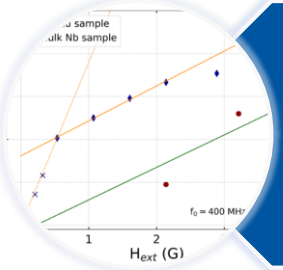
Conclusions and outlooks



QPR potential for flux trapping studies



Measurement setup to be improved



Systematic investigation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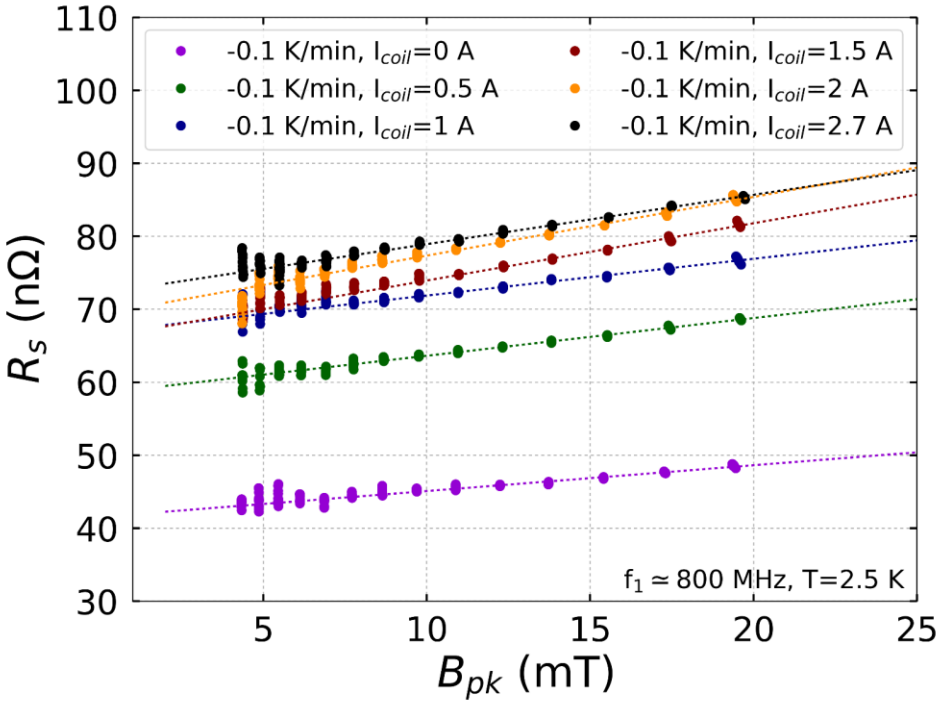
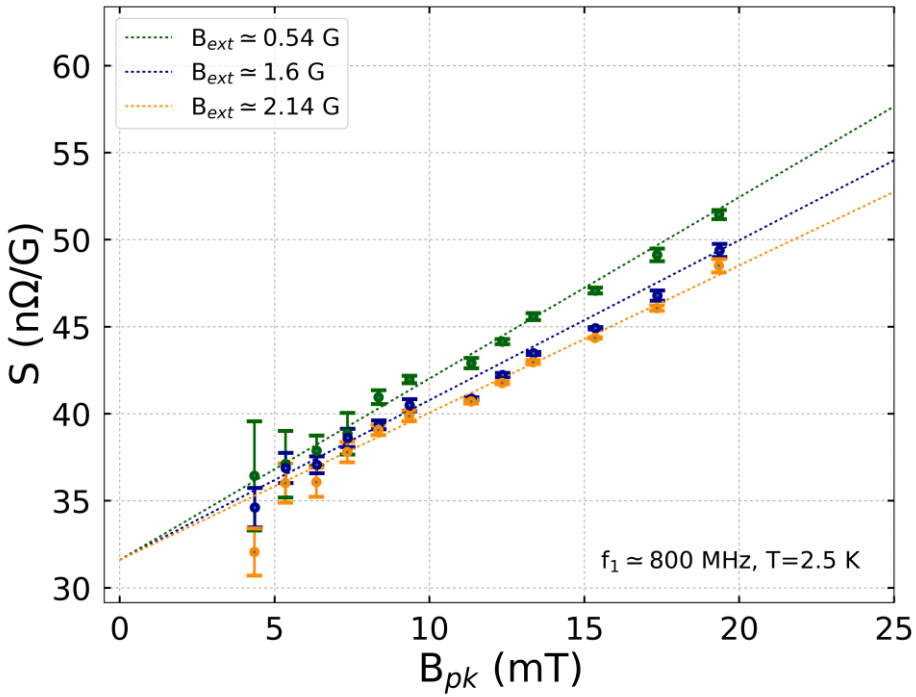
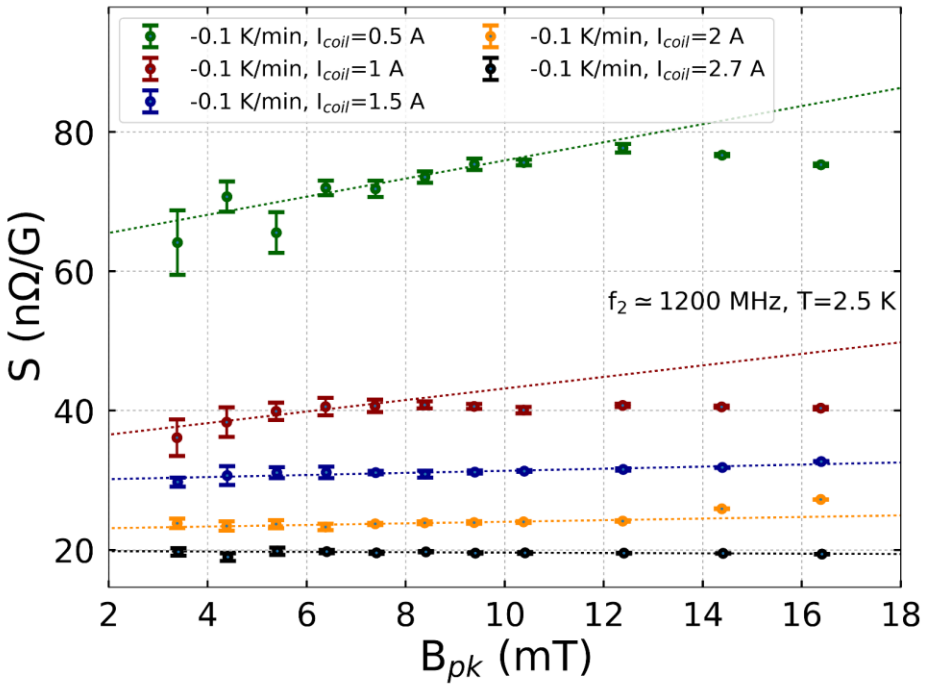
Spare slides: bulk Nb sample

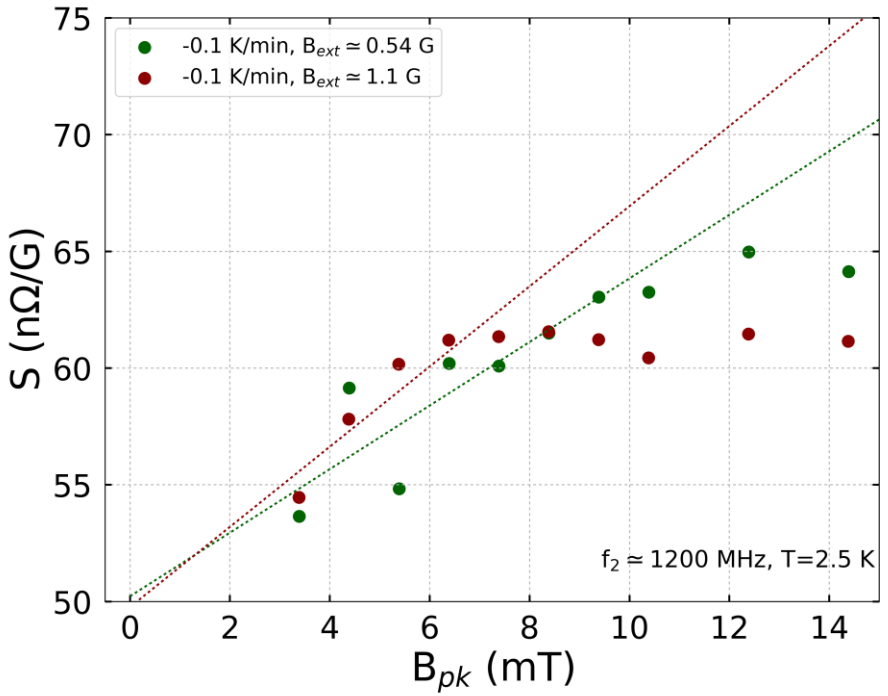
Data at 800 MHz





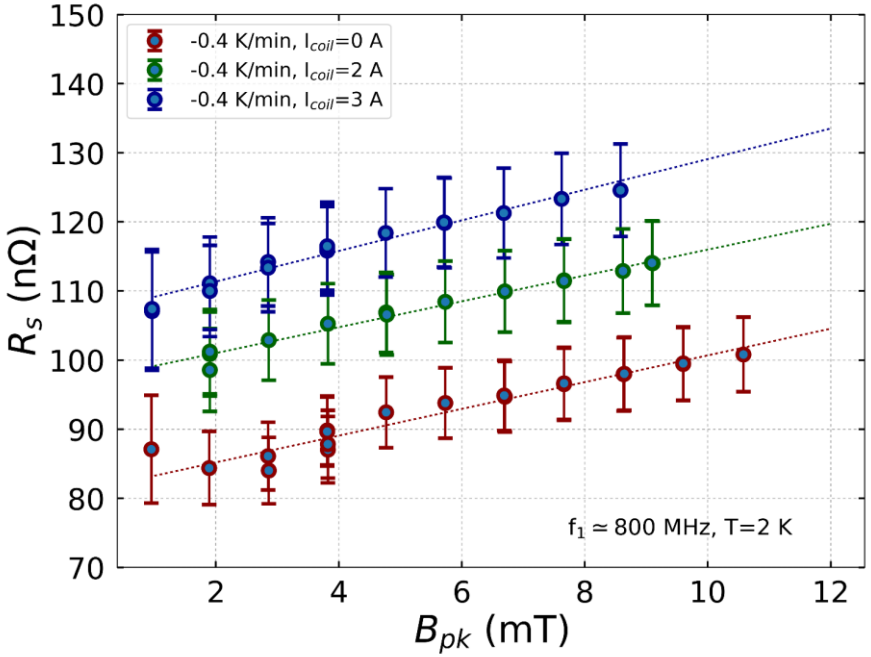
Data at 1200 MHz

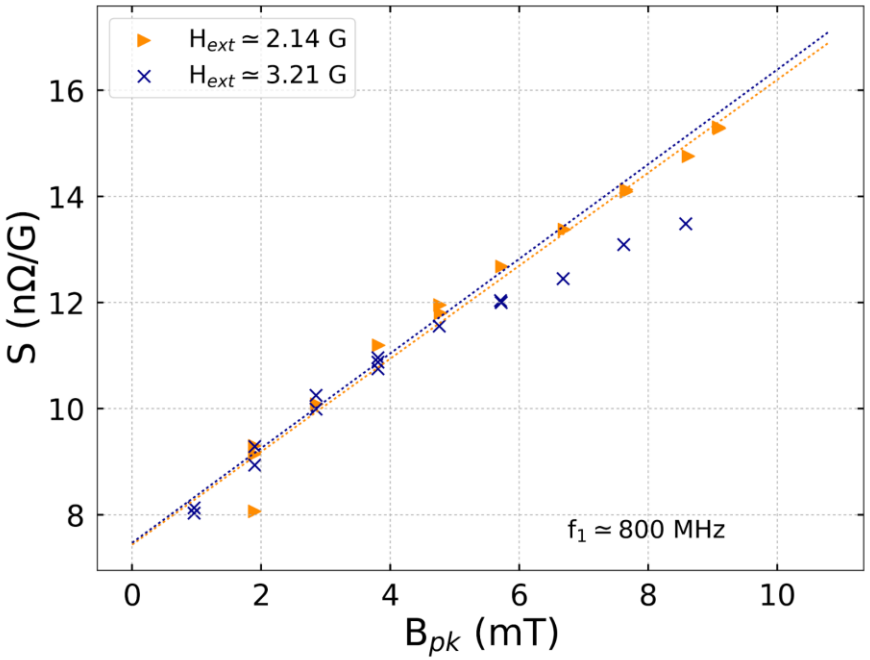




Spare slides: Nb/Cu sample

Data at 800 MHz





Both R_{fl0} and R_{fl1} increase with the frequency