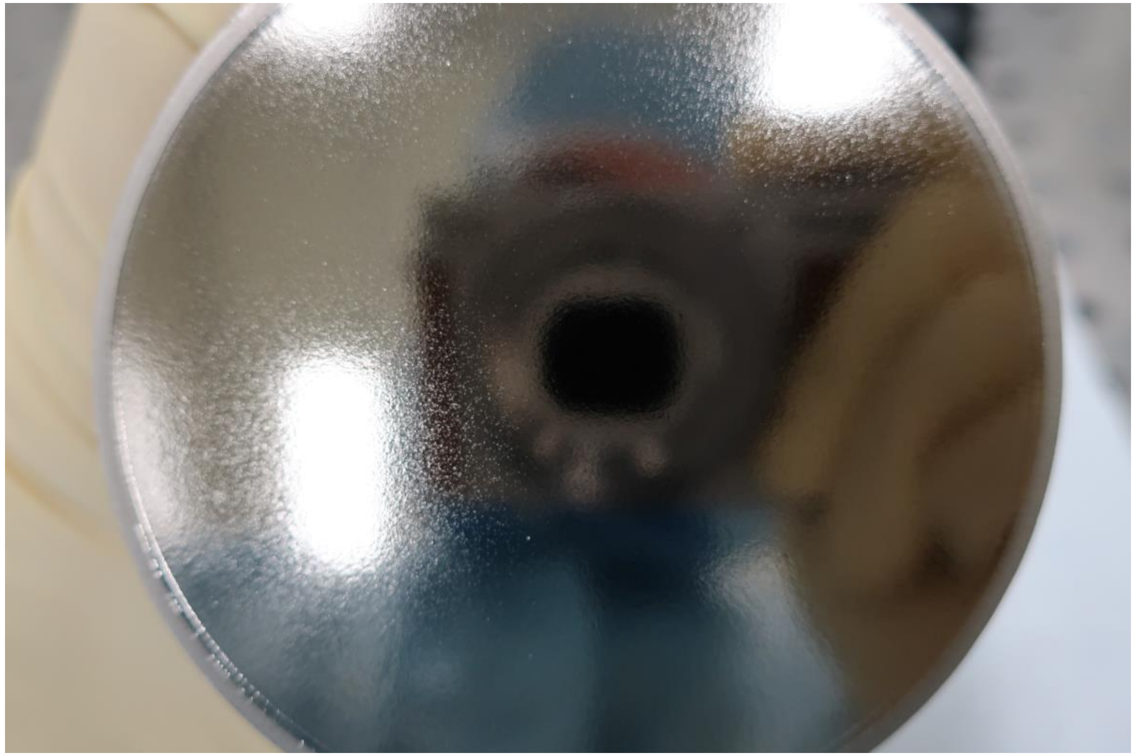
This project has received funding from the European Union's H
Innovation programme under GA No 101004730

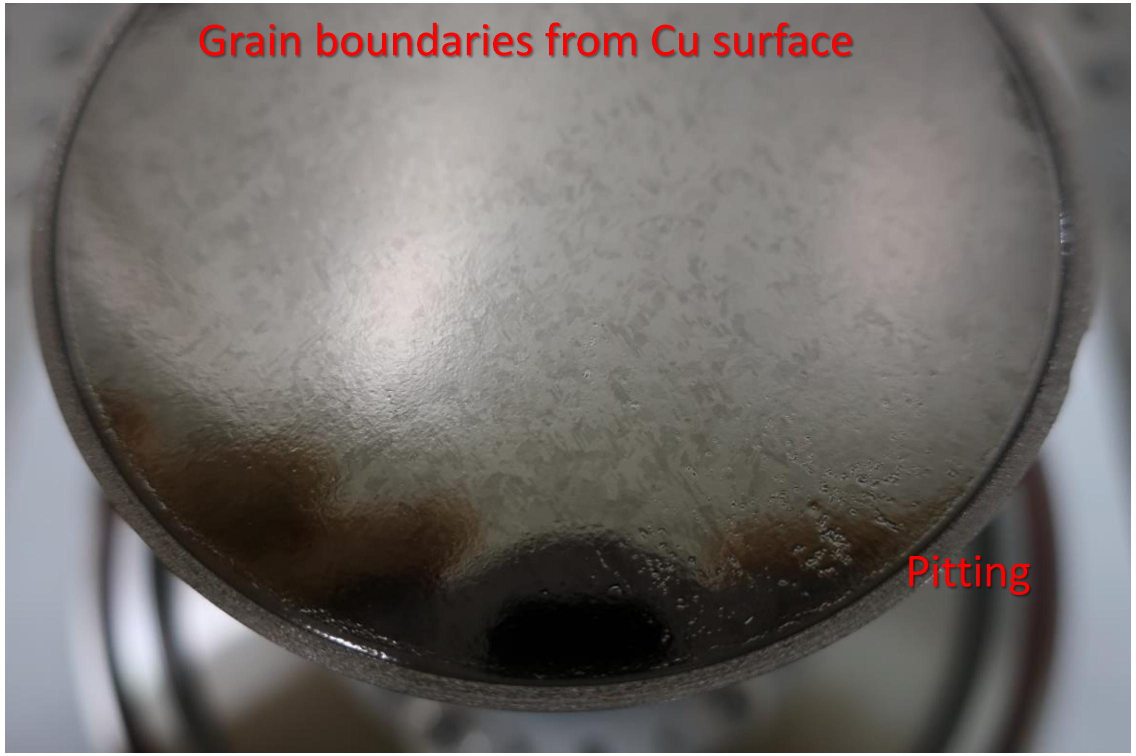
5th IFAST WP9 meeting

2022-05-03

D. Tikhonov



B-2.13 : 35 nm



B-3.19 : 0 nm

	NN		SIS films tested	Structure	Base test?	Method	place
B – 2.13	B-2.13	**5th SIS**	NbN – AlN – Nb(film)/Cu	180 nm – **35 nm** – 4 µm Nb	No	HiPIMS	SIEGEN
B – 3.19	B-3.19	**6th SIS**	NbN – Nb(film)/Cu	180 nm – **0 nm** – 4 µm Nb	No	HiPIMS	SIEGEN

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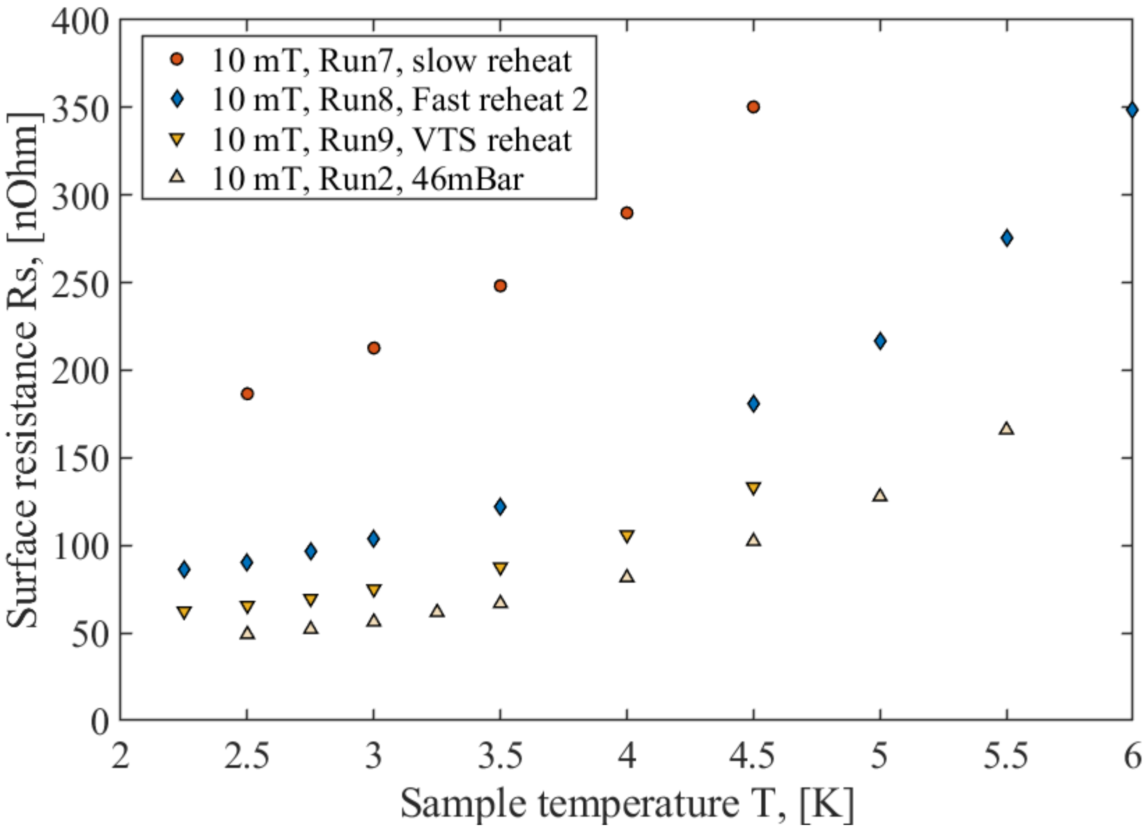
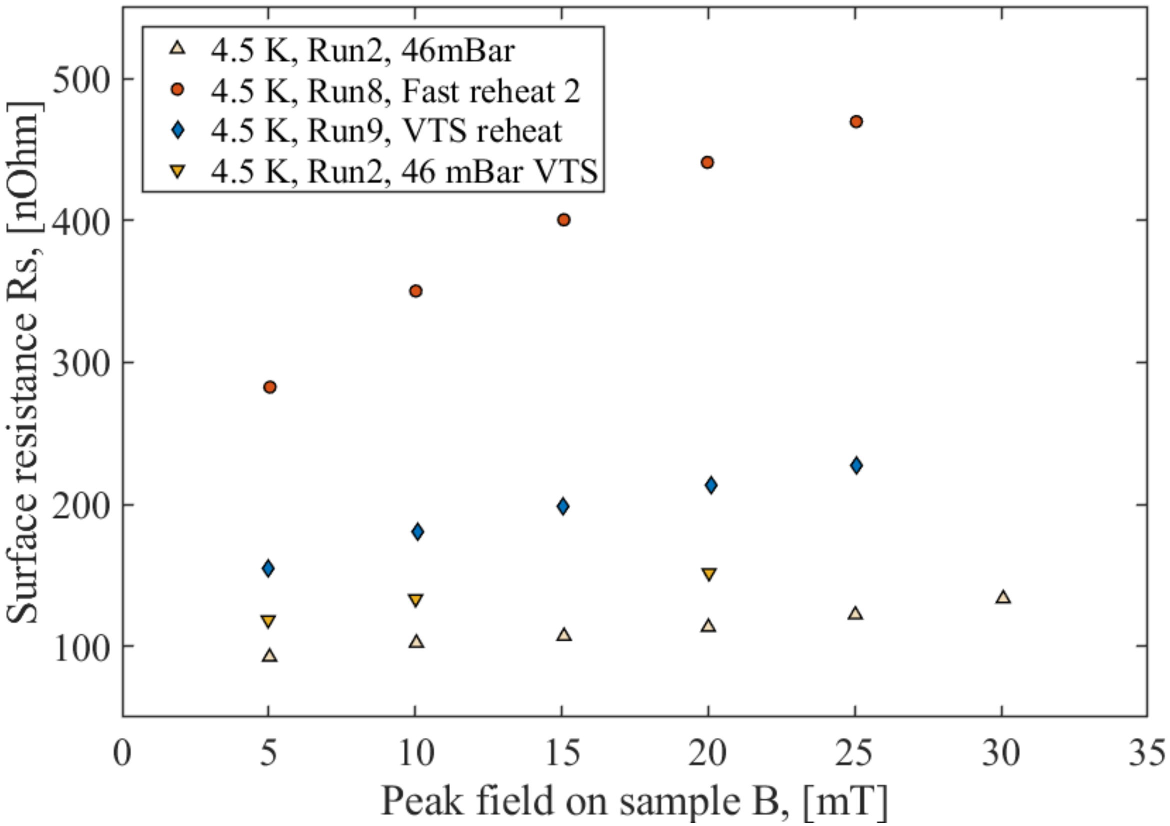
Flux-induced (?) resistance ('35 nm AlN' sample)





35 nm insulator sample: additional resistance also have f(T) and f(B) components (417 MHz)

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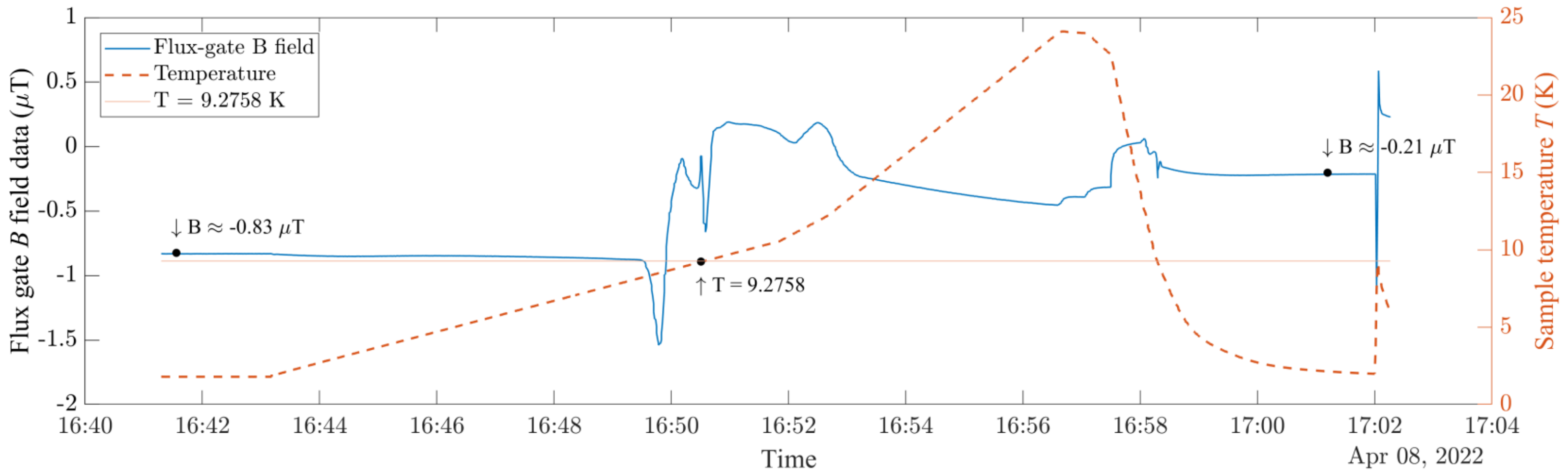
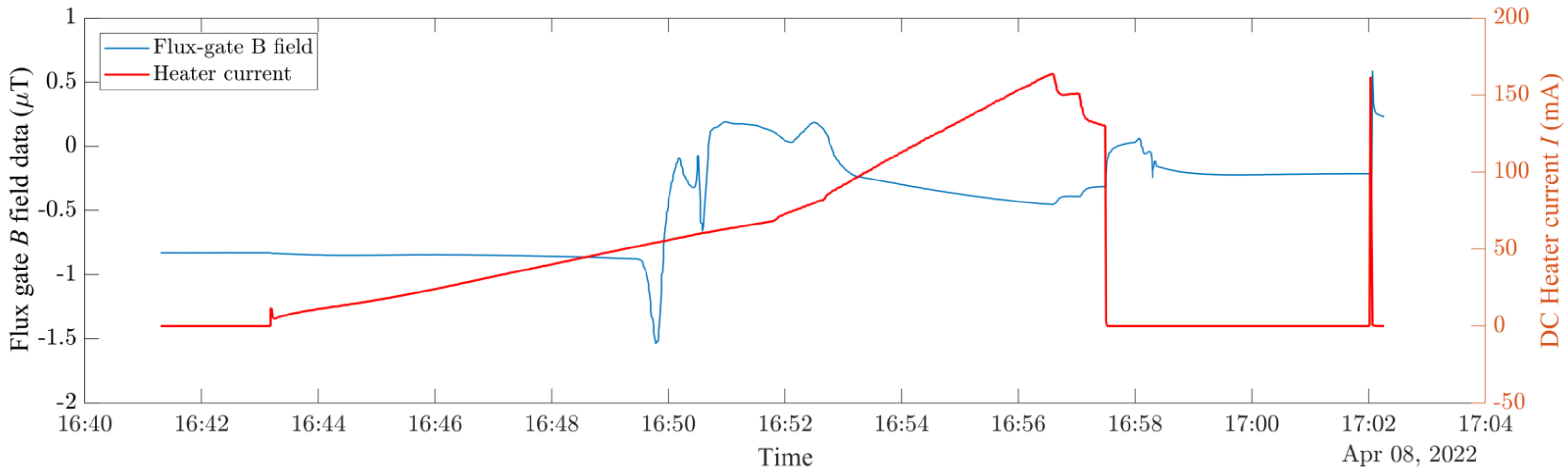
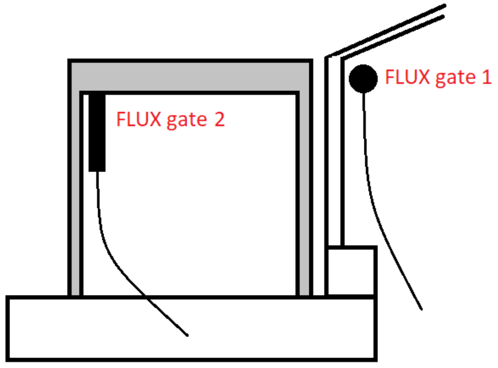
Flux measurements B-3.19 ‘no insulator’





Slow warm up with heater

Fast cooldown



1 axis flux gates
All data: Flux gate 2

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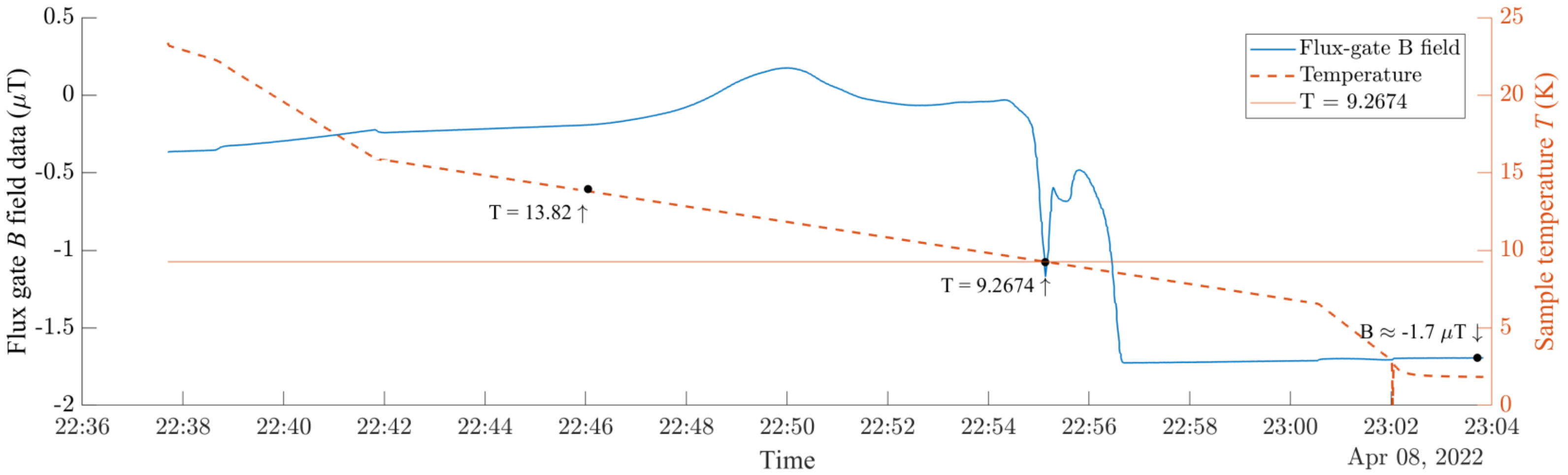

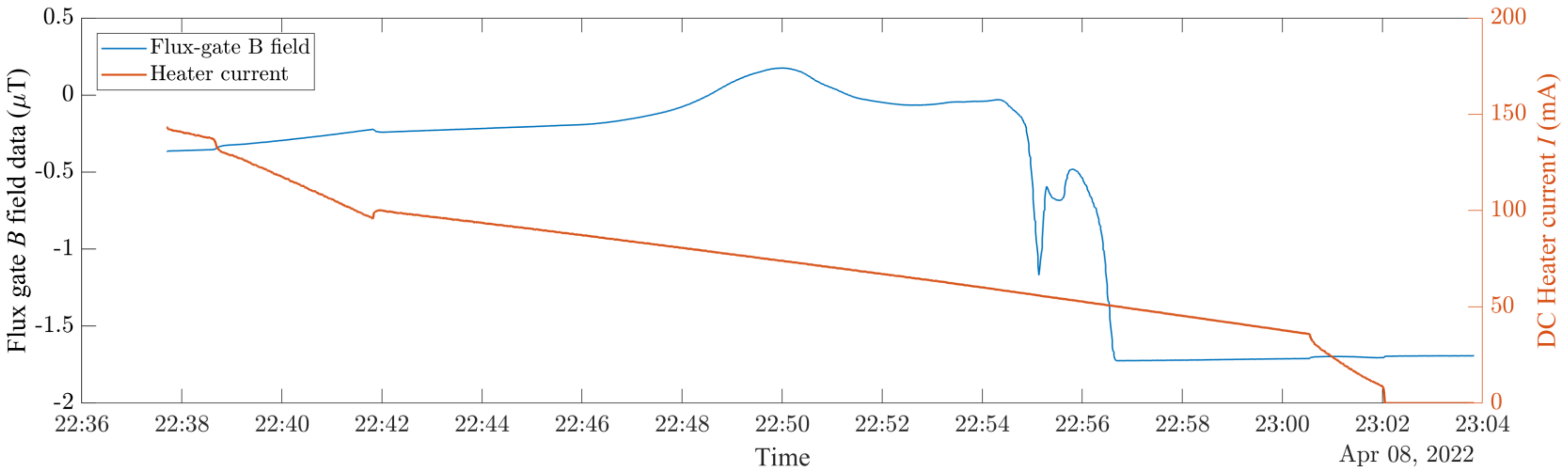

Slow cooldown with heater

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B – 3.19

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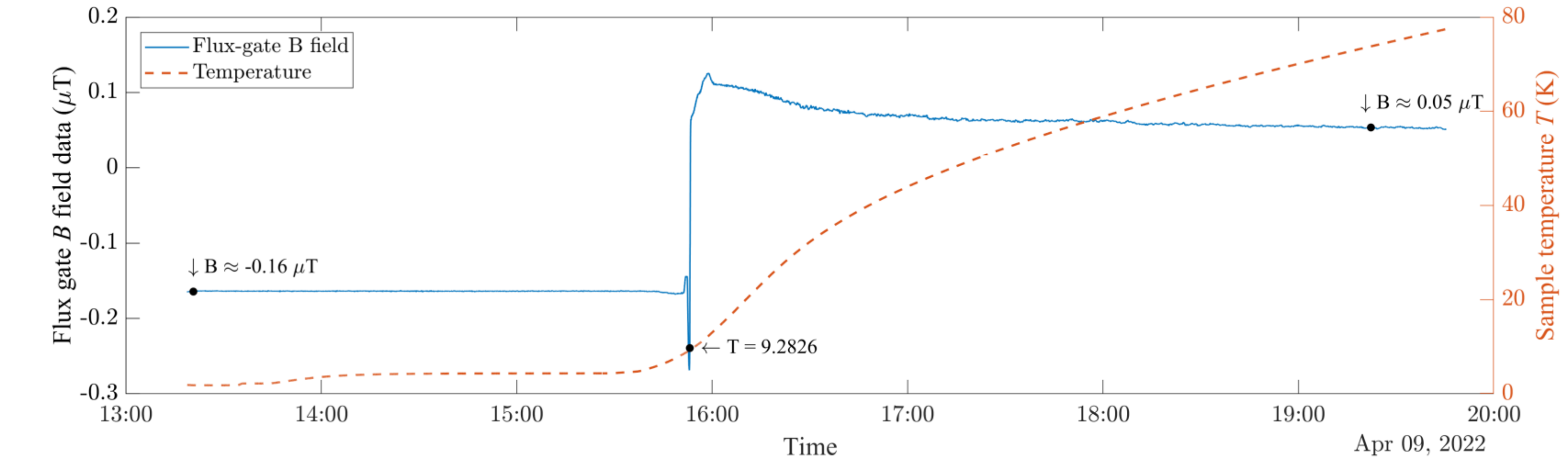

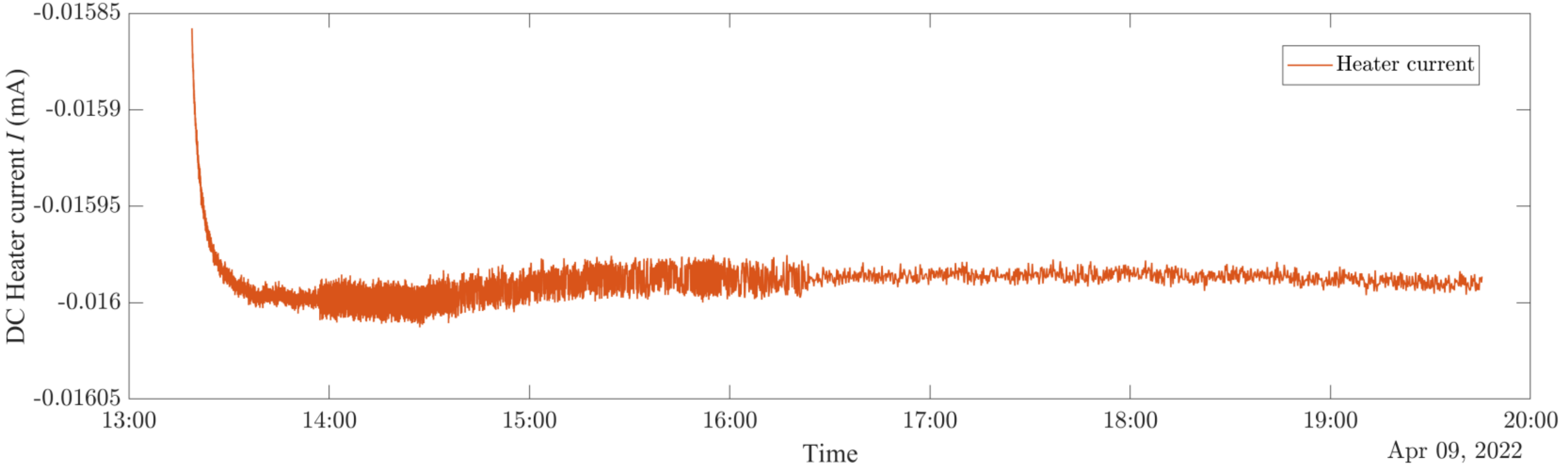

VTS warmup

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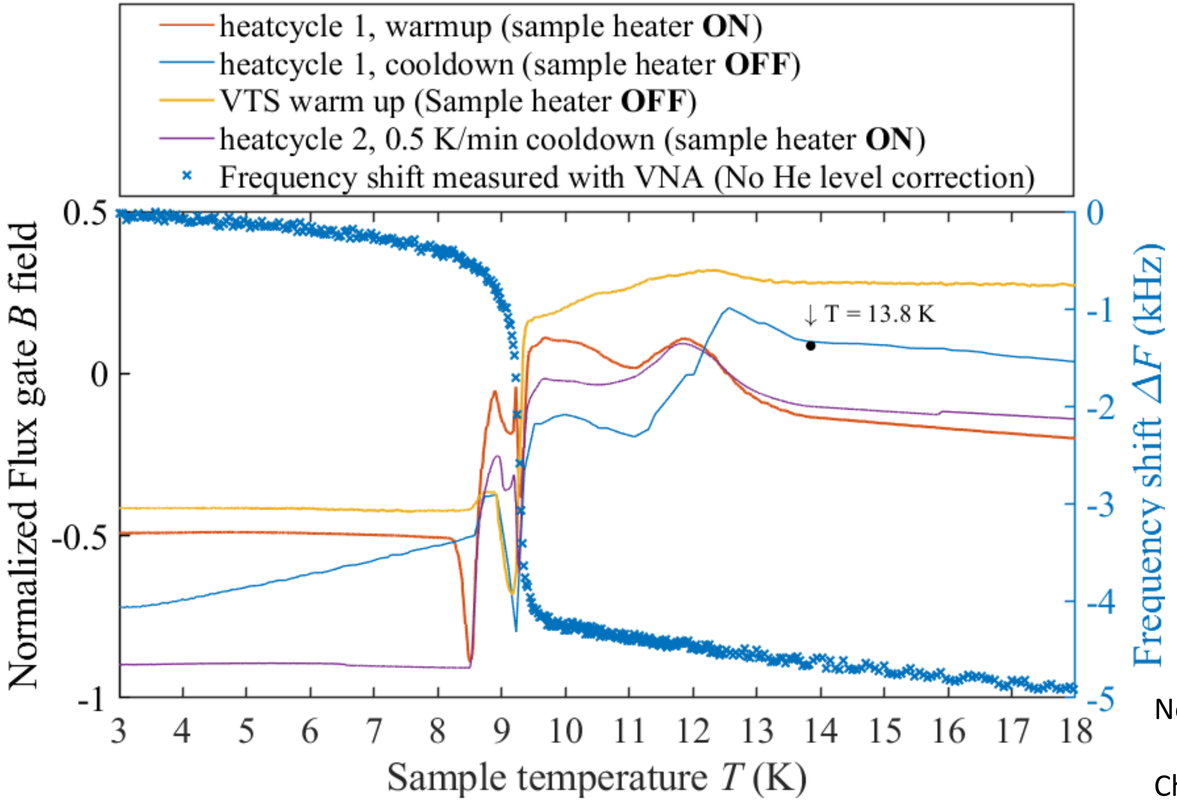

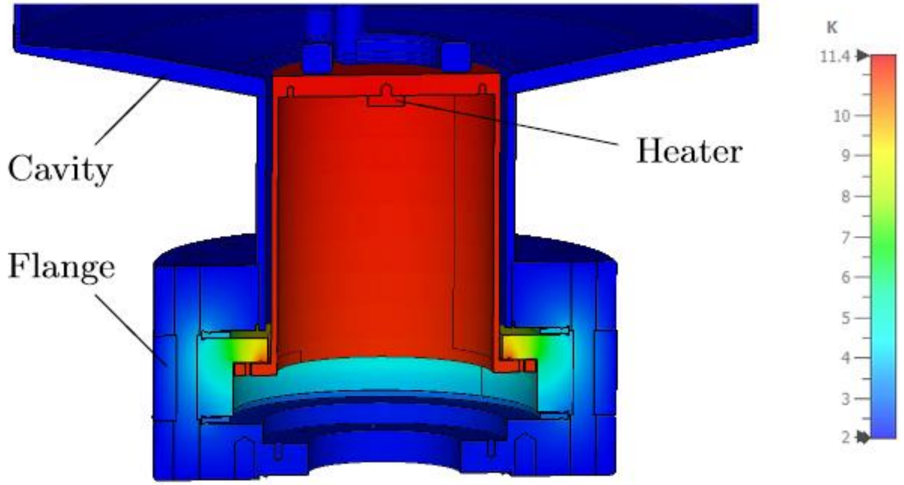

Figure 6. Simulated temperature distribution in the lower part of the QPR based on an intentional power insertion using a dedicated heater underneath the sample.

Normalisation was done locally for each plot $B_n = B/(B_{max} - B_{min})$

Changes in flux observed near Nb T_c (9.3 K) and possible **NbN T_c (13-14K)**

Name	Cooldown speed at Nb Tc cross	Heater current (mA)	Resulting flux probe value (µT)	Rs at 2.5 K 412 MHz 10 mT	Rs at 4.5 K 412 MHz 10 mT
Heat cycle 1	≈12.4 K/min	0	-0.21	48.5	103
Heat cycle 2	0.5 K/min	55	-1.7	107.8	217.6
VTS warmup	-	0	0.05	-	-

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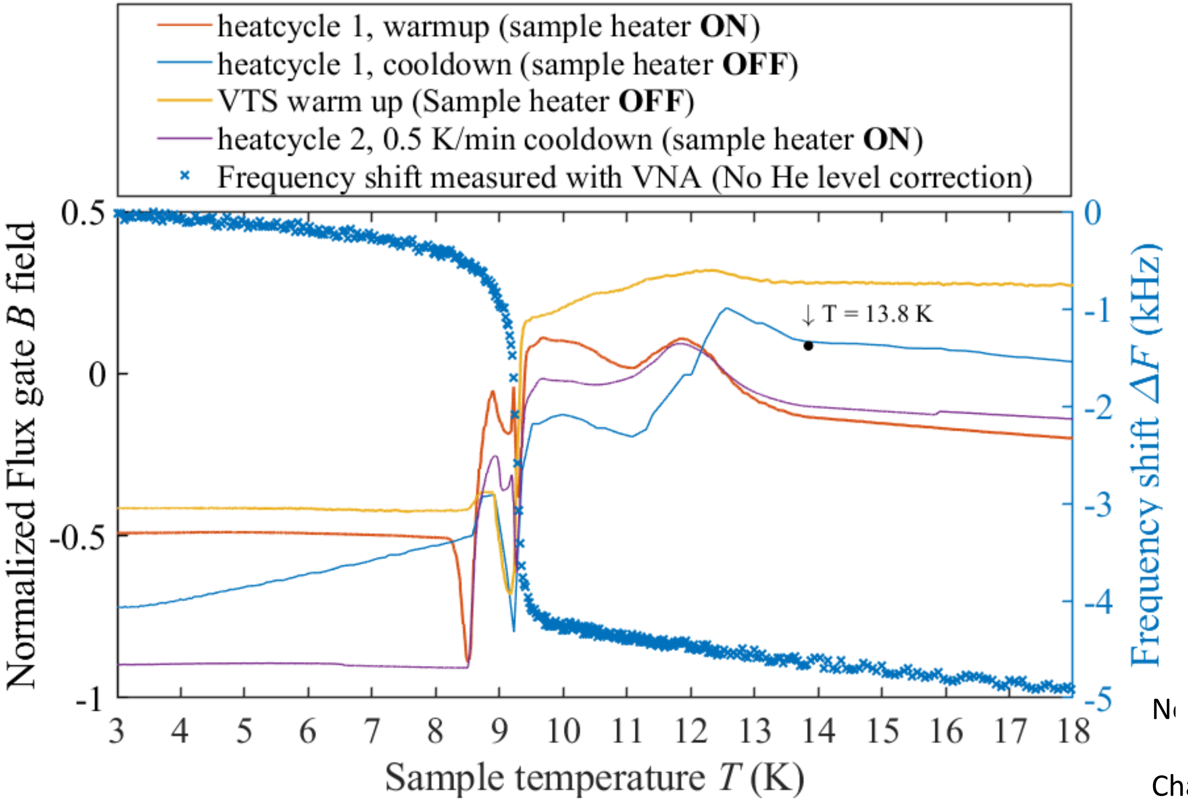
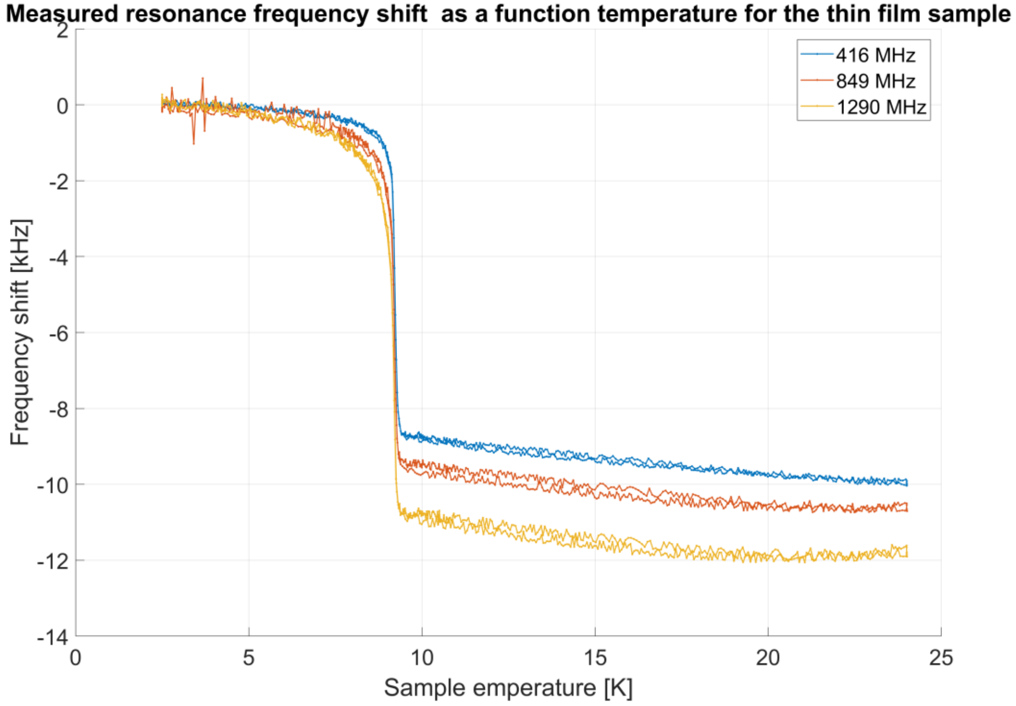
B – 3.19





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B – 3.19

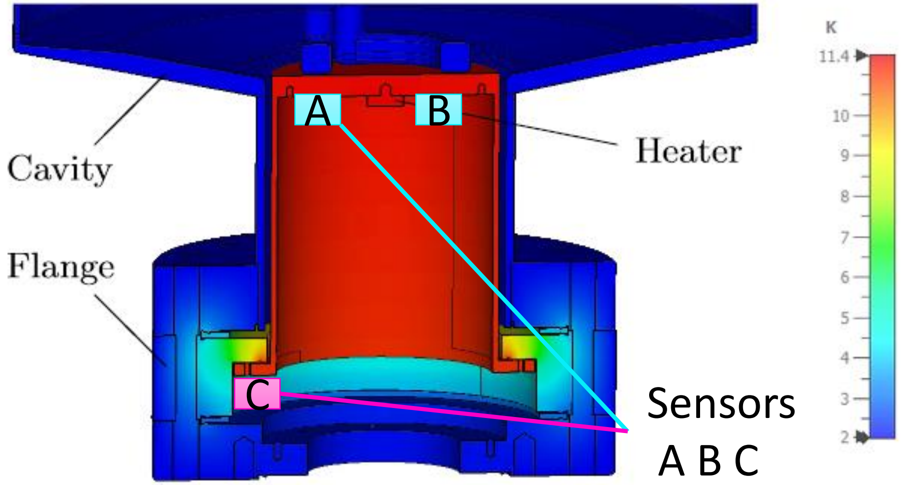
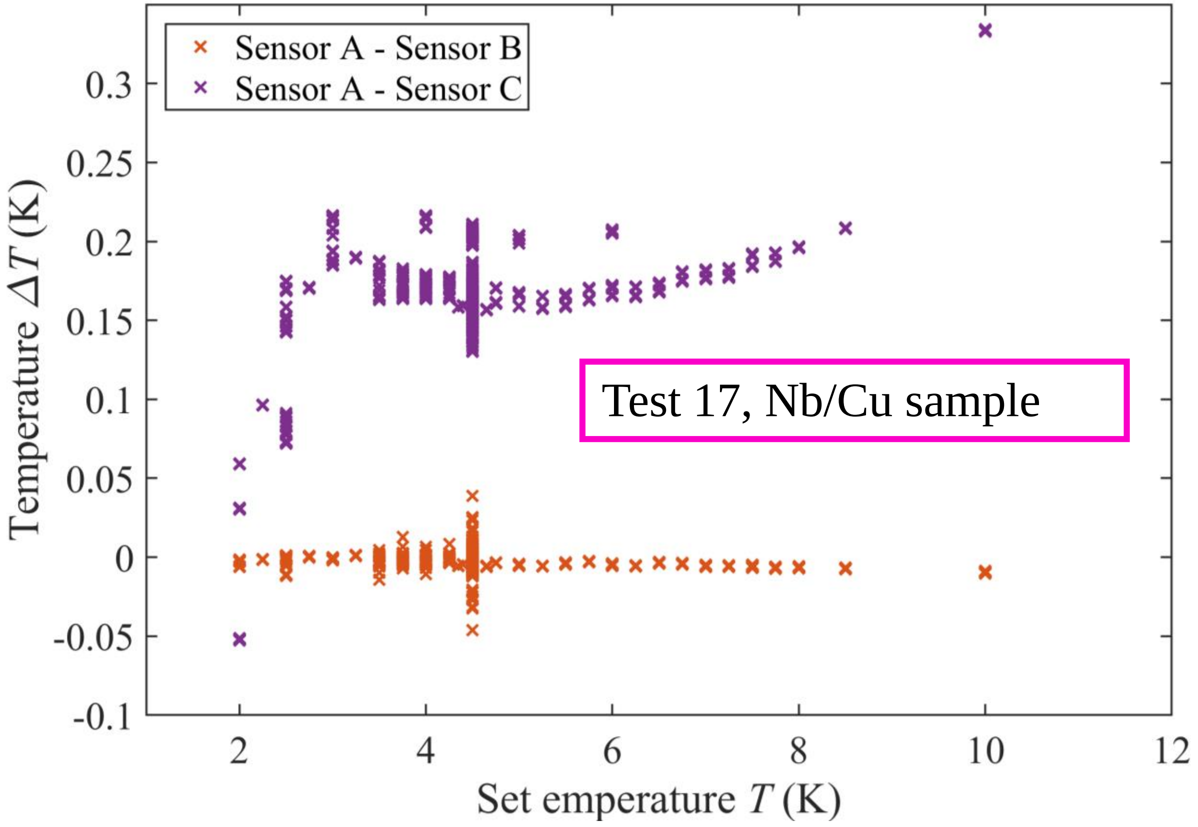


Figure 6. Simulated temperature distribution in the lower part of the QPR based on an intentional power insertion using a dedicated heater underneath the sample.



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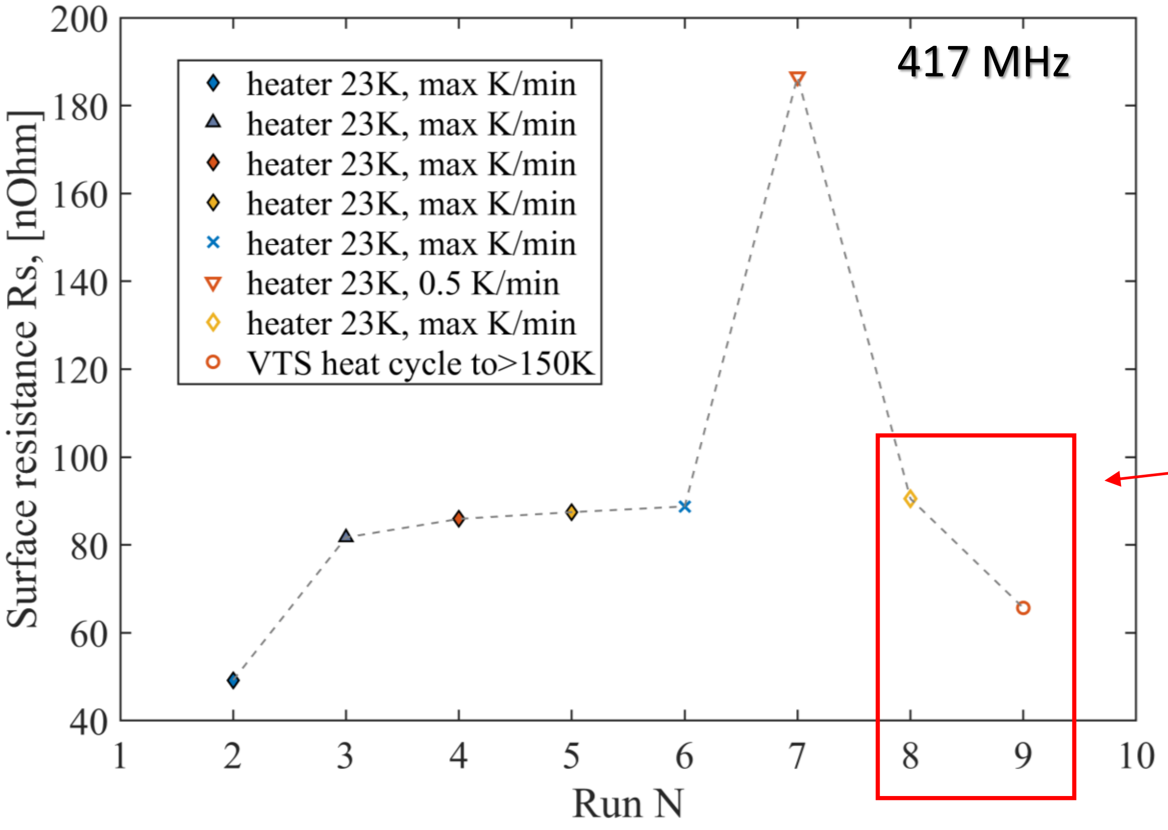
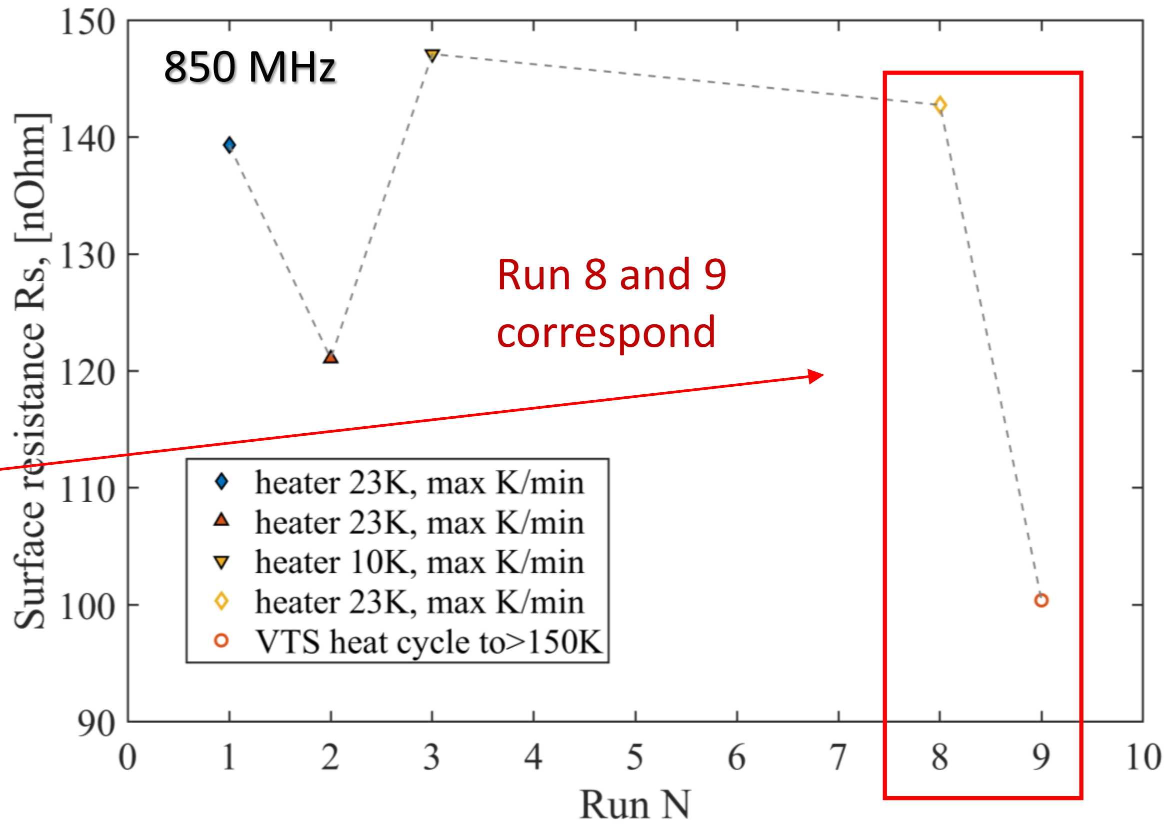
'35 nm AlN' sample. Rs data at 2.5 K; 10 mT





Run 8 and 9 correspond

Time

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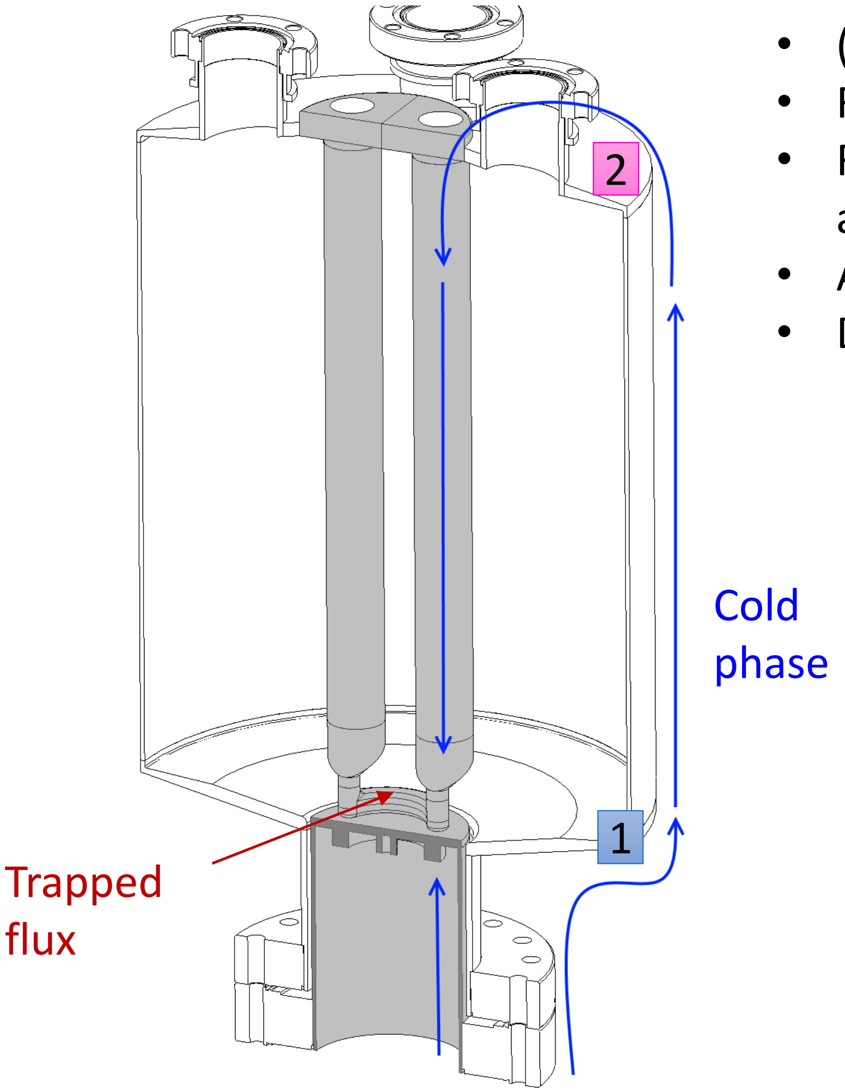
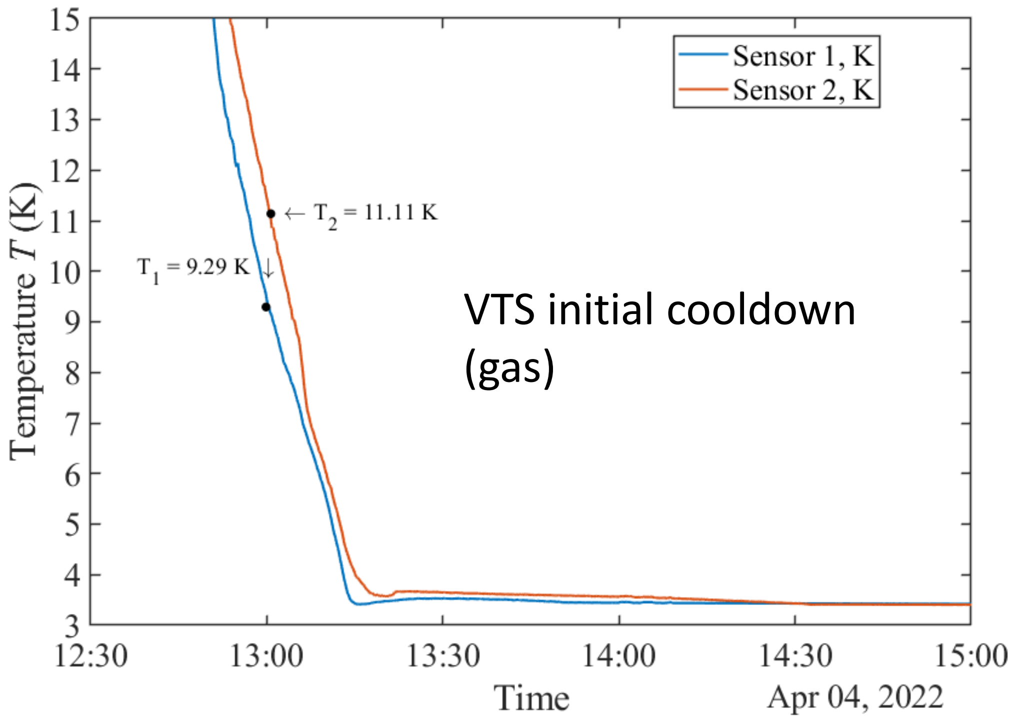
B-2.13



- (IF) Rods – last hot point:
- Flux may be pushed onto the rods and focused there
- First cooldown: Sample gets superconducting first and not “care” about rods flux anymore
- After first Tc break on sample, it traps that focused flux after each cooldown
- Different cooldown = different gradient on the QPR



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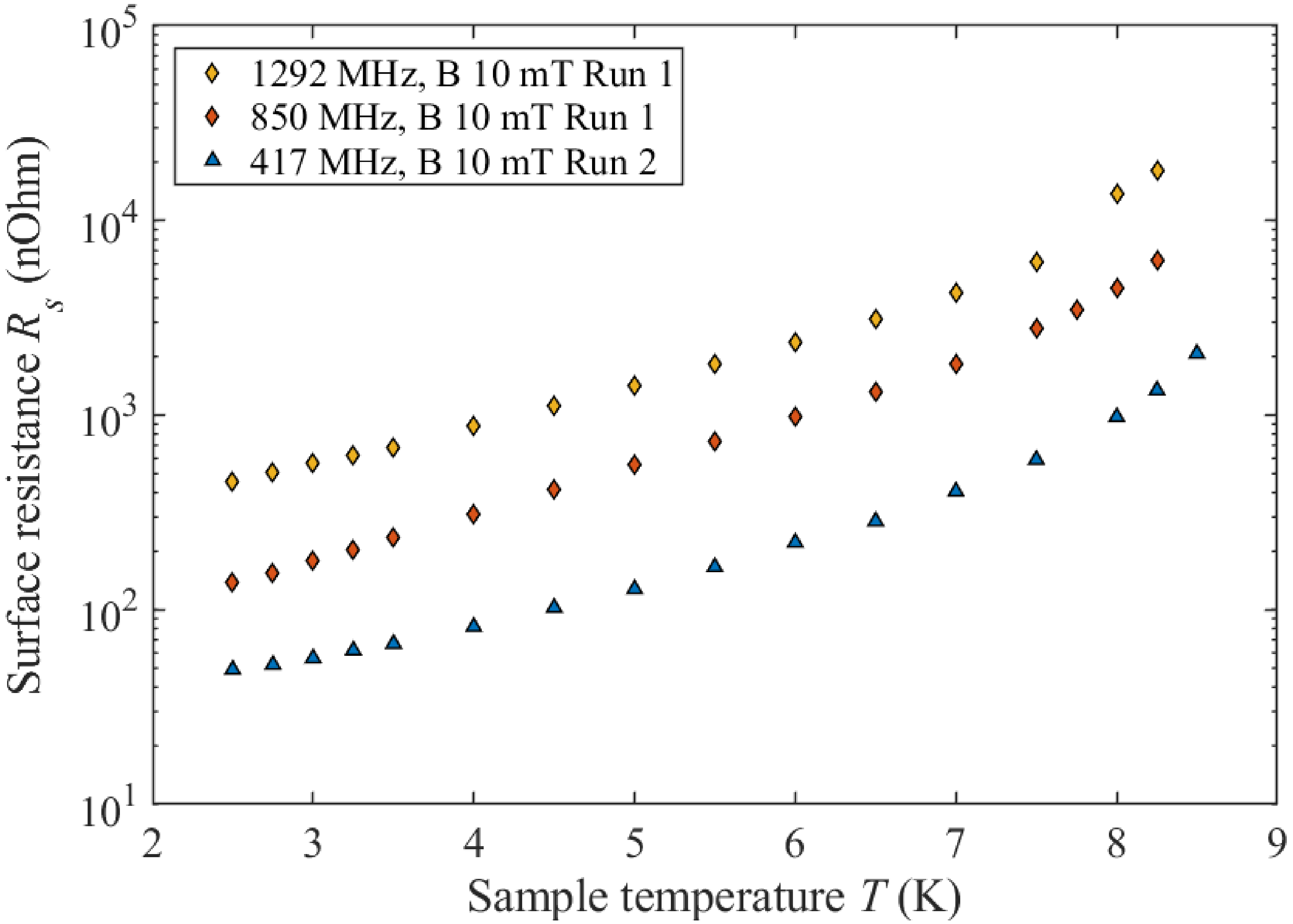
Rs vs T ‘SIS 35 nm’



- Nothing unusual on the Rs vs T plot

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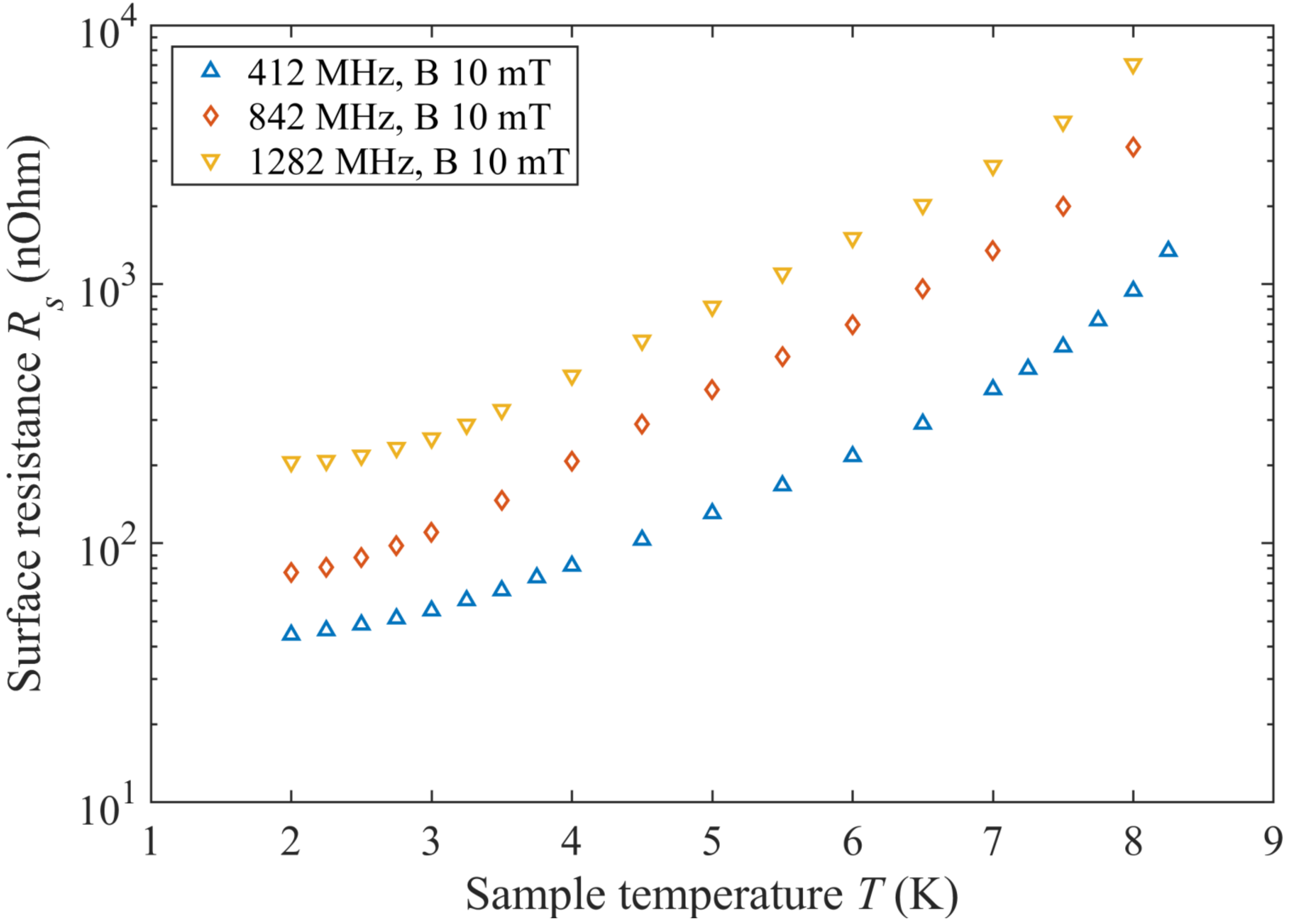
Rs vs T ‘NO insulator’



- Nothing unusual on the Rs vs T plot

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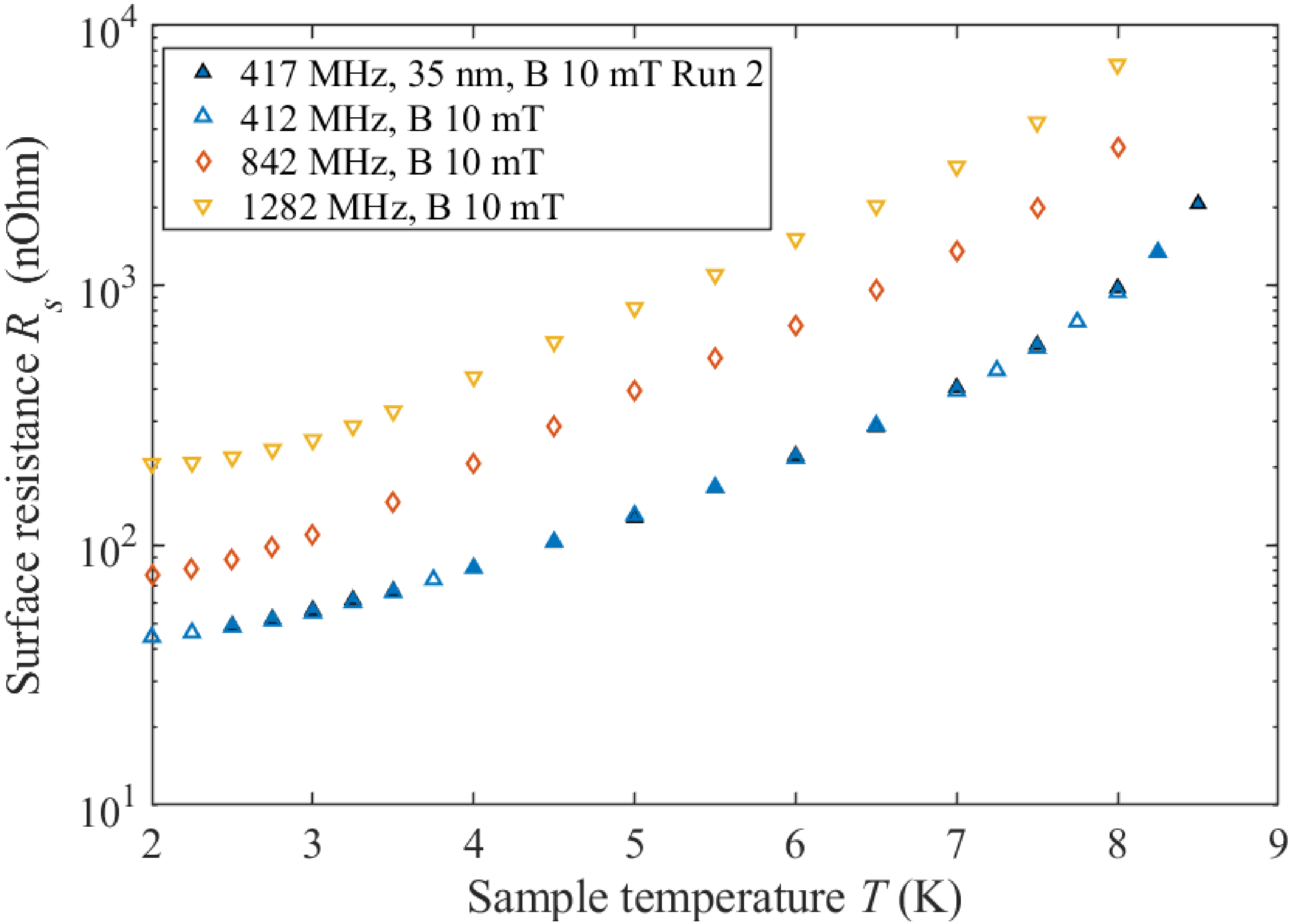
Rs vs T 'NO insulator'



- ~400 MHz mode: 2 samples identical at first run

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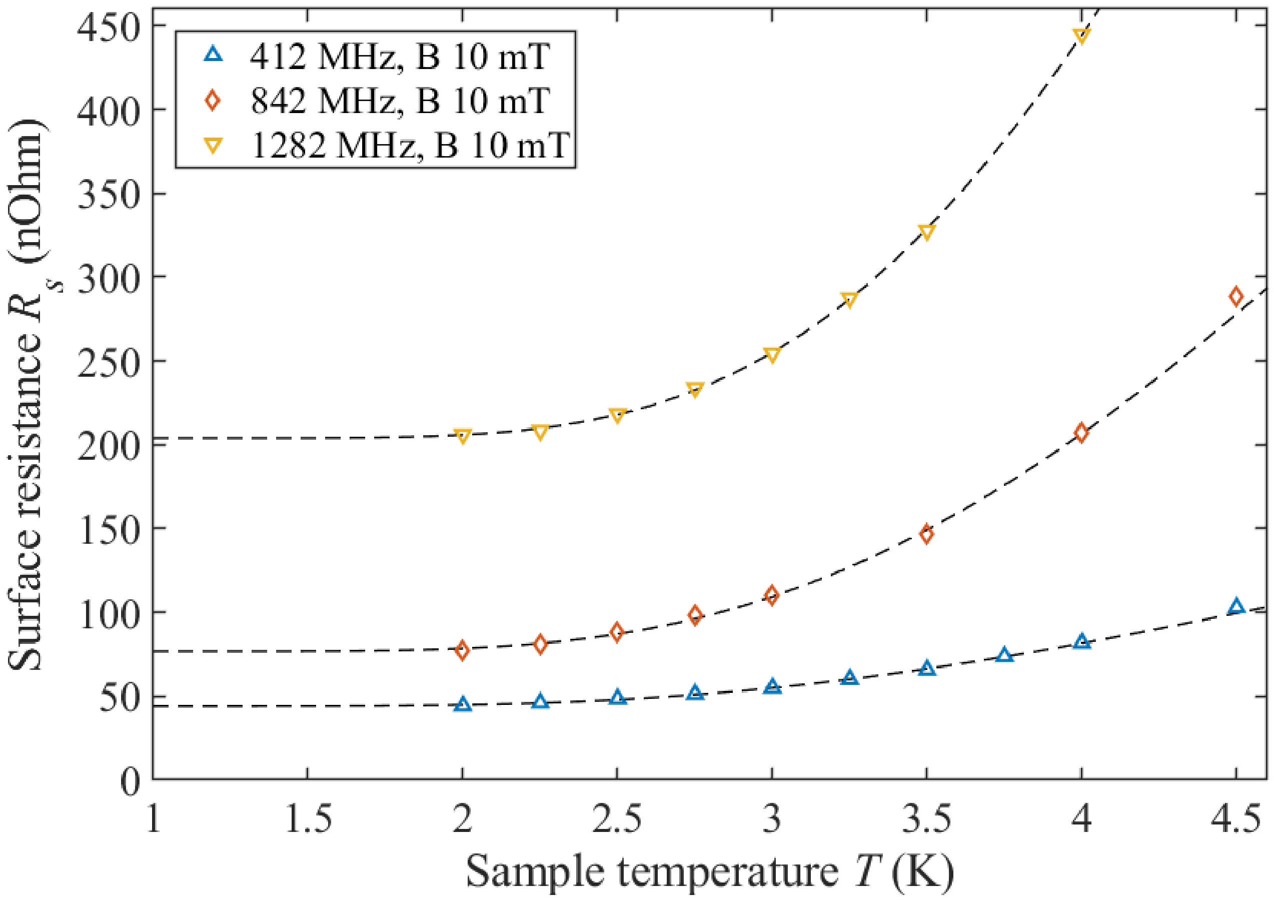

$$R_{res} + ABCS \cdot (1/x) \cdot exp(-b/x)$$

Table: fit results (test 36) at 10 mT

	412 MHz	842 MHz	1282 MHz
R_{res}	**44.12** (43.18, 45.06)	**76.87** (72.59, 81.15)	**204** (201.8, 206.1)
A_{BCS}	1.45 (1.02, 1.88) E4	7.79 (3.90, 11.68) E4	2.39 (2.04, 2.74) E5
b	18.3 (17.1, 19.49)	20.05 (18.02, 22.07)	22.06 (21.47, 22.65)

*Nb coated flange used for all tests

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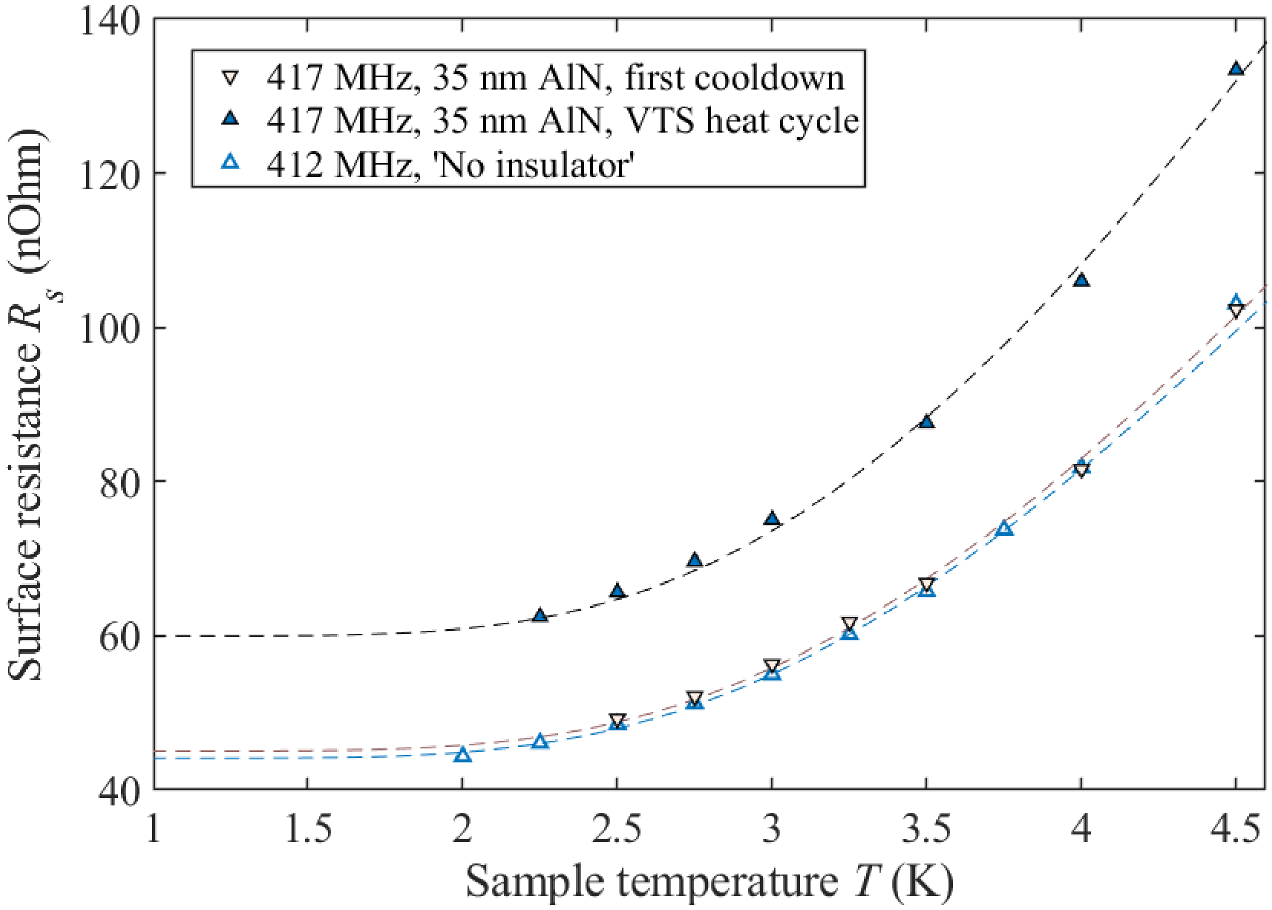

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Table: fit results (test 35) at 10 mT (Run 9)

	417 MHz	842 MHz	1282 MHz
R_{res}	**59.94** (57.29, 62.58)	**87.77** (82.17, 93.36)	**355** (297.9, 412.1)
A_{BCS}	1.33 (0.63, 2.03) E4	9.78 (7.13, 12.43) E4	14.9 (3.19, 26.61) E4
b	17.14 (14.9, 19.38)	19.98 (18.74, 21.22)	17.52 (13.84, 21.2)

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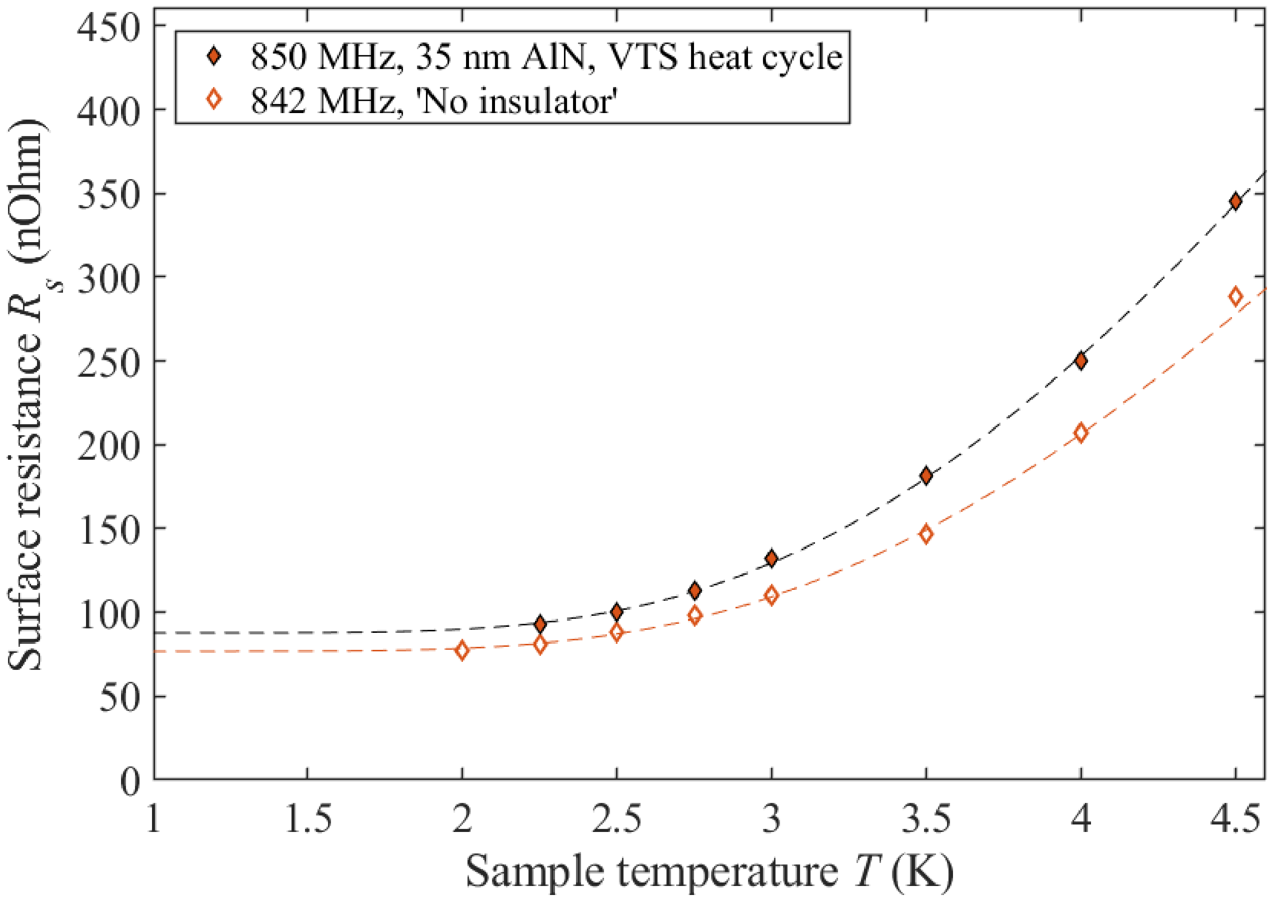

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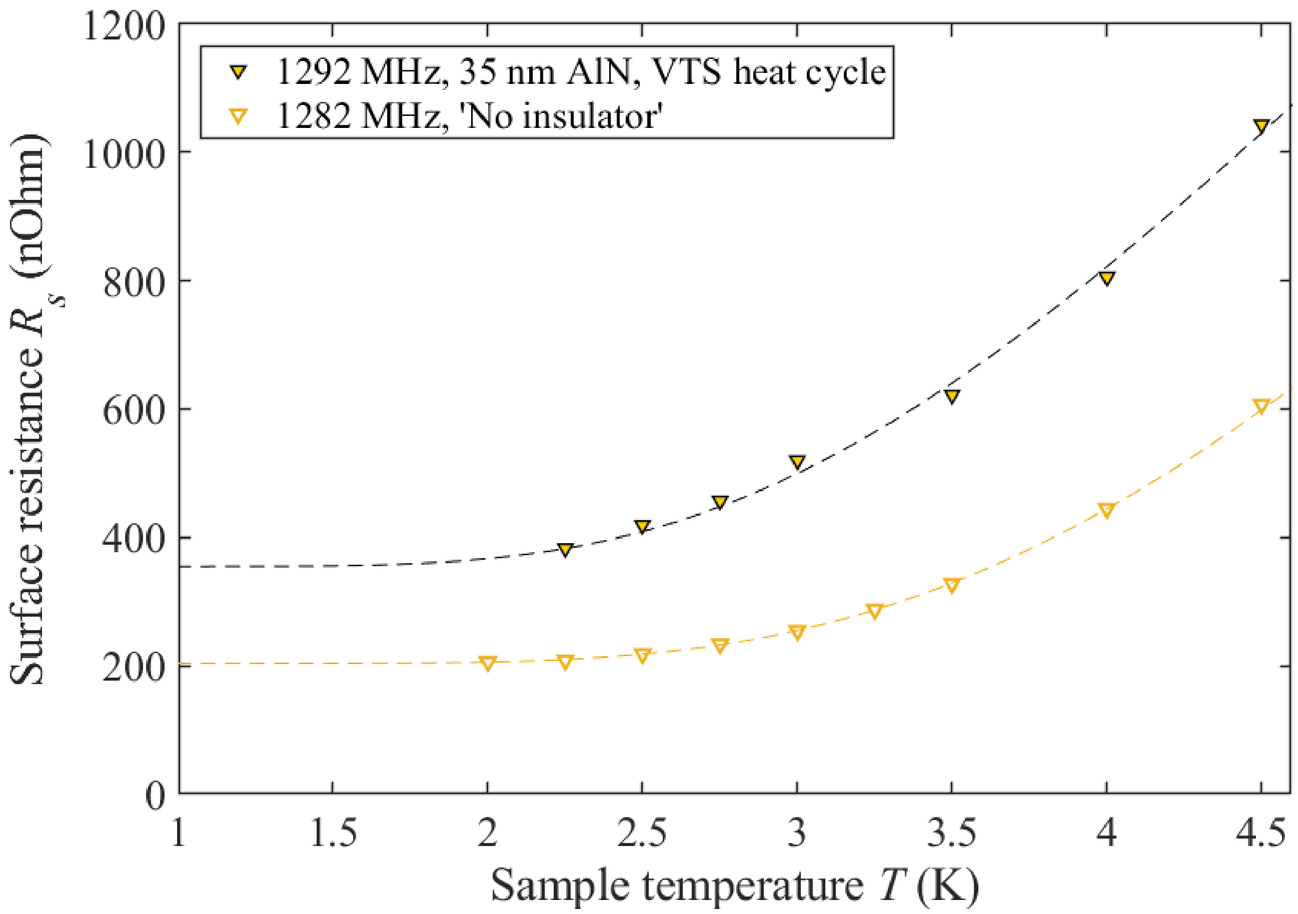

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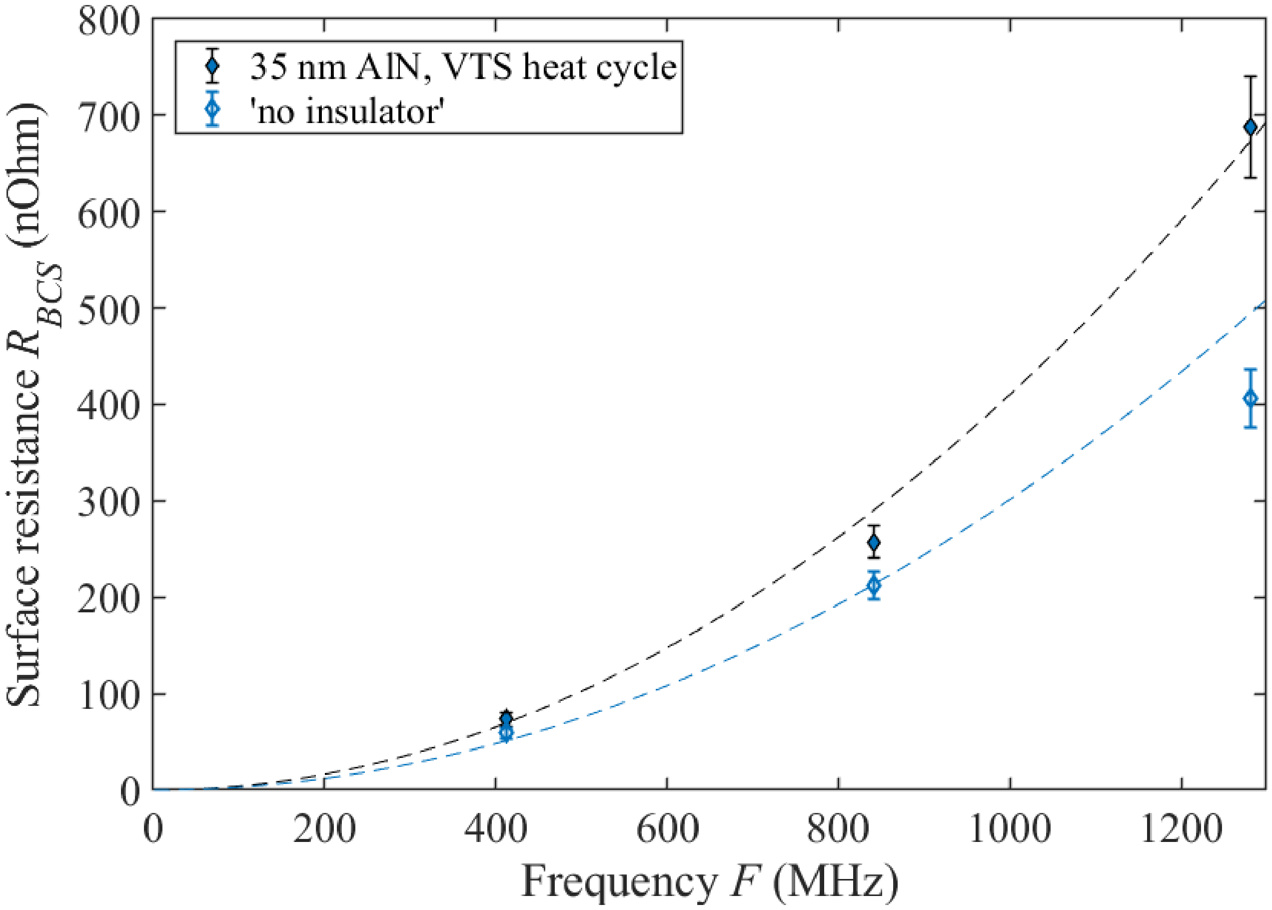
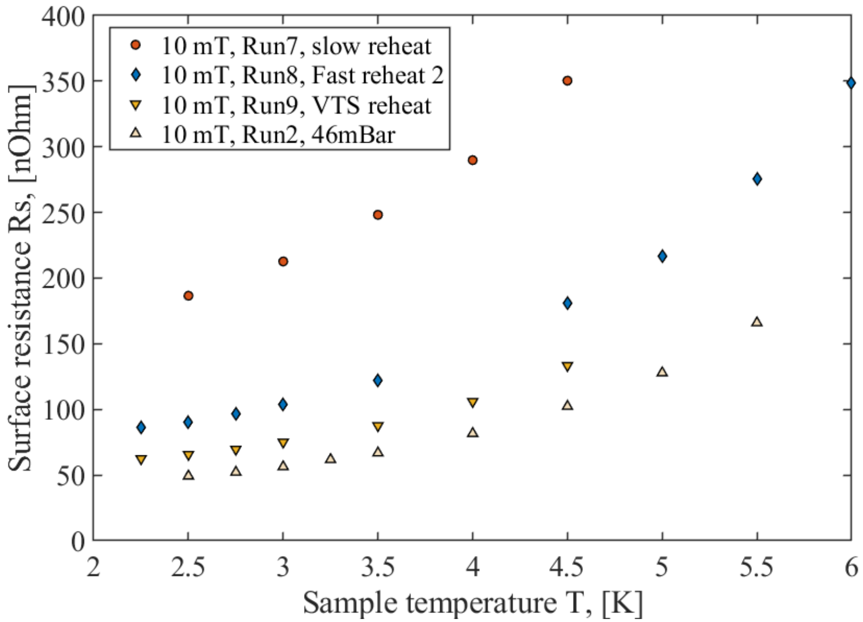


RBCS at 4.5 K and 10 mT
Data for test 35 (35 nm) taken after VTS heat cycle

“BCS part can also be influenced by trapped flux”



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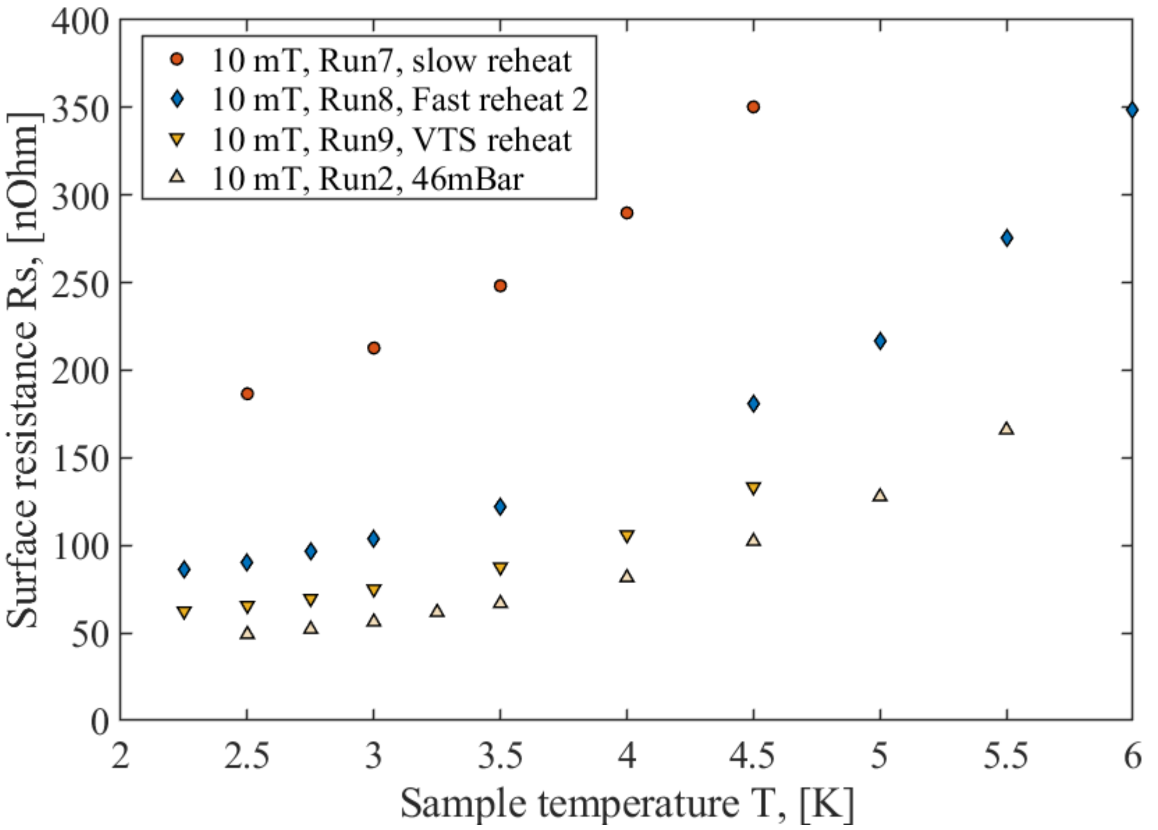
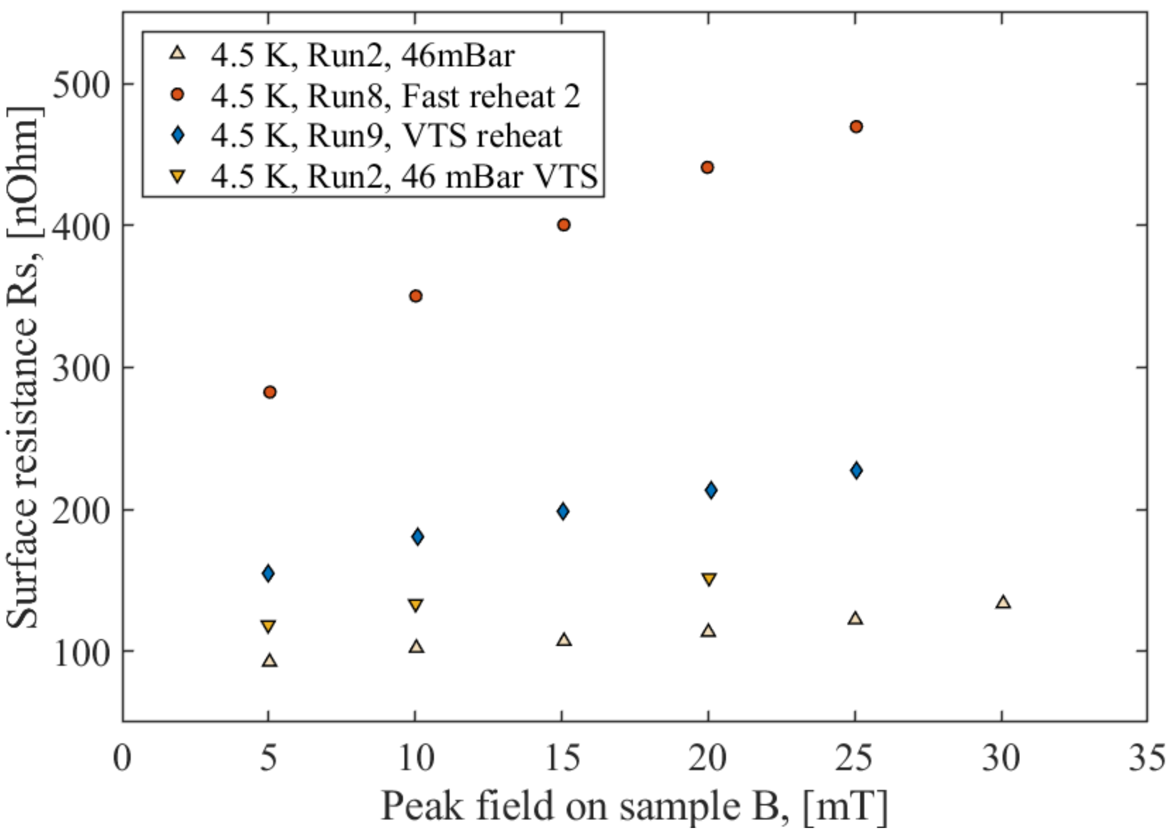
Flux-induced (?) resistance ('35 nm AlN' sample)

Helmholtz Zentrum Berlin





35 nm insulator sample: additional resistance also have f(T) and f(B) components (417 MHz)

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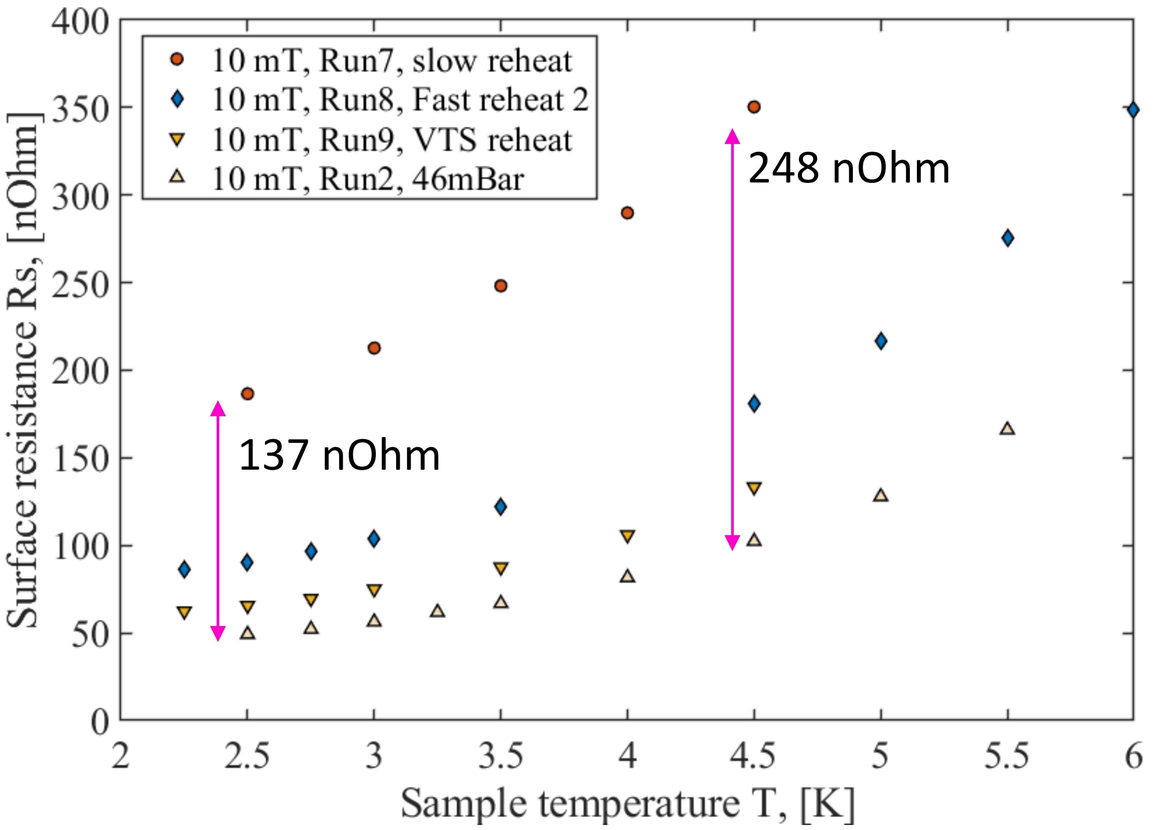

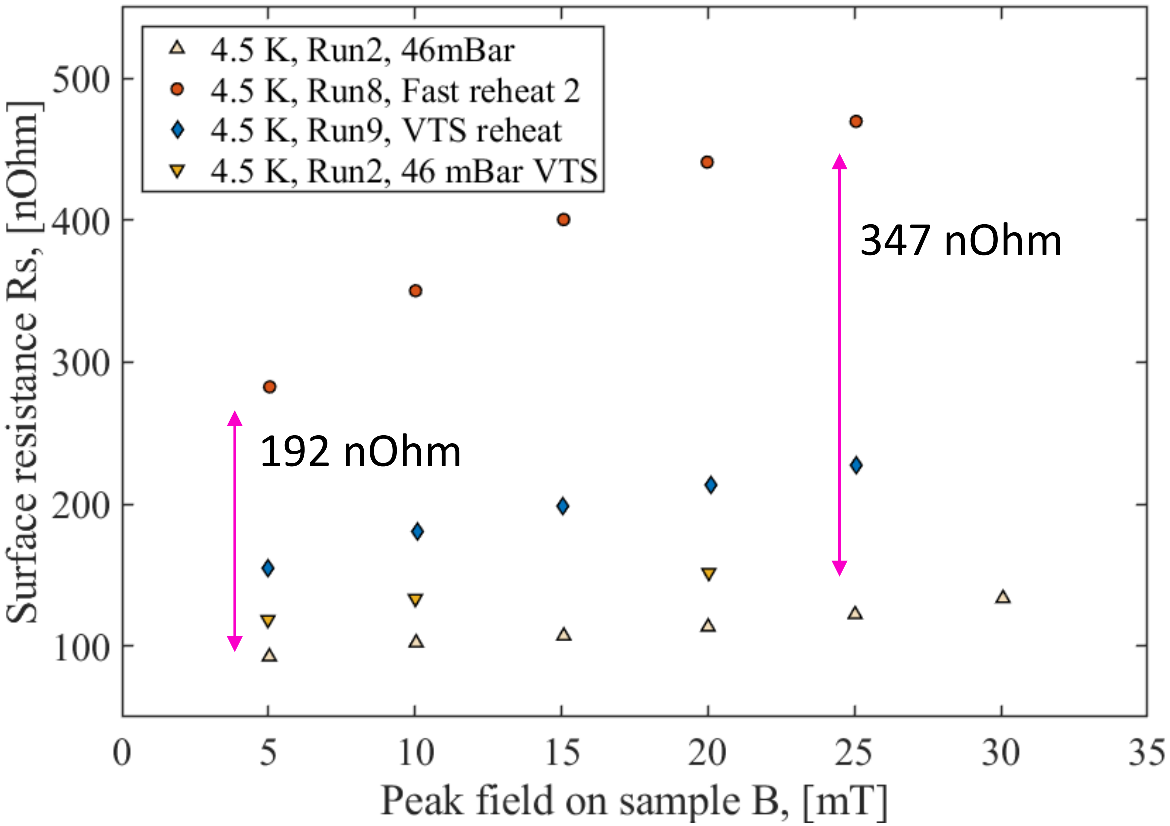

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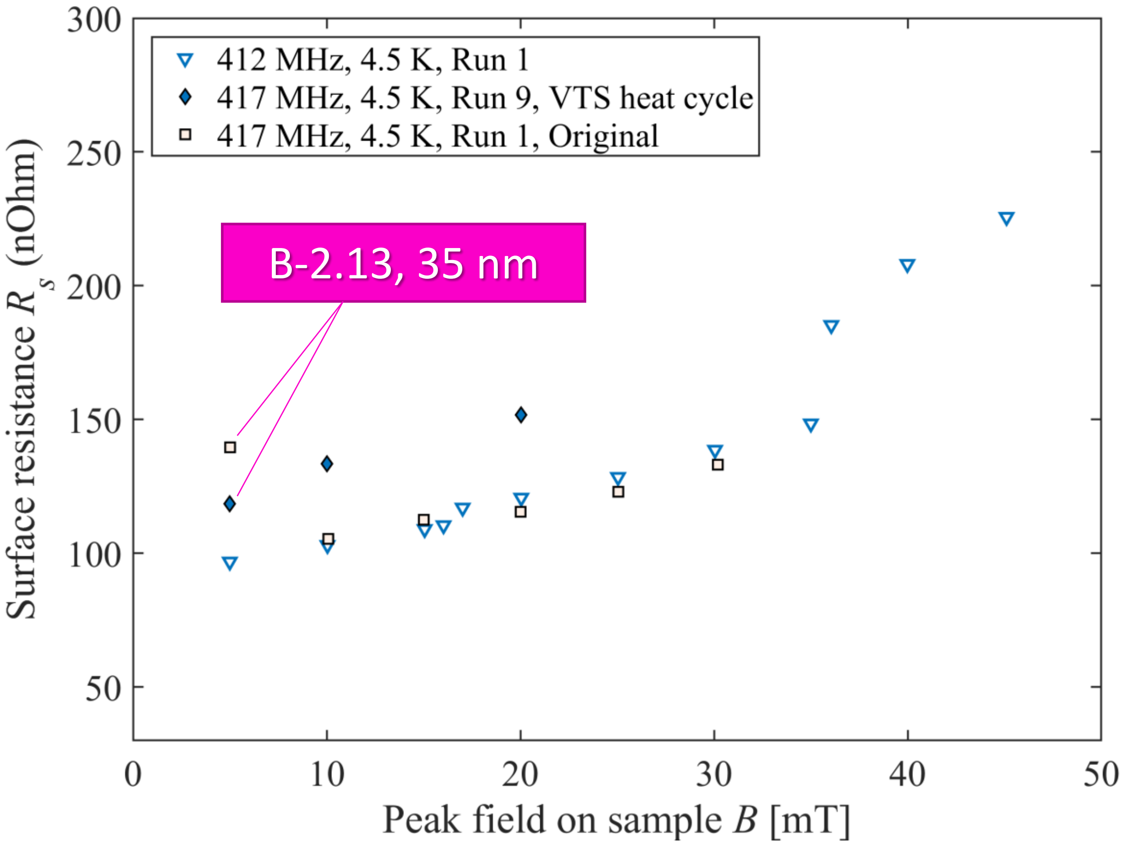

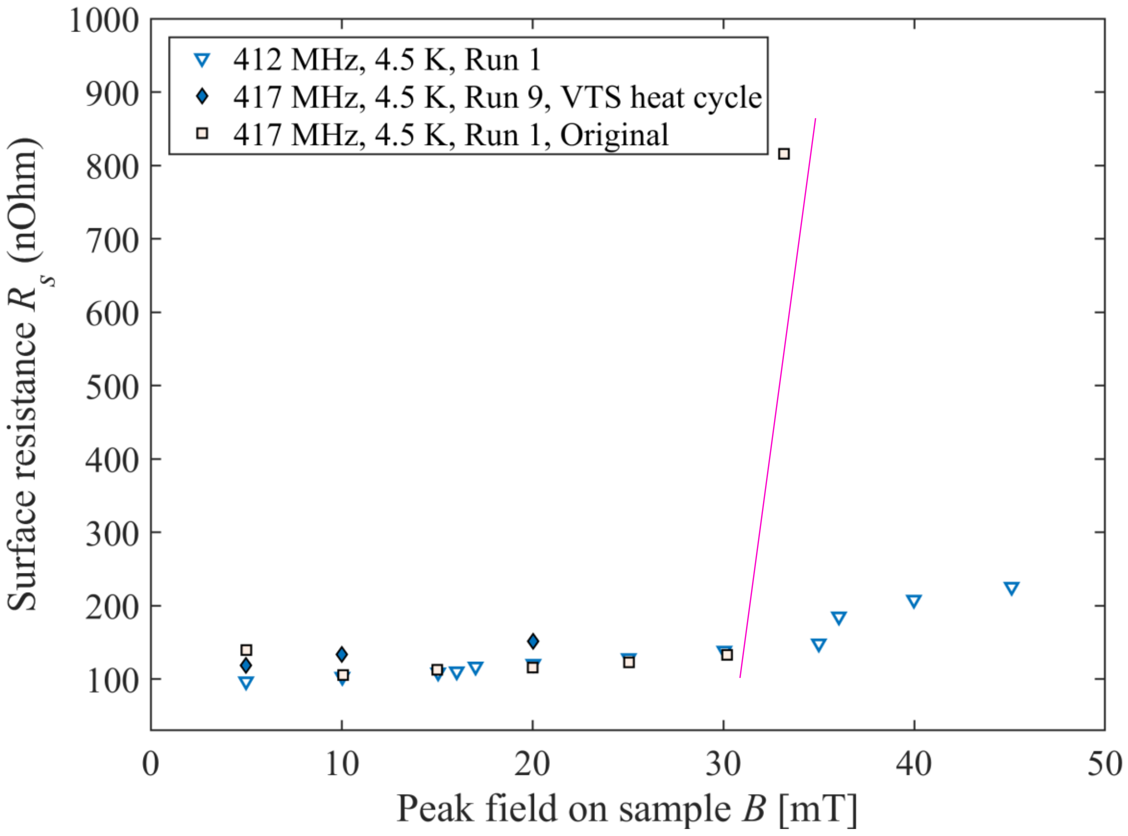

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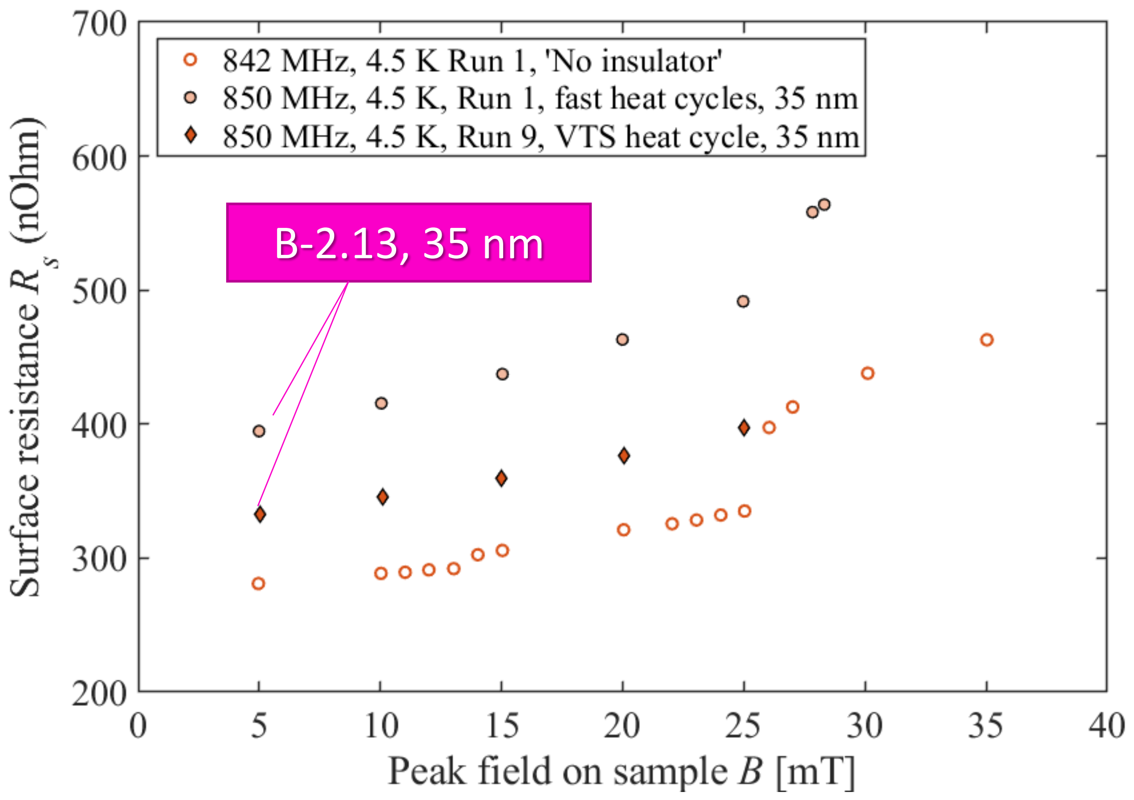

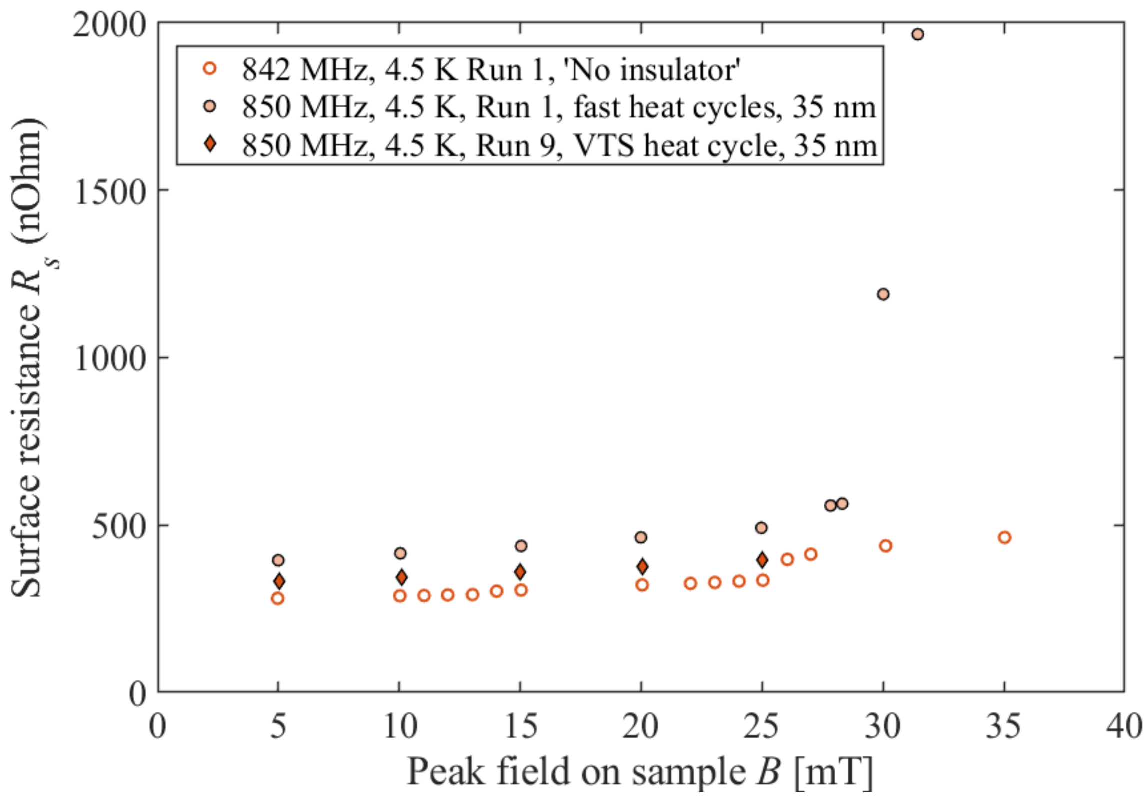

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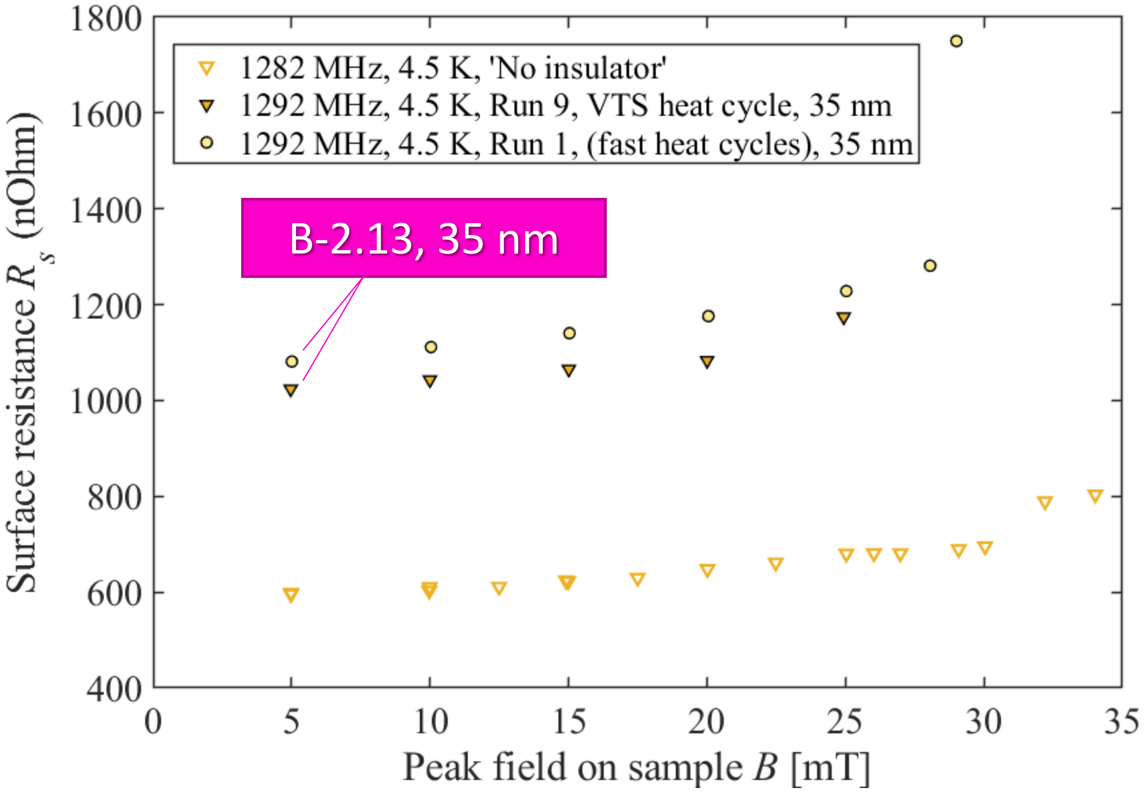

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Frequency fit (approx. data)

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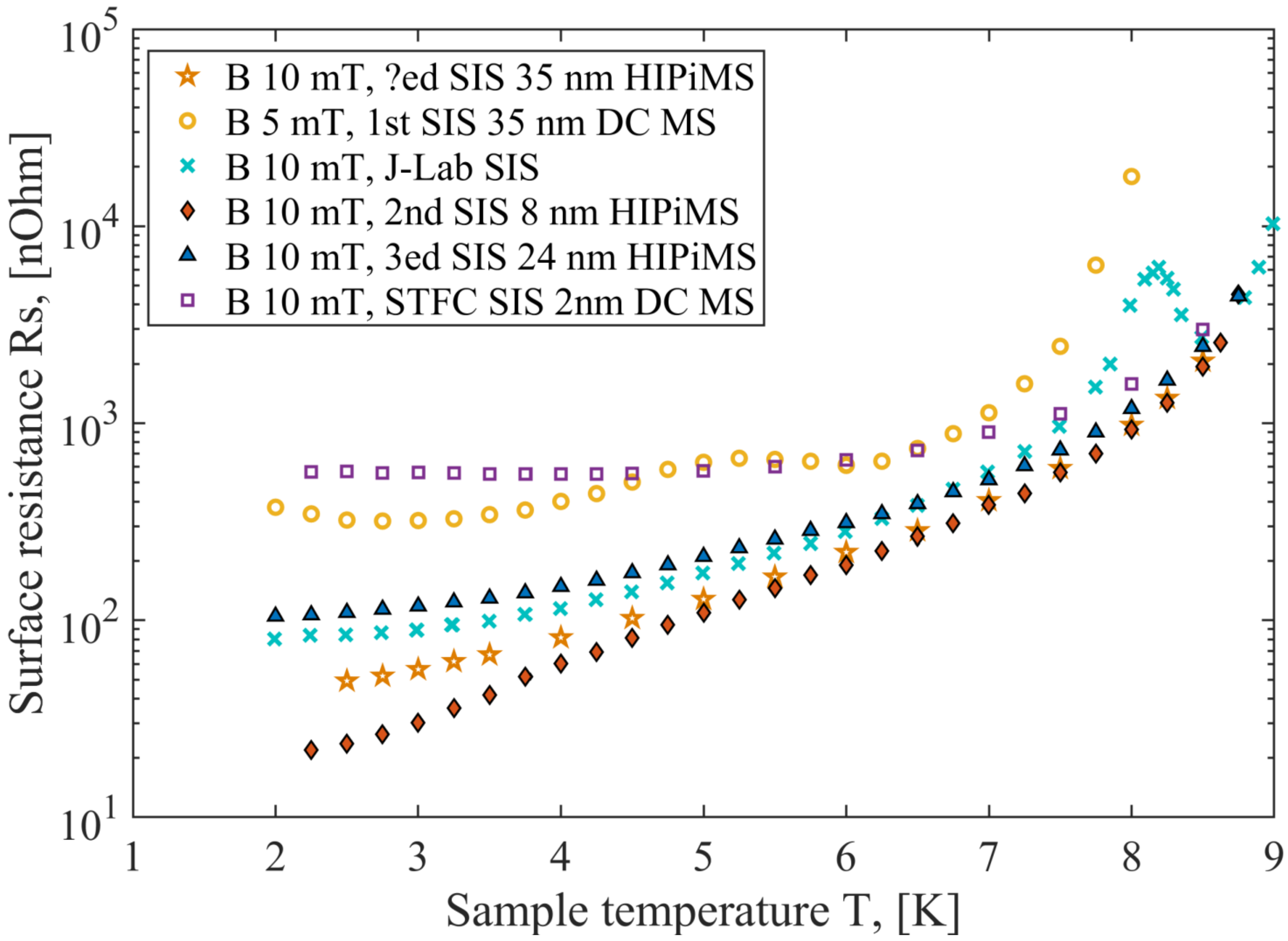

AlN thickness	Method	R_{res} (Approx) (nOhm)
35 nm	DC MS	375
☆ 35 nm	HiPIMS	44
24 nm	HiPIMS	104
8 nm	HiPIMS	21
~2 nm	DC MS	567
☆ 0	HiPIMS	44

*All data with subtracted stainless-steel shift (~24 nOhm) or with Nb coated flange

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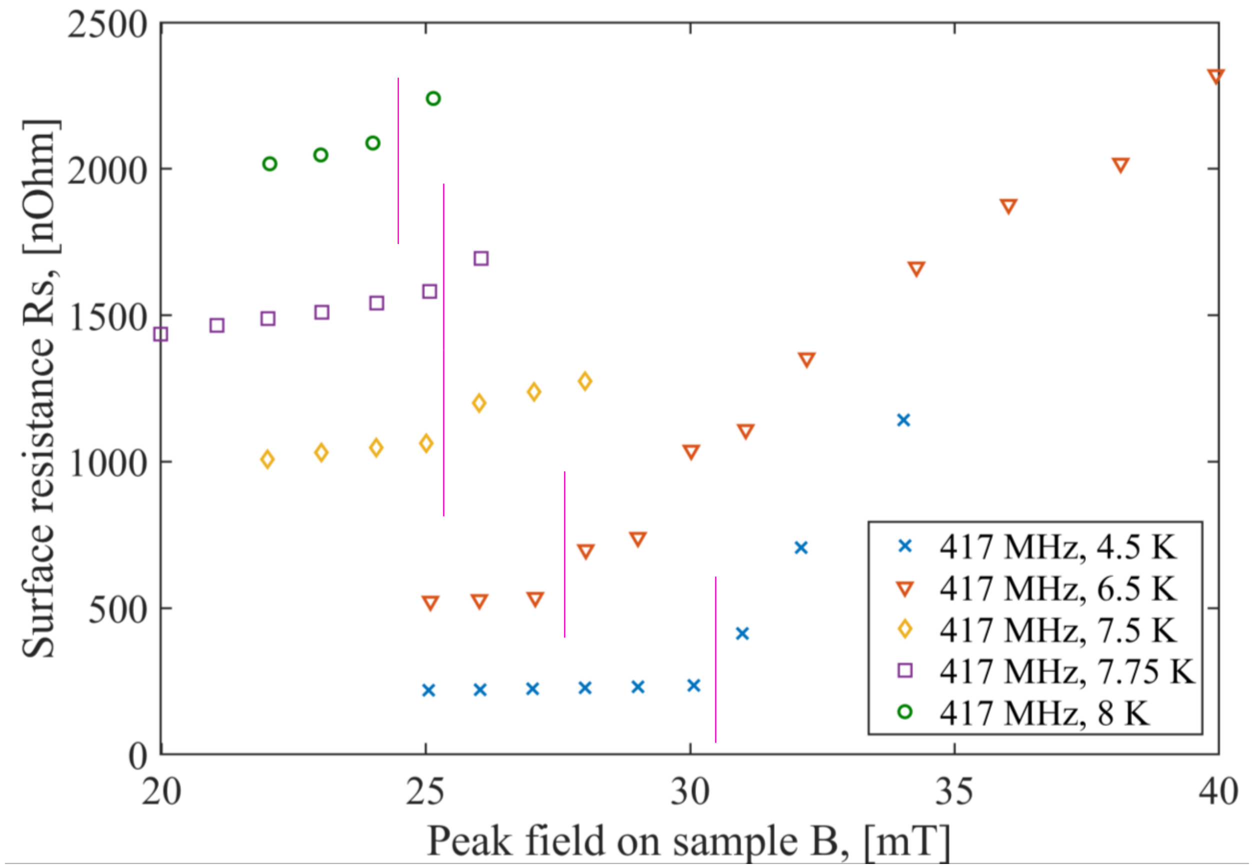
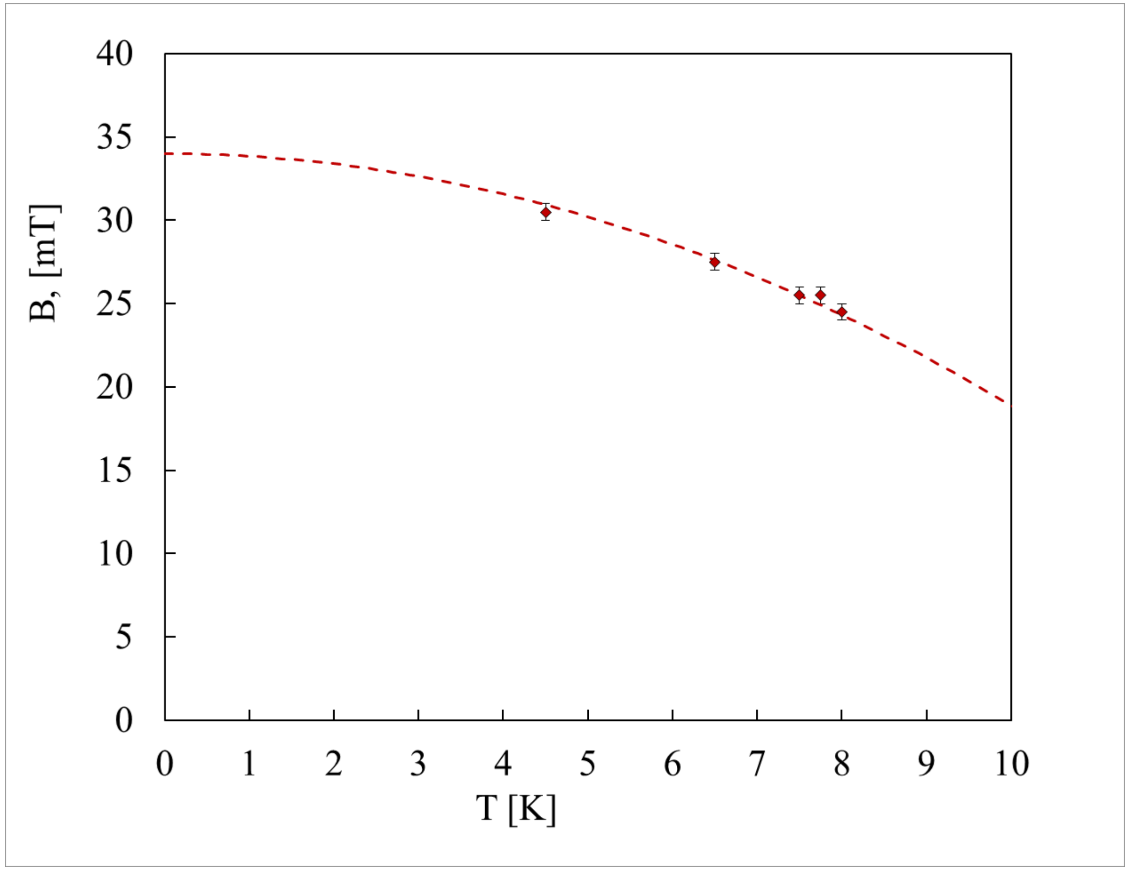
Rs vs B 35 nm sample





Hc1 field/flux partial penetration?

B0	Tc
34 mT	15 K

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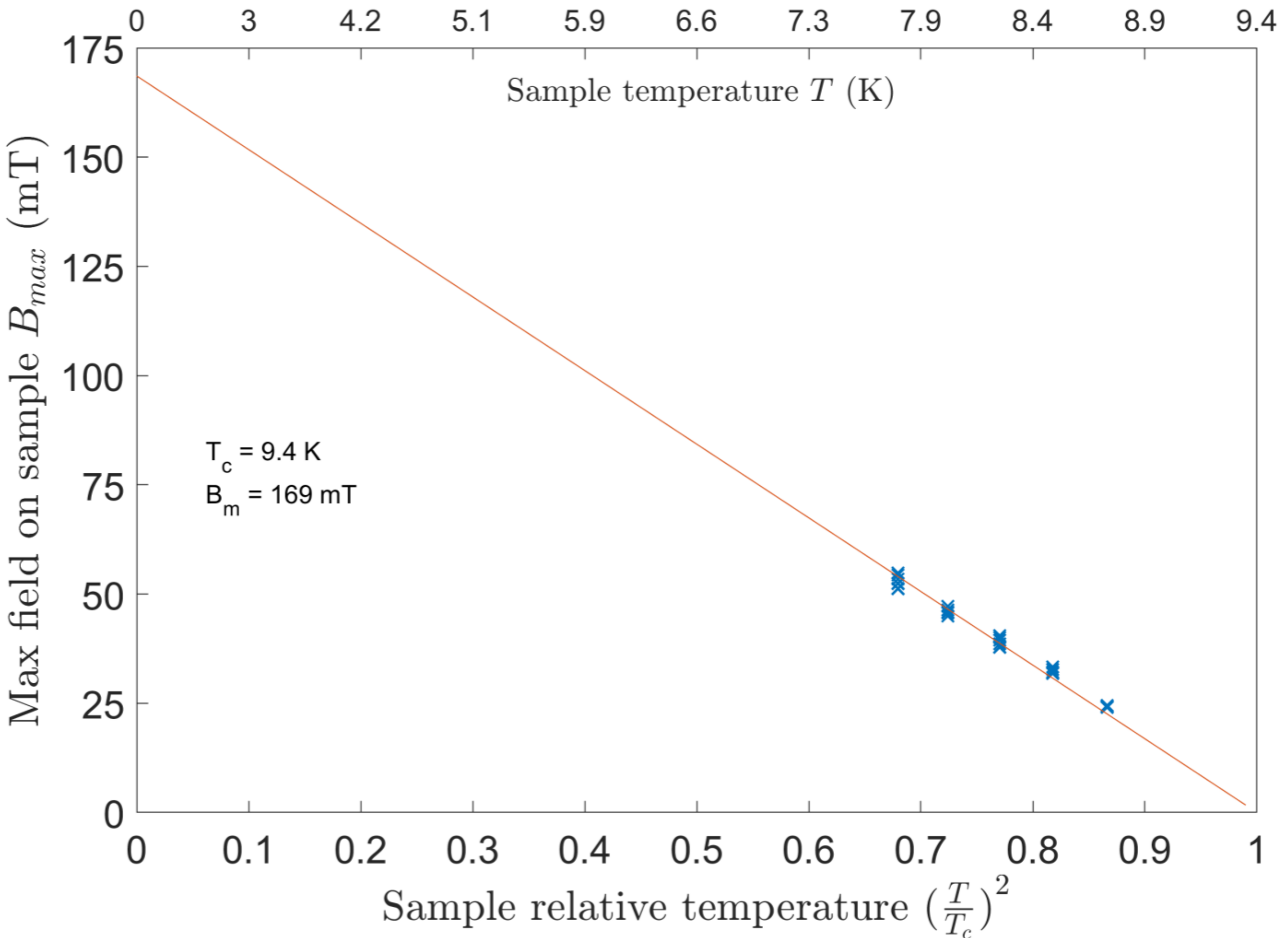
Max Quench field



416 MHz
Tc=9.4

F, (MHz)	B_0, (mT)
416	169

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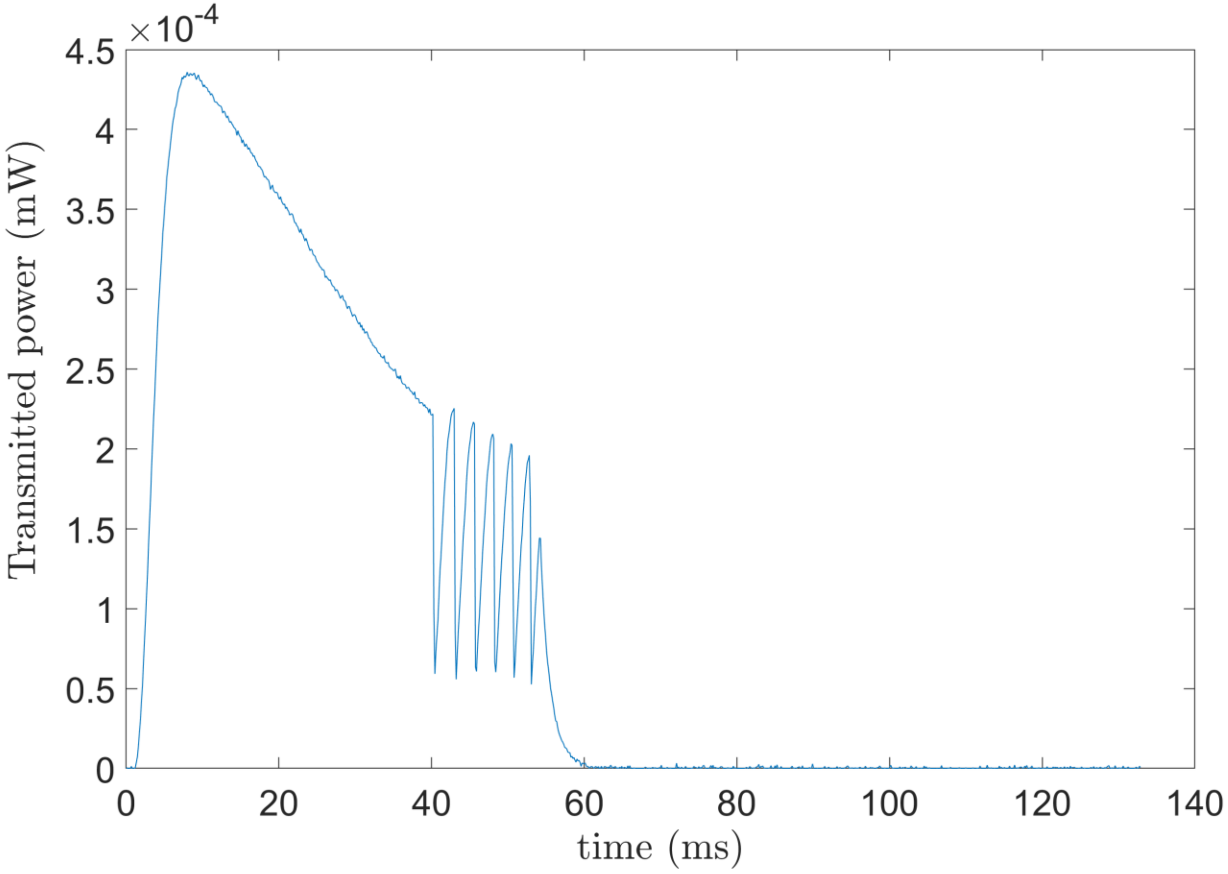

416 MHz
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F, (MHz)	B_o, (mT)
416	169

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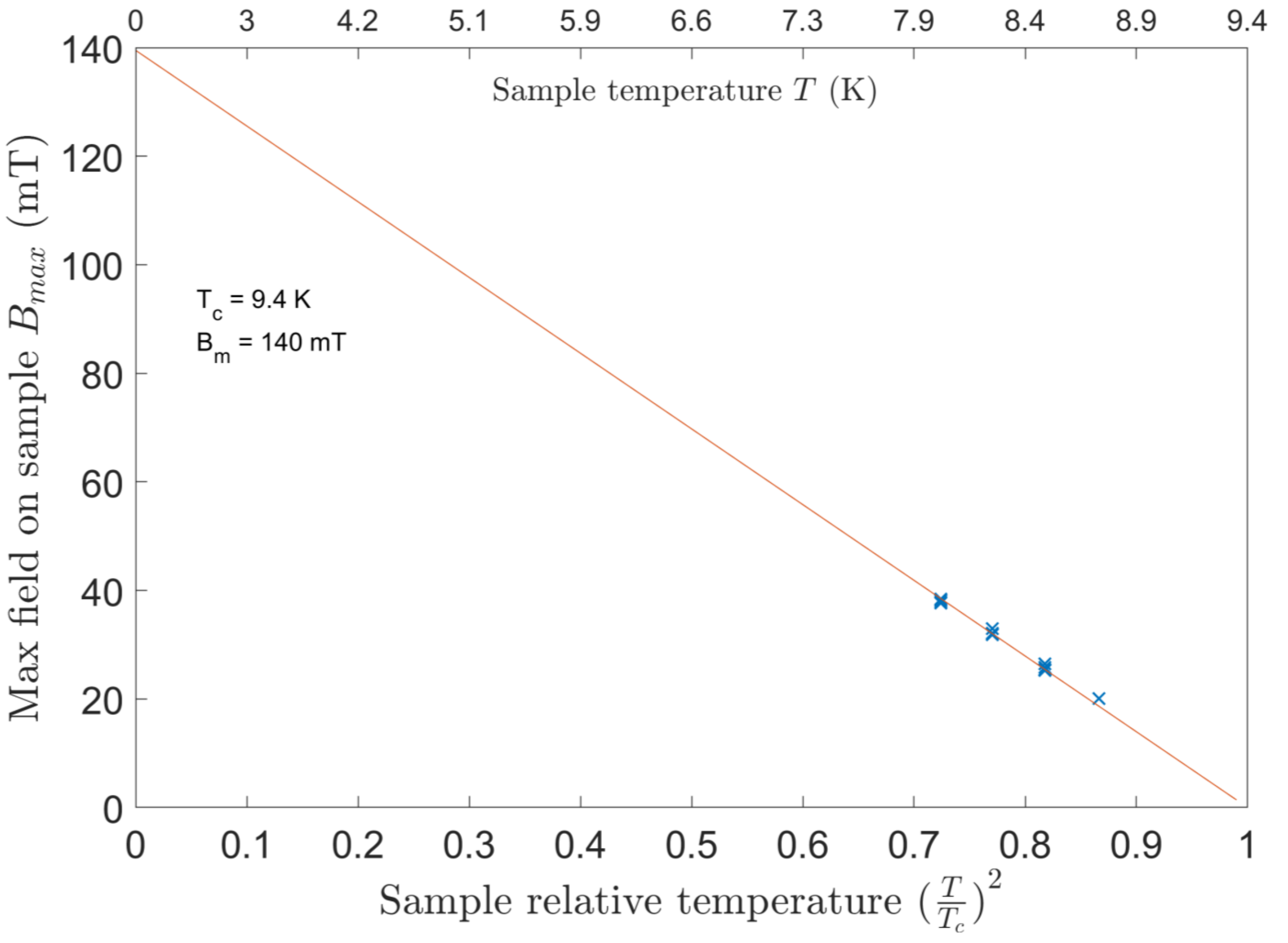
Max Quench field



850 MHz
Tc=9.4

F, (MHz)	B_0, (mT)
416	169
850	140

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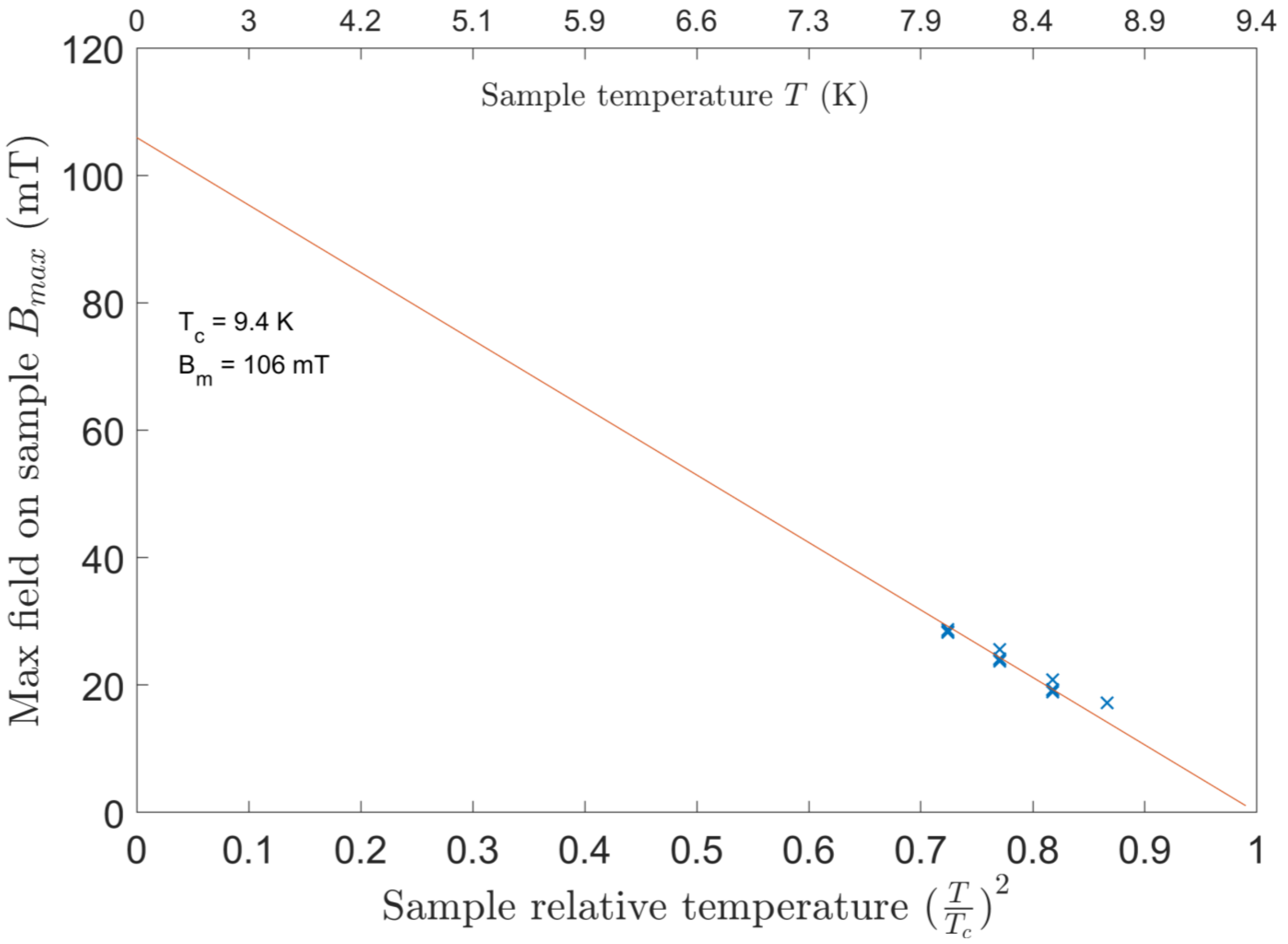
Max Quench field



1291 MHz
Tc=9.4

F, (MHz)	B₀, (mT)
416	169
850	140
1291	106

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iFAST

Thank you!

Discussion:

1. Flux measurements: SIS samples more sensible to the trapped flux?
2. What happens with flux at 8.5 K?
3. Flux educed Rs = f(B,T)
4. Insulator does not give any additional Rs
5. Max field? 30 mT Hc1 for NbN?

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Test	Q_{fp1}	Q_{fp2}	Q_{fp3}
35 (35 nm)	$(5.0\pm0.2) \cdot 10^{10}$	$(1.44\pm0.02) \cdot 10^{10}$	$(2.7\pm0.10) \cdot 10^{10}$
36 (0 nm)	$(4.58\pm0.17) \cdot 10^{10}$	$(1.61\pm0.03) \cdot 10^{10}$	$(5.20\pm0.11) \cdot 10^{9}$

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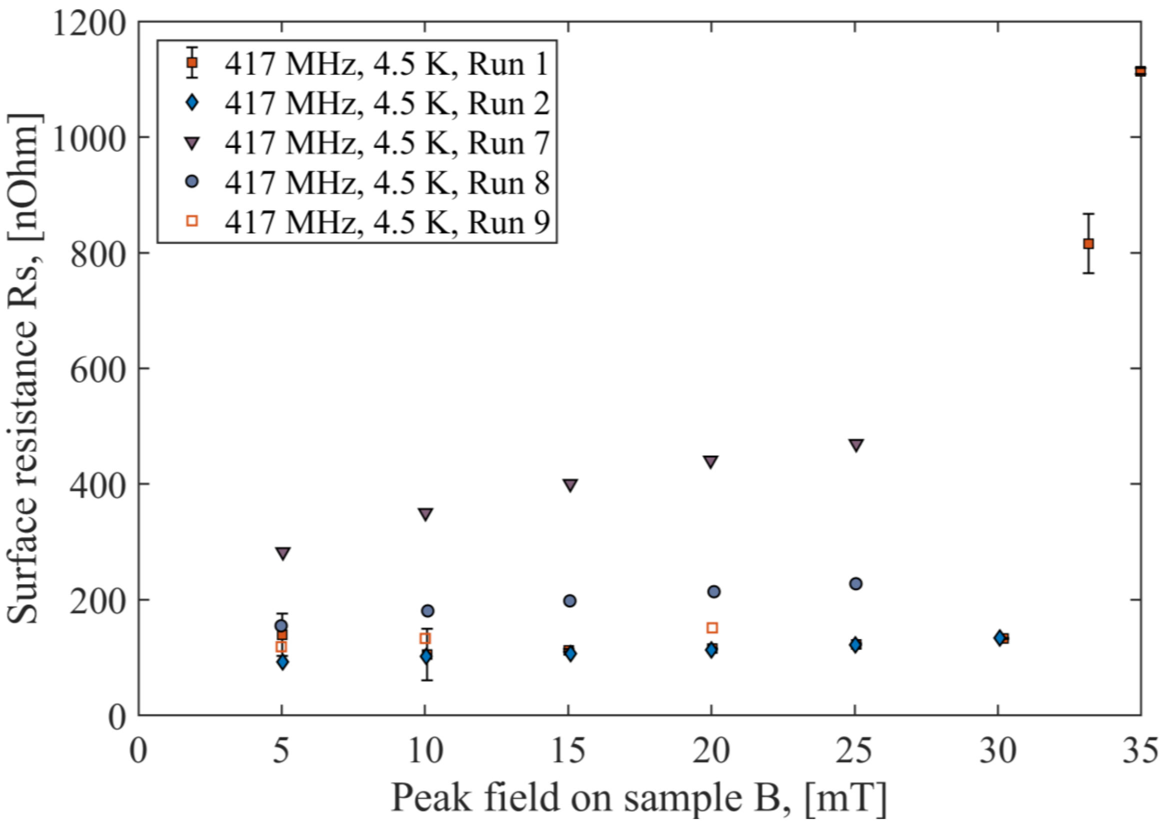

Start date	VTS P, mBar	Event (pre run)	Q1	Q2	Q3
2022/02/28 19:42:19	16	Original measurements after cooldown	Run 1	-	-
2022/03/01 6:03:22	44	Measurements after increased VTS pressure 44 mbar 2.17K and low leak ~1e-6	Run 2	-	-
2022/03/01 22:41:21	44	**Different heat cycles** (heater)	Run 3-5	-	-
2022/03/01 6:15:26	44	-	-	Run 1	-
2022/03/03 13:56:25	44	**Fast heat cycle** (heater) heated to 23K with fast cooldown	-	Run 2	-
2022/03/03 16:25:19	44	**Fast heat cycle** (heater) heated to 10K with fast cooldown	-	Run 3	-
2022/03/03 17:29:59	44	**Fast heat cycle** (heater) heated to 23K with fast cooldown	-	Run 4	Run 1
2022/03/10 12:42:21	44	**Fast heat cycle** (heater) after measurements at Q1 and Q3	Run 6	-	-
2022/03/10 8:48:27	44	**Slow heat cycle** (heater) with 0.5 K/min speed	Run 7	-	-
2022/03/11 18:00:58	44	**Fast heat cycle** (heater) after	Run 8	Run 8	Run 8
2022/03/14 18:01:52	44	**VTS heat cycle** to>150K	Run 9	Run 9	Run 9
2022/03/15 18:29:55	16	Refilled with standard VTS pressure.	Run 11	-	-

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