Progress with QPR at CERN

17th ARIES WP15 meeting

Guillaume Rosaz, Walter Venturini, Lorena Vega, Pablo Vidal

CERN

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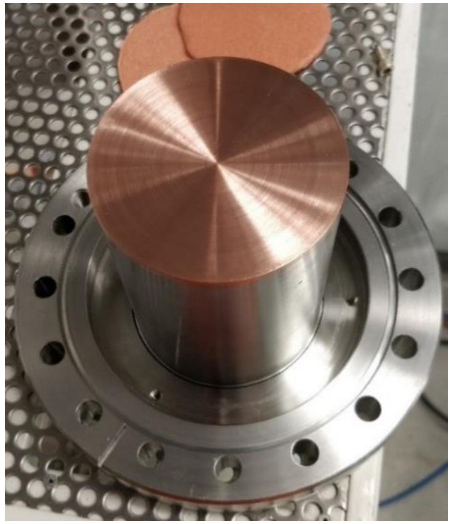
Outline

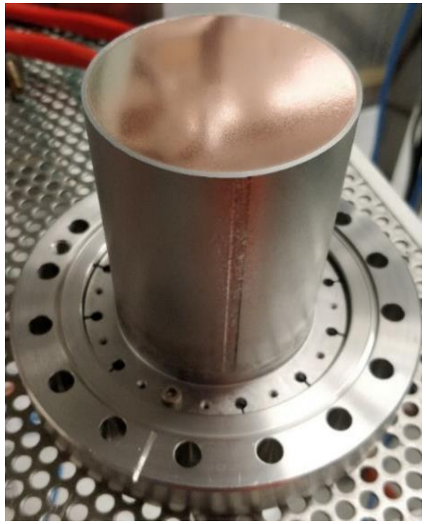
- ❑ HZB2.2 sample measurements
- ❑ Results
- ❑ Discussion
- ❑ Conclusions

HZB2.2 sample measurements

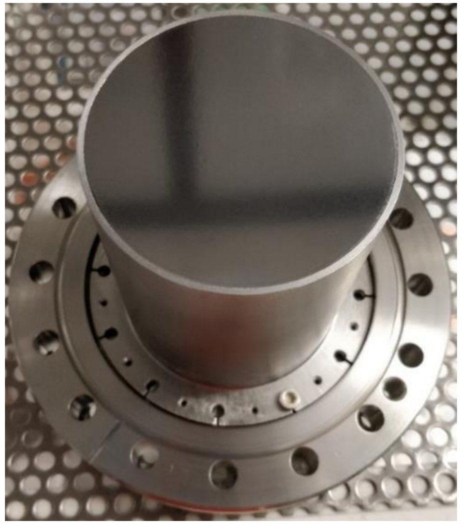
❑ Details of the coating



QPR sample holder



QPR sample mounted



After coating

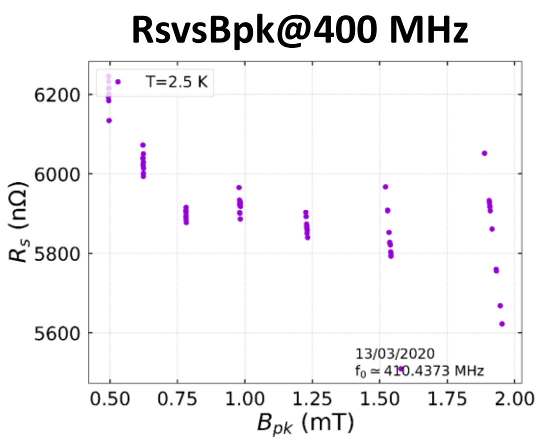
A happy ESR ☺

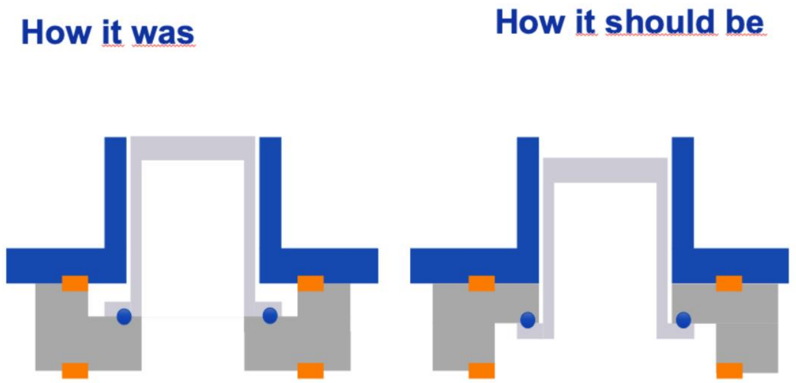
- Sample striped
- SUBU (20min)
- HPWR
- Coating HiPIMS / -50V bias.
- Final thickness ~ 8µm

HZB2.2 sample measurements

❑ Summary of measurements

1) *January 2020:* Measured in old QPR but test aborted due to vacuum leaks through indium seal of dismountable sample.
2) *March 2020:* Measured again after changing indium seal. Results were very bad because the sample was wrongly assembled and it was touching the rods.





3) *February 2021*: Measured in old QPR.

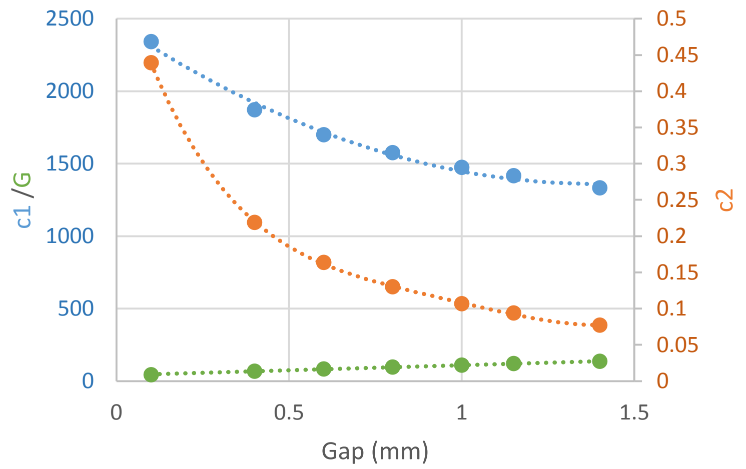
HZB2.2 sample measurements

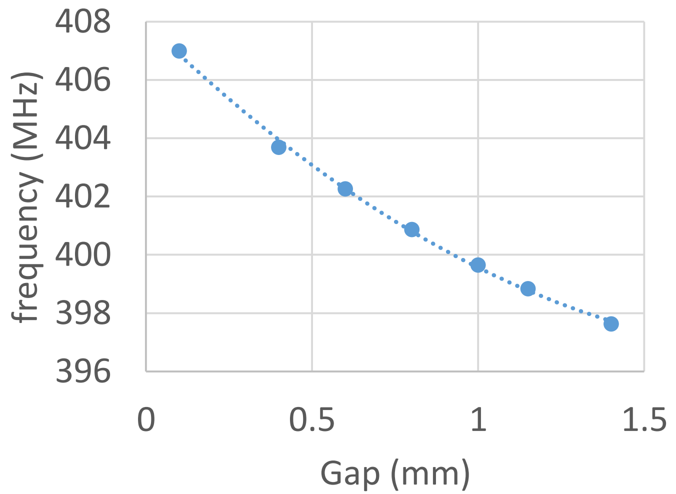
❑ Adjustment of c1 and c2 as a function of the gap

- *The parameters c1 and c2 used for calculating Rs are obtained from simulations:*

$$R_S = \frac{2{\mu_0}^2 c_1 \,(P_{DC1} - P_{DC2})}{c_2 \,\tau\, P_L} \qquad \begin{cases} c_1 = \dfrac{{B_P}^2}{\int_S |B|^2 dS} \\ c_2 = \dfrac{{B_P}^2}{U} \end{cases}$$

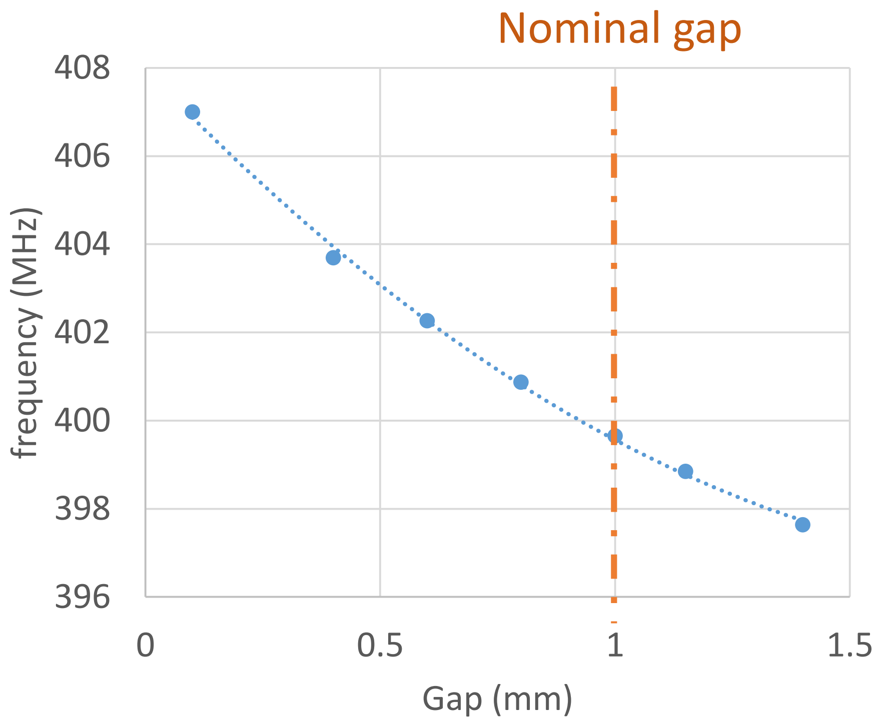
- *They depend on the gap between the sample and the pole shoes. The resonance frequency can be used for estimating the value of the gap, ensuring that the assembly is correct.*





HZB2.2 sample measurements

❑ Adjustment of c1 and c2 as a function of the gap



- The frequency measured was lower than the one expected for a nominal gap of 1 mm: The gap must be larger in this sample and a correction of c1 and c2 is needed.

	400 MHz	800 MHz	1200 MHz
HZB2.2	396.27	793.63	1197.70

HZB2.2 sample measurements

❑ Estimation of the gap from the measured frequency

- Using the previous bulk niobium as reference (gap is 1 mm) and *Slater's theorem*, the simulations can be "calibrated" as:

$$\frac{f_{I5,sim} - f_{I5,meas}}{f_{I5,meas}} \cong \frac{\boldsymbol{f_{HZB2.2,sim}} - f_{HZB2.2,meas}}{f_{HZB2.2,meas}}$$

	400 MHz		800 MHz		1200 MHz	
	f_{meas}	f_{sim}	f_{meas}	f_{sim}	f_{meas}	f_{sim}
I5	397.07	399.42	795.06	802.81	1199.69	1210.70
HZB2.2	396.27	**398.62**	793.63	**801.37**	1197.70	**1208.69**

- From this, the gap of HZB2.2 can be estimated: The inverse of f_{sim} vs. l_{gap} gives l_{gap}~**1.154±0.008 mm.**

HZB2.2 sample measurements

❑ Adjustment of c1 and c2 as a function of the gap

- The values of the surface resistance have been calculated with the estimated gap.
- The sample will be measured when taking it out from the QPR and those parameters will be further corrected if needed.

	400 MHz	800 MHz	1200 MHz
c_1 $[1/m^2]$	1430.2	1495.3	1604.2
c_2 $[T^2/\mathrm{J}]$	0.0928	0.0945	0.1051
G $[\Omega]$	122.0	252.1	366.9

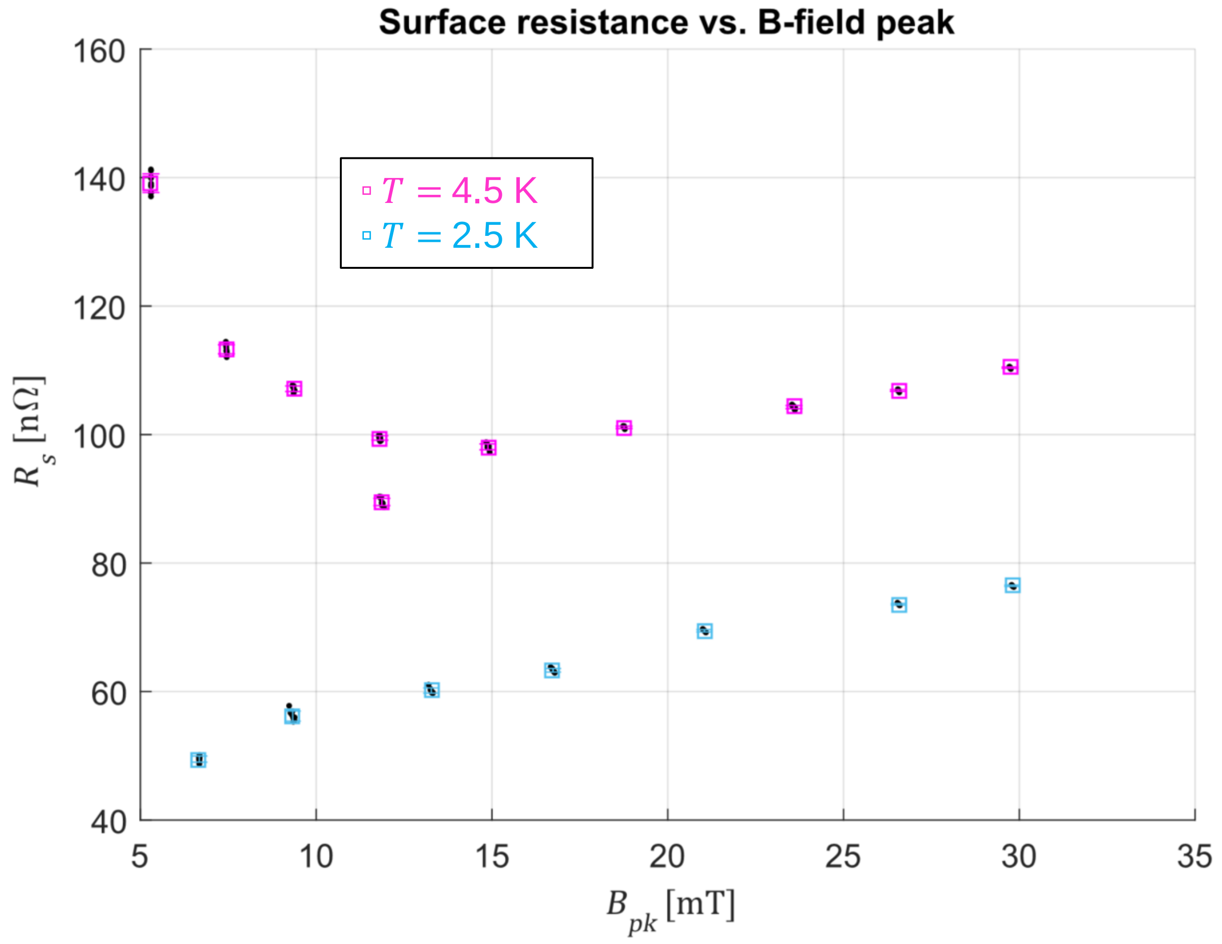
HZB2.2 sample measurements

❑ Vacuum leak through indium seal

- There was a vacuum leak through the indium seal: very small, not detected during leak check at warm.
- However, during transition to superfluid helium, we observed an increase in the pressure of both the thermometry chamber and the QPR cavity.
- Measurements could not be performed in helium bath at 1.85 K (P_{bath}~20 mbar) as usual, but at 1.9K (P_{bath}~27 mbar).
- Pressure levels in QPR cavity the order of 5E-6 mbar.

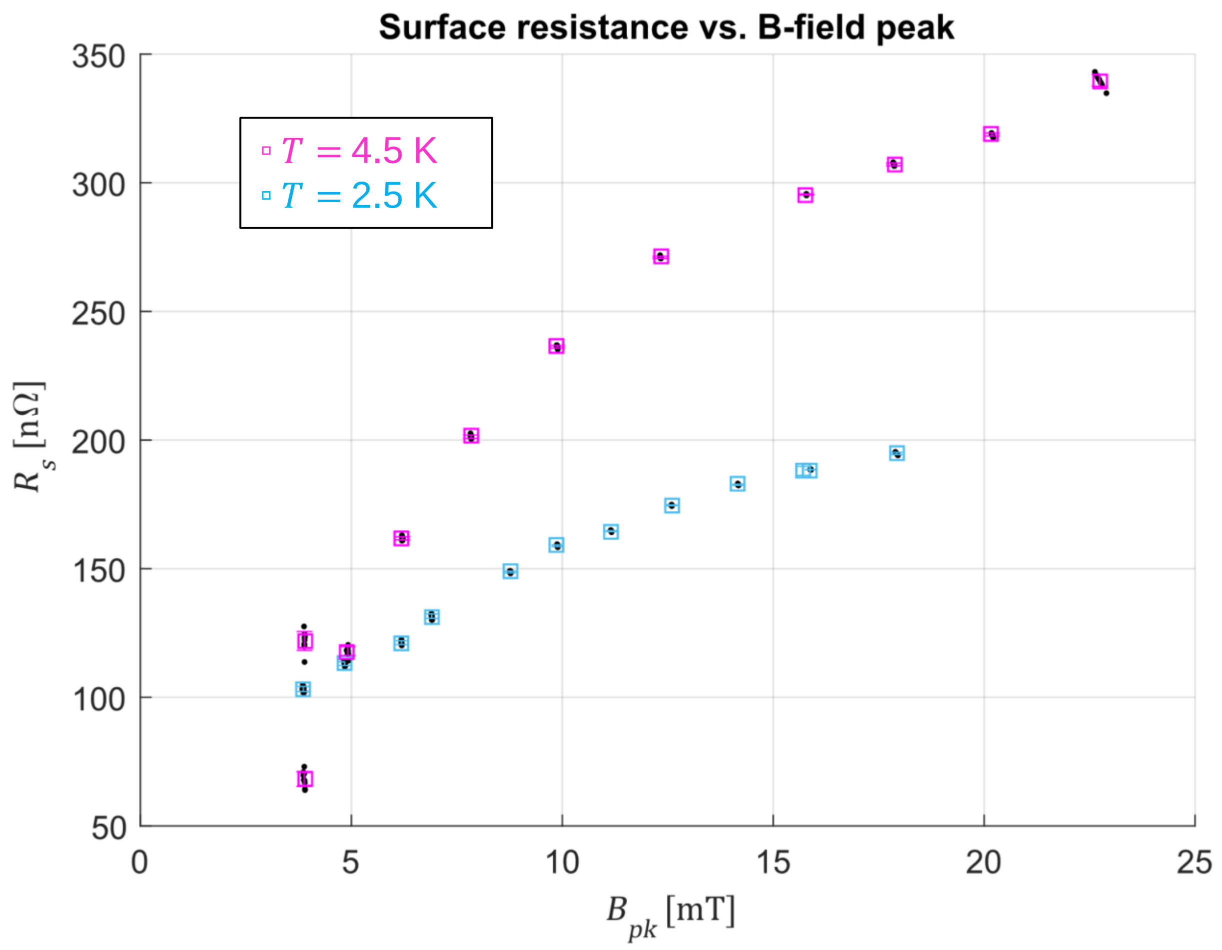
Results

- R_s vs B_{pk} at $f_0 = 400$ MHz



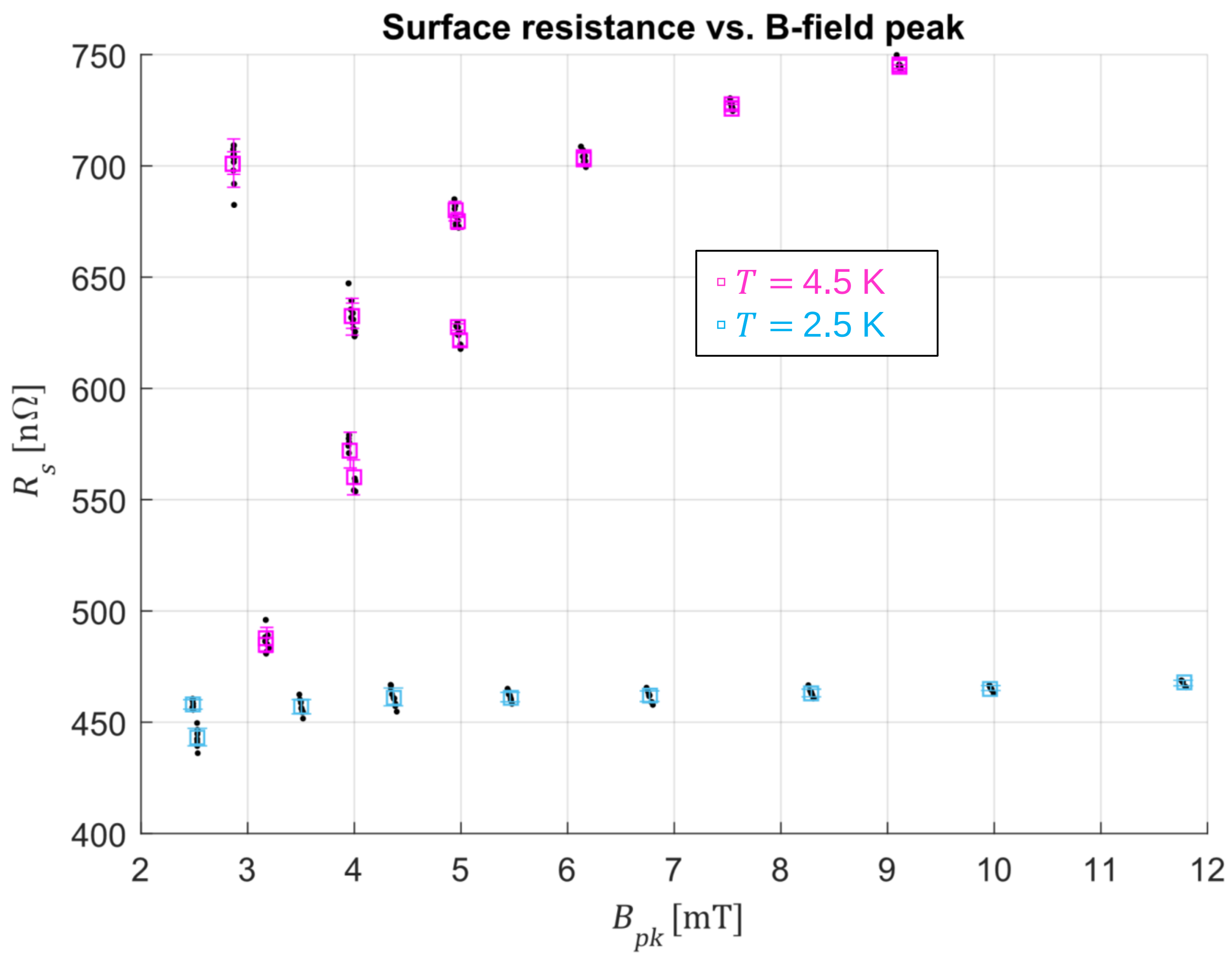
Results

- R_s vs B_{pk} at $f_0 = 800$ MHz



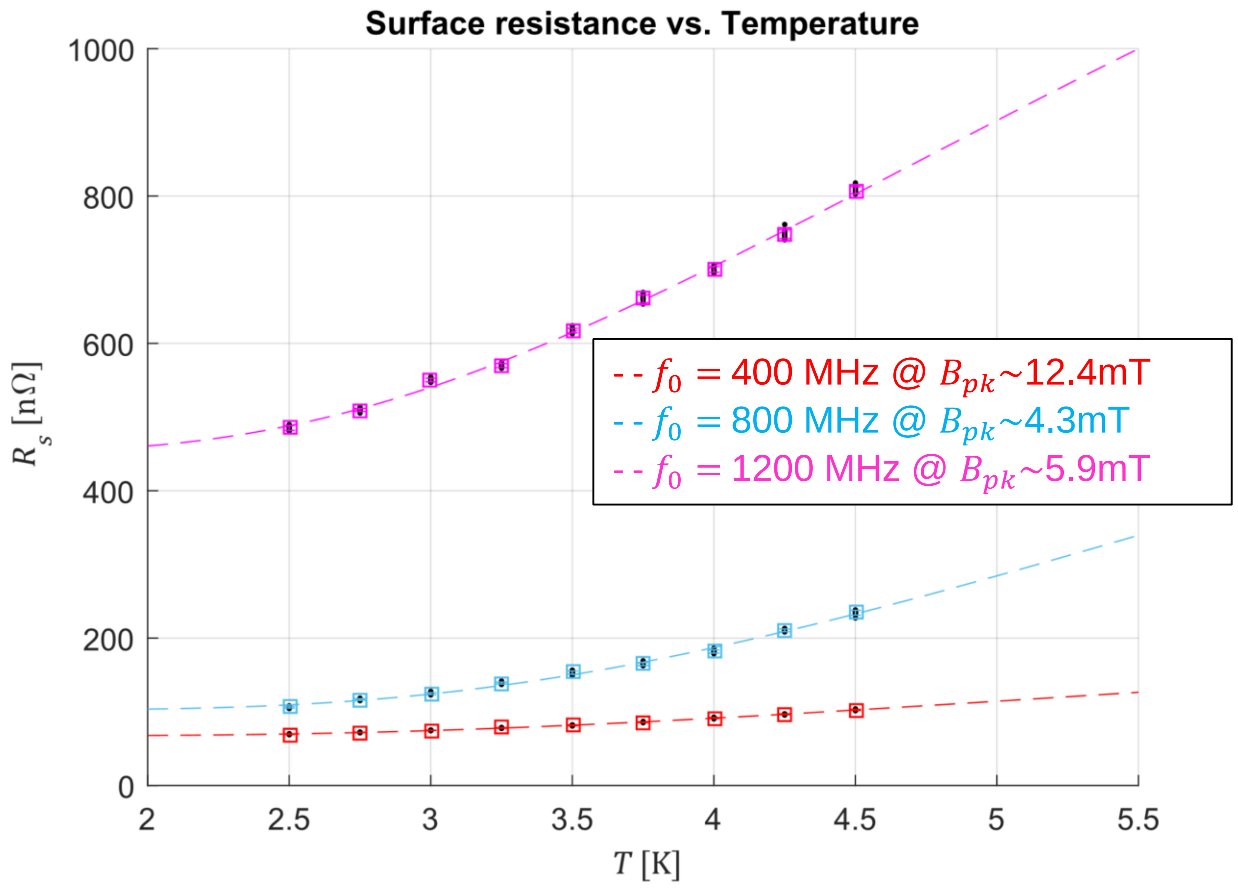
Results

- R_s vs B_{pk} at $f_0 = 1200$ MHz



Results

- R_s vs T



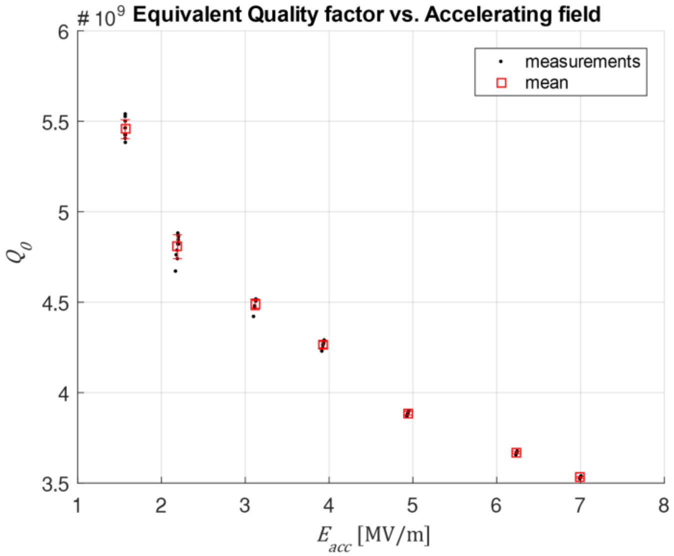
	400 MHz	800 MHz	1200 MHz
A_{BCS} [nΩ·K]	8.387E3	4.755E4	5.533E4
$\Delta(0)/k_B$ [K]	17.86	19.77	16.01
R_{res}[nΩ]	67.26	102.45	451.53

Results

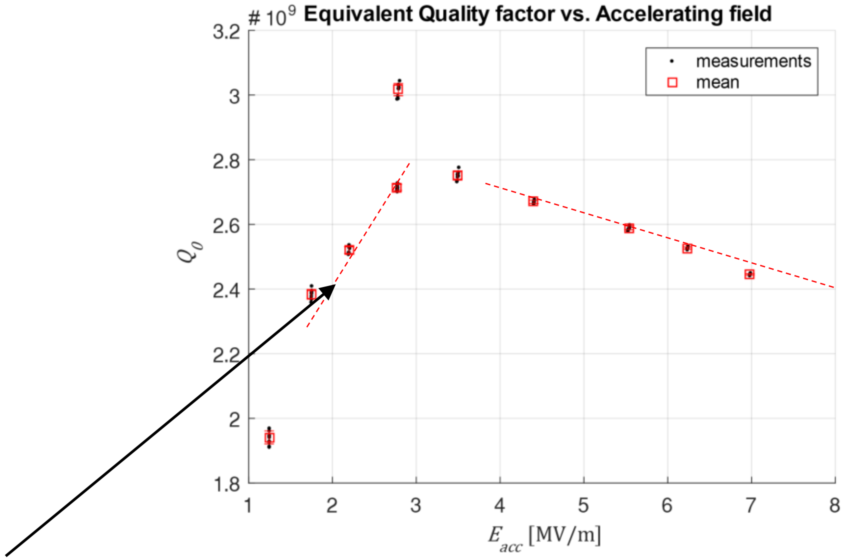
❑ Comment on R_s vs T scans

- The scans of Rs vs T at 400 MHz and 1,2 GHz had to be repeated as the first scans were done at too low field were the surface resistance presents significant slope.
- Example: (equivalent) Q_0 vs E_{acc} at $f_0 = 400$ MHz

@$T = 2.5$K



@$T = 4.5$K

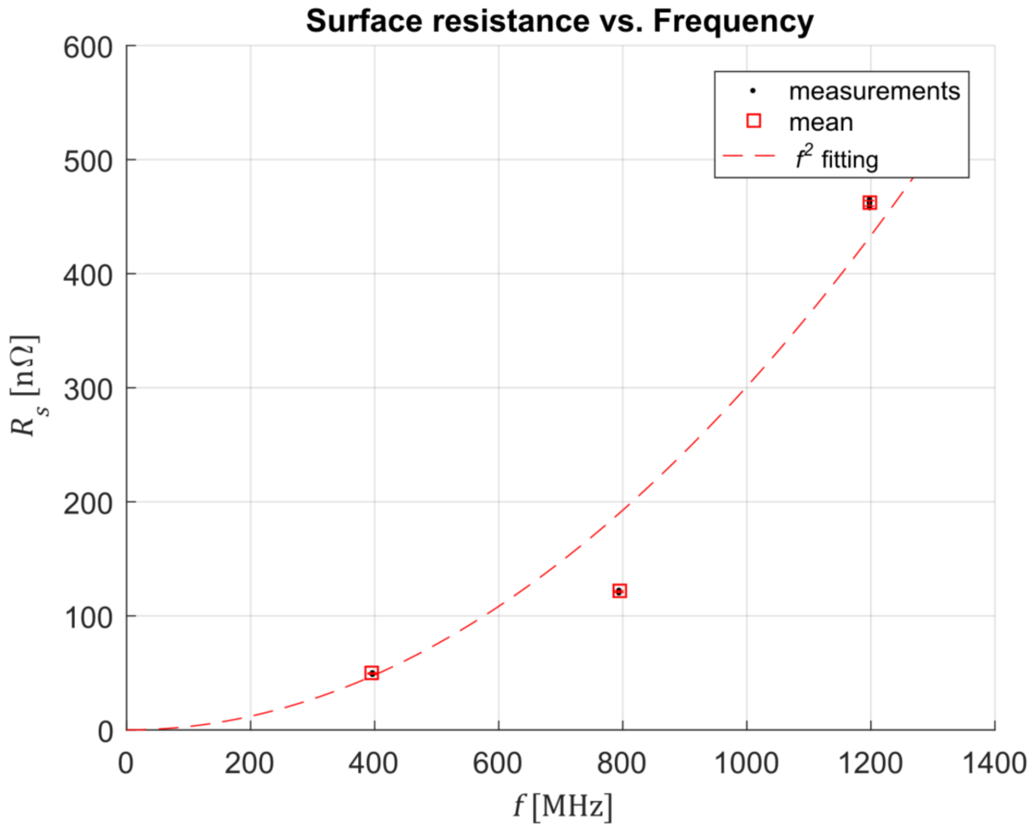


- Significant **anti-Q slope** at high T and low field leads to inaccuracies (i.e. non physical reliability) on the R_s vs T fitting.

Results

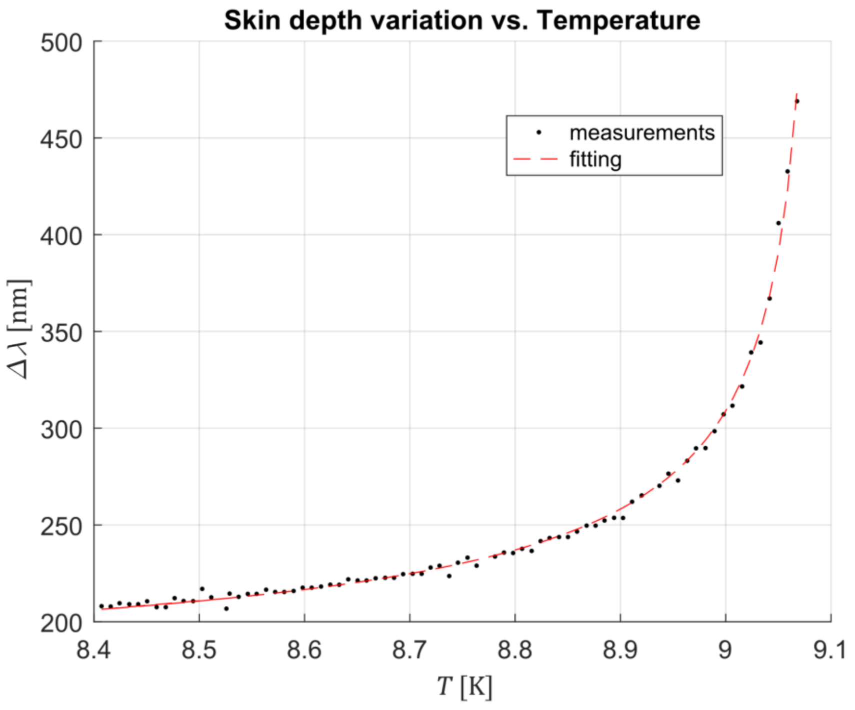
- R_s vs f at $T = 2.5$K

  $@B_{pk} \sim 5$ mT



Results

- $\Delta\lambda$ vs T around $f_0 = 400$ MHz



- $\lambda_L(0) \sim 32.713$ nm
- $T_c \sim 9.09$ K

Conclusions and discussion

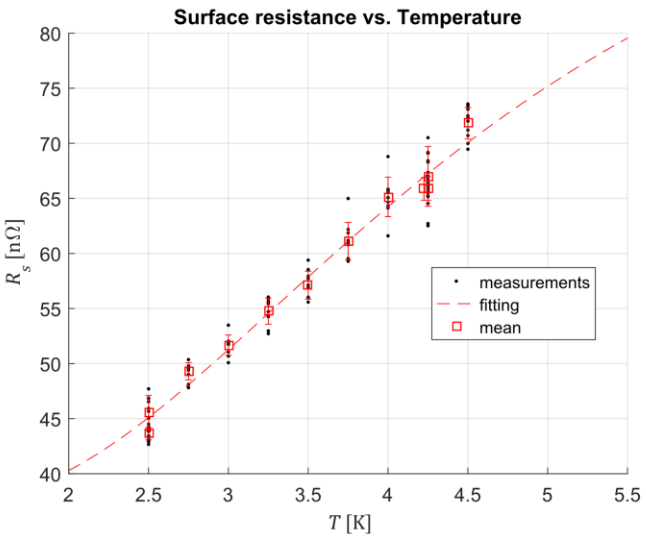
- This sample shows reasonably good results at all frequencies.
- It is a good candidate to be used for benchmarking different QPRs.
- The sample will be sent to HZB next.
- Possibility of sending it back afterwards to measure it in the new QPR?

Thanks for your attention. Any questions?

Results

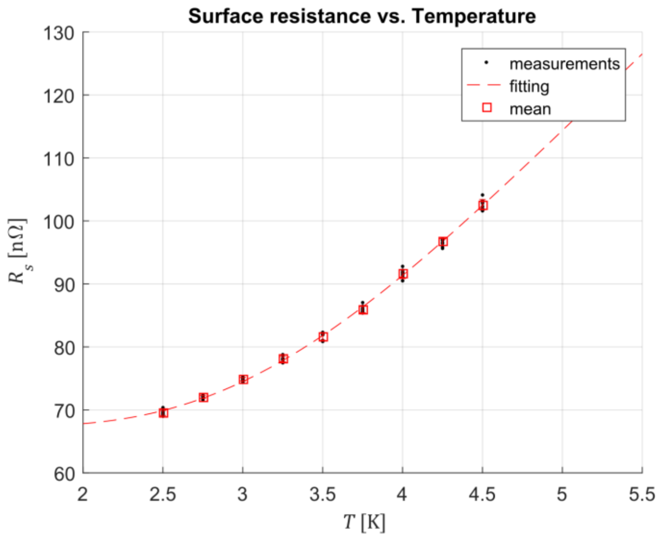
- ❑ R_s vs T at $f_0 = 400$ MHz

First scan $@B_{pk} \sim 4.7$ mT



- $A_{BCS} \sim 1.797\text{E}3$ nΩ·K.
- $\Delta(0)/k_B \sim 11.21$K
- $R_{res} \sim 36.98$ nΩ

Second scan $@B_{pk} \sim 12.4$ mT

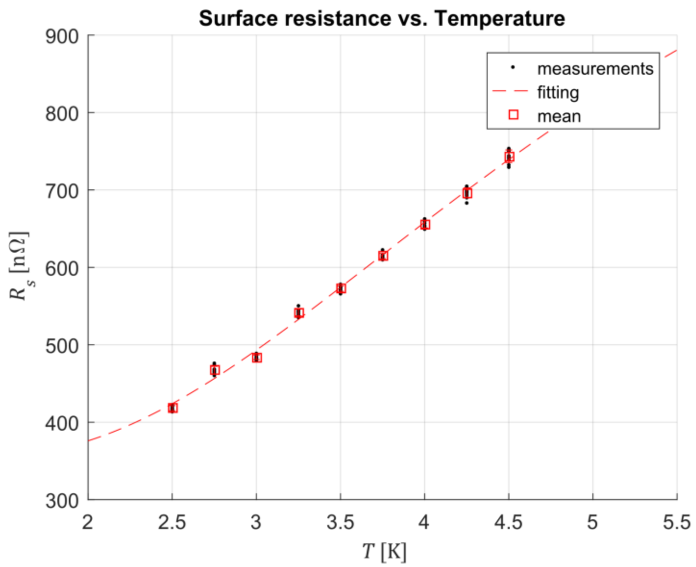


- $A_{BCS} \sim 8.387\text{E}3$ nΩ·K.
- $\Delta(0)/k_B \sim 17.86$ K
- $R_{res} \sim 67.26$ nΩ

Results

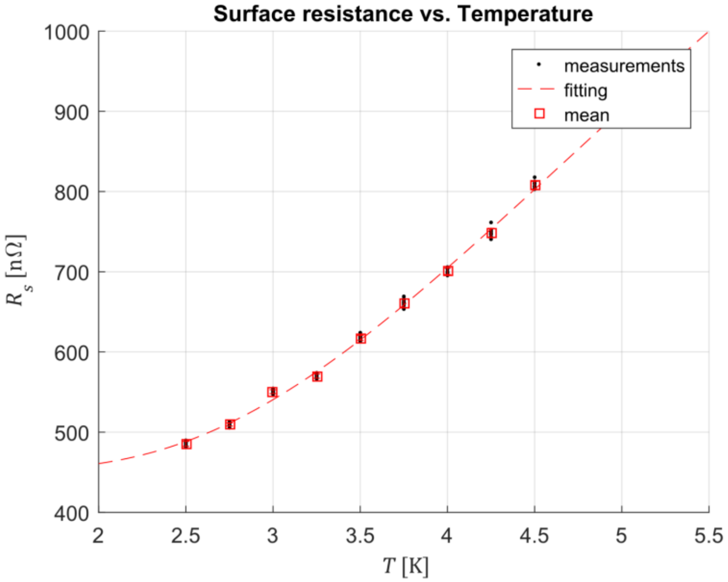
- ❑ R_s vs T at $f_0 = 1200$ MHz

First scan $@B_{pk} \sim 2.85$ mT



- $A_{BCS} \sim 2.909$E4 nΩ·K.
- $\Delta(0)/k_B \sim 12.64$K
- $R_{res} \sim 349.82$ nΩ

Second scan $@B_{pk} \sim 5.90$ mT



- $A_{BCS} \sim 5.533$E4 nΩ·K.
- $\Delta(0)/k_B \sim 16.01$K
- $R_{res} \sim 451.53$ nΩ