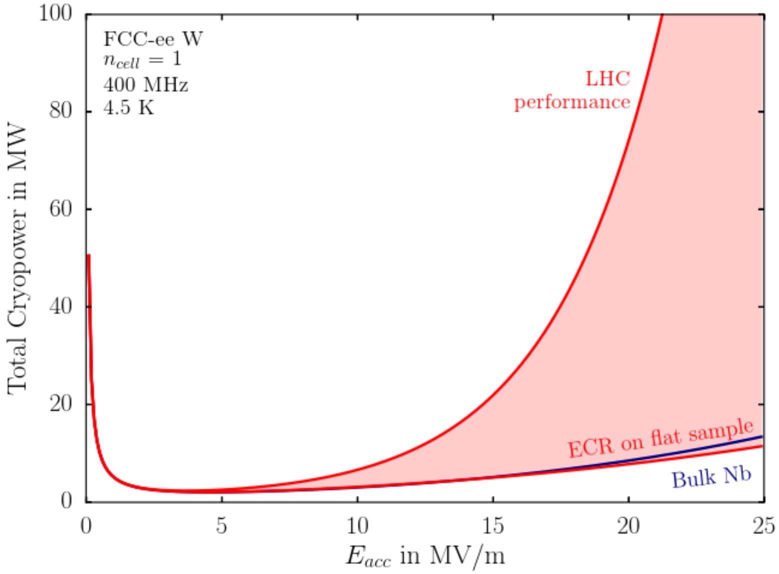
CERN

RF characterization of superconducting films on copper via quadrupole resonator

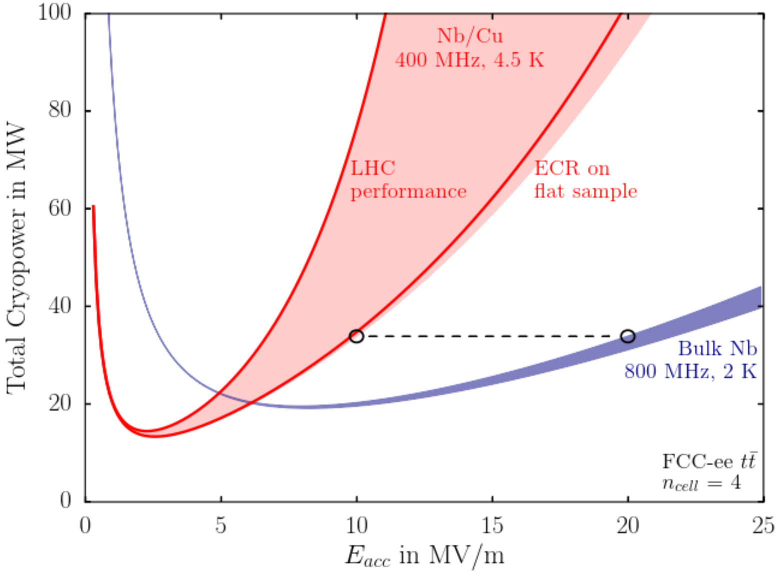
M. Arzeo, S. Aull, K. Ilyna, G. J. Rosaz, A-M Valente-Feliciano and W. Venturini Delsolaro

On behalf of FCC RF & WP 3

Niobium on Copper technology for the accelerating cavities compares to the bulk one



Courtesy of S. Aull, *FCC week 2017*



S. Aull, and co. *FCC-DRAFT-TECH-2017-002* (2017)

Nb/Cu technology has several advantages

Cheaper

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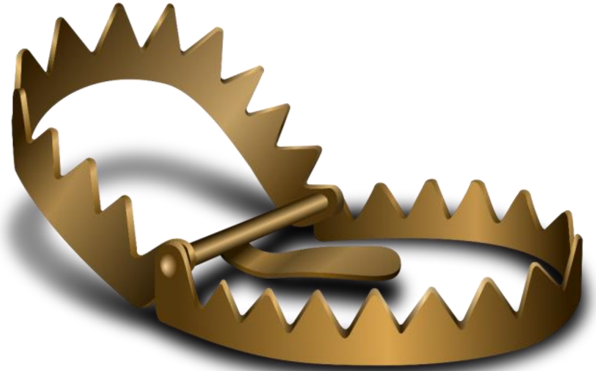
More stable

Nb/Cu technology has several advantages



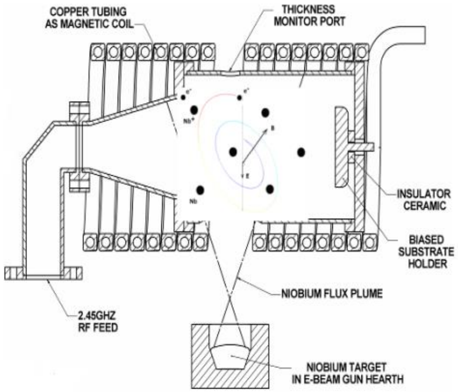
Cheaper

More stable

Less sensitive to flux trapping?

Different coating techniques are explored

Electron Cyclotron Resonance



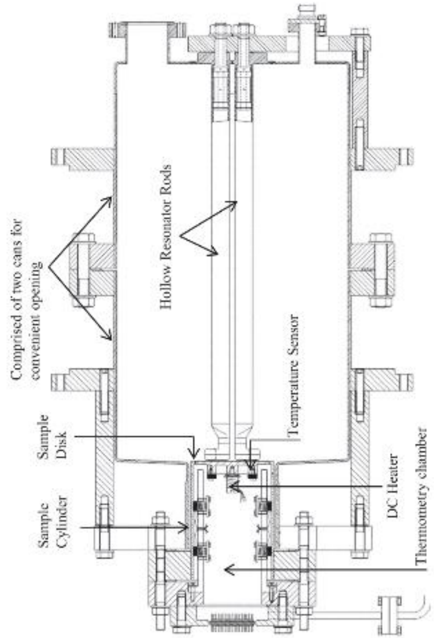
Jefferson Lab

Courtesy of A-M Valente-Feliciano (talk earlier today)

High Power Impulse Magnetron Sputtering

Courtesy of G. J. Rosaz (talk earlier today)

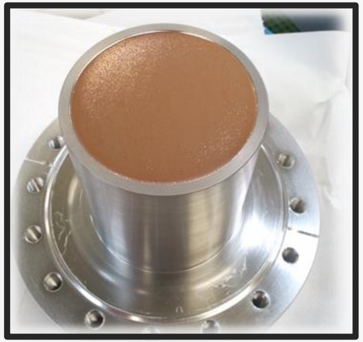
RF performances characterized via a quadrupole resonator



T. Junginger and co., *Rev. Sci. Intr.* **83**, 063902 (2012)

Calorimetric technique

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



QPR pros&cons

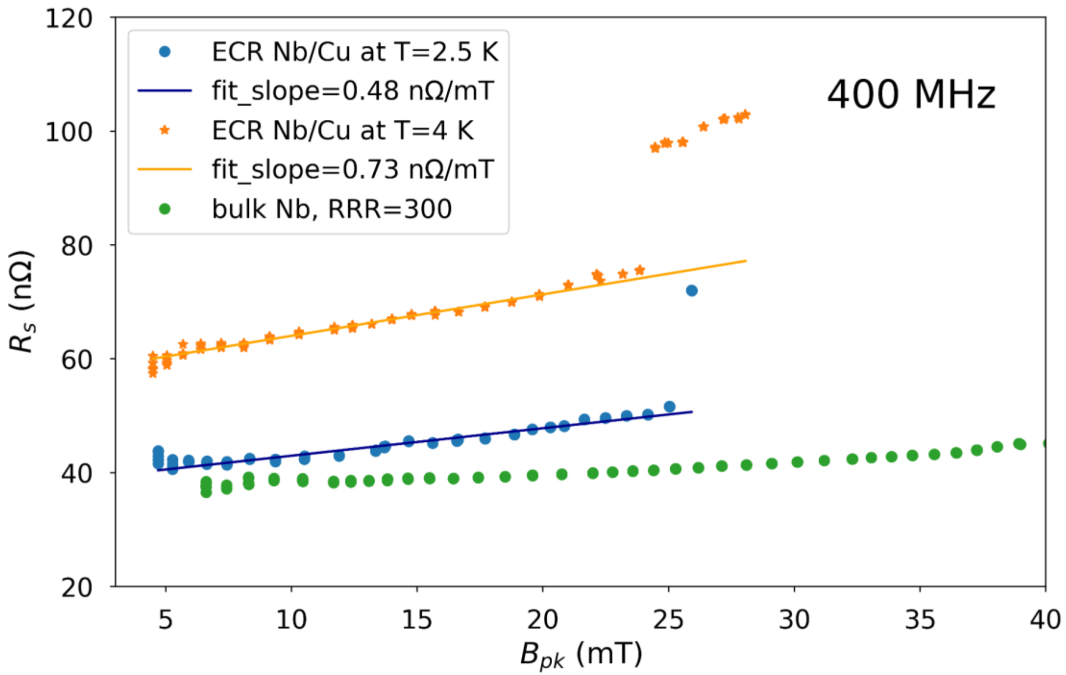
- Multi-frequency operation: ideal for basic studies
- Small samples are easily coated and can be analyzed after the RF characterization
- Samples are more cost effective than cavities

- Limited max RF field depending on the frequency mode
- Limitations on the minimum Rs measurable
- Mechanical vibration of the rods due to helium boiling

ECR Nb/Cu

recent results and trapped flux analysis

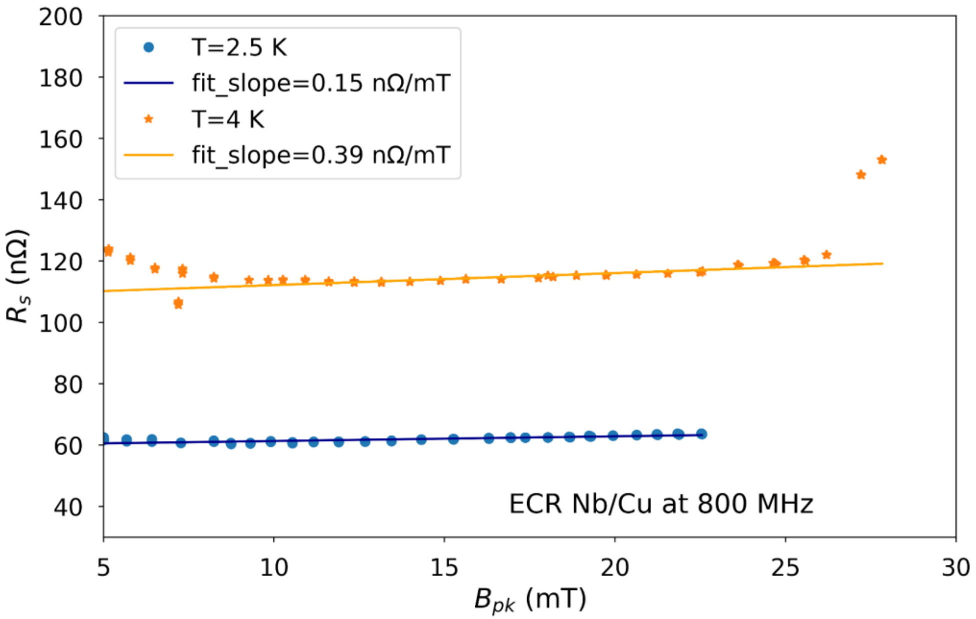
Linear field dependence indicates trapped flux



Universal behavior for SRF cavities:

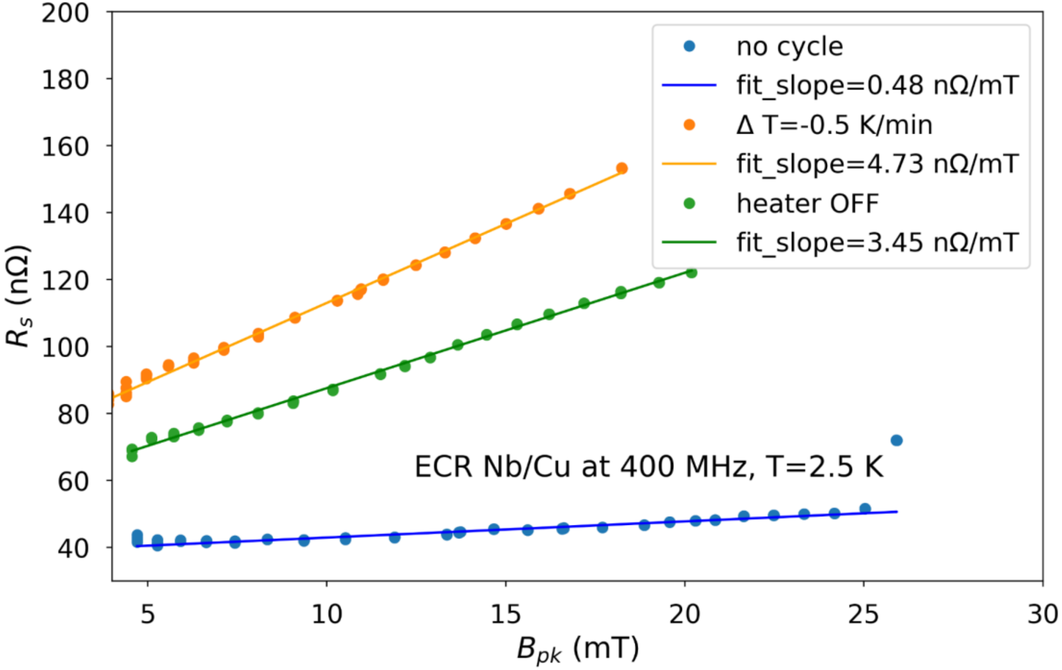
- ✓ Nb/Cu - A. Miyazaki and co., *"Analysis of HIE-ISOLDE cavity results"*
- ✓Bulk Nb – G. Ciovati and A. Gurevich, *SRF 2007*
- ✓Nb_3Sn/Nb – D. Hall, *SRF 2017*

Higher frequency results in a shallower slope



Frequency dependence might be a hint for the understanding of the physical mechanism behind it:
collective pinning (D. B. Liarte at Cornell) or something else?

Thermal cycling affects trapped flux: the faster, the shallower



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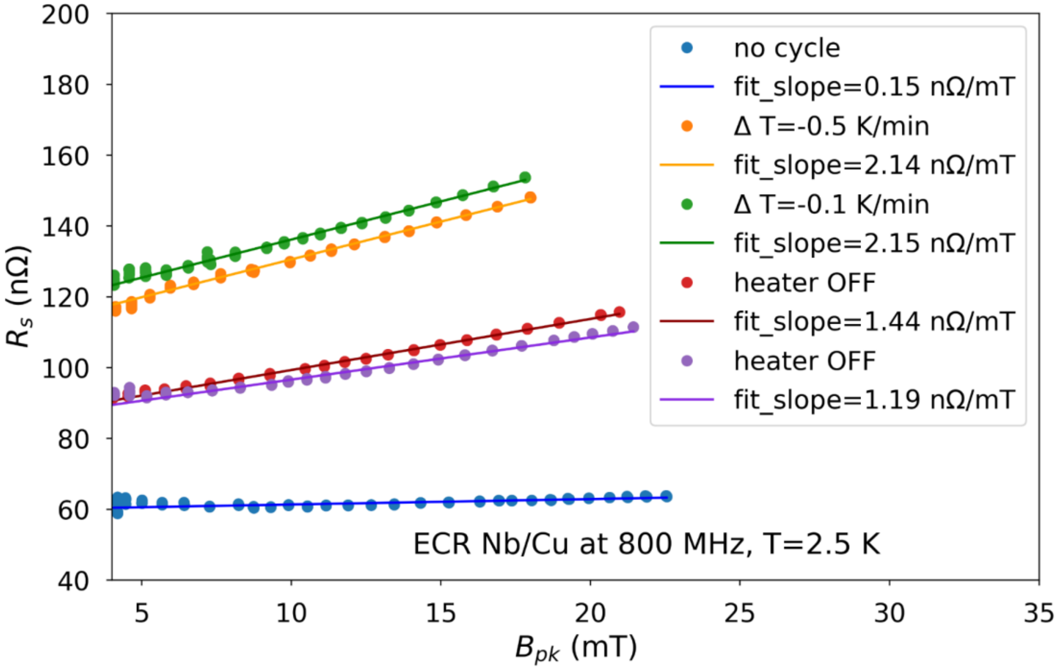
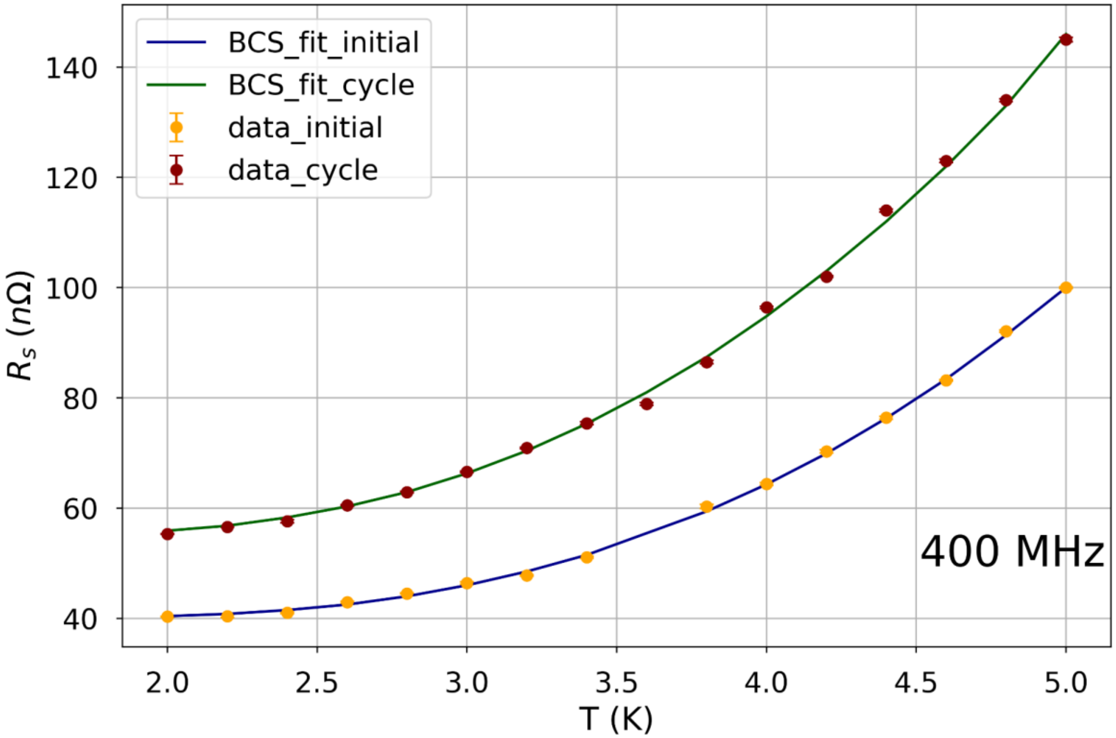


Trapped flux as reduced gap?



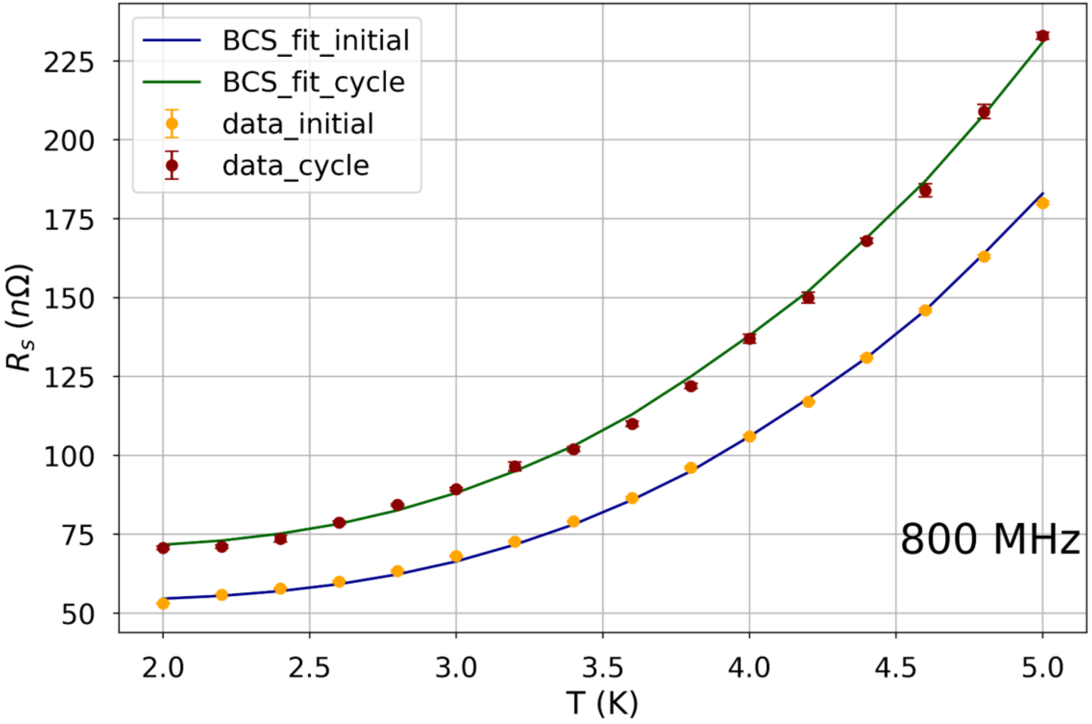
$$R_s(T) = R_{res} + R_{BCS}(T)$$

$$R_{BCS}(T;\ \Delta, \lambda_L, \xi_0, l)$$

Δ/k_BT_c= 2.02

Δ/k_BT_c= 1.81

Trapped flux as reduced gap?



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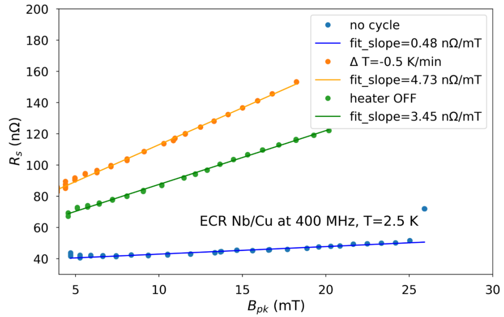
Δ/k_BT_c= 2.03

Δ/k_BT_c= 1.92

Conclusions and Outlook



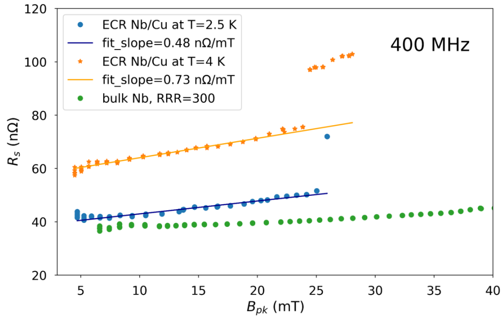
low Rs

flux trapping studies

ECR Nb/Cu

mitigated slope

ready for cavities

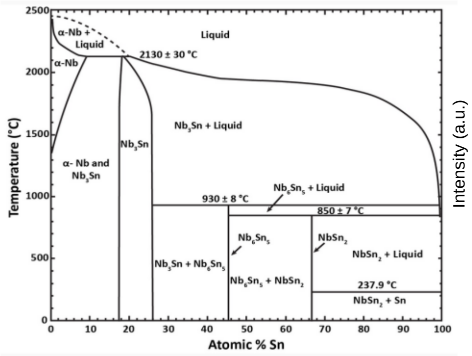


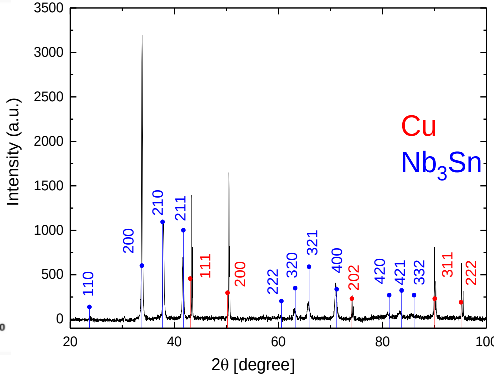
A-M Valente-Feliciano (talk earlier today)

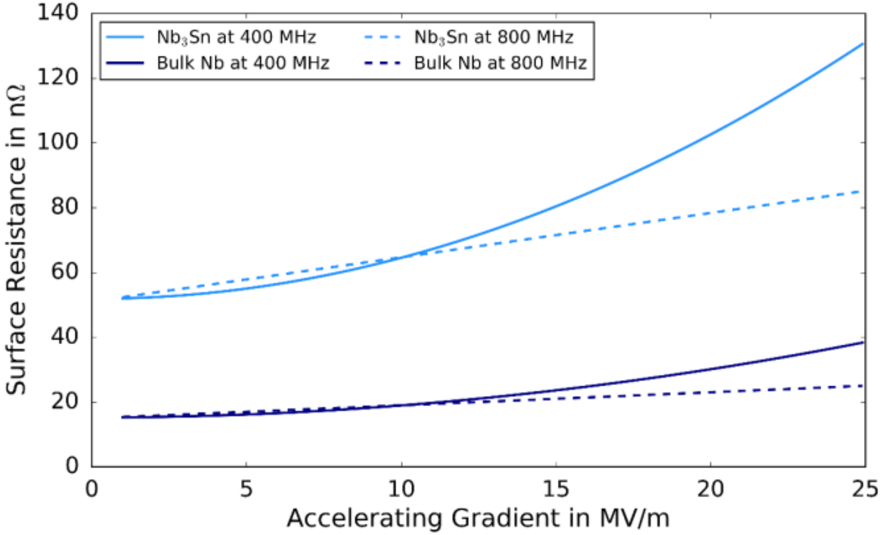
Nb_3Sn/Cu, beyond Nb/Cu

The first RF characterization of a Nb_3Sn/Cu film

Nb_3Sn: the most promising technology beyond Nb







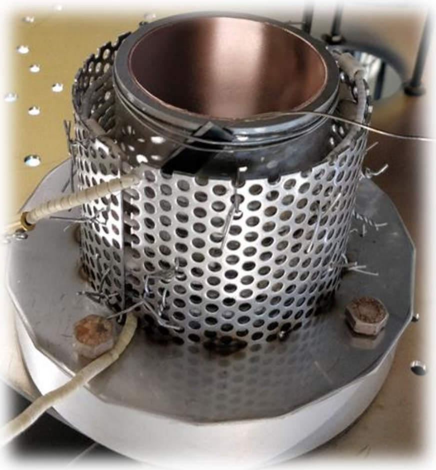
Superconducting A15 phase obtained

Courtesy of K. Ilyina (talk earlier today)

Courtesy of S. Aull, *FCC week 2017*

Very challenging: it required a strong R&D effort

The first RF characterization of Nb_3Sn/Cu



Before coating

After coating

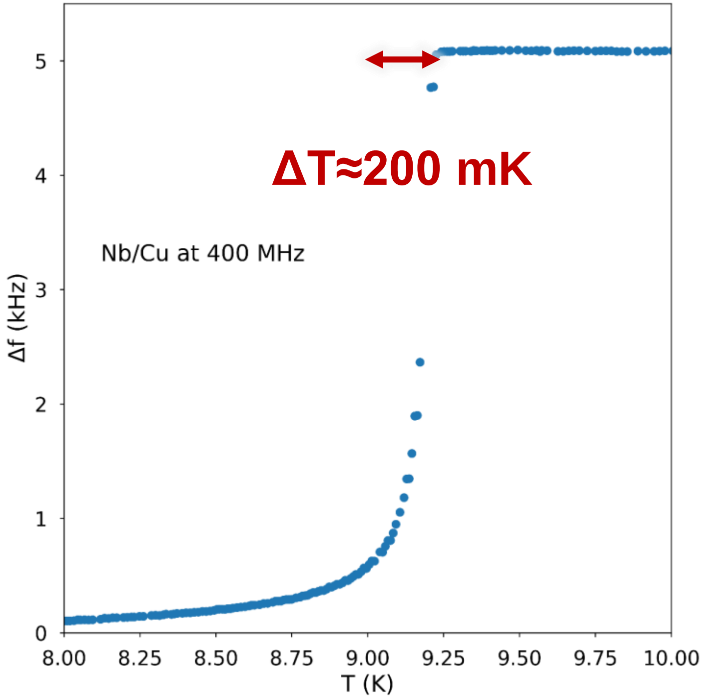
Coating parameters:

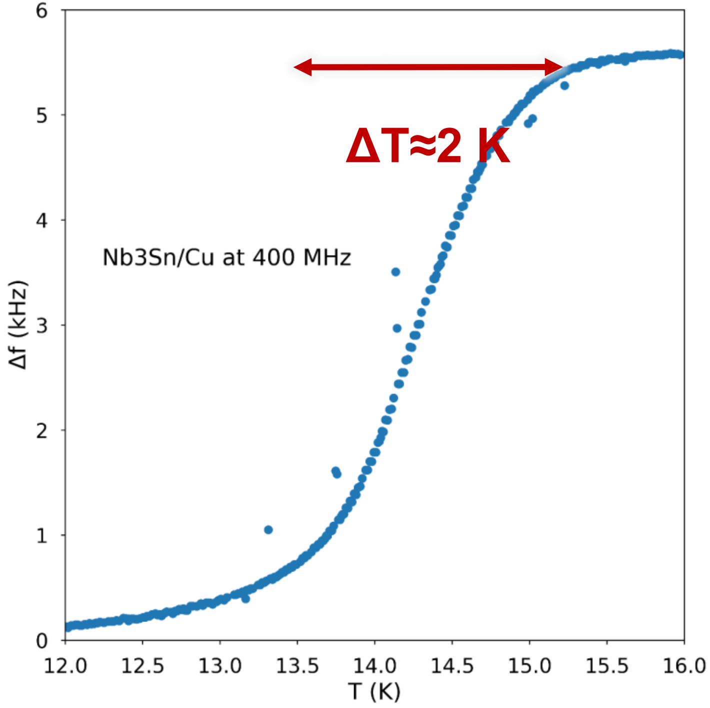
Cu/Nb (~400 - 500 nm)/*Nb_3Sn* (~1.5 – 1.7 µm)

$P_{coating}$ = 7x10^{-3} mbar (Kr)
$T_{coating}$ = 680°C (real lower)
$T_{annealing}$ = 72 hours @ 670°C (real lower)

Desired coating conditions could not be reached

Broad transition due to non homogeneity or off-stoichiometry?





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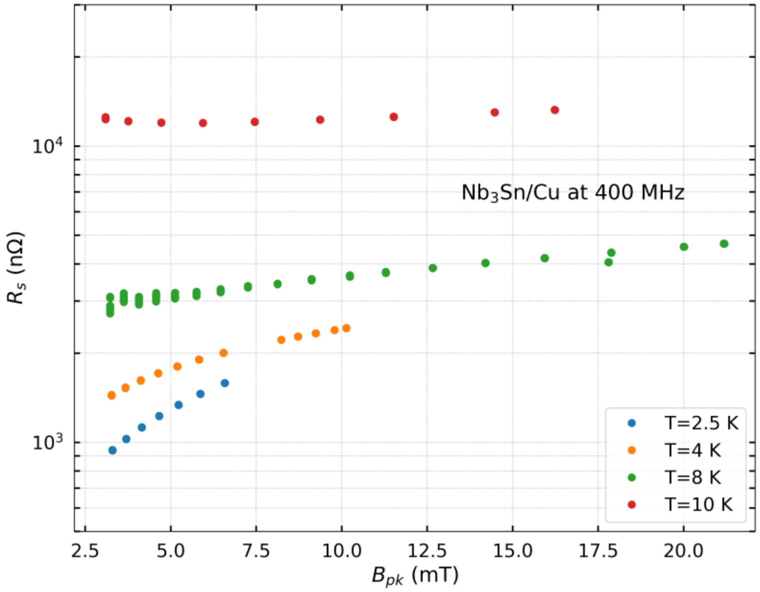
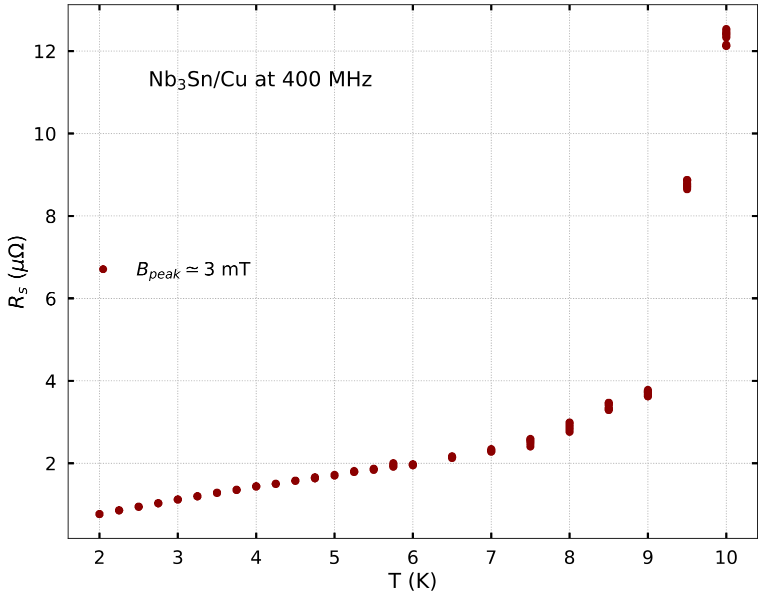
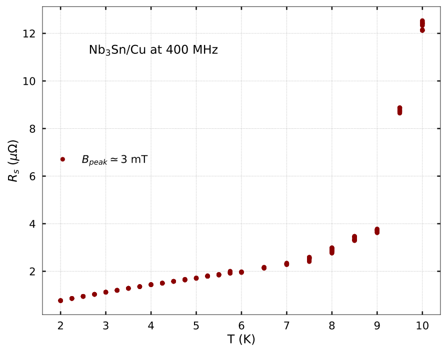




it still requires a strong R&D effort

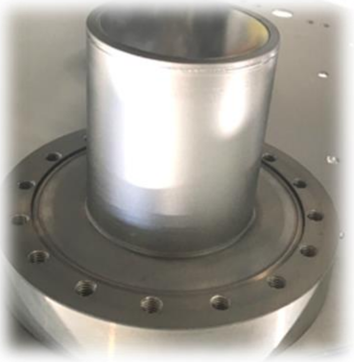
Conclusions and Outlook



First QPR Nb_3Sn/Cu sample

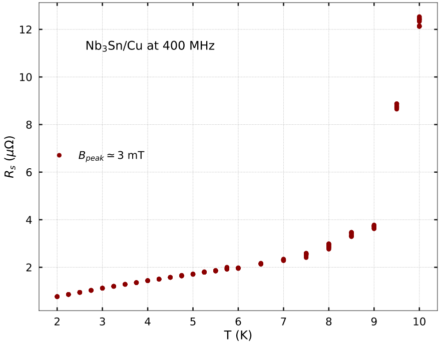
RF performances still far from goal

Proper heating system for optimal coating conditions



There is still work to do…

Conclusions and Outlook



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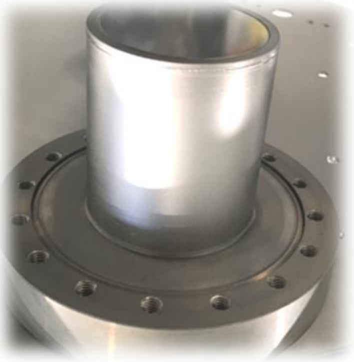
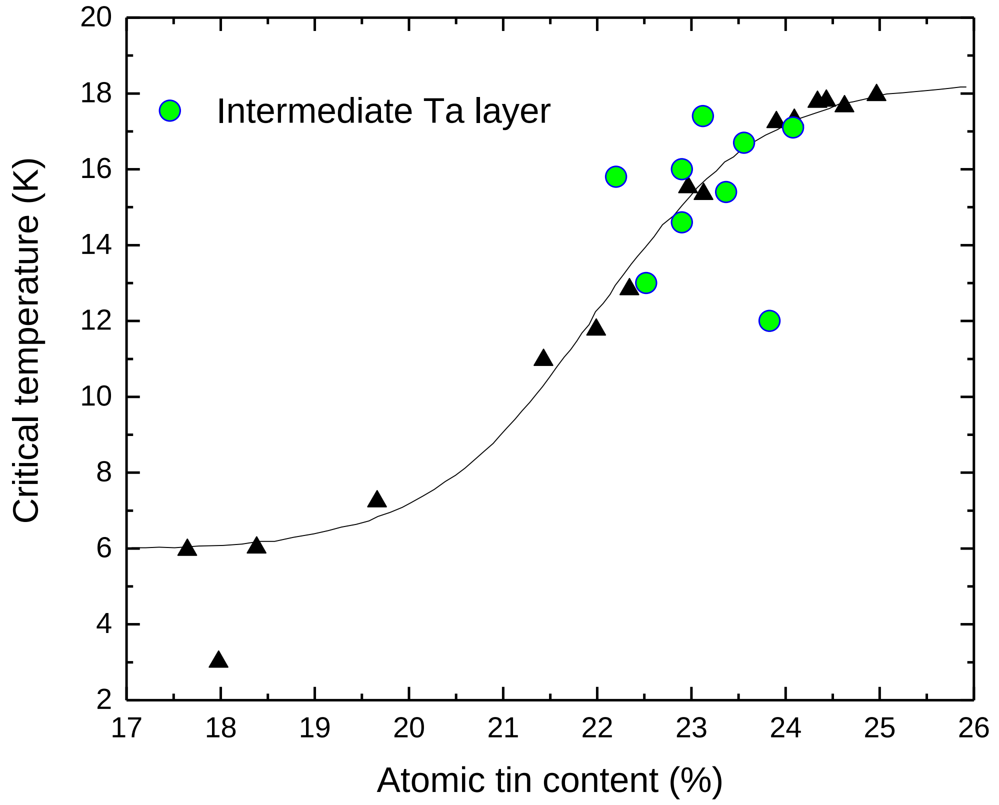


…there are reasons to be optimistic

f (MHz)	Δ/k_BT_c	R_{res} (nOhm)	*l* (nm)	ξ_0 (nm)	λ_L (nm)
1st: 400	2.02	40	83.5	59.4	24.6
2nd: 400	1.81	55	83.5	59.4	24.6
1st: 800	2.03	54	84	60	16
2nd: 800	1.92	70.5	84	60	16

NOTEs:

1st refers to the initial cool down (entire QPR)
2nd refers to the thermal cycle of the sample
Tc is fixed at 9.25 K (estimated from f0 vs T)
In red the parameters that are fixed during the fitting procedure, those in green are varied.


Intermediate Ta layer
Critical temperature (K)
Atomic tin content (%)
20
18
16
14
12
10
8
6
4
2
17
18
19
20
21
22
23
24
25
26