Mid-T furnace baking study on 1-Cell MG Nb Cavities

Ashish Kumar, Ph. D

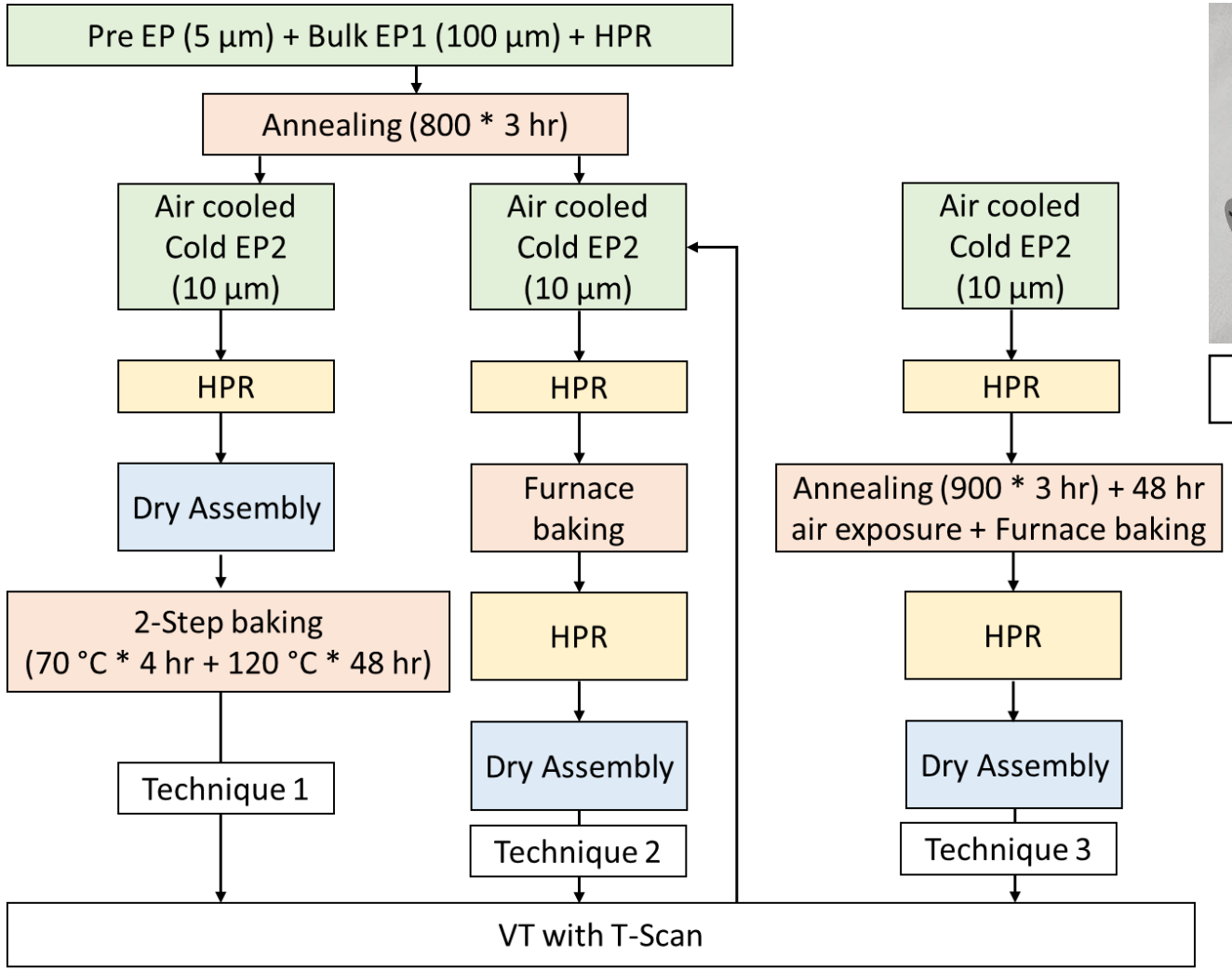
iCASA, Accelerator Laboratory

KEK / SOKENDAI

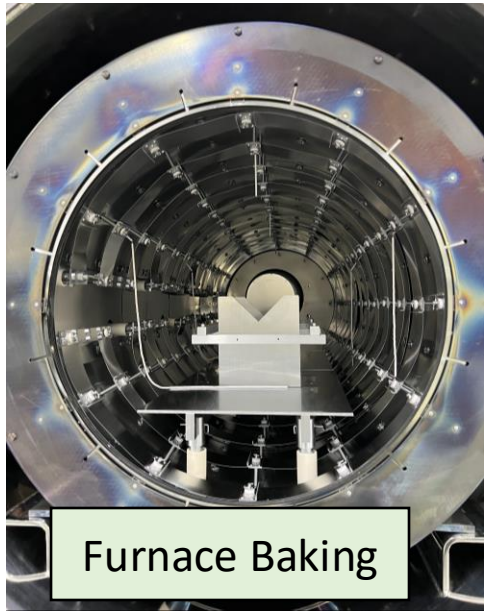
Introduction

- At KEK, two 1-cell MG Nb cavities were manufactured and tested for various high Q- high G surface treatments, such as mid-T baking and 2-step baking.
- MG Nb cavities tend to have significant orange peel effect on its surface, due to its larger grain size.
- In this presentation, the performance of MG Nb 1-Cell cavities are summarized and compared with FG Nb 1-Cell cavity.
- This work is submitted as a conference proceeding in SRF2025.

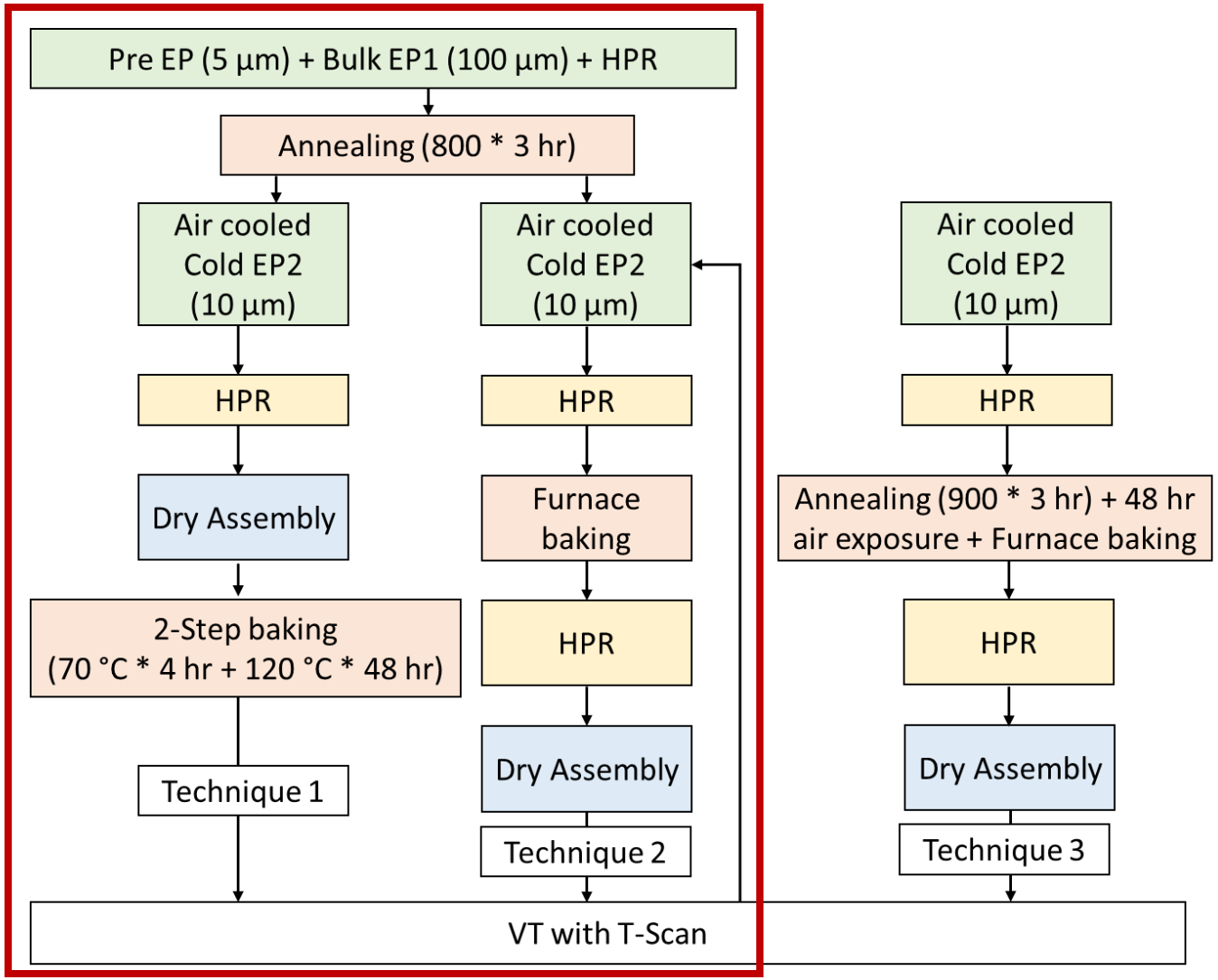
Experimental Methodology

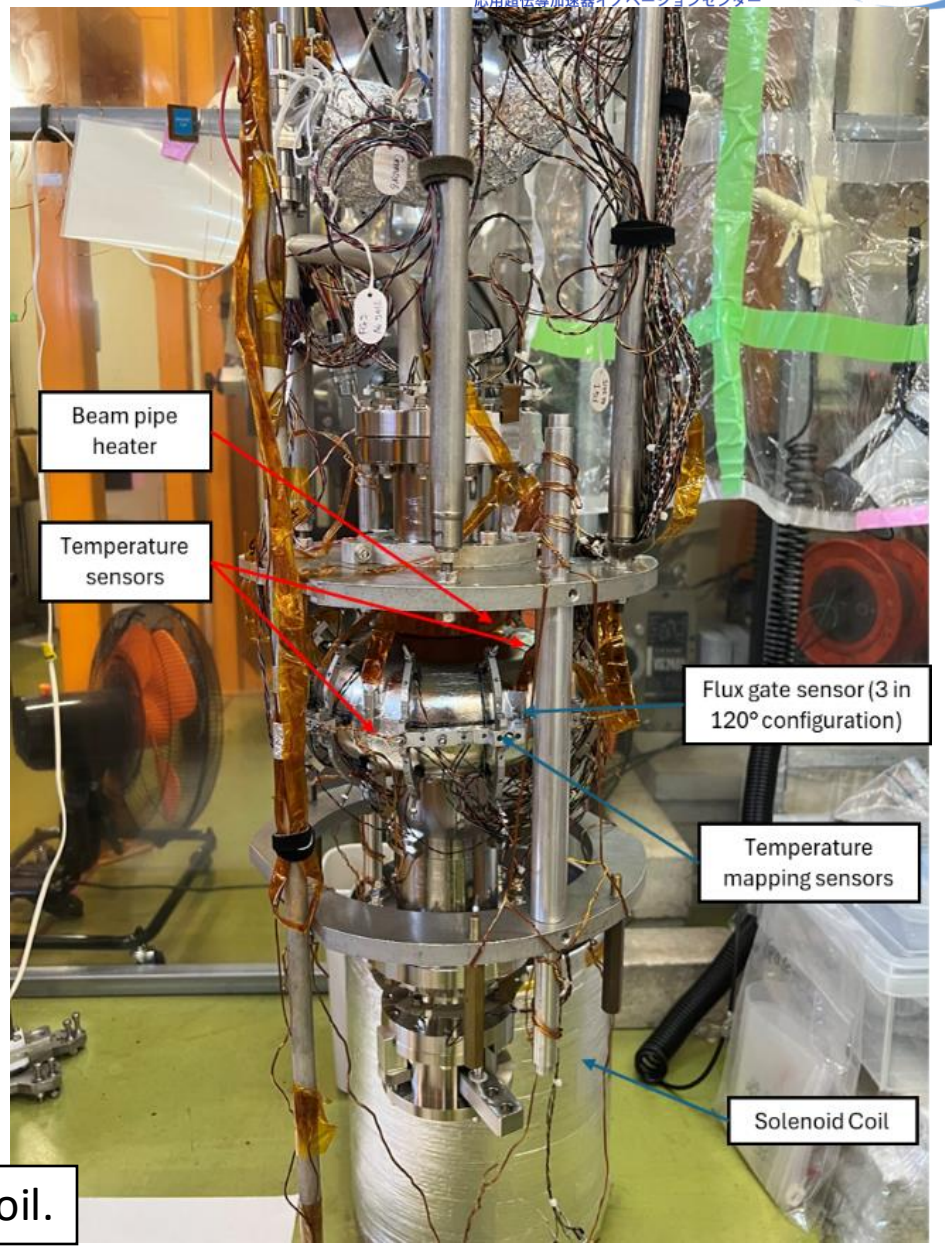


R18 & R18b HRRR MG Nb Tesla cavity manufactured at KEK-CFF



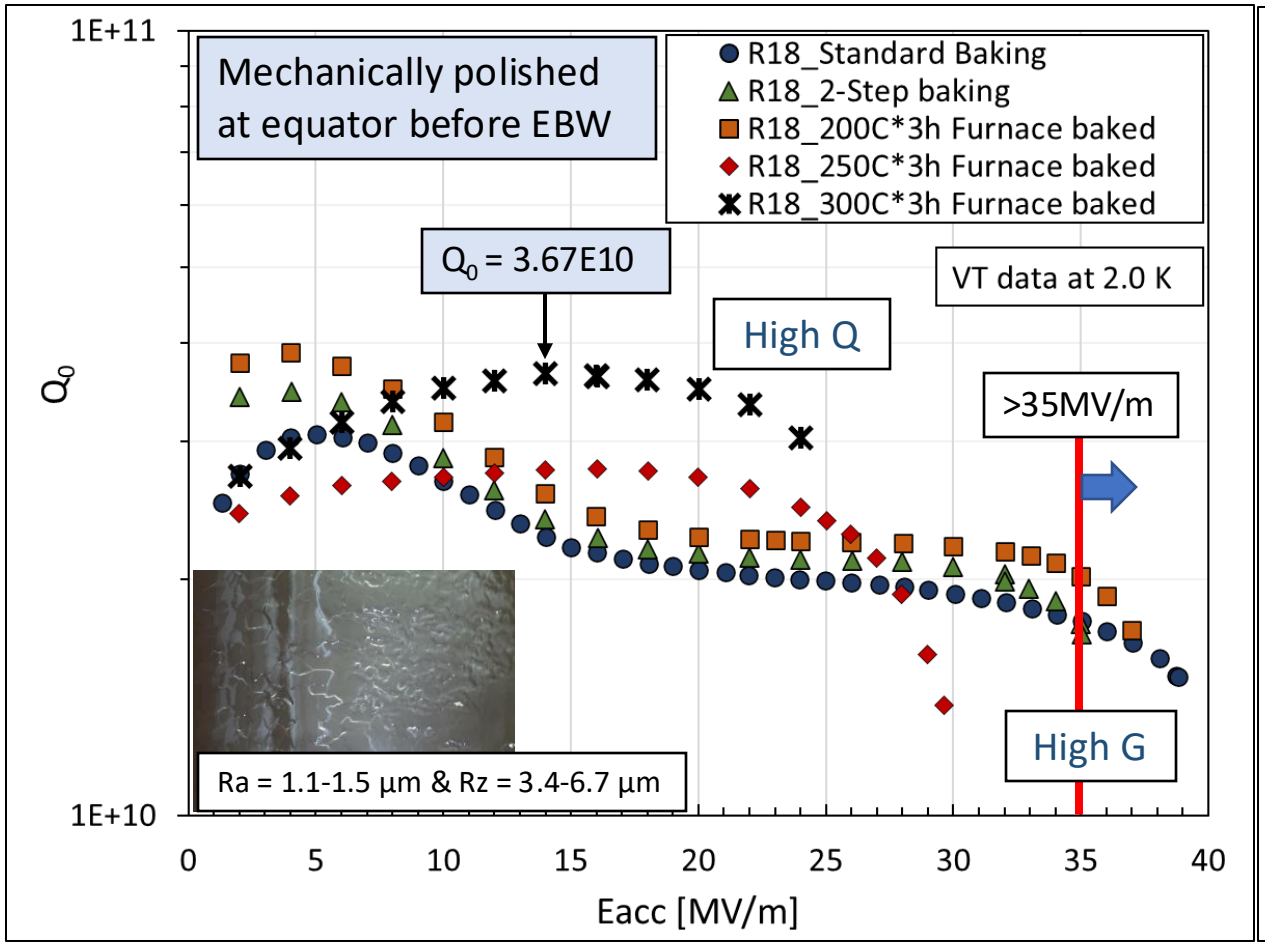
Experimental Methodology

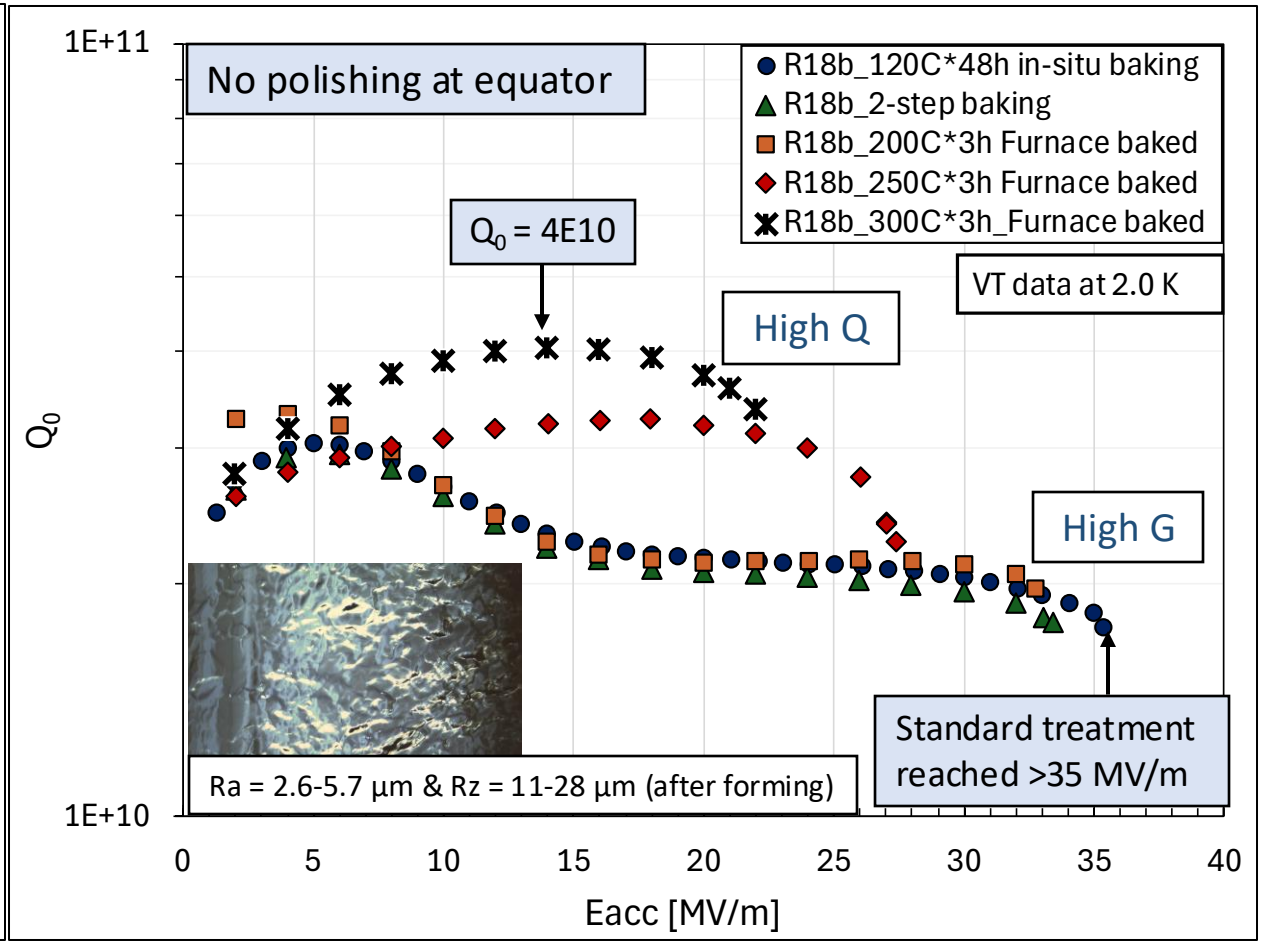




- For Flux sensitivity studies, 20 mG of flux is trapped using a solenoid coil.

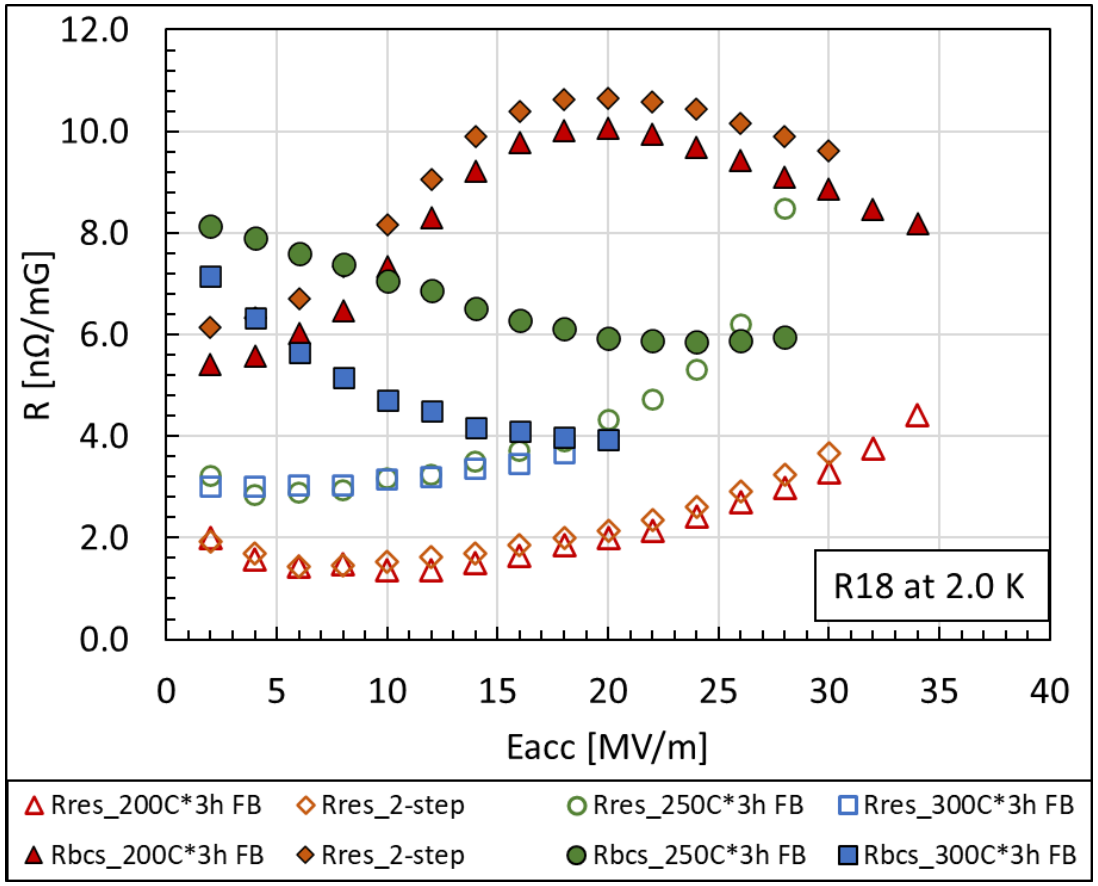
High Q – High G VT Results for MG Nb 1-Cell Cavity

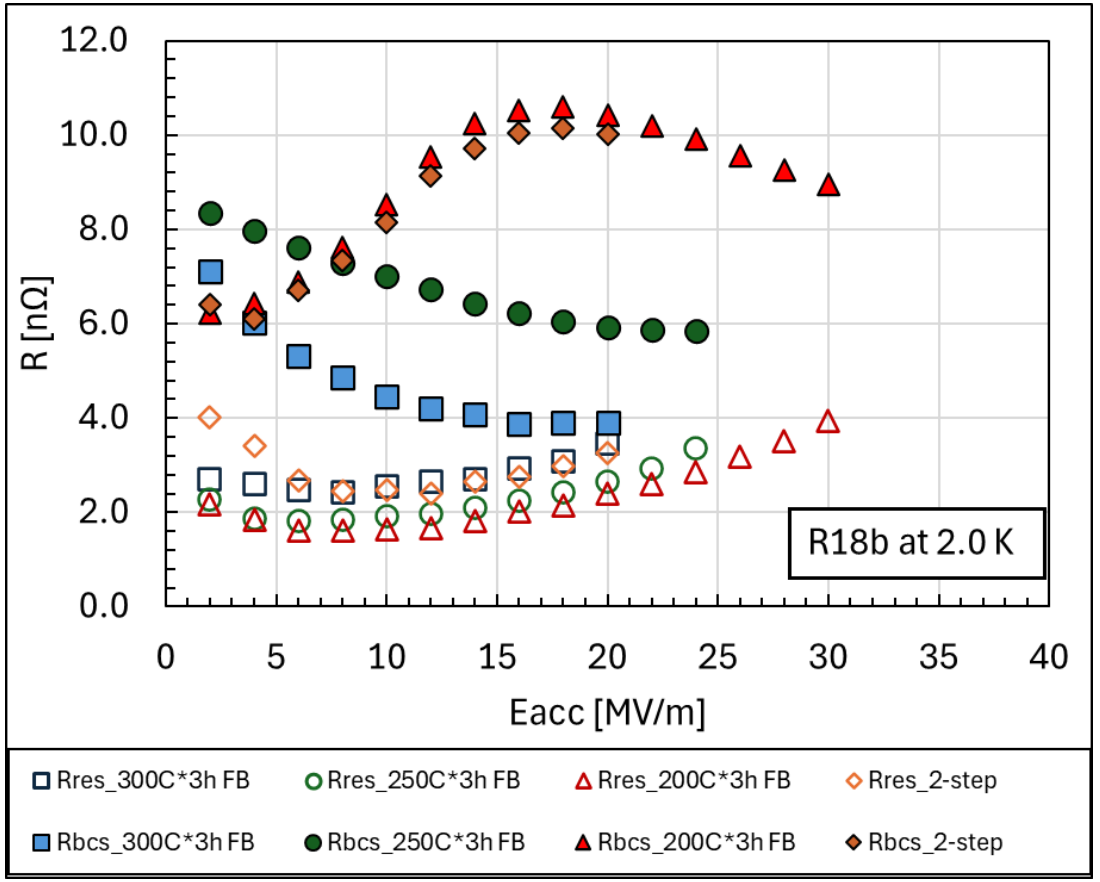




- No degradation in Eacc after quenching, degradation in Q_0 expected due to trapped flux.
- R18 maximum Eacc is > 35 MV/m for all High G surface treatments.
- R18b Eacc > 35 MV/m achieved only for Standard treatment, but Q_0 was higher for high Q treatments w.r.t R18.

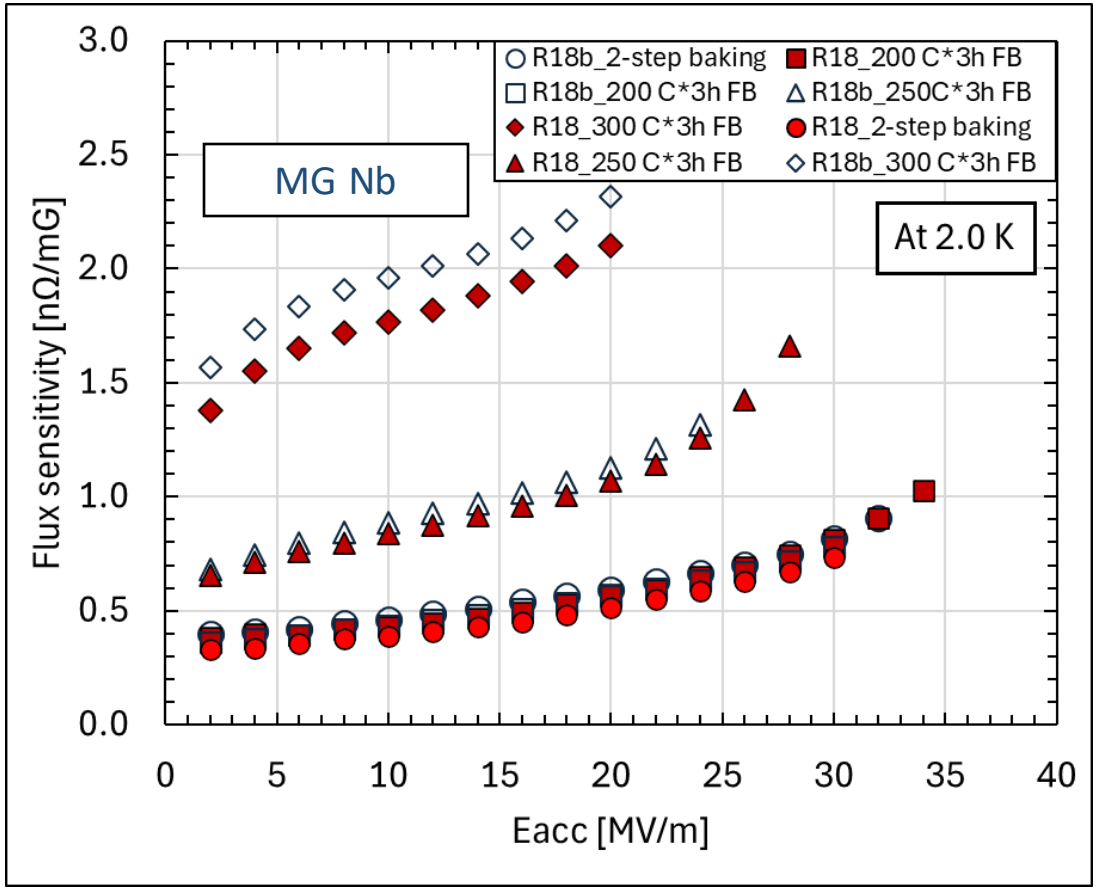
Resistance Deconvolution

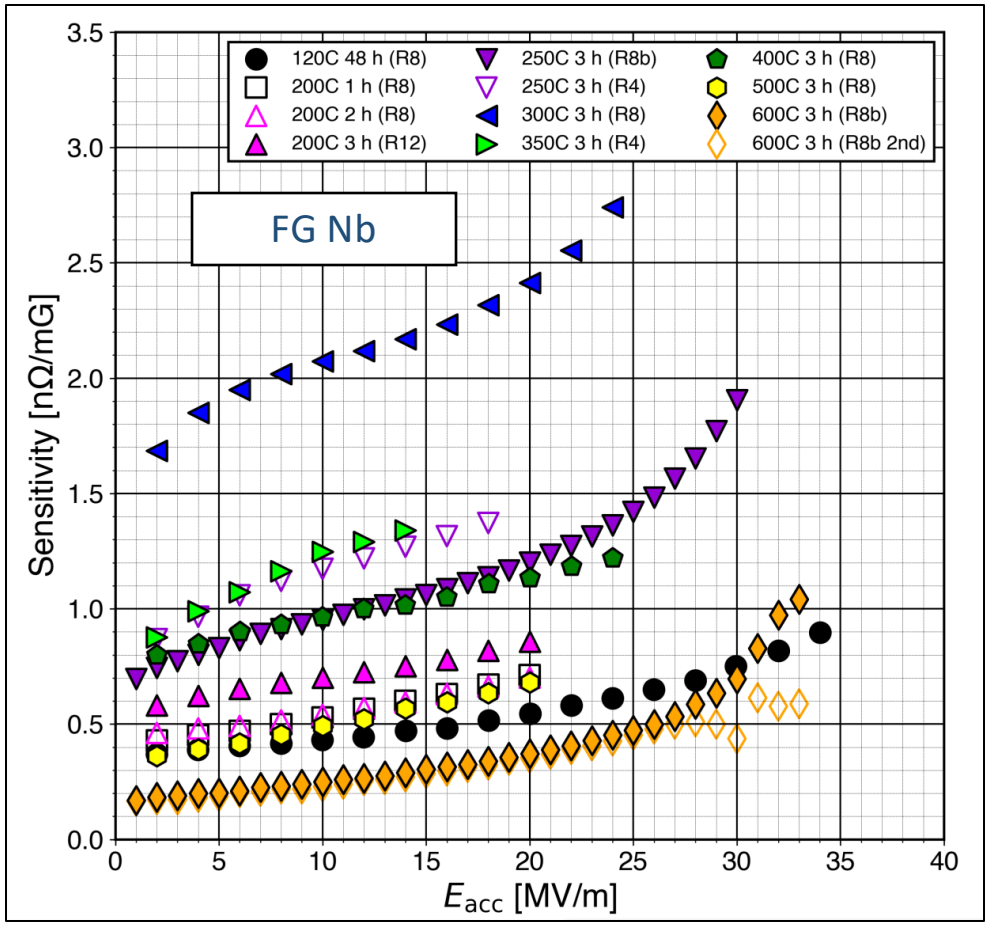




- R_{BCS} and R_{res} behavior of MG Nb is same as FG Nb.
- No difference in R_{BCS} and R_{res} behavior between both MG Nb 1-Cell cavities.

Flux Sensitivity

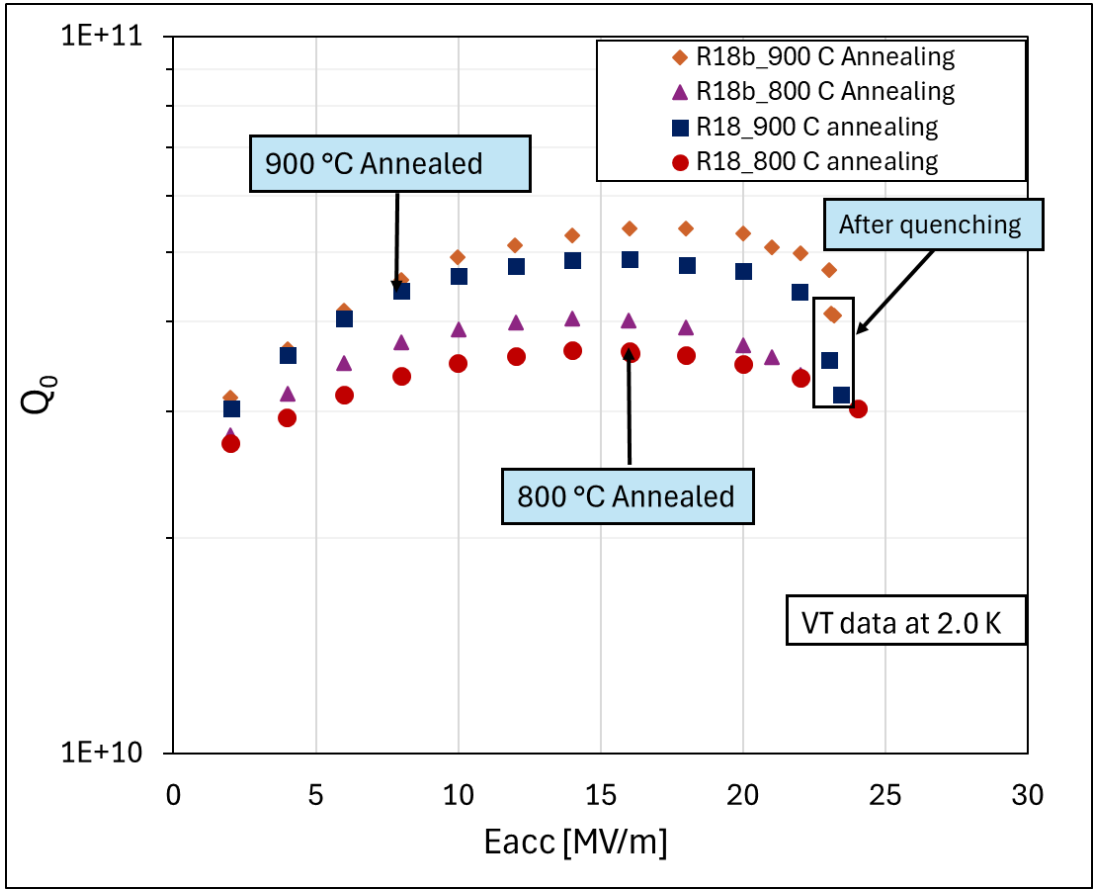


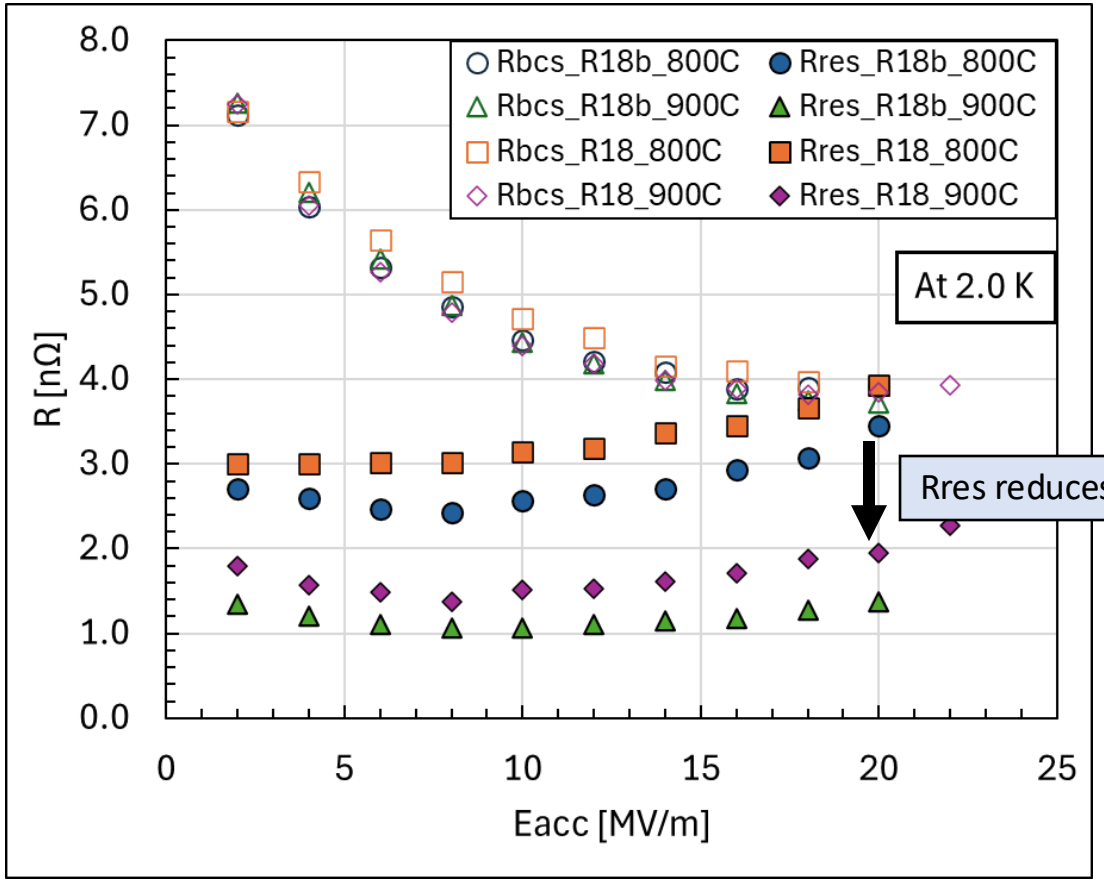


- Flux sensitivity of MG Nb 1-cell cavities is same as FG Nb.

H. Ito, H. Araki, and K. Umemori, “Surface Resistance and Trapped Flux Sensitivity as Function of Baking Temperature”, presented at the 21th Int. Conf. RF Supercond. (SRF'23), Grand Rapids, MI, USA, Jun. 2023, paper TUIXA03

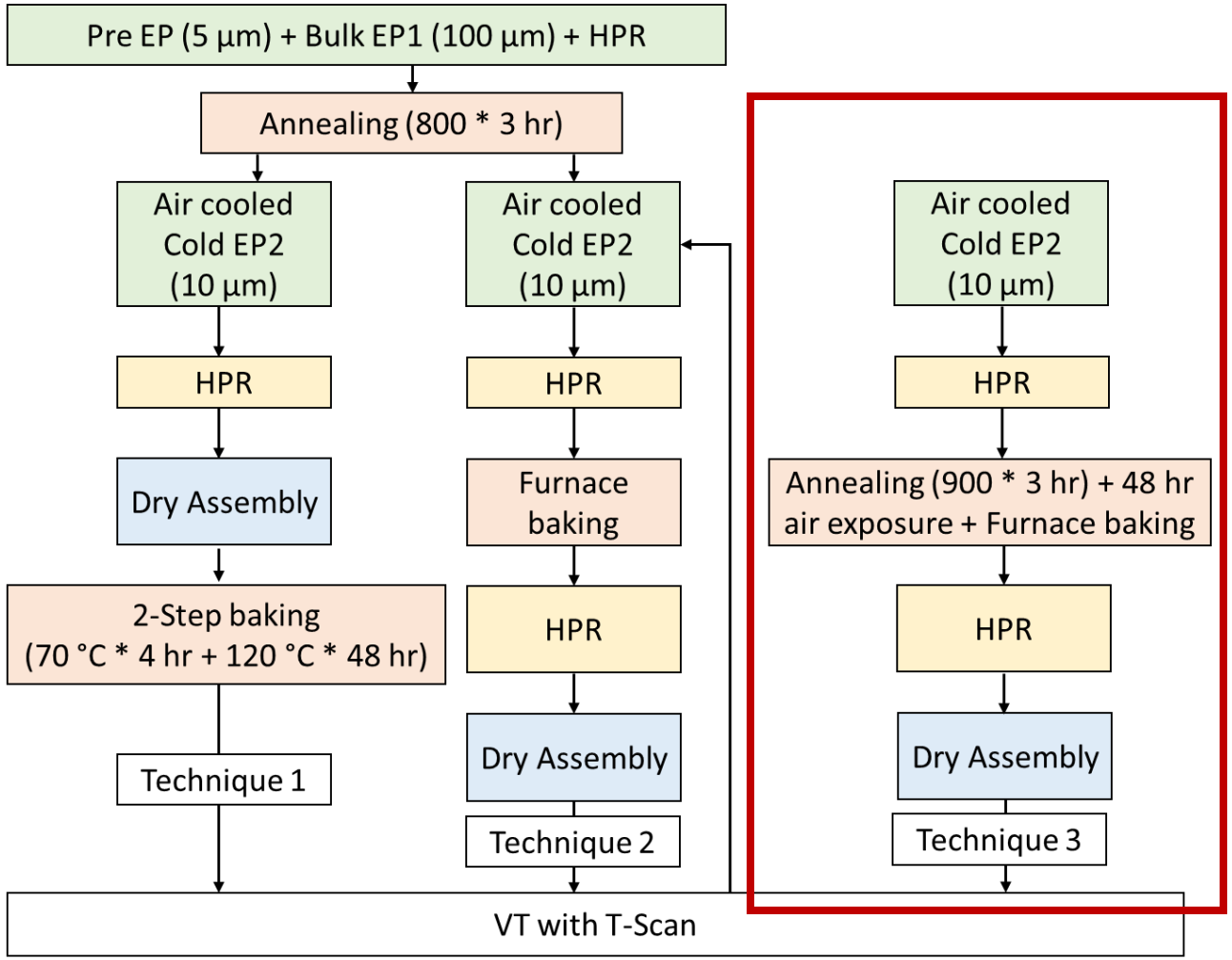
Performance Improvement with 900°C Annealing



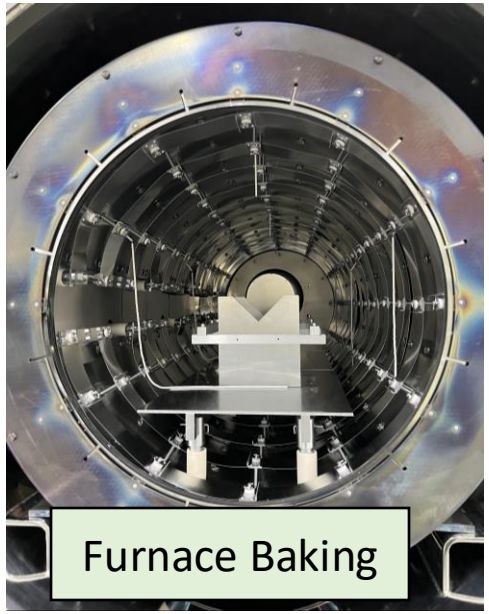


- Comparison of 300 °C furnace baking with same VT procedure.
- Significant improvement in maximum Q_0 from 3.6E10 -> 4.9E10 at Eacc = 16 MV/m, Eacc remained same.
- Performance on-par with FG Nb 1-cell cavities.

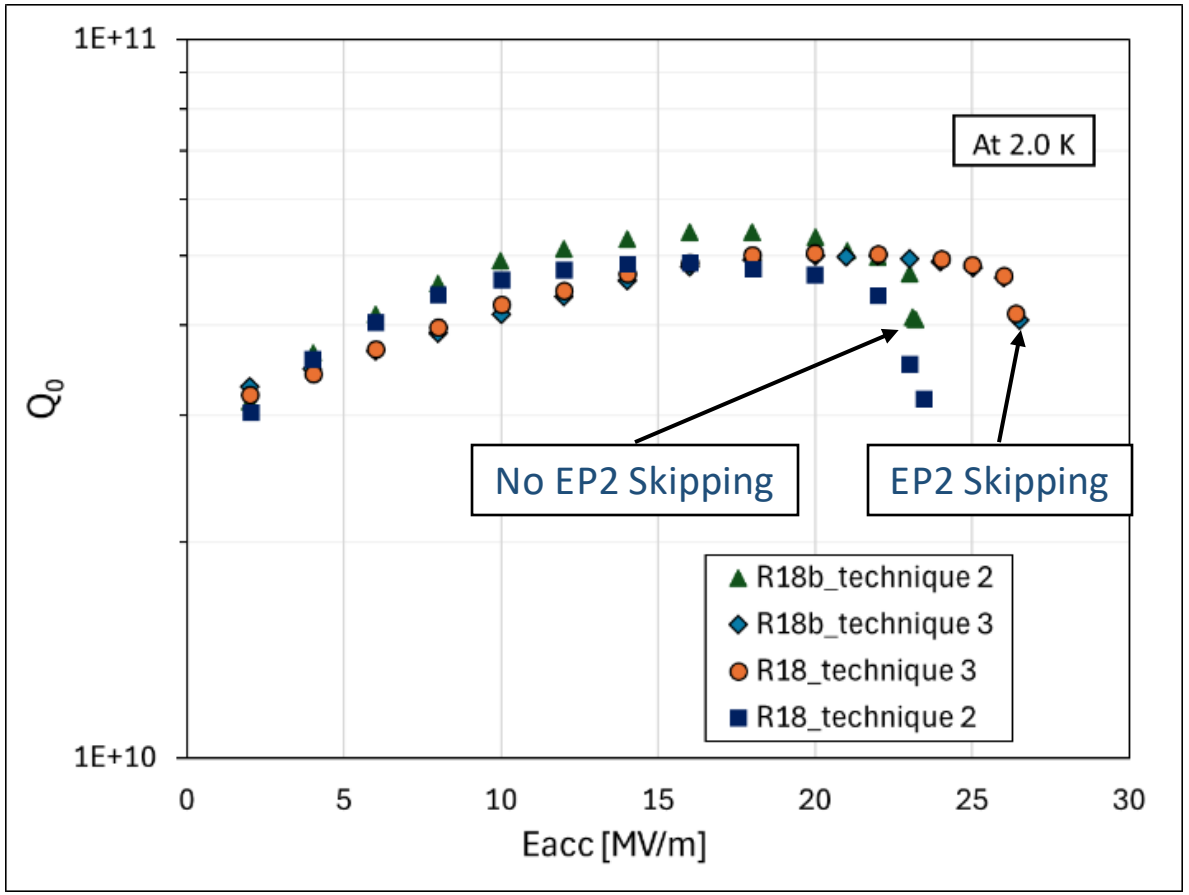
Skipping EP2 before mid-T baking

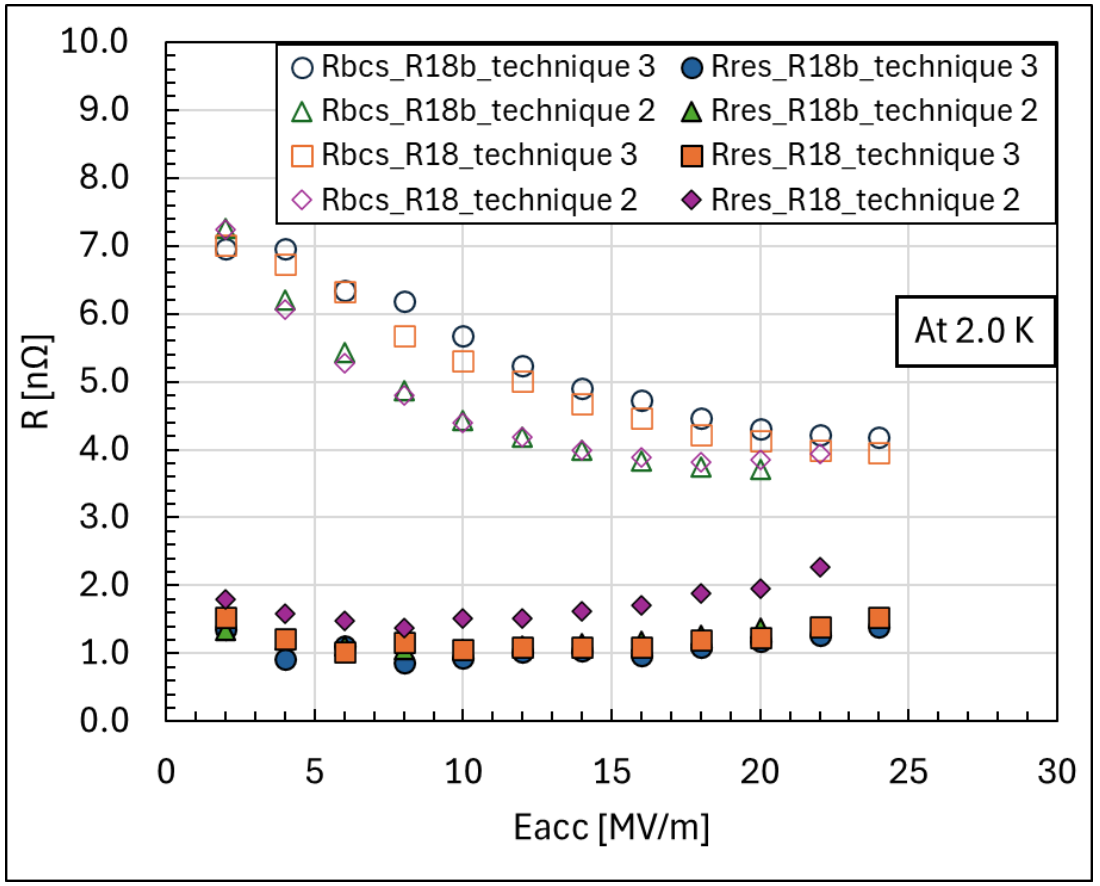


R18 & R18b HRRR MG Nb Tesla cavity manufactured at KEK-CFF



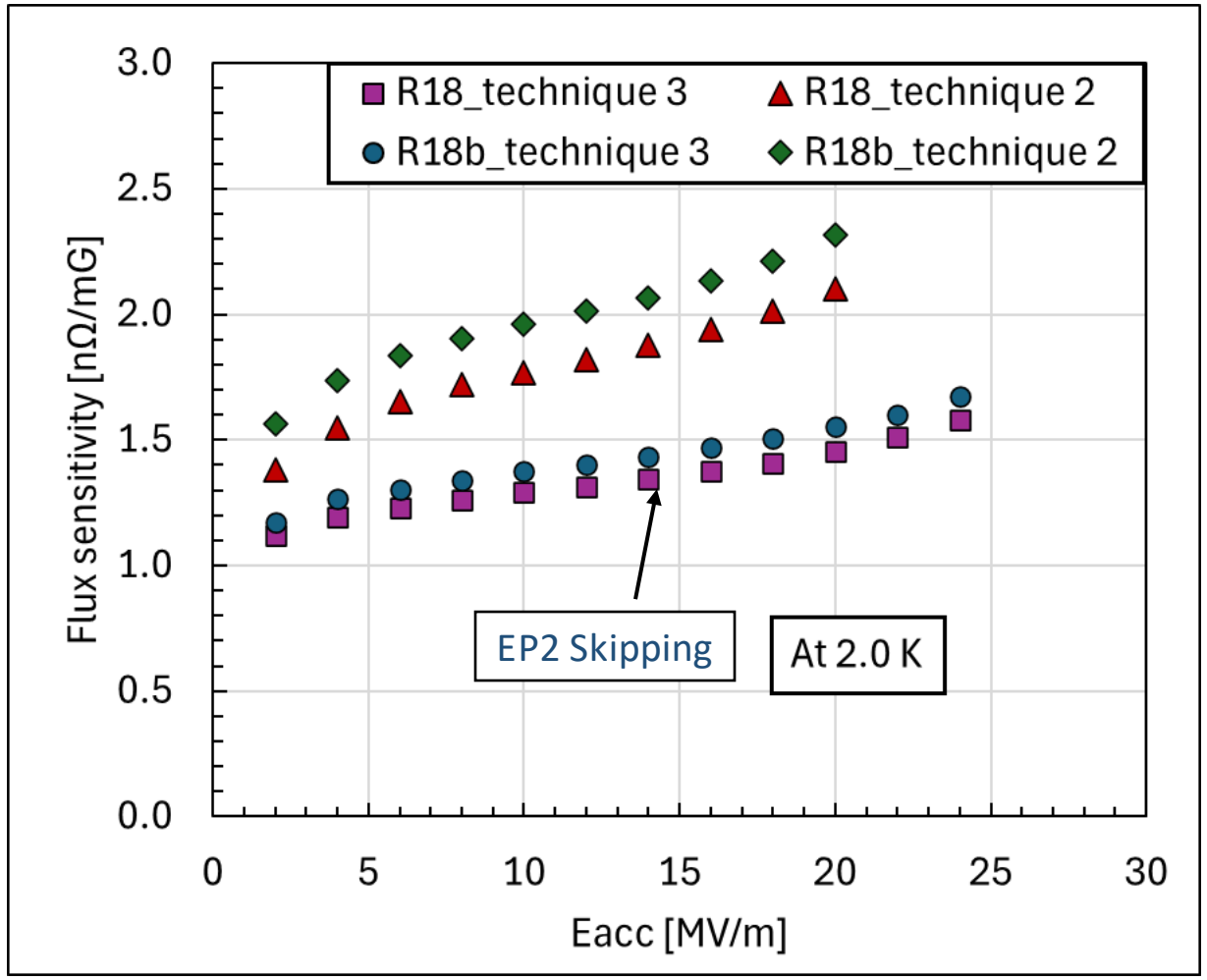
Performance Improvement by skipping EP2





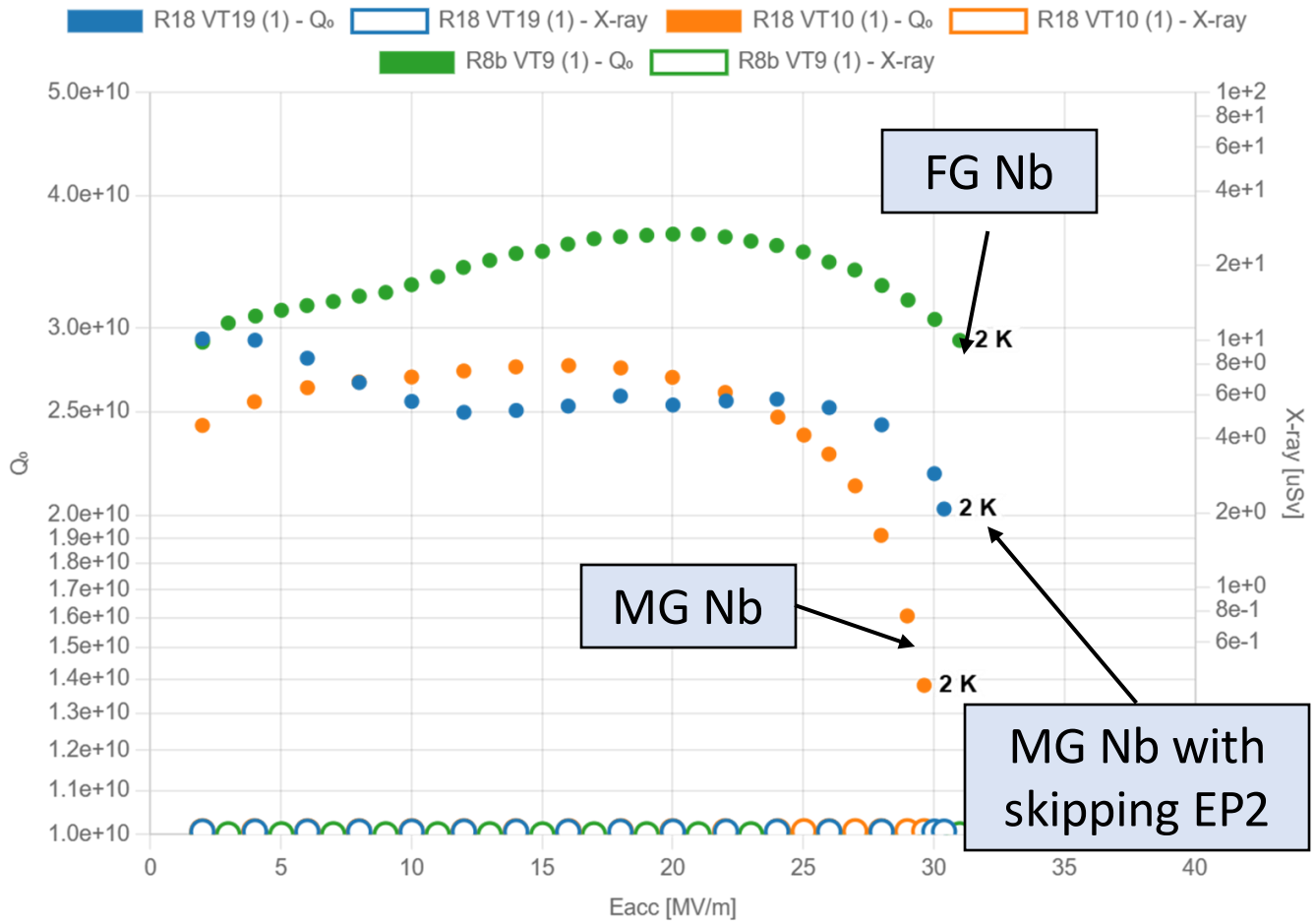
- Comparison of 300 °C furnace baking with and without EP2 between annealing and furnace baking.
- Improvement in maximum Eacc from 24 -> 27 MV/m at better Q_0.
- Peak Q_0 changed from Eacc - 16 -> 20 MV/m.

Flux Sensitivity Reduction



- Flux sensitivity reduced significantly by skipping EP2 between annealing and furnace baking.
- The reason for flux sensitivity reduction currently unknown.

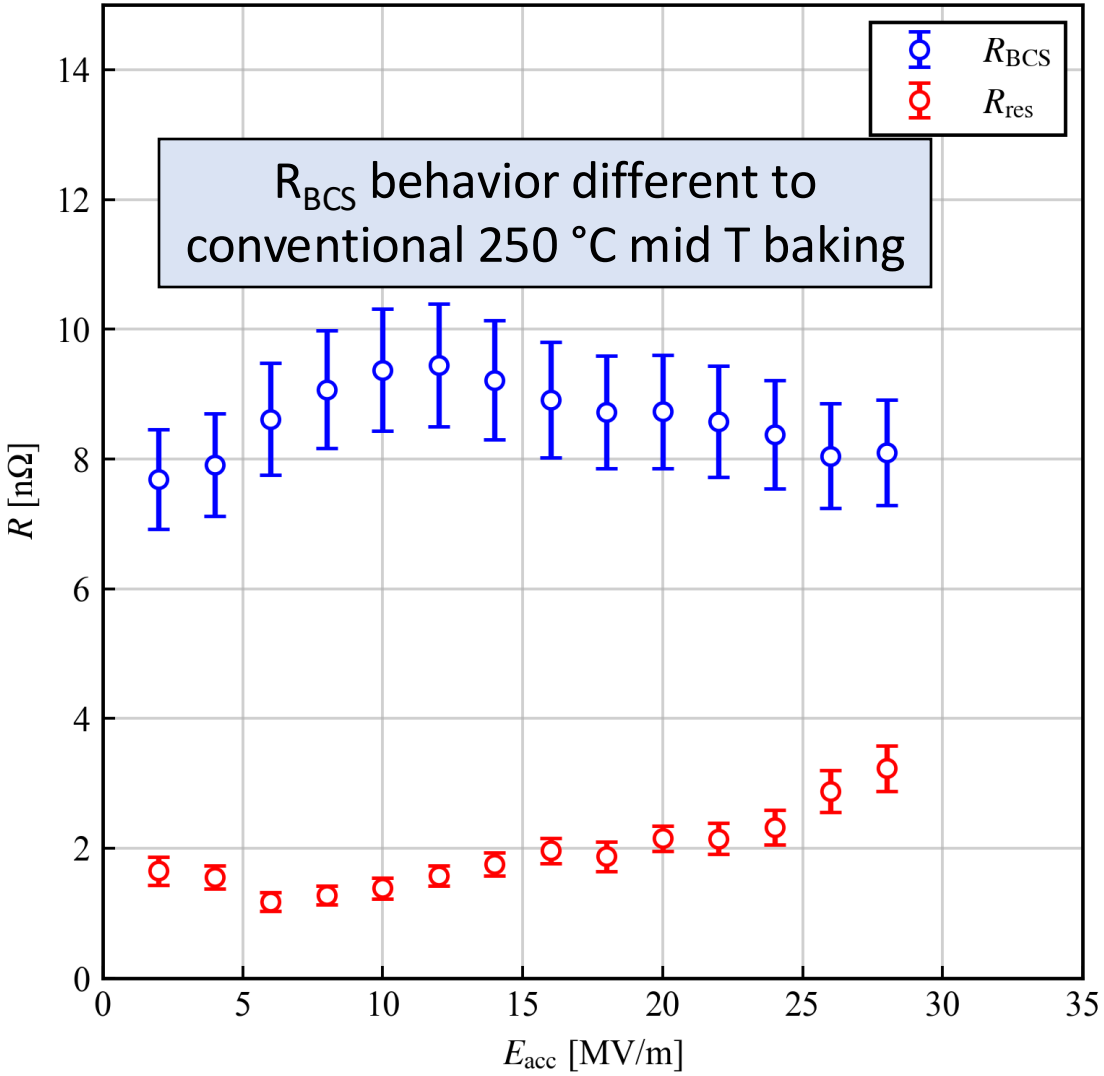
Skipping EP2 for 250 °C mid-T baking



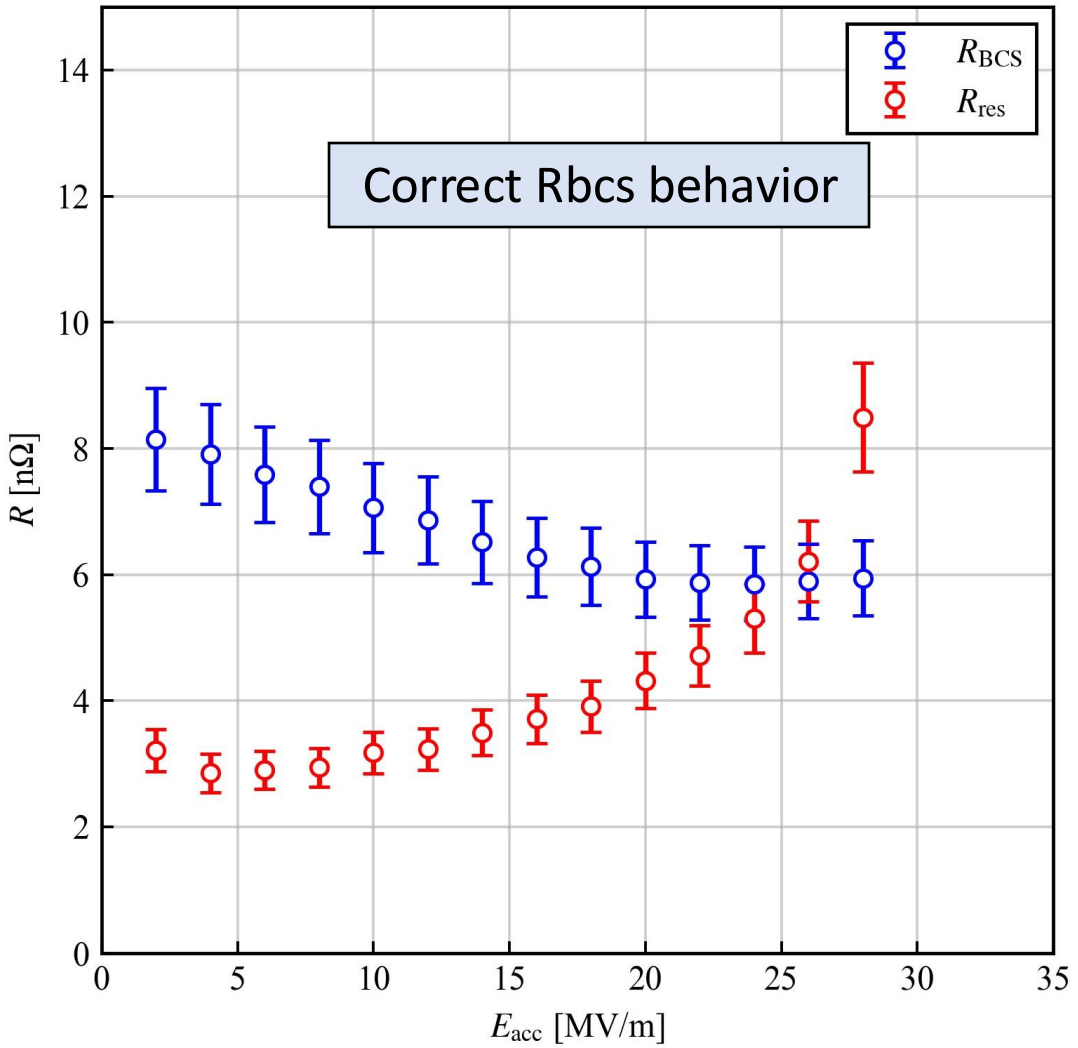
- R8b 250 °C cavity furnace baking results are much better than R18.
- Previously R18 was annealed at 800 °C for 250 °C mid-T baking, this caused Q_0 to be lower, Eacc max was comparable to R8b.
- With skipping EP2 the behavior of 250 °C mid-T baking is not reproduced, as seen in resistance deconvolution.
- Reason for this currently unknown.

Resistance Deconvolution

R18_VT19_250C 3h

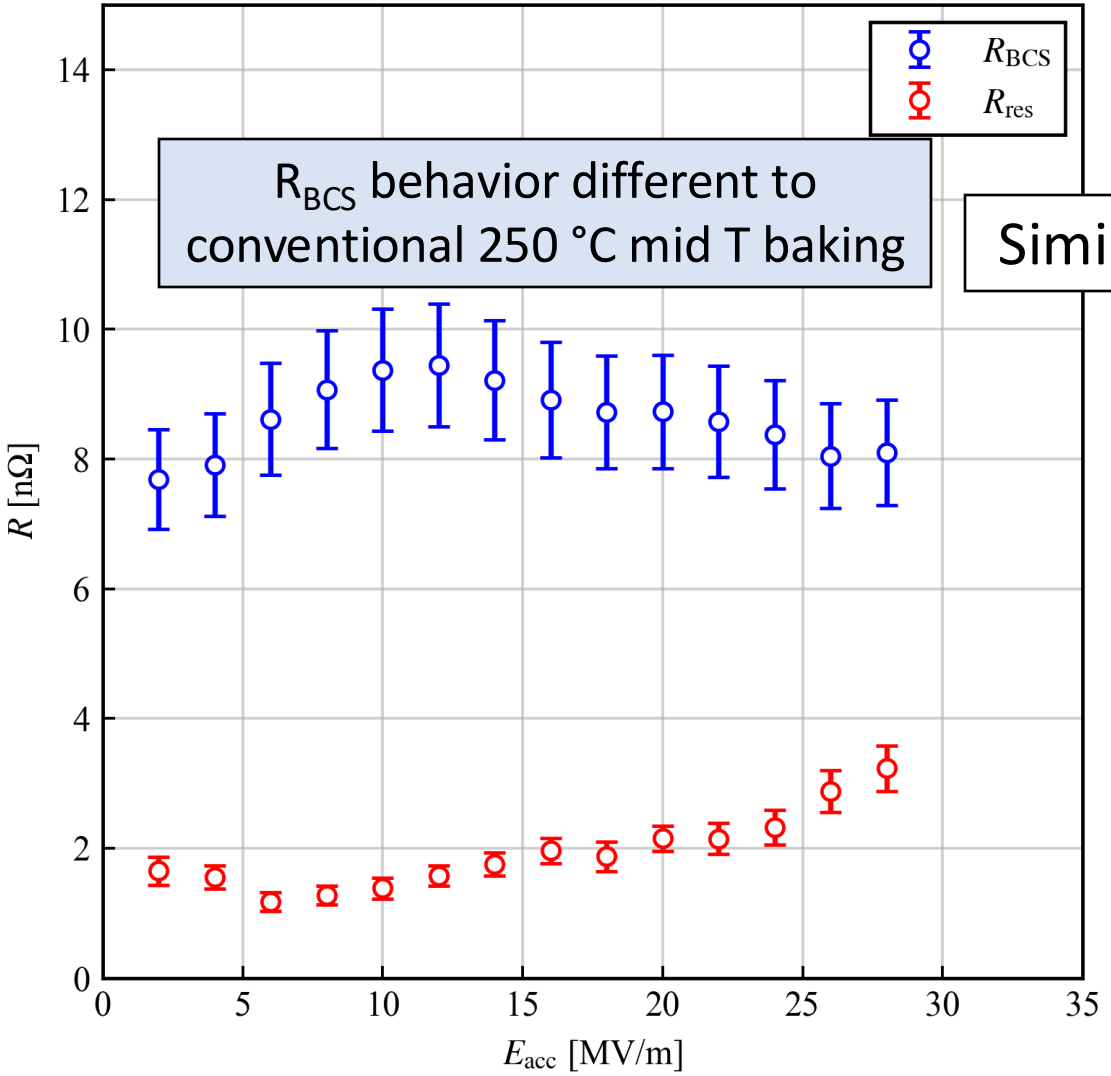


R18_VT10_250C 3h



Resistance Deconvolution

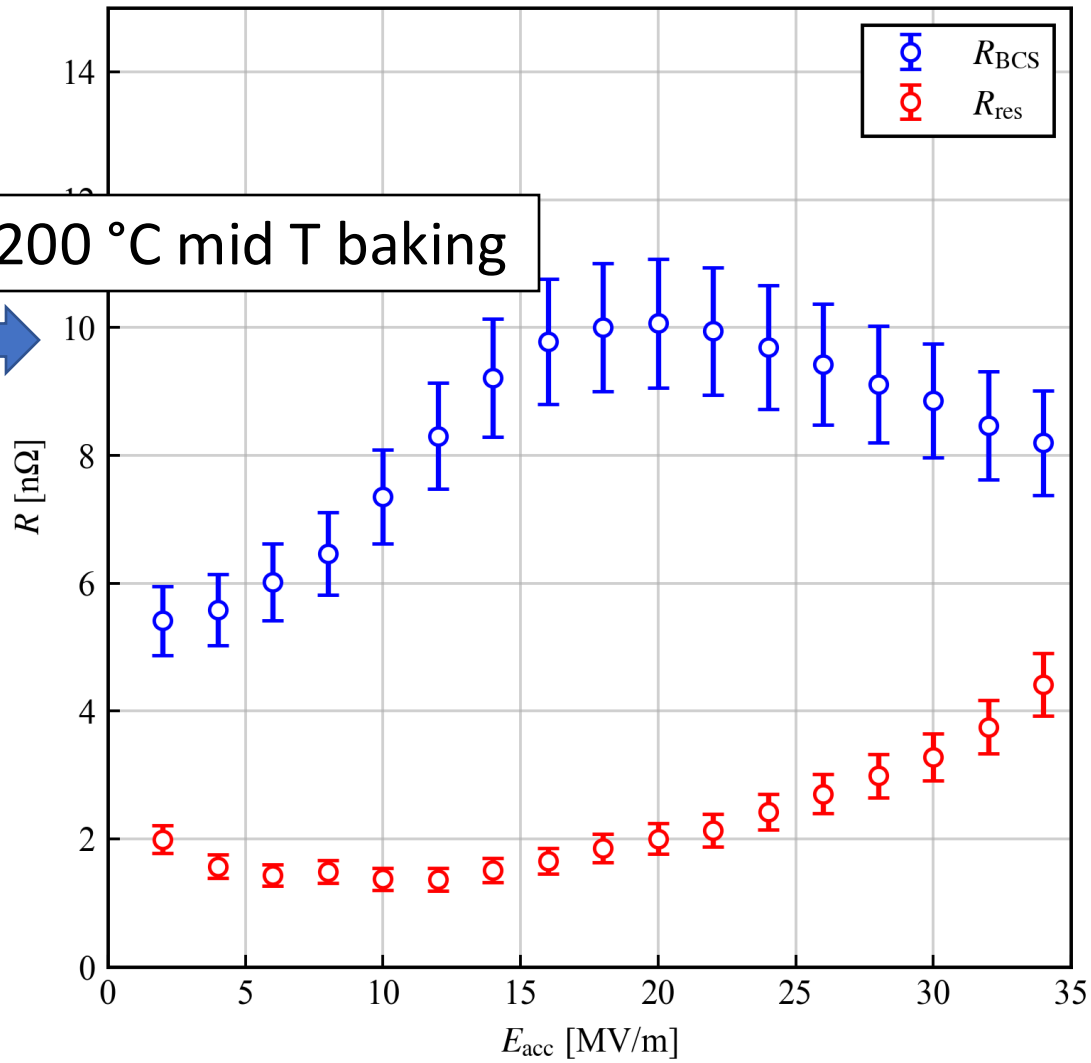
R18_VT19_250C 3h



R_{BCS} behavior different to conventional 250 °C mid T baking

Similar to 200 °C mid T baking

R18_VT6_200C 3h

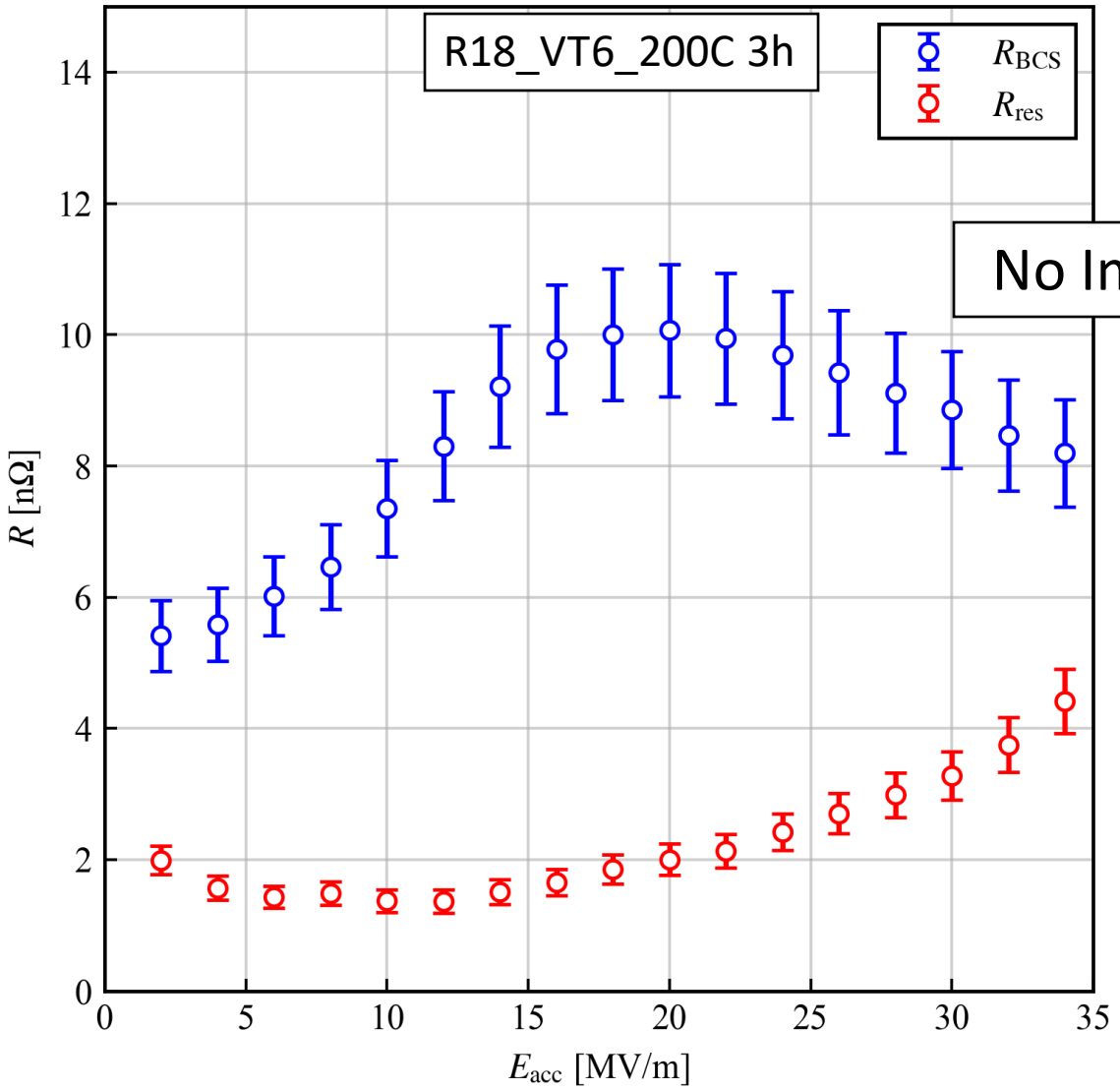


Summary

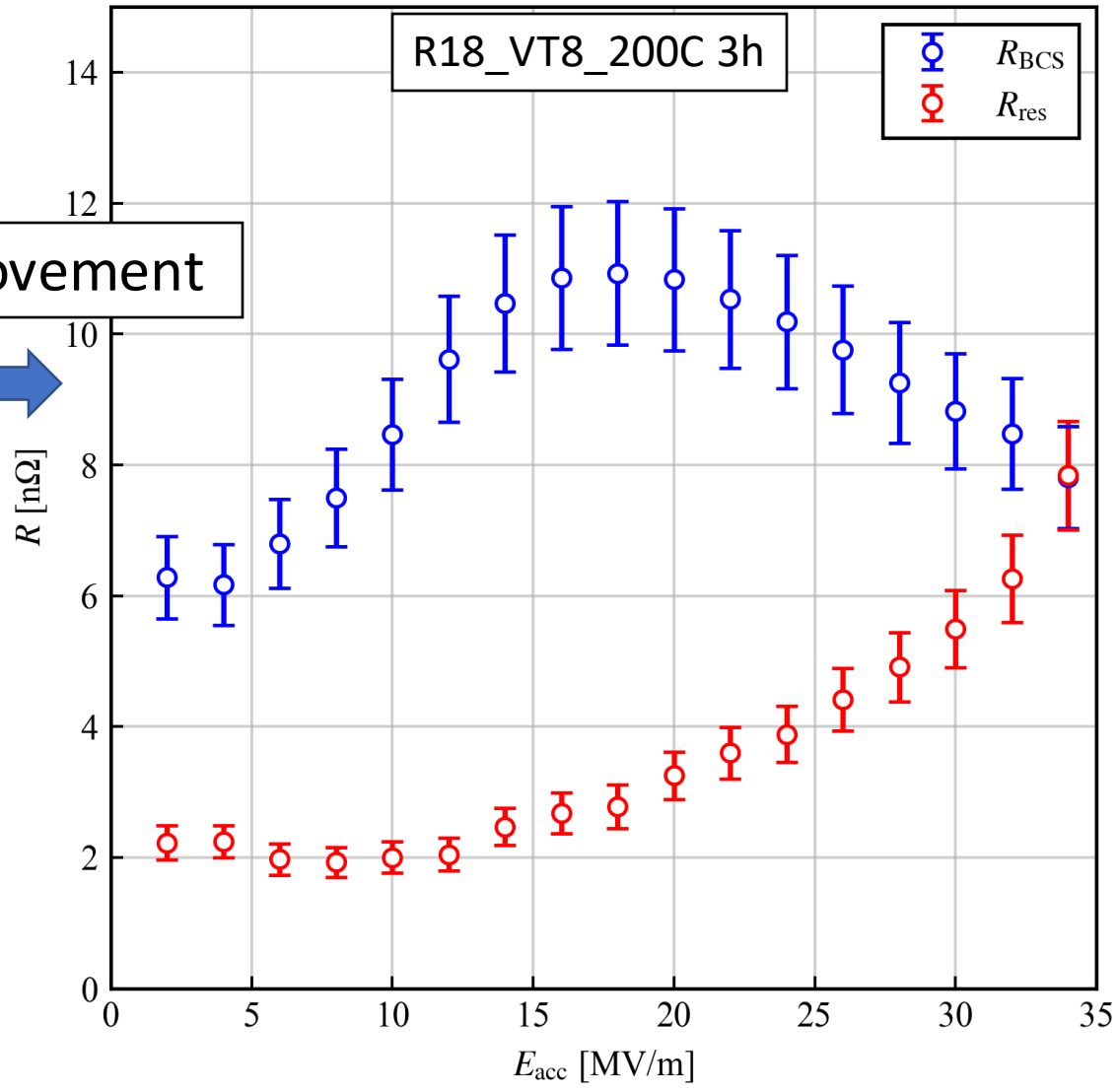
- MG Nb performance is on par with FG NB single cell cavities, even with orange peel effect.
- The flux expulsion of MG Nb cavity is comparable to FG Nb material and improves drastically with 900°C*3 hr annealing.
- For surface treatments highly sensitive to trapped flux, 900°C*3 hr annealing improved the Q_0 of MG Nb cavity drastically.
- Skipping EP2 between annealing and 300°C*3 hr furnace baking improved the cavities performance and reduced the flux sensitivity.

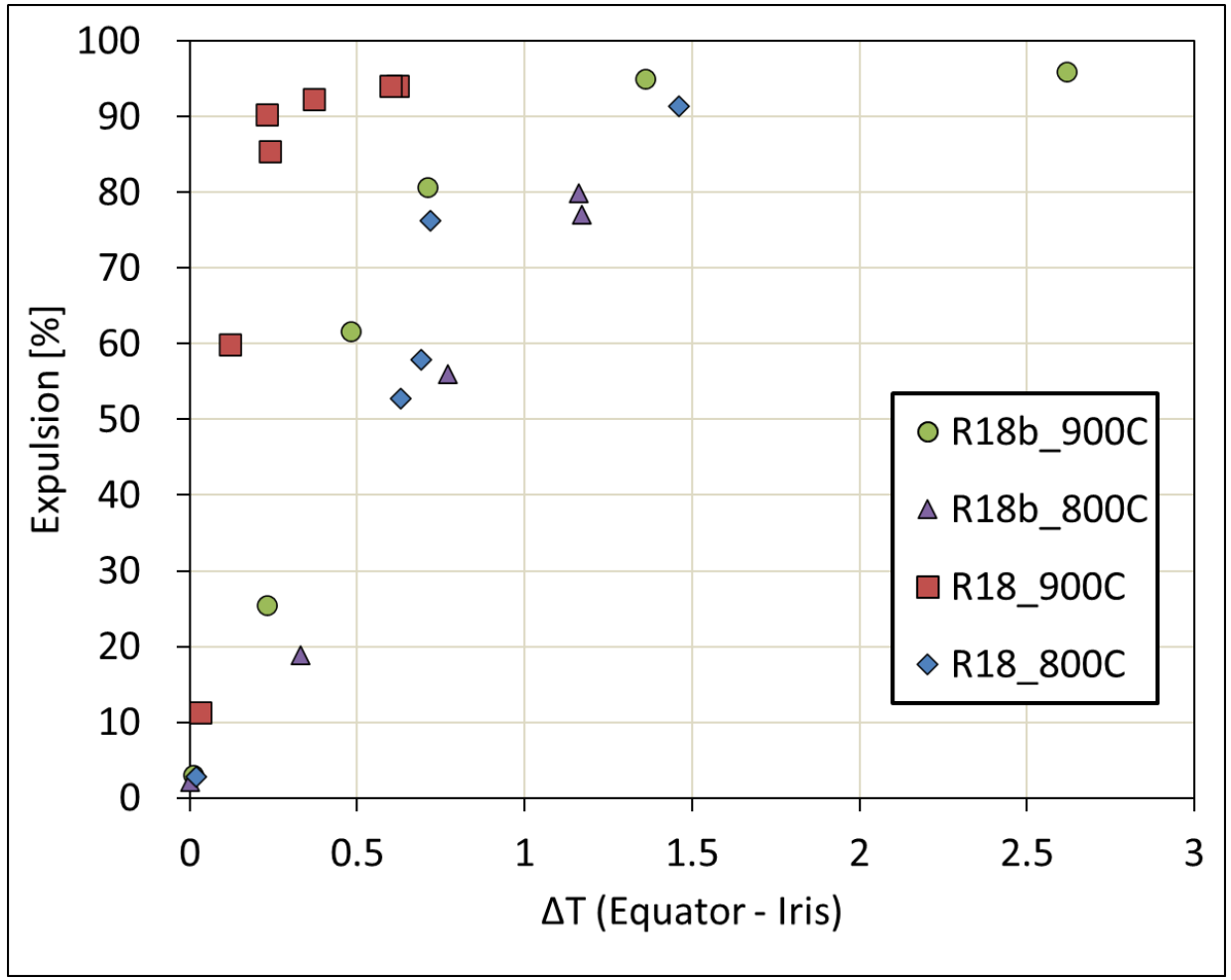
Thank You for Your Attention!

Resistance Deconvolution



No Improvement




Expulsion [%]
100
90
80
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
ΔT (Equator - Iris)
R18b_900C
R18b_800C
R18_900C
R18_800C