Upgrades to the Cornell sample host cavity

This work is supported by Center of Bright Beams from the National Science Foundation under Grant No. PHY-1549132

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March 18, 2021

Center for BRIGHT BEAMS
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Outline

Cornell sample host cavity

Demonstrate improved measurements

Progress on residual resistance issues

Introduction to sample RF characterization

Superconducting RF characterization

- Understand the response of a superconductor to an RF field

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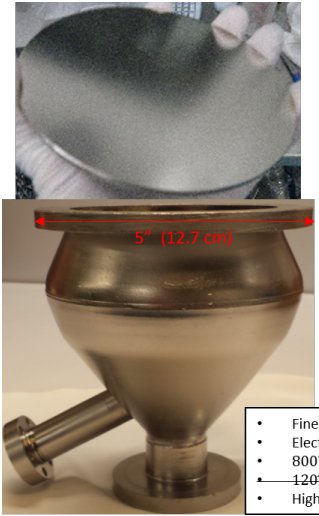
Advantages of flat samples

- Easier machining
- Easier film deposition
- Allows for studying a greater range of interesting samples

Cornell sample host cavity

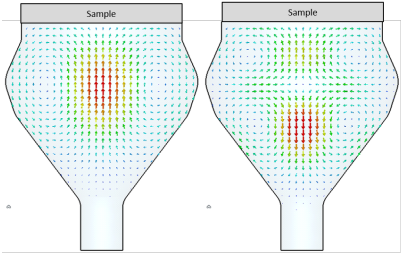


- Fine grain niobium
- Electropolished
- 800˚C bake 5 hr
- ~~120˚C bake 48 hr~~
- High pressure rinse

Operating modes

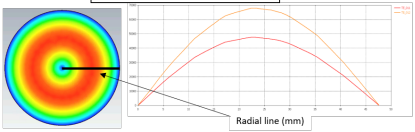
Cross-section magnetic field

TE_{011} (4 GHz) TE_{012} (5.2 GHz)



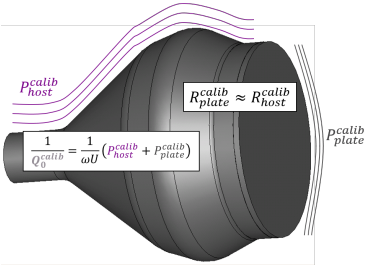
	TE_{011}	TE_{012}
Frequency (GHz)	3.99	5.27
G (Ω)	801	993
$B_{pk,\mathrm{host}}/\sqrt{U}$ $(\mathrm{mT}/\sqrt{J})$	69.3	94.2
$B_{pk,\mathrm{plate}}/B_{pk,\mathrm{host}}$	0.91	0.96
$\frac{\int_{\mathrm{plate}}\lvert H\rvert^2 dS}{\int_{\mathrm{host}}\lvert H\rvert^2 dS+\int_{\mathrm{plate}}\lvert H\rvert^2 dS}$	0.13	0.25

Sample magnetic field



Calibrated measurement

Calibration measurement: Q_0^{calib}



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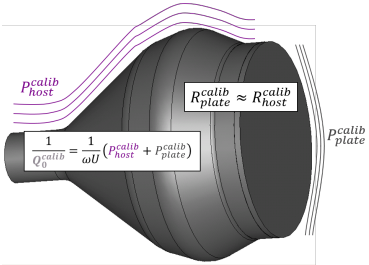
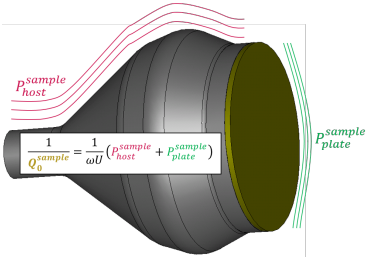


Sample measurement: Q_0^{sample}



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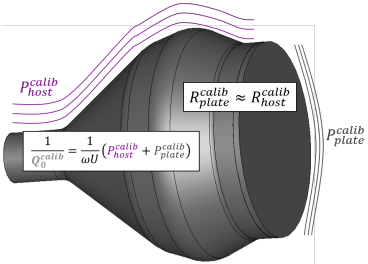

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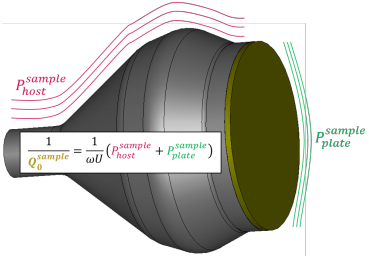
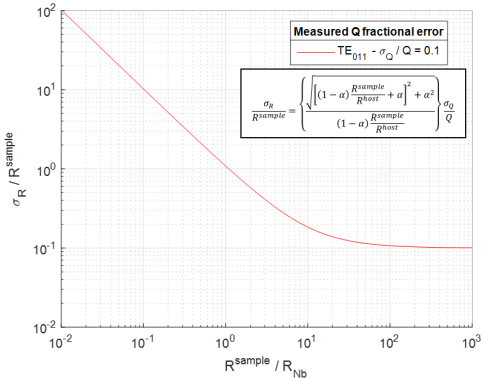


Combine calibration and sample measurements to extract R_{plate}

- $R_{avg}^{sample} = \frac{G}{1-\alpha}\left\{\left(\frac{1}{Q_0^{sample}} - \alpha\frac{1}{Q_0^{calib}}\right)\right\}$
- $\alpha = \frac{\int_{host}|H|^2 dS}{\int_{host}|H|^2 dS + \int_{plate}|H|^2 dS}$

Measurement limits

Extracted sample resistance fractional error



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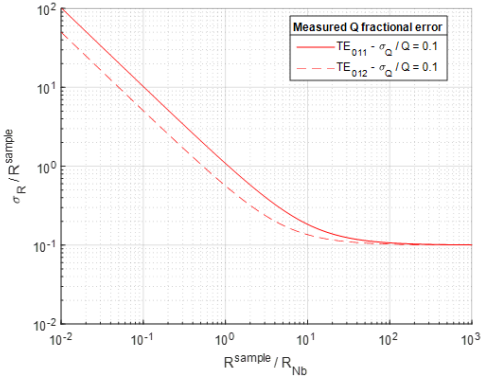

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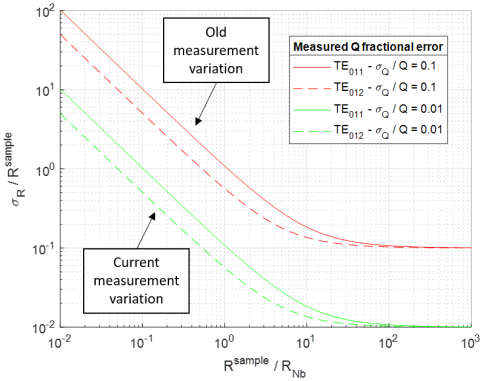

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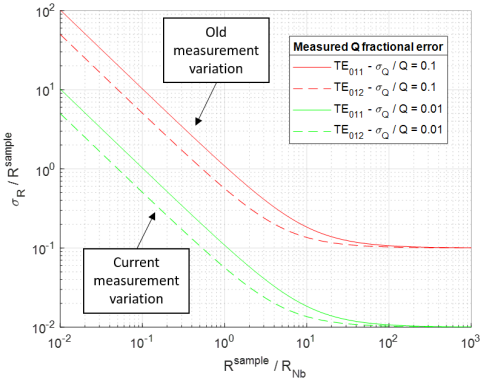
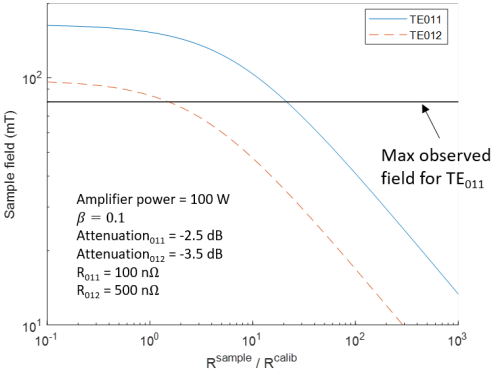


Maximum sample field



Status and progress

Previous systematic problems

- High measurement uncertainty
- Limitations to input power
- Large $R_{residual}$

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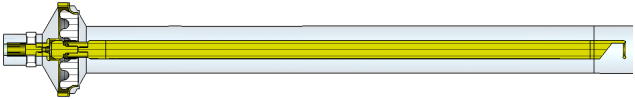
Solutions

- Redesign of fundamental power coupler (FPC)
- Transmitted power coupler (TPC)
- Improved furnace hygiene

FPC upgrade

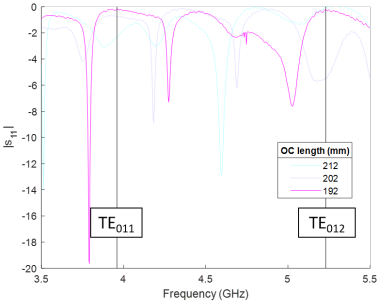
Original



Upgrade

- Less reflection
- Optimized for lower dissipation
- Better mechanical stability

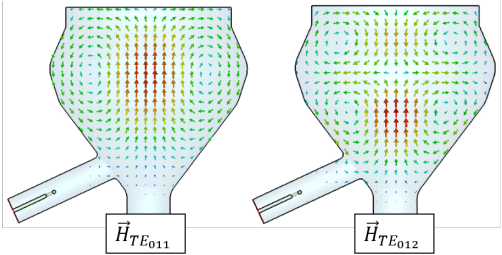
Coaxial resonances



Transmitted power probe

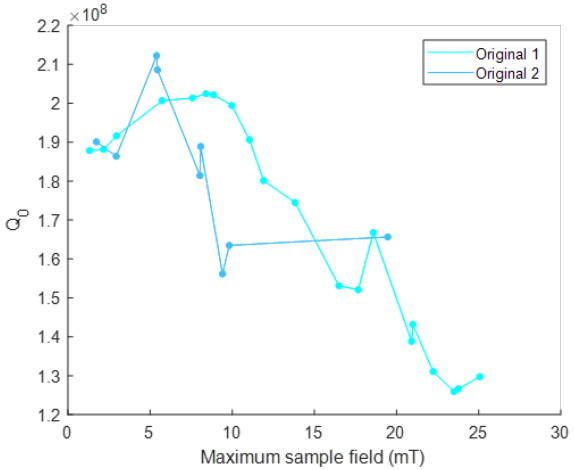
Design considerations

- For both modes
  - $Q_e \approx 10^{13}$
  - No change to $H_{\text{pk,host}}$
  - $P_{TPC}^{\text{dissipated}} < P_{FPC}^{\text{dissipated}}$
- Physical constraints



Comparing original and upgraded system

120° C bake Nb @ 4.2 K & 4 GHz



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  - Measurement uncertainty
  - H or P dependence?

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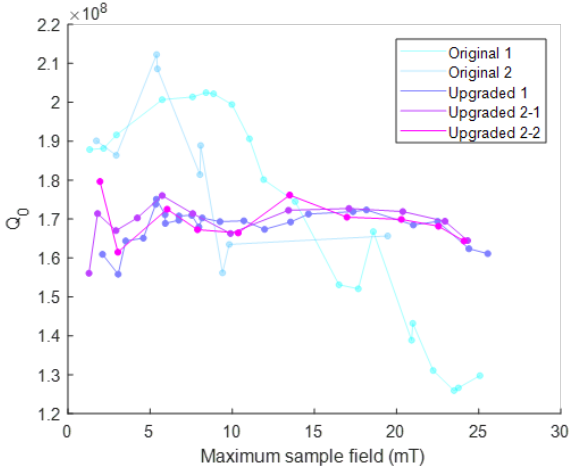

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  - Reasonable H dependence

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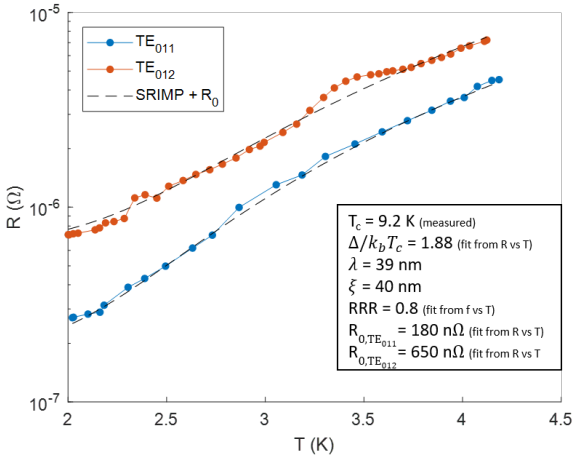

Features

- Original
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- Upgraded
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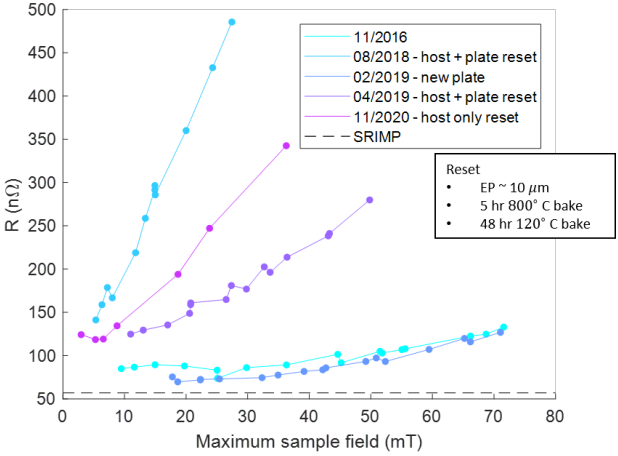
  - Reasonable H dependence
  - R vs T

Residual resistance

120° C bake Nb @ 2.0 K & 4 GHz



Features

Residual resistance categories

- High $R_0 \propto H_{rf}$
- Low R_0

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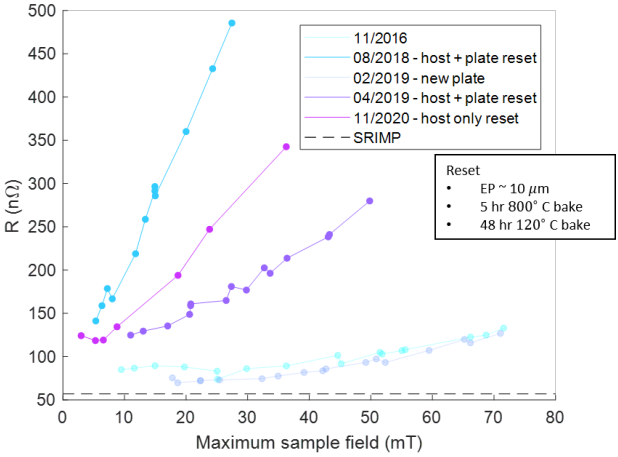

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- High $R_0 \propto H_{rf}$
  - Majority of measurements
  - Trapped flux?
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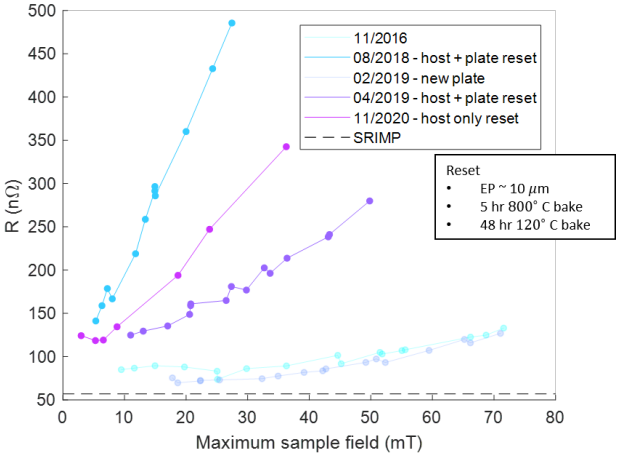
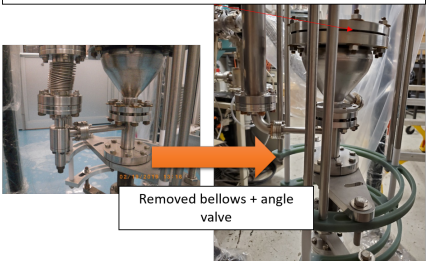


Attempts to reduce trapped flux

Reduce ambient magnetic field

316 stainless steel -> Ti clamps & silicon bronze threaded rods



→ no significant effect

Residual resistance

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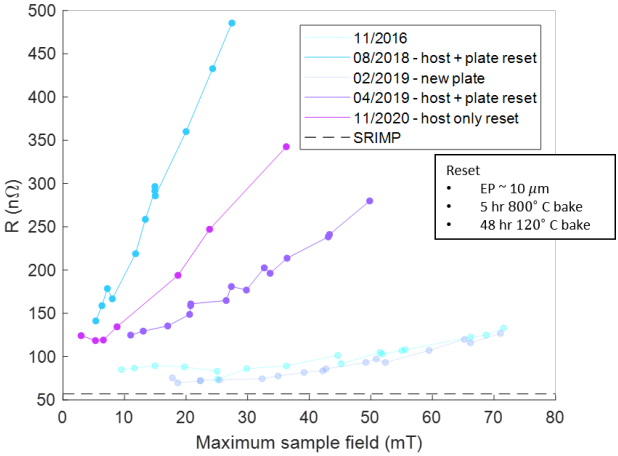
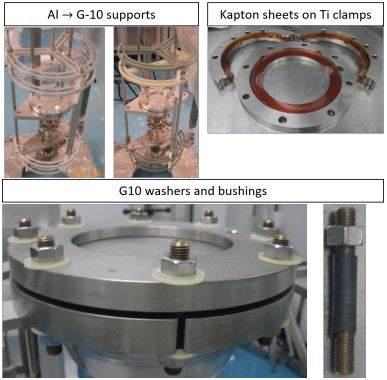


Attempts to reduce trapped flux

Eliminate thermal currents



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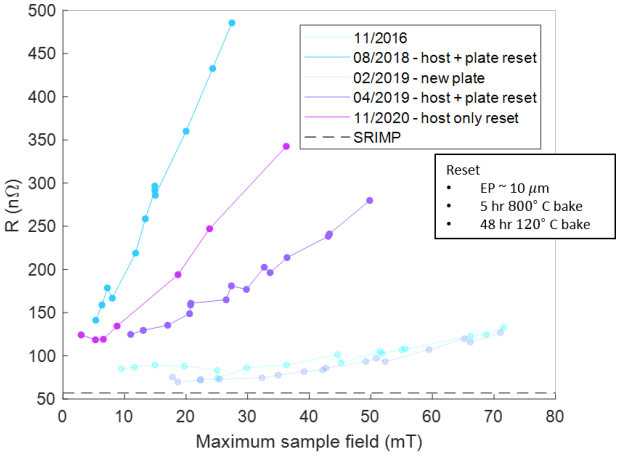
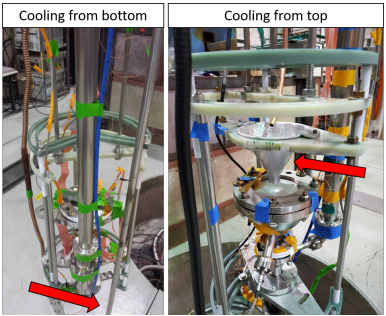


Attempts to reduce trapped flux

- Alter cooling path
- Change cooling rate



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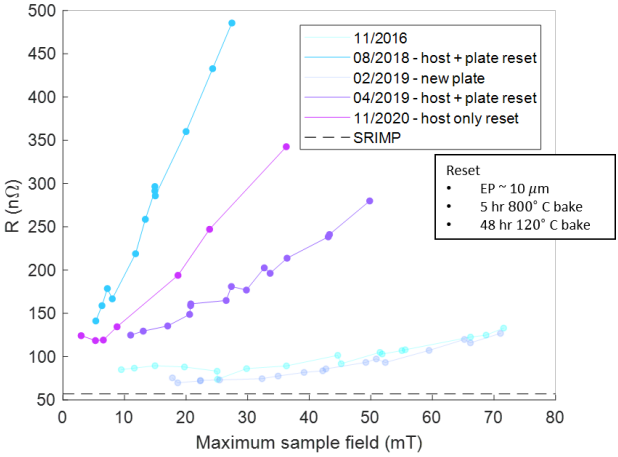

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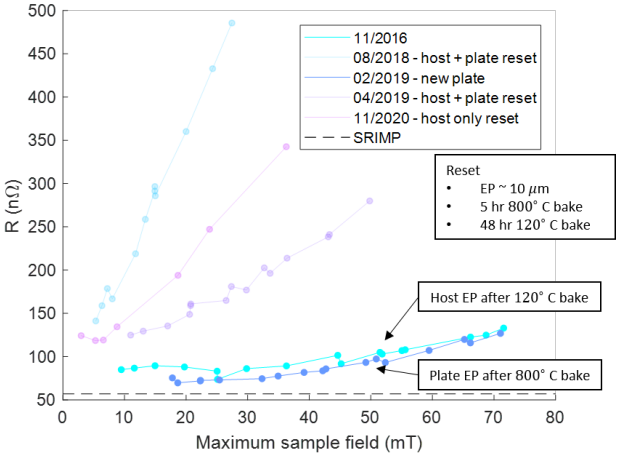

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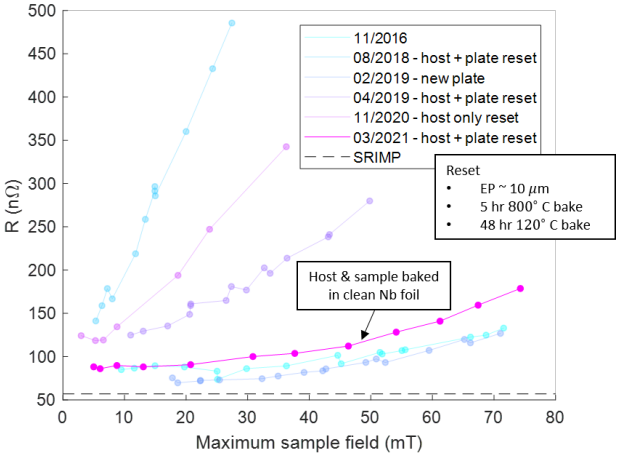

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  - Host and/or plate
  - Clean furnace run
    - More nitric acid soaks
    - Cover with clean Nb foil in furnace

Conclusion

Better measurements

- Smaller measurement uncertainty
- Full input power range

Residual resistance

- Improved understanding
- Must verify new procedure for maintaining low residual

Ready for sample measurements!

- Not well suited for samples with low surface resistance.... thick A15 ✗, thick B1 ✗
  - → Can verify it is near Nb loss up to 80 mT / quench
  - → $\sim 10\%$ error for $R^{sample} = R_{Nb}$ ... SIS ✓
- Plan to test anti-Q-slope models on lossy samples