Analyzing $R_s(T,B_{pk})$

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Toward understanding Nb $R_s(T, B_{pk})$ as a function of surface treatment

- We would like to understand the linkage between material distribution within the surface and the resulting rf surface resistance.
- For "really good" Nb cavities we take the approximation:

$$R_{s_{eff}}(B_{pk}, T) = R_{resid}(B_{pk}) + R_{BCS}(B_{pk}, T) \quad [= \frac{A(B_{pk})}{T} e^{-\frac{U}{T}}]$$

Use multiple data sets with different T to make this separation.

Analysis assumptions:

- Effective gap/T_c is constant, $2\Delta = 1.84$ meV, U = 17.02
- Heat flux is low enough that ΔT between rf surface and LHe bath T is negligible

Surface material determines A and R_{resid}

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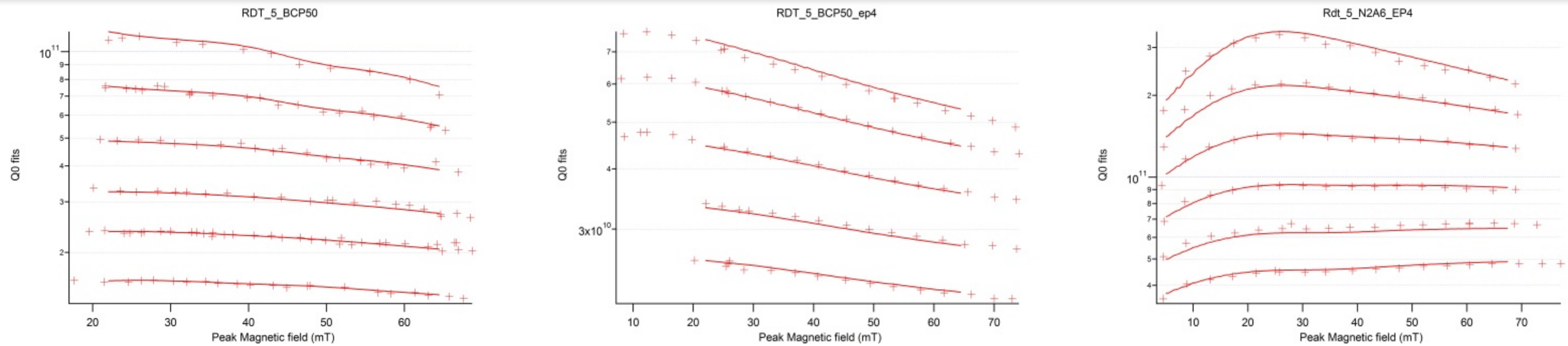
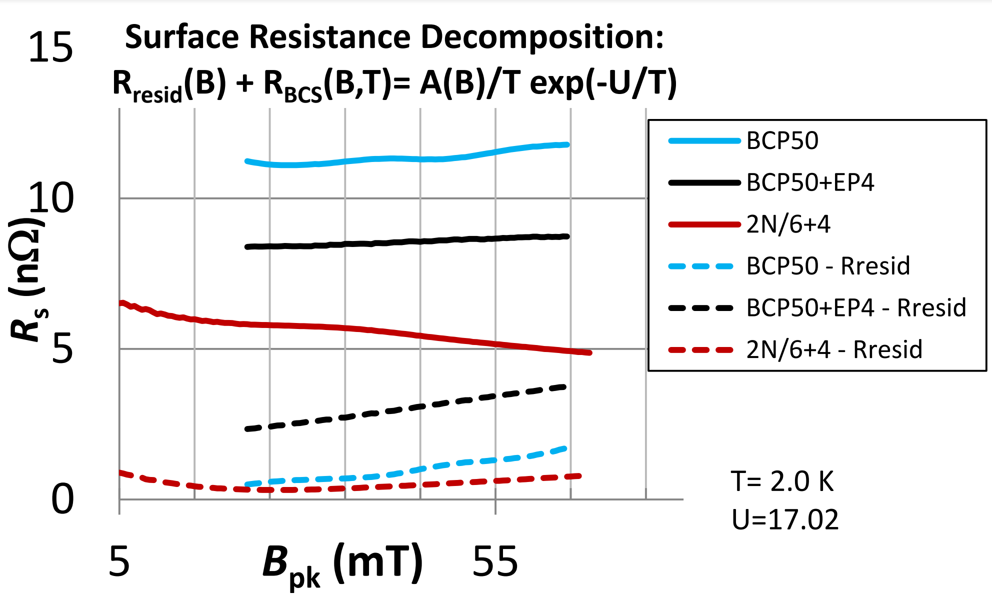
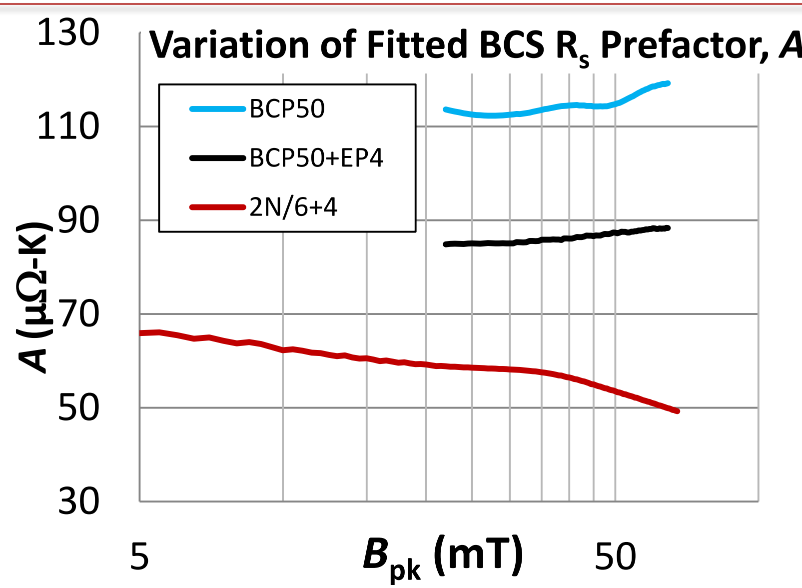


Q_0 vs. B_{pk} for single-cell cavity **RDT-5** after **BCP**, **4 µm EP**, and **2N/6+4 doping** at 2.0, 1.9, 1.8, 1.7, 1.6, and 1.5 K, together with the resulting fitted functions.





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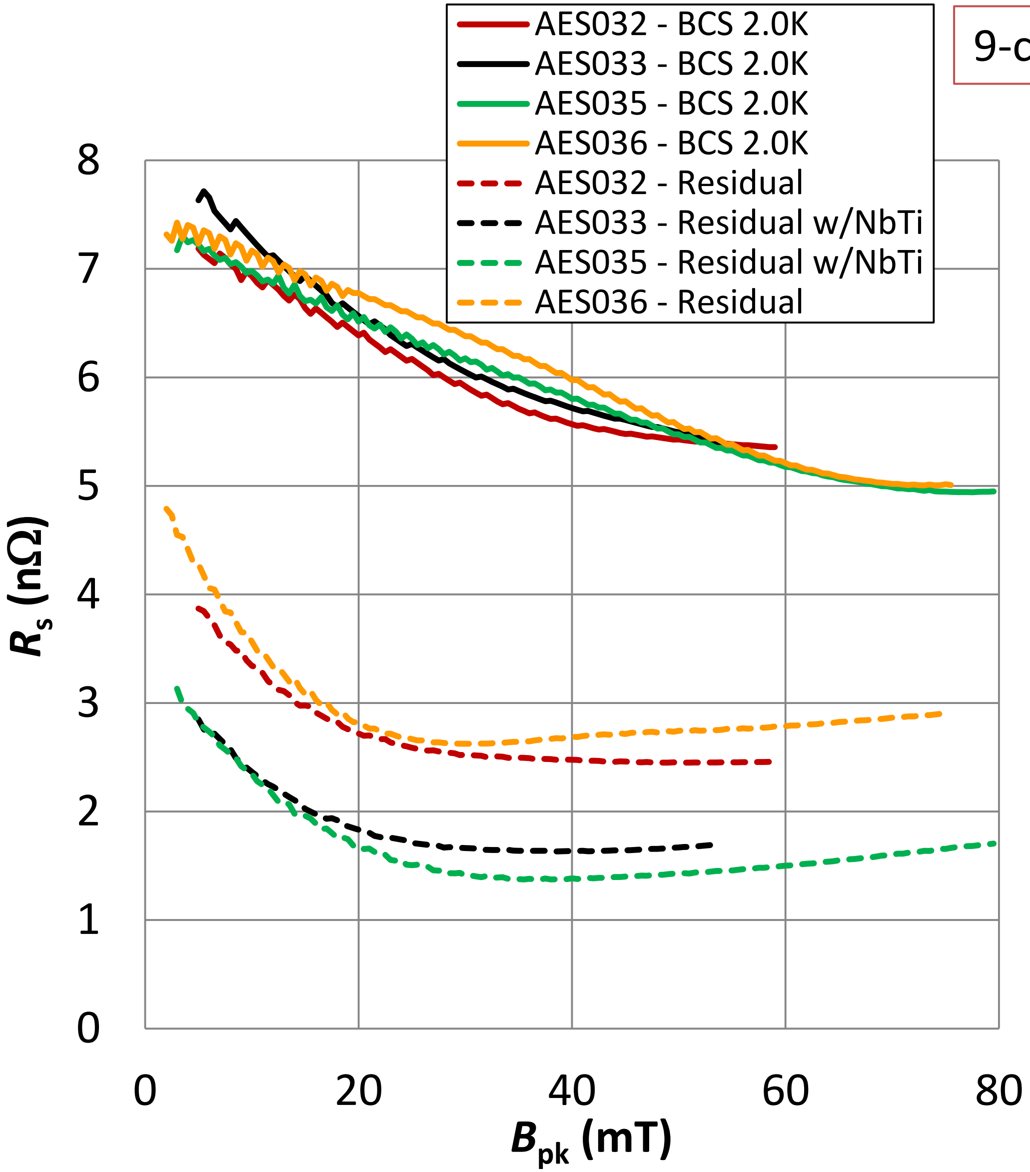
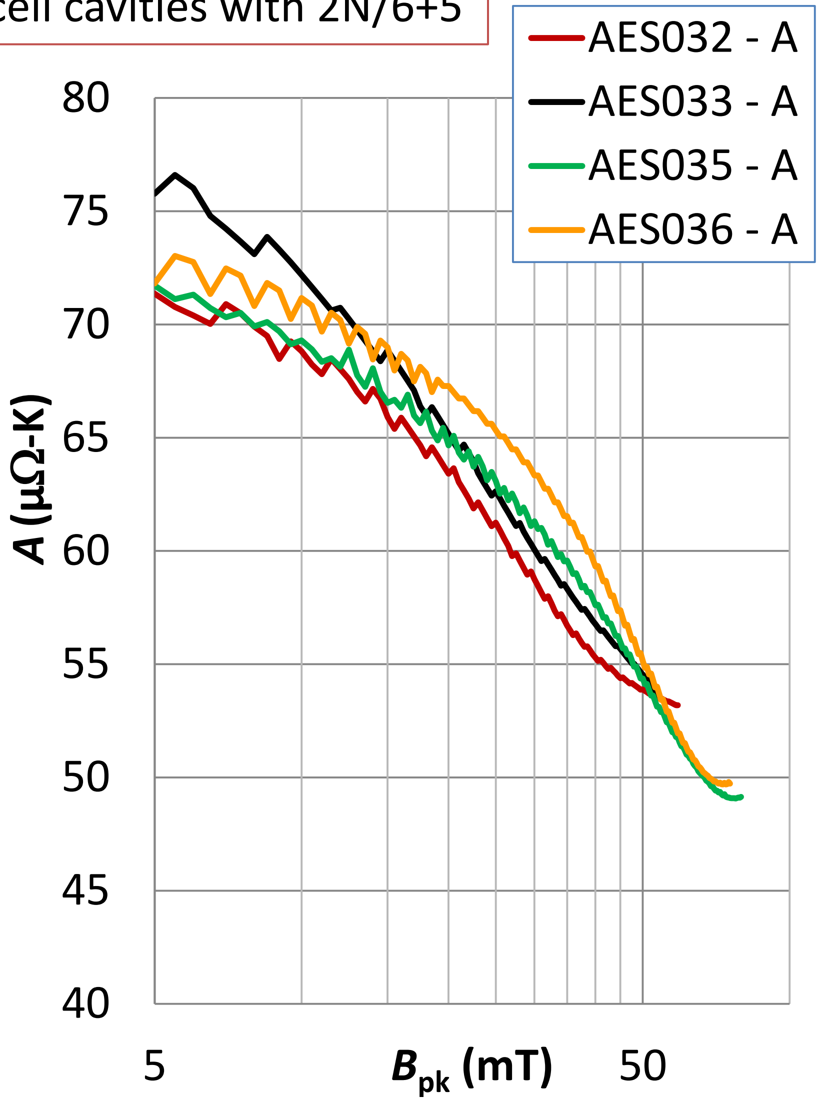
9-cell cavities with 2N/6+5





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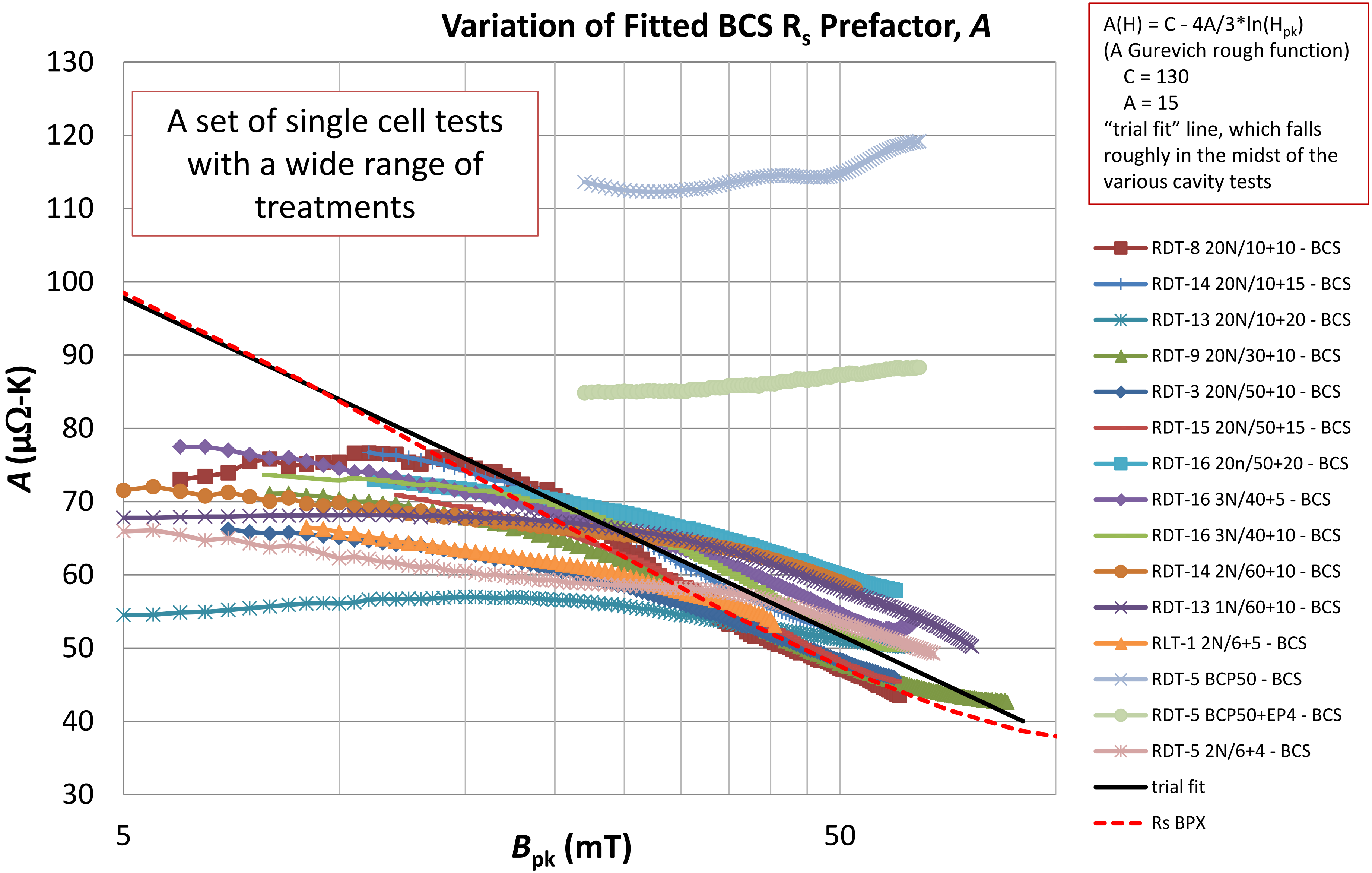

$A(H) = C - 4A/3*\ln(H_{pk})$
(A Gurevich rough function)
C = 130
A = 15
"trial fit" line, which falls roughly in the midst of the various cavity tests

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- Xiao developed an extension of Mattis-Bardeen theory to non-zero B: $R_s(B,T)$
  - This analysis noted the effects of anisotropies in the distribution function of quasiparticles due to current flow, in the limit of quasiparticle thermal equilibrium.
  - The anisotropic Fermi surface effectively induces a broadening of the peaks in the quasiparticle density of states without significantly modifying the gap.
  - The limit of thermal equilibrium constraint requires that the quasiparticle inelastic scattering time is short compared with the rf cycle.
- A much more general theoretical treatment has recently been proposed by Gurevich
- The presence of thermally annealed surface interstitials lowers the local electron mean-free-path and also significantly affects the low-temperature disposition of available hydrogen.
- Subtle differences in diffusion profiles in Nb appear to significantly affect the quasiparticle scattering, relaxation time, and availability of hydrogen for forming bonds of different types – and results in changes in $\boldsymbol{A(B_{pk})}$.
- Somehow these factors are all interrelated – the placement of atoms create all SRF properties.