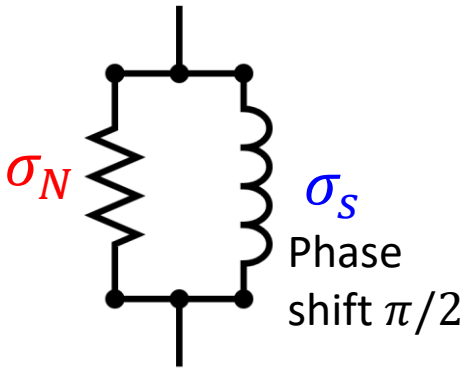
Introduction to f vs T curves in superconducting cavities

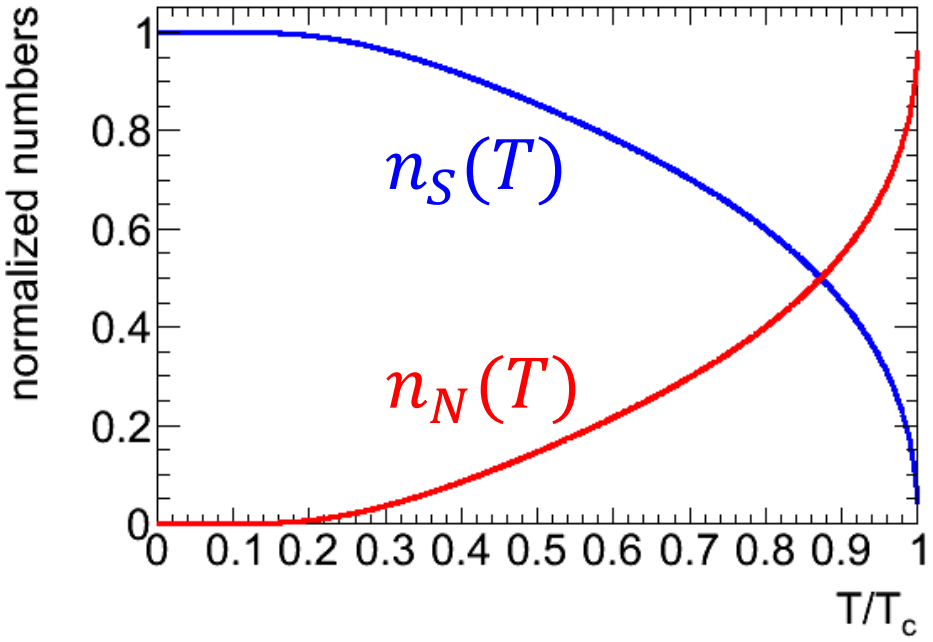
A. Miyazaki

Resonant frequency vs temperature



Surface reactance

$$X_s \equiv \mathrm{Im}\left(\frac{E_x(z=0)}{\int_0^\infty J_x(z)dz}\right) \sim \omega\mu_0\lambda(T)$$



Two fluid models

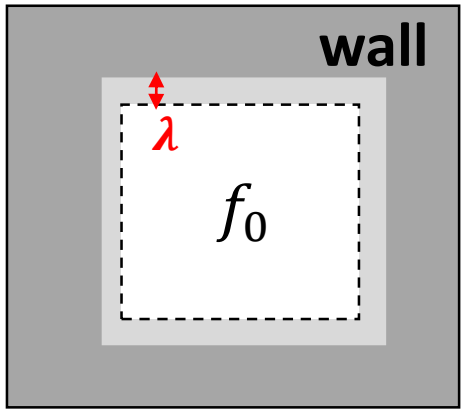
$$\lambda(T) = \frac{\lambda_0}{n_S(T)} = \frac{\lambda_0}{\sqrt{1-(T/T_c)^4}}$$

Change in penetration depth causes effective change of the cavity size and shift resonance frequency

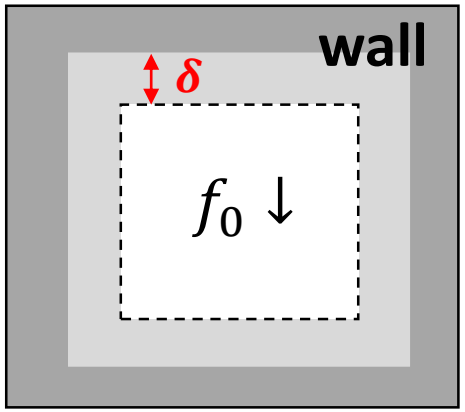
$$\frac{\Delta f}{f} = -\frac{\Delta X_s}{2G} = -\frac{\omega\mu_0\Delta\lambda}{2G}$$

The resonant frequency smoothly reaches the normal conducting value just as $\lambda \to \delta$ (skin depth)

Below T$_c$

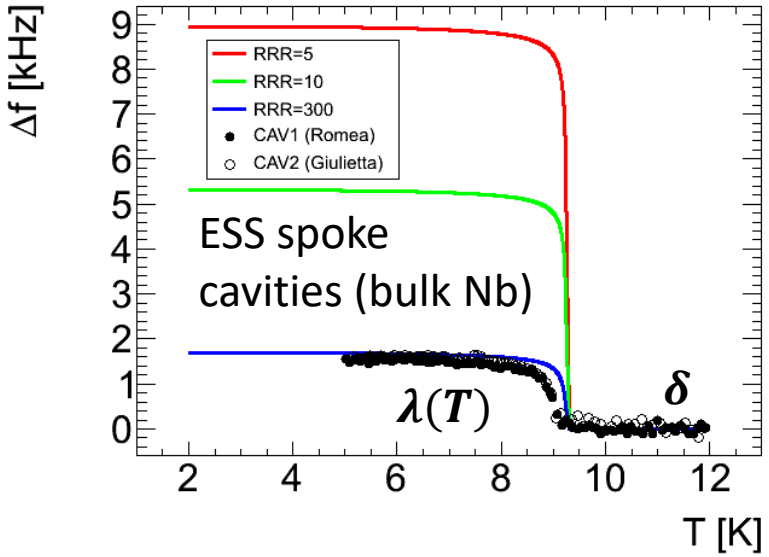


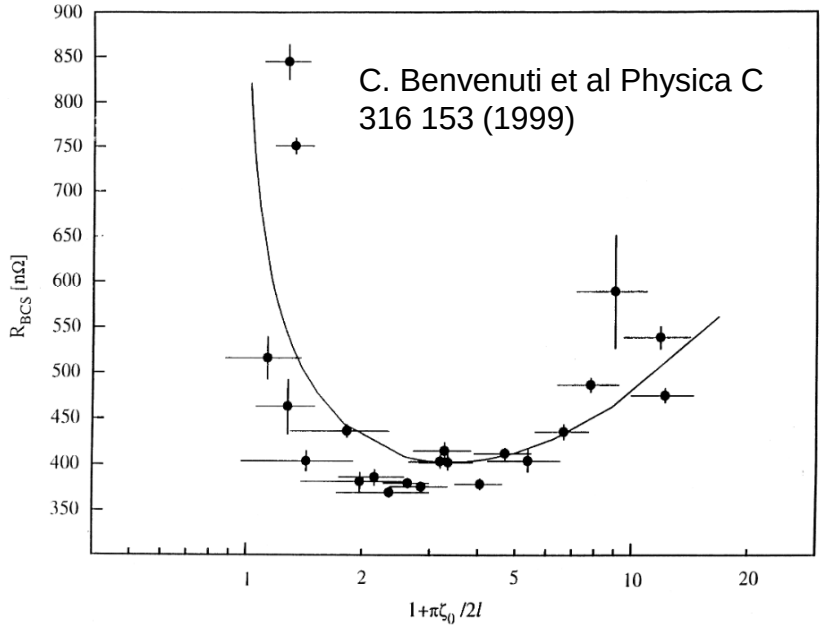
Above T$_c$

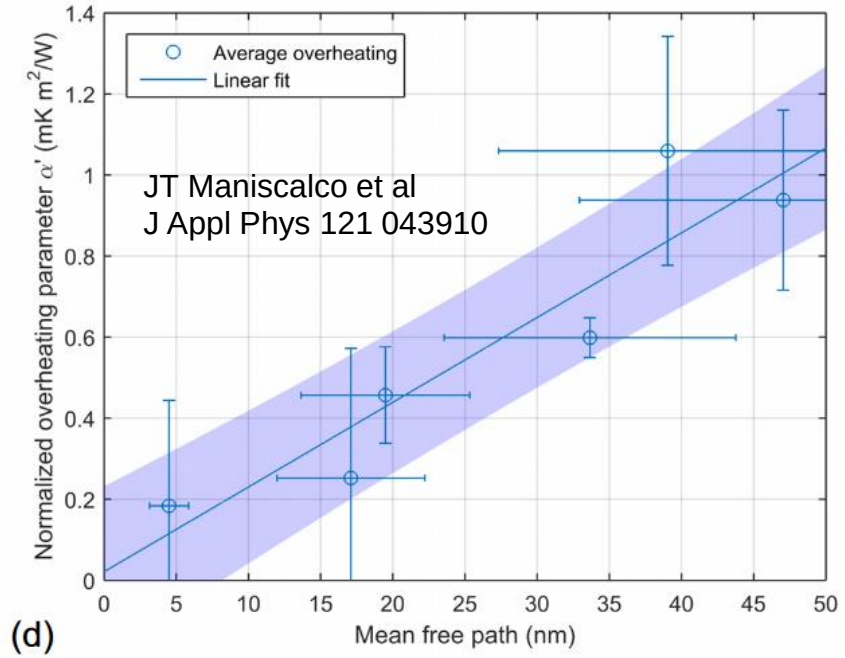


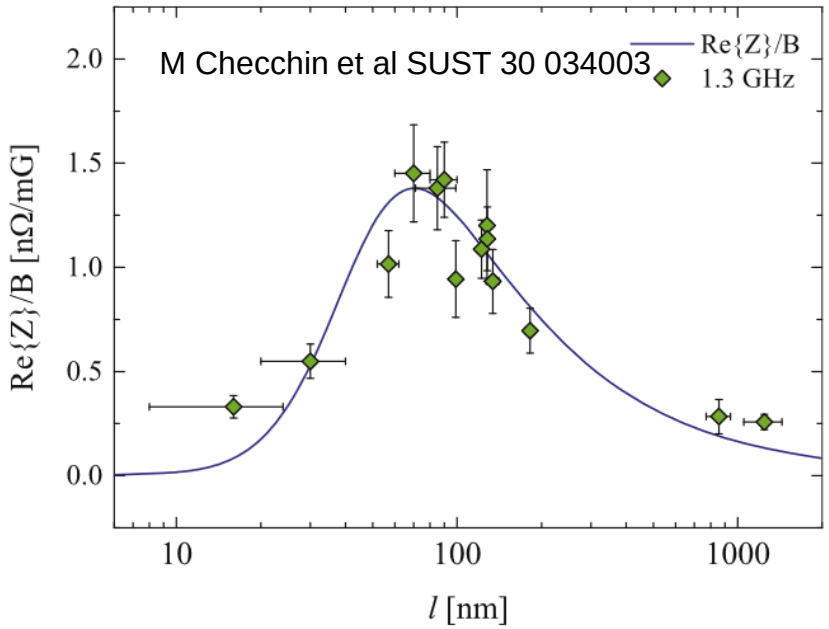
f vs T is a mean to extract $l = 2.7 \times RRR$

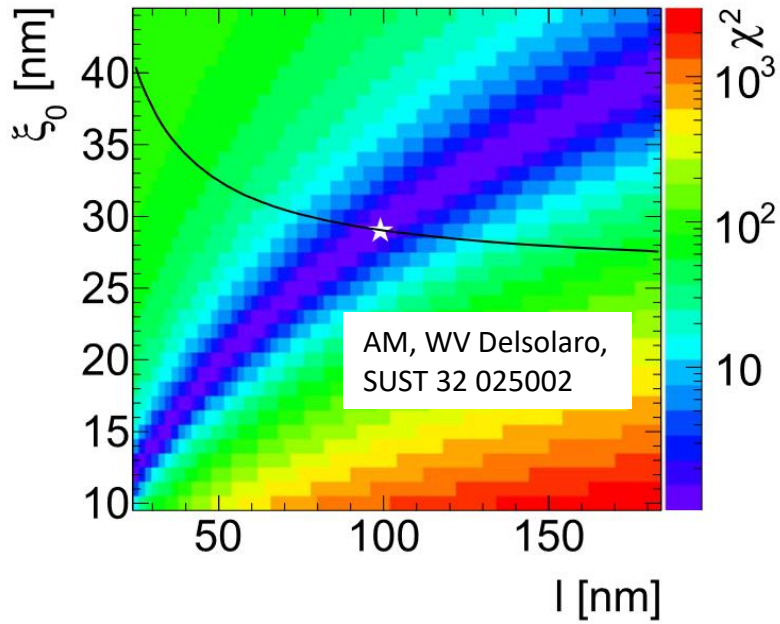
$$\lambda_0 = \lambda_L \sqrt{1 + \frac{\pi \xi_0}{2l}}$$



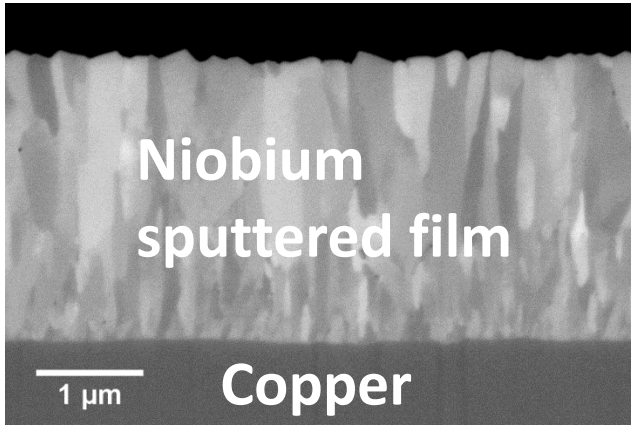




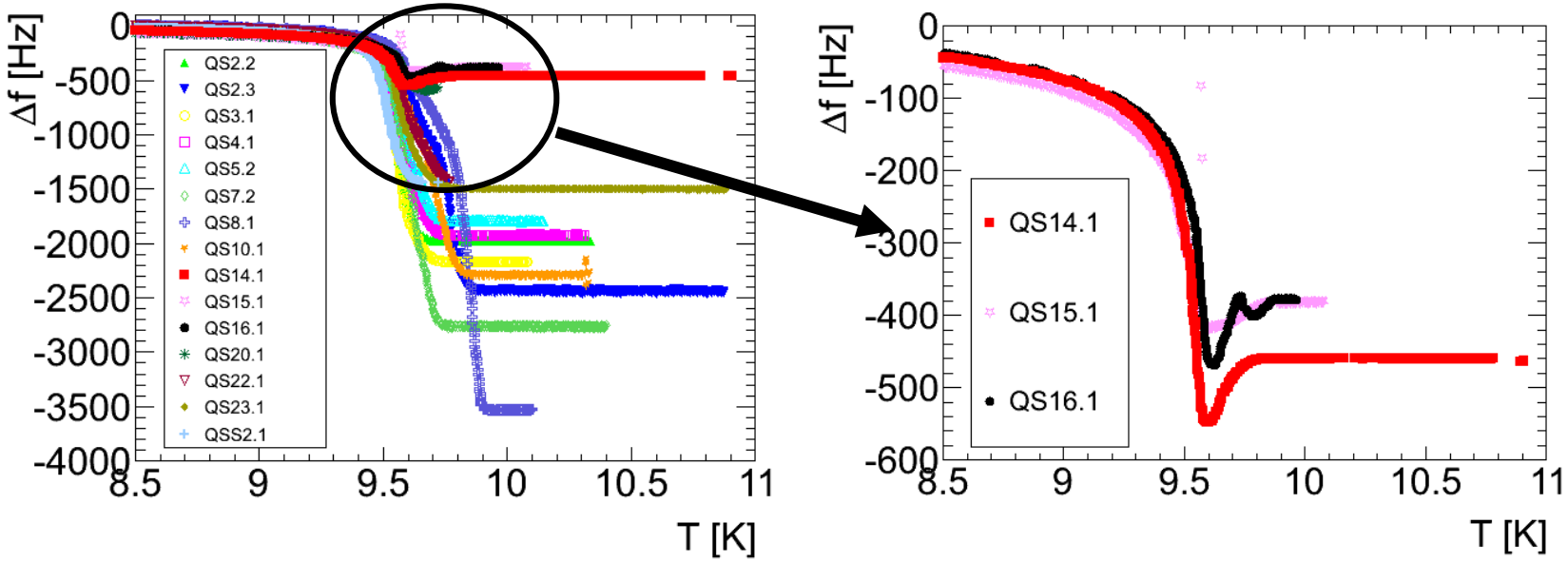




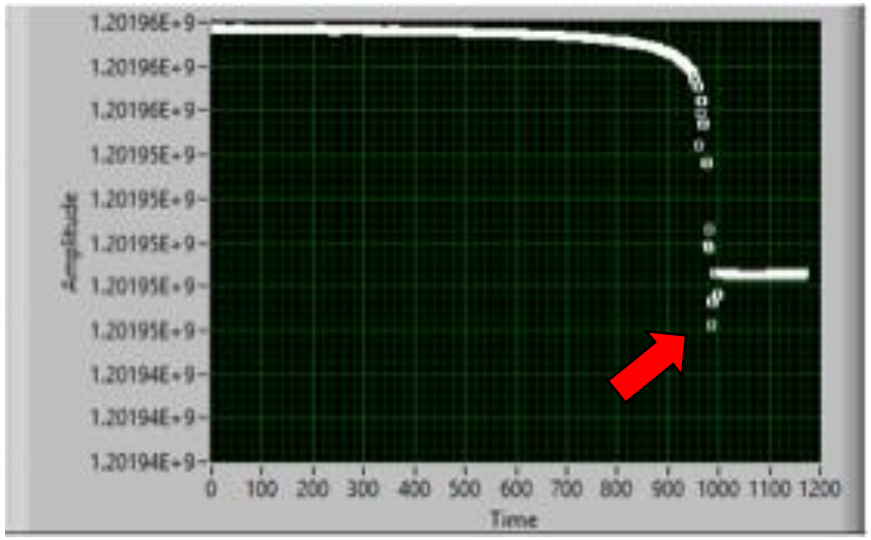
Strange phenomena in dirty cavities



HIE-ISOLDE 100 MHz



HiPIMS 1.2 GHz



- Overshoots have been observed in some Nb-film cavities at CERN but ignored for a while
- Beyond the conventional understandings of $\lambda \rightarrow \delta$
- **More information than mere mean free path?**
- Simultaneous measurement of (R_s, X_s)

$$\sigma_1(T) = \frac{2\omega\mu_0 R_s X_s}{(R_s^2 + X_s^2)^2}$$

Even more information