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## Exploring Performance Degradation in Niobium Thin Film Radio- Frequency Cavities: A Comprehensive Study

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“Niobium thin film radio-frequency (RF) cavities have historically shown performance degradation as the RF field increases, posing limitations on their use in particle accelerators where the real-estate gradient has to be maximized. This issue, often referred to as the medium field Q-slope problem, has not yet been fully understood and is currently undergoing extensive studies.

We examined the RF performance of various niobium thin film cavities reported in the literature, covering frequencies ranging from 100 MHz to 1.5 GHz. These cavities were fabricated by depositing niobium thin films using various coating techniques on copper substrates of different shapes, obtained through distinct manufacturing processes. Despite these notable differences, the performance degradation in all analysed cavities is consistently described by the same experimental law, solely dependent on RF field, resonance frequency, and temperature.

In this study, we present our analysis of the RF performance of niobium thin film cavities and evaluate how accurately the performance degradation is predicted through a systematic comparison with measurements, reported in the literature, at different resonance frequencies and several temperatures ranging from 1.9 K to 4.5 K. Based on our findings, we propose a theoretical explanation, involving non-equilibrium superconductivity, which may offer a new perspective for addressing the Q-slope problem.”

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