Synergistic Studies on Superconducting RF Cavities for Accelerator, Quantum Information Science, and Dark Matter Search Applications

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P5 Townhall

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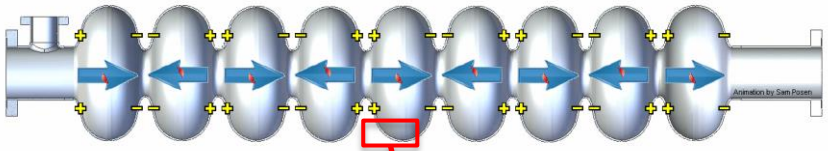
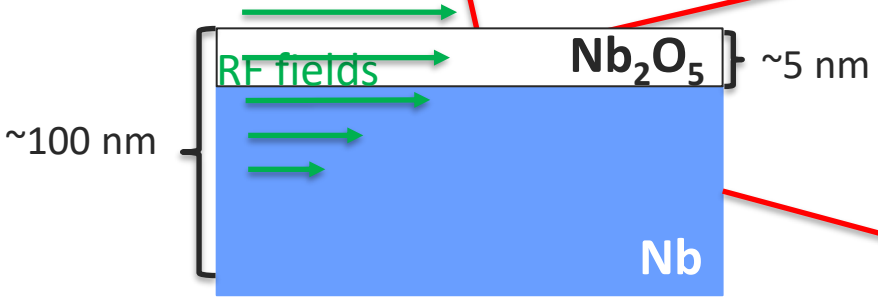
The Versatile Bulk Nb Superconducting Radio-Frequency Cavity

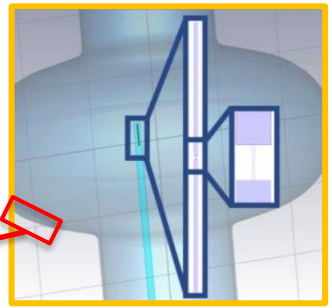
High Energy Particle Acceleration





Performance in all applications is governed by microscopic properties within the first ~100 nm from inner surface

Low Energy Quantum Computing



Dark Matter Searches (High and Low Energy)

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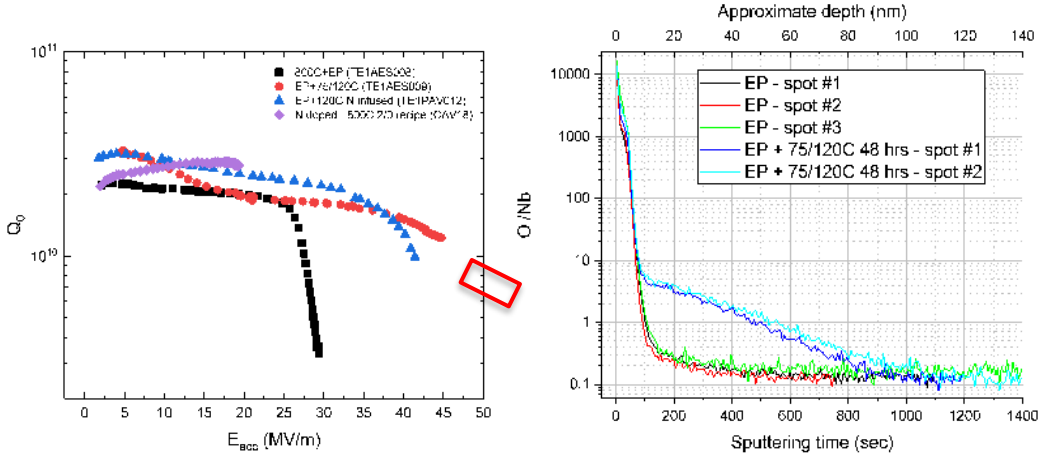
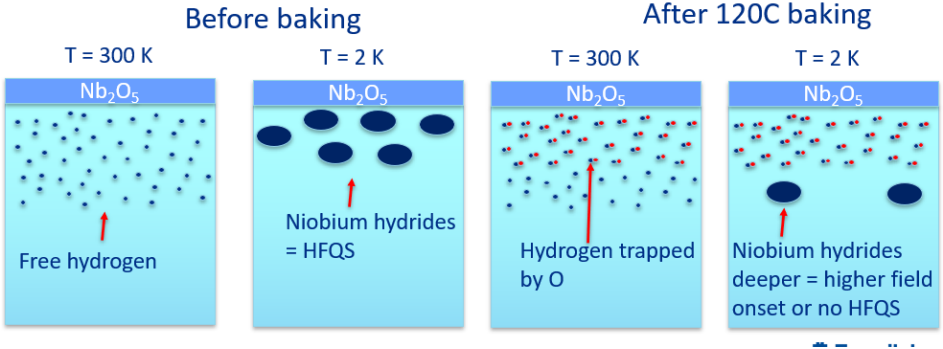
Advances in Accelerator Technology due to Material Science

- Goal of SRF accelerator R&D: simultaneously high Q and gradient
  → **Cheaper & better accelerators**
- In-depth material science studies have helped to identify several sources for for excellent cavity performance
- Such studies on the N-doping of cavities have helped to pave the way for accelerators such LCLS-II and LCLS-II HE



A. Romanenko et al, Proceedings of SRF'2019, THP014



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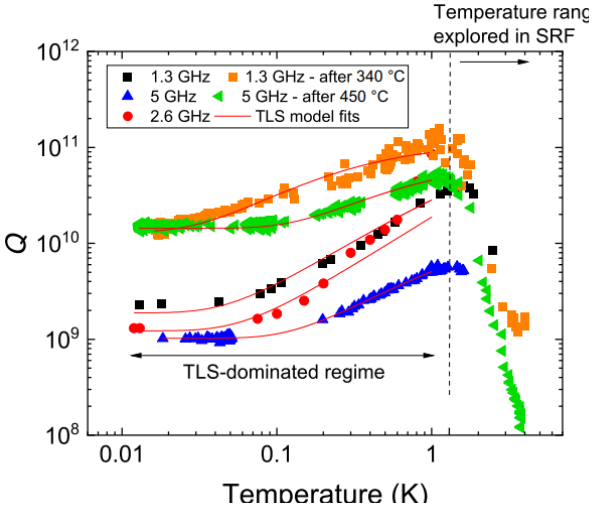
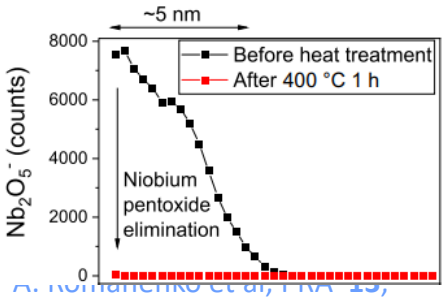
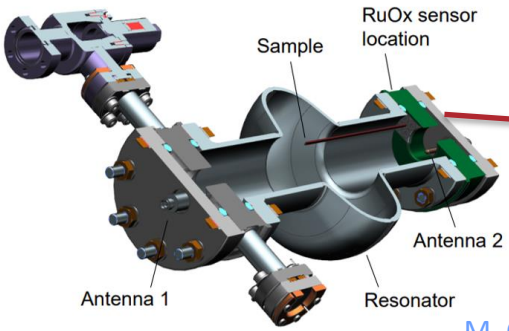
Advances in QIS Due to Material Science

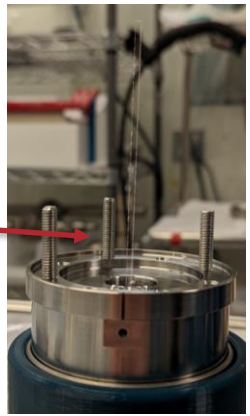
- Goal of SRF QIS R&D: Achieve highest Q_0 at mK and low field
  - **Longer photon lifetimes → better quantum computer**
  - **More sensitive probe to RF characterization of materials**
- Material science has identified two key loss mechanisms in cavities in the quantum regime
  - Enabled 10x improvement over previous state-of-the-art





A. Romanenko et al, PRA **13,** 034032 (2020)





M. Checchin *et al.* PRA **18,** 034013 (2022)

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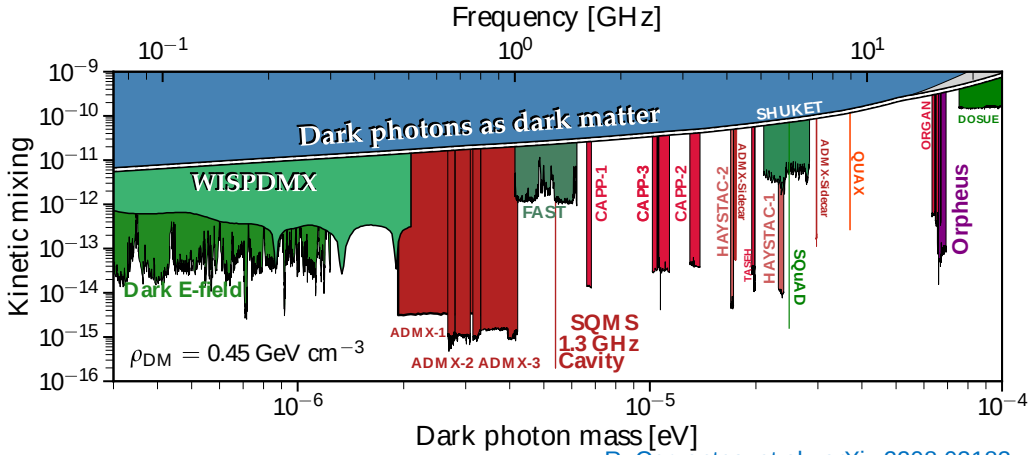
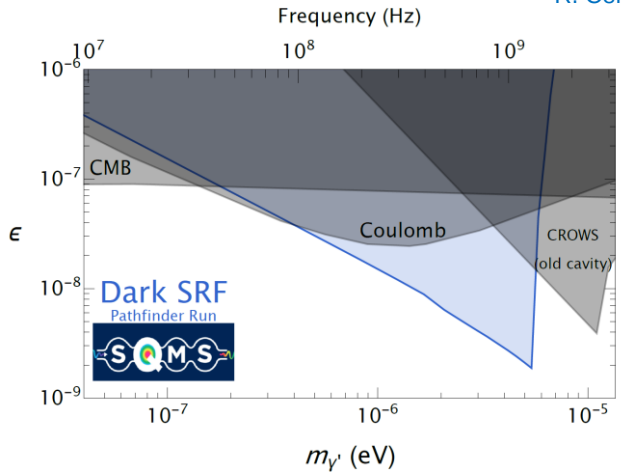
Concluding Remarks

Due to high Q and high Q/high gradient R&D, new limits on dark matter and BSM particle physics searches have been made!

Continued improvement in these cavities requires to further build up a work force that is capable of working at the intersection of material science and R&D



R. Cervantes, et al., arXiv:2208.03183 (2022)



A. Romanenko, et al., arXiv:2301.11512 (2023), accepted by PRL

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