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Flux expulsion and material properties of Niobium explored in 644-650 MHz cavities

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Upcoming projects requiring ˜650 MHz medium-to-high-beta elliptical cavities such as Michigan State University's Facility for Rare Isotope Beams'energy upgrade and Fermilab's Proton Improvement Project-II drive a need to understand magnetic RF loss mechanisms in greater detail. It remains to be seen whether flux trapping mitigation techniques used in 1.3 GHz cavities are as effective at ˜650 MHz, given differences in cavity geometry, material of manufacture vendor, and frequency-dependent superconducting RF dynamics. We explore the fast-cooldown method, and high-temperature annealing (900℃), which promote flux-expulsion efficiency, but are more difficult to implement in ˜650 MHz cavities. In high-power RF testing, we measure the cool-down temperature gradient vs flux expulsion efficiency, the cavity's residual resistance sensitivity to trapped flux as a function of cavity treatment. We further used the Physical Property Measurement System available at Fermilab to directly measure the flux pinning force in bulk niobium samples, and correlate changes in the flux pinning force with different niobium vendors, heat treatments, and cavity flux expulsion performance.

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