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C2Or4B-04: Accelerator cavity quench spot detection using particle tracking velocimetry

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Superconducting Radio-Frequency (SRF) cavities cooled by superfluid helium-4 (He II) are critical components of modern particle accelerators. Tiny defects on the inner surface of SRF cavities can cause Joule heating, leading to cavity quenching. Developing reliable technologies to locate these defects for subsequent removal is essential for improving the performance of SRF cavities. Existing methods for detecting quench spots, such as temperature mapping and second-sound trilateration, are often limited in precision and practicality. Our lab has demonstrated an alternative detection technique based on Molecular Tagging Velocimetry (MTV) in He II, which provides significantly improved spatial resolution. However, the complexity of the laser facilities required for MTV makes it challenging to implement in accelerator laboratories.
In this study, we investigate a novel method utilizing Particle Tracking Velocimetry (PTV) with solidified deuterium (D_2) tracer particles. A preliminary experiment was conducted using a miniature heater in He II to simulate a cavity quench spot. Our results show that the velocity field of the tracer particles near the heater can accurately localize the heater's position. Given the simplicity and practicality of the PTV setup, this method shows great potential as an alternative approach for quench detection in accelerator labs.

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