Experiments on a conduction cooled superconducting radio frequency cavity with field emission cathode

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High Charge Electron Beam Accelerator

High charge (>100 mA) electron beam accelerators have applications ranging from building new radiation sources to medical applications and water treatment in large metropolitan areas. The high charge beam can be obtained with continuous wave (CW) operation of the accelerator and electron bunch emission rate close to the operating RF frequency. SRF cavities can enable both these features.

Conduction Cooled SRF Cavity Development

SRF cavities are usually cooled with liquid helium. However, they can also be conduction-cooled with compact, closed-cycle 4K cryocoolers as demonstrated by Dhuley et al. The technique is demonstrated in figure 1.

Initial experiment on the Conduction Cooled Cavity with Niobium Emitter Support

The experimental set-up is shown in figure 3. The goal is to achieve average gradient CW ~1 MV/m at $Q_0 \sim 10^{10}$.

Steps to Reach the Target Gradient

The limiting factors for the present experiment are:
1) Low coupling between the input antenna and the cavity
2) The Niobium emitter support is not coated with Nb$_3$Sn.

By overcoming the above factors, the projected performance of the whole experiment set-up is shown in figure 5.

Summary and Future Plans

The experimental set-up has been successfully operated to produce 0.32 MV/m on a 650 MHz Nb$_3$Sn Cavity containing a Niobium emitter support. The future plans involve redesign of the input antenna and coating the Niobium emitter support with Nb$_3$Sn to reach the target gradient.

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