THE MAGNETIC FIELD PENETRATION MEASUREMENT OF THIN FILM AND MULTILAYERED SUPERCONDUCTORS FOR SRF CAVITIES

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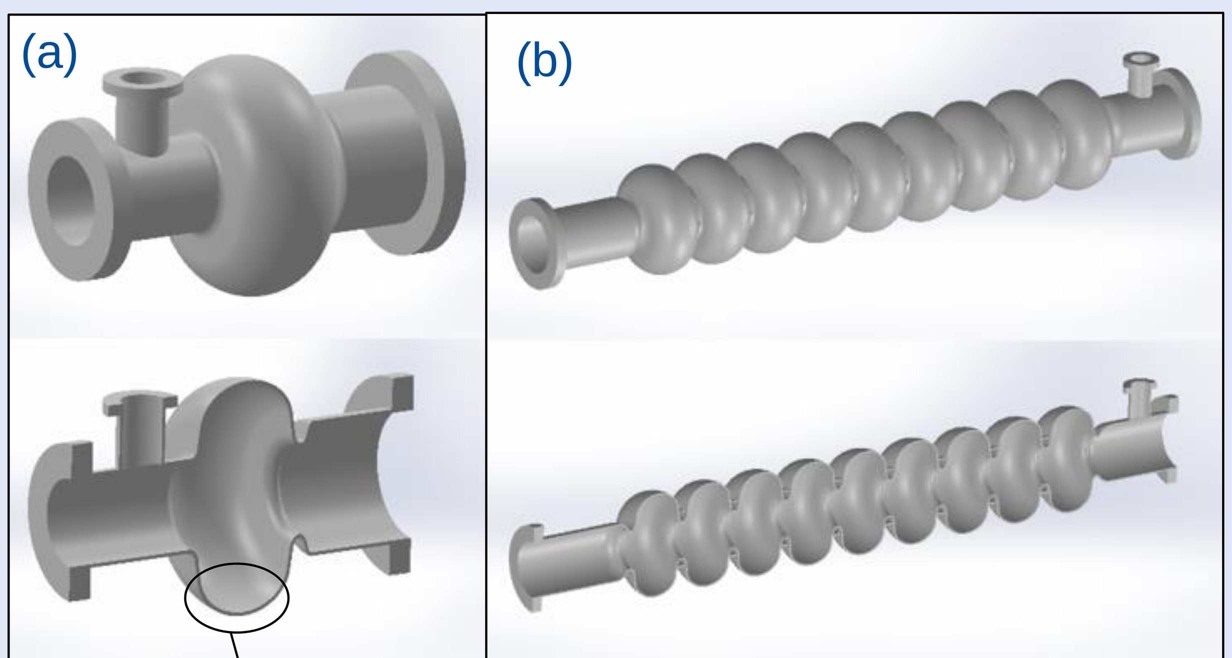
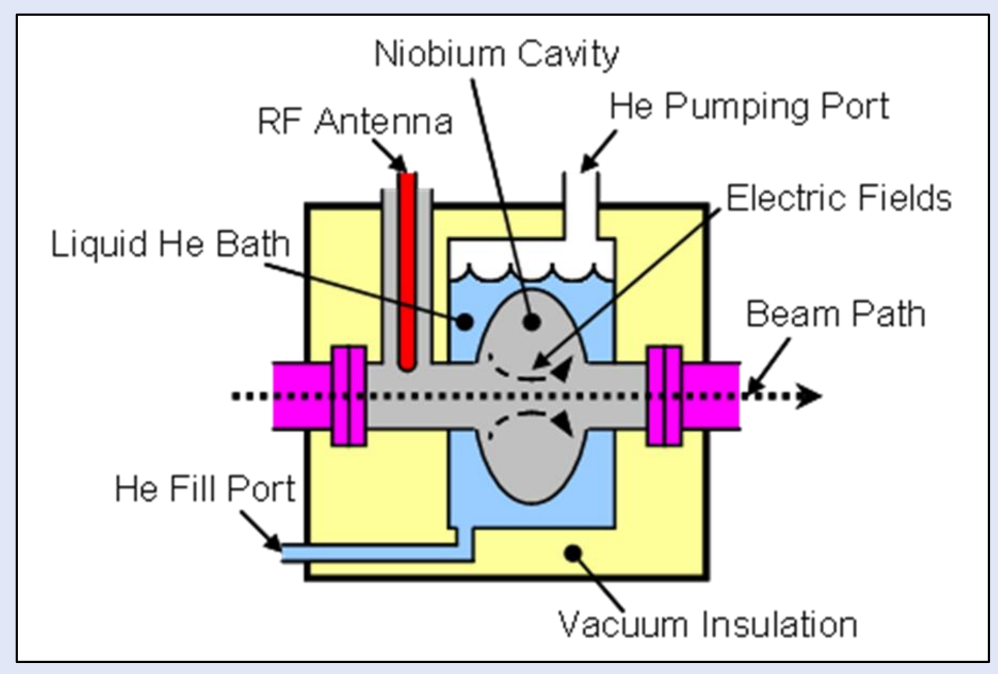
ABSTRACT

Radio Frequency (RF) cavities are used in particle accelerators and they are typically formed from or coated with superconducting materials. High purity **niobium** is the material of choice for SRF cavities and niobium cavities operate at their theoretical field limits. SRF researchers have begun a significant R&D effort to develop alternative materials to improve the performances of SRF cavities. To achieve high performance with high accelerating gradient, cavity material should have an ability to persist in superconducting state under high magnetic field without magnetic flux penetration through the cavity wall. Therefore, **the magnetic field at which first flux penetrates** is a fundamental parameter to characterize superconducting materials for SRF cavities. This leads to investigate a simple, efficient, and accurate technique to measure the penetration of the magnetic field directly. The conventional magnetometers are inconvenient for thin superconducting film measurements because these measurements are strongly influenced by orientation, edge, and shape effects. In order to measure the onset of field penetration in bulk, thin films and multi-layered superconductors, we have designed, built and calibrated a system combining a small superconducting solenoid capable of generating surface magnetic field higher than 500 mT and Hall probe to detect the first flux penetration through the superconducting sample. This setup can be used to study various promising alternative materials to niobium, especially **SIS multilayer coatings** on niobium that have been recently proposed to enhance the accelerating gradient by delaying the flux penetration into niobium surface.

INTRODUCTION

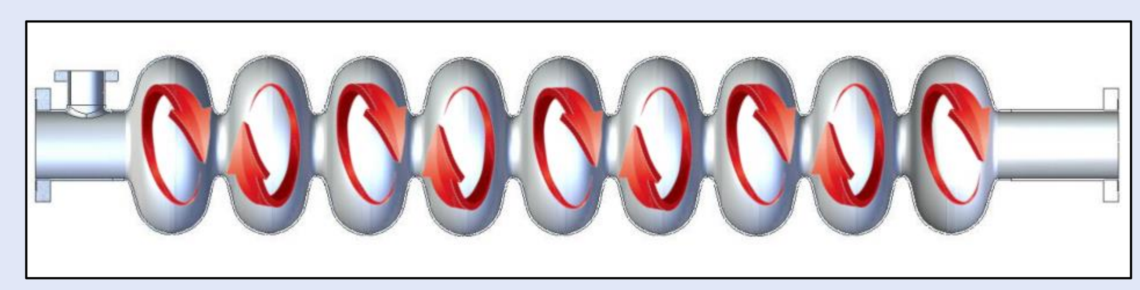


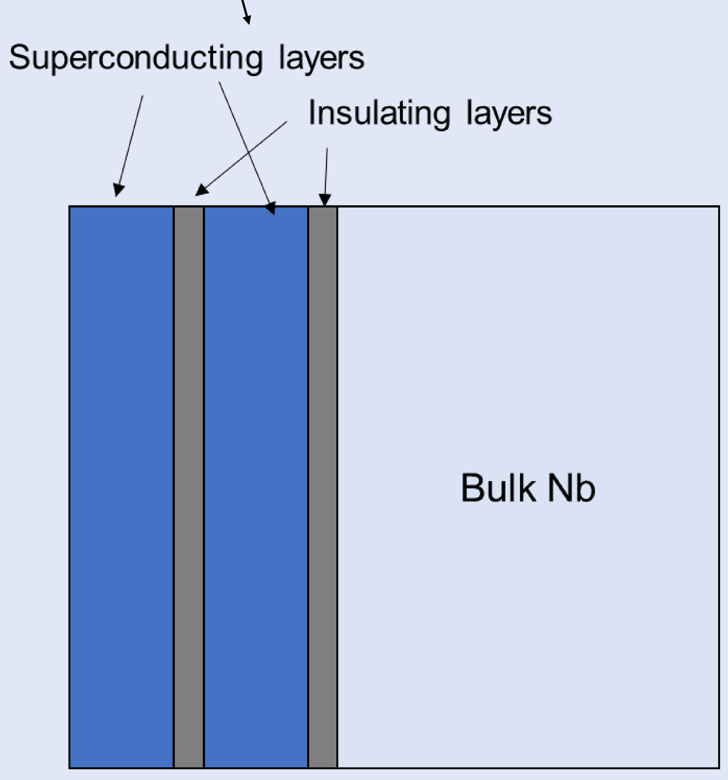
Niobium SRF Cavity (a) single cell (b) 9-cell

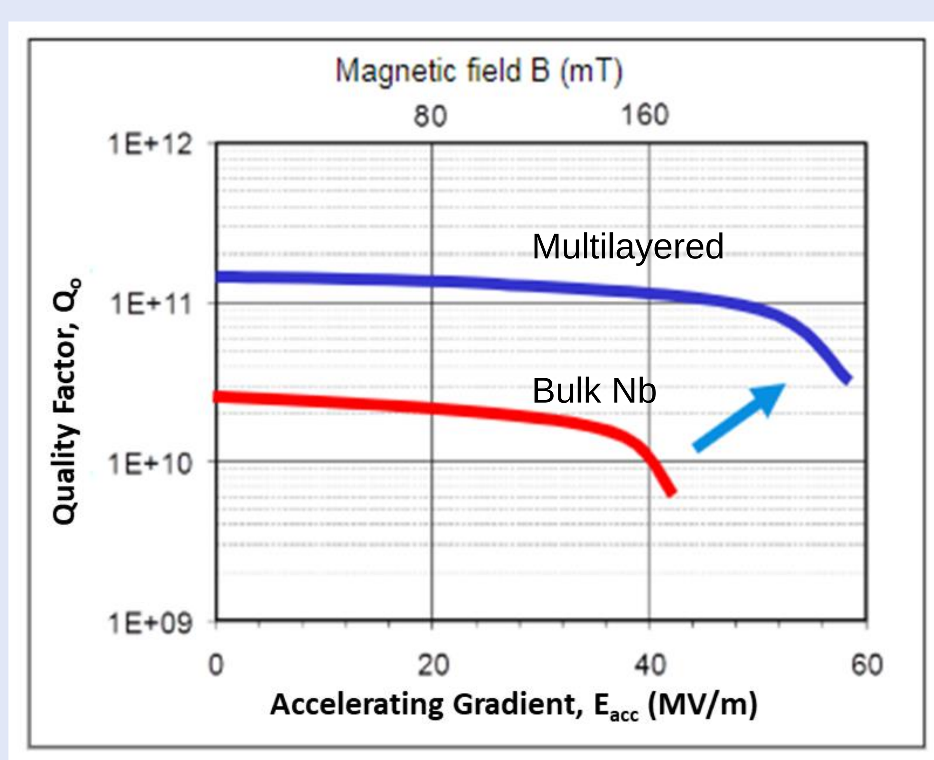


An SRF cavity in a helium bath with RF coupling and a passing particle beam

- SRF cavity: high quality EM resonator
- Particle beam gains energy as it passes through
- **Electric field** provides acceleration
- **Magnetic field** interact with cavity wall
- Performances of niobium cavities are limited by **peak surface magnetic field**





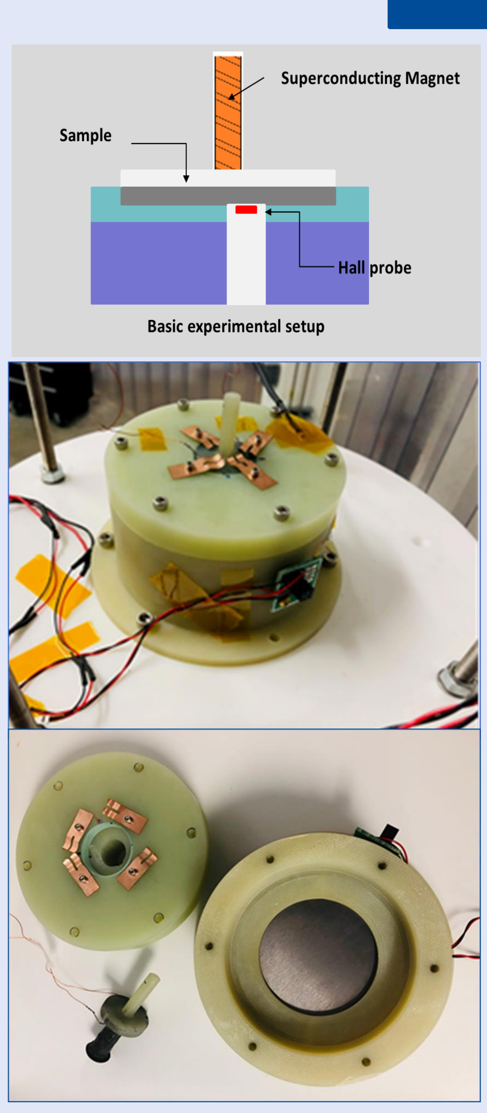


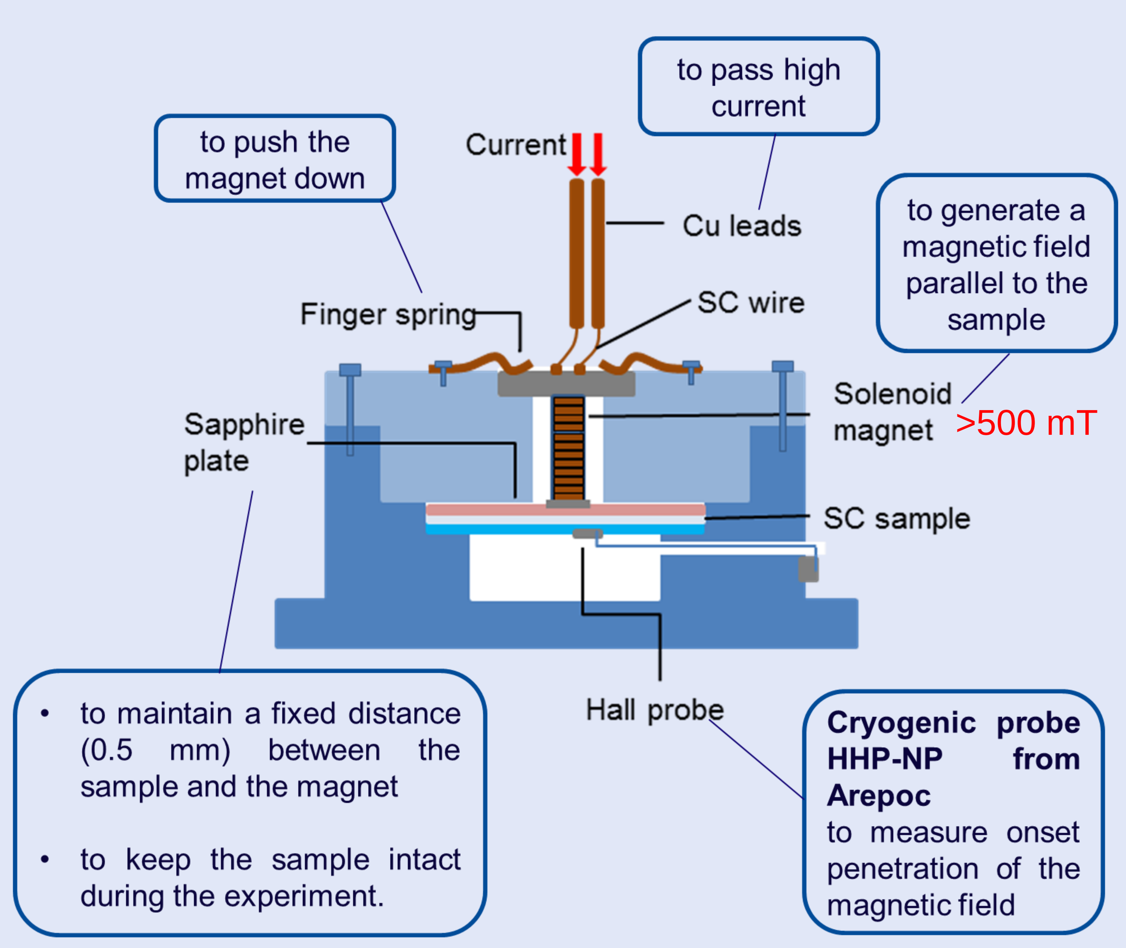
Multilayer coatings on niobium inner cavity wall protects cavity at high **surface magnetic field** and pushes performance curve to higher level

Objectives

- Design, build and calibrate a simple, efficient and accurate technique to measure onset magnetic field penetration directly
- Study multilayers for SRF cavity applications through Magnetic Field Penetration Measurements
- Characterize materials for multilayers using Magnetic Field Penetration Measurements

EXPERIMENTAL SETUP

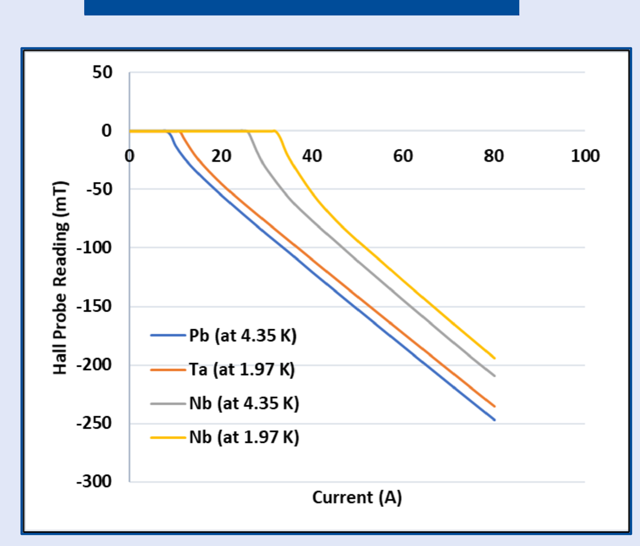




Schematic cross section of detailed experimental setup

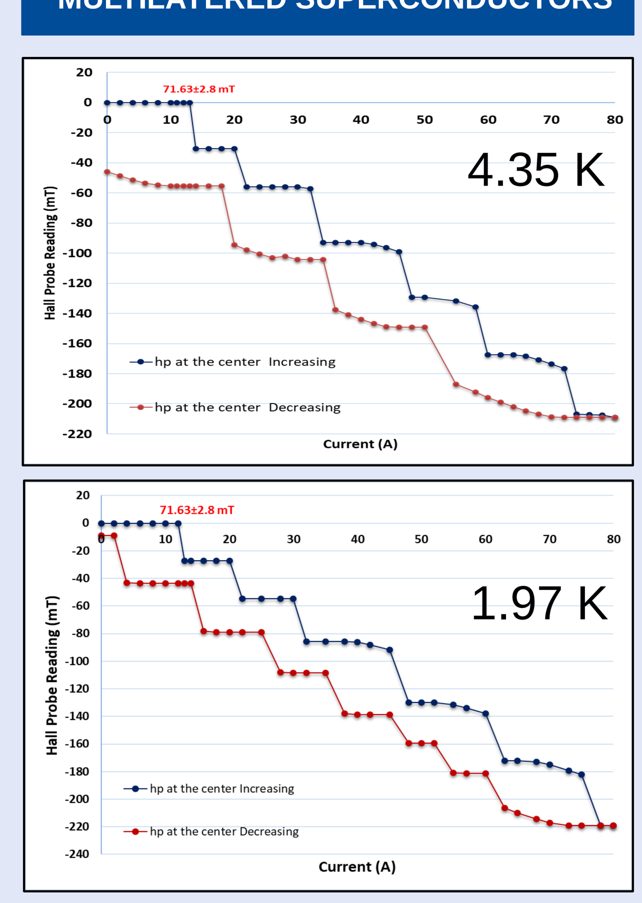
MEASUREMENTS

BULK SUPERCONDUCTORS



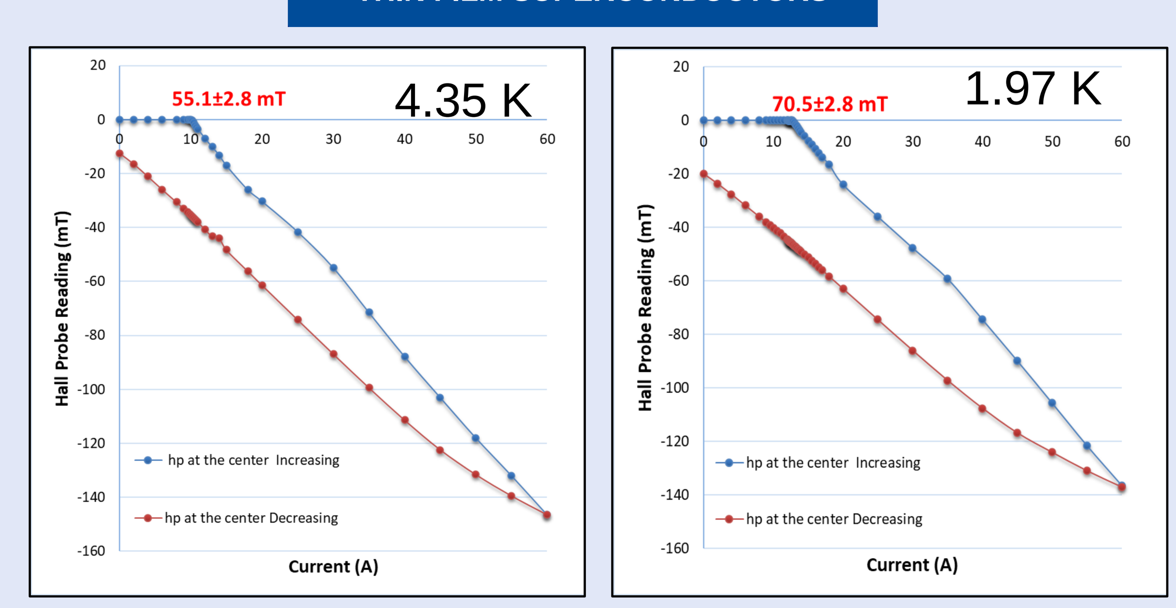
Pb, Ta, Nb bulk samples with thickness 100 µm

MULTILAYERED SUPERCONDUCTORS

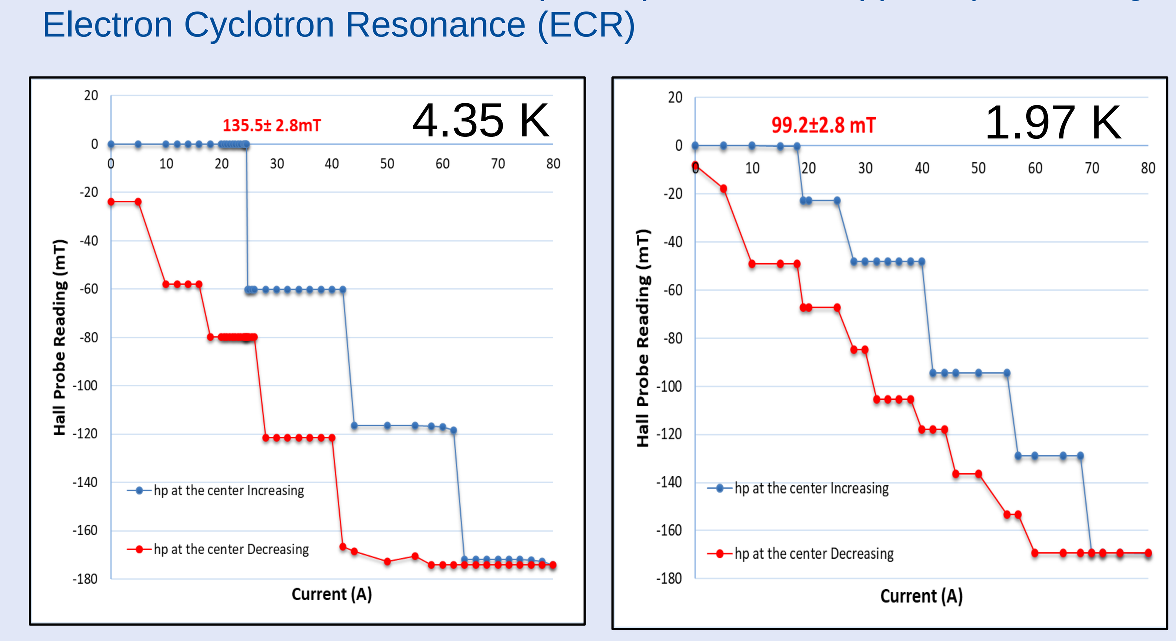


Alternative 4 layers of Nb_3Sn and SiO_2 on Nb thin film fabricated on sapphire substrate

THIN FILM SUPERCONDUCTORS



Nb thin film with thickness 3.0 µm deposited on sapphire plate using Electron Cyclotron Resonance (ECR)



Nb_3Sn thin film with thickness 1.5 µm deposited on sapphire plate using Magneton Sputtering

CONCLUSION & FUTURE WORK

- The new experimental setup for magnetic field penetration measurements of superconducting samples was designed, built and calibrated successfully at Jefferson Lab. This experimental system is appropriate for bulk samples as well as thin films.
- Future measurements are mainly focus on study of the multilayer system for SRF cavities.

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