TRIUMF

Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

Measuring magnetic flux entry in niobium samples using μSR and βNMR

With applications in SRF cavity development

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Introduction

•μSR and βNMR can be used to obtain a better understanding of how magnetic flux enters SRF cavities and degrades the beam quality. This will lead to improved cavity fabrication processes.

•μSR is used as a method of probing the local magnetic field in a material by implanting spin polarized muons into a sample and observing the direction of the positron decay.

•Recent studies have shown a correlation between the field of first flux entry into niobium samples with various surface treatments as observed by μSR and the onset of high field Q slope in RF cavity tests.

•μSR is now being used to find the field of first flux entry and pinning strength of niobium in different geometries and surface treatments.

•In the future we hope to use βNMR to take a depth profile of SRF samples in high perpendicular fields.

Transverse Field μSR

•In Transverse field μSR a beam of spin polarized muons is deposited into a sample in an external field perpendicular to the polarization of the muons.

•An asymmetry signal is created by taking the difference in counts from 2 positron detectors positioned opposite each other

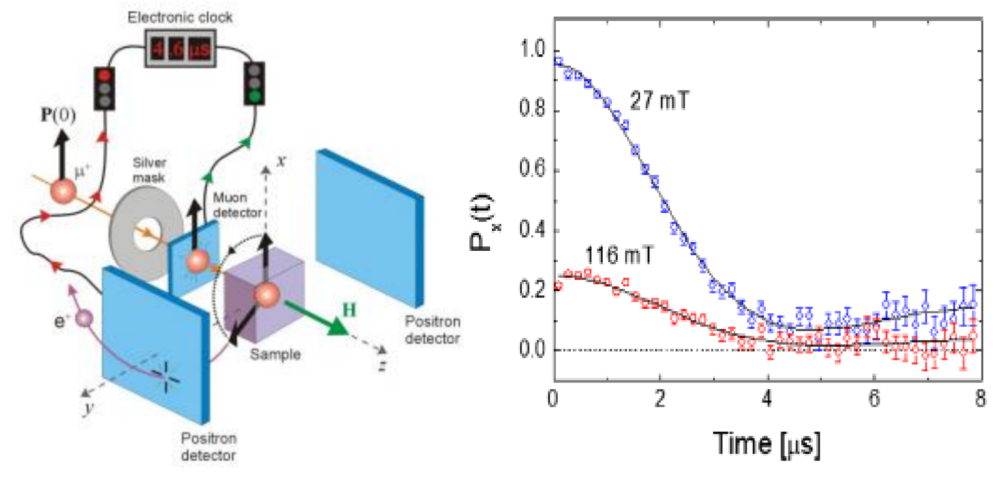

Figure 1: Left: Layout of a typical transverse field μSR experiment, Right: Asymmetry signal seen at 2 different strengths of field

•The frequency of the asymmetry signal is proportional to the field observed by the muons

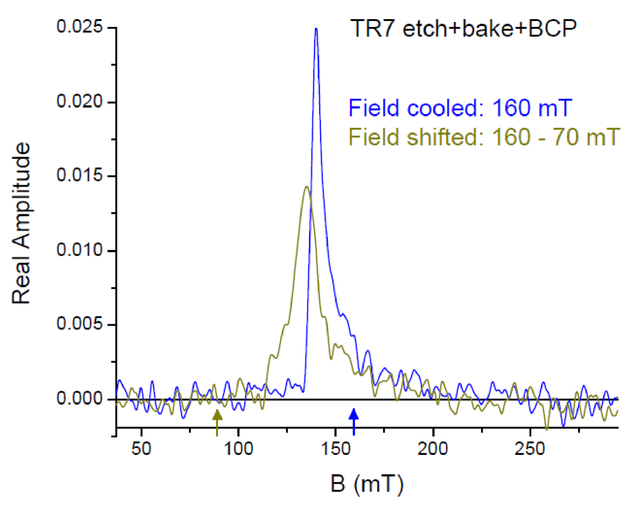

Figure 2: FFT of asymmetry at 2 different fields

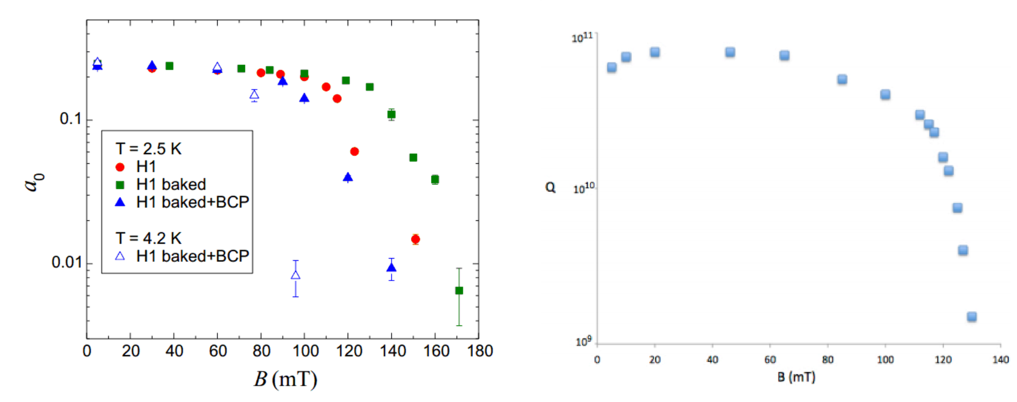

Figure 3: Left: asymmetry vs field strength for a set of ZFC runs, Right: RF cavity test showing HFQS.

Recent Results

•In October 2012, forming and annealing was observed to affect the flux entry in niobium samples

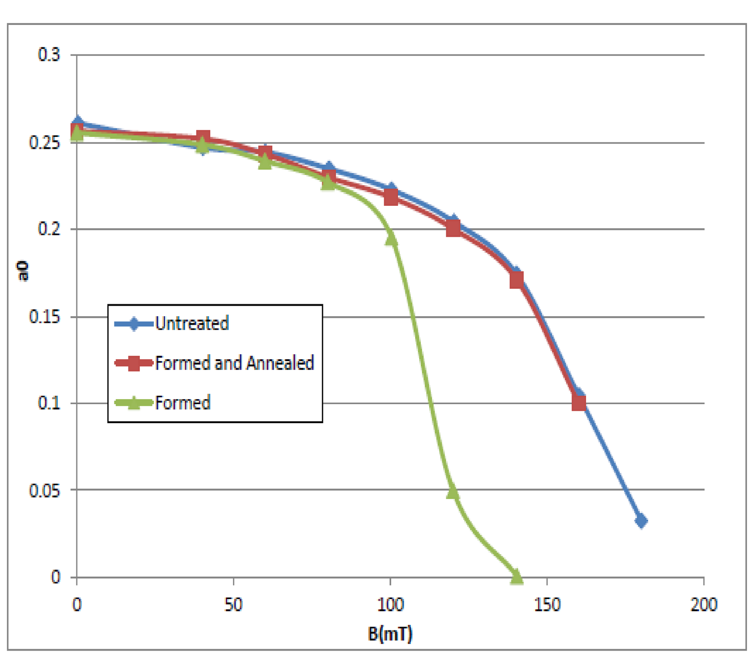

Figure 4: μSR results from formed, unformed, and formed and annealed niobium samples

•Different silver masks were also used in the 2012 set of runs to observe how pinning enters a sample

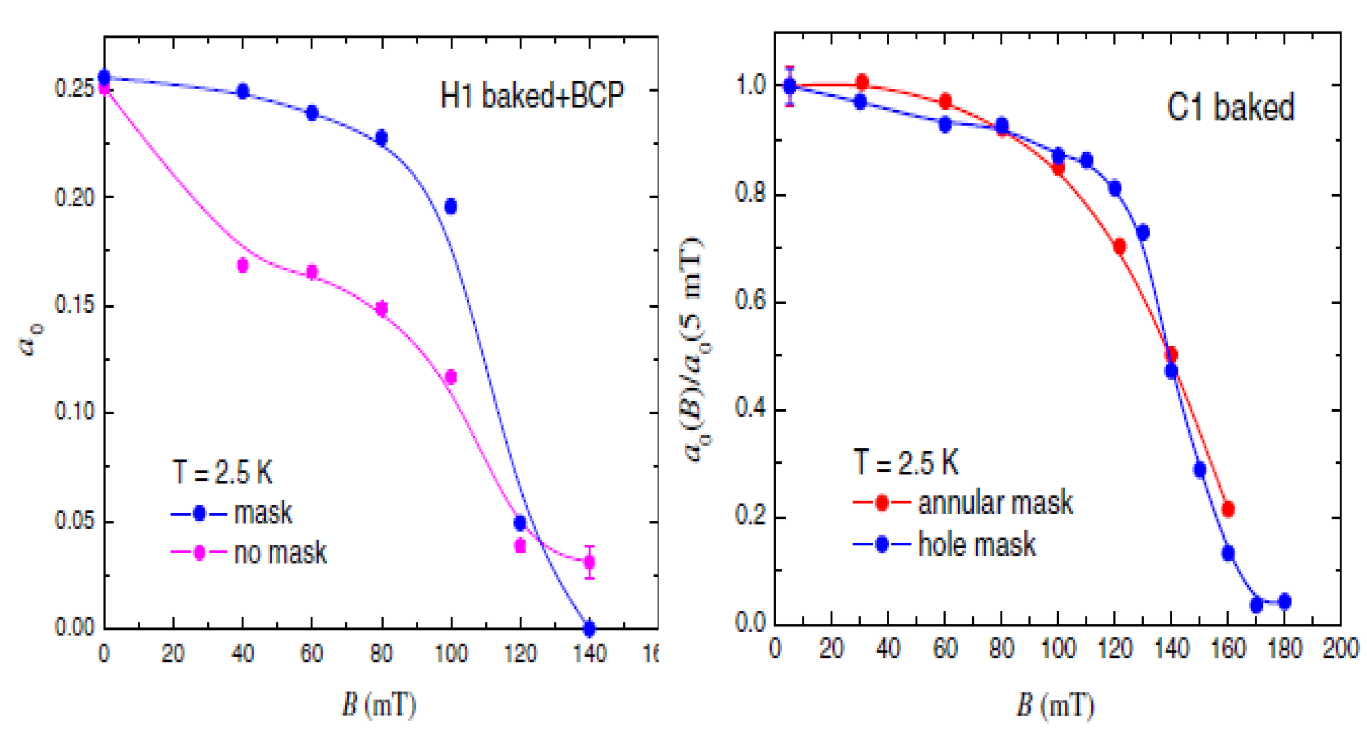

Figure 5: Results from a center hole mask, annular mask, and no mask runs from October 2012

• In September 2013 more formed, unformed, and high temperature baked samples were tested, as well as different geometries (ellipsoids).

•The pinning in niobium samples followed Brandt's 2000 paper "Superconductors in realistic geometries: geometric edge barrier versus pinning"

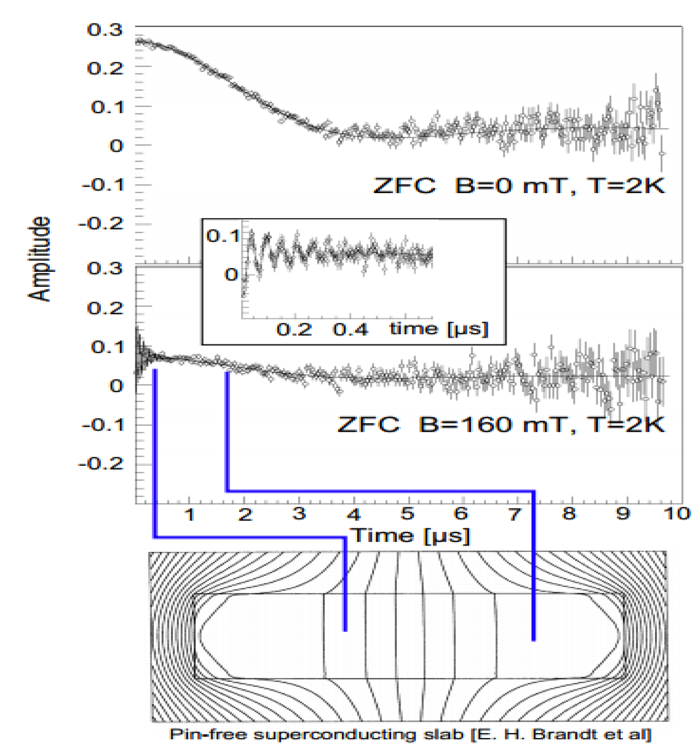

Figure 6: Results from a 0mT and 160mT run from Sept 2013 and a picture of the Brandt model of field penetration into a flat sample

βNQR extension for future measurements

•Ideally, some measurements would be taken in a field parallel to the sample surface to better simulate what an SRF cavity experiences.

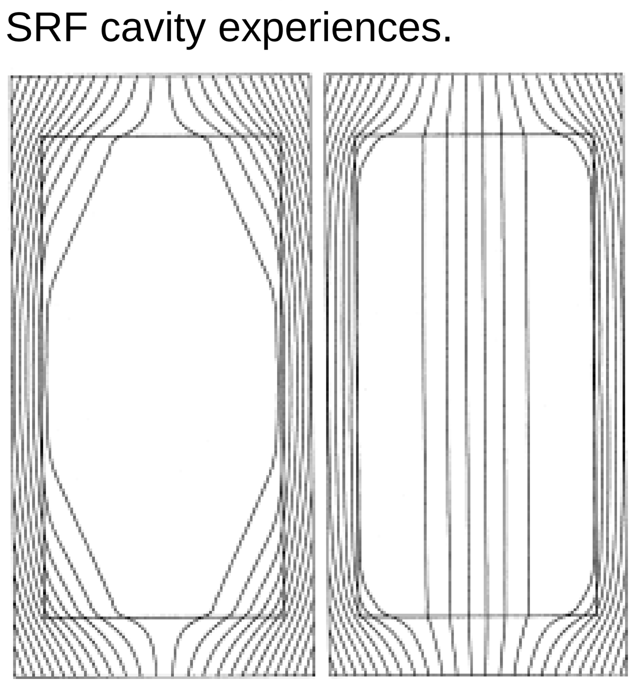

Figure 7: field lines penetrating a sample of b/a=2 from Brandt 2000 paper

•TRIUMF has designed an extension to it's βNQR beam line which would allow a field of up to 2KG parallel to the sample surface

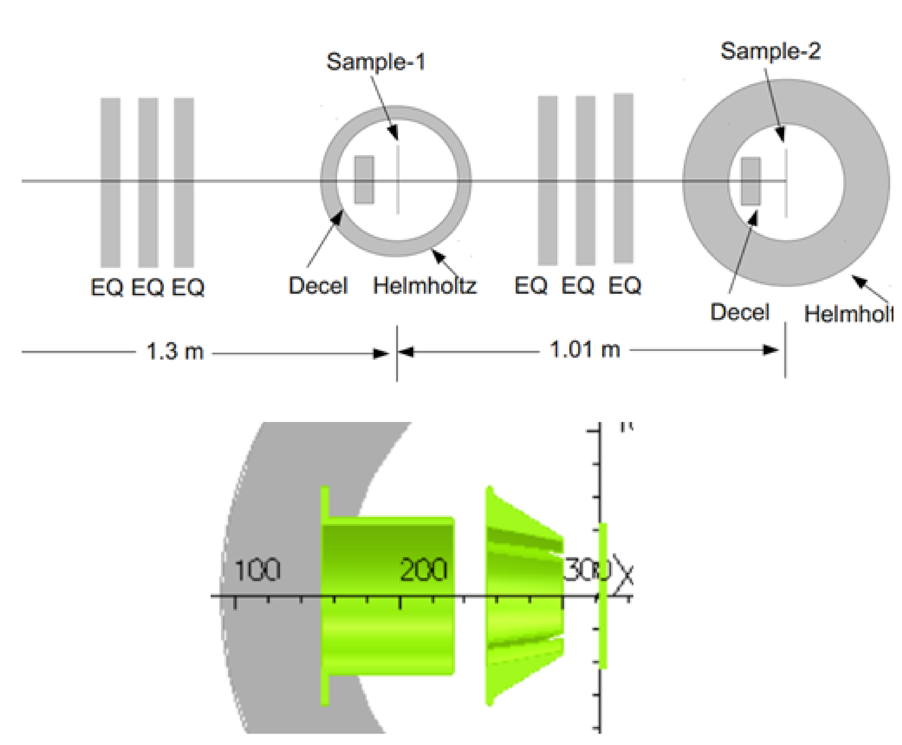

Figure 8: Layout of the proposed βNQR extension and new quadrant decelerator design

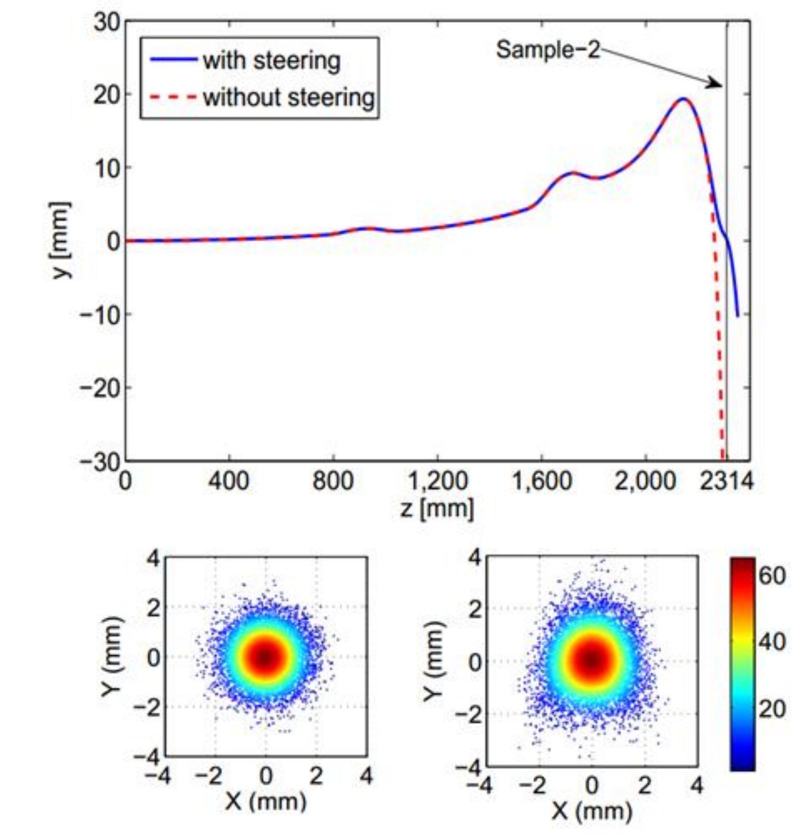

Figure 9: Top: Simulation of the βNQR extension beam deflection in a 2KG field. Bottom: simulation of the change in beam profile from entering the beam line (left) to arriving at the sample (right) in a 2KG field

Future Work

•A surface roughness study and further pinning studies are planned for spring 2014 to see if the increase in local field about a microscopic bump has a noticeable affect on the field of first flux entry

•Further geometry studies using ellipsoids are needed.

•The fabrication of the βNQR extension and design of a new spectrometer needs to be completed.

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