First μSR measurements of SRF samples in strong parallel fields

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Introduction

Muon Spin Rotation (μSR) is a powerful tool to probe local magnetism in matter and hence can be used to diagnose the entry of magnetic flux in superconductors. Previous measurements were done with applied magnetic fields perpendicular to the sample face. A new spectrometer has been developed that allows for sample testing with a field varying from 0 to 300 mT applied along the sample face which is analogous to RF fields in SRF resonators. The geometry is characterized by small demagnetization factors which lead to a reduction in pinning and edge effects on the field of first flux entry. The beamline installation and first results of the parallel field experiments are presented in the poster.

Parallel Field (PF) μSR

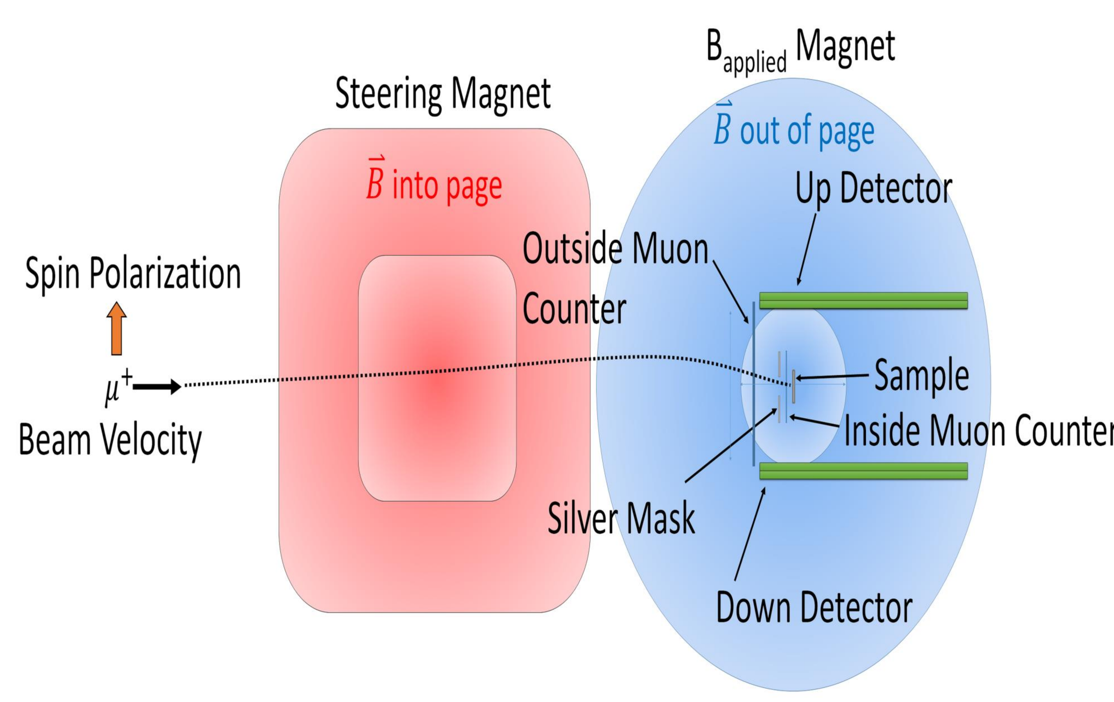

Figure 2 – Schematic of PF-μSR and beam trajectory of the spectrometer.

- PF-μSR leads to smaller demagnetization factors and less pronounced edge effects. The boundary conditions are also much closer to that of magnetic fields in SRF resonators.
- By doing this we can possibly draw conclusions on the behavior of treatments of niobium that can lead to better cavity performance.

Parallel Field Spectrometer

- The parallel field spectrometer was installed on TRIUMF's M20 C-leg. The spectrometer consists of a magnet which provides the applied field to the samples, a magnet to compensate for beam deflection due to the presence of the Lorentz force, two muon counters which determine the location of the muon and two positron detectors (up and down) which determine the location of emitted positrons.
- The beamline delivers muons with an energy 3.87 MeV +/- 6%. The muons consequently stop at an average distance of 100 μm (bulk) in the niobium. A silver mask is used to make sure muons land only in the center of the sample.

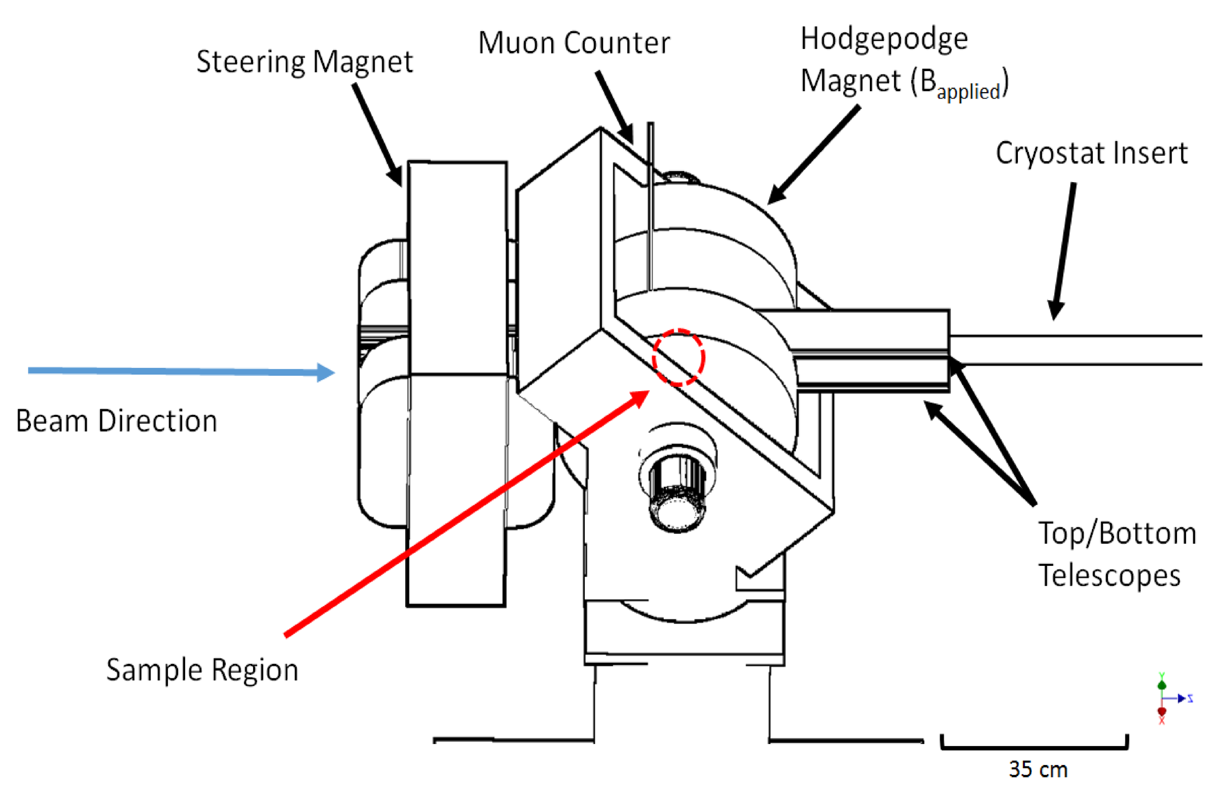

Figure 2 – 3D render of the PF-μSR spectrometer.

Samples

- Four disk-shaped niobium (3x20mm) samples were tested.
- Sample treatments include:
  - **-TR8** – Untreated (FNAL)
  - **-TR5** – 1400° C bake for 5.5 hours + 120 μm BCP etch (FNAL)
  - **-TR9** – Nitrogen doped + EP etch (FNAL)
  - **-CF1** – Nb_3Sn (Cornell)

*Parentheses indicate sample providers.

Results

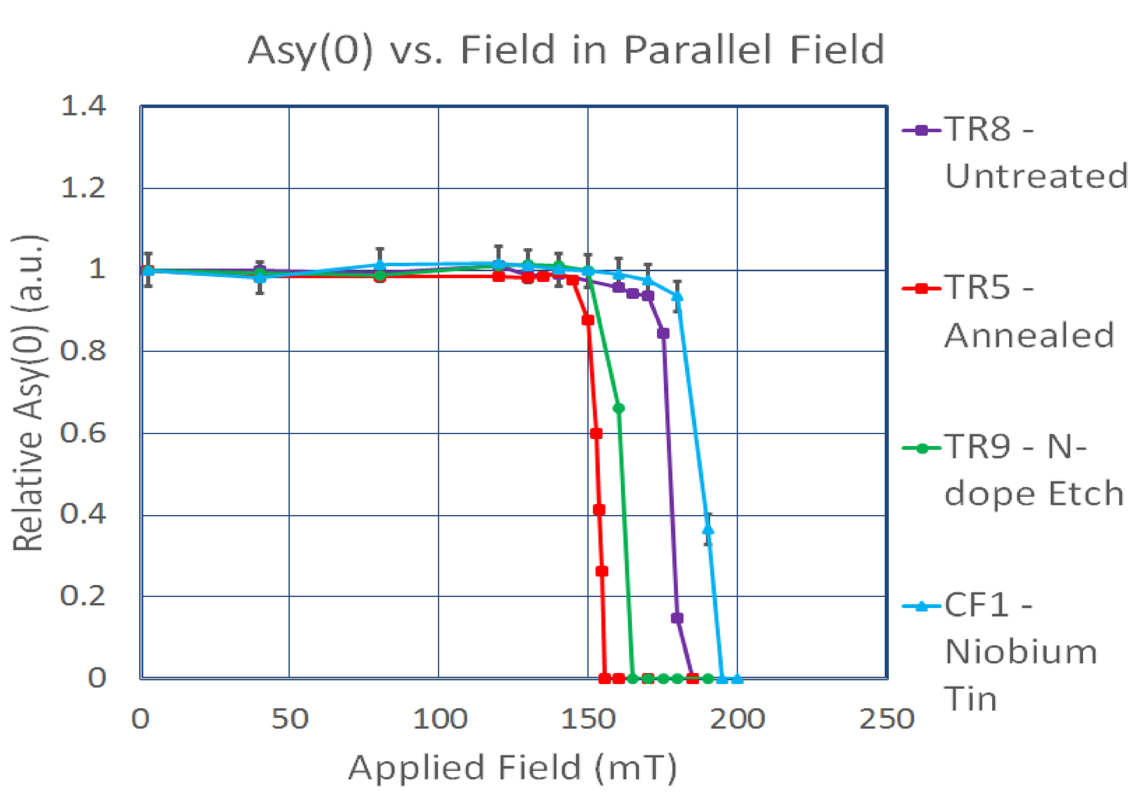

Figure 3 – Plotting "Relative Asy(0) vs. Applied Field" values illustrates the transition from the meissner state to the mixed state in PF.

- Field of first entry levels close to H_{c1} of Nb, 170mT for all samples.
- Steep slopes imply sudden transition from the Meissner state through the mixed state to the normal state.
- Small demagnetization factors, a consequence of the geometry, lead to relatively high field of first entry
- Pinning appears to be less impactful in parallel field, compared to Transverse Field (see MOPB050).
- CF1 (bulk Nb coated with 2 μm of Nb_3Sn) displays high field resistance up to 190 mT at 2K. This is above all Nb values found here, however below the expected the superheating field of Nb3Sn.

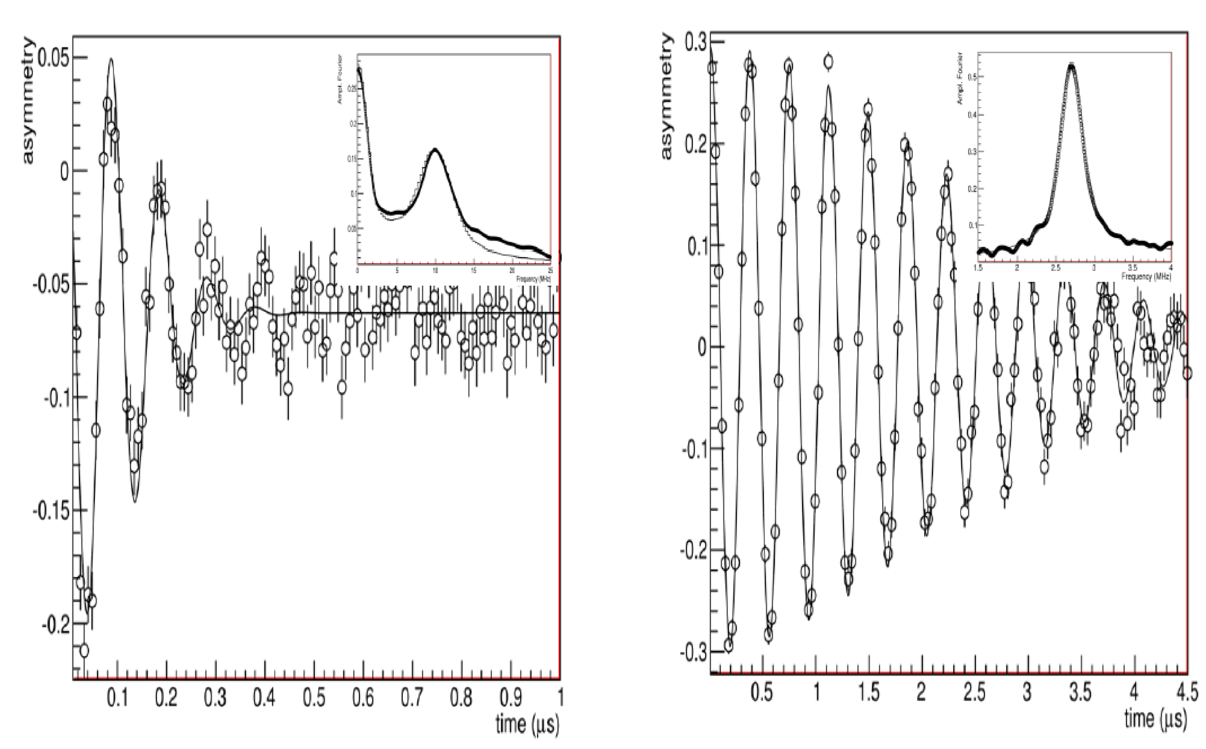

Figure 4 – μSR spectra depicting the mixed state (left) and the normal state (right). The Fourier transforms of the data are inset on the spectra.

Future Testing

- Temperature scans of Nb_3Sn.
- Tests of MgB2 and NbTiN/AlN multilayer samples
- Further field tests of other treatments and samples to test the parallel geometry.

Figure 5 – Sample CF1 (Nb_3Sn coated Nb).

Acknowledgements

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