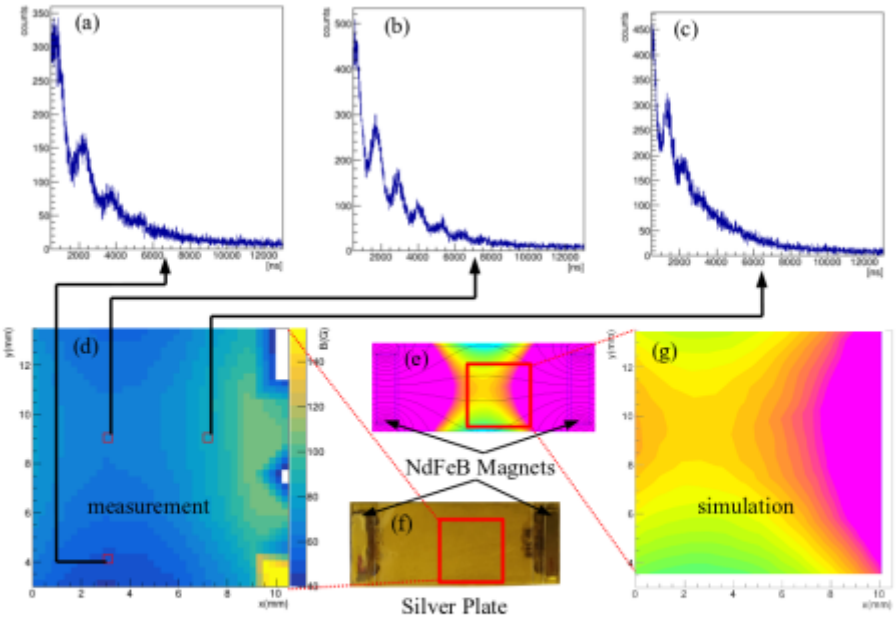
Contribution ID: **45** Type: **Contributed Oral**

Advanced Muon-Spin Spectroscopy Using Si-Pixel Detectors - A New Dawn for μSR

Tuesday, 22 July 2025 11:40 (20 minutes)

Muon Spin Relaxation measurements at continuous sources have stagnated at a stopped muons rate of 40 kHz and generally require sample sizes of at least 5 mm by 5 mm. Taking advantage of recent developments in pixel detector technology, we successfully implemented a prototype Si-pixel-based muon spin spectrometer at PSI. Unlike scintillator-based systems, this spectrometer utilizes the MuPix11 chip (≤100 μm thick), enabling tracking with high spatial resolution of 23 μm. The spectrometer is configured as a four-layered telescope, each with an active area of 4 cm by 4 cm, forming two layers upstream of the sample and two downstream. Both muons and positrons are tracked and extrapolated to the sample region. Each muon is matched to an emitted positron if their tracks intersect at the sample position. This spectrometer allows us to go beyond the 40 kHz stopped muons rate generating spatially resolved μSR spectra with low uncorrelated background.

We demonstrate the capabilities of this spectrometer by mapping the magnetic field produced by two NdFeB magnets mounted on a silver plate; see Figure. We are able to extract individual μSR spectra from areas of 1.5 mm by 1.5 mm, thus producing a 2D field map. Additional performance advantages include measurements on multiple samples simultaneously, three-dimensional surface tomography, and unprecedented resolution of submillimeter features in the measured samples.



Measured field map from two Nd magnets on a silver plate. (a)-(c) Example Vertex reconstructed μSR spectra from the marked areas of 1.5 mm by 1.5 mm. (d) The magnetic field strength extracted from fits of spectra as a function of lateral coordinates. (e) and (f) are the simulated geometry and a photo of the sample, respectively. (g) The simulated field strength in the measured region of the sample as marked in (e) and (f).

Figure 1:

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Session Classification: Oral Contributions

Track Classification: Beamlines and instruments