High transverse field $\mu$SR with $\pi/2$-RF pulse spin control technique

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Pulsed muon beam has an inherent problem that the time resolution for the conventional $\mu$SR measurements is limited by the beam pulse width ($= \delta$), which would be particularly serious for experiments at the J-PARC Muon Experiment Facility (MUSE) where $\delta$ would be 100-130 ns. It is much desired to establish routine technique to overcome the limit of pulse width for wider range of applications. For this purpose, a radio frequency (RF) technique has been known to be useful; The basic idea is to rotate the initial muon polarization ($P_\mu$) from $P_\mu \parallel H$ to $P_\mu \perp H$ direction by applying a short RF pulse that satisfies the condition $\gamma_\mu H_1 \Delta t = \pi/2$, where $H_1$ ($\perp H$) is the RF field, $\Delta t$ is the RF duration, and $H$ is the holding field. Then, because the time relative to the RF pulse is well-defined irrespective of the muon arrival time, $P_\mu$ exhibits coherent Larmor precession around $H$. Thus, the $\pi/2$-RF pulse allows us to observe TF-$\mu$SR without limitation from $\delta$.

Here, we report our result for the $\pi/2$-RF pulse experiment at 200 MHz (corresponding to 1.475 T), the highest precession frequency ever observed, using a pulsed muon beam at KEK ($\delta \simeq 50$ ns). A single-turn coil resonator fitting to a He gas-flow cryostat was fabricated, and the sample space ($\simeq 3 \times 3 \times 1 \text{ cm}^3$) in the resonator was filled with MgB$_2$ powder (a type II superconductor with $T_c \simeq 39$ K). As shown in Fig. 1, we were successful to observe a muon precession signal in time domain. The reduction of asymmetry upon the onset of superconductivity below $T_c$ was also confirmed, demonstrating that the signal was actually coming from muons stopped in the MgB$_2$ sample. Details on the experiment and a preliminary result will be presented in this contribution.

![Fig. 1: Fast Fourier Transform of $\mu$SR spectrum over a time region from 1.5 $\mu$s to 6 $\mu$s (where the RF noise is negligible) obtained from a time spectrum.](image-url)