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Positron Contamination in the Muon Beam at the J-PARC's Surface Muon Beamline (S-line)

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The surface muon beamline at J-PARC provides high-intensity muon beams that are essential for advanced materials science research, particularly in techniques such as muon spin rotation/relaxation (μSR). However, positron contamination in the beam poses a significant challenge by introducing background noise that affects the measurement precision. Therefore, achieving high-purity muon beams is critical for improving experimental reliability and accuracy. In this study, the G4beamline Monte Carlo simulation toolkit was employed to model the transport of muons and positrons from the production target through the beamline. The system includes a momentum and charge-based separator followed by a collimating slit. While the current slit configuration effectively suppresses positrons, it also causes substantial muon loss of approximately 76%, which significantly reduces the usable muon flux for downstream applications. To address this issue, a detailed investigation into slit size was performed. The results indicate that modest adjustments to the slit aperture size can improve the muon-to-positron ratio while retaining a greater fraction of the muon beam. These results provide valuable guidance for optimizing beamline performance and improving the quality of muon-based experiments at J-PARC.

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