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Design studies on a kHz–MHz repetition rate pulsed muon source based on electron accelerator

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Certain types of muon experiments, such as muon spin rotation techniques and muon lifetime measurements, require beams with repetition rates around 50 kHz for optimal statistical performance. However, existing facilities are limited to pulsed beams operating at 25-50 Hz or continuous beams, both constrained by the time structure of proton drivers. Despite ongoing efforts to optimize these proton time structures, significant limitations in flexibility persist.

This work introduces an alternative approach to muon production using high-repetition-rate (kHz-MHz) electron beams generated by superconducting linacs at XFEL facilities. This method provides unique temporal characteristics, promising substantial improvements in beam precision, flexibility, and experimental efficiency.

We present comprehensive particle tracking simulations for the design of a surface muon beamline and detailed Monte Carlo studies to optimize target materials and geometries. The results underscore the potential of electron-driven muon sources to complement muon-based fundamental and applied physics research while extending the capabilities of current and future XFEL facilities.

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