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Novel statistical measurement of longitudinal beam halo in the Fermilab Recycler using a µTCA FPGA system

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The formation of non-Gaussian halo in both the transverse and longitudinal dimensions of beam bunches has been notoriously difficult to model and measure. We present a novel technique to measure the longitudinal halo of 2.5 MHz bunches (400 ns) in the Fermilab Recycler. Out-of-time beam is a critical issue for Mu2e, as it can introduce unwanted backgrounds that compromise the experiment's precision.
Our measurement utilizes a new µTCA-based FPGA system for data acquisition and signal processing, enabling precise, high-speed measurements of scattered beam particles. A small fraction of the beam is scattered from an ion chamber in the M3 transfer beamline between the Recycler Ring and the Delivery Ring, which is detected by a charge telescope composed of quartz Cherenkov radiators and photomultiplier tubes. By integrating data over many revolutions, the time profile of the longitudinal halo (out-of-time beam) can be resolved to fractional levels below 10^{-5} relative to the in-time beam. These results are compared with simulations to validate models of halo formation and beam dynamics, providing critical input for optimizing beam delivery to Mu2e.

Footnotes

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