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Measurement techniques using the electron beam profile scanner at the Fermilab Main Injector

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This work presents techniques for non-invasive transverse profile measurements of high-intensity proton beams using an Electron Beam Profile Scanner (EBPS). The EBPS utilizes low-energy electrons as a probe to analyze the transverse size of proton beams, allowing for potential analysis on a single-bunch basis. Recent upgrades to the Fermilab Main Injector have enhanced beam power on target to 1 MW, with future developments targeting 2 MW. The higher beam power has increased the demand for non-invasive diagnostics, as invasive methods can disrupt operations.
The techniques presented include 1) the slow scan technique, which serves as a proof of concept for the probe beam, 2) the one-shot scan technique for measuring horizontal beam profiles, and 3) the raster scan technique for analyzing horizontal beam profiles as a function of the longitudinal distribution of the beam. The profiles obtained will be crucial for studying and understanding instabilities in high-power, high-intensity proton beams. This will contribute to optimizing the operation of high-power proton accelerators by minimizing beam loss, activation, and damage to both the diagnostics and the accelerator components.

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