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Space charge dominated momentum spread and compensation strategies in the post-linac section of Proton Improvement Plan-II at Fermilab

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The upcoming Proton Improvement Plan-II (PIP-II), designated for enhancements to the Fermilab accelerator complex, features a Beam Transfer Line (BTL) that channels the beam from the linac exit to the booster. In the absence of longitudinal focusing beyond the superconducting linac, the beam experiences an elevated momentum spread, primarily due to nonlinear space-charge forces, surpassing the allowable limit of 2.1×10^{-4} . This study presents a detailed examination of the space-charge-induced momentum spread and outlines mitigative strategies. The investigation includes the fine-tuning of a de-buncher cavity, analyzed in terms of operating frequency, longitudinal location, and gap voltage, under both standard and perturbed beam conditions—specifically accounting for momentum jitter and energy variation. The impact of buncher cavity misalignments on the beam's longitudinal phase space is also assessed. The paper concludes by recommending an optimized cavity configuration to effectively mitigate the observed increase in momentum spread along the BTL.

Footnotes

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