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Model-based optimization for automated Multi-Turn Extraction tuning at the CERN Proton Synchrotron

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Multi-Turn Extraction (MTE) is a resonance-based technique employed in the CERN Proton Synchrotron (PS) to split the beam in horizontal phase space before extraction to the Super Proton Synchrotron (SPS). The splitting efficiency is evaluated based on the uniformity of intensities across the beamlets, requiring fine-tuning of multiple parameters. In this paper, we investigate the influence of key parameters on MTE efficiency to improve the understanding of their impact on the process. Using a Gaussian Process model and various visualization techniques, we assess the sensitivity of the MTE efficiency to horizontal tune, transverse feedback gain, excitation frequency, beam intensity and magnetic hysteresis. Results from experiments and simulations indicate a complex, non-convex relationship between MTE performance and the parameters listed above. Additionally, external factors such as thermal fluctuations may contribute to performance variability. Our findings highlight the need for a model-based controller to counteract parameter drift, thereby ensuring consistent MTE beam quality during operation. We propose a solution supported by experimental results.

Footnotes

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