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Characterization of four-dimensional phase space for space charge-dominated beams using novel beam diagnostic techniques and generative phase space reconstruction at the KOMAC beam test stand

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Transverse phase space (x, x', y, y') measurement is crucial in beam physics to optimize the beam parameters. Typically, the phase space information of space charge-dominated beams can be characterized using well-established methods such as pepper-pot and movable slit-based scans. In addition, recent studies show that calibration of transfer matrix with considering space charge forces provides quantitative agreement in a solenoid scan-based emittance measurement. In this study, we characterize the space charge-dominated, 1 MeV/n proton beam at the Beam Test Stand (BTS) of Korea Multipurpose Accelerator Complex (KOMAC) using various beam diagnostic instruments such as pepper-pot, virtual pepper-pot, and multi slits. Furthermore, we investigate the usage of generative phase space reconstruction, based on neural networks and differentiable simulations, in the context of space-charge calibrated matrix computations and self-consistent beam propagation. We also discuss the comparison of the phase spaces obtained by conventional diagnostics, confirming the effectiveness of the reconstruction algorithm and advanced diagnostic methods for analyzing space charge-dominated beams.

Footnotes

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