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Detailed 4D phase space reconstruction of flat and magnetized beams using differentiable simulations and neural-networks

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Phase space reconstruction method based on differentiable simulations and neural-networks [R. Roussel et al., Phys. Rev. Lett. 130, 145001, 2023] is robust diagnostics to map complete 4D (x, x', y, y') phase space. It was reported that this method provides not only the uncoupled phase space (x-x', and y-y'), but also coupled phase space information (x-y', and y-x'). Recently, in addition to round, uncorrelated beam, we experimentally demonstrated the phase space reconstruction of flat and magnetized beams at the Argonne Wakefield Accelerator facility. Here, flat beam indicates the large emittance ratio in horizontal and vertical planes (e.g., enx/eny »100), and magnetized beam represents the transversely coupled beam due to canonical angular momentum from non-zero magnetic field at the cathode. In this study, we show that the phase space reconstruction method also provides the complete 4D phase space of those special beams such that we can capture i) the large emittance ratio of the flat beam and ii) magnetization value of the magnetized beam. In addition, we will discuss the uncertainty of the beam parameters obtained from conventional diagnostic method and phase space reconstruction.

Primary Keyword

differentiable models

Secondary Keyword

ML-based optimization

Tertiary Keyword

uncertainty quantification

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