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A path to efficient machine learning-based beam diagnostics: complete six-dimensional generative phase space reconstruction without RF deflecting cavity- 15'+5'

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Generative phase space reconstruction method based on neural networks and differentiable simulations has become a novel beam diagnostic technique to obtain the beam phase space information. Recent studies show that four-dimensional phase space can be successfully obtained by using only YAG images with different quadrupole magnet strength, allowing us to understand both uncoupled and coupled phase spaces. Furthermore, it has been experimentally demonstrated that the complete six-dimensional phase space can be reconstructed by additionally utilizing a spectrometer dipole magnet and RF transverse deflecting cavity. In addition to the previous research activities, we are currently investigating the complete six-dimensional phase space reconstruction method that does not require the RF transverse deflecting cavity. We demonstrate in simulation that our proposed method can also provide complete six-dimensional phase spaces including all the transverse-longitudinal couplings, which successfully represent the ground truth distributions. In this study, we present how to perform the reconstruction without such an advanced diagnostic instrument. In addition, we show the reconstruction results with synthetic examples and actual experimental data obtained at the Pohang Accelerator Laboratory X-ray Free Electron Laser (PAL-XFEL) facility.

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