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Novel diagnostics for measuring 4D beam matrix

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The widely used transverse parameters characterizing particle beams are the Twiss parameters. These parameters can be measured experimentally but they do not fully characterize the beam since they do not account for possible correlations in particle distribution between two transverse coordinates. These correlations may occur due to uncompensated magnetic field at the cathode or misalignment of focusing quadrupoles in the transport beamline. We propose a novel diagnostic for diagnosing full 4D beam matrix which may be used to identify such imperfections. The diagnostic is based on transporting the beam through the beamline which includes a quadrupole and a skew quadrupole magnets and measuring the resulting 2D beam distribution at the screen downstream. Such a measurement can be viewed as measuring a 2D projection of the 4D distribution. Different settings of the quads provide measurements of different slices of the phase space. The reconstruction of the original beam matrix from a number of measurements is done using machine learning algorithm, which provides a fast and reliable way of reconstruction for an arbitrary configuration of the scanning beamline. We study the performance of such a diagnostic, estimate its accuracy, and demonstrate that the uncertainty in the reconstructed sigma matrix can be smaller than the error of the measurements if the number of scans is large enough.

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Footnotes

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