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Development of a non-numerical model for emittance calculation in external injection scenarios

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Witness beam quality preservation (in particular energy spread and emittance) for external injection scenarios in plasma-based accelerators is a crucial requirement for downstream applications such as Free Electron Lasers. Due to the complexity of the beam-plasma interaction, extensive studies of possible mechanisms to preserve beam quality are usually done using particle-in-cell (PIC) simulations.
The sheer number of possible properties and simulation settings involved result in time-consuming iterations over the corresponding parameter space. Analytical descriptions of the witness beam evolution could allow for quick optimizations and provide useful limits for further investigations. However, these models are often limited to strong assumptions and not capable of rendering higher order details of the beam evolution along the whole acceleration procedure.
The study of instabilities arising from the introduction of beams with non-symmetric distributions can be efficiently tackled by means of an analytic model for the evolution of the statistical moments of the beam distributions, introduced by Mehrling et al. We report on results from the application of this model to the evolution of transverse beam properties of a witness beam in a plasma wakefield, including benchmarks with existing PIC codes such as HiPACE and the SANA model.

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