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Beam dynamics studies for a stable, reliable and reproducible plasma-based accelerator

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Plasma accelerators are emerging as formidable and innovative technology thanks to their compactness and reduced costs to drive of user facilities being able to sustain several GV/m accelerating gradients at normal conducting temperature.
The EuPRAXIA@SPARC_LAB collaboration is preparing a technical design report for a multi-GeV plasma-based accelerator with outstanding electron beam quality to pilot an X-ray FEL, the most demanding in terms of beam brightness. The beam dynamics has been studied aiming to a reliable operation of the RF injector to generate a so-called comb-beam with 500 MeV energy suitable as driver of the Beam-driven Plasma Wakefield Accelerator. A case of interest is the generation of a trailing bunch with 1 GeV energy, less than 1 mm-mrad transverse emittance and up to 2 kA peak current at the undulator entrance. The comb-beam is generated through the velocity bunching technique, an RF compression tool that enables high brightness beams within relatively compact machine. Since it is based on a rotation of the beam phase space inside the external RF fields, it could be particularly sensitive to amplitude and phase jitters in the RF injector. The electron beam dynamics and the machine sensitivity to the possible jitters are presented in terms of effect on the beam quality so to provide the basis for the alignment procedure and jitter tolerances. Numerical studies have been consolidated with experimental results obtained at SPARC_LAB, a test facility currently oriented to plasma acceleration physics where the velocity bunching scheme is routinely applied.

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