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Simulations of Ultrahigh Brightness Beams from a Plasma Photocathode Injector

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Plasma photocathode injectors may enable electron beams with normalised emittance at the nm-rad level from a Plasma Wakefield Acceleration (PWFA) stage [1]. These electron beams typically have kA-level peak currents leading to ultrahigh 5D brightness beams with the potential to drive advanced light sources [1]. The feasibility of the plasma photocathode was demonstrated at FACET-I at SLAC [2]. Further experimental campaigns are gradually aiming toward ultrahigh 5D and 6D brightness beams at FACET-II [3]. However, a series of milestones must be reached before these beams can be utilised for XFELs. For example, electron beams accelerated in plasma-based accelerators inherently have a significant energy chirp due to the GV/m accelerating gradients involved. Since energy chirp and energy spread can be detrimental to the high-gain FEL interaction, advanced approaches have been developed for energy spread minimisation of the initially ultrahigh 5D brightness beams towards ultrahigh 6D brightness [4]. Here we show within the framework of the PWFA-FEL project that it may also be possible to produce ultrahigh 5D brightness beams with reduced energy spread using beam-loading. We present results aiming at a trade-off between reduced energy spread, increased peak current, and increased emittance and their application to a soft XFEL in the water window.

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