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Towards a soft x-ray PWFA-FEL via Trojan Horse single bunch injection

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A barrier to realizing a plasma-based XFEL is the energy chirp of the accelerated electron bunch. If such a chirp is not removed prior to extraction it is difficult to maintain bunch qualities during transport to the undulator stage, and the FEL performance will be degraded or inhibited entirely. The Trojan Horse (TH) injection method uses a plasma photocathode approach to release and trap electrons directly inside the blowout of a PWFA stage [1], as demonstrated during the FACET-I campaign at SLAC [2]. The E310 experiment at FACET-II will aim to demonstrate ultrahigh brightness beam production via the efforts of multiple UK and US collaborators [3]. TH injection may produce low-charge electron beams with kA peak current and unprecedented emittance as low as 20 nm rad. Maintaining such ultralow emittance through a transport line may be possible via the multi-bunch dechirping scheme, which has already been developed [4]. Here, we present simulation-based efforts towards an alternative chirp-suppression scheme using a single injected electron bunch of higher charge. Exploiting the tunable nature of TH injection, we attempt to optimize an electron bunch for optimum beam-loading to remove projected energy spread while producing a multi-kA peak current, maintaining low emittance of a few hundred nm rad and few 0.1 % slice energy spread. Such a beam would have the potential to produce soft XFEL radiation using existing undulator technology.

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[2] A. Deng et al., 'Generation and acceleration of electron bunches from a plasma photocathode', Nat. Phys, Nov. 2019

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[4] G. G. Manahan, A. F. Habib et al., 'Single-stage plasma-based correlated energy spread compensation for ultrahigh 6D brightness electron beams', Nat. Commun, Aug. 2017

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