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Physics Considerations for a Plasma Booster Stage for the European XFEL

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The linac of the European XFEL accelerates high-quality electron bunches up to a maximum of 17.5 GeV, which undergo free-electron lasing in undulators at photon energies of up to 30 keV. A plasma accelerator stage could be used to significantly increase the electron bunch energy of the European XFEL cheaply and over a short distance. Towards this end we have developed models and performed the first beamtimes at the European XFEL in order to understand whether a twin-bunch structure suitable for plasma acceleration can be generated at the photocathode, then be accelerated and shaped in the following linac sections and bunch compressors. Promising first results from these studies will be presented alongside first considerations of a suitable plasma source, which must be scalable to high average powers. The high current (~5 kA) of an XFEL-derived plasma accelerator driver generates challenges for such a source, for example from ion motion and beam-induced ionisation. These effects will be explored and mitigation strategies proposed. Potential use cases for a plasma booster stage at the European XFEL will be presented.

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