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A collinear wakefield accelerator for a high repetition rate multi beamline soft x-ray free-electron laser facility

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A concept is presented for a multi beamline soft x-ray FEL facility where several free-electron laser (FEL) undulator lines are driven by equal number of high repetition rate single-stage collinear wakefield accelerators (CWA). Various means to mitigate the adverse collective effects are considered and a practical design of the CWA, embedded into a quadrupole wiggler to control a beam breakup instability, and extending over 30 meters is presented. It is shown that the maximum achievable strength of the quadrupole gradient defines a threshold charge in the drive beam and a maximum attainable acceleration gradient for the witness beam. It is also pointed out that the distance between the drive and witness bunches varies along the accelerator with a measurable impact on the energy gain of the witness bunch and its energy spread. Means to mitigate these effects are also considered. Obtaining the witness bunch with a minimum energy spread is discussed. Finally, results are presented for the expected FEL performance using an appropriately tapered undulator.

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