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Intrabeam Scattering Effects in the Electron Injector of the European XFEL

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Intrabeam scattering (IBS) causes growth of the uncorrelated energy spread of electron bunches due to multiple small-angle Coulomb collisions over long propagation distances. As such, this effect may be a limiting factor for the beam current and therefore for the achievable photon energy in the SASE process. In addition, IBS influences the noise spectrum of the bunch, thus, interfering with microbunching instability (MBI) effects. An accurate estimation of IBS is, therefore, necessary for the proper application of so-called laser heaters for MBI suppression.
Recent experimental evidence at the FERMI linac, SwissFEL and European XFEL suggests that IBS effects in FELs are important. A large uncorrelated energy spread of the electron beam was observed that could otherwise not be reproduced in numerical simulations. So far, however, this energy spread growth could not be clearly attributed to IBS alone. This is due primarily to the nonlinear, space-charge dominated beam dynamics in the injector for which theoretical IBS models are not applicable. For this reason, we introduce a simulation approach for the full space-charge dynamics in the injector of the European XFEL including IBS effects. The approach is based on a Monte-Carlo technique for modeling Coulomb collisions within an electron bunch of arbitrary distribution. The results for the slice energy spread along the beam line are presented for various operation conditions. This allows to identify exactly the amount by which IBS contributes to the overall uncorrelated energy spread growth in the injector.

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Author: GJONAJ, Erion (Technische Universität Darmstadt)

Co-authors: DE GERSEM, Herbert (Technische Universität Darmstadt); LIMBERG, Torsten (Deutsches Elektronen-Synchrotron)

Presenter: GJONAJ, Erion (Technische Universität Darmstadt)

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