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Scattered field formulation for wakefield and space charge calculations

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In the injector section of electron linacs, both internal space charge forces and wakefield effects influence the beam dynamics. To account for both effects, full electromagnetic PIC simulations are usually required. Unfortunately, PIC solvers require large computational resources. On the other hand, particle-tracking codes in the bunch reference frame describe the beam dynamics under space-charge fields. These codes, however, often fail to include the effect of geometric wakefields especially for low energy beams.

As an alternative modeling approach, we propose to decouple the wakefield scattered by the geometry from the space-charge field. Then, we use for each of the contributions the simulation approach that is more appropriate for the respective interaction. We decompose the total electromagnetic field into an incident and a scattered part. The incident field is computed by a space-charge solver in the rest frame of the bunch assuming that particles are in free space. Since this field does not fulfill the boundary conditions at the chamber walls, it acts as an excitation for the scattered part. The latter can be efficiently computed using a particle-free wakefield code. In the full paper, we will present beam dynamics simulations for the injector section of the European XFEL. The aim of these simulations is the quantification of the uncorrelated energy spread induced by geometric wakefields at low energies, which so far is not considered in existing wakefield models.

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Footnotes

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