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Simulation and optimization of a sub-THz Cherenkov FEL at AREAL

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A circular waveguide lined with a thin dielectric layer enables electron bunches propagating within the structure to radiate light in the (sub-)THz regime. In this work, we perform simulations of low-energy electron beams traversing extended waveguides to analyze the dynamics of beam bunching and lasing within the structure. By exploring the free-electron laser (FEL) process in this context, we demonstrate the potential of waveguides as a cost-effective alternative to undulator-based FELs. The study employs a simulated model of the AREAL LINAC at the CANDLE SRI to demonstrate these effects and provide realistic results. The simulations are performed using the space charge tracking algorithm ASTRA and the wakefield solver ECHO. For optimization of the system, the genetic optimization algorithm GIOTTO is applied to refine both the waveguide and accelerator variables. Using a 4 MeV electron beam with a charge of 300 pC, the optimized setup achieves a radiation frequency of 100 GHz with energy outputs exceeding 20 μJ in a waveguide of only 1.2 meters length. These results underscore the feasibility of this method, offering a innovative pathway to produce intense THz radiation.

Footnotes

Paper preparation format

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