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Considerations on Wakefield Effects in a VUV FELO Driven by a Superconducting TESLA-Type Linac

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The electron-beam properties needed for successful implementation of a free-electron-laser oscillator (FELO) on a superconducting TESLA-type linac at the Fermilab Accelerator Science and Technology (FAST) facility include the intrinsic normalized emittance and the submacropulse centroid stability. We have demonstrated that short-range wakefields (SRWs) and long-range wakefields including higher-order modes (HOMs) are generated for off-axis beams in the two, 9-cell capture cavities and eight, 9-cell cavities of a cryomodule in the FAST linac. The resulting degradation of the emittance and centroid stability would impact the FELO performance. At 300 MeV and with the 4.5-m long, 5-cm period undulator, the saturation of a vacuum ultraviolet (VUV) FELO operating at 120 nm has previously been simulated with GINGER and MEDUSA-OPC using the non-degraded beam parameters. The measured electron-beam dynamics due to the SRWs (submicropulse, 100-micron head-tail kicks) and HOMs (submacropulse centroid slew of up to 100s of microns) will be presented. These are mitigated by steering on axis as guided by the minimization of the HOM signals. Simulations using MINERVA:OPC of the effects of submacropulse centroid slew on FELO performance will also be reported.

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