Contribution ID: **529** Contribution code: **THPB005** Type: **Poster Presentation**

Simulated performance of a compact water-window FEL driven by a structure wakefield accelerator

Thursday 29 August 2024 16:00 (2 hours)

Free-electron lasers (FELs) send an accelerated electron beam through a magnetic undulator to provide a source of continuously tunable, short (10s of fs), high-peak power (GW-scale) radiation. FELs have found many applications, particularly in the infrared, extreme ultraviolet (EUV) and X-ray regimes. However, current EUV and X-ray FELs are large (100s of m) and expensive facilities, limiting the accessibility of these sources. In this work, we present FEL simulations driven by a compact accelerator combining high-gradient short pulse two-beam wakefield accelerators [1] and short-period superconducting undulators [2]. An FEL demo based on a GeV-scale accelerator is discussed as a driver for a water-window (2.3-4.4 nm) FEL with a ≈ 50 m length. Such a proof-of-principle integrated facility would serve the dual purpose of supporting user-based research in the water-window regime, and providing a proving ground for these new technologies to later be applied to shorter wavelength FELs. Here, we present early design and simulation efforts with a focus on FEL-process modeling.

Footnotes

[1]W. H. Tan et al., "Demonstration of sub-GV/m accelerating field in a photoemission electron gun powered by nanosecond x-band radio-frequency pulses,"Phys. Rev. Accel. Beams, vol. 25, no. 8, p. 083402, Aug. 2022, doi: 10.1103/PhysRevAccelBeams.25.083402.
[2]I. Kesgin et al., "Quench Behavior of 18-mm-Period, 1.1-m-Long Nb3Sn Undulator Magnets,"IEEE Transactions on Applied Superconductivity, vol. 34, no. 5, pp. 1–10, Aug. 2024, doi: 10.1109/TASC.2024.3350606.

Funding Agency

Funded by Laboratory Directed Research and Development (LDRD) at Argonne National Laboratory, provided by the Director, Office of Science, of the U.S. DOE under Contract No. DE-AC02-06CH11357.

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Session Classification: Thursday Poster Session

Track Classification: MC2: Electron Accelerators and Applications: MC2.4 FELs