Contribution ID: **99** Type: **Poster (participant)**

Beam-loaded plasma photocathode beams for XFEL application to the water-window and beyond

Monday, 14 April 2025 17:10 (1h 30m)

X-ray free-electron lasers currently rely on kilometre-scale linear accelerators to produce very high quality electron beams with GeV energies. Plasma-based accelerators are a highly compact alternative with a drastically higher accelerating gradient and smaller footprint. Here, we show in simulation how beams from a plasma wakefield accelerator (PWFA) could drive a robust and tunable compact soft XFEL using the plasma photocathode injection method. Operating in a beam-loaded regime, single low-energy injected bunches produce sub-millijoule energy radiation pulses in the water-window from 2.3-4.4 nm. Furthermore the FEL output is resilient to large drive-beam charge jitter and can be maintained over a large range of witness beam working points. Additionally, we investigate how such beams could be created at the possible future UK-XFEL facility using realistic drive beams from the linac, and how these beams may be used to reach very hard X-ray energies.

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Session Classification: Poster Session

Track Classification: Electron acceleration