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Diagnostics for ultrashort electron bunches in LWFA-driven FELs

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Laser wakefield accelerators (LWFAs) produce electron bunches that are ideal for driving free-electron lasers (FELs), both in seeded and self-amplified spontaneous emission (SASE) configurations, making them candidates for achieving compact plasma-based FEL user facilities with their ultra-high accelerating gradients and small footprints. However, the inherent shot-to-shot fluctuations, large energy spread, and femtosecond-scale bunch lengths resulting from LWFA pose significant challenges to ensuring beam quality control and optimizing FEL performance. LWFA longitudinal bunch profiles can feature complex structures with a broad range of durations (fs to several tens of fs) and substructures (sub-fs to fs long) with small bunch charges in the pC to nC ranges, all bringing critical challenges for the measurements. This talk will provide a brief and broad overview of longitudinal diagnostics applicable to FELs, drawing on recent studies developed for both LWFA-based and traditional setups, with a focus on the requirements and applicability to plasma-based FEL lasing.

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