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Leveraging the capabilities of LCLS-II: linking adaptable photoinjector laser shaping to x-ray diagnostics through start-to-end simulation

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SLAC's LCLS-II is advancing towards MHz repetition rate attosecond X-ray pulses, creating opportunities to optimize X-ray generation through machine-driven controls and diagnostics via start-to-end simulation. Advanced laser shaping and upconversion techniques at the photoinjector, such as spatial light modulator-based pre-amplifier pulse shaping linked to nonlinear methods such as dispersion-controlled nonlinear synthesis or four-wave mixing, enable precise electron bunch control at the source. Downstream, diagnostics like the Multi-Resolution COokiebox (MRCO)—a 16-channel time-of-flight spectrometer—characterize X-ray pulse profiles, providing real-time feedback on attosecond X-ray pulses or attosecond X-ray substructure. We present developments towards a framework linking programmable photoinjector laser shaping to X-ray diagnostics, enabling data-driven optimization of the X-ray source. This approach combines machine learning, high-throughput feedback, and advanced control to align LCLS-II capabilities with experimental goals, laying the foundation for optimization of attosecond-scale precision in X-ray experiments.

Footnotes

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