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Virtual pulse reconstruction diagnostic for single-shot measurement of free electron laser radiation power

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Accurate characterization of radiation pulse profiles is crucial for optimizing beam quality and enhancing experimental outcomes in free electron laser (FEL) research. In this paper, we present a unique approach that employs machine learning techniques for real-time virtual diagnostics of FEL radiation pulses. Our simple artificial intelligence (AI)-based diagnostic tool utilizes longitudinal phase space data obtained from the X-band transverse deflecting structure to reconstruct the temporal profile of FEL pulses in real time. Unlike traditional single-shot methods, this AI-driven solution provides a noninvasive, highly efficient alternative for pulse characterization. By leveraging state-of-the-art machine learning models, our method facilitates precise, single-shot measurements of FEL pulse power, offering significant advantages for FEL science research. This work outlines the conceptual framework, methodology, and validation results of our virtual diagnostic tool, demonstrating its potential to significantly impact FEL research.

Summary

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