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Ultrafast THz detection and enhanced Electro-Optical timing for longitudinal beam diagnostics at Free Electron Lasers

Thursday 14 August 2025 10:10 (20 minutes)

This work presents advancements in precision longitudinal beam diagnostics for Free Electron Lasers (FELs), integrating zero-bias Schottky-diode-based THz detectors and upgraded electro-optical bunch arrival-time monitors (EO-BAMs) for low-charge operation. The developed THz detector achieves ps-scale response times and 70 GHz intermediate-frequency bandwidth, enabling single-shot THz detection across kHz–MHz repetition rates. Characterized from DC to 5.56 THz*, it can serve as a critical tool for bunch compression monitoring** and lays the groundwork for future development ultra-broadband THz spectrometers. Concurrently, a novel printed circuit board (PCB) pickup structure enhances EO-BAM performance, preliminary results gave a slew rate of 275.7 mV/ps ± 34.6 mV/ps for a peak-to-peak voltage of 4.16 V ± 0.31 V at 3.45 pC after de-embedding***.

Optimized PCB materials and planar designs improve signal integrity, achieving a simulated jitter-charge product of 9 fs·pC****. This upgrade enables reliable operation at 1 pC for XFELs and ultrafast diffraction facilities while enhancing timing resolution in standard modes. The PCB architecture enables unprecedented flexibility for future multi-functional diagnostics. These innovations address critical challenges in low-charge, high-repetition-rate FEL diagnostics, advancing real-time beam characterization and accelerator optimization.

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No

Footnotes

*R. Yadav, et al., doi:10.3390/s23073469R. Yadav et al., doi: 10.18429/JACoW-IBIC2024-THP41***B. E. J. Scheible et al., 10.18429/JACoW-IBIC2023-TUP012**** A. Kuzmin et al., 10.18429/JACoW-IBIC2022-WEP24

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