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Single shot electro-optic measurement of bunch shapes using diversity schemes at EuXFEL, FLASH and FELBE

Single-shot detection of THz waveforms at high repetition rates is a key requirement in a growing number of THz related applications, including time-domain spectroscopy, accelerator and Free-Electron Lasers diagnostics.
Over the past decade, achieving MHz-range repetition rates has been demonstrated using chirped laser probe techniques,such as time-stretch and spectral decoding methods [1–3]. However, due to intrinsic physical limitations, these methods become increasingly unreliable when applied to broadband THz waveforms [4].
This poster details a novel measurement methodology for THz waveform characterization, utilizing information diversity [5] to achieve robust single-shot detection.
We demonstrate that simultaneous measurements provide the necessary information for precise THz signal retrieval. By combining spectral interferometry reconstruction algorithm with the recent Diversity Electro-Optical Sampling (DEOS) [5], our technique offers significant advantages, adapting to any probe laser imperfections, including high-order dispersion, and resolving the long-standing fundamental limitations of chirped pulse electro-optical detection [4], enabling high temporal resolution recording of short electron bunch shapes across extended temporal windows.
A proof-of-principle experiment for the THz measurement method (together with it "self-adaptation"to the probe laser chirp), using a classical THz time-domain spectroscopy experiment is presented.
Two experimental implementations are presented, one at DESY, designed for sub-picosecond relativistic electron bunch at MHz+ repetition rates characterization, and another at FELBE, designed for THz narrowband pulse detection at 3.44 THz, including a Carrier Envelope Phase diagnostic.
This technique promises significant advancements in single-shot THz time-domain spectroscopy and accelerator physics.

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