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Single-shot temporal characterization of SASE XUV pulses at FLASH FEL

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We present a Terahertz (THz) field driven streak camera [1] with the capability to deliver the XUV pulse duration and the arrival time information with < 10 fs resolution for each single XUV FEL pulse at FLASH. Pulse durations between ˜350 fs and ˜10 fs (FWHM) have been measured for different FLASH FEL settings [2]. In particular the arrival time analysis showed the precision with which FLASH can be operated meanwhile. A comparison with the FEL electron bunch arrival time (BAM –beam arrival time monitor) in the FLASH linac section showed a very good correlation (< 15 fs rms). For the simulation and analysis of the streaking process, a standard classical approach was used as well as a quantum mechanical theory, based on strong field approximation. Various factors limiting the temporal resolution of the presented THz streaking setup are investigated and discussed. Special attention is paid to the long and short pulse limit. Additionally SASE (Self-amplified spontaneous emission) pulses are inherently fluctuating in various properties. The pulse resolved characterization of the XUV SASE pulses regarding pulse duration, spectral distribution and pulse energy provides a large set of data that can be used to investigate the dependencies of the different parameters. Using the measurements together with simulations we can disentangle accelerator based fluctuations from pure SASE contributions and provide more insight into the SASE process [3].

[1] R. Ivanov, J. Liu, G. Brenner, M. Brachmanski, S. Düsterer, *FLASH free-electron laser single-shot temporal diagnostic: terahertz-field-driven streaking*, J. Synchrotron Rad. 25 26, 2018.
[2] R.Ivanov et al. *Single-shot temporal characterization of XUV pulses with duration from ˜10 fs to ˜350 fs at FLASH*, J. Phys B: At. Mol. Opt, accepted, 2020.
[3] I. Bermúdez Macias et al., *Study of temporal, spectral and energy fluctuations of SASE FEL pulses*, in preparation, 2020.

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