PhotonMEADOW 2023

Contribution ID: **7** Type: **Oral**

Single-shot temporal characterization of fundamental and harmonic ultra-short FEL Pulses

Thursday, September 14, 2023 2:50 PM (20 minutes)

FLASH, the free-electron laser in Hamburg, operates in the self-amplified spontaneous emission (SASE) regime, leading to a unique combination of energy, spectrum, arrival time and pulse duration. So it is critical to be able to determine the pulse duration and arrival time of each pulse. THz field-driven streaking has the potential to deliver single-shot pulse duration information basically wavelength-independent and over a large dynamic range (in pulse duration and FEL energy)[1,2].

In addition, using THz streaking, the single-shot pulse duration has been measured over a wide range from 10fs to 350fs (FWHM) [2] and correlations with other photon beam parameters have been investigated [3]. Furthermore, the study included an examination of the impact of the number of undulators on the pulse duration contributing to lasing, which was compared to results from 1D and 3D FEL simulations [4]. Furthermore, we will show the excellent agreement of the XUV pulse arrival time measured by streaking with the electron arrival time.

In SASE FELs, nonlinear energy modulation of the electron bunch gives rise to natural harmonics of the fundamental wavelength. The pulse duration of these harmonics can be determined as well using THz streaking, which employs the same scheme used for the fundamental pulse duration. In this regard, we have conducted measurements and simulations to determine the pulse duration of the third harmonic and to observe its evolution along the undulators.

1-I.Grguraš et al.,Nat. Photon. 6(2012)
2-R.Ivanov et al.,J. Phys. B 53(2020)
3-I.Bermúdez et al.,Opt. Exp. 29(2021)
4-M.Bidhendi et al.,Appl. Sci. 12(2022)

Journal of Synchrotron Radiation Special Issue: will you submit your contribution?

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Session Classification: Time-related beam properties - temporal characterisation of electron, FEL, and laser beams