K 4: X-Ray Lasers

Time: Wednesday 11:00–12:00 Location: REC/C213

K 4.1 Wed 11:00 REC/C213

Electron Optical Systems for High-Resolution Electron Time-of-Flight Spectrometer — •Niclas Wieland[1], Sara Savio[1], Lars Funke[1], Lasse Wülfing[1], Arne Held[1], Markus Ilchen[2], and Wolfram Helml[1] — [1]Fakultät Physik, Technische Universität Dortmund, Maria-Göppert-Mayer-Straße 2, 44227 Dortmund, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany

Angular streaking allows resolving the sub-femtosecond temporal structure of SASE free-electron laser pulses. A circularly polarized infrared laser imprints a phase-dependent momentum shift onto the photoelectron spectra of a gas target. Time-of-flight spectrometers can be used to resolve these. The latter devices consist of electron optics, a drift section and a detector with good time resolution. Parameters such as energy resolution and energy-dependent transmission for the whole system can be determined by simulation. In this talk, we present the finalized simulation-motivated spectrometer design used inside our new chamber for the SpeAR_XFEL project. Furthermore, we will introduce the possibility of adaptive electron optics in our spectrometer to further increase the resolution and transmission by applying specific voltage sets to our optics.
Gaining insight into electron motion using precise simulations appears to be an efficient way to improve the overall performance of such experiments. We would like to present our progress in terms of electrode design and applied voltages for a 0-4 keV electron energy spectrum, to further develop spectrometer research in this field.

K 4.2 Wed 11:15 REC/C213

Angular streaking TOF spectrometer for ultrafast FEL pulse characterization — •Sara Savio[1], Niclas Wieland[1], Lars Funke[1], Lasse Wülfing[1], Arne Held[1], Markus Ilchen[2], and Wolfram Helml[1] — [1]Fakultät Physik, Technische Universität Dortmund, Maria-Göppert-Mayer-Straße 2, 44227 Dortmund, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany

Angular Streaking is a very successful and currently the only non-invasive tool used to measure the time-energy structure of X-ray pulses with sub-femtosecond resolution. A complete reconstruction of the ultrashort FEL pulses can be realized from the angle-resolved photoelectron momentum distribution due to the energy modulation by a circularly polarized optical laser. This work mainly evaluates the performance parameter like solid angle acceptance of the electron Time-of-Flight (eTOF) spectrometer with the help of SIMION software. A systematic investigation of the overall transmission and energy resolution while considering the pointing (displacement) of the beam in the interaction region is carried out using the charged particle optical simulation. Angle resolving photoelectron spectrometer is a potential candidate for polarization and short pulse measurements. The scope of the envisioned electron spectroscopy experiments is not only limited to pulse characterization but also includes measurements of ultrafast electron dynamics in gas-phase atoms, like the Auger-Meitner decay, and following electronic pathways in more complex molecules for ultrafast movies of photochemical reactions.

K 4.3 Wed 11:30 REC/C213

Mechanical design and implementation of high-resolution electron time-of-flight spectrometers for angular atreaking — •Lasse Wülfing[1], Sara Savio[1], Niclas Wieland[1], Lars Funke[1], Arne Held[1], Markus Ilchen[2], and Wolfram Helml[1] — [1]Fakultät Physik, Technische Universität Dortmund, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

In order to reconstruct the stochastic temporal shapes of SASE FEL pulses in a non-destructive manner, a specialized *angular streaking* chamber is built at DESY and XFEL. Angular streaking superimposes the ultrashort X-ray beams with a circularly polarized infrared laser and correlates relative phases in the laser to the momenta of photoelectrons in a plane perpendicular to the beam. The energies of these photoelectrons can be obtained by Time-of-Flight spectrometers (eTOF).
In the SpeAR_XFEL project (Spectroscopy with Angular Resolution for ultrafast experiments at X-ray FELs) we develop a novel detector aimed at angular streaking. It consists of a specialized vacuum chamber, designed along with a new kind of eTOF, suitable to be implemented in the magnetic shield of the chamber. Special care has to be taken in order to create a robust and precise design compatible with the material stress resulting from the high temperature baking process of UHV components.
We present the newly developed concept for a UHV compatible installation of a Time-of-Flight spectrometer array inside a magnetically highly sensitive area.

K 4.4 Wed 11:45 REC/C213

Characterization of SASE FEL pulses with angular streaking — •Lars Funke[1], Kristina Dingel[2], Arne Held[1], Sara Savio[1], Lasse Wülfing[1], Niclas Wieland[1], Markus Ilchen[3], and Wolfram Helml[1] — [1]Fakultät Physik, Technische Universität Dortmund, Germany — [2]Intelligent Embedded Systems, Universität Kassel, Germany — [3]Deutsches Elektronensynchrotron DESY, Hamburg, Germany

SASE free-electron-laser pulses pose a challenge in terms of temporal diagnostics, due to their intrinsic stochastic structure. Few methods allow directly resolving the full spectro-temporal information. In *angular streaking*, photoelectron momenta are linked to their birth phase by superimposing a circularly polarized infrared laser pulse. This principle allows reconstructing a pulse spectrogram shot-by-shot, enabling "stochastic experiments" by evaluating measurements as a function of derived quantities such as pulse duration or delay in a (stochastic) double pulse.

The analysis of angular streaking data involves disentangling the spectral and temporal contributions to the measurement for a single shot. In this talk, we present a current adaptation of the iterative *Pacman* algorithm and further, advanced reconstruction methods.

Furthermore, we show the application of these methods to data measured using angular streaking at the SQS instrument of European XFEL in June 2022. Statistical analysis of the reconstructed spectrograms allows providing diagnostic feedback with regard to different short-pulse FEL modes.