3-in-1 Combined time-resolved photoelectron spectroscopy using a time-of-flight momentum microscope at the free-electron laser FLASH

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Time-resolved photoemission with ultrashort pump and probe pulses is an emerging technique with wide application potential. Real-time recording of non-equilibrium electronic processes, transient states in chemical reactions or the interplay of electronic and structural dynamics offers fascinating opportunities for future research. Combining valence-band and core-level spectroscopy with photoelectron diffraction for electronic, chemical and structural analysis requires few 10 fs soft X-ray pulses with some 10 meV spectral resolution, which are currently available at high repetition rate free-electron lasers (FELs). We have constructed and optimized a versatile setup (HEXTOF) commissioned at FLASH/PG2, that combines FEL capabilities together with a multidimensional recording scheme for time-resolved photoemission techniques. Time-resolved Momentum Microscopy (trMM), time-resolved X-ray Photoelectron Spectroscopy (trXPS) and time-resolved X-ray Photoelectron Diffraction (trXPD). We use a full-field imaging momentum microscope with time-of-flight energy recording as the detector for mapping of 3D band structures in (kx, ky, E) parameter space with unprecedented efficiency. Our instrument can image full surface Brillouin zones with up to 7 k1 diameter in a binding-energy range of several eV, resolving about 2.5x105 data voxels ID. [1]

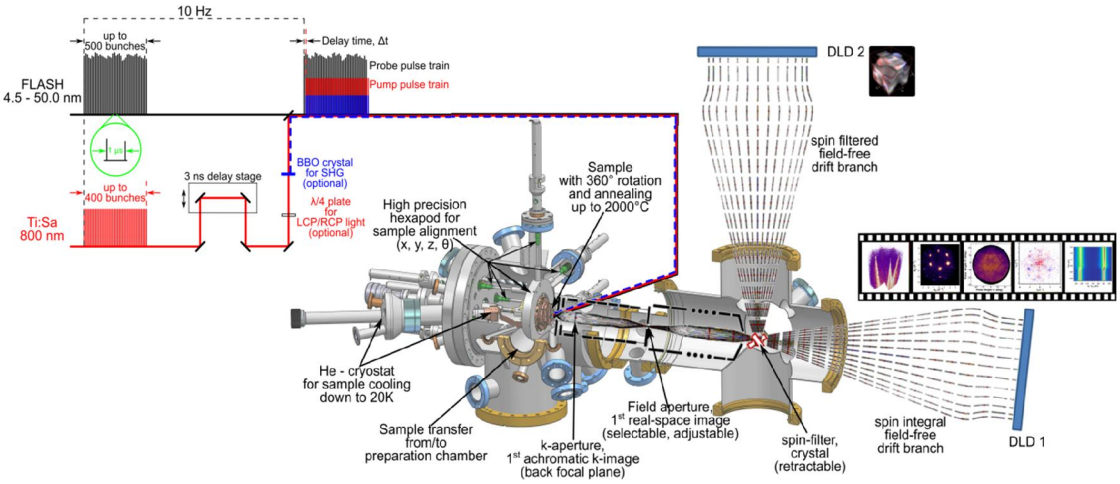

Figure 1. Scheme of the experimental setup for angular-, time-, and spin-resolved PES measurements at FLASH. The setup includes a straight drift tube for spin-integrated measurements and a vertical drift tube for spin filtering. The setup is designed for high repetition rate XUV and soft X-ray sources with monochromatized beams like PG2/FLASH. It is also possible to perform measurements in the laboratory with a HHG source and a monochromator. The PEEM mode of the electron optics allows also real space images.

References

[1] Kutnyakhov et al., Rev. Sci. Instrum. **91** , 013109 (2020).