An Autocorrelor and Delay Line for Soft X-ray FEL Pulses

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Among the new ultrashort X-ray sources the **f**ree-electron **las**er in **H**amburg at DESY (FLASH) has outstanding features. Providing pulse energies up to 100 µJ and pulse durations in the fs-regime[1] FLASH is ready for a new class of soft X-ray experiments e.g. nonlinear X-ray optics, X-ray pump and probe experiments, two beam interferometry and holography. In order to provide two correlated pulses with a precise and variable delay as well as to temporally characterize (autocorrelation) the X-ray pulses an optomechanical beam splitter and delay unit (autocorrelator) has been constructed and installed at FLASH. Based on geometrical wavefront beam splitting and grazing incident angles it covers the energy range of FLASH (20 –200 eV) with an efficiency of better than 50 % [2].

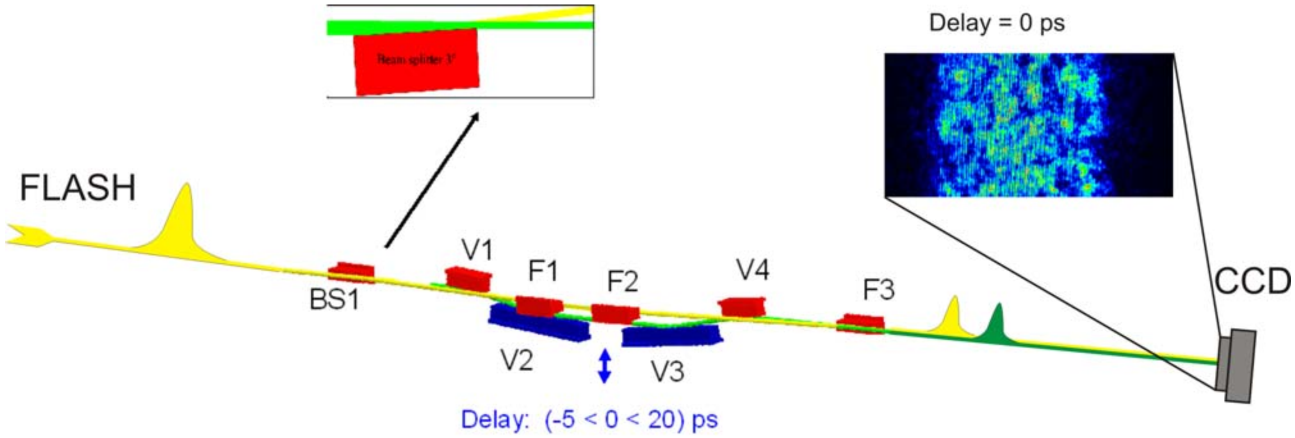

Figure1: The autocorrelator and the x-ray camera have been installed at beamline BL3 approx. 70 m behind the undulator (for details of the autocorrelator and the FEL see [1, 2]). Clear interference fringes have been observed when recombining the split beams near zero delay.

In first experiments the temporal properties of the supplied FEL pulses at 24 nm are measured. A fundamental property of a FEL pulse is its spatial and temporal coherence being essential for interferometric and holographic experiments. The good spatial coherence has been used in our experiments to record the interference pattern of the overlapped partial beams as a function of the path length difference (delay). We are thus able to extract the average coherence time of the FEL pulse. Furthermore, the knowledge of the pulse length is crucial for many experiments e.g. any kind of time resolved measurements and multiphoton processes. While the nonlinear autocorrelation is a well established method to determine the pulse length in the UV [4] and visible spectral regions there is a lack of efficient nonlinear (nonresonant) detection processes in the soft X-ray regime. Here we use direct two-photon double ionization (2PDI) of He to measure the nonlinear autocorrelation function [5].

Desorption of O_2^+ yielded a strong non linearity allowing for future nonlinear surface chemistry autocorrelation experiments.

Additionally in the near future a design will be available in which two parallel beams are supplied for user experiments e.g. pump-probe and holographic experiments.

References

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[5] Y. Nabekawa, H. Hasegawa, E.J. Takahashi, K. Midorikawa,”Production of Doubly Charged Helium Ions by Two-Photon Absorption of an Intense Sub-10-fs Soft X-Ray Pulse at 42 eV Photon Energy”, Phys. Rev. Lett. **94**, 0043001 (2005)