FLASH User Operations Newsletter, March 2018

Dear colleagues,

in order to support and inspire you when writing a proposal for FLASH, we put together this second issue of our newsletter. With this, we want to keep you updated on our recent activities and developments at the FLASH user facility. References and contact names for the corresponding in-depth information on new instrumentation and features are added to the brief summaries given here.

We would be happy to provide you with further specific details on request and are looking forward to receive your experiment proposal.

With best regards,

Wilfried Wurth and Rolf Treusch

New multilayer mirror based split-and-delay unit at CAMP@BL1

For time-resolved pump-probe experiments with intense XUV double-pulses, the multi-purpose CAMP end-station at beamline BL1 was complemented by DESC (**de**lay **s**tage for **C**AMP) [1], a wavefront-splitting, multilayer mirror based split-and-delay unit (SDU). The SDU has been commissioned and can now be requested for user experiments.

Using multilayer mirrors, DESC allows for a near-normal incidence beam path, what enables **long time delays ranging from -29 ps to 654 ps** with a 7 fs steps size (scan over time-zero is possible). To study very fast dynamics, an additional delay stage on top of the long-range delay stage, offers a sub-femtosecond resolution with up to ± 830 fs delay. Geometrical split-ratios other than 50% / 50% can be flexibly adjusted. Alternatively, different intensity ratios can also be realized by using a set of Zr filters at a fixed geometrical split-ratio of 50% / 50%. Currently, **multilayer mirrors** for a **wavelength of 13.5 nm** (91.8 eV) are installed, yielding an overall transmission of about 41 %. Depending on the future user demands, it is foreseen to add mirrors for other wavelengths to the DESC portfolio, which would then require some lead time for mirror exchange and realignment of the DESC setup.

If you consider to use DESC for your experiment, please get in touch with Benjamin Erk (benjamin.erk@desy.de).

[1] M. Sauppe et al., *XUV double-pulses with femtosecond to 650 picoseconds separation from a multilayer mirror based split-and-delay unit at FLASH*, submitted to J. Synchrotron Rad. (March 2018)

Femtosecond time-resolved X-ray absorption spectroscopy at PG2 employing new reference scheme for normalization

At the plane grating monochromator beamline PG2 a new referencing scheme for X-ray absorption spectroscopy (XAS) has been successfully tested. Similar to the approaches realized at SACLA [1] and LCLS [2], it employs a nanofabricated diffractive transmission grating to split the FEL beam into two identical copies (signal & reference) for single shot intensity normalization (see Fig.1).

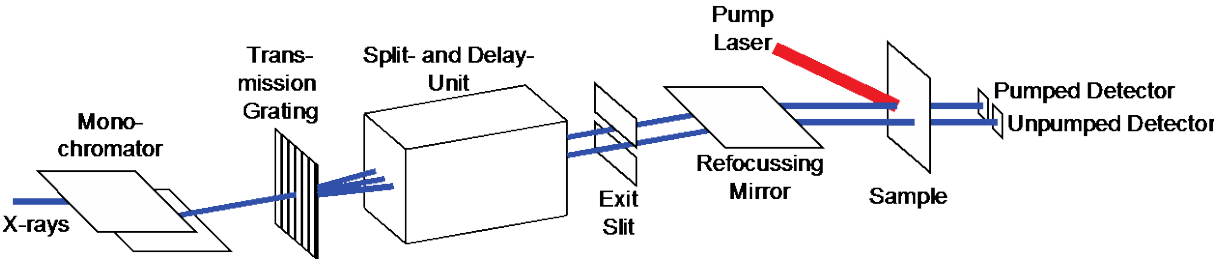

Fig. 1: The transmission grating is used as an amplitude beam splitter while the optical elements of the PG2 split-and-delay unit allow guiding the two beam arms through the monochromator beamline into the experimental setup.

The transmission grating has been provided by the X-ray Optics and Applications group of PSI (Contact: Christian David). Such a scheme with a true amplitude beam splitter (rather than the already existing wavefront beam splitter) constitutes a robust solution for SASE-FEL pulse referencing, with a probe and a reference beam that both end up at the same pixelated detector. Excellent correlation between the two beams has been demonstrated within a few percent for single bunch operation at 150 eV photon energies, and the method has proven to work also using higher harmonics of the FEL, e.g. at 400 eV photon energy for measurements at the Nitrogen K-edge. With one beam travelling through the sample, the other one can be used as an intensity reference to normalize SASE fluctuations for high sensitivity absorption measurements. Alternatively, both beams can be transmitted through the sample, while only the interaction point with one of the beams is overlapped with the pump-probe laser. This allows for balanced detection of pump-laser induced changes of the absorption. The scheme has the added benefit that it will also work in reflection geometry for opaque solid-state samples to study changes in reflectivity. Using the FLASH1 optical laser system which is synchronized to the FEL, soft X-ray pulses time-resolved pump-probe XAS measurements become feasible at this SASE FEL. We also point out that this scheme can be naturally combined with open slit dispersive operation and provide high-energy resolution measurements across the full SASE bandwidth without scanning the monochromator.

Contact: Günter Brenner (guenter.brenner@desy.de)

[1] T. Katayama et al., Appl. Phys. Lett. **103**, 131105 (2013).

[2] W.F. Schlotter, A. Sakdinawat et al. in preparation

Time-resolved RIXS at beamline PG1

The transport line for the FLASH1 optical pump-probe laser is currently being installed at the XUV double Raman spectrometer end-station of the PG1 monochromator beamline branch. This upgrade will soon allow time-resolved RIXS experiments at the transition metal M-edges (20 - 200 eV) with an **energy resolution < 20 meV** (double monochromator) **and a time resolution < 250 fs fwhm**. With such a resolution the double stage Raman spectrometer will provide information about dynamic properties of solid matter approaching the Heisenberg limit. The FLASH1 Pump-Probe laser has a fundamental wavelength of 800 nm. By non-linear optical frequency conversion, the wavelengths 400 nm and 267 nm can be generated for optical pump - XUV probe measurements. The first monochromator stage SP1 with **an energy resolution < 60 meV fwhm** will be **available** for experiments **by end of 2018**.

Contact: Siarhei Dziarzhytski (siarhei.dziarzhytski@desy.de)

MUSIX chamber open for collaborations

The new MUSIX (multi-dimensional spectroscopy and (in-)elastic X-ray scattering) end-station providing a solid state ultra-high-vacuum sample environment is open for collaborations with the Helmholtz young investigator group around Martin Beye.

The MUSIX setup can be flexibly used at open port beam lines at FLASH1 or 2. It is based upon a standard theta-two theta diffractometer, but features also a flexible grating spectrometer with a resolving power > 2000 across the whole photon energy range of FLASH including the third harmonic. While, for the diffraction setup, the sample and a photodiode can be freely rotated around the vertical axis in vacuum, the spectrometer can be attached at fixed angles between 0° and 135° scattering angle, in steps of 15°. Additionally, during the experiment, the whole chamber can be rotated by 20° without breaking vacuum. Therefore, any scattering angle in between can also be reached with the spectrometer.

The spectrometer detector is an in-vacuum CCD which is shielded from optical light with filters. The grating can be retracted from the beam path and the CCD can be moved to the beam height at a distance of about 1.2 m to the sample.
The sample can be rotated around the azimuth upon mounting and can be cooled down to 25 K. Heating up to about 350 K is also possible. The setup allows for further flexible mounting of optical elements, special CCD configurations and the like.

Contact: Martin Beye (martin.beye@desy.de)