FLASH User Operations Newsletter, September 2018

Dear colleagues,

in order to support and inspire you when writing a proposal for FLASH, we put together this third 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

The long term future of FLASH – FLASH2020+

In the framework of the DESY strategy process for the next decade – DESY2030 – several long-term goals for the future of FLASH have been defined which are in line with user wishes for a high repetition rate XUV and soft x-ray FEL facility expressed at the workshop in September 2017.

The FLASH strategy – FLASH2020+ – is based on an envisioned development program of the two FEL lines and the accelerator which includes

- the operation of two independent FEL lines (FLASH1 and FLASH2) with **variable magnet structures** (undulators) for new lasing concepts and „seeding“ with a high repetition rate
- the **extension of the wavelength range** of the fundamental to the oxygen K-edge, in order to reach the important elements for energy research and to cover the whole water window for biological questions
- **flexible pump/probe schemes** for time-resolved experiments
- **variable polarization** for the investigation of e.g. the light-induced switching of magnetic storage media; and
- **shortest pulses** up to the attosecond range.

Currently we are in process of preparing a conceptual design report for FLASH2020+. We plan to discuss the concepts and the performance goals with the users in a satellite workshop to the DESY Photon Science users meeting end of January 2019.

Femtosecond optical synchronization and bunch arrival time measurement systems upgraded

FLASH is equipped with a laser-based synchronization system [1] based on the distribution of an optical pulse train using actively length-stabilized optical fibers to provide a femtosecond-precise time reference across the accelerator facility. This optical reference is used for electron bunch arrival time measurements at different locations and the synchronization of external laser systems, such as the electron gun photocathode lasers and the pump-probe lasers for user experiments.

In summer 2018, the optical synchronization system has been upgraded significantly, beginning with laboratory infrastructure and adapting the state-of-art computing architecture for controls, the implementation of a new fiber link stabilization scheme for improved performance and reliability, as well as the preparation for future accelerator module radio-frequency stabilization. For X-ray/optical pump-probe user experiments both the FLASH1 and FLASH2 laser systems are equipped with new optical cross-correlators for femtosecond-level lock to the reference pulse train. Furthermore, laser systems for temporal photon pulse diagnostics, as well as for accelerator seeding studies are connected to the system with new fiber links and optical cross-correlators.

In addition to these upgrades of the synchronization system itself, the existing electron bunch arrival monitors (BAMs) have been upgraded to new versions which are also installed at the European XFEL. Their enhanced electro-optical front-end and the usage of the new computing architecture will yield an improvement of temporal resolution for very low electron bunch charges required for short-pulse operation, and overall reliability, in particular in coping with the different electron bunch trains delivered to the FLASH 1 and FLASH 2 undulator beamlines. This will enable an upgrade of the fast, intra-train arrival time feedback such that both bunch trains delivered to FLASH1 and FLASH2 can be stabilized individually and simultaneously. Moreover, the upgraded BAM hardware will allow for a nanosecond-range, sub-picosecond resolution monitoring of timing to complement the existing streak camera-based measurement for establishing coarse temporal overlap and compensating slow timing drifts.

In summary, the combination of high-resolution electron bunch arrival time measurements, longitudinal acceleration stabilization loops and highly precise laser synchronization will result routinely in a timing jitter on the few-ten femtosecond level with minimum temporal drift for user experiments.

[1] S. Schulz *et al.*: Femtosecond all-optical synchronization of an X-ray free-electron laser. Nature Communications **6**:5938 (2015); DOI: 10.1038/ncomms6938.

Contact:

Jost Müller (Synchronization System, jost.mueller@desy.de),

Marie Kristin Czwalinna (BAM and accelerator feedbacks, marie.kristin.czwalinna@desy.de)

Status of the FLASH2 Pump-Probe laser

The FLASH2 pump probe laser is available from September 2018 at the beamline FL26 and from January 2019 at beamline FL24. The laser system is based on optical–parametric chirped pulse amplification (OPCPA) technology and provides unique features for user experiments at FLASH2 with femtosecond time resolution. The laser beam can be delivered to both endstations FL24 and FL26 and is coupled into the experiment collinear or slightly non-collinear to the FEL beam.

The current parameter set in the interaction point is summarized below. The laser group will provide additional frequency conversion schemes: second harmonic (center wavelength 400 nm) and third harmonic (center wavelength 266 nm) generation at the endstations FL24 and FL26 will become available in spring 2019. Further frequency conversion schemes are under development. If your experiment requires a specific laser wavelength, please contact Bastian.Manschwetus@desy.de and we will do our best to make your experiment possible.

Center wavelength:	800 nm
Spectral bandwidth:	~100 nm
Pulse duration (FWHM):	< 20 fs
intra-burst-repetition rate:	50 kHz
Number of pulses in burst	1 - 40
Pulse energy:	> 250 µJ
Focus spot size: (1/e² diameter)	FL24 < 100 µm; FL26 < 50 µm
Timing jitter to FEL:	Best effort
Available frequency conversion:	SHG (400 nm), THG (266 nm)