FLASH User Operations Newsletter, September 2017

Dear colleagues,

in order to support and inspire you when writing a proposal for FLASH, we put together this newsletter. It provides you with information on many of the exciting updates and new features at the FLASH user facility which were added in course of the last year. The new installations and enhanced functionality of, e.g., data acquisition and controls, aim at widening the range of scientific applications at FLASH while easing the performance of an experiment. Many links to the corresponding in-depth information 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*

FEL polarization control now available at the FLASH1 beamlines BL1-3

A polarizer for XUV radiation based on phase retardation upon reflection off four metallic mirrors is now available at FLASH1 beamlines BL1-3. Its simple design allows fast changes of the helicity of the incoming FEL beam with high transmission and a high degree of circular polarization reaching up to 90%. The new polarizer works for photon energies between about 35eV (35nm) and 90eV (14nm), i.e. it covers the M-edges of the magnetic transition metals Mn, Fe, Co and Ni. It opens the field of (soft) X-ray magnetic circular dichroism (XMCD) at these M-edges for time-resolved experiments at FLASH.

More details:
C.von Korff Schmising et al., Rev. Sci. Instrum. 88, 053903 (2017);
http://dx.doi.org/10.1063/1.4983056

New Kirkpatrick-Baez focusing optics at beamline FL24

The new FLASH2 beamline FL24 provides an open port for user supplied experiments and has recently been equipped with a KB focusing optics with bendable mirrors in order to adapt focus size and focal position to the users' demands. The standard distance from the last beamline flange (at the differential pumping unit) to the focal point in the user provided experimental chamber is 400 mm. It can be varied from even shorter distances to about 2000 mm what allows to accommodate a variety of different setups. The design focus diameter is about 10 µm (FWHM at standard distance) and it increases slightly up to about 20 µm (for longer focal distances). Detailed parameters depend on wavelength and accelerator/undulator settings and are currently under investigation. A combination with the pump-probe laser (see below) will restrict the focal distance to a set of discrete values.

Reaction Microscope@FL26 features new split-and-delay unit

At beamline FL26, the permanent end station REMI, a reaction microscope from the MPIK Heidelberg, is installed for advanced AMO (Atomic, Molecular and Optical) physics and molecular femtochemistry experiments. With a reaction microscope all fragments of a photoionization process can be detected by means of a combination of electron and ion time-of-flight spectrometers and a specific arrangement of electric and magnetic extraction fields. Measuring all fragments in coincidence enables kinematically complete experiments.

For time resolved experiments, REMI has been recently complemented by a grazing incidence split-and-delay unit (SDU) which – in contrast to the formerly used multilayer-based SDU – allows to fully profit from the fast wavelength tunability of FLASH2. The new mirror chamber simultaneously serves as an SDU and as a focusing device. The time-delay can be adjusted in the range of ± 2.7 ps. A focal spot size of 4x5 microns (FWHM) as determined with a wavefront sensor has been achieved in the commissioning. With a 30nm carbon mirror coating, the mirror reflectivity is larger than 75% in the wavelength range between 9 and 41 nm.

Details on the REMI:
http://photon-science.desy.de/facilities/flash/beamlines/fl_beamlines_flash2/beamline_fl_26

Pump-Probe Laser for time-resolved experiments at FLASH2

A new type of high repetition rate laser based on OPCPA (optical parametric chirped pulse amplifier) technology will soon be available in the FLASH2 experimental hall. It will be transported with dedicated beamlines to the end of FL24 and FL26 which will be equipped with a nearly collinear laser incoupling (approx. 1° angle with respect to FEL beam).

The **expected initial parameter-set** which will be available for the present proposal round (beamtime in second half of 2018) is:

wavelength:	800 nm (fundamental center wavelength)
bandwidth:	100 nm
intra-burst-repetition rate:	50 kHz
number of pulses per burst:	1-40
pulse duration:	15 fs FWHM.
timing jitter to FEL:	< 50 fs rms.
pulse energy:	0-500 µJ
polarization:	flexible
focus size (1/eˆ2 diameter):	FL24: < 100 µm. FL26: < 50 µm
peak intensity	> 10^{14} W/cm^2
time delay to FEL:	-4 ns to +4 ns, 10 fs resolution. (larger delays optional)
energy instability:	<10% pulse-to-pulse peak (3% rms).

400 nm and 266 nm will be available on a best effort basis with expected conversion efficiencies of >30% SHG, >5% THG

We are working on more flexible parameters which will be available somewhat later.
Details will be also discussed on a satellite workshop at the 2018 users meeting.

New MTCA.4 electronics ➔ better timing and fast GHz ADCs

Due to the implementation of a **new hardware infrastructure** based on the µTCA (MTCA.4) standard several new options are available at all FLASH beamlines:

- Two 4 GSample or four 2 GSample ADCs (SPdevices ADQ 412) per beamline are available to record user data bunch-synchronized in the FLASH DAQ system. These ADCs are particularly interesting to record TOF traces.
- In addition, four 108 MHz ADCs per beamline are provided to record “slow” user data bunch-synchronized in the FLASH DAQ system.
- Online viewing tools and sample scripts for data analysis are available to work efficiently with the ADC data.
- The stability of the 10 Hz triggers has been significantly increased to a level of < 10 ps jitter
- Additionally triggers for each FEL bunch (burst trigger) as well as frequencies (0.1 to 54 MHz) locked to the FEL timing can be provided

More details at http://mtca.desy.de/ or http://www.desy.de/~wwwuser/index.html

Recent data acquisition (DAQ) changes

A variety of novel options for the data analysis and storage has been implemented allowing a much more efficient and faster access to the acquired data. In order ease the preparation before the beamtime and to keep users informed on the latest developments concerning controls, data acquisition and data analysis, we **extended our online documentation** considerably. From the overview page http://photon-science.desy.de/facilities/flash/beamlines/daq_and_controls/index_eng.html one can access the detailed pages via the link **CONTROLS and DAQ User manual**.

Let us give you some of the highlights which are described on the manual pages in detail:

- We provide for each experiment (access controlled) storage space to save acquired data from user detectors as well as data from the FLASH DAQ
- During the beamtime, pulse synchronized data from the FLASH DAQ can be provided (with few minutes delay) in well-structured and easy to read HDF5 files for further analysis
- Powerful DESY computing resources (Maxwell cluster) with fast access to the data storage are provided for users for (near)online analysis and they are also still available for offline analysis after the beamtime
- Easy access from abroad to the raw and processed data via web interface (gamma-portal)
- Long term storage of the raw and processed data (→ tape copy)
- A 10 Gbit network infrastructure has been installed at the beamlines to cope with larger data rates

For more information please contact the controls and DAQ group (see link to overview page).

Taking spectra "on the fly"

A particular challenge for online monitoring of FEL pulse parameters is the burst mode operation of FLASH and the European XFEL, since it requires a fast detection of all parameters. Recently two new tools have been successfully implemented at FLASH to monitor the spectral distribution of individual pulses in the burst mode (see refs. below). These tools allow sorting of experimental data according to photon energy in the vicinity of narrow photoabsorption resonances as well as enhancing the energy resolution of spectroscopy experiments by taking into account the exact distribution of spectral modes in a SASE pulse.

M. Braune et al., *A non-invasive online photoionization spectrometer for FLASH2*,
J. Synchrotron Rad. **23**, 10-20 (2016); http://dx.doi.org/10.1107/S1600577515022675

S. Palutke et al., *Spectrometer for shot-to-shot photon energy characterization in the multi-bunch mode of the free electron laser at Hamburg*,
Rev. Sci. Instrum. **86**, 113107(2015); http://dx.doi.org/10.1063/1.4936293

New operation schemes at FLASH2: beyond 4nm, less bandwith ...

In addition to the regular operation for users, FLASH2 with its variable gap undulators is presently extensively used to explore a large variety of new potential schemes to generate FEL pulses with parameters tailored to users' requests. Among those schemes are, e.g., frequency doubling, a harmonic lasing self-seeded (HLSS) FEL, test of harmonic afterburner configurations as well as many different approaches involving tapering of the undulators. Two of the achievements within these exploratory shifts were, that a new short wavelength record for FLASH2 in the fundamental was set at 3.5 nm, and, that at 13 and 20 nm wavelength a peak pulse intensity of 1 mJ was obtained with tapering. Although these parameters did not reach the stage of routine operation for users so far, many of the explored schemes hold great promises for the near future.

If you are interested in such parameters beyond the standard operation, you are encouraged to get in touch with us during the proposal phase, so that we can discuss potential options we could offer you and the trade-off decisions to make.

Background on potential new operation modes:

E.A. Schneidmiller et al., *First operation of a harmonic lasing self-seeded free electron laser*, Phys. Rev. Accel. Beams **20**, 020705 (2017),
http://dx.doi.org/10.1103/PhysRevAccelBeams.20.020705

M. Kuhlmann *et al.*, *Frequency Doubler and Two-Color Mode of Operation at Free Electron Laser FLASH2*, *Proc.* IPAC 2017, http://dx.doi.org/10.18429/JACoW-IPAC2017-WEPAB027

E. Schneidmiller, M. Yurkov, Optimum Undulator Tapering of SASE FEL: from the Theory to Experiment, Proc. IPAC 2017, http://dx.doi.org/10.18429/JACoW-IPAC2017-WEPAB029