FLASH User Operations Newsletter, September 2019

Dear colleagues,

in order to support and inspire you when writing a proposal for FLASH, we put together this fifth 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. This and all former newsletters are now also available at http://photon-science.desy.de/facilities/flash/news_and_research_highlights/user_operations_newsletter/index_eng.html

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,

Rolf Treusch for the FLASH team

New FLASH1 burst mode pump-probe laser for the PG instruments will be available starting mid-2020

The FLASH1 burst mode pump-probe laser will be retired and replaced by a commercial Yb-femtosecond laser system during summer shutdown 2020. The new laser system will be available for the PG instruments and will be installed in a dedicated hutch close to these instruments. Preliminary specifications of the new laser system are:

Central wavelength	1030 nm
Pulse energy	> 20 µJ, 3% rms
Pulse duration	< 100 fs
Repetition rate in pulse train	100 kHz – 1 MHz
Pulse train repetition rate	10 Hz
Pulse train duration	0 – 1 ms
Synchronization to FEL	< 25 fs rms

Harmonic wavelength conversion modules (515 nm, 343 nm, 257 nm) are planned to be installed shortly after commissioning of the laser, but will most likely not be available for the 2nd half of 2020. The harmonic modules will provide pulse durations of approximately 100 fs. We are currently investigating the feasibility to add an optical parametric amplifier for generating wavelengths between 1.5 and 5 µm.

Note that this is a temporary though quite flexible solution for the experiments at the PG beamlines where almost all experiments require a pulse-train laser. From second half of 2020 on, we will unfortunately not be able to provide a pulse-train laser to the BL beamline endstations for some interim period, until we upgraded the FLASH1 laser hutch and laser systems to our new state-of-the-art technology, what will be a part of the FLASH2020+ upgrade project.

For any questions regarding the FLASH pump-probe laser systems, please

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Tunable pump-probe option for CAMP endstation will be available spring 2020.

An optical parametric amplifier will be installed as an addition to the 10 Hz pump-probe laser at the CAMP endstation in fall 2019. The system will be commissioned in spring 2020 and after that be available to users. CAMP will then have the following two additional pump-probe options (preliminary specifications):

1) 190nm to 1160nm (continuously tunable) > 10uJ, < 150fs, at FEL interaction point
2) 1160nm to 2600nm (continuously tunable) > 250uJ, < 150fs, at FEL interaction point

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SynVLiFL ("Synchrone VUV Lichtquelle an FLASH2“):

New HHG source at FL26

A new HHG source driven by the FLASH2 pump-probe laser has recently been incorporated in the beamline FL26 at FLASH2. It was realized in the framework of a BMBF collaborative research (“Verbundforschung”) project led by the Leibniz Universität Hannover (Uwe Morgner, Milutin Kovacev et al.) with strong involvement of the DESY Laser Science and Technology group (FS-LA). The HHG performance is currently being optimized with the aim of carrying out the first pump-probe experiments in conjunction with the FEL at the FL26 Reaction Microscope endstation (ReMi) in the near future.

The HHG beamline consists of four main parts (Fig. 1a):

- the HHG chamber, where high harmonics can be generated either in a Semi-Infinite Gas Cell (SIGC) or in a gas nozzle jet.
- the double filter wheel, with thin (0.1-0.15 µm) metal filters to block the remaining IR driving radiation and/or select different harmonics regions.
- the in-coupling chamber, where a hyperboloidal C-coated mirror reflects and collimates the harmonics beam, blocking at the same time the upper half of the FEL beam. The lower half of the FEL propagates below the mirror, parallel to the harmonics (Fig. 1b).
- the transmission spectrometer for the spectral analysis of the harmonics beam [1]. A UV sensitive photodiode offers the possibility of measuring also the photon flux. The beam is allowed to enter the spectrometer chamber by lifting the in-coupling mirror.

Behind the in-coupling chamber FEL and harmonics beam co-propagate across the split-and-delay unit mirrors and the ellipsoidal mirror of FL26 which focuses both in the ReMi (Fig. 1b).

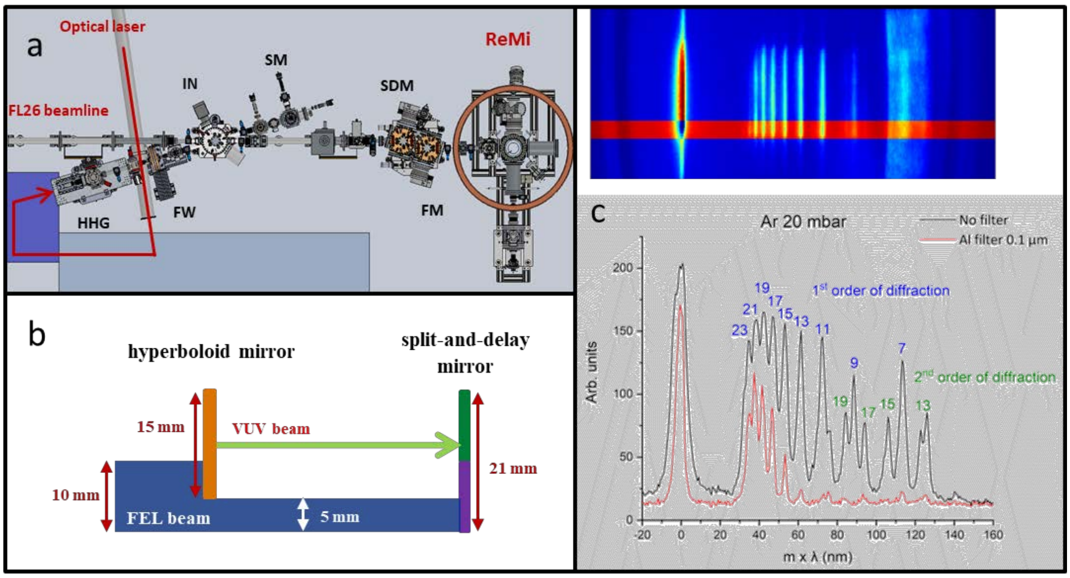

Fig. 1 a) **HHG beamline incorporated in the FL26 beamline. HHG: HHG chamber, FW: filter wheel, IN: in-coupling chamber, SM: spectrometer, SDM: split-and-delay mirror, FM: focusing ellipsoidal mirror b) the lower part of the FEL beam is centered in the lower half of the split mirror c) harmonics spectrum on the phosphor screen, calibrated with respect to mxλ (m: order of diffraction, λ: wavelength)**

So far harmonics up to the 23rd order (34 nm) driven by 800 nm in the SIGC have been clearly observed (Fig. 1c). The beam was successfully steered and focused into the ReMi and observed on the interaction screen there.

As next steps it is planned to optimize the generation in terms of the focus position in the SIGC, the gas parameters as well as the driving wavelengths (using shorter driver wavelengths). After these optimizations the generation efficiency is expected to increase [2] and the HHG source will be exploited in some first test experiments together with the ReMi team.

We will keep you updated and also provide you with detailed source specifications, once the HHG source is fully characterized and becomes available for user experiments.

[1] S. J. Goh et al., *Fabrication and characterization of free-standing, high-line-density transmission gratings for the vacuum UV to soft X-ray range*, Opt. Exp. **23**, 4421–4434 (2015); https://doi.org/10.1364/OE.23.004421

[2] C. Heyl et al., *Introduction to macroscopic power scaling principles for high-order harmonic generation*, J. Phys. B: At. Mol. Opt. Phys. **50** 013001 (2017); https://doi.org/10.1088/1361-6455/50/1/013001

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First Time-Resolved RIXS studies at the TRIXS endstation@PG1

In summer/autumn 2018, the installation of the transport line for the FLASH1 optical pump-probe laser towards the PG1 TRIXS end station for Time-Resolved Inelastic X-Ray Scattering studies [see our Newsletter from March 2018] was completed. This included a setup for non-linear optical frequency conversion close to the experiment, to provide, in addition to the fundamental at 800 nm, also 400 nm and 267 nm wavelength on demand. Right after these installations, first user experiments have been successfully conducted end of 2018 and early 2019. As an example, Figure 2 shows data from an experiment where cobalt oxides were excited by an 800 nm optical laser pulse and the excitation was then probed by RIXS at the Co M-edge around 62 eV FEL photon energy. A clear pump-probe effect in the RIXS spectrum can be identified and fast dynamics in a delay range up to 100 picoseconds were observed. The study aims at following the photo-excited state dynamics at the cobalt-site for a better understanding of potential cobalt-containing photocatalysts for a range of catalytic reactions. The achieved energy and time resolution (<60 meV, 250 fs FWHM) at the TRIXS spectrometer met the predicted specifications.

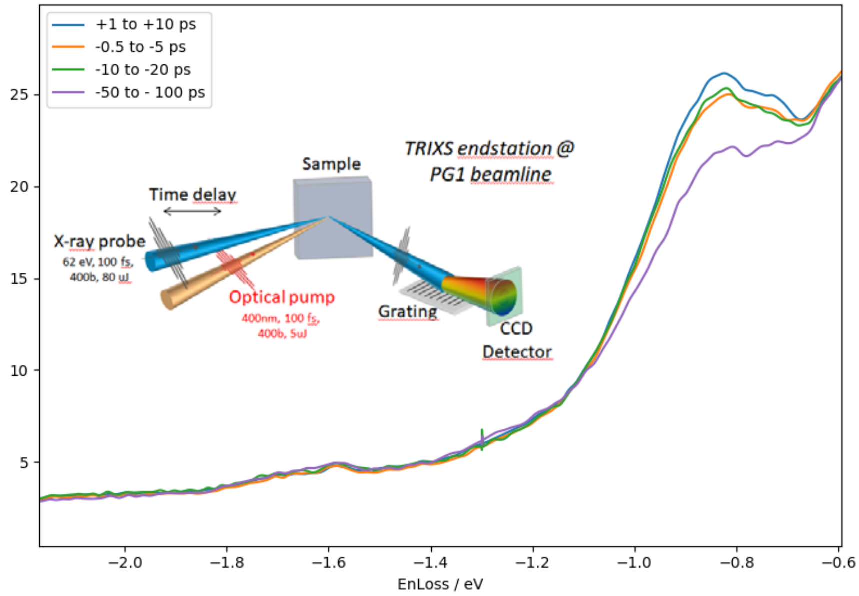

Figure 2: **Co M-edge RIXS spectrum as function of (binned) pump-probe delays measured with the TRIXS endstation at PG1. Positive delay means unpumped, i.e. optical laser arrives after FEL; negative delay means pumped (optical pump laser arrives before the FEL).**

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