FLASH: Present and new opportunities

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FLASH, the **F**ree-Electron **LAS**er in **H**amburg, started user operation in summer 2005 as the first free-electron laser for XUV and soft X-ray radiation. It is operated in the "self-amplified spontaneous emission" (SASE) mode and covers a wavelength range from 4 - 90 nm in the first harmonic with GW peak power and pulse durations between 30 fs and 200 fs. FLASH is currently the only high-repetition-rate FEL in the XUV/soft X-ray regime based on the superconducting accelerator technology developed within the TESLA Technology Collaboration at DESY. It can presently provide up to 5,000 pulses per second to users for experiments in diverse fields.

Since 2016, FLASH has offered two FEL sources in parallel and nearly independent operation, FLASH1 and FLASH2. FLASH1 is currently still equipped with fixed-gap undulators, while FLASH2 improves the performance for users with variable-gap undulators that enable easy wavelength tuning and novel FEL lasing schemes. Key developments in photon diagnostics and beamline instrumentation are combined with currently eight dedicated beamlines and endstations (five at FLASH1 and three at FLASH2).

The ongoing upgrade program FLASH2020+ will provide ambitious developments for the two FEL lines and the FLASH accelerator. An increase in electron beam energy to 1.35 GeV will extend the wavelength range of the fundamental harmonic to the oxygen K-edge while the transition metal K-edges can be reached using the third harmonic. Thus, the important elemental resonances for energy research and the entire water window for biological questions will be covered. Furthermore, FLASH1 will be fully externally seeded at the high repetition rate that FLASH can provide in burst mode while FLASH2 will exploit novel lasing concepts based on variable undulator configurations. Both FELs will be equipped with fully tunable variable-gap undulators and will be able to deliver photon pulses with variable polarization. This will allow fully parallel operation of the two FEL lines which will increase the available time for user experiments by almost 50%.