Breakthrough in sFLASH seeding experiment

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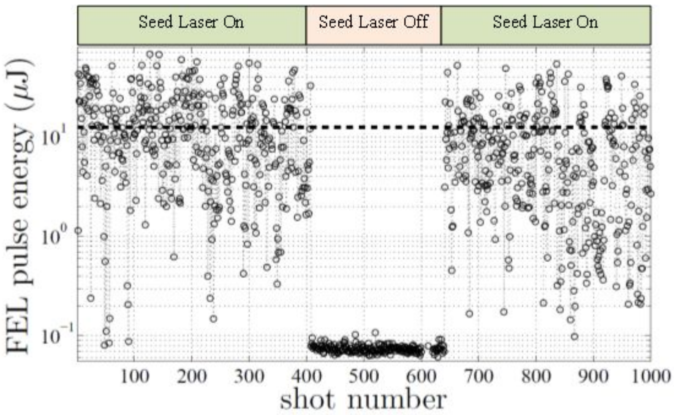
The sFLASH undulators in the FLASH tunnel.

A team of researchers from DESY, the University of Hamburg and the Technical University of Dortmund has managed to demonstrate seeding by a procedure known as HGHG at the sFLASH test facility in April. "Seeding" is supposed to make the generation of radiation in a free-electron laser more reproducible by enclosing a laser pulse in the magnetic undulator together with the packets of electrons that emit the light. By demonstrating seeding, the scientists have reached an important milestone on the way to developing a procedure for incorporating seeding in user experiments conducted at FLASH.

Free-electron lasers (FEL) produce very brief, high-intensity pulses of X-rays. Synchrotron radiation is generated by bunches of electrons travelling through an undulator at close to the speed of light, whereby light of a certain wavelength is spontaneously amplified by several orders of magnitude to produce an X-ray laser pulse. However, due to the nature of the way in which this spontaneous amplification occurs, the properties of the individual pulses vary slightly. In order to further improve the temporal and energy resolution of FEL experiments, scientists are looking for ways of triggering, or "seeding", the process of producing radiation by introducing a carefully defined pulse of laser radiation. The FLASH seeding experiment sFLASH uses its own undulators in the accelerator tunnel for this purpose, as well as a special measuring station in the FLASH tunnel, at which the pulses of photons can be examined.

The team recently managed to demonstrate seeding at sFLASH using the HGHG (High-Gain Harmonic Generation) procedure. The scientists superimposed laser light with a wavelength of 266 nanometres on an electron beam from FLASH. During its trajectory through a special arrangement of magnets, the packet of electrons is divided into a periodic microstructure, which leads to a selective amplification of the FEL radiation. This is not only the case at the incoming wavelength, but also at the far shorter distances represented by the higher harmonics of the incoming laser radiation. At 38.1 nanometres, the seventh harmonic, they managed to produce high-intensity flashes of FEL light with an energy of over 10 microjoules in the sFLASH undulator, which is just ten metres long. This result marks a crucial step towards studying an as yet unknown area of FEL seeding technology. At the same time, it shows that this principle perfectly augments the unique properties of the electron beam at FLASH, to create fully coherent, i.e. laser-like, pulses of radiation in the extreme ultraviolet range of the spectrum.



The plot for experts: In HGHG mode, the pulses of radiation inside the sFLASH undulator, which is just ten metres long, have mean energies of over 10 microjoules (µJ), whereas the “normal” SASE intensity observed when the laser beam is switched off is a factor of about a thousand lower.

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