A-04 **News from European XFEL**

Bright Future for X-ray Science

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With the advent of X-ray free electron laser (XFEL) sources, entirely new scientific opportunities have become available across various fields of physics, chemistry and biology. One of the most unprecedented features is the ability to generate high-intensity X-ray pulses with durations well below 100 femtoseconds (1 fs=10^{-15} s). This property enables dynamical studies of light–matter interactions almost in any medium (from gaseous phase to complex strongly correlated solids, i.e. high-temperature superconductors, and biomolecules [1-2]) with temporal resolution down to the very fundamental timescales of atomic processes. Moreover, the unique properties of XFEL radiation enable a solution to the well-known radiation damage problem and to take the capture of snapshots of three-dimensional structures of nanometer-sized protein crystals before the ionization and electrostatic forces destroy the crystal [3]. The XFEL developments have led to emergence of new methods in structural biology, such as serial femtosecond crystallography [4]. In the near future, a new XFEL source will expand the research opportunities of the existing laboratories, i.e. Linac Coherent Light Source in Stanford, USA [5], and SACLA XFEL in Hyogo, Japan [6]. It will be the world's brightest source of ultrashort X-ray pulses: the European XFEL [7], a 3.4 km long X-ray laser facility in the Hamburg metropolitan area (Fig. 1). Due to its unprecedented photon beam properties (Table 1), the ultrashort and ultraintense flashes of X-rays generated by the European XFEL machine will enable researchers to map the atomic details of viruses, decipher the molecular compositions of cells, record three-dimensional images of the nanoworld, film chemical reactions and study processes such as those occurring deep inside planets.

Responsible for construction and operation is the European X-Ray Free-Electron Laser Facility GmbH, a limited liability non-profit company constituted under German law that was officially founded in 2009 in Hamburg, Germany [8].

Beam parameter	Value
Wavelength range [nm]	0.05–4.7
Photon flux/pulse	10^{11}–10^{13}
Peak brilliance [photons/s•mrad^2•mm^2•0.1% BW]	5×10^{33}
Number of pulses/second	27 000
Typical pulse widths [fs]	10–100

Table 1: Photon beam parameters of the European XFEL facility.

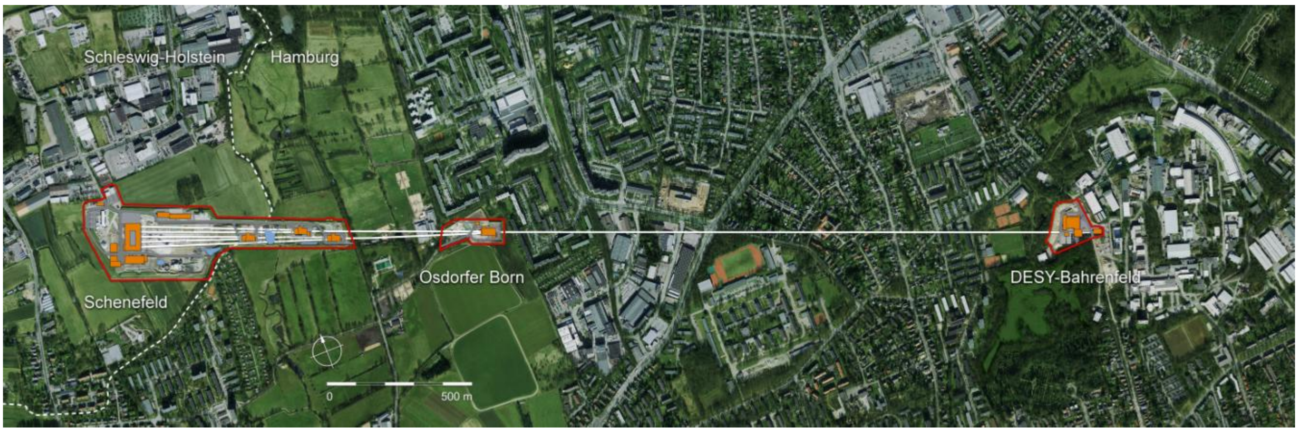

Figure 1. Aerial view of the European XFEL facility. The electron injector is located on the DESY campus in Hamburg, while the underground Experimental Hall hosting the scientific infrastructure dedicated to the user science program is located in nearby Schenefeld. Credit: European XFEL, aerial views: FHH, Landesbetrieb Geoinf. und Vermessung.

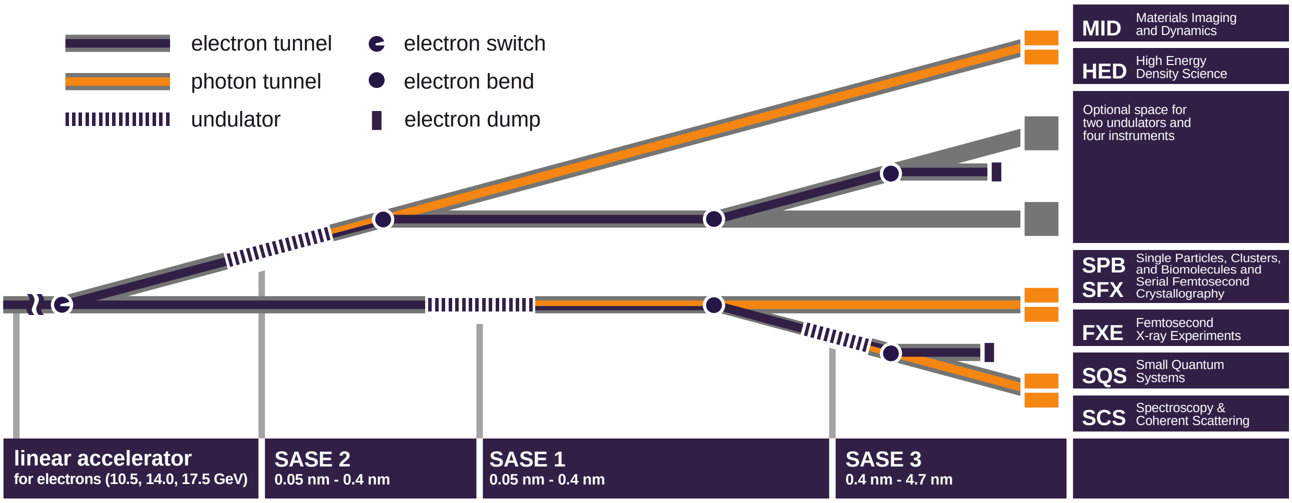

Figure 2: Schematic layout of the European XFEL facility, including the initial SASE undulators, the various beam distribution systems and the initial scientific instruments. Credit: European XFEL.

The construction work on the European XFEL started in 2009. The first electrons have been generated in the laser-driven electron gun, and commissioning of the injector started in late 2015. The installation of the main superconducting accelerator, provided through contributions by institutes from nearly all 11 partner countries, is in full swing and should be completed in late summer 2016. Soon afterwards, commissioning with electron beam will start at electron energies of 14–17.5 GeV. In early 2017, the electron beam and all undulator segments for the SASE1 XFEL source (Fig. 2), which is based on a principle of self-amplified spontaneous emission (SASE), will be ready for first generation of FEL radiation. The challenging X-ray optics and diagnostics components are currently being installed and prepared for commissioning. At the same time, the design of the initial six scientific instruments is largely complete, and the installation has started. The start of operation is foreseen in early summer 2017, which is when the first experiments on a scientific instrument will be performed. Shortly thereafter, the early first pilot user experiment program will start. Full performance of the accelerator, FEL radiation and scientific instruments will be reached in 2018. It is currently planned to increase the amount of accelerator operation dedicated to the user program from 1000 hours in 2017, to over 2000 hours in 2018, and to the final 4000 hours in 2019.

The European XFEL facility is being realized as a joint effort of many partners across Europe. Presently, 11 countries are participating in the European XFEL project: Denmark, France, Germany, Hungary, Italy, Poland, Russia, Slovakia, Spain, Sweden and Switzerland, while the UK will join the project in the near future. With its repetition rate of 27 000 pulses per second and a peak brilliance a billion times higher than that of the most conventional X-ray sources, the European XFEL will open up new research venues for scientists and industrial users across the world.

The new X-ray light generated by the European XFEL will provide unprecedented opportunities for Polish research groups. Poland has been part of the project from the very beginning and became one of the shareholders of the European XFEL GmbH with a 2% contribution, which includes both the construction and operation phases of the facility. The National Center for Nuclear Research (NCBJ) in Świerk has coordinated the Polish in-kind contributions realized during the construction phase of the machine. It also acts as the coordinator of a national consortium (XFEL-Polska), embracing various Polish universities and research institutions involved in this effort. Starting in 2017, Polish scientists can apply for user beamtime at any of the available scientific instruments [9]. It will be the role of a recently established User Office to coordinate the calls for user proposals (to be issued twice per year) and help the users to plan and carry out their proposed research while visiting the European XFEL facilities in Schenefeld. The entire beamtime application and travel arrangements will be provided digitally via a web-based portal called UPEX (User Portal for European XFEL).

The main criterion for obtaining beamtime for non-proprietary studies at the European XFEL will be the scientific excellence of the proposed research, which will be evaluated by panels of external experts. It is therefore extremely important to prepare and train the Polish scientific community, in particular the younger generation of Polish scientists, to enter this very competitive field of science and help them to exploit one of the most modern research tools in their scientific careers. In this context, it is essential to underline the efforts made by the existing consortium XFEL-Polska and its coordinator, NCBJ, to gather the interested research groups from all over Poland and support them in preparation and execution of scientific proposals at the European XFEL. We also point to the initiatives undertaken by the Polish Synchrotron Radiation Society (PTPS) in disseminating the scientific topics and research prospects that became available with the development of

XFEL sources. Each year, during either the National Symposium of Synchrotron Radiation Users (KSUPS) or the International Symposium and School on Synchrotron Radiation in Natural Science (ISSRNS), XFEL international and Polish researchers are invited to present their results to Polish scientific audience/community. The XFELs have also been remarkably present during the past 43rd Congress of Polish Physicists organized by the Polish Physical Society (PTF) in Kielce in September 2015. Last but not least, we would like to acknowledge our own effort, supported by European XFEL and Institute of Physics Polish Academy of Sciences via EAgLE grant, to organize meetings in Poland with XFEL scientists, in particular during the previous ISSRNS conference in 2014 and the Warsaw School on Science with FELs in 2015.

Further initiatives, beyond training activities, are needed in order for the new light sources to fully benefit the Polish scientific community. The XFEL science is a relatively young field, which still undergoes very rapid and constant development both on the technological and scientific sides and remains very competitive. This stems predominantly from a limited amount of beamtime provided by the only two hard X-ray XFELs currently operating worldwide. Writing competitive proposals requires the involved scientists to carry out detailed and thorough preparatory investigations and often engages them in large international collaborations that prepare jointly the experiments to be carried out at XFEL facilities.

It is therefore essential to gather now the potential Polish scientific users of the European XFEL and work jointly towards successful beamtime proposals and research activities in this field of science. Clearly, such initiatives can only become successful if dedicated funding can be provided. In that sense, the consortium XFEL-Polska, together with a number of Polish research institutes and universities, has commenced an effort to prepare a joint proposal to the Ministry of Science and Higher Education (MNiSzW) for financial support to Polish groups preparing for the operation phase of the European XFEL. Within this proposal, it is foreseen to focus the effort not only on preparatory research activities but also on training and educational aspects, which will allow preparation of younger generations of Polish scientists to take full advantage of this new light in the near future.

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