FELs OF EUROPE NEWS 08|15

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IN THIS ISSUE

The first accelerator modules installed in the underground tunnel of European XFEL.

New FELs OF EUROPE Management

As of 1st July 2015, FELs OF EUROPE have a new management. The term of the first Chair of the collaboration, Josef Feldhaus from DESY in Hamburg, Germany, ended after three years. Rafael Abela, project leader photonics and research of the Swiss-FEL project at PSI, Switzerland, was elected new Chair. He is being assisted by two vice chairs, Britta Redlich from the FELIX Laboratory at Radboud University Nijmegen, The Netherlands, and Sverker Werin, from the MAX IV Laboratory at Lund University, Sweden. Together they form the new Management Board (MB) and take care of the daily business and the overall coordination of the FELs OF EUROPE activities. The MB members are elected for a period of two years. In order to avoid changing the complete MB after two years and to ensure continuity, it was decided that Michele Svandrlik, the project director of the FERMI facility at Elettra, Trieste, Italy, will replace Sverker Werin after one year.

These decisions were taken unanimously on the last Steering Committee (SC) meeting on 26-27 March 2015 at Daresbury Laboratory. Before, the SC discussed and agreed on a strategy paper that had been worked out the months before. The strategy paper starts out from the mission and main areas of activity agreed in the Memorandum of Understanding of May 2012, it reviews the current situation, draws up the main challenges of the coming years and proposes a number of actions. The most important changes include the implementation of a Management Board instead of a single Chair, the distribution of responsibilities for key action areas among SC members, and the introduction of a small annual fee to maintain key activities such as newsletter, website, conferences etc. The strategy will be regularly revisited to adjust to new developments, e.g. after the European XFEL and SwissFEL have started user operation in 2017.

JF

Collaboration with LASERLAB-EUROPE

FELs OF EUROPE and LASERLAB-EUROPE, the Integrated Initiative of European Laser Research Infrastructures, decided to work closer together in the future. In October 2014, the two networks signed a general collaboration agreement, and in June 2015 representatives of the two parties and of the ELI project had a very constructive and fruitful meeting at Munich Airport to discuss further details.

The meeting was initiated shortly after the decision of the European Commission to fund two H2020 projects in which both FEL and optical laser facilities participate, namely the fourth LASERLAB-EUROPE Integrated Initiative with participation of the FERMI and FELIX facilities, and the EUCALL (European Cluster of Advanced Laser Light Sources) project which includes ELI and European XFEL as well as the two networks. The two EU projects provide an excellent basis for establishing a fruitful long-term collaboration.

Quantum states explored with a voltmeter

Researchers at the THz Free Electron Laser, FELIX, at the Radboud University in Nijmegen, the Netherlands have shown laser control of quantum superposition states in silicon, with electrical readout of the orbital superposition for the first time. In a collaboration between Surrey University and University College London in the UK, a trivial electrical current measurement was used to interrogate the "ghostly" superposition – a microelectronic version of Schrödinger's cat in which the electron orbiting an impurity was in both 1s and 2p states simultaneously. The silicon samples used were ordinary, commercial silicon wafers, doped with phosphorus. The work, published in Nature Communications (doi: 10.1038/ncomms7549), demonstrates atom trap physics can be performed on impurity states in silicon, the current standard in electronics, with potential for applications in future quantum technologies for example as a quantum computer gate.

Quantum Technologies are currently gathering momentum and new applications of quantum superpositions are gradually becoming available, such as quantum cryptography systems for more secure communications, miniaturised atomic clocks for more accurate time-stamping and improved GPS. In the future it may be possible to produce a quantum computer - the holy grail of QT which uses quantum superpositions to hold information, giving massive parallelism and very high speed. "So far the most successful efforts towards a quantum computer have used atoms and ions in a vacuum trap. However, any information technology system that is going to be really useful might better be based on platforms that the industry already understands, and that means likely silicon" said Dr Nik Stavrias from FELIX. "The use of the spin degree of freedom in silicon is already quite far advanced, providing a fantastic quantum memory. In this study we wanted to investigate the orbital degree of freedom, and it's crucial to be able to control that in order to be able to get the spins to talk to each other in a controllable way."

The THz free-electron laser is ideally suited to studying the control of orbits in silicon impurities. The FEL is currently the only source that provides short (picosecond) pulses with high energy, in the right frequency range. It's tunability means it is easy to investigate a wide variety of different dopants too. A coherent THz pulse from the FEL creates a superposition state in the donor electron orbitals. A second pulse creates a new superposition which depends on the exact time between the two pulses. Effectively this is an interference phenomenon between the second light pulse and the wave-like nature of the state imprinted on the donors by the first. The effect, called Ramsey interference after its discoverer, was first observed for spins of atoms in vacuum in 1949 and is crucially important in atomic clocks, but this is the first time the phenomenon has been observed in the THz region, and the first time it has been observed for orbital excitations in silicon. The pulses used in the experiment are equivalent to the so-called Pauli X-gate operation in quantum computer logic.

The result was observed through changes in the sample resistance via photo-thermal ionization and using conventional electrical measurements. "The thing that surprised us most is that the coherent state survived the conditions necessary for the electrical measurement, for example physical contacts to the sample, a flowing current and elevated temperature", said Dr Ellis Bowyer from Surrey. "This shows there are realistic possibilities for quantum devices using orbital states of impurities in silicon building up from the vast experience of the semiconductor industry".

The work was funded by the UK's EPSRC under the Programme Grant "COMPASSS".

Reference: Litvinenko, K. L. et al., Nat. Commun. 6, 6549 (2015).
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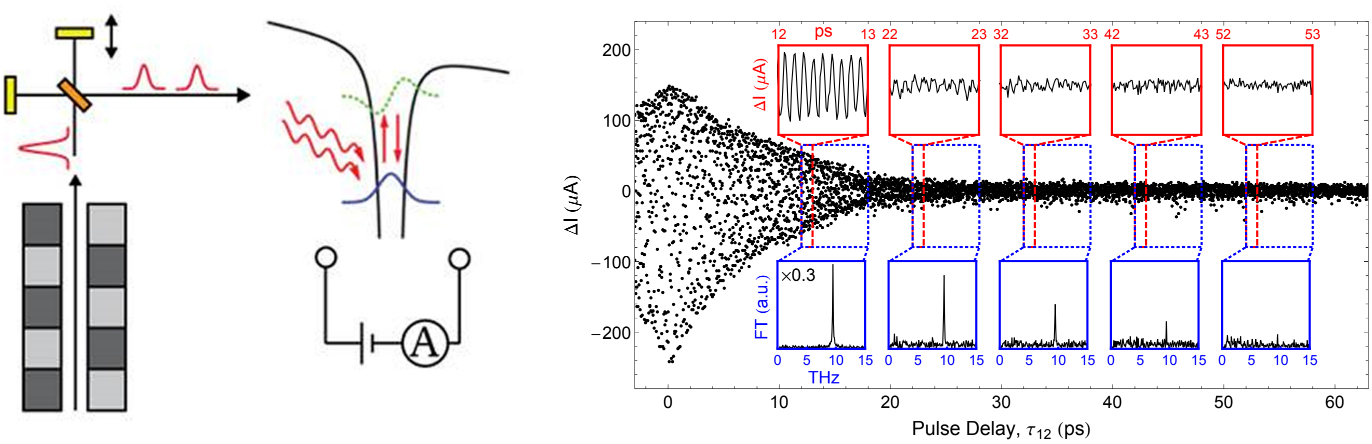
b.murdin@surrey.ac.uk or felix@science.ru.nl



The left panel shows a schematic overview of the experiment. A coherent pulse of THz radiation from the free electron laser generates a superposition state in the donor electron orbitals. A second pulse produces a new superposition which depends on the exact time between the two pulses. The interference effect between the second light pulse and the wave-like nature of the state imprinted by the first has been detected electrically by a "voltmeter". The right panel shows one of the results of these measurements.

BR

FEL-based four-wave-mixing experiments at FERMI

The development of experimental methods based on coherent non-linear interactions, such as four-wave-mixing (FWM) processes, in the optical spectral range, have represented a fundamental milestone for experimental physics, chemistry and biology. The FWM approach can provide ultrafast time resolution as well as energy and wavevector selectivity, other than allowing to probe dynamics inaccessible by linear methods. The possible extension of FWM at wavelengths shorter than the optical ones was proposed in the early 2000's. It has been shown theoretically how the multi-wave nature of FWM in combination with soft X-ray resonances might represent a unique experimental tool, able to probe, e.g., the real-time dynamics of electronic excitations between selected atoms with femtosecond-nanometer time-space resolution [1]. FWM at sub-optical wavelengths may also allow to detect elementary excitations (phonons, polarons, etc.) in an energy-wavevector range inaccessible by optical FWM [2].

Though in the last few years FEL sources have been employed to take fundamental steps into X-ray non-linear interactions, FEL-based FWM has not been put in practice. In July 2014 we used a purposely designed, compact experimental set-up ("mini-TIMER"; Fig. 1a) to demonstrate how the coherent FEL pulses delivered by the FERMI seeded FEL facility (Trieste, Italy) can generate transient gratings (TGs) in the extreme ultraviolet (EUV) range and how such TGs, when illuminated by an optical laser pulse, can stimulate an appreciable FWM response [3]. The latter has the form of a well-defined beam (Fig. 1b) that propagates downstream the sample along the "phase matched" direction (k_{out}; Fig. 1c). In our experiment we also observed a time-evolution of the FEL-stimulated FWM signal, extended throughout the whole probe timescale (≈ 0-100 ps) and featured by modulations compatible with those expected by ultrafast molecular vibrations and slower acoustic modes. This result is a fundamental milestone for more advanced EUV/soft X-ray FWM applications, which we are going to develop at FERMI in the near future.

In this respect, we plan to use in the second semester of 2015 the mini-TIMER setup to combine the FWM approach with the twin-seed two-color FEL emission, recently developed at FERMI, in order to extend the excitation energy range exploitable by FEL-based FWM. A dedicated instrument (EIS-TIMER; partially financed by the European Research Council through the Grant No. 202804) is in installation at FERMI and will start the commissioning in July 2015. EIS-TIMER will permit to carry out FWM experiments without the need of an optical probe, hence allowing to extend the wavevector range accessible by FEL-based FWM up to the inverse nanometer range [2]. Exploitation through users of such novel FWM capabilities is already possible since the mini-TIMER setup is available for user experiments at the DiProI end-station of FERMI.

References

[1] S. Tanaka and S. Mukamel, Phys. Rev. Lett. 89, 043001 (2002).
[2] F. Bencivenga and C. Masciovecchio, NIMA 606, 785-789 (2009).
[3] F. Bencivenga et al., Nature 520, 205-208 (2015).

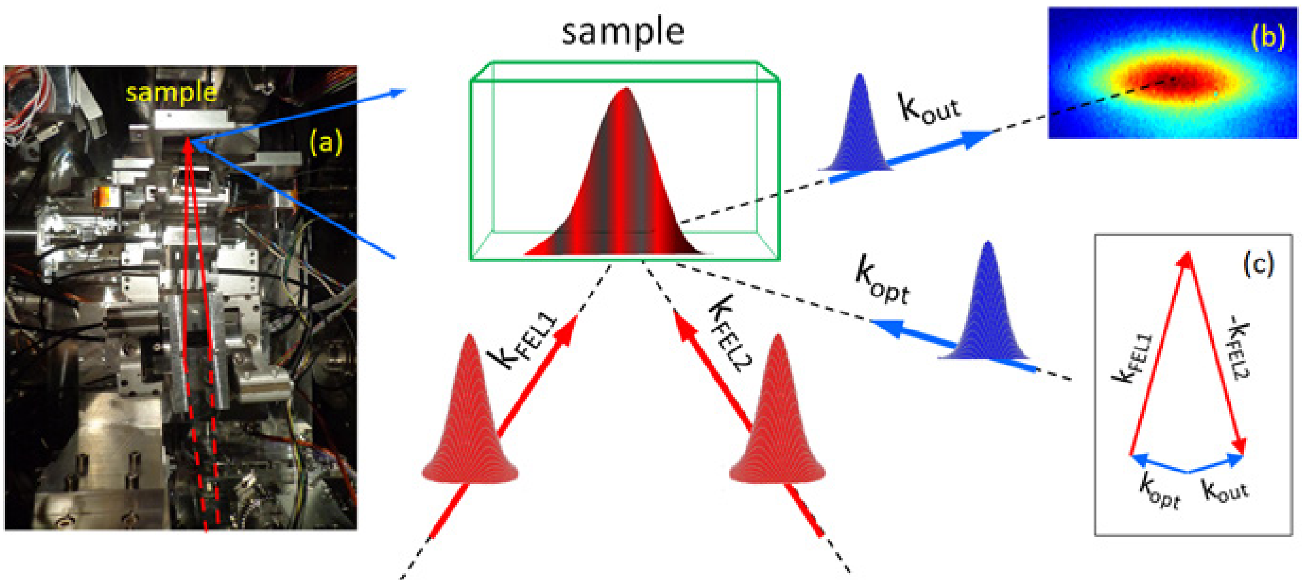


Figure 1. Sketch of the FEL-based FWM experiment: k_{FEL1}, k_{FEL2}, k_{opt} and k_{out} are the wavevectors of the two crossed FEL excitation pulses, the optical probing pulse and the FWM signal. (a) Picture of the mini-TIMER setup (close to the sample area) inside the DiProI end-station, the arrows are k_{FEL1}, k_{FEL2} k_{opt} and k_{out}. (b) Image of the FWM signal beam propagating along the phase-matched direction (k_{out}), defined by the diagram shown in (c).

FB

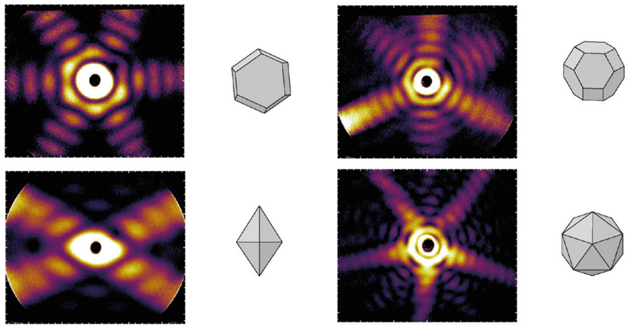
X-ray pulses from FLASH uncover free nanoparticles for the first time in 3D

For the first time, a German-American research team has determined the three-dimensional shape of free-flying silver nanoparticles, using DESY's X-ray laser FLASH. The tiny particles, hundreds of times smaller than the width of a human hair, were found to exhibit an unexpected variety of shapes, as the physicists from the Technical University (TU) Berlin, the University of Rostock, the SLAC National Accelerator Laboratory in the United States and from DESY report in the scientific journal Nature Communications. Besides this surprise, the results open up new scientific routes, such as direct observation of rapid changes in nanoparticles.

Nanoparticles are becoming increasingly pervasive in our everyday lives. These tiny particles, invisible to the naked eye, have widespread applications, ranging from sunscreen and paints to colour filters and electronic components. They are even promising for medical purposes including cancer treatment. "The functionality of nanoparticles is linked to their geometric form, which is often very difficult to determine experimentally," explains Dr. Ingo Barke from the University of Rostock. "This is particularly challenging when they are present as free particles, that is, in the absence of contact with a surface or a liquid."

The nanoparticle shape can be revealed from the characteristic way how it scatters X-ray light. So far, the spatial structure of nanoparticles has been reconstructed from multiple two-dimensional images, which were taken from different angles. This procedure is uncritical for particles on solid substrates, as the images can be taken from many different angles to uniquely reconstruct their three-dimensional shape. "Bringing nanoparticles into contact with a surface or a liquid can significantly alter the particles, such that you can no longer see their actual form," says Dr. Daniela Rupp from the TU Berlin. A free particle, however, can only be measured one time in flight before it either escapes or is destroyed by the intense X-ray light. Therefore, the scientists looked for a way to record the entire structural information of a nanoparticle with a single X-ray laser pulse.

To achieve this goal, the scientists led by Prof. Thomas Möller from the TU Berlin and Prof. Karl-Heinz Meiwes-Broer and Prof. Thomas Fennel from the University of Rostock employed a trick. Instead of taking usual small-angle scattering images, the physicists recorded the scattered X-rays in a wide angular range. "This approach virtually captures the structure from many different angles simultaneously from a single laser shot," explains Fennel. The researchers tested this method on free silver nanoparticles with diameters of 50 to 250 nanometres. The experiment did not only verify the feasibility of the tricky method, but also uncovered the surprising result that large nanoparticles exhibit a much greater variety of shapes than expected.



X-ray diffraction images of a truncated twinned tetrahedra nanoparticle with 150nm diameter (top left), a decahedra nanoparticle with 180nm diameter (bottom left), a truncated octahedra nanoparticle with 200nm diameter (top right), and of an icosahedra nanoparticle with 240nm diameter (bottom right).

Large particles composed of thousands or millions of atoms often yield predictable shapes, because the atoms can only be arranged in a particular way to obtain an energetically favourable state. In their experiment, however, the researchers observed numerous highly symmetrical three-dimensional shapes, including several types known as Platonic and Archimedean bodies. Examples include the truncated octahedron (a body consisting of eight regular hexagons and six squares) and the icosahedron (a body made up of twenty equilateral triangles). The latter is actually only favourable for extremely small particles consisting of few atoms, and its occurrence with free particles of this size was previously unknown. "The results show that metallic nanoparticles retain a type of memory of their structure, from the early stages of growth to a yet unexplored size range," emphasizes Barke.

Due to the large variety of shapes, it was especially important to use a fast computational method so that the researchers were capable of mapping the shape of each individual particle. The scientists used a two-step process: the rough shape was determined first and then refined using more complex simulations on a super computer. This approach turned out to be so efficient that it could not only determine various shapes reliably, but could also differentiate between varying orientations of the same shape.

This new method for determining the three-dimensional shape and orientation of nanoparticles with a single X-ray laser shot opens up a wide spectrum of new research directions. In future projects, particles could be directly "filmed" in three dimensions during growth or during phase changes.

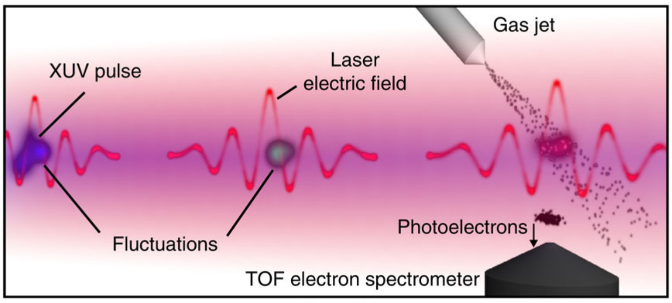
Reference

Ingo Barke et al., The 3D-architecture of individual free silver nanoparticles captured by X-ray scattering, Nature Communications 6, 6187 (2015); DOI: 10.1038/ncomms7187

JF, from DESY News

A new technique to measure the duration of FEL pulses with partial longitudinal coherence

A theoretical study carried out by researchers from the SOLEIL synchrotron and recently published in Nature Communications makes it possible to measure the temporal coherence properties of free electron lasers. The measurement scheme relies on laser-dressed XUV photoionization: the evolution of the shot-averaged photoelectron spectrum with the laser/XUV delay provides a two-dimensional spectrogram. The statistical properties of the XUV pulses accumulated during the measurement are then extracted from this spectrogram using a phase-retrieval algorithm. This not only provides a diagnostic for shot-to-shot pulse fluctuations, but it also enables the characterization of other phenomena that can reduce the pulse coherence, including the spatio-temporal pulse distortions or the limited resolution of the detection device. This method is an extension of the well-known FROG (Frequency Resolved Optical Gating) technique and therefore also applies to the temporal characterization of XUV attosecond pulses and near visible femtosecond waveforms. The next step will be to apply this technique to measure the temporal properties of currently operating XUV FELs.



Laser-dressed photoionisation enables the temporal characterization of partially coherent FEL pulses.

Reference

C. Bourassin-Bouchet and M.-E. Couprie, Partially coherent ultrafast spectrography, Nature Communications 6, 6465 (2015); doi: 10.1038/ncomms7465.

MEC

PSI-DESY Collaboration Delivers First Photonics Component for SwissFEL

The gas-based photon beam position and intensity monitor is a device originally developed at the Deutsches Elektronen-Synchrotron (DESY) for the non-destructive measurement of position and flux of the FLASH FEL beam. The accurate measurement of these variables is necessary due to the stochastic nature of the self-amplified spontaneous emission (SASE) process which can create fluctuations in the position and flux of the FEL beam on a shot-to-shot basis.

The device has been developed and adapted to fit the SwissFEL parameters in a PSI-DESY collaboration over the course of two years. The gas-based detectors will be the first components to see the photon beam created by the SwissFEL, and will be the main components that users and operators will use to optimize the operations of the machine and to better understand the data collected. The photon beam positon and intensity monitors detect the position and intensity of the FEL beam by counting the number of ions created in a pre-calibrated gas chamber through the photoionization process, and looking at the differences in a split electrode to find the position of the beam.

The device is able to measure the relative flux of the FEL beam to a 1% level or better, the absolute flux of the beam to a 10% level or better for photon energies ranging up to 20 keV, and it can measure the transverse position of the FEL beam to an accuracy of 10 micrometer. The device arrived at PSI at the end of May, and will be one of the first photonics components to be installed in the new SwissFEL facility.

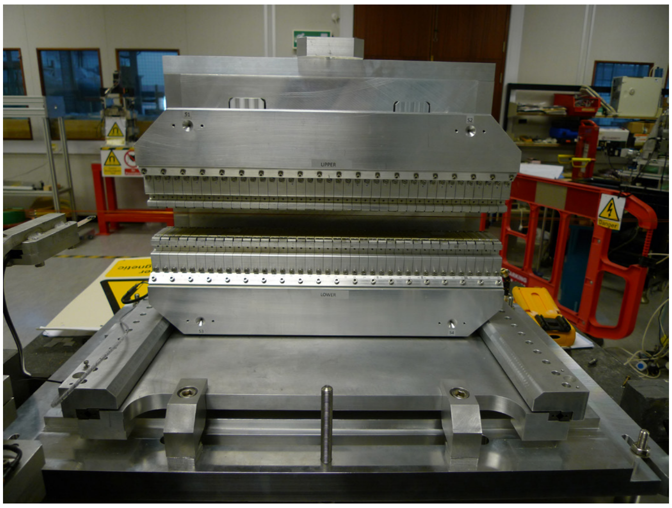
The gas-based photon position and intensity monitor arrived well in the SwissFEL ID lab, with happy collaborators from PSI and DESY.

PJ

CLARA & SwissFEL Exchange Christmas Presents

As part of the Memorandum of Understanding signed between STFC and PSI regarding the collaboration on the development of SwissFEL and CLARA it was agreed that STFC would design and build the laser heater undulator needed by SwissFEL to counteract microbunching instabilities within the accelerator. It was also agreed that SwissFEL would supply some essential accelerator equipment to CLARA at Daresbury after the SwissFEL Injector project had ceased operation.

By coincidence, the laser heater was being assembled and tested just as the SwissFEL Injector was closing down. And so, close to Christmas 2014 the two projects delivered their equipment to their new homes. The laser heater will be installed into SwissFEL during 2015 and the three linacs and associated magnets are now awaiting installation into CLARA at a suitable time, still to be determined. The collaboration between SwissFEL and CLARA continues and Daresbury staff are looking forward to helping with beam commissioning of SwissFEL at the end of 2015 and similarly SwissFEL staff will be exploiting the FEL test capabilities of CLARA once it becomes available.



The laser heater undulator for SwissFEL.

JC

European XFEL installation in full swing

In the previous years, civil construction, planning, and installation of infrastructure were the main focus at European XFEL. While civil construction and infrastructure installation are still ongoing, the balance is shifting steadily towards the fabrication, testing, and installation of parts of the X-ray free electron laser.

Following the installation of the gun in December 2013, further parts of the injector were mounted in 2014 and work is progressing towards commissioning of the injector with beam this year.

The first accelerator modules installed in the underground tunnel of European XFEL.

Downstream from the injector, the first modules of the 1.7 kilometre-long accelerator have been installed in the accelerator tunnel. There is still a long way to go until all 100 modules are finally mounted, but the module production rate eventually reached the required assembly rate—a major success in the joint efforts of all partners to ensure that user operation can start as planned in 2017.

Following the path of the electron beam further toward the experimental hall in Schenefeld, installation of the photon beam transport lines, which will guide the X-ray flashes from the undulators to the instruments in the experiment hall, is also well underway. Preparations for the start of undulator installation are in full swing, and all 91 segments for the three undulators of the startup phase have been delivered. At the end of the tunnels, in the future experiment hall, the floor is prepared for the installation of the hutches and instruments. Instrument development is also on track and the groups now focus on the final design details and procurement of individual parts. The detector group has successfully tested the first ultrafast X-ray detector to be used at the European XFEL – the Large Pixel Detector (LPD), which is intended to be used on the Femtosecond X-Ray Experiments (FXE) instrument to observe ultrafast reactions, including the formation and breaking of chemical bonds. And finally, the development of the Karabo software framework, which enables both beamline control and data analysis, has been successfully continued with the release of two new versions 1.1 and 1.2.

About 28 metres above the floor of the experiment hall, the roof of the future laboratory and office building was completed in February. This milestone in the construction of the largest above-ground European XFEL building was celebrated with a topping-out ceremony. The building's ground floor will contain a laboratory complex for biology, electron microscopy, sample preparation, and other uses, while the two other floors will house the facility's offices.

And last but not least, the UK has stated its intention to join European XFEL as a twelfth member state and invest up to 30 M£ into the construction of the facility. Earlier in 2014, the United Kingdom had already committed about 14 million euro to two user consortia.

BE

Update on a Swedish Free Electron Laser at MAX IV

The MAX IV facility is prepared to be extended with an X-ray Free Electron Laser. The FEL would provide light with such qualities that completely new experiments would be possible. An application for a planning grant to fund a design study was submitted to the Knut and Alice Wallenberg Foundation (KAW) in December 2014. The design study will address the science case, a possible technical realization, the full cost and a time plan for the realization. These are the prerequisites to take an informed decision on a full project of about 1 billion SEK and 4-5 years realization time.

In the meantime, KAW has evaluated the grant application for a feasibility study. The evaluation shows that KAW is in favor of the proposal but wishes the other financiers of the MAX IV project to participate. Therefore, discussions have begun with the Swedish Research Council and will continue with the other financiers: Vinnova, Lund University and Region Skåne. The Swedish Research Council, who is the main financer of the MAX IV facility, is launching a new model this year on how to prioritize, fund and organize national research infrastructure, and the renewed application will relate to this model.

Aerial view of the MAX IV facility with the FEL indicated to the right.

Discussions with the research community are ongoing, and the two main occasions this year are the Nobel Symposium in June 2015 and the MAX IV Laboratory's annual user meeting in September 2015.

The Free Electron Laser at the MAX IV is planned to consist of two undulator lines focused on the hard and soft X-rays, respectively. The hard X-ray FEL will reach 9 keV (1.3 Å) and the soft X-ray FEL 1.2 keV (10 Å). The system will make full use of the MAX IV linac already in operation, and extend the system up to 6 GeV for best operating conditions.

SW

Umbrella MoU Signed by 14 Parties

Umbrella is the pan-European federated identity system for the users of the large-scale European photon and neutron facilities. This IT platform offers for the first time an EU-wide, unique and persistent ID for a wide, multidisciplinary user community. It was initiated by the IRUVX-PP project and further developed with the support of several EU projects such as PaNdata and CRISP. On the 31st of March 2015, the Memorandum of Understanding of the Umbrella Collaboration was signed by 14 parties: ALBA, DESY, Diamond Light Source Ltd, Elettra, EMBL Heidelberg, ESRF, European XFEL, HZB, ILL, Instruct Academic Services Ltd, KIT, PSI, STFC and SOLEIL.

MvD

POLFEL-TWIN Proposal Submitted to EC

Beginning of May, NCBJ (Narodowe Centrum Badań Jądrowych) submitted a TWINNING proposal to the European Commission with the aim to strengthen the Polish research potential in the field of free electron lasers. Twinning partners are DESY and Elettra who have pioneered this field in Europe. The main objectives are: strengthening and widening of the Polish FEL community; exchange of know-how with DESY and Elettra; increasing participation in European XFEL-related projects; strenghtening of international networking of Polish FEL researchers; increasing visibility of FEL research and joint support for a positive decision to realize POLFEL.

JF

PhotonDiag 2015 Conference

The 2nd International Workshop on FEL Photon Diagnostics, Instrumentation, and Beamlines Design was held from 8 to 10 June, 2015 at the International Centre for Theoretical Physics (ICTP) in Trieste and attended by ~90 specialists from 12 countries.

The workshop focused on the following topics:
- Photon beam diagnostic techniques - measuring key properties of the FEL photon beam: intensity, pointing, position, spectral content, polarization, etc.
- Time-related beam properties - temporal characterization of electron/FEL/laser beams: arrival times, pulse length & shape, timing & synchronization, stability issues.
- FEL optics - challenges for ultra-short and ultra-intense pulses: fabrication and metrology - mirrors, gratings, zone plates, multilayers etc.; photon-induced damage – theory & practical avoidance.
- Photon beam transport - preserving the special properties of the FEL pulse: pulse length, spectrum, coherence, wavefront, monochromators, beam splitters, etc.
- Science instruments – meeting the special demands of experiments on FEL sources: dedicated endstations, sample injection and replacement, special experimental techniques etc.
- Detectors & data handling for FEL-based experiments – designs, challenges & perspectives: electron & photon detectors, shot-by-shot detection, collation of diagnostic data.

The PhotonDiag 2015 workshop followed a first one organized in 2010 at DESY (PhotonDiag 2010) and is henceforth being organized regularly every two years as an activity of the Free Electron Lasers of Europe (FELs OF EUROPE), alternating with the Science at FELs conference. The next PhotonDiag workshop will be jointly organised with colleagues from LCLS, SLAC (USA) and take place in 2017 in California (venue to be determined).

Participants at the PhotonDiag2015 Workshop at ICTP, Trieste, Italy. JF

CURRENT AND UPCOMING CALLS FOR PROPOSALS

for Experiments at FLASH for the beamtime period July-December 2016
Deadline: 1 October 2015
http://photon-science.desy.de/users_area/calls__deadlines/index_eng.html

for Experiments at FELBE for the beamtime period January - July 2016
Deadline: 15 October 2015
https://www.hzdr.de/db/Cms?pNid=1732

for Experiments at FELIX for the beamtime period April - September 2016
Deadline: 15 January 2016
http://www.ru.nl/felix/facility-0/application/

UPCOMING EVENTS

XIII School of Synchrotron Radiation: Fundamentals, Methods and Applications
14 - 25 September 2015, Grado, Italy
http://www.elettra.eu/Conferences/2015/XIIISILS/

International Conference on Electron Spectroscopy and Structure: ICESS-2015
28 September – 2 October 2015, Stony Brook, USA
http://www.stonybrook.edu/commcms/icess/

7th Hard X-Ray FEL Collaboration Meeting
26 - 28 October 2015, ETH Zürich Hönggerberg, Switzerland

Official Opening of the FELIX Laboratory and the Experimental Garden
30 October 2015, Radboud University, NL

RESONANCE 2015
10 – 11 December 2015, Trieste, Italy
http://www.elettra.trieste.it/Conferences/2015/RESONANCE/

IMPRINT

Publisher: FELs OF EUROPE, chaired by Dr. Rafael Abela, Paul Scherrer Institut | 5232 Villigen PSI | Switzerland
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Images: DESY/Dirk Nölle (Cover image), FELIX (pg. 2), FERMI/Filippo Bencivenga (p. 3), Universität Rostock/Hannes Hartmann (pg. 4), SOLEIL, PSI (pg. 5), STFC, DESY/Dirk Nölle (pg. 6), MAX IV Laboratory (pg. 7), Elettra/Marco Zangrando (pg. 8)

FELs OF EUROPE is an initiative of the ESFRI projects EuroFEL and European XFEL. It is a collaboration of all free electron laser (FEL) facilities in Europe, with the goal to meet the technological and scientific challenges of these novel and rapidly developing technologies and to provide a worldwide unique, pan-European research infrastructure that enables exploiting the full scientific potential of these unique accelerator based short-pulse light sources. More info at: www.fels-of-europe.eu