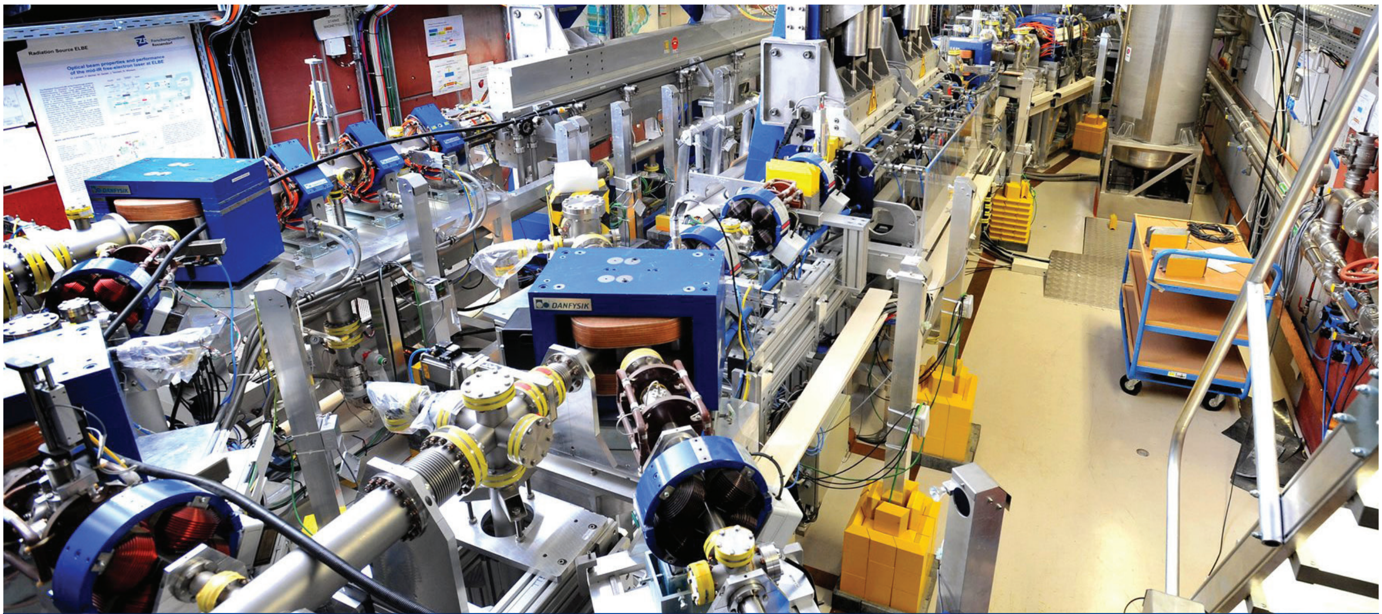
FELs OF EUROPE NEWS 11|14

1. ISSUE | www.fels-of-europe.eu



IN THIS ISSUE

With intense infrared light from HZDR's free electron lasers (above), materials can be examined on the atomic level. See press release on Page 2.

From EuroFEL to FELs OF EUROPE

Do you recognise our newsletter in the new design? The scope and structure are still the same, and we also kept some basic design elements. The main change is the title: the newsletter is now published under FELs OF EUROPE, the collaboration of European free electron laser facilities and advanced short-pulse and coherent light sources based on accelerator technologies.

After the collaboration was established in 2012, it took some time to find and agree on the short name FELs OF EUROPE, and then to develop a new logo and adapt the newsletter design. Therefore, we simply continued the EuroFEL newsletter which was originally an activity of the preparatory phase project IRUVX-PP, although FELs OF EUROPE include also the European XFEL and four infrared FEL facilities in addition to the nine original IRUVX-PP/EuroFEL partners.

Likewise, the EuroFEL project webpage was continued for some time until a new FELs OF EUROPE website (www.fels-of-europe.eu) could be established with little resources and came online in August 2014. Some improvements, including design, are still needed, but we do have a working collaboration website now on which relevant news and events are regularly updated. The old website will no longer be updated. FELs OF EUROPE can become an attractive communication platform for the FEL community if all of you contribute and actively participate.

The new name, website and newsletter clearly mark the transition to FELs OF EUROPE. All activities are now done under FELs OF EUROPE. With the enlarged collaboration, we are much stronger. Only together can we organise regular international conferences, workshops and training and have a chance to be seen and heard and to shape our future. JF

PhotonDiag 2015

1st Announcement

The 2nd FELs OF EUROPE Workshop on FEL Diagnostics, Photon Beamlines and Instrumentation, will be held in Trieste, Italy, 8-10 June 2015.

The workshop will mainly focus on optimized concepts for the photon beam transport and diagnostics of femtosecond laser-like radiation of short-wavelength FELs. Moreover, it will also address FEL electron beam diagnostics as well as metrology of optical components. Finally, a session will be dedicated to instrumentation and sample preparation techniques for experiments with FEL light.

Further information regarding the conference can be found at: *http://www.elettra.eu/Conferences/2015/PhotonDiag*

Magnetic Fields and Lasers Elicit Graphene Secret

Rossendorf (HZDR) have studied the dynamics of electrons from the “miracle material” graphene in a magnetic field for the first time. This led to the discovery of a seemingly paradoxical phenomenon in the material. Its understanding could make a new type of laser possible in the future. Together with researchers from Berlin, France, the Czech Republic and the United States, the scientists precisely described their observations in a model and have now published their findings in the scientific journal Nature Physics.

Graphene is considered a “wonder material”: It has a higher breaking strength than steel and conducts electricity and heat more effectively than copper. As a two-dimensional structure consisting of only a single layer of carbon atoms, it is also flexible, nearly transparent and approximately one million times thinner than a sheet of paper. Furthermore, shortly after its discovery ten years ago, scientists recognized that the energy states of graphene in a magnetic field – known as Landau levels – behave differently than those of semiconductors. “Many fascinating effects have been discovered with graphene in magnetic fields, but the dynamics of electrons have never been studied in such a system until now,” explains physicist Dr. Stephan Winnerl from HZDR.

The HZDR researchers exposed the graphene to a four-Tesla magnetic field – forty times stronger than a horseshoe magnet. As a result, the electrons in graphene occupy only certain energy states. The negatively charged particles were virtually forced on tracks. These energy levels were then examined with free electron laser light pulses at the HZDR. “The laser pulse excites the electrons into a certain Landau level. A temporally delayed pulse then probes how the system evolves,” explains Martin Mittendorff, doctoral candidate at the HZDR and first author of the paper.

Electron redistribution surprises scientists

The result of the experiments has astonished the researchers. This particular energy level, into which new electrons were pumped using the laser, gradually emptied. Winnerl illustrates this paradoxical effect using an everyday example: “Imagine a librarian sorting books on a bookshelf with three shelves. She places one book at a time from the lower shelf onto the middle shelf. Her son is simultaneously ‘helping’ by taking two books from the middle shelf, placing one of them on the top shelf, the other on the bottom. The son is very eager and now the number of books on the middle shelf decreases even though this is precisely the shelf his mother wishes to fill.”

Because there were neither experiments nor theories regarding such dynamics before, the Dresden physicists initially had difficulty interpreting the signals correctly. After a number of attempts, however, they found an explanation: collisions between electrons cause this unusual rearrangement. “This effect has long been known as Auger scattering, but no one expected it would be so strong and would cause an energy level to become depleted,” explains Winnerl.

This new discovery could be used in the future for developing a laser that can produce light with arbitrarily adjustable wavelengths in the infrared and terahertz ranges. “Such a Landau-level laser was long considered impossible, but now this semiconductor physicists’ dream could become a reality,” says Winnerl enthusiastically.

Berlin researchers calculate complex model for Dresden experiments

After the fundamental model used in the experiments had worked satisfactorily, the precise theoretical work followed, which was carried out at the Technical University Berlin. Berlin scientists Ermin Malic and Andreas Knorr confirmed, using complex calculations, the Dresden group’s assumptions and provided detailed insights into the underlying mechanisms. The HZDR researchers additionally cooperated with the French High Magnetic Field Laboratory in Grenoble (Laboratoire National des Champs Magnétiques Intenses – LNCMI), the Charles University Prague and the Georgia Institute of Technology in Atlanta (USA).

The research has been funded by the German research association DFG (Deutsche Forschungsgemeinschaft) within the program “Graphene”.

Publication: Martin Mittendorff, et al.: „Carrier dynamics in Landau quantized graphene featuring strong Auger scattering“, Nature Physics, in press, DOI: 10.1038/NPHYS3164

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FERMI FEL-2 Commissioning Progress

FERMI, the seeded FEL located at the Elettra laboratory in Trieste, Italy, is now in regular operation for users with its first FEL line, FEL-1, which covers the wavelength range between 100 and 20 nm. The second FEL line, FEL-2, was in commissioning during the machine run 21, in the month of September 2014. A significant amount of beam time was dedicated to the study and improvement of the spectral properties of the FEL in double cascade mode, whose distinguishing feature is that of being capable of producing single longitudinal mode clean spectra in the EUV-soft X-ray spectral range. FEL-2 is indeed an externally seeded high gain harmonic generation FEL based on the fresh bunch injection technique configuration. In this set-up, the free electron laser is configured as a two stage cascade, where the second stage is seeded by the light produced by the first stage. The photons in the second stage are generated from a fresh portion of the electron bunch which has not been heated by the seed of the first stage, overcoming the problem of the induced energy spread which limits the order of the harmonic conversion in a high-gain harmonic-generation seeded FEL. In Fig. 1 the image of the unfiltered FEL-2 spot on a YAG screen is shown. The image shows simultaneously the light from the first and second stage.

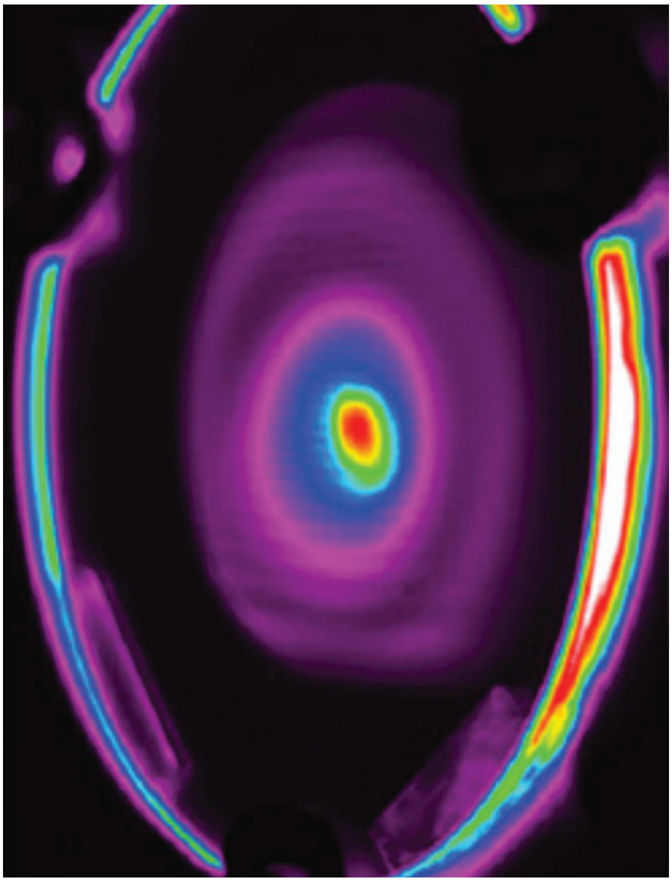


Fig. 1: Image reproducing the spot from FEL-2 on a YAG screen downstream the undulator.

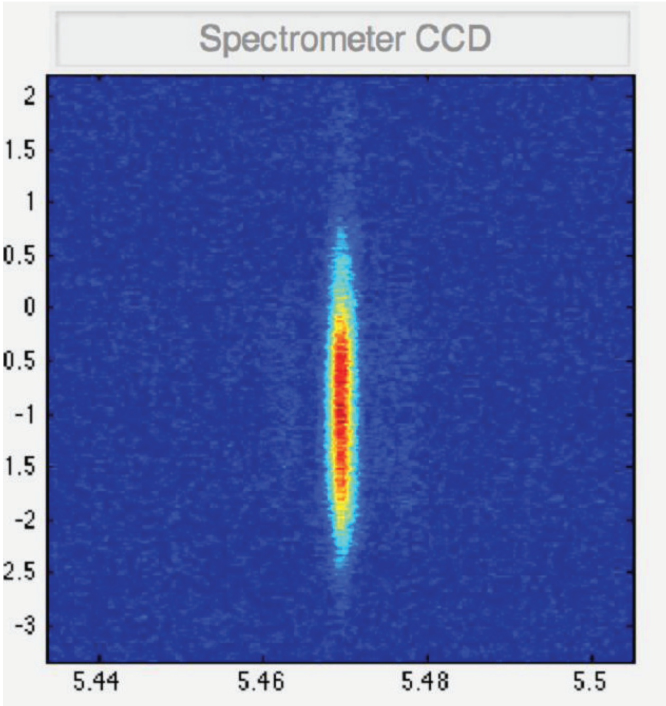


Fig. 2: FEL spectrum at 5.4 nm.

An accurate optimization of the electron beam parameters, led to the generation of a state of the art electron beam with low emittances and energy spread, with an energy corresponding to 1.45 GeV and a peak current of about 700 A. The beam was injected and matched in the long undulator cascade of FEL-2 with the first stage tuned at the 13th harmonic of the seed laser (20 nm), and the second stage at the 5th harmonic of the first stage (harmonic transition 13x5). After the first days of commissioning we could produce FEL pulses at 4 nm, corresponding to the lowest end of the design spectral range, with the expected average pulse energy of about 10 uJ. In this situation, we reproduced the FEL pulse energy values obtained during the machine run 20 in May 2014. One objective of the run was the optimization of the spectral properties of the FEL. At 4 nm, the relative average linewidth (rms) was 7×10^{-4} (25% of events were discarded). At 5.4 nm, obtained with the conversion of the seed to its 12th harmonic in the first stage and 4th harmonic in the second stage, single mode spectra were obtained in most of the shots. A typical spectrum is shown in Fig. 2. The average relative linewidth was in this case 3×10^{-4} (10% of events were discarded). LG

Simultaneous Lasing of FLASH1 and FLASH2

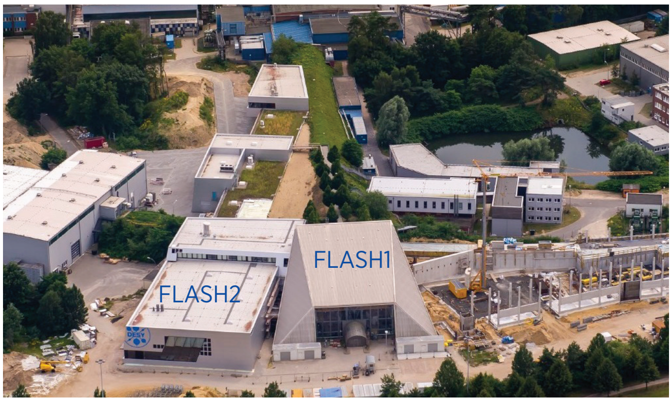


Figure 1: Aerial view of the FLASH facility with the extension on the left, consisting of a new tunnel and a new experimental hall.

FLASH – more specifically the “old” free electron laser FLASH1 – is in full user operation again since February 2014, after a long interruption due to construction work for the second FEL beamline, FLASH2. The civil construction is finished and the new FLASH2 FEL is currently under commissioning in parallel to user experiments on FLASH1.

A very important milestone was reached in August 2014: First lasing was observed at 42 nm wavelength while FLASH1 was running in parallel for user experiments with long pulse trains (250 pulses per train) at 13.5 nm. During lasing at FLASH1 the FLASH2 wavelength was changed from 42 to 23.5 nm by changing the undulator gap. Since then, lasing of the FLASH2 FEL was repeated several times at different electron beam energies, resulting in a wavelength range between 12 and 42 nm covered so far. At the longer wavelengths, gain curves were measured, showing that saturation has been reached. Further studies are currently ongoing

Figure 2: The 30 m long undulator in the FLASH2 line, consisting of 12 segments which produce the FEL radiation.

to determine the limits of the parameter space which can be used in parallel operation, such as bunch charge and compression. FLASH is the first free-electron laser facility for soft X-rays worldwide, where the many electron bunches which only linear accelerators based on superconducting RF technology can provide, are distributed simultaneously to two independent FELs - with the repetition rate of the accelerator. The FLASH accelerator can deliver up to 8000 bunches per second in bursts of 800 bunches with a repetition rate of 10 Hz. Since not all experiments need the full pulse rate, the throughput of the facility can practically be doubled by serving two experiments quasi-simultaneously. However, this requires independent tuning of FEL beam parameters such as wavelength, repetition rate and pulse duration.

The commissioning is currently done with preliminary photon diagnostics in the tunnel. In the beginning of 2015, some of these components will be removed and the complete photon diagnostics and the mirrors steering the FLASH2 photon beam into the experimental hall will be installed in the tunnel.

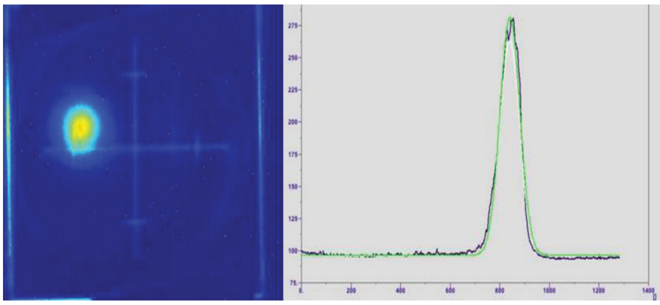


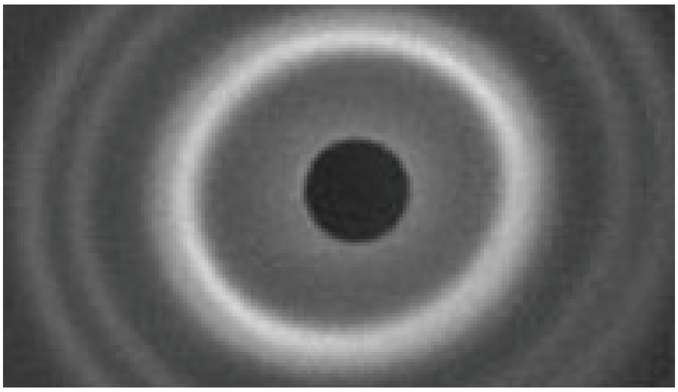
Figure 3: Lasing at 42 nm. On the left, the photon beam is shown on a YAG screen. On the right, the spectral measurement is shown with a centre wavelength of 42 nm and a bandwidth of ~2%.

Subsequentl, the basic photon diagnostics for users including monitors for pulse energy, beam position and wavelength, will be installed in the new experimental hall. After the diagnostics section the FEL beam will be diverted by plane mirrors to different experimental stations. The first mirror chamber together with two photon beamlines will be mounted in the second half of 2015. One of them will include the “reaction microscope” of the MPIK Heidelberg which will be set up as permanent end station for atomic and molecular physics. From 2016 onward, it is intended to operate FLASH1 and FLASH2 fully parallel for user experiments. BF & JF

First Electron Diffraction Images on VELA

The first electron diffraction experiments were successfully performed on the VELA photoinjector at Daresbury during September 2014. Single shot patterns have been recorded from platinum, gold and aluminium samples with sub-pC of charge transported to the detector screen. Modelling low charge transport in VELA shows that bunch lengths at the current sample position of the order of 100 fs can be achieved with 1 pC charge, but taking the sample closer to the photocathode in future will allow sub-100 fs time resolution.

Dr Jonathan Underwood (University College London) said: "this development should not be understated; with the capability for relativistic electron diffraction at VELA coupled with the synchronized femtosecond laser systems, this instrument will have the ability to take ultrafast snapshots during physical and chemical change of matter at the atomic length scale. This exact capability is being directly targeted internationally by the construction of X-ray FELs (e.g. European XFEL and LCLS). With these capabilities at VELA, the UK now has the potential to leap-frog those international developments." JC



Electron diffraction pattern from polycrystalline platinum accumulated with 1000 shots.

Recent Developments at SwissFEL

On Monday October 13 2014, the commissioning team led by Th. Schietinger sent a short and poignant e-mail: "This morning at 7:45 we switched off the modulators, thereby terminating a four-year programme of tests, trials, measurements, successes, but also disappointments." Since its official inauguration in August 2010, the SwissFEL Injector Test Facility as it is officially called has fulfilled its purpose both as a development facility for beam dynamics studies and a test bed for diagnostics developments, in view of the realization of the SwissFEL.

After an initial commissioning phase to bring into operation the photocathode RF gun and the ensuing booster linac, the facility was equipped with a magnetic bunch compression chicane. The following period was mainly dedicated to the consolidation of the S-B and RF system. During the same time, THz-based longitudinal beam diagnostics was implemented near the bunch compressor and the stability of the photo-cathode laser system was improved. In April 2012, with all RF cavities in operation, the nominal design energy of 250 MeV was attained for the first time. Soon afterwards, the transverse beam quality fulfilling the FEL requirements for uncompressed beam was demonstrated for the nominal bunch charge of 200 pC, thus reaching a first important milestone. At this time, values as small as 0.37 and 0.25 mm mrad were measured for global (projected) and so-called slice emittance, respectively. One of the stringent tests of the reliability of the injector scheme was the first lasing achieved in January 2014, proving the successful functioning of the many key components. A 4 m long prototype of the SwissFEL in-vacuum undulator module with a period length of 15 mm was installed. At beam energies varying between 120 and 200 MeV, FEL radiation in SASE mode was observed in the UV and optical spectral ranges (photon wavelength between 70 and 800 nm). The wavelength was tuned by changing the electron energy as well as the undulator gap.

The SASE nature of the radiation was confirmed both by measuring the divergence of the FEL beam and by recording the characteristic fluctuations of the photon pulse energy. The measurements with the undulator prototype also allowed the realistic testing and optimization of the alignment procedures planned for SwissFEL.

On the SwissFEL site, the civil construction is reaching the end. The tunnel is finished and installation work is under full speed. More than 150 persons are working on site distributed over the 720 meters of the facility. By the end of autumn 2014, the building will have almost completely disappeared under a mound of original ground that was excavated and preserved during the construction period as can be seen in the aerial picture taken few days ago. In the first months of 2015, parts of the experimental area will be used for the final assembly and characterization of the in-vacuum undulators, while the installation work for the injector will be started at the same time. RA

Aerial view of the SwissFEL building taken in September 2014. Work to cover the facility is currently nearing completion.

19th Steering Committee Meeting of FELs OF EUROPE

The 19th meeting of the steering committee (SC) of FELs OF EUROPE was held on 17-18 September 2014 at Park Hotel in Bad Zurzach, Switzerland, hosted and organized by Paul Scherrer Institute (PSI).

These regular semi-annual meetings are aimed at exchanging information between the facilities, discuss ways to strengthen the collaboration and increase its visibility at the European and international level. In this context, the possible establishment of collaboration with neighbouring communities, an enhanced technical collaboration through the expert groups, and the preparation of the white book on European free electron lasers were discussed.

It was agreed to proceed with establishing collaboration with Laserlab Europe through a memorandum of understanding, with the main purpose of facilitating cooperation for the establishment of programmes of exchange and collaboration in areas of mutual interest and benefit to both partners.

Another important point on the agenda was a discussion on the future management of the collaboration when the term of the current chair as well as financial support through the CALIPSO Integrating Activity end in 2015.

The next meeting will take place in Daresbury, United Kingdom, hosted and organized by STFC. JF, CI

Hard X-Ray FEL Collaboration Meets in Hamburg

The 6th Hard X-ray FEL collaboration meeting, held 19–21 May 2014, brought together over 100 scientists from all hard X-ray FEL facilities that are either in operation or under construction. Hosted and organized by European XFEL and DESY in Hamburg, Germany, the meeting focused on an exchange of experience and the discussion of joint projects in the areas of accelerator and X-ray technologies.

Following a joint session that provided an overall update of facility progress and some very important recent results, the meeting was held in two parallel sessions: the first on the topic of accelerator operation and R&D, and the second on X-ray technologies, method development, and operation experiences. Participants from European XFEL in Germany, LCLS in California, SACLA in Japan, SwissFEL in Switzerland, and PAL-XFEL in Korea presented updates on their building, assembly, and commissioning status. In addition, a special focus was put on the operation and on LCLS plans to upgrade the facility's linear accelerator to a superconducting version for LCLS-II.

Participants visiting the underground tunnel of European XFEL

A central event of the meeting was a walk through the underground tunnels of the entire 3.4 km-long European XFEL facility. Starting in the future experiment hall in Schenefeld in the state of Schleswig-Holstein, the attendees ventured all the way to the site of the facility's electron injector on the DESY campus in Hamburg. Next year's meeting will be held in Switzerland. JP

Workshop on Advanced FEL Techniques

In the framework of the FELs OF EUROPE collaboration, an international workshop dealing with advanced FEL techniques was held on May 21-23 in Hamburg, with special focus on self-seeding. It was co-organized by Gianluca Geloni from Europen XFEL and Claudio Pellegrini from UCLA and SLAC, and was completely funded by European XFEL GmbH.

The workshop allowed for a review of self-seeding activities and other advanced FEL techniques. Scientists invited to the event included the participants of the FELs OF EUROPE's expert group on seeding and top researchers in the field, worldwide. A total of 67 participants registered.

Highlights of the workshop included: Experimental requirements for X-ray FEL pulses and challenges from the users' community, present status of self-seeding, generation of multicolour spectra, alternative techniques to control the longitudinal phase space of FEL radiation, tapering techniques and limitations on the energy exchange between electron and X-ray pulse, in relation with the methods above and with SASE emission, progress and perspective on the design of compact FELs based on laser/plasma accelerators, and, diagnostics and manipulation of the longitudinal phase space of the electron beam.

In the spirit of the FELs OF EUROPE collaboration, the workshop allowed to identify critical technical issues of common interest, and facilitate the development of new ideas at the frontier of FEL techniques.

Special effort was taken by the organizers in order to make the results of the workshop available to all the scientific community without any limitations. Many of the talks were made publicly available on the website: http://www.xfel.eu/events/workshops/2014/workshop_on_advanced_x_ray_fel_development/. GG

2nd International Conference on Science at Free Electron Lasers

The 2nd International Conference on Science at Free Electron Lasers (Science@FELs) took place on the 15-17 September 2014 at the Paul Scherrer Institute (PSI), Villigen, Switzerland, bringing together over 150 international scientist and students from Europe, Japan, Republic of Korea, Iran, India, and USA.

The conference which focused on the scientific highlights achieved during the last years in the fast evolving field of free electron lasers, was a follow up of the Science@FELs 2012 jointly organized by DESY and the European XFEL in Hamburg, Germany, in July 2012 and is henceforth being organized regularly (every two years) as an activity of the Free Electron Lasers of Europe (FELs OF EUROPE). Science@FELs 2014 was organized into two parts, with the first part (first two sessions) dedicated for lectures to students by renowned experts. The lectures focussed on X-ray FELs and their potential to revolutionize scientific research such as in high energy density science and crystallography. The highly educative lectures were well received by the students many of whom expressed the desire to see such integration into subsequent conferences. Student participation was supported financially by the collaboration partners.

During the second part, eight sessions comprising of keynote talks, presentations and poster session were conducted. The talks covered a wide range of topics - Biology, Chemistry, Condensed Matter, Matter under Extreme Conditions, Theory, Atomic and Molecular Systems, and New Developments.

Another highlight of the conference was a scheduled visit to the large scale facilities at PSI which include the Swiss Light Source, the construction site of the Swiss Free Electron Laser (SwissFEL) where construction is on-going, and the SwissFEL test facility.

The next conference is scheduled to take place in 2016 in Trieste, Italy. CI

Participants at the Science@FELs 2014 at the Paul Scherrer Institute, Villigen, Switzerland

6th International Workshop on Microbunching Instability

The 6th international workshop on microbunching instability took place at the Savoia Hotel in Trieste, Italy, from the 6th to the 8th of October 2014. The workshop "Microbunching Instability and Compression Scheme for Seeded FELs" was organized by Elettra-Sincrotrone Trieste, as one of the action items of the FEL Seeding Experts workgroup, in the framework of the FELs of Europe collaboration.

The workshop, sponsored by Kyma and Cosylab, covered theoretical, numerical and experimental aspects of the so-called microbunching instability, a process of beam quality degradation affecting high brightness electron beams in both linear accelerators, and storage rings. Among the items covered by the presented talks were; coherent synchrotron radiation 1-D to 3-D effects, simulation challenges of the instability, sources of microbunching at low energy, advances on laser heater design and impact on the FEL performance, recent investigations of longitudinal space charge-induced instability, and updates on diagnostic capabilities of microbunching. Generous time for discussion was allocated after each talk and at the end of each session.

The participants visited the FERMI facility on the last day of the workshop. The workshop was attended by 44 registered participants (10 internal to Elettra) coming from 21 different institutions and 12 countries (distributed among Europe, USA and China). The oral contributions will soon be available on the workshop website: http://www.elettra.eu/Conferences/2014/MBIW6/index.php?n=Main.Program.
For additional information, please contact simone.dimitri@elettra.eu. SD

Participants at the 6th International Workshop on Microbunching Instability at Elettra, in Trieste, Italy

UPCOMING CALLS FOR PROPOSALS

4th Call for Users Experiments at FEL-1 and FEL-2 at FERMI@Elettra
Deadline: 31st December 2014
https://www.elettra.trieste.it/userarea/fermielettra-call-for-proposals.html

Application for Beamtime
At FELIX@Radboud University
Deadline: 15th January 2015
http://www.ru.nl/felix/beam-time/

UPCOMING EVENTS

DESY Photon Science and European XFEL Users' Meeting
28 – 30 January 2015, Venue: Hamburg, Germany.
http://photon-science.desy.de/users_area/users%27_meeting/index_eng.html;
http://www.xfel.eu/events/users_meetings/2015_users_meeting/

Ultrafast Dynamic Imaging of Matter
8 - 12 March 2015, Venue: Grindelwald, Switzerland
https://udim2015.ethz.ch/

Workshop for FEL Diagnostics, Photon Beamlines and Instrumentation
8 – 10 June 2015, Venue: Trieste, Italy
http://www.elettra.eu/Conferences/2015/PhotonDiag/

XXIX International Conference on Photonic, Electronic, and Atomic Collisions (ICPEAC)
22 – 28 July 2015, Venue: Toledo, Spain
http://www.icpeac2015.com/

IMPRINT

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Images: HZDR/Frank Bierstedt (Cover image), FERMI@Elettra (pg. 3), FLASH@DESY (pg. 4), Heli Partner AG. (pg. 5), STFC, European XFEL (pg. 6), PSI (pg. 7), Elettra (pg. 8)

FELs OF EUROPE 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

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