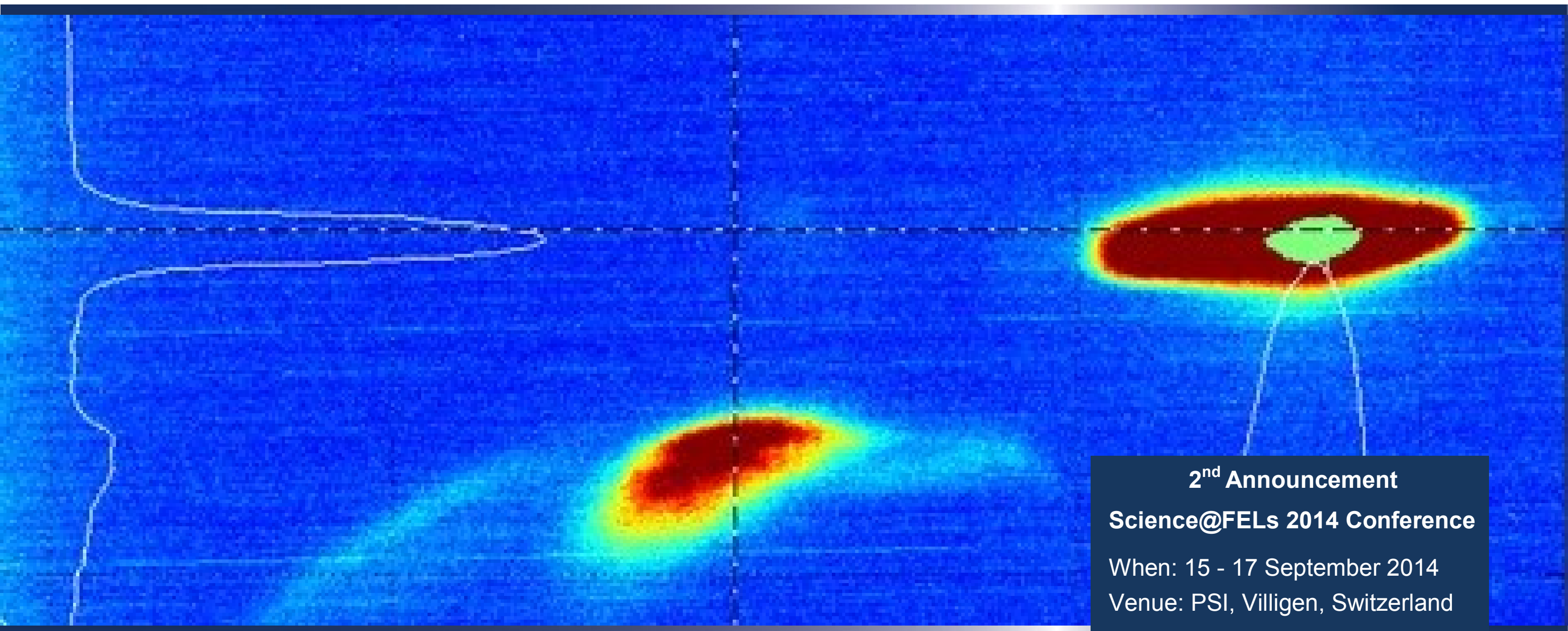
# EuroFEL NEWS 04/14

8th Issue . www.eurofel.eu

*First lasing in the UV wavelength range achieved at the SwissFEL injector test facility. The blob in the upper right corner comes from the electron beam deflected by a magnet.*

## First Lasing at the SwissFEL Test Facility

The first lasing in the UV wavelength range was achieved at the SwissFEL injector test facility on the 15th of January 2014. This is a great success towards SwissFEL, the future hard x-ray free electron laser that is currently under construction at PSI. It proves the successful functioning of many required key components together in a larger system. Since 2010, PSI has been operating the test facility to study and optimize the electron source for SwissFEL. Over the last years, the test facility has proven many new schemes and techniques, and during the last shutdown at the end of 2013, a first undulator was installed.

This innovative type of undulator is an in-vacuum design with a very small period length of only 15 mm, which was specifically developed for SwissFEL. During the very first beam time after the installation of the undulator, the electron beam could be successfully tuned to pass the undulator with low losses - this is very important to prevent radiation damage to the sensitive 1060 permanent magnets. The electrons generate spontaneous radiation when passing through the undulator, and this radiation was detected with scintillator screen monitors. In a next step, the electron beam was strongly compressed in a bunch compressor chicane to generate a very high charge density, which is required for the FEL process. This initiated the free electron lasing process, leading to an exponential increase of the emitted radiation along the undulator. An electron beam with 220 MeV energy and 200 pC bunch charge was used in this experiment. The first lasing was detected at a wavelength of 80 nm. By adjusting the gap of the undulator, the wavelength of the emitted laser light could be tuned over one octave from around 45 - 90 nm.

After this successful operation the undulator will be taken out from the test facility and final optimization steps will be carried out for the optimum configuration of the 12 undulators required for the SwissFEL ARAMIS hard X-ray beamline. *MvD*

**2nd Announcement**

**Science@FELs 2014 Conference**

When: 15 - 17 September 2014

Venue: PSI, Villigen, Switzerland

**Conference deadlines:**

| | |
|---|---|
| Abstract submission: | 30.04.2014 |
| Student grant request: | 30.06.2014 |
| Registration: | 31.07.2014 |

The Science at FELs conference series organised under the auspices of the "Collaboration of European FEL and SPS Facilities", highlights recent science achievements and new developments in the growing field of free electron lasers.

It covers applications in condensed matter research, biology, chemistry, matter under extreme conditions, atomic and molecular systems as well as theory.

Dedicated introductory lectures for students are offered at the start of the conference. Student grants are allocated by different sponsors. More information at: http://science-at-fels-2014.eurofel.eu

IN THIS ISSUE



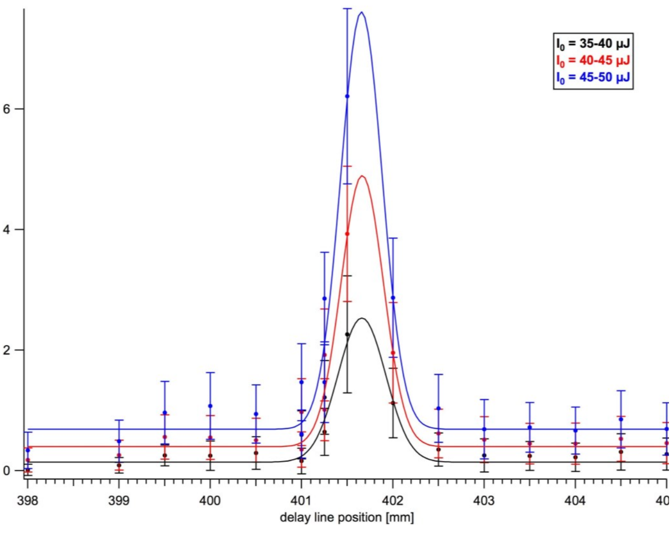

EuroFEL
FREE ELECTRON LASERS OF EUROPE

EuroFEL is part of the ESFRI Roadmap since 2006; its preparatory phase (IRUVX-PP) prepared the establishment of the EuroFEL Consortium to link FEL & SPS facilities in Europe closer together and was funded by the European Commission under FP7 from April 2008 to March 2011. Some results were taken up in the EC funded projects Pandata & PaNdataODI. EuroFEL became partner in the EC funded cluster of research infrastructures for synergies in physics-CRISP. *info@eurofel.eu*

## *Autocorrelation Measurement at FERMI*

Seeded free electron lasers such as FERMI can generate intense femtosecond pulses with high spectral purity and excellent temporal stability. The pulse duration is a fundamental parameter characterizing the source and defining the scope of state of the art experiments, especially, those relying on pump-probe techniques. Furthermore, the ability to correlate the pulse duration to the spectral bandwidth allows one to get insight into the longitudinal coherence properties of the source.

A preliminary campaign of pulse duration measurements was recently carried out at FERMI in the framework of an international collaboration involving several partner laboratories. The measurements exploit the delay line installed at FERMI i.e., the FEL pulse is split into two sub-pulses which propagate through the two arms of the delay line and recombine at the end-station of the FERMI Low Density Matter beamline. There, the two pulses interact with a gas of Xe atoms and ionize them. The yield of high-charge states is a nonlinear process in the number of absorbed photons and thus, strongly dependent on the temporal overlap between the two pulses.



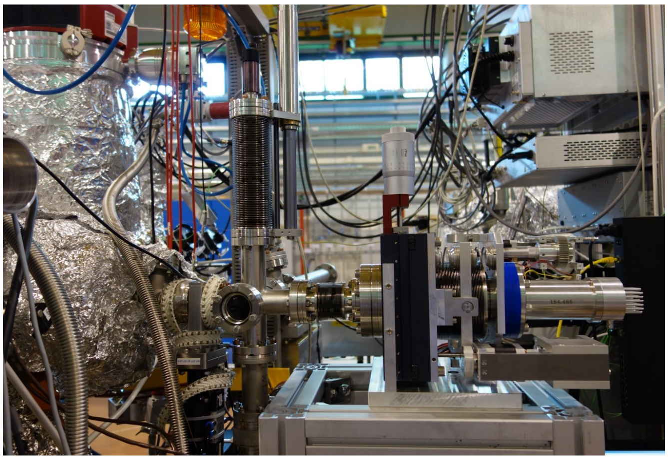

Markers: average of single-shot Xe6+ signal values for FEL pulse energy falling within a given interval, as indicated by colours (black: 35-40 mJ; red: 40-45 mJ; blue 45-50 mJ). The error bars reflect the standard deviation of the values. Lines: Gaussian fit.

The information about the pulse duration is encoded in the resulting autocorrelation curve i.e., the ion signal, for a selected charge state as a function of the delay.

The Figure above shows an example of the preliminary results obtained. For the reported experiments, the FEL was tuned at 62.5 nm. The width of the autocorrelation curves is about 20 fs (FWHM). The analysis aimed at extracting the duration of the FEL pulse is in progress. The preliminary results indicate that the pulse is close to the transform limit. *GDN*

## *Wavefront Sensors for FLASH and FERMI*

In the past years, a new compact wavefront sensor (WFS) with high stability and accuracy for the soft X-ray spectral range, ~6-40 nm, was developed at DESY in collaboration



WFS positioned behind the actual endstation behind the LDM station at FERMI.

with the Laser-Laboratorium Göttingen e.V. (LLG). This WFS has been demonstrated to be a very valuable tool to measure in real-time the wavefront quality of individual FEL pulses for beam characterization and beam parameter determination on a shot-to-shot basis at FLASH (B. Keitel et al., „Hartmann wavefront measurements at FLASH“, Proc. of SPIE Vol. 8778, 877814 (2013) and references therein). The WFS collaboration was extended to include FERMI@ELETTRA since fall 2012, where soft X-ray optics alignment of the refocusing systems (K-B and ellipsoidal mirrors) at the FERMI beamlines LDM, DiProI and EIS-TIMEX is now regularly carried out also with the FLASH WFS (L. Raimondi et al., “K-B bendable system optimization at FERMI@Elettra FEL: impact of different spatial wavelengths on the spot size”, Proc. of SPIE Vol. 8848, 88480B (2013)).

The WFS setup consists of a pinhole array (20 µm thick nickel foil) and a 14 bit CCD camera, coated with phosphor P43, in a distance of approximately 200 mm behind the pinhole array. The distance represents a compromise between attainable wavefront sensitivity and spatial resolution, the latter being given by the pitch of the pinhole array. Contrary to alternative methods to monitor the focus of demanding optical systems in the soft x-ray range such as fluorescent screens or imprints on damageable materials (PMMA or silicon substrates), a WFS allows fast online diagnostic of the focus during alignment. The experiment is not disturbed since the WFS is positioned behind the actual endstation as shown in the photo behind the LDM station at FERMI. A joint project between FERMI, LLG and FLASH is currently ongoing to build a larger WFS with an extended field of view. *EP, MZ et al.*

## *The Infrared User Facility FELIX Resumes Operation*

The international infrared and THz user facility FELIX has been successfully relocated to the Radboud University Nijmegen, the Netherlands. After re-commissioning and first light in 2013, the facility now resumes regular operation and invites users to come to Nijmegen to perform experiments using the infrared and THz radiation sources of the facility.

The Free Electron Laser for Infrared eXperiments (short "FELIX") was designed and built at the FOM Institute Rijnhuizen, The Netherlands, to produce infrared and THz radiation and has been used for various types of experiments for more than 20 years. Recently the mission of the FOM institute changed and the FELIX facility found a second home and future at the Radboud University Nijmegen. Therefore the FELIX facility has been relocated to the Radboud University where the FELIX beam lines – FELIX-1, FELIX-2 and FELICE - together with the Nijmegen free electron laser FLARE are at the heart of the new user facility. An overview of the layout of the lasers is shown in figure 1. Almost 16 months after the start of the relocation, the FELIX laser produced first light again in July 2013. Already in October 2013, the first user experiments took place and since the beginning of 2014, the new user facility has gradually resumed operation as an international user facility.


Fig. 1 - Schematic layout of the FELIX facility showing the four beam lines FLARE, FELIX-1, FELIX-2 and FELICE.

With the new setting at the Radboud University, the opportunities for users have grown considerably. The wavelength range covered has expanded largely into the THz regime. Together, the FELIX and the FLARE free electron lasers now cover the range from 3 - 1500 µm. In total four FEL beam lines are available of which three can be operated independently and simultaneously so that three user groups will be able to work in parallel. As before the FELIX beam lines will be connected to user experiments in about 12 experimental stations. These user stations have been upgraded and a number of new experimental setups e.g. He-droplet apparatus (Havenith group, Ruhr University Bochum), cold 22-pole ion trap (Schlemmer group, University of Cologne) and sophisticated equipment for solid-state physics research (Rasing group, Radboud University; Murdin group, Surrey University) will be opened to users.

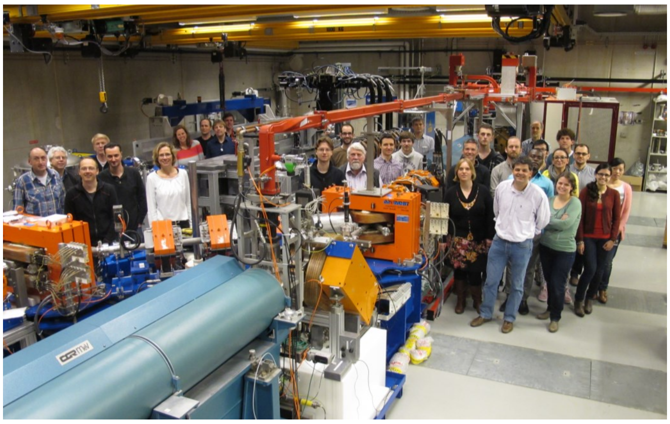


Fig. 2 - FELIX team in the accelerator vault.

The unique beam line FELICE (Free Electron Laser for Intra-Cavity Experiments) will provide infrared radiation to two intra-cavity setups where the gas-phase experiments benefit from the intra-cavity power, which is about a factor of 50 higher than what is delivered at the external experimental stations. A worldwide unique opportunity is offered by the possibility to combine the IR and THz radiation from the free electron lasers with the very high DC magnetic fields (currently up to 33 T and up to 45 T in 2016) of the adjacent High Field Magnet Laboratory (HFML). First experimental campaigns indicate the great potential of this combination. A narrow bandwidth mode of operation for FLARE aimed at achieving a spectral resolution better than $10^{-4}$ is under development for ESR-type experiments at HFML.

For the years to come the FELIX facility group and the two in-house research groups will further develop the capabilities of the lasers and instrumentation of the FELIX facility with the aim to offer the international user community attractive and unique opportunities for their research in the IR and THz spectral range. For more information on the FELIX facility, see www.ru.nl/felix or contact felix@science.ru.nl. *BR*

## *Construction of the European XFEL Facility Progresses*

Since the completion of underground construction of the European XFEL's tunnels and experiment hall last June, substantial progress has been made on many of its key parts. From the accelerator, to the X-ray generating undulators, to the instruments in Schenefeld, scientists and engineers are continuing intensive preparations for the start of user operation in 2017.

In the accelerator section of the facility, a major milestone was reached in December 2013 with the installation of and the beginning of tests on the electron gun, the first part of the electron injector. As tests on the gun continue, other parts of the injector complex will be delivered and installed throughout 2014.

Last year saw the inauguration of the Accelerator Module Test Facility, which will run various critical tests on the European XFEL's 100 superconducting accelerator modules, the final stage before their installation. The industrial production of parts for those modules, including in-kind contributions from several partner institutes in European XFEL member states, is ongoing. Major progress was also made in the light–generating parts of the facility, the undulators. European XFEL's undulator group passed the halfway point in the tuning and aligning of the magnets used in the undulator segments and expects to have all of them ready for installation at the end of this year.

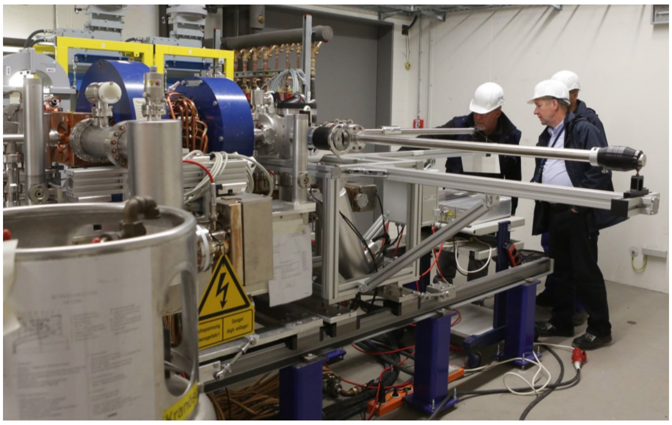


Fig. 1 - The European XFEL's electron gun, the first part of its accelerator complex, was recently installed and put through the first round of intensive tests.

At the Schenefeld campus of the facility where the six starting scientific instruments will be housed, construction crews are working on the aboveground buildings and will later this year start on European XFEL's future official headquarters. As for the instruments themselves, each instrument team now has a successfully completed conceptual design report, and several are beginning work on assembling their first parts. Meanwhile, European XFEL scientists and partners in industry have developed a prototype of the mirrors that will direct the up to 27 000 X-ray flashes toward the instruments. The mirror prototype's meter-long face is perhaps the flattest and most precise ever created.

Fig. 2 - The European XFEL undulator group has successfully measured and tuned over half of the facility's light-generating undulator segments, preparing them for tunnel installation later this year.

Finally, the system that connects all of these parts cleared a major hurdle. Karabo, the software framework developed at European XFEL which will interact with all technical components, saw its limited version 1.0 release. The framework will provide a unified structure for applications that will handle machine control, data acquisition, data analysis, and scientific computing - a feat that is unprecedented in major scientific facilities.

All of this progress was met with a strong level of anticipation at the European XFEL Users' Meeting in January, jointly organized with DESY Photon Science. Once again, the meeting had a record number of participants, with about 700 in attendance. Bit by bit, the European XFEL is coming together as it builds towards the start of user operation. *JP*

## *Accelerator Community Calls for CLARA*

The Institute of Physics, Particle Accelerator and Beams Group sponsored a meeting of UK accelerator professionals on 13$^{th}$ January 2014 at the Cockcroft Institute to discuss the accelerator science and technology opportunities that would be afforded by the proposed CLARA Test Facility.

Over sixty people attended the event, chaired by Jim Clarke (ASTeC), to hear presentations about the status of the project, the accelerator design, and the ideas that different groups have for making use of the high quality electron beam that would be available. Two of the talks reflected the fact that

CLARA is primarily an FEL test facility, particularly focused on ultra-short pulse generation, but the others covered a wide variety of other applications from plasma acceleration, to dielectric accelerators, to advanced beam dynamics benchmarking, to a technology test bed for advanced diagnostics and

Participants of the IoP CLARA community meeting, 13 January 2014.

high repetition rate photoinjectors, and even as an injector into novel circular accelerators. The breadth of the potential applications was truly impressive, and clearly demonstrated the enthusiasm and strength of the accelerator community. Several speakers identified that the science can start as soon as the front end is installed, which is currently scheduled for early 2015, and some experiments will even be starting in 2014, utilizing VELA. *JC*

## *PAL-XFEL Construction Status Update*

The PAL-XFEL project started in April 2011 is expected to be completed by 2015. It will include a 10-GeV linac consisting of a photocathode RF gun, 50 klystrons and modulators, 172 accelerating structures, three bunch compressors, one X-band system for RF linearization, and various diagnostic devices. Behind the 10-GeV linac, there is space to transport the electron beam to the undulator system. A 240 m long undulator hall follows, where three undulator chains will be installed. However, the current budget will cover only one undulator chain. An experimental area 60 m long and 16 m wide is located at the end of the facility. The total length of the building is 1,110 m and the total area is 35,917 $m^2$. Building construction started in September 2012. Since then, 1.2 million $m^3$ of soil have been removed, and the concrete shielding of the machine tunnel is completed. It is expected that the building will be ready for use by November 2014.

Fig. 1 shows the current status of building construction at the PAL site. Installation of the linac, undulator system, and beamlines will start when the beneficial occupancy of the building is available in fall 2014, and will be completed by the end of 2015. The commissioning will start in January 2016. We hope the first lasing will be achieved in early 2016. PAL-XFEL will then be available as a user facility for potential users domestically and internationally.

Fig. 1 - Construction of PAL-XFEL at the PAL site.

In August 2013, LBNL and SLAC experts were onsite at ITF (Injector Test Facility) to test a dechirper, an interesting instrument consisting of a vacuum chamber of two corrugated, metallic plates with an adjustable gap. Accelerator scientists usually try to avoid any wakefield in the accelerator. However, the wakefield generated by the dechirper when the electron beam is passing through manipulates the beam property constructively. As a result, a better-shaped electron beam (residual-energy-chirp-cancelled beam) will enter the undulator, and the

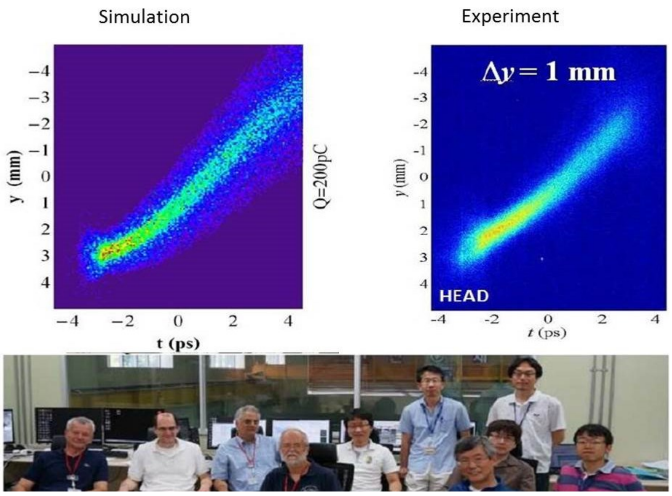



Fig. 2 - Simulation and measurement of dechirper experiment (top) and the PAL-LBL-SLAC Collaboration team (bottom).

properties of generating XFEL photons will be enhanced accordingly. This experiment gives us confidence in the practical use of a dechirper in place of more expensive options (PRL 112, 034801 (2014)). Fig. 2 shows simulation and experimental result and PAL-LBL-SLAC collaboration team. *H-SK*

### *European XFEL and DESY Photon Science Users' Meeting*

The joint DESY Photon Science and European XFEL Users' Meeting took place at DESY on 29 - 31 January 2014, with about 700 participants from all over the world. On the first day, the status of the European XFEL project and the progress of all its scientific instruments were presented. A science session in the afternoon highlighted state of the art applications of XFELs in time-dependent experiments.

The morning of the second day focused on FLASH and FEL experiments with soft X-rays ranging from atoms to nanoparticles and surfaces. A number of satellite work-shops in the afternoon discussed specific applications and developments at the European XFEL, FLASH and PETRA III.

Day three started with a general status report by the Photon Science Director, followed by selected scientific highlight presentations from PETRA III, a common poster session of all facilities with over 340 presentations, and a parallel vendor exhibition with more than 50 companies. *CI, JF*

Participants at the joint European XFEL and DESY Photon Science 2014 Users' Meeting.

### *16th SC meeting*

The 16th Steering Committee meeting of the Collaboration of European FEL and SPS facilities took place at Radboud University on 20-21 March 2014 in Nijmegen, the Netherlands. This first face-to-face meeting in 2014 was hosted by the Free Electron Laser for Infrared eXperiments (FELIX).

The main focus of the meeting was on the discussion of strategies to strengthen the cooperation between the facilities and to enhance the visibility and impact of the FEL collaboration. There was agreement that this needs to be strongly promoted, and that the establishment of a corporate identity under the new name together with the new logo and website that are currently developed, are instrumental to achieve this.

*JF*

Steering Committee members during the 16th SC meeting at the FELIX Facility, Radboud University, Nijmegen, the Netherlands.

## UPCOMING EVENTS

**Workshop on "Advanced X-Ray FEL Development**
21 - 23 May 2014
DESY, Hamburg, Germany
https://indico.desy.de/conferenceDisplay.py?confId=9829

**Photoinduced Phase Transitions and Cooperative Phenomena conference**
08 - 13 Jun. 2014
Bled, Slovenia
http://pipt5.ijs.si/

**5th International Particle Accelerator Conference IPAC'14**
15 - 20 Jun. 2014
Dresden, Germany
http://www.ipac14.org/

**FEL 2014**
25 - 29 Aug. 2014
Basel, Switzerland
http://www.fel2014.ch/

**Science@FELs 2014 Conference**
15 - 17 Sep. 2014
PSI, Villigen, Switzerland
http://science-at-fels-2014.eurofel.eu

**27th Annual MAX IV Laboratory User Meeting**
29 Sep. - 02 Oct. 2014
Lund University, Sweden
http://admin.getanewsletter.com/t/pm/532187825918/

**6th Microbunching Instability Work-shop**
07 - 08 Oct. 2014
Elettra, Trieste, Italy
http://www.elettra.eu/Conferences/2014/MBIW6/index.php?n=Main.HomePage

**AVS 61st conference, dedicated to synchrotrons and FELs**
09 - 14 Nov. 2014
Baltimore, Maryland, USA
https://www.avs.org/Meetings-Exhibits/

IMPRINT

*Publisher: EuroFEL, chaired by Josef Feldhaus, Deutsches Elektronen-Synchrotron, DESY* I Notkestr. 85 I 22607 Hamburg I Germany
Contact: Info@eurofrl.eu I www.eurofel.eu I phone +49 40 8998 3351

Contributors: Mirjam van Daalen, Giovanni De Ninno, Elke Ploenjes, Marco Zangrando, Britta Redlich, Josef Piergrossi, Jim Clarke, Heung-Sik Kang, Josef Feldhaus, Cletus Itambi

Images: Cover, PSI; Page 2/3 Giovanni De Ninno, Barbara Keitel, FELIX Facility; Page 4/5 Dirk Nölle, European XFEL, Jim Clarke, PAL-XFEL; Page 6 DESY, Cletus Itambi

Acknowledgement: This newsletter is published with the support of the Coordinated Access to Lightsources to Promote Standards and Optimization (CALIPSO) - FP7 EU-Funding Contract # 312284.