Issue 7 **March 2009**

# Laserlab Forum

Newsletter of LASERLAB-EUROPE, the integrated initiative of European laser infrastructures funded by the Seventh Framework Programme of the European Community

## IN THIS ISSUE



**www.laserlab-europe.net**


*LASERLAB-EUROPE Kick-off and General Assembly Meeting*

# Editorial

All good things must come to an end. But there is light on the horizon: this seventh issue of Laserlab Forum marks the transition from LASERLAB-EUROPE to its successor in the Seventh Framework Programme of the European Union (FP7). In the last weekend of March, LASERLAB-EUROPE II experienced its official start during the combined kick-off and General Assembly meetings held at the Institut de Ciències Fotòniques (ICFO). On pages 3 and 4, we report on this momentous event, exemplarly hosted by the new partner ICFO, who welcomed representatives from the 26 partners to their beautiful and well-equipped institute in Castelldefels near Barcelona. Laserlab Forum also took the opportunity to interview Lluis Torner, director of ICFO, and ask him about his feelings on hosting the kick-off meeting and his expectations for the future participation of ICFO in LASERLAB II.

Judging from the friendly and constructive atmosphere that surrounded the official continuation of the consortium, most ingredients to make the coming three years of LASERLAB-EUROPE II a success seem to be present, despite the disappointing budget reduction, which – according to LASERLAB coordinator Wolfgang Sandner – only allowed for one sunny day in Barcelona.

In this issue, we also look back to events and achievements from the past year. Who thought we knew everything there is to know about the ubiquitous and life-giving fluid water, will be surprised by the article on pages 8 and 9. In our regular feature *Access Highlight*, Raluca Musat reports on detailed measurements of confined water, performed in the laboratory of the Italian LASERLAB partner LENS.

As laser intensities are continually increasing, safety issues become more and more important. This fact was recognized by the LASERLAB community by organizing a workshop on Radioprotection Issues in the picturesque village of Chamonix in the French Alps, on which Sylvie Jacquemot from LULI reports on page 5.

We also feature an interview with Mauro Nisoli from CUSBO, Milan, who received an Advanced Investigators Grant of almost 2.5 million euros to continue his pioneering work in attosecond physics, illustrating the world-class quality of researchers working within the consortium. The heavy-ion facility GSI-Darmstadt has recently taken into operation a new high power laser system, PHELIX, which can now, combined with the existing ion beam, be used for a variety of novel physics experiments. On page 10, our colleagues from GSI explain the workings and possibilities of this versatile new laser.

With the end of the first term of LASERLAB-EUROPE, the two Joint Research Activities, FOSCIL and OTTER have also come to a close, and will make way for five new JRA's in LASERLAB-EUROPE II. In this issue of Laserlab Forum we look back on the finished Joint Research Activities and shall try to give a short overview of the scientific progress that was made in the five years that the JRA's existed.

**Tom Jeltes**
**Editor Laserlab Forum**

# News

## Helmholtz Award for MPQ Scientists

For the development of a monolithic, chip based optical frequency comb, Prof. Tobias Kippenberg, Dr. Ronald Holzwarth and Pascal Del'Haye, scientists at Max Planck Institute of Quantum Optics (Garching, near Munich) will receive the Helmholtz Award 2009 from the Physikalisch-Technische Bundesanstalt (PTB). This award is presented every two years for excellent precision measurements in physics, chemistry and medicine by the Stifterverband and Helmholtz funds, and is endowed with a prize money of 20 000 Euro. The award ceremony will take place on June 23rd 2009, during the Helmholtz symposium, which is organized by PTB in memory of its first president Hermann von Helmholtz.

## Outstanding Chinese Student at ICFO

Ms. Xiaojuan Shi, a PhD student at the Institut de Ciències Fotòniques (ICFO), has received the Chinese Government Award for Outstanding Students, a price awarded to Chinese students working abroad. Shi is working on quantum light sources (such as entangled photon pairs and pure single photons) using Spontaneous Parametric Down Conversion (SPDC) in the group of Prof. Dr. Juan Torres. It is the second time that this award has been granted to a young researcher working at ICFO; Dr. Zhiyong Xu received the same prize three years ago. This year, 305 Chinese students working in 27 different countries have received the award.

*Photo Cover: First short pulse mid-IR OPCPA of the Attoscience and Ultrafast Optics Group at ICFO.*

# Great start for LASERLAB-EUROPE II

**LASERLAB-EUROPE Kick-off and General Assembly Meeting, 27 and 28 March 2009, Castelldefels, Spain**

**It was both a warm reunion of old friends and an opportunity for new partners to get familiar with the LASERLAB-EUROPE community: the official kick-off meeting of the continuation of LASERLAB-EUROPE in the Seventh Framework Programme of the European Union. The meeting found a perfect location in Casteldefells, near Barcelona, where the Institut de Ciències Fotòniques (ICFO) hosted the gathering of around sixty representatives from laser facilities taking part in the consortium. The kick-off meeting on Friday afternoon was followed by a meeting of the General Assembly on Saturday, to elect new members for the several boards and discuss the agenda of the consortium for the first months.**

Professor Lluis Torner, director of ICFO, opened the meeting in the brand new building of ICFO located at the Mediterranean Technology Park, near the 1992 Olympic rowing lane. He introduced representatives from the European Union and the Spanish and Catalonian governments : Mr. Hervé Pero, Head of the Unit Research Infrastructures in the Directorate for Research of the European Union, Dr. Monserrat Torné, Director General for International Cooperation from the Ministerio de Ciencia e Innovación of Spain, and Mr. Ramon Moreno Amich, Director General for Research of the Catalonian government.

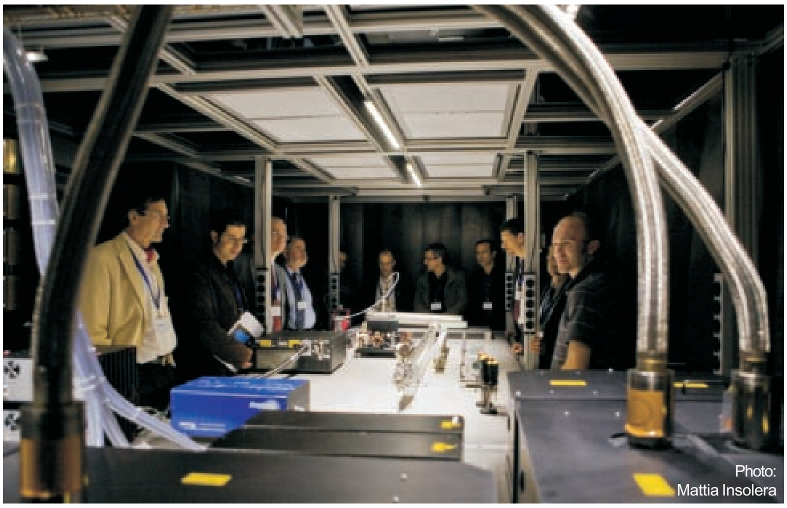
In her speech, Dr. Torné said that Spain, entering LASER-LAB-EUROPE with two laser infrastructures (ICFO and also CLPU in Salamanca), is catching up when it comes to investments into Research and Development. She expressed the expectation that the inclusion of the Spanish laser labs will be rewarding for both the labs concerned and the consortium. "This is a unique opportunity to strengthen international co-operation and to encourage the opening of national infrastructures to other countries", she said.

Mr. Moreno Amich stressed that ICFO is a Catalonian initiative and that the Catalonian government is very much aware of the fact that applications of laser technology in energy, health and security are of paramount importance for the economy. Besides, the local government promotes all types of transnational co-operation, a topic that is of course well addressed by LASERLAB-EUROPE.

Research Infrastructures are not only at the roots of Europe, but are also the future, according to the EU representative, Mr. Pero. Large infrastructures are important for business, but their costs tend to exceed the individual states' capacity, he said. Co-operation between European member states is therefore crucial. This is no problem for the scientists, who are used to working together across national boarders; the problems lie at the managing and political levels. But networking is a European strength, thinks Pero: "Americans and Asians tend to be amazed how well we overcome our language barriers in order to collaborate." He also gave LASERLAB-EUROPE a piece of advice concerning the upcoming call (due in autumn 2010) for new infrastructure proposals: "The key for acquiring structural funds is to prove socio-economic impact in medium and long term." Here lies a task for LASERLAB scientists to make clear how society will benefit in the future from their sometimes rather fundamental explorations in the lab.

LASERLAB-EUROPE started in November 2003, reminded LASERLAB coordinator Professor Wolfgang Sandner. "We had visions back then, and more has come true than envisioned. LASERLAB-EUROPE has truly changed the way the laser community interacts." Especially the concept of Transnational Access has been unique, he thinks: "The idea that you can hand in a proposal to the network for beam time has been a worldwide novelty for the laser community." He also mentioned the international infrastructures HiPER and ELI as proof that the European laser community is now self-confident enough to take on these large projects, which


Photo: Mattia Insolera




*Lab tour: the world's highest average power sub-30 fs Ti:Sapphire commissioned by the Attoscience and Ultrafast Optics Group at ICFO.*

requires trust and mutual confidence. Professor Sandner expressed the expectation that the new and enlarged LASERLAB community, now including as much as 19 European countries, will create a wealth of new world-class laser research infrastructures in Europe. Next, the coordinator – together with the three guest speakers – pushed a red button, thereby officially opening LASERLAB-EUROPE II.

In the General Assembly Meeting on Saturday, the partners' representatives elected the new Management Board (chaired by Wolfgang Sandner, MBI), Networking Board (now chaired by Philippe Balcou, LOA) and Access Board (Didier Normand, SLIC). In addition, the members of the Board of User Representatives (consisting of people who are not in the consortium, but who make use of the facilities via the Access Programme) were nominated.

Two of the five new Joint Research Activities, ALADIN (coordinated by Reinhard Kienberger, MPQ) and OPTBIO (Francesco Pavone, LENS) chose the kick-off meeting to gather for the first meeting of their new JRA on Friday afternoon. The three other JRA's supported by LASERLAB-EUROPE II are SFINX (Philippe Zeitoun, LOA), LAPTECH (Victor Malka, LOA) and HAPPIE (John Collier, CLF).

**Tom Jeltes**

# Joining LASERLAB – a milestone for ICFO

## A few questions for Prof. Dr. Lluis Torner, Director of ICFO, the new LASERLAB partner that hosted the Kick-off and General Assembly meetings at its residence in Castelldefels, near Barcelona.

**How did it feel to host the kick-off meeting of LASERLAB-EUROPE II?**

It is a great honor to become a member of LASERLAB-EUROPE. Hosting the kick-off meeting gives us an opportunity to meet in here many long-time and also new friends and colleagues, and to stress our willingness to team-up with them in all their initiatives where we can contribute. It is readily apparent that LASERLAB is the consequence of the vision and outstanding leadership of a bunch of exceptional individuals, with whom we are willing to join forces to keep pushing the weight of Laser science and technology in the continent. Also, LASERLAB includes the very top European laser centers, and an impressive list of world-class researchers. Becoming a member of such a club is a very nice opportunity, which we will honor.

**Can you tell something about the history of ICFO and the road towards becoming a LASERLAB partner?**

ICFO is a research center that was launched in March 2002 with the mission to conduct wide-scope, basic and applied research in several branches of the sciences and technologies of light. We are engaged in frontier and applied research, education & training at the post-grad level, and knowledge transfer, dissemination and outreach in Photonics. We are currently expanding and will reach steady-state operation by 2013 or so. Becoming a member of LASERLAB-EUROPE has always been one of our milestones. We believe we can make important contributions to the unique network set forth by the consortium.

**What do you think ICFO can contribute to the LASERLAB consortium, and what can LASERLAB do for your institute?**

ICFO hosts a variety of research groups in different areas of laser science and its applications. Our contributions to LASERLAB will concentrate in Ultrafast Optics, Attoscience and Biophotonics. We host a vigorous medical photonics program, generously endowed by a private donation by Cellex Foundation Barcelona, which will also be part of our contribution.

*Prof. Dr. Lluis Torner, Director of ICFO*

# Workshop on Radioprotection in Chamonix

**Chamonix, France, December 14-17, 2008**

**A workshop on radiosafety issues was successfully held in Chamonix, France, from the 14th to the 17th of December, 2008. It was the third of a series first sponsored by the European coordinated network of laser infrastructures LASERNET and now by LASERLAB-EUROPE, organised in response to the now widespread interest in handling and using intense laser-produced particle and radiation sources. It gathered about thirty persons, from eighteen institutions and eight European countries (France, Germany, Italy, Lithuania, Portugal, Spain, Sweden and the United Kingdom).**

Several topics have been broached during the meeting: (i) updated measurements and calculations of photon and particle dose generated at ultra-high intensity, (ii) radioprotection implemented at LASERLAB facilities [e.g., UHI100 at CEA/Saclay and Gemini at STFC/CLF], (iii) radiosafety issues for the ESFRI ELI and HiPER projects and (iv) biological effects of laser-produced radiation/ particles. Three round tables allowed fruitful discussions among the participants.

It was shown that a number of successful checks with experiments validate modelling capabilities – at least at currently available intensities, up to $10^{19}$ W/cm$^2$. Collected data could thus be extrapolated to higher intensities with some confidence, provided that physical processes that are still missing in present simulations (e.g., QED effects) remain marginal.

Dose equivalents close to 1 Sv, as expected to occur in future kJ laser facilities, will induce strong operational constraints on the infrastructures. KHz facility operators should therefore worry about the accumulated dose effect, which could imply, if radioprotection is improperly designed, a limitation of the annual shot number. However, incompatibility of efficient radioprotection and versatile experimental setups has been pointed out. It is thus really important to raise the awareness of the whole users' community on radiological issues. Apart from those linked to direct exposure, risks due to activated debris – mainly from samples and target chamber equipments – have also been estimated from experiments performed at Vulcan PW (the high power laser facility at CLF, UK, ed.). These risks could be of some importance at higher rep-rate, even at lower laser energy.

Among the uncertainties that have been identified, the dosimeter response above 10 MeV was questioned, as well as the reliability of some MCNPX (Monte Carlo N-particle eXtended) nuclear reaction models. Innovative diagnostics based on nuclear activation techniques have been alternatively proposed to characterize particle production while careful study of various offline detection and online monitoring systems has been undertaken. A lack of validated cross-sections for some (X,n) (nucleus-neutron) reactions has also been identified. Discussions with the accelerator's community (e.g., LASERLAB-partner GSI) should soon be engaged.

It was especially interesting to confront researchers from the laser-plasma physics community with biologists for a clearer view of the radiation effects on biological tissues: the main underlying mechanisms leading to lethal events and their occurrence rapidity (multiple inner-shell photo-ionisation followed by fragmentation in less than 10 fs) have been identified while overviews of the influence of the dose rate on health (at the basis of the international legislation) and of new concepts in radiobiology (like intrinsic radiosensitivity) were presented; it underlined the lack of knowledge at very low dose (<mGy) and the possible occurrence of some deleterious effects, as well as the influence of pulsed irradiation on cell reparability. The first measurement of dose effect on *in vitro* cells induced by a laser-driven electron beam was especially noticed and discussed.

In the framework of the ELI project, the possibility to accelerate electrons up to ~ 50 GeV and protons up to ~ 10 GeV, or to generate an intense betatron x-ray source at ~ 70 keV has been introduced while impact (in terms of beam dump for instance) of possible neutron spallation and acceleration of exotic particles has been evaluated for the Vulcan 10PW project.

Finally, it is worth knowing that dedicated facilities are now available and could contribute to our understanding of the complex physics involved in radiation effects, like the AIFIRA equipment in Aquitaine, which could be used to develop ion beam analysis and micro-irradiation techniques or the ELBE radiation source for oncology studies.

The workshop was very positive and therefore it was decided to continue the series. Subjects that could be addressed include (i) relevant (and not worst) source terms for the design of a reasonable ELI and HiPER radioprotection and (ii) reference experiments for code benchmarking. Dedicated access to LASERLAB-EUROPE laser facilities has also been mentioned: standardized diagnostics and identical targets would be used to only assess the influence of the laser parameters on dose, and would provide valuable inputs to the ELI "data collection" web site. Also, off-axis electron spectra should be collected.

**Sylvie Jacquemot**

Presentations from the workshop can be accessed on: ***www.luli.polytechnique.fr/pages/Chamonix/LASERLAB_N4-workshop_programme.html***

# Joint Research Activities come to a close

**As the first term of LASERLAB-EUROPE (now continued as LASERLAB-EUROPE II) has ended, the two Joint Research Activities FOSCIL (JRA1) and OTTER (JRA2) have also come to a close. Time for a final round-up with JRA coordinators Wim Ubachs (LCVU, FOSCIL) and John Collier (CLF, OTTER).**

*FOSCIL Coordinator Wim Ubachs*

## Frontiers of Optical Science: Controlling Intense Light (FOSCIL)

The FOSCIL Joint Research Activity was set up to stimulate developments in the production and control of femtosecond and subfemtosecond laser pulses over a wide range of frequencies. These developments should then allow application of the ultrashort laserpulses in metrology, using the novel frequency comb technique. The research groups taking part in FOSCIL have been very succesful in doing so, says Prof. Dr. Wim Ubachs, director of the Laser Centre Vrije Universiteit (LCVU), and coordinator of FOSCIL during the last period of this JRA. “At the start of FOSCIL, in 2004, I thought the goals that were set for the JRA were pretty ambitious, but looking back, we can conclude that many of the goals have been reached. We can now even control the phase of laser pulses produced by high harmonic generation, and are able to make frequency combs that extend well into the ultraviolet. And we have entered the attosecond regime. The progress made in the past five years has been impressive.”


*Optical Parametric Amplifier used within the FOSCIL JRA at LCVU.*

To focus on the development of phase-controlled femtosecond pulses in FOSCIL was a strategically sound choice, thinks Ubachs: “There were several strong research groups working in this field in Europe already. Stimulating collaborations between these groups in a coordinated way has certainly helped to consolidate Europe’s leading position in this line of research.” Researchers from the ten institutions participating in FOSCIL met twice a year during special workshops, which led to fruitful collaborations. “Clearly there can be some tension between collaborating en competing; between helping each other and trying to be the first to reach a particular result. But I think the groups in FOSCIL have found a nice balance between those two extremes.”

## FOSCIL workplans

The tasks within FOSCIL were divided into four ‘workplans’:
1) Development of phase-controlled few-cycle terawatt sources.
2) Conversion of controlled femtosecond light into the near infrared (NIR), ultraviolet (UV) and extreme ultraviolet (XUV) and soft x-ray (SXR) spectral range.
3) Reproducible, optimized generation and full characterization of XUV/SXR pulses.
4) Extension of frequency combs into the NIR and UV-XUV spectral domains.

The first goal was already accomplished to some extent in the first few years of the JRA (that ran four years from 2004, with an extension year in LASERLAB CONT in 2008), but that does not mean that no developments have followed since: source development still continues, and novel amplification techniques are leading to improvement in pulse energy, phase stability and frequency bandwidth. Moreover, phase-stable double pulse operation with a fixed delay between pulses has been demonstrated, which makes these sources ideal for applications in precision metrology.

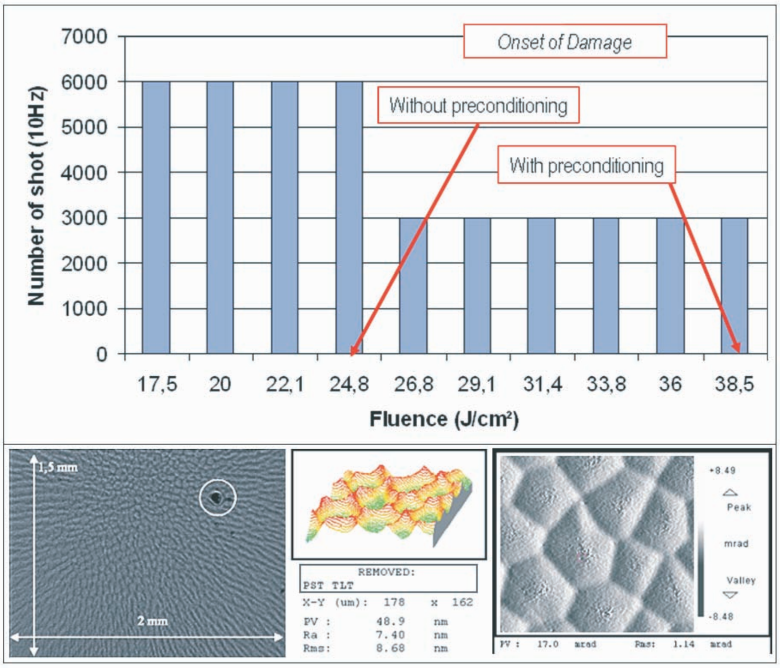
The state-of-the-art laser sources that are developed now, have already been used to generate controlled femtosecond (in the near infrared and visible spectrum), and attosecond laser pulses (in the extreme ultraviolet and soft x-ray regime).

Diagnostics such as XUV SPIDER and RABITT were successfully developed and are applied in optimizing conversion processes, allowing for example the production of broadband attosecond pulses in the extreme ultraviolet region. Furthermore, XUV- pump-probe experiments have been performed, as well as several highly accurate metrology experiments using frequency combs in various spectral ranges.

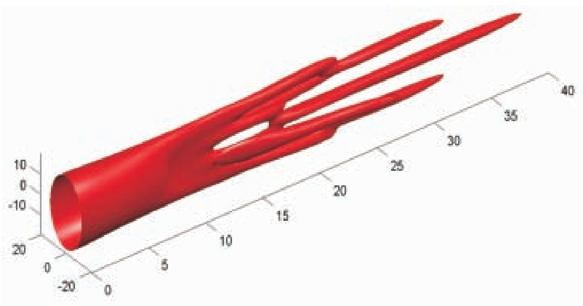
Not all collaborations that started within LASERLABE EUROPE will come to an end with the closure of the FOSCIL: important elements of this successful line of research will be part of the new JRA ALADIN, which will run in LASERLAB-EUROPE II.

## Overcoming the Technology Barriers (OTTER)

The second JRA, OTTER, focussed on some of the key technology barriers that are encountered when developing ultra high intensity laser facilities. Coordinator Dr. John Collier says OTTER's most significant achievement has been the creation, and especially *sharing* of new knowledge that relates to common challenges that most of the partner laboratories face in a collaborative manner. He names the development of so-called Phased Arrays, well known in astronomy, as an example: "Ever larger diffraction gratings are crucial elements for the further development of high-power gratings. Within OTTER, this problem was addressed by the formation of a coherent coupling of a number of smaller gratings to, in effect, form a singular element."




*An example of a Sol-gel anti-reflection coating on an Yb:YAG substrate (LULI) and its test performance (CEA). Pre-conditioning the coating leads to an increase in the damage threshold to beyond 30 $Jcm^{-2}$ for 10 ns duration pulses.*



*Computer simulation of an intense, ultra-short pulse propagating through a transparent medium indicating the onset of filamentation and self focussing leading to catastrophic damage.*

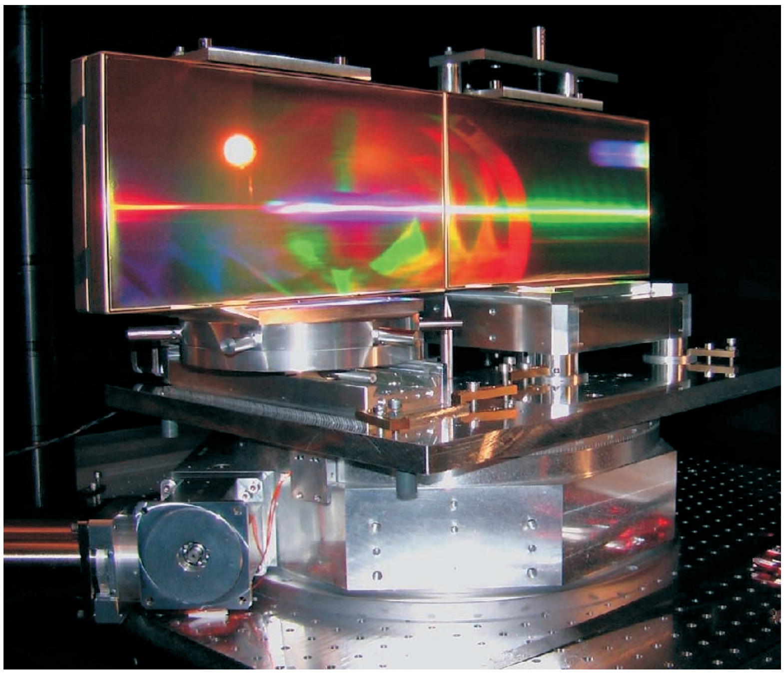
Collier also mentions the development of new optical coatings, some of which can withstand more than 30 J per $cm^2$. "These new coatings are of particular relevance for the next generation of high energy laser systems that use diode pumping techniques, where beam fluences are extremely high." Other notable achievements include the understanding of the interaction of intense femtosecond pulses with bulk material, generated by research carried out at LASERLAB-partner VULRC, and the development of novel components, such as volume holographic structures for pulse stretching (LOA) or very large adaptive optics (CLF).

*OTTER Coordinator John Collier*

The development of systems operating at the limit of pulse duration is another key achievement of the programme, according to Collier. "Several partners have demonstrated high repetition rate table top systems based on OPCPA (Optical Parametric Chirped Pulse Amplification, TJ) that operate in the few cycle regime. Some of these diode pumped systems are now in operation for user communities. Moreover, there has been considerable progress in the application of OPCPA at large aperture for extreme power production."

During the execution of the programme, the OTTER consortium met many times, leading to the formation of strong partnerships and new multilateral collaborations. The new HAPPIE JRA, part of LASERLAB-EUROPE II, is evidence for this, says Collier. "And the foundations laid by OTTER have also been important in the development of the HiPER and ELI projects."

**Tom Jeltes**



*A photograph of the Phased Array grating system developed at the FSU as part of the OTTER programme.*

# Using time resolved spectroscopy to understand nanoconfined water

**Water is of paramount importance for many chemical reactions and almost all biological processes. It is known that confinement of water to small volumes can significantly change hydrodynamic properties. Recent experiments supported by the LASERLAB Transnational Access Programme, carried out at the European Laboratory for Non-Linear Spectroscopy (LENS) in Florence, Italy, shed some light on this intriguing and important phenomenon.**

The dynamics of confined water molecules has recently attracted a great interest due to the impact it has on the chemical reactions, charge displacement and biological processes in aqueous solution, so it is of great importance to understand the physical processes that govern them [1]. In bulk, water molecules form a continuously evolving hydrogen bond network which imprints its properties. Confinement of these species distorts the hydrogen bond network through the presence of the boundaries and through the geometrical confinement itself, leading to modifications of water properties. Because the dynamics of water is strongly dependent on the hydrogen bond network, structural differences between bulk and nanoscopic water will result in different dynamics.

Numerous techniques such as infrared (IR) absorption spectroscopy, quasi-elastic neutron diffraction, nuclear magnetic resonance, molecular dynamics simulations, neutron scattering, neutron spin echo or terahertz spectroscopy have been employed in order to elucidate the impact of confinement upon structural and dynamical properties of water. All these techniques have identified modifications at structural and chemical level of these confined molecules, extending only on a 0.4-0.8 nm layer at the surface/interface, whilst the core molecules have a bulk-like behavior.

With the recent technological advances leading to the generation of infrared laser pulses that are shorter than the intermolecular motions time scales of water, it has been able to experimentally probe the dynamics of water molecules and hydrogen bonds. IR pump probe spectroscopy is a powerful tool in investigating the dynamics of nanoconfined water, allowing direct access to their dynamics and to the OH vibrators' lifetime. In these studies, hydrogen bonding is probed by monitoring the frequency of the O-H bond stretching vibration, which decreases with increased strength of the hydrogen bond in which it participates; the OH stretching vibration of a water molecule is particularly sensitive to the hydrogen bonding environment. Thus, femtosecond spectroscopy that probes the time evolution of the OH stretching vibration frequency, for selected groups of molecules, would allow the construction of molecular motions movies.

The time resolved spectroscopy studies determine the reorientation time, the dephasing time and the population relaxation time. These characteristic times give information on the dynamics of the hydrogen bond, mainly on the breaking and formation of hydrogen bonds overall process, the rotational motion of water molecules, energy transfer and the influence of this hydrogen bond on the surrounding water molecules.

The present study is a second step taken towards the unraveling/understanding of confined water molecules' dynamics, following the study of water at alumina surface properties [2]. Alumina surface was shown to present microheterogeneities that modify water's both chemical and physical properties. These studies were triggered by the need to understand how the chemistry of confined molecules changes, as previous studies on the radiolysis of water confined in porous materials indicated important changes of the radiolytic species yield.

We have performed IR pump probe experiments on nanoconfined water in fully hydrated controlled pore glasses (CPG) of 1, 13 and 50 nm pore diameters, on surface water in low hydration CPG (1 nm) and on bulk water. We used an isotopic mixture of HOD in $D_2O$ in order to tune the optical density and to suppress vibrational energy transfer between neighboring OH vibrators.

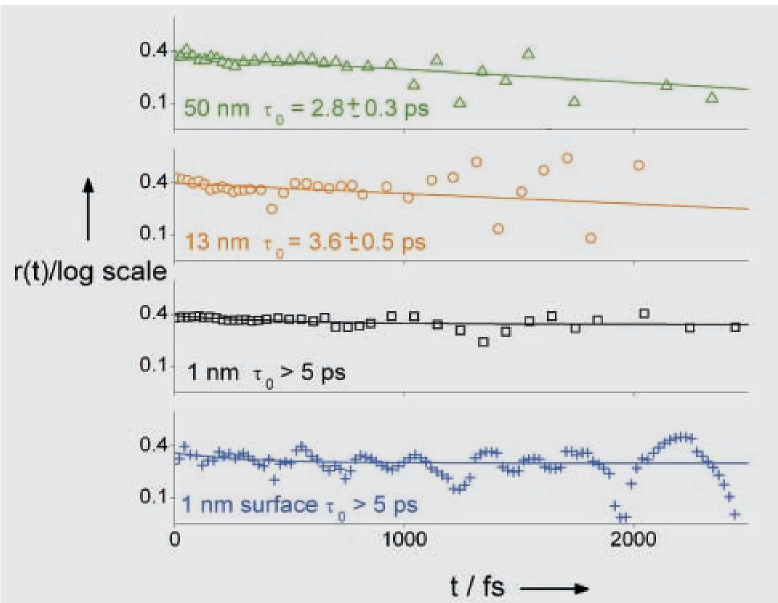



*Figure 1: Transient optical density anisotropy of water confined in CPG with a pore diameter of 50 nm (green), 13 nm (orange) and 1 nm (black) and surface water in a low hydration 1 nm porous glass (blue). The confinement of water molecules hinders the rotational motions, practically freezing them for small pores. Image reproduced from ref. [1].*

The used set-up generates 100 fs pulses at mid-IR wavelengths and allows the rotation of the probe pulse polarization, thus enabling us to record the signal in parallel and perpendicular polarizations. From the two acquired signals we could evaluate the evolution of the transient absorption anisotropy, $r(t)$, which supplies information about the rotational diffusion of molecules, and the lifetime of the OH vibrator:

$$r(t) = \frac{I_{//} - I_{\perp}}{I_{//} + 2 \times I_{\perp}}$$

with $I_{//}$ and $I_{\perp}$ being the intensity of the signals recorded in parallel and perpendicular polarizations.

Figure 1 depicts the evolution of the transient absorption anisotropy for water confined in all CPGs and for surface water. The characteristic rotational diffusion time is observed to increase with the decrease of the pore diameter. This result is in line with the prior observations of the diffusive motion by quasi-inelastic neutron scattering. For the largest pore diameter - 50 nm, the observed rotational time, 2.8 ps, is almost identical to the one corresponding to free water molecules, of 2.5 ps. For the smallest pore diameter investigated, 1 nm, the observed behavior is similar to the one of surface water, indicating hindered rotational motions. Recent observations for water adsorbed on soft and hard surfaces indicated a similar behavior as the one we observed.

The IR pump-probe spectroscopy also supplies information about the lifetime of the OH vibrators, presented in Figure 2. One can easily observe three different frequency-dependencies for the OH relaxation time, corresponding to confined, bulk and surface water. Such dependencies have been predicted or observed before, and there is a general agreement that the relaxation process depends both on structural (the O…O distance distribution, the overlap of the stretching with the bending overtone and the average number of H bonds) and dynamical (the spectral diffusion) factors. Surface OH groups present a strong frequency dependence directly following Staib and Hynes' law: $\tau_{OH} = const / (\delta\omega_{OH})^{1.8}$. They propose a predissociative vibrational energy transfer, with suggest that the relaxation process occurs through coupling of the OH stretch with the accepting O…O mode. Such a dependency observation involves a spectral diffusion that is limited at the interface, as already observed for alumina [2]. Bulk water exhibits a weak frequency dependency of the OH vibrators lifetime, centered at 500 fs, in line with previous measurements. The relaxation behavior of nanoconfined water is unique both in its average value and in its frequency dependency. On the blue side of the spectrum, we measure a marginal increase of the lifetime with the decrease of the pore diameter, which may be the signature of increased spectral diffusion for large pores and must be connected to the slower rotational dynamics with a higher confinement (Figure 1).

The present study confirms that the confinement effect influences the molecular motions, though up to now, such effects were observed only for water at the interface. Even very large pores (50 nm), where no effect was to be expected, induce specific modifications of the hydrogen bond properties, both with respect to bulk and surface water. No surface/volume ratio dependency of the changes was observed. Our findings therefore suggest that the microscopic properties of water are globally modified by nanoconfinement. The results presented in this contribution bring up new questions about the impact confinement has on water properties and the critical confinement degree at which water starts behaving as bulk. The new insights acquired should open the way for new studies that would finalize in an unambiguous and complete understanding of one of the most intriguing molecules.

**Raluca Musat**

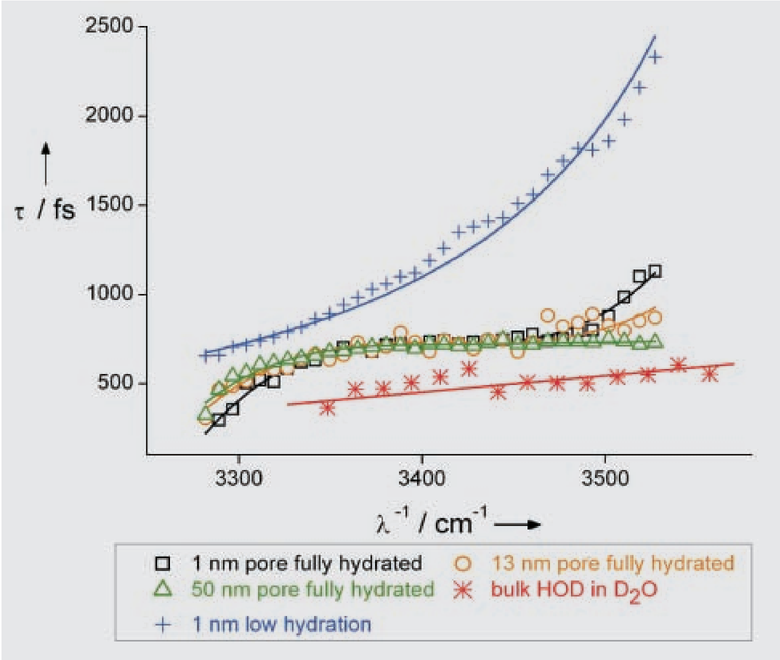



*Figure 2: OH vibrator excited state lifetime (τ) as a function of the wavenumber ($\lambda^{-1}$) for surface water in a low hydration 1 nm porous glass (blue +), of confined water in fully hydrated 50 nm (green Δ), 13 nm (orange °) and 1 nm (black □) samples and of bulk water (red *). The line for surface water is a fit following the law proposed by Staib and Hynes. (The other lines are drawn to guide the eyes). Image reproduced from ref. [1].*

References

[1] Musat, R.; Renault, J. P.; Candelaresi, M.; Palmer, D. J.; Le Caer, S.; Righini, R.; Pommeret, S. *Angew. Chem. Int. Edit.* **2008**, *47, 8033-8035.*

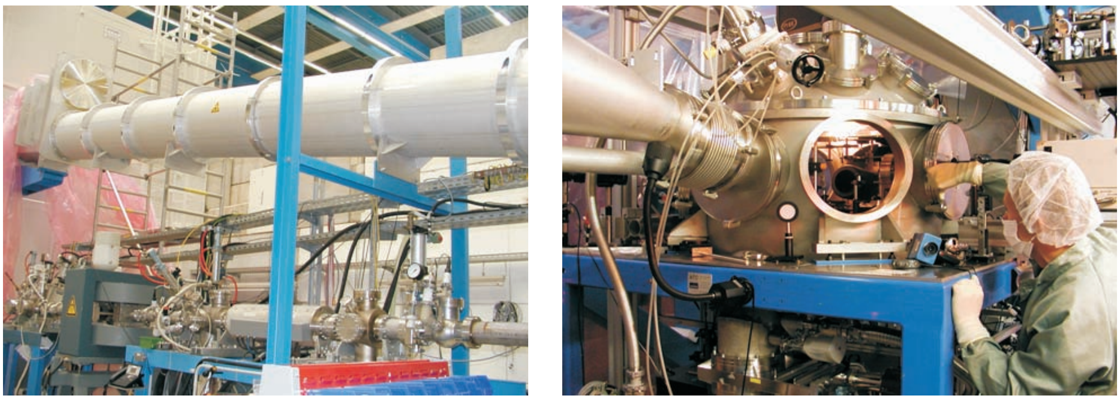
[2] Le Caer, S.; Palmer, D. J.; Lima, M.; Renault, J. P.; Vigneron, G.; Righini, R.; Pommeret, S. *J. Am. Chem. Soc.* **2007**, *129, 11721-11729.*

# Petawatt laser PHELIX for heavy ion experiments

**Recently, LASERLAB-partner GSI Darmstadt has taken into operation a powerful and versatile laser system, which can be used together with GSI's energetic beams of heavy ions: PHELIX (Petawatt High-Energy Laser for heavy Ion eXperiments) can be combined with ions accelerated up to an energy of 13 MeV/u by the heavy ion accelerator UNILAC (UNIversal Linear ACcelerator) of GSI, making possible a large number of unique experiments. Novel research opportunities are spanning from the study of ion-matter interaction, through challenging new experiments in atomic, nuclear, and astrophysics, into the field of relativistic plasma physics.**

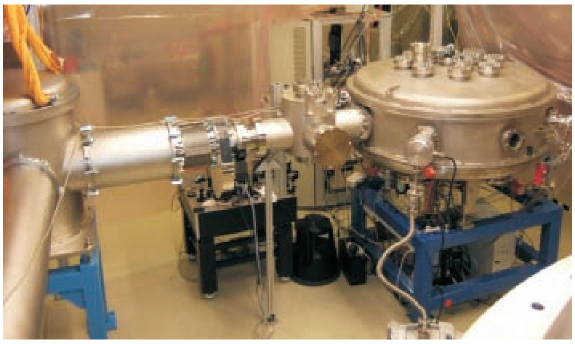
For experiments using PHELIX together with the heavy ions, the laser has already been used to generate a fully-ionized carbon-plasma, being later probed by an ion beam accelerated by the UNILAC. Other experiments have included the collimation of laser accelerated particles using pulsed dipoles and the generation of both coherent (X-ray laser) and non-coherent (k-$\alpha$) secondary sources for supporting the GSI research program.

PHELIX is a versatile dual front-end laser system being capable of delivering pulses from the sub picosecond regime up to 20 ns in duration. At the lower side of this range, a short pulse oscillator seeds a CPA system based on a hybrid



*Beam transport structure (left) and target chamber (right) used for combined heavy ion and laser experiments.*

Ti:sapphire and Nd:glass amplification system. The short pulse stretcher is set such as to provide pulses with adjustable pulse duration, which greatly simplifies operation; and it is followed by a Mach-Zehnder structure which provides the possibility to have a pre-pulse with independent energy and duration control relative to the main pulse. The output of this front-end delivers 25 mJ pulses at a repetition rate of 10 Hz; these pulses can then be locally compressed to 300 fs and they are used to generate high-order harmonics. On the long side of the pulse duration range, a fiber-based front end, using a dual amplitude-modulator, offers temporally shaped pulses between 0.5 ns and 20 ns with the 50 dB temporal contrast necessary to avoid target pre-heating.



*Petawatt interaction chamber.*

Both front ends seed the Nd:glass pre-amplifier and main amplifier sections. After pre-amplification in a rod-type amplifier to several joules of energy, the laser beam is sent to the main amplifier. This amplifier is based on 31.5-cm clear aperture Nd:glass slabs from the former Phebus and Nova lasers in France and the USA respectively. The amplifier provides a small signal gain of 100 using 5 amplification cassettes setup in a double pass configuration. After amplification energies in excess of 1 kilojoule (in several nanoseconds) are available for experiments, only limited by the damage threshold of the faraday isolator used to protect the laser against back reflected light.

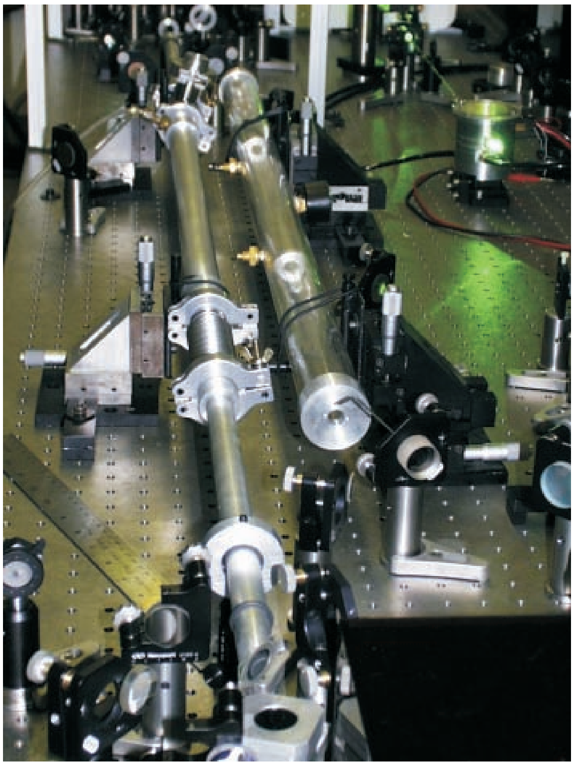
The short pulse is compressed in a single-pass compressor consisting of two 48-cm-wide MLD (multi-layer dielectric) gratings from Jobin-Yvon Horiba with a total throughput in excess of 90%. On target energies of up to 140 J have been observed and more than 100 high-energy shots have been done without showing any sign of degradation of the gratings, demonstrating reliable routine operation of PHELIX in the 100 to 200 TW range.

**Vincent Bagnoud and Thomas Kühl**

# Aiming to control attosecond electronic processes

**Prof. Dr. Mauro Nisoli from the Politecnico di Milano was awarded an Advanced Investigators Grant from the European Research Council for 'exceptional established research leaders' last year. In winning this grant of 2.44 million euros, he joins three researchers from LASERLAB-EUROPE who received that same grant in the first round (see LLF 6). Nisoli is planning to take attosecond laser physics to the next level.**

"In the past few years I have been working on isolated attosecond pulses", says Nisoli. "In 2006 we were the first to demonstrate a complete temporal characterization of isolated attosecond pulses with durations down to 130 attoseconds." Since that time he has been involved in a large collaboration with groups from Lund, MPQ Garching and AMOLF Amsterdam. "The experiments have been performed for over a year here in Milan with our attosecond setup. We have studied ultrafast electronic processes in helium atoms and deuterium molecules. The latter was the first example of a molecular attosecond pump-probe experiment." There are also theorists involved, says Nisoli, due to complexity of the physical processes involved in the attosecond measurements.



*Hollow-fiber experimental setup for the compression of high-energy laser pulses down to sub-5-fs duration. The gas-filled capillary is contained in the metallic tube on the left-hand side of the photograph.*

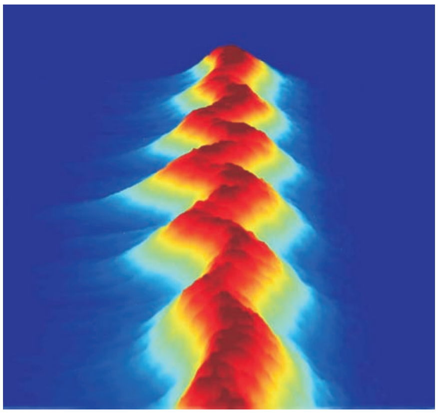
Nisoli will use the European grant to try and make attosecond pulses with higher energy. "At the moment, attosecond experiments are mainly limited by the energy of the pulses." This is due to the fact that the pulses are generated in high-order harmonics generation processes, which are rather inefficient. "The conversion efficiency for those processes is about $10^{-6}$ or $10^{-5}$, and therefore the isolated attosecond pulses we obtain have too little energy to perform, for example, pump-probe experiments using two attosecond pulses."

*Prof. Dr. Mauro Nisoli*

This is why Nisoli has so far performed pump-probe measurements using one attosecond, and one femtosecond pulse. "That still gives you an attosecond resolution, so it is fine for studying certain classes of processes, but there are also a lot of experiments for which you really need two attosecond pulses." With two high-energy attosecond pulses, one can also study non-linear effects and try to coherently control electronic processes: "One can excite an electron with the first attosecond pulse and then use the second pulse to control it."

One can use the laser pulses to influence chemical reactions, as is already being done with femtosecond pulses; or to study electron migration in biomolecules involved in photosynthesis. "There are many interesting applications of attosecond laser pulses", says Nisoli, "one could also think of studying damaging processes in DNA." The Italian will build a second attosecond beamline in a brand new lab, and plans to study simple molecules once that laser is in operation. Later on, he hopes to move on to more complex molecules. "We will buy a new high-energy femtosecond laser system, and I am currently looking for postdocs and PhD-students. We are planning a really large facility for attosecond science in Milan."

**Tom Jeltes**



*Three-dimensional plot of the evolution of the experimental photoelectron spectrum (horizontal axis) as a function of temporal delay (vertical axis) between the attosecond and the infrared 5-fs pulses. From this trace it was possible to retrieve a 130-as duration for the isolated attosecond XUV pulses.*

## HiPER takes important decision

A significant milestone in the HiPER (High Power Laser Energy Research) project was reached on March 5th at the Istituto Nazionale di Fisica Nucleare (INFN) in Frascati, Italy when its Executive Board took the unanimous decision to down-select to 'Repetition Rate' operation. Until this point, two strategic options for future construction of the facility were being pursued: 'single shot' operation based on current glass technology and 'Repetition Rate' based on Diode Pumped Solid State Laser (DPSSL) technology.

In taking this decision, the HiPER Executive Board recognise the significant contribution that the National Ignition Facility (NIF) in Livermore, US, and other facilities such as the Laser Mégajoule (LMJ) and the Petawatt Aquitaine Laser (PETAL) in France, will make to enable Inertial Fusion Energy (IFE) and Fast Ignition science on a 'single shot' basis. They recognise that the logical next step for IFE is to advance to repetition rate operation where a high efficiency driver is an essential requirement. This decision is enabled by emerging DPSSL capability and advancements in supporting technology.

A key objective of the HiPER project is to advance DPSSL and supporting technology to the required level so that HiPER will be seen as the next major advance for IFE.

The impact of this decision and the definition of 'Repetition Rate' will be assessed by the project in the coming weeks and months.

Following the Executive Board meeting, the 2nd HiPER Participants' Forum took place also at the INFN, Frascati on Friday 6th March 2009. The Participants' Forum consists of representatives of all 26 partners of the project.

**Anne-Marie Clarke**

## ELI organises Grand Challenges Meeting

On April 27-28, the Extreme Light Infrastructure (ELI) project organised a special Grand Challenges Meeting. Experts from various relevant scientific fields were invited to express their opinions on the challenges and opportunities that the ELI project will generate.


In the course of the next decade, the Extreme Light Infrastructure (ELI) should be built by the European Community in one of their countries. ELI will house an exawatt class laser, the most powerful laser ever built, providing the highest intensities.

Members of the participating countries and associated colleagues met at the Ecole Polytechnique in Palaiseau, near Paris, where they pondered over the Grand Scientific Challenges that this exceptional infrastructure can undertake in research in fundamental (vacuum) physics, attosecond physics, photonuclear physics, and particle acceleration. In addition, some societal applications were studied.

*HiPER Participants Forum March 6, 2009*

*Photo by Claudio Federici - 2009*

## Announcements

**Forthcoming events 2009**

13 -14 June
OPTBIO scientific and coordination meeting in Munich

29 June
HAPPIE Kick-off Meeting in Abingdon

16 -21 October
Related event: LEI 2009,
Light at Extreme Intensities

## How to apply for access

Interested researchers are invited to contact the LASERLAB-EUROPE website at www.laserlabeurope.net/access/, where they find all relevant information about the participating facilities and local contact points as well as details about the submission procedure. Applicants are encouraged to contact any of the facilities directly to obtain additional information and assistance in preparing a proposal.

Proposal submission is done fully electronically, using the LASERLAB-EUROPE Electronic Proposal Management System. Your proposal should contain a brief description of the scientific background and rationale of your project, of its objectives and of the added value of the expected results as well as the experimental set-up, methods and diagnostics that will be used.

Incoming proposals will be examined by the infrastructure you have indicated as host institution for formal compliance with the EU regulations, and then forwarded to the Users Selection Panel (USP) of LASERLAB-EUROPE. The USP sends the proposal to external referees, who will judge the scientific content of the project and report their judgement to the Users Selection Panel. The Users Selection Panel will then make a final decision. In case the proposal is accepted the host institution will instruct the applicant about the further procedure.

### Laserlab Forum Contact:

Professor Wolfgang Sandner
Coordinator - LASERLAB-EUROPE
The Coordinator's Office
Daniela Stozno
Assistant to the Coordinator
Max Born Institute
Max-Born-Str. 2A,
D-12489 Berlin, Germany
Phone: +49 30 6392 1508
Email: stozno@mbi-berlin.de

Laserlab Forum Editor: Tom Jeltes
Email: tomjeltes@gmail.com
Layout: Wiebke Metzgen

If you would like to subscribe to this publication or find out more about the articles in this newsletter, please contact the editorial team
newsletter@laserlab-europe.net