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Laserlab Europe

Laserlab Forum

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

Access Success Stories

Cavity-enhanced down-conversion quantum light source for solid state quantum memories

In this Issue

Editorial


Tom Jeltes

Generosity, the readiness to give freely without expecting anything in return, is a virtue which is hopefully still common in private life, but can be considered exceptional in the competitive world of science. Generally, fellow scientists are not only seen as colleagues, but mainly as potential rivals in the continuing race for funding. Having to choose between publishing and perishing, it is tempting to keep your hard-won expertise to yourself.

Within LASERLAB-EUROPE, however, the spirit of friendly collaboration seems stronger than the natural tendency to competition. As former coordinator Wolfgang Sandner stresses in an interview in this edition of Laserlab Forum, the institutions that make up LASERLAB-EUROPE are generous enough to allow allocated funds for Transnational Access to be redistributed depending on the needs. This shows that the LASERLAB community is very much aware of the fact that collaboration is not only good for science as a whole, but that, ultimately, sharing insights and expertise is also beneficial for individual institutions and researchers.

The Transnational Access Programme can be regarded as an act of generosity in itself, as the host scientists involved are willing to share their facilities and devote time to assisting the guest researchers. It must be said, though, that in many cases the hosts become an integral part of the project, and often will co-author the resulting publications. It is in those projects that the full strength of the Access Programme becomes apparent, and the collaboration is clearly to the benefit of all involved. To give an idea of the variety of projects, in addition to the regular Access Highlight, this issue of Laserlab Forum features some very successful Access projects of the past decade. Enjoy and be inspired. **Tom Jeltes**

News

ERC Advanced Grant for development of novel materials

Prof. Costas Soukoulis (IESL-FORTH, Heraklion, Crete, Greece and Ames Lab & Iowa State University, Ames, Iowa, USA) has been awarded an Advanced Grant by the European Research Council (ERC) to promote the development of photonic crystals, metamaterials and plasmonics.

The novel materials will enable the realization of innovative electromagnetic properties unattainable in naturally existing materials. The implementation of the ERC Advanced Grant project requires novel ideas, advanced computational techniques, nanofabrication approaches and experimental testing. According to Soukoulis, the broad expertise of his team and their pioneering contributions to photonic crystals, metamaterials and plasmonics qualifies them for facing the challenges, and will ensure the maximum possible success of the project.

ICFO demonstrates novel quantum light source for solid state quantum memories

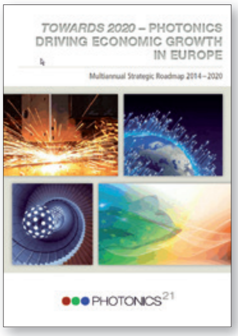
Researchers from LASERLAB-EUROPE partner ICFO, led by Prof. Hugues de Riedmatten, have demonstrated a novel quantum light source capable of connecting solid state quantum memories to the optical fibre networks. The source is ideally suited for long-distance quantum information networks.

The study has been published in Physical Review Letters and was selected as viewpoint in Physics. Quantum memories are important devices in quantum information science, in particular for the development of long-distance quantum communication using quantum repeaters. To overcome limitations of current solid state quantum memories, the authors used a novel type of quantum light source based on widely non-degenerate cavity-enhanced spontaneous down-conversion. The source creates ultra-narrowband photon pairs with one photon compatible with the solid state quantum memory and the other one at a telecommunication wavelength, thus allowing the connection between the quantum memory and the optical fibre network.

What is LASERLAB-EUROPE?

LASERLAB-EUROPE, the Integrated Initiative of European Laser Research Infrastructures, understands itself as the central place in Europe where new developments in laser research will take place in a flexible and co-ordinated fashion beyond the potential of a national scale. The Consortium currently brings together 30 leading organisations in laser-based inter-disciplinary research from 16 countries. Its main objectives are to maintain a sustainable inter-disciplinary network of European national laboratories; to strengthen the European leading role in laser research through Joint Research Activities; and to offer access to state-of-the-art laser research facilities to researchers from all fields of science and from any European laboratory in order to perform world-class research.

New Photonics Roadmap: Towards 2020 – Photonics Driving Economic Growth in Europe



The new photonics strategic roadmap 'Towards 2020 – Photonics Driving Economic Growth in Europe' was published in the frame of the Annual Meeting of the European Technology Platform Photonics21 on 30 April 2013. The rise of photonics in Europe from a niche activity to a Key Enabling Technology, and on to becoming one of the most important industries for the future, shows how photonics is on its path to making the 21st century that of the photon. The photonics roadmap outlines the photonics research and innovation priorities of the different application areas from 2014 to 2020.

www.photonics21.org

COST network on Inertial Confinement Fusion

In April 2013, a new COST Action, 'Developing the Physics and the Scientific community for Inertial Confinement Fusion at the time of NIF ignition' was approved. Chair of the new network is Dimitri Batani from LASERLAB-EUROPE partner CELIA (Bordeaux, France).

In Inertial Confinement Fusion, energy is generated by nuclear fusion initiated by heating and compressing a fuel target, in most scenarios with the help of extremely powerful lasers. The new COST network is intended to build a community of scientists devoted to Inertial Confinement Fusion, in preparation of the opening to civilian research of the French Megajoule and Petal laser facilities in 2015, and the expected achievement of ignition at the US National Ignition Facility in the foreseeable future.

The idea is that the COST network will facilitate the preparation of the European high energy density physics community for the new physics associated with both the fusion process and the high-energy laser systems that are being developed like Megajoule/Petal, as well as at HiPER and ELI. Such physics includes the realisation of 'laboratory astrophysics', extreme states of matter, and advanced particle and radiation sources.

Specific goals of the COST Action include setting up common experiments, both in Europe and overseas; educating a new generation of scientists by organising summer schools; and studying important physical problems related to Inertial Confinement Fusion.

CLF wins contract for HiLASE

LASERLAB-EUROPE partner Central Laser Facility (CLF) in Oxfordshire, UK, has won a contract of almost 12 million euro to develop laser technology for the HiLASE project, which is being constructed near Prague (Czech Republic).

The scientists at the CLF's Centre for Advanced Laser Technology and Applications have developed a higher-energy diode pumped solid state laser system, which helped them to win the contract. According to CLF director John Collier, the fact that HiLASE has chosen CLF stems directly from CLF's breakthrough in combining high energy and high repetition rates in each laser pulse.

The goal of HiLASE is to develop new laser technology that will be more powerful, efficient, stable and easily maintained than those already in place across Europe.

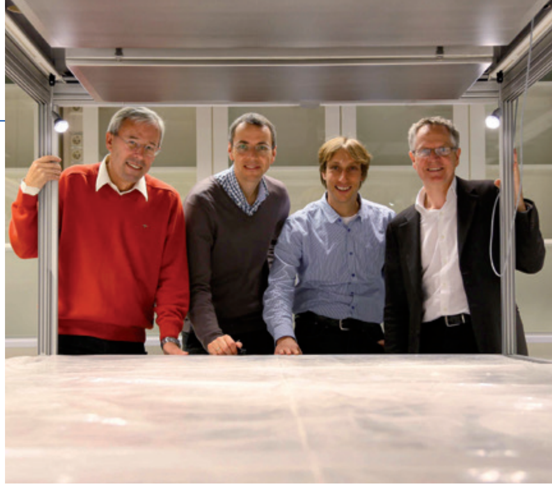
International Award to FORTH for laser cleaning of Caryatids

The Acropolis Museum and LASERLAB-EUROPE partner IESL-FORTH have been awarded the biennial Keck Award by the International Institute for Conservation of Historic and Artistic Works for their joint project regarding 'Laser rejuvenation of Caryatids opens to the public at the Acropolis Museum: A link between ancient and modern Greece'.

The award was given to the project partners for their contribution "towards the promotion of public understanding and appreciation of the accomplishments of the conservation profession". IESL-FORTH and the Acropolis Museum set up an advanced 'open-to-the-public' laser laboratory on the visitors' floor where the Caryatids are exhibited at the Acropolis Museum. This arrangement brings the visitors of the Museum in contact with conservational interventions that until now took place only inside 'restricted access' laboratory environments. Over 2 million visitors had the chance to follow the laser-assisted removal of accumulations of pollution from the Caryatids' surface.

ERC Synergy Grant

In 2012, the European Research Council introduced the Synergy Grant, which is intended to enable researchers from different backgrounds and locations to combine their skills and resources in multidisciplinary projects with a maximum funding of 15 million euros for six years. In a very competitive selection process, only the top 11 projects out of 700 applications for 2012 were selected for funding.



Peter Zoller, Immanuel Bloch, Ehud Altman, Jean Dalibard (from left to right)

One of the lucky teams includes MPQ professor Immanuel Bloch, who, together with his distinguished colleagues Peter Zoller (University of Innsbruck), Ehud Altman (Weizmann Institute of Science, Israel) and Jean Dalibard (Collège de France), will use a Synergy Grant of 10 million euros to take the field of quantum technology to the next level.

The highly counterintuitive laws of quantum mechanics govern the microscopic world, as well as the collective behaviour of matter at low temperatures. The unique properties of such 'quantum matter' not only allow deeper understanding of the nature of quantum mechanics, but will also lead to revolutionary new quantum technologies. For example, much progress has already been made in the fields of superconductive materials, ultraprecise measurements, and basic quantum computers.

Using lasers and magnetic fields, Bloch and co-workers at MPQ are able to capture and cool atoms to temperatures a fraction of a degree above absolute zero. Trapped in magnetic fields or confined in arrays by optical lattices of standing waves of laser light, these atoms can be manipulated in a myriad of ways. This allows the researchers to use the arrays of ultracold atoms as a versatile model system for condensed matter physics, as quantum information processors, or for precision measurements.

Experimentalists Bloch and Dalibard, together with theorists Altman and Zoller, will now devise the construction of a novel joint experimental setup, which would allow them to reach a new level of understanding of the complex behaviour of quantum matter. The idea is to create new states of matter, including strongly correlated and so-called topological quantum phases, which will be connected to simulations of field theories. Another important aim of the project is to engineer quantum matter in such a way that new paradigms for information processing ('quantum computing') come within reach.

ERC Starting Grant

Since 2007, young scientists trying to build up their own research group can apply for a Starting Grant of up to 1.5 million euros. The previous issue of Laserlab Forum already featured four 2012 grantees. To their names can be added those of Alex Robinson and Caterina Vozzi.

Alex Robinson (CLF)

Magnetic guiding of electrons for fusion

In Inertial Confinement Fusion (ICF) experiments, nuclear fusion is generated by heating and compressing pinhead-sized fuel pellets, usually consisting of a mixture of deuterium and tritium. In the Fast Ignition variant of ICF, the heating is performed with a high-current beam of ultrafast electrons, generated by a petawatt laser pulse. A major difficulty lies in the fact that these electrons tend to spread out, which can be countered by application of strong magnetic fields to 'guide' the electrons to the target. With his ERC Starting Grant, Alex Robinson will carry out advanced computer simulations to see how 'structured guiding', relying on the automatic generation of magnetic fields due to the interaction of the fast electrons with resistivity gradients in the target, can be used to keep the electron beam collimated.

Caterina Vozzi (CUSBO)

Ultrafast dynamic imaging of complex molecules

Molecules can be stimulated to emit extreme ultraviolet (XUV) light, using intense femtosecond laser pulses. In this process, an electron is extracted by the laser light and subsequently brought back to the molecule to recombine, which gives rise to the emission of an XUV photon. It has been shown that this XUV light contains information on the electronic structure of the molecule, and allows imaging of the electronic orbits in the molecule. So far, only molecules consisting of two atoms have been investigated in this way. Recently, Caterina Vozzi has demonstrated a new approach for extending the imaging of molecular orbitals to triatomic molecules. With her ERC Starting Grant, she will try to develop time-resolved tomographic imaging of the evolving electronic structure in complex molecules undergoing electronic or vibrational excitation.

Interview Wolfgang Sandner

After almost a decade, Wolfgang Sandner, founding father and long-time coordinator of LASERLAB-EUROPE, handed the sceptre (or laser pointer) to his successor Claes-Göran Wahlström in October 2012. Instead of resting on his laurels, Sandner accepted a probably even bigger challenge as the designated Director General of the Extreme Light Infrastructure Delivery Consortium. We talk with him about past, present and future of LASERLAB and ELI.

How are you doing at the moment?
"Well, I am very busy actually, travelling a lot. We are currently establishing ELI as an International Association after Belgian Law, and as we speak we are waiting for the signature of the King of Belgium. In the meantime, we are preparing the first General Assembly Meeting, and talking with institutions from several countries which showed interest in joining the association. Italy is already represented, as well as the host countries of ELI – Czech Republic, Hungary, and Romania –, and we expect many other countries to follow."

Is there a big difference between leading ELI and LASERLAB-EUROPE?
"The main differences are that with ELI, we have to create everything from zero, and that the ELI research pillars have both a national and a strong pan-European dimension, due to their mission and funding model. That means, for instance, that sometimes I have to remind representatives from local governments of the pan-European nature of the project, and remind the scientists of the complementarity of future research opportunities for users. So it is as much a political task as it is a coordinating task. I find it particularly attractive to be able to help shape three major research infrastructures from the beginning. It is challenging but satisfying."

What makes ELI special?
"ELI is to become the first truly international laser facility, whereas other scientific communities, such as high energy physics and astronomy, have been operating international facilities for decades. It is also special that all ELI facilities will be based in new EU member states, as well as the fact that for each of the three pillars the host countries applied for structural funds from the EU, roughly 300 million euro each. Those funds are generally used for building bridges, roads, and railways. Once these pillars are fully constructed in 2017, a European Research Infrastructure Consortium (ERIC) will be established, which will be responsible for the operation of ELI. I like to compare this to a multi-national community having decided to build and operate a new airplane, contracting three different companies in three different countries to build the wings, engines, fuselage, etc. and, after assembly, leasing the airplane to a newly established airline, ELI-ERIC, for operation. The business model will only work if the passengers – the scientific user community – find it highly attractive to "fly with ELI", i.e., ELI must become one of the best user facilities of its kind."

How do you look back on your time with LASERLAB-EUROPE?
"The real success of LASERLAB-EUROPE is that we have been able to create one unified entity, synchronising and harmonising our research profiles on a European level. LASERLAB's predecessor, LASERNET, still consisted of two subnets, for high energy and analytical facilities, respectively. There was a memorable event, where we discussed whether they should stay separated or whether they should be combined. Eventually, we applied together for LASERLAB-EUROPE. The resulting community has turned into a family, with a spirit of collegiality and professional friendship, which I very much enjoy."

Could you give an example of spirit of unity within the consortium?
"I can give a simple example, concerning the most important activity of LASERLAB-EUROPE, namely Transnational Access. We decided that the money given by the EU to each facility could be redistributed depending on the actual user demands. This was not foreseen in the European regulation, and it means that our members voluntarily have to give up money which was allocated to them. This can only happen if there is an extraordinary collaborative spirit and a collective strive for scientific excellence in providing access to the user community."

How do you see the future of LASERLAB-EUROPE?
"Laser technology will be one of the key technologies of the 21st century, and it will be both of enormous scientific and of major socio-economic impact. This is also recognized by the EU. I am therefore very confident that LASERLAB-EUROPE will consolidate itself as a major driver for science and innovation in the European Research Area. I also think there is no way back. Even if the funding would stop, which I do not foresee, I think the benefits of being in a network are so convincing to all involved that LASERLAB will always survive in some form. I can tell you that I am extremely satisfied that Claes-Göran Wahlström is my successor. He will do an excellent job and I am looking forward to collaborating with him, in order to make sure that ELI and LASERLAB-EUROPE will provide complementary services for the laser community."

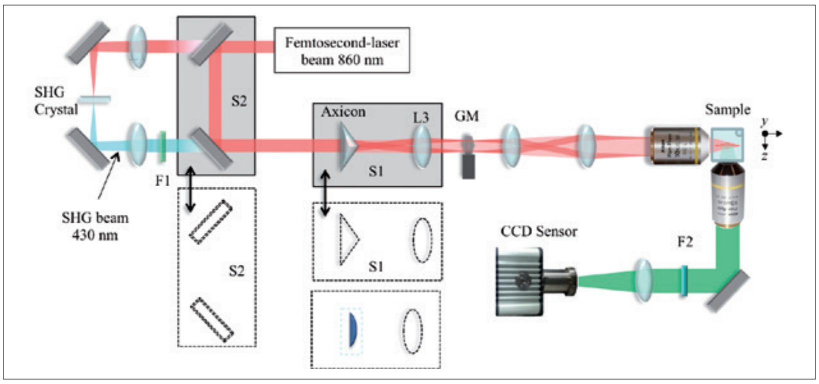
Access Success Stories

Ever since the beginning of LASERLAB-EUROPE, one of its most important features has been the Transnational Access Programme. Up to now, about 1,200 scientists from institutions outside LASERLAB-EUROPE had access to LASERLAB facilities to perform their experiments. Proposals for Transnational Access are reviewed by an external and independent Access Selection Panel on the basis of scientific merit. Access to LASERLAB facilities is free of charge; travel and accommodation expenses of visits with a typical duration of two to six weeks are covered by the Programme.

Each access project has its unique history and benefits. In many cases, the host researchers are not only involved in assisting their guests, but form an integral part of the research project. As a result, the host institutions benefit directly from the programme. Through the years, many long-term research collaborations have been formed as a result of Transnational Access. On the following pages, we highlight a few particularly successful access projects.

Tom Jeltes

Throwing light on multicellular tumour spheroids (ICFO)



Schematic of the experimental multimodal light sheet setup running at ICFO used to image multicellular tumor spheroids (MCTS) grown by ITAV. The size of the MCTS is of 400micrometers in diameter.

In a very recent project, Corinne Lorenzo from the Institute of Advanced Technologies in Life Sciences (ITAV, Toulouse, France) visited Pablo Loza-Alvarez' lab at LASERLAB-EUROPE partner ICFO in order to try and image biological model systems used to study tumour cell proliferation. The results of Lorenzo's two visits in February and March of this year are so promising that two other research groups joined the collaboration and a benchmarking toolbox is currently being developed.

The Super-resolution Light Microscopy & Nanoscopy (SLN) Lab at the Institute of Photonic Sciences (ICFO, Barcelona) has a Selective Plane Illumination Microscope (SPIM), which has the potential to image at large penetration depths and in scattering tissue. Having met at several conferences on SPIM microscopy, Lorenzo and Loza-Alvarez had discussed the possibility of using ICFO's SPIM microscope to image Lorenzo's MultiCellular Tumour Spheroids (MCTS) with the aim of retrieving the entire three-dimensional information of these samples. Loza-Alvarez, on the other hand, was interested in the elaboration of a benchmarking protocol in order to determine under which illumination conditions an absorptive and scattering tissue is best imaged. Having heard of the LASERLAB-EUROPE Transnational Access Programme, Lorenzo decided to apply for access in December of 2012 and one month later she had received the final decision granting her two visits to the SLN lab.

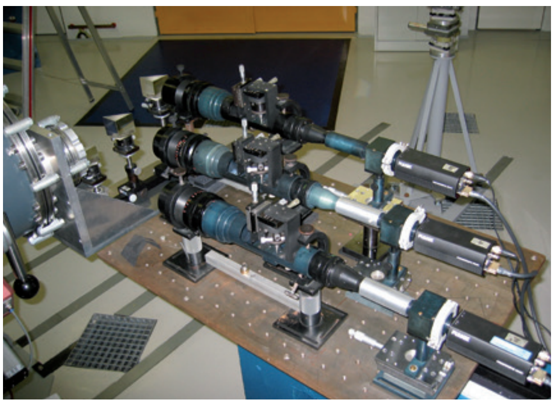
MCTS are 3D culture models with attractive advantages for investigation of cell proliferation in a multicellular context, as they display the organization of a tumour microdomain. However, due to their opacity and density, spheroids form highly challenging imaging samples for light microscopy and therefore represent, in terms of optical properties, a bona fide tissue paradigm.

The major issue addressed in the project was to find the optimal light sheet for 3D imaging of MCTS. To this aim, the 'Multi SPIM' microscope at ICFO was used and a variety of engineered fixed MCTS samples prepared by the IP3D group at the ITAV. The Multi SPIM is able to work in the linear and non-linear regime and under Gaussian or Bessel beam excitation schemes. SLN@ICFO is the only lab worldwide where such imaging techniques are available and allow a straight-forward comparison of the imaging capabilities of all different light sheet modalities.

Given the potential seen in this experiment, Lorenzo and Loza-Alvarez are now also working in collaboration with two associated groups: the Département Optique Théorique et Appliqué at Onera (Toulouse) and the Quantitative Image Analysis Unit at the Paris Pasteur Institute. All groups have complementary skills and expertise in cancer biology, cell imaging, image processing, biophotonics and optics.

Plasma interferometry diagnostic studies (PALS)

One of the longest-running and most productive access-related collaborations is situated at the Prague Asterix Laser System (PALS). Starting more than a decade ago, Tadeusz Pisarczyk from the Institute of Plasma Physics and Laser Microfusion (IPPLM, Warsaw, Poland) has used his multi-frame laser interferometry system to study plasmas in numerous experiments at PALS. For this purpose, he developed a modular optical system which allows quick assembly of the interferometer, depending on the experimental requirements. Several other researchers have since used the Polish system, benefiting from PALS facilities and Pisarczyk's expertise.



Registration system of the 3-frame interferometer at PALS

The idea of constructing multi-frame interferometric diagnostics has its origin in Pisarczyk's first LASERLAB Access project at PALS, some ten years ago. In this experiment he adapted an automated single-frame polaro-interferometer to study plasma parameters. The experience gained during the installation of this system and the results obtained turned out to be sufficiently useful and convincing to encourage extension of this method to a multi-frame approach. This led to the construction of an interferometric system with the capability to record three independent interferometric images with an adjustable time delay in the range of 1-3 nanoseconds. Each channel was equipped with a high-resolution, high dynamic range CCD camera. All cameras were connected to a computer, which allowed for easy control of the data acquisition process and maximally automated the work required to process the recorded data.

The successful implementation of a three-frame interferometer on PALS was expensive and included a great deal of complex technical work, and would not have been possible without strong support from the management of both PALS and IPPLM. The reason for this was that the components of this system had to be installed in the experimental chamber in such a way that they would not obstruct access to the chamber and could be used in parallel with other important diagnostic tools. For example, to this end a unique custom-designed lead-out of the diagnostic laser beams from the experimental chamber for different recording channels had to be constructed, using a system of prisms mounted on the window in the chamber door; when the door was opened, the prisms were removed, providing an unobstructed access to the chamber. Furthermore, the main subsystems of the interferometer (e.g., the delay line and the recording system) were designed as independent modules, with permanently mounted components, which allows for a quick assembly and disassembly of the interferometer, depending on the experimental requirements.

Over the time sufficient experience was gained with the multi-frame interferometer for it to become a routine diagnostic tool, which had the advantage that it could also be used for training of undergraduate and postgraduate students. Presently two students – one Czech and the other from Pisarczyk's Polish team – are working on PhD theses which rely on the multi-frame interferometry as a basic source of information on the parameters of the laser plasma.

Detecting explosives through non-transparent materials (LaserLaB Amsterdam)

An access project carried out at LaserLaB Amsterdam by forensic scientists shows that with the assistance of experts in laser diagnostics one can find solutions for pressing problems in society. Carmen García-Ruiz and María López-López of the University Institute of Research in Police Sciences (IUICP, Madrid) developed a way of detecting certain explosives using Raman spectroscopy during their visit to Amsterdam.

Non-invasive detection of concealed explosives is becoming a priority in terms of security, and has attracted particular attention in recent years due to the heightened threat of terrorism. Law enforcement teams throughout the world have to intensify research and development of efficient detection systems to be able to face the problem of hidden explosives at public places like airports, railway or coach stations.

In view of the growing need to apply research in experimental sciences to forensic science, the research group INQUIFOR was created as part of the University Institute of Research in Police Sciences (IUICP) of the University of Alcalá (Madrid, Spain) in 2010. Since then, INQUIFOR has focused on the development of new analytical tools to overcome analytical forensic challenges, especially those where explosive samples are involved

María López-López (left) and Carmen García-Ruiz

Time Resolved Raman spectroscopy (TTRS) is a promising tool which has been applied to identify various types of samples behind different non-transparent, diffusely-scattering materials. With the aim of detecting explosives using this technique, García-Ruiz, head of INQUIFOR, and her postdoc López-López contacted Freek Ariese from LaserLaB Amsterdam, one of the world experts in Raman technology. He provided them with detailed information on access opportunities and conditions through the LASERLAB-EUROPE Access Programme. The research proposal was submitted, reviewed, and the Spanish researchers obtained user access to LaserLaB Amsterdam to carry out the project in 2011.

The collaboration between the members of INQUIFOR and LaserLaB Amsterdam, experts in the analysis of explosives and in TRRS respectively, was considered a resounding success. With the technical support provided by the Amsterdam team, many experiments could be carried out in a short time span. The results obtained demonstrated that with TRRS the two main isomers of dinitrotoluene and other related explosive compounds can be detected non-invasively through different white plastic container walls several millimetres thick without having to manipulate the package.

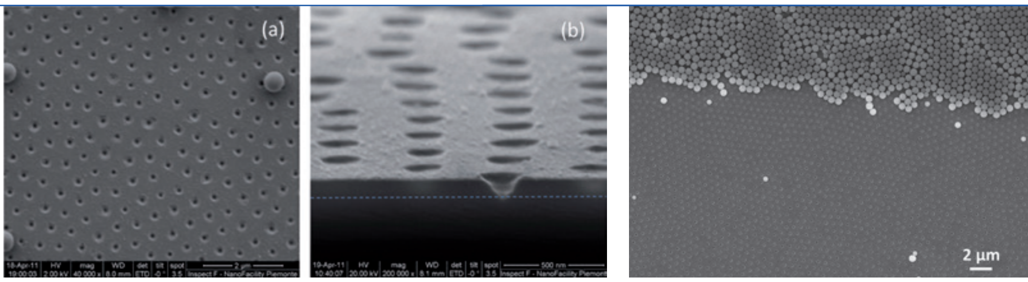
In conclusion, this study provided a new analytical tool for the non-invasive detection of explosives in the security and forensic fields. The work was published in Analytical Chemistry, and attracted substantial national and international media attention.

Periodic porous membranes produced by intense lasers (LP3)

Researchers from the Italian National Research Institute (INRIM, Torino, Italy) used the unique laser facilities at LASERLAB-EUROPE partner LP3 (Marseille, France) to create tiny holes in thin layers of silica. A chance encounter at a conference led to a new method to produce periodic porous membranes for nanofabrication.

In 2010, Luca Boarino and Natascia De Leo from INRIM participated in an international nanoscience conference (NANOSEA) held in Cassis, France. They presented a poster just next to another poster presented by researchers from LP3. The topic of the conference was 'self-assembled ordered nanomaterials' and the researchers realized during

Luca Boarino characterizing the laser-fabricated nanoporous materials at 'Nanofacility Piemonte'



Examples of a porous silica membrane produced by nanosphere-mediated laser ablation

this poster session that, combining their approaches, they could produce very efficiently periodic porous membranes – a key element for nanofabrication protocols.

The Italians were working on methods to fabricate devices on nano- and microscale from silica microspheres. They had a very large set of technological resources at their disposal, but no intense lasers. At the conference, they devised detailed methods to combine microsphere synthesis and near-field laser ablation to fabricate so-called mesoporous membranes (containing holes with a diameter of 2 to 50 nanometers). The scientists realized that the possibility to perform laser experiments with specially engineered micro- or nanospheres should provide a unique opportunity to study microsphere near-field laser ablation processes in detail.

After the conference, the INRIM researchers applied for Transnational Access, describing in their proposal the concept they discussed with the LP3 researchers. The proposal was accepted and after just two few-day visits at the LP3 laboratory, they were able to demonstrate that their concept holds.

In their experiments, they prepare silica nanospheres and assemble them into monolayers. Subsequently, a laser beam hits the monolayer deposited on top of the dense silica membranes. The laser interaction with the nanospheres creates extremely small and intense light spots, leading to a periodic nano-ablation of the membranes. Then, the approach fabricates beautifully ordered mesoporous membranes with the use of a single nanosecond laser pulse.

The LP3 laser facilities are unique, because the researchers can find all the equipment to prepare substrates (surface preparation), to irradiate the substrate (intense pulsed lasers) and to characterize directly the modified materials (optical, electron and atomic force microscopes) in one place. Thanks to all this equipment, the nanoscale experiments are not performed in the blind, which saves a lot of time. After the access experiments, further detailed characterization took place using the world-class nanoscale metrology facilities at INRIM and the results were published in *Nanotechnology*.

The Italian-French consortium will continue their research on this hybrid-photonic approach, which appears extremely promising because it is dry, clean and fast but also extremely flexible thanks to the use of laser ablation. The researchers plan to push their concept further with the help of another access project this year.

Access in numbers

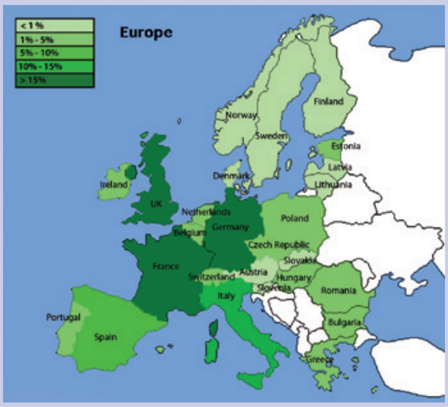


Figure 1: Geographical distribution of LASERLAB users

From 2004 to mid-2012, access to LASERLAB facilities has been granted to over 1000 scientists from institutions outside LASERLAB-EUROPE to perform 575 research projects. The LASERLAB-EUROPE users (see figure 1) come from all over Europe. Even though still almost 56% are from laboratories located in just 4 countries, namely France, Germany, Great Britain, and Italy, the LASERLAB policy towards integration of its new partners in South-Western and Eastern Europe shows an increase in the proportion of users based in these countries from 14% (2004-2008) to 16.5% (2009-2012).

More than half of the users (56%) are young researchers, i.e. PhD students or post-docs, showing that access has an important role for the training of the future European researcher community. Almost 28% of the young researchers are female, slightly more than the overall share of female users (23%), where the latter corresponds to the overall proportion in the relevant fields, mainly physics and chemistry.

The research carried out by LASERLAB users covers a broad range of scientific fields, with a clear increase of projects in life sciences (from 9% in the period 2004-2008 to 16% in 2009-2012) and a large number of projects directly linked to the new pan-European projects HiPER (mainly Fusion and Laboratory Astrophysics) and ELI (mainly Secondary Sources and Harmonics).

These collaborations have led to more than 600 publications in peer-reviewed journals, many of them in top scientific journals like Science, Nature, Nature Physics, Nature Materials and Physical Review Letters. The number is still bound to rise considerably in due course, given the delay between completion of a project, submission of a paper and actual publication. This scientific outcome is noteworthy, considering the large number of young researchers involved and the priority given to new users in the selection procedure.

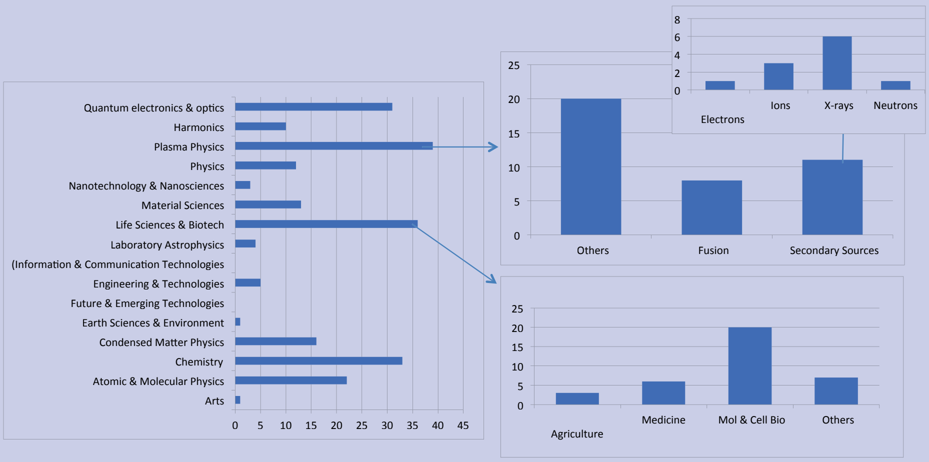


Figure 2: Scientific fields of user projects (2004-2012)

Networking Events

Venice International School on Lasers in Materials Science

Photo: courtesy of W. Kautek

Lecturers and attendees of SLIMS 2012

The Venice International School on Lasers in Materials Science (SLIMS) was held in Isola di San Servolo, Venice, Italy, from 8th to 15th of July, 2012. The School was organized in the framework of the activities of Venice International University (VIU) and continued the tradition of the first two editions of the School, which took place in the same location in 2008 and 2010. In 2012, SLIMS was recognized and supported as the 11th IUVSTA (International Union for Vacuum Science, Technique and Applications) School.

The main purpose of SLIMS was to provide PhD students and young research scientists, working in the field of laser-materials interactions with robust fundamental knowledge that is often lacking in their training, so that they may benefit from interaction with colleagues working in areas neighbouring their own research field. Although the School targeted the level of PhD students, advanced undergraduate and Master students as well as postdoctoral researchers joined in this edition. A total number of 35 students from 13 countries attended the School, with 25 students coming from EU countries.

The School comprised a set of lectures by 17 international experts in the field of laser-materials interaction. Students participated through posters and brief oral contributions. Structured discussions among lecturers and students took place in three specialized dedicated sessions. During the closing ceremony, prizes were awarded to the best student contributions.

The SLIMS 2012 programme included a number of lectures addressing the fundamentals of laser-materials interactions and laser-materials processing. The syllabus covered the mechanisms, relevant experimental and computational techniques, as well as current and emerging applications in nanoscience, biomedicine, photovoltaics, analysis and industry.

One of the distinctive features of the School was the opportunity for students to discuss their on-going projects or research plans with the lecturers. The students were strongly encouraged to present posters that were displayed over the School duration in the lecture hall. The posters were discussed during the extensive poster sessions and at coffee breaks. The students also gave brief oral presentations of their research in dedicated sessions and participated in the Best Student Presentation Award competition (dedicated to the memory of Professor Roger Kelly).

The School also included a presentation of LASERLAB-EUROPE by Marta Castillejo, one of the School Directors and Chair of the Board of User Representatives in LASERLAB-EUROPE, emphasizing the opportunities for access as well as the user training events. A round of questions and discussion about Laserlab took place after the presentation.

Marta Castillejo

Annual Meeting of NAUUL 2013

2nd Workshop on Operation of PW-class Lasers

The 2013 annual meeting of the Ultra-intense Ultrashort Lasers (NAUUL) Networking Activity took place the 13th and 14th of June 2013 at the Dornburg Castles, near Jena (Germany). It was co-organized by Gerhard Paulus (Helmholtz Institute, Jena), Philippe Martin (CEA, Saclay), and Ricardo Torres (CLPU, Salamanca). The meeting coincided with the 2nd Workshop on Operation of PW-class Lasers, the first of which took place last year in Paris.

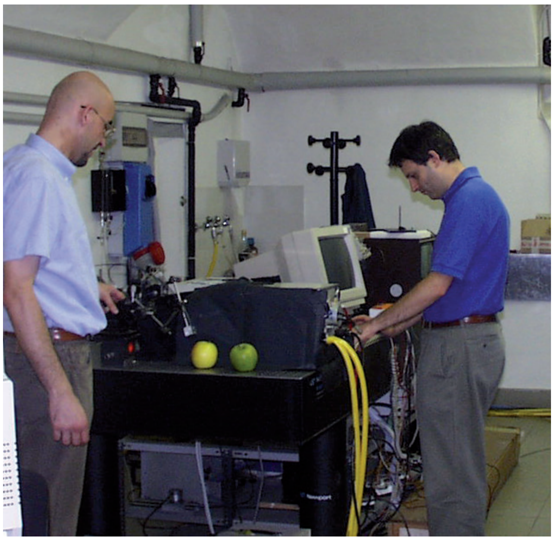
The workshop addressed the most pressing issues concerning the day-to-day operation of high-intensity lasers, and attracted some of the most recognised European experts on each topic. One of these problems is how to measure accurately the properties of laser pulses at such high powers. In particular, some novel methods for measuring ultra-high intensities were proposed, based on the momentum distribution of laser-produced ions (Gerhard Paulus), the laser-induced Zeeman effect (Evgeny Stambulchik), and non-linear Thomson scattering (Antonino Di Piazza). The enhancement of the pulse contrast and its measurement is another important issue, which becomes more critical as the intensities get higher. Also critical is the current impossibility to measure the pulse contrast in a single shot. Methods to reduce the pre/post-pulses and the experience with the Polaris laser in Jena (Malte Kaluza) and the Vulcan laser in the UK (Alexis Boyle) were presented.

Apart from the issues concerning the lasers themselves, the utilisation of these systems in the laboratory poses many technical difficulties. The protection of the electronic equipment against the electromagnetic pulse generated by the laser shot was addressed by Eyal Kroupp. The production of microtargets for laser-plasma interaction is becoming very challenging due to the ever more sophisticated target designs requested by the experimenters, and the need to deliver targets at the high repetition rates of current state-of-the-art high-intensity lasers. The most advanced techniques for target fabrication and characterization were presented by Chris Spindloe. The increasing repetition rate of forthcoming laser systems also poses a challenge to the detectors of the particles originated in the laser-target interaction. Josefine Metzkes showed her achievements in the development of online proton detectors based on scintillators.

Finally, representatives from two branches of the Extreme Light Infrastructure (ELI) – ELI-ALPS (Attosecond Light Pulse Source, Mikhail Kalashnikov) and ELI-NP (Nuclear Phyisics, Traian Dascalu) - presented an update of the progress on both projects, and the commercial companies Amplitude Technologies (Gilles Riboulet) and Thales Optronique (Denis Levaillant) provided the manufacturers' point of view into the problems of operating a PW-class laser. **Ricardo Torres**

Access Highlight:
Non-destructive assessment of internal fruit quality by time-resolved reflectance spectroscopy

With near-infrared light, the internal state of food can be probed in a non-destructive way. Consequently, near-infrared spectroscopy (NIRS) can be used to enhance the quality of the food we eat. A relatively new laser-based technique, called time-resolved reflectance spectroscopy (TRS), has several advantages over the traditional NIRS techniques using lamps or LEDs. Since 2003, the Center for Ultrafast Science and Biomedical Optics (CUSBO) at Politecnico di Milano (Milan, Italy) has been offering Transnational Access to a unique TRS system for non-destructive measurements on food. Alessandro Torricelli from CUSBO explains.



The laboratory TRS system available at CUSBO

Food, like most biological materials, is opaque to near infra-red (NIR) radiation due to the complex interplay between light absorption and light scattering. Absorption and scattering are related to tissue composition (e.g., compounds with specific absorption bands, like water, sugars, chlorophylls, and carotenoids) and tissue structure (e.g., size and density of cells, intra- and extra-cellular environment), respectively. Absorption is relatively low in the NIR range. Therefore, light can penetrate deeply into biological tissue. Conversely, scattering is remarkably larger and this allows for NIR light radiation to diffuse in the sample volume and to be reemitted at tissue boundaries. Non-destructive monitoring of food quality by near infrared spectroscopy (NIRS) has rapidly evolved from the laboratory stage to industrial applications.

The common approach to NIRS is the continuous wave (CW) technique, where steady state light sources (e.g., lamps or LEDs with constant intensity in time) and photodetectors (e.g., photodiodes or CCD cameras) are used to measure light attenuation. The absorption characteristics of the sample are then derived by the Lambert-Beer Law. Indeed, light scattering can significantly affect light attenuation, resulting in a need for calibration for each new batch of samples. To tackle this effect, a modified version of the Lambert-Beer Law has been introduced, but results are far from optimal.

The portable TRS prototype available at CUSBO

In the last decade, the study of light propagation in diffusive media has been fostered by potential diagnostic and therapeutic applications in the biomedical field. Physical models for light diffusion based on an approximate solution of the Radiative Transfer Equation have been proposed, allowing for an accurate description of the contributions from light absorption and light scattering. These models consider light as a stream of photons instead of an electromagnetic wave and the physical framework is often referred to as photon migration. The absorption coefficient and the reduced scattering coefficient are introduced, assuming a given probability for photons to be absorbed or scattered per unit length. For photons traveling inside the medium, the energy balance is used to derive the photon density (i.e., the number of photons per unit volume and time) and the photon probability of being remitted at sample boundaries (i.e., diffuse reflectance).

In addition, advanced techniques have been proposed to improve the classical CW approach to NIRS, in particular time domain and space-resolved NIRS. The main feature of time-resolved reflectance spectroscopy (TRS) is its ability to retrieve information on photon path-length in a diffusive medium. Photon path-length is influenced by scattering and absorption events and it is generally much larger than the geometrical distance between source and detector, typically on the order of a few meters. TRS measures the distribution of photon time-of-flight (related to photon path length by the speed of light in the medium) at the picosecond or nanosecond time scale at a fixed source detector distance (e.g., 15 mm) by means of pulsed laser sources (with duration of tens of picoseconds) and fast detection techniques (e.g., time correlated single photon counting) (Torricelli et al., 2008).

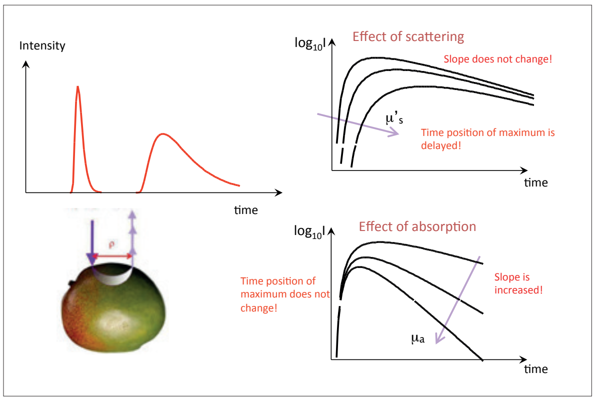
The use of TRS in combination with proper physical models for photon migration allows for complete optical characterisation, using simultaneous non-destructive measurements of the optical properties (absorption and scattering) of a diffusive medium. This can be of special interest for most fruits and vegetables, as well as for other foods (e.g. meat, fish, and cheese), because information derived by TRS refers to the internal properties of the medium, and is not so much affected by surface features as is the case for CW NIRS. Moreover, from the optical parameters information can be obtained on the physical properties, such as the density (or number) and size of particles or droplets (in case of emulsions). Those parameters are important for the processing of food (e.g., cheese, milk, juice, and puree) and subsequently for the quality of the derived food products.

TRS is totally non-invasive since the optical radiation in the 600-2000 nm spectral range (red and near infrared) is non-ionising. Moreover, very limited power (average power of a few mW) is typically employed in TRS systems. Therefore no chemical, mechanical or thermal damage can occur to the sample. TRS has the capacity to probe internal microstructural properties with minimal influence from the optical properties of the surface. Moreover, in case of anisotropic samples, suitable models are available to interpret diffuse reflectance data, e.g., fruits like melon with a thick skin can be modelled as layered media and the optical properties of upper and lower layers can be evaluated.

Within the framework of LASERLAB-EUROPE, CUSBO has been offering access to a unique TRS system for non-destructive measurements on food since 2003. The system is a broadband fully automated TRS spectrometer developed by PoliMi during the research project DIFFRUIT. PoliMi is also equipped with a portable TRS system, which can be used to perform measurements at harvest close to the orchards.

The first collaboration with experts in the food sector originated by a personal invitation to Prof. Bart Nicolai (MeBioS, KU Leuven, Belgium) and a TRS measurement campaign on pear was performed, also in comparison to CW NIRS (Nicolai et al., 2008). The following collaborations were initiated by the contacts provided by Dr. Paola Eccher Zerbini (CRA-IAA, Milan, Italy). CUSBO and CRA-IAA are closely located and actively collaborating in national and international projects. In many cases, users took advantage of the possibility to properly store fruit in controlled atmosphere rooms and to make classical destructive (e.g., firmness, brix, dry mass) and non-destructive (e.g., weight, skin colour) measurements at CRA-IAA facilities.

Dr. Eivind Vangdal (Planteforsk, Norway), for example, performed TRS measurements at CUSBO for maturity as-



Scheme of the method used for non-destructive measurements on food

sessment and detection of defects in plums (Vangdal et al., 2010), whereas Dr. Pol Tijskens (HCP-WUR, Wageningen, The Netherlands) applied biological shift models to TRS data for maturity assessment in nectarines and mango (Tijskens et al., 2007). Susan Lurie (ARO, Israel) studied internal disorders in peaches and their detection by TRS (Lurie et al., 2012). On the other hand, Dr. Manuela Zude (ATB, Potsdam, Germany) gained access to the CUSBO TRS facility for the calibration of CW NIRS sensors by directly contacting LASERLAB-EUROPE (Zude et al., 2008).

For all access projects, the specific expertise from the various partners (e.g., postharvest, biological modelling) and from the group at the laser facility (e.g., light propagation in diffusive media, advanced technique for photon detection at the picosecond scale) contributed to the success of the experiments and to the opening of further collaborations. Several research projects in fact stem from LASERLAB-EUROPE collaborations: InsideFood (coordinated by Prof. Nicolai), 3D Mosaic (coordinated by Dr. Zude, ATB Potsdam) and TROPICO (coordinated by undersigned, with WUR Wageningen as partner).

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ELI established as International Association

The Extreme Light Infrastructure (ELI), the world's first international user facility for laser research, has been established as an International Association during a notarial ceremony on April 11, 2013 in Brussels, Belgium.

The newly founded *ELI Delivery Consortium International Association* will be a non-profit organisation after Belgian law (AISBL). It will promote the sustainable development of ELI as a pan-European research infrastructure, support the coordinated implementation of the ELI research facilities, and preserve the consistency and complementarity of their scientific missions. It will also organise the establishment of an international consortium that will be in charge of the future operation of ELI, preferably in the form of a European Research Infrastructure Consortium (ERIC).

Founding members of the ELI-DC International Association are three international scientific institutions, the Romanian "Horia Hulubei" National Institute of Research and Development for Physics and Nuclear Engineering (IFIN-HH), the Hungarian ELI-Hu Research and Development Non-Profit Limited Liability Company, and the Italian Elettra-Sincrotrone Trieste S.C.p.A. The Institute of Physics of the Academy of Sciences of the Czech Republic will join the Association immediately after its establishment. Institutions from other countries such as Germany, the UK, France, and others are expected to follow.

L. Lehrner (ELI-ALPS), M. Douka (EC), N.-V. Zamfir (ELI-NP), R.-J. Smits (EC), W. Sandner (ELI-DC), V. Ružička (ELI Beamlines), C. Rizzuto (Elettra-Sincrotrone Trieste), F. Gliksohn (ELI-DC), H. Tuinder (EC) (from left to right)

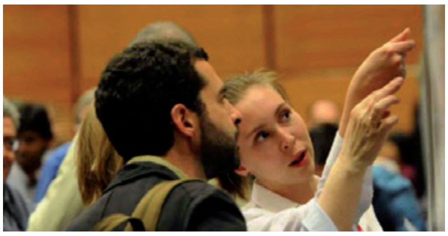
HiPER Preparatory Phase closes with a Laser Energy Workshop

A two day workshop on Laser Energy was held on 17th & 18th April in Prague to mark the end of the current 'Preparatory Phase' of the HiPER Project and the start of preparations for the next phase; 'Technology Development'.

HiPER is an ambitious ESFRI project which seeks to demonstrate the commercial viability of power production from laser-driven fusion. The workshop was held as part of the SPIE Laser and Optoelectronics Symposium and attracted over a hundred scientists, engineers and students.

Talks and posters covered every aspect of the Laser Energy challenge; laser technology, ignition physics, mass production of targets, fusion chamber concepts, advanced materials and the economic considerations of commercial power production.

The opening session included presentations from HiPER Project Director Chris Edwards and Ed Moses, Associate Director for the National Ignition Facility and Photon Science at the Lawrence Livermore National Laboratory in California. Dr Moses described progress towards ignition of Deuterium-Tritium fuel capsules at NIF and outlined plans for the LIFE project, which aims to harness fusion power within the next 15 years.



Delegates discuss details of plasma processes in fuel capsules at the HiPER poster session in Prague

The Laser Energy Workshop was followed on Friday 19th April by the Annual HiPER Participants' Forum. Chairing the closing session, Prof. John Collier, Director of STFC's Central Laser Facility, acknowledged the tremendous contribution made by the HiPER community and looked forward to the exciting advances in technology, physics and engineering which will underpin the future success of HiPER. He explained that a proposal for funding of project co-ordination and governance for the next two years was currently being considered by STFC.

Visit the HiPER website at www.hiper.org for more information and the latest HiPER Project news or send an e-mail to Chris Edwards (chris.edwards@stfc.ac.uk)

Forthcoming events

11 July 2013
JRA INREX Meeting | Paris, France

23 – 24 September 2013
Laserlab Workshop 'Characterisation of ultra-short high energy laser pulses'
Abingdon, UK

26 – 27 September 2013
Laserlab User Meeting | Marseille, France

23 – 24 October 2013
General Assembly Meeting | Lisbon, Portugal

How to apply for access

Interested researchers are invited to contact the LASERLAB-EUROPE website at www.laserlab-europe.eu/transnational-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 USP. The USP will then take a final decision. In case the proposal is accepted the host institution will instruct the applicant about further procedures.

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