Issue 3 **February 2007**

Laserlab Forum

Newsletter of Laserlab-Europe the integrated initiative of European laser infrastructures in the Sixth Framework Programme of the European Union

Editorial

Laserlab-Europe has entered the final year of the present FP6 contract. The 2007 Annual Participants Council at the Kensington Close Hotel in London provided a good opportunity to review the balance for the past three years. In one word: the overall situation seems very healthy. This is, for instance, reflected by the budget which has arrived at 70% of the total available expenditures after $^3/_4$ of the contract duration.

Looking into details, our concept of "Dynamic Access" has once again shown an amazing performance. While the 14 host facilities enjoyed (and utilised) a considerable flexibility in their response to user demands, the overall access record is, for the third year in a row, exactly on target. The number of access days is at 75% of the 4-year deliverable, while both the number of projects and users are even slightly higher. We consider this as a very satisfactory success of our model, which would not be possible without close monitoring and thoughtful steering by the Access Board. The scientific quality is controlled by our external Selection Panel under its Chair Wolfgang Demtröder.

Not surprisingly, the users seem to appreciate such services very highly. This became apparent both during the 2006 Users Meeting in Milan, Italy, and by the first evaluation of our internal user questionnaire issued earlier in the year. So it is good news for our users that ACCESS WILL CONTINUE IN 2007 AND 2008 - please don't hesitate to continue submitting proposals!

Similarly, our two JRA activities FOSCIL and OTTER showed an impressive wealth of results in their annual report for 2006 - too much to fit into a few-page document, and certainly much more than one would expect from the relatively modest JRA budget. Clearly the European add-on value lies in the synergy and co-ordination between otherwise autonomous research activities. Consequently, it was very satisfying to see two laser projects in the ESFRI Roadmap: ELI and HiPER. They represent the laser community's first serious efforts towards multi-national large scale facilities, and can be directly linked to the FOSCIL and OTTER consortia of Laserlab-Europe.

Altogether, Laserlab-Europe appears reasonably well positioned to enter the race for FP7, despite the hard, if not brutal competition one should expect under the foreseeable financial conditions. First concepts for a possible LASERLAB II were developed in a rather intense strategy session of all laboratory directors during the London meeting. In particular, Laserlab-Europe is very conscious about its obligation to observe the scenario of emerging new facilities, and to consider ways to bind them into a Europe-wide network. Also we expect internal proposals for potential JRA projects to be submitted by early May; they will undergo an internal review and selection procedure under participation of all partners. If we work it right there is every reason to look with some optimism towards FP7.

A final word: The present Newsletter has again been prepared by our experienced editorial team Armelle de Bohan and Tracey Potts. Sadly enough for us, but with high expectations from her side Armelle recently informed us that she is looking forward to a career change. Incidentally, Tracey Potts is facing no lesser challenges: she is expecting a baby, which will certainly need all her attention during the coming months. Our congratulations and best wishes go to Tracey and Armelle - many thanks to both of you for the excellent work during the past year!

Professor Wolfgang Sandner
Laserlab-Europe Coordinator

IN THIS ISSUE

First FP7 information days in France

Support measures to ensure continuity of early FP6 I3s like Laserlab

On 16 November 2006, the French Ministry for Research organised a special information day about Research Infrastructures (RI) in FP7. Mr Hervé Péro, Head of the RI unit of the European Commission DG RTD was invited to present the main features of the RI work programme. He announced support measures to ensure continuity of early FP6 I3s like Laserlab-Europe to be implemented on the first call.

Among the €50 billion budget of the 7th Framework programme, roughly €1,7 billion will be dedicated to Research Infrastructures (RI); which is a 30% increase compared to FP6. Approximately €1 billion will go to the optimization of existing infrastructures implemented through the I3 instrument of which €400 million will be allocated for ICT based infrastructures. On the basis of the European Strategic Forum for Research Infrastructure (ESFRI) roadmap, support to new infrastructures will benefit from a rough €600 million budget.

"The financial effort of the EC on Research infrastructures should be concentrated over the first five years of FP7 implementation" specified Hervé Péro during his talk while presenting the details of the two first calls. The first one, to be opened by the end of the year will put an emphasis on existing e-infrastructures (€89 million).

Interestingly, the head of the RI Unit also announced that some support measure will be implemented especially for early FP6 I3 finishing before March 2008. Among these existing I3, Hervé Péro notably mentioned Laserlab-Europe as one of the successful I3 which deserves to be supported by FP7 in order to ensure continuity in its activities.

Laserlab-Europe will end by 31 December 2007, just when the call for integrating activities (mainly I3) is launched. Therefore, a potential "Laserlab II" contract would come into force almost a year after Laserlab stopped.

In one way or another, these support measures would fill the one year gap in the activities of Laserlab-Europe until the first I3 call and support proposals from all fields of science as well as targeted approachs with topics defined by FP7 themed areas. ICT based infrastructure will get specific financial support reaching €115 million whereas an overall budget of €275 million will be attributed to 25 to 30 RTD bottom-up projects.

Among which a renewed Laserlab - Europe initiative?

Editor's note

The article was written before FP7 call was officially launched on 22 December 2006. As announced by H Péro in November, the "Infrastructure" call for proposals contains a specific topic INFRA-2007-3.6 with €4 million budget entitled "Support to ensure the continuity of FP6 actions". It will allow continuation of networking and transnational access for a maximum of one year.

Visit the call page on the Cordis website for details
http://cordis.europa.eu/fp7/dc/index.cfm?fuseaction=UserSite.CapacitiesDetailsCallPage&call_id=15

"Mr Hervé Péro, presenting the Infrastructure specific programme at the first French FP7 Info days in Paris"

Pan European research infrastructure to preserve the memory of our past

Our European Cultural Heritage (CH) might be one of our greatest assets. People's interest in works of art and monuments keeps on growing: in 2005, the Louvre Museum in Paris has welcomed 7.55 millions visitors, 10% more than in 2004. That same year, in the Italian cities of art, the tourism flow reached 55 million people.

In that context, preservation of CH is, of course, a main issue: any monuments or works of art degrade through natural aging process but also by their exposure to pollutants. Moreover, forgeries are another major threat to CH.

Undoubtedly, there is a need for techniques to preserve, identify and certify cultural heritage. In 2002, €855 million was spent in France alone for maintenance purposes, evidence of the importance of CH conservation in the European economic competitiveness. As far as laser technology is concerned, five European manufacturers dominate the laser cleaning market.

This market will develop further boosted by the existence of Research infrastructures (RI) which can establish new scientific methodologies and trigger the innovation process.

In Europe, an important number of RIs already provide state-of-the-art scientific tools and services to museum archives, libraries, excavation sites and monuments records. EUR-ARTECH, an FP6 I3 routinely provides access to a single ion beam infrastructure (AGLAE) where non-destructive elemental composition studies are carried out with high sensitivity and precision.

Moreover, neutron, laser and synchrotron facilities are developing analysis and conservation techniques which have proved to be efficient. The VII century BC Corinthian bronze helmet displayed at the Manchester Museum, *Les Demoiselles d'Avignon* by Picasso, the *Madonna dei Fusi* by Leonardo, the *San Sebastiano* by de La Tour: these are few of the many examples of artefacts and masterpieces we now have a better understanding of, thanks to the use of such RIs. In some case, they were even restored to the original splendor.

Within I3 net[1], representatives of such physical science (PS) infrastructures, among which Laserlab-Europe[2], have met to share expertise. Their discussions emphasized the high potential for a future cross distributed infrastructure. The proposal, labelled after EURICA[3], would aggregate the competences of Conservation scientists and art historians together with the high technology capacities of PS RIs in order to provide access adapted to the needs of the CH community. In EURICA, these different communities are joining forces to allow regular updates of CH knowledge and to ensure the best training to young researchers.

An emerging idea

The complexity, high expertise and high costs of the instrumentation are not available at a national level. By creating such a pan European cross disciplinary RI, fragmented skills across EU could be coordinated. Eventually, EURICA was considered as an "emerging idea" Research Infrastructure in the ESFRI Roadmap. In this context, it may be the basis for a proposal within FP7 for the sake of Our Cultural Heritage.

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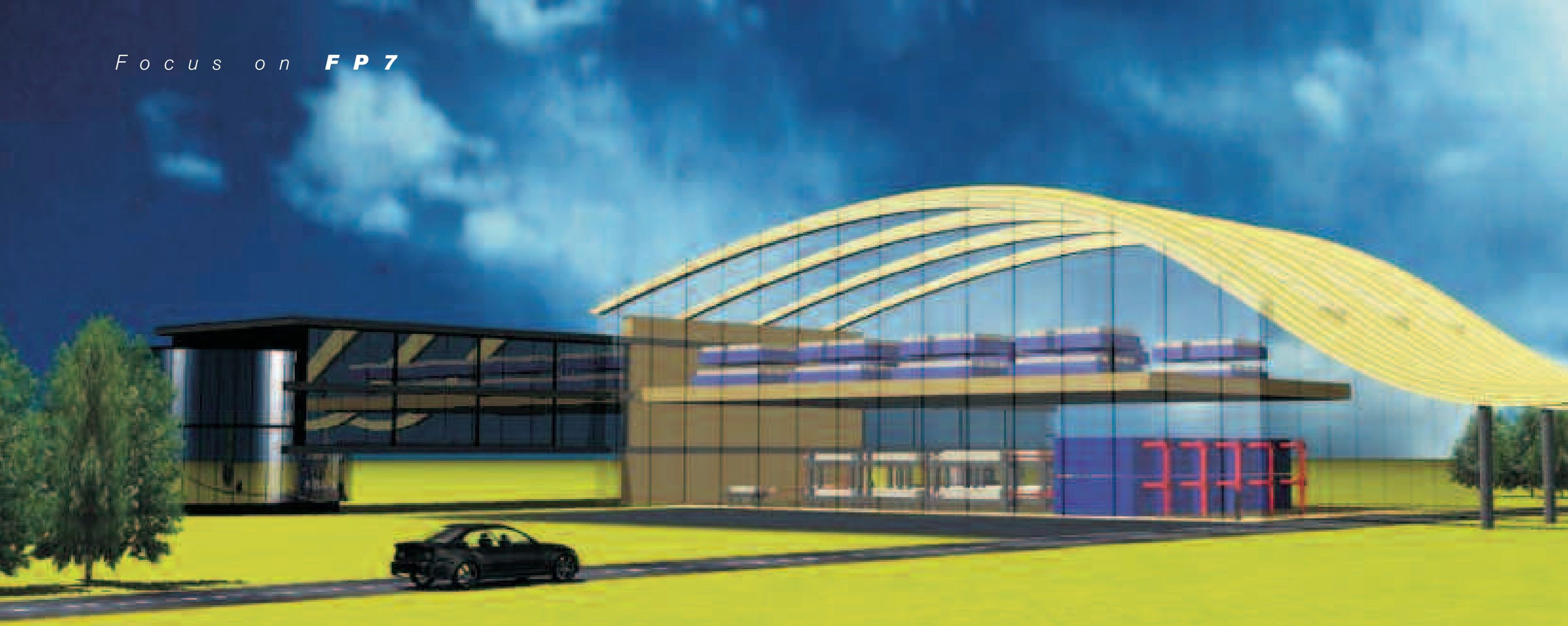
[1] introduced by Prof. McGreevy in Laserlab Forum no.2

[2] Among Laserlab partners, LLC (Sweden), LENS and CUSBO (Italy), ULF-FORTH (Greece) are involved in Cultural activities.

[3] European Research Infrastructure for Conservation and Analysis.



ELI
Extreme laser light to investigate the strata of matter from virus to quark

What is the most powerful laser researchers can build?

Theorists say an intense enough laser field would rip photons into electron-positron pairs, dousing the beam. But no one knows whether it's possible to reach that point.

This is one of the 20th fundamental questions to be answerered. (http://www.sciencemag.org/cgi/content/full/309/5731/78b) from Science, July 2005.

Laser science and technology is progressing rapidly as illustrated by the ongoing and successful joint research activities inside Laserlab-Europe. In particular, the frontiers of ultra- high intensity and ultra-short pulses are pushed toward even higher and shorter limits. The time has certainly come to design the facility so that the whole community can benefit from these innovative laser technologies which will deliver multi kJ and attosecond pulses. Professor Gérard Mourou, head of LOA, one of the French Laserlab partners is the coordinator of the Extreme Light Infrastructure (ELI) project which appears on the ESFRI roadmap. Professor Mourou outlines the background and the outlook of the whole project.

What kind of light sources will ELI deliver once it is open for access?

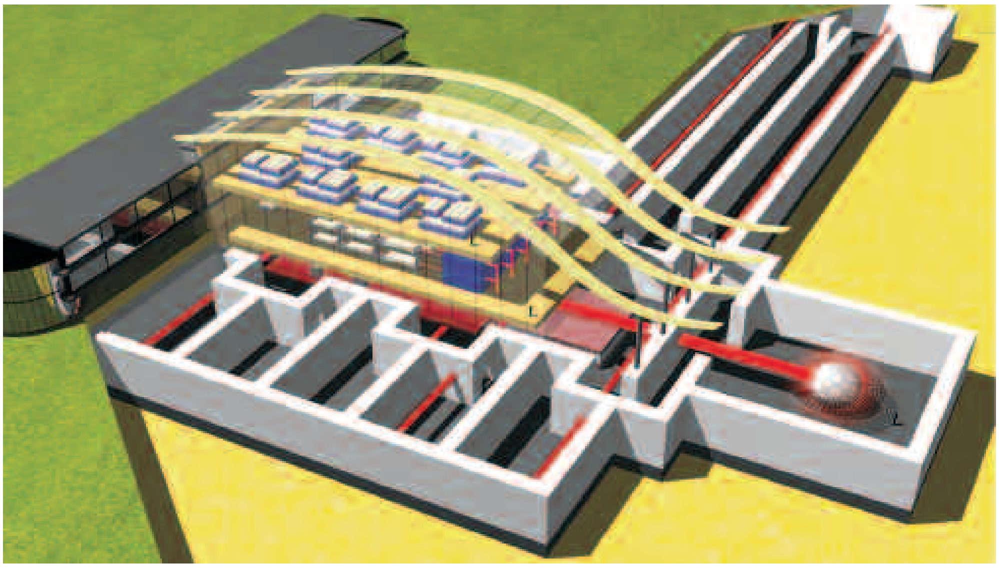
ELI will rest on the duality pulse intensity-pulse shortness. Not only will pulse shortness provide intensity but conversely pulse intensity will provide pulse shortness. ELI will be the first facility in the world dedicated to operating in the ultra-relativistic regime for laser intensity beyond 10^{24} W/cm^2, more than three orders of magnitude higher than the current most powerful laser! Until now the field was in the so called relativistic regime where only the electrons were oscillating with relativistic velocity in the laser field. Relativistic intensities are typically above 10^{18} W/cm^2. We define the ultra-relativistic regime as the regime where the protons become relativistic in the laser field. The mass of the proton being 1800 times the mass of the electron, the required intensities to reach the ultra relativistic regime will be a million times greater which means above 10^{24} W/cm^2. In fact above this ultra-relativistic threshold it is not only the proton that become relativist but all ions. It is a novel and truly important regime that will be ushered in. It will be characterised by an efficient beam generation of photons and particles with superior beam quality (low emittance).

ELI will be modular, starting at the petawatt level at a kHz repetition rate where attosecond science will be the prevailing theme. It will allow the exploitation of relativistic light-electron interaction at a solid surface for creating a source of attosecond UV, VUV and SXR light. This

Attosecond Light Source (ALS) will surpass present-day attosecond sources in terms of both peak and time-averaged brightness by 8-10 orders of magnitude and by a couple of orders of magnitude in terms of pulse duration. With two additional stages the peak power will be further extended to the sub-exawatt (10^{18} W) at a rate of 1 shot per minute.

This ultra-relativistic regime of intensity will push forward the limit of particle acceleration through laser-plasma interaction. The Exawatt range that we intend to achieve with ELI will make it possible to produce an electron beam with energy extended from 1 GeV up to the 100-1000 GeV and ion beam energy from 100MeV to 10GeV!

This ultra-high peak power, which will be 200 times the peak power of the French megajoule laser project in Bordeaux, will be obtained with exceedingly short pulse duration, in the femtosecond range (1 fs $=10^{-15}$ s). The laser power would be boosted accordingly, offering the potential of intensities exceeding 10^{25} W/cm^2.



It is difficult to imagine the potential applications for such high intensities, could you give us some examples?

In fundamental Physics, this new ultra-high intensity and ultra-short pulse laser facility will afford unprecedented new opportunities to study, hot, dense matter, which is crucial to understanding the interiors of planets, cool dense stars, and inertial confinement implosion. The laser pulse-plasma interaction would allow exploration of the fundamental properties of vacuum and its breakdown via electron-positron pair creation which represents a general process of quantum field theory. In essence, ELI intensities could help to unify nuclear physics, high-energy physics, astrophysics and cosmology.

In addition, attosecond light source will provide the opportunity to perform time-resolved science in the attosecond regime in gases, solids and plasmas. It will create the conditions for attosecond XUV pump/probe experiments for real-time observation of electronic dynamics in a wide variety of systems. These include intra-atomic processes in complex biomolecules, dynamics in clusters, electron transfer on surfaces and motion in semiconductor nanostructures.

ELI will address some real world applications. ELI's laser technology is expected to revolutionise the field of particle acceleration by ushering in the discipline of relativistic microelectronics and relativistic micro-photonics. One of the applications will be particle radiotherapy by making very compact treatment units routinely available in the hospital environment. Indeed, particular advantages of the laser-driven accelerators are their compact size ('table-top' devices) and low investment and operation costs. This would significantly reduce the size and cost of hospital-based proton and light-ion cancer treatment facilities. As a result, many more patients would benefit from highly precise and effective radiation treatment with energetic particle beams.

Finally, another important application of relativistic microelectronics will concern the aging of nuclear reactor materials. It is still challenging to elucidate the ultra-fast processes leading to defect creation or phase transformation when materials are submitted to high energy particle fluxes. ELI's secondary ultra-short particle bunches and attosecond light pulses synchronized with the laser might prove useful in order to obtain observations of the target state in the first few picoseconds after irradiation. Experiments of this type could bring decisive progress in radiation physics which is at the heart of the economic and environmental performances of nuclear technologies.

What are the steps to take before access on ELI can be opened?

Since ELI is appearing on the ESFRI roadmap, the European Commission should fund the infrastructure preparatory phase which will aim at consolidating the organisational and economic planning of the future Pan European Extreme Light Infrastructure before starting the construction.

With partners from 12 other member states already involved in the project, we are turning towards an organisational model such as the European Synchrotron Radiation Facility (ESRF) based in Grenoble (France) with a European status. It is a well tested model with a well established track record.

As to ELI's location, the ILE (Institut de la Lumière Extrême) is a candidate and, in 2007, we would like to start the construction of a single beam line prototype under regional fundings regardless of the final decision about ELI's final location. The beam line would operate in the Petawatt regime. We expect to obtain 20 PW by 2009.

Afterwards, according to the results on ELI's prototype and the decision by the member states on the final location, we will start the construction of the whole ELI infrastructure in a new building. ELI's final system, will be ten times larger than the ILE one!

According to our timetable, the first access to ELI's full power shots could be scheduled for 2012 - 2013. But remember that ELI is modular and its activities will take place at intermediate levels before the full system becomes operational.

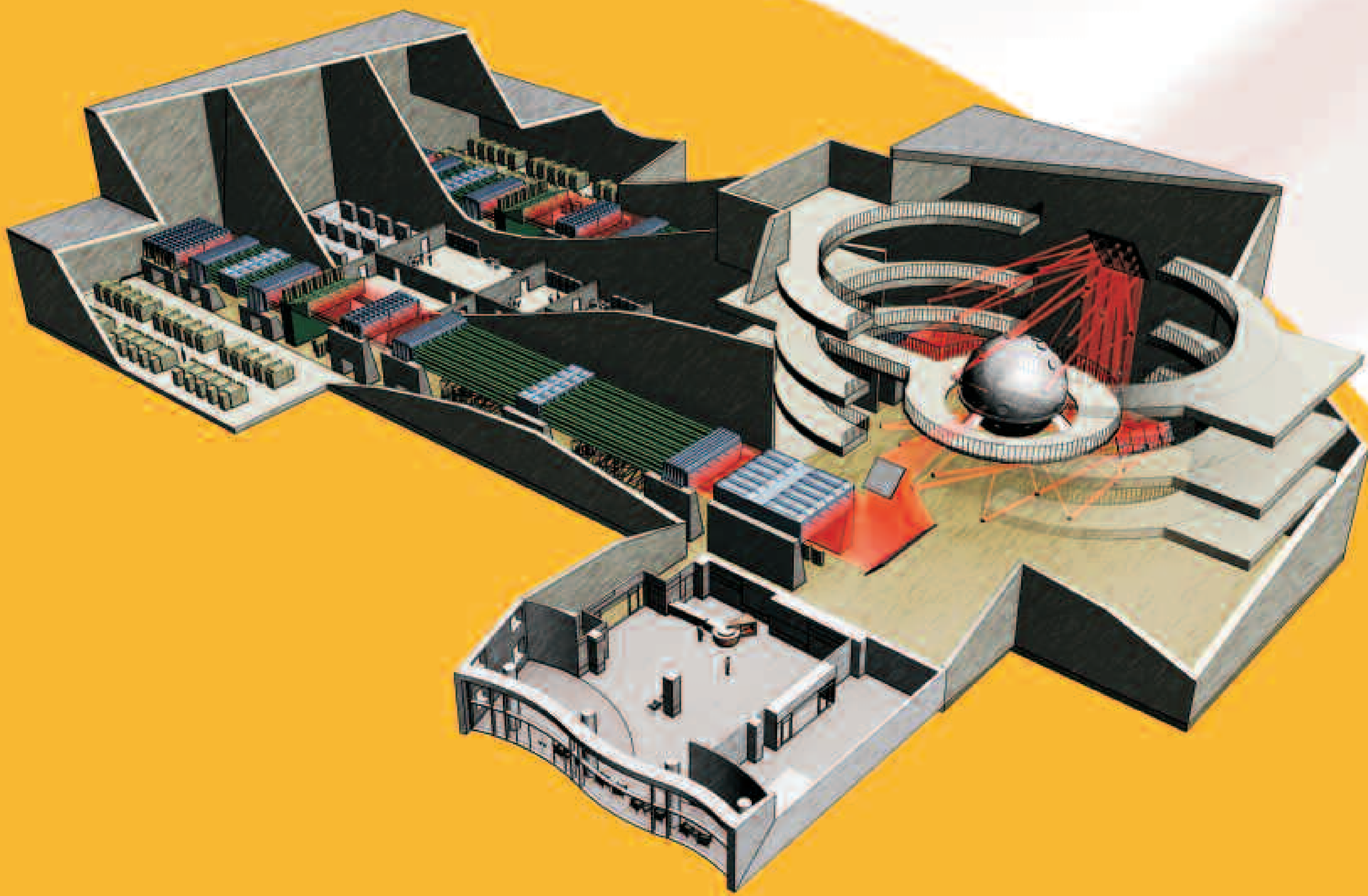
Website:
http://www.extreme-light-infrastructure.eu/

HiPER

Towards laser driven fusion energy

The HiPER research infrastructure project appears on the ESFRI roadmap among the energy projects which are allowed to apply for EC funding under FP7. This proposal is the result of a two year conceptual design phase which has involved over 40 scientists from nine European countries. This first stage was funded by the UK and coordinated by the CLF, our Laserlab partner Dr Mike Dunne (Director, CLF) is leading the HiPER team and presents the project and its related issues.

Interview by Armelle de Bohan



Could you give us an overview of the HiPER project?

HiPER will be a large scale laser system designed to demonstrate significant energy production from inertial fusion, whilst supporting a broad base of laser plasma interaction science. HiPER will make use of existing laser technology in a unique configuration, with a 200 kJ long pulse laser combined with a 70 kJ short pulse laser. This will place Europe in a true leadership position.

What is the connection with the ITER project?

It is a complementary route to achieve fusion energy. ITER is an integrated project based on magnetic confinement. This is a more mature technology that has rightly attracted multi-billion Euro funding. However, there are many uncertainties, particularly concerning the route to a commercially viable fusion power plant. Because the benefits to be gained from fusion are so great (clean, plentiful energy) we believe it is worth pursuing multiple complementary routes. This is sensible so long as these are at an affordable scale!

Laser driven fusion energy is a very good candidate for this complementary programme because it offers a new approach at relatively low cost (but of course with significant technical risk at this stage). With the ESFRI decision, we are now being asked to inform policy makers about its feasibility. We are planning a 3-year preparatory design phase at the European scale that will allow an informed decision by Member State policy makers. It will be only at this stage that the construction should be launched or abandoned.

How risky is the HiPER project?

Regarding fusion any scheme is uncertain!

However we are anticipating the demonstration of laser driven fusion energy by the Defence Community at the turn of the decade. After many years of research (which started in the 1970's), energy production is anticipated in the period 2010-12 with the National Ignition Facility in California, and slightly later in Bordeaux with Laser MegaJoule (LMJ). This is a major milestone for inertial fusion and is likely to transform our field and our visibility to the public.

The approach taken on these lasers suffers from classification problems because the technique used to ignite the pellet requires laser light conversion into X-rays, which has parallels with nuclear weapon technology.

Therefore, there is another step to take in order to demonstrate fusion energy from a civilian point of view. Fortunately, plasma physics has helped us (for once!) to 'enter the game' by providing a revolutionary approach to energy production: the fast ignition scheme. In this approach, a high energy optical laser (instead of X-Rays) is used to compress the fuel pellet, and then a very high power (multi-petawatt) laser used to provide a spark to ignite the fusion reaction. This is analogous to the spark plug in a conventional petrol engine. The physics associated with this approach is not classified, and more importantly it may allow us to reduce the size of the laser by a factor five or ten.

However, Fast Ignition is by no means certain; this is complex science and needs complex technology. That is why we need a detailed research programme to figure out whether it will work or not!

This is a high risk approach but the potential benefits are so huge that it is worth the trial!

Regarding the laser technology, how large is the step to take to achieve HiPER project?

It's huge with regard to the short pulse beams, but the facility as a whole will be smaller than the megajoule lasers currently being built. At the moment, we have 'relatively small scale lasers'. For instance, at the CLF at the end of 2004 we reported our highest power pulse ever recorded with 423 J in 410 fs. With HiPER, the energy for the short pulse should reach 70 kJ... We need to gather all the expertise in Europe in order to be able to take this huge step. Fortunately, a major stepping stone is already underway in Bordeaux with the construction of PETAL [see boxed insert]. It is vital that we make good use of that experience.

What will be the key issue during this three year preparatory phase?

The key word will be 'Coordination'. We will have to pull together all European countries to gather modelling, experimental, diagnostics and facility capabilities. So far, this has really been the missing link for our research community to be fully efficient. When HiPER is built we will need a whole network of laser labs scattered around Europe to train new researchers and to develop new ideas. Even in the case that HiPER is not built in the end, we will have made a huge step forward by the coordination of these activities. In this respect, I really think that the continuation of Laserlab-Europe in FP7 is vital to help the integration of our activities. It provides the underlying infrastructure for the broad laser community and encourages coordinated science in our field. HiPER and other future pan European RI projects such as ELI will continue to rely on such a platform.

Estimated construction cost: €850 M
First open access foreseen 2015-17
Website: www.hiper-laser.eu

PETAL is an important step towards HiPER

The PETAL project belongs to the purely academic environment surrounding the Laser Mega Joule programme in France. It involves the construction of a high energy multi-petawatt laser able to generate pulses of up to 3.5kJ energy within duration of 0.5 to 5ps, coupled to the existing high energy nanosecond multi-beam laser, LIL.

LIL (Ligne d'Intégration Laser) was built by CEA as part of the French Defence Simulation Programme. Primarily operated to validate the laser technological concepts of the LMJ, it has been opened for academic research since 2005 through the Institut Lasers & Plasmas. PETAL[1] construction has been funded by the Région Aquitaine and is scheduled for the end of 2009. Alongside this, the OCTALIL scheme - eight independent long pulse beams arranged in a quasi symmetric configuration - is also anticipated.

The combination of PETAL and OCTALIL would provide a unique capability in the world, and would represent an important step towards HiPER.

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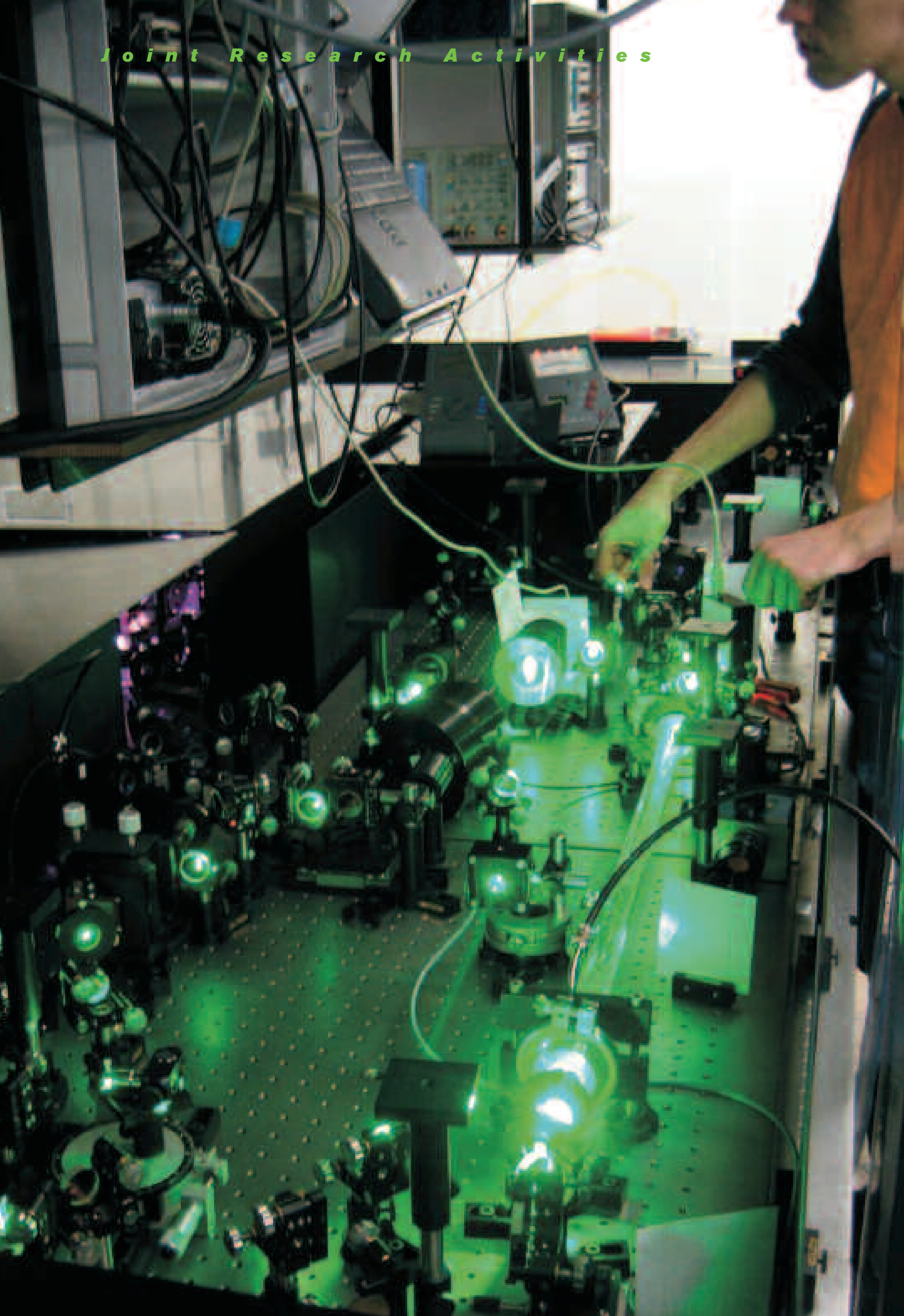
[1] **PET**awatt **A**quitaine **L**aser. Aquitaine is in the South-West region of France



The objectives of the FOSCIL Joint Research Activity are the production and control of femtosecond and subfemtosecond laserlight pulses over a wide range of frequencies as well as their application in metrology. Carrier envelope phase stabilisation of these ultrashort pulses as well as the highest possible energy flux is pursued. The JRA also aims to develop methods to characterise these pulses whatever their duration. Given the satisfactory results obtained thusfar by the Laserlab partners soon ultrashort and reproducible bursts of light of unprecedented intensity will be available for many applications, provided the rate of success continues.

FOSCIL well

Development of phase-controlled, few-femtosecond and terawatt sources

Source development is progressing rapidly

LCVU has developed an OPCPA laser system which delivers 7.6 fs, 15.5 mJ or 2 TW IR pulse operating at 30 Hz. A measurement of the stability of the carrier-envelope (CE) phase is in progress; the system requires further optimisation to improve peak-power stability.

A complementary approach at MPQ led to the construction of a kHz repetition rate, 20 GW OPCPA source. So far, a typical performance at 1 kHz of 500 μJ pulse energy and 19 fs pulse duration has been demonstrated. In addition, this team has fine tuned and minimized their stereo ATI apparatus to control and measure the CE phase: much faster and reliable feedback on the phase stabilization has been achieved.

Conversion of controlled femtosecond light into the NIR, UV, XUV and SXR spectral range

Optimising the photon yield over four orders of magnitude of the electromagnetic spectrum

Controlled fs laser light has been generated now in wide spectral ranges, using various non-linear conversion techniques and, in particular, high harmonic generation (HHG). The control over the sources is improving dramatically and tunability is no longer a real issue. The challenge is the photon yield optimisation over four orders of magnitude of the electromagnetic spectrum.

- In the near-infrared: CUSBO has developed a novel strategy for the generation of high- energy ultrabroadband near IR-pulses with passive carrier-envelope phase stabilisation using a difference frequency generation scheme. At 1.5µm 20µJ and 15fs CEP stabilised pulses were produced at 1 kHz repetition rate.

- In the VUV: At MBI tunable VUV pulses in the wavelength range 167-181nm were generated of sub-30fs duration and with pulse energies of sub-50nJ using a four-wave difference frequency-mixing scheme of 300µJ, sub-25fs pulses tunable in the range 500 to 700nm and 300µJ, 180fs pulses at 268nm.
- In the XUV: the French partners are investigating various techniques to optimise the photon yield. LOA has achieved a ten-fold increase in the generation of the 27th harmonics of a powerful Ti:Sa laser, i.e. at 30nm, using an acousto-optical spectral driver Dazzler™. Together with SLIC and CELIA, they investigated the influence of the beam spatial profile. Comparisons between Gaussian beam and flat top profile have been performed and a scaling effect was demonstrated at laser energy up to 20 mJ.
- In the soft X-ray: the LCVU team has run a first HHG experiment with their new few-cycle, TW IR laser system. The shortest wavelength that could be detected with a normal-incidence grating was 30 nm, but much shorter wavelengths must have been produced. At MPQ much effort is invested in optimising SXR production at their existing source.

Another issue of this objective is the control of the temporal coherence of the HHG source. LENS has completed this task by performing a direct interferometric measurement of the atomic dipole phase in harmonic generation. Experimental data is consistent with theoretical predictions from a semi-classical model.

Reproducible, optimized generation and full characterization of XUV/SXR pulses

Efficient generation of XUV laser pulses

Generation of sub-fs XUV pulses from HHG using a polarisation gating technique is a main task for CELIA. The technique with phase stabilised ultrashort pulses has been successfully tested in collaboration with CUSBO. Modulating the polarisation of 5 fs pulses and controlling its carrier envelope phase (CEP) allowed the confinement of the XUV emission in such a way that either one or two sub-femtosecond pulses were emitted. Through polarisation gating, an increase of the energy of isolated XUV pulses is definitely feasible.

Robust and innovative characterization techniques

LLC applied the RABBIT (Reconstruction of attosecond beatings by interference of two-photon transition) technique to several attosecond pulse trains with varying central frequency. RABITT measurements performed at several laser intensities allowed the reconstruction of the pulse to pulse variation of attosecond pulses in a femtosecond train. They also obtained information on the variation of the carrier envelope phase of attosecond pulses in the train. A momentum-shearing interferometry technique, has been applied to characterise attosecond electron wave packets (see access highlight in this issue). Its extension to pulse characterisation stricto sensu is under way.

Attosecond pump-probe at 100 ev

MPQ demonstrated that a laser-based sampling system consisting of a few cycle fs laser pulse and a synchronised soft-X ray pulse allows to sample relaxation dynamics of core excited ions with attosecond resolution. Using their attosecond streak camera technique, they also perfomed photoelectron spectroscopy of solids.

Successful implementation of dispersion free autocorrelators

Using their new attosecond XUV source ULF FORTH report two-XUV-photon ionisation of He by a train of attosecond pulses. Total ionisation and energy resolved photoelectron spectra were measured and successfully compared with the theory. A dispersion free autocorrelator has also been used for the full temporal characterisation of low harmonics (3–5) of a Ti:Sa laser through IR-UV cross-correlation measurements. Application to higher harmonics is under way.

Extension of frequency combs into the NIR and UV-XUV spectral domains

Extension of frequency combs in various spectral regions well underway

LENS improved the existing optical frequency comb synthesizer for precision spectroscopy in the mid-infrared. A high-finesse (more than 24,000) Fabry-Perot cavity at 4.5µm has been designed and built, with an effective optical path length in excess of 15 km. This optical device has been tested as a tool for high-sensitivity detection of rare CO_2 isotopomers by using the cavity ring-down technique.

The LCVU team applied an up-converted frequency comb in the deep UV/VUV to perform quantum interference spectroscopy at 212.5nm on Kr and at 125nm in Xe. Here they demonstrated the feasibility of sub-MHz resolution in the VUV with narrower resonances than ever before at 125 nm.

MPQ demonstrated 40 fs, powerful (0.5 mJ) pulses at 2 MHz repetition rate from a Ti:Sa oscillator. The stability of the pulse period is 10^{-7} and of the pulse energy is 0.3 %. To extend the frequency comb into the XUV MPQ also pursues the option of harmonic generation in an enhancement cavity for the fundamental pulses.

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underway!

Attosecond pulses to explore the phase of electronic wave packets in momentum space

The quantum picture of an atom is complete when one is able to characterise both its amplitude and phase. Experimental probing of these fundamental parameters is a real challenge. To retrieve the phase of electronic wave packets (WP) produced through laser-atom interaction, an international team* gathered at LLC (Sweden) designed an interferometric technique in analogy with optical methods used to measure the spatial or temporal phase of light.

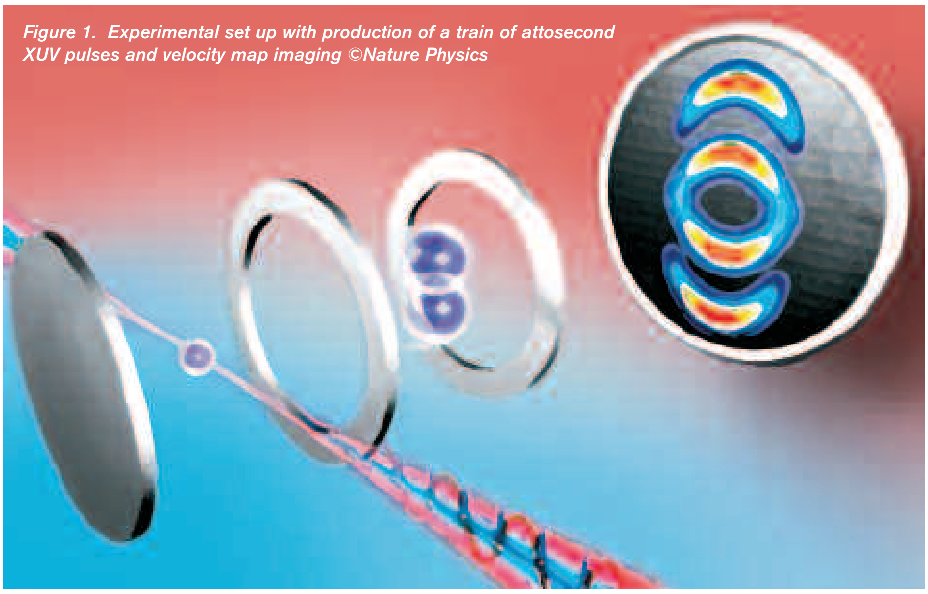


Figure 1. Experimental set up with production of a train of attosecond XUV pulses and velocity map imaging ©Nature Physics

Their method is based on the principle of shearing interferometry: two 'replicas of an electronic WP' are produced and 'shifted' with respect to one another. Then, in the region of overlap, they can interfere and the fringe pattern provides information on the electronic WP phase.

In order to implement shearing interferometry of electronic WPs, one needs to create two WPs and to induce a shear between them. Afterwards, one must also be able to visualise the fringe pattern due to the overlap of the WPs. In the usual position space (so-called "R" space), the way to detect the fringe pattern is not at all obvious, notably because of the spatial expansion of the electron wave packets.

Therefore, the team skilfully chose to measure the momentum (p=mass × velocity) of the collected electrons. Indeed, as soon as the electronic WP has been ejected outside the interaction region, its momentum distribution remains constant. Thus, provided momentum shearing is feasible, mapping the velocity of collected electrons directly gives the interference pattern induced by the shear and - a little bit less directly - the phase of the electronic WP.

To that extent, the innovative interferometric method demonstrated in this experiment has certainly benefited

The Lund Laser Centre (LLC) selected for lon

One of the partners in the Laserlab-Europe Cluster, the Lund Laser Centre (LLC), was recently awarded a long-term Swedish government grant "for cross-disciplinary laser spectroscopy".

During recent years, the basic funding for Swedish university research groups has been strongly eroded, leaving the groups to apply to central funding agencies in fierce competition to finance the basics including salaries for Professors. In a first step to alleviate these problems, the Swedish government announced a nationfrom the clever combination of two state-of-the-art techniques, namely 'production of XUV attosecond pulse trains' and 'velocity map imaging'.

The international team tailored a two colour experiment to produce the WPs and their momentum shear. To do so, they generated a train of extreme-ultraviolet (XUV) attosecond pulses through high harmonic generation in Argon. Via one-photon ionisation of argon atoms, the train of XUV attosecond pulses produced a train of electron WP. An infrared (IR) laser field, superimposed to the XUV pulse train induced the momentum shear between them (see Figure 2).

In addition, they implemented a 'velocity map imaging' technique which allowed the electrons to be collected with the same initial velocity vector onto the same point on the detector (CCD camera). As expected, the experimental momentum (velocity) distributions clearly displayed the predicted fringe pattern even though it was more complex than the theoretical simulations that the team performed in Helium. However, roads were open to retrieve information about the initial electronic WP phase.

Results of this experiment were published in *Nature physics* during Spring 2006. The high theoretical added-value of this collaborative work also emphasizes the background developed for more than two decades in the strong laser atom interaction field. It is definitely of primal importance to achieve exploration of the quantum nature of matter at the attosecond scale.

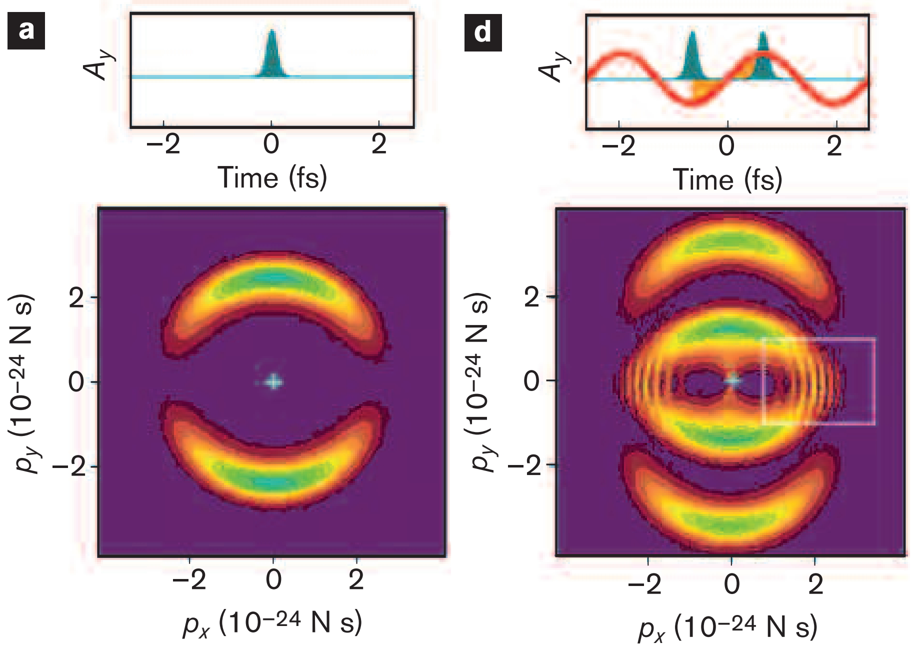
**The international team gathered scientists from the FOM institute (Netherlands), the LLC (Sweden), the LOA (France) and the Louisiana State University (USA)*

Reference: Remetter *et al.*,
Nature Physics VOL 2 MAY 2006, 323
www.nature.com/naturephysics

Two subsequent XUV attosecond pulses can ionize an Argon atom with one single photon, producing two electronic wave packets with the same momentum distribution. When an IR field is present at the times of ionization τ_1 et τ_2, the momentum distributions are shifted by the amount of momentum transferred from the field to the continuum electron wave packet. This momentum transfer is equal to $-eA(\tau_i)$ where $A(t)$ is the vector potential of the IR field. Momentum shear can be induced if $A(\tau_1) \neq A(\tau_2)$.

Figures beside display theoretical simulation of: (a) the electronic momentum distribution after ionization of helium atoms with a single XUV attosecond pulse (in blue) (d) the same but for two XUV pulses superimposed with an IR laser field. A fringe pattern visible in the region of overlap of two WPs each sheared by the same momentum absolute value $|eA_{max}|$ but with opposite sign.

Figure 2. Introducing a shear between two electronic wave packet...



g-term funding in fierce Swedish competition

wide academic competition, where university rectors were invited to put forward the projects they considered most competitive, considering all fields of research from humanities, medicine to natural sciences. The nation-wide evaluation was performed by an all-international panel of experts, and 20 projects were selected for increased funding during 10 years. Somewhat to the shock of many other Swedish universitites, the Lund University was awarded 8 of the 20 projects. The Lund Laser Centre, being a inter-faculty collaborative organisation, was one of the selected recipients, with the LLC director, Professor Sune Svanberg, as responsible for the project. The grant will help the LLC to strengthen its research profile even further, to enhance its capability on the European Scene and to provide first-class access to European users.

Workshop on New Laser Technologies

Institut de Chimie de la Matière Condensée de Bordeaux (ICMCB), Bordeaux, France

The Laserlab N6 meeting 'Workshop on New Laser Technologies' was held on 16 and 17 March 2006 at the Institut de Chimie de la Matière Condensée de Bordeaux (ICMCB) in Bordeaux, France. The host organisation for this workshop was the Commissariat à L'Energie Atomique (Centre d'Etudes Scientifiques et Techniques d'Aquitaine, CEA-CESTA). The workshop objective was to review state-of-the-art research in laser sciences and the trends toward high peak power lasers.

Among many existing topics, it was decided to focus on the following ones:

- New compressor technologies (for Petawatt class laser facilities)
- Non linear applications (OPCPA techniques)
- New active laser materials (ceramics and large bandwidth laser materials)
- Diode pumping
- Attosecond technologies
- New schemes for coherent X laser and sources
- Diagnostics for single shot short pulse.

Altogether, 26 presentations were made during the 2 day meeting, gathering 50 people from 8 European countries, mostly from Laserlab Europe partners:

- MBI, LOA, LULI, CELIA, SLIC, CESTA, CLF, FSU-IOQ, GSI, LLC, PALS, CUSBO, MPQ

and also from invited labs:

- AMOLF (Amsterdam), XLIM (Limoges), IOTA (Orsay), U-Strathclyde, Queen's University Belfast

and one company:

- Fastlite (Palaiseau).

Apart from exciting topics like attosecond technologies and coherent X-ray generation that push laser science to extreme conditions, there is a great need for "engineering" studies that will provide laser physicists with the real tools to build their laser facility (new laser materials, diode pumping, compressor technologies). Most of all, diagnostics are key issues to achieving high quality laser matter interaction : how shall I measure my tightly focused focal spot ? How can I measure my temporal, spectral and spatial 'wings' ?

From that viewpoint, the workshop was very successful gathering scientists from different communities. Many thanks to all the speakers and attendees..

Participants of the workshop had the privilege of a wine tasting evening at Chateau Petit Village (Pomerol), and a guided tour of the Laser Mégajoule (LMJ) facility under construction at Le Barp.

The workshop programme, list of participants and all the presentations given can be found at the website address: http://www.laserlab-europe.net/events/2006/n6workshop.html.

Announcements

Forthcoming events 2007

Laserlab meetings

Laserlab N6 Foresight Workshop on New and Emerging Sources of Intense Beams of Particles and Short-Wavelength Radiation, LLC, Lund, Sweden
11-13 June 2007

How to apply for access

Interested researchers are invited to contact the Laserlab-Europe website at www.laserlab-europe. 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.

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Farewell Message

Both Tracey Potts and Armelle de Bohan would like to pass on their best wishes to all the Laserlab Partners and wish them good luck in the future.