LASERLAB-EUROPE

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1 Introduction and objectives

Each member of the Laserlab-Europe Consortium possesses unique expertise in some domains of laser science and technology and infrastructure management. At the consortium level, the sum of this expertise is outstanding; at the individual level, the sharing of expertise benefits many members and increases the overall effectiveness of the Laserlab-Europe Consortium. The objective of this work package is to pool this distributed know-how and good practices concerning essential practical issues such as security, laboratory management and data acquisition procedures, as well as crucial scientific issues of relevance for many Laserlab-Europe participants. The outcome of this scientific and technological networking will be increasingly unified efforts from all members of the Consortium, pushing forward laser science and technology in the European Community at large.

2 Task 3: Thematic Networks

Regular scientific and technological exchange is crucial, but it is especially fertile on the following two frontiers of laser science: high-energy laser systems, and ultra-high intensity ultrashort-pulse laser systems. Each of these areas fits into a pan-European large-scale project: HiPER and ELI, respectively. Those projects will benefit greatly from these networking activities which aim at stimulating all possible exchanges related specifically to such high-performance lasers, and which will strengthen the link between Laserlab-Europe and the respective consortia. The Task 3 participants organised two research and technology networks within Laserlab-Europe. These networks were by nature open to all Consortium participants.

2.1 Task 3a) Networking Activity on Ultra-High Intensity Ultrashort Lasers (NAUUL)

Task leader: CLPU

Ultrashort-pulsed petawatt technology constitutes one of the main frontiers for laser infrastructures. In fact, only a few ultrashort pulse petawatt lasers are operating worldwide, and a large fraction of these within Laserlab-Europe. Moreover, some other European countries, such as Spain and Romania, have decided to invest into such technology. The aim is to increase concerted actions between the new ultra-high intensity programmes in Spain and Romania and the existing programmes in France, UK and Germany. Imperative will be knowledge sharing on topics such as large diffraction gratings, vacuum compressors and radio protection. This shall be implemented through a forum, which will ultimately help to increase efficiency, resource cost and aid in optimizing national resources. Such a forum for networking on ultra-high intensity, ultra-short lasers (NAUUL) will be implemented through annual meetings of participants. These meetings will take place at an existing or upcoming facility in order to be able to discuss issues and solution on-site. Reports will be prepared which summarize the meeting's outcome and will be disseminated to all Laserlab-Europe partners.

The Networking Activity of Ultrashort Ultraintense Lasers is building on the network established under Laserlab-Europe II and continues to monitor closely the progress made in new high-power laser facilities, intense laser technology, and related topics. NAUUL promotes personal contacts through small meetings, that is, one or two-days round-table working sessions on some specific topic with a limited number of participants. In order to do that, a call for topics was made through the forum of NAUUL on the website of Laserlab.

The first of such meetings took place in June 2013 near Jena (Germany) and addressed the most pressing issues concerning the day-to-day operation of high-intensity lasers, i.e. pulse characterisation and control, targetry, detection of secondary radiation, etc. The second proposed meeting was held in Abingdon (UK) in April 2014 and was devoted to examining

the effect of target, laser and diagnostic developments of relevance for solid target interactions. This topic is very important for inertial confinement fusion and ion acceleration research, and it is becoming critical as the power and repetition rate of currently available lasers are increasing.

The third annual meeting was organised by CLPU on 30 November 2015 in Salamanca (Spain) on the topic of target area diagnostics with ultrafast ultraintense lasers.

2013 annual network meeting: 'Operation of PW laser facilities', 13-14 June 2013, Jena, Germany

(Organisers: Philippe Martin, Ricardo Torres, Gerhard Paulus)

The first annual meeting of the Networking Activity of Ultra-intense Ultrashort Lasers (NAUUL) was held at the Dornburg Castles, near Jena (Germany), the 13th and 14th of June 2013. It was co-organized by Prof. Gerhard Paulus (Helmholtz Institute – Jena, Germany), Prof. Philippe Martin (CEA – Saclay, France), and Dr. Ricardo Torres (CLPU – Salamanca, Spain). The meeting was made to coincide with the 2nd Workshop on Operation of PW-class Lasers, the first of which took place in 2012 in Paris.

The workshop was devoted to PW-class lasers and addressed the most pressing issues concerning the day-to-day operation of high-intensity lasers, including topics like pulse characterisation and control, targetry, detection of secondary radiation, etc. It attracted some of the most recognised experts from Europe on each topic. One of these problems is how to measure accurately the properties of the 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), laser-induced Zeeman effect (Evgeny Stambulchik – Weizmann Institute of Science, Israel), and non-linear Thomson scattering (Antonino Di Piazza – Max Planck Institute for Nuclear Physics, Heidelberg, Germany). 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 – Helmholtz Institute – Jena, Germany) and the Vulcan laser in the UK (Alexis Boyle – CLF-RAL, UK) were presented.

Apart from the issues concerning the lasers themselves, the utilization 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 (Weizmann Institute of Science, Israel). The production of microtargets for laser-plasma interaction is becoming very challenging due to the ever more sophisticated target designs demanded 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 (CLF-RAL, UK). The increasing repetition rate of forthcoming laser systems also pose a challenge to the detectors of the particles originated in the laser-target interaction. Josefine Metzkes (Helmholtz-Zentrum Dresden-Rossendorf, Germany) showed her achievements in the development of online proton detectors based on scintillators.

Finally, representatives from ELI-ALPS (Mikhail Kalashnikov) and ELI-NP (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 PW-class lasers.

2014 annual network meeting: 'Target interaction challenges and developments', 28-29 April 2014, Abingdon, UK

(Organiser: CLF)

As we begin to see the construction of a number of high repetition rate, ultra-high intensity laser facilities across Europe, including, among others, Astra-Gemini in the UK, the HiBEF European XFEL beamline in Hamburg, and the ELI facilities, the issues that arise in operating a facility with such extreme environments are becoming increasingly more challenging. It was with this in mind that a two day workshop was held in Abingdon, UK, on Target Interaction Challenges and Developments and was attended by 25 participants from 12 institutions across Europe. The aim of the workshop was to gather together high intensity interaction scientists and target fabricators to discuss the current and future issues in moving towards high repetition rate operations at ultra-high intensities, which is key to unlocking the potential of current and future laser facilities. The workshop was attended by delegates from established facilities and those that are currently developing their own facilities. The sessions were divided into common themes, in order to allow the discussions at the end of each session to flow freely.

The first session was dedicated to target positioning at high repetition rate. This session was split between current methods of high rep-rate target positioning, for high intensity systems, and future methods for the ultra-intense facilities. As large facilities begin to operate at higher intensities with more complex targetry, the issue of getting targets in the correct position at 10Hz or higher is increasingly more pressing, and discussions in this session focussed around this issue.

Two sessions were dedicated to high repetition rate targetry, and a further session dedicated to the characterisation of these targets with target fabrication experts presenting their work in the mass production of targets for current and future facilities. Methods of producing novel targets, such as foams and cryogenic targets were discussed, as well as targetry for specific applications, including ion acceleration and high harmonic generation. Issues such as meeting the required specifications of target shape, surface texture and thickness during target fabrication were also discussed.

The third session of the first day was aimed at discussing facility issues that will come with operating at such high repetition rates. The discussions included the damage that occurs to metal coated optics in high intensity facilities and the effects of debris on the laser induced damage threshold of these optics. The sessions of talks were completed on the final morning, with presentations on the issues that are expected from some of the new facilities due to come online in the near future. These included the facilities at Apollon-10P in France, Vega in Spain, the high-energy density science instrument beamline at XFEL, Germany and the Extreme Light Infrastructure - Nuclear Physics facility, Romania.

The final session of the meeting was a very productive discussion session, aimed at encouraging a dialogue and collaborations between the European facilities on the issues identified during this series of talks and discussions. As a general conclusion all the participants agreed that more efforts need to be devoted to target development, especially high repetition rate targets or new generation of targets to substitute solid ones, if we want to get profit from the full capabilities our lasers systems. This becomes especially important if we want to push biomedical applications. The event was finished with a tour for the delegates of the high power laser target area facilities of the CLF.

2015 annual network meeting: 'Target area diagnostics with ultrafast ultraintense lasers', 30 November 2015, Salamanca, Spain

(Organiser: CLPU)

The Third Annual Meeting of the Networking Activity of Ultra-intense Ultrashort Lasers (NAUUL) was held at the Hospederia Fonseca in Salamanca (Spain) on 30 November 2015. It was organized by the Centro de Laseres Pulsados, chaired by prof. Luca Volpe (USAL and CLPU – Salamanca, Spain). The meeting was made to coincide with the 5th CLPU User meeting.

The one-day meeting was attended by 12 experts in the field coming from 8 different countries. The meeting was organized in three sessions plus a final discussion (round table). Each session was completed by a presentation from representative of private companies.

The advent of Ti-Sa laser systems and other promising technologies is nowadays a reality in Europe where an increasing number of Ultra short and Ultra Intense Laser facilities are growing up. The Centro de Laseres Pulsados (CLPU) is one of the most representative facilities in this area and at the moment is finalizing the implementation of a Multi-Terawatt system made by three lasers pulses from 20 TW until 1 PW power at 1-10 Hz synchronized on the fs scale. The unique combination of high power, short duration and high repetition rate is stimulating a special interest and efforts in the scientific community around the diagnostic development.

The topic of the meeting was focused on the target area diagnostics with particular emphasis on the scientific development connected to the above mentioned peculiarities. According to physicists, this kind of research is supposed to be undertaken in specialized facilities, and therefore, developed in parallel with those. At the moment researchers are moving forward to a better understanding of these issues, among which the following may be cited:

- *High rep rate and ultra high ultra fast lasers*: The possibility to work at ~ Hz frequencies opens new challenges for detectors (e.g X-ray) and the devices associated with data acquisition methods. For ultra high intense regimes GHz electromagnetic pulses are produced by the laser target interaction. These pulses interfere with the electronic instrumentation around the laser-target interaction point. For this reason particular attention in the interaction chamber design is mandatory as well as the implementation of noise filtering. Optical methods for transportation of the information outside of the chamber could also be preferable. D. Neeley (CLF) and D. Batani (Strathclyde University, UK) presented recent results on that. Martin Regehly (Greateyes Berlin) discussed the read out time comparing CCD and CMOS technologies.
- *Short pulse duration*: measuring sub-ps and fs plasma dynamic is crucial to understand particle acceleration mechanisms and particle transport at different states of matter. To date X-ray conventional diagnostics have a time resolution still above few hundreds of fs. R. Shepherd (LLNL) presented results by using an X-ray streak camera developed at LLNL with a near sub picosend resolution. J. Roux (Hamamatsu) was presenting the state of the art in the optical and X ray streak camera.
- *Open problems and challenges in diagnostics development*: Diagnostics development can be driven by mixing different techniques coming from different field of physics. A few contributions in this meeting were coming from “outside”. D. Mazon (ITER) summarized the status of the diagnostics development at ITER showing the common fields of interest. J. Veloso (Universidad de Aveiro, Portugal) showed scintillator detectors for dose measurement.

The last part of the meeting consisted in a common round table where all the considered topics have been discussed. The participation of speakers from private companies (Greateyes, Hamamatsu and Phasics) has helped and homogenized the discussion. Indeed the main topics that were discussed were connected to possible improvements of diagnostic techniques in terms of time resolution and adaptive tools on high repetition rate mode. The capability to develop our own diagnostic techniques (see for example the talk of R. Shepherd, titled "Spectroscopic measurements of short-pulse laser heated solids using sub-

picosecond streaked x-ray spectroscopy") was compared and coupled with the experimental necessity that continuously pushes down the time resolution requirements in the fs regime in which we are interested. All participants agreed that the status of the VEGA lasers system at CLPU is mature to start to address many of these issues. The natural consequence of the meetings was to gather the communication and the knowledge exchange between all partners of the network with an added value for all the partners.