Working Group 8:

Laser Technology for Laser-Plasma Accelerators

Leader: Erhard Gaul, UT-Austin and National Energetics, Inc.

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Abstract Index

Name of submitting author	Mr. Marcus Babzien
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Abstract Title	**BNL ATF Timing System Upgrades**
Author/Affiliation listing	**M. Babzien**, M. Montemagno, V. Yakimenko Brookhaven National Laboratory, Upton NY 11973
Abstract	A key enabling technology in advanced accelerators is the synchronization of precision frequency and pulse sources at the picosecond or subpicosecond level. The synchronization system employed at the BNL Accelerator Test Facility will be presented, as well as ongoing work to extend present capabilities to multiple laser and RF sources.

Summary

At the Brookhaven National Laboratory Accelerator Test Facility (BNL ATF), the low level RF system provides a reference signal for locking the phase of the Nd:YAG drive laser that illuminates the photoinjector. A TW-level picosecond CO2 laser serving user experiments is seeded with semiconductor and Kerr switches controlled by the photoinjector drive laser, providing optical synchronization between the electron bunches and CO2 laser pulses with sub-picosecond stability. Upgrades at the facility will require additional laser sources to operate with improved synchronization. Higher peak power of the CO2 laser will be reached when a shorter seed pulse than the present 1ps becomes available. A Ti:sapphire laser currently being tested will provide 300fs pulses that are frequency-converted to the 10micron spectral range for CO2 amplifier seeding, and will require an approximately threefold improvement in synchronization accuracy. A phase locked loop (PLL) controls the repetition rate of a modelocked fiber oscillator that seeds the ti:sapphire amplifiers. By operating the PLL at the 70th harmonic of the laser repetition rate, the ratio of phase error signal to amplitude noise is correspondingly enhanced. The frequency comb generated from the modelocked laser eliminates the need for a conventional RF multiplier and minimizes noise in the frequency domain. A second RF mixer is used outside the PLL to measure the residual phase error. Both temperature and laser amplitude variations can contribute to instability in the PLL and are minimized by component selection and characterization as well as temperature stabilization. Full integration of a future second Ti:sapphire laser planned for driving the electron gun will rely on RF synchronization also. A second laser seed oscillator and PLL will lock to the optical pulse train of the first laser oscillator. The 70m distance between the two laser systems will necessitate transport of the optical train through single-mode optical fiber in order to achieve minimum phase drift. The same optical train will also be used provide the low level RF required for the electron photoinjector and linac.

Name of submitting author	Federico Canova
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Abstract Title	**High peak power laser systems for application: high repetition rate PW lasers**
Author/Affiliation listing	P.M.Paul, **F. Canova**, F. Plé, F. Falcoz, G. Riboulet, L.Vigroux, P. Leroy, S. Branly Amplitude Technologies, 2-4 rue du Bois Chaland, CE2926 Lisses, Evry, France
Abstract	Amplitude has developed and is commissioning high repetition rate PW-class laser systems. We will comment our approach in term of laser technology (temporal duration and contrast, high energy amplification and compression, cryogenic cooling), infrastructure management (overall control command and supervision) and modes of operation to support application.
Summary	
Amplitude Technologies mission is to produce robust and reliable, ultra-intense femtosecond systems with the best performance with respect to pulse duration, temporal contrast and spatial beam quality. Our performance engagement continues after delivery and our close collaboration with the customer guarantees that the system's specification is maintained for the duration of its operational life. We are currently developing 3 lasers of PW-class for the Saphir project (France), for HZDR (Germany) and for CLPU (Spain) [1]. A general overview of the project will give a clear and detailed presentation fo the different type and characteristics of this kind of projects. The project management in the 3 cases will be presented, with a particular attention to the objective in term of the applications and daily operation of the laser. We will comment the required competences in the company, and we will detail the different brick of our technology in term of: • ultra-short high energy pulses amplification, to obtain pulses of less than 20fs at high energy • ultra-high contrast front-end, delivering a pulse with a temporal contrast of better than 14 orders of magnitude • high energy extraction and parasiting lasing management; • cryogenic cooling at high energy, to manage the beam profile, quality and pointing stability • pump laser technology and operation mode. The applications for high peak power lasers require high repetition rate. Thanks to the cryogenic cooling technology, Amplitude Technologies goal is to operate the PW lasers up to 5Hz. The risk management issues have been integrated in the technological approach. A set of test benches and characterization procedures have been developed to quality the supplies of the PW laser systems, as an extension of the ISO 9001 quality approach. In term of infrastructure management, we will present the issues linked to the • Control Command: overall operation and upscalabilility. • Power supplies size • Electrical supply • Control and Securities for daily operation. At the end of the presentation we will discuss different scenarios of daily operation of the PW laser systems, in term of current operation, maintenance, and ownership costs. [1] CLPU project: http://www.clpu.es/en/home.html	

Name of submitting author	Dr. Federico Canova
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Abstract Title	**Contrast Enhancement and Measurement in PW Class laser systems**
Author/Affiliation listing	P.M.Paul[1], **F. Canova[2]**, F. Plé[1], F. Falcoz[1], G. Riboulet[1], L.Vigroux[1], P. Leroy[1],P.Monot[2] 1) Amplitude Technologies, 2-4 rue du Bois Chaland, Evry, France 2) CEA-Saclay, IRAMIS, Service des Photons, Atomes et Molécules, 91191 Gif-sur-Yvette, France
Abstract	We have developed a 4mJ, 60nm bandwidth and 10^-14 contrast Laser system. We used the most energetic 1mJ-XPW signal ever produced to seed a standard CPA Laser. We report development of a new high dynamic range third order cross-correlator, which has been performed in the CEA - AT lab IMPULSE.

Summary

The ability to produce laser pulses with ASE background as low as possible is of a major importance in laser-solid target interaction, like particles acceleration. During the last few years, Cross-Polarized- Wave (XPW) [1] generation has been intensively studied. Its unique features, such as contrast enhancement or bandwidth enhancement at the fundamental wave have attracted a lot of attention. In a double CPA configuration, we were able to first, produce the most energetic XPW signal ever, and then seed a standard CPA Laser. The XPW signal has been obtained using techniques like regenerative pulse shaping via Acousto-Optic Programmable Gain Control filter (AOPGCF or Mazzler)[2] or close loop spectral phase control. The demonstration has been performed with two compact CPA lasers systems (Fig.1). The first laser system is a high contrast 10^-9 laser equipped with a contrast cleaning device. This technique used by Amplitude Technologies for many years use the direct amplification of the oscillator (booster) in combination with a saturable absorber. The first CPA also contains a Dazzler for active control of the laser overall spectral phase and a Mazzler [2] for regenerative pulse shaping. We have demonstrated a novel approach to the characterization of ultra high contrast laser systems. The demonstration has been made at the few milliJoule level but is easily scalable to several Joules, corresponding to hundreds of Terawatt or even PetaWatt lasers for particles acceleration applications. The dynamic range of almost 15 orders allows us to measure pulses contrast ratio of the order of 10^-14, this is to our knowledge, the highest contrast measured on Titanium: Sapphire based CPA Laser system.

[1] N. Minkowski, G. I. Petrov, S. Saltiel, O.Albert, J. Etchepare, J. Opt. soc. Am.B, Vol.21, No.9, 1659-1664 (2004)
[2] T. Okshendler, D. Kaplan, P. Tournois, G.M. Greetham, F.Estable, Applied Physics B 83, 491-495 (2006)
[3] L. Canova, O. Albert, A.Trisorio, R. Lopez Martens, N. Forget, T. Oksenhendler, S. Kourtev, N. Minkovski and S. M. Saltiel, submitted to CLEO Conference 2008.

Name of submitting author	Dr. Enam Chowdhury
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Abstract Title	**Construction of SCARLET laser system for reaching beyond 1021 Wcm-2**
Author/Affiliation listing	**E. Chowdhury**, C. Willis, P. Poole, R. L. Daskalova, S. Jiang, S. Feister, K. George, F. Aymond, John marketon, R. R. Freeman
Abstract	The SCARLET laser system is coming online in June 2012 with each 15 J, 30 fs pulse carrying 500 TW of peak power in a shot/min repetition rate. Based on Ti:Sapphire Dual CPA architecture,the laser will be used in selective light ion acceleration, warm and hot dense matter generation, etc.

Summary

The SCARLET laser system at The Ohio State University is an 815 nm center wavelength, Ti:Sapphire based dual CPA laser capable of producing 500 TW peak power with 15 J of energy on target with pulse width of 30 fs focused onto a > 5 μm spot, in one shot/min repetition rate. The laser chain begins at a 9 fs oscillator with a 9-pass amplifier (Femtopower) producing 25 fs 700 micro-J at kHz repetition rate. Then the pulses goes through an XPW pulse cleaning filter, stretched in an all reflective stretcher with striped grating to 800 ps, and then amplified in four stages. To enter the Final Amplifier, 1.4 J pulses are expanded through an imaging telescope with custom achromatic lenses and VSF, and are amplified by two 25 J/pulse pump lasers (each having two arms of 12.5J/pulse) at 527 nm. The 70 mm Ti:Sapphire crystal gain medum in Final Amplifier is housed in a bath of index matching fluid with dissolved dye to suppress parasitic lasing. T he pump laser arms are also double passed through the 30 mm thick crystal, which has an absorbance of 92%. Before entering the Final Amplifier the short pulses are down selected with a Pockel cell to 1 shot/min repetition rate to synchronize with the pump lasers. Amplified pulses are image relayed via an expanding telescope into the vacuum pulse compressor at 150 mm diameter. The telescope with magnification 3 is constructed with a custom achromat and a custom Off axis parabola to reduce B-integral and high order GVD caused by large aperture lenses. Currently the pulse compressor is being assembled, which is built with special substrate etched gold grating (Plymouth Grating Laboratory). All the precision vacuum optic mounts are designed and built in house, and are capable of < 5 micro-radian step size. Experimental Thrusts at SCARLET include MeV light ion acceleration (D, Li etc.), beamlike neutron generation, creation of warm and hot dense matter from laser solid interac tion at ultra-high intensities, atto-second pulse generation and much more. New results on selective pure deuteron acceleration results will be discussed.

Name of submitting author	Dr. Vladimir Chvykov
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Abstract Title	**Final Amplifier for Laser Accelerators**
Author/Affiliation listing	**V. Chvykov**, V. Yanovsky, G. Kalinchenko, A. Maksimchuk, K. Krushelnick, Center for Ultrafast Optical Science, University of Michigan P. Rousseau, ENSTA, France
Abstract	We demonstrate the existence of the severe losses due ASE (Amplified Spontaneous Emission) and ability EDP (Extraction During Pumping) technique to suppress it and parasitic lasing. The optimal conditions that can deliver up to kJ level energy with existing technology are presented.

Summary

Recently several ultrahigh intensity CPA and, OPCPA laser systems have reached petawatt output powers setting the next milestone at tens or even hundreds petawatts for the next five to ten years. The main known limitation that arises on the path toward ultrahigh output power and intensity is the restriction on the pumping and extraction energy imposed by transverse parasitic generation (TPG). The conventional preventive procedure is to reduce the reflectivity of the side wall of the gain crystals coating them with an index-matched absorbers. Our calculations reveal additional restriction for aperture of the amplifiers. This restriction is even stronger than TDP because threshold for the latter can be increased with the development of the new index matched materials for absorbers. The calculations shows that ASE in transverse direction grows dramatically after a certain time of pumping and soon becomes equal to the pumping energy. This means that further pumping is useless because all additional energy will be irradiated from the crystal as ASE. Therefore, the suppression of ASE and TPG is a very important task that has to be solved for the next generation of the ultrahigh power laser systems. To overcome this restriction we suggest deviating from the conventional method of pumping and amplifying in multi-pass amplifiers, which is based on the energy stored in the upper laser level prior to the arrival of the first pass of the input pulse. By continuing to pump after the arrival of the amplified pulse we are able to forestall ASE and parasitic lasing [1,2]. This approach was shown to double the output flux above the parasitic lasing limit in our experiments. The method has also been applied on several Ti: sapphire booster amplifiers of petawatt scale laser systems and has allowed output energies up to 50J from single channel. In this report we will discuss the optimization of EDP for presently available large aperture Ti:sapphire amplifiers. The operation of the HERCULES laser as well as its future potential developments will be presented. [1]. V. Chvykov, at all CLEO 2003, CWA34 [2]. V. Chvykov, K. Krushelnik Optics Communications 285, 8, 2134-2136. (2012)

Name of submitting author	Dr. Laura Corner
Institution	John Adams Institute, Oxford University
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Abstract Title	**Multiple pulse resonantly enhanced laser plasma wakefield acceleration**
Author/Affiliation listing	**L. Corner**, R. Walczak, L.J. Nevay, S. Dann, John Adams Institute for Accelerator Science, Oxford University, Denys Wilkinson Building, Keble Road, Oxford OX1 3RH, UK S.M. Hooker, N. Bourgeois, J. Cowley, Atomic & Laser Physics, Clarendon Laboratory, Parks Road, Oxford OX1 3PU, UK
Abstract	We present details of experiments being conducted at Oxford University on multiple pulse resonantly enhanced laser plasma wakefield acceleration. This method of laser plasma acceleration uses trains of optimally spaced low energy short pulses to drive plasma oscillations and may open laser plasma acceleration to efficient fibre laser sources.
Summary	
Laser-plasma wakefield acceleration (LWFA) generates accelerating gradients three orders of magnitude greater than conventional accelerators, promising a new generation of compact machines. To date almost all work on LWFAs has used a single, multi-Joule driving laser pulse generated by a large-scale Ti:sapphire laser system. This approach has several problems: (i) it limits work to national-scale laser facilities; (ii) the repetition rate of the LWFA is restricted to about 10 Hz, which is too low for many potential applications and (iii) the efficiency of the laser driver is very low, leading to unrealistic power requirements for high-energy, high-repetition rate accelerators involving multiple individual LWFA stages. A potential solution to the LWFA laser-driver problem is to use a train of pulses to excite the plasma wakefield. It was shown in theoretical papers from the 90s that a train of lower energy laser pulses with optimized duration and spacing can excite plasma waves as efficiently, and under some conditions more efficiently, than a single high-intensity pulse. This has been demonstrated in analytical and numerical simulations but there has been no experimental verification of these predictions. Unlike the plasma beat wave acceleration scheme, which can be seen as equivalent to a train of pulses, there is no relativistic limit on the wakefield amplitude as the spacing between the pulses can be individually optimized to the increasing plasma period. The trains of pulses required (10s of mJ, 10s of fs) are well suited to being generated by fibre laser systems which are extremely compact and much more efficient than flashlamp-pumped Ti:sapphire lasers and could enable staged plasma accelerators without prohibitive energy costs. In this presentation we describe the experimental program underway at the John Adams Institute at Oxford University to test these theoretical predictions and plans to develop a 1GeV, 1kHz electron accelerator. There are two main areas of research: tests of plasma oscillations driven by trains of pulses derived from a high energy Ti:sapp system, and development of high repetition rate fibre laser drivers.	

Name of submitting author	Dr. Kirk Flippo
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Abstract Title	**Trident 200 TW Dial-a-Contrast**
Author/Affiliation listing	**K. Flippo**, R. P. Johnson, T. Shimada, S. A. Gaillard, D. T. Offermann, R. C. Shah, F. Archuleta, S. C. Evans, R. P. Gonzales, T. R. Hurry, J. L. Kline, and S.-M. Reid Los Alamos National Laboratory
Abstract	Upgrades to the Trident laser over the past 10 years have given it the ability to produce arbitrary short-pulse prepulses as well as longer laser contrast pedestals up to a ns ahead of the main pulse, giving it a unique ability to mimic other laser systems for comparison.
Summary	
The Trident laser facility at Los Alamos National Laboratory (LANL) has served for more than 20 years as an important tool in inertial confinement fusion (ICF) and Material Dynamics research. An energy and power upgrade of the short-pulse beam line to 100J / 200 TW was made in 2007 and contrast improvements have been made continually since. The combination of this powerful new short-pulse beamline with the two flexible long pulse beamlines, and a total of three different target areas, makes Trident a highly flexible and versatile research tool for high energy density laboratory plasma (HEDLP) research. The newest "Dial-a-Contrast" (DaC) features is described, along with nominal performance of the laser at the presently available highest contrast.	

Name of submitting author	Prof. Stefan Karsch
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Abstract Title	**Electron acceleration and radiation generation at Munich - an overview**
Author/Affiliation listing	Wenz, Johannes, LMU Munich & MPI for Quantum Optics ;Khrennikov, Konstantin, LMU Munich & MPI for Quantum Optics ;Popp, Antonia, LMU Munich & MPI for Quantum Optics ;Chou, Shao-Wei, LMU Munich & MPI for Quantum Optics ;Heigoldt, Matthias, LMU Munich & MPI for Quantum Optics ;Nathaniel Kajumba, LMU Munich & MPI for Quantum Optics ;Alexander Buck, MPI for Quantum Optics ;Jiancai Xu, MPI for Quantum Optics; Laszlo Veisz, MPI for Quantum Optics ;Andreas Maier, LMU Munich & MPI for Quantum Optics; Christian Werle, LMU Munich & MPI for Quantum Optics ;Sebastian Raith, LMU Munich & MPI for Quantum Optics ;Rafael Weingartner, LMU Munich & MPI for Quantum Optics ;Florian Grüner, DESY Hamburg ;Bourgeois, Nicholas, University of Oxford ;Bajlekov, Svetjoslav, University of Oxford ;Hooker, Simon, University of Oxford
Abstract	We will give an overview on recent activities in Munich concerning the experimental investigation of various electron acceleration regimes and their application to X-ray generation. In particular, we will present the current status of quasi-monochromatic Thomson-backscattered hard X-rays and betatron phase-contrast tomography.
Summary	
We will present results from the 2010-2012 experimental campaign with MPQ's ATLAS laser facility before its recent shutdown. In electron acceleration we focused on optimizing self-injected beams through variation of electron density, acceleration length, laser parameters and trace gas amount, as well as on shock front injection in as gas jet. Various self-injected, high-charge (>100 pC) acceleration regimes in the 300-600 MeV energy band will be discussed. Using shock-front injection, background-free beams with 100 pC at 50 MeV were created in a reliable way. In addition, we will present data on longitudinal emittance of the electron beams, showing a single sub-10fs bunch for short interactions and the self-injection of a second bunch in the second wakefield period for long acceleration distances. Using the wakefield accelerator as a betatron source for X-ray photons of up to 10 keV, we recorded high signal-to-noise images of an insect in a single shot, allowing to reconstruct a first high-resolution phase-contrast tomogram from approx. 1000 laser shots. Finally, we collided a part of the ATLAS laser beam with the shock-front accelerated, narrow-band electron beam to generate Thomson-backscattered	

X-rays with a tunable, quasi-monoenergetic spectrum between 5 and 30 keV.

Name of submitting author	Mr. Karl Krushelnick
Institution	University of Michigan
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Abstract Title	**Plasma dynamics in laser wakefield accelerators**
Author/Affiliation listing	**K. Krushelnick**, W. Schumaker, C. McGuffey, M. Vargas, V. Chvykov, F. Dollar, G. Kalintchenko, V. Yanovsky, A. Maksimchuk, A.G.R. Thomas (University of Michigan)
Abstract	Recent experimental results using the HERCULES laser system at the University of Michigan will be discussed. We will describe measurements of the dynamics of ions and the electron beams from laser wakefield accelerator experiments at powers up to 200 TW using probing and scattering diagnostics.

Summary
Recent experimental results using the HERCULES laser system at the University of Michigan will be discussed. We will describe measurements of the dynamics of ions and the electron beams from laser wakefield accelerator experiments at powers up to 200 TW. These results include: 1) spatially resolved Raman scattering measurements 2) measurements of electron beam filamentation 3) measurements of ion dynamics and laser channeling during the interaction 4) effects of self-generated magnetic fields Comparisons with simulations will also be discussed as well as some potential applications for these beams.

Name of submitting author	Dr Wim Leemans
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Abstract Title	**The BELLA Facility at LBNL**
Author/Affiliation listing	**Wim Leemans**, Rob Duarte, Steve Fournier, Doug Lockhart, George Sanen, Csaba Toth, Sergio Zimmermann, LBNL François Lureau for the THALES team.
Abstract	An overview will be presented of BELLA at LBNL.
Summary	
BELLA, the BErkeley Lab Laser Accelerator, is a major facility for research funded by the DoE's Office of High Energy Physics on laser driven plasma based accelerators. An existing building has been renovated to house a new state-of-the-art laser system capable of operating at >1 PW with a repetition rate of 1 Hz. The laser system, built by THALES, is based on Ti:sapphire and will be used for experiments on generating multi-GeV electron beams from a laser plasma accelerator. After having been qualified at the factory the system has been installed in Berkeley and is now being commissioned. The system is expected to be fully operational by mid-July, 2012. The facility, the laser system performance and the diagnostic systems will be discussed.	

Name of submitting author	Prof. Wei Lu
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Abstract Title	**Recent Progress of Laser Plasma Physics and Advanced Accelerator Research at L2PA of Tsinghua University**
Author/Affiliation listing	**Wei Lu** / Tsinghua University of Beijing, UCLA Jianfei Hua / Tsinghua University of Beijing Lixin Yan / Tsinghua University of Beijing Yingchao Du / Tsinghua University of Beijing Wenhui Huang / Tsinghua University of Beijing Chuanxiang Tang/ Tsinghua University of Beijing Xinlu Xu / Tsinghua University of Beijing, UCLA Chaojie Zhang / Tsinghua University of Beijing Fei Li / Tsinghua University of Beijing Yang Wan / Tsinghua University of Beijing Yipeng Wu/ Tsinghua University of Beijing Meng Luo / Tsinghua Univeristy of Beijing Jian Ma / Tsinghua University of Beijing Warren B. Mori / UCLA Chan Joshi / UCLA
Abstract	A new group named L2PA has recently been formed at Tsinghua University of Beijng to study laser plasma physics and advanced accelerator technology. This talk will briefly introduce the recent research activities of L2PA, including progresses made on theory, simulation and experiments.
Summary	
A new group named L2PA has recently been formed at Tsinghua University of Beijng to study laser plasma physics and advanced accelerator technology. L2PA is the acronym of Laboratory of Laser Plasma Physics and Advanced Accelerator Technology. This talk will briefly introduce the recent research activities of L2PA, including progresses made on theory, simulations and experiments. On the experiments part, some details of a Thomson scattering X-ray facility equipped with a 20TW short pulse laser and a synchronized 45MeV electron LINAC will be present, together with recent experimental results on Thomson X-ray generation and laser plasma experiments. On theory and simulation part, two recent works will be discussed in details: one is on how to utilize an ultrashort electron pulse to diagnosis the electromagnetic structure of wakefield; another one is on theoretical understanding and simulations of special phase space dynamics of plasma photo-cat hode (laser ionization injection in electron beam driven nonlinear wakefield).	

Name of submitting author	Dr. Jens Osterhoff
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Abstract Title	**Linking High-Intensity Lasers to Radio-Frequency Accelerators - Technological Requirements for Hybrid Acceleration Schemes**
Author/Affiliation listing	**J. Osterhoff** [1], S. Düsterer[2], H. Schlarb[2], M. Schnepp [1], S. Schulz [2] [1]University of Hamburg, 22761 Hamburg, Germany [2]Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Germany
Abstract	The combination of established and laser-plasma-based acceleration concepts opens up novel possibilities for precise manipulation of particle-acceleration processes and might allow for stable, ultra-high gradient accelerators. Such hybrid schemes require the tight integration of high-intensity lasers into radio-frequency-accelerator facilities. In this presentation, we discuss technological challenges of this issue.
Summary	
The field of particle acceleration in plasma wakes has seen remarkable progress in recent years. Accelerating gradients of more than 10 GV/m can now be readily achieved using ultra-short intense laser pulses as wake drivers. The demonstration of the first GeV electron beams and a general trend towards improved reproducibility, beam quality and control over the involved plasma processes has led to plasma-acceleration techniques beginning to draw considerable interest in the traditional accelerator community. As a consequence, DESY, Germany's leading accelerator center, and the University of Hamburg have established a research program for plasma-based novel acceleration techniques with the goal of exploiting the synergetic combination of conventional and new accelerator concepts. In this context, a key issue to be solved is the tight integration of multi-hundred TW laser systems into an environment defined by large-scale radio-frequency (RF) cavity-based particle accelerators. We will present an overview on our recent efforts in this regard. Most crucially, the shot-to-shot accuracy of synchronization between laser and RF-clock has to be outstanding and its jitter must be small compared to the timescales of plasma wave oscillations. Such stability has been measured down to the few 10-fs level. In addition, long-timescale temporal drift by varying environmental conditions (temperature, humidity, air pressure) must be accounted for and minimized by utilizing precise air-conditioning systems and an active stabilization of laser path length. Besides temporal stability, high stability of the laser output parameters is desirable up to the level of stability of the RF systems. Furthermore, the requirements for interfacing the laser to the accelerator on a hardware and software level will be discussed.	

Name of submitting author	Dr. Jens Osterhoff
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Abstract Title	**Prospects of Plasma-Based Particle Acceleration at DESY**
Author/Affiliation listing	**J. Osterhoff** (a), R. Brinkmann (b), E. Elsen (b), K. Flöttmann (b), B. Foster (a,b), F. Grüner (a), B. Schmidt (b), H. Schlarb (b), F. Stephan (b) (a) University of Hamburg, 22761 Hamburg, Germany (b) Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Germany
Abstract	A synergetic combination of established conventional and novel particle-acceleration concepts offers an attractive pathway to study many of the mechanisms occurring in plasma-based accelerators. Here, we present plans to harness and enhance existing radio-frequency facilities at Deutsches Elektronen-Synchrotron DESY for plasma-wakefield acceleration experiments.
Summary	
The field of particle acceleration in plasma wakes has seen remarkable progress in recent years. Accelerating gradients of more than 10 GV/m can now be readily achieved using either ultra-short intense laser pulses or particle beams as wake drivers. The demonstration of the first GeV electron beams and a general trend towards improved reproducibility, beam quality and control over the involved plasma processes has led to plasma-acceleration techniques beginning to draw considerable interest in the traditional accelerator community. As a consequence, DESY, Germany's leading accelerator center, and the University of Hamburg have established a research program for plasma-based novel acceleration techniques with the goal of exploiting the synergetic combination of conventional and new accelerator concepts. Specific examples of the areas to be investigated include the external injection of pre-accelerated electron bunches from the radio-frequency accelerators REGAE (at ~5 MeV) and FLASH (at ~1.2 GeV) into high-intensity laser-driven wakefields in plasma. The interaction of phase-space-tailored beams with plasma waves will facilitate a variety of interesting and highly relevant studies, such as detection of electron-beam-emittance evolution [1], extreme bunch compression, the controlled emission of betatron radiation, and staging of accelerating units. In addition, FLASH and the Photo Injector Test Facility PITZ (at ~25 MeV) with their advanced beam-shaping capabilities will allow for a number of beam-driven plasma wakefield experiments. Some of these studies build on the recent demonstration of temporally triangular beams [2] and investigate different schemes to obtain transformer ratios beyond two. In addition, the superconducting FLASH accelerator will potentially enable the exploration of MHz repetition rates for beam-driven acceleration, a highly relevant topic for future particle-physics applications. All of these activities are planned within the framework of the newly formed LAOLA collaboration. References: [1] T. Mehrling et al., submitted (2012) [2] P. Piot et al., Phys. Rev. Lett.	

108, 034801 (2012)

Name of submitting author	Mikhail Polyanskiy
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Abstract Title	**Next-Generation Ultrafast CO2 Lasers for Strong-Field Science**
Author/Affiliation listing	**Mikhail Polyanskiy**, Igor Pogorelsky, Marcus Babzien, Vitaly Yakimenko Brookhaven National Laboratory, Accelerator Test Facility, bldg. 820M, Upton, NY, 11973, USA
Abstract	Strong-field research will benefit from developing next-generation ultrafast CO2 lasers based on optical pumping, all-solid-state femtosecond seed-pulse generation, chirped-pulse amplification, and pulse compression via self-chirping. We review progress in elaborating CO2 lasers aimed to meet requirements of ion acceleration for radiation cancer therapy.

Summary
Long-wavelength CO2 lasers open new options for strong-field research not readily supportable with solid-state chirped pulse amplification (CPA) lasers. The latest example was the first demonstration of the production of monoenergetic proton beams via a novel shock-wave acceleration mechanism in a recent series of experiments wherein a CO2 laser was focused on a hydrogen gas jet. The strong power-scaling of this regime holds much promise for realizing ~200 MeV proton beams for laser-driven proton cancer therapy, contingent upon the availability of sub-petawatt CO2 lasers. This latter demand calls for a major upgrade of CO2 laser technology beyond the state-of-art represented by the laser facilities presently operated at BNL and at UCLA. The outputs of these existing lasers reach several terawatt at down to a 3 ps pulse length. The possibilities for achieving higher peak powers with such systems primarily are limited by the current methods use d for initially generating a short pulse, and also by chromatic and nonlinear distortions and the optical breakdown that occurs when an amplified ultrafast pulse passes through an optical material (for example, a window). The invention of CPA for controlling light intensity during ultrashort pulse amplification prompted a dramatic breakthrough in solid-state laser technology. Although implementing the CPA technique for a (sub-) picosecond CO2 laser remains to be done, we might reasonably expect a comparably important outcome. Self-chirping combined with dispersive pulse compression affords another possibility for attaining an ultrafast regime with CO2 lasers. When an optical pulse propagates through a gas, its refractive index changes, and field frequency varies accordingly, so resulting in pulse chirping. By sending the pulse through a window of properly selected thickness made of a material with negative-group velocity dispersion (e.g., NaCl), we can compress the pulse down to 10-15 cycles (300-500 fs). Other proposed improvements include optimizing the generation of 10-µm ultrashort pulses, pulse shortening upon amplification in the CO2 gas under combined isotopic- and power-broadening effects, and optical pumping. These developments will support and facilitate our advances toward diversifying the applications of ultrafast CO2 lasers from

fundamental strong-field physics to medicine and other areas.

Name of submitting author	Prof. James Rosenzweig
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Abstract Title	**A 5 micron wavelength laser for dielectric laser acceleration**
Author/Affiliation listing	I. Jovanovic, G. Xu, Penn State E. Arab, P. Hoang, P. Musumeci, B. O'Shea, **J. Rosenzweig**, UCLA A. Murokh, A. Ovedenko, R. Tikhoplav, RadiaBeam Technologies I. Pogorelsky, BNL
Abstract	We describe the development of a high power, 5 micron wavelength laser system for use in GV/m dielectric laser acceleration experiments, in the context of the GALAXIE project. The main thrust of this activity is the construction of an OPA/OPG system at Penn State.
Summary	
Pending	

Name of submitting author	Carl Schroeder
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Abstract Title	**Operational plasma density and laser parameters for future colliders based on laser-plasma accelerators**
Author/Affiliation listing	**C. B. Schroeder**, E. Esarey, W. P. Leemans Lawrence Berkeley National Laboratory
Abstract	Beam-beam interaction constraints modify the plasma density scalings for a linear collider based on laser-plasma accelerators. Operating at low plasma density increases beamstrahlung. Optimal plasma density and the required laser parameters are presented for collider operation in the quantum beamstrahlung regime. The impact of laser technology is discussed.

Summary

In this talk, the basic plasma density and laser wavelength scaling laws for a collider based on laser-plasma accelerators [Schroeder et al., PR ST-AB 2010] will be presented. Under the assumptions of fixed final focusing to the interaction point, fixed efficiency of the energy conversion, and a fixed center-of-mass energy and luminosity required for high-energy physics experiments, these scaling laws indicated that the total required power for the collider scales as the square-root of plasma density. The operational plasma density determines the required drive laser parameters (duration, laser energy, peak and average power, etc.). Although the power scaling indicates lower plasma densities are favorable for reduced total collider power requirements, additional constraints may modify this basic scaling. In this talk I will present how the additional constraint, imposed by experimental high-energy physics, of fixed beamstrahlung induced beam energy loss and photon emission strongly modifies the basic plasma density scalings. Beamstrahlung effects are manifest when operating at sufficiently low plasma density. In particular, the scalings for the required power imply that it is no longer advantageous to operate at low density as opposed to more moderate densities (with higher accelerating gradients and smaller laser systems). If round beams are used in a multi-bunch train format with fixed beam loading, and the collider is constrained by beamstrahlung, then the required collider power is independent of plasma density [Schroeder et al., PR ST-AB (in press)]. The influence of laser technology on the optimal plasma density operating regime for a laser-plasma-accelerator-based collider will also be discussed.

Work supported by Office of High Energy Physics, of the US DOE, Contract No. DE-AC02-05CH11231.

Name of submitting author	Dr. Arnd Specka
Institution	Ecole Polytechnique (LLR) - CNRS/IN2P3
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Abstract Title	**Acceleration of electrons and ions at the CILEX 10PW laser facility**
Author/Affiliation listing	**Arnd Specka**, Ecole Polytechnique (LLR) - CNRS/IN2P3 (Author list to be completed)
Abstract	The Interdisciplinary Center for Extreme Light (CILEX) near Paris (France) will start to operate in 2015. It's flagship laser APOLLON (10PW, 15fs) will address frontier topics in ultrahigh intensity plasma physics as ion and electron acceleration and photon generation at intensities ranging up to 10^22 W/cm2 (a0>100).

Summary

The Interdisciplinary Center for Extreme Light (CILEX) near Paris (France) will start to operate in 2015. It's flagship laser APOLLON (10PW, 15fs) will address frontier topics in ultrahigh intensity plasma physics as ion and electron acceleration and photon generation at intensities ranging up to 1022Wcm-2 (a0>100). >From 2015 on, the Interdisciplinary Center for Extreme Light (CILEX) will address an ambitious scientific program in an unexplored range of intensities such as l acceleration of electrons and ions , and X-ray photon creation in different schemes. Its main instrument, the APOLLON laser (TiSapphire) will deliver 15 fs pulses with 10PW maximum peak power on target at a rate of one per minute thus giving access to intensities up to 1022Wcm-2 (a0>100). It will reach a very high temporal contrast through the use of a double plasma mirror. In addition to this main pulse, independent secondary beams will allow for pump-probe experiments and multi-stage LWFA. The pulse durations of the secondary beams will be adjustable independently in a range from 15fs to 1 ps in order to match a wide range of plasma wavelengths. The laser will serve two independent, fully radiation protected experimental areas, of which one is dedicated to ion acceleration and laser-matter interaction at highes power densities, whereas the other will be dedicated to LWFA acceleration. Photon creation experiments will be performed in either of these experimental areas depending on the needed experimental setup. The CILEX facility will also host two smaller 100TW class lasers in independent areas for research on connected topics at higher shot repetition rates and preparation of experiments on APOLLON. It is foreseen that the facility will be open to the national and international community. The characteristics of the facility and the detailed scientific programme of CILEX will be described.

Name of submitting author	Dr. Donald Umstadter
Institution	University of Nebraska-Lincoln, Diocles Extreme Light Laboratory
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Abstract Title	**Diocles laser system: Extreme-light at high-repetition-rate**
Author/Affiliation listing	**Donald Umstadter**, Sudeep Banerjee, Jun Zhang, Baozhen Zhao, Kevin Brown, Jared Mills / Department of Physics and Astronomy, University of Nebraska, Lincoln.
Abstract	We report on the petawatt upgrade of the Diocles laser system at the University of Nebraska-Lincoln (UNL), and its current and potential impact on the laser-driven electron beams and x-ray generation.
Summary	
Central to the mission of the Diocles Extreme Light Laboratory at UNL is the physics of the interactions of ultra-high peak power light pulses with matter. Recently, the laser facility was upgraded to increase its peak power level from 0.1 to 0.7 PW. The combined system now delivers a pulse of 800-nm light, with 20 J of energy, in pulse duration of less than 30 fs, at a repetition rate of 0.1 Hz. Meeting this challenge required the development and integration of several different novel laser technologies. The main feature of laser upgrade project was the development of a petawatt high-energy laser amplifier, by the addition of a multi-pass amplifier and a pulse compression system for the amplified laser pulse. Compact Nd:glass pump lasers capable of delivering the required energy (100 J) at the specified repetition rate were developed, to pump a new infrared amplifier. The latter is notable for its large Ti:sapphire crystal (115-mm diameter). The upgrade supports applications that include improvement in the performance of a laser-wakefield electron accelerator, and a novel source of gamma ray beams based on inverse Compton scattering.	

Name of submitting author	Karl Zeil
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Abstract Title	**High-power laser development projects for laser particle acceleration at HZDR**
Author/Affiliation listing	K Zeil [1], M Baumann [1,2,3], E Beyreuther [1], S Bock [1], T Burris-Mog [1], T E Cowan [1], W Enghardt [1,2,3], U Helbig [1], L Karsch [2], S D Kraft [1], L Laschinsky [2], M Loeser [1], J Metzkes [1], D Naumburger [2], M Oppelt [1,2], J Pawelke [1,2], C Richter [1,2], F Roeser [1], R Sauerbrey [1], M Schürer [2], U Schramm [1], M Siebold [1] 1. Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden, Germany 2. OncoRay - National Center for Radiation Research in Oncology, TU Dresden, Germany 3. Clinic for Radiation-therapy und Radio-oncology, TU Dresden, Germany
Abstract	We report on the development status of our high-power laser projects for the generation of laser accelerated protons for the radiobiology program at OncoRay and HZDR.

Summary

Recent developments in the field of laser particle acceleration enable potential applications as, e.g., radiotherapy with laser driven proton beams. Laser driven proton therapy, not only requires sufficiently high proton energies but also a reasonable repetition rate for appropriate control of the dose delivery. In Dresden, this ambitious vision is addressed by close collaborative work at OncoRay (represented by Technical University Dresden and Helmhotz-Zentrum Dresden-Rossendorf (HZDR)) combining expertise in laser plasma physics, accelerator physics, and medicine. A dedicated research building later housing both, a laser driven proton beam delivery system and a conventional proton therapy accelerator for direct comparison in clinical trials is presently under construction. For the development of a medical high intensity laser prototype to be installed at OncoRay we focus on two major projects in parallel. The first project uses a commercialized Ti:Sapphire based laser concept providing ultra short pulses of tens of femtoseconds at a repetition rate of 10 Hz. With the 150 TW Draco laser the proton acceleration process was investigated in the last three years [1], and a long-term stable and reliable mode of operation was established which has enabled first in vitro cell irradiation studies [2]. The laser system is presently upgraded by an additional amplifier stage and new front end components finally providing high contrast pulses of >500 TW on target at 1 Hz pulse repetition rate. By use of the increased pulse energy and the multiple beam option the proton energy scaling will be investigated and the radiobiological program will be extended to the irradiation of tumors in animals. Complementary to the ultra short pulse laser approach, the direct diode pumped solid state laser PENELOPE is under development. The status of this energetically more efficient technology providing longer pulse durations at comparable beam power and therefore favoring potentially higher proton acceleration performance than ultra short pulses will be presented.

[1] Zeil, K. et al. New J Phys, 12, 045015, 2010.
[2] Kraft, S. et al. New J Phys 12, 085003, 2010.