AKBP 2: New Accelerator Concepts II

Time: Tuesday 9:30–12:45 Location: MOL 213

AKBP 2.1 Tue 9:30 MOL 213

Construction and characterization of a short-period undulator for a laser-plasma driven light source — •Maximilian Trunk, Irene Dornmair, Christian Werle, Florian Holy, and Andreas R. Maier — Center for Free-Electron Laser Science & Department of Physics, University of Hamburg, 22761 Hamburg, Germany

Laser-plasma accelerators provide high accelerating gradients and are therefore promising candidates as drivers for next generation brilliant light sources. The LUX experiment, developed and operated by the LUX junior research group at the University of Hamburg and situated at DESY, aims at producing spontaneous undulator radiation from laser-plasma generated electron beams. The BEAST II undulator is based on permanent magnets and is designed and built for in-vacuum operation in the lux beamline. It features an extremely short period length of 5 mm, a gap of 2 mm and consists of 100 periods. Already for an electron beam with a kinetic energy of 400 MeV, the produced X-ray radiation is expected to reach the water window with a wavelength of 4 nm. The contribution will cover the design, construction and manufacturing of the BEAST II undulator.

AKBP 2.2 Tue 9:45 MOL 213

Intrinsic elimination of the numerical Cherenkov instability in Lorentz-boosted frame simulations of plasma accelerators — •Manuel Kirchen, Irene Dornmair, Sören Jalas, Kevin Peters, and Andreas R. Maier — Center for Free-Electron Laser Science & Department of Physics, University of Hamburg, 22761 Hamburg, Germany

We present a novel Particle-In-Cell algorithm that is intrinsically free of the numerical Cherenkov instability for relativistic plasmas flowing at a uniform velocity. The new method is independent of the geometry and - unlike previous suppression strategies - we completely avoid artificial modifications of the electromagnetic fields. Application is shown at the example of Lorentz-boosted frame simulations of plasma accelerators, achieving excellent accuracy and high speed-ups using our spectral, quasi-3D GPU code FBPIC.

AKBP 2.3 Tue 10:00 MOL 213

Detailed Analysis of a Linear Beam Transport Line from a Laser Wakefield Accelerator to a Transverse-Gradient Undulator — •Andreas Will[1], Axel Bernhard[2], Christina Widmann[1], and Anke-Susanne Müller[1,2] — [1]LAS, KIT, Karlsruhe — [2]IBPT, KIT, Karlsruhe

A linear beam transport system, experimentally tested at the Laser Wakefield Accelerator in Jena, Germany, has been carefully analyzed in order to gain a deeper understanding of the experimental results and to develop experimental strategies for the future. This analysis encompassed a detailed characterization of the focusing magnets and an investigation of the effects of source parameters as well as magnet and alignment errors on the observables accessible in the experiment. A dedicated tracking tool was developed for these investigations. In this contribution we review the main results of these studies.

AKBP 2.4 Tue 10:15 MOL 213

Staged acceleration, microbunching, and focusing in a dielectric laser accelerator — •Joshua McNeur, Martin Kozak, Norbert Schönenberger, Ang Li, Peyman Yousefi, Anna Mittelbach, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen

Dielectric laser accelerators (DLAs) form a class of novel accelerators that enables a variety of exciting applications, ranging from MeV handheld electron sources to table-top coherent x-ray sources[1]. They operate via the synchronous interaction of electrons traversing the laser-induced near-fields at dielectric nanostructures. Recently, DLAs have demonstrated acceleration gradients approaching and exceeding 1 GeV/m with a variety of dielectric materials, laser wavelengths, and nanostructure geometries [2,3,4]. Realizing the above applications, however, requires extending the interaction length between electrons and the laser induced fields via phase-controlled staging. Furthermore, the restrictive longitudinal and transverse acceptance of the nanostructures necessitates microbunching and focusing the electron beam, preferably on a similarly-miniaturized scale. Here, we report on experimental demonstration of DLA-based staging and focusing [5] and on efforts to realize a DLA-based microbunching scheme. roaches for addressing these challenges are discussed.

1. England, R. J.et al., Rev.Mod. Phys. 86, 1337 (2014).
2. Leedle, K. J. et al., Opt. Lett.40, 4344-4347 (2015).
3. McNeur, J et al.,arXiv:1604.07684 [accelerator physics] (2016).

AKBP 2.5 Tue 10:30 MOL 213

Simulations of DLA structures based on FEM in the frequency domain — •Thilo Egenolf[1], Uwe Niedermayer[1], and Oliver Boine-Frankenheim[1,2] — [1]TEMF, TU Darmstadt, Schloßgartenstraße 8, 64289 Darmstadt, Germany — [2]GSI, Planckstraße 1, 64291 Darmstadt, Germany

Grating structures of a dielectric laser accelerator (DLA) driven by ultrashort laser pulses can reach orders of magnitude larger acceleration gradients than conventional RF electron accelerators. The ratio of energy gain to laser peak amplitude defines the structure constant.

To calculate it, a new field solver based on the finite element method in the frequency domain was implemented. The maximization of the structure constant is presented as a parameter study. Based on the optimized single cell the entire design of a beta-matched grating is completed in an iterative process. The period length increment depends on the velocity of the electron, which increases, when a subrelativistic beam is accelerated. The determination of the optimal period length thus requires the knowledge of the energy gain within all periods passed before.

Furthermore, we outline estimations of the beam loading intensity limit by reversing the solver for the calculation of the beam coupling impedance at optical frequencies.

AKBP 2.6 Tue 10:45 MOL 213

Towards higher intensities and proton imaging with the laser-driven LIGHT beamline — •Diana Jahn[1], Dennis Schumacher[2], Christian Brabetz[2], Johannes Ding[1], Simon Weih[1], Abel Blazevic[2,3], Vincent Bagnoud[2,3], Florian Kroll[4,5], Florian-Emanuel Brack[4,5], Tom Cowan[4,5], Ulrich Schramm[4,5], and Markus Roth[1] — [1]Technische Universität Darmstadt, Darmstadt, Deutschland — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Deutschland — [3]Helmholtzinstitut Jena, Jena, Deutschland — [4]Das Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Deutschland — [5]Technische Universität Dresden, Deutschland

Within the Laser Ion Generation, Handling and Transport (LIGHT) research project at GSI, laser-driven ion acceleration and beam shaping are explored, combining a target normal sheath acceleration (TNSA) proton source with conventional accelerator technology. For this investigation, an ion test beamline was built and protons were accelerated via the TNSA mechanism. Out of broad energy spectrum, protons with an energy of 8 MeV are selected using chromatic focusing of a pulsed solenoid and injected into an rf cavity. Through phase focusing, temporally compressed proton bunches below 0.5 ns (FWHM) were generated with up to 5x108 particles in a single bunch at a distance of 6 m from the source and focused with a second solenoid. These bunches were successfully used for proton imaging.

15 min. break

AKBP 2.7 Tue 11:15 MOL 213

PIC Simulations of PWFA at PITZ using a high order Discontinuous Galerkin Method — Stefan Frank[1], Erion Gjonaj[2], Andreas Jankowiak[3], Gregor Loisch[1], Alberto Martinez de la Ossa[4], Atoosa Meseck[3], Anne Oppelt[1], Jens Osterhoff[4], and •Valentin Wohlfarth[1] — [1]DESY Zeuthen, 15738 Zeuthen, Deutschland — [2]TEMF TU Darmstadt, 64289 Darmstadt, Deutschland — [3]Helmholtz-Zentrum Berlin, 14109 Berlin, Deutschland — [4]DESY Hamburg, 22607 Hamburg, Deutschland

Several experiments investigating beam-driven Plasma Wakefield Acceleration (PWFA) are currently conducted at the Photo Injector Test Facility at DESY in Zeuthen (PITZ). So far, Particle-in-Cell (PIC) simulations for the preparation and theoretical evaluation of these experiments have been conducted with HiPACE, a code which is based on Poisson solvers to compute the electromagnetic fields. In this work, a code solving the fields with a high order Discontinuous Galerkin (DG) method [1] is used to reproduce simulations done with HiPACE and the resulting fields and particle beam distributions are compared.

[1] E. Gjonaj and T. Weiland, "Particle Based PWFA Simulations using a Discontinuous Galerkin Approach," in Proc. of ICEAA, 2010, pp. 604-607.

AKBP 2.8 Tue 11:30 MOL 213

Next generation plasma cell for PWFA experiments at PITZ — •Osip Lishilin[1], Reinhard Brinkmann[2], Johannes Engel[1], Florian Gruener[3,4], Matthias Gross[1], Gerald Koss[1], Gregor Loisch[1], Sebastian Phillip[1], Dieter Richter[5], Carl Schroeder[6], Rico Schuetze[1], and Frank Stephan[1] — [1]DESY, Zeuthen, Germany — [2]DESY, Hamburg, Germany — [3]Universität Hamburg, Hamburg, Germany — [4]CFEL, Hamburg, Germany — [5]HZB, Berlin, Germany — [6]LBNL, Berkeley, USA

The PWFA experiment at the Photo Injector Test facility at DESY, Zeuthen site (PITZ) was launched to experimentally demonstrate and study a promising phenomenon for future plasma-based accelerators and one of the major aspects of the upcoming AWAKE experiment - the self-modulation of long particle beams in plasma. Key points for the experiment are the plasma cell of novel design, the flexible photocathode laser system and well-developed diagnostics at PITZ. The plasma cell is a cross-shaped lithium heat pipe oven with inert gas buffer zones at input/output ports. An ArF ionization laser is coupled through side ports for the plasma generation. The next generation of plasma cell includes such improvements as an altered chamber geometry and a new heat pipe design. The ionization laser transport is improved in comparison to the previous setup. This contribution presents an overview of the current experimental setup, measurements of plasma density and homogeneity as well as highlights of the first experimental results.

AKBP 2.9 Tue 11:45 MOL 213

Gas discharge plasma cells for low density plasma wakefield acceleration — •Gregor Loisch[1], Johannes Engel[1], Matthias Gross[1], Martin Hochberg[2], Gerald Koss[1], Osip Lishilin[1], Anne Oppelt[1], Sebastian Philipp[1], Dieter Richter[3], Martin Sack[2] und Frank Stephan[1] — [1]DESY Zeuthen, 15738 Zeuthen, Deutschland — [2]Karlsruhe Institute of Technology, 76131 Karlsruhe, Deutschland — [3]Helmholtzzentrum Berlin, 14109 Berlin, Deutschland

Am Photoinjektor-Teststand bei DESY in Zeuthen (PITZ) werden derzeit Experimente zur teilchenstrahlgetriebenen Plasmabeschleunigung (PWFA) durchgeführt. Fokus der Experimente liegt auf der Selbstmodulation eines langen Elektronen-Paketes und der Untersuchung von PWFA bei hohen Transformationsverhältnissen (Verhältnis von Beschleunigungsfeldstärke zu abbremsender Feldstärke im Treiberpaket größer als 2). Dabei kommt unter anderem eine Gasentladungsplasmazelle zum Einsatz, die die Erzeugung von Plasmen mit Dichten bis 5x10^16 cm^-3 ermöglicht. Die Eignung der Zelle für diese und weitere Experimente wird anhand von spektroskopischen Messungen und Messungen mit Elektronenstrahl diskutiert, auch im Hinblick auf die Verwendung langer Gasentladungszellen als Beschleunigungsmedium für PWFA mit selbstmodulierten Protonenstrahlen.

AKBP 2.10 Tue 12:00 MOL 213

Continuous-Flow Operation of LWFA Targets — •Niels Delbos[1], Christian Werle[1], Irene Dornmair[1], Spencer Jolly[1,2], Manuel Kirchen[1], Vincent Leroux[1,2], Philipp Messner[1], Maximilian Trunk[1], Paul Winkler[1,3], Matthias Schnepp[1], and Andreas R. Maier[1] — [1]Center for Free-Electron Laser Science & Department of Physics, University of Hamburg, 22761 Hamburg, Germany — [2]ELI Beamlines, Dolní Břežany, Czech Republic — [3]Deutsches Elektronen Synchrotron (DESY)

The ability to operate plasma targets with high repetition rate is a key element for reproducible LWFA performance and experiments with good statistics. Here, we show the design and commissioning results for a target setup using a capillary-type plasma target and a differential pumping scheme, implemented at the LUX Beamline for plasma-driven undulator radiation. We show continuous flow operation with target pressures of up to 400mbar and 5Hz electron generation. With this system, the electron repetition rate is only limited by the repetition rate of the laser.

AKBP 2.11 Tue 12:15 MOL 213

Laser Plasma Module in the Space Charge Tracking Code ASTRA — •Irene Dornmair[1], Klaus Floettmann[2], and Andreas R. Maier[1] — [1]Center for Free-Electron Laser Science & Department of Physics, University of Hamburg, 22761 Hamburg — [2]Deutsches Elektronen-Synchrotron (DESY), Notkestraße 85, 22607 Hamburg

Due to their high accelerating gradients, laser-plasma accelerators (LPA) have experienced a surge of popularity over the last few years. On the quest for improved beam quality as well as for stability, also the external injection of electron beams from conventional, RF-based accelerators into LPA stages has been pursued. In the hereby typically employed linear wakefield regime the wakefield can easily be described by analytical models. We present the integration of a plasma module using the linear wakefield model into the well-known space charge tracking code ASTRA. This allows for efficient and fast estimations of the beam dynamics in an LPA stage, as well as for parameter scans and for jitter studies.

AKBP 2.12 Tue 12:30 MOL 213

Simulation of a laser-plasma-driven Thomson source for medical X-ray fluorescence imaging — •Theresa Brümmer and Florian Grüner — Institut für Experimentalphysik, Universität Hamburg, Deutschland

The topic of this talk is the development of an X-ray source for the detection of gold nanoparticles in the human body through X-ray fluorescence. These nanoparticles can act as a tracer for cancer cells or damaged neurons. On the basis of laser-plasma acceleration, an all-laser driven and thus compact X-ray source can be realised with the help of Thomson scattering (optical undulator). The medical application dictates the characteristics of the source which are a quasi-monochromatic photon spectrum at 150 keV, the maximum possible photon yield and a small opening angle to achieve a high spatial resolution. For this, electron bunch and laser pulse parameters are optimised with the help of simulations. These include the simulation of the electron trajectories. Their radiation per energy and solid angle is then calculated numerically. In this talk, first simulative results of the optimisation process are presented.