FOREWORD

Welcome to a new issue of WAKE up!, with twenty abstracts of articles published over the last four months on plasma acceleration and related topics. The list is by no means exhaustive, and its purpose is to facilitate your research and continue to strengthen the AWAKE-UK community. If you have any suggestion or an article that should be included in the next issue, please send an email to the address at the end of this newsletter. This issue, as well as all the previous ones can be accessed through the project website www.awake-uk.org under the News tab.

This quarter we will have the honour to host the AWAKE Collaboration Meeting in Liverpool, on 11 – 13 March. Details about the meeting can be found in the Indico page: https://indico.cern.ch/event/1368982/

We are looking forward to welcoming you in Liverpool!

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FUNDAMENTALS

High Average Gradient in a Laser-Gated Multistage Plasma Wakefield Accelerator

Knetsch, A.; Andriyash, I. A.; Kononenko, O.; Matheron, A.; Claveria, P. San Miguel; Zakharova, V.; Adli, E.; Corde, S.

PHYSICAL REVIEW LETTERS 131(13), 135001 (2023)
https://doi.org/10.1103/PhysRevLett.131.135001

Plasma wakefield accelerators driven by particle beams are capable of providing accelerating gradient several orders of magnitude higher than currently used radio-frequency technology, which could reduce the length of particle accelerators, with drastic influence on the development of future colliders at TeV energies and the minimization of x-ray free-electron lasers. Since interplasma components and distances are among the biggest contributors to the total accelerator length, the design of staged plasma accelerators is one of the most important outstanding questions in order to render this technology instrumental. Here, we present a novel concept to optimize interplasma distances in a staged beam-driven plasma accelerator by drive-beam coupling in the temporal domain and gating the accelerator via a femtosecond ionization laser.

Uniform onset of the long proton bunch self-modulation seeded by an electron bunch in an overdense plasma

Moon, K.; Yoon, E. S.; Chung, M.; Muggli, P.; Moreira, M.; Baistrukov, M. A.
PHYSICAL REVIEW ACCELERATORS AND BEAMS 26(11), 111301 (2023)
https://doi.org/10.1103/PhysRevAccelBeams.26.111301

The phase, growth rate, and onset of long proton bunch self-modulation in plasma can be controlled by a preceding short charged particle bunch. In this paper, by analyzing the growth rates of the self-modulation obtained from particle-in-cell simulation results, we identify two modes of self-modulation, namely noise-seeded and externally seeded self-modulations, and investigate their onset timings. We find that a uniform onset of the self-modulation at each slice of the long proton bunch is crucial for fine-tuning its phase and amplitude. We then demonstrate that a low-energy and low-current electron seed bunch in overdense plasma generates near-axis radial wakefields similar to those observed in the blowout regime. Consequently, the resultant self-modulation is excited as a single mode simultaneously along the entire long proton bunch.

Development of the self-modulation instability of a relativistic proton bunch in plasma

Verra, L. et al.
PHYSICS OF PLASMAS 30(8), 083104 (2023)
https://doi.org/10.1063/5.0157391

Self-modulation is a beam-plasma instability that is useful to drive large-amplitude wakefields with bunches much longer than the plasma skin depth. We present experimental results showing that, when increasing the ratio between the initial transverse size of the bunch and the plasma skin depth, the instability occurs later along the bunch, or not at all, over a fixed plasma length because the amplitude of the initial wakefields decreases. We show cases for which self-modulation does not develop, and we introduce a simple model discussing the conditions for which it would not occur after any plasma length. Changing bunch size and plasma electron density also changes the growth rate of the instability. We discuss the impact of these results on the design of a particle accelerator based on the self-modulation instability seeded by a relativistic ionization front, such as the future upgrade of the Advanced WAKefield Experiment.

The acceleration of a high-charge electron bunch to 10 GeV in a 10-cm nanoparticle-assisted wakefield accelerator

Aniculaesei, Constantin; Ha, Thanh; Yoffe, Samuel; Labun, Lance; Milton, Stephen; McCary, Edward; Spinks, Michael M.; Quevedo, Hernan J.; Labun, Ou Z.; Sain, Ritwik; Hannasch, Andrea; Zgadzaj, Rafal; Pagano, Isabella; Franco-Altamirano, Jose A.; Ringuette, Martin L.; Gaul, Erhart; Luedtke, Scott V.; Tiwari, Ganesh; Ersfeld, Bernhard; Brunetti, Enrico; Ruhl, Hartmut; Ditmire, Todd; Bruce, Sandra; Donovan, Michael E.; Downer, Michael C.; Jaroszynski, Dino A.; Hegelich, Bjorn Manuel
MATTER AND RADIATION AT EXTREMES 9(1), 014001 (2024)
https://doi.org/10.1063/5.0161687

An intense laser pulse focused onto a plasma can excite nonlinear plasma waves. Under appropriate conditions, electrons from the background plasma are trapped in the plasma wave and accelerated to ultra-relativistic velocities. This scheme is called a laser wakefield accelerator. In this work, we present results from a laser wakefield acceleration experiment using a petawatt-class laser to excite the wakefields as well as nanoparticles to assist the injection of electrons into the accelerating phase of the wakefields. We find that a 10-cm-long, nanoparticle-assisted laser wakefield accelerator can generate 340 pC, 10 +/- 1.86 GeV electron bunches with a 3.4 GeV rms convolved energy spread and a 0.9 mrad rms divergence. It can also produce bunches with lower energies in the 4-6 GeV range. (c) 2023 Author(s).

Generation of 10-m-lengthscale plasma columns by resonant and off-resonant laser pulses

Demeter, G.; Moody, J. T.; Kedves, M. A.; Batsch, F.; Bergamaschi, M.; Fedosseev, V.; Granados, E.; Muggli, P.; Panuganti, H.; Della Porta, G. Zevi
OPTICS AND LASER TECHNOLOGY 168, 109921 (2024)
https://doi.org/10.1016/j.optlastec.2023.109921

Creating extended, highly homogeneous plasma columns like that required by plasma wakefield accelerators can be a challenge. We study the propagation of ultra-short, terawatt power ionizing laser pulses in a 10-meter -long rubidium vapor and the plasma columns they create. We perform experiments and numerical simulations for pulses with 780 nm central wavelength, which is resonant with the D_2 transition from the ground state of rubidium atoms, as well as for pulses with 810 nm central wavelength, some distance from resonances. We measure transmitted energy and transverse width of the pulse and use schlieren imaging to probe the plasma column in the vapor close to the end of the vapor source. We find, that resonant pulses are more confined in a transverse direction by the interaction than off-resonant pulses are and that the plasma columns they create are more sharply bounded. Off-resonant pulses leave a wider layer of partially ionized atoms and thus lose more energy per unit propagation distance. Using experimental data, we estimate the energy required to generate a 20-meter-long plasma column and conclude that resonant pulses are much more suitable for creating a long, homogeneous plasma.

Excitation of wakefields in carbon nanotubes: a hydrodynamic model approach

Martin-Luna, P.; Bonatto, A.; Bontoiu, C.; Xia, G.; Resta-Lopez, J.
NEW JOURNAL OF PHYSICS 25(12), 123029 (2023)
https://doi.org/10.1088/1367-2630/ad127c

The interactions of charged particles with carbon nanotubes (CNTs) may excite electromagnetic modes in the electron gas produced in the cylindrical graphene shell constituting the nanotube wall. This wake effect has recently been proposed as a potential novel method of short-wavelength high-gradient particle acceleration. In this work, the excitation of these wakefields is studied by means of the linearized hydrodynamic model. In this model, the electronic excitations on the nanotube surface are described treating the electron gas as a 2D plasma with additional contributions to the fluid momentum equation from specific solid-state properties of the gas. General expressions are derived for the excited longitudinal and transverse wakefields. Numerical results are obtained for a charged particle moving within a CNT, paraxially to its axis, showing how the wakefield is affected by parameters such as the particle velocity and its radial position, the nanotube radius, and a friction factor, which can be used as a phenomenological parameter to describe effects from the ionic lattice. Assuming a particle driver propagating on axis at a given velocity, optimal parameters were obtained to maximize the longitudinal wakefield amplitude.

Beam current from downramp injection in electron-driven plasma wakefields

Hue, Celine; Golovanov, Anton; Tata, Sheroy; Corde, Sebastien; Malka, Victor
JOURNAL OF PLASMA PHYSICS 89(5), 965890502 (2023)
https://doi.org/10.1017/S0022377823001162

We study the stability of plasma wake wave and the properties of density-downramp injection in an electron-driven plasma accelerator. In this accelerator type, a short high-current electron bunch (generated by a conventional accelerator or a laser-wakefield acceleration stage) drives a strongly nonlinear plasma wake wave (blowout), and accelerated electrons are injected into it using a sharp density transition which leads to the elongation of the wake. The accelerating structure remains highly stable until the moment some

electrons of the driver reach almost zero energy, which corresponds to the best interaction length for optimal driver-to-plasma energy transfer efficiency. For a particular driver, this efficiency can be optimised by choosing appropriate plasma density. Studying the dependence of the current of the injected bunch on driver and plasma parameters, we show that it does not depend on the density downramp length as long as the condition for trapping is satisfied. Most importantly, we find that the current of the injected bunch primarily depends on just one parameter which combines both the properties of the driver (its current and duration) and the plasma density.

BEAMLINES & APPLICATIONS

Femtosecond multimodal imaging with a laser-driven X-ray source

Doherty, Adam; Fourmaux, Sylvain; Astolfo, Alberto; Ziesche, Ralf; Wood, Jonathan; Finlay, Oliver; Stolpe, Wiebe; Batey, Darren; Manke, Ingo; Legare, Francois; Boone, Matthieu; Symes, Dan; Najmudin, Zulfikar; Endrizzi, Marco; Olivo, Alessandro; Cipiccia, Silvia
COMMUNICATIONS PHYSICS 6(1), 288 (2023)
https://doi.org/10.1038/s42005-023-01412-9

Laser-plasma accelerators are compact linear accelerators based on the interaction of high-power lasers with plasma to form accelerating structures up to 1000 times smaller than standard radiofrequency cavities, and they come with an embedded X-ray source, namely betatron source, with unique properties: small source size and femtosecond pulse duration. A still unexplored possibility to exploit the betatron source comes from combining it with imaging methods able to encode multiple information like transmission and phase into a single-shot acquisition approach. In this work, we combine edge illumination-beam tracking (EI-BT) with a betatron X-ray source and present the demonstration of multimodal imaging (transmission, refraction, and scattering) with a compact light source down to the femtosecond timescale. The advantage of EI-BT is that it allows multimodal X-ray imaging technique, granting access to transmission, refraction and scattering signals from standard low-coherence laboratory X-ray sources in a single shot.; Laser-plasma electron accelerators are ultracompact and come with an embedded betatron X-ray source with small source size and ultrashort pulse length. The authors combine the edge illumination-beam tracking technique with a compact plasma X-ray source and present a demonstration of multimodal imaging down to the femtosecond timescale.

Positron acceleration in plasma waves driven by non-neutral fireball beams

Silva, Thales; Vieira, Jorge
PHYSICAL REVIEW ACCELERATORS AND BEAMS 26(9), 091301 (2023)
https://doi.org/10.1103/PhysRevAccelBeams.26.091301

Plasma-based positron acceleration is still an open question, as the most efficient regimes for electron acceleration (quasilinear and blowout) are not directly applicable to positrons. Nevertheless, positron acceleration is a stepping stone on the path toward a plasma-based lepton collider. In this work, we propose a scheme for positron acceleration based on the spatial overlap of a driver (electron or laser) beam and a positron beam, also known as a fireball beam. Under appropriate conditions, these beams can self consistently evolve toward a hollow driver and focused positron beam on-axis, driving plasma waves suitable for positron acceleration. This evolution seems to be a manifestation of the current filamentation instability. We discuss how the self-consistent dynamics affect the beam quality and perform a preliminary tolerance study.

Time dynamics of the dose deposited by relativistic ultra-short electron beams

Horvath, D.; Grittani, G.; Precek, M.; Versaci, R.; Bulanov, S., V; Olsovcova, V
PHYSICS IN MEDICINE AND BIOLOGY 68(22), 22NT01 (2023)
https://doi.org/10.1088/1361-6560/ad00a3

Ultra-short electron beams are used as ultra-fast radiation source for radiobiology experiments aiming at very high energy electron beams (VHEE) radiotherapy with very high dose rates. Laser plasma accelerators are capable of producing electron beams as short as 1 fs and with tunable energy from few MeV up to multi-GeV with compact footprint. This makes them an attractive source for applications in different fields, where the ultra-short (fs) duration plays an important role. The time dynamics of the dose deposited by electron beams with energies in the range 50-250 MeV have been studied and the results are presented here. The results set a quantitative limit to the maximum dose rate at which the electron beams can impart dose.

Electron-beam-driven plasma wakefield acceleration of photons

Sandberg, R. T.; Thomas, A. G. R.
PHYSICS OF PLASMAS 30(11), 113105 (2023)
https://doi.org/10.1063/5.0174055

The paper [R .T. Sandberg and A. G. R. Thomas, Phys. Rev. Lett. 130, 085001 (2023)] proposed a scheme to generate ultrashort, high energy pulses of XUV photons through dephasingless photon acceleration in a beam-driven plasma wakefield. An ultrashort laser pulse is placed in the plasma wake behind a relativistic electron bunch so that it experiences a density gradient and therefore shifts up in frequency. Using a tapered density profile provides phase-matching between the driver and witness pulses. In this paper, we study via particle-in-cell simulation the limits, practical realization, and 3D considerations for beam-driven photon acceleration using the tapered plasma density profile. We study increased efficiency by the use of a chirped drive pulse, establishing the necessity of the density profile shape we derived as opposed to a simple linear ramp, but also demonstrating that a piecewise representation of the profile-as could be experimentally achieved by a series of gas cells-is adequate for achieving phase matching. Scalings to even higher frequency shifts are given.

Radiation-dominated injection of positrons generated by the nonlinear Breit-Wheeler process into a plasma channel

Maslarova, Dominika; Martinez, Bertrand; Vranic, Marija
PHYSICS OF PLASMAS 30(9), 093107 (2023)
https://doi.org/10.1063/5.0160121

Plasma acceleration is considered a prospective technology for building a compact multi-TeV electron-positron collider in the future. The challenge of this endeavor is greater for positrons than for the electrons because usually the self-generated fields from laser-plasma interaction are not well-suited for positron focusing and on-axis guiding. In addition, an external positron source is required, while electrons are naturally available in the plasma. Here, we study electron-positron pair generation by an orthogonal collision of a multi-PW laser pulse and a GeV electron beam by the nonlinear Breit-Wheeler process. We studied conditions favorable for positron deflection in the direction of the laser pulse propagation, which favors injection into the plasma for further acceleration. We demonstrate using the OSIRIS particle-in-cell framework that the radiation reaction triggered by ultra-high laser intensity plays a crucial role in the positron injection. It provides a suppression of the initial transverse momentum gained by the positrons from the Breit-Wheeler process. For the parameters used in this work, the intensity of at least $2.2\text{x}10^{23}$ W/cm^2 is needed in order to inject more than 1% of positrons created. Above this threshold, the percentage of injected positrons rapidly increases with intensity. Moreover, subsequent direct laser acceleration of positrons in a plasma channel, using the same laser pulse that created them, can ensure a boost of the final positron energy by a factor of two. The positron focusing and guiding on the axis is provided by significant electron beam loading that changes the internal structure of the channel fields.

FACILITIES

Beam delivery and beamstrahlung considerations for ultra-high energy linear colliders

Barklow, Tim; Gessner, Spencer; Hogan, Mark; Ng, Cho-Kuen; Peskin, Michael; Raubenheimer, Tor; White, Glen; Adli, Erik; Cao, Gevy Jiawei; Lindstrom, Carl A.; Sjobak, Kyrre; Barber, Sam; Geddes, Cameron; Formenti, Arianna; Lehe, Remi; Schroeder, Carl; Terzani, Davide; van Tilborg, Jeroen; Vay, Jean-Luc; Zoni, Edoardo; Doss, Christopher; Litos, Michael; Lobach, Ihar; Power, John; Swiatlowski, Maximilian; Fedeli, Luca; Vincenti, Henri; Grismayer, Thomas; Vranic, Marija; Zhang, Wenlong

JOURNAL OF INSTRUMENTATION 18(9), P09022 (2023)
https://doi.org/10.1088/1748-0221/18/09/P09022

As part of the Snowmass'21 community planning excercise, the Advanced Accelerator Concepts (AAC) community proposed future linear colliders with center-of-mass energies up to 15 TeV and luminosities up to $50\mathrm{x}10^{34}$ cm^{-2} s^{-1} in a compact footprint. In addition to being compact, these machines must also be energy efficient. We identify two challenges that must be addressed in the design of these machines. First, the Beam Delivery System (BDS) must not add significant length to the accelerator complex. Second, beam parameters must be chosen to mitigate beamstrahlung effects and maximize the luminosity-per-power of the machine. In this paper, we review advances in plasma lens technology that will help to reduce the length of the BDS system and we detail new Particle-in-Cell simulation studies that will provide insight into beamstrahlung mitigation techniques. We apply our analysis to both e^+e^- and gamma gamma colliders. The challenges and solutions described in this paper are considered independently. A unified, self-consistent concept for a BDS system for a 15 TeV linear collider will be the subject of future work.

A hybrid, asymmetric, linear Higgs factory based on plasma-wakefield and radio-frequency acceleration

Foster, B.; D'Arcy, R.; Lindstrom, C. A.

NEW JOURNAL OF PHYSICS 25(9), 093037 (2023)
https://doi.org/10.1088/1367-2630/acf395

The construction of an electron-positron collider 'Higgs factory' has been stalled for a decade, not because of feasibility but because of the cost of conventional radio-frequency (RF) acceleration. Plasma-wakefield acceleration promises to alleviate this problem via significant cost reduction based on its orders-of-magnitude higher accelerating gradients. However, plasma-based acceleration of positrons is much more difficult than for electrons. We propose a collider scheme that avoids positron acceleration in plasma, using a mixture of beam-driven plasma-wakefield acceleration to high energy for the electrons and conventional RF acceleration to low energy for the positrons. We emphasise the benefits of asymmetric energies, asymmetric bunch charges and asymmetric transverse emittances. The implications for luminosity and experimentation at such an asymmetric facility are explored and found to be comparable to conventional facilities; the cost is found to be much lower. Some of the areas in which R & D is necessary to make HALHF a reality are highlighted, including estimates for the improvement required in key technologies. These range from a factor of 10 to a factor of 1000.

INSTRUMENTATION

Plasma Photocathodes

Habib, Ahmad Fahim; Heinemann, Thomas; Manahan, Grace G.; Ullmann, Daniel; Scherkl, Paul; Knetsch, Alexander; Sutherland, Andrew; Beaton, Andrew; Campbell, David; Rutherford, Lorne; Boulton, Lewis; Nutter, Alastair; Karger, Oliver S.; Litos, Michael D.; O'Shea, Brendon D.; Andonian, Gerard; Bruhwiler, David L.; Pretzler, Georg; Wilson, Thomas; Sheng, Zhengming; Stumpf, Michael; Reichwein, Lars; Pukhov, Alexander; Cary, John R.; Hogan, Mark J.; Yakimenko, Vitaly; Rosenzweig, James B.; Hidding, Bernhard
ANNALEN DER PHYSIK 535(10), 2200655 (2023)
https://doi.org/10.1002/andp.202200655

Plasma wakefield accelerators offer accelerating and focusing electric fields 3 to 4 orders of magnitude larger than state-of-the-art radiofrequency cavity-based accelerators. Plasma photocathodes can release ultracold electron populations within such plasma waves and thus open a path toward tunable production of well-defined, compact electron beams with normalized emittance and brightness many orders of magnitude better than state-of-the-art. Such beams will have far-reaching impact for applications such as light sources, but also open up new vistas on high energy and high field physics. This paper reviews the innovation of plasma photocathodes, and reports on the experimental progress, challenges, and future prospects of the approach. Details of the proof-of-concept demonstration of a plasma photocathode in 90° geometry at SLAC FACET within the E-210: Trojan Horse program are described. Using this experience, alongside theoretical and simulation-supported advances, an outlook is given on future realizations of plasma photocathodes such as the upcoming E-310: Trojan Horse-II program at FACET-II with prospects toward excellent witness beam parameter quality, tunability, and stability. Future installations of plasma photocathodes also at compact, hybrid plasma wakefield accelerators, will then boost capacities and open up novel capabilities for experiments at the forefront of interaction of high brightness electron and photon beams.

Double Pulse Generator for Unipolar Discharges in Long Plasma Tubes for the AWAKE Experiment

Torrado, Nuno E.; Lopes, Nelson C.; Silva, J. Fernando A.; Amoedo, Carolina; Sublet, Alban
IEEE TRANSACTIONS ON PLASMA SCIENCE 51(12), 3619 – 3627 (2023)
https://doi.org/10.1109/TPS.2023.3337314

High-voltage pulsed gas discharges can produce suitable plasma for wakefield particle acceleration experiments. Such plasmas are challenging loads characterized by significant parasitic elements and fast impedance transitions leading to hard-to-predict dynamic behavior. This hinders the use of solid-state pulse generators to replace inefficient and limited lifetime spark gaps or thyratrons. This article presents the development, simulation, and test of a new semiconductor-based double pulse generator for a 5-m-long plasma load. It uses two successive pulses. The first one consists of a step-up inductive discharge and leads to a low current arc (10 A) enough to set the plasma to a low impedance state. The second pulse, generated by a capacitive discharge, increases the arc current up to 400 A. The pulses are generated by two subcircuits integrated together and tested, showing a substantial reduction of the required instantaneous power compared with the one needed using a single pulse and resulting in a high ionization fraction gas discharge pulse with nanosecond jitter.

PetaVolts per meter Plasmonics: introducing extreme nanoscience as a route towards scientific frontiers

Sahai, Aakash A.; Golkowski, Mark; Gedney, Stephen; Katsouleas, Thomas; Andonian, Gerard; White, Glen; Stohr, Joachim; Muggli, Patric; Filippetto, Daniele; Zimmermann, Frank; Tajima, Toshiki; Mourou, Gerard; Resta-Lopez, Javier
JOURNAL OF INSTRUMENTATION 18(7), P07019 (2023)
https://doi.org/10.1088/1748-0221/18/07/P07019

A new class of plasmons has opened access to unprecedented PetaVolts per meter electromagnetic fields which can transform the paradigm of scientific and technological advances. This includes non-collider searches in fundamental physics in addition to making next generation colliders feasible. PetaVolts per meter plasmonics relies on this new class of plasmons uncovered by our work in the large amplitude limit of collective oscillations of quantum electron gas. This Fermi gas constituted by "free" conduction band electrons is inherent in conductive media endowed with a suitable combination of constituent atoms and ionic lattice structure. As this quantum gas of electrons can be as dense as 10^{24} cm^{-3}, the coherence limit of plasmonic electromagnetic fields is extended in our model from the classical to the quantum domain, $0.1\sqrt{n_0(10^{24}\text{ cm}^{-3})}$ PVm^{-1}. Appropriately engineered, structured materials that allow highly tunable material properties also make it possible to overcome disruptive instabilities that dominate the interactions in bulk media. The ultra-high density of conduction electrons and the existence of electronic energy bands engendered by the ionic lattice is only possible due to quantum mechanical effects. Based on this framework, it is critical to address various challenges that underlie PetaVolts per meter plasmonics including stable excitation of plasmons while accounting for their effects on the ionic lattice and the electronic energy band structure over femtosecond timescales. We summarize the challenges and ongoing efforts that set the strategy for the future. Extreme plasmonic fields can shape the future by not only opening the possibility of tens of TeV to multi-PeV center-of-mass-energies but also enabling novel pathways in non-collider HEP. In view of this promise, our efforts are dedicated to realization of the immense potential of PV/m plasmonics and its applications.

Plasma density profile reconstruction of a gas cell for Ionization Induced Laser Wakefield Acceleration

Filippi, F.; Dickson, L.T.; Backhouse, M.; Forestier-Colleoni, P.; Gustafsson, C.; Cobo, C.; Ballage, C.; Dobosz Dufrénoy, S.; Löfquist, E.; Maynard, G.
JOURNAL OF INSTRUMENTATION 18, C05013 (2023)
https://doi.org/10.1088/1748-0221/18/05/C05013

Laser-driven plasma wakefields can provide hundreds of MeV electron beam in mm-range distances potentially shrinking the dimension of the actual particle accelerators. The plasma density plays a fundamental role in the control and stability of the acceleration process, which is a key development for the future electron injector proposed by EuPRAXIA. A gas cell was designed by LPGP and LIDYL teams, with variable length and backing pressure, to confine the gas and tailor the gas density profile before the arrival of the laser. This cell was used during an experimental campaign with the multi TW-class laser at the Lund Laser Centre. Ionization assisted injection in a tailored density profile is used to tune the electron beam properties. During the experiment, we filled the gas cell with hydrogen mixed with different concentration of nitrogen. We also varied the backing pressure of the gas and the geometrical length of the gas cell. We used a transverse probe to acquire shadowgraphic images of the plasma and to measure the plasma electron density. Methods and results of the analysis with comparisons between shadowgraphic and interferometric images will be discussed.

Probing bulk electron temperature via x-ray emission in a solid density plasma

Makur, K.; Ramakrishna, B.; Krishnamurthy, S.; Kakolee, K. F.; Kar, S.; Cerchez, M.; Prasad, R.; Markey, K.; Quinn, M. N.; Yuan, X. H.

PLASMA PHYSICS AND CONTROLLED FUSION 65(4), 045005 (2023)
https://doi.org/10.1088/1361-6587/acb79c

Bulk electron temperatures are calculated for thin Cu targets irradiated by the petawatt class Vulcan laser, from the Kα yield obtained using highly oriented pyrolytic graphite crystals. Cu-Kα emission studies have been used to probe the bulk electron temperature. A 30–80 eV core temperature extends homogeneously over distances up to ten times the laser focal spot size. Energy shifting has been observed due to different ionization states produced for different temperatures in the plasma. Polarization dependencies of plasma temperature are observed through the production of x-rays in different targets. 2D PIC simulations were performed to measure the polarization dependency of bulk electron temperature, which supports our experimental results. This paper could be of importance in understanding the different behavior of laser coupling at different polarizations and their role in x-ray production.

THEORY & SIMULATION

Evaluation of the transfer matrix of a plasma ramp with squared cosine shape via an approximate solution of Mathieu differential equation

Romeo, S.; Biagioni, A.; Crincoli, L.; Del Dotto, A.; Ferrario, M.; Giribono, A.; Parise, G.; Rossi, A. R.; Silvi, G. J.; Vaccarezza, C.

PLASMA PHYSICS AND CONTROLLED FUSION 65(11), 115005 (2023)
https://doi.org/10.1088/1361-6587/acfbf6

The high longitudinal electric fields generated in plasma wakefields are very attractive for a new generation of high gradient plasma based accelerators. On the other hand, the strong transverse fields increase the demand for a proper matching device in order to avoid the spoiling of beam transverse quality. A solution can be provided by the use of a plasma ramp, a region at the plasma injection/extraction with smoothly increasing/decreasing plasma density. The transport of a beam inside a plasma ramp, beside its parameters, depends on the profile of the ramp itself. Establishing the transfer matrix for a plasma ramp represent a very useful tool in order to evaluate the beam evolution in the plasma. In this paper a study of a cosine squared ramp is presented. An approximate solution of the transverse equation of motion is evaluated and exploited to provide a simple transfer matrix for the plasma ramp. The transfer matrix is then employed to demonstrate that this kind of ramp has the effect to minimize the emittance growth due to betatron dephasing. The behavior of a squared cosine plasma ramp will be compared with an experimentally measured plasma ramp profile in order to validate the applicability of the transfer matrix to real cases.

***WAKE up* is a collection of publicly available abstracts from published papers that are relevant to the AWAKE project. If you want your published paper to be included in the next issue of the newsletter, please contact Ricardo Torres at ricardo.torres@cockcroft.ac.uk**

www.awake-uk.org