Working Group 4:

Beam-Driven Acceleration

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Abstract Title	**Transverse effects in plasma-wakefield acceleration at FACET**
Author/Affiliation listing	**E. Adli** (University of Oslo and SLAC), M. Hogan (SLAC), P. Muggli (MPI of Physics), W. An, W. Mori (UCLA)
Abstract	We investigate transverse effects in the plasma-wakefield acceleration experiments planned and ongoing at FACET. We use PIC simulation tools (mainly QuickPIC) to simulate the interaction of the drive electron beam and the plasma. We present correlations of simulation results with FACET early experimental results.
Summary	
We investigate transverse effects in the plasma-wakefield acceleration experiments planned and ongoing at FACET. We use PIC simulation tools (mainly QuickPIC) to simulate the interaction of the drive electron beam and the plasma. In FACET a number of beam dynamics knobs, including dispersion and bunch length knobs, can be used to vary the beam transverse characteristics in the plasma. We present correlations of simulation results with FACET early experimental results.	

Name of submitting author	Mr. Brian Allen
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Abstract Title	**Experimental Results from the Study of the Current Filamentation Instability**
Author/Affiliation listing	**Brian Allen**[1], Joana Martins[2], Luís O. Silva[2], Vitaly Yakimenko[3], Mikhail Fedurin[3], Karl Kusche[3], Marcus Babzien[3], Chengkun Huang[4], Warren Mori[5] and Patric Muggli [1,6] 1 University of Southern California - Department of Electrical Engineering - 2 GoLP/Instituto de Plasmas e Fusao Nuclear – Laboratorio Associado, Lisboa 1049-001 PORTUGAL 3 B Upton NY 11973 USA 4 Los Laboratory, Los Alamos NM 87545 USA 5 University of California at Los Angeles Los Angeles, CA 90095 USA 6 Max Planck, Institute for Physics Munich, Germany
Abstract	An experimental study of the Current Filamentation Instability is underway at the Accelerator Test Facility at Brookhaven National Laboratory with the 60MeV electron beam and plasma capillary discharge. Results include the observation of multiple filaments, scaling of the filament size with plasma skin depth and suppression of the instability.

Summary

Current Filamentation Instability, CFI, is of central importance for the propagation of relativistic electron beams in plasmas. CFI has potential relevance to astrophysics, magnetic field and radiation generation in the afterglow of gamma ray bursts, and inertial confinement fusion, energy transport in the fast-igniter concept. An experimental study is underway at the Accelerator Test Facility, ATF, at Brookhaven National Laboratory with the 60MeV electron beam and centimeter length capillary discharge plasma. The experimental program includes the systematic study and characterization of the instability as a function of beam (charge) and plasma (plasma density) parameters. The transverse beam profile is measured directly at the plasma exit using optical transition radiation from a thin gold coated silicon window. Experimental results show the appearance of multiple (1-5) beam filaments and scaling of the transverse filament size with the plasm a skin depth. The transverse size and number of the individual filaments is a function of the plasma density. Suppression of the instability is seen by lowering the growth rate of the instability through reducing the beam charge. We will present simulation and experimental results and provide discussion of these results.

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Name of submitting author	Weiming An
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Abstract Title	**Simulation Study On The Proton Beam Self Modulation In The Plasma Wake Field Using OSIRIS and QuickPIC**
Author/Affiliation listing	**Weiming An**, Chan Joshi, Warren Mori (University of California Los Angeles) J. Thangaraj, P. Spentzouris, C. Park, J.D. Lewis (Fermilab)
Abstract	The proton beam self modulation in the plasma wake field is investigated with computational simulation. The focal length (beta star) of the proton beam is considered in the simulation since it is comparable with the beam length. A condition for the self modulation is given based on the linear theory.
Summary	
A long pulse proton beam may be self modulated when propagating in a plasma. The focal length (beta star) of the beam needs to be considered when it is less than the self-modulation distance. In addition, it is typically smaller than the bunch length for parameters at the FNAL. We show that the a condition for significant self-modulation is that a few e-foldings of growth occurs at the back of the beam within a propagation distance of 2 beta star. We describe how OSIRIS and QuickPIC are both modified for initializing the beam with the twiss parameter, through which can adjust the position of the beam focus. We use OSIRIS and QuickPIC to simulate how a 120 GeV proton beam at FNAL will self-modulate. An energy modulation ~1 GeV is observed in the simulation for reasonable emittances and spot sizes.	

Name of submitting author	Dr. Sergey Antipov
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Abstract Title	**Experimental demonstration of wakefield effects in a THz planar diamond accelerating structure**
Author/Affiliation listing	C. Jing, **S. Antipov**, P. Schoessow, J. Butler, S. Zuo and A. Kanareykin / Euclid Techlabs, LLC, 5900 Harper Rd, Solon, OH-44139. W. Gai / High Energy Physics Division, Argonne National Laboratory, Argonne, IL-60439. V. Yakimenko, M. Fedurin, K. Kusche / Accelerator Test Facility, Brookhaven National Laboratory, Upton, NY-11973
Abstract	In this paper we present results from wakefield tests of structures at the Accelerator Test Facility (ATF at BNL). We have directly measured THz wakefields induced by a subpicosecond, intense relativistic electron bunch in a diamond loaded accelerating structure via the wakefield acceleration method.

Summary

Diamond has been studied as a candidate for dielectric loaded accelerating structures. It has low microwave loss, high breakdown threshold and the highest available thermoconductive coefficient. High quality diamond can be grown using a chemical vapor deposition process. Surface treatment, like dehydrogenation or oxidation, can dramatically reduce secondary electron emission from the diamond.
measured THz wakefields induced by a subpicosecond, intense relativistic electron bunch in a diamond loaded accelerating structure via the wakefield acceleration method. We present here the beam test results from the diamond-based structure. Diamond has been chosen for its high breakdown threshold and unique thermoconductive properties. Fields produced by a leading (drive) beam were used to accelerate a trailing (witness) electron bunch, which followed the drive bunch at a variable distance. The energy gain of a witness bunch as a function of its separation from the drive bunch describes the time structure of the generated wakefield.

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[3] S. Antipov, et al., Proc AAC10., pp. 359-363 (2010).

Name of submitting author	Dr. Chris Clayton
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Abstract Title	**Pulse-discharge plasmas for plasma-accelerator applications**
Author/Affiliation listing	**C. E. Clayton** and C. Joshi/ UCLA, Department of Electrical Engineering N. C. Lopes/ GLP, Instituto Superior Técnico, Lisbon
Abstract	For particle-beam-driven plasma wakefield accelerators, a long and fully-ionized plasma is desirable. We describe an experiment at UCLA to develop a prototype of such plasma using a pulsed-current discharge.
Summary	
For particle-beam-driven plasma wakefield accelerators, a long and fully-ionized plasma is desirable. We describe an experiment at UCLA to develop a prototype of such plasma using a pulsed-current discharge. Scaling of the plasma density with glass-tube diameter and with discharge-circuit parameters is currently underway. We have found that 4 Torr of Argon can be fully ionized to a density of about 1.3e17 cm^-3 when the current density in the 1 inch diameter, 1.2 meter-long tube is around 2 kA/cm^2, at least at one point along the discharge. The homogeneity of the plasma density in the longitudinal direction is crucial to prevent slippage of the driven plasma structures with the particles. Equally important are the transverse gradients since any dipole asymmetry in the transverse direction can lead to “steering” of the particle beam.[1] The longitudinal and transverse gradients may be a function of time into the discharge, the shape of the electrodes, the tube size, and the fractional ionization for a given fill pressure. Preliminary results from such studies will be presented. The work was supported by DOE grant DE-FG02-92ER40727 and NSF grant PHY-0936266. [1] P. Muggli, et al. Nature, Vol. 411, p. 43, May (2001).	

Name of submitting author	Dr. Manoel Conde
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Abstract Title	**The Upgraded Argonne Wakefield Accelerator Facility (AWA): a Test-Bed for the Development of High Gradient Accelerating Structures and Wakefield Measurements**
Author/Affiliation listing	**M.E. Conde,** S. Antipov, D.S. Doran, W. Gai, C. Jing, R. Konecny, W. Liu, J.G. Power, E. Wisniewski, Z. Yusof Argonne National Laboratory Euclid Techlabs Illinois Institute of Technology
Abstract	The AWA Facility is undergoing a major upgrade to enable it to achieve accelerating gradients of hundreds of MV/m and energy gain of 100 MeV per structure. High charge bunches will drive wakefields in the microwave range of frequencies (8 to 26 GHz), generating RF pulses with GW power levels.
Summary	
Electron beam driven wakefield acceleration is a bona fide path to reach high gradient acceleration of electrons and positrons. With the goal of demonstrating the feasibility of this concept with realistic parameters, well beyond a proof-of-principle scenario, the AWA Facility is currently undergoing a major upgrade that will enable it to achieve accelerating gradients of hundreds of MV/m and energy gains on the order of 100 MeV per structure. A key aspect of the studies and experiments carried out at the AWA facility is the use of relatively short RF pulses (15 – 25 ns), which is believed to mitigate the risk of breakdown and structure damage. The upgraded facility will utilize long trains of high charge electron bunches to drive wakefields in the microwave range of frequencies (8 to 26 GHz), generating RF pulses with GW power levels.	

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Abstract Title	**High Transformer Ratio Drive Beams for Wakefield Accelerator Studies**
Author/Affiliation listing	**J. Frederico**, M. J. Hogan, M. Litos, E. Adli, S. Gessner, Z. Wu, S. Corde / SLAC C. Joshi, W. An, W. Lu, W. Mori, G. Andonian / UCLA P. Muggli / MPQ
Abstract	For the plasma wakefield accelerator, a linearly ramped drive bunch current is predicted to enhance the transformer ratio and generate large accelerating wakes. We discuss plans and initial results for producing such bunches using the 20 GeV FACET electron beam at SLAC National Accelerator Laboratory and generating high transformer ratios.

Summary

For wakefield based acceleration schemes, use of an asymmetric (or linearly ramped) drive bunch current profile has been predicted to enhance the transformer ratio and generate large accelerating wakes. We discuss plans and initial results for producing such bunches using the 20 GeV electron beam at the FACET facility at SLAC National Accelerator Laboratory and sending them through plasmas and dielectric tubes to generate transformer ratios greater than 2 (the limit for symmetric bunches). The scheme proposed utilizes the final FACET chicane compressor and transverse collimation to shape the longitudinal phase space of the beam.

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Name of submitting author	Yun Fang
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Abstract Title	**First Observation of Self-Modulation Instability Seeding**
Author/Affiliation listing	**Y. Fang**, University of Southern California, Los Angeles P. Muggli, University of Southern California, Max Planck Institute for physics, Germany W. Mori, University of California, Los Angeles J. Vieira, Luis Silva, Instituto Superior Tcnico (IST), Lisbon, Portugal V. E. Yakimento, M. Babzien, M. Fedurin, K. P. Kusche, C. Swinson, R. Malone, Brookhaven National Laboratory, Upton, N.Y.
Abstract	We demonstrate experimentally for the first time the self-modulation seeding of a relativistic electron bunch in a plasma.
Summary	
We demonstrate experimentally for the first time the self-modulation seeding of a relativistic electron bunch in a plasma. This demonstration serves as a proof -of -principle test for the mechanisms of transverse self -modulation of particle bunches in plasmas, and indicates the possibility of using long electron or proton bunches as drivers for plasma based accelerators. The long (~3.2ps) bunch with low charge (50pC) available at BNL-ATF is used in this experiment and in the particle-in-cell OSIRIS. We use the 2D version for cylindrically symmetric geometries. We show that electron bunches with a square temporal current profile drive wakefields that seed the instability efficiently and modulate the bunch energy spectrum with a period dependent on the plasma density. While numerical simulations indicate that the self-modulation instability does not grow significantly over the 2cm-long plasma, the observed transverse momentum is the seed for the development of the instability. Detailed simulations and experimental results will be presented.	

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Abstract Title	**Quadrupole Diagnostics for Large Energy-Spread Beams**
Author/Affiliation listing	**Joel Frederico**, Mark Hogan, Tor Raubenheimer
Abstract	The Facility for Advanced Accelerator and Experimental Tests (FACET) is a new user facility at the SLAC National Accelerator Laboratory, servicing next-generation accelerator experiments. The 1.5% RMS energy spread of the FACET beam causes large chromatic aberrations in optics. These aberrations necessitate updated quadrupole scan fits to remain accurate.

Summary

The Facility for Advanced Accelerator and Experimental Tests (FACET) is a new user facility at the SLAC National Accelerator Laboratory. FACET will deliver a 20 μm x 20 μm x 20 μm beam with 1.5% RMS energy spread [1,2]. Typically, emittance and optics functions in the linac are measured by performing a quadrupole scan and performing a linear fit [3,4]. With a finite energy spread, beams focused by quadrupoles have chromatic aberrations. At FACET, the large energy spread and strong focusing optics result in aberrated beams with large tails. A linear fit that does not include a chromatic term has been found to return an excellent fit with emittance, beta, and alpha values that deviate up to factors of 4 from design values. An energy-spread correction to the linear fit can recover the first-order optics. Typical experimental fit routines use gaussian fits to spot size as noise in the tails can overwhelm RMS calculations. However, the linear fit requires an RMS measure ment, and thus requires fits that includes the large tails without including noise. Chromatic aberrations represent an important physical effect when tuning a beamline.

number DE-AC02-76SF00515.

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Abstract Title	**Simulations of Positron Beams at FACET**
Author/Affiliation listing	SLAC: Erik Adli, Sebastien Corde, Joel England, Joel Frederico, Mark Hogan, Selina Li, Michael Litos, Ziran Wu UCLA: Warren Mori, Weiming An
Abstract	We rely heavily on particle-in-cell simulations, such as QuickPIC, to provide insight into the evolution of a high charge density positron beam in a plasma. These studies are interesting in the context of both electron-positron plasma wakefield colliders and for modeling proton beams in plasmas.

Summary

FACET is uniquely equipped to deliver high energy, high charge density positron bunches for plasma wakefield acceleration experiments. We look forward to studying the interaction between positron beams and plasmas in a number of different contexts.
toward the beam axis, creating a region of extremely large charge density with complicated, nonlinear fields. Few analytic solutions exist to describe these fields, and this necessitates the use of simulations to model positron beam and plasma interactions. This presentation will cover recent work on positron PWFA simulations using the QuickPIC* particle-in-cell code. I will discuss the computational challenges associated with positron PWFA and specific applications of the simulations for future experimental tests at the FACET user facility at SLAC.
positron beams to model proton-plasma interactions, due to the prospect of a new plasma wakefield experiment at CERN. The betatron frequency of the beam in plasma is the scaling parameter that allows us to compare the evolution of positron and proton beams at different energies and plasma densities. I will compare the evolution of a positron beam in a typical FACET plasma with a density of ~10^17 cm^-3 to the proton beam described in Caldwell's paper**. Of particular interest is the distance required for an underdense positron bunch to evolve and drive a nonlinear wake.

* C. Huang et al., "QuickPIC: A highly efficient particle-in-cell code for modeling wakefield acceleration in plasmas," J. Comp. Phys. 217, 658 (2006).
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Name of submitting author	Dr. Bernhard Hidding
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Abstract Title	**Beyond Injection: Trojan Horse Plasma Wakefield Acceleration**
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Abstract	The recently put forward "Trojan Horse" (aka underdense/plasma photocathode) scheme is a flexible concept involving a synchronized electron bunch, ionization laser and a multi-component gas mixture. This concept allows for the first time to generate plasma-based electron bunches of higher quality than in the finest conventional accelerators.
Summary	
Laser-triggered release of electrons directly within a beam-driven plasma wave paves the way to shaping ultra-compact electron bunches with unprecedented emittance [1]. In contrast to conventional injection methods, where the trajectories of background plasma electrons are altered in order to eventually achieve trapping, here the electrons are born within the plasma blowout. Electrons can be "beamed" there by a synchronized laser operating just above the ionization threshold, which for species with ionization states of about ~25 eV corresponds to a laser intensity of a0 ~ 0.02, only. The electrons produced by this underdense photocathode are easily trapped, and due to minimized transverse momentum and GV/m fields are accelerated quickly and form bunches with ultralow emittance. This concept (dubbed "Trojan Horse") is applicable to both, laser-plasma-accelerators as well as to highest-energy electron accelerators such as SLAC. Theoretic al as well as experimental investigations, as well as PIC-simulations are used in order to determine the interaction requirements and limits of both cases. Gas mixture and densities, release laser and driver bunch properties are considered with regard to how to tune the released electron bunch charge, emittance and energy. Preliminary experimental results are given for the at-threshold ionization dynamics with a 30-fs (compressible to 8-fs in a hollow fiber), few-100 µJ Ti:Sapphire laser pulse – a laser pulse obtainable by the laser system to be installed at FACET, for which we currently pre-design a proof-of-concept experiment entitled "E-210: Trojan Horse" for 2013/14.	

Name of submitting author	Jay L. Hirshfield
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Abstract Title	**A High Gradient THz Coaxial Dielectric Wakefield Accelerator**
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Abstract	We have designed a mm-scale THz Coaxial Dielectric Wakefield Accelerator structure to produce acceleration gradients approaching 0.35 GeV/m per each nC of drive charge when excited by an annular-like bunch, which we plan to build and test at FACET/SLAC (USA). The details of design and experimental plans are presented

Summary

A new scheme [1] for a dielectric wakefield accelerator has been proposed that uses two hollow concentric dielectric tubes with vacuum channels for drive and accelerated bunches. Such a two-channel coaxial dielectric accelerator (CDWA) could be a promising candidate for a future TeV [2] collider. The scheme of the CDWA structure consists of two coaxial dielectric tubes, enclosed one inside the other, with two vacuum channels for the annular drive bunch and an accelerated on-axis witness bunch. In addition to providing a high acceleration gradient ~ 1GeV/m for mm-scale structures, the two-channel structure has a larger transformer ratio than the single-channel DWA, the transverse forces acting upon the bunch to be accelerated are focusing, and the annular drive bunch has been shown to move appreciable distance without undergoing distortion or deflection [2]. An experiment is now underway at FACET (SLAC) to test a mm-scale THz CDWA using their “point-like” drive bunch. We can show that the point drive bunch will establish the fields we wish to study; furthermore, we shall show how we may obtain information from this study whereby the data can be compared with theoretical simulations obtained with the CST STUDIO code. Experience with this THz structure, together with information obtained from a larger GHz module now under study at the Argonne Wakefield Accelerator facility (ANL), will provide the necessary stimulus for further development of this type of DWA structure in a collider-type accelerator.

Support by US Department of Energy.

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Name of submitting author	Yong Jiang
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Abstract Title	**Design of Detuned-Cavity Two-Beam Electron Accelerator Structure**
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Abstract	Progress has been made in the theory and simulation study, cavity design and optimization, beam dynamics analysis, beam transport design, and hardware reconstruction for an experiment to evaluate a detuned-cavity two-beam collinear electron accelerator structure.

Summary

A high-gradient two-beam electron accelerator structure is currently under development. The structure is comprised of a chain of detuned cavities disposed along the axis along which an interspersed high current drive beam and a low current test beam travel. Purposeful cavity detuning is used to provide much smaller deceleration for drive beam bunches, than acceleration for test beam bunches, i.e., to provide a high transformer ratio. Analytic theory has been modified over our earlier version [1] to include inter-cavity coupling, and structure optimization using simulation studies has been carried out. Parameters including cavity dimensions, detuning angle, cell-to-cell phase advance and inter-cavity coupling have been adjusted to optimize acceleration gradient, transformer ratio, beam-to-beam energy transfer efficiency and field flatness. The beam dynamic simulation shows no severe degradation of beam quality. An experiment to measure the transformer ratio of this structure that is being set up at Yale Beam Physics Lab will be described.

Research is supported by U.S. Department of Energy, Office of High Energy Physics.

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Abstract Title	**Applications of the Dielectric Based Accelerators**
Author/Affiliation listing	**C. Jing**, S. Antipov, P. Schoessow, and A. Kanareykin / Euclid Techlabs, LLC, 5900 Harper Rd, Solon, OH-44139. J. Power, M. Conde, W. Liu, and W. Gai / High Energy Physics Division, Argonne National Laboratory, Argonne, IL-60439. A. Zholents/ APS, Argonne National Laboratory, Argonne, IL-60439 P. Piot / Northern Illinois University, Department of Physics, DeKalb, IL 60115, USA
Abstract	Important progress on the development of dielectric based accelerators has been made experimentally and theoretically since the last workshop. Some challenges remain. We discuss the applications of dielectric structures in short pulse rf generation, high gradient accelerator, and collinear wakefield accelerator, etc.

Summary

Dielectric based accelerators offer a potential path to future high gradient accelerator machines for both HEP and FEL light source facilities. The attractiveness stems from its simplicity and high breakdown limit; particularly after the demonstration of GV/m level in the wakefield acceleration regime. Exploration into using dielectric structures in a two beam accelerator HEP collider and a collinear wakefield accelerator to drive an FEL light source have recently received much attention. Since the AAC10, progress has been made towards laying down the foundation of these conceptual designs. This talk will cover a few recent related experiments and structure development:
frequency rf generation using dielectric based wakefield power extractors.
and development of the short pulse (~20ns) high gradient two beam accelerator.
Bunch shaping and its application for dielectric collinear wakefield accelerators and FEL. -
SC0006301, #DE-SC0004322, and DE-FG02-07ER84820.

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Abstract Title	**Experimental Testing of Dielectric Based THz and Ka-band Accelerating Structures.**

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Abstract	We present our last year results on development and experimental high gradient testing of the dielectric based wakefield accelerating structures. The list of these dielectrics includes low loss microwave ceramic and quartz, CVD diamonds and nonlinear ferroelectrics.

Summary

In this paper we report on a group of experiments with dielectric-based accelerating structures performed laste year at the ATF (BNL), the AWA (ANL) and the FACET (SLAC). Advanced dielectric materials can sustain high surface fields and high pulsed power at GHz frequency range. CVD polycrystalline and single crystal diamonds, low loss microwave ceramic and fused silica have been considered for a dielectric based accelerating structure to study of the physical limitations encountered driving extremely high amplitude wakefields of a dielectric based accelerator. THz radiation has been previously generated for short ~10 GV/m pulse with the 100 μm diameter dielectric fiber. A THz diamond based structures tested at BNL/ATF showed no evidence of polycrystalline structure deformation after electron beam exposure. The high gradient beam test at AWA has demonstrated no breakdown evidence for a diamond-based structure after 300 MV/m, 35 ns long pulse. The electrical and mechanical properties of diamond make it an ideal candidate material for use in dielectric rf structures: high breakdown voltage, extremely low dielectric losses and the highest thermo-conductive coefficient available for removing waste heat from the device.

collinear wakefield experiment using the first tunable dielectric loaded accelerating (DLA) structure. By introducing an extra layer of nonlinear ferroelectric, which has a dielectric constant sensitive to temperature and DC bias, the frequency of a DLA structure can be tuned. We report on our recent experiments in this field.

Name of submitting author	Ki-yong Kim
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Abstract Title	**Intense Broadband Terahertz Generation via Two-color Photoionization**
Author/Affiliation listing	**Ki-Yong Kim**/University of Maryland
Abstract	We review intense, broadband electromagnetic (EM) wave generation at terahertz (THz) and infrared (IR) frequencies in two-color, femtosecond laser ionization of gases. In particular, we report quasi-phase-matched THz generation in long plasma filaments and enhanced THz emission from 2-dimensional plasma sheets.

Summary

Intense terahertz (THz) radiation can be produced when an ultrashort pulsed laser's fundamental and second harmonic fields are mixed to ionize a gas [1-4]. Depending on the relative phase between two-color pulses, symmetry can be broken to produce a sub-picosecond electron current, producing THz radiation at the far-field (see Fig. 1). This plasma current model, first proposed by Kim et al. [2], is now widely adopted in the community.

producing intense THz radiation, and much of the current research in our lab is focused in that direction. Recently, we showed that such coherent radiation is extremely broad and may cover the entire infrared (IR) bandwidth (4 ~ 3000 um) [3]. In particular, in the case of near-atmospheric air, the radiation extends up to ~75 THz (corresponding to ~4 um) [3]. In addition, we recently observed quasi-phase-matched THz generation in long plasma filaments. Our experiment and simulation show that the far-field terahertz radiation profiles and yields are greatly sensitive to the filament length. For plasma longer than the characteristic dephasing length, it emits conical terahertz radiation in the forward direction, peaked at 4~7 degrees depending on the radiation frequencies. The total terahertz yield continuously increases with the filament length, even beyond the dephasing length. This trend occurs regardless of the relative phase between two-color pulses in the filament. The quasi-phase-matching condition observed here provides a simple method for scalable terahertz generation in elongated plasmas.

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Abstract Title	**Head Erosion with Emittance Growth in PWFA**
Author/Affiliation listing	**S. Z. Li**, E. Adli, S. Corde, R. J. England, J. Frederico, M. J. Hogan, M. D. Litos, D. R. Walz (SLAC, Menlo Park, CA 94025, U.S.A.) W. An, C.E. Clayton, C. Joshi, W. Lu, K.A. Marsh, W. Mori, S. Tochitsky (UCLA, Los Angeles, CA 90095, U.S.A.) P. Muggli (Max Planck Institute for Physics, Munchen, Germany)
Abstract	We present a study of head erosion with emittance growth in field-ionized plasma from the PWFA experiments performed at FACET user facility at SLAC.
Summary	
Head erosion is one of the limiting factors in plasma wakefield acceleration (PWFA). We present a study of head erosion with emittance growth in field-ionized plasma from the PWFA experiments performed at FACET user facility at SLAC. At FACET, a 20 GeV electron beam with 1.8x10^10 electrons is optimized in beam spot size and combined with a high-density lithium plasma to provide beam-driven PWFA. A target foil is inserted upstream of the plasma source to increase the emittance through multiple scattering. Its effect on beam-plasma interaction is observed in an energy spectrometer after a vertical bend magnet. Scaling of the head erosion rate with emittance is compared with theoretical predictions.	

Name of submitting author	Dr. Alberto Martinez de la Ossa
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Abstract Title	**Self-modulation of long electron beams in plasma at PITZ.**
Author/Affiliation listing	**Alberto Martinez de la Ossa**[1], Matthias Gross[1], Martin Khojoyan[1], Mikhail Krasilnikov[1], Anne Oppelt[1], Frank Stephan[1], Florian Grüner[2], Carl Schroeder[3], and Jens Osterhoff[2]. 1 Deutsches Electronen-Synchrotron DESY, Germany. 2 University of Hamburg, Germany . 3 Lawrence Berkeley National Laboratory, USA.
Abstract	The Photo Injector Test facility at DESY (PITZ) offers the unique possibility to study and demonstrate the self-modulation of long electron beams when propagating into a uniform plasma. The experiment aims to recover key physics for the design of future beam-driven plasma wakefield acceleration experiments.
Summary	
Beam-driven plasma wakefield acceleration has generated a high scientific interest since it was experimentally proven that electrons can be accelerated up to energies close to 100 GeV in less than a meter of propagation in plasma [Nature 445 (2007) 741-744]. Recently, it has been proposed to use the high energetic (450 GeV) proton beams from the CERN SPS to drive a plasma wave [Conf.Proc. C100523 (2010) THPD050] which would potentially be able to accelerate electron beams into the TeV energy regime in a single stage. The whole project relies on the fact that a long proton bunch (L≫λp) is self-modulated through its propagation in plasma, splitting itself in ultrashort sub-bunches of length ~λp, which then can resonantly excite the plasma wave. The Photo Injector Test facility at DESY, Zeuthen site (PITZ), offers the unique possibility to study and demonstrate this self-modulation effect by using long electron bunches in plasma. A set of numerical simulations with the particle-in-cell code Osiris[Lect. Notes Comput. Sci. 2331, 342 (2002)] has been carried out for a better understanding of the process. Of particular interest is the measurement of the energy modulation induced to the beam itself by means of the generated wakefields in plasma. It will reflect the key properties of the accelerating electric fields like their magnitude and their phase velocity, both of significant importance in the design of experiments relying on this technique.	

Name of submitting author	Behnam Montazeri
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Abstract Title	**Particle-In-Cell and Time Domain Simulation of Beam Dynamics and Wakefields in Laser-Driven Double Grating Accelerator**
Author/Affiliation listing	**Behnam Montazeri N.** / SLAC National Lab, Stanford University Rebert L. Byer / Stanford University Cho Ng / SLAC National Lab
Abstract	The idea of developing high gradient laser driven dielectric structures for electron acceleration has been a topic of interest over recent years. In this paper we present the results of beam dynamic and short range longitudinal wake field simulation of double grating accelerating structure.

Summary

Due in part to the small (micron-scale) beam apertures of advanced accelerator schemes using dielectric micro-structures driven by lasers, beam dynamics and wake effects in these structures are of particular interest. We have developed a MATLAB code for beam dynamic studies. The code uses electromagnetic fields from HFSS simulation of a dual-grating accelerator topology similar to that proposed by Plettner, Lu, and Byer in [PR-STAB 9, 111301 (2006)]. We set periodic boundary condition for the one period of grating structure and find electromagnetic fields inside the channel. Having the fields imported in MATLAB, we step an electron with arbitrary phase inside the time varying accelerating fields to find the expected gradient and deflection of that electron. The highest expected gradient has been calculated to be 0.47E0 where E0 is the maximum Electric field of the incident laser. Furthermore we calculate the transmission matrices for this structure and present the beam dynamic simulations for an electron bunch passing through the structure. We present results of expected system performance by the code, and discuss the necessary optimization to design and fabrication, which will be followed by simulation of a many-period structure. We also discuss particle-in-cell simulations with ACE3P simulation package at SLAC. T3P tool from ACE3P package enables us to do time domain electromagnetic simulation of the beam inside the grating structure, followed by calculation of longitudinal wakes in the structure. We study the convergence of numerical methods for calculating wake fields and finally having metallic beam pipes added at both ends of the structure, we can see that the short range longitudinal wake fields are in the order of 10^4 to 10^5 V/pC which keeps us in the safe side to operate this structure under beam loaded conditions.

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Name of submitting author	Prof. Patric Muggli
Institution	Max Planck Institute for Physics, Munich, Germany
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Abstract Title	**Plasma Wakefields Resonant Excitation**
Author/Affiliation listing	**P. Muggli** Max Planck Institute for Physics, Munich, Germany & University of Southern California, Los Angeles, CA 90089, USA B. Allen, Y. Fang University of Southern California, Los Angeles, CA 90089, USA V. E. Yakimenko, M. Babzien, M. Fedurin, K. P. Kusche, C. Swinson, R. Malone Brookhaven National Laboratory, Upton, Long Island, NY 11973, USA
Abstract	We demonstrate that plasma wakefields can be resonantly driven to large amplitude by a train of electron bunches. We also show that shaped bunches leading to large transformer ration can be generated using a mask technique.
Summary	
Plasma wakefields ca be driven to large amplitude by a train of equidistant charged particle bunches. We vary the plasma accelerator frequency by more than two orders of magnitude by changing the plasma frequency. We demonstrate that when the plasma period is equal to the drive bunch train period resonant excitation occurs. However, this leads to low transformer ratio. In order to reach a large transformer ratio (R>2), the charge of the bunch or train must be varied. We use a masking technique we previously developed [P. Muggli et al., Phys. Rev. Lett. 101, 054801 (2008)] to produce ramped bunch trains as well as triangular bunches. A large transformer ratio cannot be maintained upon propagation in the linear regime. We show through numerical simulations that in the quasi-linear regime of the PWFA, taking advantage of the linear superposition of the wakefields and of the weakly dependence of the accelerating fields on the bunch transverse s ize, a transformer ratio R>2 can be maintained while propagating along the plasma. In this case, the three drive bunches loose energy at approximately the same rate, in principle allowing for large energy transfer efficiency to the witness bunch. This work is supported by the US department of Energy.	

Name of submitting author	Mr. Brendan O'Shea
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Abstract Title	**Transformer Ratio Improvement For Beam Based Plasma Accelerators**
Author/Affiliation listing	**B. O'Shea**, S. Barber, P. Muggli, J. Rosenzweig, V. Yakimenko
Abstract	Use of asymmetric-bunches-to-improve-transformer-ratio-of-beam-based-plasma-systems-has-been-proposed-for-some-time but suffered from lack appropriate beam-generation. The ability now exists to create bunches with current profiles shaped to overcome limit of R = 2. We discuss projects to be carried out in blowout-regime at UCLA-Neptune-Laboratory and in the quasi-nonlinear-regime at Accelerator-Test-Facility at Brookhaven-National-Lab.

Summary

Increasing the transformer ratio of present wakefield accelerating system greatly improves the viability of present novel accelerating schemes. The use of asymmetric bunches to improve the transformer ratio of beam based plasma systems has been proposed for some time[1,2], but suffered from lack appropriate beam creation systems. Recently these impediments have been overcome [3,4] and the ability now exists to create bunches with current profiles shaped to overcome the Gaussian limit of R = 2. We present here work towards experiments designed to measure the transformer ratio of such beams, including theoretical models, simulations using VORPAL (a 3D capable PIC code) and plasma source design. Specifically we discuss projects to be carried out in the blowout regime at the UCLA Neptune Laboratory and in the quasi-nonlinear[5] regime at the Accelerator Test Facility at Brookhaven National Lab.

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Name of submitting author	Dr. Philippe Piot
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Abstract Title	**A dielectric-wakefield energy-doubler module for the Advanced Superconducting Test Accelerator at Fermilab**
Author/Affiliation listing	**P. Piot**, D. Mihalcea, C. Prokop, Northern Illinois University and Fermi National Accelerator Laboratory P. Stoltz, Tech-X
Abstract	Fermilab is current constructing an accelerator test facility, the Advanced Superconducting Test Accelerator. The facility will initially produce 250-MeV and eventually up to 700-MeV electron beams. In this contribution we explore the upgrade of this facility with advanced phase space manipulations and dielectric-lined structure to produce higher-energy low-charge electron bunches.
Summary	
The Advanced Superconducting Test Accelerator in construction at Fermilab will produce high-charge (~<3 nC) 250-750-MeV electron bunches. The facility is based on a superconducting linac capable of producing up to 3000 bunches in 1-ms macropulses with macropulses repeated at 1 Hz. In this contribution we explore the use of a short dielectric-lined-waveguide (DLW) linac to significantly increase the bunch energy. The method consist in (1) using advanced phase space manipulation to shape the beam current [i] and enhance the transformer ratio, and (2) use a dedicated high-frequency photo-injector to produce low charge witness bunch. Start-to-end simulations are presented. The DLW linac is simulated with the finite-difference time-domain program VORPAL and a with a modified version of the IMPACT-T particle-in-cell code [ii]. This DLW module could also be used to test some of aspects the proposed concept toward a DLW-based short-wavelength free-electron laser [iii]. [i] P. Piot, Y.-E Sun, J. Power, M. Rihaoui, Phys. Rev. ST Accel. Beams 14, 022801 (2011). [ii] D. Mihalcea, P. Piot, and P. Stoltz, "Three-Dimensional Analysis of Wakefields Generated by Flat Electron Beams in Planar Dielectric-Loaded Structures", arXiv:1204.6724v1 [physics.acc-ph] (2012). [iii] C. Jing, J. G. Power and A. Zholents, "Dielectric Wakefield Accelerator to Drive the Future FEL Light Source", LS-ANL/APS/LS-326; technical note Argonne National Accelerator (2011).	

Name of submitting author	Prof. James Rosenzweig
Institution	UCLA Dept. of Physics and Astronomy
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Abstract Title	**Experimental Testing of the PWFA Quasinonlinear Regime**
Author/Affiliation listing	UCLA Dept. of Physics and Astronomy
Abstract	The physical scenario known as the PWFA quasinonlinear regime is described, in which the major advantages of the blowout regime of the PWFA are preserved, while permitting resonant, multi-pulse excitation. The physics of this regime are delineated, and the initial proof-of-principle experiments at the BNL ATF are discussed.
Summary	
Pending	

Name of submitting author	Prof. James Rosenzweig
Institution	UCLA Dept. of Physics and Astronomy
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Abstract Title	**Wakefield Tests in Optimized Photonic Structures**
Author/Affiliation listing	G. Andonian, E. Arab S. Barber, K. Fitzmorris, A. Fukusawa, B. Naranjo, B. O'Shea, **J. Rosenzweig**, H. Phuc, A. Valloni, O. Williams, UCLA M. Hogan, SLAC P. Muggli, MPI V. Yakimenko, BNL
Abstract	We describe experiments at the BNL ATF and SLAC FACET in which optimized photonic structures are utilized. These experiments, while are performed in the THz regime, have high relevance to the development of laser-driven accelerators such as the 5 micron wavelength GALAXIE structure.
Summary	
Pending	

Name of submitting author	Aakash Sahai
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Abstract Title	**Excitation of wakefields in a relativistically hot plasma created by dying non-linear plasma wakefields**
Author/Affiliation listing	**Aakash A. Sahai**, Duke University Thomas C. Katsouleas, Duke University Spencer Gessner, SLAC National Lab Mark Hogan, SLAC National Lab Chandrashekhar Joshi, UCLA

Abstract	In this study we try to determine the nature of wakefields in relativistically Hot plasma. We also explore the physical processes involved in the long-term evolution (ps-ns) of the femtosecond timescale wakefields. The physics studied here is directly relevant to future high repetition rate electron and positron plasma wakefield colliders.

Summary

We study the various physical processes and their timescales involved in the excitation of wakefields in a relativistically hot plasma. This has relevance to the design of a high repetition-rate plasma wakefield collider in which the plasma has not had time to cool between bunches in addition to understanding the physics of cosmic jets in relativistically hot astrophysical plasmas. When the plasma is relativistically hot (plasma temperature near mc2), the thermal pressure competes with the restoring force of ion space charge and can reduce or even eliminate the accelerating field of a wake. We will investigate explicitly the case where the hot plasma is created by a preceding wakefield driver 10's of ps to many ns ahead of the next drive bunch. The relativestically hot plasma is created when the energy in the wake driven by the first drive pulse is rtevdentua thermal energy on a tens of picosecond timescale. We will investigate the thermalization and diffusion processes of this non-equilibrium plasma on longer time scales, including the effects of ambipolar diffusion of ions driven by hot electron expansion, possible Coulombic explosion of ions producing higher ionization states and ionization of surrounding neutral atoms via collisions with hot electrons. Preliminary results of the transverse and longitudinal wakefields at different timescales of separation between a first and second bunch are presented and a
FACET facility is described.

Name of submitting author	Prof. Levi Schachter
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Abstract Title	**2D Formulation of E-beam Interaction with Multi-resonant Gaseous Medium**
Author/Affiliation listing	Miron Voin[1], Wayne Kimura[2], Patric Muggli [3,4] and **Levi Schächter[1]** (1)Dept. of Electrical Engineering, Technion, Haifa 32000, ISRAEL (2) STI Optronics, Bellevue, WA 98004, USA (3) Dept. of Electrical Engineering, University of Southern California, Los Angeles, CA 90089, USA (4) Max-Planck Institute für Physik, 80805 München, GERMANY
Abstract	Interaction of a beam of electrons with an excited gaseous medium is formulated and a few examples are presented.
Summary	
Interaction of a beam of electrons with an excited gaseous medium is formulated and a few examples are presented. In the framework of the model, the dielectric properties of the gaseous medium are represented by a finite set of resonances corresponding to spectral lines of the gas constituents. Both stimulated emission and absorption from the various states are considered. It is assumed that the population of one of the energy states is inverted. Longitudinal and transverse dynamics are evaluated analytically and Panofsky-Wenzel theorem for such a medium is derived. Based on the numerical simulations performed, possible implications on the operation as either an afterburner or an injector are discussed.	

Name of submitting author	Dr. Paul Schoessow
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Abstract Title	**Dielectric Structures: Collimation and Nonlinear THz Source Applications**
Author/Affiliation listing	**Paul Schoessow**, Alexei Kanareykin (Euclid Techlabs) Stanislav Baturin (St Petersburg Electrotechnical Institute)
Abstract	The wakefield accelerator concept has produced a number of interesting spinoffs. Two will be discussed here. The possibility of reducing wakefields in CLIC and ILC beam delivery systems using dielectric collimators employing novel damping techniques. Second, progress towards a ferroelectric based THz nonlinear frequency multiplier structure will be presented.
Summary	
Advances in dielectric materials and components have arisen in the context of research into new particle acceleration techniques, particularly those related to the dielectric wakefield accelerator. In this paper we focus on two of these applications, collimation and nonlinear THz generation. additional research on wakefield reduction in the collimator sections. New materials and new geometries have been considered recently. Dielectric collimators for the CLIC Beam Delivery System have been discussed with a view to minimize the BDS collimation wakefields. We present a number of dielectric collimator concepts for the linear collider; cylindrical and novel layered planar collimators for the CLIC parameters are considered. We show results of simulations of wakefields in these collimator configurations. dielectric wakefield accelerator, electromagnetic fields excited by an electron beam in a dielectric structure are used to accelerate a second, trailing beam to high energy. Energy can be efficiently extracted from the beam in this manner and thus the accelerating structure can also be used as an RF source, with frequencies extending into the THz. New ferroelectric materials, particularly Barium-Strontium Titanates exhibit potentially transformational uses in this technology. We discuss the applications to nonlinear frequency multiplication of the wakefield in a ferroelectric structure. for experimental tests of prototype collimator systems and nonlinear THz structures at Facilities for Accelerator Science and Experimental Test Beams (FACET) at SLAC.	

Name of submitting author	Carl Schroeder
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Abstract Title	**Coupled hosing and self-modulation instabilities in proton beam driven PWFA**
Author/Affiliation listing	**C. B. Schroeder** (LBNL), C. Benedetti (LBNL), E. Esarey (LBNL), F. J. Grüner (Hamburg), W. P. Leemans (LBNL)
Abstract	A long beam propagating in an overdense plasma is subject to envelope modulation and centroid displacement (hosing) instabilities. Coupled equations for the beam centroid and envelope are solved. It is shown that the hosing growth is comparable to self-modulation, and coupling of self-modulation enhances hosing and induces harmonic content.

Summary

Recently the use of proton beams (such as those at CERN and Fermilab) to drive plasma waves for compact acceleration of electron beams has attracted considerable attention [see for example, Caldwell et al., Nature Physics (2009)]. Owing to the difficulty of proton beam compression, researchers are considering relying on the beam-plasma interaction to modulate the beam, driving a large plasma wave for acceleration. Experimental programs at CERN (using proton beams), and at BNL, SLAC, and DESY (using electron beams) are presently underway or being considered to test this concept and its applicability to the next generation of high-energy colliders. A self-modulated proton-driven PWFA presents many challenges. For example, it has been pointed out the the phase velocity of the self-modulated beam (in the linear regime) is significantly slower than the beam velocity [Schroeder et al. PRL (2011); Pukhov et al. PRL (2011)], resulting in beam dephasing. The dephasing could be compensated by tapering, although it was also shown that small plasma density inhomogeneities can strongly suppress the modulation [Schroeder et al., Phys. Plasmas (2012)]. In addition, the transverse stability of drive beams is a critical concern for beam-driven plasma wakefield accelerators, and in particular for long beams.
hosing of a long (many plasma periods) charged particle beam undergoing the self-modulation instability while propagating in an overdense plasma [Schroeder et al., submitted (2012)]. In particular, the coupled evolutions for the beam centroid (hosing) and envelope (self-modulation) are analyzed and solved. The hosing growth rate is calculated. The coupling of the beam envelope self-modulation to the beam centroid displacement is shown to enhance beam hosing. Seeding options to increase beam self-modulation will be discussed.

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

Name of submitting author	Mr. Carl Siemon
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Abstract Title	**Laser-seeded modulation instability within LHC proton beams**
Author/Affiliation listing	**Carl Siemon**, Vladimir Khudik, S. Austin Yi, Gennady Shvets University of Texas at Austin
Abstract	A new method for seeding the modulation instability (MI) within an SPS-LHC proton beam using a laser pulse is presented.
Summary	
A new method for seeding the modulation instability (MI) within an SPS-LHC proton beam using a laser pulse is presented. Using simulations, we show that a laser pulse placed ahead of a proton beam excites axially symmetric self-modulation modes within the proton beam and leads to peak accelerating fields that are comparable to previously proposed seeding methods. We then demonstrate that a plasma density ramp placed in the early stages of the laser-seeded MI leads to stabilization and sustained accelerating electric fields (of order several hundred MeV/m) over long propagation distances ($\sim$100 − 1000 meters). To directly compare the efficiencies of the laser and other seeding methods, simulation results for two scenarios are discussed: a) a laser is placed in the 'center' of an infinitely long (no laser pulse). Analytics are presented that determine the behavior of the strongly coupled, long beam regime for each of these cases.	

Name of submitting author	Dr. Evgenya Simakov
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Abstract Title	**Possibility for Ultra-Bright Electron Beam Acceleration in Dielectric Wakefield Accelerators**
Author/Affiliation listing	**Evgenya I. Simakov** and Bruce E. Carlsten Los Alamos National Laboratory
Abstract	We present a conceptual proposal to combine the Dielectric Wakefield Accelerator (DWA) with the Emittance Exchanger (EEX) to demonstrate a high-brightness DWA with the gradient of above 100 MV/m and less than 0.1% induced energy spread in the accelerated beam.
Summary	

We currently evaluate the DWA concept as a performance upgrade for the future LANL signature facility MaRIE with the goal of significantly reducing the electron beam energy spread. The Matter-Radiation Interactions in Extremes (MaRIE) experimental facility will be used to discover and design the advanced materials needed to meet 21st century national security and energy security challenges. The pre-conceptual design for MaRIE is underway at LANL, with the design of the electron linear accelerator being one of the main research goals. The cost of the linac is significant and the LANL space constraints dictate that the final energy of the electron beam for the X-ray Free-Electron Laser (XFEL) is no higher than 12 GeV. The number and the energy of photons produced by the XFEL is however strongly dependent on the electron beam's energy with the more energetic beam delivering more energetic photons to the user. Although generally the baseline design needs to be conservative and rely on existing technology, any future upgrade would immediately call for looking into the advanced accelerator concepts capable of boosting the electron beam energy up by a few GeV in a very short distance without degrading the beam's quality. Scoping studies have identified large induced energy spreads as the major cause of beam quality degradation in high-gradient advanced accelerators for FELs. Among advanced accelerator technologies, DWAs hold significant advantages over plasma wakefield accelerators due to the elimination of plasma-induced effects (e.g. bunch erosion and hosing), the fact that having the wakefield in vacuum ensures linearity, and their higher technological maturity. We will present simulations demonstrating that trapezoidal bunch shapes can be used in a DWA to greatly reduce the beam energy spread, and, in doing so, also preserve the beam brightness at levels never previously achieved. This concept has the potential to advance DWA technology to a level that would make it suitable for the proposed Los Alamos MaRIE signature facility.

This work is supported by the U.S. Department of Energy through the Laboratory Directed Research and Development (LDRD) program at Los Alamos National Laboratory.

Name of submitting author	Navid Vafaei-Najafabadi
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Abstract Title	**Meter scale plasma source for plasma wakefield experiments**
Author/Affiliation listing	**N. Vafaei-Najafabadi**, J. Shaw, K. A. Marsh, C. Joshi/ UCLA, Department of Electrical Engineering M. J. Hogan/ SLAC National Accelerator Lab

Abstract	Development of a meter scale preformed plasma source for plasma wakefield acceleration experiments at SLAC will be discussed. Developed at UCLA, the plasma is generated by multi-photon ionization of alkali metal vapor with a short pulse TW scale power Ti:Saph laser.

Summary

High accelerating gradient generated by high-density electron beam moving through plasma has been used to double the energy of the SLAC electron beam [1]. During that experiment, the electron current density was high enough to generate its own plasma without significant head erosion. In the newly commissioned FACET facility at SLAC, the peak current will be lower and without preionization, head erosion will be a significant challenge for the planned experiments.
of a meter scale plasma source for these experiments to effectively avoid the problem of head erosion. The plasma source is based on a homogeneous metal vapor gas column that is generated in a heat pipe oven [2]. Lithium oven over 30 cm long at densities over 1017 cm-3 has been constructed and tested at UCLA. Plasma is then generated by coupling a 10 TW short pulse Ti:Saph laser into the gas column using an axicon lens setup. The Bessel profile of the axicon setup creates a region of high intensity that can stretch over the full length of the gas column with approximately constant diameter. In this region of high intensity, the alkali metal vapor is ionized through the multi-photon ionization process. In this manner, a fully ionized meter scale plasma of uniform density can be formed. Methods for controlling the plasma diameter and length will also be discussed.

The work was supported by DOE grant DE-FG02-92ER40727 and NSF grant PHY-0936266.

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[2] P. Muggli, et al. IEEE Transactions on Plasma Science, 27, 791-799 (1999).

Name of submitting author	Dr. Jorge Vieira
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Abstract Title	**Self-modulation of long lepton and hadron bunches**
Author/Affiliation listing	**J. Vieira** Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Portugal Y. Fang University of Southern California, Los Angeles, USA W. B. Mori Department of Physics and Astronomy, University of California, Los Angeles, USA P. Muggli University of Southern California, USA and Max Planck Institute for physics, Germany L. O. Silva Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Portugal

Abstract	We explore the self-modulated plasma wakefield accelerator driven by proton and lepton bunches. We find that the key physics can be explored using long lepton bunches at SLAC FACET which can lead to the generation of accelerating gradients larger than 20 GV/m and to 10 GeV lepton bunch energy variation.

Summary

Proton bunches are attractive for plasma wakefield acceleration because the total amount of energy they carry is much larger than that of the lepton bunches of a future linear collider. The initial proposal for a proton-driven PWFA (or PDPWFA) [1] considered the case of a short proton bunch driver (shorter than 100 microns). However, such short proton bunches are not currently available. It was recently suggested [2] that the self-modulation (S-M) of a long proton bunch at the wavelength of the relativistic plasma wave can lead to the resonant excitation of large amplitude plasma wakefields. In this work we explore the self-modulation of ultra-relativistic hadron and lepton bunches. We show that the self-modulation of 1 TeV, 12 cm long proton bunches can lead to large accelerating gradients (>200 MeV/m) in 5 meter long plasmas with 10^14 electrons/cm^3. The plasma ion motion can degrade the wakefields and suppress the self-modulation instability unless heavier plasma ions are used (e.g. Argon) [3]. Furthermore, the physics of the PDPWFA could be tested very soon with the ultra-relativistic (E=25 GeV) and long (500 microns) lepton bunches available at SLAC FACET [4]. 3D simulations reveal that hosing may limit S-M, but that hard-cut bunches ensure that saturation of S-M can be reached. The saturation of the S-M instability is reached over only a few centimeters of plasma at a density of 2.3x10^17/cm^3. Accelerating gradients in excess of 20 GeV/m can be generated, and energy variations up to 10 GeV at the 1% level were observed after one meter. We find that the self-modulation of positively and negatively charged bunches differ. Because the blowout regime is reached, positron driven wakes lead to accelerating gradients that can be less than half than those of electrons [5].

[1] A. Caldwell et al, Nat. Phys. 5, 363 (2009). [2] N. K[illegible] 3 (2010); A. Pukhov et al PRL 107 145003 (2011); C. B. Schroeder et al PRL 107 145002 (2011).

Vieira et al to be submitted (2012) al PoP, accepted, (2012).

Name of submitting author	Ziran Wu
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Abstract Title	**Coherent Terahertz Radiation Source at FACET**
Author/Affiliation listing	**Ziran Wu**, SLAC Alan Fisher, SLAC
Abstract	This paper presents preliminary characterization of the terahertz pulses generated by the FACET electron beam via coherent transition radiation. The measured THz frequency content spans from 0.25 THz to 2.3 THz and peaks at around 0.5 THz, with 0.69 mJ collected total energy per pulse.
Summary	
The Facility for Accelerator science and Experimental Tests (FACET) at SLAC provides a high charge, high peak current, sub-picosecond bunched electron beam that is ideal for 0.1 to 2 THz radiation generation via coherent transition radiation. The intense EM fields generated are orders of magnitude stronger than those available from laboratory tabletop sources, and open up opportunities for nonlinear THz experiments. This paper presents preliminary characterization of the terahertz pulses generated by the FACET electron beam. A one-micron thick Titanium foil has been inserted into the beam path and the radiated photons collected. Michelson spectroscopy yields THz frequency content spanning from 0.25 THz to 2.3 THz and peaked at around 0.5 THz. Multiple scans at different bunch compression show a monotonic increase of the peak radiation frequency as the electron bunch gets shorter. Several filtering effects are identified in the spectrum, including the water vapor absorption, the detector response, and the low frequency roll-off due to diffraction limit and skin depth of the foil. Using the Kramers-Kronig relation, the temporal profile of the THz pulse is reconstructed from the power spectrum indicating a ~ 4 picosecond main pulse followed by a long oscillating tail due to the water absorption lines and detector response. Knife-edge scans measure a 4.4 x 4.8 mm2 transverse spot size at the focal point of the THz optical path. The total collected energy per pulse is 0.69 mJ measured by a Joulemeter. Fitting this total energy to the spatiotemporal profile of the THz pulse yields peak e-field amplitude of 1.5 MV/cm. Work supported by the U.S. Department of Energy under contract number DE-AC02-76SF00515.	

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Abstract Title	**Emittance Limits Due to Laser Intensity Effects in Trojan Horse PWFA Injection**
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Abstract	Early this year, a new plasma acceleration nicknamed as "Trojan Horse" is designed and simulated as success. Traditional photocathode is replaced by laser ionization inside the blowout regime to produce low emittance beam. We estimated beam emittance as order of 10^-9 due to laser intensity effects.
Summary	
A novel plasma wakefield acceleration known as “Trojan horse” has been proposed recently and scheduled to run in FACET next year. In this scenario, an ultrashort, synchronized laser pulse at ionization threshold is releasing photoelectrons into the blowout. It is necessary to examine the exact impact of this release laser on the phase space volume of the photoelectrons, namely beam emittance. Instead of ADK theory, non-adiabatic ionization theory for few-cycle laser pulse was adopted to determine initial spatial distribution of photoelectrons. We tracked the motion of photoelectrons by solving relativistic Newton equation of motion as electrons witness both wakefields and laser fields. Wakefields were lineouted from 2D PIC(Particle in cell) simulation with VORPAL while laser fields can be described by bi-Gaussian distribution analytically. By projecting all electron trajectories to same z, we estimate the emittance of beam as order of 10^-9 mrad without including space charge effect which confirms the intriguing potential of producing ultralow emittance beam.	

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Abstract Title	**Theoretical Analysis and Simulations of Plasma Photo-Cathode (Laser Ionization Injection in Beam Driven Plasma Wakefield)**
Author/Affiliation listing	**Xinlu Xu** / Tsinghua University of Beijing, UCLA Fei Li / Tsinghua University of Beijing Jianfei Hua / Tsinghua University of Beijing Wei Lu / Tsinghua University of Beijing, UCLA Peicheng Yu / UCLA Weiming An / UCLA Warren B. Mori / UCLA Chan Joshi / UCLA
Abstract	We present new results from OSIRIS simulations and analytical theory on the unique electron beams produced by laser-induced ionization injection into beam driven plasma wakefield. Our theory clarifies the unique phase space dynamics of this injection process and also evaluates the space charge effects. OSIRIS simulations support this theory.
Summary	
We present new results from OSIRIS simulations and analytical theory on the unique electron beams produced by laser-induced ionization injection into a electron beam driven plasma wakefield. When the injected charge is sufficiently low this scheme exhibits unique physical processes and the electron beam it generates has unique structure in its 6D phase space. In addition, we will discuss how space charge effects modify the beam properties for high injected charge. The OSIRIS results support our theoretical investigation.	

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Abstract Title	**Analytic model of electron self-injection in a plasma wakefield accelerator in the strongly nonlinear bubble regime**
Author/Affiliation listing	**S.A. Yi**, V. Khudik, G. Shvets The Department of Physics and Institute for Fusion Studies, The University of Texas at Austin
Abstract	Self-injection of background plasma electrons in plasma wakefield accelerators in the highly nonlinear bubble regime is analyzed using particle-in-cell and semi-analytic modeling. It is shown that the return current in the bubble sheath layer is crucial for accurate determination of the trapped particle trajectories.

Summary

We study self-injection into a plasma wakefield accelerator (PWFA) in the blowout (or bubble) regime with an inhomogeneous background plasma density. Using an analytic model and particle-in-cell simulations, we explore an injection mechanism into a PWFA, where a growing bubble causes reduction of the electron Hamiltonian in the co-moving frame, which leads to electron trapping [1,2]. In contrast to earlier work with steep density gradients, growth of the blowout region is caused by a slow decrease in plasma density along the propagation direction. To demonstrate this trapping mechanism, we generalize an analytic model for the wakefields inside the bubble [3], to derive expressions for the fields outside. With this extended model, we study the trapping of initially quiescent plasma electrons into the growing ultra-relativistic bubble, and show that a return current in the bubble sheath layer plays an important role in determining the trapped electron trajectories. We estimate the plasma density gradients and driver beam parameters required for self-injection, and compare our results with particle-in-cell simulations.

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Abstract Title	**Frequency-domain inteferometric visualization of electron-bunch-driven wakes**
Author/Affiliation listing	**Rafal Zgadzaj**, Michael C. Downer (UT Austin), Patrick Muggli (Max-Planck-Institut für Physik, Munich) Vitaly Yakimenko, Marcus Babzien, Karl Kusche, Mikhail Fedurin (BNL/ATF)
Abstract	We report progress in the development of single shot Frequency-Domain Holographic (FDH) probing of two, and multibunch, driven plasma wakefield structures, in the Accelerator Test Facility at the Brookhaven National Laboratory.

Summary

Beam-driven plasma wakefield accelerators (PWFA), such as the ``plasma afterburner," can potentially greatly increase the particle energies of conventional accelerators [1]. Various schemes using single and multiple bunches of electrons, positrons and protons have been investigated. Appropriately delayed witness bunches have been the usual method to probe the fields of such wakes, and indirectly, the corresponding plasma wake structures. However, the wake structure has not been observed directly in the PWFA. We will report our progress in the development of direct, optical interferometric methods of measuring the plasma density modulation in electron beam driven wakefields [2,3]. Frequency Domain Holography (FDH) [3], employing two chirped laser pulses (probe and reference) co-propagating with the particle drive-beam and its plasma wake, permits a single shot observation of an extended section of the wakefield behind a drive bunch. The chirped, temporally stretched, probe samples several periods of the wake, while the undisturbed reference pulse propagates ahead of the electron drive bunch. The technique is being developed in the Accelerator Test Facility at the Brookhaven National Laboratory as a probe for two and multibunch driven plasmawakefield experiments [4,5].

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