ALEGRO Workshop 2024, Lisbon, 19-22 March

Report of Contributions

https://indico.cern.ch/e/1364999

Contribution ID: **40** Type: **not specified**

Undepleted direct laser acceleration

Thursday 21 March 2024 16:40 (20 minutes)

In direct laser acceleration (DLA) of electrons, the leading part of the laser pulse ionizes the target material and forms a positively charged ion plasma channel into which electrons are injected and accelerated.
I will describe our recent work **[Cohen, I., et. al, Science advances, 10(2), eadk1947(2024)]** which shows that for efficient DLA to prevail, target materials of sufficiently high atomic number maintain the injection of ionization electrons at the peak intensity of the pulse.
Using the 20 TW laser system at Tel-Aviv University, we generated electron beams from plasma plumes created by pre-exploding foils of Au and CH. The plume's density was tailored by setting the pre-pulse energy and the pre-pulse to main-pulse delay to optimize the generated electron beam charge and energy. A new analytical solution to the plasma equations **[Cohen I, et. al, Phys. Plasmas 31 (1):013103 (2024)]** was used to describe the temporal evolution of the plume' s density profile. PIC simulations revealed highly efficient acceleration of electrons injected from a specific range of ionization levels into the DLA channel.
I will conclude by describing an upcoming beam-time at ELI-Beamlines in which this new understanding will be employed to generate copious amounts of photoneutrons.

Available for oral presentation in a session

Yes

Primary authors: COHEN, Itamar (Tel Aviv University); MEIR, Talia (Tel Aviv University); TANG-TARTHARAKUL, Kavin (UC San-Diego); AREFIEV, Alexey V. (UC San-Diego); POMERANTZ, Ishay (Tel Aviv University)

Session Classification: Poster Session

Contribution ID: **41** Type: **not specified**

Towards a Higgs Factory based on Proton-Driven Plasma Wakefield Acceleration

Wednesday 20 March 2024 16:30 (30 minutes)

A Higgs Factory is considered the highest priority next collider project by the high-energy physics community. Very advanced designs based on radio-frequency cavities exist, and variations on this approach are still being developed. Recently, also an option based on electron bunch driven plasma wakefield acceleration has been proposed.
Here, we discuss a further option based on proton-driven plasma wakefield acceleration. This option has significant potential advantages due to the high energy of the plasma wakefield driver, simplifying the plasma acceleration stage, and to the breadth of particle physics research it will make possible. Its success will depend on further developments in producing compact high-energy proton bunches at a high rate.

Available for oral presentation in a session

Yes

Primary author: PUKHOV, Alexander

Co-authors: CALDWELL, Allen Christopher (Max-Planck-Institut fuer Physik (Werner-Heisenberg-Institut) (D); FARMER, John Patrick (MPP / CERN)

Presenter: PUKHOV, Alexander

Session Classification: Advanced collider concepts

Contribution ID: **42** Type: **not specified**

Complete elimination of BBU in open structured channels

Thursday 21 March 2024 16:40 (20 minutes)

The plasma-based particle acceleration promises very high accelerating fields. At the same time, it is widely accepted that uniform plasma only can support acceleration of negatively charged witness particles. Hollow plasma channels would be suitable for acceleration of witnesses of both charges due to the absence of focusing fields inside the vacuum channel core. Unfortunately, beams in the hollow channels suffer from beam break-up (BBU) due to fast growth of skewed (asymmetric) wakes. The BBU leads to a fast beam loss and prohibits a useful application of the round hollow channels in bulk plasmas.
Here, I show that properly structured hollow plasma channels allow to eliminate BBU instability completely. For the first time, high-gradient particle acceleration becomes feasible in hollow channels over long distances. Moreover, even long-beam drivers with a shaped current profile remain stable in such structured channels. This opens the unique possibility to achieve extremely high transformer ratios (TR˜10 or even higher) in beam-driven accelerators.
The concept can be applied both to low density plasma channels as well as to corrugated solid-state structures.
Full 3D electromagnetic PIC simulations will be presented.

Available for oral presentation in a session

Yes

Primary author: PUKHOV, Alexander

Session Classification: Poster Session

Contribution ID: **43** Type: **not specified**

Hybrid LWFA-driven PWFA as a test platform for staged plasma acceleration

Wednesday 20 March 2024 14:30 (30 minutes)

Staging, sequencing plasma accelerator modules, is an important concept for the further development of plasma-based acceleration methods to reach the energy level required for high energy physic applications. In- and out-coupling of drive laser beams as well as matching of the electron beam into the plasma cavity of a subsequent energy booster stage require spatio-temporal control to achieve quality-preserving acceleration. This demands extremely tight tolerance in pointing stability and the ability to precisely monitor the process. In our recent hybrid LPWFA experiments some of these aspects are addressed, using the multibeam capability of the DRACO laser system. Here, one arm (150TW) generates high peak current electron beams in an LWFA stage, which are transported into a downstream plasma module to excite plasma waves. To consitently inject electrons, a synchronized injector laser extracted from the other arm (1PW line) is used, which requires stable spatio (micrometer scale) and temporal (fs scale) overlap with respect to the accelerating plasma cavity. Besides for high quality beam generation, this demonstrates the ability to control positioning of the injector laser aided by ultrafast optical probing. Our unique infrastructure is also applicable for multiple LWFA stages, thus providing a testbed for staging.

Available for oral presentation in a session

Yes

Primary author: SCHÖBEL, Susanne (Helmholtz-Zentrum Dresden-Rossendorf)

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Presenter: SCHÖBEL, Susanne (Helmholtz-Zentrum Dresden-Rossendorf)

Session Classification: Staging

Contribution ID: **44** Type: **not specified**

Developing expectations for AWAKE with simulations.

Thursday 21 March 2024 16:40 (20 minutes)

The AWAKE experiment at CERN makes use of a self-modulated proton bunch to excite wakefields and accelerate a witness electron bunch. Run 2c of the experiment will demonstrate stabilization of the wakefield amplitude and control of the witness bunch emittance during injection and acceleration. In this work, we present an overview of the ongoing simulation efforts to support the project as it moves towards controlled acceleration and first particle-physics applications.

Available for oral presentation in a session

Yes

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Co-authors: WALTER, Erwin; LOTOV, Konstantin (Budker Institute of Nuclear Physics (RU)); YARYGIVA, Vlada (Budker Institute of Nuclear Physics & Novosibirsk State University); THE AWAKE COLLABORATION

Session Classification: Poster Session

Contribution ID: **45** Type: **not specified**

Phase Control of Nonlinear Breit-Wheeler Pair Creation

Thursday 21 March 2024 16:40 (20 minutes)

Some astrophysical objects (e.g., pulsars) harbor extremely intense electromagnetic fields in their immediate surroundings. These fields allow for spontaneous and proliferous electron-positron pair creation, generating what is called a lepton pair plasma. It has so far been impossible to replicate these conditions in a laboratory setup. The advances of state-of-the-art laser and accelerator facilities achieving intensities on the order of 10^{23} $\mathrm{W/cm^2}$ and multi-GeV electron energies enable strong-field QED phenomena to occur. The lowest-order processes are nonlinear Compton scattering and nonlinear Breit-Wheeler pair creation, ultimately leading to electron-positron creation. Characterizing these processes is necessary if we want to bridge micro- and macro-scale phenomena in astrophysical plasmas, such as radiation emission and production of seed field fluctuations, which can later grow into instabilities and be further amplified. In this work, we present analytical predictions on how a two-colored high-intensity laser pulse, composed of a fundamental and a second harmonic, interacts with a relativistic electron beam. By controlling their relative phase, it is possible to control the transverse momentum imprinted on the leptons created during the interaction and ultimately separate positrons from electrons. This can greatly facilitate experimental detection of the out-coming pairs. The results are confirmed with fully self-consistent particle-in-cell simulations.

Available for oral presentation in a session

Yes

Primary author: PEREIRA DA COSTA DE PESSANHA BARBOSA, Bernardo Maria

Co-authors: Dr PALASTRO, John P. (LLE - Rochester); Dr RAMSEY, Dillon (LLE - Rochester); Dr WEICHMAN, Kale (LLE - Rochester); Dr VRANIC, Marija (IST - Lisbon)

Session Classification: Poster Session

Contribution ID: **46** Type: **not specified**

LASY: an open-source Python library for easy interfacing of laser pulses between experiments and simulations

Wednesday 20 March 2024 13:30 (30 minutes)

While multiple works demonstrated the importance of using realistic laser profiles for simulations of laser-plasma accelerators to accurately reproduce experimental measurements, the handshake between experiments and simulations can be challenging. Similarly, transferring a laser pulse from one code to another, as needed for start-to-end simulations, may require some error-prone manipulations. In this poster, we will present LASY (which stands for LAser manipulations made eaSY), a new open-source Python library to simplify these workflows. Developed in an international collaboration between experimental, theoretical and computation physicists, LASY can be used to create a laser profile from a measurement, from a simulation, or analytic, propagate it, manipulate it (e.g., convert from field to envelope, or from vector potential to electric field) and write it to file in compliance with the openPMD standard. The profile can then be used as input by any simulation code that adopts the standard. We will show use cases and discuss the accuracy of this method.

Available for oral presentation in a session

No

Primary authors: FERRAN POUSA, Angel (Deutsches Elektronen Synchtrotron DESY); Dr HUEBL, Axel (Lawrence Berkeley National Laboratory); Dr ANDRIYASH, Igor (Laboratoire d'Optique Appliquee); PÕDER, Kristjan (Deutsches Elektronen Synchtrotron DESY); Dr FEDELI, Luca (CEA-LIDYL); Dr KIRCHEN, Manuel (Deutsches Elektronen Synchtrotron DESY); THEVENET, Maxence (Deutsches Elektronen Synchtrotron DESY); Dr LEHE, Remi (Lawrence Berkeley National Laboratory); Dr SHALLOO, Rob (Deutsches Elektronen Synchtrotron DESY); Dr JALAS, Sören (Deutsches Elektronen Synchtrotron DESY)

Presenter: PÕDER, Kristjan (Deutsches Elektronen Synchtrotron DESY)

Session Classification: Staging

Contribution ID: **47** Type: **not specified**

Generation and acceleration of polarised electron bunches in plasma accelerators

Friday 22 March 2024 10:00 (30 minutes)

Highly polarised, high current electron bunches from compact plasma accelerators are sought after for numerous applications. However, current proposals to generate these beams from plasmas suffer from intrinsic limitations to the reproducibility, charge, beam shape and final polarisation degree. We propose colliding pulse injection as a technique for the generation of highly polarised electron bunches from pre-polarised plasma targets. Using particle-in-cell simulations, we show that colliding pulse injection enables accurate control of the spin-polarisation during the trapping of electrons, enabling high-current electron bunches with high degrees of polarisation to be generated. Bayesian optimisation is employed to optimise the multi-dimensional parameter space of colliding pulse injection, demonstrating the generation of highly polarised, high-quality electron bunches employing 100-TW class laser technology. We also discuss simulations of acceleration of polarised electron bunches in scenarios relevant to future collider proposals.

Available for oral presentation in a session

Yes

Primary authors: PÕDER, Kristjan (Deutsches Elektronen Synchtrotron DESY); Dr TAMBURINI, Matteo (Max Planck-Institut für Kernphysik); THEVENET, Maxence (Deutsches Elektronen Synchtrotron DESY); Dr MICHAEL, Quin (Max Planck-Institut für Kernphysik); BOHLEN, Simon (Deutsches Elektronen Synchtrotron DESY); Dr GONG, Zheng (Max Planck-Institut für Kernphysik)

Presenter: PÕDER, Kristjan (Deutsches Elektronen Synchtrotron DESY)

Session Classification: Positrons and disruption physics

Contribution ID: **48** Type: **not specified**

Laser focusing trade-off in the multi-PW regime

Thursday 21 March 2024 16:40 (20 minutes)

The development of laser technology will soon enable experiments focused on the interaction of laser pulses with power up to 10 PW with various types of plasma targets for purposes of electron acceleration. Amongst the others, the motivation is to reach the highest possible energies on distances shorter compared to conventional accelerators. We have recently shown using particle-in-cell framework OSIRIS that multi-PW lasers are capable of delivering electron bunches with energies of several GeV by the mechanism direct laser acceleration (DLA). The total accelerated charge can exceed the 100 nC limit which results in very high conversion efficiency of the laser energy into energetic electrons. Many applications such as gamma-ray radiation, neutron generation or seeding of electron-positron showers may strongly benefit from the DLA.

We show that the correct focusing and consequent guiding of the laser pulse is key to using the full potential of the DLA acceleration scheme. The correct focusing is necessary to accelerate electrons far from the axis. However, higher laser intensity enables electron acceleration further from the axis, which results in the nonlinear interplay for the optimal focusing strategy in order to achieve high intensity but using sufficiently wide laser pulse.

Available for oral presentation in a session

Yes

Primary author: BABJAK, Róbert (GoLP - Group for Lasers and Plasmas)

Co-authors: AREFIEV, Alexey V. (UC San-Diego); Prof. WILLINGALE, Louise; VRANIC, Marija (IST - Lisbon)

Session Classification: Poster Session

Contribution ID: **49** Type: **not specified**

SFQED - Disruption Interplay in Leptonic Beam Interaction for Future Colliders

Friday 22 March 2024 09:00 (30 minutes)

High-luminosity collisions between dense and high-energy beams (100s GeV to a few TeV) planned for future colliders, including utilizing advanced collider concepts through high-gradient plasma-based accelerators, will push beamstrahlung into the quantum regime. The typical beam parameters at the final focus will necessitate the disruption parameter to be \(D < 1\). However, the bunch length will remain on the micron scale, indicating that several hard photons per beam particle will be emitted during the collisions. This phenomenon has already been estimated to lead to severe energy loss in colliding beams.

In this talk, we will demonstrate that two unintuitive effects can emerge due to SFQED - disruption interplay. First, in the collision of electron-positron beams with \(D < 1\), luminosity enhancement effects from beam disruption are typically weak. Recent QED-PIC simulations have revealed that disruption, in the presence of SFQED effects, transforms into a dynamical parameter that can be significantly increased during the interaction. Second, electron-electron collisions are usually not considered viable due to the tendency of the two beams to repel each other. However, we will present findings that for special beam parameters, pair production enables the anomalous pinching of the beam tail.

Available for oral presentation in a session

Yes

Primary author: Dr GRISMAYER, Thomas (GoLP/IPFN, Instituto Superior Técnico, Universidade de Lisboa)

Co-authors: Prof. SILVA, Luis (Instituto Superior Tecnico); MORI, Warren (University of California, Los Angeles, Los Angeles); ZHANG, Wenlong (East China University of Technology)

Presenter: Dr GRISMAYER, Thomas (GoLP/IPFN, Instituto Superior Técnico, Universidade de Lisboa)

Session Classification: Positrons and disruption physics

Contribution ID: **50** Type: **not specified**

MPI-GPU Algorithm in QuickPIC

Thursday 21 March 2024 16:40 (20 minutes)

QuickPIC is a quasi-static PIC code for efficiently modeling the plasma based accelerators. It can be 1000 times faster than the conventional PIC code without losing accuracy. QuickPIC is developed based on the frame work UPIC. It has a hybrid parallelism algorithm that uses both OpenMP and MPI. Such an algorithm is also suitable for a GPU cluster. In this work, we will introduce the GPU+MPI version of QuickPIC, including the algorithm for deposit, particle mover and sine and cosine FFTs.

Available for oral presentation in a session

No

Primary authors: TIAN, Yueran (Beijing Normal University); WANG, Yueluo (Beijing Normal University); DECYK, Viktor (University of California Los Angeles); DALICHAOUCH, Thamine (University of California Los Angeles); MORI, Warren (University of California Los Angeles); AN, Weiming (Beijing Normal University)

Session Classification: Poster Session

Contribution ID: **51** Type: **not specified**

Advancements in Plasma-Driven Acceleration for Non-Relativistic Particles

Thursday 21 March 2024 16:40 (20 minutes)

In plasma-wakefield acceleration, non-relativistic particles quickly lose phase-locking due to the substantial difference between the driver's group velocity (nearly the speed of light) and the particles' velocities. Heavier particles such as muons [1] and pions have thus conventionally been excluded from this method. Recent advancements have introduced methods for shaping electromagnetic wave packet spectra, producing pulses with variable group velocities [2,3,4]. These pulses can drive subluminal acceleration plasma wakes. Through theoretical analysis and numerical calculations, we demonstrate how employing these pulses as subluminal drivers alongside a tailored plasma density profile enables the possibility to accelerate these particles from non-relativistic to relativistic speeds within a single acceleration stage. Our theoretical model predicts muons and pions can accelerate from around 0.9c to 0.99c in millimetre-scale plasma. These findings align well with quasi-3D particle-in-cell simulations using the OSIRIS code [5], suggesting that 3 Joules lasers could achieve this goal.

[1] K.R. Long et al., Nat. Phys. 17, 289–292 (2021).
[2] A. Sainte-Marie et al., Optica 4, 1298-1304 (2017).
[3] D.H. Froula et al., Nature Photonics 12, 262–265 (2018).
[4] H. Kondakci, Y. F. Abouraddy, Nat. Commun. 10, 929 (2019).
[5] R.A. Fonseca et al., Phys. Plasmas Control. Fusion 55, 124011 (2013).

Available for oral presentation in a session

Yes

Primary author: BADIALI, Chiara

Co-authors: Mr MALACA, Bernardo (GoLP/Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal); VIEIRA, Jorge; RUSSO DE ALMEIDA, Rafael (IST); Dr SILVA, Thales (GoLP/Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal)

Session Classification: Poster Session

Contribution ID: **52** Type: **not specified**

Opening Words

Tuesday 19 March 2024 14:00 (30 minutes)

Presenters: SILVA, Luis; MUGGLI, Patric

Session Classification: Welcome Session and Introduction

Contribution ID: **53** Type: **not specified**

R&D Roadmap of the European Particle Physics Strategy

Tuesday 19 March 2024 14:30 (30 minutes)

Available for oral presentation in a session

Presenter: LEEMANS, Wim (DESY)

Session Classification: Welcome Session and Introduction

Contribution ID: **54** Type: **not specified**

US perspective on plasma based accelerators and future colliders

Tuesday 19 March 2024 15:00 (30 minutes)

Available for oral presentation in a session

Presenter: GEDDES, Cameron (LBNL)

Session Classification: Welcome Session and Introduction

Contribution ID: **55** Type: **not specified**

Physics considerations for laser-plasma linear colliders: achievements and perspectives

Tuesday 19 March 2024 16:30 (30 minutes)

Available for oral presentation in a session

Presenter: BENEDETTI, Carlo (LBNL)

Session Classification: EU and US Roadmaps

Contribution ID: **56** Type: **not specified**

Advances in Structure Wakefield Accelerator R&D for Integration in a Linear Collider

Tuesday 19 March 2024 17:00 (30 minutes)

Available for oral presentation in a session

Presenter: PIOT, Philippe (Northern Illinois University)

Session Classification: EU and US Roadmaps

Contribution ID: **57** Type: **not specified**

Introduction to Sustainability for large Research Infrastructures

Wednesday 20 March 2024 09:00 (30 minutes)

Available for oral presentation in a session

Presenter: VOELKER, Denise

Session Classification: Sustainability

Contribution ID: **58** Type: **not specified**

Sustainability at CERN: strategy for future machines

Wednesday 20 March 2024 09:30 (30 minutes)

Presenter: LOSITO, Roberto (CERN)

Session Classification: Sustainability

Contribution ID: **59** Type: **not specified**

Discussion on sustainability (efficiency budget prospects for LWFA, PWFA)

Wednesday 20 March 2024 10:00 (1 hour)

Session Classification: Sustainability

Contribution ID: **61** Type: **not specified**

Prospects and challenges for high-repetition-rate plasma sources for future colliders

Wednesday 20 March 2024 11:30 (30 minutes)

Available for oral presentation in a session

Presenter: HOOKER, Simon

Session Classification: Staging and scalability

Contribution ID: **62** Type: **not specified**

Staging LWFAs using plasma mirrors

Wednesday 20 March 2024 12:00 (30 minutes)

The coupling of fresh drive laser pulses into LWFA stages compactly can be achieved by using thin film plasma mirrors. Plasma mirrors allow acceleration stages to be placed close to each other, which both increases the average acceleration gradient and reduces drift driven emittance growth. To be effective, plasma mirrors need to preserve the intensity to which the laser can be focussed while running stably at high repetition rates. Further, placing a plasma mirror in the path of the electron beam can adversely affect its beam quality through several mechanisms, and these will need to be mitigated if ultra-low emittances are to be preserved after multiple inter-stage couplings. In this talk, measurements of plasma mirror reflectivity, guiding of the reflected pulse, and high repetition rate operation will be presented, and methods for reducing emittance growth of the beam will be discussed.

Available for oral presentation in a session

Presenter: BACKHOUSE, Michael

Session Classification: Staging and scalability

Contribution ID: **64** Type: **not specified**

Multistage LWFA based on curved plasma channels

Wednesday 20 March 2024 14:00 (30 minutes)

Available for oral presentation in a session

Presenter: LI, Boyuan

Session Classification: Staging

Contribution ID: **65** Type: **not specified**

Conclusions

Friday 22 March 2024 12:00 (30 minutes)

Available for oral presentation in a session

Session Classification: Open Discussion and Conclusion

Contribution ID: **66** Type: **not specified**

Discussion on Simulations

Friday 22 March 2024 11:30 (30 minutes)

Available for oral presentation in a session

Presenter: VIEIRA, Jorge

Session Classification: Open Discussion and Conclusion

Contribution ID: **67** Type: **not specified**

Laser-driven production of ultra-short high quality positron beams

Thursday 21 March 2024 10:00 (30 minutes)

Available for oral presentation in a session

Presenter: SARRI, Gianluca (Queen's University Belfast)

Session Classification: Beam Delivery System and positron acceleration

Contribution ID: **68** Type: **not specified**

Positron acceleration in plasma wakefields for linear colliders: a review of progress and challenges

Friday 22 March 2024 09:30 (30 minutes)

Available for oral presentation in a session

Presenter: CORDE, Sebastien

Session Classification: Positrons and disruption physics

Contribution ID: **69** Type: **not specified**

Positrons at FACET-II: Status and Potential

Thursday 21 March 2024 14:30 (30 minutes)

Available for oral presentation in a session

Presenter: HOGAN, Mark

Session Classification: Applications of advanced accelerators

Contribution ID: **70** Type: **not specified**

Simulations of Next-Generation Colliders

Wednesday 20 March 2024 15:00 (30 minutes)

Available for oral presentation in a session

Presenter: Dr HUEBL, Axel (Lawrence Berkeley National Laboratory)

Session Classification: Staging

Contribution ID: **71** Type: **not specified**

Hybrid Asymmetric Linear Higgs Factory (HALHF): Updates and Upgrades

Wednesday 20 March 2024 16:00 (30 minutes)

Available for oral presentation in a session

Presenter: D'ARCY, Richard (DESY)

Session Classification: Advanced collider concepts

Contribution ID: **73** Type: **not specified**

Emittance mixing of flat beams in plasma accelerators

Thursday 21 March 2024 09:00 (30 minutes)

Available for oral presentation in a session

Presenter: DIEDERICHS, Severin

Session Classification: Beam Delivery System and positron acceleration

Contribution ID: **74** Type: **not specified**

Advancements in Beam Delivery Systems: CLIC Innovations and Plasma Collider Applications

Thursday 21 March 2024 09:30 (30 minutes)

Available for oral presentation in a session

Presenter: CILENTO, Vera (CERN)

Session Classification: Beam Delivery System and positron acceleration

Contribution ID: **76** Type: **not specified**

Experience with Wakefield Acceleration at SwissFEL

Thursday 21 March 2024 11:00 (30 minutes)

Available for oral presentation in a session

Presenter: ERICSON, Evan (EPFL/PSI)

Session Classification: Structured Wakefield Accelerators

Contribution ID: **77** Type: **not specified**

Beam quality preservation using multi-staged dielectric-lined rectangular waveguides

Thursday 21 March 2024 11:30 (30 minutes)

Available for oral presentation in a session

Presenter: APSIMON, Oznur (University of Manchester (GB))

Session Classification: Structured Wakefield Accelerators

Contribution ID: **78** Type: **not specified**

AWAKE a plasma wakefield accelerator for particle physics

Thursday 21 March 2024 13:30 (30 minutes)

Available for oral presentation in a session

Presenter: TURNER, Marlene (CERN)

Session Classification: Applications of advanced accelerators

Contribution ID: **79** Type: **not specified**

The EuPRAXIA project: a plasma-based accelerator user facility for the next decade

Thursday 21 March 2024 14:00 (30 minutes)

The EuPRAXIA@SPARC_LAB facility is the beam driven pillar of the EuPRAXIA project which is expected to provide by the end of 2028 the first European Research Infrastructure dedicated to demonstrating usability of plasma accelerators delivering high brightness beams up to 1-5 GeV for users.
Among the possible EuPRAXIA@SPARC_LAB applications the realization of a short wavelength Free Electron Laser (FEL) able to provide radiation in the "water window"of the e.m. spectrum for bio-physical investigations is one of its main goals. Another interesting X-ray radiation source based on betatron radiation will be implemented by the end of 2025 in the framework of the PNRR initiatives. In addition the production of high-quality electron beam as the one required to drive an FEL is expected to be also a fundamental milestone towards the realization of a plasma driven future Linear Collider (LC). In addition an intense R&D program towards high repetition rate plasma module is underway.
In this talk we report about the recent progress in the context of the EuPRAXIA collaboration with reference to the possible contribution in the framework of the ALEGRO collaboration.

Available for oral presentation in a session

Presenter: FERRARIO, Massimo

Session Classification: Applications of advanced accelerators

Contribution ID: **81** Type: **not specified**

Plasma based Accelerator research for future collider in China

Thursday 21 March 2024 15:00 (30 minutes)

Available for oral presentation in a session

Presenter: LU, wei (tsinghua university)

Session Classification: Applications of advanced accelerators

Contribution ID: **82** Type: **not specified**

A Tutorial on Particle in Cell simulation of Laser Wakefield Acceleration

Thursday 21 March 2024 16:40 (20 minutes)

Laser Wakefield Acceleration (LWFA) stands as a promising particle acceleration mechanism leading to accelerating gradients orders of magnitude higher than those of conventional methods. Detailed understanding of the nonlinear laser-plasma interaction mechanisms of LWFA at the kinetic scale requires performing Particle in Cell (PIC) simulations.
Although PIC codes exist since several decades, presently there is not much hands-on free online material available to teach how to properly use them specifically to simulate plasma acceleration. To start bridging this gap, a tutorial on Laser Wakefield Acceleration is presented and made available online, to guide future practitioners of LWFA modelling towards setting up and analysing their plasma acceleration simulations through structured and progressive exercises, assisted by explanations and postprocessing scripts.

Available for oral presentation in a session

Yes

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Session Classification: Poster Session

Contribution ID: **83** Type: **not specified**

Discussion on Organisation / Funding

Tuesday 19 March 2024 15:30 (30 minutes)

Session Classification: Welcome Session and Introduction

Contribution ID: **84** Type: **not specified**

Discussion

Wednesday 20 March 2024 17:00 (30 minutes)

Session Classification: Advanced collider concepts

Contribution ID: **85** Type: **not specified**

Optimisation of Quasi-Neutral Lepton Beams using Direct Laser Acceleration

Thursday 21 March 2024 16:40 (20 minutes)

Particle acceleration over a short distance has a vast range of potential acceleration applications. While electron acceleration in plasmas has proven widely successful, accelerating positrons is an ongoing challenge. Positron acceleration is challenging as the accelerating guiding structures for electrons are inadequate to guide positrons. Recently, Direct Laser Acceleration has emerged as a particle acceleration technique which can accelerate both, negatively and positively charged leptons to high energies; however, the accelerated positron beam quality and injection need to be improved. In this work, we optimise the positron beam creation and acceleration by leveraging DLA first to accelerate electrons and form a guiding structure for positrons. The electrons and laser then collide with the target producing pairs from Bethe-Heitler. This optimisation is done by performing Particle-in-Cell simulations using laser parameters available from next-generation laser facilities and exploring different experimental configurations. Preliminary results indicate a threefold increase in produced and accelerated positrons. The collision of these optimised beams can be potentially used for seeding QED cascades.

Available for oral presentation in a session

No

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Co-authors: MARTINEZ, Bertrand; BABJAK, Róbert (GoLP - Group for Lasers and Plasmas); VRANIC, Marija (IST - Lisbon)

Session Classification: Poster Session

Contribution ID: **86** Type: **not specified**

Arbitrary Electromagnetic Wave Packets in Particle in Cell Codes

Thursday 21 March 2024 16:40 (20 minutes)

Particle-in-Cell (PIC) codes commonly employ laser injection algorithms rooted in analytical solutions of the paraxial wave equation under the slowly-varying envelope approximation. These algorithms, while computationally efficient, are tailored to lasers with transverse spot sizes and temporal durations significantly larger than their respective wavelengths and periods. Consequently, they encounter limitations when representing the field structure of ultra-short or ultra-tightly focused laser pulses, crucial for applications in ultra-high intensity physics.

Here, we introduce a groundbreaking algorithm for the injection of electromagnetic wave packets in PIC codes that precisely satisfies Maxwell's Equations without resorting to any approximations. The algorithm, applicable to 2D and 3D full-scale simulations, as well as cylindrical coordinates simulations with Fourier decomposition along the azimuthal direction, has been successfully implemented in OSIRIS and is readily adaptable to any other PIC code.

An inherent feature of this algorithm is its capability for the continuous injection of laser fields from any simulation boundary, enabling the usage of smaller simulation domains. Furthermore, we provide illustrative examples of its practical applications, such as leveraging lasers with spatiotemporal couplings to excite plasma wake fields with controllable phase velocity and the accurate modelling of wave packets with realistic spectra.

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No

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All-optical induced twist without angular momentum via local pump depletion

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Angular momentum transfer in nonlinear laser-plasma interactions, accompanied by strong axial magnetic field generation (Tesla to kilo-Tesla) [1-2], can significantly influence the dynamics during laser-driven particle acceleration. Axial magnetic field generation is typically identified in systems using lasers with angular momentum, such as circularly polarized lasers [1] and lasers with orbital angular momentum [2]. We demonstrate a novel mechanism for angular momentum transfer with a laser that lacks this characteristic. The mechanism is based on the conservation of canonical momentum during the laser depletion of an ultra-intense, azimuthally polarized laser pulse in underdense plasma. During this process, a strong axial magnetic field (˜2 kT) is generated within a nonlinear wakefield in the bubble regime. Our findings are supported by analytical considerations and three-dimensional particle-in-cell simulations with OSIRIS [3].

[1] Z. Najmudin et al., Phys. Rev. Lett. 87, 215004 (2001).

[2] Longman and R. Fedosejevs, Phys. Rev. Research 3, 043180 (2021).

[3] R. A. Fonseca et al., In Computational Science—ICCS 2002, pages 342–351. Springer, 2002.

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Yes

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Is Attosecond Pulse Generation Achievable at ELI Beamline Facilities through the Flying Mirror Mechanism?

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The allure of attosecond pulses, which unravel electron behavior in atoms and find diverse applications across ultrafast phenomena, nuclear physics, and astrophysics, have captivated scientists in this field. The present investigation delves into the feasibility of generating attosecond pulses utilizing the Flying Mirror Mechanism at ELI Beamline Facilities. Achieving optimal reflection from the flying mirror necessitates a laser system of high energy and short duration coupled with sufficient plasma density. This study analyzed four ELI lasers, considering stable mirror conditions within the bubble regime and reflection coefficients. Our findings highlight the L1 ALLEGRA laser as exceptionally promising for generating attosecond pulses via the flying mirror mechanism in modern laboratories. By aligning parameters within the bubble regime using the L1 ALLEGRA laser, a stable mirror configuration was achievable, facilitating attosecond pulse generation upon reflection. Osiris simulation results demonstrate precise alignment of maximum reflectivity along the mirror central axis. The resulting attosecond pulse, lasting in order of 100 attoseconds, falls within the extreme ultraviolet (XUV) range, underscoring the potential for attosecond pulse generation in modern laboratories and its applications.

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