6th European Advanced Accelerator Concepts workshop

Report of Contributions

https://agenda.infn.it/e/eaac2023

Contribution ID: **364** Type: **Invited talk**

Free electron lasers driven by plasma accelerators: status and near-term perspectives

Monday, 18 September 2023 09:20 (40 minutes)

In an echo of the cluster of breakthrough laser wakefield acceleration experiments in the mid-2000's, there have been multiple milestone experiments in the past few years demonstrating free electron lasers (FELs) powered by plasma-based accelerators. The smallest lasing wavelength was observed by the SIOM group, 27 nanometers, but more than an order of magnitude in photon energy still remains to close the gap between plasma-powered FELs and conventional X-ray FEL facilities. Two of the greatest remaining challenges to achieve application readiness are the reduction of the electron beam energy spread, and operational stability. In this talk, the state-of-the-art in plasma-powered FELs will be described along with ongoing efforts to address these remaining challenges. In addition, new theoretical progress will be presented related to the ion channel laser: a plasma-based alternative to the free electron laser.

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Presenter: LITOS, Michael (University of Colorado Boulder)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **423** Type: **Invited talk**

New ideas for high beam quality from plasmas for FELs

Monday, 18 September 2023 10:00 (40 minutes)

Plasma accelerators offer orders of magnitude more rapid acceleration, and in turn can be used to reduce the size of accelerators significantly. The experimentally obtained electron beam quality closes the gap to conventional linacs and has now reached levels where first free-electron lasing becomes possible. However, advanced plasma wakefield accelerators do also open up the possibility for generation of electron beams orders of magnitude brighter than state-of-the-art. Orders of magnitude brighter beams from orders of magnitude more compact accelerators would have profound impact on applications such as free-electron-lasers. Progress on conceptual approaches, simulation and theory, and experimental realization, is presented.

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Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **369** Type: **Invited talk**

Advancement in plasma sources towards high repetition rate operation

Monday, 18 September 2023 11:00 (30 minutes)

Laser wakefield electron acceleration has attracted significant attention over the last decades, due to its ability to generate acceleration gradients orders of magnitude greater than those in conventional accelerators. However, in order to realise a multi-GeV laser-driven plasma accelerator stage, the laser pulse must remain focussed through tens of centimetres of low-density plasma. Such lengths are orders of magnitude greater than the Rayleigh range, and some form of waveguiding is required. Particularly promising are hydrodynamic optical-field-ionized (HOFI) plasma channels, where a plasma channel is formed by the hydrodynamic expansion of a plasma column formed by OFI.

Thanks to their free-standing nature, HOFI channels appear as a suitable option for the high-repetition rate operation of future multi-GeV plasma accelerator stages. We present experimental results demonstrating that HOFI channels can be stably generated at kHz-scale pulse repetition rates. Further, we experimentally demonstrate the stable generation of HOFI channels at a mean pulse repetition rate of 0.4kHz for a period of 6.5hours without degradation of the channel properties due to the effects of heating or damage to the laser optics. These developments, in combination with novel schemes such as Plasma-Modulated Plasma Accelerator (P-MoPA), open a viable route towards an all-optical, high-repetition-rate accelerator stages.

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Presenter: Dr ALEJO, Aaron (IGFAE, USC)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **378** Type: **Invited talk**

Modeling a novel laser-driven acceleration scheme using particle-in-cell simulations on exascale-class supercomputers

Monday, 18 September 2023 11:30 (30 minutes)

Laser WakeField Acceleration (LWFA) can accelerate ultra-short electron bunches up to very high energies (from hundreds of MeV to several GeV). However, LWFA usually does not provide enough charge for most of the foreseen applications, especially if high beam quality and high energies are also required.
Recently, we have devised a novel injection scheme consisting of a solid target coupled to a gas jet to accelerate substantially more charge than conventional injection schemes, while preserving at the same time the quality of the beam. In 2022 we validated this concept with proof-of-principle experiments at the LOA (France), and with a large-scale Particle-In-Cell simulation campaign, carried out with the open-source WarpX code[1,2]. In this contribution, we will summarize the insights gained from these simulations, carried out on the most powerful supercomputers in the world, including Summit (OLCF, #5 in the Top500), Fugaku (Riken, #2 in the Top500), and Frontier (OLCF, #1 in the Top500). A work describing the technical challenges that we addressed to make these simulations possible was awarded the Gordon Bell prize in 2022 [3].

1. https://ecp-warpx.github.io/
2. A.Myers et al. Parallel Computing 2021
3. L.Fedeli et al. 2022 SC22 IEEE Computer Society, 2022

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Presenter: VINCENTI, Henri

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **360** Type: **Invited talk**

On the Confluence of Data-Driven Techniques and Laser-Plasma Acceleration

Monday, 18 September 2023 12:00 (30 minutes)

Over the past several decades, the domain of laser-plasma acceleration has witnessed remarkable progress, largely credited to the escalating potency and availability of high-power lasers. Unlike the earlier phases of research where investigations were primarily confined to singular experiments with limited parameter probing, today's experiments and simulations afford exhaustive data harvesting. Consequently, the community is increasingly leveraging data-driven techniques to augment both understanding and control of laser-based accelerators.

This evolution can be systematically understood through three intertwined phases: Firstly, as an essential foundational step, research groups are mandated to institute cohesive data acquisition and management systems, ensuring the efficient collation and utilization of emergent data. Following this, the availability of data paves the way for the application of standardized machine learning techniques. The final, holistic phase involves deployment of bespoke machine learning solutions, which are adapted to the requirements and nuances of laser-plasma acceleration.

I will present two recent examples from the Centre for Advanced Laser Applications in Garching for such "tailor-made" solutions. Specifically, I will delve into Bayesian for managing a laser-powered accelerator, and introduce the FALCON technique for measuring spatio-temporal couplings in high-intensity lasers. Lastly, I will give an outlook on future developments towards "intelligent" accelerator facilities.

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Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **182** Type: **Oral contribution**

Energy conserving theory of plasma blowout

Monday, 18 September 2023 16:25 (20 minutes)

We present an energy-conserving theory of plasma wakefield in the strongly-nonlinear (“bubble” or “blowout”) regime. Previous phenomenological models [W. Lu et al. PRL 96, 165002 (2006)] were based on using the electron motion equations in plasma and assumptions about the electron sheath on the bubble’s boundary. However, they often included fitting parameters and, in general, provided an unsatisfactory fit to results of particle-in-cell (PIC) simulations in the case of smaller size bubbles. In the new theory, we derive a different equation for the boundary of the bubble starting from the energy conservation law in a plasma wakefield. The derived equation does not contain fitting parameters and accurately describes the boundary of the bubble and the accelerating field in it in a wide range of driver parameters, including the case of small transverse sizes of the bubble. We develop a way to self-consistently describe the excitation of the bubble by an electron driver based on the new theory. We also show that the new model gives similar results as the previous models in the limit of a large bubble size. The predictions of the new model are verified by 3D PIC simulations and show very good correspondence to them.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **185** Type: **Oral contribution**

The ZEUS laser user facility

Monday, 18 September 2023 16:25 (20 minutes)

The Zettawatt Equivalent Ultrashort pulse laser System (ZEUS) is a National Science Foundation-funded user facility housed at the University of Michigan. The laser will be capable of producing 3-Petawatt pulses, or may be split to create synchronized 2.5-PW and 0.5-PW pulses. The first user experiments are due to begin in late 2023. This presentation will describe the different capabilities of the facility available to users in each of the three target areas and the current laser status. Target Area 1 has a very long focal-length optic, ideal for laser wakefield acceleration (LWFA) of electron beams, and can accommodate dual pulse, including colliding beam experiments. Target Area 2 houses short focal-length optics and a dual plasma mirror set-up to achieve the highest intensity and best pre-pulse contrast. Target Area 3 accommodates up to 0.5-PW pulses, but at a higher repetition rate of 1-5 Hz burst modes and is suited to LWFA and betatron x-ray studies and applications. There will be a modest long-pulse capability available for pump-probe experiments.

The ZEUS facility construction and operation is supported by the National Science Foundation under award 1935950 and 2126181, as well as by the AFOSR grant number FA9550-22-1-0118 and the University of Michigan.

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Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **216** Type: **Oral contribution**

Seeded FEL lasing of the COXINEL beamline driven by the HZDR plasma accelerator

Monday, 18 September 2023 16:25 (20 minutes)

Laser Plasma Accelerators (LPAs), harnessing gigavolt-per-centimeter accelerating fields, can generate high peak current, low emittance and GeV class electron beams paving the way for the realization of future compact free-electron lasers (FELs). Here, we report on the commissioning of the COXINEL beamline driven by the HZDR plasma accelerator and experimental demonstration of FEL lasing at 270 nm in a seeded configuration[1]. Control over the radiation wavelength is achieved with an improved bandwidth stability. Furthermore, the appearance of interference fringes, resulting from the interaction between the phase-locked emitted radiation and the seed, confirms longitudinal coherence, representing a key feature of such a seeded FEL. These results are cross-checked with simulations, ELEGANT for beam optics and GENESIS for FEL radiation. We anticipate a navigable pathway toward smaller-scale free-electron lasers at extreme ultra-violet wavelengths.

[1] M. Labat, A. Irman, et al, Nat. Photonics 17, 150(2023)

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Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **253** Type: **Oral contribution**

Progress towards resonantly-driven, high-repetition-rate GeV-scale plasma accelerators

Monday, 18 September 2023 16:25 (20 minutes)

We describe our programme to develop GeV-scale laser-driven plasma accelerators operating at pulse repetition rates in the kHz range. This is based on two novel approaches.
First is the hydrodynamic optical-field-ionized (HOFI) plasma channel. We describe the operation of HOFI channels, and demonstrate that they can guide relativistically-intense pulses through metre-scale channels with axial densities of order $10^{17}\,\mathrm{cm}^{-3}$, and power attenuation lengths of order $20\,\mathrm{m}^{-1}$.
Second is excitation of the wakefield by a train of short pulses —- or a longer, modulated pulse — which allows the use of novel, efficient, high-repetition-rate lasers, such as thin-disk lasers. We describe the plasma-modulated plasma accelerator (P-MoPA), which has three stages: (i) a modulator, in which a joule-scale, ps-duration pulse is guided in a HOFI channel and is spectrally modulated by the wake driven by a short, low-energy pulse; (ii) a compressor, which converts the spectrally-modulated drive pulse to a train of short pulses; and (iii) a resonantly-driven accelerator stage, also based on a HOFI channel. We outline the operation of P-MoPAs, describe new experimental results demonstrating resonant excitation of plasma wakefields in a HOFI channel, and outline progress of the kilohertz Plasma Accelerator (kPAC) Consortium to demonstrate each of the P-MoPA stages.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **178** Type: **Oral contribution**

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

Monday, 18 September 2023 16:45 (20 minutes)

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

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **272** Type: **Oral contribution**

ELI Beamlines L1 ALLEGRA laser: experience with operation of high energy, 1 kHz, 15 fs OPCPA based system for user experiments

Monday, 18 September 2023 16:45 (20 minutes)

L1 ALLEGRA system has been regularly and reliably operating for user experiments offering over 20 weeks of user beamtime per year. The laser generates 15 fs pulses with energy of up to 50 mJ and repetition rate of 1 kHz. Since the laser is completely based on OPCPA pumped by 3 ps pulses, it has inherently very high picosecond temporal contrast. The output pulse energy is limited by the availability of the suitable high energy pump laser. For this purpose we are currently developing a multipass Yb:YAG thin disk amplifier which should enable us to increase the final pulse energy of the L1 Allegra laser to 100 mJ at 1kHz, providing up to 6.6 TW peak power.
We will also present newly developed FSYNC laser with 10 mJ energy that is synchronized with L1 Allegra and can provide pulses with adjustable delay in the second beam for pump-probe type experiments.

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Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **303** Type: **Oral contribution**

EuPRAXIA Advanced Photon Source

Monday, 18 September 2023 16:45 (20 minutes)

In this talk, we would like to introduce the EuPRAXIA Advanced Photon Source (EuAPS), a betatron-based X-ray source for users, devoted to several applications. In particular, we would like to focus on the layout, the expected properties of the source, and its role as one of the fundamental bricks of the EuPRAXIA project.

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Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **339** Type: **Oral contribution**

Accurate electron beam phase-space theory for ionization injection schemes

Monday, 18 September 2023 16:45 (20 minutes)

After the introduction of high-quality electron beam generation methods as two-color [1] or the Resonant Multi Pulse Ionization injection (ReMPI) [2], the theory of thermal emittance by C. Schroeder et al. [3] has been used to predict the beam normalized emittance obtainable with those schemes. We [4] recast and extend such a theory, including both higher order terms in the polinomial laser field expansion and corrections due to the onset of saturation effects within a single cycle. Also, a very accurate model for predicting the cycle averaged distribution of the extracted electrons, including saturation and multi-process events, is proposed and tested. The accurate prediction of the beam phase-space can be implemented e.g. in laser-envelope or hybrid PIC/fluid codes, to correctly mimic the cycle-averaged momentum distribution without the need of resolving the intra-cycle dynamics. We introduce further spatial averaging, obtaining expressions for the whole-beam emittance fitting with simulations in a saturated regime, too.

References
[1] L. L. Yu et al., Phys. Rev. Lett. 112 125001 (2014)
[2] P. Tomassini et al., PoP 24 103120 (2017)
[3] CB Schroeder et al., PRAB, 17 101301, 2014
[4] P. Tomassini et al., HPLS 10 10.1017 (2022)

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **228** Type: **Oral contribution**

A Lattice Boltzmann approach to plasma simulation in the context of wakefield acceleration

Monday, 18 September 2023 17:05 (20 minutes)

In this talk, we present a new and efficient methodology for the simulation of fluid models in the framework of wakefield acceleration (WFA). This technique hinges on the Lattice Boltzmann Method (LBM), a popular numerical scheme used in several contexts of computational fluid dynamics and beyond, and couples it with a finite difference time domain for the solution of electromagnetic fields. We present the main features of the LBM, how the method can be adapted for the simulation of the fluid equations in the WFA, and show its core capabilities. Lastly, we discuss some performances and its numerical advantages over the state of the art in the context of WFA computer simulations.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **251** Type: **Oral contribution**

Observation of resonant wakefield excitation by pulse trains guided in long plasma channels

Monday, 18 September 2023 17:05 (20 minutes)

The plasma-modulated plasma accelerator (P-MoPA) scheme [1, 2] provides a route for GeV-scale accelerators operating at kilohertz-repetition-rates driven by picosecond-duration laser pulses. In P-MoPa, trains of pulses are generated from a long, high-energy drive pulse via the spectral modulation caused by a low amplitude wakefield driven by a leading short, low-energy seed pulse. Our simulations, discussed elsewhere in this conference, show that temporal compression of the modulated drive pulse yields a pulse train that can resonantly drive a wakefield, allowing for acceleration of a test electron bunch to 1.5 GeV in a 100 mm long plasma channel [2,3].
We present the results of recent experiments with Astra-Gemini at the Central Laser Facility, UK for parameters relevant to the accelerator stage of the P-MoPA scheme. We demonstrate guiding of 2.5 J pulse trains in a 100 mm long plasma channel. Measurements of the spectrum of the transmitted laser pulse train show that a wakefield was resonantly excited in the plasma channel. We compare these experimental results with numerical simulations.
[1] S.M. Hooker et al., J. Phys. B, 47, 234003 (2014)
[2] O. Jakobsson et al., PRL, 127, 184801 (2021)
[3] J. J. van de Wetering et al., Phys E., 108,015204 (2023)

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **275** Type: **Oral contribution**

Amplitude Roadmap for high average power ultraintense laser for plasma accelration

Monday, 18 September 2023 17:05 (20 minutes)

We will present the latest results obtained on ELI ALPS (700TW @ 10Hz) which is up to now the TiSa ultrashort system wih the highest average power.
We will then show the main developments that we are following to increase the average power of Petawatt systems. We will mainly focus on the different solutions proposed to overcome the thermal issues induced by the increase of the repetition rate (>100Hz) : cooling of the TiSa crystals, gratings..
We will also present the status of the development for our 10J/200Hz pump laser that could be use for these high energy, high repetition rate TiSa laser.

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Presenter: FALCOZ, Franck

Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **281** Type: **Oral contribution**

Advanced bandwidth control of an all-optical Compton source

Monday, 18 September 2023 17:05 (20 minutes)

Bright, high-energy X-ray beam sources with narrow bandwidths and tunable energies hold great potential for widespread use in a variety of novel applications as alternatives to large-scale and costly radiation sources. Inverse Compton scattering sources based on electron beams from laser-plasma accelerators represent a promising candidate for increasing availability. However, in practice these sources are currently limited to bandwidths of tens of percent, making them unsuitable for many applications. We present results of a proof-of-principle experiment designed to mitigate these restrictions using an active plasma lens to tailor the electron-photon interaction, allowing for reduced bandwidth and tunability of the generated radiation. In the experiments, tunability of the central X-ray energy in the range from 34 keV to 81 keV was demonstrated by changing the focusing strength of the plasma lens. At the same time, bunch shaping by the plasma lens reduced the bandwidth of the produced photon beams. Our results closely follow theory, highlighting the potential of this technique as a future small-scale high-quality X-ray source that provides bandwidth and X-ray energy control.

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Presenter: MEISEL, Martin

Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **207** Type: **Oral contribution**

High precision probing of laser-solid interaction with LWFA-generated electron beams

Monday, 18 September 2023 17:25 (20 minutes)

The collision of ultra-intense laser pulses with solids may initiate processes like current filamentation instability (CFI) and target normal sheath acceleration (TNSA). Studying the interplay of these processes is crucial, as they play an important role in novel particle accelerator concepts and are believed to be present in astrophysical events.

In the scope of this work, laser-solid interaction has been studied with unprecedentedly high temporal and spatial precision. For that, we use electron beams from a laser-plasma accelerator as probe beams. Their inherently small size and duration allow to locally probe the electromagnetic fields generated in the interaction and to distinguish the TNSA and plasma instabilities due to the difference in their effects on the probe beam. In our study we were able to observe expanding surface charge clouds which are responsible for TNSA, as well as strong localized electromagnetic fields, which may be attributed to CFI.

These experimental studies are accompanied by involved simulations, we briefly discuss the numerical approaches and results.

Our work establishes a very important application for laser-accelerated electron beams, particularly for the research on laser-solid interaction, and thus opens new possibilities for understanding important processes in plasma accelerators as well as astrophysical phenomena.

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Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **255** Type: **Oral contribution**

Energy Depletion and Re-Acceleration of Driver Electrons in a Plasma-Wakefield Accelerator

Monday, 18 September 2023 17:25 (20 minutes)

For plasma-wakefield accelerators to fulfil their potential for cost effectiveness and reduced environmental footprint, it is essential that their energy-transfer efficiency be maximized. A key aspect of this efficiency is the near-complete transfer of energy, or depletion, from the driver electrons to the plasma wake. Achieving full depletion is limited by the process of re-acceleration, which occurs when the driver electrons decelerate to non-relativistic energies, slipping backwards into the accelerating phase of the wakefield and being subsequently re-accelerated. Such re-acceleration is observed here for the first time. At this re-acceleration limit, we measure a beam driver depositing (56 ± 5)% of its energy into a 195-mm-long plasma. Combining this driver-to-plasma efficiency with previously measured plasma-to-beam and expected wall-plug-to-driver efficiencies, our result shows that plasma-wakefield accelerators can in principle reach or even exceed the energy-transfer efficiency of conventional accelerators.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **280** Type: **Oral contribution**

"Bivoj / DiPOLE"as a pump source for high repetition rate laser particle accelerators

Monday, 18 September 2023 17:25 (20 minutes)

The laser system "Bivoj"built on "DiPOLE"cryogenically cooled multi-slab technology (150J / 10Hz / 10ns) has been enhanced by a conversion module for second harmonic frequency generation (95J/10Hz @515nm) with 79% conversion efficiency. This allows the laser to be used as a pump source for short pulse beamlines (CPA or OPCPA) that can be used for efficient particle acceleration. Achieving such high conversion efficiency at high average power laser system was allowed by successful mitigation of depolarization effects, which inevitably occur in such types of laser amplifiers and significantly decrease polarization homogeneity. Additionally, a recent incorporation of large aperture high average power Faraday isolator into the "Bivoj"chain allows use of the laser for direct particle generation experiments.

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Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **335** Type: **Oral contribution**

Optimised density tailoring for dephasing mitigation in laser wakefield accelerators

Monday, 18 September 2023 17:25 (20 minutes)

One of the key effects in laser wakefield acceleration is dephasing, whereby the electron beam outruns the accelerating structure created by the sub-luminal driving laser pulse. This process reduces the effectiveness of the accelerator and limits the maximum electron energy achievable with a given laser pulse. Therefore, mitigating dephasing is important in maximising the energy gain and efficiency of laser wakefield accelerators.

Several previous works have explored tailoring of the plasma density profile of a laser-wakefield accelerator such that the accelerating electron bunch remains in the ideal accelerating phase. In the non-linear regime, analytical calculation of optimal density profiles is complicated by the evolution of the laser pulse and the loss of validity of simplified models. Nevertheless, numerical, and experimental work have shown the promise of density tailoring if properly tuned.

In this work, I will present a methodology for optimising dephasing mitigation in quasi-3D simulations, and show results of applying this technique for different setups.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **271** Type: **Oral contribution**

Start-to-end simulations of HOFI waveguides

Monday, 18 September 2023 17:45 (20 minutes)

To enable the generation of high-quality electron beams from laser plasma accelerators, understanding and tailoring of plasma sources is of critical importance. With limited experimental setups and measurement options, hydrodynamic simulations can be used to study their ns- to ms-evolution in detail and evaluate new concepts.

In recent years, hydrodynamic optical-field-ionized (HOFI) channels have emerged as a promising technique to create laser waveguides suitable for guiding tightly focused laser pulses in a plasma, as needed for laser-plasma accelerators. While experimental advances in HOFI channels continue to be made, the underlying mechanisms and the roles of the main parameters remain largely unexplored.

We propose a start-to-end simulation pipeline describing the formation of HOFI channels, from laser ionization to hydrodynamic expansion, as well as the resulting laser guiding. The approach is benchmarked against experimental measurements and allows us to explore their underlying physics and tunability. HOFI channels are shown to feature excellent guiding properties over a wide range of parameters, making them a promising and tunable waveguide option for laser-plasma accelerators.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **301** Type: **Oral contribution**

Design of direct diode pumped amplification stages based on Tm ceramics for kHz rep-rate, kW average power lasers: Design issues and material characterization

Monday, 18 September 2023 17:45 (20 minutes)

Scaling current ultrashort/ultraintense laser technology, based on Nd-pumped TiSa amplifiers, to the rep-rate and average power required for future laser-driven electron accelerators is ultimately hindered by wall plug efficiency. One of the paths currently pursued to overcome the limits of TiSa technology is based on the usage of long ($\sim$ ms) upper state lifetime materials that can be directly pumped using (quasi-)CW diode pumping. Energy is extracted over multiple laser pulses, in what is called a *Multi-Pulse Extraction (MPE)* scheme, at a rep rate higher than the inverse of the active material lifetime. Thulium doped hosts are among these materials, while at the same time featuring large bandwidths, and thus allow amplification of ultrashort pulses, dramatically increasing, at the same time, wall-plug efficiency.
Here we report on the design and development of a kW-class average power, J-level laser system, featuring amplification stages based on Tm-doped sesquioxides ceramics in an active mirror configuration. After a quick look at the overall system design, we will focus, in particular, on issues related to the diode pump characterization and pumping geometry optimization, as well as on the experimental characterization of the Tm ceramics affecting the MPE dynamics.

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Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **309** Type: **Oral contribution**

Experimental Observation of Beam-Plasma Resonance Detuning due to Motion of Ions

Monday, 18 September 2023 17:45 (20 minutes)

In this contribution we discuss experimental results that show how plasma ion motion affects a proton drive bunch train and wakefields using the AWAKE experiment. Plasma ions move due to the ponderomotive force of transverse wakefields and lead to an average ion density decrease in the region around the axis. This, in turn, leads to a shift in the local plasma frequency, resulting in a sharp decrease in the wakefield amplitude along the bunch, which we observe by measuring a clear beam tail in the experimentally obtained proton bunch density images. The same effect is also present in particle in cell simulations. We performed experiments using Helium (A=4), Argon (A=40) and Xenon (A=131) plasma and show that the observed effect scales as expected with ion mass (less for heavier ions) and wakefield amplitude (more for higher amplitudes). The results we present are important for any wakefield accelerator that is driven using long or multiple drivers. These will work best with sufficiently heavy ions to avoid their motion. Additionally, we detune a resonantly-driven beam-plasma system. This is an important validation of the idea of suppressing the beam-hose instability using ion motion, which is based on the same physics concept.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **330** Type: **Oral contribution**

Verification Simulation Studies for FLASH therapy Ultra-High-Dose Rate (UHDR) Beams

Monday, 18 September 2023 17:45 (20 minutes)

The main results of the electron pulse and ultra-high-dose-rate (UHDR) parameter verification simulation studies are reported for the FLASH mode radiobiological treatment. There were reproduced the percentage depth dose (PDD) at energies: 5, 7, 15, 25, 50 and 100 MeV, to Polymethyl-methacrylate (PMMA) and to water fantom vs the penetration depth. Additionally, the PDD transverse profile was simulated for the above energies and with various size applicators, delivering the beam to the fantom. Pencil mode beam size has been achieved with the optimum applicator geometry.
Simulations were, also, performed for various materials, PMMA, Al, Cu and Stainless Steel of the applicators, leading to the best material for the FLASH therapy. Beam distribution plots are presented vs the beam energy, the fantom material and applicator geometry.
The results show that the system can provide UHDR irradiation satisfying the FLASH requirements with very good performance in terms of the beam profile flatness for any size of the fields, depending, mainly, on the linear accelerator beam stability.

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Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **181** Type: **Oral contribution**

Transverse envelope dynamics of beam slices in a uniform charged ellipsoidal model of the plasma bubble regime

Monday, 18 September 2023 18:05 (20 minutes)

We consider a relativistic witness electron bunch propagating in an ionized gas background of opposite charge, a simplified configuration similar to the one produced in a capillary discharge where a plasma oscillation has been excited by a driving pulse. We assume in the nonlinear regime, the plasma electrons behind the driver are completely expelled and an ellipsoidal cavity filled with ions is formed. It is justified that the fields are linear in both longitudinal and transverse directions, at least in the region of interest for particle acceleration, as the one produced by a uniform ion distribution within a uniformly charged ellipsoidal distribution. The fields produced by the ions and experienced by a witness electron beam are purely electrostatic, being the ions at rest in the laboratory frame on the time scale of interest and it can be represented with the field distribution produced by a 3D charged ellipsoidal. The energy spread and emittance degradation has been studied by slicing the bunch in an array of cylinders and solving envelope equations for each bunch slice. The properties of transverse envelope and emittance oscillations and energy spread degradation have been analyzed together with the related matching conditions for optimal transport and acceleration.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **206** Type: **Oral contribution**

Enhanced stability of a Free-Electron Laser driven by a plasma beam-driven accelerator and seeded by an external laser beam

Monday, 18 September 2023 18:05 (20 minutes)

Plasma-based accelerators allow to boost the electron beam energy within a few centimeters. Two pioneering experiments [1,2], reporting the observation of self-amplified spontaneous emission (SASE) driven by plasma-accelerated beams, have already demonstrated their potential use for the realization of ultracompact light sources based on free-electron lasers (FELs).
However, the stochastic nature of the SASE process, together with the beam instabilities from the plasma acceleration process, lead to the lack of stability and reproducibility of the generated FEL pulses and may hinder their effective implementation for user purposes.
A proof-of-principle experiment [3], using plasma-accelerated beams seeded by an external laser in the infrared range, has been also implemented. A slightly off-resonance seed laser with respect to the undulator resonance was employed for this experiment, allowing to seed the FEL process with an emission wavelength following the resonant condition set by the undulator and to easily discriminate between the seed and FEL light spectra.
Here, the main results of FEL lasing in this configuration, showing the enhanced pulse energy and stability compared to SASE, are discussed.
[1] W.Wang et al., Nature 95, 516 (2021).
[2] R.Pompili et al., Nature 605, 659 (2022).
[3] M.Galletti et al., Physical Review Letters 129, 234801 (2022).

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **356** Type: **Oral contribution**

Diode Laser Pumps for Advanced Accelerators

Monday, 18 September 2023 18:05 (20 minutes)

Diode laser pumps are a critical technology for advanced accelerators based on plasma acceleration, and essential system components when higher repetition rate operation is needed. They are a significant cost element in larger systems, and there is only a limited number of commercial suppliers who can support the needs of emerging systems and applications.
An overview of progress in research and industry is presented, summarizing status of the technology, focusing on efforts to economically scale peak and average power and to enable new options in plasma acceleration, for example the use of Thulium-doped gain media with its pumping wavelength at 780 nm. Development needs to support the accelerator community will be collected, covering topics such as efforts to lower cost in €/W by raising the diode laser output power, to increase repetition rates to 100 Hz and even up to 1 kHz, to scale TRL of emerging diode laser technologies, to ensure low-failure-rate operation of large systems and to ensure security of supply.

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Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **379** Type: **Oral contribution**

Laser-driven positron sources for applications

Monday, 18 September 2023 18:05 (20 minutes)

Positron annihilation lifetime spectroscopy (PALS) is one of the methods for the non-invasive inspection of materials and identification of small-scale defects. PALS presents several unique advantages when compared to other inspection techniques: it works virtually with any type of material (crystalline and amorphous, organic and inorganic) and it can identify even sub-nanometer defects with concentrations as low as less than a part per million. Laser-generated high-charge electrons can be used with a high-Z converter target to generate positron beams that are suitable for PALS. Unlike the conventional positron sources, these laser-driven positrons can be intrinsically of short duration and can have tuneable energies in the MeV range, which is suitable for high-resolution scanning of a material. Based on our preliminary experimental work at a lower repetition rate and extensive numerical modelling using FLUKA, it is observed that laser-wakefield driven electron beams, produced at a high repetition rate (~ 1kHz) by 10s of mJ laser system, have the potential to drive a high average flux positron source (>10^6 e^+/s) suitable for industrial applications and material science. Positron sources with high average flux, tuneable energy, and a beam duration in the range of 30 -50 ps can be obtained.

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Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **180** Type: **Poster (student)**

Dielectric Assist Accelerating (DAA) structures for compact linear accelerators of low energy particles in hadrontherapy treatments.

Monday, 18 September 2023 19:00 (1h 30m)

Dielectric Assist Accelerating (DAA) structures based on ultralow-loss ceramic are being studied as an alternative to conventional disk-loaded copper cavities. This accelerating structure consists of dielectric disks with irises arranged periodically in metallic structures working under the TM02–𝜋 mode.
Here, the numerical design of an S-band DAA structure for low beta particles, such as protons or carbon ions used for hadrontherapy treatments, is shown. Four dielectrics with different permittivity and loss tangent are studied as well as different particle velocities depending on the energy range.
Through optimization, most of the RF power is stored in the vacuum space near the beam axis, leading to a significant reduction of power loss on the metallic walls. This allows to fabricate cavities with extremely high quality factor over 100 000 and shunt impedance over 300 MΩ/m at room temperature.
During the numerical study, the design optimization has been improved by adjusting some of the cell parameters in order to both increase the shunt impedance and reduce the peak electric field in certain locations of the cavity, which can lead to instabilities in its normal operation. In addition, first multipactor simulations are being carried out, using several coatings to reduce SEY.

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Session Classification: Poster session

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **191** Type: **Poster (student)**

Towards spin-polarised electron beams from a laser-plasma accelerator

Monday, 18 September 2023 19:00 (1h 30m)

Polarised beams are indispensable for many experiments in particle, atomic and nuclear physics where spin-dependent processes are to be studied. Unlike RF accelerators, Laser-Plasma-Accelerators (LPA) are not limited by material breakdown and can therefore support thousand times higher accelerating fields, which make them a promising alternative to conventional accelerators.
The LEAP (Laser Electron Acceleration with Polarisation) project at DESY aims to generate and measure spin-polarised electron beams from a compact LPA for the first time.
Spin-polarised electron beams can be generated from an LPA by employing a pre-polarised plasma source, where hydrogen halide molecules are dissociated by a circularly polarised UV laser pulse. For the subsequent polarisation measurement photon transmission polarimetry will be used due to the expected beam energy of tens of MeVs. The basic concept is to pass circularly polarised gamma rays generated by bremsstrahlung of the longitudinally polarised electrons through a magnetised iron absorber, where the transmission is spin dependent. The transmission asymmetry with respect to the magnetisation direction is proportional to the initial electron polarisation, which can be measured with a calorimeter. This poster provides an overview of the LEAP project, the physics of polarised LPA and experimental progress.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **195** Type: **Poster (student)**

Proton Beam Self-Modulation Instability in a DC Discharge Plasma Source at AWAKE

Monday, 18 September 2023 19:00 (1h 30m)

The Advanced Proton Driven Plasma Wakefield Acceleration Experiment (AWAKE) explores plasma wakefield acceleration of electrons, using a proton bunches as driver. AWAKE requires plasma sources capable of reaching densities of 1 to 10x10^14 cm^-3, and that allow extending the acceleration length from tens to hundreds of meters, beyond the achievable length with the present laser-ionised, rubidium vapor plasma source.
As a possible candidate, a DC discharge plasma source (DPS) was qualified and installed in the AWAKE experiment. The target densities were achieved in three different gases of increasing ion mass: He, Ar and Xe. The applicability of the DPS was assessed by sending the 400 GeV proton bunch through the plasma and observing the development of the self-modulation instability (SMI). The frequency of the micro bunching imposed on the proton bunch by the SMI was measured for three different plasma lengths (3.5, 6.5 and 10 m). The plasma density integrated along the DPS, inferred from that frequency, matches that previously measured by longitudinal interferometry. We discuss the use of the DPS in future runs of the AWAKE experiment.

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Presenter: AMOEDO, Carolina (CERN)

Session Classification: Poster session

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **229** Type: **Poster (participant)**

Integrated beam physics for the laser wakefield accelerator project EARLI

Monday, 18 September 2023 19:00 (1h 30m)

Transition to practical laser wakefield accelerator (LWFA) facilities with users, especially for multi-stage LWFAs, requires significantly improving the electron beam quality. An integrated study of the beam dynamics is presented, from the electron beam creation in the plasma to the target, including magnetic elements of the transport line. The focus is made on high-charge (more than one hundred pC), low energy spread (three percent std), and low emittance beams at 200 MeV from the ionization-induced injection mechanism. A refined multi-parameter optimisation of laser and plasma profiles is performed to ensure the best beam outputs. Then, a compact transport and focusing line, design with TraceWin is proposed to ensure maintaining the beam quality from given constraints. These outcomes are part of the EARLI project, which focuses on designing a stand-alone LWFA for the AWAKE collaboration. An integrated design of EARLI has been obtained with exit beam parameters meetings the AWAKE requirements.

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Presenter: MARINI, Samuel (CEA)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **238** Type: **Poster (student)**

Schemes of Electron Beam Loading in Blowout Regime in Plasma Wakefield Accelerators

Monday, 18 September 2023 19:00 (1h 30m)

Many impressive experimental results in electron acceleration have been achieved using wakefields excited in a plasma. Plasma-wakefield acceleration provides high accelerating gradients and promises compact accelerators of high brightness and high-energy electron beams. Future applications of plasma-wakefield accelerators, in particular, particle colliders and free-electron lasers strongly benefit from or demand low energy spread beams, small emittances, high charge, large transformer ratios, and high-efficiency operation. The simultaneous achievement of these properties requires the formation of plateaus in both the accelerating field for witness bunches and the decelerating fields for driver bunches. Plateau formation is facilitated by controlled beam loading with carefully shaped current profiles. We demonstrate by numerical simulation optimal beam loading conditions in a blowout electron-driven plasma accelerator.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **259** Type: **Poster (student)**

All-optical GeV electron bunch generation in a laser-plasma accelerator via truncated-channel injection

Monday, 18 September 2023 19:00 (1h 30m)

We describe a simple scheme, truncated-channel injection, to inject electrons directly into the wakefield driven by a drive pulse guided by an all-optical plasma channel. We use this approach to generate dark-current-free 1.2 GeV, 4.5% relative energy spread electron bunches with 120 TW laser pulses guided in a 110 mm-long hydrodynamic optical-field-ionized (HOFI) plasma channel. Our experiments and particle-in-cell simulations show that high-quality electron bunches were only obtained when the drive pulse was closely aligned with the channel axis, and was focused close to the density down-ramp formed at the channel entrance. Start-to-end simulations of the channel formation, and electron injection and acceleration show that increasing the channel length to 410mm would yield 3.65 GeV bunches, with a slice energy spread 5e-4. We will also present initial results of a follow-up experiment in which a second, perpendicular HOFI channel was used to enhance the control of injection of electrons into the plasma wave driven in an approximately 40 mm-long HOFI channel.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **264** Type: **Poster (student)**

Generation of high-quality electron beams from trojan horse injection in a compact plasma accelerator powered by laser-accelerated electron beams

Monday, 18 September 2023 19:00 (1h 30m)

Ultrashort high-peak current electron beams generated from laser wakefield acceleration (LWFA) are capable to drive high accelerating gradient plasma wakefield accelerators (PWFAs) operating in high plasma density regime. Implementation of advanced cold-injection schemes in this hybrid platform promises the generation of high brightness electron beams with unprecedented low emittance and energy spread.
Here we report on the realization of plasma photocathode (a.k.a trojan horse) injection using 90 degree geometry in such a compact plasma accelerator consisting of a mixture of hydrogen and helium gas. Electrons from the highest ionization level of helium are released into the wakefield by an auxiliary low intensity laser pulse. Scanning of the laser arrival time shows that the injection only occurs within the first cavity, characterizing this injection scheme. In this proof-of-concept experiment, witness beams with an absolute energy bandwidth as low as 2 MeV (full-width at half-maximum) peaked at 140 MeV were obtained at divergence of only 0.4 mrad (root-mean-square). Further post-acceleration of such a witness beam, i.e elongating the PWFA stage close to the depletion distance of the driver in future work, would result to projected relative energy spread in per mille level required for beam-quality-demanding light source applications.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **269** Type: **Poster (participant)**

FEL performance of the APPLE-X undulators for the EuPRAXIA@SPARC_LAB AQUA beamline

Monday, 18 September 2023 19:00 (1h 30m)

The Free-Electron Laser facility of the EuPRAXIA@SPARC_LAB infrastructure is driven by an electron beam with 1 GeV energy, produced by an X-band normal conducting LINAC followed by a plasma wakefield acceleration stage.
The AQUA beamline aims at delivering variable polarization photons in the 3-4 nm wavelength range by means of out-of-vacuum APPLE-X permanent magnet undulators with 18 mm period length. The main radiator is composed by an array of ten APPLE-X 2m long modules.
The current AQUA design is investigated and discussed taking into account effects on the FEL performance both from realistic undulator magnetic errors and from modelling of the resistive wall wakefields in the foreseen vacuum chamber.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **276** Type: **Poster (student)**

Beam Dynamics Simulation of a High Brightness, High Repetition Rate RF C-band Photoinjector for Future EuPRAXIA@SPARC_LAB Upgrade

Monday, 18 September 2023 19:00 (1h 30m)

High-brightness RF photo-injectors are crucial for generating high peak current and low transverse emittance electron beams, which are necessary for driving plasma Wake-field acceleration in advanced accelerator concepts and novel radiation sources. To enhance the EuPRAXIA@SPARC_LAB photo-injector for future upgrades, it is essential to investigate and assess the feasibility of achieving higher charge and multi-bunch working points, commonly referred to as the "comb configuration" for particle-driven Wake-field acceleration. A solution to reduce the photo-injector's footprint while preserving beam quality and brightness is to implement a C-band injector operating at 5.712 GHz. Evaluating the possibility of achieving a working point within the velocity bunching acceleration scheme is critical, as this will determine the degree of compression achievable with a full C-band injector. Start-to-end beam dynamics simulations will be conducted to identify the optimum configuration for the C-band photo-injector dedicated to particle-driven plasma-based acceleration.

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Session Classification: Poster session

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **277** Type: **Poster (student)**

Very High Energy Electrons with high charge and moderate energy spread from laser- wakefield acceleration

Monday, 18 September 2023 19:00 (1h 30m)

The capability to sustain high accelerating gradients ($\sim$ 100s GV/m) in plasmas leads to electron bunches at GeV-scale energies in short distances, making Laser-Plasma Acceleration (LPA) a promising approach to high gradient particle accelerators. Among injection schemes, ionization injection is one of the most practical with outstanding numerical results (see ReMPI acceleration).

An intriguing application of LPA is in the context of *Very High Energy Electrons* radiotherapy (VHEE-RT). In a recent work we explored the use of laser-driven electrons, with typical dose per shot ~ 0.1 Gy and high peak dose rate $\sim 10^{12} - 10^{13}$ Gy/s, as an effective approach to VHEE-RT, with energy range $\sim 100 - 250$ MeV to limit lateral dose spread.

Spectral features and quality of typical RT bunches affect dose deposition: these can be improved usually at the cost of bunch charge. Here we propose a laser-driven plasma "bubble" acceleration scheme of 115 pC, ionization-injected bunch at $\mathcal{E} = 220$ MeV with $\sigma_{\mathcal{E}} = 5.6\%$, providing more refined electrons for VHEE-RT. A tailored downramp is shown to be needed to prevent emittance growth. Moreover we show that full-PIC results are well reproduced by a model based on beam envelope equation, solved with a standard Runge-Kutta method.

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Session Classification: Poster session

Track Classification: WG3: Theory and simulations

Contribution ID: **278** Type: **Poster (student)**

Measurement of the timing-jitter effects on a beam-driven plasma wakefield accelerator

Monday, 18 September 2023 19:00 (1h 30m)

Plasma wakefield acceleration is nowadays very attractive in terms of accelerating gradient, able to overcome conventional accelerators by orders of magnitude. However, this poses very demanding requirements on the accelerator stability to avoid large instabilities on the final beam energy. In this study we analyze the correlation between the driver-witness distance jitter (due to the RF timing jitter) and the witness energy gain in a plasma wakefield accelerator stage. Experimental measurements are reported using electro-optical sampling diagnostics, with which we correlate the distance between the driver and witness beams before the plasma accelerator stage. The results show a clear correlation due to such a distance jitter highlighting the contribution coming from the RF compression.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **287** Type: **Poster (student)**

Experimental parameters for plasma wakefield acceleration in a narrow plasma channel

Monday, 18 September 2023 19:00 (1h 30m)

Recent theoretical advancements propose multiple positron acceleration schemes in plasma wakefield acceleration (PWFA). One of the most promising ideas involves the creation of an electron-driven blowout wake within a finite-radius pre-ionized plasma column. This leads to the formation of an elongated region of sheath electrons at the closing of the first wake period capable of accelerating positrons while simultaneously providing a transverse focusing force. Additionally, the proposed scheme improves the stability of the drive electron beam, making it interesting as a potential means of suppressing instabilities. We present an experimental opportunity to explore the narrow channel PWFA at the Facility for Advanced Accelerator Experimental Tests II (FACET-II): the E333 experiment. As a pivotal first step towards achieving positron acceleration in PWFA, we have planned a precursor experiment utilizing only electrons to study the physics of the narrow plasma PWFA scheme. The experiment will use a low-charge witness electron beam to study the longitudinal and the traverse wakefields in the sheath closure region, where a positron bunch would ideally be loaded. We outline the feasible experimental parameters, including beam and ionization laser parameters, along with the required optics for the experiment. Comprehensive simulations are used to detail our experimental plan.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **292** Type: **Poster (student)**

High Resolution Radiography for Inertial Confinement Fusion Fuel Capsule Target Metrology from Laser-Plasma Acceleration based X-ray Sources

Monday, 18 September 2023 19:00 (1h 30m)

The goal of this work is to use Laser Wakefield Acceleration (LWFA) based X-ray sources to develop a diagnostic capable of improved target metrology for Inertial Confinement Fusion (ICF) fuel capsules. We aim to develop a sub-ps, sub-10 micron X-ray source, which is capable not only of imaging ICF fuel capsules with high resolution, but could additionally be deployed for dynamic radiography of High Energy Density Science (HEDS) phenomena. Using the Self-Modulated LWFA X-ray sources at the Jupiter Laser Facility (LLNL), we were able to develop radiography based tools to calculate the spatial resolution of X-ray sources. A Fresnel-diffraction based code is used for straight edge radiographs, and a modified X-ray ray tracing code for curved objects. Here, we present on the results of a Texas Petawatt experiment, where 2-3 GeV generated X-rays were used to capture radiographs of a 400 micron radius Tungsten sphere, and compare spatial and spectral data from self-injection and nanoparticle injection mechanisms. We will discuss preliminary results using X-ray Phase Contrast Imaging radiography to image ICF fuel capsules at the Advanced Laser Light Source, part of a demonstration of current LWFA application capabilities which will be compared to industrial methods.

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Session Classification: Poster session

Track Classification: WG5: Applications

Contribution ID: **293** Type: **Poster (participant)**

Double pulse generator for AWAKE scalable discharge plasma source

Monday, 18 September 2023 19:00 (1h 30m)

High-voltage pulsed discharges can produce suitable plasma for wakefield particle acceleration experiments, such as the AWAKE. Using two successive voltage pulses, the first for plasma ignition (up to 60kV of ignition voltage with around 20A of plasma current) followed by a second pulse (currents up to 600A) for plasma heating, it is possible, by taking advantage of the low impedance state created by the first pulse, to effectively obtain a highly reproducible plasma lasting tens of microseconds. Length scalability is achievable by adding multiple plasma modules in series (sharing electrodes), and by using a magnetic circuit for current balancing between the modules.
A discharge plasma source, based on this principle was installed in the AWAKE experiment producing over 21 thousand plasma discharges and tested with a double-plasma set-up (3.5 + 6.5m) using two pulse generators and a shared cathode. It was tested as well with different single plasma loads: three different gases (Ar, Xe, and He) and three different plasma lengths (3.5, 6.5 and 10m). The experiment resulted in promising reproducibility results: nanosecond jitter in the main heating pulse and around 1% current variation, crucial for the plasma required precision. Current balancing was possible even with asymmetric plasma lengths.

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Presenter: TORRADO, Nuno (Instituto Superior Técnico)

Session Classification: Poster session

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **299** Type: **Poster (student)**

Plasma density and ionisation degree evolution with long-term ion motion in a beam-driven plasma-wakefield accelerator

Monday, 18 September 2023 19:00 (1h 30m)

Beam-driven plasma-wakefield acceleration is a promising avenue for the future design of compact linear accelerators with applications in high-energy physics and photon science. Meeting the luminosity and brilliance demands of current users requires the delivery of thousands of bunches per second: many orders of magnitude beyond the current state-of-the-art of plasma-wakefield accelerators, which typically operate at the Hz-level. As recently explored at FLASHForward, a fundamental limitation for the highest repetition rate is the long-term motion of ions that follows the dissipation of the driven wakefield (R. D'Arcy, et al. Nature 603, 58,62 (2022)). The duration of this ion motion could vary with the mass of the plasma ions, thus significantly decreasing in lighter gas species. To observe this, the understanding of the background processes, such as microsecond-level plasma density evolution of different gases in a capillary, is needed. Here we present the exploration of plasma density evolution together with insights into the estimated ionisation degree.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **316** Type: **Poster (participant)**

Simulation study on the impact of a single plasma accelerator stage to existing free-electron lasers.

Monday, 18 September 2023 19:00 (1h 30m)

Free-electron lasers (FELs) are powerful tools for studying matter at the atomic level and its dynamics on the femtosecond scale. Plasma accelerators hold the promise of drastically reducing the size and costs of future accelerators, which could also help make FELs more widely applicable and perhaps even viable for industry. While a truly compact, fully plasma-based FEL still faces several challenges to reach the capabilities of today's X-ray FELs, upgrading an existing FEL with a single-stage plasma-based energy booster appears a realistic goal within this decade. Such a first application of a plasma accelerator will drive advances to strengthen the credibility of plasma acceleration as a reliable technology for future compact particle accelerators, ultimately uncovering the necessary developmental steps for maturing it as a standard technology. In this contribution, we discuss the potential scientific impact of adding a plasma booster to different existing FEL facilities, based on simulations.

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Session Classification: Poster session

Track Classification: WG5: Applications

Contribution ID: **328** Type: **Poster (participant)**

Wakefield regeneration in a plasma accelerator

Monday, 18 September 2023 19:00 (1h 30m)

The AWAKE experiment at CERN makes use of a high-energy proton beam to drive plasma wakefields. The long drive bunch self-modulates in the plasma, resulting in a train of microbunches. However, nonlinear effects shift the plasma resonance, causing the wakefield amplitude to saturate after only a fraction of the microbunch train. In this work, we use particle-in-cell simulations to show that the microbunches trailing an accelerated witness bunch can act to regenerate the wakefields, allowing a subsequent witness bunch to be accelerated. A train of witness bunches can thus be used to overcome the limitations of saturation, increasing the total accelerated charge and the overall efficiency. We discuss how such a scheme could be implemented in AWAKE, and the implications for related acceleration schemes.

Primary authors: ZEVI DELLA PORTA, Giovanni; FARMER, John (Max Planck Institute for Physics)

Presenter: FARMER, John (Max Planck Institute for Physics)

Session Classification: Poster session

Track Classification: WG3: Theory and simulations

Contribution ID: **348** Type: **Poster (participant)**

A focused very high energy electron beam for fractionated stereotactic radiotherapy

Monday, 18 September 2023 19:00 (1h 30m)

Electron beams of very high energy (50–250 MeV) can potentially produce a more favourable radiotherapy dose distribution compared to state-of-the-art photon-based radiotherapy techniques. To produce an electron beam of sufficiently high energy to allow for a long penetration depth (several cm), very large accelerating structures are needed when using conventional radio-frequency technology, which may not be possible due to economical or spatial constraints. In this work, we show transport and focusing of laser wakefield accelerated electron beams with a maximum energy of 160 MeV using electromagnetic quadrupole magnets in a point-to-point imaging configuration, yielding a spatial uncertainty of less than 0.1 mm, a total charge variation below 1%. Focusing the electron beam enables control of the depth dose distribution and improved dose conformity. It is further shown that irradiation from many different angles allows for the precise dose delivery that is required for stereotactic radiotherapy treatment.

Primary author: LUNDH, Olle (Lund University)

Co-authors: SVENDSEN, Kristoffer (Lund University); GUENOT, Diego (Lund University); Dr BJÖRKLUND SVENSSON, Jonas (DESY); PERSSON, Anders (Lund University); PETERSSON, Kristoffer (University of Oxford)

Presenter: LUNDH, Olle (Lund University)

Session Classification: Poster session

Track Classification: WG5: Applications

Contribution ID: **351** Type: **Poster (participant)**

Automated ML/AI software tools for high repetition rate laser particle accelerators

Monday, 18 September 2023 19:00 (1h 30m)

In order to transform current laser-driven particle accelerators into commercially-viable systems, the primary challenges to be addressed are stability, repeatability and repetition rate. Tau Systems Inc. is a private company working to bring laser-plasma accelerator technology into the commercial sphere by leveraging expertise in laser physics, laser-driven plasmas, conventional accelerators, and data science. For next generation plasma accelerators, consistent high data throughput analysis providing percent-level precision particle energy spectra is essential. As a first step, TAU Systems is developing the TAU Electron Spectrometer Software (TESS). TESS uses advanced statistical methods and algorithms to reconstruct the electron beam distribution in energy, divergence and space. It includes fast routines for real-time feedback on high repetition rate systems, high accuracy routines for offline post-processing with more detailed electron beam phase space, as well as customizable statistical visualizations and complete uncertainty characterization. TAU Systems has also developed TauOpt, a versatile optimization code to automate PIC and other simulations using ML/AI techniques. It features automatic adjustment of simulation parameters to optimize a user-defined objective function and utilizes HPC resources for efficient simulation runs.

Primary authors: ZHANG-LABUN, O. (TAU Systems Inc., University of Texas at Austin); GRACIA, M. (TAU Systems Inc.); HA, T. (TAU Systems Inc., University of Texas at Austin); HEGELICH, M. (TAU Systems Inc., University of Texas at Austin); KUMAR, R. (TAU Systems Inc.); LABUN, L. (TAU Systems Inc.); PHAN, D. (University of Texas at Austin); VAN MOURIK, R. (TAU Systems Inc.)

Presenter: HEGELICH, M. (TAU Systems Inc., University of Texas at Austin)

Session Classification: Poster session

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **355** Type: **Poster (participant)**

Beam Instrumentation for EuPRAXIA

Monday, 18 September 2023 19:00 (1h 30m)

Electron and X-ray beam instrumentation will be a core component of the EuPRAXIA X-ray free electron laser. It will be used to set up the accelerator, to demonstrate and optimize the beam parameters, to stabilize the beam using feedback and adaptive feed-forward loops, and to diagnose errors.
We present here an overview of the requirements and outline a comprehensive suite of instruments.

Primary author: ISCHEBECK, Rasmus (PSI)

Co-author: Prof. CIANCHI, Alessandro (Tor Vergata University and INFN)

Presenter: ISCHEBECK, Rasmus (PSI)

Session Classification: Poster session

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **357** Type: **Poster (participant)**

On maximizing LWFA by tailoring the plasma density

Monday, 18 September 2023 19:00 (1h 30m)

We present a preliminary analytical procedure [1,2] in 4 steps to tailor the initial density of an inhomogenous cold diluted plasma to the laser pulse (both assumed plane-symmetrical) so as to control wave-breakings of the plasma wave and maximize the acceleration of small bunches of electrons self-injected by the first wave-breaking at the density down-ramp. We use an improved fully relativistic plane hydrodynamic model [3,4,5] whereby the pulse is modeled as a plane wave travelling in the z direction and the Lorentz-Maxwell and electrons' fluid continuity equations are reduced to a family, parametrized by $Z>0$, of decoupled pairs of Hamilton equations; Z pinpoints the infinitesimal layer of electrons having coordinate $z=Z$ for $t\leq 0$, while $\xi = ct-z$ replaces time t as the independent variable. Our (1+1)-dimensional results may help also in realistic (3+1)-dimensional problems.

[1] G. Fiore, arXiv:2305.04580, to appear in the IEEE Proceedings of the Workshop AAC'22.

[2] G. Fiore, On maximizing LWFA by tailoring the plasma density,
in preparation.

[3] G. Fiore, J.Phys.A:Math.Theor. 51, 085203 (2018).

[4] G. Fiore, M. De Angelis, R. Fedele, G. Guerriero, D. Jovanovic,
Mathematics 10, 2622 (2022).

[5] G. Fiore, S. De Nicola, T. Akhter, R. Fedele, D. Jovanovic,
arXiv:2303.03322, PhysicaD:NonlinearPhenomena in press.
doi:10.1016/j.physd.2023.133878

Primary author: FIORE, Gaetano (Istituto Nazionale di Fisica Nucleare)

Presenter: FIORE, Gaetano (Istituto Nazionale di Fisica Nucleare)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **352** Type: **Invited talk**

2023 AWAKE Run Results

Tuesday, 19 September 2023 09:00 (30 minutes)

The AWAKE experiment moved successfully from proof-of-concept to an experiment with a clear scientific roadmap towards accelerating electrons suitable for particle physics applications within the next decade. The goal is to produce high-charge electron-bunches accelerated to high energies (0.5-1 GeV/m), while maintaining beam quality and to develop plasma sources scalable to 100s of meters.
This talk will present preliminary results of the rich measurement program of 2023:
In May 2023, AWAKE profited from a unique opportunity during a 3-week proton-run to test a scalable plasma source prototype performing measurements with a 10m long discharge plasma source (DPS). Different gases, bunch charges, plasma densities and plasma lengths and their influence on the proton-bunch self-modulation, ion-motion, current filamentation instabilities and plasma light were studied; the DPS performance and preliminary results of the effects on the drive-beam train and wakefields are presented.
In July 2023, a new 10m long rubidium vapour source has been installed generating two regions of different densities to achieve higher gradients w.r.t. that currently achieved. The vapour source commissioning is described and preliminary performance results with the proton drive-beam are shown.
In addition, the challenges, key components and plans of the next phases in the AWAKE roadmap are highlighted.

Primary author: GSCHWENDTNER, Edda (CERN)

Co-author: AWAKE COLLABORATION

Presenter: GSCHWENDTNER, Edda (CERN)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **424** Type: **Invited talk**

The EuPRAXIA ESFRI Preparatory Phase

Tuesday, 19 September 2023 09:30 (30 minutes)

TBD

Primary author: ASSMANN, Ralph (DESY)

Presenter: ASSMANN, Ralph (DESY)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **246** Type: **Invited talk**

EuPRAXIA@SPARC_LAB

Tuesday, 19 September 2023 10:00 (30 minutes)

EuPRAXIA@SPARC_LAB will be a new multi-disciplinary user-facility that is currently under construction at the Laboratori Nazionali di Frascati of the INFN in the framework of the EuPRAXIA collaboration.
The electrons acceleration will be provided through an X-band normal conducting linac followed by a plasma module from WakeField Acceleration (PWFA).
Downstream, the beam will drive two FEL beamlines for experiments, one in the VUV and the other in the XUV-soft x-rays spectral region. As an ancillary beamline, a betatron source in the x-ray from laser-plasma interaction, is considered. We present the status and the update of the project.

Primary author: DEL DOTTO, Alessio (Istituto Nazionale di Fisica Nucleare)

Presenter: DEL DOTTO, Alessio (Istituto Nazionale di Fisica Nucleare)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **425** Type: **not specified**

EuPRAXIA Second Site Options

Tuesday, 19 September 2023 10:50 (25 minutes)

TBD

Primary author: SPECKA, Arnd (LLR - Ecole Polytechnique - CNRS/IN2P3)

Presenter: SPECKA, Arnd (LLR - Ecole Polytechnique - CNRS/IN2P3)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **438** Type: **Invited talk**

View from ELI-Beamlines

Tuesday, 19 September 2023 11:15 (10 minutes)

Presenter: Dr MOLODOZHENTSEV, Alexander (ELI-Beamlines)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **432** Type: **Invited talk**

View on EPAC

Tuesday, 19 September 2023 11:25 (10 minutes)

Presenter: PATTATHIL, Rajeev (Rutherford Appleton Laboratory)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **433** Type: **Invited talk**

View from CNR

Tuesday, 19 September 2023 11:35 (10 minutes)

Presenters: Dr GIZZI, Leonida Antonio (CNR - INO, and INFN - Sez. di Pisa); GIZZI, Leonida Antonio (CNR - INO, and INFN - Sez. di Pisa)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **434** Type: **Invited talk**

View on CLPU

Tuesday, 19 September 2023 11:45 (10 minutes)

Presenter: Prof. RODRIGUEZ FRIAS, Maria (CLPU)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **435** Type: **Invited talk**

View on Excellence Centers

Tuesday, 19 September 2023 11:55 (15 minutes)

Presenter: FERRARIO, Massimo (Istituto Nazionale di Fisica Nucleare)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **176** Type: **Oral contribution**

GA-assisted Single-shot 3D-charge-density reconstruction of a laser wakefield kilo-ampere electron bunch via a TR-EO detector

Tuesday, 19 September 2023 16:25 (20 minutes)

The realization of a compact X-ray free-electron laser for pump-probe applications is a popular topic in the research of laser wakefield acceleration. The 3D charge density is closely related with the 6D brightness that primarily determines the lasing process in the undulator. However, this parameter has not been experimentally measured in previous studies. We measured the 3D charge density of the electron bunch by simultaneously performing OTR imaging and electro-optic sampling. Detailed 3D structures were reconstructed using a genetic algorithm. The electron bunch possesses a transverse size of less than 30 micrometers. The current profile shows a multi-peak structure. The main peak has a duration of < 10 fs and a peak current of approximately 1 kA. The peak electron 3D number density is $> 9 \times 10^{21}$ m^{-3}.

Primary author: Dr HUANG, Kai (Kansai Institute for Photon Science (KPSI), National Institutes for Quantum Science and Technology (QST))

Co-authors: Dr NAKANII, Nobuhiko (KPSI, QST); Prof. ZHAN, Jin (SANKEN, Osaka University); Prof. HOSOKAI, Tomonao (SANKEN, Osaka University); KANDO, Masaki (KPSI, QST)

Presenter: Dr HUANG, Kai (Kansai Institute for Photon Science (KPSI), National Institutes for Quantum Science and Technology (QST))

Session Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **231** Type: **Oral contribution**

All-optical GeV electron bunch generation in a laser-plasma accelerator via truncated-channel injection

Tuesday, 19 September 2023 16:25 (20 minutes)

We describe a simple scheme, truncated-channel injection, to inject electrons directly into the wakefield driven by a drive pulse guided by an all-optical plasma channel. We use this approach to generate dark-current-free 1.2 GeV, 4.5% relative energy spread electron bunches with 120 TW laser pulses guided in a 110 mm-long hydrodynamic optical-field-ionized (HOFI) plasma channel. Our experiments and particle-in-cell simulations show that high-quality electron bunches were only obtained when the drive pulse was closely aligned with the channel axis, and was focused close to the density down-ramp formed at the channel entrance. Start-to-end simulations of the channel formation, and electron injection and acceleration show that increasing the channel length to 410 mm would yield 3.65 GeV bunches, with a slice energy spread 5E-4. We will also present initial results of a follow-up experiment in which a second, perpendicular HOFI channel was used to enhance the control of injection of electrons into the plasma wave driven in an approximately 40 mm-long HOFI channel.

Primary authors: Dr PICKSLEY, Alex (Lawrence Berkeley National Laboratory); Dr CHAPPELL, James (John Adams Institute for Accelerator Science and Department of Physics); Ms ARCHER, Emily (John Adams Institute for Accelerator Science and Department of Physics); Dr BOURGEOIS, Nicolas (Central Laser Facility, STFC Rutherford Appleton Laboratory,); Dr COWLEY, James (John Adams Institute for Accelerator Science and Department of Physics); Prof. EMERSON, David R. (Scientific Computing Department, STFC Daresbury Laboratory); Dr FEDER, Linus (John Adams Institute for Accelerator Science and Department of Physics); Dr GU, Xiao-Jun (Scientific Computing Department, STFC Daresbury Laboratory); Mr JAKOBSSON, Oscar (John Adams Institute for Accelerator Science and Department of Physics); Dr ROSS, Aimee J. (John Adams Institute for Accelerator Science and Department of Physics); Mr WANG, Warren (John Adams Institute for Accelerator Science and Department of Physics); Prof. WALCZAK, Roman (John Adams Institute for Accelerator Science and Department of Physics); Prof. HOOKER, Simon (John Adams Institute for Accelerator Science and Department of Physics)

Presenter: Ms ARCHER, Emily (John Adams Institute for Accelerator Science and Department of Physics)

Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **243** Type: **Oral contribution**

Acceleration of stable, low-divergence proton beams from novel liquid sheet targets

Tuesday, 19 September 2023 16:25 (20 minutes)

Despite the huge potential of laser-driven proton acceleration to provide compact sources of MeV proton beams suitable for a variety of applications, several factors hamper their wider adoption including: the challenges associated with operating these accelerators at high-repetition rate; low shot-to-shot stability; and large beam divergence which leads to rapidly decreasing proton flux with distance from the source. Recent experiments at the GEMINI TA2 laser facility (200 mJ, 10 TW, 5 Hz) have demonstrated the acceleration of high-stability, low-divergence proton beams with high-flux and MeV energies using a sub- micron thickness water-sheet target developed at SLAC National Accelerator Laboratory. Here, we will report on the experimental results and supporting PIC simulations which highlight the important role of the water vapour on collimation of the proton beam. The measured proton beams are already suitable for applications requiring high proton flux and the platform can be easily extended to kHz repetition rates extending the utility of the source to a wide range of applications in radiobiology, materials science and fundamental physics.

Primary author: PALMER, Charlotte (Queen's University Belfast)

Co-authors: Mr DIIORIO, Stephen (Gerard Mourou Center for Ultrafast Optical Science); Dr TREFFERT, Franziska (SLAC National Accelerator Lab.); AHMED, Hamad (STFC Rutherford Appleton Laboratory); Mr BALCAZAR, Mario (Gerard Mourou Center for Ultrafast Optical Science); Mr GLENN, Griffin (SLAC National Accelerator Lab.); Mr ASTBURY, Sam (Central Laser Facility); BOURGEOIS, Nicolas (Central Laser Facility, STFC Rutherford Appleton Laboratory,); Dr DANN, Stephen (Central Laser Facility); DZELZAINIS, Thomas (STFC Rutherford Appleton Laboratory); GAUTHIER, Maxence (SLAC National Accelerator Laboratory); GIUFFRIDA, Lorenzo (ELI beamlines); GRAY, Ross (University of Strathclyde); XU, Nuo; THOMAS, Alexander GR (University of Michigan); SYMES, Daniel (Rutherford Appleton Laboratory); Mr SPINDLOE, Chris (Central Laser Facility); PARSONS, Peter; Ms PARISUAÑA, Claudia (SLAC National Accelerator Lab.); NAJMUDIN, Zulfikar (Imperial College London); MCKENNA, Paul (University of Strathclyde); Ms MCCUSKER, Orla (Queen's University Belfast); MARGARONE, Daniele (ELI-Beamlines, IoP-ASCR); KING, Martin (University of Strathclyde); ISTOKSKAIA, Valeria; Dr HYLAND, Cormac (Queen's University Belfast); HICKS, George (Imperial College London); GLENZER, Siegfried (SLAC National Accelerator Laboratory); GREEN, James (STFC Rutherford Appleton Laboratory); ETTLINGER, Oliver (Imperial College London); DOVER, Nicholas; CURRY, Chandra (SLAC National Accelerator Laboratory); BORGHESI, Marco (Queen's University Belfast); Mr LOUGHRAN, Brendan (Queen's University Belfast); STREETER, Matthew (Queen's University Belfast)

Presenter: PALMER, Charlotte (Queen's University Belfast)

Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **310** Type: **Oral contribution**

Pulse characterisation technique for multi-pulse laser plasma wakefield accelerators

Tuesday, 19 September 2023 16:25 (20 minutes)

Multi-pulse laser plasma wakefield accelerators (MP-LWFA) provide an alternative way towards compact and kiloherz (kHz) operation of Gigavolts (GeV) electron acceleration for advanced light sources and future particle accelerators. The aim of this research is to understand whether or not spectral and temporal structures of pico-second (ps) long multi-pulses can be characterised with the latest ultrafast pulse measurement techniques. A single shot frequency resolved optical gating (FROG) device was developed to measure various pulse structures generated by temporal interference of two chirped pulses. Our research demonstrates that multi-pulse trains with 11 pulses and 194-fs pulse spacing could be retrieved by the temporal tychographic iterative engine (PIE) phase retrieval algorithm. The systematic error of the retrieved phase could be as low as 4 per cent accompanied by a standard deviation of 15 per cent. Our experimental results indicate that the structured pulses adopted in MP-LWFA can be characterised and the FROG technique can assist the development of advanced high power laser pulse shaping techniques for multi-GeV electron acceleration in tens of centimeter-long plasma channels.

Primary author: WANG, Wei-Ting (University of Oxford)

Presenter: WANG, Wei-Ting (University of Oxford)

Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **405** Type: **Oral contribution**

Dielectric Assist Accelerating (DAA) structures for compact linear accelerators of low energy particles in hadrontherapy treatments.

Tuesday, 19 September 2023 16:25 (20 minutes)

Dielectric Assist Accelerating (DAA) structures based on ultralow-loss ceramic are being studied as an alternative to conventional disk-loaded copper cavities. This accelerating structure consists of dielectric disks with irises arranged periodically in metallic structures working under the TM02–𝜋 mode.
Here, the numerical design of an S-band DAA structure for low beta particles, such as protons or carbon ions used for hadrontherapy treatments, is shown. Four dielectrics with different permittivity and loss tangent are studied as well as different particle velocities depending on the energy range.
Through optimization, most of the RF power is stored in the vacuum space near the beam axis, leading to a significant reduction of power loss on the metallic walls. This allows to fabricate cavities with extremely high quality factor over 100 000 and shunt impedance over 300 MΩ/m at room temperature.
During the numerical study, the design optimization has been improved by adjusting some of the cell parameters in order to both increase the shunt impedance and reduce the peak electric field in certain locations of the cavity, which can lead to instabilities in its normal operation. In addition, first multipactor simulations are being carried out, using several coatings to reduce SEY.

Primary author: MARTINEZ-REVIRIEGO, Pablo (Instituto de Fisica Corpuscular (IFIC))

Presenter: MARTINEZ-REVIRIEGO, Pablo (Instituto de Fisica Corpuscular (IFIC))

Session Classification: WG4: High gradient vacuum structures

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **175** Type: **Oral contribution**

Demonstrating MeVs protons acceleration in near critical imploding gas target

Tuesday, 19 September 2023 16:45 (20 minutes)

The interaction between relativistic intensity laser pulses and near-critical density targets has been sought after to increase the efficiency of laser-plasma energy coupling, particularly for proton acceleration. To achieve this density regime for high repetition rate applications, one approach is to use gas targets, provided that stringent target density profile requirements are met, including reaching the critical plasma density while maintaining micron-scale density gradients.
In this work, I'll present a novel scheme for achieving the necessary requirements using a tens of mJ optical laser pulses to shape the gas by colliding shock wave in planar geometry or by generating a cylindrical implosion. Utilizing this approach, we experimentally demonstrated stable proton acceleration and achieved up to ~ 5 MeV in a mono-energetic distribution and particle numbers above 10^8 /Sr/MeV
using a 1-2 Joule laser system. The presented results open the door for future work in controlling gas targets and optimizing the acceleration process for multi-PW laser system.

Primary author: Mr SEEMANN, Omri (Weizmann Institute of Science)

Co-authors: WAN, Yang (Weizmann Institute of Science); Dr TATA, Sheroy (Weizmann Institute of Science); Dr KROUPP, Eyal (Weizmann Institute of Science); MALKA, Victor (Weizmann Institute of Science)

Presenter: MALKA, Victor (Weizmann Institute of Science)

Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **196** Type: **Oral contribution**

Rooting out the gremlins - stable LWFA operation at the PW frontier

Tuesday, 19 September 2023 16:45 (20 minutes)

In labs worldwide, 100TW laser systems dominate systematic studies on laser-driven accelerators and secondary sources. The stable LWFA performance that has been achieved on such systems is vital for meaningful parameter studies and application-driven experiments. However, a recent upgrade of our previously highly stable 100 TW ATLAS laser system at LMU with a multi-PW capable final amplifier resulted in a significant drop in LWFA repeatability and performance per peak power, despite seeming excellent laser performance in traditional laser diagnostic instruments (measuring near & far field, spectrum, duration and contrast). Similar issues seem to affect other facilities entering the Petawatt realm. After nearly 4 years, we finally restored the former stability of LWFA. We learned valuable lessons about mitigating air turbulence effects on large beams, addressing spatio-temporal couplings, optimizing focusing geometry, and adapting longer gas targets for sophisticated injection methods. We will detail these solutions to help others facing similar challenges.

Primary author: Prof. KARSCH, Stefan (LMU München)

Co-authors: DÖPP, Andreas (LMU Munich); Mr TRAVAC, Enes (LMU München); Mr IRSHAD, Faran (LMU München); HABERSTROH, Florian (LMU Munich); Mr SCHILLING, Gregor (LMU München); Mr ESSLINGER, Jannik (LMU München); Dr LIN, Jinpu (LMU München); Dr ZIRKELBACH, Johannes (LMU München); VON GRAFENSTEIN, Katinka (Ludwig-Maximilians-Universität); FOERSTER, Moritz (LMU Munich); WEISSE, Nils (LMU Munich)

Presenter: Prof. KARSCH, Stefan (LMU München)

Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **258** Type: **Oral contribution**

Tunable Dielectric Structure for Extended Interaction Length Laser-Driven Acceleration

Tuesday, 19 September 2023 16:45 (20 minutes)

Dielectric Laser Accelerators (DLAs) can support GeV/m gradients, allowing for the possibility of MeV energy gain over only millimeters. Increasing energy gain requires developing tunable multi-mm structures. We present experimental results using a tunable dual grating structure to modulate 6 MeV electrons by up to 200 keV. We observe energy modulation up to an interaction length of 1 mm, the longest observed DLA interaction so far.

Primary author: CRISP, Sophie (UCLA)

Co-authors: ODY, Alexander (UCLA); MUSUMECI, Pietro; ENGLAND, Robert Joel

Presenter: CRISP, Sophie (UCLA)

Session Classification: WG4: High gradient vacuum structures

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **324** Type: **Oral contribution**

Diagnosing longitudinal electron bunch profiles by single-shot CTR spectrometry – a window to LWFA injection dynamics

Tuesday, 19 September 2023 16:45 (20 minutes)

The longitudinal profile of ultra-short electron bunches from Laser wakefield accelerators (LWFA) intricately depends on the ultrafast injection dynamics and laser-electron beam interaction during acceleration. Detailed knowledge of these electron bunch temporal profile is critical for the design of future table-top x-ray light-sources, as well as for the characterization of ultrashort electron beam probes or THz sources.

We present experimental results based on spectral single-shot measurements of broadband coherent transition radiation (UV to mid-IR, 250nm-11.35µm) from LWFA electron bunches passing through a metal foil. In particular, we examine different LWFA injection mechanisms, such as self-truncated ionization-injection, density-shock-assisted injection and self-injection. By analyzing the transition radiation spectra, we reconstruct electron bunch profiles including sensitivity and uniqueness properties. The electron bunch profiles of the respective injection regimes show a broad range of bunch durations, while individual shots feature complex longitudinal electron pulse profiles that stretch accross several time scales, covering the bunch envelope, its microstructures to below sub-µm, both on top of temporally more extended charge-pedestals and tails. Based on hundreds of LWFA shots, we present systematic statistics and correlations on bunch duration, peak currents with respect to electron injection-method, gas-density, as well as bunch energy, energy spread and charge.

Primary author: DEBUS, Alexander (Helmholtz-Zentrum Dresden-Rossendorf)

Co-authors: ZARINI, Omid (Helmholtz-Zentrum Dresden-Rossendorf); Dr LABERGE, Maxwell (Helmholtz-Zentrum Dresden-Rossendorf); Dr COUPERUS CABADAĞ, Jurjen (Helmholtz-Zentrum Dresden - Rossendorf); KOEHLER, Alexander (Helmholtz-Zentrum Dresden - Rossendorf); KURZ, Thomas (HZDR); SCHOEBEL, Susanne (Helmholtz-Zentrum Dresden-Rossendorf); Mrs TIEBEL, Jessica (Helmholtz-Zentrum Dresden-Rossendorf); PAUSCH, Richard (Helmholtz-Zentrum Dresden - Rossendorf); ZGADZAJ, Rafal (University of Texas at Austin); CHANG, Yen-Yu (Helmholtz Zentrum Dresden Rossendorf); Dr BUSSMANN, Michael (Helmholtz-Zentrum Dresden-Rossendorf); DOWNER, Michael (The University of Texas at Austin); IRMAN, Arie (Helmholtz Zentrum Dresden-Rossendorf); SCHRAMM, Ulrich (Helmholtz-Zentrum Dresden-Rossendorf)

Presenter: DEBUS, Alexander (Helmholtz-Zentrum Dresden-Rossendorf)

Session Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **367** Type: **Oral contribution**

EuPRAXIA laser requirements and current conceptual design issues

Tuesday, 19 September 2023 16:45 (20 minutes)

EuPRAXIA is the first European project that develops a dedicated particle accelerator research infrastructure based on novel plasma acceleration concepts and laser technology and one of the projects on the European Strategy Forum on Research Infrastructures (ESFRI) Roadmap of 2021. The EuPRAXIA preparatory phase project is now underway, with the beam driven site at LNF-INFN in Frascati under construction and the laser-driven site being selected and its specifications and options being finalized.
The project foresees a two-steps laser performance to enable outstanding user operation at day one of implementation with 20 Hz repetition rate, and successive upgrade to final performance of 100 Hz. In this paper we will discuss the requirements of the laser driver and the existing conceptual design. Open technical design issues and main developments needed will also be outlined in view of current industrial capabilities and planned R&D at relevant user facilities.

Primary author: Dr GIZZI, Leonida Antonio (Intense Laser Irraadiation Lab, CNR - INO, and INFN - Sez. di Pisa, Italy)

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Presenter: Dr GIZZI, Leonida Antonio (Intense Laser Irraadiation Lab, CNR - INO, and INFN - Sez. di Pisa, Italy)

Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **200** Type: **Oral contribution**

The Interaction of Intense Light with Wavelength-Scale Objects

Tuesday, 19 September 2023 17:05 (20 minutes)

Intense laser fields interact very differently with micrometric rough surfaces than with flat objects. The interaction features high laser energy absorption and increased emission of MeV electrons, ions, and of hard x-rays.
I will report on how we revealed the underlying reason for this phenomenon by irradiating isolated, micrometric, translationally-symmetric objects by 20 TW laser pulses. The interaction resulted in the emission of two forward-directed electron jets having a small opening angle, a narrow energy spread in the MeV range.
PIC simulations show that electrons that are ionized and pulled into vacuum through the vacuum heating mechanism near the edge of the object, manage to circumvent it because of the combined action of the transverse electric field and their cyclotron motion under the magnetic field of the laser. Then, after they pass the object, the electrons form attosecond duration bunches and interact with the laser field over large distances in vacuum. The diffraction of the laser fields obscured by the target creates confined volumes that trap and accelerate electrons within a narrow range of initial momentum. The preservation of the attosecond duration of the electron bunches over large distances, may be applied to the design of future laser-based light sources.

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Presenter: POMERANTZ, Ishay

Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **240** Type: **Oral contribution**

Coherent Nanophotonic Electron Accelerator

Tuesday, 19 September 2023 17:05 (20 minutes)

In 2013 the concept of dielectric or nanophotonic laser acceleration was experimentally demonstrated. Rather simple dielectric gratings with their periodicity matched to the electron velocity, in the same manner as the original Widerøe linear accelerator almost century ago, only driven with light. Now, a decade later, we can demonstrate what one might call a dielectric laser accelerator, namely combined coherent acceleration and guiding. The dielectric accelerator is driven by femtosecond laser pulses, and the role of the RF cavities of conventional accelerators is taken over by microscopic dielectric pillars, which generate the driving nearfield once illuminated by the pulsed laser beam. The amplitudes of these nearfields can be substantial, exceeding 1 GV/m, which drove DLA research for the past decade. The design of these pillars, i.e. their placement and dimensions, allows us to generate an optical mode matched to the propagating electron. In addition, we designed the structure to employ alternating phase focusing as a method to focus the electron beam transversally while maintaining acceleration. We will show guiding and acceleration of electrons from an initial energy 28.4 keV all the way to 40.7 keV, a gain of 12.3 keV over 0.5 mm distance in just 225 nm wide channel.

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Session Classification: WG4: High gradient vacuum structures

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **261** Type: **Oral contribution**

Deuteron acceleration and fast neutron generation with a 10Hz few-cycle laser

Tuesday, 19 September 2023 17:05 (20 minutes)

Many applications require a (quasi) continuous source of ions and neutrons operating in a 24/7 mode. Recent developments of few-cycle laser systems with an average optical power of 100 W have laid the technological basis for the development of such a particle source.
In the experimental series in ELI-ALPS, Hungary, first we have demonstrated that ions can be efficiently accelerated above 1MeV with laser pulses of 20 mJ energy and 12 fs pulse duration. The accelerated deuterons generate fast neutrons via DD fusion reaction in a deuterated PE tablet. The deuterons have been measured shot-by-shot with Thomson ion spectrometers. Neutrons were characterized by time-of-flight scintillators as well as bubble detectors. Following the development of an ultrathin liquid sheet target system, it became possible to operate the laser deuteron accelerator continuously for more than six hours at 10 Hz repetition rate. As a next step, the neutron flux will reach 10^8 neutron / sec with the use of a kHz laser system.

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Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **331** Type: **Oral contribution**

High-power laser development in Jena

Tuesday, 19 September 2023 17:05 (20 minutes)

The possibilities for experimental research on laser-particle acceleration strongly depend on the available laser and laboratory infrastructure. The Helmholtz-Institute Jena and the Institute of Optics and Quantum Electronics in Jena, Germany, currently operate two individual high-power laser systems (JETI and POLARIS), which differ in their laser parameters. In the future, these two laser systems will be synchronized to deliver laser pulses to a new radiation-shielded target area for two-beam experiments, either on pump-probe setups, sophisticated staged-acceleration experiments, or strong-field QED scenarios. Furthermore, the IOQ is developing high-power laser systems delivering pulses in the mid-IR region based on classical laser amplification in Cr:ZnSe as the active medium using well-suited mid-IR pump lasers. This presentation will give an overview on these different developments and the future prospects.

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Presenter: KALUZA, Malte (University of Jena, Helmholtz-Institute Jena)

Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **347** Type: **Oral contribution**

Single-Shot Ionization-Based Monitor for Pulsed Electron Beams

Tuesday, 19 September 2023 17:05 (20 minutes)

We present an experimental demonstration of a single-shot, non-destructive electron beam diagnostic based on detecting the ionized particles generated by the passage of the primary beam through a low density pulsed gas sheet.
Efficient detection of the ionization events, coupled with a flexible electrostatic column design, allows the retrieval of information on beam charge, centroid position, and transverse profile at the gas plane.
In our study, we used up to 100~pC, 7~MeV electron bunches from a radio frequency photoinjector, traversing through a localized nitrogen gas distribution. For varying electron beam parameters, the interaction with the N_2 gas produces a correlated signature in the ionized particle distribution, which is spatially magnified by a series of electrostatic lenses and recorded using a micro-channel-plate detector.
By adjusting the voltages on the electrostatic column, various modalities including point-to-point imaging and velocity mapping are explored for both ions and secondary electrons.

Primary author: MUSUMECI, Pietro

Presenter: MUSUMECI, Pietro

Session Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **184** Type: **Oral contribution**

Transverse instabilities induced periodic modulation in laser driven proton beams

Tuesday, 19 September 2023 17:25 (20 minutes)

We report on experimental observation on periodic modulation in the energy spectrum of laser accelerated proton beams. Interestingly, theoretical model and two-dimensional particle-in-cell simulations, in good agreement with the experimental finding, indicated that such modulation is associated with periodic modulated electron density induced by transverse instability. These results, may have implications for further understanding for the accelerating mechanisms as well as optimization strategies for laser driven ion acceleration.

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Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **219** Type: **Oral contribution**

Staging of high-efficiency and high-quality laser-plasma accelerators for collider applications

Tuesday, 19 September 2023 17:25 (20 minutes)

The viability of next generation TeV-class electron-positron colliders based on staging of independently-powered plasma-based accelerators relies on the possibility of accelerating high-charge bunches to high energy with high efficiency and high accelerating gradient, while maintaining a small energy spread and emittance. Achieving a small energy spread with high efficiency requires employing witness bunches with tailored current profiles (optimal beamloading). Such profiles are analytically known in the case of plasma wakefield accelerators operating in the blowout regime, while in the case of laser-plasma accelerators (LPAs) can only by computed numerically, and their determination requires taking into account the laser driver evolution. A small bunch energy spread is a necessary condition to enable staging and minimize emittance degradation from chromaticity when bunches are transported from one plasma accelerator stage to the following one. In this talk we will discuss examples of LPA stages operating in different regimes, namely a self-guided stage in the nonlinear regime and a quasi-linear stage in a hollow plasma channel, providing high-gradient, high-efficiency, and quality-preserving acceleration of bunches for collider applications. We will present, for each example, the current profile distribution for optimal beamloading, and we will analyze emittance degradation when staging of such LPAs is considered.

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Presenter: BENEDETTI, Carlo (LBNL)

Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **342** Type: **Oral contribution**

Diode-pumped Laser-drivers for plasma accelerators

Tuesday, 19 September 2023 17:25 (20 minutes)

Here we give a brief overview of the development of DPSSL-based high-average power laser drivers for plasma accelerators in CLF. We will describe the design of the Extreme Photonics Applications Centre (EPAC): a unique facility dedicated for the exploitation of the applications of plasma accelerators. Future upgrade paths for EPAC, especially in repetition rate, would be discussed.

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Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **354** Type: **Oral contribution**

Single Electron Accelerator for Dark Matter Search

Tuesday, 19 September 2023 17:25 (20 minutes)

We present here a concept of a laser-driven accelerator for single electrons, designed to generate a beam of relativistic electrons for indirect search of dark sector particles.
The beam dynamics is verified by tracking them along the structure using DLAtrack6D. The optimization process, including determining the transverse periodicity lengths, electric field magnitude at the structure's center, and the number of micro-cells per macro-cell, is performed using a genetic algorithm. We propose integrating the accelerating structure into a mm-scale laser oscillator, which could facilitate extremely high repetition rates and enhances the accelerator's energy efficiency. We present the initial simulation of an intra-cavity accelerator, where a small structure with a few periods is placed inside the cavity. The simulation utilizes CST Studio Suite to calculate the structure impedance and its impact on the cavity.

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Presenter: ISCHEBECK, Rasmus (PSI)

Session Classification: WG4: High gradient vacuum structures

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **304** Type: **Oral contribution**

Multi-objective and multi-fidelity Bayesian optimization of laser-plasma acceleration

Tuesday, 19 September 2023 17:40 (25 minutes)

Beam parameter optimization in accelerators involves multiple, sometimes competing objectives. Condensing these individual objectives into a single figure of merit unavoidably results in a bias towards particular outcomes. Finding an optimal objective definition then requires operators to iterate over many possible objective weights and definitions, a process that can take many times longer than the optimization itself. A more versatile approach is multi-objective optimization, which establishes the trade-off curve usually referred to as Pareto front between objectives. In this talk, I present the first results on multi- objective multi-fidelity Bayesian optimization of a simulated and experimental laser-plasma accelerator. We find that multi-objective optimization reaches comparable performance to its single-objective counterparts while allowing for instant evaluation of entirely new objectives. This dramatically reduces the time required to find appropriate objective definitions for new problems. Additionally, our multi-objective, multi-fidelity method reduces the time required for an optimization run by an order of magnitude. It does so by dynamically choosing simulation resolution and box size, requiring fewer slow and expensive simulations as it learns about the Pareto-optimal solutions from fast low-resolution runs. The techniques demonstrated here can easily be translated into many different computational and experimental use cases beyond accelerator optimization.

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Co-authors: DÖPP, Andreas (LMU Munich); Prof. KARSCH, Stefan (LMU München)

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Session Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **186** Type: **Oral contribution**

CEBAF Polarized Positrons and 22 GeV Energy Upgrade

Tuesday, 19 September 2023 17:45 (20 minutes)

CEBAF is a recirculating CW SRF accelerator running polarized electron beams at 12 GeV to fixed targets for nuclear physics study. A very efficient upgrade proposal has been developed for energy increase to 22 GeV without any additional SRF, based on increase of the number of recirculations using new FFA permanent magnet arcs. The polarized positron beam capability, synergistic to the energy upgrade, has also been developed, and will be presented in this talk together with the details of the 22 GeV energy upgrade.

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Presenter: SERYI, Andrei (Jefferson Lab)

Session Classification: WG4: High gradient vacuum structures

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **298** Type: **Oral contribution**

High-quality polarised electron bunches from colliding pulse injection

Tuesday, 19 September 2023 17:45 (20 minutes)

Highly polarised, high current electron bunches from compact laser-plasma accelerators are sought after for numerous application. However, current proposals to produce these beams 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.

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Presenter: PODER, Kristjan (DESY)

Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **322** Type: **Oral contribution**

Highly efficient proton acceleration from solid and pre-expanded thin foils

Tuesday, 19 September 2023 17:45 (20 minutes)

We present the preliminary results of proton acceleration from tens of nanometer thick plastic foils that are irradiated by a 10^{21} W/cm^2 laser pulse with 25 fs pulse duration and 1.8 μm focal spot size (FWHM). We consider the effect of circular (CP) and linear (LP) polarization on the proton energy spectra. For CP we observe an optimum in the proton energy in dependence of the target thickness; such an optimum is absent from the LP data. Thinner targets in the range of (10-50) nm exhibit monoenergetic proton spectra. This feature is lost for foils thicker than 90 nm and the cut-off energy is significantly lowered.
Further, we study the impact of pre-expanding the target by introducing a pre-pulse on the order of 10^{15} W/cm^2 that arrives at the target a few picoseconds before the main pulse. Record peak proton energies per Joule of laser energy are observed.

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Presenter: SALAHELDIN, Israa (Helmholtz Institute Jena)

Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **349** Type: **Oral contribution**

Joule-class Yb:YAG lasers for driving plasma-modulated plasma accelerators

Tuesday, 19 September 2023 17:45 (20 minutes)

The kilohertz Plasma Accelerator Consortium (kPAC) is developing GeV-scale, laser-driven plasma accelerators, utilizing highly efficient, diode-pumped lasers with kHz repetition rate. The concept is based on the plasma-modulated plasma accelerator (P-MoPA). In such an accelerator, a joule-class pulse with picosecond duration is first spectrally modulated by the wake of a second, millijoule-class pulse with sub-50 fs duration, which co-propagates inside a hydrodynamic optical-field-ionized (HOFI) plasma channel. Afterwards, the spectrally modulated, picosecond long pulse is converted to a train of sub-100 fs long pulses using a dispersion system. This train of pulses can then resonantly drive a subsequent acceleration stage. A first demonstrator of such kind is currently being developed at the Center for Advanced Laser Applications (CALA) of the Ludwig-Maximilians-Universität in Munich.
Here, we present the demonstrator's laser source, a unique combination of two state-of-the-art, Yb:YAG-based laser systems which are able to generate laser pulses with energies of up to 10 J at 700 fs and 10 Hz, and laser pulses with up to 100 mJ at sub-50 fs and 1 kHz. This combination enables a broad range of parameters to thoroughly investigate the creation of HOFI channels as well as the modulation, conversion and acceleration in the P-MoPA demonstrator.

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Presenter: Dr KRÜGER, Mathias (LMU Munich)

Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **222** Type: **Oral contribution**

Tuning curves for a laser-plasma accelerator

Tuesday, 19 September 2023 18:05 (25 minutes)

In this talk, we explore recent results on optimal tuning of beam parameters of laser-plasma accelerators (LPA) at the LUX experiment. Precise control over electron beam parameters is essential for realizing the wide range of applications projected for LPAs. However, the complexity of the laser-plasma interaction makes tuning challenging, often leading to suboptimal outcomes. To address this issue, we employ an approach called multiobjective Bayesian optimization to navigate this complexity and derive optimal tuning curves for LPAs. For various electron energies, we demonstrate tuning of the charge over a broad range, while preserving optimal beam loading conditions and low energy spread. This is achieved by moving the system's control parameters along Pareto-optimal tuning curves. These tuning curves can explain the sometimes counterintuitive interplay between laser and plasma control variables that is necessary to find the best trade-off between competing beam properties, allowing operators to precisely tune the machine to the demands of a given application.

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Presenter: JALAS, Sören (DESY)

Session Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **340** Type: **Oral contribution**

Bright attosecond electron beams and brilliant gamma ray sources with the Resonant Multi-Pulse Ionization Injection

Tuesday, 19 September 2023 18:05 (20 minutes)

High-brightness e-beams with duration of a few hundreds of attoseconds can be employed as direct probes, as drivers of Compton/Thomson X/γ or single-spike FEL sources. We show, by means of theory and quasi-3D-PIC simulations, that GeV scale electron beam sources having duration widely tunable in the interval 100–2000 as, with 6D brightness exceeding 10^17A/m^2/0.1% and normalized emittances below 100 nm×rad can be obtained with the ReMPI scheme.
In the simplified simulations setup, a train of two pulses resonantly excite the plasma wave on He-Ar mixture plasma target. A pulse in second/fourth harmonics extracts electrons from the inner shell of the dopant ions, placing them the favorable phase of the wakefield as in the Two Color ionization injection. During the slippage in the bucket and up to the trapping point, the bunch length reduces down to tiny fraction of the initial one.
The tuning of beam duration is obtained by changing the delay between the ionization and the drivers pulses. Results of the model giving the beam duration obtainable with a given ionization pulse/driver delay are confirmed by simulations. Compton/Thomson backscattering process simulations showed that quasi monochromatic attosecond X/γ beams with high brilliance can be obtained with current technology PW-class lasers.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **353** Type: **Oral contribution**

Efficient Laser ion acceleration from foils and isolated targets

Tuesday, 19 September 2023 18:05 (20 minutes)

We present our recent findings on laser efficient laser ion acceleration with various target systems.
One target system is based on a Paul-trap, which allows us to position sub-focus sized spherical targets (1 μm diameter) with sub-micrometer precision into the focus.
The other target system are thin plastic foils(with 10 - 200 nm thickness).
Experiments were conducted at the JeTi laser with a plasma mirror and dedicated pre-pulse.
For the spherical targets we find most energetic protons when the target is pre-expanded to near critical densities.
For foil targets, we identify a local maximum for pre-expanded targets in the range of critical densities, similar to spherical targets. Nevertheless, non pre-expanded foil targets lead to higher ion energies.
Both target systems lead to very high conversion efficiencies better than 20MeV per Joule on target.
Next to the experimental results, this talk will address the underlying acceleration processes. While they differ significantly in some aspects, they still have some similarities. Strategies for future experiments will presented.

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Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **372** Type: **Oral contribution**

Robust high-average-power lasers and scaling to high pulse energy

Tuesday, 19 September 2023 18:05 (20 minutes)

Pulsed laser sources have a plethora of applications, many of which require or benefit from high average power. This presentation gives an overview of modern laser and optics development at the Fraunhofer ILT in Aachen for various applications in industry, energy, health, and science. These include robust laser systems tailored for space applications, the upscaling of femtosecond lasers to the multi-kilowatt range using the Innoslab platform, and nonlinear pulse compression to achieve few-10-femtosecond durations using the multi-pass cell scheme. Furthermore, architectures for high-energy, high-average-power diode-pumped solid-state lasers are being explored for a variety of applications, including secondary sources such as particle acceleration and inertial confinement fusion.

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Presenter: WEITENBERG, Johannes (Fraunhofer ILT)

Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **179** Type: **Poster (participant)**

Electron yield numerical studies for the EuAPS betatron source

Tuesday, 19 September 2023 19:00 (1h 30m)

The EuAPS project (EuPRAXIA Advanced Photon Source) aims at realizing an X-ray photon source for users applications. The photons will be produced by betatron radiation mechanism inside a laser plasma accelerator, exploiting an internal injection scheme. The source will produce short pulses of photons in the spectral range 1 - 10 keV for a wide set of applications ranging from imaging to spectroscopy to pump-and-probe. The presence of external users makes the source performances, in terms of photon yield and spectral properties, a paramount factor of merit.
In this contribution, we will show numerical studies aimed at assessing the potential performances employing either plain self-injection or internal injection with the presence of a gas mixture.

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Presenter: ROSSI, Andrea Renato (Istituto Nazionale di Fisica Nucleare)

Session Classification: Poster session

Track Classification: WG5: Applications

Contribution ID: **183** Type: **Poster (participant)**

Beam current from downramp injection in electron-driven nonlinear plasma wakefields

Tuesday, 19 September 2023 19:00 (1h 30m)

We study the stability of plasma wakes and the properties of density-downramp injection in an electron-driven plasma accelerator in the blowout regime. As shown by particle-in-cell (PIC) simulations, the accelerating structure remains highly stable until the moment some electrons of the driver reach almost zero energy, which corresponds to the best interaction length for optimal driver-to-plasma energy transfer efficiency. For a particular electron driver, this efficiency can be optimized by choosing the plasma density. Studying the dependence of the current of the injected beam on driver and plasma parameters, we show that it does not depend on the density downramp length as long as the condition for trapping is satisfied. Most importantly, based on theoretical scalings and PIC simulations, we find that the current of the injected beam primarily depends on just one parameter which combines both the properties of the driver (its current and duration) and the plasma density.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **187** Type: **Poster (student)**

Machine Learning-based Data Analysis and Surrogate Modeling For COXINEL Experiment

Tuesday, 19 September 2023 19:00 (1h 30m)

Recently, free electron lasing at UV wavelength has been demonstrated by deploying the COXINEL beamline driven by HZDR plasma accelerator in a seeded configuration[1]. Further control and optimization of such an FEL radiation require full knowledge of strongly-coupled multivariate parameters involved in laser plasma acceleration, electron beam transport and radiation generation. For this purpose, one has to solve an inverse problem, i.e. finding matching parameters of the simulation to reproduce the experiment. Such inverse problems are ill-posed and cannot be easily resolved due to high computational complexity. Here, machine learning-based methods have a high potential to accelerate theoretical comprehension of the system, novel means for design space exploration and promise reliable in-situ analysis of experimental diagnostics and parameters. We apply simulation-based inference technique for this purpose. This method is a combination of deep learning and statistical approaches to resolve an inverse problem up to a posterior distribution of the simulation parameters given an experimental sample. In addition, we have developed machine learning-based surrogate models that can significantly accelerate forward computations for even faster results of the inverse solver.

[1] M. Labat, et al. "Seeded free-electron laser in driven by a compact laser plasma accelerator", Nat. Photonics, 17, 150(2023)

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Presenter: WILLMANN, Anna (HZDR)

Session Classification: Poster session

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **194** Type: **Poster (participant)**

Status of the CLARA Facility at Daresbury Laboratory and exploitation for advanced acceleration research

Tuesday, 19 September 2023 19:00 (1h 30m)

The Compact Linear Accelerator for Research and Applications (CLARA) is an ultra-bright 250 MeV electron beam test facility under development at STFC Daresbury Laboratory. Originally conceived to test advanced Free Electron Laser schemes, CLARA has become a unique facility for user-led experiments in a wide range of disciplines, including advanced accelerator concepts.

Here we report on the status of the CLARA facility. A summary of our last user run (2021-2022) is presented, in which the CLARA 35 MeV front end was operated for R&D including plasma and dielectric acceleration. We provide an update on the construction of the facility, which is nearing completion and will enter technical systems commissioning in November 2023. Finally, prospects for future community exploitation of CLARA are discussed, focussing on capability and access. User exploitation of the CLARA facility is expected to begin early 2025.

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Presenter: SNEDDEN, Edward (STFC Daresbury Laboratory)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **198** Type: **Poster (student)**

Witness-driver beam dynamics optimization in the SPARC_LAB photoinjector

Tuesday, 19 September 2023 19:00 (1h 30m)

The SPARC-LAB test facility at LNF (Frascati) is equipped with a high-brightness photo injector used to explore and develop advanced beam manipulation techniques. This photo-injector can generate high brightness two electron bunches (witness and driver) needed for plasma acceleration. To obtain these, the cathode of the photo-injector at SPARC-LAB is illuminated by a train of laser pulses, while the first acceleration section exploits the "velocity bunching" technique. This combination allows for the creation of well-controlled electron bunch trains with high brightness. The goal of this research is to optimize the dynamics of the photo-injector to improve the beam quality and enhance the performance of plasma acceleration. To achieve this, beam dynamics analyses have been performed, involving the scanning and variation of different parameters of the electron beams, using the ASTRA simulation code. The results obtained from these optimization studies have then been applied in the operation of the actual machine setup and have been positively confirmed by good experimental results concerning the stability and accelerating gradient in the plasma.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **208** Type: **Poster (participant)**

The E336 experiment at FACET-II: Wakefield acceleration and modulation of dense electron beams in nanostructures

Tuesday, 19 September 2023 19:00 (1h 30m)

When a high intensity electron beam passes through a structured nano target, the created solid-state density plasma can support ultra-high accelerating gradients on the order of 1 TeV/m to 10 TeV/m with similarly strong focusing fields. This process may thus lead to an acceleration method with extremely high single-stage energy gains for electron or muon beams. Additionally, simulations indicate that structured solid targets can modulate electron beams to generate an effective and controllable seed for beam-plasma instabilities that are e.g. believed to be present in astrophysical phenomena.

Driving these extreme wakefields requires high energy and high-density electron bunches. Such bunches are now within reach at the FACET-II facility at SLAC National Accelerator Laboratory. The E336 experiment at FACET-II is a proof of principle experiment that will utilize the high-density electron beams produced by the facility to demonstrate the unique processes expected to occur in structured solid targets. We discuss the motivation, status, and future plans for the experiment. We will furthermore present particle-in-cell simulations that demonstrate fundamental processes of the interaction including magnetic trapping and beam deflection.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **215** Type: **Poster (participant)**

Transverse instability in HALHF plasma stages

Tuesday, 19 September 2023 19:00 (1h 30m)

We present first results for a parameter study including transverse instability in the acceleration stages of HALHF, a novel electron positron collider concept combining plasma wakefield acceleration and mature RF acceleration to reach centre of mass energies of 250 GeV. This study is a preliminary extension of the previous studies that indicated promising performance, by including transverse instability. Transverse instability was simulated using start-to-end simulations, where PIC simulations were combined with a simplified model to efficiently modell transverse instability in the plasma acceleration stages and electron beam transport in interstages.

Primary authors: Dr CHEN, Jian Bin Ben (University of Oslo); Dr LINDSTRØM, Carl A. (University of Oslo); ADLI, Erik (University of Oslo, Norway); FINNERUD, Ole Gunnar (University of Oslo)

Presenter: Dr CHEN, Jian Bin Ben (University of Oslo)

Session Classification: Poster session

Track Classification: WG3: Theory and simulations

Contribution ID: **217** Type: **Poster (student)**

Reduced divergence of TNSA proton beams using a foil target and a gas jet

Tuesday, 19 September 2023 19:00 (1h 30m)

Typically, target normal sheath accelerated protons have a high divergence, often greater than 10s of degrees. However, a lower divergence beam is beneficial for many applications and for beam capture by a transport system. An experiment in at the Gemini TA2 laser facility (Central Laser Facility), using a water sheet target, observed proton beams with a divergence in the order of 1 degree; the reduction in beam divergence has been attributed to the effect of a low-density plasma in the water vapour surrounding the target on proton beam propagation. This motivated an experiment to explore the effect of a low-density plasma behind the target on beam divergence at the Vulcan Petawatt laser (Central Laser Facility), using a gas jet behind a thin foil target. Initial results suggest that the presence of a gas reduced the divergence of the proton beam and that the gas only had a small effect on maximum proton energies and proton numbers. The preliminary results of this experiment will be presented in this poster.

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Presenter: PARSONS, Peter

Session Classification: Poster session

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **225** Type: **Poster (student)**

Bayesian optimization of the LUX laser-plasma accelerator

Tuesday, 19 September 2023 19:00 (1h 30m)

Laser-plasma accelerators (LPAs) are on the cusp of becoming instrumental in real-world scientific applications. Nevertheless, to be seriously considered as viable alternatives to traditional machines, LPAs must offer competitive quality and flexibility in their electron beam parameters, meeting the diverse requirements of potential applications.
While previous experiments have demonstrated LPAs' inherent capacity to meet these challenges, pinpointing the ideal machine configuration to cater to the specific demands of an application remains a complex task. This complexity is due to the necessity of optimizing a single or multiple objectives, which often conflict with one another.
Bayesian optimization emerges as a promising solution to this challenge. It provides an efficient framework for finely tuning machines to generate beams that are custom-designed for each targeted application.

We present results on optimizing plasma accelerators, demonstrating this both in the design stage using simulations and in real-time at the LUX experiment. The aim is to offer insights into how we can effectively tune the experiment to accommodate a range of applications.

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Presenter: JALAS, Sören

Session Classification: Poster session

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **227** Type: **Poster (student)**

Instability and Efficiency in Beam-Driven Plasma Wakefield Accelerators

Tuesday, 19 September 2023 19:00 (1h 30m)

Beam-driven plasma-wakefield acceleration has the potential to produce accelerating fields up to three orders of magnitude stronger than those in traditional accelerators using RF cavities. However, in recent years, an efficiency-instability relation has been proposed, which limits the energy transfer from the wake to the trailing bunch that can be achieved without causing detrimental transverse instabilities. We discuss the efficiency-instability relation for a misaligned trailing bunch and methods that can be used to mitigate this effect, such as ion motion and operating in the quasilinear regime. Using start-to-end simulations, we simulate intra-beam transverse instabilities seeded by a misaligned trailing bunch in a plasma acceleration stage. These studies will be the basis of the upcoming E302 experiment at the FACET-II facility.

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Presenter: FINNERUD, Ole Gunnar (University of Oslo)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **236** Type: **Poster (student)**

Radioisotope production using a high-repetition-rate, laser-based proton source

Tuesday, 19 September 2023 19:00 (1h 30m)

The level of maturity of laser-based ion accelerators is opening the path for their use in real-life applications. Particularly promising is the in-situ production of short-lived radionuclides for medical imaging, with techniques such as Positron-Emission-Tomography (PET). However, the large activities required (>10MBq for pre-clinical, >200MBq for clinical) are well-above those achievable from a single irradiation using commercial high-power lasers.
In this context, we have developed a novel multi-shot target system capable of operating for thousands of irradiations at rates of up to 10Hz. In particular, the system is based on a rotating wheel with automatised target pre-characterisation, avoiding the need for re-alignment between shots and allowing for rapid changeovers. With this system, stable ion acceleration ($\sigma_{E_{max}}$~15%) has been demonstrated for >1000shots under operation at 10Hz.
In a proof-of-principle experiment, this target system has been deployed at a campaign at CLPU aiming to produce ^{11}C. Using the 100TW laser operating at 0.1Hz, activities >12kBq/shot and total activities >230kBq from bursts were demonstrated. These results indicate that pre-clinical activities are already achievable under the current conditions with extended irradiation times. Furthermore, we demonstrate that multi-Hertz table-top systems, typically producing lower-energy ion beams, can reach clinical activities thanks to the increased repetition rate.

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Session Classification: Poster session

Track Classification: WG5: Applications

Contribution ID: **245** Type: **Poster (student)**

Characterization of Liquid Micro-Droplets for Laser-Driven Proton Acceleration

Tuesday, 19 September 2023 19:00 (1h 30m)

In laser-driven particle acceleration the choice of the target material can have a large impact on the acceleration process. Therefore, a laser-driven proton acceleration experiment was conducted at the POLARIS laser system, where liquid micro-droplets made of water or ethylene glycole were used as targets.
Droplet chains were created by a pressurized capillary nozzle, which was made to vibrate with an oscillating piezo element. The driving frequency was synchronized to the laser pulses to create stable droplets for each laser shot. The stability of the droplets was examined for different pressures, driving frequencies and liquid types.
The droplets were then irradiated by laser pulses from the POLARIS laser system, which had intensites up to $4 \cdot 10^{19}$ W/cm^2 and accelerated protons via the TNSA-mechanism. The shape of the resulting proton beam was observed with a Thomson-Parabola.
In the experiments, the proton beam profile showed modulations in the beam density, which could be strongly reduced, when ethylene glycole was used. A possible explanation for these modulations could be electric fields, which are created in the background gas. Since ethylene glycole has a much lower vapor pressure, the modulations are less severe.

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Session Classification: Poster session

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **248** Type: **Poster (participant)**

Superconducting undulator activities at the European XFEL

Tuesday, 19 September 2023 19:00 (1h 30m)

For more than 5 years, superconducting undulators (SCUs) have been successfully delivering X-rays in storage rings. The European XFEL (EuXFEL) plans to demonstrate the operation of SCUs in XFELs. For the same geometry, SCUs can reach a higher peak field on the axis with respect to all other available technologies, offering a larger photon energy tunability range. The application of short-period SCUs in a high electron beam energy FEL > 11 GeV will enable lasing at very hard X-rays > 40 keV. The large tunability range of SCUs will allow covering the complete photon energy range of the soft X-ray experiments at the European XFEL without changing electron beam energy, as currently needed with the installed permanent magnet undulators. For a possible CW upgrade under discussion at the EuXFEL with a lower electron beam energy of approximately 7–8 GeV, SCUs can provide the same photon energy range as available at present with the permanent magnet undulators and electron energies. This paper will describe the potential of SCUs for XFELs. In particular, it will focus on the different activities ongoing at the EuXFEL and in collaboration with DESY to allow the implementation of SCUs in the EuXFEL in the upcoming years.

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Presenter: CASALBUONI, Sara

Session Classification: Poster session

Track Classification: WG5: Applications

Contribution ID: **252** Type: **Poster (participant)**

Laser Wakefield Accelerator Design for the Extreme Photonics Applications Centre (EPAC)

Tuesday, 19 September 2023 19:00 (1h 30m)

The Extreme Photonics Applications Centre (EPAC) is an ultra-short pulse, petawatt laser facility under construction on the Rutherford Appleton Laboratory Site in the UK. In Experimental Area 1, it will deliver stable electron beams at a rep rate of 10 Hz for industrial and academic users via laser plasma wakefield acceleration. Simulation studies have been performed in order to understand the gas dynamics of the target, the laser interaction with the gas and the propagation of the accelerated electron beam further down the beamline.

The EPAC facility will offer a number of facility-designed target options to users for different applications. The first target that has been designed is a rectangular, slot gas jet. Two prototypes have been manufactured based on fluid simulations and subsequently characterised by interferometry of neutral gas and of laser ionised plasma.

Particle-in-cell simulations using FBPIC guided by Bayesian optimisation have been performed to generate representative electrons beams from the accelerator. Outputs from these simulations have been fed into a magnetic lattice, simulated in elegant, for electron focusing studies. Current beam transport studies have considered a 1 GeV electron bunch but ultimately hopes to be flexible with regards to electron beam energy.

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Presenter: FINLAY, Oliver (Central Laser Facility)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **256** Type: **Poster (participant)**

The Oxford Plasma Accelerator Laboratory

Tuesday, 19 September 2023 19:00 (1h 30m)

An overview is presented of the Oxford Plasma Accelerator Laboratory (OPAL), which houses a 600mJ (shortly to be upgraded to 1 J), 10Hz, 45fs Ti:Sapphire laser, and a suite of diagnostics tailored to the development of channel-guided laser-plasma accelerators. A channel is formed with a ~100mJ "channel-forming"beam, focused by an axicon. This channel guides the "drive" beam, thereby supporting extended acceleration [1].

In addition to standard diagnostics, we have developed and installed a plasma fluorescence diagnostic, for characterising the pressure uniformity of gas cells [2], and a single-shot 2-color interferometer to measure low-density (~10^17 cm^(-3)) mixed plasma and neutral gas structures. A "leak diagnostic"images light transmitted through a high-reflectivity mirror placed immediately before the target. Coupled with novel analysis techniques, it enables simultaneous on-shot measurements of the channel-forming and drive beam focus positions. An active stabilisation system mitigates drift during long-term operation. Combined, these diagnostics enable high-resolution high-volume statistics to be collected on channel-guided laser-plasma acceleration.

OPAL will be used to test novel methods to enhance conditioned hydrodynamic optical-field-ionized (CHOFI) channels to facilitate meter-scale laser-plasma accelerators and improve controlled injection.

1. Picksley, A. et al. Phys. Rev. E 102, 053201 (2020).
2. Picksley, A. et al. http://arxiv.org/abs/2307.13689 (2023).

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Presenter: MCMAHON, David (University of Oxford)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **288** Type: **Poster (participant)**

Toward an automated tool for interferogram analysis for real time characterization of plasma density profile in laser produced plasmas

Tuesday, 19 September 2023 19:00 (1h 30m)

Laser-driven plasma wakefields accelerators (LWFA) in the past few years have shown rapid progress towards the realization of compact and stable electron sources. Many efforts are devoted to increase the repetition rate of these sources, which is mandatory for their future applications. This requires diagnostics that can work in real-time without losing their precision. This is particularly difficult for the characterization of the plasma density profile, which is crucial for the tuning of the plasma density and the laser properties to reach the optimal match for the acceleration. Interferometry is a widely used method, particularly appreciated since it allows for non-intercepting, single-shot measurements of the local plasma density. Still, the analysis of the raw data is a non-trivial task, prone to many sources of error and dependent on the manual inputs.
In this presentation, we will show an automated tool we are investigating for a fast and operator-independent analysis of the plasma density that could enable a real time feedback of the formed plasma density to help the operation of LWFA at high repetition rate.

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Presenter: FILIPPI, Francesco (ENEA)

Session Classification: Poster session

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **297** Type: **Poster (participant)**

Megahertz repetition rate discharge plasma cells for plasma-based particle accelerators

Tuesday, 19 September 2023 19:00 (1h 30m)

Particle acceleration in wakefields excited in a plasma medium is one of the prime candidates to complement or even replace conventional radiofrequency accelerators in future accelerator facilities due to the far superior acceleration gradients achievable in plasma. In contrast to conventional acceleration techniques, which routinely supply experiments with up to 100's of thousands of bunches per second, allowing data taking in a short period of time, plasma accelerators at the moment usually operate at repetition rates of a few Hz. To enable high-gradient-acceleration at competitive repetition rates, the plasma acceleration medium has to be supplied with high reproducibility at similarly high repetition rates. Here, we report on the development of gas discharge plasma cells capable of producing plasma acceleration media with MHz repetition rate in bursts of tens of discharges.

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Presenter: Dr LOISCH, Gregor (Deutches Elektronen-Synchrotron DESY)

Session Classification: Poster session

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **306** Type: **Poster (student)**

Effect of driver charge on wakefield characteristics in a plasma accelerator probed by femtosecond shadowgraphy

Tuesday, 19 September 2023 19:00 (1h 30m)

High peak current electron beams from laser wakefield accelerators (LWFAs) can excite a high amplitude plasma wave in a subsequent plasma wakefield acceleration (PWFA) stage. The intrinsic short duration of these driver beams enables a new operational regime of PWFAs at plasma densities above $10^{18}\mathrm{cm}^{-3}$ which is important for the acceleration of ultra-short and ultra-low emittance witness bunches. Benefiting from existing femtosecond optical probing techniques at this density regime, direct observation of beam-driven plasma waves becomes possible. Here we present experimental results of optical probing of such beam driven waves, showing the shape and size of the first cavity of the wakefields correlates with the driver beam charge. In addition, precise analysis of the plasma wavelength enables on-shot measurement of the ionisation level caused by the driver beam in a hydrogen-helium mixture, which is particularly important for the study of advanced injection techniques such as Trojan horse injection. The experimental results are supported by 3D particle-in-cell simulations performed with PIConGPU. This method can be extended to a detailed study of driver charge depletion by probing the evolution of the wakefield when propagating through the plasma. This is an important step for further understanding and optimization of high energy efficiency PWFAs.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **308** Type: **Poster (student)**

Phase Control of Nonlinear Breit-Wheeler Pair Creation

Tuesday, 19 September 2023 19:00 (1h 30m)

High-charge energetic positron beams are a useful tool for probing the Standard Model of particle physics, however, the large scale and cost of accelerators used to conventionally produce such beams (e.g., LEP) have led to the search for smaller and cheaper alternatives. One candidate for $e^- - e^+$ pair creation is to collide an ultra-relativistic electron beam with a high-intensity laser pulse, generating energetic photons through nonlinear Compton scattering which then decay into pairs via the nonlinear Breit-Wheeler process. The next generation of laser facilities will be able to reach intensities of $10^{23} - 10^{24}$ $\mathrm{W/cm^2}$, paving the way to drastically increase the number of pairs that can be observed experimentally beyond the current record of $\sim$100. Conventionally, these experiments result in a neutral beam where both electrons and positrons co-propagate. To separate the species, a strong magnetic field must be sustained over a several centimeter scale. Here, we show that using a two-colored laser pulse in a head-on electron-laser collision not only creates electron-positron pairs through the Breit-Wheeler process but naturally causes them to be deflected in opposite asymptotic angles from the moment of creation, which removes the need for magnetic deflection while facilitating the diagnosis of nonlinear Breit-Wheeler pair creation.

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Session Classification: Poster session

Track Classification: WG3: Theory and simulations

Contribution ID: **329** Type: **Poster (participant)**

Update on PALLAS project

Tuesday, 19 September 2023 19:00 (1h 30m)

The prototyping of accelerator based on laser-plasma technology (PALLAS) project aims to build a laser-plasma injector accelerator (LPI) test facility with the objective to deliver within a few years electron beam of 150-250 MeV, >30 pC, <1 mm.mrad emittance beam at 10 Hz with control and stability comparable with RF accelerator. The project developments are structured around advanced laser control [1], plasma target development [2,3] and electron beam characterization [4].
An update on the project's progress will be given, focusing on two aspects. Firstly, the recent numerical and experimental results in plasma targetry for localised ionisation injection targets with two different approaches will be presented and discussed. Secondly, the recent development for automated data acquisition using Tango Controls will be reported on the control command aspect.

[1] G. Kane et al. EAAC (2023), S. Feister et al. HPLE (2023)
[2] P. Drobniak et al. arxiv 2023, V. Kubytsky EAAC (2023)
[3] P. Drobniak et al. to be submitted (2023)
[4] C. Guyot et al. EAAC (2023)

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **350** Type: **Poster (participant)**

BELLA iP2: The Short Focal Length Beamline for High Energy Density Research at High Repetition Rates at the BELLA PW

Tuesday, 19 September 2023 19:00 (1h 30m)

The high-intensity iP2 beamline at the BELLA PW laser enables frontier capabilities in High Energy Density Science, including accessing new regimes of ion acceleration. This system provides a focal spot of ~3 μm diameter, resulting in peak intensities of >5×10²¹ W/cm². The 1 Hz pulse repetition rate, if paired with replenishable target systems, can increase the particle flux for applications and allows for the collection of large data sets. During commissioning, proton beams were accelerated up to 40 MeV with TNSA at 17 J laser pulse energy. We have implemented a double plasma mirror to improve the temporal contrast of the laser pulse before target interaction. These capabilities enable a series of experiments to study advanced ion acceleration mechanisms and fundamental plasma processes relevant for Inertial Fusion Energy, and to develop innovative plasma-based technologies for ion beam applications. Those include improvements for radiation therapy, or studies of radiation effects in materials and (quantum) electronic devices. The iP2 beamline is accessible to users through LaserNetUS. In this contribution we present the iP2 facility and recent ion acceleration results.
Work was supported by the U.S. DOE Office of Science, Offices of FES and HEP, and the LaserNetUS, under Contract No. DE-AC02-05CH11231.

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Session Classification: Poster session

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **370** Type: **Poster (participant)**

A tale of three beams: towards stable and reproducible operation of the AWAKE facility

Tuesday, 19 September 2023 19:00 (1h 30m)

The Advanced Wakefield Experiment (AWAKE) relies on proton-driven wakefields created in a laser-ionized plasma to accelerate electrons. Accurate measurement and control of the optics, trajectory and timing of the three beams—proton, laser and electron—is a fundamental requirement for successful operation of the facility. Continuous advances in both instrumentation and methods are necessary to improve operational stability, reproducibility and efficiency. Since the three beams have drastically different characteristics, their performance is limited by different sources (such as thermal effects, magnetic hysteresis, current ripples, phase locking), requiring dedicated approaches. Recent improvements and measurement campaigns are described, highlighting the lessons learned. Finally, the challenges expected in future upgrades of the AWAKE facility are discussed.

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Session Classification: Poster session

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **373** Type: **Poster (participant)**

External Electron Injection for the AWAKE Run 2b Experiment

Tuesday, 19 September 2023 19:00 (1h 30m)

We summarize and explain plans for witness particle beam injection into wakefields for the AWAKE Run 2b experiments. In AWAKE, the plasma wakefields are driven by a self-modulating relativistic proton bunch. For Run 2b, we use a novel Rubidium vapor source that allows for a plasma density step. To demonstrate that the density step can stabilize the wakefield amplitude and to probe the longitudinal fields, we are planning on injecting a 20 MeV electron bunch produced by a photo-injector. We summarize the experimental challenges of this injection process and present our plans for the near future.

Primary authors: VAN GILS, Nikita (CERN); TURNER, Marlene (CERN); PANNELL, Fern; ZEVI DELLA PORTA, Giovanni; BENCINI, Vittorio; GSCHWENDTNER, Edda (CERN); MUGGLI, Patric (Max-Planck-Institut für Physik)

Presenter: VAN GILS, Nikita (CERN)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **381** Type: **Poster (participant)**

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

Tuesday, 19 September 2023 19:00 (1h 30m)

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.

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Presenter: THEVENET, Maxence (DESY)

Session Classification: Poster session

Track Classification: WG3: Theory and simulations

Contribution ID: **422** Type: **Invited talk**

Status and recent results of FLASHForward

Wednesday, 20 September 2023 09:00 (35 minutes)

The realization of the reduced cost and environmental footprint promised by plasma-wakefield-driven free-electron lasers and particle colliders requires that their luminosity and brightness be comparable to that provided by conventional RF-driven facilities. This requires operating at high repetition rates, preserving the beam's energy spread, emittance and charge, and ensuring a high energy-transfer efficiency. In pursuit of this goal, we present new results from the beam-driven plasma-acceleration experiment FLASHForward (DESY, Hamburg), which include: beam quality preservation, a new diagnostic to longitudinally resolve energy-extraction efficiency, and a new record in energy-deposition efficiency.

Primary author: Mr PEÑA, Felipe (DESY)

Presenter: Mr PEÑA, Felipe (DESY)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **257** Type: **Invited talk**

High-quality 1 GeV electron beam with a 50 TW laser

Wednesday, 20 September 2023 09:35 (35 minutes)

For the last decades, the development of Laser-Plasma Accelerators (LPAs) has attracted tremendous interest thanks to the capacity of plasma to produce and sustain very high electric fields. The accelerating gradients in plasma accelerators can exceed 100 GV/m, which is three orders of magnitude larger than those obtained in metallic-cavity accelerators, thus promising very compact alternatives to conventional linear machines. However, a high field is not the only ingredient required for multi-GeV energy gains, as the accelerated beam has to follow this field over long distances. This point out the need to guide the laser.
Here we will present the first experimental demonstration of the acceleration of quasi-monoenergetic electron beams at the GeV level in a plasma waveguide. The latter is created all-optically by a quasi-Bessel machining beam shaped by an axiparabola mirror. We will also discuss a new acceleration concept that employs an advanced optical shaping of the laser driver that allows a diffraction-free propagation over a long distance while controlling the group velocity of the laser, thus avoiding dephasing, which opens up prospects for producing tens of GeV in single-stage, single-laser beam experiments.

Primary author: THAURY, Cedric (LOA)

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Presenter: THAURY, Cedric (LOA)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **171** Type: **Invited talk**

Experimental Demonstration of Laser Guiding and Wakefield Acceleration in a Curved Plasma Channel

Wednesday, 20 September 2023 10:10 (30 minutes)

Curved plasma channels have been proposed to guide intense lasers for various applications, such as x-ray laser emission, compact synchrotron radiation, and multistage laser wakefield acceleration. In this talk, we will introduce our recent study on a carefully designed experiment showing evidences of intense laser guidance and wakefield acceleration in a centimeter-scale curved plasma channel. Both experiments and simulations indicate that when the channel curvature radius is gradually increased and the laser incidence offset is optimized, the transverse oscillation of the laser beam can be mitigated, and the stably guided laser pulse excites wakefields and accelerates electrons along the curved plasma channel to a maximum energy of 0.7 GeV. Our results also show that such a channel exhibits good potential for seamless multistage laser wakefield acceleration. After that, a brief introduction to our 200+300TW laser system and experimental platform on laser plasma acceleration and QED-plasma at Shanghai Jiao Tong university will be given.

Primary author: CHEN, Min (Shanghai Jiao Tong University)

Presenter: CHEN, Min (Shanghai Jiao Tong University)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **203** Type: **Invited talk**

3D structure of microbunched plasma-wakefield-accelerated electron beams inferred by coherent optical transition radiation

Wednesday, 20 September 2023 11:00 (30 minutes)

Plasma-wakefield accelerators produce relativistic, micron-scale electron bunches. The sub-micrometer internal distribution of these bunches, which critically influences gain in free-electron lasers or particle yield in colliders, has proven elusive to characterize. Through analysis of multi-spectral images of coherent optical transition radiation (COTR) that laser-wakefield-accelerated e-bunchs generated when transiting a metal foil, we elucidate the micro- and macro-structure of these bunches. Key features of COTR images and spectra correlate uniquely with how plasma electrons inject into the wake. We measured COTR from bunches injected by three different regimes: by a plasma-density discontinuity, by ionizing high-Z gas-target dopants, or by uncontrolled laser-plasma dynamics. With additional input from electron spectra, and particle-in-cell simulations, we reconstructed not only the longitudinal profile of these beams, but also their coherent 3D charge structures. The results demonstrate versatile metrology for next-generation X-ray free-electron lasers.

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Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **270** Type: **Invited talk**

Temperature effects in plasma-based positron acceleration

Wednesday, 20 September 2023 11:30 (30 minutes)

Preserving the quality of a positron beam in plasma-based accelerators, where a wakefield suitable for positron transport and acceleration is generated by an electron filament, poses significant challenges. The wakefields are nonlinear in the transverse direction and non-uniform in the longitudinal direction, leading to potential degradation of the beam quality. Maintaining high beam quality is crucial for the successful application of positron beams in plasma-based colliders. In this talk, we discuss how to mitigate the positron beam quality degradation by introducing an initial background plasma temperature in acceleration concepts that rely on electron filaments. Using ultra-high-resolution simulations enabled by the novel mesh refinement algorithm in HiPACE++, we demonstrate that temperature effects play a key role in broadening the electron filament and consequently smoothing both the non-linear transverse and non-uniform longitudinal wakefields. Leveraging warm plasmas opens up promising avenues for enhancing beam quality in various plasma-based positron acceleration concepts.

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Presenter: DIEDERICHS, Severin (DESY)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **363** Type: **Invited talk**

FACET-II: Status of the first experiments and the road ahead

Wednesday, 20 September 2023 12:00 (30 minutes)

The FACET-II facility at SLAC National Accelerator Laboratory conducts a broad science program based on the interaction of low-emittance high-current 10 GeV electron beams with lasers, plasmas and solids. FACET-II operates as a National User Facility while engaging a broad User community to develop and execute experimental proposals that advance the development of plasma wakefield accelerators. The FACET-II facility began first experiments in the summer of 2022, paused for an eight month-long laboratory-wide shutdown in 2023, and resumed operation this summer. The special features of FACET-II will be shown and the status of the first experiments invited for beam time will be presented.

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Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **170** Type: **Oral contribution**

Optical Probing of Ultrafast Laser-Induced Transitions from Solid to Overdense Plasma

Wednesday, 20 September 2023 16:25 (20 minutes)

Capturing the target behavior during a high-intensity laser-solid interaction is crucial to understanding the interplay of fundamental processes such as ionization, collisions, and plasma kinetics. Furthermore, the pre-plasma evolution caused by the laser's rising edge is key for enhancing the properties of the accelerated particles and secondary X-ray sources. We present experimentally and numerically the onset and development of a plasma induced by the interaction of laser pulses with nm-thin DLC foils. A chirped probe pulse propagates longitudinally through the foil and records the ultrafast transmission dynamics during a single-pulse illumination. Numerical results shed light on the dynamics of the generation and evolution of a plasma. To achieve a good agreement between simulation and experiment, we developed a novel Two-Step Model. First, a solid-state interaction model is used to describe the interaction up to the target-melting. Second, a PIC-code is used for the kinetic description of the plasma. This investigation provides a direct insight into the interplay of various ionization processes. In addition, a detailed description of the spatio-temporal evolution of the plasma properties is obtained. Finally, this work is a first step towards providing the description of unprecedented detailed pre-plasma conditions for relativistic laser-solid interaction in PIC-codes and experiments.

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Session Classification: WG8: Plasma sources and related diagnostics

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **197** Type: **Oral contribution**

A new facility dedicated to VHEE radiotherapy based on laser-plasma accelerators

Wednesday, 20 September 2023 16:25 (20 minutes)

The notion of utilizing very high energy electrons (VHEE) in the 200MeV range for treating deep-seated cancerous tumors has recently gained traction in the particle accelerator community. As a result, numerous technical advances aimed at developing medically sound conventional and non-conventional electron accelerators have emerged. Since late 2022, the European Innovation Council has been funding eBeam4Therapy, a project with the goal of optimizing VHEE beam performances for radiotherapy applications. This involves characterizing the 3D dose deposition, improving and scaling down each component of the machine, and ultimately building a laser-plasma accelerator that demonstrates technical feasibility while being economically competitive. In this discussion, we will explore the novelty of the project, the physics of electron acceleration at its heart, and the interaction between VHEE and tissues.

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Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **290** Type: **Oral contribution**

Novel positron source for PWFA experiments

Wednesday, 20 September 2023 16:25 (20 minutes)

We present a novel, compact, low-emittance positron source that is compatible with existing PWFA and LWFA facilities (https://arxiv.org/abs/2301.08368). The device is based on a Penning-Malmberg trap that collects and cools positrons. The resulting beam has low thermal emittance (less than 1 micron), but it is magnetized and the bunch length is cm-scale. We describe a method for extracting and compressing the beam to 100 um-scale bunch lengths, which is compatible for acceleration in low-density PWFA experiments.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **317** Type: **Oral contribution**

Affordable simulations of collider-relevant plasma-based accelerators (and more) with mesh refinement

Wednesday, 20 September 2023 16:25 (20 minutes)

While simulations of plasma acceleration are becoming affordable, specific problems remain hard to model. This is the case for collider-relevant parameters (high energy, low emittance beam), long beams (as seen for example in the AWAKE experiment) or positron acceleration, where scale discrepancies call for impractical number of grid cells. In this work, we present numerical methods to reduce the cost of simulations by orders of magnitude. In particular, the implementation of mesh refinement and adaptive resolution in recent quasi-static codes HiPACE++ (3D quasi-static particle-in-cell on GPU) and Wake-T (axisymmetric reduced model for fast evaluations on a laptop) make challenging simulations very cost-effective. Integrated in a suite of open-source and documented tools, these improvements allow for multi-physics studies of the most demanding scenarios of plasma acceleration.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **333** Type: **Oral contribution**

ALBUS –Advanced Laser-driven Beamlines for User-specific Studies

Wednesday, 20 September 2023 16:25 (20 minutes)

The ALBUS technology platform tackles the challenges arising from the unique properties of laser-driven ion beams. The central part of ALBUS is the advanced pulsed electromagnet technology adapted from high-field laboratory know-how in combination with custom-designed current pulse generators, with a repetition rate matching the pulsed nature of a common LPA source, aiming towards 1 Hz.
The magnets can be used as particle beam optics, featuring inherent tunability, large apertures and short focal lengths for efficient beam capture, transport, and energy selection. Arranged as beamlines, the magnets not only allow to tailor LPA particle sources for application but also provide a valuable test bed for detector development. The ALBUS-2S beamline configuration, based on two pulsed high-field solenoid magnets (B ≤ 20 T), was designed to transport and shape laser-driven proton beams to provide homogeneous dose distributions to volumetric radiobiological samples and according dose-detection setups. It enabled the worldwide-first controlled volumetric in vivo tumor irradiations with laser-accelerated protons.
Furthermore, split-pair coils for the investigation of magnetized plasma phenomena in the laboratory are developed. Featuring optical access to the magnetized laser-driven plasma they enable optical and X-ray probing as well as insertion of obstacles and/or laser targets.

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Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **174** Type: **Oral contribution**

New methods to produce polarized 3He ion beams

Wednesday, 20 September 2023 16:45 (20 minutes)

The use of polarized ^{3}He ions in storage rings opens a new window to investigate nuclear forces, because nuclear polarized ^{3}He ions can be regarded as an ideal substitute for polarized neutron beams. Polarized $^3He^{2+}$ ions were used in the 1960's, but either the nuclear polarization or the intensity of the ion sources was rather small. Numerous efforts to improve the performance of these sources have so far been unsuccessful.

I will present two new methods for producing polarized ^{3}He beams: the first uses a pre-polarized ^{3}He gas target from which few-MeV $^3He^{1+,2+}$ ions are accelerated with petawatt laser pulses. Data from the Phelix facility show for the first time a polarization signal that confirms numerous theoretical works predicting the potential of plasma-based accelerators to produce polarized beams (electrons, protons, and ions). Our data also support the concept of "Polarized Fuel"to increase the efficiency of future fusion reactors. The second method is based on a Sona transition unit, in which an intense beam of few-keV $^3He^{1+}$ ions can be polarized up to $P \sim 90\%$ by means of a coherent and monochromatic radio-wave pulse. A status report on a first beam time at COSY-Jülich (Sept. 2023) will be given.

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Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **214** Type: **Oral contribution**

Reduction of the electron beam divergence of laser wakefield-accelerators by integrated plasma lenses

Wednesday, 20 September 2023 16:45 (20 minutes)

We report on electron beam collimation using a passive plasma lens, integrated directly into a laser wakefield accelerator stage operating in the high-charge regime. The lens is created by reshaping the gas density profile of a super-sonic jet at the beam's exit side through an obstacle mounted above the jet. It reduces the beam's divergence by a factor of two, to below 1 mrad (root-mean-square), while preserving the total charge of 170 pC and maintaining the same energy spread. The resulting
spectral-charge density, charge contained within MeV energy bandwidth propagating at mrad angular direction, of up to 7 pC/(MeV·mrad) played a key role in the recent experimental demonstration of free-electron lasing. The presented simple and robust gas shaping technique holds the potential to generate specific density profiles, essential for the application of adiabatic focusing or staging of accelerators

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Session Classification: WG8: Plasma sources and related diagnostics

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **226** Type: **Oral contribution**

Full Energy Beam Exploitation at CLARA: Opportunities for Advanced Accelerator Experiments

Wednesday, 20 September 2023 16:45 (20 minutes)

The Full Energy Beam Exploitation (FEBE) beamline and experimental hutch at CLARA will combine a 250 MeV FEL quality electron beam with a 100 TW class laser and will support exploitation of the CLARA beam for advanced acceleration experiments and research. This includes plasma based and structure based acceleration, with laser and beam drivers. FEBE has been designed to provide flexibility in both electron and laser beam delivery. We present an overview of capabilities of FEBE including: targeted electron beam parameters, broad range of beam diagnostic systems, TW laser parameters and integration, and timing and synchronisation system. Finally, the potential for supporting experiments aimed at overcoming some of the pressing novel acceleration challenges – e.g. beam quality perseveration, stability and synchronisation, staging –will be discussed. User exploitation of the CLARA facility is expected to begin early 2025.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **285** Type: **Oral contribution**

Exascale and ML Models for Accelerator Simulations

Wednesday, 20 September 2023 16:45 (20 minutes)

Computational modeling is essential to the exploration and design of advanced particle accelerators. The modeling of laser-plasma acceleration and interaction can achieve predictive quality for experiments if adequate resolution, full geometry and physical effects are included. Here, we report on the significant evolution in fully relativistic full-3D modeling of conventional and advanced accelerators in the WarpX and ImpactX codes with the introduction of Exascale supercomputing and AI/ML models. We will cover the first PIC simulations on an Exascale machine, the need for and evolution of open standards, and based on our fully open community codes, the connection of time and space scales from plasma to conventional beamlines with data-driven machine-learning models.

Supported by the Exascale Computing Project (17-SC-20-SC), a collaborative effort of two U.S. Department of Energy organizations (Office of Science and the National Nuclear Security Administration), by the CAMPA collaboration, a project of the U.S. Department of Energy, Office of Science, Office of Advanced Scientific Computing Research and Office of High Energy Physics, Scientific Discovery through Advanced Computing (SciDAC) program and by an LBNL LDRD supported by the U.S. Department of Energy, Office of Science, under contract numbers DE-AC02-05CH11231.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **332** Type: **Oral contribution**

Emerging trends in cellular response to proton irradiations at ultra-high dose rates

Wednesday, 20 September 2023 16:45 (20 minutes)

The ultrashort nature of laser-driven proton bursts allows, with appropriate arrangements, to perform single pulse irradiation of cellular samples at dose rates reaching 1010 Gy/s. Motivated by the FLASH radiotherapy context, there is significant interest in assessing any divergence in biological response at these ultra-high dose rates (UHDR) from the behaviour observed in irradiations under conventional conditions.
We will report on results of recent campaigns using laser-accelerated proton beams at the VULCAN laser at the Rutherford Appleton Laboratory, UK. A magnetic transport system, coupled in selected shots to a target-based collimation technique, allowed the delivery of doses up to 10s of Gy at ~30 MeV energies, in single pulses of ~400 picoseconds. The irradiations employed different cell models, including cancerous glioblastoma stem-like cells (GSCs, irradiated as 2D monolayers and 3D spheroids), and normal fibroblast cells AG01522. Cell survival and DNA damage were investigated and compared to X-Ray and conventional proton irradiations.
The comparison highlights clear differences in biological response, pointing to the ability of the UHDR pulses to remove differences related to the microenvironment in cancerous cells (e.g. hypoxic effects in the spheroid's core) and to a significant sparing of the normal AG01522 cells.

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Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **211** Type: **Oral contribution**

DiWaCAT: An Efficient Field Solver and Beam Tracker for Dielectric Wakefield Acceleration Applications

Wednesday, 20 September 2023 17:05 (20 minutes)

Dielectric Wakefield Acceleration (DWA) is a promising technology with potential applications in future accelerators. To facilitate DWA research and experimentation, we have developed Dielectric Wakefield Calculator and Tracker (DiWaCAT), a versatile python and C++ based code. DiWaCAT enables rapid and accurate 3D wakefield calculations in circular and planar dielectric-lined waveguides (DLWs) and provides comprehensive beam tracking capabilities through these structures. The accuracy of fields calculated has been validated by benchmarking against the commercially available code CST and beam property measurements have been benchmarked against experimental results. Input beams for DiWaCAT can be made with arbitrary 6D beam properties, including a variety of longitudinal bunch profiles, or imported from other accelerator simulation codes. Particles can be tracked and outputted in a format compatible with accelerator codes for start-to-end simulations. The software presented allows for fast simulations of DWA experiments across a wide range of beam and DLW parameters and enables exploration of future applications of DWA technologies.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **218** Type: **Oral contribution**

Segmented plasma discharge capillary for staged particle acceleration

Wednesday, 20 September 2023 17:05 (20 minutes)

Novel particle accelerators based on plasma technology allow a drastic reduction in size, due to the high accelerating and focusing fields established inside plasmas. In this regard, we present a compact gas-filled plasma discharge capillary for particle accelerators applications, including staged wakefield acceleration and active plasma lensing. A first design of the plasma source is characterized by two segments fed by parallel high voltage circuits, which establish two independent discharges. By synchronizing the circuits and setting the same voltage, the two discharges result in a uniform m-scale long plasma channel, with lower breakdown voltage compared to a single m-scale plasma discharge. On the other hand, a voltage difference between the pulses entails a density profile with a steep gradient between the segments. A second design consists in a three-staged capillary composed by two active plasma lenses and one plasma wakefield acceleration stage. For this source three independent discharges are created and properly synchronized with the beam, to obtain the focusing effect in the external segments and acceleration in the central one. As proof of principle, combined acceleration and focusing of electron beams with such three-staged source were demonstrated at SPARC_LAB accelerating facility in Laboratori Nazionali di Frascati (INFN).

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Session Classification: WG8: Plasma sources and related diagnostics

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **289** Type: **Oral contribution**

Recent BELLA PW experiments exploring radiobiological effects in the ultra-high instantaneous proton dose rate regime

Wednesday, 20 September 2023 17:05 (20 minutes)

Laser-driven (LD) proton sources are of interest for various applications due to their ability to produce short proton bunches with high charge and low emittance. These sources can be used in biological studies investigating improvements to radiation cancer therapy. Recently, the differential sparing effect on normal tissues versus tumors using the delivery of high radiation doses >10 Gy at extremely high dose rates (DR), has received increasing attention and was termed the FLASH effect. However, the molecular and cellular mechanisms underlying FLASH are not yet fully understood. To explore these mechanisms, we have implemented a beamline at the BELLA PW that delivers proton bunches at ultra-high instantaneous DR (UHIDR) up to 10⁸ Gy/s to a sample irradiation site. This allowed us to study in vitro the differential sparing of normal versus prostate cancer cells [Bin Sci. Rep. 12:1585 (2022)]. More recently, we extended our capabilities to investigate in vivo the acute skin damage and late radiation-induced fibrosis in mouse ears after UHIDR with 10 MeV protons and prescribed doses up to 40 Gy.
Work supported by U.S. DOE Office of Science, Offices of FES and HEP, and LaserNetUS under Contract No. DE-AC02-05CH11231 and LBNL LDRD, PI Snijders.

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Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **377** Type: **Oral contribution**

The effect of exit plasma scale-length and plasma mirrors on electron beams from a laser wakefield accelerator

Wednesday, 20 September 2023 17:05 (20 minutes)

The effect of density ramps and plasma mirrors on electron beam divergence was measured in the context of staged laser wakefield acceleration. Termination of an acceleration stage was found to increase total beam divergence from 3.38 $\pm$ 0.07 mrad to 6.13 $\pm$ 0.13 mrad, and the effect was observed to persist at high energies, up to 2.2 GeV. Additionally, shot-to-shot fluctuations in divergence dropped from 12.4$\pm$1.3% to 4.7 $\pm$ 1.2%. Using simulations and numerical models, the presence of the density ramp was shown to have a divergence-reducing effect with a magnitude that matched the experiment. The kT magnetic fields generated in plasma mirrors were investigated using simulations, and the effect of these fields on the electron beam was quantified. Compared to normal incidence, a 45 degree angle of the plasma mirror to the beam axis reduced the integrated magnetic fields inside the mirror, benefiting the electron beam emittance. The improved shot-to-shot stability was found to be due to a transition to the beam-driven regime in the density ramp. These results provide validation for the use of density ramps in future multi-stage wakefield target design.

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Presenter: BACKHOUSE, Michael

Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **421** Type: **Oral contribution**

Characterization of Liquid Micro-Droplets for Laser-Driven Proton Acceleration

Wednesday, 20 September 2023 17:05 (20 minutes)

In laser-driven particle acceleration the choice of the target material can have a large impact on the acceleration process. Therefore, a laser-driven proton acceleration experiment was conducted at the POLARIS laser system, where liquid micro-droplets made of water or ethylene glycole were used as targets.
Droplet chains were created by a pressurized capillary nozzle, which was made to vibrate with an oscillating piezo element. The driving frequency was synchronized to the laser pulses to create stable droplets for each laser shot. The stability of the droplets was examined for different pressures, driving frequencies and liquid types.
The droplets were then irradiated by laser pulses from the POLARIS laser system, which had intensites up to W/cm and accelerated protons via the TNSA-mechanism. The shape of the resulting proton beam was observed with a Thomson-Parabola.
In the experiments, the proton beam profile showed modulations in the beam density, which could be strongly reduced, when ethylene glycole was used. A possible explanation for these modulations could be electric fields, which are created in the background gas. Since ethylene glycole has a much lower vapor pressure, the modulations are less severe.

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Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **230** Type: **Oral contribution**

Monoenergetic ion acceleration in laser-plasma peeler regime

Wednesday, 20 September 2023 17:25 (20 minutes)

We discuss relativistic laser interaction with overdense plasmas, where the laser pulse is incident parallel to the plasma surface, the so-called "peeler"regime [1]. The laser pulse impinges on an edge of a tape. The edge allows for an efficient conversion of the laser pulse into a surface plasma wave (SPW). The SPW peels off and accelerates electrons (tens of nC) from the target skin layer. They emit bright betatron radiation and lead to monoenergetic ion acceleration.

[1] X. F. Shen, A. Pukhov, B. Qiao Phys. Rev. X 11 041002

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Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **247** Type: **Oral contribution**

Laboratory Astrophysics and Plasma Wakefield Acceleration: Experimental Study of Magnetic Field Generation by Current Filamentation Instability of a Relativistic Proton Bunch in Plasma

Wednesday, 20 September 2023 17:25 (20 minutes)

Current Filamentation Instability (CFI) can occur in plasma wakefield accelerators as well as in astrophysical media. This instability takes place when a charged particle bunch streams through a plasma with skin depth smaller than the bunch transverse size, so that the plasma return current flows within the bunch. Repulsion between opposite currents tends to reinforce any initial transverse perturbation or anisotropy in the current density profiles, causing the instability to grow, transforming the bunch into multiple high-current-density transverse filaments.
Occurrence of CFI generates magnetic fields within a non-magnetized background, by converting part of the kinetic energy stored in the bunch into magnetic energy. This process is in fact a plausible candidate for magnetization of astrophysical media, as well as for the magnetic fields enhancement that could explain phenomena such as long-duration afterglow of gamma-ray bursts and collisionless shocks.
We demonstrate with experimental results, in the context of the AWAKE experiment at CERN, that CFI occurs for a relativistic, wide proton bunch traveling in plasma. We discuss the implications for the design of a plasma wakefield accelerator and we show that the instability feeds the generation of magnetic fields.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **249** Type: **Oral contribution**

High-Field Physics on Dual-Beam Ultrafast High-Power Lasers at SJTU

Wednesday, 20 September 2023 17:25 (20 minutes)

Electron–photon scattering is one of the most fundamental mechanisms in electrodynamics, underlying laboratory and astrophysical sources of high-energy X-rays. After a century of studies, it is only recently that sufficiently high electromagnetic field strengths have been available to experimentally study the nonlinear regime of the scattering in the laboratory. This can act as a new generation of accelerator-based hard X/γ-ray sources driven exclusively by laser light. One ultra-high intense CPA laser pulses will act as two means: first used to accelerate electrons by laser driven wake field (LWFA) to hundreds MeV, and second, from split beam or LWFA-leftover energy reflected by plasma mirror, to collide on the electron for the generation of X/γ-rays. Such all-laser-driven X/γ source have recently been demonstrated to be energetic, tunable, narrow/broad in bandwidth, short pulsed and well collimated. Such characteristics, especially from a compact source, are highly advantageous for numerous advanced X-ray applications. Moreover, the scattering interaction can act a test bed for high-field QED study. Also, preliminary plan of laser wake-field accelerator and radiation source in two high-power laser facilities, 0.5PW in SJTU and 2.5PW in TDLI will be presented, both lasers include two independently compressed two beamlines.

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Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **283** Type: **Oral contribution**

Latest algorithmic advances in the Exascale Particle-In-Cell code WarpX

Wednesday, 20 September 2023 17:25 (20 minutes)

The electromagnetic Particle-In-Cell (PIC) code WarpX has been developed within the the U.S. Department of Energy's Exascale Computing Project toward the modeling of plasma accelerators for future high-energy physics colliders on Exascale Supercomputers. We will present the latest algorithmic advances that were developed for first-principles modeling of plasma-based accelerators with higher efficiency. We will also present the latest developments in the application of WarpX' mesh refinement capabilities to the modeling of ion motion in a plasma accelerator. Future plans will also be presented and discussed.

Supported by the Exascale Computing Project (17-SC-20-SC), a collaborative effort of two U.S. Department of Energy organizations (Office of Science and the National Nuclear Security Administration).

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **286** Type: **Oral contribution**

Plasma afterglow light dynamics and measurement technics of a plasma accelerator plasma source

Wednesday, 20 September 2023 17:25 (20 minutes)

We present an experimental and simulated investigation of helium plasma glow light dynamics and its application to the physical measurements of a plasma wakefield accelerator (PWFA) plasma source. We model the plasma formation with a split-step Fourier optical propagation code and a particle-in-cell (PIC) code. We then simulate the plasma expansion dynamics using a plasma fluid code. Using a combination of analytical reasoning and simulations, we develop a simple model to estimate the photon emission density from the plasma based on the initial plasma density and temperature. Our findings indicate that electron-induced collisional excitations dominate the light emission process over electron-ion recombination. We also introduce an innovative experimental technique that enables a machine vision gigabit Ethernet (GigE) camera to resolve nanosecond-scale temporal dynamics of the plasma source. This is cost-effective method is well suited high-radiation settings like PWFA experimental environments. We find good agreement between experimental data and simulations. Further, we demonstrate that a PWFA-like plasma source's integrated peak plasma light density, a common measurement in PWFA experiments, can be written in an analytical form dominated by the electron-neutral collisional excitation in the light emission process.

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Session Classification: WG8: Plasma sources and related diagnostics

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **235** Type: **Oral contribution**

A mid-beta booster for proton beams

Wednesday, 20 September 2023 17:45 (20 minutes)

Acceleration of proton beams in laser-driven plasma waves is challenging, owing to the difficulty of trapping the slow velocity protons in the relativistic plasma wave. In a laser-plasma accelerator, the phase velocity of the plasma wave is approximately the group velocity of the laser driver propagating in the underdense plasma. Due to their high rest mass, protons only reach comparable velocities with multi-GeV kinetic energies. However, the typical proton energy obtained from a compact laser-solid source is 10s to $\sim$ 100 MeV. Here, we explore the possibility of post-accelerating a proton beam produced in a compact laser-based source using the "snow-plow"field of an intense laser pulse propagating in a near-critical density target [B. Liu, et al., PRL 129, 274801 (2022)]. The electron sheet that accumulates in front of the laser pulse generates an electric field on the order of $\geq$ 10TV/m, that yields GeV energy gains within a 100 μm target, eventually reaching an energy sufficient for a subsequent beam injection into a laser-plasma accelerator.

Work supported by the Director, Office of Science, Office of High Energy Physics, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

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Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **273** Type: **Oral contribution**

Beam dynamics studies for a stable, reliable and reproducible high brightness, high gradient plasma wakefield accelerator

Wednesday, 20 September 2023 17:45 (20 minutes)

Plasma accelerators are emerging as formidable and innovative technology for the creation of table-top devices thanks to the possibility to sustain several GV/m accelerating gradients. Recently the research activity of the SPARC_LAB collaboration has been mainly devoted to heightening and stabilize the energy gain of a beam-driven plasma wakefield accelerator. Beside the upgrade of the SPARC facility in the framework of the SABINA project, a new working point has been set up with a comb beam consisting of higher beam charges, i.e. a 500~pC driver followed by a 50~pC trailing bunch. A maximum accelerating gradient of the order of 1.2 GV/m have been measured, a factor four with respect to previous results obtained with the SPARC RF injector. This result represents a fundamental achievement for the forthcoming EuPRAXIA@SPARC_LAB plasma-based user facility, whose operation relies on similar beam dynamics concepts.
The paper reports on the experimental results obtained at SPARC and on numerical studies to enable a stable, reliable and reproducible plasma based accelerator with outstanding beam quality for the EuPRAXIA@SPARC_LAB facility.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **315** Type: **Oral contribution**

Beam Reproducibility in a Density Downramp Plasma Wakefield Accelerator

Wednesday, 20 September 2023 17:45 (20 minutes)

Plasma wakefield accelerators offer exceptional gradients, enabling compact accelerators. Using a density downramp injection scheme, ultra-short electron bunches with sub-micron emittance and tens of pico-Coulombs of charge can be generated and promptly accelerated. While these beam parameters are of utmost interest for future compact X-ray sources and other imaging techniques, the viability of plasma accelerators for these demanding applications depends critically on controlling and reliably reproducing the electron beam parameters. In this work, we investigate the physics effects of system input variations and their impact on the performance of a gas-jet density downramp plasma accelerator. The HTU experiment of the BELLA center is accurately modeled using particle-in-cell simulations to determine jitter tolerances and provide guidance for optimal operation. The results presented will discuss the sensitivity analysis and its implications for achieving high-quality electron beams.

Work supported by U.S. DOE under Contract No. DE-AC02-05CH11231.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **321** Type: **Oral contribution**

First test of a 10 m discharge plasma source with a proton beam in the AWAKE experiment

Wednesday, 20 September 2023 17:45 (20 minutes)

Scalable plasma sources R&D for the AWAKE experiment at CERN focus on two technologies as alternatives to the existing laser-ionised rubidium vapor plasma source: the Helicon Plasma Source (HPS) and the Discharge Plasma Source (DPS). As a proof of principle of such alternative sources, a 10 m long DPS has been designed, built and tested with a 400 GeV proton beam over a 3 weeks run in the AWAKE tunnel. The main objective of this unique test was to measure the self-modulation instability (SMI) of the proton beam. Thanks to the flexibility of the DPS setup (adjustable plasma length, density and gas type), several other features have been explored: observation of current filamentation instability at high plasma densities, investigation of ion motion as a function of the mass of the discharge gas (He, Ar and Xe), time and space resolved imaging of the plasma light to observe the wakefield dynamics.
This presentation will describe the DPS setup, its implementation, commissioning and operation in the AWAKE tunnel and will give an overview of its performance during the run. Finally the next milestones of the plasma sources R&D program will be shown.

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Session Classification: WG8: Plasma sources and related diagnostics

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **368** Type: **Oral contribution**

E-320: Current Status and Future Plans

Wednesday, 20 September 2023 17:45 (20 minutes)

The experiment E-320 installed at SLAC FACET-II aims to study QED in the strong field regime. By colliding 10 GeV, high-quality electron beams with 10 TW NIR laser pulses it is aspired to probe the QED critical (Schwinger) intensity of 10^{29} Wcm^{-2} in the electron rest frame.
In this regime, characterized by $\chi = E^*/E_{\rm cr}$
$gtrsim1$, quantum corrections to classical synchrotron radiation become important and the probability for
electron-positron pair production is no longer exponentially suppressed [1-3].
A central objective of E-320 is to observe the transition from the perturbative ($a_0^2 \ll 1$) to the non-perturbative regime ($a_0^2 \gg 1$), characterized by the intensity parameter $a_0 = eE/(mc\omega)$, while quantum effects are important (i.e., χ∼1). During this transition, qualitative changes are expected to occur, namely a substantial red-shift of the Compton edges in the photon-emission spectrum and a quasi-continuous spectrum.
We will report on first results from the commissioning run 2022 at $a_0 < 1$ [4], ongoing developments, and future plans.
[1] A. Fedotov et al., Phys. Rep. (2023)
[2] A. Gonoskov et al., Rev. Mod. Phys. (2022)
[3] A. Di Piazza et al., Rev. Mod. Phys. (2012)
[4] C. Clarke et al., LINAC2022 (2022)

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Presenter: Dr KNETSCH, Alexander (SLAC National Accelerator Laboratory (On behalf of the E-320 collaboration))

Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **173** Type: **Invited talk**

Real-time electron microscopy of the laser-plasma wakefield dynamics

Wednesday, 20 September 2023 18:05 (20 minutes)

Nowadays laser-plasma-based wakefield accelerators are capable to deliver GeV-level femtosecond electron bunches crucial for emerging applications in medicine, industry, and fundamental science. Many of these applications critically require the precise characterization of the accelerated electron bunch as well as the plasma wakefield that largely affects the bunch's quality. Advanced diagnostics of such highly transient, microscopic bunch and field structures, however, remains very challenging. Here we address this challenge with a novel technique we name as \textit{femtosecond ultrarelativistic electron microscopy}, which utilizes a high-energy electron bunch from another laser-plasma accelerator as a probe. This single-shot electron microscopy allows us to characterize the nonlinear plasma wakes, the associated electron bunch and the entire transition from laser wakefield to bunch-driven wakefield with high spatiotemporal resolution. We anticipate that these results will significantly advance the understanding of the complex laser-beam-plasma dynamics and also provide a powerful diagnostic tool for the real-time optimization of plasma accelerators.

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Presenter: MALKA, Victor (Weizmann Institute of Science)

Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **209** Type: **Oral contribution**

The E332 experiment at FACET-II: Towards solid density beams and intense gamma-ray beams

Wednesday, 20 September 2023 18:05 (20 minutes)

The passage of an electron bunch through a conducting foil has a focusing effect from the Near-Field Coherent Transition Radiation (NF-CTR) generated on the surfaces. Passing through multiple foils may allow to focus bunches down to solid densities and generate collimated gamma-rays with micrometer source sizes and conversion efficiencies exceeding 10%. The possibility offered by this scheme to self-focus high-energy beams and generate extremely dense gamma-ray beams calls for an experimental demonstration.

We present the E332 experiment at FACET-II (SLAC) where this mechanism can be studied with unprecedented electron beam parameters. Initial measurements were investigating the presence of NF-CTR focusing on single foils and the beam-induced heat damage, and are now followed by the first experimental tests with multiple foils. We furthermore report on simulations of realistic electron beam and target configurations for FACET-II that give rise to focusing of electron bunches from 5 μm down to 1.5 μm (rms) and conversion efficiencies from electron beam to gamma rays in the few-percent range. The relative simplicity, unique properties, and high efficiency of this gamma-ray source open up new opportunities for both applied and fundamental research including laserless investigations of strong-field QED processes with a single electron beam.

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Session Classification: WG5: Applications

Track Classification: WG5: Applications

Contribution ID: **254** Type: **Oral contribution**

Recent progress in the modeling of laser wakefield acceleration

Wednesday, 20 September 2023 18:05 (20 minutes)

The demonstration of a multi-stage scheme is one of the milestones to make laser wakefield acceleration (LWFA) a scalable acceleration mechanism to reach high energies. The design of such complex scheme will require advanced multi physics modeling of the different components of the machine and integrating data-driven approaches into the exploration of the parameter space of interest.
A selection of recent results addressing these challenges in close synergy with experiments will be reviewed, such as the fast reconstruction of the laser pulse field transverse profile for accurate modeling to obtain unprecedented agreements with experimental results, the online shaping of the laser pulse characteristics to reduce the accelerated beams' energy spread, a fast and accurate reduced model for Particle in Cell modeling of ionization injection allowing massive data generation for machine optimization and Artificial Intelligence for LWFA.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **319** Type: **Oral contribution**

Boosting Laser-Driven Proton Beams to Relativistic Energies with Hollow-Channel Magnetic Vortex Acceleration and Readily Available Petawatt Laser Pulse Energy

Wednesday, 20 September 2023 18:05 (20 minutes)

Laser-driven proton acceleration can provide ultra-short, high-charge, low-emittance bunches. Despite extensive research, current laser-ion sources fall short of delivering the desired energies for pivotal applications, like proton tumor therapy. Moreover, the generated non-relativistic beams cannot be injected into high-β accelerator elements for further acceleration and use in high-energy physics applications. Relieving the requirements for a single laser-ion source, we introduce a proof-of-principle concept that boosts a proton beam into the desired energy regime within a few compact laser-plasma stages. Our approach is based on magnetic vortex acceleration, using near-critical density target stages with a pre-formed hollow channel. Each individual booster stage accepts an incident proton bunch whose arrival is temporally matched to the driving laser pulse. With 3D particle-in-cell simulations using the exascale code WarpX, we showcase the approach's robustness in bunch acceptance (temporal and spatial), transport, energy boost, and bunch quality preservation. While our approach unveils a multi-parameter design space for future optimization and in-situ tuning, the scheme can be operated with presently available laser pulse parameters. Arxiv preprint describing the work planned to be presented: https://arxiv.org/abs/2308.04745

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Presenter: Dr GARTEN, Marco (LBNL)

Session Classification: WG6: Ion acceleration and developments towards fusion

Track Classification: WG6: Ion acceleration and developments towards fusion

Contribution ID: **366** Type: **Oral contribution**

Gas jet design for laser plasma wakefield acceleration

Wednesday, 20 September 2023 18:05 (20 minutes)

Gas jets are an attractive technology for high repetition rate LWFA as they are less prone to damage and therefore last longer than other options. However, it has proved difficult to tailor the gas density profile with jets as for capillaries and cells which has restricted their utility. We report on preliminary experimental measurements of a novel gas jet design suitable for density downramp injection without auxiliary laser beams or the insertion of additional material structures into the gas flow.

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Session Classification: WG8: Plasma sources and related diagnostics

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **295** Type: **Oral contribution**

Plasma source development at LUX

Wednesday, 20 September 2023 18:25 (20 minutes)

The development of plasma sources that enable the reliable and reproducible generation of high quality beams is key to moving closer to our goal of powering real-world applications with laser-plasma accelerators. An ideal design must feature a robust injection method with precise control over the trapped phase space, allow for tunability of the subsequent acceleration process through density tailoring, and support high-repetition rate operation. Supported by simulations and selected experimental results, this talk reviews our continuous efforts to implement this rich set of features into the plasma source at LUX. We motivate the principles guiding our development process, discuss the evolution of the design over recent years and provide a brief outlook on transferring the concept to MAGMA, the first plasma accelerator that will be driven by the high-average power laser KALDERA that is developed by our group at DESY.

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Session Classification: WG8: Plasma sources and related diagnostics

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **338** Type: **Oral contribution**

Unravelling ultrashort dynamics of plasma-based accelerators – leveraging synthetic diagnostics to match PIC simulations with experimental data

Wednesday, 20 September 2023 18:25 (20 minutes)

Exascale computing has recently become a reality. PIConGPU has paved the way to accelerating plasma simulations across compute platforms using the Alpaka framework. These capabilities not only enables conducting high-fidelity parameter scans of start-to-end simulations modeling experiments at full 3D3V geometry, but also make it possible to include additional physics.

However, experience has shown that the real challenges are of a different nature. Not only has the increasing quality of experiments put more demand on simulation quality, but more and more the need for fast analysis has grown. Based on recent experiment-driven simulation campaigns, we present results elucidating the LWFA bunch evolution within complex gas targets with plasma lensing, the injection dynamics of micro-structured LWFA bunches from CTR measurements and the pre-plasma dynamics in solid-density targets, correlating proton energies with reflected HHG radiation spectra. Here, we put an emphasis on synthetic diagnostics for radiation processes (HHG, CTR and scattered probe lasers) and atomic physics beyond the thermal equilibrium. We discuss I/O, code coupling, visual analytics and large-scale data analytics workflows to match experiment and provide an outlook on how feedback loops between experiment and simulation can be optimized.

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Session Classification: WG3: Theory and simulations

Track Classification: WG3: Theory and simulations

Contribution ID: **169** Type: **Poster (participant)**

The Plasma Injector for PETRA IV: Conceptual Design Report

Wednesday, 20 September 2023 19:00 (1h 30m)

We present the conceptual design of an alternative injector system based on laser-plasma accelerator technology, to deliver high-quality electron bunches to PETRA IV –the future 4th generation synchrotron light source at DESY. The design consists of a laser-plasma accelerator to produce electron bunches at 6 GeV with state-of-the-art energy spread and stability, and a X-band energy compressor beamline to further reduce the overall beam energy deviations and maximize the charge injection throughput into the PETRA IV storage ring. Driven by the Petawatt upgrade of DESY' s new flagship laser KALDERA, the plasma injector system can be used to top up the PETRA IV storage ring, significantly lowering the load on the conventional injector chain. Ultimately, upon further development of high-efficiency, high-power laser drivers that operate at high repetition rates, the plasma injector could potentially replace the conventional system in the future and dramatically reduce the spatial footprint and energetic cost of the whole injector complex.

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **172** Type: **Poster (student)**

Lattice Boltzmann Method applications: a characterization of thermal effects in plasma waves

Wednesday, 20 September 2023 19:00 (1h 30m)

Lattice Boltzmann Method (LBM) is a novel numerical approach for simulating of Plasma Wake-Field Acceleration (PWFA) processes. In this talk, we employ the LBM to investigate the influence of temperature on plasma waves. Thermal effects can be relevant, for example, in PWFA processes with a high repetition rate, which holds significant importance for various PWFA applications. By utilizing LBM, we explore and characterize well-known thermal features of plasma waves documented in the literature, including acoustic motion, dispersion relations, and thermal anisotropies, providing quantitative assessments on the validity of the LBM for PWFA.

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Presenter: PARISE, Gianmarco (Istituto Nazionale di Fisica Nucleare)

Session Classification: Poster session

Track Classification: WG3: Theory and simulations

Contribution ID: **177** Type: **Poster (student)**

Transport line design for laser wakefield accelerators

Wednesday, 20 September 2023 19:00 (1h 30m)

Laser WakeField Accelerators (LWFA) are a promising alternative for many industrial and medical applications. Despite significant progress, the use of LWFAs for real-world applications requires improvements in beam and transport quality. LWFAs beams differ from those studied in conventional accelerators. This calls for a dedicated study of transport lines for laser plasma acceleration. The aim is to control the quality of the beam in the line, despite the constraints imposed by the beam leaving the plasma of an LWFA (emittance, energy dispersion and divergence important for small sizes). Several configurations are therefore studied using TraceWin and optimization codes. As a result, scaling laws are obtained to impose limits on the characteristics of the beam produced by the plasma stage, depending on the targeted applications.

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Presenter: BATISTA, Laury (French Atomic Energy and Alternative Energies Commission)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **189** Type: **Poster (participant)**

Laser-based plasma stabilization effect on a particle PWFA beam

Wednesday, 20 September 2023 19:00 (1h 30m)

Efforts towards the next generation of compact accelerators based on plasma wakefield acceleration (PWFA) are aimed at enabling their application in various fields, including basic research, medicine, and industrial uses. To achieve this goal, significant focus is directed towards controlling the plasma creation process, ensuring the development of a time-jitter free channel, and maintaining stability, particularly in terms of uniformity and reproducibility. At SPARC_LAB, we are developing a beam driven PWFA, where an electron bunch drive the wakefield in the plasma and a second bunch, at ps delay from the first, is accelerated by the plasma. In this contribution, we present the results of an experimental campaign using a gas-filled discharge-capillary where the plasma and its generation are stabilized by triggering its ignition with an external laser pulse. The results show an efficient stabilization of the energy of the plasma accelerated beam.

Primary authors: VILLA, Fabio (Istituto Nazionale di Fisica Nucleare); ON BEHALF OF SPARC_LAB GROUP

Presenter: VILLA, Fabio (Istituto Nazionale di Fisica Nucleare)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **190** Type: **Poster (student)**

Average Current Enhancement of Laser-Plasma Accelerators

Wednesday, 20 September 2023 19:00 (1h 30m)

Since they have been proposed, laser-plasma accelerators have interested the scientific community for their ability to generate electric fields exceeding the ones of Linacs and RF cavities. Several efforts have been made in order to produce monochromatic electron beams and to increase their maximum energy, often at the expense of the charge. However, some applications like femtosecond chemistry, radio-biology and industrial radiography do not need monochromatic beams, but rather highly charged
ones (i.e., > 1 nC). For some of these applications it is also necessary to reduce the amount of high energy electrons (i.e., > 10 MeV), in order to avoid the activation of materials. Such beams can be produced using high Z gases like Nitrogen and Argon, exploiting the ionization injection of several plasma period. Here we numerically and experimentally investigate this little-known regime, employing different laser energies, f-numbers and plasma densities. This allowed us to find the conditions to produce electron beams with charges up to tens of nC and exceeding 100 mrad in divergence. We will also show and explain the dependencies of these beams (e.g., their charges and energy spectra) as functions of the aforementioned laser and plasma parameters.

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Presenter: Mr MARTELLI, Lorenzo (Thales-MIS & LOA)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **193** Type: **Poster (student)**

A plasma-based acceleration method for heavier particles

Wednesday, 20 September 2023 19:00 (1h 30m)

The last decades have seen a growing interest in plasma-based accelerator technology, leading to establishing these techniques in the particle accelerator community [1, 2]. Nonetheless, they are still only effective on particles already traveling close to the speed of light. Unfortunately, this excludes heavier particles (e.g. muons), naturally produced at lower velocities due to the higher masses.
Non-relativistic accelerating wakes can be achieved. For example, cutting-edge methods have recently been devised for shaping the spatio-temporal spectrum of electromagnetic wave packets that pro- duce pulses with variable group velocities [3]. These pulses can propagate with subluminal velocities, making them suitable candidates to drive slower wakes.
This work presents our ongoing research toward a plasma-based acceleration method for non-relativistic particles using accelerating wakes slower than c. The suggested method has been studied analytically and then tested using 2D and quasi-3D particle-in-cell simulations with the code OSIRIS [4].

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[3] H.E.Kondakci and A.F.Abouraddy, Nature Communications 10, 929 (2019)
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Primary author: BADIALI, Chiara

Co-authors: MALACA, Bernardo (GoLP/ Instituto Superior Técnico); VIEIRA, Jorge (Instituto Superior Técnico); Mr ALMEIDA, Rafael; SILVA, Thales (GoLP/Instituto Superior Técnico (Lisbon))

Presenter: BADIALI, Chiara

Session Classification: Poster session

Track Classification: WG3: Theory and simulations

Contribution ID: **199** Type: **Poster (participant)**

Undepleted Direct Laser Acceleration

Wednesday, 20 September 2023 19:00 (1h 30m)

With the direct laser acceleration (DLA) method, the leading part of an intense laser pulse ionizes the target material and forms a positively charged ion plasma channel into which electrons are injected and accelerated. DLA has been realized over a wide range of laser parameters, using low-atomic-number target materials. The electron beam energy has been confirmed to scale with the normalized laser intensity up to values of ⍰0 ~1.5. However, the electron energies obtained with the highest laser intensities available nowadays, fail to meet the prediction of these scaling laws.

I will present experimental results followed by a numerical study, which show that for efficient DLA to prevail, a target material of sufficiently high atomic number is required to maintain the injection of ionization electrons at the peak intensity of the pulse when the DLA channel is already formed. Applying this new understanding to experiments on multi-petawatt laser facilities now coming online is expected to increase the electron energy overlap with the neutron production cross-sections of any material. These increased neutron yields are required to enable a wide range of research and applications, such as investigation of nucleosynthesis in the laboratory, performing non-destructive material analysis, and industrial applications.

Primary authors: Prof. AREFIEV, Alexey (UC San Diego); Dr LEVANON, Assaf (Tel-Aviv University); POMERANTZ, Ishay; Mr COHEN, Itamar (Tel Aviv University); TANGTARTHARAKUL, Kavin (UC San Diego); Dr PERELMUTTER, Lior (Tel-Aviv University); Ms ELKIND, Michal (Tel-Aviv University); Ms MEIR, Talia (Tel Aviv University)

Presenter: POMERANTZ, Ishay

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **210** Type: **Poster (student)**

Spatiotemporal beam-plasma instabilities in the ultrarelativistic regime

Wednesday, 20 September 2023 19:00 (1h 30m)

The propagation of particle beams through plasma can give rise to instabilities, relevant for astrophysical and laboratory systems. For ultrarelativistic beams, the oblique two-stream instability (OTSI) generally prevails the early beam-plasma interaction. For conditions relevant to the E305 experiment, which is devoted to study such beam-plasma instabilities with the FACET-II facility at SLAC, we have shown that the instability is spatiotemporal due to the finite length of the beam. This spatiotemporal character is not only prominent during the linear growth, as demonstrated with our recently developed theory, but also during the nonlinear phase of the instability. Next, we will discuss two innovative methods of the instability probing: ultrafast dark-field shadowgraphy and single-shot energy-resolved transverse-momentum-spread measurements. The latter method relies on the use of chirped beams and allows to access the front-to-rear spatial coordinate from energy-resolved measurements in a single shot. Our modeling demonstrates their potential to benchmark OTSI theory and codes against experimental data. Finally, while the instability generally starts from noise, we have also shown that it can be seeded and controlled using the beam interaction with a nano-structured solid target. Our work thus opens the way to a powerful experimental platform for the study of ultrarelativistic beam-plasma instabilities.

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Presenter: MANKOVSKA, Yuliia (Laboratoire d'Optique Appliquee, ENSTA, Ecole Polytechnique de Paris, IP Paris)

Session Classification: Poster session

Track Classification: WG5: Applications

Contribution ID: **221** Type: **Poster (participant)**

Radiation generation in high power laser applications

Wednesday, 20 September 2023 19:00 (1h 30m)

Lasers with femtosecond pulse durations have become readily available and are used in numerous applications from material processing to plasma-based accelerators. Often, the lasers are focused to small spot sizes, exceeding intensities of 10^{13} W/cm2 and thus the ionization threshold in most materials. As this can lead to the production of x-rays, national law in Germany made it mandatory to monitor the dose rate if this intensity threshold is exceeded. At Deutsches Elektronen-Synchrotron DESY, research has now started to further investigate and understand the production of x-rays in different materials or gases to enable safe working conditions and compliance with the legal framework while maintaining the flexible workflow required at universities and research institutes. This poster gives an overview of existing research on this topic, shows plans for the research at DESY and invites to discuss implications for future work in the development of plasma accelerators.

Primary author: Dr BOHLEN, Simon (DESY)

Presenter: Dr BOHLEN, Simon (DESY)

Session Classification: Poster session

Track Classification: WG5: Applications

Contribution ID: **232** Type: **Poster (student)**

Stability of the Plasma-Modulated Plasma Accelerator (P-MoPA)

Wednesday, 20 September 2023 19:00 (1h 30m)

We investigate the operation regime and performance of the Plasma-Modulated Plasma Accelerator (P-MoPA), a new approach offering the potential for high-repetition-rate, GeV-scale laser plasma accelerators (LPA) driven by picosecond-duration laser pulses [Phys. Rev. Lett. 127, 184801 (2021)]. P-MoPA uses a plasma modulator stage, which introduces a spectral modulation to a picosecond pulse from a Yb:YAG thin-disk laser. This forms a frequency comb, allowing for compression into a train of femtosecond-class pulses, promising a drive for a kHz rep-rate, GeV-scale LPA. We derive a 3D analytic theory of the plasma modulator for the pulse and wakefield evolution in long pre-formed plasma channels, identifying a transverse mode instability (TMI) that can limit the energy of the drive pulse [Phys. Rev. E 108, 015204 (2023)]. We find the theory agrees with PIC simulations, showing that TMI is the limiting factor of the plasma modulator and allows multi-joule drive pulses corresponding with multi-GeV electron beams. Optimization of LPAs driven by P-MoPA pulse trains showcases the key differences between the pulse trains formed by P-MoPA and the traditional beatwave method, emphasizing P-MoPA's unique feature of longitudinal shaping control. This study contributes to advancements in overcoming the repetition rates and energy efficiency limitations of traditional LPAs.

Primary author: VAN DE WETERING, Johannes (University of Oxford)

Co-authors: WALCZAK, Roman (University of Oxford); HOOKER, Simon (University of Oxford)

Presenter: VAN DE WETERING, Johannes (University of Oxford)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **241** Type: **Poster (student)**

Shadowgraphy of the plasma evolution around water micro-droplets irradiated by high-power laser pulses

Wednesday, 20 September 2023 19:00 (1h 30m)

We present the results of an experiment at the POLARIS laser system (at 1030 nm) using an off-harmonic optical probe, in which the laser-plasma interaction with water micro-droplets was investigated. In contrast to experiments with thin foils, the spherical symmetry of droplets facilitates a direct imaging of the plasma expansion process using shadowgraphy. In the experimental setup, a jet of water was broken up into droplets with a diameter of 20 µm. The POLARIS main laser pulses were focused onto the water droplets to intensities of $4 \cdot 10^{19}$ W/cm^2. The plasma expansion process was probed in a temporal window between 0 ps and 258 ps after the arrival of the main laser pulse. The strong light emission from the laser-induced plasma at the fundamental and second harmonic frequencies was suppressed by using an off-harmonic probe with a band-pass filter. The probe pulses were generated with a synchronized NOPA (µJ-level pulse energy and 750 . . . 950 nm bandwidth). The plasma emission was further reduced by a polarization and a spatial filter. A detailed analysis of the shadowgraphy images allowed us to estimate the plasma expansion velocity of the front ($v_{\text{front}} = 1.27(6)$ µm/ps) and rear side ($v_{\text{rear}} = 0.77(5)$ µm/ps) at the beginning of the expansion process.

Primary author: BEYER, Martin (Helmholtz Institue Jena)

Presenter: BEYER, Martin (Helmholtz Institue Jena)

Session Classification: Poster session

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **244** Type: **Poster (participant)**

Towards the first electron acceleration with an industrial Yb:YAG laser

Wednesday, 20 September 2023 19:00 (1h 30m)

High average power, kHz laser-plasma acceleration is an emerging technique which could supply few MeV, few femtosecond electron bunches with high average current. Here we present exciting experimental results, drawing the path towards the first electron acceleration driven by an industrial Yb:YAG laser at multi-kHz repetition rate.

KHz lasers usually deliver few mJ pulses and, hence, compressing the output pulse duration down to the few-cycle regime is essential in order to efficiently drive plasma waves. We report on record post-compression results, where 10mJ, 1.2ps pulses have been compressed to below 10fs, with 70% efficiency. The interaction of these pulses with an high density nitrogen plasma shows exciting evidence of plasma waves being driven.

Furthermore, Particle-In-Cell simulations including the real pulse, the retrieved plasma density and the measured spot size prove the potential of such pulses to accelerate electrons in the few MeV regime.

Primary author: FARACE, Bonaventura (DESY)

Co-authors: PODER, Kristjan (DESY); LEEMANS, Wim

Presenter: FARACE, Bonaventura (DESY)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **250** Type: **Poster (student)**

Burst shot of the self-injection dynamics of a laser wakefield accelerator in bubble regime

Wednesday, 20 September 2023 19:00 (1h 30m)

Ultrafast shadowgraphy with transverse few-cycle probe pulses has enabled the snapshot of the underdense laser-plasma interactions with unprecedented temporal (~ 4 fs) and spatial (< 10 μm) resolution. However, in laser-plasma experiments, the shot-to-shot fluctuation of high-power laser systems is not negligible. This limits the application of snapshot imaging techniques, especially in observing fast-evolving dynamics, such as the lengthening of the bubble induced by pump pulse self-focusing and self-compression. In this research, we are developing a burst shot imaging technique based on ultrafast shadowgraphy. Instead of a Fourier transform limit few-cycle probe pulse, a linearly chirped few-cycle pulse with a duration of ~ 300 fs is used as the probe. After the probe pulse propagates through the microscopic imaging system, three plate beamsplitters are used to create four replicas of the probe. Each replica is independently recorded by a CCD camera with a 10 nm narrow bandpass filter (BPF) to recover the temporal resolution of the shadowgram. The BPFs in front of the different cameras have different central wavelengths. As a result, the shadowgrams recorded by different cameras correspond to different delays between the main pulse. Some preliminary results are presented in this poster.

Primary author: ZHAO, Yu

Co-authors: SÄVERT, Alexander (Helmholtz Institut Jena); KALUZA, Malte (University of Jena, Helmholtz-Institute Jena)

Presenter: ZHAO, Yu

Session Classification: Poster session

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **262** Type: **Poster (participant)**

Noninvasive Cavity-Based Charge Diagnostic for Plasma Accelerators

Wednesday, 20 September 2023 19:00 (1h 30m)

The charge of an electron bunch is one of the most fundamental parameters in accelerator physics. Therefore, several techniques to measure the electron bunch charge exist. However, many conventional charge diagnostics face serious drawbacks when applied to plasma accelerators. For example, integrating current transformers (ICTs or toroids) have shown to be sensitive to the EMP originating from the plasma, whereas scintillating screens are sensitive to background radiation such as betatron radiation or bremsstrahlung and only allow for a destructive measurement of the bunch charge. We show measurements of a noninvasive, cavity-based charge diagnostic (so-called DaMon), which demonstrate its high sensitivity, high dynamic range and resistance towards plasma EMP. The measurements are compared to both an ICT and a scintillator screen.

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Presenter: Dr BOHLEN, Simon (DESY)

Session Classification: Poster session

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **263** Type: **Poster (student)**

ON THE BETATRON RADIATION IN CYLINDRICALLY SYMMETRIC PLASMA-ION CHANNELS

Wednesday, 20 September 2023 19:00 (1h 30m)

The relativistic interaction of short pulsed lasers or electrons with plasma has recently led to the birth of a new generation of femtosecond X-ray sources. Radiations with properties similar to those that can be observed from a wiggler or undulator, can be generated by the oscillations induced in the excited plasma by electrons (PWFA) or by lasers (LWFA), making plasma an interesting medium both for the acceleration as well as for the radiation source, with properties of being compact, providing collimated, incoherent, femtosecond radiation. Thus, a lot of effort is being made to understand and improve this new source to make it really competitive, in this poster is summarizes and shown some numerical results of a simplified model called plasma ion column, highlighting strenghts, limitation ans scaling laws which allow for a comparison with other types of more consolidated sources of light.

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Presenter: FRANCESCONE, Daniele (Istituto Nazionale di Fisica Nucleare)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **268** Type: **Poster (student)**

Betatron radiation from accelerated electrons: an analytical study

Wednesday, 20 September 2023 19:00 (1h 30m)

X-rays production through betatron radiation emission from electron bunches is a valuable resource for several research fields. The EuAPS (EuPRAXIA Advanced Photon Sources) project, within the framework of the EuPRAXIA project, aims to provide 1-10 keV photons (soft X-rays) using a compact plasma based system designed to exploit self-injection processes that occur in highly nonlinear laser-plasma interaction (LWFA) to drive electron betatronic oscillations. While numerical analysis is being pursued, we also aim to gain insights into the emission process through an analytical approach. By generalizing well-known results (I. Kostyukov, S. Kiselev, and A. Pukhov), we derive a comprehensive analytical expression for the emission spectrum in solid angle for single particles subjected to constant longitudinal force and linear transverse force moving in a planar trajectory. Model's approximations are presented, along with intensity plots on the detector and trends in critical frequency for some plasma wiggler strength and longitudinal force values.

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Presenter: FRAZZITTA, Andrea (Istituto Nazionale di Fisica Nucleare)

Session Classification: Poster session

Track Classification: WG5: Applications

Contribution ID: **274** Type: **Poster (student)**

Compact beamline for laser-plasma electron characterization

Wednesday, 20 September 2023 19:00 (1h 30m)

PALLAS is a laser-plasma injector test facility at IJCLab developed in the framework of the preparatory phase of EuPRAXIA. It aims to achieve reliability, stability and control closer to conventional RF accelerator standards while using Laser Wakefield Acceleration (LWFA) in a plasma target with electron bunches produced by localized ionization injection.
One of the purposes is to correlate the parameters of the electron bunch to ones of the laser and plasma during its acceleration. To do so, a dedicated transport line for electron beam characterization has been designed based on start-to-end simulations. The poster will present the strategy adopted for the PALLAS electron characterization beamline to meet the project's need for simplicity, flexibility and robustness.

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Presenter: GUYOT, Coline (IJCLab)

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **279** Type: **Poster (student)**

Exploring Wavelength Dependence in Laser Plasma Accelerators

Wednesday, 20 September 2023 19:00 (1h 30m)

In laser wakefield acceleration (LWFA) experiments at major facilities, emphasis is typically placed on standard laser and gas parameters such as pulse duration, spot size, normalised vector potential, gas constituents and gas density in order to produce the most stable, high charge, high energy, narrow spread electron beams. While these parameters are certainly of unquestionable importance, the most fundamental laser parameter, its wavelength, remains relatively unexplored. A long wavelength driving laser may be advantageous to a laser wakefield accelerator; both theoretically from scaling laws deriving from the ponderomotive force, and from some early simulation results using particle-in-cell codes. Here we present simulation results and further discuss the experimental and theoretical implications of using long wavelength, short pulse drivers in LWFA experiments, with particular emphasis on the high intensity, short pulse, multi-beam mid-infrared (3.7μm central wavelength) Chimera laser system, currently under active development at Imperial College London.

Primary author: GUNN, Annabel

Presenter: GUNN, Annabel

Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **282** Type: **Poster (student)**

Fast laser field reconstruction method based on a Gerchberg-Saxton algorithm with modes decomposition

Wednesday, 20 September 2023 19:00 (1h 30m)

Numerical simulations of laser-plasma acceleration in the non-linear regime require an accurate modelling of the laser driving the plasma waves. To reconstruct the transverse laser field distribution from fluence measurements, a fast and flexible field reconstruction method based on the Gerchberg-Saxton Algorithm with Hermite-Gauss Modes Decomposition (GSA-MD) has been developped [2].
The minimisation of the reconstruction error via tuning of the Hermite-Gauss modes origins is used to improve the accuracy of the GSA-MD.
This algorithm was used to reconstruct the asymmetries of the energy distribution in the focal volume [1,2,3] from fluence images collected during two experimental campaigns at the APOLLON and Lund Laser Centre facilities.
It will be shown how using the GSA-MD-reconstructed laser field as input for quasi-cylindrical PIC simulations allowed to obtain a better agreement with experimental results compared to using an ideal laser field [1,3]. This led to a better understanding of the effects of laser asymmetries on the quality of the output electrons bunch in the injector stage.

References

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[2] *I. Moulanier et al., Submitted paper to JOSA B* (2023)
[3] *L. T. Dickson et al., Physical Review Accelerators and Beams 25*, 101301 (2022)

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Presenter: MOULANIER, Ioaquin (Laboratoire de Physique des Gaz et Plamas)

Session Classification: Poster session

Track Classification: WG3: Theory and simulations

Contribution ID: **302** Type: **Poster (participant)**

Internally self-consistent temperature diagnostic of hydrogen plasma from H-alpha and H-beta line spectra

Wednesday, 20 September 2023 19:00 (1h 30m)

Plasma temperature is a critical parameter in the physics of discharge capillary plasma sources. It determines their ability to form guiding channels in LWFA, can influence the gas refill time and therefore the maximum repetition rate and confound density measurements taken via optical emission spectroscopy; to name but a few effects. Accurately determining the temperature of these plasmas is therefore essential to properly characterise, understand and improve these plasma sources. This is difficult to achieve in practise, especially with pure hydrogen plasma, due to limited number of spectral lines, single ionisation state and lack of other elements.

Here we present the results of a successfully implemented analysis method based on an internally self-consistent comparison between H-alpha and H-beta line densities of a discharge-generated pure hydrogen plasma.

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Presenter: JONES, Harry (DESY)

Session Classification: Poster session

Track Classification: WG8: Plasma sources and related diagnostics

Contribution ID: **323** Type: **Poster (student)**

Parametric study of low-divergence X-rays from a laser-plasma-lens

Wednesday, 20 September 2023 19:00 (1h 30m)

Betatron radiation from laser wakefield accelerators is a powerful X-ray source, proven useful in several applications, e.g. in medical imaging and tomography, X-ray absorption spectroscopy for warm dense matter among others. However, due to the large X-ray divergence typically on the order of tens of mrad, an effective beam transport to the sample and subsequent detection becomes challenging which limits the signal to noise ratio. In a previous study [1], we showed that the X-ray divergence can be significantly reduced by utilising a passive plasma lens, here consisting of a gas ionised by the drive laser itself. As the accelerated electrons propagate through this second plasma they generate strong transverse fields, which focuses the beam and produces bright X-rays. In this work, a detailed study of the X-ray lens radiation is performed, looking at the plasma parameters themselves, such as drift space and density atomic composition, and electron beam properties.

[1] J Björklund Svensson, J., Guénot, D., Ferri, J. et al. Low-divergence femtosecond X-ray pulses from a passive plasma lens. Nat. Phys. 17, 639–645 (2021). https://doi.org/10.1038/s41567-020-01158-z

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Session Classification: Poster session

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **327** Type: **Poster (participant)**

Research data management of laser-plasma science at HZDR

Wednesday, 20 September 2023 19:00 (1h 30m)

The Draco laboratory at HZDR is a versatile, multi-arm and multi-target-area facility, consisting of several, independent subsystems. The lack of an overarching DAQ is balanced by interfaces of the subsystems and custom inter-linking agents. We present recent progress of implementing such software agents, connecting to the center's electronic lab documentation system. First, manual logging of shot parameters and observations is lifted from spreadsheet software to a flexible web-app, writing to a database (DB). The laser-internal logging is exported to a DB and internal software triggering is forwarded to experiments. That provides a connection between laser-internal indexing and experiment-based indexing (another DB) and enables near-online data processing. The latter comprises file path logging and validation according to the shot's acquisition settings for further analysis as well as basic on-shot analysis scripts, both enabling near-online visualization to better guide the course of experiments.
Likewise, parameters and results from simulations are logged to databases, enabling machine learning techniques and better computing resource management.
For a long-term, FAIR storage, the HELPMI project starts exploring the possibilities of openPMD and NeXus to ingest experimental data. That project shall serve as initiative for the global LPA community to find a data and metadata standard.

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Session Classification: Poster session

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **334** Type: **Poster (participant)**

Surrogate model for laser-plasma injector development

Wednesday, 20 September 2023 19:00 (1h 30m)

Plasma targetry design for PALLAS experiment relies on numerical PIC parametric studies, computational fluid dynamic studies and an experimental test bench equipped with plasma density profile diagnostics, density measurement and plasma species spatial distribution for target charecterisation.
We discuss construction of surrogate model of PALLAS, based on 15000 simulations performed for sparsely spaced input parameters for laser-plasma injector (laser, target density profile and species distribution). Parametric studies were performed with Smilei PIC code [1] using the azimuthal mode and envelop approximation with a low number of particles per cell [2]. Based on these simulation data we constructed ML models with KFolds validation [3] to limit the overfitting (GP , Neuronal Network and decision trees]). The surrogate model is then used to quickly probe parameter set of interest, predict the optimum and interpret relation between parameters. Goal of these studies is to assist the plasma target cell design and determined working points of the laser-plasma injector for a specified energy, charge, beam emittance and beam divergence.

[1] P. Drobniak et al., arxiv (2023)
[2] SMILEI: smileipic.github.io/Smilei/
[3] Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. " O'Reilly Media, Inc.", 2022.

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Session Classification: Poster session

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **205** Type: **Oral contribution**

Probing strong-field QED in beam-plasma collisions

Thursday, 21 September 2023 09:00 (35 minutes)

Recent progress in laser and accelerator technology opens new possibilities to investigate the largely unexplored strong-field quantum electrodynamics (SFQED) regime where electron-positron pairs can be created directly from light-vacuum fluctuations. When a high charge, ultra-relativistic electron beam collides with a solid density plasma, the beam self-fields are reflected, partly or fully, depending on the beam shape and can exceed the Schwinger critical field in the beam rest frame thus triggering SFQED processes as nonlinear inverse Compton scattering and nonlinear Breit-Wheeler electron positron pair creation. We report on this new concept to probe SFQED using a single electron beam and show that copious amount of positron can be created from this interaction [Commun Phys 6, 141 (2023)]. This setup can achieve conditions similar to those envisioned in beam-beam collisions, but in a simpler and more controllable way owing to the automatic overlap of the beam and driving fields. This scheme also eases the way to precision studies of SFQED as the observables are cleaner than in the electron-laser collision case. We will report on the study of the beam self-field reflection depending on the beam shape and plasma density, and study the SFQED observables resulting from this ultrafast interaction.

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Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **314** Type: **Invited talk**

Coherence and superradiance from a plasma-based quasiparticle accelerator

Thursday, 21 September 2023 09:35 (35 minutes)

Because the brightness delivered by coherent light sources - such as free electron lasers (FELs) - grows with the interaction distance, they can be several km long (e.g., LCLS). Making FELs more compact while keeping their brightness, could open unprecedented research and applications to university-scale laboratories. Here, compact plasma accelerators could play a major role, but so far they have only produced incoherent temporal radiation, limiting their brightness and uses.

Using theory combined with PIC simulations and the Radiation Diagnostic for Osiris (RaDiO), we show that radiation emitted by a collective excitation (which we denote as a quasiparticle), such as a non-linear plasma wakefield, can generate temporally coherent superradiant light with current technology. This concept can provide temporally coherent and superradiant light from THz (including the THz gap) to the extreme ultra-violet. Photon energy control can be tailored straightforwardly, mostly by adjusting plasma density. This flexibility extends further, and brings unprecedented control over finer spectral features, such as its bandwidth, which can be essencial for applications that often require specified spectra. Akin to a single particle, these features depend on the quasiparticle velocity and acceleration, which can be adjusted via tailored plasma density profiles using experimentally proven techniques.

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Presenter: MALACA, Bernardo (GoLP/ Instituto Superior Técnico)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **260** Type: **Invited talk**

Accelerator on a chip: Recent results and perspectives for applications

Thursday, 21 September 2023 10:10 (30 minutes)

Nanophotonic laser acceleration is a fast-evolving, emerging field aimed at providing a solution to the miniaturization of electron accelerators, down to the chip-scale. Although the average gradients are still limited by the material breakdown threshold (up to ~10 GV/m), this technology currently already offers acceleration of superb-quality single-electron pulses (normalized emittance ~100 pm*rad) at kHz and potentially MHz repetition rates, and favorably at academic-scale costs and settings. The opportunity to design accelerator structures and nanofabricate them in a university clean-room is a great advantage for cutting-edge research in quantum electron-light interaction, and to the recent proposals for the temporal modulation of electron wavepackets in the attosecond regime, potentially soon in the MeV energy range.
In this talk I will give an overview of the current state of nanophotonic acceleration research, with the different schemes being pursued both theoretically and experimentally, some recent proposals and application directions, and the latest results in the sub-relativistic (~30 keV) regime.

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Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **167** Type: **Invited talk**

Acceleration of polarized protons from laser-plasmas

Thursday, 21 September 2023 11:00 (30 minutes)

High-energy, spin-polarized particles are of great interest for a variety of applications like deep-inelastic scattering for the investigation of the proton nuclear structure or fusion, where the use of polarized reactants can increase the fusion cross-section. Acceleration of such particles via laser-plasma interaction can prove to be difficult, as the target needs to be pre-polarized. This rules out solid-state based mechanisms. Further, strong laser fields can induce the final beam's depolarization. Thus, novel acceleration schemes are required to ensure a significant degree of polarization.
In this talk, we will present an overview of the state-of-the-art for the acceleration of spin-polarized protons. Two acceleration mechanisms, Magnetic Vortex Acceleration and Collisionless Shock Acceleration, will by investigated by means of particle-in-cell simulations. The two schemes prove to be feasible options for producing highly polarized proton beams even for parameters of near-future laser facilities.

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Presenter: Dr REICHWEIN, Lars (Heinrich-Heine-Universität Düsseldorf)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **192** Type: **Invited talk**

Ion acceleration activities at ELI NP with the acceleration of more than 100 MeV protons

Thursday, 21 September 2023 11:30 (30 minutes)

Currently, the 10 PW experimental area is under commissioning with the first shot being fired on April 13. The experimental campaign started at the end of last year when the 10 PW laser beam was delivered to the interaction chamber with the short focal parabolic mirror. The laser is a Ti:sapphire system with a central wavelength of 810nm and a pulse duration of about 24fs. The best laser spot size achieved is 2.8μm at FWHM, with an encircled energy of about 50%, giving an effective laser peak intensity on target of about 6x10ˆ22Wcm-2. All high-power shots were performed via a single plasma mirror both to improve the laser temporal contrast and reduce the probability of back-reflected laser light. To commission the laser and the experimental area we have performed proton acceleration via the TNSA mechanism. Many diagnostics were implemented to gather a wide range of information to better understand the interaction of the laser with a solid target. Proton energies exceeding 100 MeV have been attained, even if the laser temporal contrast is still affected by a few pre-pulses mainly in the nanosecond regime.
In this talk, the preliminary results obtained with the 10 PW laser system will be presented.

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Presenter: Dr DORIA, Domenico (ELI-NP, IFIN-HH)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **168** Type: **Invited talk**

High energy proton acceleration at DRACO-PW and radiobiological applications

Thursday, 21 September 2023 12:00 (30 minutes)

Recent developments at the high-power laser facility DRACO-PW enabled the production of polychromatic proton beams with unprecedented stability. This allowed the first in vivo radiobiological study to be conducted using a laser-driven proton source. Yet, the ability to achieve energies beyond the 100 MeV frontier is matter of ongoing research, mainly addressed by exploring advanced acceleration schemes like the relativistically induced transparency (RIT) regime.

In this talk, we report on experimental proton acceleration studies at the onset of relativistic transparency using pre-expanded plastic foils. Combined hydrodynamic and 3D particle-in-cell (PIC) simulations helped to identify the most promising target parameter range matched to the prevailing laser contrast conditions carefully mapped out in great detail beforehand. A complex suite of particle and optical diagnostics allowed characterization of spatial and spectral proton beam parameters and the stability of the regime of best acceleration performance, yielding cut-off energies larger than 100 MeV in the best shots.

The reported progress for proton acceleration directly feeds into our program on ultra-high dose rate radiobiology. We operate a fully-equipped beamline including beam monitoring and dosimetry adapted to ultra-high dose rate proton pulses at DRACO-PW.

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Presenter: METZKES-NG, Josefine

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **202** Type: **Oral contribution**

Acceleration of positrons in plasmas with high energy efficiency

Thursday, 21 September 2023 16:25 (20 minutes)

Accelerating particles to high energies with high efficiency and beam quality is crucial in developing accelerator technologies. While particle acceleration in plasmas has made important progress for electrons, identifying a reliable plasma acceleration technique for positrons would pave the way to a linear collider for high-energy physics applications.

Here, we show that a tradeoff between energy efficiency and beam quality needs to be established in the presence of a positron load in the plasma [Phys. Rev. Research 3, 043063 (2021)]. This tradeoff is intrinsically related to the quick response of plasma electrons within the positron bunch, a response which becomes stronger at higher positron charge and energy efficiency. In linear plasma wakefields, it is found that the main limitation for the beam quality lies in the uncorrelated energy spread that the positron bunch acquired during acceleration in the plasma. Different schemes are discussed, and the results demonstrate that when the plasma response is driven in a moderately nonlinear regime, one can achieve simultaneously energy transfer efficiencies exceeding 30% and uncorrelated energy spread below 1%. A strongly nonlinear wake produced by a donut-shaped driver is more suitable for high-charge, high-gradient acceleration, at the cost of a degraded efficiency and beam quality.

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Session Classification: WG10: ALEGRO towards colliders

Track Classification: WG10: ALEGRO towards colliders

Contribution ID: **224** Type: **Oral contribution**

All-optical emittance measurement of LWFA electron beams

Thursday, 21 September 2023 16:25 (20 minutes)

The emittance of an electron bunch is a fundamental property, which characterizes its quality in terms of applications. Nowadays, electron beams from laser wakefield accelerators have matured to even drive free electron lasers. Characterizing these beams in terms of emittance is still challenging, as single-shot measurements are required. However, widely used techniques like a pepper-pot mask aren´t sensitive enough. Here, we employ the scheme described by A. Seidel et al. (PRAB 24, 012803 (2021)) to measure the emittance of electron bunches from a laser wakefield accelerator in an all-optical way. In this talk, we present the first experimental results showing an improvement of more than one order of magnitude compared to pepper pot measurements.

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Session Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **234** Type: **Oral contribution**

Development and commissioning of a novel C-band hybrid photoinjector at RadiaBeam

Thursday, 21 September 2023 16:25 (20 minutes)

RadiaBeam, in collaboration with UCLA, SLAC, and Amplitude Lasers, is developing a compact tunable ICS gamma ray source for industrial, medical, and security applications. The entire system is designed to be transportable in a standard cargo container, requiring minimizing longitudinal footprints of the individual components. To this end, a compact C-band hybrid photoinjector was developed, simultaneously enabling high brightness e-beam generation, acceleration, and longitudinal compression with only 80 cm of space, between the photocathode surface and the linac entrance plane. This novel photoinjector was designed, manufactured, and recently commissioned at the RadiaBeam gun test stand facility, achieving a micron-level emittance, and over 200 A peak current at the linac injection plane, and a reliable and reproducible operation. In this paper, the C-band hybrid design and features are discussed, and the commissioning results are presented. The unique hybrid dynamics is illuminated by the parametric phase scans. The near plans for completion of the ongoing 100 MeV beam energy upgrade, and ICS source commissioning are also presented. Finally, other applications of this novel photoinjector technology, relevant to AAC programs, will be summarized.

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Session Classification: WG4: High gradient vacuum structures

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **296** Type: **Oral contribution**

Beam-driven plasma wakefield acceleration at Megahertz repetition rates

Thursday, 21 September 2023 16:25 (20 minutes)

Despite the great advances that have been made in beam-driven plasma wakefield acceleration (PWFA) in the past decade in terms of acceleration gradient, efficiency, and beam quality preservation, so far the repetition rates of PWFAs were limited to a few Hz. In contrast, user facilities based on conventional acceleration technology routinely supply 1,000's of bunches to 100's of thousands (1 million) of bunches for experiments per second. For PWFA's to be competitive and compatible with the average brightness of these conventional machines, their repetition rates also have to be advanced to the kHz and MHz regime. The FLASH linac at DESY, which provides the electron bunches for the FLASHForward PWFA experiment, is capable of producing bunch trains of 100's of bunches at MHz repetition rates. In this contribution we show the current status of beam-driven plasma wakefield acceleration at FLASHForward with MHz repetition rates.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **365** Type: **Oral contribution**

Laser development for LWFA and future plans

Thursday, 21 September 2023 16:25 (20 minutes)

In this presentation I shall review recent developments in laser technology for high average power drivers for LWFA, concentrating on coherent combination of fibre systems. This shows great promise for achieving high repetition rate, high power pulses with wall plug efficiencies in the tens of percent. I shall also outline plans for LWFA experiments at the upgraded CLARA facility at the Daresbury Laboratory, UK.

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Presenter: Dr CORNER, Laura (Cockcroft Institute, University of Liverpool)

Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **201** Type: **Oral contribution**

Acceleration and focusing capabilities integrated in a new plasma-based device

Thursday, 21 September 2023 16:45 (20 minutes)

Plasma wakefield acceleration revolutionized the field of particle accelerators by generating gigavolt-per-centimeter fields and paved the way toward the development of compact Free-Electron Lasers. To achieve such large accelerations in a beam-driven plasma accelerator it is necessary to focus the driver bunch to increase its density and, at the same time, transversely match the witness the plasma wakefield.
Here we show the first results obtained at SPARC_LAB by using a compact composite discharge-capillary device consisting of two active-plasma lenses and a PWFA accelerator module. The results demonstrate that it is possible to integrate several plasma-based devices with the goal to build a very compact accelerator stage.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **220** Type: **Oral contribution**

In Situ Measurement of Electron Energy Evolution in a Laser-Plasma Accelerator

Thursday, 21 September 2023 16:45 (20 minutes)

Plasma acceleration enables the acceleration of electrons to high energies over short distances as high electric fields on the order of 100 GV/m can be sustained in plasma. A precise knowledge of these fields is necessary for the stable and reliable operation of plasma accelerators. We report on a noninvasive method applying Thomson scattering to measure the evolution of the electron beam energy inside a laser-plasma accelerator with high spatial resolution. The determination of the local electron energy enabled the in-situ detection of the acting acceleration fields without altering the final beam state. Our experiments show the evolution of the accelerating fields from 265 ± 119 GV/m to 9 ± 4 GV/m in a plasma density ramp. Our data show excellent agreement with particle-in-cell simulations and demonstrates the new possibilities of this method for detecting the dynamics of plasma-based accelerators and their optimization.

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Session Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **291** Type: **Oral contribution**

Energy recovery in filament-regime plasma wakefield acceleration of positron beams

Thursday, 21 September 2023 16:45 (20 minutes)

The filament regime is a promising candidate for the acceleration of positron beams in plasma because it is emittance-preserving and stable to transverse offsets [Diederichs et al, PRAB 25, 091304 (2022), Diederichs et al, PRAB 23, 121301 (2020]. Beam loading dynamics limit the maximum amount of energy that can be extracted from the wake by the trailing positron bunch. We explore efficiency enhancements through the use of an additional trailing electron recovery bunch using the HiPACE++ PIC code. We discuss potential experiments at the FACET-II facility as part of the E-333 experimental collaboration. We also provide a concept for a future collider facility that would accelerate positron bunches in the filament regime and use electron recovery beams as drivers of subsequent stages.

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Presenter: GESSNER, Spencer (SLAC)

Session Classification: WG10: ALEGRO towards colliders

Track Classification: WG10: ALEGRO towards colliders

Contribution ID: **383** Type: **Oral contribution**

Precision high average power ultrashort pulse lasers

Thursday, 21 September 2023 16:45 (20 minutes)

Joule-class femtosecond lasers are being developed to increase repetition rates from current values of a few Hertz to kiloHertz rates and beyond with multi-kW average power. This is critical to enable precision feedback and control required to make the next steps in performance and to enable applications of accelerators, photon sources and future particle colliders. Coherent combination of many fiber laser pulses - in space, time and wavelength - is being developed to combine the high average power and high efficiency of fiber lasers with high peak powers. A 100mJ-class spatially combined 100-fs-class and a 200 mJ-class, 30 fs spatially and spectrally combined multi-kHz demonstrator are in progress. The technology path from current systems to a near-term kHz facility and to efficient technologies capable of tens of kiloHertz at tens of Joules using these and related paths will be discussed.
Work supported by U.S. DOE Office of Science, Offices of HEP and ARDAP, by DARPA, and by the Gordon and Betty Moore Foundation, under Contract No. DE-AC02-05CH11231 and by LBNL LDRD.

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Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **404** Type: **Oral contribution**

Beam Dynamics Simulation of a High Brightness, High Repetition Rate RF C-band Photoinjector for Future EuPRAXIA@SPARC_LAB Upgrade

Thursday, 21 September 2023 16:45 (20 minutes)

High-brightness RF photo-injectors are crucial for generating high peak current and low transverse emittance electron beams, which are necessary for driving plasma Wake-field acceleration in advanced accelerator concepts and novel radiation sources. To enhance the EuPRAXIA@SPARC_LAB photo-injector for future upgrades, it is essential to investigate and assess the feasibility of achieving higher charge and multi-bunch working points, commonly referred to as the "comb configuration" for particle-driven Wake-field acceleration. A solution to reduce the photo-injector's footprint while preserving beam quality and brightness is to implement a C-band injector operating at 5.712 GHz. Evaluating the possibility of achieving a working point within the velocity bunching acceleration scheme is critical, as this will determine the degree of compression achievable with a full C-band injector. Start-to-end beam dynamics simulations will be conducted to identify the optimum configuration for the C-band photo-injector dedicated to particle-driven plasma-based acceleration.

Primary author: SILVI, Gilles Jacopo (Istituto Nazionale di Fisica Nucleare)

Presenter: SILVI, Gilles Jacopo (Istituto Nazionale di Fisica Nucleare)

Session Classification: WG4: High gradient vacuum structures

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **239** Type: **Oral contribution**

Schemes for Simultaneous Large Transformer Ratio, High Efficiency, Low Energy Spread, High Charge of Accelerated Electron Beams by Tailored Wakefield Plateaus for Long Driver and Witness Bunches

Thursday, 21 September 2023 17:05 (20 minutes)

A long driver forming a decelerating plateau in a plasma wakefield is required for maximizing the acceleration efficiency and energy gain of a witness beam. Maximizing the efficiency of the acceleration process by injecting a large witness charge, requires a tailored, long witness beam creating a beam-loaded plateau in the accelerating field. As a consequence, in the case of the highest efficiency, the transformer ratio is typically small (≈ 1). We formulate concepts for the simultaneous increase of the charge of the accelerated electron beams, the transformer ratio, and the efficiency while maintaining a low energy spread and emittance of bunches of accelerated electrons in the blowout regime.

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Session Classification: WG10: ALEGRO towards colliders

Track Classification: WG10: ALEGRO towards colliders

Contribution ID: **305** Type: **Oral contribution**

High peak power and high average power Ti :Sa lasers for high performance particle acceleration

Thursday, 21 September 2023 17:05 (20 minutes)

Laser plasma accelerators have seen an incredible development over the 2 past decades, leading to production of high electron energy close to 10 GeV. Both performance and reliability can be further improved thanks to the latest generation multi-PW lasers like the 10 PW laser of ELI-NP having performed its first shots on target few months ago. Data about pulse measurements at focal spot will be presented. In the same time, low repetition rate of these lasers prevents their use in many applications in industry and medicine where high accelerator currents are required for efficiency and speed of the process. This is why Thales and LOA have decided to develop a new electron acceleration platform within the LAPLACE HC project, using a brand new high repetition rate TiSa laser system operating at a repetition rate of 100 Hz becoming therefore compatible with the requirements of most societal applications of electron acceleration. We will present latest results obtained from Titanium Sapphire amplifiers at 100 Hz with output energy close to 1 Joule and average power close to 100 Watts thanks to a significant improvement in TiSa crystals thermal management while operating at ambient temperature.

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Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **307** Type: **Oral contribution**

Gas-dynamic density downramp injection in a beam-driven plasma wakefield accelerator

Thursday, 21 September 2023 17:05 (20 minutes)

Development of internal injection methods in beam-driven plasma accelerators (PWFAs) is a crucial task toward high-quality low-emittance bunch generation and improved control over bunch parameters for quality-demanding applications like free-electron lasers. For this, ultrashort high peak current electron beams are required to drive a PWFA in the blowout regime which enables trapping of the background plasma. Here we present the experimental demonstration of density downramp injection at a gas-dynamic shock in a beam driven plasma accelerator powered by laser-accelerated electron beams. The femtosecond electron beam driver with a peak-current exceeding 10 kA enables injection of electron witness bunches at gentle density ramps, i.e., longer than the plasma wavelength, which nurtures prospects for ultralow bunch emittance. By precision control over the position of injection we show that
these bunches can be energy-tuned in acceleration gradients of near 120 GV/m. We anticipate that this setup paves the way for further investigation of various internal injection schemes in PWFAs for the generation of high brightness witness beam.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **437** Type: **Invited talk**

High Gradient Cryo-RF Enabled Hard X-ray Free-electron Laser for Chip Metrology

Thursday, 21 September 2023 17:05 (20 minutes)

Recently, muc work has been directed at R&D a ultra-compact X-ray FEL (UC-XFEL) based on rapidly emerging techniques in high field cryogenic acceleration, attendant dramatic improvements in beam brightness, and state-of-the-art concepts in beam dynamics, magnetic undulators, and X-ray optics. A full conceptual design of a 1 nm XFEL with a length and cost over an order of magnitude below current XFELs has been developed. This instrument has been conceived with an emphasis on permitting exploratory scientific research in a university setting. Concurrently, compact FELs are undergoing rapid development for use in next-generation chip manufacturing as a high flux, few-nm lithography source. This new role suggests consideration of XFELs to address urgent demands in this sector, as identified by recent national need studies, for new radiation sources aimed at chip manufacturing: a coherent hard X-ray source which enables frontier metrology methods. Indeed, it has been shown that one may use coherent X-rays to perform few nm-resolution surveys of macroscopic structures using ptychographic tomography. As the XFEL is an extremely promising candidate for realizing such methods, we present here an analysis of the issues and likely solutions associated with extending the UC-XFEL to X-rays above 7 keV, much higher fluxes, and methods of applying such a source to ptychographic tomography for microelectronic device measurements. We discuss the development path to move the concept to rapid realization.

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Session Classification: WG4: High gradient vacuum structures

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **188** Type: **Oral contribution**

Machine Learning-based Data Analysis and Surrogate Modeling For COXINEL Experiment

Thursday, 21 September 2023 17:20 (25 minutes)

Recently, free electron lasing at UV wavelength has been demonstrated by deploying the COXINEL beamline driven by HZDR plasma accelerator in a seeded configuration[1]. Further control and optimization of such an FEL radiation require full knowledge of strongly-coupled multivariate parameters involved in laser plasma acceleration, electron beam transport and radiation generation. For this purpose, one has to solve an inverse problem, i.e. finding matching parameters of the simulation to reproduce the experiment. Such inverse problems are ill-posed and cannot be easily resolved due to high computational complexity. Here, machine learning-based methods have a high potential to accelerate theoretical comprehension of the system, novel means for design space exploration and promise reliable in-situ analysis of experimental diagnostics and parameters. We apply simulation-based inference technique for this purpose. This method is a combination of deep learning and statistical approaches to resolve an inverse problem up to a posterior distribution of the simulation parameters given an experimental sample. In addition, we have developed machine learning-based surrogate models that can significantly accelerate forward computations for even faster results of the inverse solver.

[1] M. Labat, et al. "Seeded free-electron laser in driven by a compact laser plasma accelerator", Nat. Photonics, 17, 150(2023)

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Presenter: WILLMANN, Anna (HZDR)

Session Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **313** Type: **Oral contribution**

High average gradient in a laser-gated multistage plasma wakefield accelerator

Thursday, 21 September 2023 17:25 (20 minutes)

Inter-stage distances and components in multistage PWFA concepts are among the biggest potential contributors to the total accelerator length and may strongly reduce the average gradient of a plasma based accelerator.
Here, we discuss a concept to optimize inter-plasma
distances by drive-beam coupling in the temporal domain
and gating the accelerator via a femtosecond ionization laser.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **361** Type: **Oral contribution**

A 100 Hz laser system with with few-cycle and TW Pulses

Thursday, 21 September 2023 17:25 (20 minutes)

Ultrashort pulse laser systems operational in large scale facilities like ELI are heavily booked for secondary source developments and user experiments. The requirement for scientific and technological developments related to high average power laser-matter interactions, like target systems, diagnostics, etc., calls for frequent experimental testing with appropriate laser sources.
Our versatile laser system was designed utilizing the recent achievements in Ti:S -based short pulse amplification. The three stage, 100Hz repetition rate laser system is based on the configuration of negatively and positively chirped pulse amplification. Since cryogenic cooling increases CEP noise, our water-cooled amplifiers have been designed according to the scheme of extraction during pump. In the current status, the few cycle output provides pulses with 9.2fs and 0.3mJ, while the power output supports sub-25fs pulses with almost 40mJ. The output energy stability is better than 1.5%. Such a system has been successfully used for the development of two high repetition rate target systems.
To shorten the pulse duration, the booster amplifier is converted to a polarization encoded operation mode, so that 15 fs pulses are expected still with 40mJ. For experiments requiring sub-two cycle laser pulses, a single-plate pulse compressor have been developed.

Primary author: OSVAY, Karoly (University of Szeged)

Presenter: OSVAY, Karoly (University of Szeged)

Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **384** Type: **Oral contribution**

AWAKE and future colliders

Thursday, 21 September 2023 17:25 (20 minutes)

Proton-driven plasma wakefield acceleration may allow to accelerate electrons to TeV energies in a single plasma stage. The concept is developed using the AWAKE facility, which already demonstrated electron acceleration to GeV energies over 10 m of plasma during Run 1. In 2022, AWAKE started Run 2, where the goal is to: 1) demonstrate stable accelerating gradients of 0.5–1 GV/m, 2) accelerate bunches of electrons with high beam quality, and 3) develop plasma sources scalable to 100s of meters and beyond. By the end of Run 2, the scheme developed in AWAKE should be able to provide electron beams for particle physics experiments and several possibilities have already been evaluated. This contribution summarizes the AWAKE Run 2 program as well as the possible application of the AWAKE scheme to novel particle physics experiments.

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Presenter: TURNER, Marlene (CERN)

Session Classification: WG10: ALEGRO towards colliders

Track Classification: WG10: ALEGRO towards colliders

Contribution ID: **436** Type: **Oral contribution**

Superconducting short period undulators

Thursday, 21 September 2023 17:25 (20 minutes)

Short period/high field undulators allow to reach the same photon energy as conventional ones by lower electron beam energies, and they therefore contribute to make accelerator based light sources more compact.
Different efforts have been made in the past decades to reduce the period of the undulators while keeping a high magnetic field on axis B.
We report here on such efforts focusing on superconducting undulators.

Primary author: CASALBUONI, Sara

Presenter: CASALBUONI, Sara

Session Classification: WG4: High gradient vacuum structures

Track Classification: WG4: High gradient vacuum structures

Contribution ID: **325** Type: **Oral contribution**

Industrial Compact Free Electron Lasers and Laser-driven Accelerators

Thursday, 21 September 2023 17:45 (20 minutes)

Ultrahigh-intensity lasers and laser-driven particle accelerators made rapid progress towards becoming commercial tools. Tau Systems Inc. is working to bring laser-plasma acceleration into the commercial sphere by leveraging expertise in laser physics, laser-driven plasma, conventional accelerators, and data science. Major challenges facing future LWFA-based commercial systems are stability and repeatability, low repetition rates, technical expertise required for operation. To address such challenges, we construct a fully-integrated high average power laser-accelerator facility at TAU Labs (San Diego, CA). The phase I system is driven by a 100 Hz, 1J, 25fs Ti:Sapphire laser accelerating electrons to >100 MeV and will be outfitted with electron, neutron, and X-ray target stations. Diagnostics, control systems, etc. are developed from the ground up to operate at 100+ Hz and be fully integrated. Furthermore, TAU partners with UT Austin and the Berkeley Laser Laboratory Accelerator (BELLA) Center. At UT we upgraded the UT3 Ti:Sapphire laser with a second beamline and dedicated LWFA setup with stable performance at 10Hz, 35fs, 1J on-target. At BELLA we jointly operate the Bella-HTU (100 TW Undulator) to demonstrate laser-driven FEL. We present first results, progress of the 100Hz TAU Labs system and technology considerations for reaching into the multi-kHz regime.

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Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **326** Type: **Oral contribution**

HELPMI: HElmholtz Laser-Plasma Metadata Initiative

Thursday, 21 September 2023 17:45 (25 minutes)

HELPMI is a 2-year project, subsidized by the Helmholtz Metadata Collaboration, conducted by GSI, HI Jena and HZDR (lead). The aim is to start the development of a F.A.I.R. data standard for experimental data of the entire laser-plasma (LPA) community. Such standard does not yet exist. It will facilitate management and analysis of usually quite heterogeneous experimental data and logs by rich and machine-actionable metadata, allowing automated processing of broad and long data sets. To date, the LPA community is widely using openPMD, an open meta-standard, well-established for simulations. NeXus is a similarly hierarchical and extensible standard for various experimental methods of the Photon and Neutron science community. Within HELPMI, we plan to adopt NeXus for LPA experimental data and simultaneously to make openPMD and its API extensible for custom hierarchies like NeXus. Thereby we can achieve interoperability of the standards, circumventing the need for another standard. Alongside we will start developing a glossary of LPA experimental terms in order to achieve re-usability. The glossary shall be community-driven and technically open, extensible and implementation-independent.

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Session Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Track Classification: WG7: Beam diagnostics, instrumentation, Machine Learning

Contribution ID: **336** Type: **Oral contribution**

Electron beam self-focusing and X-ray radiation in a self-ionized plasma wakefield accelerator

Thursday, 21 September 2023 17:45 (20 minutes)

The E300 experiment at FACET-II on PWFA relies on electron and X-ray/ɣ-ray detectors to measure the beam dynamics and assess its matching in plasma, with the aim of preserving the beam quality, one of the most important milestone for the field. The plasma accelerator was operated in a self-ionized hydrogen plasma. The electron beam had a large enough peak current and density to trigger some level of ionization of the gas. Observations revealed a strong beam-plasma interaction over several meters, with the 10 GeV beam transferring more than half of its energy to plasma, and with bright betatron X rays being emitted. Dedicated detectors enabled the characterisation of the betatron radiation at different plasma densities, with photon energies in the 10-100 keV range. They allowed to infer a beam size in the plasma and a betatron oscillation amplitude of a few μm, thus providing an evidence of the beam self-focusing in the self-ionized plasma. This is confirmed by the data taken with the 20 GeV FACET-I beam, with gamma range betatron radiation and photon energies exceeding 10 MeV. We report on these results highlighting how the characterization of betatron radiation can provide crucial insight into the beam dynamics for PWFA.

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Presenter: Ms ZAKHAROVA, Viktoriia (LOA)

Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **382** Type: **Oral contribution**

Staging in LWFA - challenges and prospects

Thursday, 21 September 2023 17:45 (20 minutes)

It is likely that the achievement of electron beam energies significantly above 10 GeV with plasma wakefield acceleration will require the successful coupling of multiple independent stages. To maintain a high average acceleration gradient over the full length of the accelerator it is critical that the space used to couple the driver into the plasma is kept as compact as possible, and in this respect, using a laser as a driver is advantageous. However, achieving this compact coupling while also minimising emittance growth and satisfying the tight spatiotemporal alignment requirements is difficult, and may require trade-offs. In this talk, the current state of laser-driven staging will be presented, and proposed solutions to the challenges faced by both multi-stage acceleration in general, and LWFA specifically, will be discussed.

Primary author: BACKHOUSE, Michael

Presenter: BACKHOUSE, Michael

Session Classification: WG10: ALEGRO towards colliders

Track Classification: WG10: ALEGRO towards colliders

Contribution ID: **212** Type: **Oral contribution**

The X-lites Network

Thursday, 21 September 2023 18:05 (20 minutes)

The Extreme Light in Intensity, Time, and Space (X-lites) Network promotes collaboration around the world to make use of new extreme light facilities. X-lites was founded in 2022 with three goals: 1. To promote collaboration across the global community of laser facility users and operators, 2. To broaden engagement across diverse scientific fields and with next generation research leaders, and 3. Identify and address knowledge and technological gaps that require a collaborative approach to tackle as a community. This presentation will detail the planned activities and potential opportunities for the X-lites network and how individual extreme light facilities or networks and their members can get involved.

X-lites is supported by the National Science Foundation (NSF) Award 2201502.

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Presenter: WILLINGALE, Louise (University of Michigan)

Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **284** Type: **Oral contribution**

Toward start-to-end modeling of plasma-based colliders with the Exascale Particle-In-Cell code WarpX

Thursday, 21 September 2023 18:05 (20 minutes)

The electromagnetic Particle-In-Cell (PIC) code WarpX has been developed within the the U.S. Department of Energy's Exascale Computing Project toward the modeling of plasma accelerators for future high-energy physics colliders on Exascale Supercomputers. The code can be used for start-to-end modeling of plasma-based colliders, from beams' creation to their acceleration in chains of stages to beam-beam interaction at the interaction point (with inclusion of QED effects). The code can also be coupled with other codes and integrated in an ecosystem for fast multi-resolution convergence, cross-benchmarking and design optimization. We will present the latest in the modeling of collider-relevant plasma-based sources, acceleration sections and interaction points with WarpX. Future plans will also be presented and discussed.

Supported by the Exascale Computing Project (17-SC-20-SC), a collaborative effort of two U.S. Department of Energy organizations (Office of Science and the National Nuclear Security Administration), by the CAMPA collaboration, a project of the U.S. Department of Energy, Office of Science, Office of Advanced Scientific Computing Research and Office of High Energy Physics, Scientific Discovery through Advanced Computing (SciDAC) program and by an LBNL LDRD supported by the U.S. Department of Energy, Office of Science, under contract numbers DE-AC02-05CH11231.

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Session Classification: WG10: ALEGRO towards colliders

Track Classification: WG10: ALEGRO towards colliders

Contribution ID: **337** Type: **Oral contribution**

Longitudinally Resolved Measurements of Energy-Transfer Efficiency in a Plasma-Wakefield Accelerator

Thursday, 21 September 2023 18:05 (20 minutes)

Energy-transfer efficiency is an important quantity in plasma-wakefield acceleration, especially for applications that demand high average power. Normally, this efficiency is measured using an electron spectrometer; an invasive method that provides an energy-transfer efficiency averaged over the full length of the plasma accelerator. We present an experimental demonstration of a novel diagnostic that utilises the excess light emitted by the plasma after a beam–plasma interaction, yielding noninvasive, longitudinally resolved measurements of the local energy-transfer efficiency from the wake to the accelerated bunch. The applications of this diagnostic, such as experimental studies of the efficiency-stability relation and online optimisation of future multistage plasma accelerators, are then discussed.

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Session Classification: WG1:Plasma-based accelerators and ancillary components

Track Classification: WG1: Plasma-based accelerators and ancillary components

Contribution ID: **266** Type: **Oral contribution**

Readiness of electron plasma linacs for a collider application

Thursday, 21 September 2023 18:25 (20 minutes)

We discuss how ready the field is to deliver the parameters needed to realize a 500 GeV PWFA electron linac for the HALHF collider. Using the current, tentative HALHF linac parameter set, we investigate in a systematic manner the difference between the the required collider parameters, including beam quality, efficiency and plasma-cell parameters, and the corresponding performance demonstrated in experiments as well as what has been shown in simulations.

Primary author: ADLI, Erik (University of Oslo, Norway)

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Presenter: ADLI, Erik (University of Oslo, Norway)

Session Classification: WG10: ALEGRO towards colliders

Track Classification: WG10: ALEGRO towards colliders

Contribution ID: **401** Type: **Oral contribution**

The HORIZON project : towards face-cooled kiloWatt-class Yb:YAG laser systems

Thursday, 21 September 2023 18:25 (20 minutes)

The LEAP/HORIZON project at CELIA in Bordeaux aims to develop new laser amplification technologies, suitable for the next generation of compact chirped-pulse amplification lasers, with high repetition rate and high average power, at or beyond the kiloWatt landmark, with Joule-level interaction pulses –a range of parameters in energy and repetition rate of interest for laser-wakefield electron acceleration. While the choices of cw diode-pumping and of Ytterbium-YAG amplification media are commonplace, the HORIZON project decided not to resort to cryogenic temperatures of bulk slabs, but to explore and test a panel of alternative technologies to ensure amplification, especially direct face-cooling on the amplifier disks.

The talk will first present the main features of the HORIZON laser prototype, with its three main stages –custom seeder, pre-amplifier, and power amplifier, then focus on the latter, especially on the crucial issue of thermal management. The patented rotating disk approach will be described ; we will introduce the thermo-hydrodynamical issues of direct face-cooling, advantages and possible limitations. We will present results on cw amplification on the power head, that demonstrate the ability of this technology to reach the kiloWatt level.

Primary author: BALCOU, Philippe (CELIA/Université de Bordeaux)

Presenter: BALCOU, Philippe (CELIA/Université de Bordeaux)

Session Classification: WG2: Laser technology (WP6 - Task2)

Track Classification: WG2: Laser technology

Contribution ID: **362** Type: **Invited talk**

High average power, high rep rate lasers: Technological challenges towards multi-disciplinary applications

Friday, 22 September 2023 09:20 (40 minutes)

Lasers with high peak powers and high-energy have long been used for discovery science as well as technology demonstrations, ranging from recreating astrophysical conditions in the laboratory to driving plasma-based accelerators and inertial confinement fusion. With the novel schemes that enable high power lasers operating at high repetition rates with kW average power, we are now entering a new era of applications of these lasers in industry, medicine, security, and defence sectors. Any sustainable high-average power laser technology should include schemes to manage the heat load in the system, ensuring maximum gain and conversion efficiencies, whilst maintaining a good beam quality. I will discuss the Diode-Pumped Solid State Laser (DPSSL) developments in CLF, enabling high-average power laser drivers for future plasma accelerators, including EPAC and potentially EuPRAXIA.

Primary author: COLLIER, John (CLF, STFC, UKRI)

Presenter: COLLIER, John (CLF, STFC, UKRI)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **318** Type: **Invited talk**

Toward an Inertial Fusion Energy Future: Challenges and Opportunities in Science & Technology

Friday, 22 September 2023 10:00 (40 minutes)

The repeated achievement of fusion ignition on the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory in the U.S. has demonstrated more energy generated out of the plasma than was delivered by the lasers, thus establishing the basic scientific feasibility of harnessing fusion in the laboratory as an energy source. Fusion energy may be the ultimate clean and nearly limitless form of power, offering energy and climate security. In this talk, we will discuss recent developments in the field, as well as the many challenges and opportunities in the road ahead to realizing Inertial Fusion Energy, including in high power lasers, target fabrication and delivery, blankets and fuel cycles, new materials, computation, and systems integration.

Primary author: MA, Tammy (Lawrence Livermore National Laboratory)

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Presenter: MA, Tammy (Lawrence Livermore National Laboratory)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **267** Type: **Invited talk**

A hybrid, asymmetric, linear Higgs factory (HALHF)

Friday, 22 September 2023 11:00 (30 minutes)

Construction of a Higgs factory is the top priority for particle physics in the next decades, but the costs are prohibitively high. Plasma-wakefield accelerators (PWFAs) promise to drastically reduce the footprint and therefore the cost of such machines. However, while progress on electron acceleration is rapid, positron acceleration in plasma remains challenging. We propose a linear-collider concept that bypasses the positron problem by using PWFAs to accelerate electrons and conventional RF accelerators to accelerate positrons. This hybrid scheme requires the beam energies to be highly asymmetric, and, we argue, benefits from the use of asymmetric bunch charges as well as asymmetric transverse emittances. This talk presents an overview of the HALHF concept and the R&D required to implement it.

Primary author: Dr LINDSTRØM, Carl A. (University of Oslo)

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Presenter: Dr LINDSTRØM, Carl A. (University of Oslo)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **344** Type: **Invited talk**

The plans to prepare for the next European Strategy

Friday, 22 September 2023 11:30 (30 minutes)

In this talk, we will discuss the European Strategy for Particle Physics Accelerator R&D Roadmap and the activities under plasma accelerators. The agreed activities in this area over the next few years will be discussed.

Primary authors: PATTATHIL, Rajeev (Rutherford Appleton Laboratory); LEEMANS, Wim

Presenter: PATTATHIL, Rajeev (Rutherford Appleton Laboratory)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **380** Type: **Invited talk**

Advanced Accelerator Concept activities at Snowmass

Friday, 22 September 2023 12:00 (30 minutes)

New concepts for particle acceleration, generation, and focusing at ultra high acceleration gradients (GeV/m and beyond) have the potential to enable future e+e- and γ − γ colliders to and beyond 15 TeV energies. In addition to proven high gradient and ultra-bright beam generation, these systems have the potential to increase luminosity per unit beam power via short beams, for practical energy recovery to extend the reach of high energy physics, and for fast cooling. Conceptual collider parameters have been developed for colliders at a range of energies, and continuing to develop these concepts in interaction with the collider and high energy physics communities is important; as is development of technologies through nearer-term applications. Progress, next steps, and results of Snowmass Accelerator Frontier topical group # 6, Advanced Accelerator Concepts (https://doi.org/10.48550/arXiv.2208.13279) will be discussed.
We gratefully acknowledge the input of all of the members of the Accelerator Frontier 6 group of Snowmass, and of colleagues in the Accelerator, Energy, Community and other Frontiers.
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Primary authors: GEDDES, Cameron (Lawrence Berkeley National Laboratory); HOGAN, Mark (SLAC National Accelerator Laboratory); MUSUMECI, Pietro; ASSMANN, Ralph (DESY)

Presenter: GEDDES, Cameron (Lawrence Berkeley National Laboratory)

Session Classification: Plenary session

Track Classification: Invited

Contribution ID: **223** Type: **Invited talk**

Laser plasma accelerators: then and now through cutting-edge experiments

Friday, 22 September 2023 16:20 (40 minutes)

Laser Plasma Accelerators (LPA) are changing the scientific and societal landscape. Opening new hopes for high energy physics, offering alternative to synchrotron light sources with the recent demonstration with LPA's based Free Electron Radiation, and delivering particle and radiation beams for medical and security applications, they are among the most innovative tools of modern sciences. I'll explain the main involved concepts, and why these wonderful machines rely on our ability to control finely the electrons motion with intense laser pulses. I'll show how the electrons collective manipulation permits to produce giant electric fields of value in the 100GV/m exceeding by 3 orders of magnitude or more the ones used in current machines. This control is crucial for electrons injection that is essential for delivering stable ultra-short and ultra-bright energetic particle or radiation beams. To illustrate the beauty of laser plasma accelerators I will show some concepts we recently demonstrated that allow these controls for beams improvements. Finally, I will discuss on the next challenges together with new ideas that will be tested in the next future.

Primary author: Prof. MALKA, Victor (Weizmann Institute of Science)

Presenter: Prof. MALKA, Victor (Weizmann Institute of Science)

Session Classification: Plenary session

Track Classification: Invited