EuPRAXIA-DN School on Plasma Accelerators

Report of Contributions

https://agenda.infn.it/e/eupraxia-school-on-plasma-accelerators

Contribution ID: **1** Type: **not specified**

Welcome and Logistics

Monday, 22 April 2024 09:15 (45 minutes)

Presenters: MOSTACCI, Andrea (Sapienza); WELSCH, Carsten Peter; FERRARIO, Massimo (Istituto Nazionale di Fisica Nucleare); CAO, Minh (University of Liverpool / The Cockcroft Institute)

Contribution ID: **4** Type: **not specified**

Introduction to High Power Lasers

Monday, 22 April 2024 10:00 (1 hour)

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

Contribution ID: **5** Type: **not specified**

Introduction to Plasma Physics

Monday, 22 April 2024 11:30 (1 hour)

Presenter: SAN MIGUEL CLAVERIA, Pablo (IST)

Contribution ID: **6** Type: **not specified**

Intro to Linacs

Monday, 22 April 2024 12:30 (1 hour)

Presenter: BELLAVEGLIA, Marco (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **7** Type: **not specified**

Beam Physics of High Quality Beams

Monday, 22 April 2024 14:30 (1 hour)

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

Contribution ID: **8** Type: **not specified**

Beam Diagnostics for Plasma Accelerators

Monday, 22 April 2024 15:30 (1 hour)

Presenter: WOLFENDEN, Joseph (University of Liverpool)

Contribution ID: **9** Type: **not specified**

Seminar: History of plasma accelerators: From the dream beam to EuPRAXIA

Monday, 22 April 2024 17:00 (1 hour)

Presenter: Prof. MALKA, Victor (Weizmann Institute of Science)

Contribution ID: **10** Type: **not specified**

Technology of Plasma Sources

Tuesday, 23 April 2024 09:15 (1 hour)

Presenter: BIAGIONI, Angelo (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **11** Type: **not specified**

Introduction to Laser Wakefield Acceleration

Tuesday, 23 April 2024 10:15 (1 hour)

Presenter: GRITTANI, Gabriele Maria (ELI-Beamlines)

Contribution ID: **12** Type: **not specified**

Introduction to Particle-driven Acceleration

Tuesday, 23 April 2024 11:45 (1 hour)

Presenter: VERRA, Livio (INFN-LNF)

Contribution ID: **13** Type: **not specified**

Introduction to Laser-driven Heavy Ion Acceleration

Tuesday, 23 April 2024 12:45 (1 hour)

Presenter: METZKES-NG, Josefine

Contribution ID: **14** Type: **not specified**

Seminar: Ultra-short Laser Pulse Generation and Applications

Tuesday, 23 April 2024 17:00 (1 hour)

Presenter: Prof. L'HUILLIER, Anne

Contribution ID: **15** Type: **not specified**

EuPRAXIA

Wednesday, 24 April 2024 13:00 (30 minutes)

Presenter: WELSCH, Carsten Peter

Contribution ID: **16** Type: **not specified**

Free Electron Lasers

Wednesday, 24 April 2024 10:30 (1 hour)

Presenter: CHIADRONI, Enrica (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **17** Type: **not specified**

Betatron Radiation Emission in Plasma

Wednesday, 24 April 2024 09:30 (1 hour)

Presenter: CURCIO, Alessandro (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **18** Type: **not specified**

Beam Manipulation with a Plasma Accelerator

Wednesday, 24 April 2024 12:00 (1 hour)

Presenter: Dr POMPILI, Riccardo (Istituto Nazionale di Fisica Nucleare)

Contribution ID: **19** Type: **not specified**

History of INFN

Wednesday, 24 April 2024 14:30 (1 hour)

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

Contribution ID: **20** Type: **not specified**

Introduction of the INFN-LNF

Wednesday, 24 April 2024 15:30 (10 minutes)

Contribution ID: **21** Type: **not specified**

Plasma Diagnostics for Plasma Accelerators

Thursday, 25 April 2024 09:15 (1 hour)

Presenter: NAJMUDIN, Zulfikar (Imperial College London)

Contribution ID: **22** Type: **not specified**

Extreme Light Infrastructure –a Distributed European Research Infrastructure

Thursday, 25 April 2024 10:15 (1 hour)

Presenter: GRITTANI, Gabriele Maria (ELI-Beamlines)

Contribution ID: **23** Type: **not specified**

The Role of Computing in the Development of Plasma Accelerators

Thursday, 25 April 2024 11:45 (1 hour)

Presenter: VIEIRA, Jorge (Instituto Superior Técnico)

Contribution ID: **24** Type: **not specified**

Plasma Simulation for Optimization

Thursday, 25 April 2024 12:45 (1 hour)

Presenter: DÖPP, Andreas (LMU Munich)

Contribution ID: **25** Type: **not specified**

Seminar: The AWAKE Experiment at CERN

Thursday, 25 April 2024 17:00 (1 hour)

Presenter: GSCHWENDTNER, Edda (CERN)

Contribution ID: **26** Type: **not specified**

Micro Accelerators THz

Friday, 26 April 2024 10:00 (1 hour)

Presenter: TURNÁR, Szabolcs (University of Pécs)

Contribution ID: **27** Type: **not specified**

Primer on Low Level RF

Friday, 26 April 2024 11:30 (30 minutes)

Presenter: CARGNELUTTI, Manuel (Instrumentation Technologies d.o.o.)

Contribution ID: **28** Type: **not specified**

Primer on Integrated Diagnostics

Friday, 26 April 2024 12:00 (30 minutes)

Presenter: GRIESMAYER, Erich (CIVIDEC Instrumentation GmbH)

Contribution ID: **29** Type: **not specified**

Closing Remarks

Friday, 26 April 2024 12:30 (30 minutes)

Outlook and roadmaps

Presenter: WELSCH, Carsten Peter

Contribution ID: **30** Type: **Poster**

TeV/m Electron Acceleration in Carbon Nanotubes

We report the first numerical demonstration of electron self-injection and resonant acceleration in ordered carbon nanotube (CNT) structures. Using the PIConGPU code CNT bundles are modelled as 25-nm-thick carbon tubes of 1e22 cm^-3 plasma density. Following their ionization with 3-cycles-long laser pulse of 800 nm wavelength and 1ed21 W/cm^2 peak intensity, laser wakefield acceleration (LWFA) is triggered in the resulting carbon plasma with an effective density of 1e20-1e21 cm^-3. Simulation results indicate that self-injected fs-long electron bunches with hundreds of pC charge can be accelerated at gradients which exceed 1 TeV/m. Both charge and accelerating gradient figures are unprecedented when compared with LWFA in gaseous plasma.

Primary author: BONTOIU, Cristian

Presenter: BONTOIU, Cristian

Session Classification: Poster Session & Industry Display

Contribution ID: **31** Type: **Poster**

High-sensitivity tomography of gas jet flow and its instabilities

Optical probing provides a fundamental tool for research and development and for exploring the mysteries of nature. However, when dealing with objects made of transparent materials with a refractive index near unity, such as low-density gas jets, these samples frequently challenge the limits of sensitivity in optical probing techniques.
To address this challenge, we introduce an advanced optical probing method utilizing multiple probe passes through the object [1], thereby enhancing phase sensitivity. The effectiveness of this approach was validated through the tomographic characterization of low-density supersonic gas jets. The results demonstrate a significant increase in sensitivity, enabling precise quantification of intricate features such as shocks formed by obstacles to the gas flow or barrel shocks formed by ambient pressure [1,2,3].
Gas target characterization traditionally relies on optical methods with millisecond time resolution. However, these techniques often overlook fluctuations occurring at shorter timescales, presenting sensitivity challenges. These rapid fluctuations may originate from manufacturing defects in nozzles or interactions between the gas flow and static ambient gas, particularly common in high repetition rate operations [4].
The accurate characterization of gas jets demands the resolution of rapid fluctuations, particularly for applications like laser-matter interaction in laser wakefield electron acceleration or plasma X-ray sources [5,6]. To address this, we employ Schlieren imaging, enabling the visualization of rapid density fluctuations with a temporal resolution of hundreds of microseconds [3]. This integration of time-averaged density measurements on a millisecond timescale and visualization of shorter instabilities represents a significant advancement in achieving a comprehensive and accurate portrayal of gas jet dynamics.
References

1. Karatodorov, S. et al. Multi-pass probing for high-sensitivity tomographic interferometry. Sci Rep 11, 15072 (2021).
2. Chaulagain, U. et al. Tomographic characterization of gas jets for laser-plasma acceleration with increased sensitivity, Proc. SPIE 11886, International Conference on X-Ray Lasers 2020
3. Raclavský, M. et al. High-sensitivity optical tomography of instabilities in supersonic gas flow, Optics Express 2024
4. F. Brandi, F. Giammanco, F. Conti, et al., Rev. Sci. Instruments 87257 (2016)
5. Chaulagain, U. et al. ELI Gammatron Beamline: A Dawn of Ultrafast Hard X-ray Science. Photonics 2022
6. J. Nejdl et al. "Update on Laser-driven X-ray Sources at ELI Beamlines," in Optica High-brightness Sources and Light-driven Interactions Congress 2022, (Optica Publishing Group, 2022)

Primary author: RACLAVSKY, Marek

Co-authors: NEJDL, Jaroslav (ELI Beamlines Facility, Extreme Light Infrastructure ERIC); Mrs RAO, Kavya H.; Mr LAMAČ, Marcel (ELI ERIC); CHAULAGAIN, Uddhab (ELI beamlines)

Presenter: RACLAVSKY, Marek

Session Classification: Poster Session & Industry Display

Contribution ID: **32** Type: **Poster**

Durability Assessment of Discharge Capillaries Wall Materials in Plasma-based Particle Accelerators for the EuPRAXIA Project

As part of the ongoing advancements in plasma wake-field technology for particle acceleration within the EuPRAXIA@SPARC_LAB project, this study investigates the impact of high repetition rate plasma acceleration experiments on plasma sources. Utilizing an established experimental setup for plasma generation through gas-filled discharge capillaries, where plasma formation is achieved by ionizing hydrogen gas with high-voltage pulses, we assess the performance and longevity of capillaries made of plastic. This research builds upon previous work that optimized plasma density measurements and capillary configurations for efficient particle beam acceleration, focusing on the capillaries' ability to sustain future stable operations at high frequencies from 100Hz to 400Hz. Such a criterion is vital for the long-term feasibility of the EuPRAXIA project. The characterization of plasma sources, particularly through spectroscopic techniques based on Stark broadening, provides insights into the interplay between capillary materials and high-frequency plasma formation. This highlights the critical role of material durability in advancing plasma-based particle acceleration technology.

Primary author: DEMITRA, Romain (Istituto Nazionale di Fisica Nucleare)

Co-authors: BIAGIONI, Angelo (Istituto Nazionale di Fisica Nucleare); CRINCOLI, Lucio (Istituto Nazionale di Fisica Nucleare); PITTI, Marco (Istituto Nazionale di Fisica Nucleare); Dr POMPILI, Riccardo (Istituto Nazionale di Fisica Nucleare); FERRARIO, Massimo (Istituto Nazionale di Fisica Nucleare)

Presenter: DEMITRA, Romain (Istituto Nazionale di Fisica Nucleare)

Session Classification: Poster Session & Industry Display

Contribution ID: **33** Type: **Poster**

Nanoparticle-assisted laser wakefield acceleration and the influence of nanoparticle material on accelerated electrons

Laser-driven plasma-wakefield acceleration has the potential to reduce the size and construction cost of large-scale accelerator facilities, by providing accelerating fields up to three orders of magnitude greater than that of conventional accelerators. However, the parameters of the electron beam and its stability need to be further improved to enable efficient use in many interesting industrial and medical applications as well as in various areas of fundamental research.

Since electron injection is one of the key features determining the beam characteristics, various injection mechanisms yielding better electron beam parameters were proposed over the last several years. The most recent and very promising scheme is a gas target containing nanoparticles which, according to simulations, seems very promising, especially in experiments trying to reach multi-GeV electrons. The improvement in terms of the stability of the electron beam have alredy been proven in experiments.

This poster presents a study focused on the influence of various nanoparticle materials, on the injection process and accelerated electron beam. The study was performed using large-scale particle-in-cell simulations which were carried out with PIC code Smilei.

Primary author: ŠPÁDOVÁ, Alžběta (ELI Beamlines Facility, Czech Technical University in Prague)

Co-authors: GRITTANI, Gabriele Maria (ELI Beamlines Facility); VALENTA, Petr (ELI Beamlines Facility); LORENZ, Sebastian (ELI Beamlines Facility); BULANOV, Sergei (ELI Beamlines Facility)

Presenter: ŠPÁDOVÁ, Alžběta (ELI Beamlines Facility, Czech Technical University in Prague)

Session Classification: Poster Session & Industry Display

Contribution ID: **34** Type: **Poster**

Characteristics of sCVD Diamond Sensors

Radiation hard and reproducible diamond sensors are fundamental for the development of beam diagnostics instrumentation for accelerators. The quality control of diamond sensors is vital to determine the sensor's characteristics for dedicated applications. The optical quality control tells the defect level in the diamond material before metallisation while Transit Current Technique (TCT) is instrumental in understanding the movement of electrons and holes in the diamond sensors and their respective ionisation energies. The IV and It measurements provide the dark current profile of the sensors for DC-based applications. This study presents an overview of characteristics of single-crystal chemical vapour deposition (sCVD) diamond sensors and a selective data analysis of different parameters measured during quality control.

Primary author: Ms DIVYA, Divya (TU Wien & CIVIDEC Instrumentation GmbH)

Co-authors: Dr WEISS, Christina (TU Wien & CIVIDEC Instrumentation GmbH); Prof. GRIESMAYER, Erich (TU Wien & CIVIDEC Instrumentation GmbH); Mr MELBINGER, Julian (TU Wien & CIVIDEC Instrumentation GmbH)

Presenter: Ms DIVYA, Divya (TU Wien & CIVIDEC Instrumentation GmbH)

Session Classification: Poster Session & Industry Display

Contribution ID: **35** Type: **Poster**

Implementing betatron radiation for beam diagnostics studies

Betatron radiation is a form of synchrotron radiation emitted by moving or accelerated electron or positron-like charged particles. As a valuable tool it can provide useful information about their trajectories, momentum and acceleration. It has good potential as a novel non-destructive diagnostic for laser-driven plasma wakefield acceleration (LWFA) and beam-driven plasma wakefield acceleration (PWFA).

Since information about the properties of the beam is encoded in the betatron radiation, measurements using the Maximum Likelihood Estimation (MLE) method, rich information about the beam parameters (beam spot size, emittance, charge, energy etc.) can be extracted. Machine learning (ML) techniques can then be applied to improve the accuracy of these measurements. It has already been observed that betatron radiation can give an insight into the change in plasma density.

The QUASAR Group, based at the Cockcroft Institute on Daresbury Sci-Tech campus, is planning to build on and expand an existing collaboration with UoM and UCLA and also to apply the technique for the AWAKE experiment at CERN. In this work, a hybrid ML-MLE approach is attempted to optimize the use of these diagnostics and obtain a deep insight into the beam's parameters e.g. beam spot sizes where ML and MLE individually have their limitations.

Primary author: GHOSAL, Debdeep (University of Liverpool)

Co-author: Mr NOAKES, Joe (University of Liverpool)

Presenter: GHOSAL, Debdeep (University of Liverpool)

Session Classification: Poster Session & Industry Display

Contribution ID: **36** Type: **Poster**

Conceptual design of a laser integration scheme to the existing LUIS-beamline

A 120TW laser system called L2-DUHA is currently under development at ELI-ERIC. The laser system is designed to have a high repetition rate and high pulse energy, with the following parameters: 3J, 25fs, with a repetition rate from 50 up to 100Hz.

The L2-DUHA laser beam will be transported from the L2-hall to the E5-LUIS experimental hall using a dedicated L2-laser beam transport. Once it reaches the LUIS-target chamber, it will be focused to produce a high laser beam intensity of approximately 5x10^18 W/cm2 . This high intensity is necessary for the laser wakefield acceleration of the electron beam, required for the soft X-ray LPA-based Free Electron Laser. The goal is to achieve a high-quality electron beam with an energy of 1 GeV beam for the EuPRAXIA Phase-1.

To combine the L2-DUHA laser beam transport with the current LUIS local laser beam transport, a specialized telescope system will be needed. This system will be placed near the LUIS focusing optics and will use a Galilean telescope system. Key components of the LUIS local laser beam transport have been designed and tested at DESY in collaboration between UHH (Hamburg, Germany) and the Institute of Physics of CAS (Prague, Czech Republic). The updated version of the LUIS local laser beam transport, integrated with the telescope system, has been optimized using the Zemax software. The modeling of the laser beam propagation through the local laser beam transport shows that optical aberrations will be corrected using the LUIS off-axis parabolic mirror, in conjunction with flat mirrors to control the position of the laser beam focus inside the LUIS capillary in the target chamber. The proposed integration of the L2-laser beam transport with the LUIS local laser beam transport will be prepared in the second half of 2024 for upcoming experimental activities utilizing the L2-LUIS technologies.

Primary author: WHITEHEAD, Alex (ELI-ERIC)

Co-author: MOLODOZHENTSEV, Alexander (ELI-ERIC)

Presenter: WHITEHEAD, Alex (ELI-ERIC)

Session Classification: Poster Session & Industry Display

Contribution ID: **37** Type: **Poster**

Electron and x-ray steering using pulse front tilts in laser plasma accelerators

Controlling the pointing of laser wakefield accelerated electrons is essential for applying them both directly, e.g. in stereotactic radiotherapy, and indirectly such as when coupling them to subsequent acceleration stages or beam transporting magnets. However, the electron beam can substantially deviate by tens of milliradians from the laser's optical axis when the laser exhibits a pulse front tilt. Here we present a method for controlling the pulse front tilt to reliably steer the electron beam to a desired angle. The control is shown to also extend to the generated x-ray radiation. The scheme could be used to stabilize the electron pointing over time, or for agile scanning of the electron beam without changing the optical axis.

Primary author: LÖFQUIST, Erik (Lund University, Sweden)

Co-authors: GUSTAFSSON, Cornelia (Lund University); ANGELLA, Andrea (Lund University); Dr PERSSON, Anders (Lund University, Sweden); WAHLSTRÖM, Claes-Göran (Lund University); LUNDH, Olle (Lund University)

Presenter: LÖFQUIST, Erik (Lund University, Sweden)

Session Classification: Poster Session & Industry Display

Contribution ID: **38** Type: **Poster**

The New OPCPA Laser at Lund High Power Laser Facility and LWFA Applications

The 31 year successful story of the old Terawatt laser at Lund University finally came to an end last year, when the laser was retired to make way for the new laser system. Manufactured by the Lithuanian company "Light Conversion", the new laser offers a 9 fs, 800 nm, CEP stable beam. The laser is split into 2 arms capable of delivering 250 mJ pulses at 10 Hz and 50 mJ pulses at 100 Hz. My poster will focus on the upgraded 10 Hz beamline, which is used to perform LWFA experiments. The stretched pulse from the laser room is compressed using an array of 16 broadband chirped mirrors which add a positive group delay dispersion of 800 fs^2, allowing the laser to reach its Fourier-limited pulse duration of 9 fs. The beam's wavefront aberrations are corrected with a deformable mirror and the beam is telescoped down to allow it to be steered with 4" optics. The pulse is transferred to an interaction chamber, where it is focused with an off-axis parabola into the exhaust of a supersonic gas jet. The tail of the pulse has sufficient intensity to ionize the gas (usually a mixture of helium and nitrogen in a 99:1 ratio), so that the center of the pulse meets the gas in its plasma phase. The extremely high intensity of the order of 10^{19} W/cm^2 in the focus pushes the electrons of the plasma out of its path, whereas the heavier ions are relatively unaffected. This creates a plasma channel comprised of a series of bubbles where electrons have been ejected out of. If electrons are somehow injected into these bubbles, they can be accelerated to relativistic velocities thanks to the extremely high field gradients of the order of several hundreds of GV/m which are supported by the plasma, reaching energies in the order of hundreds of MeV across just few mm. Future plans of the beamline include combining LWFA with attosecond pulses which are generated in the other 100 Hz beamline.

Primary author: ANGELLA, Andrea

Presenter: ANGELLA, Andrea

Session Classification: Poster Session & Industry Display

Contribution ID: **39** Type: **Poster**

X-Band Low Level Radio Frequency System Development

EuPRAXIA stands for "European Plasma Research Accelerator with eXcellence In Applications". It's a collaborative project aimed at developing a compact, cost-effective particle accelerator based on plasma technology. This initiative involves researchers and institutions across Europe working together to advance the field of accelerator science. EuPRAXIA aims to produce a new generation of accelerators with potential applications in various fields, including medicine, industry, and fundamental research in physics. LLRF stands for Low-Level Radio Frequency. It's a system used in particle accelerators to stabilize and control the radiofrequency fields used to accelerate charged particles, ensuring precise energy levels and beam stability. The goal of this project is the development of a prototype for an X-band LLRF system, tailored to address the challenging requirements of the EuPRAXIA@SPARC_LAB application. Once confirmed on a real testbench, the prototype will be used as a starting point for the industrialization into a commercial instrument. This poster will present the Conceptual Block diagram of the LLRF prototype.

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Co-author: Mr BARIČEVIČ, Borut (Instrumentation Technologies)

Presenter: MERUGA, Phani Deep (Instrumentation Technologies)

Session Classification: Poster Session & Industry Display

Contribution ID: **40** Type: **Poster**

Optimisation of Inverse Compton Scattering via spatiotemporal tailoring of scattering pulse

All-optical High-energy X-ray (HEX) beam sources based on Inverse Compton scattering constitute a promising alternative to conventional x-ray sources due to their compactness and tunability. The X-rays are obtained through collision between a laser and relativistic electron beams from laser plasma accelerator. Reaching a low bandwidth of HEX is crucial for practical applications: after minimising the electron beam contributions, the scattering laser pulse will be the dominating factor. By tailoring the scattering pulse and properly matching it with the electron beam, significant reductions in bandwidth, down to a few percent, can be achieved. In this work we aim to obtain, through different approaches to spatio-temporal shaping, a scattering pulse shape that permits the maximisation of both the the interaction length and the overlap of the two beams, ensuring the production of a high number of photons in a narrow bandwidth. Such tailoring enables

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Co-authors: PÕDER, Kristjan (Deutsches Elektronen-Synchrotron DESY); MEISEL, Martin (Deutsches Elektronen-Synchrotron DESY); Dr SHALLOO, Rob (Deutsches Elektronen-Synchrotron DESY)

Presenter: MARIANI, Cristina (Deutsches Elektronen-Synchrotron DESY)

Session Classification: Poster Session & Industry Display

Contribution ID: **41** Type: **Poster**

Using a passive dielectric structure to manipulate FEL beams

Plasma wakefield accelerators have the potential to reduce the size of particle accelerators because of the high accelerating gradients in plasma wakes. However, the finite length of bunches combined with the short wavelength of plasma wakes can give output beams with non-negligible energy spread that can negatively impact FEL performance. SwissFEL routinely operates a passive dielectric structure to perform beam manipulations that modify the FEL bandwidth and produce sub-femtosecond X-ray pulses. In this poster we present experimental observations and accompanying simulations that show the short-range wakefields in the SwissFEL passive dielectric structure can be used to modify the energy spread of the beam. We also show long-range wakefields produced in the passive structure can accelerate the SwissFEL beam.

Primary author: ERICSON, Evan (PSI/EPFL)

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Presenter: ERICSON, Evan (PSI/EPFL)

Session Classification: Poster Session & Industry Display

Contribution ID: **42** Type: **Poster**

Research on Ultra-short Bunch Length Measurements with Femtosecond Resolution for EuPRAXIA

While plasma-based concepts and experiments offer increasingly high acceleration gradients with every new advancement, there is a growing need to develop and implement suitable beam diagnostics. Longitudinal diagnostics are significantly challenging when the bunch length is in the few femtoseconds scale, which is the case for ultra-short electron bunches produced on Plasma Wakefield Accelerators.

Previous research has found that coherent radiation emitted by the beam in different conditions depends on bunch length. More specifically, at the University of Liverpool, a THz-based imaging system has already been developed to image the source distribution of coherent transition and diffraction radiation, for which theory and simulations have already shown their dependence on bunch length.

This research project focuses on using broadband imaging of coherent radiation to develop a bunch-length monitor with femtosecond resolution, which will also be integrated into a virtual diagnostics suite for EuPRAXIA that works online on a non-invasive and single-shot basis.

Until now, the research activities have been focused on studying the use of coherent radiation for bunch-length measurements, reviewing cases of implementation of virtual diagnostics for several accelerator experiments around the globe, and training in machine learning tools.

The research activities are now ready to focus on (a) identifying the specific EuPRAXIA parameters and requirements for the monitor's design and optimization in close collaboration with the company D-Beam and (b) planning a future secondment for testing and integration at INFN.

Primary author: GUISAO BETANCUR, Ana Maria (University of Liverpool)

Co-authors: WOLFENDEN, Joseph (University of Liverpool); WELSCH, Carsten Peter

Presenter: GUISAO BETANCUR, Ana Maria (University of Liverpool)

Contribution ID: **43** Type: **Poster**

Investegation of Laser wakefield acceleration through numerical modeling

Laser Wakefield Accelerators (LWFA) introduce a novel mechanism [1] for generating high-energy electron beams. Laser plasma interaction in an under dense gas generates plasma waves with accelerating fields orders of magnitude greater than the ones supported by radiofrequency cavities in conventional accelerators.
Further research is required to generate a more charged electron bunches with low energy spread, and low emittance suited for a variety of applications like the radiation therapy [2], free electron lasers, and future compact colliders.
Numerical modeling is a powerful method to analyze and design the optimum laser and plasma parameters for LWFA experiments. A brief overview of fluid and kinetic LWFA description models and numerical SMILEI simulations for future LWFA experiments by the ITFIP team (LPGP) is presented.

Primary author: MASCKALA, Mohamad

Co-authors: Mrs CROS, Brigitte (Université Paris-Saclay, CNRS); Mr MASSIMO, Francesco (CNRS, Université Paris-Saclay)

Presenter: MASCKALA, Mohamad

Session Classification: Poster Session & Industry Display

Contribution ID: **44** Type: **Poster**

A novel optical fibre analysis system for particle accelerators

Development of an optical fibre-based beam loss monitor (oBLM) is in progress at the Cockcroft Institute (CI), UK. It utilises the Cherenkov radiation (CR) emitted in optical fibres by relativistic particle showers generated in beam loss or RF breakdown events. Emitted CR is channelled along the fibres to photomultiplier detectors, and a time-of-flight method is used to calculate the beam loss/RF breakdown location from the CR arrival time. The oBLM system has previously been shown to reliably detect both types of events, and work has currently focused on a detector upgrade to improve the signal-to-noise ratio and position resolution. The main application of this detector to EuPRAXIA would likely be within the BLM systems, which could allow for measurements of the beam loss background near sensitive beam diagnostic elements such as spectrometers. This contribution presents a summary of the recent developments on the oBLM project and invites further discussion on its potential use cases in EuPRAXIA.

Primary author: JONES, Angus (University of Liverpool)

Co-authors: WOLFENDEN, Joseph (University of Liverpool); ZHANG, Hao (University of Liverpool / Cockcroft Institute); WELSCH, Carsten Peter

Presenter: JONES, Angus (University of Liverpool)

Session Classification: Poster Session & Industry Display

Contribution ID: **45** Type: **Poster**

A dielectric THz-driven Acceleration setup using a metallic waveguide: Simulations and experiment.

It would be hard to picture our world without all the benefits particle accelerators provide humanity. Science, industry, and the medical community extensively utilize accelerators for their applications. As the demand for more powerful accelerators increased in the last decades, their size and cost also increased considerably. The particle accelerator scientific community is looking for more affordable, efficient accelerators that could help break the size and limited injected power of nowadays accelerators. Dielectric Laser-driven Accelerators (DLA) are potential candidates for overcoming the issues above. While using optical lasers instead of radiofrequency waves reduces the size of the accelerating structure and offers more significant accelerating gradients, it comes with some challenges in practice. Thanks to the advance of terahertz lasers in the last decades, employing THz pulses instead of IR frequencies helps to overcome some of the issues faced by structure-based optical laser accelerators. The tenfold to hundredfold increase in the operational wavelength softens the restrictions on the bunch parameters, and the accelerator performance is less prone to decrease due to fabrication imperfections.

This work presents a simple setup for electron acceleration combining a multi-cycle terahertz pulse, a metallic waveguide, and a grating Dielectric THz-driven Accelerator (DTA). The multi-cycle terahertz pulse has been generated by quasi-phase-matching in periodically-poled Lithium Niobate (ppLN). It consists of 12 layers alternating their optical axis in an up-down periodic fashion. A 6-cycle terahertz pulse is obtained from optically pumping the crystal. The power accepted by the accelerating structure is a key figure of merit of any accelerator. Therefore, the waveguide structural parameters have been optimized through simulations to maximize the electric field intended for acceleration. The exiting THz electric field after the waveguide was measured with different foci inside the waveguide with reflective EOS technique. Once the waveguide coupling efficiency has been optimized for this setup, investigation and optimization of dual-grating geometry accelerator parameters are followed. Electron acceleration with the above setup was shown in simulations. The structure performance could be further improved using high-intensity terahertz generation techniques.

Primary author: LEIVA GENRE, Andrés

Co-authors: NASI, Luis (University of Pécs); Mr KISS, Mátyás (University of Pécs); Dr TIBAI, Zoltán (University of Pécs); Prof. ALMÁSI, Gábor (HUN-RUN-PTE High Field Terahertz Research Group); HEBLING, János (Physics Institute, University of Pécs); TURNÁR, Szabolcs (University of Pécs)

Presenter: LEIVA GENRE, Andrés

Session Classification: Poster Session & Industry Display

Contribution ID: **46** Type: **Poster**

Analysis of electron beam parameters and comparative study of electron beam capture for the Laser-Plasma-Accelerator-based EUV-FEL

The LINAC-based Free Electron Lasers, which is known as the fourth generation of synchrotron radiation sources, provide an intense source of brilliant X-ray beams for the worldwide user community to investigate matter at the atomic scale with unprecedented time resolution. In the frame of this presentation, we explore the development of a novel compact LASER-PLASMA-Accelerator (LPA)-based Free-Electron laser (FEL) operating in the extreme ultraviolet (EUV) range of the radiation spectrum. However, achieving the desired electron beam parameters within a single-unit Swiss-FEL type undulator (as a commercially available option) presents a significant challenge.
The presentation will cover the essential requirements of the LPA-based electron beam parameters for the LPA-based FEL and various options for capturing electron beams from a compact laser-plasma accelerator to reach the saturation of the FEL power. The focus will be on minimizing the dilution of the normalized transverse RMS emittance, which is a critical parameter for high-quality FEL radiation. By addressing these challenges, this research aims to pave the way for a compact and powerful EUV light source utilizing laser-plasma accelerator technology.

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X-ray radiation source characterization within the EuAPS project.

Plasma Wakefield Acceleration is a widely adopted technique able to increase the accelerating gradient and overcome the electrical breakdown phenomena, occurring in metallic structures, while reducing the size and the cost of conventional Radio-Frequency (RF) accelerators.

Plasma-based accelerators are capable of intrinsically generating betatron radiation emitted by accelerated electrons. This radiation is ultra-short (fs-range), spatially coherent, and its emission spectrum ranges from soft/hard X-ray up to gamma rays.
It can be adopted in a wide range of scientific areas for several user-oriented applications, including high-energy physics, materials science, medical and biological applications.

In this contribution, we will show the betatron source characterization. Two dedicated experimental campaigns, within the EuAPS project (EuPRAXIA Advanced Photon Source), were carried out at the INFN laboratory in Frascati and at the CLPU laboratory in Salamanca, with the aim of completely characterizing the radiation source and the laser-plasma acceleration process.

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GAS JET BASED ONLINE BEAM MONITORING FOR ADVANCED PROTON THERAPY FACILITIES

Abstract: Proton therapy holds great promise in cancer treatment due to its precise dose conformity and minimal impact on organs at risk (OARs). However, quality assurance remains a challenge amidst the increasing global adoption of proton therapy facilities. Emerging accelerators like LhARA, which deliver high dose rates for the innovative FLASH treatment modality, demand new diagnostic methodologies. Established techniques like SEM Grid and Ionization chambers, despite offering high resolution and reliability, respectively, at conventional dose rates fails maintain it in FLASH regime. Most of the instruments can perturb the beam and lack real-time feedback, posing substantial challenges for quality assurance, especially in FLASH therapy.

This study introduces the gas jet monitor as a non-invasive solution that leverages the ionization and emission from the interaction between the gas curtain and the beam to measure beam profile without disturbing it. The gas jet monitor, equipped with a fast-response detection system requiring less integration time, enables online monitoring and reduces pre-clinical calibration time, thereby enhancing treatment efficacy. To optimize its application for proton beam dosimetry, parameters such as sensitivity to detect single bunch ions and jet density need optimization along with experimental validation. The gas jet monitor presents a promising solution to overcome the limitations of conventional diagnostic techniques, paving the way for advancements in novel treatment facilities using FLASH therapy.

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Contribution ID: **49** Type: **Poster**

Multicycle THz pulse generation enhancement by Gires-Tournois etalons

The use of high-energy multi-cycle THz pulses is increasingly important in fields such as imaging, spectroscopy, and particularly particle acceleration [1]. Optical rectification in periodically poled lithium niobate is a method for generating such pulses [2]. Instead of utilizing a periodically poled crystal, it is feasible to pump a wafer stack where the z-axis of consecutive wafers points in opposite directions. The size of the wafers can be significantly larger than that of the periodically poled crystals, which allows for the use of much higher pump energies and also results in greater generated THz energy. Although pumping the resulting wafer stack structure with a single pulse [3] has been demonstrated, to the best of our knowledge, the employment of the output from a Gires-Tournois etalon to create a multi-pulse pump has been explored only with tilted-pulse-front THz source [4].
In a Gires-Tournois etalon –wafer-stack system the thickness of the etalon has to be selected so that the delay between two consecutive reflections matches the inverse of the THz frequency: $d = c/(2n_g)$. To achieve the same intensity for the first two output pulses, the reflectivity of the etalon is adjusted to approximately 38%. According to numerical calculations, under identical pumping pulse intensities, using a GT etalon leads to almost twice higher peak electric fields.

In our experiments, two wafer stacks, consisting of layers having different thickness, have been assembled using commercially available x-cut lithium niobate wafers with anti-reflection coating on both sides. The wafers were pumped by a laser with a central wavelength of 1030 nm, pulse duration of 175 fs, and pulse energy of 1 mJ. The efficiency of THz generation and the obtained waveforms and spectra were characterized using electro-optical sampling. Measurements involving the use of Gires-Tournois etalons in the pump are ongoing, with completion planned by the end of March 2024. The results and discussions will be presented on the poster.

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Towards acceleration of high-quality electron beams: Manipulation and characterization of ultra-short laser pulses

Abstract: The state-of-art generation of high-intensity laser pulses enables the construction of a particle accelerator with accelerating gradients on the order of hundreds of GV/m. Through laser-plasma interaction and the charge dynamics within the resultant plasma wave structure, high-amplitude accelerating and focusing electric fields are formed [1]. These enable electron beams to be accelerated to relativistic energies. In order to establish a solid infrastructure for commercial applications of such an acceleration method, the generation of high-quality electron bunches is essential. One of the reasons for the deteriorated quality of the electron beam is the quality of the interacting laser pulse itself, which can generally be affected by dispersive and nonlinear effects that occur in refractive optics. For this reason, Off-Axis Parabolic (OAP) mirrors have become vital in many high-power laser facilities. One of them is the Intense Laser Irradiation Laboratory at CNR-INO in Pisa, Italy, with peak power up to 220 TW generating <25 fs laser pulses of energy >5 J [2]. Their frequent use is caused by their achromaticity and the possibility of attaining extremely high intensity, as they do not exhibit the inherent Fresnel losses or absorption of the bulk material. However, when dealing with ultra-short and ultra-intense laser pulses, knowledge of the temporal and spatial structure of the electric fields in the focal region of OAPs is fundamental. Furthermore, a broad spectrum of fs-laser pulses should also be considered. Therefore, a preliminary study on the spatial and temporal profiles of non-monochromatic laser pulses based on the full Stratton-Chu vector diffraction theory [3,4] is presented.

Keywords: Laser Wakefield Acceleration, Off-axis parabolic mirrors, Full Stratton–Chu vector diffraction theory, Non-monochromatic laser pulse

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The current status of the compact proton accelerator at KAHVE-Lab

The linear accelerator system of the Proton Testbeam at the Kandilli campus (known as the PTAK project) at Boğaziçi University is focused on constructing an experimental setup for Proton-Induced X-ray Emission (PIXE) analysis, aimed at elemental analysis of historical artifacts. A microwave ion source and a low-energy beam transfer (LEBT) section have already been built. Additionally, an 800 MHz Radio Frequency Quadrupole (RFQ) has been designed to accelerate the proton beam to 2 MeV energy within a distance shorter than one meter in KAHVE-Lab, Turkey. Furthermore, a prototype module of the four-vane RFQ has been produced and subjected to mechanical, vacuum, and electromagnetic tests to adjust pressure, EM field, and frequency parameters to the desired operational settings. This study introduces a general framework regarding the current status of the PTAK project and discusses ongoing commissioning studies.

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