# AKBP 4: New Accelerator Concepts and Hadron Accelerators

Time: Tuesday 16:30–18:30 Location: AKBPa

AKBP 4.1 Tue 16:30 AKBPa

**Miniature transport-line design and experimental investigations of the superconducting transverse gradient undulator source for laser plasma accelerator-driven FELs** — •Samira Fatehi[1], Maisui Ning[1], Kantaphon Damminsek[1], Axel Bernhard[1], and Anke-Susanne Müller[1,2] — [1]LAS, KIT, Karlsruhe — [2]IBPT, KIT, Karlsruhe

Laser-plasma acceleration is an outstanding candidate to drive the next-generation compact light sources and FELs. Having orders of magnitude larger electrical field gradients than RF cavities-based machines makes them more compact. To compensate large chromatic effects, beam divergence and energy spread, using novel compact beam optic elements in the beam transport line as well as a transverse-gradient undulator (TGU) has been considered. We aim to design miniaturized, high strength, normal conducting and superconducting magnets for the transport line planned to be experimentally tested and employed at the JETI laser facility in Jena, along with the experimental efforts for investigating and modifying the TGU as the final light source. In this contribution we present an overview over the project and its current status.

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AKBP 4.2 Tue 16:45 AKBPa

**Bayesian optimization of a laser-plasma accelerator** — •Soeren Jalas[1], Manuel Kirchen[1], Laurids Jeppe[1], and Andreas R. Maier[2] — [1]Center for Free-Electron Laser Science and Department of Physics Universität Hamburg — [2]Deutsches Elektronen Synchrotron (DESY)

Generating high-quality laser-plasma accelerated electron beams requires carefully balancing a plethora of physical effects and is therefore challenging * both conceptually and in experiments. Here, we use Bayesian optimization of key laser and plasma parameters to flatten the longitudinal phase space of an ionization-injected electron bunch via optimal beam loading. We first study the concept with particle-in-cell simulations and then demonstrate it in experiments. Starting from an arbitrary set-point the plasma accelerator autonomously tunes the beam energy spread to the sub-percent level at 254 MeV and 4.7 pC/MeV spectral density. Finally, we study a robust regime, which improves the stability of the laser-plasma accelerator and delivers sub-5-percent rms energy spread beams for 90% of all shots.

AKBP 4.3 Tue 17:00 AKBPa

**FLASHForward X-1: Injection dynamics of high brightness beams from a plasma cathode** — •Lewis Boulton[1,2,3] and Jonathan Wood[1] for the FLASHForward-Collaboration — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]SUPA, Department of Physics, University of Strathclyde, Glasgow, UK — [3]The Cockcroft Institute, Daresbury, UK

Plasma-wakefield accelerators promise to deliver high-energy particle beams over acceleration lengths orders of magnitude smaller than that of their conventional counterparts. However, some injection schemes also have the potential to act as beam-brightness transformers. The X-1 experiment at FLASHForward, DESY Hamburg, focuses on using density-downramp injection of electrons into a beam-driven plasma wake as a means of generating sub-$\mu$m emittance beams. Recent results have shown that the use of an optically-generated spike in the plasma-density profile results in the controlled, stable injection of witness beams with charges up to 105 pC, accelerated in an effective electric field of 2.5 GV/m. Further work explores via simulations the key parameters that influence the quality of the injected beams, shedding light on the underlying physics whilst also informing the next round of planned experiments.

AKBP 4.4 Tue 17:15 AKBPa

**Beamline Design Studies for a Laser-Plasma Driven FEL** — •Lars Hübner[1,2], Cora Braun[1,2], Julian Dirkwinkel[1], Timo Eichner[2], Thomas Hülsenbusch[1,2], Sören Jalas[2], Laurids Jeppe[2], Manuel Kirchen[2], Philipp Messner[1], Guido Palmer[1], Matthias Schnepp[2], Maximilian Trunk[2], P. Andreas Walker[1], Paul Winkler[1], Christian Werle[1], and Andreas R. Maier[1,2] — [1]Deutsches Elektronen Synchrotron (DESY) — [2]Center for Free-Electron Laser Science and Department of Physics, Universität Hamburg

Laser-plasma accelerators are promising candidates to drive compact, laboratory-scale free-electron lasers. However, the unique properties of plasma accelerated electron beams present a challenge to the beam transport and lasing concepts. Here, we present the upgrade of the LUX beamline with the goal of demonstrating FEL gain from a laser-plasma accelerator. The beamline features a chicane to decompress the electron beam and relax the conditions on the initial beam parameters from the plasma target. The concept shows a balancing between the decrease in beam peak current due to the decompression and the manipulation of the phase-space to optimize the slice properties of the beam. The transport to and the focusing scheme into the undulator are presented.

AKBP 4.5 Tue 17:30 AKBPa

**Staging Laser and Plasma Wakefield Accelerators for low emittance electron generation** — •Moritz Foerster for the Hybrid Collaboration-Collaboration — LMU München

Low emittance relativistic electron bunches are of crucial importance for the generation of high brilliance x-ray light. This light is needed in medical imaging to achieve the best trade-off between image quality, acceptable radiation dose, compactness and affordable coasts. However, there is little technology available to bridge the regime between conventional x-ray tubes and large-scale synchrotrons/free electron lasers.

Plasma Wakefield Acceleration (PWFA) can generate low emittance electrons. However, PWFA typically requires large scale particle accelerators like linacs or synchrotron machines to generate the particle driver. Laser Wakefield Acceleration (LWFA) on the other hand is widely available in many university scale labs but often suffers from higher emittance of the electron bunches created.

Here we describe a novel approach using a staged laser driven electron accelerator to produce the low emittance electrons needed. Nanocoulomb class electron bunches at a few hundred MeV energy are produced via LWFA. Thereafter those electrons drive a second PWFA stage a few millimetres downstream.

First experimental results show injection and acceleration in the second stage. These first proof of principle results pave the way to actual emittance optimisation necessary for making the source interesting for actual applications.

AKBP 4.6 Tue 17:45 AKBPa

**Commissioning of the laser-driven ion acceleration beamline at the Centre for Advanced Laser Applications** — •Jens Hartmann, Thomas Rösch, Luisa Tischendorf, Leonard Doyle, Lotta Flaig, Marc Berndl, Felix Balling, Sonja Gerlach, and Jörg Schreiber — Department of Medical Physics, Faculty of Physics at the Ludwig-Maximilians-Universtität München

The Centre for Advanced Laser Applications (CALA) in Garching near Munich features the ATLAS-3000 laser system, which can deliver up to 3 PW within a pulse duration of 20 fs. It is the driver for the Laser-driven ION (LION) beamline, which aims to accelerate protons and carbon ions for applications. A 20 degrees off-axis parabolic mirror with a focal length of 1.5 m focusses the 28 cm diameter laser-beam down to a micrometre-sized spot, where a vacuum-compatible wave-front sensor is used for a deformable mirror feedback loop focus optimization. Commissioning started mid 2019 with regular proton acceleration using nm-thin plastic foils as targets. The amount of light traveling backwards from the experiment into the laser is constantly monitored and currently limits safe operation to 5 J on target. Protons with a kinetic energy of 12 MeV are stably accelerated with the given laser parameters and are suitable for transport with permanent magnet quadrupoles towards our application platform 1.8 m downstream of the source. We have performed parameter scans varying target thicknesses and laser-pulse shape to optimize for highest and most stable proton numbers at 12 MeV kinetic energy, and investigated shot-to-shot particle number stability for the best parameters.

AKBP 4.7 Tue 18:00 AKBPa

**Laser Wakefield Acceleration to GeV Energies** — •Katinka v. Grafenstein for the Non-perturbative Pair Production-Collaboration

— Ludwig-Maximilians-Universität München, Am Coulombwall 1, 85748 Garching, Germany

For the creation of matter-antimatter pairs from the quantum vacuum via the Breit-Wheeler mechanism, energetic $\gamma$-rays and an intense laser need to interact with each other. The Breit-Wheeler experiment in the perturbative regime has been accomplished at the Stanford Linear Accelerator Center in 1997 but was never implemented in the non-perturbative regime. At the moment, this experiment is in preparation in a fully laser-driven set-up using Laser Wakefield Acceleration (LWFA) with the ATLAS3000 laser in Garching. In the experiment an initial high energy electron beam will be sent onto a Bremsstrahlung converter to generate $\gamma$-rays that are to interact with the intense laser. For this, an electron beam with multi-Gev energies is needed. Using LWFA, electron energies of the order of few hundred MeV are nowadays commonly reached. Reaching multi-GeV energies on the other hand still holds many challenges, even though it has been accomplished. Especially, the careful design of gas targets, such as gas jets and gas cells, is essential. These have to provide homogeneous gas densities over a distance of a few centimetres. In preparation for the Breit-Wheeler experiment in Garching, Computational Fluid Dynamic simulations were conducted to design and build such gas nozzles. Their gas flow was tested using a Mach-Zehnder interferometer and first LWFA experiments using these nozzles are to be conducted soon.

AKBP 4.8 Tue 18:15 AKBPa

**Construction and first beam tests of a novel focalisation system for novel medical radioisotope production** — •Philipp Daniel Häffner — Universität Bern, Sidlerstrasse 5, 3012 Bern

Radioisotopes are fundamental in modern medicine. A research program focused on the production of novel medical radionuclides is ongoing at the Laboratory for High Energy Physics of the University of Bern. Cross sections are measured and novel production routes explored using the 18 MeV PET proton cyclotron located at the Bern University Hospital. The production is carried out by irradiating a 6 mm diameter pellet embedded in a specific capsule developed by our group that can be inserted in a commercial solid target station. This talk reviews the development and first beam tests of a compact irradiation system consisting of a set of electromagnets, a beam profile detector and a specific feedback software. We proved that the system is able to focus a flat beam down to the size matching the pellet surface. The expected increase in the production yield was observed. The system is also able to detect and correct possible deviations in the beam position and shape that may occur during irradiation. This was tested by inducing external perturbations and by verifying that the system restores the good beam parameters. Being about 1 m long, this system can be installed and operated in any medical cyclotron facility.