HK 18: Instrumentation IV

Time: Tuesday 16:15–18:15 Location: PHIL B 302

HK 18.1 Tue 16:15 PHIL B 302

The LowRAD project: achieving ultra-Low background for the future liquid xenon experiments — •Ying-Ting Lin, Christian Weinheimer, Volker Hannen, Christian Huhmann, Lutz Althüser, Daniel Wenz, Robert Braun, David Koke, Philipp Schulte, and Patrick Unkhoff — Universität Münster, Institut für Kernphysik

Liquid xenon (LXe) has become a cornerstone medium for rare event detection, including searches for dark matter and neutrino physics. To achieve an order of magnitude improvement in sensitivity for the next generation LXe experiment such as XLZD, the requirement of having ultra-low background must be satisfied, as even a trace amount of radioactive impurity can impact the sensitivity of the detector. The LowRAD project aims to establish the guidelines for the construction of cryogenic distillation systems capable of reducing the concentrations of the most critical radioactive impurities, 222Rn and 85Kr, to unprecedented levels. Demonstrators are actively under construction with their performance systematically evaluated. This talk will present the working principles and design choices of each system, including a multi-column configuration that maximizes xenon recovery and a novel heat pump dedicated to LXe distillation. Furthermore, online diagnostic systems are planned to enable continuous monitoring of, crucially, the level of background reduction. The emphasis will be placed not only on the performance, but also on the integrative design philosophy that ensures scalability and long-term operation.

Supported by the ERC Advanced Grant "LowRad" (101055063).

HK 18.2 Tue 16:30 PHIL B 302

Measuring the nuclear spin polarization of a pulsed H^- ion source — •Simon Jakob Pütz[1,2,4], Tarek El-Kordy[5], Ralf Engels[2], Nicolas Faatz[1,2,6], Ralf Gebel[1], Kirill Grigoryev[1], Chrysovalantis Kannis[3], Yury Valdau[1], Jan Wirtz[1], and Yury Litvinov[1] — [1]GSI, Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt — [2]Institut für Kernphysik, Forschungszentrum Jülich, Wilhelm-Johnen-Straße, 52428 Jülich — [3]Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf — [4]Institut für Kernphysik, Universität zu Köln, Zülpicherstraße 77, 50937 Köln — [5]FH Aachen, University of Applied Sciences, Bayernallee 11, 52066 Aachen — [6]RWTH Aachen, Otto-Blumenthal-Straße 19, 52074 Aachen

At the Forschungszentrum Jülich, the COSY accelerator was fed with polarized H^- / D^- ions for stripping injection into the ring. For polarized beamtimes, knowing the initial polarization directly behind the source is essential before conducting experiments. An automated and reliable data acquisition system was developed to improve the time and energy effieciency of the process. For this purpose, the applicability of the Lamb-shift polarimeter was expanded to include pulsed H^- and D^- ion beams. Unlike other methods, the LSP is capable of measuring the nuclear spin polarization of particle beams in the keV energy range. The presented study adresses the optimization of nuclear spin polarimetry for upcoming polarized sources of the COSY type without pre-acceleration.

HK 18.3 Tue 16:45 PHIL B 302

Design of a High-Power Liquid Hydrogen Target for the P2 Experiment at MESA using CFD — Sebastian Baunack[1], Maarten Bonnekamp[2,4], Boris Gläser[1], Shruti Gudla[1], Rahima Krini[1], Frank Maas[1,2,3], Jayanta Naik[1], Moran Neher[1], Tobias Rimke[1], Paul Schöner[2], •Siddharth Thakker[1], and Malte Wilfert[1] for the P2-Collaboration — [1]Institut für Kernphysik, Johannes Gutenberg-Universität Mainz — [2]Helmholtz-Institut Mainz, Johannes Gutenberg-Universität Mainz — [3]PRISMA Cluster of Excellence, Johannes Gutenberg-Universität Mainz — [4]IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette, France

The upcoming P2 experiment at the MESA accelerator in Mainz aims to detect parity-violating asymmetries in elastic electron-proton scattering. It is designed for a determination of the weak mixing angle, $\sin^2\theta_W$, to a high precision of 0.16% at low momentum transfer.
To measure this small asymmetry with high precision, the experiment requires a high-luminosity, 60 cm liquid hydrogen (lH_2) target cell, which is designed using Computational Fluid Dynamics (CFD). The total heat deposited by the electron beam into the target cell materials is estimated to be over 3100 W, with a total loop heat load of 4000 W. The lH2 flowing through the cell is cooled by a heat exchanger coupled to a helium coolant supply. Additionally, a dedicated gas system is being constructed to manage all required operational gases. This talk presents the CFD simulations of the target cell, the design of the target loop and gas system, and an introduction to the P2 experiment itself.

HK 18.4 Tue 17:00 PHIL B 302

Completion of the $\overline{\text{P}}$ANDA cluster-jet target setup — •Hanna Eick, Daniel Bonaventura, Philipp Brand, Liridon Deda, Friederike Rummler, Michael Weide, and Alfons Khoukaz for the PANDA-Collaboration — Institute for Nuclear Physics, University of Münster, Germany

Cluster-jet targets offer a wide range of potential applications, due to their unique windowless and internal design, making them an attractive choice for various experimental settings. A powerful state-of-the-art cluster target source, specifically designed and constructed for the future $\overline{\text{P}}$ANDA experiment at FAIR, has been successfully assembled and integrated with a dedicated target setup at COSY/Jülich. This target system will play a decisive role in the upcoming KOALA experiment at the GSI in Darmstadt over the next years. To optimize its performance, a comprehensive study has been conducted to investigate the target's properties, focusing on vacuum pressure distributions along the target beam line and target jet density at different stagnation conditions. Furthermore, a newly commissioned beam dump, equipped with multiple diagnostic tools, has undergone intensive testing. This presentation highlights the key findings, with particular emphasis on achieving a high target density of up to 10^{15} atoms/cm^2 at the interaction point and > 2.1 m behind the jet nozzle, while maintaining minimal residual pressure background, through careful adjustment of the orifice system within the beam dump. This project has received funding from GSI F&E (MSKHOU2023, MSKHOU2527), NRW Netzwerke (NW21-024-E), BMBF (05P21PMFP1).

HK 18.5 Tue 17:15 PHIL B 302

New nozzle production method and vacuum simulations for the $\overline{\text{P}}$ANDA cluster-jet target — •Michael Weide, Daniel Bonaventura, Philipp Brand, Hanna Eick, Sophia Vestrick, and Alfons Khoukaz for the PANDA-Collaboration — Institut für Kernphysik, Universität Münster, 48149 Münster, Germany

In antiproton-proton annihilation experiments such as the upcoming $\overline{\text{P}}$ANDA experiment at FAIR, internal targets have a key role as they allow the accelerator beam to be utilized for multiple interactions with the target. Initially, this target will be realized by a cluster-jet target (CJT) operated with H_2, that produces clusters of sizes ≤ 20 microns in diameter.

Due to the costly production of antiprotons, a challenge of such an experiment is minimizing background reactions. Thus, good vacuum conditions are mandatory. To predict the vacuum conditions for an experimental setup, a vacuum simulation model is developed and compared with experimental data recorded at a similar experimental setup at COSY (FZ Jülich).

The core piece of a CJT is a copper de-Laval nozzle, for which a new in-house production process is being developed at the Institute of Nuclear Physics at the University of Münster. This allows to perform detailed analysis on the influence of the geometry and shape of the nozzle. The current status as well as beam studies of the new nozzle design are presented.

The research project was supported by BMBF (05P21PMFP1) and NRW Netzwerke (NW21-024-E).

HK 18.6 Tue 17:30 PHIL B 302

The cryogenic windowless jet target for e-p scattering experiments at MAGIX at MESA — •Liridon Deda, Philipp Brand, Jost Froning, and Alfons Khoukaz — Institut für Kernphysik, Universität Münster, 48149 Münster, Germany

MAGIX experiment will provide a versatile physics program, ranging from studies of baryonic matter structure to searches for dark sector particles. By combining the high-intensity, energy-recovering electron beam of MESA with a state-of-the-art windowless jet target, MAGIX aims to perform high-precision e-p scattering experiments without tar-

get background. The MAGIX jet target is designed to be operated with various gases, including hydrogen, helium, and almost all heavier gases. A target thickness of more than 10^{18} atoms/cm^2 is delivered at the interaction point when using hydrogen. Achieving such high target thickness requires a high gas flow rate at cryogenic temperatures, which is then pressed through a de Laval nozzle. The nozzle geometry defines how the target expands, thus numerical simulations of the jet's formation and propagation are necessary to understand and optimize the target performance. In this contribution, the setup, performance, and development of the MAGIX jet target including various simulations for different gases will be presented and discussed. Additionally, the adaptation for the generation of a frozen filament jet structure will be described.

This project has received funding from CRC1660 (project number 514321794).

HK 18.7 Tue 17:45 PHIL B 302

Development and Commissioning of an RFQ Cooler-Buncher for Laser Spectroscopy — •Finn Köhler[1], Julian Palmes[1], Bernhard Maass[2], Kristian König[1], and Wilfried Nörtershäuser[1] — [1]Institut für Kernphysik, TU Darmstadt, Germany — [2]Physics division, Argonne National Laboratory, USA

At rare-isotope beam facilities, radio-frequency-based beam cooler-bunchers (RFQCB) are particularly used to prepare ion beams for high-precision experiments at low energies ($<$ 50 keV). They can accumulate rare beams for up to several seconds, cool them through collisions with a buffer gas, and emit ion bunches with a short time and energy width. This contribution will report on the development of a new, compact RFQCB that produces ion bunches well suited for laser spectroscopy measurements at the Collinear Apparatus for Laser Spectroscopy and Applied Physics (COALA) in Darmstadt. A two level differential pumping scheme allows for a high-pressure region at the entrance of the RFQCB to efficiently capture incoming ions despite its short length. A laser ablation ion source is included at the injection side of the device to give access to a wide variety of ion species. We will report on the first commissioning results at COALA. As a next step, the device will serve as an injector, paving the way for laser-spectroscopy studies of ion bunches separated and extracted directly from a multi-reflection time-of-flight (MR-ToF) mass spectrometer. This project was supported by DFG (Project-ID 279384907 - SFB 1245) and BMFTR (05P24RD8).

HK 18.8 Tue 18:00 PHIL B 302

Characterization of hydrogen clusters using shadowgraphy measurements — •Anna Luna Hannen, Hanna Eick, and Alfons Khoukaz — Institute for Nuclear Physics, University of Münster, Germany

Cluster-jet targets can be used in accelerator beam experiments that require high event rates and precise measurements of the resulting particles, for example the upcoming $\overline{P}$ANDA experiment or MAGIX the experiment.

The properties of a cluster beam and the individual clusters can be studied using e.g. shadowgraphy measurements. The cluster beam is created using a cluster-jet source. The clusters are then illuminated with a short-pulsed laser, allowing the shadow of the clusters to be photographed. Through the analysis of the resulting shadowgraphy images, the size and velocity distributions of the clusters can be determined.

Measurements were taken at the Münster cluster-jet target using shadowgraphy, and size distributions were already measured as a result. Future goals are to refine the measurements and analysis of the shadowgraphy images.

This talk provides an overview of the shadowgraphy experiment and the new developments in the shadowgraphy measurements. This research project was supported by BMBF (05P21PMFP1) and NRW Netzwerke (NW21-024-E).