HK 15: Instrumentation VI

Time: Tuesday 17:00–18:45 Location: SCH/A117

HK 15.1 Tue 17:00 SCH/A117

Decelerating Antiprotons from 100keV to 4keV — •Jonas Fischer for the PUMA-Collaboration — IKP TU Darmstadt

The PUMA collaboration aims at trapping, storing and transporting 10^9 antiprotons in a cryogenic penning trap to perform experiments with radioactive nuclei and investigate the nuclear density at the outermost part of the nucleus itself. To achieve this, antiprotons delivered from the ELENA storage ring at CERN need to be decelerated from 100keV to 4keV in a first step to be able to capture them in the penning trap [1].

To minimise losses in the deceleration process, a Pulsed Drift Tube (PDT) was installed at a beam line connected to the ELENA storage ring (LNE51) at CERN. A vacuum of below 10^{-10} mbar is necessary to avoid the annihilations of the antiprotons with the residual gas. This, and the required high voltage of about 100 kV, impose strict restrains on the design and operation of the pulsed drift tube. In this talk I will introduce the current setup and its mayor design considerations. Furthermore, the first successful tests of the setup with antiprotons will be presented.

[1] Aumann, T., Bartmann, W., Boine-Frankenheim, O. et al. PUMA, antiProton unstable matter annihilation. Eur. Phys. J. A 58, 88 (2022). https://doi.org/10.1140/epja/s10050-022-00713-x

HK 15.2 Tue 17:15 SCH/A117

The PUMA trap setup at ELENA — •Alexander Schmidt for the PUMA-Collaboration — IKP TU Darmstadt

The antiProton Unstable Matter Annihilation (PUMA) experiment at CERN will provide the ratio of protons and neutrons in the nuclear density tail as a new observable to test nuclear structure theories. To determine this ratio, the concept of antiprotonic atoms is used. After capture onto an antiprotonic orbital, the antiproton cascades towards the nucleus and eventually annihilates with a nucleon in the tail of the nuclear density distribution [1].

As there is no facility worldwide which provides both low-energy antiprotons and radioactive ions, PUMA uses a transportable setup which combines a cryogenic Penning trap for the long-term storage of antiprotons after accumulation at the ELENA ring and a detection system for the identification of pions originating from annihilations of antiprotons and ions of interest, which are either provided by the offline ion source of PUMA at ELENA, for experiments with stable nuclei, or the ISOLDE facility at CERN for investigating radioactive nuclei.

The first commissioning of a part of the PUMA beam line is currently performed at the Antimatter factory at CERN. This talk will give an status report of the trap and cryostat development and its foreseen implementation for the upcoming ELENA beam time starting in April 2023.

[1] Aumann T. *et al.*, PUMA, antiProton unstable matter annihilation. Eur. Phys. J. A 58, 88 (2022).

HK 15.3 Tue 17:30 SCH/A117

Recent developments at the sources for ultra-cold neutrons located at the TRIGA research reactor Mainz — •Simon Kaufmann for the tauSPECT-Collaboration — Department of Chemistry, TRIGA site, Johannes Gutenberg University Mainz

Neutrons created by fission inside the TRIGA research reactor have kinetic energies in the range of MeV. When they are moderated in the range below kinetic energies of 350 neV, they are called ultra-cold neutrons (UCNs). Using materials with a larger Fermi potential than the kinetic energies allows to guide and trap these UCNs. This makes UCNs especially attractive for a variety of neutron based experiments.

In order to provide these UCNs, two UCN-sources are currently operated regularly at TRIGA's beam ports C&D. While the source at beam port C is mainly operated in a continuous irradiation mode of the reactor, the one at beam port D is operated in a pulsed mode of the reactor. Both face the challenge of converting the kinetic energy of the neutrons from MeV down to neV with a solid deuterium crystal as the main converter. Their efficiency is strongly influenced by the structure of the crystal. This structure can be influenced by controlled thermal changes in order to increase the conversion efficiency.

This talk will present the latest measurements that were performed at beam port D with the aim to create a controlled thermal change sequence to increase and saturate the moderation efficiency.

HK 15.4 Tue 17:45 SCH/A117

Simulations for the ultra-cold neutron lifetime experiment τSPECT — •Niklas Pfeifer for the tauSPECT-Collaboration — Institut für Physik, Mainz, Deutschland

The τSPECT experiment aims to measure the free neutron lifetime with an uncertainity goal of sub second by storing ultra-cold neutrons in a fully magnetic bottle. To study and understand systematic effects and reduce systematic uncertainties, simulations of neutron trajectories and their parameters during the whole measurement cycle are needed. For this we evaluate and use several software packages that can accurately simulate the trajectories of ultra-cold neutrons, protons, and electrons in complex electromagnetic fields as well as the precession of their spins.

This talk will present how the simulation for the τSPECT experiment is set up, challenges and limits of the simulation software and the latest results of the simulations.

HK 15.5 Tue 18:00 SCH/A117

A nuclear magnetic resonance magnetometer for position verification of a neutron spin-flipper — •Viktoria Ermuth for the tauSPECT-Collaboration — Institut für Physik, Johannes Gutenberg-Universität, Mainz

To measure the free neutron lifetime the τSPECT experiment stores ultracold neutrons fully using magnetic field gradients. By flipping the spin of spin-polarized neutrons and thereby transforming high-field-seeking neutrons, whose magnetic moments are aligned with the field, to the low-field-seeking state, where the magnetic moment is aligned opposite the field, the neutrons are filled into the magnetic trap. For the spin flip to be successful the frequency of the spin flipper has to be the Lamor frequency of the neutron at that point in the magnetic field. Therefore, it is necessary to know the magnetic field at the location of the spin flipper. The magnetic field is measured using a nuclear magnetic resonance (NMR) probe to monitor the stability of the magnetic field and provide a reference for the spin flipper. Although the NMR probe does not sit directly at the spin flipper, conclusions about the field at the spin flipper can be made. Despite of environmental challenges, like cryogenic temperatures in vacuum, it is possible to measure the magnetic field with a high accuracy and a constant offset and temperature dependency.
This talk will show the construction and functionality of such an NMR probe as well as commissioning data.

HK 15.6 Tue 18:15 SCH/A117

n2EDM - production and coating of ultra-cold neutron storage vessel — •Noah Yazdandoost — Department of Chemistry, Johannes Gutenberg-University, Mainz

A non-zero nEDM would break time and parity reversal symmetry and if large enough could explain observations like the matter-antimatter asymmetry of the universe. The standard model of particle physics predicts a neutron electric dipole moment (nEDM) on the order of (10^{-29}-10^{-34}) e·cm. To probe the standard model of particle physics and constrain the parameter space for other theories, a more precise measurement of the nEDM is needed (current upper limit $1.8 \cdot 10^{-26}$ e·cm). The aim of the n2EDM experiment is to measure or exclude an nEDM on the order of 10^{-27} e·cm.

In the n2EDM experiment polarized ultra cold neutrons (UCNs) are stored in a vessel across which a combination of a constant electric and magnetic field is applied along the cylinder axis. The vessel consist of the high voltage and ground electrodes and the insulating ring. The Larmor precession frequency of the neutrons is measured by the Ramsey method of separated oscillatory fields. If a shift in the Larmor precession frequency between parallel and antiparallel field orientation is measured, the nEDM is non-zero. To ensure long storage and long depolarization times of the UCNs which directly influence the sensitivity of the experiment, a special coating of the storage vessel is needed.

This talk gives an overview of the n2EDM experiment and the production and coating process of the insulating rings of the experiment.

HK 15.7 Tue 18:30 SCH/A117

Ion optical simulations for the NEXT solenoid separator —

•Arif Soylu[1], Xiangcheng Chen[1], Julia Even[1], Alexander V. Karpov[2], Vyacheslav Saiko[2], Jan Sáren[3], and Juha Uusitalo[3] — [1]University of Groningen, Groningen, The Netherlands — [2]Dubna, Russia — [3]University of Jyväskylä, Jyväskylä, Finland

The NEXT project aims to study Neutron-rich, EXotic heavy nuclei produced in multi-nucleon Transfer reactions[1]. In order to focus and separate these transfer products from unwanted by-products and unreacted primary beam, a 3T solenoid magnet with an 87-cm wide bore will be used.

A Python code was developed to simulate the trajectories of ions through the magnetic field of the solenoid magnet. The purpose of this simulation is to determine the optimal settings for the solenoid separator in order to achieve the highest transmission yields for the ions of interest and the strongest background suppression.

In my contribution, I will explain the various stages involved in the simulations of the ion trajectories through the magnetic field. I will present the simulation results obtained for selected multinucleon transfer products that are of interest for nuclear structure and nuclear astrophysics.

References [1] J. Even et al., Atoms 10 (2022) 59.