HK 4: Instrumentation I

Time: Monday 15:00–16:30 Location: SR Exp1A Chemie

Group Report HK 4.1 Mon 15:00 SR Exp1A Chemie

The MAGIX Experiment at MESA — •Sebastian Stengel for the MAGIX-Collaboration — Institute for Nuclear Physics, Johannes Gutenberg University Mainz, Germany

At the new high-intensity, low-energy electron accelerator MESA, the multi-purpose MAGIX setup will be used for high-precision scattering experiments including dark sector searches, the study of hadron structure and few-body systems, as well as investigations of reactions relevant to nuclear astrophysics.

The MAGIX experiment features a fully windowless scattering chamber housing an internal gas jet target that can be operated with a variety of different gases, two high-precision magnetic spectrometers, and sophisticated detector systems positioned at the spectrometers' focal planes. This setup, combined with MESA's high-intensity electron beam, allows for an exceptionally clean experimental environment, in which effects like multiple scattering or energy straggling are drastically reduced.

The focal plane detectors include a tracking detector realized by a time projection chamber, and a trigger veto system built from plastic scintillation detectors and passive lead absorbers. Moreover, a recoil detector system based on silicon strip detectors can be installed inside the scattering chamber to detect nuclear recoil particles in addition to the scattered electrons.

The present contribution outlines the physics program at MAGIX and provides an overview on the sophisticated setup of the versatile MAGIX experiment.

HK 4.2 Mon 15:30 SR Exp1A Chemie

Design and Calibration Studies of the DarkMESA Experiment — •Michail Kontogoulas for the MAGIX-Collaboration — Institute for Nuclear Physics, Johannes Gutenberg University Mainz, Germany

An electron beam-dump experiment, called DarkMESA, is currently under construction at the new MESA accelerator facility in Mainz. DarkMESA is designed to detect light dark matter particles, which, in the simplest model, could couple via a hypothetical dark photon γ' to Standard Model matter. Such a dark photon could potentially be produced in the beam-dump of the P2 experiment and subsequently decay into a pair of dark matter particles, $\chi\bar{\chi}$, which scatter off electrons in the DarkMESA calorimeter. The prototype calorimeter Phase A is made up of 25 PbF_2 Cherenkov crystals. The calorimeter is planned to be scaled up to its Phase B which will incorporate a $0.7\,m^3$ active volume of both PbF_2 and lead glass SF5 blocks. Layers of active and passive shielding will surround the detector to minimize cosmic and beam-related backgrounds.

This contribution will focus on the development of the DarkMESA prototype and the calibration of its individual detectors, which was conducted during the MAMI beam time. The calibrated prototype was then used to measure cosmic radiation to determine its efficiency. A brief outlook of this experiment's future plans will highlight its ongoing development, wherein different types of scintillator crystal as well as liquid scintillators are currently being studied with the purpose of being implemented in DarkMESA's design.

HK 4.3 Mon 15:45 SR Exp1A Chemie

Design Overview of the Segmented Scintillation Detector "*RUBIK*" for Space Radiation Monitoring — •Roman Bergert, Hans-Georg Zaunick, and Kai-Thomas Brinkmann — Institute of Experimental Physics II, Justus Liebig University Giessen

A segmented particle tracking detector for space applications, named *RUBIK*, will be presented. The detector utilizes 125 individual PVT-based scintillator cubes (1 x 1 x 1 cm^3) as the sensitive volume, providing compactness and high efficiency. This scintillation detector array is based on custom-developed front-end readout electronics, utilizing commercial off-the-shelf components, and is specifically designed to meet the stringent power consumption, size, weight and environmental requirements of the ROMEO space mission by the Institute of Space Systems at the University of Stuttgart.

The primary objective of *RUBIK* is to measure fluences and dose rates of charged particles with energies above 100 MeV, while determining their momentum vectors and providing precise event timing. This functionality has been tested under proton beam and laboratory conditions.

The overview will cover the current design concept, including signal processing schematics, as well as the mechanical and electronic layout. The performance of the detector will be evaluated in the context of mission-specific parameters, with a focus on hardware capabilities and the ability of the readout electronics to meet the required performance thresholds.

HK 4.4 Mon 16:00 SR Exp1A Chemie

Cluster-jet target developments for the KOALA experiment — •Hanna Eick and Alfons Khoukaz for the PANDA-Collaboration — Institute for Nuclear Physics, University of Münster

Cluster-jet targets are developed, designed and built at the University of Münster. These unique targets offer a wide range of possible applications ranging from hadron physics to plasma physics experiments. They are characterized by an internal, windowless operation in which densities of up to $2 \cdot 10^{15}$ atoms/cm^2 more than 2 meters away from their origin can be reached.

A future experiment which will be running complimentary to the $\overline{\text{P}}$ANDA experiment at the High Energy Storage Ring (HESR) at the Facility for Antiproton and Ion Research (FAIR) is the KOALA experiment. It has the task to measure the cross section of the antiproton-proton elastic scattering to be able to determine the luminosity of the accelerator beam and the cluster target which is essential for the analysis of the data collected at $\overline{\text{P}}$ANDA.

To ensure the knowledge of the integrated luminosity with an accuracy better than 3 %, a new cluster-jet target is designed in the framework of the KOALA experiment to fulfill all requirements with regard to the target density, thickness and vacuum conditions at the interaction point with the accelerator beam.

The considerations and developments of the design ideas as well as vacuum simulations are explained and presented.

This project has received funding from NRW Netzwerke (NW21-024-E).

HK 4.5 Mon 16:15 SR Exp1A Chemie

Quasi-real-time range monitoring using positron-emitting therapy beams — •Sivaji Purushothaman for the Super-FRS Experiment-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH

Therapeutic ion beams of positron emitters enable advanced cancer treatments by combining precise dose delivery with quasi-real-time range monitoring. Accurate range determination is critical to enhance treatment efficacy and protect healthy tissue. An experimental study at the FRS fragment separator of GSI Helmholtzzentrum investigated positron annihilation activity profiles during the implantation of positron-emitting oxygen and carbon beams into a PMMA phantom. This study compares ^{10}C, ^{11}C, ^{14}O, and ^{15}O isotopes for quasi-real-time range monitoring. A figure of merit was developed to assess the trade-offs between half-life, beam intensity, and measurement time. Shorter half-lives allow fewer implanted ions for accurate peak determination (e.g., ^{10}C vs. ^{11}C), but lower production cross-sections complicate their use. With a cross-section similar to ^{11}C but a 10-fold shorter half-life, ^{15}O offers quicker, more precise peak localisation with fewer ions. The study also highlights the effectiveness of in-flight production for generating therapeutic-quality ion beams.