HK 8: Instrumentation I

Time: Monday 16:15–18:15 Location: PHIL A 301

Group Report HK 8.1 Mon 16:15 PHIL A 301

Status report on the CBM-TRD — •Dennis Spicker for the CBM-Collaboration — Institut für Kernphysik, Goethe-Uni, Max von Laue Str. 1, 60438, Frankfurt am Main

At the Facility for Antiproton and Ion Research (FAIR), the Compressed Baryonic Matter experiment (CBM) is designed to measure particles resulting from heavy-ion collisions at exceedingly high interaction rates. The Transition Radiation Detector (TRD), a subsystem of the CBM experiment, will comprise four layers of Multi-Wire-Proportional-Chambers (MWPC), each equipped with a foam radiator enabling the generation of transition radiation. The principal objective of the TRD is to distinguish between electrons and pions, to augment the light nuclei identification, and to provide tracking information.

This report gives an overview of the current status of the TRD project. Series production of detector modules is commencing. Various quality assurance procedures have been developed for use during series production and on finished detector modules. A new software framework is intended to facilitate the management of the results of these procedures. Also, an improved version of the readout front-end electronics is currently undergoing testing.

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HK 8.2 Mon 16:45 PHIL A 301

Development of a gas system for the Transition Radiation Detector of the CBM experiment — •Nikolai Podgornov[1,2], James Ritman[1,2,3], and Peter Wintz[3] for the CBM-Collaboration — [1]Ruhr-Universität Bochum — [2]GSI — [3]Forschungszentrum Jülich

The Transition Radiation Detector (TRD) of the Compressed Baryonic Matter (CBM) experiment is essential to identify electrons with a momentum p>1 GeV/c with an efficiency of over 90%. The TRD uses a mixture of the noble gas xenon and the quenching gas CO2. Since xenon is an expensive gas, a critical part of the TRD is its gas system, which must maintain a stable and optimal gas mixture to ensure efficient detection of charged particles and transition radiation. Gas mixture purity is also an important factor. This requires a constant flow for purging of the TRD chambers with precisely controlled overpressure maintained within a range of 0.3 - 0.7 mbar. In addition, the system must be closed and ensure complete xenon recovery and purification. This report discusses the status of a gas system prototype and plans for its upgrade toward the full-size system. This includes reassembling the prototype on a new chassis and conducting subsequent long-term leak-tightness and stability tests. An updated piping and instrumentation diagram will be presented, and the control logic will be discussed in the context of migration to a new Programmable Logic Controller suitable for a full-size system. Additionally, a concept for system monitoring based on the Experimental Physics and Industrial Control System (EPICS) will be presented.

HK 8.3 Mon 17:00 PHIL A 301

Measuring the gas tightness of CBM-TRD wire chambers in Node-RED flows — •Philipp Kähler — Institut für Kernphysik, Universität Münster

The Transition Radiation Detector (TRD) in the CBM experiment at FAIR will provide electron identification, enabling the study of the hot and dense medium created in heavy-ion collisions via the measurement of di-electrons at intermediate masses. Furthermore, the TRD will serve as an intermediate tracking station and, moreover, augments the identification of light nuclei for the hypernuclei programme of CBM.

As gaseous detector using a Xe/CO_2 85:15 gas mixture, the gas loss per detector chamber has to be minimised to not exceed an accepted upper limit of 1 ml/h. To test the corresponding gas tightness is a crucial QA step during serial chamber production for this detector.

In this talk, a new QA test stand for gas tightness assessment based on a direct gas loss measurement is presented. The data acquisition is implemented in *Node-RED* flows on a *Raspberry Pi*-based platform, which includes ADCs of corresponding required precision as well as a high automation level of the measurement routines.

HK 8.4 Mon 17:15 PHIL A 301

Construction of the Cherenkov-Detector for the P2-Experiment — Sebastian Baunack[1], Maarten Boonekamp[4], Boris Gläser[1], Shruti Gudla[1], •Franz Halter[1], Jayanta Naik[1], Rahima Krini[1], Frank Maas[1,2,3], Moran Neher[1], Tobias Rimke[1], Paul Schöner[2], Siddharth Takker[1], and Malte Wilfert[1] for the P2-Collaboration — [1]Institute of Nuclear Physics, Mainz, Germany — [2]Helmholtz-Institut Mainz, Mainz, Germany — [3]PRISMA+ Cluster of Excellence, Mainz, Germany — [4]IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette, France

The P2 experiment at the MESA accelerator facility in Mainz aims at a precise determination of the weak mixing angle $\sin^2\theta_W$. The Weinberg angle will be extracted from parity violating asymmetry in elastic electron-proton scattering at low Q^2. Therefore the measurement verifies a fundamental parameter of the Standard Model and may open a door to new physics with a target relative accuracy of 0.16%.
The key detector element will be a Cherenkov detector ring, in which Cherenkov light is detected by photomultiplier tubes. To ensure an accurate measurement, the detectors must be carefully aligned and shielded.
This talk will present the design challenges, current status, and recent progress of the detector components.

HK 8.5 Mon 17:30 PHIL A 301

Design of a luminosity monitor for the P2 parity violating experiment at MESA — 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] — [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, Universite Paris-Saclay, Gif-sur-Yvette, France

The P2 experiment at the future MESA accelerator in Mainz plans to measure the weak mixing angle $\sin^2(\theta_W)$ in parity violating elastic electron-proton scattering. The aim of the experiment is a very precise measurement of the weak mixing angle with an accuracy of 0.15% at a low four-momentum transfer of $Q^2 = 4.5 \cdot 10^{-3}$ GeV^2. In order to achieve this accuracy, it is necessary to monitor the stability of the electron beam and the liquid hydrogen target. Any helicity correlated fluctuation of the target density leads to false asymmetries.

Therefore, it is planned to install a luminosity monitor in forward direction close to the beam axis. The motivation and challenges for designing an air Cherenkov luminosity monitor will be discussed. Furthermore, I show the current prototype design with results from promising test runs with the electron beam of the MAMI accelerator and detailed simulation studies.

HK 8.6 Mon 17:45 PHIL A 301

Magnetic-field mapping requirements and strategy for the P2 parity violating experiment at MESA — 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 P2 experiment at the upcoming MESA accelerator aims to perform a high-precision determination of the weak mixing angle by measuring the parity-violating asymmetry in elastic electron-proton scattering at low momentum transfer ($Q^2 \approx 4.5 \times 10^{-3}$ GeV^2). To reach the targeted uncertainty, the experiment relies on a solenoid-based spectrometer providing full 2π azimuthal acceptance and controlled transport of scattered electrons to the integrating Cherenkov detector system. Precise knowledge of the magnetic field distribution inside the solenoid is essential for Q^2 reconstruction, systematic-uncertainty control, and background separation. Therefore, a dedicated magnetic-field mapping approach is planned to characterize the 3D field response under operating conditions. The talk will outline requirements of map-

ping a high-current, large-aperture solenoid and discuss strategies for establishing a validated magnetic-field model for the P2 spectrometer.

HK 8.7 Mon 18:00 PHIL A 301

Mirror System and Mirror Alignment Monitoring of the CBM RICH — •Sven Peter for the CBM-Collaboration — Justus Liebig University, Gießen

The CBM (Compressed Baryonic Matter) experiment at FAIR (Facility for Antiproton and Ion Research) will study extremely dense matter resulting from heavy ion collisions starting in 2028. The CBM Ring Imaging Cherenkov Detector (RICH) uses CO_2 as radiator and multi-anode photomultiplier tubes as readout. The mirrors (R=3 m) consist of 80 individual mirror tiles (about 40 cm×40 cm). A prototype of the mirror wall has been built and a gluing procedure has been developed that does not cause harmful distortion of the mirror. The RICH is planned to be periodically exchanged with the MUCH (Muon Chamber) detector by craning. This carries the risk of mirror misalignment but only misalignment upto 1 mrad can be tolerated. Potential misalignment must be detected and accounted for during data analysis to ensure accurate ring diameters, locations, and subsequent ring-track matching. The CLAM method (Continuous Line Alignment and Monitoring, originally developed for the COMPASS RICH-1) was adapted for the CBM RICH. A ray-optics simulation of the mirror system was used to compare different approaches for misalignment quantification. Supported by BMBF grant no. 05P24RG6.