A High-rate GEM-based TPC for $\overline{\mathrm{P}}$ANDA ◇

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1. Introduction

$\overline{\mathrm{P}}$ANDA (Anti**P**roton **An**nihilations at **Da**rmstadt) [1] is a universal detector system to study fundamental questions of hadron physics in proton-antiproton interactions. It is designed as an internal target detector at the antiproton storage ring HESR (**H**igh **E**nergy **S**torage **R**ing), which is planned in the context of the future research center FAIR (**F**acility for **A**ntiproton and **I**on **R**esearch) at Darmstadt. The rich physics program foreseen at $\overline{\mathrm{P}}$ANDA requires an excellent 4π charged particle tracking system. Minimal material budget and a momentum resolution on the per cent level are mandatory. A possible solution for the central tracker of $\overline{\mathrm{P}}$ANDA fulfilling these requirements is a TPC (**T**ime **P**rojection **C**hamber). In addition to the above mentioned requirements it would allow for PID (**p**article **id**entification via $\mathrm{d}E/\mathrm{d}x$ measurements, in particular in the momentum range below 1 GeV/c. The continuous beam structure at the HESR in combination with interaction rates of the order of 10^7/s, however, poses a big challenge for such a detector. The feedback of ions from the amplification region into the drift region is intrinsically suppressed in a GEM (**G**as **E**lectron **M**ultiplier) [2], thus opening the possibility to operate a TPC in an ungated mode without accumulating excessive space charge. This report summarizes the ongoing activities in our group to study the feasibility of a GEM-based TPC for $\overline{\mathrm{P}}$ANDA, both in simulations and prototype development.

2. Prototype Development

A small GEM-based TPC prototype with a drift length of ~ 8 cm and an active area of 10×10 cm^2 has been designed and assembled (see Fig. 1). The layout has been adapted from a similar detector which was built and successfully operated with GEMs for studies of the TESLA TPC [3]. It allows easy raplacement of the gas amplification stage, readout-PCB and front-end electronics. In particular the fieldcage can be exchanged by a longer one without major modifications. It is realized as a multilayer structure where the two major components are a 125 μm Kapton foil, which has a set of 18 μm thick copper strips on both sides to form the drift field, and a laminated honeycomb structure for mechanical stability. Aiming for a drift field of ~ 400 V/cm, the cathode end cap has to be set to a potential of ~ 8 kV (taking into account a voltage of ~ 4 kV, which is needed to operate the GEM stack). The readout PCB, which also holds the GEM stack and the corresponding high voltage feedthroughs, is currently equipped with 2×6 mm^2 pads. For first tests, the front-end electronics developed for the ALICE TPC [4] will be used.

The prototype design was chosen in a way that the chamber fits into a dipole magnet which is available at TU München. With this setup we intend to study systematically the detector performance in a magnetic field. In order to investigate the influence of field distortions due to space charge accumulation inside the drift volume of the TPC, an X-ray gun will be used. For this purpose, irradiation windows are foreseen in the prototype fieldcage. An open gas system has been designed to be able to test different gas mixtures for the TPC. At the moment Ar or Ne as counting gas, CO_2 as quencher, and possibly CH_4 as third admixture are foreseen.

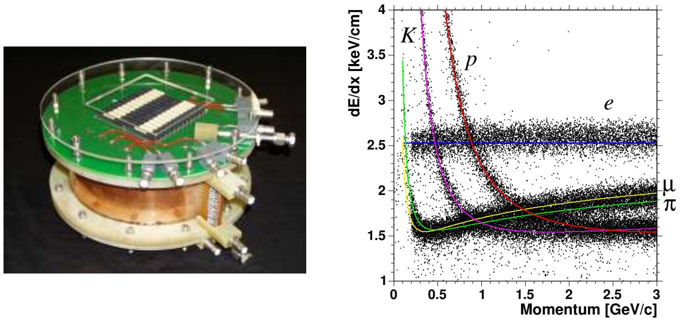

Fig. 1: Left: Picture of the assembled TPC prototype. Right: Reconstructed energy loss per unit track length vs. momentum for p, K, π, μ and e; lines are fits of a parameterization.

3. Simulation Results

In order to simulate the TPC and its integration into the whole detector system it has been fully implemented into the $\overline{\mathrm{P}}$ANDA simulation framework. This includes the simulation of charged particles traversing the gas volume, as well as the creation of signals and their reconstruction to tracks and vertices. With this tool the dependence of the tracking performance on certain design parameters like the pad size or the gas mixture have been studied. Especially the capability of the TPC to contribute to the particle identification of $\overline{\mathrm{P}}$ANDA via $\mathrm{d}E/\mathrm{d}x$ measurements has been investigated. As can be seen from Fig.1 the TPC can provide PID information for particle momenta below 1 GeV/c, where the Cerenkov detectors are not sensitive anymore. According to the simulations, a $\mathrm{d}E/\mathrm{d}x$ resolution of the order of 4 % can be achieved.

References

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