T555 : Development of TPC and HBD for the PHENIX Upgrade

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The PHENIX experiment at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory has been performed to create and study extremely hot and dense matter. Although there are some strong indications that a new state of matter is being created, we need additional measurements to conclude that the new matter is Quark Gluon Plasma. One of required measurements is the measurement of low mass vector mesons (ρ, ω and ϕ) to study chiral symmetry restoration. The dielectron channel is suitable for this measurement, however, there is huge background from π^0 Dalitz decays and gamma conversions with the present detector configuration.

We are planning to install a Hadron Blind Detector (HBD) and a Time Projection Chamber (TPC) using Gas Electron Multipliers (GEMs) in the PHENIX detector to reduce the background. The GEM is a metalized polyimide foil with holes and used for charge multiplication. High electric fields are realized inside the holes with relatively low voltage difference. The HBD is a sort of gas Cherenkov detector and consists of a 50-cm long radiator with CF_4 gas directly coupled to a triple-GEM detector element with a CsI photocathode and pad readout. A mesh locates before the first GEM foil to ensure a zero field above the photocathode, which rejects ionization charges. The TPC uses GEM foils as a readout instead of wires to improve spatial resolution and adjacent track resolution, and to reduce positive ion feedback into the drift region.

T555 experiment was carried out to evaluate the performance of the TPC and the HBD at the KEK-PS $\pi 2$ test beam line.

Detection efficiency, spatial resolution, adjacent track resolution, particle identification capability by energy loss of the TPC are measured using 1.0-GeV/c negative pion beams. In addition to such basic measurements, those dependence on gas (P10, Ar(70%)-C_2H_6(30%) and pure CF_4), drift length (20–290 mm), readout pad shape (rectangle and zigzag) and beam momentum (0.5–3.0 GeV/c) are measured. Figure 1 shows spatial resolution both in the pad-row direction and in the drift direction as functions of the drift length. Spatial resolution of 80 μm in the pad-row direction, adjacent track separation of 12 mm in the drift direction and detection efficiency of 99.3% are achieved. Energy loss measurements show the good particle identification capability. Beam rate dependence of the TPC characteristics are also checked. The TPC holds high detection efficiency and good spatial resolution with high particle rate of 4800 cps/cm^2, which exceeds the rate of RHIC. The test results show that the TPC meets the requirements for operation in the PHENIX detector.

Measurements of the number of photons in the bandwidth (110–200 nm) per unit distance, N_0, and hadron rejection factor of the HBD are also objectives of T555 experiment. Figure 2 shows the mean amplitude versus the drift field E_D in the gap between the mesh and the first GEM with 1.0-GeV/c negative pion beams. The amplitude decreases as sharply as expected when the polarity of the drift field is switched. The figure shows also the results of similar measurements performed with an α-ray source. A direct measurement of N_0 was not possible due to the large UV absorption in the available gas system. We observed only 6–10 photo electrons for a 1.0-GeV/c electron. This number is however consistent with the expected number of $\sim$35 p.e. after correcting it for the measured absorption in the gas.

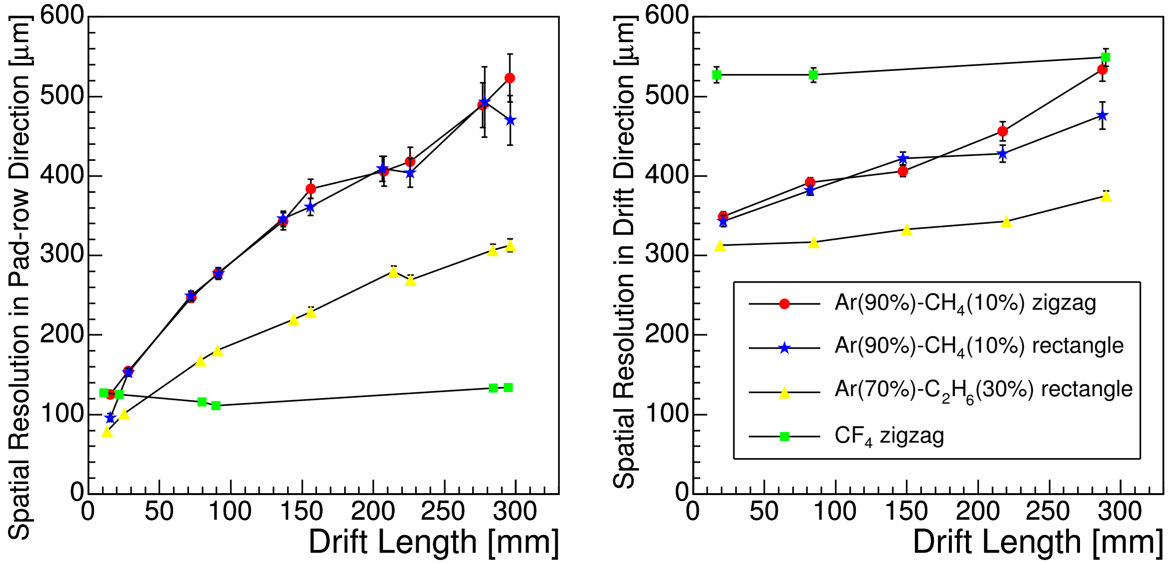

Figure 1: Spatial resolution of the TPC versus the drift length in the pad-row direction (left) and the drift direction (right).

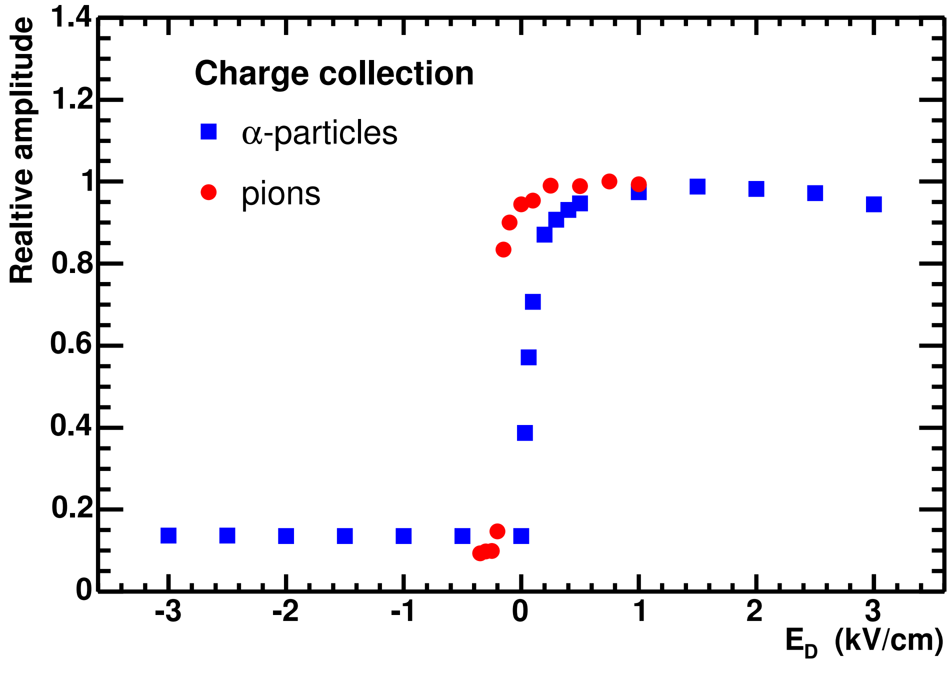

Figure 2: Collection of ionization charge of the HBD versus the drift field E_D in the gap between the mesh and the first GEM.