Advanced Micro-Pattern Gas Detectors for Tracking at the Electron Ion Collider

Letter of Interest – Aug 31, 2020

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We would like to express our interest in studying advanced Micro-Pattern Gas Detectors (MPGDs) as tracking detectors in experiments at the Electron Ion Collider (EIC) [1] to be constructed at Brookhaven National Laboratory. Specifically, we intend to investigate the application of micro resistive-well (μRWELL) detectors [2–4] in central and forward/backward trackers with simulations and preliminary hardware development.

In the central detector, the envisioned μRWELL layer(s) with cylindrical geometry would supply fast tracking information and seed particle identification by providing precise track point and direction for particles impacting a PID detector near the μRWELL. For the forward and backward directions, we are interested in exploring large-area planar μRWELL detectors as alternatives to standard Triple-GEM detectors. The main benefit will be a reduction in material needed in the detector, which will be particularly beneficial for electron reconstruction in the backward direction where most of the electrons will scatter at the EIC.

Fast Central Tracking Layer with Cylindrical μRWELL: We have begun studying the impact that fast cylindrical μRWELL tracker layers would have on the angular tracking resolution in the central region. We simulated three detector setups. The first ("No MPGD"), consisted of a silicon vertex tracker, a TPC, and a DIRC material volume. In the second setup ("1 MPGD") we added two μRWELLs, one just before the TPC inner field cage and the other just outside the outer TPC field cage and before the DIRC. For the third setup ("2 MPGD") we had the μRWELL trackers inserted in front and behind the DIRC.

This initial study was done for π^- particles in a 1.5 T magnetic field for scattering angles of 43^o, 66^o, and 89^o over a momentum range of 1-7 GeV. Fig. 1 shows the results of the polar angle resolution ($\Delta\theta$) vs. momentum for pions at $\theta = 43^o$ (similar trends were seen for the other scattering angles). The resolutions of the three detector setups are compared. The left panel shows the θ resolution that would be achieved at the front face of the DIRC, while the right plot shows resolutions that would be measured behind the DIRC. We see a drastic improvement in angular resolution at the front face of the DIRC when there is a μRWELL detector before the DIRC compared to when there is none. As expected, the resolution at the front of the DIRC is insensitive to whether the second tracker is before the TPC ("1 MPGD") or after the DIRC ("2 MPGD"). We find a significant improvement in angular resolution measured behind the DIRC when a μRWELL tracker is inserted after the DIRC. Due to the multiple scattering within the DIRC material, the angular resolution of the track exiting the DIRC is much worse compared to the angular resolution of the track as it enters the DIRC, which suggests having a tracker behind the DIRC could also help with the PID performance of the DIRC. From this initial study we found that the DIRC would benefit the most from having 2 cylindrical μRELLs located just before and after it. Of course the absolute value of the angular resolution depends on the overall resolutions of the tracking detectors, e.g. the TPC. We will revisit this as detector parameters become finalized. So far our simulation studies have been carried with no support materials included. We plan to create a more realistic description of the detector material budget by incorporating the support structure that we have developed for a mechanical mock-up of a small cylindrical μRWELL (Fig. 2).

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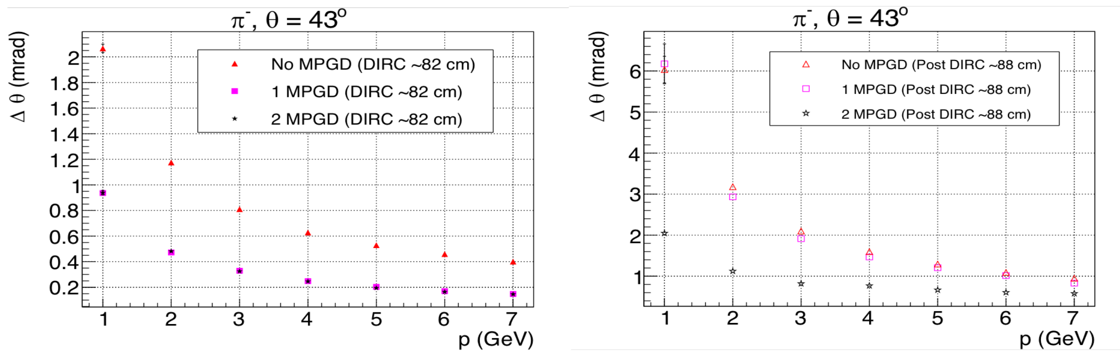

Figure 1: $\Delta\theta$ vs. momentum for π^- at $\theta = 43^o$. Resolutions in the left plot are determined at the front of the DIRC (closer to IP), and the right plot after the DIRC.

Figure 2: Side view of assembled and suspended mechanical mockup for a cylindrical μRWELL. Total length (w/o endplates): 60.3 cm; diameter of inner Kapton foil: 16.2 cm; diameter of outer Kapton foil: 19.6 cm.

Forward and Backward Trackers with Planar μRWELLs: We previously developed large-area Triple-GEM prototypes for tracking in these regions attempting to minimize material [5–14]. We found that this can pose a challenge due to the complex mechanics and tight tolerances of Triple-GEMs. We propose to investigate μRWELLs as an application for this detector region because their mechanical construction is simpler and they intrinsically have a smaller material budget than Triple-GEMs. Our investigation will most likely focus on simulations as well as construction and testing of small planar μRWELL prototypes.

Capacitive μRWELL readout structures with low channel count: In an effort to advance MPGD technology, we are exploring a new large-pad & capacitive-sharing anode readout PCB concept to be coupled with MPGD amplification devices such as GEMs, μRWELLs, or Micromegas. This novel readout PCB decouples spatial resolution performance from the size of the readout layer pads connected to the FE readout electronics and is expected to provide excellent spatial resolution with significantly lower readout channel count.

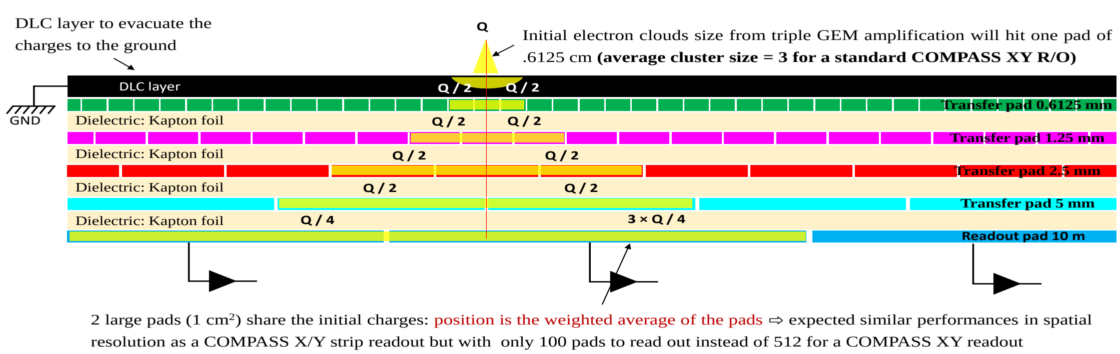

Figure 3: Principle of capacitive-coupling large-pads anode readout for MPGDs.

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