Development of Large Micro Pattern Gaseous Detectors for High Rate Tracking at Jefferson Lab

Letter of Interest – Aug 31, 2020

(submitted to the Instrumentation Frontier of the 2021 DPF Snowmass Study)

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1 Introduction

Micro-Pattern Gas Detectors (MPGDs) present several key advantages over alternative technologies for tracking system in High Energy and Nuclear physics experiments for their high rate capability (1 MHz / mm^2), excellent spatial resolution (≤ 100 µm), good timing performances (≤ 5 ns) and low cost for large area coverage. As such, large area MPGDs options such as Gas Electron Multipliers (GEMs), Micro Mesh Gaseous Structures (Micromegas) or Resistive Micro Well Detector (µRWELL) have been selected for the tracking system for several current and future experiments of the 12 GeV CEBAF physics program at JLab. The MPGD-Detector Lab group at the University of Virginia is excited to actively participate to the MPGD topical group program of the Snowmass instrumentation frontier. Our group has demonstrated its expertise in the MPGD detector R&D and successfully building large scale GEM-based trackers for several JLab 12 GeV experiments. We intend to investigate further the development of large area & low mass GEM for high rate tracking for the JLab Hall A SoLID and MOLLER spectrometers as well as the new concept of Multi-TPC tracking device for the TDIS experiment. We are also involved in the development of cutting edge technology such as the high performance, low channel, count large area µRWELL layers for tracking system for the lower luminosity Hall-B equipment such as the instrumentation device for PRad-II and Forward Tracker Upgrade of the High Luminosity CLAS12.

2 GEM Trackers for SoLID, MOLLER & TDIS Equipments at JLab

The Solenoidal Large Intensity Device (SoLID) [1] apparatus is a large acceptance spectrometer and a detector system capable of handling very high rates designed to satisfy the requirements a set of approved highly rated experiment including but not limited to the Semi-Inclusive Deep Inelastic Scattering (SIDIS) and the Parity-Violating Deep Inelastic Scattering (PVDIS) physics programs in the 12 GeV era at Jefferson Lab that requires both high luminosity and large acceptance. The Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) [2] experiment proposes to measure the parity-violating asymmetry in electron-electron (Møller) scattering. This asymmetry is proportional to the weak charge of the electron, which in turn is a function of the electroweak mixing angle, a fundamental parameter of the electroweak theory. The accuracy of the proposed measurement allows for a low energy determination of the mixing angle with precision on par with the two best measurements at electron-positron colliders. The Tagged Deep Inelastic Scattering (TDIS) is another Hall A highly rated approved experiment aimed at the measurement of high W^2, Q^2 electrons scattered from hydrogen and deuterium targets in coincidence with low momentum recoiling protons to probe the elusive mesonic content of the nucleon, using the tagging technique to isolate scattering from the pion in proton to pion fluctuations. All three apparatuses described above, require high resolution track reconstruction under high rate conditions over a large area. A cost effective solution for such requirements is provided by the Gas Electron Multiplier (GEM) technology invented by F. Sauli [3]. GEM Trackers [4–6] can operate in the very high rate environment well over 1 MHz per cm^2 with position resolution better than

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70 μm over large area of 1 m^2. One additional crucial requirement for fixed target experiments at JLab is the need for low mass tracking detector to minimize multiple scattering and background production. Combining all these requirements of low mass, high rate and high spatial resolution over a large detection area present a set of technological challenges requiring substantial R&D. This is the area that we propose to investigate.

3 Large μRWELL Detectors for Tracking Systems at JLab

For the lower luminosity environment such as in the experimental Hall B at Jefferson Lab where the particle flux rate at the tracking detectors is several order of magnitude lower than for Hall A, we are exploring the new emerging MPGD technology known as Resistive Micro Well (μRWELL) detector as better suited option for the large area and high performance tracking system to equip Hall B spectrometers. Compared to triple-GEM detector, μRWELL offer intrinsic low mass due to single amplification stage, simpler mechanical construction and low production cost specially for large area tracking devices with similar spatial and timing resolution performances expected to be similar than for triple-GEMs. The focus of our investigation will be on the development of ultra low mass and low channel count large area 2D μRWELL trackers for future detector equipment upgrade such as the PRad-II trackers for the proton charge radius precision measurement [7] and the upgrade of the forward trackers of the high luminosity CLAS12 [8]

4 High Performance & Low Channel Count Anode Readout Structures

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.

References

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