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# A Comparison of Micromegas with x/y Strip Charge Readouts for Directional Recoil Detection

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Detecting the topology and direction of low-energy nuclear and electronic recoils is broadly desirable in nuclear and particle physics, with applications in coherent elastic neutrino-nucleus scattering (CE$\nu$NS), astrophysical neutrino measurements, probing dark matter (DM) beneath the neutrino fog, and confirming the galactic origin of DM. Gaseous Time Projection Chambers (TPCs) offer the required gain and readout granularity, but must be large to achieve the required volume. Therefore, scalable, cost-effective TPC readout technologies are essential. High-resolution $x/y$ strip readouts, previously identified as the optimal balance between cost-efficiency and performance, are examined here. To guide the readout design of a 40-L detector under construction, we present a comparative analysis of nine $x/y$ strip configurations with Micromegas amplification. Each setup employs VMM3a ASIC within the RD51 Scalable Readout System (SRS) for strip readout and a pulse height analyzer for reading out the Micromegas mesh. These complementary techniques assess gain, gain resolution, $x/y$ charge sharing, and point resolution of each setup. Configurations with a diamond-like carbon (DLC) layer exhibit improved spark resistance, allowing larger maximal gain and improved fractional gain resolution without notable impact on the point resolution. Although the DLC reduces charge fraction on lower strips, this can be mitigated by narrowing the upper strips. Our results allow us to select the optimal readout for future detectors. We also observe clear 3D tracks from alpha particles, with performance in good agreement with a simple simulation. Overall, Micromegas with $x/y$ strip readout are promising for low-energy recoil observatories. However, dedicated amplification devices and/or improved electronics are needed to reach the fundamental performance limit of 3D electron counting.


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