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Mesh Transparency of Electrons in a MMThGEM Gain Stage Device for Directional Dark Matter Searches

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Conventional Dark Matter (DM) detectors are approaching the limitations of the neutrino floor, however DM searches with directional sensitivity offer the potential for probing beneath this neutrino background by measuring the galactic origin of Nuclear Recoil (NR) signals. CYGNUS is a global collaboration between several research groups with the common goal of building a galactic NR observatory distributed across sites around the globe. The proposed CYGNUS detector network will consist of multiple large scale gaseous Time Projection Chambers (TPCs) filled with Helium and SF6 gas mixture up to atmospheric pressure. These detectors will be able to probe the neutrino floor parameter space with directional sensitivity.

Due to the electronegative nature of SF6, careful consideration of the detector's gain stage is required to ensure that sufficient charge amplification can be achieved. A Multi-Mesh Thick Gaseous Electron Multiplier (MMThGEM) is a unique gain stage device that provides multiple amplification stages in a single ThGEM structure by including internal meshes that span across the holes. These meshes can be biased individually to set up transfer and amplification regions in the MMThGEM device.

The internal meshes were originally introduced to reduce positive Ion BackFlow (IBF) in the device, however these meshes also inhibit the passage of desirable negative charge. The effect of varying field strength on the electron mesh transparency was investigated through a series of Garfield++ simulations studies and subsequent experimental tests. A low pressure electron drift gas, CF4, was used so that signals could be easily measured on multiple meshes across a wide range of field strengths. By considering both the electron mesh transparency and the energy resolution of an X-ray photopeak, the transmission of electrons between transfer and amplification regions was optimised. These findings are discussed along with the limitations of the work to Negative Ion Drift (NID) gases like SF6.

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