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Novel GEM foil layout for high-rate particle environment in the CMS ME0 muon detector

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Triple GEM technology has been selected to extend the acceptance of the CMS muon spectrometer to the region 2.4< |η| <2.8, the so called ME0 project. The ME0 stations will be formed by stacks (six-layer stations) of triple-GEM chambers, which must operate in a harsh environment with expected background particle fluxes ranging between 3 and 150 kHz/cm2 on the chamber surface. Both the maximum background rate and the large range in particle rate set a new challenge for particle detector technologies. The rate capability of triple-GEM detectors is limited by voltage drops on the chamber electrodes due to avalanche induced currents flowing through the resistive protection circuits (discharge quenchers).
Studies with large-area triple-GEM detectors with moderate fluxes, show drops up to 40% of the nominal detector gas gain. The traditional GEM foils segmentation does not allow for feasible gain compensation acting on the HV settings. To overcome this strong limitation and to cope with the large variation in background flux a novel GEM foil design with electrode segmentation in the radial direction, instead of the "traditional" transverse segmentation has been introduced.
The advantages of the new design include uniform hit rate across different sectors, minimization of gain-loss limiting the need for voltage compensation, and independence of detector gain on background flux shape.
Rate capability studies with ME0 chamber prototype by using a high intensity 22 keV X-ray generator will be presented. We prove the possibility to restore the original gain compensating the voltages applied on each GEM electrode, this makes this novel GEM foil layout suitable for the CMS-ME0 application and for all experiments which expose GEM detectors to a high background rate and large rate variation on the detector surface. Additional results from a beam test on pion and muon beam done in October 2021 will be also presented.

Collaboration

CMS

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