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Numerical predictions of GEM nonlinear mechanical properties under large deformations

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Gas Electron Multiplier (GEM) based detectors have been used in many applications since their introduction in 1997. Large areas of GEM are foreseen in several experiments such as the future upgrade of the CMS muon detection system, where triple GEM based detectors will be installed and operated. During the assembly and operation, GEM foils are stretched in order to keep the vertical distance between adjacent horizontal layers constant and uniform across the large area. This is a serious challenge for the assembly process. Indeed, the deformation of the perforated holes in the GEM are proven to have significant effect on the detector gain. Numerical calculations are therefore required to optimize the stretching forces to ensure uniform GEM sheet assembly and consequently uniform detector gain. In this work, two methods are used to predict the nonlinear mechanical properties of the GEM foil using finite element method. In the first method, linear elastic properties are predicted in the longitudinal and transvers alignment of the GEM sheet. In the second method, the plastic deformations are considered in the model to predict the load limitations. The results show slight variation of elastic moduli in longitudinal and transvers directions due to the hexagon pattern of the perforated holes. However, the directional Poisson rations are nearly similar. The nonlinear analysis shows local plastic strains at the perforated holes edges. These plastic deformations start at very low loadings and developed without affecting the linearity of the deformation loadings relation. We investigate the linearity limit at both longitudinal and transverse loadings and define the safety margin for the GEM stretching operation. Resulted are compared to recent measurements.

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