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A new technique for assembling large-size GEM detectors and its experimental results

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GEM detectors have been successfully used in modern nuclear and high-energy physics experiments which demonstrates the maturity of the GEM detector technology in applications for high-rate experiments. The key to the GEM application at large-scale experiments is cost-effective realization of large-size detectors, in which development of GEM detector assembly techniques plays a key role. The detector group at the University of Science and Technology of China (USTC) has been conducting intensive R&D of large-size GEM detectors, particularly on assembly techniques, since 2013, with one of the aims being to build up technology for the tracking detector at the SoLID experiment proposed for the 12-GeV upgrade program at JLab.
The large-size GEM R&D at USTC started with implementing the "No Stretching, No Spacer (NS2)"GEM assembly technique developed in the context of the CMS Muon GEM upgrade project at CERN. Two large-size GEM prototypes were built using the NS2 technique, with an active area of 30cm×30cm at USTC. A great deal of experience with the NS2 technique was gained through the prototyping. The performance of both prototypes including the response uniformity, effective gain and spatial resolution was tested.
From the implementation and practice of the NS2 technique, it was found that there is a major disadvantage in application for the GEM detectors size close to or larger than 1m. When GEM foil size reaches ~1m, the overall foil strain of a triple-GEM stack as used in the NS2 technique from a normal tension of ~ 5N/cm can be as large as ~2.5mm. This was precisely measured by a dedicated GEM stretching platform as shown in Figure 1. The screws will then be pulled by the inner frames and tilted towards the GEM stretching direction, and finally exceed the tolerance of the screw hole size and get blocked. This causes the stretching force can' t be applied to the foil correctly and gas leakage. In view of these problems inherited from the original NS2 technique, a new GEM stretching technique called "Sliding NS2"(Figure2) has been developed based upon the NS2 technique. In this new technique,the nuts are fixed by the main frame which forces the stretching screws to keep vertical to the side-plane of the mainframe, and the GEM foils can move freely up to 5mm inside the main frame. With this "Sliding"NS2 technique, GEM foils as large as ~1m can still be stretched very uniformly and gas tightness is ensured. A large-size GEM prototype (1m*0.5m) has been successfully built with the Sliding NS2 technique, demonstrating the advantage of the Sliding NS2 technique over the original one in large-size GEM assembly. The GEM prototype was thoroughly tested in terms of uniformity, effective gain.
This report presents the details of the Sliding NS2 technique for large-size GEM assembly and the test results of the large-size GEM prototypes built for the GEM R&D. The performance of the GEM prototypes is also compared.

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