Building and testing a large size triple GEM detector at VECC

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As part of GEM R&D related to CBM MUCH, we have so far studied and reported triple GEM detector characteristics and its response to charged particles using a standard 10 cm x 10 cm GEMs[1,2]. However, the actual layout of the CBM detector consists of large sector shaped chambers. These would employ large size GEM foils. In this contribution, we report our first attempt towards building large size triple GEM detector.

Stretching and Framing of GEMs

GEM foils being 50 microns thin need to be stretched which is followed by gluing of FR4 based boundary frame. Stretching and gluing of GEMs is a delicate procedure and at times can be pretty complex. Large area increases the complexity. The foils need to be taught and without any mechanical sag. So stretching technique should ensure that there is no under-stretch. Edge frames with thin supporting cross ribs having a minimum of dead area are used. The edge frames being 1 mm thick and typically 1.5 cm wide, care has to be taken that there is no overstretch either, otherwise it causes the opposite corners to bend. The foil clamped in suitable jig can be stretched either mechanically or by using thermal techniques. Each of these procedures have their own advantages and disadvantages. These foil-creeps that can occur in mechanical stretching can be avoided if one follows the thermal stretching techniques, which though consume relatively more time, are in fact relatively simple to follow. The later technique has been followed by several groups in the world. At VECC, we followed such a thermal stretching technique as our first attempt to stretch and frame large size GEMs. The goal is to learn and arrive at an efficient production procedure for making large GEM modules for MUCH.

31 cm x 31 cm GEM foils were procured from CERN along with the edge frames. The thickness of these frames are equal to the gaps between the two consecutive GEMs. The top surface of the foil is segmented into 12 strips. This reduces the overall capacitance of the foil, so that no severe discharge takes place. This foil was sandwiched

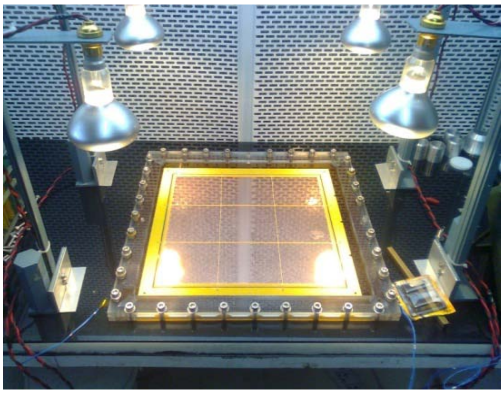

Fig.1. Picture of the setup at VECC, for stretching of large size GEMs.

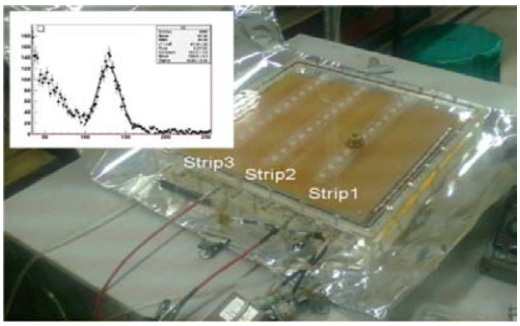

Fig.2 A locally framed and stretched 31 cm x 31 cm GEM foil under test with ^{55}Fe source. Inset: signal using 5.9 keV X-ray source.

between perspex frames of appropriate dimension as shown in Fig. 1. The perspex jig

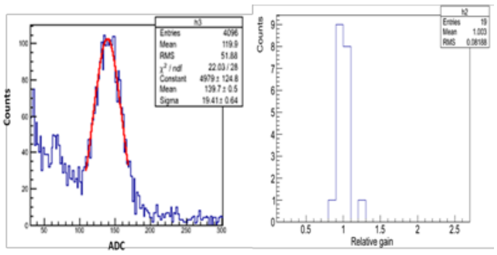

Fig.3 Left: [55]Fe X-rays spectra from 31 cm x 31 cm prototype. Right: Relative gain distribution

Fig.4 Picture of the first 6-layered PCB with projective pad geometry.

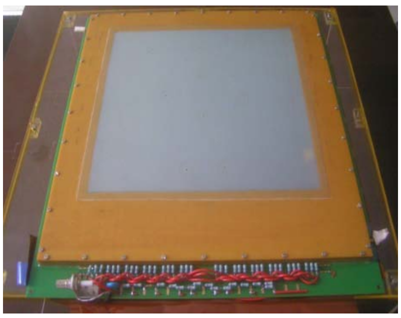

Fig.5 Picture of the 31 cm x 31 cm triple GEM detector.

was then heated using lamps as shown in the figure. Once the membrane became taught after optimum heating, a thin layer of glue was then applied on the surface of the edge frame and this frame was then gently placed over the stretched foil. The entire assembly is then left undisturbed for at least 20 hours for the glue to settle and fix. It is very important to control the temperature of the frames to prevent overstretching. We built appropriate temperature controllers for this purpose which maintained the temperatures to about 45^{o}C with a permissible deviation of 1 ^{o}C.

Prototype building and tests

The framed GEM thus obtained was tested in Ar/CO_2(70/30) gas mixture at V_{gem} of ~520 V. The readout plane consisted of three strips and together with the drift plane, the assembly was placed in a specially built chamber as shown in the Fig. 2. Appropriate provisions were done to allow ^{55}Fe X-rays to pass through. Data was taken with source placed at several places on the chamber in order to estimate the gain variation. A reasonably good gain variation of ~6% was observed. After a satisfactory test and assessment of each individual GEMs layers, a triple GEM stack was assembled in the same chamber. ^{55}Fe pulse height spectra as obtained using conventional NIM electronics from this prototype is shown in Fig. 3(left). A position scan as before was carried with this source placed at 19 different positions. A relative gain variation of less than 10% was observed (Fig.3(right)). The next step was to build a large size triple GEM prototype for beamtest with proton beams at COSY accelerator facility in Julich. For the first time we used a 6 layer PCB which was indigenously fabricated. The total active area was sector-shaped with progressively increasing pad sizes, as the case would be in the actual MUCH sector. Fig. 4 shows the picture of such a readout board, consisting of ~1200 pads. 10 FEB connectors were soldered at the sides along with 10 ohm SMDs as protection resistance for every pads, close to the connectors. Fig. 5 shows the picture of the first 31 cm x 31 cm triple GEM detector prototype which was tested successfully with proton beams [3].

References

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