Building of a 4-GEM prototype for ALICE-TPC upgrade

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Introduction

A Large Ion Collider Experiment (ALICE) at the Large Hadron Collider (LHC) facility will upgrade its multi-wire proportional chamber based Time Projection Chamber (TPC) with Gas Electron Multiplier (GEM) chambers [1, 2]. In order to achieve a low ion back flow ($< 1\%$) and good energy resolution (better than 12% (sigma) for 55Fe X-rays) it is decided that new read-out chambers will consist of stacks of 4-GEM foils combining different hole pitches [3, 4].

As part of the R&D required for this upgrade program, a 4-GEM prototype has been built at the IOP Detector Laboratory. The details of building procedure is described in this article.

Construction of 4-GEM module

Firstly the working table is cleaned by alcohol followed by vacuum cleaner. All the 4 10 cm $\times$ 10 cm standard GEM foils are made dust-free very carefully using vacuum cleaner. The top and bottom voltage strips are cut according to the requirement. There are four holes in the middle region of the readout PCB. Four PVC screws are inserted from bottom into the holes. These screws used as the pillers of the stack of GEM foils and the drift plane. 3 $\times$ 4 ring shaped spacers each of thickness 0.5 mm are needed to make 2 mm induction gap since each GEM foil is sandwitched between two frames of 0.5 mm thickness. After inserting the spacers, the first GEM foil (GEM4) is mounted. This is the 4th GEM foil. Now to make 2 mm transfer gap (Transfer Gap 3) 2 spacers are inserted into each screw end. After this another GEM foil (GEM3) is placed. Now a transfer gap 2 of 2 mm is made using 2 $\times$ 4 spacers. The next GEM foil (GEM2) is placed after that. Now 2 $\times$ 4 spacers are inserted into screws to make transfer gap 1 of 2 mm thickness and a GEM foil (GEM1) is placed. To maintain a drift gap of 3 mm, 4 $\times$ 4 spacers are inserted. Finally the 10 cm $\times$ 10 cm kapton drift plane of thickness 50 μm with bottom side claded by 5 μm copper is placed. Now the four PVC screws are tightened with the PVC nuts. After stacking all the GEM foils and the drift plane, a sealed chamber is needed. The stack of 4 stretched GEM foils and the drift plane placed on the 30 cm $\times$ 30 cm readout plane is shown in FIG. 1. So the drift gap, three transfer gaps and the induction gap is made 3,2,2,2,2 mm respectively.

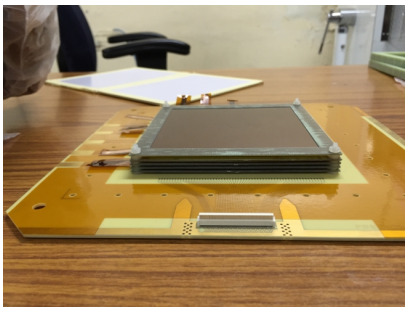

FIG. 1: Stack of 4 GEM foils along with the drift plane.

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Two G10 edge frames of 20 cm × 20 cm in size and 1 cm high, are placed one over another to make a wall of 2 cm height. Two O-ring gaskets are pasted on the top and bottom of each frame. So, in total 4 O-Rings gaskets are needed.

The two voltage strips from the top and bottom of each GEM foils are soldered in the respective connections on the base PCB. Also the voltage strip from the drift plane is soldered in the connection on the base PCB. Special cares are taken during soldering.

After placing the edge frames, a kapton sheet of about 100 μm thickness and 20 cm × 20 cm of area is placed on the top of the edge frame. Finally the chamber is covered by a G10 frame of area 20 cm × 20 cm and thickness of 2 mm. The cover frame has an opening of 10 cm × 10 cm. There are total 28 vertical holes from top cover plane upto bottom readout PCB plane through the kapton sheet and the edge wall. 28 pieces of M3 metal screws are inserted into the vertical holes on the wall and the screws are tightened to make the chamber gas sealed. Next, the heads of four PVC screws are sealed with araldite epoxy adhesive (hardener and resin are mixed in 1 : 1 ratio) and kept for 24 hours to cure.

Metal gas nozzle connectors are fixed inside horizontal holes on the wall (3 holes in each frame). After this push-fit connector is pushed into the gas nozzle. In the chamber, there are 6 holes but one input and one output hole is sufficient for such a small chamber. So four holes are closed using plastic screws. Two diagonal holes are used as input and output for the gas connection.

To make the resistor chain for power supply, appropriate resistances are soldered. After soldering, the junction points are covered by kapton tape. Now the chamber is ready for testing. The whole chamber is placed on a aluminium plate.

Testing of the Chamber

The ready quad GEM chamber is flushed with premixed Argon/CO_2 in 70/30 ratio for 24 hours. The voltage is applied to the detector using a high voltage power supply through the divider chain. The I-V characteristic for the divider is shown in in FIG. 2. The cosmic signal at -4300 V is shown in FIG. 3.

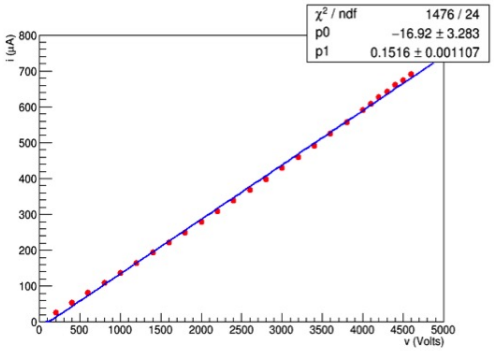

FIG. 2: I-V characteristics.

FIG. 3: The cosmic signal in the oscilloscope at -4300 V (20 mV/Div, 500 ns/Div, 50 Ω load).

Summary and outlooks

The first 4-GEM prototype is built in India and tested initially with Ar/CO_2 gas in 70/30 ratio with cosmic muons. The chamber will be used for long-term test of quad GEM with high radiation.

References

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