Some aspects of characterization of GEM detector

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Introduction

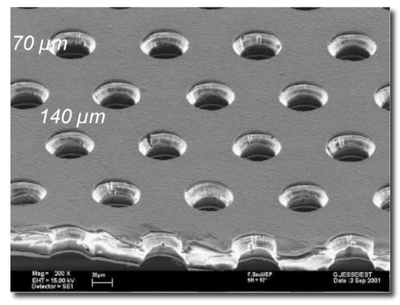
• A new type of Time Projection Chamber (TPC) has been proposed for the upgrade of the ALICE (A Large Ion Collider Experiment at CERN) so as to cater to the high luminosity environment expected at the Large Hadron Collider (LHC) facility in future.
• The main goal of this upgrade is to record Pb–Pb interactions at a rate of 50 kHz after the Long Shutdown 2 (LS2) in the year 2018-2019, which is a factor of about 100 times more than the current data acquisition rate of about 500 Hz.
• To overcome the rate limitations imposed by the present gated read-out scheme, the existing Multi Wire Proportional Chamber (MWPC) based read-out chambers will be replaced by GEM based detectors for the TPC.

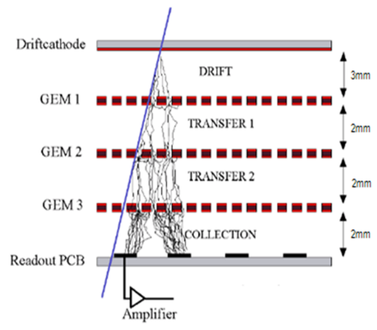
Main goal of the study

- Long term test of GEM detector
- Gain uniformity measurement of GEM over it's active area.
- Study of dependence of Relative humidity on gain of the detector.

Brief details of GEM detector

- GEM foils are 50 micron thick Kapton sheets sandwiched between two 5 micron thick copper cladding.
- Holes of diameter 70 micron are etched into the combination using photolithography technique.
- With the application of High voltage across the copper layers, primary electrons passing through the holes create avalanche.
- The resulting signal is collected in the anode, which is a number of pads or strips, giving the accurate position of the incoming particle.
- Three or more foils are stacked on top of one another to achieve sufficient gain at a lower applied voltage, also reducing the probability of spark.





Gain uniformity tests

The gain of the GEM detector will not be the same over all of it's active area. It is to be mentioned here that because of intrinsic gain inhomogeneities for GEM geometry variations and also for the inhomogeneity in the gap between individual GEM foils a gain variation up to 25% is possible.

The active area of the triple GEM detector prototype was divided into 81 equal areas and the Fe^{55} X-ray source was kept on each of them and corresponding anode current was recorded.

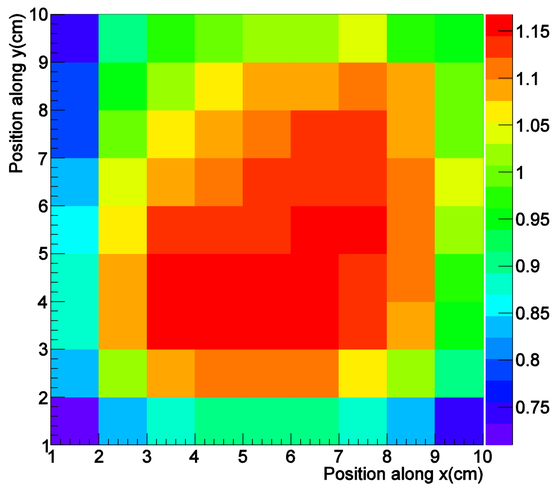
The output anode current due to the source:

$$i_{\text{source}} = i_{\text{with source}} - i_{\text{without source}}$$

The absolute gain of the detector is calculated from the formula:

$$\text{gain} = \frac{i_{\text{source}}}{r \times n \times e}$$

r is the rate of the X-ray,
n is the number of primary electrons and e is the electronic charge.



Long-term stability test

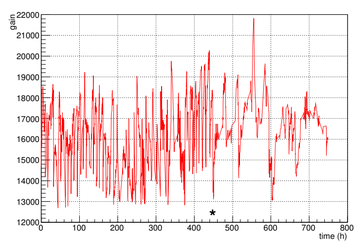
- Long term stability test is done with Fe^{55} source
- Gas used is Ar/CO_2 mixed in the ratio 70/30
- Constant applied voltage to the divider: -4300 V
- Anode current is measured with and without source continuously
- Temperature, pressure and relative humidity are measured continuously with time stamp

The dependence of the gain (G) of a GEM detector on absolute temperature and pressure is given by:

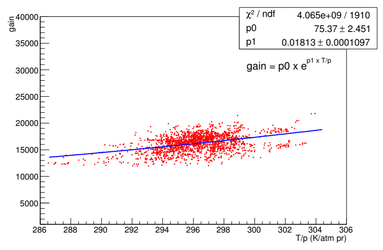
$$G(T/p) = Ae^{(B\frac{T}{P})}$$

The gain is normalized by using the relation:

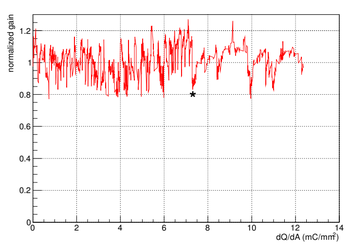
$$\text{gain}_{\text{normalized}} = \frac{\text{gain}_{\text{measured}}}{Ae^{(B\frac{T}{P})}}$$



Gain Vs. time



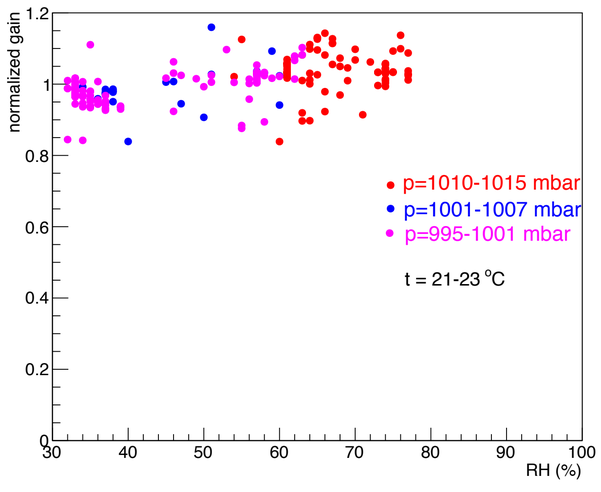
Gain Vs. T/p



Normalized gain Vs. $\frac{dQ}{dA}$

Gain variation with RH

We have also studied the variation of normalized gain of GEM detectors with Relative Humidity. Relative humidity was measured with a DHT11 module.



From experimental data it is clear that the normalized gain does not depend on relative humidity.

Summary

- One triple GEM prototype is built and is being tested
- Long term stability test has been done with a Fe^{55} X-ray source
- No ageing has been observed
- Gain uniformity is also tested over it's total active surface area
- Relative humidity has no effect on the normalized gain

Acknowledgements

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References

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