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Characteristic study of a triple GEM detector for future experiments

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Advanced Detectors for Nuclear, High Energy and Astroparticle Physics,
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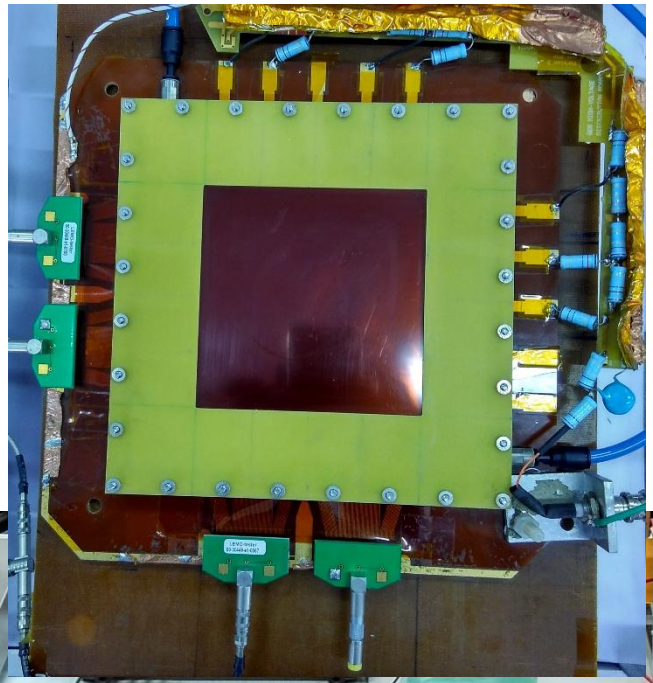
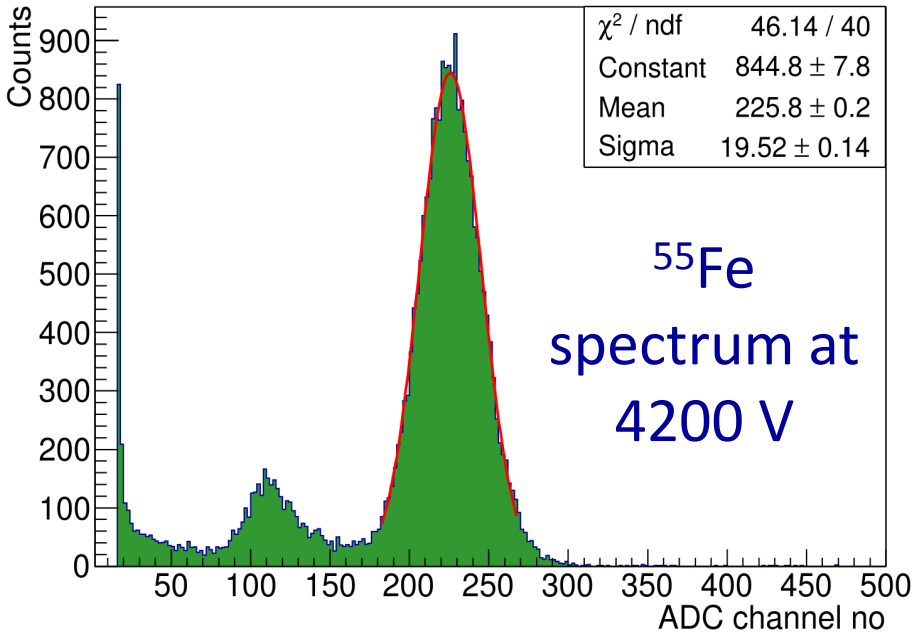
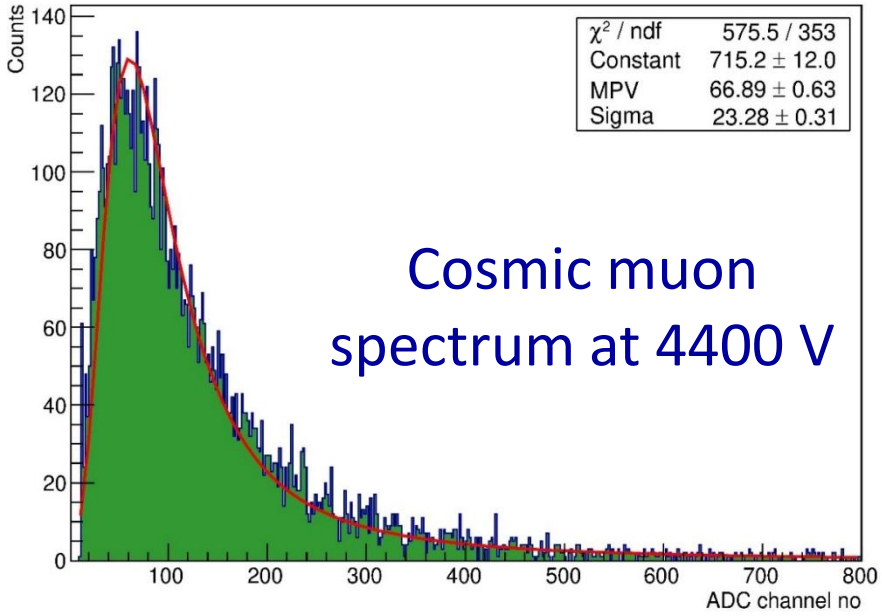
Detector set-up



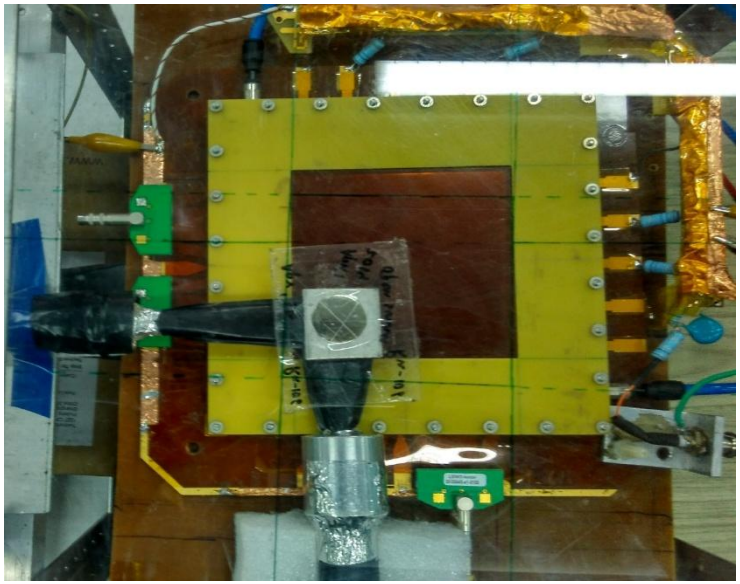
A 10X10 cm^2 triple GEM detector using Ar/CO_2 70:30 and 90:10 gas mixture, with 3-2-2-2 mm gap configuration, has been tested. The set-up picture of the detector is given below.

Spectrum of ^{55}Fe and Cosmic ray



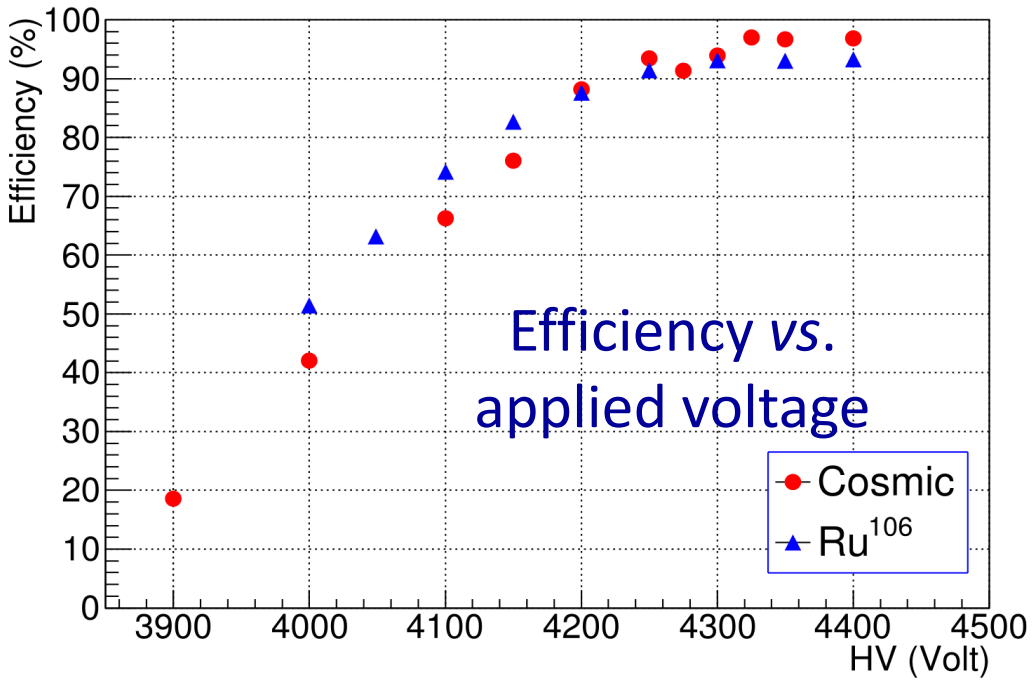


Efficiency measurement using ^{106}Ru-Rh source

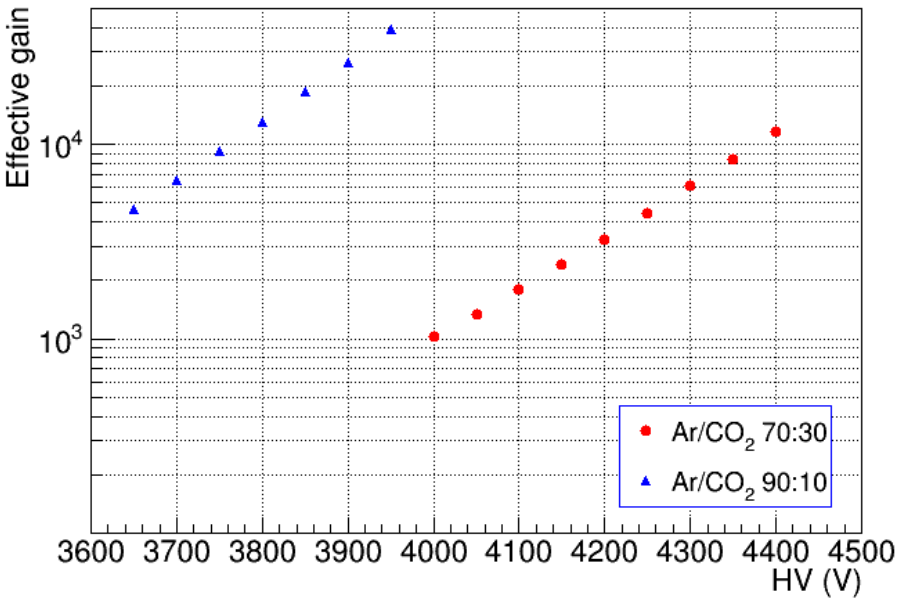


- Efficiency measurement was performed using Cosmic muon and ^{106}Ru-Rh β-source.
- Efficiencies are observed very similar at the plateau for the two different sources.

$$Eff = \frac{4F}{3F}$$

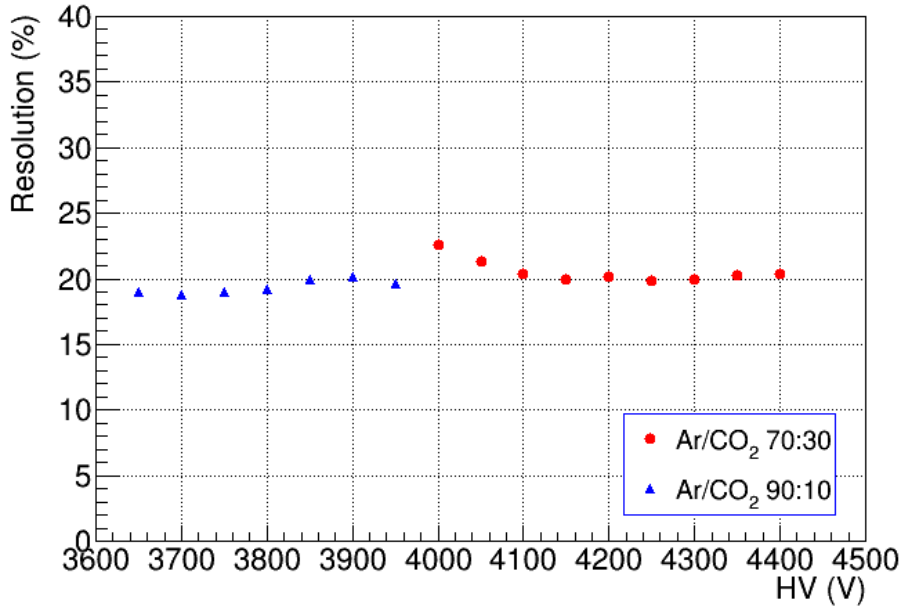


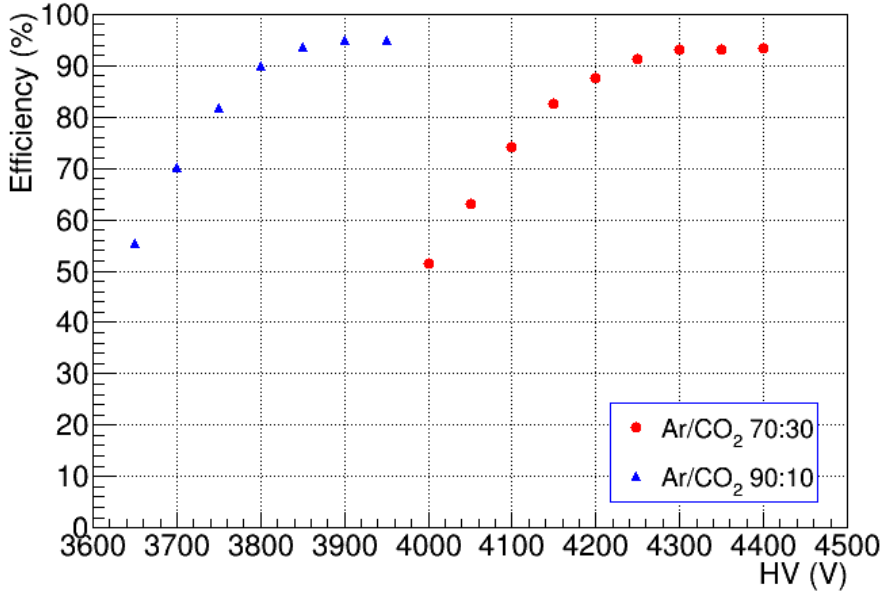
Measurements with different gas mixtures



The energy resolution ~ 20% for both the cases.

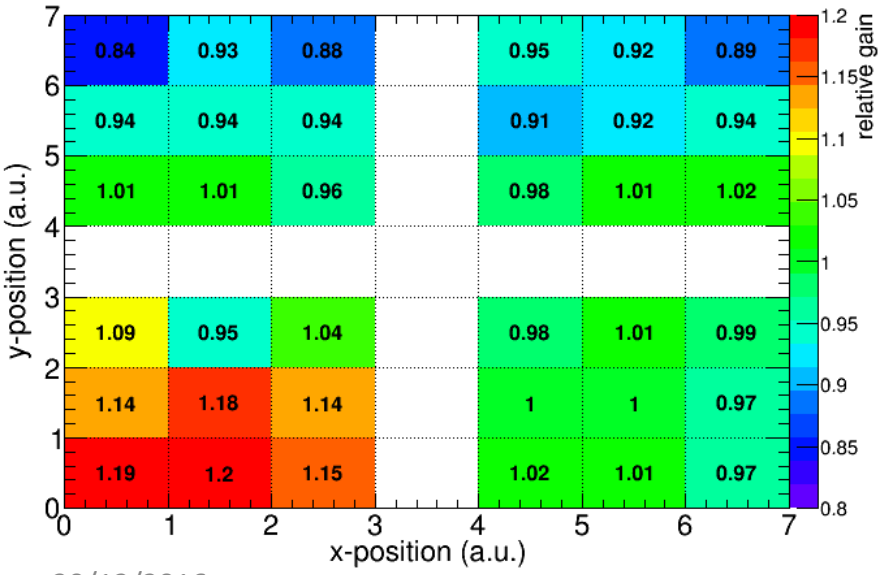
Efficiency at operating voltage ~95%

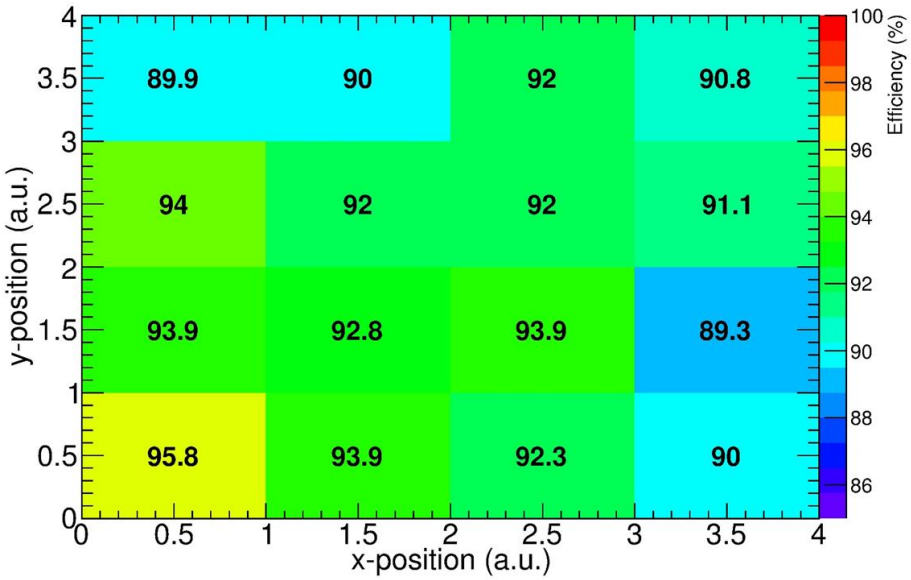




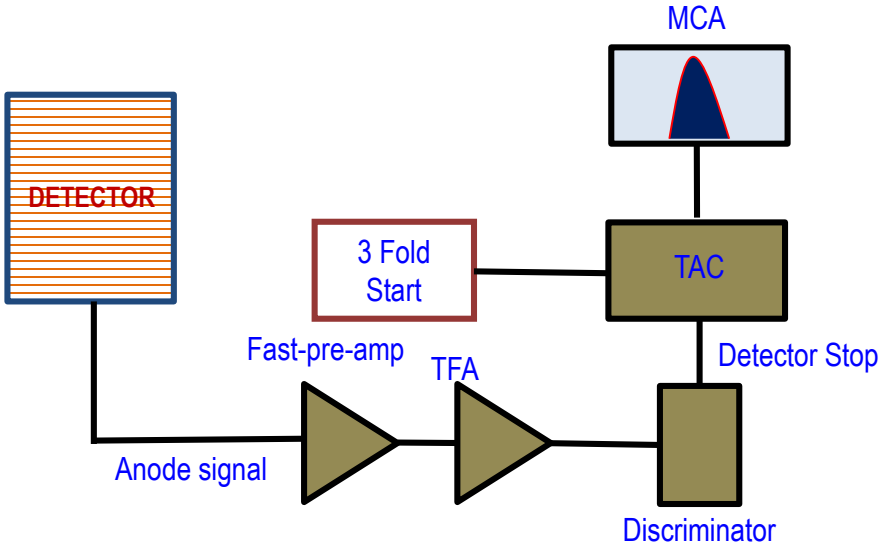
Uniformity: gain and efficiency

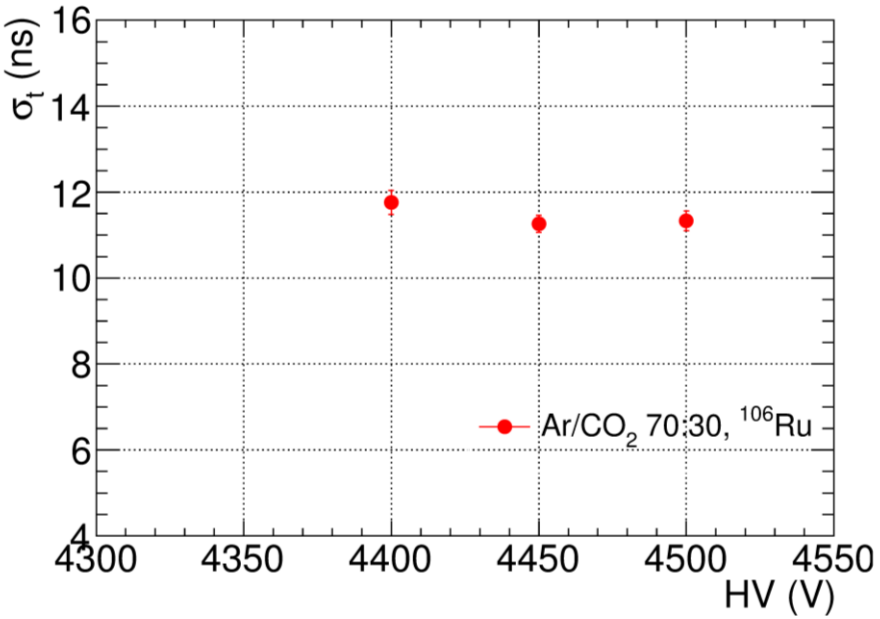
- Gain and efficiency of the detector were measured using ^{55}Fe and ^{106}Ru-Rh sources respectively.
- RMS variations of the gain and efficiency were 8.8% and 1.9% respectively.

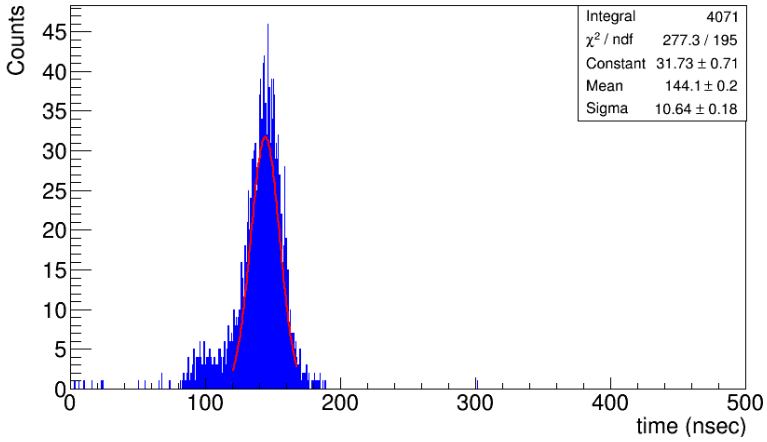


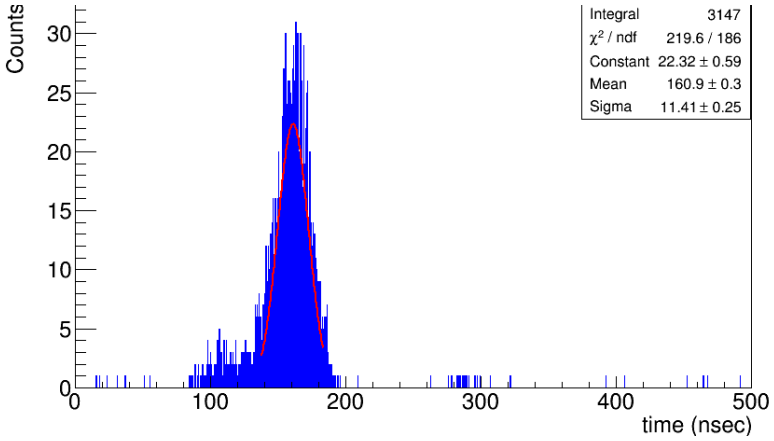


Time resolution of triple GEM





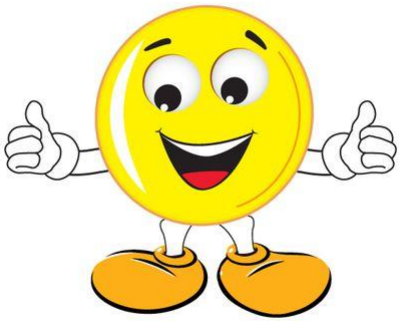




Summary

- Tests of a prototype triple GEM detector has been carried out using different radioactive sources.
- Characteristic of the detector is done in terms of gain, energy resolution and efficiency with the help of Ar/CO_2 70:30 and 90:10 gas mixture.
- Gain and efficiency uniformity is also measured.
- Time resolution is obtained for Ar/CO_2 70:30 gas.

THANK YOU



Backup slides

Ionization of gas detector

- Ionisation in medium is statistical nature.

In a gas mixture, $W = \sum w_i \, . W_i$

Average no of electron-ion pairs from all mechanism are created for ΔE energy loss,

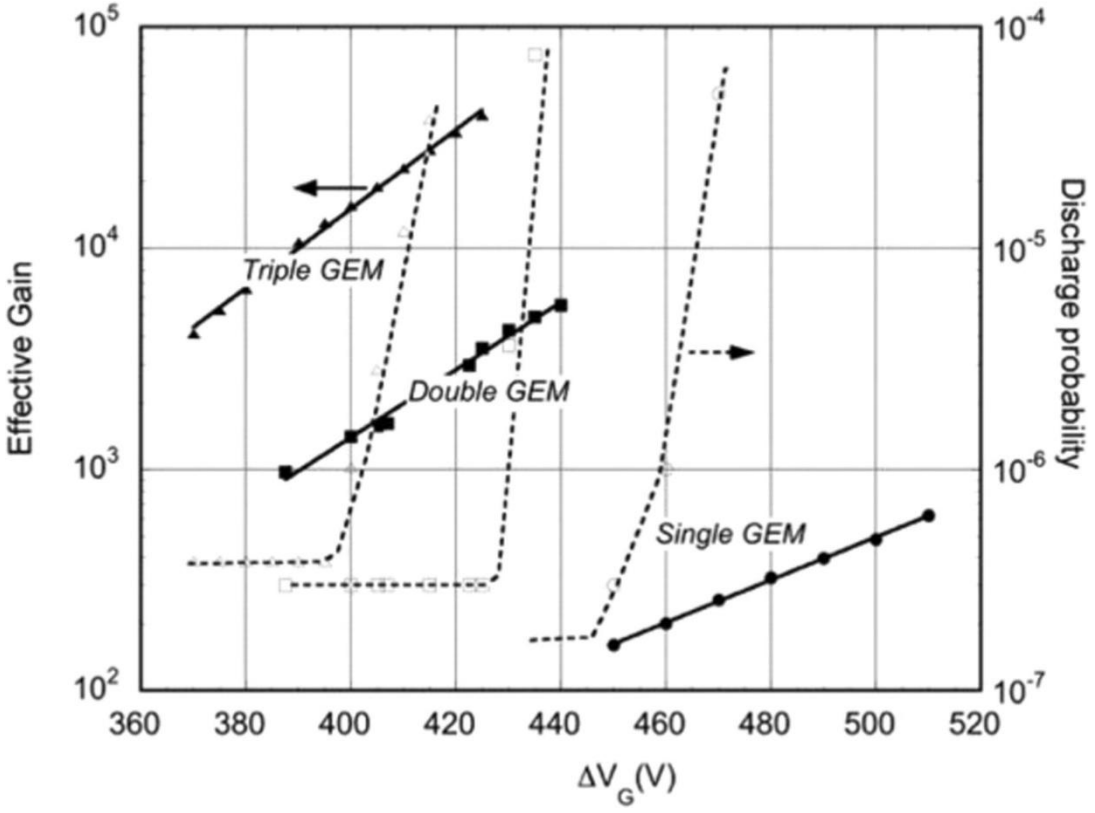
$$N = \frac{\Delta E}{W}$$

in Ar/CO_2(70:30) mixture 5.9 keV X-ray will produce ~**212** electron-ion pairs and for cosmic ray ~**100**/cm.

Gas	I [eV]	W [eV]
Ar	15.8	26
He_2	24.6	41
H_2	15.4	37
N_2	15.5	35
O_2	12.2	31
Air		33.8
CO_2	13.7	33
CH_4	13.1	28

I-first ionization potential
W-average energy for electron-ion pair production

GEM: Gain and discharge



Ref: F. Sauli NIM A 805(2016)2–24

Discharge probability

$$P_{Disch} = \frac{N_{Disch}}{R_{meas} \cdot \Delta T_{meas}} \quad (2)$$

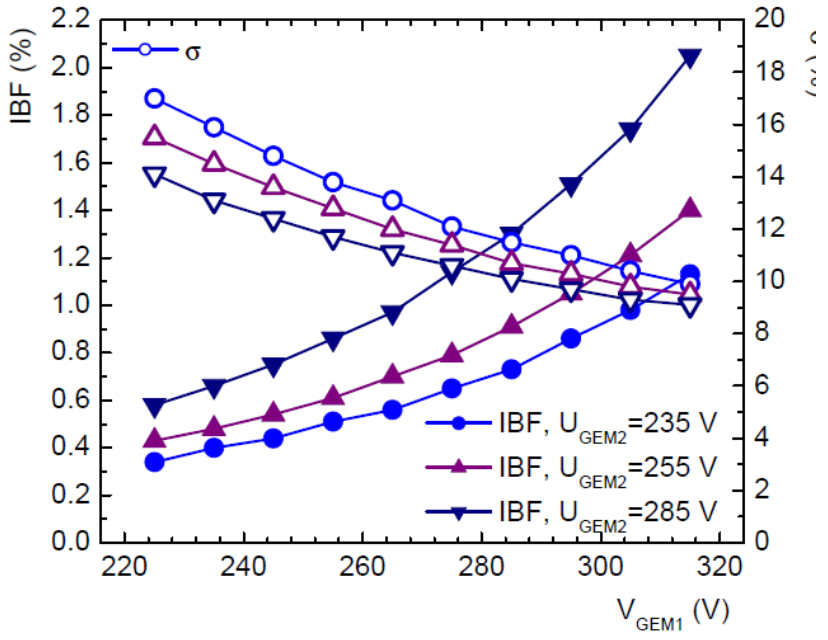
where R_{meas} is the measured neutron interaction rate and ΔT_{meas} is the measurement period.

In the case of the maximum gain used in the measurement, since $R_{meas} = 7260$ Hz (see Section 2.4), $N_{Disch} = 1$ and $\Delta T_{meas} = 1000$ s, $P_{Disch} = 1.37 \times 10^{-7}$ at $G = 5 \times 10^4$.

This result shows that in GEM-based detectors neutrons induced discharge probability is lower than alphas induced discharge probability [4].

Ref: G. Croci et al. / Nuclear Instruments and Methods in Physics Research A 712 (2013) 108–112

IBF ALICE TPC TDR



Ref: ALICE TPC Upgrade TDR

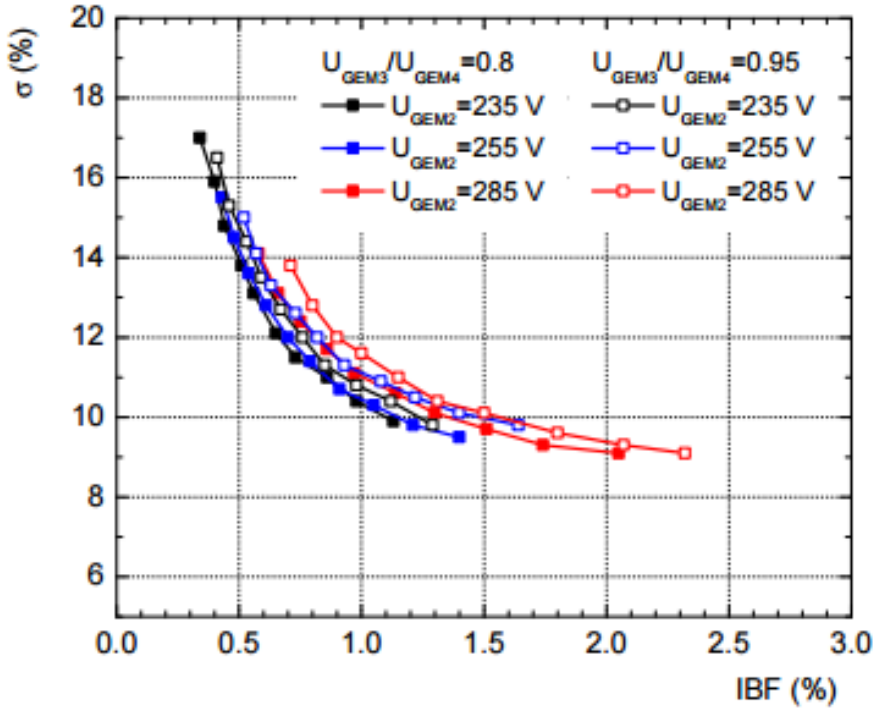


Figure 1. Correlation between IBF and energy resolution at 5.9 keV in a 4 GEM setup (S-LP-LP-S) in Ne-CO_2-N_2 (90-10-5) for various settings of voltage of GEM2.

Ref:T. Gunji, arxiv.org/pdf/1408.3484.pdf

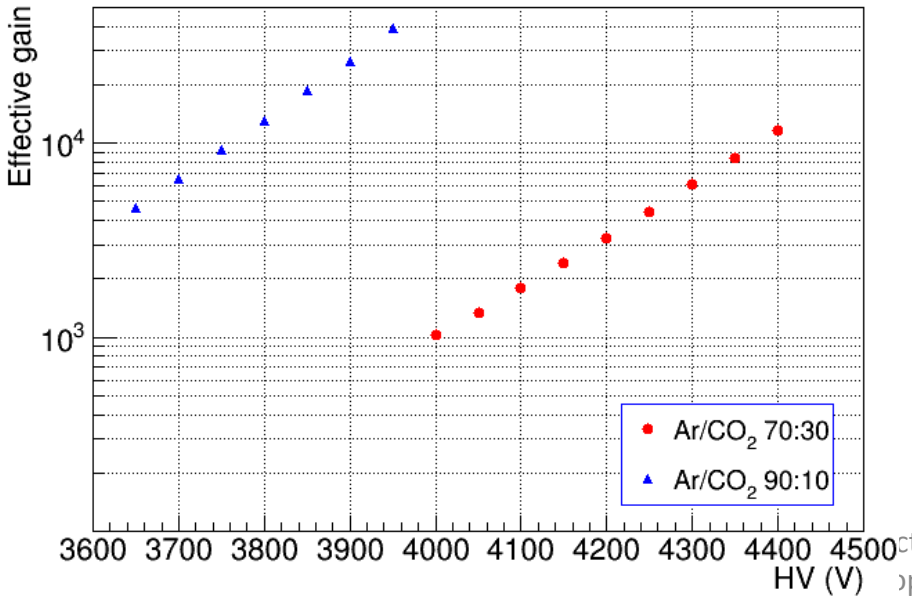
Gain and energy resolution (FWHM)

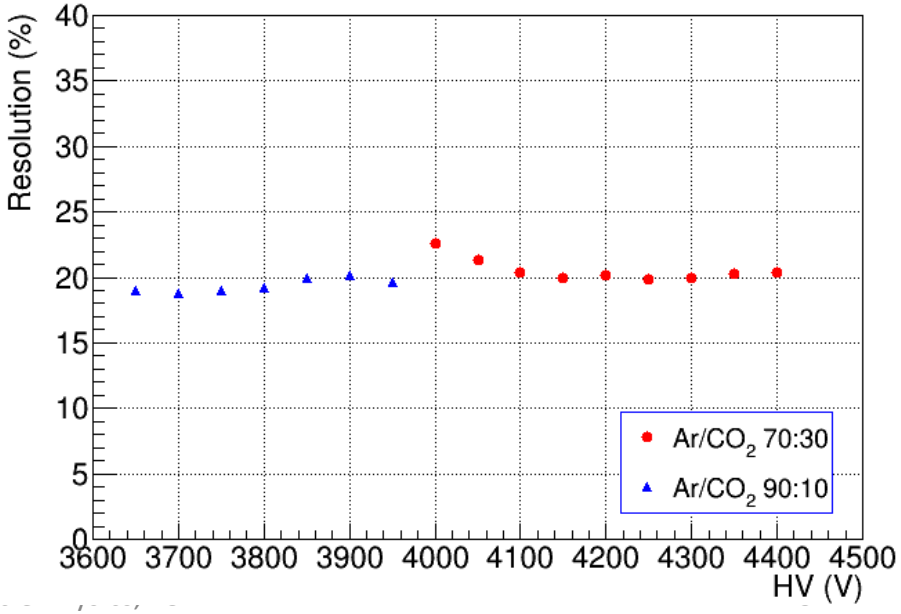
- Gain and energy resolution of the detector is calculated from the ^{55}Fe energy spectrums with different HV setting for Ar/CO_2 90:10 gas
- Resolution is corresponding to 5.9 keV X-ray and the optimum value is ~24%

$$G_{eff} = \frac{Q}{N_p q_e}$$

$$Where, \quad Q = \frac{V_{amp}}{G_{pre-amp} G_{amp}}$$

- Q – measured charge
- N_p – no. of primary ionization
- [N_p = 220, for Ar/CO2 (90:10)]
- q_e – electron charge





Time resolution: Basic principle

Time resolution of a detector determines how accurately two closed time incidents are separable.

Time resolution of any gas detector depends on many factors like detector geometry, gas mixtures, electric field, diffusion of the electron, cluster formation and also electronics