

# Performance of real-size GEM Detector with Particles at High Rate



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# *Plan*

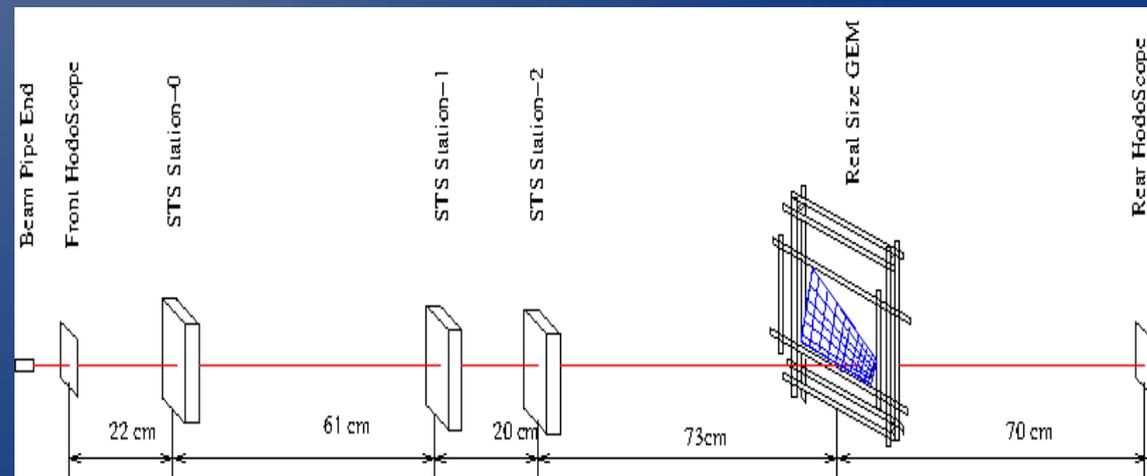
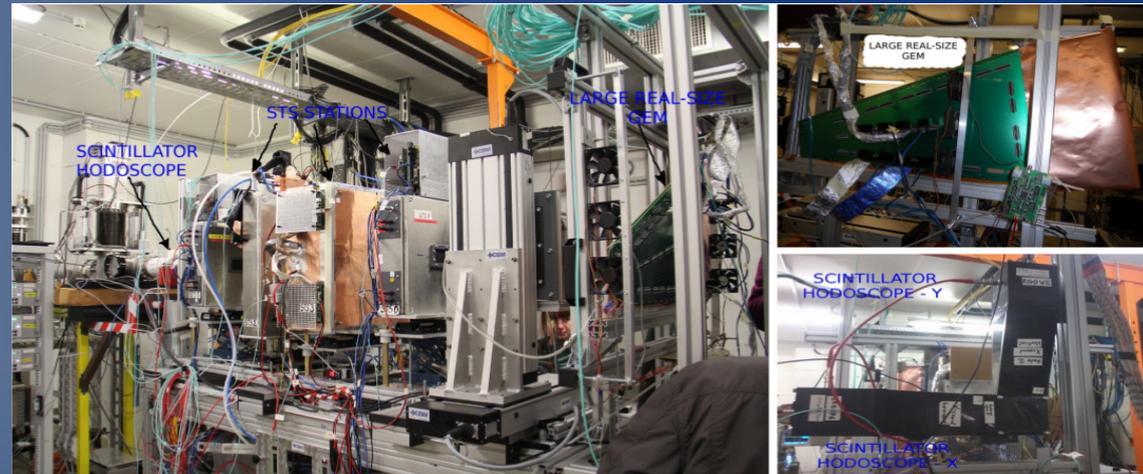
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# Motivation

- The interaction rate of particles in CBM is 10 MHz.
- 1<sup>st</sup> detector Station has to be operated at 300kHz/cm<sup>2</sup>.
- GEM based detector technology has been chosen to build the 1<sup>st</sup>, 2<sup>nd</sup> detector stations of MUCH.
- Already a 10 cm X 10 cm prototype triple GEM has been tested in 2012 at CERN SPS.
- In 2013 a trapezoidal shaped 31 cm X 31 cm triple GEM was tested at COSY.
- Finally a large GEM suitable for the 1<sup>st</sup> detector station has been tested in Dec' 2014 at COSY using ion beam of high intensity.

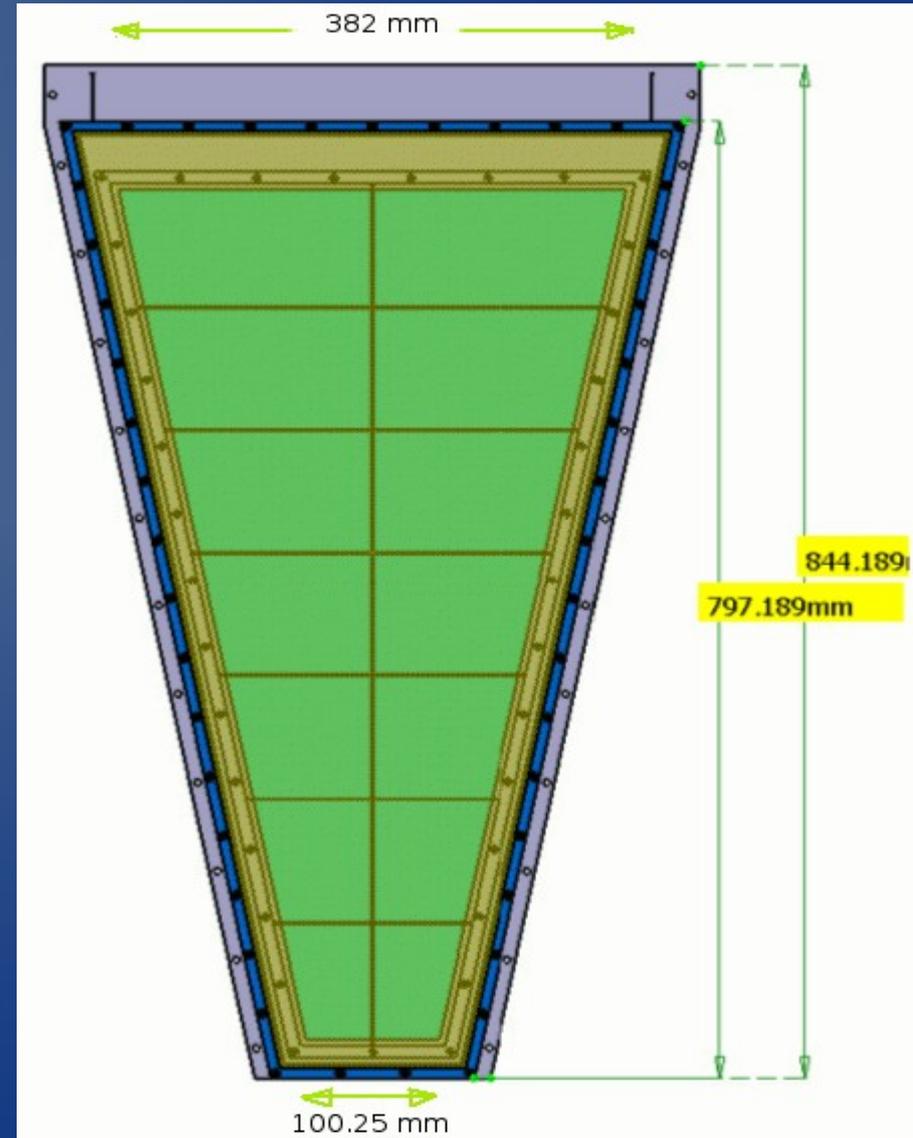
# Experimental Setup

- **Beam Used** – Proton Beam of momentum  $2.36 \text{ GeV}/c$ .
- **Gas mixture** – Ar:CO<sub>2</sub> in 70:30 ratio by mass.
- **Electronics** – nXYTER based readout system.



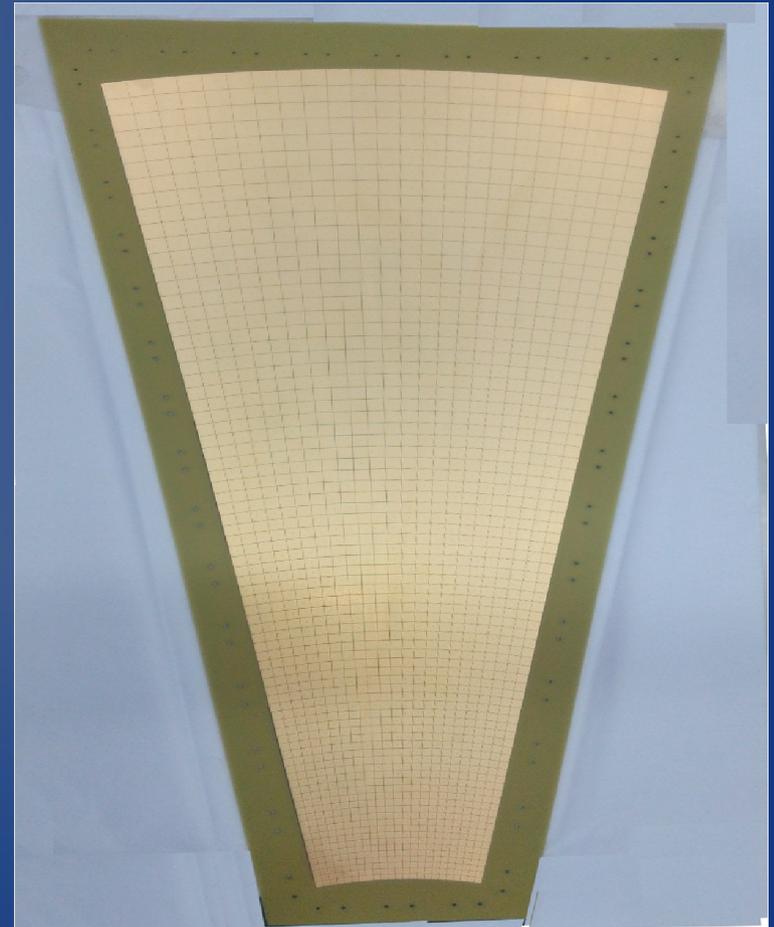
# Large GEM for CBM MUCH

- This trapezoidal shaped Large GEM is suitable for the 1st detector station.
- Dimension – 100.25 mm and 382 mm inner and outer radius respectively. 708 mm long active area. Final dimension 471 mm X 797 mm.



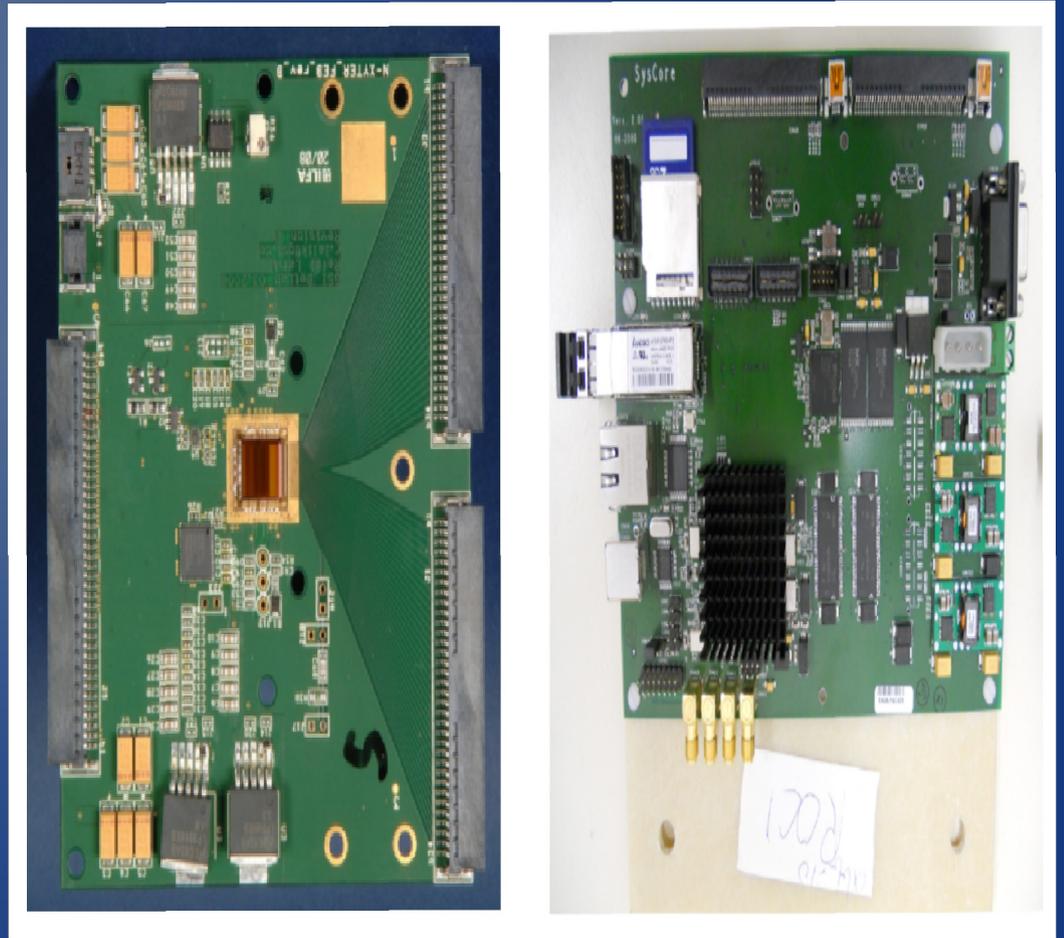
# Readout Anode Plane

- 1° progressive size readout pad.
- 23 X 79 pads.
- 3.96 mm X 3.96 mm to 16.6 mm X 16.6 mm.
- Each pad is trapezium with larger angle of 90.5° .



# Readout Electronics

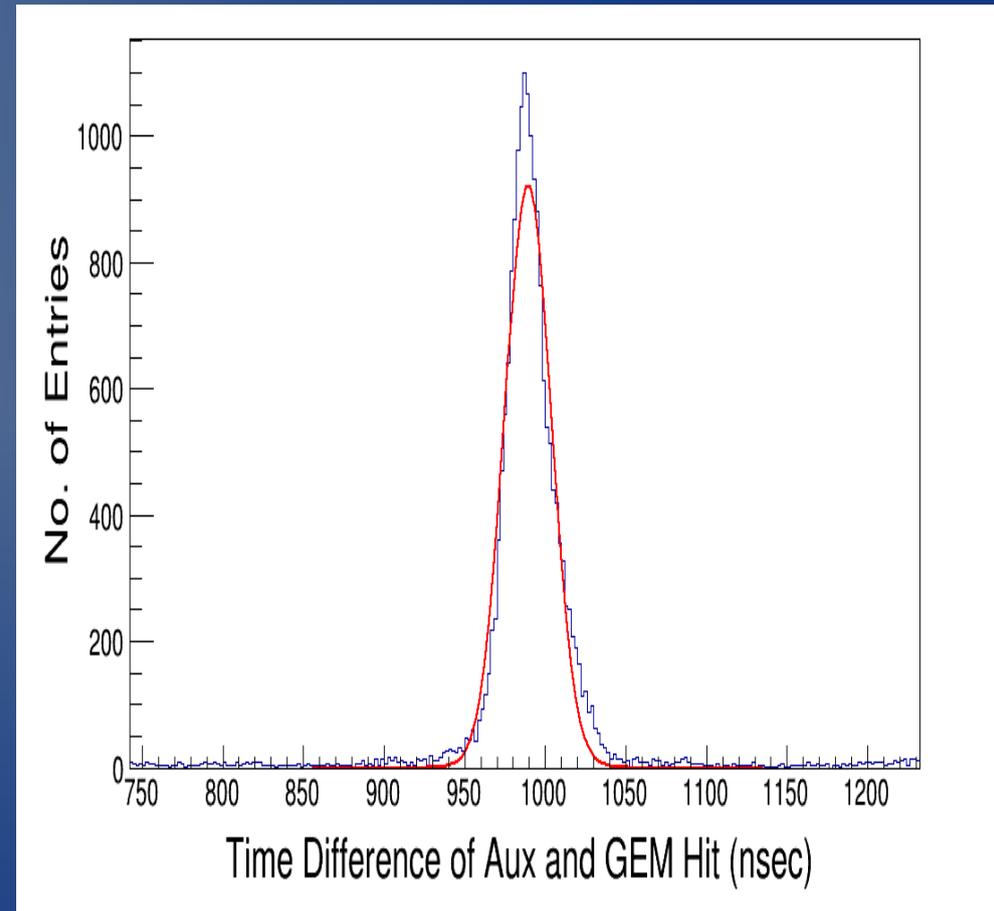
- We used nXYTER based Front End Board (FEB) connected to Readout Controller (ROC).
- 15 FEBs (8 ROCs) are needed to read signal from total GEM.



# Analysis Results

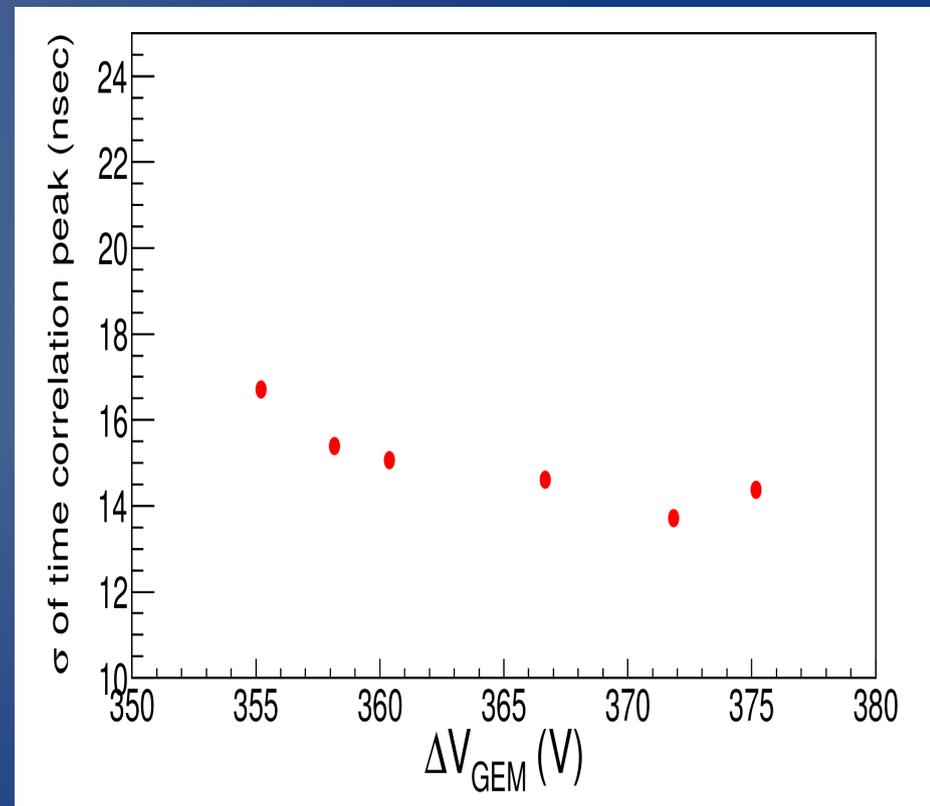
# Time Correlation of Aux Signal and Hit on GEM

- Two sets of crossed scintillator hodoscopes create the aux signal.
- Noise is uncorrelated but signal is correlated with the aux signal.
- The distribution of time difference between aux and signal at GEM is Gaussian.

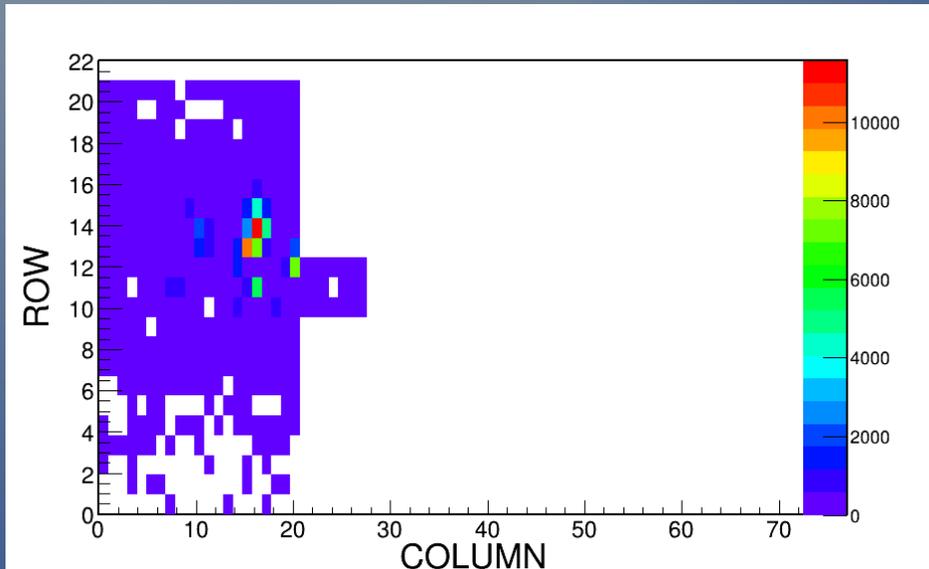


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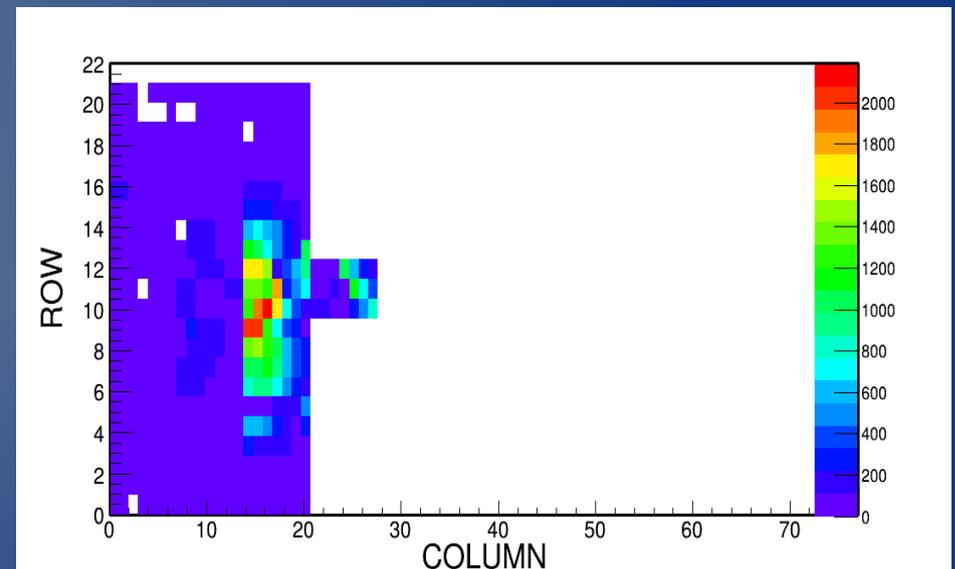
- The sigma of time correlation is related to time resolution of the detector.
- The sigma reaches minimum value of 13.7 nsec for  $\Delta V_{\text{GEM}} = 371.8 \text{ V}$



# 2D Beamspot on GEM



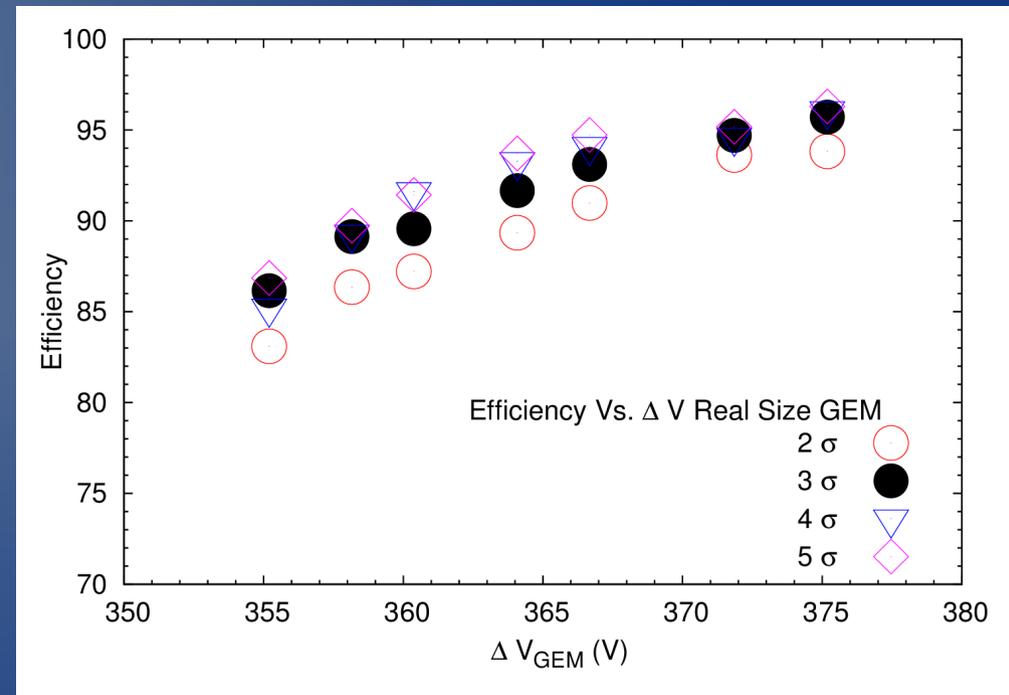
Beamspot at  $\Delta V_{\text{GEM}} = 375.2 \text{ V}$



Beamspot at  $\Delta V_{\text{GEM}} = 366.7 \text{ V}$

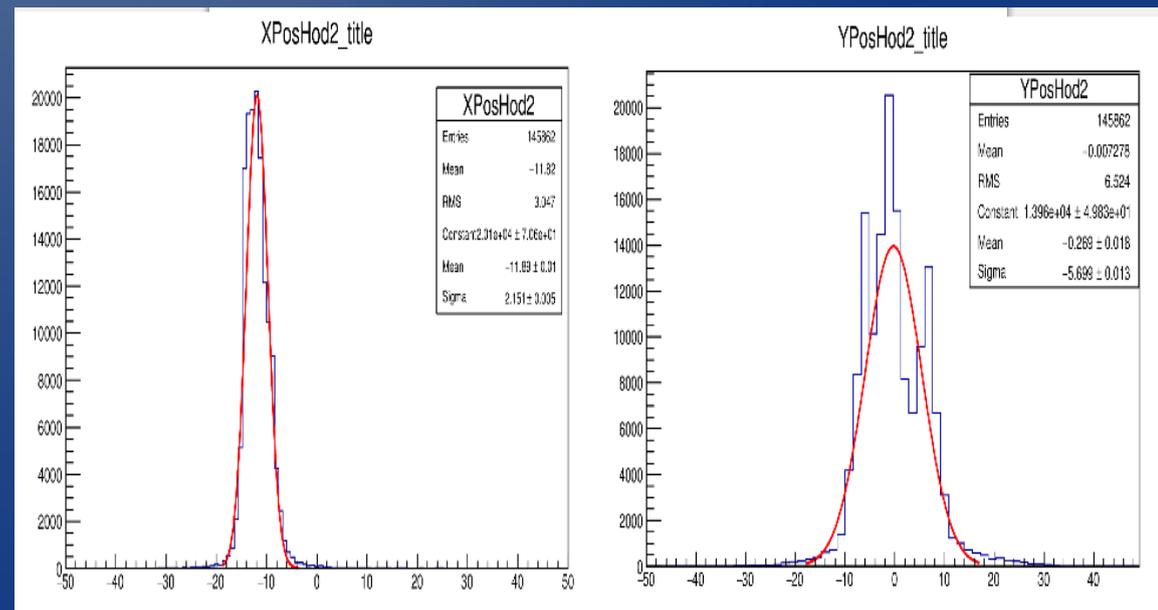
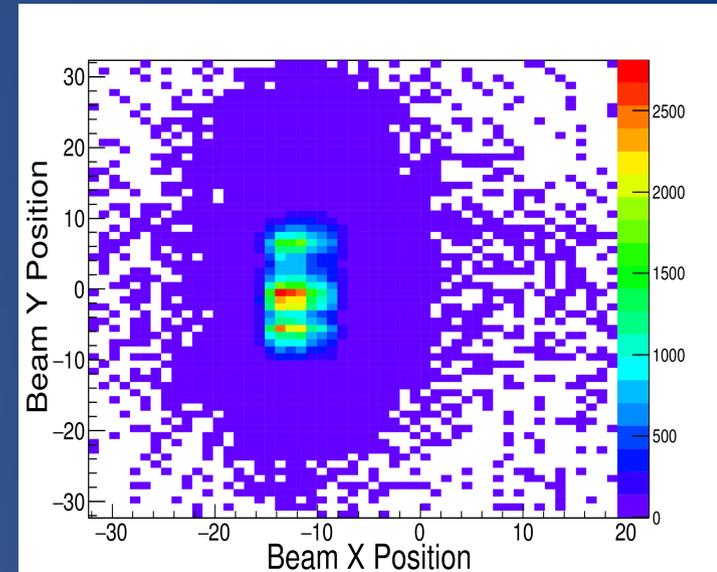
# Efficiency

- All hits correlated with aux signal are only taken for efficiency calculation.
- Efficiency = (No. of events with at least one hit on GEM/ No. of aux signals)
- We have calculated efficiency for different time windows ( $2\sigma$ ,  $3\sigma$ ,  $4\sigma$ ,  $5\sigma$  of time correlation spectra)



# Particle Rate Calculation

- The dimension of the beam is calculated from the XY distribution of hits on hodoscope.
- $\sigma_x$  and  $\sigma_y$  are calculated.
- $\sigma = \sqrt{(\sigma_x * \sigma_y)}$
- $\sigma_x = 2.15 \text{ mm}$ ,  $\sigma_y = 5.69 \text{ mm}$
- Beam size =  $12.23 \text{ mm}^2$

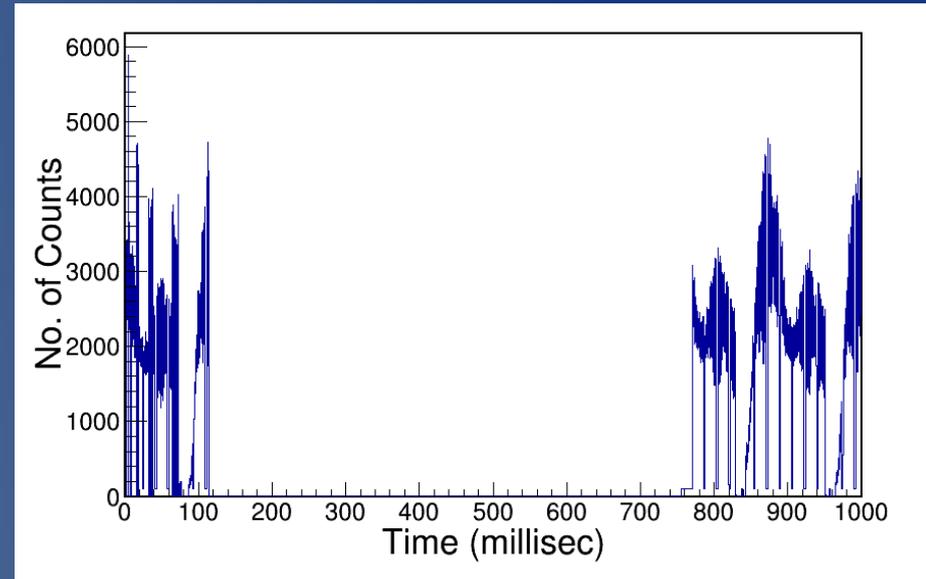


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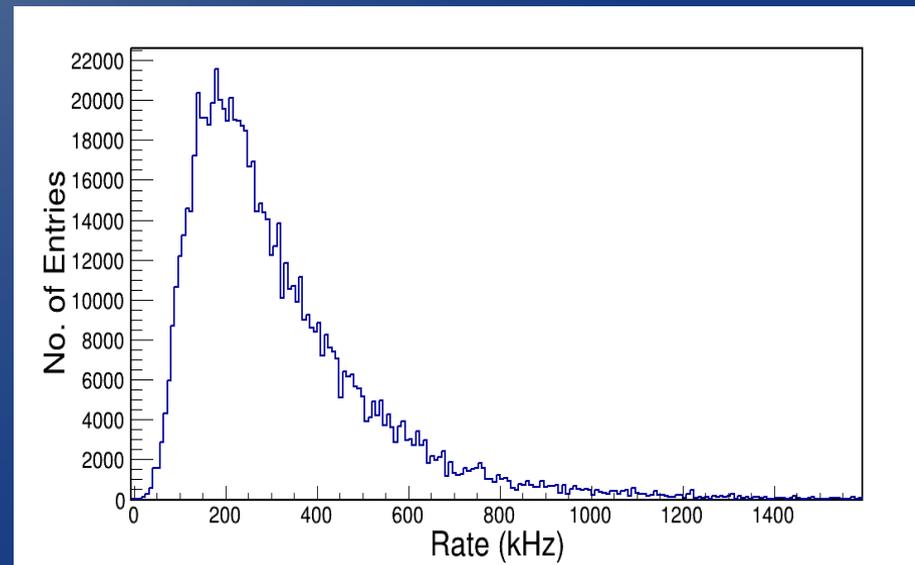
- The rate of incoming particles are calculated using two methods

- From the beam spill
- Taking average for 100 nsec time slice.

- So for a beam of rate 350 kHz of area 12.25 mm<sup>2</sup>, the rate is 2.85 MHz/cm<sup>2</sup>



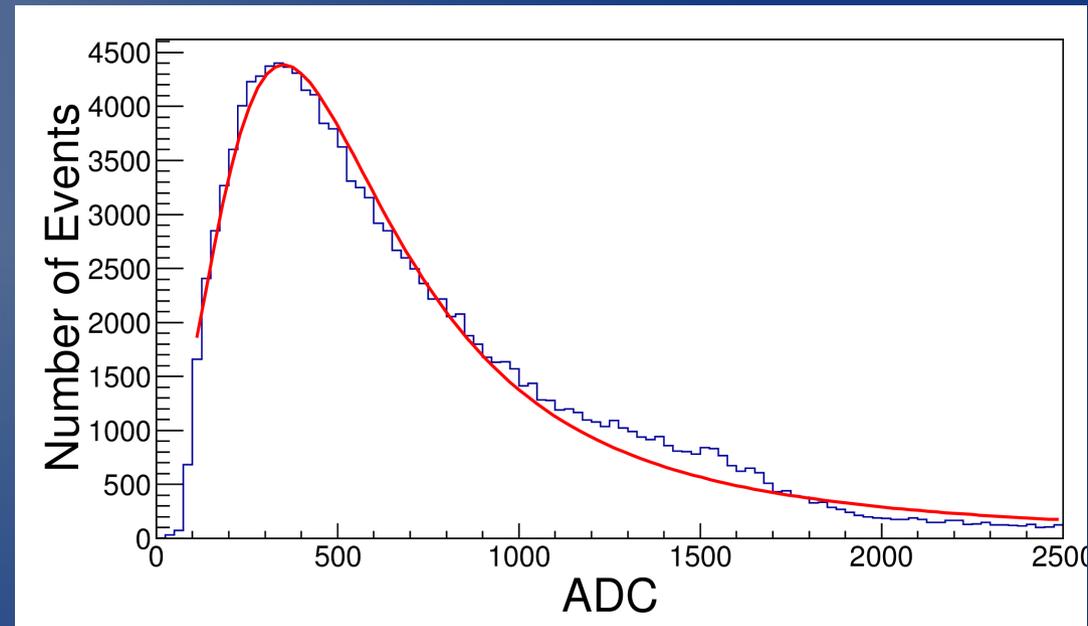
Spill structure at  $\Delta V_{\text{GEM}} = 375.2 \text{ V}$



Rate spectra at  $\Delta V_{\text{GEM}} = 375.2 \text{ V}$

# ADC Spectra

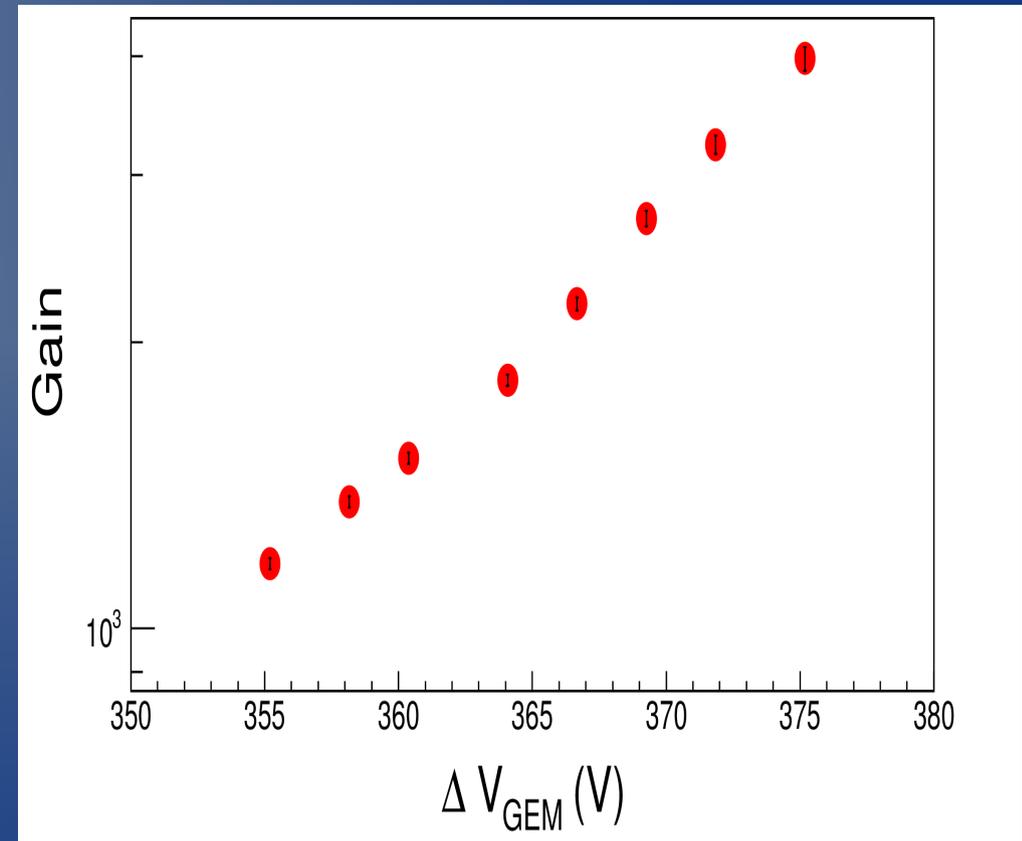
- The ADC of the hits within a time-correlation window of 250 nsec are taken.
- Pedestal are taken using auto-calibration method.
- ADC spectra is fitted using Landau distribution to find MPV.



ADC spectra for  $\Delta V_{\text{GEM}} = 366.7 \text{ V}$ ,  
MPV = 386.6

# Gain

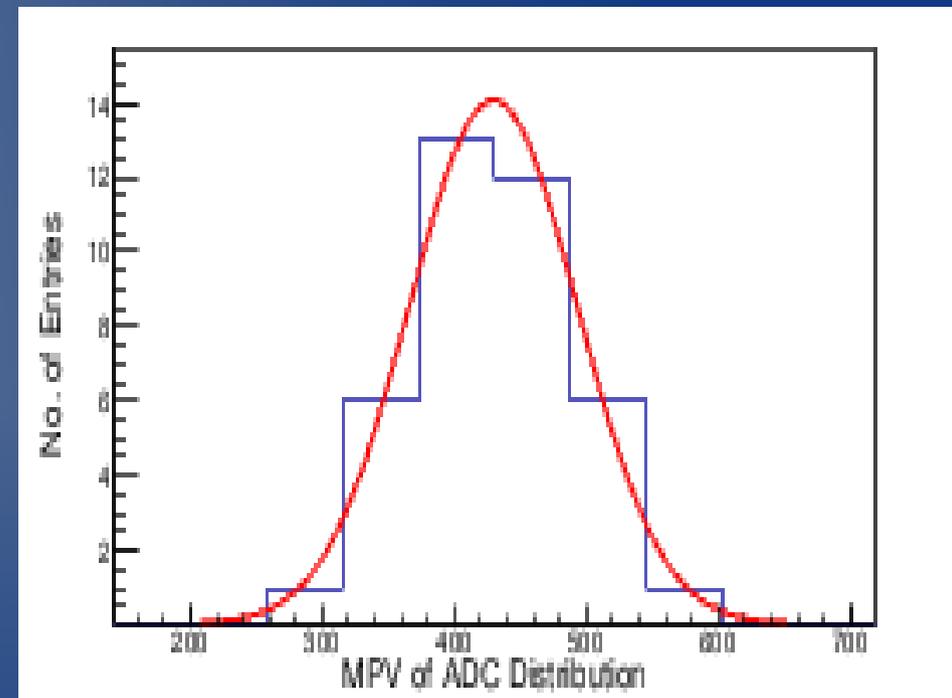
- The no. of primary electron in 3 mm gas gap is 33.
- Charge corresponding to ADC are taken from nXYTER calibration (NIM A 714(2013) 136).



Variation of Gain with  $\Delta V_{\text{GEM}}$

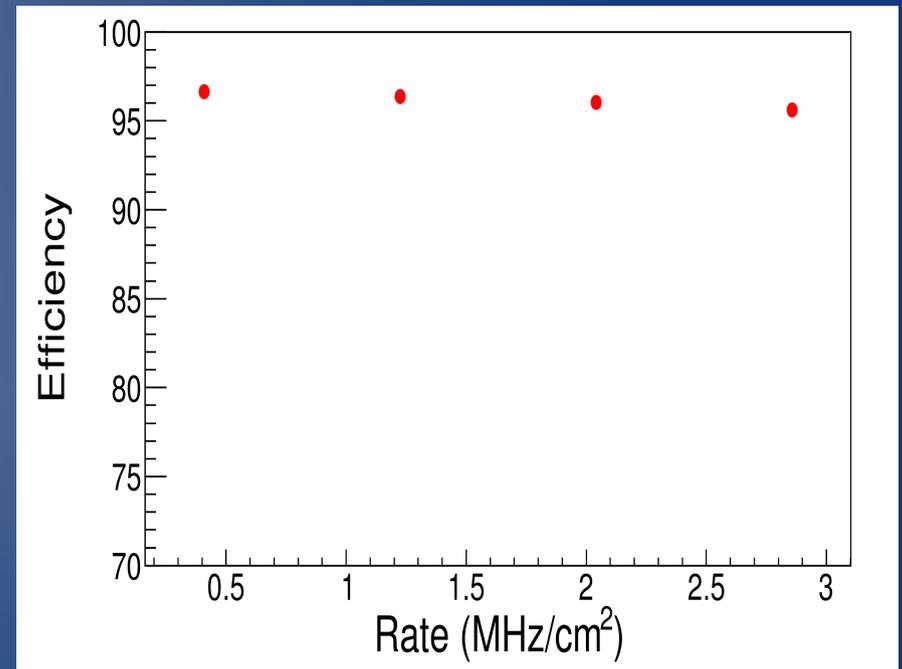
# Uniformity of gain

- We have chosen 39 different pads/regions for  $\Delta V_{\text{GEM}} = 369.2 \text{ V}$ .
- The MPV/gain distribution is uniform with MPV = 429 and  $\sigma = 63 \text{ ADC}$



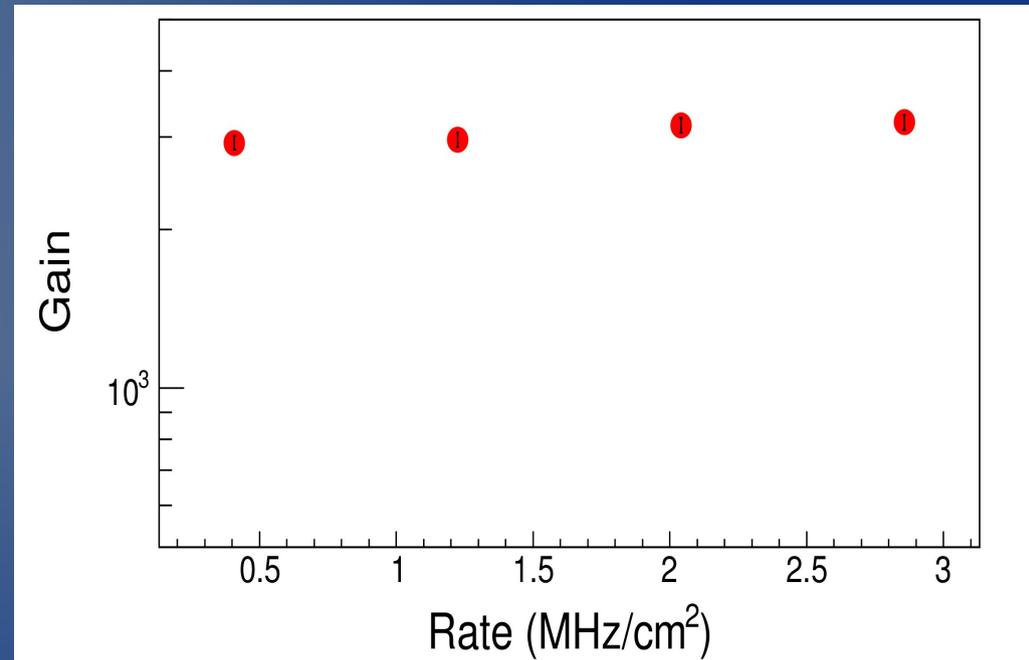
# Rate Handling Capacity

- The efficiency is uniform with the rate, but we see slight ( $\sim 2\%$ ) decrease in very high particle rate region.



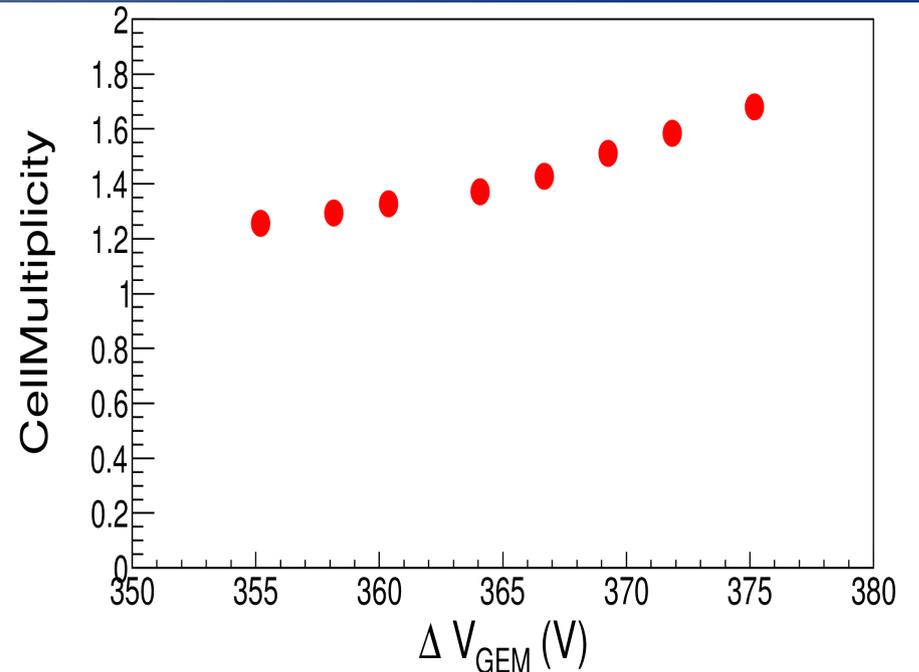
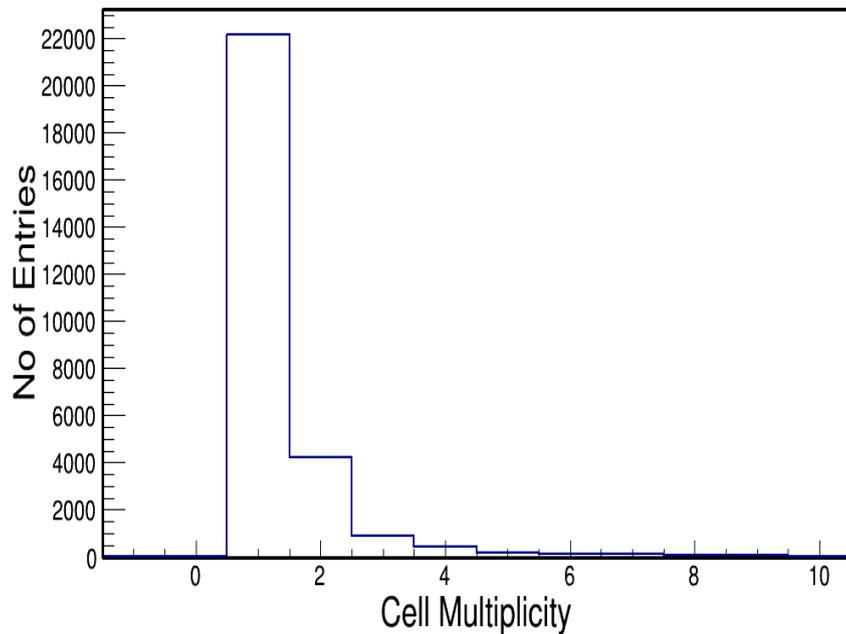
# Variation of Gain with Particle Rate

- The gain of the detector is uniform with the rate of the beam (slightly increases ~8%).



Gain Variation with particle rate for  $\Delta V_{\text{GEM}} = 375.2 \text{ V}$

# Cell Multiplicity



- The beam was falling within almost 1 readout pad of size 5.46 mm X 5.46mm .
- As the voltage increases the cluster size increases resulting in an increase of cell multiplicity.

# Conclusion

- First GEM detector has to be operated at a rate 300 kHz/cm<sup>2</sup> .
- We have operated a realistic size GEM with efficiency > 96% .
- The efficiency is uniform upto 2.85 MHz/cm<sup>2</sup>.
- The gain of the detector is uniform over different channels.
- The gain is uniform with respect to rate of particle upto the highest rate it will handle.

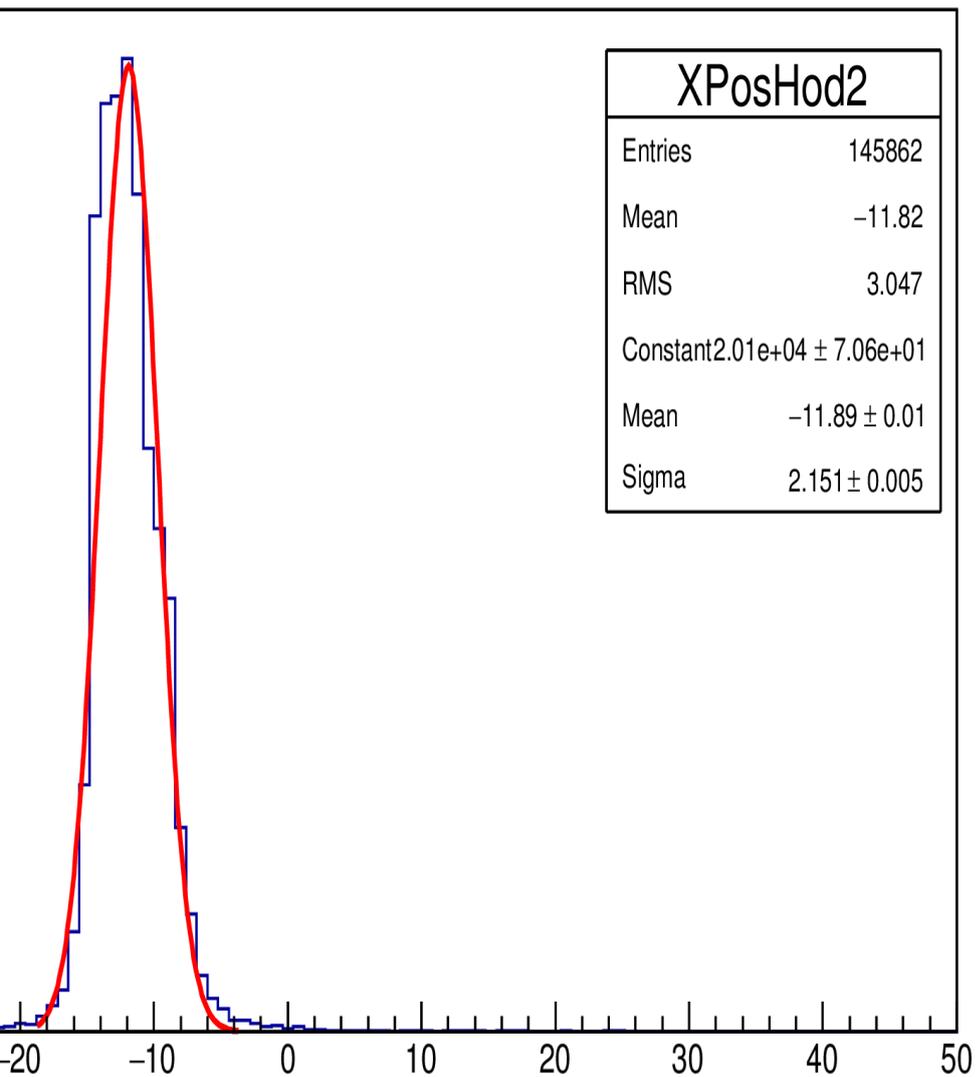
# Acknowledgement

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*THANK YOU*



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