The Triple GEM detector for relativistic hadron beams

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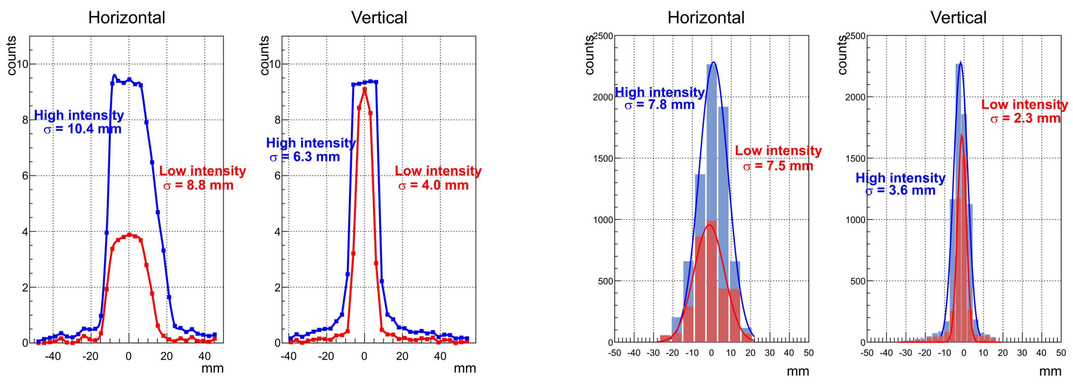
Introduction

A triple GEM detector [1] was tested at the CERF Facility [2] at CERN as an on-line beam imaging monitor and as a counting reference device (Fig. 1). It was exposed to a 120 GeV/c positively charged hadron beam for its alignment to a copper target installed inside the facility. The profile of the beam acquired from the GEM was compared to the one acquired from a Multi Wire Proportional Chamber (MWPC) and its counting to the one from an ionization chamber (IC) [3], routinely used at CERF for the monitoring of the beam intensity. The flux of beam particles ranged from $8 \cdot 10^4$ s^{-1} to $8 \cdot 10^7 s^{-1}$. The device was equipped with a thin Aluminium cathode and filled with $Ar/C0_2$ (70/30), with an active area of 5x5 cm^2 .

Figure 1. *Experimental set-up*

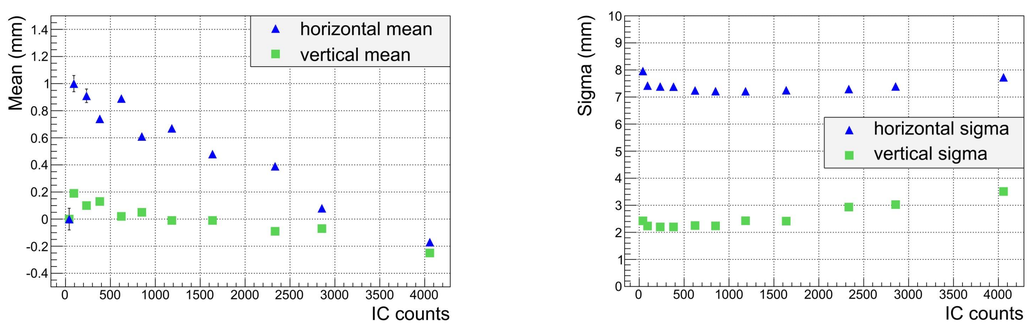
Comparison with the MWPC

The vertical and horizontal position of the beam and the sigma of the associated Gaussian distribution were determined with the MWPC (Fig. 2a) and the GEM (Fig. 2b). The beam remained aligned to the target with increasing intensity but opening the collimators lead to a slight diffusion. Saturation of the MWPC is observed in Fig. 2a.



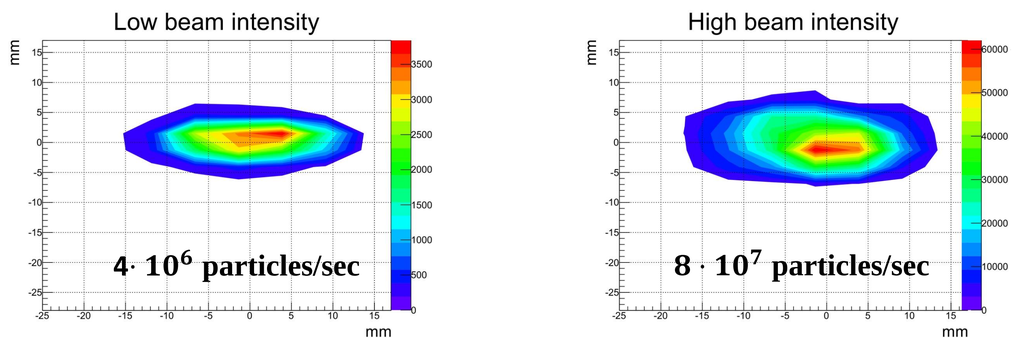
Figures 2a and 2b. *Beam profile from the MWPC and the GEM*

The mean and the sigma of the beam image as measured with the GEM detector during an intensity scan are summarized in Fig. 3a and Fig. 3b respectively, normalized to IC counts.



Figures 3a and 3b. *Mean and sigma of the beam profile in increasing intensity*

The beam dimensions did not increase symmetrically, as displayed in Fig. 4a and Fig. 4b.



Figures 4a and 4b. *Beam 2D image at low and high intensity*

Efficiency of the detector

The efficiency is illustrated in Fig. 8 as a function of the beam intensity and the average is $0.63 \pm 0.02\%$.

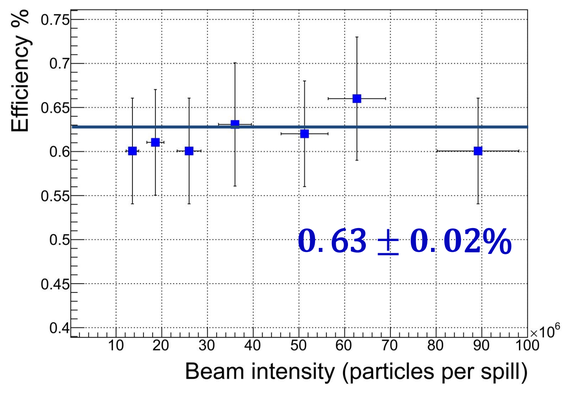


Figure 8. *Detector efficiency (per cent)*

Comparison with the IC

The particle flux has been measured both with the IC counts (Fig. 5) and the total current driven by the GEM foils (Fig. 6)

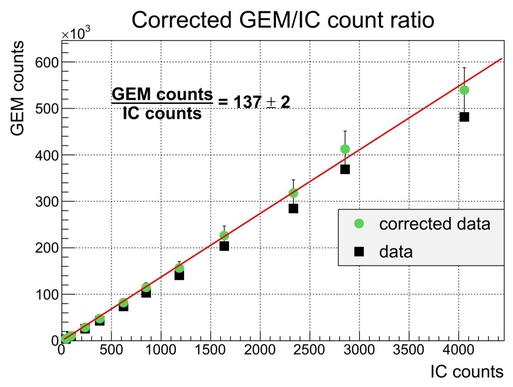


Figure 5. *GEM/IC count ratio*

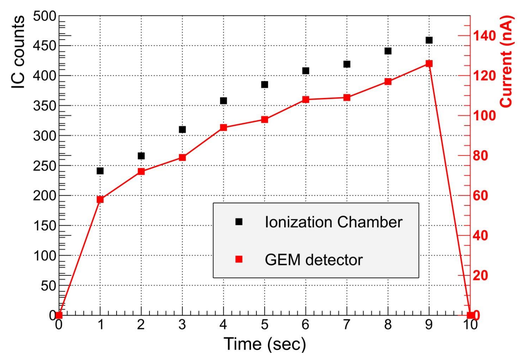


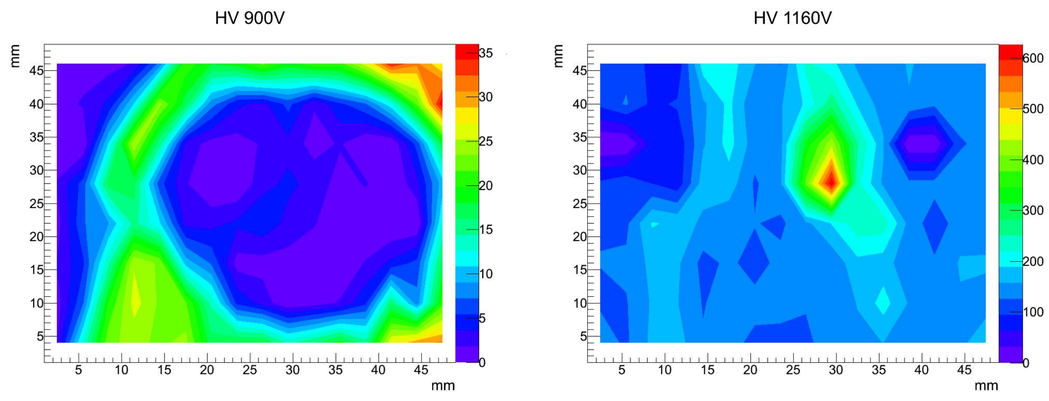
Figure 6. *Particle flux measured by IC and total GEM current from one spill*

Systematic errors in the number of GEM counts arise from:

- Dead time
- Sparks and masked channels
- Limited dimensions of the active area in high intensity

Activation of the detector

The detector was switched on 7 hours after its irradiation. The distribution of counts at 900V and 1160V is displayed in Fig. 7a and 7b respectively. The activation of the detector is probably responsible for the signal acquired.
This phenomenon is still under investigation via the FLUKA simulation code [4] & [5].



Figures 7a and 7b. *Activation at 900 V and 1160 V*

Conclusions

The detector showed good linearity in correspondence with the IC chamber without saturating. The digital readout allowed making a 2D online image of the beam for the alignment with the target. The efficiency of the detector was measured and possible activation was observed. The triple GEM detector could be permanently installed in the CERF facility for monitoring the beam intensity and profile.

References

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