Performance of the Triple GEM detector for low energy neutrons at the CERF facility

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Introduction

A side-on triple GEM detector for low energy neutrons and high rejection of gamma background [1] was tested at the CERF Facility [2] at CERN. It was exposed to a wide spectrum of neutrons generated by a 120 GeV/c positively charged hadron beam (approximately 2/3 pions and 1/3 protons) which hits a copper target. The flux of beam particles on target ranged over three orders of magnitude, from $8\cdot10^4$ s^{-1} to $8\cdot 10^7$ s^{-1}. The neutron count rate measured with the GEM was correlated with the count rate from an Ionization Chamber [3], the reference instrument routinely used for monitoring the beam intensity.

The detector

Borated glass sheets were used for the detection of slow neutrons. When a neutron is absorbed into the ^{10}B layer, an alpha particle and a ^{7}Li ion are produced through the following reactions:

$$n + {}^{10}B \rightarrow {}^{4}He + {}^{7}Li \text{ (Q=2.8 MeV, BR=7\%) or}$$
$$n + {}^{10}B \rightarrow {}^{4}He + {}^{7}Li + \gamma \text{ (478 keV) (Q=2.3 MeV, BR=93\%)}$$

One set of five glass sheets 40x10x1 mm^3 was borated using an electron deposition technique and placed in the same detector with another set of five sheets, which were not borated (Fig. 1).

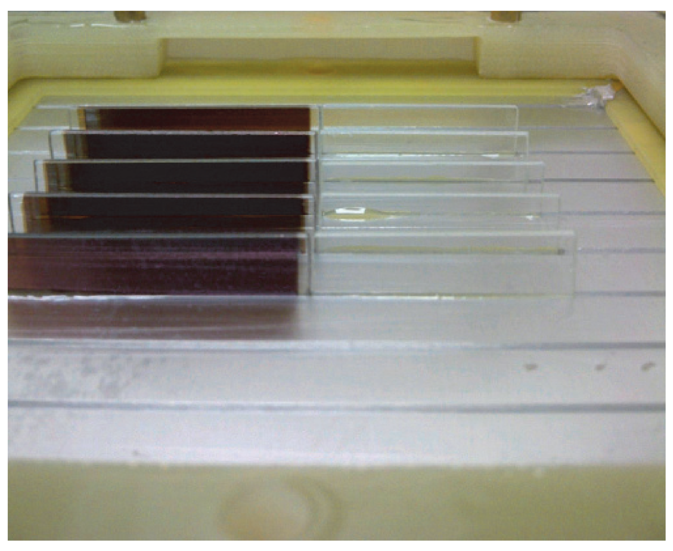

Fig. 1: View of the cathode with borated glass (left) and simple glass (right)

The charged particles produced from neutron interactions in the borated glass ionize the gas mixture in the drift region of the detector thus producing secondary electrons. These electrons drift reaching the GEM foils where they are multiplied and induce a detectable signal (Fig. 2).

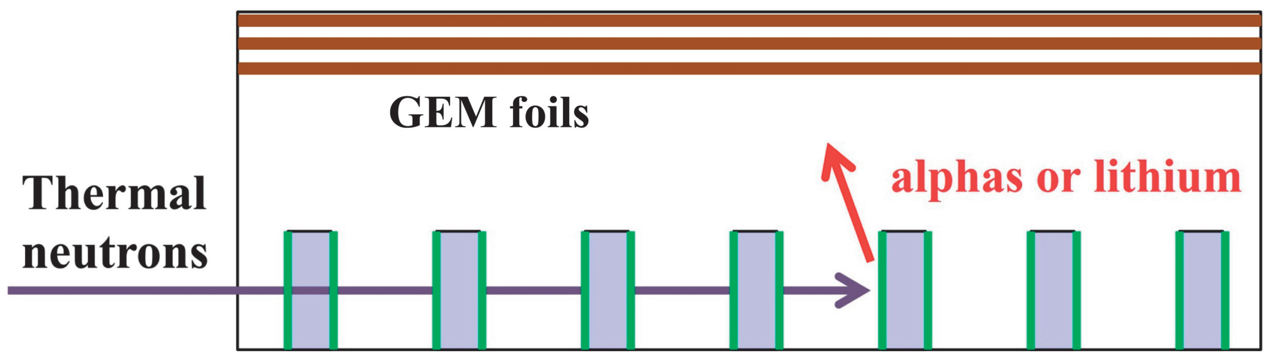

Fig. 2: Thermal neutron conversion in the borated sheets

Detected neutron rate

The intensity of the primary beam was monitored by an air-filled Ionization Chamber (IC) and the number of neutrons detected per beam particle impinging on the target was equal to $(35 \pm 1) \cdot 10^{-6}$ (Fig. 6).

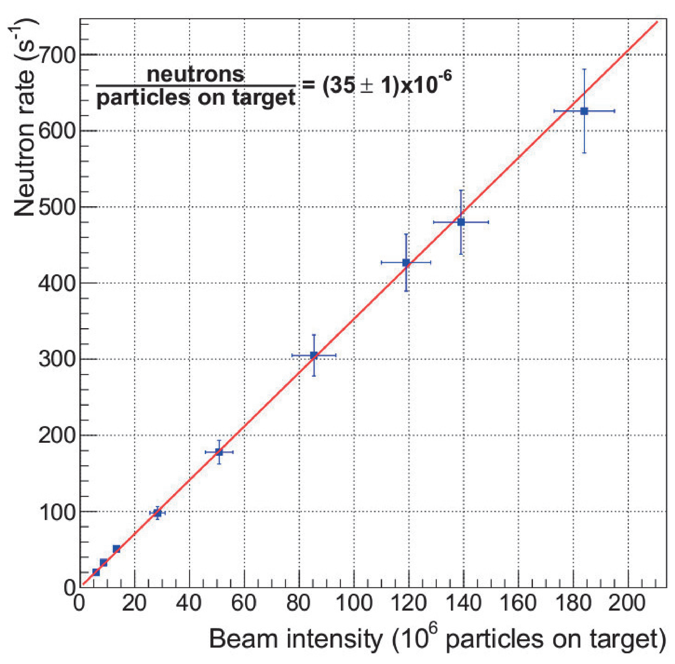

Fig. 6: Neutrons detected per beam particle on target per second

Conclusions

A Triple GEM detector with borated glass sheets was tested at the CERF Facility at CERN for the detection of slow neutrons. By applying suitable voltage to the foils, the detector can be tuned in order to obtain high rejection of gammas and thus a satisfactory efficiency for neutron detection.

Cluster size and HV scan

The cluster size was measured from the mean number of pad multiplicity with a statistical error of 10%; the results are shown in Fig. 3. The size increases with increasing voltage.

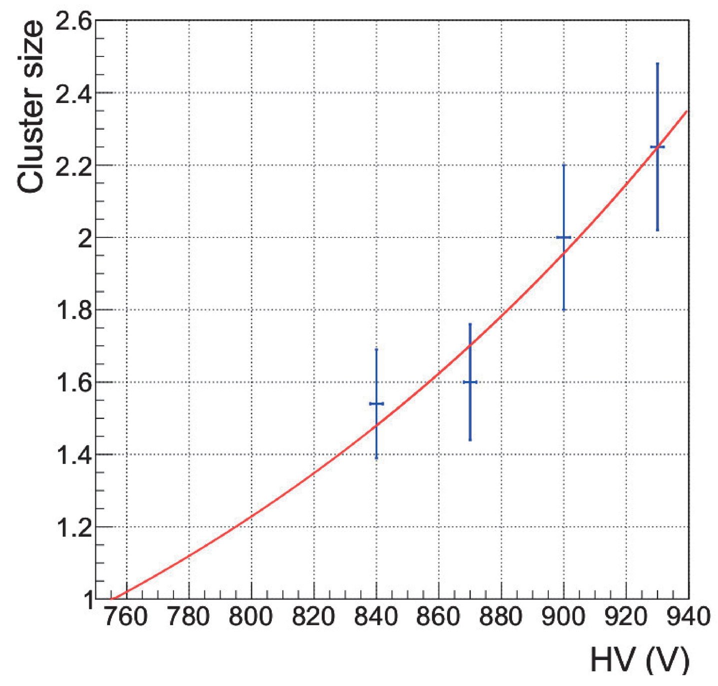

Fig. 3: Pad cluster size as a function of increasing HV

The signal acquired from the area with glass sheets works as a background monitor and the total number of counts collected from this area is subtracted from the counts from the borated glass sheets. As shown in Fig. 4, with increasing voltage the number of detected neutrons increases, reaching a plateau between 830 V and 870 V.

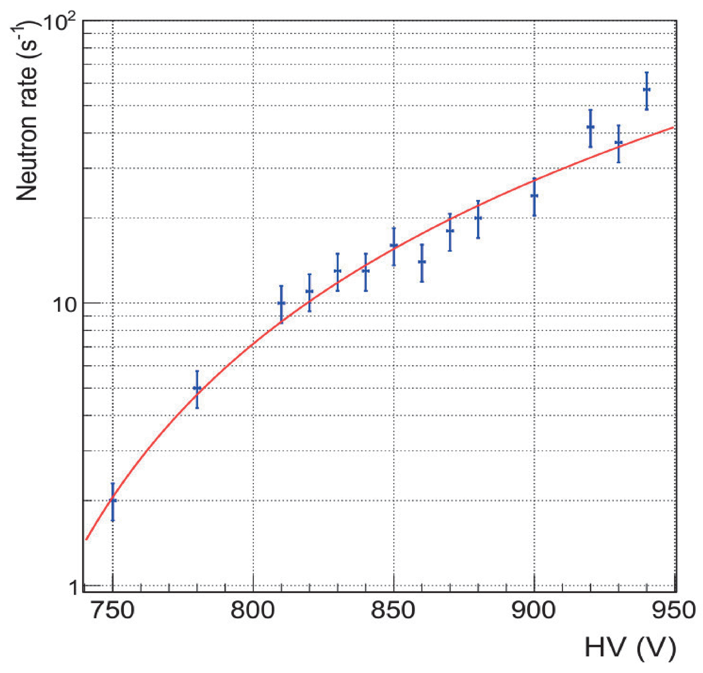

Fig. 4: Detected neutron rate as a function of increasing HV

An additional scan was performed in the laboratory with a ^{137}Cs source (Fig. 5). For an applied voltage lower than 870 V, the signal is derived only from neutrons, but for higher voltages photons contribute. The working point was determined as 850 V.

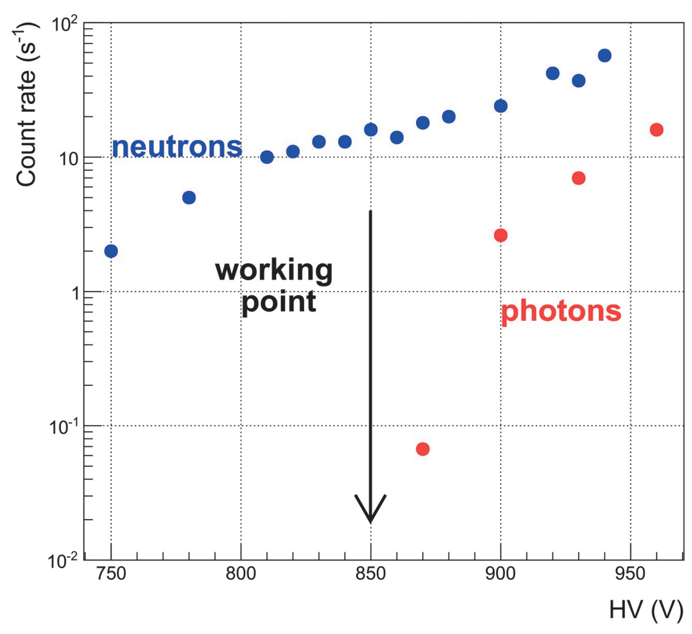

Fig. 5: The photon rejection is below 870 V

References

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