Test of a triple GEM chamber with neutrons using alpha beam at VECC cyclotron

A. K. Dubey[1,*] J. Saini[1], R. Ravishankar[2], T. Bandopadhyay[2], P.P. Bhaduri[1], R. Adak[3], S. Samanta[3], S. Chattopadhyay[1], G.S.N. Murthy[1], Z. Ahammed[1], S.A. Khan[1], S. Ramnarayan[1], S. Muhuri[1], P. Ghosh[1], S.K. Pal[1], T.K. Nayak[1] and Y.P. Viyogi[1]

[1]*Experimental High Energy Physics and Applications group VECC, Kolkata, 700064*

[2]*Health Physics group VECC, Kolkata, 700064*

[3]*Bose Institute, Kolkata, 700064*

* *email: anand@vecc.gov.in*

A GEM based detector system is being developed at VECC for use as muon tracker in the Compressed Baryonic Matter (CBM) experiment at the upcoming FAIR facility at Germany[1][2]. The Muon Chambers(MUCH) consist of alternating layer of six absorbers and detector stations. The harsh radiation dose in CBM owing to high hadronic environment poses severe constraints on the design of the detectors. In addition to this, the thick iron absorbers of

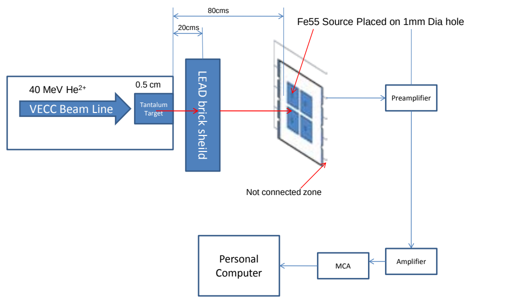

Fig. 1 Schematic of the neutron test setup at VECC.

MUCH also contribute to the neutron background immensely. As per fluka calculations[3], it is estimated that the MUCH detectors will have to cope up with a very high neutron flux which may contribute to the background hits in the detector. The detector will also have to withstand a high neutron dose of the order of 10^{13} neq/cm^2/year. It thereby becomes important to study the response of the GEM detector to neutrons. The aim of the neutron tests is two fold: to measure how many neutron hits is seen by the detector so as to have an idea of the number of background hits per event on the GEM detector and also to study the response of the detector before and after neutron irradiation, in terms of relative change in gain, or in terms of any physical damage due to irradiation. In this direction, we conducted the first such test of a triple GEM chamber in VECC cyclotron. As shown schematically in Fig.1, a 40 MeV alpha

Fig. 2 Picture of the neutron test setup at VECC. Top picture shows the setup with beam shielding.

beam on hitting 0.5 cm thick Tantalum target produces neutrons and gammas as the end product. To screen away the gammas, a Pb shield of 30 cm is placed in front of this target thus allowing only the neutrons. The triple GEM chamber was placed at about 80 cm away from the tantullum target and was operated at Vgem ~340 Volts across each GEM layer. The gas mixture consisted of Ar/CO_2 mixed in the ratio (70/30). The GEM signal collected by the readout pads was connected to standard Ortec NIM electronics and the amplified signal was fed to an MCA from where it was recorded onto a PC. Data corresponding to different beam currents(which corresponded to different neutron intesities) were taken with and without the Pb absorber and the response of the detector studied. Neutrons flux was estimated by measuring the flux with BF_3 counters for current ranges from 50 – 500 nA for both with and without Pb shield.

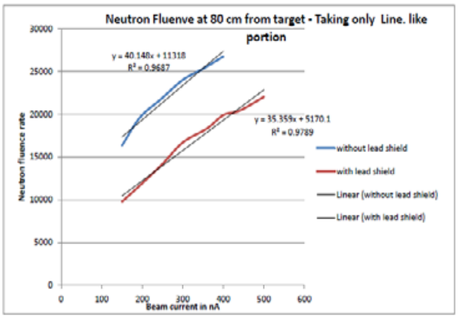

Fig. 3 Neutron fluence vs. beam current as measured by BF_3 counter.

A calibration relation thus obtained as shown in Fig.3 was used to obtain the neutron flux for higher beam currents. The BF_3 counter was then

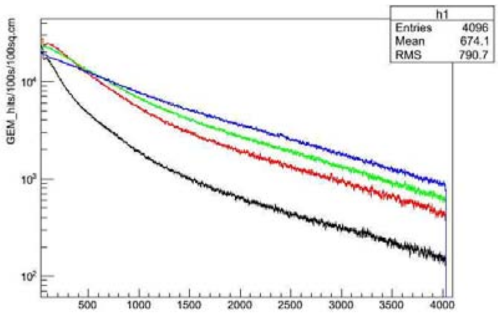

Fig. 4 Pulse height spectra from the triple GEM detector for four different neutron beam intensities.

replaced by the GEM detector. Fig. 4 shows the pulse height spectra from the detector for four different beam currents(neutron intensities) without Pb shielding. Counts have been normalized to number of GEM hits per 100 seconds per 100 sq.cm. The highest neutron flux corresponding to a beam current of 4 uA, as derived from the calibrated fit was about ~ 10^5 neutrons/cm^2/s. For every current setting, three sets of data were taken and the number of GEM hits for each of these sets were estimated. Fig. 5 shows these hits vs. the beam current. About 350 hits/sq.cm/s was seen corresponding to a maximum neutron flux of ~ 10^5/sq.cm/s. The expected neutron rate in CBM experiment is

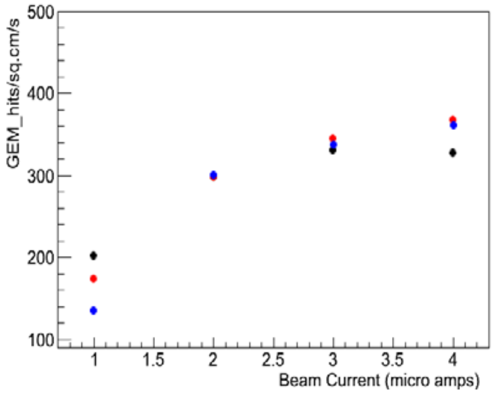

Fig. 5 number of GEM_chamber hits/sq.cm/s vs. beam current.

expected to be 10^5/s resulting from 10^6 collisions/s. The test results indicate that the background hits per event in the GEM detector due to neutrons would be insignificant thereby ruling out any tracking issues due to neutron hits. The prototype detector was exposed to neutron radiation for about four days and the integrated dose of exposure in four days of beamtest was about 10^{11} neq. over 100 sq. cm. No visible damages were observed after this irradiation. It is planned to conduct more such tests in future at higher beam intensities and at higher overall dose of neutron exposure to investigate the detector response in detail.

Acknowledgements

We acknowledge the help from Anna Senger and Peter Senger of GSI, Darmstadt, in Fluka calculations. We also thank the VECC cyclotron division for excellent beam during the tests.

References

[1] Conceptual Design Report (CDR)
[2] A.K. Dubey, et. al, DAE Symp. On Nucl.Phys. **vv**, ppp (2010), Anna Kiseleva, P.P. Bhaduri, et.al. 85, 211-216 (2011)
[3] A. Senger, CBM Progress Report 2012, p26.