A study on detector Crosstalk due to pileup in preamplifier

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Introduction

A GEM-based tracking system is proposed to be used for muon tracking in the upcoming CBM[1][2] experiment at FAIR, Germany. The peak hit density in the central region of the chamber is expected to reach 1 MHz/cm^2. Such high rate of operations coupled to high granularity (pad size 3mm X 3mm) led to more complex PCB-layouts designs. It is always desired to build circuits with low crosstalk, but in a dense design, crosstalk may be unavoidable and could complicate the data analysis. Conventionally, frequency dependent crosstalk is determined by rise time and fall time of the signal, which results in change of amplitude of crosstalk signal. However in the present study, the frequency refers to the pulse repetition rate rather than a pulse shape. This paper shows a case where in addition to crosstalk there is a pile-up of crosstalk, which initially looks like a frequency dependent phenomenon but with careful analysis it has been found to be caused by the slow feedback circuit of preamplifier. To analyze this, a systematic study was done using triple-GEM [3] detector along with self-triggered nXYTER [4] electronics.

Test setup and result

A triple-GEM chamber with pad readout of 3*mm* × 3*mm* pads, was tested at CERN H4 beam line using 150*GeV/c* muon and pion beams of intensities varying approximately from 100*Hz* (mostly muons) to 300*KHz* (mostly pions). nXYTER consists of a preamplifier followed by a fast shaper and a slow shaper. The shaping time constants of the slow and fast shapers are 140ns and 40ns respectively suiting the high rate application of the detector.

Fig. 1 and Fig. 2 show the 2D histogram of the pad response of the detector, readout via nXYTER electronics at beam rates of 600Hz and 30 KHz respectively. The detector gain was kept same for both the cases. It is clear from the figures that, as opposed to the low intensity run, where a well-defined beam spot is seen at the center and no crosstalk seen at the edges, the beam-spot is not clear at high intensity run. It can be seen from the Fig2 that the center cell is receiving very less hits due to saturation [5] and crosstalk presents at the edges of the detector which looks more prominent then central region.

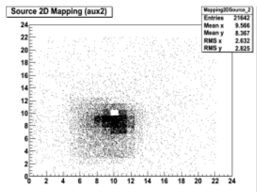

Fig. 1 2D plot at 600Hz

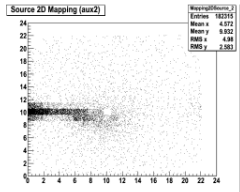

Fig. 2 2D plot at 30KHz

This effect is observed to be more prominent at higher gain of the chamber. Since for both the cases, input pulse shape is similar as it is from the same detector and it reflects the same rise time of input signal and only change in repetition rate, so the present study is focused on reasons other than crosstalk alone.

Lab test and Results

For testing the crosstalk seen in Fig. 2, we have used a triple GEM detector and irradiated it with X-ray generator. Detector was readout by self-triggered nXYTER based electronics and data have been stored in the personal computer using readout controller developed by CBM collaboration. For change of intensity, we could change the current of the mini X-ray generator and to further reduce the intensity, we put the copper filter provided along with the generator. To perform this study we started with the low gain of chamber which is represented by HV of 3100V and low frequency corresponds to mini X-ray supply of 15KV with current of 5mA with one copper filter inserted. There are different sets of reading taken but here we will take 15KV/100mA and 15KV/200mA as a high frequency runs. For this study, beam position was not changed and the central channel with peak hits with low intensity was CH#29 and peak crosstalk channel was CH#28 for intensity condition. Fig.3 and Fig.4, Leftmost figure is 2D plot, middle is ADC plot for crosstalk cell and rightmost is ADC plot for center cell. Fig.3 represents the low frequency (i.e. 5mA x-ray current) and high feedback resistance of preamplifier (i.e. Vbfb=50) and we can clearly see no crosstalk in nearby cell. Fig.4 represents high frequency (i.e. 200mA x-ray current) with same feedback resistance and we see the center cell is saturated and crosstalk cell is more prominent then the center cell.

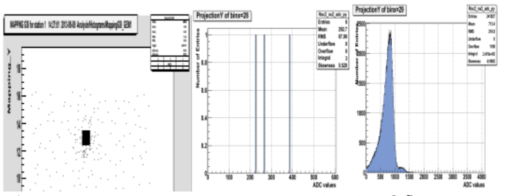

Fig. 3 HV3100V, X-ray setting 15KV/5mA, Vbfb 50

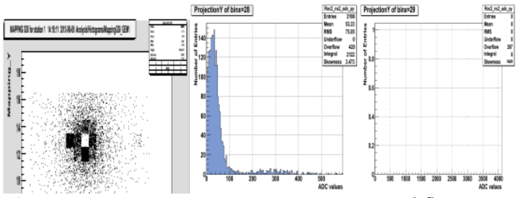

Fig. 4 HV3100V, X-ray setting 15KV/200mA, Vbfb 50

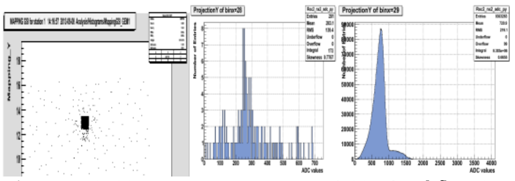

Fig. 5 HV3100V, X-ray settings 15KV/200mA, Vbfb 150

Fig.5 shows with high frequency and with low feedback resistance (i.e. Vbfb=150), we see crosstalk is reduced and there is no saturation in center cell. At low frequencies crosstalk is not seen (ref. Fig.1), since it is not crossing the threshold, as shown schematically in Fig.6, where top waveform represents center cell and bottom represents crosstalk cell. But with high frequency (ref. Fig. 2), pile up of crosstalk is crossing the threshold as represented by bottom waveform of Fig. 7 and center cell is saturated as represented in top waveform of Fig. 7.

Further studies were done with varying charge injected to preamplifier by varying gain of the GEM chamber and it was observed that after certain gain settings, the crosstalk is unavoidable. This indicates increase of cross-talk due to geometrical reasons, while the earlier crosstalk which was electronics parameter dependent was due to pileup in preamplifier.

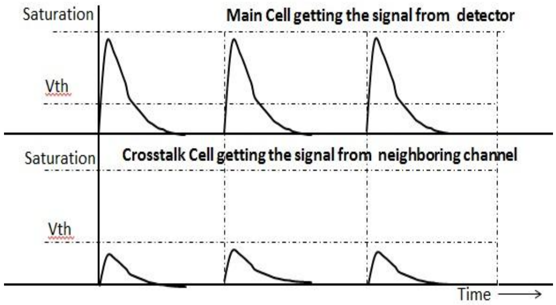

Fig.6 Pulse response at low frequency

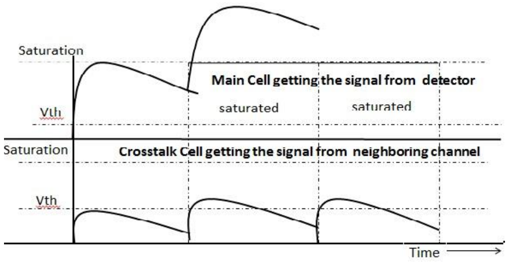

Fig.7 Pulse response at high frequency

Conclusion

With the x-ray test results, the structure in the beam spot which appears only at high frequency is understood and this is attributed to crosstalk pileup in nXYTER preamplifier.

Acknowledgement

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