Testing of self-triggered nXYTER electronics for integrating with GEM detector for high frequency operation

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Introduction

A GEM-based tracking system is planned to be used for muon tracking in the proposed CBM[1][2] experiment at FAIR. The peak hit density in the central region of the chamber is expected to reach 1 MHz/cm^2. For a detector to be operational at high intensity (upto MHz), it is useful to know the compatibility of the readout electronics with the detector. At very high rates and sufficiently large signal amplitude, there is a possibility of preamplifier saturation resulting in zero or distorted amplitude of the output signal. Conventional method of using either a square or tail pulse for injecting a test signal thorough a capacitor, may give better results for validating electronics only configuration. However when the electronics are connected to the detector, inefficiency of detection and output distortion might arise even at low frequencies. In this paper we have presented tests with two different types of waveform and reported that the staircase waveform is best suited for high frequency integration tests and validation of electronics.

Test with Fe55 Source using GEM detector and nXYTER electronics

A triple-GEM chamber with pad readout with a $3mm \times 3mm$ pads, was tested using Fe55 X-ray source. The source frequency with 1 mm collimation was about 5 kHz as recorded by conventional electronics coupled to an MCA. For detailed study, later detector was readout by a self-triggered readout ASIC called nXYTER [4]. nXYTER consists of a preamplifier followed by a slow shaper and a fast shaper. The shaping time constants for the slow and fast shapers are 140 ns and 40 ns respectively suiting the high rate application of the detector. After analysis of beam spot acquired with Fe55 source, we observed that the center cell is not receiving any hits and a ring like structure is formed as shown in Fig. 1. ADC plot shown in Fig. 2 also verifies no hits in central cell. To solve this issue, we tried by changing the feedback resistance of nXYTER which is controlled by a bias parameter (Vbfb). Large value of Vbfb represents the lower feedback resistance of Charge Sensitive Preamplifier (CSA) and vice versa resulting in lowering of discharge time of CSA..

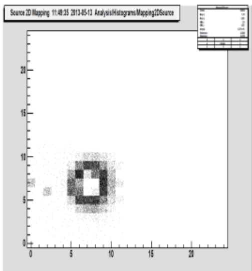

Fig.1 DAQ 2D plot with Fe55 Vbfb=6

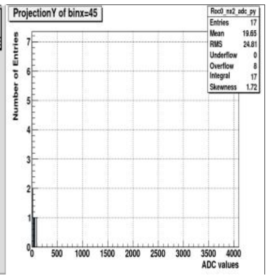

Fig.2 DAQ 2D plot with Fe55 Vbfb=6

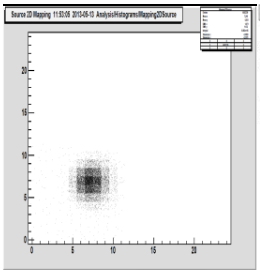

Fig.3 DAQ 2D plot with Fe55 Vbfb=55

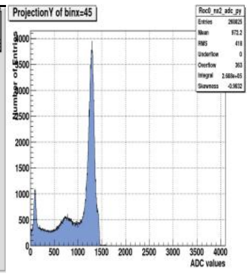

Fig.4 DAQ 2D plot with Fe55 Vbfb=55

With larger Vbfb=55 (i.e. low feedback resistance) we observe that the center cell hits are restored and we see a well-defined beam spot as shown in 2D plot in Fig.3. At this Vbfb setting, characteristic peaks of Fe55 are seen clearly including the escape peak as shown in Fig. 4. This indicates the saturation in the main cell at the frequency of approximately 5 KHz at low Vbfb=6 while the GEM detector is reported to be operational at much higher frequency [5]. To study this inconsistency, a systematic study was done to check the integration of nXYTER electronics with GEM detector.

Lab test and Results

To study the electronics behavior in detail, we injected charge to the test channel of nXYTER using a tail pulse with frequency of 500 KHz and input charge of 50fc. Fig. 5 waveform (a) shows the tail pulse fed through a charge injector and waveform (b) shows the shaper output from nXYTER. The output shows good pulse shape at this frequency which does not explains saturation in preamplifier seen in Fig. 1.

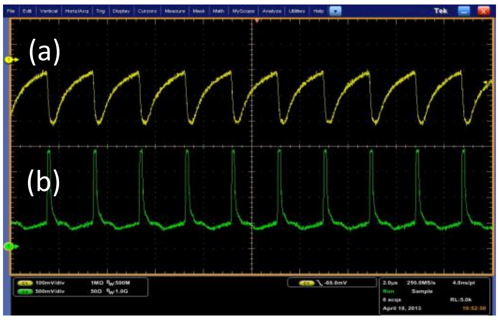

Fig. 5 tail pulse input to preamplifier and Shaper output at 500Khz and Vbfb=6, Input charge = 50fc

To solve this, a special type of staircase waveform is designed to inject 9 consecutive charge pulses to the test channel of nXYTER without a discharge unlike tail pulse shown in Fig. 5. With this input, we have studied the nXYTER output waveforms by varying Vbfb.

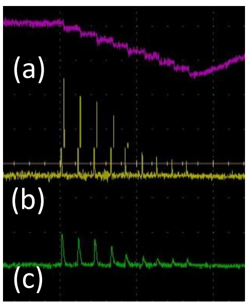

Fig.6 Scope screen shot with Vbfb=25 and freq=500Khz Input charge = 15fc

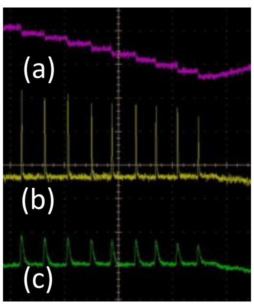

Fig.7 Scope screenshot with Vbfb=70 and Freq=500Khz Input charge = 15fc

Fig.6 and Fig.7 are scope screenshots, where waveform (a) is ladder pulse as input to a 1pf capacitor which injects the charge in the test channel of nXYTER. Waveforms (b) and (c) are the fast and slow shaper output responses of nXYTER respectively. In fig.6 & 7, pulse injection frequency is 500 KHz with each pulse height of 15mV, injecting charge of 15fc per pulse step. The effect can be seen clearly that with consecutive pulses, CSA of nXYTER gets saturated and shaper pulse amplitude gets reduced. In fig.7 with Vbfb setting of 70, we see restoration of all pulse amplitudes.

We have also studied the effect of high input charge. It is seen in Fig.6 that with higher charge input of 50fc, even with Vbfb=70, the distortion of amplitude persists. So we increased the Vbfb further to 100 to nullify this effect for 50fc charge input as can be seen in Fig.7.

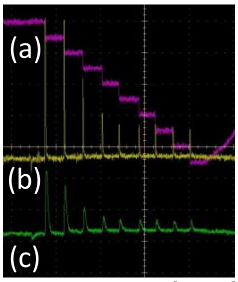

Fig.6 Scope screen shot with Vbfb=70 and freq=500Khz Input charge = 50fc

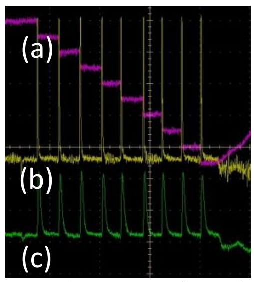

Fig.7 Scope screenshot with Vbfb=100 and Freq=500Khz Input charge = 50fc

Conclusion:

It has been shown using staircase pulse as input nXYTER coupled with GEM detector that, with appropriate setting of feedback resistance (Vbfb), nXYTER can be integrated with GEM detector for high frequency of operation. The detail analysis results will be presented.

References

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