Study of a Multiwire Proportional Chambers (MWPC) detector using NIM and MANAS based electronics

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Introduction

Multi wire Proportional Chambers (MWPC) with varieties of configurations have been extensively used in nuclear and particle physics experiments [1]. In this report, we present a detailed study of MWPC in terms of energy spectrum, gain, resolution, and efficiency measurements. The measurements are performed with both NIM and MANAS electronics [2].

Design of the Detector

The detector contains a number of gold-coated tungsten wires (20 μm diameter) on the anode frame, with a pitch of 2.8 mm. This frame is placed between the cathode and read-out planes. The gap between the anode and the cathode is 3 mm and the distance between anode and read-out is also 3 mm. The geometrical design of the detector is shown in Fig. 1.

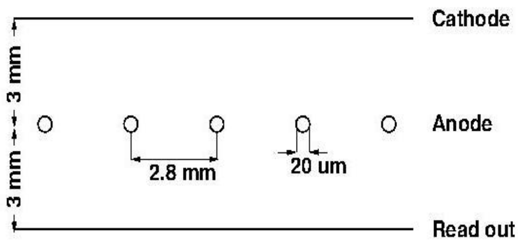

Fig. 1 Design and dimensions of the MWPC.

The detector is inserted inside a gas chamber containing Ar/CO_2 (70:30) gas mixture in flow mode. Positive high voltage (HV) is applied to the anode and the cathode and read-out planes are kept at ground potential. Since the diameter of the anode wires is small, a very high electric field close to the anode wires is formed, which produces avalanches of primary electrons. A negative signal at the anode is obtained because of the collection of avalanche as well as an induced positive signal at read-out plane.

Experimental Set-up

We have used two different electronics i.e. the NIM and MANAS based electronics. For the NIM read-out, sum of analog signals from the anode (or read-out plane) is taken through the pre-amplifier, amplifier and Multi Channel Analyzer (MCA). For MANAS readout, the sum signal is connected to one of the input channels of MANAS. The data is stored into the PC.

Test Results

The detector is tested with radioactive sources (^{55}Fe, ^{90}Sr) and cosmic muons by acquiring both signals from anode and readout plane. ADC spectrum from anode signal of ^{55}Fe 5.9 keV X-ray source is given in Fig 2.

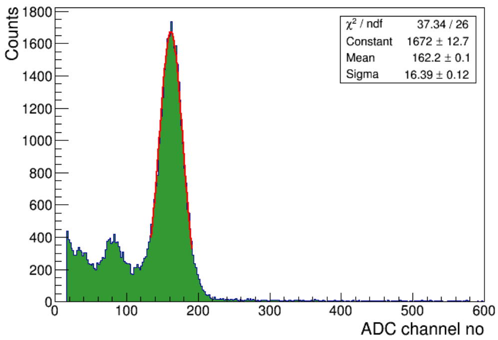

Fig. 2 ADC anode spectrum of ^{55}Fe at 1800 V using NIM electronics.

Cosmic ray test of the detector is done using NIM and MANAS electronics. Here we have used three scintillator detectors to acquire the true signal from the MWPC. The cosmic muon spectrum from anode is given in Fig. 3. The spectrum follows the Landau distribution.

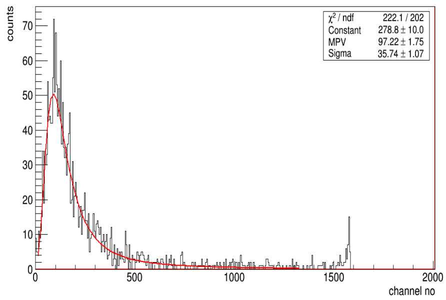

Fig. 3 Cosmic muon spectrum of anode signals using MANAS electronics.

The ADC values from the readout plane are lower compared to that of the anode. This is because of the charge sharing between cathode and readout plane. The fraction of charge induced at the readout with respect to the anode is defined as charge fraction. In Fig. 4 charge fraction is plotted as a function of HV with both electronics NIM and MANAS. We found that the charge fraction is about 46% for our detector.

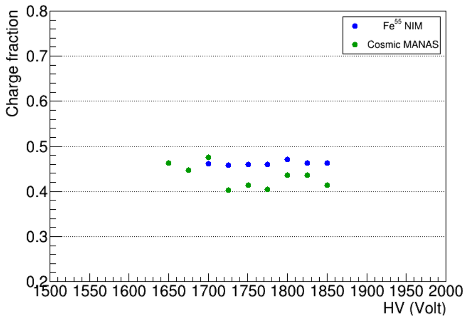

Fig. 4 Charge fraction as a function of HV using NIM and MANAS electronics.

The gain of the detector is calculated from the anode ADC with 5.9 keV X-ray and with cosmic muon using NIM and MANAS electronics. The gain variation against HV is given in Fig. 5. From this, it is seen that the gain values are comparable for both electronics. Energy resolution (in terms of FWHM) of the detector was found ~24% of 5.9 keV X-ray.

The efficiency measurement is done using the cosmic ray setup, where the efficiency is calculated using the number of true signal from the MWPC with respect of the three-fold external trigger signal. The efficiency plot is given in Fig. 6. Efficiency from the readout plane is less than that of the anode. This is because of the threshold dependency. The obtained efficiency is quite good and comparable with other type of detectors.

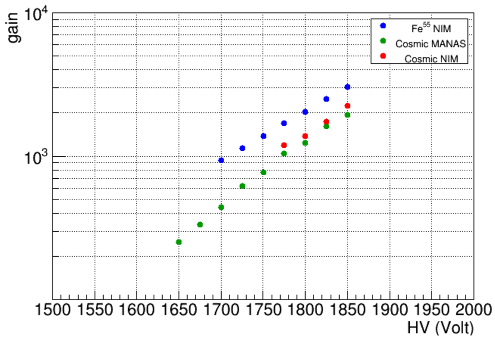

Fig. 5 Gain variation as a function of HV using NIM and MANAS electronics.

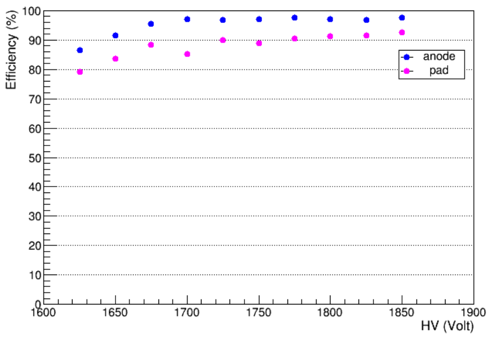

Fig. 6 Efficiency plot as a function of HV using MANAS electronics.

Summary

We have designed and built an MWPC detector and successfully tested it with different radioactive sources and cosmic muons with both NIM and MANAS electronics. Tests using MANAS demonstrate that it can be used in high rate experiments. Charge fraction and gain are calculated for both the electronics setup, and are found to be close to each other. An efficiency of ~96% has been obtained.

References

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