Preliminary Test of 5-gap Glass Multi-gap Resistive Plate Chamber for Photon Detection for Time of Flight Positron Emission Tomography (TOF-PET) Imaging

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1. Introduction

Multi-gap Resistive Plate Chamber (MRPC)[1][2] is a type of gas detector which uses constant and uniform electric field in between several high resistive electrodes and works on the principle of gas ionisation. In MRPC a particular gas gap is divided into several parts with the help of thin high resistive electrodes. Division of the gas gap helps to improve the time resolution of the detector significantly. MRPCs with time resolution of ∼15 ps[3] have been reported.

Time of flight (TOF) measurement is the basic principle in Positron Emission Tomography (PET)[4] Imaging. In PET imaging, a pair of back to back photons created by the annihilation of e^+ and e^- is detected and their TOF is measured. The detectors used in PET imaging are scintillators as they have very good photon detction efficiency and time resolution. Scintillators being very expensive detectors, the effective cost of PET scan is also very high. As MRPCs are low cost detectors, we have made an effort to test whether they can be a suitable replacement for the scintillators in PET imaging.

2. Test Results of 5-gap MRPC

There are sevaral advantages of MRPCs over scintillators for PET imaging like they have good time resolution (∼15 ps), they can be fabricated over large area (∼m^2), they are low cost detectors, easy to fabricate and maintain. But the suitability of MRPCs have to be tested for using them in PET imaging. Although MRPCs are know to have very good detection efficiency (>90%) to detect charged particles, their efficiency comes down to ∼1% to detect photons as they are neutral. We have developed a 5-gap MRPC of dimension 18 cm × 18 cm with each gas gap of ∼250 μm using glass electrodes of thickness ∼700 μm. In order to study the suitability of MRPC in PET imaging, first we should know the response of the detector in presence of e^+ source because in PET imaging the photons are created by the annihilation of e^+ (from fludeoxyglucose(^{18}F)[5]) with an e^- (from tissues). Hence, we have looked into the variation of noise rate, which is the number of detectable avalanches, with and without Na-22 source, at different signal thresholds and a particular voltage. In 90.6% of the cases, Na-22 emits a e^+ with 0.543 MeV energy and in 0.06% of the cases it emits a e^+ with 1.830 MeV energy. If these positrons can create a detectable avalanche inside the gas gap of MRPC, then the noise rate of the detector should increase in presence of Na-22.

During the testing period a gas mixture of freon (R134a) and iso-butane in a ratio 90:10 (by volume) was flown through the detector. The detector was operated at ±7700 V. The signals from the MRPC have been tapped with pick up pannels of dimension 18 cm × 18 cm having copper strips of width 2.5 cm. Two adjacents strips were separated by a gap of 5 mm. We have varied the signal threshold from 20 mV to 90 mV after amplification of the analogue signal. Fig. 1 shows the variation of the noise rate of the detector at different

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thresholds, in presence and in absence of Na-22 source.

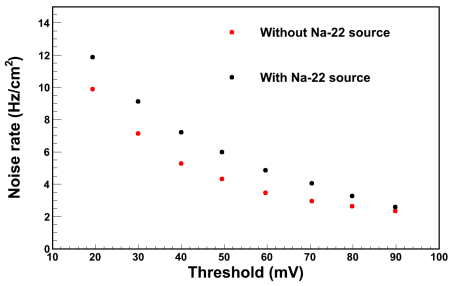

FIG. 1: Variation of noise rate of the MRPC with and without Na-22 source at different thresholds.

The figure clearly shows that there is an increase of $\sim 2Hz/cm^2$ in the noise rate of the MRPC in presence of Na-22 source at 20mV threshold. The difference in the noise rate decreases with the increase in threshold. We have also tested the noise rate of the MRPC with Sr-90 source. Sr-90 is an electron emitter having an energy of 0.546 MeV. Fig. 2 shows the noise rate values in presence and absence of Sr-90 at various thresholds.

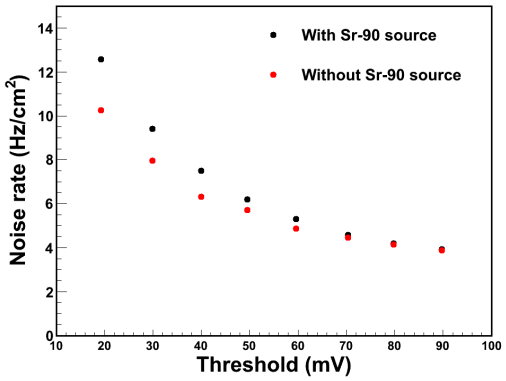

FIG. 2: Variation of corrected time resolution(σ) of the MRPC with applied high voltage. The error bars are within the marker size.

A clear increase in the noise rate of the detector is seen in presence of Sr-90. The difference minimises as the threshold value is increased.

3. Conclusion and Outlook

A 5-gap glass MRPC has been successfully developed. The effect of the presence of a e^+ emitter (Na-22) and e^-emitter (Sr-90) has been established. It is seen that the noise rate increases in presence of both Na-22 and Sr-90, at lower discriminator threshold values. The difference in noise rate minimises with increase in threshold. For Na-22, the noise rate values, in presence and absence of the source, nearly matches at a threshold of 90 mV whereas for Sr-90, the noise rate values nearly matches at a threshold $\geq$ 70 mV.

For our future work, we have to measure the photon detection efficiency of the MRPC. We also have to test the MRPC in actual TOF-PET experimental set up.

References

[1] M C S Williams et. al., *Particle identification using time of flight*, J. Phys. G: Nucl. Part. Phys. **39** (2012) 123001.

[2] E. Cerron Zeballos et. al., *A new type of resistive plate chamber: The multigap RPC* , Nucl. Inst. and Methods in Physics Research A **374** (1996) 132-135.

[3] Crispin Williams, *Latest Results from MRPC Time Resolution* , **http://www.pas.va/content/dam/accademia/pdf/sv119/sv119-williams.pdf**

[4] Anne M.J. Paans et. al., *Positron emission tomography: the conceptual idea using a multidisciplinary approach, Methods*, **27** (2002) 195207.

[5] Didier Le Bars et. al., *Fluorine-18 and medical imaging: Radiopharmaceuticals for positron emission tomography*, Journal of Flourine Chemistry, **127**, (2006) 1488-1493.