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

R. Ganai[1],* A. Roy[2], S. Mehta[3], M. Mondal[1], Z. Ahammed[1], and S. Chattopadhyay[1]
[1] *Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata-700064, INDIA*
[2] *Department of Particle Physics and Astrophysics, Weizmann Institute of Science, Herzl St 234, Rehovot, 7610001, Israel and*
[3] *School of Physics and Material Sciences, Thapar University, Patiala, Punjab-147004, INDIA*

1. Introduction

Positron Emission Tomography (PET)[1] is a nuclear medicinal imaging technique that is used to observe metabolic processes in the body by the basic principle of detecting a pair of back to back photons created by the annihiliation of e^+ and e^-. A positron emitting radionuclide tracer is injected into the patient's bloodstream, emitting e^+ which finds an e^- and annhiliates to give two back to back photons. The radionuclide tracer used is fludeoxyglucose(^{18}F)[2], commonly known as fluorodeoxyglucose. The IUPAC name is 2-Deoxy-2-[^{18}F]fluoroglucose. It is an analogue of glucose.

Nowadays, in PET Imaging scintillator based detectors are used to detect the photons. The reason being, they are very efficient in detecting photons and also have good time resolution. As the cost of scintillators is very high, the cost of a single scan for PET imaging is also expensive. Our aim is to develop Multigap Resistive Plate Chambers(MRPCs)[3] for PET Imaging. MRPC is a gas detctor which works on the principle of gas ionisation. It is an advanced form of Resistive Plate Chamber (RPC)[4] where the gas gap is divided into smaller sub-gaps. Fig. 1 shows the schematic of a 5-gap MRPC having 6 electrically floating equi-spaced resistive plates. The two outermost electrodes are graphite-painted for the application of the high voltage.

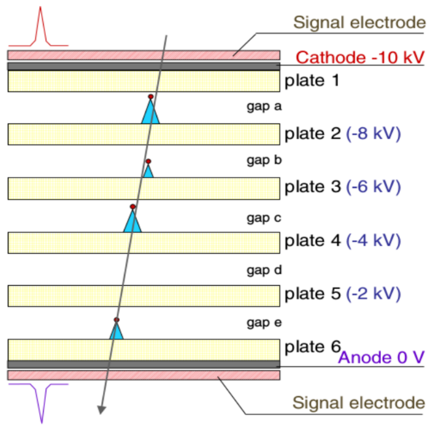

FIG. 1: Schematic of a 5-gap MRPC[3].

2. Development and Test Results of 5-gap MRPC

MRPCs can prove a suitable replacement for scintillators in PET Imaging as

1. They are of low cost and easy to fabricate.
2. They have good time resolution (10 ps).
3. They can easily be fabricated over a large area.

We have developed two nearly identical 5-gap glass MRPCs to establish the basic

*Electronic address: `rajesh.ganai.physics@gmail.com`

working principle of PET imaging. The developed MRPCs are of dimensions 18 cm × 18 cm with each gas gap of ∼250 μm. The thickness of the glass electrodes used is ∼700 μm. The developed MRPC has been tested with cosmic rays with a gas composition of Freon:Isobutane::90:10. Fig. 2 shows the I-V characteristics of the MRPC. Clearly, two distinct slopes are seen with a breakdown voltage at ∼13000 V. We have also measured the time resolution of the MRPC using three scintillators - one finger ($\sim 7cm \times 1.5cm$) and two paddle scintillators ($\sim\ 20cm \times 8.5cm$). The details of the time resolution measurement set up and calculations have been described in[5]. Fig. 3 shows the variation of time resolution of the MRPC with applied high voltage at a threshold of -20 mV after amplification of the MRPC signal. The best time resolutin obtained is ∼100 ps at ∼15800 V.

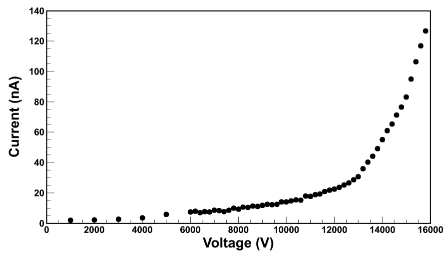

FIG. 2: I-V characterisitcs of the developed 5-gap glass MRPC.

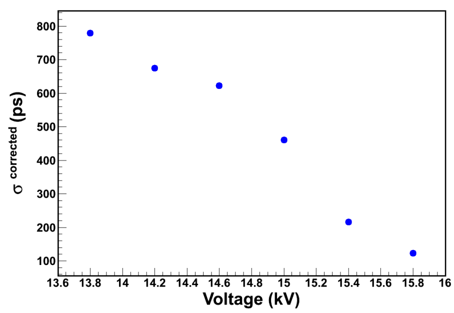

FIG. 3: Variation of corrected time resolution(σ) of the MRPC with applied high voltage. The error bars are within the marker size.

3. Conclusion and Outlook

We have successfully developed 5-gap glass MRPC for TOF-PET Imaging. The MRPC has shown a good I-V characteristic with a breakdown voltage at ∼13000 V. The variation of time resolution of the MRPC with the applied high voltage showed a good behaviour. The best time resolution obtained is ∼100 ps at ∼15800 V.

For our future work, we have to measure the cosmic ray detection efficiency and later on the photon detection efficiency of the MRPC. The detector has to be tested in actual TOF-PET imaging set up with e^+ source like Na-22. Few more prototype MRPCs have to be develop in order to find the Line of Responce (LOR) in PET Imaging.

References

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

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

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

[4] R. Santonico, R. Cardarelli, *Development of Resistive Plate Counters*, *Nucl. Instr. and Meth.* **187** (1981) 377.

[5] R. Ganai et. al., *Fabrication and Characterisation of Oil-free Large High Pressure Laminate Pesistive Plate Chamber*, *Journal of Instrumentation*, **2016 JINST 11 P04026.**