Development of a bi-dimensional hybrid resistive plate detector for particle imaging

C. Yadav, R.G. Thomas*, L.M. Pant, P. Patale, and R.K. Choudhury
Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA
*. * email: rgthomas@barc.gov.in*

Introduction

Position sensitive gaseous detectors are widely employed in experiments in particle and nuclear physics and also for various applications such as imaging and radiography[1]. Although Multi Wire Proportional Chambers (MWPC) and Parallel Plate Avalanche Chambers (PPAC) are the ones most commonly used[1], the Resistive Plate Chambers (RPC) are soon replacing them due to their robustness and excellent timing properties[2]. However, one drawback of RPC is its low count rate capability. In this paper we report the design and fabrication of a bi-dimensional hybrid resistive plate chamber which is expected to retain the high rate capability of the PPAC and the robustness and fast rise time properties of the RPC. The basic design of the detector consists of two electrodes, one metallic and the other resistive, separated by a gap of about 3 mm. While the metallic electrode retains the property of the rate capability of a parallel plate avalanche chamber, the resistive electrode allows the detector to be operated at very high voltages without breakdowns. Thus the hybrid detector is expected to be a robust, high rate capable, fast rise time, spark free detector for ionizing radiation.

The detector

The detector has an active area of 15cmx15cm, consisting of a cathode, anode and a bi-dimensional read out layer all assembled in a stainless steel chamber with perspex supports. The schematic is shown in Fig. 1. The cathode is realized on a G-10 board, with an aluminized mylar foil (~ 1.5 micron thick) stretched on it. The anode is a 1.5 mm G-10 board on which a thin graphite layer (a few hundred microns) is coated. The average surface resistivity of the layer is ~ 100 kohms/square which corresponds to about 80% transmission of the induced signal[3]. The gap between the two electrodes is 3 mm maintained using G-10 spacers.All these electrodes are assembled on to the base plate using teflon and perspex spacers (Fig. 3).

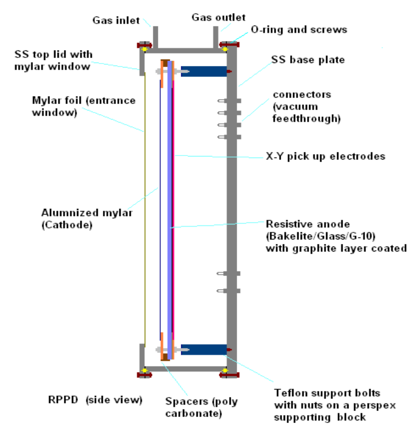

Fig. 1: The schematic of the detector

High voltage is applied to the resistive electrode while the metallic electrode is grounded. The X-Y bi-dimensional readout electrode is fabricated on a double sided PCB of thickness around 400 micron. It consists of 59 strips (inter connected diamond structured pads) on either side orthogonal to each other with minimal overlap to avoid capacitative coupling (See Fig. 2)[4]. Each of the strips is connected to a discrete delay line tap having a delay of 7.6 ns per tap and a characteristic impedance of 450 Ohms.The entire assembly is enclosed in a stainless steel chamber with an entrance window of 1.5 micron mylar foil glued on the front flange supported by stainless steel wires.

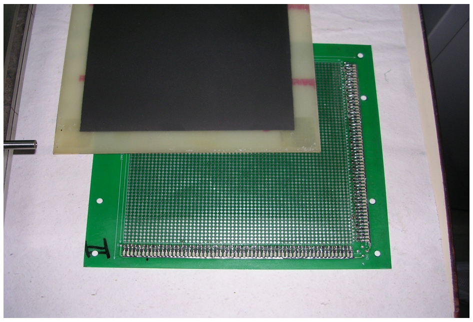

Fig.2: The resistive electrode and X-Y pickup board with discrete delay line LC cells.

The detector can be operated at atmospheric pressure (for minimum ionizing particles) in streamer/avalanche mode and at low pressure (for heavily ionizing particles such as fission fragments) in avalanche mode. As the ionizing radiation enters the gas medium they create primary electron-ion pairs. The primary electrons produced in the high effective field gas gap lead to further ionization eventually creating an avalanche near the anode. The drift of the avalanche in the high field region creates induced signal on all the surrounding electrodes. Since the resistive electrode is transparent to the signal, pulses are induced on the bi-dimensional pick-up electrode placed outside the gas gap.

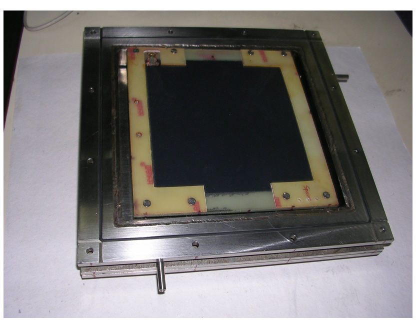

Fig.3: Photograph of bi-dimensional hybrid resistive plate detector.

The bi-dimensional position sensitivity is achieved by measuring the time delay between the signals arriving at either end of the delay line for both X and Y directions. The resistive electrode localizes the induced signal to a few tens of microns allowing sub-millimeter position resolution for the detector. The delay line read out system has been tested for its uniformity per cell by feeding a negative pulse from a tail pulse generator. The attenuation is found to be 30% along the delay line, and the cross talk due to capacitative coupling between the X and Y strips is found to be less than 5%.The performance of detector is being tested using a ^{252}Cf fission source for its position and time resolution.

Acknowledgments

We would like to acknowledge the help received from S.K. Gupta and A. Agarwal during the design of the chamber. We also acknowledge the MDPDD staff for their excellent support in the fabrication of various components of the detector. Thanks are also due to K.Mahata, R.P.Vind, H.Kumawat, R.V.Jangle, S.D.Tripati, P.Sapna, Shailaja Ware and A.L. Inkar for their help at various stages.

References

1. Research on Particle Imaging Detector, Ed. Georges Charpak, World Scientific.
2. R. Santonico and R. Cardarelli, Nucl. Instr. and Meth.187 (1981) 377-380.
3. G. Battinstoni et al., Nucl. Instr.and Meth.164 (1979) 51.
4. O.Jagutzki, J.S. Lapington, L.B.C. Worth, U. Spillman, V. Mergel and H.Schmidt Bocking, Nucl. Instr.and Meth. A 477 (2002) 256.