Avalanche mode operation of a Glass RPC with humid Gas mixture

V. K. S. Kashyap[1], C. Yadav[1], R. Sehgal[1], R. G. Thomas[1] and L. M. Pant[1,*], R. S. Shastrakar[2], V. M. Shedam[2], V. B. Chandratre[2]

[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA,*
[2]*Electronics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*
**email: lmpant@barc.gov.in*

Introduction :

Resistive plate Chambers (RPC) are gaseous detectors that are very effective for experiments where detection of particles overlarge area is required [1]. The salient features of the RPC are: good timing resolution (~1ns), good efficiency (~ 98%), and count rate capability upto several kHz/cm^2. CMS (Compact Muon Solenoid) detector at the LHC (Large Hadron Collider) employs RPC in the barrel and endcap regions for muon trigger and tracking. INO (India-based Neutrino Observatory) project will be employing RPCs as the detector elements in its ICAL (Iron CALorimeter) detector to track muons generated from neutrino interactions.

Assembly of 1 m x 1 m glass RPC:

The glass gas gap was obtained from the KODEL (Korean DEtector Lab), South Korea. The dimension of the gas gap is 1 m x 1m. The thickness of the glass used is 3 mm. The distance of 2 mm between the glass electrodes is maintained by using polycarbonate button spacers of ~1 cm Ø and 2 mm thickness in a matrix having interspacer distance not less than 10 cm. The gas gap is sealed from the sides except at the corners where, nozzles are attached to facilitate gas flow inside the gap.

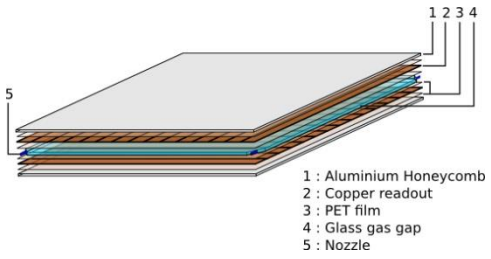

Fig.1: Illustration of an RPC.

The glass gas gap is sandwiched between two PET films. Then it is sandwiched between the copper readout, PET films and aluminium honey combs successively. The whole construction is illustrated layer wise in the Fig. 1. The copper readouts are kept orthogonal so that X-Y position coordinates of the particle interaction can be obtained. Copper strips run longitudinally on the readout with a width of 3cm and length of 1 m. Separation between strips is around 1 mm. There are 32 strips in each readout. The strips are terminated by 50 Ω resistors at one end and connected to 50 Ω coaxial cables at the other (to match the impedence). The cables have length of ~1 m. They are connected to preamplifier boards having 8 channels each. There are 8 preamplifier boards and a total of 64 signals from the RPC (X-32 and Y-32). The gain of board for each channel was set at 80.

Gas mixture and Efficiency :

The typical gas mixture used in RPC operating in the avalanche mode is 95.2% Freon (r134a), 4.5% *i*-butane and 0.3% SF6. The RPC lab at NPD-BARC has been characterizing bakelite RPCs for the CMS experiment at CERN. Bakelite RPCs require an additional 40% Relative Humidity (RH) as their resistivity changes with RH. We employed a similar mixture in the glass RPC and performed efficiency measurements in the Hodoscope [2] at NPD-BARC. The geometry during the efficiency scan and the results are shown in Fig.2. The distance between the paddle and the RPC is ~0.9 m (Fig. 2(a)). The X strips were parallel to the length of the scintillator of dimension 72 cm x 20 cm x 2 cm. Data was taken for 15,000 triggers at each step of the voltage with

VME based acquisition system [2]. The OR of scintillators 3, 4, 5, 6 of the TOP and OR of the same in BOTTOM plane together in coincidence with the paddle signal formed the trigger (3-fold). The efficiency was calculated as

$$\text{Efficiency} = \frac{N_s^{total}}{N_T} \times 100$$

where, N_s^{total} is the total of the hits in all the strips (32) and N_T is the No. of triggers. We observed that the RPC was about 80 % efficient at a threshold of 150 mV.

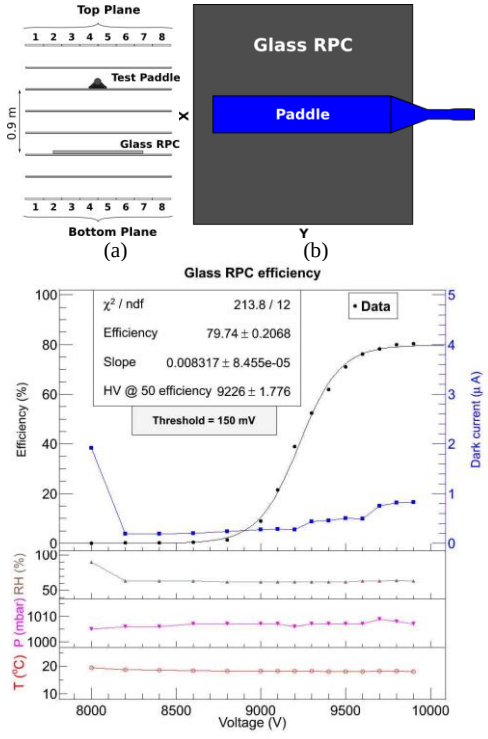

Fig.2: (a) The RPC position in the Hodoscope with respect to the paddle when viewed from the front. (b) The paddle and RPC when viewed from the top. (c) The plot of efficiency vs. voltage.

In Fig. 3(a), the distribution of the hits in the X strips w.r.t the 12th Y strip (arbitrary). The paddle was along the length of the X-strips. So the distribution looks sort of Gaussian. Similarly, Fig. 3(b) shows the distribution of the hits in the Y strips w.r.t the 12th X strip. As the paddle was orthogonal to the Y-strips it looks uniform. The increasing trend towards the 32nd strip is because the high voltage contact of the gas gap is near to the 32nd strip which will induce noise.

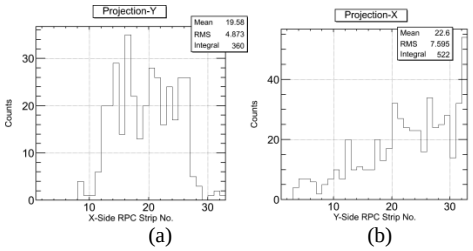

FIG. 3: (a) Y-Side hits for a single X strip. (b)X-Side hits for a single Y strip.

Conclusions and Outlook :

Avalanche mode operation of a glass RPC of 1 m x 1 m with a humid gas mixture appears to be ~80 % efficient at a threshold of 150 mV. Further tests will be performed with dry gas mixture and thresholds optimized to improve the results. These studies are part of the continuing development towards six such detectors, for muon tomography. The electronics for the present glass RPC shall also be replaced with ASICs, which have been developed by Electronics Division. We will also be doing a study of a Double Gap RPC where the read out will be sandwiched between two gas gaps which will definitely improve the efficiency.

Acknowledgments :

We like to thank Prof. N K Mondal and group at TIFR for providing the honey comb panels with copper readout strips and the components for the preamplifier electronics.

References :

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[2] Proceedings of the DAE Symp. On Nucl. Phys. 57, G40, 938 (2012).