Characterization of 1 m x 1 m Glass RPC with "ANUSPARSH-II" ASIC based Frontend & DAQ Electronics

V. B. Chandratre[1,*] Menka Sukhwani[1], K. Hari Prasad[1],
V. K. S. Kashyap[2], S. T. Sehgal[2], L. M. Pant[2]
[1]Electronics Division, [2]Nuclear Physics Division,
Bhabha Atomic Research Centre, Trombay, Mumbai 400085.
**E-mail: vbc@barc.gov.in*

Introduction

The Resistive Plate Chambers (RPC) are gaseous detectors that are used in particle and astro-particle physics experiments. They form the detector elements in the ICAL detector of the upcoming mega science project; INO (India-based Neutrino Observatory) [1]. The Glass RPC assembled at BARC has a dimension 1 m x 1 m [2]. The glass gas gap is obtained from KODEL (KOrean DEtector Lab, South Korea). The readout has 32 strips of copper of width ~3 cm and length 1 m.

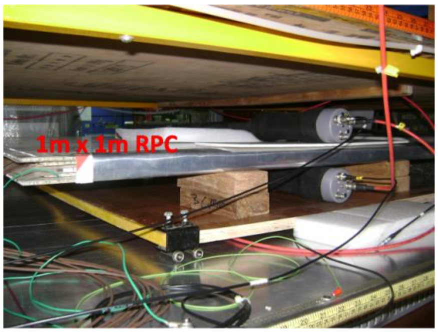

Figure 1: RPC with Scintillator paddles

The signal from the strips is taken using 50 Ω coaxial cables of ~1 m length with relimate connectors. The other ends of the strips are terminated by 50 Ω resistors. The RPC with paddles for trigger generation is shown in Fig. 1. The gas mixture used is 95.2% Freon (r134a), 4.5% *i*-butane and 0.3% SF_6. The RH in the gas mixture as measured by the Humidiprobe was ~40 %.

Frontend Electronics and DAQ

The ANUSPARSH-II ASIC [3], is a low power, eight channel fast amplifier-discriminator frontend ASIC, designed for readout of INO-ICAL RPC detector. The ANUSPARSH-II ASIC exhibits input impedance of ~50 Ω over wide frequency range, matching with the RPC pick strip characteristic impedance and provide total channel gain of ~7 mV/µA. This ASIC provides discriminator output in LVDS standard for eight frontend channels and a multiplexed analog amplifier output on 50 Ω cable line for detector signal profile analysis.

The discriminator LVDS data from the frontend electronics is acquired and processed by a portable data acquisition module [4] comprising of ANUPAL ASIC [5], an FPGA and a microcontroller with serial interface to the PC. The ANUPAL ASIC is a four-channel, vernier ring oscillator method based standard-cell Time-to-Digital converter ASIC with SPI interface. This ASIC has resolution of 127 ps and wide dynamic range of 1.8 us. The DAQ module also acquires NIM data from the two-fold coincidence unit to perform noise rate, efficiency and timing measurements, with respect to the FE LVDS data. The measurement data is then sent through the serial interface for display on Lab-Windows based GUI.

Experimental Set-up and Results

In the experimental set-up for characterization of 1 m x 1 m glass gap RPC installed at NPD, BARC, the validating trigger was generated using two-fold telescopic coincidence of ~ 20 cm wide scintillator paddles covering six pick-up strips of the RPC detector. The signals from five out of the six pick-up strips, between the scintillator paddles were amplified and discriminated using "ANUSPARSH-II" ASIC based frontend electronics, with discriminator threshold of 35 mV. The discriminator LVDS signals of these five channels were acquired by the "ANUPAL" ASIC based data acquisition module along with the two-fold coincidence logic.

The online analysis of the detector signal profile, noise rate, efficiency and timing performance (σ ~2 ns) with respect to the applied high voltage were performed. The efficiency of detector was calculated with respect to the 'OR' of five pick-up strip hit patterns and the two-fold coincidence signal, over the HV sweep from 9.1 kV to 9.9 kV.

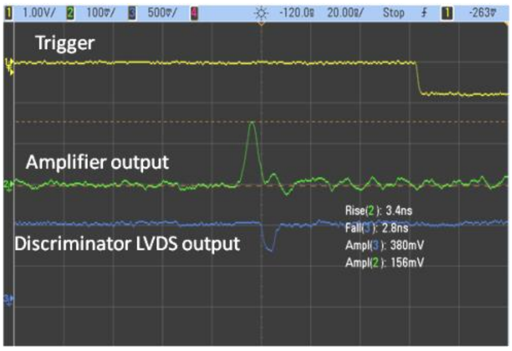

Figure 2: The RPC detector pulse at the output of ANUSPARSH-II ASIC

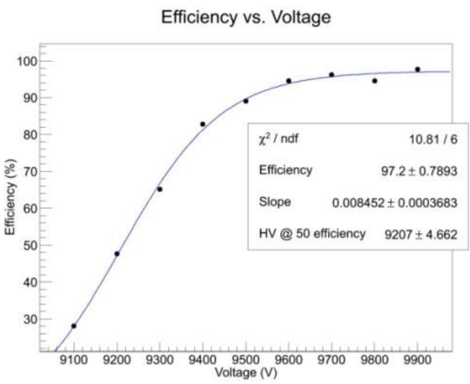

Figure 3: Efficiency vs. applied High Voltage

Fig. 2 shows the signal profile of the detector at the amplifier (green) and discriminator (blue) stage with the trigger (yellow).

Fig. 3 shows the efficiency as a function of high voltage. The efficiency is ~ 97% at 9.9 kV.

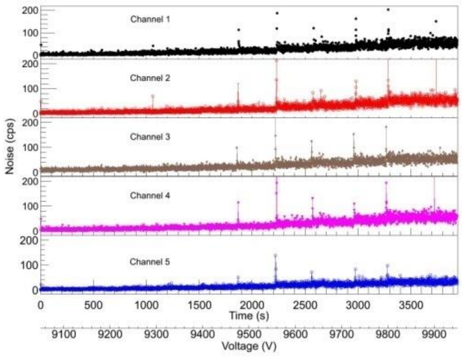

Figure 4: Noise rate variation with respect to HV

The noise rate variation for the five channels with voltage and time are shown in Fig. 4. The noise rate increases with the increase in voltage.

References

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