Results from longterm stability tests of Resistive Plate Chambers

B.Satyanarayana
Tata Institute of Fundamental Research, Mumbai, 400005
For India-based Neutrino Observatory Collaboration

Abstract

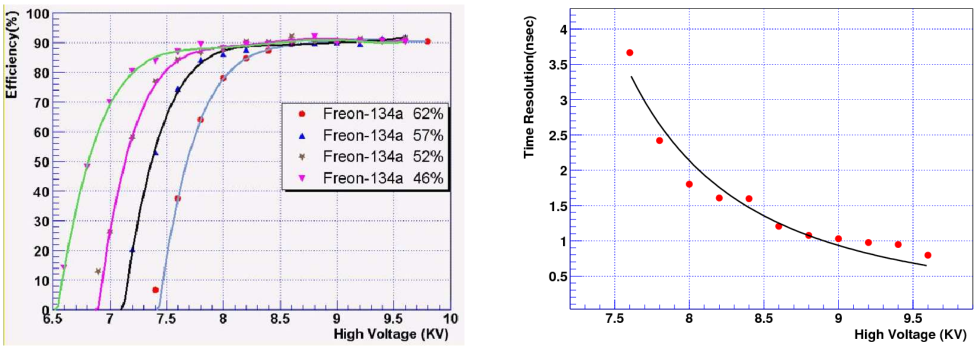
Resistive Plate Chambers (RPCs) will be used as active detector elements for the Iron Calorimeter (ICAL), proposed to be built by the India-based Neutrino Observatory (INO) collaboration. We are currently developing and studying the performance of glass RPC prototypes. While we were successful in building a large number of chambers using local glass and characterising them, these have met with severe aging problems after a few months of continuous operation. We have then built a couple of RPCs using a Japanese glass. We report in this paper on our longterm stability tests of these RPCs.

1 Introduction

India-based Neutrino Observatory (INO) collaboration is proposing a large magnetized iron tracking calorimeter of total weight 50 kton, using atmospheric neutrinos as source[1]. The proposed detector will have modular structure of lateral size 48 m $\times$ 16 m and will consist of a stack of 140 layers of 6 cm thick iron plates interleaved with Resistive Plate Chamber (RPC) detector layers. A total of about 27,000 RPCs of dimension 2 m $\times$ 2 m will be needed for this experiment. A dedicated effort for development of RPC detectors, leading to their large scale production is in progress.

2 Development of glass RPCs

A large number of single gap glass RPCs of area 30 cm $\times$ 30 cm as well as a few of area 120 cm $\times$ 90 cm were developed, using float glass procured from local market. The Voltage-Current characteristics of these detectors were studied. The noise rate was found to be a reliable way of monitoring the stability of the RPC. Fig. 1a shows plots of the RPC efficiency as a function of the detector bias voltage for different gas mixtures. Plateau efficiencies of over 90% have been obtained for all the gas mixtures beyond a bias voltage of 8.5 kV. Fig. 1b shows the timing resolution σ as a function of bias voltage. As can be seen from the plot, the timing resolution



(a) Efficiency plateaus (b) Timing resolution

Figure 1: A couple of earlier RPC results

improves with the increase of detector bias voltage and reaches a value of about 1.2 nsec in the plateau region [2, 3]. We have in the process, developed considerable infrastructure and optimised procedures for fabrication as well as for characterising these chambers.

While the results obtained from the tests mentioned above were largely encouraging, we have started facing a severe problem with regard to their longterm operation. Glass RPCs operating in the streamer mode are known to be stable and have a long lifetime (more than 8 years) as evidenced by the successful operation of these chambers by the Belle Collaboration. However, the prototype detectors showed signs of sudden aging when operated continuously for a few months[4, 5]. After a considerable R&D in trying to understand the reason for this problem, we have come to the conclusion that quality of the glass which is used as chamber electrodes could be the major factor affecting the longterm stability of these chambers.

3 Long term stability tests of INO RPCs

While the problem of short lifetime of our glass RPCs is being investigated, we fabricated a few RPCs of dimension 40 cm $\times$ 30 cm using glass procured from Japan. The same procedure for fabrication and testing as in the case of earlier RPCs was followed for these new chambers. Two of these new chambers (called J2 and J3) are currently being operated in the avalanche mode, in which a gas mixture of freon (R134a) and isobutane in the proportion 95.5 : 4.5 by volume is used. The chambers are operated at a high voltage of 9.3 kV. Since the pickup signals in the avalanche mode are in the range of few millivolts, external amplification has been provided by preamplifiers of gain 50. The rest of the electronics and data acquisition chain is the same as that used earlier [6].

A comprehensive monitoring system for the periodic recording of the detector

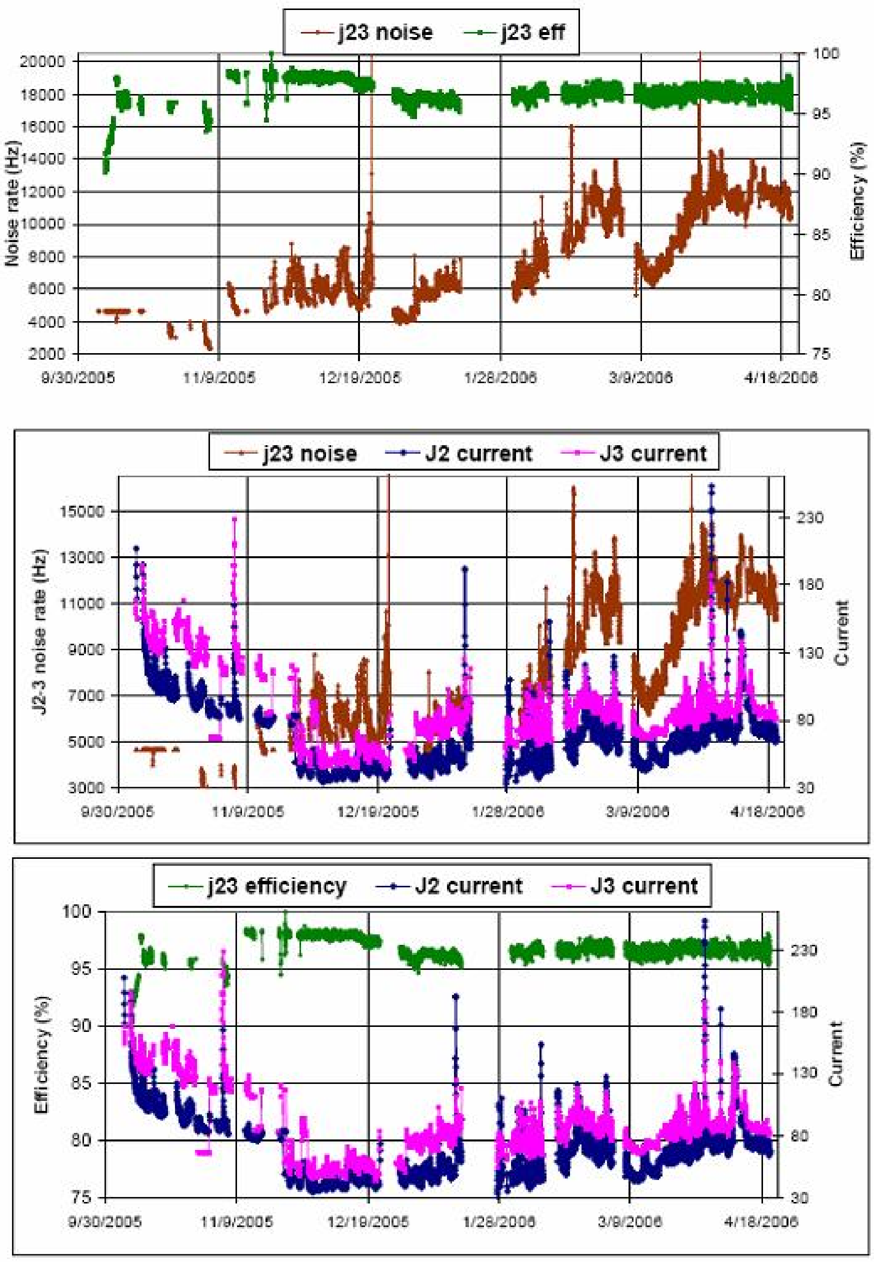


Figure 2: Long term stability monitoring plots of J2 and J3 RPCs

currents of these two RPCs (J2 and J3) together with the ambient parameters such as temperature, pressure and relative humidity both inside and outside the laboratory has been designed and implemented. Using this data, several correlations between the ambient parameters and the RPC operating characteristics could be established. The longterm stability tests were started on these two chambers from September 2005. As can be seen from the plots in Fig. 2, the performance of these chambers, characterised by their efficiency, leakage currents and noise rates, remained stable over the last year and a half. It is interesting to note the dependence of dark currents, noise rates of the chambers on ambient parameters such as temperature and relative humidity in the laboratory. Dark currents of the chambers increase with increase in the relative humidity, mainly due to the increase in the surface leakage currents. Changes in temperature also affect the bulk resistivity of the glass electrodes and thus cause changes in the dark currents.

4 Conclusions and future plans

The longterm tests on these RPCs indicate that the aging problem associated with the previous RPCs is related to the quality of glass used to fabricate those RPCs. We have therefore initiated comparative studies on samples of glass from local market versus the glass imported from Japan [7]. While continuing with these longterm stability tests, we are also in the process of fabricating large size chambers using glass obtained from Japan.

References

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