Long term stability tests of INO RPC prototypes

While the problem of sudden aging in the glass RPC prototypes is being investigated, a few RPCs of dimension 40 cm × 30 cm were fabricated, using glass procured from Japan. The fabrication and test procedures were similar to those of the earlier prototypes. These new chambers were being operated in avalanche gas mode, in which a gas mixture of Freon (R134a) and Isobutene in the proportion 95.5:4.5 by volume. The chambers are being operated at a high voltage of 9.3KV. Since the pickup signal strength in avalanche mode is much smaller to that in streamer mode, external amplification has been provided by preamplifiers of gain 10. Rest of the electronics and data acquisition chain is again the same as that used earlier.

A comprehensive monitoring system for periodically recording the RPC high voltage currents as well as the ambient parameters such as temperature, pressure and relative humidity – both inside and outside the laboratory has been designed and implemented. Using this data with the RPC test data, several correlations between the ambient parameters and the RPC operating characteristics could be established.

The long term stability tests were started on two chambers named J2 and J3, during September 2005. As it can be observed from the monitoring plots shown below, performance of these chambers in terms of their efficiency, chamber currents and noise rates are unchanged over the last seven months.

These tests have clearly demonstrated that indeed, the quality of glass used to fabricate the RPC is the key factor for long term stability of the chamber. Currently more of these large area glass plates are being procured so that many more large area chambers using this glass could be fabricated and tested simultaneously for their long term stability.

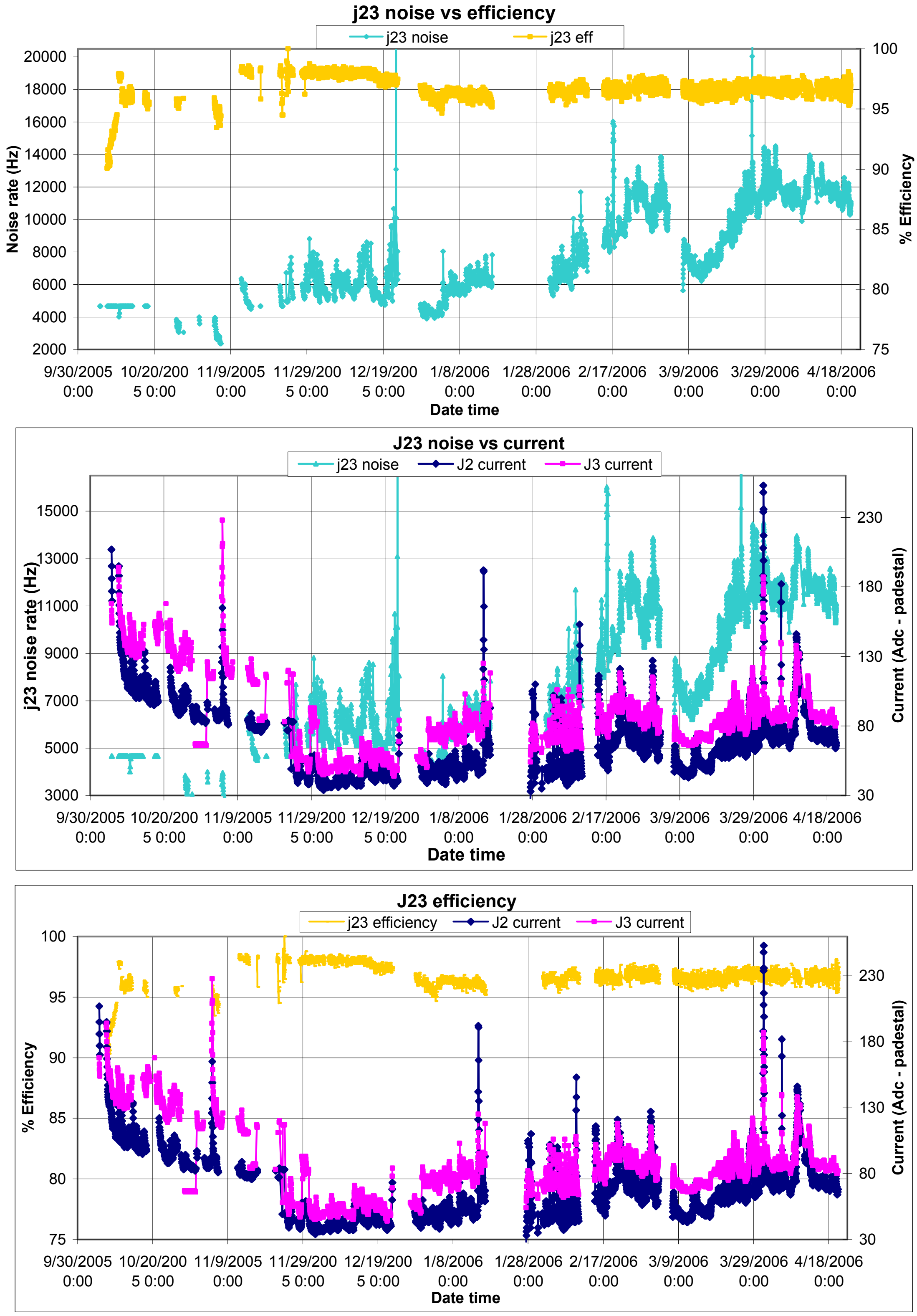

Figure: Long term stability monitoring plots of J2 and J3 chambers

Development of 16-channel gas mixing system

A sophisticated, multi-channel gas mixing and distribution system was designed and developed. It mixes four input gases viz. Argon, Freon (134A), Isobutene and SF_6 using *volumetric method*. The mixed gas can be supplied simultaneously into 16 individually controlled output channels. The gas flow rate in each of output channels is maintained to be identical, using flow resistors. The return gas from connected chambers is collected into a common manifold before it is finally vented out into the atmosphere. Gas flows at every stage of the system are achieved through using electrically or pneumatically operated switches or valves. The system is equipped with a host of sensors and monitoring devices and appropriate displays of various crucial operating and quality control parameters.

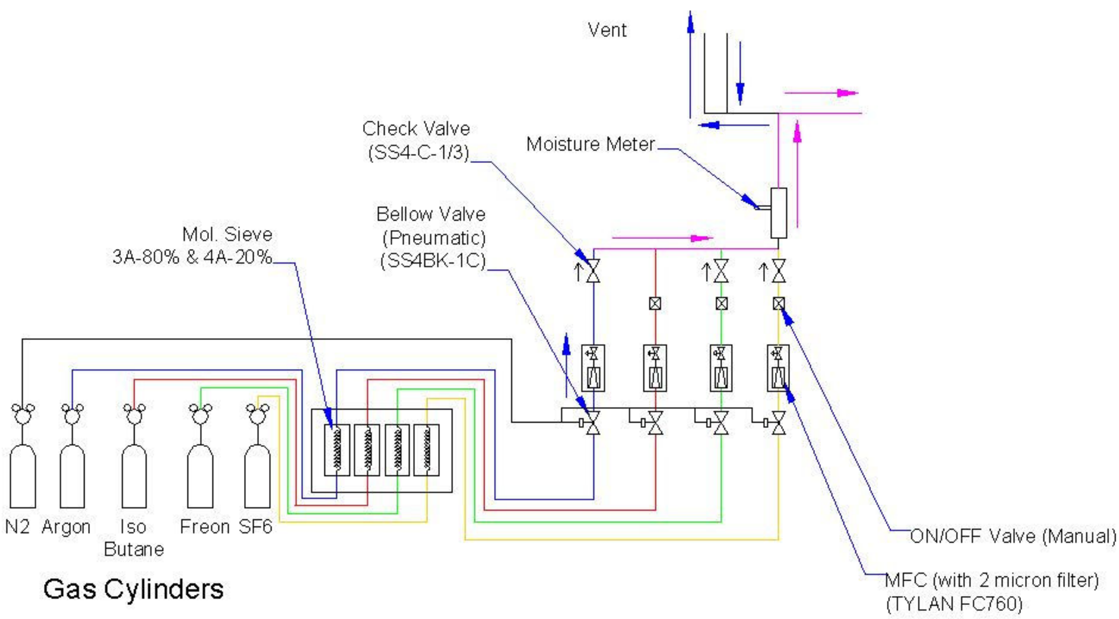

Figure: Flow diagram of the gas system

The main components and salient features of the system are:

1. Input gas purifier columns: Four (one for each input gas), in-situ rechargeable molecular sieve based columns, mounted on the input gas lines in order to absorb moister, oil traces and other contaminants from the input gases.
2. Gas mixing section: This crucial section is based on Tylan made FC-760 model Mass Flow Controllers (MFCs). Input section of these filters feature 2 micron dust filters. Flow rates of individual gases (calibrated in Standard Cubic Centimeter per Minute, SCCM) are settable from and the same are displayed on the front-panel. Small amounts of water vapour are added in the gas mixtures used for Bakelite RPCs. A provision has been made in this section for the same.

3. Moisture meter: A microprocessor based SHAW capacitive type sensor with a suitable display of PPM as well dew point, is mounted on the mixed gas line to monitor the moisture content in the mixed gas.
4. Distribution unit: The mixed gas is distributed into 16 individually controlled gas outlets in parallel. This achieved by using SS capillaries of 2m in length and 200 microns in diameter, as *flow resistors*. A pressure sensor is mounted on this line to indicate the inside pressure of the system. A Parker made fine particle filter is mounted on this unit in order to purify the mixed gas further, before it enters the chambers.
5. Safety bubblers: These bubblers are mounted on individual output lines in order to take care of the back pressure exerted from and to protect the RPCs from damage due to over pressurising.
6. Isolation bubblers: These bubblers serve dual purpose of preventing back diffusion of air into the RPCs as well as to indicate the flow of gas through the chambers. The silicon oil levels in the safety and isolation bubblers are so chosen as per the pressure gradient calculations of the system.
7. Exhaust manifold: Return gas from all connected chambers is collected into this manifold, and a single output is provided to vent the used gas into the atmosphere. This manifold too has a pressure sensor to indicate the system pressure with reference to the ambient room pressure.
8. Remote control and monitoring: Required flow rates of individual gases can be set or monitored through a PC interface of the system. Other important system parameters such as pressures at various stages of the unit can also be monitored using this interface.

Figure: Front view of the gas system

Tracking of Cosmic ray muons using INO RPC prototypes

A separate laboratory has been setup for this detector, in which the newly developed gas system was installed. RPCs for this setup were fabricated using the same materials, fabrication procedures and parameters as of those fabricated for earlier studies. 2mm thick float glass of dimension 30 cm × 30 cm is used. However, chambers were made using glass from different sources and manufacturers are used, in order to study the role of glass in the aging phenomenon that we have observed with earlier chambers. An RPC of this typical design is shown below.

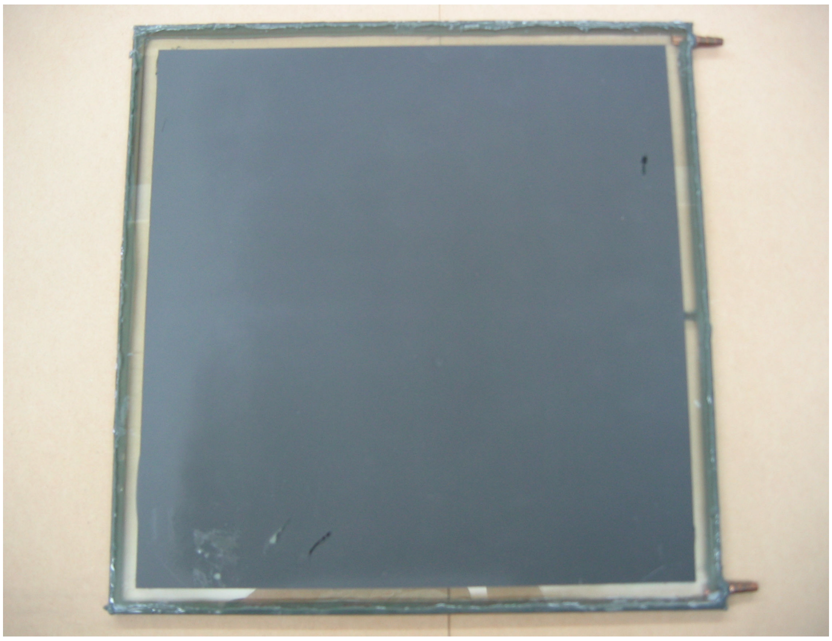

Figure: A typical design of the RPCs used for muon tracking

A suitable rack to house 12 chambers of 1 ft^2 in area was fabricated. The rack allows easy access to any individual chamber in the stack. It also integrates a spring loaded mechanism to keep the signal pickup panels pressed uniformly against the chambers.

The Cosmic ray muon telescope was set up using seven scintillator paddles. These include one narrow paddle of 2cm in width to define the telescope window such that it centres on an individual signal pickup strip as well as a couple of them to veto muons which are passing outside the strip of our interest. Cosmic ray muon trigger based on appropriate coincidence of trigger paddle signals is generated using a logic circuit.

A stack of 10 RPCs were mounted in the above mentioned rack such that signal pickup strips of all the chambers were well aligned geometrically. The chambers were operated in streamer gas mode, using a mixture of Argon, Isobutene and Freon in the ratio of 30:8:62 by volume, using the gas system described above. The operating high voltage for the entire tests was kept at 8.6KV. The high voltage supply current was monitored online as a quick measure of the stability of chambers.

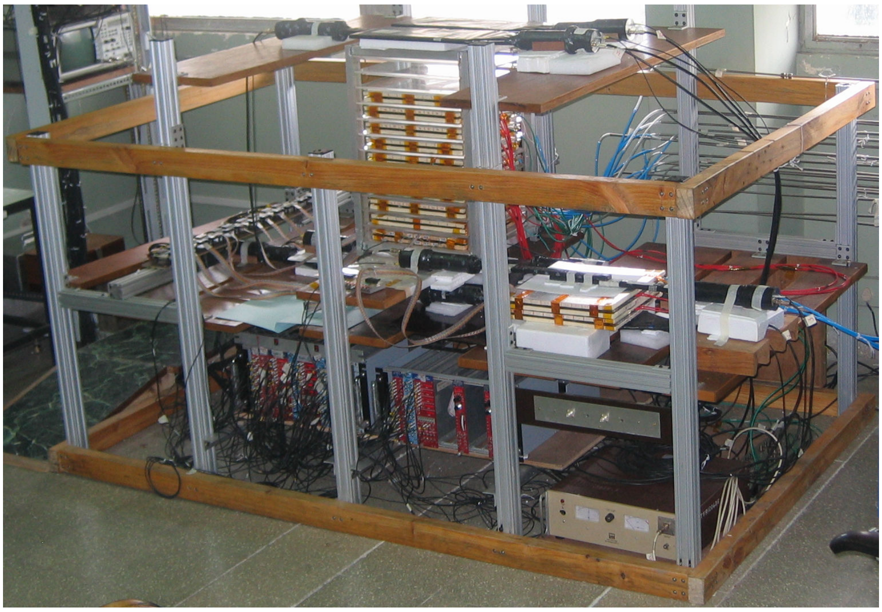

Figure: Muon tracking setup using RPC stack

The signals picked up by the pickup strips were transmitted on twisted pair cables into patch panels, where the line impedances are transformed in order to match to that of NIM electronics. The RPC strip analog signals are fed to discriminator and latch modules. Cosmic ray telescope trigger signal is used as strobe signal to these latch modules, so that they record binary information on presence of absence of signal on the RPC strip of our interest on every trigger. Counting rates of the RPC strips of interest are measured using scalers on its logic signal. The strips' logic signals are also used to record the timing information of the RPC signal with reference to the Cosmic muon trigger, using TDC modules. Strips of only one pickup panel are readout.

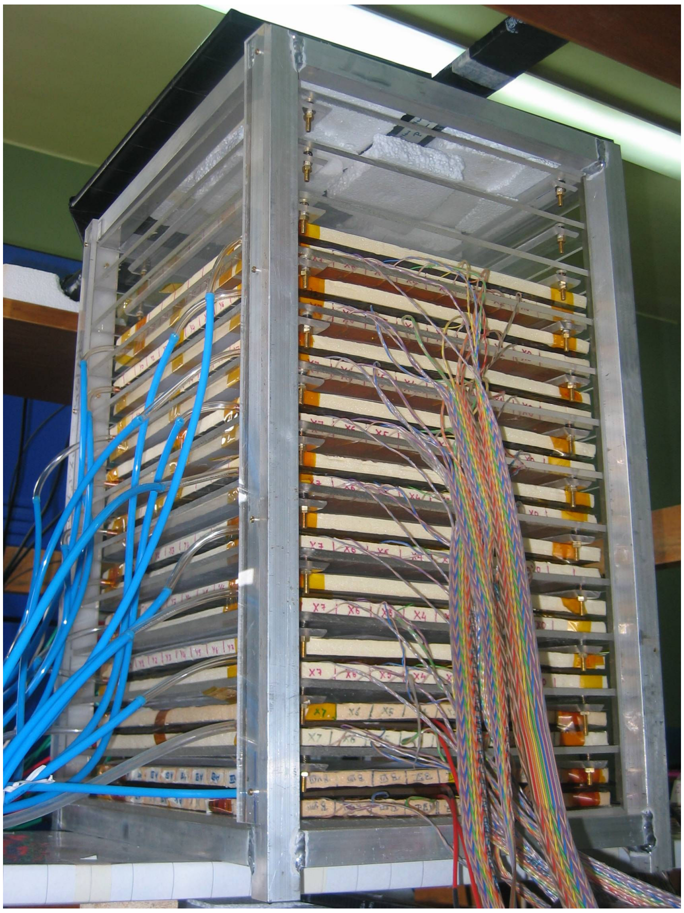

Figure: A stack of 10 RPCs mounted in a rack

Shown in Figure below some interesting tracking events recorded using the above setup. Muons arriving at different angles could be captured simply by relocating the telescope window. This has demonstrated that indeed these prototype chambers are capable of tracking Cosmic ray muons effectively.

The information recorded in these tests could also be used extract other parameters of interest, such as efficiency, noise rate and timing of individual RPCs and their long term stability. Ambient parameters such as temperature, barometric pressure and relative humidity are also being monitored on-line in order to collate and correlate dependence chamber performance values on these ambient parameters.

It was also established from these studies that the chambers made with Modi, Asai Float, Saint Gobian glasses suffered from the aging problem which was observed in the previous studies. However an RPC fabricated using the glass procured from Japan is surviving the long term stability tests so far.

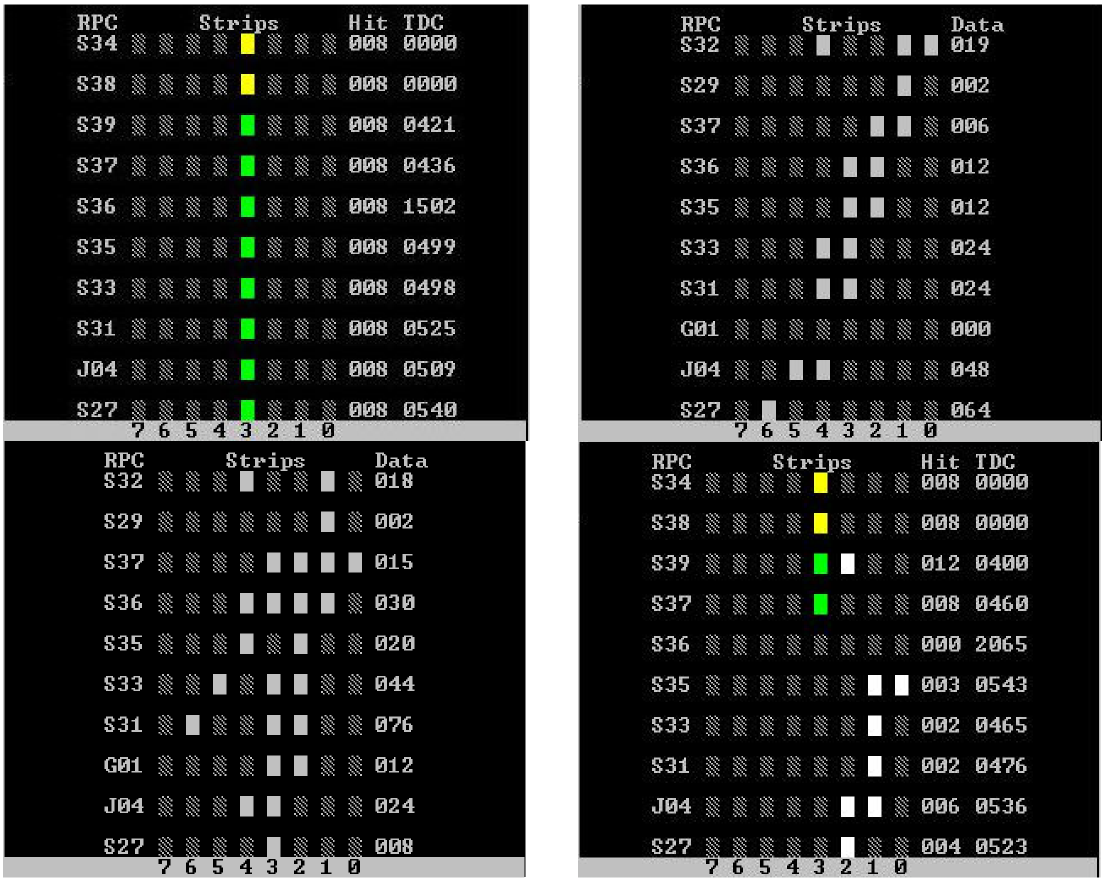

Figure: Some interesting tracks recorded in the detector