Detector Related R&D for the INO Project

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Abstract

The India-Based Neutrino Observatory (INO) Project plans to set-up a magnetized 50 kton Iron Calorimeter (ICAL) to study and analyze neutrino oscillations. The detector will consist of 3 modules each having around 150 layers of Resistive Plate Chambers (RPC) inter-leaved by Iron plates. Each layer in a module will have 64 (8x8) 2m x 2m RPCs amounting to around 30,000 RPCs in the entire detector. Over 3 million electronic channels will carry the data from these detectors to recording and measurement systems. An overview of the detector and the research and development work carried out in this context is shown in this poster.

Prototype Stack at TIFR

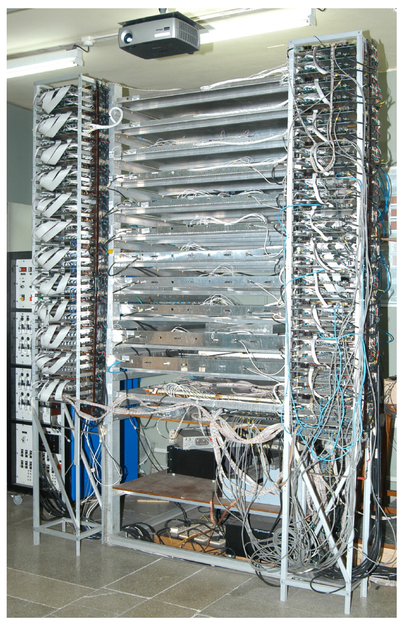

Figure: The 1m x 1m RPC stack at TIFR.

At TIFR, a prototype stack consisting of 12 layers of 1m x 1m RPCs was developed and is now in operation tracking cosmic muons. We have also started the development and testing of 2m x 2m RPCs. The prototype was used to study and monitor the long term stability and efficiency of the detector and the related electronics. Studies on cosmic muons were also carried out using this stack.

Results of the Prototype

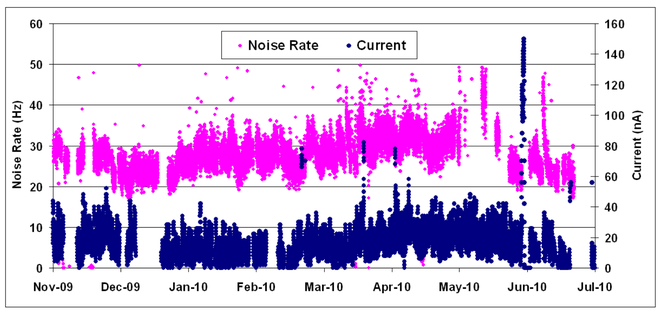

Figure: The noise rate and current of one of the RPCs.

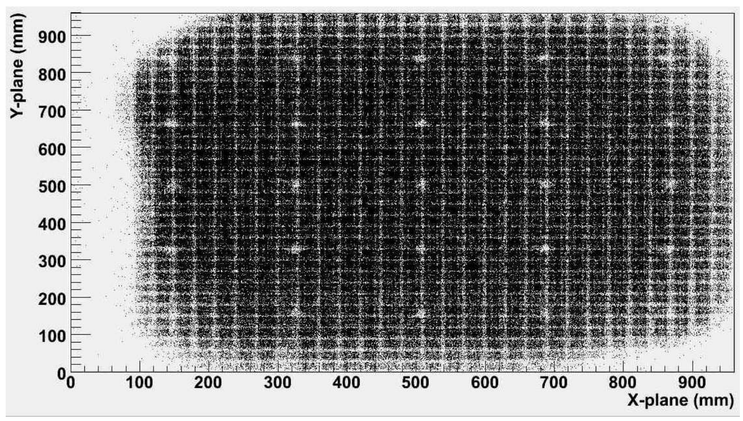

Figure: Tomograph of a RPC using cosmic muons. The faint white spots are dead zones due to the buttons.

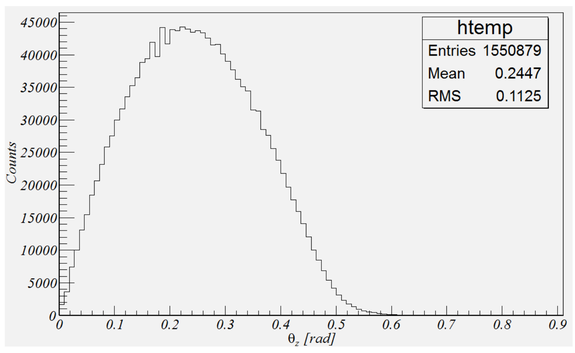

Figure: Zenith angle distribution of the muons passing through the detector.

Resistive Plate Chambers

RPCs are fast, planar, rugged and low-cost gas detectors which are used extensively in a number of high energy and astro-particle physics experiments.They find applications for charged particle detection, time of flight, tracking and digital calorimetry due to their large signal amplitudes, high efficiencies as well as excellent position and time resolutions.

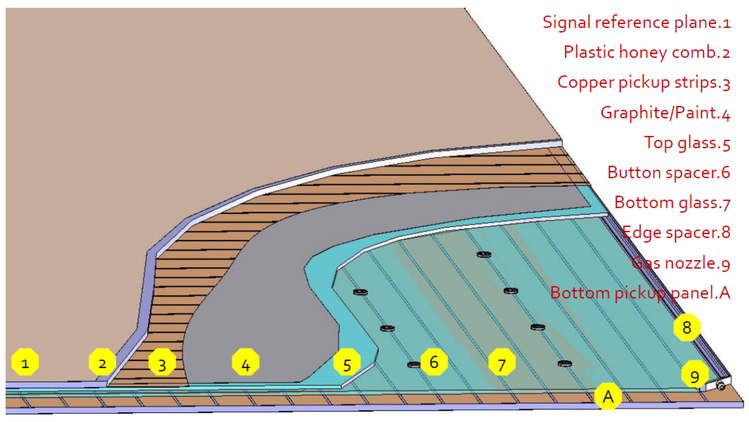

Figure: Structure of a RPC.

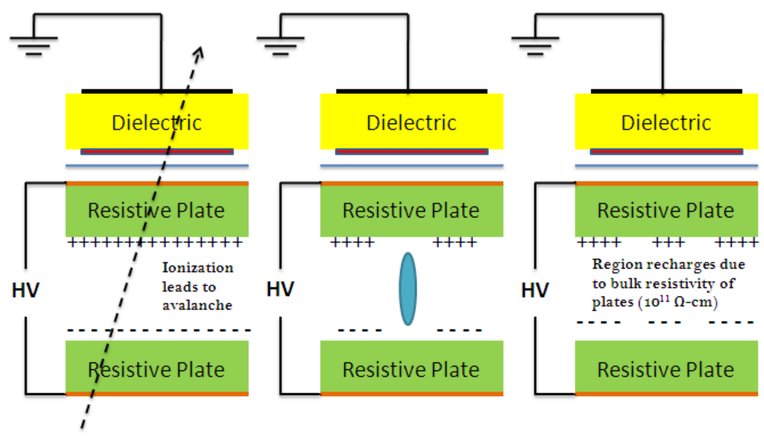

Figure: Principle of operation of a RPC.

RPC Modes of Operation and Characteristics

Parameter	Avalanche	Streamer
Gain	$<<10^8$	$>10^8$
Charge developed	1pC	100pC
Pre-Amplification	Needed	Not neccessary
Lifetime	Longer	Relatively short
Gas mixture	Fr:iB:SF_6 :: $94.5 : 4.5 : 0.5$	Fr:iB:Ar::62:8:30
Purity of gas	Moderate	High
Counting rate	High	Low

Electronics for ICAL

A standalone RPC-based DAQ system is being planned for the final ICAL detector where each RPC will have 8-channel FE ASICs along with TDC, coincidence logic generation, strip hit latch, event rate counter, monitoring unit and network interface mounted on it along with VME bus at the back-end. The RPC pick-up signals require very fast preamplifier, comparator and LVDS driver with sub-nanosecond timing requirement for front end signal processing. 8-channel front end ASIC with variable threshold and gain bypass stage has been designed in 0.35μm CMOS technology and has been shipped for fabrication.

Electronics specifications

- Dynamic range: 18fC 1.36 pC
- Input impedance: 45at 350 MHz
- Amplifier gain: 8mV/μA
- 3dB bandwidth: 274 MHz
- Rise time: 1.2 ns
- Power/Channel: 40 mW

Figure: The gas recirculation system for the prototype.

Contact

- Visit www.ino.tifr.res.in or write to nkm@tifr.res.in for more information.

Figure: The 2m x 2m RPC stack at TIFR.

Neutrinoless double beta decay

Figure: Bolometer for the NDBD experiment.

The INO project will also host the neutrinoless double beta decay (NDBD) experiment. A crucial criterion for detector design for this experiment is high energy resolution for a precision measurement of the sum energy of two electrons emitted in the decay. The low temperature bolometric detectors are ideally suited for this purpose. We currently focus on the feasibility of a Sn cryogenic bolometric detector for the study of NDBD in ^{124}Sn.

Gas Recirculation System

The main component in the RPC is the gas that it is filled with. The gas governs the main operational characteristics of the detector and therefore a good gas circulation system is essential. A gas recirculation system has been designed for this purpose.

Features of the gas recirculation system

- 16 pneumatically controlled output channels.
- Molecular sieve based input filter columns to absorb moisture and purify the gas.
- Nippon Tylan made model FC-760 MFCs to ensure controlled gas flow rate.
- Output flow control by SS 0.3 mm capillaries to maintain uniform flow in all channels.
- Bleeder bubblers for RPC protection.
- Online moisture readout on mixed gas.