

Study of timing properties of single gap high-resistive bakelite RPC

Saikat Biswas^{a,*}, Sudeb Bhattacharya^b, Suvendunath Bose^b, Subhasis Chattopadhyay^a, Satyajit Saha^b, Yogendra P. Viyogi^c

^a Variable Energy Cyclotron Centre, 1/AF Bidhannagar, Kolkata-700064, India

^b Saha Institute of Nuclear Physics, 1/AF Bidhannagar, Kolkata-700064, India

^c Institute of Physics, Sachivalaya Marg, Bhubaneswar, Orissa-751005, India

*e-mail: saikatb@veccal.ernet.in

Introduction

The active detector in India-based Neutrino Observatory (INO) \Rightarrow RPC

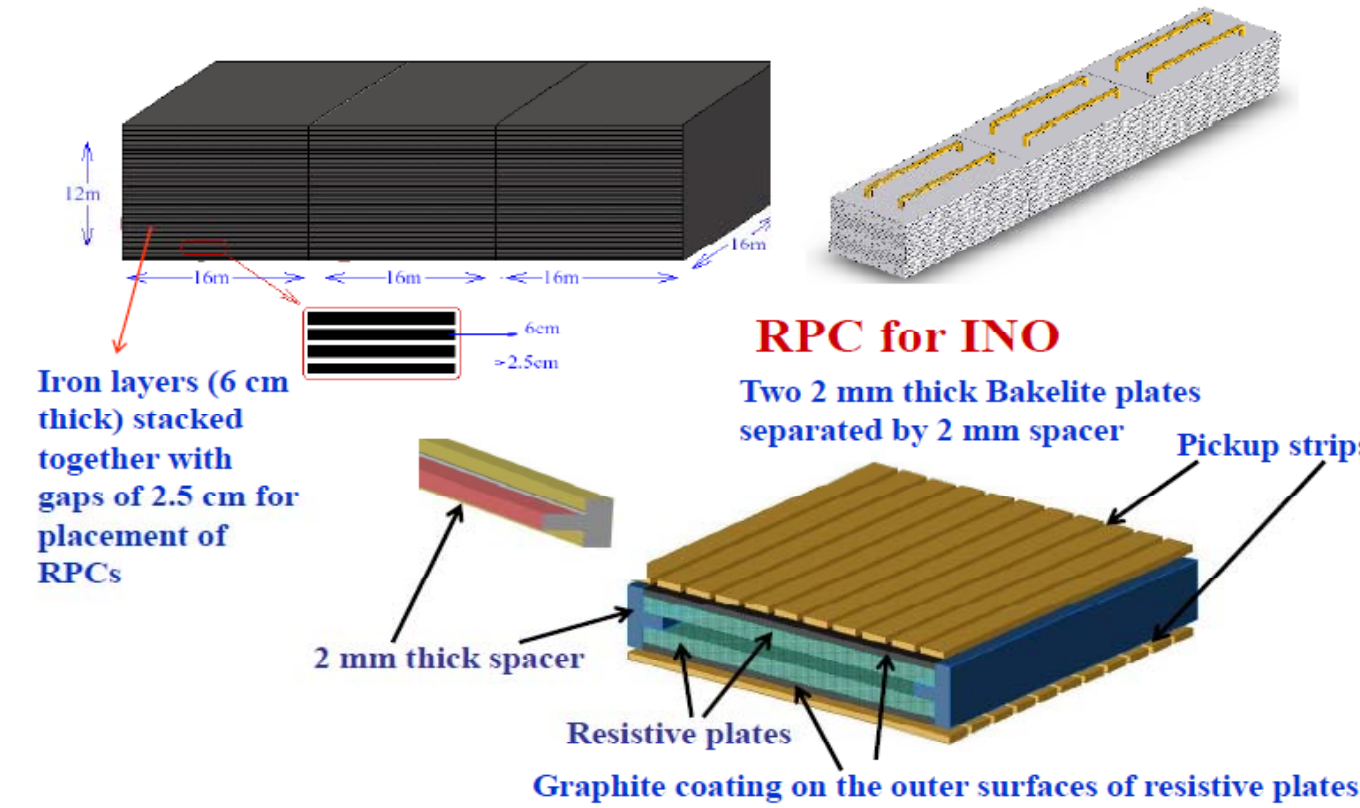
- Built from simple and common materials.
- Low fabrication cost per unit area.
- Easy to construct and operate.
- Simple signal pick up and readout system.
- Large detector area coverage.
- High efficiency (>90%) and time resolution (~2ns).
- Particle tracking capability and good position resolution.
- Two dimensional (x and y) readout from the same chamber.
- Long term stability.

Main goal of the study

To construct large bakelite RPC without linsed oil coating for the experiment in India-based Neutrino Observatory (INO)

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For operation in streamer mode

INO Detector (ICAL) Concept



ICAL Detector Specifications

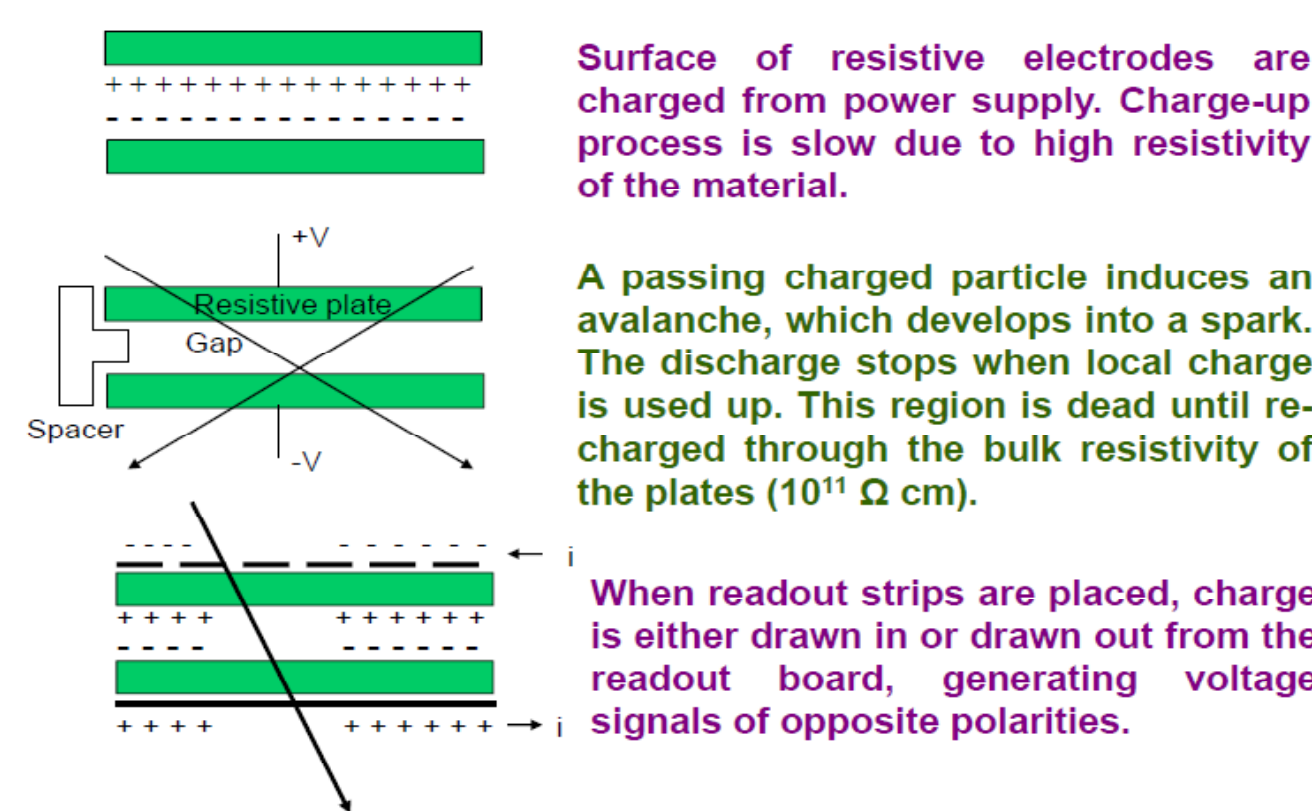
No. of modules	3
Module dimension	16 m × 16 m × 12 m
Detector dimension	48 m × 16 m × 12 m
No. of layers	140
Iron plate thickness	6 cm
Gap for RPC trays	2.5 cm
Magnetic field	1.5 Tesla
RPC unit dimension	2 m × 2 m
Readout strip width	2 cm
No. of RPCs/Road/Layer	8
No. of Roads/Layer/Module	8
No. of RPC units/Layer	192
Total no. of RPC units	27000
No. of Electronic channels	3.6 × 10 ⁶

ICAL prototype at VECC, Kolkata



- 13 layers of iron
- Dimension: 2.5m × 2.5m × 1.3m
- 5 cm thick iron plates separated by 5 cm, with Resistive Plate Chambers (RPCs) as active elements
- Total mass ~ 30 Ton
- Magnetic field ~1.25 Tesla
- 12 RPCs of dimension 1m × 1m (active area) will be used

Basic principle of RPC



Surface of resistive electrodes are charged from power supply. Charge-up process is slow due to high resistivity of the material.

A passing charged particle induces an avalanche, which develops into a spark. The discharge stops when local charge is used up. This region is dead until recharged through the bulk resistivity of the plates (10¹¹ Ω cm).

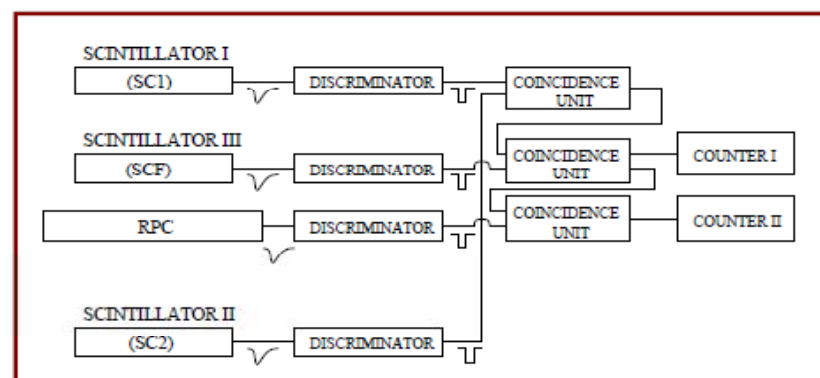
When readout strips are placed, charge is either drawn in or drawn out from the readout board, generating voltage signals of opposite polarities.

Fabrication Procedure

- Bulk resistivity measurement
- Cut in proper dimension
- Making of polycarbonate
 - Edge spacers
 - Button spacers
 - Gas nozzles
- Gluing and
- Silicone coating
- Partially conducting graphite coating on the outer sides
- Surface resistivity measurement
- Electrical leads connection
- Leak test using Argon and Helium sniffer probes



Schematic representation of cosmic ray setup

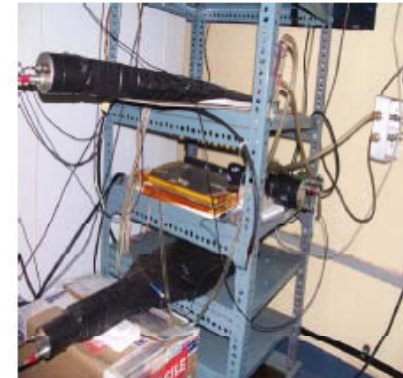


Complete RPC

All RPCs are tested in streamer mode. Discriminator threshold for the RPC signal is set at -40 mV.

Master trigger signal = SC1 .AND. SC2 .AND. SC3
Efficiency = $\frac{\text{RPC signal in coincidence with master trigger}}{\text{Master trigger count}}$

Cosmic ray test bench



Arrangement of the scintillators and the RPC

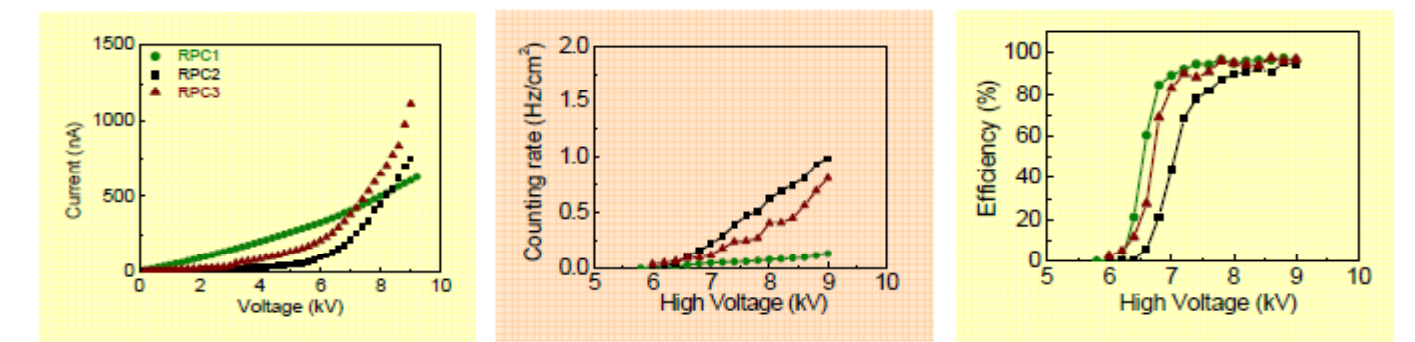
- Used gas: Argon, Iso-butane, R-134a (34.7:59).
- Flow rate: 0.4 ml/min (3 detector volume/day)



Power supply, front-end electronics and DAQ

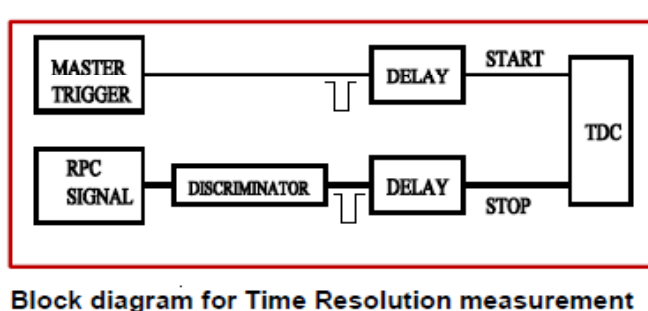
Mixing unit for 4 gases

Results

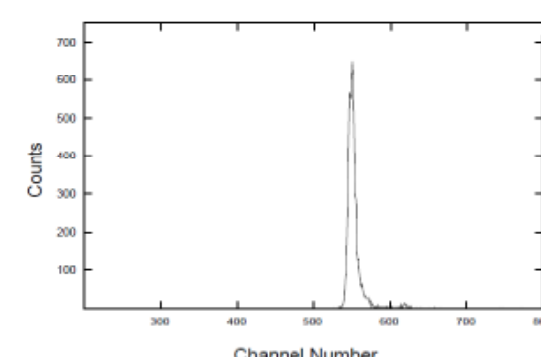


- The RPCs are tested in streamer mode using premixed gas.
- The Trigger rate was around 0.005 Hz/cm².
- Efficiency plateau >90% obtained.
- The counting rate is found to be < 1 Hz/cm²

Time resolution of RPC

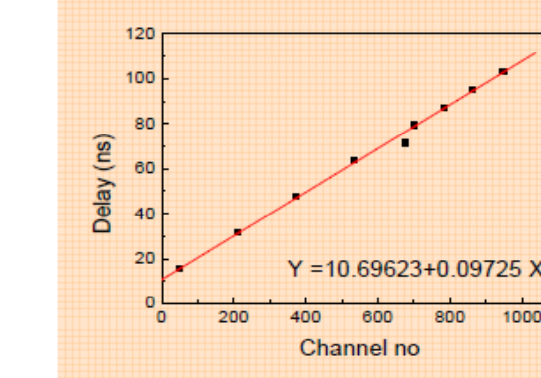


Block diagram for Time Resolution measurement



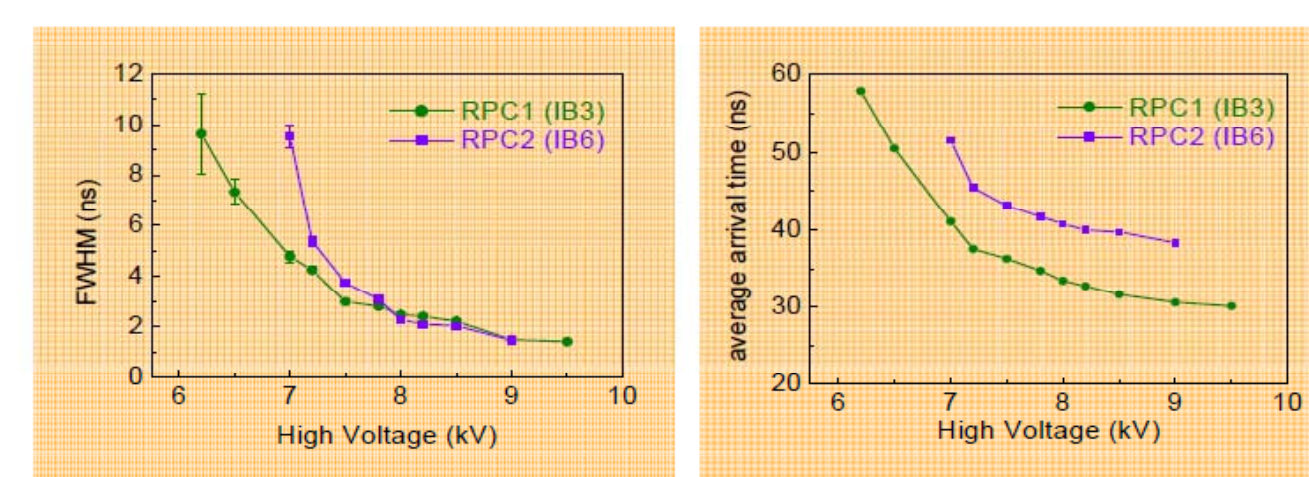
Time spectra of RPC

- P/S 7186 TDC is used
- Offset delay ~ 10 ns
- 1 ch of TDC = 0.097 ns
- FWHM_{SCF} = 1.98 ± 0.02 ns
- FWHM_{SC1} = 3.20 ± 0.07 ns
- FWHM_{SC2} = 3.39 ± 0.08 ns



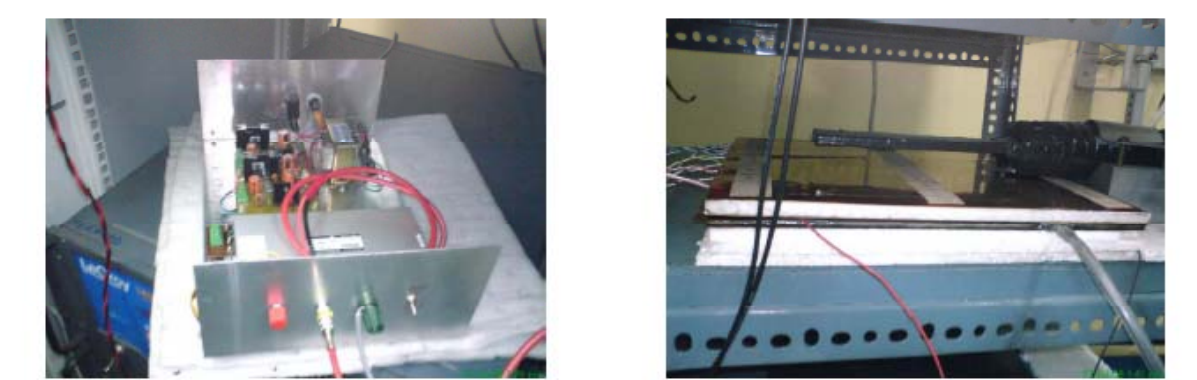
Calibration curve

Results of time resolution measurement



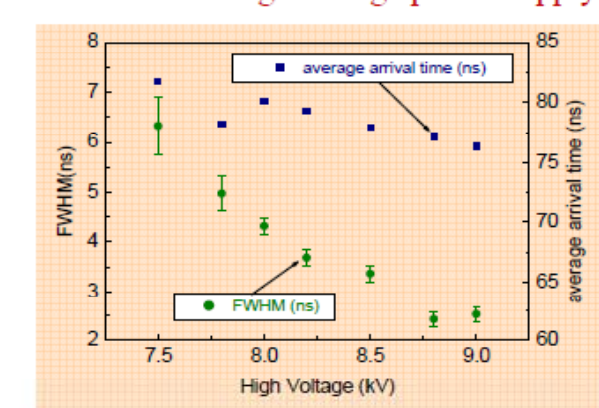
- RPC dimension: 30 cm × 30 cm
- TDC Start: Master trigger (3 fold scintillator)
- TDC Stop: Signal from RPC
- Time resolution of RPC at plateau region ~ 2 ns
- Average arrival time decreases with increasing high voltage

More result on timing measurement



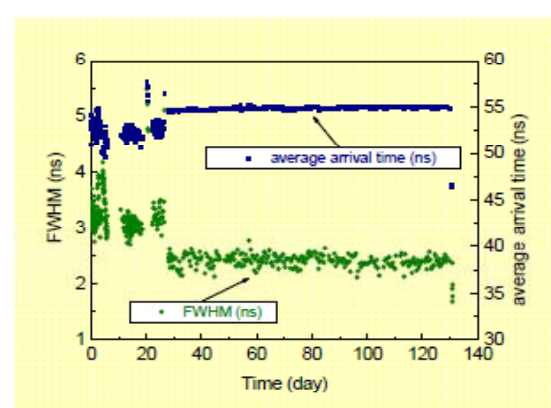
High voltage power supply

Foam and G-10 based copper pick-up strips

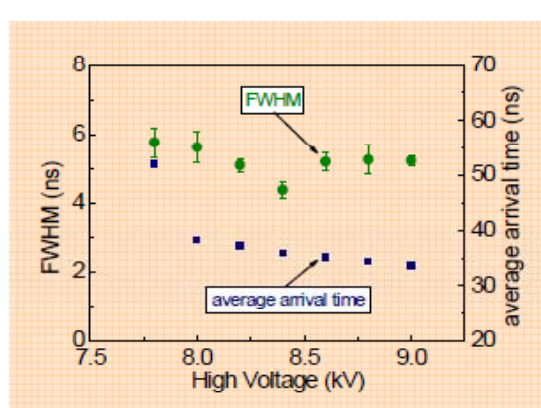


- One 10 kV Power supply has been made in SINP (EWF)
- Foam and G-10 based copper pick-up strips for both the RPCs have been made at VECC
- Average time resolution ~ 3 ns
- TDC start: RPC 1
- TDC stop: RPC 2

Long term test and time resolution of large RPC



- RPC was tested at 8 kV for more than 130 days
- Time resolution remains constant ~ 2-3 ns
- Average signal arrival time remains constant



- RPC dimension: 1m × 1m
- Average time resolution at plateau region ~ 5 ns
- Average signal arrival time decreases with high voltage

Summary and Outlook

- Time resolution of several small (30 cm × 30 cm) silicone coated RPC prototypes were measured in streamer mode using a common start TDC
- The START signal was taken from the scintillators and the STOP signal was obtained from the RPC pick-up strips
- Average time resolution at plateau region ~ 2.48 ± 0.08 ns for the smaller (30 cm × 30 cm) RPC
- Average signal arrival time decreases with high voltage
- One of the modules was tested continuously for more than 130 days. Stable time resolution (2.40 ± 0.12 ns) with average signal arrival time 54.70 ± 1.12 ns obtained.
- Time resolution between two RPCs ~ 3 ns.
- Average time resolution of large (1 m × 1 m) RPC ~ 5 ns.

Acknowledgement

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References

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