Development & Characterization of Large size RPC Detectors for INO-ICAL Experiment

Md. Naimuddin, Ashok Kumar & Ankit Gaur
University of Delhi

ICHEP2016
August 03 - 10, 2016
Chicago, USA

06/08/2016 Md. Naimuddin
At the beginning of 2015, INO received approval for building the facility near Madurai in south India.

A cavern of dimensions $132 \text{ m} \times 26 \text{ m} \times 32.5 \text{ m}$ will be constructed at the end of a $1.91 \text{ km}$ long tunnel.

INO will have a 50 kilotons magnetized Iron Calorimeter (ICAL) to detect the atmospheric muonic neutrinos and anti neutrinos interactions.

Uniqueness of this experiment is its capability to differentiate between a positive charged muon and a negatively charged muon and thus between a muon neutrino and a muon anti-neutrino that produces it.
ICAL Detector

- Three modules, each of size 16m × 16m × 14.4m.
- In each module 151 layers of iron plates and RPC.
- 5.6 cm Thick iron plates are separated by 4.0 cm gap for RPC, act as active detector element.
- Total mass of 51 kton.
- Magnetic field applied 1~1.5T
- The readout of RPC is performed by external orthogonal pick up strips (X and Y strips).
ICAL Detector
RPC for ICAL

Two 3 mm thick float Glass
Separated by 2 mm spacer

Glass plates

2 mm thick spacer

Pickup strips

Resistive coating on the outer surfaces of glass
Evolution of RPC R&D

- ICAL would require a total of about 30,000 RPC of size 2mX2m.
- The R&D started with small size 30cm X 30cm RPC made up of various types of glasses available locally.
- The performance of various types of glass electrodes were studied.
- After freezing some of the operating parameters with smaller detectors, large size RPCs of 1m X 1m & 2m X 2m were fabricated.
- Option of bakelite RPCs were also explored and R&D on this still ongoing.
Construction of RPCs

Terminations on the non-readout end

Machined pickup strips on honeycomb panel

Preamp connections on the readout end
Surface Resistivity

Saint Gobain (Surface Resistivity in $10^{11}$ Ohm/Square)

Modi (Surface Resistivity in $10^{11}$ Ohm/Square)

Asahi (Surface Resistivity in $10^{11}$ Ohm/Square)
Gas Mixing Unit
Gas Mixing Unit Calibration

- Argon Calibration
- Freon Calibration
- Isobutane Calibration
- Sulphur Hexafluoride Calibration
Characterization of Electrodes

- Bulk Resistivity (Ohm-cm)
- Current (nA)
- Noise (Hz/Sq.cm)
- Efficiency (%)
Temperature and Threshold effects

- Saint Gobain glass gives the lowest current and count rate.
- All RPCs gives about 95% efficiency.
- No significant effect on efficiency due to temperature and threshold. Count rate and current varies as expected.
Gas Mixture Effects

ASAHI

- Current and count rate decreases with increase in the SF$_6$ Concentration.
- Absence of SF$_6$ shifts the threshold.
- Highest fraction of SF$_6$ (1%) gives lowest count rate and current as well as low efficiency.
**Gas Mixture Effects**

### Saint Gobain Gas Mixture Effects

- SF$_6$ concentration of 0.5% gives comparable current and count rate as well as higher efficiency.
Time Resolution

ASAHI

Saint Gobain
• A time resolution of less than 2 ns is achieved for efficiency plateau turn on at 95%.
• Threshold of 50mV provides good trade between efficiency and time resolution.
Charge Spectra

ASAHI

Gas composition: R134a(95%): C4H10(5%): SF6(0%)

Saint Gobain

Gas composition: R134a(95%): C4H10(4.5%): SF6(0.5%)

R134a(95%): C4H10(4.5%): SF6(0.5%)
R134A(90%): C4H10(9%): SF6(1%)
R134a(95%): C4H10(5%): SF6(0%)
Conclusions

- Comprehensive R&D performed on RPC detectors for ICAL experiment.
- An efficiency of more than 95%, low current and noise rate achieved for these detectors.
- Most of the cavern operating parameters has also been studied and optimized.
- Lots of studies for the gas mixing optimization has been performed and we recommend to run the RPCs in avalanche mode with R134A/Isobutane(4.5)/SF6 mixture in (95/4.5/0.5)%.
- A time resolution ~ 1.6 ns achieved for Saint Gobain and Asahi RPCs.
THANK YOU!