Performance Study of Glass RPC Detectors for INO-ICAL Experiment

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Plan of the presentation

- The INO-ICAL Detector

- Resistive Plate Chamber(RPC)

- Development of facilities ,University of Delhi

- Characterization and performance study with prototype RPC's

- Timing and Charge Spectra study

- Performance study with 1m x 1m RPC

- Conclusions

The INO Experiment

➢ A proposed underground facility at Bodi west hills in Theni district, near Madurai in south India.

➢ The project includes construction of an magnetised 50kTons Iron CALorimeter detector, called ICAL.

➢ A cavern of dimensions 132m × 26 m × 32.5m will be constructed at the end of a 1.91 km long tunnel

➢ Uniqueness of this experiment is its capability to differentiate between a positive charged muon and a negatively charged muon produced from interaction of a muon neutrino and a muon anti-neutrino.
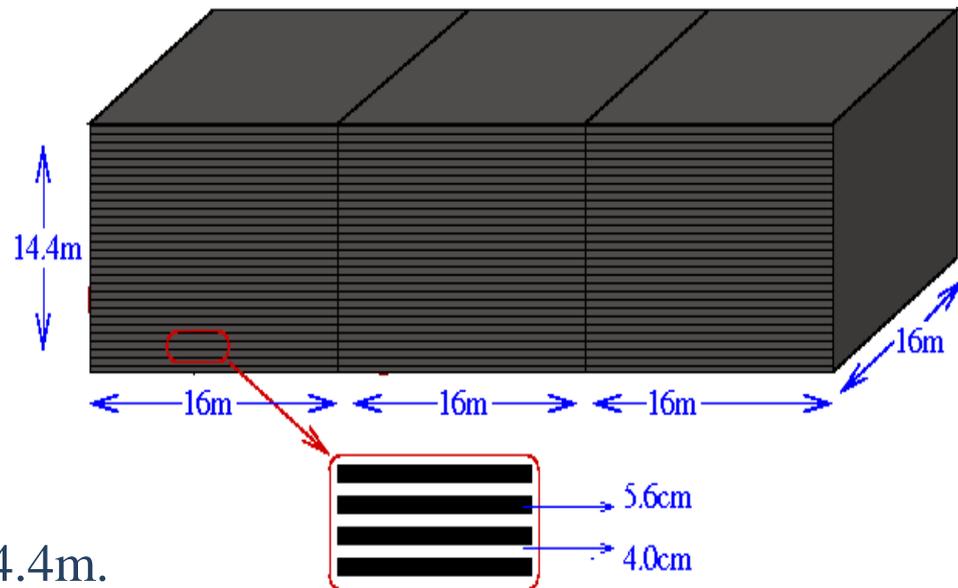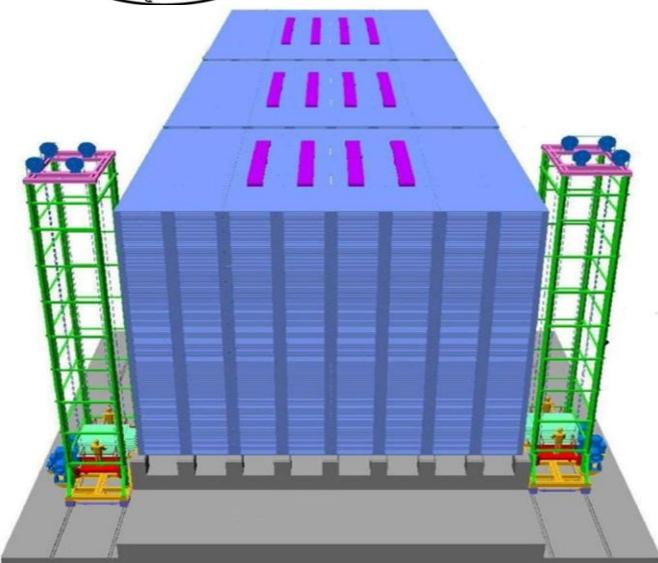

INO Peak at Bodi West Hills
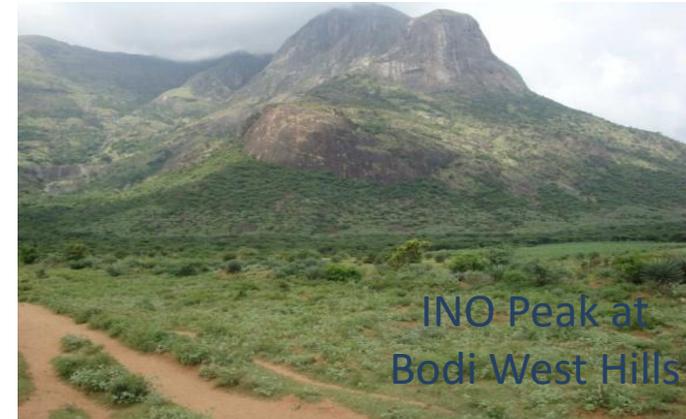
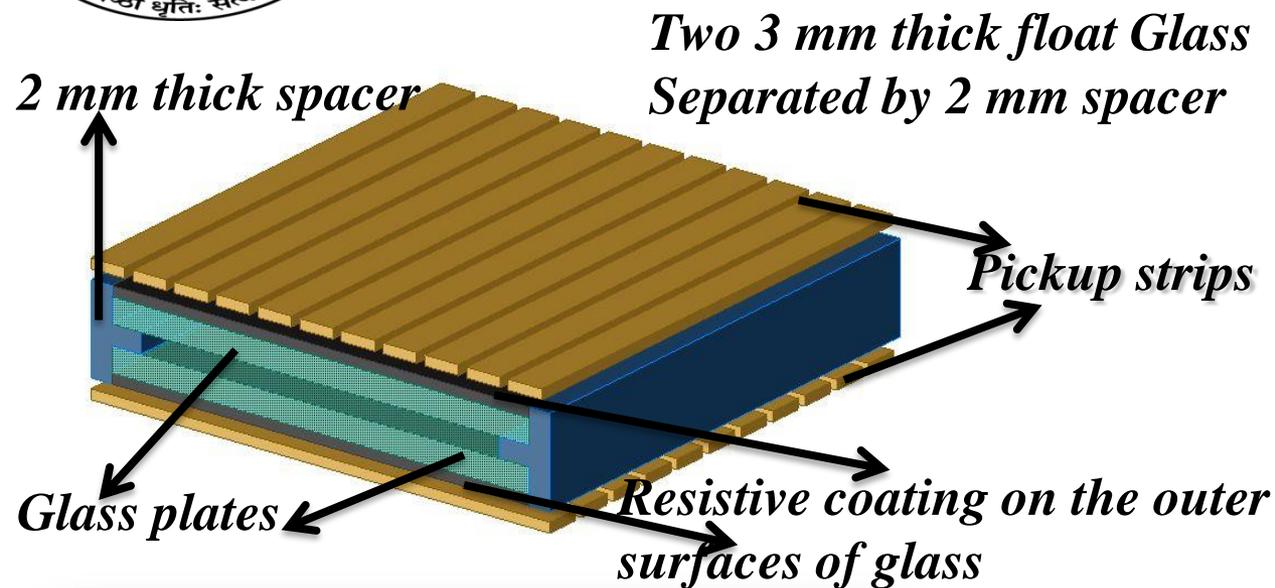INDIA BASED NEUTRINO OBSERVATORY

INO PEAK
2207 Mts.

Access Tunnel

ICAL Detector

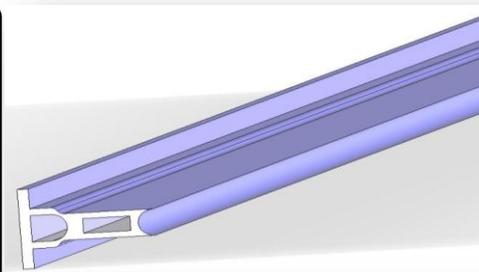➢ 3 Modules each of size 16m x 16m x14.4m.

➢ Resistive Plate Chamber gaseous detector as active element.

➢ 150 layers of RPCs interleaved by iron plates (56mm).

➢ 64(8 x8) RPCs per layer per module.

➢ Total of 28,800 RPCs of size 2m x 2m, with 64 strips   (30mm pitch) on either readout plane.
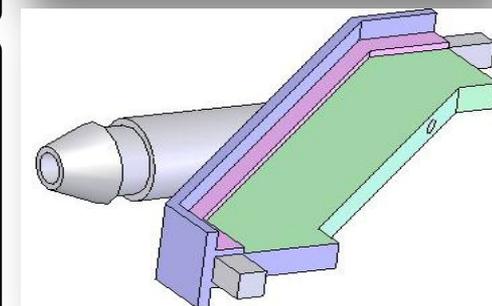
➢ Magnetic field of 1.5 Tesla.

Resistive Plate Chamber

2 mm thick spacer

Two 3 mm thick float Glass Separated by 2 mm spacer

Pickup strips

Glass plates

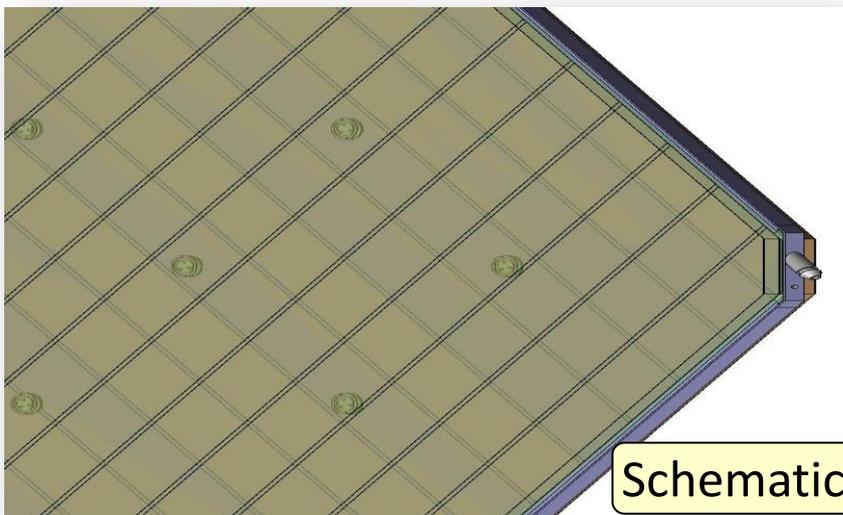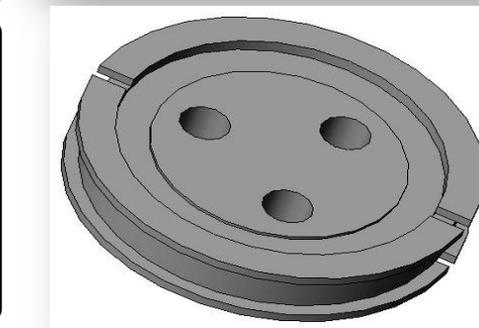*Resistive coating on the outer surfaces of glass*

Edge spacer

Gas nozzle
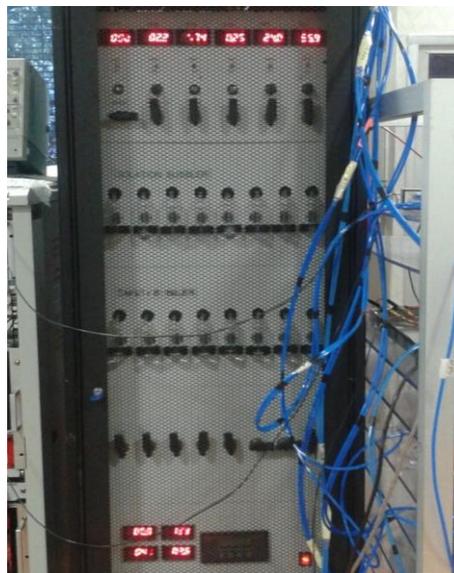
Glass spacer

Schematic of an assembled gas volume

Facilities at University of Delhi

➤ We set up a hardware and software INO lab in University of Delhi for fabrication and data analyses of RPCs.

➤ Gas mixing unit of 8 channel capable of mixing and distributing input gases were procured. The constituent gases are mixed in the required proportion into a buffer cylinder and distributed from there into the RPCs under test.

(a) Gas mixing unit

(b)Cosmic muon set up

➤ RPC test system, consisting of a scintillator paddle based Cosmic ray muon telescope as well as a NIM and VME based DAQ system were commissioned and completely functional.
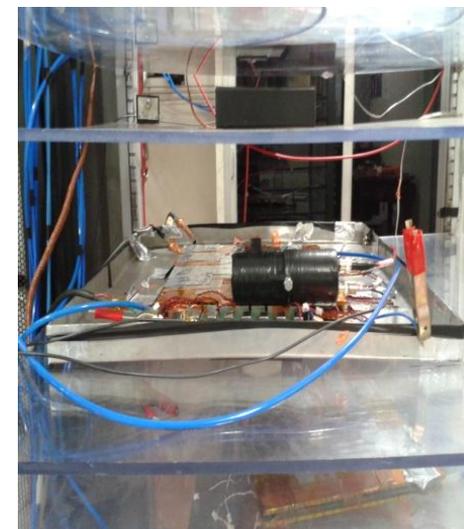
(c)VME/NIM DAQ

Characterization study with prototype RPC's

- For RPC Electrode careful choice of material is required:

- The parameter that must keep in mind for material selection:
  - 1   High Resistivity :   Counting rate, prevent Spreading of Discharge.
  -
  - 2.   Smoothness of Surface: Avoid localisation of Excess Charge, uniform Electric field .

- Material Used:
  - GLASS   :   Saint Gobain , Asahi and Modi

- For First Parameter we determined:
  - Bulk Resistivity
  - Surface Resistivity

- For Second Parameter we performed:
  - SEM
  - AFM.

Characterisation Results

The high resistivity ensures that the generated discharge are localised to an area around the primary avalanche and do not affect the entire detector.
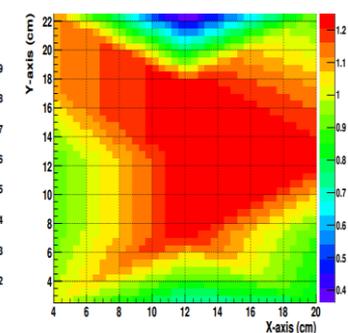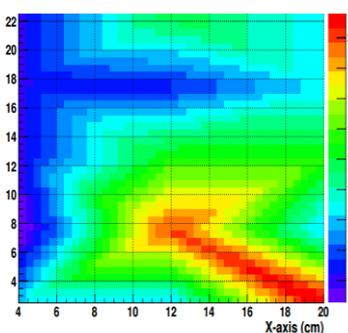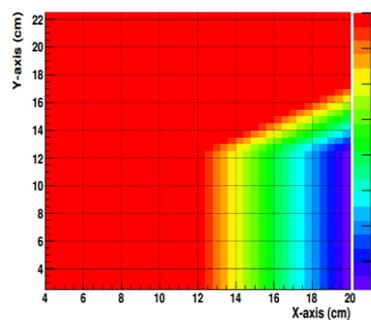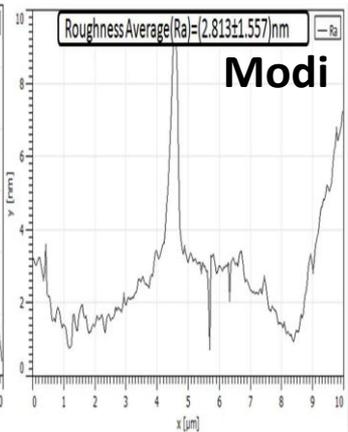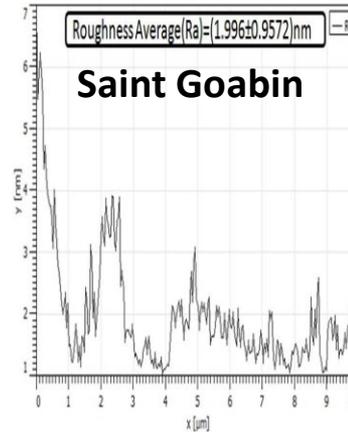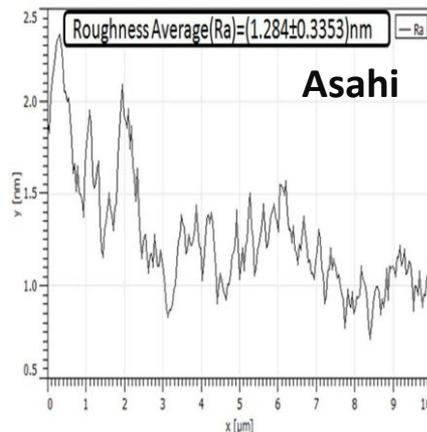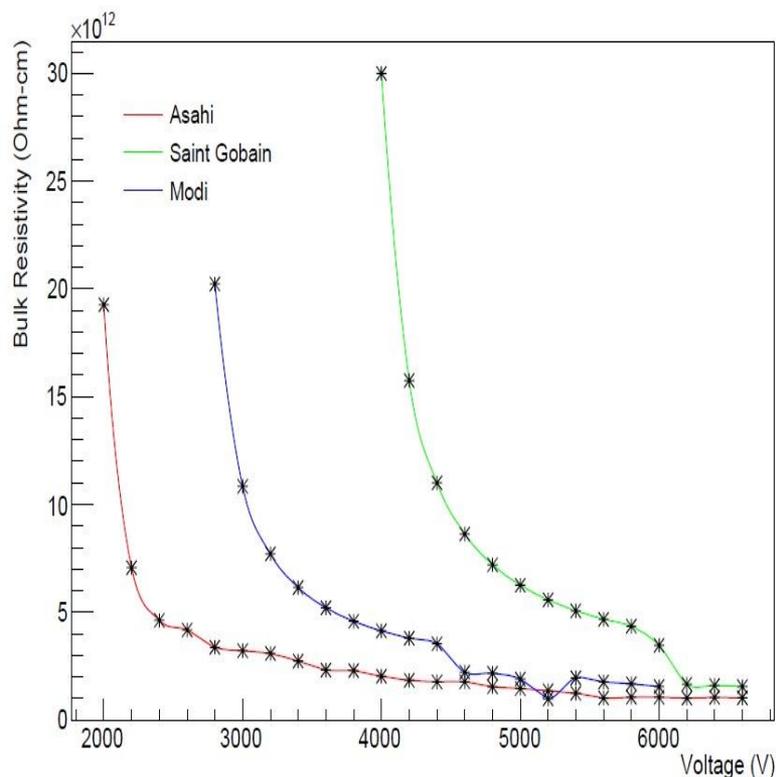

Fig: Bulk resistivity of all the three types of glasses in Ω-cm as a function of the applied voltage

Fig: Atomic Force Microscopy all the three types of Glasses

# Characterization summary

S. No.	Analysis	Asahi	Saint Gobain	Modi
1	Density (gm/cc)	2.527273	2.975833	4.792308
2	Bulk Resistivity	1.5E+12 ohm-cm	5E+12 ohm-cm	1.48E+12 ohm-cm
3	Surface Resistivity	2E+11 $\Omega/\square$	1.46E+11 $\Omega/\square$	0.8E+11 $\Omega/\square$
4	XRD	Amorphous	Amorphous	Amorphous
5	AFM	Roughness (1.28±0.3313) nm	Roughness (1.996±0.9572) nm	Roughness (2.813±1.557) nm
6	SEM	Better	Best	Normal
7	UV Transmittance	Higher	Highest	Low
9	EDX	$C_5Na_7Mg_2Al_{0.3}Si_{22}Ca_3O_{62}$	$Na_8Mg_2Al_{0.3}Si_{25}Ca_3O_{62}Sn_{0.6}F_1$	$C_7Na_6Mg_2Al_{0.3}Si_{20}Ca_2O_{62}K_{0.2}$
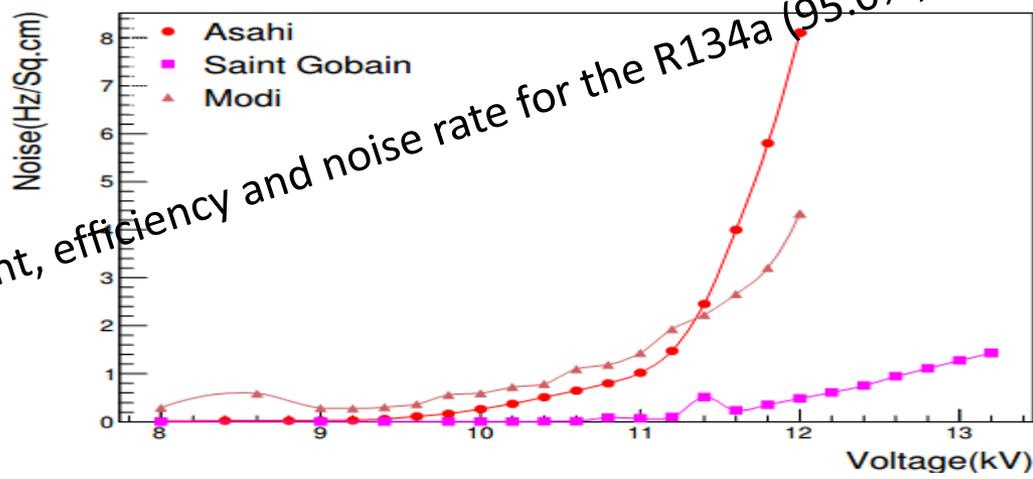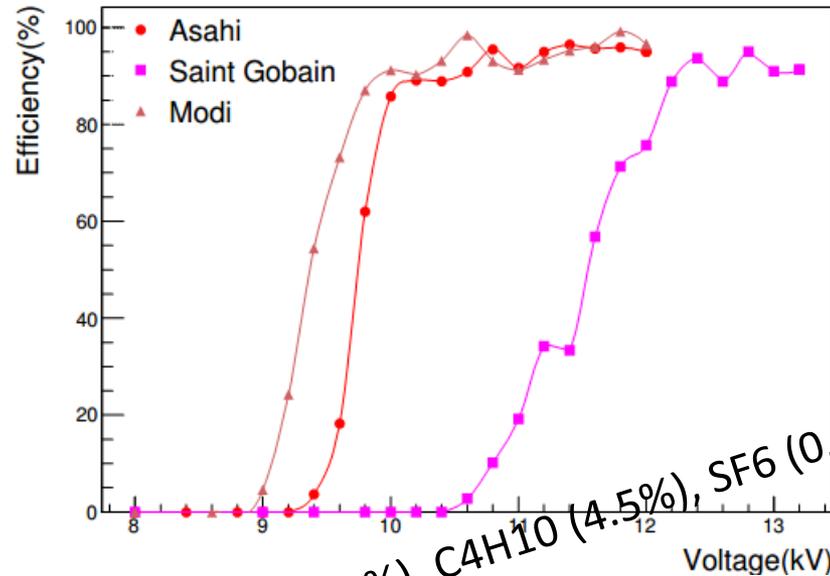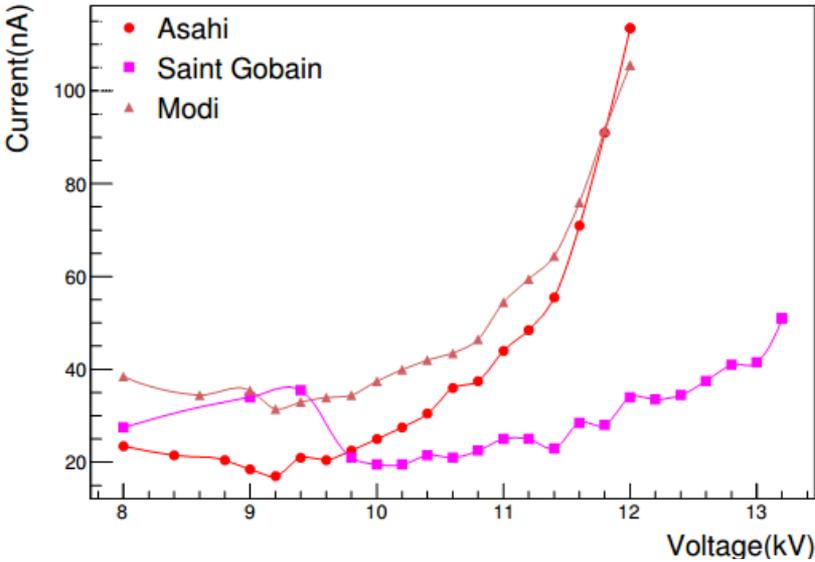
Leakage current, efficiency and noise rate for the R134a (95.0%), C4H10 (4.5%), SF6 (0.5%).

D. Kaur,Ankit Gaur et al. / Nuclear Instruments and Methods in Physics Research A 774 (2015) 74–81

Time   Resolution

➢We have choose Saint Gobain/Asahi and Set up the data acquisition system for the measurement

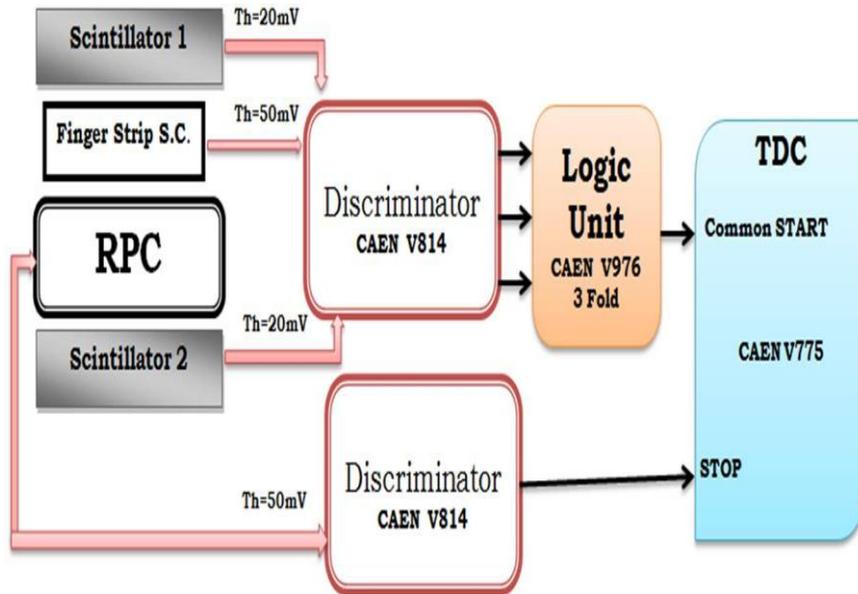➢Three scintillator co incidence pulse used as START & Discriminated RPC pulse used as STOP

Fig: Schematic representation of the experimental set-up used for timing measurements for glass based RPC.
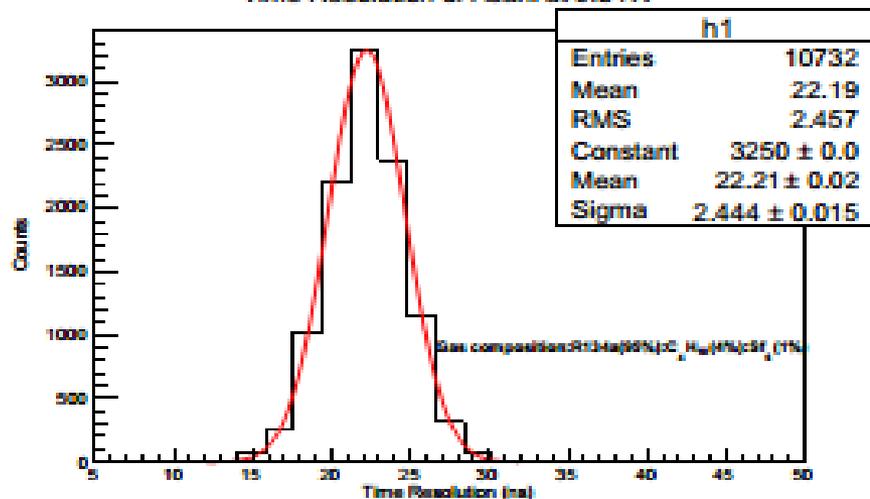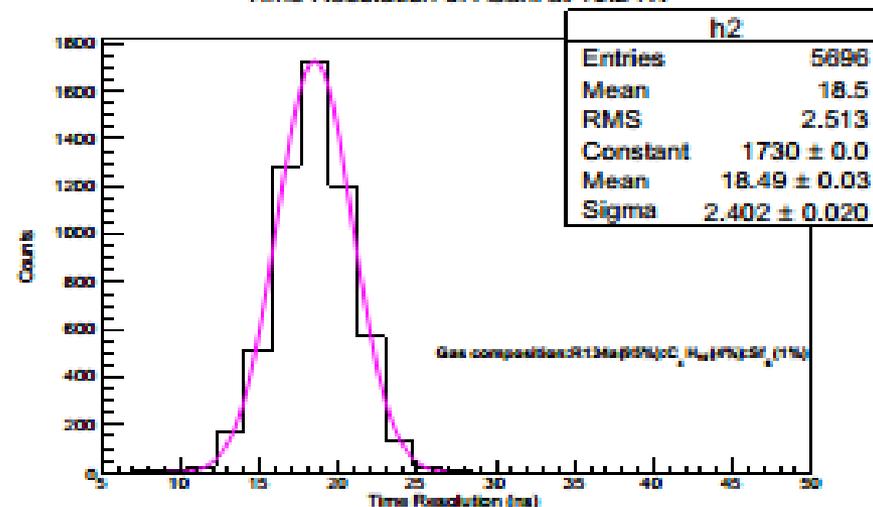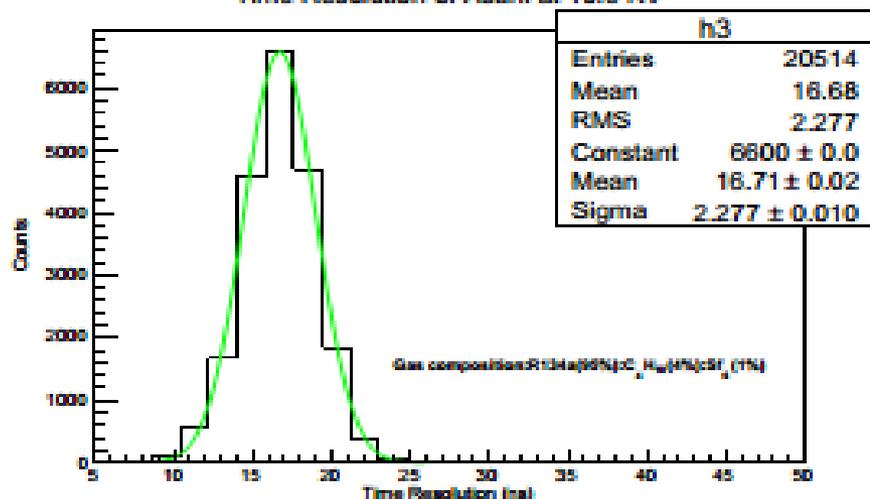
Asahi Results
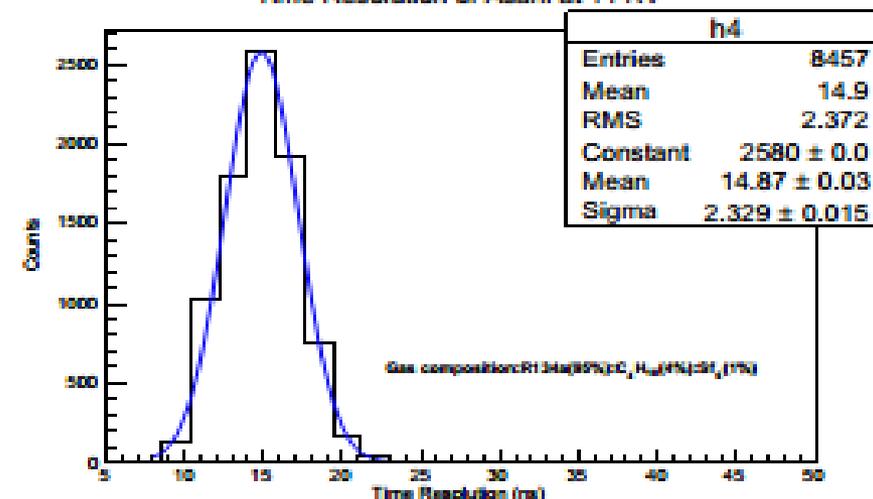
Gas composition(95.0%), C4H10 (4.5%), SF6 (1%).

Saint Gobain Results

Gas composition(95.0%), C4H10 (4.5%), SF6 (1%).
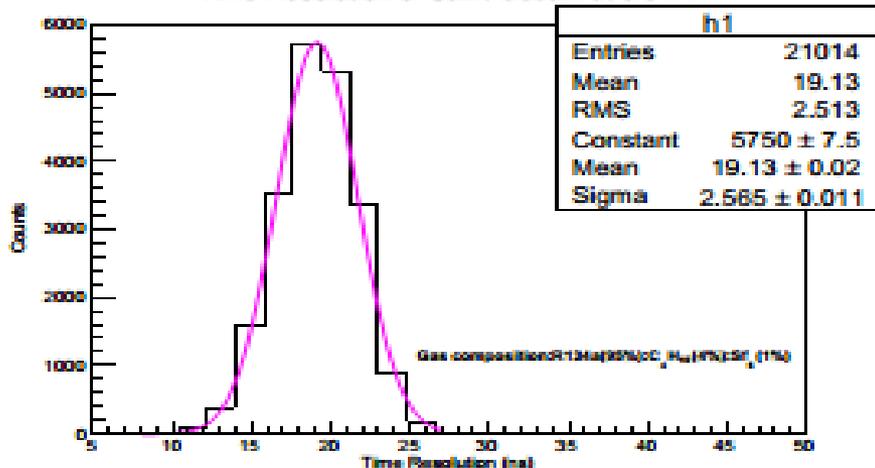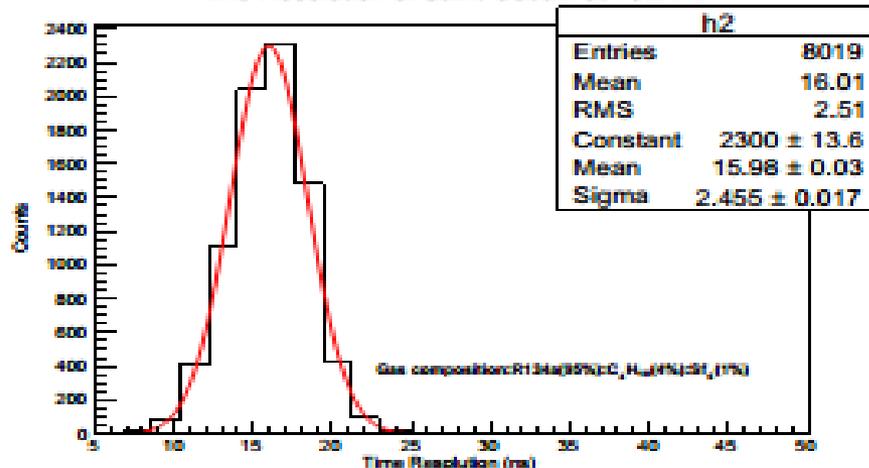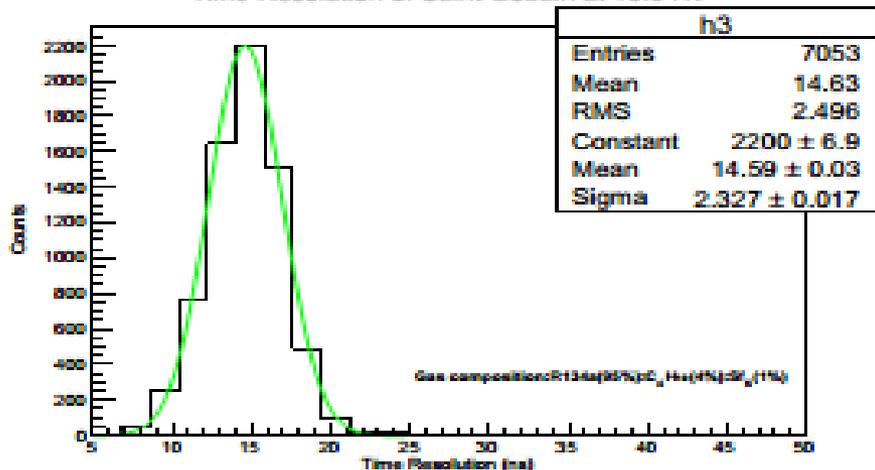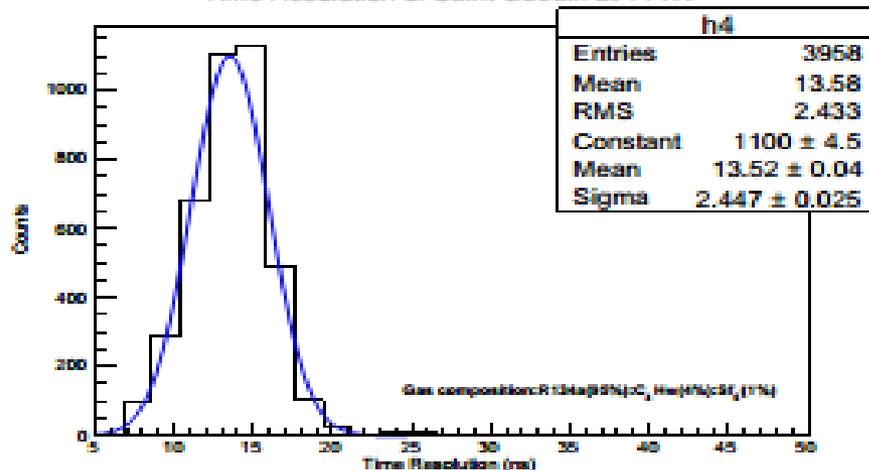
Charge Spectra

- Charge spectra for Asahi and Saint Gobain have been studied

- QDC is used to Study induced charge at Different Voltage

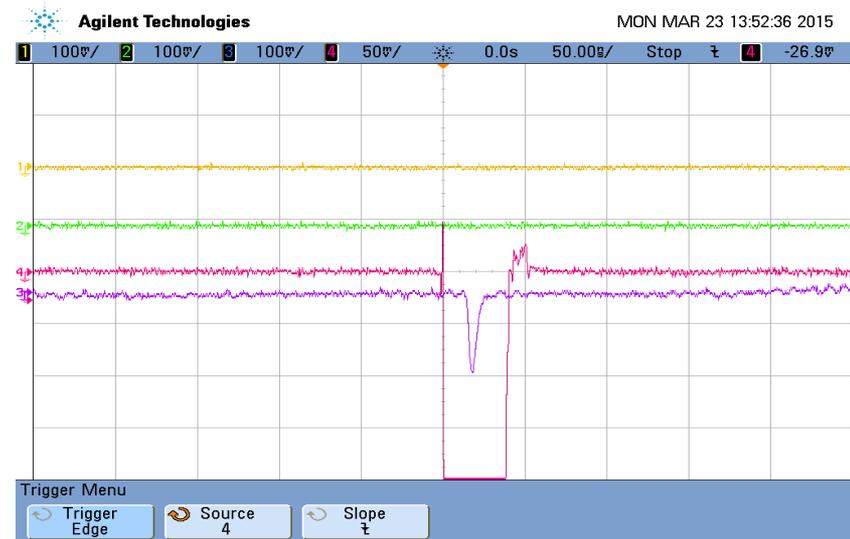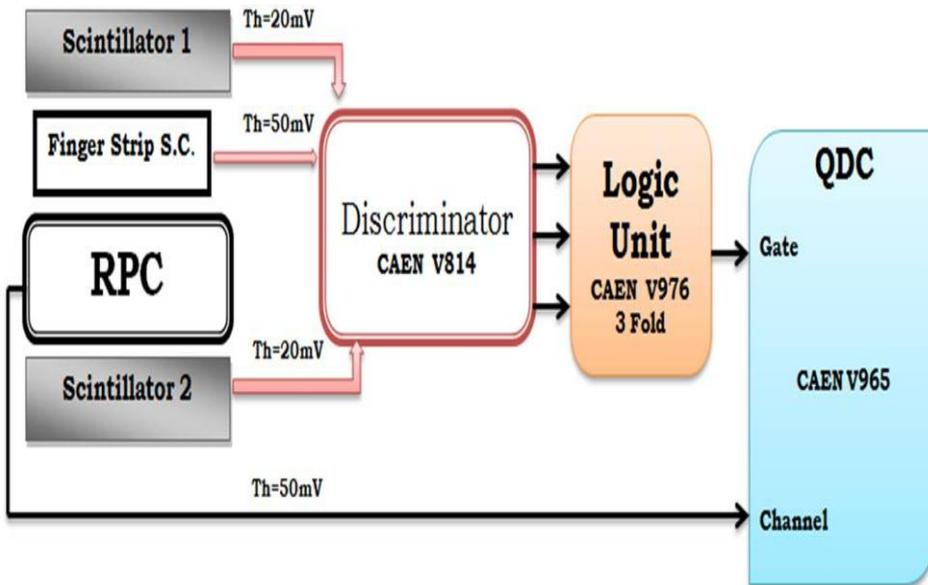- Coincidence pulse of three Scintillator is used as Gate for QDC

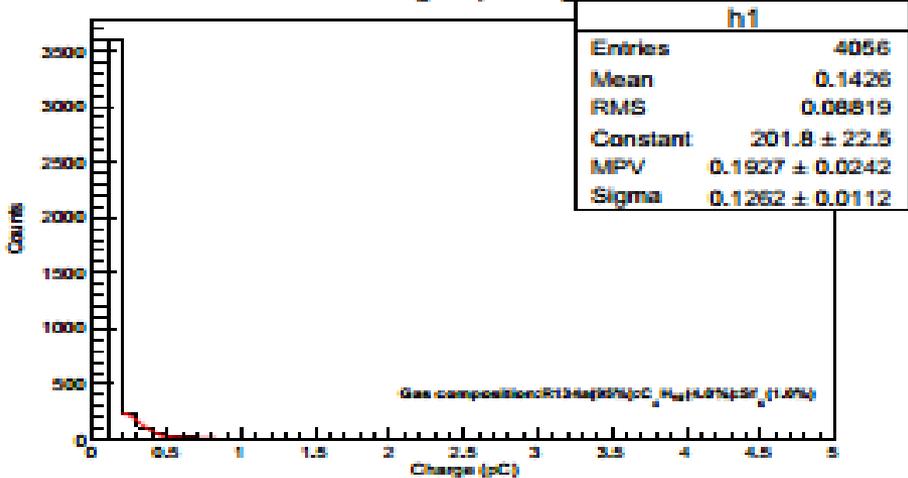Fig: Schematic representation of the experimental set-up used for Charge measurements for glass based RPC

Asahi Results

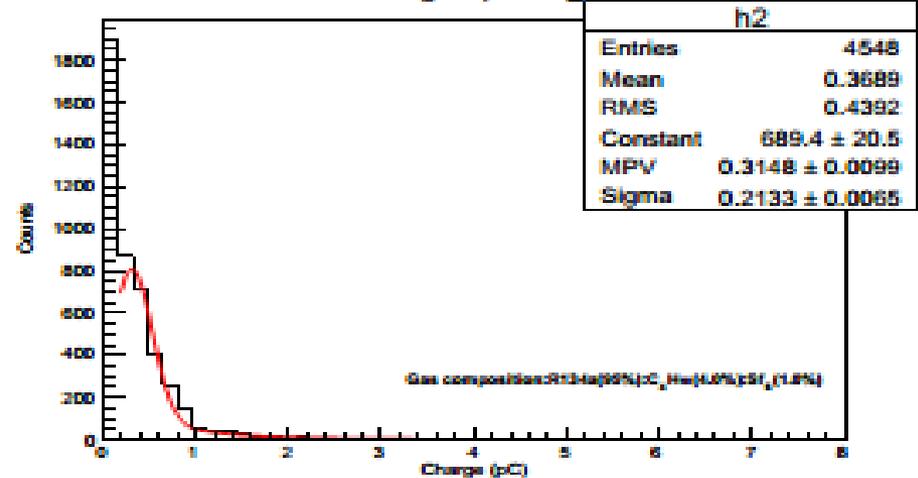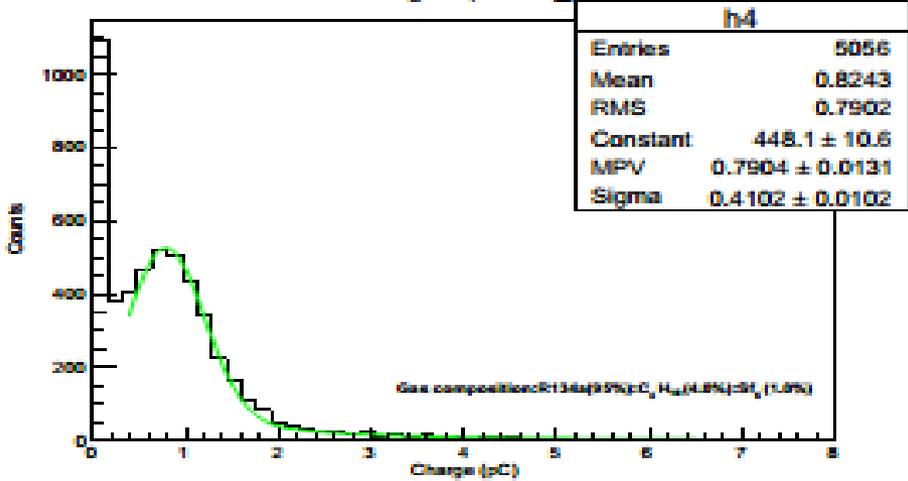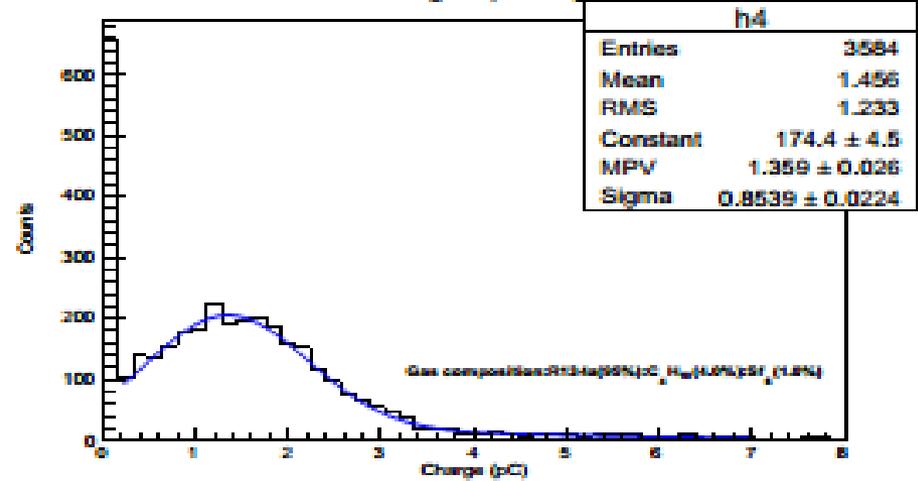Gas composition(95.0%), C4H10 (4.5%), SF6 (1%).

Saint Gobain Results

Gas composition(95.0%), C4H10 (4.5%), SF6 (1%).
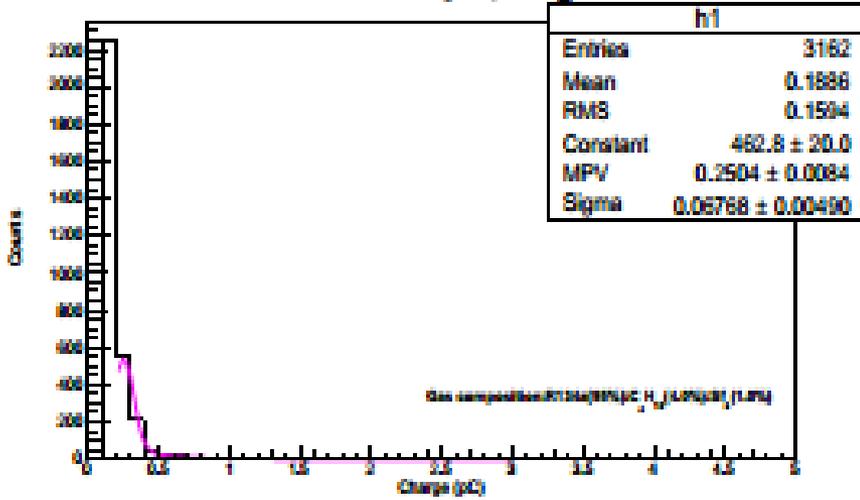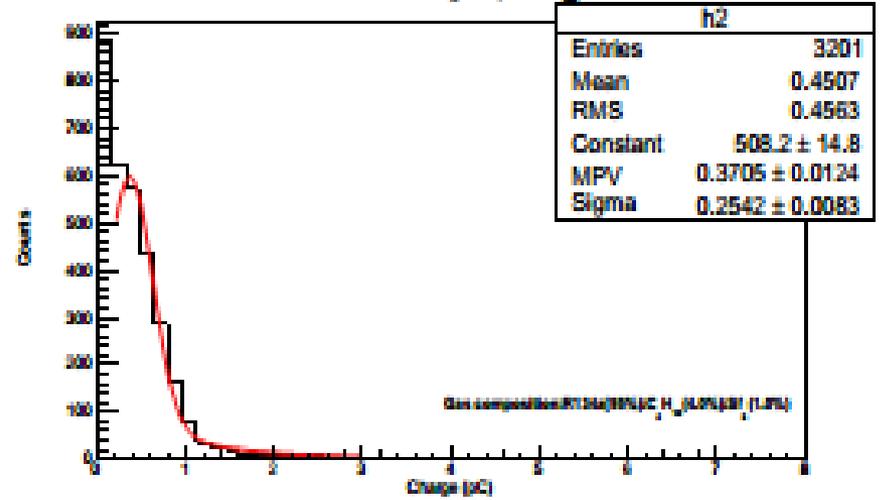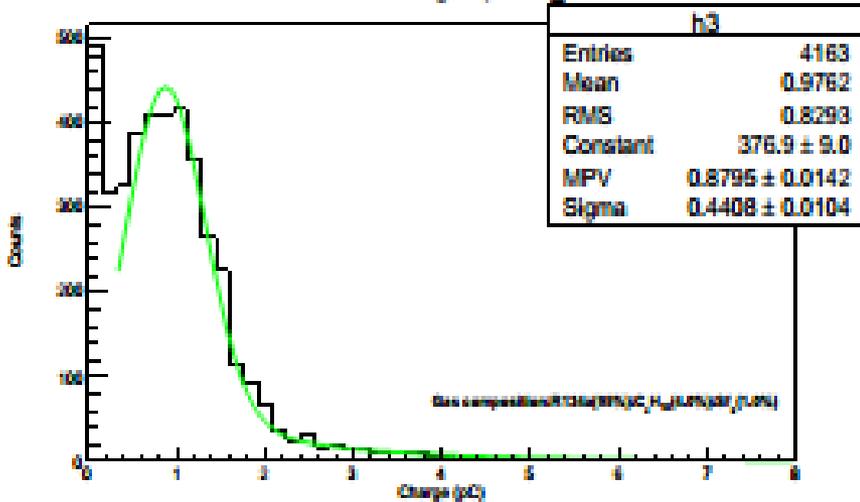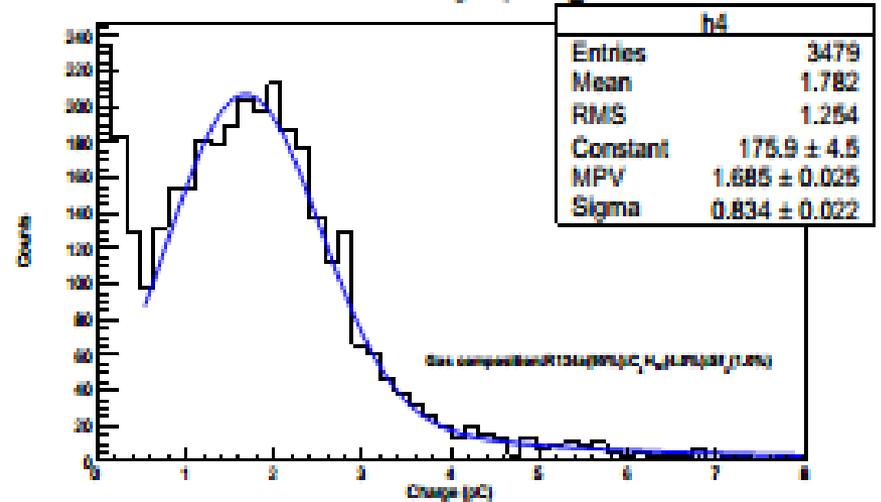
Fabrication of 1m x 1m RPC

➢ Glass cutting and cleaning
➢ Coating the surface with graphite paint
➢ Gluing of buttons and side spacers
➢ Preparation of pick up panels and soldering of high voltage connection

Graphite paint

Stack for embarking 12 RPC of dimension 1m x1m

Placing of Pick up panels on honey comb

Gluing of buttons

Fabricated 1mx 1m RPC
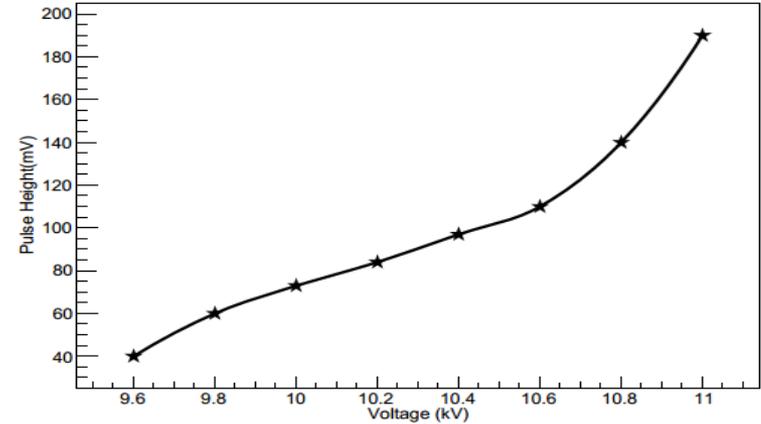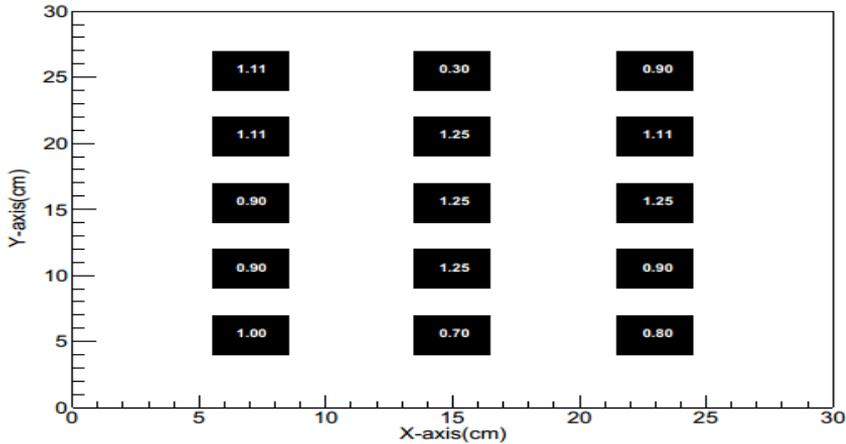
(a) The measured Graphite surface resistivity values in MΩ/ for the glass electrode

(b) Pulse height variation with applied bias voltage
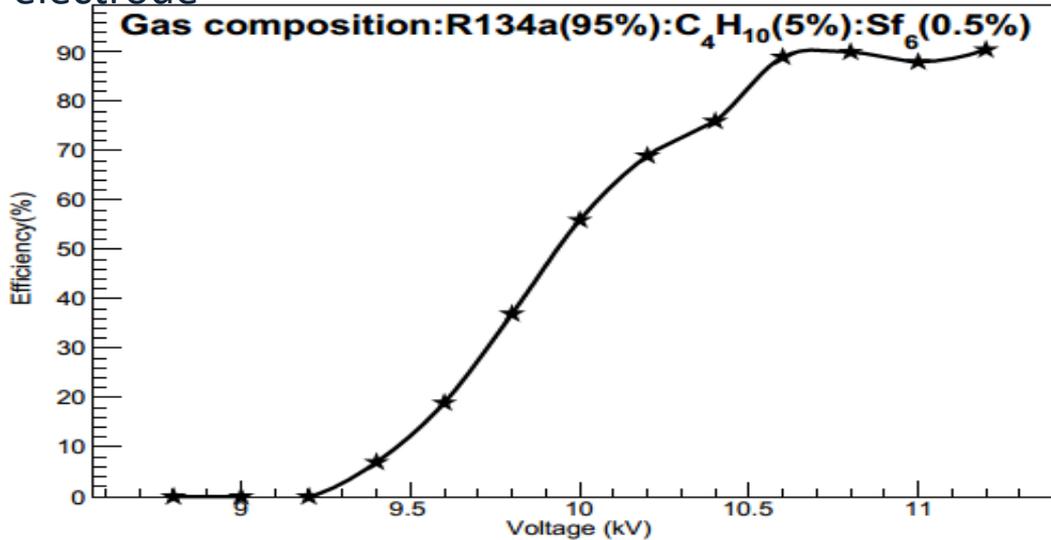
(c) Efficiency variation with respect to applied bias voltage

Conclusion

✓ **Efficiency of more than 90% observed for all three glass electrodes.**

✓ **Operation of RPC's under Gas composition R134a (95.0%), C4H10 (4.5%), SF6 (0.5%) with temperature around 20°C and 35-45 % relative humidity gives best results.**

✓ **Saint Gobain and Asahi glasses are best suited for the INO-ICAL RPCs.**

✓ **Timing resolution of Asahi varies between 2.44ns-2.27ns while Saint Gobain have 2.56-2.32ns.**

✓ **Charge spectra of Asahi shows charge variation between 0.192pC-1.375 while Saint Gobain have 0.250pC-1.685pC.**

✓ **Study of time and charge under different gas compositions for RPCs prototypes are on going.**

THANK YOU