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

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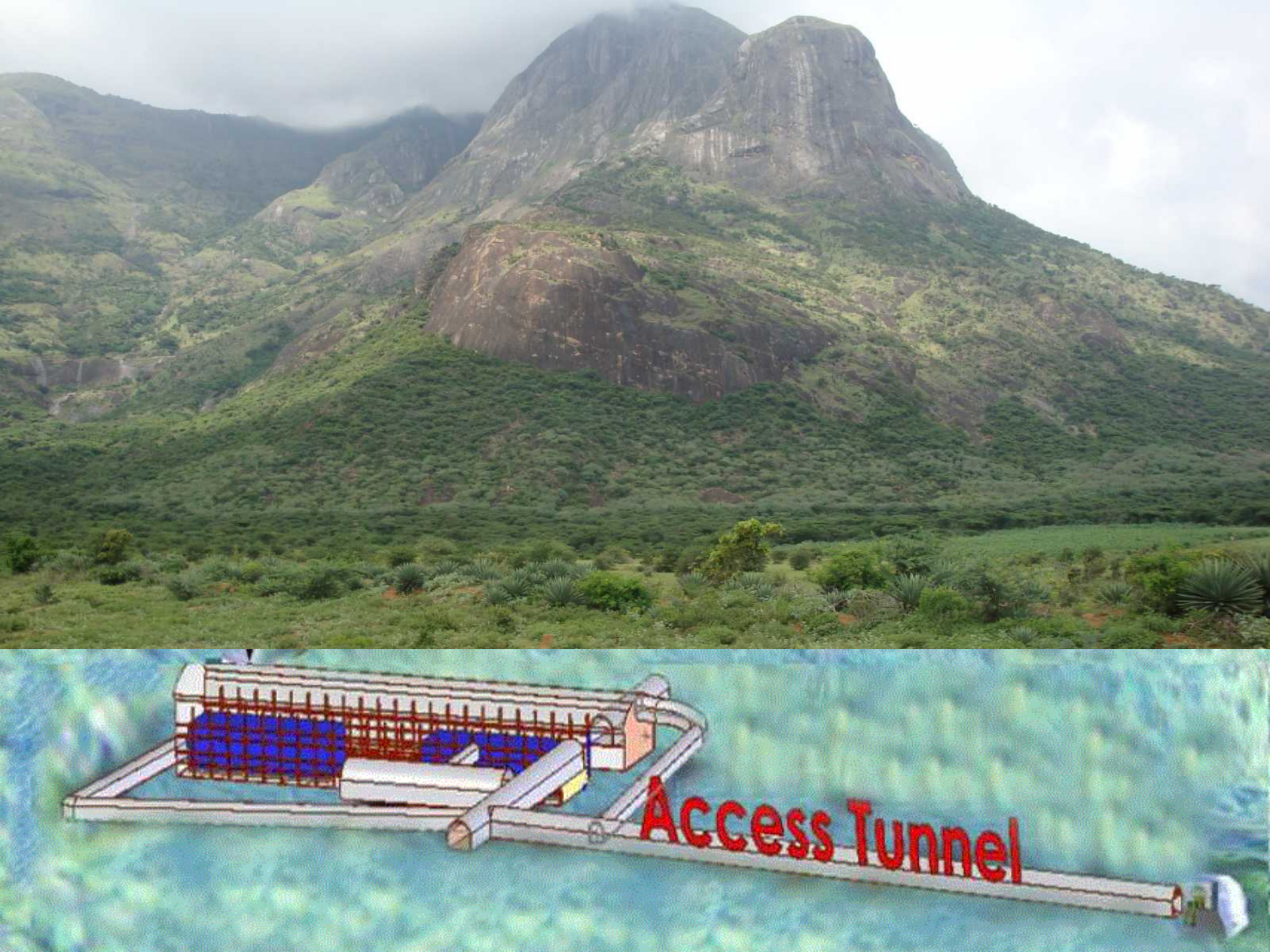
Chicago, USA


Access Tunnel

The INO Experiment

- At the beginning of 2015, INO received approval for building the facility near Madurai in south India.

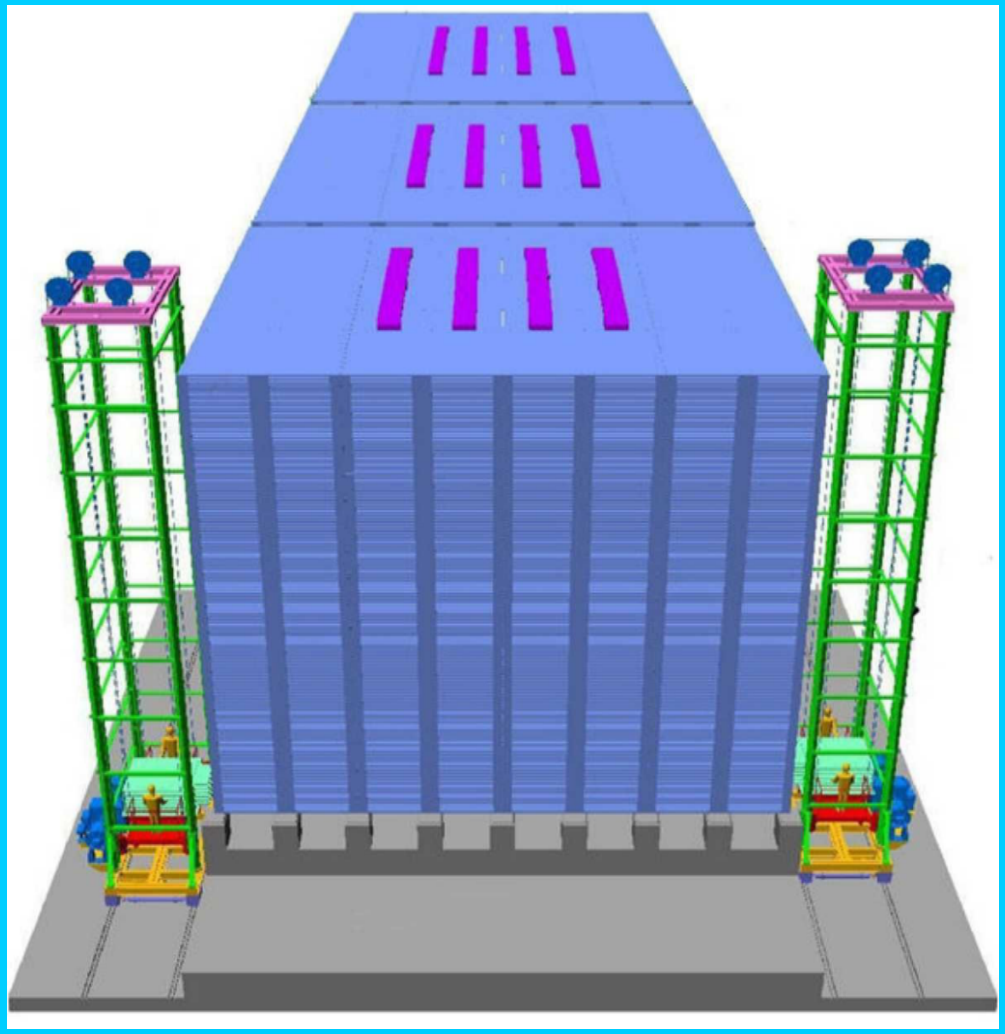
- A cavern of dimensions 132m × 26 m × 32.5m will be constructed at the end of a 1.91 km long tunnel.

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

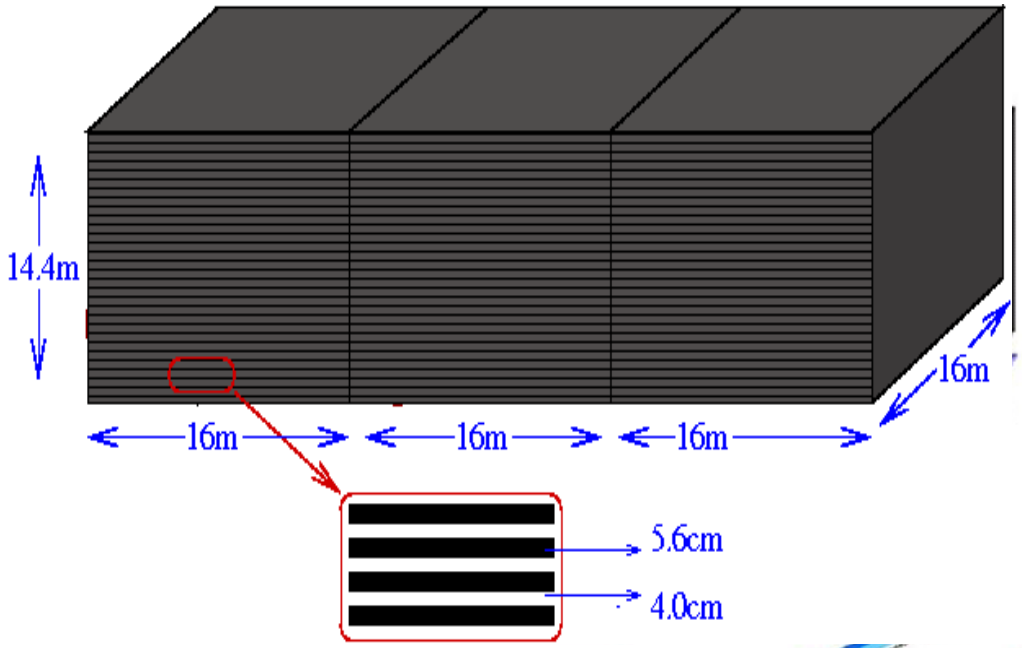
- Uniqueness of this experiment is its capability to differentiate between a positive charged muon and a negatively charged muon and thus between a muon neutrino and a muon anti-neutrino that produces it.

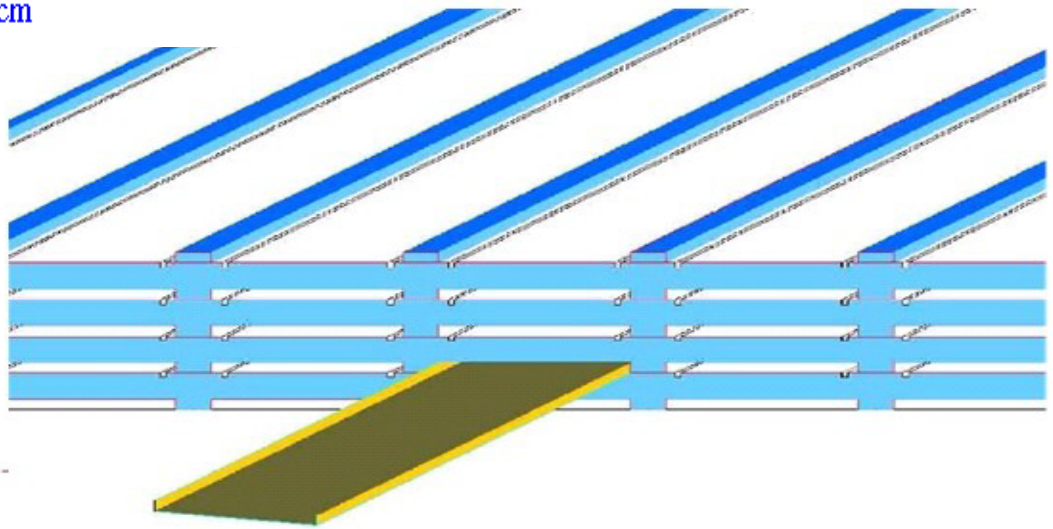
ICAL Detector

- 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 4.0cm gap for RPC, act as active detector element.
- Total mass of 51kton.
- Magnetic field applied 1~ 1.5T
- The readout of RPC is performed by external orthogonal pick up strips(X and Y strips).

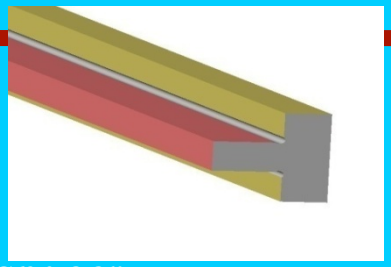


ICAL Detector





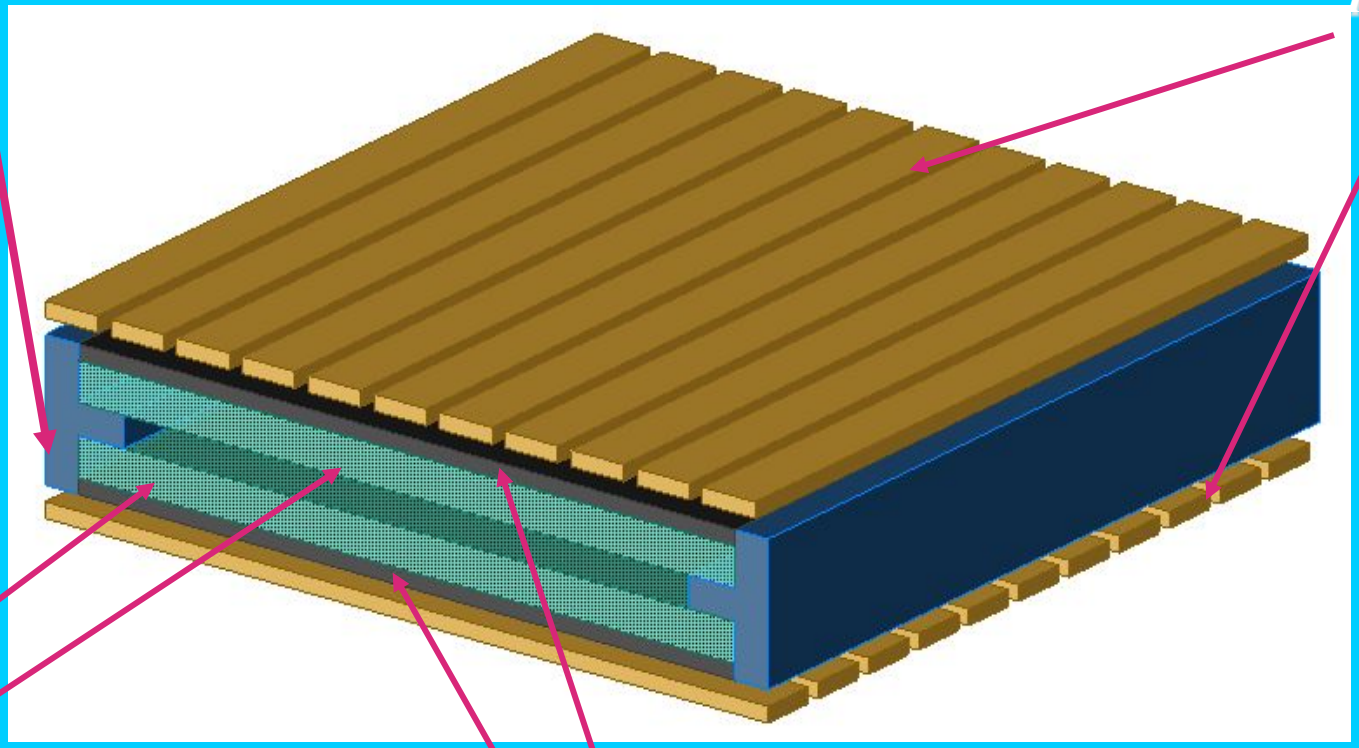
RPC for ICAL



2 mm thick spacer

Two 3 mm thick float Glass
Separated by 2 mm spacer

Pickup strips



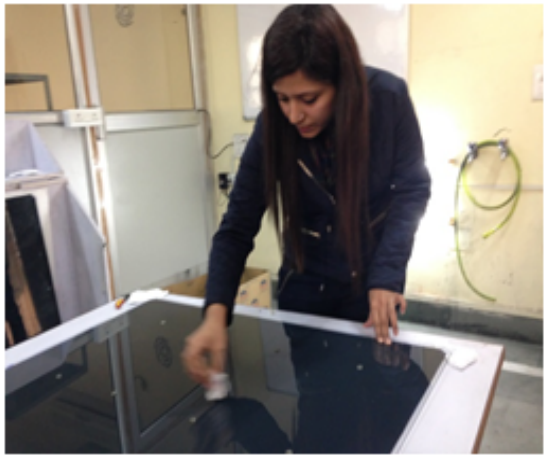
Glass plates

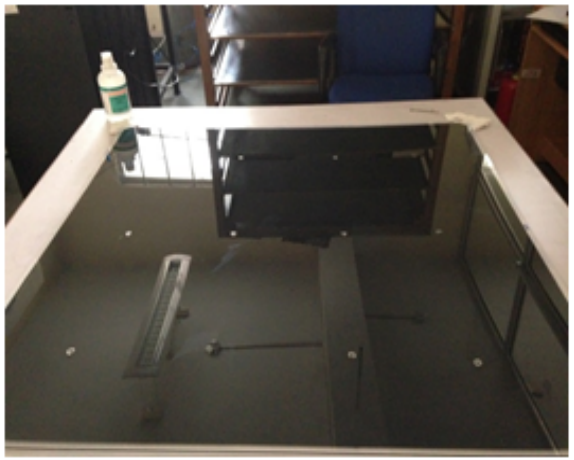
Resistive coating on the outer surfaces of glass

Evolution of RPC R&D

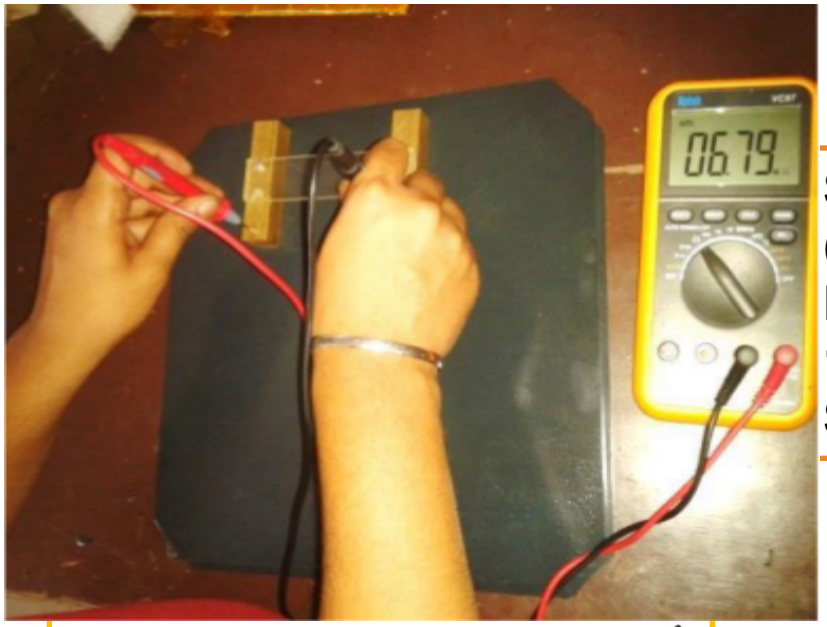
- ICAL would require a total of about 30,000 RPC of size 2mX2m
- The R&D started with small size 30cm X 30cm RPC made up of various types of glasses available locally.
- The performance of various types of glass electrodes were studied.
- After freezing some of the operating parameters with smaller detectors, 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

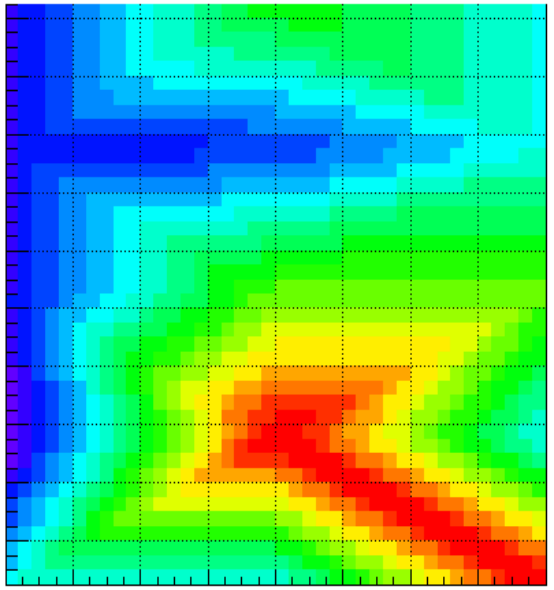


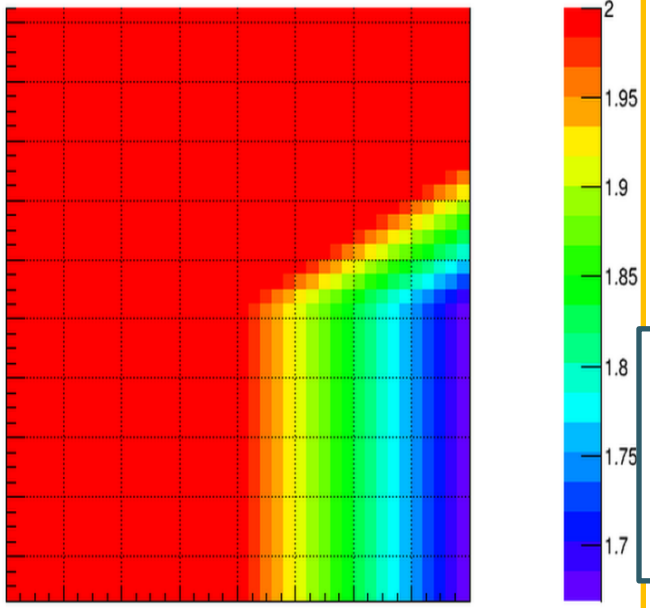


Surface Resistivity



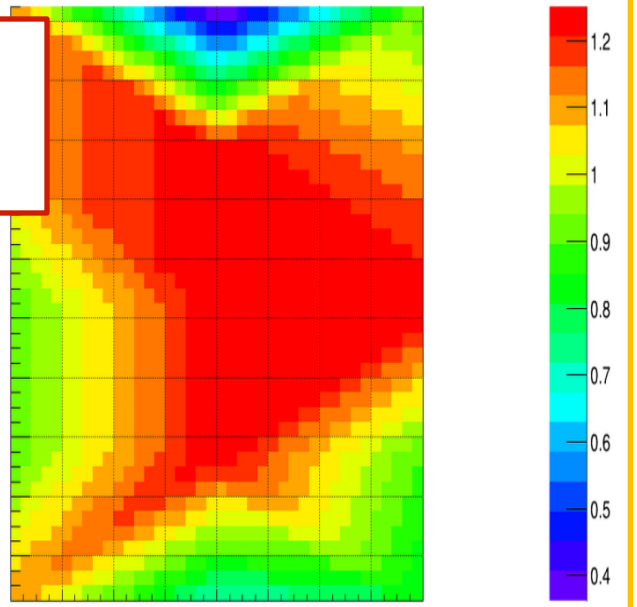
Saint Gobain (Surface Resistivity in 10^{11} Ohm/ Square)



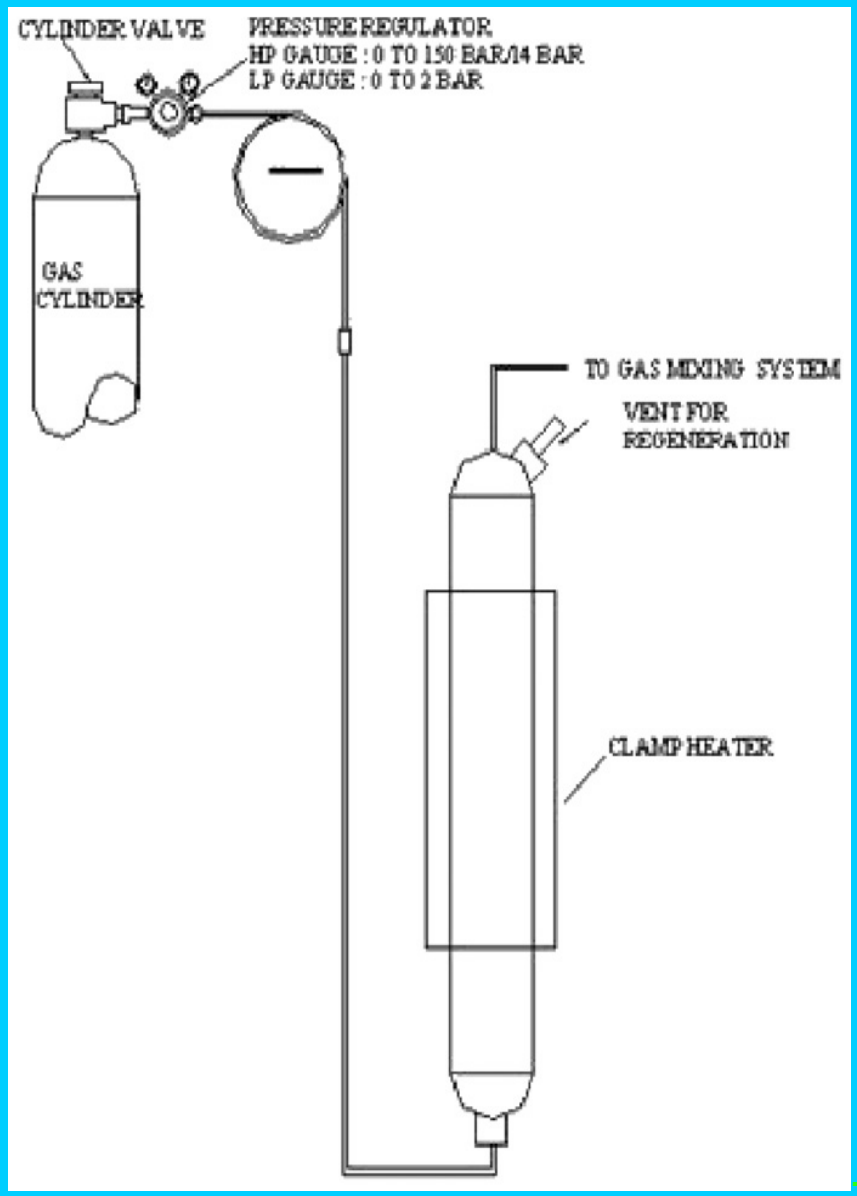


Modi (Surface Resistivity in 10^{11} Ohm/Square)

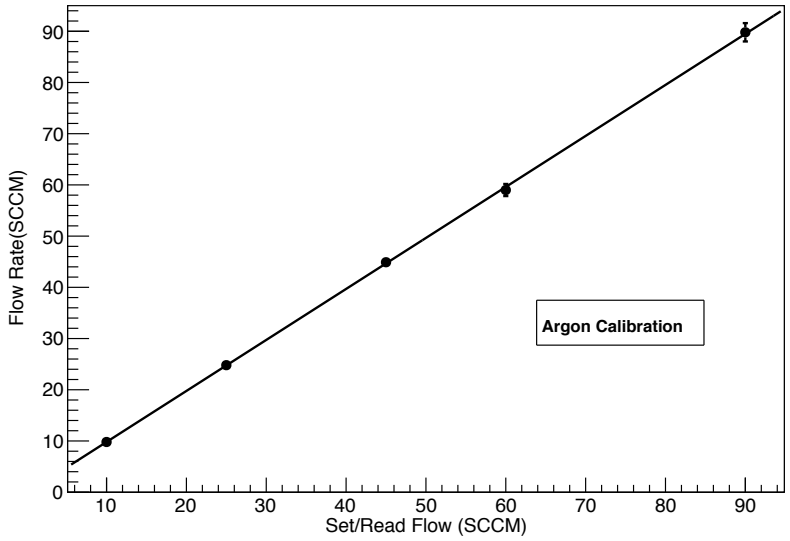
Asahi (Surface Resistivity in 10^{11} Ohm/ Square)

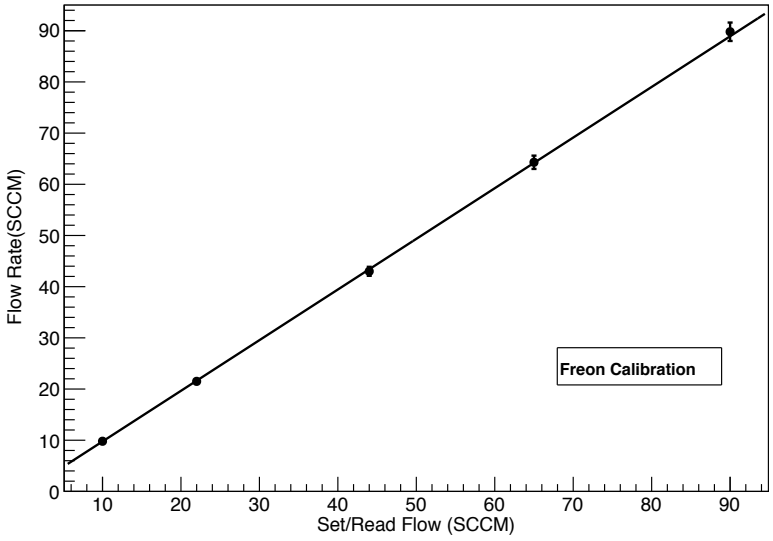


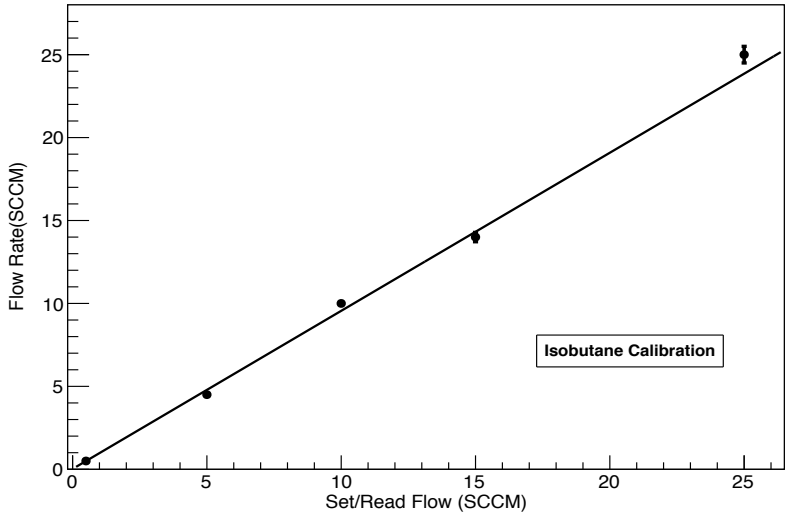
Gas Mixing Unit

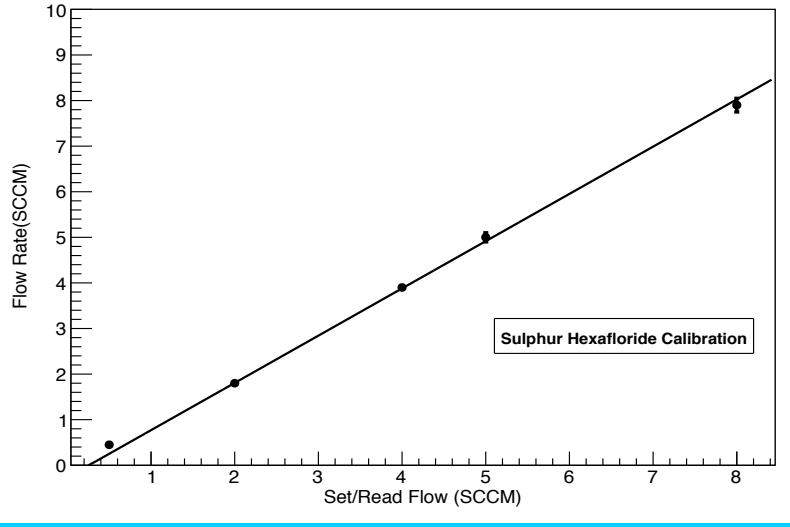


Gas Mixing Unit Calibration

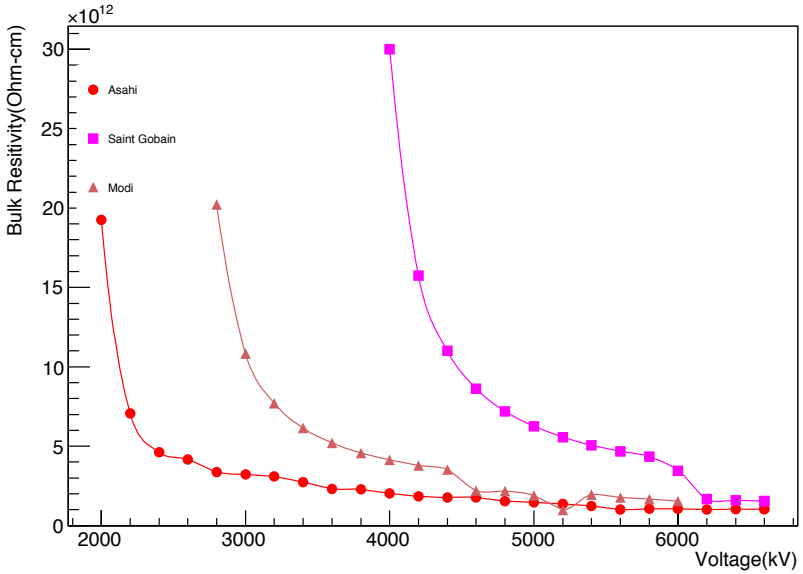


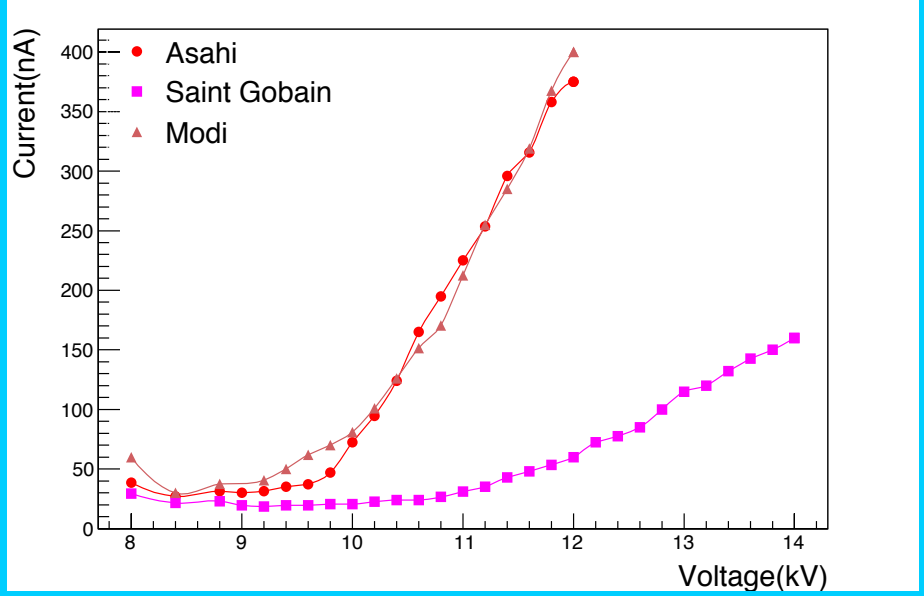


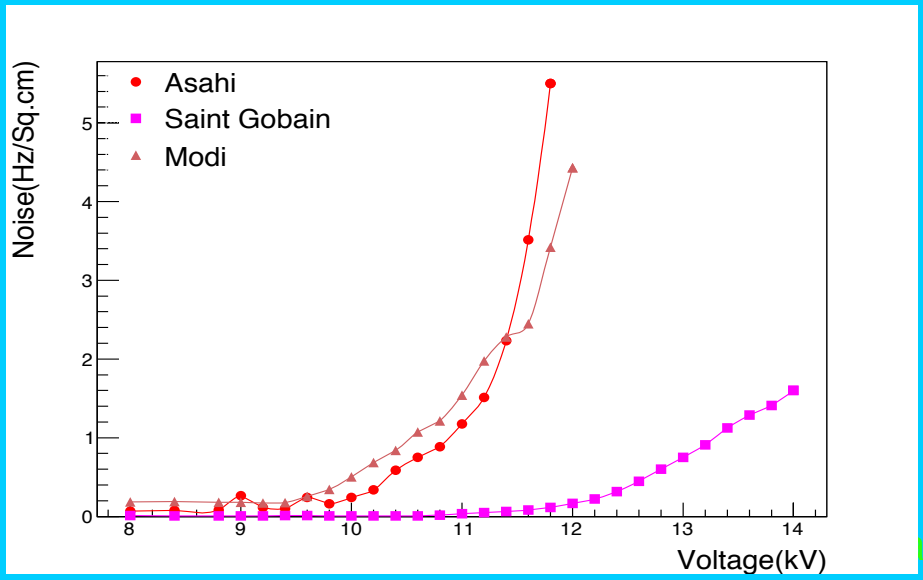


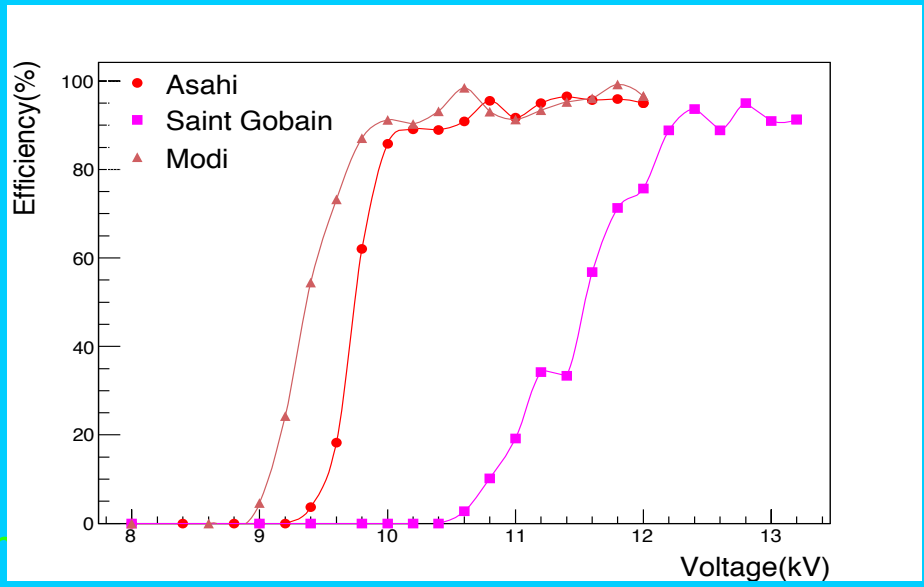


Characterization of Electrodes

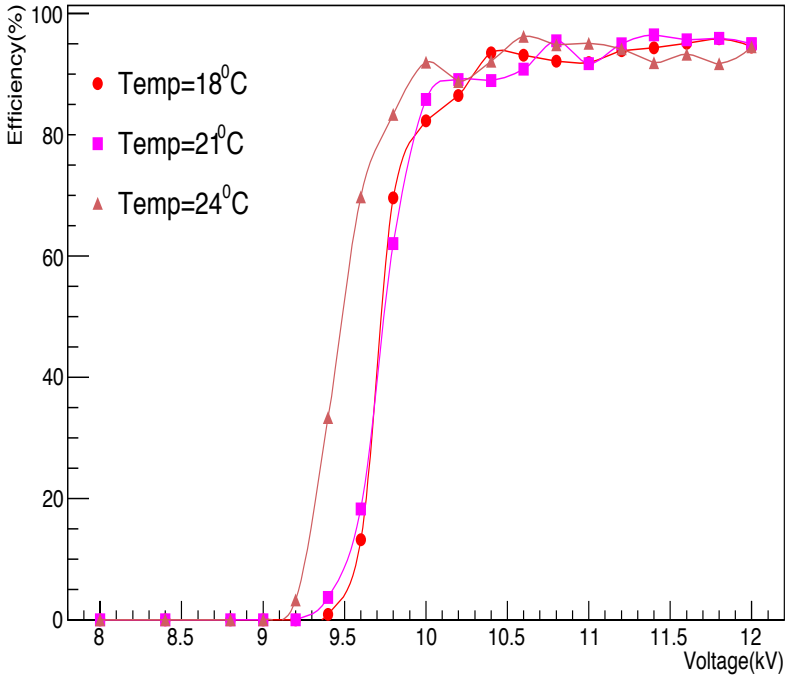


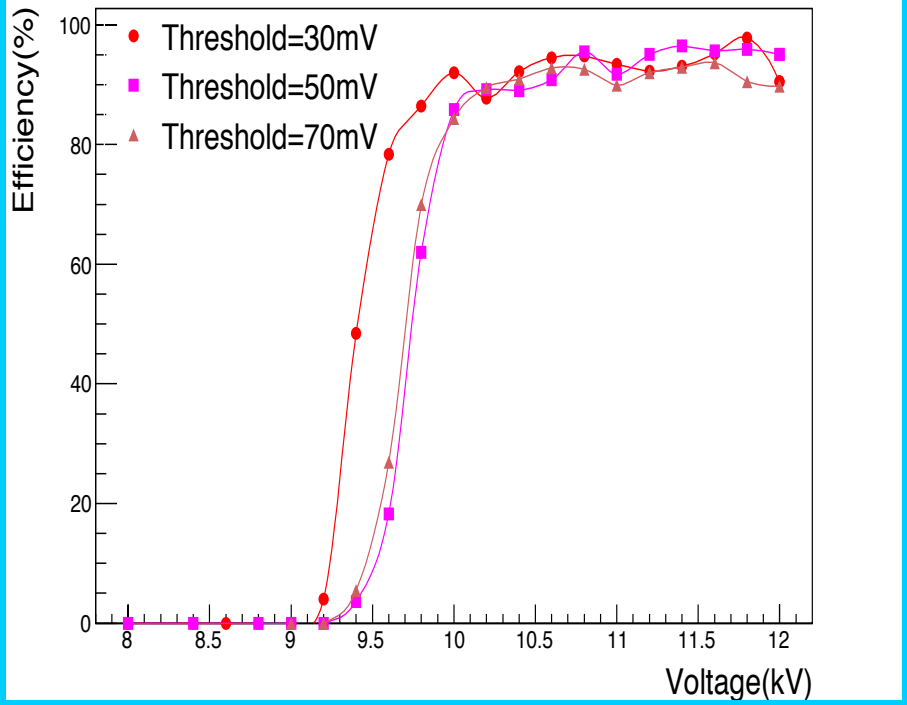






Temperature and Threshold effects

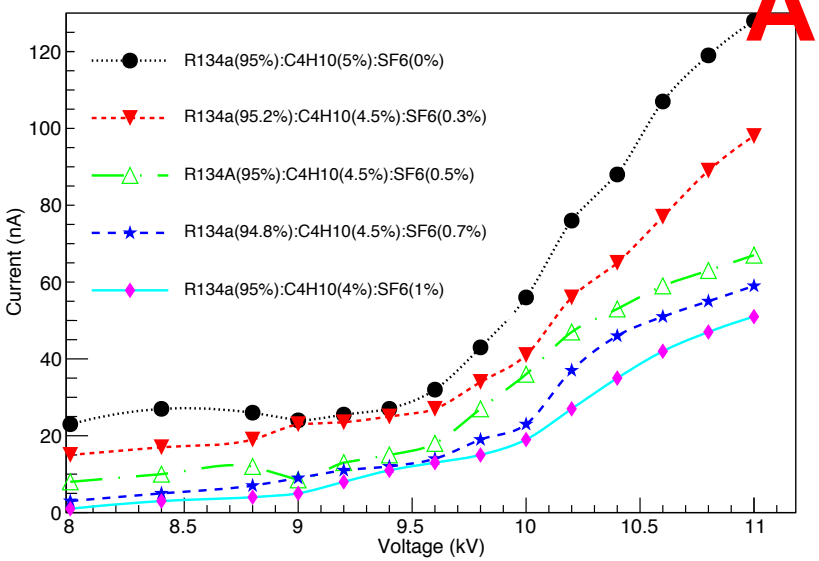


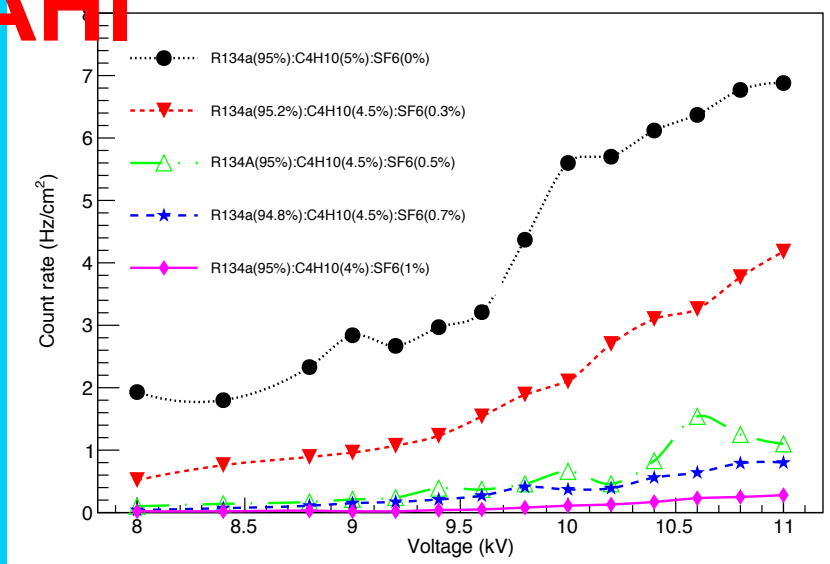


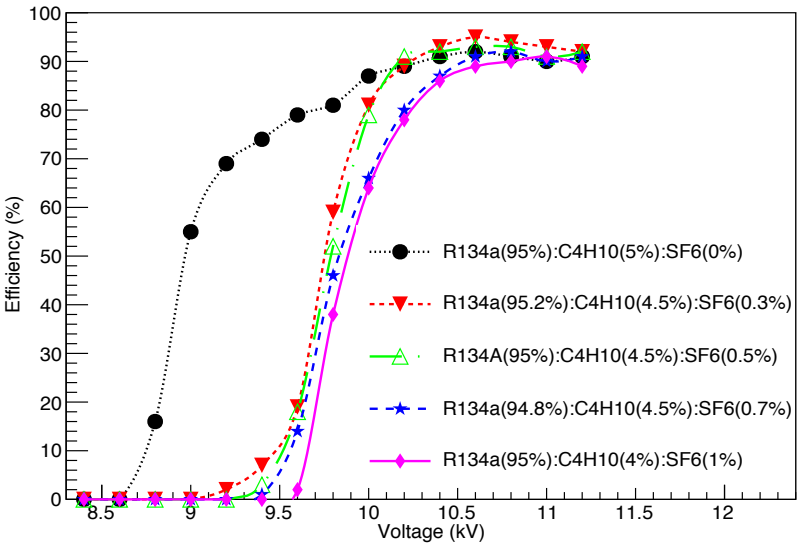
- Saint Gobain glass gives the lowest current and count rate.
- All RPCs gives about 95% efficiency.
- No significant effect on efficiency due to temperature and threshold. Count rate and current varies as expected.

Gas Mixture Effects

ASAHI



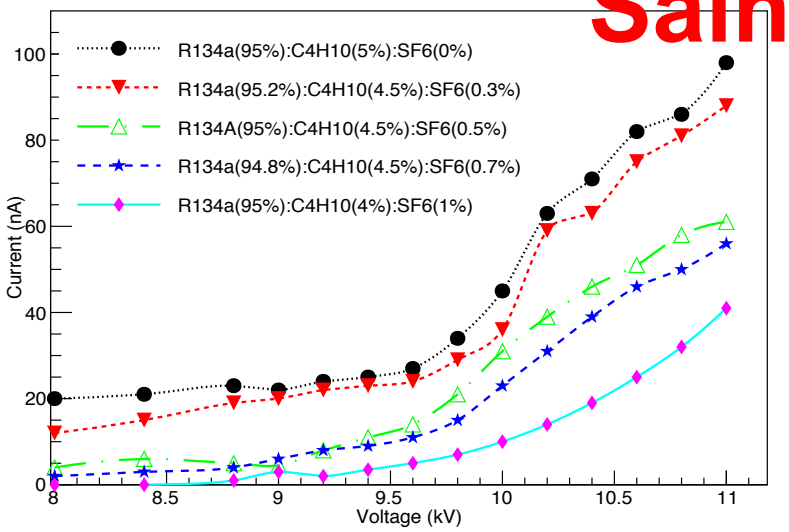


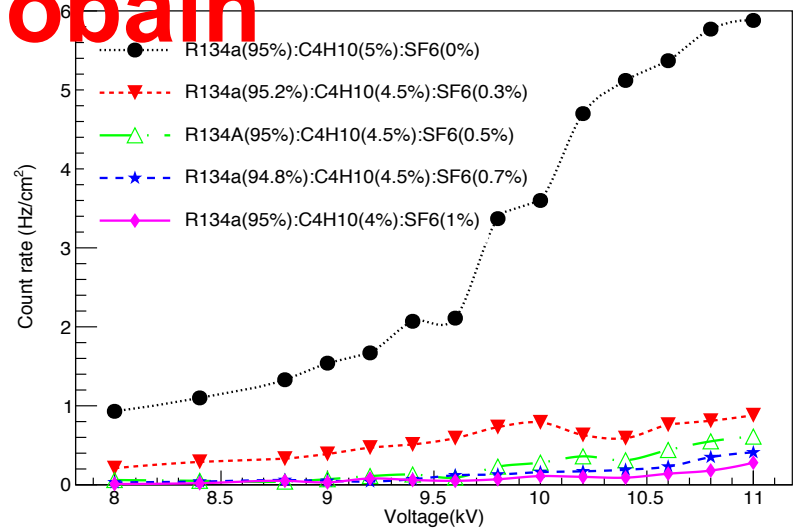


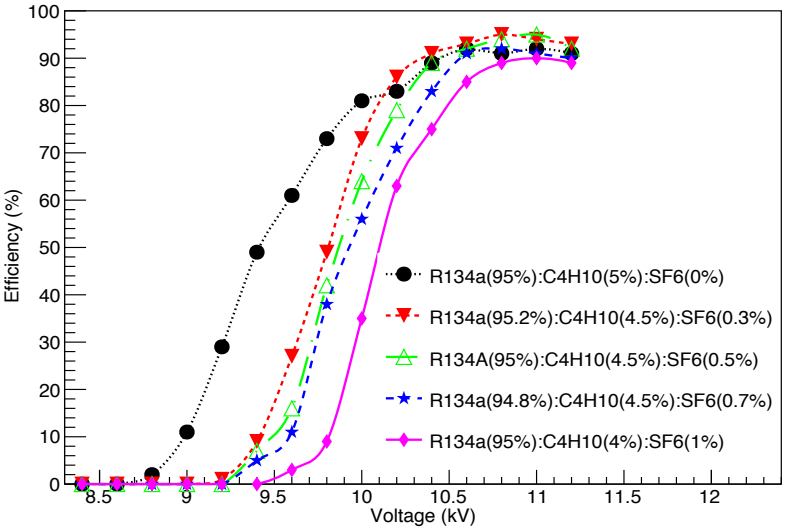
- Current and count rate decreases with increase in the SF_6 Concentration.
- Absence of SF_6 shifts the threshold.
- Highest fraction of SF_6 (1%) gives lowest count rate and current as well as low efficiency.

Gas Mixture Effects

Saint Gobain

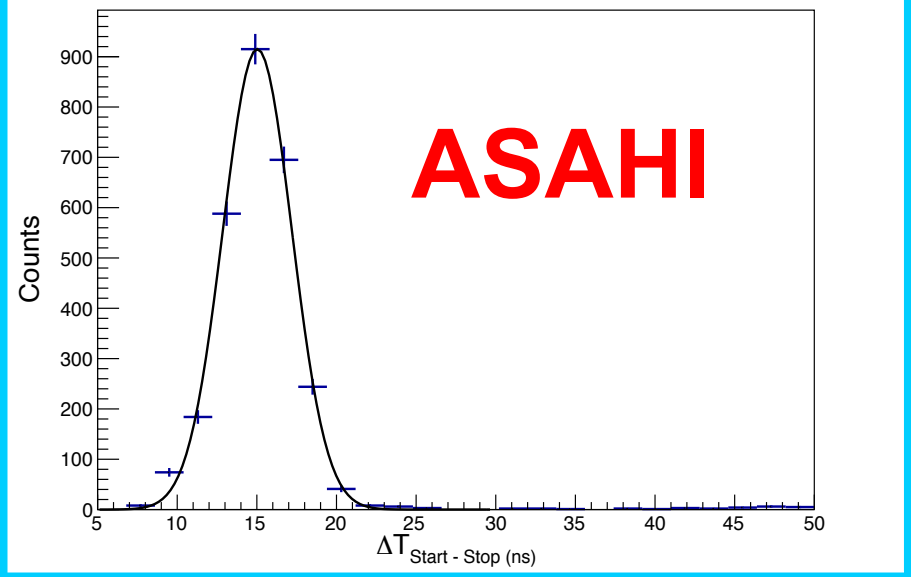


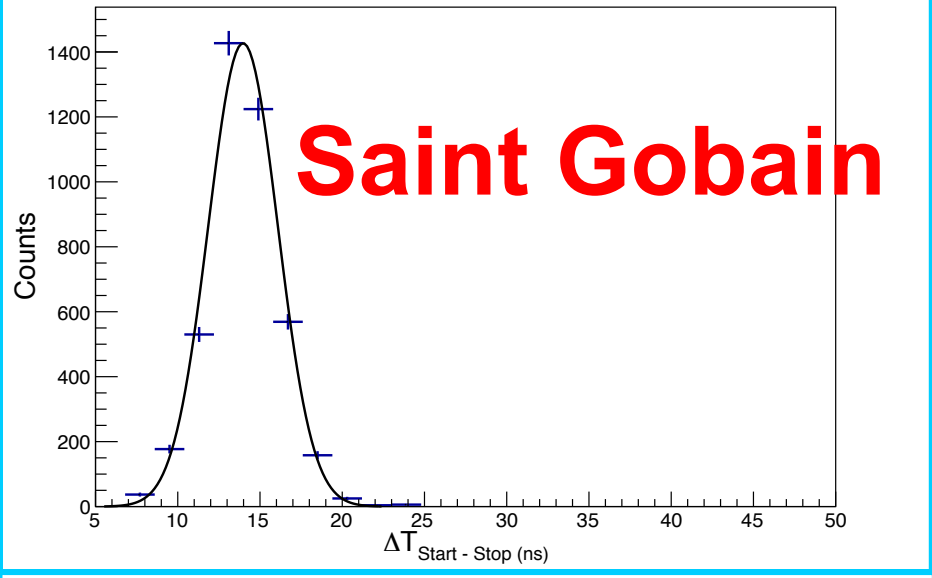


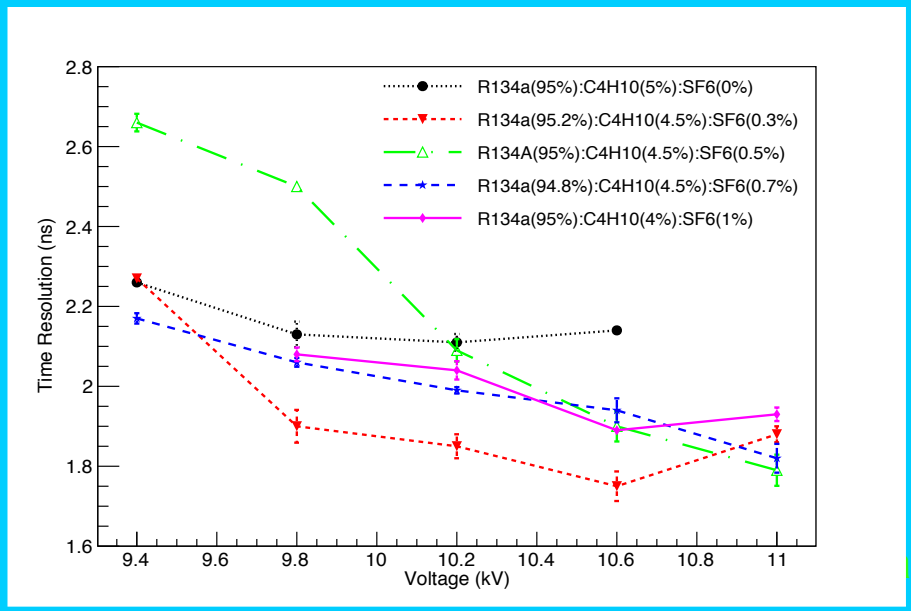


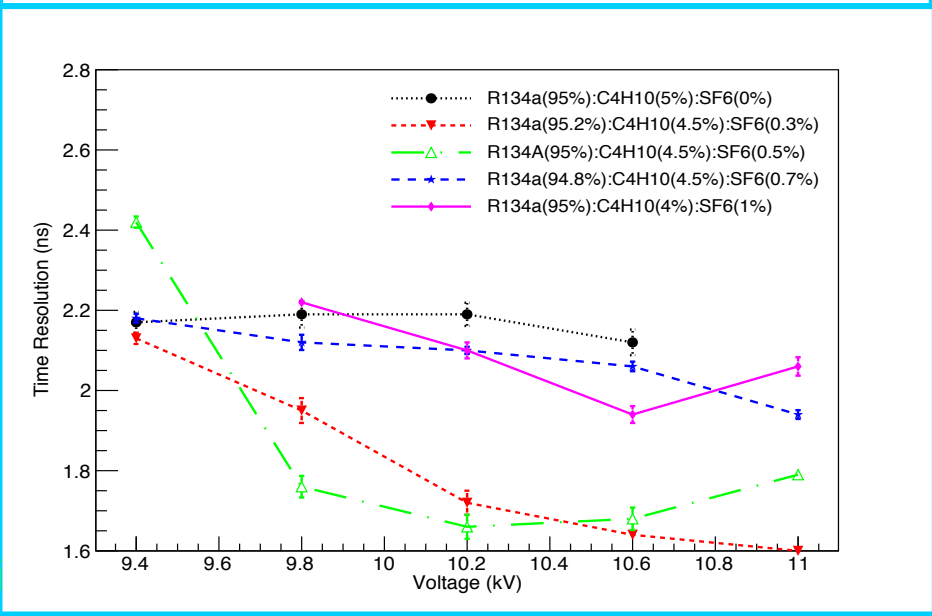
- SF_6 concentration of 0.5% gives comparable current and count rate as well as higher efficiency.

Time Resolution



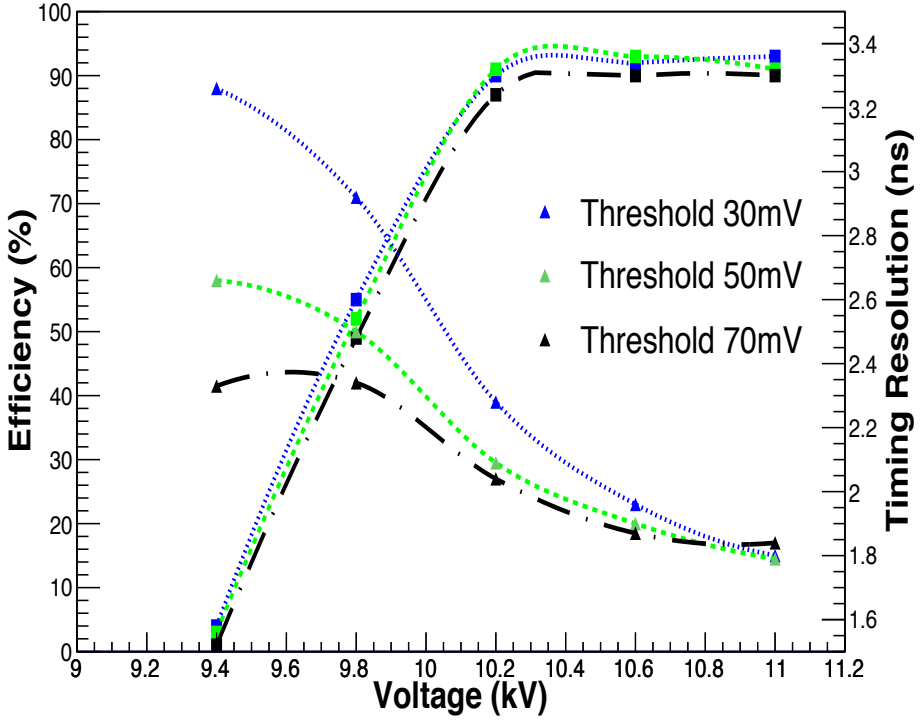




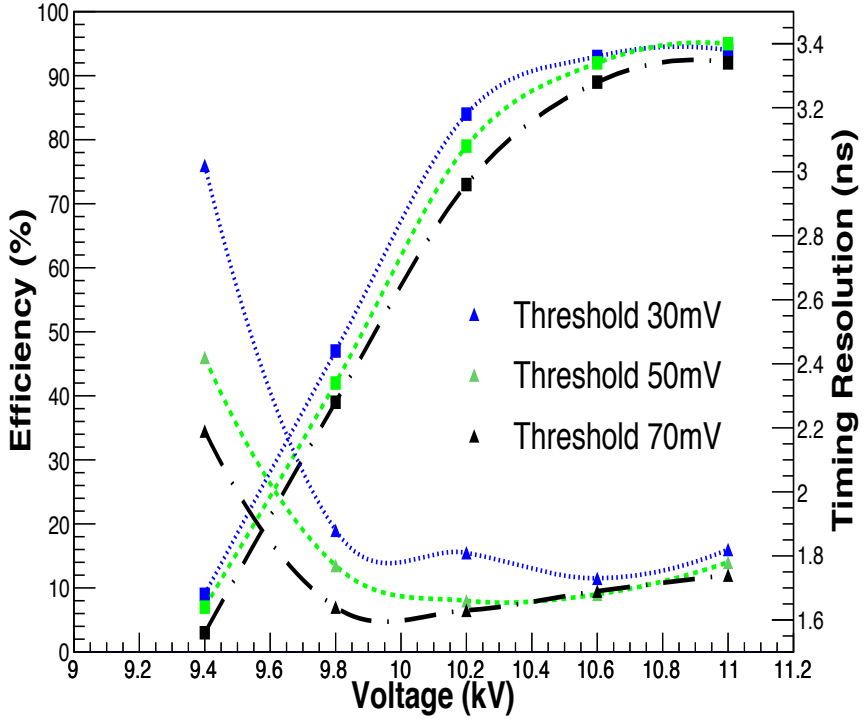


Efficiency Vs Time Resolution

ASAHI

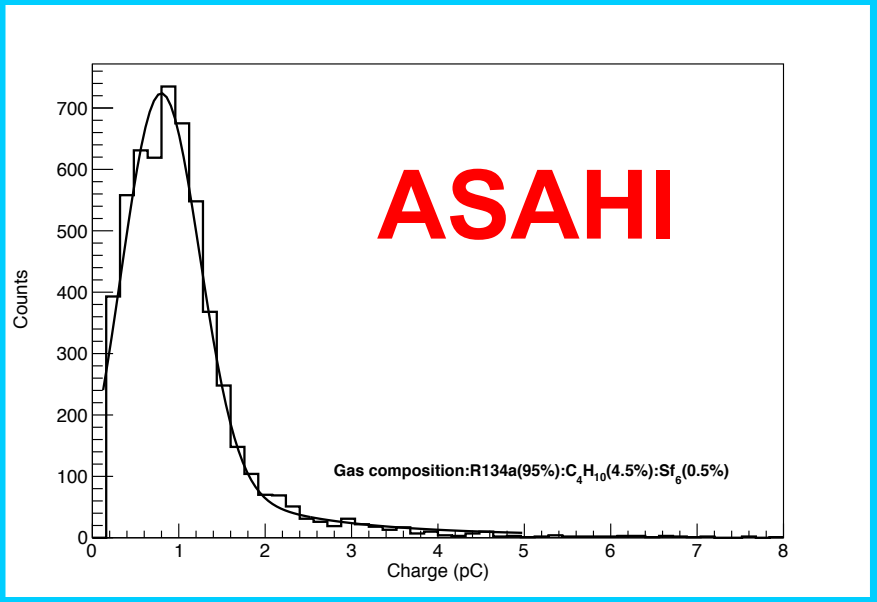


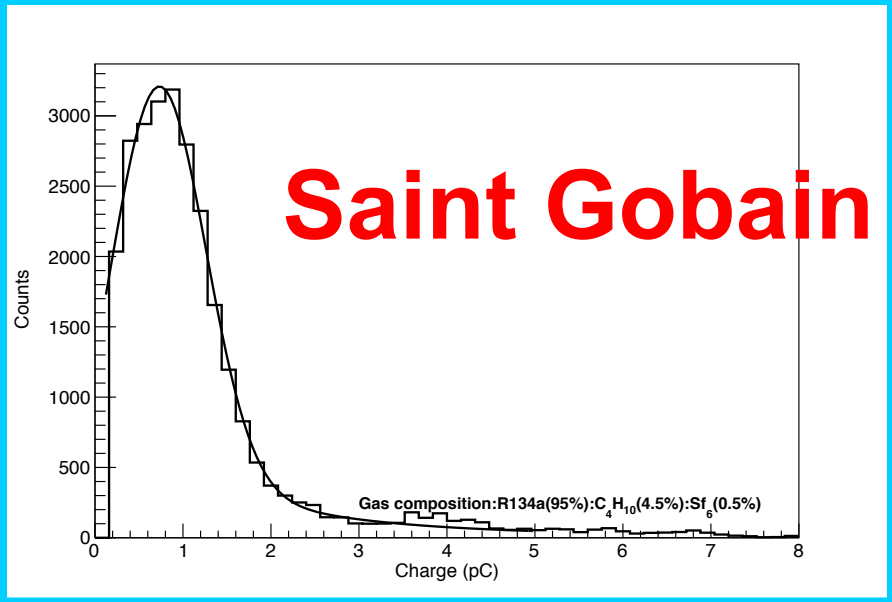
Saint Gobain

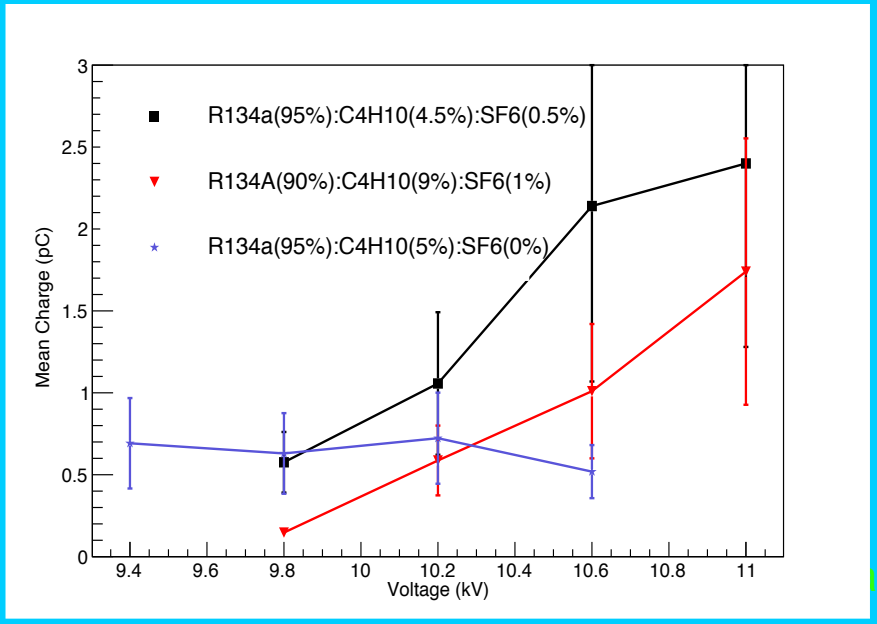


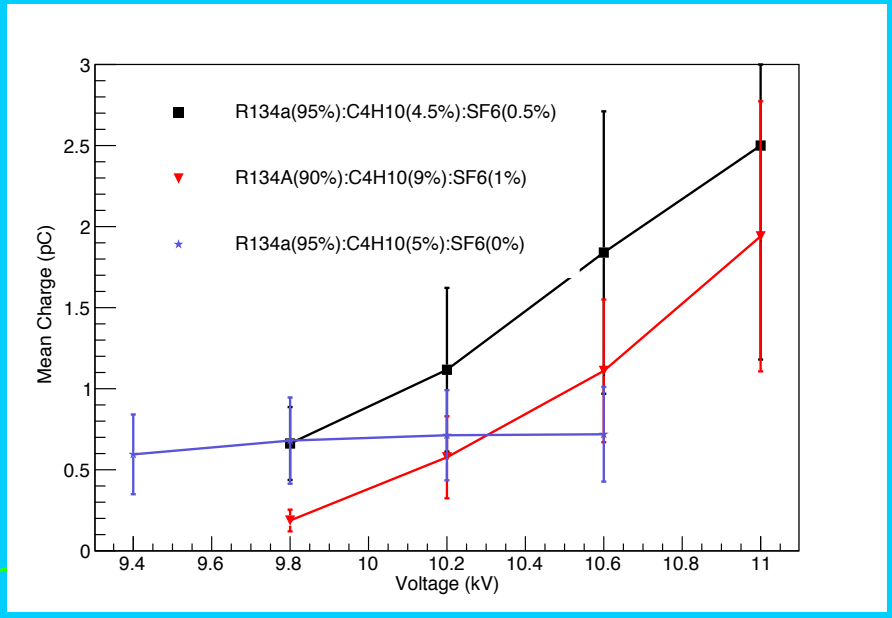
- A time resolution of less than 2 ns is achieved for efficiency plateau turn on at 95%.
- Threshold of 50mV provides good trade between efficiency and time resolution.

Charge Spectra





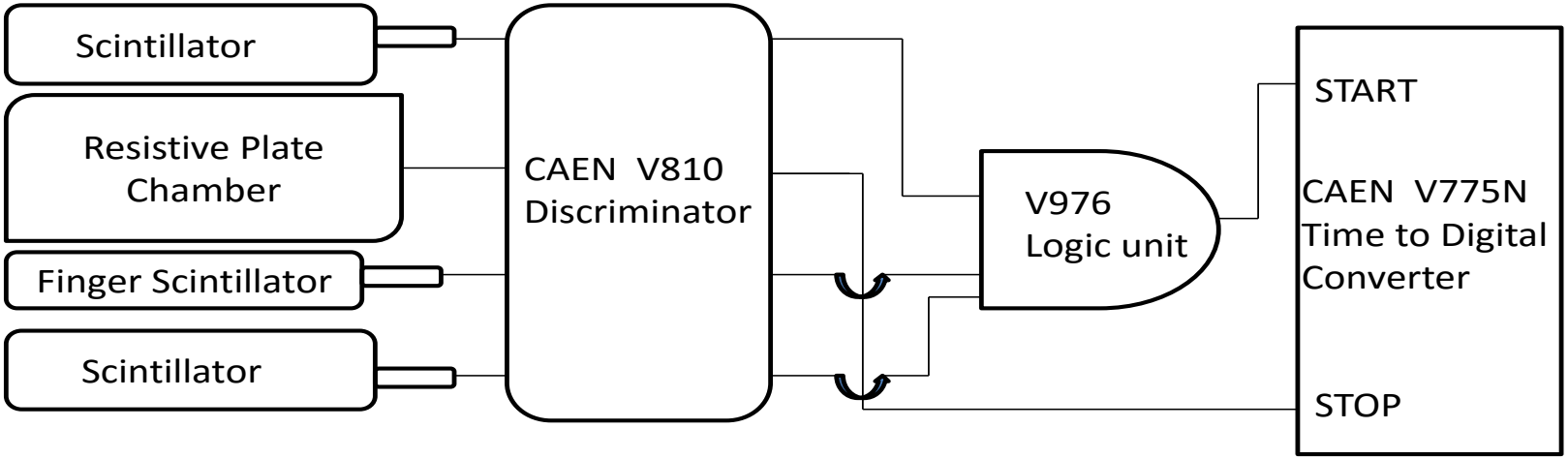




Conclusions

- 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!


Scintillator
Resistive Plate Chamber
Finger Scintillator
Scintillator
CAEN V810 Discriminator
V976 Logic unit
START
CAEN V775N Time to Digital Converter
STOP