RPC Performance with HARDROC based Readout

Aman Phogat Ashok Kumar* Moh. Rafik Md. Naimuddin

Department of Physics & Astrophysics
University of Delhi

* *ashok.hep@gmail.com*

21st International Workshop on Radiation Imaging Detectors (iWoRiD)
July 7-12, 2019

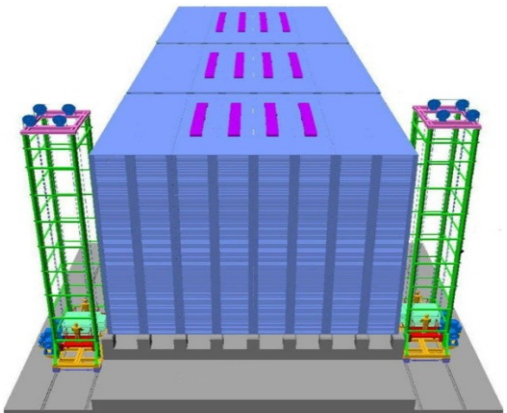
Overview

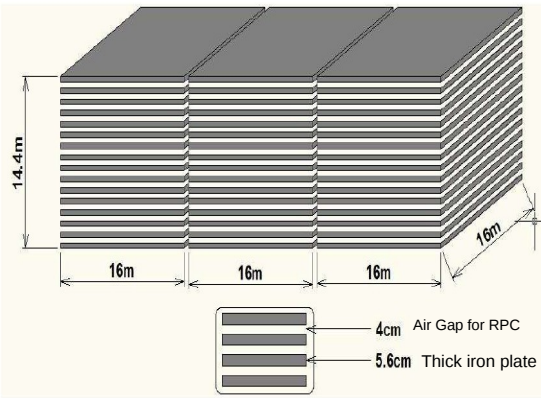
Introduction

The proposed 50 kton magnetized Iron-CALorimeter (ICAL) detector at the India-based Neutrino Observatory (INO) aims to study the atmospheric neutrinos and antineutrinos.

The ICAL will employ about 28,800 Resistive Plate Chambers (RPCs) as the active detector elements and requires millions of electronic channels to be readout.

Such a large number of channels require an efficient, compact, low power consumption and cost-effective readout system.

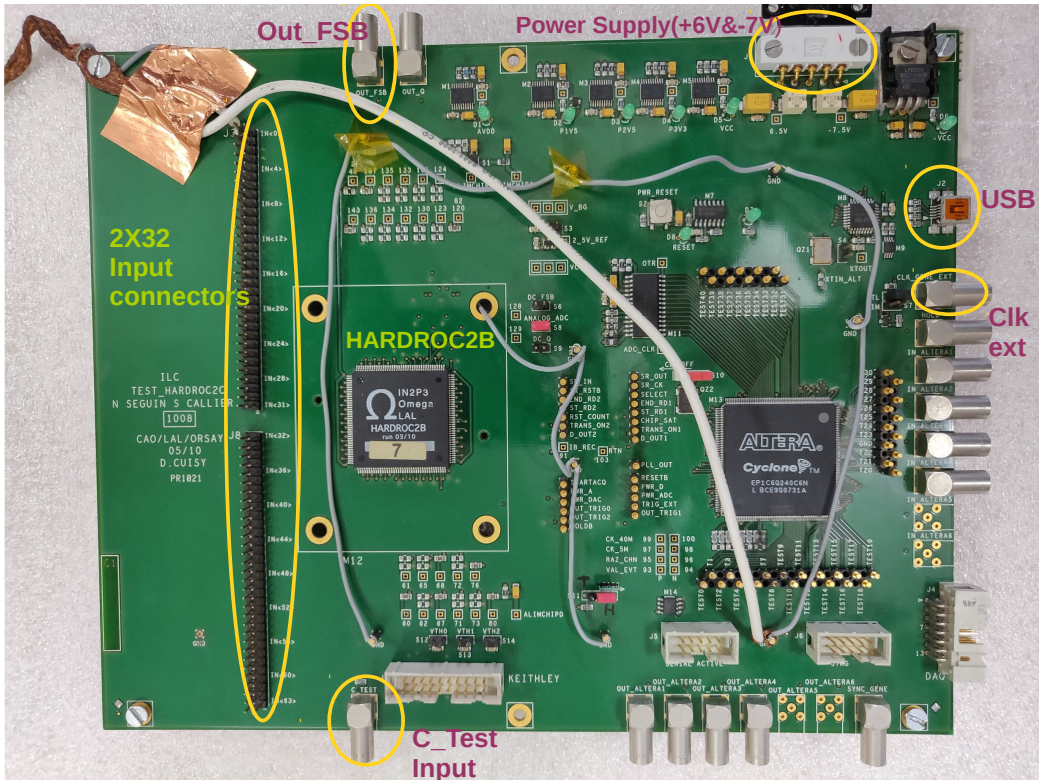




ASIC Testboard

The University of Delhi group tested and commissioned multichannel system HARDROC as an readout option for the ICAL RPCs.

HARDROC (Hadronic Rpc Detector ReadOut Chip) is a 64-channel front end ASIC designed primarily for the readout of gaseous detector like RPCs.

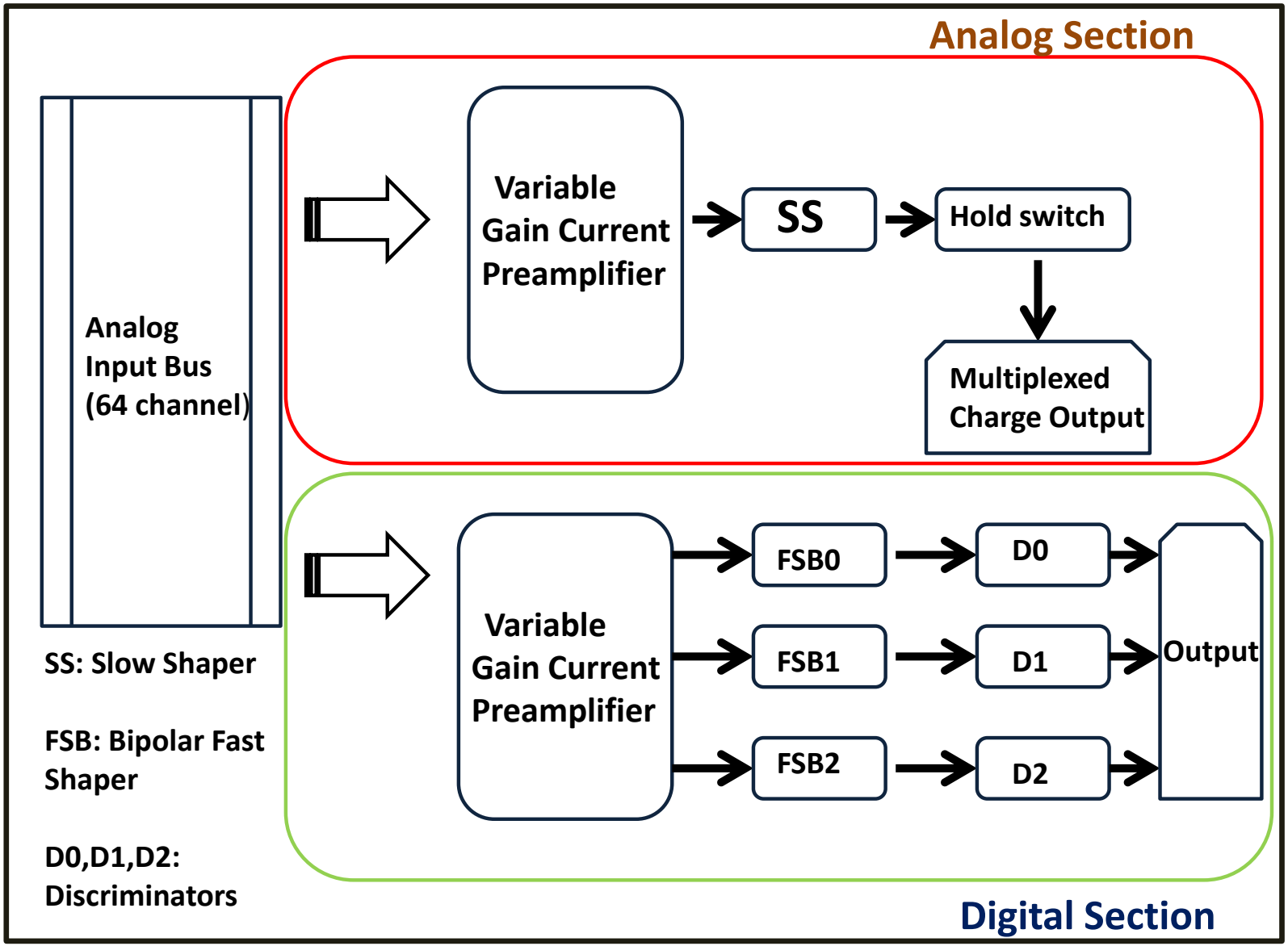


Characteristics of HARDROC ASIC

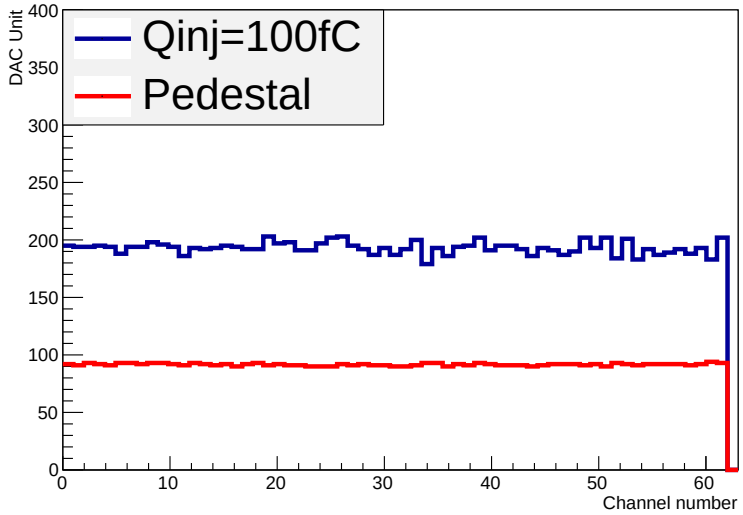
The 64 channels of the HARDROC2 are made of:

- A fast low impedance current preamplifier with 8-bit variable gain (analog G=0 to 2)
- A variable slow shaper (50-150ns) followed by a Track and Hold buffer to provide a multiplexed analog charge output up to 10pC
- 3 variable gain CR-RC fast shapers (peaking time 20-25 ns)
  FSB0 is dedicated for input charges from 10fC up to 100fC
  FSB1 for input charges from 100fC up to 1pC
  FSB2 for input charges from 1pC up to 10pC
- 3 low offset discriminators
  3 internal 10 bit- DACs to set the thresholds
  3 discriminators are sent to a 3 input to 2 output encoder.

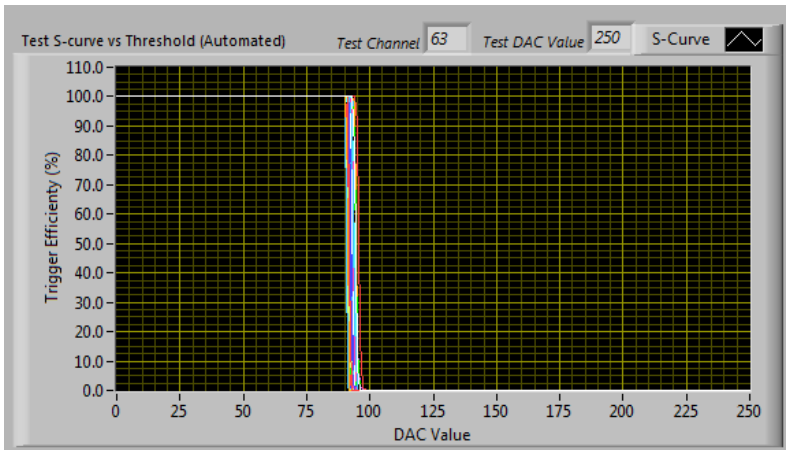
Synoptic layout of HARDROC2 ASIC



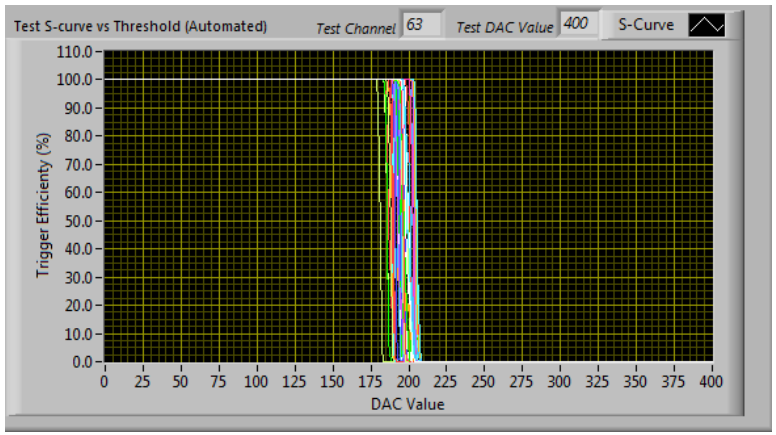
S-Curve



Threshold value in DAC units corresponding to 50% efficiency of the curve

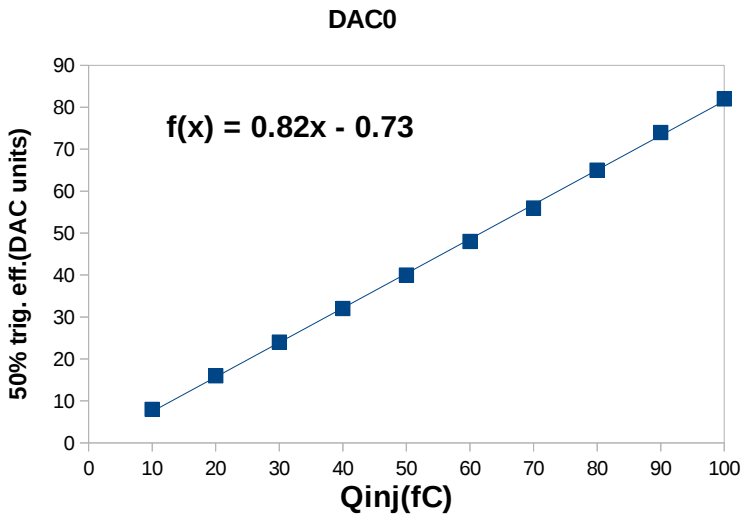


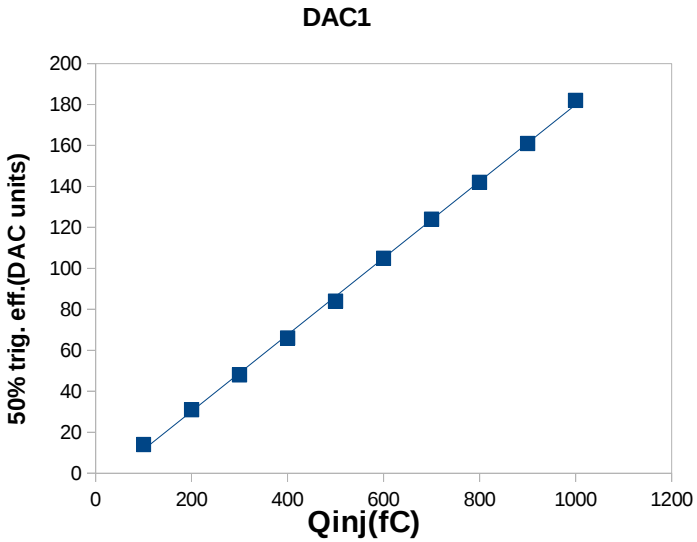
S-curve: dispersion of 64 pedestals

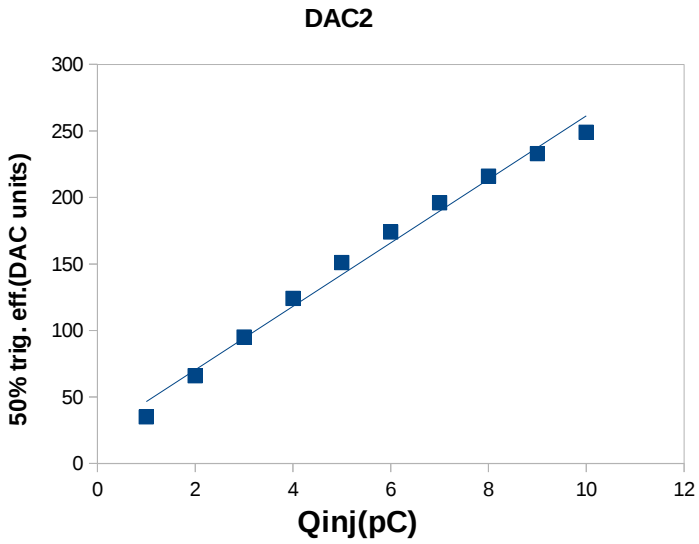


Injected Charge=100fC

Shaper Linearity





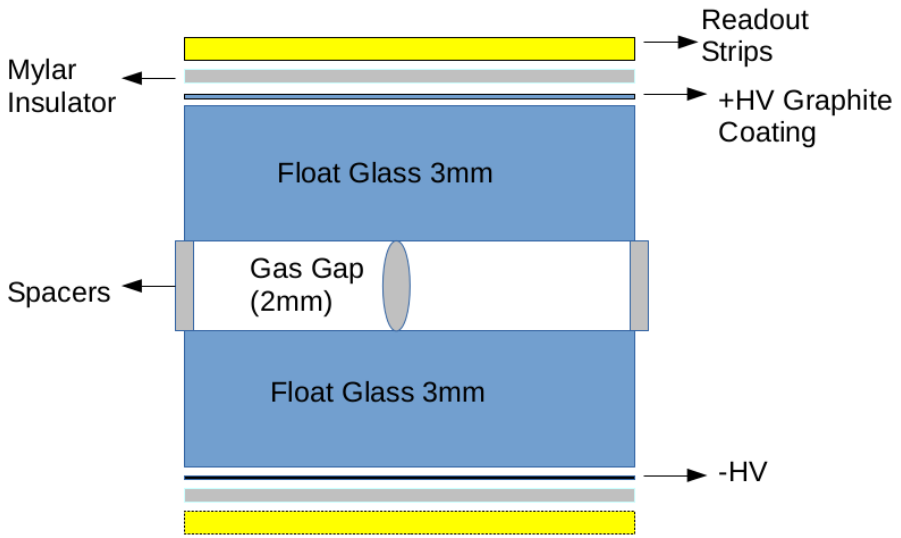


Resistive Plate Chamber (RPC) Detector

- Resistive Plate Chambers(RPCs) are gaseous parallel plate particle detectors utilising a constant and uniform electric field produced by two parallel resistive electrode plates, a gas mixture with a high absorption coefficient for ultraviolet light is flown through the gap between the electrodes.
- Advantage: RPCs are simple to construct and operate, low cost per unit area of coverage, good homogeneity of the sensitive medium, excellent sub-nanosecond time resolutions and good position resolution. This makes them excellent timing and triggering detectors, especially in muon systems for general purpose detector experiments.
- Working Principle: The passage of charged particle through the gas gap produce primary ionization cluster which under the effect of electric field develop avalanches in the gas. This exponential avalanche growth induces signal on the external readout electrodes.

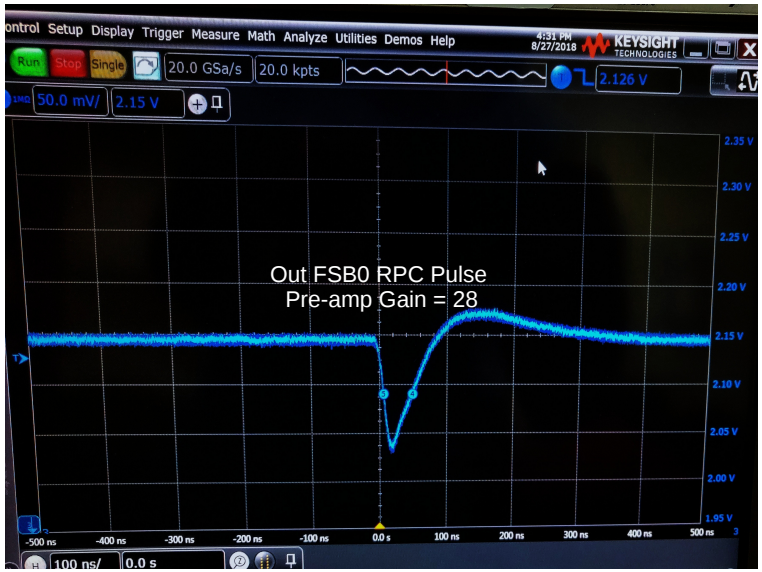
Structure of an RPC

- Two parallel high resistive electrodes: Glass 10^{12} - 10^{13} Ω-cm
- Graphite coating to distribute the high voltage
- Spacers to ensure uniform gap thickness (2mm)
- Copper readout strips (strip pitch 30mm) on both read-out planes
- Gases: R134a (95%), isobutane (4.5%), SF_6 (0.5%)



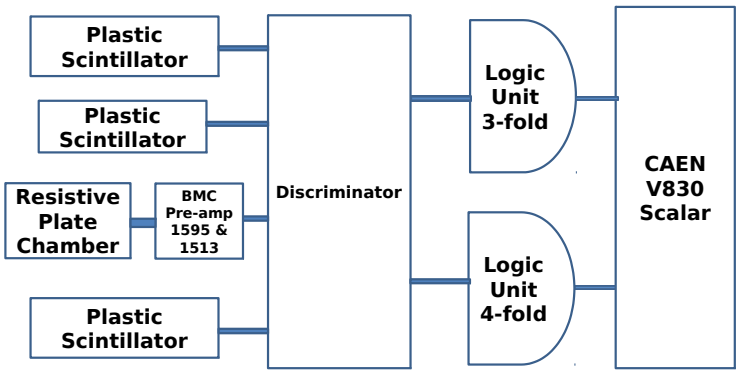
RPC/HARDROC pulse

Detector Read-out	RPC
No of Channels	64
Polarity	Negative
Dynamic Range	10fC-10pC
Power Consumption	10μW/channel
Input	64 current input
Peaking Time	20 ns

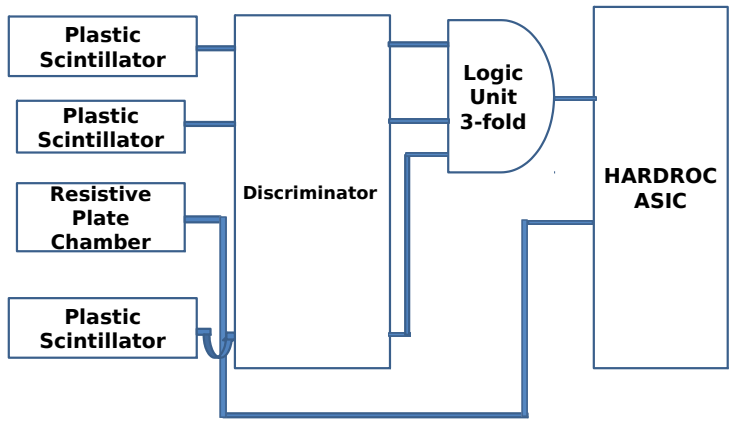


Experimental Set-up

The trigger system is made of three scintillators each couples to a PMT. The detector performance and characterization were carried out by using cosmic ray muons. The efficiency is obtained by evaluating the ratio between the number of events in which RPC strip under consideration has fired to the total number of triggered events in the time window of 200 ns.

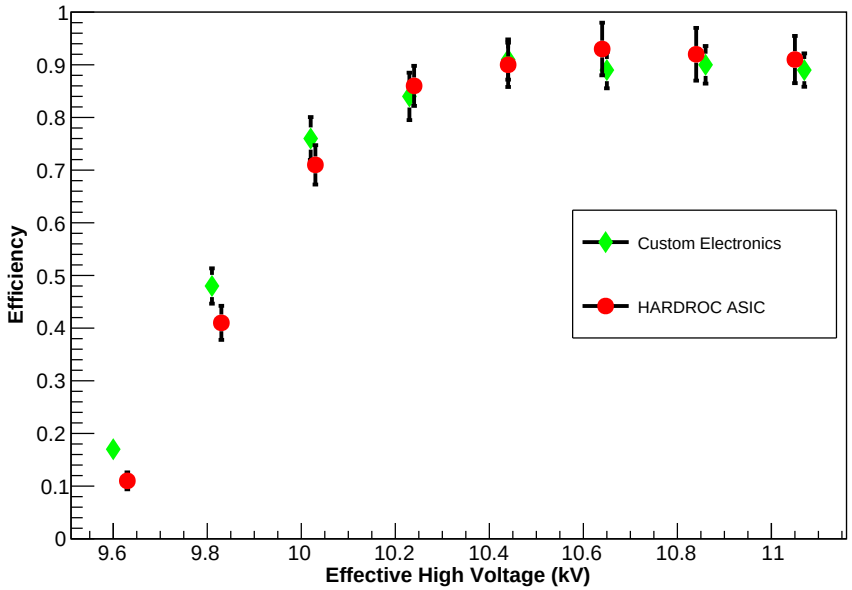


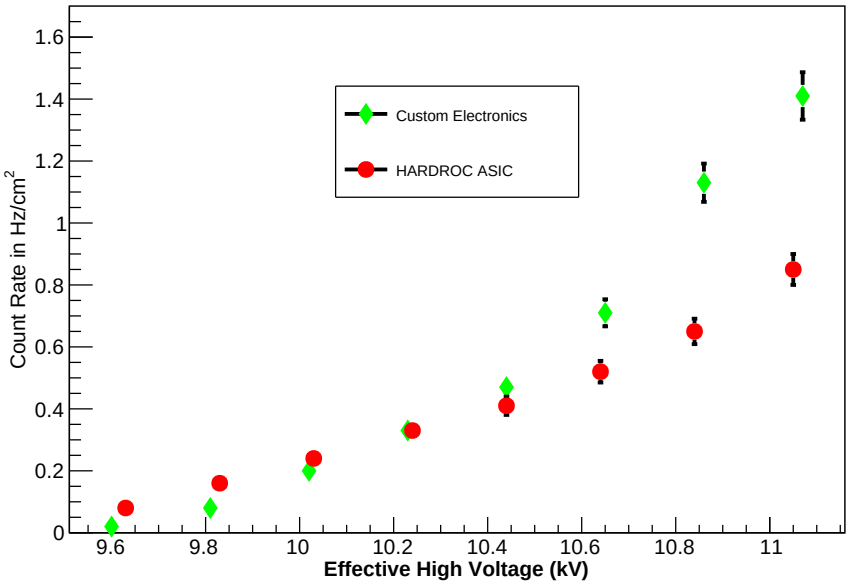
Custom Electronics Set-up



HARDROC Set-up

Efficiency & Count Rate



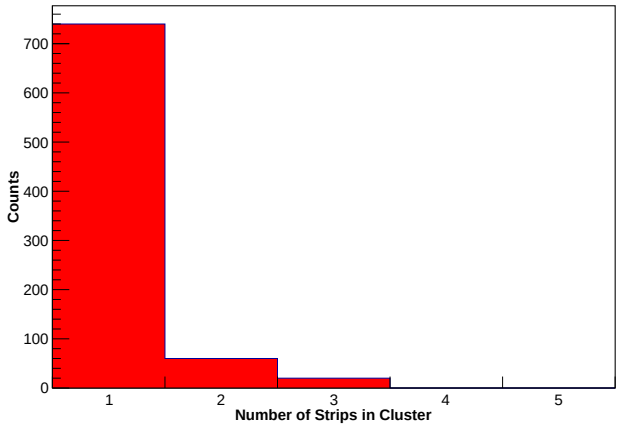


The variation of the environmental pressure P and lab temperature T was taken into account through high voltage correction equation

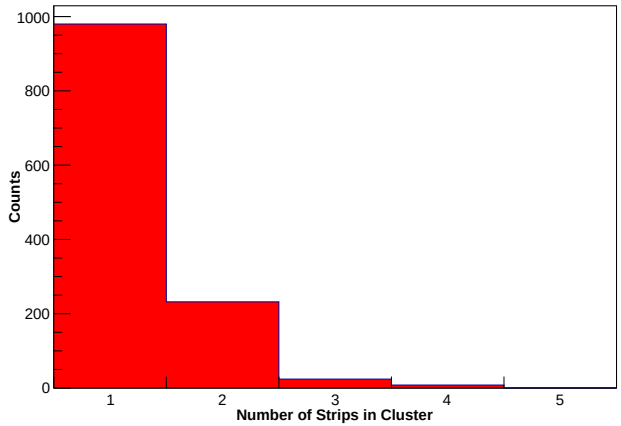
$$V_{eff} = \frac{P_o}{P} \times \frac{T}{T_o} \times V_{app}$$

where V_{eff} is the resulting effective high voltage. The chosen reference value is P_o= 1010 mbar and T_o= 293K.

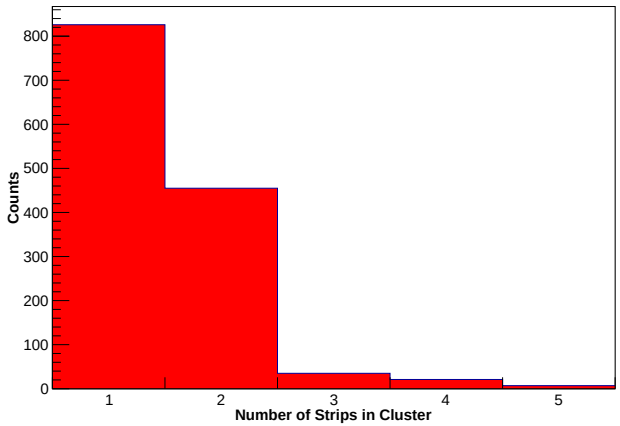
Hit Multiplicity



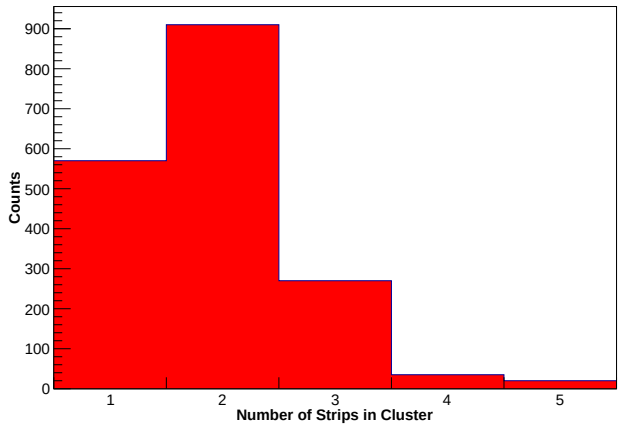
HV=9.8KV



HV=10.2KV



HV=10.6KV



HV=11KV

Summary

Test Study

The calibration and testing of The HARDROC ASIC has been performed.

DAC Threshold

The correlation between the DAC values and charge of FSB0 is used to set the proper threshold.

Performance

Compared to custom electronics, the HARDROC ASIC prototype provide improved noise.
At 10.4 kV HV, RPC plateau efficiency is more than 90% and count rate$<0.5 Hz/cm^2$ using HARDROC ASIC.

References

Aman Phogat et al. (2018)

New front-end electronics for INO-ICAL experiment

Nucl.Instrum.Meth. A905, 193-198.

Ashok Kumar et al. (2016)

Development and Commissioning of the HARDROC based Readout for the INO-ICAL Experiment

JINST 11, C10004.

I. Laktineh (2009)

Semi-Digital hadronic calorimeter for future high energy physics experiments

Journal of Physics : Conference Series 160, 012030.

M. Bedjidian et al. (2011)

Performance of Glass Resistive Plate Chambers for a high-granularity semi-digital calorimeter

JINST 6, P02001.

The End