Performance testing of gas-tight portable RPC for muography application

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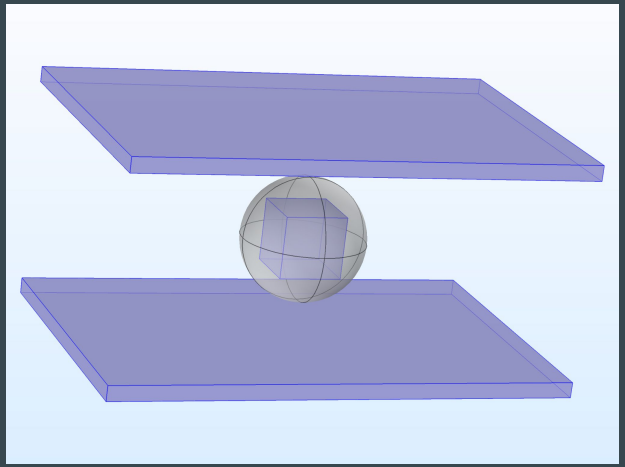
Motivation

- Muography is a technique used to scan a target object by analysing its interaction with the muons.
- The muography techniques are classified into two major categories: absorption based muography and scattering-based muography.
- Our goal is to develop a RPC based muography system for scanning and discriminating object based on their shape and material.
- We are currently building a portable RPC prototypes for muon tracking.



A representative image of a scattering-based muography system

Gas tight portable RPC

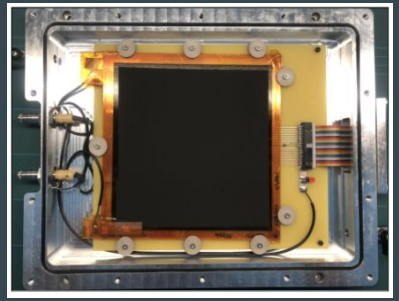
The concept of a gas-tight Resistive Plate Chamber (RPC) is relatively novel and introduces several challenges:

- The absence of gas flow within the RPC can potentially result in variations in the homogeneity of the gas mixture over time.
- This, in turn, can cause an increased discharge probability, reducing the detector performance with time.
- Furthermore, the stationary/static state of gas mixture within the chamber may contribute to acceleration in polymerization on the detector surface.

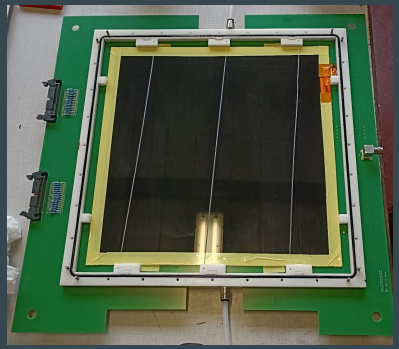
The detector are economical, easily fabricated and transported, have reasonable efficiency and spatial resolution.

RPC Prototypes

Detector	Size (cm^2)	Casing	Gas gap	Readout	Strip pitch	Portability
A	16 x 16	Aluminium	Single	16 - 1D	10 mm	Yes
B	30 x 30	PCB	Double	32 x 32 - 2D	8 mm	No



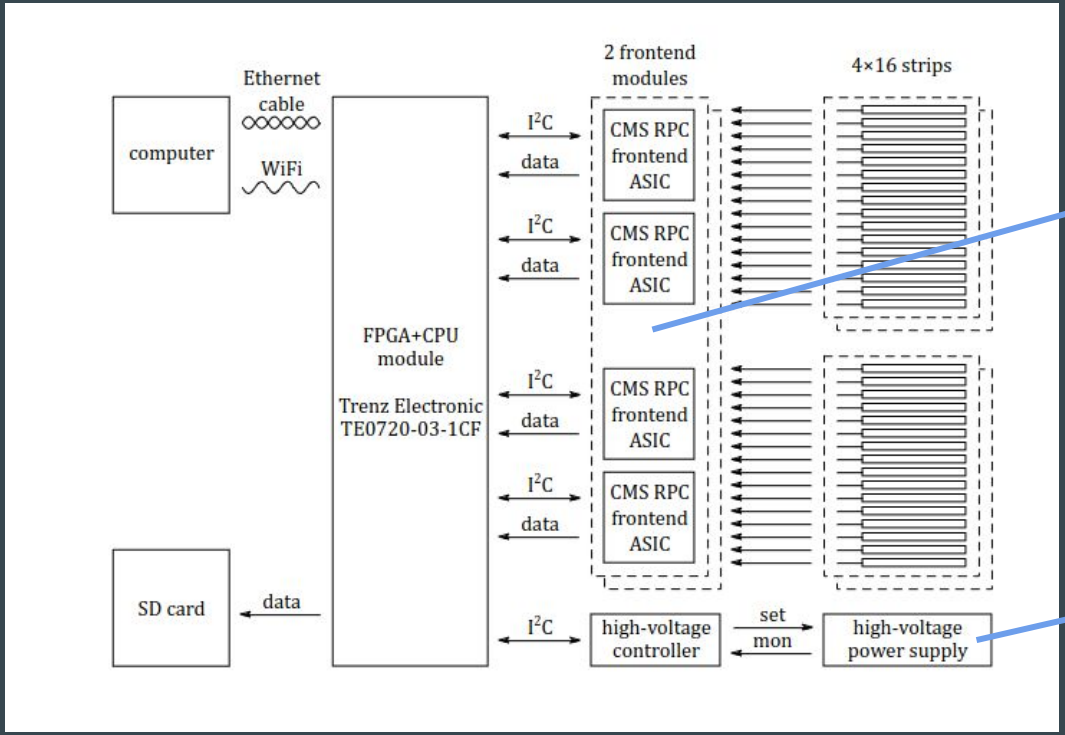
gRPC - A



gRPC - B

- Both the prototypes are glass based RPC (gRPC) having glass thickness of 1.1 mm and are working with 95.2% Freon, 4.5% iso-butane and 0.3% SF6 gas mixture.
- The gap in gRPC-A is ensured by side spacers of 1 mm and in gRPC-B the gaps are maintained using a 1 mm diameter fishline.
- The DAQ used for gRPC-A is a custom made using CMS chip combined with a FPGA and for gRPC-B is a NIM & CAEN based.
- The resistivity of gRPC-A and gRPC-B were ~4.0 and ~1.5 MΩ/□ respectively.

DAQ system used for gRPC - A



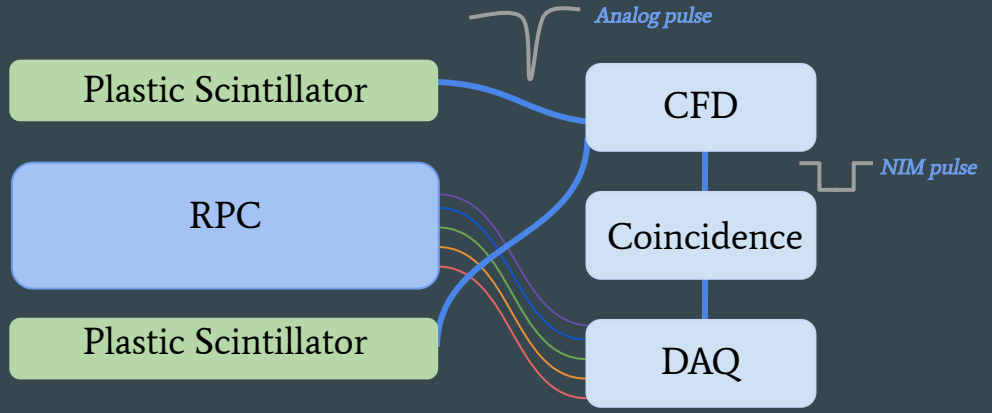
Technical layout of the custom made DAQ

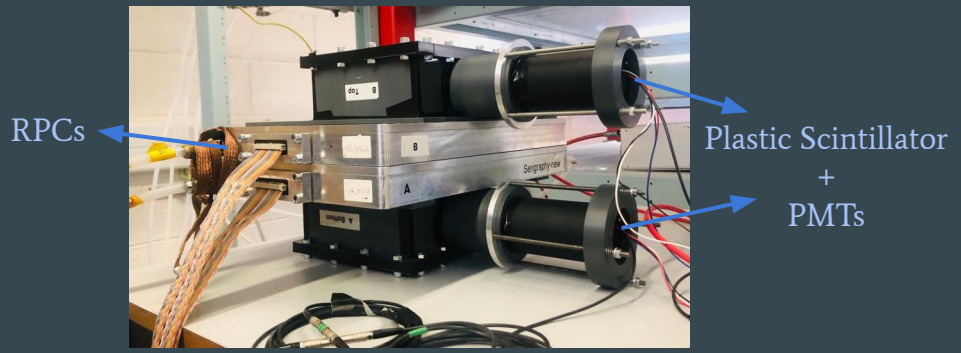
CMS RPC Front End Board

Iseg DSP mini
High Voltage Supply

Experimental setup

- Muon signal received by plastic scintillators
- The signal from the scintillators PMT are converted into digital pulse via CFD
- These digital pulses are send to a coincidence unit
- DAQ is set to active mode ones the coincidence signal arrives
- The DAQ that is connected to the RPC via ribbon cable stores pre-trigger data if the coincidence is active.





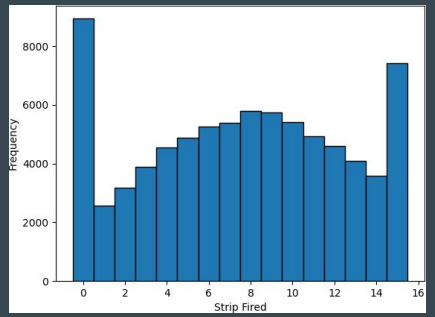
Lab setup with two RPC

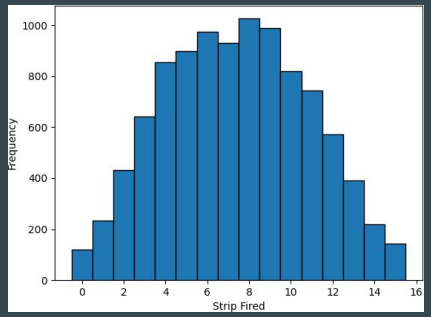
RPC performance and filters

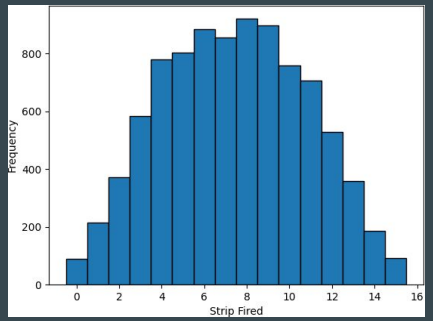
3 hrs data with 9194 PMT counts

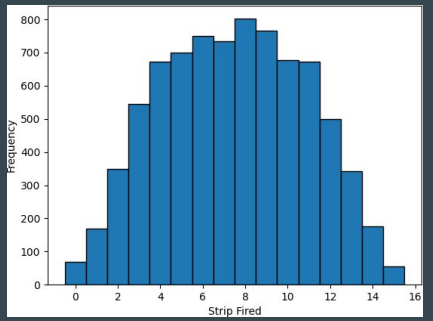
Efficiency = RPC hits / PMT counts

Hits in strips

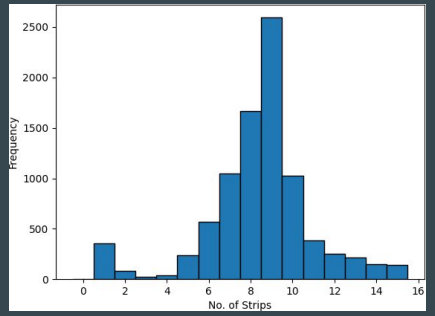


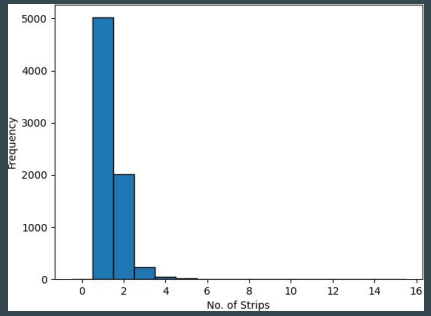


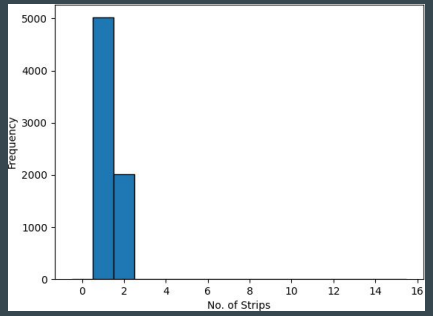


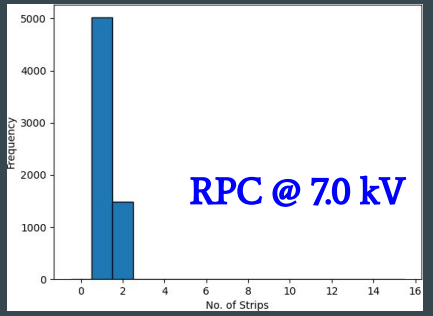


Strip Multiplicity









Time width of 625 ns
Efficiency: 99.9%

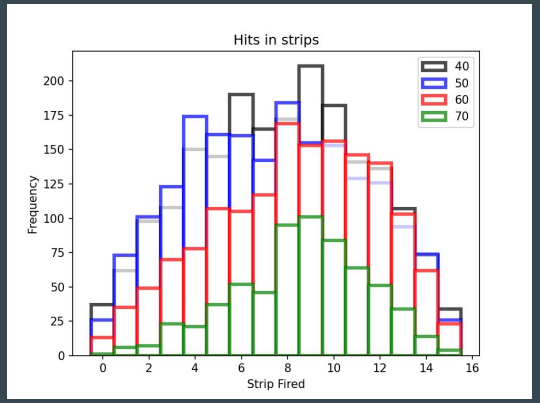
Time filter (10 ns)
79.56%

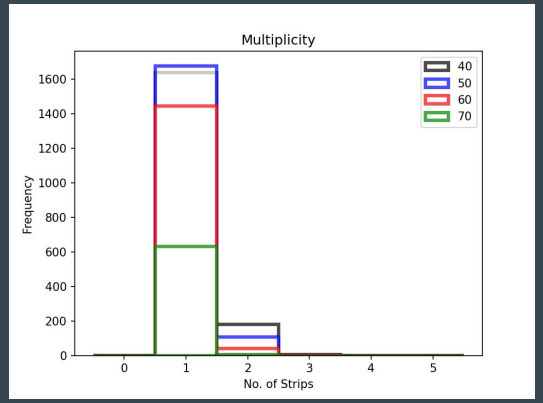
No. of strips/event (2)
76.45%

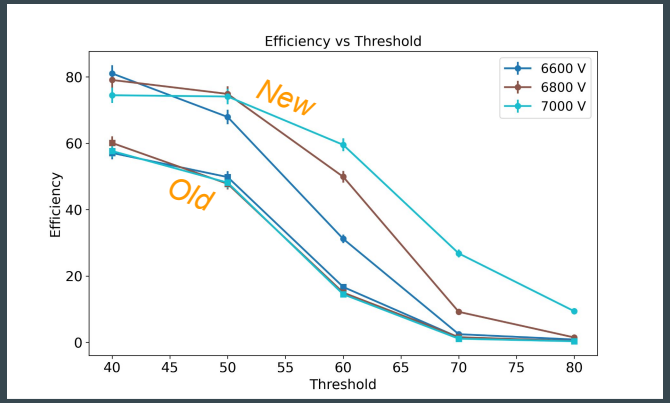
No. of muons/event (1)
70.68%

These filters are implemented to effectively remove noise and get the genuine muon hits.

RPC performance result







- The efficiency reduces with threshold
- The gain difference in CMS chip is observed
- The gas tight detector efficiency reduced to ~57% after 6 months of operation.

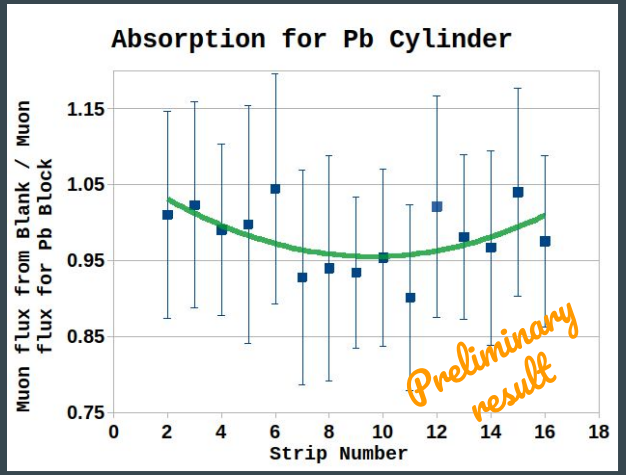
Efficiency of RPC wrt threshold

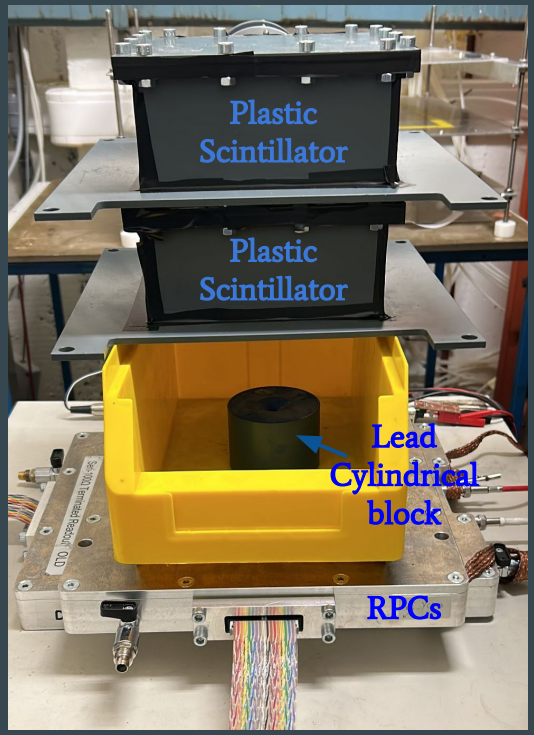
Detector \ V_{Th}	40	50	60	70	80
New	74.5	74.1	59.5	26.8	9.4
Old	57.7	48.1	14.5	1.1	0.4

Absorption muography

- Two plastic scintillators are placed at top
- The mouns then passes through the scanning region (tray)
- Finally reaches the RPCs giving the position map.
- The data is taken with and without the Lead block.

➢ Plot of muon flux before and after placing the Lead.
➢ Reduction in flux at the center due to absorption
➢ Increase in flux at the edge due to scattering.





An absorption setup with two scintillators, a lead block and RPCs

Conclusion and Future prospective

- ➢ On increasing the threshold the efficiency initially increases before reducing due to exclusion of low ionizing events.
- ➢ The implementation of filters successfully reduces the noise from genuine muons events.
- ➢ Although the RPC's efficiency decreases over time, a comprehensive, long-term study involving multiple RPCs is important before drawing a final conclusion.
- ➢ The ASIC chip in the present DAQ system exhibits gain differences that has to be accounted for during data acquisition.

- A new DAQ system work is underway the uses MAROC3, providing 64 current-sensitive inputs within a compact chip. The advancement will significantly enhance strip density, thereby improving position resolution.
- The portable muon tracking system will play a pivotal role, enabling the scanning of complex objects too large and dense for traditional x-rays.

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Thank You