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CORRELATION OF STREAMER PULSE WITH CONTAMINANTS IN THE RPC DETECTOR.

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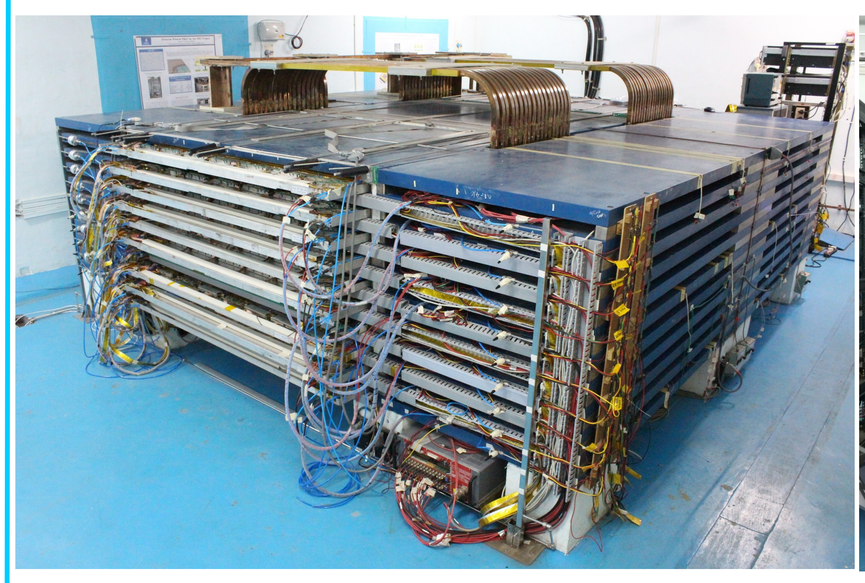
INTRODUCTION:

The India-based Neutrino Observatory (INO) collaboration plans to construct a large 50 K ton magnetized iron tracking calorimeter (ICAL) in an underground cavern in the Bodi hills, in Tamil Nadu, India. One of the main goals of the ICAL detector is the precision measurement of neutrino oscillation parameters including the sign of the 2-3 mass-squared difference, Δm^2_{32} (= m^2_3-m^2_2) through matter effects. The INO-ICAL experiment will be instrumented with 28,800 glass-based Resistive Plate Chambers (RPCs) of dimension 1.85 m x 1.74 m each, and are used as an active detector element. Resistive Plate Chamber (RPC) is a parallel plate avalanche type particle detector which uses gas mixture as its active detection medium.

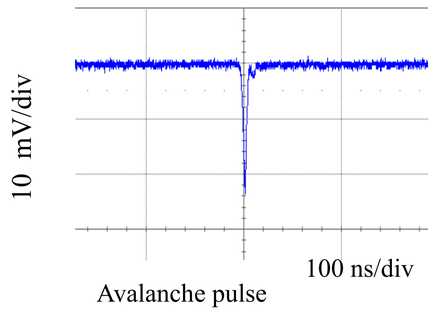
MINI - ICAL (MINI IRON CALORIMETER) :

- The mini-ICAL is a 600-times scaled-down version of the ICAL.
- The prototype is operational at the IICHEP in Madurai, mainly to study the engineering challenges of constructing large scale magnets, magnetic field measurement systems, long-term performance of the RPC detector and electronics.
- The mini-ICAL consists of an ~ 85 ton magnet built using 11 layers of iron plates with a dimension of 4mx4m stacked with an inter-layer gap of 45 mm, to accommodate 10 layers of RPCs.
- Totally, 20 RPCs (2 RPC per layer) can be accommodated between iron layers.
- RPCs are operated in the avalanche mode using a gas mixture of R134a ($C_2H_2F_4$, 95.2%), Iso-butane (C_4H_{10}, 4.5%) and Sulfur hexafluoride (SF_6, 0.3%).

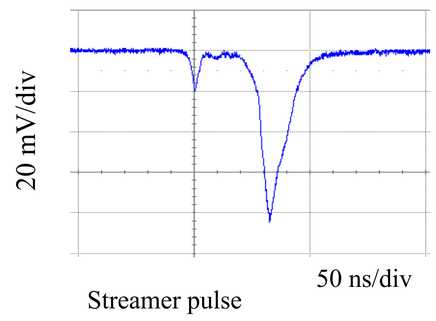


STREAMER PULSE:

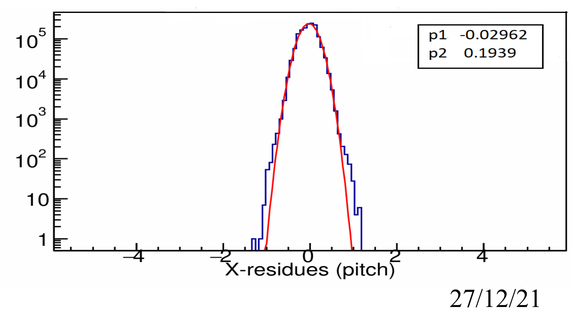
- The contamination in the gas mixture can affect the RPC pulse shape.
- As the electron multiplicity reaches to an extreme value, the avalanche mode has a chance to transform into streamer mode.
- Streamer mode - decrease the life time of the RPC chamber
- Increase the position resolution, which is one of the main goals of the ICAL experiment.



Avalanche pulse



Streamer pulse



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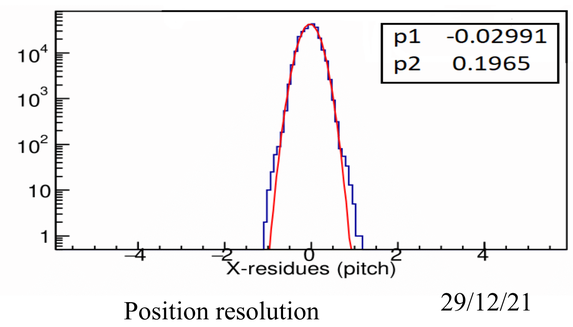
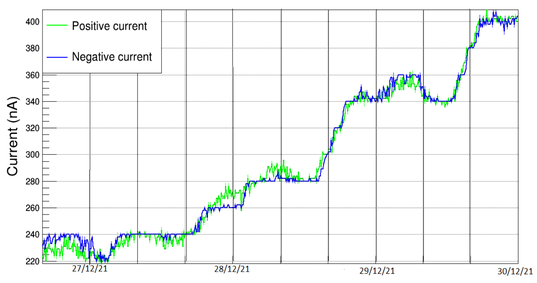


Position resolution 29/12/21

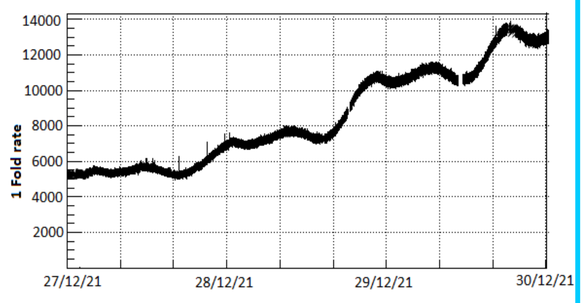
A STUDY WITH CONTAMINATED GAS MIXTURE :

- A dedicated study was done by inserting different fractions of atmospheric air into the RPC system with and without removing the water vapour.
- At each top-up cycles, a controlled percentage of 10% of zero air (a mixture of pure nitrogen of 78%, oxygen of 21% and 1% of Argon) along with the 90 % of standard avalanche gas mixture was filled to the storage tank of the CLS and circulated into the RPCs.
- After the study with zero air (dry air), a study of inserting 10% atmospheric air (with water vapour) into the RPCs was carried out.
- The CLS system was operated in an open loop mode during both these studies and a flow rate of 5 SCCM per RPC was set.
- With the 5 SCCM flow, it will take 1 volume change per day.

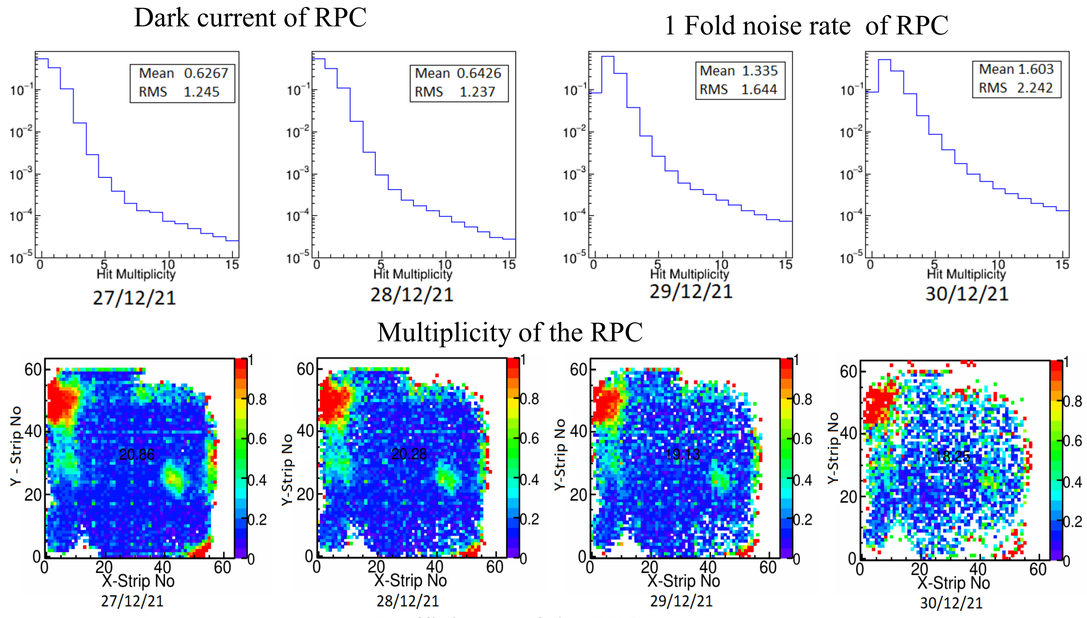
RESULTS:



Dark current of RPC

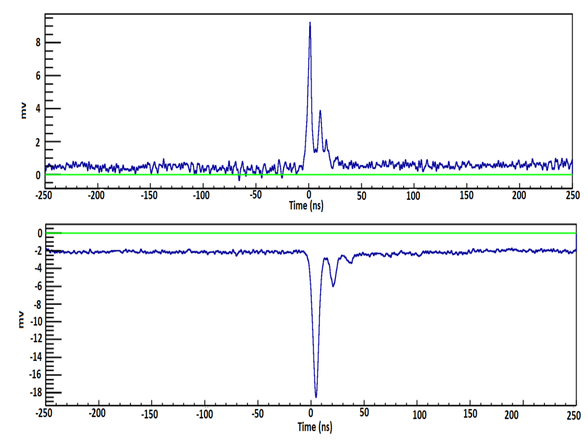


1 Fold noise rate of RPC

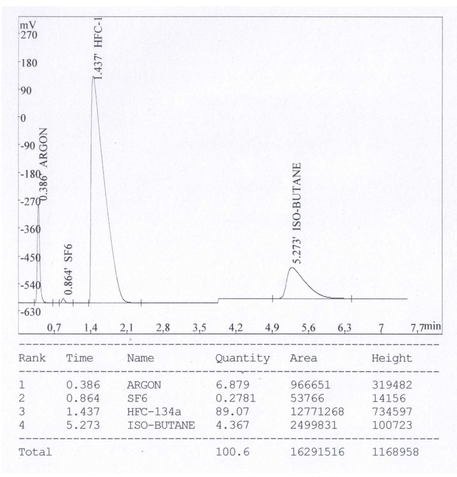


Multiplicity of the RPC

Inefficiency of the RPC



Bad raw signal from the RPC due to contamination



Rank	Time	Name	Quantity	Area	Height
1	0.386	ARGON	6.879	966651	319482
2	0.864	SF6	0.2781	53766	14156
3	1.437	HFC-134a	89.07	12771268	734597
4	5.273	ISO-BUTANE	4.367	2499831	100723
Total			100.6	16291516	1168958

Gas mixture data - GC

- The dark current started to increase slowly and steadily as the contaminated gas mixture flowed through the RPCs.
- Rise in count rates and hit multiplicity as well as the efficiency.
- The percentage of impurities is monitored by the Gas Chromatograph (GC).
- It was observed from the data, the formation of streamer signals was observed after approximately 4% of the contaminated gas in the RPC gas mixture.

CONCLUSION:

The motivation for this study is that the ICAL experiment will use hundreds of kilometres of gas lines with joints. To avoid streamer pulse, we need to take care of all connections to reduce the leakage.

ACKNOWLEDGEMENT:

We would like to thank all the members of INO lab.