Study of Resistive Plate Chambers Scintillation detectors and Reconstruction of muon tracks in RPCs

Medha Soni

VSRP Student 2012

Under the guidance of Prof. Sudeshna Banerjee

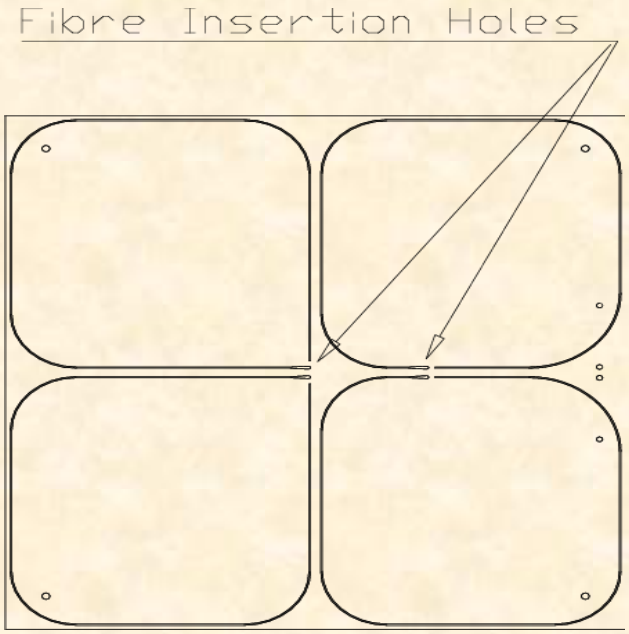
What are we trying to do?

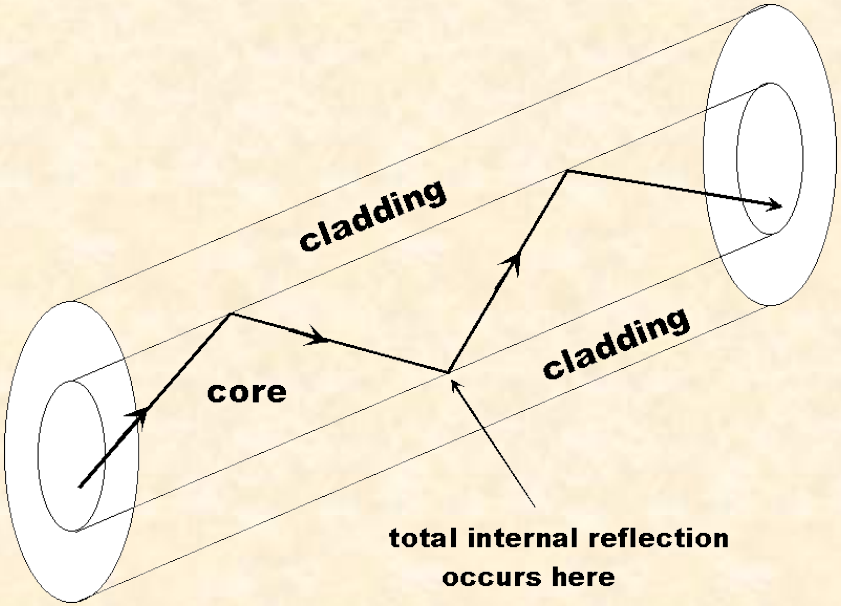
- Study cosmic ray muons
  - Weakly interacting leptons
  - 200 times more massive than the electron
  - Long decay lifetime of 2.2 μs

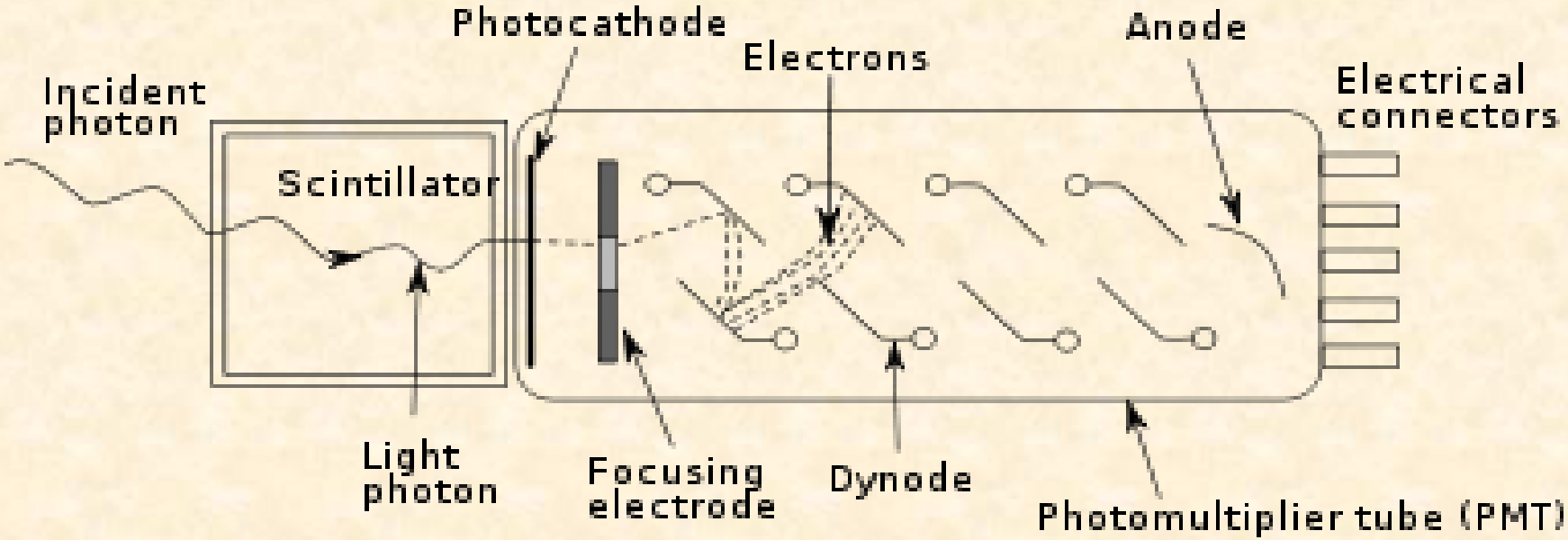
How are we doing this?

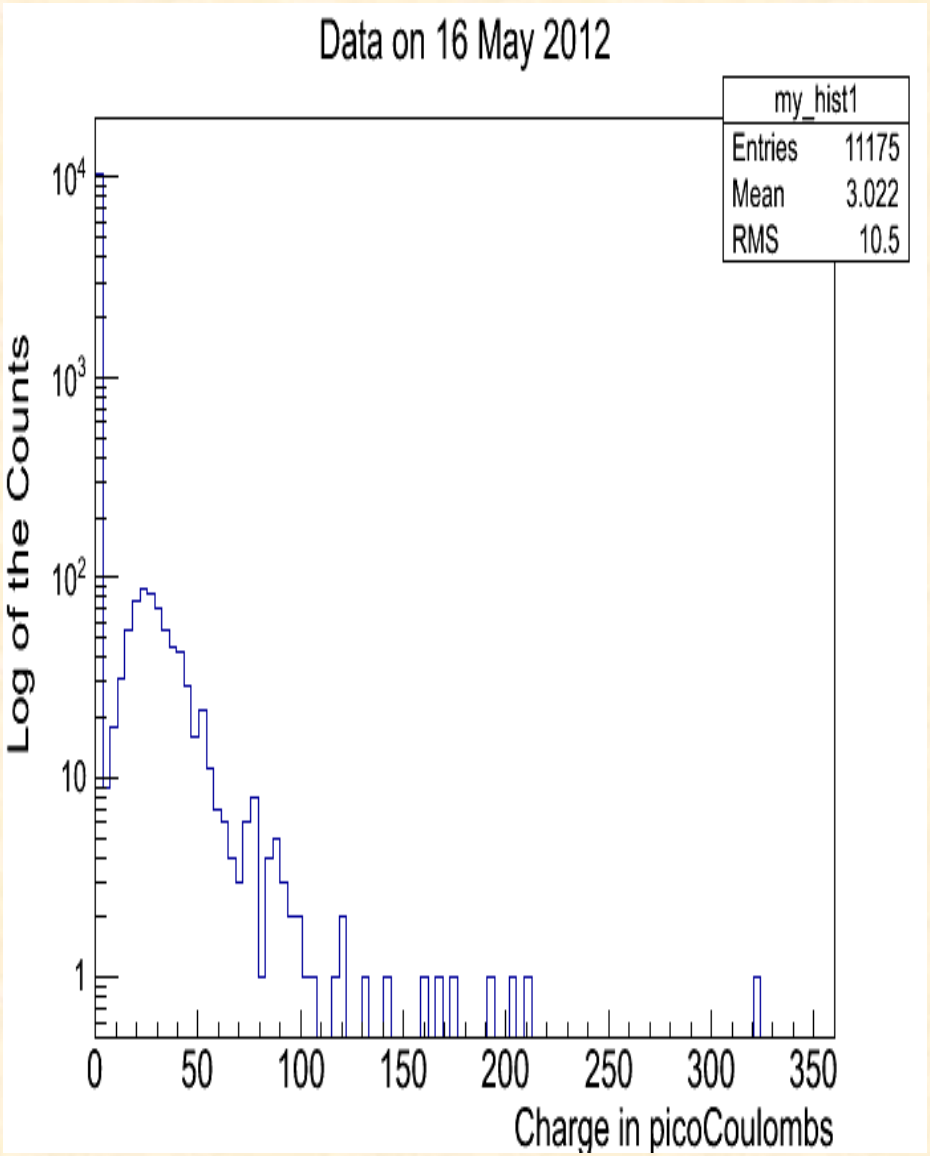
- By using scintillation detectors and resistive plate chambers to detect them
- Reconstruct the track of the muons in the Resistive Plate Chambers (RPCs)

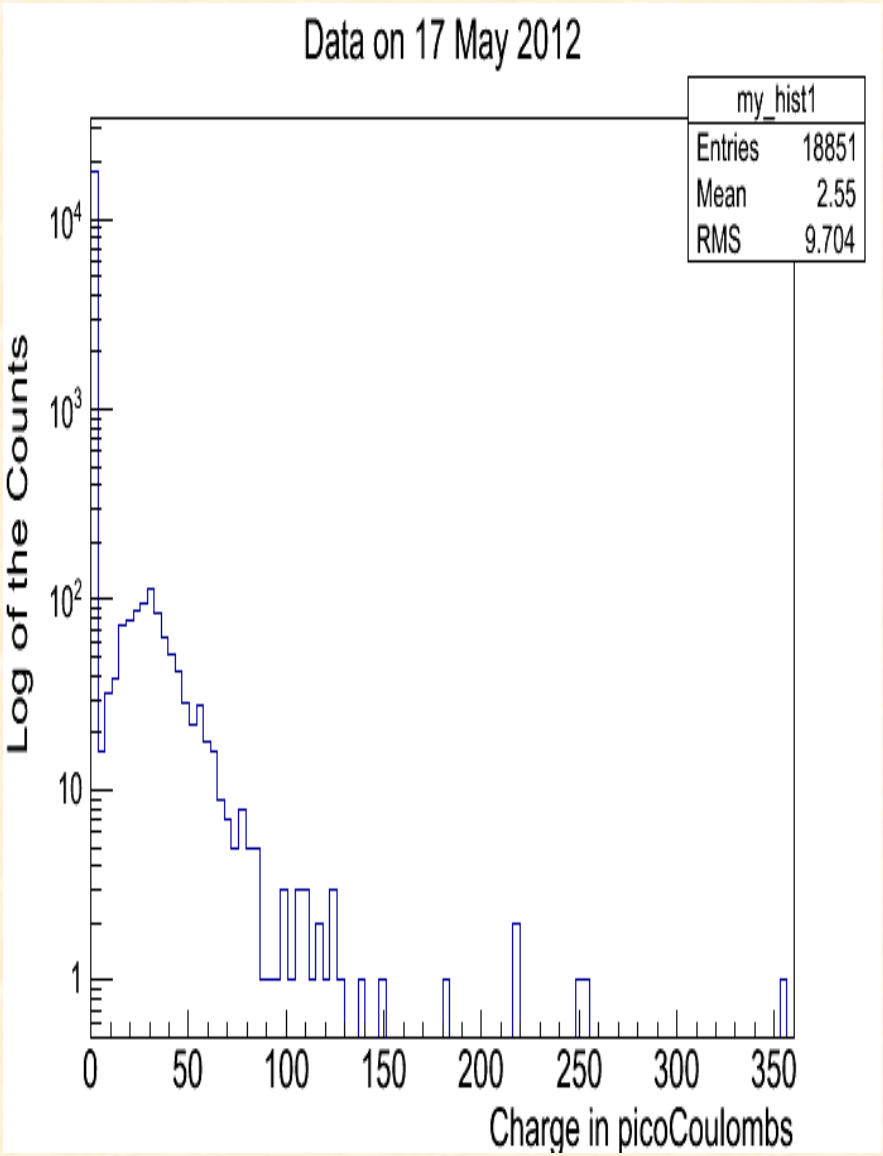
Scintillation Detectors











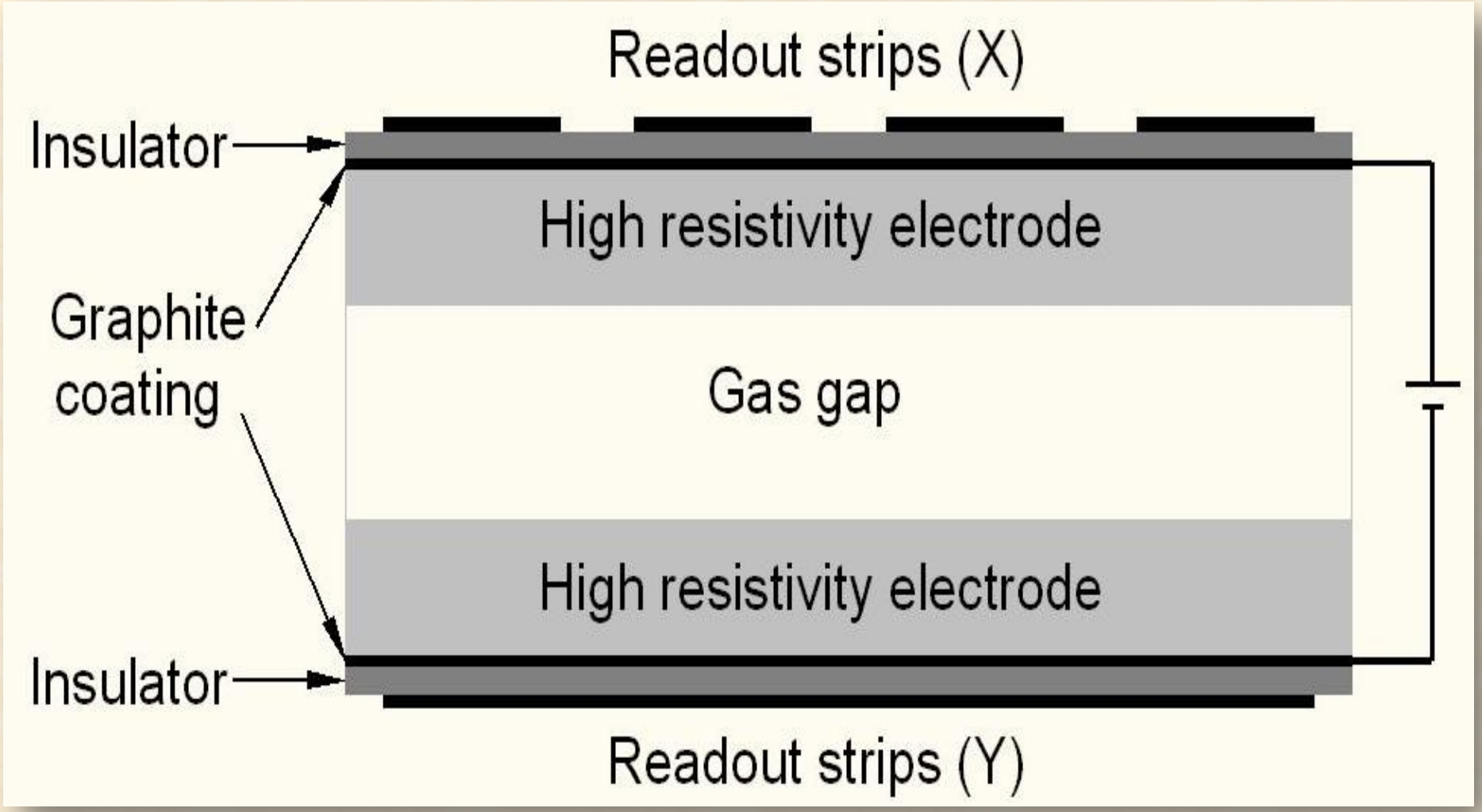
Histograms for the charge deposited in the scintillator.
The peak around zero is called the "pedestal" that is when no particle is present.

Mounting a scintillation detector

The scintillator tile with the fibres fitted in the grooves

The fully packaged and complete scintillator

Schematic Diagram of an RPC



The Labs where we worked at TIFR

Top: New INO RPC Lab

Left: INO Detector Lab at C-217

❖ Modes of Operation:

- Avalanche:

Operation voltage range about 10kV

Pulse amplitudes 1mV (needs amplification)

- Streamer:

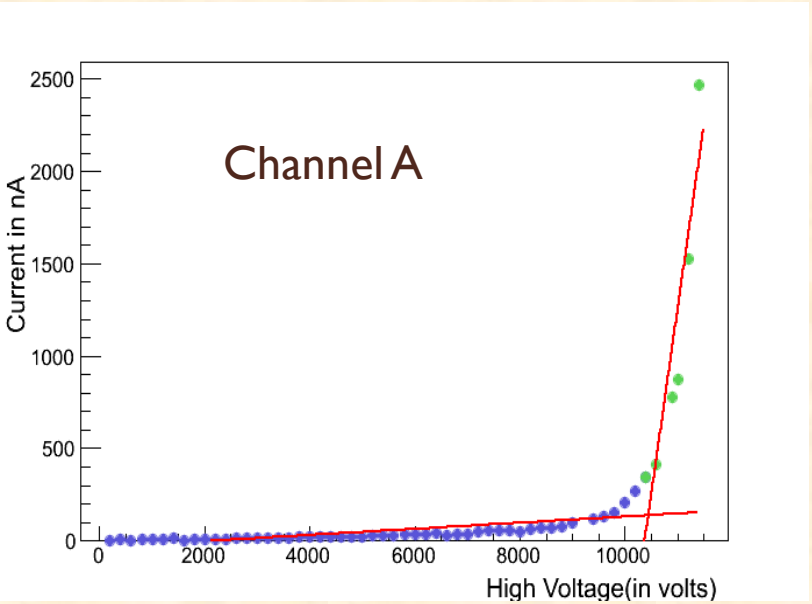
Operated at very high voltages

Pulse amplitudes ~100 mV

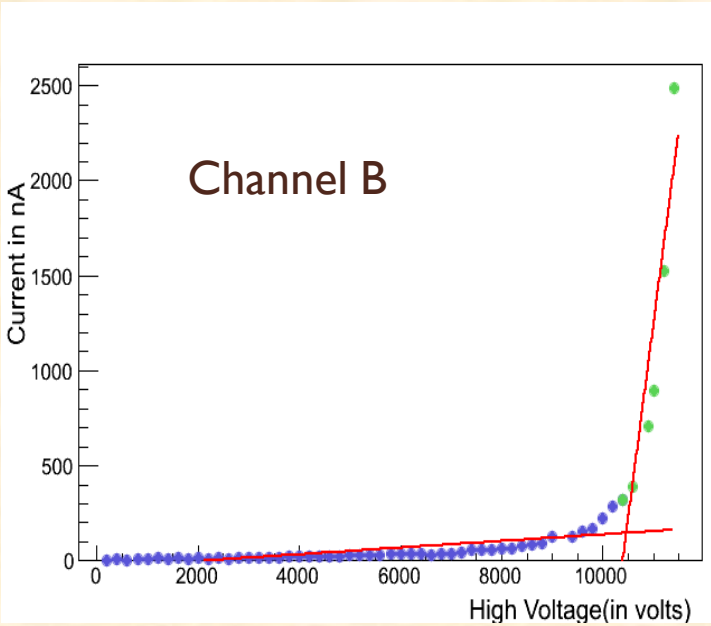
❖ Gas Mixture:

- Freon(R134A): 95.2% High ionization
- Iso-butane: 4.5% Quenches UV photons
- SF_6: 0.3% Controls excess electrons

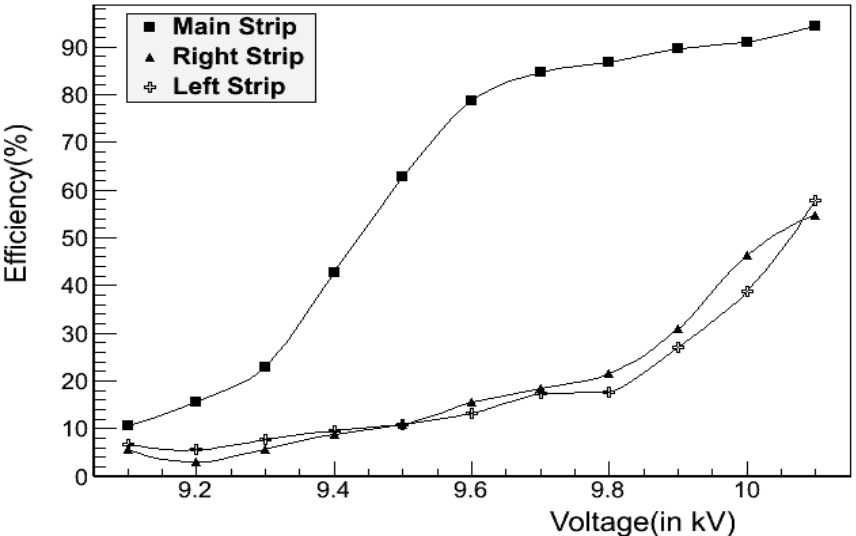
Characterization of RPCs



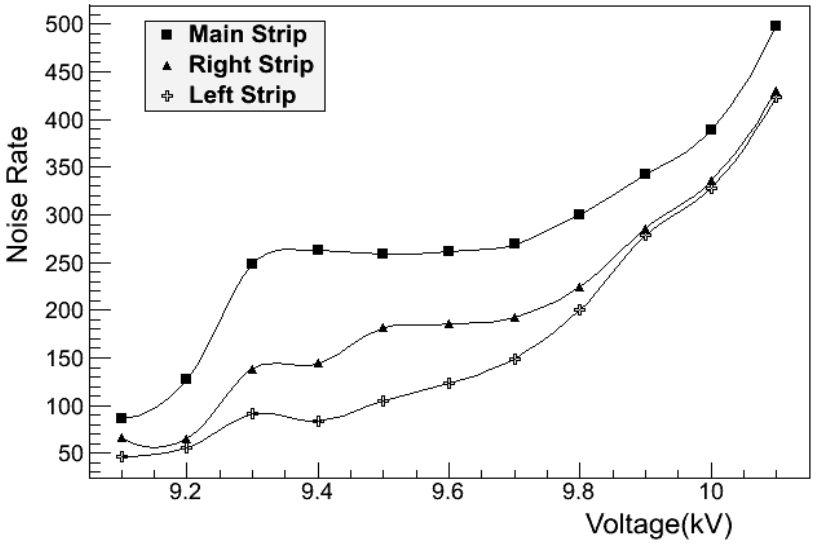
V-I Characteristics

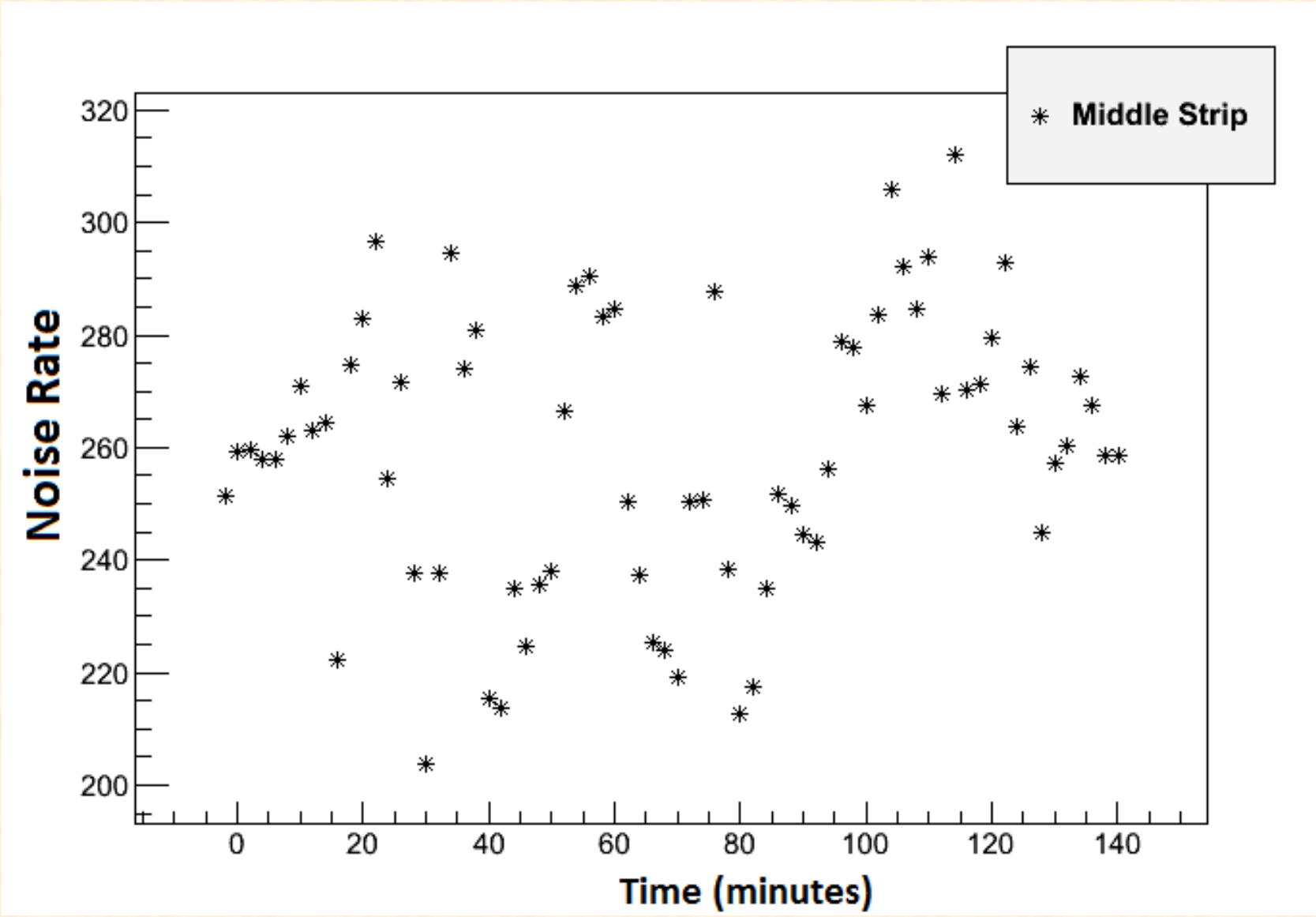


Efficiency of the RPC = 3F/2F *100



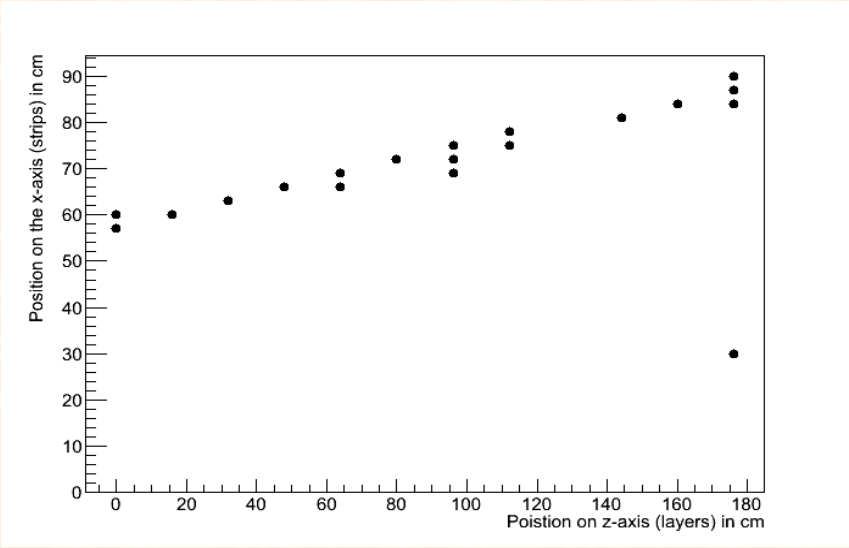
Noise Rate of the RPC

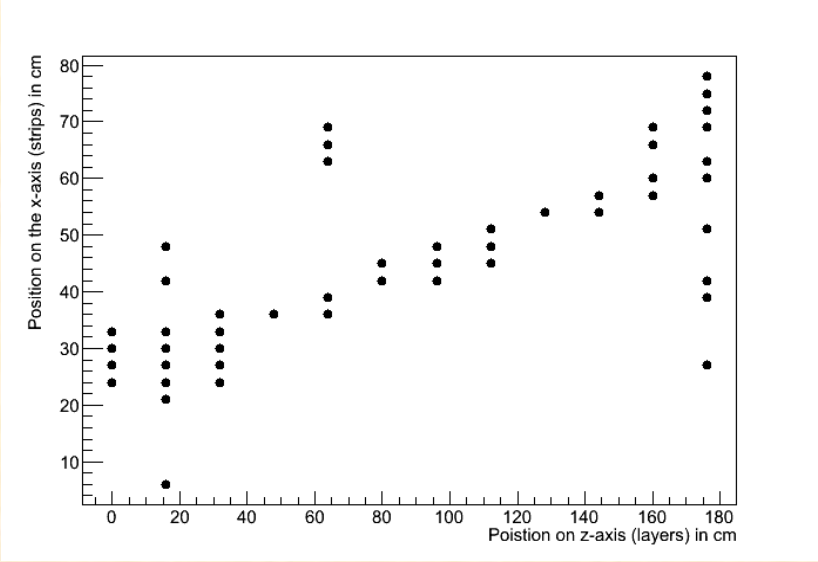


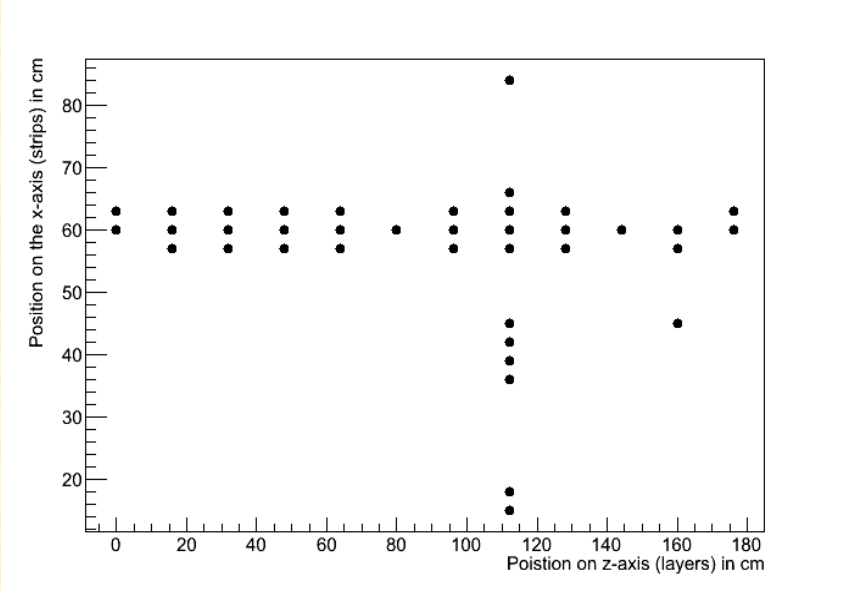


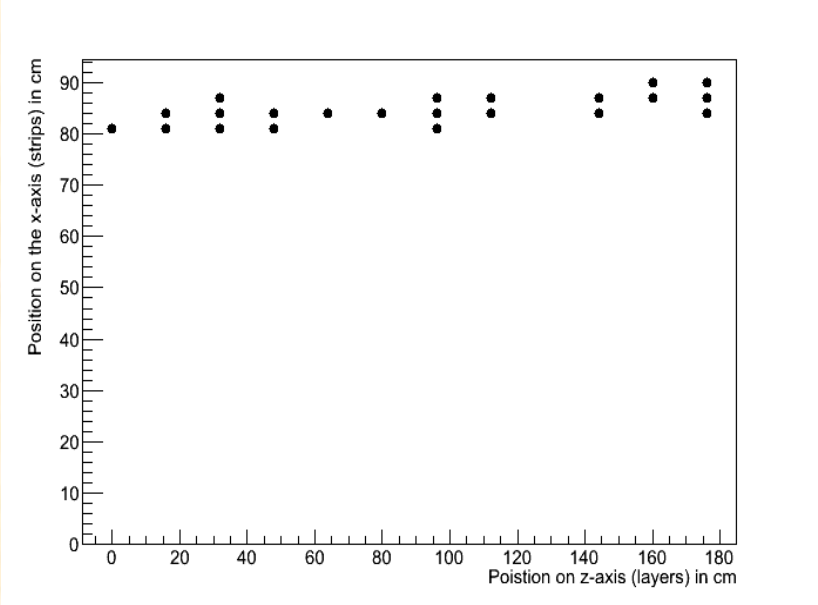
A typical noise vs time plot. This plot shows how the noise rate varies as a function of time.

A glimpse of the event data



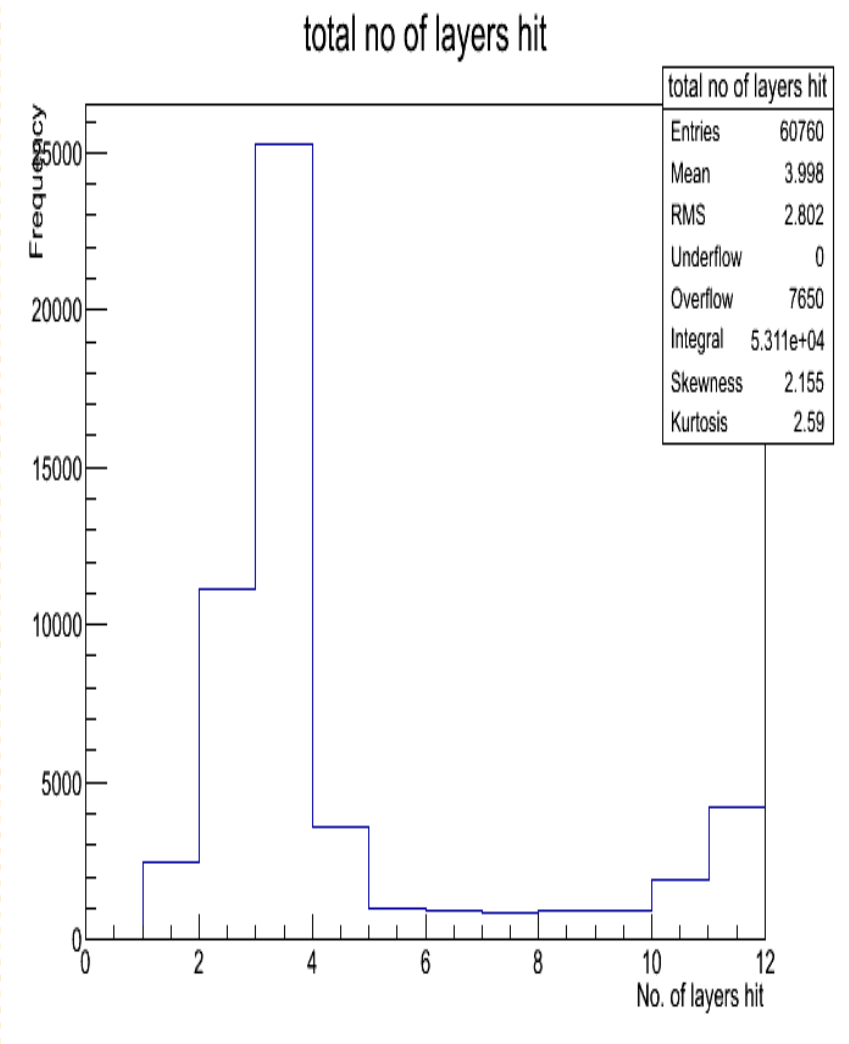


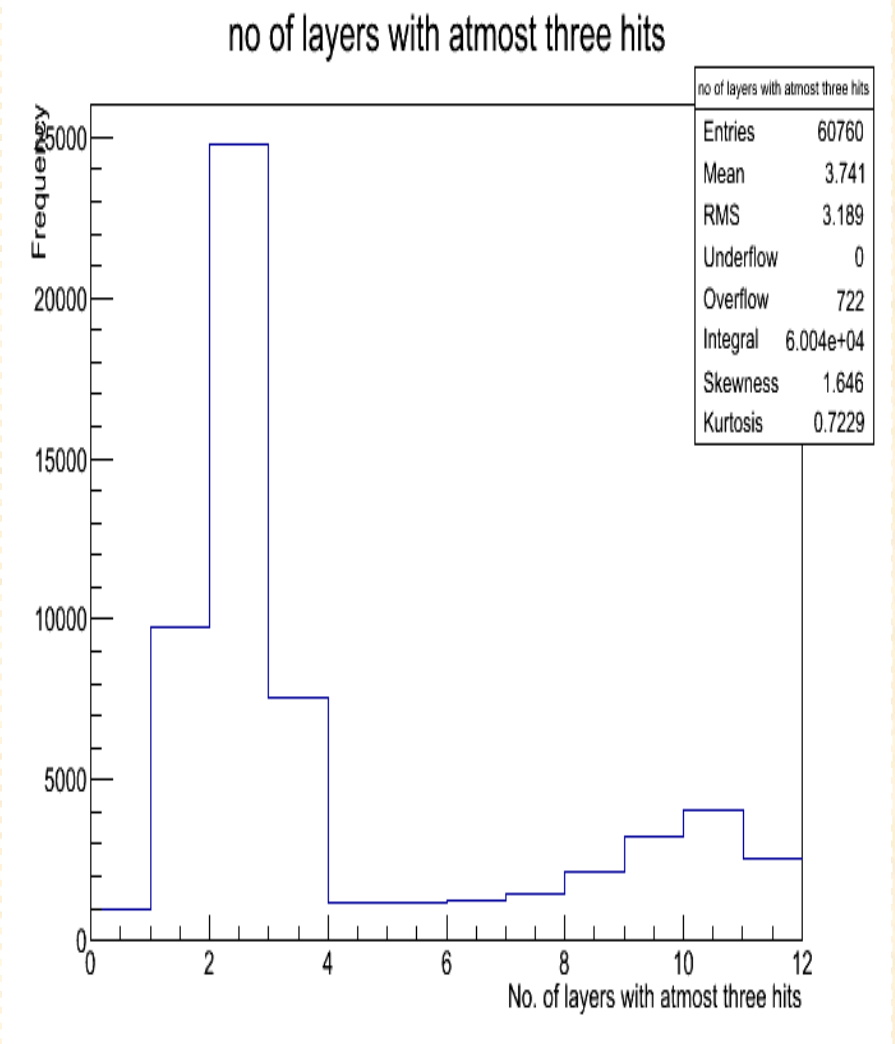




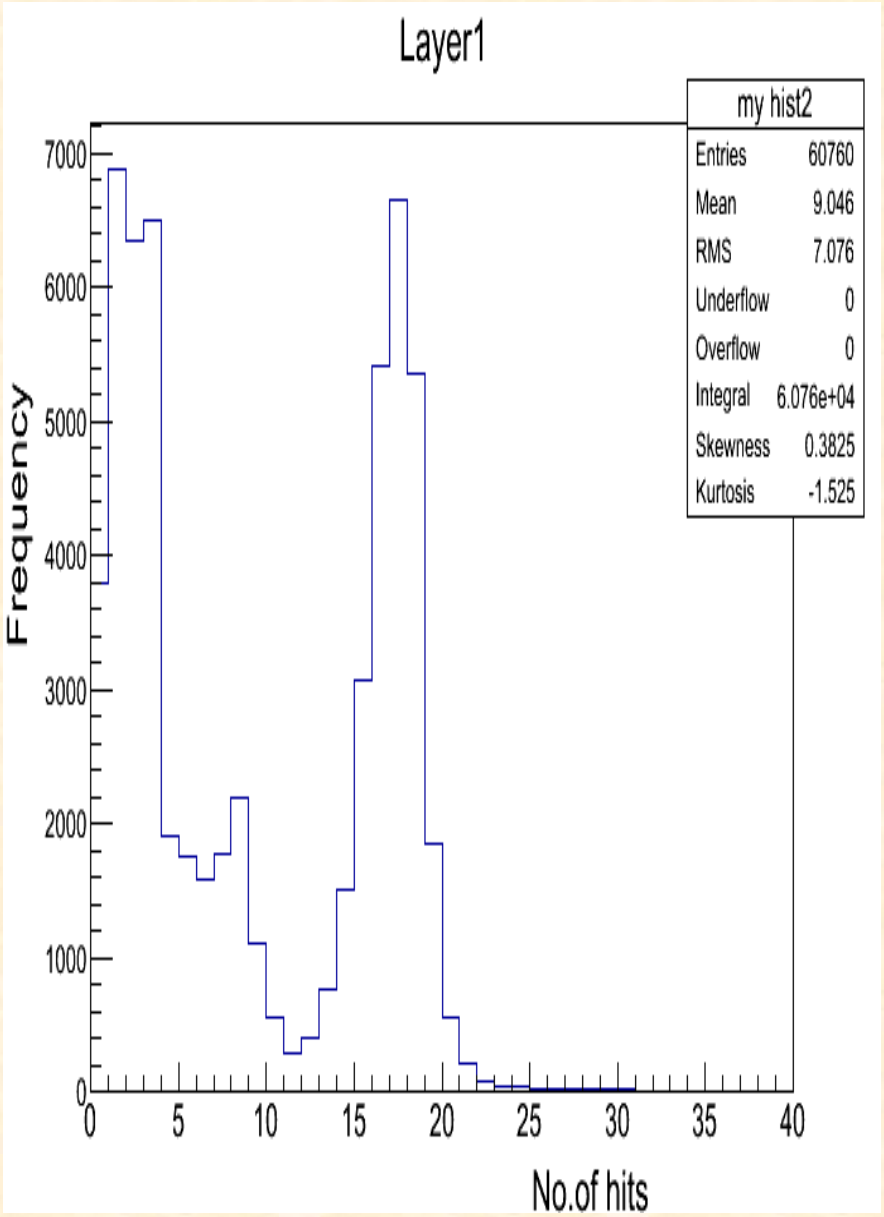
Very few events have all the layers hit, these are the ones that correspond to the muons. A lot of them have few layers being hit.

The layers that have a maximum of three hits. Only events which have atleast 4 such layers would be considered for reconstruction of the muon tracks.

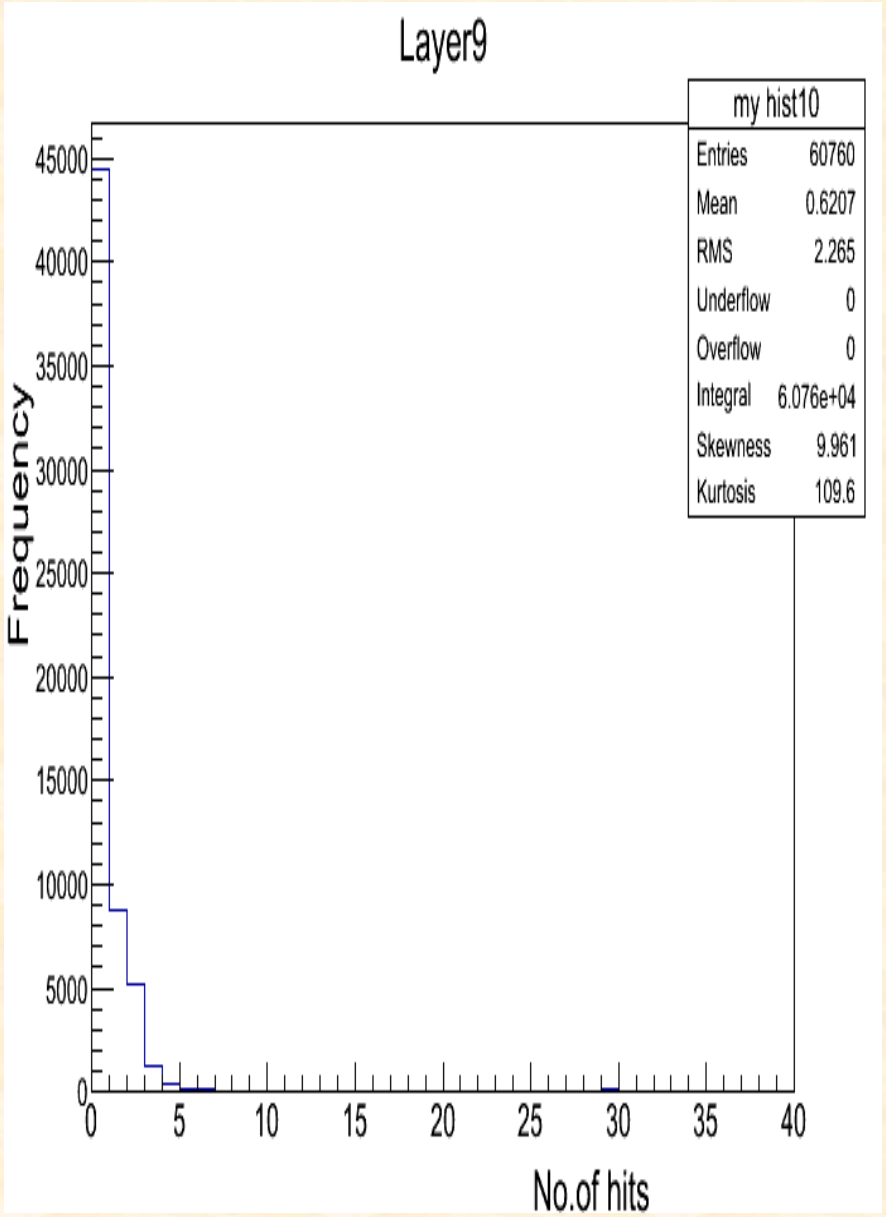




Noisy Layer



Non-noisy layer

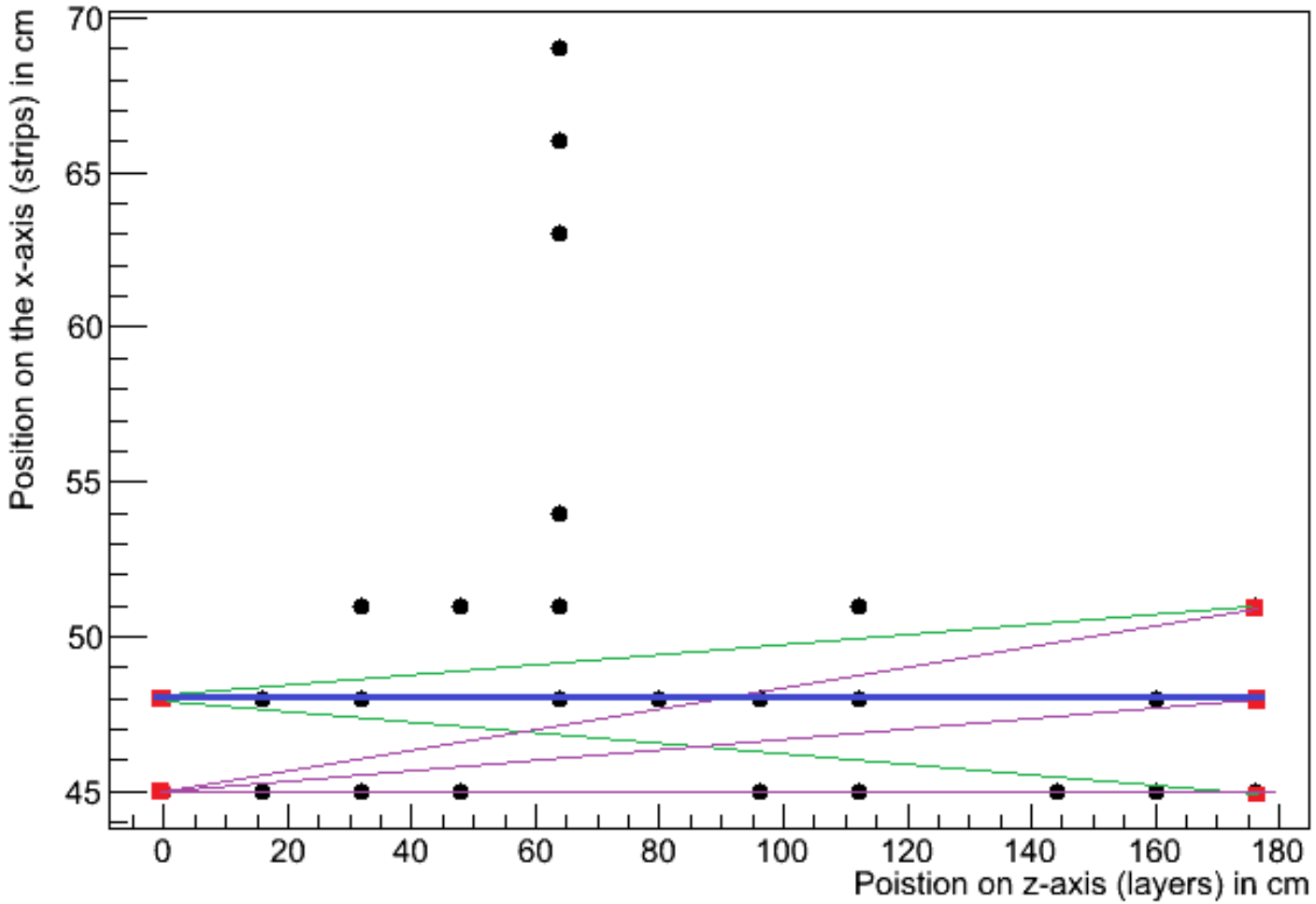


Reconstruction of muon tracks

Getting the track candidates:

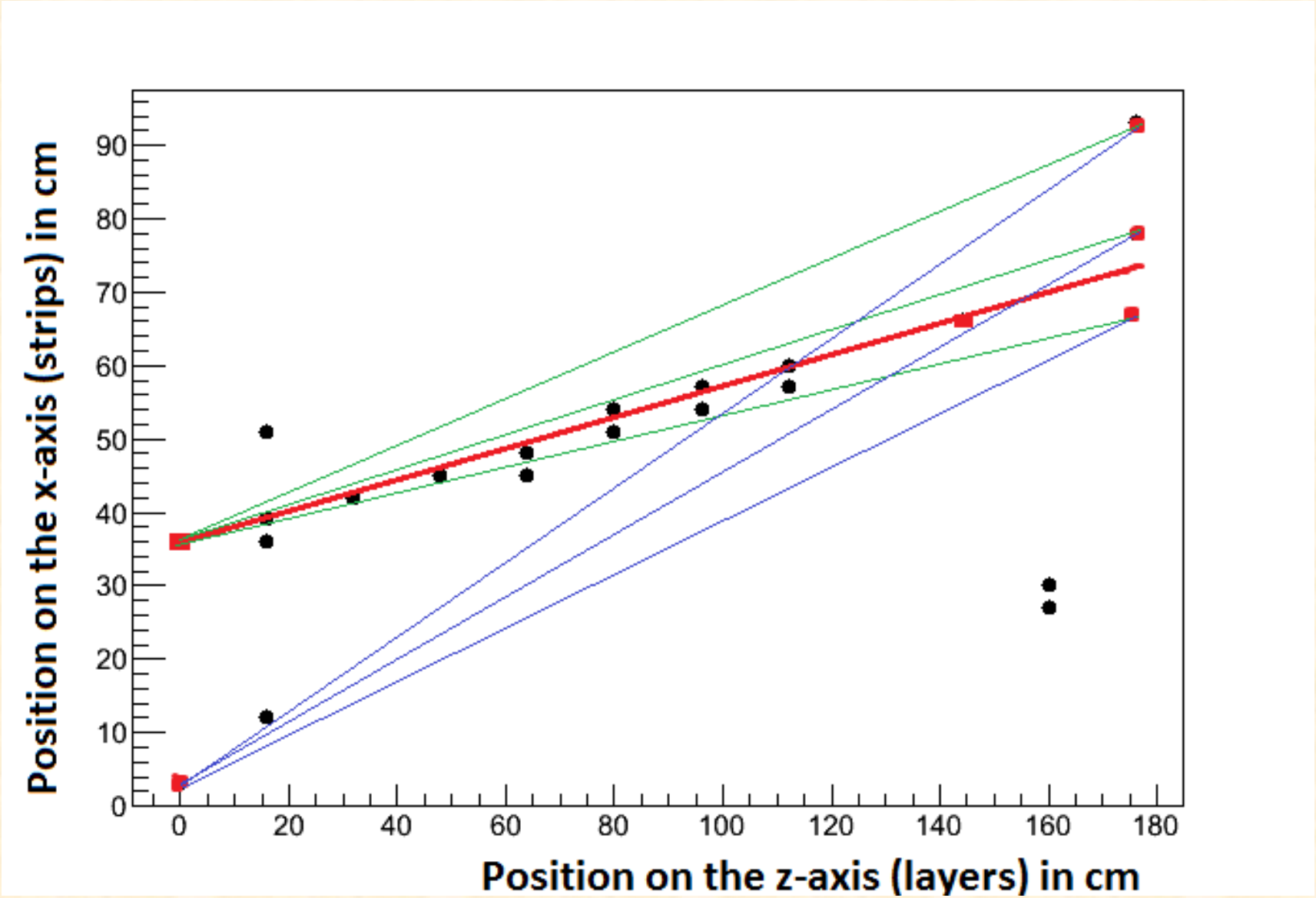
- Consider the layers which have three or less hits- the non-noisy layers.
- Consider only such events which have atleast four non-noisy layers.
- Get the track candidates by considering all possible combinations of hits in these layers.

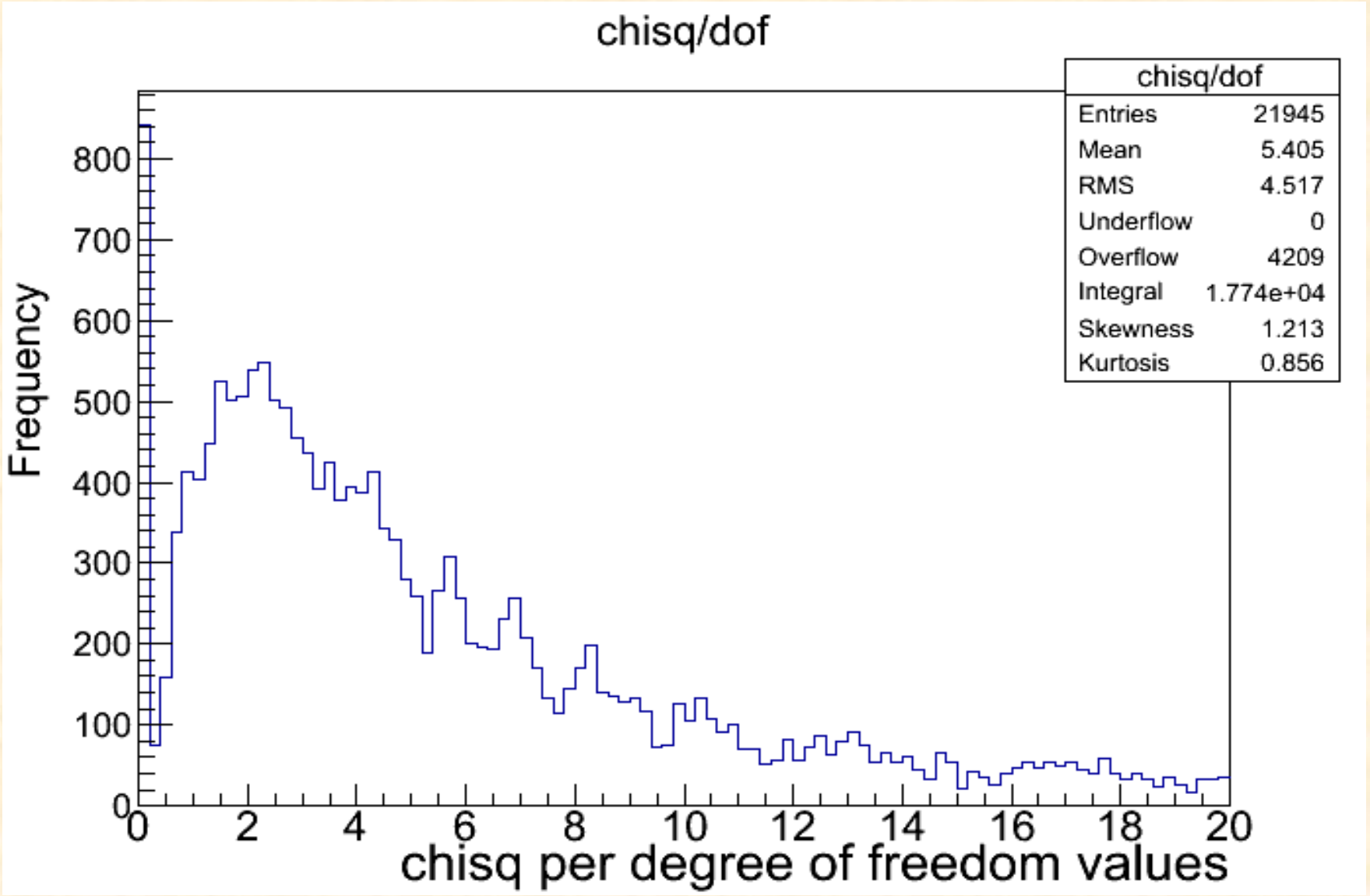
Reconstruction of muon tracks



$$\chi^2 = \Sigma \text{ (observed - expected)}^2 / \sigma^2$$

Reconstruction of muon tracks

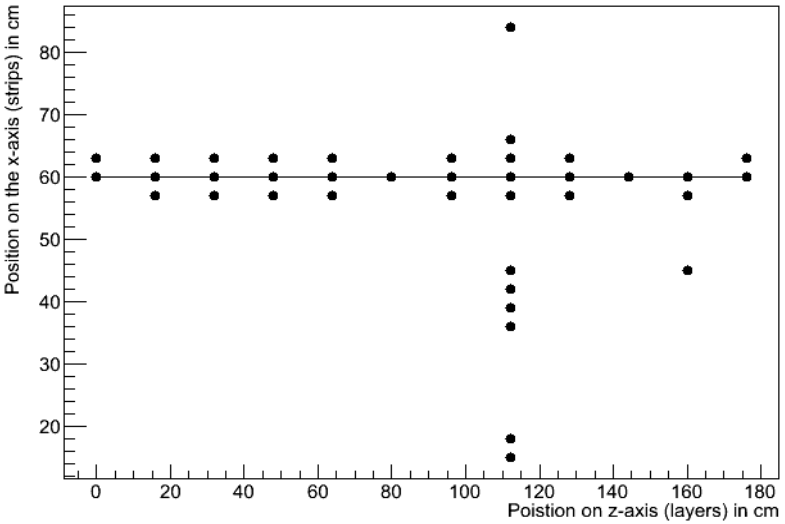


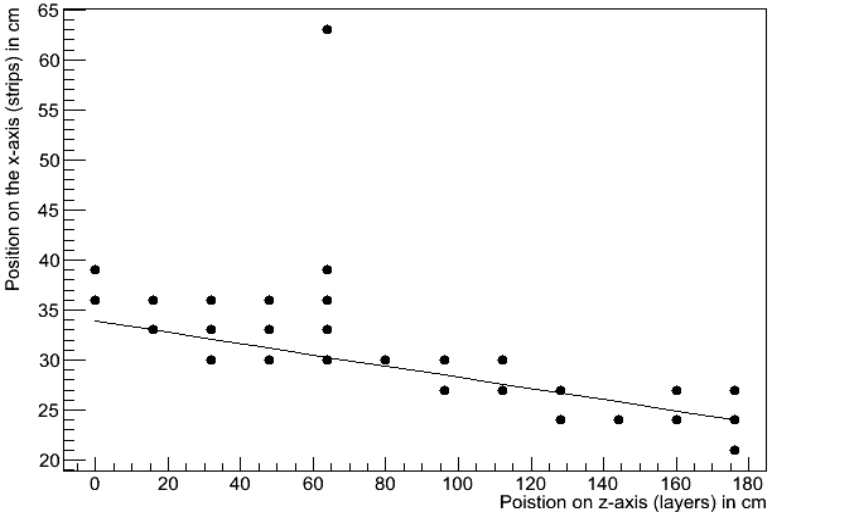


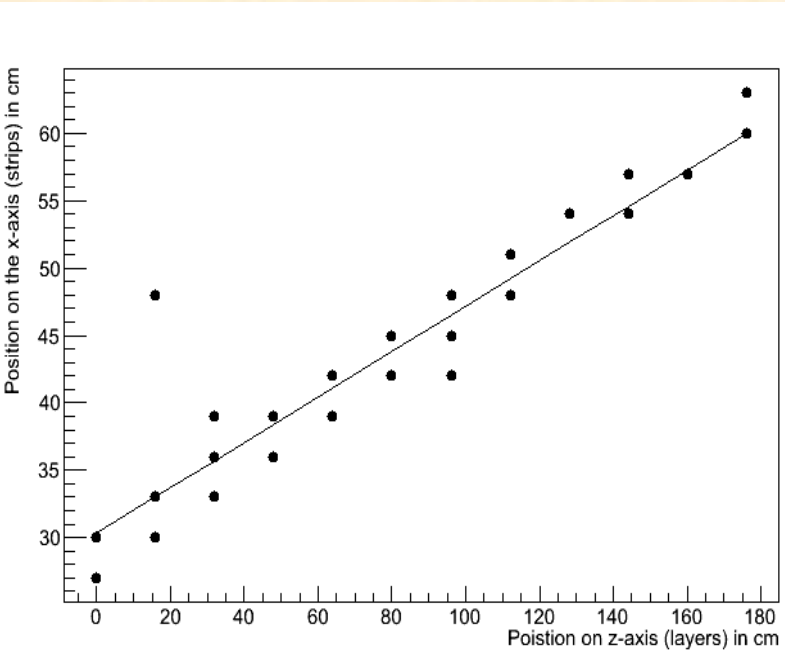
Histogram showing the chisquare/dof values

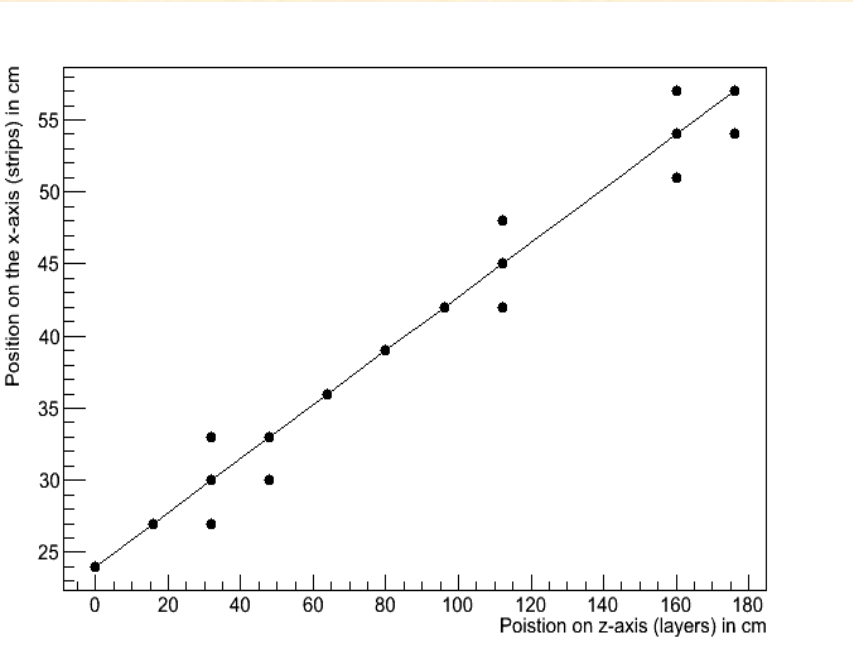
$\chi^2 = \Sigma \text{ (observed - expected)}^2 / \sigma^2$

Some of the events along with their estimated tracks

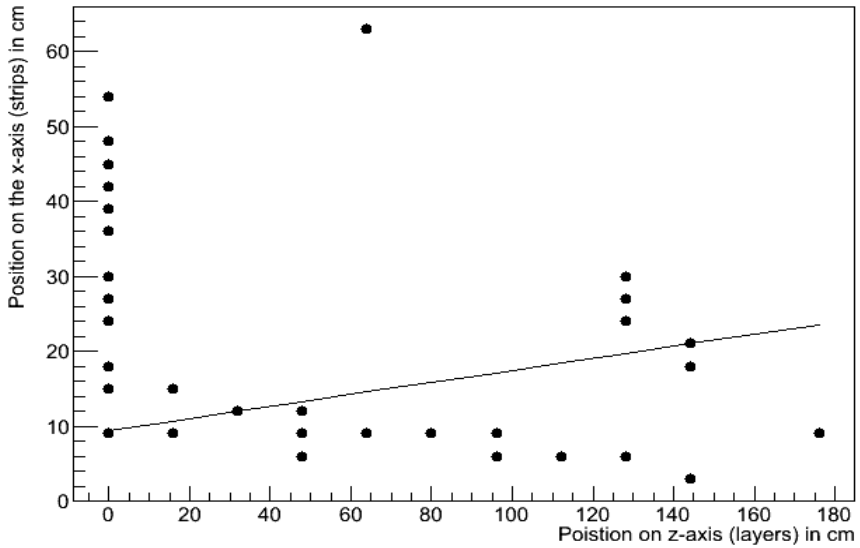


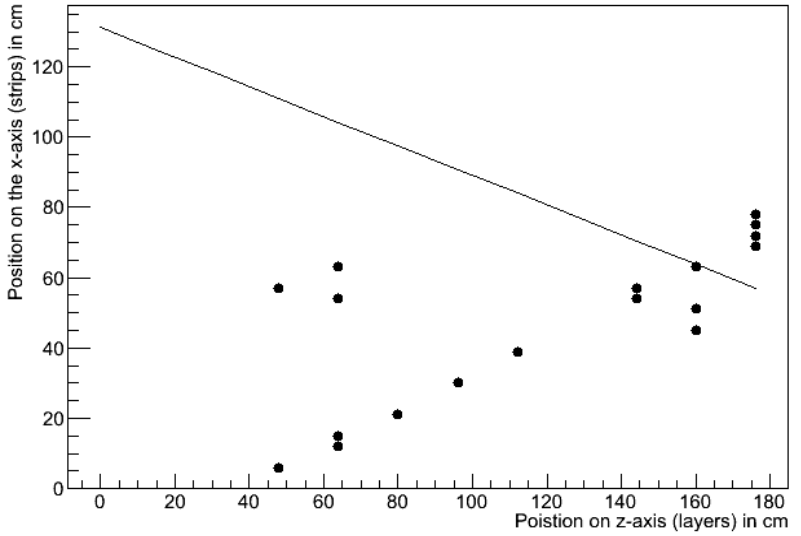


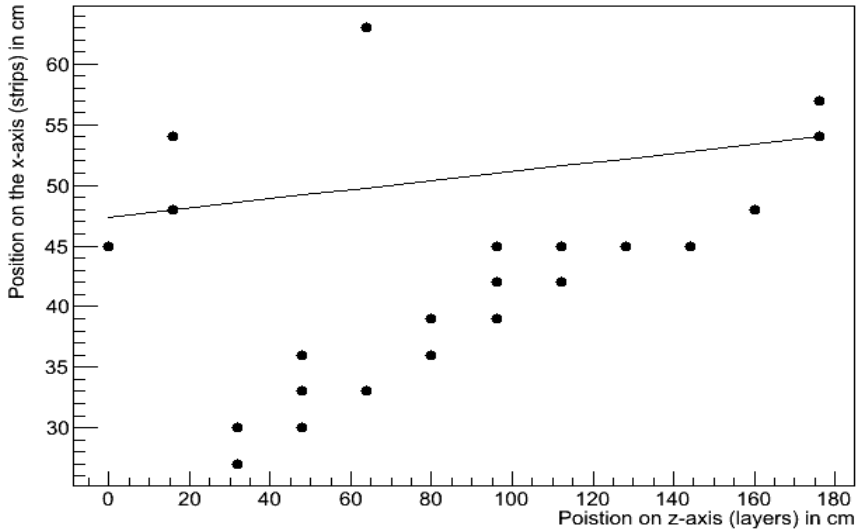


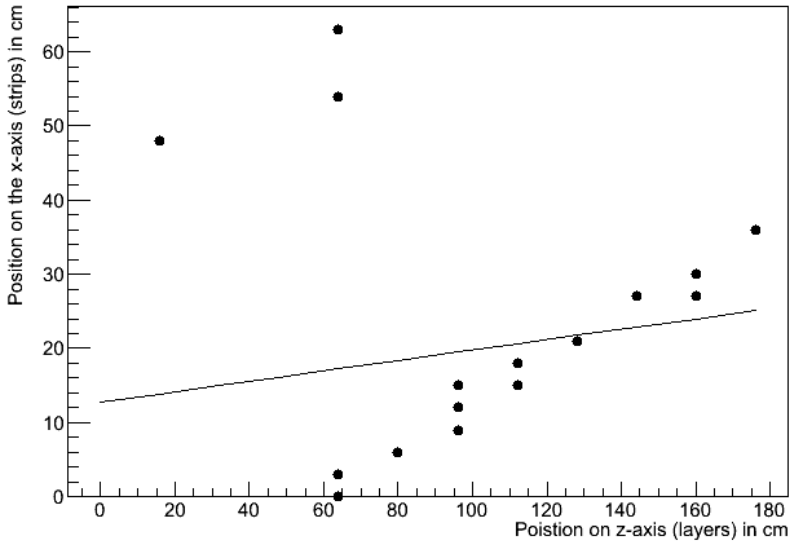


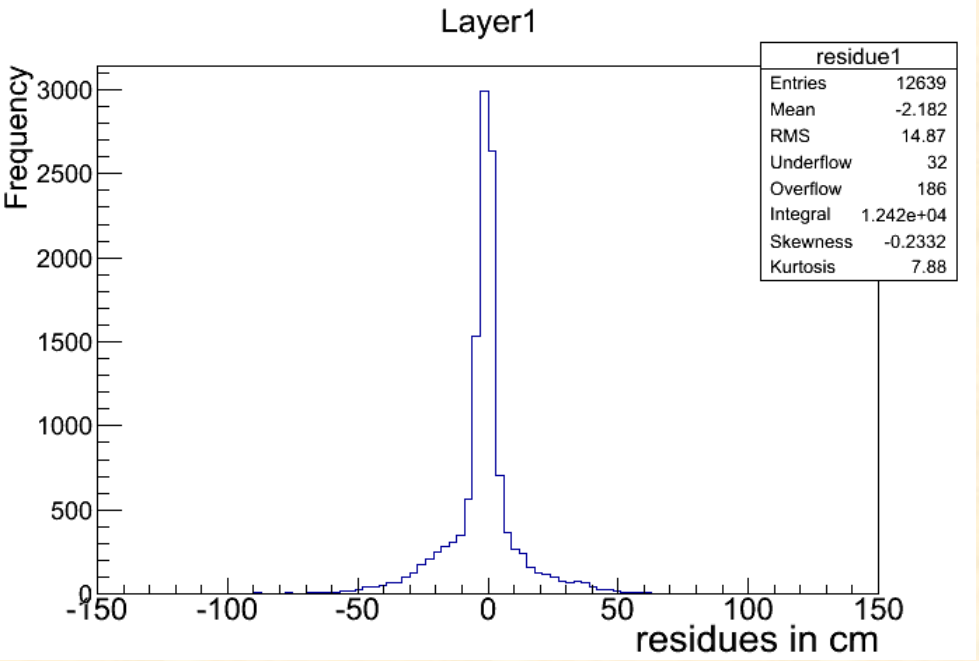
Some of the bad tracks

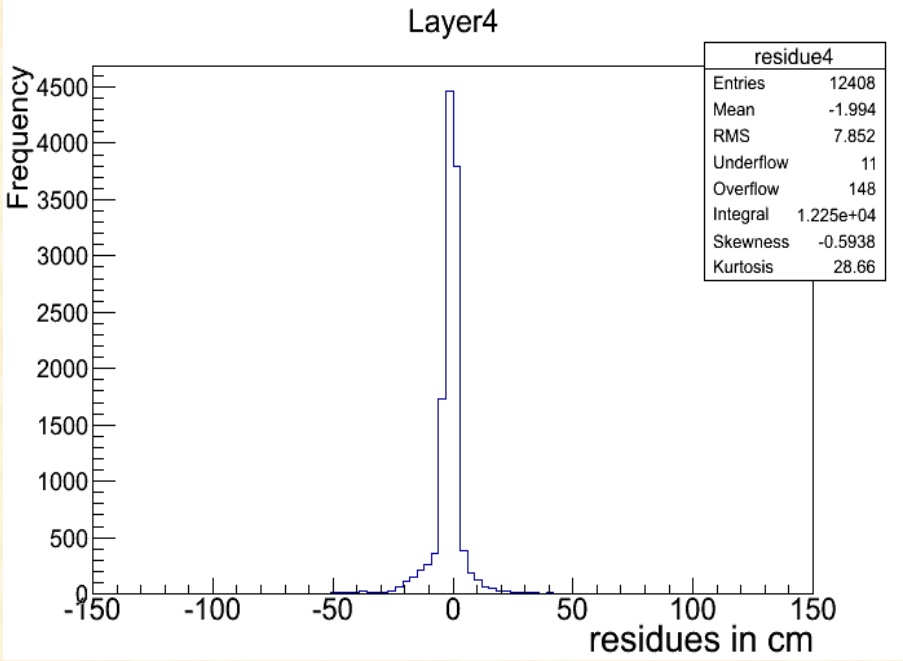




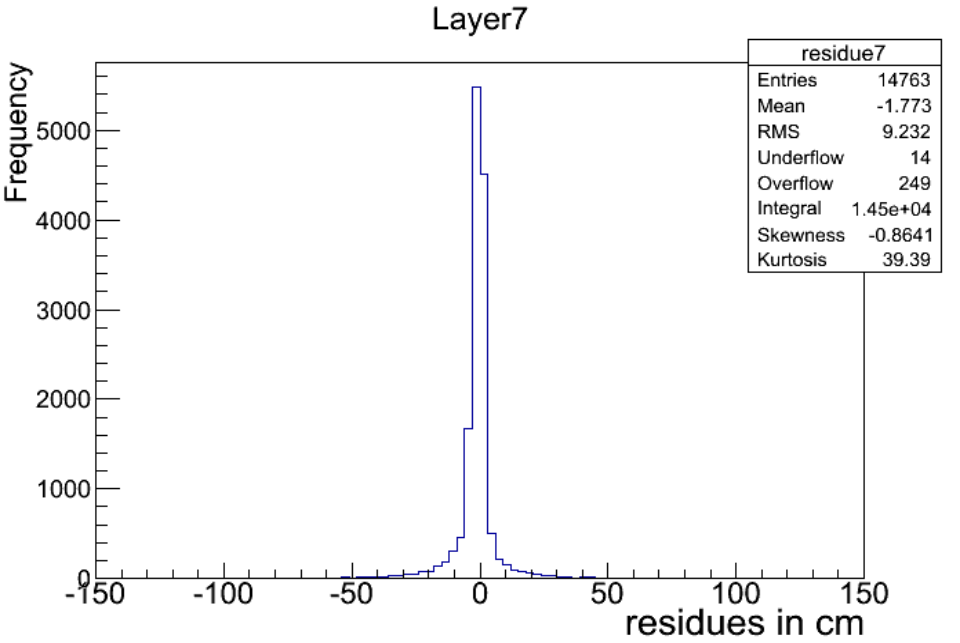


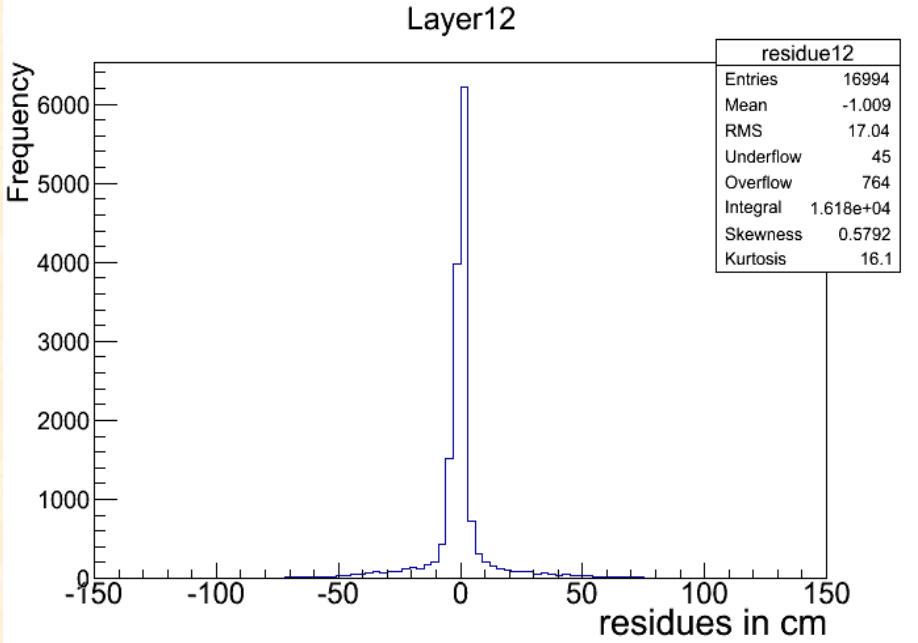






Residual Plots






Thank You!

Acknowledgements

- My guide: Professor Sudeshna Banerjee
- Scientific Officer: Mr L V Reddy
- R R Shinde
- Sudeshna Dasgupta
- Sumanta Pal
- And all the members of the lab
- My VSRP Friends

Backup Slides

Specifications

PMT:

- Brand Name: EMI
- Gain: 10^6
- Quantum efficiency: 25 - 30%
- Maximum Voltage that can be applied: 2kV (we used 1850V)
- No of dynode stages: 12

WLS Fibers:

- Brand Name: Kuraray
- Attenuation length: 1.5-2 metres

Scintillator Tile used:

- Material: Bicron 408
- Dimensions: 40cm × 43 cm

RPC:

- Pickup strip: Copper –honeycomb – copper
- Insulator: Mylar sheet (100 micron thick)

Reconstruction of muon tracks

- Consider only those layers in each event which have a maximum of three hits.
- Consider only those events which have at least four such layers.
- Consider all possible hits between the first and the last non-noisy layers .
- Find the slopes and intercepts for all possible combinations of hits in these layers.
- Using these different values of slopes and intercepts, get different track candidates.
- Use the track candidates to get the estimated positions for hits in each layer.
- Choose the candidate which has the minimum chisquare value.
- Now, there is ONE line which is the best fit line.
- Next, find the hit position that is closest to this estimated line.
- Using the closest hit position and the estimated positions, get the residuals and the chisquare value.
- If the chisquare value is less than 4.5, keep this line. Else, try the same procedure with a new combination of layers.
- If the new chisquare value (from the positions of closest hit) is greater than the previous one, retain the previous one. If it is less than the previous one, update the value of chisquare. If chisquare is still quite high i.e. greater than 6, try the same procedure with another combination of layers.
- Finally retain the chisquare value that it is the least out of the three that were calculated.
- Use the final residuals and chisquare value to plot histograms.
- Finally, plot the track which corresponds to the minimum value of chisquare out of the three calculated ones.
- Plot the hits and overlay the fitted line for the track.