INDIA-BASED NEUTRINO OBSERVATORY

VELOCITY MEASUREMENT OF COSMIC MUONS USING THE INO-PROTOTYPE DETECTOR

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ABSTRACT

The India based Neutrino Observatory (INO) collaboration is planning to set up a magnetised Iron Calorimeter with Resistive Plate Chambers (RPC) as active detectors to study Neutrino Oscillations. A prototype detector stack comprising of 12 layers of RPCs of 1m x 1m in area has been set-up to track cosmic ray muons. To demonstrate its capability and feasibility of distinguishing between up-going and down-going particles, we measured the velocity of cosmic muons recorded in this stack. The detector setup, measurement procedure, calibraion and results are described here.

DETECTOR SET-UP

- 12 Layers of RPC's
- Detector Dimensions: 1m x 1m x 1.8m
- RPC Dimensions: 1m x 1m ; 32 strips/plane
- Avalanche Mode
- Strip Hit Information, Noise Rate and Timings recorded by VME based DAQ

MEASUREMENT

DATA ACQUISITION

The VME based data acquisition developed for this prototype detector was used for the calibration measurement and the measurement of the velocity of cosmic muons[1]. The DAQ system stores the strip hit information and the timing information of the 12 layers along with other useful parameters.

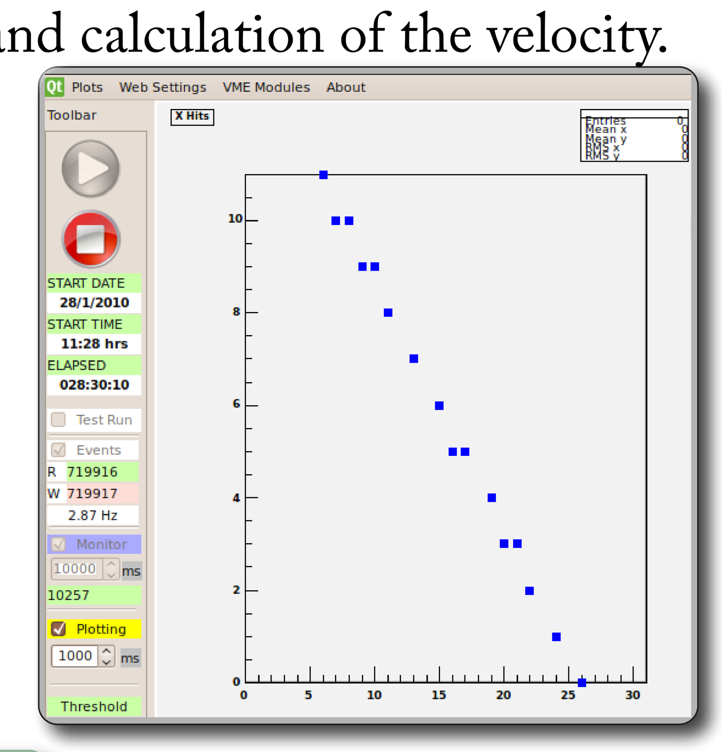
DATA ANALYSIS

A straight line fit to the tracks (X side and Y side) gives the slope and the intercept of the tracks. The Zenith Angle of the muon track is computed from the path length of the particle inside the detector. The relative time of arrival of the particles at the different layers are first corrected using the calibration data.

DATA REDUCTION

A following cuts are made before the analysis and calculation of the velocity.

- Removal of Layers with multiplicity > 1
- Straight Line Fit - Restrain Chi-Squared
- Removal of Layers falling outside a defined time-window

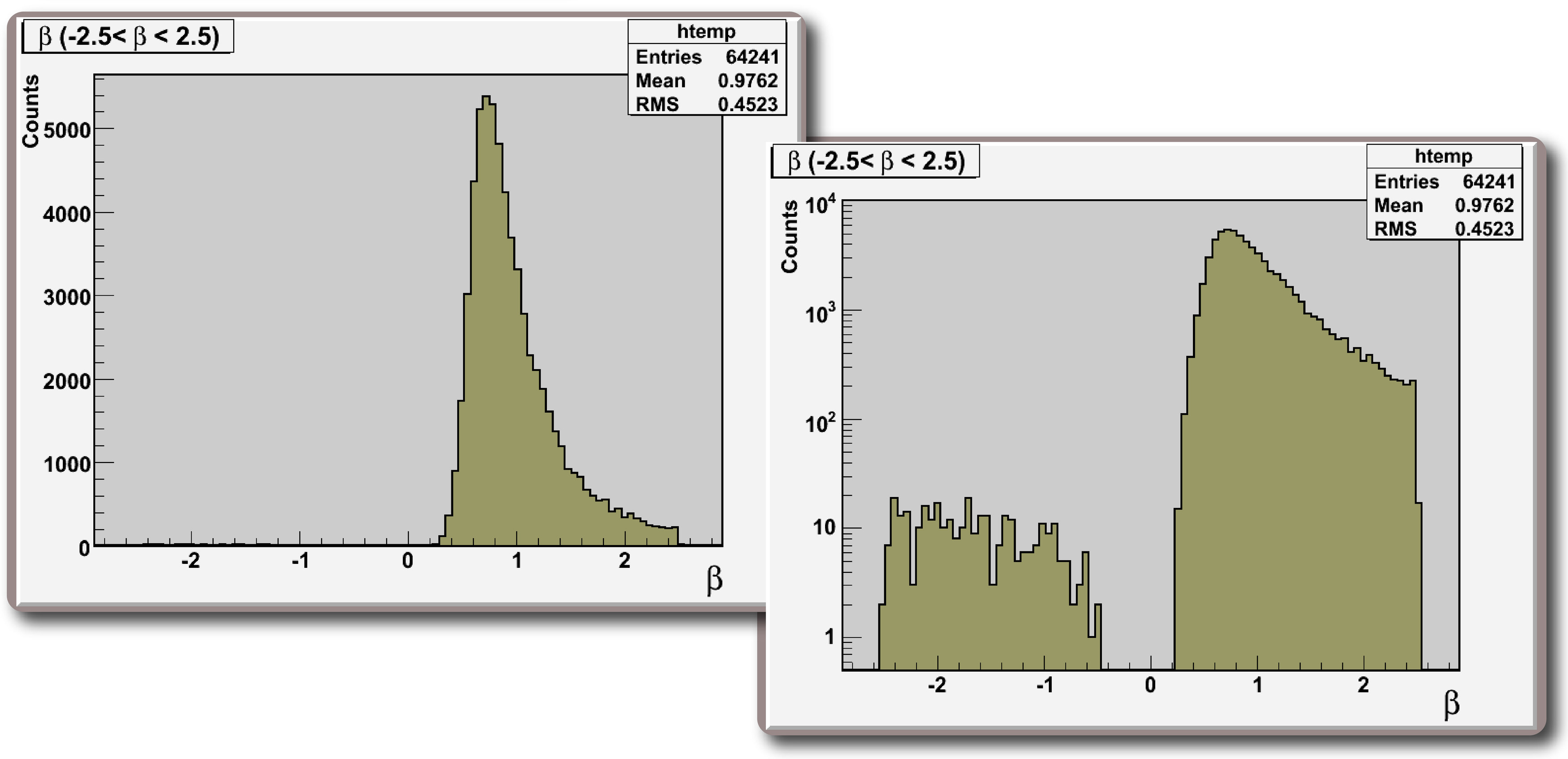


VELOCITY CALCULATION

The most probable velocity (1/v′) is calculated by fitting a straight line to the corrected time -data.

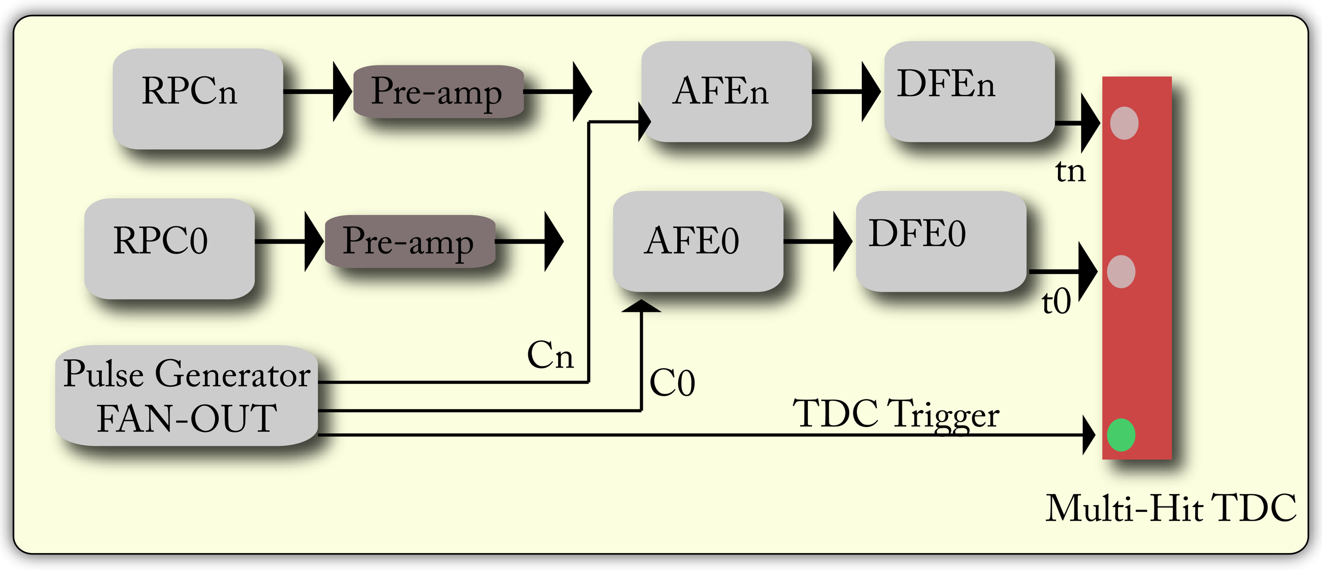
$$\Delta t = v' x + t_0$$

RESULTS



CALIBRATION

The measurement of the time arrival of the particles at the layers is a crucial part of this study. The timing signals from the different layers take different paths although the electronic cicuitries are similar. Hence a calibration of the timing signals is necessary to compensate any sych systematic errors.



The calibration set-up is shown in the block diagram above. Since the effective contribution to the time delays come mainly from the electronics succeeding the pre-amplification stage, all calibration signals are input to the Analog Front-End (AFE) stage of the signal processing.
Signals from the fan-out of a pulse generator are sent simultaneously to

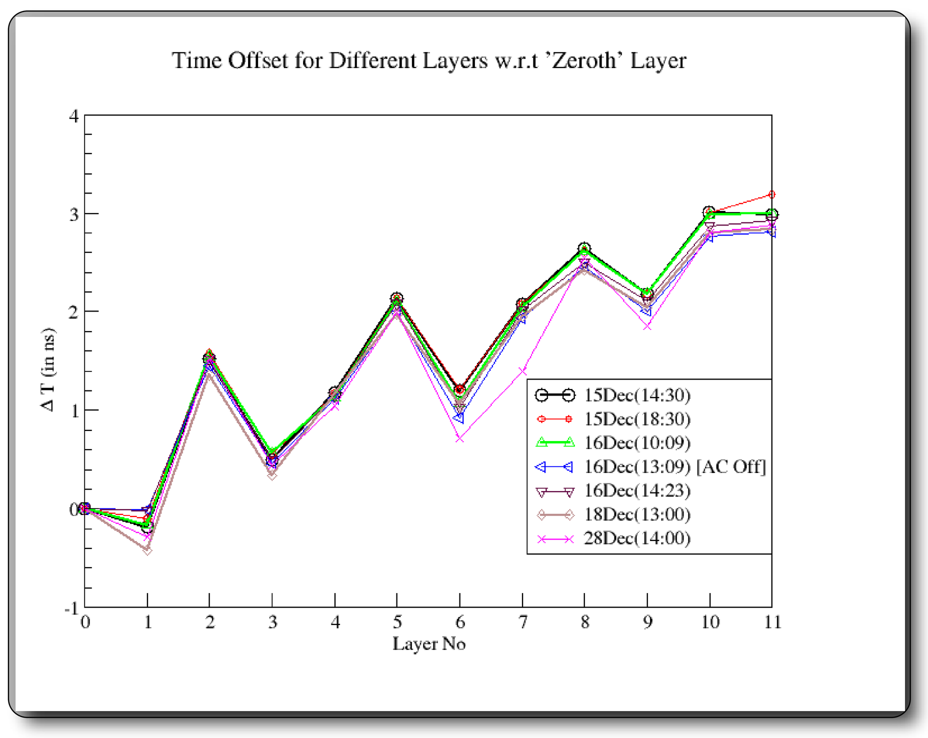
(a) The lower most layer RPC_0,
(b) The layer to be calibrated RPC_n and
(c) The TDC trigger input.

To reduce the systematics due to the Pulse Generator, the fan-out channels are swapped and the measurement, repeated. The difference between the two measurements yields the corrected time difference relative to RPC_0.

$$\Delta t = (\Delta C_0 - \Delta C_n) + (\Delta t_0 - \Delta t_n)$$

$$\Delta t_{swap} = (\Delta C_n - \Delta C_0) + (\Delta t_0 - \Delta t_n)$$

$$\Delta t_{corr} = (\Delta t + \Delta t_{swap})/2$$



The plot shows the relative time-differences for the different layers taken over a period of time. These data were used to correct the timing data .

The relative velocity (β) distribution of the cosmic muons are plotted above. The plot in the lograthmic scale reaveals the presence of a considerable amount of outliers (especially β> 1) indicating a possible unknown source of errors in our measurements. Although the results reveal a higher positive to negative event ratio, as expected, further studies need to be made and are currently in progress to address this anamoly.

Reference: 1. VME BASED DATA AQUISATION SYSTEM, by Deepak Samuel, X. Workshop on RPC and Related Detectors, G.S.I, 2010.