INDIA-BASED NEUTRINO OBSERVATORY

VME BASED DATA ACQUISITION SYSTEM

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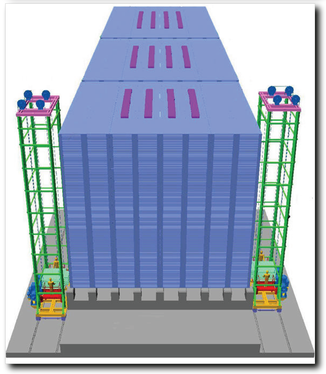
TIFR A Deemed University

The India-Based Neutrino Observatory (INO) Project plans to set-up a magnetized 50 kt on Iron Calorimeter (ICAL) to study and analyze neutrino oscillations [1].

INO - ICAL



- 3 Modules (16 m x 16 m x 12 m each)
- 151 Layers of Iron Plates interleaved by RPC's
- 5.6 cm Thick Iron Plates
- 28,800 RPC's (2m x 2m), 64 strips/plane
- 1.3 Tesla Magnetic Field
- 3.6 Million Electronic channels

HARDWARE

The Resistive Plate Chambers (RPC) in the prototype stack operate in the Avalanche mode and therefore the strips signals are amplified (80x Gain) before they are processed.

The amplified signals are threshold-discriminated and a pre-trigger is generated from the ese pulses by the AFE's.

In the DFE, the discriminated signals are bifurcated to a) Pulse Stretcher (~700 ns) and b) 40:1 Multiplexer (32 Strip Signals + 8 Calibration & Fold Signals). Various Fold-Rates (1 Fold, 2 Fold, 3 Fold & 4 Fold) are generated from the pre-trigger signals from the AFE.

The signals from the DFE's of all the 12 layers are then sent accordingly to the Control/ Data Router and the Trigger Router.

The Control /Data Router and the Trigger Router are passive devices which route the signals from the electronics to the DAQ.

All the Fold-signals are fed to the Trigger-Router from which the timing information is received for further trigger generation and timing measurements.

PROTOTYPE

- 1m x 1m x 1.8m
- 12 RPC's (1m x 1m), 32 strips /plane
- No Iron Layers

The prototype stack at TIFR is being used as a cosmic ray telescope and serves as a test bench for the detector and its related electronics[2,3]. Long term stability and performance studies are carried out in the stack. A VME based DAQ was developed for this set-up.

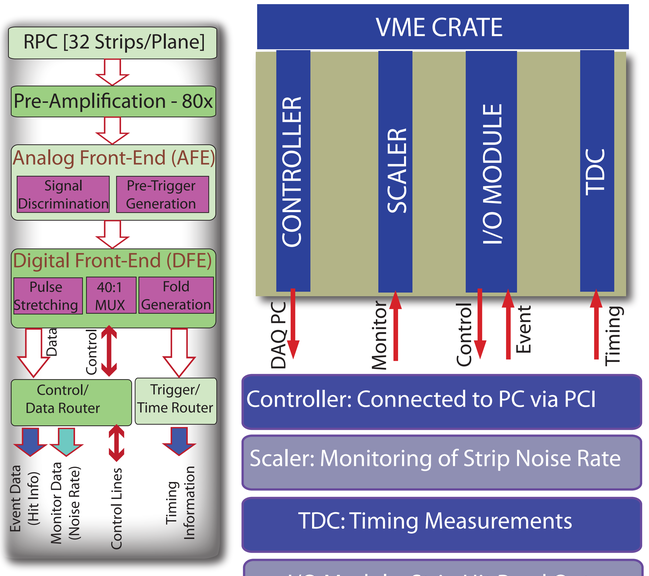
DAQ FEATURES

Hardware

VME Modules		PC Configuration	
Controller	CAEN V2718, optical link	CPU	Intel Xeon CPU, 2.80 GHz
Scaler	CAEN V830	Physical Memory	1 GB
TDC	CAEN V1190, Multihit	Operating System	Debian Linux (Ubuntu 9.10)
I/O Module	CAEN V1495, Customized		

Software

Language/Add-ons	
Front-End GUI and Back-End	C++ with Qt Libraries
Graphing, Analysis & Data Structure	ROOT, Qt ROOT
Online Plots in webpage	Flot (JavaScript)
Features	✔ Interrupt based ✔ Multi-threaded ✔ User-Friendly GUI



Two Interrupt Sources in VME

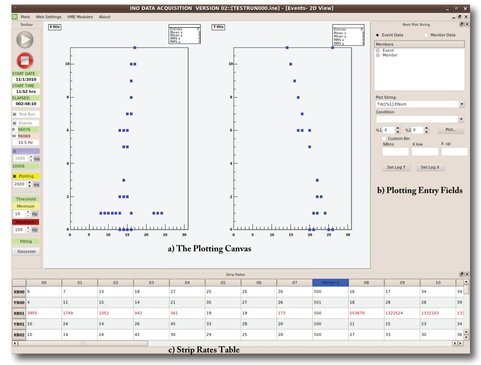
- TDC: Trigger Conditions Satisfied (Event Data + TDC Readout)
- Scaler: Current Monitor Cycle Complete (Noise Rate Readout, Change-over to next strip)

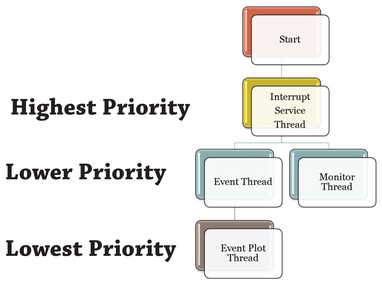
TDC intterupt is random as it signals the arrival of a particle satisfyinging trigger condition while the Scaler interrupt is periodic, the frequency of which is preset in the software by the user. Both the interrupts are routed by the I/O Module to their respective modules.

SOFTWARE

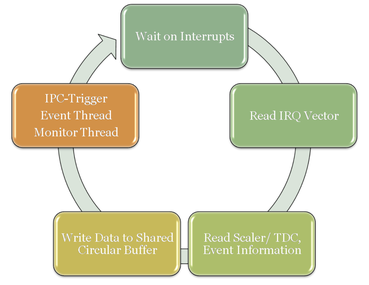
The software was developed with the aim of providing utmost flexibility to users especially during the primitive stages of the experiment where debugging and troubleshooting of the detector is a non-trivial task. Plotting and display of relevant parameters in a suitable way even during data acquisition is one main requirement in this case. An intuitive Graphical User Interface (GUI) is very useful for such purposes.

The GUI was developed using Qt from Nokia Corporation (LGPL License). For plotting, ROOT canvases were embedded inside the DAQ framework using the Qt ROOT plug-in developed at BNL[4]. Due to the features like compression and optimized data access, the data structures are implemented using ROOT's TTree class. This helped in realizing a versatile plotting and analysis environment, both online and offline. The GUI has a worksheet showing the updated strip noise rates, a VME module set-up tab and a plotting entry field where-in the user can type in the variable (with conditions, if any) to be plotted.

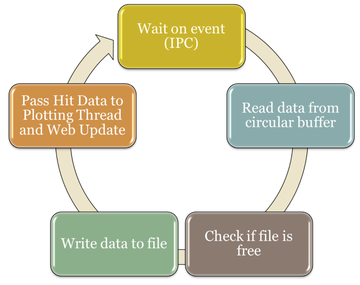




The DAQ software has a multi-threaded structure, running 4 threads, as described in the block diagram, concurrently, although with different priorities. This segregation minimizes the overhead of the Interrupt Service Thread (IST) thus making it available for the next interrupt in the shortest time possible.



The IST waits on interrupts and once asserted, reads the Interrupt Request Vector (IRQ) to ascertain the source of the interrupt (TDC/Scaler) and proceeds to read the data from the respective modules. Two circular buffers are used, one for Event Data and another for Monitor Data. The IST transfers the contents to these buffers and triggers the appropriate threads.



The other threads are semantically similar to each other. On receiving a trigger from the IST, the latest contents from the circular buffer are appended to the file and saved. During an active plotting process, the file may not be available for any other operation and therefore the file writing section is "mutexed". The plotting threads run with the lowest priority to save CPU time.

References:

1) INO Project Report, INO/2006/01.

2) Proc. 9th Intl. Workshop on RPC's and Related Detectors, NIM A, Vol 602 (3).

3) Proc. Linear Collider Workshop, Pramana, Vol 69 (6).

4) http://root.bnl.gov/QtRoot/QtRoot.html