Electronics and data acquisition system for prototype INO-ICAL detector

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1. Introduction

A 1m^3 prototype detector is built for studying feasibility of INO-ICAL experiment as in fig.1. The detector is built using 1mx1m glass RPC detectors which are interleaved with 60mm thick iron plates. Considering an active detector thickness of about 20mm, this detector will consist of 14 RPC layers in total. Each RPC layer has 32 parallel signal pickup strips on each side laid orthogonally. These X-Y signal strips maps the points of interactions in a RPC detector.

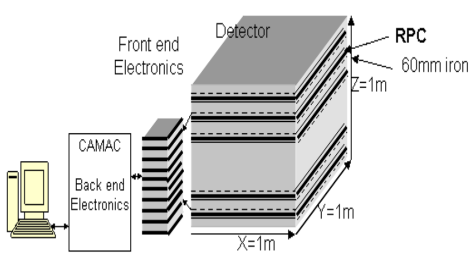

Fig 1. Detector and Electronics

In Front End Electronics, the RPC pickup signals are shaped, processed and pre-triggers are generated. A final trigger is generated from the pre-trigger signals in the TRIGGER module at back end. On a final trigger, CAMAC controller invokes the interrupt handler routine, where INO controller initiates data transfer from front end modules in a bit serial mode and data is buffered in the Read out module for further CAMAC readout. A set of eight pick-up signals are selected in each monitoring cycle using INO controller. INO controller invokes interrupt handler at predefined monitoring period where the rates of the pick-up signals are recorded and next set of signals are selected for monitoring.

2. Electronics and DAq System

The need was to record the event time, three dimensional interaction tracks and its direction in the detector. The event initiated by the trigger logic records the Boolean status information of all pickup channels contributing to the track information. The relative time (TDC) of interaction of the track at each layer gives the directional information. The flexibility, scalability and quick implementation using existing hardware and expertise are some of the main design criteria while building the electronics for the prototype detector. Figure 2 shows over all functional blocks of the electronics.

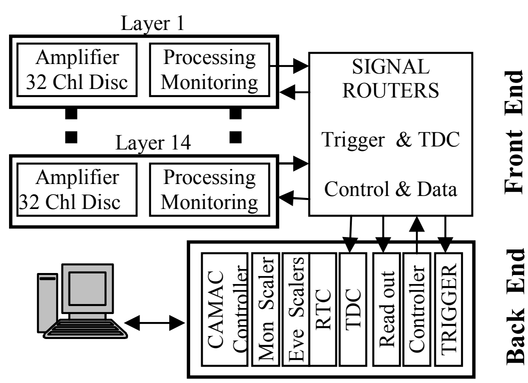

Fig 2. DAq. Electronics

The main modules are briefed below.

2.1 Signal processing electronics

The signal from a pickup strip is passed through a 50 gain amplifier and its output is fed to two 16 channel Discriminator modules in the front end. The signal crossing the set threshold in the discriminator generates differential ECL signal output. The common threshold is adjustable from 0 to 500mV. This module also houses primitive trigger_0 logic.

2.2 Trigger logic

The trigger logic picks up the events to be recorded. The basic principle of trigger logic is

M x N fold coincidence

where M is the layer coincidence of M consecutive signals out of 32 pickup signals and N is no. of consecutive layers satisfying M fold layer coincidence. The M x N folds implemented are 1x5, 2x4, 3x3, 4x2.

Trigger is implemented in three stages.

In first stage ie Trigger_0 logic, the shaped Discriminator pulses from every 8^{th} channel of 32 channels in a X pick-up plane of RPC are logically ORed to get eight T0 signals.

These eight T0 signals are logically ANDed to achieve the required M fold triggers (T1 signals – 1F,2F,3F,4F) in each layer. The Trigger_1 logic is implemented in the Front End Processing module (FEP) using CPLDs.

The M fold signals (T1) from X plane of all RPC layers are routed via Trigger and TDC Router module to the Final Trigger module in CAMAC crate. The MxN coincidence logic (T2 trigger) is implemented in this module using T1 signals. The T2 signals from X plane and Y plane are logically ORed to get a final trigger signaling valid Event to be recorded.

2.3 Data Acquisition system

A PC based Data acquisition system is built using CAMAC standard modules in the back end and is connected to front end by a fast serial link. The modular approach has been adopted to achieve flexibility, scalability and fast implementation. The two main functions of DAq. System vide Event data recording and Monitoring is controlled by a INO Controller module housed in the CAMAC crate at the back end. The front end processing modules (FEP) of X & Y planes of all the RPCs are daisy chained into two groups respectively for event data recording. The data is transferred bit serially via daisy chains to backend INO Readout module in the event process. These 28 FEP modules are daisy chained into 8 groups for monitoring purpose. One pickup signal from each of eight monitor daisy chains are linked to CAMAC based Monitoring .Scalers during the monitoring process. An intelligent CAEN make CAMAC controller communicates to DAq. PC via Ethernet link for easy data acquisition and control.

3. Software

The Data Acquisition program is developed in 'C' under Linux. The DAq. program can communicate to the CAEN CAMAC controller using TCP/IP socket command via ethernet link. A final trigger invokes LAM for event process where as periodic Timer in INO controller invokes LAM for monitoring process. A LAM interrupts the CAEN Controller which invokes LAM handler program by sending interrupt message socket. LAM handler reads 24 bit LAM information corresponding 24 CAMAC slots and checks for Event and Monitor LAM flags. Event flag initiates Event process where front end data is flushed to Read out module. The time of event (RTC), TDC data, Event scaler data and front end boolean status of pick signals are recorded for each event. The monitor LAM flag enables the Monitor process where RTC time, rates of monitoring pick-up signals are recorded. At the end of LAM handler, respective LAMs are enabled for next triggers and program control is returned to main program. After initialization , main program enters indefinite loop executing user selected back ground jobs like display sample Event data, Monitoring data and check for key hit services.

4. Performance

The DAq. system is functional for last few months with few layers of RPCs as a part of proposed detector and performance is found satisfactory.