Local Station: the data read-out basic unit for the ARGO-YBJ experiment

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ARGO-YBJ is a full coverage layer of Resistive Plate Counters (RPCs) covering an area of about 5.800 m^2 to be installed at the YangBaJing Laboratory (Tibet, China) at 4.300 m a.s.l. The DAQ system is based on a Central Station which receives the detector information from distributed readout electronics. Data from each RPC are acquired from a Receiver Card which reads out and digitizes the space and time information from 10 pick-up pads and gives out the pad multiplicity for trigger purposes. The Receiver Cards are hosted in Local Stations which Group 12 RPCs. On trigger occurrence, each Local Station sends the collected data to the Central Station. Both the detector and the electronics allow 1 ns accuracy in time measurements. In this work a detailed description of the Local Station and the Trigger System are presented.

1. Introduction

The ARGO-YBJ experiment is located at the YangBaJing High Altitude Cosmic Ray Laboratory 4300 m a.s.l.(Tibet, China). This experiment is devoted to a wide range of fundamental issues in cosmic ray and astroparticle physics[1].

The apparatus consists of a full coverage array of 74×78 m^2 dimension, realized with a single layer of RPCs (Resistive Plate Counters), 280×125 cm^2 each.

The detector is able to sample with high space-time granularity the front of atmospheric showers. The basic element providing the time of the shower is the logic pad. It is defined as the fast-OR of 8 strips used to pick up the signals from the RPCs[2]. These logic pads (56×62 cm^2) define the time granularity of the detector (there are 18480 pads in the carpet, 10 for each RPC); the space granularity is defined by the strips (147840 in the carpet).

From the data acquisition point of view, the basic detection unit is the *Cluster*, a set of 12 contiguous RPCs. All the information collected and managed by the Local Station are sent to the Central Station for trigger evaluation and data archiving

2. Local Station

The Local Station is the place where the shower information from the RPCs are collected. Here the particle position and their arriving time are recorded.

The front-end electronics is based on an 8-channel discriminator chip which is mounted on boards fixed at the edge of the readout panel [3]. The digital signals originating from front-end ele-

*deceased

cronics are sent to receiver cards housed inside the Local Station crate.

Each receiver card collects the signals coming from 10 front-end cards and produces an output (FAST-OR) for each hit pad. FAST-OR signals are sent to TDCs and trigger logic both for time measurements and trigger definition.

All the electronic Local Station modules are housed in a 9U 16 inch standard crate (see fig.1). The crate contains twelve RECEIVER cards (one for each CLUSTER RPC), one IN/OUT card for the data communication with the Central Station, one active BACKPLANE, two low voltage power supply and one fan unit.

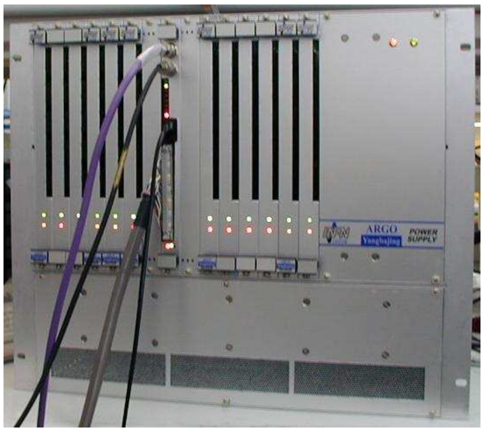

Figure 1. Local Station

2.1. Receiver Card

The Receiver card is a standard double Euro Card. It has 10 8-pin connectors for the input data and one 32-pin output connector; this card is logically divided into 2 sections: one contains the formation circuitery and acquisition logic, and the other is devoted to the communication with the backplane. The logic operations are made by 11 PLD (*Programmable Logic Device*) Xilinx XC9572, 10 for the data acquisition and one for the board operation and communication control. The input connectors (one for each pad) collect 8 strip digitalized signals via a flat cable. These signals are converted to TTL, with a minimum forming time of $3ns$ and sent to the respective acquisition PLD.

When receiving a signal, the acquisition PLD, if enabled, turn on a data flag signal, record the active strips and send out a fast-or signal 90-105 ns long to the backplane. The control PLD reads the data flag and gives out a data flag to the backplane. When the trigger occure, a common stop signal arrives from the backplane to all the acquisition PLD to froze the strip pattern configuration. If no common stop arrives in 2μs the strip information are erased. After the Common stop, a data strobe from the backplane arrives to the control PLD which send it to the acquisition PLDs to command them to put out the strip information to the backplane and clear their buffers.

2.2. Backplane

The active backplane collects all the Local Station electronic RECEIVER cards and it can be physically divided in three sections (see fig. 2). The first section contains the 15 connectors for the various Local Station cards (12 receivers, one In/Out card and two free slots for future purposes) and 5 shift registers for the initialization mask.

In the second section 4 TDCs are grouped to collect the fast-or signals from the receiver cards for the relative time measurement. The element is a 32 channel TDC with 1 ns LSB developed by the KLOE collaboration[4]. It is capable to detect rising and falling edges. Each channel has independent data paths down to readout time, which can be started promptly after receiving the common signal, at a maximum frequency of $33MHz$. Each TDC receives data from 3 receivers (10 channel each).

In the third section, 5 FPGAs define the local trigger information by calculating the hit pad multiplicity using the Fast_or signals coming from the receivers. The information is coded using 10 bits: a 6-bit Low Multiplicity (LM) weighted bus (when $\geq$ 1, $\geq$ 2, $\geq$ 3, $\geq$ 4, $\geq$ 5, $\geq$ 6 PADs are fired) and a 4-bit High Multiplicity (HM) weighted bus (when ≥ 7, ≥ 16, ≥ 32, ≥ 64 PADs are fired). The LM signals are 150 ns long while the HM signals are 400 ns long to allow the correct coincidence for inclined showers.

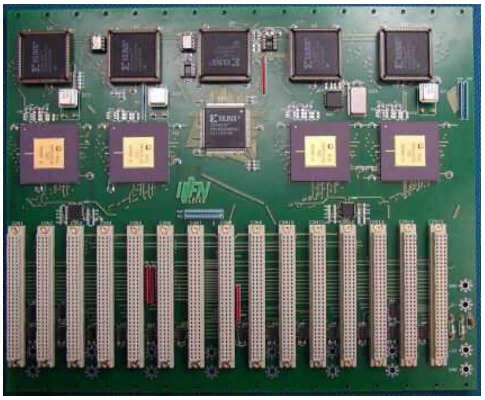

Figure 2. The Backplane

An additional FPGA manages all the operations and prepares the information to be sent to the Central Station. When a common_stop arrives it start reading, packing and sending the TDC data informations. When finished to read the TDCs it manages the strip pattern information readout and send them to the CS.

2.3. In/Out Card

The IN/OUT card is devoted to the communication between the Local Station and the Central Station. This card is inserted in the central slot of the backplane. Three different kinds of lines are used for several purposes. Two 75 Ω shielded coaxial lines receive the distributed Common Stop and test signals with high precision.

Two 4 wire telephonic cables are used to receive and retransmit in a daisy chain data for initialization, such as bad channel kill mask, reset mask, etc. Finally 32 twisted pair channels are used to transmit data and multiplicity to the Central Station, and to receive the reset signal and another test signal.

3. The Trigger Architecture[5]

The Low Multiplicity (LM) and High Multiplicity (HM) information from the Local Station are used in the Central Station to form the trigger. The two mutliplicity are used independently to get a wide range of possible combination for topological and multiplicity triggers. In particular three trigger logic have been designed.

The first is based on Low Multiplicity. As shown in fig. 3. the entire carpet is divided in two parts. Each part is made by 65 CLUSTERs processed by 6 LOWM boards which calculate the partial and total multiplicity by the LM information. When the programmed multiplicity is exceeded, a trigger signal is released.

Each LOWM divide a 12 CLUSTERS region in 3 SUPERCLUSTERS. The second trigger logic is based on them. As a prefixed multiplicity on a SUPERCLUSTER is exceeded a trigger signal is generated. This allows topological triggers.

The third logic is based on High Multplicity (see fig. 4). Each of the 4 HM multiplicity bit are handled in parallel. When the programmed threshold is exceeded, the trigger signal is released.

All trigger levels are handled by a TRBOX board which can mask a specific trigger source and OR them together.

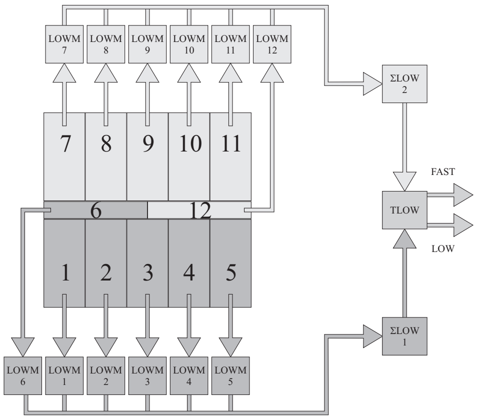

Figure 3. The Low Multiplicity Trigger logic.

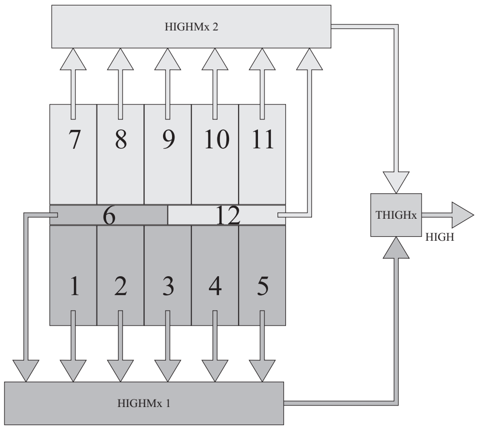

Figure 4. The High Multiplicity Trigger logic.

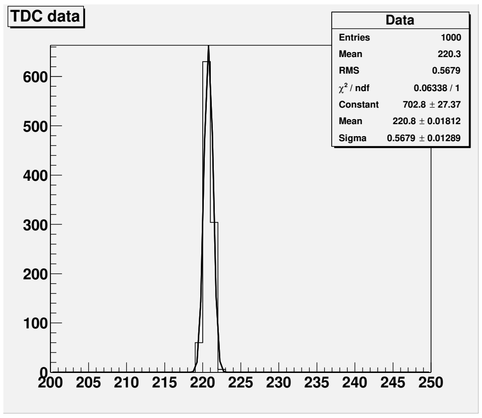

Figure 5. Time distribution of a test signal on one TDC channel.

4. Operation

When a shower hit the detector data are sent to the receiver cards in the LS where a fast_or signal is generated and sent to the backplane. The Fast_or signals coming from the receiver cards are splitted in two ways: one goes to the TDCs that store the data and start counting until the Common Stop from the central trigger arrives or 2μs elapse, the other one goes to the local trigger section where the actual mutiplicity is calculated and sent to the central trigger module.

The Central Station receives multiplicity information; when the trigger conditions are satisfied, a Common Stop signal is distributed on fast cables to each Local Station to store the data. Once the Common Stop is received, data are prepared by the LS and sent to the CS for the disk storage. Due to the TDC features the convertion time is zero and the total acquisition dead time, caused by the transmission time, depends only from the event size. Data are transferred at a rate of 160 $Mbit/s$ (16 bit word in 100 ns) on a 75 m long copper cable. The all system has been tested in laboratory. In fig. 5 the time ditribution of a test signal on one channel is presented. The resulting rms is less than 0.6 ns

5. Conclusions

The distributed read-out and trigger system for ARGO-YB has been described. It is made by a large number of Local Stations for the front-end readout, local pad multiplicity definition and data collection. Such information is sent to the Central Station for global trigger definition and data storage. An overall accuracy of 1 ns in time resolution has been achieved. This precision is fundamental to get a sufficient angular accuracy for physical goals.

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