Data Acquisition System for Quality Tests of the ATLAS Muon Endcap Trigger Chambers.

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ABSTRACT

The ATLAS Collaboration is building a general-purpose pp detector which is designed to exploit the full discovery potential of the high energy proton-proton interaction Large Hadron Collider (LHC) at Cern. The LHC offers a large range of physics opportunities, among which the origin of mass at the electroweak scale is a major focus of interest of ATLAS. The Thin Gap Chambers (TGCs) are detectors designed to detect the high transverse momentum muons in the endcap of the ATLAS detector. The short response time of the TGCs makes it an ideal trigger system for selecting interesting events in the highly packed environment of the LHC accelerator [1]. The subject of this paper is the design and operation of the data acquisition system, which serves to automatize the procedure of the performance of the TGC detector, before are to be installed in the ATLAS experiment.

1 PRINCIPLE OPERATION OF TGCs

The TGCs are constructed in doublets and triplets. A TGC doublet is a unit which has two chambers. A TGC triplet has two chambers and one plane of wire between them. A chamber is a single layer of active detector element. For TGCs, this is a wire plane and its strips [2].

1.1 TGC test bench

The TGC units are produced in the Weizmann Institute in Israel and also in KEK in Japan and in China. There are three test benches to check the performance of TGC modules, two in Israel, in Technion and Tel-Aviv, and one in Kobe University in Japan. The purpose of these tests is too-fold. For each detector a detailed map of detection efficiency for the wires and strips is determined as well as their respective time resolution.

At the test site the TGC units pass the following steps of processing

- Preliminary checks
- Efficiency test
- Validation (Acceptance/Rejection)

A visual inspection of the incoming TGC units is performed to check if no damage was done to them during the transport. The basic view of the cosmic ray telescope is shown in Figure 1.

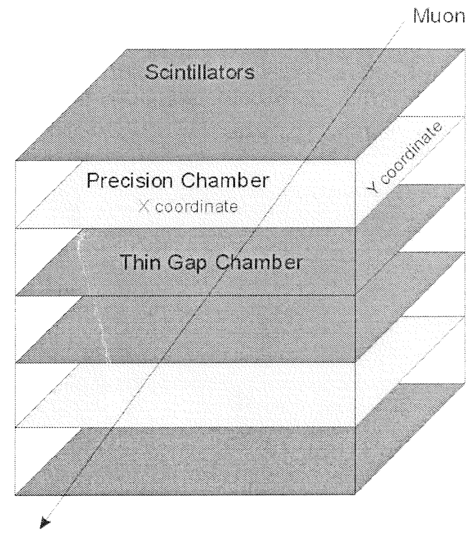

Figure 1: Schematic diagram of cosmic ray telescope.

The cosmic ray telescope is 2.2 m high, 1.6 m wide and 2.5 m long. There are 11 slots with a distance of 20 cm between them. The top and the bottom layers consists of scintillators planes. A signal in coincidence from the two planes signals the passage of a cosmic muon. The next layers from the bottom and from the top consist of the so called Precision Chambers. The latter are made of TGC detectors which differ from the tested TGC chambers by their readout granularity. Their role is to accurately measure the positions where the muon crossed the chambers. Accumulating events for a period of one week will permit a full mapping of the efficiency of each detector in the stack. The criteria for a good chamber is having 95% of its active area efficient at level of higher then 95% within a 25 nsec gate.

If the unit failed the test it is removed from the test bench and returned to the Weizmann Institute. After successfully passing this test, the detector are flushed with CO2, sealed and prepared for the transportation to CERN.

2 THE READOUT SYSTEM

The readout system is divided into two parts, namely:

- The readout system from the Precision Chambers
- The readout system from the TGCs

The data from the Precision Chambers are read using the serial readout system since the all channels of the Precision Chambers are read to obtain the good resolution of the position hit. Whereas the data from the TGCs are collected using the parallel readout mode. In this case the moun cross time is required. The time of taking and storing the one event depends on the read time from the Precision Chambers. This factor decides the acquisition time. The data are collected in the output FIFO of the VME cards in order to be read by the online code. To fulfil that task the online program synchronizes the operations between the VME cards. The offline code program calculates the position of hits and the time response of the TGC chambers uses the online binary output file. The online program produces during the test the output binary file and three ASCII files. These files serve as an input to a slow control code which monitors the behaviour of the system during the data acquisition process. The online program is built with four main blocks:

- Initialize the memory of the VME cards
- Setting the VME cards
- Setting the pedestals and the thresholds of the Precision Chambers
- Data acquisition process

The VME cards are set and initialized by the online code according to the requirement of the test bench system.

3 RESULTS

The efficiency of the TGC chambers is calculated by the offline code. The C++ analysis program calculates the trajectory of muon and estimates the point muon crossing through the TGC. The TGC surface is divided into small square bins. The efficiency of each square is equal to the number of muons extrapolated to go through it and detected by the TGC divided by all muons extrapolated to go through that bin. The plots of efficiency maps and the timing are done by the ROOT An Object-Oriented Data Analysis Framework. The scale are shown on the right side of the map plots. The white color represents a 100% efficiency and the black one is equal to efficiency under 50%. The criteria of a detector to pass the cosmic ray test is when the 95% of its surface has the efficiency over then 98%. The results of the TGC doublet are shown in the following figure. The efficiency map of this unit is shown on the Figure 2. The plot clearly shows the structure of the tested TGC chamber. The lines and separators which have the efficiency under the 50% can be seen on the surface on the TGC. They are the support and separators on the TGC. We obviously expect low efficiency in these regions. The first detector is efficient uniformly on the all its surface but the second detector has few unefficient areas. These unefficient regions are probably a result of gluing problem during the construction. However the edges of the TGCs are sharp and there are no hits outside the chambers.

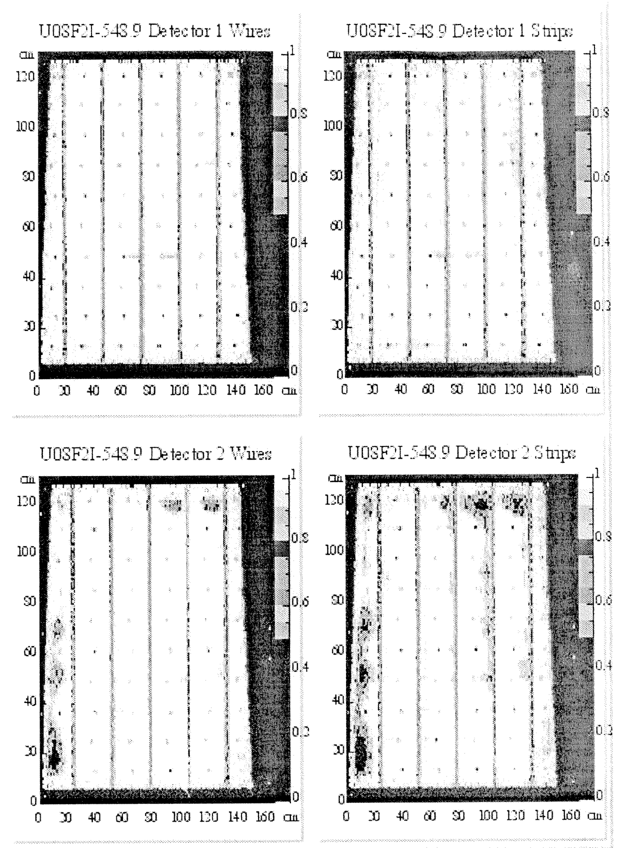

Figure 2: The efficiency map of unit U08F2I-548.9.

It seems that all surface is well covered by the Precision Chambers and the Scintillators and the offline code determines the trajectory and the hit points correctly. To obtain good resolution of the efficiency map a few milion events are required. Each square of the TGC surface should have at the order 50 hits for precision of about 5%. The online code collects this amount of data during about five days of run [3].

SUMMARY

This paper describes the Test Bench that was built in order to test the Muon Endcap Trigger Chambers of the ATLAS detector. The results are sufficient to provide detailed mapping of the chambers. This Test Bench is starting now to acquire data and it will continue testing about 1000 more chambers.

REFERENCES

[1] CERN/LHCC/95-15, "ATLAS Detector and physics performance Technical Design Report", , 25 May 1999

[2] ATLAS TGC Collaboration, " ATLAS Muon Spectrometer, Thin Gap Chambers Construction Manual" , 23 March 1998

[1] Jacek Wasilewski, "Data Acquisition System for Quality Tests of the ATLAS", 22 July 2002 Muon Endcap Trigger Chambers.