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Endcap Muon Chamber Calibration and Monitoring Procedures in CMS

Oana Vickey Boeriu (on behalf of the CMS Collaboration)

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Endcap Muon Chamber Calibration and Monitoring Procedures in CMS

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Abstract

The cathode strip chamber (CSC) system is one of the three types of muon detectors used in the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC). It consists of 468 chambers, with a total of ∼218k strips and ∼183k wires, placed onto two endcaps. Calibration tests which monitor the system stability, measure configuration constants that will be downloaded to electronics and calculate the calibration constants needed in the offline reconstruction - like crosstalk, gains, noise and connectivity - are performed regularly. The full chain of acquiring, analyzing and applying the calibration constants was successfully tested recently for the first time on the CSC system, using cosmic-ray data recorded during the Magnet Test and Cosmic Challenge (MTCC).

1 Introduction

The Endcap Muon (EMU) system [1], consists of 468 cathode strip chambers (CSCs) which are multiwire proportional chambers containing cathode planes segmented into strips and running across groups of wires. The CSCs are trapezoidal in shape, cover either 10° or 20° in ϕ and are located on four stations placed on each end of the detector. The muon coordinate along the wires (the ϕ-coordinate) is obtained by interpolating charges induced on strips (Fig.1). The number of cathode strip readout channels with 12-bit signal digitization is about 218000 and the number of anode readout channels is about 183000, both sets require calibration before data taking. Thirty-six chambers have been part of the 60° detector slice included in the 2006 MTCC, when millions of cosmic events were collected.This setup was an important step toward the full commissioning of the CMS detector and of the EMU system in particular.

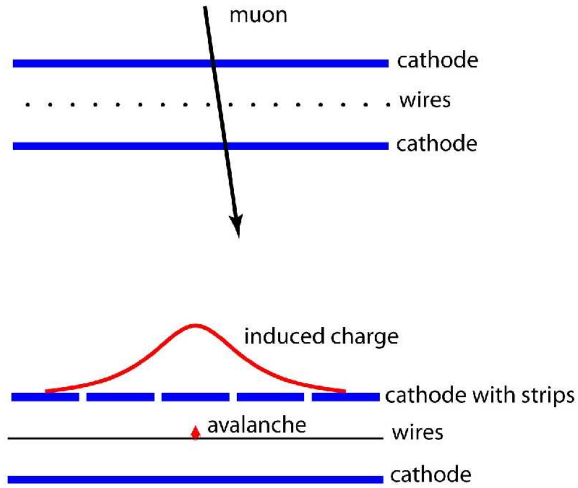

Fig. 1. Principle of CSC operation: by interpolating charges induced on cathode strips by avalanche positive ions near a wire, the precise location of an avalanche along a wire direction can be obtained.

2 Cathode Strip Chamber Readout Procedure

The calibration procedure involves the full readout chain used for physics runs. Signals from 16 cathode strips in each layer are channeled into one cathode front-end board (CFEB) through an amplifier and shaped into voltage pulses. Channel-by-channel calibration is done using a set of precisely matched capacitors that couple a test pulse to each channel's input. One output of the shaper is connected to the trigger path whose main component is a comparator ASIC, which locates the centroids of the strip charge clusters in each chamber layer to an accuracy of half the strip width and marks its time. The resulting information is sent via cable to the trigger mother board (TMB), which contains the anode/cathode coincidence logic used to determine trigger primitive parameters for the Level-1 muon trigger. The other output of the shaper is connected to the DAQ readout path. The voltage is sampled every 50 ns and held in a switch capacitor array (SCA) during the Level-1 latency. The digitized data is sent to the data acquisition mother board (DMB) and transmitted to the central DAQ system [2].
The anode readout uses information regarding the accuracy of timing instead of pulse height. Each input channel of the anode front-end board (AFEB) is a ganged group of wires from a layer. Similar to the CFEB readout, each AFEB is designed to read out a section of a chamber layer which is 16 wire groups wide. The input signals go into 16-channel amplifiers, which are similar to the ones on the CFEB, but optimized for the summed anode input capacitance. The signals are shaped with a peaking time of 30 ns and sent to discriminators and from there the pulses are sent to the anode local charged track (ALCT) board where they are latched and these bits are used to form the ALCT and to determine the bunch crossing time of the track segment [3]. DMBs receive triggers and raw-hit data from the TMBs for inclusion in the data output

stream, as well as active front-end board hits which indicate that AFEBs and CFEBs have triggered. The detector dependent unit (DDU) is the interface point between the front-end board electronics and the data acquisition (DAQ) system. The chamber readout electronics boards are held in peripheral crates, each CSC chamber having its own TMB-DMB pair for readout.

3 Calibration and Monitoring Tests

Calibration tests are performed on the chambers, as well as the anode and cathode front-end electronics boards. The tests provide configuration, monitoring and offline reconstruction constants. The configuration constants include AFEB discriminator thresholds and delays, CFEB trigger primitive thresholds and mode bits, as well as numerous timing constants for the peripheral crate electronics. For monitoring we are interested in chamber noise, counting rates and channel connectivity. The offline reconstruction constants include strip-to-strip crosstalk, noise and gains.

The CFEB offline calibration constant tests are based on sending test pulses of specific amplitudes to all strips in all layers and chambers and recording their height in ADC counts or fC.

The AFEB threshold and noise tests are based on sending test pulses to all wire groups in all layers and chambers simultaneously. For time delay tests asynchronous pulses are sent to the ALCTs.

Connectivity tests are part of the monitoring and commissioning tests and are required for both wires and strips. For the wires a pulse having a set amplitude is sent to each layer separately, looking for activity on the previous and next layer to the one pulsed. For strips an ALCT pulse of maximum allowed amplitude is sent to all wires and layers and the charge obtained is read back from each strip channel. The connectivity test is important in detecting dead channels; the noise and crosstalk tests can determine which channels are noisy; comparator logic tests determine if charges are correctly registered for each strip; time delay tests make sure that the system is well timed in, using the correct windows for signal readout between all readout components.

Data is sent to dedicated local DAQ machines and analyzed later offline for extraction of the constants. The offline analysis procedures make sure that the constants are sent to the Online Master Data Storage (OMDS), where all constants are stored. The constants are saved by run number which acts as the interval of validity (IOV) period and is the time range for which a certain calibration object is valid.

During the 2006 MTCC period, the CFEB calibration constants - crosstalk, gains and noise matrix elements - were read back from the offline database for the first time and applied in the local muon track reconstruction software for hits and track segments in each chamber. It was shown [4] that residuals become smaller when these constants are applied correctly in the reconstruction of hits (Fig.2). It is possible to some degree to use the calibration constants for removing some of the worst delta rays, based on the χ^2 values used in the Gatti fit [5] applied in reconstruction [4].

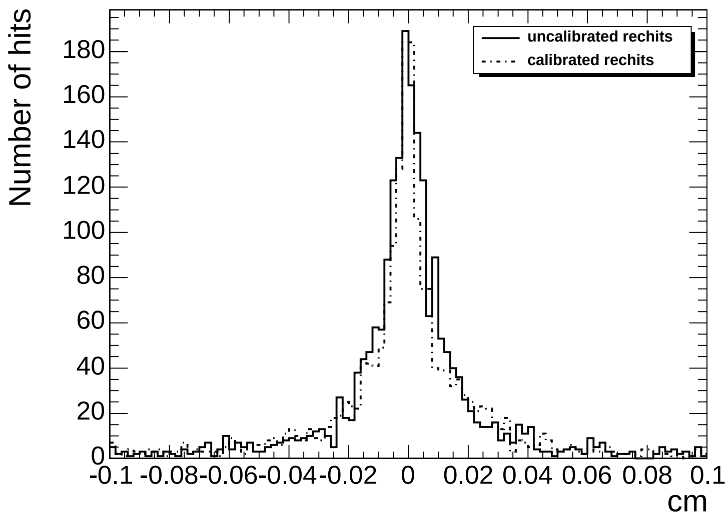

Fig. 2. Comparison of residuals between uncalibrated and calibrated hits.

4 Figure captions

Fig. 1: Principle of CSC operation: by interpolating charges induced on cathode strips by avalanche positive ions near a wire, the precise location of an avalanche along a wire direction can be obtained.

Fig. 2: Comparison of residuals between uncalibrated and calibrated hits.

References

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