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CMS CR -2009/163

The Compact Muon Solenoid Experiment

Conference Report

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24 June 2009

Calibration of the Barrel Muon Drift Tubes of CMS

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Abstract

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Presented at *FDFP09: Frontier Detectors for Frontier Physics,25-30 May 2009,La Biodola - Isola d*

Calibration of the Barrel Muon Drift Tubes of CMS

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Abstract

In this report, the description of the CMS Drift Tube (DT) chambers and their calibration procedure is presented and the main results obtained with data collected during the high statistics cosmic ray runs, taken by the experiment at the end of 2008, are reported. The accurate measurement of the main calibration conditions provide the necessary space-time relationship and leads to the expected nominal DT local reconstruction resolution.

Key words:
Compact Muon Solenoid, Drift Tube, Calibration

1. The DT calibration procedure

The CMS [1] Drift Tubes are designed to provide a fast trigger and precise tracking measurements in the muon spectrometer [2]. The Drift Tube structure is shown in Fig.1 and contains two Super Layers formed by four Layers of adjacent drift tubes each, which measure the r-phi coordinate. The first three stations also contain one Super Layer of orthogonal drift tubes measuring the r-theta coordinate.

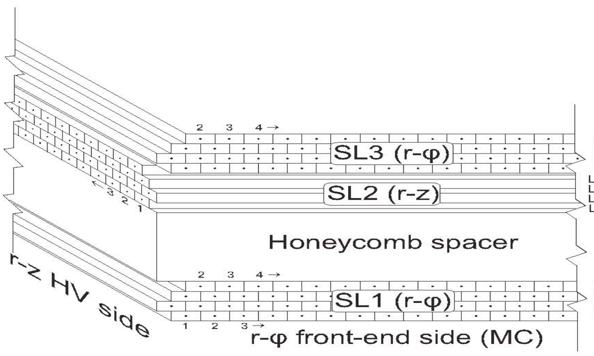

Figure 1: Schematic view of a DT chamber

Electrons produced by an incoming particle reach the anode wire after a certain drift time which is measured by the TDC. The main goal of the DT calibration is to determine the time pedestal of the signal which is needed to extract the drift time from the TDC measurement and to measure the drift velocity within the cell. The calibration process starts with the inter-channel synchronisation, which has the main aim to synchronise all the signals within each chamber taking into account the cable lengths of the read-out electronics. Then the pedestals are estimated directly from the distribution of the measured times, called time box. The complete description of the method is given in [3] and it is based on the fit to the rising edge of the time box using the integral of a Gaussian, in order to identify the beginning of the rising edge of the drift time distribution (Fig.2).

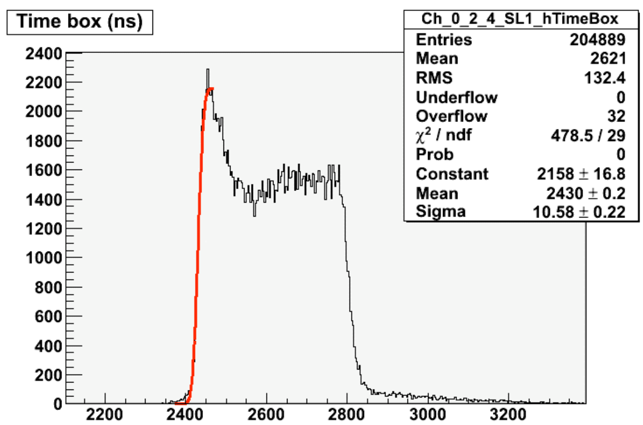

Figure 2: Distribution of the signal arrival time recorded by the TDC from all the cells inside a single Super Layer, after the inter-channel synchronisation. The continuous line indicates the fit to the time box rising edge with the integral of a Gaussian.

The effective drift velocity is computed with a granularity which takes into account local variations of the track angles and of the residual magnetic field, using the mean timer algorithm [3]. This method estimates the maximum drift time considering nearby cells of adjacent layers and with a linear expression it computes the average drift velocity, considering different patterns of segments as shown in Fig.3. The mean timer relation depends on the track angle and on the pattern of cells hit by the track, and the maximum drift time is obtained with a weighting procedure of all geometrical possibilities.

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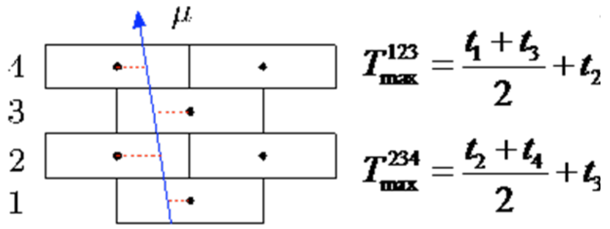

Figure 3: Schematic view of a Super Layer section showing the pattern of semi-cells crossed by the track.

2. Results on commissioning data from Cosmic Rays

The preliminary calibration step is the subtraction of noisy channels (cells with rate of noise hits > 500 Hz) to have a clean structure of the drift time distribution. A good stability of the number of noisy cells (below the 0.01%) within the DT system has been observed and the average noise rate is 4 Hz with the discrimination threshold of 30 mV. Further studies on noise have been performed in order to understand its geometrical distribution. The noisy cells have been observed usually in the inner most layer of the Drift Tubes, which are the chambers nearest to the magnet coiling system, and they are positioned at the extremities of the Layers, where there are the cables used for the voltage and data transmission.
The time corrections computed during the inter-channel synchronisation, which is performed using special test pulse calibration runs, depend only from the hardware conditions and are lower than 10 ns. Fig.4 show an example of distribution of these relative time offset for all the Layers of the 4 chambers of one sector as a function of the channel number.

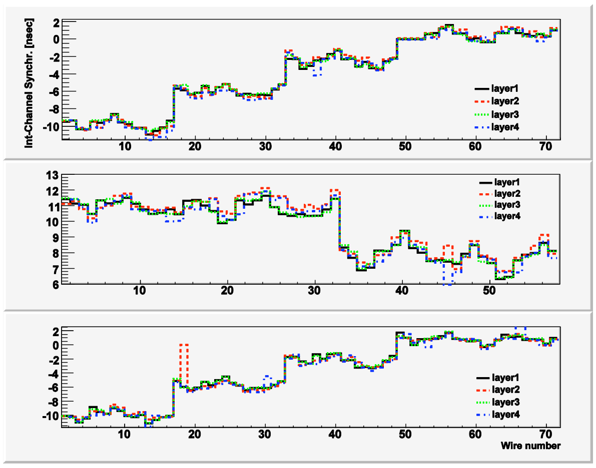

Figure 4: Distribution of inter-channel synchronization constants calculated from a test pulse run.

The results of the time pedestal and drift velocity calibration for a typical run of cosmics ray events are shown in Fig.5,6. The time pedestals are stable for all the wheels showing a periodic structure which corresponds approximately to the time of flight of the cosmic muon from the upper sector to the lower sectors. The drift velocity is constant around the value 54.3 μm/ns, although some fluctuations are present due to the residual magnetic field (higher in the inner DTs) and to the contribution of problematic chambers where the average impact angles of cosmic muon is particularly big. Once the time pedestal and the drift velocity calibrations have been computed they are used in the local reconstruction and the calibration procedure proceeds with the validation step studying the effect of the calibration on the reconstruction algorithm. The analysed quantities are the residuals computed as the difference between the distance of the hit and the reconstructed segment. The standard deviation of the fit to the residuals is a first indication of the resolution of the DT system. Taking into account the random arrival time of cosmic muons which affects the segment reconstruction, the resolution obtained is 200 μm, equal to the nominal expected one.

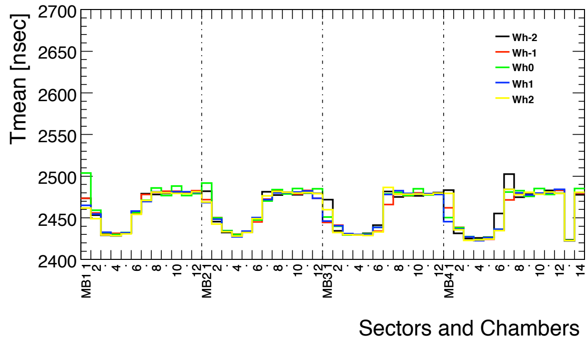

Figure 5: Distribution of the mean of the fit to the drift time distribution rising edge as a function of the chamber and sector number for all the wheels of the muon DT system.

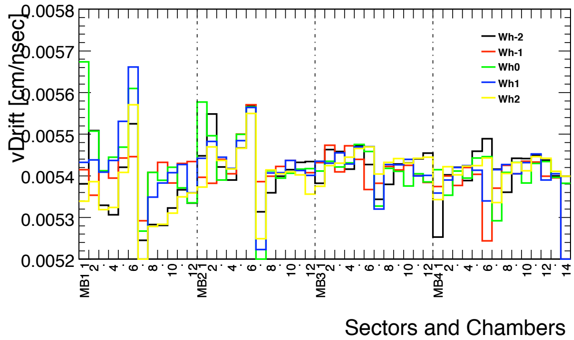

Figure 6: Distribution of the drift velocity distribution as a function of the chamber and sector number for all the wheels of the muon DT system.

References

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[2] CMS Collaboration, The Muon Project Technical Design Report, CERN-LHCC 97,32.
[3] G. Abbiendi et al. Offline Calibration Procedure of the Drift Tube Detectors, JINST 4 (2009) P05002.