Time calibration stability studies for the DT Slice Test of the CMS detector

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For the future operation at the HL-LHC (after LS3), the electronics of the DT system need to be upgraded in order to cope with both high radiation levels and high rates. This upgrade is being developed in the context of the so-called CMS Phase-2 upgrade.

The new electronics will be able to stand an increase of the LHC beam luminosity between $5 \times 10^{34}$ cm$^{-2}$s$^{-1}$ and $7.5 \times 10^{34}$ cm$^{-2}$s$^{-1}$.

During LS2, prototypes of the new electronics have been installed in the CMS detector and studies related to the time calibration and stability have been performed.

Four different DT chambers of the Sector 12 of Wheel +2 [1] have been equipped with Phase-2 on-board DT electronics (OBDT) operating in parallel with the old Phase-1 (Legacy) electronics. This setup - called DT Slice Test (ST) [2] - is a demonstrator of the upgraded Phase-2 system. The main task of the OBDTs is the digitization of the signal time from the OBDTs to the backend electronics (AB7 boards), where they are used for Trigger Primitive generation and readout.

A DT chamber is made of three (or two) Superlayers (SL), each consisting of four layers of rectangular drift cells.

1. The wires in the inner and outer SLs are parallel to the beam line and provide track measurements in the magnetic bending plane ($r, \phi$).
2. In the central SL, the wires are orthogonal to the beam line and measure the position along the beam ($z$).

The Drift Tube electronics receive the signals from the anode wires through the Front End Boards (FEB) which forward them to both the DT readout and the DT trigger.

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PHASE-2 ELECTRONIC PERFORMANCE RESULTS

The Drift Tube electronics receive the signals from the anode wires through the Front End Boards (FEB) which forward them to both the DT readout and the DT trigger. DT readout electronics perform time measurement of the chamber signals that are used for track reconstruction of charged particle and precise momentum measurement.

These results compare the bit detection and local offline reconstruction when using (1) Phase-1 DT readout and (2) Phase-2 prototypes operating in the DT ST.

TIME CALIBRATION PERFORMANCE AND STABILITY

The trigger primitive generation and track segment reconstruction require a calibration process to remove offsets (cable lengths, etc.). The first step of calibration is the inter-channel equalization, consisting in the determination of individual pedestals ($t_{0i}$) for every channel (anode wires).

Why do we need it?

The trigger primitive generation and track segment reconstruction require a calibration process to remove offsets (cable lengths, etc.).

What do we use to calibrate?

Test Pulse (TP) is an operation mode used to test and calibrate the drift tubes electronic chain by injecting simultaneous signals in all the channels [3]. These signals during this phase of the ST are generated by the Phase-1 (Legacy system) and emulate vertical tracks.

How do we check it?

The $t_{0i}$ calibration stability of the Phase-2 system is checked by comparing the average TDC time values obtained for the same wire with different TP runs. One run is chosen as reference.

$t_{0i}$ calibration stability for the MB4 SL 1. The studied runs are labelled by their run number. The $z$-axis contains the $t_{0i}$ variation in nanoseconds. Wires affected by sporadic problems related to the TP injection are shown in black.

Conclusions: The stability of the time measurement of the Phase-2 electronics have been verified, and we have ensured the reproducibility of the time measurements against reconconfigurations, resets and power cycles (switching off-on the system).