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The CMS Muon Drift Tubes HL-LHC Upgrade Demonstrator at Run 3 Start

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The electronic system of the CMS Drift Tubes (DT) chambers will be replaced to operate during High Luminosity (HL-LHC). The upgraded architecture ships all signals to the backend, where complex logic will be performed with a precision matching the maximum chamber resolution. A demonstrator has been installed during Long Shutdown 2 (LS2) in one of the sixty sectors of the detector. Over LS2 we have integrated this system in CMS operations environment and tested its stability over extended cosmics data-taking campaigns, also with the magnetic field on. The time synchronization achieved and early performance in collisions will be presented.

Summary (500 words)

The CMS DT chambers instrument the return yoke of CMS, being responsible for identifying, measuring, and triggering muons in the barrel acceptance. The electronic system will be replaced during Long Shutdown 3 (LS3) to be able to cope with the stringent data-taking conditions during HL-LHC [1]. The new architecture ships the full time digitized data through high-speed optical links to the backend, where trigger primitives and event matching logic will be performed. This is in contrast with the legacy system which was forced to perform the above-mentioned functionalities locally in the front-end with lower precision due to bandwidth limitations of the available copper links. The time signals coming from the chambers will be digitized by 840 On detector Board for the Drift Tube chambers (OBDT), which are built around a Microsemi PolarFire FPGA and will use CERN's LpGBT and VTRX+ optics in its production version, now under validation. During LS2 we have instrumented one of the sixty sectors of the CMS DT subdetector with 13 prototypes of the first version of the On detector Board for the Drift Tube chambers (OBDTv1 [2]) , which differs from the final version in using GBTx links and commercial optics, but still hosting a PolarFire which digitizes 240 channels. Clock distribution, slow control, readout and trigger primitive generation is performed in the demonstrator backend which is based on legacy hardware (DT uTCA boards, TM7) with firmware performing the required Phase-2 functionality. In this demonstrator, so-called DT Phase-2 Slice Test, the time pulses coming from the chambers are split allowing standard operation of the legacy system and full event-by-event validation of the prototype electronics and the firmware logic. This is greatly helped by fully integrating the Phase-2 chain data into the CMS DAQ environment as a standard CMS DAQ unit (FED). Detector Control System and DQM have also been integrated into central CMS systems. During extended cosmic data-taking campaigns in LS2, with and without magnetic field, the long-term stability of the system and the synchronization methods of the ˜3000 channels have been thoroughly tested. The Analytical Method (AM) algorithm [3] has been deployed in the backend FPGAs reaching a time resolution matching within 2 ns that of the offline reconstruction, as promised by the new architecture. We plan to run this Phase-2 parallel system in collisions during Run 3 of LHC, which will allow us to further refine trigger algorithms under realistic conditions (radiation, magnetic field, background rate) and test main components also used in the final board, as the PolarFire. We plan to deploy backend prototypes based on the ATCA standard. Final OBDT boards, now ongoing validation, will be installed in an appropriate technical stop during Run 3.

[1] CMS Collaboration, The Phase-2 Upgrade of the CMS Muon Detectors, CERN-LHCC-2017-012, CMS-TDR-016,2017. [2] A. Triossi et al, "Electronics Developments for Phase-2 Upgrade of CMS Drift Tubes", TWEPP2018 [3] J.M. Cela on behalf of CMS, "A muon tracking algorithm for the Level 1 trigger in the CMS barrel muon chambers during HL-LHC", TIPP2021

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