Contribution ID: **16** Type: **Poster**

The status of the CMS Muon Drift Tubes HL-LHC Upgrade and the Safety System for the new front-end

Thursday 9 October 2025 18:40 (20 minutes)

To sustain the unprecedented radiation and rates of HL-LHC, the readout and trigger electronics for the Drift Tubes (DT) in CMS have been upgraded. The time digitization is implemented on the new OBDT board, and the data are streamed to the new back-end electronics where event building and trigger primitive generation are performed. The development of a new hardware, called MONitor for SAfety (Monsa) system, monitors and enables each single OBDT. In this report, the status of the development and testing of the DT Upgrade electronics, with a focus on the newly introduced safety electronics, is provided.

Summary (500 words)

The CMS Drift Tube detector is composed of 4 muon barrel Drift Tube (DT) chambers which instrument the 5 wheels of the CMS return yoke. They are responsible for identifying, measuring, and triggering muons in the barrel acceptance region.

To withstand the challenging conditions of increased instantaneous luminosity and higher pileup expected during the HL-LHC operation, the DT system plans for an upgrade that affects the front-end electronics, the back-end electronics and the safety system.

The front-end electronics are placed on the side of the muon chamber, where a metal structure called Minicrate contains all the cards for the readout of the drift tubes. The On-Board electronics for Drift Tubes (OBDT) is the main board inside the Minicrates, whose primary function is to perform temporal digitization of signals originating from the DT chambers and forward this digital information to the next level of the electronics chain. It also fulfils other essential functionalities such as slow control and timing distribution.

The final version of the OBDT design includes the safety circuitry that protects the system against over-temperatures, over-currents and over-voltages. This circuit can autonomously detect the alarms and dialogue with the so called MONitor for SAfety (Monsa) system. The main functionality of the Monsa system is therefore on one hand to monitor the status and receive the eventual alarm signals of OBDT, on the other hand to activate or cut each OBDT, if requested by the operator.

The Monsa main board implements a full hardware solution and it is located in the experimental cavern on one side of the CMS wheels. It multiplexes/demultiplexes the signals coming from OBDT and sends them to the Monsa back-end electronics which is being developed on a PLC platform. The PLC is managed by the use of the WinCC control system and it will be integrated into the DT Detector Control System (DCS).

Prototypes of OBDT and Monsa boards have been extensively tested to assess their radiation tolerance to significantly higher radiation doses than the one expected during 10 years of HL-LHC operation.

The back-end system of the new DT electronics is composed primarily of the custom developed Barrel Muon Trigger Layer 1 (BMTL1) electronics, that are in charge of the readout and trigger primitives generation, and by the configuration service electronics implemented on an open platform Serenity board which hosts a vu13p Virtex UltraScale+ FPGA in charge of timing and control.

The front-end boards, the safety system and the back-end new DT electronics have been extensively validated in the laboratory and demonstrators have been installed in two CMS sectors. Rigorous testing procedures have been conducted on the DT upgrade electronics which is currently operated in parallel to the legacy DT electronics, showing the goodness of the design for the expected functionality during HL-LHC.

This report outlines an overview of the innovative DT upgrade electronics, and focalizes on the safety aspects of the system which enhances the electronic functionality in the challenging HL-LHC environment.

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Session Classification: Poster 2

Track Classification: Module, PCB and Component Design