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ATLAS MDT AMT Simulations for LHC Run3 and HL-LHC

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The Large Hadron Collider (LHC) started Run 3 operation in 2022, and the peak instantaneous luminosity will reach $2.3 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ and the average number of collisions per bunch crossing is expected to be around 60 in 2023. The ATLAS Monitored Drift Tube (MDT) chambers are the main component of the precision tracking system in the ATLAS muon spectrometer. It is important to understand any potential issues with the MDT Front-End (FE) readout electronics for an expected Level 1 (L1) trigger rate of 98 kHz and a complex dead time of over 4% for RUN3 operations. We use raw data collected in 2022 to emulate the expected hit rates in MDT chambers and perform a realistic simulation on the ATLAS Muon TDC (AMT) chip with the current configuration. We study the AMT chip performances by analyzing the trigger/L1/readout buffer occupancies and hit-loss fractions under different luminosities with L1 rate of 100 kHz by using the Modelsim software. The hit-loss fraction of the hottest MDT chamber (BIL3C05) is lower than 0.1% due to FE readout, even at a luminosity of $2.98 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ with a complex dead time of 5% and a L1 rate of 100 kHz, indicating that AMT can operate under Run 3 conditions without problems. The MDT trigger and readout electronics will be replaced for triggerless readout during High-Luminosity LHC (HL-LHC) operation. We also simulate the AMT behavior in the trigger-less mode up to $7 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ and propose possible AMT configurations in case some FE electronics could not be replaced during the pre-HL-LHC shutdown.

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