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Upgrade of the CMS Drift Tube electronics for the High Luminosity LHC

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The High Luminosity LHC upgrade requires a full revamp of CMS Drift Tubes (DT) electronics due to trigger rates exceeding current capabilities. Leveraging optical and bandwidth advancements, this upgrade redefines DT electronics architecture. On-detector functions are streamlined for data processing relocation to a more accessible back-end. The On-detector Board for Drift Tubes (OBDT) is pivotal, integrating essential functions like slow control and time distribution. Design enhancements prioritize integration into CMS, with radiation-resistant components. OBDT deployment in a CMS sector alongside ATCA-compliant back-end prototypes marks a significant milestone. Rigorous testing ensures suitability for HL-LHC, promising enhanced performance in challenging conditions.

Summary (500 words)

The High Luminosity LHC (HL-LHC) upgrade demands significant improvements to the electronics of the CMS Drift Tubes (DT) subdetector. This is because the current electronics can't keep up with the trigger rate requirements [1]. So, both the on-detector electronics and their backend systems need a complete overhaul.

The Phase 2 upgrade gives us a chance to rethink how we do things, using faster optical links and better technology. We'll simplify the on-detector electronics to just handle digitizing data, moving the rest of the processing to backend systems in easier-to-access places. This makes everything more reliable and sets us up for future improvements.

For Phase 2, we're consolidating the on-detector electronics into a single board called the On-detector Board for Drift Tubes (OBDT). We've already tested a preliminary version and are now working on the final version [2].

We've made some important changes to make sure the OBDT integrates well with the CMS system. This includes giving it functions like slow control and time distribution through special chips and optical devices. We've also redesigned how the clock works on the board to make sure it can handle digitizing hits effectively.

To deal with maintenance issues, we've added a safety system to the design, ensuring the board stays safe even during maintenance work. We've also been careful to choose materials that can handle radiation well, like the PolarFire FPGA from Microsemi, which has already passed tests for this [3,4].

We've tested the OBDT extensively, including exposing it to much higher levels of radiation than it will experience during its lifetime at the HL-LHC. These tests, along with other quality checks, show that the board works well under real conditions.

Finally, we've set up a testbed to check the OBDT's performance after manufacturing and installation, making sure everything works as it should before it's put into action. This report outlines an innovative approach to DT electronics, promising enhanced performance in a challenging HL-LHC environment.

[1] The Phase-2 Upgrade of the CMS Muon Detectors. Technical report, CERN, Geneva, Sep 2017.
[2] A. Triossi et al. Electronics Developments for Phase-2 Upgrade of CMS Drift Tubes. PoS, TWEPP2018:035, 2019.
[3] Microsemi. PolarFire Neutron SEE Test Report. Technical report, Microsemi, LANL, 2018.

[4] A. Scialdone, R. Ferraro. Microsemi PolarFire MPF300TS FPGA PSI Radiation Test Report. Technical report, CERN, 2020.

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