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Fast Online Trigger System for COMET Phase-I

The COMET experiment aims to search for the coherent neutrinoless conversion of a muon to an electron in an aluminum atomic nucleus, one of the processes of charged Lepton Flavor Violation, which has never been observed. The experiment is being conducted in two phases. The first phase, Phase-I, targets a single event sensitivity of 3×10^{-15}, an improvement by a factor of 100 over the current upper limit on the branching ratio. To achieve this sensitivity, a high-intensity proton beam is used to produce a large number of stopped muons. The Cylindrical Detector System (CyDet), which is the main detector system in COMET Phase-I, consists of the Cylindrical Drift Chamber (CDC) for momentum measurement and the Cylindrical Trigger Hodoscope (CTH) for primary trigger generation and timing measurement. The trigger system is required to operate with a latency below 7 μs due to hardware limitations and a maximum trigger rate of 20 kHz limited by the data acquisition system. Under the high-intensity beam, a large number of background hits occur, leading to a high rate of accidental triggers in the CTH. To address this, the CDC trigger, which uses CDC hit information, has been developed. The trigger logic is implemented as a multi stage system with FPGA-based electronics boards. The CDC trigger is generated by using 86 CDC readout boards, 10 trigger front-end boards, and one merger board. The production of all boards for the CDC trigger has been completed, and the construction and performance testing are ongoing.
The trigger latency was measured to be 3.2 μs in a test setup, satisfying the requirement. The CDC trigger system has now been fully assembled by connecting all readout boards to the CDC detector and all trigger boards. We confirmed that all board communications were successful without any errors. The measured upper limit of the communication error rate was 4.6×10^{-5} errors per second, satisfying the requirement of maintaining a data acquisition livetime above 99% with a 95% confidence level. The system is currently under evaluation in its full configuration to finalize its performance verification.

Secondary track

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