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Level-1 Tracking at CMS for the HL-LHC

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The success of the CMS physics program at the HL-LHC requires maintaining sufficiently low trigger thresholds to select processes at the electroweak scale. With an average expected 200 pileup interactions, critical to achieve this goal while maintaining manageable trigger rates is in the inclusion of tracking in the L1 trigger. A 40 MHz silicon-tracker based track trigger on the scale of the CMS detector has never before been built; it is a novel handle, which in addition to maintaining trigger rates can enable entirely new physics studies.

The main challenges of reconstructing tracks in the L1 trigger are the large data throughput at 40 MHz and the need for a trigger decision within 12.5 μs out of which 4 μs is for track finding. The CMS outer tracker for HL-LHC uses modules with closely-spaced silicon sensors to read out only hits compatible with charged particles with pT above 2 GeV (”stubs”). These are used in the backend L1 track finding system, based on commercially available FPGA technology. The ever-increasing capability of modern FPGAs combined with their programming flexibility is ideal for a fast track finding algorithm. The L1 tracking algorithm forms track seeds (”tracklets”) from pairs of stubs in adjacent layers of the outer tracker. These seeds provide roads where consistent stubs are included to form track candidates. Track candidates sharing multiple stubs are combined prior to being fitted. A Kalman Filter track fitting algorithm is employed to identify the final track candidates and determine the track parameters. The system is divided into nine sectors in the r-phi plane, where the processing for each sector is performed by a dedicated track finding board.

This presentation will discuss the latest status of the CMS L1 track finding and its implementation, present simulation studies of the estimated performance, and discuss the developments of hardware demonstrators.

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