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Design and Performance of the Upgrade of the CMS L1 Trigger

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The upgraded CMS Level-1 trigger is designed to improve the performance at high luminosity and large number of simultaneous inelastic collisions per crossing (pile-up). During the technical stop at the beginning of 2016, all the electronic boards of the CMS Level-1 trigger have been replaced and the upgraded electronics tested, and commissioned with data. The upgrade of both the Stage-1 and Stage-2 happened during the shutdown of the LS1. Smarter, more sophisticated, and innovative algorithms are now the core of the first decision layer of CMS. The upgrade reduces the trigger rate and improves the trigger efficiency for a wide variety of physics signals. In this presentation the upgraded CMS Level-1 trigger design and its performance are described.

Summary

During its second run of operation, the LHC delivered proton-proton collisions at a centre-of-mass energy of 13 TeV with a peak instantaneous luminosity of $1.5 \cdot 10^{34} cm^{-2} s^{-1}$, almost double the peak luminosity reached during Run1 and far larger than the design value. To maintain acceptance for proton and heavy ion collision events of interest without exceeding the 100 kHz limit, the CMS Level-1 (L1) trigger has been being upgraded. The upgraded system makes use of new Xilinx Virtex-7 based AMC cards form the microTCA technology.

The L1 calorimeter trigger, which finds electrons, photons, tau leptons, jet candidates and computes energy sums has been upgraded implementing isolation requirement, multivariate regression, and pile-up mitigation techniques in order to reach acceptable performance.

The CMS muon detector was designed for preserving the complementarity and redundancy of three separate muon detection systems, Cathode Strip Chambers (CSC), Drift Tubes (DT) and Resistive Plate Chambers (RPC), until they were combined at the input to the Global Trigger. The upgrade of the muon trigger aimed at exploiting the redundancy of the three muon detection systems earlier in the trigger processing chain in order to obtain a high-performance trigger with higher efficiency and better rate reduction, implementing pattern recognition and MVA (Boosted Decision Tree) regression techniques directly in the trigger boards.

In addition, the new global trigger is capable of evaluating complex selection algorithms such as those involving the invariant mass of trigger objects.

The talk will cover the technological aspects of the Run II calorimeter trigger system. Results of its performance during the 2016 collisions of the LHC will be presented.

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