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Pileup Mitigation in Hadron Forward Calorimeter at the Level-1 Trigger of the CMS experiment for the HL-LHC

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The high luminosity operation of the LHC will deliver collisions with a luminosity about 10 times the original design value. This poses a big challenge for trigger and data acquisition due to nearly 200 overlapping collisions, called pile up, within the same bunch crossing. Disentanglement of the pileup particles from those of interesting physics processes is achieved by implementing the Pile-Up Per Particle or PUPPI algorithm. We present the strategy for implementation of PUPPI at Level-1 trigger, focusing on the Hadron Forward Calorimeter detector of the CMS experiment. The features of the custom firmware developed for this purpose is discussed.

Summary (500 words)

The CMS experiment at the LHC will revamp its Level-1 (L1) trigger architecture as part of the Phase2 upgrade[1] for the high luminosity operation of the LHC (HL-LHC). The custom hardware will employ the latest state-of-the-art technologies including high-end FPGAs to implement efficient trigger decisions for expanding the physics scope. The firmware, presented here briefly, will be used for considering information from the hadron forward (HF) calorimeter region after the pile up mitigation. The description of the implementation for the HF firmware is detailed as follows.

The calorimeter trigger system in the Phase2 L1 trigger consists of Hadron Calorimeter (HCAL), Electromagnetic Calorimeter (ECAL), High Granularity Calorimeter (HGC) and the Hadron Forward (HF) calorimeter. HF covers the pseudorapidity ($|\eta|$) range between 3.0 and 5.2 .and is critical in fr physics related to vector boson scattering (VBS), vector boson fusion (VBF) production of the Higgs boson etc. which have a pair of energetic forward-backward jets. At the HL-LHC operations due to the very large number of pile up (PU) events it becomes important to remove the contribution from PU interactions from the objects we are interested in and keep the sensitivity to the physics high at trigger level. To achieve this, the pile-up-per-particle-interaction or PUPPI[2] algorithm has been employed recently for the HF system. The algorithm is implemented in C++ and compiled using High Level Synthesis (HLS) to run on advanced FPGAs, like VU13P. The clustering of the energy deposits uses a fixed grid approach after dividing the HF geometry into 6 sectors each covering 600 in the azimuthal direction ϕ . The pile-up subtraction by the PUPPI method is done on these clustered objects. The algorithm is optimized such that it can process the incoming raw HF data at the LHC collision frequency of 40 MHz and meet the latency and resource constraints on the target boards of the global calorimeter trigger(GCT). The correlator units down the decision pipeline will further process the PUPPI outputs, correlating it to other sub-detector systems of the CMS detector making a global event description through the particle flow (PF) approach. We have performed the single board test and the firmware-emulator comparison. In near future the multi-board tests will be conducted from the GCT card to the Correlator card.

[1] The Phase-2 Upgrade of the CMS Level-1 Trigger. CERN.
[2] Bertolini, D., Harris, P., Low, M., & Tran, N. (2014). Pileup per particle identification. Journal of High Energy Physics, 2014(10).

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