Contribution ID: **148** Type: **Oral**

Particle Flow Reconstruction for the CMS Phase-II Level-1 Trigger

Tuesday, 20 September 2022 12:00 (20 minutes)

The upgrade of the CMS detector for the high-luminosity LHC will include track-finding for the first time in the Level-1 trigger, enabling Particle Flow reconstruction of every event in addition to comprehensive pileup mitigation. The Correlator trigger will reconstruct isolated leptons and photons, hadronic jets, and energy sums, assisted in many cases by machine learning to benefit from the complete particle-level event record. We present the logic of these algorithms, possible implementations using large FPGAs and their demonstration in prototype hardware, in addition to the expected physics performance.

Summary (500 words)

Following the high-luminosity upgrade of the LHC (HL-LHC), the CMS Level-1 (L1) trigger system must be able to identify signatures of interesting physics that are obfuscated by up to 200 overlapping 'pileup' collisions. High-granularity detector data and tracking in particular is needed to remove these contributions and expose the leptons and jets of modest energies, which are required to collect large samples of electroweak-scale physics processes. The upgraded L1 trigger will accomplish this with a simplified Particle Flow (PF) algorithm, reconstructing particle candidates from track, calorimeter, and muon trigger primitives; the PUPPI algorithm will remove pileup contributions.

The first layer of the L1 Correlator has been designed to perform PF reconstruction in a parallelized system targeting 36 Xilinx VU13P FPGAs with time multiplex (TM) factor of 6. Primitives are combined into PF candidates, corrected for pileup, and sorted within independent detector regions within a latency budget of 1.5 us. We present the logic of these algorithms and a prototype design, whose modularity facilitates mixing of HDL and HLS cores, eases timing constraints, and takes full advantage of all SLRs.

Each FPGA in the second layer of the Correlator receives the complete event record of Puppi candidates from a set of Layer-1 boards that cover the full detector, transmitted via high-speed (25Gbps) links. We describe how nearby candidates are clustered to form particle jets, hadronically-decaying taus, and lepton isolation sums, as well as energy sums. Machine learning algorithms are also designed to perform kinematic regression and identification of these objects, in addition to selecting interesting full-event topologies. Their firmware implementations are optimized to reduce FPGA resources and latency, generally to fit within a single VU9P SLR and achieve latencies less than 1us. In addition to the algorithm logic and resources, we show the expected physics performance using simulated Monte Carlo samples.

Finally, we show several demonstrations of the Correlator system, using prototypes of the trigger boards under development by the APx and Serenity consortiums. These include two Layer-1 boards designed to receive inputs from the barrel and endcap sub-detectors, as well as Layer-2 boards running a selection of the algorithms described above. Multi-board tests are also described, receiving inputs to the Layer-1 system and passing PF candidates to Layer-2. In all cases, excellent agreement is found with software emulators of the trigger logic.

Primary author: HERWIG, Christian (Fermi National Accelerator Lab. (US))

Presenter: HERWIG, Christian (Fermi National Accelerator Lab. (US))

Session Classification: Trigger

Track Classification: Trigger