Contribution ID: **91** Type: **Oral**

A CMS Level-1 Track Finder for the HL-LHC

Friday, 24 September 2021 12:40 (16 minutes)

The High-Luminosity LHC will put significant demands on trigger systems. To control trigger thresholds, the CMS Collaboration is designing a novel Level-1 track trigger. The Outer Tracker will use modules with pairs of sensor layers to read out hits compatible with charged particles above 2-3 GeV. The system will combine these front-end trigger primitives to reconstruct tracks, providing a measurement of P_T, \eta , \phi, and z_0. This presentation will introduce the CMS L1 track finding system: the algorithm and its estimated performance, hardware prototypes, and the unique challenges associated with this system.

Summary (500 words)

The High-Luminosity Large Hadron Collider (HL-HLC) expects to become operational later this decade and deliver an instantaneous luminosity of approximately 7.5 x 1034 cm-2 s-1. This luminosity will create an average of 200 proton-proton collisions for each bunch crossing of the beams. This creates a very busy environment that is challenging for the trigger and data acquisition systems of the collider experiments. To explore the physics topics of interest, such as further study of the Higgs boson, the trigger thresholds need to be kept as low as possible. However, trigger rates must also be controlled and new approaches need to be developed. One method for controlling trigger rates is using charged track reconstruction at the earliest possible stage of the trigger decision. The CMS Collaboration is designing a Level-1 Track Finder (L1TF) for the trigger system in the HL-LHC era.

The L1TF will use trigger primitives from the CMS Outer Tracker, a silicon-based detector being developed for the HL-LHC. The trigger primitives are "stubs", which are pairs of hits in closely space silicon sensors. These stubs will be required to be consistent with those created by charged particles with PT > 2 GeV. As the charge particles traverse the tracking volume, a 3.8T magnetic field will bend the charged particles into a helical path. Reconstructing that path and measuring the curvature allows a measurement of the particle' s momentum transverse to the beamline. Performing tracking is a massive pattern recognition problem and there are many challenges involved in achieving this within a trigger system: a large input data rate of about 20–40 Tb/s; processing a new batch of input data every 25 ns, each consisting of about 15,000 stubs with precise position measurements and rough transverse momentum measurements of particles; performing the pattern recognition on these stubs to find the trajectories; and fitting the trajectories to determine optimal trajectory parameters (P_T, \eta , \phi, and z_0) to produce the list of tracks all within 4 microseconds.

The L1TF will be built on an FPGA architecture using Xilinx Virtex® UltraScale+TM FPGA technology and using a custom-designed Track Finding card. The algorithm within the FPGA is pipelined into ten distinct processing steps with intermediate results being stored in internal memories. The processing steps are being implemented in HLS within Vivado. The presentation will discuss each stage of the processing and the expected performance of the algorithm. The presentation will also discuss Monte Carlo studies that have shown that we expect to achieve a PT resolution of ˜1%, a zo resolution of ˜2mm, and an efficiency above 95%. The timeline for further development leading up to installation will be briefly described. This system represents the most ambitious track trigger ever attempted in particle physics.

Primary author: WINER, Brian Lee (Ohio State University (US))

Presenter: YATES, Brent (Ohio State University (US))

Session Classification: Trigger

Track Classification: Trigger