Reconstruction of Photons and Electrons using GPUs instead of CPUs

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Abstract

Abstract: Traditionally pixel trackers, Electromagnetic Calorimeters(ECAL), and Hadron Calorimeters(HCAL) all run on CPUs in order to reconstruct data taken from a particle detector. The software used to reconstruct events/objects/electrons etc., that uses readout information from different detectors runs on CPUs. In fact, CPUs are used to reconstruct and analyze all of the detector readout information. Unfortunately, as the complexity and the number of recorded events increases CPUs won't be enough! They will take too much time to analyze our data, and reconstruct our objects and events. That is where GPUs are introduced. GPUs can run the same simple task over and over again, in parallel with other GPUs each with thousands of cores. This is very beneficial for our task at hand, which is to analyze data that repeats the same process countless times, and can therefore be parallelized. This study involves testing how well and fast GPUs can reconstruct the collisions within the detector. This is done with a series of algorithms and track reconstructions ran on the online event reconstruction. GPUs have already been put to use in CMS's detector and is progressing.

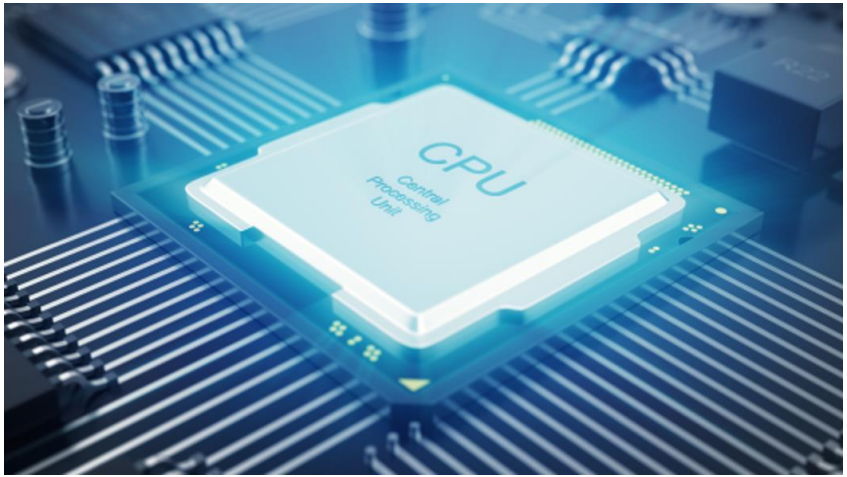
Introduction to CPUs and GPUs

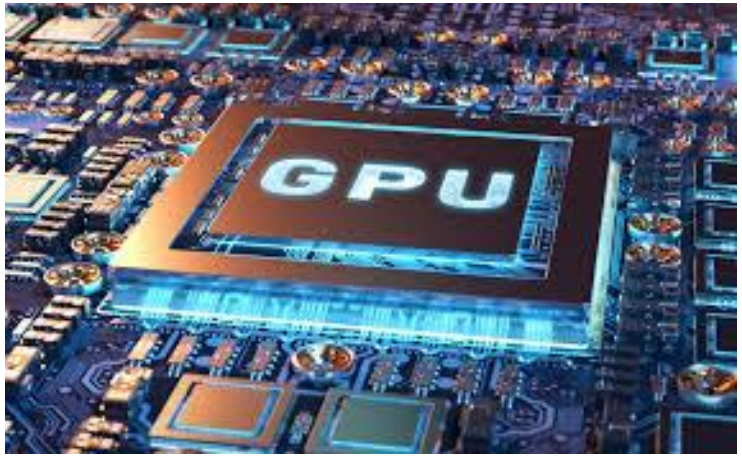
CPUs

- Uses only a few cores
- Can run complex tasks
- Cannot run many tasks in parallel
- Low latency

GPUs

- Uses thousands of cores
- Runs simple tasks
- Can run many tasks in parallel
- High throughput



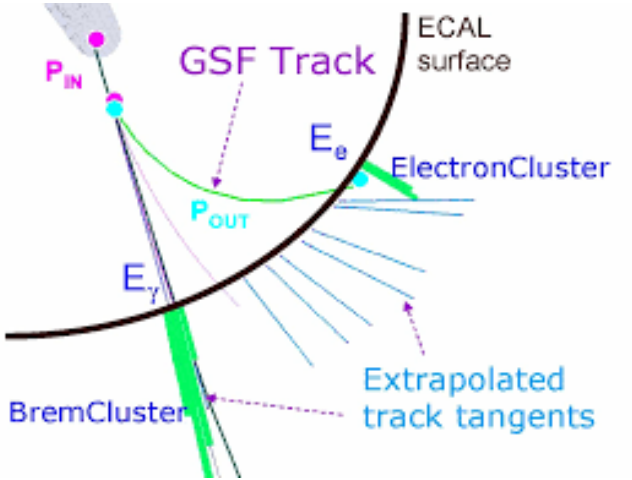


Why is this Important?

- CPUs cannot keep up with the large amounts of data being taken when we increase the luminosity.
- CPUs can only do a few complicated tasks at once, while GPUs can do many simple tasks at once in parallel. This will beneficial for specific tasks. (Such as track reconstruction)
- We can analyze more data using a smaller amount of resources.
- Use of GPUs allows introduction of more computer intensive tasks using the same processing time.
- Pixel tracks , ECAL & HCAL local reconstruction able to run on GPUs in the high level trigger.

Methods

- We start from energy deposits found in the electromagnetic calorimeter (the so called ECAL SC)
- Then we hypothesize two trajectories (one for a +e and one for a -e) taking into account the interaction point the magnetic field and the energy of the SC
- We search for hits in the tracker along these trajectories in order to find hits that could be associated with an electron.
- These are used as seeds for the GSF tracking algorithm



We will explore if parts of the above algorithm can be altered in order to run on a GPU instead of a CPU

Expectations

- These efforts are expected to yield positive results for the algorithms performance (efficiency and speed).
- If this happens we will be able to make more use of GPU's for the CMS experiment rather than CPU's.
- Improve timing and overall performance.
- My expectations are:
  - Become more familiar with using python, C++, ROOT,and SHELL.
  - Learning how to analyze physics data.
  - Become familiar with the CMS detector event reconstruction software.
  - Get introduced to CUDA.
  - Gain new relationships with CMS faculty.