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Accelerating the ATLAS Trigger system with Graphical Processing Units

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The Large Hadron Collider (LHC) is the highest energy particle accelerator ever built. The High Luminosity LHC Upgrade, expected for the years 2026-2028, will increase the LHC collision rate up to a factor 7 with respect to the nominal values, to allow acquiring a huge amount of data and pushing the limits of our understanding of Nature. The ATLAS experiment, which records the proton and ion collisions produced by the LHC to study the most fundamental matter particles and the forces between them, will need to improve its online event selection system (trigger) to accommodate the estimated increase in the collision rate, which leads to longer event reconstruction times due to the higher density of the events. However, the expected growth in computing power at a fixed cost is slower than the projected increase of the event reconstruction times. Thus, improvements to the algorithmic approach in itself are needed to ensure the trigger continues to perform as expected, in particular by considering the use of hardware accelerators, such as Graphical Processing Units (GPUs) or Field Programmable Gate Arrays (FPGAs), to increase performance in a way that could be more cost-effective than the use of the Central Processing Units (CPUs) that are more commonly employed for most computational tasks.
My work has the goal of demonstrating the feasibility of applying hardware acceleration via GPUs to the calorimeter reconstruction algorithms used within the ATLAS trigger. In particular, my work is focused on the Topological Clustering algorithm, which is used to reconstruct the showers generated by the particles that pass through the calorimeter, and its more GPU-friendly counterpart, Topo-Automaton Clustering. The performance and results of both will be compared, and I will give a brief overview of possible directions for further improvement.

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