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Reconstructing proton-proton collision positions at the Large Hadron Collider with a D-Wave quantum computer

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Clustering of charged particle tracks along the beam axis is the first step in reconstructing the positions of proton-proton (p-p) collisions at Large Hadron Collider (LHC) experiments. In this talk, we formulate this problem for a 2048 qubit D-Wave quantum computer that works by quantum annealing. We show the performance of the quantum annealer on artificial events generated from p-p collision and track distributions measured by the Compact Muon Solenoid experiment at the LHC. The quantum clustering algorithm is found to be limited by the connectivity of the qubits and the overall efficiency of the algorithm in addressing event topologies with more than 5 collisions. We identify three obstacles to reaching current LHC event complexities and outline research directions we are embarking on to overcome each.

Summary

The talk will open with a succinct description of the problem of reconstructing proton-proton collision positions, also known as primary vertexing, at LHC experiments. We will then introduce the D-Wave quantum computer and the form that problems need to take for it. While the track clustering necessary for primary vertexing is done at CMS on a classical computer using deterministic annealing, we will show a natural mapping for the problem to quantum annealing. We will then demonstrate how the D-Wave processor arrives at solutions for a simple 2 p-p collision event, and how to interpret the solutions. The solution finding efficiency as a function of increasing event complexities will be shown. Finally, we will identify three obstacles to reaching current LHC event complexities and outline research directions we are embarking on to overcome each.

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