Triggering on charged particles using silicon pixel detectors

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We have proposed an algorithm capable of providing a trigger on charged particles at the Large Hadron Collider and future colliders. The algorithm can be implemented in field-programmable gate arrays. We will be studying this algorithm in more detail to understand its performance under realistic conditions. This method may be used to trigger on "disappearing tracks", which decay invisibly after traversing the small-radius pixel detectors.

Keywords: charged particle tracking; track trigger; unsupervised machine learning; field-programmable gate array; electronics

The rapid reconstruction of charged particles is one of the important experimental tasks in collider detectors. There are a number of benefits to performing this task rapidly in hardware. We have proposed an algorithm [1] to perform track-triggering using the silicon pixel detectors in collider experiments. The speed is achieved by embedding the algorithm in commercial field-programmable gate arrays (FPGAs). Among other benefits, our method may be used to trigger on "disappearing tracks", i.e. charged particles that decay before reaching the calorimeters. An example is provided by models [2–4] of particulate dark matter (DM) whose interaction is mediated by metastable charged particles, such as charginos decaying to neutralino DM. Our methodology is well-situated to take advantage of advances in FPGA architectures.

In the first study [1], we have not included noise hits, sensor inefficiencies and sensor resolution, in order to understand the viability of our approach with a perfect pixel detector. In subsequent studies we plan to investigate these effects and their impact on algorithm performance. In addition, the previous results were based on the measurements of the azimuthal point coordinates only. We will extend the algorithm to make use of both the azimuthal and longitudinal coordinates measured in the pixel detectors.

Unlike other methods of supervised or unsupervised machine learning, this algorithm does not require training. Our approach can be described as the partitioning of a point cloud into graphs which minimize the total Dirichlet energy.

[1] A. V. Kotwal, A fast method for particle tracking and triggering using small-radius silicon detectors. *Nucl. Instrum. Meth. Phys. Res.* **A 835** (2016) 186.

[2] A. Boveia and C. Doglioni, Dark matter searches at colliders. *Annu. Rev. Nucl. Part. Sci.* **68,** 429 (2018).

[3] J. Bramante, N. Desai, P. Fox, A. Martin, B. Ostdiek, and T. Plehn, Towards the final word on neutralino dark matter. *Phys. Rev. D* **93,** 063525 (2016).

[4] M. Low and LT. Wang, Neutralino dark matter at 14 TeV and 100 TeV. *J. High Energ. Phys.* **1408,** 161 (2014).