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High-throughout GNN track reconstruction at LHCb

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Over the next decade, increases in instantaneous luminosity and detector granularity will increase the amount of data that has to be analyzed by high-energy physics experiments, whether in real time or offline, by an order of magnitude. The reconstruction of charged
particles, which has always been a crucial element of offline data processing pipelines, must increasingly be deployed from the very first stages of the real time processing to enable experiments to achieve their physics goals. Graph Neural Networks have received a great deal of attention in the community because their computational complexity scales linearly with the number of hits in the detector, unlike conventional algorithms which often scale quadratically or worse. We present a first implementation of the vertex detector reconstruction for the LHCb experiment using GNNs, and benchmark its computational performance in the context of LHCb's fully GPU-based first-level trigger system, Allen. As Allen performs charged particle reconstruction at the full LHC collision rate, over 20˜MHz in the ongoing Run˜3, each GPU card must process around one hundred thousand collisions per second. Our work is the first attempt to operate a GNN charged particle reconstruction in such a high-throughput environment using GPUs, and we discuss the pros and cons of the GNN and classical algorithms in a detailed like-for-like comparison.

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