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From Prototyping to Production: Integrating and Scaling GNN Tracking for the HL-LHC within the ATLAS Software Framework

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The High-Luminosity LHC (HL-LHC) upgrade of the ATLAS Inner Tracker (ITk) presents unprecedented challenges for track reconstruction, driven by the large number of silicon cluster readouts and the high throughput required under tight computing constraints. Graph Neural Networks (GNNs) have emerged as a promising solution to address these challenges [1–3], delivering competitive reconstruction performance at sub-second inference time.

This contribution presents recent progress in deploying the GNN-based tracking pipeline within the ATLAS software framework [4]. Advances include inference optimizations (mixed precision, model reduction, compilation technologies) - as well as the implementation of dedicated GPU kernels to accelerate graph building and segmentation. We will present the first studies of end-to-end throughput in the ATLAS production environment, highlighting the integration of the GNN pipeline into existing workflows, its robustness under realistic detector conditions, and its ability to scale to the data volumes expected at the HL-LHC. These results demonstrate the maturity of the approach and its readiness for large-scale deployment in preparation for HL-LHC data taking.

[1] C. Rougier et al., Towards a realistic track reconstruction algorithm based on Graph Neural Networks for the HL-LHC, CHEP 2021, https://doi.org/10.1051/epjconf/202125103047

[2] C. Rougier et al., ATLAS ITk Track Reconstruction with a GNN-based Pipeline, CTD 2022, https://doi.org/10.5281/zenodo.8119864

[3] A. Lazar et al., Improving Computational Performance of ATLAS GNN Track Reconstruction Pipeline, to appear in CHEP 2024 proceedings

[4] B. Huth et al., Expected physics and computing performance of the ATLAS ITk GNN-based Track Reconstruction Chain, CTD 2025, available at https://indico.cern.ch/event/1499357/contributions/6621928/

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