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Semi-supervised machine learning for pileup per particle identification at the LHC with Graph Neural Networks

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The high instantaneous luminosity of the LHC leads to multiple proton-proton interactions in the same or nearby bunch crossings (pileup). With the planned increasing instantaneous luminosity in the LHC's future runs, precise identification of individual particles produced from the hard scattering against pileup becomes crucial as this can significantly improve the performance of many physics observables. Thanks to the excellent performance of the tracking detector and reconstruction algorithm, most of the charged particles from the hard scattering and pileup can be correctly distinguished, while for neutral particles this remains uncertain. Studies have been performed for applying machine learning techniques in pileup mitigation tasks, but most of them rely on the accurate labels of neutral particles, which is hard to retrieve in full simulations and real data.

This talk presents a study of applying Graph Neural Network (GNN) for pileup per particle identification. A semi-supervised machine learning approach is used and the GNN is trained exclusively on the charged particles, whose labels can be determined in the real data without relying on any ground truth information from simulation. The post-training model is then inferred on neutral particles to identify if each of them is produced from pileup. The effectiveness of this approach is validated in the simulation of different physics processes under different pileup conditions, at the particle level and the event level with jet observables and missing transverse momentum. The performance is similar to fully supervised training, consistently better than widely-used domain algorithms such as PUPPI.

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