Contribution ID: **45** Type: **YSF Plenary**

GNN Track Reconstruction of Non-helical BSM Signatures

Thursday 12 October 2023 11:40 (15 minutes)

Accurate track reconstruction is essential for high sensitivity to beyond Standard Model (BSM) signatures. However, many BSM particles undergo interactions that produce non-helical trajectories, which are difficult to incorporate into traditional tracking techniques. One such signature is produced by "quirks", pairs of particles bound by a new, long-range confining force with a confinement scale much less than the quirk mass, leading to a stable, macroscopic flux tube that generates large oscillations between the quirk pair. The length scale of these oscillations is dependent on the confinement scale, and in general can be shorter than a micron, or longer than a kilometer. We present a version of the ML-based GNN4ITk track reconstruction pipeline, applied to a custom detector environment for quirk simulation.

We explore the ability of an SM-trained graph neural network (GNN) to handle BSM track reconstruction out-of-the-box. Further, we explore the extent to which a pre-trained SM GNN requires fine-tuning to specific BSM signatures. Finally, we compare GNN performance with traditional tracking algorithms in the simplified detector environment, for both helical SM and non-helical BSM cases.

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Session Classification: YSF Plenary