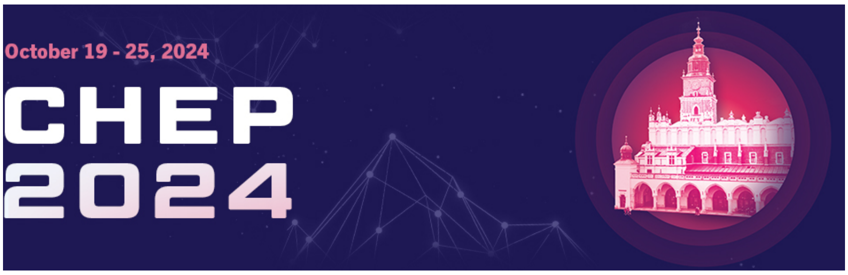

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Ranking-based machine learning for track seed selection in ACTS

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The reconstruction of particle trajectories is a key challenge of particle physics experiments, as it directly impacts particle identification and physics performances while also representing one of the primary CPU consumers of many high-energy physics experiments. As the luminosity of particle colliders increases, this reconstruction will become more challenging and resource-intensive. New algorithms are thus needed to address these challenges efficiently. During track reconstruction, many more tracks are reconstructed than truth particles. This is partially due to fake tracks resulting from an arbitrary combination of detector hits and redundant duplicates of truth particle tracks. Reducing their amount could thus directly improve the speed of our tracking chain.
Those extra tracks are usually removed at the end of the tracking chain in a step called ambiguity resolution. We previously demonstrated (https://indico.jlab.org/event/459/contributions/11453/) that machine learning could speed up this step. Unfortunately, when a track is removed at the end of the tracking chain, all the time spent reconstructing it is lost. Eliminating fake and duplicated tracks before they are reconstructed would thus significantly speed up the reconstruction chain.
Cutting is usually applied to the seeds to mitigate this effect based on seed quality computed by the seeding algorithm. But those algorithms might not always be the most effective, requiring a lot of hand tuning and might not always keep the seed leading to the best possible track.
We propose using a ranking-based machine learning algorithm to select the track seeds before the track finding reconstructs them. The problem is fundamentally the same as with ambiguity resolution but with much less information available on the seeds than the tracks. With a clustering algorithm (such as DBSCAN), we can bundle together nearby seeds that appear to come from the same truth particle. Afterwards, we can apply a Neural Network (NN) using a novel Margin Ranking Loss Function to compare the seeds in each group and only keep one, which should lead to the closest reconstructed track to the truth. In order to fully evaluate this approach's potential, we implemented it within the A Common Tracking Software (ACTS) framework and tested it on the Open Data Detector (ODD), a realistic virtual detector similar to a future ATLAS one. This evaluation showed an up to ten times speedup of the track finding and an improvement in the quality of the reconstructed tracks at the cost of a slight decrease in efficiency.

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