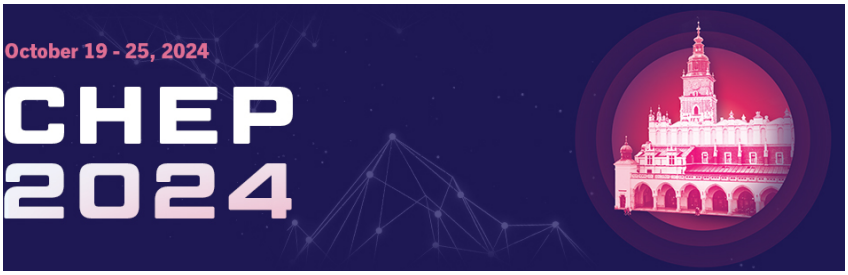

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A Multi-Objective Optimization Tool for Track Reconstruction in CMS

Thursday 24 October 2024 13:30 (18 minutes)

Efficient and precise track reconstruction is critical for the results of the Compact Muon Solenoid (CMS) experiment. The current CMS track reconstruction algorithm is a multi-step procedure based on the combinatorial Kalman filter as well as a Cellular Automaton technique to create track seeds. Multiple parameters regulate the reconstruction steps, populating a large phase space of possible solutions. The fine-tuning of these parameters is necessary to ensure an optimal reconstruction. The CMS tracker featured robust performance and efficient tracking in Run 3 condition, however, the High Lumi environment is expected to be much more demanding. The upgrade will lead to higher rates and pile-up that require further improvement in all the reconstruction processes, with more complex algorithms featuring additional parameters. Alternative techniques to help the experts in properly tuning these environments are thus being investigated.

This report presents an original tool based on the established Particle Swarm heuristic optimization algorithm (PSO) to perform parameter tuning of the pixel track reconstruction software currently employed in the CMS experiment. The software enables multi-objective optimization against tracking efficiency and fake rate, resulting in the individuation of a Pareto front of valid parameters'sets for reconstruction.

The algorithm has been tested at the end of the data-taking period of 2023 on the pixel track reconstruction algorithm with excellent results. The parameters obtained with the optimization resulted in comparable reconstruction efficiency for both phase 1 data and phase 2 simulations, with a 50\% improvement in fake rates, especially for low transverse momentum of the particles.

Further research and development can explore the application of this tool to other aspects of the CMS reconstruction process. Additionally, investigating the integration of this tool within the existing CMS framework can streamline the optimization workflow for future data-taking periods.

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