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Accelerating LHCb VELO U2 Design with Machine Learning: A Fast Simulation Approach for the TimeSPOT Sensor

The VELO Upgrade 2 (VELO U2) for the LHCb experiment relies on the TimeSPOT sensor for enhanced timing resolution and radiation hardness. Efficient simulation is crucial for optimizing the sensor design and predicting performance. Traditional Geant4/TCoDe simulations, while accurate, are computationally intensive, hindering large-scale design studies. This talk presents a novel approach using machine learning to develop a fast and accurate simulation for the TimeSPOT sensor.

We trained a Multi-Layer Perceptron (MLP) on a dataset of 400,000 simulated events from Geant4/TCoDe. The model accurately predicts the sensor response (charge collection and time of arrival) using particle properties as input. Importantly, the ML-based simulation achieves a remarkable speedup of 10^4 - 10^5 compared to traditional methods. This significant acceleration enables rapid exploration of sensor placement within the VELO U2 geometry, contributing to optimized design decisions.

We have successfully integrated this fast simulation model into the Gauss framework using TMVA SOFIE, paving the way for widespread adoption within the LHCb collaboration. This presentation will outline the model development, performance results, integration process, and the potential impact on VELO U2 design and analysis. Future directions, including the exploration of more advanced ML models and comprehensive validation, will also be discussed.

Giorno preferito

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