Relational deep learning for LHCb reconstruction and identification

Master thesis internship (M2), 2026–2027

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Abstract

At the LHC, each bunch crossing produces several proton–proton collisions, and the first step of almost every LHCb measurement is to identify the primary vertices (PVs) where these collisions occurred. In LHCb, this reconstruction runs in real time on GPUs within the Allen trigger framework, which processes the full 30 MHz collision rate. A graph neural network (GNN) developed in the group uses the point of closest approach (POCA) of each track to the beam axis, together with its uncertainty, and already reaches high physics performance compared with the existing convolutional approach.

The internship can follow one of two directions, or a combination of both, depending on the student's profile. The first explores new architectures, in particular a transformer combined with object condensation, which predicts the number and positions of PVs directly, without hand-tuned post-processing. These models will be benchmarked against the current GNN in 3D, with a natural extension to 4D vertexing using track timing information for the LHCb Upgrade II, where the higher number of collisions per crossing makes vertices increasingly difficult to separate in space alone. The second direction focuses on integrating the 3D model into the Allen GPU trigger, targeting Run 4, and on studying the trade-off between physics performance and throughput.

The student will gain experience with PyTorch, graph and attention-based models, and GPU computing, as a member of the LHCb collaboration, with a possible short stay at CERN. A continuation into a PhD on the same or a closely related topic is possible.