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Quantum Computing for Track Reconstruction at LHCb

Reconstructing the trajectories of charged particles as they traverse several detector layers is a key ingredient for event reconstruction at LHC and virtually any particle physics experiment. The limited bandwidth available, together with the high rate of tracks per second O(10^10) - where each track consists of a variable number of measurements - makes this problem exceptionally challenging from the computational perspective. With this in mind, Quantum Computing is being explored as a new technology for future detectors, where larger datasets will further complicate this task.

Several quantum algorithms have been explored in this regard - e.g., Variational algorithms and HHL offering a heterogeneous set of advantages and disadvantages. In this talk, an extensive study using the Quantum Approximate Optimization Algorithm (QAOA) for track reconstruction at LHC will be presented. The robustness of QAOA to hardware noise when compared to other algorithms makes it a good candidate for the near-term utility era in Quantum Computing. In this talk, implementations with simplified simulations will be presented, both for QAOA and a modified version of the algorithm that could improve performance in comparison with Quantum annealers as per recent Q-CTRL results. Finally, a complete study of hardware requirements, prospects on improving scalability, and energy consumption for different technologies will also be discussed.

Secondary track

T12 - Data Handling and Computing

Author: LUCIO MARTINEZ, Miriam (IFIC and University of Valencia)

Session Classification: T15

Track Classification: T15 - Quantum technologies in HEP (special topic 2025)