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Particle Track Reconstruction with Quantum Algorithms

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Accurate particle track reconstruction will be a major challenge for the High Luminosity LHC experiments. Increase in the expected number of simultaneous collisions and the high detector occupancy will make the algorithms extremely demanding in terms of time and computing resources.

The sheer increase in the number of hits would increase the complexity exponentially, however the finite resolution of the detector and the physical "closeness"of the hits increase the ambiguity of their assignment to a trajectory, making the track reconstruction problem a major obstacle to the correct interpretation of the HL-LHC data. Most methods currently in use are based on the Kalman filter: they have shown to be robust and to provide good physics performance, however, they are expected to scale worse than quadratically.

Designing an algorithm capable of reducing the combinatorial background at the hit level, would provide a much "cleaner"initial seed to the Kalman filter, thus strongly reducing the total processing time.

One of the salient features of Quantum Computers is the ability to evaluate a very large number of states simultaneously, making them an ideal instrument for searches in a large parameter space and, in fact, different R&D initiatives are exploring how Quantum Tracking Algorithms could leverage such capabilities. In this paper we present our work on the implementation of a quantum-based track finding algorithm aimed at reducing combinatorial background during the initial seeding stage. We use the publicly available dataset designed for last year's kaggle TrackML challenge.

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