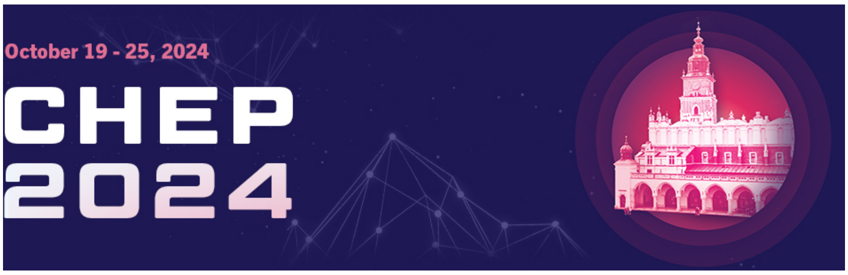

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TrackHHL: A Quantum Computing Algorithm for Track Reconstruction at the LHCb

Monday 21 October 2024 13:48 (18 minutes)

With the future high-luminosity LHC era fast approaching high-energy physics faces large computational challenges for event reconstruction. Employing the LHCb vertex locator as our case study we are investigating a new approach for charged particle track reconstruction. This new algorithm hinges on minimizing an Ising-like Hamiltonian using matrix inversion. Performing this matrix inversion classically achieves reconstruction efficiency akin to the current state-of-the-art algorithms but is hindered by worse time complexity. Exploiting the Harrow-Hassadim-Lloyd (HHL) quantum algorithm for linear systems holds the promise of an exponential speedup in the number of input hits over its classical counterpart. Contingent upon the following conditions: efficient quantum phase estimation (QPE) and an intuitive way to read out the algorithm's output. This contribution builds on previous work (DOI 10.1088/1748-0221/18/11/P11028) and strives to fulfil these conditions and streamlines the proposed algorithm's circuit depth, by a factor up to 10^4. We propose a modified version of the HHL algorithm by restricting QPE precision to two bits. Enabling us to introduce a novel post-processing algorithm, which estimates event Primary Vertices (PVs), then efficiently computes all event tracks though an Adaptive Hough Transform. This alteration significantly reduces circuit depth and addresses HHL's readout issue, bringing the reconstruction of small events closer to current hardware implementation. The findings presented here aim to further illuminate the potential of harnessing quantum computing for the future of particle track reconstruction in high-energy physics.

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