Quantum Associative Memory in HEP Track Pattern Recognition

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We have entered the Noisy Intermediate-Scale Quantum Era. A plethora of quantum processor prototypes allow evaluation of potential of the Quantum Computing paradigm in applications to pressing computational problems of the future. Growing data input rates and detector resolution foreseen in High-Energy LHC (2030s) experiments expose the often high time and/or space complexity of classical algorithms. Quantum algorithms can potentially become the lower-complexity alternatives in such cases. In this work we discuss the potential of Quantum Associative Memory (QuAM) in the context of LHC data triggering. We examine the practical limits of storage capacity, as well as store and recall efficiencies, from the viewpoints of state-of-the-art quantum hardware and LHC real-time charged track pattern recognition requirements. We present experimental tests of QuAM on the IBM 5Q chip - a cloud-based 5-qubit superconducting quantum processor. We further compare the results to QuAM simulations on LIQUi|> - the Microsoft's Quantum Simulator toolsuite - as well as to theoretical expectations of QuAM efficiency bounds. We also review several difficulties integrating the end-to-end quantum pattern recognition into a real-time production workflow, and discuss possible mitigations.

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