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Quantum Computing and Simulation Platform for HEP at IHEP

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With the dramatic growth of data in high-energy physics and the increasing demand for accuracy of physical analysis, the current classical computing model and computing power will become the bottleneck in the near future. There is an urgent need to explore new computational approaches. As a new computing device with great potential, quantum computers have become one of the possible solutions.

A quantum computer is a computing device which explicitly leverage the principles of quantum mechanics. The computing unit - qubit, can represent more information than classical bit in classical computers widely used by scientific computing nowadays. Because of the unique quantum superposition and quantum entanglement properties of quantum systems, quantum computers can naturally "parallelize" a large number of different situations and have a computing power far beyond that of classical computers.

Current quantum computers are very immature in terms of hardware manufacturing and software ecosystem. Unlike classical program development, quantum programs currently have great difficulties in problem abstraction, data processing, algorithm design and implementation due to the difference in information representation and computing model. A large amount of infrastructure needs to be researched and developed to help the development of quantum algorithm.

Motivated by the interests of LHAASO, BESIII and other HEP experiments and theory research, we have developed and deployed a quantum computing simulation platform for high-energy physics analysis combined with existing data computing clusters to provide a friendly and efficient development environment for the development of high-energy physics quantum algorithms, simplify the quantum algorithm development process, and improve the efficiency of quantum program development. Simulating large-scale quantum bits on a classical computing cluster, thus prototyping quantum algorithms and quantum software, is a more realistic approach at this stage.

Specifically, based on jupyter, we have developed and deployed a visualized interactive quantum algorithm development environment combined with the unified authentication of IHEP to help researchers in quantum algorithm development. By combining with high performance computing clusters, researchers can simulate large-scale quantum circuits and quantum annealing algorithms on our quantum simulation platform to make proof of concept of their quantum algorithms.

Together with various physical experimental and theoretical researchers, we will explore the applications of quantum computing in physical analysis and multi-body simulation, etc. We will abstract generic algorithms to form a library of generic quantum algorithm templates, and provide corresponding algorithm application examples. Users can use these examples to conduct research quickly.

Based on this platform, we will also conduct training related to quantum computing, and together promote the research and application practice of quantum computing.

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