Contribution ID: **188** Type: **talk**

Building quantum event generators through particle-based formulations

Thursday 23 January 2025 11:15 (15 minutes)

Quantum computers may revolutionize event generation for collider physics by allowing calculation of scattering amplitudes from full quantum simulation of field theories. Although rapid progress is being made in understanding how best to encode quantum fields onto the states of quantum registers, most formulations are lattice-based and would require an unrealistically large number of qubits when applied to scattering events at colliders with a wide momentum dynamic range. In this regard, particle-based formulations of field theory dynamics developed in works such as Barata et al. (Phys. Rev. A 103) and Gálvez-Viruet (arXiv:2406.03147) are highly attractive for their qubit efficiency and strong association with scattering. In fact, we believe that adopting some sort of sparse Fock representation is the only viable approach to realizing quantum event generators.

Since particle-based formulations are uncommon, basic properties such as their relation to analytic perturbation theory calculations are yet to be established. In this presentation, we compare physical observables computed numerically through a particle-based formulation to corresponding results of perturbation theory calculation using the 1+1d scalar field theory. We then discuss a possible roadmap to realizing quantum event generators, describing the known unknowns along the way.

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Short summary

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Session Classification: Quantum Computing