Topical Groups:

■ (CompF2) Theoretical Calculations and Simulation [1–7]
■ (TF05) Lattice Gauge Theory [1–7]

■ (EF01) EW Physics: Higgs Boson Properties and Couplings [1]
■ (EF05) QCD and Strong Interactions: Precision QCD [1, 2]
■ (EF06) QCD and Strong Interactions: Hadronic Structure and Forward QCD [2]
■ (EF07) QCD and Strong Interactions: Heavy Ions [3]
■ (EF08) BSM: Model-specific Explorations [4]
■ (EF09) BSM: More General Explorations [4]
■ (EF10) BSM: Dark Matter at Colliders [4]

■ (NF06) Neutrino Interaction Cross Sections [5]
■ (TF11) Theory of Neutrino Physics [5]

■ (RF1) Weak Decays of b and c Quarks [1]
■ (RF2) Weak Decays of Strange and Light Quarks [1]
■ (RF3) Fundamental Physics in Small Experiments [1, 6]
■ (RF4) Baryon and Lepton Number Violating Processes [6]
■ (RF5) Charged Lepton Flavor Violation [1, 6]
■ (RF6) Dark Sector Studies at High Intensities [4, 6]
■ (RF7) Hadron Spectroscopy [2]

■ (TF2) Effective Field Theory Techniques [1, 2, 4–6]
■ (TF6) Theory Techniques for Precision Physics [1, 2, 5, 6]
■ (TF8) BSM Model Building [4]
■ (TF10) Quantum Information Science [7]
■ (CompF6) Quantum Computing [7]

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Numerical Lattice Gauge Theory

USQCD Collaboration Executive Committee

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This Letter provides information on recent and near-future activities of the USQCD Collaboration related to the Snowmass Study. USQCD is a federation of science collaborations, the latter being the groups that carry out research and submit scientific papers for publication. The purpose of USQCD is to secure and coordinate computing resources for numerical calculations of lattice gauge theory; membership is open to anyone engaged in this kind of research based at an institution in the United States. For details, please see the USQCD website, www.usqcd.org.

For the past two decades, the main USQCD-coordinated resource has been clusters of Linux computers connected by a fast, low-latency network, built from commodity parts. In the early days, the committee that grew into the USQCD Executive Committee acquired a QCDOC computer designed especially for lattice QCD; in a later year, the cost-effective "cluster" solution proved to be an IBM Blue/Gene P. The cluster computing has been supported by funding from the DOE Office of High Energy Physics (HEP) and the Office of Nuclear Physics (NP). They have been hosted at Brookhaven National Laboratory, Fermilab, and Jefferson Lab. In addition, USQCD has sometimes coordinated proposals for time on leadership-class computers at Argonne National Laboratory and Oak Ridge National Laboratory.

In 2019, the USQCD Collaboration prepared seven whitepapers to support a proposal to DOE HEP for funding during five fiscal years, 2020–2024. They cover a wide range of topics in nuclear and particle physics: hadonic properties pertinent to quark and lepton flavor physics [1]; spectroscopy and structure of hadrons and (small) nuclei [2]; hot, dense QCD, such as the environment of heavy-ion collisions [3]; lattice gauge theories beyond the Standard Model [4]; lattice-QCD calculations useful for understanding neutrino-nucleus scattering [5]; the strong-interaction part in violations of fundamental symmetries [6]; and the status and perspectives for computing during and after the exascale era [7]. The reference numbers on the information page connect the papers to Topical Groups of several Frontiers.

The whitepapers were well received. An Editor of the *European Physics Journal A* noticed them on the archive and invited us to submit them for a special issue of the journal. The whitepapers helped the DOE-HEP review panel understand how lattice QCD fits into various aspects of high-energy physics, now and in the future, leading to very favorable recommendations to USQCD, the labs, and DOE HEP towards a field-work proposal at Fermilab to support cluster computing at BNL and Fermilab. (DOE NP supports clusters at Jefferson Lab.)

Many of the whitepapers classify specific calculations as "straightforward" (*i.e.*, a full error budget can be developed with current computer resources), "challenging" (*i.e.*, work is currently exploratory but expected to become "straightforward" with anticipated future computing resources), and "very challenging" (*i.e.*, ideas are probably necessary not to mention much more computing). Examples in the three categories are as follows—straightforward: quark masses and $1 \to 1$ electroweak matrix elements; challenging: hadronic contributions to muon $g-2$ (by now "straightforward") and parton distribution functions ("straightforward" in a few years); and very challenging: anything with nuclei as large as ^{12}C. One should bear in mind that even a straightforward calculation requires several 100 petaflop s^{-1}yr as well as several FTE years.

Within the high-energy physics community, lattice-gauge theorists have notable expertise in software development and experience with high-performance computing. One of the whitepapers explores our status and future perspectives for our work in the exascale computing era and beyond [7]. The role of significant funding for software development is difficult to overestimate in the progress in calculations of direct relevance to the high-energy and nuclear physics programs. At present, the Exascale Computing Project (ECP) [8] supports around a dozen FTEs, and a SciDAC grant from DOE NP supports another dozen. After ECP ends in June 2023, it will be crucial to secure new funding to retain expertise in lattice-QCD codes and algorithms.

Most (if not all) of the Topical Groups on the information page will be receiving further LOIs about various physics topics supported by calculations using lattice QCD and other lattice field theories, not from USQCD but from various science collaborations or groups of lattice-gauge theorists with common interests. Similarly, these groups will develop their LOIs into contributions to the Snowmass Study proceedings. Some (that we know of) will discuss quark and charged lepton flavor physics, where lattice QCD has already been successful and influential, in light of expected progress from several experiments. Others will address more ambitious calculations that will play an important future role in neutrino-oscillation and hadron-collider experiments. If it is considered useful, the USQCD Executive Committee can contribute an updated summary of the whitepapers.

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Andreas Kronfeld (Chair), Robert Edwards (Deputy Chair), Thomas Blum, Norman Christ, Carleton DeTar, William Detmold, Anna Hasenfratz, Huey-Wen Lin, Swagato Mukherjee, Konstantinos Orginos, David Richards (*ex officio*; Chair, Scientific Program Committee)

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[8] The DOE-led Exascale Computing Initiative is a partnership between two DOE organizations, the Office of Science and the National Nuclear Security Administration.