What can we learn from USQCD?

EuroLat Meeting April 2025

Christoph Lehner, April 3rd 2025

USQCD - A quick overview

Political representation

- Membership of a large fraction of US researchers in lattice QCD
- Executive committee (incl. Spokesperson and Deputy Spokesperson)
- Joint participation in planning phases (Snowmass) and periodic whitepapers on state of the art
- Gets advice from scientific advisory board (appx. 7 non-lattice nuclear and particle physics researchers)
- Annual All-Hands-Meetings
- Joint software proposals (SciDAC), software committee

Resource management

- Operates hardware (both compute and storage) for the community, centered around labs, funded by DOE project
- Storage component crucial for large US collaborations
- Compute component crucial to develop new projects before scaling them up to the leadership class machines
- Scientific Program Committee allocates the resources after an USQCD-internal review process. Idea: low-effort, quick access, different tiers

Membership

- 208 members in 2025
- Membership includes both senior researchers as well as students and postdocs
- Senior researchers take on responsibility to maintain membership of junior researchers in local groups; sign up once postdoc or PhD is started
- Joint mailing lists
- The large fraction of participation including junior researchers is crucial to demonstrate legitimate representation vis a vis funding agencies

Executive Committee

- Members 2025:

  Thomas Blum (EC chair), William Detmold (EC deputy chair), Peter Boyle, Martha Constantinou, Carleton DeTar, Robert Edwards, Anna Hasenfratz, Andreas Kronfeld, Huey-Wen Lin, Kostas Orginos, Peter Petreczky (SPC chair), Phiala Shanahan

- Better to be inclusive and fully represent the US community instead of having a small and lean committee

- Chairs take on leadership of the effort and act as spokespeople towards agencies, decisions made jointly in EC

- Due to resource management component: have SPC chair be a member of the EC; appeals in resource distribution are handled by EC

Joint representation in community planning

- 2019 White Papers (published in Euro. Phys. J. A 55 (2019))
  - Hadrons and Nuclei
  - Hot-dense QCD
  - Opportunities for Lattice QCD in Quark and Lepton Flavor Physics
  - Lattice QCD and Neutrino-Nucleus Scattering
  - The Role of Lattice QCD in Searches for Violations of Fundamental Symmetries and Signals for New Physics
  - Lattice Gauge Theory for Physics Beyond the Standard Model
  - Status and Future Perspectives for Lattice Gauge Theory Calculations to the Exascale and Beyond

- USQCD coordinated lattice QCD contributions to last Snowmass process:

[1] P. A. Boyle *et al.*, A lattice QCD perspective on weak decays of b and c quarks, in *2022 Snowmass Summer Study* (2022) arXiv:2204.xxxxx [hep-lat].
[2] B. Bhattacharya, T. Browder, Q. Campagna, A. Datta, S. Dubey, L. Mukherjee, and A. Sibidanov, A new tool to search for physics beyond the Standard Model in $\bar{B} \to D^{**}\ell^-\bar{\nu}$, in *2022 Snowmass Summer Study* (2022) arXiv:2203.07189 [hep-ph].
[3] A. Sibidanov, T. E. Browder, S. Dubey, S. Kohani, R. Mandal, S. Sandilya, R. Sinha, and S. E. Vahsen, A new tool for detecting BSM physics in $B \to K^*\ell\ell$ decays, in *2022 Snowmass Summer Study* (2022) arXiv:2203.06827 [hep-ph].
[4] H.-Y. Cheng, X.-R. Lyu, and Z.-Z. Xing, Charm physics in the high-luminosity super τ-charm factory, in *2022 Snowmass Summer Study* (2022) arXiv:2203.03211 [hep-ph].
[5] T. Blum *et al.*, Discovering new physics in rare kaon decays, in *2022 Snowmass Summer Study* (2022) arXiv:2203.10998 [hep-lat].
[6] E. Worcester *et al.* (KOTO, LHCb, NA62/KLEVER, and the US Kaon Interest Group), Searches for new physics with high-intensity kaon beams, in *2022 Snowmass Summer Study* (2022).
[7] J. Aebischer, A. J. Buras, and J. Kumar, On the importance of rare kaon decays, in *2022 Snowmass Summer Study* (2022) arXiv:2203.09524 [hep-ph].
[8] J. Elam *et al.* (REDTOP), The REDTOP experiment: Rare η/η' decays to probe new physics, in *2022 Snowmass Summer Study* (2022) arXiv:2203.07651 [hep-ex].
[9] G. Colangelo *et al.* (Muon $g-2$ Theory Initiative), Prospects for precise predictions of a_μ in the Standard Model, in *2022 Snowmass Summer Study* (2022) arXiv:2203.15810 [hep-ph].
[10] R. Alarcon *et al.*, Electric dipole moments and the search for new physics, in *2022 Snowmass Summer Study* (2022) arXiv:2203.08103 [hep-ph].
[10] R. Alarcon *et al.*, Electric dipole moments and the search for new physics, in *2022 Snowmass Summer Study* (2022) arXiv:2203.08103 [hep-ph].
[11] N. Blinov, N. Craig, M. J. Dolan, J. de Vries, P. Draper, I. Garcia Garcia, B. Lillard, and J. Shelton, Strong CP beyond axion direct detection, in *2022 Snowmass Summer Study* (2022) arXiv:2203.07218 [hep-ph].
[12] P. S. B. Dev *et al.*, Searches for baryon number violation in neutrino experiments, (2022), arXiv:2203.08771 [hep-ex].
[13] V. Cirigliano *et al.*, Neutrinoless double-beta decay: A roadmap for matching theory to experiment, in *2022 Snowmass Summer Study* (2022) arXiv:2203.12169 [hep-ph].
[14] J. Bulava *et al.*, Hadron spectroscopy with lattice QCD, in *2022 Snowmass Summer Study* (2022) arXiv:2203.03230 [hep-lat].
[15] L. Alvarez Ruso *et al.*, Theoretical tools for neutrino scattering: interplay between lattice QCD, EFTs, nuclear physics, phenomenology, and neutrino event generators, in *2022 Snowmass Summer Study* (2022) arXiv:2203.09030 [hep-ph].
[16] J. M. Campbell *et al.*, Event generators for high-energy physics experiments, in *2022 Snowmass Summer Study* (2022) arXiv:2203.11110 [hep-ph].
[17] D. d'Enterria *et al.*, The strong coupling constant: State of the art and the decade ahead, in *2022 Snowmass Summer Study* (2022) arXiv:2203.08271 [hep-ph].
[18] M. Constantinou *et al.*, Lattice QCD calculations of parton physics, in *2022 Snowmass Summer Study* (2022) arXiv:2202.07193 [hep-lat].
[19] P. Nadolsky, M. Ubiali, *et al.*, Proton structure at the precision frontier (2022).
[20] R. A. Khalek *et al.*, Electron ion collider for high energy physics, in *2022 Snowmass Summer Study* (2022) arXiv:2203.13199 [hep-ph].
[21] T. S. Humble *et al.*, Quantum computing systems and software for high-energy physics research, in *2022 Snowmass Summer Study* (2022) arXiv:2203.07091 [quant-ph].
[22] T. Faulkner, T. Hartman, M. Headrick, M. Rangamani, and B. Swingle, Quantum information in quantum field theory and quantum gravity, in *2022 Snowmass Summer Study* (2022) arXiv:2203.07117 [hep-th].
[23] Y. Meurice, J. C. Osborn, R. Sakai, J. Unmuth-Yockey, S. Catterall, and R. D. Somma, Tensor networks for high energy physics, in *2022 Snowmass Summer Study* (2022) arXiv:2203.04902 [hep-lat].
[24] C. Bauer, Z. Davoudi, *et al.*, Quantum simulation for high-energy physics, in *2022 Snowmass Summer Study* (2022).
[25] D. Boyda *et al.*, Applications of machine learning to lattice quantum field theory, in *2022 Snowmass Summer Study* (2022) arXiv:2202.05838 [hep-lat].
[26] P. Boyle *et al.*, Lattice QCD and the computational frontier, in *2022 Snowmass Summer Study* (2022) arXiv:2204.00039 [hep-lat].

- Joint representation can be much more effective compared to uncoordinated individual contributions

All-hands meetings

- 2025 meeting: 94 of 208 members participated in in-person meeting last week at UMD
- Talks about scientific projects performed by junior researchers (exposure, review how centrally-managed resources are used)
- Tutorials on joint software (QUDA, Grid, Chroma) or methodology (LaMET, ...)
- Discussion sessions to coordinate policy, make sure representation still works

Joint proposals

- Some joint proposals for software development (SciDAC) coordinated by USQCD.

  This has been very effective!

- Some joint proposals for early science time and readiness for next computing frontiers (exascale computing projects) coordinated by USQCD.

  This has been very effective!

- Some joint compute-proposals (omnibus proposals) were tried for a few years, mixed results, has in some cases led to reduced total amount of compute resources distributed to USQCD researchers compared to larger number of individual projects.

  One main challenge: omnibus proposals leave very little space to explain the scientific reasoning for the various projects, which can harm competitiveness in evaluation.

Joint hardware

- Clusters operated at BNL, Fermilab, JLab
- Hardware selected by lattice researchers, so optimized e.g. in compute/bandwidth for LQCD
- In recent years reduced total funding and institutional cluster model with large overheads led to reduced importance of these resources. Still very useful to support young researchers in particular also in many smaller Universities that may not have good local compute access.

  Institutional cluster model is now being replaced with lower-overhead approach, so things are changing.

- Recent component: large amounts of tape/disk storage at labs managed by USQCD.

  It is good to have a solution for long-term storage needs! This is crucial in age of FAIR principles being enforced.

Scientific Program Committee

- Members 2025:

  Peter Petreczky (SPC chair), Zohreh Davoudi, George Fleming, Chris Kelly, Stefan Meinel, Chris Monahan, Jim Simone

- Evaluates the proposals by USQCD members for access to resources (compute+storage) managed by USQCD

- Yearly allocation process for larger allocations, year-round allocation process for smaller scale requests

- Disputes handled by the EC, SPC chair is also member of EC

Aspects to consider

- What is the scope of EuroLat (now, in 5 years)? Only political component or also jointly managed resources?
- **Key components of political component:**
  - Large membership crucial for claim to represent a vibrant community
  - Large Executive Committee: 12 / 208 or 6% of all members

    Full representation, all crucial decisions taken with support of all major stakeholders

    2 Spokespeople represent community to outside world
  - Annual All-Hands-Meetings: visibility for young researchers, training, platform to discuss policy broadly
  - Joint representation in community planning, expressing the needs of the community
  - Joint projects to adopt new computing paradigms (SciDAC, exascale compute project)
- **Key components of resource management:**
  - hardware optimized for LQCD
  - support for researchers at smaller institutions (Not clear this is needed in Europe with different tier compute centers)
  - Joint long-term storage options (This may be interesting?)