Lattice @ DESY the next decade

Stefan Schaefer

June 19th 2025

HELMHOLTZ

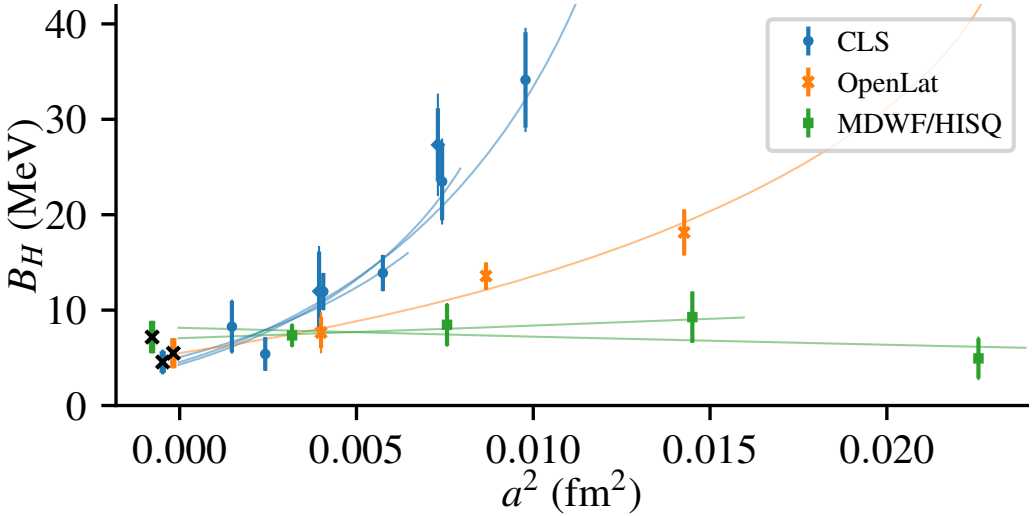
Physics

Hadrons and Nuclei

Nuclear physics from QCD

- Basis of **nuclear physics**
  two-nucleon and three-nucleon interactions
- Ingredients for exotic **neutron star structure**
  dibaryons and hyperon interaction
- external probes on two-nucleon systems
  - EMC effect
  - neutrino-nucleus interactions → important for DUNE
  - neutrinoless double beta decay

  → QCD input important in case of detection



Green et al., Phys. Rev. Lett. 127 (2021) 242003,
Green, arXiv:2502.15546

Glueballs

- What happens to glueballs in the presense of quarks?
- help searches at BESIII, LHCb, GlueX, …

B physics

- Leptonic and semileptonic decays → Belle II
- …

MeV scale effects in systems with mass of several GeV
→ **New era of precision**

Community support

Organization

Long tradition in supporting the German and international lattice community

Leadership in large simulation efforts

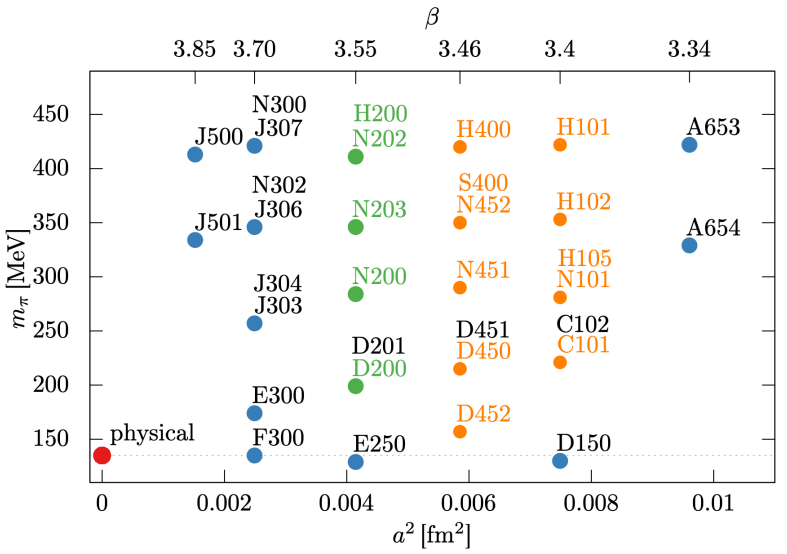
In the past: ALPHA, CLS, ETMC, QCDSF collaborations organized by DESY scientists

Future: new CLS simulations (~50 scientists + students in Europe)
Better discrete action → smaller discretization effects
Better algorithms
Better planning → less CO_2 emission

Simulation software and algorithms
Computer architectures are changing

Massively parallel machines based on GPUs
→ Need new software and algorithms

Make computations more efficient and sustainable.



Community support

International lattice data grid

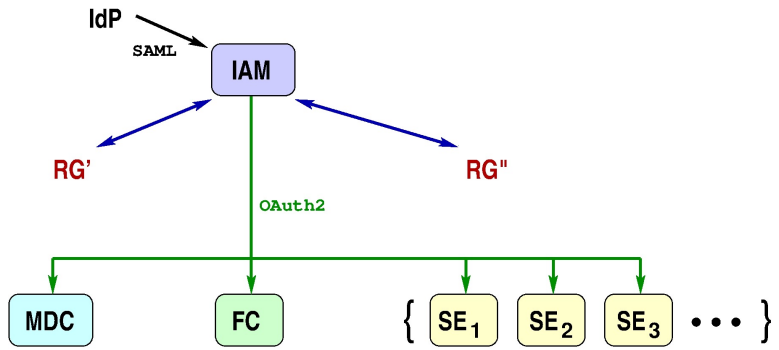
Sharing and management of large datasets of gauge field configurations.

Reuse of data and underlying computation → sustainability

Implementation of FAIR data principles.

Flexible and modern middleware

- metadata catalogue with freely configurable schema
- support of embargo periods (fine-grained access control with WLCG-compliant token profile)
- distributed architecture with modular building blocks - simple
- containerized deployment (catalogues now also used in Japan and UK)



Use cases beyond lattice QCD?

- Radio-Astronomy
- Small and medium-size HEP experiments

Relevant for POF-V

- Operation of services
- Curation (and proper publishing) of data

Summary

Lattice computations provide input to on-going experimental efforts

- B physics
- Nuclear physics → interaction with nuclei
- Glueballs

Lattice QCD requires significant resources.

Make it more sustainable by
- Good planning of simulations
- Efficient software and algorithms
- Sharing and re-using data

Data management: Synergies with experiment?