Topical Collaborations in Nuclear Theory

- Fixed-term (5-years), multi-institution collaborations (selected by DOE/NP via FOA)
- Investigate a specific topic in nuclear physics of special interest to the community
- Aligned with programmatic goals of the Office of Nuclear Physics at DOE

Introduced in 2010 – 3 collaboration projects awarded

Re-competed in 2015 – 4 collaboration projects awarded

Latest in 2022 – 5 collaboration projects awarded

Jianwei Qiu
Jefferson Lab, Theory Center

Overview

- **Topical collaboration in NP Theory is a RECURRING solicitation from DOE/NP**
  - First introduced in 2010: 3 Theory Topical Collaboration Projects awarded
  - Re-competed in 2015: 3+1 Theory Topical Collaboration projects awarded
    (3 Funded by NP, 1 funded jointly by NP and NNSA)
  - Last competition in 2022: 4+1 Theory Topical Collaboration projects awarded
    (4 Funded by NP, 1 funded jointly by NP and HEP for a total $11.24M)

- **Eligible Institutions:**

  Universities/colleges, non-profit organizations, for profit organizations,
  SC/NNSA laboratories, other federal agencies

- **Eligible Collaborations:**
  - Must be multi-institutional team; an institution can lead up to two proposals.
  - New collaborative proposals only, no renewals

Mission and Impact

- **Topical Collaboration is important to Nuclear Physics Mission:**
  - Bring together the resources of several institutions in a coordinated way to address well-defined topical areas
  - Provides support for long-term sustained efforts in these areas
- **Aligns with Nuclear Physics Program Priorities:**
  - Interpret the results of current experimental programs at CEBAF, RHIC, FRIB, and realize the full scientific potential of these programs
  - Inform the future experimental programs in these facilities and future EIC
- **NP Topical Collaboration contributes to Science Workforce Development (2016-2021):**
  - Undergraduate students trained/supported: 7
  - Ph.D. students trained/supported: 43
  - Postdoctoral researchers: 41
  - Junior faculty through joint/bridge: 6
  - Early Career Award recipients: 8

2022 FOA physics topics in the context of NP program

Major Facilities and experiments:

Argonne Tandem Linac Accelerator System (**ATLAS**)

Facility for Rare Isotope Beams (**FRIB**)

Continuous Electron Beam Accelerator Facility (**CEBAF**)

Relativistic Heavy Ion Collider (**RHIC**)

Electron Ion Collider (**EIC**)

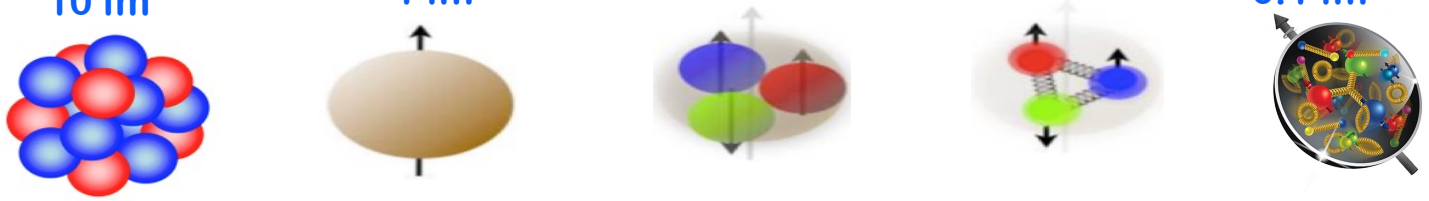
Energy Scale probed

~ 20 MeV — 200 MeV — > 2 GeV

Distance scale probed

Color Confinement — Asymptotic freedom — Q (GeV)

10 fm — 1 fm — 0.1 fm



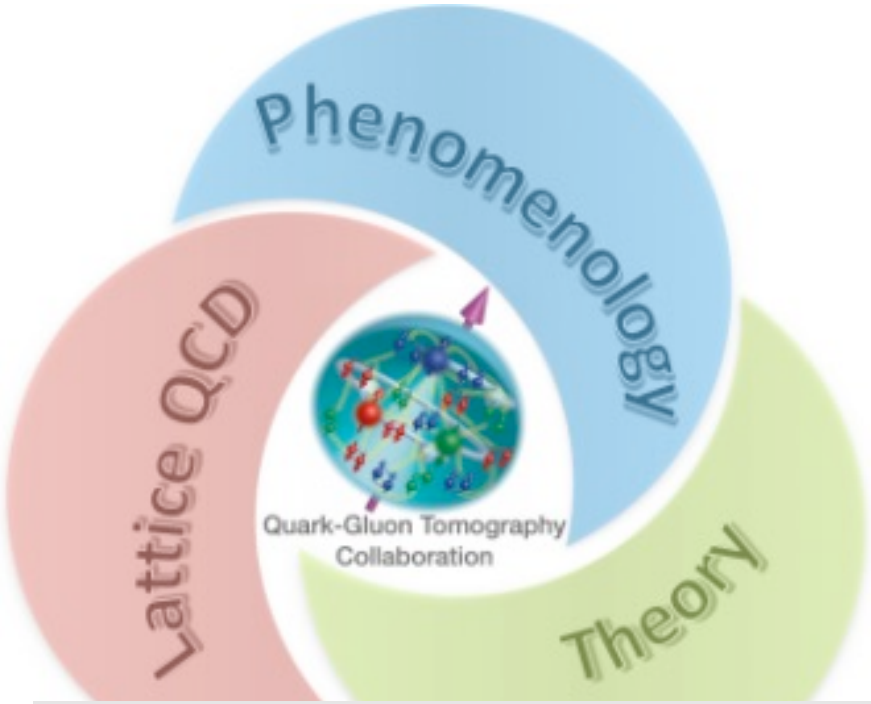
Physics topics:

- Nuclear reactions
- Fission and nucleosynthesis
- Properties of nuclei
- Nuclear structure
- Microscopic models

- Hadron spectra
- Exotic states of QCD
- Neutrino and electron interactions in nuclei and dense matter

- Nuclear tomography at femtometer scale (New)
- Properties of quark-gluon plasma

2022 Awards – 5 Topical Collaboration Projects



QGT Collaboration: 3-dimensional imaging of the internal structure of nucleons and nuclei

Title: 3D quark-gluon structure of hadrons: mass, spin, and tomography

Lead institution: Temple University

PI: Martha Constantinou

Goal/approach:

Utilizing lattice QCD computation, developing comprehensive global analysis framework for extracting 3-D GPD based on QCD factorization theorem

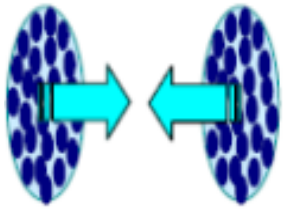
Relevance to NP mission, facilities and experiment programs:

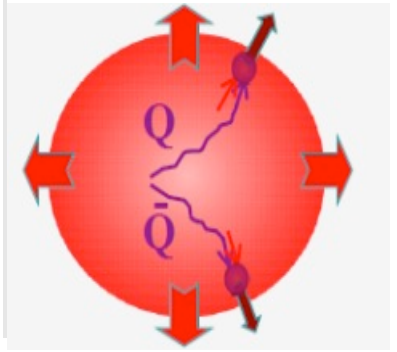
EIC and JLab 12GeV experiment programs

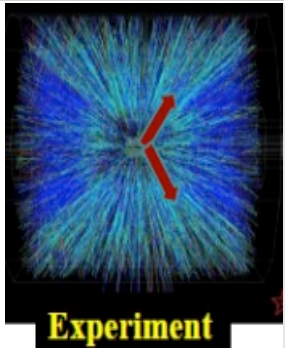
2022 Awards – 5 Topical Collaboration Projects

HEFTY COLLABORATION

Develop comprehensive heavy-quark theory to unravel properties of quark-gluon plasma (QGP) – a new state of matter created in heavy-ion collisions







Title: Heavy-Flavor Theory (HEFTY) for QCD Matter

Lead institution:

Texas A&M University

PI: Ralf Rapp

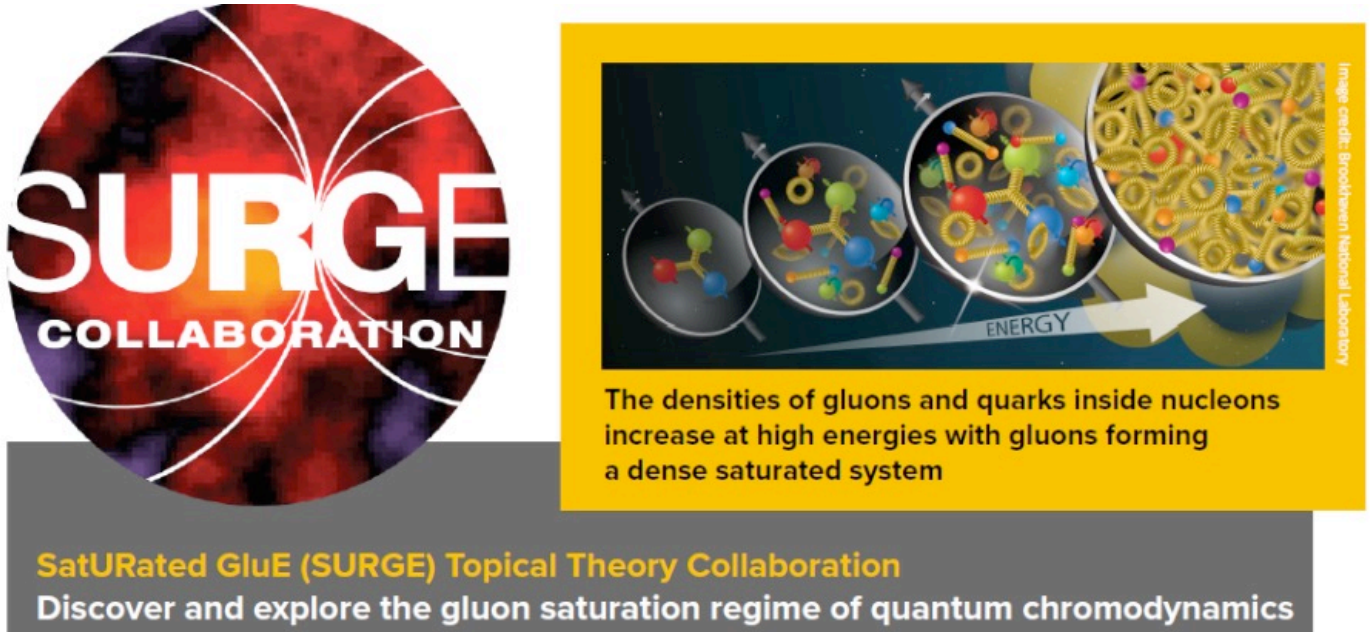
Goal/approach:

Developing framework for Heavy quarks in QCD by employing Lattice QCD computation and rigorous statistical data analysis based on effective field theory

Relevance to NP mission and NP facilities/experiment programs:

Heavy Ion program, RHIC/sPHENIX and LHCb

2022 Awards – 5 Topical Collaboration Projects



Title: Saturated Glue Topical Collaboration

Lead institution:

Brookhaven National Lab

PI: Bjoern Schenke

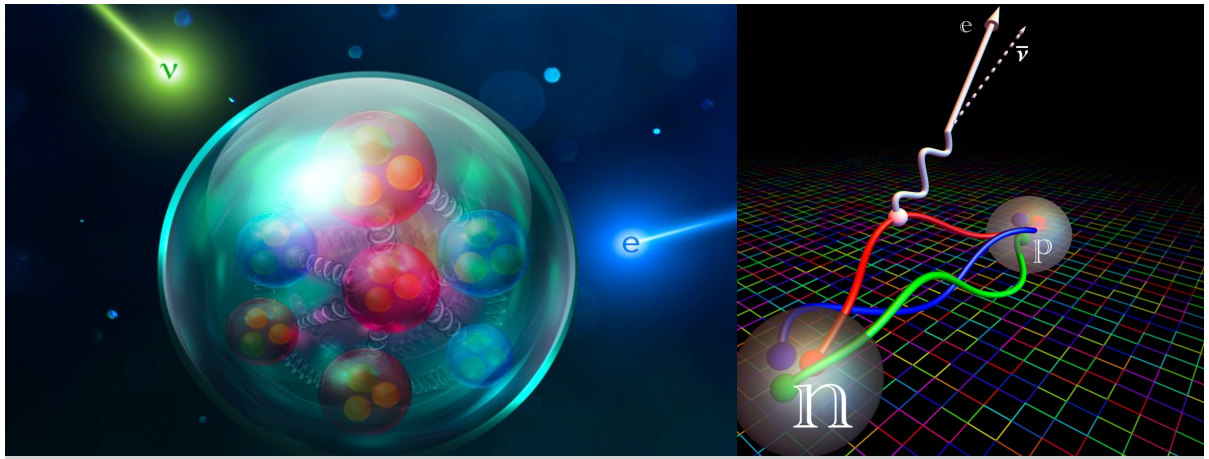
Goal/approach:

Establishing an end-to-end framework for small-x observables by employing Lattice QCD and light-cone method, developing global data analysis tool, and incorporating Monte-Carlo hadronization, to enable “day-one” discovery potential for gluon saturation and spin puzzle

Relevance to NP mission, facilities/experiment programs:

RHIC, LHC, and EIC

2022 Awards – 5 Topical Collaboration Projects



NTNP Collaboration: precision study of neutron and nuclear decays, neutrino interactions, and electric dipole moments to uncover fundamental laws of physics

Title: Nuclear Theory for New Physics

Lead institution:

University of Washington

PI: Vincenzo Cirigliano

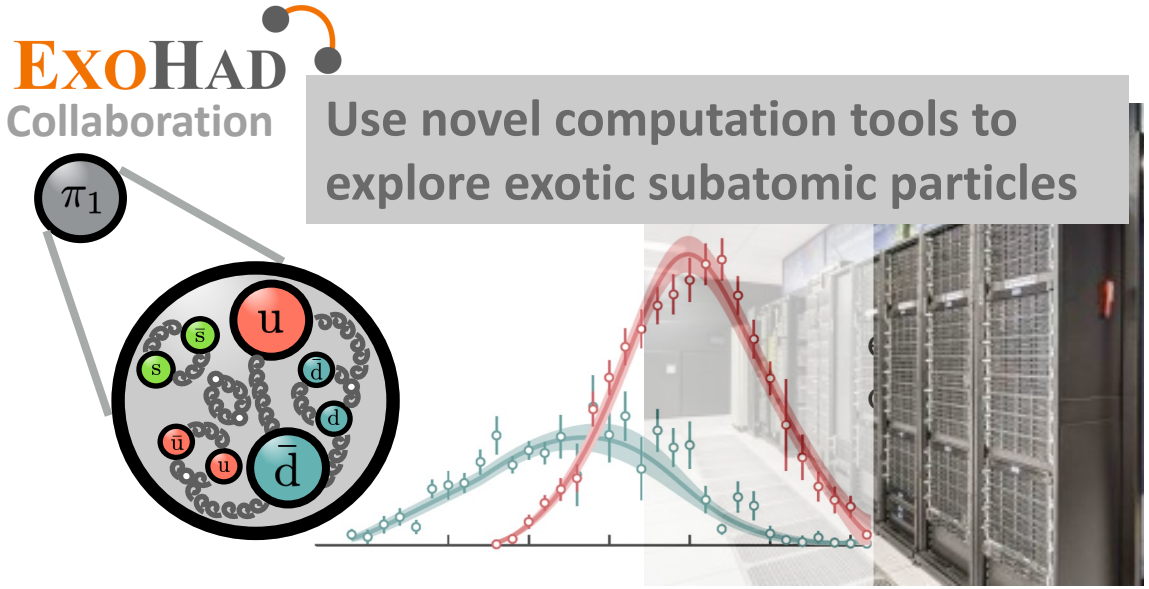
Goal/approach:

Combining Lattice QCD, nuclear many-body and effective field theory, to compute the beta decays and neutrino-nucleus cross sections with controlled uncertainties, to provide theoretical input for fundamental symmetries portfolio at FRIB, neutrinoless double beta decays and DUNE experiments

Relevance to NP mission, facilities/experiment programs:

FRIB, Double Beta Decay, DUNE experiments

2022 Awards – 5 Topical Collaboration Projects



Title: Coordinated Theoretical Approach for Exotic Hadron Spectroscopy

Lead institution:

Indiana University

PI: Adam Szczepaniak

Goal/approach:

Explore all aspects of exotic hadron physics, through the numerical computations of Lattice QCD and extraction of experimental data for a robust determination of the presence and properties of exotic hadron states.

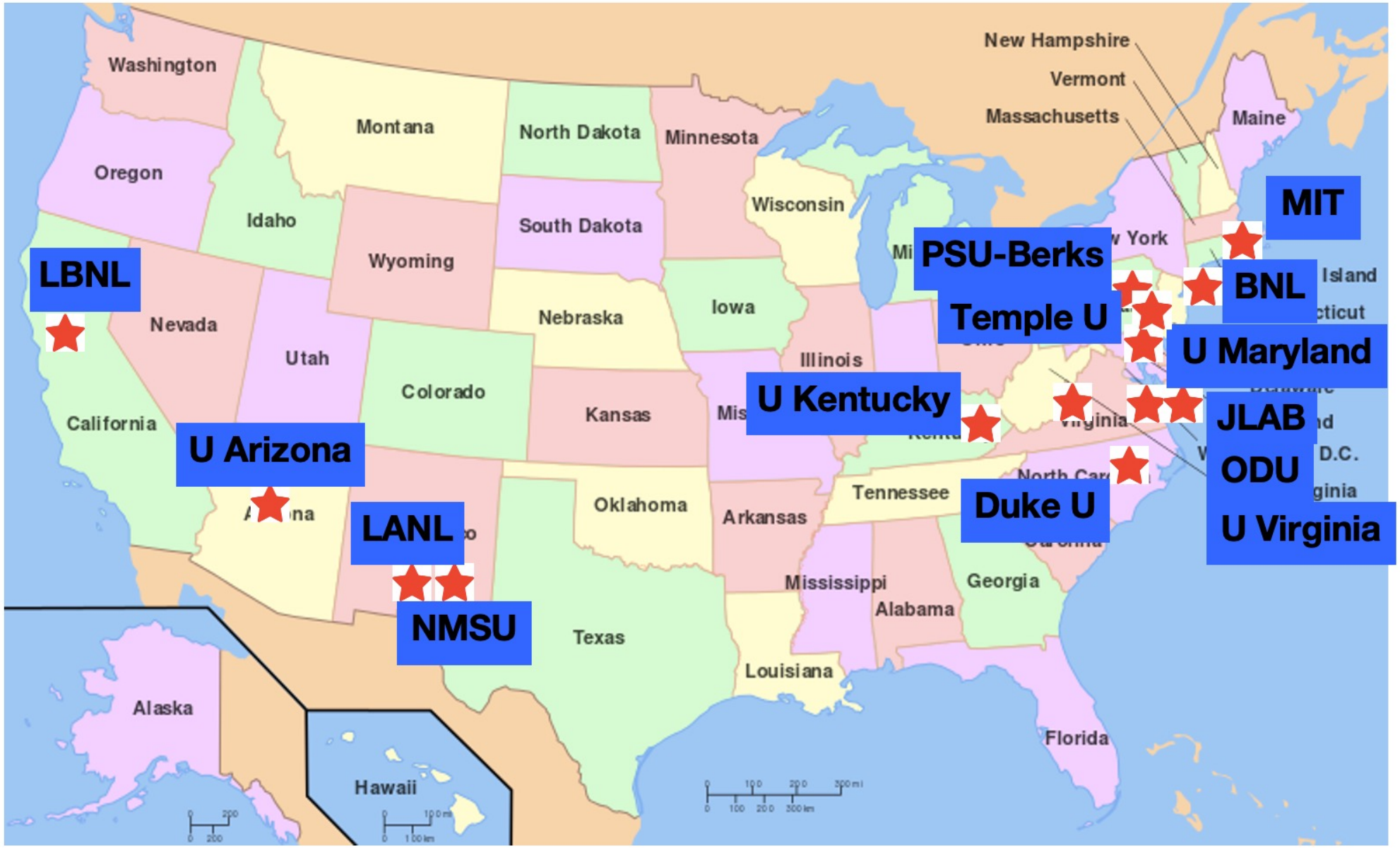
Relevance to NP mission, facilities/experiment programs:

JLab12 hadron spectroscopy experiment programs and EIC

TMD Collaboration – Response to DOE call

- Must be in support of multi-institutional teams
  - 10 States, 4 National Labs, 10 Universities
- Provide expanded opportunities for the next generation of nuclear theorists
  - Support postdocs and students, summer schools
- Support sustained interaction and communication within the network
  - Working groups, collaboration meeting, workshop, visits, Web page
- Provide a mechanism for placing new researchers in permanent positions in nuclear theory
  - Two bridged faculty positions
- Promote greater diversity, equity, and inclusion in research efforts
  - Consideration in all searching
- Foster more collaboration with underrepresented groups and minority serving institutions
  - Hampton, Temple, …

TMD Collaboration – member institutions – the team



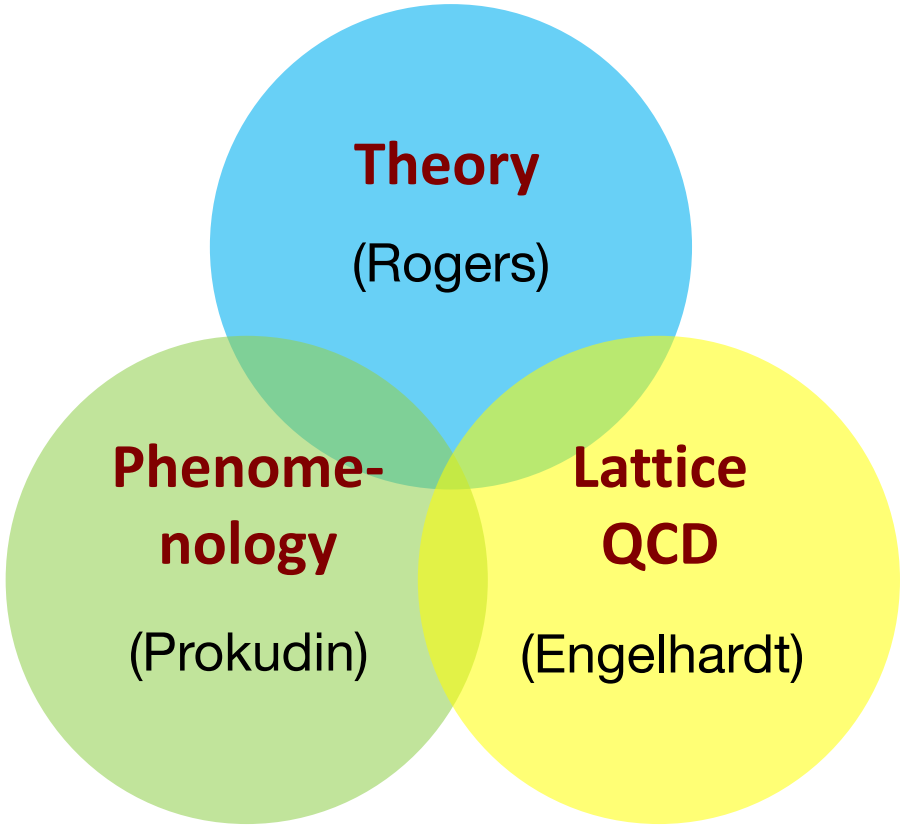
TMD Collaboration

10 States,
14 Institutions

Jefferson Lab

TMD Collaboration – Focus, Coherence, Productivity

- **Research Focus: QCD and structure of the hadrons and nuclei**
- **Physics objectives:**



Theory

– Strengthen the theoretical foundation of TMD physics;

- Scrutinize the definition,
- Broaden our knowledge on the role and impact of TMDs
- Devise new ways to access them

– connection to facilities, JLab, RHIC, the LHC, EIC

Phenomenology

– Extract TMD knowledge from experimental data

- Develop fast software to do global fit of TMDs
- Produce extensive TMDs from global fitting data
- Make them available to the community

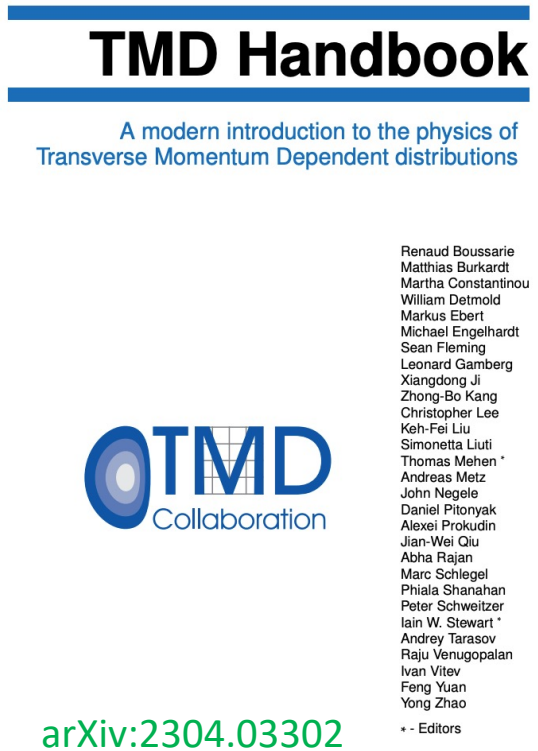
Lattice QCD

– Pursue non-perturbative calculations of TMDs

- Establish LQCD capability to study partonic structure
- Understand nonperturbative input to TMD evolution
- Explore the nature of parton orbital angular momentum

TMD Collaboration – Activities

- **Annual collaboration meetings:**
  - Organized at different collaborative institutions
  - Awareness of the TMD activities
  - Review progresses, milestone status, and the preparation of progress reports
  - Presentations of postdocs and students, strengthen the network
  - Collaboration business sessions
- **Topical and focused workshops:**
  - Solve one problem at a time
  - Connecting to experimentalists
  - Involvement of domestic and foreign affiliated members
- **Collaboration visits:**
  - Postdocs and students to travel between collaboration institutions
  - Advantage and strength of the collaborative efforts
- **Summer/Winter schools, handbook, … :**
  - Bring career opportunities and training to young nuclear theorists and the community



arXiv:2304.03302

Jefferson Lab

TMD Collaboration – Service to the Community

- TMD Summer School – June 22 – 28, 2017 (Temple University)
- TMD Winter School – January 20 – 26, 2022 (Santa Fe,

30 students

Summary

- TC functioned as a hub of experts with a common focus while having different strengths at different participating institutions to provide a unique environment for sustained interactions and communications, and development of new ideas.
- TC created networks of sustained interactions and communications through summer/winter schools, workshops, and collaboration visits/meetings, energized many young people (postdocs and students) and their interests in research, and strengthened our field with new tenure-track faculty members in theoretical nuclear physics (six for each round)
- TC is widely participated, highly leveraged from universities to create new faculty positions to strengthen the field, all proposals are evaluated by a peer review process, as well as panel review
- For TC, every nuclear theorist who has a good idea can be the PI pulling a team together to make the impact.
- TC complements to DOE's continuous support to the base research program of individuals to provide a balanced ecosystem to address today's much broader and complex challenges in theory and in supporting the experiments at much advanced and sophisticated facilities.