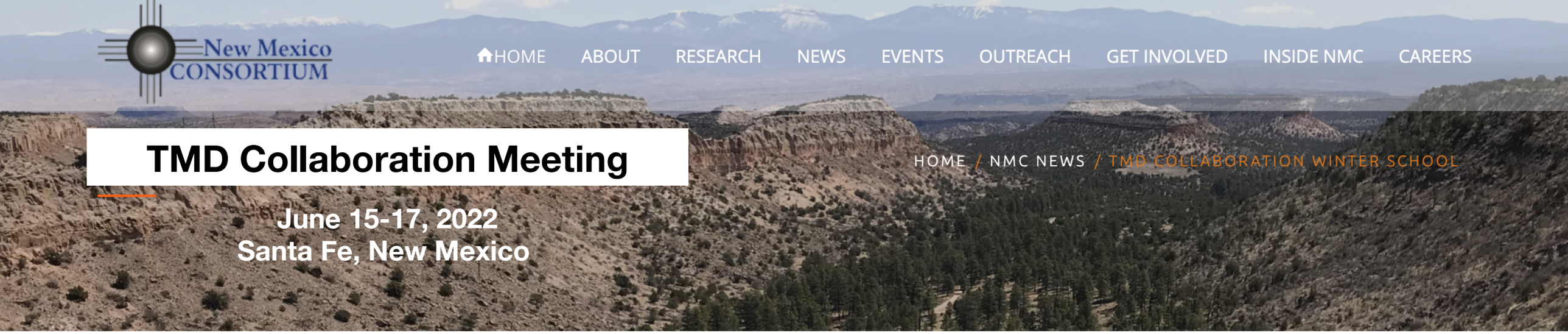

What a treat to see all of you after more than two years!

- **Exciting new development in TMD physics**
  (Morning of Wed-Fri, 9:00-12:30pm)
- **TMD Handbook – would not happen without Tom & Iain!**
  (Today at 2-3:30pm, Tomorrow 2-5:30pm)
- **Final Report:**
  Highlights – hard to achieve without the collaboration, …
  Milestones – writing assignment, deadlines, …
- **Future opportunities – NSF center, …**

Jianwei Qiu

TMD Collaboration

From: Jianwei Qiu <qjianw@gmail.com>
Subject: Urgent: TMD Annual Progress Report
Date: April 3, 2020 at 10:30:21 EDT
To: tmd-collab <tmd-collab@mit.edu>

Annual Progress Report

[for the period of January 15, 2019 (when the last report was submitted) to now]
[I also enclosed a copy of our annual progress report submitted in 2018]

1) Due on May 1, 2020 by email submission to George Fai

2) Proposed Table of Content
[similar to our Report submitted in 2018, not the same as the Midterm Report]

- Introduction
- Achievements
- Progresses
- TMD-related Publications
- TMD-related Invited Talks

3) Introduction

- **Will and Jianwei are in charge**
- **Chris and Ivan to draft a paragraph to summarize our effort for the 2nd Summer School, which represents our effort and progress although it is postponed**
- **Tom and Iain to draft a paragraph to summarize our effort on the Handbook of TMD Physics. It is good to presence this at the beginning of our report although we have a milestone on this later.**

4) Achievements + Progresses

- **These two parts are organized in terms of milestones, we decide later which milestones are put in “Achievements” and the others are in “Progresses”.**
- **If a milestone is completed as we declared in our previous report, we might want to add any additional work did, otherwise, we put a single statement, such as "the milestone is completed as previously reported.”**
- **For the milestones to be included in “Progresses”, in addition to the work done last year, it might be good for assigned leaders to add a couple of sentences at the end to give our “expectation on when this milestone will be completed.**
- **Assigned coordinator for each milestone - same as that for our midterm report:**

(1) Perform global fit of the quark Sivers functions from the DIS processes and make predictions for future Drell-Yan processes with the next-to-leading logarithmic TMD evolution

Coordinator: A. Prokudin

(2) Study scheme dependence in the TMD definitions and applications

Coordinator: T. Rogers

(3) Solidify the theoretical foundations of the relationship between space-like separated matrix elements calculated using lattice QCD and the TMDs

Coordinator: I. Stewart

(4) Extend the TMD framework to small-x in particular in the context of gluon TMDs that will be relevant at the EIC

Coordinator: R. Venugopalan

(5) Investigate factorization relevant for lattice studies of PDFs through the quasi-PDF approach using lattice regulators in perturbative matching

Coordinator: M. Constantinou

(6) Extend the work in (1) to perform global analysis of all existing data on SIDIS, Drell-Yan lepton pair production and di-hadron production in e+e- to extract a universal set of TMDs -- referred as the TMD collaboration TMD parameterization set

Coordinator: L. Gamberg

(7) Obtain a smooth description of the transverse momentum dependence of TMD-related unpolarized and polarized cross sections and a simultaneous description of the Sivers asymmetry in SIDIS and transverse SSAs for single-particle production in hadronic collisions

Coordinator: Z.B. Kang

(8) Investigate ways in which the functional forms of the non-perturbative input needed for TMD evolution can be constrained using phenomenology and lattice calculations

Coordinator: Y. Zhao

(9) Extend the effort of (1) and (6) to include gluon TMDs into the QCD global fitting project using data from observables sensitive to gluon TMDs, as well as to include all other leading power TMDs, such as Boer-Mulders function h_1 and transverse spin dependent h_{1_T}, higher order corrections and contributions from the matching Y-term, and more data

Coordinator: A. Metz

(10) Extend the work (5) to perform lattice calculations of the x-dependence of PDFs, controlling the perturbative matching and sub-leading power corrections

Coordinator: M. Engelhardt

(11) Explore the connection between parton orbital angular momentum (OAM) and physical observables

Coordinator: S. Liuti

(12) Perform lattice calculations of the quark and gluon spin, orbital, and total angular momentum contributions S_q, $L_q^{\rm Ji}$, $L_g^{\rm Ji}$, and $L_q^{\rm JM}$, $L_g^{\rm JM}$, appearing in the Ji and Jaffe-Manohar (JM) decompositions of the nucleon spin

Coordinator: K.F. Liu

(13) Extend the work in (4) to provide a quantitative understanding of TMDs at small-x

Coordinator: F. Yuan

(14) Produce a handbook of TMD physics

Coordinator: T. Mehen

5) Publications + Invited Talks

Send your TMD-related publications and Invited Talks in the relevant time period to Jianwei, who will include them into the final report.

6) Timelines:

April 10, 2020 (one week from now):

Please send your contribution to the relevant milestone Coordinators

April 17, 2020:

All Coordinators from the received contributions to produce the draft for the assigned milestone in the latex form with the standard inspires citation convention, and send them to Will and Jianwei

April 22, 2020:

Will and Jianwei will distribute a completel draft to the full collaboration for review and improvements

April 26, 2020:

All suggestions for the improvement should be sent to Will and Jianwei

April 29, 2020

Working with Coordinators, Will and Jianwei produce the Final version of the Progress Report, and send it to the collaboration for the final review (any suggestion for further improvement should be submitted immediately)

May 1st, 2020:

Jianwei submits the Progress Report to George Fai via email

CTEQ Experience:

Established for studying QCD at SSC in 1990
Funded by Texas National Laboratory Research Commission
Funding was terminated after the SSC project was stopped by congress

Collaboration still exists
CTEQ PDFs, PQCD handbook, CSS approaches, …
CTEQ Summer school annually, alternated between U. Pittsburgh and country around the world
Support: NSF/DOE equal support for CTEQ summer school
Two collaboration meetings per year: Summer school + Fall meeting (~November)

Previous TC – JET collaboration:

JET TC collaboration completed in 2015
Established a new JETSCAPE collaboration – supported by NSF

JETSCAPE

The JETSCAPE Collaboration

The Jet Energy-loss Tomography with a Statistically and Computationally Advanced Program Envelope (JETSCAPE) collaboration is an NSF funded multi-institutional effort to design the next generation of event generators to simulate the physics of ultra-relativistic heavy-ion collisions.

NSF

NSF Funding opportunities:

(1) Focused Research Hubs in Theoretical Physics (FRHTP)

Focused Research Hubs in Theoretical Physics (FRHTP) are designed to enhance significant breakthroughs at an intellectual frontier of physics by providing resources beyond those available to individual investigators, so as to promote a collaborative approach to a focused topic while promoting the preparation of scientists at the beginning of their independent scientific careers. Although interdisciplinary aspects may be included, the bulk of the effort must fall within the purview of the Division of Physics.

The successful hub will demonstrate: (1) the potential to advance science; (2) the enhancement of the development of early career scientists; (3) creative, substantive activities aimed at enhancing education, diversity, and public outreach; (4) potential for broader impacts, e.g., impacts on other field(s) and benefits to society; (5) a synergy or value-added rationale that justifies a group approach.

FY2021 call (Jan 15, 2021):

$250,000 – $850,000 per year for 5 years

Topics for the FY 2021 competition:

1. **Theoretical Atomic, Molecular and Optical Physics (TAMOP)**
2. **Quantum Information Science (QIS)**
3. **Theoretical Nuclear Physics (TNP)**

   in the area of Models and Simulations for Nuclear Astrophysics

NSF Funding opportunities:

(2) Physics Frontiers Centers (PFC)

The Physics Frontiers Centers (PFC) program supports university-based centers and institutes where the collective efforts of a larger group of individuals can enable transformational advances in the most promising research areas. The program is designed to foster major breakthroughs at the intellectual frontiers of physics by providing needed resources such as combinations of talents, skills, disciplines, and/or specialized infrastructure, not usually available to individual investigators or small groups, in an environment in which the collective efforts of the larger group can be shown to be seminal to promoting significant progress in the science and the education of students.

The successful PFC activity will demonstrate: (1) the potential for a profound advance in physics; (2) creative, substantive activities aimed at enhancing education, diversity, and public outreach; (3) potential for broader impacts, e.g., impacts on other field(s) and benefits to society; (4) a synergy or value-added rationale that justifies a center- or institute-like approach.

Recent awards:

Network for Neutrinos, Nuclear Astrophysics, and Symmetries: Wick Haxton, $3,7M
… QC …

Preliminary proposal required
Due August 1, 2022

(2) Focused Research Hubs in Theoretical Physics (FRHTP)

Focused Research Hubs in Theoretical Physics (FRHTP) are designed to enhance significant breakthroughs at an intellectual frontier of physics by providing resources beyond those available to individual investigators, so as to promote a collaborative approach to a focused topic while promoting the preparation of scientists at the beginning of their independent scientific careers. Although interdisciplinary aspects may be included, the bulk of the effort must fall within the purview of the Division of Physics.

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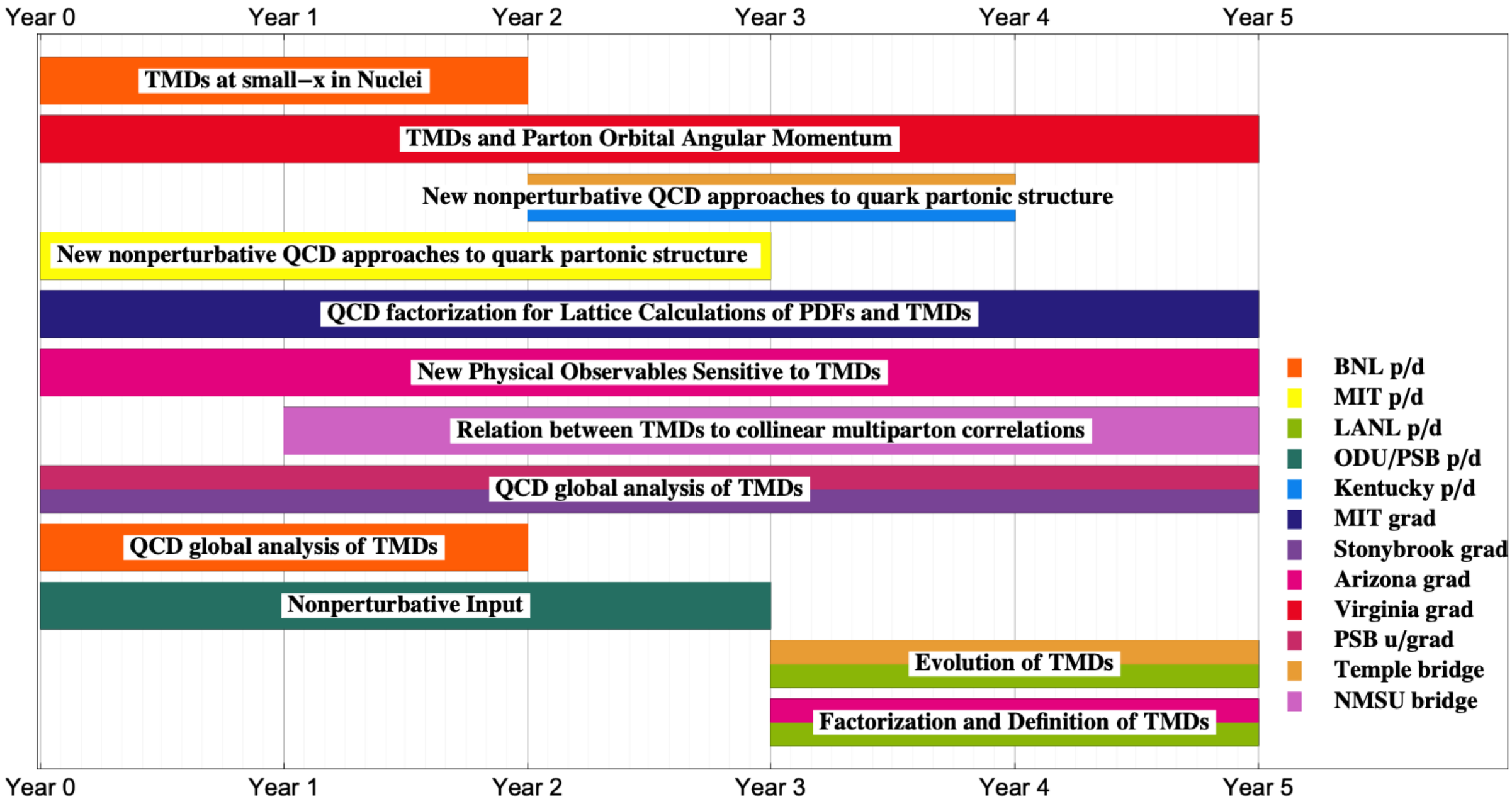
Highlights:

1. **Handbook**

2. **Summer and Winter schools, and Outreach**

3. **Global analysis –theory, lattice, phenomenology**

Timetable of Activities:



Milestones:

1. **Perform global fit of the quark Sivers functions from the DIS processes and make predictions for future Drell-Yan processes with the next-to-leading logarithmic TMD evolution (Kang)**

2. **Study scheme dependence in the TMD definitions and applications (Stewart)**

3. **Solidify the theoretical foundations of the relationship between space-like separated matrix elements calculated using lattice QCD and the TMDs (Qiu)**

4. **Extend the TMD framework to small-x in particular in the context of gluon TMDs that will be relevant at the EIC (Yuan)**

5. **Investigate factorization relevant for lattice studies of PDFs through the quasi-PDF approach using lattice regulators in perturbative matching (Zhao)**

6. **Extend the work in (1) to perform global analysis of all existing data on SIDIS, Drell-Yan lepton pair production and di-hadron production in e+e- to extract a universal set of TMDs- referred as the TMD collaboration TMD parameterization set (Prokudin & Yuan)**

7. **Obtain a smooth description of the transverse momentum dependence of TMD-related unpolarized and polarized cross sections and a simultaneous description of the Sivers asymmetry in SIDIS and transverse SSAs for single-particle production in hadronic collision**

8. **(Metz)**

Milestones:

8. **Investigate ways in which the functional forms of the non-perturbative input needed for TMD evolution can be constrained using phenomenology and lattice calculations (Rogers)**

9. **Extend the effort of (1) and (6) to include gluon TMDs into the QCD global fitting project using data from observables sensitive to gluon TMDs, as well as to include all other leading power TMDs, such as Boer-Mulders function h⊥1 and transverse spin dependent h1T , higher order corrections and contributions from the matching Y -term, and more data (Gamberg)**

10. **Extend the work (5) to perform lattice calculations of the x-dependence of PDFs, controlling the perturbative matching and sub-leading power corrections (Detmold)**

11. **Explore the connection between parton orbital angular momentum (OAM) and physical observables (Burkardt)**

12. **Perform lattice calculations of the quark and gluon spin, orbital, and total angular momentum contributions S_q, L_q(Ji), L_g(Ji), and L_q(JM), L_g(JM), appearing in the Ji and Jaffe-Manohar (JM) decompositions of the nucleon spin (Liuti)**

13. **Extend the work in (4) to provide a quantitative understanding of TMDs at small-x (Raju)**

14. **Produce a TMD handbook (Mehen and Stewart)**