Theory and computation highlights in March, 2019
(April 2, 2019)

Theory Center has been participating the Lattice QCD portion of the Exascale Computing Project (ECP) to support the development of the software infrastructure of applications and libraries, along with their testing and deployment, on the two planned Exascale machines - Aurora in FY21 (Argonne) and Frontier in FY23 (Oak Ridge). With the anticipated CD-2, the Exascale Project has recently decided to extend the funding for the Lattice QCD project through FY23 with an additional $7.7M for FY20-FY23. JLab portion will be $2.14M to support staff as well as postdocs and students. With the funding extension, new milestones for the project have been established. Successful completion of these new milestones will allow for efficient large-scale calculations of observables that will impact the High Energy and Nuclear Physics programs.

The Theory Center is very active in developing new techniques to calculate the quark-gluon structure of hadrons in Lattice QCD, and has pioneered Lattice QCD calculation of current-current correlations to extract the valence quark distribution in a pion for the first time [Phys. Rev. D (in press)]. Such effort could not be carried without significant computation time on the leadership supercomputers. A team of researchers from the Theory Center and William & Mary have been selected as an early-science team for the new NSF-funded Frontera system at the Texas Advanced Computer Center ((TACC)), and received an award of 1.8M node hours computing time allocation for study nucleon and pion structure through lattice QCD calculations, capitalizing on theoretical advances developed in the Theory Center. Frontera is a soon-to-be-deployed petascale computing system comprising over 8000 compute nodes. In addition, a team of researchers centered at JLab received an award of 6M Service Units at the Pittsburg Supercomputer Center (PSC), and 360K Service Units on Stampede2 (TACC) to enable initial studies of the systematics uncertainties in Lattice QCD calculations of hadron structure, and will provide a code-development resource for the award on the Frontera system, beginning 1st April, 2019.

The jet quenching and flow have been recognized as two key evidences for the discovery of the quark-gluon plasma, known as a perfect fluid. Theory Center postdoc, Dr. Carlota Andres and her collaborators showed for the first time that a combination of jet quenching observables is sensitive to the initial stages of heavy-ion collisions, where thermalization is expected to occur [arXiv:1902.03231]. To reproduce at the same time the suppression of inclusive particle production and the azimuthal asymmetries at large transverse momentum, the energy loss, which is responsible for the jet quenching, must be strongly suppressed at early times (<0.6 fm). Their analysis clearly shows the potential of jet observables to constrain the dynamics of the initial stages of the jet evolution.

Understanding transverse momentum dependence in semi-inclusive lepton-hadron deep-inelastic scattering cross sections entails an understanding of the large transverse momentum component generated in the collision. It has recently been noticed that there is in fact tension between existing theoretical calculations and measurements at large transverse momentum. By performing high order calculations in terms of QCD collinear factorization, Theory Center joint staff, Dr. Ted Roger, together with postdocs and student, confirms that this disagreement persists to higher order, and discusses possible resolutions [arXiv:1903.01529], which will directly impact the analyses and interpretation of upcoming JLab12 data.