Theory and computation highlights in August, 2019
(September 6, 2019)

JPAC published the paper "Interpretation of the LHCb $P_c(4312)$ Signal" in Physical Review Letters [Phys.Rev.Lett. 123 (2019) 092001]. In this paper they performed an amplitude analysis of the J/psi-p spectrum measured by the LHCb collaboration showing that data favor a virtual state interpretation for the $P_c(4312)$ pentaquark candidate. That is, the observed signal is generated by the opening of the Sigma_c Dbar0 threshold, whose meson-baryon interaction is able to produce a sizeable effect in the data but not to bind the system into a molecule. This work uses a model-independent approach and allows to gain information on the hadron signals without any prior assumption on the internal structure.

The members of the Theory Center completed a new paper [arXiv:1908.02441 [hep-lat]] to present a general, relativistic framework for studying three-hadron systems accommodating resonant or bound subsystems. This is necessary for future lattice QCD calculations of three-body systems, but it can also be used for studying scattering amplitudes of such systems given some suitable model. The paper illustrates this by determining the scattering amplitudes of a three-nucleon toy-model below threshold, where a triton-like bound state is recovered, as well as known nontrivial features of the deuteron-nucleon phase shifts.

The Center for Nuclear Femtography (CNF) Symposium was held at SURA on August 12 and 13, bringing together the teams of the multi-disciplinary projects funded by the CNF, and keynote speakers from the realms of machine learning and astrophysics/cosmology. Of the seven funded projects, three have PIs or co-PIs who are members of the Theory Center. Those projects showed the progress that had made in using machine learning to refine global analysis of parton-distribution functions (PDFs) and to predict the impact of future experiments, in visualizing data from Deeply Virtual Compton Scattering Experiments, and in accelerating the performance of lattice QCD calculations of hadron structure and the reliability of PDFs extracted from those calculations. Together, these projects will advance our ability to use current and proposed experiments, and forefront lattice QCD calculations, to reveal the three-dimensional internal structure of the nucleon. For example, C. Weiss of Theory Center participates in one of the interdisciplinary projects with the aim to apply modern digital image processing tools to the analysis of the phase space distributions measured in nuclear physics experiments. As part of this project, a two-day workshop was held at JLab on August 19-20, bringing together developers of medical imaging tools (3D Slicer, Harvard Medical School), computer scientists (mesh-based image representation, Old Dominion U.), nuclear physicists (theory and experiment), and professionals with expertise in technology transfer and startup ventures https://cepm.cs.odu.edu/CNF Imaging Workshop. The workshop discussed not only the potential use of medical imaging technology in nuclear physics problems, but also the general experience with tool development, user community building, and commercialization in the medical imaging community, which enabled new contacts between researchers and developers in different fields and may lead to future interdisciplinary projects.

The Theory Center, represented by A. Accardi, participated in the organization of the "5th International Workshop on Nucleon Structure at Large Bjorken x" (HiX2019), held at the Orthodox Academy of Crete, in Kolymbari, Crete (Greece) on August 16-21, 2019. About 60

participants gathered to discuss recent progress in determining the quark and gluon structure of the nucleon and nuclei, particularly in the valence quark region where the parton momentum fraction x is large. Recent experimental results and advances in global QCD analysis and lattice QCD calculations of the quark and gluon structure of hadrons were presented, along with plans for future experiments at JLab, Fermilab, J-PARC, RHIC and LHC. One of the highlights was the results from the MARATHON experiment at JLab, which measured the ratios of helium-3 and tritium to deuterium deep-inelastic scattering cross sections, and the extraction from these of the long-sought-after neutron to proton structure function ratio.