Research Statement

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I have a broad interest in Nuclear/Particle Spin Physics research. In the following I mention some of my present and near-future projects and just briefly mention more long term possibilities.

I have ongoing analysis projects in the spin physics of photoproduction hadronic spectroscopy using Jefferson Labs (Hall B) CLAS6 and have a keen interest in the probing of QCD and the nature of confinement using the spectrum of resonances and the search for exotic states. I am also involved in the development of machine learning algorithms to use in conjunction with polarized observables where a broad phase-space can be exploited using multilayers of classification giving a great deal more information on the contributing partial waves. I also believe it is important to be part of the next phase of Nuclear/Particle physics analysis evolution which will entail the use of increasingly sophisticated pattern recognition techniques to use in signal extraction. Incorporating experimental covariance information into these types of analyses can improve resolving power even further. Recently, I have published work on U-Spin symmetry tests of the strange sector electromagnetic decays, and have extracted transition magnetic moments, branching ratios, and cross sections with the use of these types tools using photoproduction data from CLAS6.

I am also interested in Nucleon Tomography and using processes like Deeply Virtual (DVCS), Time-like (TCS), and Wide-angle Compton scattering (WACS) to probe the nucleons internal structure. I am involved in exploring ways to impose more theoretical, analytical, and experimental constraints on the extraction framework with the intention of improving the resolution of the 3D nucleon picture as well as to improve and expand the method of proposing experiments to add to this picture. In collaboration with UVA nuclear theory and Data Science Institute we are exploiting unsupervised machine learning in dimensionality reduction of the phenomenological contributions from the helicity amplitudes for each type of process at higher twist. Our UVA effort will likely merged into a larger state wide initiative known as the Center for Nuclear Femtography which has the potential of attracting additional state funding to the department. We expect that our work will not only improve the framework of GPD and TMD interpretation but also improve the method of proposing experiments that are sensitive to tomographical information with greater precision and less experimental run time. This work has direct implication for experiments running today but also for the future. Especially relevant is the possibilities of further proposals to run at the furture Electron Ion Collider (EIC) that is likely to be build in Virginia. With the use of this new framework the EIC will provide a significantly more focused image of the internal constituents allowing for the extraction of a detailed map of the gluons and sea quarks spin, flavor, energy and charge density, spatial structure as well as uncertainty boundries. Other types of DIS, DY, and SIDIS processes can also be used together to build a comprehensive and holistic picture of the nucleons.

Several of my project at JLab have lead to innovations in hardware. Most recently at UVA I have been heavily involved in polarized targets and have developed new instrumentation as well as techniques. The most notable of these is a target rastering system, an RF spin alignment technique, a rotating target system to enhance tensor polarization, the instrumentation for optimized-Q adiabatic fast passage in solid targets, and several designs for high cooling power polarization target refrigerators. I am also part of a collaboration that designed a new compact photon source (CPS) to use at JLab. This CPS in combination with a dynamically nuclear polarized targets offers access to a whole host of physics not otherwise accessible. Capable of producing over 10^{12} equivalent photons per second, the deployment of the CPS will result in a large gain in polarized experiment figure-of-merit (about a factor of 30) for the previously mentioned WACS and TCS. I expect to continue instrumental innovation for years to come on both a independent and collaborative level.

Another important upcoming project is the experiment at the High Intensity Gamma Source (HIGS) at the Duke Free Electron Laser Lab and Triangle Universities Nuclear Lab. This experiment proposes to measure the tensor analyzing power T_{20} in deuteron photodisintegration in an energy range not covered in any previous measurement. Several measurements have shown disagreements with our current theoretical descriptions of the deuteron. The experiment will help to clarify this ambiguity and explore the possibility of exotic configurations. This project is part of a set of polarized target experiments with a frozen spin target that will be used in demonstration and preparation for an effort lead by UVA to upgraded the polarized target for the HIGS2 facility. The new HIGS will have more than two orders of magnitude higher gamma-ray beam intensity than is currently available at HIGS. Along with the greater intensity the new target system requires multiple field orientations, an active (scintillating) polarized target, and new NMR manipulating technology. A design for this new target system is underway.

I am in a leadership role in several major experiments and assist on a contributing level on many others. I am Spokesperson, Collaboration Chair, and Contact on a large scale experiment at Fermilab to measure the Sea Quark contribution to the protons spin. This project has received full funding and is the first experiment to measure not only the sign, but also the magnitude and shape of the Sivers function with sub-percent precision directly using the dynamics of the sea quarks. The project has significantly increase the UVA profile with Nuclear DOE. The success of this experiment greatly depends on UVA leadership and experience with polarized target systems. This experiment is on the proton beam intensity frontier and there are many new aspects to the target that will be the fist of their kind.

Given a successful run at Fermilab it will be worth exploring what other innovative projects might be possible with a similar setup. One example could be a longitudinal polarized target to measure semi-inclusive di-muon processes which may give more direct information on orbital angular momentum using GPDs. It may also be possible to make a photon beam source using the FNAL proton beam. Polarizing a photon beam will give access to the double-polarized observables and might give the opportunity to probe the connection to the total quark angular momentum sum rule for a polarized spin-1 hadronic system. In addition, polarized proton-deuteron Drell-Yan processes can be explored by studying the tensor-polarized antiquark distributions. If we find that the deuteron has an exotic quark signature, it may open a new field of spin physics.

I have recently been invited to join the next generation of the LHCb effort which is likely to include a version of a polarized target. There is much information to be gained at higher energy in both hadron spectroscopy and in gluon quark imaging using TMDs, GPDs and the evolution of the fluctuating proton structure. In addition, using the Λ spontaneous polarization from pp collisions at 7 TeV can be used to extract transverse polarization observables as a function of P_T and compared to lower energy Λ spontaneous polarization at JLab from photoproduction. The prospects of expanding the LHCb project to include polarized fixed target physics would allow for the extraction of more observables in the search for exotics created by the excitation of the gluonic field, physics with helicity correlations and spin dependent information on hadronic structure as well as interesting heavy ions physics. Such a configuration gives access to unique kinematic sensitivity with $\sqrt{s} \approx 115$ GeV which is between SPS and RHIC. This would be an effort that could materialize in a few year to come but would still be much sooner than the EIC and offer some similar physics not otherwise accesssible.

In short, I am highly motivated to work on problems that will open the door to new types of experiments that can access information not otherwise obtainable. I enjoy a challenge and am continuously seeking avenues to be creative.