

1.0 "Physics potential of polarized light ions with EIC@JLab"

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Project Status

Project execution started 01 Dec 2013. A postdoctoral fellow in experimental physics, Dr. Kijun Park, is working for the project at 50% FTE per agreement with Old Dominion University, as planned. Project schedule and first-year deliverables were revisited in view of the compressed timeline, and short-term visits of the senior theory collaborators were arranged on short notice to accelerate the startup (M. Sargsian 1 week in Jan; V. Guzey 2 weeks in Jan/Feb). No major changes to the overall schedule were deemed necessary; only a minor adjustment was made re the implementation of nuclear shadowing and final-state interactions (see below). Mechanisms for communication and documentation were put in place (regular meetings, project Wiki at https://eic.jlab.org/forward_tagging/, github for code development). Results obtained so far:

- 1) Developed cross section model for unpolarized e - D DIS with spectator tagging in EIC kinematics, implementing state-of-the art theoretical methods to account for nuclear binding effects (codes available, documentation in preparation, testing on-going). Prepared extension of formalism to polarized e - D ; no major obstacles foreseen.
- 2) Developed two independent event generators for e - D DIS at EIC with spectator tagging: (a) using FSGEN framework adapted from existing fixed-target code; (b) newly developed scheme for collider kinematics, which includes intrinsic momentum spread of beam particles (codes posted on github, documentation on Wiki, testing on-going)
- 3) Performed MC simulations of spectator tagging in unpolarized e - D with MEIC, including on-shell extrapolation to extract free neutron structure function. Studied effect of intrinsic momentum spread of beam particles and detector resolution. Results so far indicate that on-shell extrapolation is well feasible with MEIC beam and detectors, providing basis for extension to spin structure functions (results available on Wiki, reported at conferences [1,2,3], testing/documentation on-going)
- 4) Exported spectator-tagged e - D events to GEMC-based MEIC detector MC to enable first study of particle tracking and detector acceptance effects.
- 5) Developed theoretical formalism to compute shadowing and final-state interaction effects in tagged deuteron DIS at $x < 10^{-1}$ (technical note on Wiki, code developed, MC implementation in progress). This part of the agenda was moved ahead because (a) the theory could be made ready on short notice; (b) it was realized that these effects are an important factor in the overall systematic uncertainty of neutron structure extraction with spectator tagging at $x < 10^{-1}$.

Preliminary results were disseminated in conference presentations to different audiences (nuclear/accelerator/general physics) [1,2,3], and more presentations at international conferences in deep-inelastic scattering are coming up [4]. Contributions to proceedings (to be posted on the HEP archive) are in preparation. A journal publication summarizing the prospects for unpolarized neutron structure extraction with forward tagging is in planning.

Altogether, the project is well on track to meet the 6-month milestone: *"Feasibility of spectator tagging with unpolarized 2H: Neutron structure, bound nucleon (codes, tech. report)."*

Broader interest and collaboration with Users: The progress of the LDRD project is generating demonstrable interest among JLab Users and in the broader scientific community. Charles Hyde (ODU) has followed our efforts from the start and made valuable contributions to the MC generator development; he is particularly interested in using the capabilities of MEIC for future studies of neutron DVCS with spectator tagging. Abhay Deshpande (Stony Brook/RIKEN BNL) has proposed to use our results to simulate precision measurements of the Bjorken sum rule with polarized e -D and spectator tagging at MEIC. Sebastian Kuhn (ODU) is interested in extending the spectator tagging method to semi-inclusive DIS (involving analysis of the current jet with the central detector) and has offered to participate in future joint studies. Very recently, the Tel Aviv group (Eli Piasetzky, Or Hen) have approached us with the suggestion to study short-range NN correlations with spectator tagging at EIC; they have already performed exploratory studies at their own initiative. We plan to collaborate with these groups in a suitable framework separate from the LDRD project proper, providing them with the infrastructure developed through the project (physics models, generators) and technical advice.

Project Plan

R&D for the remainder of the year will focus on (a) implementing deuteron polarization and final-state interactions in the cross section models for e -D with spectator tagging; (b) performing realistic process simulations for MEIC, including effects of intrinsic beam momentum spread and detector acceptance and resolution, and extracting partonic structure from simulated data; (c) preparing the physics model and generator for polarized ^3He , to be studied in the 2nd year; (d) testing, documenting, and publishing codes/results obtained so far. No major changes to the original schedule are foreseen. The main goal is to meet the year-end milestone: *"Feasibility of neutron spin structure with polarized 2H spectator tagging (codes, tech. report, publication)"*

Because of recently imposed restrictions on visits of Russian scientists at DOE labs it is likely that Dr Vadim Guzey (Petersburg Nuclear Physics Institute) will not be allowed to perform work at JLab in Summer 2014. While this is very unfortunate, we have taken steps to ensure that we shall be able to meet the needs of the LDRD project and achieve our overall objectives in the new situation. Dr Wim Cosyn (Ghent U., Belgium) has agreed to come to JLab for 6 weeks in May and July/August and take over the work of developing the physics model for polarized deuterium, under the supervision of the senior collaborators (Weiss, Melnitchouk, Sargsian), and based on input provided by Dr Guzey earlier. Dr Cosyn is a young postdoc in nuclear theory, with a strong record and excellent reputation, and is already actively collaborating with Sargsian and Melnitchouk on related subjects. He is well qualified to perform the task. Dr Cosyn has taken a keen interest in the LDRD project and regularly attended our meetings. He presently holds a postdoctoral fellowship from the Research Foundation Flanders (3 + 3 years, until Sep 2015), which gives him considerable flexibility in going abroad and working for us on a short-term contract.

Dr Guzey has graciously assured us that he will continue the scientific collaboration with us remotely and provide specific input to the LDRD project irrespective of the political situation. The theoretical framework for shadowing in spectator-tagged structure functions has in large parts already been worked out by him and communicated to us during his LDRD-supported visit at JLab in January/February, so that the implementation in a cross section model and the writing of a code can now be taken over by Dr Cosyn. Should the situation change in the near future, we would make every effort to get Dr Guzey to come JLab and work here in the 2nd year of the project, as planned.

Budget

Budget use of the project in FY2014 is on track; no issues foreseen. The unused funds marked for staff salary and postdoc labor in October/November 2013 were used in part for a 2-week visit of Dr Guzey in January/February (to accelerate startup), and will be used further to expand the effort of the JLab investigators or the postdoc in the coming months of FY2014 on a flexible basis (to accelerate work on publications, code testing, documentation), in keeping with our overall mission. The work of Dr Cosyn in summer 2014 is covered by the funds originally marked for Dr Guzey, so the change does not impact on the overall budget.

Publications

Workshops/Conferences

1. C. Weiss, *"Polarized Deuterium Physics with EIC,"* Presentation at Tensor Polarized Solid Target Workshop, Jefferson Lab, March 10-12, 2014, JLAB-THY-14-1859
2. C. Weiss, *"Next-Generation Nuclear Physics with Forward Proton/Neutron Detection at MEIC,"* Presentation at Accelerator Science and Technology for the Electron-Ion Collider (EIC14), Jefferson Lab, March 17-21, 2014, JLAB-THY-14-1860
3. Kijun Park et al., *"Neutron structure via forward tagging of the $eD \rightarrow e'NX$ reaction at the Electron-Ion Collider,"* Presentation at APS April Meeting, Savannah, GA, April 5-8, 2014
4. V. Guzey et al, *"Physics opportunities with tagged deep inelastic scattering on polarized light nuclei at EIC,"* Presentation accepted at XXII. International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2014), Warsaw, Poland, April 28 - May 2, 2014