PR12-25-003: *Final-State Interactions Studies in Deuterium at Very High Missing Momenta*

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As a followup of the Letter of Intent (LOI 12-24-005), this proposal aims to measure the $d(e, e'p)n$ reaction in Hall C with a 10.55 GeV electron beam incident on a 10 cm long liquid deuterium target. The scattered electrons will be detected by the Super High Momentum Spectrometer (SHMS) in coincidence with the knocked-out protons detected by the High Momentum Spectrometer (HMS), and the recoil ("missing") neutrons will be reconstructed from momentum conservation. The proposed measurement will focus on the kinematic region with high missing neutron momentum $p_m = 800$ MeV/c at $Q^2 = 4.5$ (GeV/c)^2 and measure the unpolarized absolute cross sections for three central neutron recoil angles: $\theta_{nq} = 49^0, 60^0, 72^0$ relative to the direction of momentum transferred from the scattered electron to the deuterium target.

The main goal of the proposed experiment is to study the final-state interactions (FSI) between the outgoing proton and neutron in the proposed $d(e, e'p)n$ reaction at very high missing neutron momentum p_m. The knowledge of such FSI is critically important for identifying and discovering the onset of non-nucleonic components in nucleon-nucleon correlations, which is crucial for understanding the dynamics of short-range correlations in nuclei as well as superdense nuclear matter relevant to the cores of neutron stars.

In its appendix, the proposal clarified that the focus of this proposed experiment is to understand and quantify the role of the FSI in the $d(e, e'p)n$ reaction at the unprecedented large missing neutron momentum $p_m = 800$ MeV/c at various central neutron recoil angles, rather than searching for the onset of the non-nucleonic components at this kinematics, and addressed the questions and comments raised by PAC to the LOI.

We found that the proposed experiment is important for understanding the FSI in this new kinematics regime which is necessary for our study to understand the repulsive core of the short-range proton-neutron correlation and to discover the onset and characteristic features of non-nucleonic components of short-range nucleon-nucleon correlations, which is a fundamental properties of QCD and strong interaction physics.

Previous experiments and the simulation results in Fig. 14 showed a strong angular dependence of FSI with respect to the neutron recoil angle θ_{nq} relative to the direction of momentum transferred from the scattered electron to the deuterium target. Since the proposed experiment only measures scattered electron and the knocked-out proton, the "missing" neutron will be reconstructed from momentum conservation, any collision-induced photon radiation would not be measured and it could alter both the direction (θ_q in Fig. 6) and the value of exchanged virtual photon momentum q between the electron and the deuterium. Since the central neutron recoil angles are defined relative to direction of momentum transferred from the scattered electron to the deuterium target ($\vec{q}$), a careful simulation and control of such collision-induced radiation will be needed and important for the proposed study of FSI.