PR12-17-012A *Tagged EMC Measurements on Light Nuclei*

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— Revised report —

This Run Group Proposal aims to use spectator-tagged deep-inelastic scattering (DIS) on light nuclei as a means to control the state of the active nucleon during the DIS process and explore the dynamical origin of the EMC effect. The targets and breakup channels are $d(e, e'p)X$, ${}^4\text{He}(e'e'^3\text{H})X$, and ${}^4\text{He}(e'e'^3\text{He})X$, and the $A-1$ remnant would be detected at recoil momenta $P_{A-1} \sim$ 70–400 MeV/c. The proposed setup exploits the ALERT detector's capability to identify low-energy and wide-angle hadrons and the large acceptance of CLAS12.

Despite many years of effort the dynamical origin of the EMC effect observed in inclusive nuclear DIS $A(e, e')X$ remains poorly understood. Theoretical explanations rely on various assumptions about the modifications of partonic structure due to nuclear binding, such as a change of the average nucleon properties in nuclei, the suppression of point-like configurations, and a possible connection with short-range NN correlations. Inclusive measurements alone cannot distinguish between the different scenarios. Essential progress could come from measurements in which one controls the configuration of the active nucleon during the DIS process by detecting the nuclear breakup in the final state, as is the goal of the present experiment. By measuring the dependence of the tagged structure function on the recoil momentum one can vary the virtuality (off-shellness) of the active nucleon in the initial state, which is seen as the main variable controling the nuclear modifications. A challenge arises from the fact that the recoil momentum dependence is generally also affected by nuclear final-state interactions. It is expected that with theoretical models (to be tested and refined with the forthcoming data) and judicious choice of kinematics (angular dependence on recoil momentum, backward/sideways regions) one would be able to disentangle nuclear initial-state modifications and final-state interactions.

The proposed method is particularly effective in tagged DIS on the deuteron $d(e, e'p)X$, where detection of the recoiling proton completely fixes the virtuality of the active neutron in the PWIA. Furthermore, for the deuteron detailed model calculations of FSI effects are available, which could be tested further with the expected data and used to separate nuclear initial-state modifications and FSI. The proposed measurements could thus significanlty enhance the understanding of the EMC effect, and at the same time provide valuable information about nuclear FSI.

The interpretation of the proposed measurements on $A > 2$ nuclei with breakup into an $A-1$ system is generally more challenging. The present predictions shown in the proposal are based on the spectator mechanism, which assumes that the nuclear modification of the $A \rightarrow A - 1$ "tagged" structure function is due to nuclear binding effects in the initial state and described by the nuclear momentum distribution. FSI arise mainly from "slow" hadrons produced in the DIS process on the active nucleon (with momenta $\sim<$ 1 GeV in the nuclear rest frame), which are fully formed inside the nucleus and interact with the spectators with hadronic cross sections. While it is correct that FSI are generally suppressed in events with recoil of a bound $A - 1$ nucleus, and at backward recoil angles $\sim 180°$, their effects could still be of the same order as the expected initial-state modifications. The analysis should eventually be performed within a comprehensive theoretical framework that incorporates both effects. The development of such a framework requires data on nuclear breakup in DIS over a wide range of recoil momenta, as would be taken in the proposed experiment, including the measurements on the deuteron. The proposed experiment would thus enable and stimulate further theoretical research in this area. We note that DIS with detection of nuclear final states is also being studied as a next-generation measurement with a future Electron-Ion Collider, and that the theoretical development stimulated by this 12 GeV experiment would be synergistic with that effort.