JLab Experiment PR12-14-012
Measurement of the spectral function of ^{40}Ar through the $(\mathrm{e}, \mathrm{e}'\mathrm{p})$ reaction

The correct interpretation of the signal detected by high-precision neutrino-oscillation measurements requires an accurate description of neutrino cross sections. At the kinematics of accelerator-based experiments, such as the Deep Underground Neutrino Experiment (DUNE), neutrinos predominantly interact with nucleons bound in target nuclei. Under these conditions, the treatment of nuclear effects in data analysis plays a crucial role, and is now considered one of the main sources of systematic uncertainties.

A considerable effort is currently being made to develop theoretical models capable of providing a fully quantitative description of the neutrino-nucleus cross sections in the kinematical regime relevant to DUNE. In particular, the approach based the spectral function formalism has proved very successful in explaining the electron-nucleus cross sections, measured in a broad kinematical range using a variety of targets. The application of this approach to the analysis of neutrino interactions, however, requires the availability of accurate models of the spectral functions for the nuclei employed in neutrino detectors. Of paramount importance, in this context, is $^{40}_{18}$Ar, to be employed in the detectors of DUNE.

We propose a measurement of the coincidence $(e, e'p)$ cross section for argon. This data will provide the experimental input indispensable to construct the argon spectral function, needed to achieve a reliable estimate of the relevant neutrino cross sections. In addition, the analysis of the $(e, e'p)$ data will promote theoretical developments, such as the description of final-state interactions (FSI), necessary for the correct interpretation of events collected by neutrino experiments. Note that the role of FSI increases with the atomic number, making their accurate estimate in argon even more significant than that in the carbon nucleus, the target in many recent oscillation experiments.

The 9 PAC days of beam time at 2.2 GeV include a single day for calibration and 8 days for the measurement of the $(e, e'p)$ cross section in both parallel and antiparallel kinematics. Our planning accounts for radiative losses and we will use part of one day to measure backgrounds. This measurement, in kinematics selected to minimize FSI, will provide the only available high-statistics sample of electron scattering single nucleon knockout data for argon. Besides yielding previously unavailable information on nuclear structure and dynamics, the analysis of the argon data will provide the input needed to improve the simulation of neutrino interactions in liquid-argon detectors, thus reducing the systematic uncertainties in the analysis of neutrino-oscillation experiments such as DUNE.