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Study of $\gamma d \rightarrow pn$, and $\gamma d \rightarrow p\Delta^0$ reactions for small momentum transfers

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The experimental identification of quark effects in nuclei would constitute an important progress towards the understanding of the nucleus in terms of fundamental strongly interacting particles, and would clarify the mechanisms underlying the transition from the nucleonic degrees of freedom to the quantum chromodynamics (QCD) based description of the nucleus.

To this respect, the study of deuteron with electromagnetic probes of high (and, may be, intermediate) energies has very interesting features. In fact, the deuteron is the simplest nucleus, and allows the best separation of nuclear structure ambiguities from reaction mechanism ambiguities.

Cross sections for photodisintegration of deuteron have been measured up to 4.2 GeV and discussed theoretically with a number of models. Anyway, at present there are no calculations available which describe the whole set of information which one can deduce from the experiments, Moreover, it is not clear whether the conventional theory with nucleon, meson and isobar degrees of freedom alone will be able to describe the experimental results or some basic ingredients (like quark-gluon degrees of freedom), which are still missing in the current theory, are of fundamental importance.

We propose an accurate measurement of the cross section for the $\gamma d \rightarrow pn$, and $\gamma d \rightarrow p\Delta^0$ reactions between 800 and 1500 MeV in suitable kinematics conditions in order to:

a) Test if $\gamma d \rightarrow pn$ and $\gamma d \rightarrow p\Delta^0$ reactions obey to the same energy behavior which is predicted for hadronic reactions by the QGS model, checking whether the energy behavior of these reactions at fixed t is consistent with the contributions of the nucleon and Δ trajectories, respectively;

b) Verify the QGS model prediction of the appearance of the forward and backward peaks in the angular distributions of the $\gamma d \rightarrow pn$ reaction; and measure the values of the forward-to-backward ratio of the cross sections;

c) Overlap measurements at other laboratories and provide an accurate data set over broad angular and energy ranges to test the different theoretical models of deuteron from low energies, where pion exchange phenomena are dominant, to higher energies, where quark phenomena are expected to appear.

We propose to use the CEBAF Large Acceptance Spectrometer (CLAS) and the Hall B photon tagger which will allow to obtain data with reduced uncertainties over a broad kinematics region.

A trigger for an event will be a proton count in one of the scintillators.

For 570 hours of requested beam time we expect that data accumulated in angular bins of about 10° and energy bins of 100 MeV will have 0.7% and 2.5% statistical errors (neglecting background), respectively at the lower and higher end of the energy range. We estimate a total systematic error of about ≤ 3 %.