Abstract

We propose to measure the differential cross section of ^{3}He(γ, d) at center-of-mass deuteron angles of 45° and 90° for incident photon energies between 300 and 2000 MeV. This experiment is an extension of existing and proposed measurements of the reactions $d(\gamma,p)n$ and $d(\gamma,d)\pi^0$. This and the other proposed measurements represent a crucial test of quark models of nuclei via the Reduced Nuclear Amplitude or constituent counting formalisms. The constituent counting rule predicts a cross section dependence of s^{-17}, while the Reduced Nuclear Amplitudes predict an even faster drop with incident energy. Thus ^{3}He may be the heaviest nucleus (and only "real" nucleus) that can be studied in an energy region where one of these models may apply to exclusive two body reactions. Depending on how rapidly the cross section drops with photon energy, this proposal has the potential to extend the maximum energy of existing ^{3}He(γ, d) measurements by about a factor of four.

1 Introduction

Photonuclear knockout reactions are characterized by a large transfer of momentum to the knocked out particle. Because such (γ, X) reactions can reach higher momentum transfers than the typical $(e, e'p)$, they are appropriate for CEBAF's role in exploring the transition between a nuclear and a quark description of nuclei. Measurements of the reactions $d(\gamma,p)n$ and $d(\gamma,d)\pi^0$ at several fixed center of mass angles are already planned at CEBAF[1]. Such highly exclusive reactions drop quickly with increasing A or incident energy, but a measurement of the reaction ^{3}He(γ, d) over a modest energy range is both possible and a desirable addition to the planned deuteron measurements.

Perturbative QCD can make predictions of the asymptotic energy dependence of two-body reaction processes. These predictions are presented as "constituent counting rules"[2, 3, 4, 5, 6] which state that for a fixed angle scattering of hadrons $A + B \rightarrow C + D$ at high energies, the asymptotic form is

$$\lim_{s\rightarrow\infty} \frac{d\sigma}{dt}(A + B \rightarrow C + D) = f(\theta)s^{2-(n_A+n_B+n_C+n_D)}, \tag{1}$$

where $s = (p_A + p_B)^2$, $t = (p_A - p_C)^2$, and the n_x's are the minimum number of fields or constituents in each particle. Despite theoretical uncertainties, this counting rule work well for scattering reactions involving elementary particles. For example, this rule predicts that elastic proton-proton scattering is proportional to s^{-10}, while experimentally, the behaviour $s^{-9.7\pm0.4}$ is observed. For photonuclear reactions, the reaction $\gamma p \rightarrow \pi^+ n$ follows the expected s^{-7} scaling for $s > 5$ GeV^2[7] as seen in figure 1a. There are equivalent counting rules for form factors. Figure 1b shows the form factors for the pion, proton and neutron. These form factors have been divided by the expected asymptotic behaviour of Q^{2-2n}, showing that by Q^2 of 4 (GeV/c)^2, the counting rule applies.