Abstract

We propose a precision measurement of A_e, the electron helicity flip asymmetry, in the reaction $p(\vec{e}, e'p)\pi^0$ over the $\Delta(1232)$ resonance at Q^2 of .3 and .4 $(\mathrm{GeV/c})^2$. The observable A_e is interesting because it is sensitive to the G_C (charge) form factor in the N→ Δ transition, and a non-zero value for this form factor would suggest nucleon or Δ deformation. A_e is also of interest because its relatively simple multipole structure may simplify the treatment of Born backgrounds. We show this important out-of-plane measurement is possible due to the large vertical acceptance of the HMS-SOS spectrometer system for $Q^2 \geq .3$ $(\mathrm{GeV/c})^2$.

1 Introduction

1.1 Physics Motivation

The Δ(1232) resonance has a very special place in N^* physics. It is the least massive baryon resonance, the most strongly excited at low Q^2, and it is relatively well separated from other resonances. Its first-order quark structure, three spin-aligned quarks in relative s-states, is well known. Because effects of the Δ are ubiquitous in intermediate energy nuclear physics, Hamiltonian models exist which incorporate the $\Delta \rightarrow N\pi$ transition and the effects of off-shell pion rescattering. Measurements are simplified by the fact that the Δ tends to decay into two-body final states: $N+\pi$ (99.4%) or $N+\gamma$ (.6%). For these reasons, the Δ(1232) is an ideal candidate for modern precision studies of baryon structure which go beyond the first order quark model.

Isgur and collaborators [1] have predicted that both the N and Δ have small d-wave components due to quark-quark hyperfine interactions. These components would permit a very small E2 amplitude (E2/M1 $\simeq$ .007) in the $\Delta \rightarrow N\gamma$ transition. (C2 amplitudes were not estimated because only $\Delta \rightarrow N\gamma$ *decays* were considered.) In a nonrelativistic model with no hyperfine interactions, the quark wave functions for the N and Δ are L=0 and so cannot be coupled by the L=2 quadrupole operator. The transition is then purely M1 [2]. Complicating this tale is the observation of Bienkowska *et al.* [3] that the use of relativistic wave functions yields E2/M1 = -.002 even in the absense of tensor forces. Isgur *et al.* also mention a number of apparent successes of the quark-quark hyperfine interaction, and propose the search for E2 admixtures as a way to rule out an alternative explanation in terms of spin-orbit effects.

There is also evidence from bag models of non-strange baryons that at least some baryons may be deformed. Viollier *et al.* [4] found that the one-gluon exchange interaction caused the Δ bag to become deformed as much as 30%. Meanwhile, minimum energy was obtained for the nucleon bag when it was given zero deformation. Murphy and Bhaduri [5] have investigated deformation as a means of improving the description of higher mass resonances such as the N(1440) and the N(1710), while maintaining the successes of the spherical model of Isgur and Karl. [6]

Many researchers believe that possible deformation of the nucleon and Δ is a question of fundamental importance. There are other pieces of circumstancial evidence which suggest