Exclusive ρ^0 Production in Polarized DIS at SMC

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Preliminary spin cross section asymmetries for exclusive ρ^0 lepto-production, $\vec{\mu}+\vec{N} \to \mu'+N+\rho^0$ ($\rho^0 \to \pi^+\pi^-$), are reported. These asymmetries have been determined for the first time by the Spin Muon Collaboration (SMC) at low Q^2 (photoproduction) and at large Q^2 (DIS) for different p_T^2 intervals in the kinematic range $0.01 < Q^2 < 60$ GeV^2 and $140 <$ W$^2 < 310$ GeV^2 ($< W >\simeq 15$ GeV) for the full SMC data set. About 100 K ρ^0's have been selected for $0.62 < m(\pi^+\pi^-) < 1.07$ GeV/c^2 and $|I| < 0.05$. Within the statistical precision, no significant asymmetries have been observed at low Q^2 in the preliminary results.

1. INTRODUCTION

For the first time, results on exclusive ρ^0 spin cross section asymmetries have been presented in this workshop. The experiment was carried out at CERN by the Spin Muon Collaboration (SMC). SMC is a fixed target experiment using a 190 GeV polarized muon beam impinging on polarized proton (butanol or ammonia) and deuteron (deuterated butanol) targets in the kinematic range $0.0008 <$ x < 0.7, 0.01 GeV$^2 < Q^2 < 60$ GeV^2, and $140 <$ W$^2 < 310$ GeV^2 ($< W >\simeq 15$ GeV). A detailed description of the SMC experiment is given in ref [1]. Only aspects particular to the exclusive ρ^0 production will be discussed.

Exclusive ρ^0 production is a process in which only a ρ^0 is produced and the nucleon recoils elastically: $\vec{\mu} + \vec{N} \to \mu' + N + \rho^0$ ($\rho^0 \to \pi^+\pi^-$). In SMC the kinematics is entirely determined by the scattered muon, which is precisely reconstructed even at low Q^2, and the ρ^0 via its decay into π^+ and π^-. Although the nucleon is undetected, the kinematics of the scattered muon and of the ρ^0 are sufficient to select the elastic process [2].

Such a measurement will add more insight into the ρ^0 production mechanism, as well as into its spin dependence. It will also allow to study the spin properties of the hadronic photon at very low Q^2. Given the high energy of the SMC muon beam, the spin cross section asymmetries are measured in the $< W >$ region of ~ 15 GeV, where at low Q^2 unpolarized data are interpreted in terms of a *soft* pomeron exchange [3].

2. THE ρ^0 EVENT SAMPLE

First, *good* DIS events are selected based on the scattered muon kinematics: $Q^2 >$ **0.01 GeV**^{2}, $y >$ **0.4** and $y <$ **0.9**, **scattered muon momentum** $>$ **19 GeV**.

Second, the vector mesons are identified via their decay into π^+ and π^-. In order to obtain an elastic ρ^0 sample, events have been selected requiring:

a) **only two hadron tracks of opposite charge** associated with the vertex defined by the incident and scattered muon tracks. To each track the pion mass has been assigned, since there was no hadron identification. Electron pairs from bremsstrahlung photons have been removed using the SMC calorimeter [4], and events with the invariant mass $m(K^+K^-)$ in the range of the ϕ meson have been excluded.

b) to isolate an elastic process, events in the inelasticity, I, interval $-\mathbf{0.05} < \mathbf{I} < \mathbf{0.05}$, where I $= (M_x^2 - M_p^2)/W^2$ (M_x is the missing mass squared of the undetected recoiling system), have been selected. Figure 1 shows the inelasticity distribution. The peak around zero contains the elastic events above a very small background. Other experiments cut on $\Delta E = (M_x^2 - M_p^2)/2M_p$ ($\simeq$ I $\cdot\nu$ for large ν). In SMC the width of the ΔE distribution is about m_π, and the I interval corresponds to $-0.5 < \Delta E < 0.5$ GeV. The I cut has been chosen because it does not depend on W^2;

c) finally a cut on the invariant mass has been applied: $\mathbf{0.62} < m(\pi^+\pi^-) < \mathbf{1.07}$ GeV/c^2.

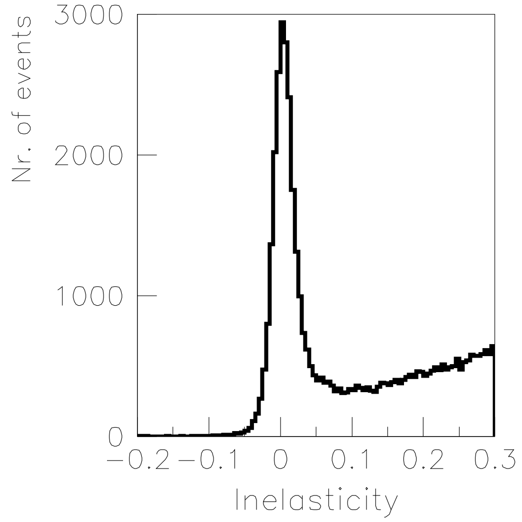

Figure 1. Inelasticity distribution (1995 data) after selections.

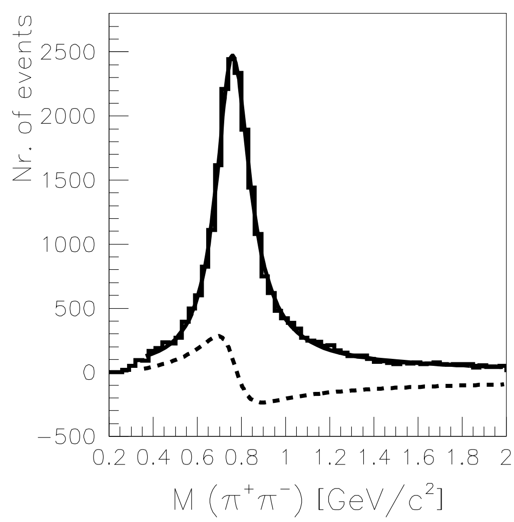

Figure 2. Mass spectrum (1995 data) after selections. The full line represents a fit according to the Söding model, the dotted line the interference term between the resonant and non resonant amplitudes.

Figure 2 shows the invariant mass spectrum of the selected data sample with a clear ρ^0 peak. This ρ^0 invariant mass distribution is well described by different models. In Figure 2 a fit to the distribution is performed according to the Söding model [5].

The final ρ^0 sample consists of $\sim$ 52 K ρ^0's produced on polarized protons and $\sim$ 43 K ρ^0's on polarized deuterons. For $p_T^2 >$ 0.09 GeV$^2/c^2$, $\sim$ 17 K ρ^0's on protons and $\sim$ 14 K ρ^0's on deuterons are left, where p_T is the ρ^0 transverse momentum with respect to the virtual photon.

3. THE SPIN CROSS SECTION ASYMMETRIES

The ρ^0 lepton-nucleon spin cross section asymmetry is given by:

$$A_{LL}^{lN\to\rho^0 l'N} = \frac{\Delta\sigma_\parallel}{2\overline{\sigma}} = \frac{\sigma^{lN}(\Uparrow\downarrow) - \sigma^{lN}(\Uparrow\uparrow)}{\sigma^{lN}(\Uparrow\downarrow) + \sigma^{lN}(\Uparrow\uparrow)} =$$
$$= \frac{1}{f}\cdot\frac{1}{P_b}\cdot\frac{1}{P_t}\cdot\frac{1}{2}\left[\frac{N_{\Uparrow\downarrow} - N_{\Uparrow\uparrow}}{N_{\Uparrow\downarrow} + N_{\Uparrow\uparrow}} - \frac{N'_{\Uparrow\downarrow} - N'_{\Uparrow\uparrow}}{N'_{\Uparrow\downarrow} + N'_{\Uparrow\uparrow}}\right]$$

where N (N') is the number of reconstructed events before (after) the target polarization reversal. The indices $\Uparrow\downarrow$ and $\Uparrow\uparrow$ refer to the relative orientation of the photon and proton (or deuteron) spins. P_t and P_b are the target and beam polarizations, respectively, and

$$f = \frac{n_{p(d)}\sigma_{p(d)}}{n_{p(d)}\sigma_{p(d)} + \Sigma_A n_A \sigma_A}$$

is the dilution factor giving the fraction of polarized nucleons to the total nucleons in the target. In order to estimate $f = f(Q^2,\, \mathrm{p}_T^2)$, all available cross section measurements for elastic ρ^0 production on nuclei in our kinematic range were used.

Figure 3 shows the ρ^0 production spin asymmetries for the proton and the deuteron separately. The data have been divided in 5 Q^2 bins in order to study the Q^2 dependence. In Figure 4 the same data are shown for $p_T^2 > 0.09$ GeV$^2/c^2$. In both cases the data show no significant asymmetry neither for the proton nor for the deuteron. Note that the spin asymmetry originates only from scattering on the polarized proton or deuteron, while the ρ^0's produced from nuclei represent an unpolarized background, which is properly taken into account by the dilution factor.

The ρ^0 lepton-nucleon production spin asymmetries have also been studied as a function of the ϑ polar angle of the decay π^+ in the ρ^0 c.m.s. For $|\cos\vartheta| < 0.5$ ($|\cos\vartheta| > 0.5$) the ρ^0's are mainly transversely (longitudinally) polarized. Figure 5 shows $A_{LL}^{lN\to\rho^0 l'N}$ as a function

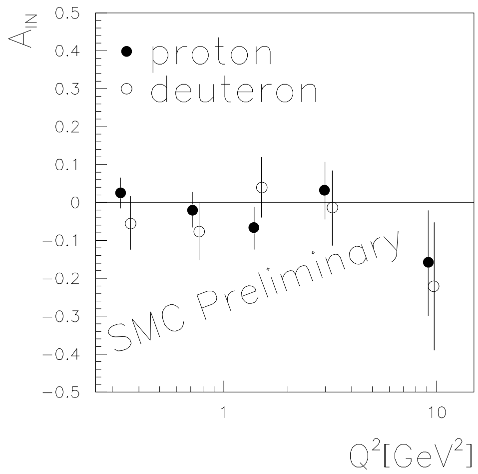

Figure 3. $A_{LL}^{lN\rightarrow\rho^0 l' N}$ for proton and deuteron as a function of Q^2 (the errors are statistical only).

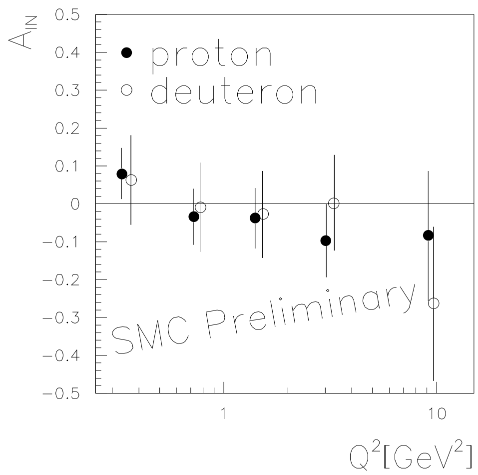

Figure 4. $A_{LL}^{lN\rightarrow\rho^0 l' N}$ for $p_T^2 > 0.09$ GeV$^2/c^2$ (the errors are statistical only).

of Q^2 for $|\cos\vartheta| > 0.5$ and $|\cos\vartheta| < 0.5$ (proton and deuteron combined).

As a check of systematic effects, the false asymmetries, which by construction should give zero, have been computed. They have been found to be zero. The contribution of radiative events has been estimated to be less than 2 % for the SMC kinematics.

The main sources of systematic errors are
1) the non-elastic background below the inelasticity peak: it is less than 5 % at low Q^2, and slightly higher (less than 10 %) at high Q^2;

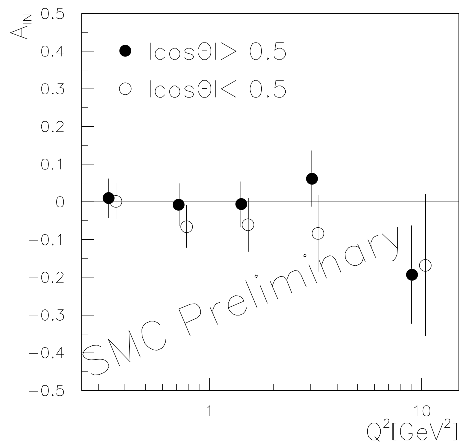

Figure 5. $A_{LL}^{lN\rightarrow\rho^0 l' N}$ for $|\cos\vartheta| > 0.5$ and $|\cos\vartheta| < 0.5$ for proton and deuteron combined (the errors are statistical only).

2) the uncertainty on the dilution factor coming from the poor knowledge of the A-dependence of the cross section $\sigma_A(Q^2, p_T^2)$ giving $\frac{\Delta f}{f} < 0.15$.

4. SUMMARY

The SMC collaboration at CERN has presented for the first time preliminary results on exclusive spin cross section asymmetries of the ρ^0 mesons for $Q^2 > 0.01$ GeV^2 and $< W > \simeq 15$ GeV over a large Q^2 range. The preliminary data, within the statistical accuracy of the measurement, show no significant spin asymmetries at low Q^2 ($Q^2 < 5$ GeV^2) both for the whole p_T^2 range and $p_T^2 > 0.09$ GeV$^2/c^2$, neither for the proton nor for the deuteron. In the last Q^2 bin ($Q^2 \sim 10$ GeV^2) an indication of a non-zero spin asymmetry is observed. Combining proton and deuteron data, a value of -0.18 ± 0.11 for $A_{LL}^{lN\rightarrow\rho^0 l' N}$ is obtained.

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4. SMC, B. Adeva *et al.*, *Phys. Lett.* B **420** (1998) 180.
5. P. Söding, *Phys. Lett.* **19** (1966) 702.