EXCLUSIVE ρ^0 PRODUCTION USING COMPASS AT CERN

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COMPASS has measured the incoherent exclusive electroproduction of ρ^0 over a wide Q^2 range and at $< W >= 10$ GeV. Spin density matrix elements were extracted from the angular distribution. Preliminary results of the analysis of the data taken in 2002 presented here are consistent with a substantial increase of $R = \sigma_L/\sigma_T$ with Q^2 and a weak violation of SCHC, in agreement with other high energy experiments.

1. Physics Motivations

Exclusive incoherent production of ρ^0 vector mesons is part of the wide physics program that can be adressed by the COMPASS experiment [1]. It can provide significant information on the helicity structure of the diffractive production. The study of the angular distributions of the process $\mu^+ + N \rightarrow \mu^+ + N + \rho^0$ allows to extract spin-density matrix elements which can be used to test the s-channel helicity conservation (SCHC) hypothesis and to allow for a determination of $R = \sigma_L/\sigma_T$. Moreover, it provides a determination of the longitudinal cross section which can be described at high Q^2 in terms of the Generalized Parton Distributions.

2. Experimental signature and selection

The COMPASS experiment uses the 160 GeV/c polarized muon beam of the CERN SPS. Muons are scattered off polarized nucleons in a 1.2 m long frozen ^{6}LiD target. The scattered particles and the decay products of the ρ are detected in the two magnetic spectrometers composed of tracking devices, hodoscopes, calorimeters, RICH and muon filters. In this paper we report on the full data sample taken in 2002 for a longitudinally polarised target. In the analysis, only events that have an incoming muon, a scattered muon, two hadron tracks of opposite charge and no other charged particles are kept. The production of ρ^0 is identified through the decay $\rho^0 \rightarrow \pi^+\pi^-$ by requiring that the invariant mass of the hadron pair (assuming they are pions) satifies $0.5 < M_{h^+h^-} < 1.0$ GeV. The exclusivity of the reaction is constrained by requiring that the absolute value of the missing energy $|E_{miss}| = |\frac{M_X^2 - M_p^2}{2M_p}| < 2.5$ GeV where M_X is the mass of the undetected particle system and M_P is the proton mass. A cut on the tranverse momentum of the ρ^0 with respect to the virtual photon direction is also applied to restrict the sample to incoherent diffractive scattering off quasi-free nucleons of the polarized ^{6}LiD target material ($p_t^2 > 0.15$ GeV^2) and also to minimize the amount of non-exclusive background ($p_t^2 < 0.5$ GeV^2). Finally, cuts on kinematical variables $Q^2 > 0.01$ GeV^2, $\nu > 30$ GeV

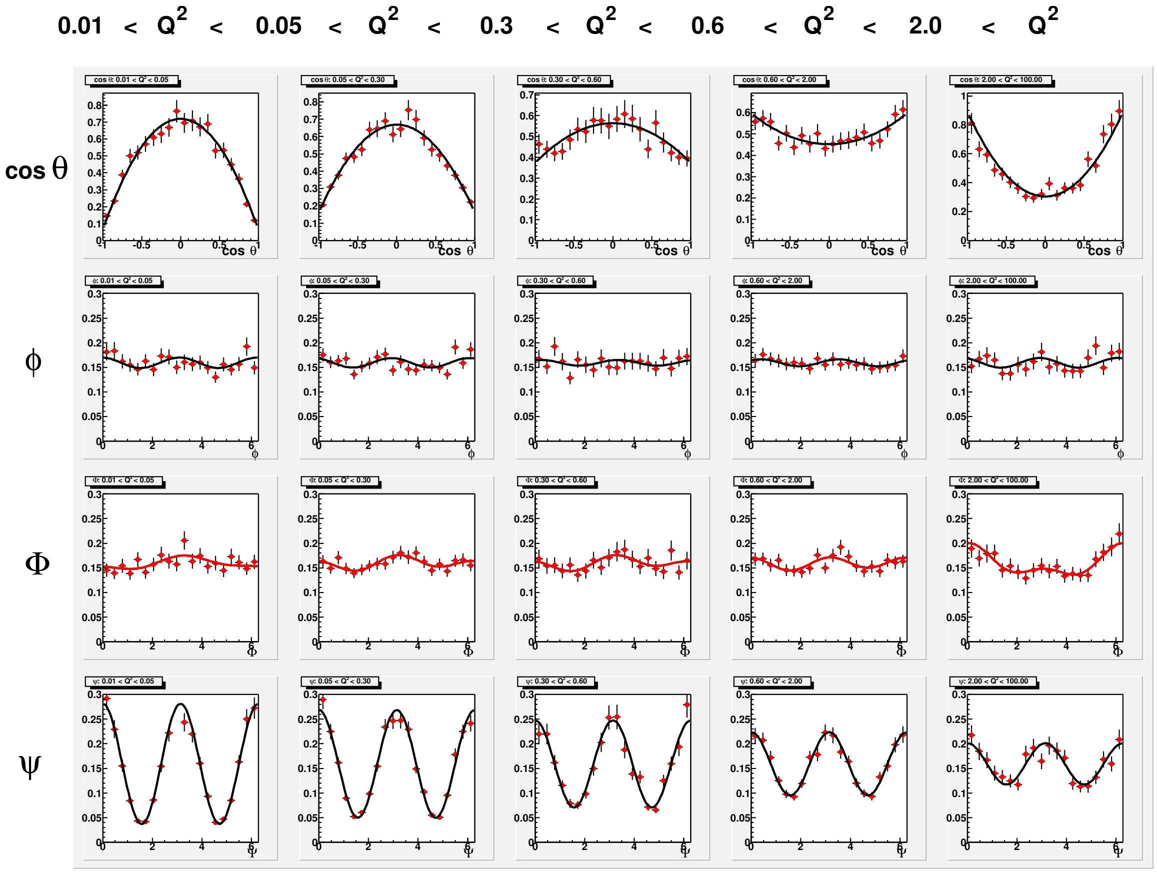

Figure 1. Distributions of the angles defined in the text ($\cos\theta$, ϕ, Φ and $\Psi = \phi - \Phi$) for different five intervals in Q^2.

and $E_{\mu'} > 20$ GeV are used to avoid large corrections for acceptance or smearing and to avoid misidentification of the particles or poor reconstruction.

3. Extraction of spin density matrix elements

The angular distribution $W(\cos\theta, \phi, \Phi)$ for the process is studied in the s-channel helicity frame where it depends on 3 angles : θ is the polar angle of the π^+ production in the ρ^0 rest frame, ϕ is the angle between the production plane and the decay plane and Φ is the angle between the lepton scattering plane and the production plane. In principle 23 spin density matrix elements (denoted r in the following) can be extracted with a longitudinally polarized beam. However, in the preliminary analysis presented here, we considered only one-dimensional projections of the angular distribution leading to the determination of a few spin density matrix elements. For $\cos\theta$ and ϕ the angular distributions are [3]:

$$W(cos\theta) = \frac{3}{4}\left[(1 - r^{04}_{00}) + (3r^{04}_{00} - 1)\cos^2\theta\right]$$

$$W(\phi) = \frac{1}{2\pi}\left[1 - 2r^{04}_{1-1}\cos 2\phi + 2P_\mu\sqrt{1-\epsilon}\Im m\, r^{3}_{1-1}\sin 2\phi\right]$$

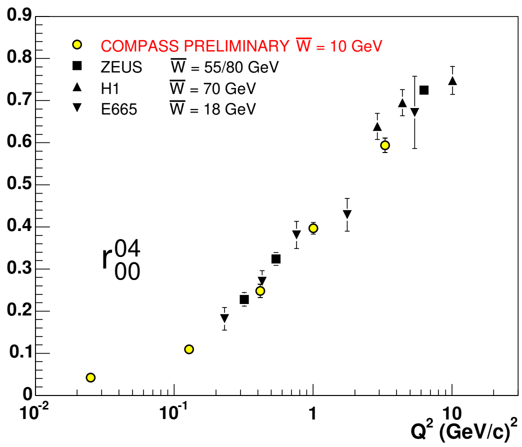

Figure 2. r^{04}_{00} as a function of Q^2

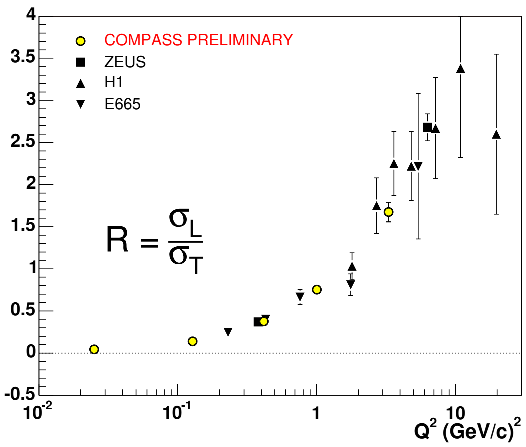

Figure 3. Evolution of $R = \sigma_L/\sigma_T$ as a function of Q^2

where $P_\mu = -0.76$ is the average muon beam polarisation and ϵ is the virtual photon polarisation parameter. The s-channel helicity conservation states that the helicity of the virtual photon is fully transmitted to the ρ^0 meson. If this hypothesis is valid then both r^{04}_{1-1} and $\Im m\, r^3_{1-1}$ must be equal to 0. Moreover, the angular distribution reduces to $W(\cos\theta, \Psi)$ where $\Psi = \phi - \Phi$ is the angle between the leptonic and the ρ decay plane, and one has :

$$W(\Psi) = \frac{1}{2\pi}\left[1 + 2\epsilon r^1_{1-1}\cos 2\Psi\right]$$

Generalized acceptance functions taking care of the combined effects of acceptance, efficiency and smearing are determined using a Monte-Carlo simulation. Events generated using the DIPSI [2] event generator are processed by the Geant-based simulation of the COMPASS spectrometer and analyzed by the usual COMPASS data analysis programs.

4. Results

The angular distributions, corrected for acceptance, are displayed in Fig. 1. Fits of these distributions allow to extract some of the spin-density matrix elements. The variation of r^{04}_{00} as a function of Q^2 extracted from the $\cos\theta$ distribution is displayed in Fig. 2 where statistical errors only have been drawn. Our data cover a wide range of Q^2 from quasi-real photoproduction to the hard scattering regime ($0.01 < Q^2 < 10$ GeV^2) and have a very good statistical precision. The data are found to be in agreement with other experiments [4–6]. Assuming SCHC, $R = \sigma_L/\sigma_T = \frac{1}{\epsilon+\delta}\frac{r^{04}_{00}}{1-r^{04}_{00}}$ is determined and displayed on Fig. 3. Our results confirm the tendency observed that R increases with Q^2. Therefore, the production of longitudinal ρ^0 is found to be dominant at high Q^2. This is an important point for further investigations of the Generalized Parton Distributions because the factorisation has only been proven valid for the longitudinal case. From the ϕ distribution, two other matrix elements, r^{04}_{1-1} and $\Im m\, r^3_{1-1}$, are extracted and displayed in Fig. 4. r^{04}_{1-1} is found to be non-zero over the whole Q^2 domain. This indicates a mild violation of SCHC. Although, $\Im m\, r^3_{1-1}$ which can only be accessed using a polarized

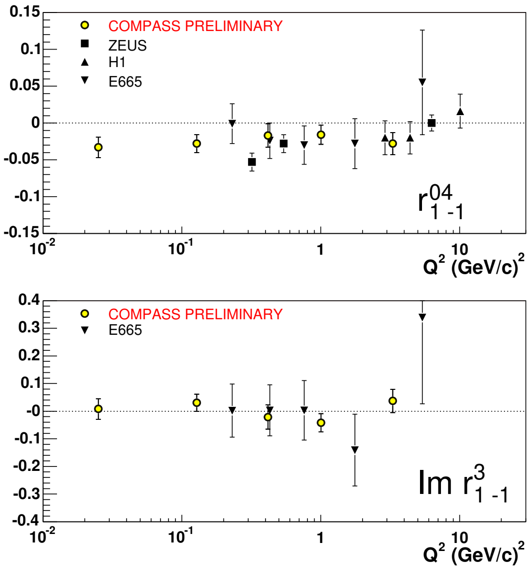

Figure 4. r^{04}_{1-1} and $\Im m\, r^{3}_{1-1}$ spin density matrix elements as a function of Q^2.

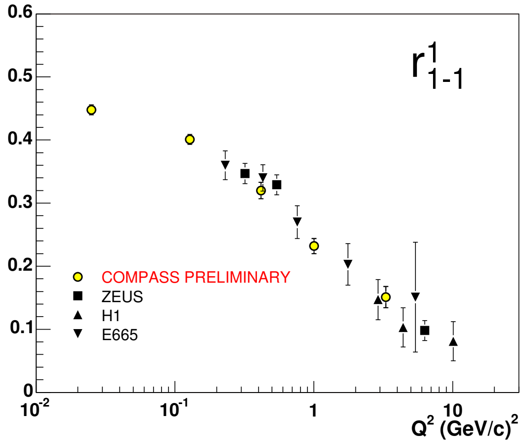

Figure 5. $^{1}_{1-1}$ spin density matrix elements as a function of Q^2.

beam, is compatible with 0. Finally, the matrix element r^1_{1-1} is extracted from the Ψ distribution (see figure 5).

5. Conclusions

COMPASS has measured the exclusive incoherent muoproduction of ρ^0 at $< W >=$ 10 GeV over a wide Q^2 range. The results of the preliminary analysis of the data taken in 2002 presented here are consistent with a substantial increase of R with Q^2 and a weak violation of SCHC, in agreement with other high energy experiments. The precision of our result is limited by the Monte-Carlo sample and more production is foreseen. The studies of systematic effects and background processes substraction are in progress. The analysis of data taken in 2003 and 2004 will improve significantly the statistical precision of our result.

REFERENCES

1. The COMPASS Collaboration, COMPASS proposal, CERN/SPSLC/96-14, SPSC/P 297 (March 1996); CERN/SPSLC 96-30 (May 1996).
2. M.Arneodo, L. Lamberti and M. Ryskin, Comput. Phys. Commun. **100** (1997) 195, hep/ph-9610286.
3. K. Schilling and G.Wolf, Nucl. Phys. **B 61** (1973) 381.
4. ZEUS Collaboration, J. Breitweg *et al.*, Eur. Phys. J. **C 12** (2000) 393.
5. H1 Collaboration, C. Adloff *et al.*, Eur. Phys. J. **C 13** (2000) 371; C. Adloff *et al.*, Phys. Lett. **B 539** (2002) 25.
6. E665 Collaboration, M.R. Adams *et al.*, Z. Phys. **C 74** (1997) 237.