DIFFRACTIVE ρ^0 PRODUCTION AT COMPASS

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Diffractive leptoproduction of ρ^0 mesons, $\mu + N \to \mu + N + \rho$ is measured at COMPASS at $< W > = 10$ GeV over a wide range of Q^2, $0.01 < Q^2 < 10$ GeV^2. Angular distributions to determine spin density matrix elements and longitudinal double-spin asymmetry A_1^ρ are investigated. Preliminary results are presented. They are consistent with a substantial increase of $R = \sigma_L/\sigma_T$ with Q^2, a weak violation of SCHC. The asymmetry is consistent with zero in the whole kinematical range.

1. Physics motivation

Exclusive production of vector mesons is part of the COMPASS physics program. Here the reaction, $\mu + N \to \mu + N + \rho$, where N is a quasi-free nucleon from any of the nuclei of the COMPASS polarised target is studied in the diffractive regime at small ($|t|$, $< W > = 10$ GeV over a wide range of Q^2, $0.01 < Q^2 < 10$ GeV^2.

In Regge phenomenology diffractive ρ^0 production in lepton-nucleon scattering is described by the exchange in the t channel of an intermediate object (Reggeon at low energy ($W < 5$ GeV^2) and Pomeron at higher energy). The Reggeons can be regarded as mesons as ρ, ω (with $J^P = 1^-$), f_2, a_2 (with $J^P = 2^+$), ω_3, ρ_3 (with $J^P = 3^-$),... all lying on the same Regge trajectories. Experimental data obtained at E665 [1], ZEUS [2] and H1 [3] have indicated that the exchange in the t channel of an object of natural parity (with J^P such as $P = (-1)^J$) dominates such diffractive processes, and that the helicity of the photon in the $\gamma^* N$ centre-of-mass system is approximatively retained by the vector meson, these two phenomena are known as natural parity exchange (NPE) or s-channel helicity conservation (SCHC). The goal of the COMPASS experiment is to quantify any violation of SCHC and NPE which could give rise to new physics insight.

2. Selection of diffractive events

The COMPASS experiment uses the 160 GeV/c polarised muon beam of the CERN SPS. Muons are scattered off longitudinally polarised nucleons in a double-cell solid-state ^{6}LiD target. The two cells are polarised in opposite directions and polarization is reversed frequently. The scattered particles and the decay products of the ρ are detected in two high resolution magnetic spectrometers [4]. For an event to be selected we required incident and scattered muon tracks with only two additional tracks, which correspond to charged pions from the decay of the ρ^0. A cut on the invariant mass of two pions, $0.5 < M_{\pi\pi} < 1$ GeV, is applied to identify the ρ^0. In order to select exclusive events as the slow recoiling target particles are not detected, we use cuts on the missing energy, $-2.5 < E_{miss} < 2.5$ GeV and on the transverse momentum of ρ^0 with respect to the virtual photon direction, $p_t^2 < 0.5$ GeV^2. Here $E_{miss} = (M_X^2 - M_p^2)/2M_p$ where M_X is the mass of the undetected system and M_p the proton mass. Coherent interactions on the target nuclei are removed by a cut $p_t^2 > 0.15$ GeV^2. After all selections the 2002 and 2003 data sample consists of about 2 400 000 events, of which about 60000 events at $Q^2 > 1$ GeV^2. The remaining non-exclusive background in the whole sample is about 12%.

3. Spin density matrix elements and $R = \sigma_L/\sigma_T$

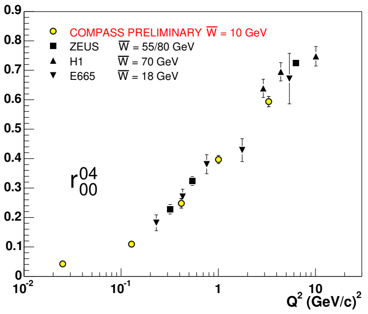

Figure 1. Q^2 dependence of r^{04}_{00}

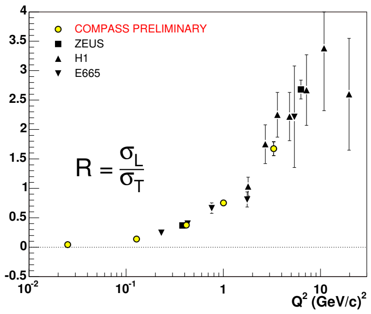

Figure 2. Q^2 dependence of $R = \sigma_L/\sigma_T$

The angular distributions of the 2 decay pions in the s-channel helicity frame reflect the helicity properties of the reaction and allow us to extract spin density matrix elements (SDME). The angular distributions are studied for 1/3 of the collected statistics (only 2002 data) and are corrected for acceptance, smearing and efficiency using a full MC simulation of the apparatus and the DIPSI event generator. r^{04}_{00} determined from the polar distribution of the positive decay pion, is displayed as a function of Q^2 in Fig.1. The COMPASS data, with its good statistical precision, cover a wide range of Q^2 from quasi-real photoproduction to the hard scattering regime ($0.01 < Q^2 < 10$ GeV^2). The results are in fair agreement with the other experiments [1,2,3].

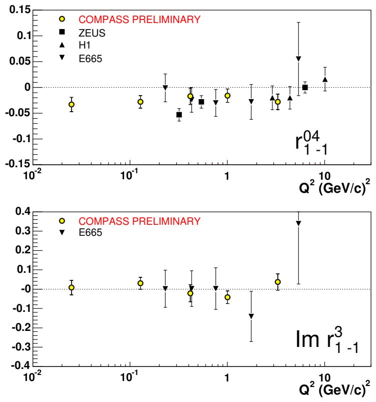

Figure 3. Q^2 dependence of r^{04}_{1-1} and $\Im m\, r^3_{1-1}$

If SCHC holds r^{04}_{00} represents σ_L/σ_{tot} and $R = \sigma_L/\sigma_T$ can be determined (see Fig.2). At small Q^2 the production by transverse photons dominates while when $Q^2 > 2$ GeV^2 the production by longitudinal photons takes overs. From the azimuthal distribution of the positive decay pion the SDME r^{04}_{1-1} and $\Im m\ r^3_{1-1}$ are extracted and compared to other experiments in Fig.3. They should be 0 if SCHC holds. The non-zero value of r^{04}_{1-1} indicates a small contribution of amplitudes with helicity flip.

4. Longitudinal double spin asymmetry

The photoabsorption asymmetry $A_1^\rho = (\sigma_{1/2} - \sigma_{3/2})/(\sigma_{1/2} + \sigma_{3/2})$ describes the spin dependence of the interaction between a transverse photon and a longitudinally polarised nucleon. $\sigma_{1/2}$ and $\sigma_{3/2}$ denotes the virtual-photon interaction cross sections for ρ^0 production, with 1/2 and 3/2 the projections of the total spin of the photon-nucleon system along the photon momentum. The measured asymmetry $A^\rho_{LL} = (\sigma^{\uparrow\downarrow} - \sigma^{\uparrow\uparrow})/(\sigma^{\uparrow\downarrow} + \sigma^{\uparrow\uparrow})$, where arrows correspond to relative orientations of the incoming muon and the target deuteron spins, is related to A_1^ρ by $A^\rho_{LL} \approx D\dot{A}_1^\rho$. The depolarization factor D has been evaluated specifically for the incoherent exclusive ρ^0 production. Details of this analysis can be found in [6].

The A_1^ρ preliminary results for a deuteron target from the COMPASS 2002 and 2003 data are reported (circles) as a function of Q^2 (upper panel) and x_{Bj} (lower panel) in Fig.4 and 5. The error bars mark statistical errors, the shaded band indicates the systematic ones. The A_1^ρ asymmetry is consistent with 0 in the investigated Q^2 and x_{Bj} range. Comparison with the HERMES results [7] is shown in Fig 5. Note that A_1^ρ is measured at different $< W >$, equal to 10 (5) GeV for COMPASS (HERMES).

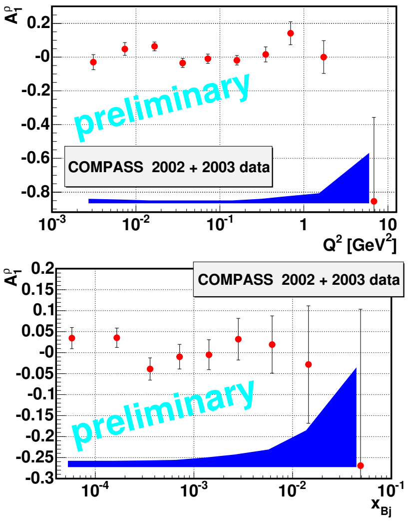

Figure 4. A_1^ρ asymmetry as a function of Q^2 (upper panel) and x_{Bj} (lower panel).

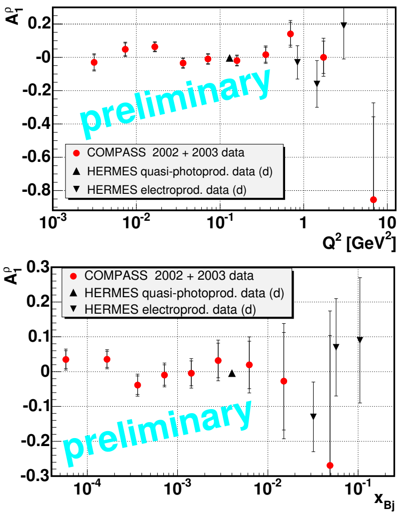

Figure 5. A_1^ρ from COMPASS and HERMES experiments for a deuteron target.

In the approach of Ref [8] a non zero-asymmetry can arise from an interference from a tiny unnatural parity exchange contribution (as for π or a_1 Regge trajectories) with a dominant NPE contribution. Our results indicate that UNPE contribution is rather small. At $Q^2 > 1$ GeV^2 a non-zero asymmetry would indicate sensitivity to some non-dominant Generalized Parton Distributions [9] but more data are needed to clarify this issue.

References

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