Diffractive ρ^0 production at COMPASS

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Abstract. Diffractive leptoproduction of ρ^0 mesons, $\mu+N\rightarrow\mu+N+\rho$ is measured at COMPASS at $< W >$ = 10 GeV over a wide range of Q^2, $0.01 < Q^2 < 10$ GeV^2. Angular distributions allow to determine spin density matrix elements. Preliminary results from COMPASS 2002 data are presented. They 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.

Keywords: COMPASS, DIFFRACTION, HELICITY, SCHC, SPIN DENSITY MATRIX
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PHYSICS MOTIVATIONS

Exclusive production of vector mesons is part of the COMPASS physics program. Here the reaction, $\mu+N\rightarrow\mu+N+\rho$, 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.

Diffractive ρ^0 production in lepton-nucleon scattering is often described as the fluctuation of the virtual photon emitted by the lepton into an intermediate $q\bar{q}$ state or off-shell ρ^0 meson. The intermediate state is scattered onto the mass shell by a diffractive interaction leaving the target nucleon intact. In Regge phenomenology the process 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). 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, a phenomenon known as s-channel helicity conservation (SCHC).

The angular distributions of the reaction give access to spin density matrix elements, which are bilinear combinations of the helicity amplitudes $T_{\lambda_{VM}\lambda_\gamma}$, where $\lambda_{VM}(\lambda_\gamma)$ is the vector meson (virtual photon) helicity. Assuming natural parity exchange to hold $T_{-\lambda_{VM}-\lambda_\gamma} = (-1)^{\lambda_{VM}-\lambda_\gamma} T_{\lambda_{VM}\lambda_\gamma}$, the 9 helicity amplitudes reduce to 5 independent complex amplitudes. At $Q^2 > 2$ GeV^2, the following hierarchy has emerged from previous measurements: the longitudinal T_{00} helicity non-flip amplitude dominates over the transverse T_{11} helicity non-flip amplitude, which dominates over the helicity single flip amplitude from transverse photon to longitudinal vector meson T_{01} which finally dominates over the single T_{10} and double T_{1-1} helicity flip amplitudes.

The goal of the COMPASS experiment is to quantify any violation of SCHC and to

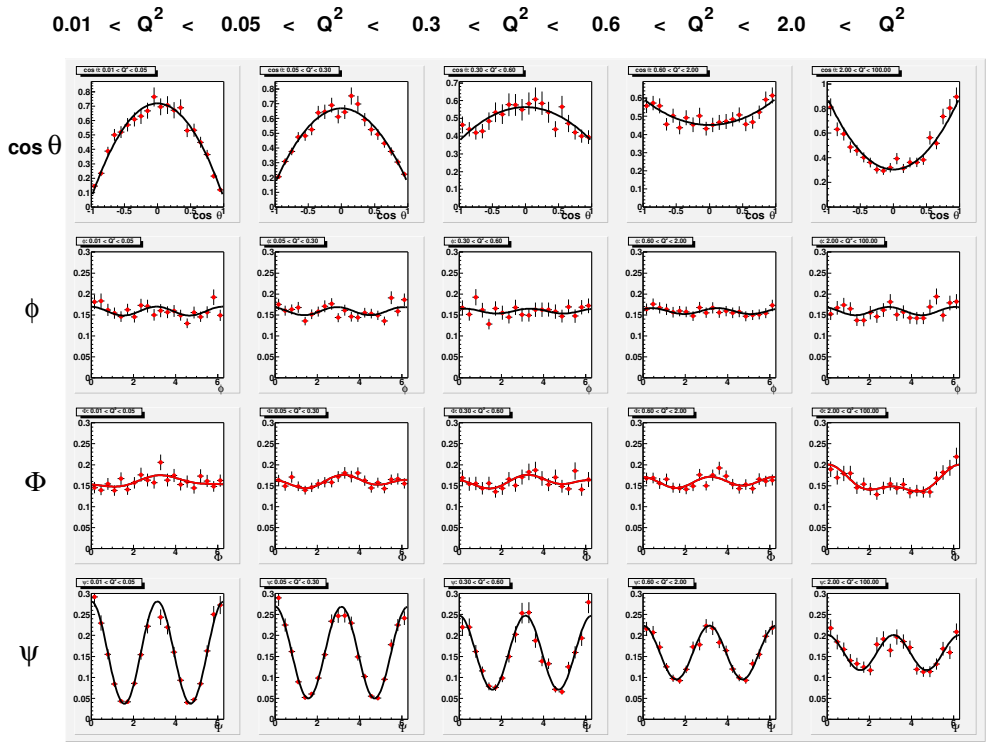

FIGURE 1. Angular distributions as a function of $cos\theta$, ϕ, Φ and $\psi = \phi - \Phi$ for 5 intervals in Q^2.

allow for a extraction of $R = \sigma_L/\sigma_T$. This will provide an easy determination of the longitudinal cross section which can be described at high Q^2 in terms of Generalized Partons Distributions.

SELECTION OF DIFFRACTIVE EVENTS

The COMPASS experiment uses the 160 GeV/c polarised muon beam of the CERN SPS. Muons are scattered off polarised nucleons in a 1.2m long frozen ^{6}LiD target.The scattered particles and the decay products of the ρ are detected in two high resolution magnetic spectrometers equipped with tracking detectors, calorimetry, RICH and muon identification (see ref. [4] for more detailed description of the COMPASS apparatus). The present analysis concerns the full data sample taken in 2002 with a longitudinally polarised target. For an event to be selected we required it to originate inside the target, to have reconstructed beam and scattered muon tracks and to have 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. Finally to avoid large corrections for acceptance, smearing and misidendification of events additional cuts are applied: $Q^2 > 0.01$ GeV^2, $\nu > 30$ GeV and $E_{\mu'} > 20$ GeV. After all selections the sample consists of about 700 000 events, of which about 6000 events at $Q^2 > 2$ GeV^2. The remaining non-exclusive background in the whole sample is about 12%.

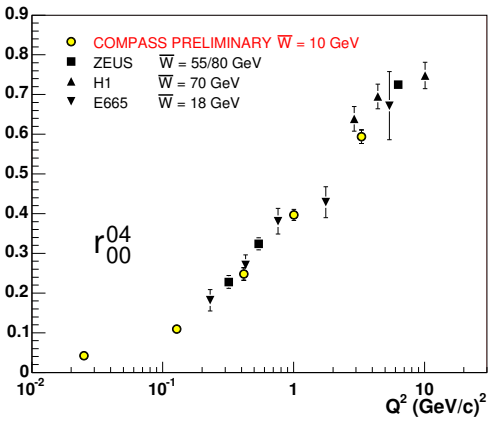

Figure 2. Q^2 dependence of r_{00}^{04}.

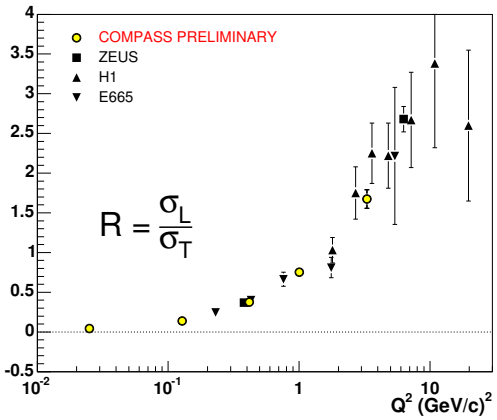

Figure 3. Q^2 dependence of $R = \sigma_L/\sigma_T$.

EXTRACTION OF SPIN DENSITY MATRIX

The angular distribution $W(\cos\theta, \phi, \Phi)$ is studied in the s-channel helicity frame [5]. The ρ^0 direction in the $\gamma^* N$ centre-of-mass system is taken as the quantization axis. The angle θ is the polar angle and ϕ the azimuthal angle of the positive decay meson in the ρ^0 centre-of-mass system. ϕ is then the angle between the production plane and the decay plane and Φ is the angle between the production plane and the lepton scattering plane. In principle 23 spin density matrix elements (SDME) can be extracted with a longitudinally polarised beam. However in this preliminary analysis, we consider only single dimensional projections of the angular distribution leading to the determination of a few SDME. For cos θ et ϕ the angular distributions are:

$$W(\cos\ \theta) = \frac{3}{4}[(1 - r_{00}^{04}) + (3\, r_{00}^{04} - 1)\cos^2\theta]$$

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

where the r's are the SDME, P_μ is the polarisation of the muon beam and ε is the virtual photon polarisation parameter. If the SCHC holds the complete angular distribution reduces to $W(\cos\theta, \psi)$ where $\psi = \phi - \Phi$ is the angle between the ρ^0 decay plane and the lepton scattering plane:

$$W(\psi) = \frac{1}{2\pi}[1 + 2\varepsilon\, r_{1-1}^{1}\cos 2\psi]$$

RESULTS

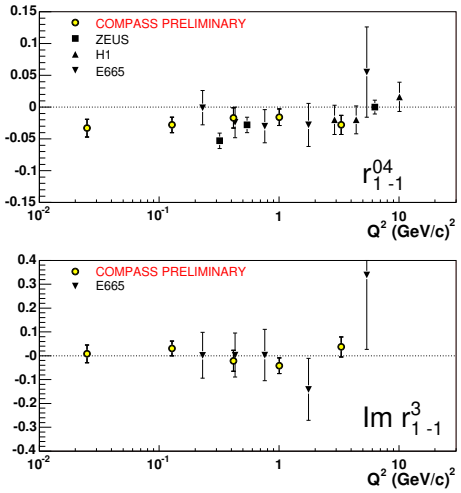

Figure 4. Q^2 dependence of r^{04}_{1-1} and $\Im m\, r^3_{1-1}$.

The angular distributions presented in Fig. 1 are corrected for acceptance, smearing and efficiency using a full MC simulation of the apparatus and the DIPSI event generator. Fits of these distributions allow to extract some SDME. r^{04}_{00} determined from $cos\theta$ distribution, is displayed as a function of Q^2 in Fig. 2 where only statistical errors have been drawn. 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].

$$r^{04}_{00} \propto (|T_{00}|^2 + |T_{01}|^2)/\sigma_{tot} \overset{if\ SCHC}{\rightarrow} \sigma_L/\sigma_{tot}$$

Then if SCHC holds, $R = \sigma_L/\sigma_T$ can be determined (see Fig. 3). 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 ϕ distribution the SDME r^{04}_{1-1} and $\Im m\, r^3_{1-1}$ are extracted and compared to other experiments in Fig. 4. $r^{04}_{1-1} \propto (\Re e\ (T_{11}T^*_{1-1}) + |T_{10}|^2)/\sigma_{tot}$ should be 0 if SCHC holds. Its non-zero value indicates a small contribution of amplitudes with helicity flip. Note, that $\Im m\, r^3_{1-1}$ could be accessed only with polarised lepton beams. It is consistent with 0.

SUMMARY AND OUTLOOK

Preliminary results from the analysis of angular distributions for exclusive incoherent ρ^0 production from COMPASS 2002 data are presented. The data measured at $< W >= 10$ GeV over a wide range of Q^2, $0.01 < Q^2 < 10$ GeV^2 are consistent with a substantial increase of R with Q^2 and a weak violation of SCHC in agreement with other high energy experiments. These new COMPASS data will be completed by the 2003 and 2004 sets. Although matching previous measurements, they are of much higher statistical significance and cover a larger range in Q^2. At $Q^2 > 1$ GeV^2 they consist of a very first step towards the study of Generalized Parton Distributions.

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