Diffractive vector meson production at COMPASS and plans for GPDs measurements

Andrzej Sandacz
on behalf of the COMPASS Collaboration

Sołtan Institute for Nuclear Studies, ul. Hoża 69, 00681 Warsaw, Poland

Abstract. Preliminary results on the spin dependence of exclusive ρ^0 muoproduction at COMPASS are discussed. The Q^2 dependence of several spin density matrix elements and of $R = \sigma_L/\sigma_T$ is presented. The data are consistent with a substantial increase of R with Q^2 and a weak violation of SCHC. Next, the longitudinal double-spin asymmetry A_1^ρ for ρ^0 production on polarized deuterons is shown as a function of Q^2 and x_{Bj}. The asymmetry is compatible with zero in the whole kinematical range. Finally, we discuss the prospects for measuring DVCS and exclusive meson production at COMPASS in order to investigate GPDs.

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We present preliminary results of the COMPASS experiment on exclusive incoherent ρ^0 muoproduction, $\mu + N \to \mu' + N' + \rho^0$, where N is a quasi-free nucleon from any of the nuclei of the COMPASS polarized target. The reaction can be described in terms of the virtual photoproduction $\gamma^* + N \to \rho^0 + N'$.

The angular distributions of the ρ^0 production and its decay into two pions allow one to determine ρ^0 spin density matrix elements (SDME) [1], which carry information on the spin structure of the production amplitudes. In particular, SDMEs allow one to test the s-channel helicity conservation (SCHC) and to determine $R = \sigma_L/\sigma_T$, the ratio of the longitudinal to transverse virtual photon cross section, for $\gamma^* + N \to \rho^0 + N'$.

A different information can be obtained from measurements of the spin asymmetry of cross section, when the information on both the beam and the target polarization is used. Here we discuss the longitudinal double-spin asymmetry $A_1^\rho = (\sigma_{1/2} - \sigma_{3/2})/(\sigma_{1/2} + \sigma_{3/2})$ for incoherent ρ^0 production on polarized deuterons. The cross sections $\sigma_{1/2}$ and $\sigma_{3/2}$ refer to the cases when the absolute value of the total photon-nucleon angular momentum component along the virtual photon axis is 1/2 or 3/2, respectively. Non-zero asymmetry can arise either due to an exchange in the t-channel of a_1-trajectory or due to the interference of amplitudes for exchanges of reggeons with natural parity P (ρ, ω, f, a_2, *pomeron*) and those with unnatural parity (π, a_1) [2, 3].

The data were collected with the high intensity positive muon beam at CERN, of 160 GeV/c momentum and -76% average polarisation, which impinges on a double-cell ^{6}LiD polarized target. The beam traverses two 60 cm long target cells, in which the target material is polarized in opposite directions. Polarization directions in each target cell are reversed frequently. A detailed description of the COMPASS apparatus can be found in [4]. The selections of events and details of the SDMEs and the asymmetry

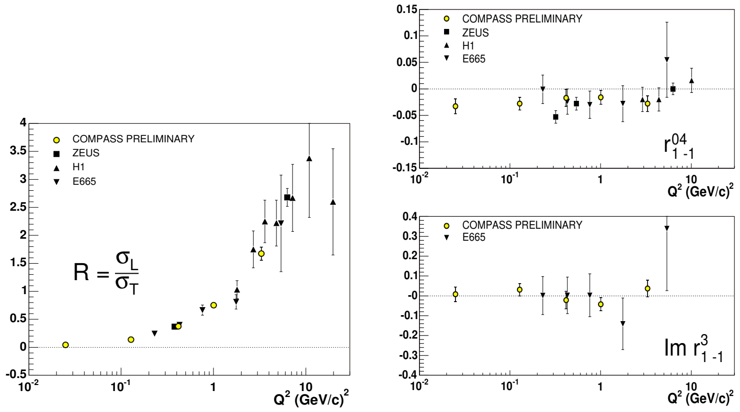

FIGURE 1. Q^2 dependence of $R = \sigma_L/\sigma_T$ (left) and of matrix elements r^{04}_{1-1} and $\Im m\, r^3_{1-1}$ (right)

analyses are described in [5] and [6], respectively.

The SDME r^{04}_{00}, which can be interpreted as a fraction of longitudinal (helicity 0) ρ^0 in the sample, is directly obtained from the fit to the $\cos\theta$ distribution, where θ is the polar angle of the positive decay meson in the ρ^0 center of mass system. If SCHC holds, R can be evaluated using the measured value of r^{04}_{00} [1]. The COMPASS results on Q^2 dependence of R are compared to other experiments in Fig. 1(left). At small Q^2 the production by transverse photons (σ_T) dominates, while with increasing Q^2 the contribution of the production by longitudinal photons (σ_L) takes over. No strong W dependence of R is observed.

From the ϕ distribution,where ϕ is the azimuthal angle between ρ^0 production and decay planes, one can determine the two matrix elements r^{04}_{1-1} and $\Im m\, r^3_{1-1}$. COMPASS preliminary results are compared to other experiments in Fig. 1(right). The measurements exhibit small negative values of r^{04}_{1-1} (≈ -0.03) approximately independent of Q^2, whereas $\Im m\, r^3_{1-1}$ is consistent with 0. The non-zero value of r^{04}_{1-1} indicates a small contribution of amplitudes with helicity flip.

The preliminary results for A_1^ρ from COMPASS are shown as a function of Q^2 (left panel) and x_{Bj} (right panel) in Fig. 2. The asymmetry A_1^ρ is consistent with zero as a function of both Q^2 and x_{Bj} in the whole kinematical range. The HERMES results

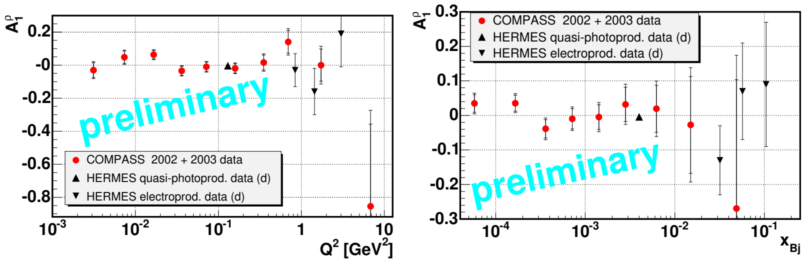

FIGURE 2. The asymmetry A_1^ρ from COMPASS (circles) shown as a function of Q^2 (left) and x_{Bj} (right panel). The HERMES results are also shown for comparison.

on A_1^{ρ} from a deuteron target are also shown for comparison. The results from both experiments are consistent. The small values of A_1^{ρ} may indicate that the contribution of unnatural parity exchanges is negligible.

Plans for future dedicated studies of exclusive processes in muoproduction are presently actively investigated at COMPASS. The aim is to access the generalised parton distributions (GPDs) via various exclusive processes such as Hard Exclusive Meson (ρ, π, ...) Production and Deeply Virtual Compton Scattering (DVCS). They may be studied with 100-190 GeV muon beams from the SPS M2 beam line allowing beams of both polarities. With an expected flux of $2{\cdot}10^8$ muons per SPS spill and a new 2.5m long liquid hydrogen target we can reach a luminosity of $\mathscr{L} = 1.3 \cdot 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$. COMPASS will cover the large kinematical range of Q^2 and x_{Bj} (e.g. $1.5 \leq Q^2 \leq 7$ GeV^2 and $0.03 \leq x_{Bj} \leq 0.25$, as far as DVCS is concerned).

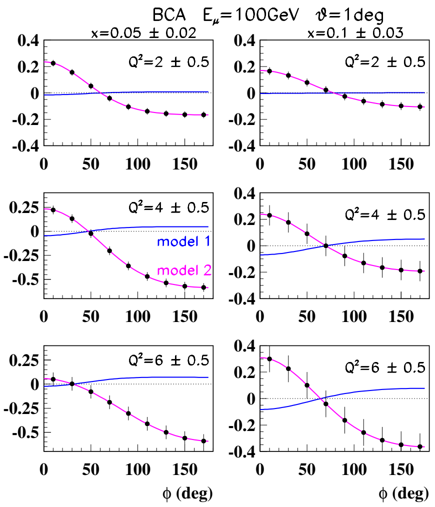

FIGURE 3. Azimuthal distributions of beam asymmetry BCA at COMPASS at $E_\mu = 100$ GeV and $|t| \leq 0.6$ GeV^2

To realise the program of comprehensive studies of DVCS and other exclusive channels, in addition to a new long liquid hydrogen target, the present COMPASS setup has to be complemented by new equipements. They include a recoil detecor, an extended calorimetry up to 24 degrees and a veto for charged particles up to 40 degrees. With muon beams one naturally reverses both charge and helicity, and by taking appropriate combinations of cross sections for different muon beams, and studying Q^2 and azimuthal dependences, one can extract the real and imaginary parts of the DVCS amplitude [7]. In Fig. 3 the projection for measurements of the beam asymmetry $\mathrm{BCA} = (\sigma(\mu^{+\downarrow}) - \sigma(\mu^{-\uparrow}))/(\sigma(\mu^{+\downarrow}) + \sigma(\mu^{-\uparrow}))$ (arrows indicate beam helicities) is shown together with predictions of two models for GPDs [7]. The results were obtained assuming 6 months of data taking with a global efficiency of 25%. The figure illustrates that COMPASS will have a power to discriminate between different models for GPDs.

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