MEASUREMENT OF DENSITY MATRIX ELEMENTS FOR ρ MESON ELECTROPRODUCTION AS A FUNCTION OF t.

CAROLINE COLLARD,
ON BEHALF OF THE H1 COLLABORATION

Université libre de Bruxelles, Bd de la Plaine, CP 230, 1050 Bruxelles, Belgium
E-mail: ccollard@hep.iihe.ac.be

A sample of $e^+\pi^+\pi^-$ events with $Q^2 > 2.5$ GeV^2, $40 < W < 120$ GeV and $t' = |t| - t_{min}$ in the range $0.5 < t' < 3.0$ GeV^2 is used to measure the density matrix element r^{04}_{00} and the combinations $r^5_{00} + 2r^5_{11}$ and $r^1_{00} + 2r^1_{11}$. The t' dependences are determined.

1 Introduction

The mechanism of diffraction, especially in a QCD approach, can be studied through the diffractive electroproduction of ρ vector mesons at high energy: $e + p \to e + \rho + Y$, $\rho \to \pi^+ + \pi^-$, where Y is a proton ("elastic" scattering) or a baryonic system of mass M_Y much lower than the invariant mass W of the hadronic system: $M_p < M_Y \ll W$ ("proton dissociation" scattering).

In particular, the measurement of the angular distributions of θ^* (the angle between the π^+ and ρ meson directions in the ρ rest frame) and Φ (the angle between the electron scattering plane and the ρ production plane in the γp centre of mass) provides information on the angular momentum structure of the interaction.

Here, new measurements of spin density matrix elements r^{04}_{00}, $r^5_{00} + 2r^5_{11}$ and $r^1_{00} + 2r^1_{11}$ are presented in a kinematical range which has been extended w.r.t. to previous analyses[1,2,3] to larger t' : $0.5 < t' < 3$ GeV^2, for a virtuality of the photon $2.5 < Q^2 < 30$ GeV^2, $40 < W < 120$ GeV and a reconstructed mass of the ρ meson $0.6 < M_\rho < 1.1$ GeV. t' is related to t, the square of the four-momentum transferred to the proton, by $t' = |t| - t_{min}$, t_{min} being the minimal value of $|t|$ kinematically necessary to put the vector meson and the Y system on shell.

2 Theoretical Models

The spin density matrix elements are related to the helicity amplitudes $T_{\lambda_\rho \lambda_\gamma}$ by the following relations[4]:

$$
\begin{array}{rl}
r_{00}^{04} \propto 1/N & (|T_{00}|^2 + |T_{01}|^2) \\
r_{00}^{5} \propto 1/N & \mathrm{Re}\ (T_{00}\ T_{01}^{\dagger}) \\
r_{11}^{5} \propto 1/N & (\mathrm{Re}\ (T_{10}T_{11}^{\dagger}) - \mathrm{Re}\ (T_{10}T_{1-1}^{\dagger})) \\
r_{00}^{1} \propto -1/N & |T_{01}|^2 \\
r_{11}^{1} \propto 1/N & (T_{1-1}T_{11}^{\dagger} + T_{11}T_{1-1}^{\dagger}) \\
\text{with } N = \sum_{i,j} |T_{ij}|^2 & i = \lambda_\rho, j = \lambda_\gamma \ = -1, 0, 1
\end{array}
\tag{1}
$$

Models based on perturbative QCD calculations [5,6,7] predict, for moderate Q^2 and $|t|$, the amplitude hierarchy: $|T_{00}| > |T_{11}| > |T_{01}| > |T_{10}| > |T_{1-1}|$. The following t dependences of amplitude ratios are predicted: similar dependences for the helicity conserving amplitudes (T_{00} and T_{11}), $\sqrt{|t|}$ dependence for the ratio of the single helicity flip (T_{01} and T_{10}) to the no-flip amplitudes, linear dependence for the ratio of the double flip (T_{1-1}) to the no-flip amplitudes.

3 Data Sample

The data, taken by the H1 detector in 1997 and corresponding to an integrated luminosity of 6 pb^{-1}, are selected by requesting two charged tracks and an electromagnetic cluster. Background events have been identified as ω, ϕ and ρ' production at low $|t|$ mimicking large t' ρ production when the produced π^0's escape detection. Because backgrounds are larger when no activity is detected in the forward detectors (i.e. in the outgoing proton direction), the data are restricted to the sample with some activity in these detectors.

4 θ^* Distribution, r_{00}^{04} and R

The r_{00}^{04} density matrix element is extracted by fitting the fully corrected θ^* distribution with the function[4] $W(\cos\theta^*) \propto 1 - r_{00}^{04} + (3\,r_{00}^{04} - 1)\cos\theta^{*2}$ for two bins in t': $0.5 < t' < 1.0$ GeV^2 and $1.0 < t' < 3.0$ GeV^2. The measurements are plotted in fig. 1a, together with lower t' measurements in similar energy and Q^2 ranges ($Q^2 > 2.5$ GeV^2 for ref. [1], $Q^2 > 3.0$ GeV^2 for ref. [2] and $Q^2 > 1.5$ GeV^2 for ref. [3]). The inner error bars are statistical. The full error bars include the systematic errors added in quadrature, the dominant error being related to the background estimate. As expected from pQCD calculations, no significant variation of r_{00}^{04} with t' is observed. A linear fit of the measurements in the same Q^2 range (present analysis and ref. [1]) is performed, giving $r_{00}^{04} = 0.68 \pm 0.02$, $\chi^2_{\mathrm{fit/ndf}} = 0.38$.

Measurements of $R = \sigma_L/\sigma_T$, which are extracted from r_{00}^{04} using $R = 1/\epsilon\ \ r_{00}^{04}/(1 - r_{00}^{04})$ in the approximation of SCHC, with the polarisation parameter $\epsilon \simeq 0.99$ in the HERA range, are shown as a function of t' in fig. 1b.

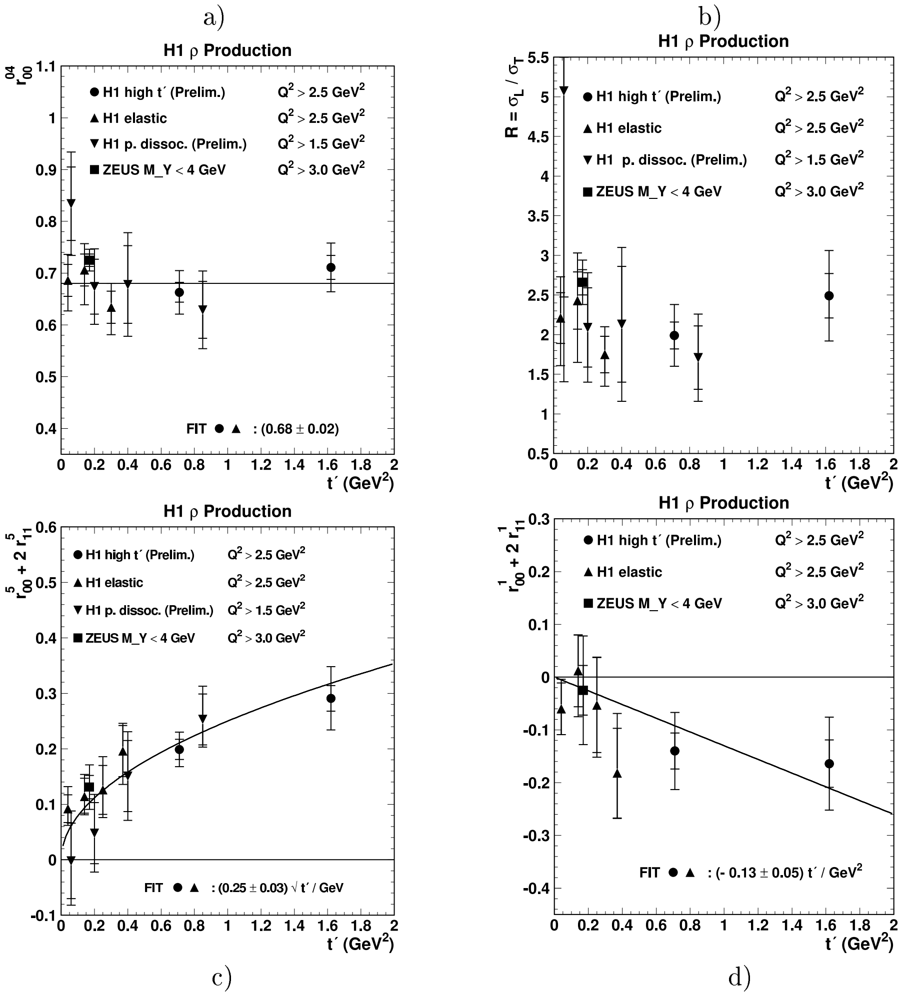

Figure 1. Measurements of a) r^{04}_{00}, b) $R = \sigma_L/\sigma_T$, c) $r^5_{00} + 2r^5_{11}$ and d) $r^1_{00} + 2r^1_{11}$ as a function of t', for the present experiment and for previous measurements [1,2,3]. The curves represent the results of fits of the t' dependence with data of the present analysis and of ref. [1], see text for details. In all plots, the inner error bars are statistical, the full error bars include the systematic errors added in quadrature.

5 Φ Distribution, $r^5_{00} + 2r^5_{11}$ and $r^1_{00} + 2r^1_{11}$

The determination of the $r^5_{00} + 2r^5_{11}$ and $r^1_{00} + 2r^1_{11}$ density matrix element combinations is performed by fitting the fully corrected Φ distribution with the function[4] $W(\Phi) \propto 1 + \sqrt{2\epsilon(1+\epsilon)}\ \cos\Phi\ (r^5_{00} + 2r^5_{11}) - \epsilon\ \cos 2\Phi\ (r^1_{00} + 2r^1_{11})$. The results are shown in fig. 1c and d.

Significant helicity non conservation is observed for the combination $r^5_{00} + 2r^5_{11}$. This effect is mainly attributed to the r^5_{00} element which is related to T_{01}, the expected largest helicity flip amplitude. A fit to the present measurements and those of ref.[1] gives $r^5_{00} + 2r^5_{11} = (0.25 \pm 0.03)\ \sqrt{t'/\mathrm{GeV}^2}$, $\chi^2_{\mathrm{fit/ndf}} = 0.45$.

In fig. 1d, the values found for $r^1_{00} + 2r^1_{11}$ appear to be different from zero and negative. The sign of the combination gives interesting information on the relative strength of the products $T_{01}T^\dagger_{01}$ and $T_{11}T^\dagger_{1-1}$. It tends to confirm that T_{01} is relatively large in the present kinematical domain, and is presumably the dominant single-flip amplitude. A linear fit to the present measurements and those of ref. [1] gives $r^1_{00} + 2r^1_{11}$ = (-0.13 $\pm$ 0.05) t' / GeV^2, $\chi^2_{\mathrm{fit/ndf}} = 0.65$.

6 Conclusion

A measurement has been performed of ρ meson production in the t' range $0.5 < t' < 3.0$ GeV^2 for $Q^2 > 2.5$ GeV^2 and 40 < W < 120 GeV^2. The r^{04}_{00} density matrix element and the combinations $r^5_{00} + 2r^5_{11}$ and $r^1_{00} + 2r^1_{11}$ have been measured as a function of t'. No significant t' dependence for r^{04}_{00}, a dependence as $\sqrt{t'}$ for $r^5_{00} + 2r^5_{11}$ and a linear behaviour for $r^1_{00} + 2r^1_{11}$ have been observed, in agreement with perturbative QCD predictions.

References

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