

Exclusive diffraction at HERA

Ewald Paul

Physikalisches Institut der Universität Bonn

Abstract

The cross section of the diffractive process $\gamma\pi^+ \rightarrow \rho^0\pi^+$ was measured first time in ep scattering. Elastic and proton-dissociative photoproduction of J/Ψ were measured as a function of the four-momentum transfer squared and of the photon-proton centre-of-mass energy. The energy dependence is consistent with a model prediction assuming a two-gluon exchange. The ratio of cross sections of the elastic production of $\Psi(2S)$ and J/Ψ was measured with improved precision in Deep Inelastic Scattering (DIS). The diffractive exchange was studied in a measurement of exclusive dijet production in DIS. The data are consistent with a model prediction assuming a two-gluon exchange.

Keywords:

1. Introduction

Four new measurements from HERA have been presented: From the H1 experiment, exclusive photoproduction of ρ^0 associated with leading neutron and elastic and proton-dissociative photoproduction of J/Ψ , and from the ZEUS experiment, the cross section ratio $\sigma(\gamma p \rightarrow \Psi(2S)p)/\sigma(\gamma p \rightarrow J/\Psi p)$ in DIS and the measurement of an angular distribution of exclusive dijet production in DIS.

2. Exclusive photoproduction of ρ^0 with forward neutron at HERA

The photon from the beam electron was scattered elastically on the pion emitted from the proton (Fig. 1 left). The neutron was detected in a neutron detector placed downstream close the proton beamline selecting neutrons with large longitudinal momentum, x_L . Three pions and the neutron with $x_L > 0.35$ were measured. The $\gamma\pi$ centre-of-mass energy was 22 GeV on

average. The analysis was carried out with a total luminosity of $1.16pb^{-1}$. Theoretical models based on the exchange of two Regge trajectories in a double-peripheral scattering process, describe the data (Fig. 1 right). The cross section for elastic ρ production on π^+ is rather constant within the range of energy (Fig. 2 left). The ratio $\sigma_{\gamma\pi}^{el}/\sigma_{\gamma p}^{el} = 0.21 \pm 0.06$. The $p_{t,\rho}^2$ dependence of the cross section shows two slopes (Fig. 2 right) as it is predicted for a double-peripheral process.

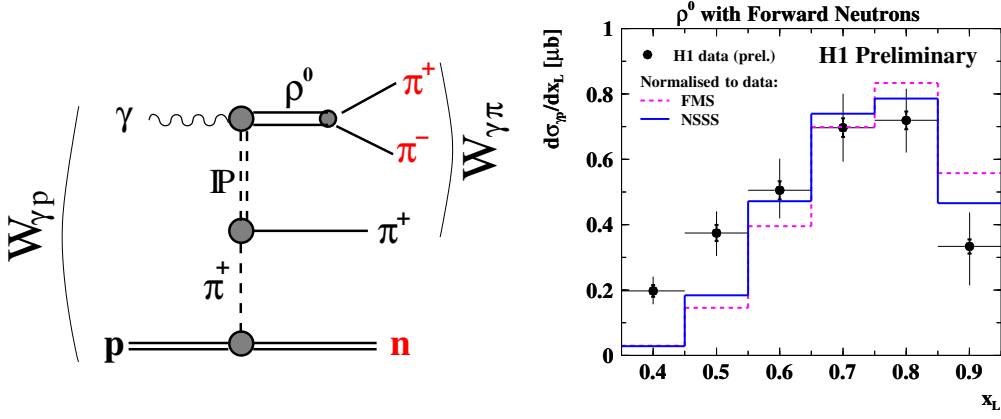


Figure 1: Left: Double peripheral process contributing to photoproduction of ρ^0 associated with leading neutron. Right: $d\sigma_{\gamma\rho}/dx_L$ compared to predictions based on different estimates of the photon flux [1, 2].

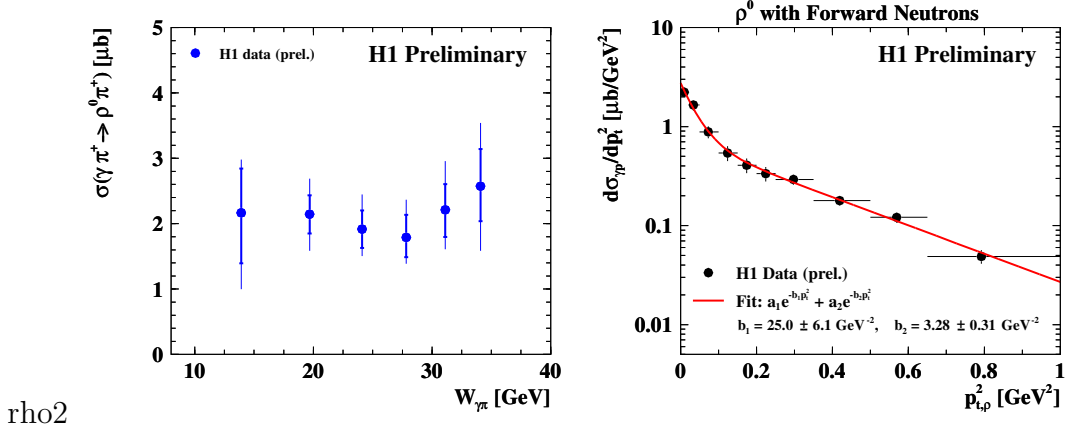


Figure 2: Left: Cross section of the reaction $\gamma p \rightarrow \rho^0 \pi^+$ as a function of the photon-pion energy. Right: $d\sigma/dp_t^2$ fitted to the sum of two exponential functions.

3. Elastic and proton-dissociative photoproduction of J/Ψ mesons at HERA

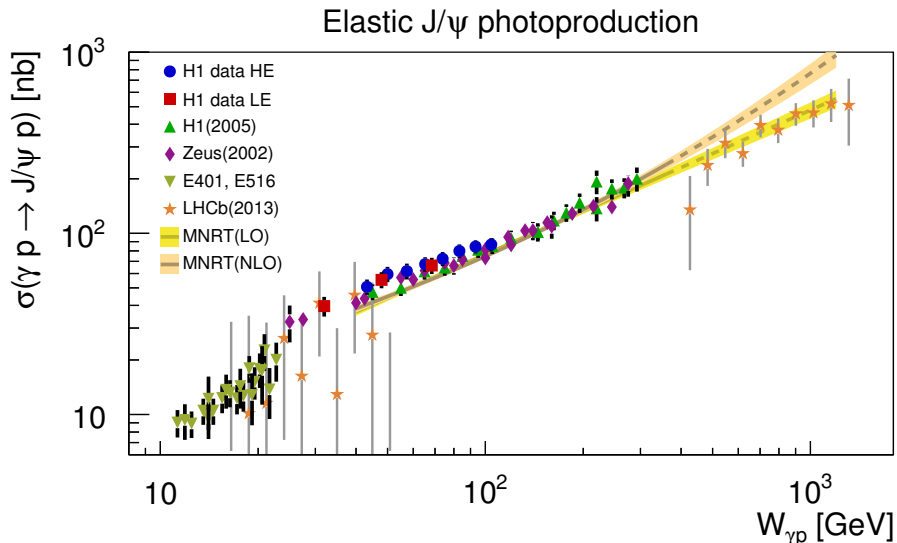


Figure 3: Compilation of elastic J/Ψ production cross section measurements including HERA results, results from fixed target experiments and from LHCb. The curves were obtained from QCD fits to previous HERA data [3]. The dashed lines are extrapolations into the energy range of LHCb.

The J/Ψ meson was produced in diffractive scattering of the virtual photon at the proton moderated by a colourless exchange. The cross section was measured via the decay modes $\mu^+\mu^-$ and e^+e^- . Hadrons from proton dissociation were measured down to small four-momentum transfers by means of three subdetectors placed in proton beam direction.

Data were taken at two γp centre-of-mass energies. This allowed to measure the energy dependence of the cross sections. The elastic cross section is shown together with previous HERA results, results from fixed-target experiments and from LHCb in Fig. 3. The data are compared to QCD predictions calculated assuming that the diffractive exchange a colourless is a two-gluon pair exchange. The LO and NLO predictions were determined by fits of the gluon PDFs to previous HERA data. The dashed lines are extrapolations into the LHCb energy range. The comparison to data supports the two-gluon exchange hypothesis.

4. Measurement of the cross section ratio $\sigma(\Psi(2S))/\sigma(J\Psi)$ in DIS at HERA

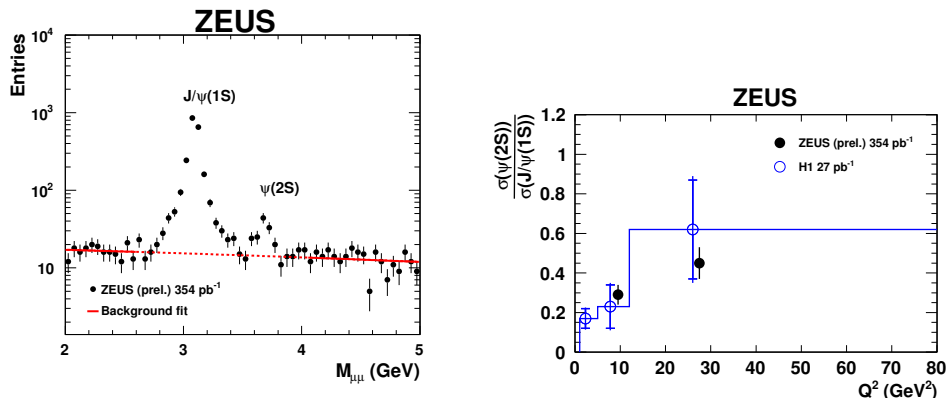


Figure 4: Left: Two-muon invariant mass distribution. The solid line is the result of a fit to the background outside the J/Ψ and $\Psi(2S)$ signal region. Right: The ratio of the cross sections as a function of Q^2 .

The elastic production of $\Psi(2S)$ and J/Ψ particles was studied in the kinematic range $5 < Q^2 < 70 \text{ GeV}^2$ and $30 < W < 70 \text{ GeV}$. The scattered electron and decay products of the particles, $\mu^+\mu^-$ for both $\Psi(2S)$ and J/Ψ (see mass distribution in Fig. 4 left) and $\mu^+\mu^-\pi^+\pi^-$ for $\Psi(2S)$ (not shown), were measured. The ratio of cross sections, $\sigma(\Psi(2S))/\sigma(J/\Psi)$, was determined to be $0.28 \pm 0.03^{+0.02}_{-0.01}$. The Q^2 dependence of the ratio is shown in Fig. 4 right.

5. Exclusive dijet production in diffractive DIS at HERA

This process was studied in order to test, at elastic dijet production in DIS (Fig. 5 left), predictions describing the diffractive exchange. The cross section was measured as a function of ϕ , the angle between the γ^* -dijet plane and the γ^*-e^\pm plane in the rest frame of the dijet system (Fig. 5 right), in the kinematic range $Q^2 > 25 \text{ GeV}^2$ and $90 < W < 250 \text{ GeV}$. Jets were reconstructed by the k_T -cluster algorithm, and further cuts were applied to select hard jets and events with rapidity gap in order to select a diffractive process.

The ϕ distribution was studied in the range $0.5 < \beta < 0.7$ where β is the ratio of the Bjorken variable x to the fractional loss of the proton

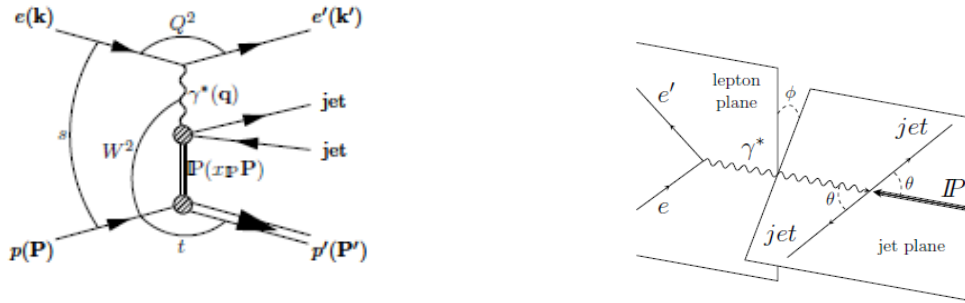


Figure 5: Left: Exclusive production of dijets in ep scattering. Right: Definition of planes and angles in the γ^* Pomeron rest system. The azimuthal angle, ϕ , is the angle between the γ^* -dijet plane and the γ^*e^\pm plane.

longitudinal momentum: $\beta = x/x_{IP}$. The cross section $d\sigma/d\phi$, normalised to the integrated cross section, is compared to predictions of the the Resolved-Pomeron model [4] and the Two-Gluon Exchange model [5] in Fig. 6. The Resolved-Pomeron model predicts a negative slope and fails to describe the data, while the Two-Gluon Exchange model predicts a positive slope which is consistent with the data.

6. Summary

- Photoproduction of exclusive ρ associated with leading neutron was measured by H1. The elastic cross section $\sigma(\gamma\pi^+ \rightarrow \rho^0\pi^+)$ was extracted. The ratio of cross sections $\sigma(\gamma\pi \rightarrow \rho\pi)/\sigma(\gamma p \rightarrow \rho p)$ was determined to be 0.21 ± 0.06 .
- Cross sections of elastic and proton-dissociative production of J/Ψ were measured by H1 at low and high four-momentum transfer squared. The W dependence of the elastic process is consistent with QCD predictions assuming a colourless two-gluon exchange.
- The ratio of cross sections for the elastic production of $\Psi(2S)$ and J/Ψ in DIS was measured by ZEUS and determined to be $0.28 \pm 0.03_{-0.01}^{+0.02}$.
- Exclusive dijet production was measured in DIS by ZEUS. The shape of the azimuthal distribution of the dijet system is well described by QCD assuming a colourless two-gluon exchange.

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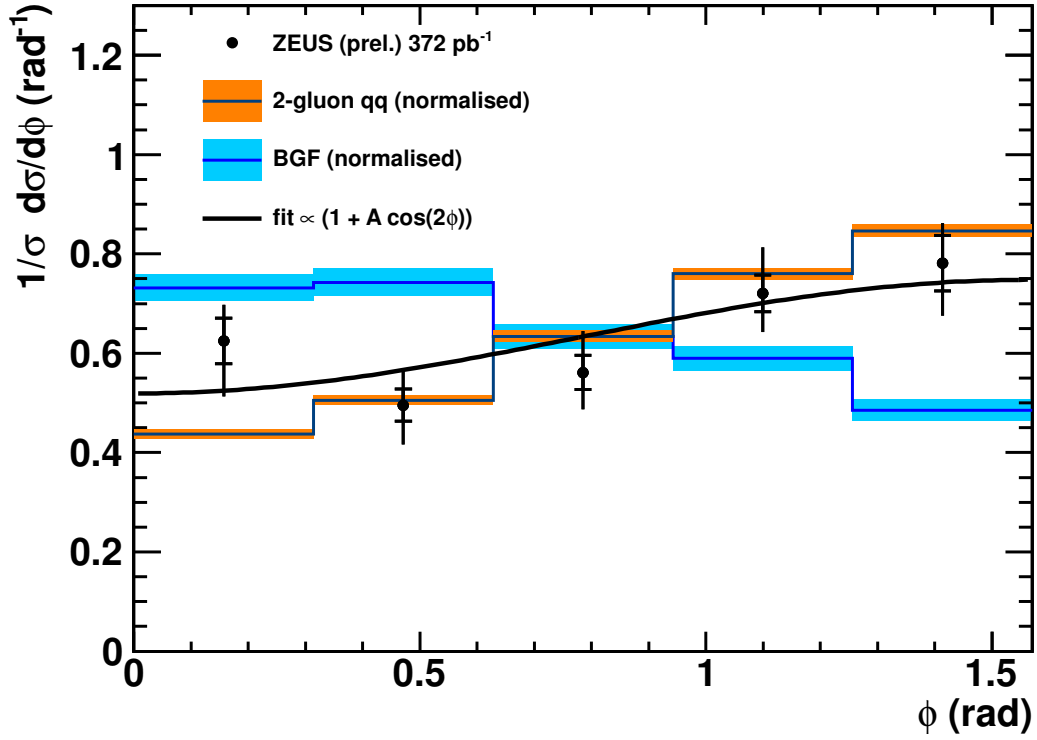


Figure 6: Normalised differential cross section of exclusive dijet production in DIS. The curve represents the results of a fit to the function $\propto 1 + A \cos(2\phi)$. The data is compared to predictions of the Resolved-Pomeron model and the Two-Gluon Exchange model, both normalised to the data.

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