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LEADING BARYON PRODUCTION AT ZEUS

ROBERTO SACCHI
Università degli Studi di Torino and INFN
Via P.Giuria 1, 10125 Turin, Italy
E-mail: roberto.sacchi@desy.de

New ZEUS results on leading baryon production in ep scattering are presented. The energy distribution of photoproduced neutrons as a function of the four-momentum squared t at the proton-neutron vertex is shown to be consistent with pion exchange models, and the pion trajectory is extracted. The leading proton production cross section is also presented in deep inelastic scattering.

1 Introduction

A significant fraction of the HERA ep events have been found to contain a leading baryon (LB) carrying a large fraction x_L of the incoming proton energy ($x_L > 0.2$) but a small transverse momentum ($p_T < 0.7$ GeV) [1,2]. The production mechanism is not completely understood. Although the hadronization mechanisms in strong interactions are expected to yield a fraction of these LBs as the result of the hadronization of the proton remnant, the t-channel exchange of colour singlet virtual particles is expected to contribute significantly. In virtual exchange models, leading neutron (LN) production occurs through the exchange of isovector states, and π^+ exchange is expected to dominate. For leading proton (LP) production, isoscalar exchanges also contribute, including Reggeon and Pomeron mediated interactions. Finally, LBs can also originate from the decay of low mass proton resonances in diffractive interactions.

In the following, two recent ZEUS results are presented [3]. First, the x_L distribution for the inclusive photoproduction of LNs is presented in bins of the square of the four-momentum transfer at the proton vertex, t, measured for the first time by ZEUS in LN production, and the results interpreted in the context of a single pion exchange model. Then, the LP production cross section for large photon virtualities Q^2 is presented using much larger statistics compared to previous ZEUS publications [2].

2 Photoproduction of leading neutrons and the pion trajectory

Fig. 1(a) shows the corrected x_L distributions of photoproduced leading neutrons ($\gamma p \rightarrow nX$) in bins of t, measured at an average photon-proton center-of-mass energy, W, of 220 GeV and in the range $0.6 < x_L < 0.925$ and $|t| < 0.425$ GeV^2. The distributions are consistent with a power-law dependence in $(1 - x_L)$ of the form $dN/dx_L \propto (1 - x_L)^{a(t)}$. For each t bin, the power $a(t)$ was determined by a least-squares fit of this function to the observed distribution. The resulting fits are superimposed on the measured points in fig. 1(a).

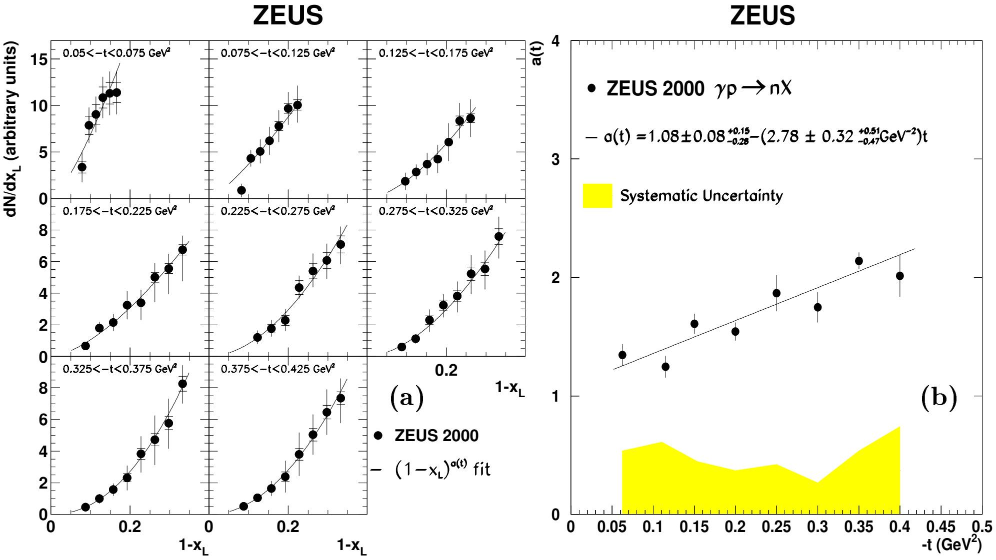

Figure 1. **(a)** The x_L distribution in eight bins of t for leading neutron photoproduction. The curves show the result of the fit described in the text. **(b)** The powers $a(t)$ as a function of $-t$. The solid line represents a fit to a straight line. The band at the bottom shows the systematic uncertainty.

The powers determined from the fits are shown in fig. 1(b) as a function of $-t$. They are consistent with a linear function of t:

$$a(t) = 1.08 \pm 0.08(\text{stat.})^{+0.15}_{-0.28}(\text{syst.}) - (2.78 \pm 0.32(\text{stat.})^{+0.51}_{-0.47}(\text{syst.})\text{GeV}^{-2})t$$

This result can be used to test the consistency of the pion-exchange models by assuming that pion exchange is the dominant mechanism and by deriving the pion Regge trajectory from the measured power $a(t)$. Within this framework, the cross section for the photoproduction of LNs is given by the product of a flux $f_{\pi/p}$ of pions in the proton and the total $\gamma\pi$ cross section

$$\frac{d^2\sigma_{\gamma p\to nX}}{dx_L dt} = f_{\pi/p}(x_L, t) \times \sigma_{\gamma\pi}(s')$$

where the pion flux can be expressed as [4] $f_{\pi/p} = A(t)(1-x_L)^{1-2\alpha_\pi(t)}$, $\alpha_\pi(t) = \alpha'_\pi(t - m_\pi^2)$ being the Regge trajectory of the pion. The total γp cross section is assumed to have a power law dependence on the $\gamma\pi$ center-of-mass energy $s' = (1-x_L)W^2$ dominated by the soft Pomeron intercept $\alpha_{I\!P}(0)$ [5]: $\sigma_{\gamma\pi}(s') = \mathcal{A}(s')^{\alpha_{I\!P}(0)-1}$. Combining these two terms, the cross section is expected to be proportional to $(1-x_L)^{a(t)}$ where, neglecting m_π^2, $a(t) = \alpha_{I\!P}(0) - 2\alpha'_\pi \cdot t$.
The values extracted from a fit to a line in fig. 1(b) ($\alpha_{I\!P}(0) = 1.08 \pm 0.08^{+0.15}_{-0.28}$, $\alpha'_\pi = 1.39 \pm 0.16^{+0.26}_{-0.24}\text{GeV}^{-2}$) are consistent with the expectations of a soft pomeron intercept, $\alpha_{I\!P}(0)$, of about 1.1 and a slope of the pion trajectory, α'_π, of about

1 GeV^{-2} [6], and so support the hypothesis that pion exchange is the dominant process in this reaction. If for example the ρ trajectory $\alpha_\rho(t) = 0.5 + t$ is substituted for the pion trajectory, the value of $\alpha_{I\!P}(0)$ exctracted from the data would be 2.08 rather than 1.08, which is an inconsistent result for the pomeron intercept.

3 Study of DIS events containing a leading proton

The leading proton production cross section has been measured by ZEUS in the kinematic range $x_L > 0.56$, $p_T^2 < 0.5$ GeV^2, $45 < W < 225$ GeV and for photon virtualities $Q^2 > 3$ GeV^2 using an integrated luminosity of 12.8 pb^{-1}.

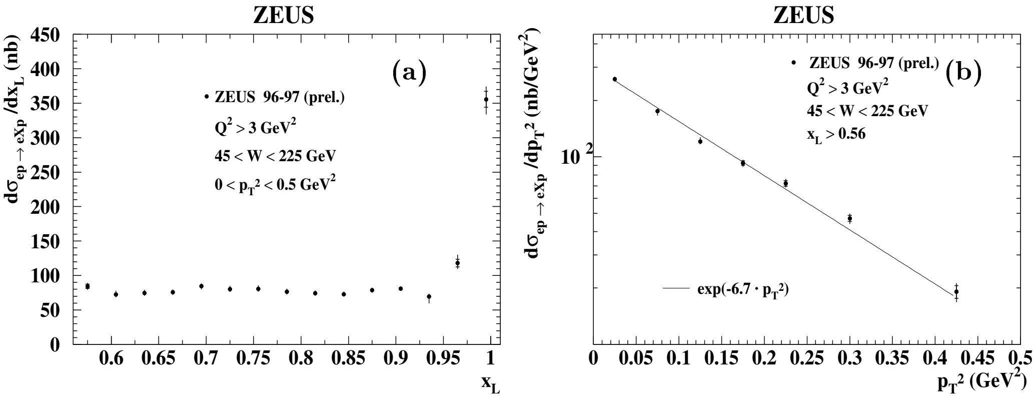

Figure 2. The DIS differential cross section for leading proton production $d\sigma_{ep\to eXp}/dx_L$ (a) and $d\sigma_{ep\to eXp}/dp_T^2$ (b). The line in figure (b), which shows the function $e^{-6.7p_T^2}$ normalized to the data, is to guide the eye.

Fig. 2(a) shows the differential cross section $d\sigma_{ep\to eXp}/dx_L$. It is found to be flat as a function of x_L up to the diffractive peak, where the cross-section grows by about a factor of five. Similar behaviour was observed for leading proton production in proton-proton collisions [7].

The cross section $d\sigma_{ep\to eXp}/dp_T^2$, shown in fig. 2(b), is found to decrease by an order of magnitude in the measured p_T^2 interval. The data are not perfectly described by a single exponential function (shown in the same figure) as the steepness of the fall of the cross section with p_T^2 appears to increase at lower p_T^2 values.

A fit to a single exponential function $d^2\sigma/dx_L dp_T^2 \propto e^{-b(x_L)\cdot p_T^2}$ was anyway performed in bins of x_L, resulting in a slope parameter b varying with x_L as shown in fig. 3. The measurements are consistent with the earlier published results [2] and confirm the smaller slopes observed around $x_L = 0.75$ and $x_L = 0.9$. This can anyway be partially explained as an effect of the different p_T^2 ranges used in each x_L bin (also shown in fig. 3) and to the fact that the steepness of the fall of the cross section decreases with increasing p_T^2.

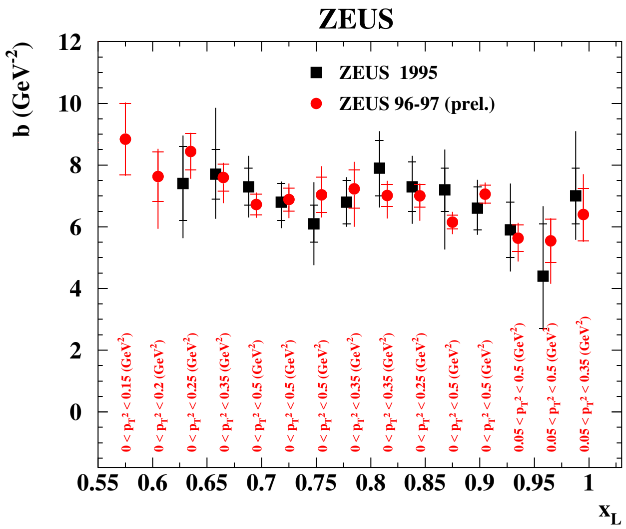

Figure 3. The slope parameter b of the cross section $d\sigma_{ep\to eXp}/dp_T^2$, obtained by fitting the data the the function $A \cdot e^{-b \cdot p_T^2}$, is shown as a function of x_L. Results of a previous analyis [2] are also added for comparison. The range in p_T^2 used to extract the parameter b in each x_L bin is reported at the bottom of the figure.

4 Conclusion

The measurements of reactions involving the production of leading baryons in ep collisions are becoming more precise. Here, the x_L distribution of photoproduced leading neutrons as a function of t was shown to be consistent with a single pion exchange model. The leading proton production cross section for $Q^2 > 3$ GeV^2 was also reported as a function of x_L and p_T^2 confirming, outside the diffractive region, the weak dependence on x_L observed in pp collisions and a slope of the exponential fall-off with p_T^2 which is almost independent of x_L.

References

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