Leading Baryon Production at ZEUS

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Using the ZEUS forward detectors, the Leading Proton Spectrometer (LPS) and the Forward Neutron Calorimeter (FNC), the spectrum of neutrons and protons with fractional momentum with respect to the proton beam momentum, $x_L > 0.2$, was measured. The structure function of Deep Inelastic Scattering (DIS) events with a leading baryon F_2^{LB}, were determined. It was found that DIS events with a leading baryon behave like normal DIS events with respect to x_{BJ} and Q^2.

1. INTRODUCTION

Protons and neutrons with large longitudinal momentum were detected by LPS and FNC. Existing Monte Carlo programs, as ARIADNE, incorporating the Color Dipole Model, and LEPTO incorporating Soft Color Interaction, do not describe the data well.

Production of Leading Baryons in the Regge picture can occur through the exchange of charged or neutral particles (eg. $\pi^{\pm}$, π^0, f_0, pomeron). Also, leading baryons can be produced during proton remnant hadronization.

2. DETECTOR-ANALYSIS

For the description of the events the normal Deep Inelastic Scattering variables are used, x_{BJ}, Q^2, and y. To describe the leading baryon, the fractional longitudinal momentum x_L, the four-momentum transfer squared at the proton vertex, t and the leading baryon transverse momentum squared, p_T^2, are used.

Events were tagged by detecting neutrons in the FNC and protons in the LPS. The DIS events were selected by detecting a positron in the ZEUS calorimeter. Near photoproduction events were selected by detecting a positron in the Beam Pipe Calorimeter (BPC), positioned near the beam pipe just outside the ZEUS Rear Calorimeter (RCAL).

The DIS events were selected by requiring $3 < Q^2 < 254\ GeV^2$, $1.2 \cdot 10^{-4} < x_{BJ} < 4 \cdot 10^{-2}$, $45 < W < 225\ GeV$, $-50 < z_{vtx} < +50\ cm$, and $E_e > 10\ GeV$.

The BPC events were selected requiring $0.11 < Q^2 < 0.65\ GeV^2$, $45 < W < 225\ GeV$, $-50 < z_{vtx} < +50\ cm$, $10 < E_e < 28\ GeV$.

The LPS consists of six stations, contained in Roman pots, along the beam line. Each station consists of six Si strip planes. In this analysis, only the S4, S5, S6 stations were used. The resolution of the detector is 0.3% in x_L and about 3% in p_T. Events with a proton track were kept if $0.6 < x_L < 1.0$ and $0 < p_T^2 < 0.5\ GeV^2$.

The FNC is a Pb-Scintillator sampling calorimeter 10λ deep, with veto counters in front to veto charged particle deposits. Its energy resolution is given by $\sigma(E_n) \simeq 0.65\sqrt{E_n}$. Its acceptance is determined by the beam-pipe apertures. Events with energy deposition in the FNC were kept if a neutral hadronic shower could be reconstructed, $0.6 < x_L < 1.0$, and $\theta < 0.8\ mrad$.

3. RESULTS

In figure 1 the x_L distributions for both protons and neutrons can be seen, together with the predictions given by Ariadne. If the mechanism at work is an isovector exchange, it is expected that $N_{LP} = 0.5 N_{LN}$. Instead, it is observed that $N_{LP} \simeq 4 N_{LN}$. Figure 2 shows the x_L distri-

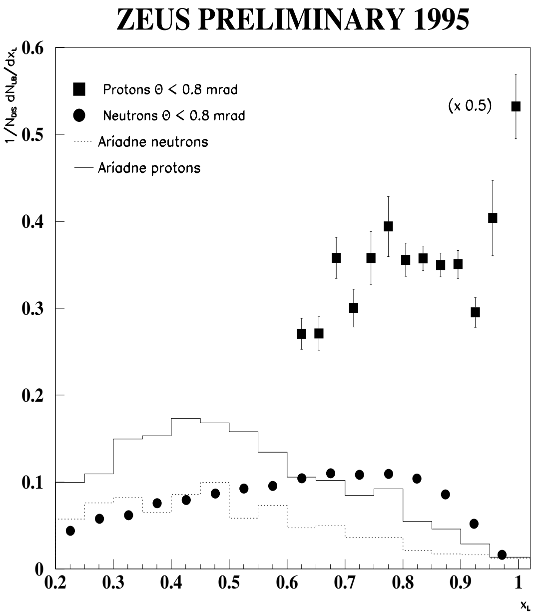

Figure 1. Distribution of DIS events with a leading baryon versus x_L, normalized to the number of DIS events. Both the neutron and proton distributions were obtained using the same $\theta < 0.8$ $mrad$ cut. The lines indicate the prediction of the Ariadne Monte Carlo implementing Color Dipole Model.

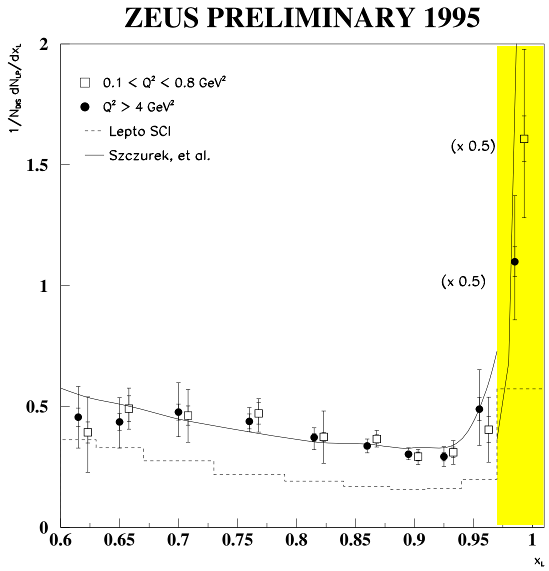

Figure 2. The x_L spectrum for DIS and BPC events with a leading proton. The dashed line is the prediction of the Lepto Monte Carlo implementing Soft Color Interactions. The solid line is from [1]

bution of the ratio of number of events with a leading proton to all events for both the DIS and the BPC regimes. The region of $x_L > 0.97$ corresponds to the diffractive peak and is excluded from this analysis. The LEPTO prediction implementing Soft Color Interaction does not describe the observed proton rates. It is found that

- $N_{LP}/N_{DIS} = 12.7 \pm 0.3 \pm 0.9$ %
- $N_{LP}/N_{BPC} = 13.0 \pm 0.5 \pm 0.7$ %

The data were divided in x_L bins and for each bin the p_T^2 distribution was plotted. The distributions were fit to a single exponential. In figure 5 the resulting slopes were plotted versus x_L. It can be seen that the slopes are almost flat in x_L, and they are similar for the DIS and the BPC events. The slopes are sensitive to the reaction mechanism. A model based on a summation of contributions of various exchange mechanisms approximates the data well [1]. The results of the model have been overlayed on figures 2 and 5.

In both the Regge and the fragmentation pictures, the cross sections can be factorized, ie. one can write $\sigma_{ep\to e'pX} = f(x_L,t)\sigma_{ei\to e'X}(\beta,Q^2)$ where $\beta = x_{BJ}/(1-x_L)$. In such a case, the ratios of events or of F_2 with and without a leading baryon should be independent of x_L and p_T^2. In figure 3 the ratio F_2^{LP}/F_2^{DIS} is plotted for $0.73 < x_L < 0.85$. On the left side the ratio is plotted versus $log_{10}(x_{BJ})$ for various Q^2 ranges. On the right side the same ratio is plotted versus Q^2 for various x_{BJ} ranges. Similar results hold for other x_L bins. In figure 4 the ratio of events with a leading neutron to all events is plotted versus Q^2. For $Q^2 < 1\,GeV^2$ the data are taken with

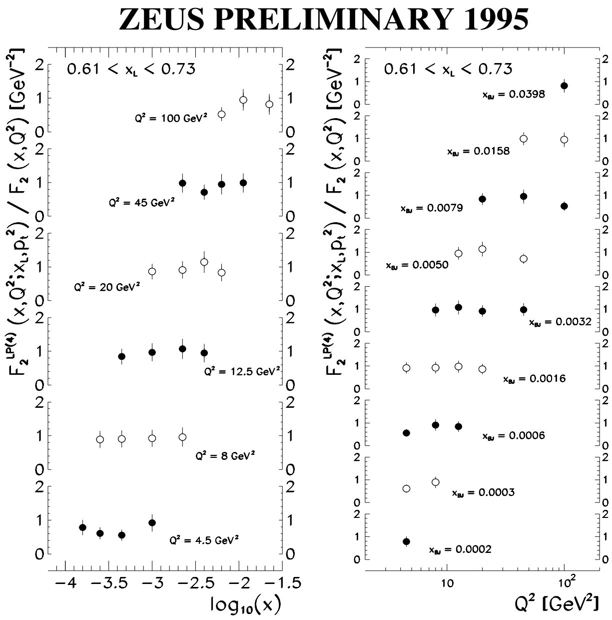

Figure 3. The ratio F_2^{LP}/F_2^{DIS} is plotted against **(a)** $log_{10}(x_{BJ})$ and **(b)** Q^2, for events with a leading proton with $0.61 < x_L < 0.73$

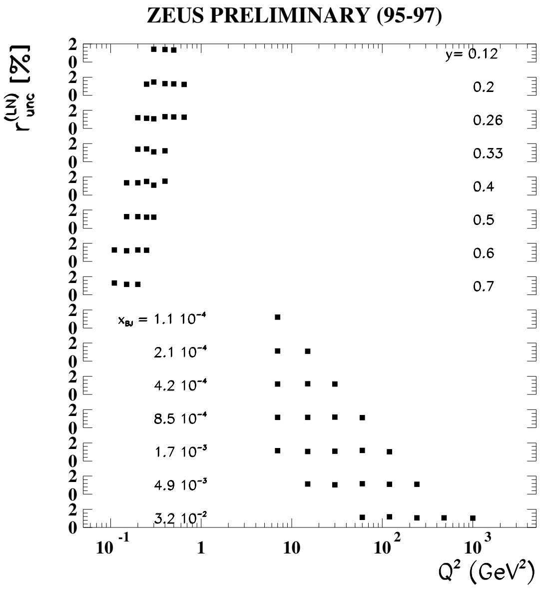

Figure 4. The ratio $r_{unc}^{LN} \simeq N_{LN}/N$ is plotted against Q^2.

the BPC and are plotted in y bins. For the DIS events, the data are plotted in x_{BJ} bins.

4. SUMMARY

Leading proton and neutron production was studied for $0.2 < Q^2 < 250\ GeV^2$. The data can be described by a sum of various particle exchanges. The structure function F_2^{LP} was determined by measuring the ratio F_2^{LP}/F_2^{DIS} was measured, thus minimizing systematic uncertainties. The dependence of the ratios on Q^2 is flat indicating that F_2^{LB} exhibits the same x_{BJ} behaviour and Q^2 scaling as F_2^{DIS}. The flatness of F_2^{LP}/F_2^{DIS} and r_{unc}^{LN} with respect to Q^2 and x_{BJ} is an indication of factorization.

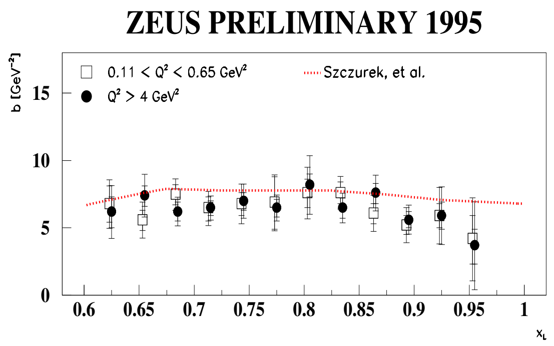

Figure 5. Distribution of the p_T^2 exponential slopes versus x_L for DIS and BPC events with a leading proton.

REFERENCES

1. S. Szczurek, N.N. Nikolaev, J. Speth, Phys. Lett. **B428** (1998) 383.