Strange particle production at HERA

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Abstract. Scaled momentum distributions of strange particles in the Breit frame are presented for *ep* deep inelastic scattering. The measurements are compared with leading order Monte Carlo simulations and next to leading order QCD calculations.

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INTRODUCTION

Study of the strange particle production is an interesting subject in the collider physics. Extensive studies of the fragmentation properties of the hadronic final state have been performed in e^+e^- experiments and in deep inelastic *ep* scattering (DIS) at HERA, and helped to understand the hadronization process. By comparing the *ep* data with the next to leading order (NLO) calculations using various fragmentation functions (FFs) tuned with the e^+e^- and *pp* data, the universality of the quark fragmentation can be tested.

High precision measurements of K_s^0 and Λ produced in *ep* collisions at HERA, presented in this talk, have the potential to further constrain the FFs if included as input to global fits.

SCALED MOMENTUM DISTRIBUTIONS

The measurement of strange particle productions was performed in the Breit frame in which the exchanged virtual boson is purely space-like. This frame provides a maximal separation between the products of the beam fragmentation and the hard interaction. The latter occurs mostly in the current region which is similar to one hemisphere in e^+e^- annihilations.

The scaled momentum (x_p) is defined as

$$x_p = 2p^{Breit}/\sqrt{Q^2}, \qquad (1)$$

where p^{Breit} is the momentum of the hadron in the Breit frame and Q^2 is the negative square of four-momentum transfer. In perturbative QCD, the differential cross section,

$d\sigma/dx_p$, of strange hadrons are expressed as a convolution of three terms as

$$\frac{d\sigma}{dx_p} \propto \int f(x,Q^2) \otimes \sigma(Q^2) \otimes D(z,Q^2), \quad (2)$$

where $f(x,Q^2)$ are the parton density functions, $\sigma(Q^2)$ is the cross section of the hard scattering process and $D(z,Q^2)$ is the FF.

The scaled momentum distributions presented in this talk are defined as

$$\frac{1}{N}\left(\frac{n_h}{\Delta x_p}\right) \qquad h = K_s^0, \Lambda, \quad (3)$$

where N is total number of DIS events in the corresponding Q^2 region, n_h is number of the hadron in the bin (Δx_p).

The measured distribution of K_s^0 and Λ are compared with NLO calculations. Two different FFs are tested in that analysis: One is AKK05+CYCLOPS [1] for K_s^0 and Λ, which was obtained from fits to e^+e^- data and includes hadron mass effect at small x_p and Q^2. The other is DSS [2] for K_s^0. This function was obtained from lp and pp data, and does not include hadrons mass corrections.

MEASUREMENT

The measurement was performed with the HERA $e^{\pm}p$ data at $\sqrt{s} = 318$ GeV collected in 2005-2007 by the ZEUS experiment. The total integrated luminosity used in this analysis is 290 pb^{-1}. DIS events are selected in the following kinematic ranges; $10 < Q^2 < 40000$ GeV^2, $0.001 < x < 0.75$, where x is the fraction of proton momentum carried by the struck quark. Q^2 and x are reconstructed with the double angle (DA) method [3]. K_s^0 and Λ are selected by the invariant mass of the two charged particles measured in the trackers. The measured scaled momentum distributions were corrected to the hadron level.

Fig. 1 shows the results of scaled momentum distribution of K_s^0 and Λ, as a function of Q^2 in different x_p ranges in the current region. The predictions of ARIADNE and LEPTO Monte Carlo (MC) and NLO calculations [4, 5] are also shown. The scaling violations are clearly observed for both K_s^0 and Λ. At low x_p, the yield grows as the Q^2 increases while at high x_p it is opposite. Both MCs reasonably agree with the data for the entire kinematic range investigated.

The NLO+FFs calculations show less agreement with the measured x_p dependence.

The DSS gives a good description of the data for $x_p > 0.3$ and $20 < Q^2 < 40000$ GeV^2. In this region of phase space, the FFs are well constrained with the pp data. At lower x_p, the calculations have a different shape than the data though the normalization is similar.

The AKK+CYCLOPS calculation gives an adequate description of the data only at $0.6 < x_p < 1$ and $Q^2 > 40$ GeV^2. In the other regions, the prediction overestimates the yield, but its shapes reasonably follow the data. The inclusion of the hadron mass effect might be effective for the description of the shape. For Λ, the predictions describe the data only for $0.6 < x_p < 1$. In the other regions, the prediction is higher than the data

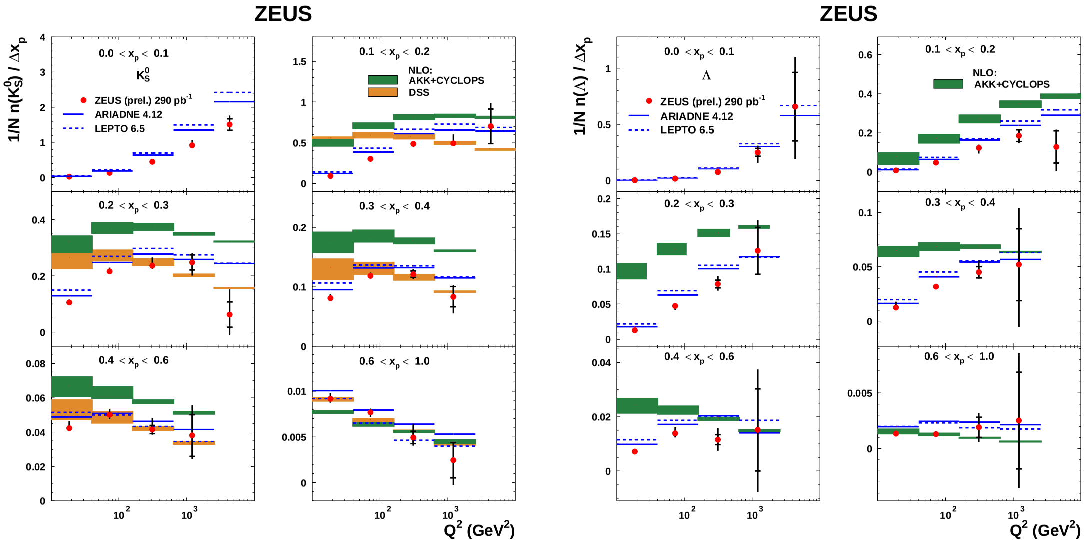

FIGURE 1. Scaled momentum distribution of K_s^0 (left) and Λ (right). The data (solid dots) are shown as a function of Q^2 in six different regions of x_p and they are compared with MCs, ARIADNE (solid line) and LEPTO (dash line) and NLO+FFs, AKK+CYCLOPS (dark shade) and DSS (light shade, K_s^0 only).

and the shape is also different.

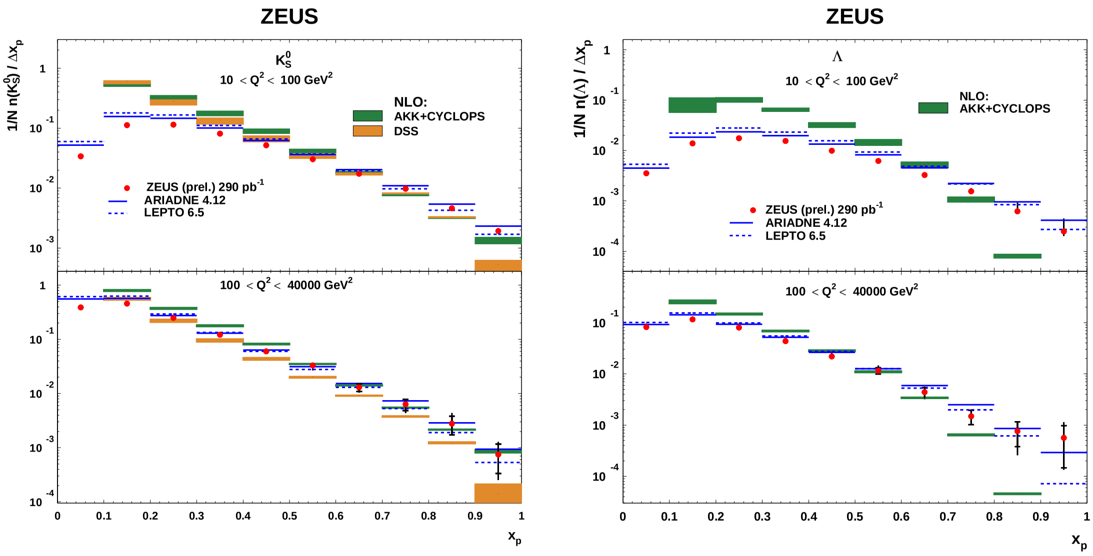

FIGURE 2. Scaled momentum distribution of K_s^0 (left) and Λ (right). The data (solid dots) are shown as a function of x_p in two different Q^2 regions which are $10 < Q^2 < 100$ GeV^2 (top) and $100 < Q^2 < 40000$ GeV^2 (bottom). They are compared with MCs, ARIADNE (solid line) and LEPTO (dash line) and NLO+FFs, AKK+CYCLOPS (dark shade) and DSS (light shade, K_s^0 only).

Fig. 2 shows the results as a function of x_p. The comparisons with the MCs and NLO calculations are also shown. ARIADNE and LEPTO describe the data in the full investigated phase space. For K_s^0, at low Q^2, the AKK+CYCLOPS and DSS NLO calculations are similar and describe the data well for $0.3 < x_p < 0.8$. At high Q^2, the AKK+CYCLOPS calculation gives a good description of the data for $x_p > 0.5$ and it is slightly above for lower x_p values. The DSS calculation gives an adequate description of the data for $x_p < 0.4$ and it is below the data for larger x_p values. Thus, none of the calculations is able to describe the measured x_p dependence. For Λ, the predictions can't reproduce the x_p dependence of the measured scaled momentum distributions.

SUMMARY

The two scaled momentum distributions of K_s^0 and Λ in the Breit frame in DIS are presented. The data clearly show the scaling violation. LEPTO and ARIADNE describe the data well in the investigated phase space. NLO QCD calculations using two different theoretical approaches (AKK+CYCLOPS and DSS) to FFs are able to describe the data in certain regions of the phase space, but not perfectly. We hope that ZEUS results will be useful to constrain the theoretical uncertainties in the description of the strange hadrons.

REFERENCES

1. S.Albino, B.A.Kniekl, G.Kramer, *Nucl. Phys. B725, (2005)* **181**
   S.Albino, B.A.Kniekl, G.Kramer, *Nucl. Phys. B734, (2006)* **50**
2. D.de Florian, R.Sassot, M.Strtmann *Phys. Rev. D75, (2007)* **114010**
3. S.Bentvelsen, J.Engelenand, P.Kooijman, *Proc.of 430 the Workshopon Physics at HERA, W.BuchmüllerandG.Ingelman(eds.), Vol.1, 431 p.23. Hamburg, Germany, DESY (1992)*
4. L.Lönnblad *Comp. Phys. Comm. 71, (1992)* **15**
   L.Lönnblad *Z. Phys.C65, (1995)* **285**
5. G.Ingelman, A.Edin and J.Rathsman, *Comp. Phys. Comm.462101, (1997)* **108**