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Strange Particle Production in Deep-Inelastic Scattering at HERA

H1 Collaboration

Abstract

The production of charged kaons is studied in deep-inelastic positron-proton scattering data taken with the H1 detector at the ep collider HERA. Measurements are presented of the distributions of transverse momentum and pseudorapidity in the hadronic centre of mass system for different intervals of Bjorken-x and Q^2. QCD based models are compared to the data and are also used to investigate the universality of the suppression of strange particles.

Abstract: 157h
Parallel sessions: 3
Plenary sessions: 3

1 Introduction

Measurements by the H1 and ZEUS Collaborations of the hadronic final state at the ep collider HERA have proven important in probing QCD dynamics and have revealed new information on the partonic nature of the proton and the photon [1]. This paper continues a series of studies which are designed to provide a picture of the ep induced hadronic final state that is as complete as is experimentally possible. Measurements are presented of the kinematic properties of low transverse momentum charged kaons inclusively produced in deep-inelastic scattering (DIS) interactions. The aim of this study is to investigate the production of strange quarks in DIS processes and investigate their suppression with respect to the lighter u and d flavours.

Within the traditional theoretical framework for calculating ep scattering processes strange quarks can be produced via several mechanisms: as part of the quark and gluon components of the proton or photon structure; from the QCD evolution of partons before and after the boson-parton scattering and from the vacuum production of $s\bar{s}$ pairs in the hadronisation step. These latter two mechanisms can be probed by the soft particle measurements presented here. QCD evolution effects are studied by comparing calculations using the parton shower [2] approach and the phenomenological Colour Dipole Model [3] of QCD radiation to our data. The environmental independence of quark flavour production within the hadronisation process is investigated by testing a string fragmentation [4] approach determined from e^+e^- results[5] with our data. Such a prescription describes well earlier measurements of the production characteristics of neutral kaons in DIS and photoproduction interactions [6, 7].

2 Event Selection and Detector Description

Experimental data for this analysis were collected with the H1 detector [8] during the 1996 running period, in which HERA collided 27.5 GeV positrons on 820 GeV protons. The data sample used corresponds to an integrated luminosity of 5.3 pb^{-1}.

DIS events are selected and the kinematics calculated with the scattered positron in the backward scintillating fibre calorimeter (SPACAL [9]).

Charged particles measured in the H1 central tracker [10] are used in this study. This device covers a range of polar angle, θ, with respect to the incoming proton direction of $22^\circ < \theta < 150^\circ$. The specific ionisation energy loss of the particles, dE/dx, is also measured and this is used in this study to identify kaons for momentum values of between 0.1 and 0.6 GeV.

In order to maintain high acceptance for performing the studies presented here, a restricted kinematic range is used. All measurements are shown for values of the Bjorken scaling variable x, the exchanged boson virtuality Q^2 and the inelasticity variable y of $10^{-4} < x < 10^{-2}$, $5 < Q^2 < 70$ GeV^2 and $0.1 < y < 0.6$.

3 QCD based models

Two QCD based models, LEPTO 6.51 [11] and ARIADNE 4.08 [12], are compared with the results presented here. Both models use exact matrix elements, calculated to leading order in perturbative QCD although they differ in their approach to modelling QCD evolution effects. LEPTO 6.51 implements a parton shower scheme while ARIADNE 4.10 uses a colour dipole prescription.

Both of the models use string fragmentation as implemented JETSET 7.4 [2], to perform the hadronisation step. The production of strange quarks within this scheme is mainly regulated by the strangeness suppression parameter PARJ(2) which determines the probability of producing a $s\bar{s}$ pair relative to $u\bar{u}$ and $d\bar{d}$ pairs. The default value of this parameter is 0.3 although results from DELPHI [5] on neutral kaon and other light meson measurements support a lower value of 0.23 and the tuning of additional parameters, PARJ(11) and PARJ(12) which determine the probabilities of forming non-strange and strange spin 1 meson states, respectively[1].

The predictions of these models that are made using the string parameters determined by DELPHI are marked LEPTO-D and ARIADNE-D, where shown.

4 Results

Measurements are presented of the differential transverse momentum squared ($\frac{1}{N}\frac{dn}{dp_T^{*2}}$) and pseudorapidity ($\frac{1}{N}\frac{dn}{d\eta^*}$) spectra of charged kaons in the hadronic centre of mass system, for which the incoming photon direction defines the $+z^*$ direction[2]. The kaon measurements are made within the following range of high experimental acceptance in P_T^*, η^* and momentum p^*: $p_T^* < 0.5$ GeV, $2.5 < p^* < 4$ GeV and $2.25 < \eta^* < 4.25$.

In order to investigate the evolution of strangeness production with the kinematics of the ep scattering, the distributions are presented in one bin which covers the full kinematic range (bin 0) and six independent bins in x and Q^2 (bins 1 to 6). Owing to the transformation to the hadronic centre of mass system, the range in pseudorapidity of the produced particles is strongly affected by the changing DIS kinematics and is thus adjusted to maintain high acceptance in each bin. The limits in η^* and the average values of x and Q^2 for the different bins are given in table 1.

The transverse momentum spectra of charged kaons for these seven bins are shown in figure 1. The distributions peak at values of p_T^* of about 0.25 GeV and fall at the larger values of p_T^*. There is no large dependence of the distributions in either shape or yield over the kinematic range presented here. The predictions of ARIADNE-D and LEPTO-D are also shown; ARIADNE-D agrees well with the data whereas the LEPTO-D calculations predict too much strangeness. The measured range in η^* and the values of $\langle x \rangle$ and $\langle Q^2 \rangle$ for each bin are also shown.

[1] The parameters PARJ(11) and PARJ(12) were set to 0.365 and 0.410, respectively

[2] All quantities presented in the this frame are denoted by the superscript *

Bin	$\langle Q^2 \rangle$ /GeV^2	$\langle x \rangle \times 10^{-3}$	η^*
0	14.8	0.76	2.5-3.5
1	6.4	0.16	2.25-3.25
2	6.9	0.43	2.5-3.5
3	12.8	0.40	2.5-3.5
4	14.3	0.99	2.75-3.75
5	30.3	0.97	2.75-3.75
6	40.9	2.6	3.25-4.25

Table 1: The bin number, $\langle Q^2 \rangle$, $\langle x \rangle$ and range in η^* for each bin.

The pseudorapidity distributions of charged kaons are shown in figures 2. The distributions show a peak at $\eta^* \approx 3$. Again, there are no large changes in the shape of the data distributions studied over the studied range in x and Q^2 and ARIADNE-D is found to give a better description of the the spectra than LEPTO-D.

The behaviour of ARIADNE and LEPTO using a strangeness suppression of 0.3 was also examined. The predictions of both models using this parameter setting are about 20% higher than the calculations shown here for charged kaon production. However, this change has little effect on the predictions for inclusive charged particle production and the models give a reasonable description of earlier measurements of transverse momentum spectra in this pseudorapidity range [13] with both tunings.

5 Summary

Measurements have been presented on the properties of charged kaons inclusively produced in deep-inelastic ep scattering interactions at HERA over in the kinematic region: $10^{-4} < x < 10^{-2}$, $5 < Q^2 < 70$ GeV^2 and $0.1 < y < 0.6$.

The differential transverse momentum and pseudorapidity spectra of charged kaons in the range $p_T^* < 0.5$ GeV, $2.5 < p^* < 4$ GeV and $2.25 < \eta^* < 4.25$ were presented in the hadronic centre of mass system for seven different intervals of x and Q^2. No large dependence of the kaon properties on x and Q^2 was found.

The measurements are able to discriminate between QCD based models. The colour dipole model of QCD radiation is preferred over a parton shower scheme. Using ARIADNE, a strangeness suppression factor of about 0.23 is supported by the data, as was also found in e^+e^- measurements.

Acknowledgements

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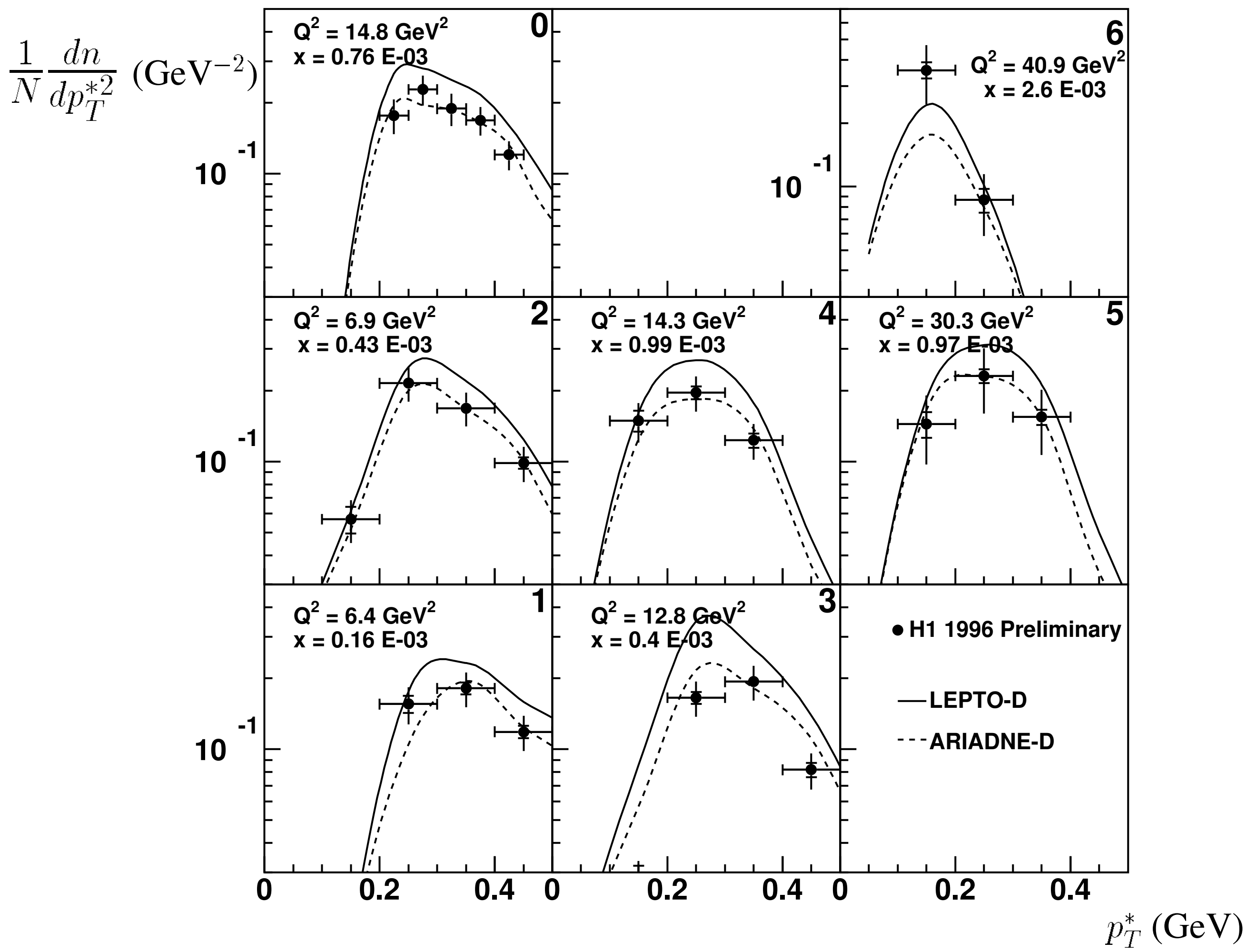

Figure 1: The inclusive charged kaon distributions $\frac{1}{N}\frac{dn}{dp_T^{*2}}$ in seven different bins of x and Q^2. The average values of x and Q^2 for each bin are given. A comparison is made with the predictions of ARIADNE-D and LEPTO-D.

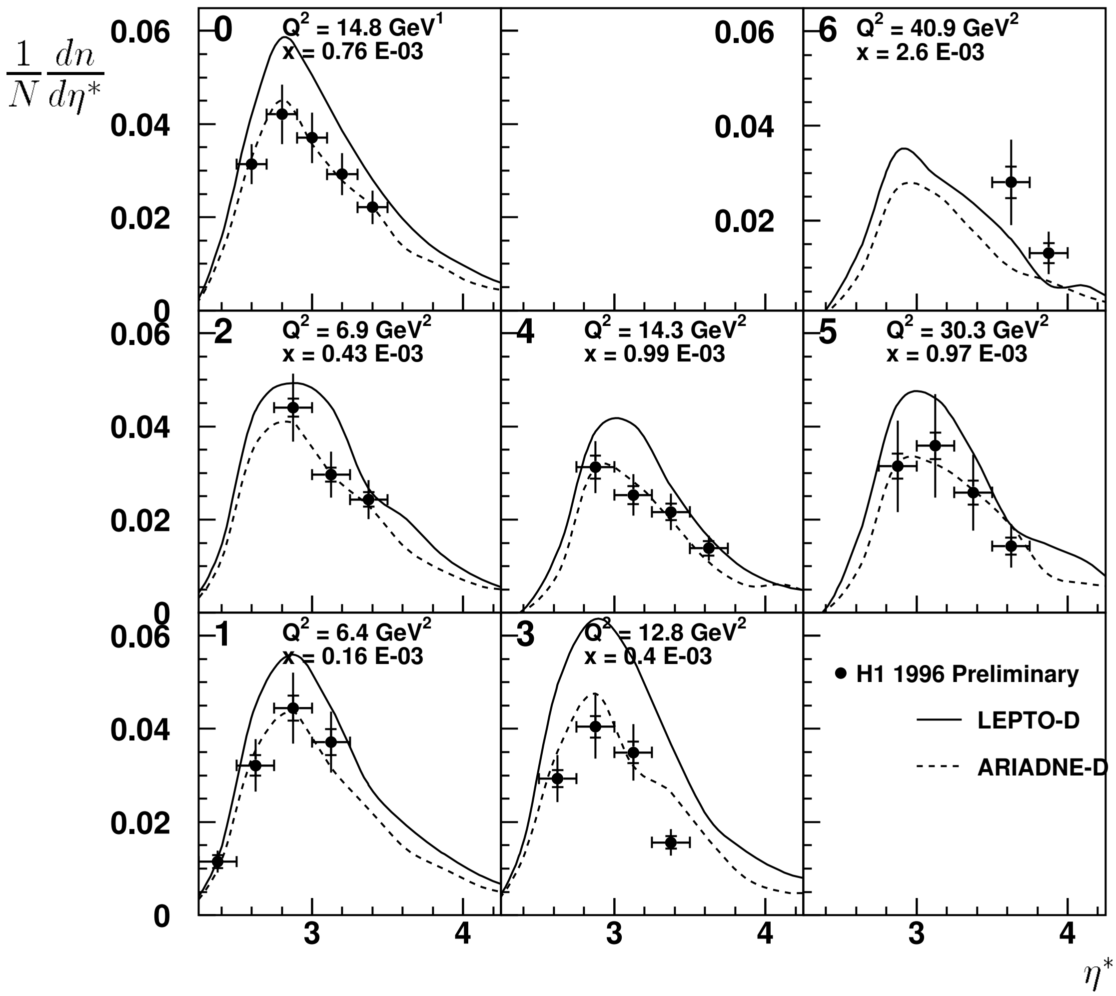

Figure 2: The inclusive charged kaon distributions $\frac{1}{N}\frac{dn}{d\eta^*}$ in seven different bins of x and Q^2. The average values of x and Q^2 for each bin are given. A comparison is made with the predictions of ARIADNE-D and LEPTO-D.