PROCEEDINGS OF SCIENCE

Strangeness Production in Deep Inelastic ep Scattering at HERA

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The production of strange hadrons is investigated using deep-inelastic scattering events measured with the H1 detector at HERA. The K_s^0 and Λ production cross sections and their ratios are determined and presented differentially as functions of several kinematical variables. The K_s^0 production rate is compared to the production of charged particles in the same region of phase space. In addition, the Λ - $\bar{\Lambda}$ asymmetry is measured. The production of K*(892) vector mesons in deep-inelastic scattering at low Q^2, observed through the decay chain $K^{*\pm} \rightarrow K_s^0\pi^{\pm}$, is measured for the first time at HERA. Inclusive cross sections are presented as functions of the transverse momentum squared P_T^{*2} and Feymann-x x_F of the hadronic center of mass frame. The data are compared to theoretical predictions based on leading order Monte Carlo programs with parton showers.

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1. Introduction

The measurement of strange particle production in neutral current deep inelastic scattering (DIS) events recorded at the HERA ep collider is presented. The mesons K_s^0 and $K^{*\pm}$ and the baryon Λ[1] are studied through the following decay channels: $K_s^0 \to \pi^+\pi^-$, $K^{*\pm} \to K_s^0\pi^\pm \to \pi^+\pi^-\pi^\pm$ and $\Lambda \to p\pi^-$ in the central region of the detector and low values of the negative four-momentum squared of the photon, $Q^2 <$100 GeV^2.

The total cross section of strange particles and their differential cross sections as functions of Q^2, pseudorapidity η and transverse momentum P_T are measured in the laboratory frame and as functions of x_p^{Breit} and P_T^{Breit} in the Breit frame. The K_s^0 to light mesons production cross section rate ($K_s^0/h^\pm$) and the baryon to meson ratio (Λ/K_S^0) are also measured. The $\Lambda - \overline{\Lambda}$ asymmetry is measured in order to look for evidence of baryon number transfer. The results are compared to the CDM and MEPS models, as implemented in ARIADNE [1] and LEPTO [2], respectively, both interfaced to the LUND string fragmentation model [3].

Differential cross sections for $K^{*\pm}(892)$ are also presented as functions of Feymann-x x_F and transverse momentum P_T^{*2} in the hadronic center of mass system and compared to the CDM model. CDM is then used to estimate the contribution of each flavour to the cross section.

Strange hadrons can be produced in the non-perturbative process of fragmentation, or they can originate from the strange sea in the nucleon, boson-gluon fusion or heavy quark decays [4]. This analysis allows to test model predictions as implemented in Monte Carlo programs and the optimization of their parameters. It also tests the universality of the fragmentation mechanism.

2. Selection of DIS Events and Strange Particles

The data for this analysis correspond to an integrated luminosity value of 50 pb^{-1} for the sample of K_s^0 and Λ and 302 pb^{-1} for $K^{*\pm}$, both collected by the H1 detector during the HERA collision of electrons at energy E_e =27.6 GeV with protons at 920 GeV.

The selection of DIS events is based on the identification of the scattered electron with the energy requirement $E_{e'} >$11 GeV. The negative four momentum transfer squared of the photon is in the range of 2< Q^2 <100 GeV^2 for K_S^0 and Λ, and 5< Q^2 <100 GeV^2 for $K^{*\pm}$.

The selection of strange particles depends on the measurement of their final charged daughter particles. The tracks of the daughters of the K_S^0 and Λ must be in the central region of the detector and must point back to a common secondary decay vertex with the direction of flight of the mother particle constrained to the primary event vertex. The transverse momentum P_T and the pseudorapidity η of the strange particle candidates must be between $0.5 < P_T < 3.5$ GeV, $|\eta| < 1.3$ for K_S^0 and Λ, and $P_T > 1.0$ GeV, $|\eta| < 1.5$ for $K^{*\pm}$. The charged particle tracks considered for the $K_s^0/h^\pm$ ratio must point to the primary vertex and have to fulfill the same P_T and η ranges as the K_S^0 .

All the particles passing the selection criteria above contribute to the invariant mass distributions. By fitting these plots with different functions to describe background and signal, a number of approximately 213,000 K_S^0 , 22,000 Λ, 20,000 $\overline{\Lambda}$ and 80,000 $K^{*\pm}$ are identified with a fitted mass value in concordance with the reported PDG [5] values, for each particle under study.

3. Results

3.1 Inclusive Cross Sections

The total inclusive production cross sections in the visible kinematic range are found to be:

$$\sigma_{K_s^0} = 21.18 \pm 0.09(\text{stat.})^{+1.19}_{-1.23}(\text{syst.})\text{ nb},$$

[1]Unless explicitly mentioned, a reference to a state implicitly includes the charge conjugate of that state.

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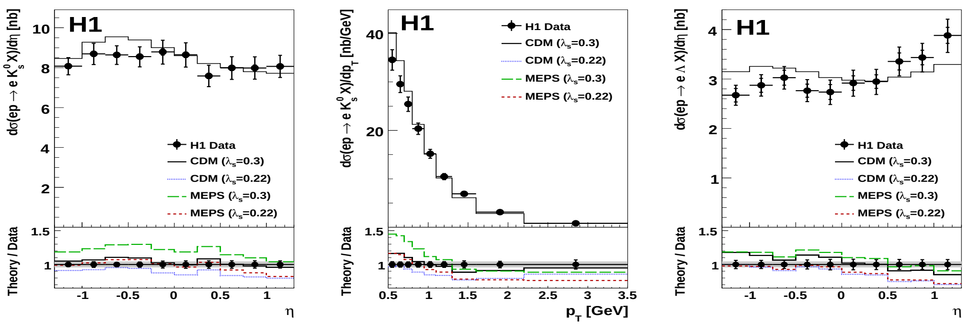

Figure 1: Differential cross sections for K^0_S as functions of pseudorapidity η and transverse momentum P_T of the particle and for Λ as function of η in the laboratory frame. The error bars show the total uncertainty. The ratio of different model predictions to data are shown by the solid and dashed lines in the bottom of the plot.

$$\sigma_\Lambda = 7.88 \pm 0.10(\text{stat.})^{+0.45}_{-0.47}(\text{syst.})\ \text{nb},$$
$$\sigma_{K^*} = 7.36 \pm 0.087(\text{stat.}) \pm 0.88(\text{syst.})\ \text{nb},$$

all of them consistent with Monte Carlo expectations.

3.2 K^0_S and Λ Differential Cross Sections

K^0_S and Λ cross sections are measured differentially in laboratory and breit frames as functions of the kinematic variable Q^2, the pseudorapidity η, transverse momentum P_t, x_p^{Breit} and P_T^{Breit}. They are compared to the mentioned Monte Carlo predictions for two values of the strangeness suppression factor, λ_s= 0.22 and 0.3.

The differential cross section measurements quickly decrease when the value of the variables Q^2 and P_T increase. The η cross section is flat for K^0_S but rises in the forward region for Λ (Figure 1). The CDM model with λ_s =0.3 agrees best with the data although it has difficulties with the η shape and at low P_T.

In the current region of the Breit frame the sensitivity to λ_s is reduced compared to the laboratory frame and the target region. This is due to larger errors and a smaller fraction of strangeness produced in the fragmentation process. The cross sections in the current and the target region are generally well described by both the MEPS and CDM model predictions [6].

The asymmetry in the Λ and $\bar{\Lambda}$ production measurement, denoted as $A_\Lambda = \sigma_\Lambda - \sigma_{\bar{\Lambda}}/\sigma_\Lambda + \sigma_{\bar{\Lambda}}$, is consistent with zero within errors. Thus, no evidence of baryon transfer number from the proton beam to the Λ final states is visible.

The measument of the Λ/K^0_S cross section ratio reduces theoretical and experimental uncertainties and allows the observation of differences in the strange baryon to meson production. As expected, this ratio does not depend on λ_s. CDM describes the data better but deviations are seen in the shape of the η distribution [6]. The increase of the ratio with P_T obeys the kinematics of heavy particles carring more momentum. The $K^0_s/h^\pm$ ratio is approximately constant as function of Q^2 and η. The MEPS model tends to describe better the data.

3.3 $K^{*\pm}$ Differential Cross Sections

The $K^{*\pm}$ differential cross section results in the laboratory frame are compared to models with λ_s =0.286. As was observed for K^0_S and Λ, for $K^{*\pm}$ both models fail to describe the η cross section but in general CDM seems better than MEPS. In the hadronic center of mass frame the cross section as function of x_F and P_T^{*2} is compared to contributions of light, strange and heavy quarks from CDM (Figure 2). The processes contributing to strangeness production show a different behaviour as function of x_F. The fragmentation of light

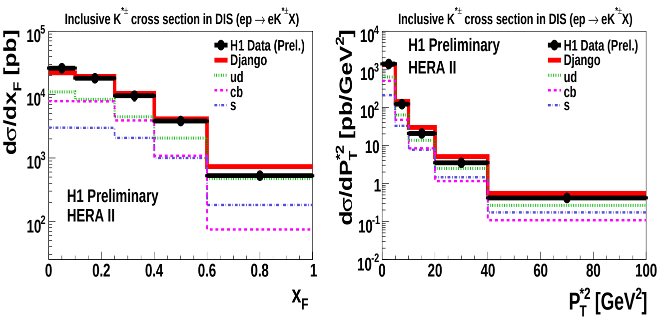

Figure 2: Differential cross sections for $K^{*\pm}$ as functions of Feymann-x X_F and transverse momentum P_T^{*2} of the particle in the hadronic center of mass frame. The error bars show the total uncertainty. The flavour contributions of light, strange and heavy quarks from CDM are shown by the solid and dashed lines.

quarks (ud) is expected to dominate everywhere. The decay of heavy quarks (cb) contributes mainly at small x_F, while the strangeness produced directly in the hard subprocess plays a larger role at large x_F.

4. Conclusions

Strange K_S^0 and $K^{*\pm}$ mesons and Λ baryon total and differential cross sections, as well as the baryon to meson ratio and the K_S^0 to charged particles ratio, have been measured by the H1 collaboration at low $Q^2 < 100$ GeV^2 as functions of the negative four-momentum squared of the photon Q^2, pseudorapidity η, transverse momentum P_T, and x_p^{Breit} and P_T^{Breit} in Breit frame.

The comparison to CDM and MEPS models with the strangeness suppression factor $\lambda_s = 0.22$ and 0.3 show that no single model prediction or strangeness factor is able to describe all results. The measurement of the Λ asymmetry shows no evidence of baryon number transfer from the proton beam.

The shape of the Feymann-x x_F distribution in the hadronic center of mass frame is sensitive to the different strangeness production processes for $K^{*\pm}$ meson.

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[5] http://pdg.lbl.gov/

[6] http://indico.ifj.edu.pl/MaKaC/sessionDisplay.py?sessionId=19&slotId=0&confId=11#2009-07-16