PROCEEDINGS OF SCIENCE

Strangeness production at high Q^2 with the H1 detector

Julia E. Ruiz Tabasco[*†]
Centro de Investigaciones y Estudios Avanzados del Instituto Politécnico Nacional
Antigua carretera a Progreso Km. 6
97310, Mérida, Yucatán, México
E-mail: `jruiz@mda.cinvestav.mx`

The production of K_S^0 mesons is studied using deep-inelastic scattering events (DIS) recorded with the H1 detector at the HERA ep collider. The measurement is performed in the phase space defined by the four-momentum transfer squared of the photon, 145 GeV$^2 < Q^2 <$ 20000 GeV^2. The differential production cross sections are presented as function of the transverse momentum p_T of the particle in the laboratory frame, and as function of the scaled momentum fraction x_p^{BF} and transverse momentum p_T^{BF} in the Breit frame. The K_S^0 production rate is also compared to the production of charged particles and to the production of DIS events in the same region of phase space. The data are compared to theoretical predictions, based on leading order Monte Carlo programs with matched parton showers. The Monte Carlo models are used to study the flavour contribution to the K_S^0 production.

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[†]On behalf of the H1 Collaboration.

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1. Introduction

The production of strange hadrons in high energy particle collisions allows the investigation of strong interactions in the perturbative and non-perturbative regimes. Strange quarks are created in the non-perturbative process of colour string fragmentation, which constitutes the dominant production mechanism of strange hadrons. In deep-inelastic scattering (DIS), strange quarks also originate from the strange sea in the nucleon, boson-gluon fusion and heavy quark decays. Measurements of strangeness production have been used to investigate the suppression of strangeness relative to lighter flavours in fragmentation.

Previous studies of strangeness production have been done by the H1 collaboration, as the most recent published results at low values of the four-momentum squared of the photon 2 GeV^2 $<$ $Q^2 < 100$ GeV^2 [1]. The analysis presented here, corresponds to the first measurements of strangeness production in the range, 145 GeV^2 $< Q^2 <$ 20000 GeV^2, in deep-inelastic scattering events (DIS) recorded with the H1 detector at the HERA ep collider. The K_S^0 meson is studied through its decay channel $K_S^0 \rightarrow \pi^+\pi^-$. The differential cross section as function of the transverse momentum p_T of the strange particle is determined in the laboratory frame. The analysis is also carried out in the Breit frame [2] as function of the scaled momentum fraction x_p^{BF} and the transverse momentum p_T^{BF} in both, current (CBF) and target (TBF) hemispheres. The ratio of the differential cross section of the K_S^0 over the charged particles ($K_S^0/h^{\pm}$) and the K_S^0 over the DIS events (K_S^0/DIS) are also determined.

Two models are used for the comparison to data, the CDM and MEPS models based on ARIADNE [3] and LEPTO [4], respectively. Both are interfaced to the LUND string fragmentation [5] for the modeling of the hadronization process, where the strangeness suppresion factor λ_s is the most important parameter for this study and represents the relative probability of producing a $s\bar{s}$ pair with respect to the creation of a light flavour $q\bar{q}$ pair. The contribution of different quark flavours to the K_S^0 production is studied using the MEPS model.

From the measurements, the theoretical models of the hadronization and fragmentation processes are tested allowing to optimize their parameters. In particular, for the LUND model, a test of λ_s universality is carried out.

2. Selection of DIS events, charged particles and K_S^0 candidates

The analysed data period corresponds to the years from 2004 to 2007 where the HERA machine operated with a center of mass energy of $\sqrt{s} = 319$ GeV. The total accumulated luminosity collected by the H1 detector is $\mathscr{L} = 340$ pb^{-1}.

DIS events are identified by the detection of the scattered electron and selected in the high range of the four-momentum squared of the photon 145 GeV$^2 < Q^2 < 20000$ GeV^2 and inelasticity in the range of $0.2 < y < 0.6$.

The K_S^0 meson is reconstructed through the tracks of its daughters π^+ and π^-, which must be in the central region of the H1 detector (-1.5 $< \eta <$ 1.5) and share a common secondary vertex with the direction of flight of the mother constrained to the primary event vertex. The transverse momentum p_T of the K_S^0 is chosen to be higher than 0.3 GeV. The DIS events used for the measurement of the ratio of the K_S^0 production cross section to the inclusive DIS cross section must satisfy

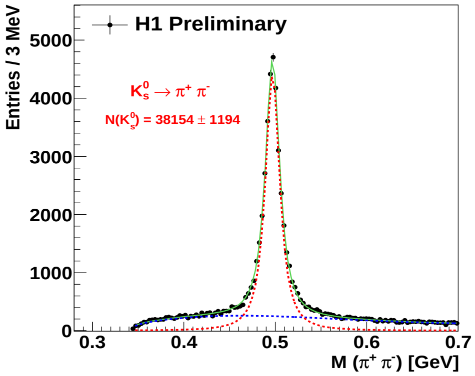

Figure 1: Invariant mass distribution of the K_S^0 candidates identified in the decay channel $K_S^0 \to \pi^+\pi^-$. The fit functions to describe the signal and the background are shown in dashed lines.

the same Q^2 and y ranges as the K_S^0. The charged particles $h^\pm$ considered for the ratio $K_S^0/h^\pm$ must originate from the primary vertex and have to fulfill the same phase space selection criteria than the K_S^0.

The invariant mass distribution of the K_S^0 candidates is presented in Figure 1. The total number of K_S^0 candidates is extracted from the fit to a t-student distribution to describe the signal and the function $p_0(x-0.344)^{p_1} * Exp(p_2x + p_3x^2 + p_4x^3)$ for the background. In total, 38154 ± 1194 candidates are observed with a fitted mass value in concordance with the value reported in PDG [6].

3. Results

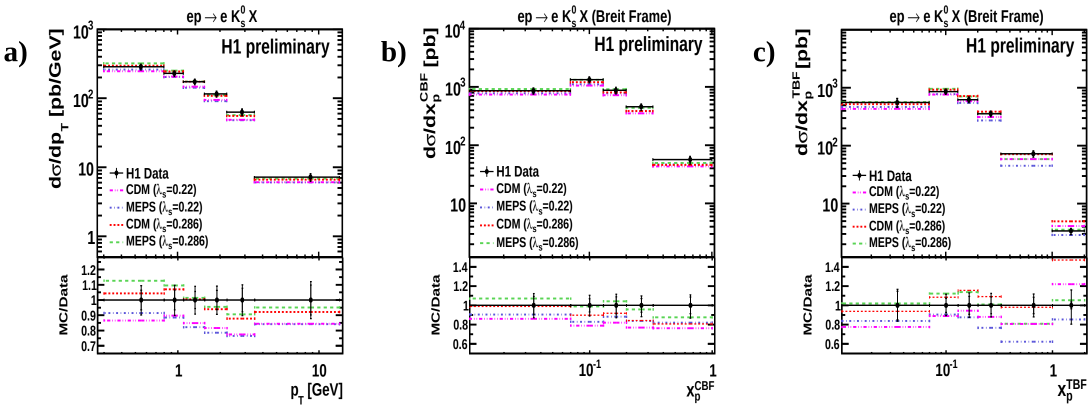

Figure 2: The K_S^0 differential cross sections as function of a) the transverse momentum of the particle in the laboratory frame, and the scaled momentum fraction in b) current x_p^{CBF} and c) target x_p^{TBF} hemipheres in the Breit frame.

The measured inclusive cross section of K_S^0 production in the visible kinematic range is:

$$\sigma_{vis} = 531 \pm 17(\text{stat.})^{+37}_{-39}(\text{syst.})\ \text{pb},$$

which is consistent with the predictions from the CDM and MEPS models with $\lambda_s = 0.286$.

Figure 2 shows the differential cross section of K_S^0 production as a function of p_T in the laboratory frame and of the scaled momenta x_p^{CBF} and x_p^{TBF} in the current and target hemisphere of the Breit frame, respectively. The measurements are compared to CDM and MEPS models with two different values of strangeness factor, $\lambda_s = 0.22$ and $\lambda_s = 0.286$. Both models with $\lambda_s = 0.286$ give similar descriptions and agree better with data in shape and normalization than the models with $\lambda_s = 0.22$. The CBF is mainly sensitive to the dynamics of the hard sub-process while in the TBF the influence from hadronization is expected to be significant. Therefore more sensitivity to λ_s in x_p^{TBF} compared to x_p^{CBF} is expected. However, the data of the current measurement are not precise enough to see significant differences in the sensitivity to hadronization of the two hemispheres.

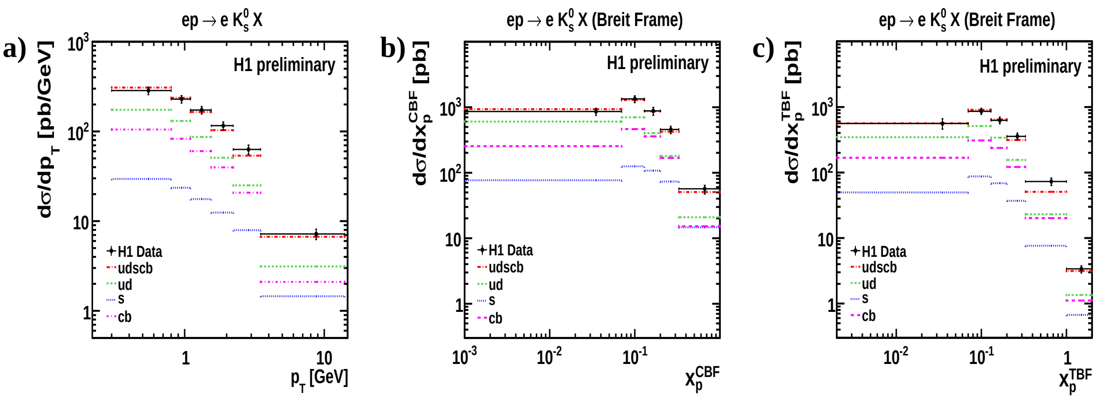

Figure 3: Differential cross sections of the K_S^0 separated in flavour contributions as function of a) the transverse momentum p_T in laboratory frame and the scaled momentum fraction b) in current x_p^{CBF} and c) target x_p^{TBF} regions in the Breit frame.

Figure 3 shows the flavour decomposition of K_S^0 production as a function of p_T, x_p^{CBF} and x_p^{TBF} as obtained by the MEPS Monte Carlo program. This figure shows that K_S^0 mesons are mainly originating from u and d quarks in this analysis. The second largest contribution is obtained from the decay of heavy flavoured hadrons. Strange quarks contribute only very little to the K_S^0 production cross section in general. The contribution increases at large p_T as well as at large x_p^{CBF}. In these phase space regions the K_S^0 production from heavy flavours are suppressed because charm and beauty mainly originate from boson-gluon fusion.

The measured differential ratio of the K_S^0 cross section over the charged particle production in the same phase space, refered as $K_S^0/h^{\pm}$, are shown in Figures 4 a) and b) as function of Q^2 and p_T in laboratory frame. This ratio is almost constant in Q^2 while it rises significantly with p_T, which is expected due to the heavier mass of the K_S^0 with respect to the most common charged particles. All distributions agree best with the predictions for a strangeness suppression factor $\lambda_s = 0.286$.

The density (K_S^0/DIS), or production rate of the K_S^0 compared to the DIS events selected in the same kinematic phase space, gives a flat distribution around 0.4 independently of Q^2 as shown in Figure 4 c). Again, both models with $\lambda_s = 0.286$ describe the data but in x a small decrease is predicted, which is not observed from the measurement.

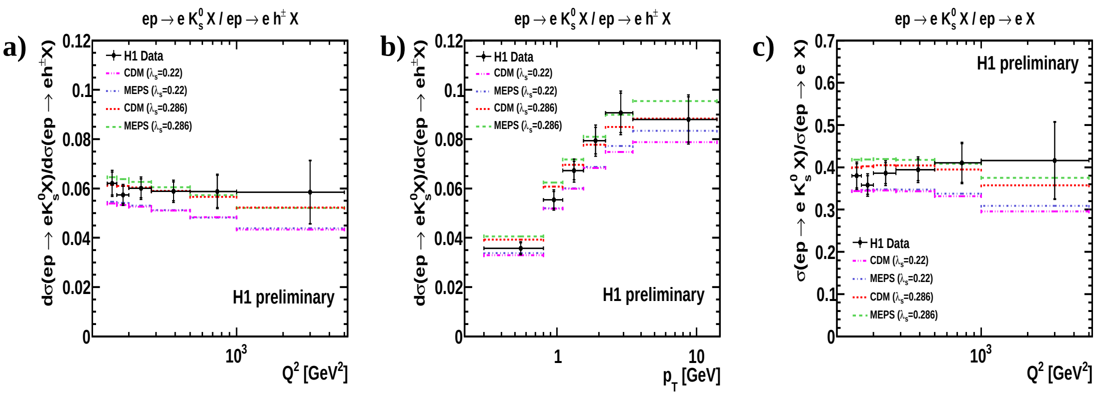

Figure 4: The measured ratios of the K^0_S over charged particles ($h^{\pm}$) as function of a) four-momentum of the transfer photon Q^2 and b) the transverse momentum p_T of the K^0_S . c) The density distribution K^0_S/DIS as function of Q^2.

4. Conclusions

Results on K^0_S production at high $Q^{\,2}$ from the H1 Collaboration have been presented. Differential cross sections as a function of p_T, x_p^{CBF} and x_p^{TBF} have been shown. The ratio of K^0_S to charged hadron production has been determined. It has been shown that K^0_S production at HERA is dominated by fragmentation in the kinematic range of this analysis. All measurements are found to be described best by a strangeness suppression factor $\lambda_s = 0.286$ independently of the models under consideration.

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