Particle production at HERA

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Abstract. H1 has measured a number of different known particles and compared their production to QCD models and to other reactions such as N-N collisions. ZEUS has also measured the production of $K^0_S K^0_S$ pairs with a view to searching for glueballs. Several resonances are seen which are glueball candidates. The results on the masses and widths are compared to other experiments.

At HERA acceleration ring, electron (positron) and proton beams were accelerated and made to collide with a center-of-mass energy of above 300 GeV at two interaction points where the H1 and ZEUS detectors were located.

1. Energy dependence of the charged multiplicity in deep inelastic scattering

The production of multi-hadronic final states has been an interesting subject. Charged multiplicity in DIS are measured in both the hadronic center-of-mass (HCM) frame and the Breit frame, using an integrated luminosity of 38.6 pb^{-1}. Only hadrons in the current fragmentation regions of both frames were used due to detector acceptance limitations.

The mean charged multiplicity is shown in Figure 1(left) in the current region of the HCM frame as a function of energy, W, and in the current region of the Breit frame as a function of $2 \cdot E_B^{cr}$. The data are compared and in good agreement with the ARIADNE and LEPTO Monte Carlo predictions, while results from HERWIG Monte Carlo prediction are lower. The data are also compared with results of previously published ZEUS [1] and H1 [2, 3, 4] measurements. The measurements agree within the experimental uncertainties at higher values of $2 \cdot E_B^{cr}$, but differ at low values as a function of Q. The energy scale $2 \cdot E_B^{cr}$ gives better agreement in the current region of the Breit frame and results from e^+e^- experiment than using Q. The mean charged multiplicities are compared with results from e^+e^- [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16] and fixed-target [17, 18, 19] experiments in Figure 1 (right). Both the current regions of the Breit and HCM frames are used as function of the energy scales, $2 \cdot E_B^{cr}$ and W, respectively. Good overall agreement is observed among these experiments, presenting the same dependence of the mean charged multiplicity on the respective energy scale. In general conclusion, universality of mean charged multiplicity dependence with energy scale is observed.

2. Strangeness production at low Q^2 in deep inelastic ep scattering

The production measurement of strangeness production gives insight into the suppression of strangeness involved in lighter flavours fragmentation process studies. This non-perturbative

[1] On behalf of the H1 and ZEUS collaborations

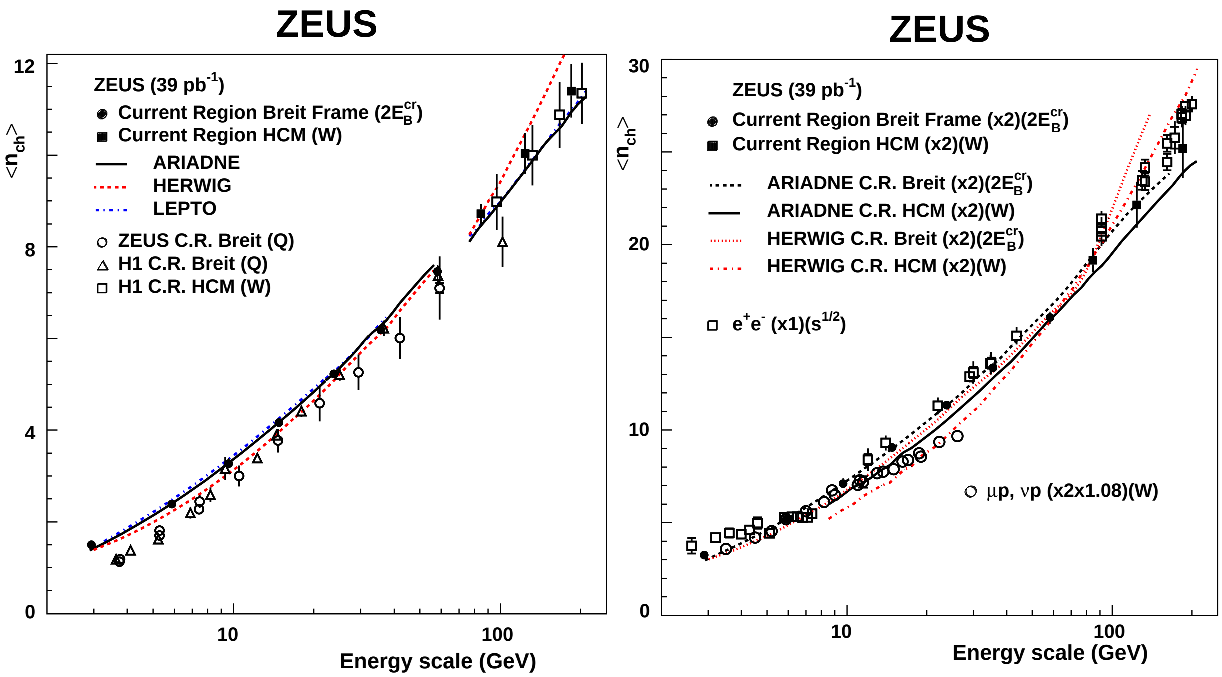

Figure 1. Mean charged multiplicity, $< n_{ch} >$, as a function of energy scale.

colour string fragmentation process dominates the mechanism of strange hadrons, followed by the QPM(Quark Parton Model), BGF(Boson-Gluon Fusion) and heavy quark decays.

Neutral strange particles (K_S^0 and $\Lambda(\overline{\Lambda})$) production in DIS with $2 < Q^2 < 100\ GeV^2$ are measured by the H1 collaboration with the data sample collected in the years 1999 and 2000, superseding a previous H1 publication [20] with 40 times larger statistics.

The neutral strange meson K_S^0 and baryon $\Lambda(\overline{\Lambda})$ are reconstructed via their dominant decay channels: $K_S^0 \to \pi^+\pi^-$ and $\Lambda(\bar{\Lambda}) \to p(\bar{p})\pi^-(\pi^+)$. Various selection cuts are applied to purify the data sample.

The total inclusive cross section σ_{vis} in the selected kinematic region is given by:

$$\sigma_{vis}(ep \to e[K_S^0, \Lambda, h^{\pm}]X) = \frac{N}{\mathcal{L} \cdot \epsilon \cdot BR \cdot (1 + \delta_{rad})} \qquad (1)$$

where N represents the observed number of K_s^0, the sum of Λ and $\overline{\Lambda}$ baryons or the charged hadrons $h^{\pm}$, respectively. $\mathcal{L}$ is the integrated luminosity. BR are the branching ratios for the K_s^0 and Λ decays and $BR = 1$ for charged hadrons.

The production cross section and their ratios of K_S^0 , Λ and charged hadrons are measured inclusively. The results are in good agreement with DJANGOH Monte Carlo predictions. The cross section ratio is better described by the CDM(Colour Dipole Model) than the MEPS(Matrix Element plus Parton Shower). The K_S^0 to charged hadrons cross section ratio shows better agreement with the data with $\lambda_s = 0.22$, where λ_s is the ratio of the possibilities of the strange and light quark productions. The result is demonstrated in Figure 2.

3. Inclusive photoproduction of ρ^0, K^0 and ϕ mesons

Inclusive non-diffractive photoproduction of $\rho(770)^0$, $K^*(892)^0$ and $\phi(1020)$ mesons is investigated by the H1 collaboration with an integrated luminosity of $\mathcal{L} = 36.5\ \text{pb}^{-1}$ taken in year 2000.

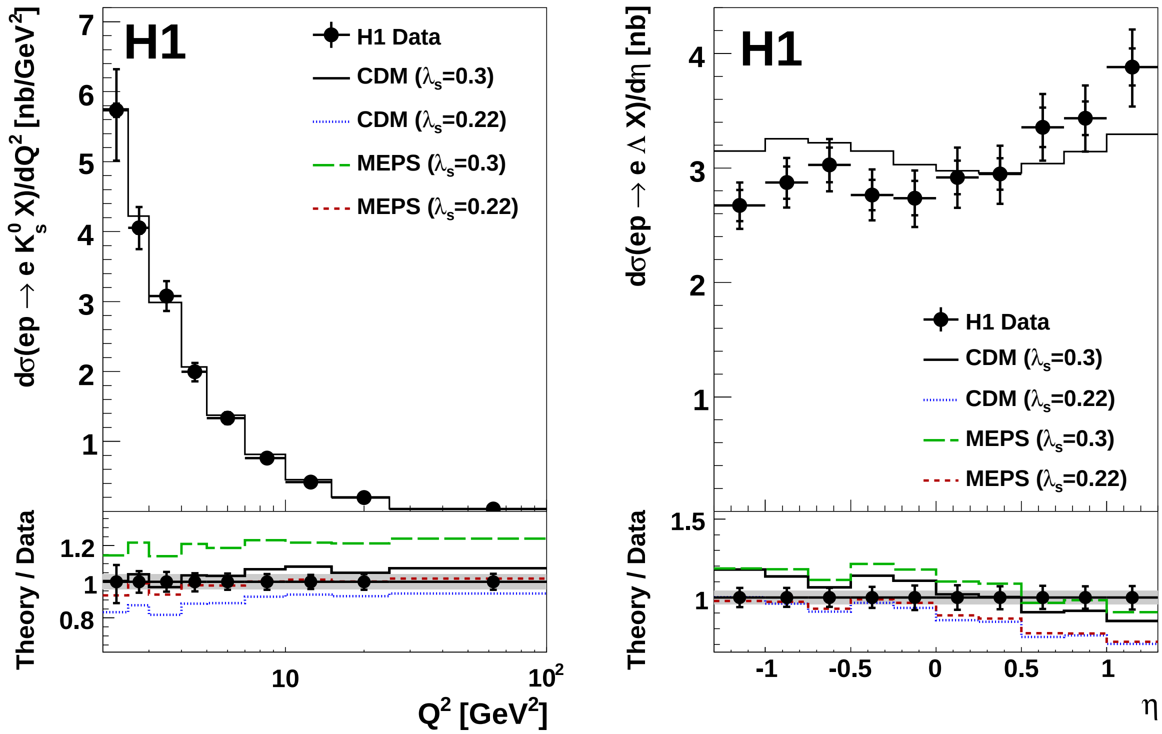

Figure 2. The differential cross section in the laboratory frame for K^0_S as a function of the photon virtuality squared Q^2 (left) and for Λ as a function of pseudorapidity η (right).

The mesons are reconstructed using their dominant decay channels: $\rho(770)^0 \to \pi^+\pi^-$, $K^*(892)^0 \to K^+\pi^-$ or $\overline{K}^*(892)^0 \to K^-\pi^+$ and $\phi(1020) \to K^+K^-$. Differential cross sections are presented as a function of transverse momentum in Figure 3, and are compared to the predictions of hadroproduction models.

The results supports the thermodynamic picture of hadronic interactions [21], in which the different primary hadrons are thermalized and produced in different extends.

The cross section ratios are determined and compared to results obtained in pp and heavy-ion collisions. General agreements are achieved.

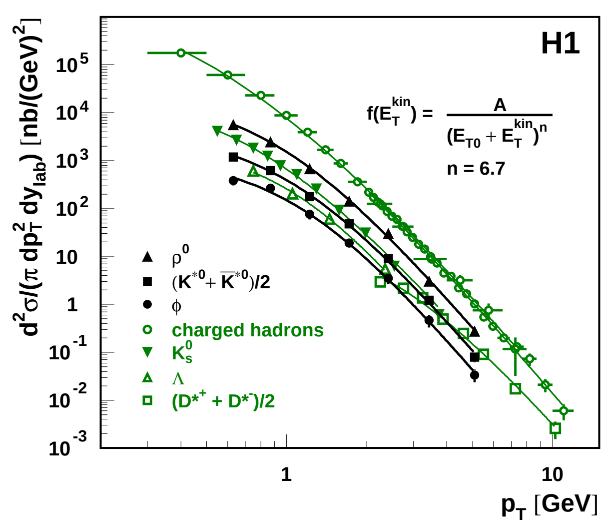

Figure 3. The curves are the fits to the power law.

4. Inclusive $K^0_S K^0_S$ resonance production in ep collisions

The lightest glueball is predicted by theory [22, 23] to have $J^{PC} = 0^{++}$ and it has a mass in the range 1450–1750 MeV. It can mix with $q\overline{q}$ states from the scalar meson nonet, like $K^0_S K^0_S$ resonance states.

Inclusive $K^0_S K^0_S$ production in ep collisions at HERA has been studied with the ZEUS detector using the full set of the integrated luminosity of 0.5 fb^{-1}. K_S^0 mesons were reconstructed through the charged-decay mode, $K_s^0 \to \pi^+\pi^-$. The $K_S^0 K_S^0$ invariant mass distribution was reconstructed by combining two K_S^0 candidates. Enhancements attributed to the production of $f_2(1270)/a_2^0(1320)$, $f_2'(1525)$ and $f_0(1710)$ are observed in the $K_S^0 K_S^0$ mass spectrum.

The $f_2(1270)$, $a_2^0(1320)$ and $f_2'(1525)$ states have $J^P = 2^+$ spin. The intensity of the modulus-squared of the sum of these three amplitudes with ratios of $5 : -3 : 2$ as expected for production via an electromagnetic process [24, 25] and the incoherent addition of $f_0(1710)$ can be derived from the SU(3) symmetry argument. Very competitive measurements on peak position and width for $f_2'(1525)$ and $f_0(1710)$ are done with interference fit and the overall fit describes the data very well as shown in Figure 4. The values with statistical and systematical uncertainties were compared well with the PDG values [26].

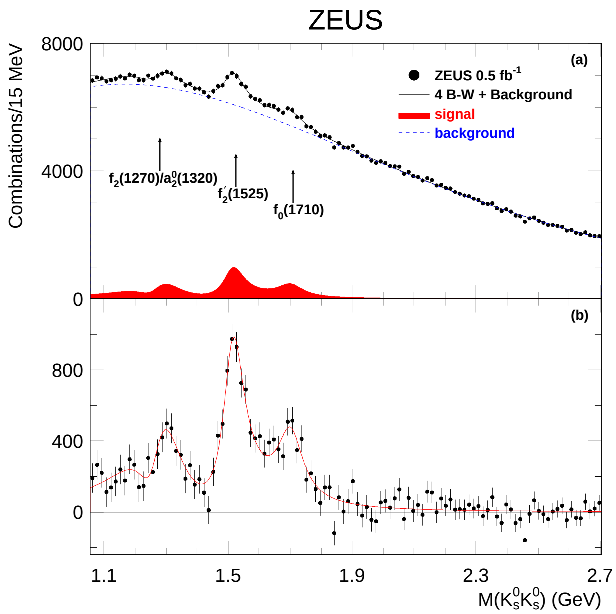

Figure 4. The measured $K_S^0 K_S^0$ invariant-mass spectrum (a) and background-subtracted $K_S^0 K_S^0$ invariant-mass spectrum (b) with fits

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6. References

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