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Measurement of the $\psi(2S)$ and J/ψ cross section ratio in photoproduction with the ZEUS detector at HERA

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The exclusive photoproduction reaction $\gamma p \to \psi(2S)p$ has been studied with the ZEUS detector in ep collisions at HERA using an integrated luminosity of 333 pb^{-1}, in the kinematic range $30 < W < 180$ GeV, $Q^2 < 1$ GeV^2, $|t| < 5$ GeV^2, where W is the photon proton centre-of-mass energy, Q^2 - the photon virtuality and t - four-momentum transfer at the proton vertex. The $\psi(2S)$ mesons were identified via the decay channels: $\psi(2S) \to \mu^+\mu^-$ and $J/\psi\pi^+\pi^-$ with $J/\psi \to \mu^+\mu^-$. The ratio of the production cross sections $R = \sigma(\psi(2S))/\sigma(J/\psi)$ was measured as a function of W, for three W intervals: $30 < W < 80$ GeV, $80 < W < 130$ GeV and $130 < W < 180$ GeV and in the whole kinematic range accessible in this analysis. The advantage of including the 4-prong final state channel is its negligible background in the respective invariant mass distribution and small systematic uncertainty due to the branching ratio (BR) comparing to the BR of direct decay of $\psi(2S)$ into a muon pair.

The presented analysis is complementary to already published ZEUS measurement of the same quantity as a function of Q^2 in deep-inelastic (DIS) channel [1].

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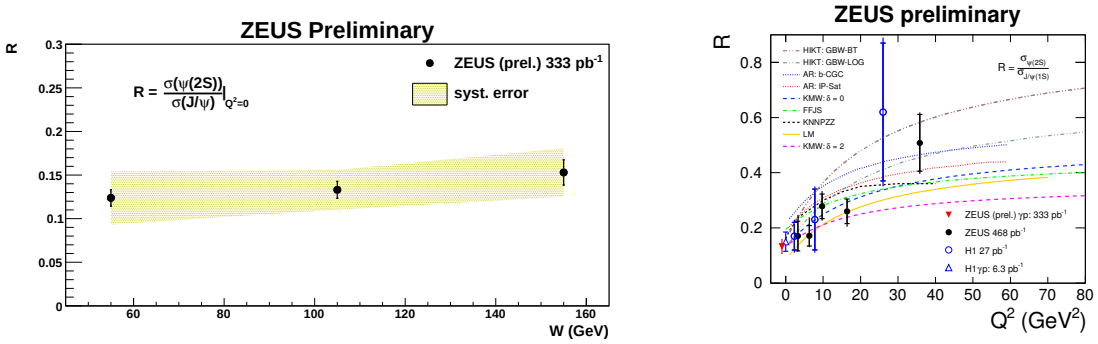

Figure 1: Mean cross section ratio R of $\psi(2S)$ to J/ψ production calculated using 2- and 4-prong channels as a function of W at $Q^2 = 0$ GeV^2 (left plot) and as a function of Q^2 (right plot). The ZEUS results (solid points) are shown compared to the previous H1 results (open points) [2, 3]. The model predictions are labeled by the names of the authors: HIKT [4], KNNPZZ [5], AR [6], LM [7], FFJS [8] and KMW [9] are shown as curves. New ZEUS preliminary result is plotted as full red triangle at $Q^2 = 0$ GeV^2.

Exclusive heavy vector meson production in ep collisions

The exclusive photo- and electro-production of light and heavy vector mesons has been extensively studied at HERA. Exclusive photoproduction of heavy vector mesons, like J/ψ, $\psi(2S)$ and Υ, can be described by models based on perturbative QCD (pQCD) since the large masses of the charm and the bottom quarks provide the hard scale. In such models the process is assumed to proceed in three steps: the photon fluctuates into a corresponding $q\bar{q}$ pair of small transverse size which subsequently, in the lowest order, interacts with the proton via the exchange of a pair of gluons in a color-singlet state forming a heavy vector meson.

The $\psi(2S)$ and the $J/\psi(1S)$ have the same quark content but different radial distributions of the wave functions, and their mass difference is small compared to the HERA centre-of-mass energy. Therefore, this measurement allows QCD predictions of the wave function dependence of the $c\bar{c}$–proton cross section to be tested. A suppression of the $\psi(2S)$ cross section relative to the $J/\psi(1S)$ is expected and observed (Fig. 1), as the $\psi(2S)$ wave function has a radial node close to the typical transverse separation of the virtual $c\bar{c}$ pair.

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