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On possible implications of the exponential distribution of constituent quarks within proton at high energies

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The differential cross section of the diffractive vector meson production in electron proton deeply inelastic scattering is considered to be one of the most promising observables to probe the spatial structure of the proton and the QCD dynamics in the high energy limit. In this work, we investigate the dependence of the differential cross section of vector meson production on the position distribution of the constituent quarks on top of the hot spot model. We consider two types of distribution functions, Gaussian and exponential, and include them into the dipole-proton scattering amplitude which is a key ingredient of the
vector meson production cross section. We calculate the cross sections for the production of J/Ψ mesons as function of the center of mass energy (W) and momentum transfer (|t|), respectively. At low |t| (|t| < 1.0 GeVˆ2), the coherent cross sections calculated with both Gaussian and exponential position distributions of the constituent quarks give similarly good description of the J/Ψ production data at HERA. However, we find that at relative large |t| (|t| > 1.0 GeVˆ2
) the coherent cross sections calculated with Gaussian position distribution function cannot describe the HERA data, while the coherent cross sections
computed with exponential position distribution function are in good agreement with the HERA data. This outcome indicates that the position of the constituent quarks in the proton may obey the exponential distribution, and the coherent process can be as a probe to resolve the position distribution of the constituent quarks. Moreover, our calculations show that the description of the coherent cross section of J/Ψ production remains robust when modeling the constituent quark positions with exponential distribution, independent of the particular
distribution function selected for the hot spot density profiles.

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