Quakonium Polarization in ep System

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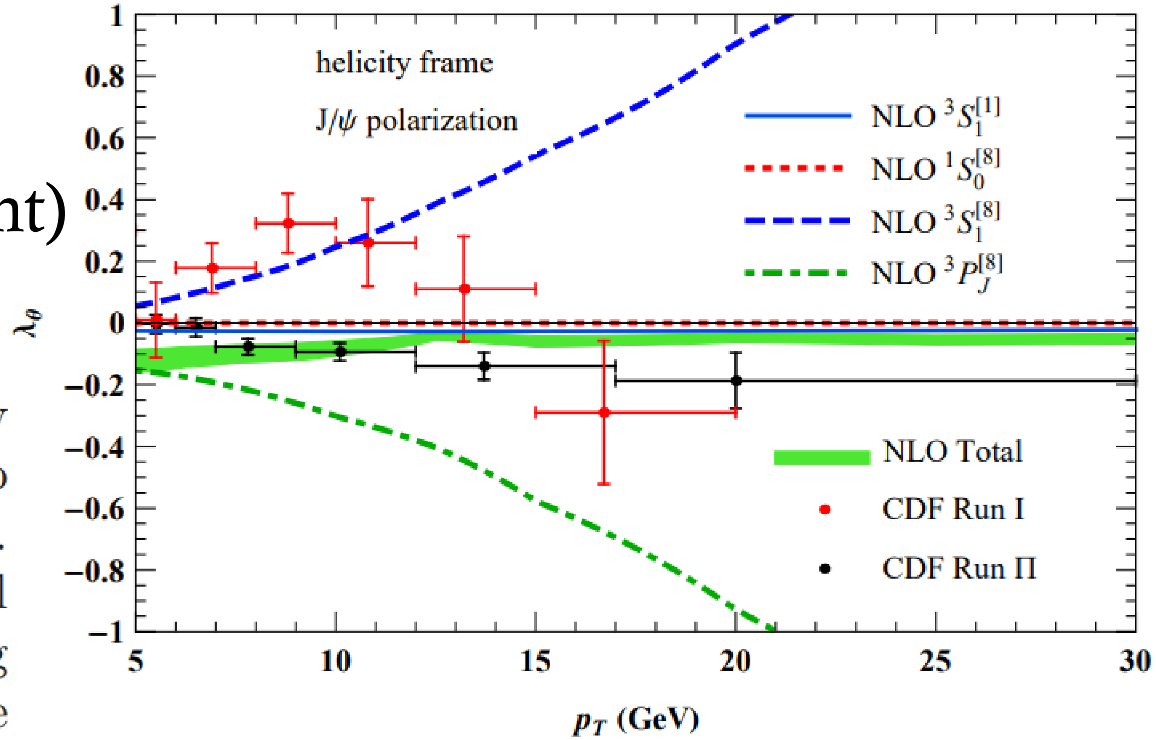
Motivation

- Polarization Access
- NRQCD
  - LDME(Long Distance Matrix Element)

factor of $\frac{1}{2}$ to 2 with respect to their central values. By fitting only the cross sections, it was found that only two linear combinations of CO LDMEs can be extracted[8]. Since polarization information is also available, we will try to extract the three independent CO LDMEs using the polarization observable λ_θ and the production rate $\mathrm{d}\sigma/\mathrm{dp_T}$ of the J/ψ measured by CDF Run II [4] simultaneously, where the data in the low transverse momentum region ($p_T < 7\mathrm{GeV}$) are not included in our fit because of existing nonperturbative effects. By minimizing χ^2, the



$$\frac{\mathrm{d}\mathcal{N}}{\mathrm{d}\cos\theta} \propto 1 + \lambda_\theta \cos^2\theta, \lambda_\theta = \frac{\mathrm{d}\sigma_{11} - \mathrm{d}\sigma_{00}}{\mathrm{d}\sigma_{11} + \mathrm{d}\sigma_{00}}.$$

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Quarkonium cross section(Reggeon framework)

$$\sigma_{ep} \simeq \Phi_\gamma^T \sigma_{\gamma p} \left(\langle y \rangle , \langle Q^2 \rangle \right) .$$

$$\sigma_{el}^{\gamma^* p \to Vp}(W^2; M_V^2, Q^2) = \sigma_T(W^2; M_V^2, Q^2) + \sigma_L(W^2; M_V^2, Q^2)$$

$$\sigma_T(W^2; M_V^2, Q^2) = 4\pi \int_{-\infty}^{0} dt |A_{I\!P}(W^2, t; M_V^2) + A_{I\!R}(W^2, t; M_V^2)|^2|_{Q^2 \to \infty} \propto \frac{1}{Q^8} ;$$

$$\sigma_L(W^2; M_V^2, Q^2) = R(Q^2, M_V^2)\sigma_T(W^2; M_V^2, Q^2)|_{Q^2 \to \infty} \propto \frac{1}{Q^6} ;$$

$$\sigma = (\sigma_T + \sigma_L)|_{Q^2 \to \infty} \sim \sigma_L .$$

$$R(Q^2, M_V^2) = c \frac{Q^2 + M_V^2}{Q_r^2 + Q^2 + M_V^2} \frac{Q^2}{M_V^2}$$

Photon polarization and J/ψ polarization

$$\rho_{\lambda\mu} = \frac{1}{1+R}\begin{bmatrix} \frac{1}{2}(1+\epsilon) & & \\ & \frac{1}{2}(1-\epsilon) & \\ & & R \end{bmatrix}, \epsilon = (1+\frac{Q^2}{2l_x^2})^{-1}$$

$$U_{\lambda\mu} = \frac{1}{\sqrt{2}}\begin{bmatrix} -e^{-i\Phi} & -ie^{-i\Phi} & \\ & & \sqrt{2} \\ e^{i\Phi} & e^{i\Phi} & \end{bmatrix}$$

$$D_{\lambda\mu} = \begin{bmatrix} \frac{1}{2}(1+cos\theta) & -\frac{1}{2}sin\theta e^{-i\phi^*} & \frac{1}{2}(1-cos\theta)e^{-2i\phi^*} \\ \frac{1}{\sqrt{2}}sin\theta e^{i\phi^*} & cos\theta & -\frac{1}{\sqrt{2}}sin\theta e^{-i\phi^*} \\ \frac{1}{2}(1-cos\theta)e^{2i\phi^*} & \frac{1}{\sqrt{2}}sin\theta e^{i\phi^*} & \frac{1}{2}(1-cos\theta) \end{bmatrix}$$

↓ Helicity Conservation(to $spin_{1/2}$)

$$D'_{\lambda\mu} = \frac{1}{\sqrt{2}}\begin{bmatrix} \frac{1}{2}(1+cos\theta) & & \frac{1}{2}(1-cos\theta)e^{-2i\phi^*} \\ & \sqrt{2}cos\theta & \\ \frac{1}{2}(1-cos\theta)e^{2i\phi^*} & & \frac{1}{2}(1-cos\theta) \end{bmatrix}$$

$$W(cos\theta, \phi^*, \Phi) \propto Tr(D'^\dagger U \rho U^\dagger D') = \frac{3}{16\pi(1+R)}(1+(1+4R)cos^2\theta - \epsilon\, sin^2\theta cos2(\phi^* - \Phi))$$