QWG 07 @ DESY 16/10/07

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Quarkonium polarization with PHP data





Outlook:

- (inelastic) quarkonium at HERA
- cross section measurements in PHP
- (new) polarization measurements in PHP
- conclusions and future prospects



- PHP \Leftrightarrow low Q² \Leftrightarrow electron escape undetected
- inelastic \Leftrightarrow accompanying final state hadrons



cross section measurements in PHP



• no strong conclusion because of the large normalization uncertainties of the theoretical predictions

polarization measurements (helicity parameters)

study of the polar and azimuthal decay angular distribution of J/ψ mesons;

in general the μ decay angular distribution in the J/ ψ rest frame is parameterized as

(M. Beneke, M. Kramer and M. Vanttinen, Phys. Rev. **D 57**, 4258 (1998)):

 $d^2\sigma/d\Omega dy \propto 1 + \lambda(y) \cos^2 \theta + \mu(y) \sin 2\theta \cos \varphi + \frac{1}{2} \nu(y) \sin^2 \theta \cos 2\varphi$

where y stands for a set of variables (z and $p_t(J/\psi)$ are good candidates)

- λ , μ , ν are related to the different color-octet matrix elements involved
- λ , μ , ν also depend on the definition of a coordinate system

main advantage:

"Since the decay angular distribution parameters are normalized, the dependence on parameters that affect the absolute normalization of cross sections, such as m_c , α_s , μ_R , μ_F and parton distribution, cancels to a large extent and does not constitute a significant uncertainty"

\Rightarrow main source of theoretical uncertainties gone

main disadvantage:

for every y bin we have to fit a distribution

 \Rightarrow unlikely requires large statistics

polarization measurements (helicity parameters)

integrate the "helicity" master formula

• in ϕ

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1/\sigma d^2\sigma/d\cos\theta dy \propto 1 + \lambda(y) \cos^2\theta
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• in $\cos \theta$

 $1/\sigma \ d^2\sigma/d\cos\theta \ dy \ \propto \ 1 + 1/3 \ \lambda(y) + 1/3 \ \nu(y) \ \cos 2\phi$

q which frame ? frame accessible experimentally using PHP events: target frame

- z axis (quantization axis): along the opposite of the incoming proton direction in the J/ψ rest frame

• x and y axis: chosen to complete a right-handed coordinate system in the J/ ψ rest frame according to some conventions we were given by the theorists

q different helicity of the lepton beam does not matter as long as the proton beam is unpolarized (always true at HERA)

 $\S \theta$: angle between the μ^+ vector in the J/ ψ rest frame and the z axis $\S \phi$: azimuthal angle in the x-y plane of the μ^+ vector in the J/ ψ rest frame

polarization measurements (helicity parameters)

data NOT corrected for:



• experimentally it is very difficult to perform reliably these corrections

q (new) polarization measurements in PHP



• high p_T region difficult to access at HERA

q (new) polarization measurements in PHP



- λ : good agreement between data and (degenerous) theory
- v: do not see the positive values expected in the "CS model"

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conclusions

q the ZEUS helicity measurement has been updated with all the HERA available stat.

q v seems to be the more interesting parameter in order to access the size of the color octet matrix elements at HERA

q hopefully this measurement will be converted soon to a journal paper ... may try to improve the sys. with some more work

q ZEUS helicity data are compared to a LO prediction ... can the theory be improved in this respect ?

q can we have predictions also in the k_t approach ?

 ${\tt q} \ \ldots$ later on we plan a paper on J/ ψ differential cross sections (PHP and DIS)