J/ψ Production in pp Collision at PHENIX

N.HAYASHI, Y. GOTO, K. KURITA and N. SAITO

The spin-dependent structure functions of the nucleon, particularly the quark spin contributions, have been studied extensively in polarized deep inelastic scattering experiments in the last decade. However, the the gluon spin contribution to the nucleon spin remains as a weakly constrained quantity.

J/ψ production in proton-proton collision is dominated by gluon-gluon scattering process and relatively high rate is expected. Furthermore, the detection of J/ψ through its dilepton decay is experimentally rather unambiguous. Then, J/ψ production in pp is a good tool to study the gluon inside the proton.

However, theoretical understanding of the J/ψ production mechanism is not settled yet. There are three major models which describe J/ψ production and those were discussed in this talk. The best candidate is Color-Octet Model (COM) which has been developed in terms of NRQCD (Non-relativistic QCD) seems to agree the CDF J/ψ data, although still few problems remain.

The COM contribution is implemented into a physics event generator *PYTHIA* by following B.Cano-Coloma *et al.*prescription [1]. By using this program, we calculated that over 10^6 J/ψ ($p_T > 2$ GeV/c) would be expected at PHENIX Muon-arm acceptance at $\sqrt{s} = 200$ GeV, which allows a precise asymmetry measurement. Sensitive x region of the gluon has a peak for larger $x \sim 0.1$, but much broader for the lower x. Subprocess asymmetries $\hat{a}_{LL}$ have been calculated for each color-octet intermediate states. Next step is to calculate an inclusive J/ψ asymmetry basing on those facts for different ΔG predicted models.

References

[1] B. Cano-Coloma, M.A. Sanchis-Lozano, Nucl. Phys. **B508** (1997) 753.

J/ψ Production Models

We have to start from production mechanisim not only spin-dependent part.

- Color-Singlet Model (CSM):

  R.Baier and R.Rückl, Z. Phys. C19 (1983) 251.

  - J/ψ formation in color-singlet states $c\bar{c}$
  - can't explain CDF direct J/ψ, $\psi(2S)$ results

- Color-Octet Model (COM):

  E.Braaten *et al.*, Annu.Rev.Nucl.Part.Sci. **46** (1996) 197.

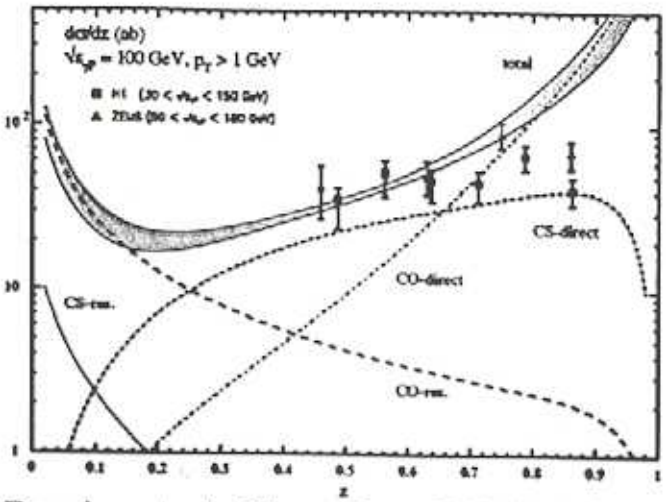
  - color-octet states becomes J/ψ in non-perturbative region
  - $g \to c$ fragmentation
  - non-perturbative matrix elements ($\langle \mathcal{O}_8^{J/\psi}(^3S_1)\rangle$, etc.) determined by experimental data
  - But HERA data not supportive

- Color Evapolation Model (CEM):

  H.Fritzsch, Phys. Lett. **B67** (1977) 217.

  - a certain fraction of $c\bar{c}$ pair forms J/ψ
  - χ_c photoproduction rate can't be explained

J/ψ Photoproduction at HERA



M.Beneke, et al. Phys. Rev. D57(1998) 4258.

- How to interprete?
  - NLO correction
  - Modify non-perturbative matrix elements
  - $p_T(J/\psi) < 5$ is too sensitve ...
  - Small x behavior of the gluon ...
- Proof of COM
  - J/ψ polarization predicted by COM
  - Determination of non-perturbative matrix elements from other process ($b \to J/\psi$)

    S.Fleming *et al.*, Phys. Rev. **D55** (1997) 4098
  - Lattice Calculation ...

    G.T.Bodwin *et al.*, Phys. Rev. Lett. **77** (1996) 2376.

Origin of J/ψ

$$J/\psi \begin{cases} prompt & \begin{cases} direct \\ \chi_c, \psi(2S)\ decay \end{cases} \\ B\ decay & \end{cases}$$

It was thought main contribution is **B dceay**.
CDF separated **B decay** origin by using SVX.
They found that ...

Monte Carlo for J/ψ

PYTHIA : Monte Carlo generator
CTEQ2L : parton parameterization

Color-Octet Model implemented into PYTHIA

hep-ph/9706270 B.Cano-Coloma, et al.

- tuned for CDF data
- For our study, only $g + g \to J/\psi + g$ is used.
  - Estimated 25% $g + q$ contribution is included by increasing a factor
- B decay contribution at CDF, 30%

J/ψ Yield

320 pb^{-1} at $\sqrt{s} = 200$ GeV
800 pb^{-1} at $\sqrt{s} = 500$ GeV

p_T (GeV/c)	$\sqrt{s} = 200$		$\sqrt{s} = 500$	
	Singlet	Octet	Singlet	Octet
2 – 4	72[illegible]k	1.2M	540k	9.0M
4 – 6	2200	170k	19k	1.8M
6 – 8	140	3200	2200	520k
8 – 10			320	160k
10 – 12				62k
12 – 14				25k
14 – 16				11k
16 – 18				4700
18 – 20				2800

Summary

- J/ψ production in pp gluon-gluon process dominant
- J/ψ detection less problem and high statistics
- Color-Octed Model seems to be a choice...
  - But HERA data need to be explained
  - J/ψ polarization measurement is a test for the model
  - More theoretical progress should be done
- Color-Octet Model implemented into *PYTHIA*
- Consistency check with CDF J/ψ data
- J/ψ Yield Estimation for PHENIX