Kinematic corrections to Quarkonium production in the NRQCD approach

Sergey Baranov
P.N.Lebedev Institute of Physics, Moscow, Russia

P L A N O F T H E T A L K

1. Introduction and motivation
2. Theoretical approach
3. Numerical results
4. Conclusions

INTRODUCTION and MOTIVATION

Non-relativistic QCD is a widely discussed approach to Quarkonium production at high energies

Basic assumptions

- Heavy quark pair is produced perturbatively in hard interaction in any color state – singlet or octet
- Meson formation probability for singlet state is determined by the meson's wave function (measured or taken from a potential model)
- Meson formation probability for octet state is determined by non-perturbative matrix elements fitted to data. Totally unpredictable, though thought to be universal.

Further assumptions

Conversion of octets into singlets proceeds via emitting "soft gluons" which change the quantum numbers but not the kinematics.

A close analogy to classical multipole radiation theory with immediate consequence for the hierarchy of octet matrix elements.

G.T.Bodwin, E.Braaten, G.P.Lepage, Phys. Rev. D 51, 1125 (1995); 55, 5853(E) (1997)

THEORETICAL APPROACH

Inherent inconsistency of NRQCD

"Soft gluons" are confined and can never be radiated. Something needs to be radiated in reality, not in pretence; or any kind of final state interaction: not too soft (to avoid confinement), and not too hard (to avoid perturbative domain).

This talk represents the frist (probably, the crudest) attempt to estimate the numerical effect of final state radiation on the experimental observables.

The model

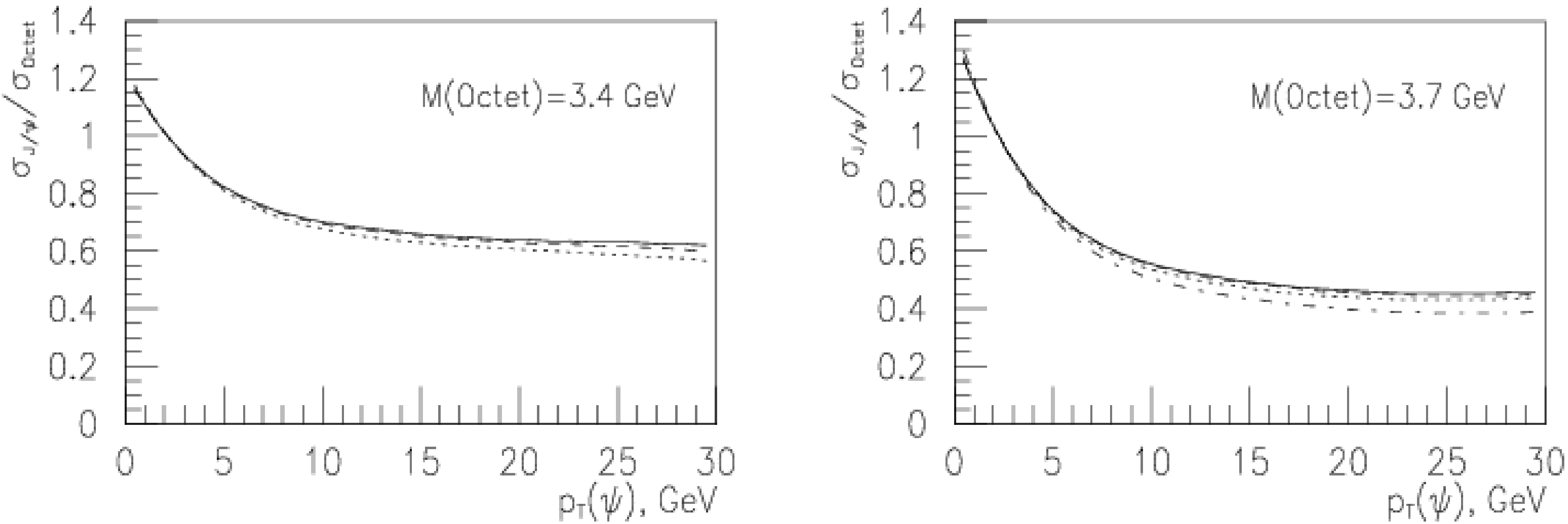
• Generate the production of a color-octet $Q\bar{Q}[8]$ state in a usual perturbative way, but with a mass value $m_{[8]}$ slightly higher than the nominal Quarkonium mass. Usual Feyman rules are employed here. k_t-factorization with $A0$ gluon densities.

H. Jung, http://www.desy.de/~jung/cascade/updf.html

• Generate a two-body decay $c\bar{c}[8] \to J/\psi + X$ or $b\bar{b}[8] \to \Upsilon + X$. Only the mass of X is important. We tried $m_{[8]}$=3.4 and 3.7 GeV; and m_X=0, 150, 300, 500 MeV.

NUMERICAL RESULTS FOR J/ψ MESONS AT LHC

The ratio of the cross sections before and after emission



$m_X = 0$ **(solid); 150 MeV (dashed), 300 MeV (dotted), 500 MeV (dash-dotted)**

The p_t **of the final** J/ψ **is smaller than that of the original** $c\bar{c}[8]$ **pair, as part of the initial** p_t **is carried away by the emitted quantum** X **.**
Similar results for all intermediate octet states: ${}^3S_1^{[8]}, {}^3P_0^{[8]}, {}^3P_1^{[8]}, {}^3P_2^{[8]}, {}^1S_0^{[8]}$

DISCUSSION AND CONCLUSIONS

- **The effect is large; dramatic change in the p_t slope at $p_t < 10$ GeV**
- **The effect is not sensitive to the mass $m_{[8]}$ but only to the mass difference $m_{[8]} - m_{\psi}$**
- **The effect is the same for all octet states ${}^3S_1^{[8]}, {}^3P_0^{[8]}, {}^3P_1^{[8]}, {}^3P_2^{[8]}, {}^1S_0^{[8]}$**
- **The ratio of the cross sections flattens at $p_t > 10$ GeV;**
the net kinematic correction can be effectively absorbed into redefined nonperturbative color-octet matrix elements.

MANY THANKS FOR ATTENTION!