The Fermi motion contribution To j/ψ Production at The Tevatron RunII ,LHC and RICH

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Content:

Here in this work, we introduce the fermi motion into quarkonia production in direct fragmentation process using a light cone wave function. Our aim is to show the size of the effect.

We demonstrate the enhancement of the fragmentation function due to this effect for j/ψ with such a significant enhancment we evaluate the differential cross section times the branching ratio for process $j/\psi \to \mu^+\mu^-$ and compare it with CDF data and present the integrated total cross sections for j/ψ state production at **TevatronRunII LHC and RICH**

Introduction:

Evaluation of the j/ψ Cross section at tevatron energies has been one of the interesting problems of QCD in theory and in experiment.

Fermi Motion

The common procedure to introduce the bound state effects, is to use the wave function at the center of momentum frame in a harmonic oscillator model.

The **parameter** β is related to avarge transverse momentum of of quark or aniquark within $q\bar{q}$ component of the meson's wave wave function .

$$\psi_M(x_i, k_T) = A_M \exp[-\frac{1}{8\beta^2} \times \frac{m^2 + q_T^2}{x_1 x_2}]$$

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Where A_M is the normalization coefficient,m is the quark (antiquark) mass, q_T is the transvers momentum of constituents the x's are the energy momentum ratios and finally the parameter β is the **confinement parameter which controls the width of the wave packet** representing the bound state.The normalization condition is:

$$\sum_{n,\lambda_i} \int [dx][d^2 q_T] \left| \psi_n(x_i, q_T, \lambda_i) \right|^2 = 1$$

Where

$$[dx] = \prod_{i=1}^{n} dx_i \delta[1 - \sum_{i=1}^{n} x_i]$$

and

$$[d^2 q_T] = \prod_{i=1}^{n} d^2 q_{T_i} 16\pi^3 \delta^2 [\sum_{i=1}^{n} q_{T_i}]$$

Therefore we will have **2 fragmentataion fuctions**:

Fermi motion off:

$$D(z,\mu_o,\beta=0)=\frac{\alpha_s^2 C_F^2 \langle {k_T}^2\rangle^{1/2}}{16mF(z)}\Big\{z(1-z)^2\Big[\xi^2 z^4+2\xi z^2(4-4z+5z^2)$$
$$+(16-32z+24z^2-8z^3+9z^4)\Big]\Big\},$$

$$\xi = \langle {k_T}^2\rangle / m^2$$

$$F(z)=\left[\xi^2 z^4-(z-2)^2(3z-4)+\xi z^2(8-7z+z^2)\right]^2.$$

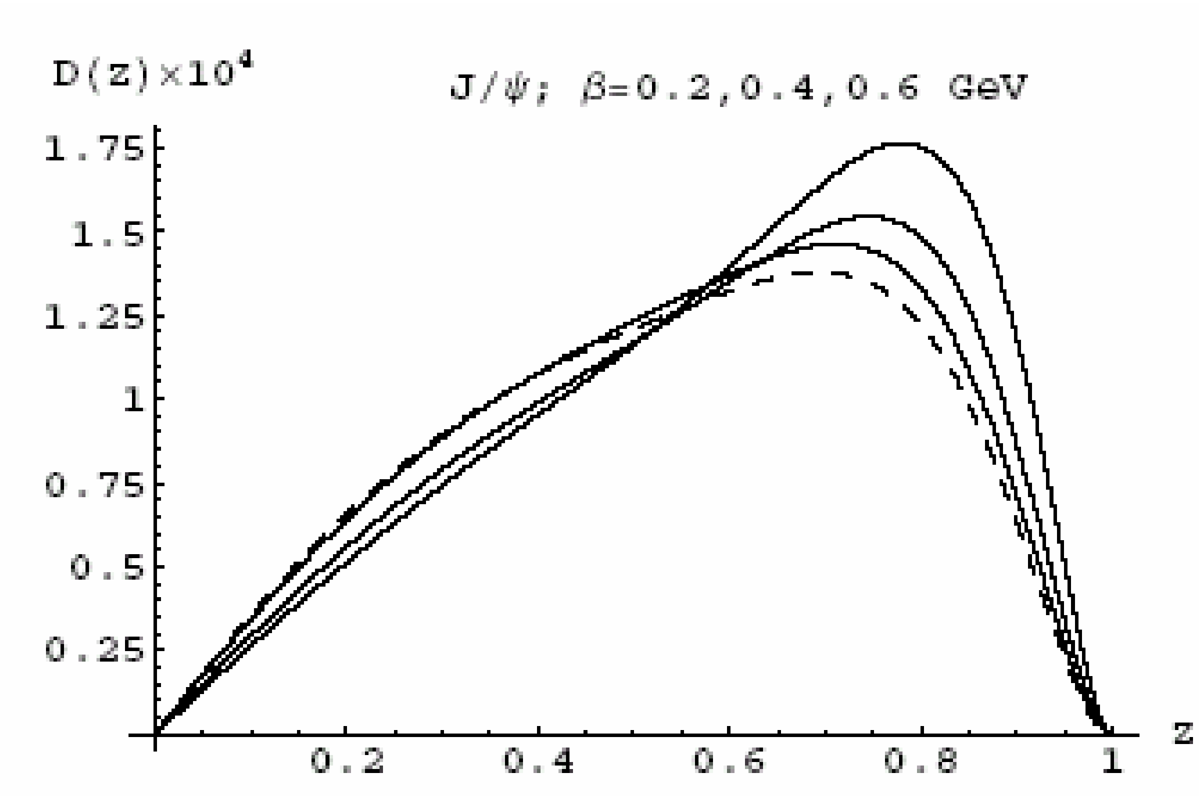
Fermi motion on:

$$D(z,\mu_\circ,\beta)=\frac{\pi^2\alpha_s^2A_M^2C_F^2\langle k_T{}^2\rangle^{1/2}}{4m}\int\frac{dqdx|\psi_M|^2x^2(1-z)^2zq}{G(z)}$$
$$\times\Big\{1-4(1-x)z+2(4-10x+7x^2)z^2$$
$$-4(1-x^3+5x^2-4x)z^3+(1-4x+8x^2-4x^3+x^4)z^4$$
$$+\eta\xi z^2\Big[1-2x+z^2+x^2(2-2z+z^2)\Big]+\Big[\eta\Big(2+(4x-6)z$$
$$+(9-8x+2x^2)z^2-2(2-x+x^2)z^3+(1+x^2)z^4\Big)$$
$$+\xi z^2\Big(1+2x^3(2-3z)z+z^2+2x^4z^2-x(4z^2-2z+2)$$
$$+x^2(2-8z+9z^2)\Big)+\eta^2(1-z)^2+\xi^2(1-x)^2x^2z^4\Big]\Big\},$$

Where the function $G(z)$ reads as

$$G(z) = \Big\{ \Big[\eta(1-z)^2 + \xi x^2 z^2 + (1-(1-x)z)^2 \Big] \times \Big[\eta(1-z) - \xi(1-x)xz^2 + ((1-x+x^2)z-1) \Big] \Big\}^2 .$$

Here we have defined $\eta = q_T^2/m^2$ and A_M is determined by the normalization condition.



Fragmentation function for ccbar production(for beta=0.2 ,0.4,0.6)

Inclusive Production Cross Section

We have employed the idea of factorization to evaluate the quarkonia Production cross section at hadron colliders.For *pp* collisions we may write

$$\frac{d\sigma}{dp_T}(pp \to J/\psi(p_T)X) = \sum_{i,j} \int dx_1 dx_2 dz f_{i/p}(x_1, \mu) f_{j/p}(x_2, \mu) \times \Big[\hat{\sigma}(ij \to c(p_T/z)X, \mu) D_{c \to J/\psi}(z, \mu, \beta)\Big].$$

Where $f_{i,j}$ are parton distribution functions with momentum Fractions of x_1 and x_2 and $\hat{\sigma}$ is the heavy quark production cross section and $D(z, \mu, \beta)$ represents the fragmentation of the produced heavy quark into $\bar{Q}Q$ state. We have used The parameterization due to Martin-Robert-Striling(MRS) for parton distribution function and have included the heavy Quark production cross section up to the order of α_s^3 .We will estimate the dependence on μ by choosing the transvers mass Of the heavy quark as our central choice of scale defined by:

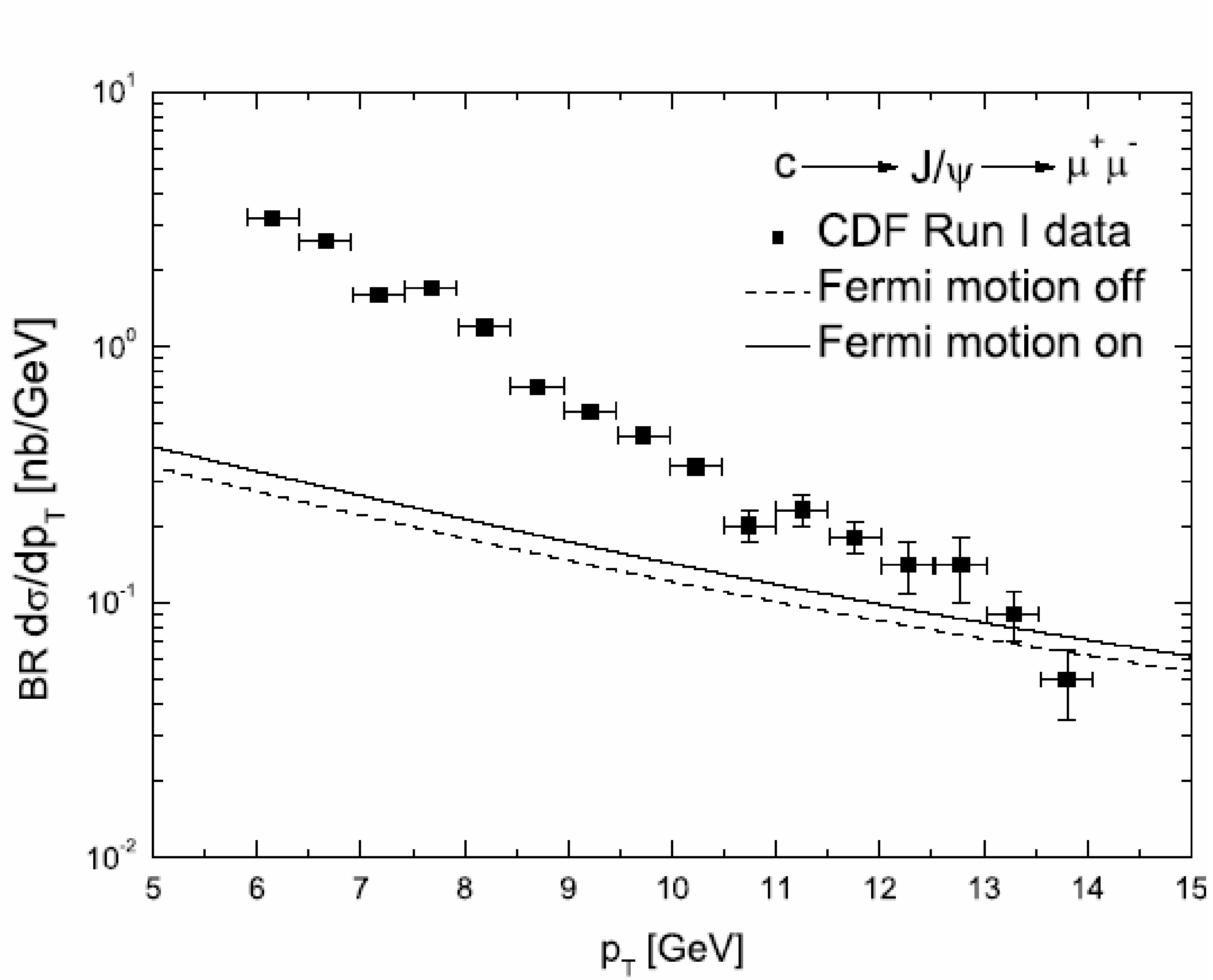
$$\mu_R = \sqrt{{p_T}^2(\text{parton}) + {m_Q}^2},$$

We used the **Altarelli-parisi equation** and evolve the Fragmentation function to suitable scale.

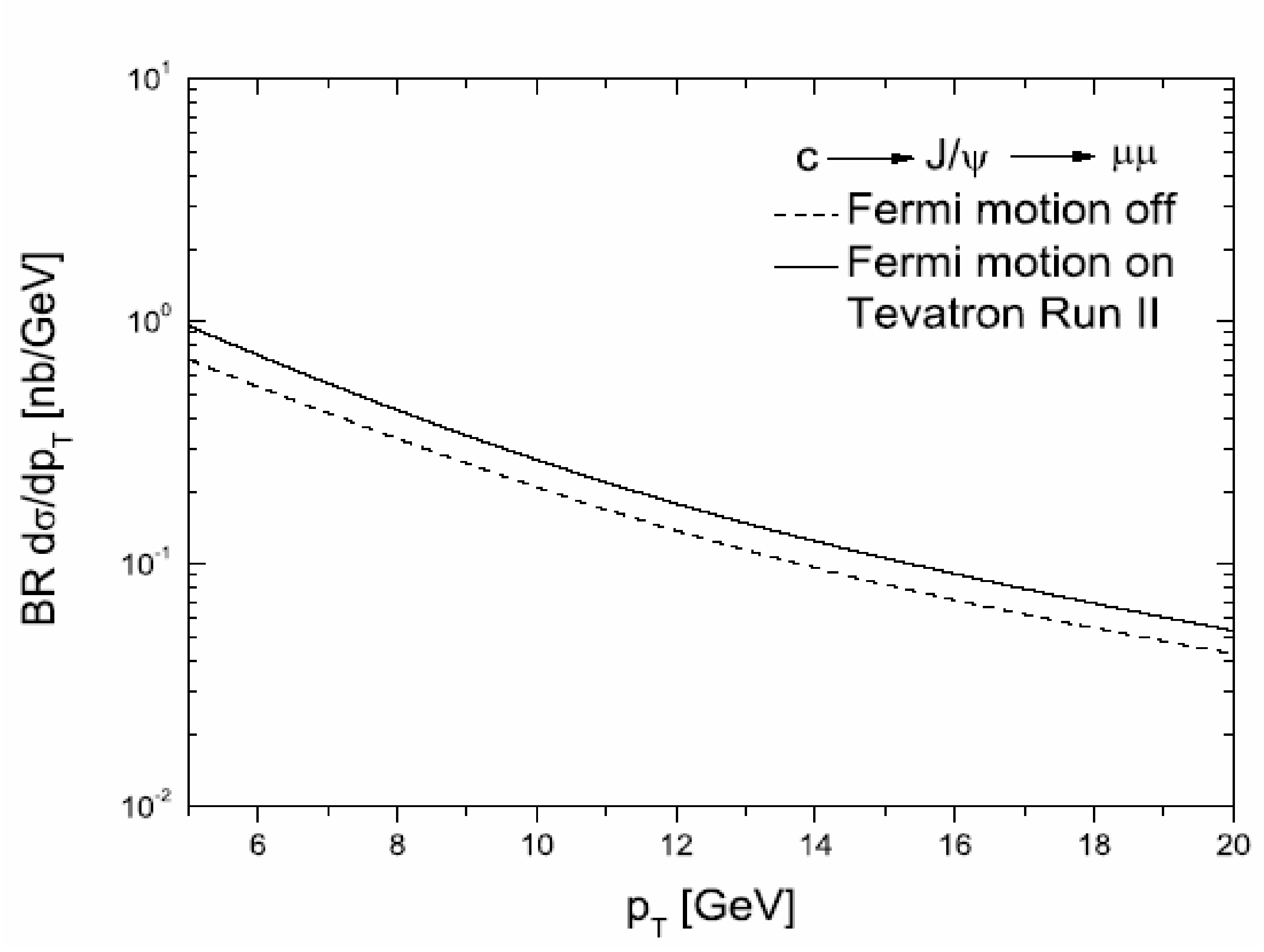
$$\mu\frac{\partial}{\partial\mu}D_{Q\to M}(z,\mu)=\int_z^1\frac{dy}{y}P_{Q\to Q}(z/y,\mu)D_{Q\to M}(y,\mu)$$

Here $P_{Q\to Q}(x=z/y,\mu)$ is the Altareli-Parisi splitting Function.

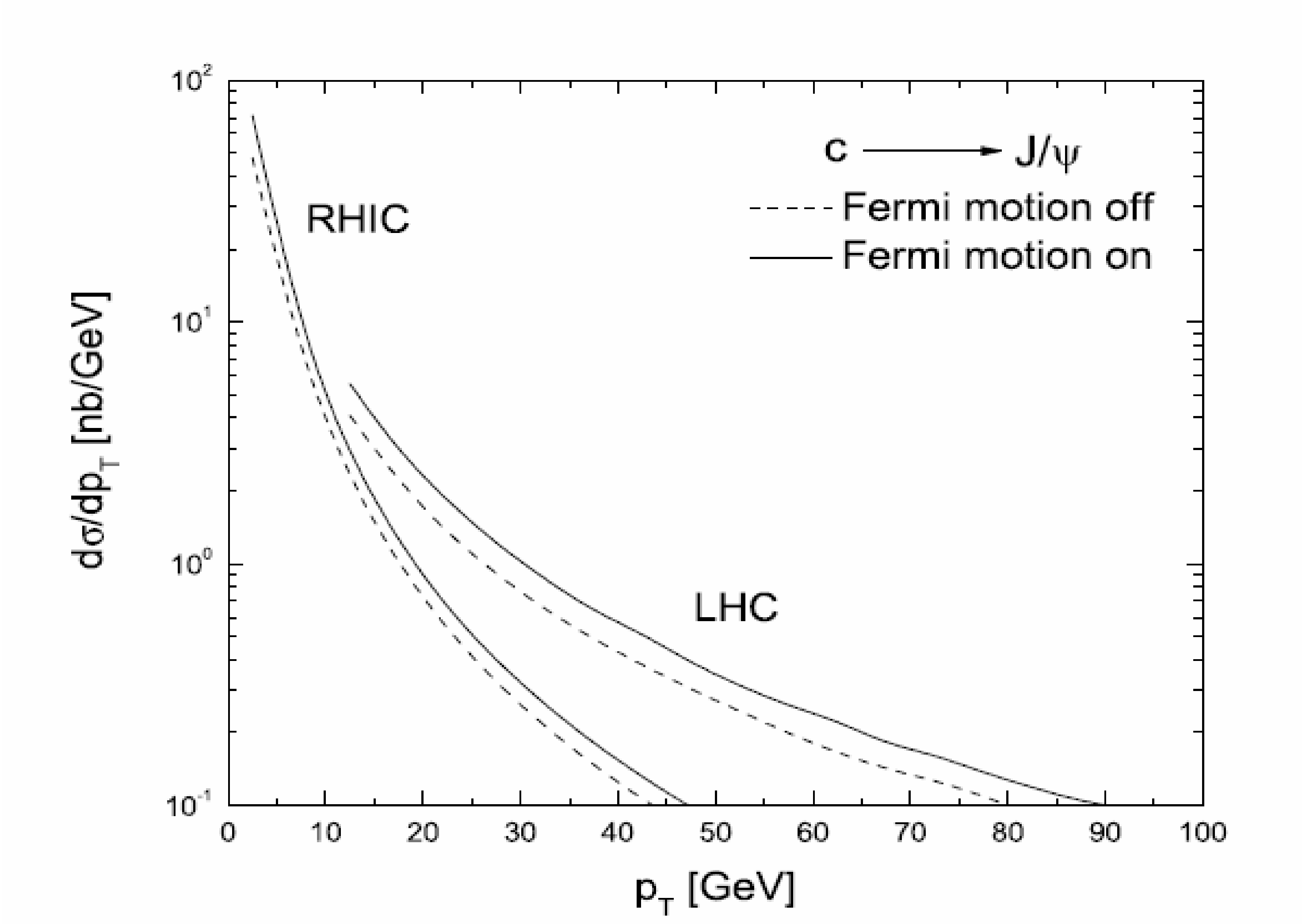
The differential cross section for direct fragmentation function Production ccbar to CDF data.



The differential cross section for ccbar at RunII



The differential cross section for ccbar at LHC and RICH



The total cross section in nb at RunI , RunII ,LHC and RICH With fermi motion off and on.

Colliding facility	Fermi motion off	Fermi motion on	$\Delta\sigma/\sigma$
Run I ($\bar{p}p \to c \to J/\psi \to \mu^+\mu^-$)	1.7	2	0.150
Run II ($\bar{p}p \to c \to J/\psi \to \mu\mu$)	56.5	67.3	0.160
RHIC ($pp \to c \to J/\psi$)	800	954	0.161
CERN LHC ($pp \to c \to J/\psi$)	97.2	116	0.162

We showed this effect at other hadron colliders such as LHC RICH and we found that this effect is more striking at tevatron And the CERN LHC but poor at the RICH