Novel effects in J/Psi production in nuclei

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Diffraction 2010, Otranto

Introduction

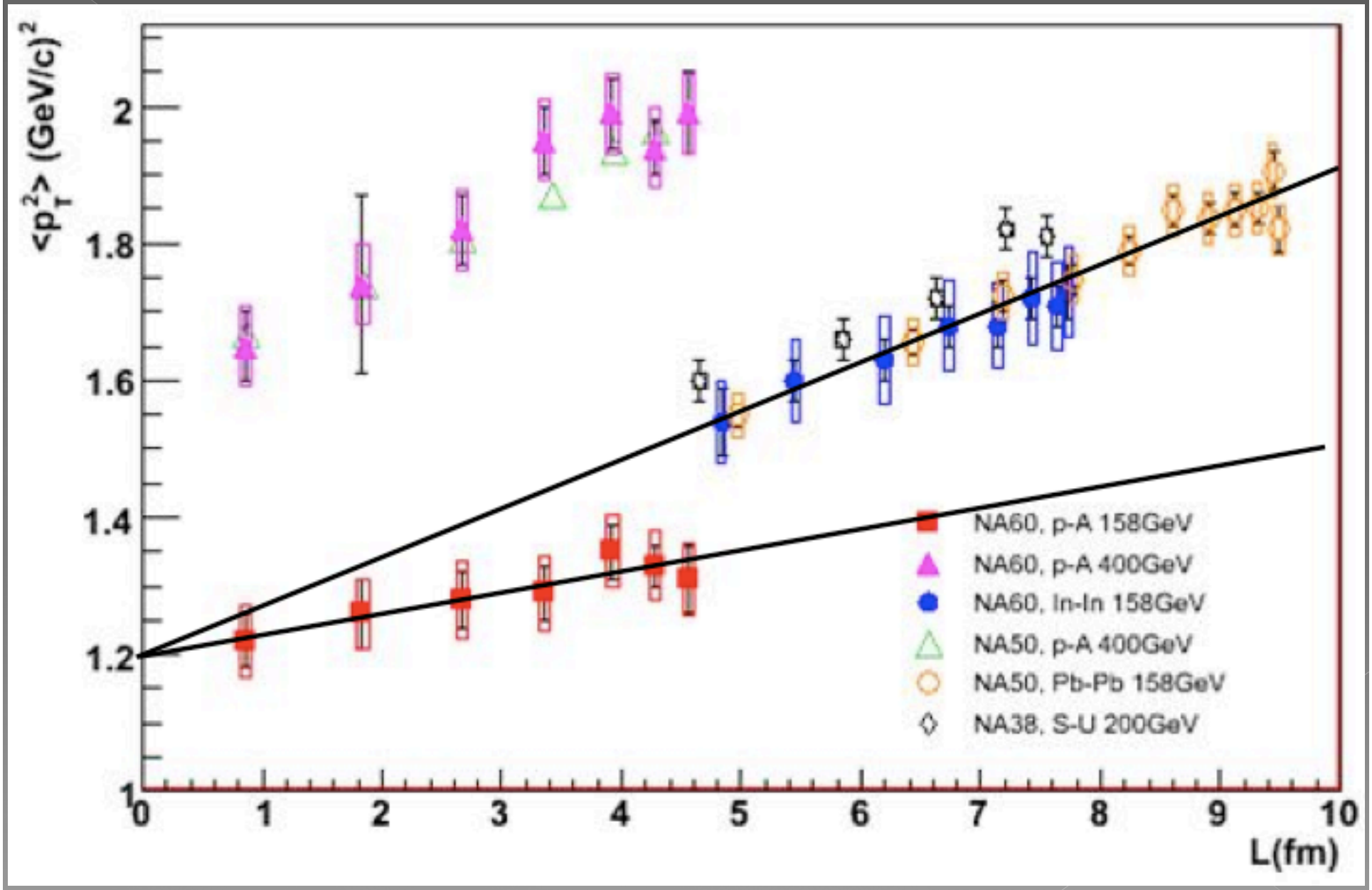
Nuclear suppresion of J/Psi — considered sensitive probe of produced medium in heavy ion collisions

Difficulty — distinguish between
- ISI (cold nuclear matter effects)
- FSI (dense matter effects)

Comments

ISI should be studied in pA (no dense matter effects), and extrapolate to pA (not easy)

broadening has ISI only, and it is very different in pA and AA


$<p_T^2>$ (GeV/c)^2
2
1.8
1.6
1.4
1.2
1
0
1
2
3
4
5
6
7
8
9
10
L(fm)
NA60, p-A 158GeV
NA60, p-A 400GeV
NA60, In-In 158GeV
NA50, p-A 400GeV
NA50, Pb-Pb 158GeV
NA38, S-U 200GeV

AA collisions several effects
- shadowing
- break-up
- double color filtering
- boosting of saturation scale

New effects

1) Double color filtering

Survival probability of dipole is higher than just the product

2) Boosting of saturation scale

Multiple interactions in both nuclei stronger at high energies: medium more opaque than in pA

Usual simplification: instantaneous production but production time is long

pA collisions

Coherence effects in propagation of color octet

$$t_c \sim \frac{2E}{M^2_{J/\Psi}}.$$

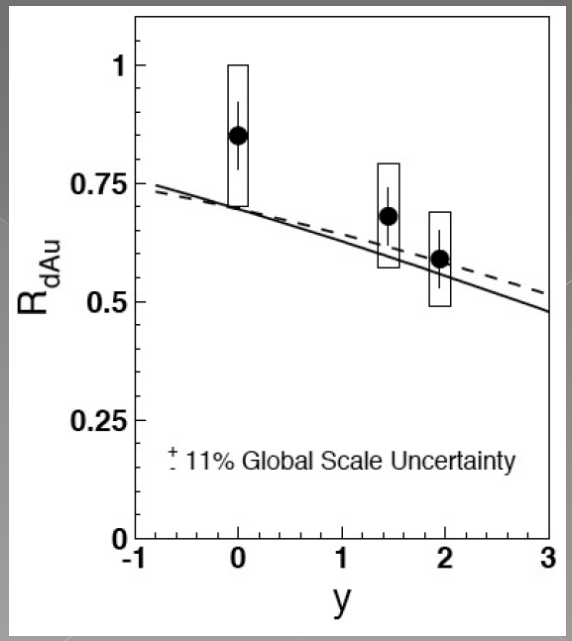
Survival amplitude

$$S_{pA}(b,z) = \int d^2 r_T \, W_{\bar{c}c}(r_T) \times \exp\left[-\frac{1}{2} C(E_{\bar{c}c})\, r_T^2 \left(\frac{7}{16} T_-(b,z) + T_+(b,z)\right)\right]$$

dipole-nucleon CS

Suppresion factor

$$R_{pA} = \frac{1}{A}\int d^2 b\, T_A(b) \left[1 + \frac{1}{2} C(E_{\bar{c}c}) \langle r_T^2 \rangle T_A(b)\right]^{-1} \times \left[1 + \frac{7}{32} C(E_{\bar{c}c}) \langle r_T^2 \rangle T_A(b)\right]^{-1}.$$



From pA to AA

$$R_{AA}(\vec{b},\vec{r}) = R_{pA}(\vec{r}) \times R_{pA}(\vec{b}-\vec{r})$$?

1) Double color filtering

Simple example: cc(bar) propagating through slice of nuclear matter

Survival probability

$$P_A(r_T, T_A) = \exp(-C\, r_T^2\, T_A)$$

$$P_A(T_A) = \int d^2 r_T\, W(r_T)\, P_A(r_T, T_A) = \frac{1}{1 + C\langle r_T^2\rangle T_A}$$

$$P_{AB}^{Gl}(T_A, T_B) = \frac{1}{(1 + C\langle r_T^2\rangle T_A)(1 + C\langle r_T^2\rangle T_B)}$$

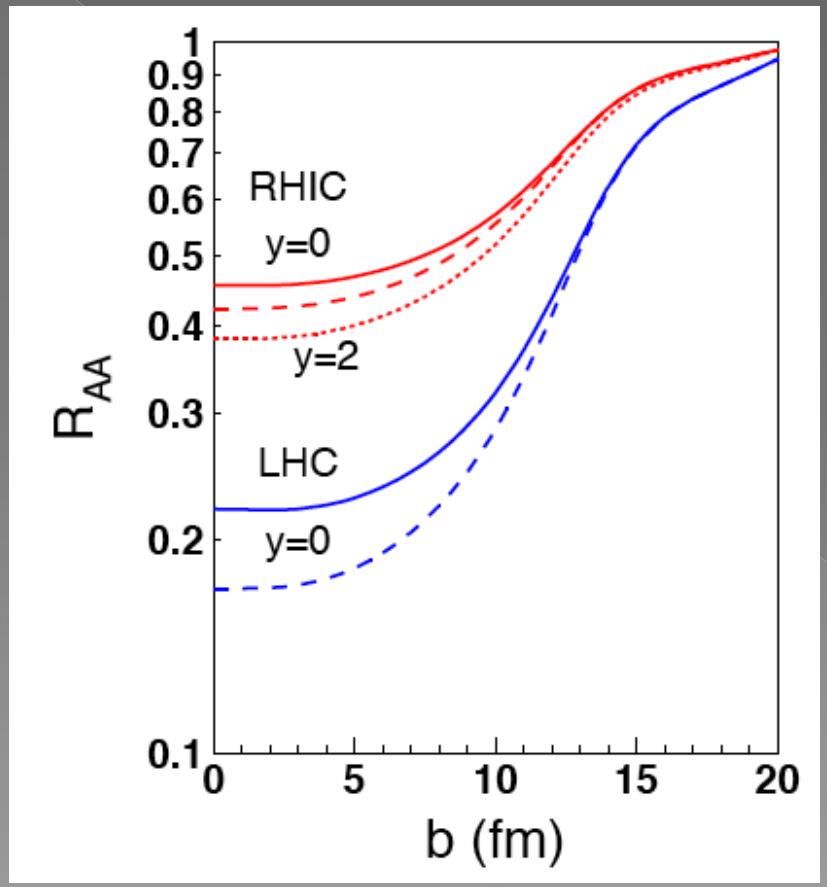
Correct

$$\begin{aligned} P_{AB}(r_T, T_A, T_B) &= P_A(r_T, T_A)\, P_B(r_T, T_B) \\ &= e^{-C\, r_T^2 (T_A + T_B)}. \end{aligned}$$

$$P_{AB}(T_A, T_B) = \frac{1}{1 + C\langle r_T^2\rangle\, (T_A + T_B)},$$

Realistic calculation:

$$R_{AB}(b) = \frac{1}{T_{AB}(b)} \int d^2\tau \int_{-\infty}^{\infty} dz_1\, \rho_A(\vec{\tau}, z_1) \int_{-\infty}^{\infty} dz_2\, \rho_B(\vec{b}-\vec{\tau}, z_2) \left| \int d^2 r_T\, W_{\bar{c}c}(r_T)\, S_{pA}(\vec{\tau}, z_1, r_T)\, S_{pB}(\vec{b}-\vec{\tau}, z_2, r_T) \right|^2$$



2) Boosting of saturation scale

In nuclei: transverse momentum distribution modified

up to $$Q^2_{sA} = \Delta p_T^2(E) = 2\frac{d\sigma(r,E)}{dr^2}\Big|_{r=0} \int dz\, \rho_A(b,z),$$

→ modification of beam PDFs $$Q^2 \Rightarrow Q^2_{eff} = Q^2 + Q^2_{sA}$$

remember DGLAP

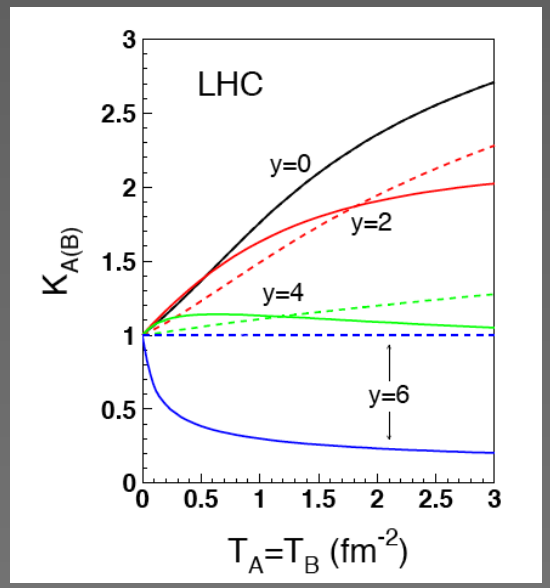
AA → both colliding nuclei participate

$$Q^2_{sA(B)} \Rightarrow \tilde{Q}^2_{sA(B)}$$

$$\begin{aligned}
\tilde{Q}^2_{sB}(x_B) &= \frac{3\pi^2}{2}\alpha_s(\tilde{Q}^2_{sA} + Q_0^2)\, x_A g_N(x_A, \tilde{Q}^2_{sA} + Q_0^2)\, T_B; \\
\tilde{Q}^2_{sA}(x_A) &= \frac{3\pi^2}{2}\alpha_s(\tilde{Q}^2_{sB} + Q_0^2)\, x_B g_N(x_B, \tilde{Q}^2_{sB} + Q_0^2)\, T_A.
\end{aligned}$$

Results

Effect on break up CS



Effect on suppresion factor