Long-range correlations in the model with string fusion on a lattice

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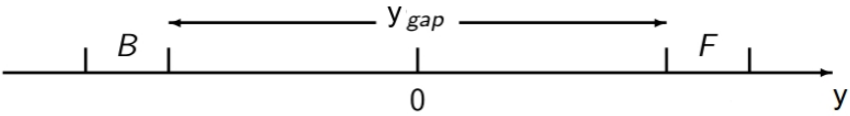
Introduction

- The string model:
  - A. Capella, U. Sukhatme, Chung-I Tan, J. Tran Thanh Van, Phys. Lett. B 81, 68 (1979).
  - A.B. Kaidalov, Phys. Lett. B 116, 459 (1982).
  - A.B.Kaidalov, K.A.Ter-Martirosyan, Phys. Lett., 117B (1982) 247.
  - A. Capella, U. Sukhatme, Chung-I Tan, J. Tran Thanh Van, Phys. Rep. 236 (1994) 225.
- The model with string fusion:
  - M.A. Braun and C. Pajares, Particle production in nuclear collisions and string interactions" Phys. Lett. B f287, 154 (1992).
  - M.A. Braun and C. Pajares, "A probabilistic model of interacting strings", Nucl. Phys. B f390, 542 (1993).
- The discrete model with transverse lattice:
  - V.V. Vechernin, R.S. Kolevatov, Vestnik SPbU Ser. 4 (2) (2004) 12-23, arXiv: hep-ph/0305136.
  - V.V. Vechernin, R.S. Kolevatov, Vestnik SPbU Ser. 4 (4) (2004) 11-27, arXiv:hep-ph/0304295.

Model

The definition of the rapidity:

$$y = \frac{1}{2} \ln \frac{p_0 + p_z}{p_0 - p_z}.$$



Model

M is the number of cells.

Event is characterized by the set of numbers:

$$C = \left\{C_\eta,\ C_n^B,\ C_n^F,\ C_p^B,\ C_p^F\right\},$$
$$C_\eta = \{\eta_1, \ldots \eta_M\}\ ,$$
$$C_n^F = \left\{n_1^F,\ \ldots,\ n_M^F\right\},$$
$$C_p^F = \left\{p_1^{1F},\ \ldots,\ p_1^{n_1 F};\ \ldots;\ p_M^{1F},\ \ldots,\ p_M^{n_M F}\right\}$$
$$C_n^B = \left\{n_1^B,\ \ldots,\ n_M^B\right\},$$
$$C_p^B = \left\{p_1^{1B},\ \ldots,\ p_1^{n_1 B};\ \ldots;\ p_M^{1B},\ \ldots,\ p_M^{n_M B}\right\}.$$

The Gaussian approximation

$$P(\eta_i) = \frac{1}{\sqrt{2\pi d_{\eta_i}}} e^{-\frac{(\eta_i - \overline{\eta}_i)^2}{2 d_{\eta_i}}}$$

$$d_{\eta_i} = \omega_\eta \overline{\eta}_i$$

$$P(n_i^F) = \frac{1}{\sqrt{2\pi d_{n_i^F}}} e^{-\frac{\left(n_i^F - \overline{n}_i^F\right)^2}{2 d_{n_i^F}}}, \quad P(n_i^B) = \frac{1}{\sqrt{2\pi d_{n_i^B}}} e^{-\frac{\left(n_i^B - \overline{n}_i^B\right)^2}{2 d_{n_i^B}}}$$

$$d_{n_i^F} = \omega_\mu \overline{n}_i^F, \; d_{n_i^B} = \omega_\mu \overline{n}_i^B$$

$$d_{p_i}(\eta_i) = \overline{p^2}(\eta_i) - \overline{p}^2(\eta_i) = \gamma \overline{p}^2(\eta_i).$$

Model

The dependence of the average number of particles formed by hadronization of the string in the cell and the transverse momentum of these particles of the number of strings η_i in the cell:

$$\overline{n}\left(\eta_i\right) = \sqrt{\eta_i},\ \overline{p}\left(\eta_i\right) = p_0\sqrt[4]{\eta_i}.$$

The numbers of particles formed from the hadronizations of the i-th string in forward rapidity window

$$n_i^F = \mu_F \overline{n}(\eta_i).$$

And the same for the backward window

$$n_i^B = \mu_B \overline{n}(\eta_i).$$

The small paremeters:

$$\frac{1}{\overline{\eta}_i} \ll 1,\ \frac{1}{M} \ll 1.$$

Two alternative definitions of the correlation coefficient

$$b_{FB}^{mean} \equiv \frac{\langle FB \rangle - \langle F \rangle \langle B \rangle}{\langle F^2 \rangle - \langle F \rangle^2}.$$

$$b_{FB}^{corr\ f} \equiv \left. \frac{d\langle B \rangle_F}{dF} \right|_{F=\langle F \rangle}.$$

Three types of correlations: $b_{n\,n}$, $b_{p_t\,n}$, $b_{p_t\,p_t}$.

F and B: mean transverse momenta of particles in forward and backward windows

$$p_t^F = \frac{1}{n_F}\sum_{i=1}^{M}\sum_{j=1}^{n_i^F} p_i^{j\,F}, \;\; p_t^B = \frac{1}{n_B}\sum_{i=1}^{M}\sum_{j=1}^{n_i^B} p_i^{j\,B},$$

$$n_F = \sum_{i=1}^{M} n_i^F, \;\; n_B = \sum_{i=1}^{M} n_i^B$$

The calculating of the asymptote $b_{p_t\,p_t}$. Definition

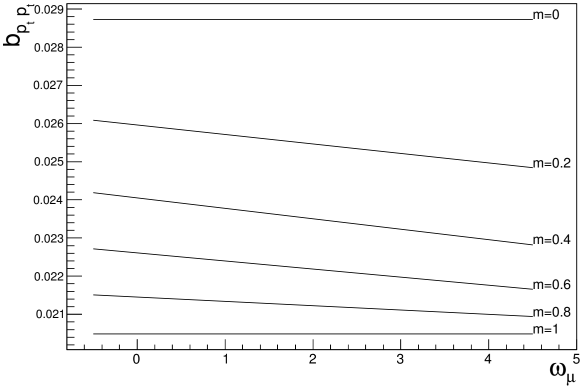
$$b^{mean}_{p_t\,p_t} = \frac{\left\langle p_t^F p_t^B \right\rangle - \left\langle p_t^F \right\rangle \left\langle p_t^B \right\rangle}{\left\langle (p_t^F)^2 \right\rangle - \left\langle p_t^F \right\rangle^2}, \quad b^{corr\,f}_{p_t\,p_t} = \left.\frac{d\langle p_B \rangle_{p_F}}{dp_F}\right|_{p_F = \langle p_F \rangle}$$

$$b^{mean}_{p_t\,p_t} = b^{corr\,f}_{p_t\,p_t} =$$

$$\frac{\omega_\eta \mu_F \left(9S_{1/2}^3 - 12S_{1/4}S_{3/4}S_{1/2} + 4MS_{3/4}^2\right)}{16\gamma S_1 S_{1/2}^2 + \omega_\eta \mu_F \left(9S_{1/2}^3 - 12S_{1/4}S_{3/4}S_{1/2} + 4MS_{3/4}^2\right) + 16\omega_\mu S_{1/2}\left(S_1 S_{1/2} - S_{3/4}^2\right)}$$

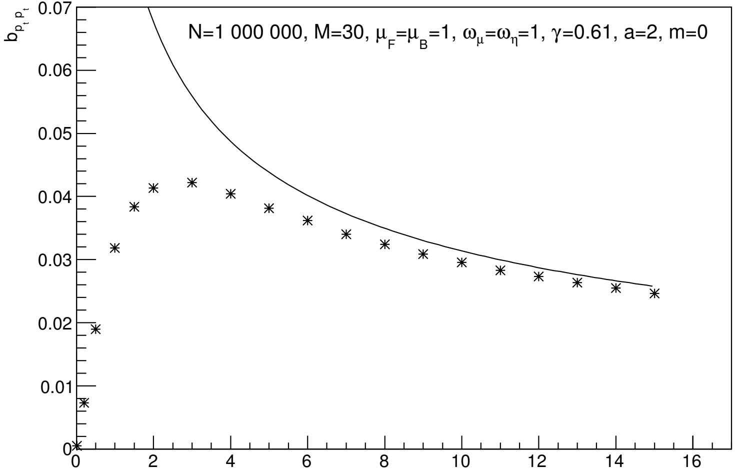
$$S_\nu = \sum_{i=1}^{M} \overline{\eta}_i^\nu .$$

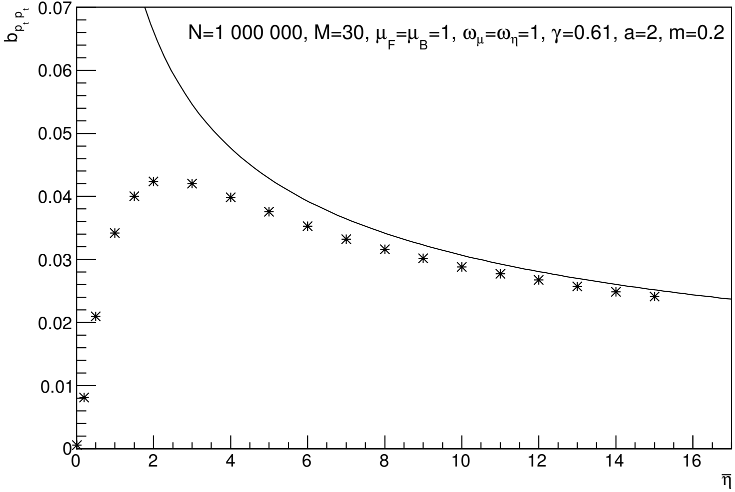
Studing dependence of $b_{p_t\,n}$ on ω_μ

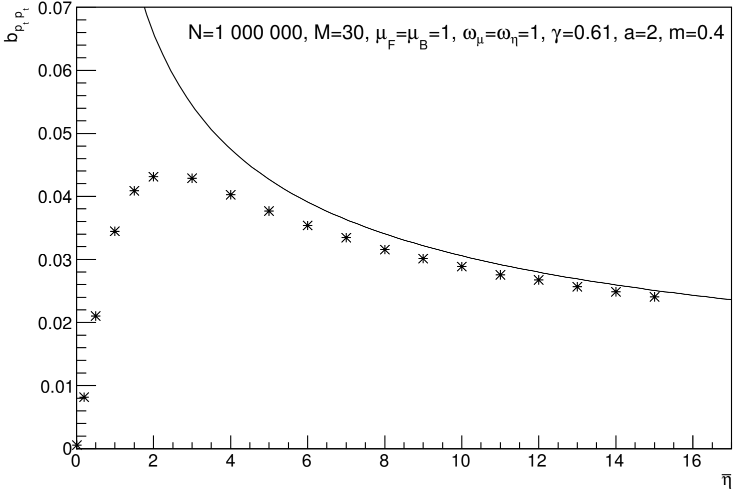


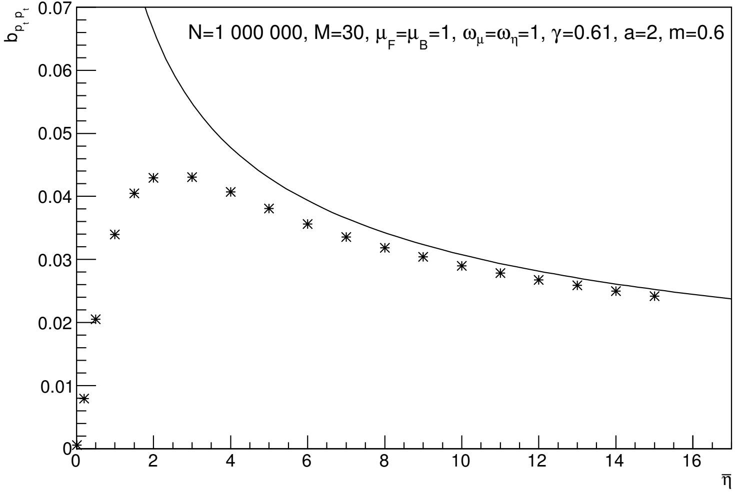
$$M = 450,\ a = 2,\ \eta = 12,\ \omega_\eta = 1,\ \mu_F = \mu_B = 1,\ \gamma = 0.61$$

MC numerical calculations of the coefficient $b_{p_t\,p_t}$ in the case of random string distribution

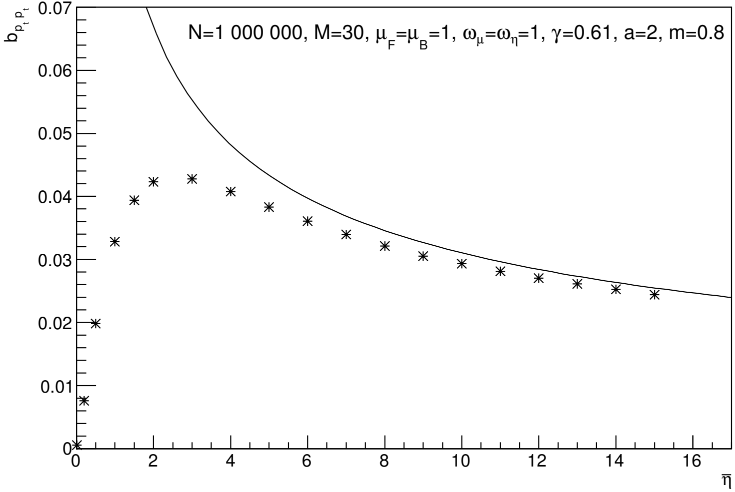



N=1 000 000, M=30, μ_F=μ_B=1, ω_μ=ω_η=1, γ=0.61, a=2, m=0.2
b_{p_t p_t}
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
2
4
6
8
10
12
14
16
η̄


N=1 000 000, M=30, μ_F=μ_B=1, ω_μ=ω_η=1, γ=0.61, a=2, m=0.4
b_{p_t p_t}
η̄
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0
2
4
6
8
10
12
14
16



N=1 000 000, M=30, μ_F=μ_B=1, ω_μ=ω_η=1, γ=0.61, a=2, m=0.6
b_{p_t p_t}
η̄
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2
4
6
8
10
12
14
16


N=1 000 000, M=30, μ_F=μ_B=1, ω_μ=ω_η=1, γ=0.61, a=2, m=0.8
b_{p_t p_t}
η̄
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
2
4
6
8
10
12
14
16

The main results

- $b_{p_t\,p_t}^{mean} = b_{p_t\,p_t}^{corr\,f}$.
- The dependence of the correlation coefficient $b_{p_t\,p_t}$ on ω_μ disappears in the case of a homogeneous distribution of strings.
- The received asymptotes for the correlation coefficient between transverse momenta were compared are compared with the results of the MC numerical calculations of this coefficient.