Three particle Bose-Einstein correlation

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Contents

Introduction

- We want to obtain new information about sQGP by measuring 3 particle BE
- Definition of correlation function:

$$C_3(\mathbf{k_1}, \mathbf{k_2}, \mathbf{k_3}) = \frac{N_3(\mathbf{k_1}, \mathbf{k_2}, \mathbf{k_3})}{N_1(\mathbf{k_1}) N_1(\mathbf{k_2}) N_1(\mathbf{k_3})} \tag{1}$$

- Where the particle number is defined by:

$$N_1(\mathbf{k}) = \int S(\mathbf{x}, \mathbf{k}) |\psi_1(\mathbf{x}, \mathbf{k})|^2 d^4 x \tag{2}$$

$$\begin{aligned} N_3(\mathbf{k_1}, \mathbf{k_2}, \mathbf{k_3}) = \int S(\mathbf{x_1}, \mathbf{k_1}) S(\mathbf{x_2}, \mathbf{k_2}) S(\mathbf{x_3}, \mathbf{k_3}) \cdot \\ \cdot |\psi_3(\mathbf{x_1}, \mathbf{x_2}, \mathbf{x_3}, \mathbf{k_1}, \mathbf{k_2}, \mathbf{k_3})|^2 d^4 x_1 d^4 x_2 d^4 x_3 \end{aligned} \tag{3}$$

Introduction

- For free particles:

$$\psi(\boldsymbol{x}, \boldsymbol{k}) \propto e^{-i\boldsymbol{xk}} \tag{4}$$

  C_3 can be expressed as function of $\boldsymbol{k_{ij}} = \boldsymbol{k_i} - \boldsymbol{k_j}$ and $\boldsymbol{K_{ij}} = \frac{1}{2}(\boldsymbol{k_i} + \boldsymbol{k_j})$

- Same as in 2 particle analysis we expect: $\boldsymbol{k_{ij}}$ main kinematic variable, $\boldsymbol{K_{ij}}$ dependency smoother:

$$\boldsymbol{K_{ij}} \to p_T = \sqrt{\boldsymbol{K^2_{12x}} + \boldsymbol{K^2_{12y}} + \boldsymbol{K^2_{13x}} + \boldsymbol{K^2_{13y}} + \boldsymbol{K^2_{23x}} + \boldsymbol{K^2_{23y}}}/3$$

- So we want to measure $C_3(\boldsymbol{k_{12}}, \boldsymbol{k_{13}}, \boldsymbol{k_{23}})$ for different p_T bins

Introduction

- C_3 can be measured as various decomposition of components of relative momentum
- We use side-out-longitudinal (Bertsch-Pratt) decomposition
- Coordinate system: LCMS (longitudinal co-moving system) of the three particle
- Instead of $\boldsymbol{k}_{ij}^{\mathbf{LCMS}}$ we measure correlation as function of

$$k_{ij} = |\boldsymbol{k}_{ij}^{\mathbf{LCMS3}}|$$

- Reason: in 2 particle analysis we have seen C_2 do not depend significantly on the orientation of $\boldsymbol{k}$

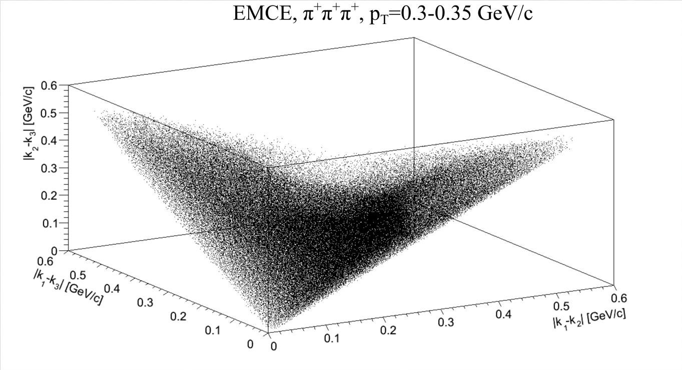
Details of measurement

- We use the so called event-mixing method to measure correlation
- We take the momentum difference distributions of pion pairs within the triplet from same event: $A(k_{12}, k_{13}, k_{23})$
- A will contain effects as acceptance, kinematics, etc.
- To transform this out: we create a background distribution ($B(k_{12}, k_{13}, k_{23})$) for triples which members are from different events

Details of measurement

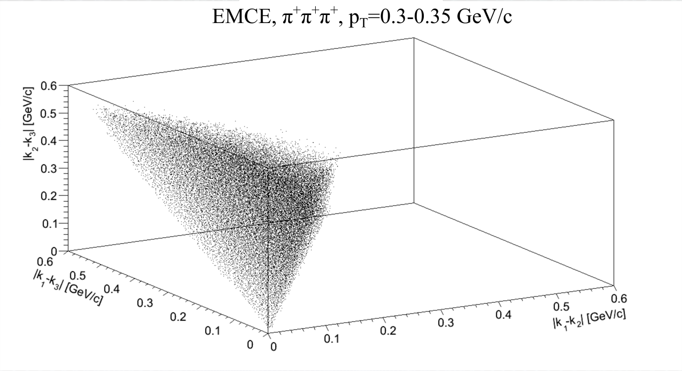
- The correlation:

$$C_3(k_{12}, k_{13}, k_{23}) = \frac{A(k_{12}, k_{13}, k_{23})}{B(k_{12}, k_{13}, k_{23})} \frac{\int B(k_{12}, k_{13}, k_{23}) dk_{12} dk_{13} dk_{23}}{\int A(k_{12}, k_{13}, k_{23}) dk_{12} dk_{13} dk_{23}} \tag{5}$$



Details of measurement

- Changing order of particles within triplet $\rightarrow$ new bin in histogram
- But this is not physics $\rightarrow$ we force: $k_{12} < k_{13} < k_{23}$ order



Model without Coulomb correction

- Assumption for source: Levy-distribution

$$\mathcal{L}(\alpha, R, r) = \frac{1}{(2\pi)^3} \int d^3 q e^{i\boldsymbol{qr}} e^{-0.5|\boldsymbol{q}R|^\alpha} \tag{6}$$

- The 1, 2, 3 equations with free particle wave function:

$$\begin{aligned} C_3^{(0)}(k_{12}, k_{13}, k_{23}) = 1 + Le^{-0.5(|2k_{12}R_C|^\alpha + |2k_{13}R_C|^\alpha + |2k_{23}R_C|^\alpha)} \\ + f_C^2 \left(e^{|2k_{12}R_C|^\alpha} + e^{|2k_{13}R_C|^\alpha} + e^{|2k_{23}R_C|^\alpha} \right) \end{aligned} \tag{7}$$

- R_C, f_C same as in 2 particle case

- We are looking for: $\lambda_3 = L - 3f_C^2$

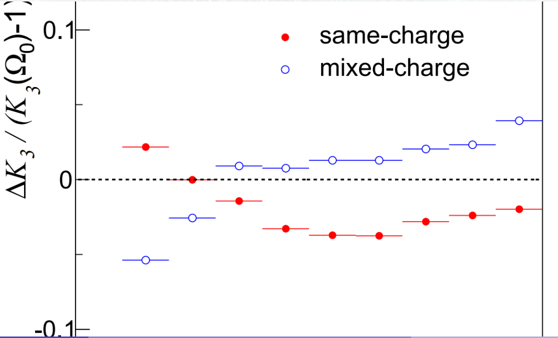
Coulomb correction

- Corrected model:

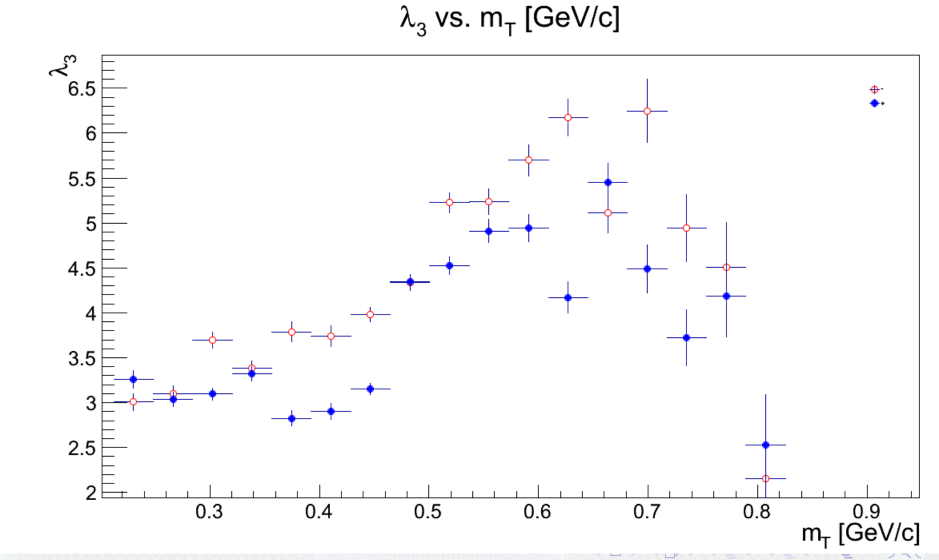
$$C_3(k_{12}, k_{13}, k_{23}) = C_3^{(0)}(k_{12}, k_{13}, k_{23}) \cdot K_3(k_{12}, k_{13}, k_{23}) \quad (8)$$

- We use Generalized Riverside method to handle the three particle Coulomb problem

$$K_3(k_{12}, k_{13}, k_{23}) = K_1(k_{12})K_1(k_{13})K_1(k_{23}) \quad (9)$$



Analysis status



Analysis status