PHENIX PLHF PWG
Three particle Bose-Einstein correlation

Attila Bagoly
Eötvös Loránd University

Supervisor: Máté Csanád

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Contents

Motivation

- Three particle correlations will reveal new aspects of particle creation
- What does λ_2 (λ in PPG194) mean?
- Core-Halo:

$$\lambda_2 = f_C^2, \quad \lambda_3 = 2f_C^3 + 3f_C^2 \tag{1}$$

$$\mu_3 = (\lambda_3 - 3\lambda_2)/(2\sqrt{\lambda_2^3}) = 1 \tag{2}$$

- Partial coherence (p_c fraction of coherently produced π):

$$\lambda_2 = f_C^2\left[(1-p_c)^2 + 2p_c(1-p_c)\right] \tag{3}$$

$$\lambda_3 = 2f_C^3\left[(1-p_c)^3 + 3p_c(1-p_c)^2\right] + 3f_C^2\left[(1-p_c)^2 + 2p_c(1-p_c)\right]$$

$$\mu_3 = \mu_3(p_c) \tag{4}$$

- Or other effects: $\lambda_2 = f_C^2(...)$, $\lambda_3 = 2f_C^3(...) + 3f_C^2(...)$

Definitions

- Definition of correlation function:

$$C_3(\boldsymbol{k_1}, \boldsymbol{k_2}, \boldsymbol{k_3}) = \frac{N_3(\boldsymbol{k_1}, \boldsymbol{k_2}, \boldsymbol{k_3})}{N_1(\boldsymbol{k_1})N_1(\boldsymbol{k_2})N_1(\boldsymbol{k_3})} \quad \text{(9D)} \tag{5}$$

- Transverse momentum:

$$p_T = \left|\boldsymbol{p}_{T1} + \boldsymbol{p}_{T2} + \boldsymbol{p}_{T3}\right|/3 \tag{6}$$

- Momentum differences: $\boldsymbol{k_{ij}} = \boldsymbol{k_i} - \boldsymbol{k_j}$

- So we want to measure $C_3(\boldsymbol{k_{12}}, \boldsymbol{k_{13}}, \boldsymbol{k_{23}})$ for different p_T bins (6D)

Correlation function

- We use side-out-longitudinal decomposition
- Coordinate system: LCMS (longitudinal co-moving system) of the triplet
- Instead of $\boldsymbol{k}_{ij}^{\mathbf{LCMS}}$ we measure correlation as function of

$$k_{ij} = |\boldsymbol{k}_{ij}^{\mathbf{LCMS3}}| \qquad (3D)$$

- Reason: not enough statistics, $q_{\rm inv}$ not good as we seen in PPG194
- $q = \sqrt{k_{12}^2 + k_{13}^2 + k_{23}^2}$ also not a good choice: no spherical symmetry

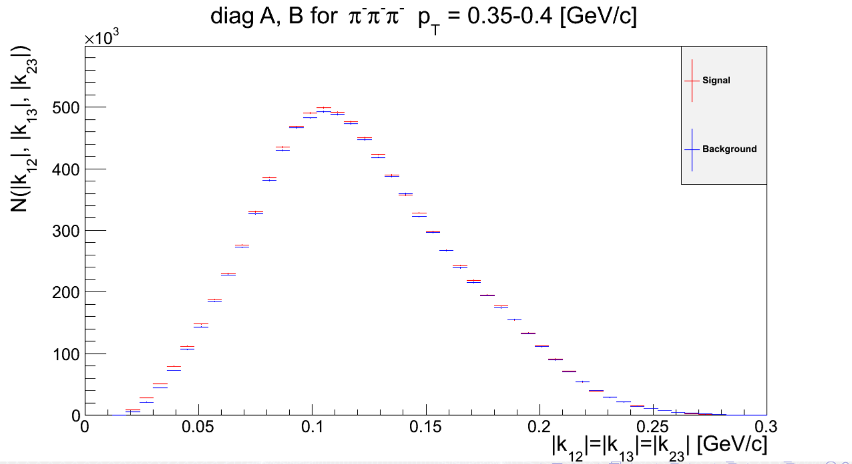
Details of measurement

- PPG194 generalized to three particle
- Event-mixing method to measure correlation
- Momentum difference distributions of pion pairs within the triplet from same event: $A(k_{12}, k_{13}, k_{23})$
- Background distribution (triplets from different events): $B(k_{12}, k_{13}, k_{23})$
- Same global, track and pair cuts as PPG194

Details of measurement

- Low bin behavior:

$$k_{ij} \to 0 \quad \overset{?}{\Longrightarrow} \quad A, B \to 0 \tag{7}$$

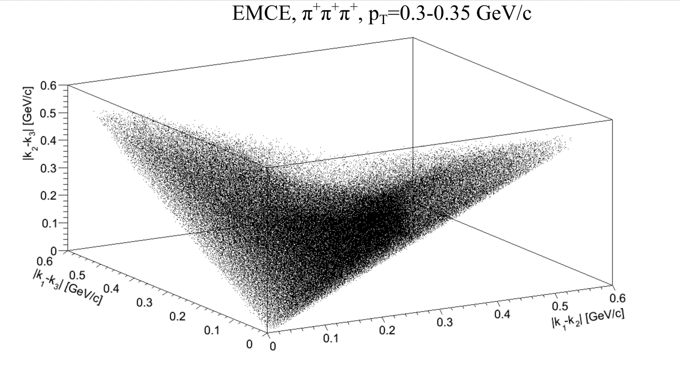


Details of measurement

- The correlation:

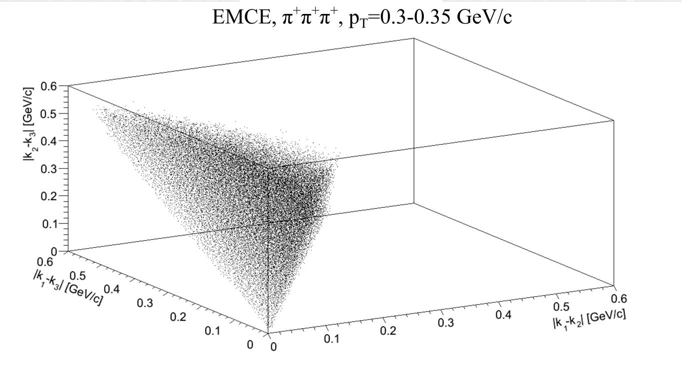
$$C_3(k_{12}, k_{13}, k_{23}) = \frac{A(k_{12}, k_{13}, k_{23})}{B(k_{12}, k_{13}, k_{23})} \frac{\int B}{\int A} \quad (8)$$

- Triangle inequality for $\vec{k}_{12}$, $\vec{k}_{13}$, $\vec{k}_{23}$



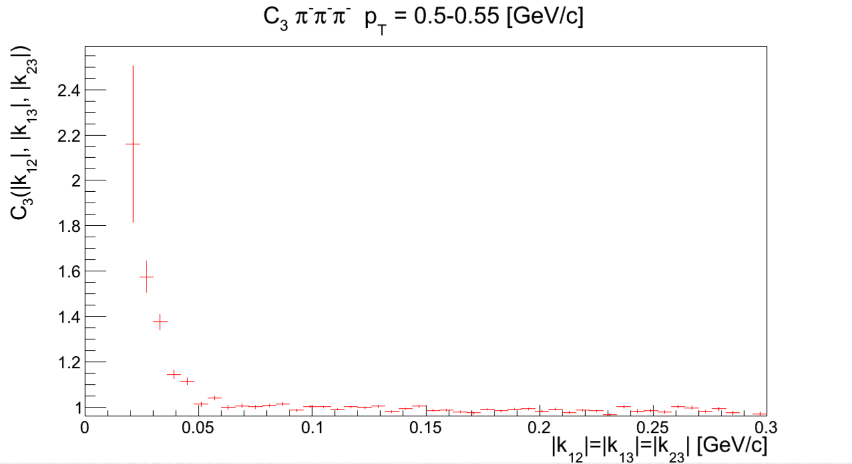
Details of measurement

- Order within triplet doesn't matter
- But when we measure do matter $\Rightarrow$ we have to fold the histogram
  $A(5,6,7) += A(6,7,5) + A(7,5,6) + A(5,7,6)$
  $+ A(7,6,5) + A(6,5,7)$



Details of measurement

- Diagonal correlation function



Model without Coulomb correction

- Assumption for source: Levy-distribution
- Approximation for C_3 can be derived ($\mathcal{L}_3 = 2f_C^3$):

$$C_3^{(0)}(k_{12}, k_{13}, k_{23}) = 1 + \mathcal{L}_3 e^{-0.5(|2k_{12}R_C|^\alpha + |2k_{13}R_C|^\alpha + |2k_{23}R_C|^\alpha)} + f_C^2\left(e^{|2k_{12}R_C|^\alpha} + e^{|2k_{13}R_C|^\alpha} + e^{|2k_{23}R_C|^\alpha}\right) \quad (9)$$

- Idea: $\mathcal{L}_3$ new fitting parameter
- We already know (from PPG194): R_C, f_C, α
- We are looking for: $\lambda_3 = \mathcal{L}_3 + 3f_C^2$

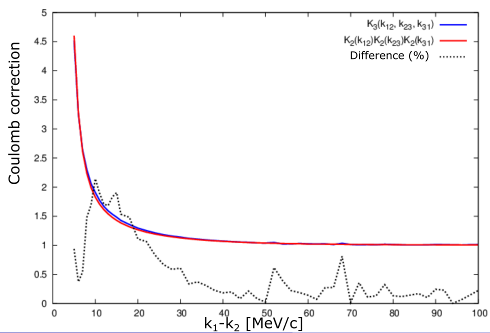
Coulomb correction

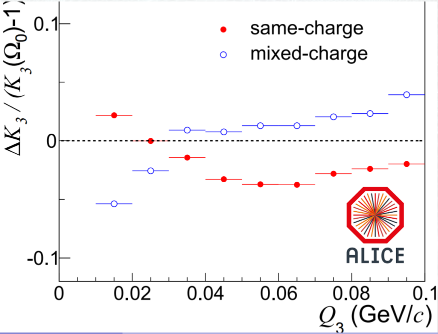
- Corrected model:

$$C_3(k_{12}, k_{13}, k_{23}) = C_3^{(0)}(k_{12}, k_{13}, k_{23}) \cdot K_3(k_{12}, k_{13}, k_{23}) \qquad (10)$$

- "Generalized Riverside" method for 3 particle Coulomb problem

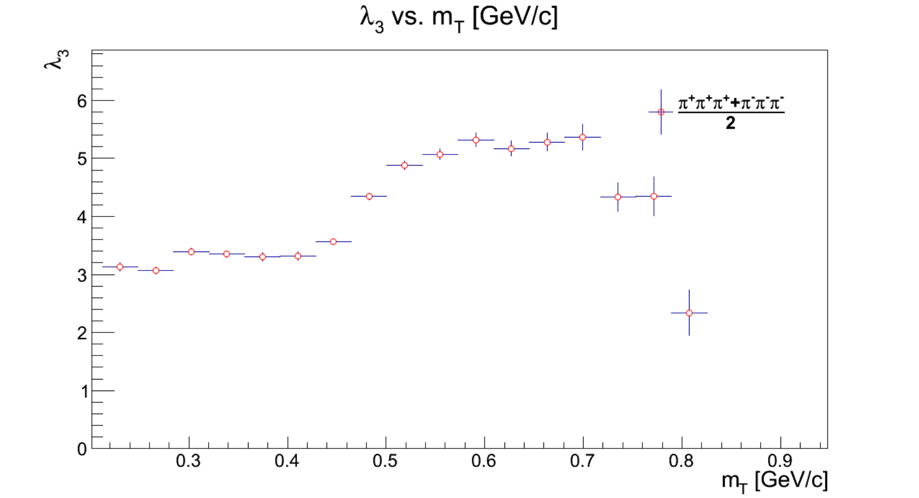
$$K_3(k_{12}, k_{13}, k_{23}) \approx K_1(k_{12}) K_1(k_{13}) K_1(k_{23}) \qquad (11)$$





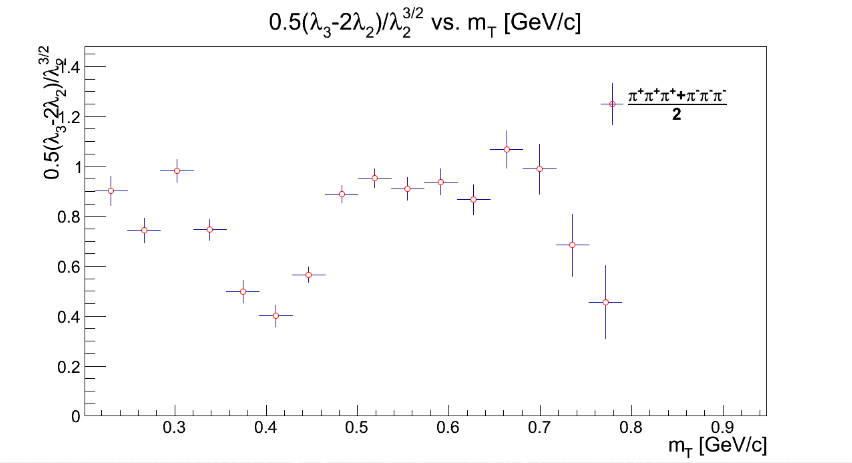
Analysis status

- Fittings not quite good: R, α, f_C fixed, $\mathcal{L}_3$ fitting parameter



Analysis status

- Core-Halo transformed out: $\frac{\lambda_3 - 3\lambda_2}{2\sqrt{\lambda_2^3}}$ not depend on f_C
- This combination will 1 in Core-Halo



Thank you for your attention!