PHENIX PLHF PWG
Three particle Bose-Einstein correlation

Attila Bagoly
Eötvös Loránd University

Supervisor: Máté Csanád

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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

Three-particle Bose-Einstein correlation function

- Correlation function:

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

- Three particle momentum distribution:

$$N(\boldsymbol{k_1}, \boldsymbol{k_2}, \boldsymbol{k_3}) = \int S(\boldsymbol{r_1}, \boldsymbol{k_1})S(\boldsymbol{r_2}, \boldsymbol{k_2})S(\boldsymbol{r_3}, \boldsymbol{k_3})|\Psi_{\boldsymbol{k_1},\boldsymbol{k_2},\boldsymbol{k_3}}(\boldsymbol{r_1}, \boldsymbol{r_2}, \boldsymbol{r_3})|^2\Pi_{i=0}^{3} d^4\boldsymbol{r_i} \tag{2}$$

- Assumption for source: Levy-distribution

- Coulomb-correction:

$$C_3(\boldsymbol{k_1}, \boldsymbol{k_2}, \boldsymbol{k_3}) = C_3^{(0)}(\boldsymbol{k_1}, \boldsymbol{k_2}, \boldsymbol{k_3})K(\boldsymbol{k_1}, \boldsymbol{k_2}, \boldsymbol{k_3}) \tag{3}$$

- Coulomb-correction from Generalized Riverside

Quantum statistical correlation function

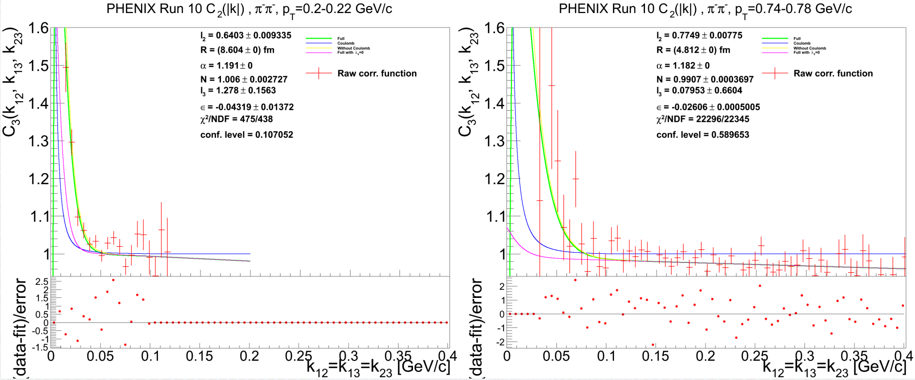
- Dimension: 9D $\rightarrow$ 3D
- Approximation for $C_3^{(0)}$ can be derived (similar as in PPG194):

$$C_3^{(0)}(k_{12}, k_{13}, k_{23}) = 1 + \ell_3 e^{-0.5(|2k_{12}R|^\alpha + |2k_{13}R|^\alpha + |2k_{23}R|^\alpha)} + \ell_2 \left(e^{|2k_{12}R|^\alpha} + e^{|2k_{13}R|^\alpha} + e^{|2k_{23}R|^\alpha} \right) \quad (4)$$

- Background: $N(1+\epsilon k_{12})(1+\epsilon k_{13})(1+\epsilon k_{23})$
- Fitted parameters: $\ell_2, \ell_3, \epsilon, N$
- We already know (from PPG194): R, α
- We are looking for: $\lambda_3 = \ell_3 + 3\ell_2$

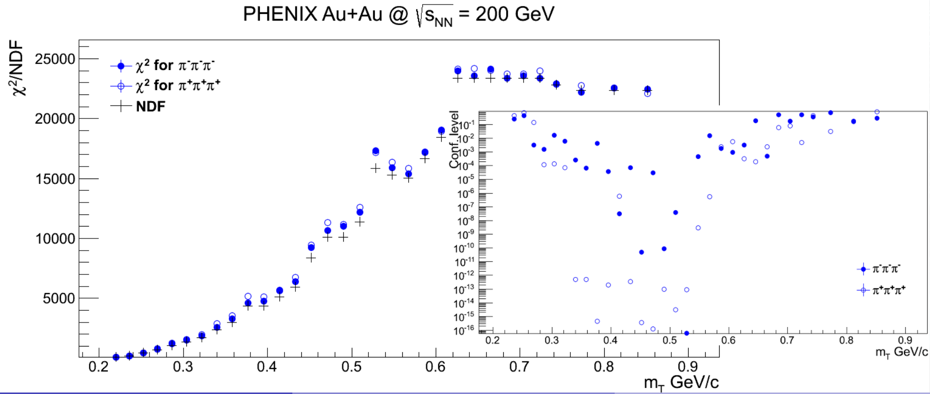
Diagonal visualization of fits

- Visualization in $k_{12} = k_{13} = k_{23}$ subspace: shows good fits
- Fitted: ℓ_2, ℓ_3, ϵ, N; Fixed (PPG194): R, α



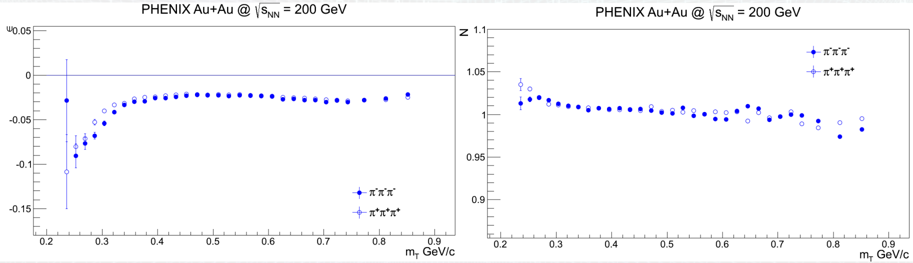
χ^2 / NDF

- p_T divided into 32 bins
- Fitted: ℓ_2, ℓ_3, ϵ, N; Fixed (PPG194): R, α
- Quite good χ^2 / NDF, not so good confidence levels for mid p_T



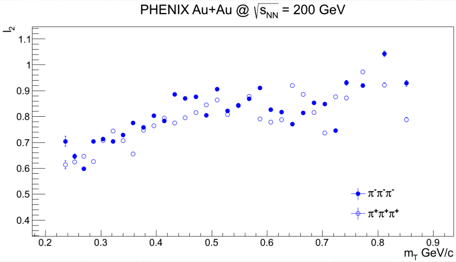
Fit parameter ϵ and N

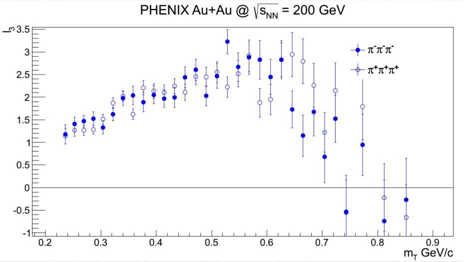
- Fitted: ℓ_2, ℓ_3, ϵ, N, Fixed (PPG194): R, α
- N, ϵ looks like in PPG194



Fit parameter ℓ_2 and ℓ_3

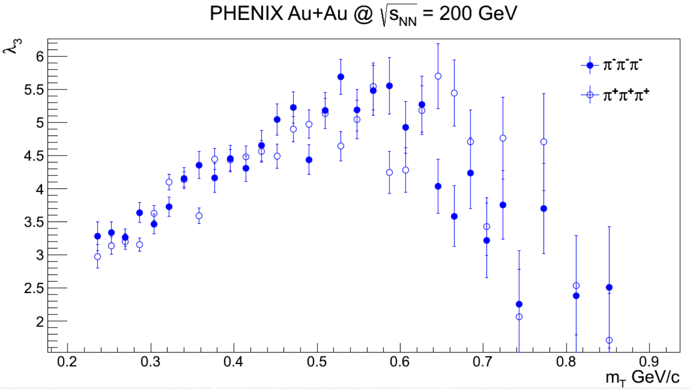
- Fitted: ℓ_2, ℓ_3, ϵ, N; Fixed (PPG194): R, α
- fitting with small error for ℓ_2
- bigger error for ℓ_3 at high p_T





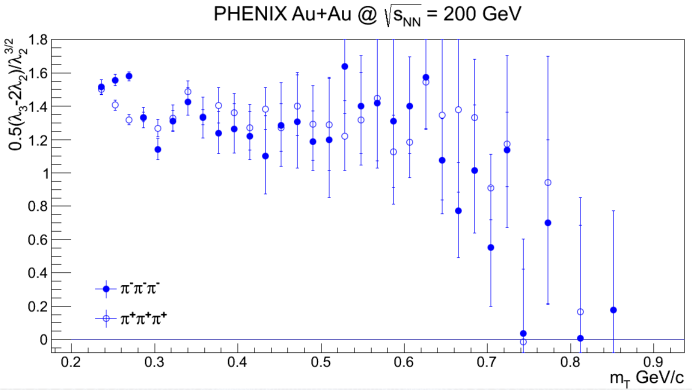
Derived parameter: λ_3

- Fitted: ℓ_2, ℓ_3, ϵ, N; Fixed (PPG194): R, α
- $\lambda_3 := C_3(k_{12} = k_{13} = k_{23} = 0) - 1 = \ell_3 + 3\ell_2$
- Core-Halo model: $0 < \lambda_3 < 5$



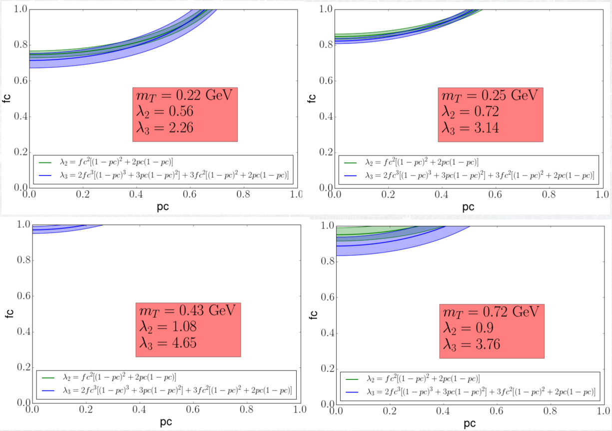
Core-Halo independent parameter

- Core-Halo transformed out: $\kappa_3 = \frac{\lambda_3 - 3\lambda_2}{2\sqrt{\lambda_2^3}}$ not depend on f_C ($f_c = \text{core}/(\text{core}+\text{halo})$)
- This combination will be 1 in Core-Halo



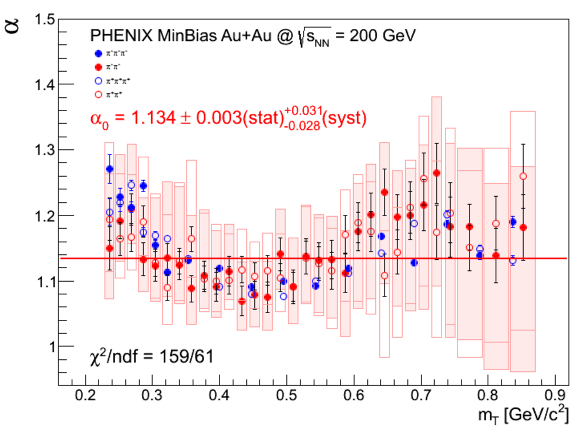
f_c vs p_c

- Partial coherence (p_c = coherent/(coherent + incoherent), f_c = core/(core + halo)):
  $\lambda_2 = f_C^2\left[(1-p_c)^2 + 2p_c(1-p_c)\right]$
  $\lambda_3 = 2f_C^3\left[(1-p_c)^3 + 3p_c(1-p_c)^2\right] + 3f_C^2\left[(1-p_c)^2 + 2p_c(1-p_c)\right]$



Consistency check: fit α

- α as fitting parameter
- Comparing with PPG194 α



Summary

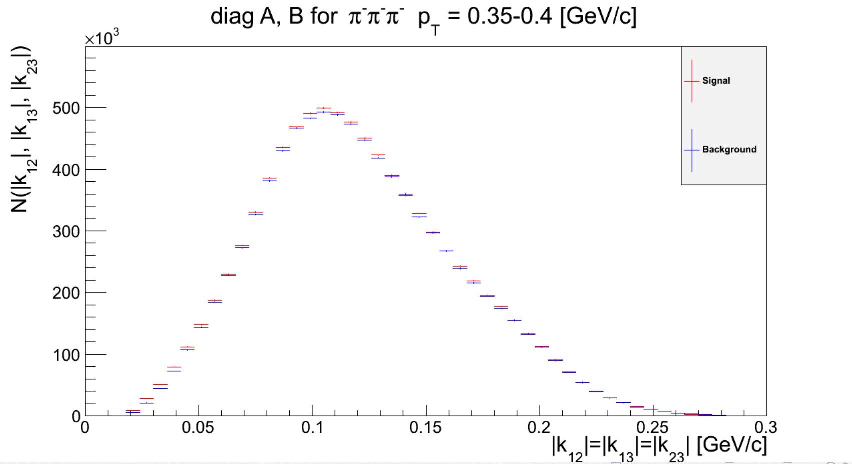
- PPG194 generalized to three particle
- Coulomb correction: Generalized Riverside
- Good fittings: χ^2 close to NDF, fitted α close to PPG194 α
- λ_3 goes above 5 (Core-Halo less then 5)
- $\kappa_3 = \frac{\lambda_3 - 3\lambda_2}{2\sqrt{\lambda_2^3}}$ parameter in Core-Halo 1
- κ_3 bigger than 1 for small m_T, smaller than 1 for big m_T
- We will ask preliminary for λ_3, κ_3, f_c vs p_c

Thank you for your attention!

Details of measurement

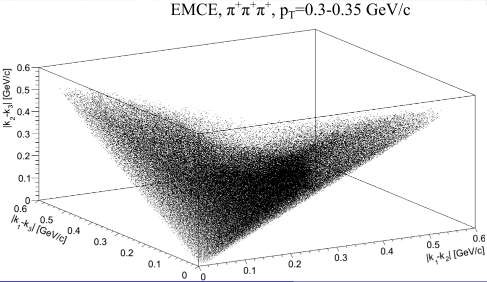
- Low bin behavior:

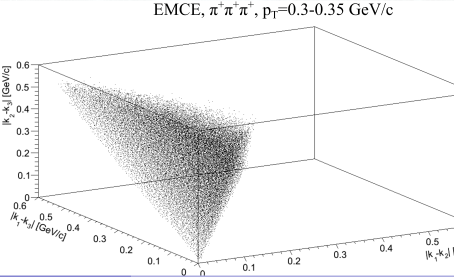
$$k_{ij} \to 0 \quad \overset{?}{\Longrightarrow} \quad A, B \to 0 \tag{5}$$



Details of measurement

- The correlation: $C_3(k_{12}, k_{13}, k_{23}) = \frac{A(k_{12},k_{13},k_{23})}{B(k_{12},k_{13},k_{23})} \frac{\int B}{\int A}$
- Triangle inequality for $\vec{k}_{12}$, $\vec{k}_{13}$, $\vec{k}_{23}$
- Order within triplet doesn't matter
- But when we measure do matter $\Rightarrow$ we have to fold the histogram
  $A(5,6,7) += A(6,7,5) + A(7,5,6) + A(5,7,6) + \ldots$





Coulomb correction

- Corrected model:

$$C_3(k_{12}, k_{13}, k_{23}) = C_3^{(0)}(k_{12}, k_{13}, k_{23}) \cdot K_3(k_{12}, k_{13}, k_{23}) \tag{6}$$

- "Generalized Riverside" method for 3 particle Coulomb problem

$$K_3(k_{12}, k_{13}, k_{23}) \approx K_1(k_{12})K_1(k_{13})K_1(k_{23}) \tag{7}$$