Charged kaon femtoscopy with Lévy sources in $\sqrt{s_{NN}} = 200$ GeV Au+Au collisions at PHENIX

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Abstract

The PHENIX experiment measured two-particle Bose- Einstein quantum-statistical correlations of charged kaons in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV collision. The correlation functions are parametrized assuming that the source emitting the particles has a Lévy shape, characterized by the α Lévy exponent and the R Lévy scale. By introducing the λ intercept parameter we account for the core-halo fraction. The parameters are investigated as the function of transverse mass. The comparison of the parameters measured for charged kaons to those measured from pion-pion correlation may clarify the connection of Lévy parameters to physical processes.

References

Lévy-type of distribution and anomalous diffusion

- Increasing mean free path: anomalous diffusion
- Lévy-distribution from generalized central limit theorem could be valid [1-3]
- \( L(\alpha, R; x) = (2\pi)^{-3/2} \int d^3 q e^{i q x} e^{-\frac{1}{2} |q R|^{\alpha}} \)

\( \alpha = 2 \) (Gaussian dist.)

\( 0 < \alpha < 2 \)

\( \rightarrow \) anomalous diffusion

\( \lambda \): strength (height)

\( R \): width

\( \alpha \): shape

Distortion effects on the correlation function

- Like-charged kaons \( \rightarrow \) Coulomb correction needed:
  - \( C_{\text{meas}}(Q) = K(Q) \cdot C_{B-E}(Q) \)
  - Solved with numerical method
- Effect of the resonance kaons \( \rightarrow \) core-halo model [4]:
  - \( S = S_{\text{core}} + S_{\text{halo}} \)
  - Long-lived resonances contribute to the halo
  - Introducing the core/halo ratio:
    \( \lambda = \left[ N_{\text{core}}/(N_{\text{core}} + N_{\text{halo}}) \right]^2 \)
  - Fit func.: \( C_2(Q) = 1 - \lambda + \lambda \cdot K(Q) \cdot C_{B-E}(Q) \)

References:
Correlation function variable:

\[ Q = \left| q_{LCMS} \right| = \sqrt{(p_{1x} - p_{2x})^2 + (p_{1y} - p_{2y})^2 + q_{long,LCMS}^2} \]

\[ q_{long,LCMS}^2 = \frac{4(p_{1z}E_2 - p_{2z}E_1)}{(E_1 + E_2)^2 - (p_{1z} + p_{2z})^2} \]

3D source nearly spherical in LCMS → \( q_{LCMS} \) proper 1D variable

Particle identification:

- time-of-flight data from TOF e/w, momentum, flight length
- 2.5 \( \sigma \) cuts on invariant mass distribution

Event cuts: \( |z_{vtx}| < 30 \) cm, no centrality cut

Varied track cuts

- Kaon PID cut: \( 2.0 \sigma - 2.5 \sigma - 3.0 \sigma \)
- Pion PID veto: \( 3.0 \sigma - 2.5 \sigma - 2.0 \sigma \)
- PC3 matching cut: 2 \( \sigma \) or no cut
- EMCal/TOF matching cut: 1.5 \( \sigma - 2.0 \sigma - 2.5 \sigma \)

Pair-cuts: customary shaped cuts on \( \Delta \phi - \Delta z \) plane for DCH, ToF e/w, EMCal