Factorization breaking in transverse momentum from hydrodynamic fluctuations

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Abstract
The factorization breaking in transverse momentum direction has been measured by CMS collaboration. We analyze results of the factorization ratio using an integrated dynamical model with hydrodynamic fluctuations.

1. Introduction

Factorization ratio \( r_2(p_T^1, p_T^2) \) \( \Rightarrow \) Event plane decorrelation in different \( p_T \) regions

Factorization breaking known to be sensitive to
- Initial state model
- Granularity of initial transverse profile

Do hydrodynamic fluctuations affect transverse dynamics?

2. Integrated dynamical model

2.1. Introduction

Two particle azimuth distribution

\[ \Delta \phi = < \cos(\phi_n) > \]

\( \Delta \phi \): Azimuthal angle measured from the reaction plane

2.2. Event plane correlation

\[ \Psi_1: \text{The second order event plane angle} \]

\[ \Psi_2(p_T) = \Psi_2(p_T) \]

\( \Rightarrow \) Event plane decorrelation in different \( p_T \) regions

Factorization ratio

\[ r_2(p_T^1, p_T^2) = \frac{\Psi_2(p_T^2)}{\Psi_2(p_T^1, p_T^2) \cdot \Psi_2(p_T^1)} \]

3. Relativistic fluctuating hydrodynamics


Second order constitutive equation

Hydrodynamic fluctuations

\[ \tau_r \Delta \Pi^\nu_{\mu \nu} \equiv \begin{cases} \frac{1}{\xi} \eta \Delta \Pi^\mu_{\nu} + \Delta \Pi^\mu_{\nu} \equiv g_{\mu \nu} \Delta \Pi^\mu_{\nu} \\ \tau_r \eta \Delta \Pi^\mu_{\nu} \equiv \begin{cases} \frac{1}{\xi} \eta \Delta \Pi^\mu_{\nu} + \Delta \Pi^\mu_{\nu} \equiv g_{\mu \nu} \Delta \Pi^\mu_{\nu} \end{cases} \end{cases} \]

Fluctuation dissipation relation

\[ \frac{\delta n}{\delta t} = -2 \beta \eta \tau_r \Delta \Pi^\mu_{\nu} \delta n^\mu_{\nu} \]

\[ \lambda: \text{Cutoff parameter} \]

4. Results

Factorization ratio in \( p_T \) in Pb+Pb collisions at \( \sqrt{s_{NN}} = 2.76 \) TeV

Centrality 0-5% 2.5 GeV < \( p_T < 3.0 \) GeV Centrality 5-10%

Centrality 40-50%

Central: The stronger hydrodynamic fluctuations are, the more factorization is broken.
Non-central: Effects of hydrodynamic fluctuations on factorization ratio are small.

5. Summary

- We analyzed the factorization ratios in transverse momentum using the integrated dynamic model with hydrodynamic fluctuations.
- Factorization ratios in central collisions depend on the strength of hydrodynamic fluctuations.
- Factorization is not broken significantly in non-central collisions even when hydrodynamic fluctuations are introduced.