Impact of magnetic field fluctuations on the CME in small systems

Xin-Li Zhao, Yu-Gang Ma, and Guo-Liang Ma
Shanghai Institute of Applied Physics, Chinese Academy of Sciences, Shanghai, China

A. Motivation

- In Pb + Pb collisions, $\Psi_{B} - \Psi_{2} \approx \frac{\pi}{2}$.
- In p + p collisions, $\Psi_{B} - \Psi_{2}$ is uncorrelated [1].

- The CMS measurements correlation $\gamma$ are similar, which indicates that dominant contribution to the CME observable of charge azimuthal correlation $\gamma$ may not be related to the CME in Pb + Pb and p + Pb collisions [2].

- $\gamma = \langle \cos(\phi^{p} + \phi^{p} - 2\Psi_{EP}) \rangle / \langle \Psi_{2} \rangle$

- The spatial distributions of the electromagnetic fields in the transverse plane at $t = 0$ for $p + p$ collisions at 5.02 TeV, which are different from $A + A$ collisions [3]. Here the unit is $m_{0}$. In three small systems, the average of absolute values of magnetic fields are still strong over the whole $N_{\text{track}}$ range, which could potentially bring some electromagnetic-field-based effects.

- We set $|b| < 2.4$ and $p_{T} > 0.4$ GeV/$c$ at the LHC energy and $|b| < 1$ and $p_{T} > 0.15$ GeV/$c$ at the RHIC energy to match the CMS definition or the STAR acceptance of $N_{\text{track}}$.

- For $b = 0$, 3, and 6 fm, $\Psi_{B} - \Psi_{2}$ are basically flat indicating that $\Psi_{B}$ and $\Psi_{2}$ are uncorrelated.

- For $b = 9$ fm, $\Psi_{B} - \Psi_{2}$ has a shape peaking at $\Psi_{B} - \Psi_{2} = 0$ with a corresponding width.

- However, $\Psi_{B}$ and $\Psi_{2}$ have strong correlations for mid-central events in $A + A$ collisions [4].

- $\langle \cos(2(\Psi_{B} - \Psi_{2})) \rangle$ are almost zero in high-multiplicity events, which hint the traditional CME observable is not valid to study the CME in those events.

- $\langle \cos(2(\Psi_{B} - \Psi_{2})) \rangle$ are finite in low-multiplicity events, which can reduce or even change sign of the traditional CME observable. Therefore, we suggest searching for a possible CME signal in small systems with low multiplicities.

B. String-melting AMPT model

(C) Results and discussions

- The spatial distributions of the electromagnetic fields in the transverse plane at $t = 0$ for $p + p$ collisions at 5.02 TeV, which are different from $A + A$ collisions [3]. Here the unit is $m_{0}$.

D. Summary

1. Compared to $A + A$ collisions, the magnitudes of absolute electric and magnetic fields in small systems are comparable.

2. The correlation of $\langle \cos(2(\Psi_{B} - \Psi_{2})) \rangle$ is strongly suppressed in high multiplicity events, which indicates that the traditional CME observable is not valid to study the CME in high-multiplicity events.

3. However, strongly correlated in parallel in low-multiplicity events, which can reduce or even change sign of the traditional CME observable, which is qualitatively consistent with the recent event-shape engineering measurement from the CMS [2].

4. As a result, we suggest searching for a possible CME signal in small systems with low multiplicities.

References