Impact of magnetic field fluctuations on the CME in small systems

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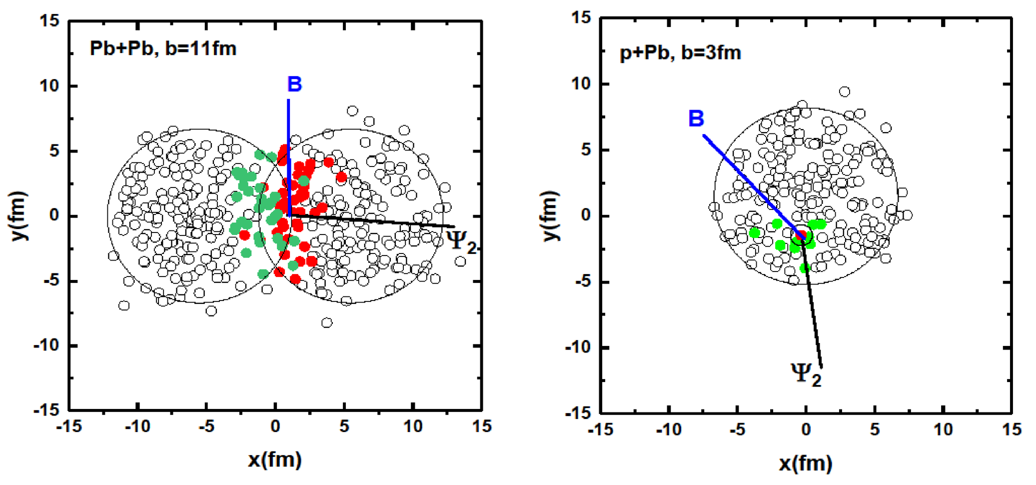
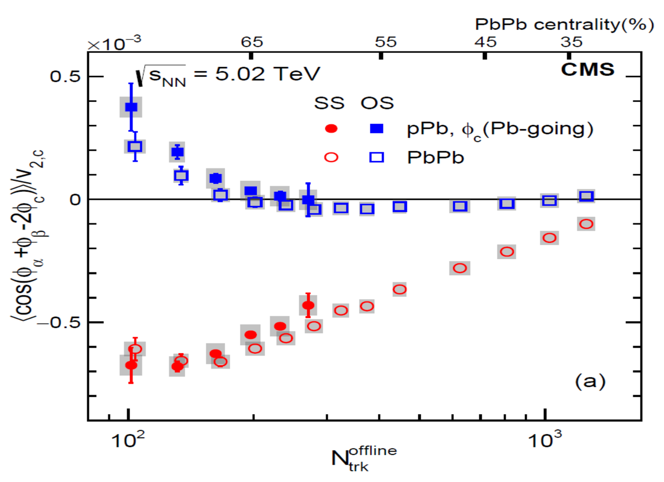
A Motivation



⇨ In Pb + Pb collisions, $\Psi_B - \Psi_2 \approx \frac{\pi}{2}$.

⇨ In p + Pb collisions, $\Psi_B - \Psi_2$ is uncorrelated [1].



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

⇨ $\gamma = \langle \cos(\phi_\alpha + \phi_\beta - 2\Psi_{RP}) \rangle$

$= \langle \cos(\phi_\alpha + \phi_\beta - 2\phi_c) \rangle / v_{2,c}$

⇨ Charge separation signal,

$\Delta\gamma \propto \langle B^2 \cos 2(\Psi_B - \Psi_{EP}) \rangle$.

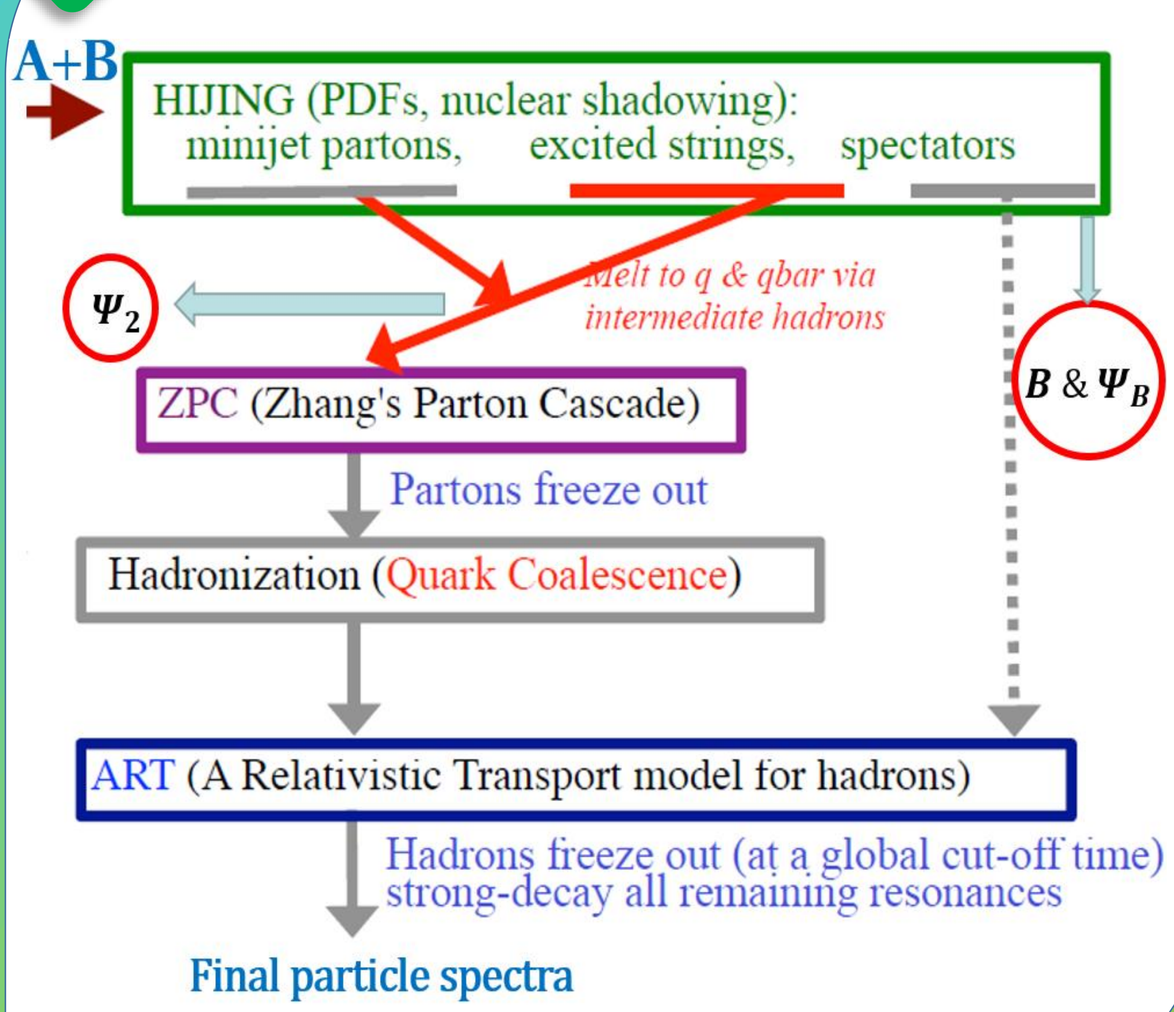
In p + A collisions, if $\langle \cos 2(\Psi_B - \Psi_{EP}) \rangle \approx 0$, $\Delta\gamma^{CME} \approx 0$.

⇨ In our work, we calculate

① magnetic field $\boldsymbol{B}$ ② $\langle \cos 2(\Psi_B - \Psi_2) \rangle$

in small systems, e.g., p + Au, d + Au, and p + Pb collisions. Here $\Psi_2 \approx \Psi_{EP}$.

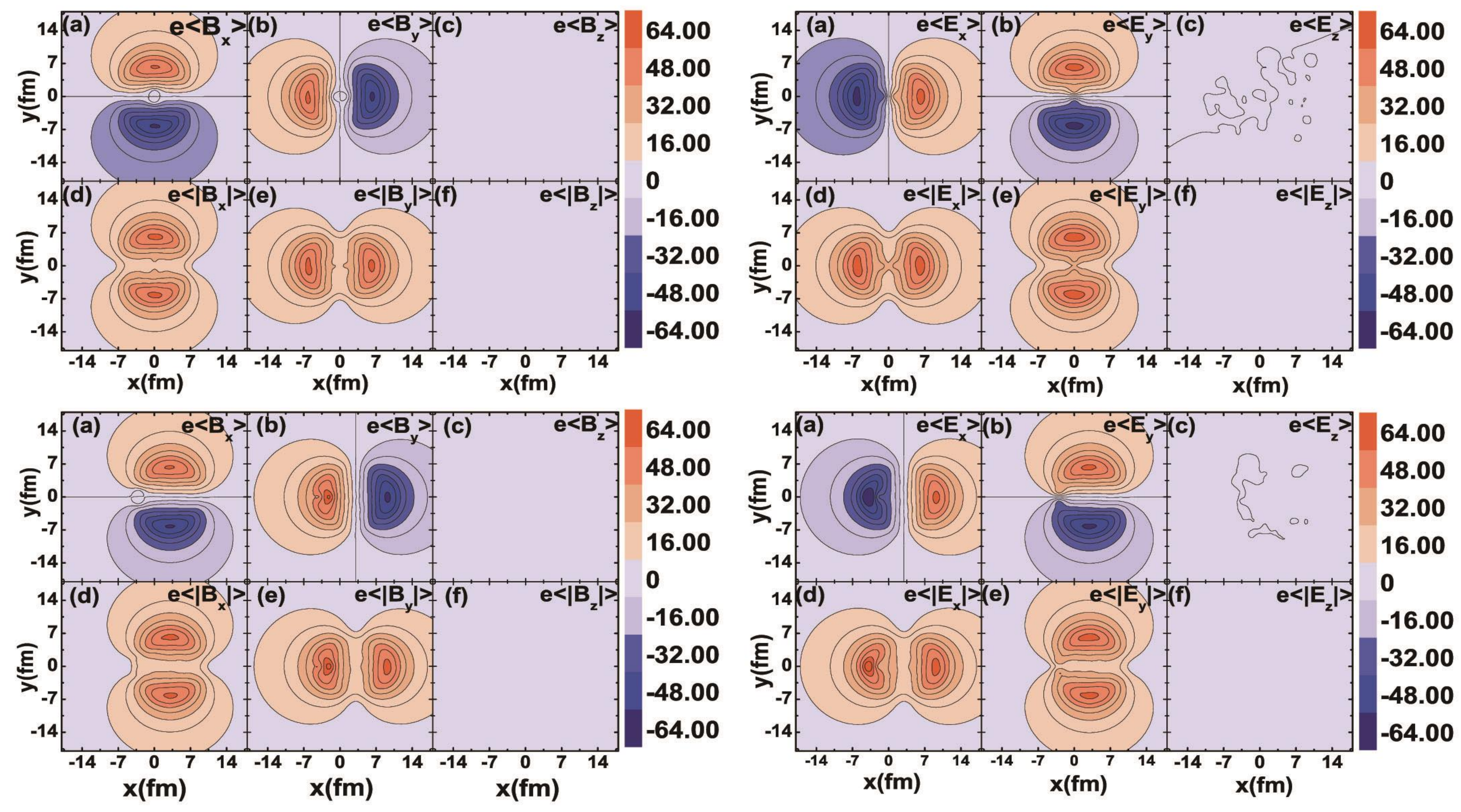
B String-melting AMPT model



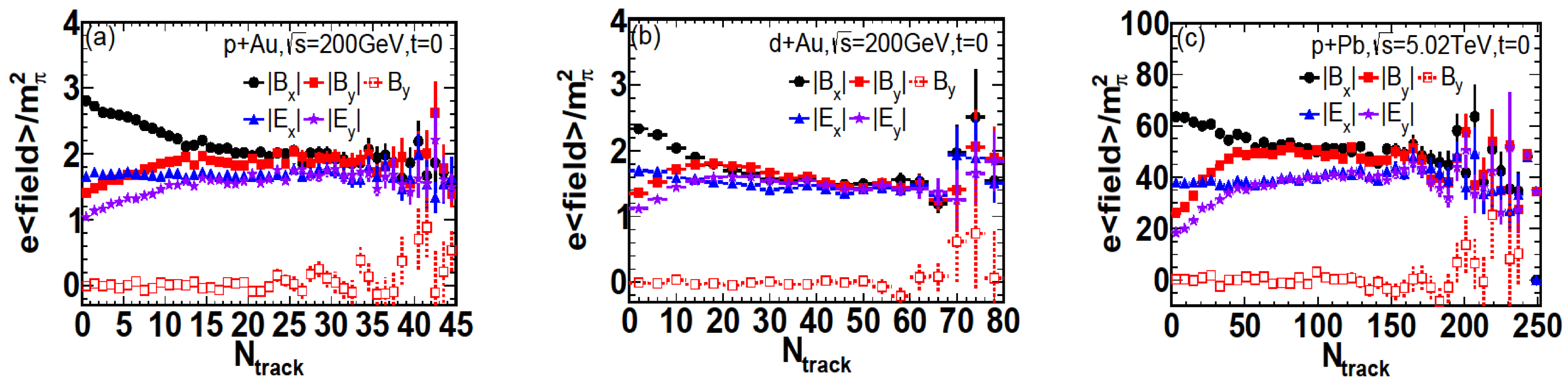
C Results and discussions

b = 0 fm

b = 6 fm

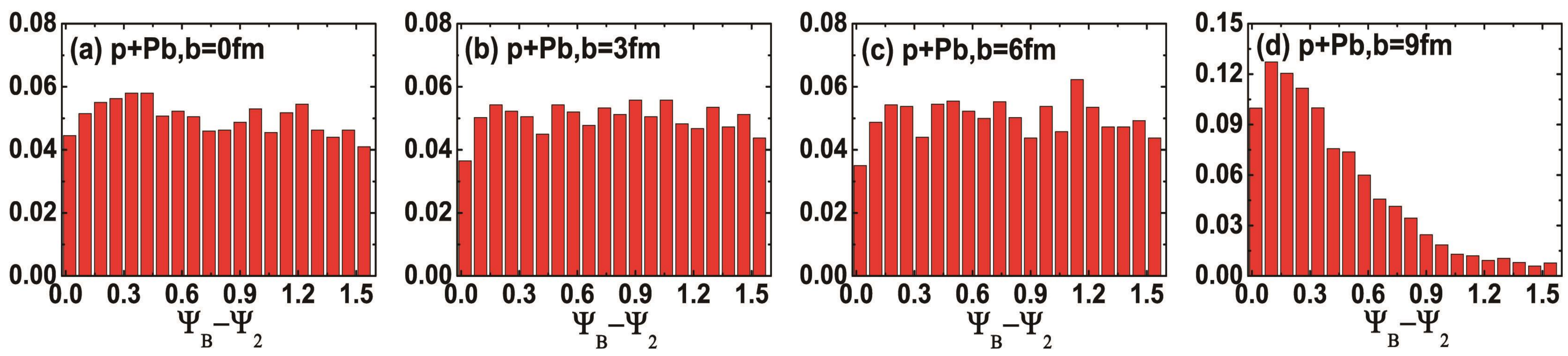


⇨ The spatial distributions of the electromagnetic fields in the transverse plane at t = 0 for p + Pb collisions at 5.02 TeV, which are different from Au+Au collisions [3]. Here the unit is m_π^2.



⇨ In three small systems, the average of absolute values of magnetic fields are still strong over the whole N_{track} range, which could potentially bring some electromagnetic-field-based effects.

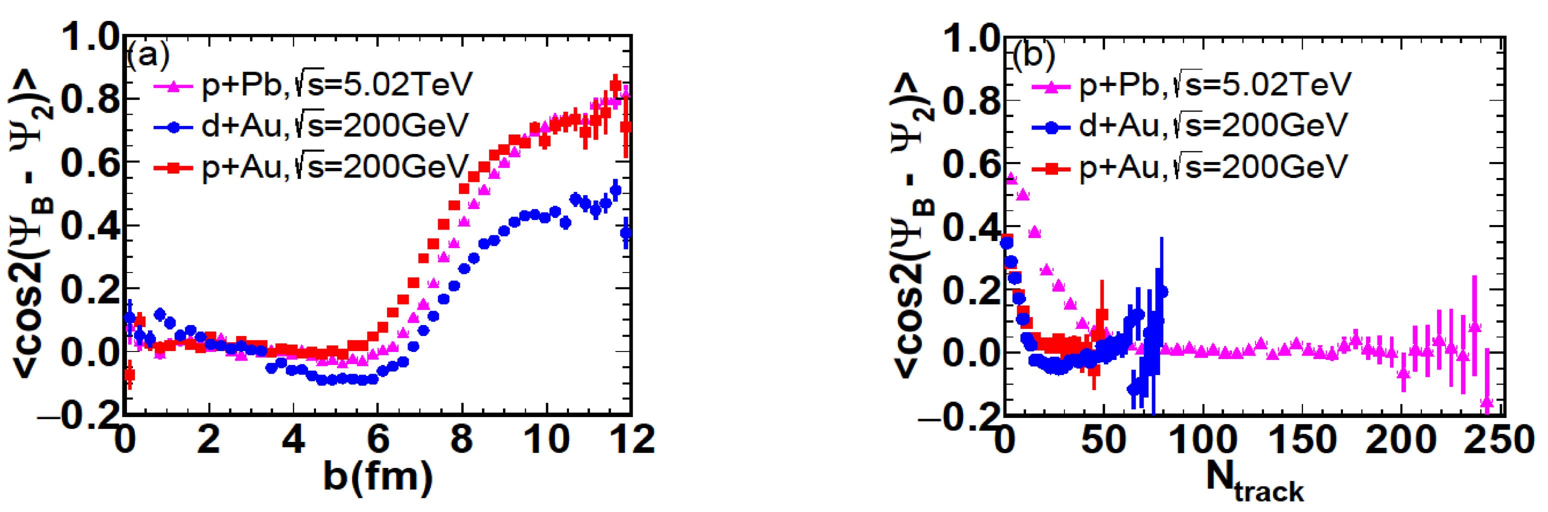
⇨ We set $|\eta| < 2.4$ & $P_T > 0.4$ GeV/c at the LHC energy and $|\eta| < 1$ & $P_T > 0.15$ GeV/c at the RHIC energy to match the CMS definition or the STAR acceptance of N_{track}.



⇨ For b = 0, 3, and 6 fm, $\Psi_B - \Psi_2$ are basically flat indicating that Ψ_B and Ψ_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, Ψ_B and Ψ_2 have strong correlations for mid-central events in Au+Au 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.

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

[1] X. L. Zhao, Y. G. Ma and G. L. Ma, Phys. Rev. C **97**, 024910 (2018).
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[4] J. Bloczynski, X. G. Huang, X. Zhang, and J. Liao, Phys. Lett. B **718**, 1529 (2013).

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