A study of ϕ-meson spin alignment with a multi-phase transport (AMPT) model

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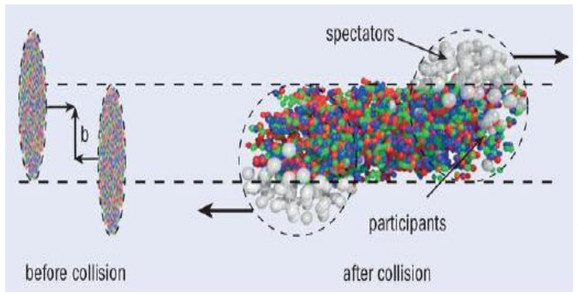
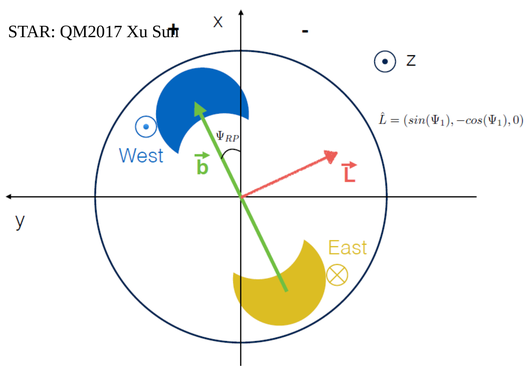
Abstract

Observables sensitive to the vorticity allow us to study the fundamental property of the hot and dense nuclear matter created in high-energy nuclear collisions. The spin alignment of vector meson such as ϕ-meson could be sensitive to the vorticity of the colliding system and its space-time evolution. In this presentation, we will present results from a multi-phase transport (AMPT) model which has been modified to include the spin alignment information of ϕ-meson. We will discuss the extraction of spin alignment parameter with respect to the global angular momentum, and study how hadronic interactions could influence the spin alignment observables. We will also discuss the effect of acceptance , especially the pseudorapidity coverage, on the extraction of spin alignment parameter.

Motivation





- Non-central heavy ion collsions have large initial angular momentum**.**
- Due to spin-orbit coupling, this orbital angular momentum may result in net polarization of produced particles along the direction of the initial angular momentum[1] **(L)**.
- ϕ-mesons, which have small hadronic scattering cross sections, are expected to originate predominantly from primordial production.
- The 00-conponent of ϕ - meson spin density matrix (ρ_{00})[4] can be measured by angular distribution of decay daughter $\phi \rightarrow K^+ + K^-$ using:

$$\frac{dN}{d(\cos\theta^*)} = \frac{3}{4}[(1-\rho_{00}) + (3\rho_{00}-1)\cos^2\theta^*]$$

- A deviation of ρ_{00} from 1/3 indicates a spin alignment of ϕ-meson[2].
- θ^* is the angle between the polarization direction and the momentum direction of K^- in the rest frame of the parent ϕ-meson.

Analysis Method

A Multi-Phase Transport Model[3]

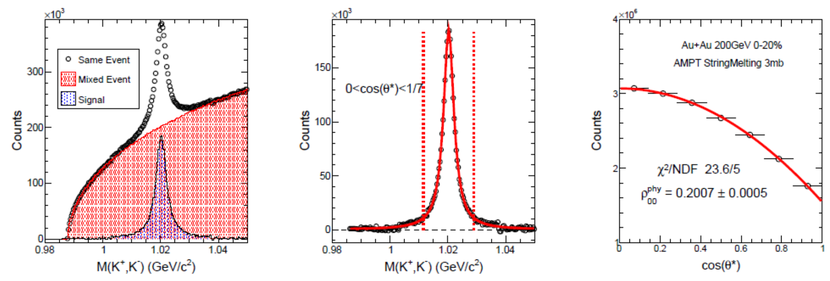
Four Main Parts:

- The initial condition.
- Partonic scattering.
- Hadronization.
- Hadronic scattering.

AMPT Input

- Add input ρ_{00} parameter to specify the degree of spin alignment of ϕ-meson versus the direction of angular momentum.
- Au+Au at $\sqrt{s_{NN}}$ = 200GeV with StringMelting, partonic scattering cross section = 3 mb.

ρ_{00} Extraction

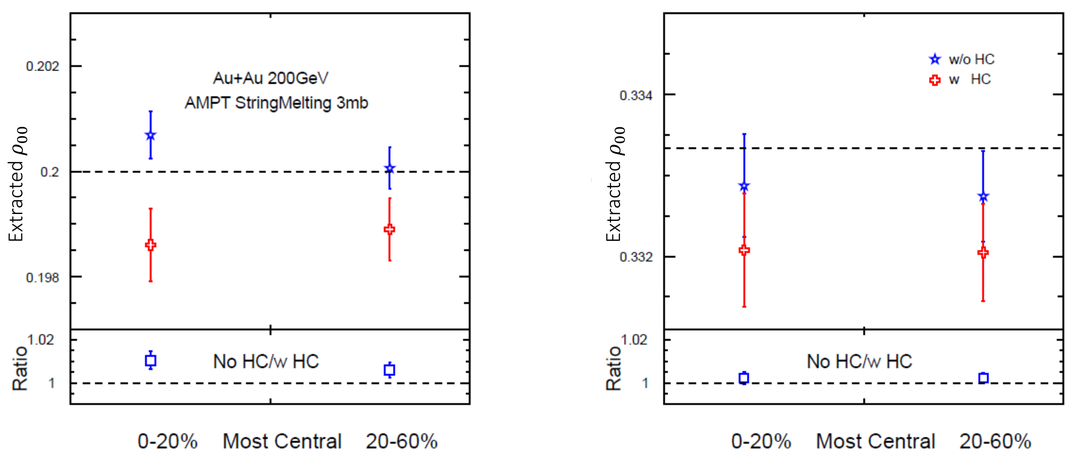


- Background : Event Mixing technique.
- Invariant mass distributions for 7 different $cos\theta^*$ bins.
- Fit $cos\theta^*$ distribution with $\frac{dN}{d(\cos\theta^*)} = \frac{3}{4}[(1-\rho_{00}) + (3\rho_{00}-1)\cos^2\theta^*]$ to extract ρ_{00}.

- ρ_{00}^{obs}: Calculated with reconstructed event plane.
- ρ_{00}^{phy}: Calculated with direction of angular momentum.
- In experiment only ρ_{00}^{obs} can be measured. Technically, ρ_{00}^{obs} can be corrected *to* ρ_{00}^{phy}.

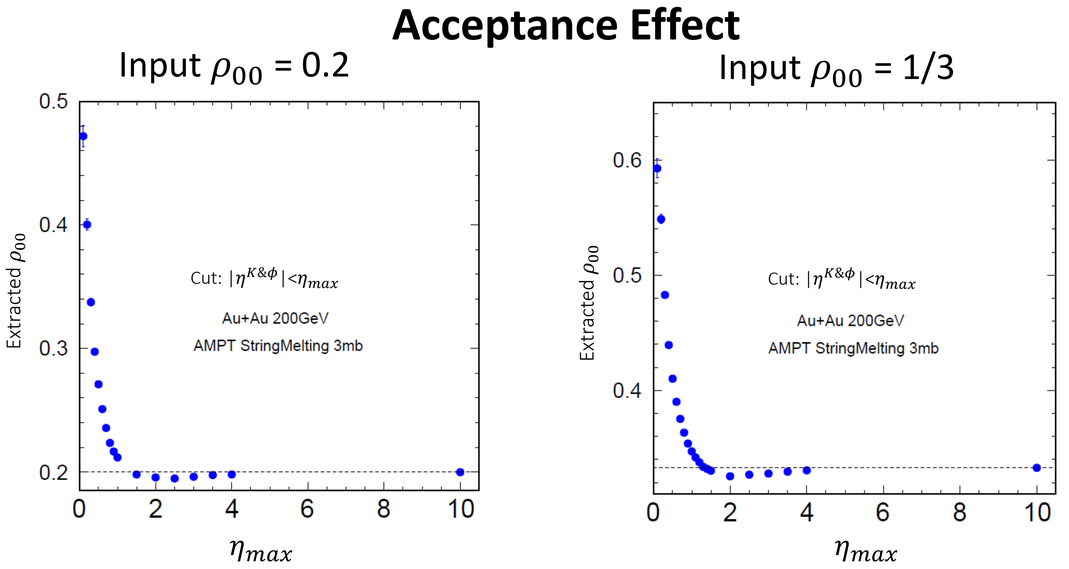
Results

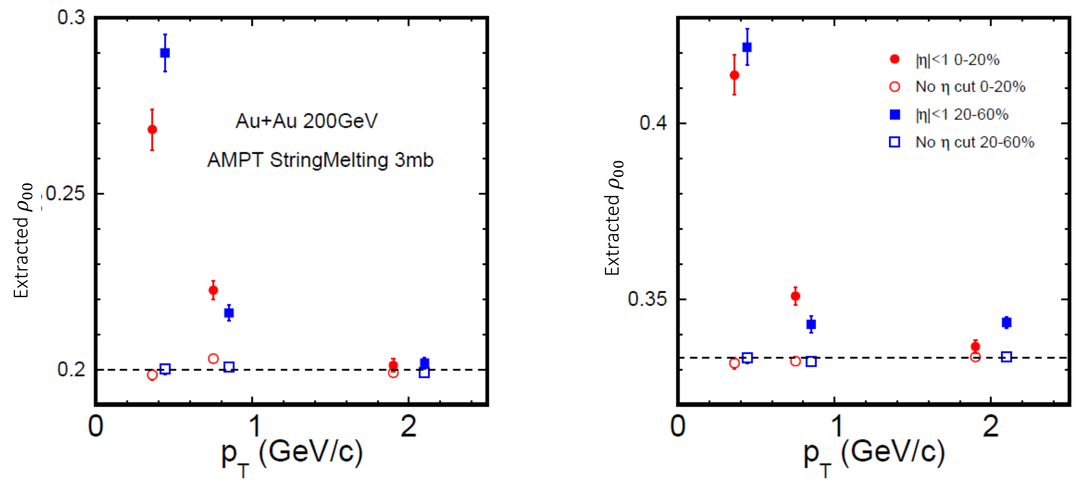
Hadron Cascade Effect



- Hadron cascade(HC) is irrelevant for ϕ-meson spin alignment.
- The extracted ρ_{00} from AMPT model depends on the η cut of ϕ meson and daughter kaons. When the cut is below $|\eta|<1$, a narrower η acceptance generates a significantly larger extracted ρ_{00} value than the input ρ_{00}.
- With the η coverage of $|\eta|<1$, the extracted ρ_{00} depends on transverse momentum, Larger deviation is observed in low transverse momentum range. Without η coverage cut, the extracted ρ_{00} values as function of transverse momentum are consistent with input.

Acceptance Effect





Summary

- We use a new AMPT version with input ρ_{00} parameter to specify the degree of spin alignment of ϕ-meson versus the direction of angular momentum.
- Hadron cascade effect is found to be small on the extraction of ϕ-meson spin alignment parameter in AMPT model.
- The peseudorapidity coverage and transverse momentum dependence of extraction of ϕ-meson spin alignment parameter are observed in AMPT model. It indicates that the experiment measurements of ρ_{00} parameter should be corrected for this effect.

References

[1] Z. T. Liang and X. N. Wang, Phys. Rev. L94,102301 (2005) [2] Z. T. Liang and X. N. Wang, Phys. Lett. B629,20-26 (2005)[3] Zi-Wei Lin, Ko, Li, Zhang and Pal, Phys. Rev. C72,064901 (2005)[4] STAR Phys. Rev. C77,061902(R) (2008)