Rescattering effect on the measurement of K* spin alignment in heavy-ion collisions with UrQMD

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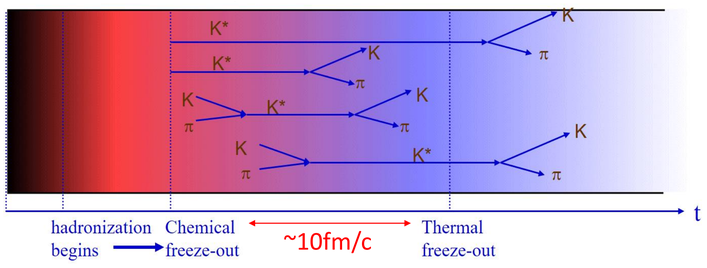
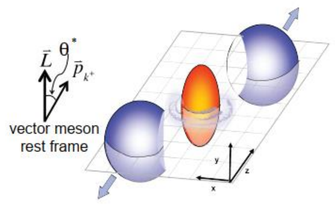
Abstract

In non-central relativistic heavy ion collisions, the created matter possesses a large initial orbital angular momentum. Particles produced in the collisions could be polarized globally in the direction of the orbital angular momentum due to spin-orbit coupling. The measurement of vector mesons K* and phi can provide information of the large vorticity of the hot, dense medium created in non-central heavy-ion collisions. Due to short lifetime of K* which is comparable to the time between chemical freeze-out and kinetic freeze-out, the reconstructed K* suffers from the rescattering effect (A K* can not be reconstructed experimentally via the invariant mass method if the K* decays in the medium and one or more daughters is scattered in the medium). Because of the anisotropy of the medium in coordination space, the rescattering effect on K* could depend on cosθ* thus result in non-uniform cosθ* distribution for reconstructed K*. It could be a very important background for the study of global polarization via the K* spin alignment measurements in non-central heavy-ion collisions.

Motivation

- Large initial orbital angular momentum **L** in non-central relativistic heavy ion collisions. Due to spin-orbit coupling, Particles could be polarized globally in the direction of **L**. [1]The spin alignment of vector mesons K* and φ can provide information of the large vorticity of the hot, dense medium created in non-central heavy-ion collisions.
- Due to short lifetime of K* which is comparable to the time between chemical freeze-out and kinetic freeze-out, the reconstructed K* suffers from the rescattering effect. [2]





- Because of the anisotropy of the medium in coordination space, the rescattering effect on K* could depend on cosθ* thus result in non-uniform cosθ* distribution for reconstructed K*.

UrQMD model

- Choose UrQMD model to test.
- History file can trace K* decays and select the reconstructable K*.
  - Select all decay K*
  - Get daughter index
  - Identify the scattered daughter
  - Distinguish reconstructable and lost K*

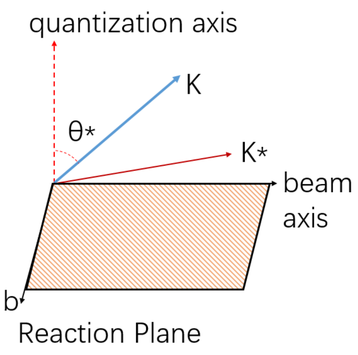
Collision system and energy : Au-Au 200GeV output time: 100fm/c	
Collision Centrality	No. of events
0-20%	0.1M
20-60%	1M
60-80%	1M
80-100%	1M

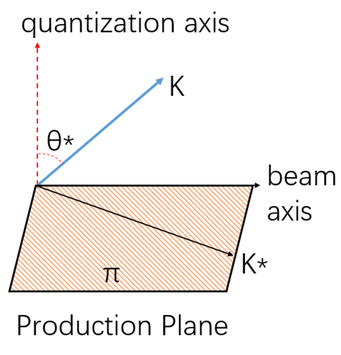
Global Spin Alignment

- For vector meson, spin alignment can be described by ρ00.
- ρ00 can be determined from the angular distribution of the decay products [3]:

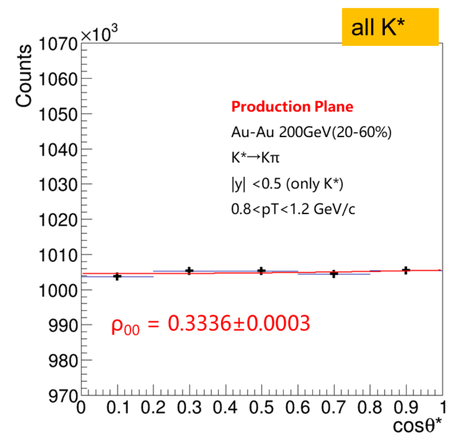
$$\frac{dN}{d(\cos\theta^*)} = N_0 \times [(1-\rho_{00}) + (3\rho_{00}-1)\cos^2\theta^*]$$

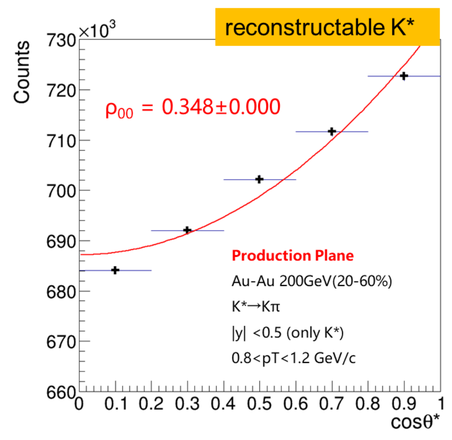
θ*: the angle between the quantization direction and the momentum direction of a daughter



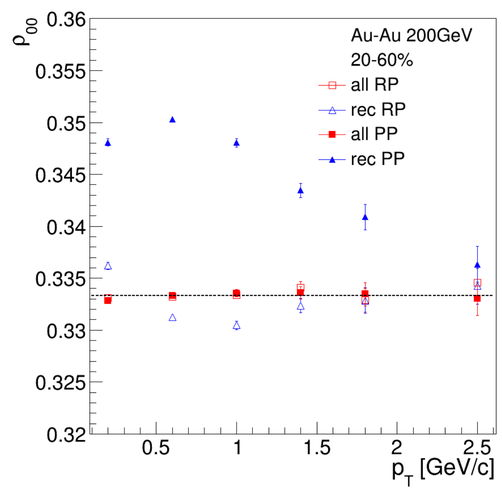


Angular distribution w.r.t. Production plane

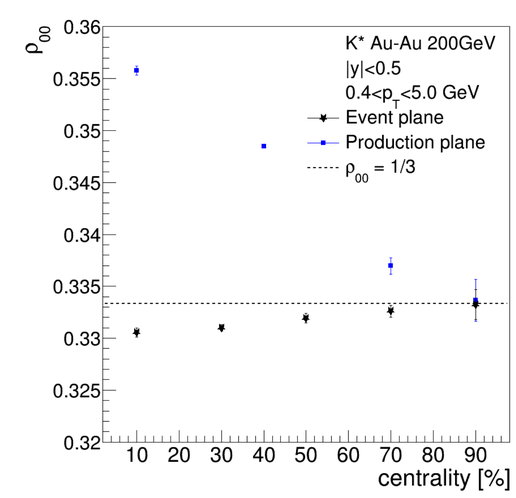




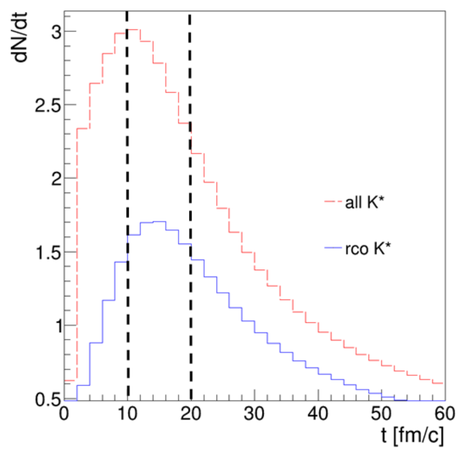
- Consider all decay K*, ρ_{00} ~ 1/3. Reconstructable ρ_{00} values larger than 1/3.
- Production plane result shows that the daughter particles along the direction of K* are more likely to be scattered.

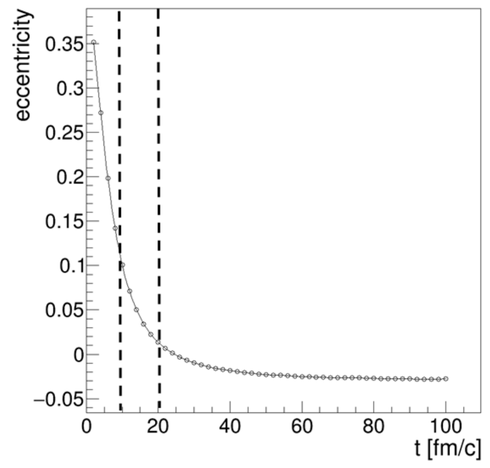


ρ00 as function of p_T

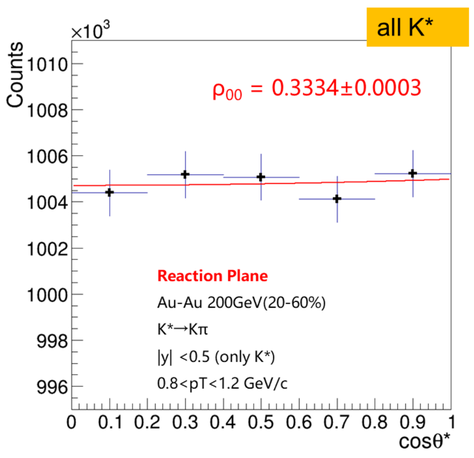


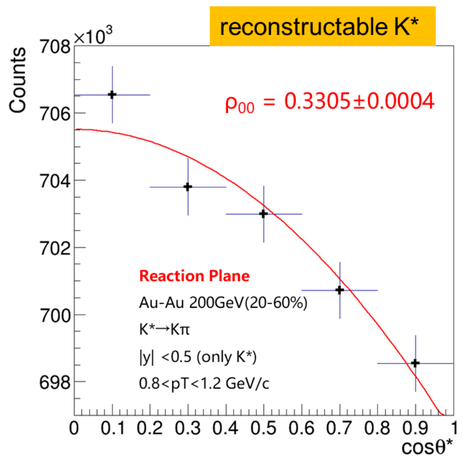
centrality dependence





Angular distribution w.r.t. Reaction plane





- Consider all decay K*, ρ_{00} ~ 1/3. Reconstructable ρ_{00} values below 1/3.
- Reaction plane result shows the rescattering effect caused by the anisotropy of the medium in coordination space.

Summary

- ✓Use UrQMD history file to distinguish all and reconstructable K*.
- ✓ρ00 consistent with 1/3 for all K* and deviate from 1/3 for reconstructable K* both in Reaction plane and Production plane.
- ✓ Reaction plane result shows the effect caused by the anisotropy of the medium in coordination space.
- Production plane result shows that the daughter particles along the direction of K* are more likely to be scattered.
- ✓ Eccentricity decreases with time, so the rescattering effect is small.
- ✓ρ00 shows centrality dependence in both Reaction and Production plane.

References

[1] Liang Z T, Wang X N. Physical review letters, 2005, 94(10): 102301.
[2] (STAR Collaboration) PHYSICAL REVIEW C 84, 034909 (2011)
[3] K.Schilling el al.,Nucl. Phys. B 15,397(1970)
[4] Global Λ hyperon polarization in nuclear collisions-STAR Collaboration Nature 548,62-65(2017)