Measurement of K^{*0} and K^{*+-} in Ru+Ru and Zr+Zr collisions at RHIC

STAR 25 YEARS

Quark Matter 2025

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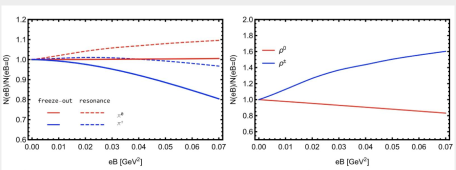
Abstract

The neutral K^{*0} and charged K^{*+-} vector mesons have similar masses and isospin, their quark magnetic moment differ by a factor of five, making them ideal probes for studying Landau level splitting in presence of magnetic (*B*) field in heavy-ion collisions. We present the reconstruction of K^{*0} and K^{*+-} mesons in RHIC isobar (*Ru+Ru* and *Zr+Zr*) collisions. We report on the yield and $\langle p_T \rangle$ of K^{*0} mesons as well as K^{*0}/K ratio in these collisions as a function of collision centrality. The analysis of $K^{*0,+-}$ involving isospin-asymmetric nuclei (*Au+Au*, *Ru+Ru* and *Zr+Zr*) and isospin-symmetric nuclei (*O+O*), as well as in *p+p* collisions at *200* GeV is underway. This study can offer insights into Landau levels, isospin violation, and late-stage B-fields in QCD medium.

Introduction:



K. Xu et al, Phys Lett B 809, 135706 (2020)

$$\rho^0 \to \pi^+\pi^-,\ \rho^\pm \to \pi^0\pi^\pm$$
$$K^{*0} \to K^\pm\pi^\mp,\ K^{*\pm} \to K_S^0\pi^\pm$$

The energy level for a point-like charged particle under static uniform magnetic field (B)

$$\epsilon^2_{n,s_z}(p_z) = p_z^2 + (2n - 2\,\mathrm{sign}(q)s_z + 1)\,|qB| + m^2$$

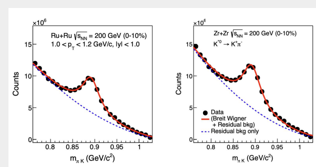
q = electric charge
n = Landau level
s_z = projection of spin along magnetic field
p_z = momentum along magnetic field

- Under *B*-field, $N_{K^{*+-}} > N_{K^{*0}}$ is expected from Landau level splitting (isospin violation)
- Neutral and charged vector meson's yield ratio can be used to constraint *B*-field at freeze-out

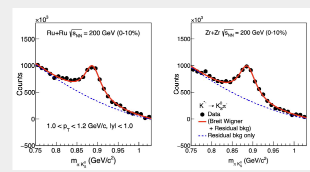
Signal reconstruction:

Invariant mass method is used to reconstruct $K^{*0,+,-}$ signal; combinatorial background is constructed via track-rotation technique. A clear signal is observed on top of a combinatorial background

K^{*0}



K^{*-}

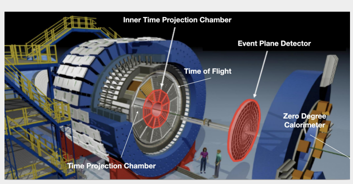


Signal is fitted with a non-relativistic Breit-Wigner function and a second order polynomial for residual background

$$\frac{Y}{2\pi}\frac{\Gamma_0}{(m-m_0)^2 + (\Gamma_0/2)^2} + AM^2 + BM + C$$

Experimental details:

STAR offers uniform acceptance, full azimuthal coverage and excellent particle identification using Time Projection Chamber (TPC) and Time Of Flight (TOF)



Event selection:

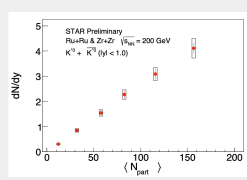
- Vertex: *-35 <* V_Z *< 25 cm*, V_r *< 2 cm*; Centrality from TPC; Rejection of pile-up events

Track selection:

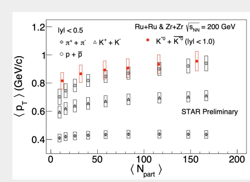
$K^{*0} \to K^+ \pi^-$
$K^{*+-} \to K_S^0 \pi^-$

- No. of TPC hits *> 15*,
- K^{*0}: p_T *> 0.2* GeV/c, DCA *< 2 cm*, $|\eta|$ *< 1.0 for K and* π
- K^{*+-}: STAR helix topology method for K_S^0 selection, p_T *> 0.2* GeV/c, DCA *< 2 cm*, $|\eta|$ *< 1.0* for π
- *K* and π*'s* are identified using TPC and TOF

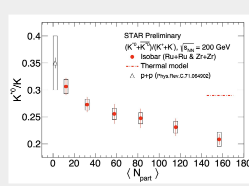
Yield, $\langle p_T \rangle$ and particle ratios:



- K^{*0} *dN/dy* increase with $\langle N_{part} \rangle$



- K^{*0} $\langle p_T \rangle$ similar to protons (mass dependence)



- Evidence of late-stage hadronic re-scattering
- $(K^{*0}/K)_{central} < (K^{*0}/K)_{peripheral}$ (~ 3.3 σ)

Summary and outlook:

- K^{*0} production → studied in isobar collisions (***Ru+Ru, Zr+Zr***)
- K^{*0}/K → evidence of late-stage hadronic re-scattering
- K^{*+-} → analysis in ***Au+Au, Ru+Ru, Zr+Zr, O+O*** and ***p+p*** collisions is underway
- Yield difference between neutral K^{*0} and charged K^{*+-} in heavy-ion collisions can help constrain the B-field at freeze-out

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The STAR Collaboration