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

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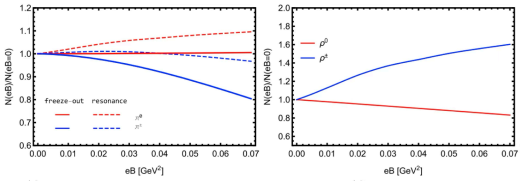
Abstract

The neutral K^{*0} and charged $K^{*\pm}$ vector mesons have similar masses and total isospin (I), but their third component of isospin (I_3) has opposite sign, and their quark magnetic moment differ by a factor of five. These properties 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 $K^{*\pm}$ 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 $K^{*0,\pm}$ 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:



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

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

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

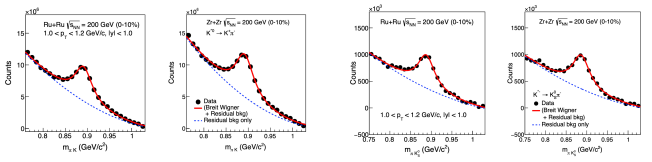
$$\epsilon^2_{n,s_z}(p_z) = p_z^2 + (2n - 2\,\mathrm{sign}(q)s_z + 1)|qB| + m^2$$

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

- Under B-field, $N_{K^{*\pm}} > N_{K^{*0}}$ 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 $K^{*0,\pm}$ signal; combinatorial background is constructed via track-rotation technique; after combinatorial background subtraction a clear signal is observed



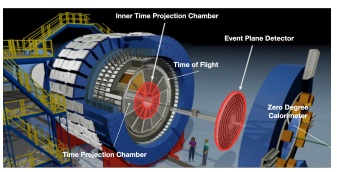
Signal is fitted with a non-relativistic Breit-Wigner function and a second order polynomial for residual background

$$\frac{Y}{2\pi} \times \frac{\Gamma_0}{(m - m_0)^2 + (\Gamma_0/2)^2} + A\,M^2 + B\,M + C$$

Source of systematic uncertainty on yield and $\langle p_T \rangle$:
Signal extraction (fit range and background variation); Yield calculation (histogram vs function integration); Event, track quality, **PID** selection variation; tracking uncertainty

Experimental details:

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

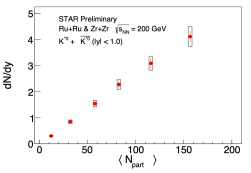


Event selection:
- Vertex: *-35* < V_z < *25 cm*, V_r< *2 cm*; Centrality from TPC; Rejection of pile-up events

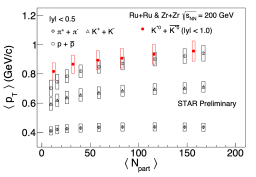
Track selection:
- No. of TPC hits > *15*,
- K^{*0}: p_T > *0.2* GeV/c, DCA < *2 cm*, $|\eta|$ < *1.0 for K* and π
- $K^{*\pm}$: STAR helix topology method for K^0_S selection, p_T > *0.2* GeV/c, DCA < *2 cm*, $|\eta|$ < *1.0* for π
- *K* and π's are identified using TPC and TOF detectors

$K^{*0} \to K^\pm + \pi^\mp$
$K^{*\pm} \to K^0_S + \pi^\pm$

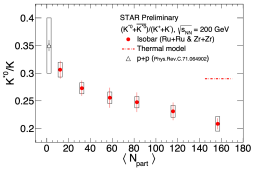
Yield, $\langle p_T \rangle$ and particle ratios:



- 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), Thermal Model

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^{*0} analysis is ongoing for *O+O* and *p+p* collisions
- $K^{*\pm}$ analysis is underway for *Au+Au, Ru+Ru, Zr+Zr, O+O* and *p+p* collisions
- $K^{*0,\pm}$ → both are expected to have a similar re-scattering effect; however, their yields can differ due to Landau splitting under *B*-field

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The STAR Collaboration