K^{*0} production in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{NN}}$ = 200 GeV at RHIC

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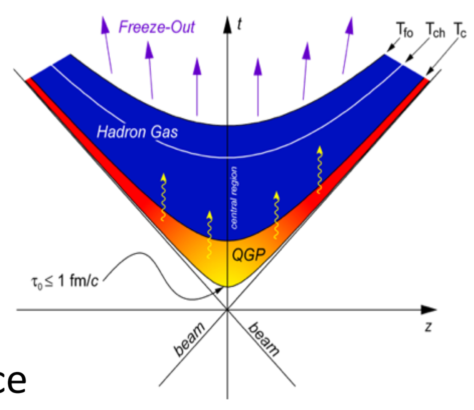
Abstract

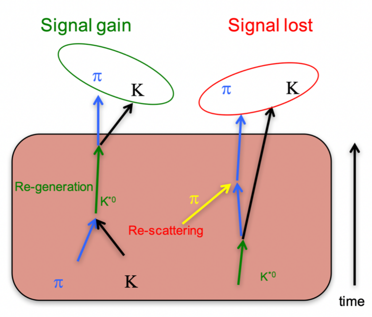
The comparison between the production of short-lived resonances (e.g., K^{*0}) to non-resonances (e.g., K) is commonly employed to understand the role of re-scattering and regeneration processes that occur during the late stages of hadronic interactions. We will present the transverse momentum (p_T) spectra, yield (dN/dy), and $\langle p_T \rangle$ of K^{*0} mesons utilizing the high statistics data of the isobar collisions (Ru+Ru and Zr+Zr) at $\sqrt{s_{NN}}$ = 200 GeV. The K^{*0}/K ratios are shown as a function of collision centrality. This ratio in central isobar collisions is smaller than for peripheral collisions with a significance of 3.3σ, consistent with the picture of dominance of hadronic re-scattering in central heavy ion collisions. The K^{*0} $\langle p_T \rangle$ is consistent with that of protons (anti-protons) indicating the role of radial flow (mass dependence).

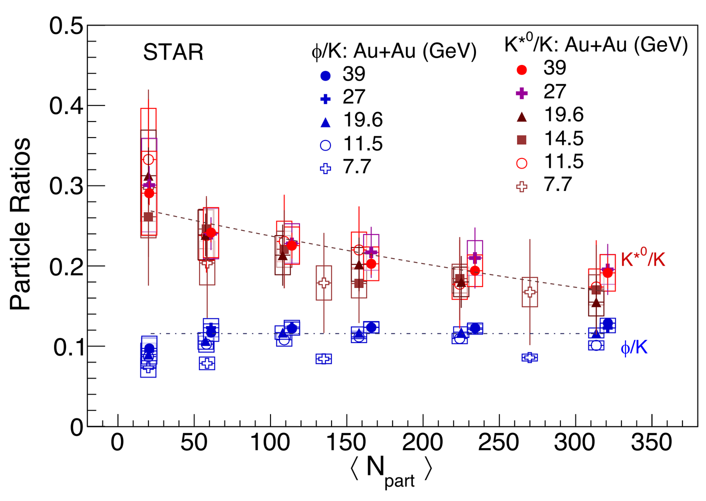
Introduction:

Resonances are sensitive to the properties of the medium, since their lifetime is comparable to that of the fireball ($\tau_{Resonance} \sim \tau_{Fireball}$).

The decay products of resonances can be re-scattered in the hadronic medium, causing a loss in the reconstructed signal. Moreover, resonances can be regenerated due to pseudo-elastic interactions. Competition between re-scattering and regeneration determines the final resonance yield and hence the resonance-to non-resonance ratio.







Recent observations from STAR Beam Energy Scan-I:

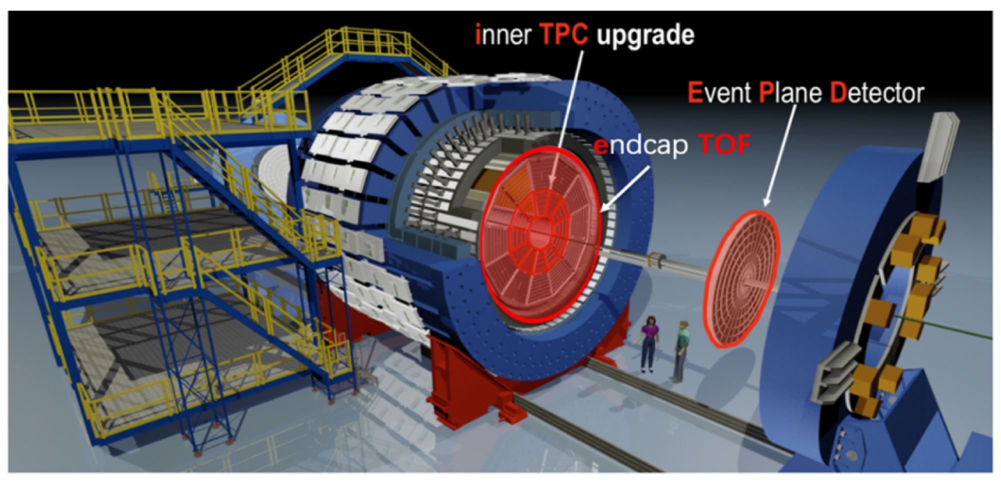
→ **Hints** of suppression of K^{*0} yield in central collisions

→ Centrality dependence of (K^{*0}/K): Not sufficient significance

→ High statistics isobar collisions (Ru+Ru and Zr+Zr) at $\sqrt{s_{NN}}$ = 200 GeV : about 4-billion events

Experimental details:

The STAR detector offers uniform acceptance, full azimuthal coverage, and excellent particle identification. The Time Projection Chamber (TPC) is used for particle tracking, collision centrality determination.



Track cuts used in the analysis:

p_T > 0.2 GeV/c

DCA < 2 cm

|Rapidity| < 1.0

$K^{*0}(\overline{K^{*0}})$ reconstructed via hadronic decay channel: $K^{*0}(\overline{K^{*0}}) \rightarrow K^+\pi^-$ ($K^-\pi^+$) (BR ~ 66%)

For p_T spectra analysis, charged kaons and pions are identified using a combination of TPC and Time Of Flight (TOF) information

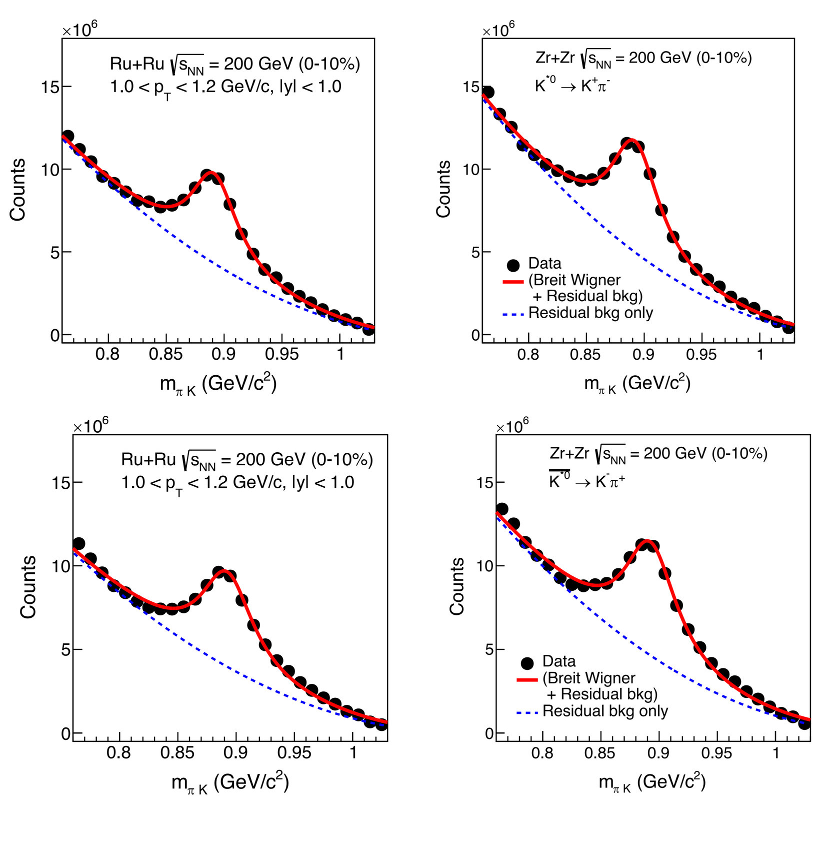
If TOF hits available we use |1-1/β| < 0.02

Otherwise, we use TPC $|N\sigma|$ < 2

$$N\sigma = \frac{\left(\frac{dE}{dx}\right)_{expt} - \left(\frac{dE}{dx}\right)_{theo}}{\sigma_{TPC-PID}} \qquad \beta = \frac{L}{c\tau}$$

Signal reconstruction:

The invariant mass method was used to investigate the K^{*0} signal. The combinatorial background is constructed via the track rotation technique. A clear signal is observed on top of a residual background after combinatorial background subtraction.



→ Signal fitted with non-relativistic Breit Wigner function and a residual background

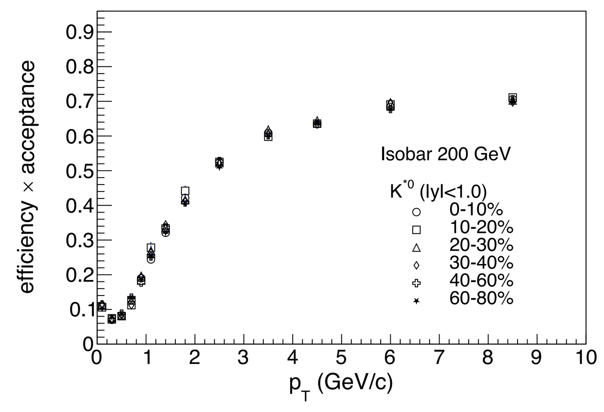
$$\frac{Y}{2\pi} \times \left[\frac{\Gamma_0}{(M-M_0)^2 + \frac{\Gamma_0^2}{4}}\right] + AM^2 + BM + C$$

→ Yield is calculated from histogram bin counting in the range (0.75, 1.04) GeV/c^2

Transverse momentum spectra:

The raw yield of K^{*0} is extracted in different p_T bins for six different collision centralities in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{NN}}$ = 200 GeV.

Efficiency x acceptance: estimated using STAR embedding simulations



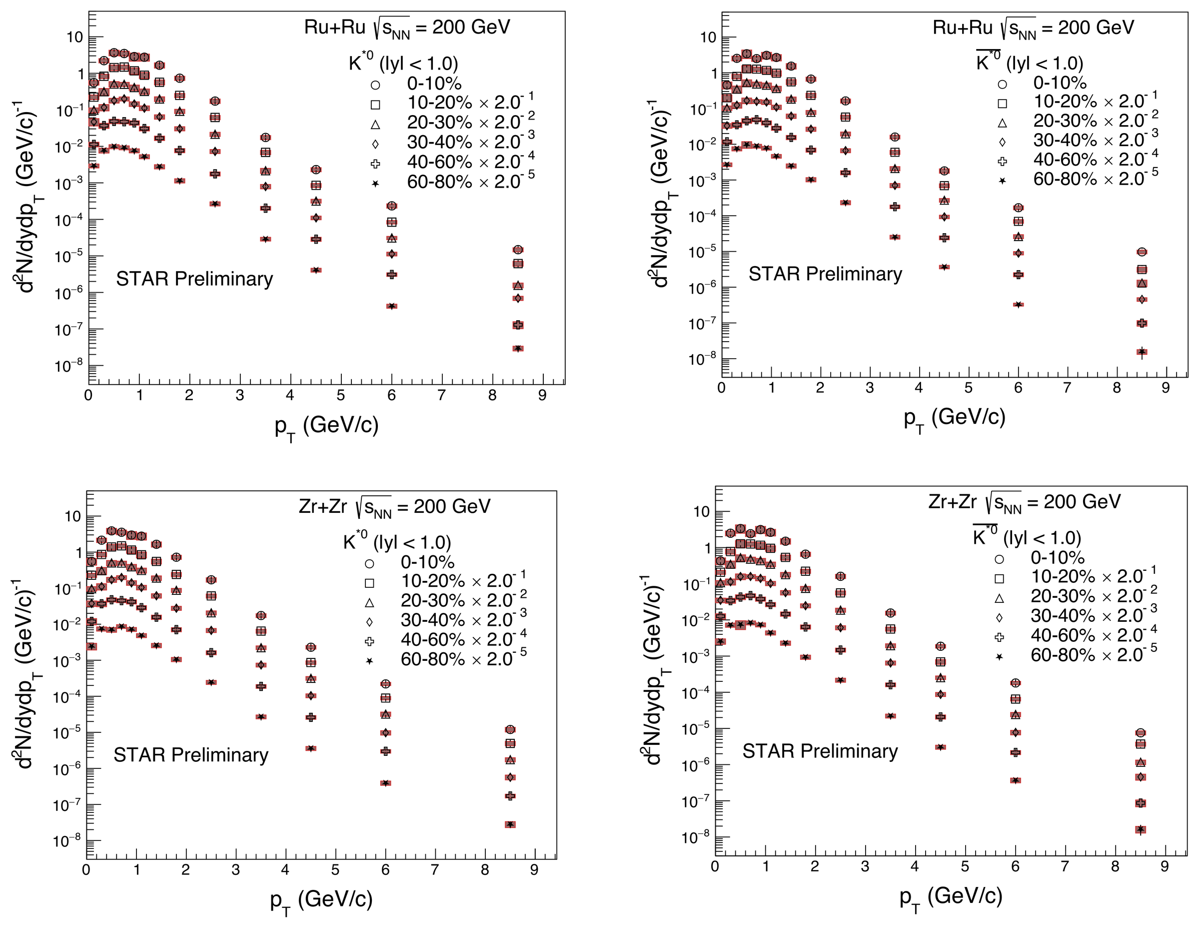
$$\epsilon_{rec-acc} = \frac{N_{RC-event/track\ selections}}{N_{MC-input}}$$

$$\epsilon = \epsilon_{rec-acc} \times \epsilon_{PID}$$

Raw yield of K^{*0} is corrected by acceptance x reconstruction efficiency, PID efficiency and branching ratio (BR):

$$\frac{d^2N}{dp_T dy} = \frac{1}{N_{evt}} \times \frac{N^{raw}}{dp_T dy} \times \frac{1}{\epsilon_{rec-acc} \times \epsilon_{PID} \times BR}$$

Spectra:

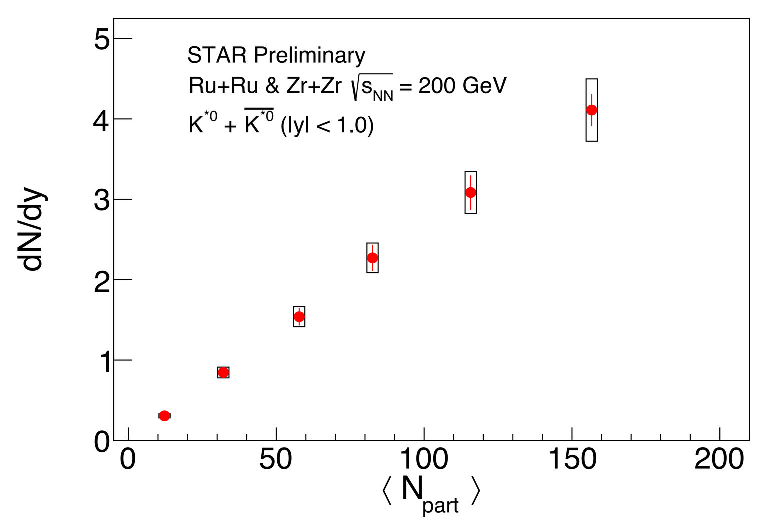


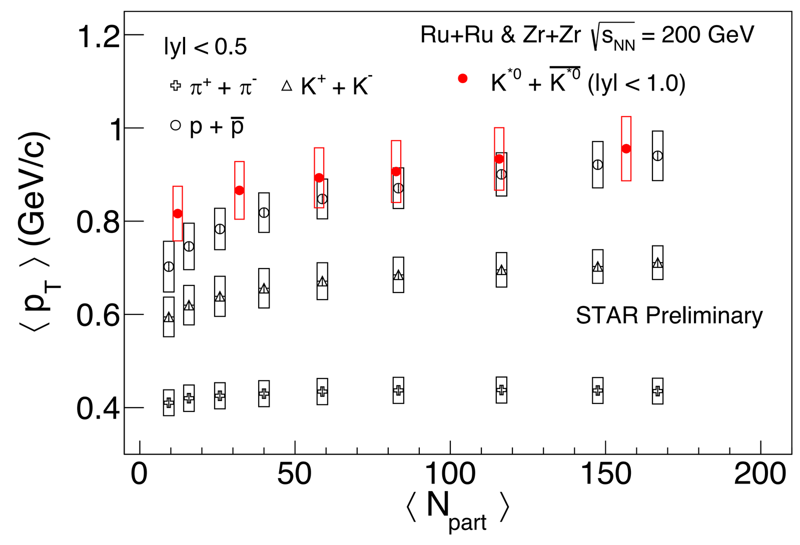
p_T reach:
Lowest bin:
0.0 – 0.2 GeV/c

Highest bin:
8.0 - 10.0 GeV/c

dN/dy and $\langle p_T \rangle$:
From data;
no low-p_T extrapolation is needed

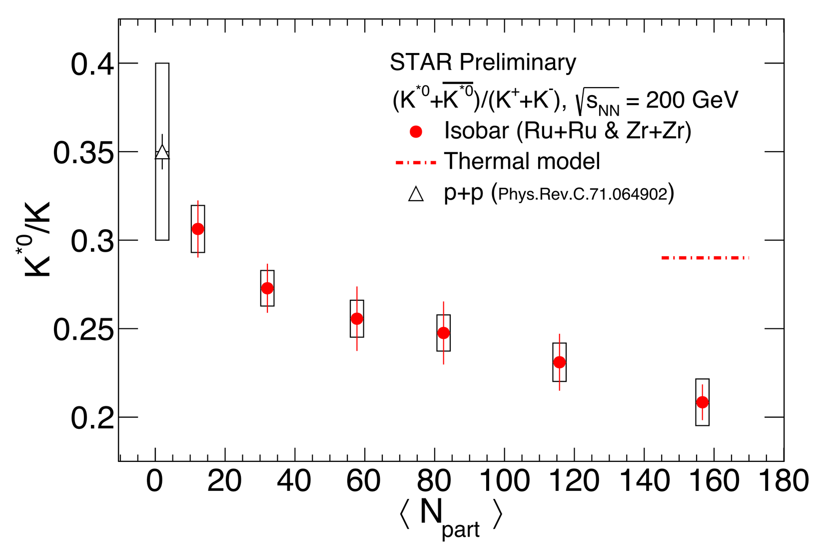
Yield (dN/dy), $\langle p_T \rangle$ and particle ratio:





→ Yield (dN/dy): increase with $\langle N_{part} \rangle$

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



→ $(K^{*0}/K)_{central} < (K^{*0}/K)_{peripheral}$ (3.3σ)

→ $(K^{*0}/K)_{central} <$ Thermal Model prediction (T=150 MeV, μ_B=20 MeV)

Evidence of late stage hadronic re-scattering

Summary:

→ K^{*0} p_T spectra, yield (dN/dy) and $\langle p_T \rangle$ are presented for isobar collisions at $\sqrt{s_{NN}}$ = 200 GeV

→ Clear centrality dependence observed in p_T spectra

→ $(K^{*0}/K)_{central} < (K^{*0}/K)_{peripheral}$ and Thermal model prediction

→ Evidence of late stage hadronic re-scattering effect in heavy ion collisions at RHIC

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