Beam Energy Dependence of Bulk Properties via K^{*0} and ϕ resonances at RHIC

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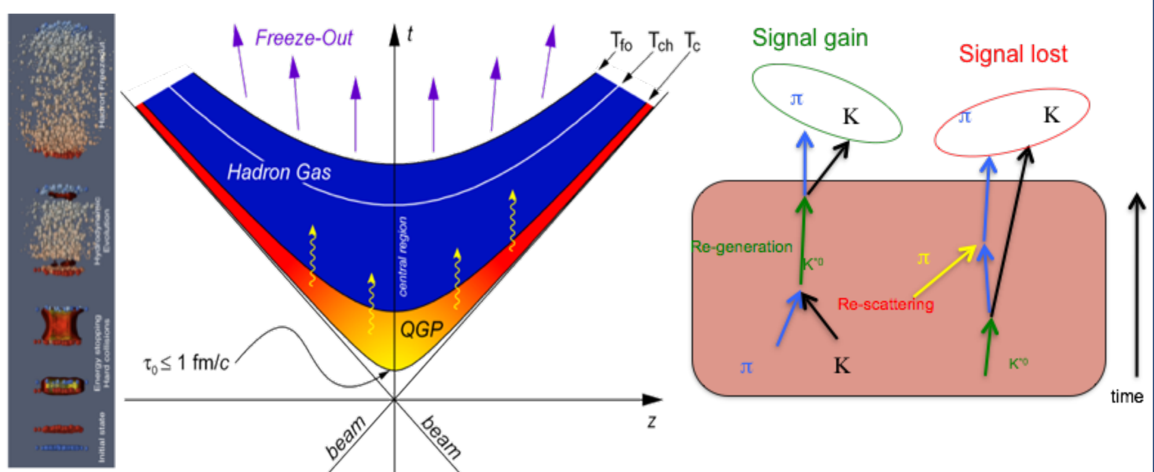
Abstract

Resonances are excellent probes to understand the properties and evolution of the QCD medium created in relativistic heavy-ion collisions. Because of their short lifetime, resonances decay inside the fireball and their decay daughters interact with the medium. The properties of the resonance can be modified because of in-medium interactions. The centrality dependence of the resonance to non-resonance yield ratio measured at top RHIC and LHC energies suggests a dominance of hadronic re-scattering at these energies. The elliptic flow parameter v_2 has been widely used as a tool for understanding the dynamics of the system created in the early stages of a collision. Comparison between K^{*0} and φ is very promising because the lifetime of these examples differs by a factor of ten, and K^{*0} is affected more by the hadronic phase. Moreover, both offer the advantage of being vector mesons with masses close to that of the proton. We report production of K^{*0} and φ resonances in Au+Au collisions at $\sqrt{s_{NN}}$ = 11.5 to 39 GeV using the STAR detector. We present transverse momentum spectra, yields at midrapidity (dN/dy) and elliptic flow of K^{*0} at these beam energies. Resonance to non-resonance particle ratios (ϕ/K^- and K^{*0}/K^-) are shown as a function of collision centrality. Elliptic flow of K^{*0} is compared to that of Λ, K_S^0 and the φ meson.

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.

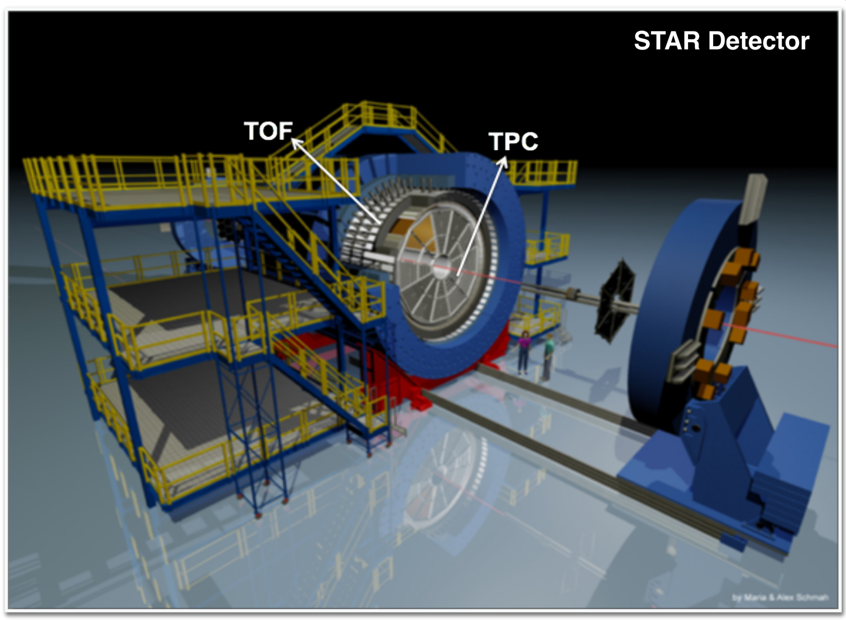


Comparison of K^{*0} and φ is interesting because their lifetimes differ by a factor of ten. Moreover, they offer the unique advantage of being vector mesons with masses close to that of the proton.

	Lifetime
K(892)^{*0}	4 fm/c
φ (1020)	45 fm/c

Experimental Details:

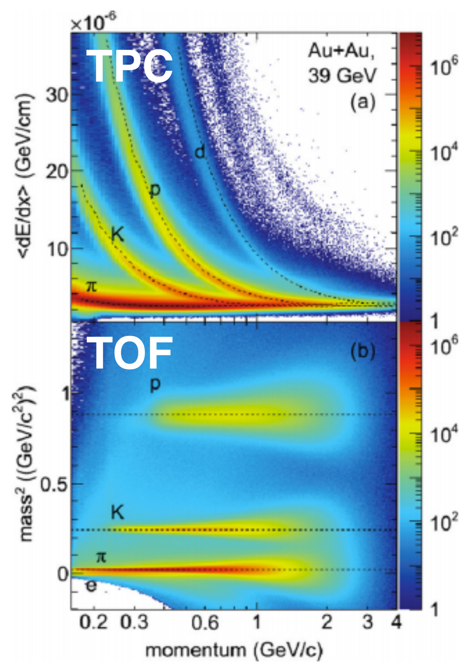
The STAR detector offers uniform acceptance, full azimuthal coverage, and excellent particle identification. The Time Projection Chamber (TPC) is used for charged particle tracking, collision centrality determination, and event plane estimation.



Track cuts used in the analysis:
$p_T > 0.15$ (GeV/c)
DCA < 3 cm
|Rapidity| < 1.0

K^{*0} and φ reconstructed via hadronic decay channel:
$K^{*0} \rightarrow K^{\pm}\pi^{\pm}$ (BR ~ 66%) and
$\phi \rightarrow K^+K^-$ (BR ~ 48%)

For p_T spectra analysis, charged kaons and pions are selected using specific ionization energy loss inside the TPC ($|N\sigma| < 2$).
For v_2 analysis, a combination of Time Of Flight (TOF) and TPC is used for kaon and pion selection.
If TOF information available we use $-0.2 < m^2 < 0.15$ (GeV/c^2)^2 for identifying pion & use $0.16 < m^2 < 0.36$ (GeV/c^2)^2 for kaon. Otherwise, we use TPC$|N\sigma| < 2$.



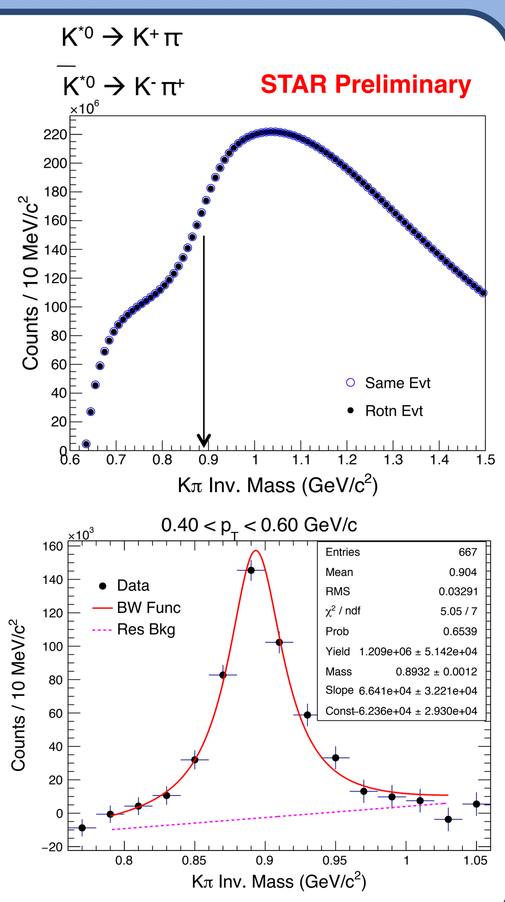
Signal Reconstruction:

The invariant mass method was used to investigate the K^{*0} signal.

The combinatorial background is constructed via the event rotation technique. A clear signal is observed on top of a residual background after combinatorial background subtraction.

The signal is fitted with a Breit-Wigner function plus a linear residual background:

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



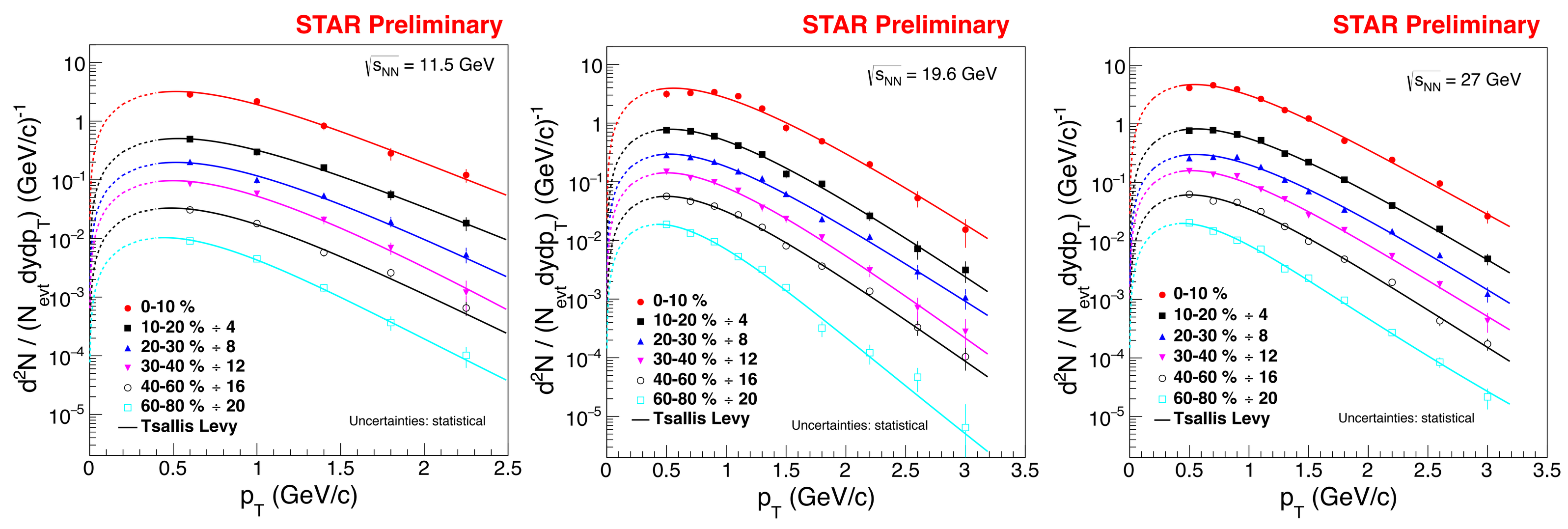
Transverse Momentum Spectra:

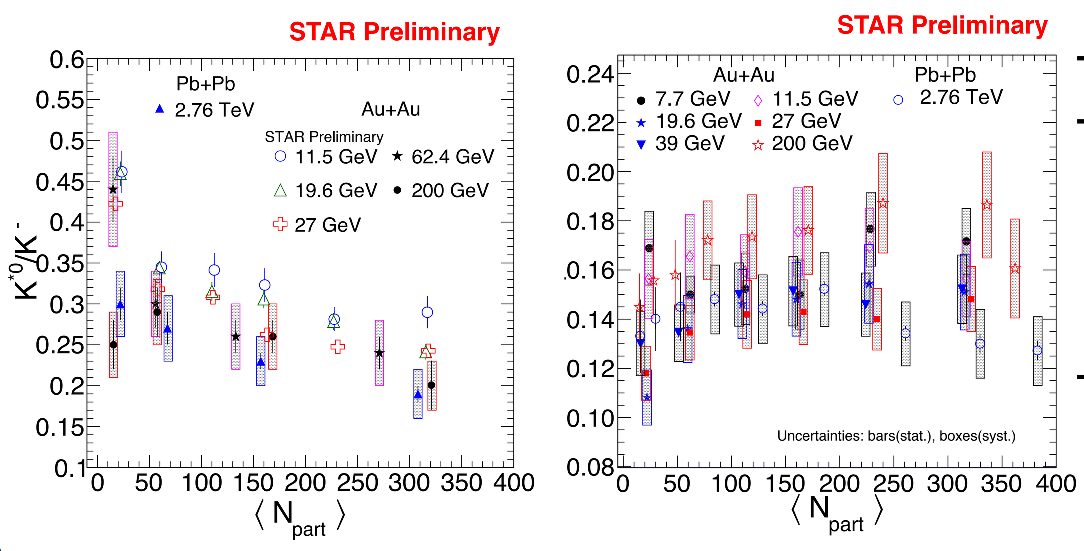
The raw yield of K^{*0} is extracted in different p_T bins for six different collision centralities at $\sqrt{s_{NN}}$ = 11.5, 19.6 and 27 GeV.

Raw yield of K^{*0} is corrected by reconstruction efficiency, PID efficiency and branching ratio.

$$\frac{d^2N}{dydp_T} = \frac{N_{raw}}{dydp_T} \frac{1}{\epsilon_{rec} \times \epsilon_{PID} \times BR}$$

Levy-Tsallis fits to the spectra are used to extrapolate yields (dN/dy) to the un-measured region

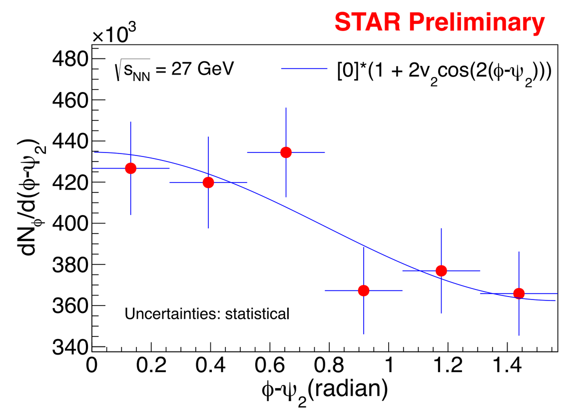




→ (ϕ/K^-) is independent of centrality
→ Decreasing trend as a function of centrality is observed in (K^{*0}/K^-) for $\sqrt{s_{NN}}$ = 11.5 GeV up to 2.76 TeV
→ Seems to favor a possible increase in re-scattering for central collisions

Elliptic Flow:

Elliptic flow of K^{*0} is estimated by utilizing η-sub event plane method and ($\phi - \psi_2$) method.
Event plane is determined using the TPC tracks separated by η > 0.1 from K^{*0}.
K^{*0} yield in each p_T bin is divided into six ($\phi - \psi_2$) bins.
To extract v_2, the yield is fitted with a function

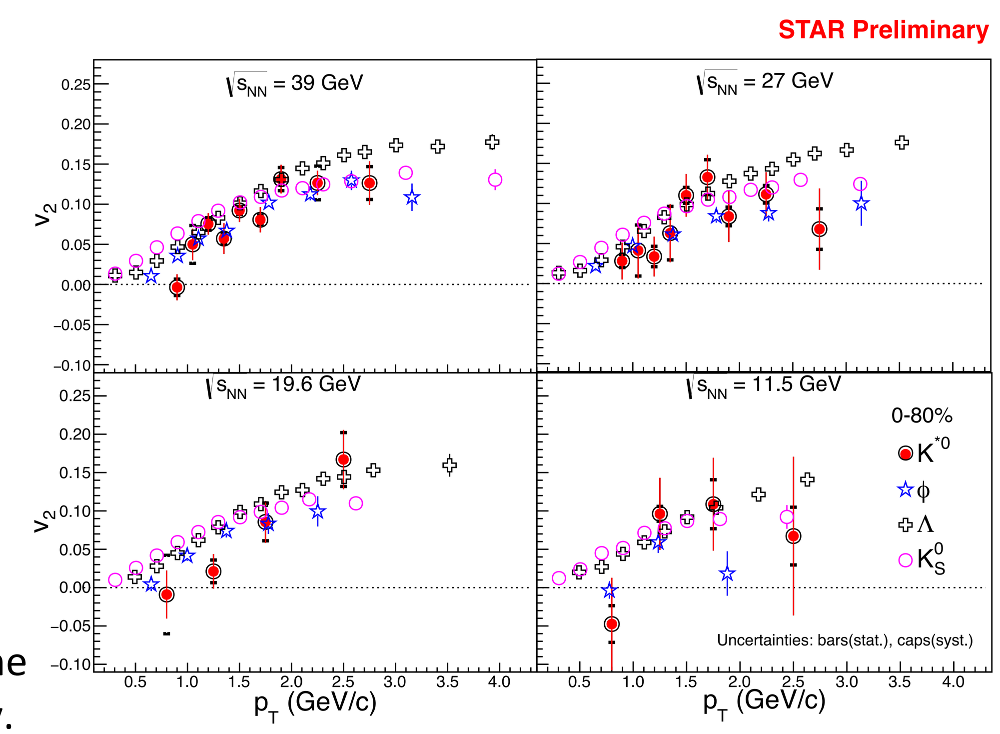


$$\frac{dN}{d(\phi - \Psi)} = p_0[1 + 2v_2\cos(2(\phi - \Psi))]$$

The v_2 values are corrected for event-plane resolution in finer centrality bins.

K^{*0} v_2 is estimated at 0-80% centrality for $\sqrt{s_{NN}}$ = 11.5 - 39 GeV.
The results for K^{*0} are compared with those for Λ, K_S^0 and φ.

K^{*0} v_2 seems to follow the trends of the φ meson, but with a large uncertainty.



Conclusion:

→ K^{*0} p_T spectra and v_2 presented at lower BES energies
→ Decreasing trend as function of centrality is observed in K^{*0}/K^- for $\sqrt{s_{NN}}$ = 11.5 GeV – 2.76 TeV while ϕ/K^- is flat as a function of centrality, implying a stronger hadronic re-scattering in more central collisions
→ K^{*0} v_2 seems to follow the trend of the φ meson, but with a large statistical uncertainty
→ v_2 measurements will achieve better statistical significance with the BES-II data

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References:
[1] Adams, J. *et al.* (STAR) 2005 *Phys. Rev. C.* 71 064902
[2] Aggarwal, M. *et al.* (STAR) 2011 *Phys. Rev. C.* 84 034909
[3] Adamczyk, L. *et al.* (STAR) 2013 *Phys. Rev. C.* **88** 014902
[4] Abelev, B. *et al.* (STAR) 2009 *Phys. Lett. B* **673** 014902
[5] Abelev, B *et al.* (ALICE) 2015 *Phys. Rev. C.* 91 024609

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