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Probing QCD matter via K^{*0} and ϕ resonance production at RHIC

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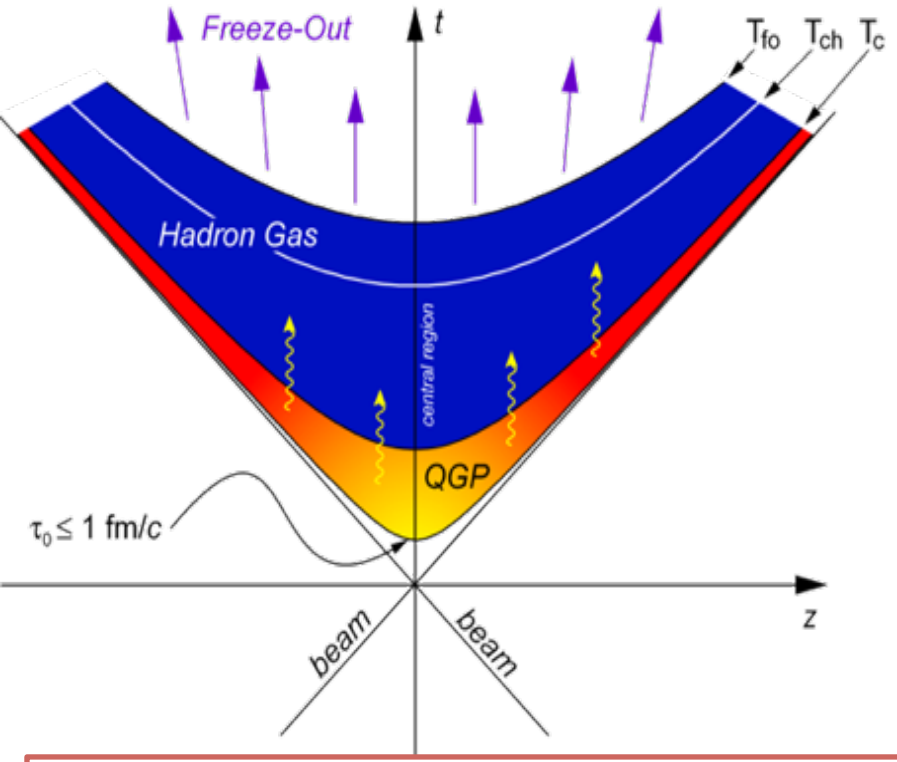
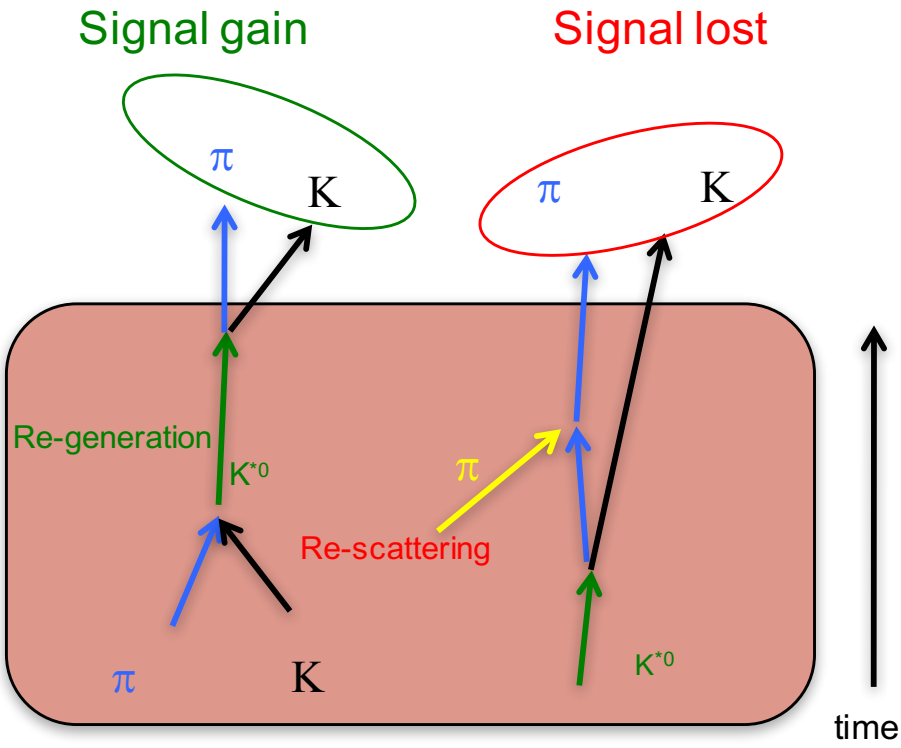
BERHAMPUR

Outline

- Motivation
- The STAR Experiment
- Invariant yields of K^{*0} and ϕ
- Elliptic flow of K^{*0} and ϕ
- Directed flow of ϕ
- Summary

Motivation



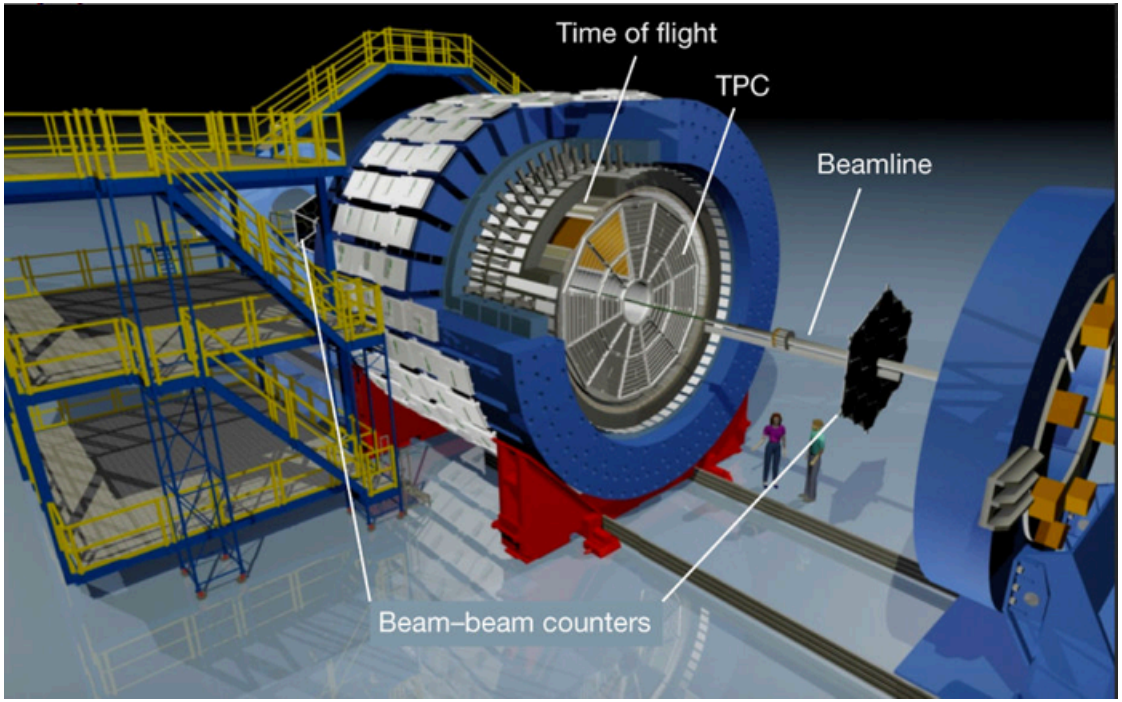


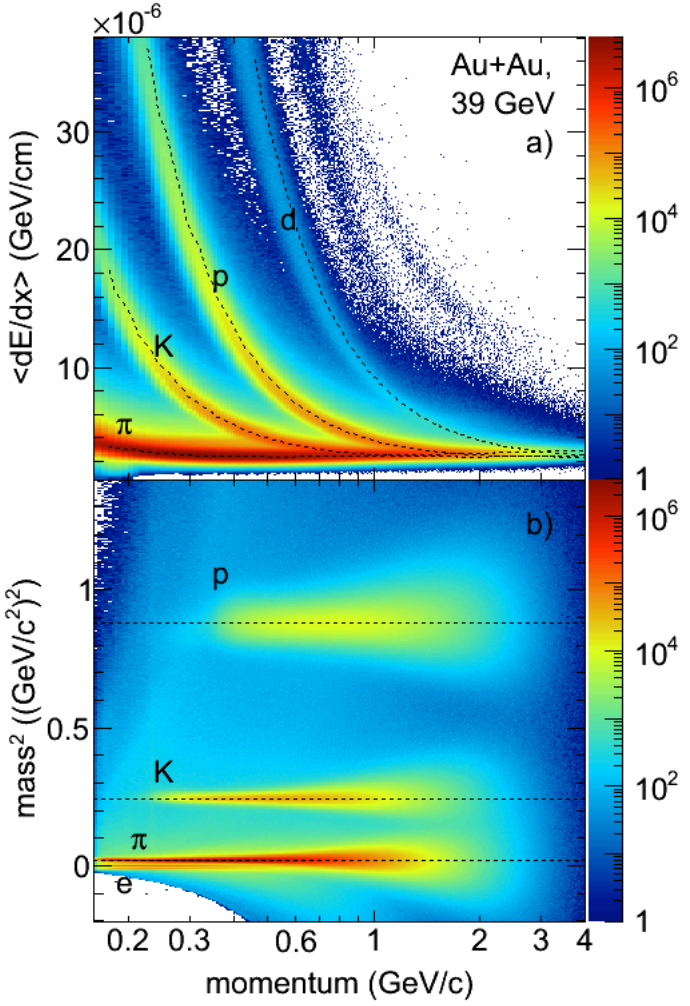
K*0 and ϕ:

- Factor of 10 difference in lifetimes
- Close to proton (baryon) mass
- Small hadronic interaction cross section for ϕ

- Lifetime of resonances are comparable to the typical lifetime of the fireball.
- Resonances in heavy-ion collisions can be used to study properties and evolution of the medium

The STAR Experiment



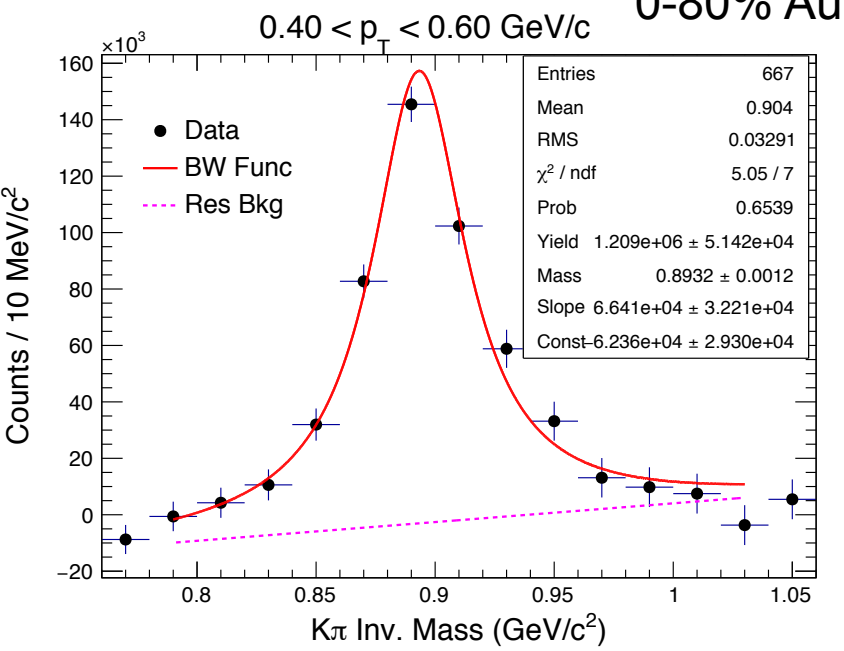


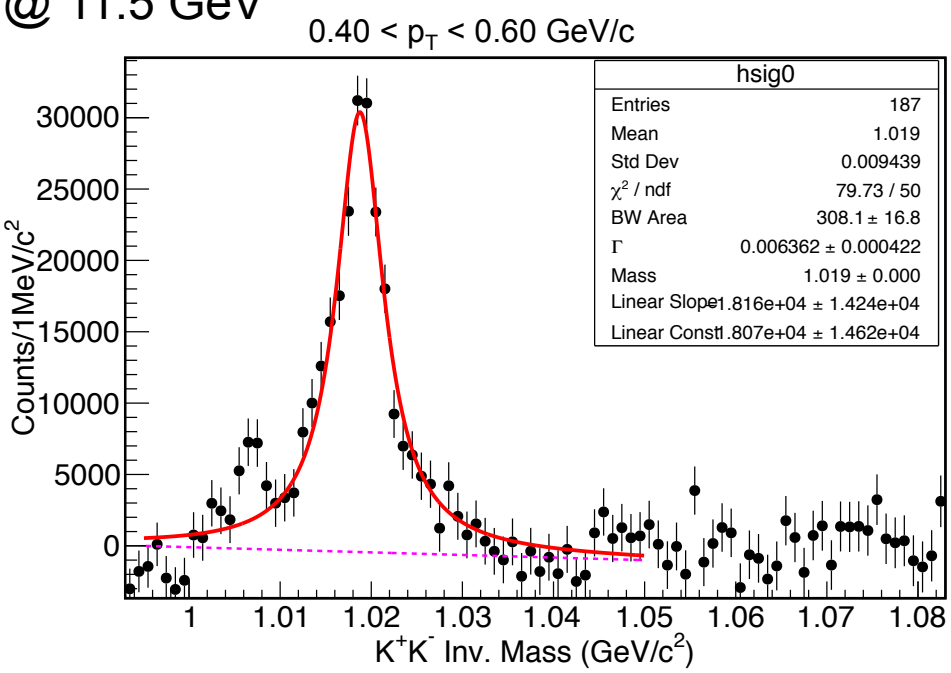
- Uniform acceptance
- Full azimuthal coverage
- Excellent particle identification capability

K*^{0} and ϕ reconstruction

K*^{0} and ϕ reconstructed via hadronic decay channels

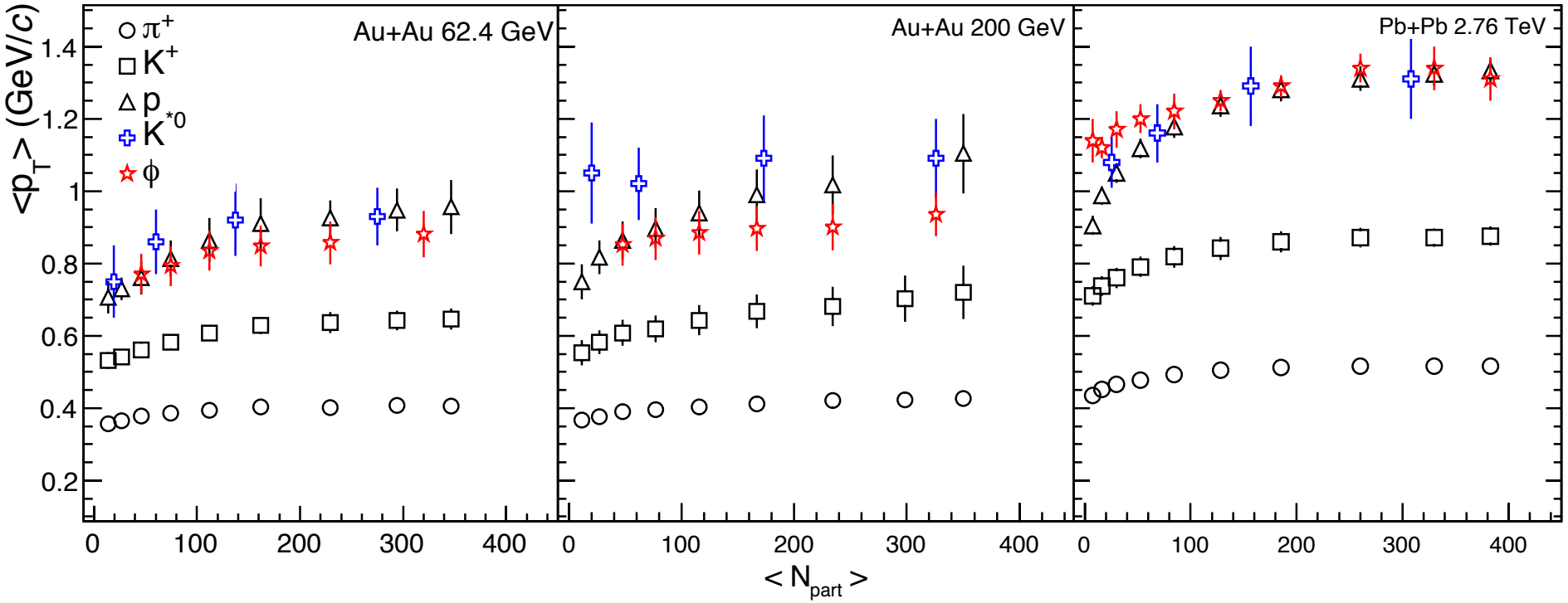
0-80% Au+Au @ 11.5 GeV





The signal is fitted with a Breit-Wigner function plus a linear residual background after mixed event background subtraction.

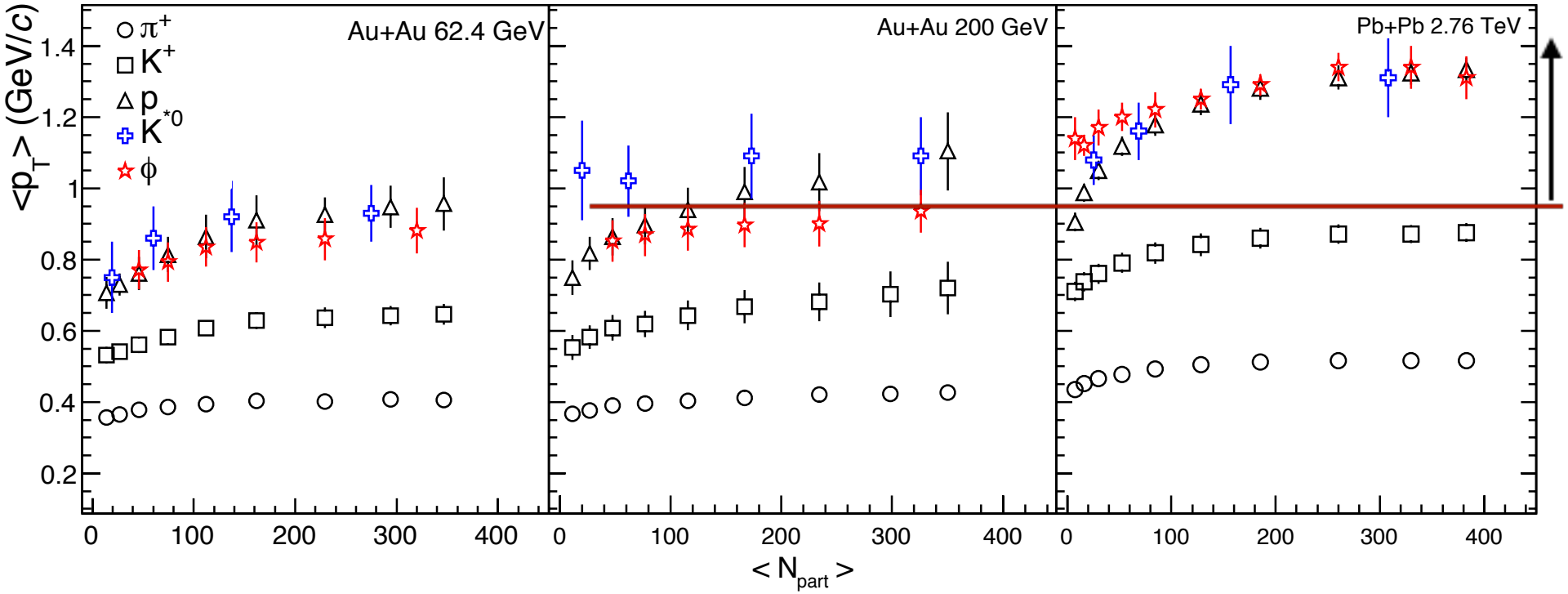
Mean transverse momentum at Top RHIC and LHC energies



Phys. Rev. C 84 (2011) 034909 (STAR)
Phys. Rev. C 79 (2009) 064903 (STAR)
Phys. Rev. C 79 (2009) 034909 (STAR)

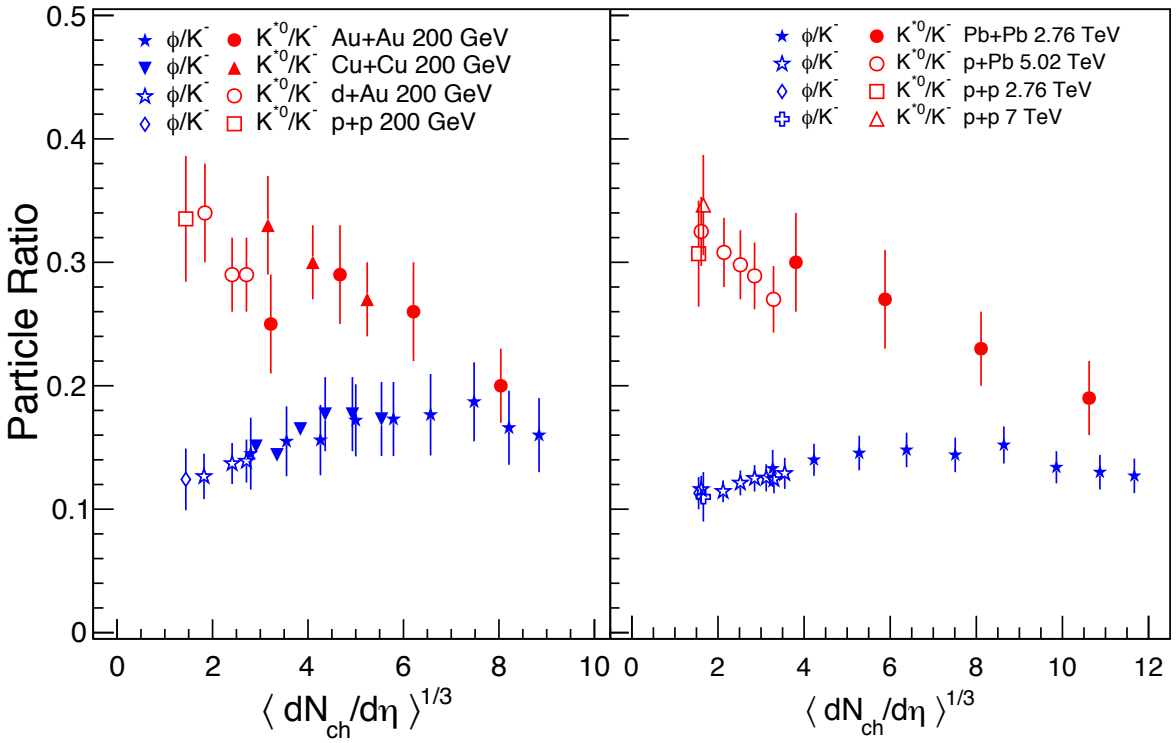
Phys. Rev. C 91 (2015) 024609 (ALICE)
Phys. Rev. C 88 (2013) 044910 (ALICE)

Mean transverse momentum at top RHIC and LHC energies



- Mean p_T increases with mass
- Mean p_T of K* and ϕ close to proton (similar mass)
- Mean p_T at LHC > Mean p_T at RHIC, consistent with increased radial flow at LHC

Particle ratios (K^{*0}/K- and ϕ/K-) at top RHIC and LHC energies



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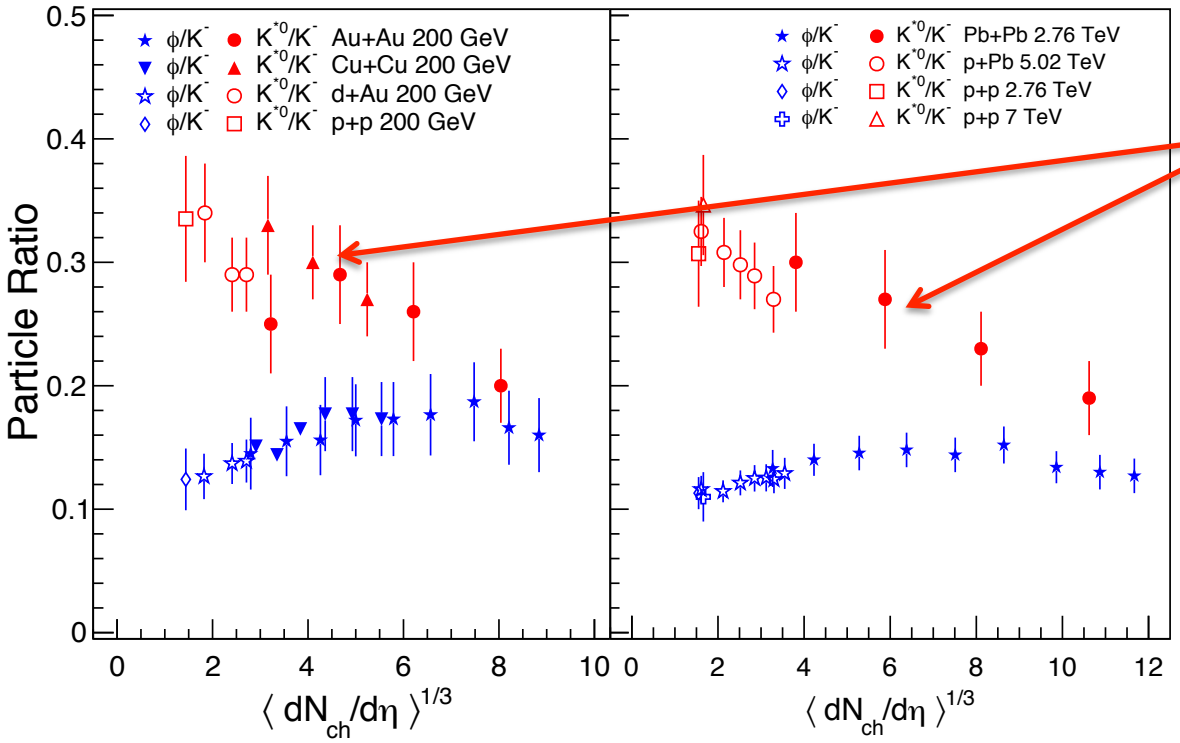
Particle ratios (K^{*0}/K^{-} and ϕ/K^{-}) at top RHIC and LHC energies



K^{*0}/K^{-} decreases with centrality

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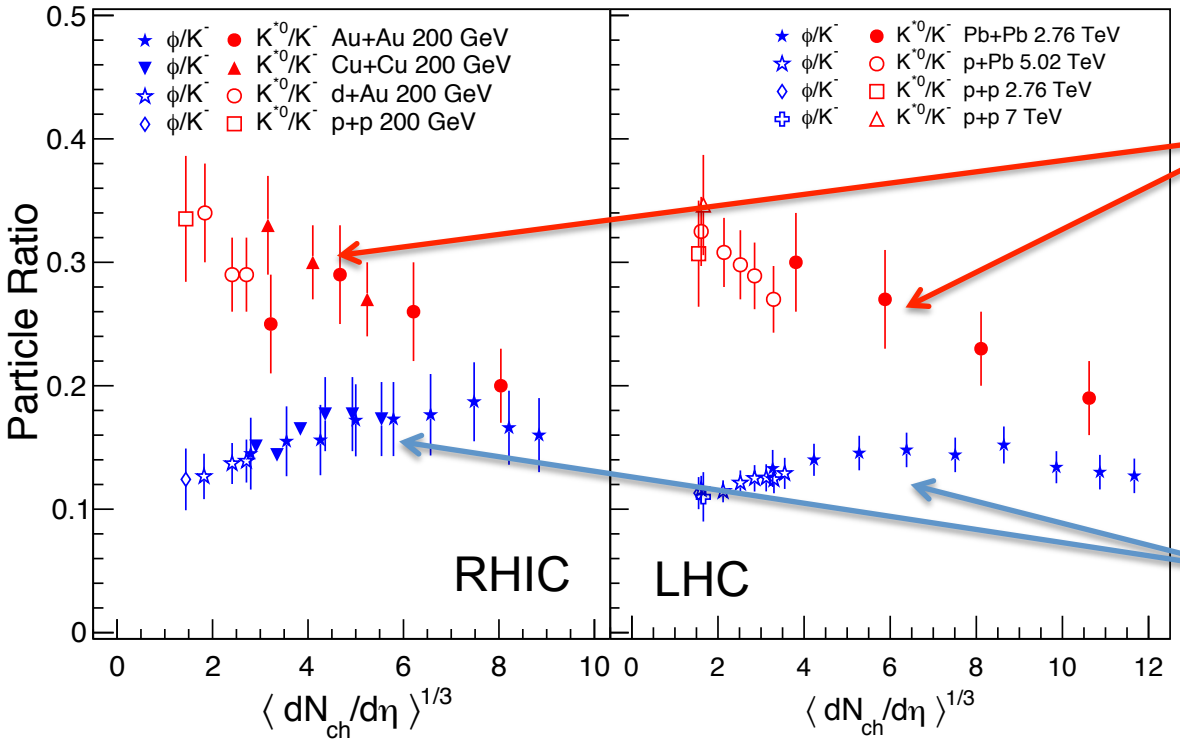
Particle ratios (K^{*0}/K^- and ϕ/K^-) at top RHIC and LHC energies



K^{*0}/K^- ratio decreases with increasing centrality

ϕ/K^- ratio is independent of centrality

Dominance of hadronic re-scattering at top RHIC and LHC energies

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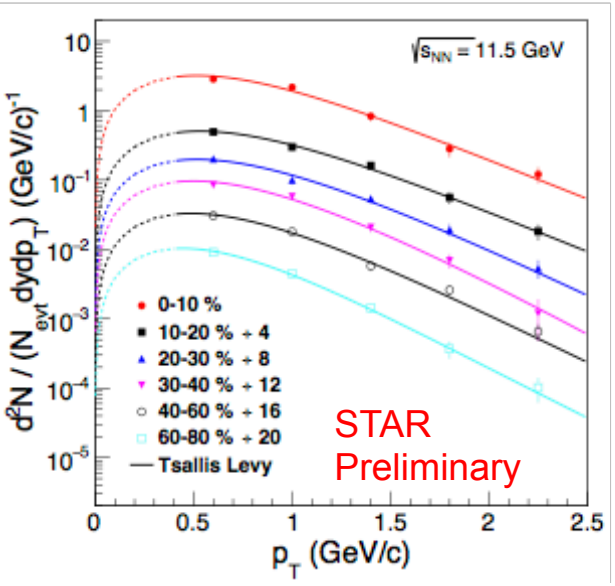
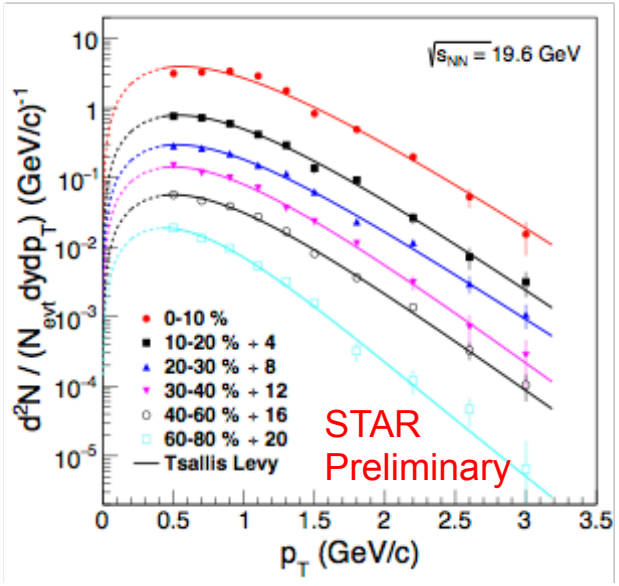
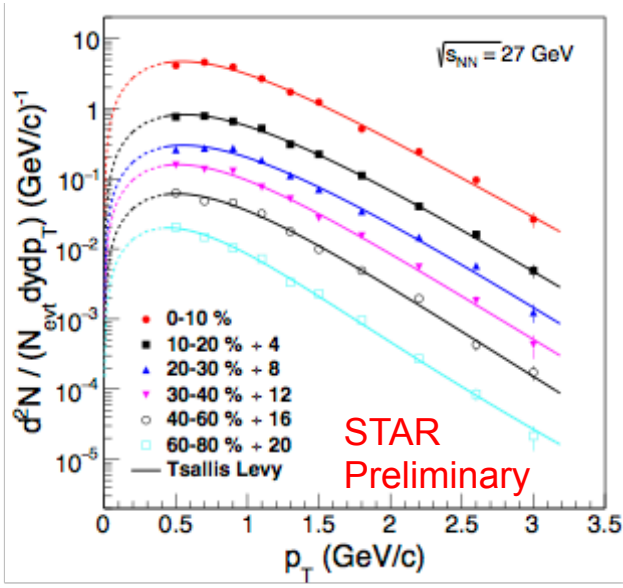
K^{*0} spectra measurement at lower BES energies

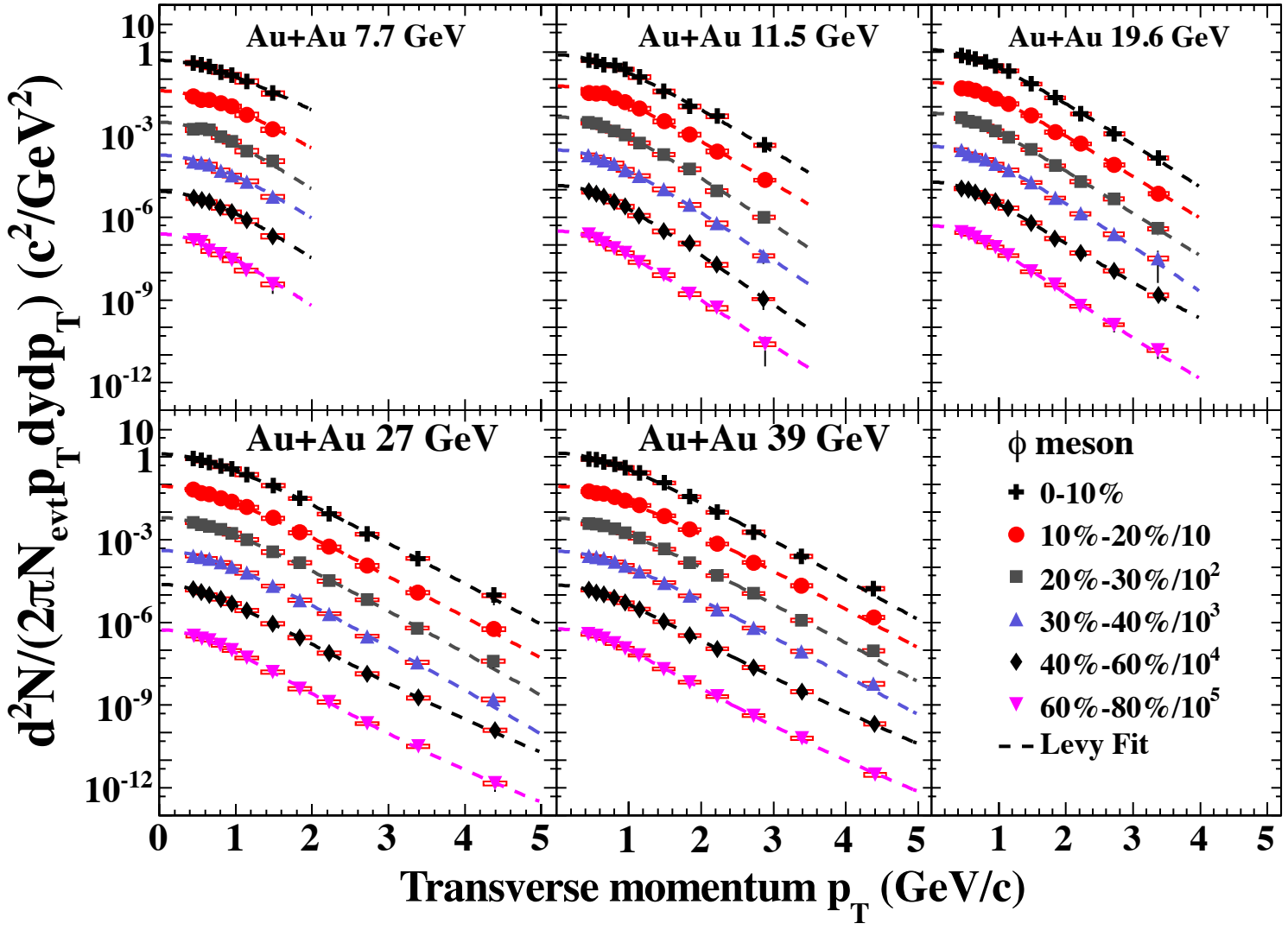






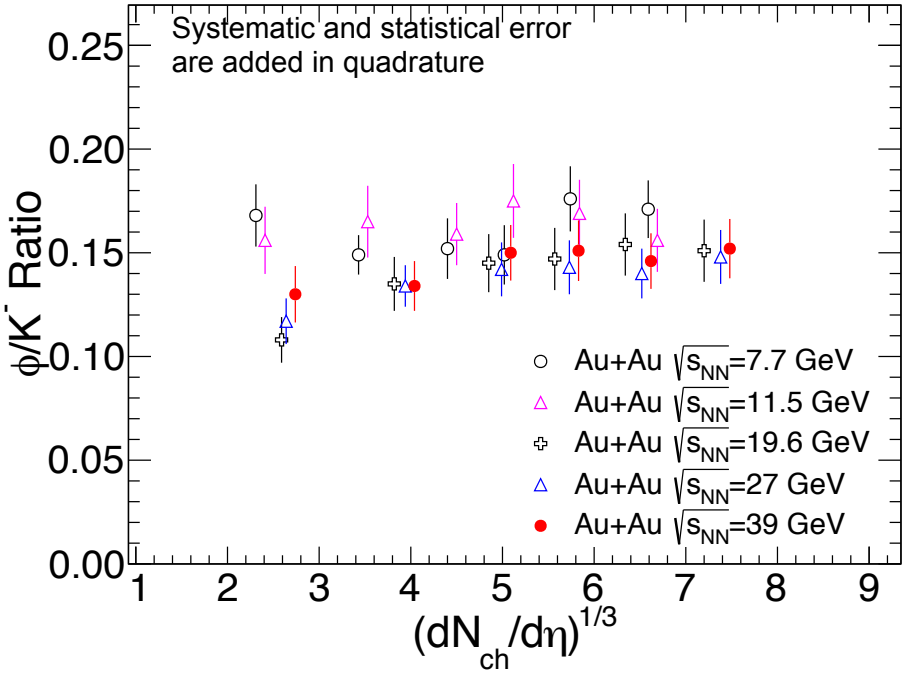
- Spectra is fitted with Levy fit
- Fit functions used to extrapolate yields in unmeasured regions

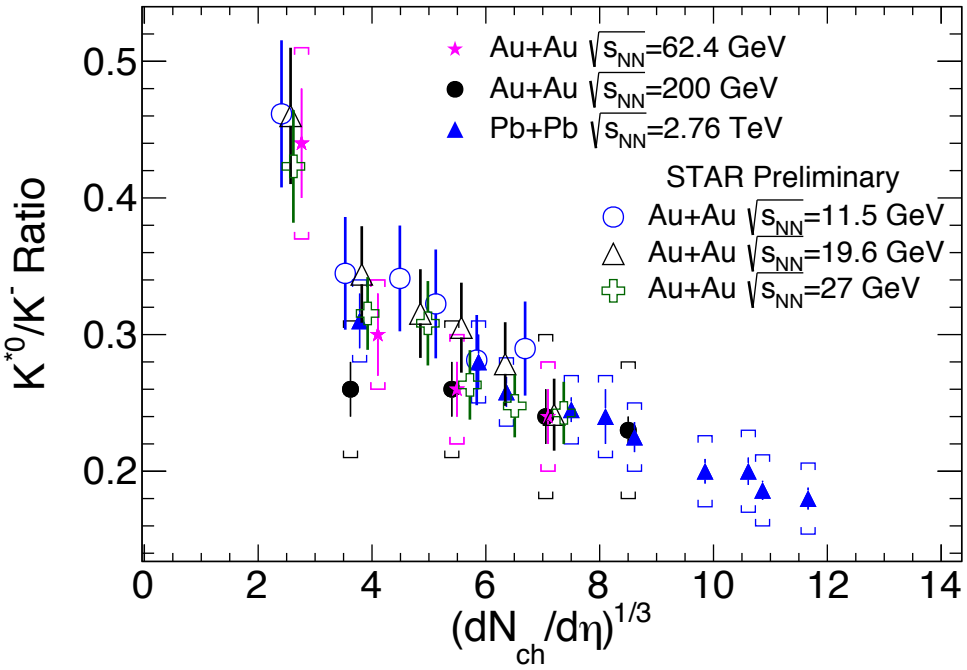
ϕ spectra measurement at lower BES energies



Phys. Rev. C 93 (2016) (R) 21903 (STAR)

Particle ratios (K^{*0}/K^- and ϕ/K^-) at BES energies





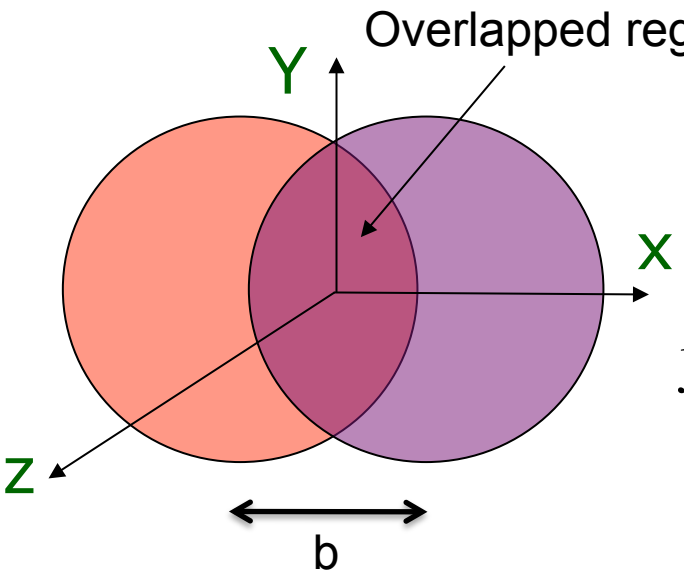
ϕ/K^- ratio : independent of centrality

K^{*0}/K^- ratio: decreases with increasing centrality, more re-scattering in central collisions

Phys. Rev. C 93 (2016) (R) 21903 (STAR)

Phys. Rev. C 91 (2015) 024609 (ALICE)

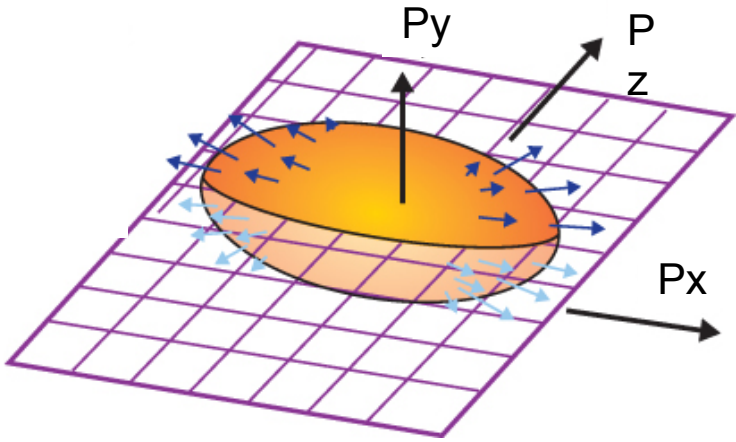
Collectivity in heavy-ion collisions



Interactions

Pressure (*P*)

$$y > x \longrightarrow \frac{\partial P}{\partial x} > \frac{\partial P}{\partial y}$$



$$E\frac{d^3N}{dp^3} = \frac{1}{2\pi}\frac{d^2N}{p_T dp_T dy}[1 + 2v_1\cos(\phi - \Psi_R) + 2v_2\cos 2(\phi - \Psi_R) + \ldots]$$

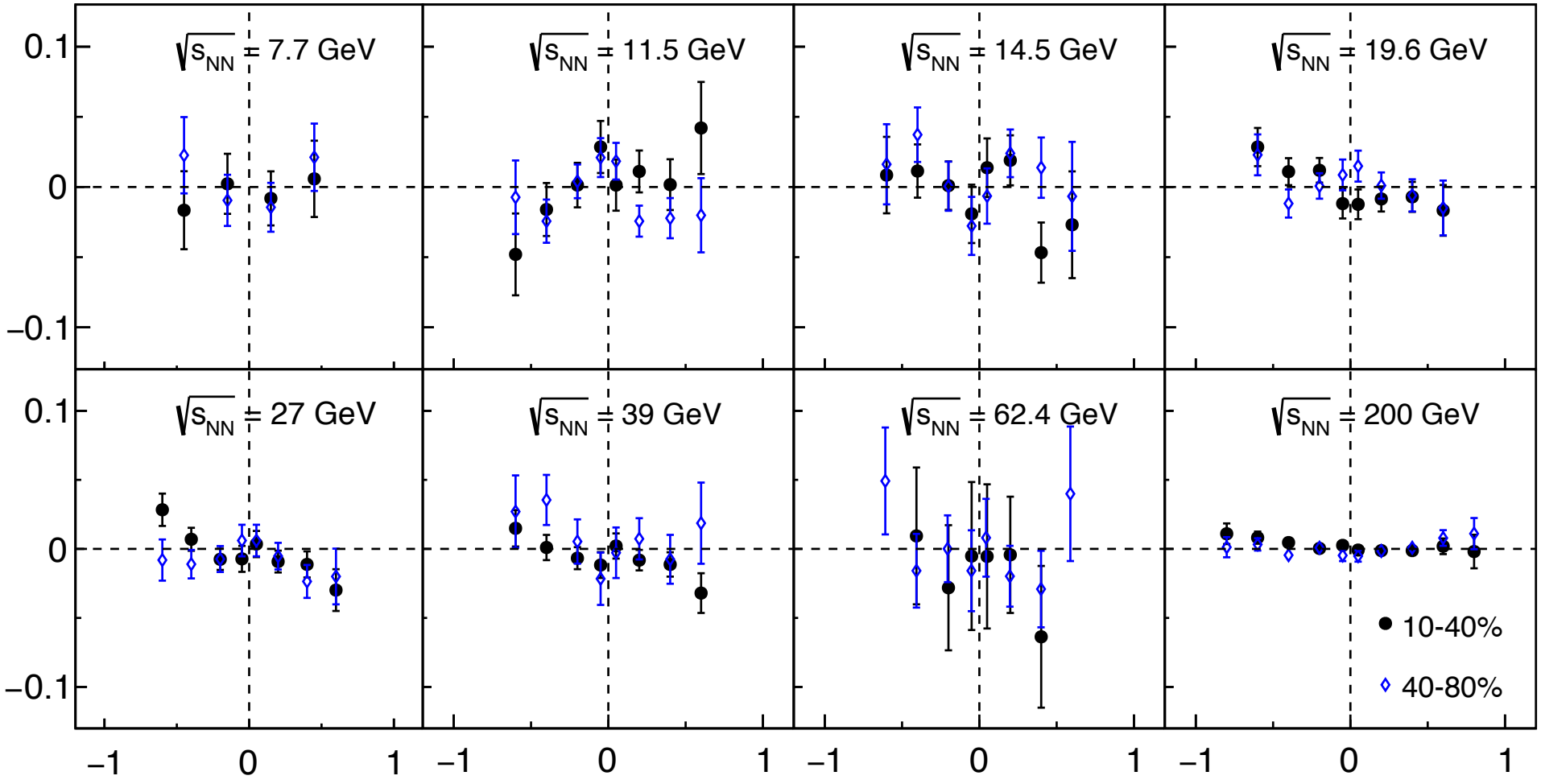
v_1 – Directed flow

v_2 – Elliptic flow

Sensitive to initial dynamics

ϕ meson $v_1(y)$ from RHIC BES

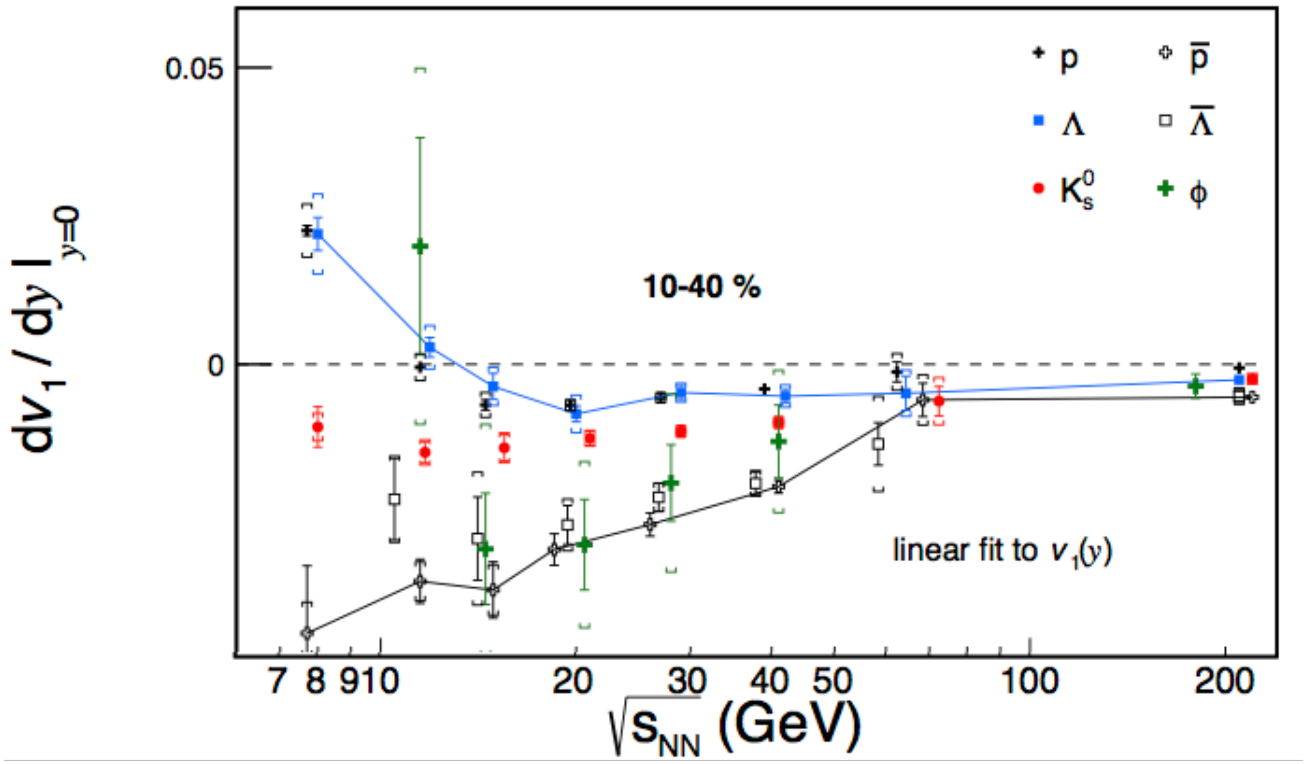
Phys. Rev. Lett. 120 (2018) 062301 (STAR)



dv_1/dy slope is extracted from a linear fit ($|y| < 0.6$)

ϕ meson dv_1/dy from RHIC BES

Phys. Rev. Lett. 120 (2018) 062301 (STAR)

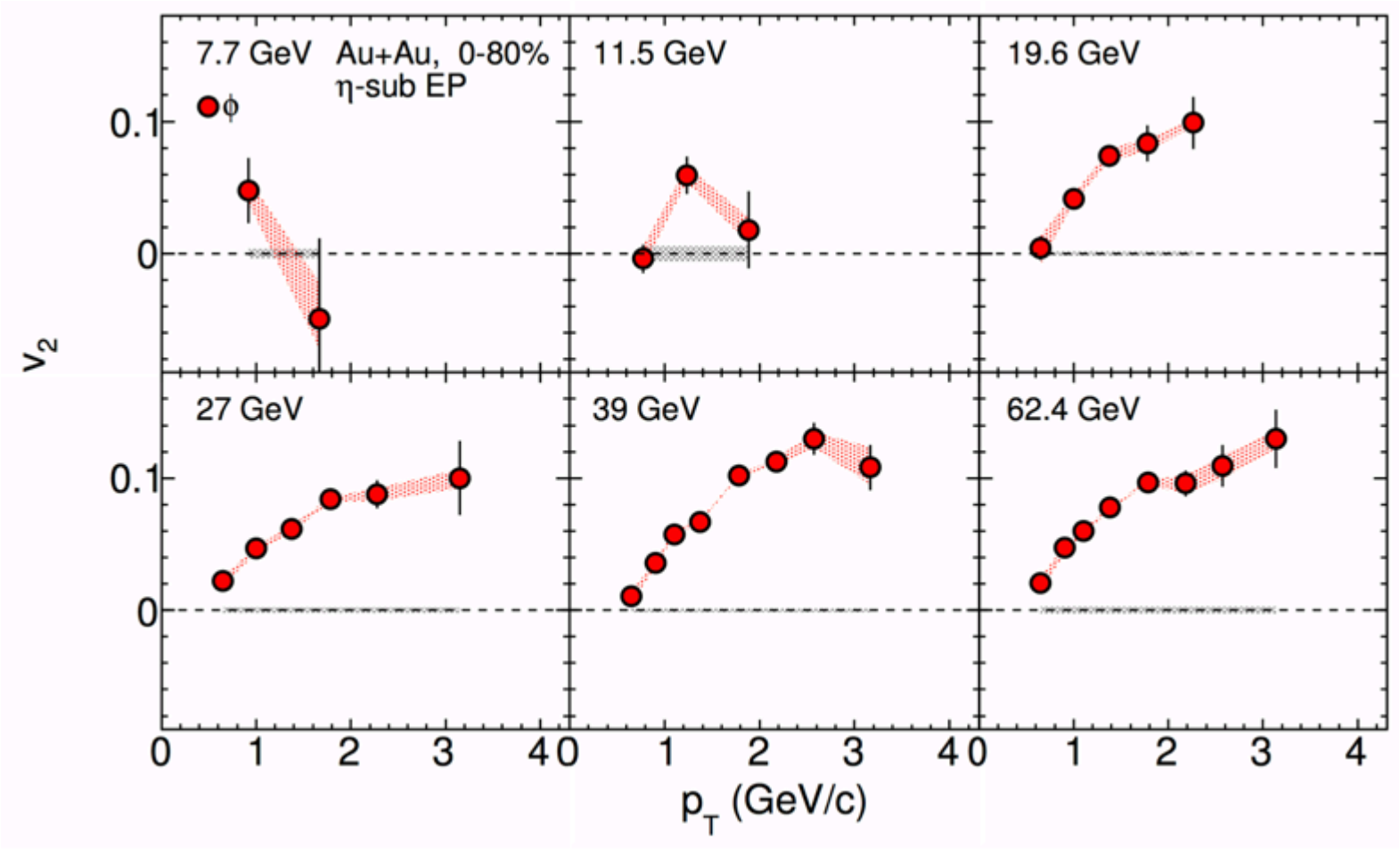


Particles	Quark content
anti-Λ	$\overline{uds}$
anti-p	$\overline{uud}$
Φ	$s\bar{s}$

For $\sqrt{s_{NN}}$ > 14.5 GeV: (dv_1/dy) anti-Λ ~ (dv_1/dy) anti-p ~ (dv_1/dy) ϕ

- Particles which consist from produced quarks show similar behavior

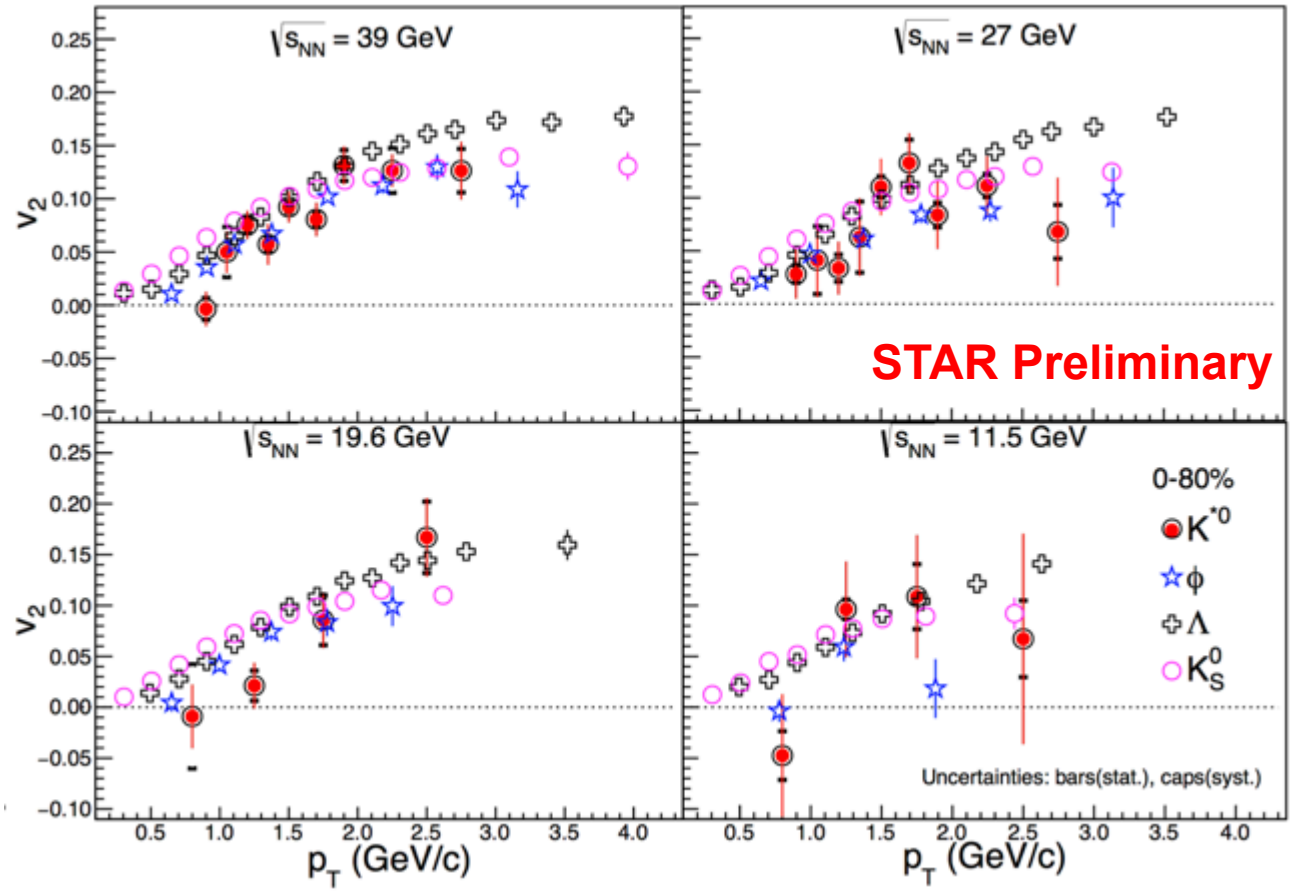
ϕ v_2 from RHIC BES



Indication of small ϕ-meson v_2 at 11.5 and 7.7 GeV

Phys. Rev. C 88 (2013) 014902 (STAR)

K^{*0} v_2 from RHIC BES



- K^{*0} seems to follow the trend of ϕ v_2 but with large uncertainty
- v_2 measurements will achieve better statistical significance with BES-II data

Summary

Invariant Yield:

- K^{*0}/K^{-} ratio in central Au+Au collisions is smaller than in d+Au (p+Au) and p+p collisions
- ϕ/K^{-} ratio does not depend on centrality

Consistent with hadronic re-scattering for resonances with short lifetime

Directed Flow:

- For $\sqrt{s_{NN}}$ > 14.5 GeV: (dv1/dy) anti-Λ ~ (dv1/dy) anti-p ~ (dv1/dy) ϕ

Particles which consist from produced quarks show similar behavior

Elliptic Flow:

- Indication of small ϕ-meson v_2 at 11.5 and 7.7 GeV
- K^{*0} v_2 seems to follow the trend of ϕ v_2 but with large uncertainty

Dominance of hadronic interaction over partonic interaction at $\sqrt{s_{NN}}$ <= 11.5 GeV