Study of elliptic and triangular flow of identified particles in Au+Au collisions $\sqrt{s_{NN}}$ = 11.5 - 62.4 GeV in the STAR experiment

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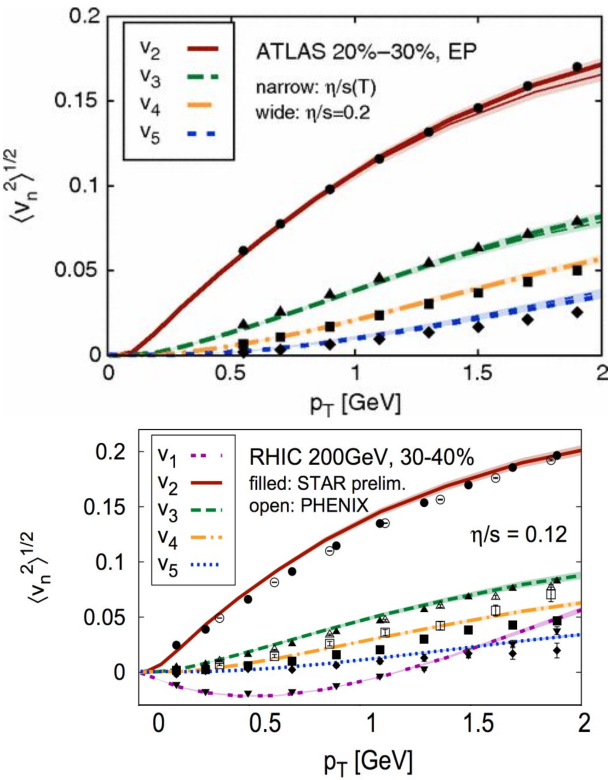
Outline

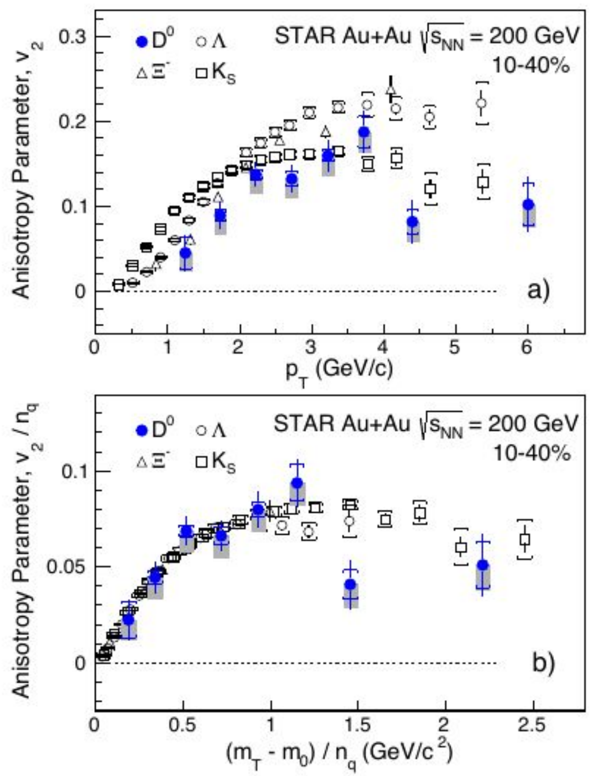
- Introduction
- Anisotropic flow at RHIC
- The STAR detector at RHIC
- Analysis methods
- Results
- Summary and Outlook

Anisotropic collective flow at RHIC/LHC

Gale et al., Phys. Rev. Lett. 110, 012302



STAR PRL118 (2017) 212301



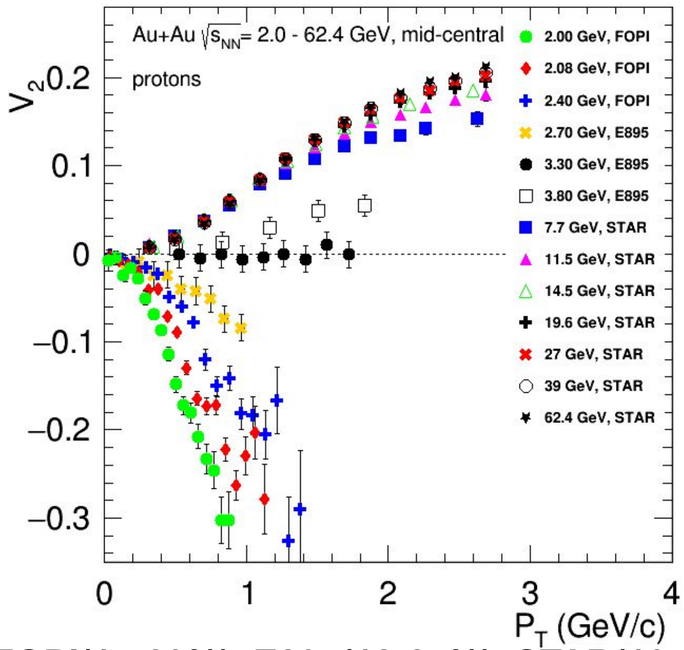
υ_n**(p_T, centrality)** - sensitive to the early stages of collision.
Important constraint for transport properties: EOS, η/s, ζ/s, etc.

Mass ordering at p_T < 2 GeV/c (hydrodynamic flow, hadron rescattering)

Baryon/meson grouping at p_T > 2 GeV/c (recombination/coalescence), Number of constituent quark (NCQ) scaling

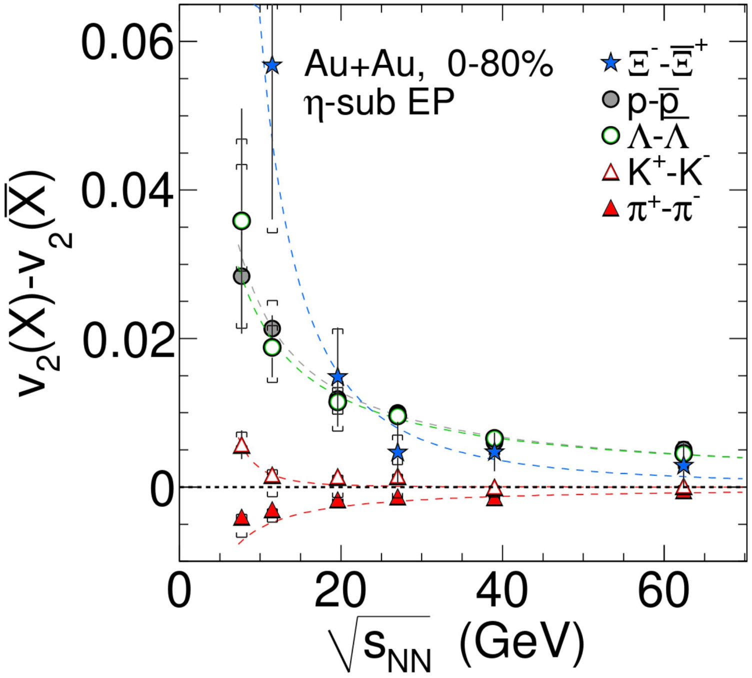
Anisotropic collective flow at STAR BES

Taranenko, EPJ Web Conf. 204 (2019) 03009



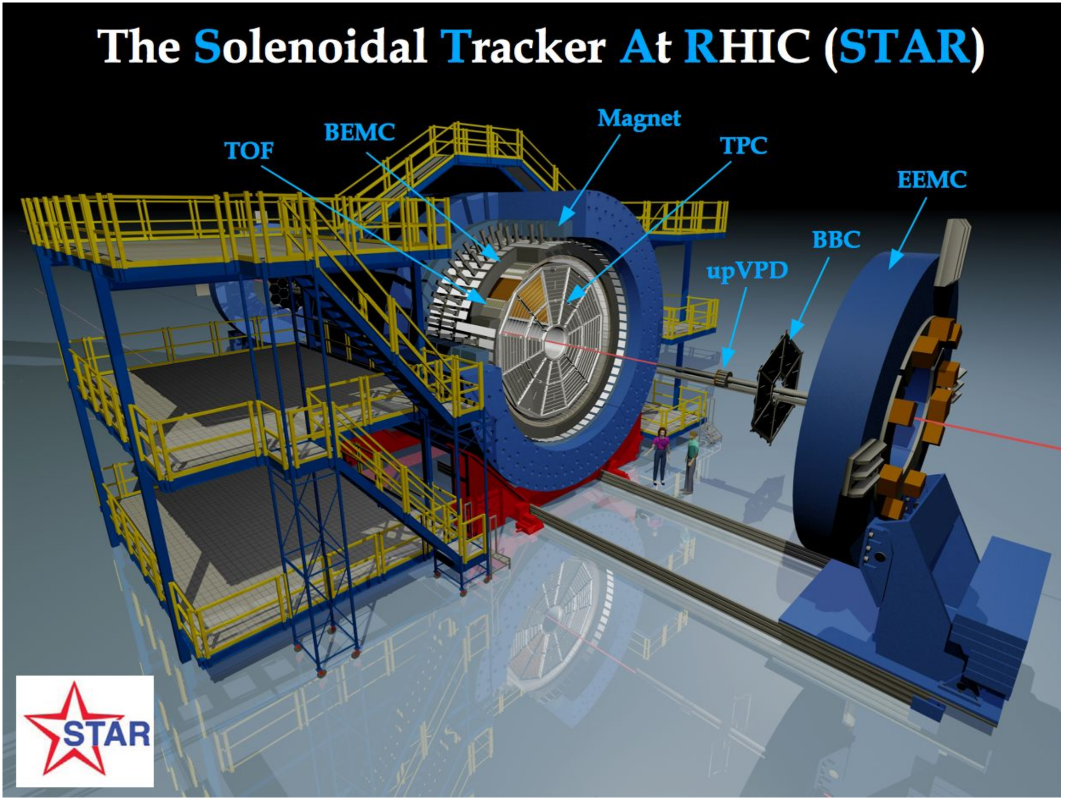
FOPI(15-29%) E895(12-25%) STAR(10-40%)

STAR Collaboration, Phys. Rev. C 88 (2013) 14902



- Small change in $v_2(p_T)$ for Au+Au $\sqrt{s_{NN}}$ = 7.7 – 62.4 GeV (STAR BES-I)
- Strong energy dependence of the difference in v_2 of particles and antiparticles
- **Our aim is to measure $v_3(\sqrt{s_{NN}}, \text{centrality,PID}, p_T)$**

The STAR detector at RHIC



Time Projection Chamber (TPC):
- Tracking of charged particles with |η| < 1, 2π in φ.
- PID using dE/dx measurements

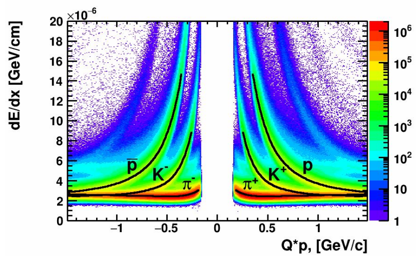
Time-Of-Flight (TOF):
- |η| < 0.9, 2π in φ
- PID using time-of-flight information

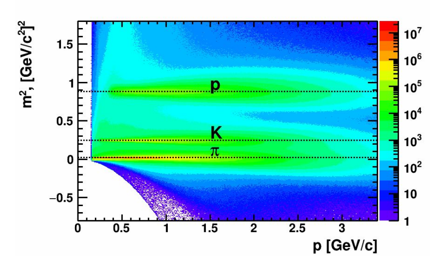
Event planes:

TPC (|η| < 1), BBC (3.8 <|η| < 5.2)

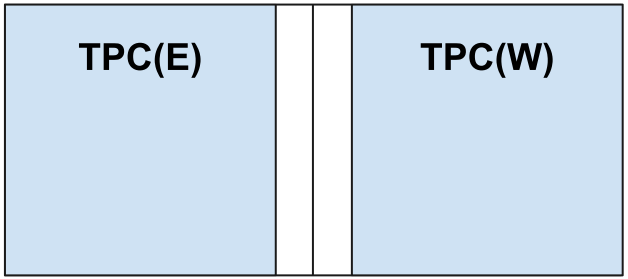
Data set:

Au+Au at $\sqrt{s_{NN}}$ = 11.5 - 62.4 GeV





Analysis technique: Event Plane Method (EP)



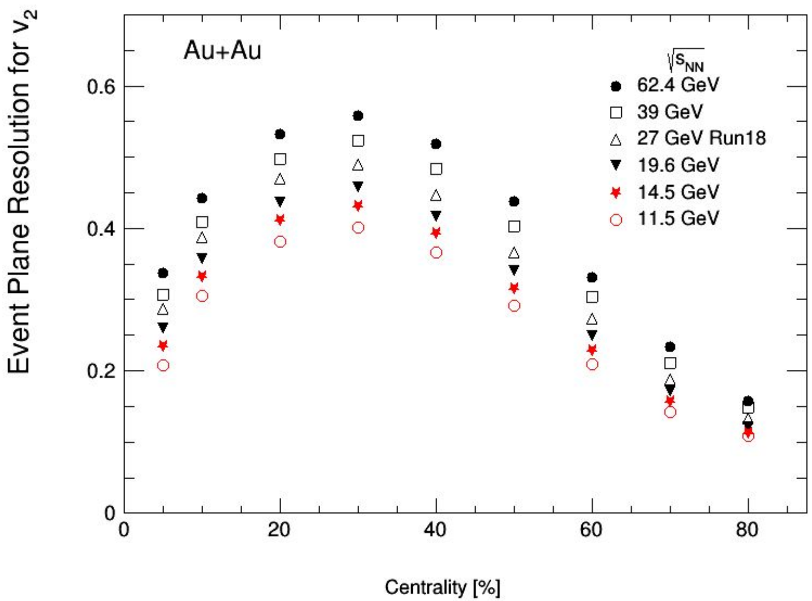
-1 < η < -0.05   0.05 < η < 1

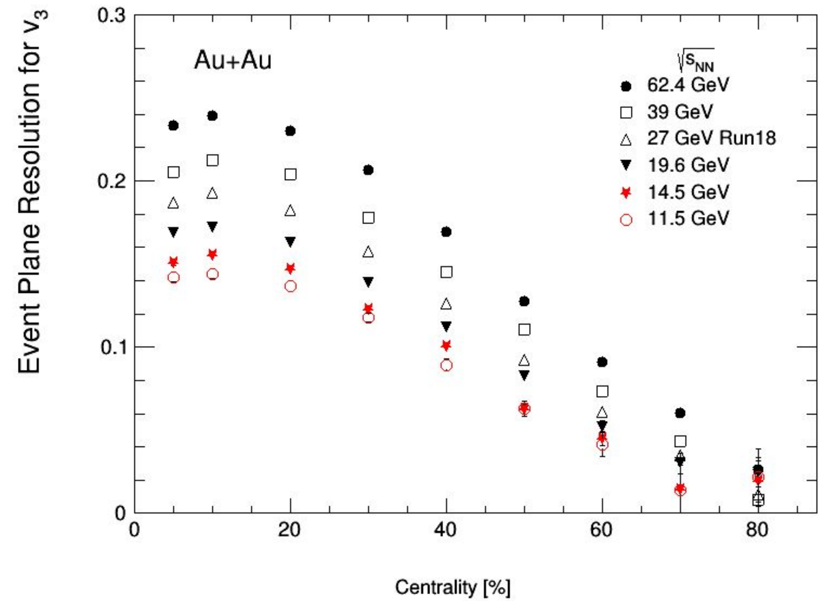
TPC(E) half $(\eta < 0) \rightarrow \eta_-$

TPC(W) half $(\eta < 0) \rightarrow \eta_+$

$$v_n = \frac{\langle \cos[n(\phi_{\eta\pm} - \Psi_{n,\eta\mp})] \rangle}{Res\{\Psi_n\}}$$

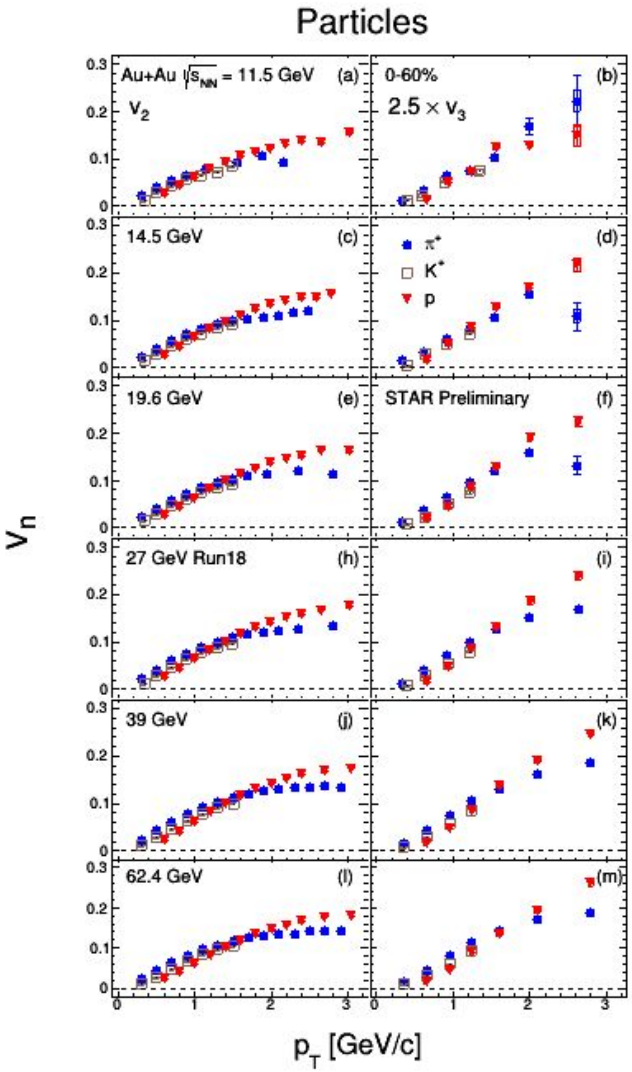
$$Res\{\Psi_n\} = \sqrt{\langle \cos[n(\Psi_{n,\eta+} - \Psi_{n,\eta-})] \rangle}$$

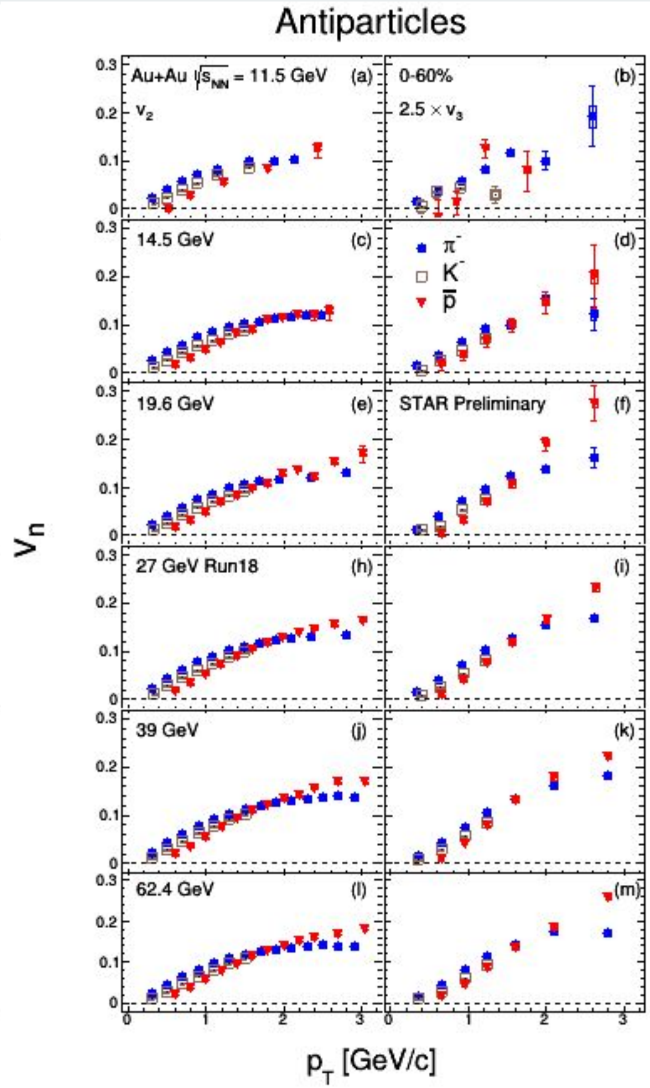


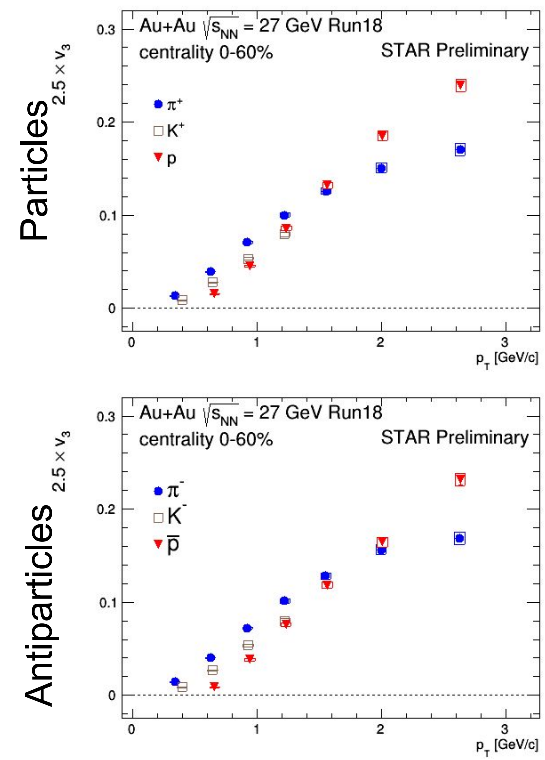


Used the same method as in Phys. Rev. C 88 (2013) 14902

$v_2(p_T)$ and $v_3(p_T)$ of identified hadrons



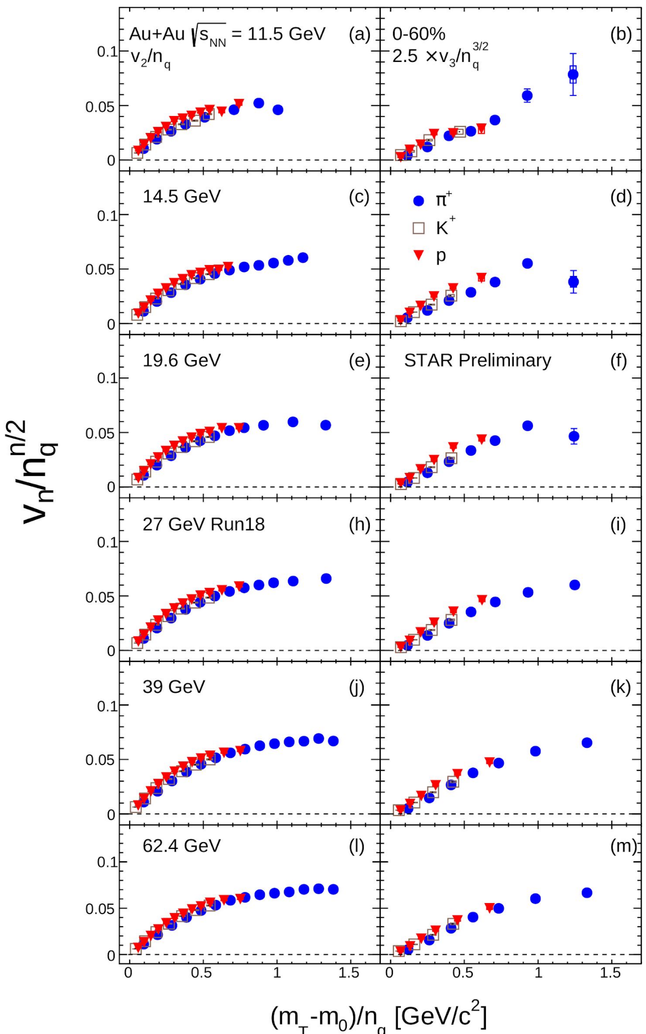




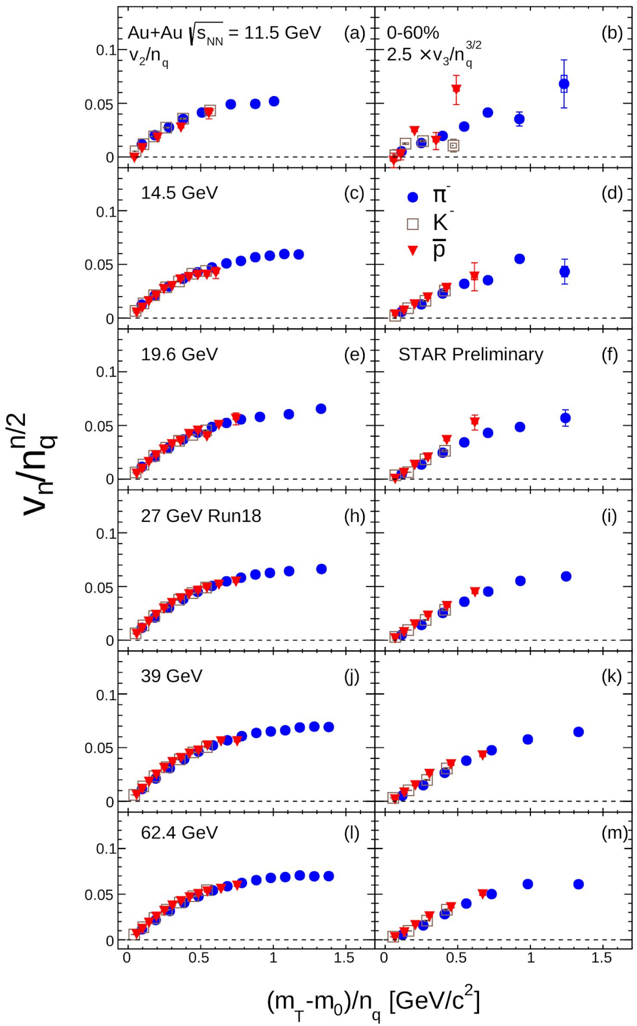
Mass ordering for p_T< 1.5 GeV/c
Baryon/meson grouping for p_T>2 GeV/c

NCQ scaling of v_2 and v_3

Particles



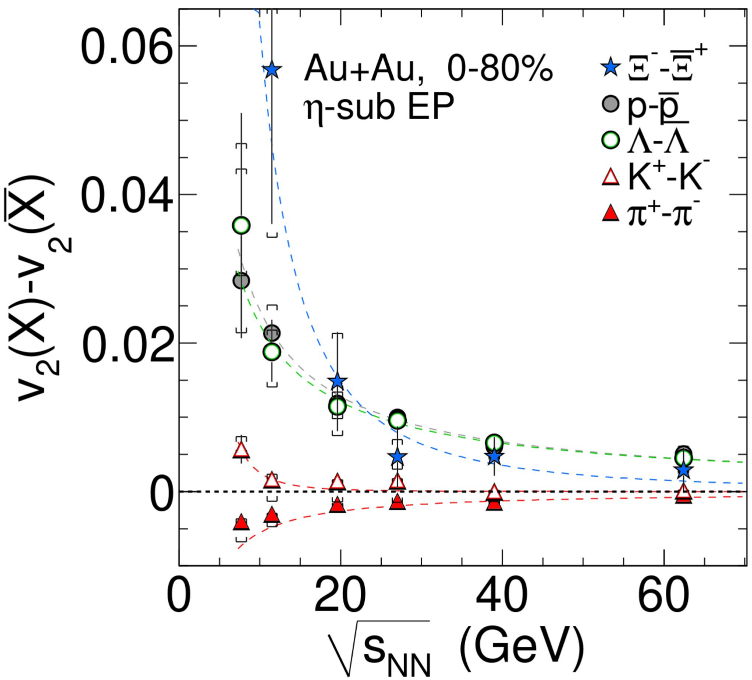
Antiparticles



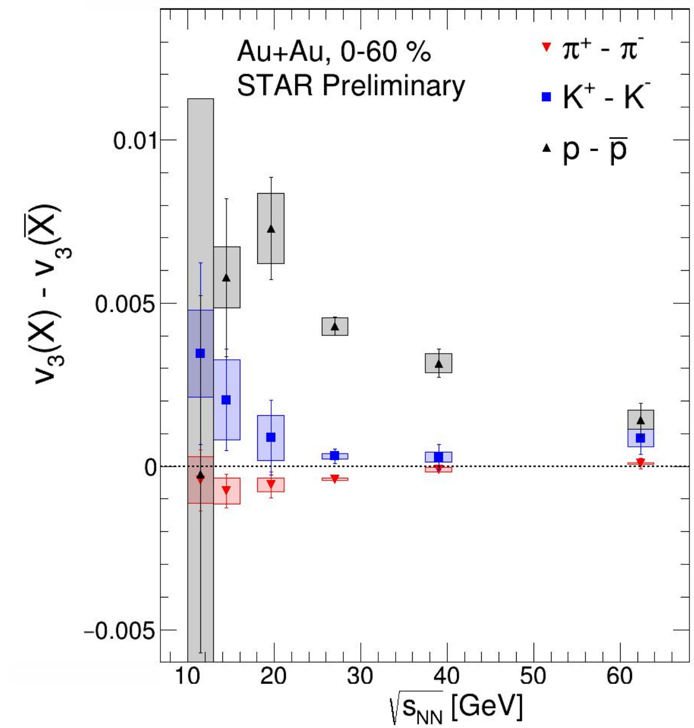
- NCQ scaling tests were performed for v_2 and v_3 for particles and antiparticles
- Scaling holds better for higher energies

Beam-energy dependence of v_2 and v_3 particle-antiparticle difference

STAR Collaboration, Phys. Rev. C 88 (2013) 14902



New results



- Differences for v_2 and v_3 between particles and antiparticles increase with decreasing beam energy
- $v_n(p) - v_n(\bar{p})$ shows growth with decreasing collision energy
- Absolute value of $v_n(X) - v_n(\bar{X})$ is larger for $(p, \bar{p})$ than for $\pi^{\pm}, K^{\pm}$

Summary

Results of v_2, v_3 in Au+Au collisions at BES energies $\sqrt{s_{NN}}$ = 11.5 - 62.4 GeV are presented.

($\sqrt{s_{NN}}$,centrality,PID,p_T)-dependence of v_2 and v_3:

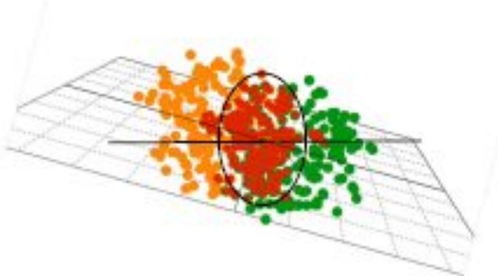
- Mass ordering for p_T < 1.5 GeV/c and baryon/meson grouping for p_T > 2 GeV/c
- NCQ scaling holds better for higher energies

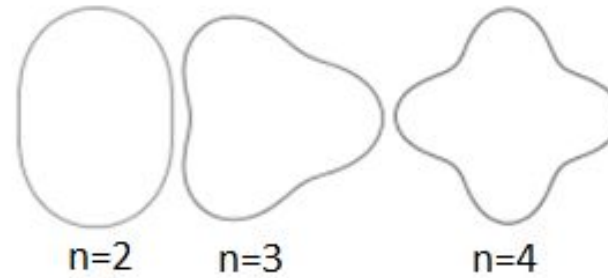
$v_n(X) - v_n(\bar{X})$:

- The difference increases with decreasing collision energy
- $v_n(p) - v_n(\bar{p})$ shows growth at lower collision energies
- Absolute value of $v_n(X) - v_n(\bar{X})$ is larger for $(p, \bar{p})$ than for $\pi^{\pm}, K^{\pm}$

Backup slides

Anisotropic collective flow



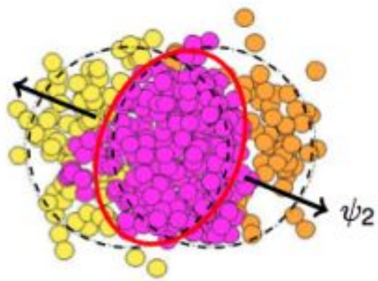


$$\epsilon_n = \sqrt{\frac{\langle r^n \cos n\phi \rangle + \langle r^n \sin n\phi \rangle}{\langle r^n \rangle}}$$

$$\frac{dN}{d\phi} \approx \left(1 + 2 \sum_{n=1} v_n cos[n(\phi - \Psi_n)]\right)$$

Initial eccentricity (and its attendant fluctuations), ε_n, drives momentum anisotropy, v_n, with specific viscous modulation

v_2 - elliptic flow



v_3 - triangular flow