D^0-meson elliptic flow measurement in Au+Au collisions at $\sqrt{s_{NN}}$= 200 GeV from STAR

[1]Yue Liang, *for the STAR Collaboration*

[1]*Kent State University & Lawrence Berkeley National Laboratory*

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Abstract

A recent result from the STAR experiment shows that in 10-40% central Au+Au collisions at the top RHIC energy the elliptic flow v_2 of D^0-meson follows the Number-of-Constituent-Quark scaling in the same way as it does for light flavor hadrons. This suggests that charm quarks have gained sufficiently large collectivity through their interactions with the Quark-Gluon Plasma (QGP).

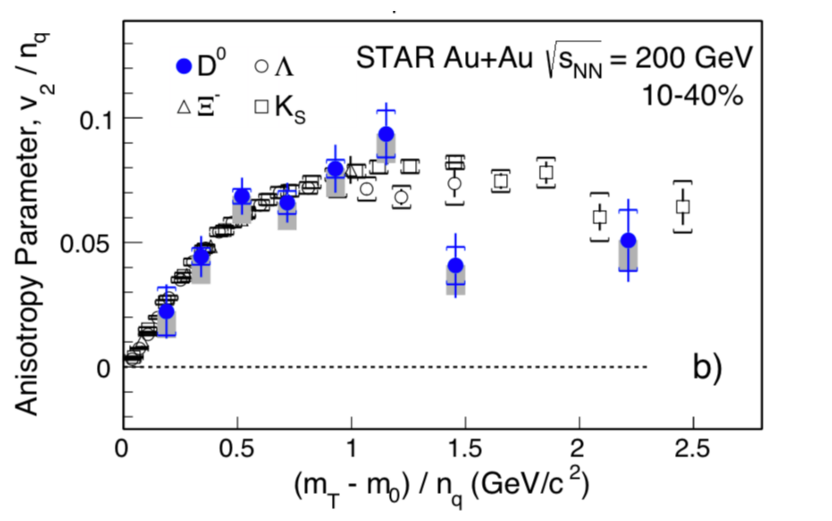
In this poster, we present the centrality and transverse momentum dependences of the D^0-meson v_2 measured in Au+Au collisions at $\sqrt{s_{NN}}$= 200 GeV by the STAR experiment. The measurement is based on the combined datasets recorded in 2014 and 2016, which improve the precision by 30% compared to the previously published results.

Motivation

- Elliptic flow (v_2) - second order Fourier coefficient of the azimuthal distribution.

$$E\frac{d^3N}{d^3p} = \frac{1}{2\pi}\frac{d^2N}{p_T dp_T dy}\left(1+\sum_{n=1}^{\infty}2v_n\cos(n(\phi-\Psi_r))\right)$$

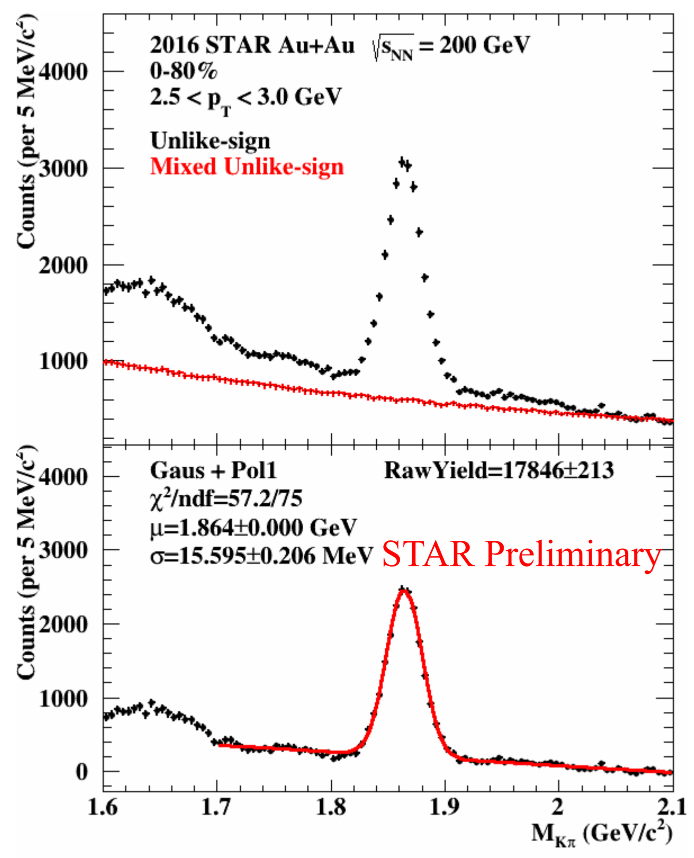
- D^0 v_2 studies the heavy quark-medium interaction and the degree of thermalization of the charm quarks
- Results on D^0 v_2 using 2014 data indicate significant flow and are consistent with that of light hadrons in 10-40% central collisions.

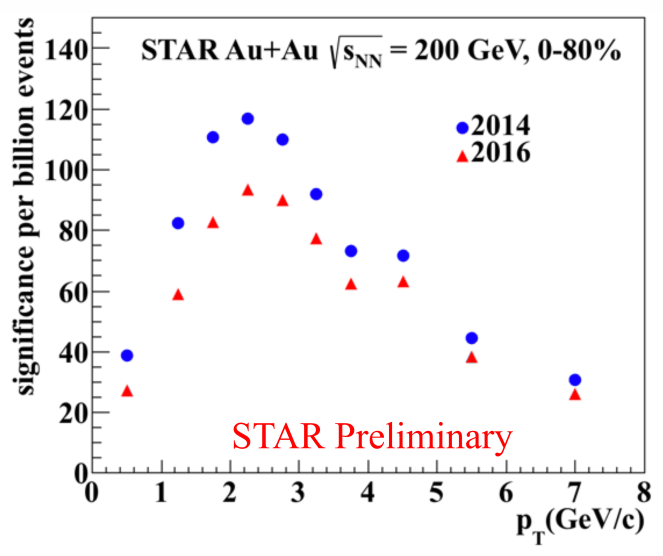


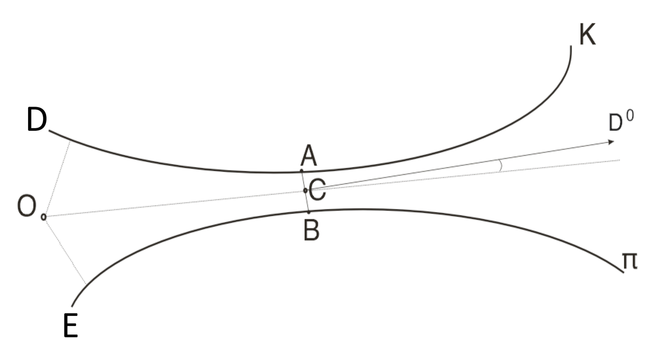
STAR, Phys. Rev. Lett. 118, 212301 (2017)

D^0 Reconstruction

- STAR Au+Au $\sqrt{s_{NN}}$ = 200 GeV 2014 + 2016 dataset: ~0.9B (2014)+1.2B (2016) events
- Daughter PID:
  - Tracks with three hits in Heavy Flavor Tracker (HFT)
  - TPC PID: $|n\sigma_K^{dE/dx}| < 2$, $|n\sigma_\pi^{dE/dx}| < 3$
  - If TOF available, apply TOF PID
  - TOF PID: $|1/\beta - 1/\beta_K| < 0.03$, $|1/\beta - 1/\beta_\pi| < 0.03$
- D^0 topological cuts:
  - TMVA Rectangular Cut Method for each p_T bin separately, and also for each centrality bin separately for year 2016 data
  - Decay length (OC)
  - DCA between 2 daughters (AB)
  - DCA between D0 and Primary Vertex
  - DCA between K and Primary Vertex (OD)
  - DCA between π and Primary Vertex (OE)







Event plane Reconstruction

- Estimation of event plane Ψ
  - η -sub method with additional η - gap of 0.05 away from D^0 candidates
  - Re-centering applied on a run by run basis using primary tracks,
  - Shift correction to flatten the event plane angle distribution.

$q_x = \cos(n\varphi_i)$, $q_y = \sin(n\varphi_i)$

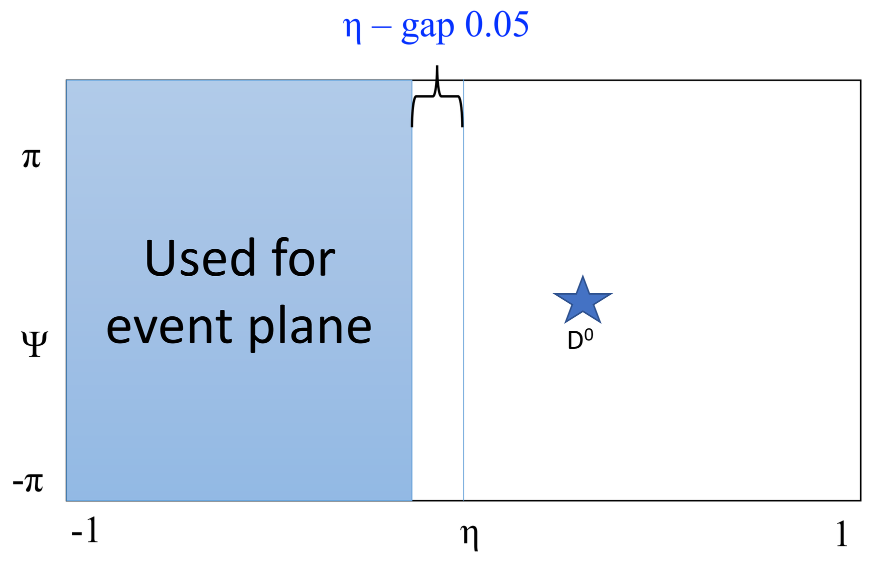
$$Q_x = \sum w_i * (q_x - \langle q_x \rangle)$$

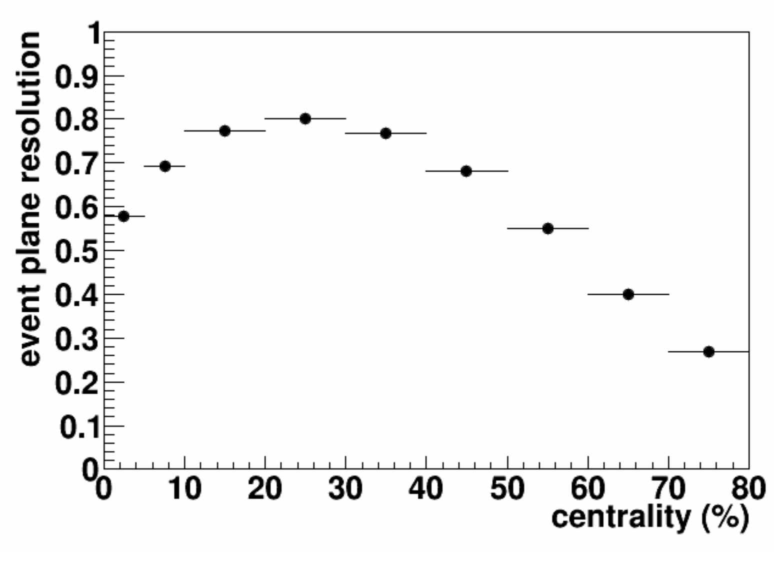
$$Q_y = \sum w_i * (q_y - \langle q_y \rangle)$$

$$\Psi n = tan^{-1}(Q_y/Q_x)/n$$

w_i is transverse momentum (p_T)

A. M. Poskanzer and S. A. Voloshin, Phys. Rev. C 58, 1671,(1998)





Event plane resolution as a function of centrality

v_2 Results

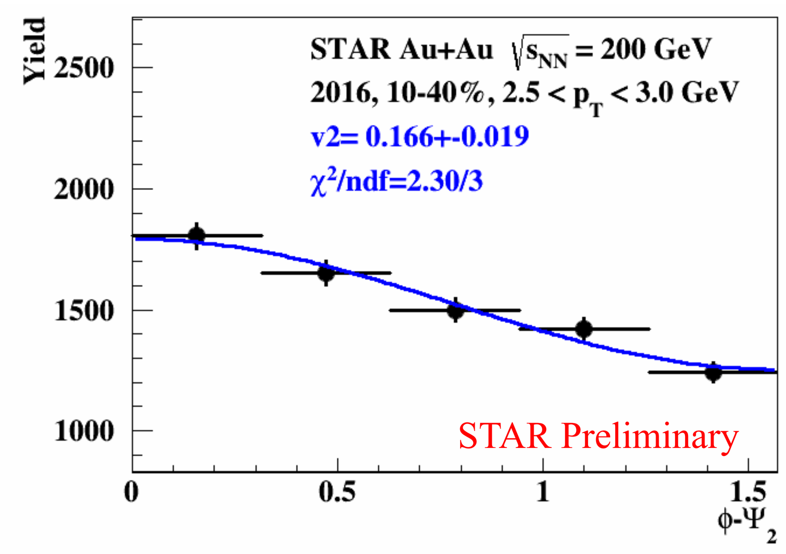


Fig. 1: D^0 yields are measured in bins of the relative azimuthal angle with respect to the event plane angle (φ-Ψ_2). D^0 decayed daughters are excluded from event plane reconstruction.

v_2 is measured by fitting the azimuthal distribution with the function :

$$A * (1 + 2 * v_2\cos(2 * (\varphi - \Psi_2)))$$

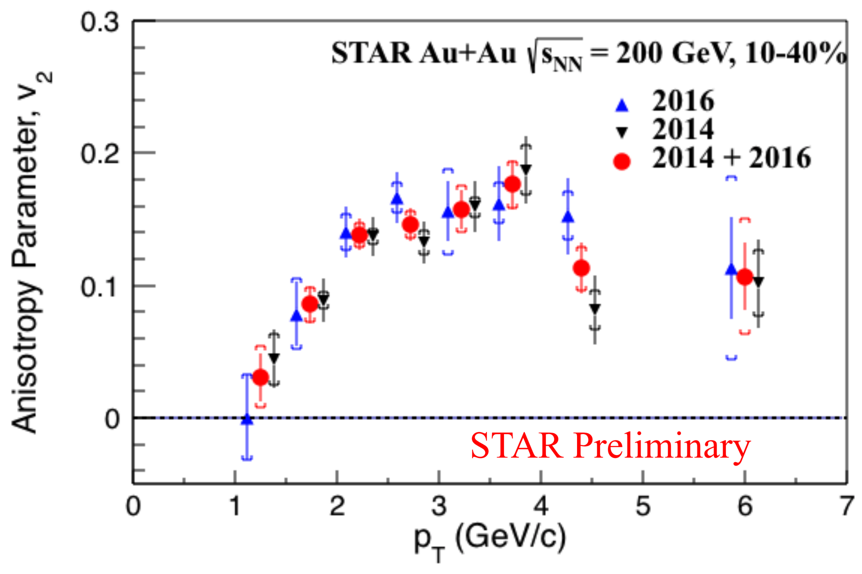


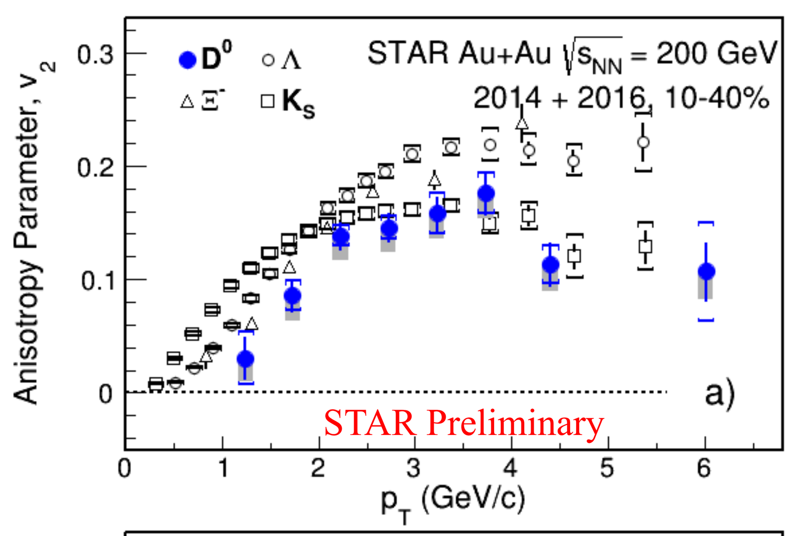
Fig. 2: D^0 v_2 as a function of p_T from 2014 and 2016 STAR data. Data points are shifted along x-axis for clarity.

- v_2 results from 2014 and 2016 are combined as:

$$< v_2 >= \sum_i w_i * v_2^i \Big/ \sum_i w_i$$

$$w_i = \frac{1}{\sigma_i^2}$$

- Systematic uncertainties are assumed fully correlated between 2014 and 2016 dataset



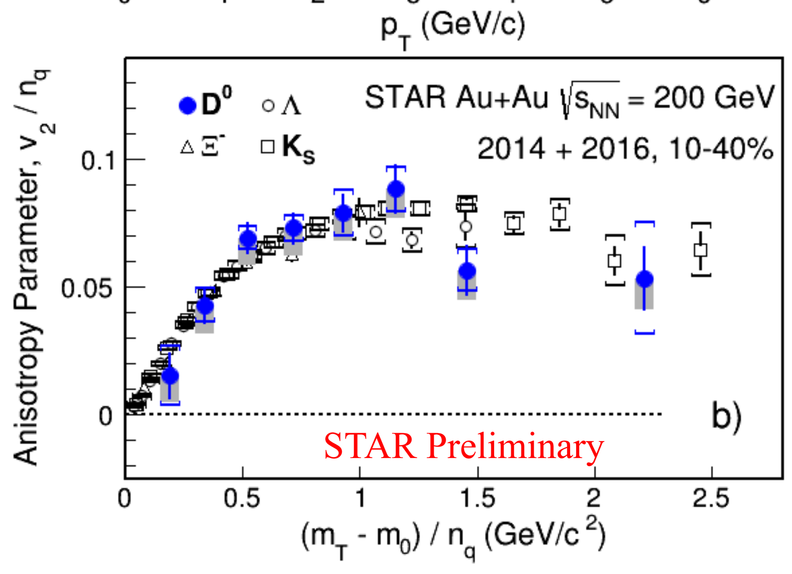
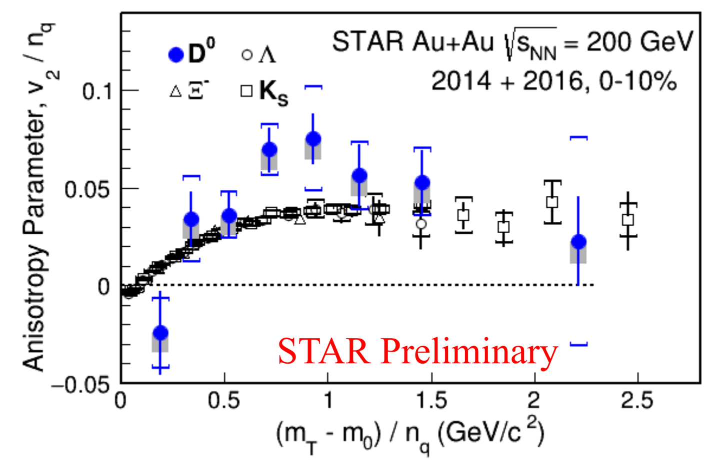


Fig. 3: a) v_2 as a function of p_T, and b) v_2/n_q as a function of $(m_T - m_0)/n_q$ for D^0 compared with Λ, Ξ, K_S^0. The vertical bars and brackets represent statistical and systematic uncertainties, respectively, and the grey bands represent the estimated maximum non-flow contribution.



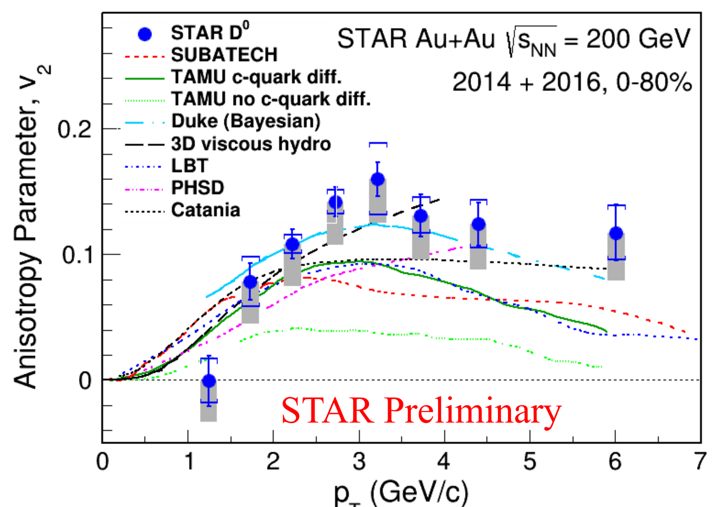


Fig. 4: D^0 v_2 in 0-80% Au+Au collisions at 200 GeV compared to model calculations.

Compared Models	χ^2/NDF	p-value
TAMU c quark diff [1]	12.0/8	0.15
TAMU no c quark diff [1]	33.7/8	4.5e-05
SUBATECH [2]	17.3/8	0.026
Duke(Bayesian) [3]	8.5/8	0.39
LBT [4]	13.3/8	0.10
PHSD [5]	8.7/7	0.27
Hydro [6]	3.7/6	0.71
Catania [7]	9.7/8	0.29

Conclusions

- The D^0 v_2 in Au+Au collisions at $\sqrt{s_{NN}}$= 200 GeV is measured by STAR utilizing Heavy Flavor Tracker. Results using 2014 and 2016 dataset are consistent with each other and are combined.
- The D^0 v_2/n_q is consistent with other hadrons at $(m_T - m_0)/n_q < 2.5$ GeV/c^2 in 0-10% and 10-40% centrality intervals.
- Results suggest that charm quarks exhibit the same strong collective behavior as light hadrons and may be close to thermal equilibrium in Au+Au collisions at $\sqrt{s_{NN}}$= 200 GeV.

Outlook

- Further study : Enlarge η - gap to further reduce non-flow effect, and to study D^0 v_2 in the peripheral (40-80%) interval.
- Study higher Fourier coefficient of the azimuthal distribution, such as triangular flow (v_3), and also correlations with light hadron flow.

References

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