# Measurement of the $D^0$ meson elliptic and triangular flow in Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV from STAR

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Motivation /STAR detector/Analysis details

Results:

- $D^0$ elliptic flow($v_2$) and triangular flow($v_3$)
- Number-of-constituent-quark(NCQ) scaling comparison with other hadrons
- $D^0$ $v_2$ comparison with model calculations

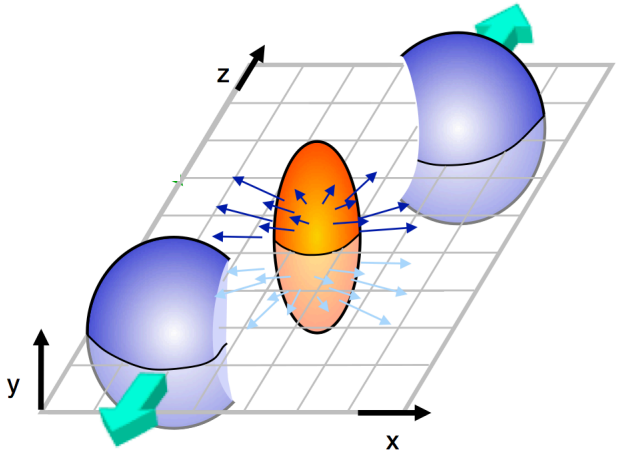
Summary

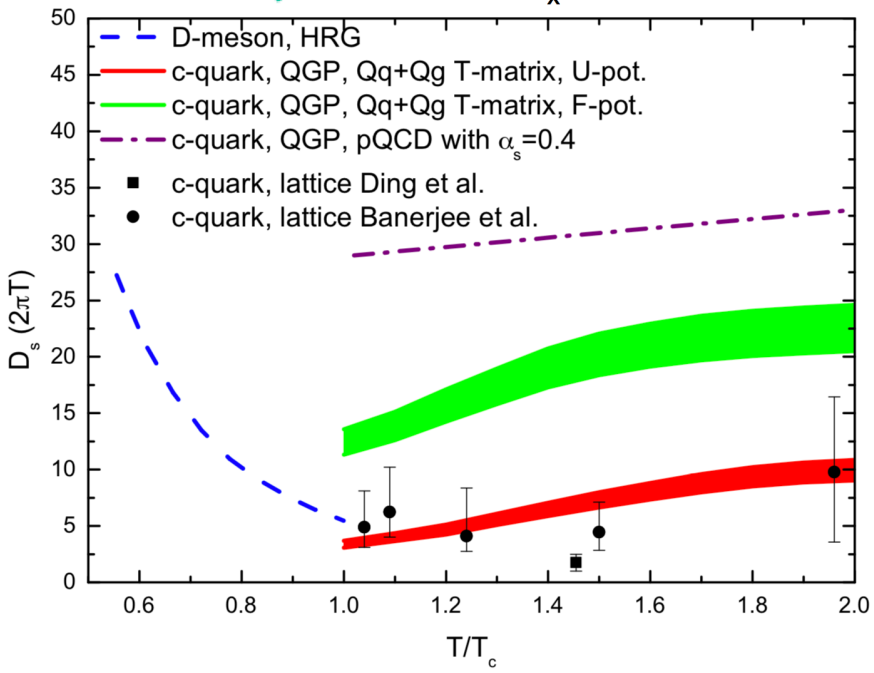
# Motivation

- Elliptic/Triangular flow ($v_2$ /$v_3$) – second/third order Fourier coefficient of the azimuthal distribution.

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

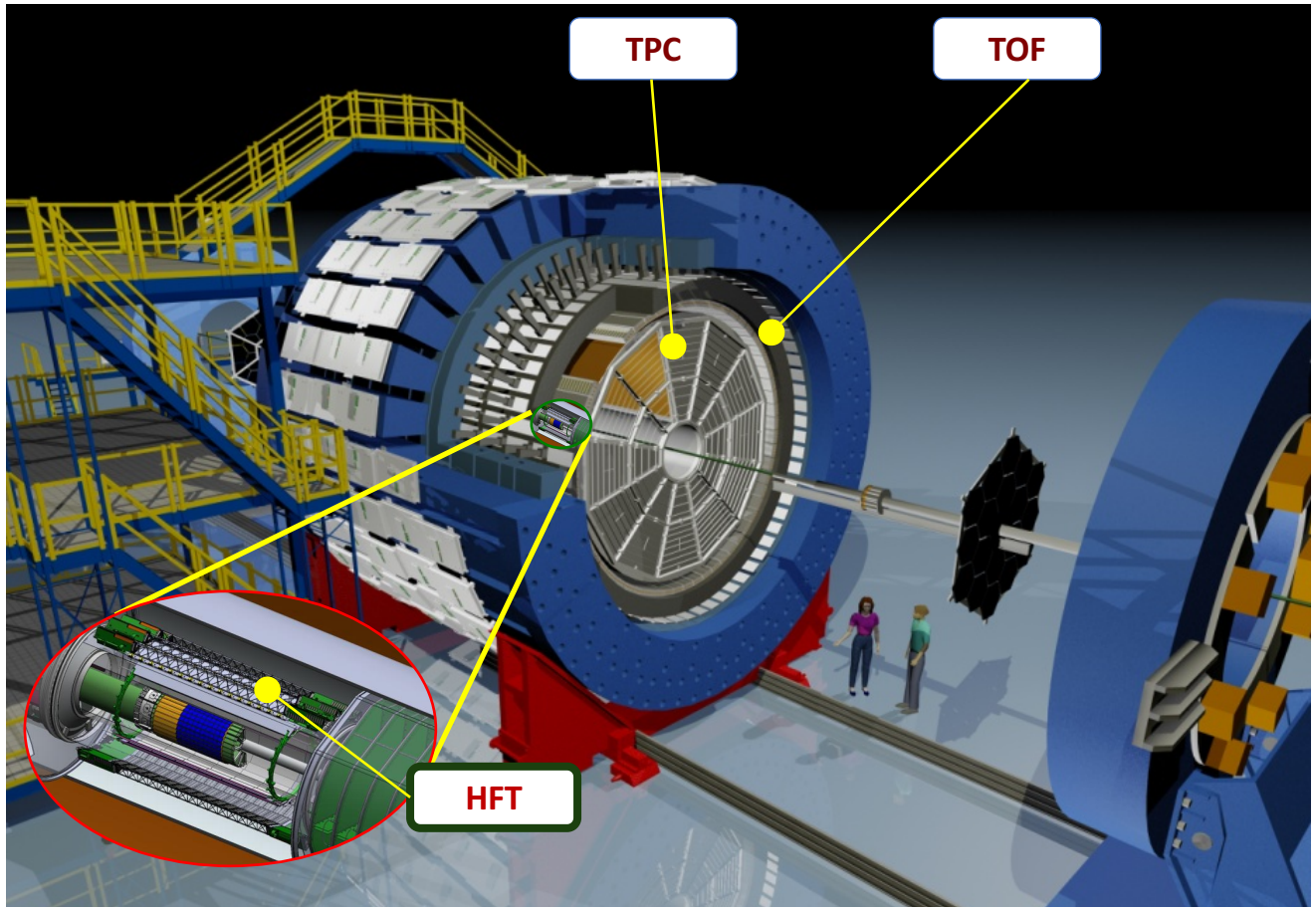
- Heavy quarks produced from initial hard scattering, transported through QGP.
- Heavy quarks due to their large masses, have a longer thermalization time.
- $D^0$ $v_n$ , sensitive to charm quark diffusion coefficient - QGP intrinsic transport parameter.

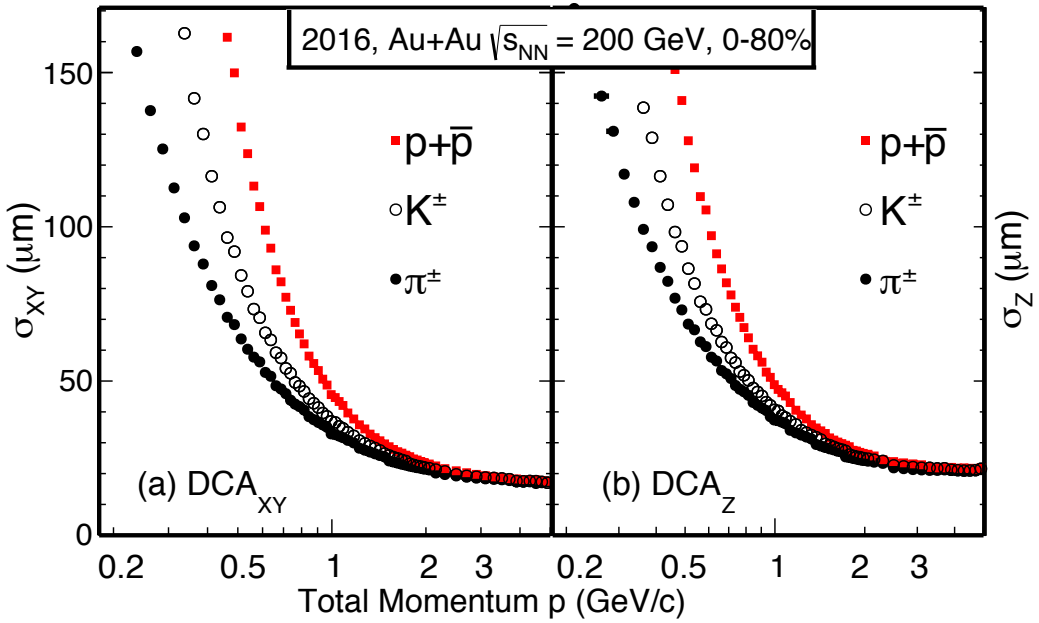



arXiv:1502.02730

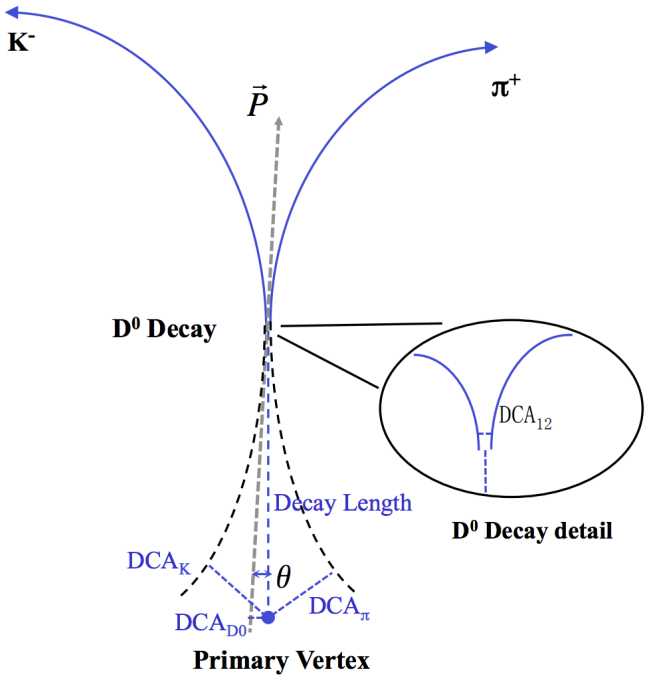
# STAR Detector



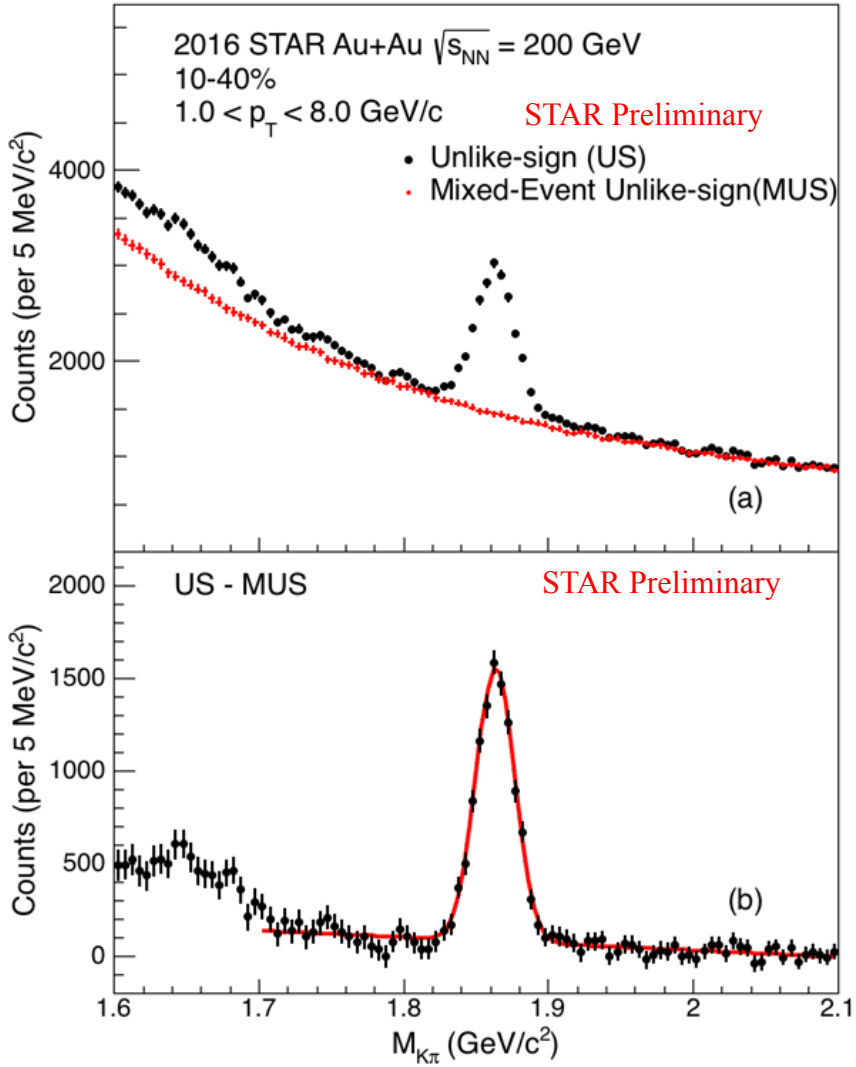

- TPC: Tracking , PID (dE/dx)
- TOF: PID (1/ β)
- HFT:
  Excellent track impact parameter resolution
  35 **μm** at p = 1GeV/c

# $D^0$ topological reconstruction with HFT




$D^0(\bar{u}c)$, $\overline{D^0}$ $(u\bar{c})$,
Decay channel: $D^0 \rightarrow K^- + \pi^+$
$c\tau$: 120 **μm**

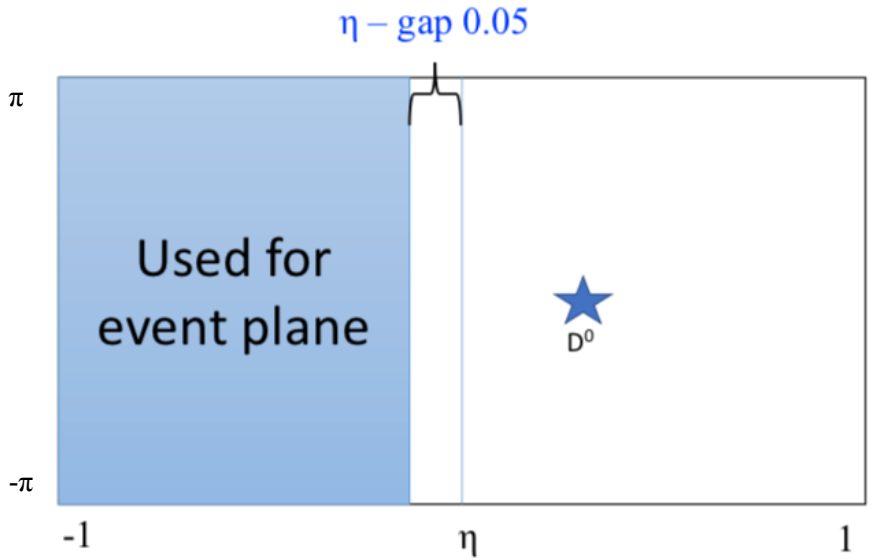
TMVA Rectangular Cut Method for optimizing cuts on topological variables.
Done separately for each $p_T$ / centrality bin.

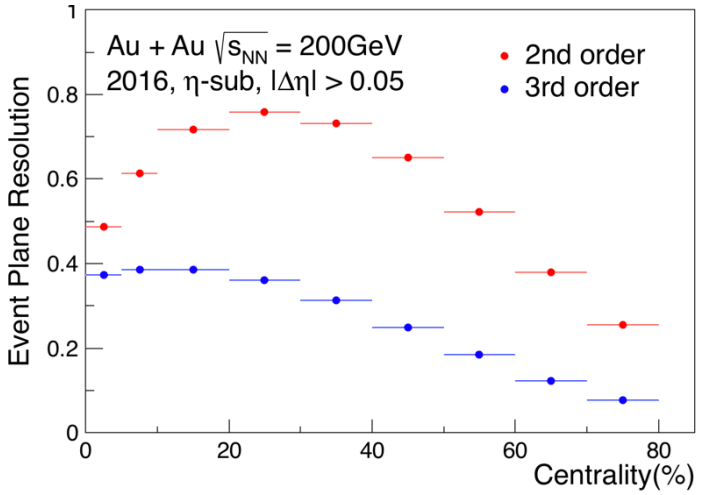



| | 2010+2011 w/o HFT | 2014 w/ HFT |
|---|---|---|
| #Event(MB) | 1.1 billion | ~900 million |
| Sig. per billion events | 13 | 220 |

STAR: Phys. Rev. Lett. 113, 142301 (2014)  STAR: Phys. Rev. Lett. 118, 212301 (2017)

# $D^0$ $v_2$ $v_3$ : event plane method



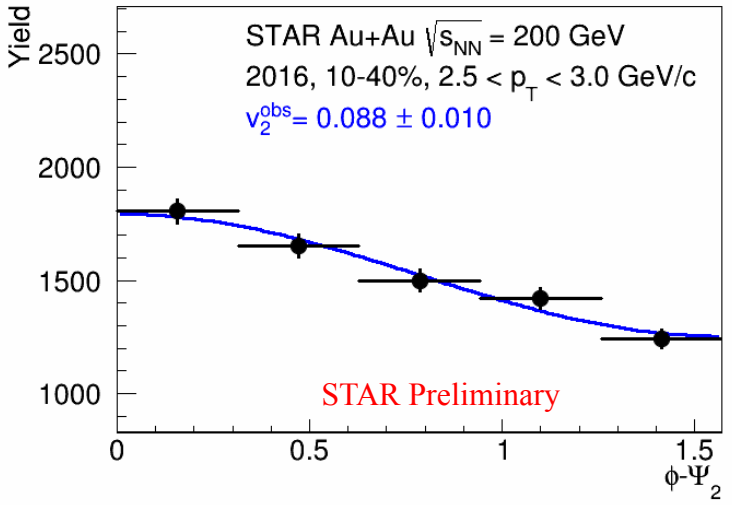

- $D^0$ $v_n$ measured using η-Sub event plane method.
- $D^0$ yield as a function of $\varphi-\Psi_n$ fit to $A(1 + 2v_n^{obs}\cos(n(\varphi - \Psi_n)))$.
- Results are corrected for event plane resolution.

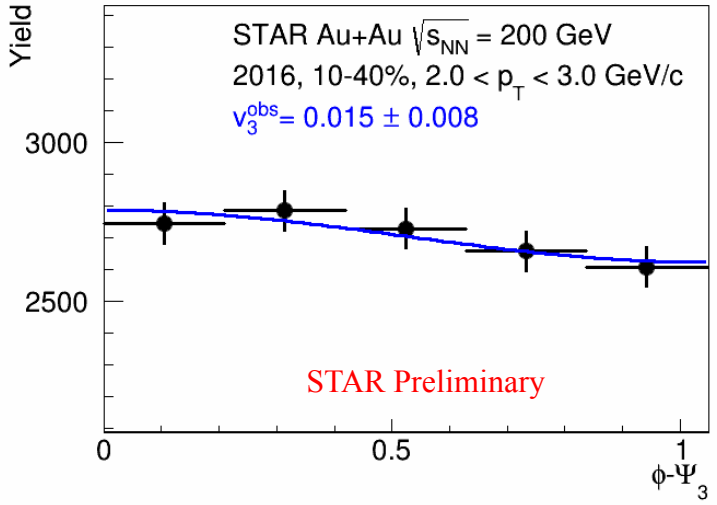
$$v_n = \frac{v_n^{obs}}{E.P\ Resolution}$$

- Non-flow estimated from measured D-h correlations in p+p 200GeV

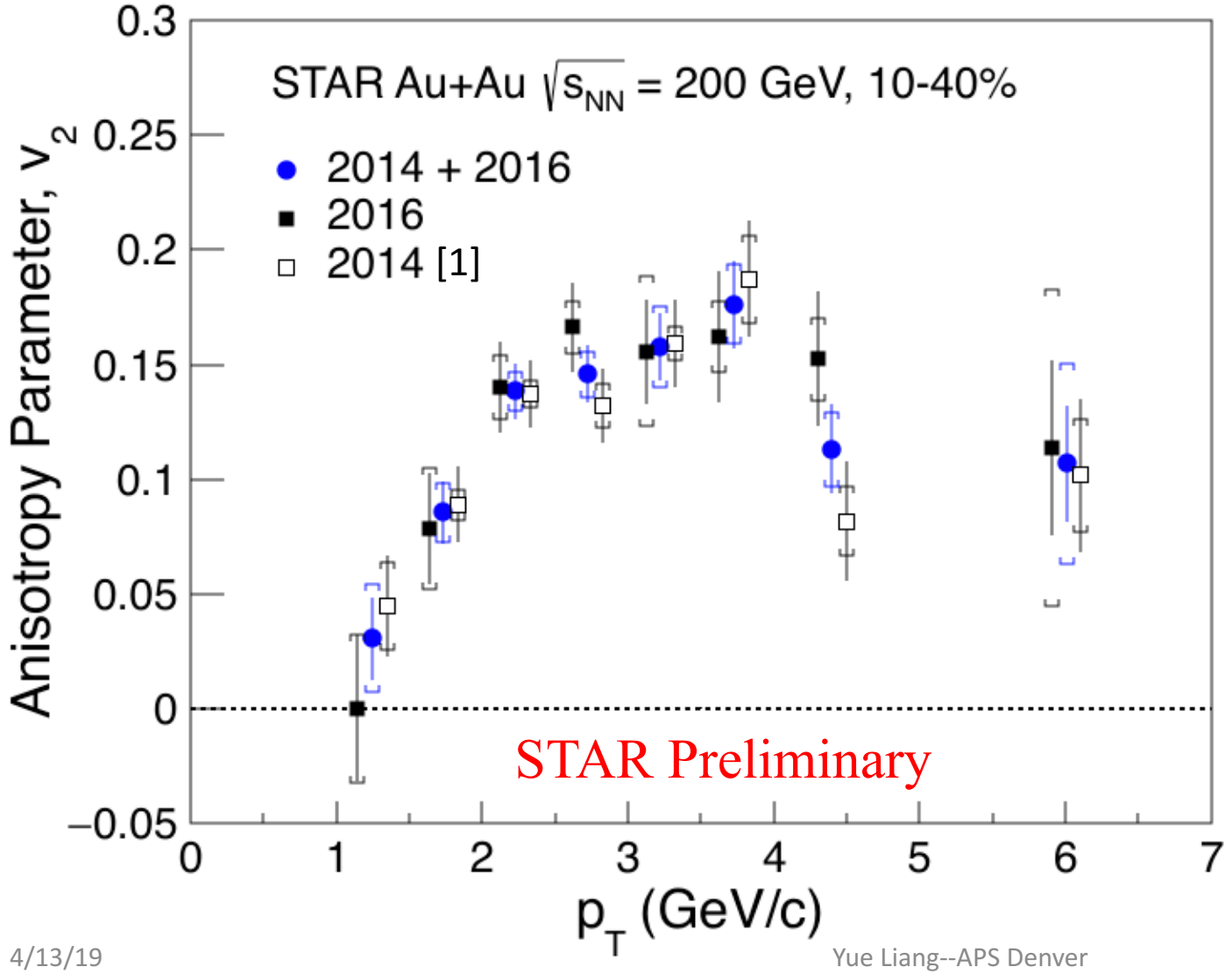
$$v_2^{non-Flow} = \frac{<\sum_h \cos(2(\phi_{D^0} - \phi_h))>}{M v_2^h}$$

- B->D feed down is negligible at RHIC energies (< 4%)



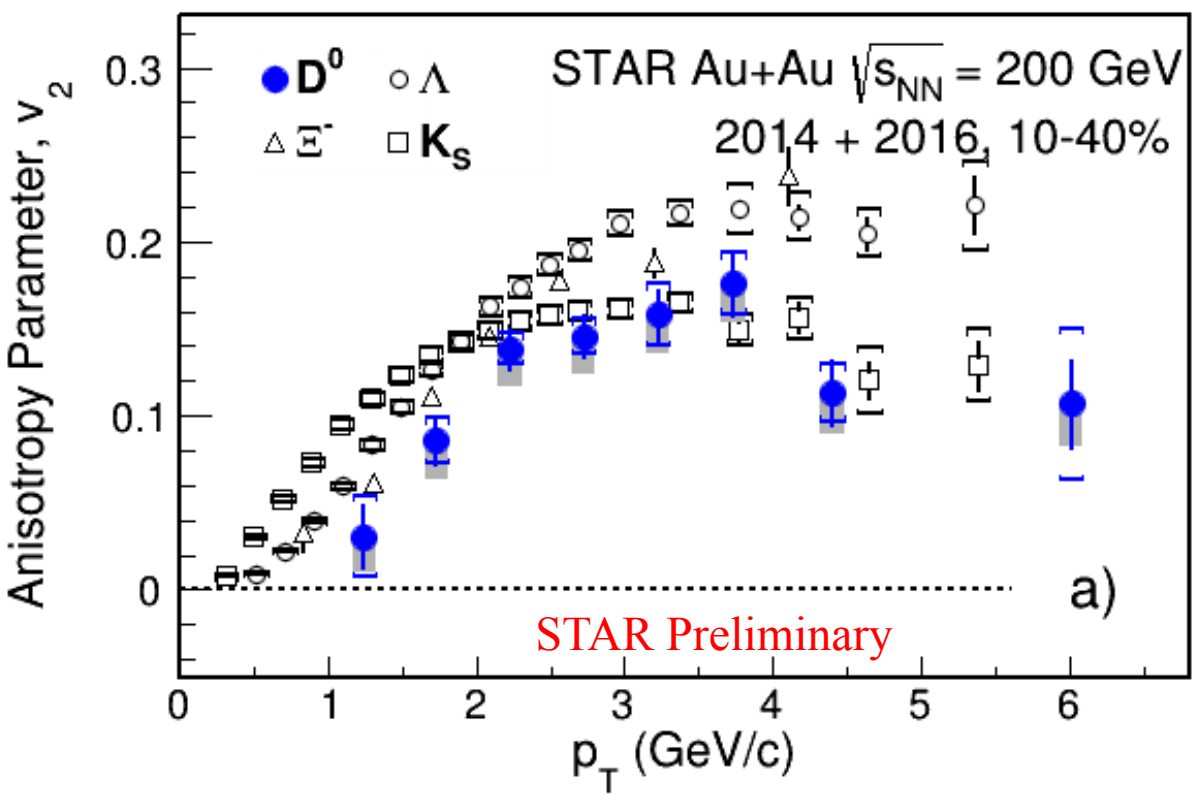
# $D^0$ $v_2$ from 2014 and 2016

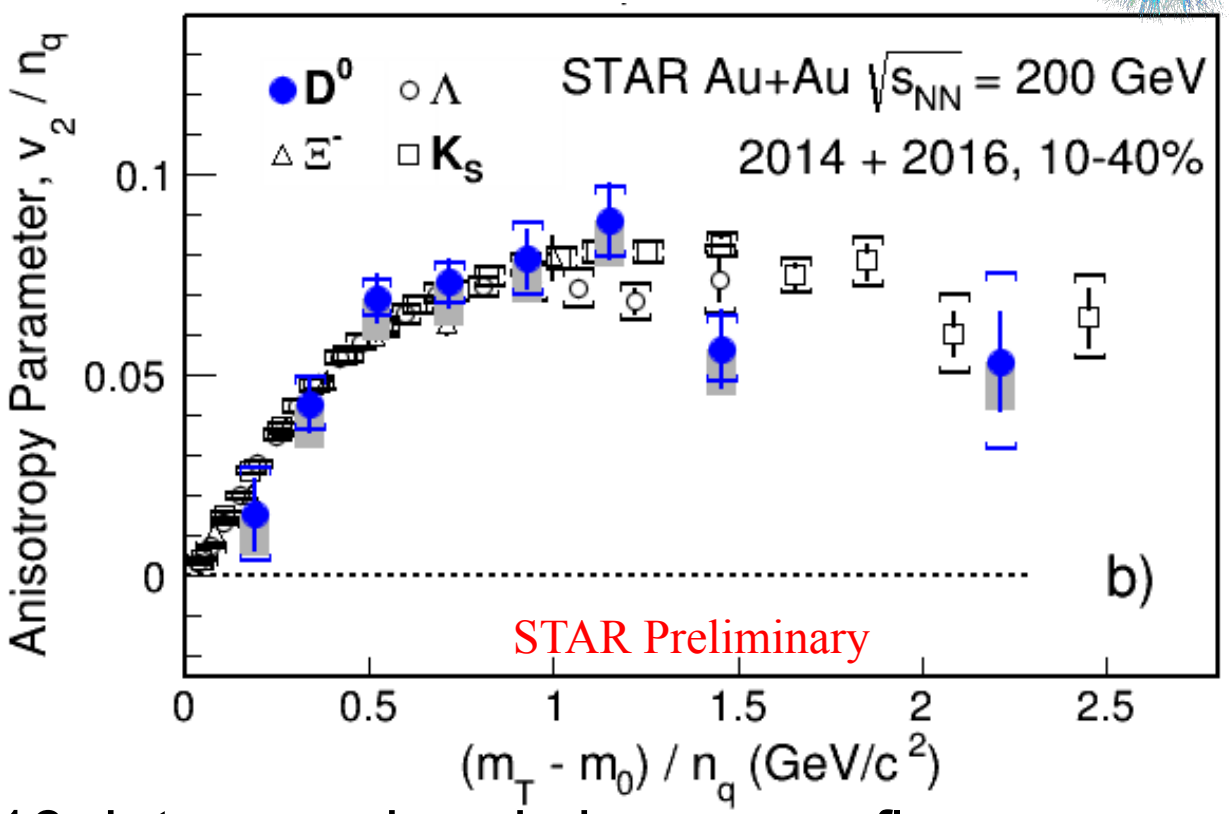



- 2016 and 2014 $D^0$ $v_2$ are consistent
- Improved precision from combined two years of data
- Non-flow uncertainty not shown in this plot

[1]STAR, Phys. Rev. Lett. 118, 212301 (2017)

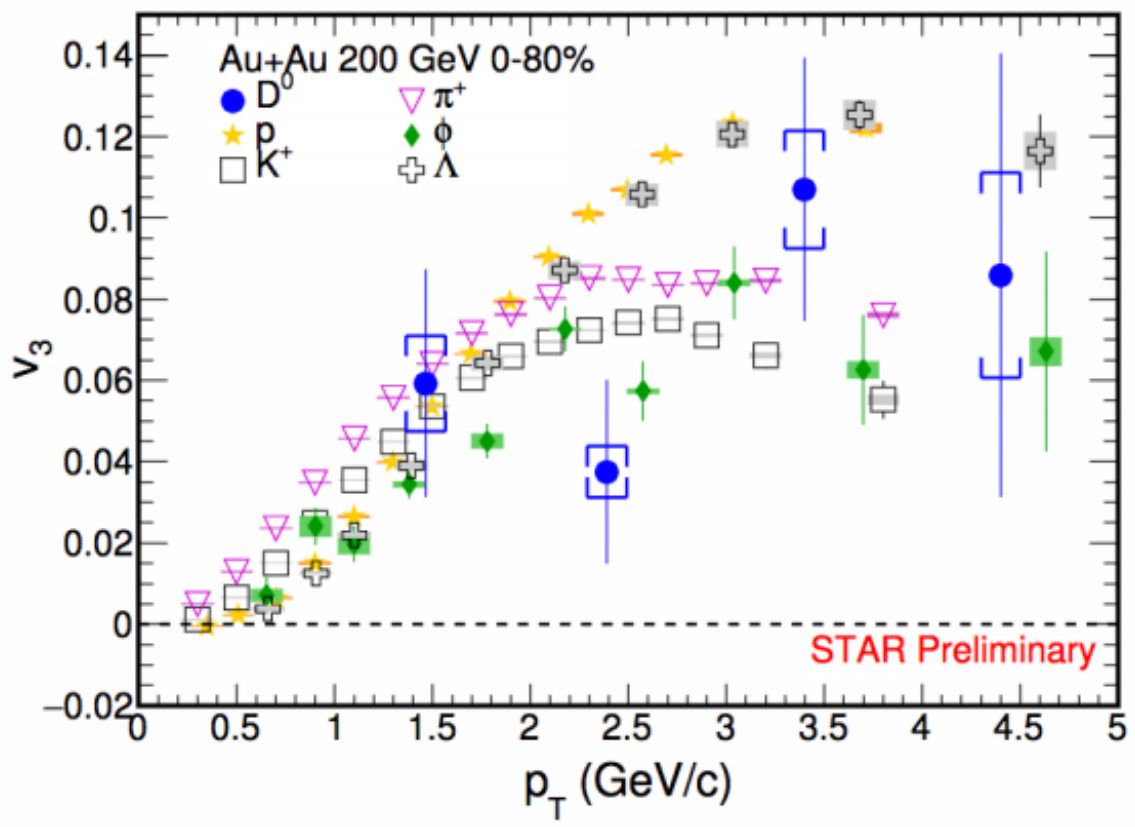
# $D^0$ $v_2$ comparison with light flavor hadrons

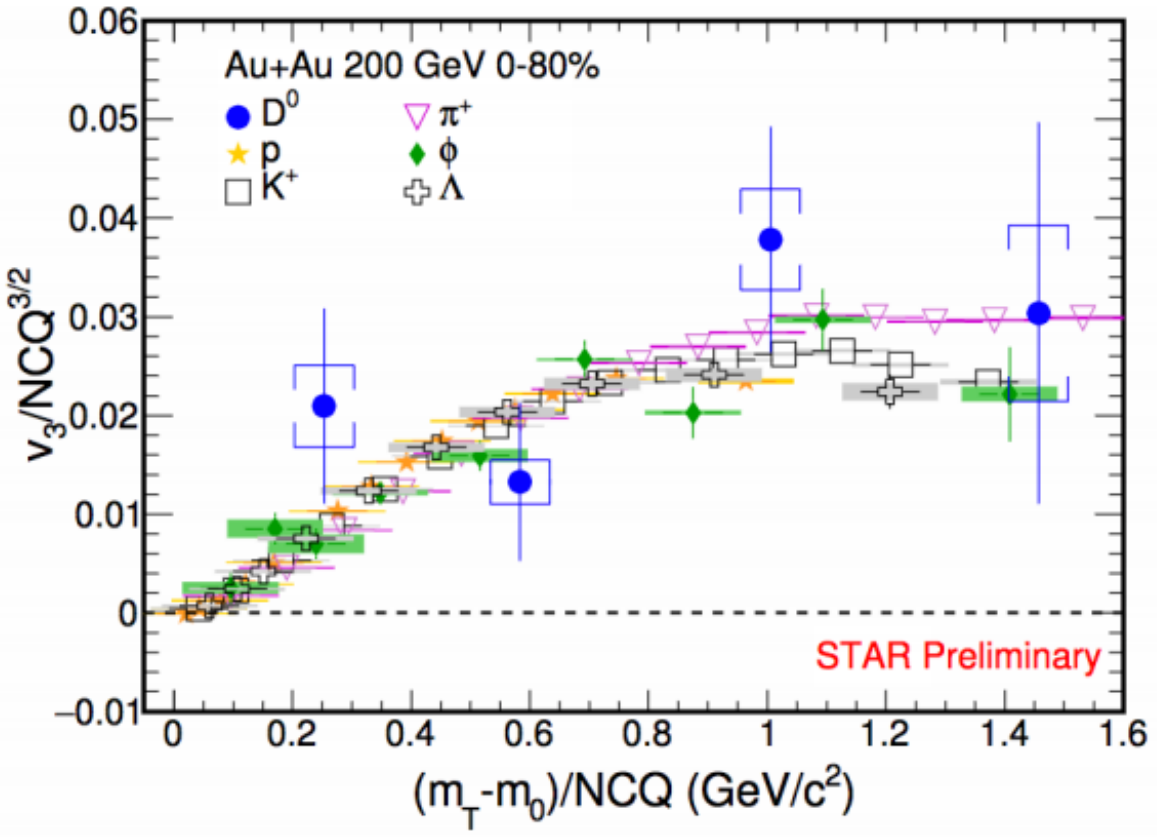



- $D^0$ $v_2$ from combined 2014 + 2016 data, grey band shows non-flow estimation.
- NCQ-scaled $D^0$ $v_2$ consistent with light flavor hadrons.
- Suggest charm quarks flow with the QGP.

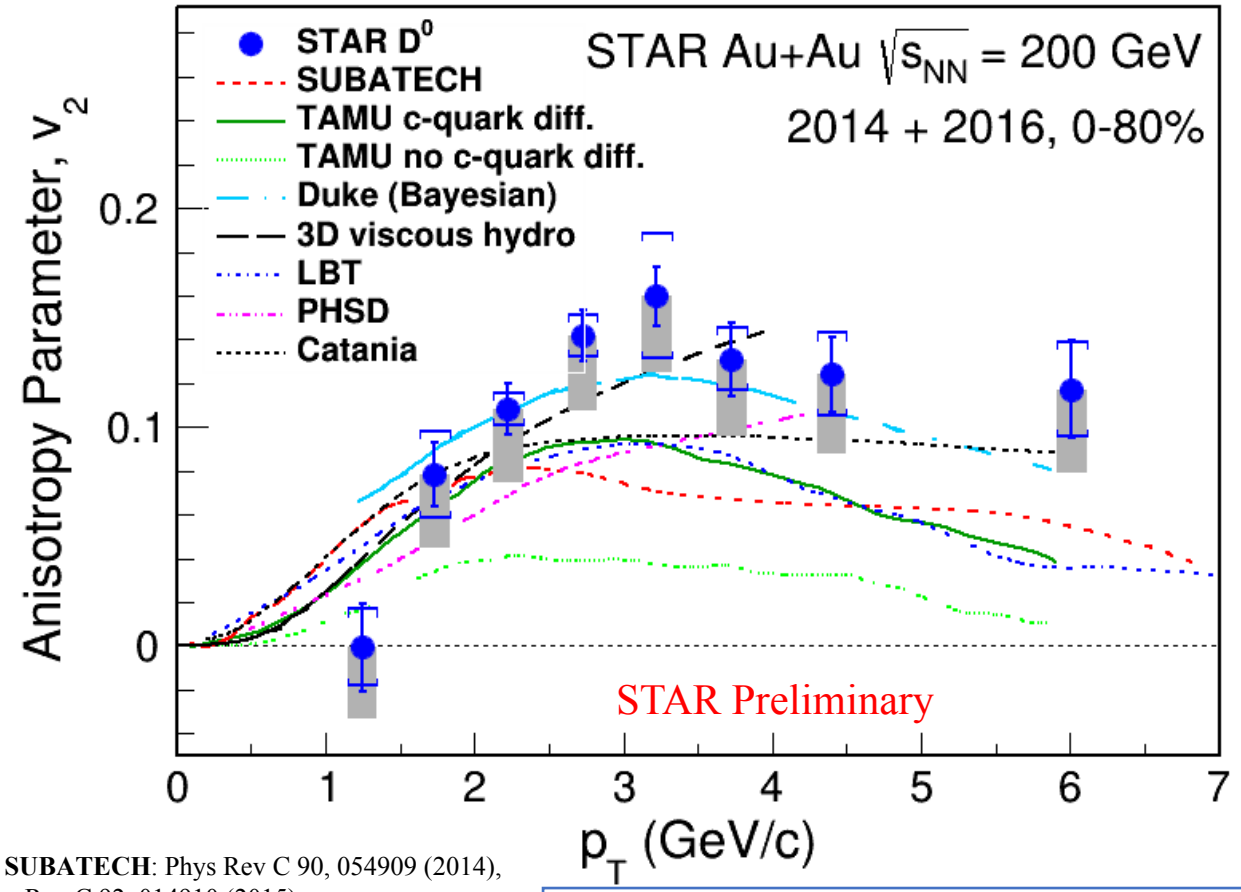
# $D^0$ $v_3$ comparison with other hadrons

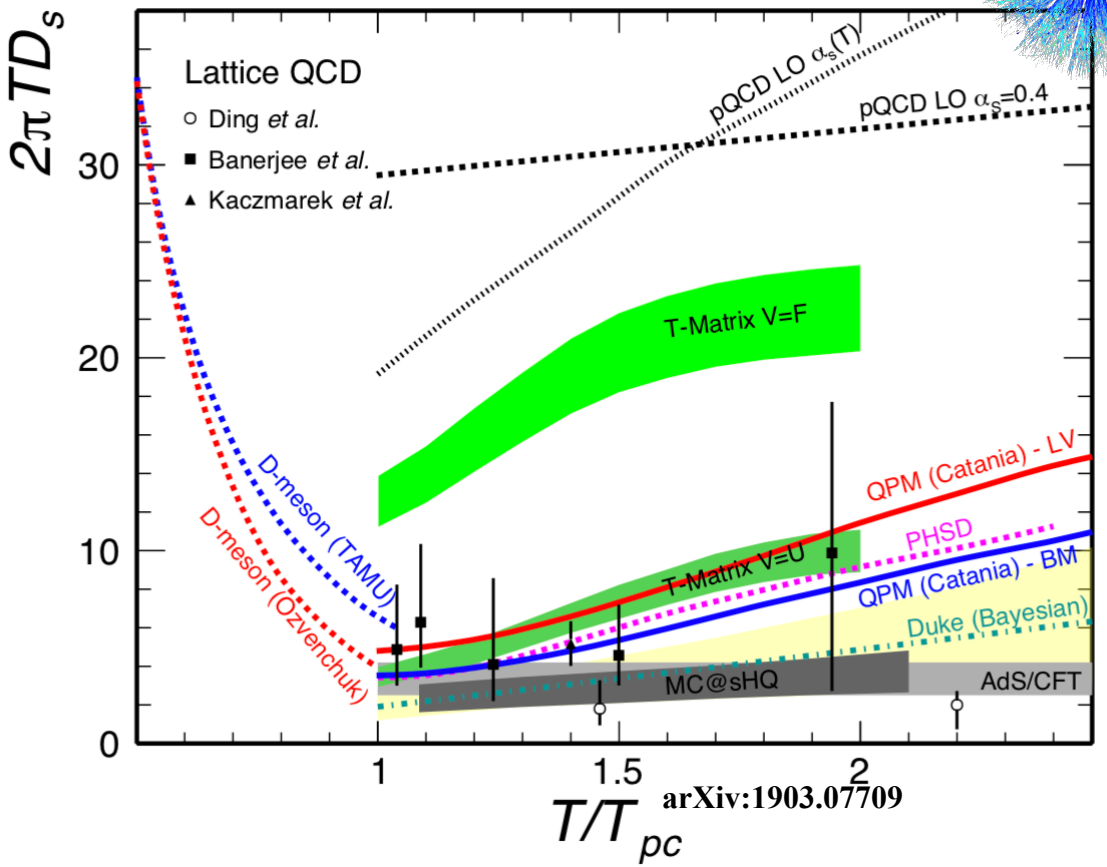



- Non-zero $D^0$ $v_3$ values; comparable to light flavor hadrons $v_3$
- NCQ-scaled $D^0$ $v_3$ consistent within error bars

# $D^0$ $v_2$ comparison with Models



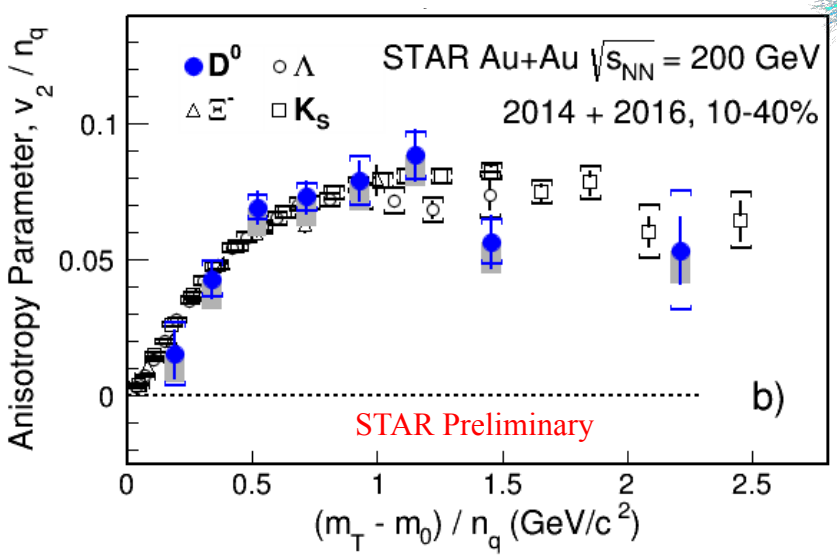


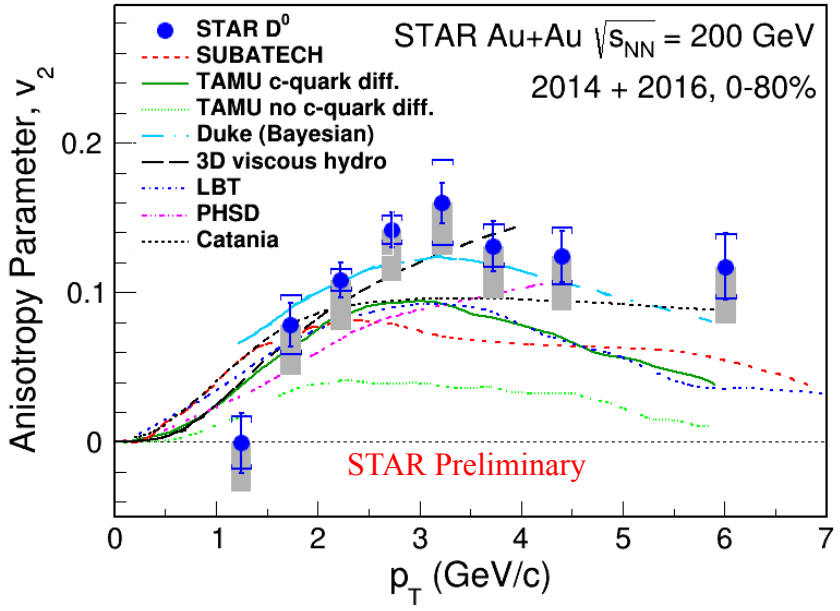
[1] **SUBATECH**: Phys Rev C 90, 054909 (2014), Phys Rev C 92, 014910 (2015)
[2] **TAMU**: Phys Rev C 86, 014903 (2012), Phys Rev Lett 110, 112301 (2013)
[3] **Duke**: Phys Rev C 92, 024907 (2015)
[4] **3D viscous hydro**: Phys Rev C 86, 024911 (2012)
[5] **LBT**: Phys Rev C 94, 014909 (2016)
[6] **PHSD**: Phys ReV 90, 051901 (2014), Phys ReV 90, 051901 (2014)
[7] **Catania**: Phys ReV 96, 044905 (2017)


- Improved precision to constrain the models
- TAMU no c-quark diffusion failed to fit with data, indicate heavy quark diffusion
- Models describe $D^0$ $v_2$ well with $2\pi TD_s$ in the range of 2 – 5 around $T_c$

# Summary

- Improved precision of $D^0$ $v_2$ results with combined 2014 and 2016 data.
- $D^0$ $v_2$ and $v_3$ follow the NCQ scaling with other light flavor hadrons.
- $D^0$ $v_2$ constrain model calculation. Models with $2\pi TD_s$ in the range of 2 – 5 near $T_c$ describe data.



# BACK UP

- Model comparison Table

| Compared Models | $\chi^2$/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 |