Elliptic flow of hadrons in relativistic heavy-ion collisions using the PHSD model

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Outline:

- Introdution: Collective flow
- Results:
  - Charged hadron elliptic flow
  - Identified hadron elliptic flow
- Summary

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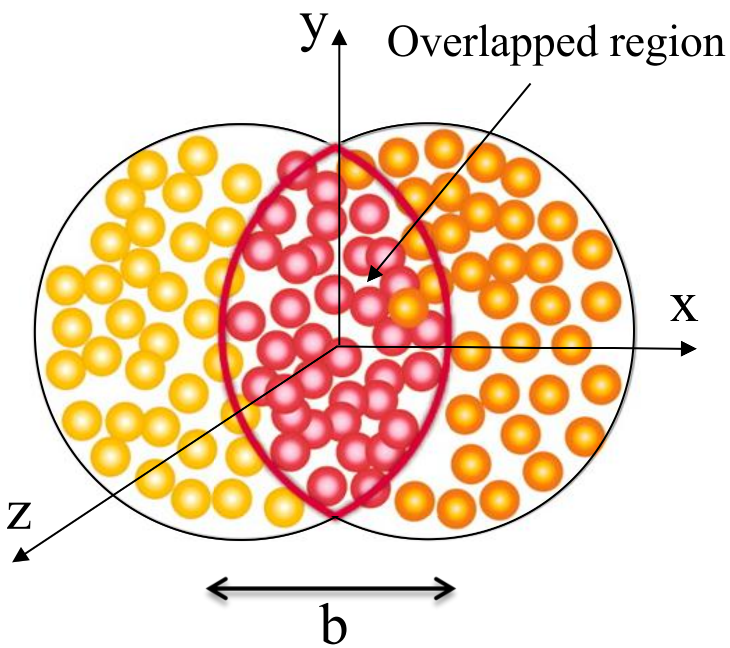
Introduction: Collective Flow

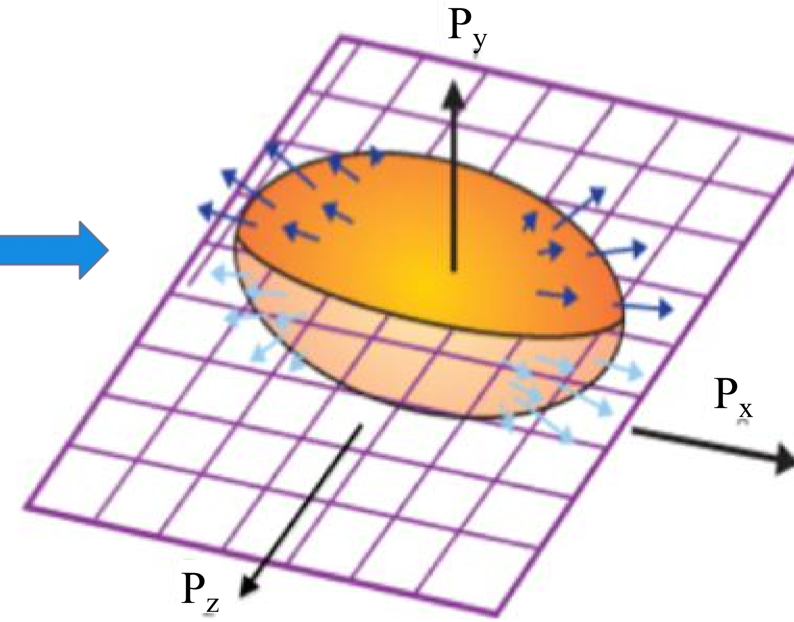


Interactions

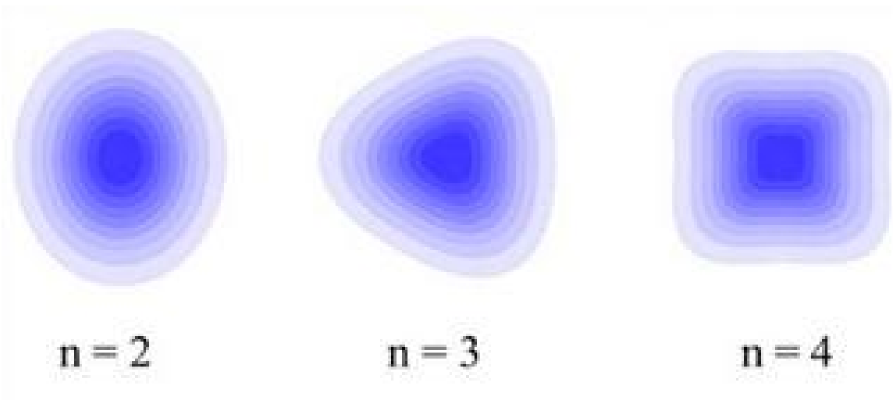
↓

Pressure(P)

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



Different flow harmonics



Elliptic flow (v_2)

Momentum space anisotropy in the azimuthal angle distribution of produced particles with respect to the reaction plane.

- **Sensitive to initial conditions of collisions**
- **Sensitive to transport properties (η/s) of system**
- **Probe for the particle production mechanism (e.g. quark coalescence)**

- *P. Klob, U. W. Heinz, Nucl. Phys. A715, (2003) 653c*

Flow Measurements

▶ **Single particle distribution:**

$$E\frac{d^3N}{dp^3} = E\frac{d^2N}{2\pi p_T dp_T d\eta}\left[1 + 2\sum_{n=1}^{\infty} v_n(p_T,\eta)\cos\{n(\phi-\Psi_n)\}\right]$$

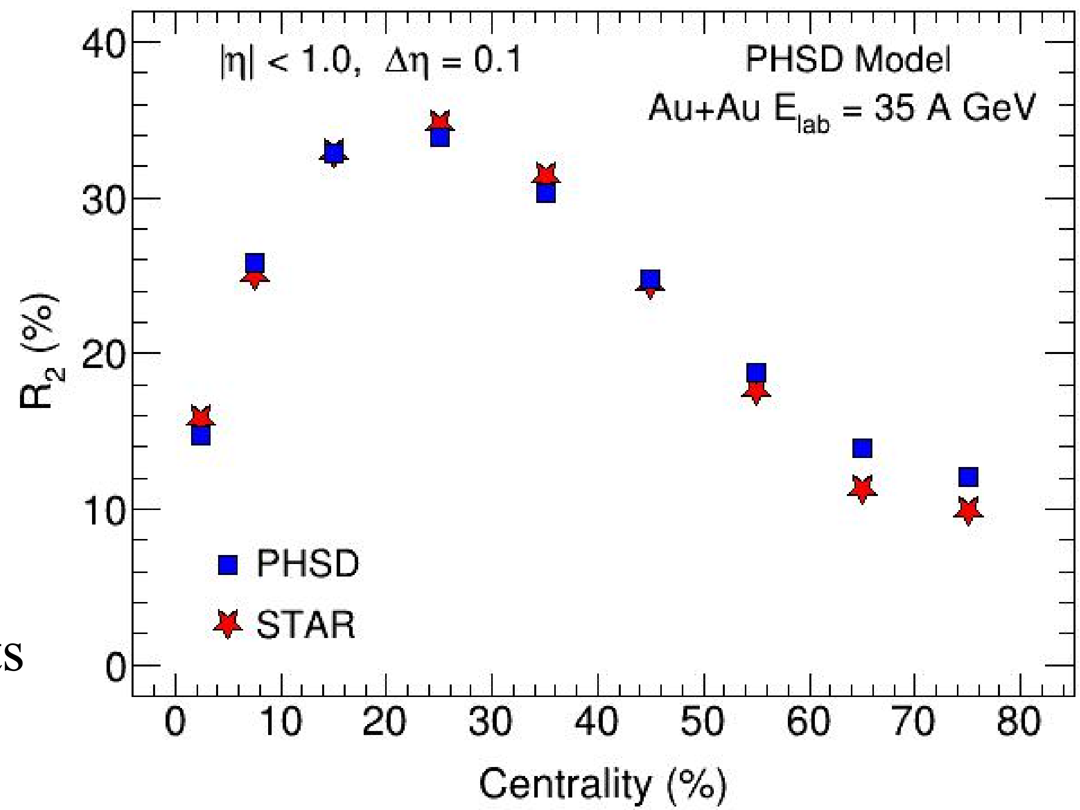
anisotropic flow $v_n = \langle\cos[n(\phi-\Psi_n)]\rangle$, Ψ_n = n^{th}-order reaction plane angle

▶ **η-sub event plane method**

$$\Psi_n = \frac{1}{n}\tan^{-1}\left(\frac{\sum_{i=1}^{M} w_i \sin(n\phi_i)}{\sum_{i=1}^{M} w_i \cos(n\phi_i)}\right)$$

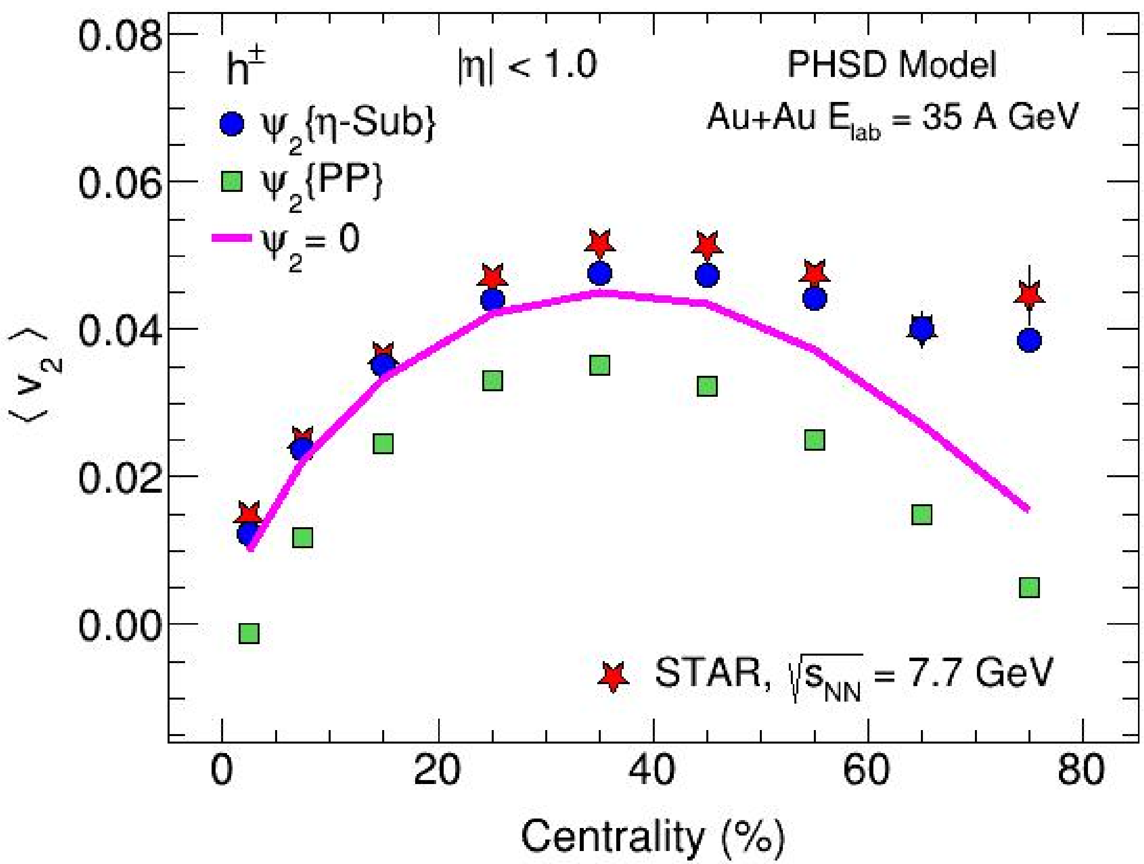
$$R_n = \sqrt{\langle\cos[n(\Psi_n^A - \Psi_n^B)]\rangle}$$

Event plane angle calculated in two sub-events A (0.05 < η < 1.0) and B (-1.0 < η < -0.05).



- *A.M. Poskanzer & S.A. Voloshin, Phys.Rev. C 58 (1998)*
- *L. Adamczyk et al. (STAR), Phys. Rev. C 88, 014902 (2013)*

Results: Charged Hadrons Elliptic Flow

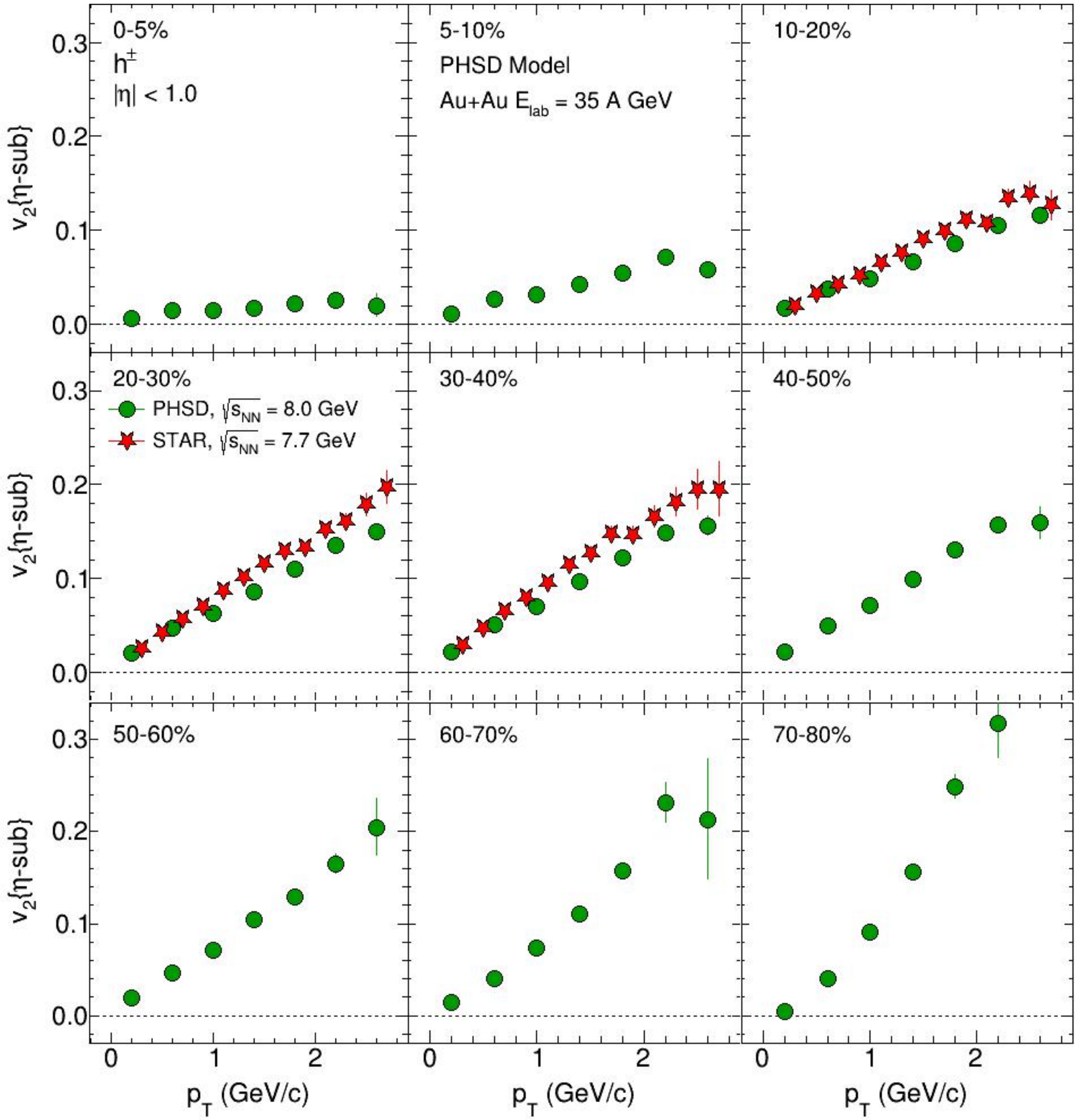


- Elliptic flow $<v_2>$ increases from central to pheripheral collisions showing strong centrality depdendence.

- $<v_2>$ with respect to $\psi_2\{\eta\text{-sub}\}$ in Au+Au collisions at E_{lab} = 35 A GeV from the PHSD model is similar to the Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7 GeV from the STAR experiment.

- *L. Adamczyk et al. (STAR Collaboration), Phys. Rev. C 86, 054908 (2012)*

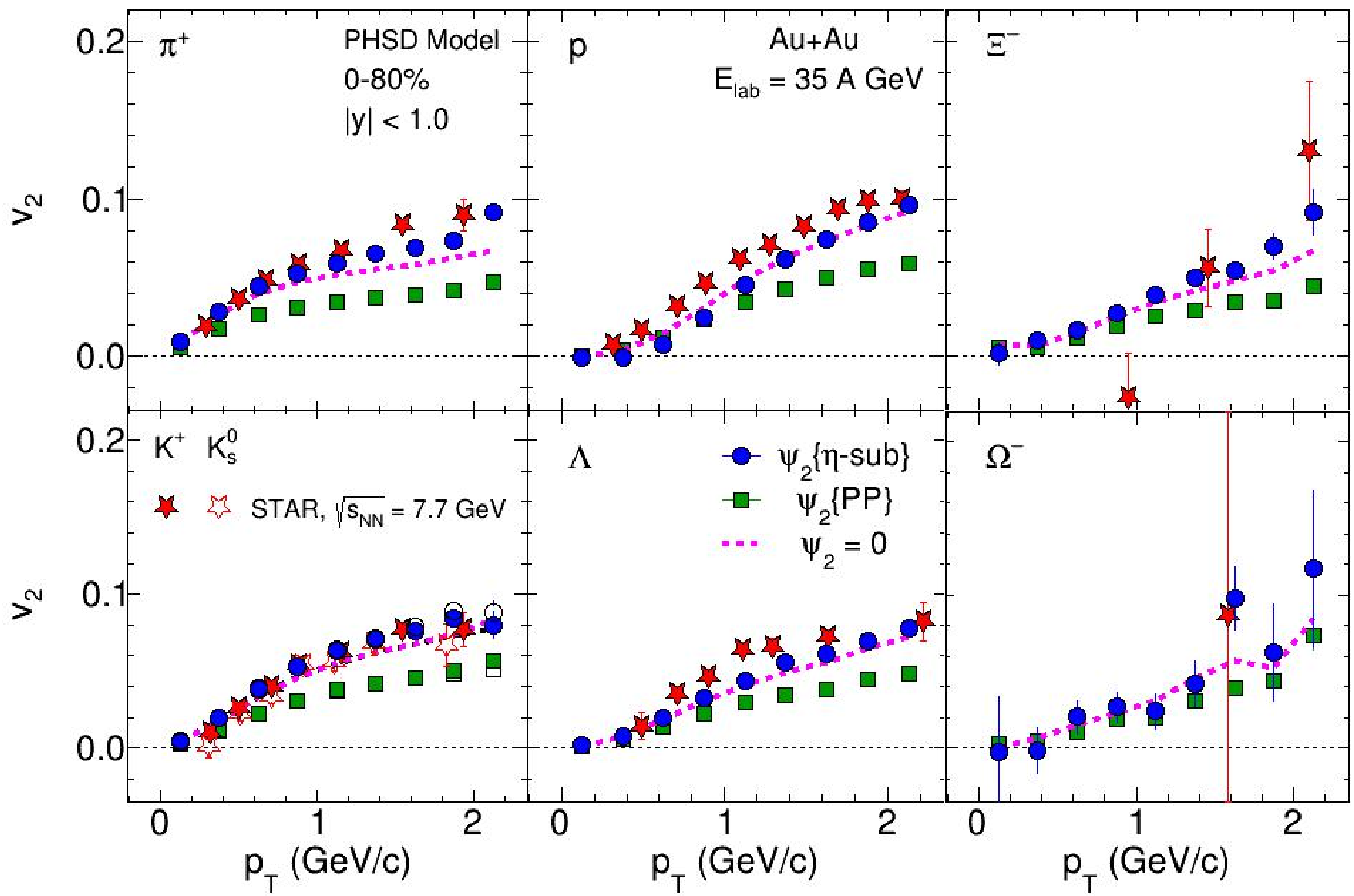
Differential $v_2(p_T)$



- Elliptic flow $v_2(p_T)$ increases monotonically with transverse momentum (p_T) till 2.0 GeV/c.
- Differential $v_2(p_T)$ also increases from central to pheripheral collisions showing strong centrality depdendence.
- Differential $v_2(p_T)$ in Au+Au collisions at E_{lab} = 35 A GeV from the PHSD model is similar to the Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7 GeV from the STAR experiment.

- *L. Adamczyk et al. (STAR Collaboration), Phys. Rev. C 86, 054908 (2012)*

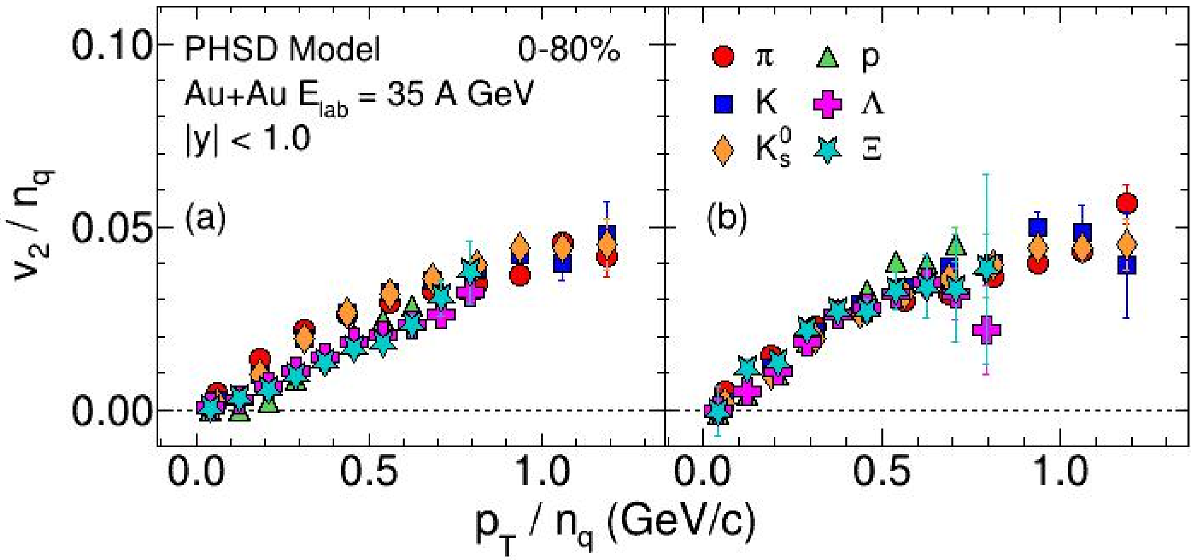
Results: Identified Hadrons Elliptic Flow



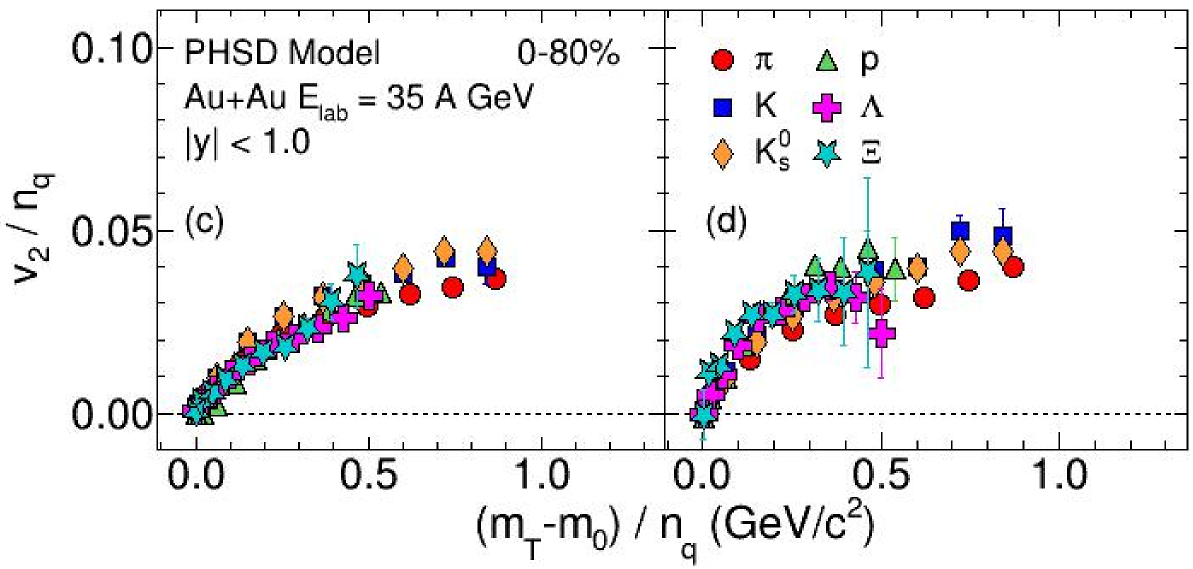
- Identified hadron v_2 (p_T) in Au+Au collisions at E_{lab} = 35 A GeV from the PHSD model calculated with respect to the event plane and participant plane angle is compared to the published STAR experimental results from Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7 GeV.

- *L. Adamczyk et al. (STAR Collaboration), Phys. Rev. C 88, 014902 (2013)*

NCQ Scaling



- **Hydrodynamics flow:**
  - large v_2 for lighter mass particles compare to the heavier mass particles consistent with the hydrodynamics flow.
  - Mass ordering of v_2 below $p_T < 1.5$ GeV/c indicates effect of radial flow.



- **Hadronisation via quark coalescence:**
  - Elliptic flow v_2 of baryons > mesons above intermediate $p_T \approx 1.5$ GeV/c. v_2 scaled by number of constituent quarks (n_q) follows a single curve.
  - The NCQ scaling of identified hadron v_2 suggests quark coalescence as dominate particle production mechanism.

Summary

- Inclusive and identified hadron elliptic flow v_2 at mid-rapidity measured using eta-sub event plane method is presented for Au+Au collisions at E_{lab} = 35 A GeV from the PHSD model.

Sensitive to initial conditions

- v_2 increases from central to pheripheral collisions showing strong centrality dependence indicates senstivity towards the initial conditions.
- Elliptic flow v_2 measured with respect to the participant plane angle is lower compared to the $\psi_2\{\eta\text{-sub}\}$ also indicate effect of initial condition of the colliding system.

Hydrodynamic flow and partonic collectivity

- Mass ordering of v_2 at low $p_T < 1.5$ GeV/c suggest hydrodynamic flow of identified hadrons.
- Number of constituent quarks scaling of v_2 at intermediate p_T indicates parton coalescence as dominate particle production mechanism.

Thank you!

Backup

centrality selection

- Centrality Selection is based on reference multiplicity (N_{ch} in |eta| < 0.5) in the PHSD model same as in case of the experimental measurements.