Multi-strange hadron elliptic flow in $\sqrt{s_{NN}}$ = 200 GeV Au + Au collisions at RHIC-STAR

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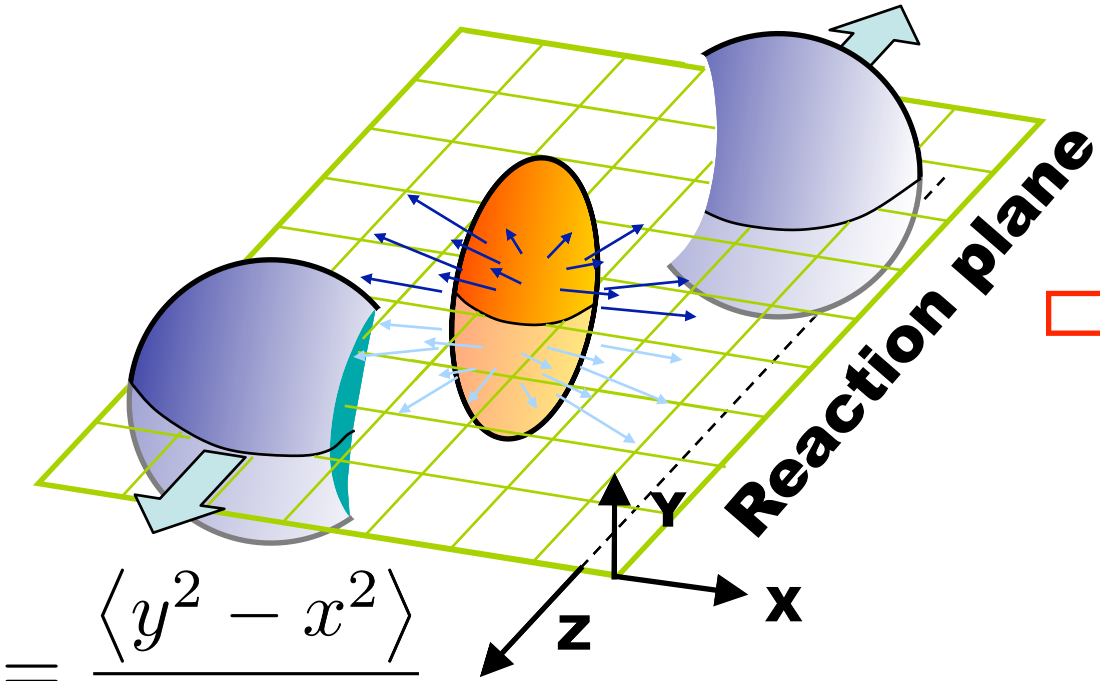
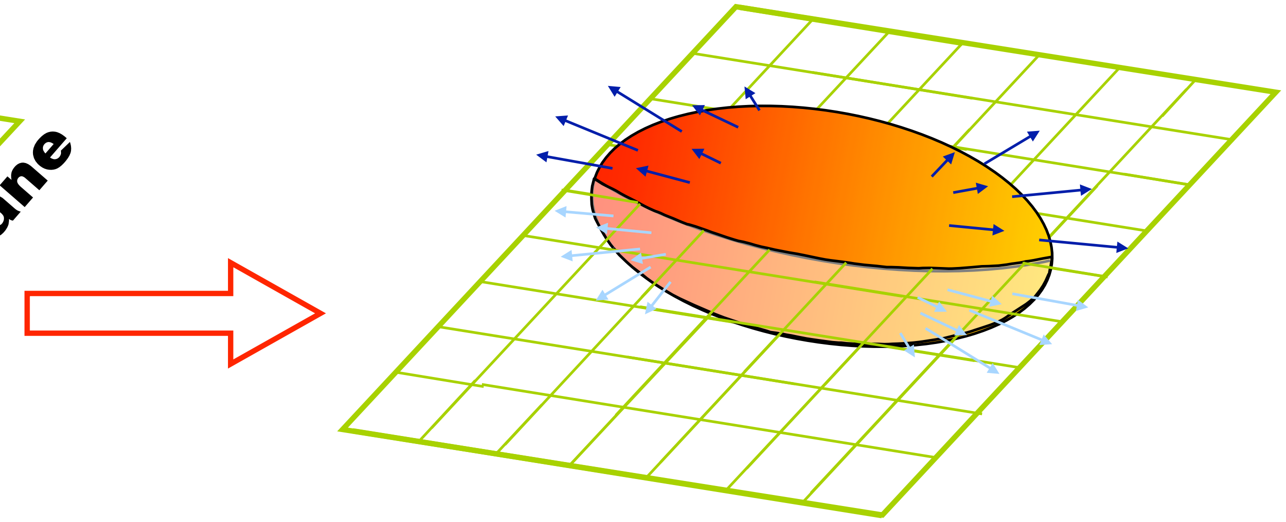
BERKELEY LAB

Why elliptic flow ?



$$\varepsilon = \frac{\langle y^2 - x^2 \rangle}{\langle y^2 + x^2 \rangle}$$



$$v_2 = \left\langle \frac{p_x^2 - p_y^2}{p_x^2 + p_y^2} \right\rangle = \langle \cos \phi' \rangle$$

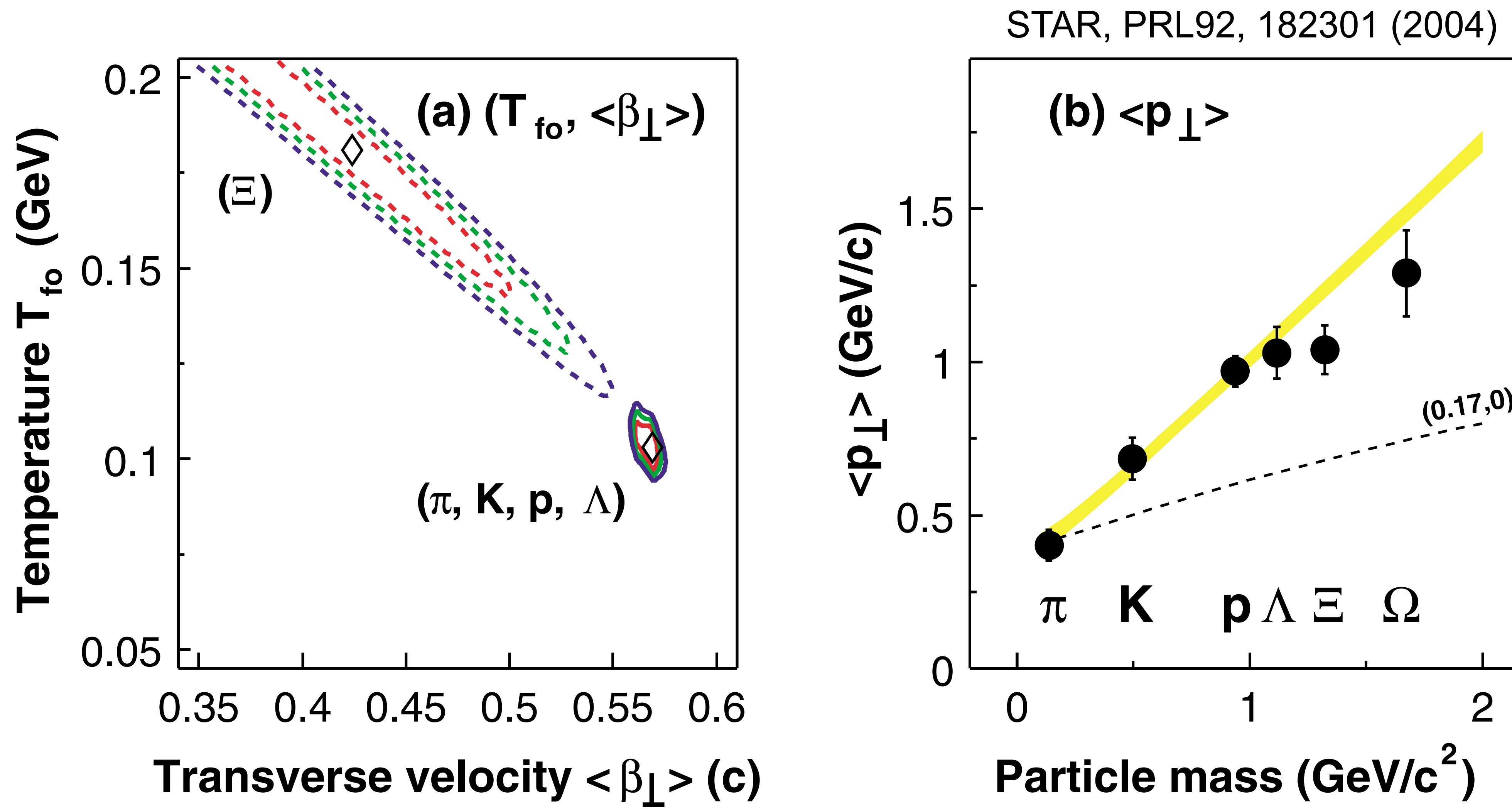
- One of the most sensitive probes to the partonic EOS in the early stage of heavy ion collisions

✓ Initial geometry overlap (eccentricity ε) → final momentum anisotropy (elliptic flow)

✓ Pressure gradient drives flow

➡ Sensitive to the (partonic) equation of state, d. o. f., and transport coefficients

Why multi-strange hadrons ?



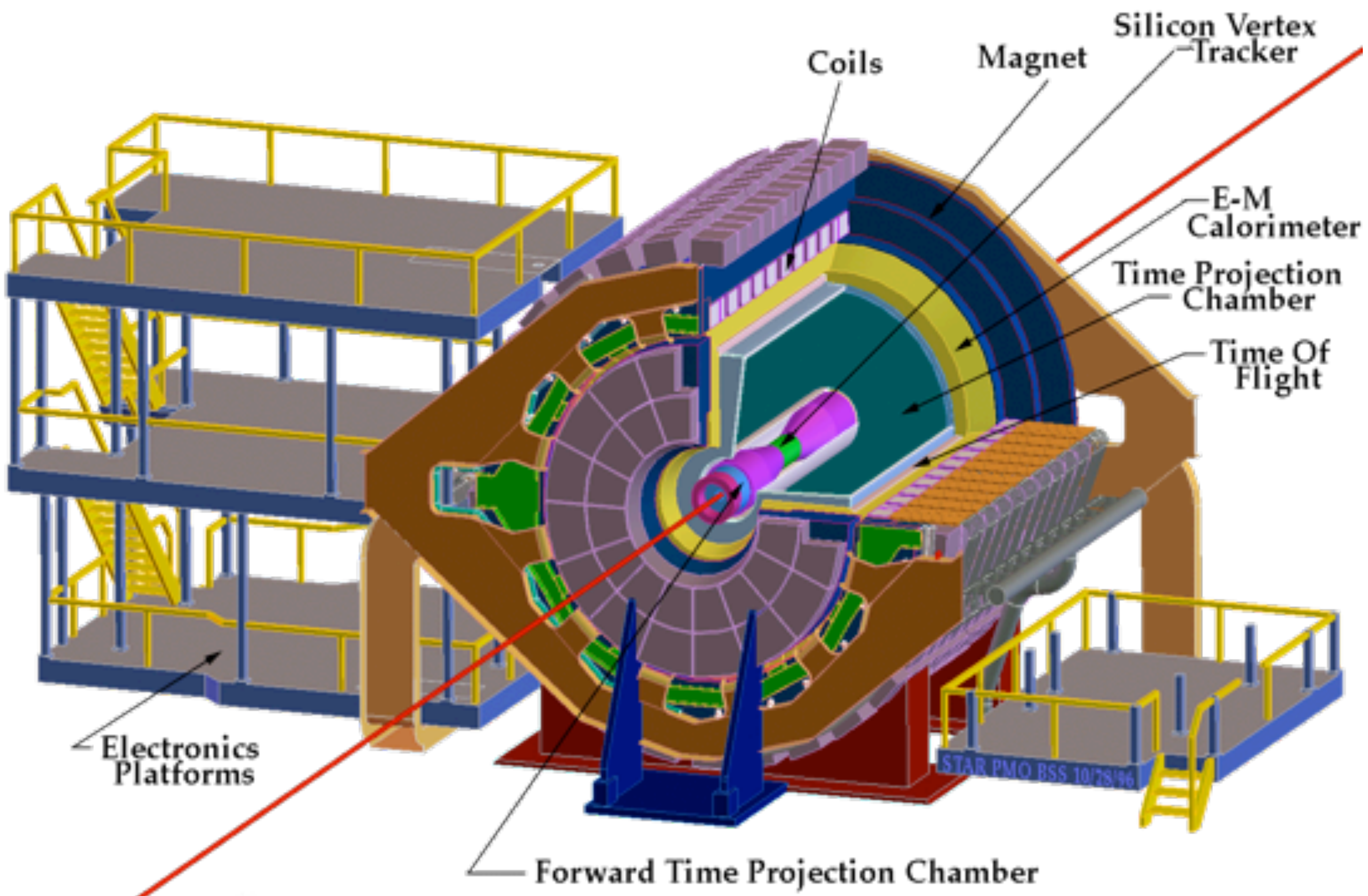
- Probe for the partonic stage

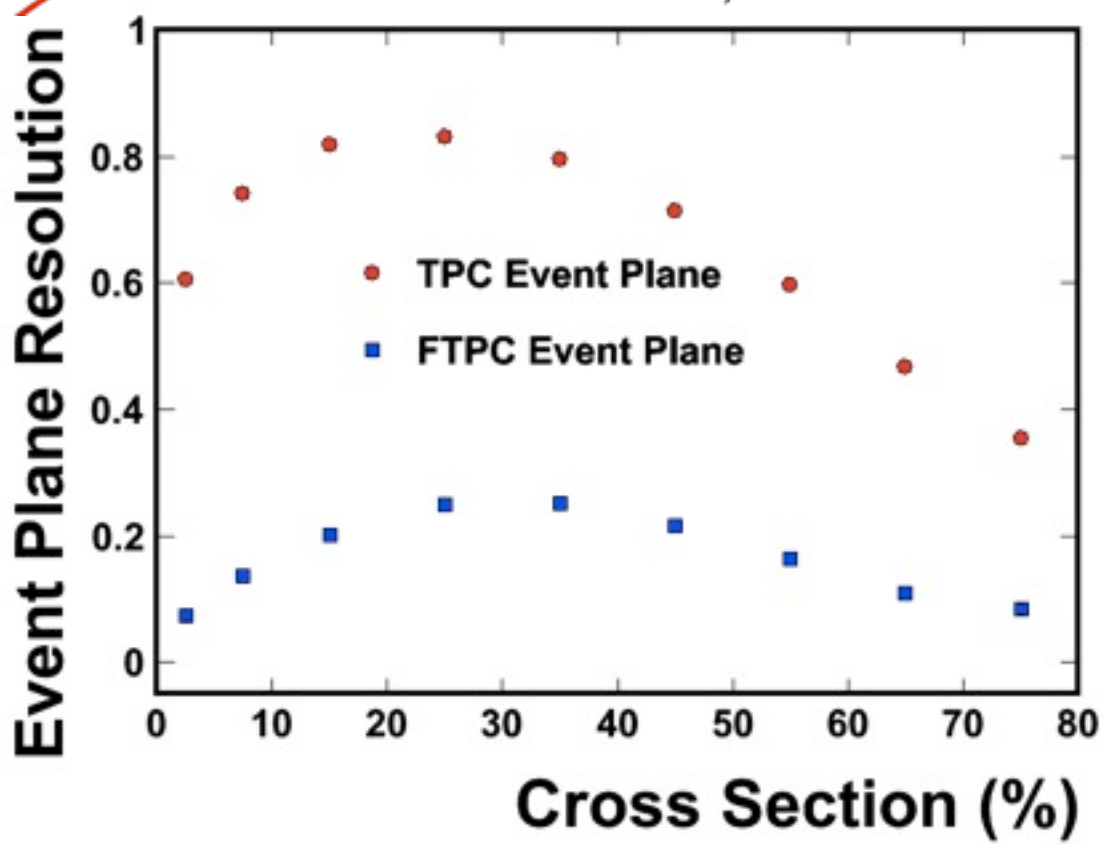
✓ Smaller $\langle\beta_\perp\rangle$, larger T_{fo} (~ T_{ch}) and deviation of $\langle p_T\rangle$

➡ Radial flow is cumulative → less time to develop radial flow

➡ freeze-out earlier than other light hadrons

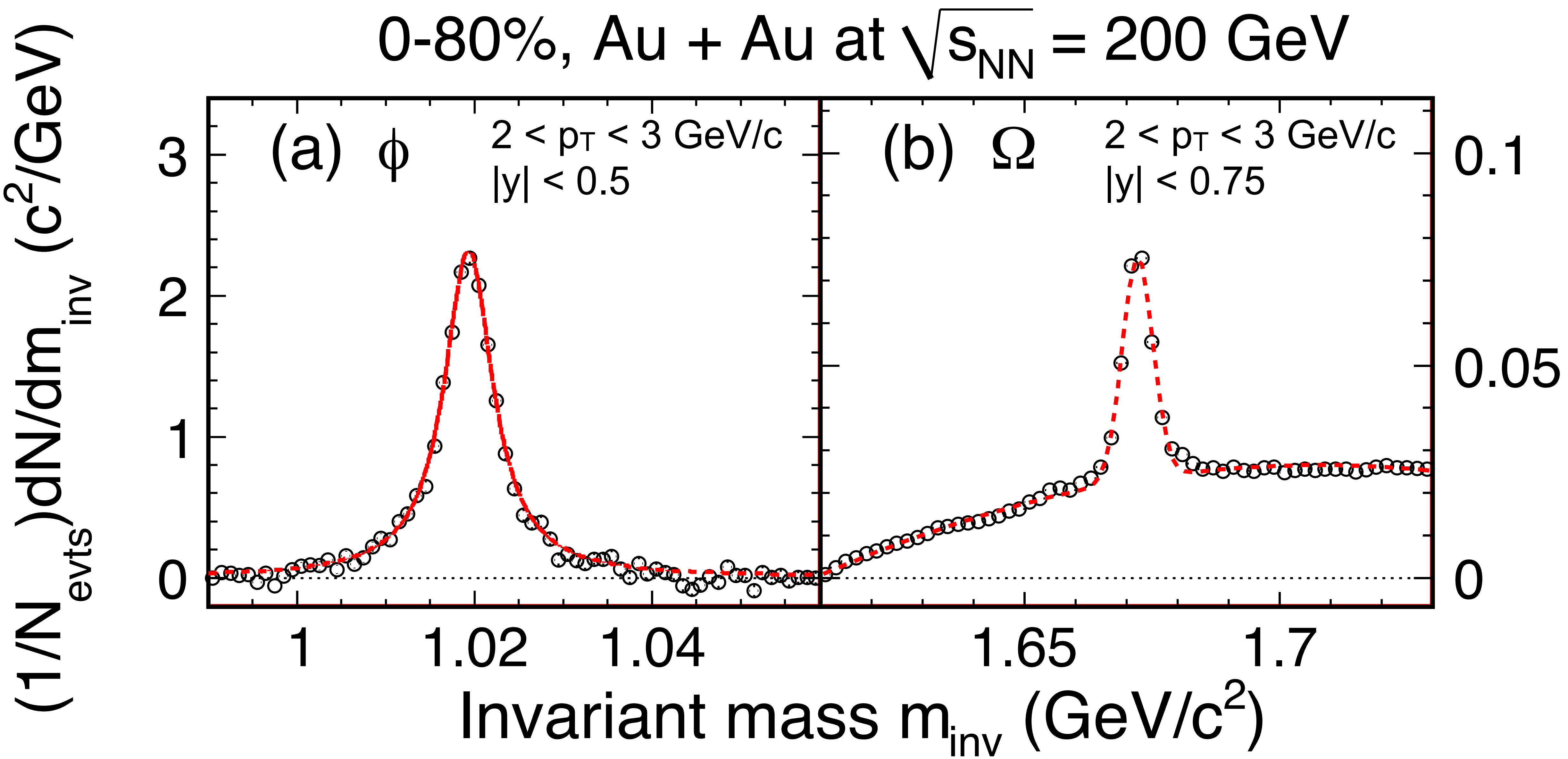
Data set, analysis method





- TPC
  - ✓ Full azimuth, $|\eta| < 1$
- Year 7 data
  - ✓ ~ 60 M minimum bias events in $|v_z| < 30$ cm
    - Vertex Position Detector ($|\eta|$ ~ 4-5) + Zero Degree Calorimeter trigger
  - ✓ Centrality from uncorrected $dN_{ch}/d\eta$ in $|\eta| < 0.5$
  - ✓ Event plane methods
    - TPC event plane due to the limited statistics for multi-strange hadrons
  - ✓ Particle identification
    - dE/dx in the TPC
    - Secondary vertex finder for Ξ, Ω

Signal extraction



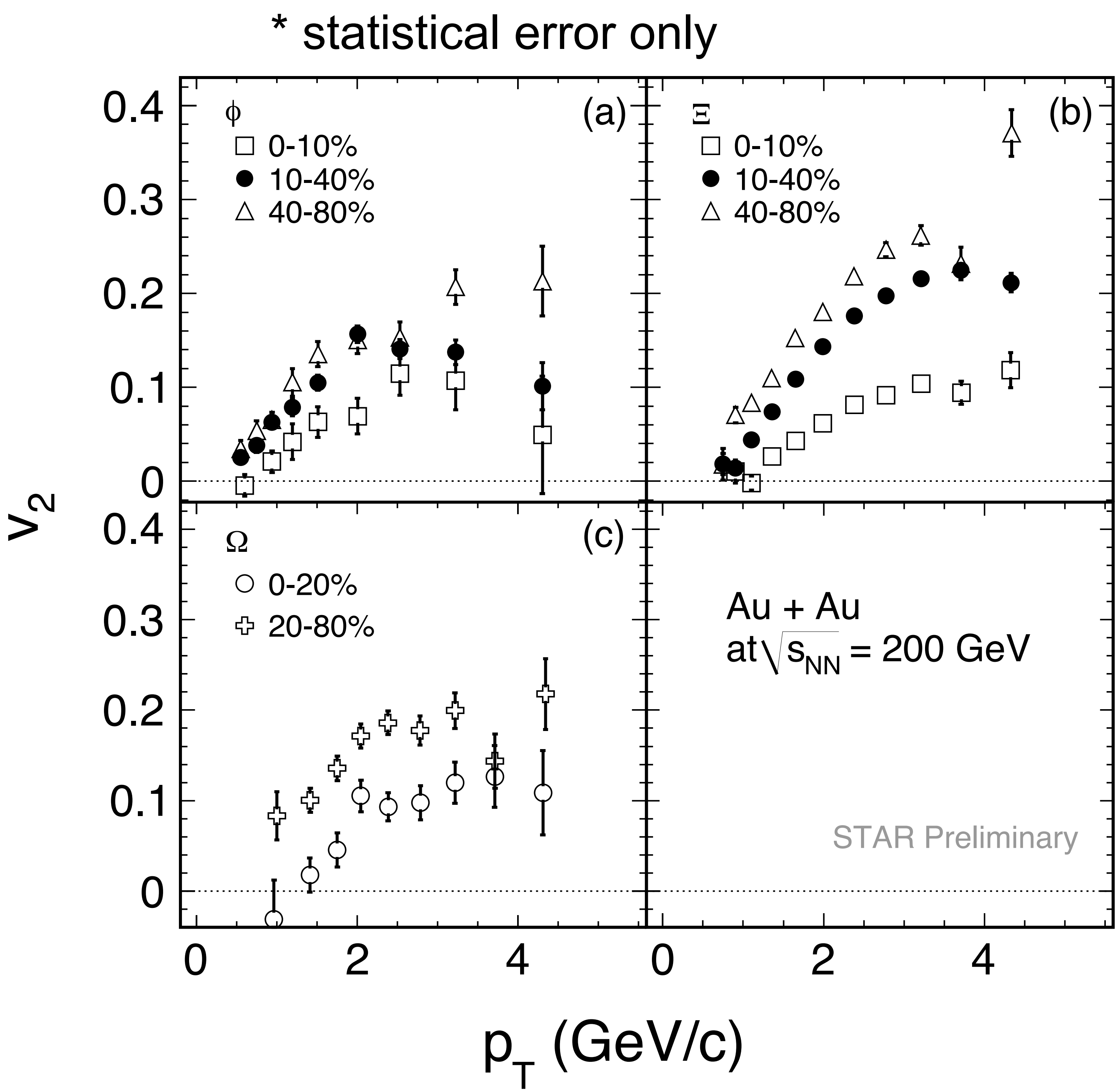
- Clear signal for φ and Ω

✓ φ : Breit-Wigner + linear fit

- after combinatorial background subtraction by event mixing

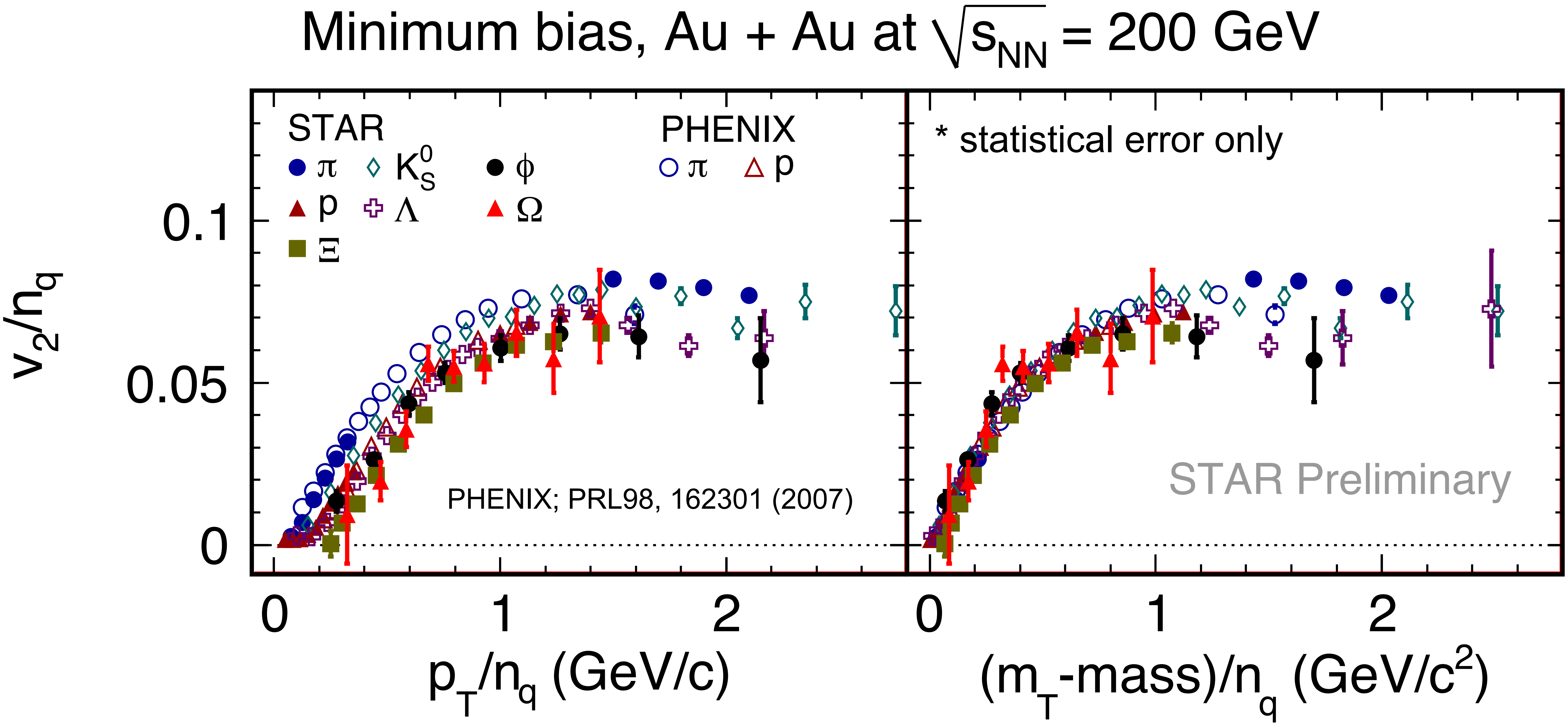
✓ Ω : Gaussian + 2nd order polynomial fit

Large v_2 for multi-strange hadrons



- v_2 increases from central to peripheral
  - ✓ driven by eccentricity
- The v_2 for multi-strange hadrons is as large as other light hadrons
- Systematic error
  - ✓ Non-flow contributions ~ 15-20%
    - from PRC77, 054901 (2008)
  - ✓ Other sources ~ 5-10%
    - Background evaluation, track selection criteria

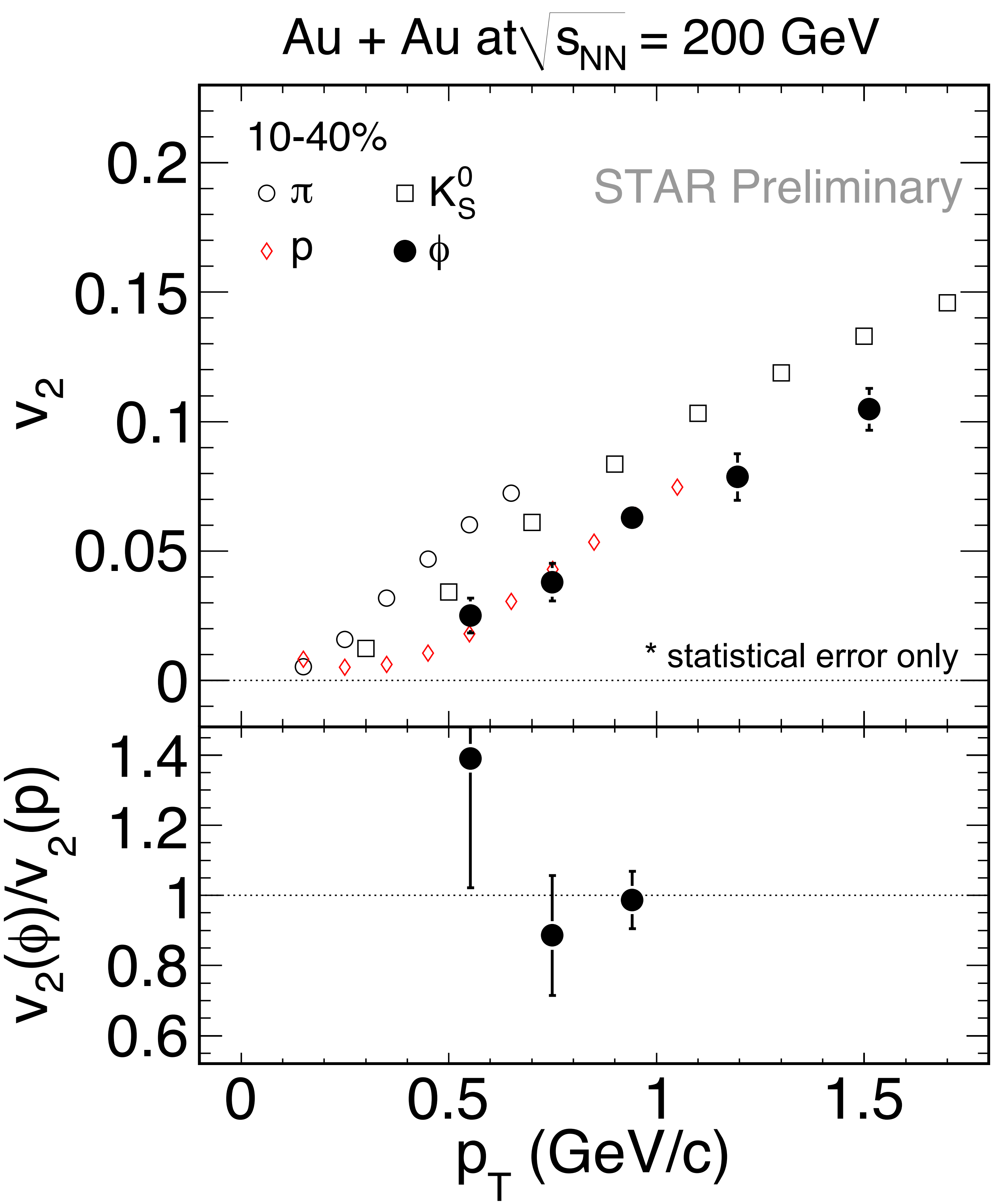
Number of quark scaling of v_2



- NQ scaling works up to p_T/n_q or $(m_T\text{-mass})/n_q$ ~ 1-1.5 GeV/c

✓ Partonic collectivity → Deconfinement

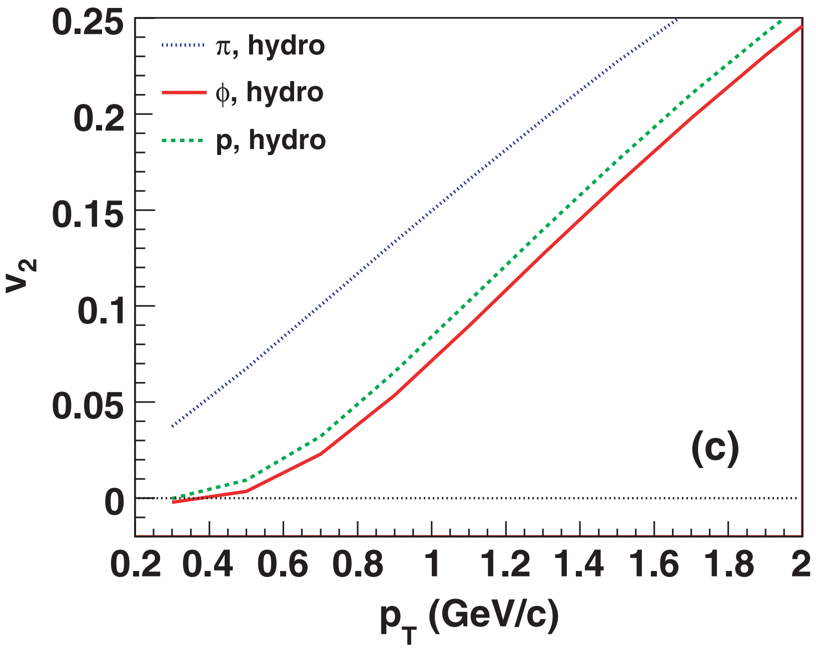
ϕ meson v_2 at low p_T



- Radial flow boosts heavier hadrons to higher p_T
  - ✓ smaller v_2 for heavier hadrons for a given p_T
  - ✓ $v_2(\pi) > v_2(K) > v_2(p)$
- Mass ordering from ideal hydrodynamics
  - ✓ $v_2(p) > v_2(\phi)$
- Data: $v_2(\phi) \sim v_2(p)$
  - ✓ Why ?

Effect of hadronic rescattering

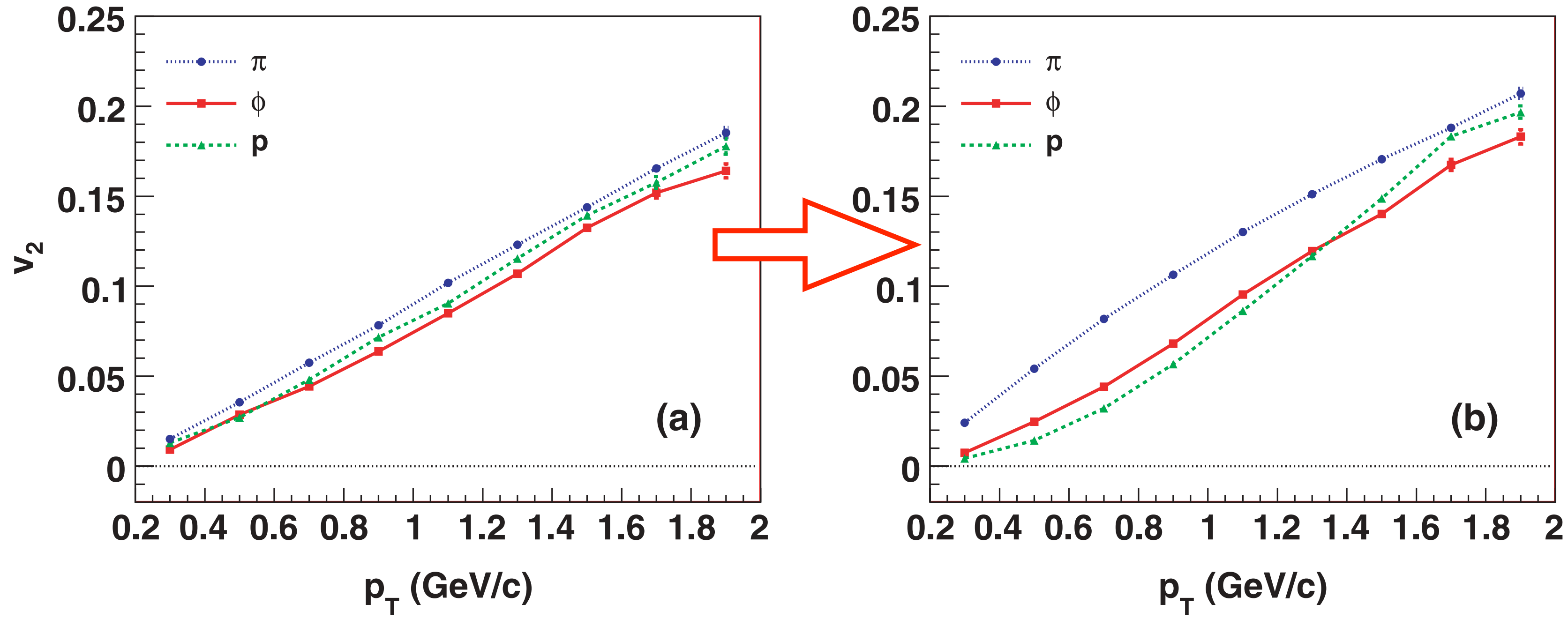
at kinetic freeze-out



Ideal hydro

at chemical freeze-out

at kinetic freeze-out



Ideal hydro
+ hadron cascade

T. Hirano et al.,
Phys. Rev. **C**77, 044909 (2008)

- Two different simulations
  - ✓ (c) Pure ideal hydro down to T = 100 MeV
  - ✓ (a), (b) Ideal hydro + hadron cascade JAM
- Break mass ordering of ϕ meson due to
  - ✓ small hadronic cross section + hadronic rescattering effect on v_2

Conclusions

- Multi-strange hadron v_2 have been measured in Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV
  - ✓ v_2 increases from central to peripheral collisions
  - ✓ as large as other lighter hadrons
- Number of quark scaling holds in $p_T/n_q < 1.5$ GeV/c
  - ✓ Partonic collectivity
- v_2 of ϕ mesons is consistent with that of protons within statistical errors in $p_T < 1$ GeV/c
  - ✓ comparison of ϕ meson v_2 to proton v_2 is useful for understanding the effect of hadronic stage