Partonic collectivity

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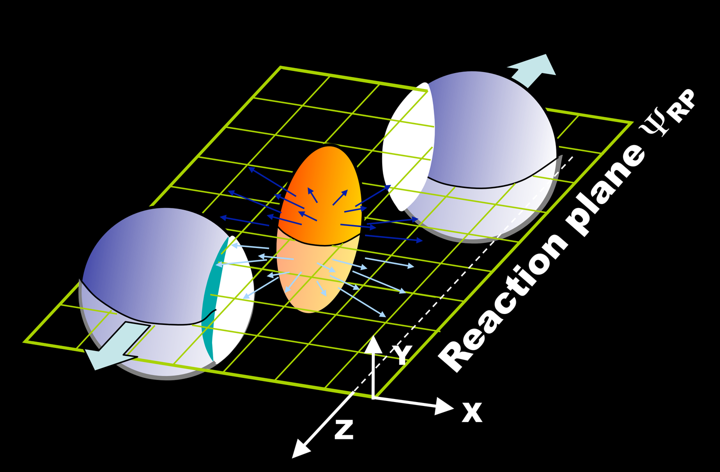
Goal:

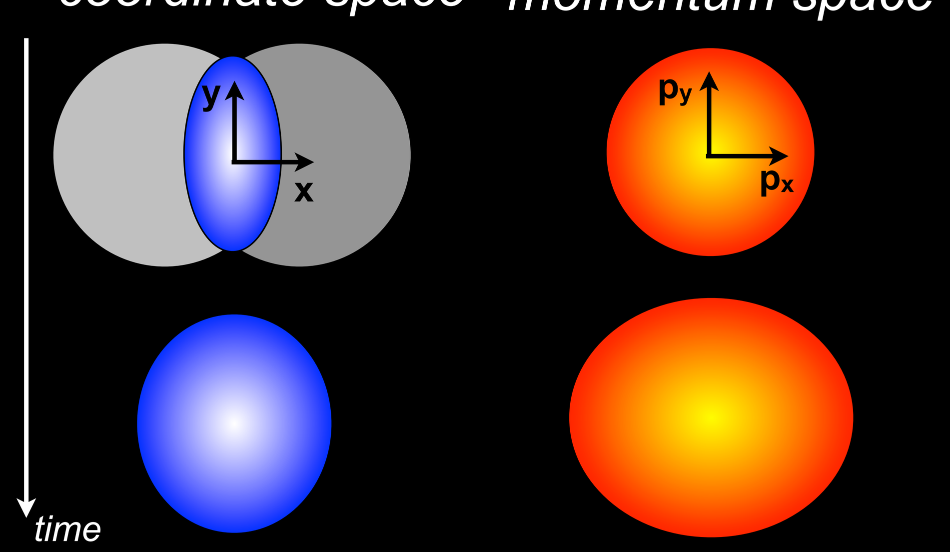
Hadronization by quark coalescence predicts that azimuthal anisotropy (v_2) for baryons (mesons) is enhanced by a factor of 3 (2) compared to that for partons (***Number of Constituent Quark scaling***). Predicted ordering of v_2 strongly relies on the assumption that deconfinement is achieved in heavy ion collisions. Therefore, experimental observation of the NCQ scaling may indicate the formation of a Quark-Gluon Plasma phase in the early stage of heavy ion reactions.

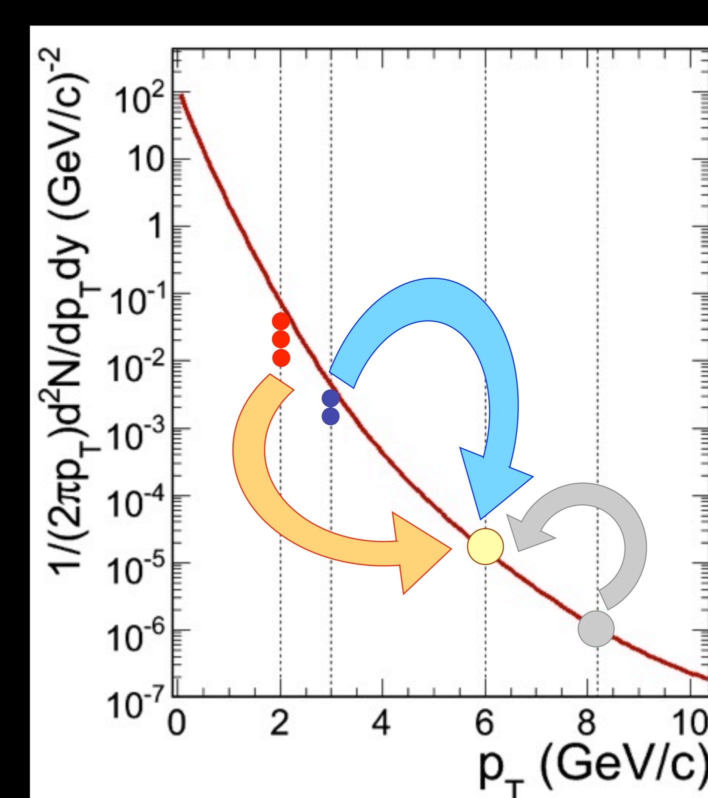
The goal of this study is to verify NCQ scaling of v_2 by precision measurements of v_2 for identified hadrons as a function of collision centrality, and transverse momentum p_T. It is observed that multi-strange hadrons (hadrons that contain 2 or 3 strange quarks) show smaller v_2 than other strange hadrons in peripheral 30-80% centrality. Results may indicate that partonic phase is less dominant at peripheral collisions. Results for ϕ mesons and protons are compared to predictions from ideal hydrodynamical with hadronic cascade model. It is observed that the ordering of v_2 at low p_T is consistent with the effect of hadronic rescattering.

1. Anisotropic flow and quark coalescence hadronization



$v_2 = \langle \cos [2(\phi - \Psi_{RP})] \rangle$





S. A. Voloshin, NPA**715**, 379 (2003)
D. Molnar, S. A. Voloshin, PRL**91**, 092301 (2003)

$$\frac{dN_B}{d^2p_\perp}(\vec{p}_\perp) = C_B(p_\perp)\left[\frac{dN_q}{d^2p_\perp}(\vec{p}_\perp/3)\right]^3,$$

$$\frac{dN_M}{d^2p_\perp}(\vec{p}_\perp) = C_M(p_\perp)\left[\frac{dN_q}{d^2p_\perp}(\vec{p}_\perp/2)\right]^2,$$

$$v_{2,M}(p_\perp) \approx 2v_{2,q}\left(\frac{p_\perp}{2}\right), \quad v_{2,B}(p_\perp) \approx 3v_{2,q}\left(\frac{p_\perp}{3}\right) \quad (\text{if } v_2 \ll 1)$$

Space-momentum correlation

- Interactions convert **initial coordinate space anisotropy** into **final momentum anisotropy**

Sensitive to properties of produced matter

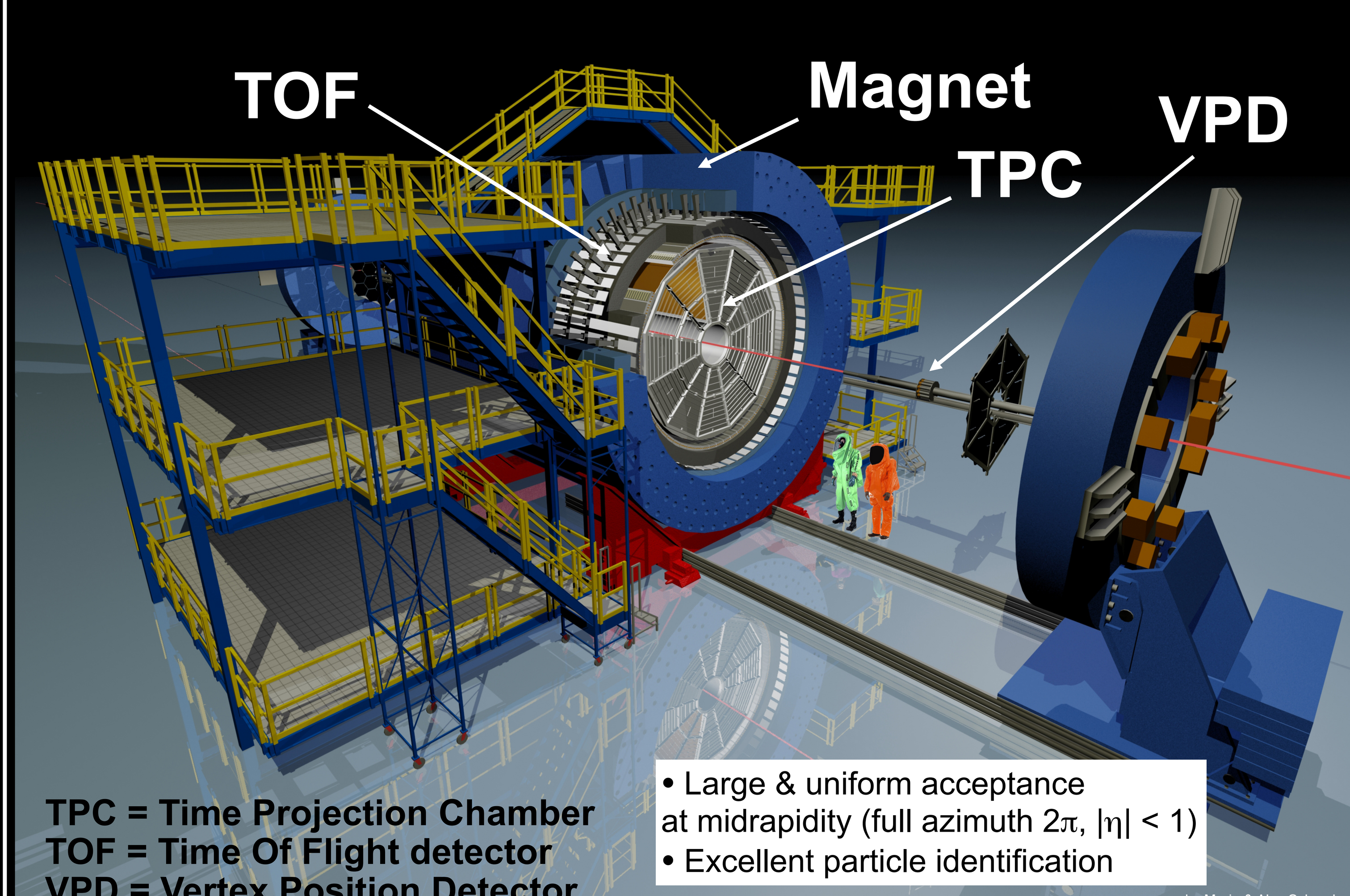
- Equation of State, transport coefficients (η/s)

Number of Constituent Quark (NCQ) scaling of v_2

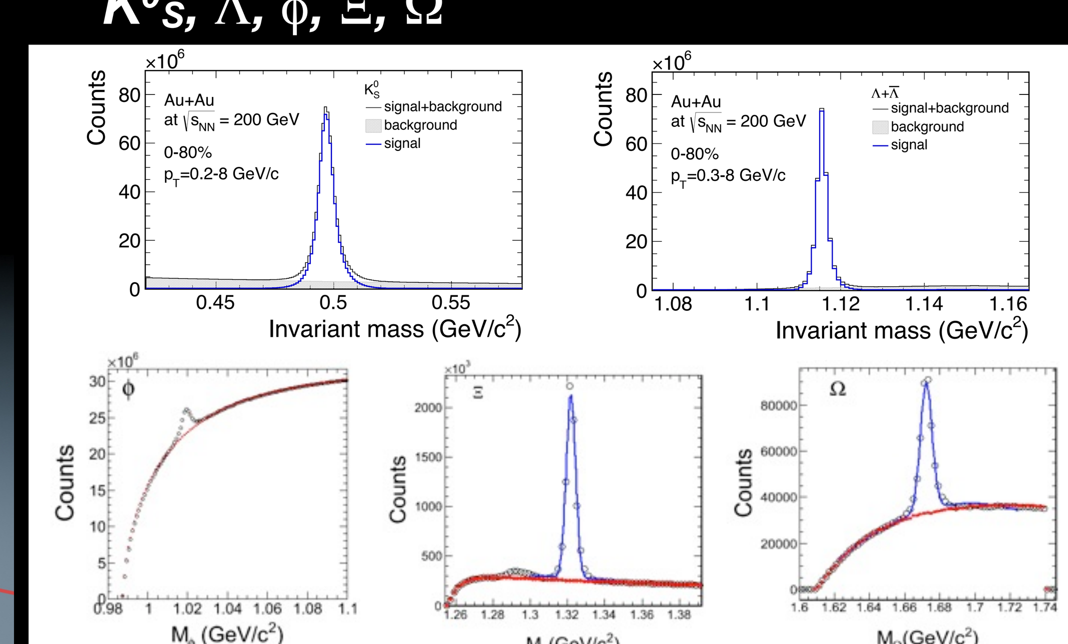
- assume quark degrees of freedom is dominant at hadronization

2. STAR Detector, particle identification, event plane method

Solenoidal Tracker At RHIC

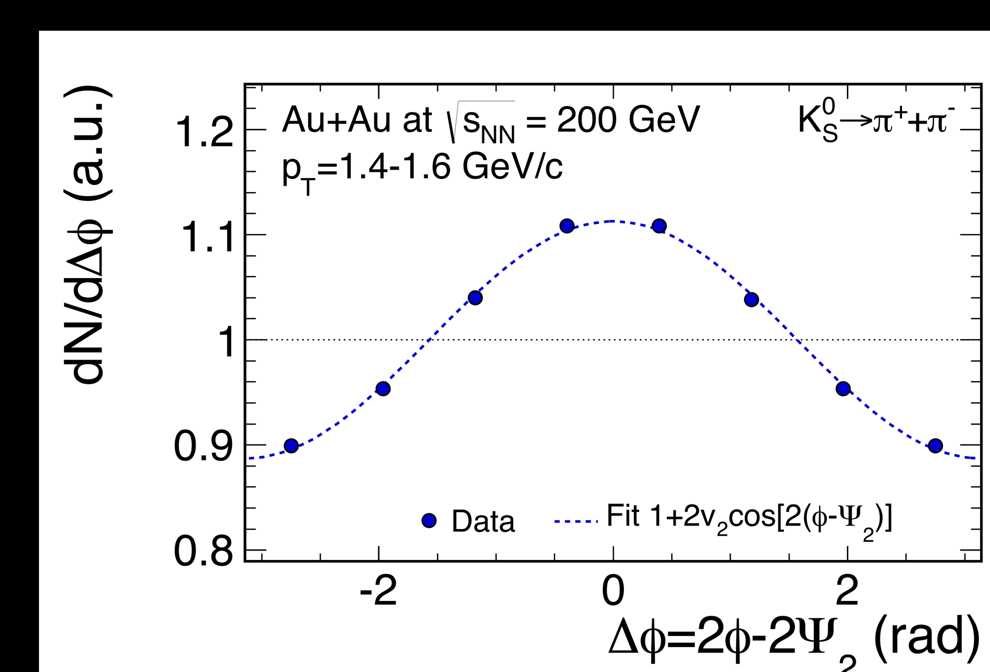


K^0_S, Λ, ϕ, Ξ, Ω



Particle identification by TPC+TOF

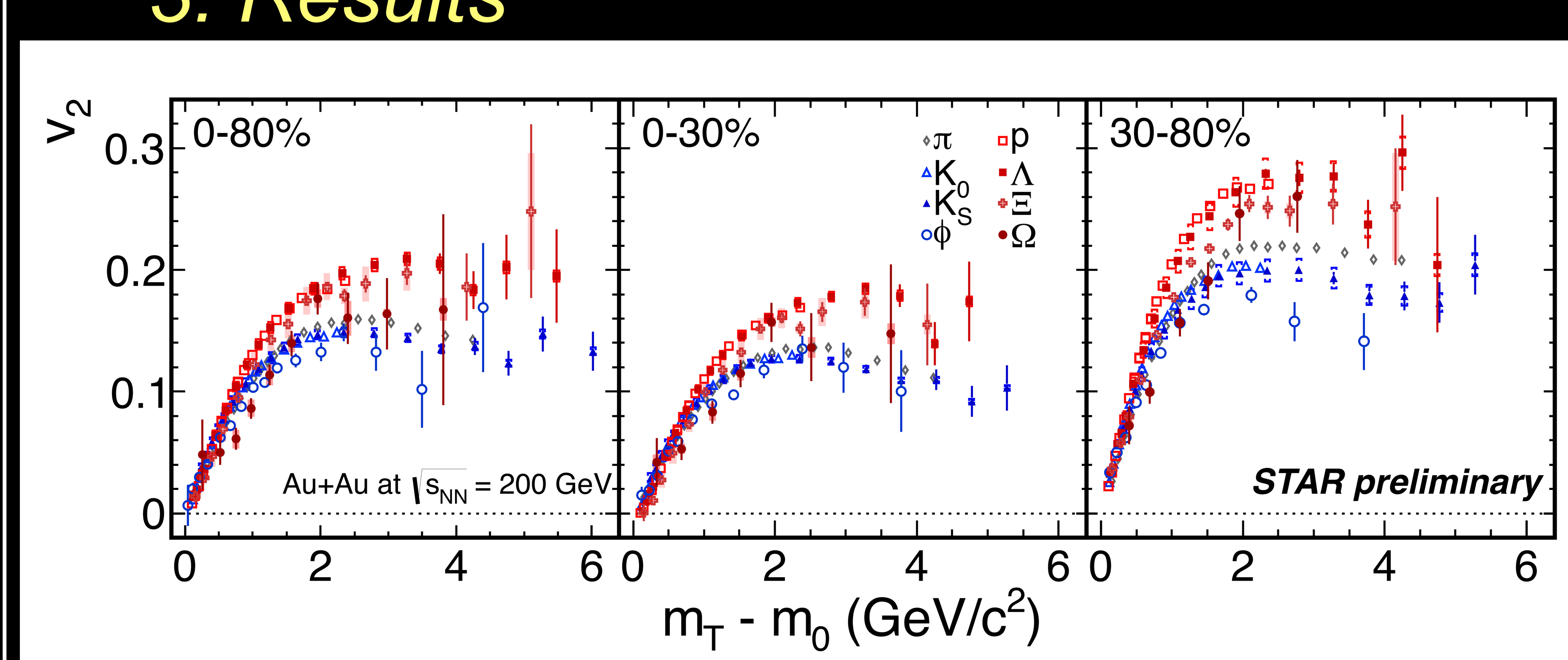
- Specific energy loss *dE/dx* in the TPC
- Flight time in the TOF
- Topological reconstruction for weak decay
- Reconstruct invariant mass distributions



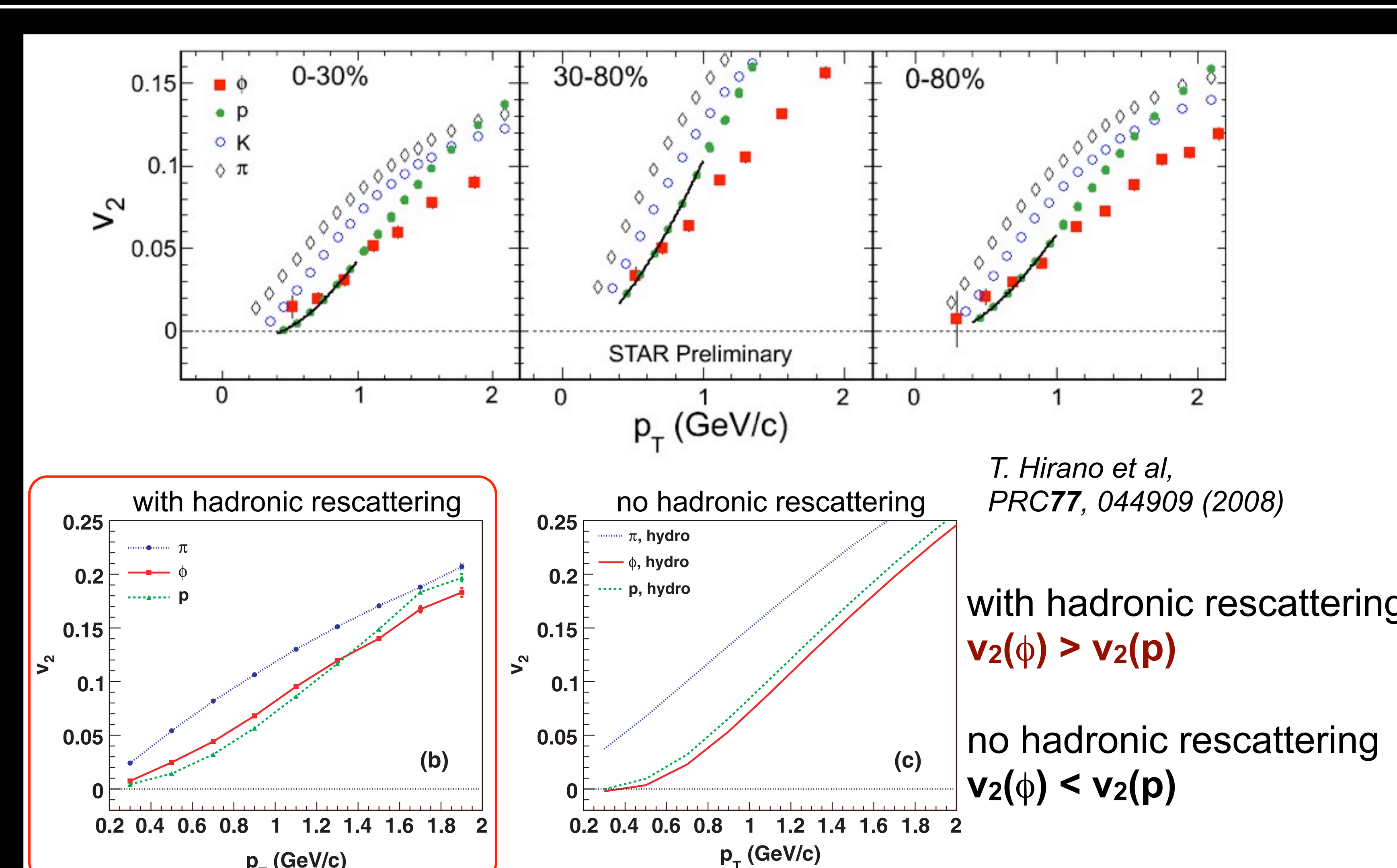
Event plane method

- Estimate reaction plane by measured momentum anisotropy (event plane)
- Measure v_2 with respect to the event plane for each p_T, centrality bin

3. Results



- **Clear baryon and meson branches in central 0-30%**
  - NCQ scaling holds within ±10%
- **Deviation of multi-strange hadrons in peripheral 30-80% centrality**
  - $v_2(\phi) < v_2(K^0_S)$, $v_2(\Xi) \sim v_2(\Omega) < v_2(\Lambda)$ at m_T-m_0 > 1 GeV/c^2
  - Partonic phase may be less dominant at peripheral collisions



Consistent with hadronic rescattering effect as predicted by one of hydrodynamical models

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