Elliptic Flow from Pairs and Quadruplets in Au+Au Collisions at $\sqrt{s_{NN}}$ =130 GeV

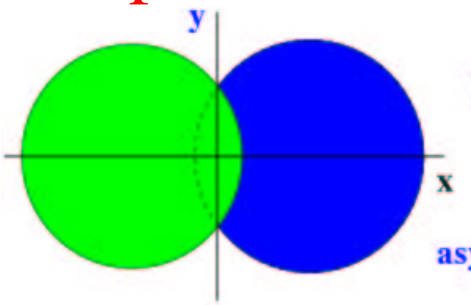
- Motivations
- Four particle correlations
- Centrality dependence of elliptic flow and model comparisons

Aihong Tang, STAR Collaboration

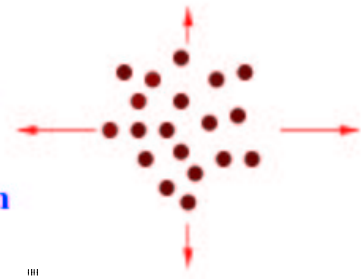
Workshop on interferometry and elliptic flow at RHIC
June 14−15, 2002
Brookhaven National Laboratory

You can find the content of this talk in e−print nucl−ex/0206001

Elliptic flow – theoretical motivation



In region of overlap asymmetry of spatial distribution -> asymmetry of momentum distribution

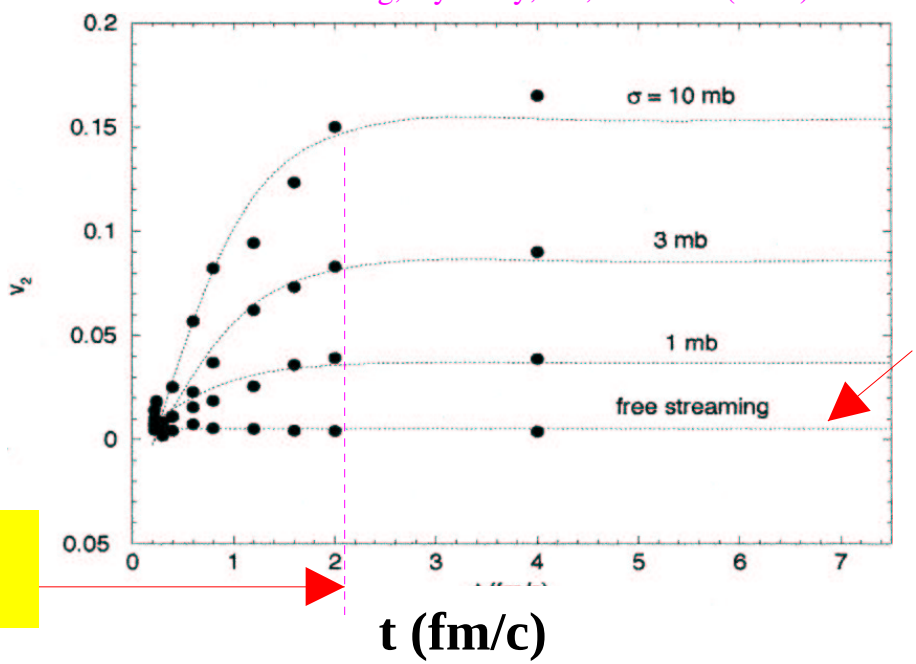


$$\epsilon = \frac{y^2 - x^2}{y^2 + x^2}$$

$$v_2 = \frac{p_x^2 - p_y^2}{\langle p_x^2 \rangle + \langle p_y^2 \rangle}$$

Sensitive to the physics of constituent interactions at early time

Zhang, Gyulassy, Ko, PL B455 (1999) 45



Free–streaming does not convert spatial anisotropy to momentum anisotropy

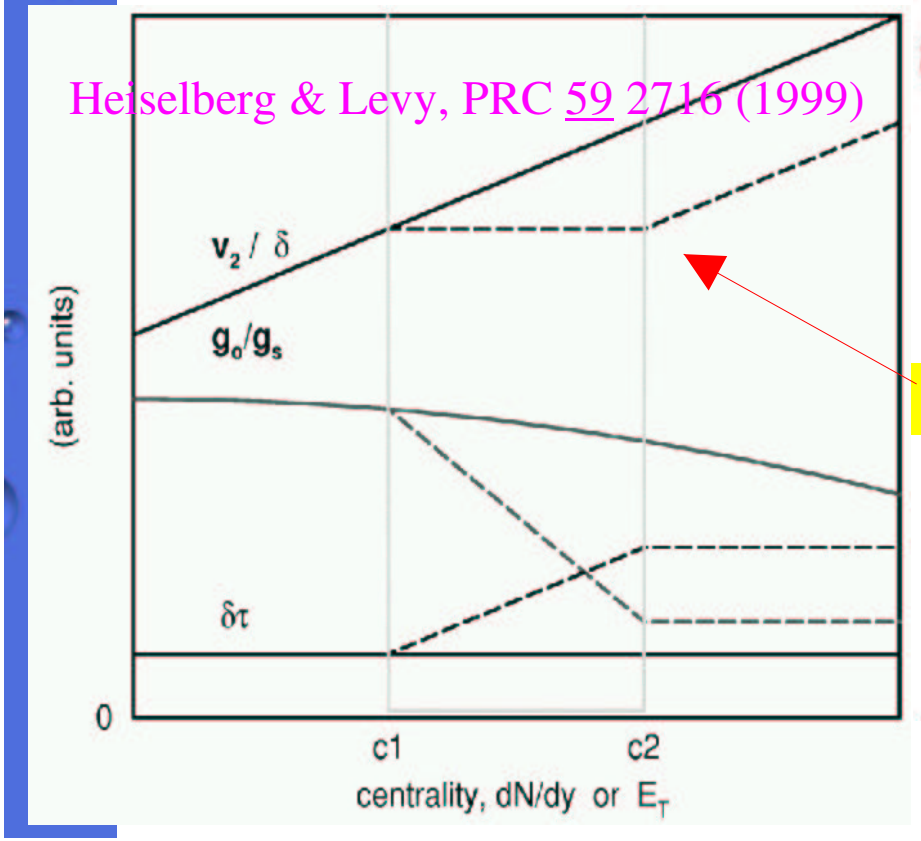
Developed early (t < 2 fm/c)

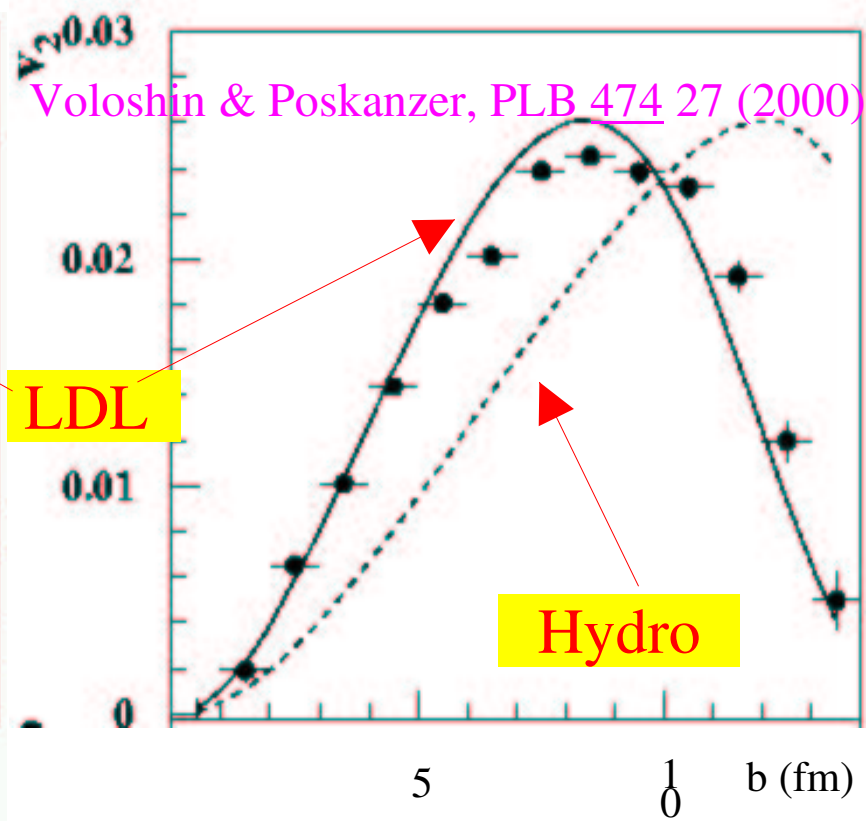
Elliptic flow – theoretical motivation

- v_2/ϵ Approx. independent of b. [hydro model with const. sound speed]

  Ollitrault, PRD 46 229 (1992)

- v_2/ϵ vs. particle density rises linearly. [in LDL picture]

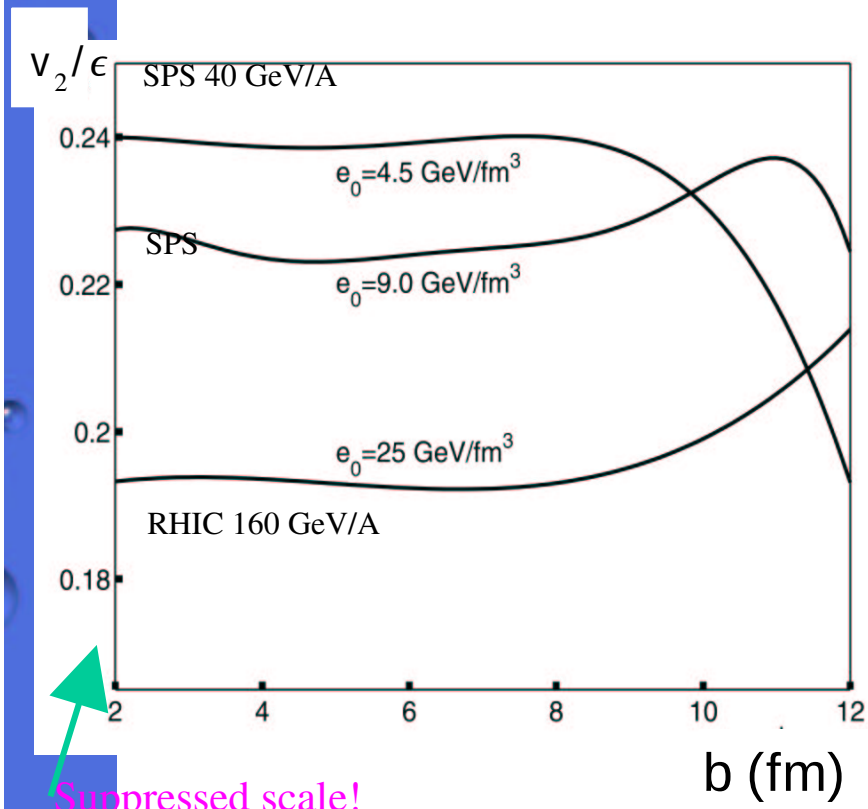




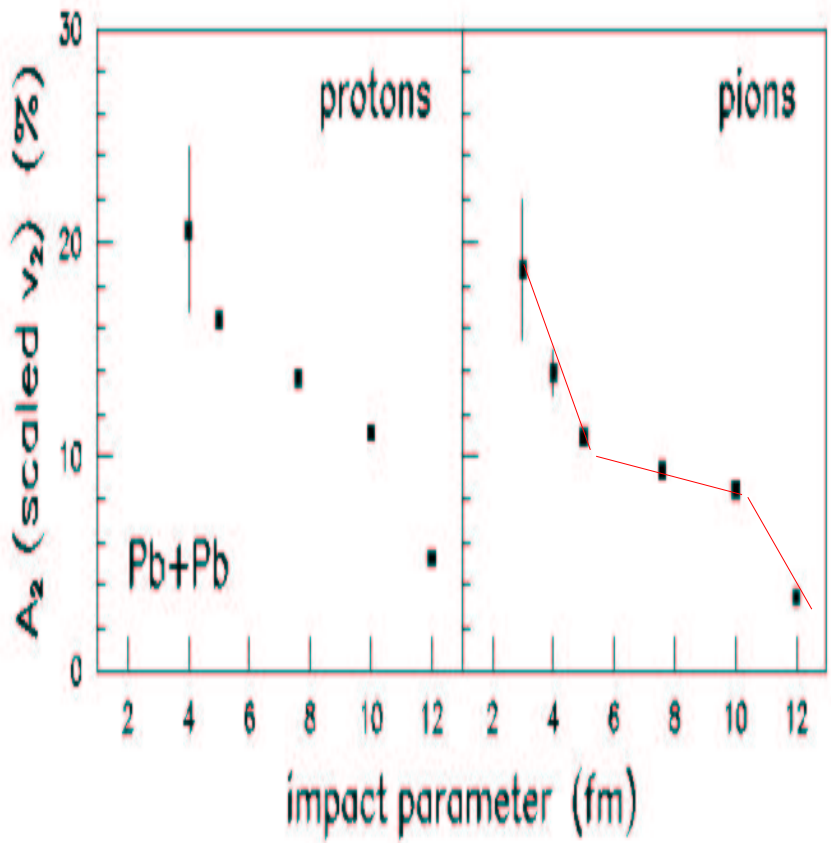
Elliptic flow – theoretical motivation

v_2/ϵ a few % rise with b, or kinks. [hydro with phase transition]

Kolb, Sollfrank & Heinz, PRC 62 054909 (2000) Heiselberg & Levy, PRC 59 2716 (1999), Sorge, PRL 82 2048 (1999)

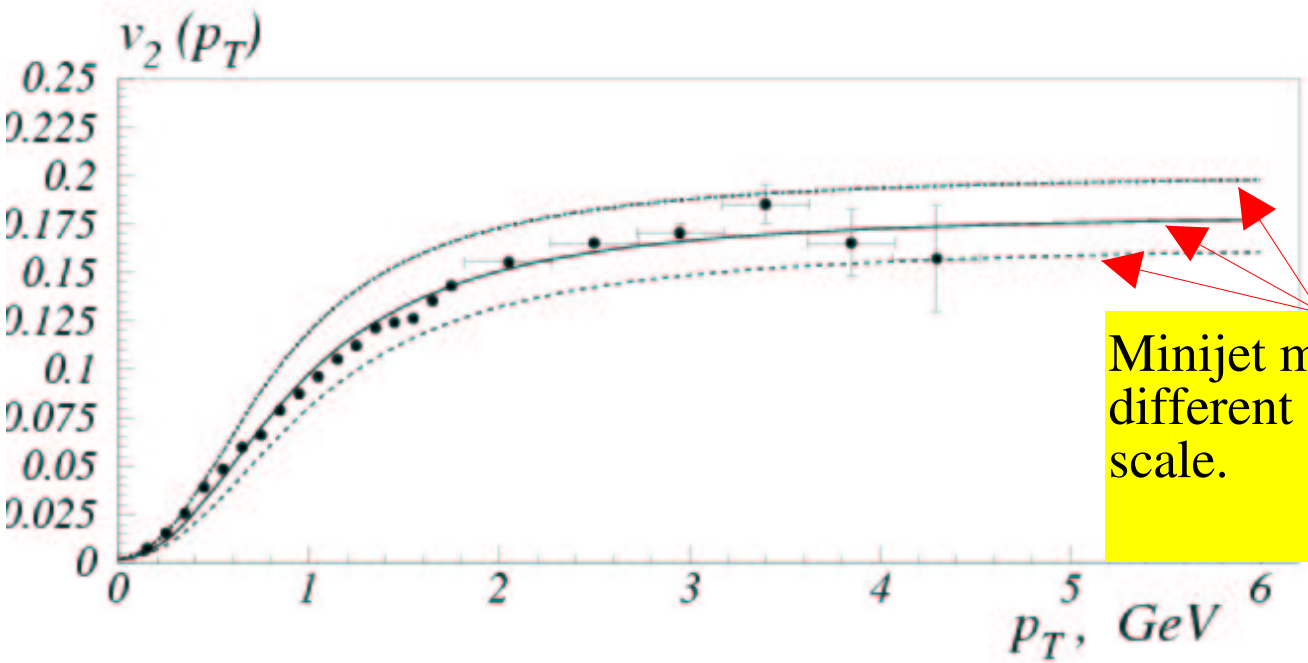


Suppressed scale!



Elliptic flow – theoretical motivation

Yuri V. Kovchegov and Kirill L. Tuchin hep–ph/0203213



Minijet model with different saturation scale.

Is high momentum tail of v2 saturated by the two–particle correlated minijet production?

Needs to be answered by a method of flow analysis that would be insensitive to minijet contribution.

Elliptic flow – Implications for experiment

Many suggested signals are subtle effects,– need to measure elliptic flow with the least possible systematic uncertainty.

Some correlations may contribute to standard v_2, but are unrelated to collective motion rel. to reaction plane… Examples of these NON–FLOW effects include:

- (Mini)jets and strings
- Resonances
- FSI (especially Coulomb)
- Momemtum conservation
- Quantum statistics

} Previous STAR analyses treated these case–by–case e.g., partition subevents randomly, also by charge, and also on either side of a pseudorapidity gap.

4 particle correlation analysis: reduce or eliminate sensitivity to non–flow

Four–particle correlations
Motivation for cumulants

- The correlation between two particle is :

$$\langle u_{n,1} u_{n,2}^{*} \rangle \equiv \langle e^{in\phi_1} e^{-in\phi_2} \rangle = v_n^2 + \delta_n$$

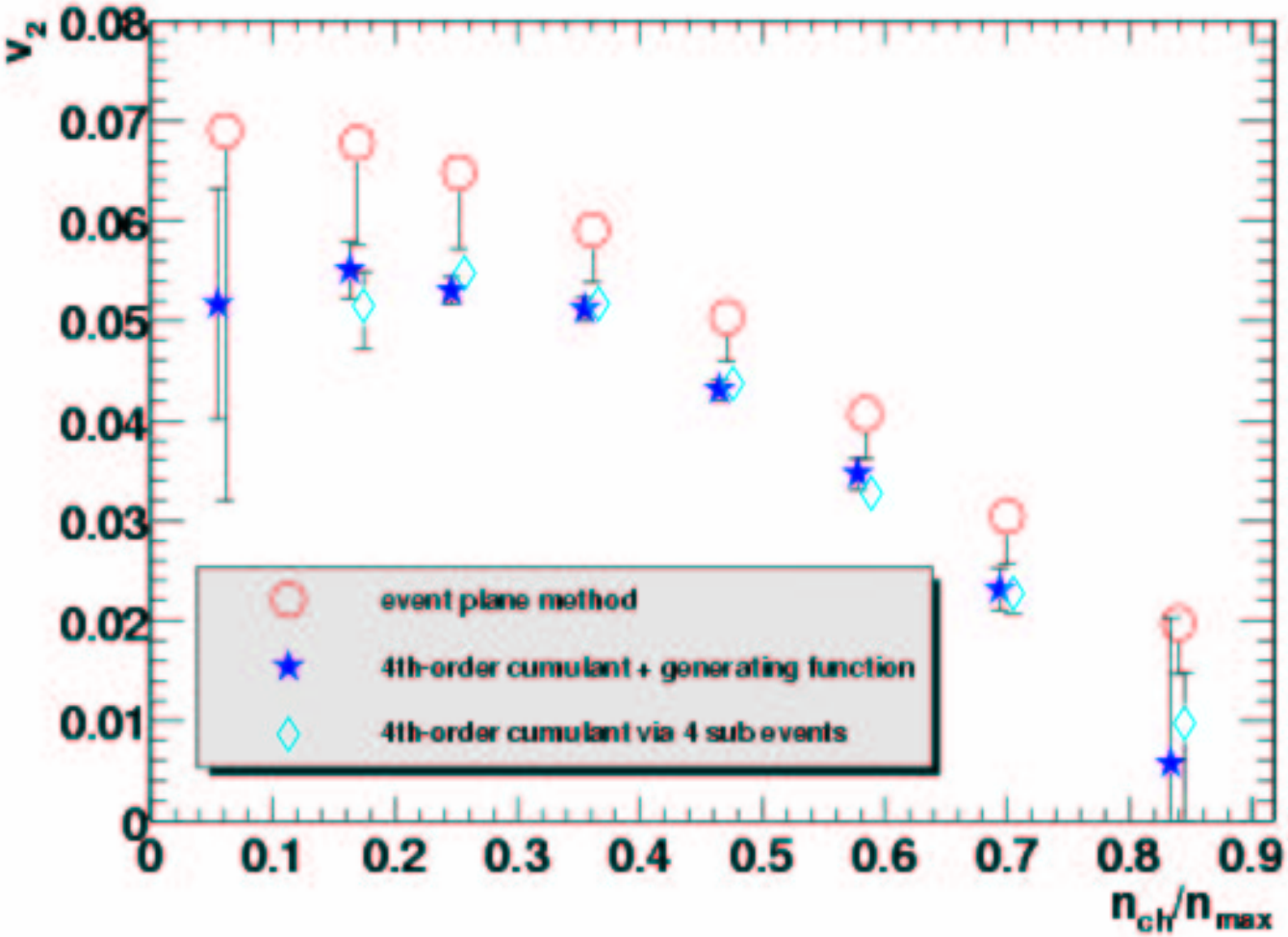
Correlating four particles, one gets

$$\langle u_{n,1} u_{n,2} u_{n,3}^{*} u_{n,4}^{*} \rangle = v_n^4 + 2 \cdot 2 \cdot v_n^2 \delta_n + 2 \langle \delta_n^2 \rangle$$

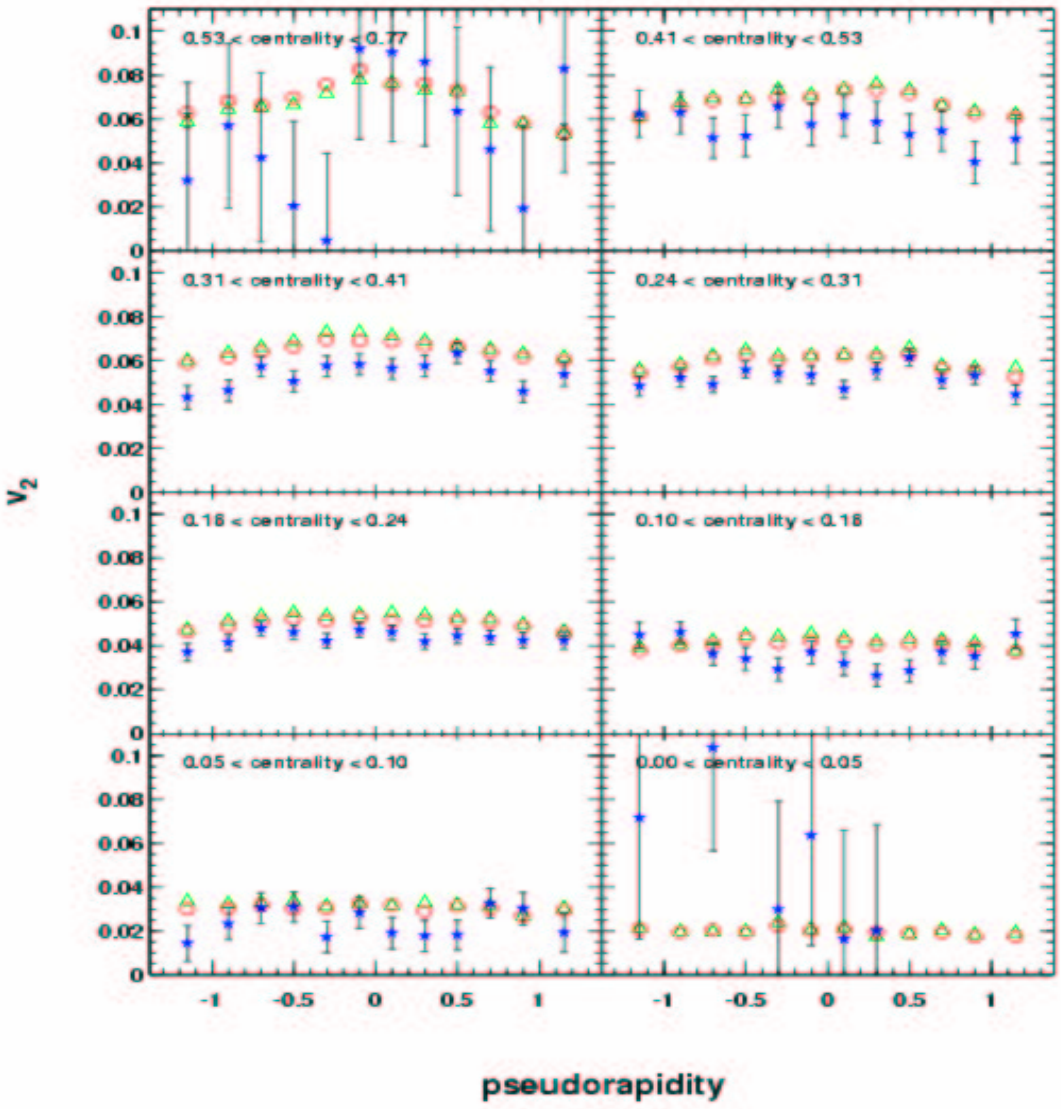
the non–flow term δ_n is thus cancelled by the cumulant defined below:

$$\langle\langle u_{n,1} u_{n,2} u_{n,3}^{*} u_{n,4}^{*} \rangle\rangle \equiv \langle u_{n,1} u_{n,2} u_{n,3}^{*} u_{n,4}^{*} \rangle - 2 \langle u_{n,1} u_{n,2}^{*} \rangle^2 = -v_n^4$$

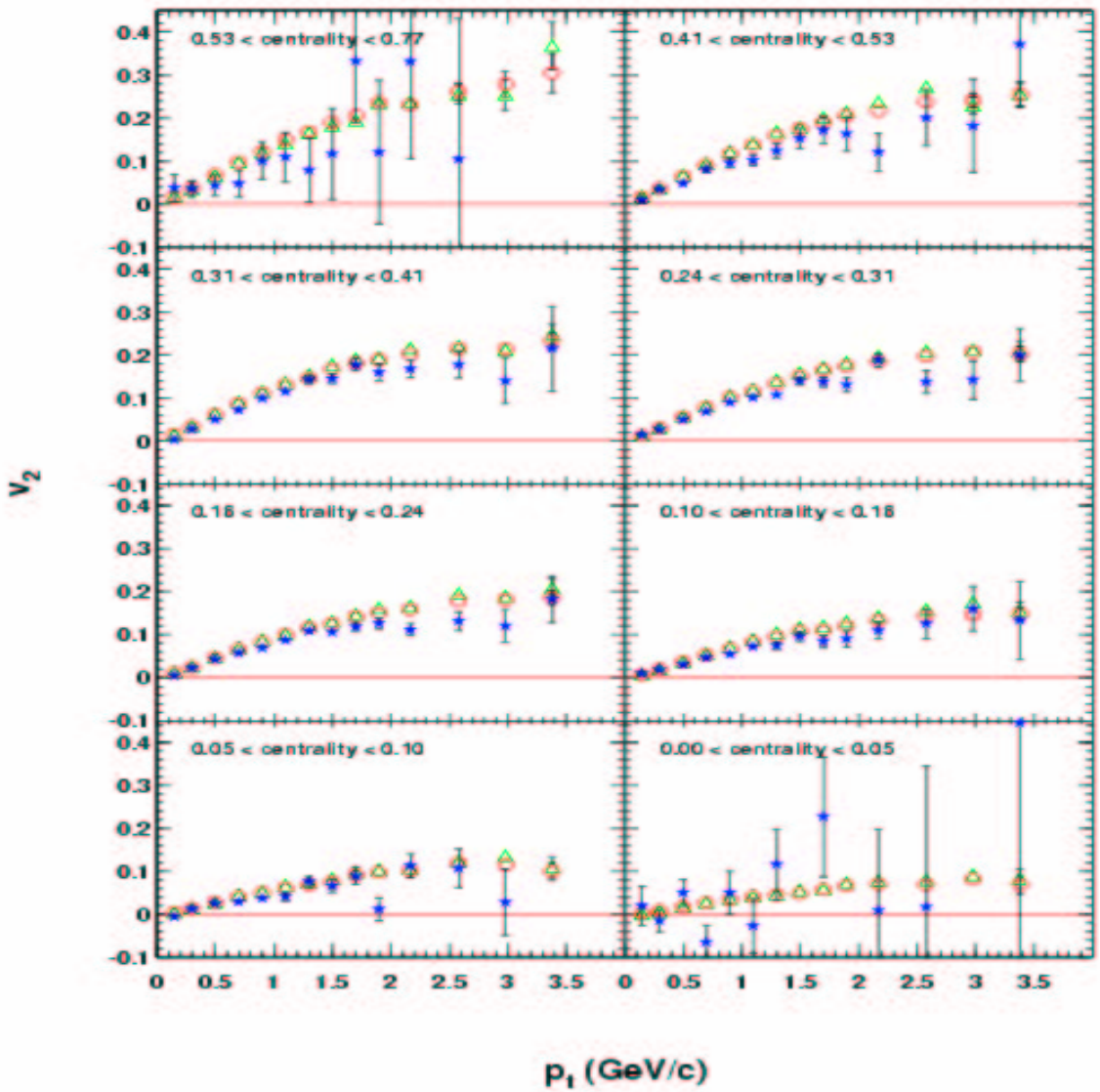
Four−particle correlations
STAR results



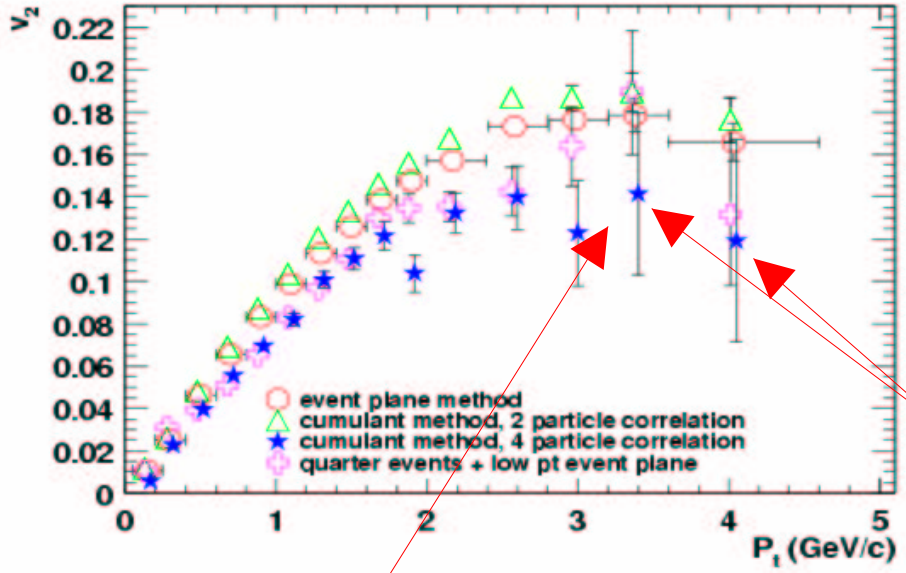
Four−particle correlations
STAR results



Four–particle correlations
STAR results

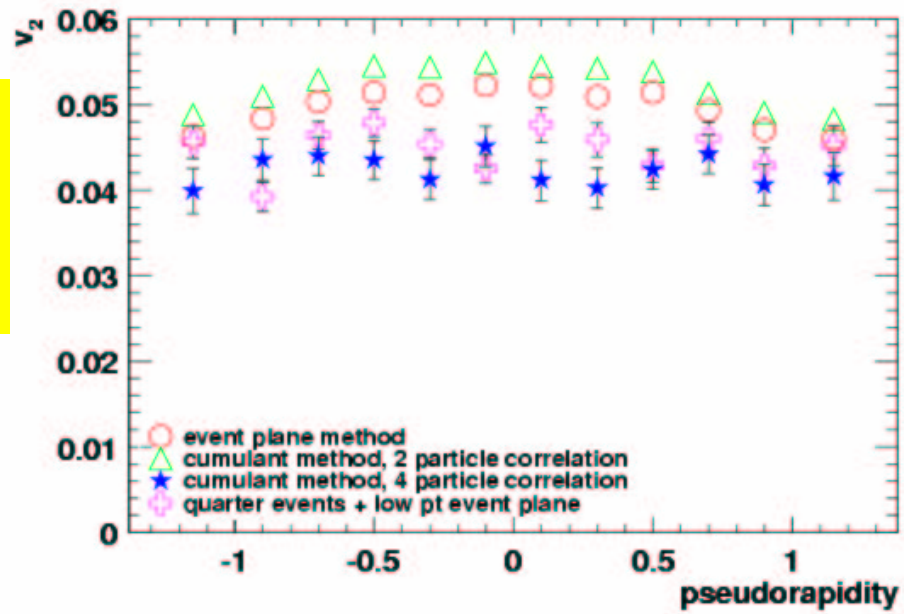


Four−particle correlations
STAR results



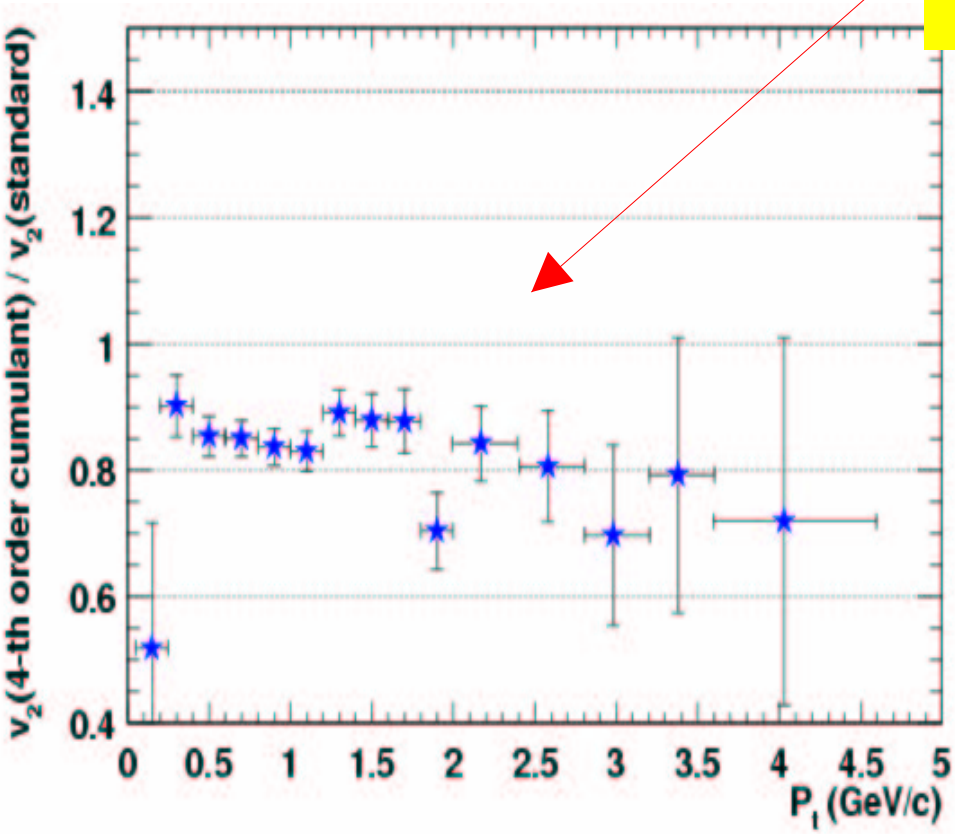
High−order cumulant + STAR year−one data
rel. large stat. errors − not best suited for testing initial parton density − (v2 work by K. Filimonov/LBNL)

Is the high momentum tail of the v2 saturated by the two−particle correlated minijet production? − Not likely, yet needs to be confirmed with more statistics.



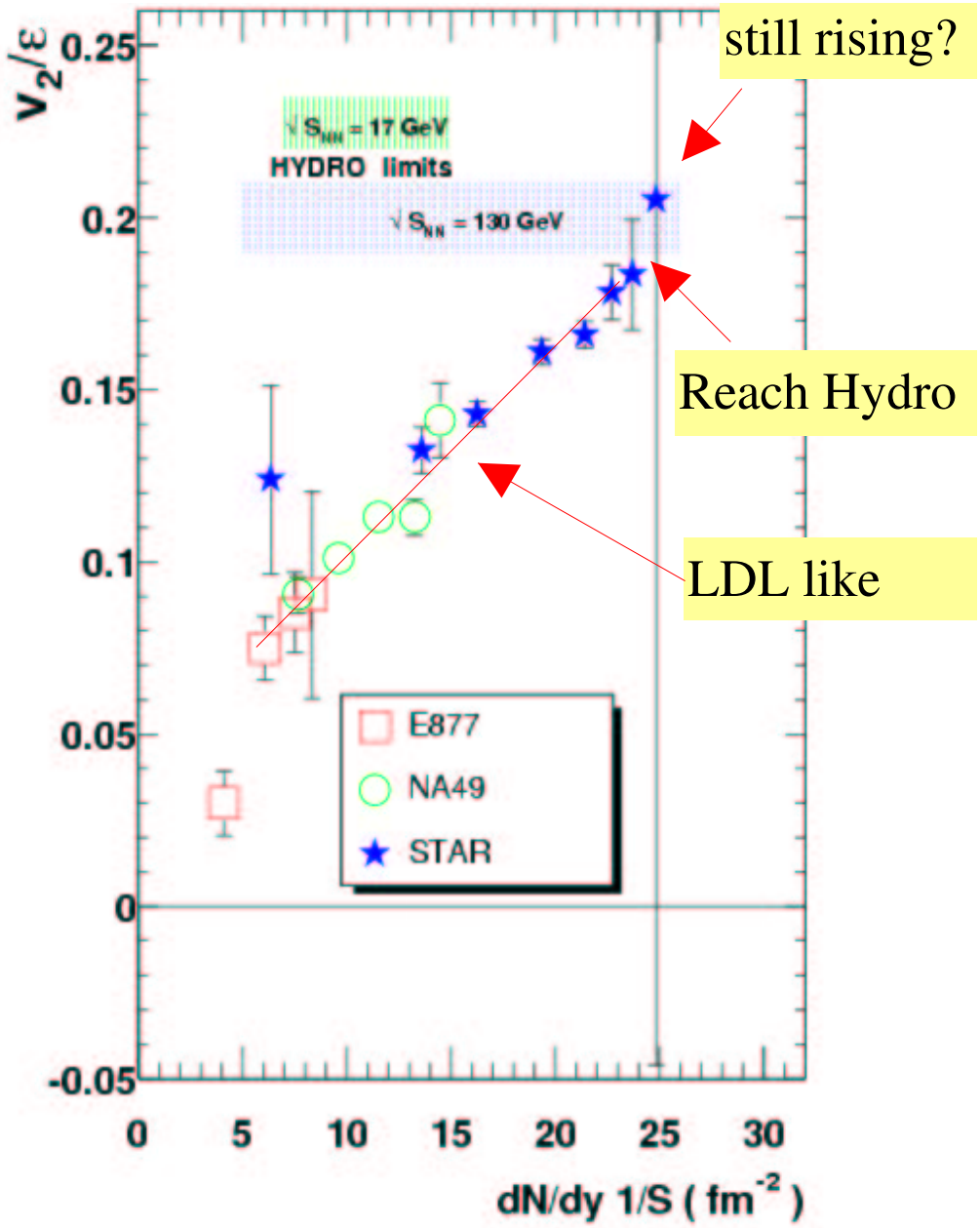
What are dominant non−flow sources at RHIC ?

No strong pt dependence of "net" non−flow



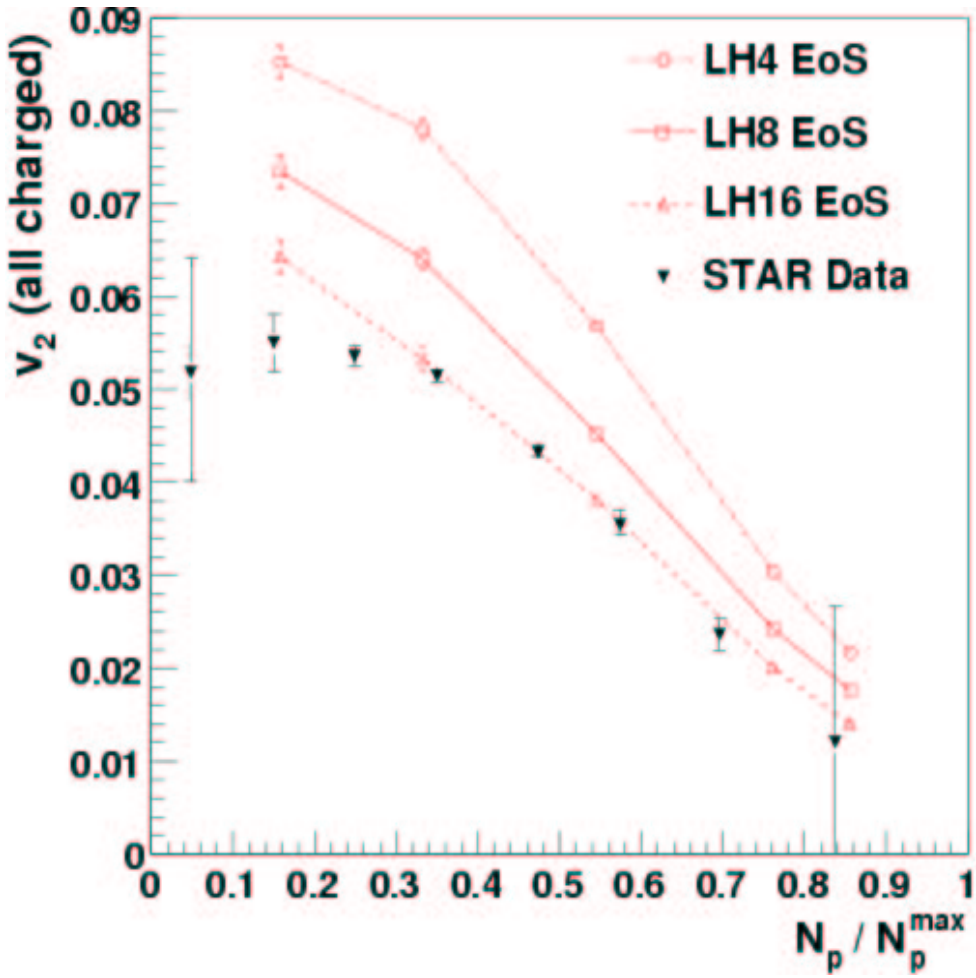
However, it does not mean that individual non−flow source has no pt dependence

Compare with
AGS & SPS,
LDL or Hydro?



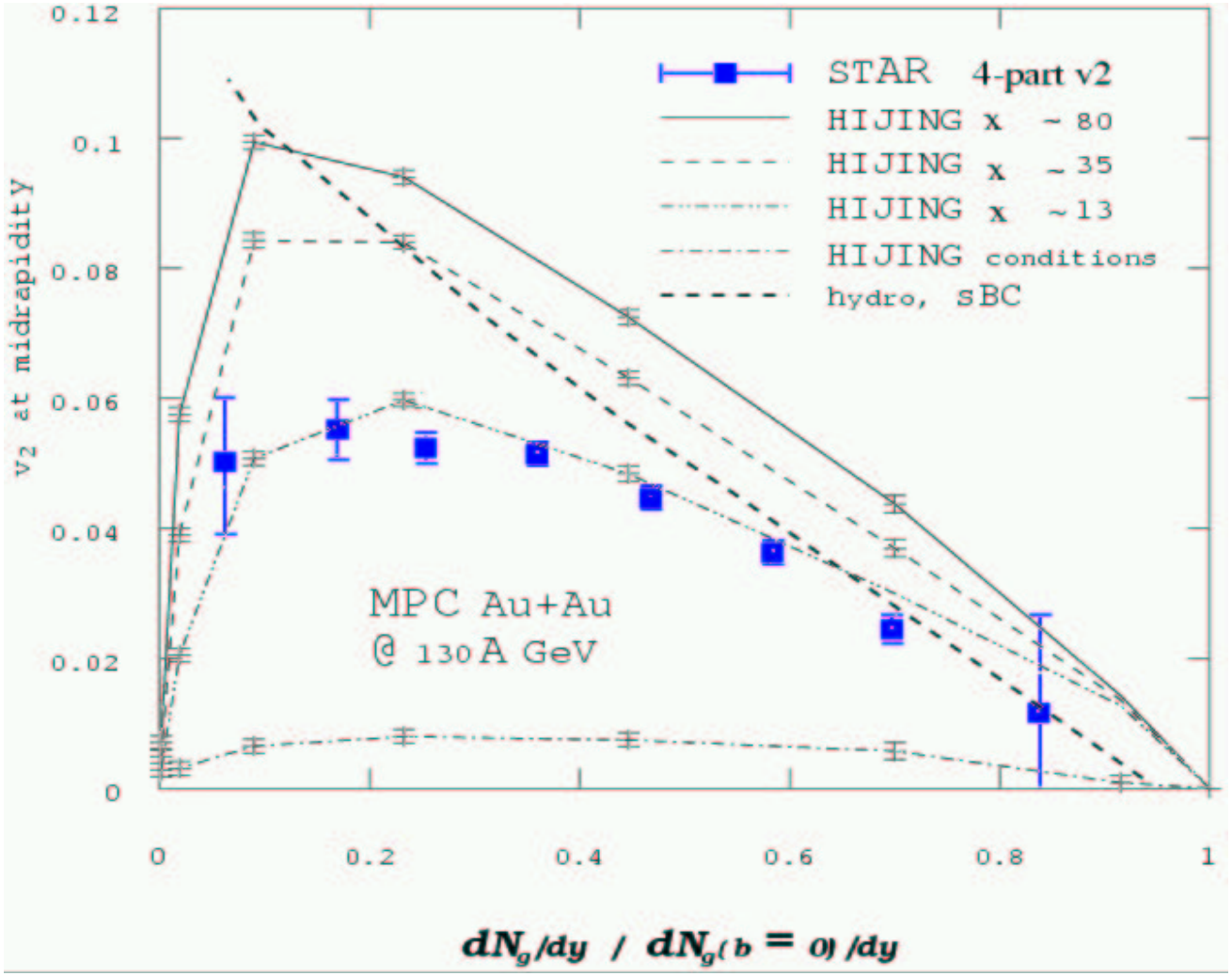
Model Comparisons – Hydro + Cascade

Instead of freeze out at a "universal freeze out temperature", particles undergo cascade after leaving hydro.



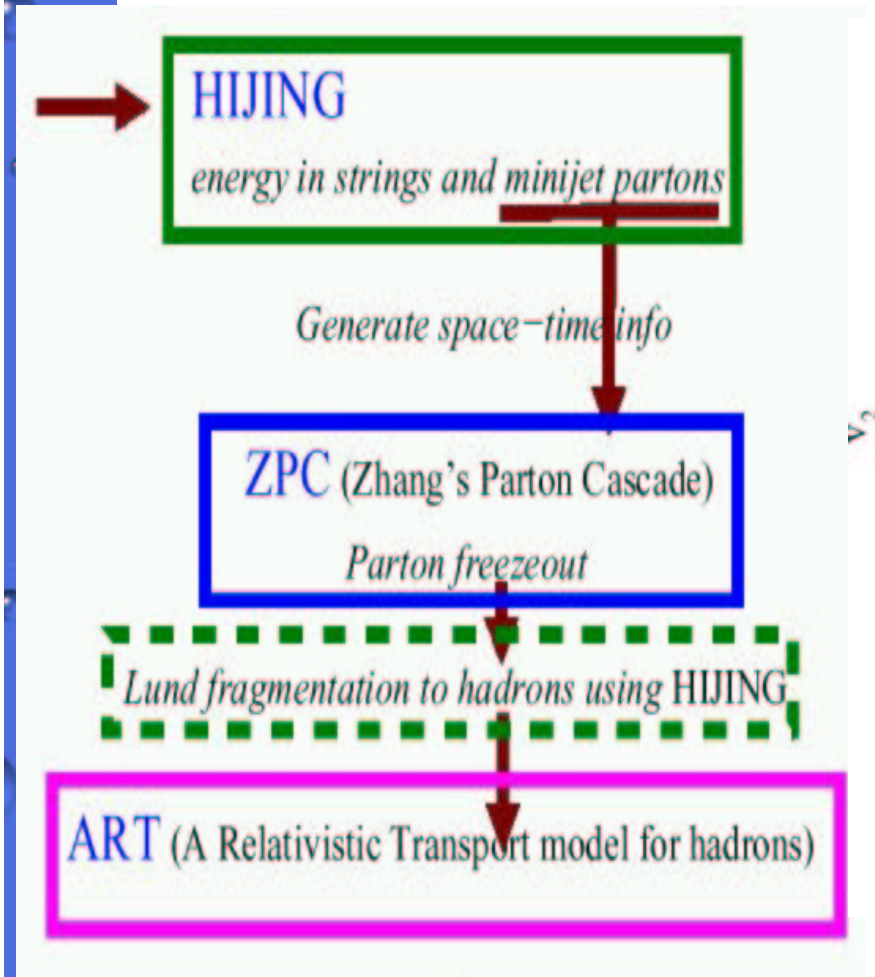
D. Teaney, J. Lauret, and E. V. Shuryak, nucl–th/0104041

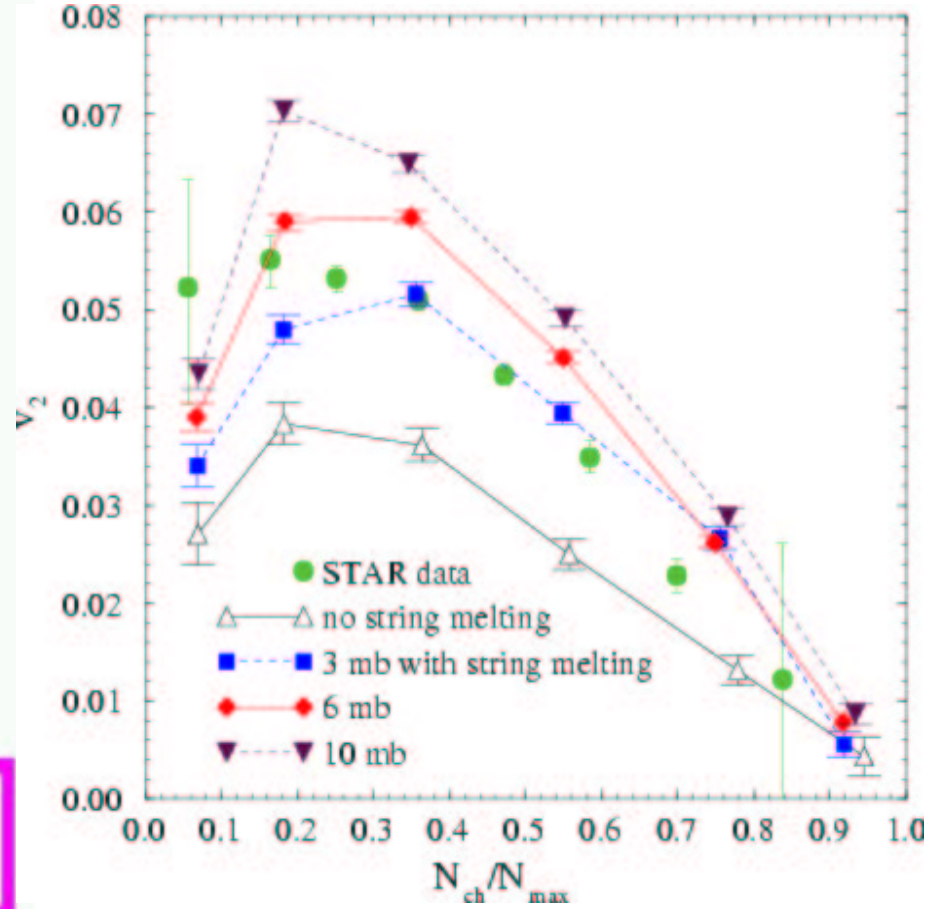
Model Comparisons – MPC



Denes Molnar, hep–ph/0111401

Model Comparisons – AMPT + string melting





Zi–Wei Lin and C. M. Ko, nucl–th/0108039

Summary & conclusions

Elliptic flow

- Multipurpose diagnostic of early stage
- Subject of several proposed PT signatures
- With other observables, builds big picture”

4th–order v2

- Practically zero sensitivity to non–flow
- Non–flow correction 15% at RHIC
- Confirms earlier non–flow estimates
- Needs large stats. rel. to pair analyses

STAR data

- Scaled elliptic flow consistent with LDL. However, pt dependence from LDL does not agree with STAR data.
- Hydro limit in central collisions