# Two-Particle Azimuthal Correlation Functions in PHENIX


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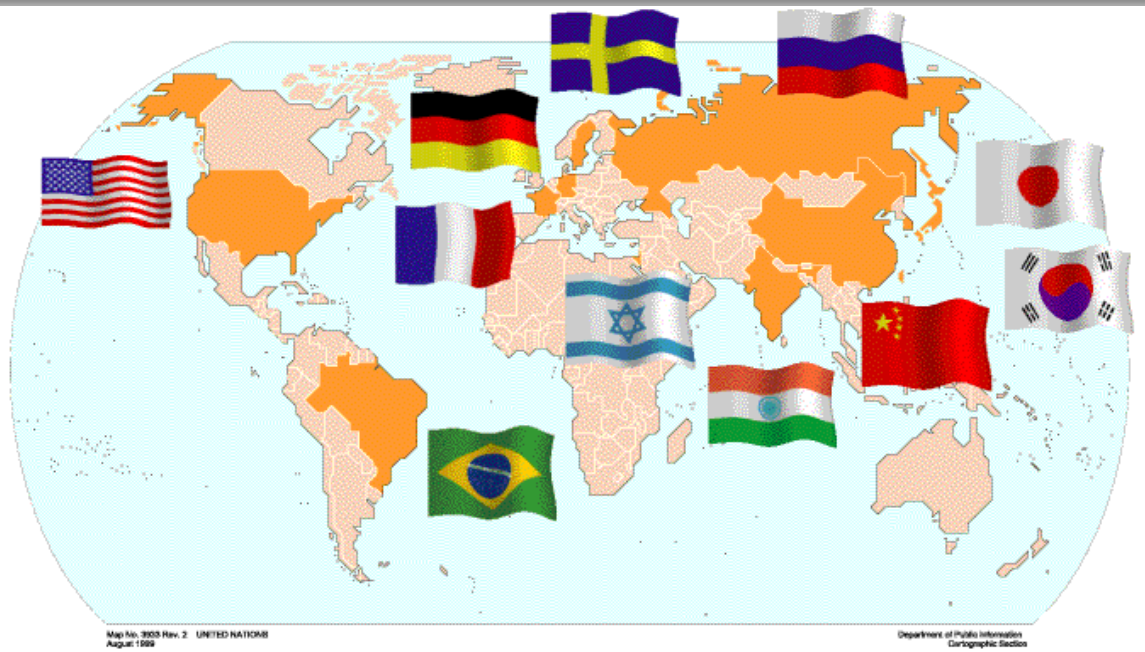
***For***

***the PHENIX Collaboration***

PHENIX



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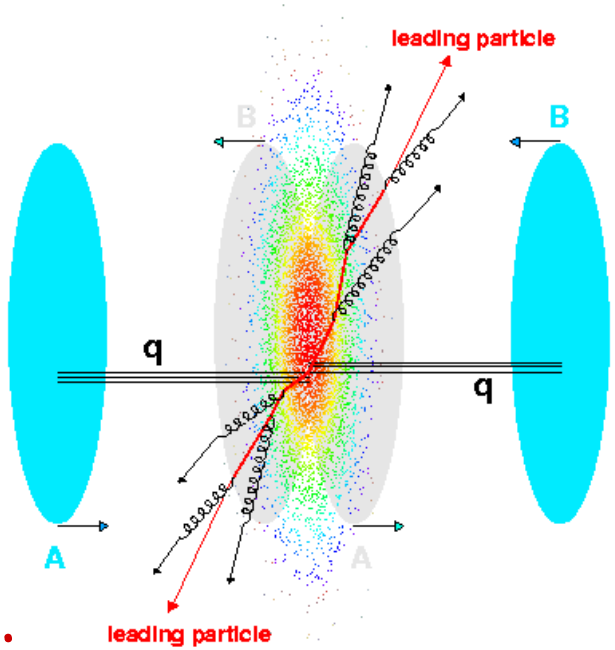
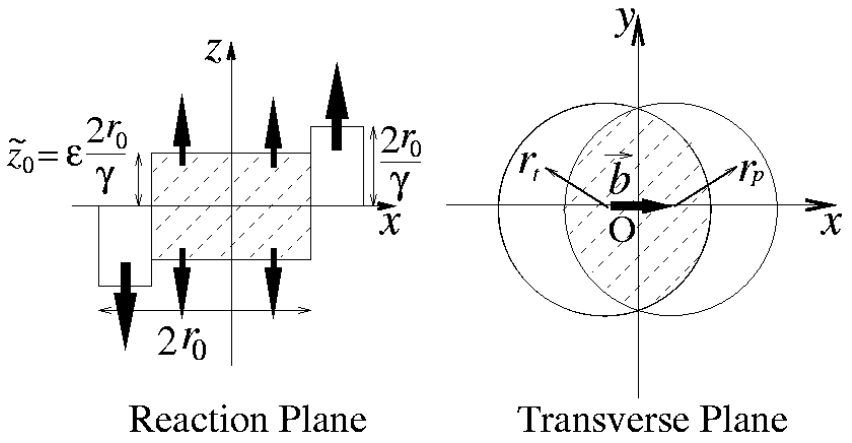
# *Outline*

- Brief Motivation
- Correlation Technique
- Flow & Jet Correlation Functions
- Data
  - Typical Correlation Functions
  - pT reference study
  - dEta Study
  - pT dependence
  - Centrality Dependence
- Model comparisons
- Summary/Outlook

**See posters by W. Holtzman & P. Constantin**

# Why Study Correlations




## Jets:

- Primarily from gluons at RHIC
- Produced early ($\tau$<1fm)
- Sensitive to the QCD medium (dE/dx)

## Flow:

- Primarily from pressure build-up
- Produced early ($\tau$<1fm)
- Reflect conditions in collision zone (energy density etc.)

**Correlation Studies can provide information on the particle production mechanism and QGP formation at RHIC**

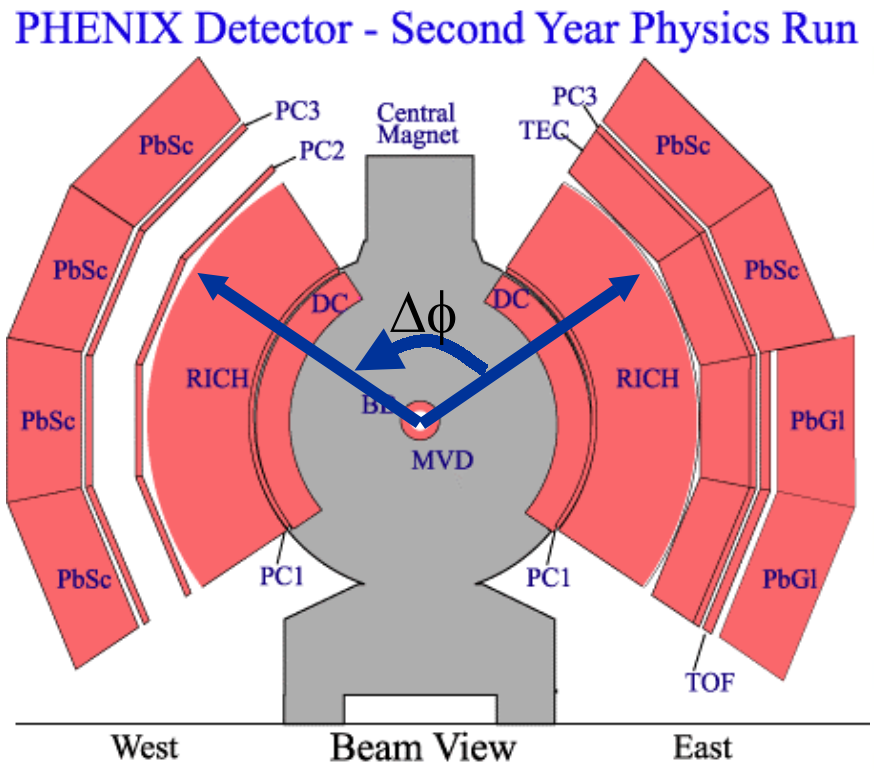
N. N Ajitanand QM2002

# *Correlation Technique*

## Study $\Delta\phi$ Correlation Functions:

$$\frac{dN_{pairs}}{d\Delta\phi} \propto \left(1 + \sum_{n=1}^{\infty} 2v_n^2 \cos(n\Delta\phi)\right)$$

Wang et al.,
PRC 44, 1091 (1991)
Lacey et al.
PRL 70, 1224 (1993)




- Event by event reaction plane determination & Dispersion Corrections Circumvented

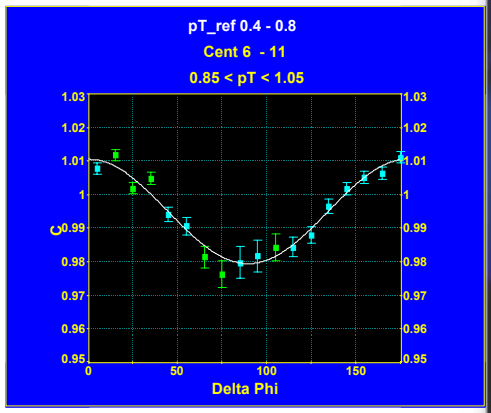
- Uncertainties associated with Acceptance, efficiency, etc Reduced

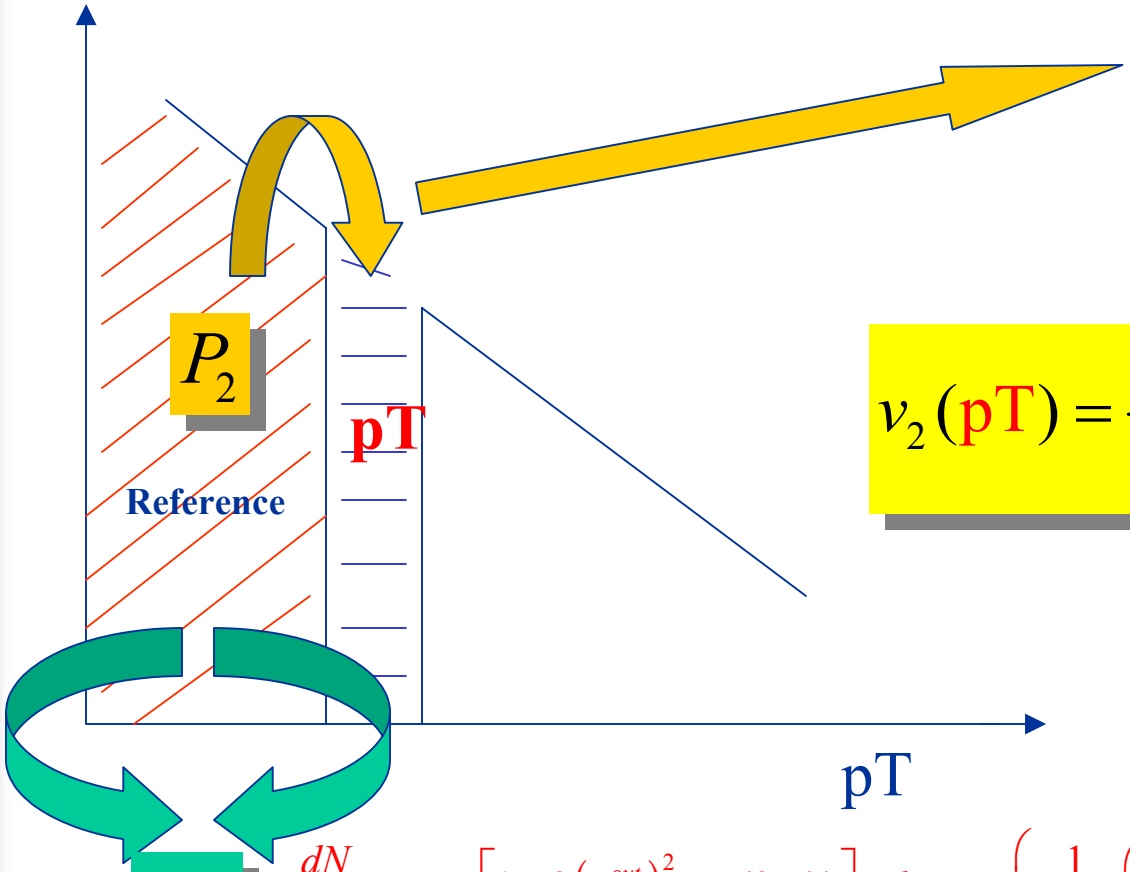
**Smaller Signal !!**

**30 Million minimum bias events analysed**

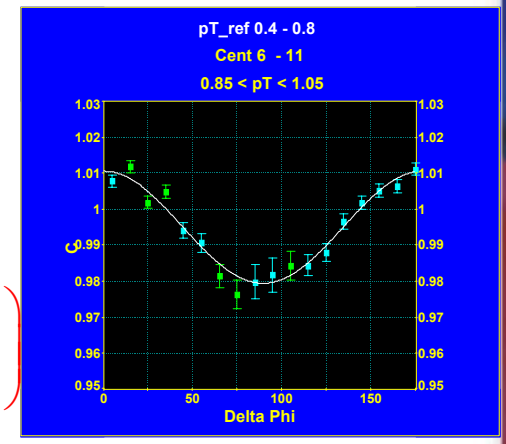
# Extracting v2 via Assorted Correlations

$$\frac{dN}{d(\Delta\phi)} = a \times \left[1 + 2P_2 \cos(2\Delta\phi)\right] + b \times \exp\left(-\frac{1}{2} \times \left(\frac{\Delta\phi}{\sigma}\right)^2\right)$$




$$v_2(\mathrm{pT}) = \frac{P_2}{v_2^{out}}$$



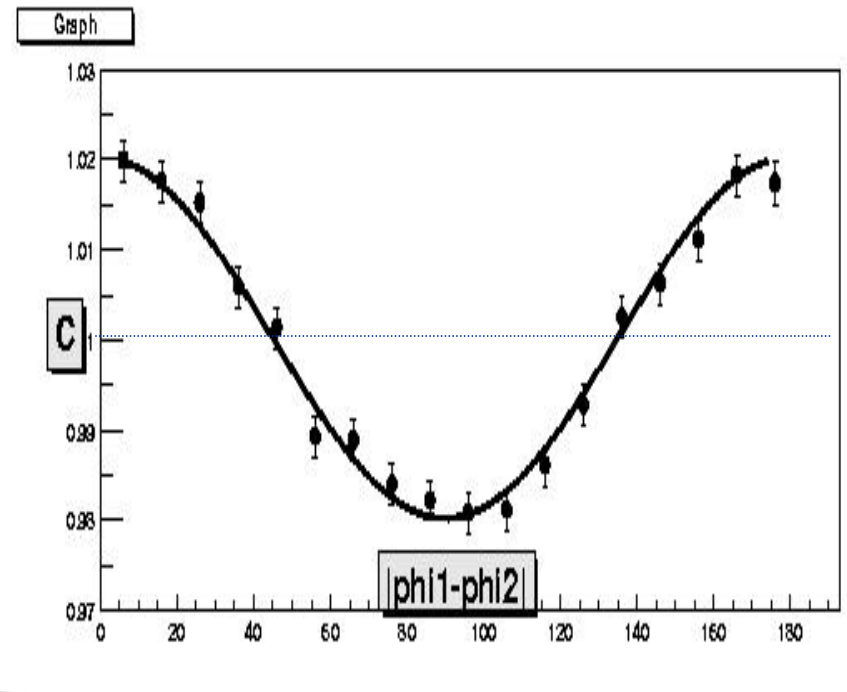

$v_2^{out}$

$$\frac{dN}{d(\Delta\phi)} = a \times \left[1 + 2\left(v_2^{out}\right)^2 \cos(2\Delta\phi)\right] + b \times \exp\left(-\frac{1}{2} \times \left(\frac{\Delta\phi}{\sigma}\right)^2\right)$$

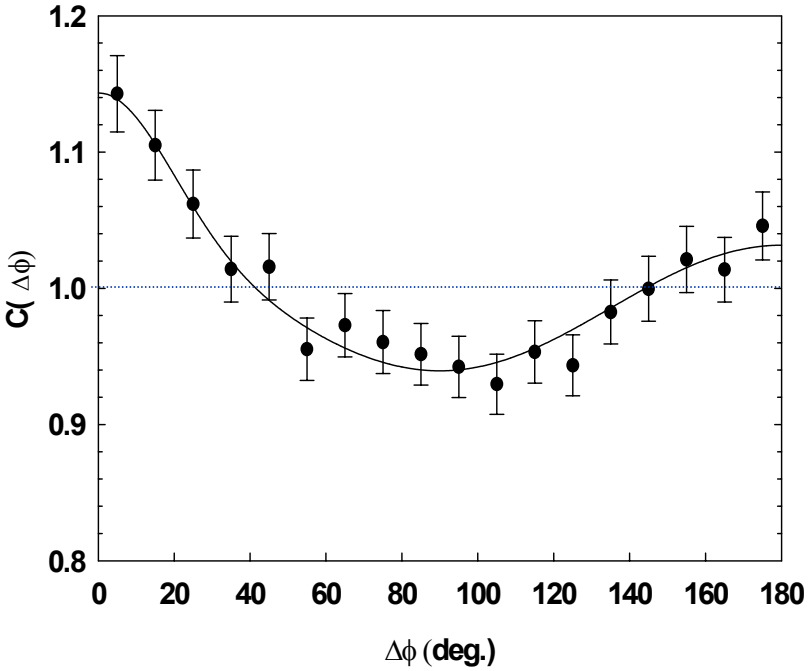
## *Simulated Correlation Functions*

PHENIX @ RHIC

### Hydro-Flow




### HIJING




**Flow leads to strong anisotropy**

**Jets lead to strong anisotropy and an asymmetry**

**The anisotropy of the correlation function reflects both flow and Jet contribution**

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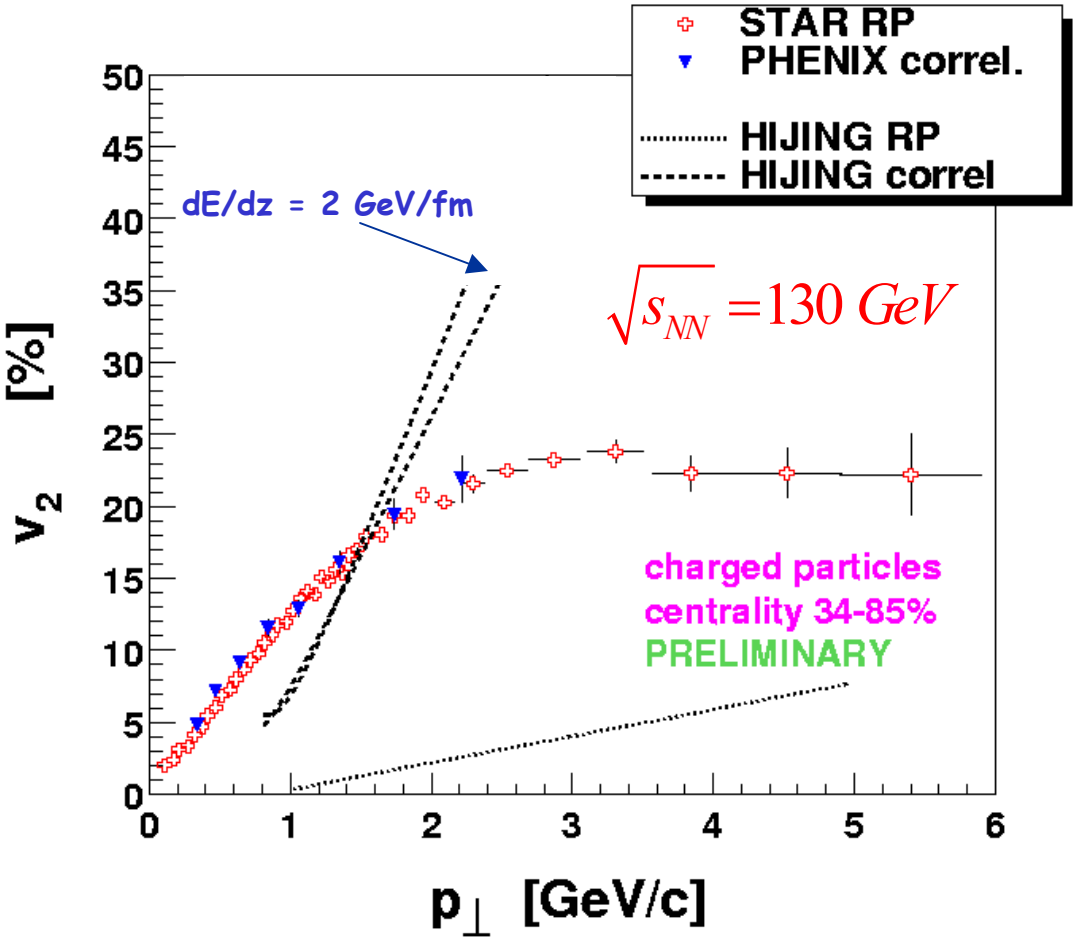
# *Summary of 130 GeV Results*




J. Rak, Hirschegg 2001

## Year – 1

- Reaction Plane and two particle correlation technique give similar v2
- Hydro over predict correlation function above ~ 2 GeV/c.
- Hydro show good agreement with data for pT < 1.0 GeV/c
- **HIJING** under predicts correlation function below ~ 1.5 GeV/c
- **HIJING** over predicts correlation function above ~ 1.5 GeV/c

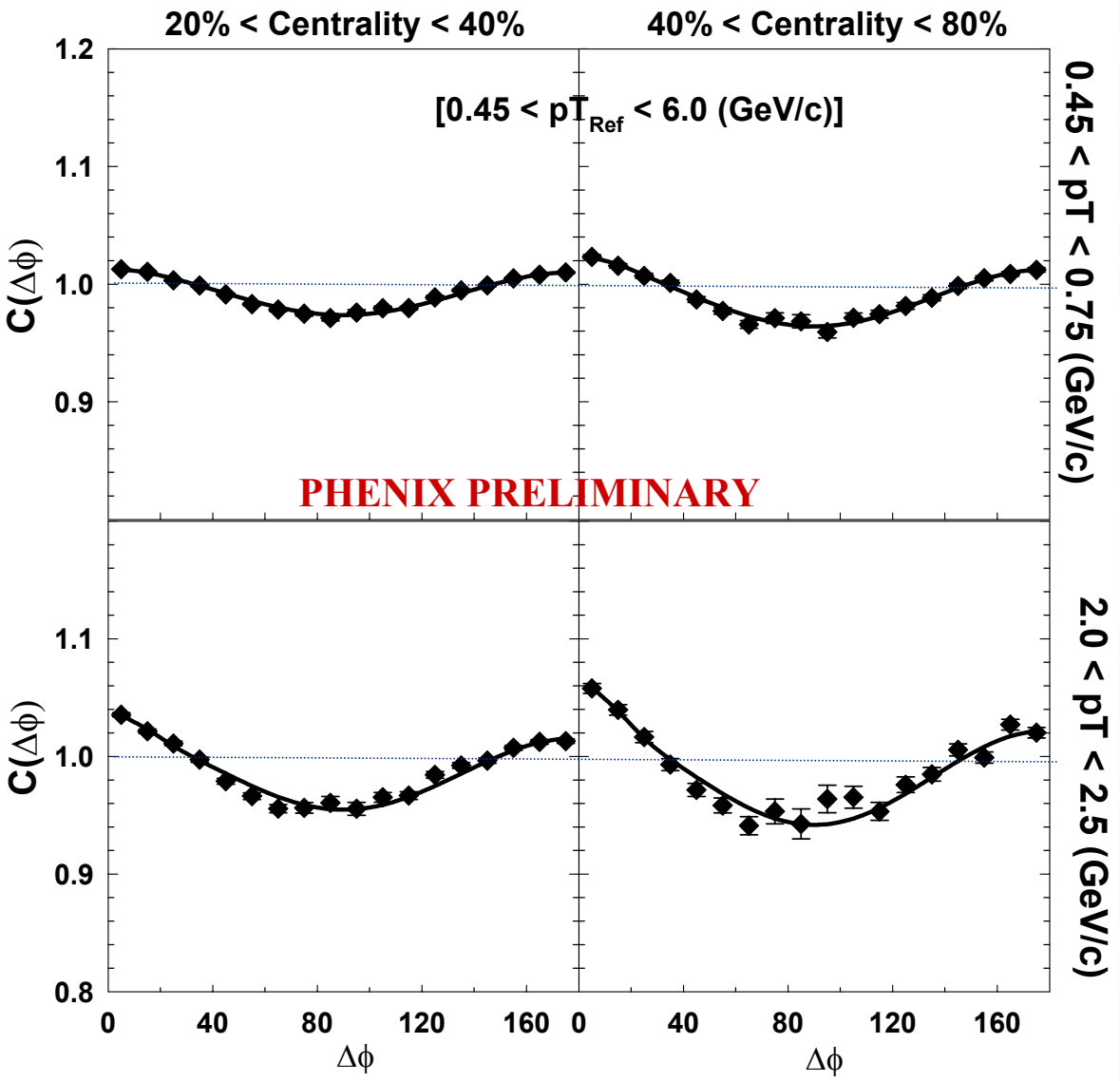
# *Differential Correlation Functions*

$\sqrt{s_{NN}} = 200\ GeV$

- Magnitudes and trends similar to Year – 1
- Anisotropy increases with pT and Centrality
- Asymmetric Component seen especially at high pT – Jets ?

**Important to test the response of the asymmetry to various Cuts**

- **Jets**
- **v2 values**

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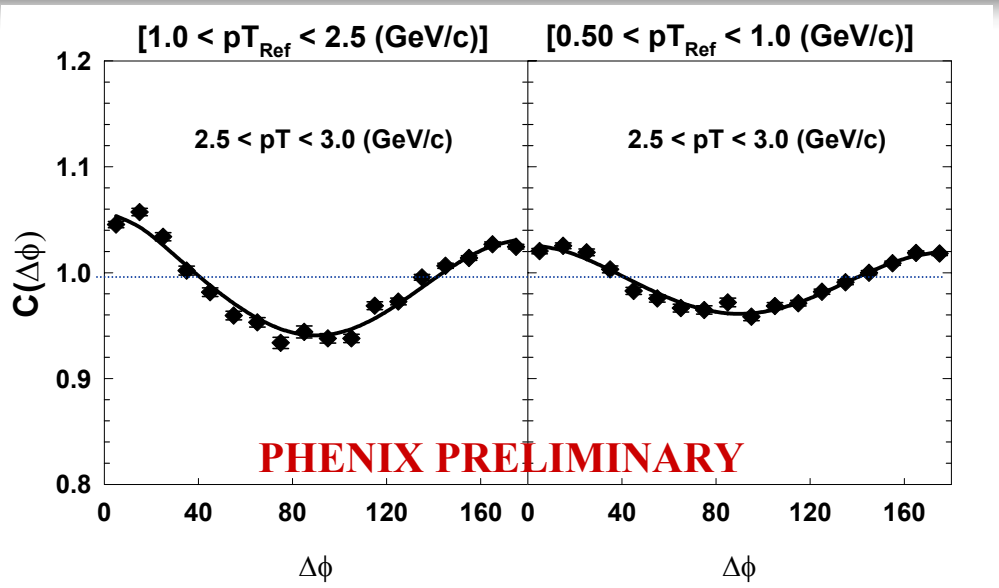
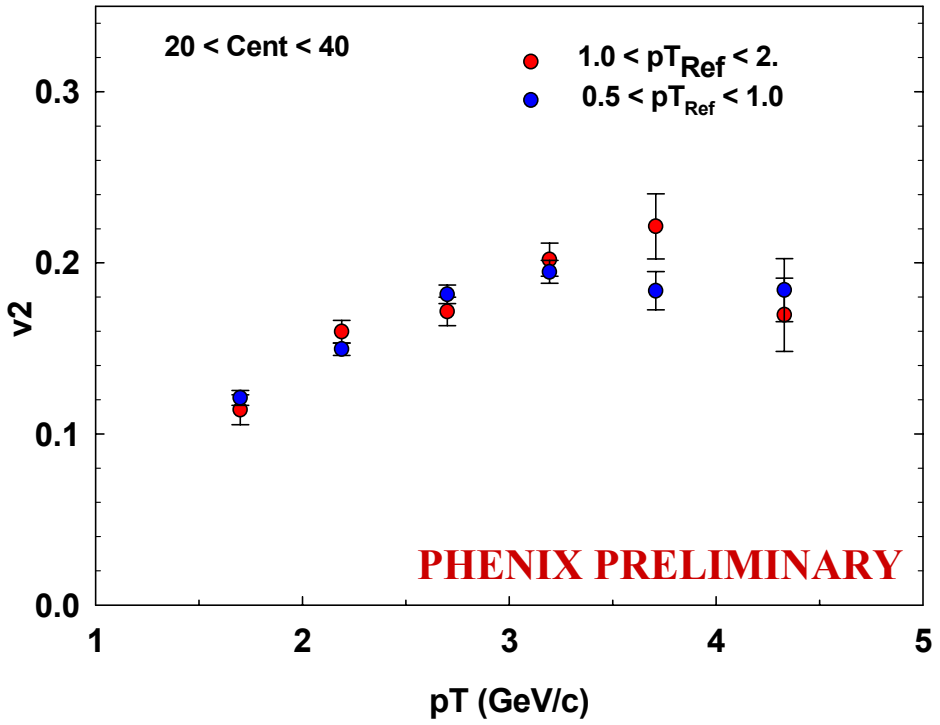



$\sqrt{s_{NN}} = 200\ GeV$

**Reference pT dependence**

- Asymmetry of Correlation function sensitive to pT reference
  - Consistent with Jets/Minijets
- Extracted v2 relatively insensitive

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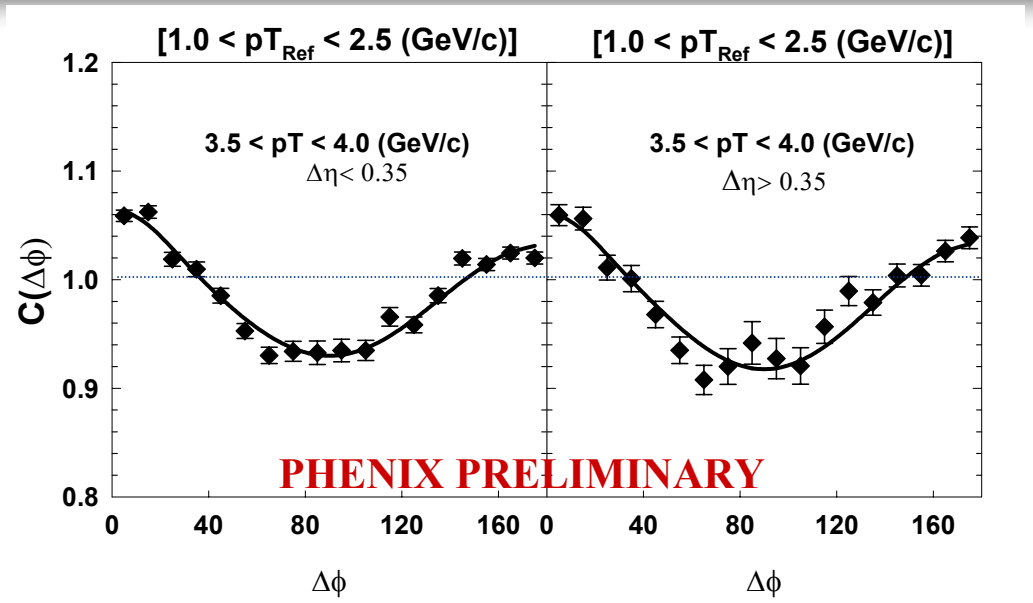
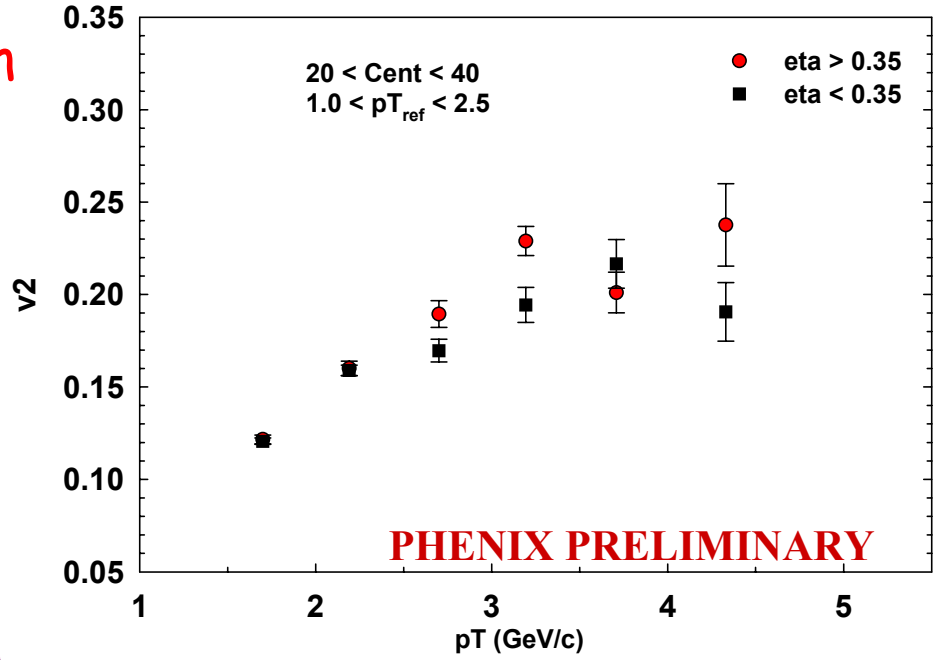



$\sqrt{s_{NN}} = 200\ GeV$

**Δη dependence**

**See poster by P. Constantin**

- Asymmetry of Correlation function sensitive to Δη
  - Consistent with Jets
- Extracted v2 relatively insensitive

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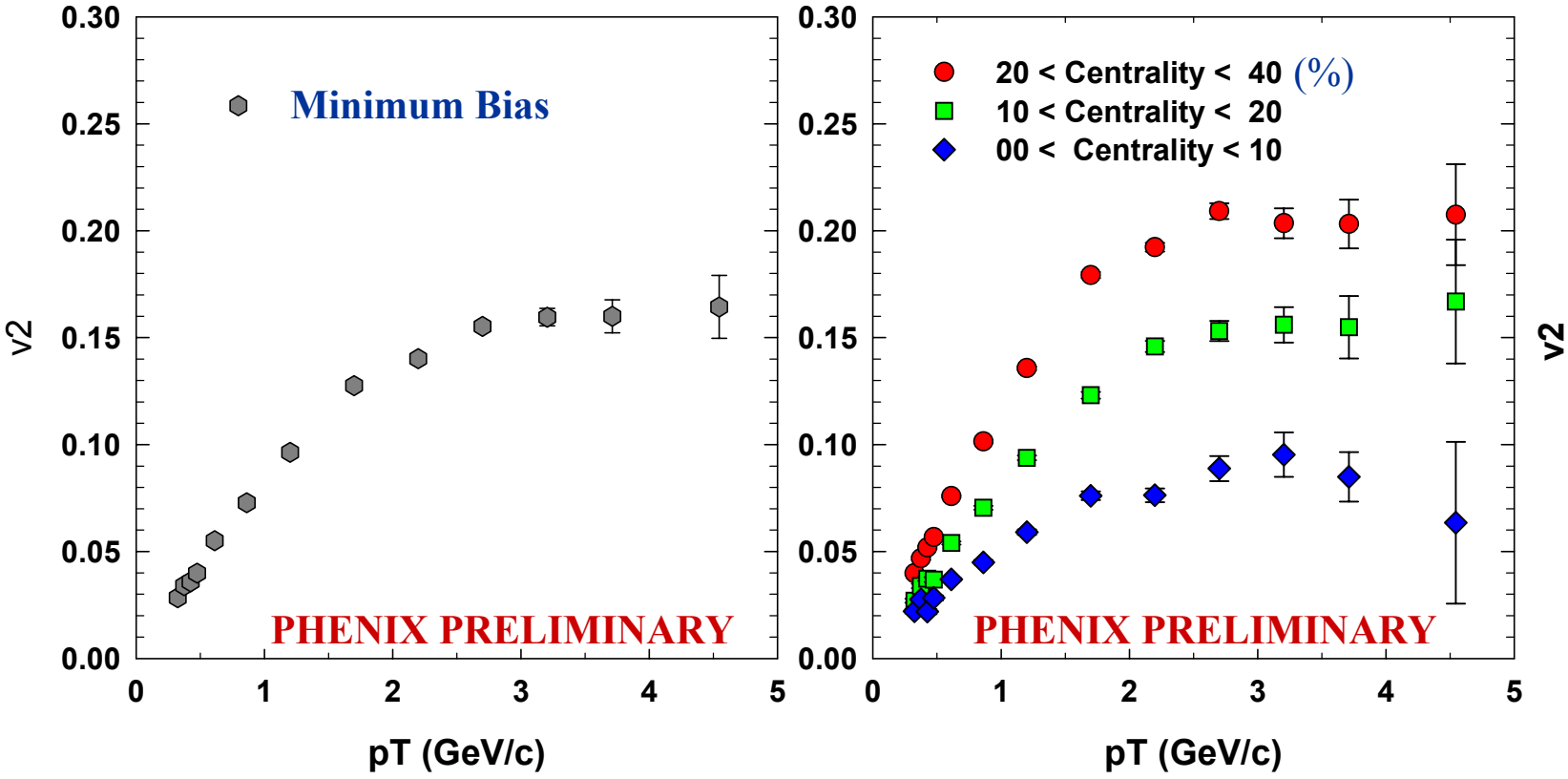
# *Differential v2*

$\sqrt{s_{NN}} = 200\ GeV$




**V2 Saturates at ~ 2.5 GeV/c; Similar Trend for all Centralities**
**V2 increases with Centrality**

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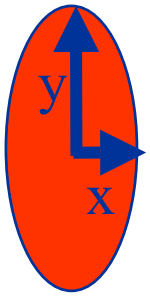
# *Centrality Dependence of v2*

**Different Models predict different scaling Behavior for the centrality dependence of v2**

- **Hydro --- eccentricity scaling**
- **Minijet – Overlap Area scaling**

$$\sim \frac{1}{\sqrt{N_{part}}}$$

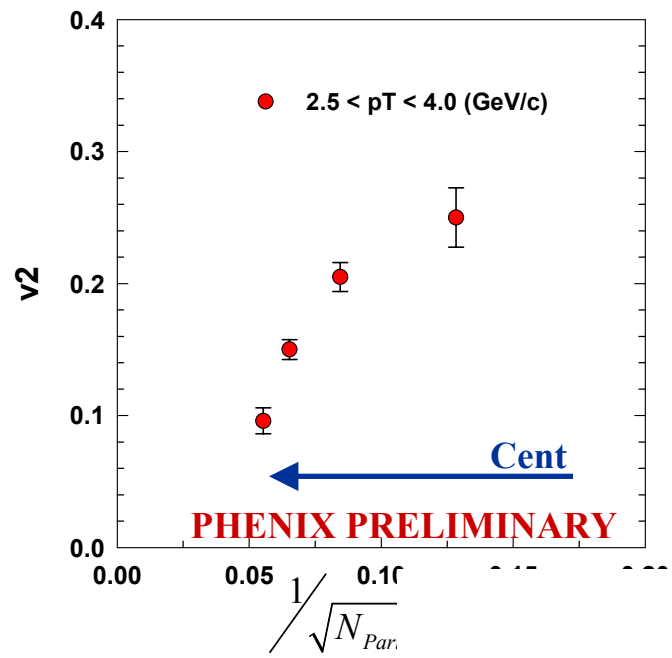
**eccentricity**

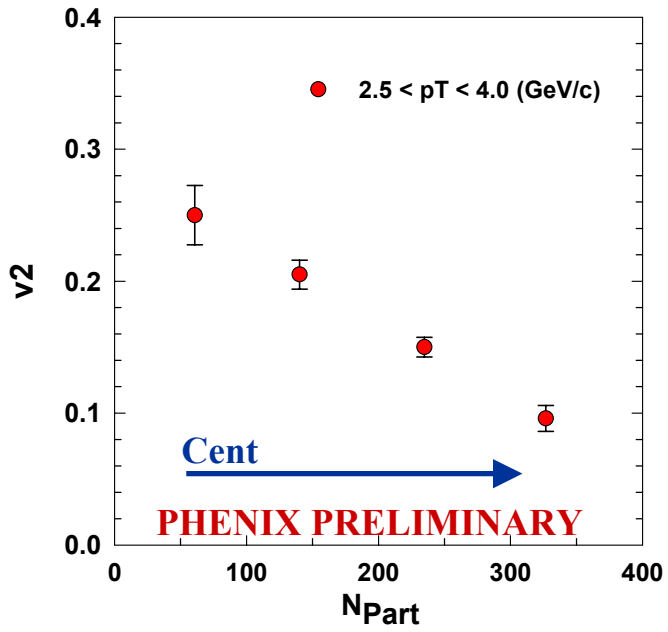


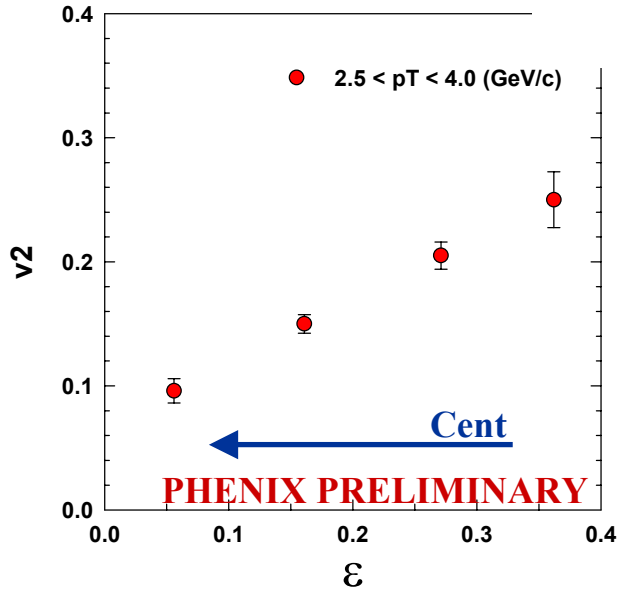

$$\varepsilon = \frac{\langle y^2 \rangle - \langle x^2 \rangle}{\langle y^2 \rangle + \langle x^2 \rangle}$$

**It is important to test for these different scaling behavior !**

$\sqrt{s_{NN}} = 200\ GeV$




Centrality Dependence Compatible with:

$N_{part}$ scaling ?

ε scaling ?

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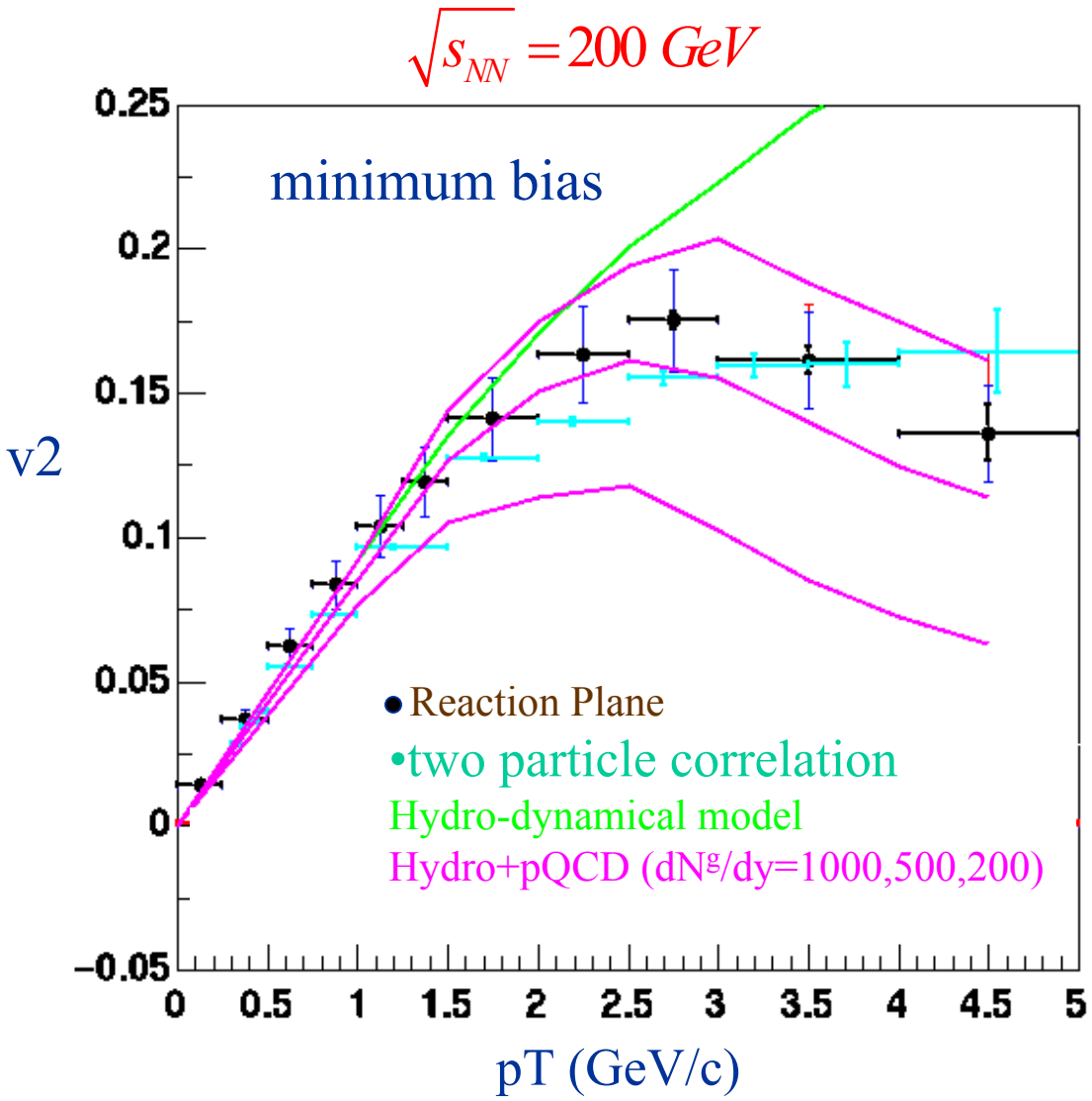
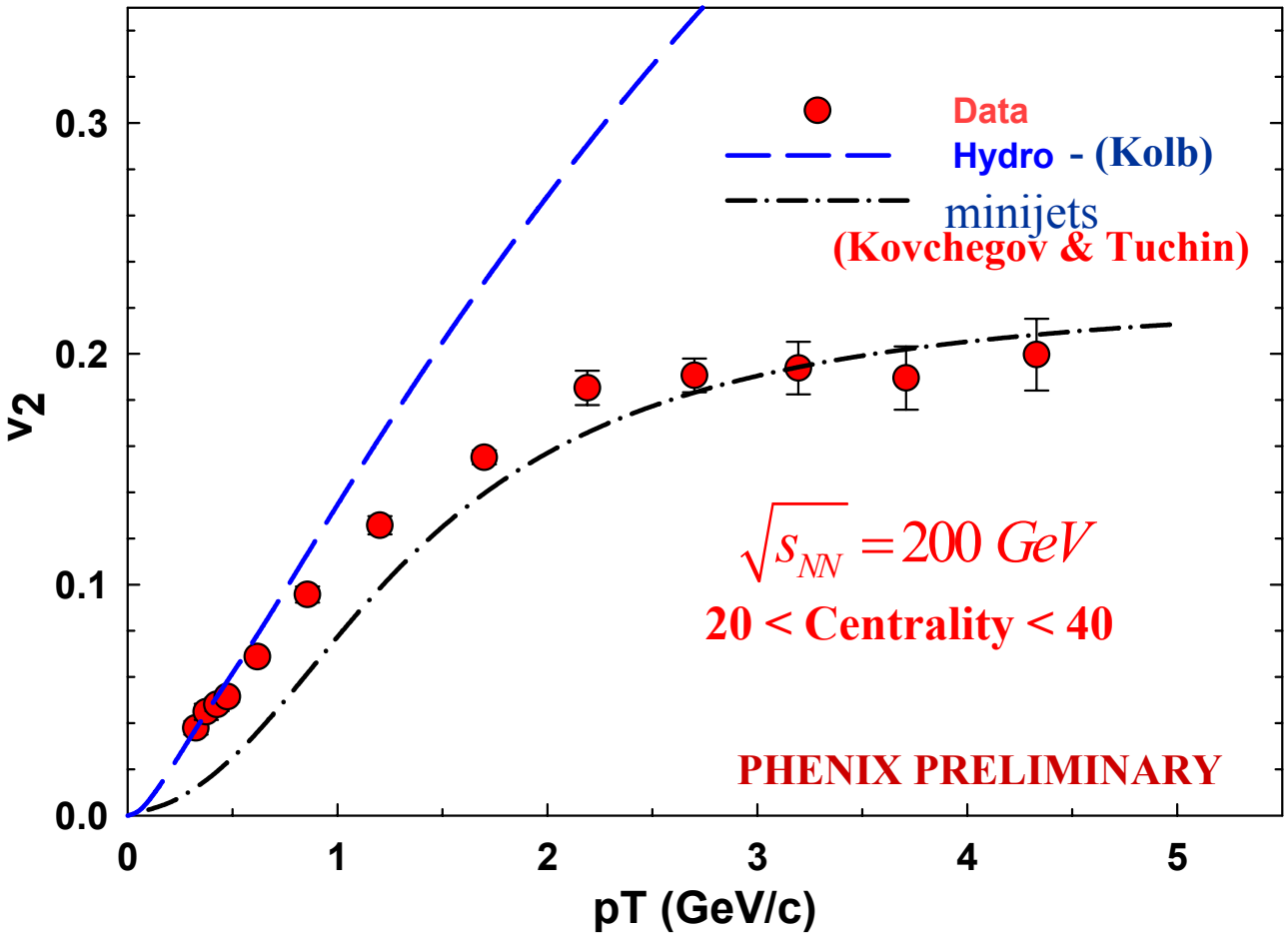
# *Model Comparisons*



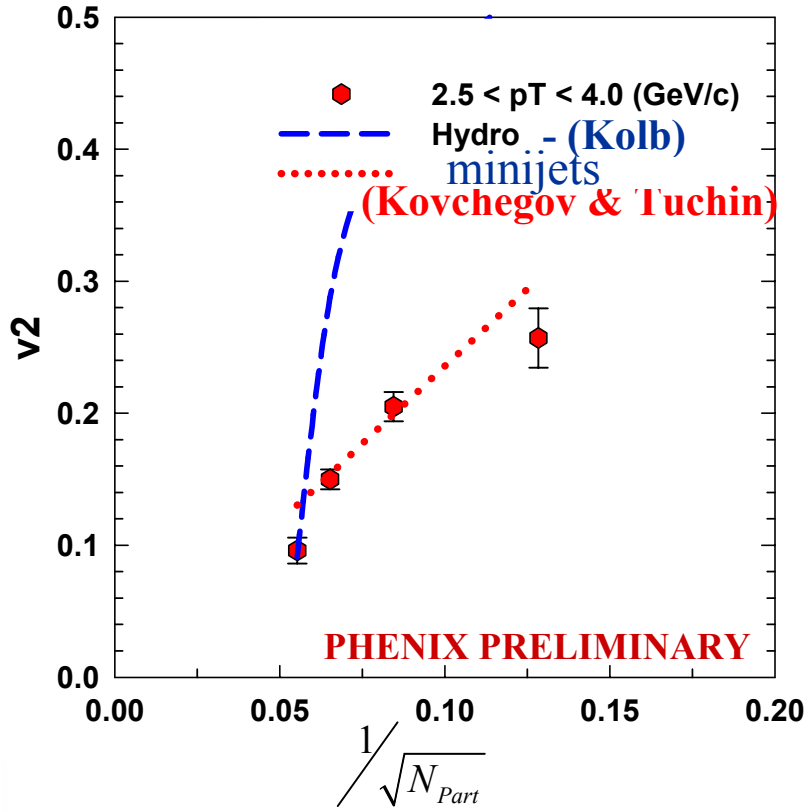
# *Model Comparisons*

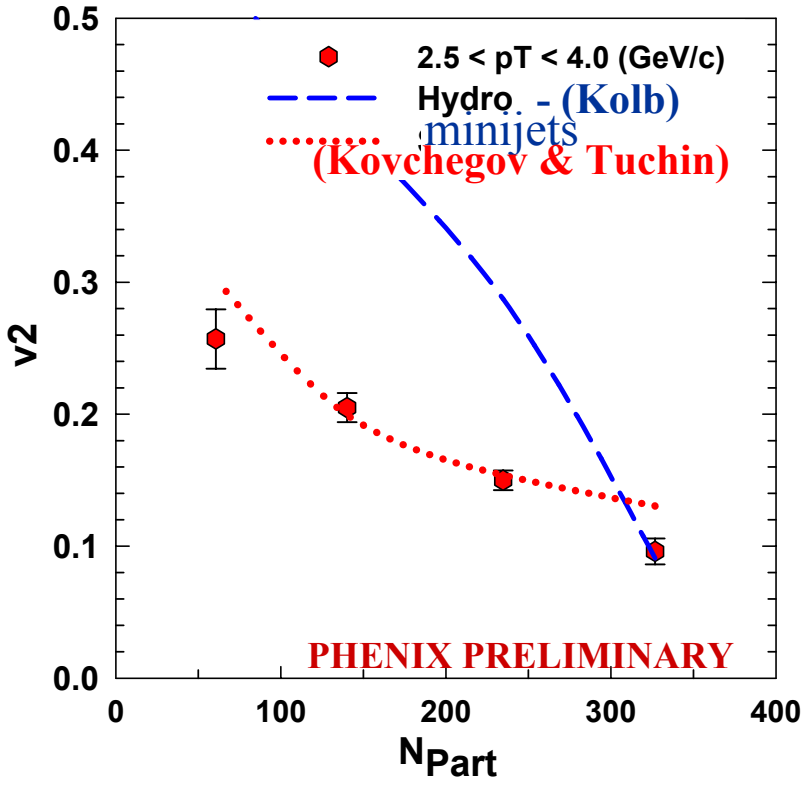



- **Good agreement with Hydro at low pT**
- **Good Agreement with Minijet Model at high pT**
  **(Kovchegov & Tuchin)**

# *Model Comparisons*

## Centrality Dependence for High-pT Charged Hadrons




**Centrality Dependence shows good agreement with the Minijet Model**

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# Summary

**Correlation Measurements serve as an important probe for the high-energy-density nuclear matter created at RHIC.**

- The Observed Asymmetries in the Correlation Functions are Consistent with Jet/Mini-Jet Production
- Sizeable Integral and Differential $v_2$ Observed
- Separate Effects of Geometry and Dynamics can be Identified
- Model Comparisons
  - All Models Require Large Energy Densities to Achieve Results Compatible with the Data (Prerequisite for QGP).
  - Good Agreement with Hydro below ~ 1 GeV/c
  - Both Hydro and HIJING over predicts the data above ~ 1.5 GeV/c
  - Saturation model under predicts the data at low pT
  - Saturation Model gives good agreement with pT and centrality
  - Dependence at high pT.

**Model comparisons compatible with Flow at low pT and Jets/Mini-Jets at high pT.**