Measurement of higher harmonic flow of ϕ meson in STAR at RHIC

Mukesh Kumar Sharma (for the STAR Collaboration)

University of Jammu, Jammu, INDIA

Abstract

One of the main goals of the STAR experiment at Relativistic Heavy Ion Collider (RHIC) is to study the properties of hot and dense matter created in the collision of two heavy nuclei [1].The higher harmonics of azimuthal anisotropy v_n of produced particles are believed to be a sensitive way to characterize the system created in the heavy-ion collision [2, 3]. Moreover higher harmonics of the ϕ meson are a clean probe for the early dynamics since the ϕ meson freeze-out early and it has small hadronic interaction cross section. The relation between various v_n is sensitive to thermalization and dissipation effects in heavy-ion collision [4]. We present the first measurements of ϕ-meson $v_3(p_T)$ and $v_4(p_T)$ at mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}}$= 200 GeV. Centrality dependence of $v_3(p_T)$ and $v_4(p_T)$ are shown and compared to corresponding v_2 values. Ratios between various harmonics are presented and possible implication of those results are discussed.

Introduction

- ϕ meson is a clean probe for early dynamics
- The ratios between various harmonics can be used to understand the properties of the system created in heavy-ion collision

Coalescence Model:

$$\frac{v_{4,M}(2p_T)}{v_{2,M}^2(2p_T)} \approx \frac{1}{4} + \frac{1}{2}\frac{v_{4,q}(p_T)}{v_{2,q}^2(p_T)}$$

Where $v_{n,q}(p_T) = K v_{2,q}^{n/2}(p_T)$

If K=1 $\frac{v_{4,M}(2p_T)}{v_{2,M}^2(2p_T)} \approx 0.75$

L. W. Chen et al., Phys. Rev. C 73, 044903 (2006).

Hydro Model:

$$\frac{v_4}{v_2^2} = 0.5$$

$\frac{v_3}{v_2}$ = constant at high p_T

C. Lang et al., arXiv:1312.7763 [nucl-th] (2013).

Track Selection and Particle Identification with the STAR TPC and TOF

Event plane reconstruction:

Nhits > 15, Nhits/Nmax > 0.52

DCA < 2cm, |η| < 1.0

$p_T \le 2$ GeV/c

Kaon selection for v_n analysis:

Nhits > 15, DCA < 3cm,

Nhits/Nmax > 0.52, |η| < 1.0

p_T>0.15GeV/c

p_T< 0.6GeV/c

TPC +TOF

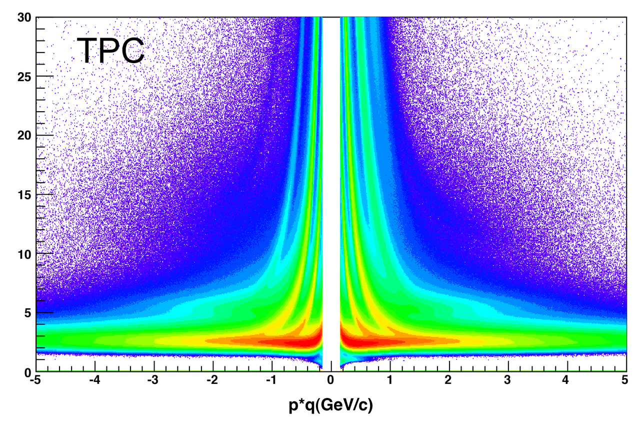
- $n\sigma_K \le 2$
- 0.16 < m^2 < 0.36 $(GeV/c^2)^2$

$p_T \ge$ 0.6 GeV/c:

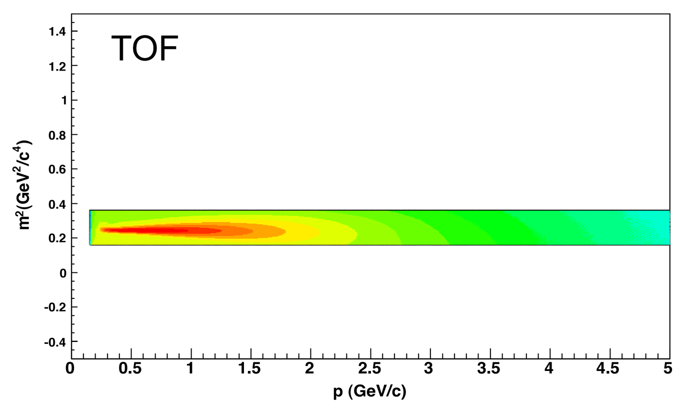
Only TOF

- 0.16 < m^2 < 0.36 $(GeV/c^2)^2$

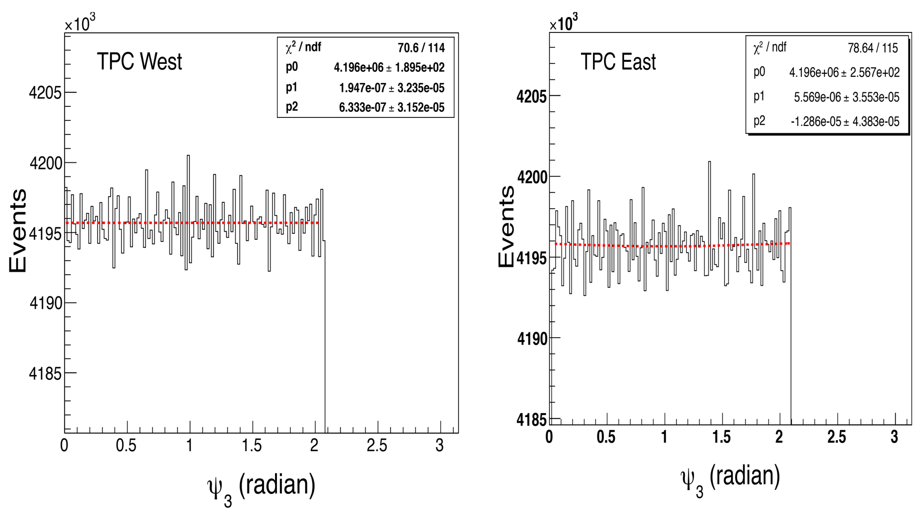
$$< dE/dX > \sim A(1+\frac{m^2}{p^2})$$



$$< \tau > = L(1+\frac{m^2}{p^2})^{1/2}$$



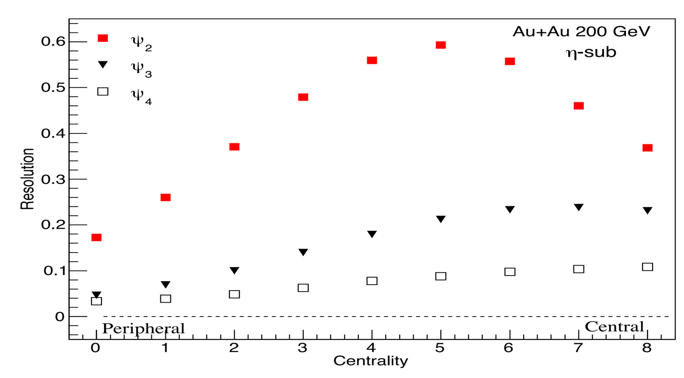
Event Plane Distribution



- Corrected by Recentre+Shift method
- Event planes are fitted with function
  f = $p_0(1+2p_1\cos(n\Psi_n)+2p_2\sin(n\Psi_n))$
- η gap between east and west event plane is 0.1

A. M. Poskanzer et al., Phys. Rev. C, 58 (1998).

Event Plane Resolution



$$R = \sqrt{<\cos[m(\Psi_n^{west} - \Psi_n^{east})]>}$$

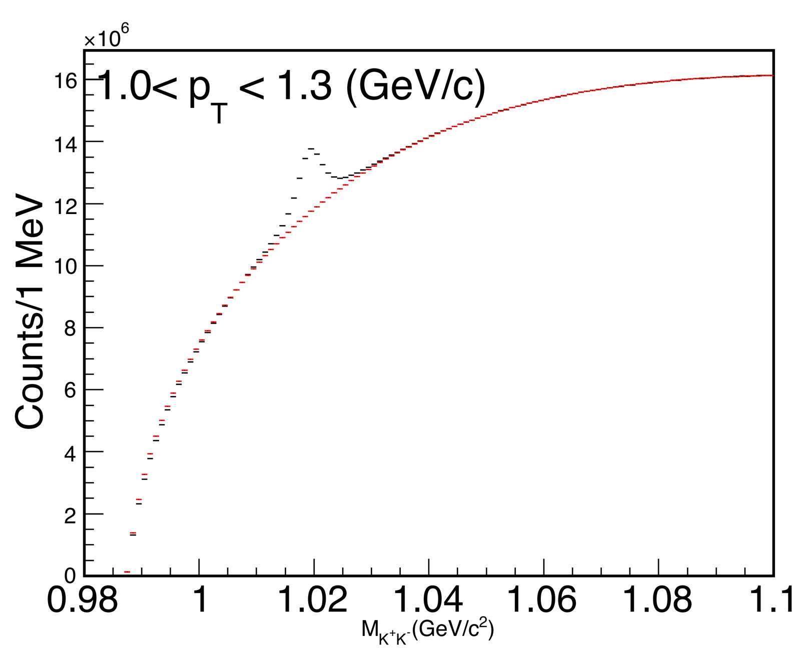
Where m -> harmonic of interest
n is the order of event plane

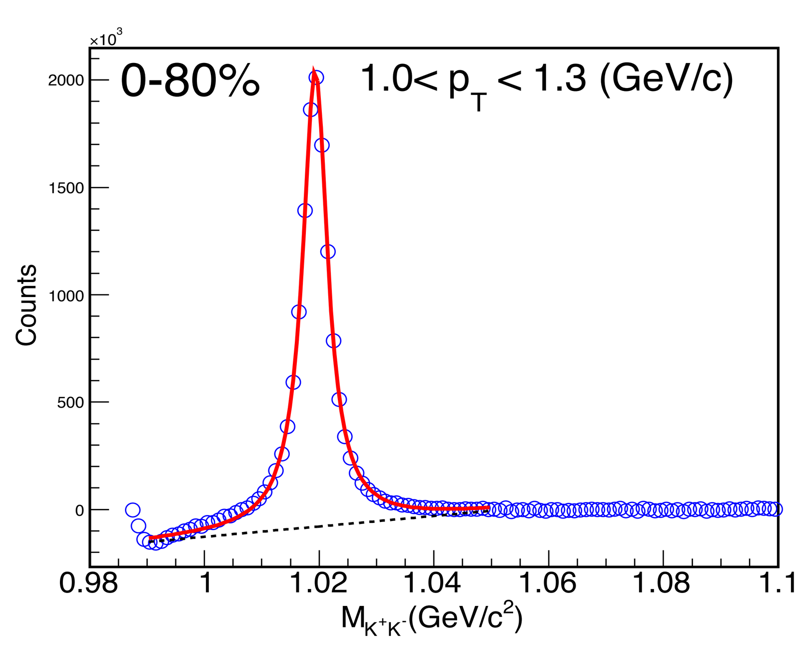
Event by event resolution correction

$$\langle v_n \rangle = \langle \frac{v_n^{obs.}}{R} \rangle$$

H.Masui et al., arXiv:1212.3650 [nucl-ex](2012)

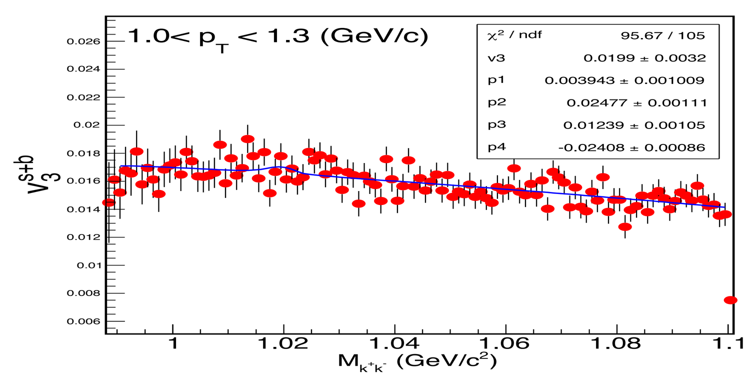
Reconstruction of ϕ meson





- ϕ meson is reconstructed from $K^+ K^-$ decay channel
- Background: Event mixing
- ϕ signal is fitted with Breit-Wigner + 1st order polynomial

v_n vs Invariant Mass Method



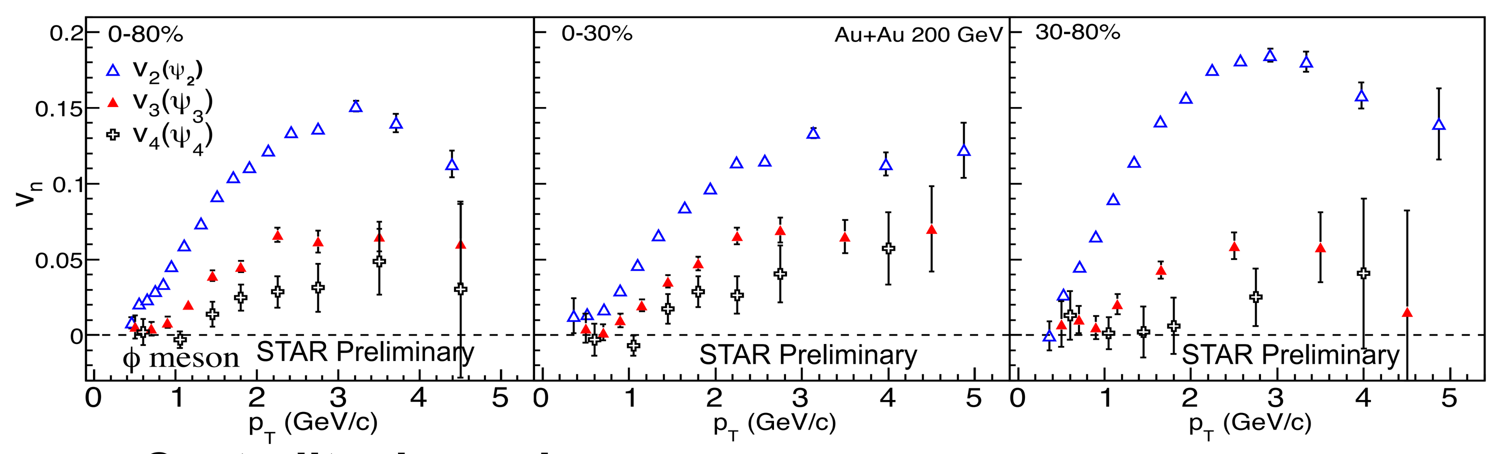
$$v_n^{Sig+Bg}(m_{inv}) = < \cos(n(\Phi - \Psi)) >$$

$$= v_n^{Sig} \cdot \frac{Sig}{Sig+Bg}(m_{inv}) + v_n^{Bg} \cdot \frac{Bg}{Sig+Bg}(m_{inv})$$

N. Borghini and J. Ollitrault Phys.Rev. C 70, 064905(2004)

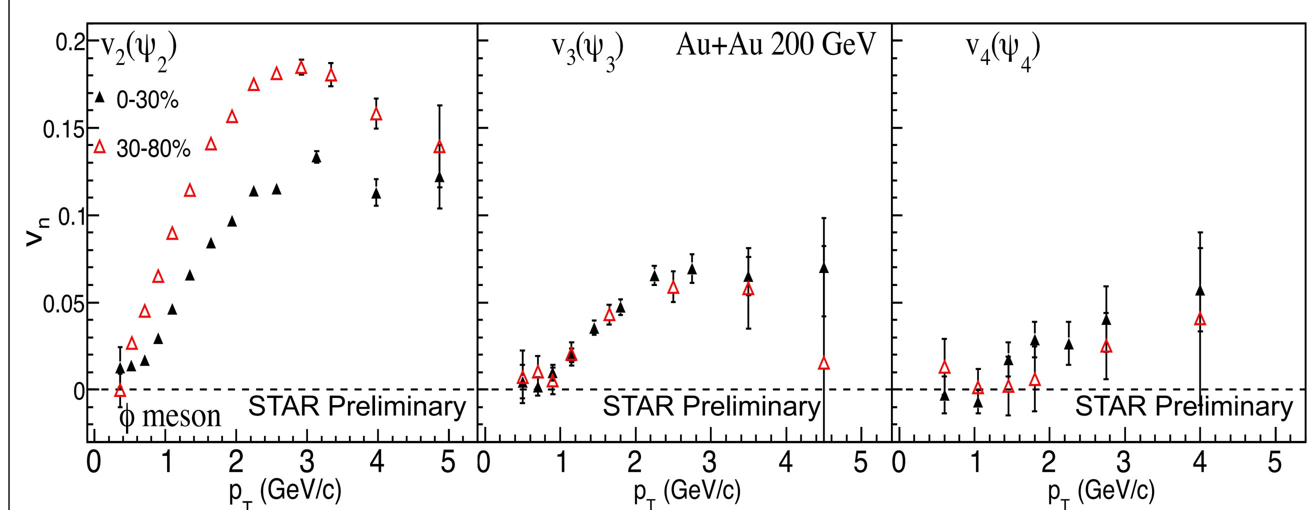
Results

v_2 , v_3 , v_4 of ϕ meson



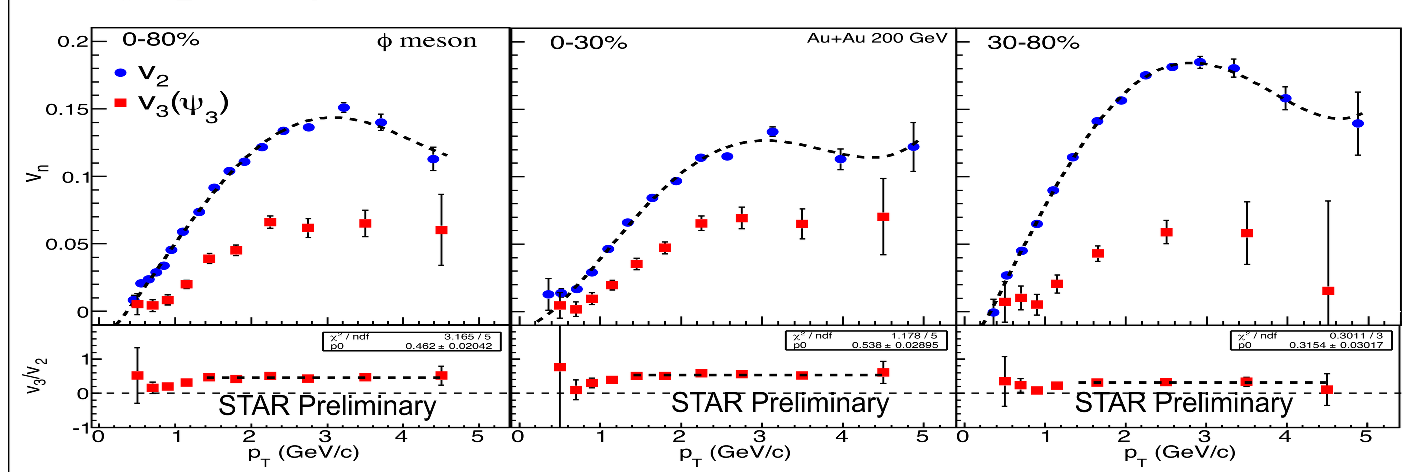
- $v_2 > v_3 >\sim v_4$

v_n Centrality dependence:



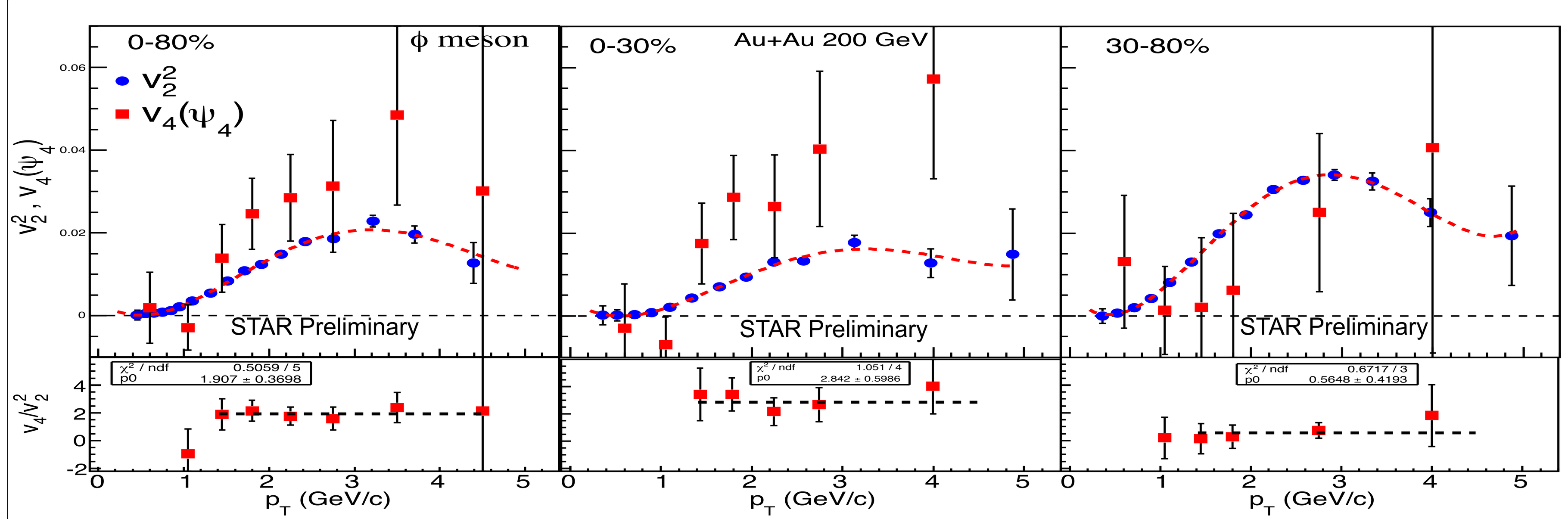
- $v_2(\psi_2)$ shows strong centrality dependence
- No visible centrality dependence for $v_3(\psi_3)$ and $v_4(\Psi_4)$ within statistical uncertainties

v_3/v_2 vs p_T ratio:



- For p_T > 1.5 GeV/c, v_3/v_2 ratio is constant

v_4/v_2^2 vs p_T ratio:



0-80%	0-30%	30-80%
$v_4(\psi_4)/v_2^2$ = 1.91 ± 0.37	$v_4(\psi_4)/v_2^2$ = 2.84 ± 0.60	$v_4(\psi_4)/v_2^2$ = 0.56 ± 0.42

Summary

- We have presented $v_3(p_T)$ and $v_4(p_T)$ of ϕ meson in Au+Au collisions at $\sqrt{s_{NN}}$= 200 GeV
- No visible centrality dependence for $v_3(\psi_3)$ and $v_4(\psi_4)$ within statistical uncertainties
- v_3/v_2 ratio is constant for p_T>1.5 GeV/c which is qualitatively consistent with hydro model prediction
- $v_4(\psi_4)/v_2^2$ is larger than ideal for central collisions but comparable in peripheral collisions

References

[1] J. Adams et al. (STAR Collaboration), Nucl. Phys. A 757, 102 (2005).

[2] L. W. Chen et al. Phys. Rev. C 73, 044903 (2006).

[3] L. Adamczyk et al. (STAR Collaboration), Phys. Rev. C 88, 014904 (2013).

[4] C. Lang et al. arXiv:1312.7763 [nucl-th] (2013).

XXIV QUARK MATTER DARMSTADT 2014

BROOKHAVEN NATIONAL LABORATORY