Energy Dependence of ϕ-meson v_2 in STAR at RHIC

Md. Nasim for STAR Collaboration

VECC, INDIA

Outline :

- Introduction and Motivation
- STAR detector set-up
- Flow Analysis Methods
- Particle Identification
- Results
- Conclusion

Introduction and Motivation

Why v_2 of ϕ-meson is important ?

- ✔ v_2 is early time phenomenon and *hadronic cross-section* of ϕ-meson is small

  ⟶ ϕ-meson v_2 can retain information of the initial system at partonic level.

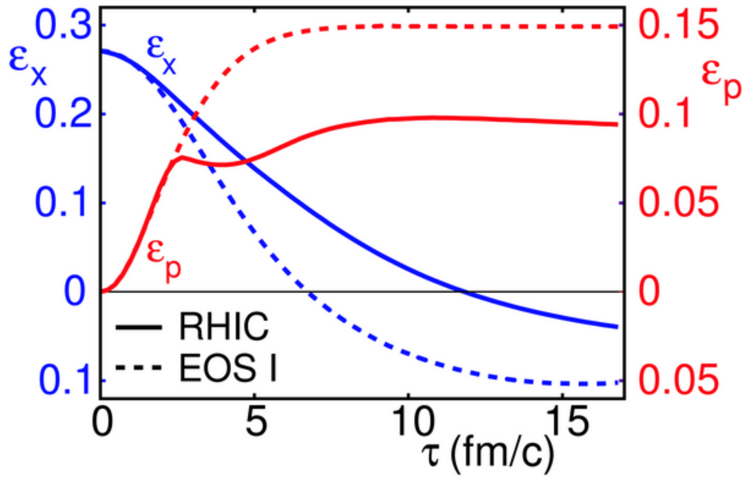
$\sigma_{\rho N} \sim 3\ \sigma_{\phi N}$
$\sigma_{\pi N} \sim 2.6\ \sigma_{\phi N}$
$\sigma_{KN} \sim 2.1\ \sigma_{\phi N}$

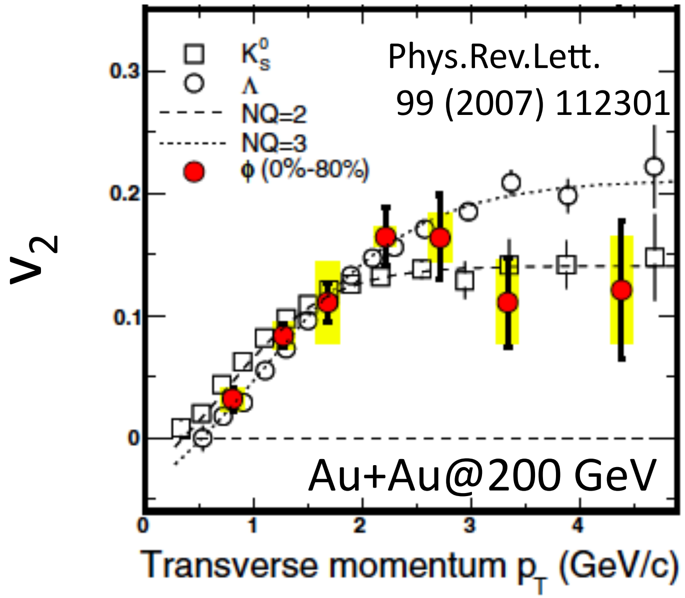
$\sigma_{\Lambda N} \sim 3.5\ \sigma_{\phi N}$
$\sigma_{NN} \sim 4\ \sigma_{\phi N}$

- ✔ Mass of ϕ-meson (1.019 GeV) is comparable to mass of lightest baryon

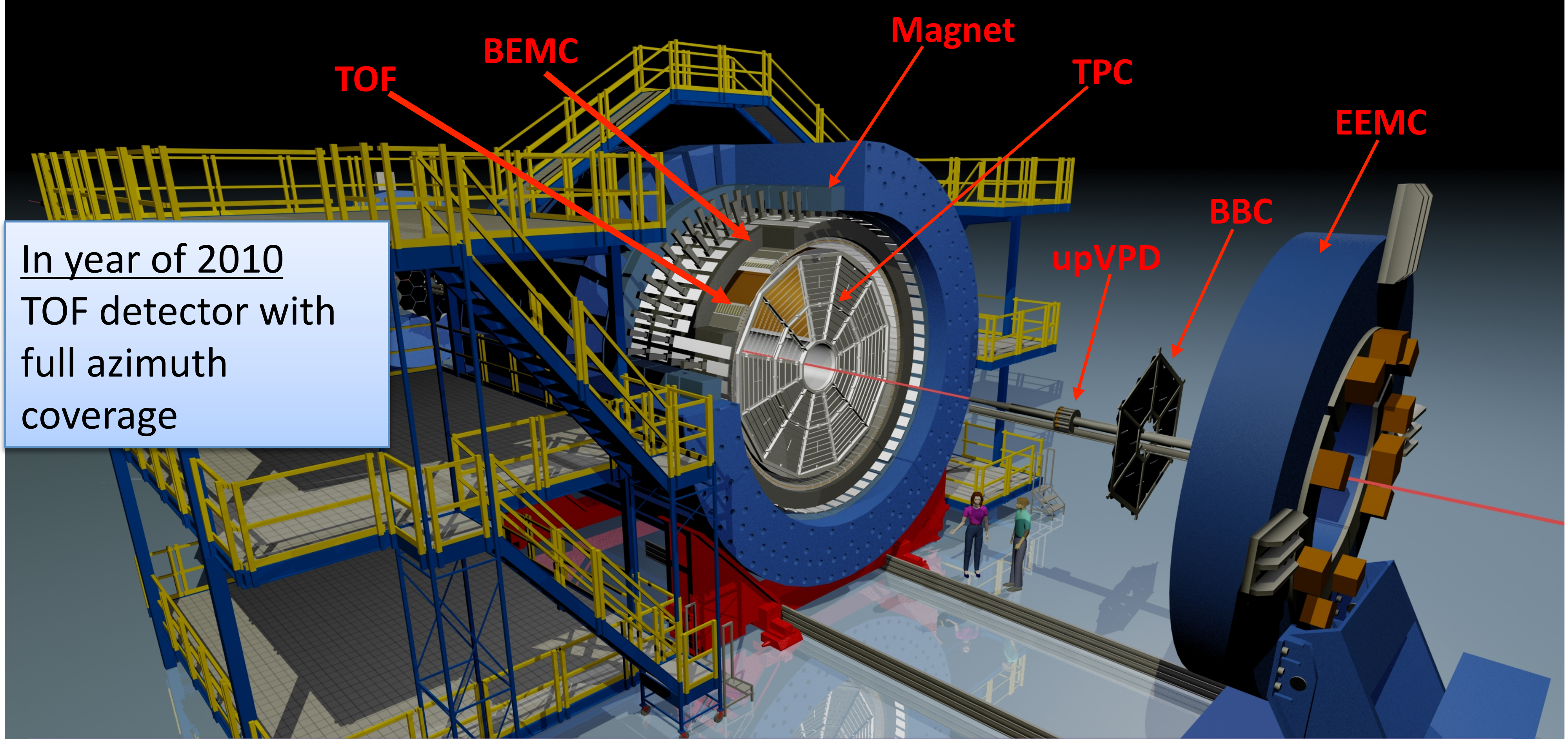
  ⟶ comparison of ϕ-meson v_2 with that of other particles can help to differentiate between mass type and meson/baryon type dependence of particle production. Will tell us about partonic collectivity.

P. Klob, U. W. Heinz
Nucl. Phys. A715, (2003) 653c





The Solenoid Tracker At RHIC (STAR)



In year of 2010
TOF detector with full azimuth coverage

Data set	Trigger	Vz cut	V_R = sqrt(v_x*v_x +v_y*v_y) cut	Number of good events
Au+Au@39 GeV	Minimum bias	+- 40 cm	< 2 cm	169 M
Au+Au@11.5 GeV	Minimum bias	+- 50 cm	< 2cm	11 M
Au+Au@7.7 GeV	Minimum bias	+- 70 cm	< 2cm	4.2 M

Flow Analysis methods

- **Full Event Plane Method :**
  1. Flow track from $-1.0 < \eta < 1.0$.
  2. Particle of interest from $-1.0 < \eta < 1.0$

  ✓Affected by non flow correlations

- **η Sub Event Plane Method :** Define 2 independent group of particles with a constant η gap

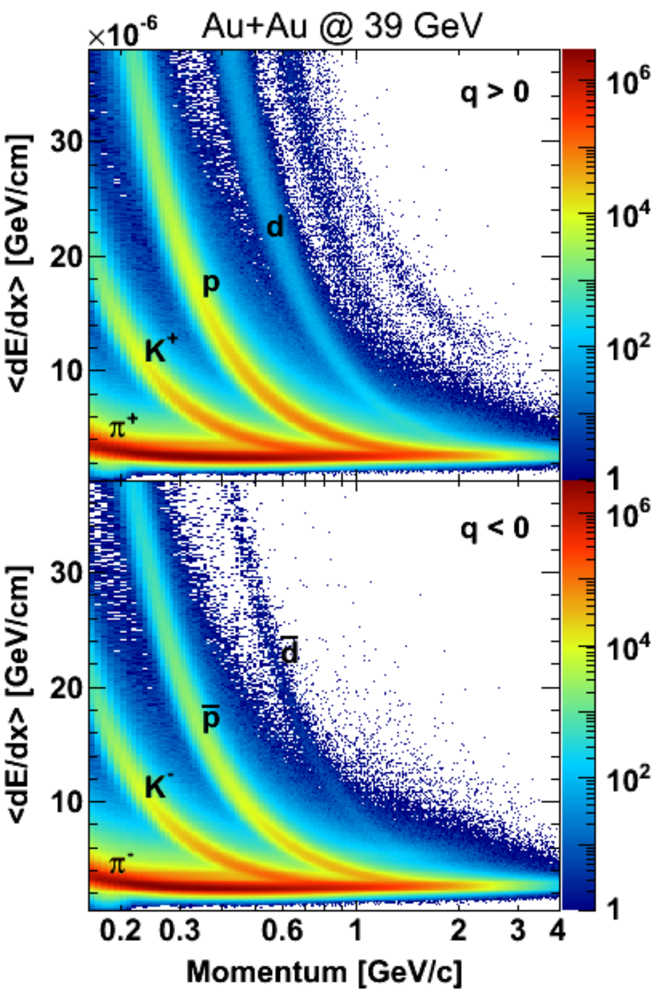
  ✓Suppresses short-range correlations

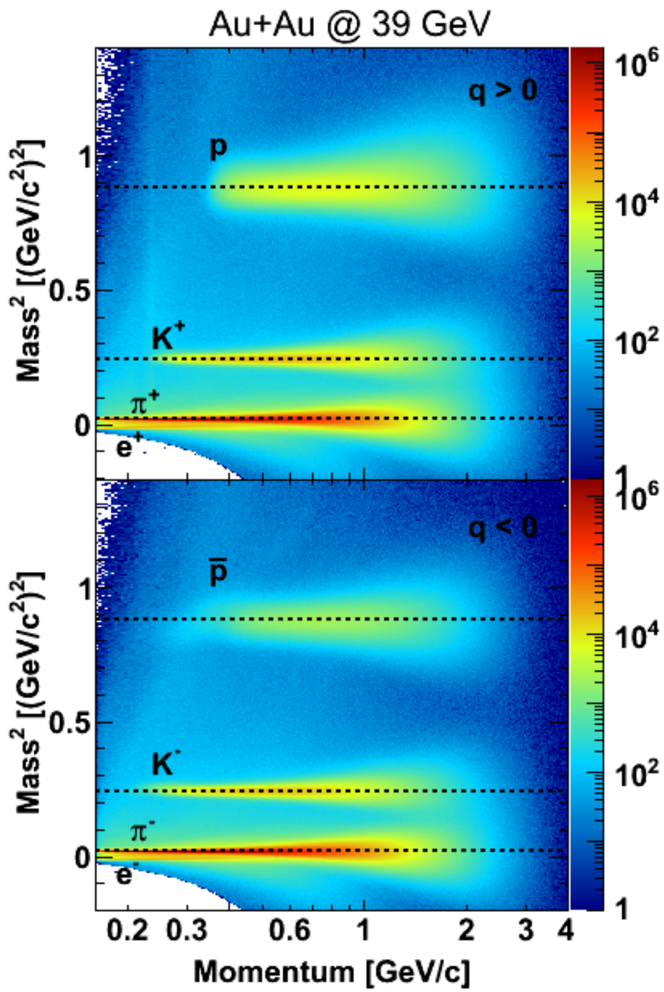
❖ Event Plane Resolution :

- Correlate subevent planes $\langle \cos[n(\Psi_n^a - \Psi_n^b)] \rangle$
- Subevent plane resolution $\mathrm{resSub} \equiv \langle \cos(n(\Psi_n^a - \Psi_{RP})) \rangle = \sqrt{\langle \cos(n(\Psi_n^a - \Psi_n^b)) \rangle}$
- Full event plane resolution $\mathrm{res} \equiv \langle \cos(n(\Psi_n - \Psi_{RP})) \rangle \leq \sqrt{2}\,\mathrm{resSub}$

A.M. Poskanzer and S.A. Voloshin, PRC **58**, 1671 (1998)

Particle Identification

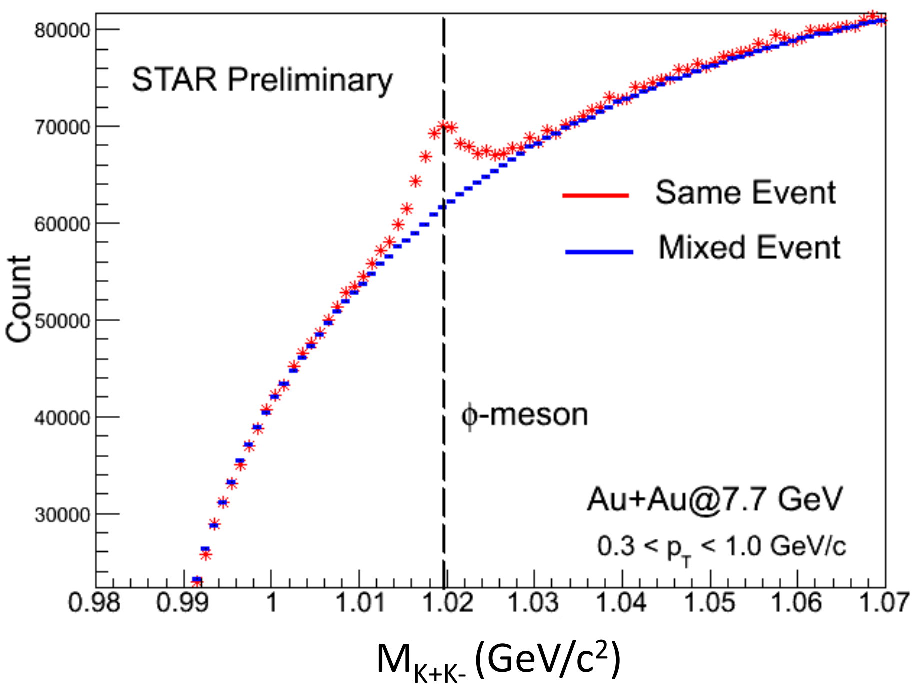


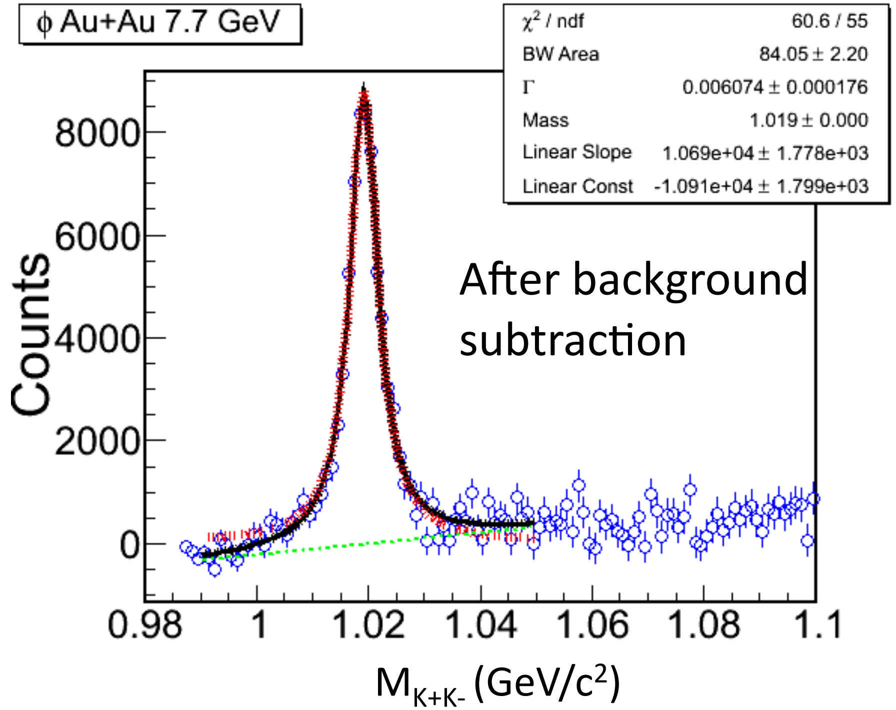


dE/dx PID: pion/kaon: p_T ~ 0.6 GeV/c; **With full TOF :** pion/kaon: p_T ~ 1.6 GeV/c;

ϕ –meson reconstruction

Decay mode : $\phi \longrightarrow K^+ + K^-$, (Branching ratio 49.2 %)





✔ Briet-Wigner function for signal fit and 1st order polynomial for residual background

$$B.W = \frac{1}{2\pi}\left[\frac{A\Gamma_{\phi}}{(m - m_{\phi})^2 + (\frac{\Gamma_{\phi}}{2})^2}\right]$$

v_2 extraction methods for resonance particle

Invariant Mass Method

Fit v_2 (obs.) vs m_{inv} using :

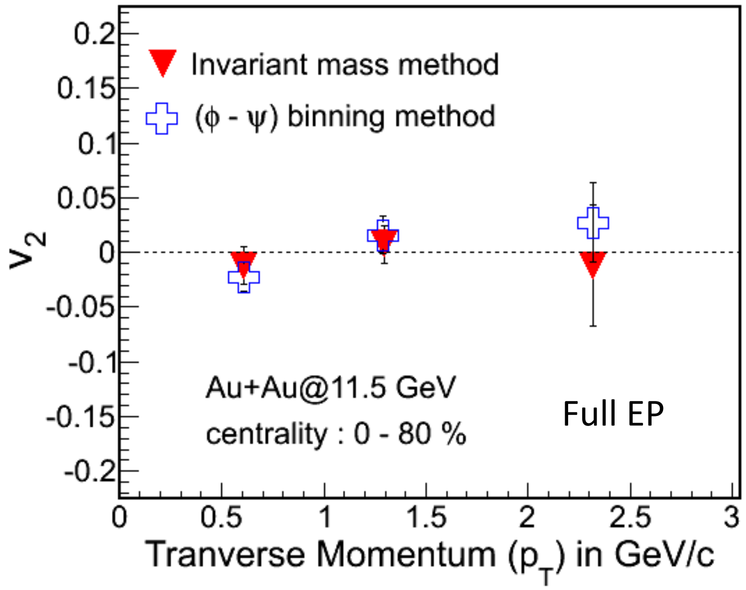
$$v_2^{Sig+Bg}(m_{inv}) = \langle \cos(2(\Phi - \Psi)) \rangle = v_2^{Sig} . \frac{Sig}{Sig+Bg}(m_{inv}) + v_2^{Bg} . \frac{Bg}{Sig+Bg}(m_{inv})$$

Assume $$v_2^{Bg}(m_{inv}) = p_0 + p_1 m_{inv} + p_2 m_{inv}^2 + p_3 m_{inv}^3$$

$(\phi - \psi)$ Binning Method

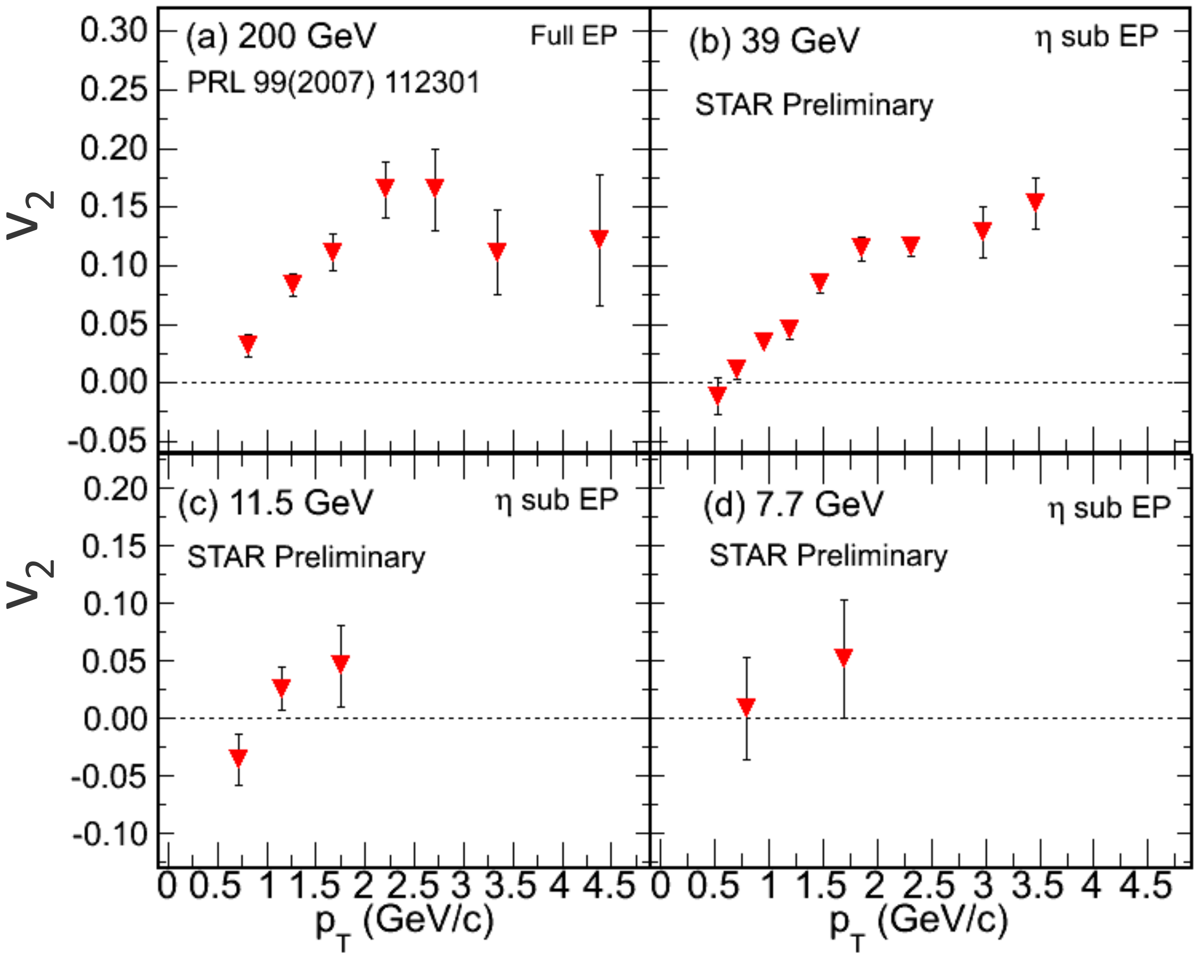
Raw ϕ-meson yield as a function of $(\Phi - \Psi)$ is fitted with

$$\phi_{yield}(\Phi - \Psi) = p_0 .(1 + 2.v_2 .\cos(\Phi - \Psi))$$



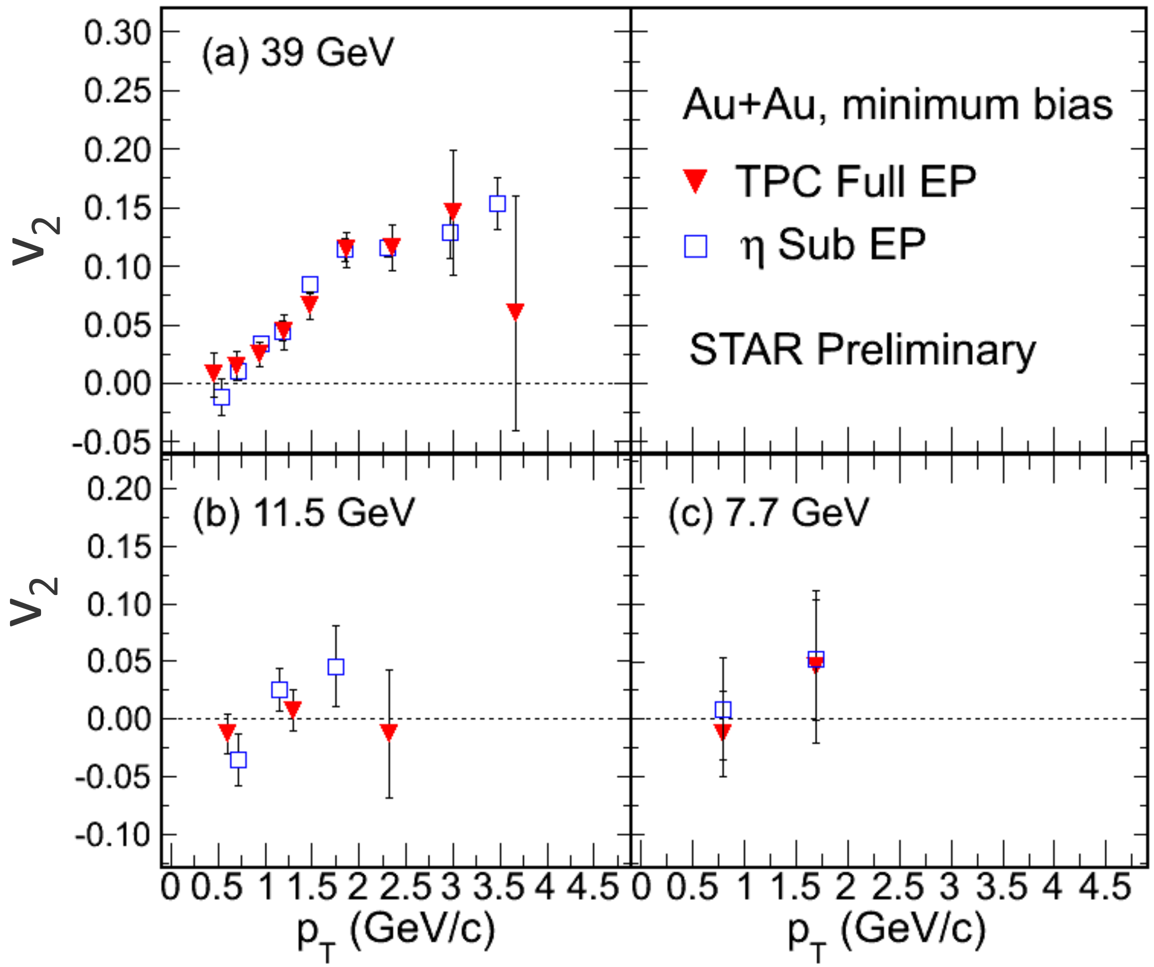
φ-meson v_2 @ 7.7, 11.5 , 39 and 200 GeV

Au+Au, (0-80%) , η sub EP



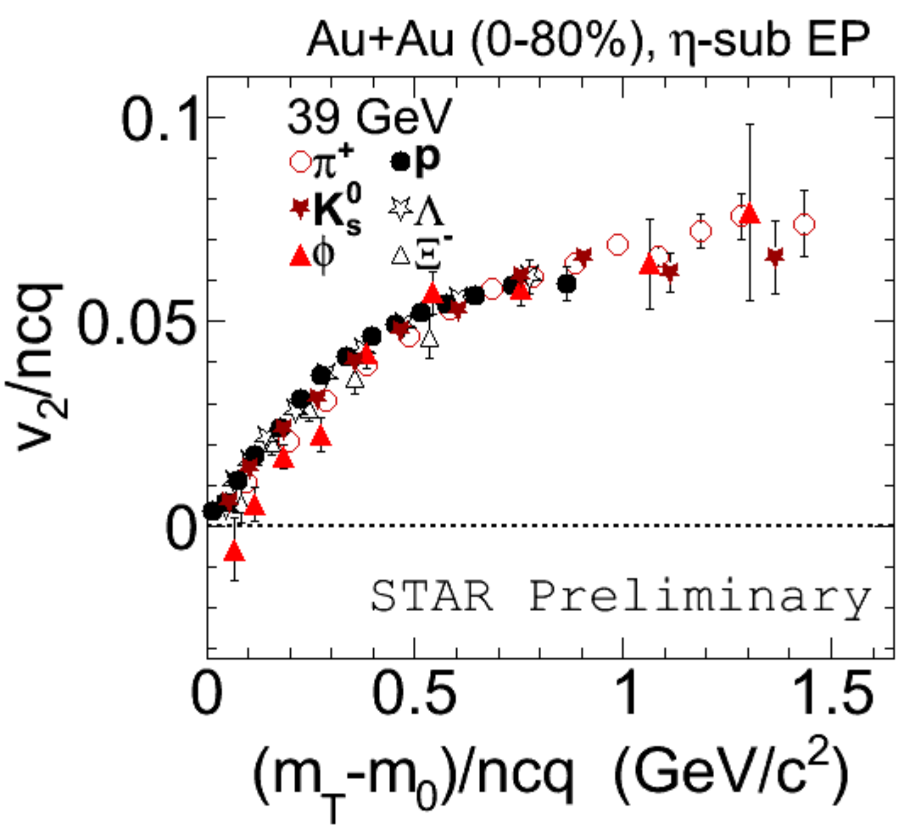
- φ-meson $v_2 (p_T)$ @ 11.5 GeV is smaller than 39 and 200 GeV

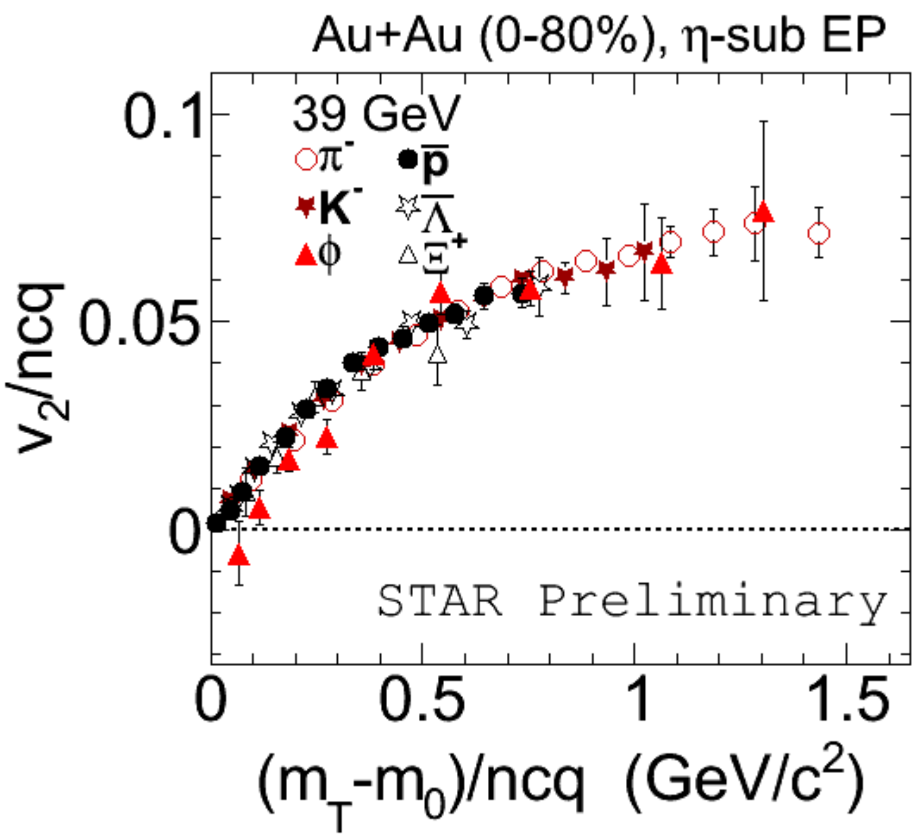
ϕ-meson v_2 from different method



Results are consistent from two different methods

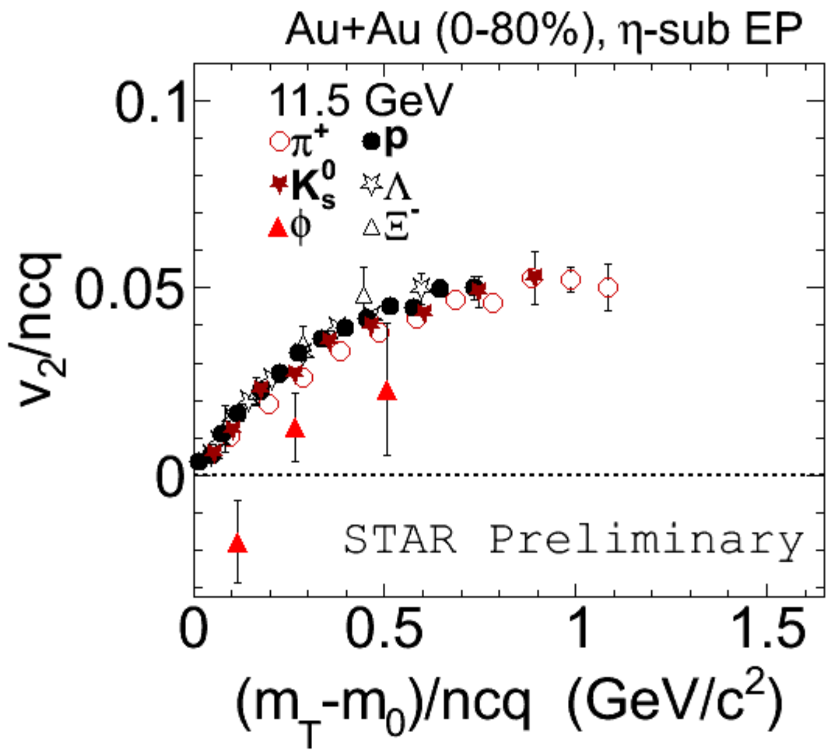
NCQ Scaling test @39 GeV

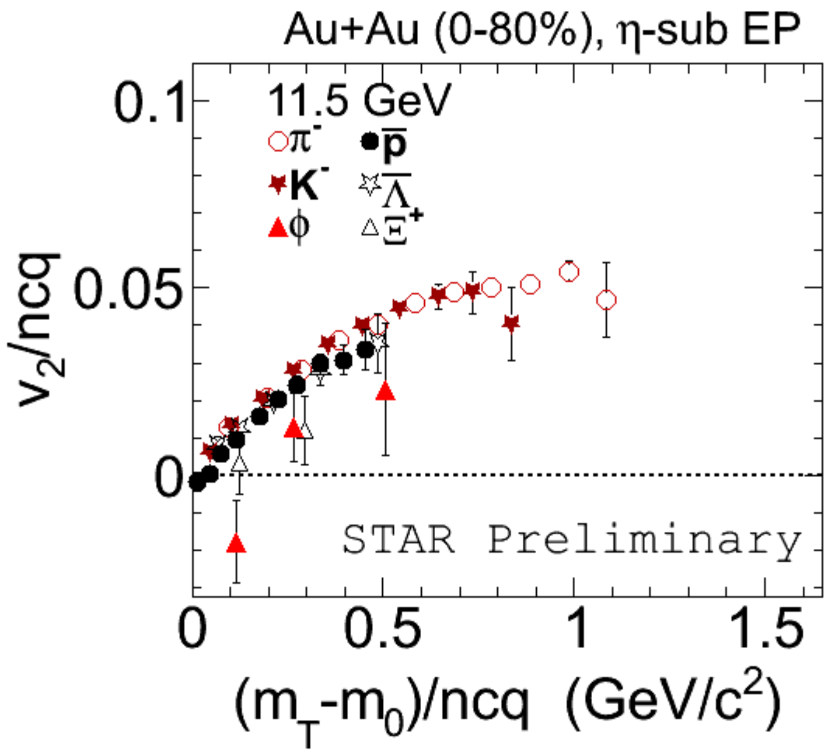




- ϕ-meson v_2 (p_T) @39 GeV shows NCQ scaling

NCQ Scaling test @11.5 GeV





- ϕ-meson v_2 (p_T) @11.5 GeV shows different trend than other hadrons
- Mean deviation of ϕ-meson v_2 from the pion v_2 is ~ 2.6 σ
- Small or zero ϕ-meson v_2 → hadronic matter

Ref: B. Mohanty and N. Xu , J.Phys. G 36,064022(2009

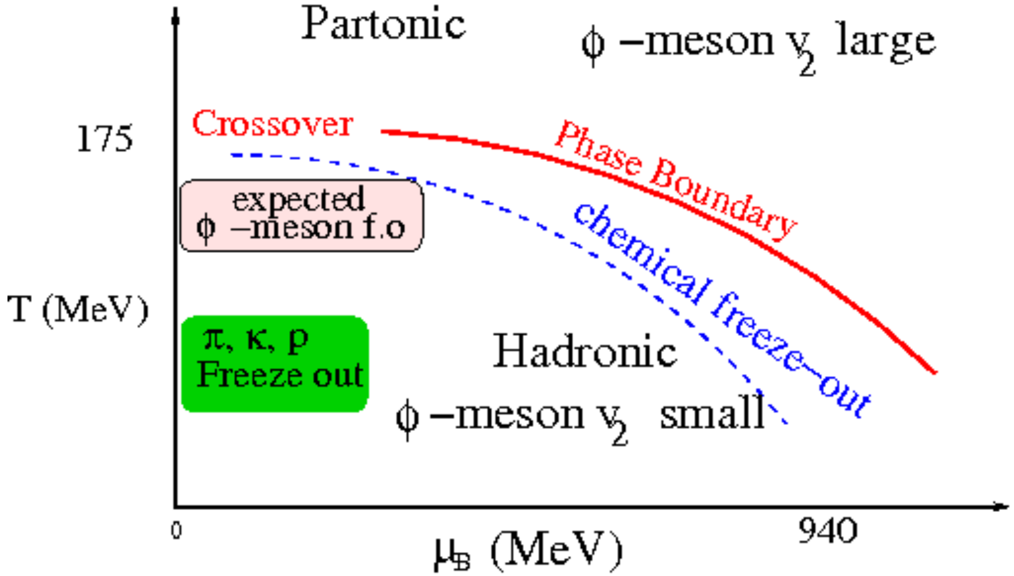
Conclusion

- We present ϕ-meson $v_2\,(p_T)$ results at 7.7, 11.5 and 39 GeV.

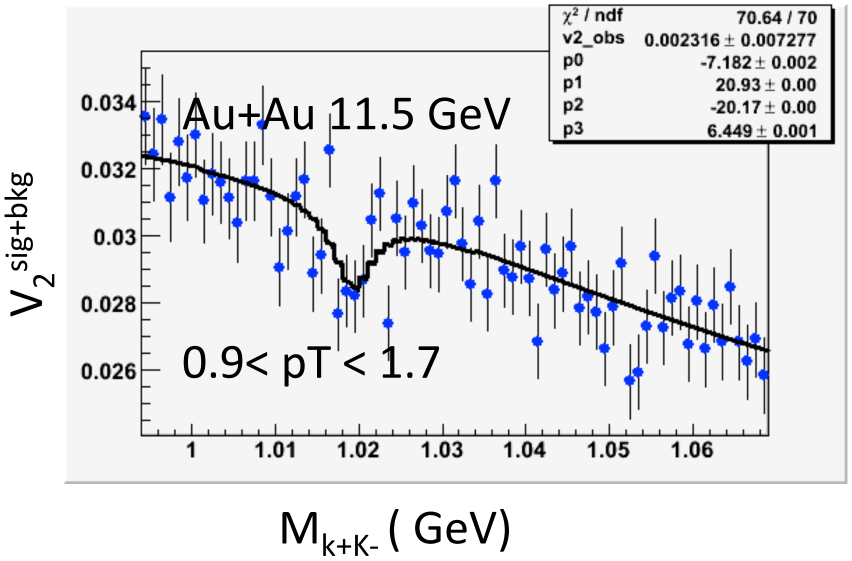
- ϕ-meson $v_2\,(p_T)$ at 39 GeV follows NCQ scaling.
  partonic collectivity @39 GeV as observed @200GeV

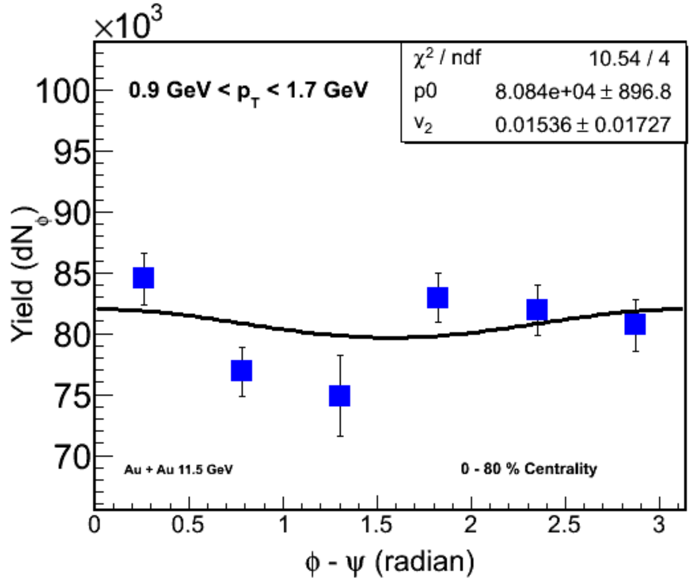
- ϕ-meson $v_2\,(p_T)$ @11.5 GeV shows different trend than other hadrons. Mean deviation of ϕ-meson v_2 from the pion v_2 is ~ 2.6 σ

- Dominance of hadronic interactions over partonic interactions with decrease in beam energy.



Back-up


χ² / ndf 70.64 / 70
v2_obs 0.002316 ± 0.007277
p0 -7.182 ± 0.002
p1 20.93 ± 0.00
p2 -20.17 ± 0.00
p3 6.449 ± 0.001
Au+Au 11.5 GeV
0.9< pT < 1.7
$V_2^{sig+bkg}$
M_{k+K-} (GeV)


×10³
χ² / ndf 10.54 / 4
p0 8.084e+04 ± 896.8
v_2 0.01536 ± 0.01727
0.9 GeV < p_T < 1.7 GeV
Yield (dN_ϕ)
Au + Au 11.5 GeV
0 - 80 % Centrality
ϕ - ψ (radian)