Azimuthal Anisotropy Measurement of ϕ meson in Au+Au collisions at 27 and 54.4 GeV at STAR

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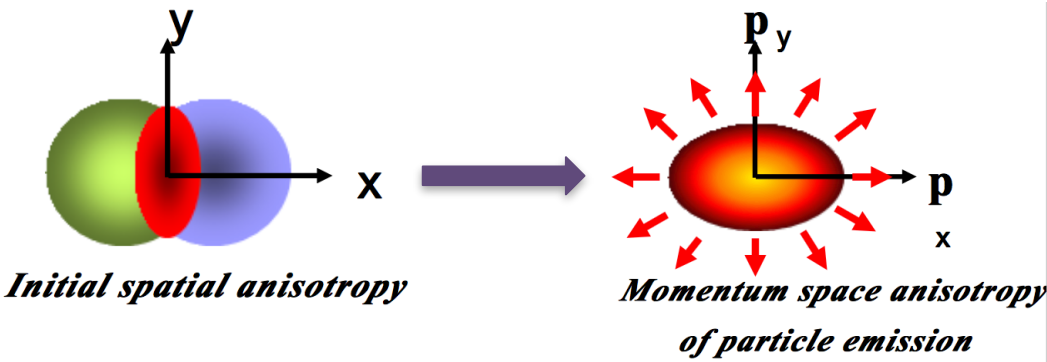
Outline

- Introduction
- The STAR Detector
- Results
  - Azimuthal Anisotropy (v_2) of φ mesons
  - Number of Constituents Quark Scaling of v_2
  - Comparison with AMPT model
- Summary

Azimuthal Anisotropy

Pressure gradient transfers initial spatial anisotropy to final state momentum space anisotropy

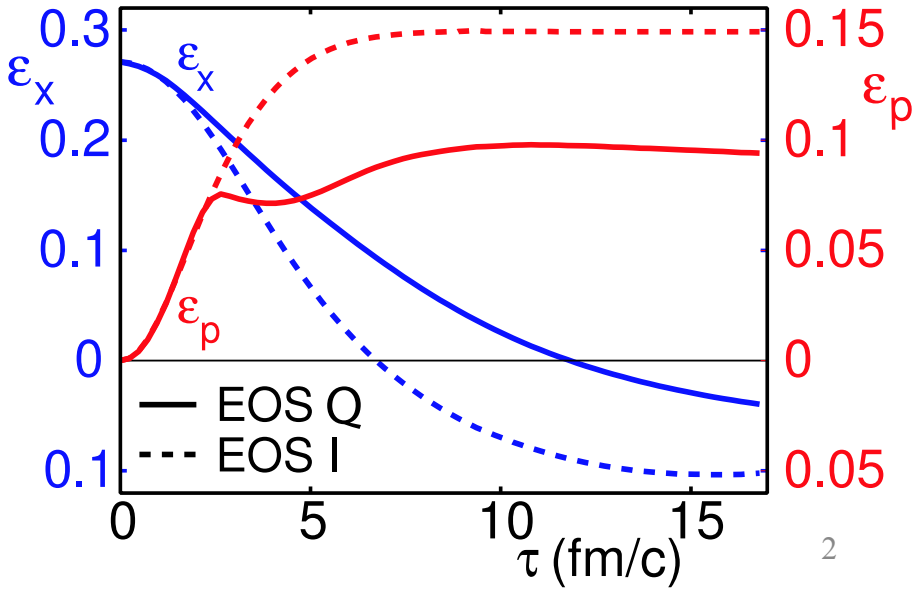


$$E\frac{d^3N}{dp^3} = \frac{1}{2\pi}\frac{d^2N}{p_T dp_T dy}[1 + 2v_1\cos(\phi - \Psi_R) + 2v_2\cos 2(\phi - \Psi_R) + \ldots]$$

v_1 – Directed flow

v_2 – Elliptic flow

Sensitive to initial dynamics



Nucl. Phys. A715, (2003) 653c

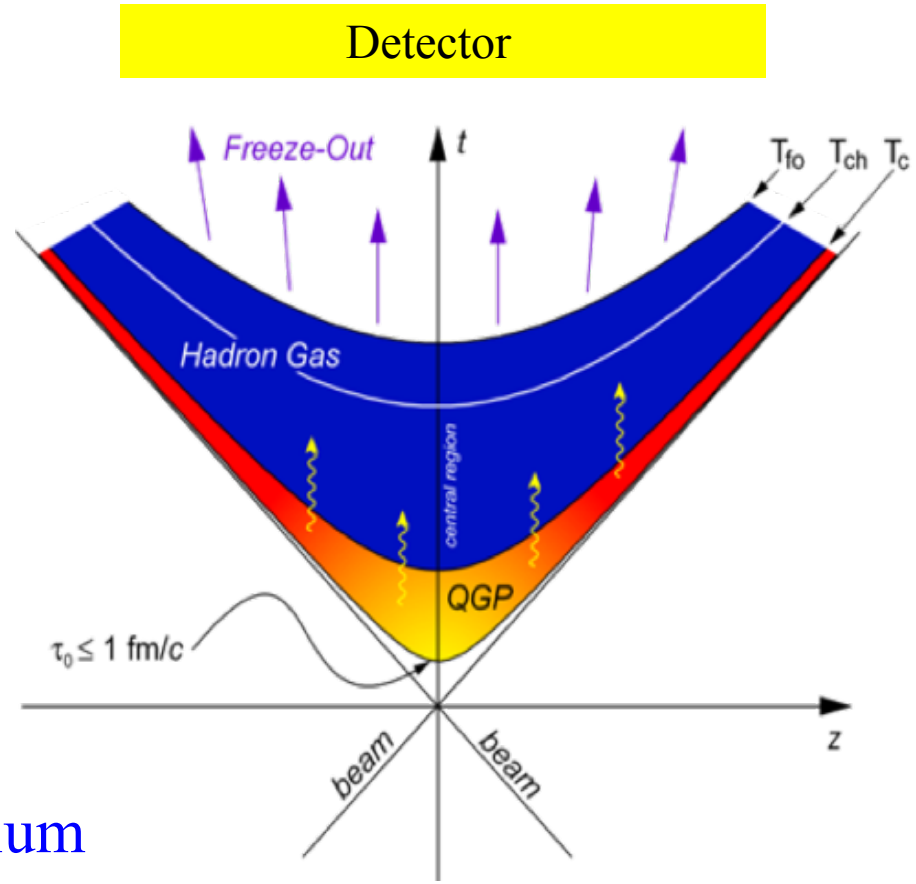
Why study ϕ meson ?

Goals :

Study the properties of QCD matter

ϕ meson :

- Small hadronic interaction cross-section
- Early Freeze-out

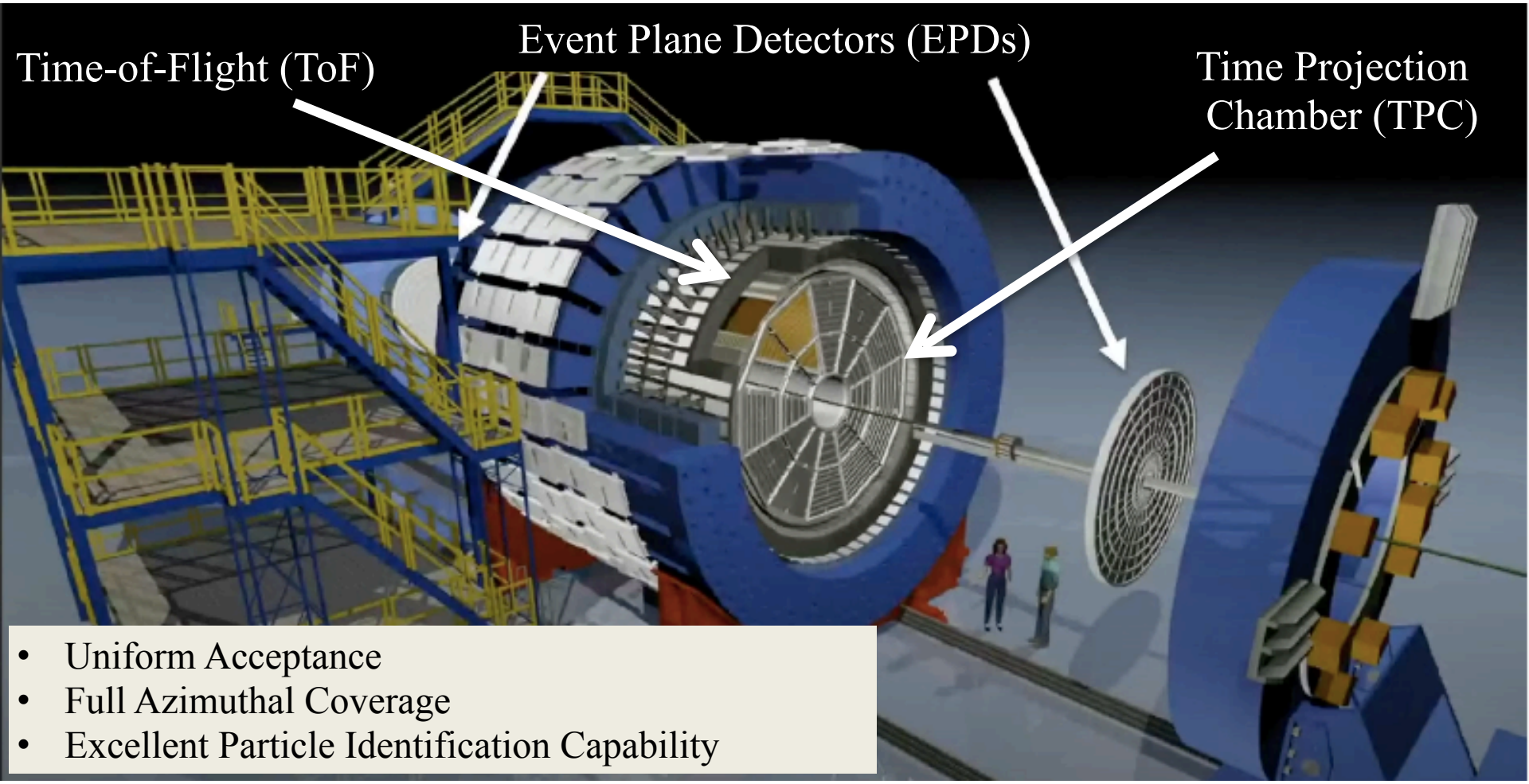


Excellent probe for the QGP medium

Phys. Rev. Lett. 54, 11 (1985)

Nucl.Phys .A 757 (2005)

The STAR Detector and Data Sets



- Uniform Acceptance
- Full Azimuthal Coverage
- Excellent Particle Identification Capability

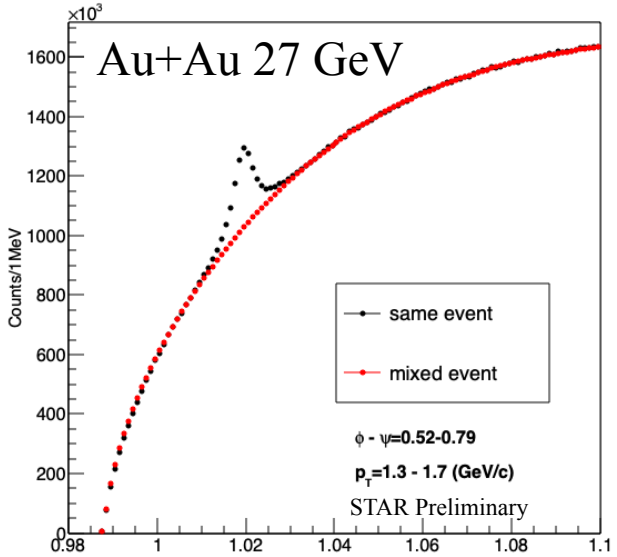
Collisions	**Centre-of-mass Energy**	**# of events analyzed**
Au+Au	27 GeV	300 M
Au+Au	54.4 GeV	600 M

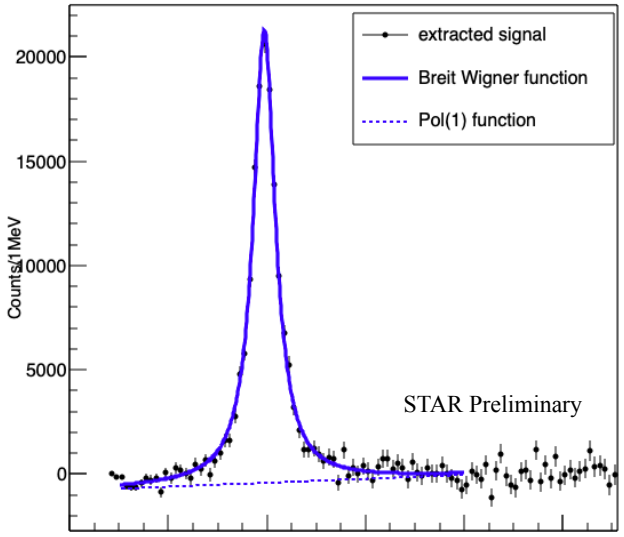
Reconstruction of ϕ mesons

- Decay Mode: $\phi \longrightarrow K^+ + K^-$
- Branching Ratio : 49%
- Kaons are identified using TPC and TOF detectors.
- φ mesons are reconstructed using invariant mass method

$$M_{inv}^2 = \sum_i E_i^2 - \sum_i p_i^2$$

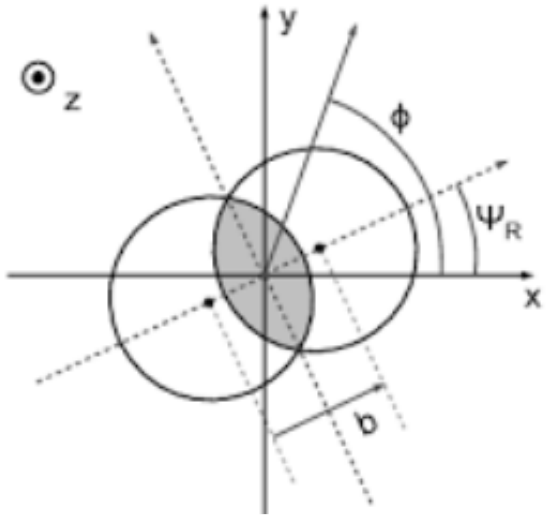
- Combinatorial background are estimated using mixed events method





Event Plane and Resolution

- The true reaction plane(Ψ_R) is the plane spanned by the impact parameter vector and the collision axis.
- It's not possible to determine Ψ_R directly from the experiment.
- The proxy for the reaction plane is called Event plane.



$$\psi_n = \frac{1}{n}\left(tan^{-1}(Q_y/Q_x)\right)$$

Ref: Phys. Rev. C 58, 1671 (1998)

Q_y and Q_x are the flow vectors given by

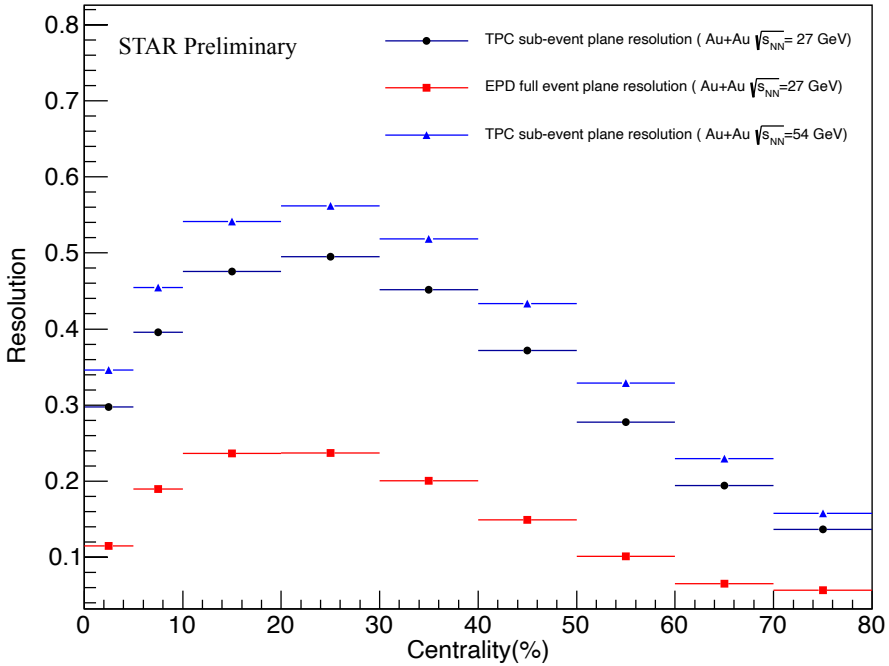
$$Q_x = \sum_i w_i cos(n\phi_i)$$

$$Q_y = \sum_i w_i sin(n\phi_i)$$

Event plane resolution is given by

$$R = \sqrt{< cos2(\psi_A - \psi_B) >}$$

Ψ_A and Ψ_B are two sub-events plane in +ve and -ve region of η.



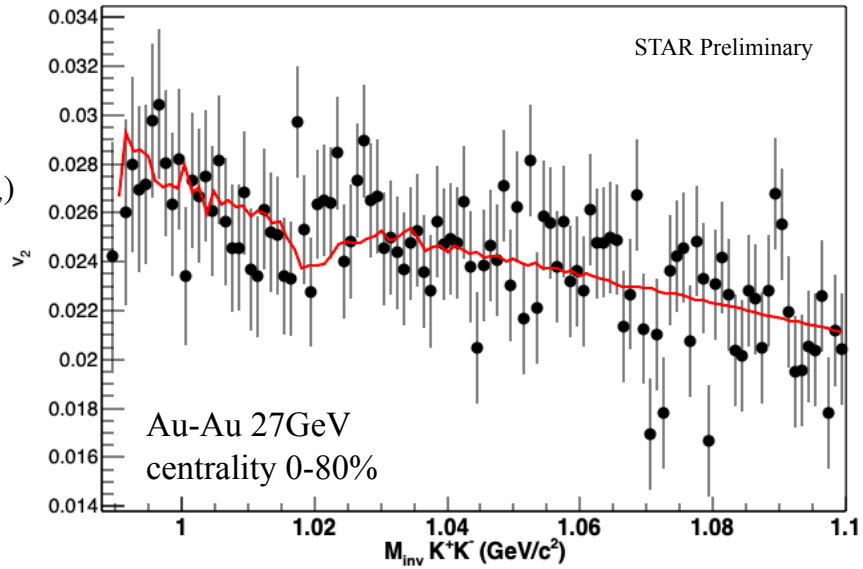
Flow Measurement Methods

v_2 vs Invariant Mass Method:

$$v_2^{S+B}(M_{inv}) = \langle cos\left[2(\phi - \psi_2)\right]\rangle = v_2^S \frac{S}{S+B}(M_{inv}) + v_2^B \frac{B}{S+B}(M_{inv})$$

$$v_2^B(M_{inv}) = p_0 + p_1 M_{inv}$$

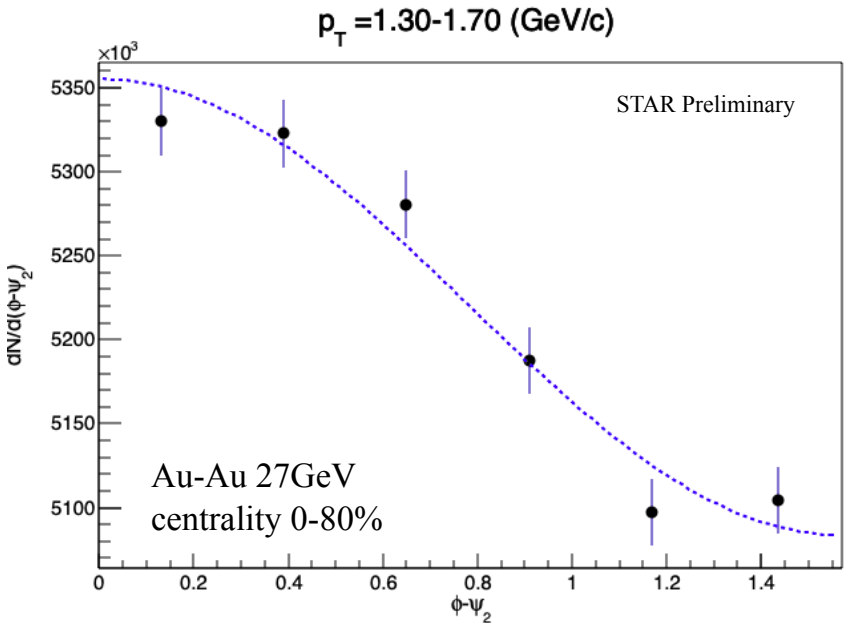
Ref.: Phys. Rev. C 70, 064905 (2004)



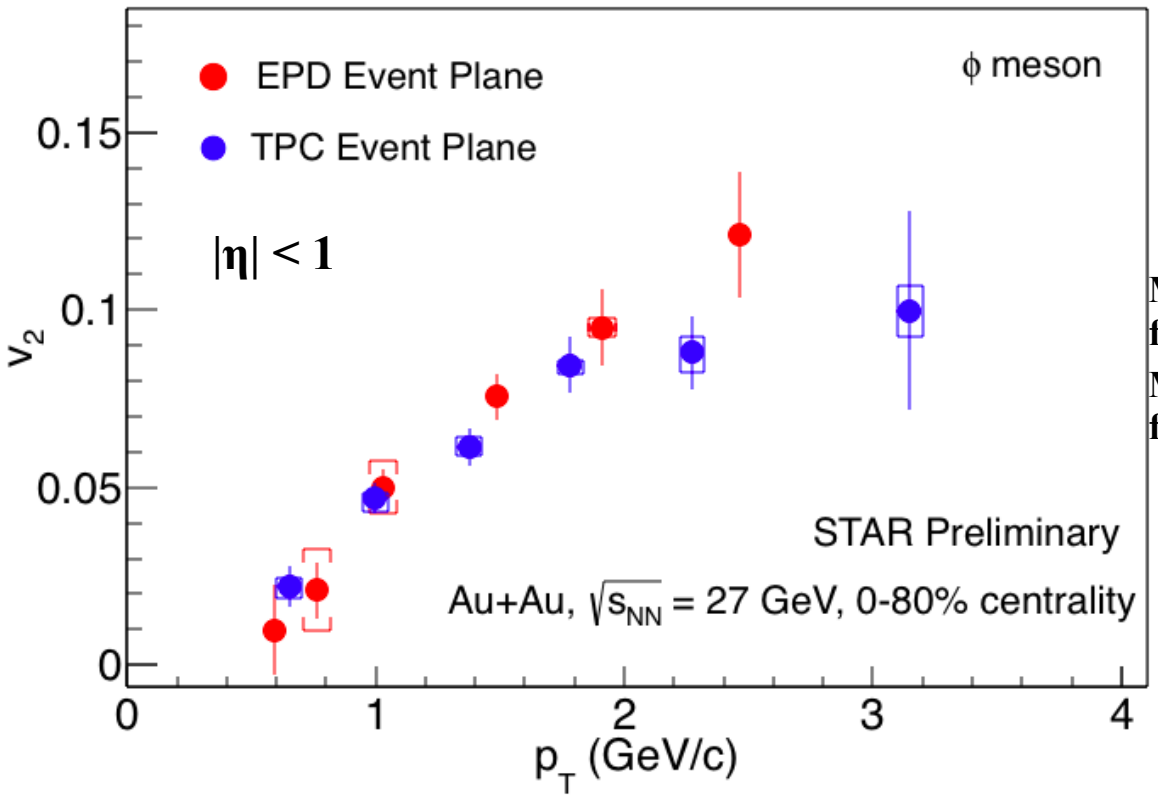
(Φ-Ψ) Bin Method:

$$\frac{dN}{d(\phi - \psi_2)} = \frac{N_0}{2\pi}\left(1 + v_2 cos[2(\phi - \psi_2)]\right)$$

Ref: Phys. Rev. C 58, 1671 (1998)



Elliptic flow (v_2) of ϕ mesons at 27 GeV



EPD Coverage: 2.1 < |η| <5.1

TPC Coverage: |η| < 1

Min. η gap = 0.05 between EP and φ meson for TPC

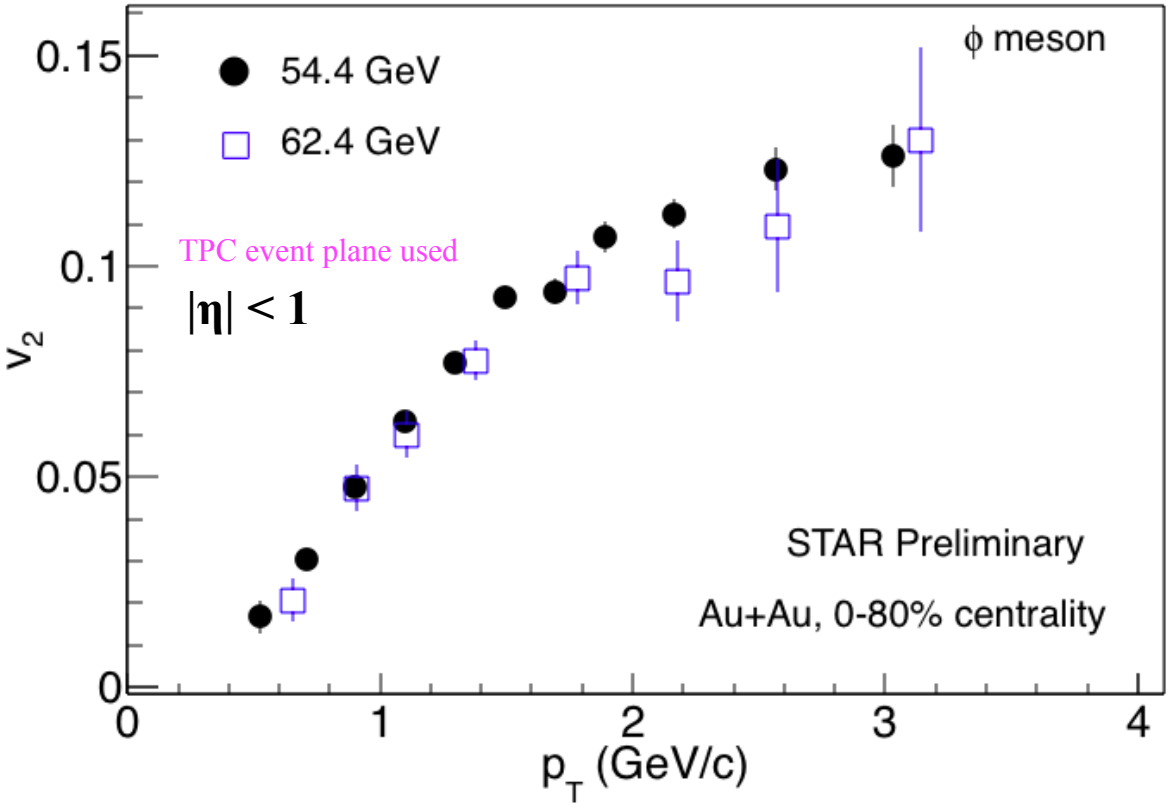
Min. η gap = 1.1 between EP and φ meson for EPD

Ref. for 27 GeV data using TPC event plane : (STAR) Phys. Rev. C 88 (2013) 14902

Invariant mass method has been used to calculate v_2 using EPD event plane

Two measurements are consistent with each other within uncertainties. This indicates effect of "non-flow" is negligible.

Elliptic flow (v_2) of ϕ mesons at 54.4 GeV

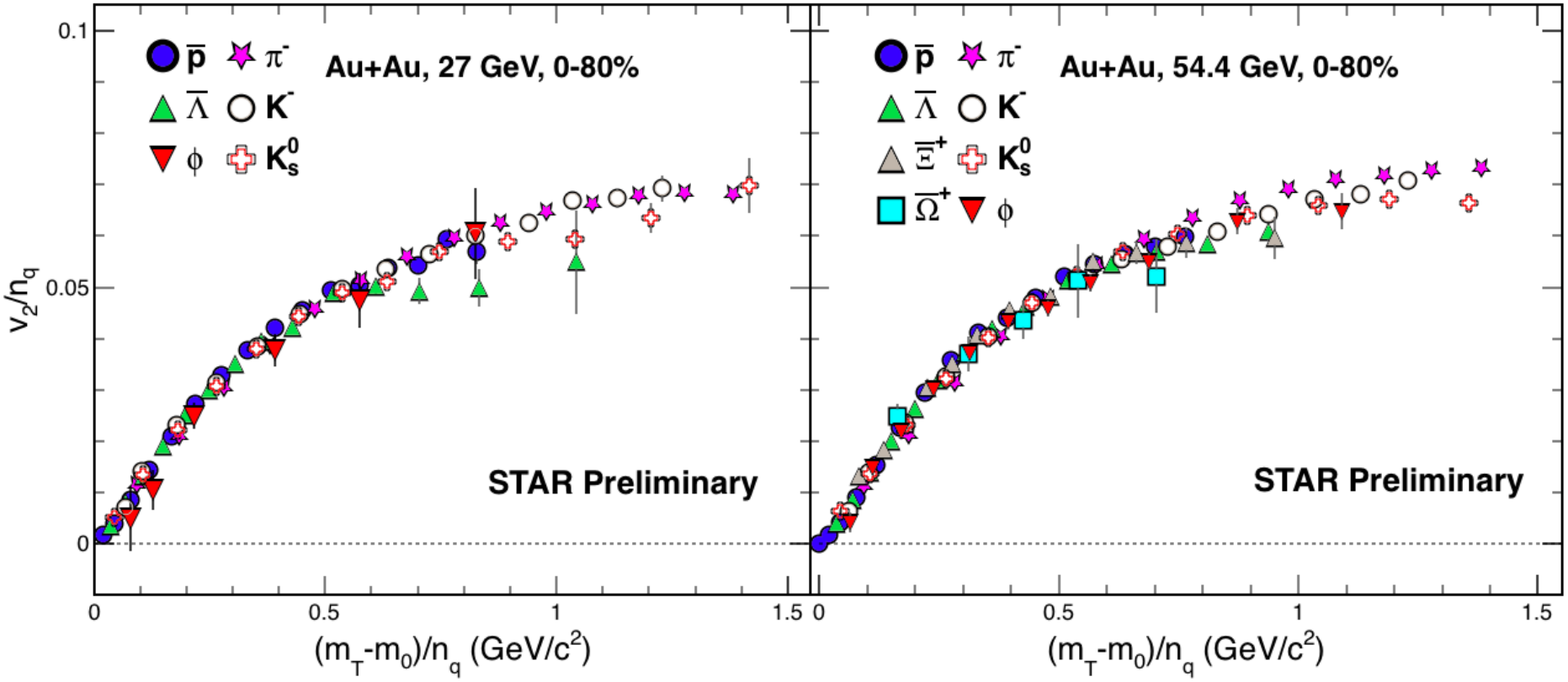


Ref. for 62.4 GeV data
: (STAR)
Phys. Rev. C 88 (2013) 14902

Min. η gap = 0.05 between EP and φ meson

- **Precision measurement of ϕ meson v_2 at 54.4 GeV**
- **ϕ meson v_2 at 54.4 GeV are comparable with that at 62.4 GeV.**

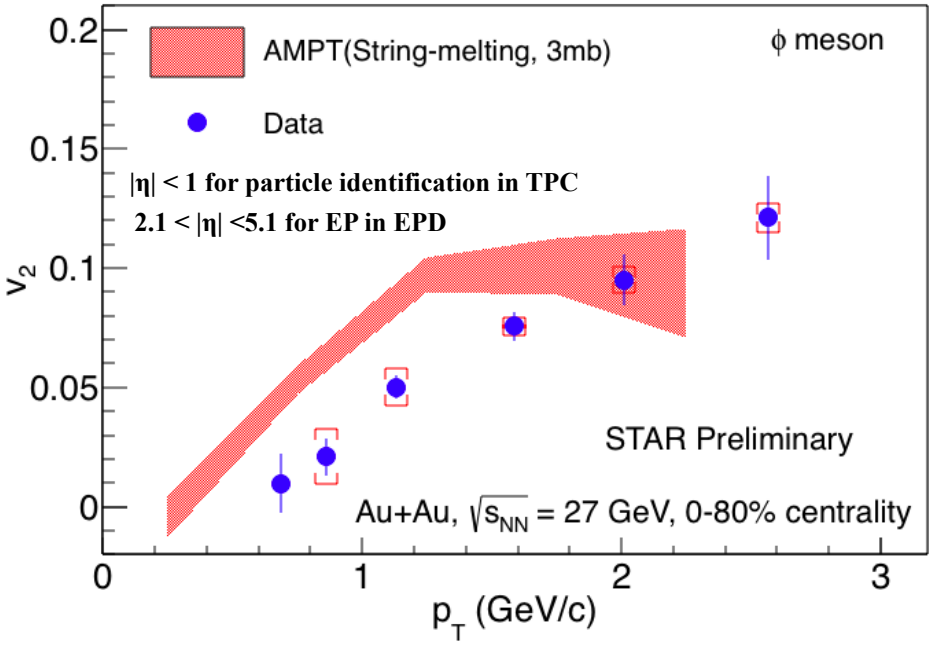
NCQ Scaling



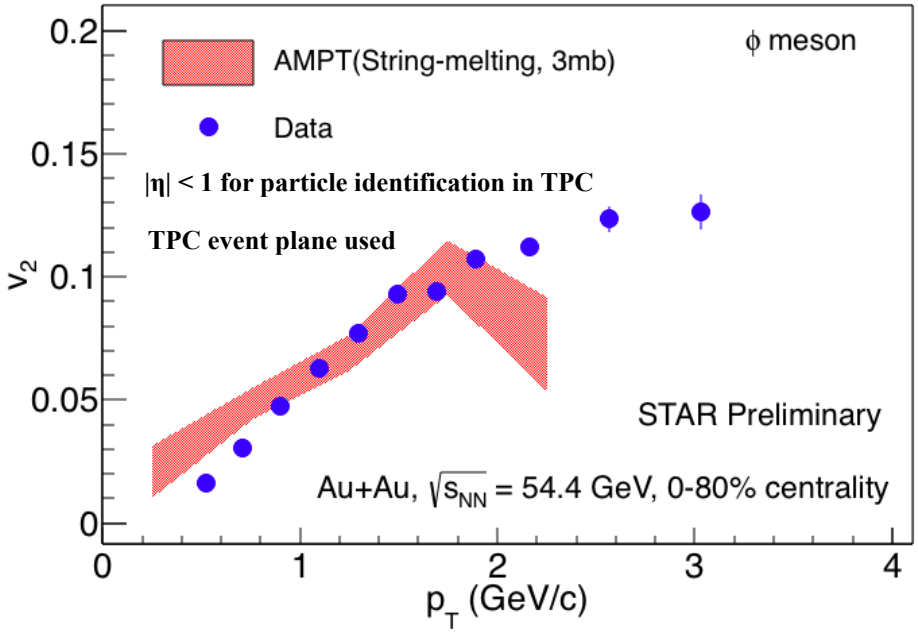
NCQ scaling holds at 27 and 54.4 GeV
Signature of partonic collectivity.

Ref. for published identified hadrons
Phys.Rev.C88, 014902,2013

Model Comparison



Min. η gap = 1.1 between EP and φ meson



Min. η gap = 0.05 between EP and φ meson

AMPT string melting with parton-parton cross-section 3mb shows better agreement with 54 GeV data compared to 27 GeV.

Ref. for AMPT model calculation
Phys.Rev.C72:064901,2005

Summary

- Elliptic flow of φ mesons in Au+Au collisions at 27 GeV and 54.4 GeV are presented.
- v_2 of φ mesons at 27 GeV using EPD event plane is presented here for the first time.
- Number-of-constituent-quark scaling holds at 27 and 54.4 GeV, which is considered as evidence of partonic collectivity.
- AMPT model (string melting) with parton-parton cross-section describes 54 GeV data, but overpredicts 27 GeV data.