Searching for the Turn-Off Signature of the QGP via Anisotropic Flow Measurements at RHIC

Prabhupada Dixit

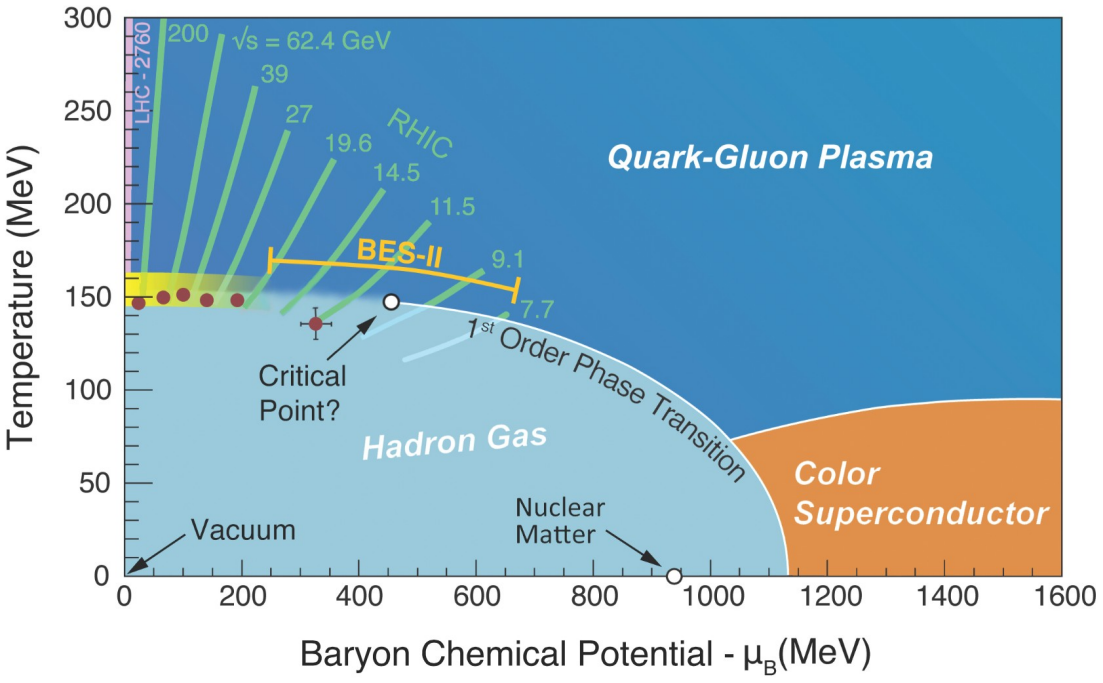
(for the STAR collaboration)

Indian Institute of Science Education and Research (IISER) Berhampur

10th Asian Triangle Heavy-Ion Conference - ATHIC 2025

P. Dixit

QCD phase diagram



Goals of the STAR experiment

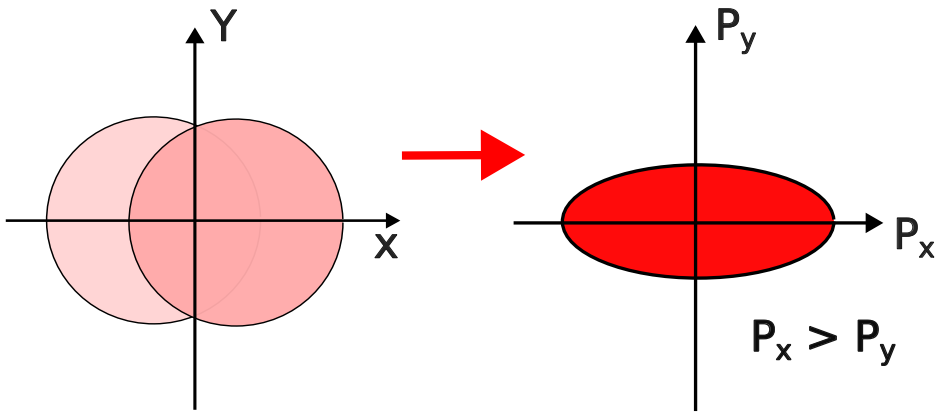
- Search for the critical point.
- Search for the 1st order phase transition.
- Search for the turn-off signature of QGP.

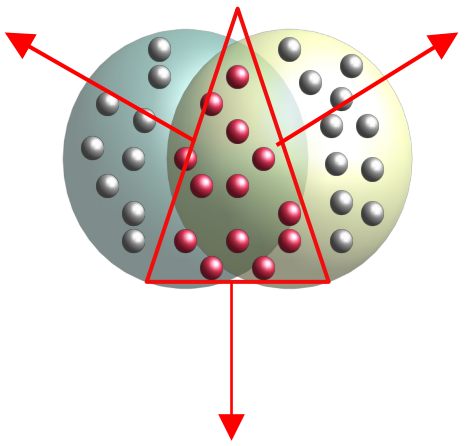
- Study the disappearance of partonic collectivity via flow measurements at various beam energies (proxy for baryon chemical potential)

Introduction

P. Dixit

Collective expansion of the medium: **Flow**





Elliptic flow: Driven by initial spatial anisotropy.
Triangular flow: Driven by the fluctuation in the position of the participant nucleons.

$$\frac{dN}{d\phi} = \frac{N_0}{2\pi}\left[1 + 2v_1\cos(\phi - \Psi_1) + 2v_2\cos(\phi - \Psi_2) + 2v_3\cos(\phi - \Psi_3) + ...\right]$$

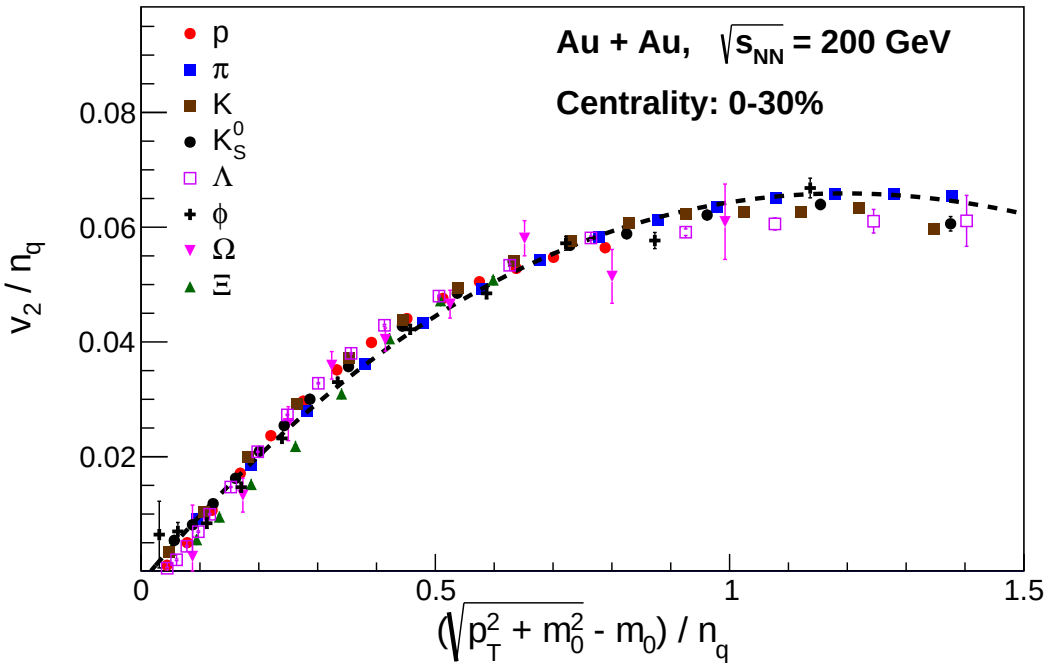
Phys. Rev. C 58, 1671 (1998)

Introduction

P. Dixit

Constituent quark scaling in v_2 : **Signature of partonic collectivity**

Phys. Rev. Lett. 116 (2016) 62301



$$v_2^H(p_T) = n_q \times v_2^q(p_T/n_q)$$

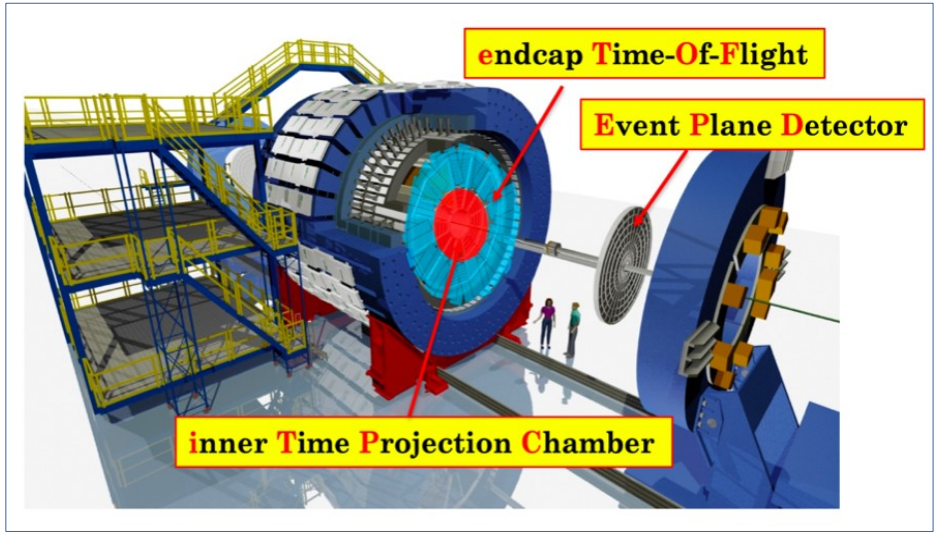
NCQ scaling at 200 GeV:

- Signature of partonic collectivity in the produced medium.
- Quark recombination model of hadronization.

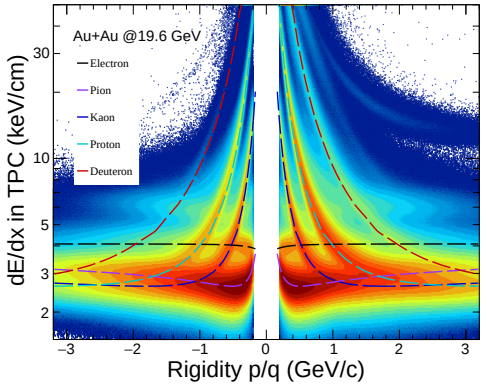
Does this scaling persist at lower collision energies? If so, up to what minimum energy does it remain valid?

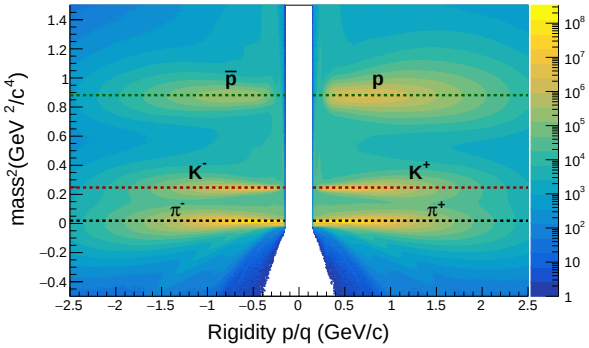
STAR detector

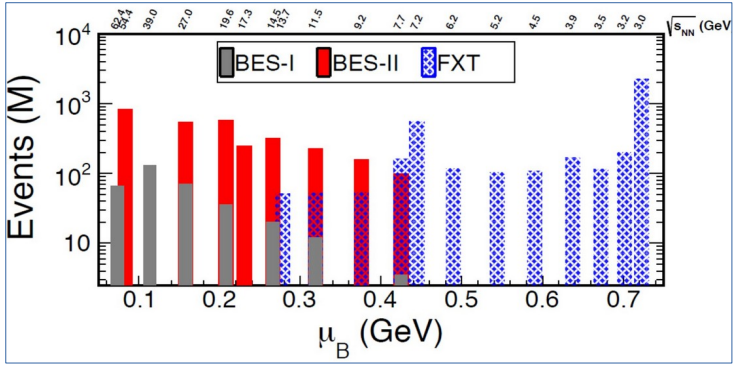
P. Dixit



Particle identification





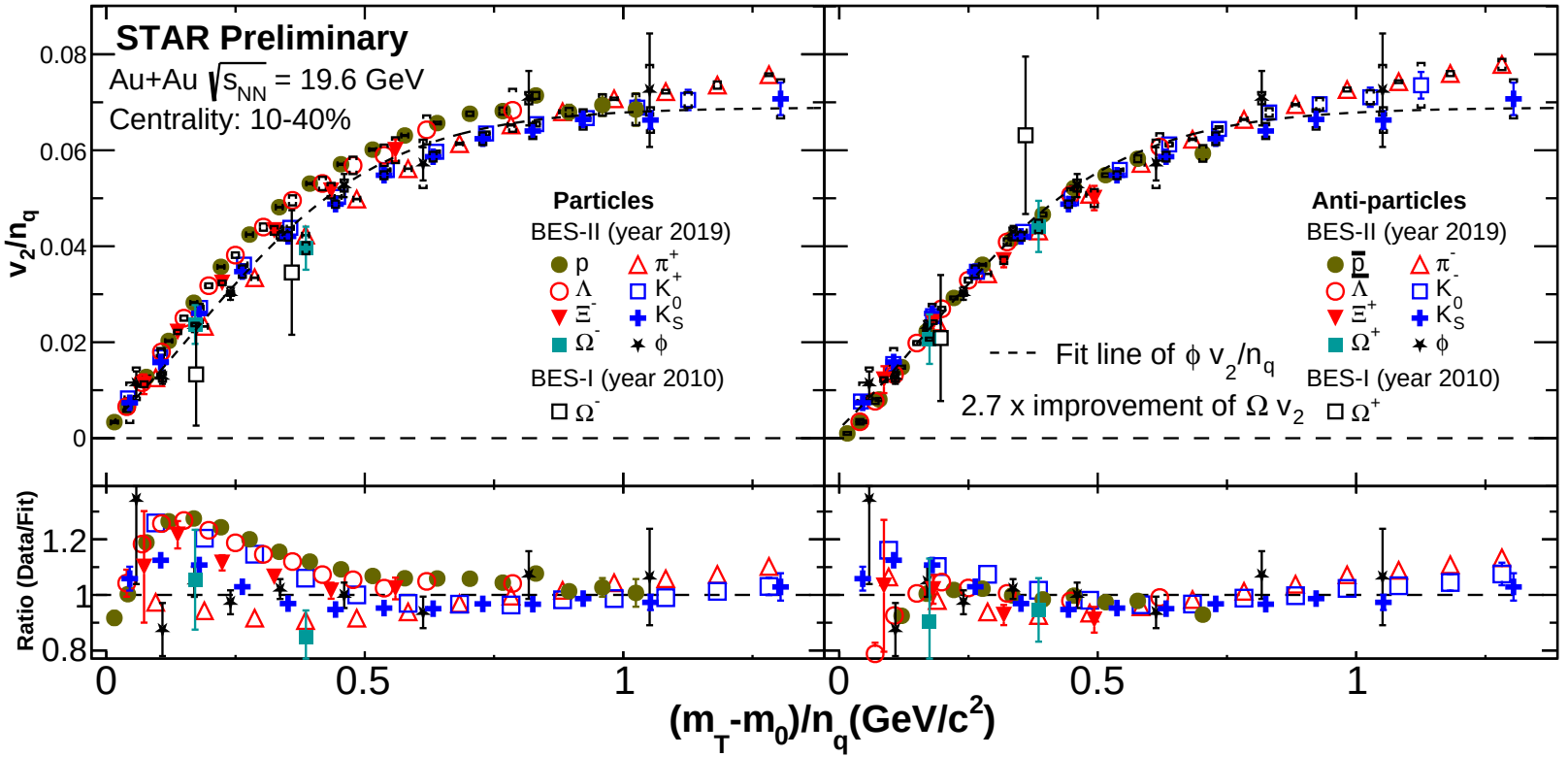


Major upgrades in BES-II:

- **iTPC upgrade:** Larger η coverage (-1.5 < |η| < 1.5) and better dE/dx and momentum resolution.
- Dedicated Event Plane Detector (EPD) (2.1 < |η| < 5.1)
- eToF: PID at larger rapidity (1.1 < η < 1.5)

Results: NCQ scaling in v_2 at $\sqrt{s_{NN}}$ = 19.6 GeV

P. Dixit



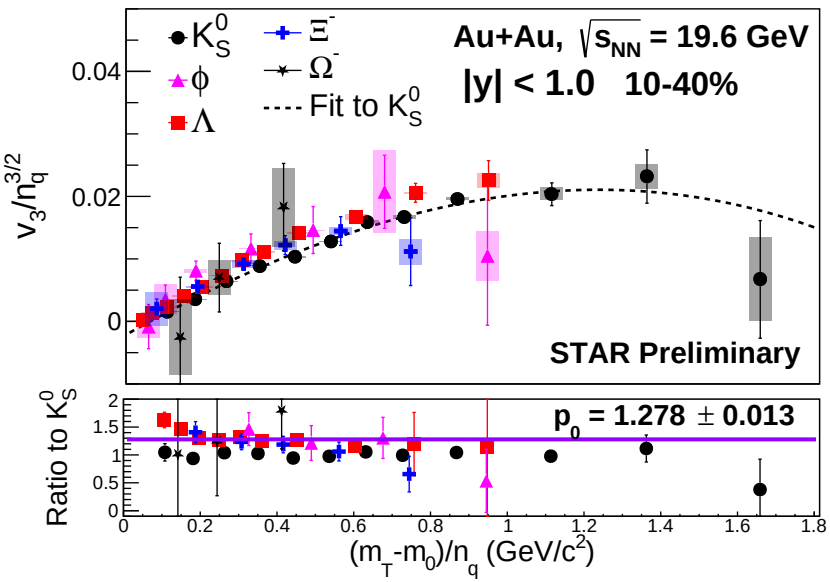
The NCQ scaling holds within 20% for particles and within 10% for antiparticles

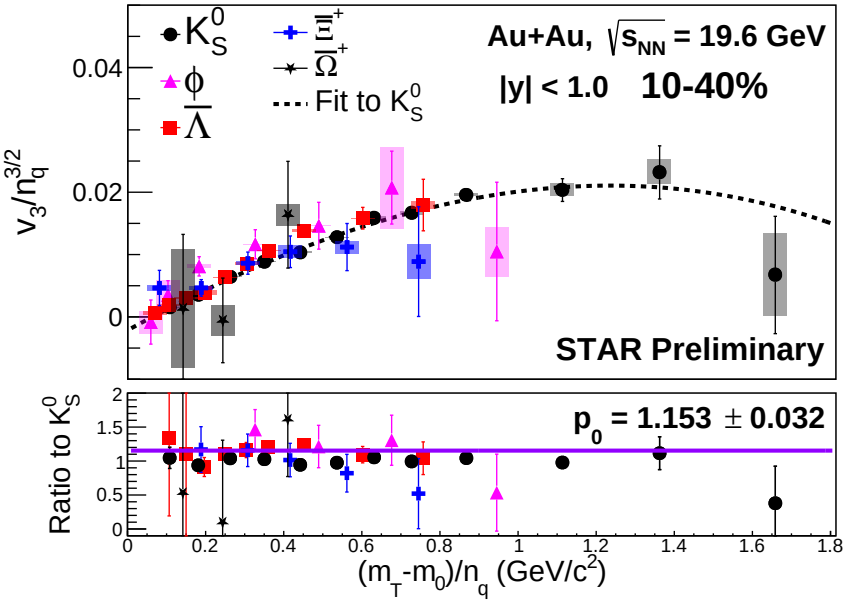
Better scaling for antiparticles: might be the effect of transported quarks in particles.

Signature of partonic degrees of freedom in the produced medium.

Results: NCQ scaling in v_3 at $\sqrt{s_{NN}}$ = 19.6 GeV

P. Dixit

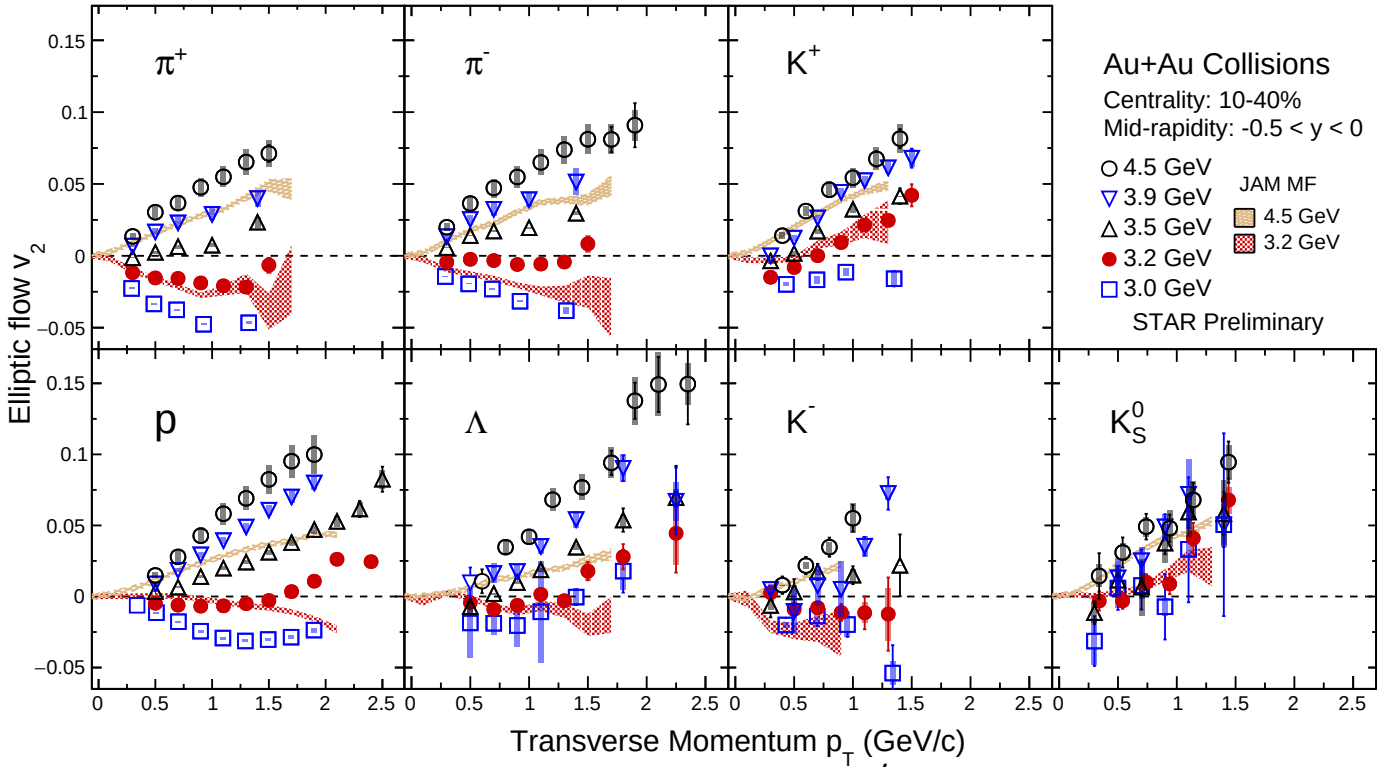




The NCQ scaling for v_3 holds within 30% for particles and within 15% for antiparticles
Better scaling for antiparticles.

Results: Energy dependence of v_2 at $\sqrt{s_{NN}}$ = 3.0 – 4.5 GeV

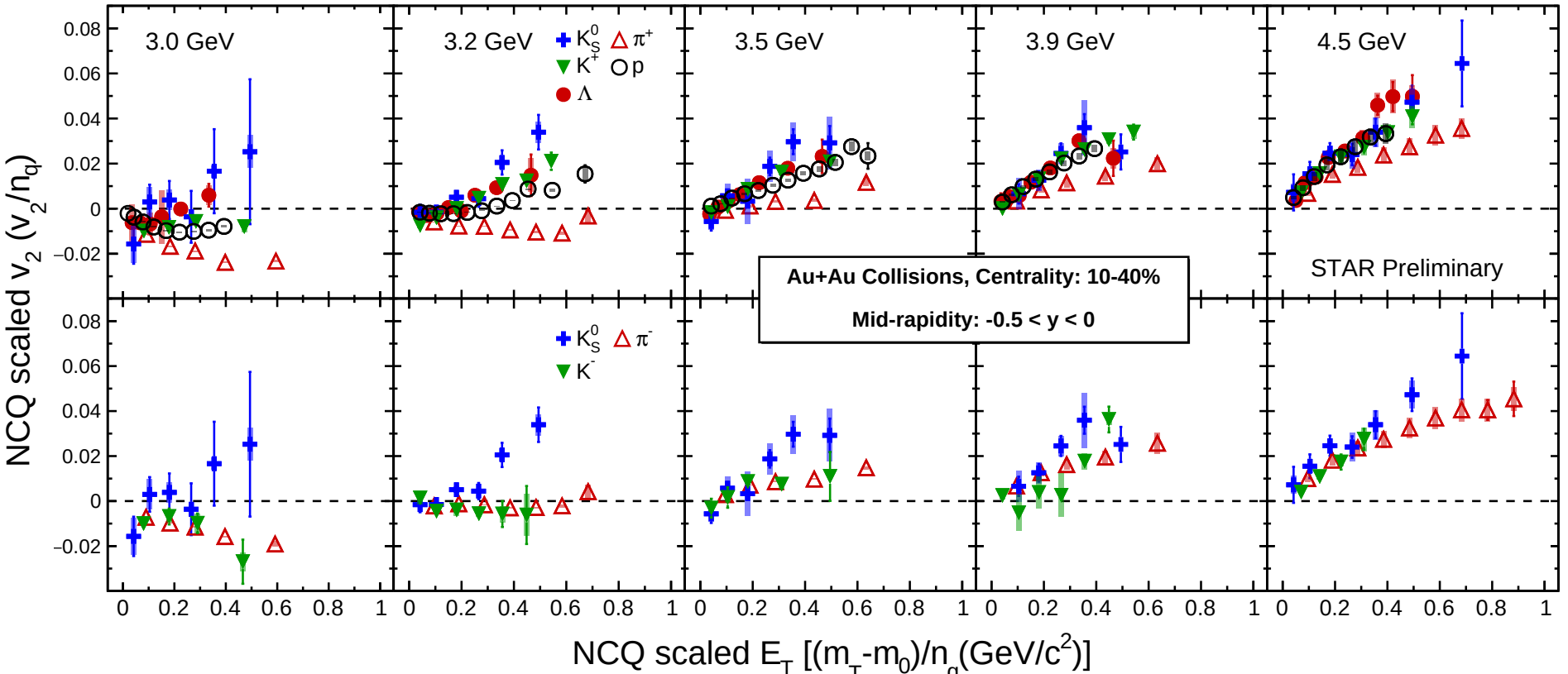
P. Dixit



- Change of sign of v_2 from positive to negative below $\sqrt{s_{NN}}$ < 3.5 GeV: **spectator shadowing effect**
- JAM + baryonic mean field describe the 3.2 GeV data while underestimate 4.5 GeV data.

Results: Energy dependence of NCQ scaling at $\sqrt{s_{NN}}$ = 3.0 – 4.5 GeV

P. Dixit



NCQ scaling is broken completely below $\sqrt{s_{NN}}$ < 3.5 GeV : **dominance of hadronic interaction.**

Summary

- Measurements of v_2 and v_3 for identified hadrons are presented in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV. Additionally, these measurements are extended to high baryon density region in Au+Au collisions using fixed target experiments at $\sqrt{s_{NN}}$ = 3.0-4.5 GeV.

- NCQ scaling holds for v_2 and v_3 at $\sqrt{s_{NN}}$ = 19.6 GeV indicating the presence of partonic degrees of freedom.

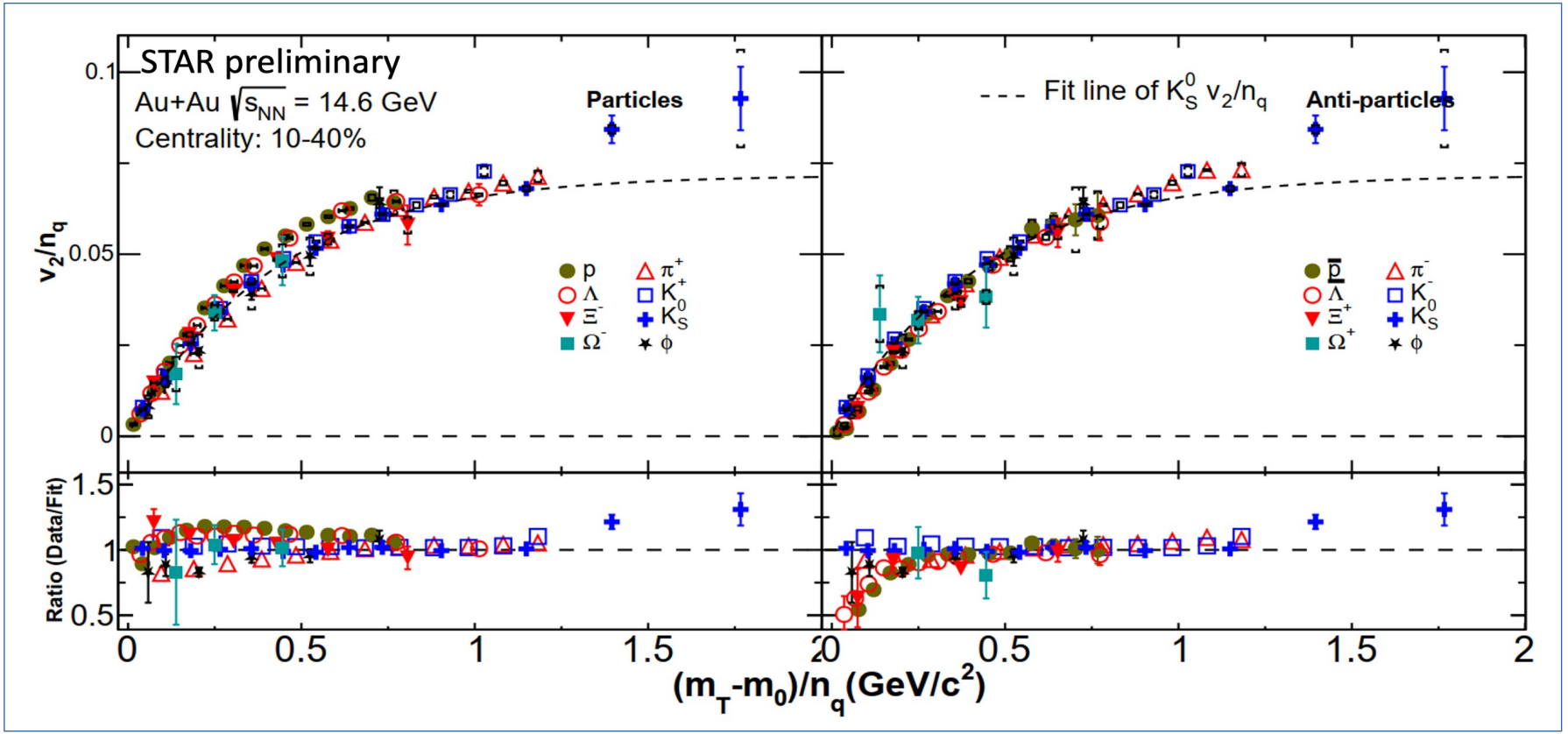
- NCQ scaling completely disappears at $\sqrt{s_{NN}}$ < 3.5 GeV indicating the dominance of hadronic interaction in the produced medium at these lower energy regimes.

Thank you...

Back up

Results: NCQ scaling in v_2 at 14.6 GeV

P. Dixit



The NCQ scaling holds within 25% for particles and within 15% for antiparticles.