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Triangular flow measurements of (multi-)strange hadrons in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV in RHIC BES-II

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Abstract

Azimuthal anisotropy of the final state particles produced in heavy-ion collisions is one of the sensitive observables to the equation of state and transport properties of the medium. In this poster, we present the 3rd order azimuthal anisotropy (v_3) of multi-strange hadrons such as K_S^0, Λ, ϕ, Ξ^- and Ω^- and their corresponding anti-particles in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV in mid-rapidity ($|y| < 1.0$) using high statistics BES-II data. The number of constituent quarks (NCQ) scaling for v_3 and the hydrodynamics motivated ratio $v_3/v_2^{3/2}$ are studied.

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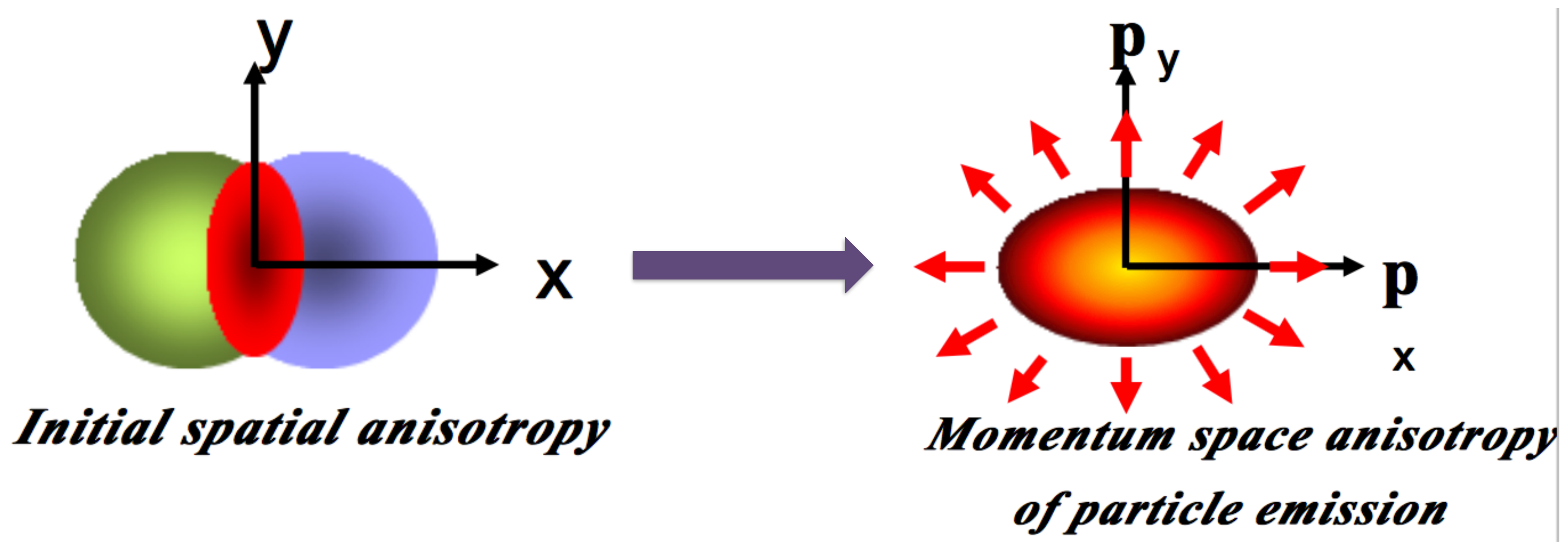
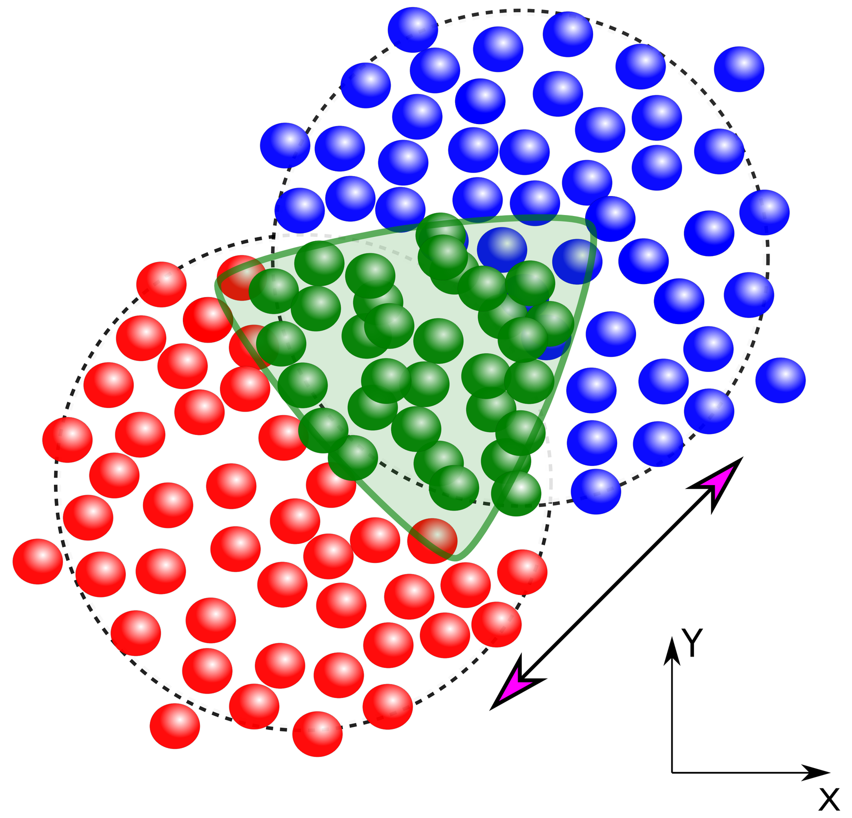
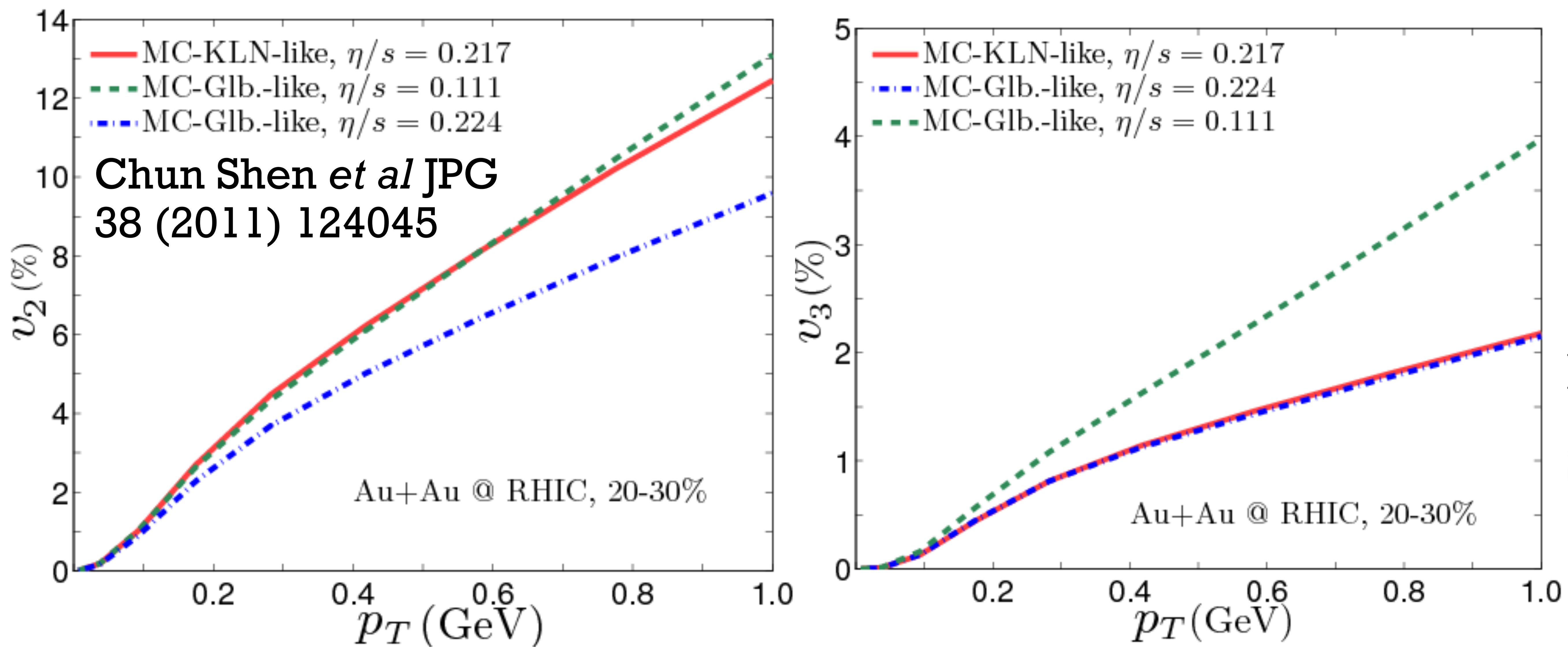
Motivation





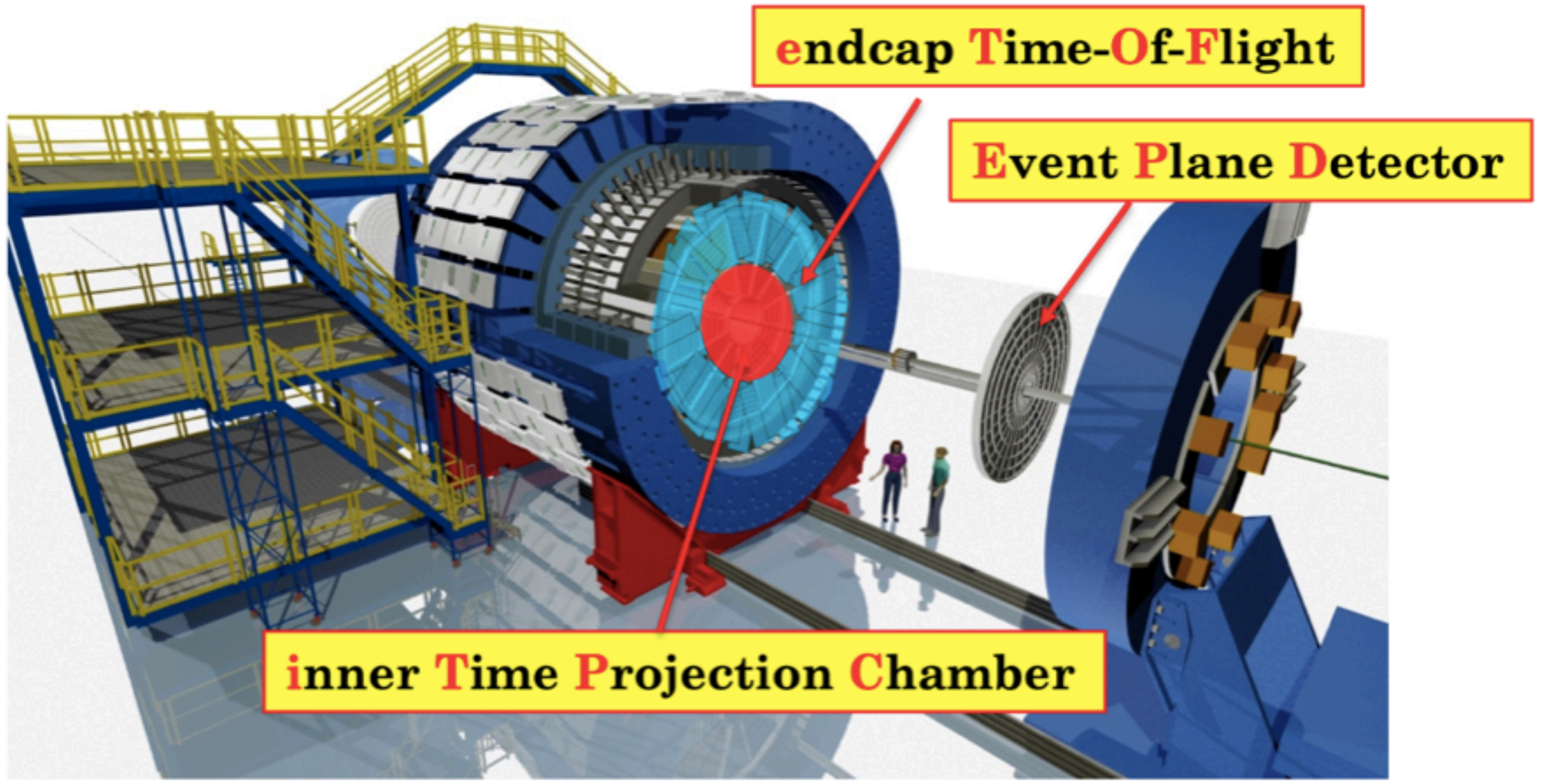
Elliptic flow coefficient (v_2) : Initial spatial anisotropy (dominant source) + Event-by-event fluctuations
Triangular flow coefficient (v_3) : Event-by-event fluctuations in the overlap region



Simultaneous measurements of v_2 and v_3 are important to constrain the initial condition and shear viscosity to entropy ratio (η/s).

- Early freeze-out and small hadronic interaction cross section of multi-strange hadrons and ϕ mesons make these particles excellent probe for the initial state. STAR, Nucl. Phys. A757, 102 (2005)
- High statistics data from BES-II with improved detector condition enables us to measure v_3 at lower beam energies.

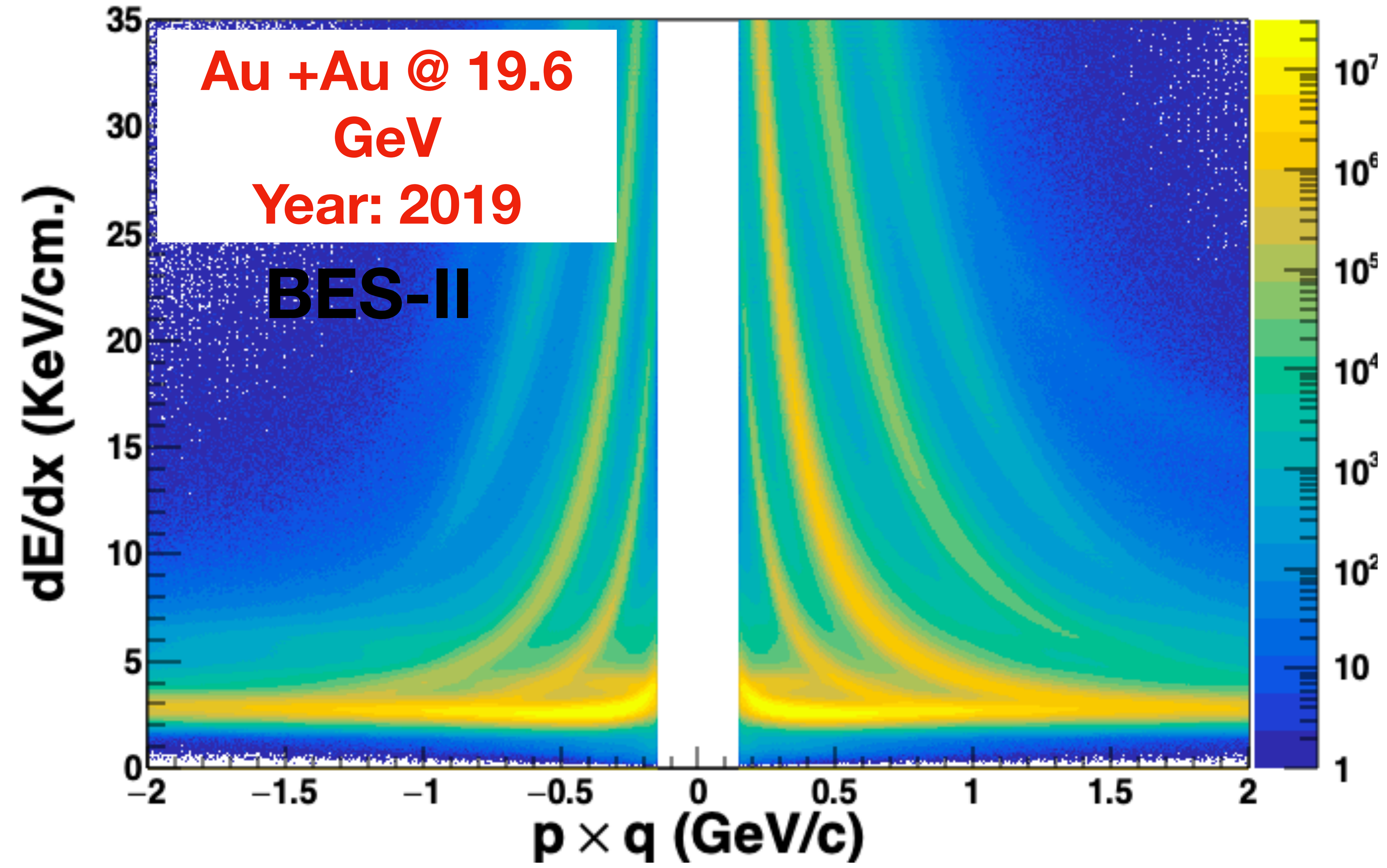
Data sets and STAR detector



Data set information for this analysis:

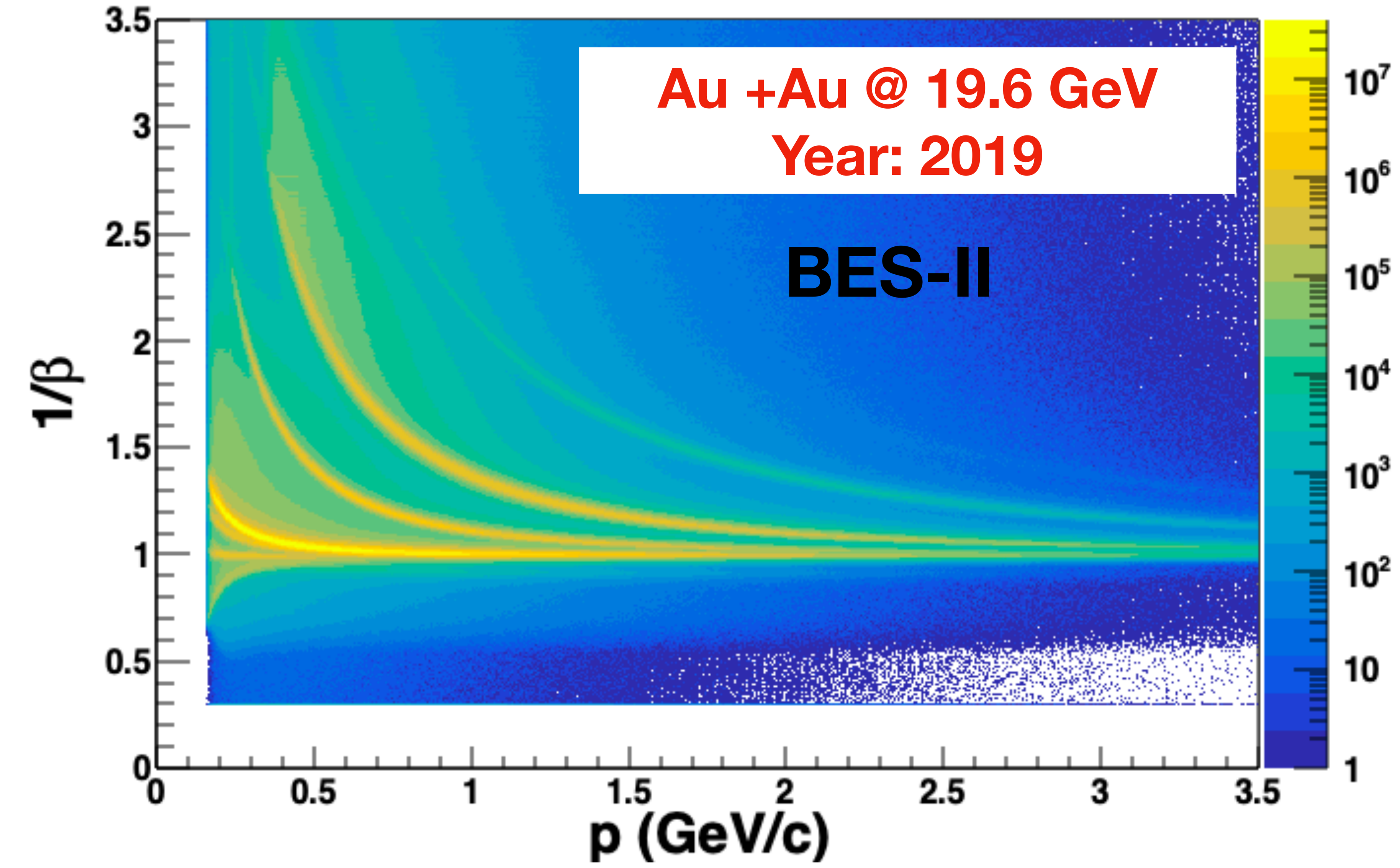
- System: Au+Au
- Year: 2019 (BES-II data)
- Collision energy: 19.6 GeV
- Number of events: ~ 380 M

Time Projection chamber (TPC)



- **Particle track reconstruction**
- **Particle identification by specific energy loss in TPC gas medium.**
- **Upgraded TPC has large pseudorapidity coverage (|η|<1.5) compared to BES-I measurements.**

Time of Flight (ToF)



- **Particle identification for high p_T ($p_T > 1.0$ GeV/c) tracks.**

Analysis details

The nth order flow coefficient is given by

$$v_n = \langle \cos n(\phi - \Psi_n) \rangle \quad \boldsymbol{\Psi_n} : n^{th} \text{ order event plane.}$$

Ψ_n measurements

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

A. M. Poskanzer and S. A. Voloshin, Phys. Rev. C 58, 1671 (1998)

$$Q_x = \sum_i w_i \cos(n\phi_i) \quad Q_y = \sum_i w_i \sin(n\phi_i)$$

Where the weight factor $w_i = p_T \times \phi$-weight.

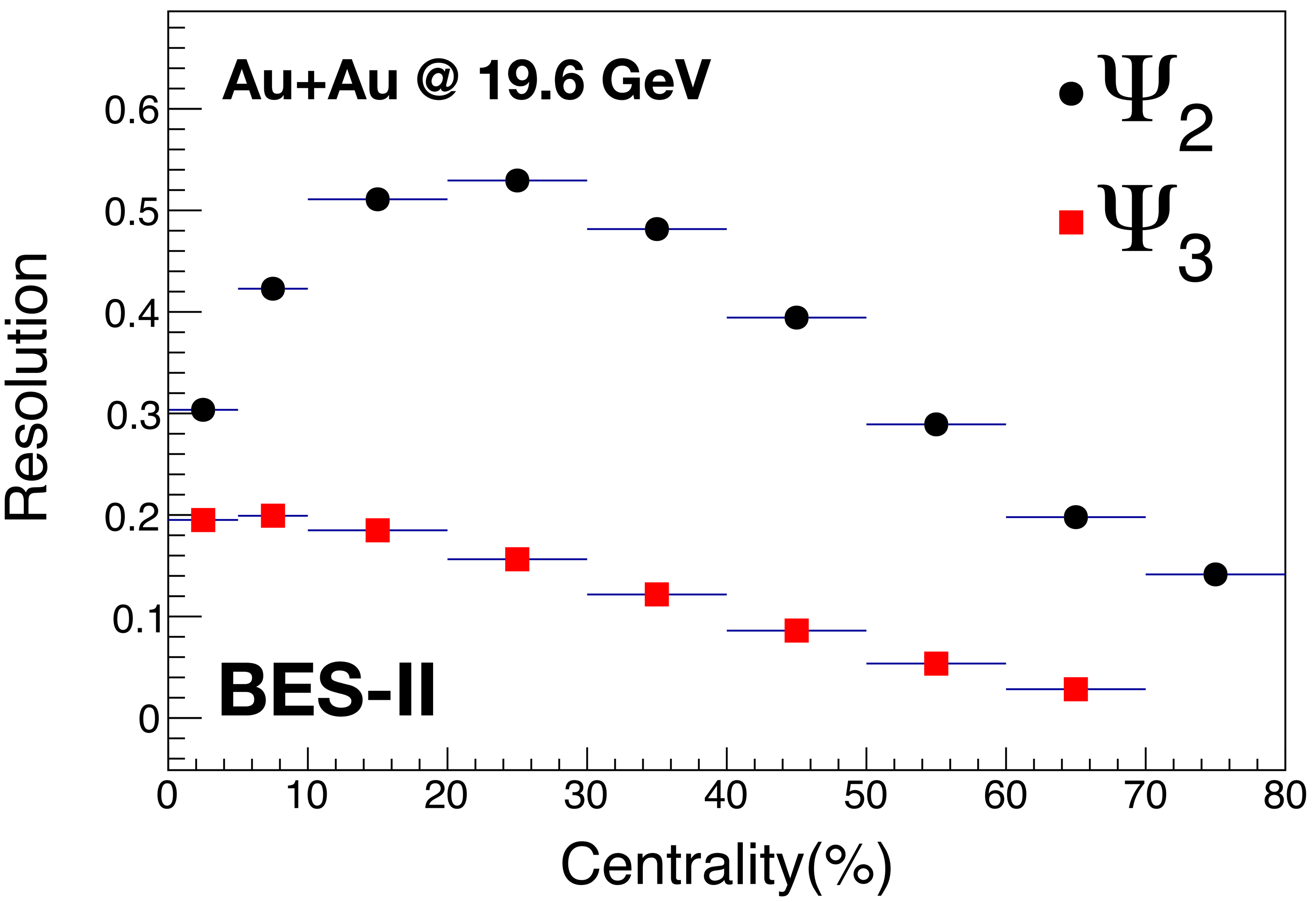
ϕ-weight: accounts for the azimuthal acceptance correction of the detectors.

Event plane resolution

$$R_{sub} = \langle \cos n(\psi_n - \psi_R) \rangle$$

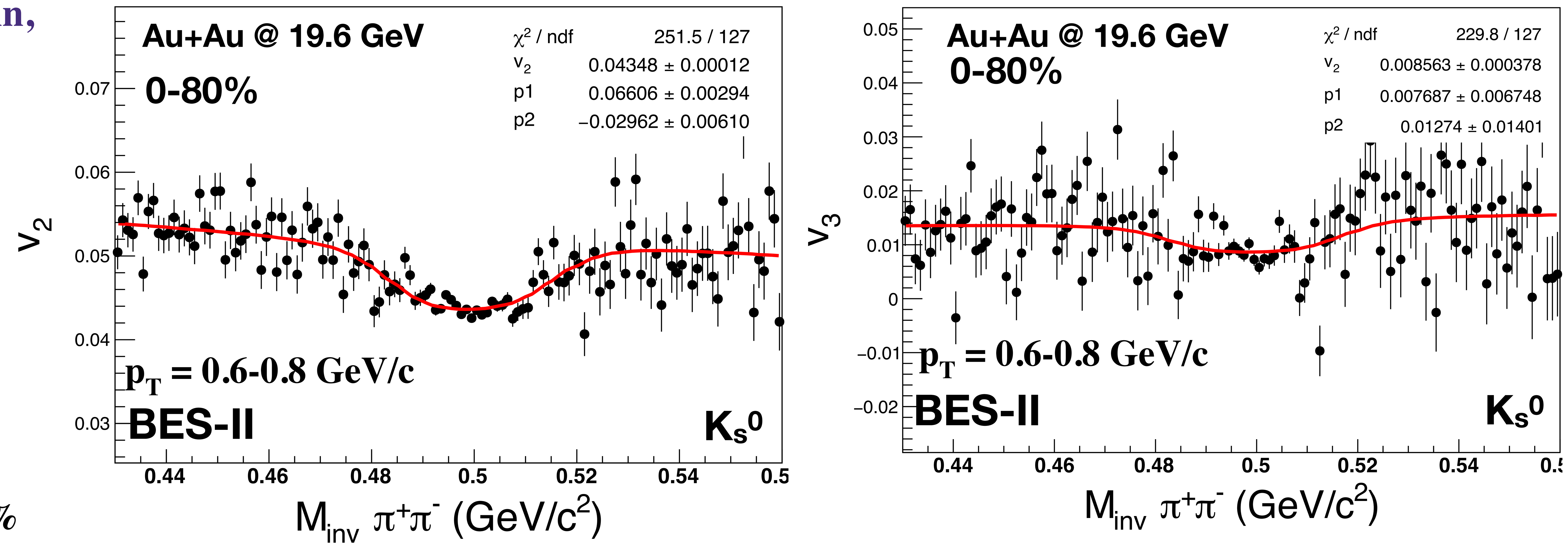
Ψ_R : true reaction plane angle

The Ψ_2 resolution improved by 10% compared to BES-I.



v_n measurements

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



$$v_n^{S+B}(M_{inv}) = \langle cos\left[n(\phi - \psi_n)\right] \rangle = v_n^S \frac{S}{S+B}(M_{inv}) + v_n^B \frac{B}{S+B}(M_{inv})$$

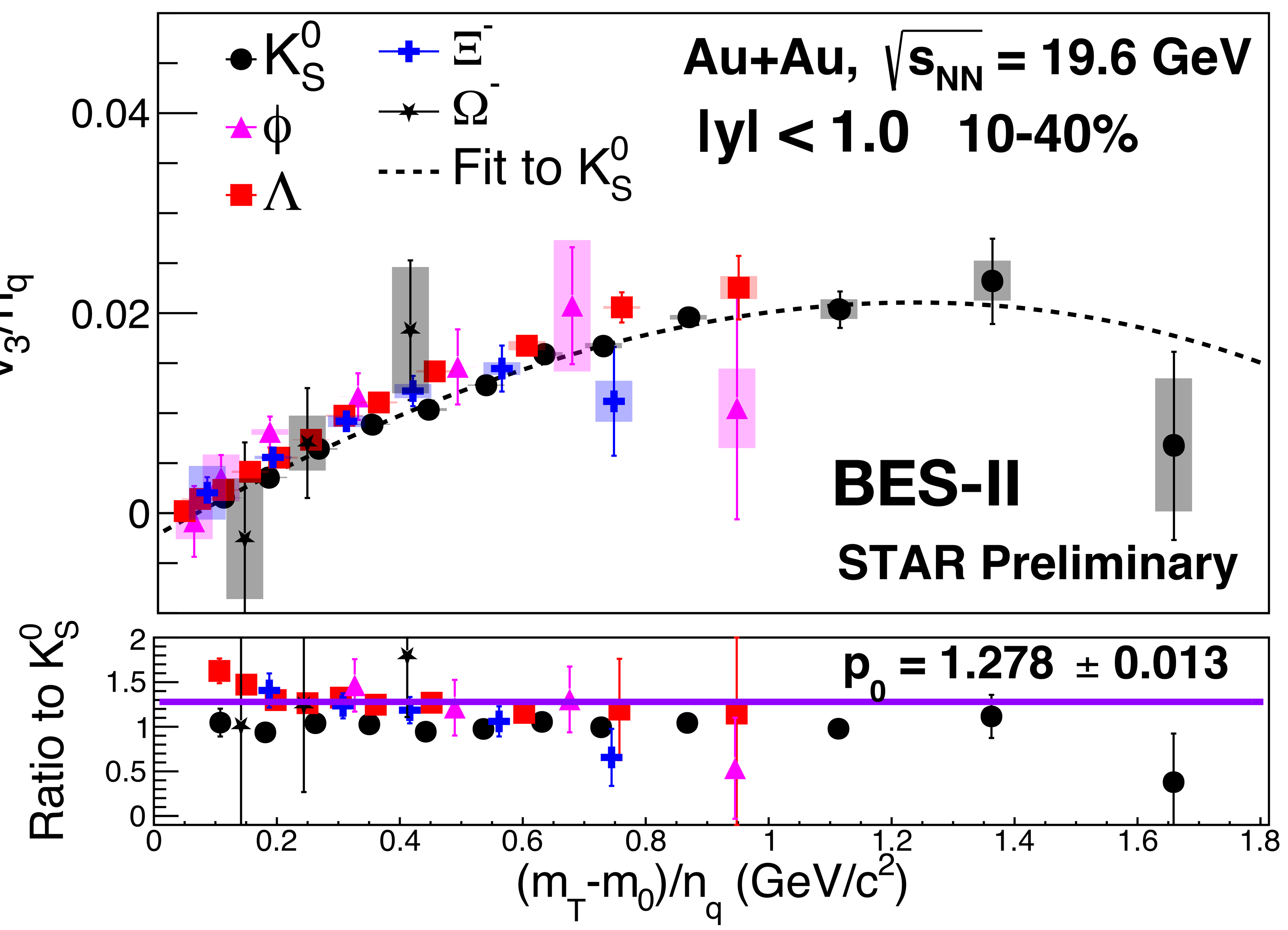
Where, $v_n^B(M_{inv}) = p_0 + p_1 M_{inv}$

Due to finite resolution of the event plane the observed v_2 must be corrected with the event plane resolution.

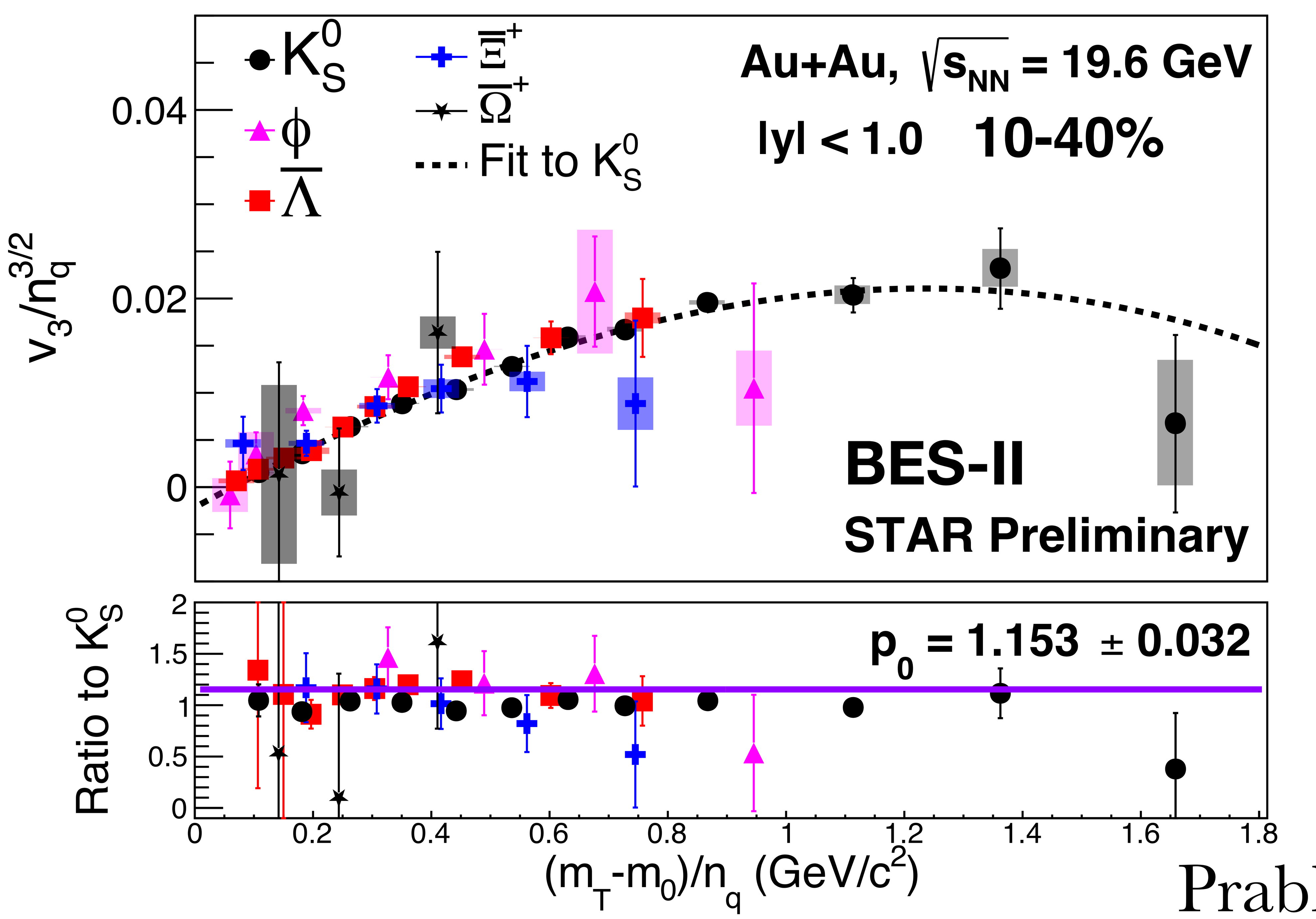
Results and summary

NCQ Scaling

Particles



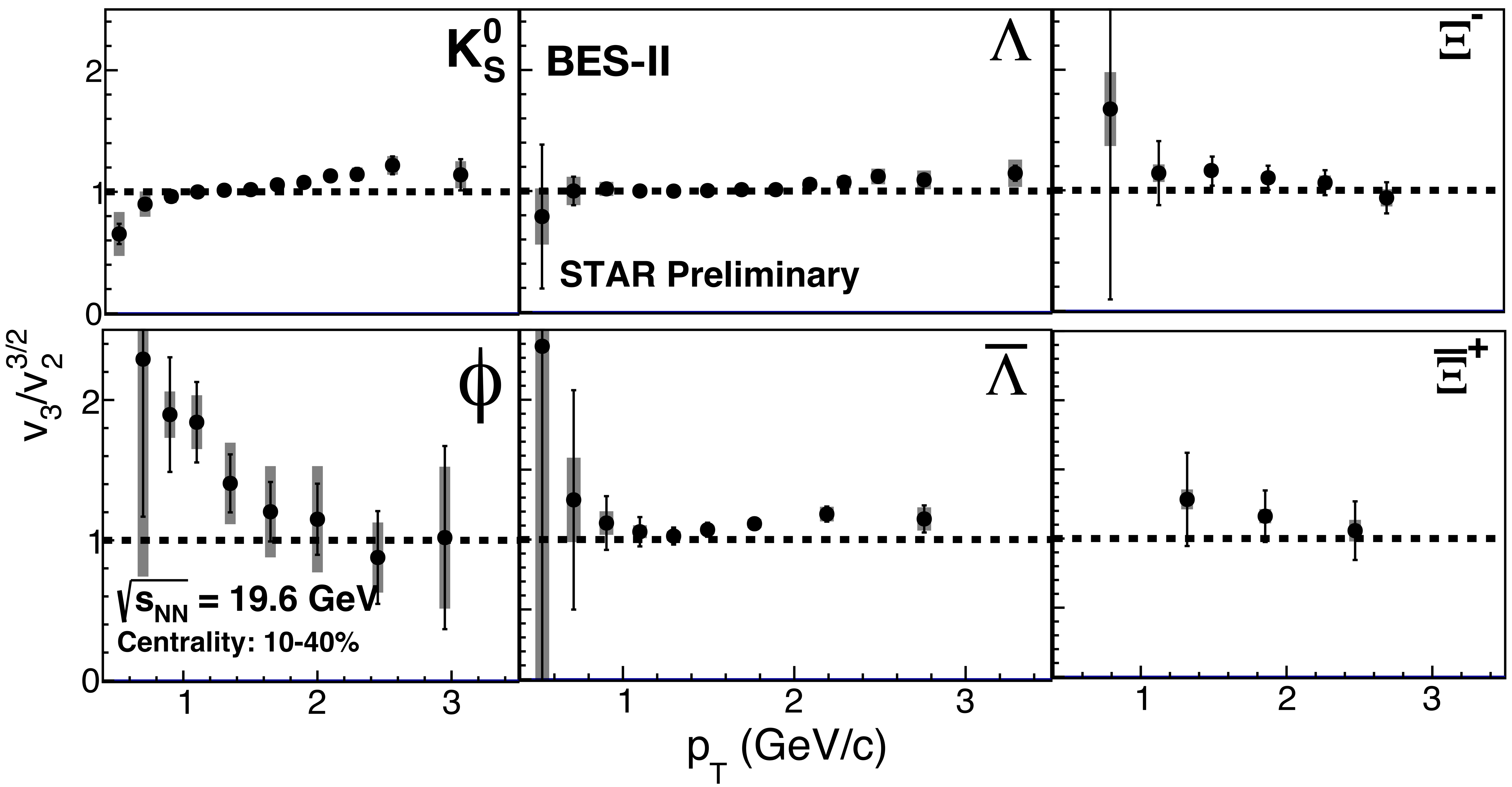
Anti-particles



$v_3/v_2^{3/2}$ ratio

Third order flow coefficient (v_3) is proportional to the $v_2^{3/2}$.

STAR Phys. Rev. Lett. 92, 062301 (2004)



- **The NCQ scaling holds within 30% for particles and within 15% for anti-particles which indicates the contribution from transported quarks in particles.**
- **The ratio $v_3/v_2^{3/2}$ shows weak p_T dependence above $p_T > 1.0$ GeV/c.**
- **$v_3/v_2^{3/2}$ ratios are sensitive to the initial state fluctuations and transport properties of the medium; can be used to constrain the hydrodynamics models.**

PHENIX Phys. Rev. Lett 105, 062301 (2010)

Ekaterina Retinskaya et al. Phys. Rev. C 89, 014902 (2014)