Anisotropic flow of (multi-)strange hadrons in Au+Au collisions at $\sqrt{s_{NN}}$ = 14.6 and 19.6 GeV from the STAR experiment at RHIC

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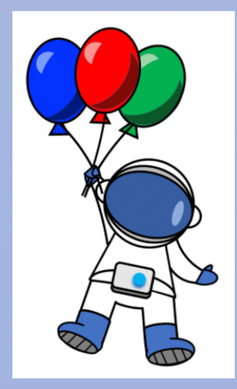
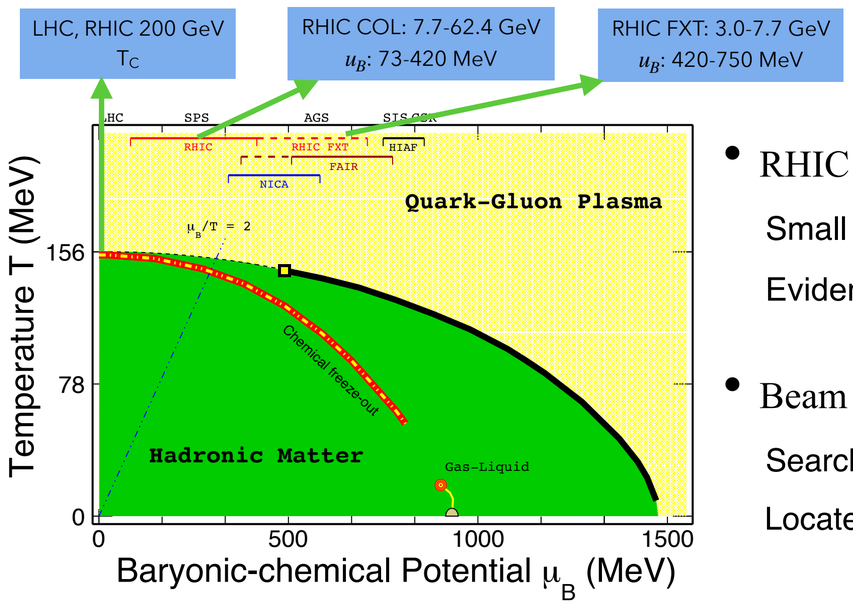


Motivation



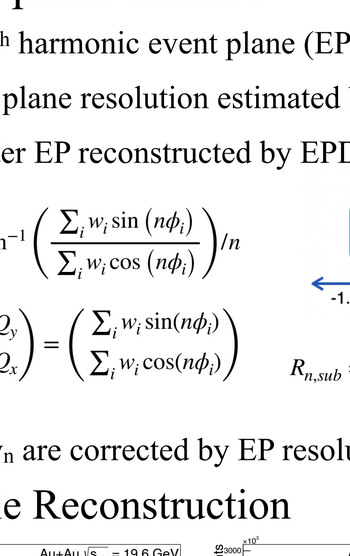
- RHIC 200 GeV and LHC
  - Small viscosity, high temperature
  - Evidence of Quark-Gluon Plasma
- Beam energy scan program
  - Search for Critical Point
  - Locate the phase boundary

A. Bazavov et al., Phys. Rev. D 85, 054503 (2012);
X. Luo, S. Shi, N. Xu, and Y. Zhang, Particles 3(2), 278-307 (2020)

Anisotropic flow

- Anisotropies in particle momentum distributions relative to the reaction plane

Initial spatial anisotropy → Pressure gradient → Anisotropic flow in momentum space



$$E\frac{d^3N}{dp^3} = \frac{1}{2\pi}\frac{d^2N}{p_T dp_T dy}\left(1 + \sum_1^\infty 2v_n \cos\left[n\left(\phi - \psi_{RP}\right)\right]\right)$$

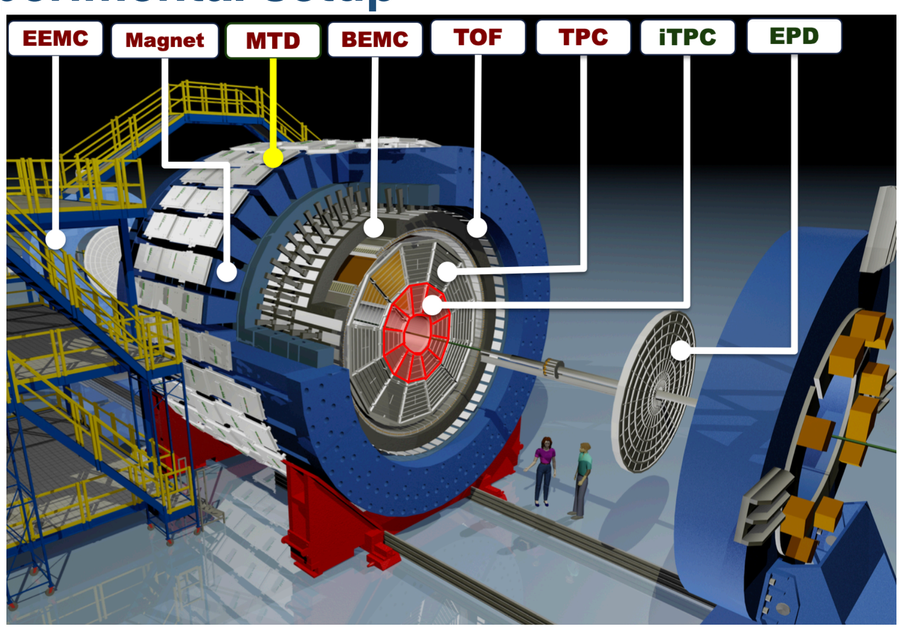
v_1: directed flow **v_2: elliptic flow**

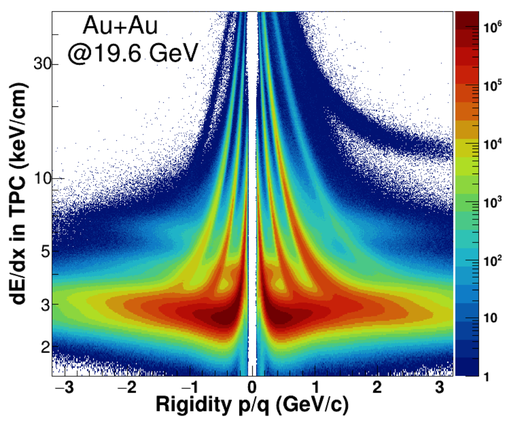
$$v_1 = \cos(\phi) = < \frac{p_x}{p_T} > \qquad v_2 = \cos(2\phi) = < \frac{p_x^2 - p_y^2}{p_x^2 + p_y^2} >$$

- Spatial asymmetries rapidly decrease with time, anisotropic flow developed early in the medium evolution
- Multi-strange hadrons more sensitive to the partonic stage of the collision
  - Small hadronic interaction cross sections
  - Freeze-out earlier than other light hadrons

A. M. Poskanzer and S. A. Voloshin, Phys. Rev. C58, 1671 (1998); B. Mohanty, N. Xu, Journal of Physics G 36, 064022 (2009)

Experimental setup





- The STAR Detector
  - Full 2π azimuthal coverage
  - Large acceptance at mid-rapidity
  - Excellent particle identification
- Upgrade of inner-TPC
  - Better track quality
  - Larger acceptance:
    |η|: 1 -> 1.5, p_T: 125 -> 60 MeV/c
- TPC, TOF and EPD used in this analysis

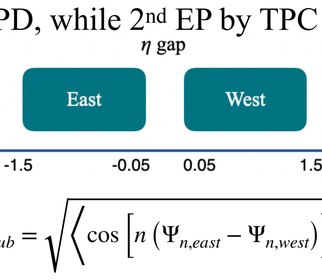
Analysis method

Event plane method

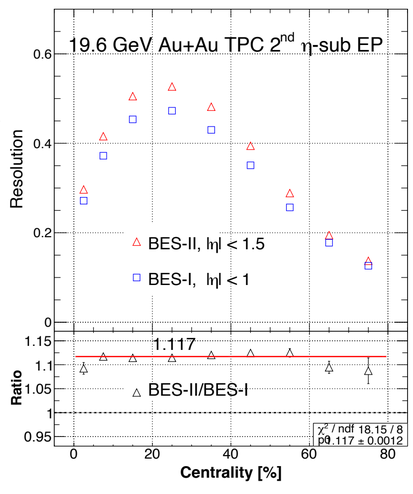
- The n^{th} harmonic event plane (EP) was calculated by Q vector
- Event plane resolution estimated by two sub-events method
- 1st order EP reconstructed by EPD, while 2nd EP by TPC

$$\Psi_n = \tan^{-1}\left(\frac{\sum_i w_i \sin\left(n\phi_i\right)}{\sum_i w_i \cos\left(n\phi_i\right)}\right)/n$$

$$\vec{Q} = \begin{pmatrix} Q_y \\ Q_x \end{pmatrix} = \begin{pmatrix} \sum_i w_i \sin(n\phi_i) \\ \sum_i w_i \cos(n\phi_i) \end{pmatrix}$$

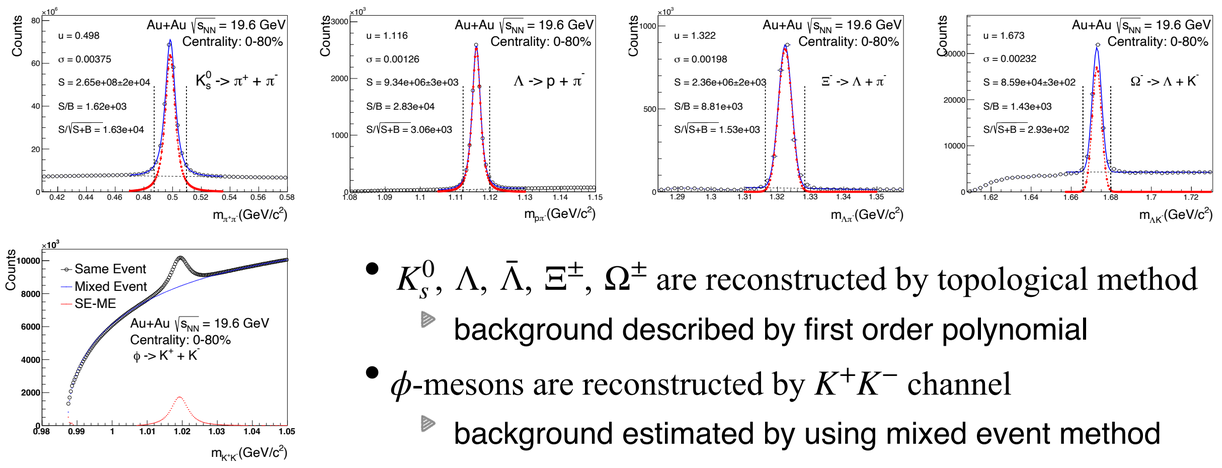


$$R_{n,sub} = \sqrt{\left\langle \cos\left[n\left(\Psi_{n,east} - \Psi_{n,west}\right)\right]\right\rangle}$$



- The v_n are corrected by EP resolution: $v_n = \frac{< \cos[n(\phi - \Psi_n)] >}{R_n}$

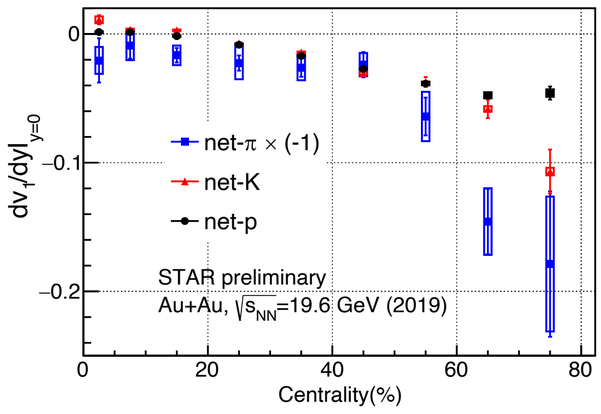
Particle Reconstruction



- K^0_S, Λ, $\bar{\Lambda}$, $\Xi^{\pm}$, $\Omega^{\pm}$ are reconstructed by topological method
  - background described by first order polynomial
- ϕ-mesons are reconstructed by K^+K^- channel
  - background estimated by using mixed event method

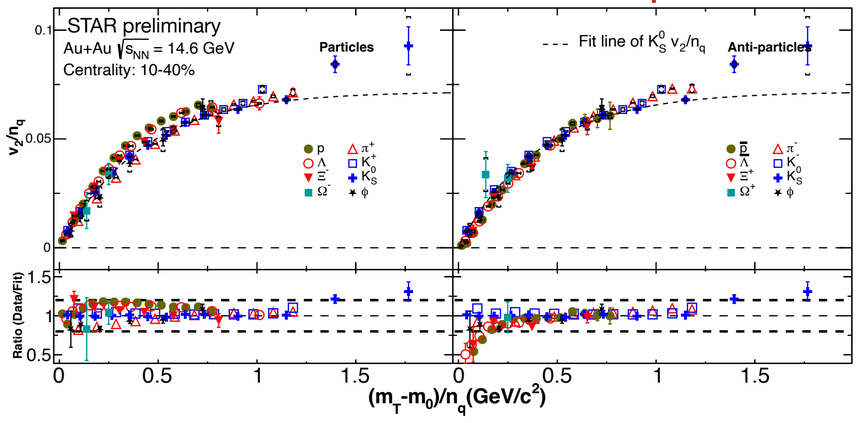
Results

Directed flow



- Net-particles v_1: $v_{1,\mathrm{net}} = \frac{n_p v_{1,p} - n_{\bar{p}} v_{1,\bar{p}}}{n_p - n_{\bar{p}}}$, n_p is particles yield, $n_{\bar{p}}$ is anti-particles yield, define π^-, K^- are anti-particles
- Centrality dependence of v_1 slope for net-particle (net-p, net-K and net-pion), larger in more peripheral collisions, an ordering of net-particles flow observed

Elliptic flow



- NCQ scaling of v_2 holds
  - **Partonic collective flow**
- NCQ scaling of anti-particles is better than particles
  - **Produced vs. transported quarks**

Summary & Outlook

- Centrality dependence of dv_1/dy for net-particle (net-p, net-K, net-pion), and v_2 (p_T) for strange particles ($K^{\pm}$, K^0_S, Λ, $\bar{\Lambda}$, ϕ, Ξ^-, Ξ^+, Ω^-, and Ω^+) are measured
- An ordering of centrality dependence of dv_1/dy for net-p, net-K and net-pion are observed, provides additional constraints to the models
- NCQ scaling of v_2 holds well indicates collective flow has been built up in the partonic stage
- Outlook: Explore the QCD phase diagram with v_1, v_2 of (multi-)strange hadrons in BES-II

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The STAR Collaboration
https://drupal.star.bnl.gov/STAR/presentations

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