Measurement of ϕ meson directed flow in $\sqrt{s_{NN}}$ =3-19.6 GeV Au+Au collisions from RHIC-STAR

Guangyu Zheng (zhengguangyu23@mails.ucas.ac.cn)
for the STAR Collaboration
University of Chinese Academy of Sciences

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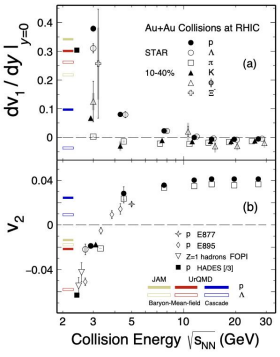
Abstract

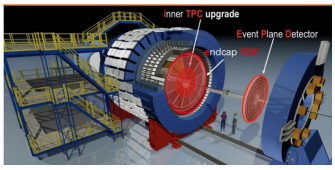
Directed flow (v_1) has been suggested as a sensitive probe of the equation of state of hot and dense matter. The hadronic cross section of ϕ mesons is smaller than that of light flavor hadrons, allowing them to provide information about the early stage of heavy-ion collisions. In this poster, we present measurements of ϕ meson directed flow in $\sqrt{s_{NN}}$ =3-19.6 GeV Au+Au collisions from the RHIC Beam Energy Scan Phase - II (BES-II) by STAR . Additionally, we present directed flow measurements for protons (p), kaons (K), and Λ particles, comparing them to the ϕ meson.The experimental results are compared with theoretical calculations from the hadronic transport model JAM2[1] model.

Introduction:



- ϕ meson has relatively small hadronic interaction cross sections and it can be used to study the QGP dynamics at early times giving access the the degrees-of-freedom.
- The v_1 slope of ϕ meson seems larger in magnitude than other mesons and changes sign below 11.5 GeV[2].
- BES-II data has higher statistics, better detector performance and a larger range of $\sqrt{s_{NN}}$ than previous data.

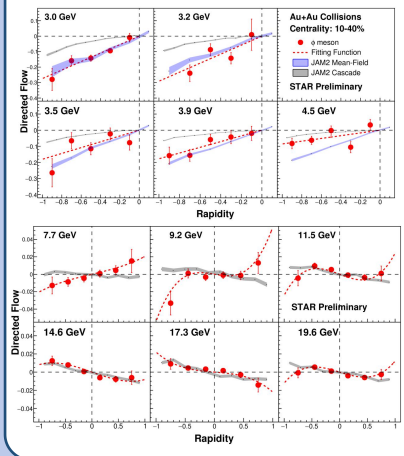
Experimental Setup:



➢ The STAR Detector
- 2π azimuthal coverage
- Large acceptance
- Excellent PID

➢ BES-II detector upgrade
- Inner TPC , endcap TOF
- EPD (2.1 < |η| < 5.1)

ϕ meson v_1 Results:



- v_1 extraction range

  0.6< p_T < 1.8 GeV/c for 3-4.5 GeV.

  0.15< p_T < 10 GeV/c for 7.7-19.6 GeV.

- Fitting function for v_1 slope

  Linear for 3- 4.5 GeV

  $v_1(y) = F * y$

  Cubic for 7.7- 19.6 GeV

  $v_1(y) = F * y + C * y^3$

  F is the v_1 slope

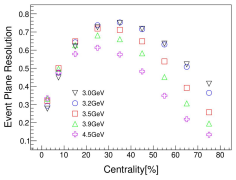
  Fitting Range:|y|<1

References:

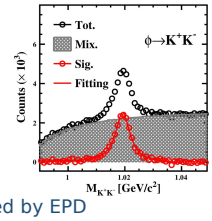
[1] Y. Nara and A. Ohnishi, Phys. Rev. C 105, 014911 (2022), 2109.07594.
[2] M. S. Abdallah et al. (STAR), Phys. Lett. B 827, 137003 (2022), 2108.00908.

Analysis Procedure:

➢ Event Plane Reconstruction



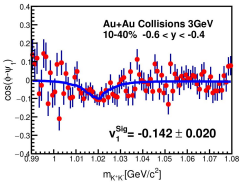
➢ Signal Reconstruction



- Background from mixed events

- 1st order event plane reconstructed by EPD

➢ v_1 extraction: invariant mass method



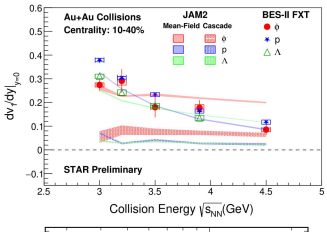
$$v_n^{Sig+Bg}(M_{inv}) = \left\langle \cos\left[n\left(\phi - \Psi_1\right)\right]_{M_{inv}} / R_n \right\rangle$$

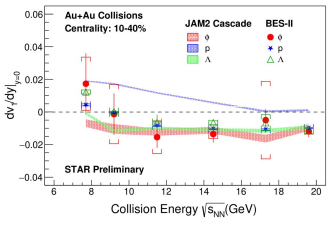
$$v_n^{Sig+Bg}(M_{inv}) = v_n^{Sig}\frac{Sig}{Sig+Bg}(M_{inv}) + v_n^{Bg}(M_{inv})\frac{Bg}{Sig+Bg}(M_{inv})$$

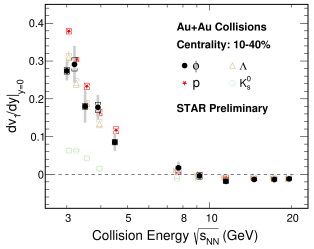
$$v_n^{Bg}(M_{inv}) = p_0 + p_1 M_{inv}$$

- v_n value is the sum of signal and background contributions.
- Background term was parameterized with the polynominal.

Energy dependence of v_1 Slope:







- The v_1 slope of ϕ mesons shows similar trends to that of proton and Λ and is consistent with that of the Kaon above 9.2 GeV.
- JAM2 Cascade mode can qualitatively describe the trend for ϕ meson above 7.7 GeV, but a momentum dependent mean field potential with κ=380MeV is needed at 4.5 GeV and below.

Summary:

- v_1 Measurement of ϕ meson in Au + Au collisions at 3 GeV - 19.6 GeV.
- JAM2 Cascade mode can qualitatively describe the trend above 7.7 GeV, but need momentum dependent mean field potential with κ=380MeV at 3.9 GeV and below.

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