Measurement of ϕ meson production and collectivity in Au+Au collisions at high baryon density region

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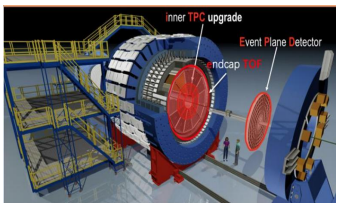
Abstract

The STAR Beam Energy Scan II (BES-II) program at RHIC is crucial for exploring the phase structure of strong interactions and understanding the properties of the created medium. With the strange quark content of (ss), the ϕ meson has smaller hadronic interaction cross sections. Thus it offers a unique tool for studying early stage dynamics of heavy-ion collisions especially at the high baryon density region.In this poster, we present measurements of ϕ meson directed flow and production in the high baryon density region at $\sqrt{s_{NN}}$ = 3-4.5 GeV Au+Au collisions. The experimental results are compared with theoretical calculations from both the statistics models and hadronic transport models[2,3,4].

Introduction:

- ϕ meson has relatively small hadronic interaction cross sections and it can be used to study early stage of heavy-ion collisions.
- Directed flow (v_1) has been suggested as a sensitive probe of the equation of state of hot and dense matter.
- ϕ/K and ϕ/Ξ^- ratio and their energy dependence are sensitive to strangeness production in the system [1].
- BES-II data has higher statistics, better detector performance and a larger range of $\sqrt{s_{NN}}$ thanthan BES-I data.

Experimental Setup:

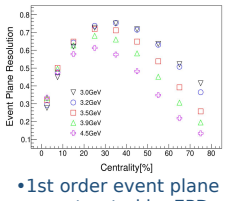


➢ The STAR Detector
- 2π azimuthal coverage
- Large acceptance
- Excellent PID

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

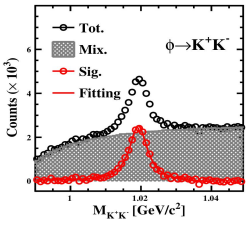
Analysis Procedure:

➢ Event Plane Reconstruction



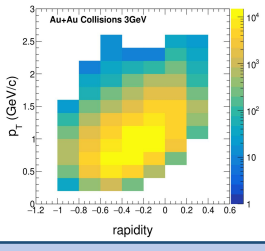
•1st order event plane reconstructed by EPD

➢ Signal Reconstruction

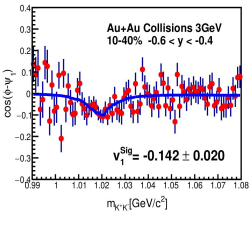


•Combinatorial background from mixed events

➢ Acceptance

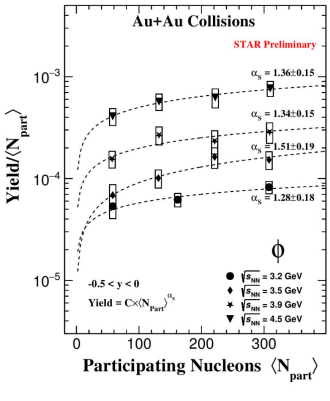


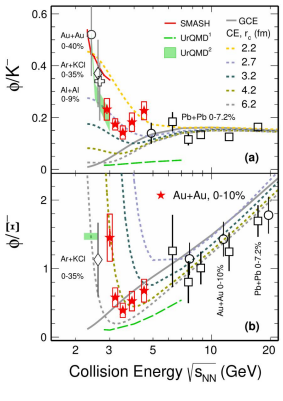
➢ v_1 extraction: invariant mass method



- v_n value is the sum of signal and background contributions.
- Background term was parameterized with the 1st order polynominal.

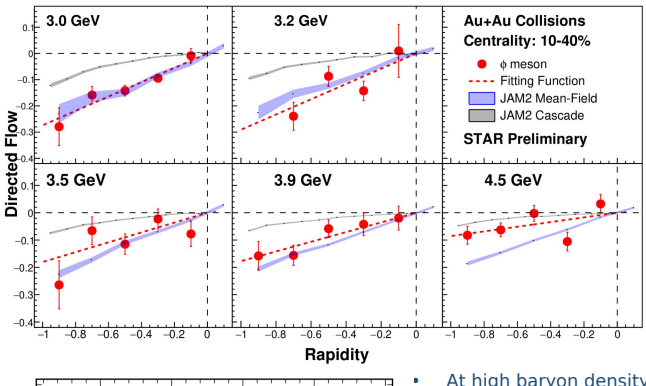
ϕ meson production Results:

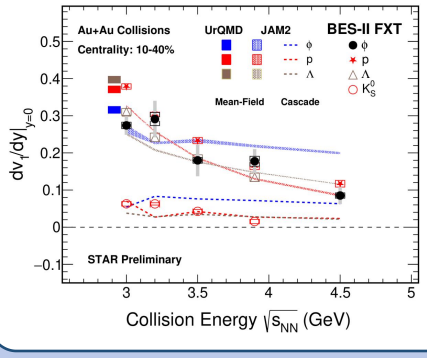




- ϕ meson yield is increasing faster than the participating nucleons from peripheral to central collisions.
- GCE describes yield ratio at high energy, while strangeness CE is required in the low energies in order to describe the data.
- Modified UrQMD[2] with new decay channels from high mass baryon resonances to ϕ and Ξ^- describe the data better than default UrQMD[3].
- Non-monotonic energy dependence of ϕ/K^- and ϕ/Ξ^-.

ϕ meson v_1 vs. rapidity and energy dependence:





- At high baryon density region, ϕ meson v_1 has the similar strength with that of proton and Λ baryons while Kaon v_1 is much smaller.
- Baryon mean field option (κ = 380 MeV) also show strong effect on ϕ meson v_1.
- Modified UrQMD[2] with new decay channels from high mass baryon resonances to ϕ and JAM2 with baryonic mean field can qualitatively describe the trend.

Summary:

- Measurement of yields and v_1 of ϕ meson is presented in Au+Au collisions at 3 GeV - 4.5 GeV.
- Strangeness CE is required to describe the non-monotonic energy dependence of ϕ/K^- and ϕ/Ξ^- Yields ratio.
- At high baryon density region, ϕ meson v_1 has the similar strength with that of proton and Λ baryon ,hadronic transport models modified UrQMD and JAM2 with baryonic meanfield could qualitatively describe the results of both ϕ/K^- ratio and v_1, from 3GeV Au+Au collisions.

References:

[1] M. S. Abdallah et al. (STAR), Phys. Lett. B 831, 137152 (2022), arXiv:2108.00924.
[2] J. Steinheimer and M. Bleicher, J. Phys. G: Nucl. Part. Phys.43, 015104 (2015).
[3] S. Bass et al., Prog. Part. Nucl. Phys. 41, 255 (1998).
[4] Y. Nara and A. Ohnishi, Phys. Rev. C 105, 014911 (2022), arXiv:2109.07594.

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