Anisotropic flows of $\phi$-meson in Au+Au collisions at 7.2 GeV from STAR

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The $\phi$-meson has small hadronic cross-section - sensitive to early stage of collisions.

BES-I shows hint of sign change of $\phi$-meson $dv_1/dy$ around 11.5 GeV, with large uncertainties.

The minimum of net-proton and net-$\Lambda$ $dv_1/dy$ may indicate the softest point of Equation of State (EoS)$^1$. How are the $\phi$-meson?

Fixed-target (FXT) program at STAR enables us to scan a range of low collision energies that collider mode (COL) cannot reach ($\sqrt{s_{NN}} < 7.7$ GeV down to a minimum of 3 GeV).

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The $\phi$-meson Reconstruction

$\phi$-mesons are reconstructed by $K^+K^-$ pairs.

Kaons are identified by $dE/dx$ from TPC and mass$^2$ from TOF.

Combinatorial background (Bkg) are from mixed-events and subtracted.

Convention used in this analysis:

$$y = y_{Lab} - y_{mid}, \quad y_{mid} = -2.02.$$  

Fitting Function:

- Sig : Gaussian + Constant
- Bkg : 2nd order polynomial
Flow Extraction: Invariant Mass Method

- $\phi$-meson $v_1$ is measured with respect to the first-order event plane (EP) from EPD ($-5.1 < \eta < -2.1$), corrected for the EP resolution $R_1$.

- Fitting Function:
  
  $$ \text{Sig} + \text{Bkg}: Y_R v_1^{\text{Sig}}(m_{\text{inv}}) + (1 - Y_R) v_1^{\text{Bkg}}(m_{\text{inv}}) $$

  $$ Y_R = \frac{\text{Yields(Sig)}}{\text{Yields(Sig)} + \text{Yields(Bkg)}} $$

- $v_1^{\text{Bkg}}$: Modeled by 2$^{nd}$ order polynomial

Note: Fit for slope is required to go through origin.
Results and Summary

- FXT and COL modes follow similar trend. Combining FXT and COL data for higher statistics and greater coverage will improve the flow measurements.

- With decreasing $\sqrt{s_{NN}}$, the $dv_1/dy|_{y=0}$ of the $\phi$-meson shows a trend of turning from negative to positive.

- This may indicate a softest point of EoS$^3$ for the $\phi$-meson - call for theory/model calculations.

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