Kaon flow measured with HADES

Au+Au collisions at $1.23A\,\mathrm{GeV}$

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Abstract

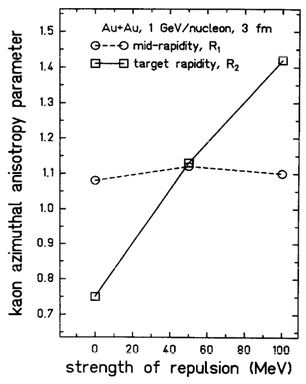
We present results on the anisotropic transverse flow of kaons (K^+, K^0_S and K^-) in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}} = 2.42\,\mathrm{GeV}$ measured with HADES. It was proposed already in the mid-nineties that kaon flow close to its production threshold might be a good probe for the kaon-nucleon potential and, consequently, for the nuclear equation-of-state (PRL 74 (1995) 235). The presented analysis was performed on more than 2 billion events of the 40% most central collisions, which opened the possibility to analyze kaon flow differentially as a function of transverse momentum, rapidity and centrality, even in this low energy regime. The measurements are compared to microscopic transport model predictions and to other data at similar collision energies. Implications on the properties of compressed nuclear matter will be discussed.

Motivation

- scare precision of kaon production at subthreshold energy
- $\mathrm{d}N/\mathrm{d}\Delta\phi$ sensitivity predicted to V_{KN}

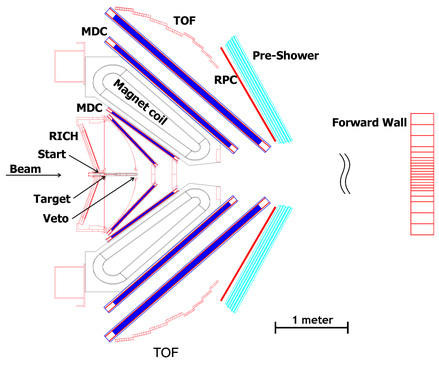
$$R_1 = \frac{N(90°) + N(270°)}{N(0°) + N(180°)} \qquad R_2 = \frac{N(90°)}{N(180°)}$$

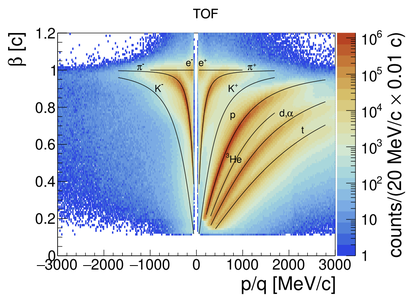
- differential analysis very important (PRL 82 (1999) 5004) but seldom for kaons

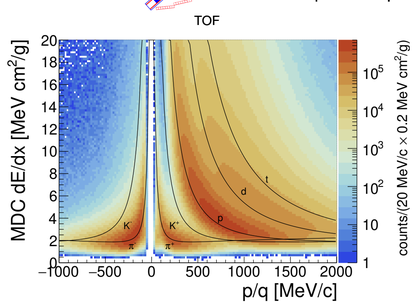


HADES

- fixed target at $\sqrt{s_{\mathrm{NN}}} \sim 2.5\,\mathrm{GeV}$
- diamond START and VETO (trigger, $\sigma_{t_0} = 50\,\mathrm{ps}$)
- RICH and Pre-SHOWER ($\mathrm{e}^{\pm}$ ID)
- MDC + magnet (tracking and hadrons ID via $\mathrm{d}E/\mathrm{d}x$)
- TOF + RPC (trigger and hadrons ID via $\beta(p)$)
- FWall (event plane determination)
- DAQ (read-out with $10\,\mathrm{kHz}$ for HIC)

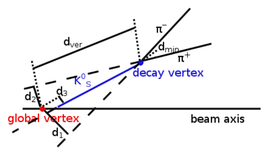




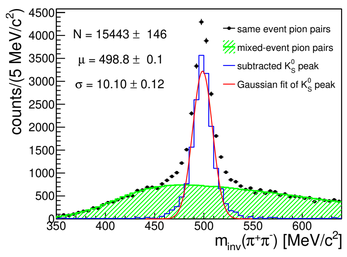


Kaon identification

Neutral kaons

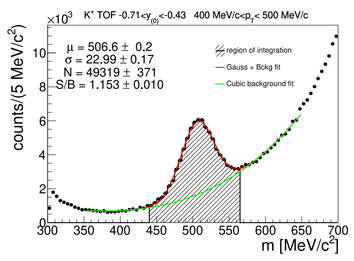


- $\pi^{\pm}$ identification via $\beta(p)$
- optimization of topology cuts using TMVA
- combinatorial background description with ME technique

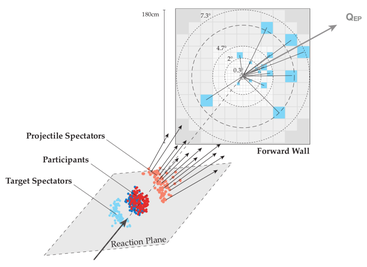


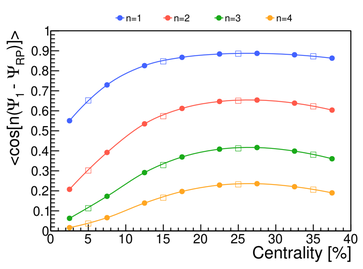
Charged kaons

- cuts on the quality of reconstructed track
- region selection of $\mathrm{d}E/\mathrm{d}x$ in MDC and TOF
- residual background subtraction using a fit of the mass spectrum



Flow measurement





- measuring flow of energy as a Fourier decomposition of azimuthal distribution w.r.t. reaction plane

$$E\frac{\mathrm{d}^3N}{\mathrm{d}p^3} = \frac{1}{2\pi}\frac{\mathrm{d}^2N}{p_{\mathrm{T}}\mathrm{d}p_{\mathrm{T}}\mathrm{d}y}\left(1 + \sum_{n=1}^{\infty} 2v_n\left(p_{\mathrm{T}}, y\right)\cos\left[n(\phi - \Psi_{\mathrm{RP}})\right]\right)$$

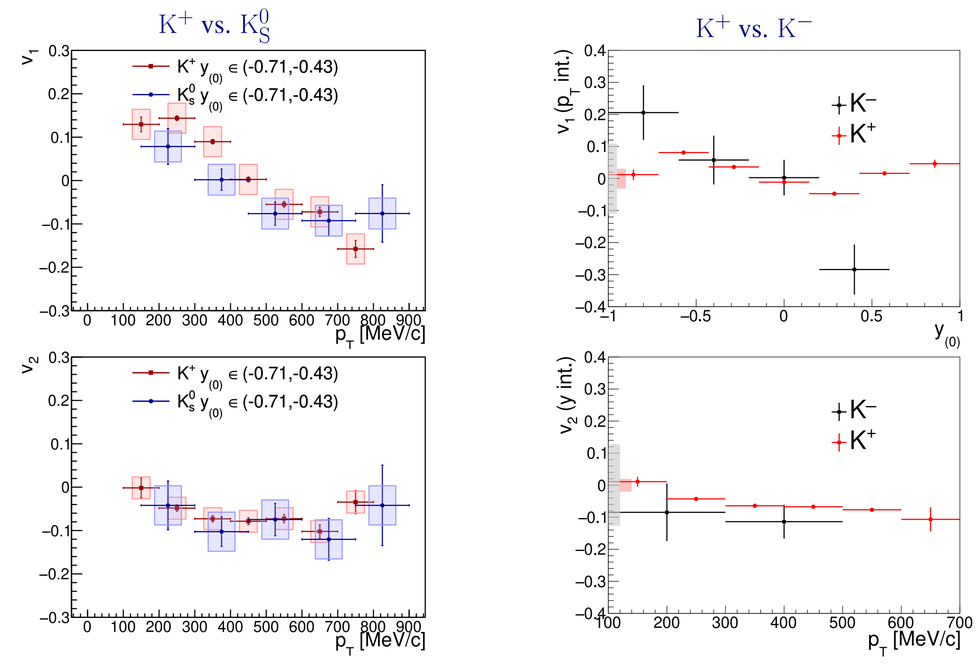
- experimentally unavailable Ψ_{RP} approximated with event planes Ψ_n (in HADES case hits in FWall are used for their determination)

$$Q_n\cos(n\Psi_n) = \frac{1}{N_{\mathrm{FW}}}\sum_{i=1}^{N_{\mathrm{FW}}}|Z_i|\cos(n\phi_{\mathrm{FW},i})$$

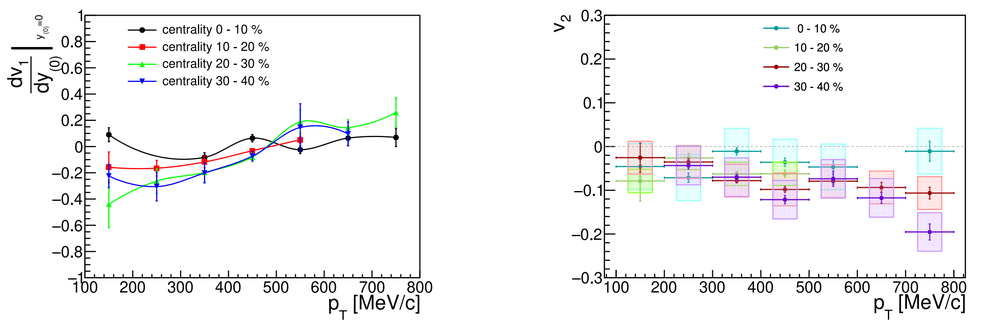
- measured azimuthal distribution w.r.t. Ψ_1 needs a correction for the EP resolution $v_n = \frac{v_n^{\mathrm{obs}}}{\langle\cos[n(\Psi_1 - \Psi_{\mathrm{RP}})]\rangle}$

Results

Comparison within kaon charges

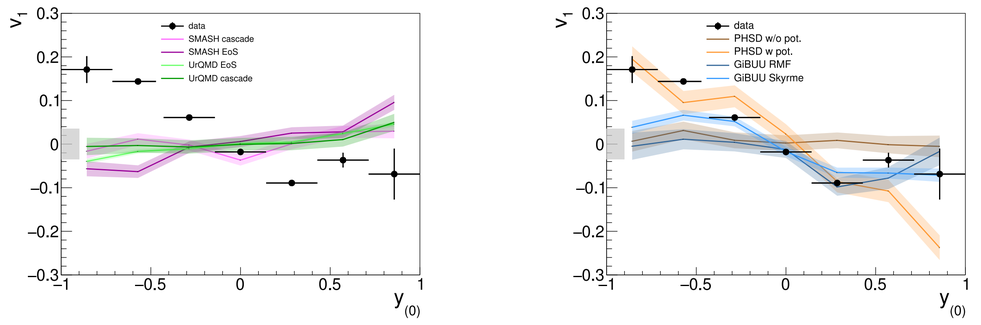


Centrality dependence for K^+

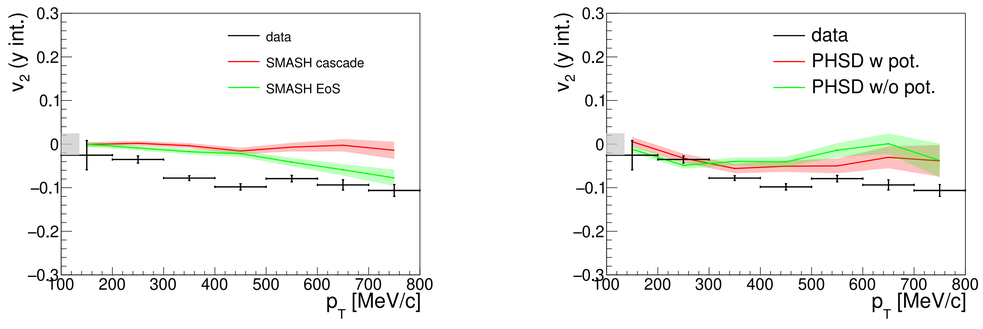


Transport model predictions for K^+

- directed flow at high p_{T} is mainly well described, but we observe significant differences for low $p_{\mathrm{T}} \in (200; 300)\,\mathrm{MeV}/c$



- measured negative elliptic flow is only obtained if EoS is included, a better agreement for the models with V_{KN}



Conclusions

- Kaons can provide unique information about the hot and dense baryonic matter created during HIC.
- We observed transverse flow at subthreshold energy with following properties
  - ◇ no significant differences between charged/neutral kaons and not even kaons/antikaons,
  - ◇ directed flow is strongly dependent on transverse momentum,
  - ◇ elliptic flow is negative, independent of rapidity, and decreasing for higher p_{T},
  - ◇ $\left|v_{1,2}\right|$ are greater in more peripheral collisions.
- From comparison with the predictions of selected transport models: the inclusion of repulsive potential V_{KN} is in better agreement with our measurements.
- HADES measured in 2019 Ag+Ag at $\sqrt{s_{\mathrm{NN}}} = 2.55\,\mathrm{GeV}$ and recorded 14×10^9 events $\Rightarrow$ very interesting results are about to come.
- These detailed results of differential kaon flow have the potential to improve our understanding of dynamics in HIC.

Acknowledgements

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