Highlight of PHENIX Results

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Outline

- Long-range correlation, $v_n$ and HBT in d+Au and $^3$He+Au at 200GeV
- Photon measurements in 200GeV Au+Au
- Beam energy scan results
- Heavy quark and quarkonia
- Summary
Long range correlation in d+Au

“Au-going” vs “d-going”

arXiv:1404.7461
Large $\eta$ gap ($|\Delta\eta| > 2.75$).

- In d+Au, the contribution from elementary processes estimated by pp is small
- Estimation is less sensitive to the final state interactions on jets

C$_2$ in 0-5% d+Au collision
The $v_2$ of $\pi$ and $p$ in d+Au

Mass ordering for identified hadron is observed in both d+Au and p+Pb ---- consistent with hydrodynamic flow
Long range correlation in $^3$He+Au

“Au-going” vs “$^3$He-going”

Ridges are seen on both Au-going and $^3$He-going sides
The $v_2$ and $v_3$ in $^3$He+Au


$^{3}$He+Au (0-5%) $N_{\text{part}}=25.0$  $\varepsilon_2=0.504$  $\varepsilon_3=0.283$

d+Au (0-5%) $N_{\text{part}}=17.8$  $\varepsilon_2=0.540$  $\varepsilon_3=0.190$

The $v_2$ of $^3$He+Au is similar to that of d+Au

A clear $v_3$ signal is observed in 0-5% $^3$He+Au collisions
The HBT radii in d+Au

arXiv:1410.5291

- Linear dependence and good scaling from small (p/d+A) to bigger(A+A) collision systems, implying radial expansion in p/d+A collisions
- The different slopes between RHIC and LHC imply different expansion rates

**Rbar(initial transverse size):** \(1/R_{\text{bar}} = \sqrt{1/\sigma_x^2 + 1/\sigma_y^2}\)
• A medium produced near CEP will show a stalling of expansion speed \( \sim (R_{\text{side}} - \sqrt{2}R_{\text{bar}})/R_{\text{long}} \) as well as a longer expansion time \( \Delta \tau^2 \propto R_{\text{out}}^2 - R_{\text{side}}^2 \).

• Non-monotonic behaviors are found for expansion time and expansion speed.
Below 39 GeV, the $dN/d\eta$ scales well with participant nucleons.

Above 39 GeV, participant quark scaling describes the data well.
Higher moments of net charge fluctuation

The correlation length ($\xi$) is related to various moments of conserved quantities:

- **Variance:** $\sigma^2 = \langle (N-<N>)^2 \rangle \sim \xi^2$
- **Skewness:** $S = \langle (N-<N>)^3 \rangle / \sigma^3 \sim \xi^{4.5}$
- **Kurtosis:** $\kappa = \langle (N-<N>)^4 \rangle / \sigma^4 - 3 \sim \xi^7$

The products of the net charge moments show no significant increase above URQMD, HIJING, or Hadron Resonance Gas predictions.
Direct photon at low $p_T$

arXiv:1405.3940

New analysis using external conversion of real photon

Consistent with previous results from virtual photon

Extension to lower $p_T$

direct photons
The direct photon $v_2$ has been measured with new external conversions methods. The model calculations under-predict our measurements. The new $v_3$ measurement will bring more challenges to theorists.
Dark photons

PHENIX: excellent electron ID and $e^+e^-$ mass resolution – huge sample of $\pi^0$ Dalitz decays

With recent combined limits – WASA, HADES, A1, BaBar, PHENIX, NA48/2 – essentially all parameter space for the minimal version of a dark photon to explain $(g-2)_{\mu}$ anomaly has been ruled out.
HF e in 62.4 GeV Au+Au

HF electron $R_{AA} > 1 \&\& v_2 > 0$ in 62.4 GeV Au+Au collisions. The systematic uncertainties of $R_{AA}$ are mainly from pp reference.

HF e in 62.4 GeV Au+Au will help to understand how the HF coupling to the medium
i) Temperature
ii) Pseudo-critical region

Possible strong coupling nearer $T_c$ drives interest in Au+Au and p+p at $\sqrt{s_{NN}} = 62.4$ GeV for 2016 Run.
J/psi is more suppressed in Cu-going direction
Trend is comparable with the calculations using EPS09
Suppression of Upsilon at RHIC observed!

Consistent with disappearance of 2s and 3s contributions!

Within uncertainties similar to the suppression in Pb+Pb@CMS
Summary

• The ridge is observed in d+Au and $^3$He+Au. There is a clear $v_3$ signal in $^3$He+Au
• The $v_3$ of direct photon is seen in AuAu@200GeV
• Non-monotonic behaviors are found for expansion speed and time by HBT@collision energies
• The HF e $R_{AA}>1$ and $v_2>0$ in 62.4GeV Au+Au collision. Improved measurements in the future will help us to address “possible strong coupling near $T_c$”
Backup

- d+Au 200GeV
- p+p 200GeV

$0.2 < p_{T,\text{Track}} < 2.0 \text{ GeV/c}$

$-0.35 < \eta_{\text{Track}} < 0.35$

$-3.7 < \eta_{\text{Tower}} < -3.1$, Au-going