The STAR measurements on off-diagonal cumulants of net-particle multiplicity distributions in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7-200 GeV

Arghya Chatterjee, for the STAR Collaboration[(1,2)]

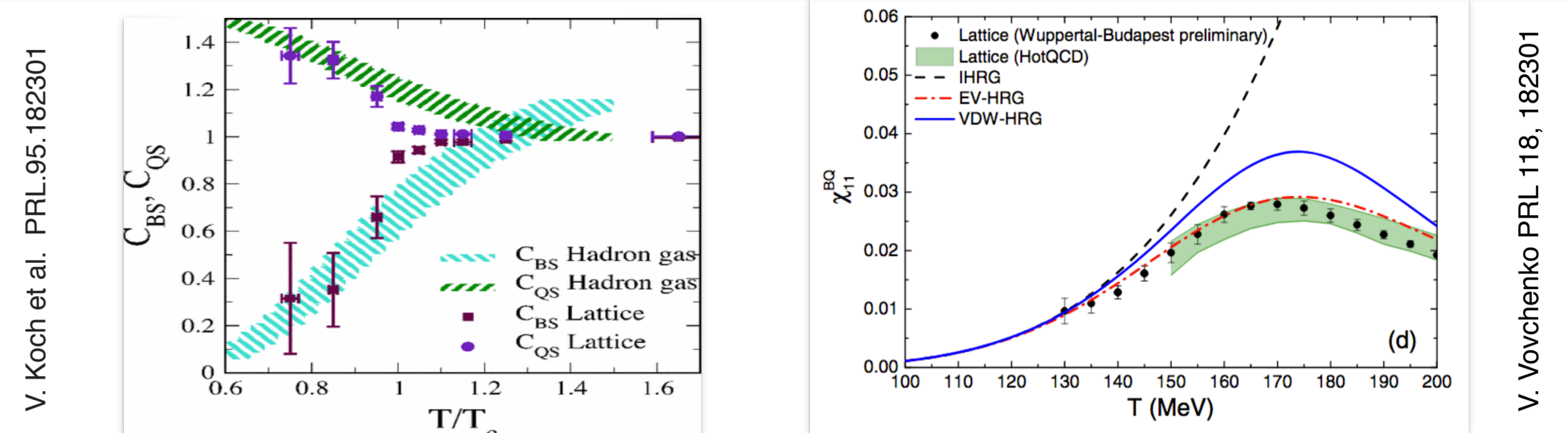[(1)] Central China Normal University, Wuhan 430079, China

[(2)] Variable Energy Cyclotron Centre, Kolkata 700064, India

Abstract

We present the STAR measurements of diagonal and off-diagonal cumulants of net charge, net proton, and net kaon multiplicity distributions in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7-200 GeV. We focus on the pseudorapidity window and centrality dependence of these cumulants. The results are compared to HRG and UrQMD calculations. The energy dependence of off-diagonal over diagonal cumulant ratios cannot be fully described by different model calculations. These measurements provide important insights on the correlations between different conserved charges from the QGP and hadronic phase, as well as their dependence with temperature and baryon chemical potential.

Introduction

➢ Event-by-event fluctuations (cumulants) of conserved quantities, such as net baryon [proxy: net proton (p)], net charge (Q), net strangeness [proxy: net kaon (k)] are related to thermodynamic susceptibilities and sensitive tools to study the QCD phase diagram.

➢ Off-diagonal cumulant ratios: different values for hadronic or partonic contributions [2].

➢ Sensitivity to the difference between HRG and lattice calculations at the lowest order. New constraints on **freeze-out** conditions.
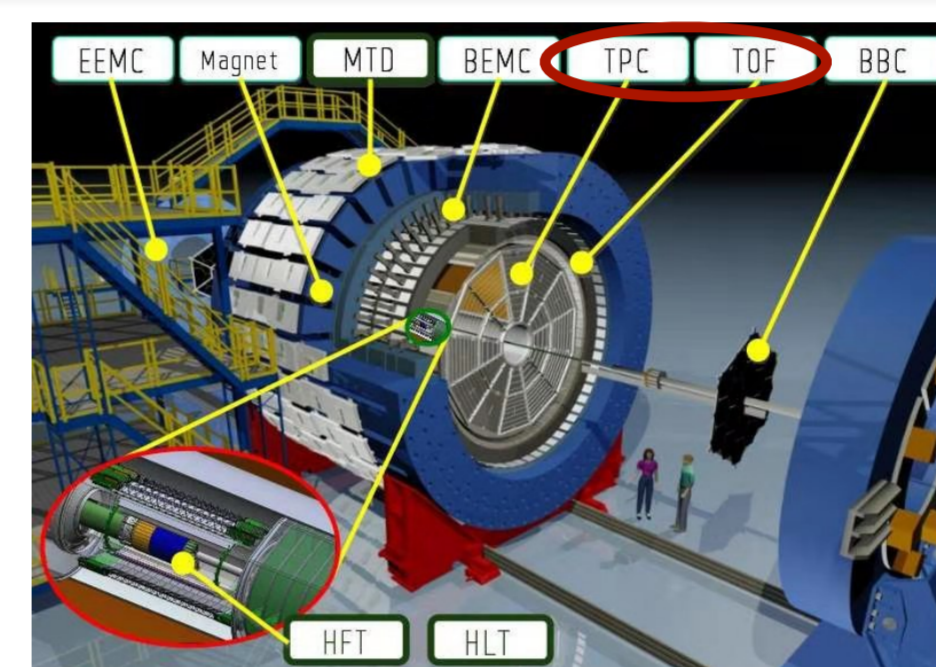
V. Koch et al. PRL.95.182301

V. Vovchenko PRL 118, 182301

Observables (Connection between cumulants and susceptibilities)

◉ σ^2: $\quad VT\chi_x = \sigma_x^2 = \langle x^2 \rangle - \langle x \rangle^2$

◉ $\sigma^{1,1}$: $\quad VT\chi_{x,y} = \sigma_{x,y}^{1,1} = \langle xy \rangle - \langle x \rangle \langle y \rangle$

◉ $C_{x,y}$: ($\sigma^{1,1}/\sigma^2$): Volume-independent "Koch ratios"

$\chi_{x,y}/\chi_x = C_{x,y} = \sigma_{x,y}^{1,1}/\sigma_y^2$

x,y → p/k/Q
p → net proton
k → net kaon
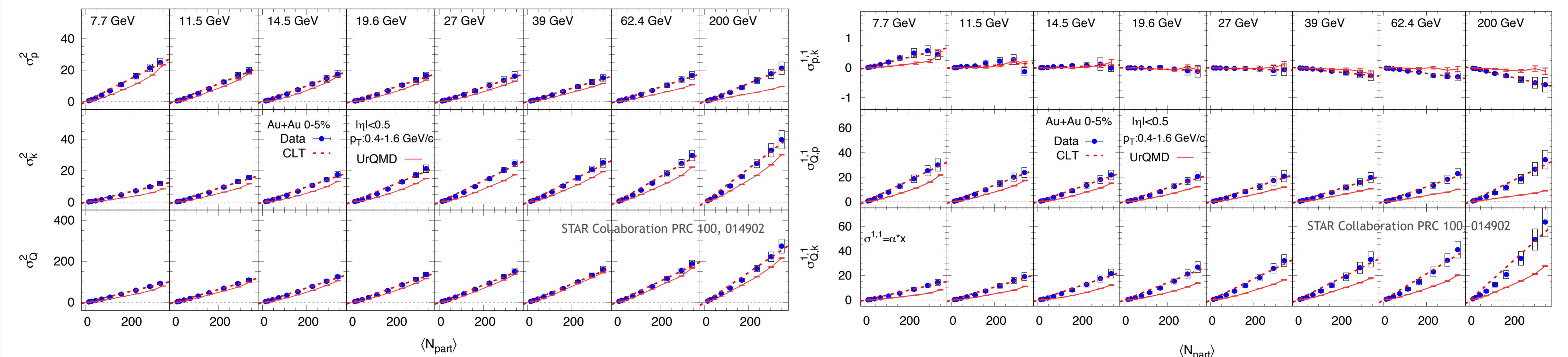Q → net charge
V → volume
T → temperature

Experiment

◉ **Particle identification** ($|\eta| < 0.5$ & $0.4 < p_T < 1.6$ GeV/c)

◉ **Centrality selection** charged particles $0.5 < |\eta| < 1.0$

◉ **CBWC and efficiency corrected** [1,3]

Particles	TPC	TPC + TOF
$p(\bar{p})$	$0.4 < p_T < 0.8$ (GeV/c) $|n\sigma_p| < 2$	$0.8 < p_T < 1.6$ (GeV/c) $0.6 < m^2 < 1.2$
$k^+(k^-)$	$|n\sigma_K| < 2, |n\sigma_\pi| > 2$	$0.4 < p_T < 1.6$ (GeV/c) $0.15 < m^2 < 0.4$
$Q^+(Q^-)$	$0.4 < p_T < 1.6$ (GeV/c)	

Results

Centrality dependence of cumulants

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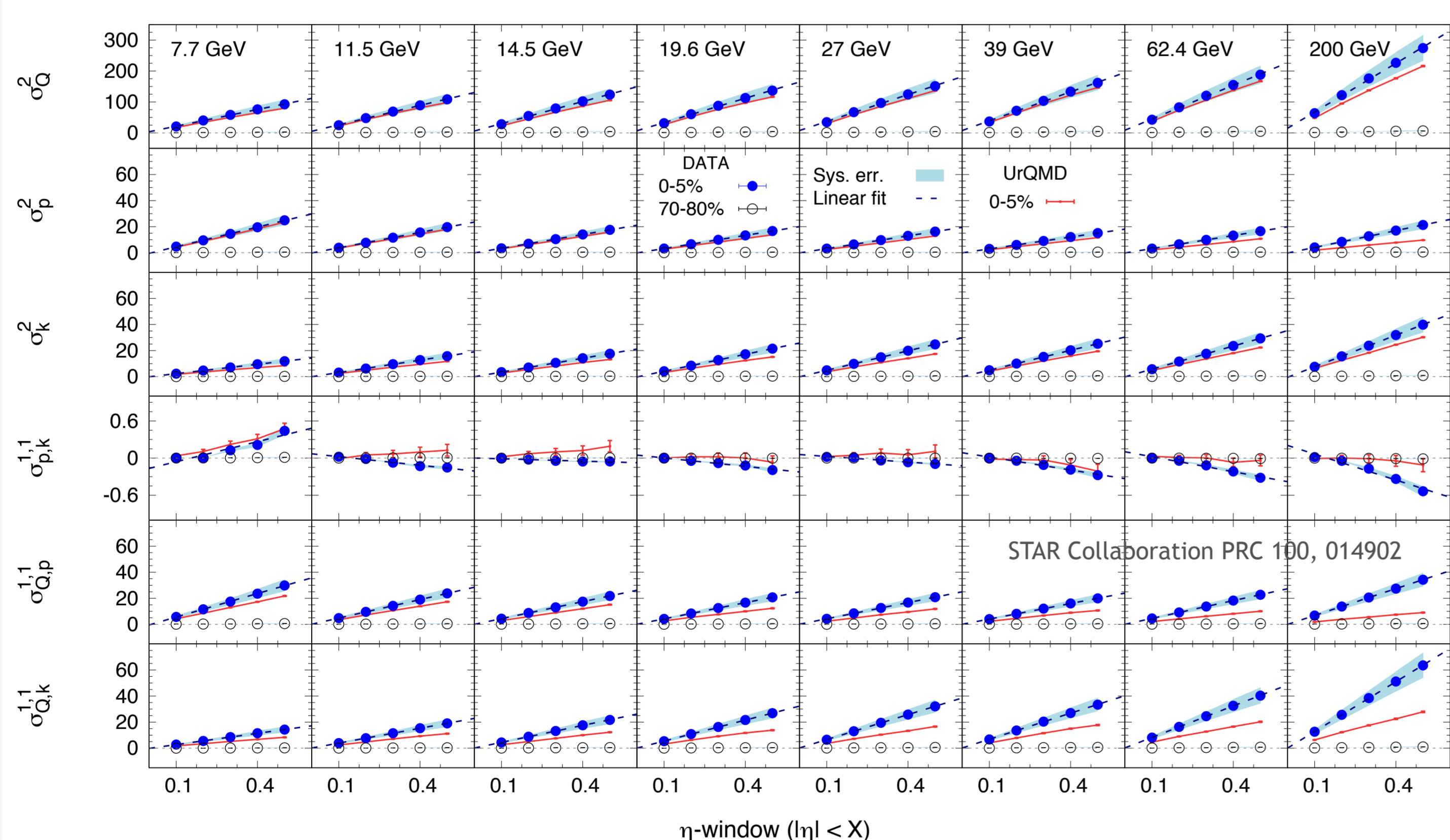
◉ Variance increases linearly with centrality.
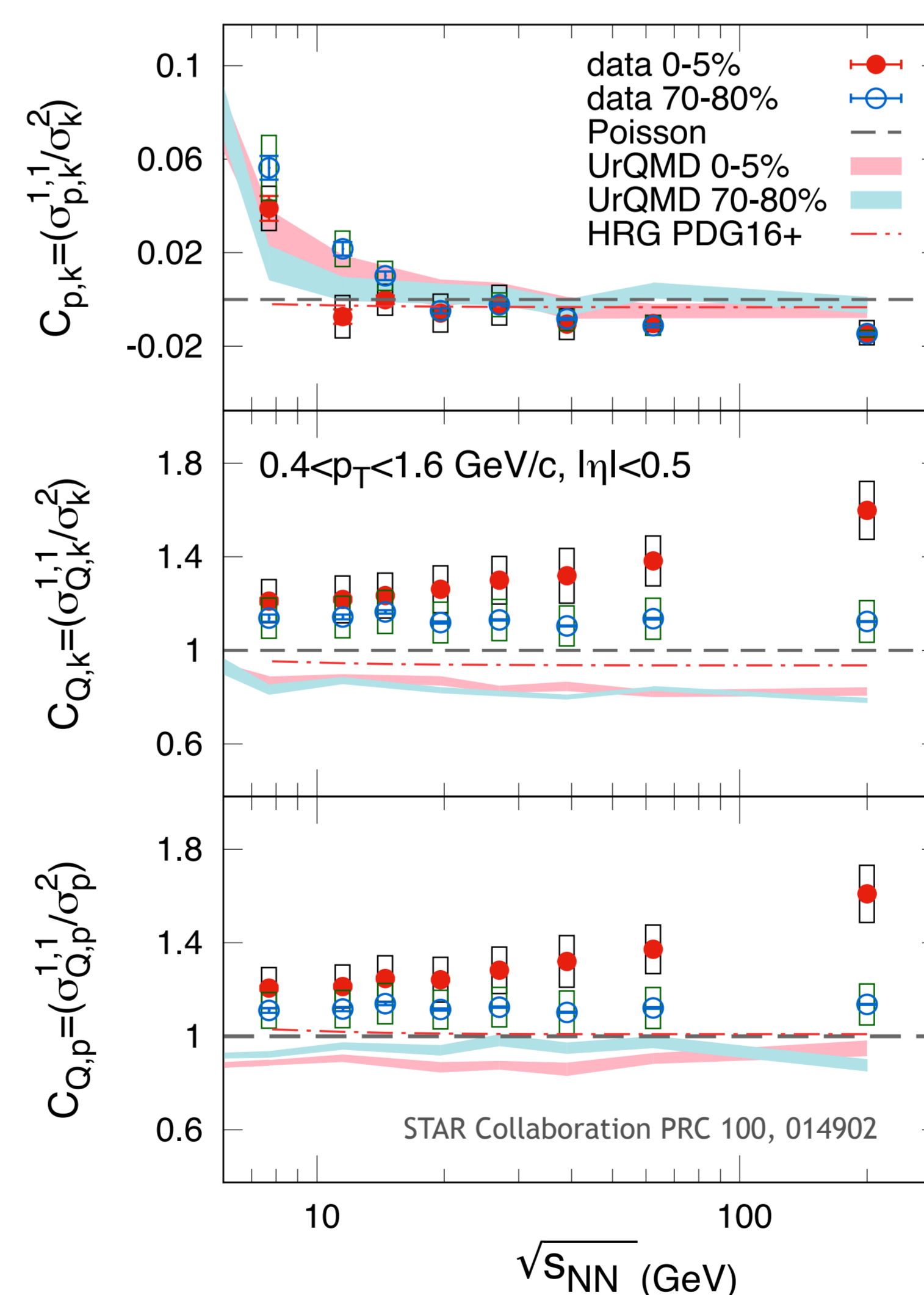
◉ UrQMD slightly underestimate but qualitatively describe the trend.

◉ Covariance between net p and net k is decreasing with beam energy from positive to negative.

η-window dependence

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◉ For $\Delta y_{corr} \gg \Delta y_{window}$ one expect deviation from linear dependence [4].

◉ Cumulants of net Q, p, and k show linear trend as a function of $|\eta|$ acceptance window.

◉ BES-II will cover $|\eta| \sim 1.5$

Energy dependence of cumulant ratios

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◉ Volume-independent correlation of net p and net k is positive at lower collision energy and negative at high collision energy.

◉ In QGP phase, B-S correlation is negative [2]. We also observed negative p-K correlation. The direct quantitative comparison is not possible.

◉ C_{Qp} and C_{Qk} both show significantly higher correlations in central compare to peripheral collisions. The correlations increase with the increase of beam energy.

◉ The excess correlation is not observed in both UrQMD and HRG [5,7].

Summary

◉ Second-order cumulant matrix elements of net p,k, and Q for Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7 to 200 GeV are presented. Detailed results are shown for the uniform kinematic acceptance range as well as with different $|\eta|$ windows.

◉ C_{pk} shows anticorrelations for central collisions for $\sqrt{s_{NN}} > 27$ GeV.

◉ Significant excess of correlations is observed in C_{Qk} and C_{Qp} with respect to peripheral collisions. These correlations increases with increasing beam energy.

Outlook ◉ Stay tuned for higher-order off-diagonal cumulants [8].

References

[1] J. Adam et al. (STAR collaboration) PRC 100, 014902
[2] V. Koch et al. PRL 95, 182301, A. Majumder and B. Muller, PRC 74, 054901
[3] X. Luo: PRC.91.034907, JPG 40.105104, JPG39.025008, A. Bzdak et al. PRC.91.027901
[4] B. Ling et al. PRC 93, 034915.
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