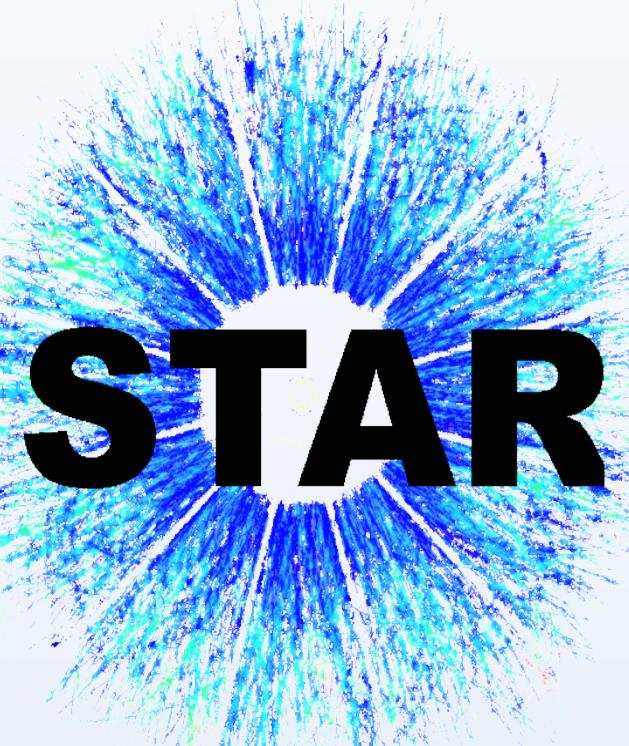


# Off-diagonal cumulants of net-charge, net-proton and net-kaon multiplicity distributions in Au+Au collisions at STAR



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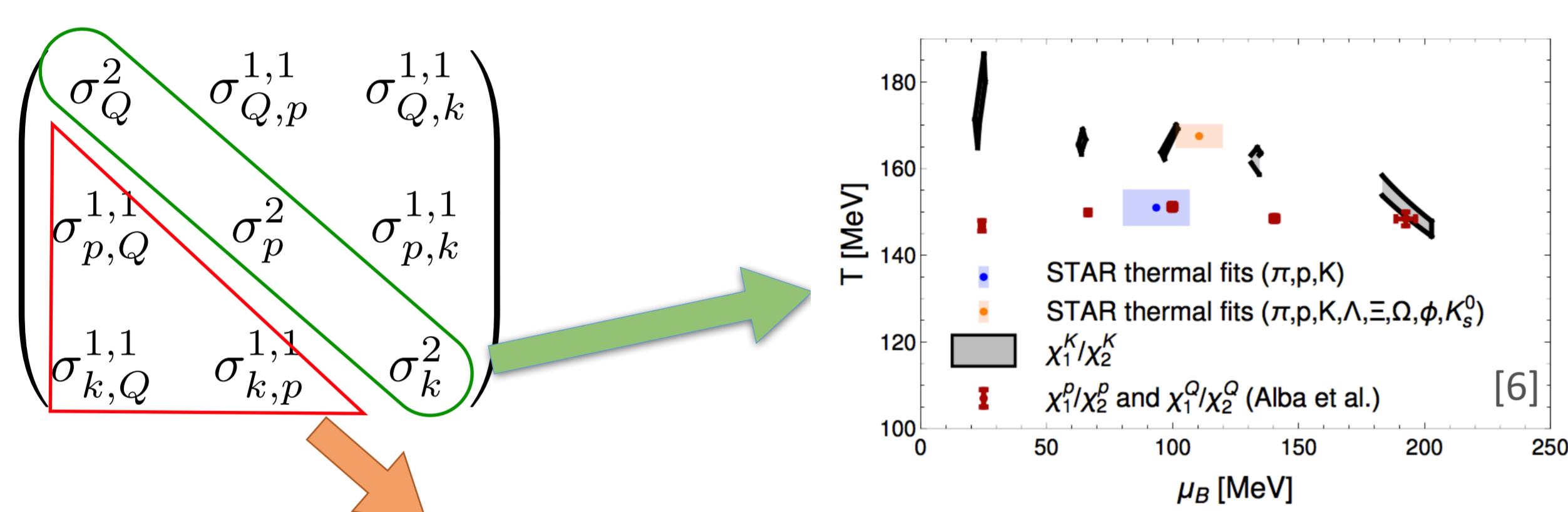


## Abstract

Event-by-event fluctuations of conserved quantities have been extensively used to study the thermodynamic properties near the phase transition region of the QCD matter. According to the lattice QCD calculation, the off-diagonal cumulants of net-charge (Q), net-baryon (B) and net-strangeness (S) and their ratios to diagonal cumulants are sensitive to the evolution of the system and the freeze-out parameters on the QCD phase diagram [1,2]. In this poster, we report the first measurements of 2nd-order off-diagonal cumulants of net-charge, net-proton and net-kaon multiplicity distributions at RHIC in Au+Au collisions at  $\sqrt{s_{NN}} = 7.7, 11.5, 14.5, 19.6, 27, 39, 62.4$  and  $200 \text{ GeV}$ . We study beam energy, centrality, and acceptance ( $\eta$ ) dependence of off-diagonal cumulants after implementing efficiency and other experimental corrections. Both non-thermal and thermal resonance production implemented in UrQMD and HRG respectively, can not explain the data, indicating the measured correlations can have a possible contribution from the partonic phase.

## Introduction

- Event-by-event fluctuations of conserved quantities, such as net-baryon [proxy: net-proton (p)], net-charge (Q), net-strangeness [proxy: net-kaon (k)] are sensitive tools to study the QCD phase diagram.
- The 2nd-order diagonal and off-diagonal cumulants of net-p, Q and k can provide a better understanding on the freeze-out parameters and constrain the hadron models [1-4].
- Only diagonal cumulants of net-p, Q and k measured before [5].



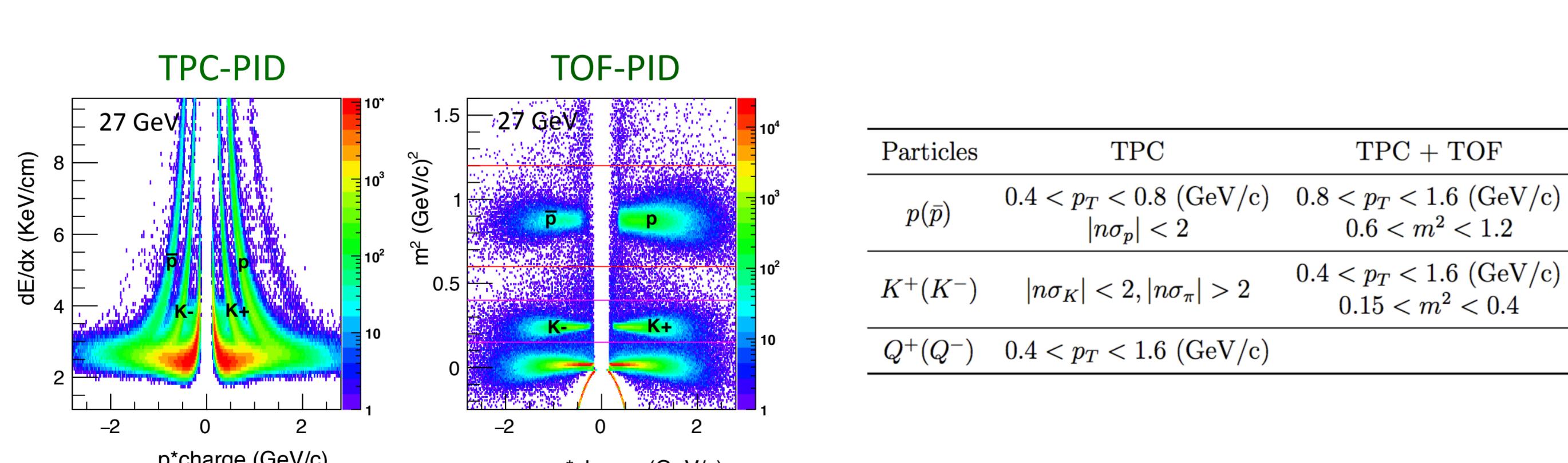
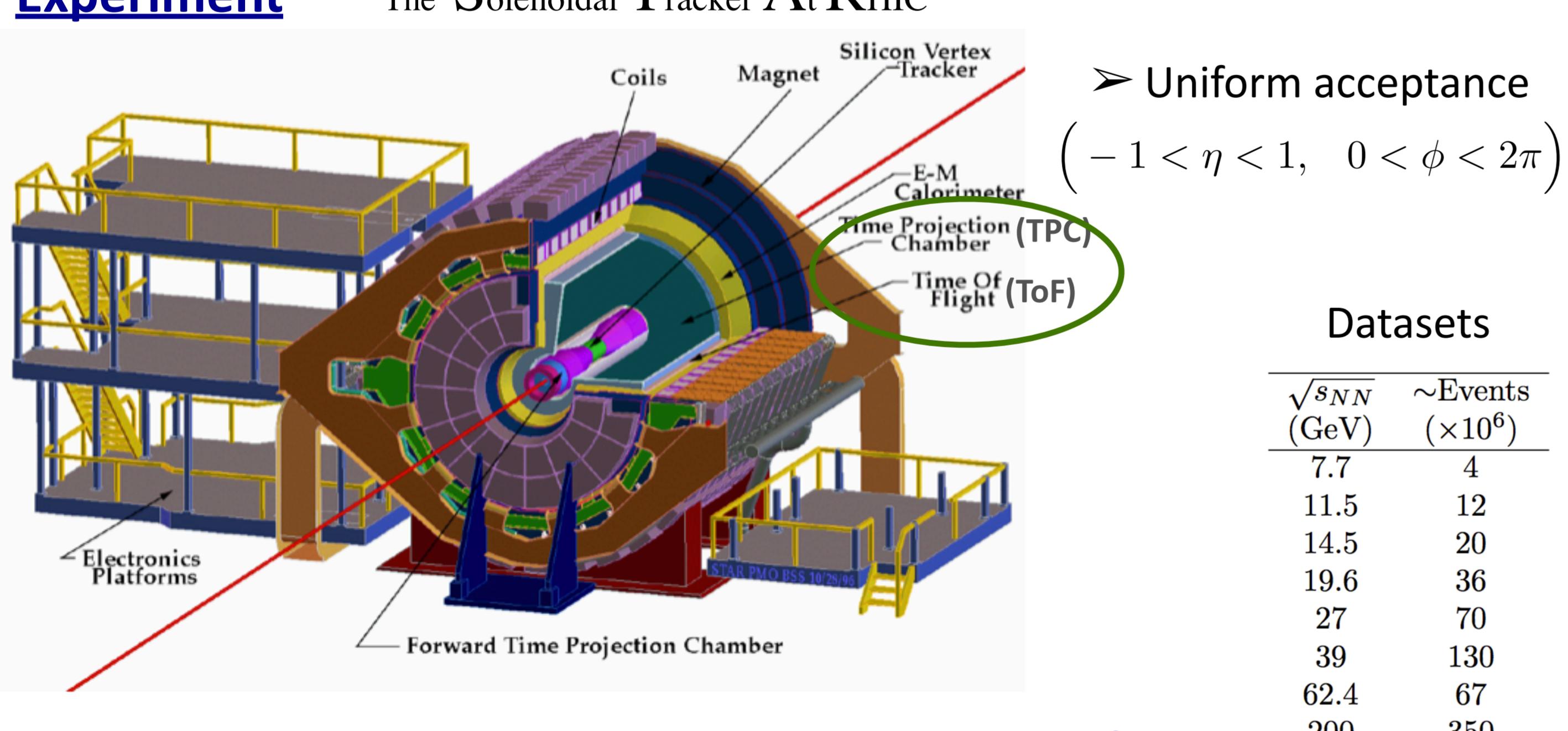
- First measurement of the 2nd-order off-diagonal cumulants.

## Observables (Connection to thermodynamic susceptibilities)

- $\sigma^2$ : Self correlation  $\rightarrow VT\chi_x = \sigma_x^2 = \langle x^2 \rangle - \langle x \rangle^2$
  - $\sigma^{1,1}$ : Cross correlation  $\rightarrow VT\chi_{x,y} = \sigma_{x,y}^{1,1} = \langle xy \rangle - \langle x \rangle \langle y \rangle$
  - $C_{x,y}$ : ( $\sigma^{1,1}/\sigma^2$ ): Excess correlation compared to self correlation [1]  $\rightarrow \chi_{x,y}/\chi_x = C_{x,y} = \sigma_{x,y}^{1,1}/\sigma_y^2$
- One can use x or y in the denominator.

## Experiment

### The Solenoidal Tracker At RHIC

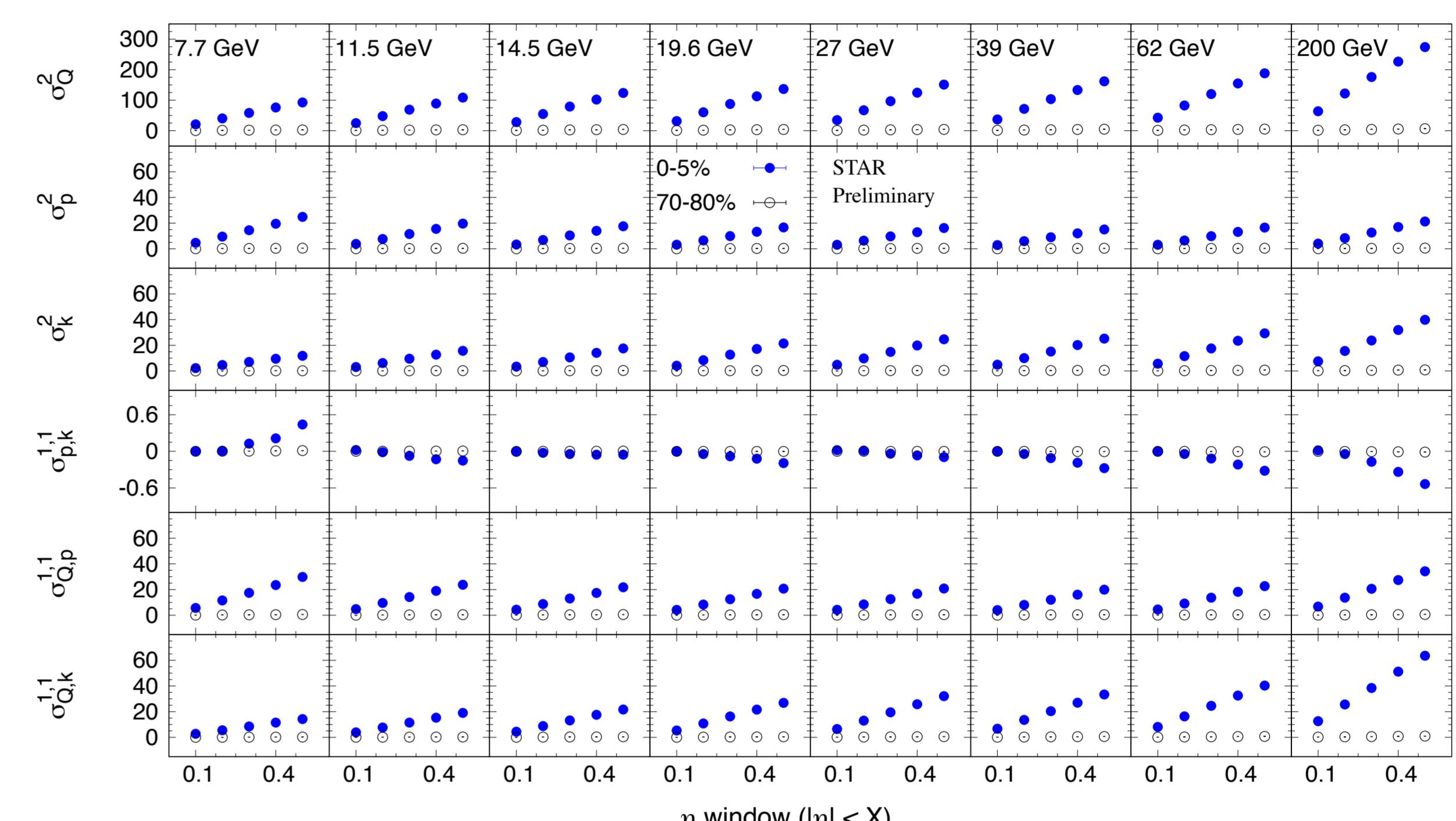


- Centrality determination: charged particles within  $0.5 < |\eta| < 1.0$
- Centrality bin width correction: to suppress the volume fluctuation.
- Efficiency correction : Binomial efficiency assumption.

## References:

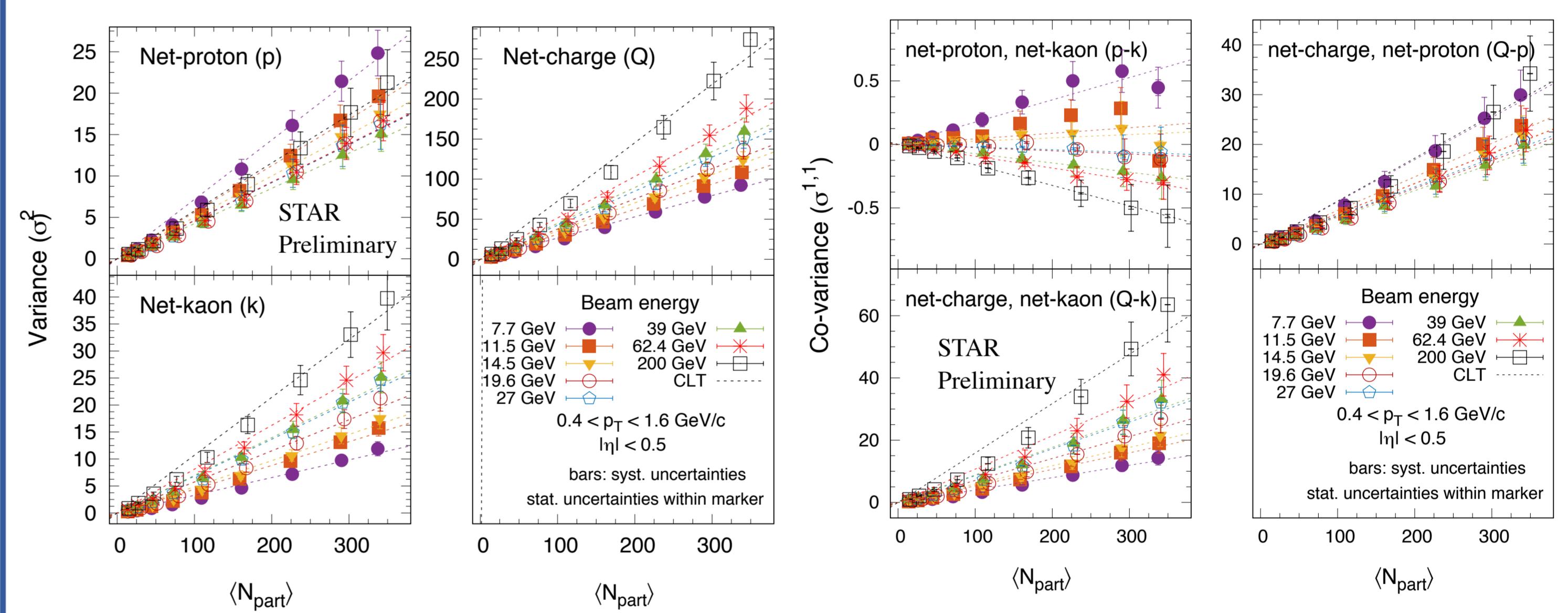
- [1] V. Koch et al. PRL 95.182301 (2005), A. Majumder and B. Muller, PRC 74 (2006)
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- [3] A. Bazavov et al, arXiv:1701.04325 [hep-lat].
- [4] A Chatterjee et al. JPG: Nucl. Part. Phys. 43 125103 (2016).
- [5] STAR collaboration PRL 105, 022302, PRL 113, 092301, arXiv:1709.00773
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- [7] J. Noronha-Hostler et al. (private comm.)

## Results



- Both diagonal and off-diagonal cumulants of net-Q, p and k increase linearly with  $|\eta|$  acceptance window compared to peripheral ones.

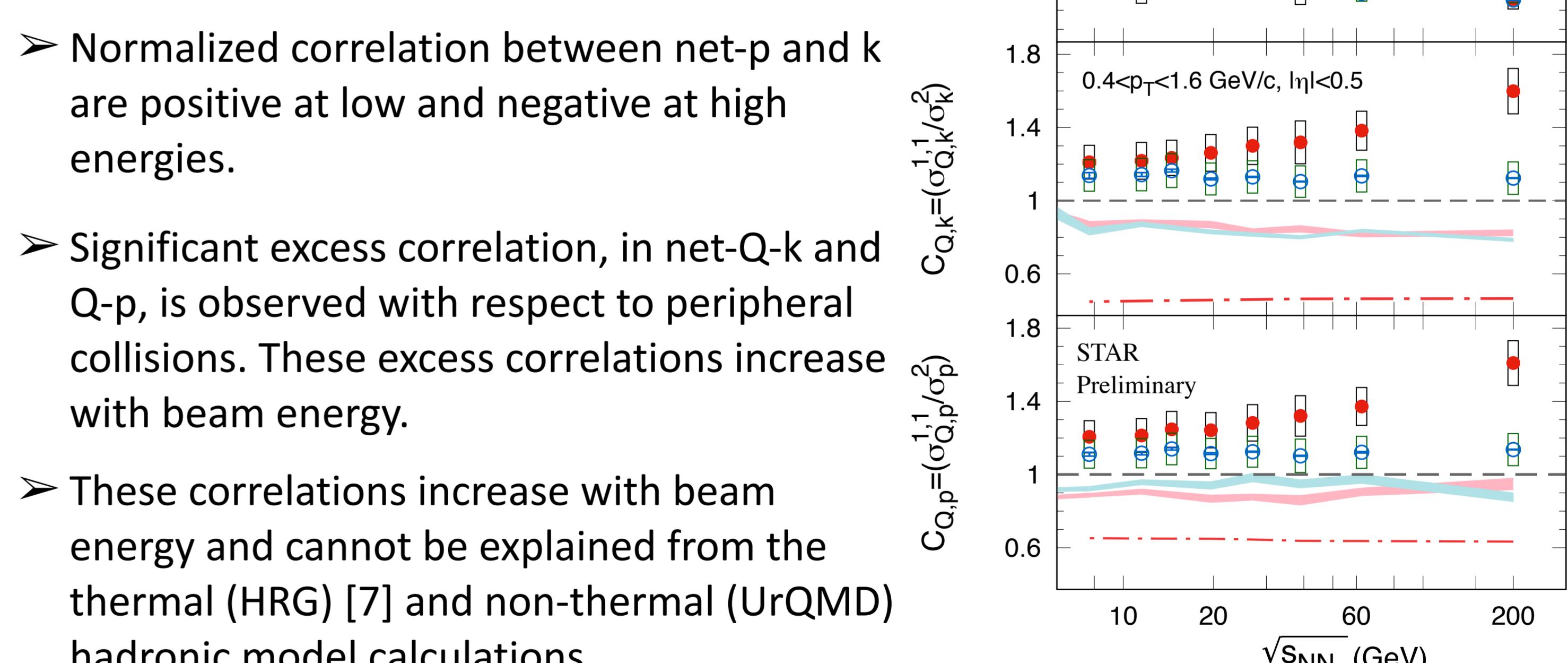
## Centrality dependence of cumulants



- Self-correlation increases linearly with centrality.

- Covariance between net p-k decreases with beam energy from positive to negative.

## Energy dependence of cumulant ratios



## Summary

- First measurements of full 2nd-order cumulant matrix elements of net-p,k, and Q for Au+Au collisions  $\sqrt{s_{NN}} = 7.7$  to  $200 \text{ GeV}$  are presented. Detailed results are shown for the uniform kinematic acceptance range as well as with different  $|\eta|$  window.
- $C_{p,k}$  shows anti-correlations for central collisions for  $\sqrt{s_{NN}} > 27 \text{ GeV}$ .
- Significant excess correlation observed in  $C_{Q,k}$  and  $C_{Q,p}$  with respect to peripheral collisions. These correlations increase with beam energy.
- UrQMD and HRG models cannot describe the data.