Energy Dependence of Moments of Net-Kaon Multiplicity Distributions at STAR

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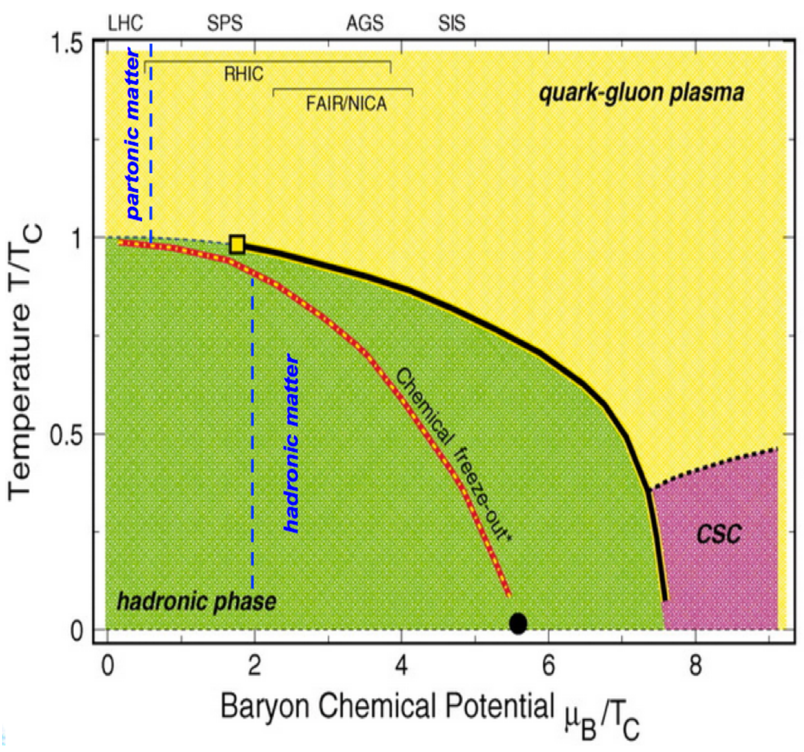
One of the main goals of the RHIC Beam Energy Scan (BES) program is to study the QCD phase structure, including the search for the critical point, over a wide range of the collision energy. Theoretical calculations predict that fluctuations of conserved quantities, such as baryon number (B), charge (Q), and strangeness (S), are sensitive to the correlation length of the dynamical system. Experimentally, higher moments of multiplicity distributions have been utilized to search for the QCD critical point and extract freeze-out conditions in heavy-ion collisions. The STAR Collaboration has published moments of net-proton and net-charge multiplicity distributions. In this poster, we will report efficiency-corrected cumulants and higher moments of the net-kaon multiplicity distributions at mid-rapidity (|y| < 0.5) in Au +Au collisions at √sNN =7.7, 11.5, 14.5, 19.6, 27, 39, 62.4 and 200GeV obtained from the first phase of the RHIC BES program. The collision energy and centrality dependence of the cumulants up to the fourth order, as well as their ratios, will be shown. The comparisons with a Poissonian baseline and non-critical-point models will also be discussed.

Introduction

In the lattice QCD theory, fluctuations of conserved quantities: Baryon(B), Charge(Q), Strangeness(S), directly connected to the particle number susceptibilities. These could diverge at a QCD critical point.



S. Gupta et al., Science, 332, 1525 (2011)
Y. Aoki et al., Nature 443, 675 (2006)

- Sensitive to the correlation length(ξ) :

$$\langle(\delta N)^2\rangle \sim \xi^2$$
$$\langle(\delta N)^3\rangle \sim \xi^{4.5}$$
$$\langle(\delta N)^4\rangle - 3\langle(\delta N)^2\rangle^2 \sim \xi^7$$

M. A. Stephanov, PRL102, 032301 (2009);
M. Akasawa, et al., PRL103,262301 (2009).

- Susceptibility ⇔ moments:

$$\kappa\sigma^2 \sim \frac{\chi^{(4)}}{\chi^{(2)}}, S\sigma \sim \frac{\chi^{(3)}}{\chi^{(2)}}, \frac{\sigma^2}{M} \sim \frac{\chi^{(2)}}{\chi^{(1)}}$$

A. Bazavov et al. PRL109,192302,(2012).
F. Karsch et al, PLB 695,136(2011).

Theory：Lattice QCD, Models etc.
- Crossover at μ_B=0, first order phase transition expected at large μ_B.
- QCD Critical Point: The end point of first order phase transition boundary.

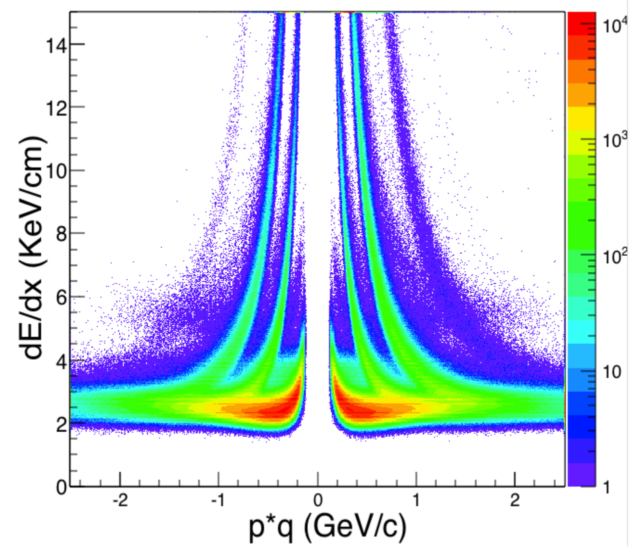
Main observables:
Volume Independent Cumulant Ratios:

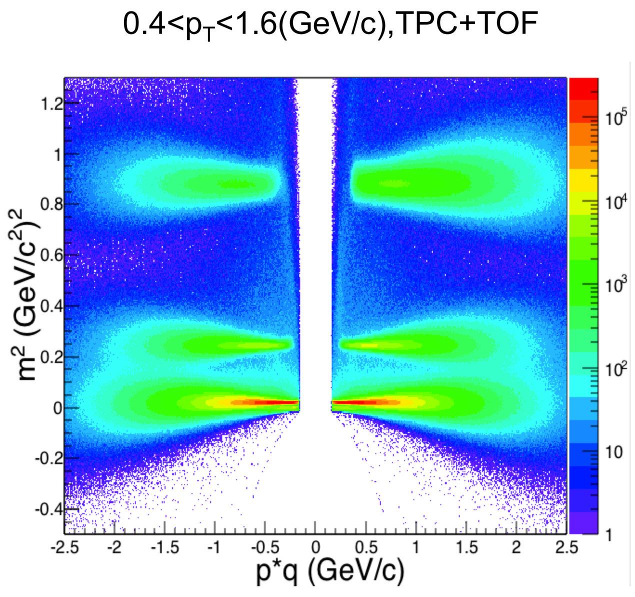
$$\kappa\sigma^2 = \frac{C_{4,x}}{C_{2,x}}, S\sigma = \frac{C_{3,x}}{C_{2,x}}, \frac{\sigma^2}{M} = \frac{C_{2,x}}{C_{1,x}}$$

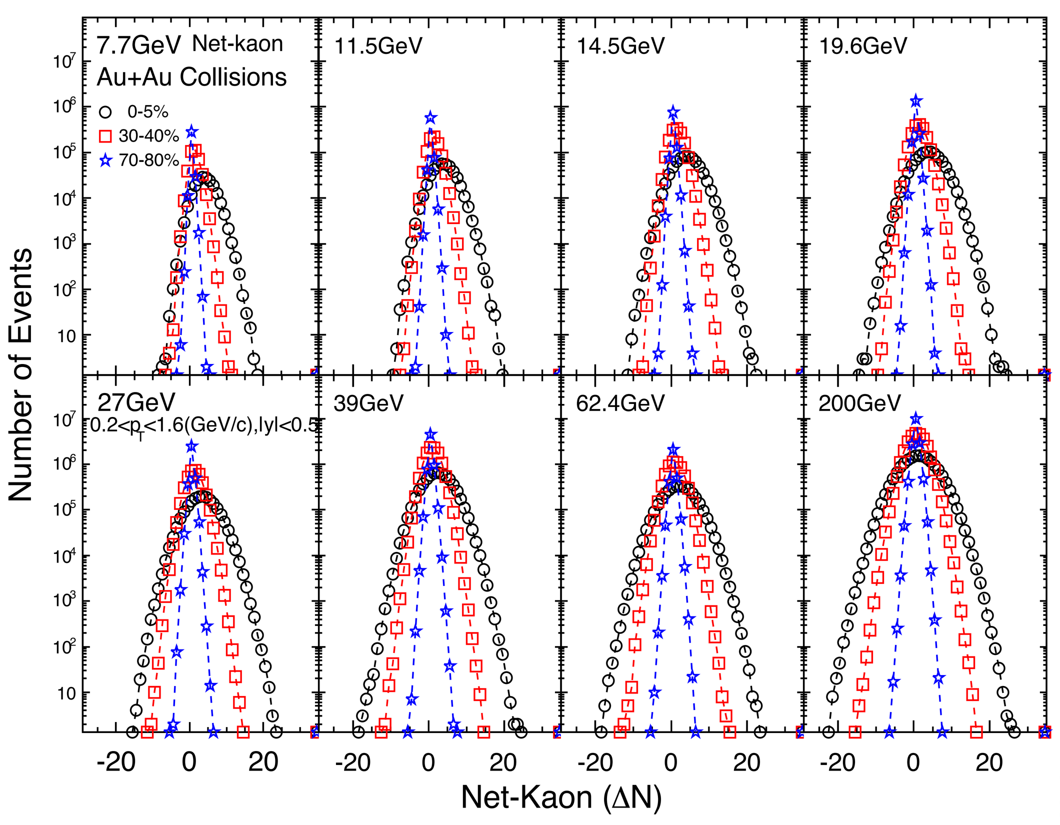
Data Analysis and Results

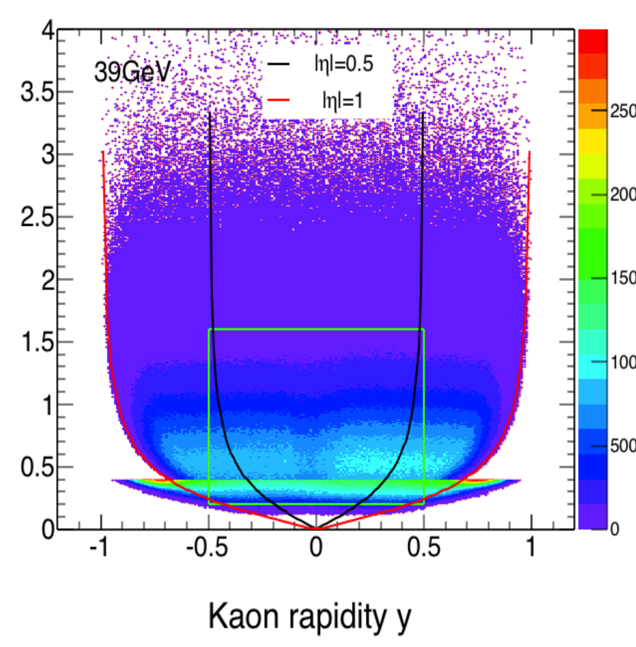
- With a large uniform acceptance and excellent particle identification, STAR detector is an ideal detector to probe the hot dense QCD matter created in the heavy-ion collision. In the first phase of the Beam Energy Scan (BES) program, eight beam energies have already been surveyed from $\sqrt{s_{NN}}$=7.7GeV to 200GeV.

- PID: Energy loss (dE/dx) in Time Projection Chamber and mass-squared (m^2) from Time of Flight are used to identify kaons within $0.2<p_T<1.6$ (GeV/c) and at mid-rapidity $|y|<0.5$.



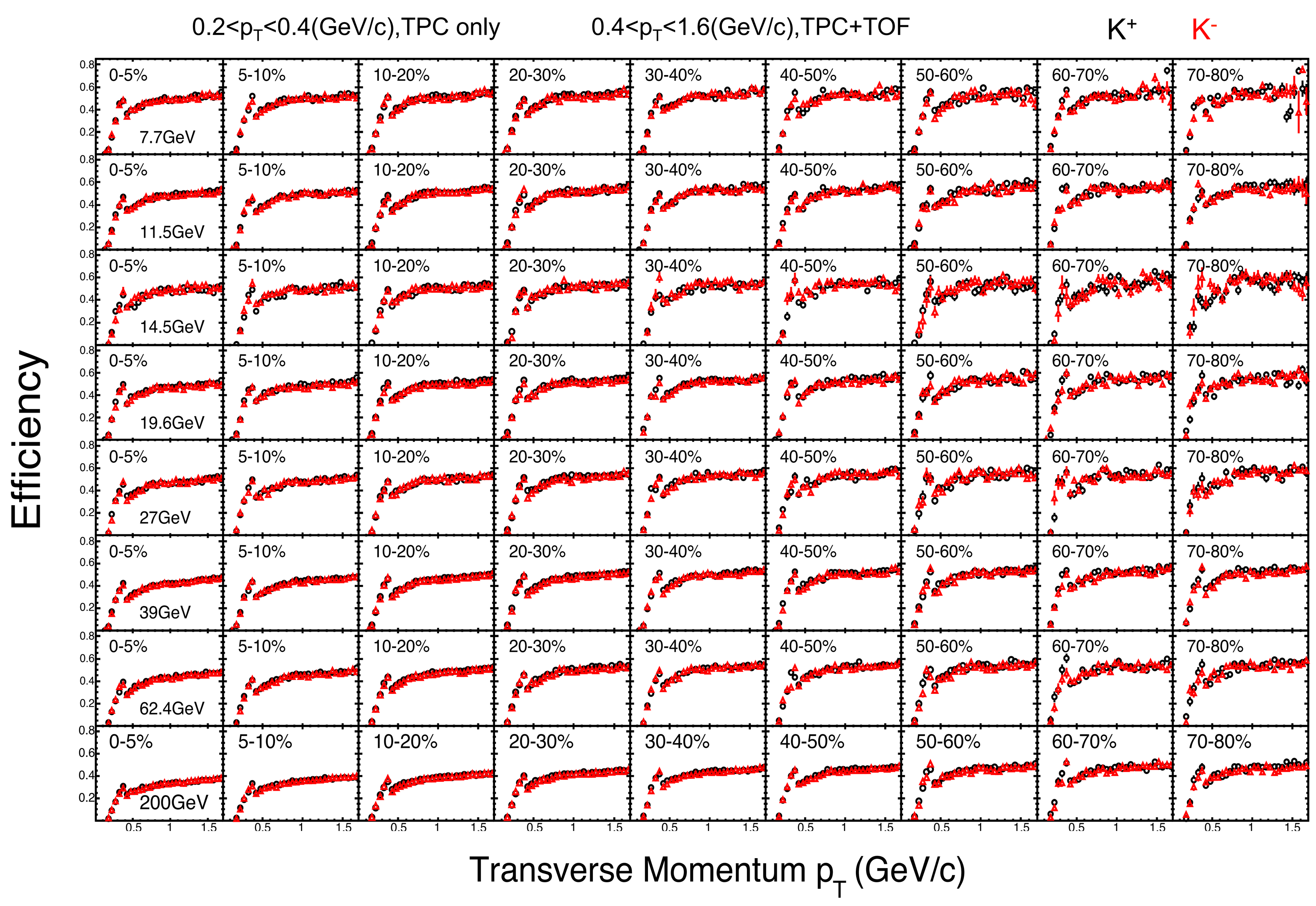


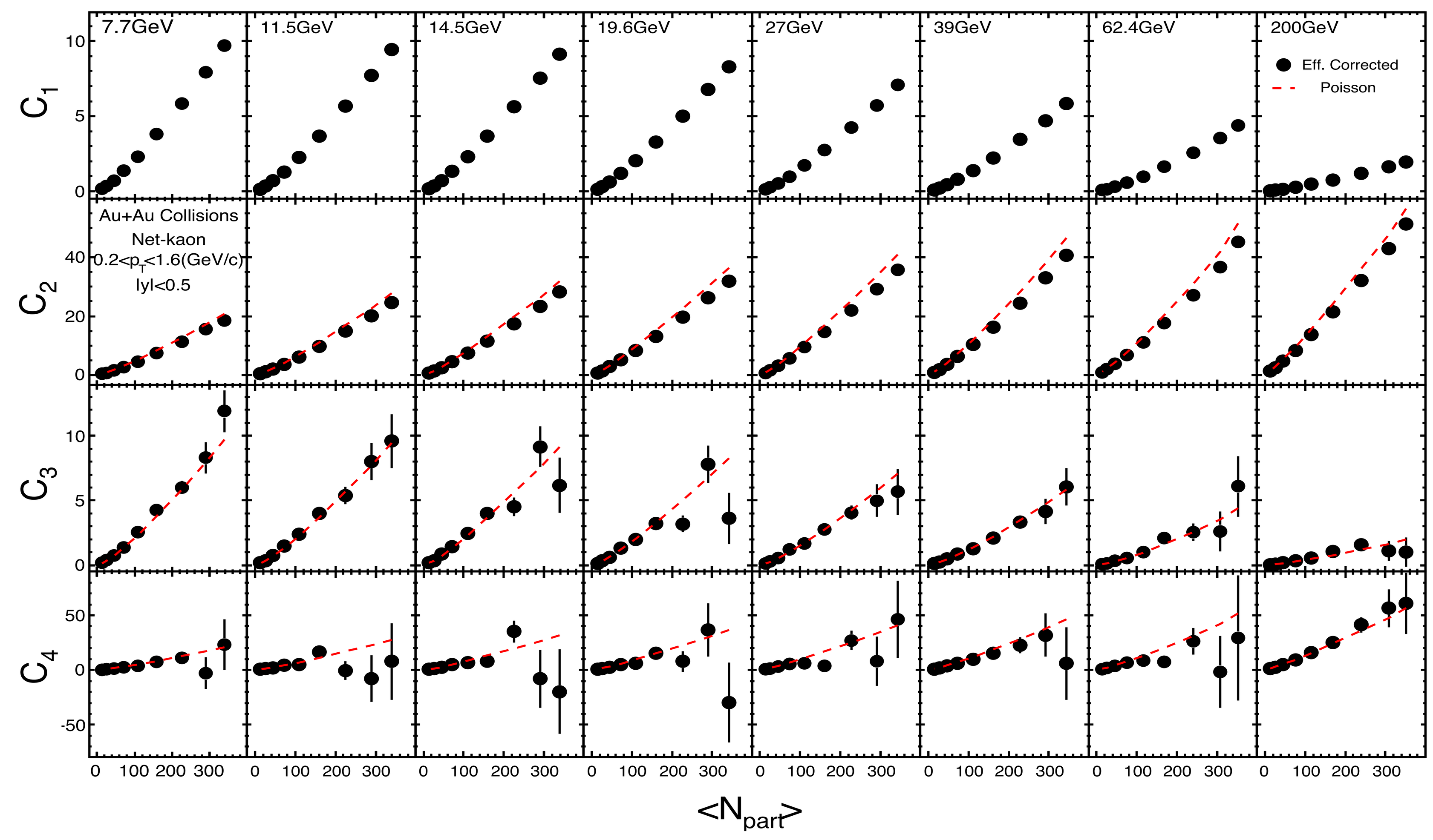




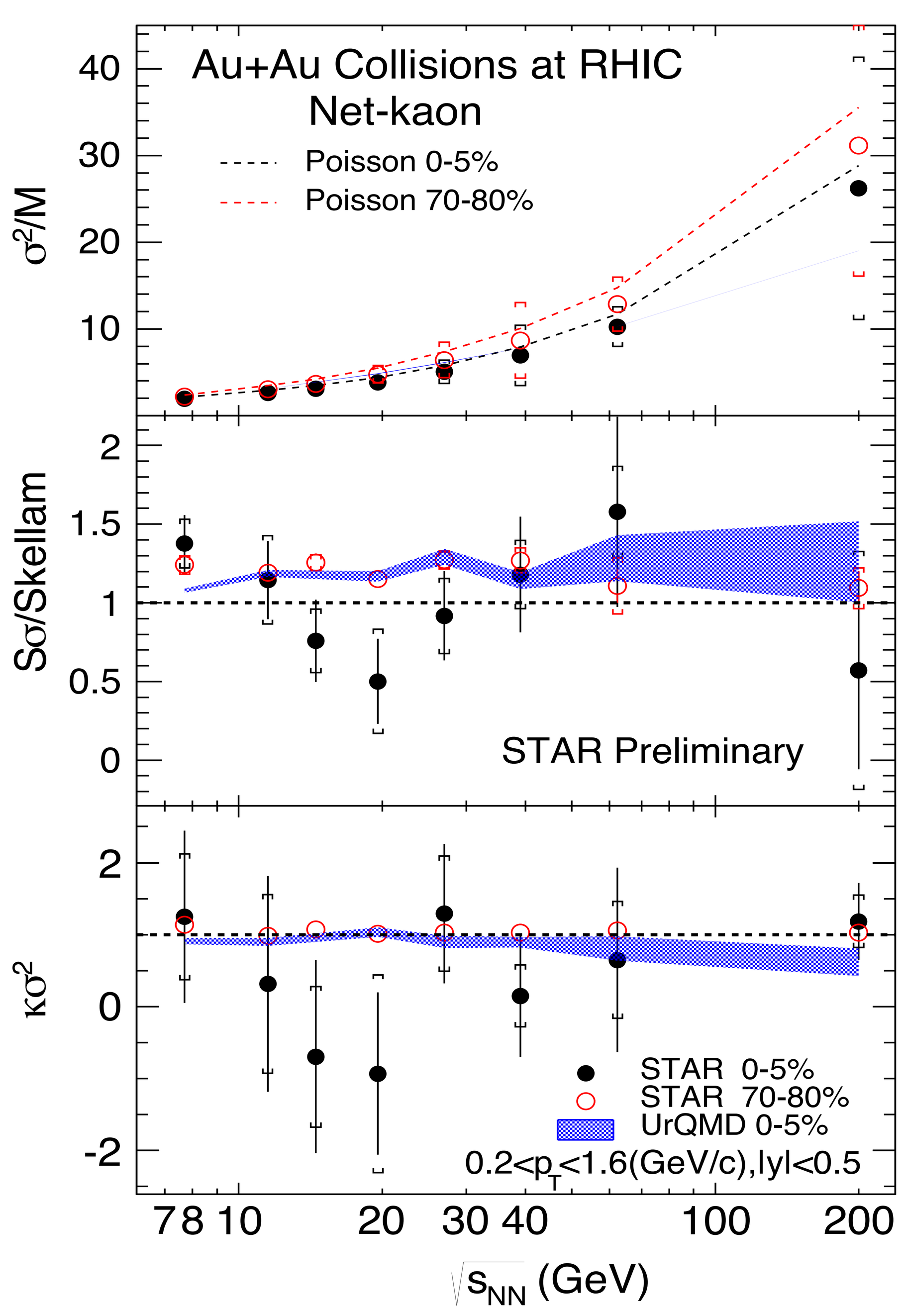
The raw distributions are only for illustration. Several effects needed to be addressed to get final cumulants:
1. Autocorrelations with centrality definition.
2. Volume fluctuations.
3. Finite detector efficiency.

X.Luo ,Phys. Rev. C 91, 034907 (2015)
X.Luo, et al,J. Phys. G40,105104(2013)





Summary



- We present centrality and energy dependence of cumulants and their ratios for net-kaon within the kinematic range (|y|<0.5, 0.2< p_T < 1.6 (GeV/c)) for Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5, 14.5, 19.6, 27, 39, 62.4 and 200 GeV.
- The values of σ^2/M increase as the energy increases.
- The values of Sσ/Skellam are consistent with unity, although with large uncertainties.
- For the most central collisions (0-5%), the values of $\kappa\sigma^2$ are consistent with unity with large uncertainties.
- BES-II is planned and will significantly reduce the uncertainties.

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The STAR Collaboration: http://drupal.star.bnl.gov/STAR/presentations