Higher Moments of Net-Proton Multiplicity Distributions in Cu+Cu Collisions at $\sqrt{s_{NN}} = 22.4$, 62.4 and 200 GeV from STAR

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Abstract
Fluctuation of conserved charges is an important tool for studying the properties of QCD phase structures in high-energy nuclear collisions. Previously, the STAR experiment has reported the energy dependence of the cumulants of net-proton, net-charge and net-kaon distributions in Au+Au collisions at RHIC. Non-monotonic energy dependence has been observed in the 4th-order net-proton fluctuations in the top 5% central Au+Au collisions at RHIC. In this poster, we report the efficiency-uncorrected collision energy and centrality dependence of net-proton higher moments for Cu+Cu collisions at $\sqrt{s_{NN}} = 22.4$, 62.4 and 200 GeV at RHIC.

Introduction
- Higher moments of the distribution of conserved quantities are predicted to be sensitive to the correlation length, and thus are suitable for the search for the QCD critical point $^{[1,2,3]}$.
- Main observables:
  - Volume independent cumulant ratios:
    \[ K_{\sigma^2} = \frac{C_2}{C_1} = \frac{\langle x^2 \rangle}{\langle x \rangle} \]
    \[ S_{\sigma^2} = \frac{C_3}{C_2} = \frac{\langle x^3 \rangle}{\langle x^2 \rangle} \]
    \[ \frac{\sigma^2}{\langle x \rangle} = \frac{C_4}{C_2} = \frac{\langle x^4 \rangle}{\langle x^2 \rangle} \]
- Cumulant ratios of Cu+Cu collisions from RHIC similar to those of the Au+Au collisions present a new opportunity to measure the system size dependence $^{[4]}$.

Particle Identification
- PID: Energy Loss (dE/dx) in the Time Projection Chamber is used to identify protons within $0.4 < p_T < 0.8$ (GeV/c) and $|y| < 0.5$.

Centrality Determination
- Collision centrality was estimated via the charged particle multiplicity.
- In order to avoid auto-correlations, (anti)protons were excluded from centrality estimation.

Efficiency Uncorrected Cumulant Ratios
- The cumulants of proton, anti-proton and net-proton multiplicity distributions linearly increase with the number of participant.

Summary
- The efficiency-uncorrected cumulants and their ratios of net-proton have been measured in Cu+Cu collisions at $\sqrt{s_{NN}} = 22.4$, 62.4 and 200 GeV.
- The values of $C_4/C_2$ and $C_2/C_4$ of net-proton increase (decrease) with increasing collision energy, while the $C_2/C_1$ values are flat as a function of energy.
- Efficiency corrections and systematic uncertainty estimation are in progress.

Reference