Measurement of higher-order cumulants of net-(K+Λ) multiplicity distributions in $\sqrt{s_{NN}}$ = 27 GeV Au+Au collisions with STAR

Changfeng Li (li@rcf.rhic.bnl.gov)
Shandong University, Qingdao, China, for the STAR Collaboration

Abstract

The main goal of the RHIC Beam Energy Scan program is to explore the QCD phase diagram and search for the location of the QCD critical point. The cumulants of net-charge, net-proton, and net-kaon multiplicity distributions are related to the susceptibilities of conserved quantities, such as net-charge, net-baryon, and net-strangeness, respectively. However, the cumulants of net- (K+Λ) multiplicity distributions are sensitive to net-strangeness susceptibility in heavy-ion collisions. Hence it can provide an insight to study flavor-dependent chemical freeze-out parameters in heavy-ion collisions. We report the higher-order diagonal cumulants (1st up to 3rd order) in Au+Au collisions at $\sqrt{s_{NN}}$ = 27 GeV using the data taken in the year 2018. The cumulants of lambda, kaon and their anti-particles are measured with transverse momentum between 0.4 and 1.6 GeV/c, and rapidity |y|<0.5, and compared with the Poisson baseline.

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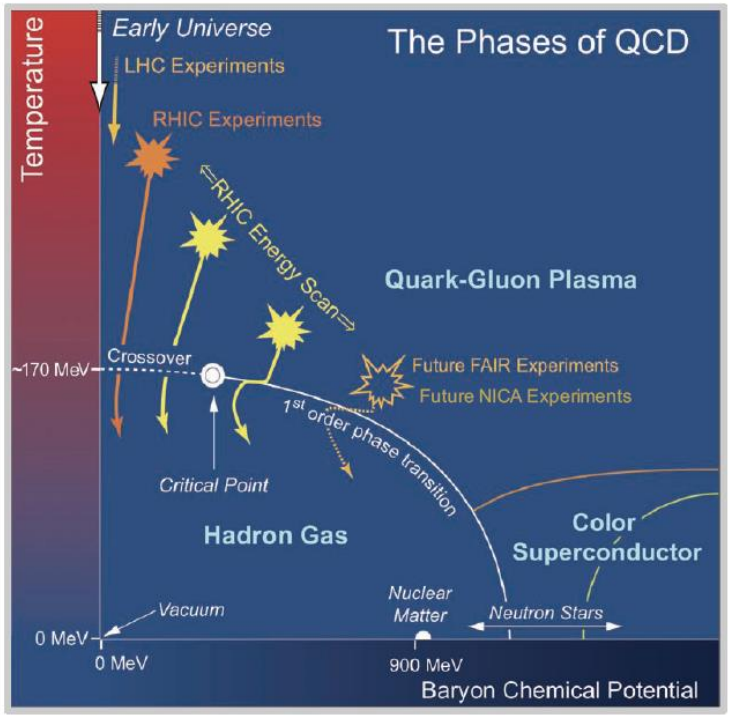
Motivation and Dataset



Motivation

- One of goal of the RHIC BES program is to explore the QCD Phase diagram and search for the QCD Critical Point.
- Differential and precision measurements of net-(K+Λ) are needed to understand the critical fluctuations and strangeness chemical freeze-out parameters at the BES energies .

Dataset

- Au+Au $\sqrt{s_{NN}} = 27$ GeV (year 2018)

Analysis details

- Thermodynamic susceptibilities and cumulants

$$C_{\mathrm{X}}^{m} = VT^{3}\chi_{X}^{m}(T,\mu)$$

- X is conserved charge such as net-strangeness(S)
- C_X^m is m-th order cumulant
- V is volume of the system.

- Relation between cumulants and moment

$C_N^1 = \langle N \rangle$

$C_N^2 = \langle (\delta N)^2 \rangle$

$C_N^3 = \langle (\delta N)^3 \rangle$

$C_N^4 = \langle (\delta N)^4 \rangle - 3\langle (\delta N)^2 \rangle^2$

Here N is number of Net-(K+Λ)

- Net-(K+Λ) multiplicity

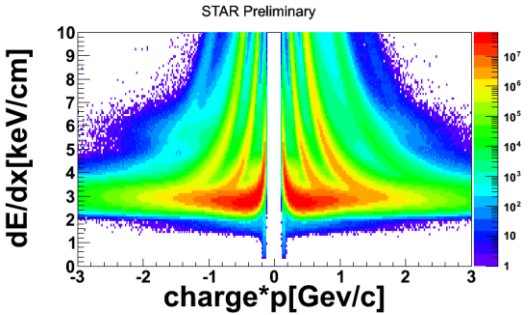
Net-(K+Λ) = $\Delta N_{(K+\Lambda)}$

= $(N_{K+} + N_{\bar{\Lambda}}) - (N_{K-} + N_{\Lambda})$

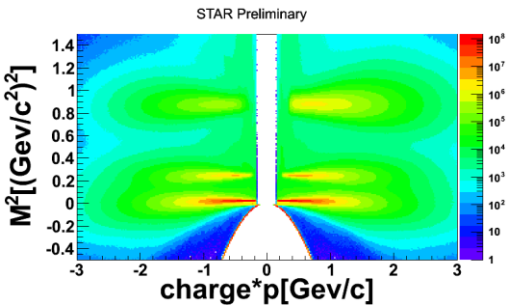
We calculate net-(K+Λ)

- Track cuts and K+ and K- identification using TPC and TOF
  - TPC: $|n\sigma_{Kaon}| < 2$ and $|n\sigma_{\pi}| > 2$
  - TOF: $0.15 < m^2 < 0.4\ GeV^2/c^4$
  - $0.4 < p_T < 1.6$ GeV/c
  - $|y|<0.5$

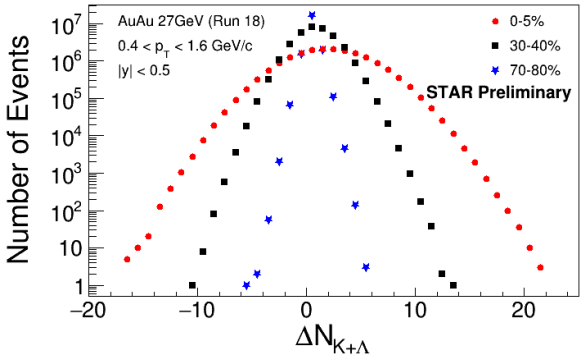
TPC

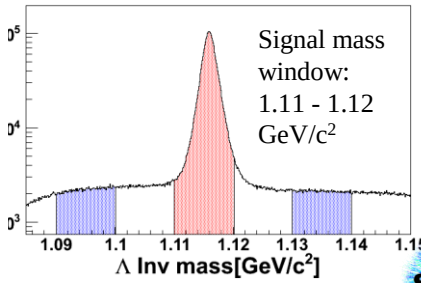


TPC + TOF

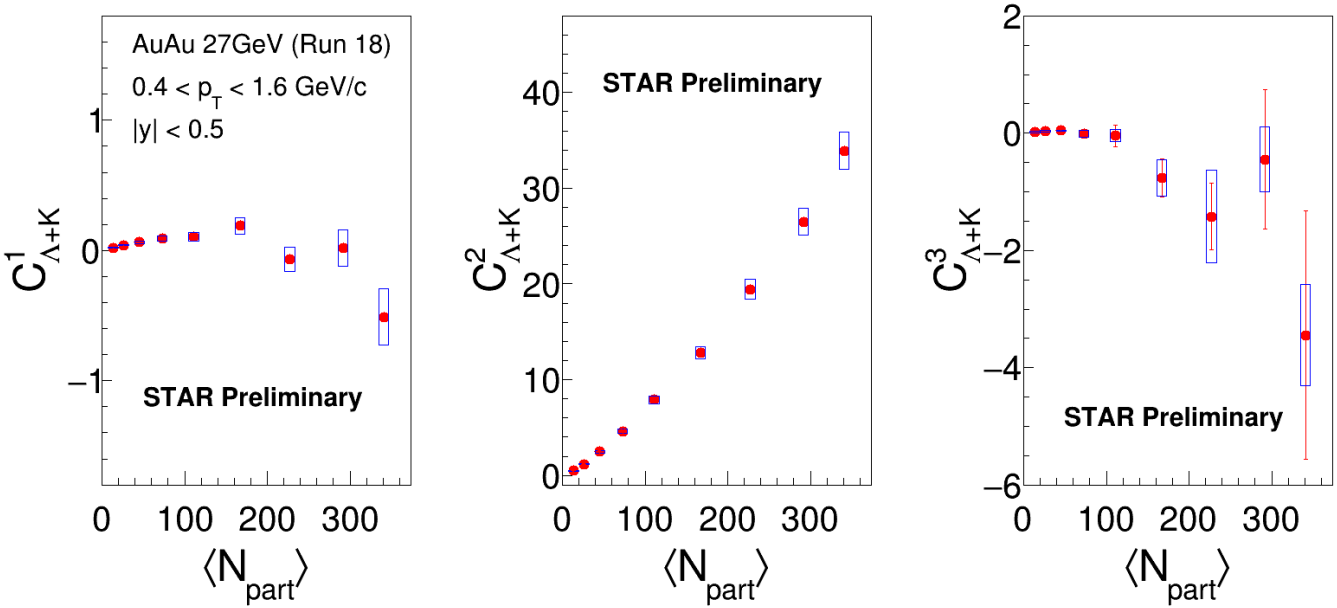


- Λ Invariant Mass: 0-5%





Results: Cumulants of net-(K+Λ) multiplicity distributions



- Track by track efficiency correction applied
- Vertical bars and boxes are statistical and systematic uncertainties.

Mean and 3rd order cumulant of net-(Λ+k) distributions are negative at central collisions, whereas 2nd order cumulants show linear dependence.

Summary and outlook

- First attempt to measure cumulants of net-(K+Λ) multiplicity distributions in Au+Au collsions at $\sqrt{s_{NN}}$ = 27 GeV
- Measurement of net-(K+Λ) distribution can provide access to measure net-strangeness in heavy-ion collisions.
- Preliminary results show that the values of the mean and 3rd order cumulant of net-(Λ+k) distributions are negative at central collisions, whereas 2nd order cumulant shows linear dependence in Au+Au collisions at $\sqrt{s_{NN}}$ = 27 GeV
- All BES energies will be reported in future.