Influence of initial size in higher cumulant ratios of net-proton distribution

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Outline

- **Motivation**
- **Influence of centrality selection in higher moments**
- **Centrality dependence of the ratios at RHIC/BES energies**
- **Summary and outlook**

Higher moments

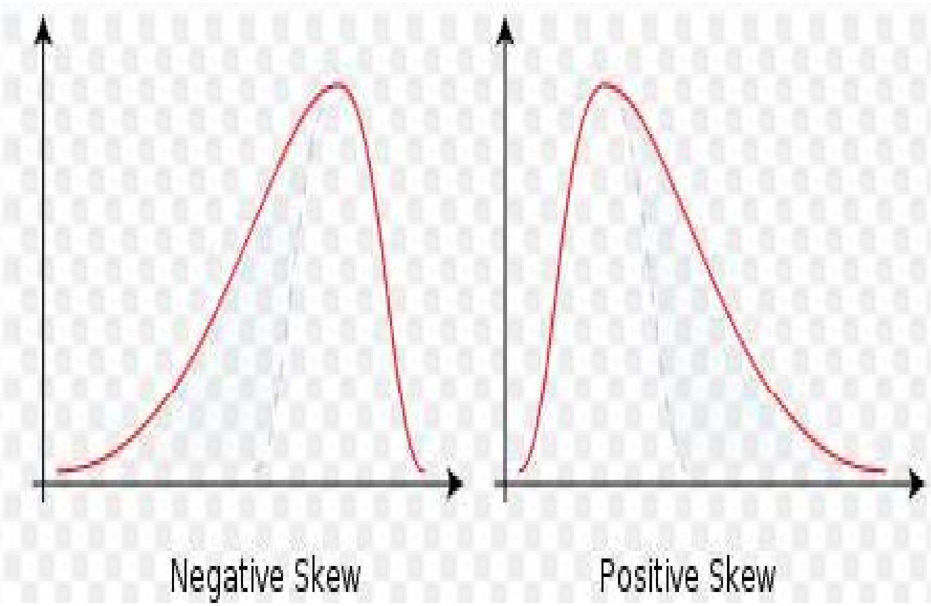
definition

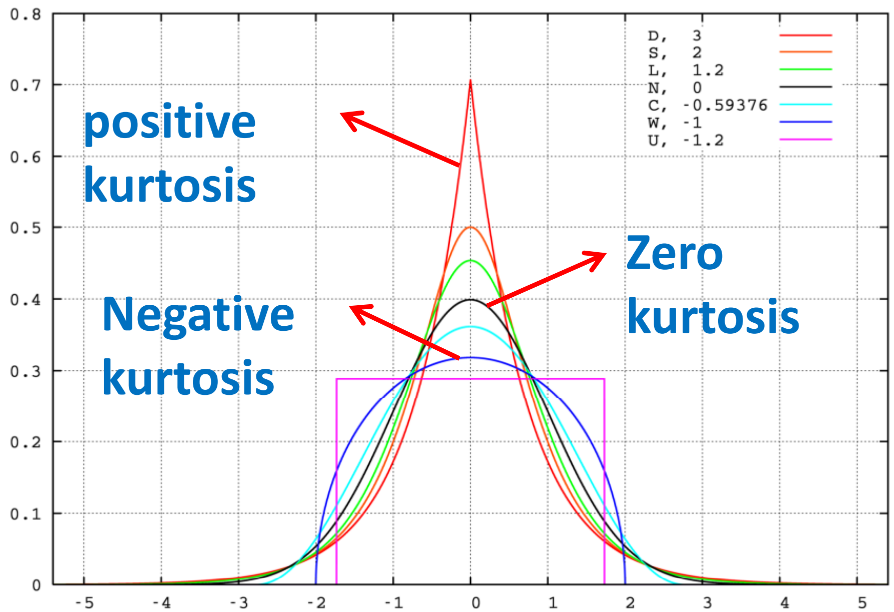
Skewness: $s = \dfrac{<(N-<N>)^3>}{\sigma^3}$ **Kurtosis**: $\kappa = \dfrac{<(N-<N>)^4>}{\sigma^4} - 3$

- **For Gaussian distribution, the skewness and kurtosis equal to zero.**

Ideal probe of the non-Gaussian fluctuations near critical point.

M. Stephanov, Phys. Rev. Lett. 102, 032301(2009).





Dynamic corrected higher cumulants

Dynamic higher cumulants

$$S_{dyn} = S - S_{stat} \qquad \kappa_{dyn} = \kappa - \kappa_{stat}$$

$$S_{stat} = \frac{\langle N_p \rangle - \langle N_{\bar{p}} \rangle}{[\langle N_p \rangle + \langle N_{\bar{p}} \rangle]^{3/2}}, \quad K_{stat} = \frac{1}{\langle N_p \rangle + \langle N_p \rangle},$$

- They measure the deviations from statistical fluctuations.
- If proton and antiproton are (obey) independent statistical distributions, the S_{dyn} and K_{dyn} will be 0.

Chen Lizhu et al, J. Phys. G: Nucl. Part. Phys. 38 (2011) 115004

Weighted method

- Cumulants are calculated Nch by Nch, then weighted with the number of event of each Nch.
- This correction well eliminate centrality bin width effect.

STAR， arxiv :1106.2926

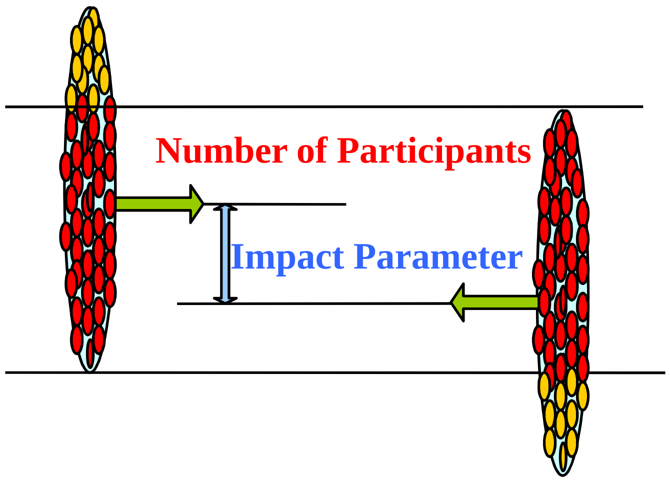
Centrality

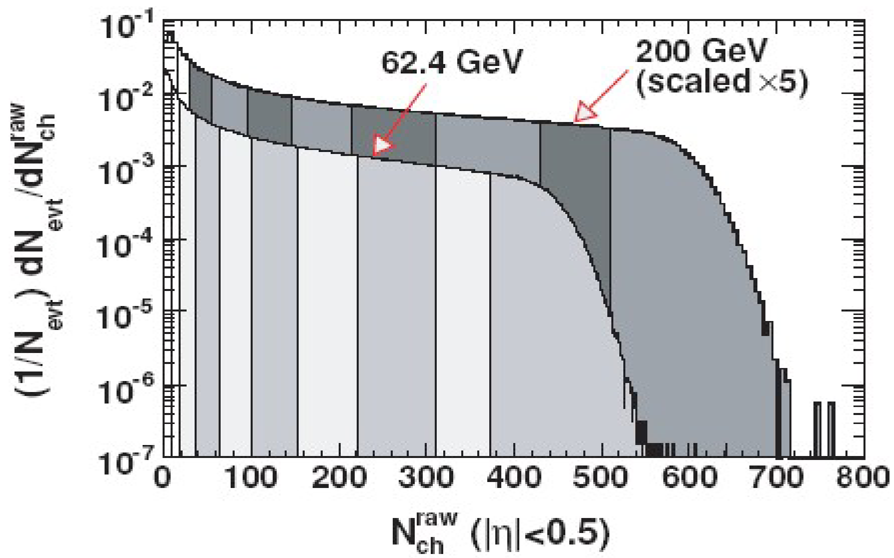
Experimentally

- The detected charged particles are used to define the centrality.

Other approaches

- Impact parameter b and number of participants are used as the definition of centrality.





STAR ,PRC 79, 034909

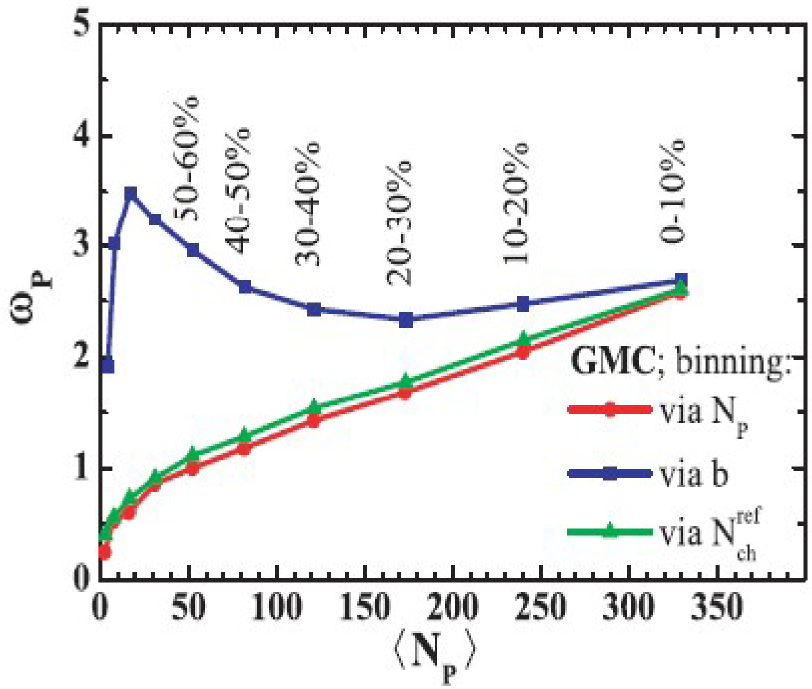
- **Is there any difference among the three centrality definitions?**

Influence of centrality on conventional observables(1)

System size fluctuations

$$\omega_P \equiv \frac{\langle(\Delta N_P)^2\rangle_c}{\langle N_P\rangle_c}$$

Np: number of participants



P. Konchakovski et al, PRC 79, 034910

- The different centrality definitions show different behaviors of this observable.

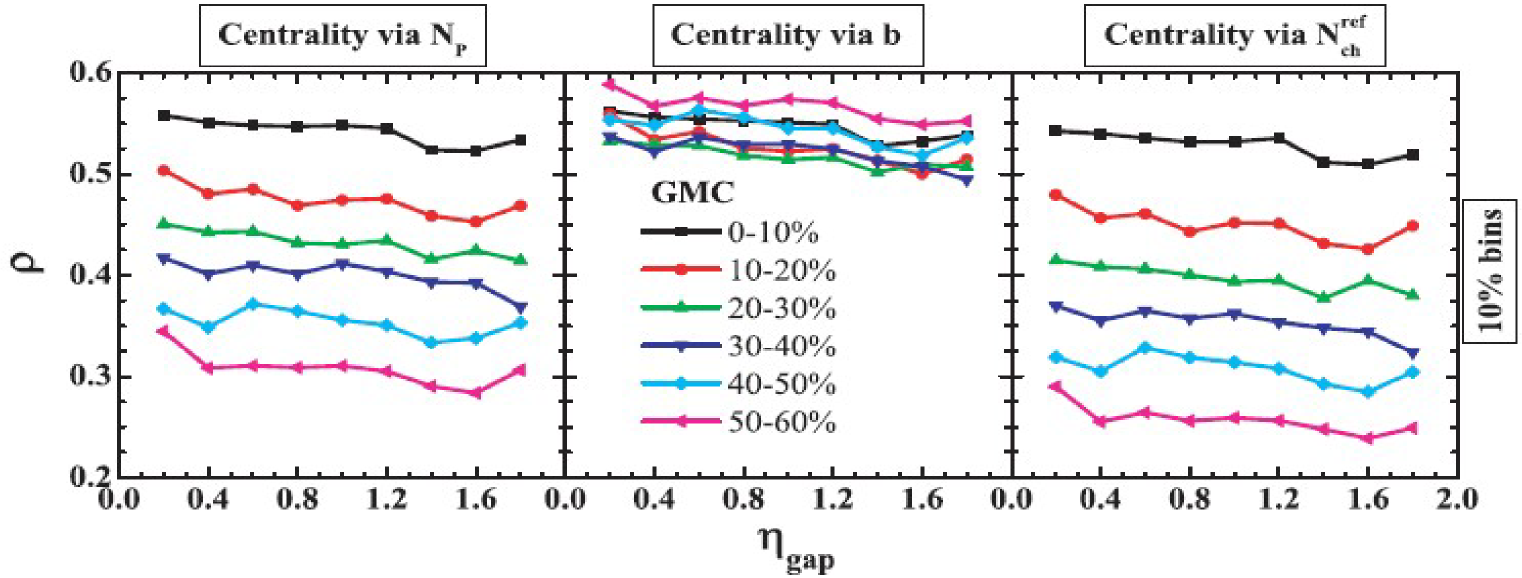
Influence of centrality on conventional observables(2)

Forward-backward correlation

V. P. Konchakovski et al, PRC 79, 034910

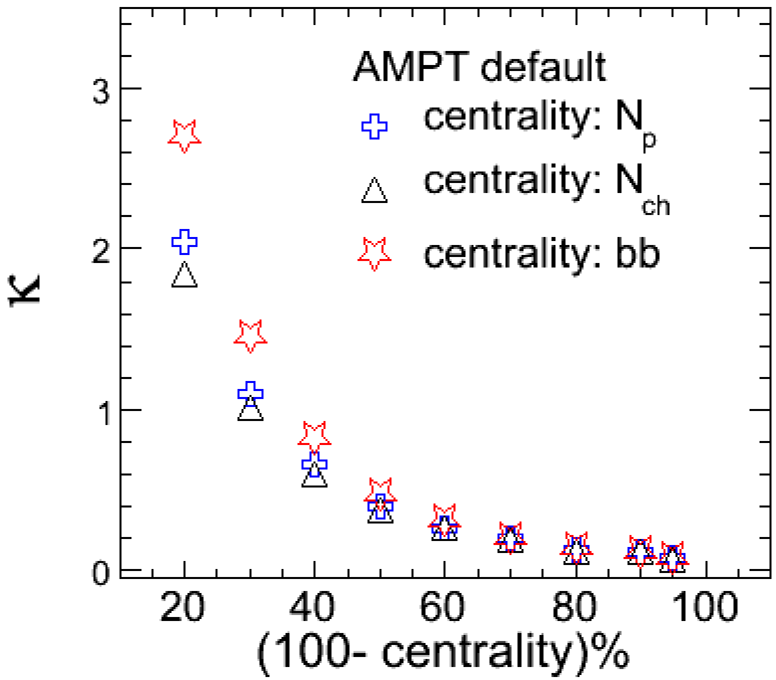
$$\rho \equiv \frac{\langle \Delta N_A \cdot \Delta N_B \rangle_c^{\eta_{\rm gap}}}{\sqrt{\langle (\Delta N_A)^2 \rangle_c^{\eta_{\rm gap}} \langle (\Delta N_B)^2 \rangle_c^{\eta_{\rm gap}}}}$$

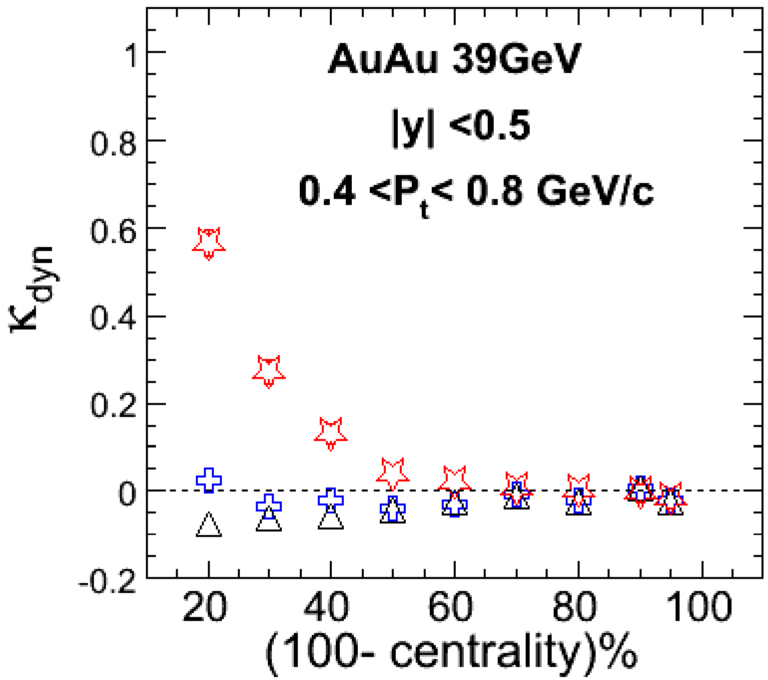
$$\langle N_A^k \cdot N_B^l \rangle_c^{\eta_{\rm gap}} \equiv \sum_{N_A, N_B} N_A^k N_B^l P_c^{\eta_{\rm gap}}(N_A, N_B; \Delta\eta).$$



- The different centrality definitions show different behaviors of this observable.
- **What about higher cumulant ratios of net-proton distribution?**

Influence of centrality definition(1)

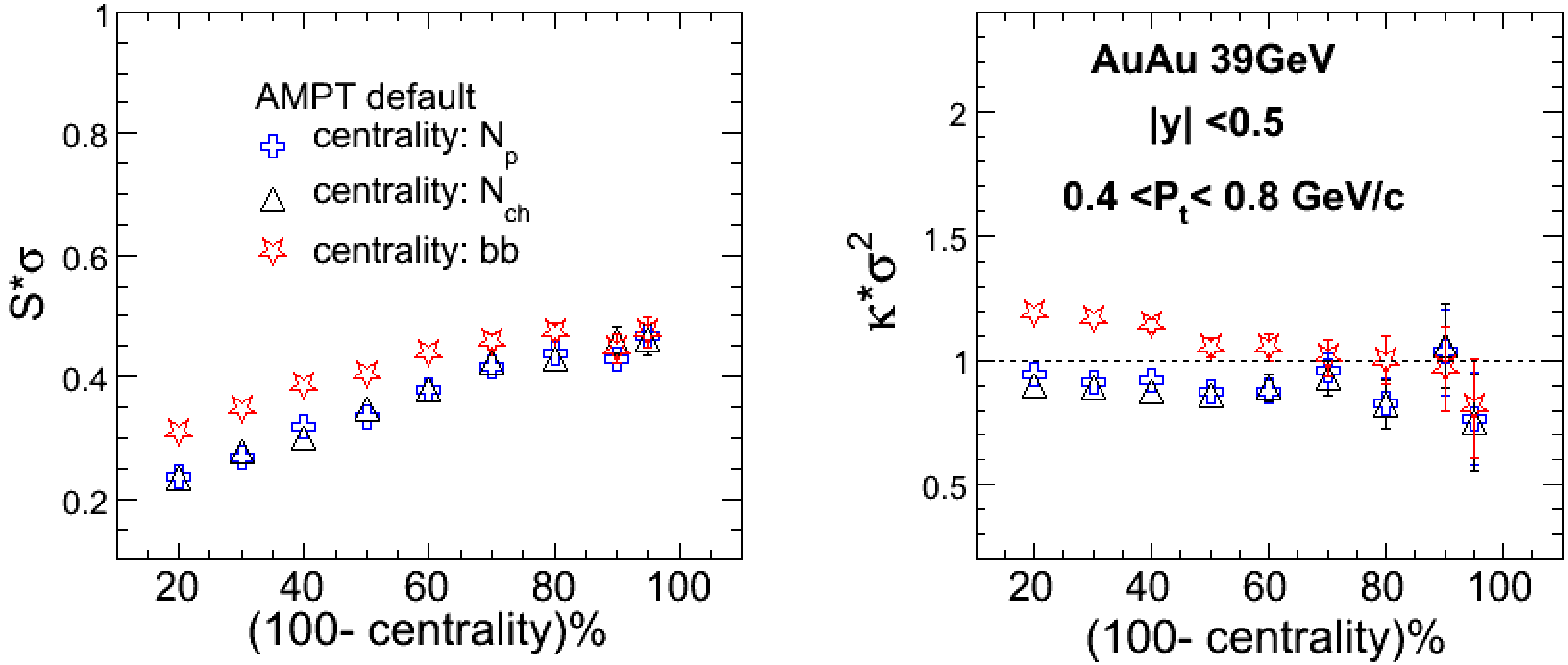




Nch: the same as STAR

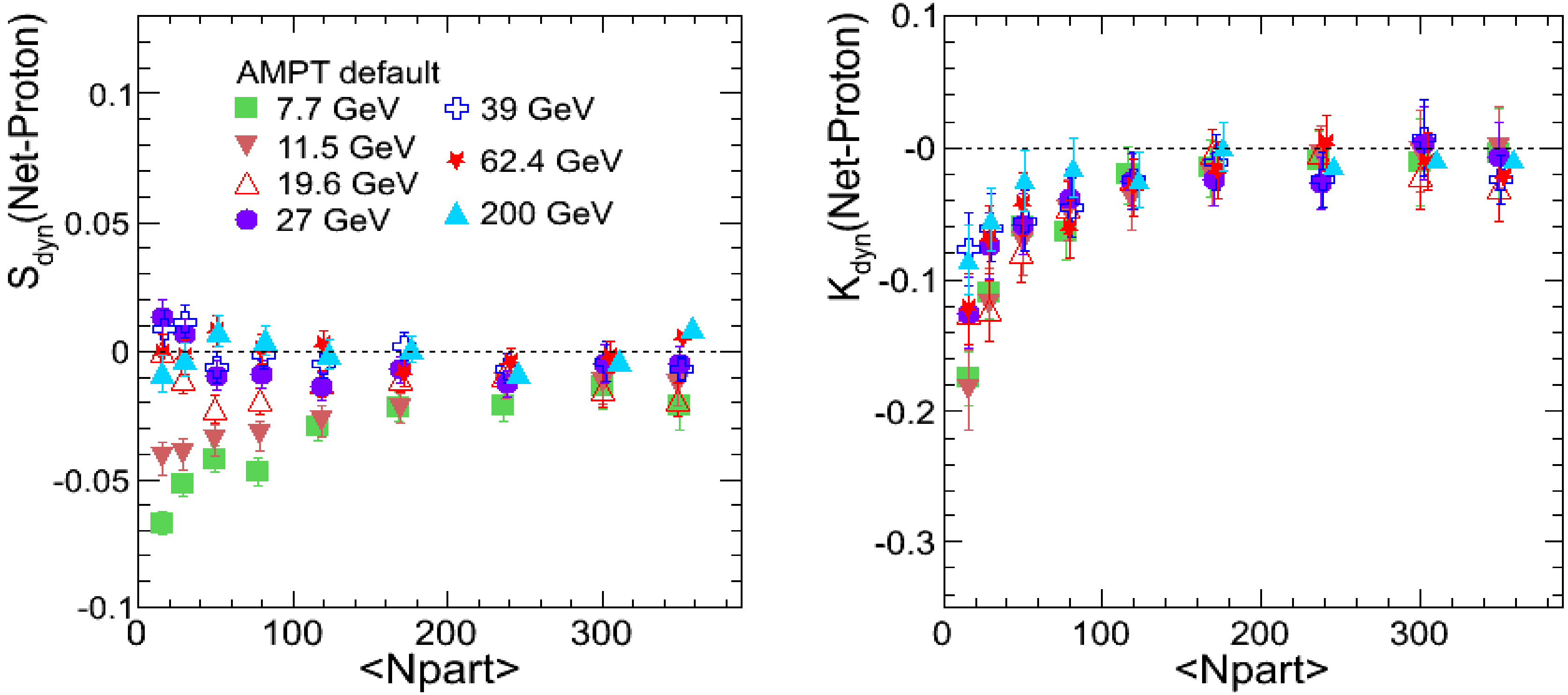
- *The centrality bin width effect is considered.*
- *The values from b are different with other two definitions, especially in peripheral collisions..*
- *The dynamic kurtosis from Npart shows weak centrality dependence, which is consistent with zero.*
- *The dynamic kurtosis from Nch and b show contrary centrality dependence.*

Influence of centrality definition(2)



- *The values from b are different from other two definitions, especially in peripheral collisions.*
- *The $\kappa\sigma^2$ from Npart and Nch are smaller than unit, but the values from impact parameter are bigger in peripheral.*

Centrality dependence at RHIC/BES energies



- *Centrality defined by Nch are used.*
- S_{dyn} *shows weak centrality dependence and is around zero at higher energies.*
- S_{dyn} *are negative at lower energies and smaller in more peripheral collisions.*
- The values of K_{dyn} *are around zero in central collisions, and negative in peripheral collisions*

Summary and outlook

summary

- Higher cumulant ratios are strongly influence by centrality definition.
- The centrality defined with Npart is similar with Nch, but is different from impact parameter.
- Dynamical ratios well eliminate the statistical fluctuations.

Outlook

- The centrality dependence of S_{dyn} and K_{dyn} at RHIC/BES energies are expected to compare with experiment.
- The dependence of dynamical ratios on pt, eta cuts and efficiency are on going