Forward-backward centrality fluctuation in HI

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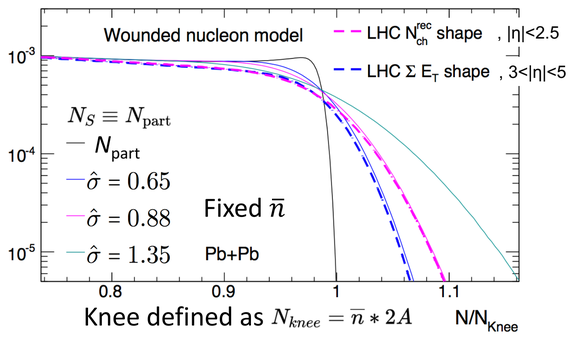
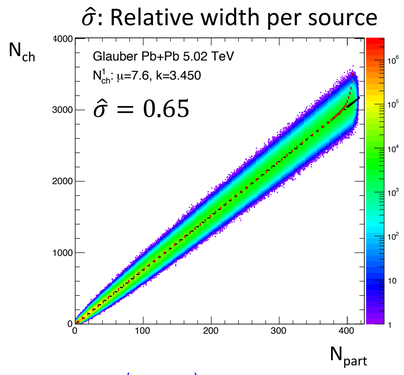
Centrality fluctuation and longitudinal dynamics

Toy model for particle production: Glauber+NBD[1]



$\bar{n}$: Charge particle per source

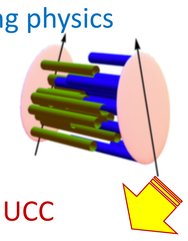
$\hat{\sigma}$: Relative width per source



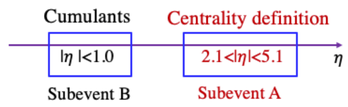
Fluct. in particle production ⇒ Fluct. of N_s given fixed N ⇒ $\langle(\delta N_s)^2\rangle, \delta N_s = N_s - \overline{N}_s$

Volume fluctuation

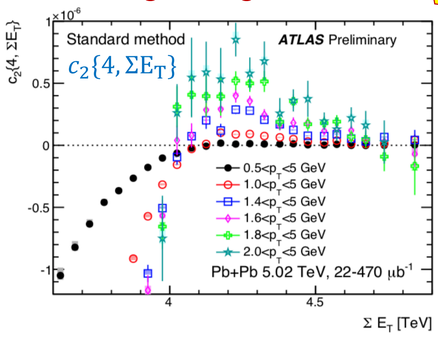
Underlying physics



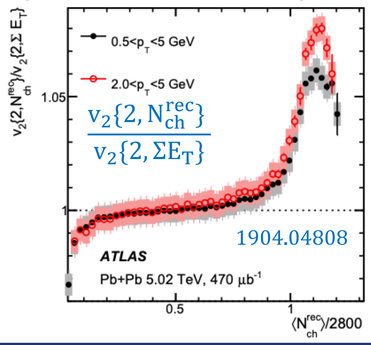
Experimental method and observables



Sign change in UCC



Dependence on Centrality definition



Observables: mean and variance of $p(N_{ch})$

Multiplicity cumulant(up to 2nd order)[2]:

$$k_2 = \frac{\langle(\delta n)^2\rangle}{\overline{n}}, \delta n = n - \overline{n} \qquad k_2^{\rm v} = \frac{\langle(\delta N_s)^2\rangle}{\overline{N}_s}, \delta N_s = N_s - \overline{N}_s \qquad K_2 = \frac{\langle(\delta N)^2\rangle}{\overline{N}}, \delta N = N - \overline{N}$$

Fluctuation in each source | Fluctuation in number of source | Fluctuation in total multiplicity

Experiment: centrality selection in subevent A, cumulant calculated in subevent B

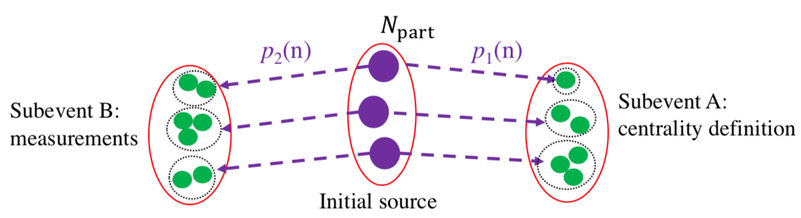
Mean N_{ch} in subevent B | Mean N_s in subevent A | Cumulant for centrality fluctuations in subevent A

$$\overline{N}_B = \overline{n}_B \overline{N}_{s,A} \qquad K_{2,B|A} = k_{2,B} + \overline{n}_B k_{2,A}^{\rm v}$$

Average multiplicity per source in subevent B | Total multiplicity cumulant in subevent B | Cumulant for one source in subevent B

Centrality fluctuation due to multiplicity smearing

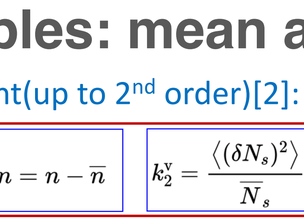
We implement particle production in boost invariance using total $N_{\rm part}$:

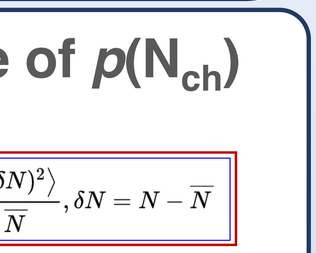


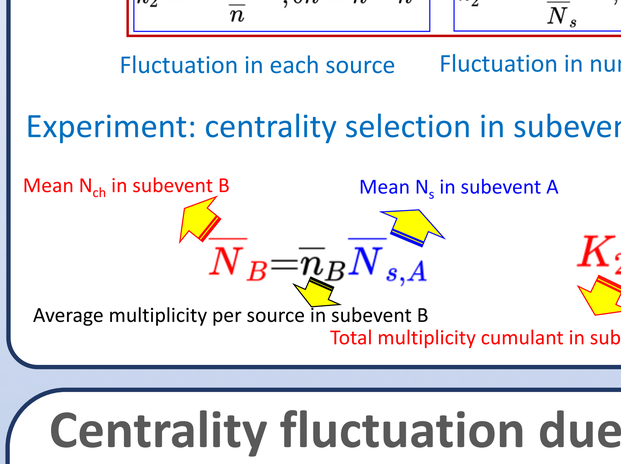
Number of source are same between subevent A and subevent B

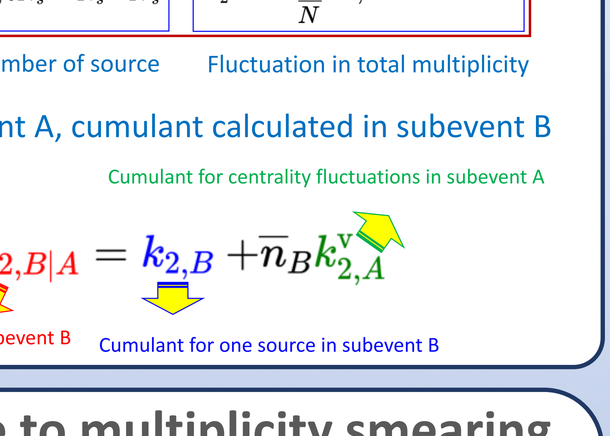
	$\bar{n}$	$\hat{\sigma}$
Par0	7.6	0.46
Par1	7.6	0.65
Par2	7.6	0.88
Par3	7.6	1.35

p(n) parameters









Centrality defined in subevent A

- ❑ The shape of $K_{2,B|A}$ reflects of the shape of $k_{2,\rm A}^{\rm v}$.
- ❑ In UCC, the dropoff of $k_{2,\rm A}^{\rm v}$ is mainly controlled by $\hat{\sigma}$ in subevent A.

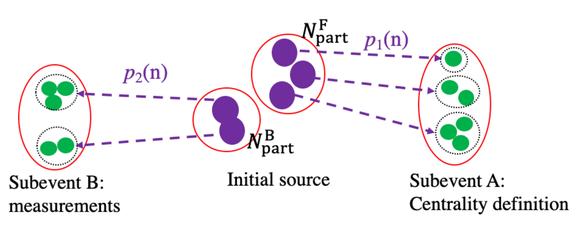
References

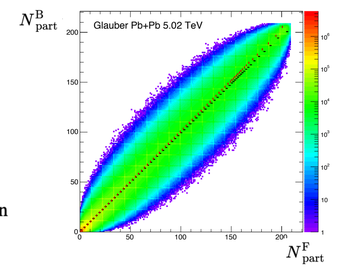
[1] Mingliang Zhou and Jiangyong Jia, PRC98, 044903(2018).

[2] S. Skokov, B.Friman and K. Redlich, PRC88, 034911(2013).

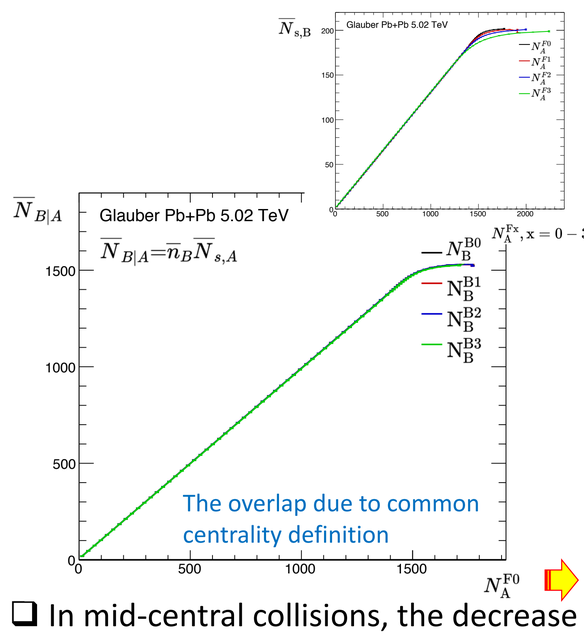
Centrality decorrelation due to forward-backward $N_{\rm part}$ fluctuation

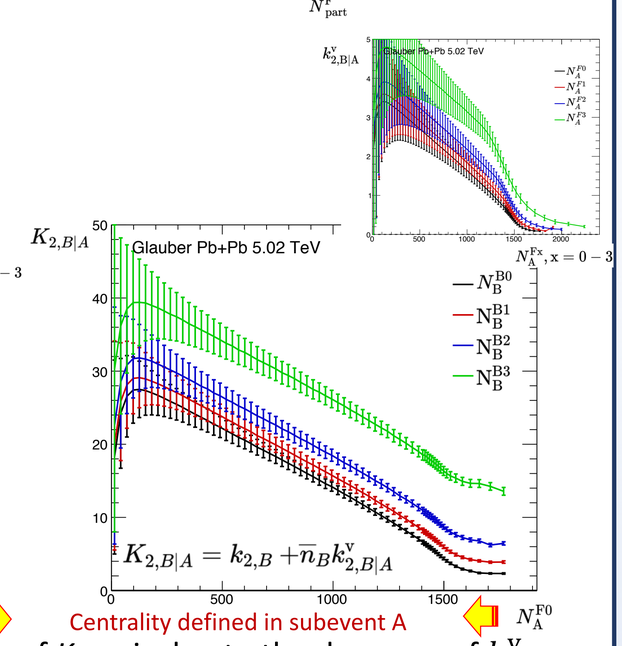
We separate particle production in $N_{\rm part}^{\rm F}$ and $N_{\rm part}^{\rm B}$:





Forward-backward fluctuation arises from relative fluctuation between $N_{\rm part}^{\rm F}$ and $N_{\rm part}^{\rm B}$

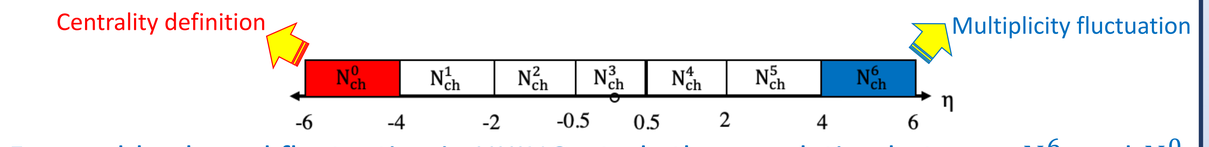




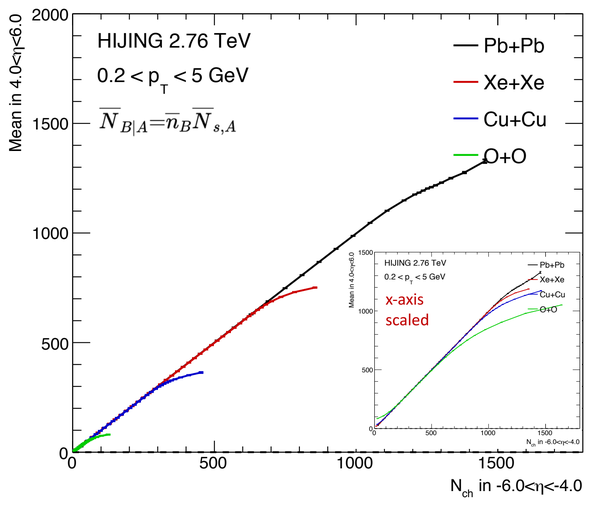
- ❑ In mid-central collisions, the decrease of $K_{2,B|A}$ is due to the decrease of $k_{2,\rm B|A}^{\rm v}$.
  - The decrease of $k_{2,\rm B|A}^{\rm v}$ is due to relative fluctuation between $N_{\rm part}^{\rm F}$ and $N_{\rm part}^{\rm B}$.
- ❑ In UCC, the sharp decrease of $K_{2,B|A}$ is due to the boundary effect of $N_{\rm part}^{\rm B}$.

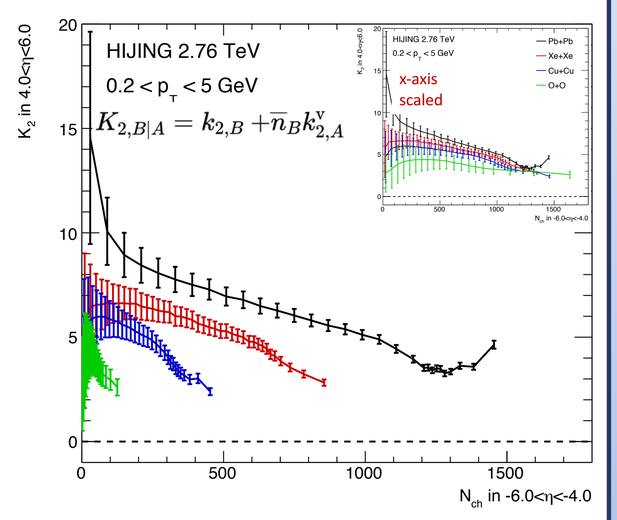
Centrality fluctuation and system-size dependence

N_{ch} with 0.2 < p_T < 5 GeV in seven η bins:



Forward-backward fluctuation in HIJING: study the correlation between N_{ch}^6 and N_{ch}^0





- ❑ Mean $\overline{N}_{B|A}$ breaks off at different $N_{\rm ch}$ for each system.
- ❑ Variance $K_{2,B|A}$ shows a strong dependence on system-size.
- ❑ After x-axis scaling, $\overline{N}_{B|A}$ and $K_{2,B|A}$ decrease from large to small system.

Summaries

- ❑ Centrality is a 0th-order long-range correlation and it fluctuates in the longitudinal direction within each event.
  - This fluctuation affects any observable that depends on centrality.
- ❑ Centrality fluctuation can arise from:
  - Global multiplicity fluctuation.
  - Forward-backward fluctuation.
- ❑ UCC is the best place to study centrality fluctuation.
  - Where mean and variance show strong non-linear behavior.
- ❑ The influence of centrality fluctuation shows strong dependence on system size.