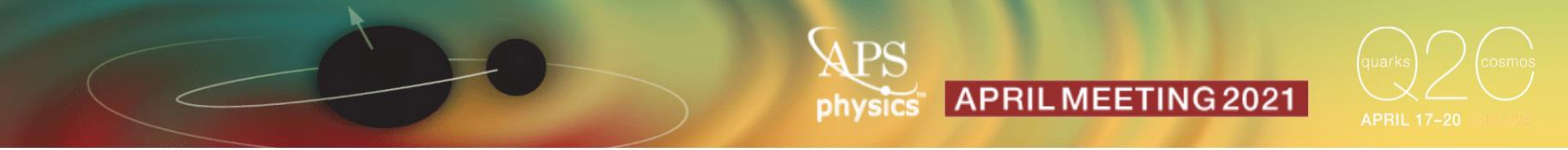

Energy and centrality dependence of forward-backward transverse momentum correlation from STAR

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Apr. 19   2021

STAR

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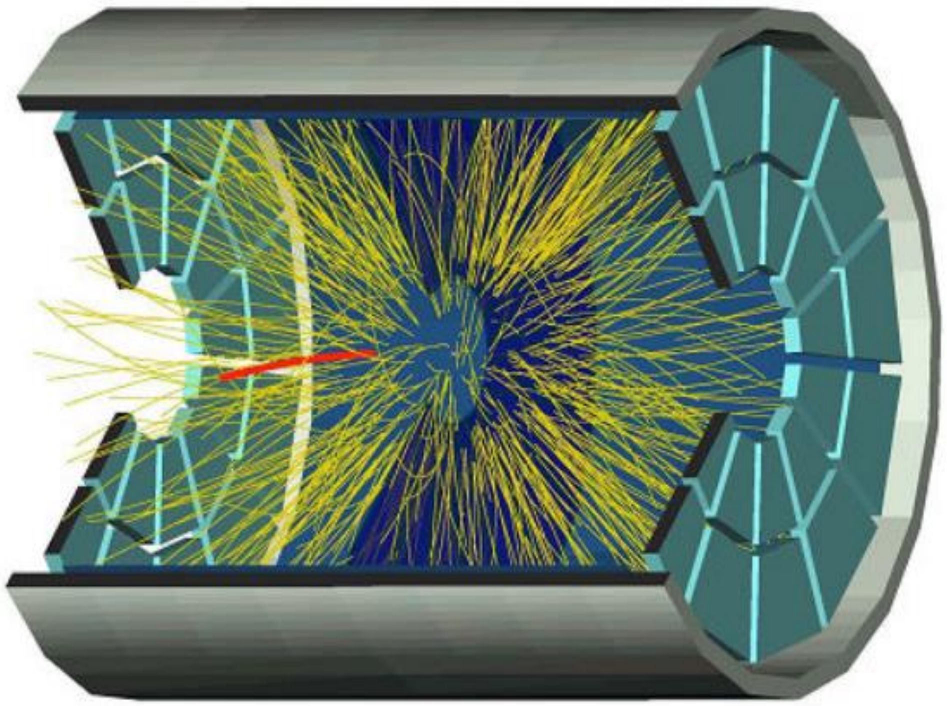
In part supported by
U.S. DEPARTMENT OF ENERGY | Office of Science

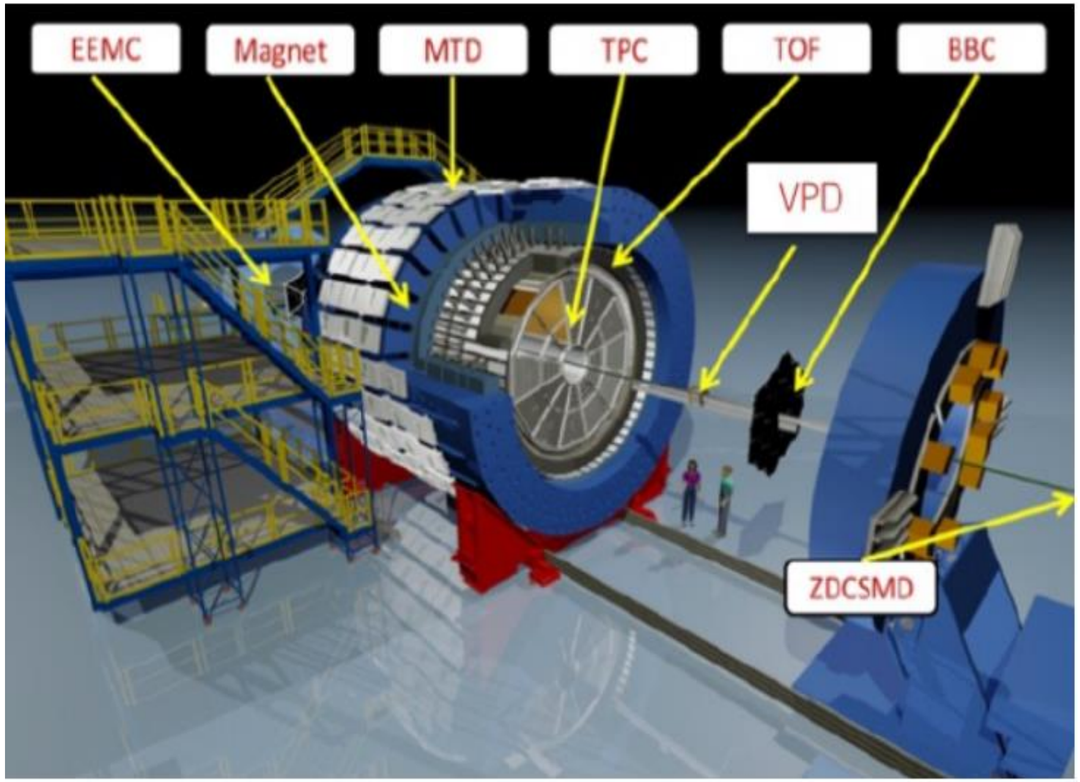
Outline

- Physical motivations to study the forward-backward transverse momentum ($\boldsymbol{p_T}$) correlations for heavy-ion collisions.
- A quick review for the previous results from ALICE Collaboration.
- Results for energy and centrality dependence of p_T correlations.
- Results for pseudorapidity ($\boldsymbol{\eta}$) gap width dependence of p_T correlations.
- Simple conclusions and the outlooks.



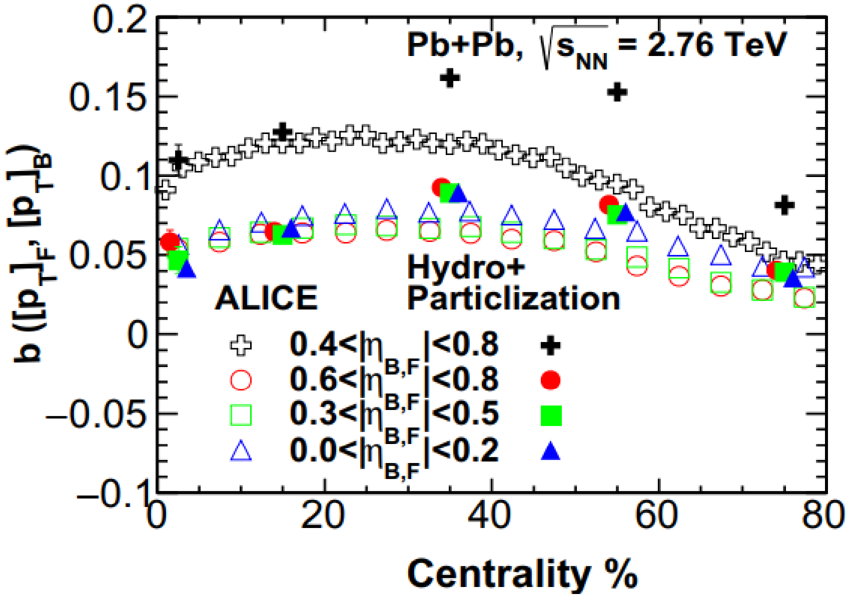
➢ Physical motivations

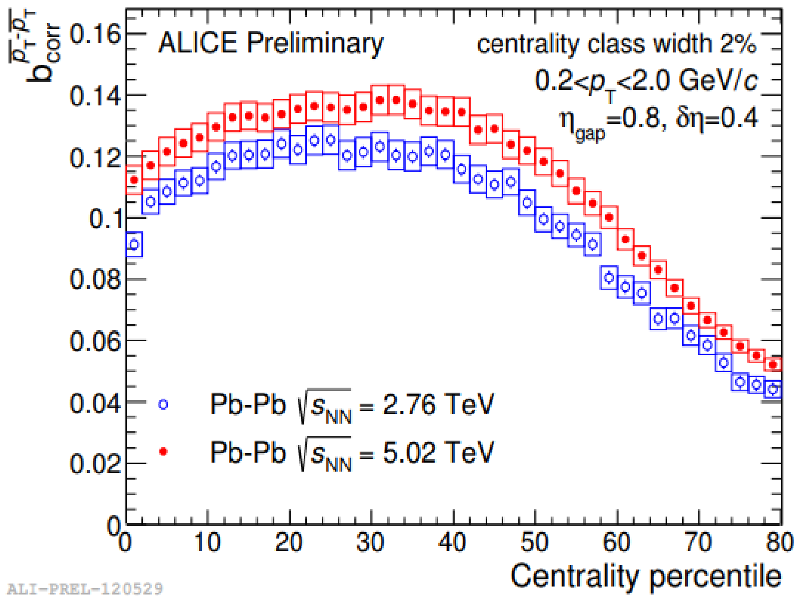
- Created predominantly at the early stages, the study of $\boldsymbol{p_T}$ correlations will lead to a better understanding of the early dynamics for heavy-ion collisions.
- $\boldsymbol{p_T}$ correlations are believed to give insight into the mechanism of energy deposition in heavy-ion collisions.
- Forward-backward $\boldsymbol{p_T}$ correlations could serve as a probe of the properties of the medium formed.



Previous results from ALICE Collaboration

- The centrality and energy dependence of $\boldsymbol{p_T}$ correlation coefficient b has been studied for Pb+Pb 2.76 TeV and 5.02 TeV collisions at ALICE.
- $\boldsymbol{p_T}$ correlation coefficient: $\mathrm{b}([p_T]_F,[p_T]_B)=\frac{Cov([p_T]_F,[p_T]_B)}{\sqrt{Var([p_T]_F)}\sqrt{Var([p_T]_B)}}$ or $b_{corr}^{\overline{p_T}-\overline{p_T}}=\frac{Cov([p_T]_F,[p_T]_B)}{Var([p_T]_F)}$
- The variance of transverse momentum: $\mathrm{Var}([p_T])=\left\langle\frac{1}{n(n-1)}\sum_{i,j}(p_T^i-\langle[p_T]\rangle)(p_T^j-\langle[p_T]\rangle)\right\rangle$





- Centrality dependence of **b** with different η selections.
- Centrality dependence of **b** with different energy levels.

Sandeep Chatterjee et al., Phys. Rev. C 96, 014 906 (2017)

Igor Altsybeev, arXiv:1711.04844v1

➢ Observables

- Notations: the event-average $\boldsymbol{p_T}$: $[p_T] = \frac{1}{n}\sum_{i=1}^{n} p_T^i$

  and the ensemble-average $\boldsymbol{p_T}$: $\langle [p_T] \rangle = \frac{1}{N}\sum_{ev=1}^{N} [p_T]_{ev}$.

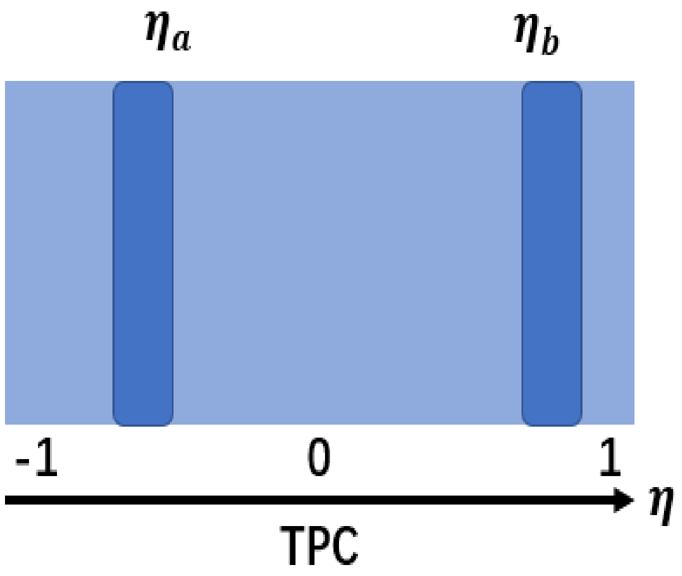
- $Cov([p_T]_a,\ [p_T]_b) = \langle([p_T]_a - \langle[p_T]\rangle_a)([p_T]_b - \langle[p_T]\rangle_b)\rangle$

- Variance excluding the self-correlations applied in the normalization: $\mathrm{C}([p_T]) = \left\langle \frac{1}{n(n-1)} \sum_{i \neq j} (p_T^i - \langle[p_T]\rangle)(p_T^j - \langle[p_T]\rangle) \right\rangle$

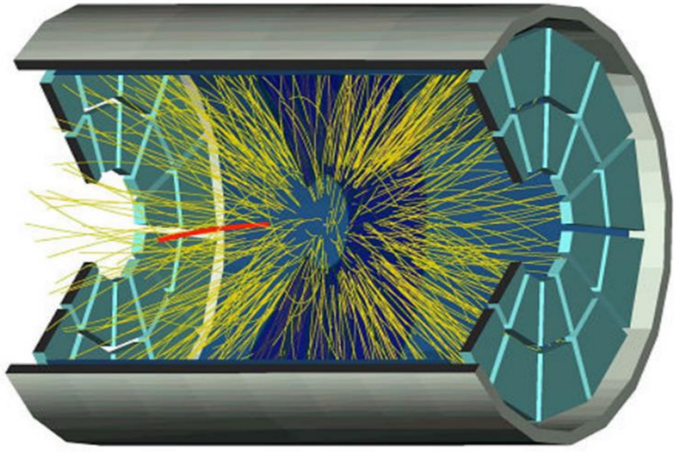
- Pearson coefficient: $\rho([p_T]_a,\ [p_T]_b) = \frac{Cov([p_T]_a, [p_T]_b)}{\sqrt{C([p_T]_a)}\sqrt{C([p_T]_b)}}$

- $\mathrm{C}([p_T])$ eliminates statistical fluctuations from the estimate of the variance of the transverse flow. It has been used in experimental measurements of the $\boldsymbol{p_T}$ fluctuations.

- Applied track cuts: $|\boldsymbol{\eta}|<1$ $0.2 < \boldsymbol{p_T} < 2.0\ GeV/c$

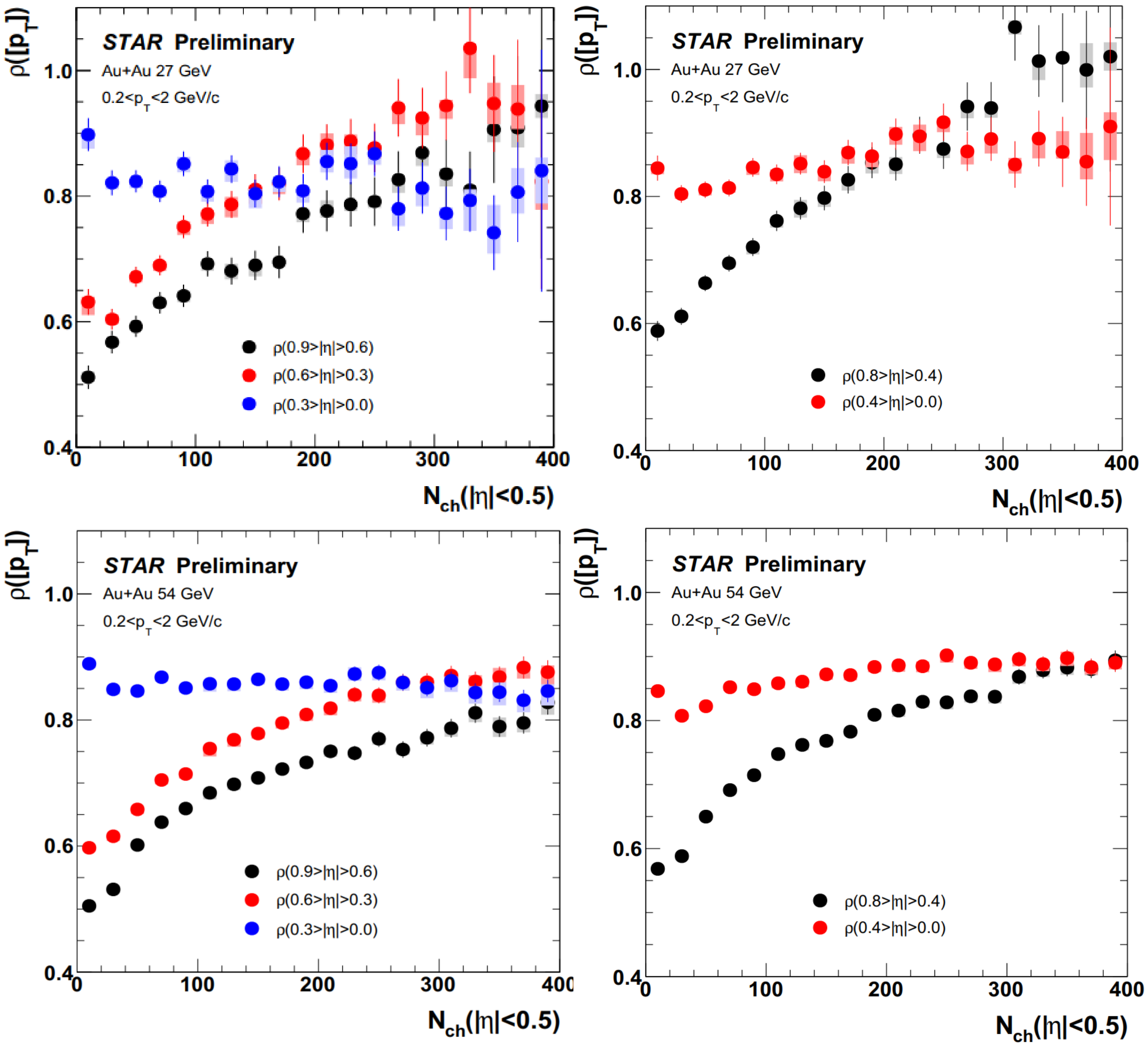


- η_a and η_b: two different η regions.



- STAR TPC: measuring the transverse momentum.

Results for 27 GeV and 54 GeV with different η rigon selections



- ➢ Comparisons between different η gap and η region widths.
  - The slope is greater with the increasing of η gap width.
  - ρ is robust against η region width and volume fluctuations, which means ρ is an ***intensive*** observable.
- ➢ Comparisons between different collision energies.
  - The curves cross each oher for 27 GeV, providing a different η gap width dependence for different centralities.
  - The statistical (partly due to the total number of events) and systematic errors are much greater for 27 GeV results.

Pseudorapidity gap width dependence of p_T correlations for 54 GeV

➢ Basic methods

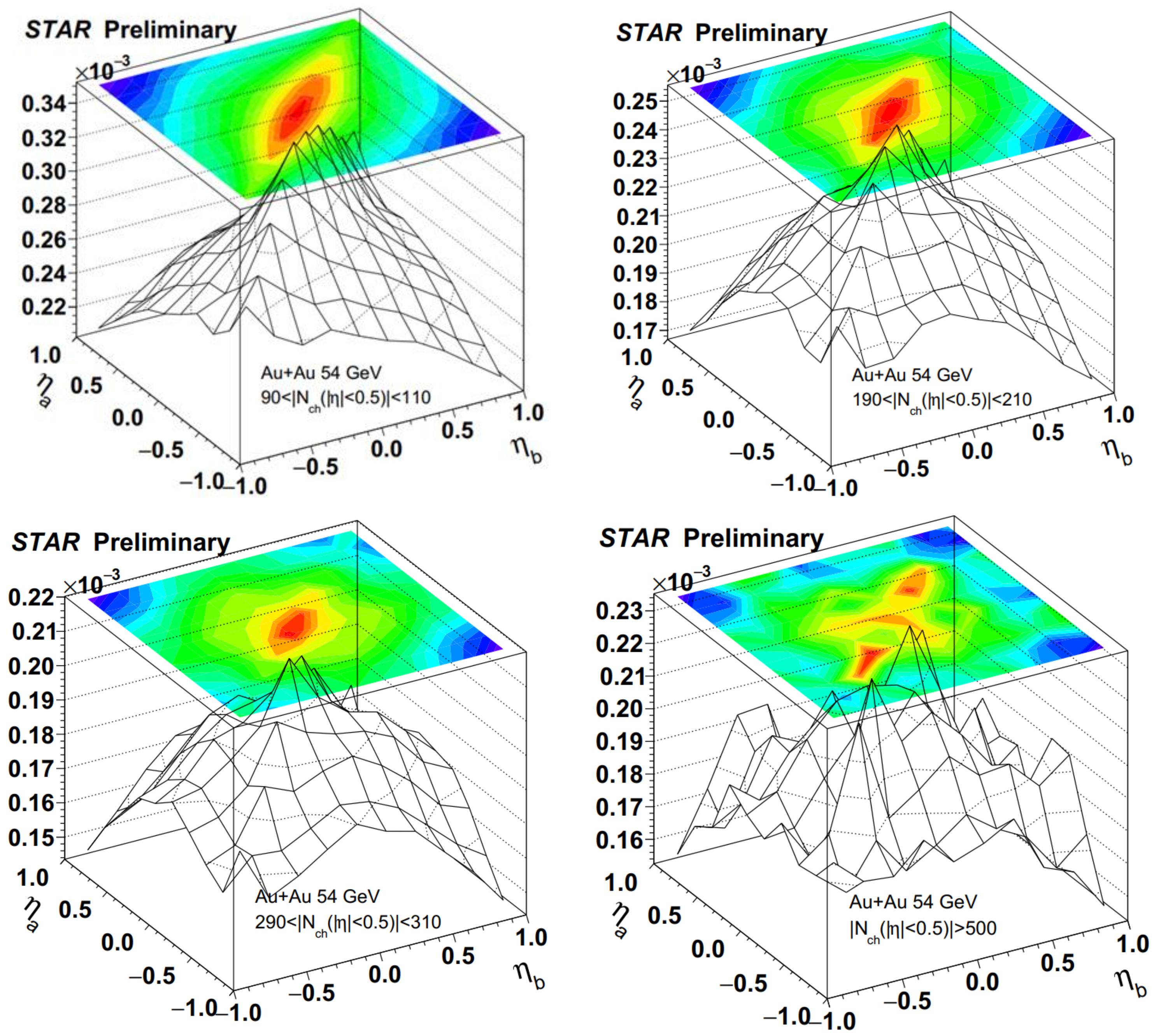
- Two-particle covariance:

$$Cov\left(p_T^i,\ p_T^j\right) = \frac{1}{n(n-1)}\sum_{i\neq j}(p_T^i - [p_T]_a)(p_T^j - [p_T]_b).$$

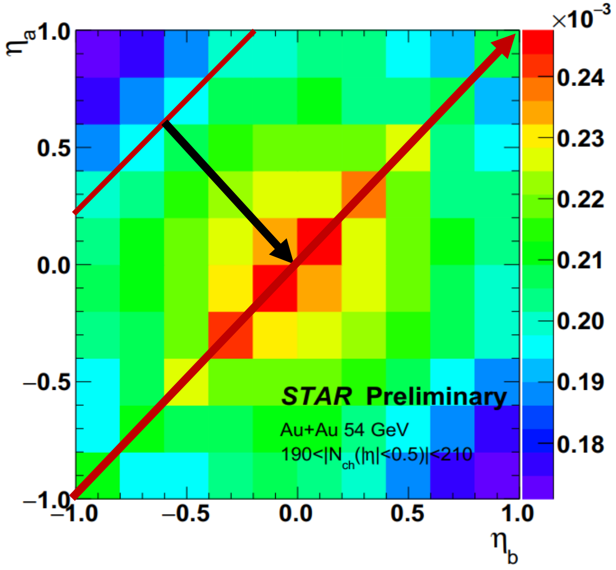
- The region of $|\eta|$<1 had been devided into 10 regions: (-1.0,-0.8), (-0.8,-0.6), … (0.8,1.0).
- The results are presented with TProfile2D plots for (η_b, η_a, Cov).

➢ Quick discussions

- Due to the commutative law of multiplication, η_a and η_b should be symmetric in pattern.
- The distribution of covariance for $|N_{ch}(|\eta| < 0.5)|$>500 is different due to the total number of events in this centrality and possible detector effects.



Further discussions for p_T correlation effects

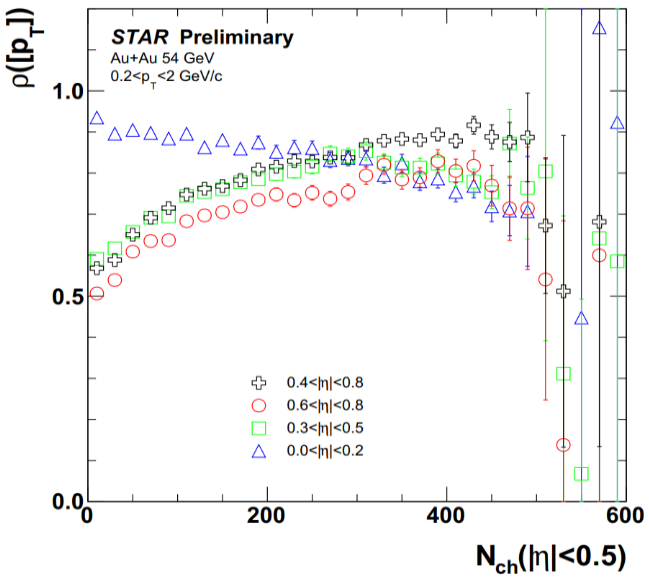


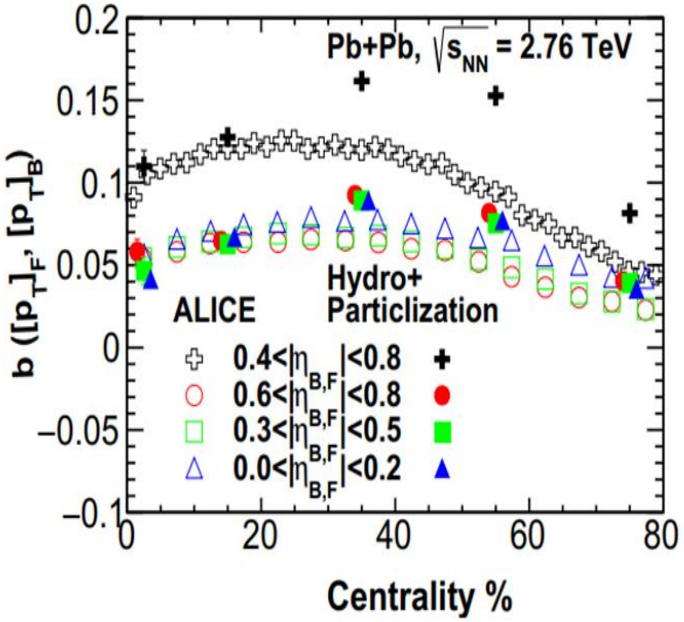
➢ Gap width dependence

- Select the centrality 190<$|N_{ch}(|\eta| < 0.5)|$<210 and apply the upper-left section: $\eta_a = \eta_b + \boldsymbol{\eta_{gap}}$
- A short range correlation (correlator increases with the decreasing of η_{gap}) can be distinguished (black arrow).
- The $\boldsymbol{p_T}$ correlations are more noticeable for the central $\boldsymbol{\eta}$ regions (red arrow).

➢ A comparison with results from ALICE

- Ignoring the absolute value, the trend of Pearson coefficient $\boldsymbol{\rho}$ and the correlation coefficient $\boldsymbol{b}$ are similar for these two systems.
- Due to the small event numbers and large statistical uncertainties, more calculations and discussions are required to clarify the behaviors for high multiplicity regions.
- The correlations for the central $\boldsymbol{\eta}$ region 0.0<| η|<0.2 are influenced by short range correlations.





➢ Conclusions

- A centrality dependence can be observed in forward-backward $\boldsymbol{p_T}$ correlations.
- The performances of centrality dependence of $\boldsymbol{p_T}$ correlations are similar for different collision energies (27 GeV and 54 GeV) and different systems (Au+Au and Pb+Pb).
- The short range correlation effects can be distinguished when having small η gaps.

➢ Outlooks

- The $\boldsymbol{p_T}$ correlations for other collision energies should be studied to verify the energy dependence effect.
- Model simulations remain to be performed for Au+Au system.
- A more comprehensive study for forward-backward $\boldsymbol{p_T}$ correlation effects should start, including the calculations for azimuthal angle difference ($\Delta\varphi$) dependence and $\boldsymbol{p_T}$ correlation effects for PID compositions.

Thanks for listening!