Flow and transverse momentum correlations in Pb+Pb and Xe+Xe collisions with ATLAS

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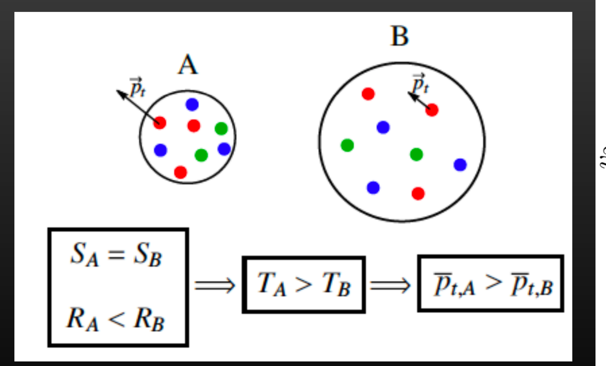
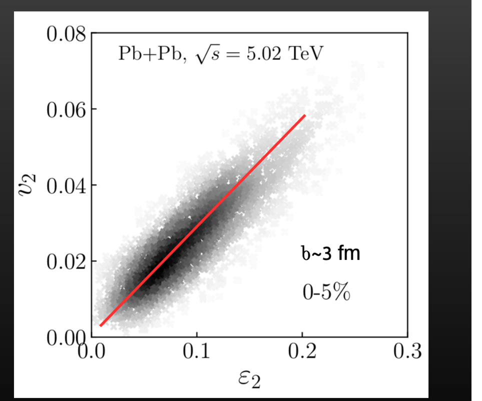
ATLAS EXPERIMENT

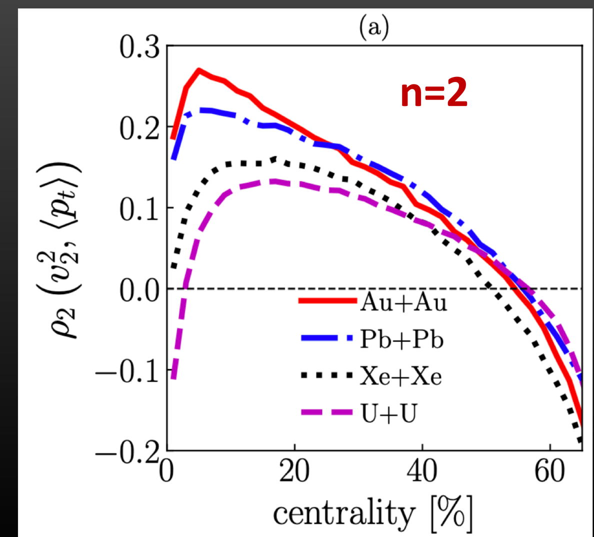
INTRODUCTION



$1/R \longrightarrow [p_T]$



$\epsilon_n \longrightarrow v_n$



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Theory predicts:

1. $\rho_{Xe} < \rho_{Pb}$.
2. Negative PCC for peripheral centralities for n=2 and 3

- Initial state correlation between ε_n and $\frac{1}{R}$ generates final state $v_n - [p_T]$ correlations.

➢ $v_n - [p_T]$ correlation is quantified by Pearson correlation

- coefficient (PCC) given by: $\rho(v_n^2\{2\},[p_T]) = \frac{cov(v_n^2\{2\},[p_T])}{\sqrt{var(v_n^2), c_k}}$

- Smearing between N_{ch} and FCal-E_T affects experimental observables magnitude as a function of centrality.

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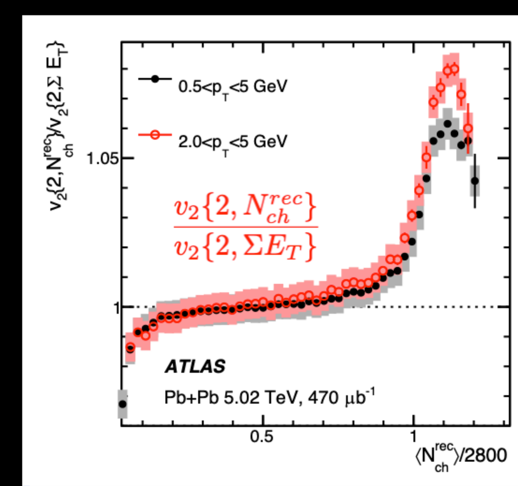


OBSERVABLES

- Normalized PCC consists of:
  1. Covariance of $v_n^2 - [p_T]$.
  2. Normalization terms: Dynamic variances of v_n^2 and $[p_T]$.

$$\rho(v_n^2\{2\},[p_T]) = \frac{cov(v_n^2\{2\},[p_T])}{\sqrt{var(v_n^2), c_k}}$$

➢ Components of ρ

1. $cov(v_n\{2\}^2,[p_T]) = \left\langle \frac{\sum_{i\neq j\neq k} w_i w_j w_k e^{in(\phi_i-\phi_j)}(p_{T,k}-\langle[p_T]\rangle)}{\sum_{i\neq j\neq k} w_i w_j w_k} \right\rangle$

2. $var(v_n^2\{2\}) = \langle v_n^4\rangle - \langle v_n^2\rangle^2$

3. $c_k = \left\langle \frac{\sum_{i\neq j} w_i w_j (p_{T,i}-\langle p_T\rangle)(p_{T,j}-\langle p_T\rangle)}{\sum_{i\neq j} w_i w_j} \right\rangle$

w_i: Track weights correct for detector performance.

$[p_T] = \frac{\sum_i w_i p_{T,i}}{\sum_i w_i}$

$p_{m;k} = \frac{\sum_i w_i^k (p_{T,i}-\langle[p_T]\rangle)^m}{\sum_i w_i^k}$

$q_{n;k} = \frac{\sum_i w_i^k e^{in\phi_i}}{\sum_i w_i^k}$

METHOD

- Sub-Event cumulant framework is used to calculate the covariance and variance terms.

Full-Event method: $-2.5 \leq \eta \leq 2.5$

Subevent A	Subevent B	Subevent C
$-2.5 \leq \eta \leq -0.75$	$\lvert\eta\rvert \leq 0.5$	$0.75 \leq \eta \leq 2.5$

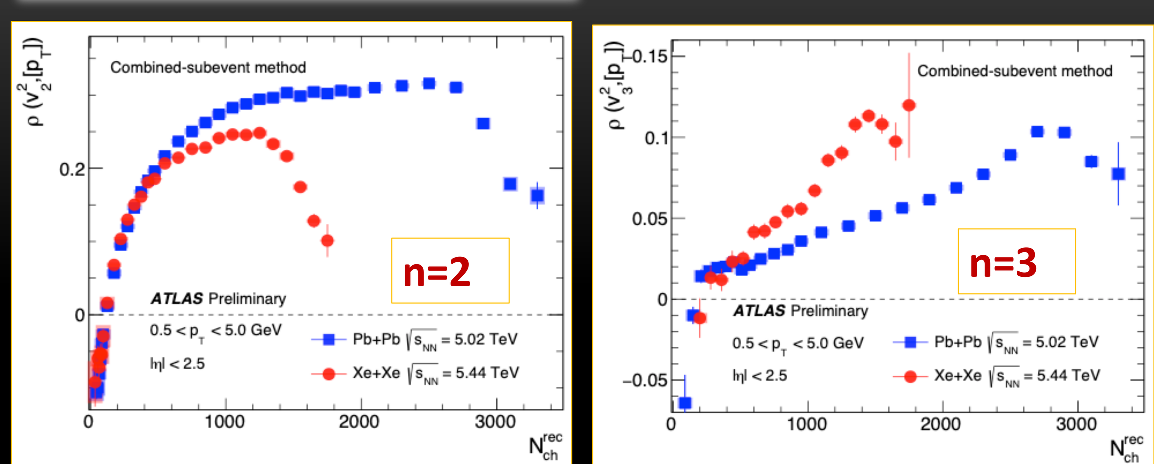
$$cov(v_n\{2\}^2,[p_T]) = \left\langle \frac{\sum_{i\neq j\neq k} w_i w_j w_k e^{in(\phi_i-\phi_j)}(p_{T,k}-\langle[p_T]\rangle)}{\sum_{i\neq j\neq k} w_i w_j w_k} \right\rangle$$

$$c_k = \left\langle \frac{\sum_{i\neq j} w_i w_j (p_{T,i}-\langle p_T\rangle)(p_{T,j}-\langle p_T\rangle)}{\sum_{i\neq j} w_i w_j} \right\rangle$$

- The covariance and variances are calculated on on event-by-event basis in given event class.
- $var(v_n^2\{2\}) = c_n\{4\}_{std} + c_n\{2\}^2_{two-sub}$ is used to maximize statistics.
- $\rho(v_n^2\{2\},[p_T])$ is calculated in different η and p_T ranges.

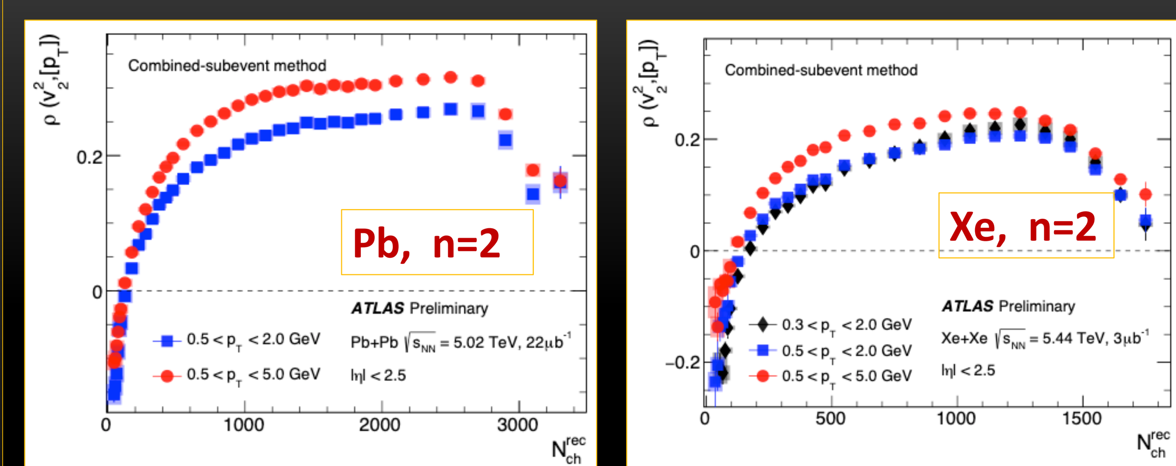
RESULTS

Size Dependence:



❖ Smaller magnitude in Xe+Xe for n=2 as a function of N_{Ch}^{rec}.
❖ Larger magnitude for Xe+Xe for n=3 observed due to larger fluctuations in smaller system

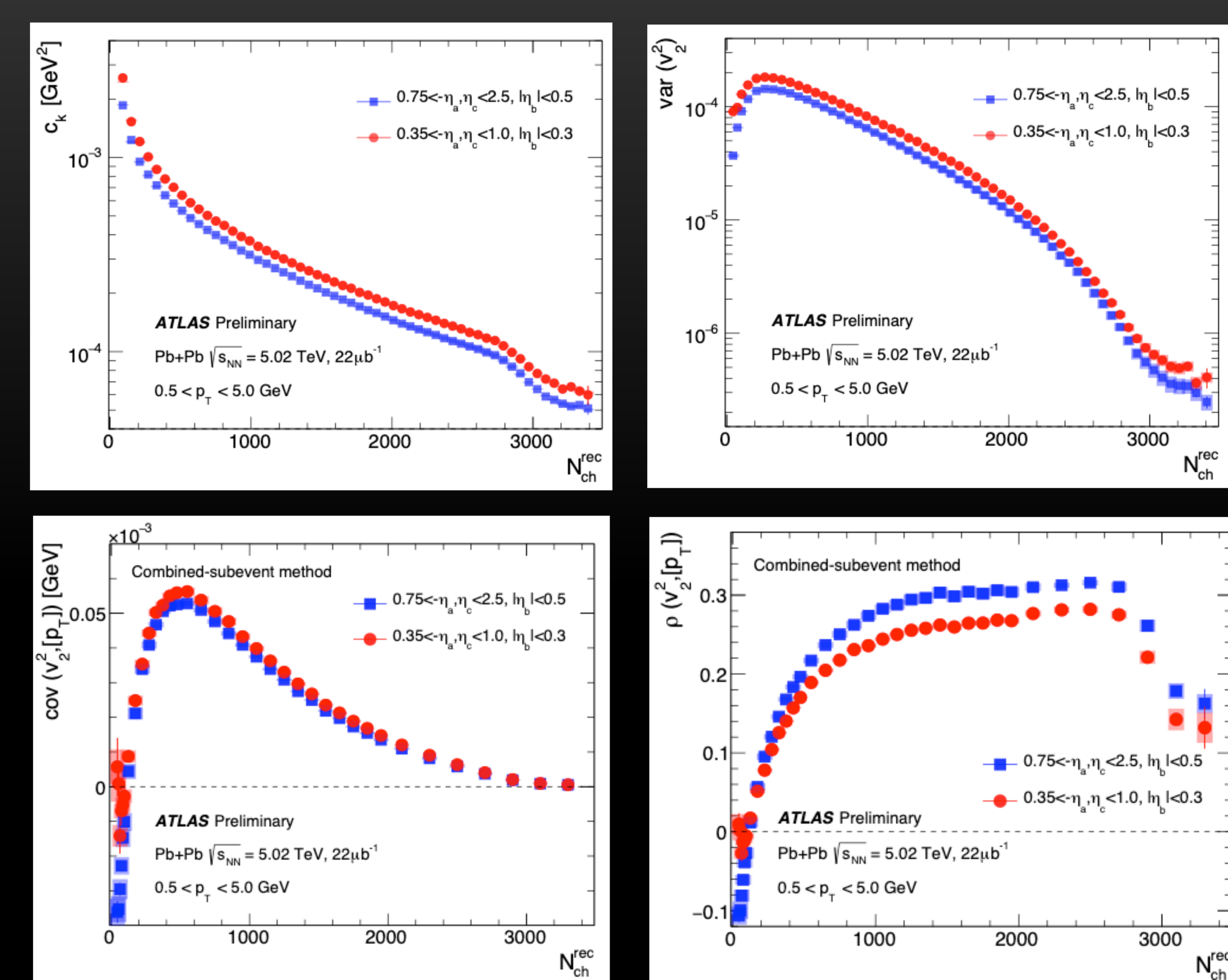
p_T Dependence:



❖ Collective behavior is insensitive to change in lower limit of p_T-Low p_T region well described by hydrodynamics.

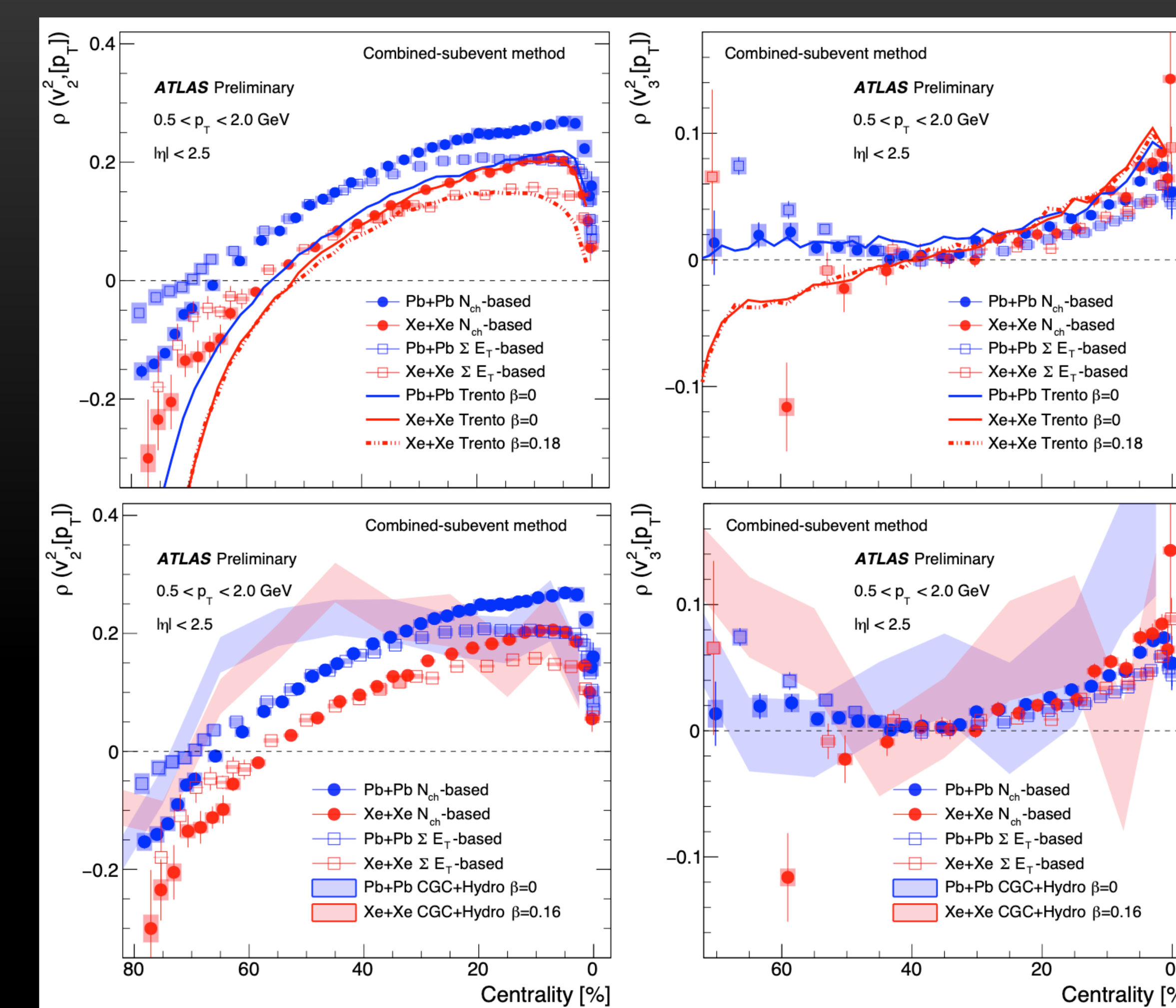
η Dependence:

η < -0.35 | |η| < 0.3 | η > 0.35



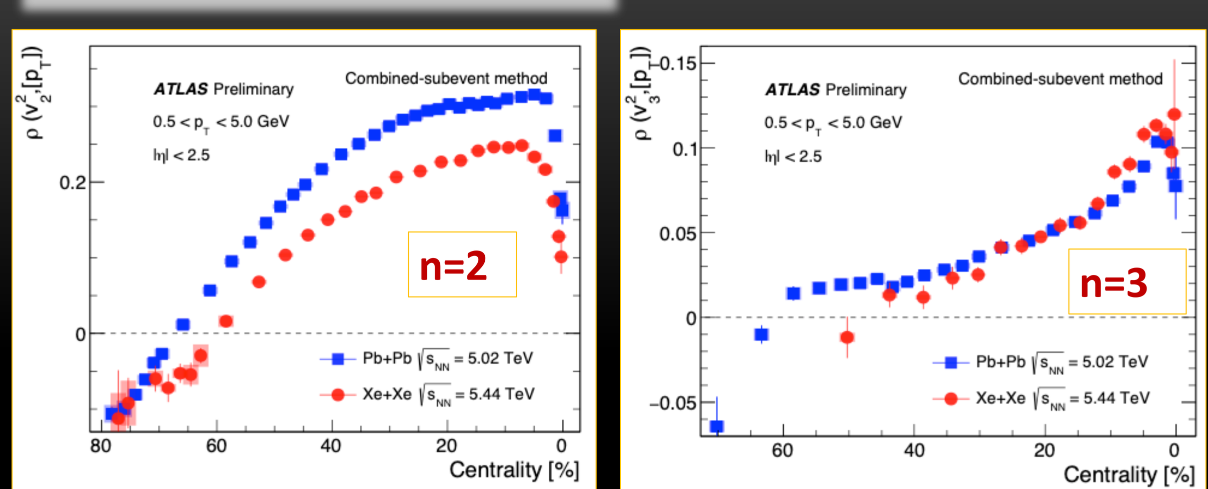
❖ c_k is larger by 10% for $|\eta| < 1$, $var(v_n)$ is larger by 10-20% for $|\eta| < 1$.
❖ Covariances show good agreement between eta-ranges.
❖ ρ is systematically smaller for $|\eta| < 2.5$ due to smaller c_k and $var(v_n)$.

Comparison to theoretical models:



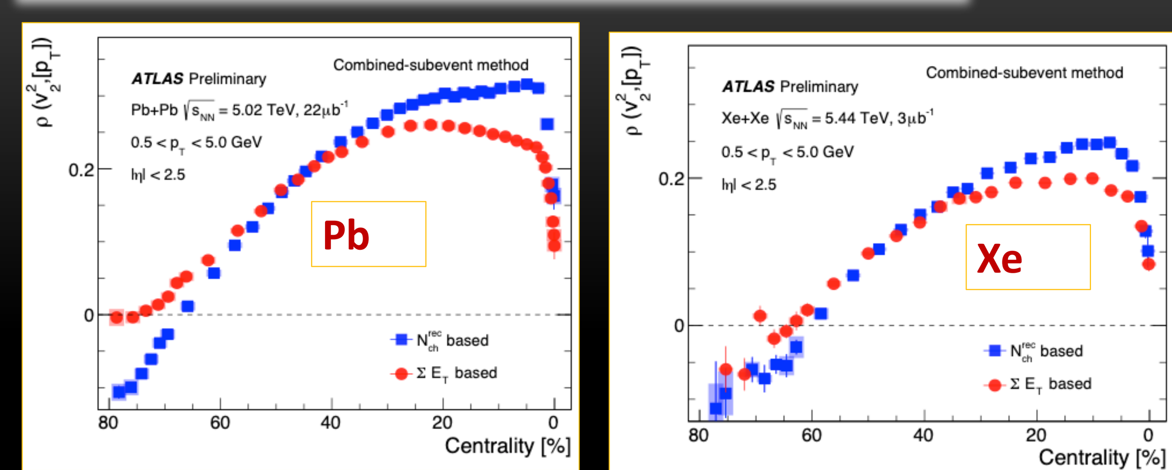
❖ **Trento** - Can explain some qualitative trends in data but not quantitatively
❖ Scaling for n=3 seen both in data and model
❖ **CGC+Hydro** Cannot explain data qualitatively or quantitatively
❖ Centrality fluctuation makes conclusion on deformation effect unclear in Xe+Xe.

Shape Dependence:



❖ Smaller magnitude in Xe+Xe for n=2 as a function of centrality.
❖ ρ_3 is comparable between two systems as a function of centrality.

Effect of Centrality Fluctuation:



❖ E_T and N_{ch} are mapped to centrality (based on ET cuts)
❖ **Large influences** of centrality fluctuations for all harmonics.
❖ Trends similar in Pb+Pb and Xe+Xe.

CONCLUSION & OUTLOOK

❖ **System-size dependence :** 1. Smaller magnitude of ρ_n in XeXe for n=2 and n=4.
2. Larger magnitude in XeXe for n=3.

❖ **η ranges dependence :** 1. Larger variances for smaller eta range of $|\eta|$<1 .
2. Much smaller difference in covariance between η ranges.

❖ **p_T ranges dependence :** behavior is insensitive to change in lower p_T limit

❖ **Centrality fluctuations :**
1. N_{ch} vs FCal-E_T binnings - significant differences.
2. Nature similar for different p_T ranges in both Pb+Pb and Xe+Xe.

❖ **Theory Comparison. :**
1. Models do not explain the measurements quantitatively.
2. Trento model captures only qualitative trends in data.
3. Theoretical comparisons should address centrality fluctuation