Flow harmonics and mean p_{T} correlations in 5.02 TeV Pb+Pb and p+Pb collisions with the ATLAS detector

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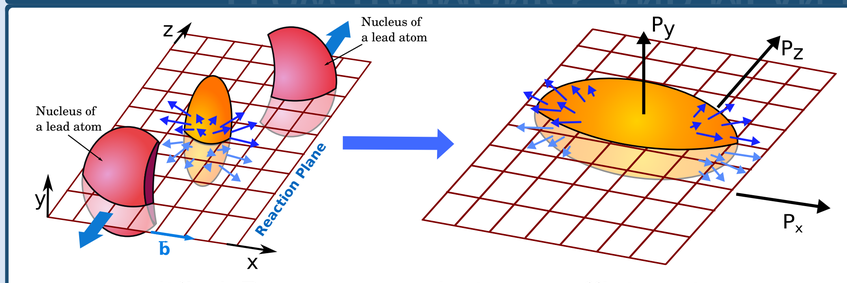
ABSTRACT

Recently collected data by the ATLAS experiment at the LHC offer opportunities to explore dynamic properties of quark-gluon plasma. A new tool to study these properties is the modified Pearson's correlation coefficient, ρ. It quantifies the correlation between the mean transverse momentum in an event, $[p_{\mathrm{T}}]$, and the square of the event flow harmonic, v_n^2. The measurement of ρ is performed using minimum-bias Pb+Pb and p+Pb collisions (new at this conference) at the same energy $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV allowing for a comparison of the medium dynamics in small and large systems. In Pb+Pb collisions, values of ρ coefficients are found to significantly deviate from zero for v_2, v_3, and v_4. In p+Pb collisions, the ρ coefficient for the second order flow harmonics is found to be negative indicating a compact particle source. All measured coefficients are compared to theoretical models.

FLOW HARMONICS AND MEAN p_{T} CORRELATIONS



- it is expected that the event-by-event average transverse momentum and flow harmonics, v_n, should be correlated
- a modified Pearson correlation coefficient is proposed to study the $p_{\mathrm{T}} - v_n$ correlation

$$R = \frac{cov(v_n\{2\}^2, [p_{\mathrm{T}}])}{\sqrt{var(v_n\{2\}^2)}\sqrt{var([p_{\mathrm{T}}])}} \rightarrow \rho = \frac{cov(v_n\{2\}^2, [p_{\mathrm{T}}])}{\sqrt{var(v_n\{2\}^2)_{dyn}}\sqrt{c_k}}$$

→ R modification includes replacement of multiplicity dependent variances by dynamic counterparts: Var_{dyn} and c_k

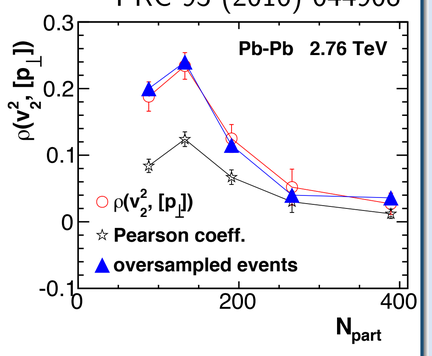
$$\mathrm{Var}(v_n\{2\}^2)_{dyn} = v_n\{2\}^4 - v_n\{4\}^4 = \langle \mathrm{corr}_n\{4\}\rangle - \langle \mathrm{corr}_n\{2\}\rangle^2$$

$$c_k = \langle \frac{1}{N_{\mathrm{pair}}} \sum_i \sum_{j\neq i} (p_{\mathrm{T},i} - \langle [p_{\mathrm{T}}]\rangle)(p_{\mathrm{T},j} - \langle [p_{\mathrm{T}}]\rangle)\rangle$$

EPJ. C74 (2014) 3157
PRC 72 (2005) 044902

→ detector independent measurement

PRC 93 (2016) 044908

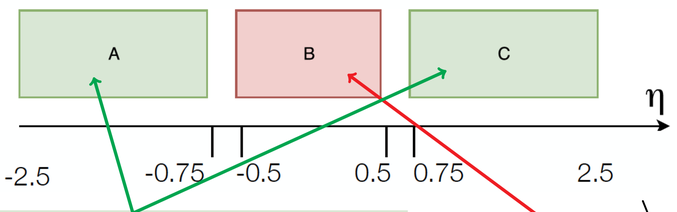


MEASUREMENT DETAILS

- weights, w, correct for tracking performance
- mean p_{T} and covariance:

$$[p_{\mathrm{T}}] = \frac{1}{\sum_b w_b} \sum_b w_b p_{\mathrm{T},b}$$

$$\mathrm{cov}(v_n\{2\}^2, [p_{\mathrm{T}}]) = \left\langle \frac{1}{\sum_{a,c} w_a w_c} \sum w_a w_c e^{in\phi_a - in\phi_c} \left([p_{\mathrm{T}}] - \langle [p_{\mathrm{T}}]\rangle\right) \right\rangle$$



- B → sub-event where the mean event p_{T} is measured
- A+C → sub-events for v_n^2 measurement
- multiplicity is used to estimate "event activity" classes
- rapidity gaps are used to suppress non-flow
- measurements for different p_{T} intervals for each system:

	p+Pb	Pb+Pb
hydrodynamical region (main result):	0.3 - 2 GeV	0.5 - 2 GeV
including higher p_{T} for energy loss sector:	0.3 - 5 GeV	0.5 - 5 GeV
low p_{T} and low multiplicity:	0.5 - 2 GeV	1 - 2/5 GeV

"INGREDIENTS" OF ρ: c_k, Var_{dyn} and cov

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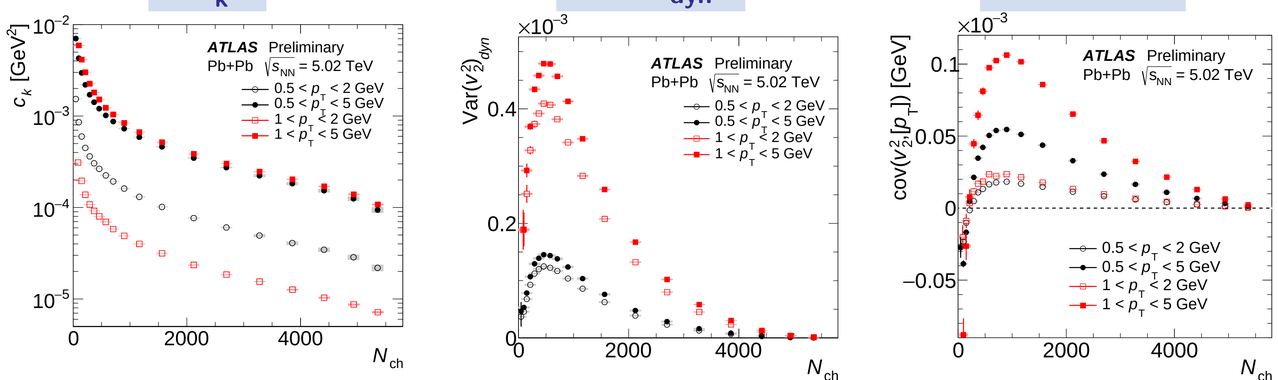
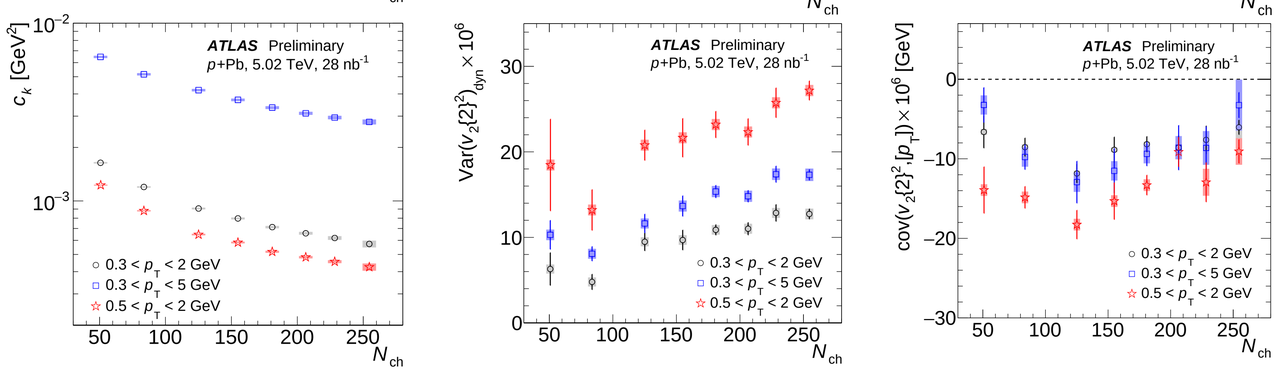
PbPb



- c_k decreases with increasing N_{ch} and significantly depends on p_{T} interval
- $\mathrm{Var}(v_n)_{dyn}(N_{ch})$ dependence is similar to $v_n(N_{ch})$
- larger $\mathrm{Var}(v_n)_{dyn}$ for larger min. p_{T} threshold
- cov(v_2) rapidly changes from negative to positive values in peripheral events, after reaching maximum decreases

pPb



- c_k decreases with increasing N_{ch} and significantly depends on p_{T} interval
- a weak increase of $\mathrm{Var}(v_n)_{dyn}(N_{ch})$ with N_{ch} is observed in p+Pb
- in p+Pb collisions covariance is negative, no apparent dependence on N_{ch} is observed

$v_n - p_{\mathrm{T}}$ CORRELATIONS: MODIFIED PEARSON COEFFICIENT ρ

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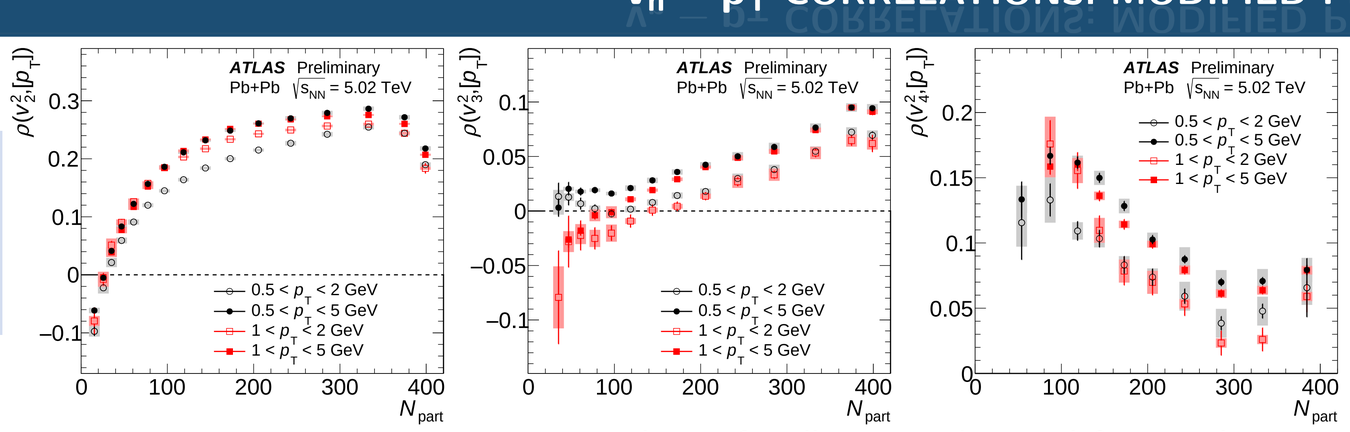
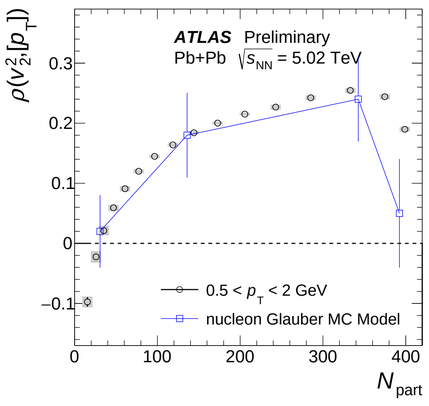
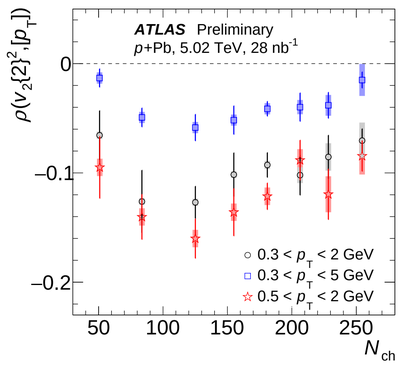
PbPb





- positive correlation for all v_n in mid-central & central events
- ρ increases with collision centrality starting from negative values at $N_{\mathrm{part}} < 40$
- in the most central collisions ρ decreases with N_{part}
- the strongest correlation, $\rho = 0.24 - 0.30$, is observed at $N_{\mathrm{part}} \sim 320$ for the v_2
- correlation for v_3 is weaker than for v_2, a weak N_{part} dependence for v_3 is observed
- reasonable agreement with the theory predictions

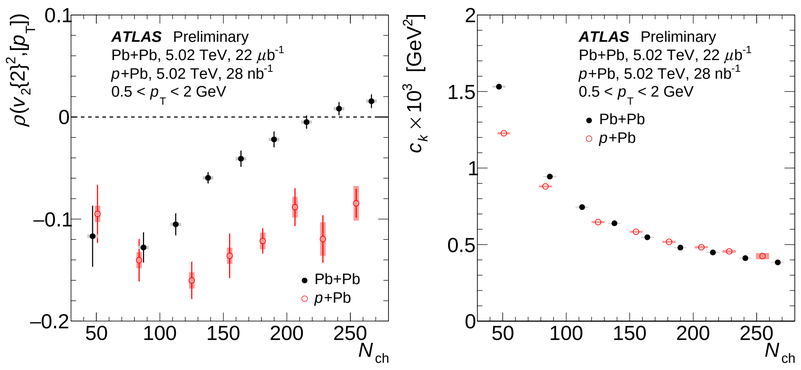
pPb



- p+Pb: negative values of ρ, constant within uncertainties

  Pb+Pb and p+Pb comparison

- weak N_{ch} dependence in p+Pb collisions
- correlation in peripheral Pb+Pb and p+Pb events is negative → insight into the small system initial stage
- the N_{ch} dependence of ρ is different for two collision systems



- c_k comparable in Pb+Pb and p+Pb for the same p_{T} interval

AGH University of Science and Technology

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