Longitudinal factorization of the Fourier coefficients of two-particle distributions in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV

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Why study the factorization of the two-particle Fourier coefficients?

- Factorization is a common assumption in the Flow ansatz (particles are created independent of each other)
- Fluctuations of the Flow coefficients v_n or the event-planes Ψ_n break the factorization assumption in event sample averages
- Factorization is **known to be broken** in p_{T}[1] and in η due to the *event-plane twist* [2, 3]
- A better understanding of this breaking helps to constrain fluctuations of the initial state and to improve future 3+1D hydrodynamical model calculations

Two-particle Fourier coefficients $\hat{v}_{n,n}(\eta_a, \eta_b)$

The two-particle Fourier coefficients $\hat{v}_{n,n}(\eta_a, \eta_b)$ are computed from the *reduced* two-particle distribution r_2:

$$r_2(\eta_a, \eta_b, \varphi_a, \varphi_b) = \frac{\langle N_{\mathrm{ch}}(\eta_a, \varphi_a) N_{\mathrm{ch}}(\eta_b, \varphi_b)\rangle}{\langle N_{\mathrm{ch}}(\eta_a, \varphi_a)\rangle \langle N_{\mathrm{ch}}(\eta_b, \varphi_b)\rangle} \xrightarrow[\text{transform}]{\text{Fourier}} \hat{v}_{n,n}(\eta_a, \eta_b)$$

To first order r_2 is insensitive to detector efficiencies but effects from secondary particles may remain

Factorization of the Fourier coefficients

- Investigate if $\hat{v}_{n,n}(\eta_a, \eta_b)$ is **consistent** with a given *model*
- Most flow analyses *assume* perfect factorization

$$\hat{v}_{n,n}(\eta_a, \eta_b) = v_n(\eta_a) v_n(\eta_b)$$

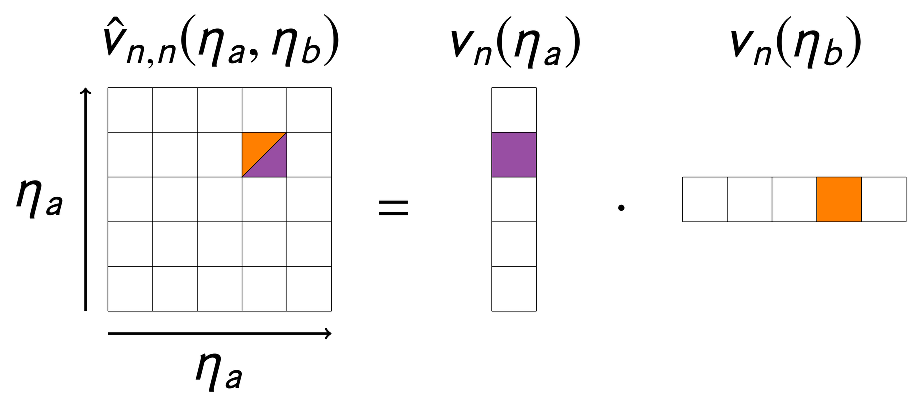
- CMS proposed model with empirical *twist* parameter F_n^η

$$\hat{v}_{n,n}(\eta_a, \eta_b) = v_n(\eta_a) v_n(\eta_b) e^{-F_n^\eta |\eta_a - \eta_b|}$$

- $\hat{v}_{2,2}(\eta_a, \eta_b)$ fit with each model assumption to extract $v_n(\eta)$ and F_n^η

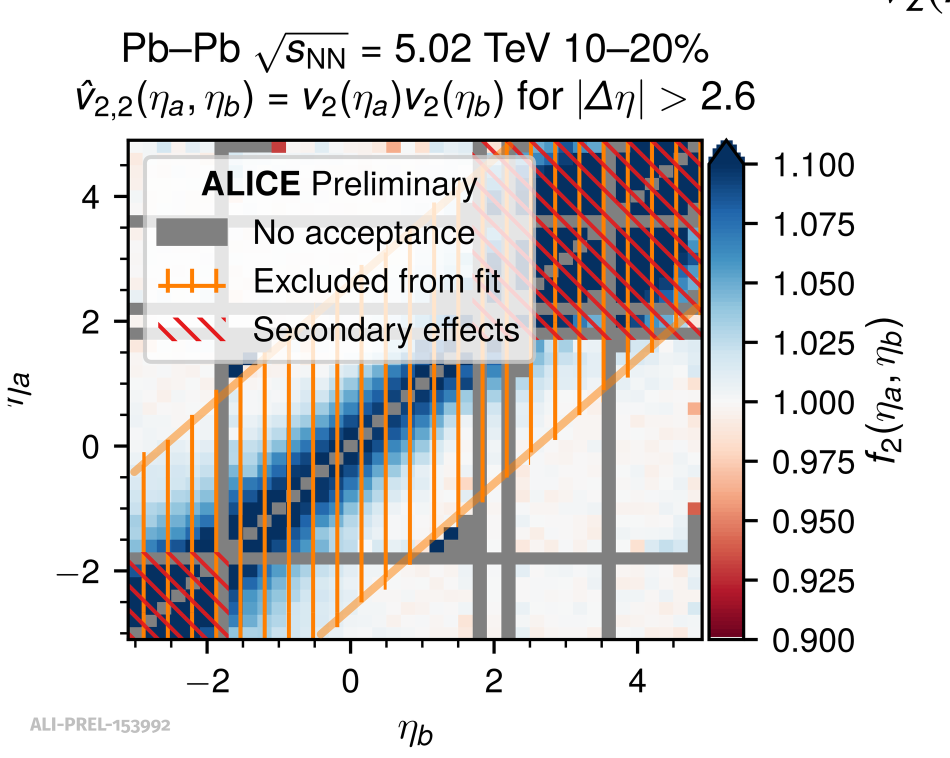
Perfect factorization model

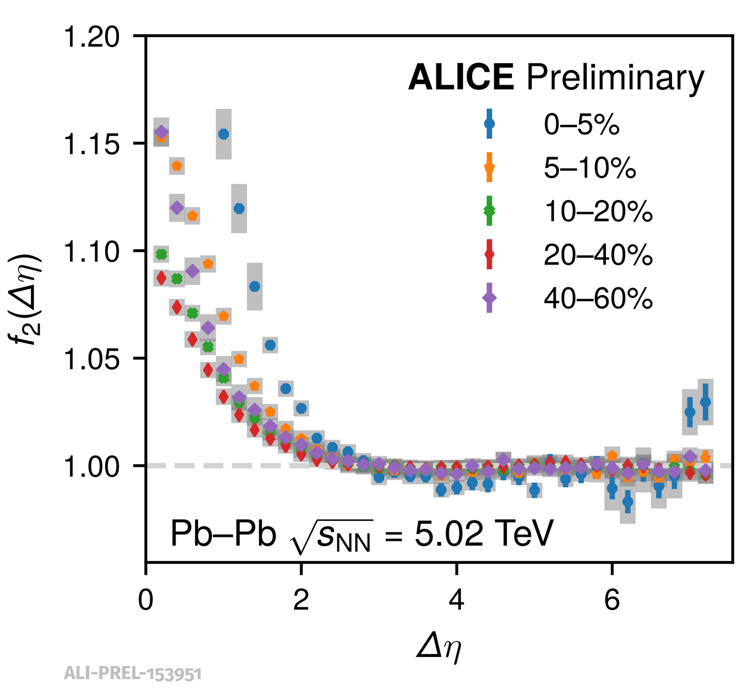
Assumption: The two-particle Fourier coefficients can be written as the product of the single particle Flow coefficients $v_n(\eta)$:



- χ^2-minimization yields $v_n(\eta)$ best describing observed $\hat{v}_{n,n}(\eta_a, \eta_b)$
- Non-flow dominated region and acceptance gaps can be excluded in minimization procedure (here: $|\Delta\eta| > 2.6$)
- Factorization ratio $f_2(\eta_a, \eta_b)$ is the ratio between the observed $\hat{v}_{2,2}(\eta_a, \eta_b)$ and the best fit to this model:

$$f_2(\eta_a, \eta_b) = \frac{\hat{v}_{2,2}(\eta_a, \eta_b)}{v_2(\eta_a) v_2(\eta_b)}$$

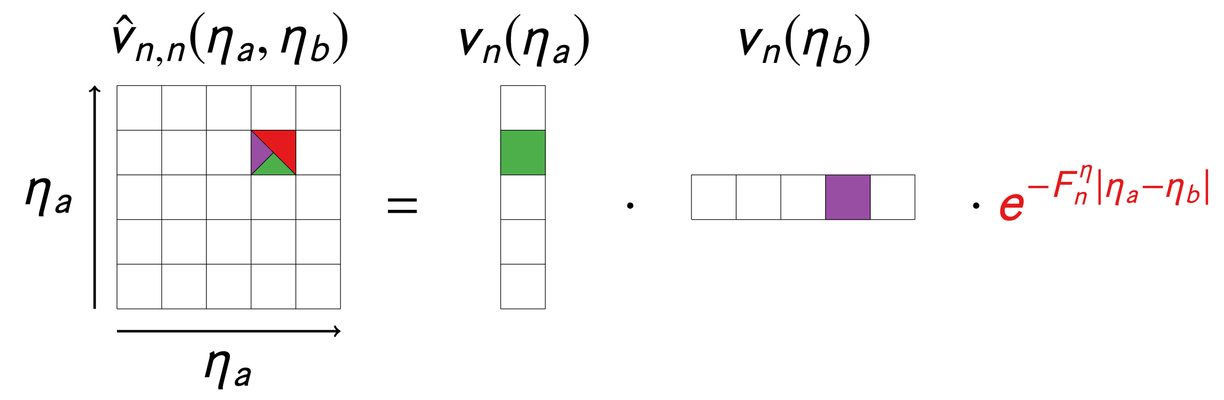




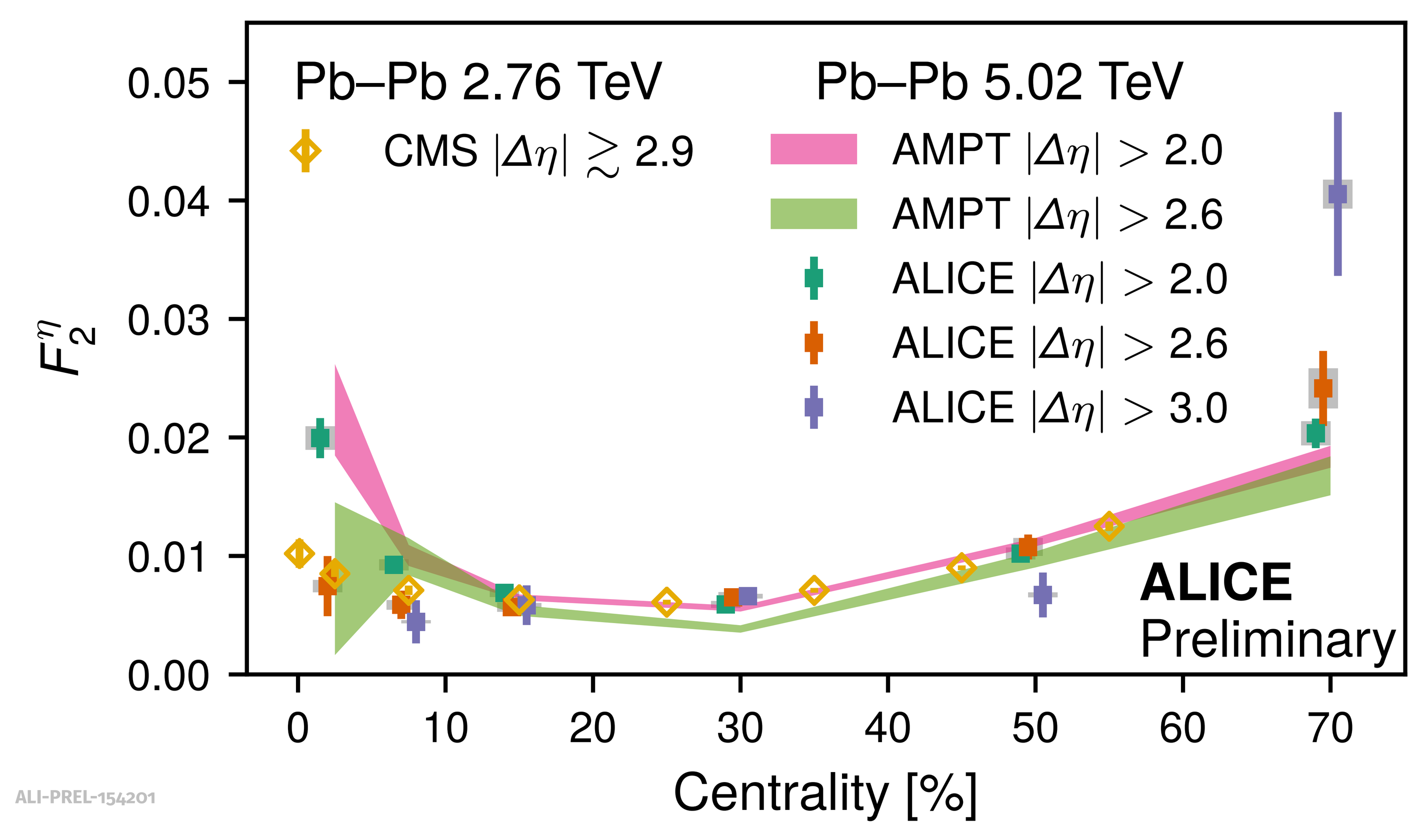
- Projection onto $\Delta\eta$ reveals good fit in long range region

Event-plane twist model

Assumption: $\hat{v}_{n,n}(\eta_a, \eta_b)$ can be written as the product of the Flow coefficients $v_n(\eta)$ **and** an event-plane decorrelation factor $e^{-F_n^\eta |\eta_a - \eta_b|}$:



- Identical minimization method as for *perfect factorization model*
- Flow coefficients $v_n(\eta)$ found with this model are **not** identical to those found with the perfect factorization model
- Empirical parameter F_n^η quantifies a $\Delta\eta$-dependent event-plane decorrelation



- Qualitative agreement with CMS at $\sqrt{s_{\mathrm{NN}}}$ = 2.76 TeV is observed
- **AMPT reproduces the decorrelation**

References and further information

References

[1] F. G. Gardim et al. In: *Physical Review C* 87.3 (Mar. 2013). arXiv: 1211.0989.
[2] ATLAS Collaboration. In: *The European Physical Journal C* 78.2 (Feb. 2018). arXiv: 1709.02301.
[3] CMS Collaboration. In: *Physical Review C* 92.3 (Sept. 2015). arXiv: 1503.01692.

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Summary

- Versatile, simple, and precise method for analyzing the Fourier coefficients of two-particle distributions
- Findings give insight into **longitudinal dynamics** and provide valuable input for future **three dimensional modeling of the QGP**.
- More sophisticated models including jet contributions or p_{T} can be deployed with exactly the same method