p_T STRUCTURE OF TWO-PARTICLE CORRELATIONS

FLOW, NON-FLOW, AND FLUCTUATIONS

Matthew Luzum

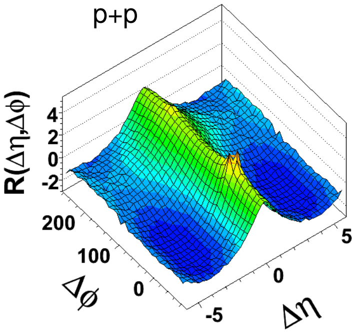
(with Gardim, Grassi, and Ollitrault; *Phys. Rev. C 87, 031901(R) (2013), arXiv:1211.0989*)

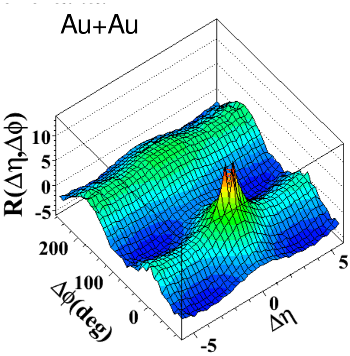
McGill University / Lawrence Berkeley National Laboratory

2nd Workshop on Initial Fluctuations and Final Correlations
11 August, 2013

LONG-RANGE CORRELATIONS

Heavy-ion collisions exhibit distinct correlations





(PHOBOS, Phys.Rev. C81 (2010) 024904)

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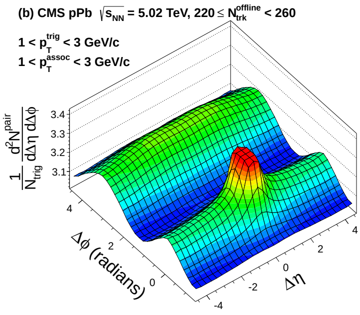

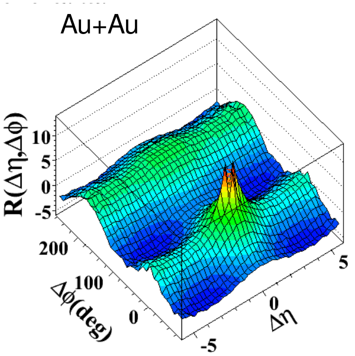

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Also now seen in high multiplicity p-A collisions.

HISTORY

Evolution of flow picture:

- Large $\langle \cos 2\Delta\phi \rangle$ due to (elliptic) flow
- Flow fluctuations are important for understanding v_2
- Flow fluctuations imply other harmonics
- Long-range correlations may be dominated by flow
- $\Longrightarrow$ correlations directly measure (moments of) flow coefficients

How do we know if correlations are really dominated by flow?

1. Fit data with hydro calculations
2. Find and test generic properties that don't depend on unknown parameters

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FLOW VS. NON-FLOW

- Particles in a single collision can be described by an underlying probability distribution:

$$\frac{2\pi}{N}\frac{dN}{d\phi} = \sum_{n=-\infty}^{\infty} V_n(p_T,\eta)e^{-in\phi}$$

$$V_n = \{e^{-in\phi}\}$$

- And similarly for pairs in a single event

$$\frac{dN_{pairs}}{d^3p^a d^3p^b} = \frac{dN}{d^3p^a} \times \frac{dN}{d^3p^b} + C(p^a, p^b)$$

$$= \quad \text{flow} \quad + \quad \text{nonflow}$$

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FACTORIZATION

Two-particle correlation is a multidimensional matrix:

$$\langle \cos n(\phi^a - \phi^b) \rangle = f(p_T^a, \eta^a, p_T^b, \eta^b)$$

(Most flow measurements probe momentum of at most one particle of the pair)

CLAIM*:

If the correlation is dominated by flow, the correlation factorizes:

$$\begin{aligned} \langle \cos n(\phi^a - \phi^b) \rangle &= f(p_T^a) f(p_T^b) \\ &= v_n(p_T^a) v_n(p_T^b) \end{aligned}$$

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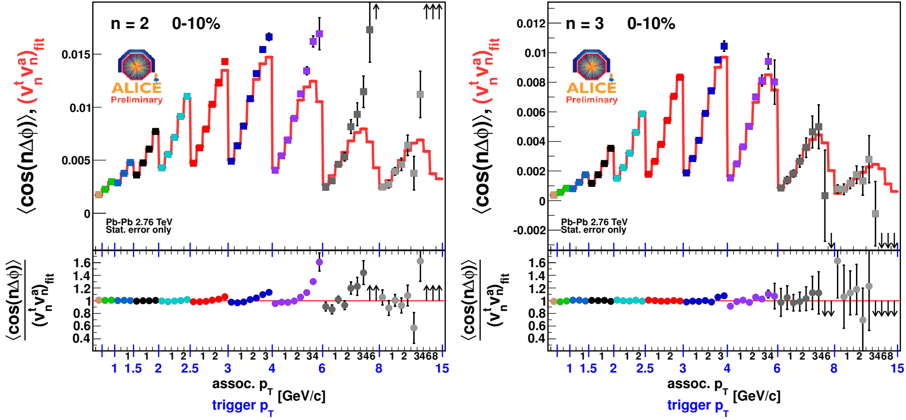
EXPERIMENTAL FACTORIZATION TESTS

This was tested by each LHC experiment. E.g.. global fit of matrix:



(ALICE, arXiv:1109.2501; See also ATLAS, arXiv:1203.3087; CMS, arXiv:1201.3158)

A triumph of the flow hypothesis:

- The matrix approximately factorizes
- Factorization gets worse with increasing p_T*
- Interpreted as the onset of non-flow correlations above 3–4 GeV
- But is this factorization really true in hydrodynamics?

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Flow inequalities

This expression directly implies a set of inequalities:

$$V_{n\Delta}(p_T^a, p_T^b) \equiv \left\langle V_n^a V_n^{b*} \right\rangle = \left\langle v_n^a v_n^b e^{in(\Psi_n^a - \Psi_n^b)} \right\rangle$$

$$\implies \quad V_{n\Delta}(p_T^a, p_T^a) \geq 0$$

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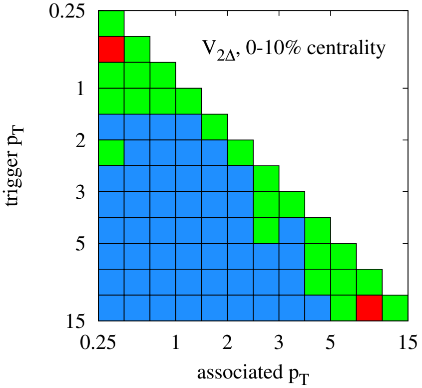
Test data for non-flow correlations

Can we find non-flow in data?



Green = factorization, Blue = flow fluctuations, Red = non-flow

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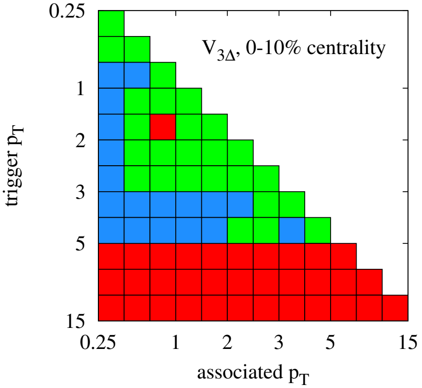

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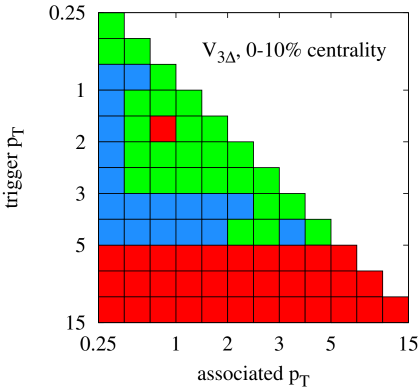

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- Most of the correlation is actually inconsistent with factorization.

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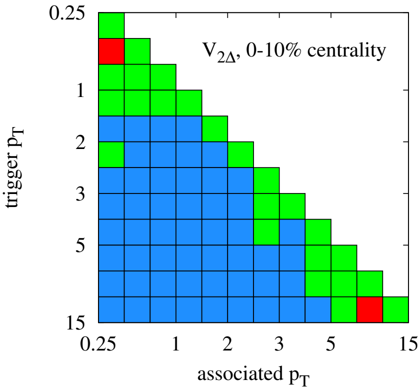

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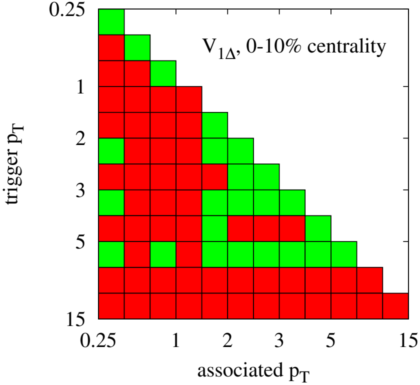

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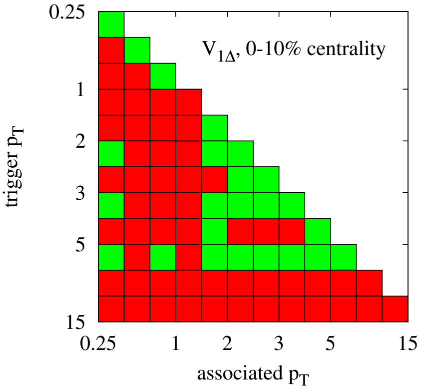

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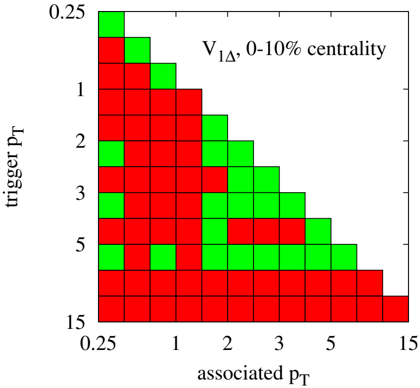

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Factorization breaking in hydrodynamics

- Is broken factorization in data really inconsistent with hydro?
- If we define a ratio

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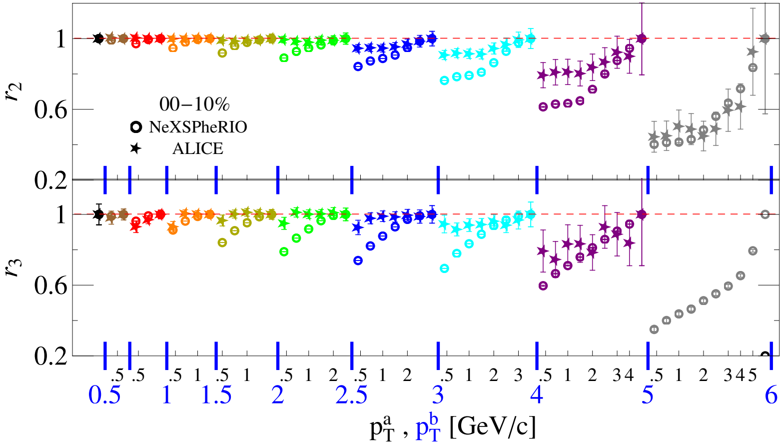

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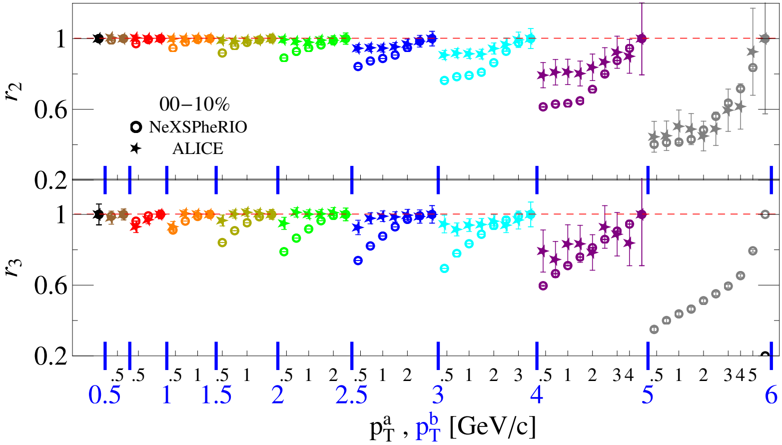

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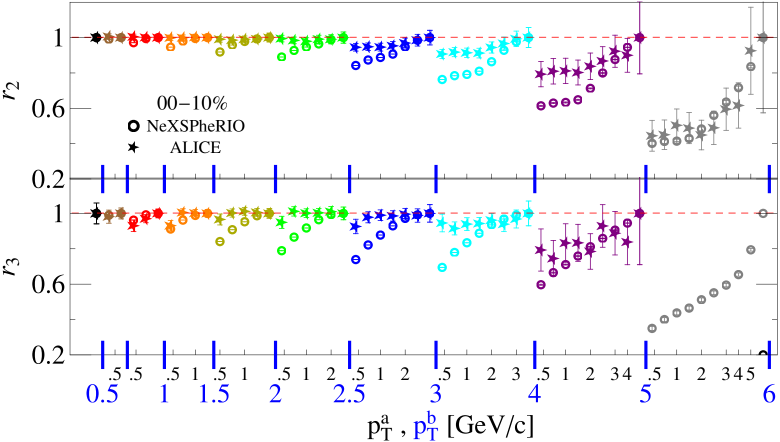

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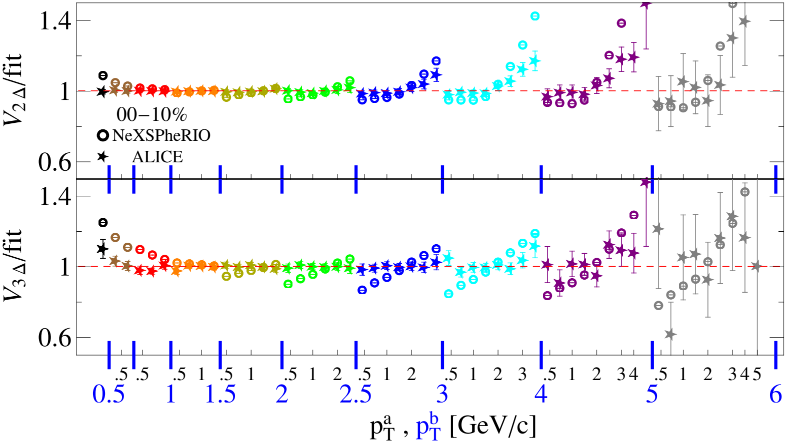
Or compare to global fit *à la* ALICE:



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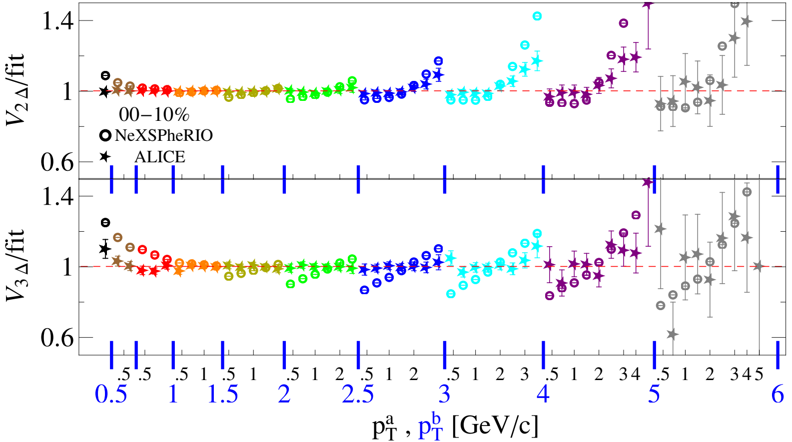

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- Two-particle correlations show approximate, but not perfect factorization in p_T.
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Extra slides