$p_\perp$ fluctuations

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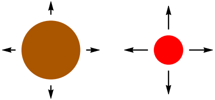
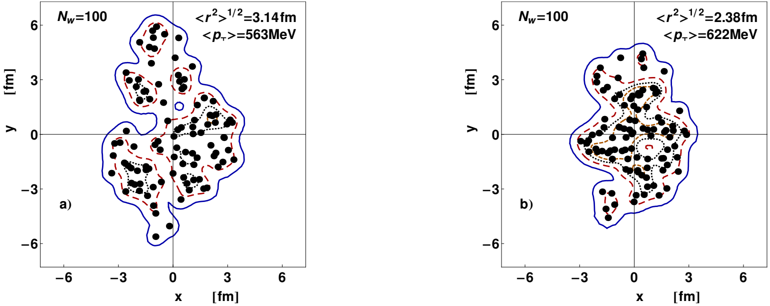
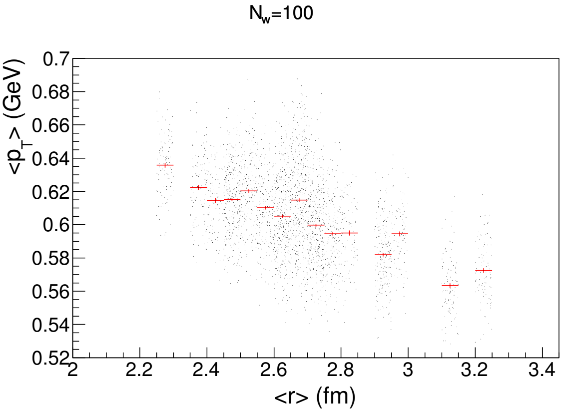
with: W. Broniowski, arXiv: 1701.09105
and S. Chatterjee *in progress*

Size fluctuations $\leftrightarrow$ $p_\perp$ fluctuations



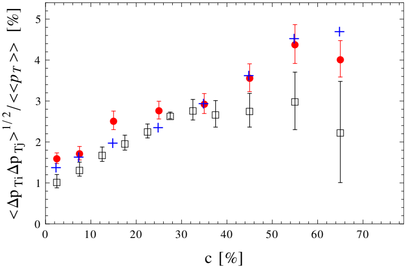


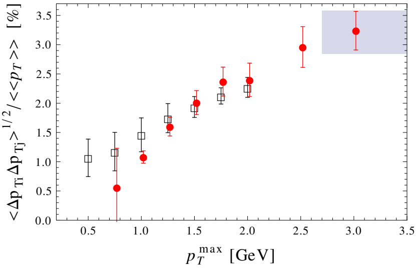
proposed by Broniowski et al. Phys.Rev. C80 (2009) 051902 : two-shots calculation



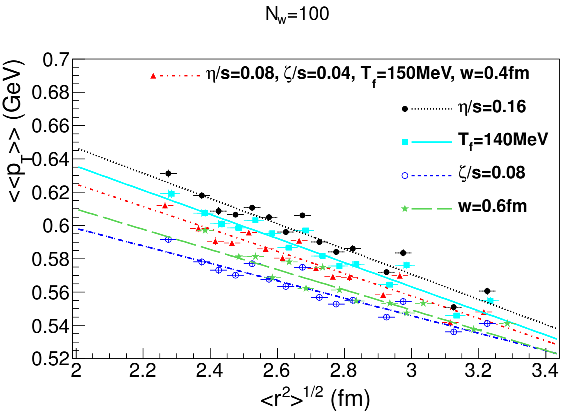
$$C_{p_\perp} = \frac{\frac{1}{N(N-1)} \sum_{i \neq j} \langle (p_i - \langle\langle p \rangle\rangle)(p_j - \langle\langle p \rangle\rangle) \rangle}{\langle\langle p_\perp \rangle\rangle^2}$$

PHENIX data vs. hydro.





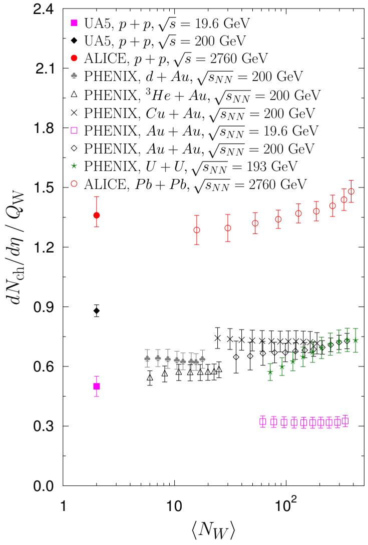
Viscosity effects on hydro response



$$\frac{\Delta p}{p} \simeq 0.4 \frac{\Delta r}{r}$$

- size fl. $\leftrightarrow$ $p_\perp$ fluctuations
- hydro. response not modified by
  - viscosity
  - T_F
  - smearing
  - core-corona
  - P_{tot} conservation
  - centrality def.
- too much fluctuations?

Wounded quark model in AA

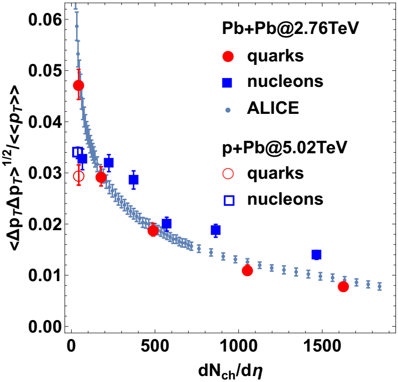


- very good (full) scaling at LHC
- approximate scaling at RHIC

LHC - 3 partons , RHIC - 2 partons ?

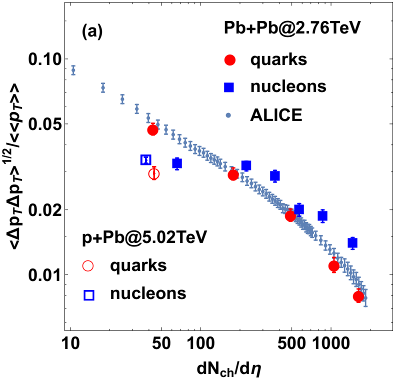
PB, W. Broniowski, M. Rybczyński, PRC 2016

$p_\perp$ fluctuation quark Glauber model initial conditions



Quark Glauber model gives better description of initial volume fluctuations

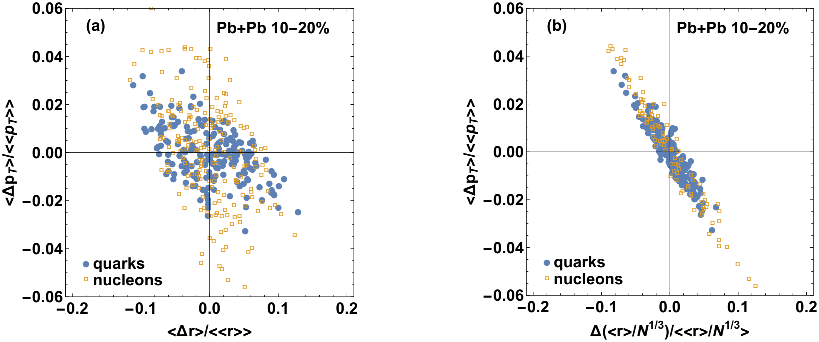
Same in log scale



more than simple $N^{-1/2}$ scaling

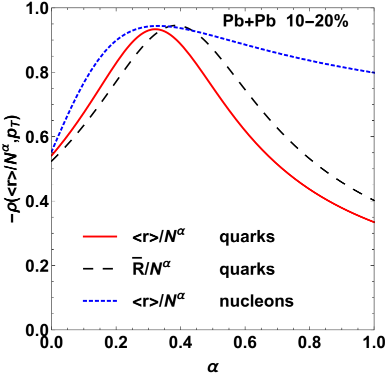
both experiment and theory $\longrightarrow$ not minijets

Size - $p_\perp$ correlation



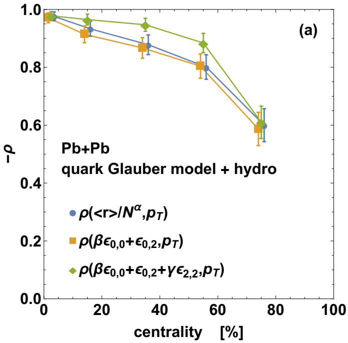
$\frac{N_q^\alpha}{<r>}$ - predictor of the final $p_\perp$

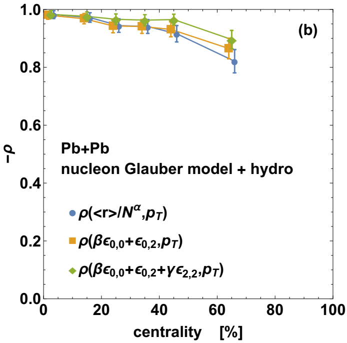
Best correlation



$$\frac{N^{1/3}}{<r>}$$

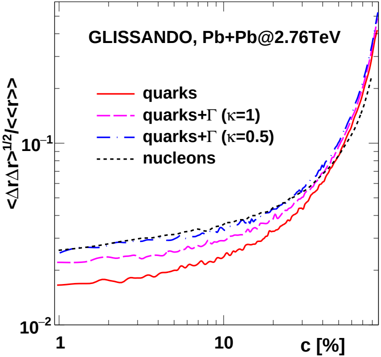
$p_\perp$ predictor





consistent with predcitor of Mazellauskas-Teaney, PRC 2016

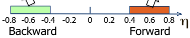
Caution - additional fluctuation may change the results

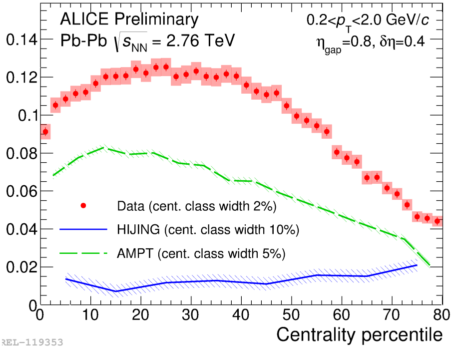


$p_\perp - p_\perp$ correlation in rapidity - ALICE preliminary

$$b_{\rm corr} = \frac{\langle FB\rangle - \langle F\rangle\langle B\rangle}{\langle F^2\rangle - \langle F\rangle^2}$$

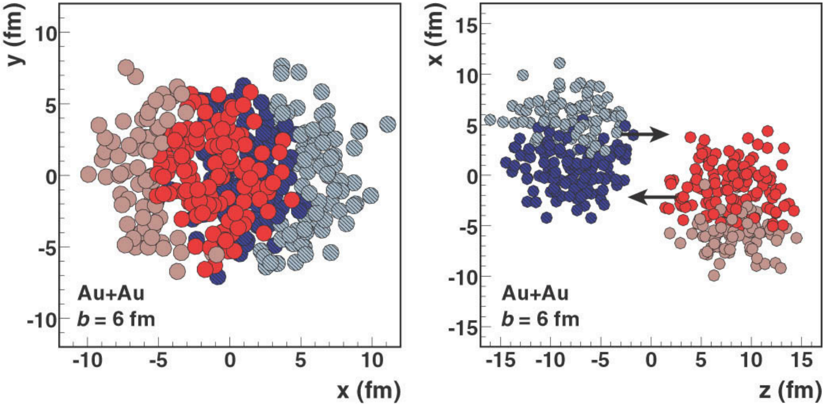
$$B \equiv \overline{p_{\rm T}}_B = \frac{\sum_{i=1}^{n_B} p_{\rm T}^{(i)}}{n_B} \qquad F \equiv \overline{p_{\rm T}}_F = \frac{\sum_{j=1}^{n_F} p_{\rm T}^{(j)}}{n_F}$$





QM poster I. Altsybeev for ALICE

Forward and backward going participants



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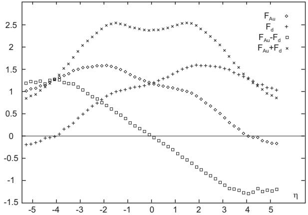
- Glauber Monte Carlo model $\longrightarrow$ different distributions for forward and backward going participants

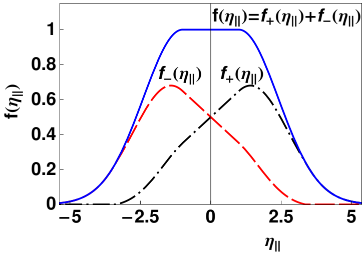
- different fireball shape at forward and backward rapidities

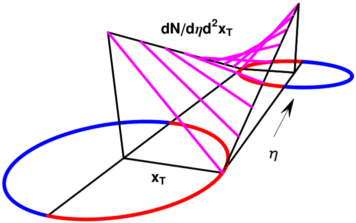


$$\rho(\eta,x,y) \quad \propto \quad f_+(\eta)N_+(x,y) + f_-(\eta)N_-(x,y)$$

Asymmetric emission

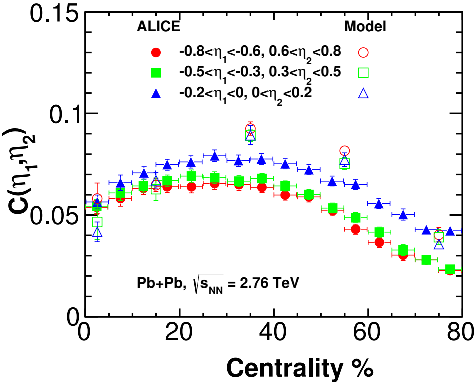
(Białas, Czyż, Acta Phys.Polon.B36, 905 (2005)





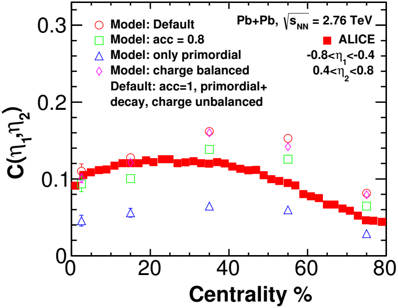
bremsstrahlung Adil Gyulassy, Phys. Rev. C72, 034907 (2005)

$p_\perp - p_\perp$ correlation in rapidity - hydro



reasonable description of the data

$p_\perp - p_\perp$ correlation coefficient - ill defined



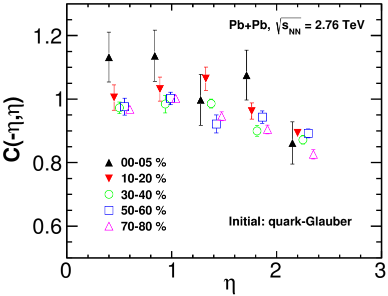
$$b = \frac{< [p_\perp]_A [p_\perp]_B > - < [p_\perp]_A >< [p_\perp]_B >}{\sqrt{(< p_A^2 > - < p_A >^2)(< p_B^2 > - < p_B >^2)}} = \frac{\dots}{\sqrt{\frac{1}{n_A^2}\sum_{ij} p_i^A p_j^A \dots}}$$

sensitive to accepteance, particle multiplicity

dominated by statistical fluctuations!

$[p_\perp] - [p_\perp]$ correlation coefficient

$$\frac{< [p_\perp]_A [p_\perp]_B > - < [p_\perp]_A >< [p_\perp]_B >}{\sqrt{C^A_{p_\perp} C^B_{p_\perp}}} = \frac{\dots}{\sqrt{\frac{1}{n_A(n_A-1)} \sum_{i\neq j} p_i^A p_j^A \dots}}$$



insensitive to acceptnace, mulitplicity

true measure of flow-flow correlations

Summary

- size fluctuations $\leftrightarrow$ $p_\perp$ fluctuations
- Glauber+hydro qualitatively consistent
- suggest scenarios with less fluctuations (quark Glauber model)
- $p_\perp$ correlations in η interesting
- strong $[p_\perp] - [p_\perp]$ correlations? - should be measured