Influence of initial-state momentum anisotropy on the final-state collectivity in small collision systems

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October 10, 2019

Based on : arXiv:1906.01422

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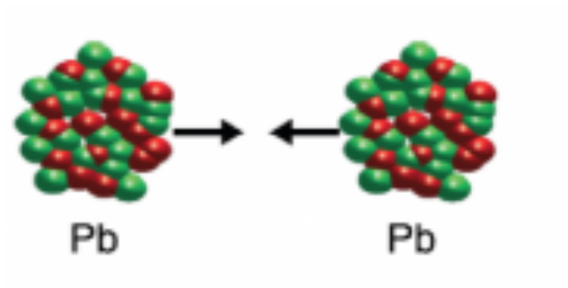
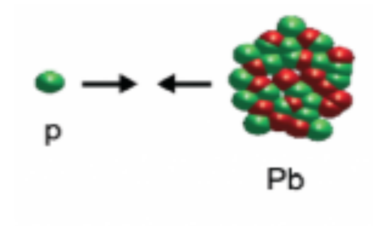
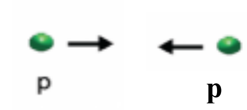
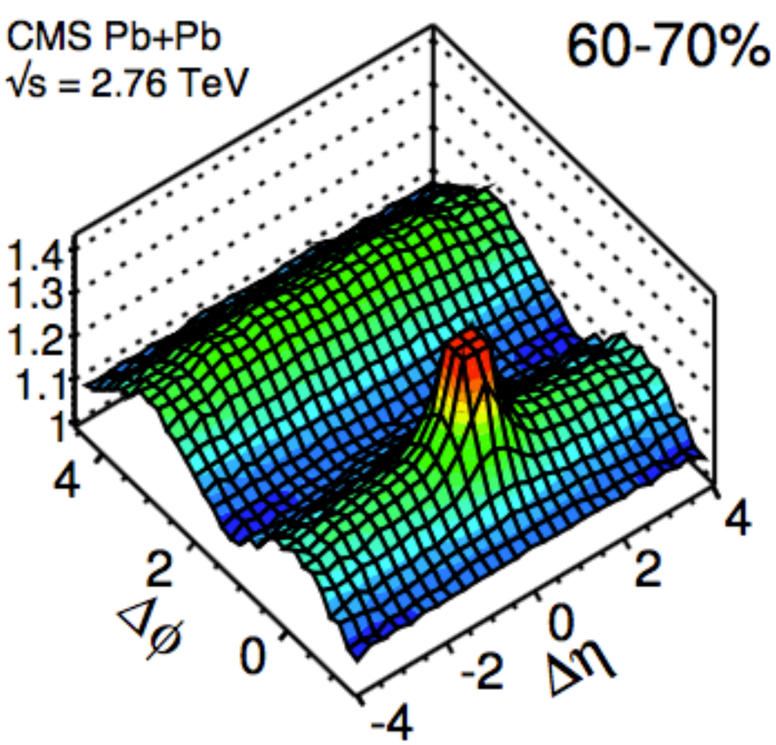
“ridge” in different collision system



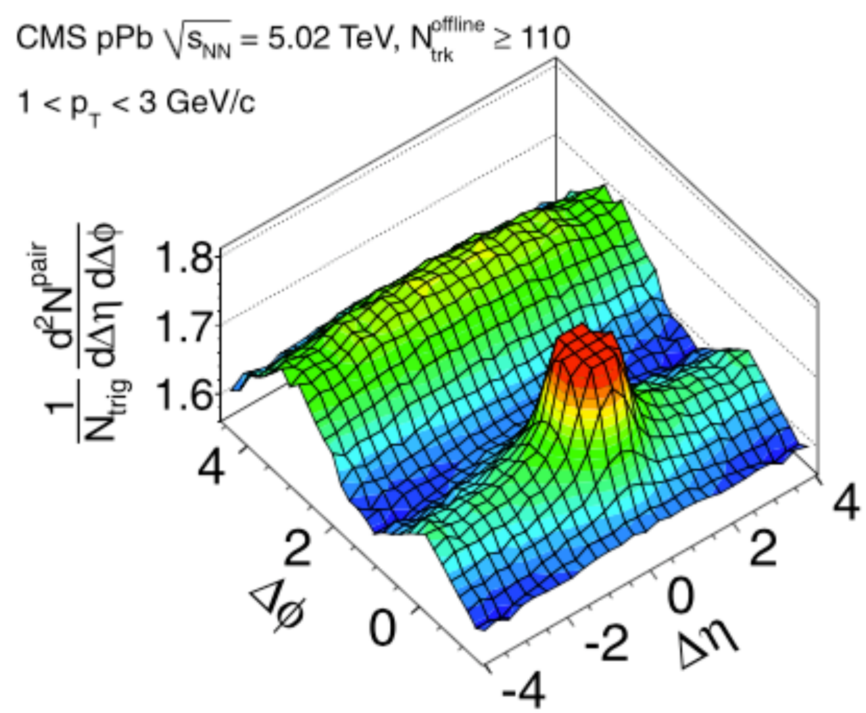




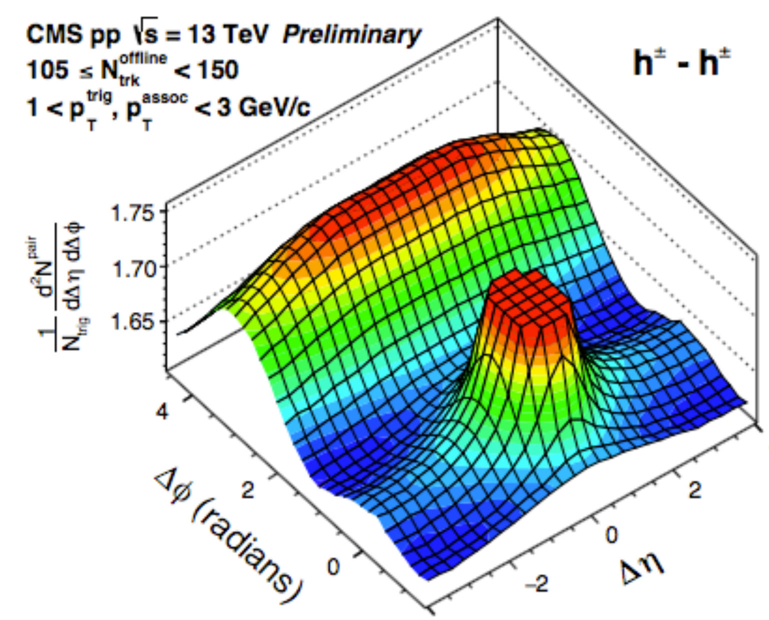
CMS, PLB 718, 795 (2013)



CMS, PRL116, 172302 (2016)



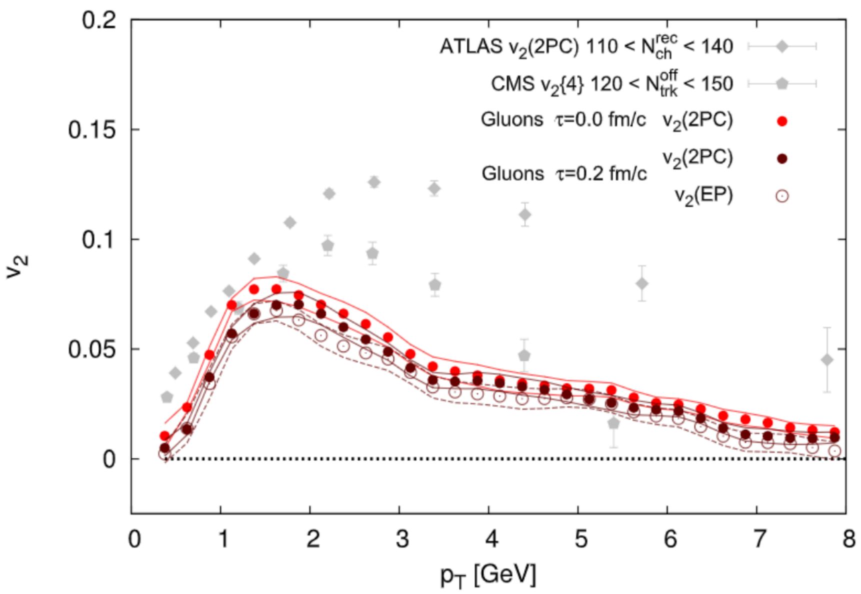
CMS. EPJC 72, 2012 (2012)



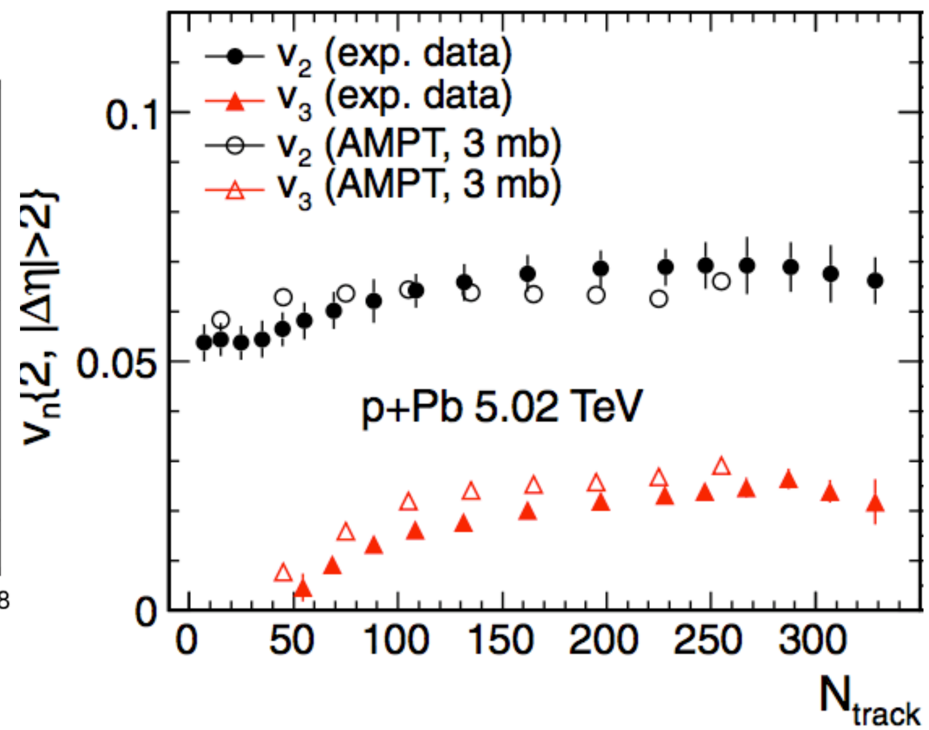
Where is the onset of collectivity flow if any?

Origin of v_n in small system

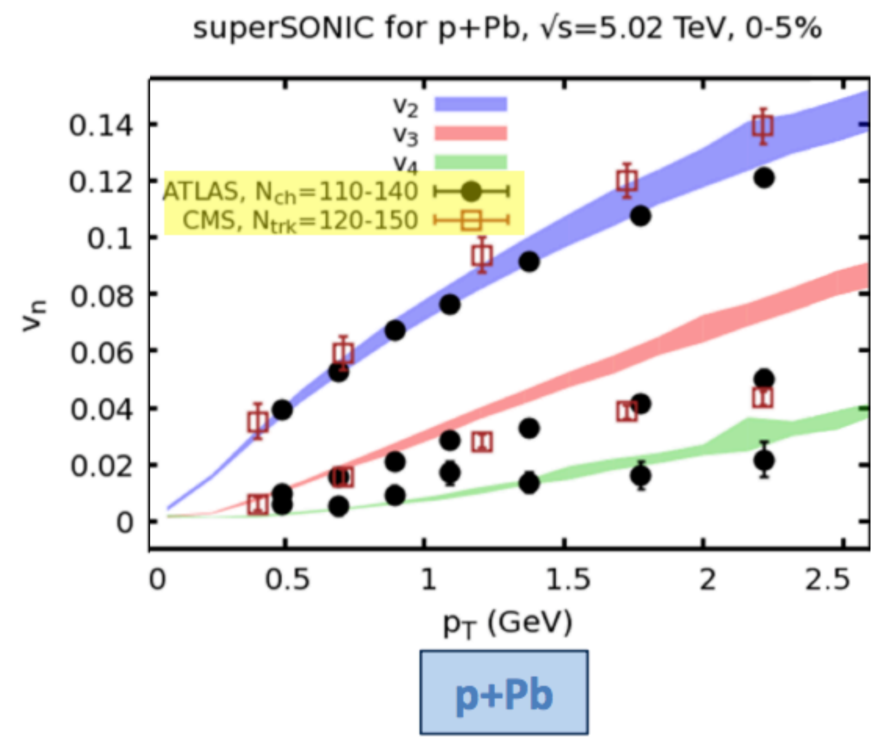
B. Schenke et al. PLB747 (2015) 76–82



A. Bzdak and G. Ma PRL 113, 252301 (2014)



R. Weller and P. Romatschke, PLB 774, 351-356 (2017)



CGC

Initial momentum anisotropy, before QGP.

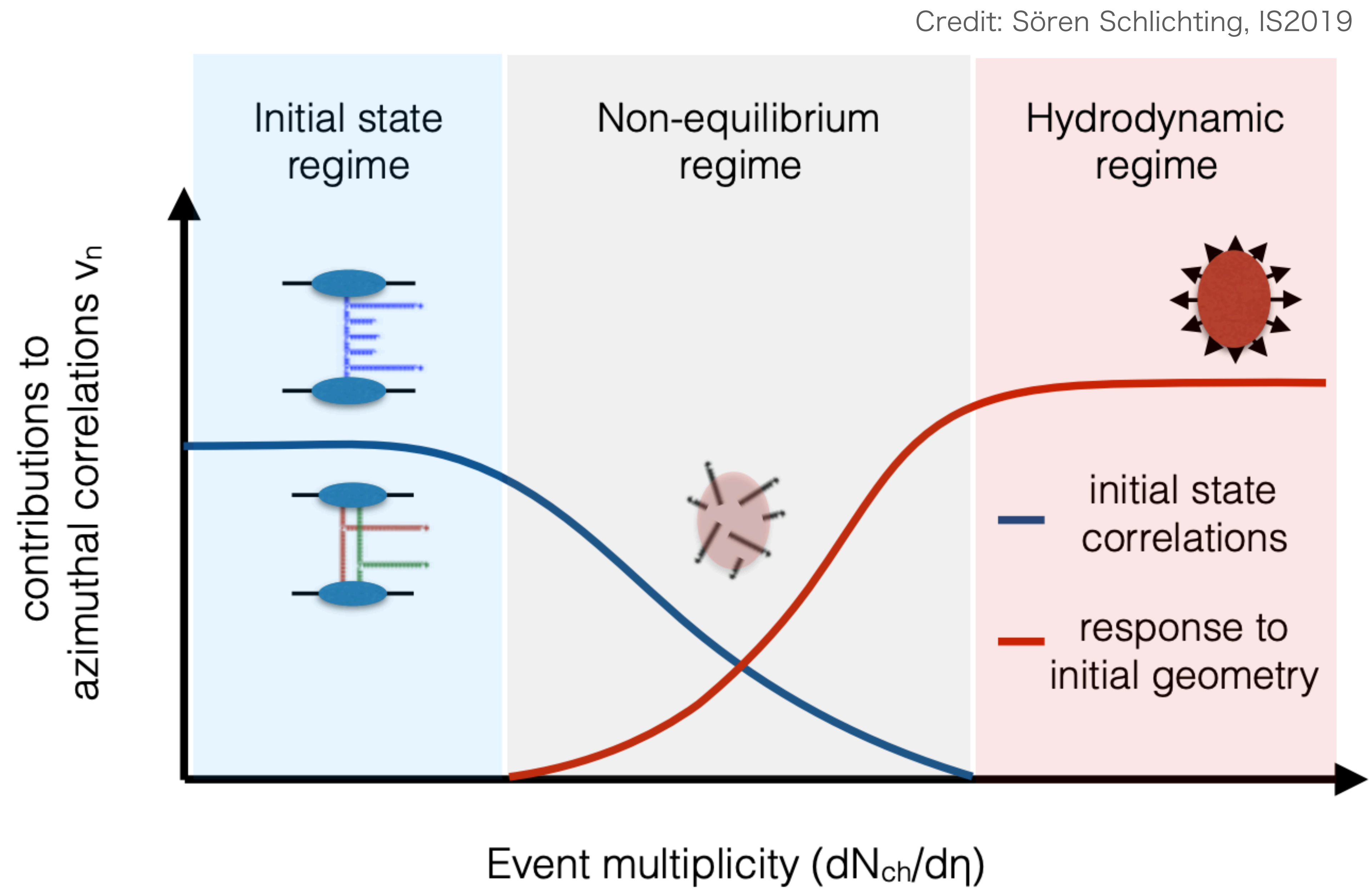
AMPT

Initial spatial anisotropy. Kinetic transport model "parton escape"

Hydro

Initial spatial anisotropy, driven by pressure gradient QGP droplet?

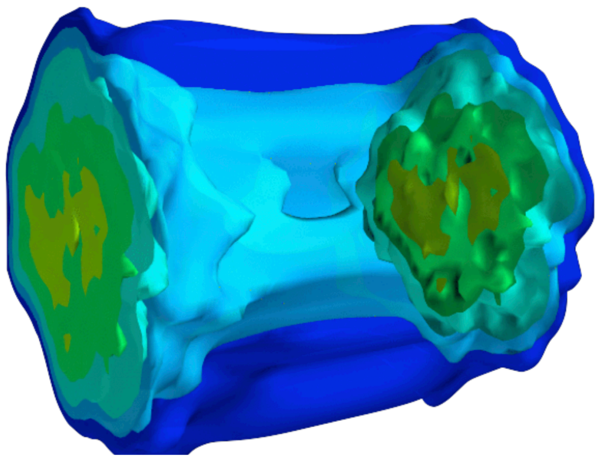
Emergence of collectivity



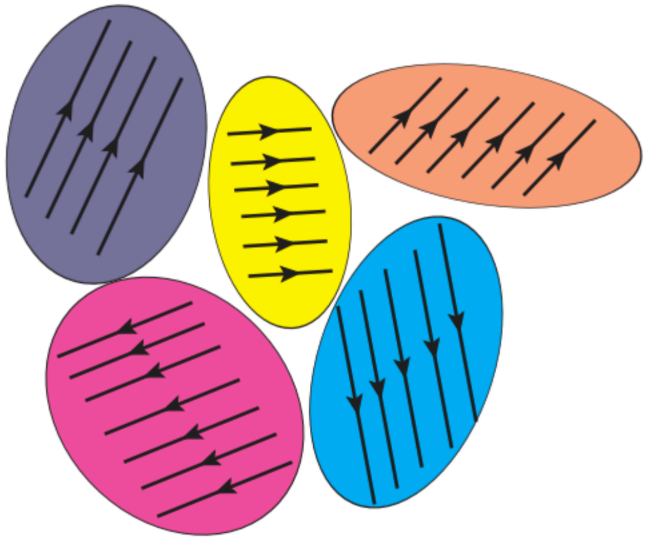
Qualitatively not Quantitatively!

- **Sizable azimuthal anisotropy can be induced by the initial state correlations or parton escape mechanism at low multiplicity.**

Go beyond the long ongoing debate between



and



AMPT model

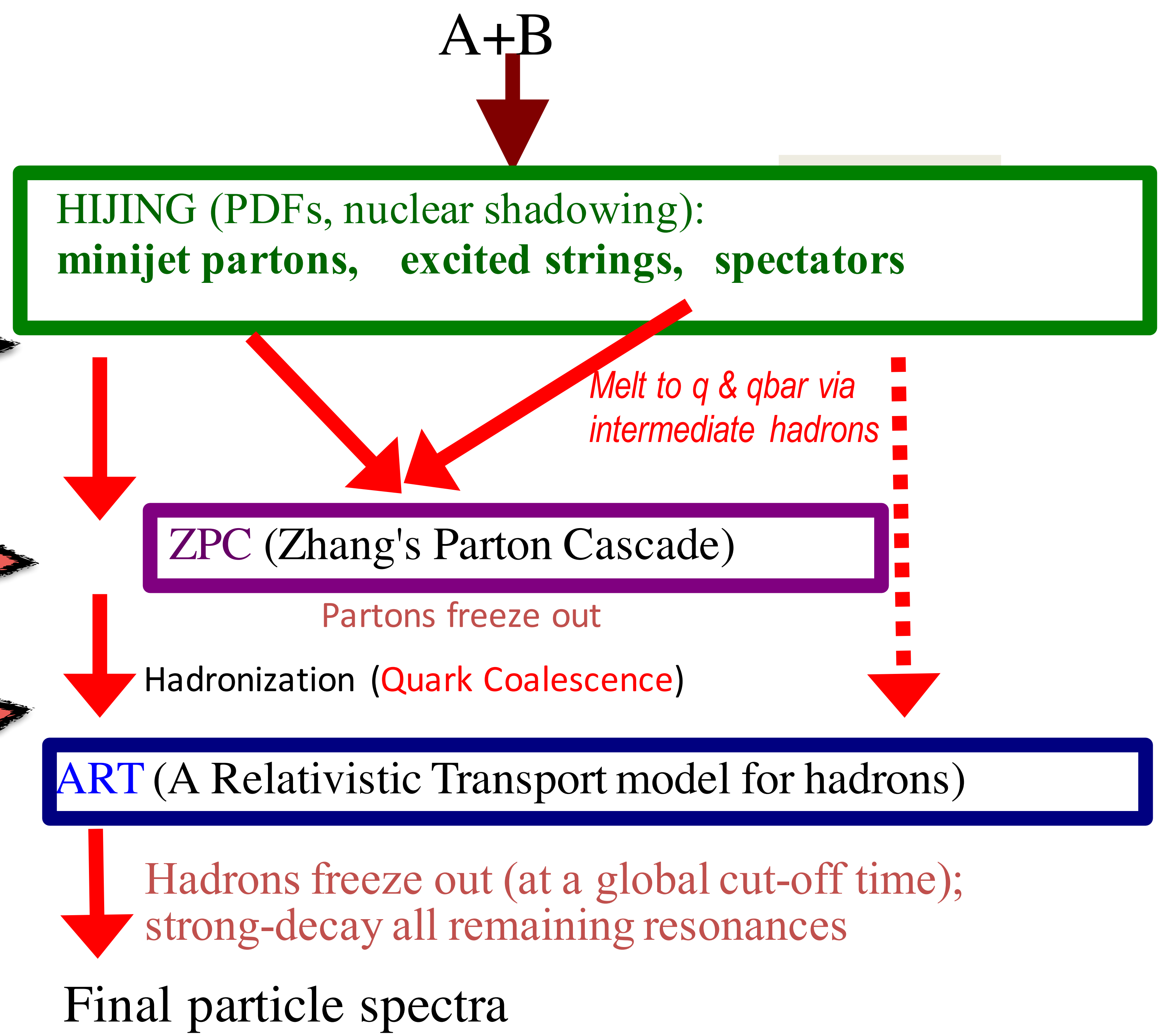
- **AMPT-string melting**
- **parton cross section σ=3mb**
- **p+Pb $\sqrt{s_{NN}}$ = 5.02 TeV**

initial state

after parton cascade

after coalescence

after hadronic rescatterings



AMPT model setup

- **AMPT-string melting**
- **parton cross section σ=3mb**
- **p+Pb $\sqrt{s_{NN}}$ = 5.02 TeV**

M. MASERA et al PRC 79, 064909 (2009)

for each parton:

keep the x, y, z unchanged (geometry response remains)

keep the p_T, η unchanged,

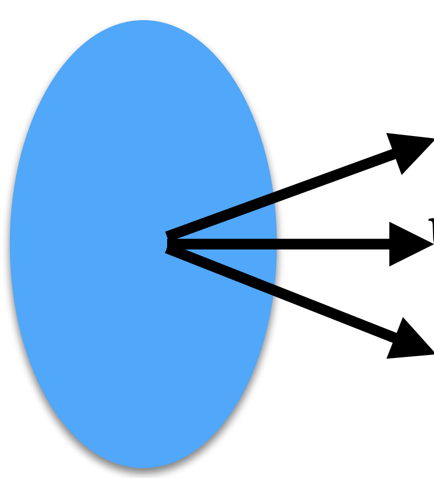
change the ϕ

$$\phi = \sum \frac{2}{n} v_n \sin(n(\phi - \Psi_n)) = \phi_0$$

A so-called "initial flow" is introduced at the initial stage.

v_n is controllable in the equation!

Ψ_{MP} is randomly choose form 0-2π

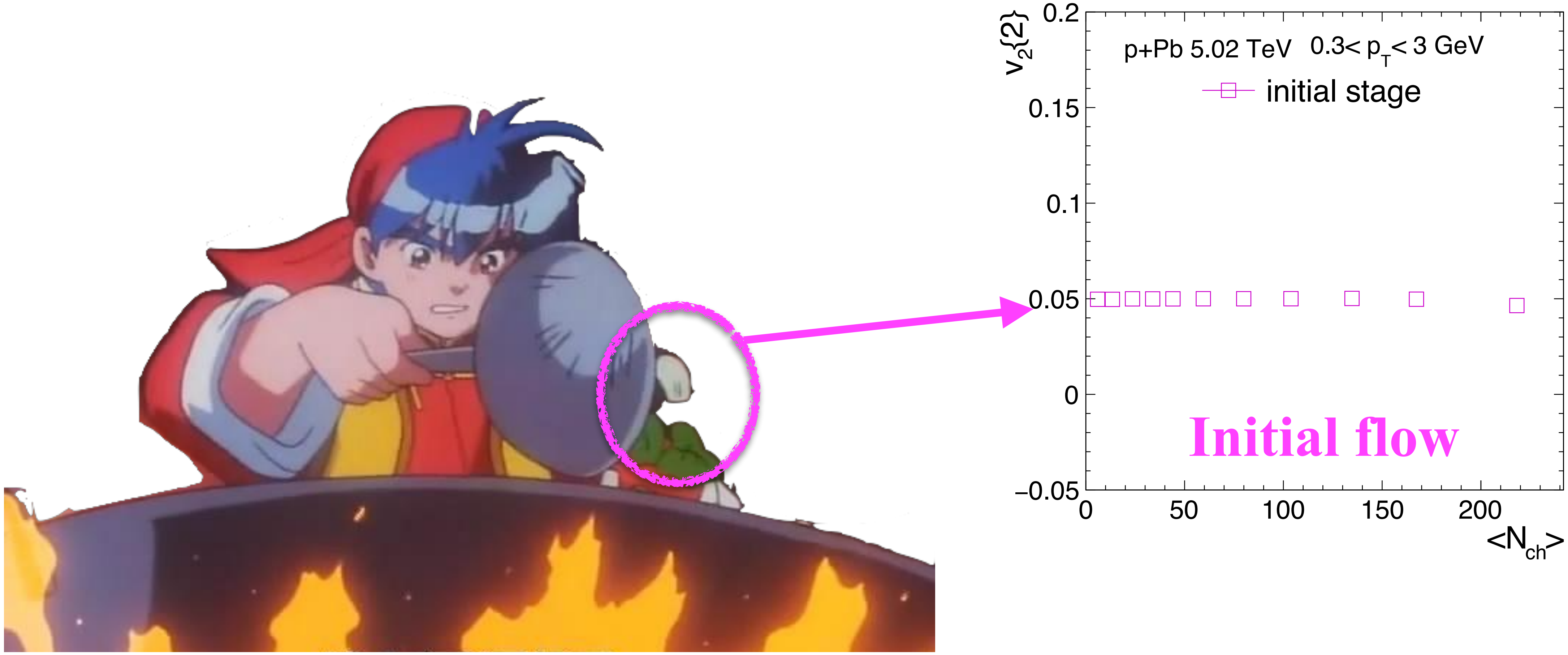


Ψ_{MP} initial momentum plane

Ψ_{PP} initial geometry plane

Ψ_{EP} final state flow event plane

Simplify the idea



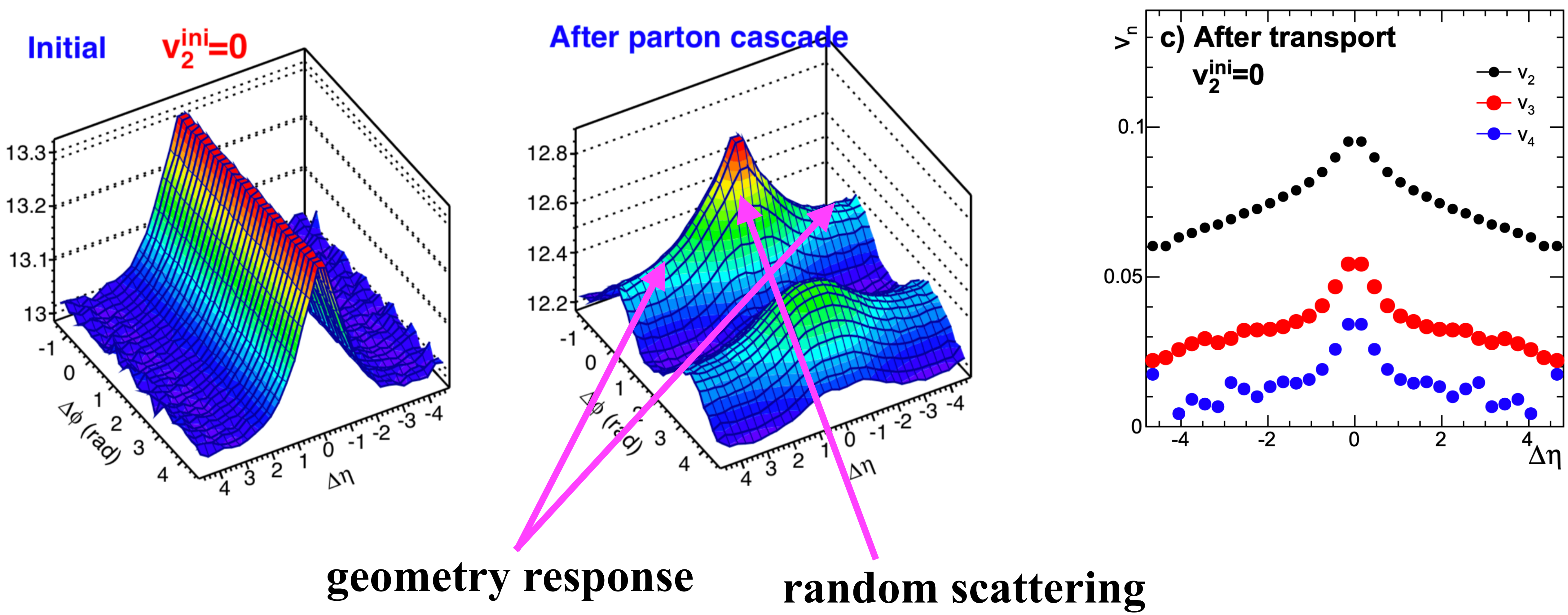
Initial flow **Final-state interaction**

vs.

=

Test with AMPT

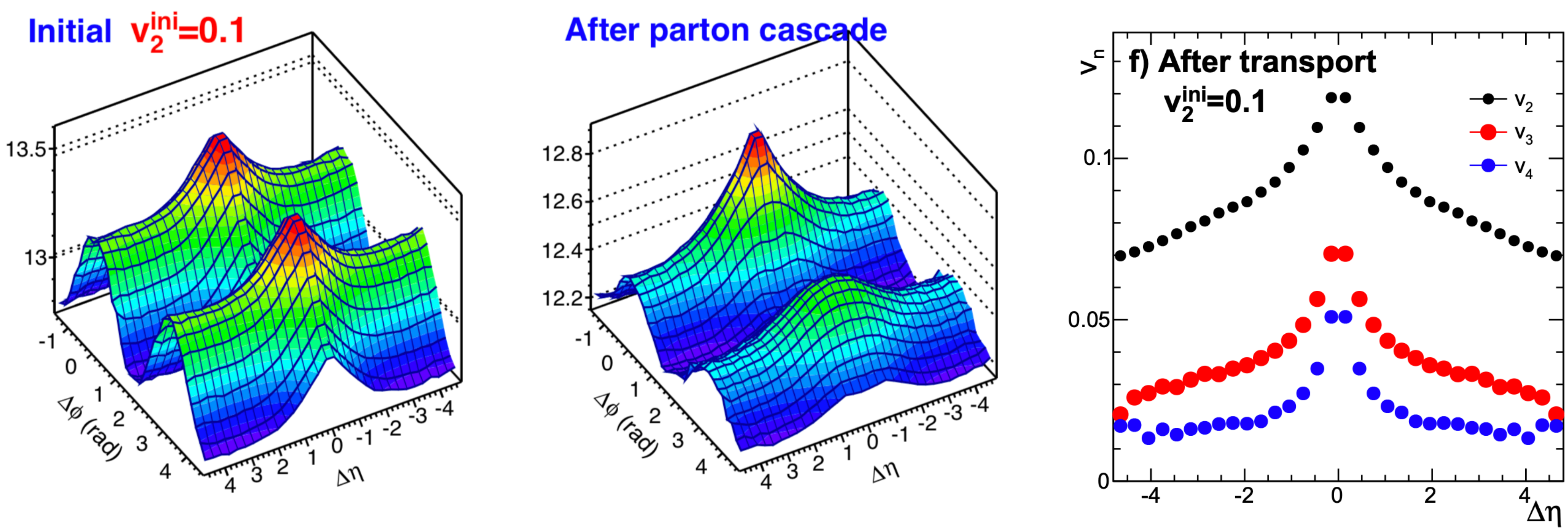
- randomize azimuthal angle of the parton, $v_2^{ini} = 0$



- long-range correlation (LRC) -> geometry response
- short-range correlation (SRC) -> non-equilibrium dynamics

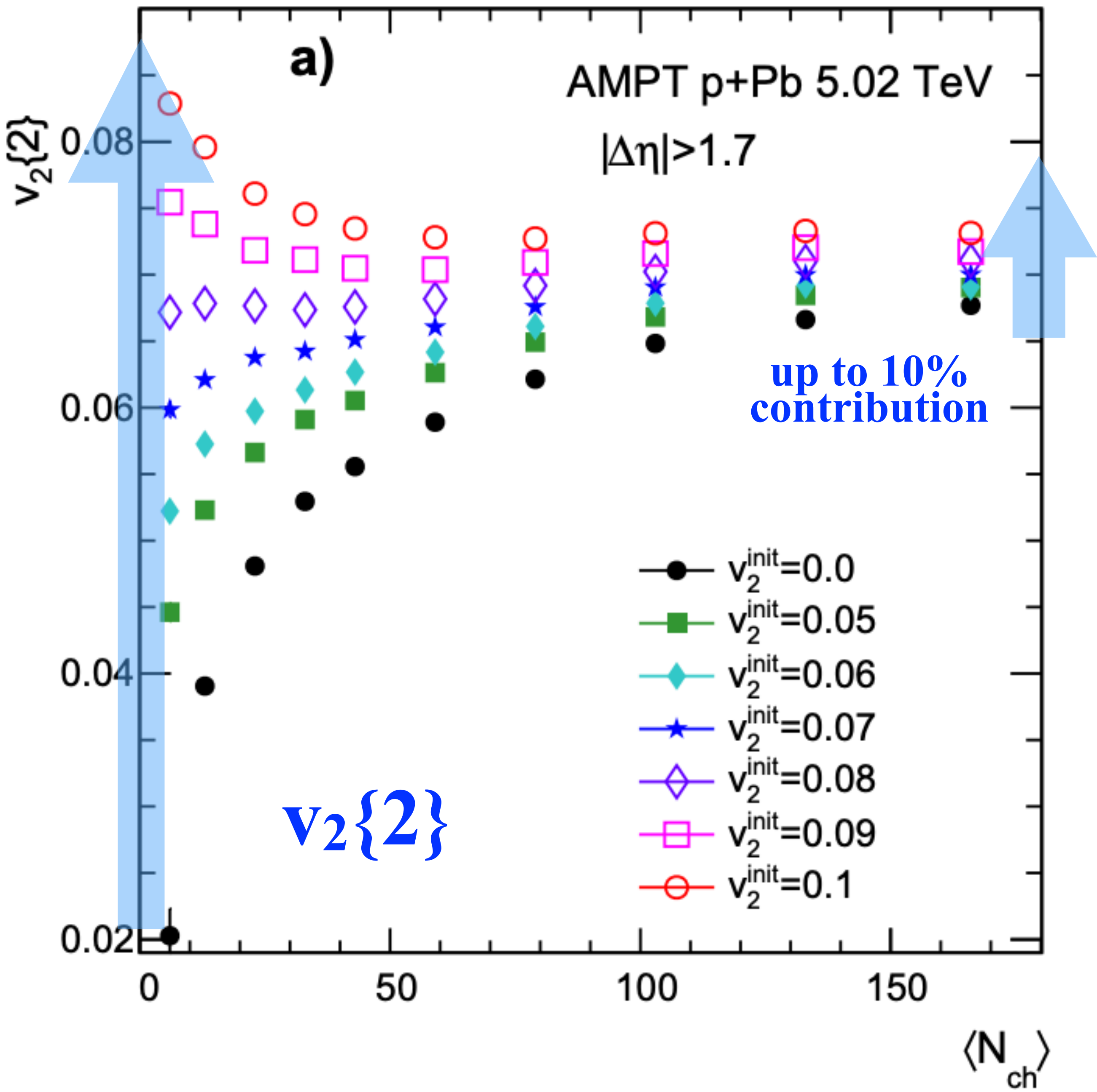
Test with AMPT

- **With an input v_2^{ini} = 0.1 at initial stage**



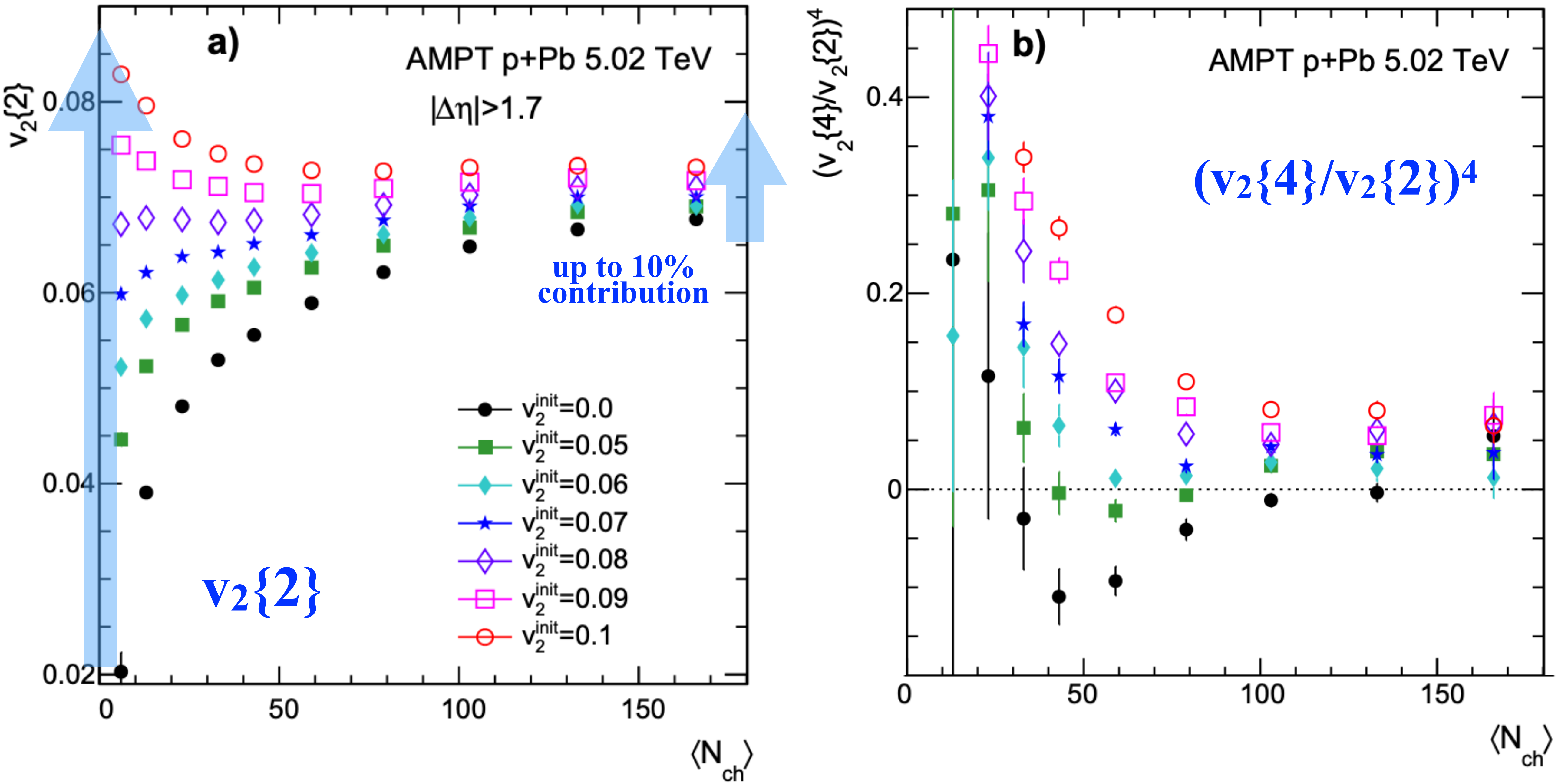
A simultaneous study of LRC and SRC are essential to disentangle the geometry response and non-equilibrium behavior.

Influence of final flow by initial flow



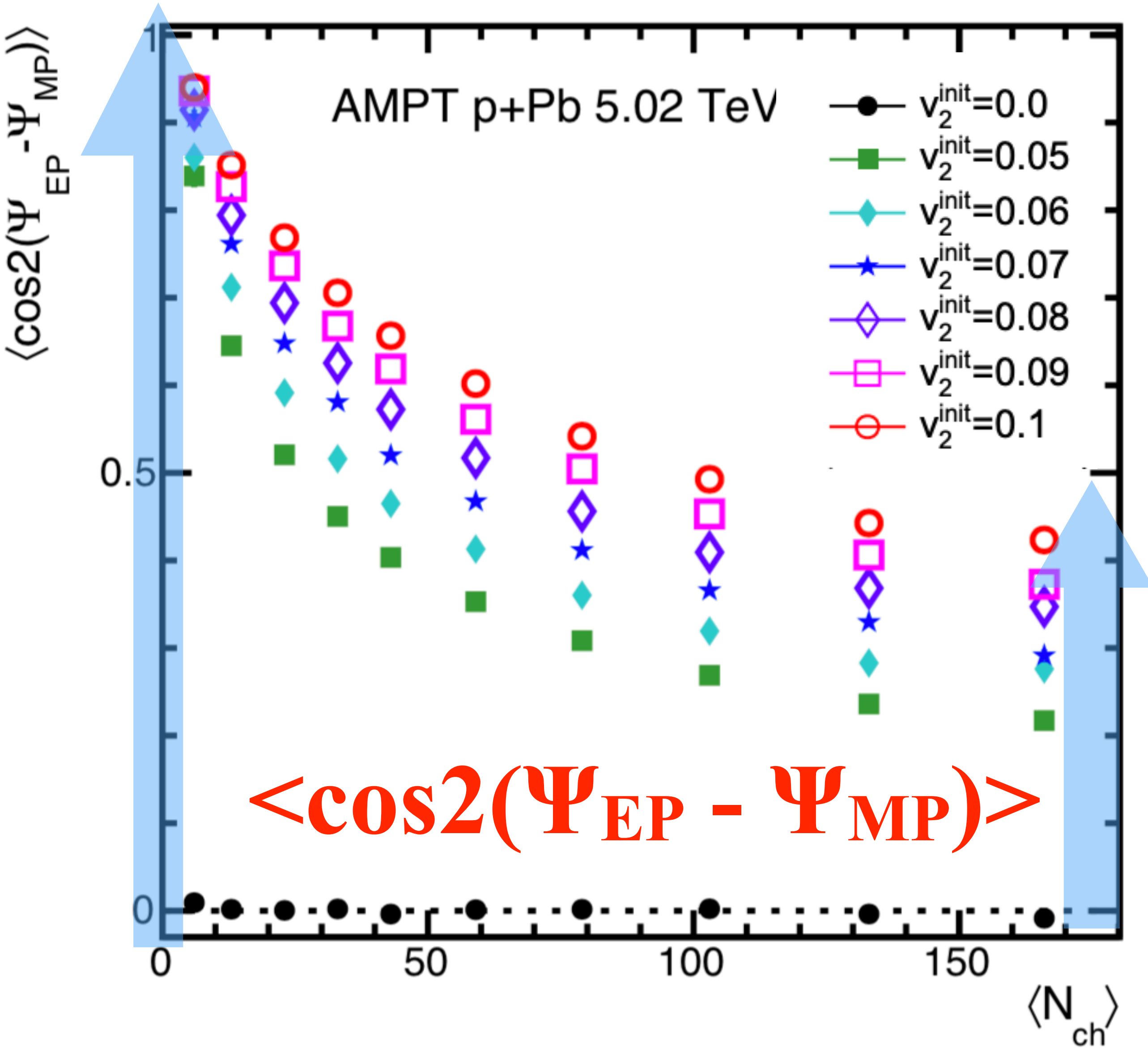
- **Low Nch:** **final flow strongly biased by initial flow.**
- **High Nch:** **final flow increases slowly with initial flow.**

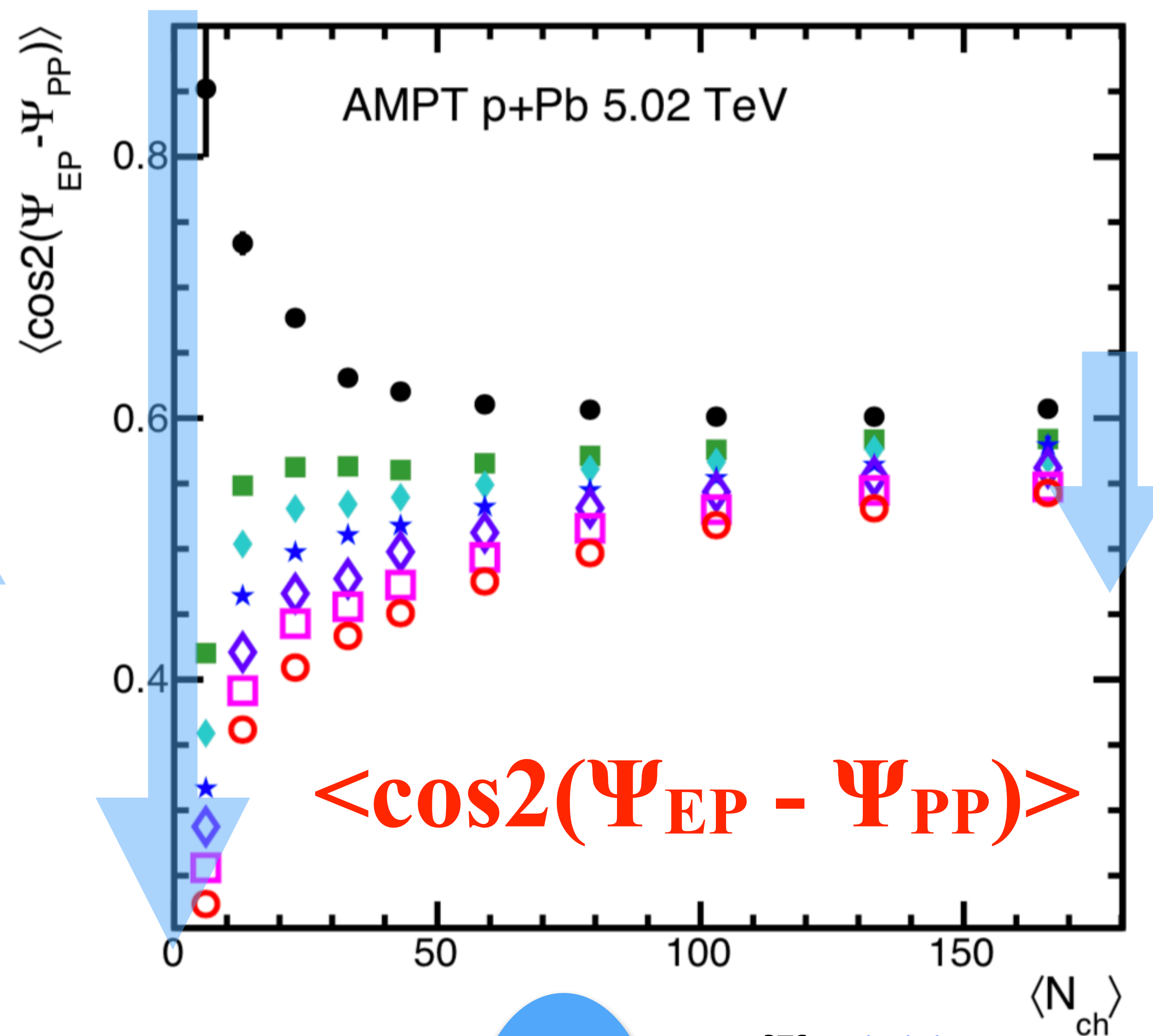
Influence of final flow by initial flow



- **Low Nch:** final flow strongly biased by initial flow.
- **High Nch:** final flow increases slowly with initial flow.
- **Initial anisotropy survives and biases both the geometry-driven flow and flow fluctuation.**

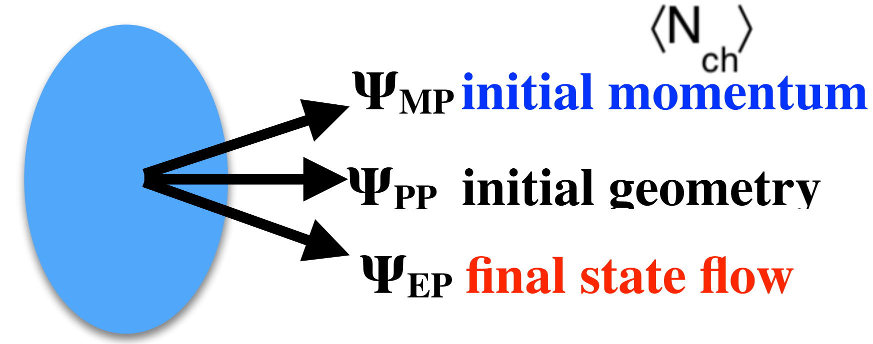
phase correlation





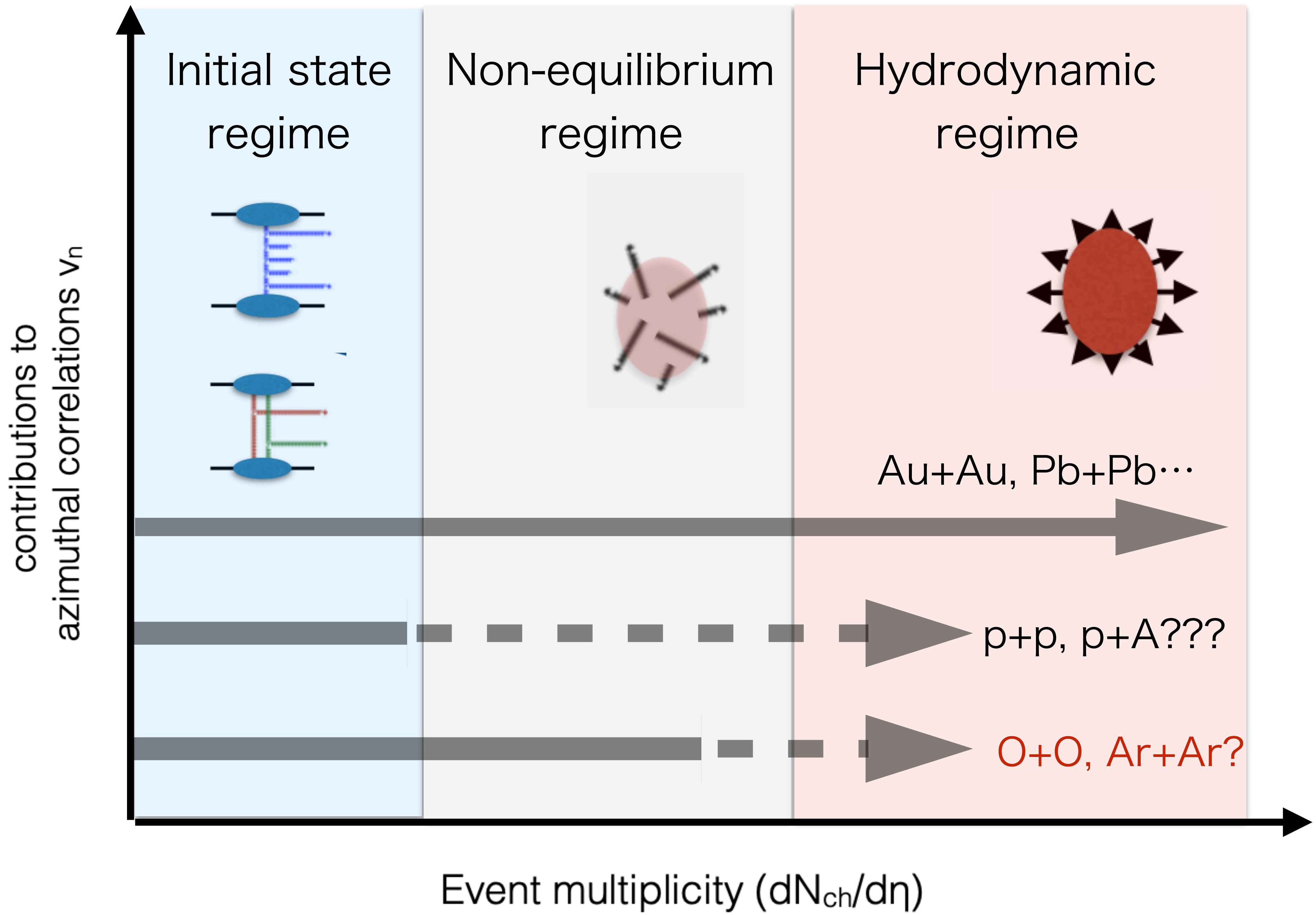
$\Psi_{EP}\sim\Psi_{MP}$

$\Psi_{EP}\sim\Psi_{PP}$



- **Final EP can be strongly biased by the initial flow.**
- **Final EP is more influenced at low Nch and less influenced at high Nch.**

What do we learn so far…



- **The final flow**(both magnitude and phase) **can be large influenced by the initial anisotropy, especially at low Nch.**
- **Smaller systems (O+O, Ar+Ar) can shed light on the mechanism of collectivity.**

Summary

- The presence of initial momentum anisotropy can change dramatically the final observed flow.

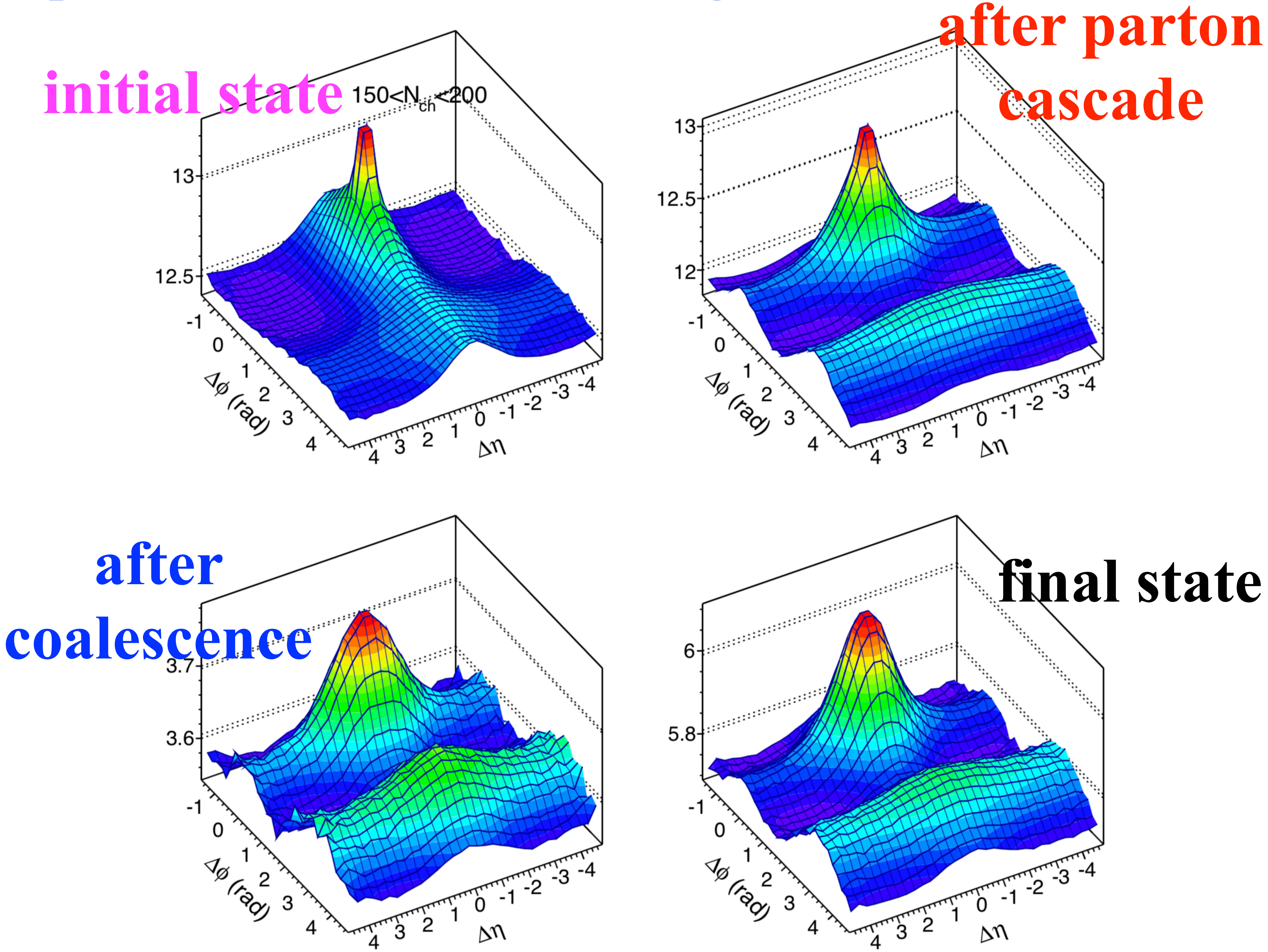
- Mere evidence for geometry response does not rule out possible large contributions from initial state in small systems.

- Disentangling these requires further detailed small system scan (O+O, Ar+Ar).

Backup

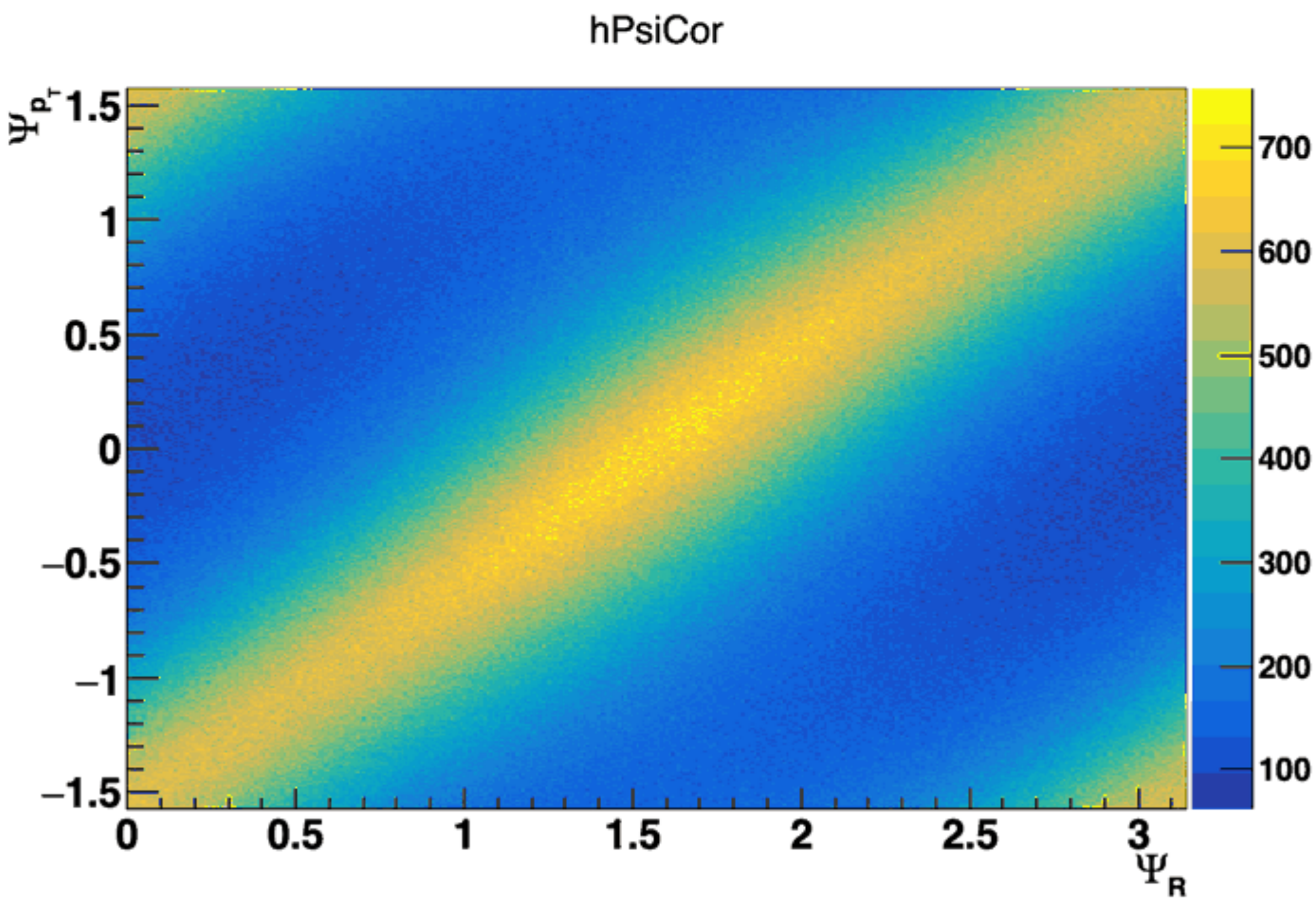
AMPT model

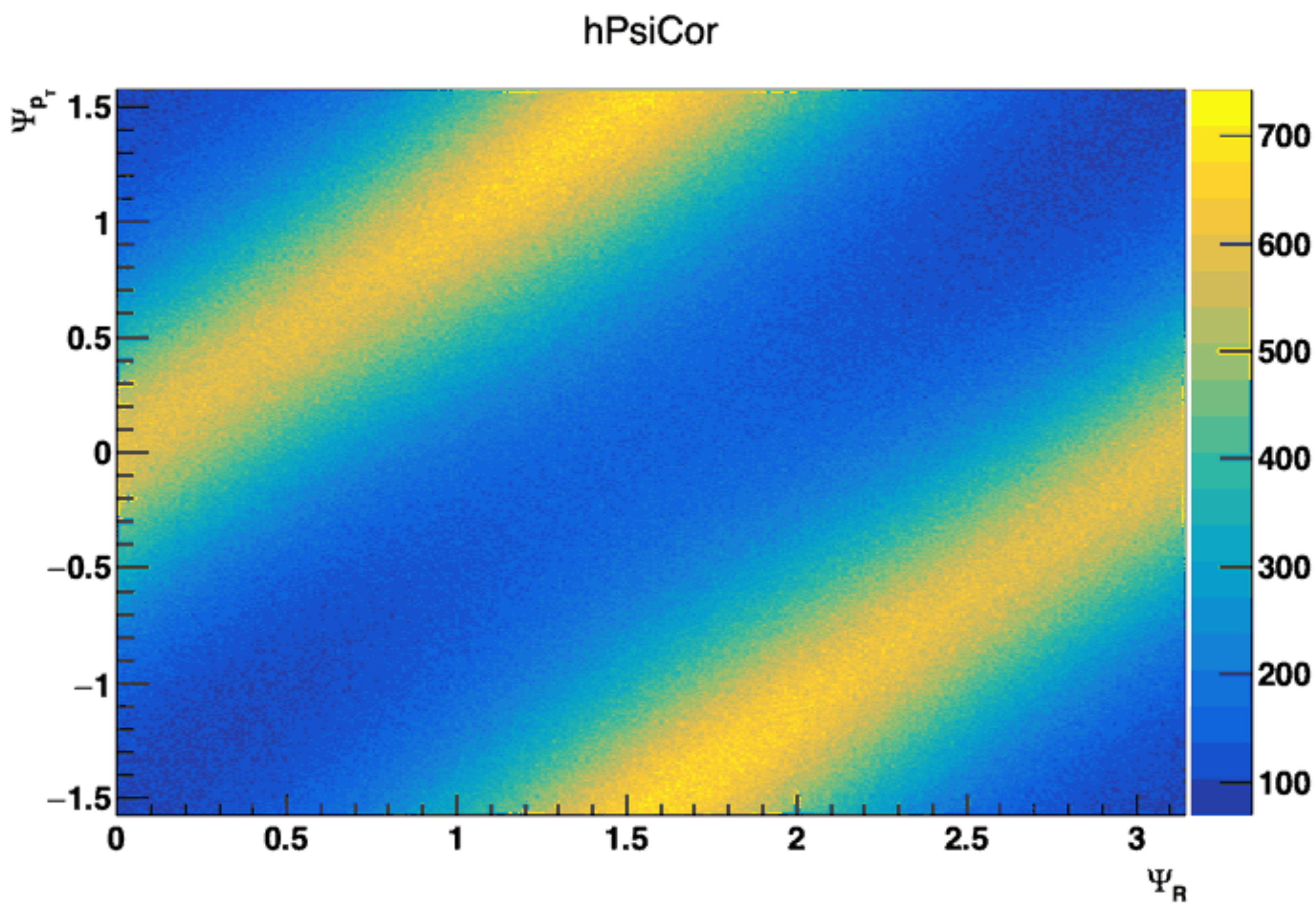
- eta-phi correlation for the four stages



Further investigation with fixed Ψ_{MP}

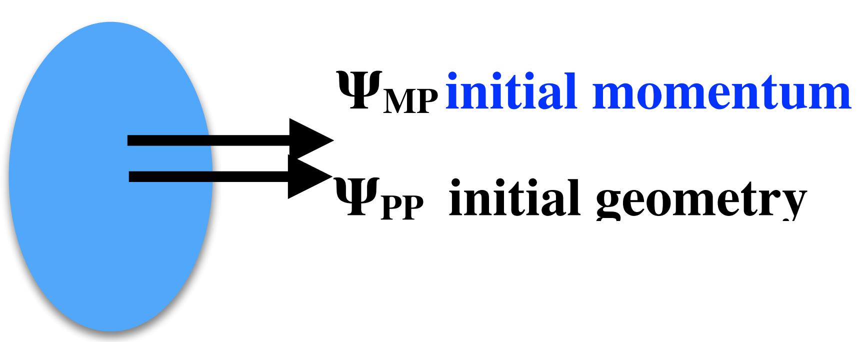
initial flow $v_2^{ini} = 0.05$

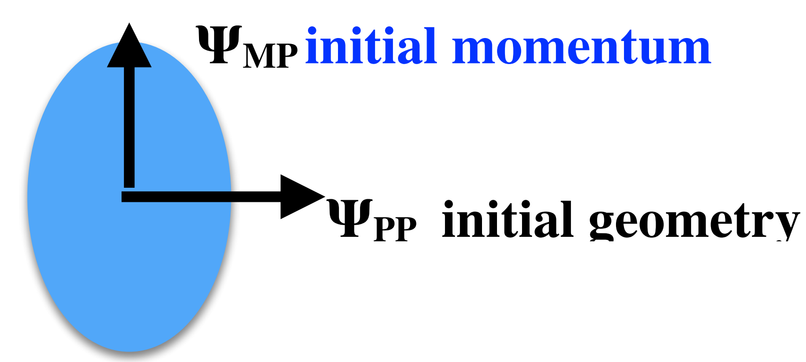




$\Psi_{MP} = \Psi_{PP}$

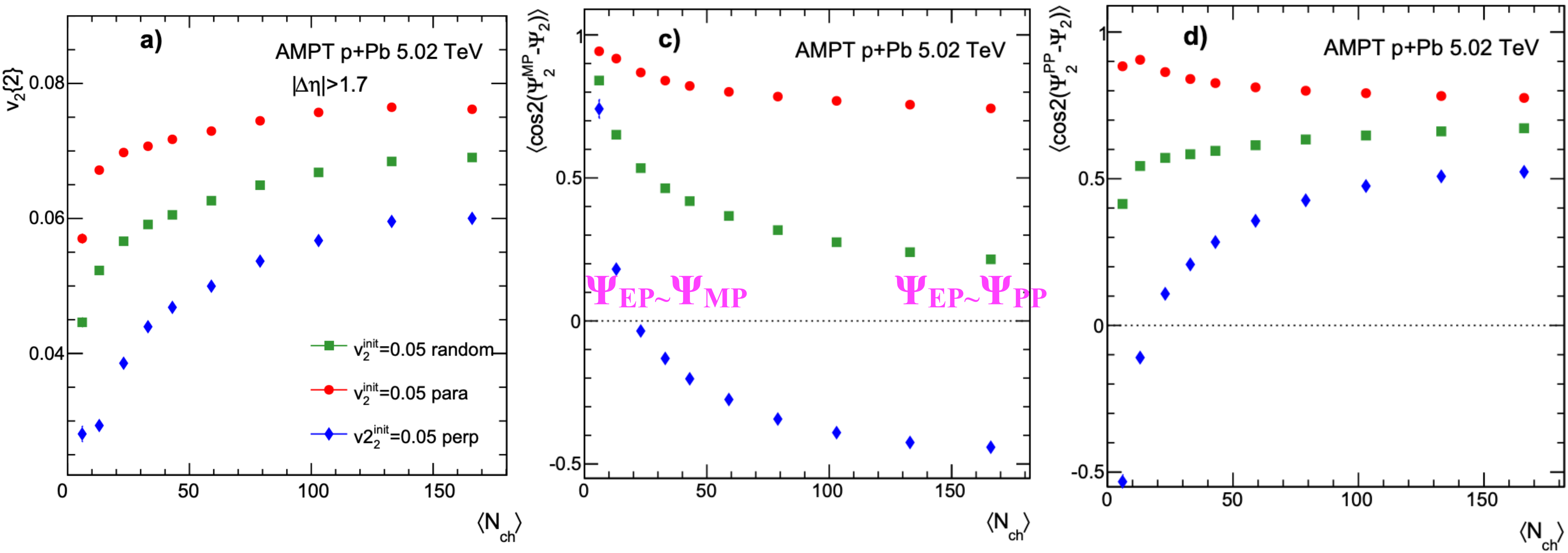
$\Psi_{MP} = \Psi_{PP} + \pi/2$

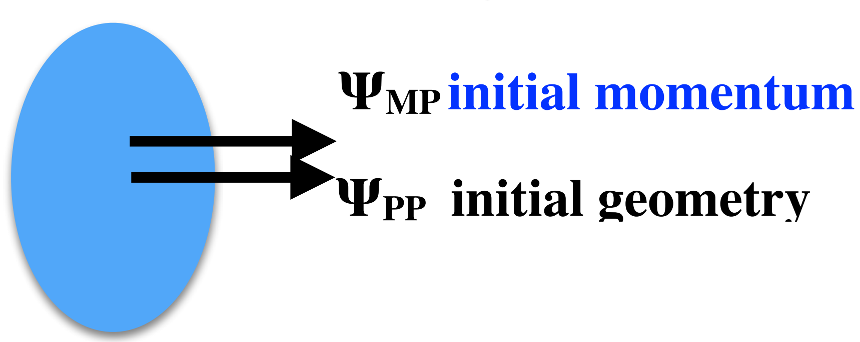


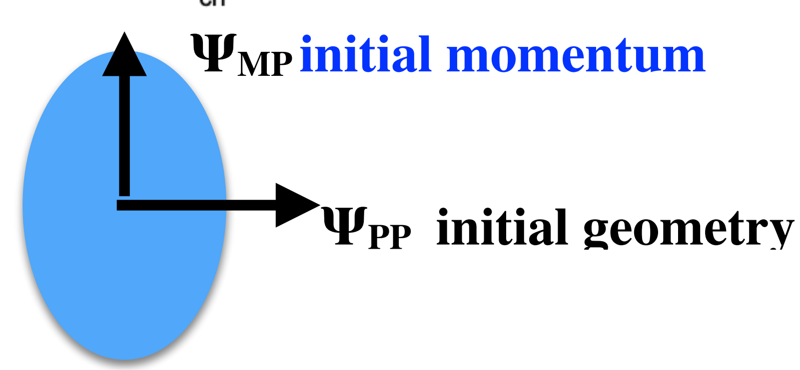


Further investigation with fixed Ψ_{MP}

$v_2\{2\}$ $\langle\cos 2(\Psi_{EP} - \Psi_{MP})\rangle$ $\langle\cos 2(\Psi_{EP} - \Psi_{PP})\rangle$

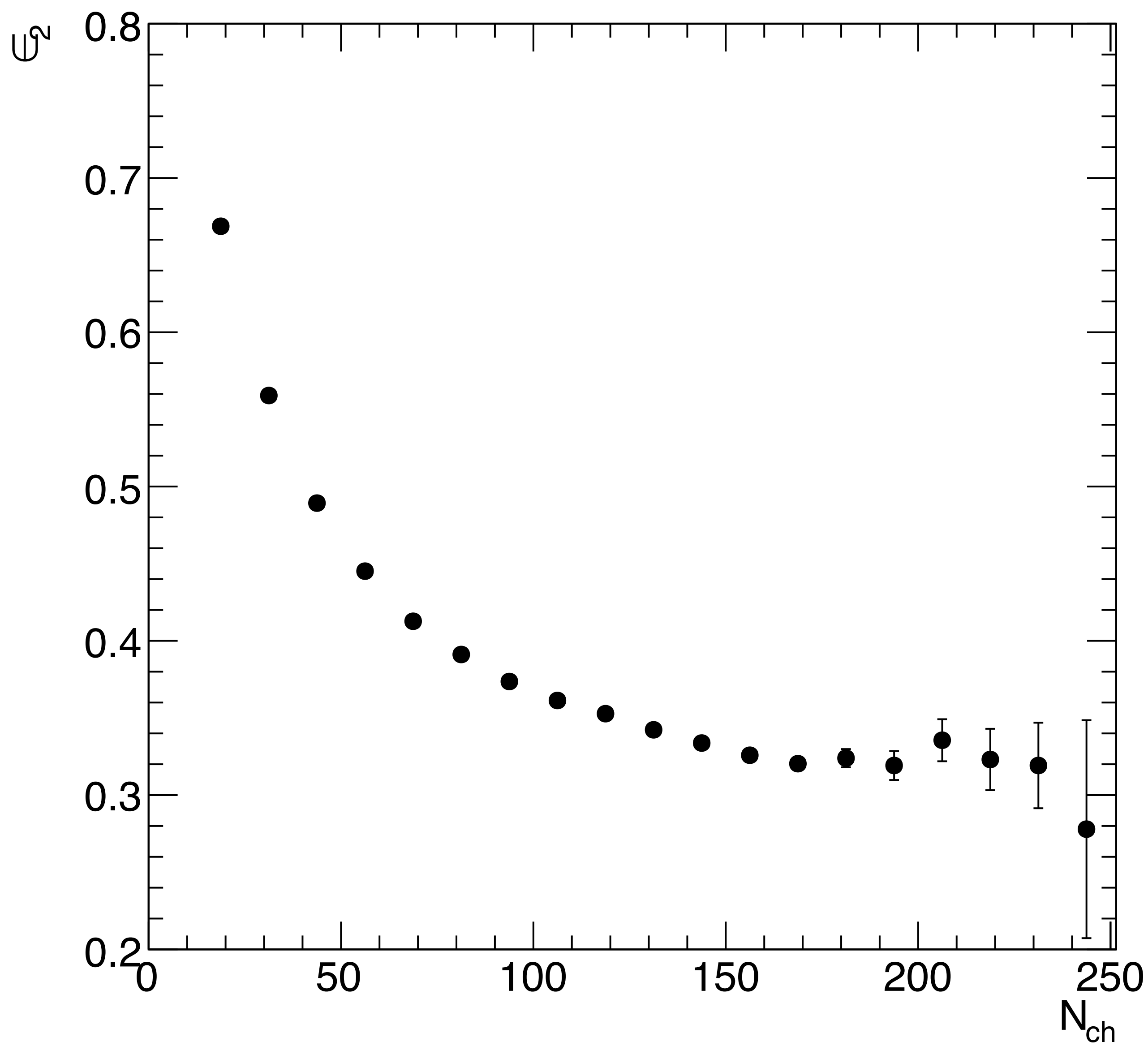




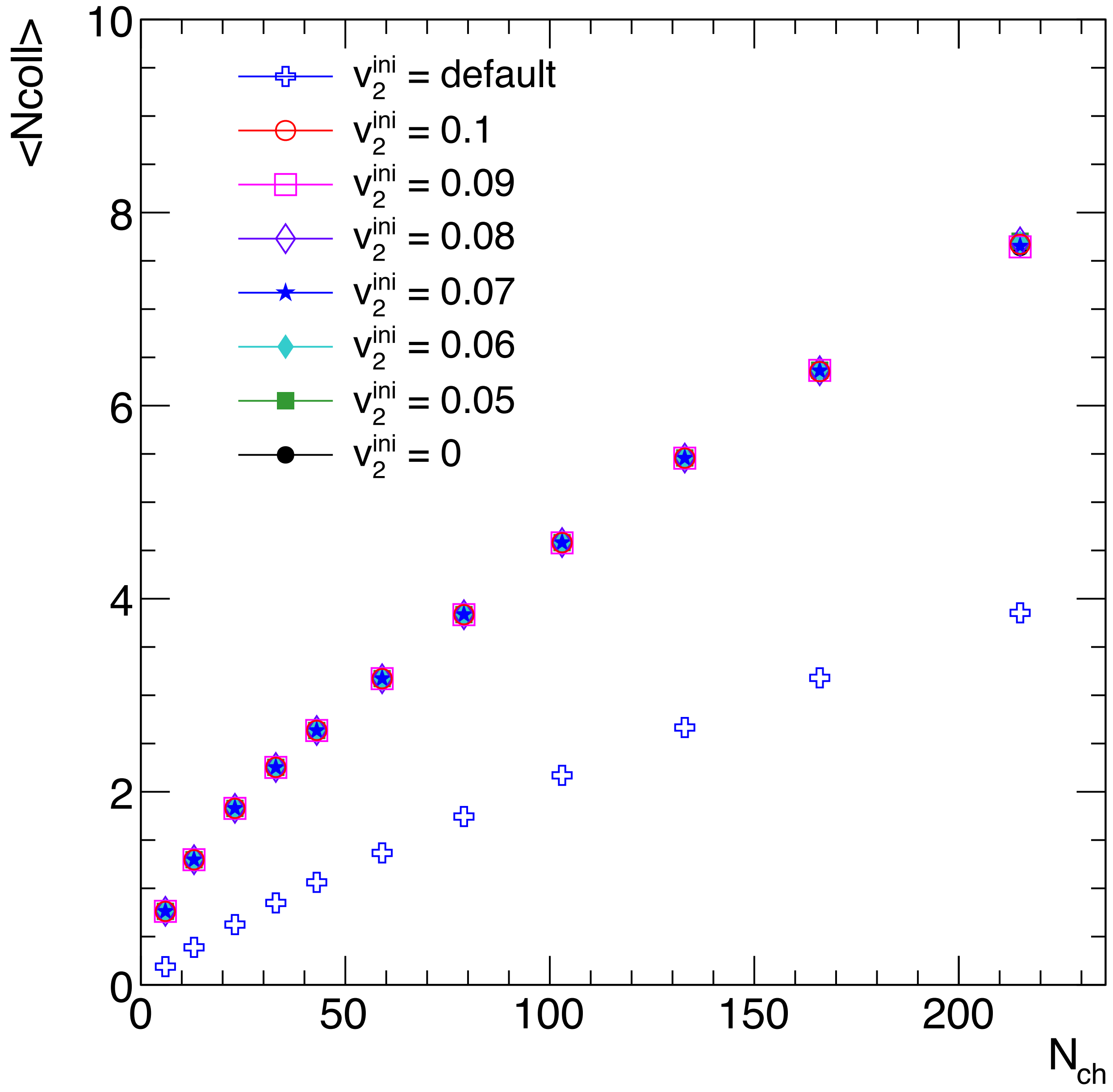


- **When Ψ_{MP} is aligned with Ψ_{PP}, the final v_2 and the angular correlations are stronger.**

eccentricity vs. Nch



<Ncoll> vs. Nch



<Ncoll>
10
8
6
4
2
0
0
50
100
150
200
N_ch
v_2^ini = default
v_2^ini = 0.1
v_2^ini = 0.09
v_2^ini = 0.08
v_2^ini = 0.07
v_2^ini = 0.06
v_2^ini = 0.05
v_2^ini = 0