KNEE STRUCTURE IN ELLIPTIC FLOW FROM HYDRODYNAMIC SIMULATIONS FOR U+U COLLISIONS

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THE OHIO STATE UNIVERSITY DEPARTMENT OF PHYSICS

JET Collaboration

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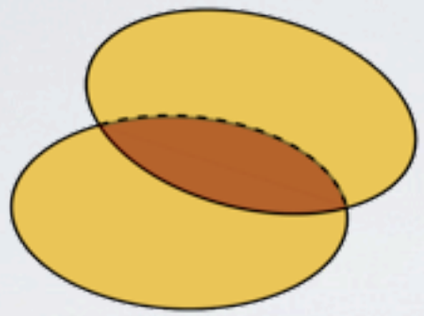
U+U versus Au+Au

U+U | Au+Au

Peripheral



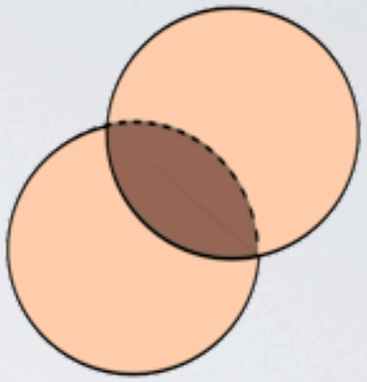


Illustration in the transverse plane

U+U versus Au+Au

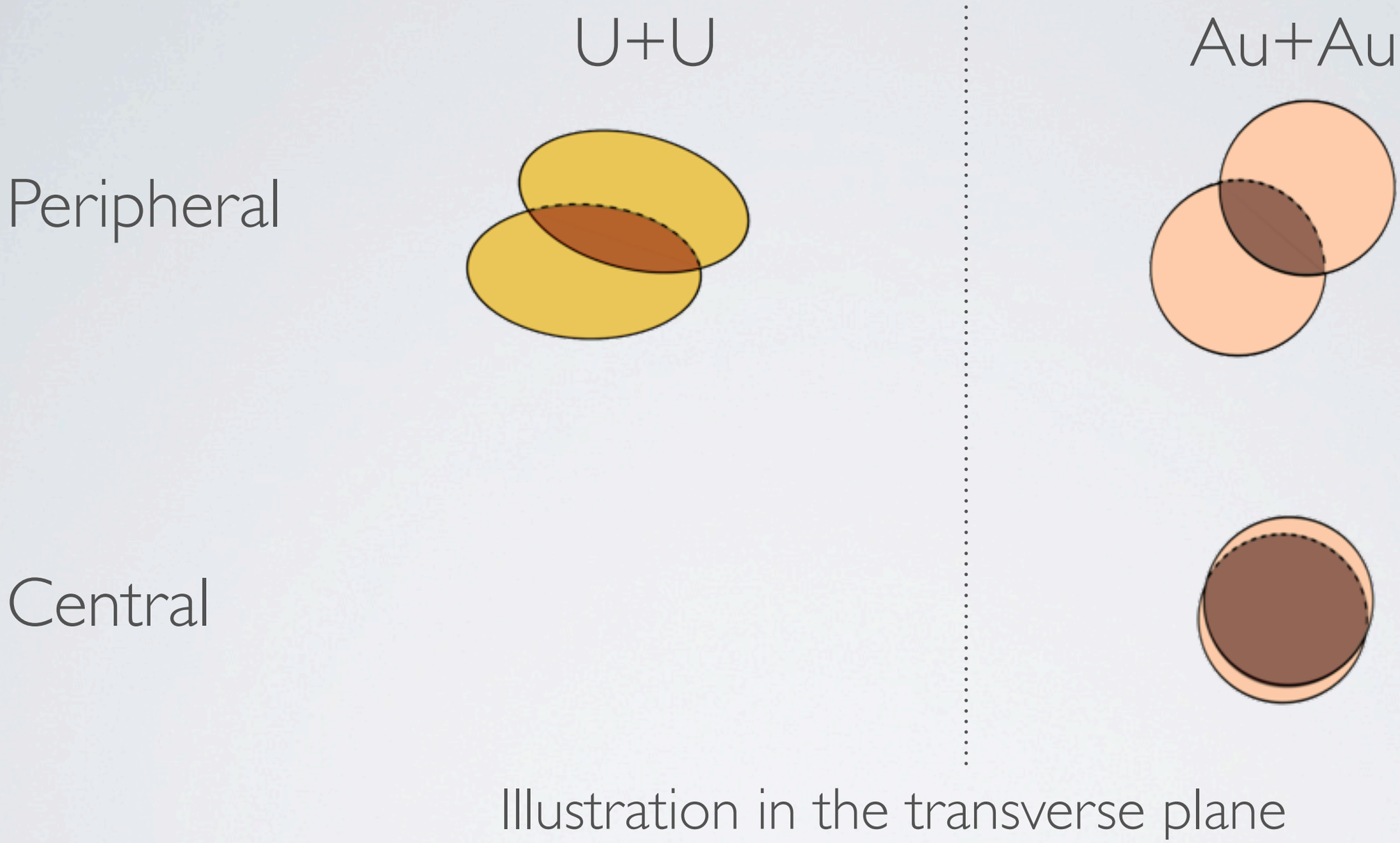


Illustration in the transverse plane

U+U versus Au+Au

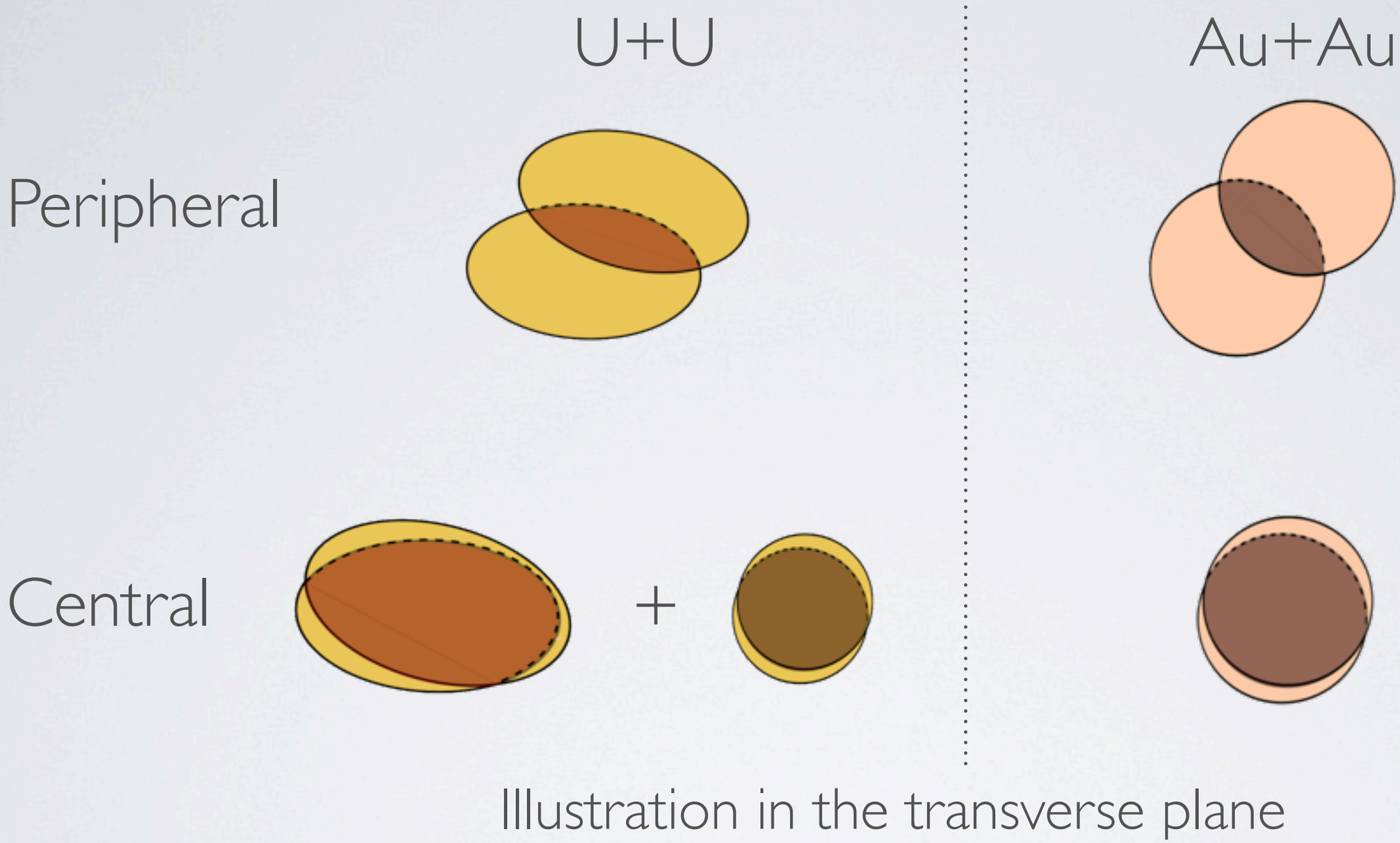
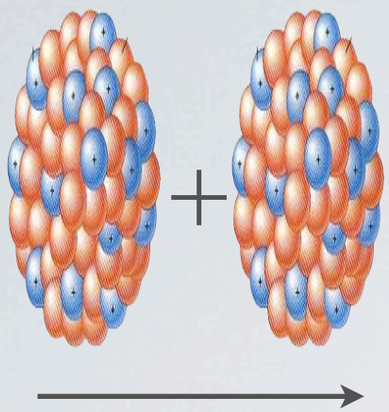


Illustration in the transverse plane

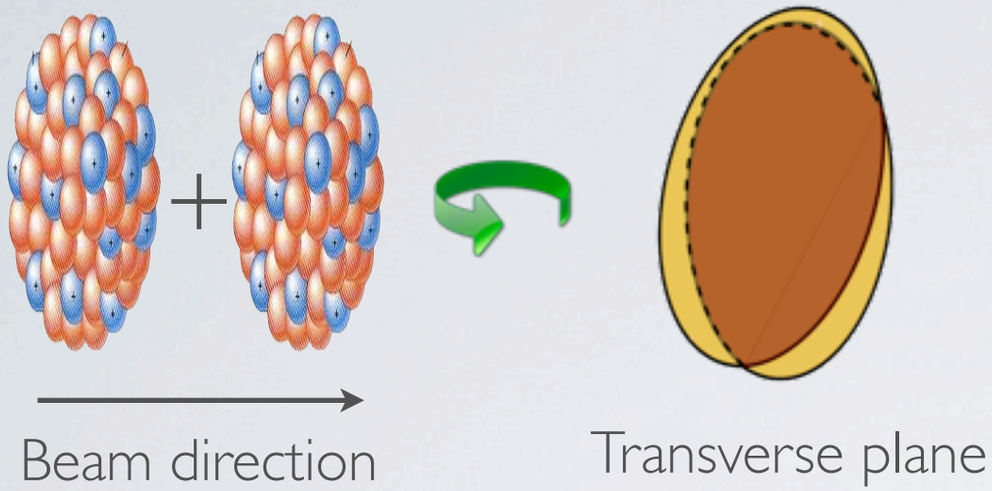
Two nuclei orientation configurations in central U+U collisions

What do we expect



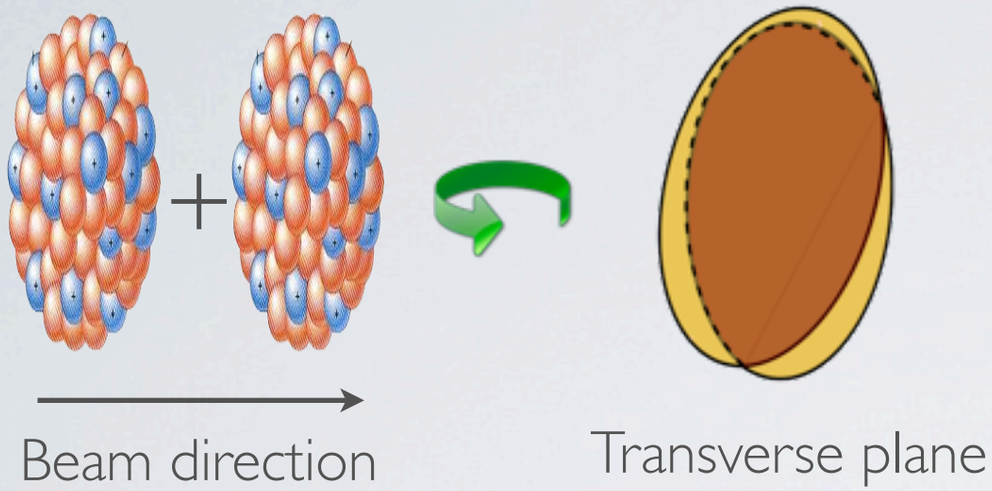
Beam direction

What do we expect



Side-side configuration

What do we expect



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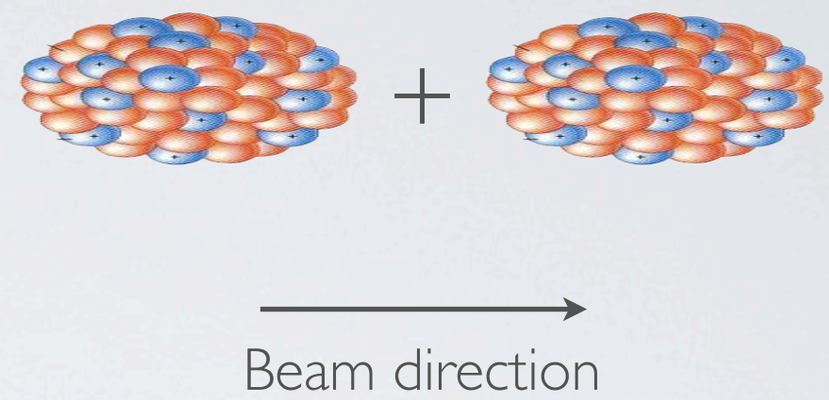
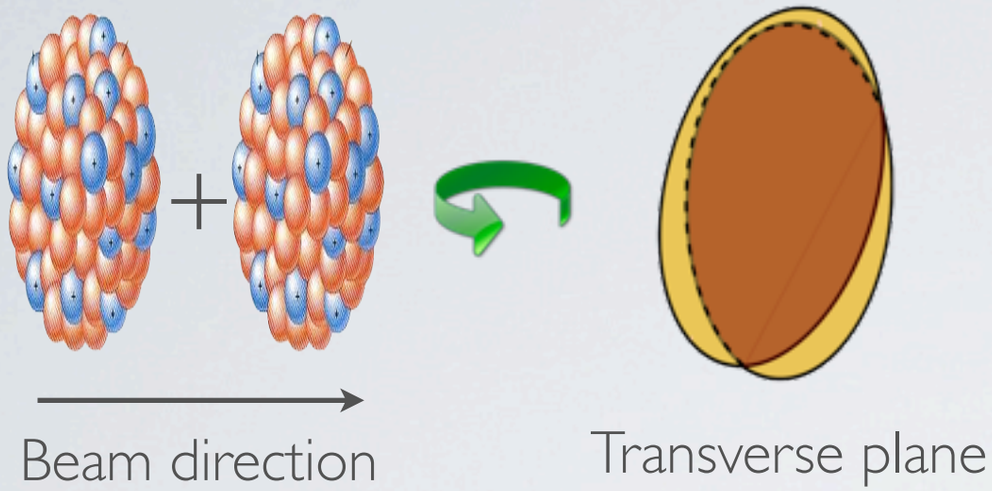
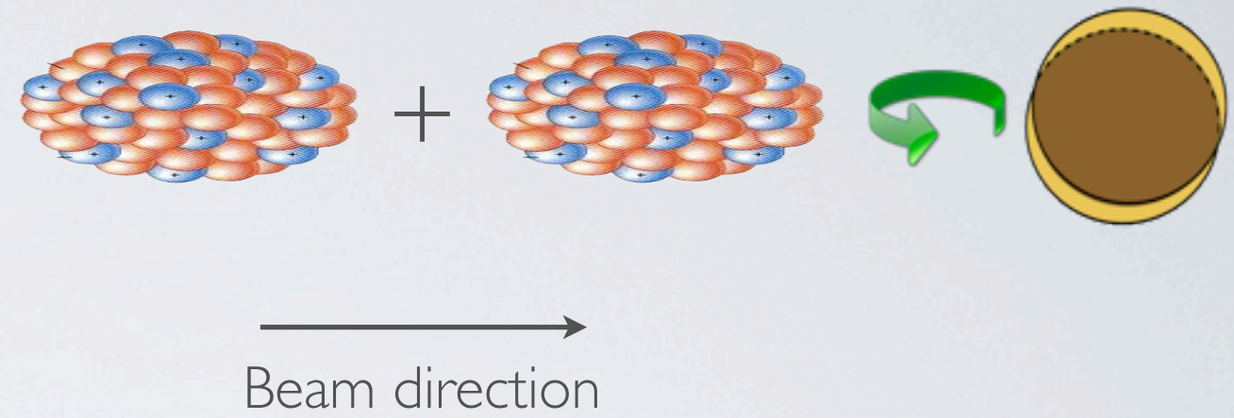


What do we expect

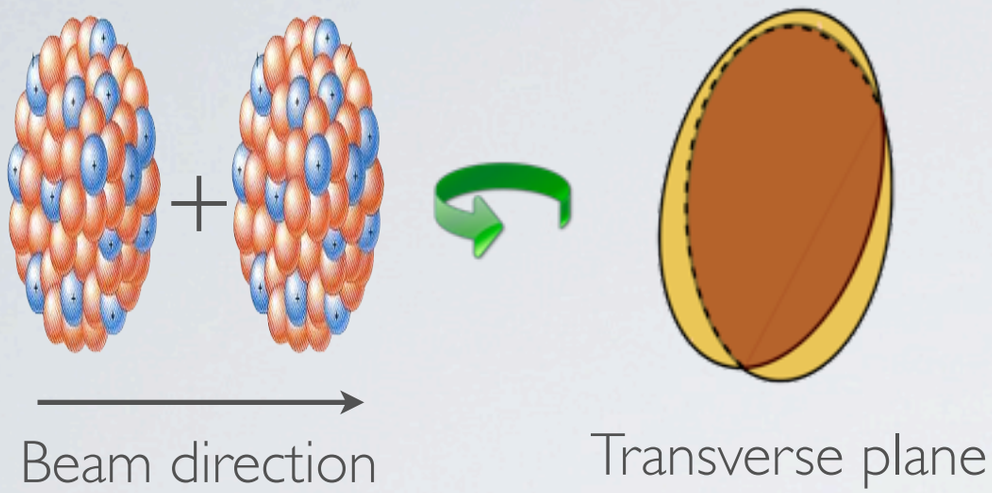


Side-side configuration

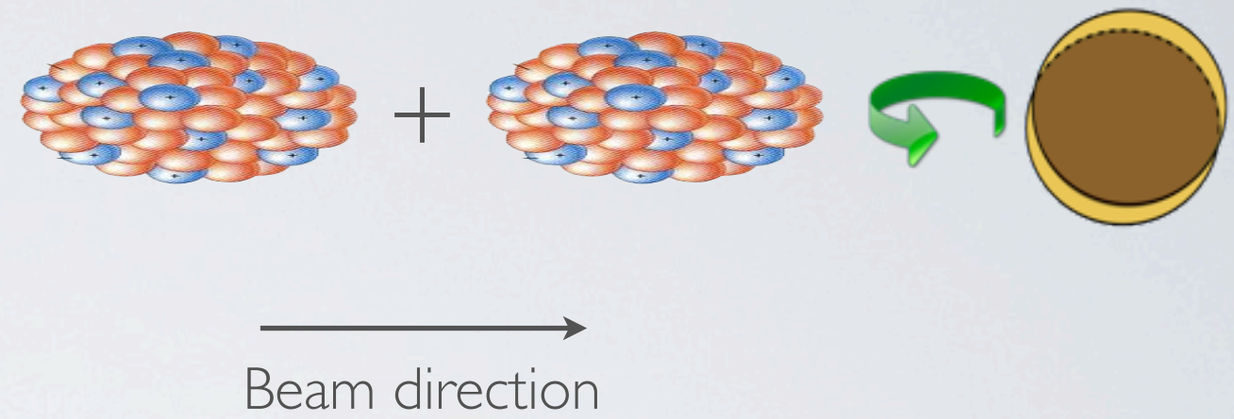


Tip-tip configuration

What do we expect



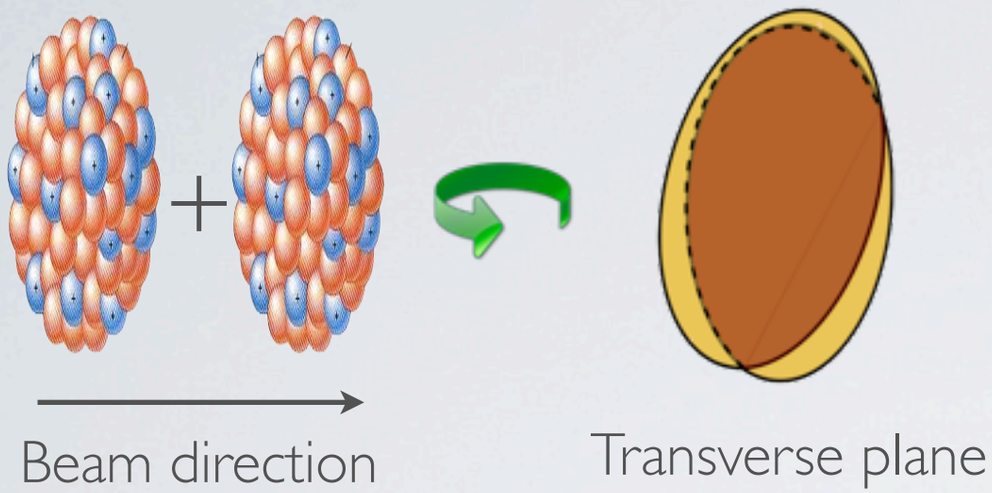
Side-side configuration



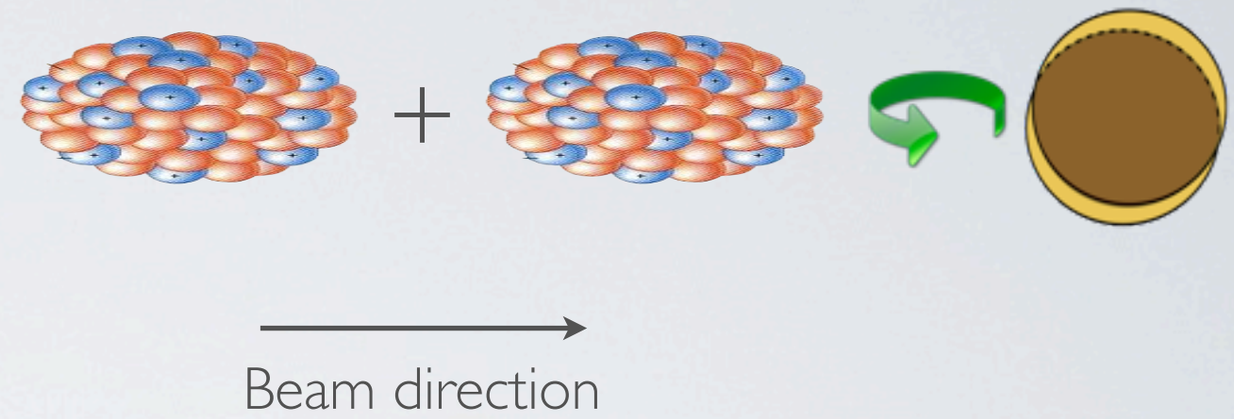
Tip-tip configuration

Same number of participant nucleons but different number of binary collisions.

What do we expect



Side-side configuration



Tip-tip configuration

Same number of participant nucleons but different number of binary collisions.

As we approach ultra-central events (selecting events with large dN/dy):

- Selecting more tip-tip configurations
- Overlap area drops
- Ellipticity (thus v_2) drops significantly

Setups for our calculation

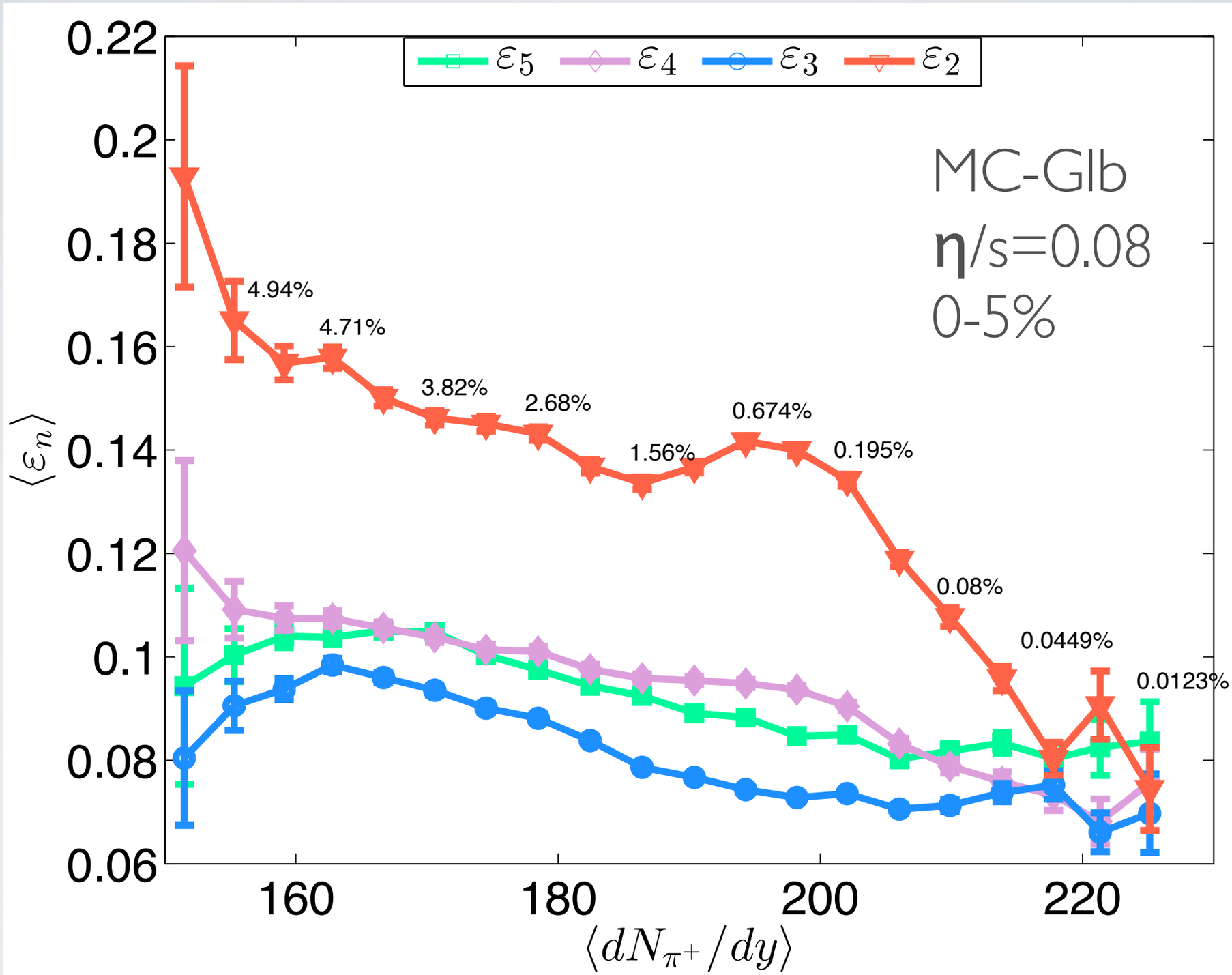
Event-by-event (33K) viscous ($\eta/s=0.08$) hydrodynamic simulations using MC-Glauber initial conditions.

- Parameters are chosen same as those that reproduce Au+Au collision observables @ 200 GeV.

- Only thermal π^+ are calculated (roughly x5 to get total charged particle yields).

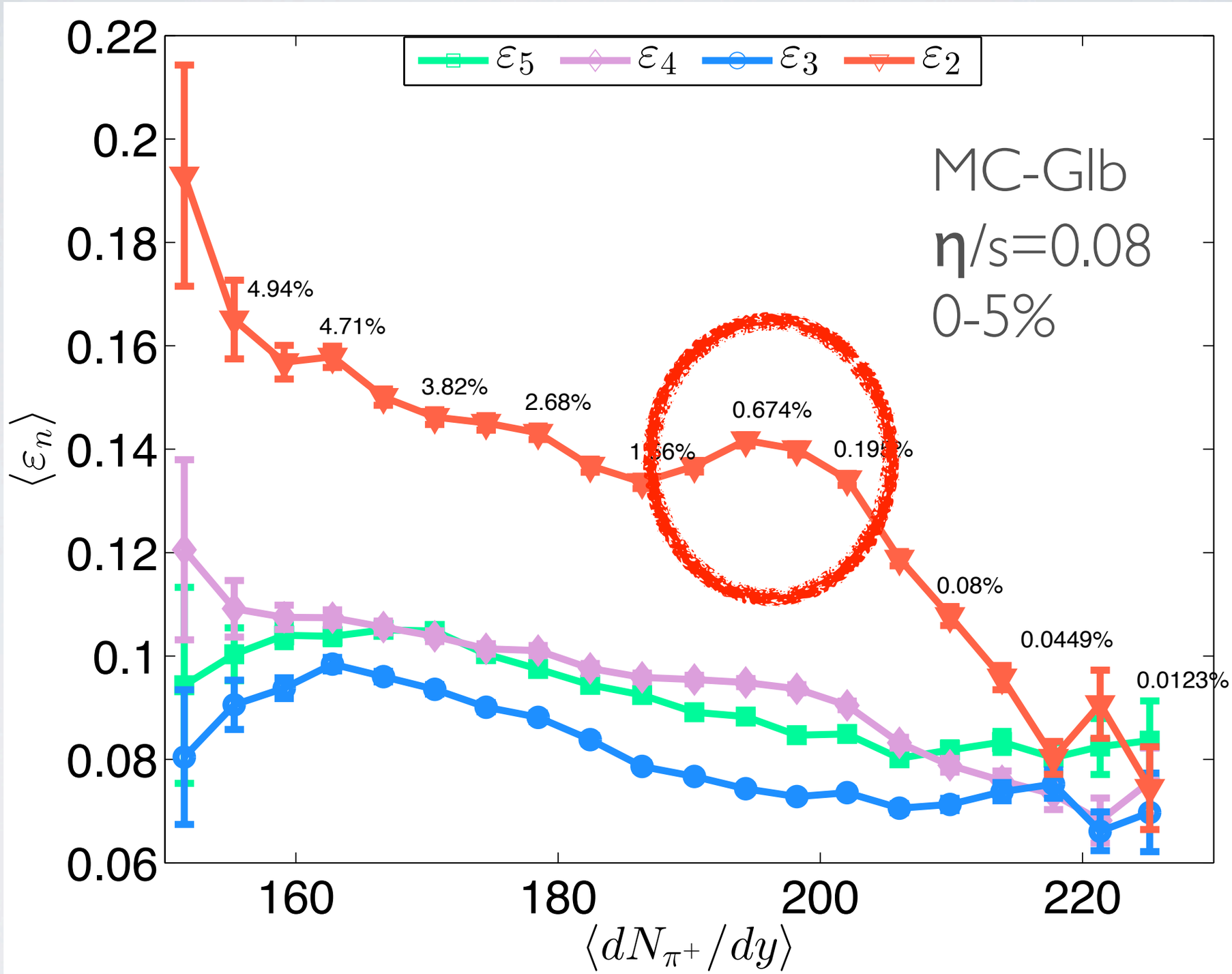
- Focus only in the ultra-central region (0-5%, with over-sampled events in 0-1%).

Eccentricities



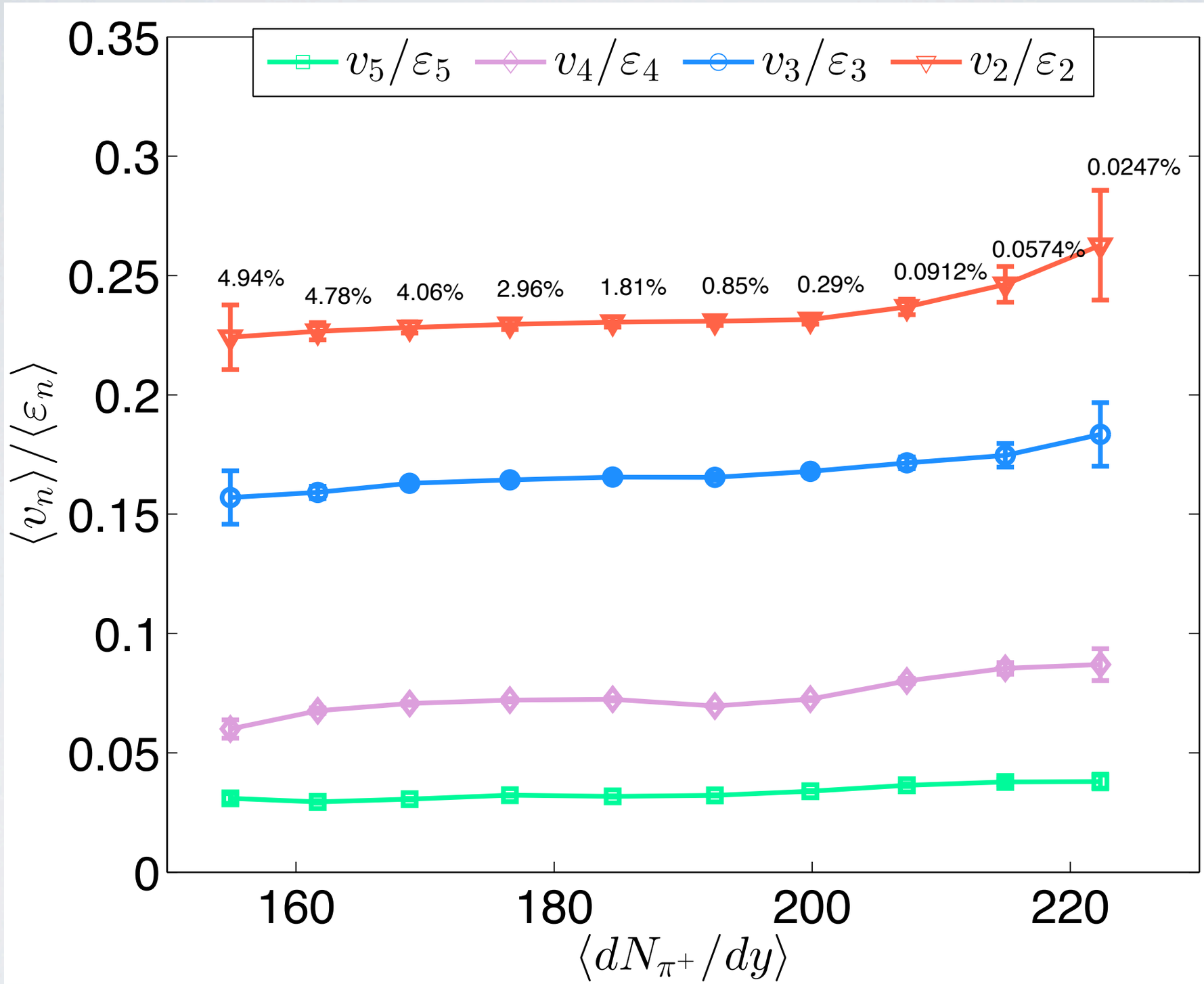
$$\varepsilon_n \, e^{in\Phi_n} = -\frac{\int dx\, dy\, r^n e^{in\phi}\, e(x,y)}{\int dx\, dy\, r^n\, e(x,y)}$$

Eccentricities



- ε_2 has "knee" structure at ~0.5% centrality, when plotted against dN/dy.
- $\varepsilon_{3,4,5}$ have no significant "knee" structure.

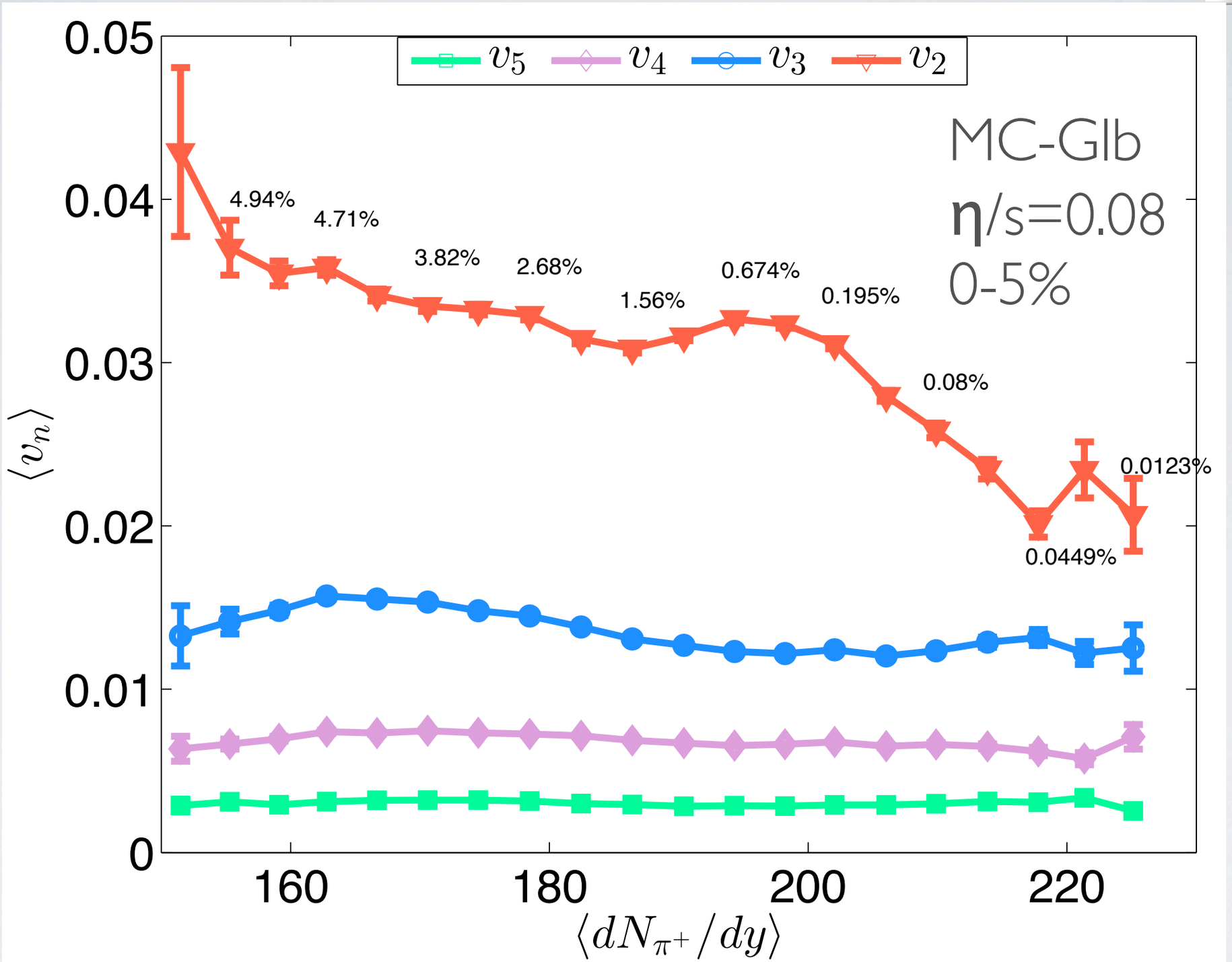
Conversion coefficient



MC-Glb
η/s=0.08
0-5%

✳ The conversion coefficient has little dependence on dN/dy.

Anisotropic flows (I)



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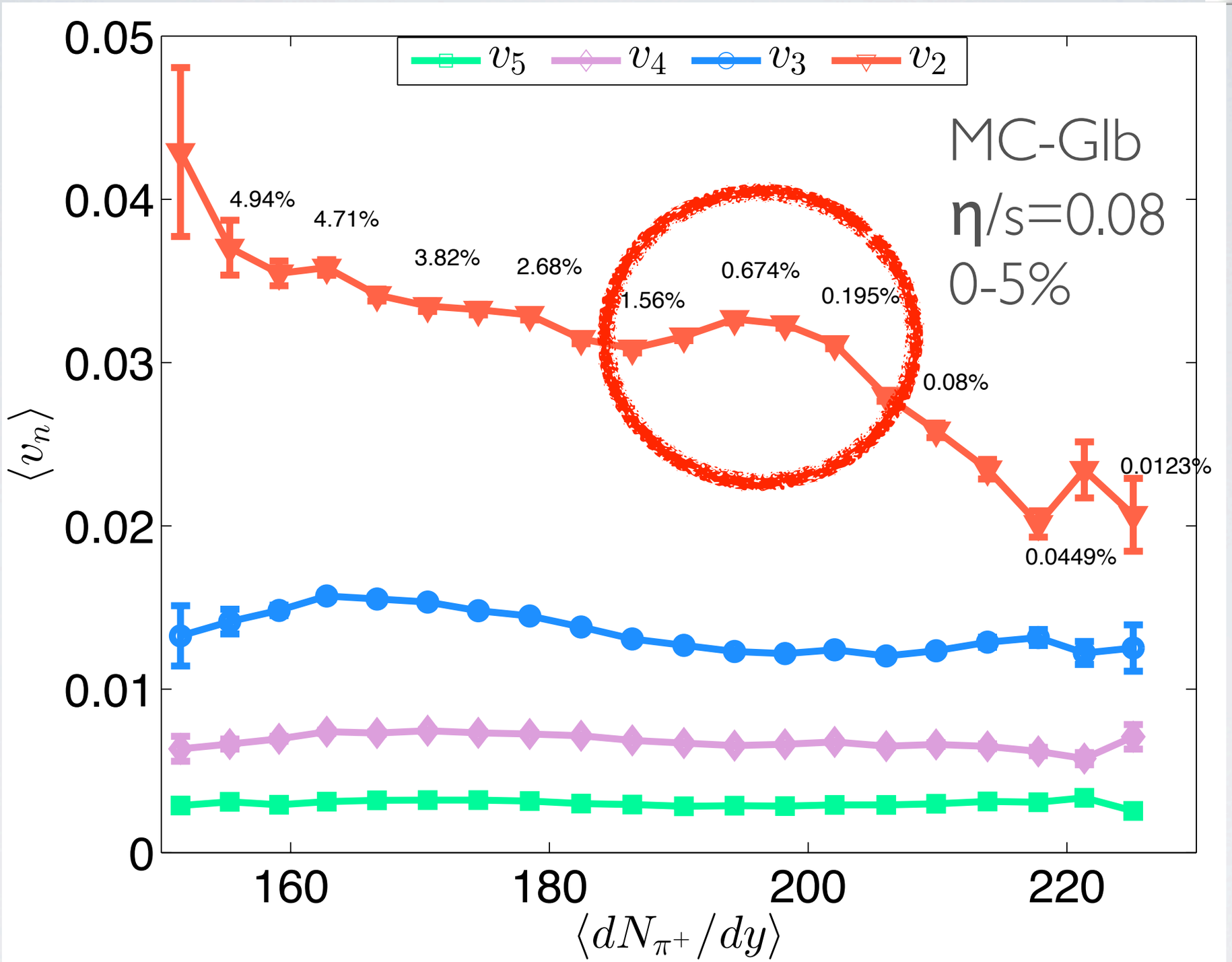
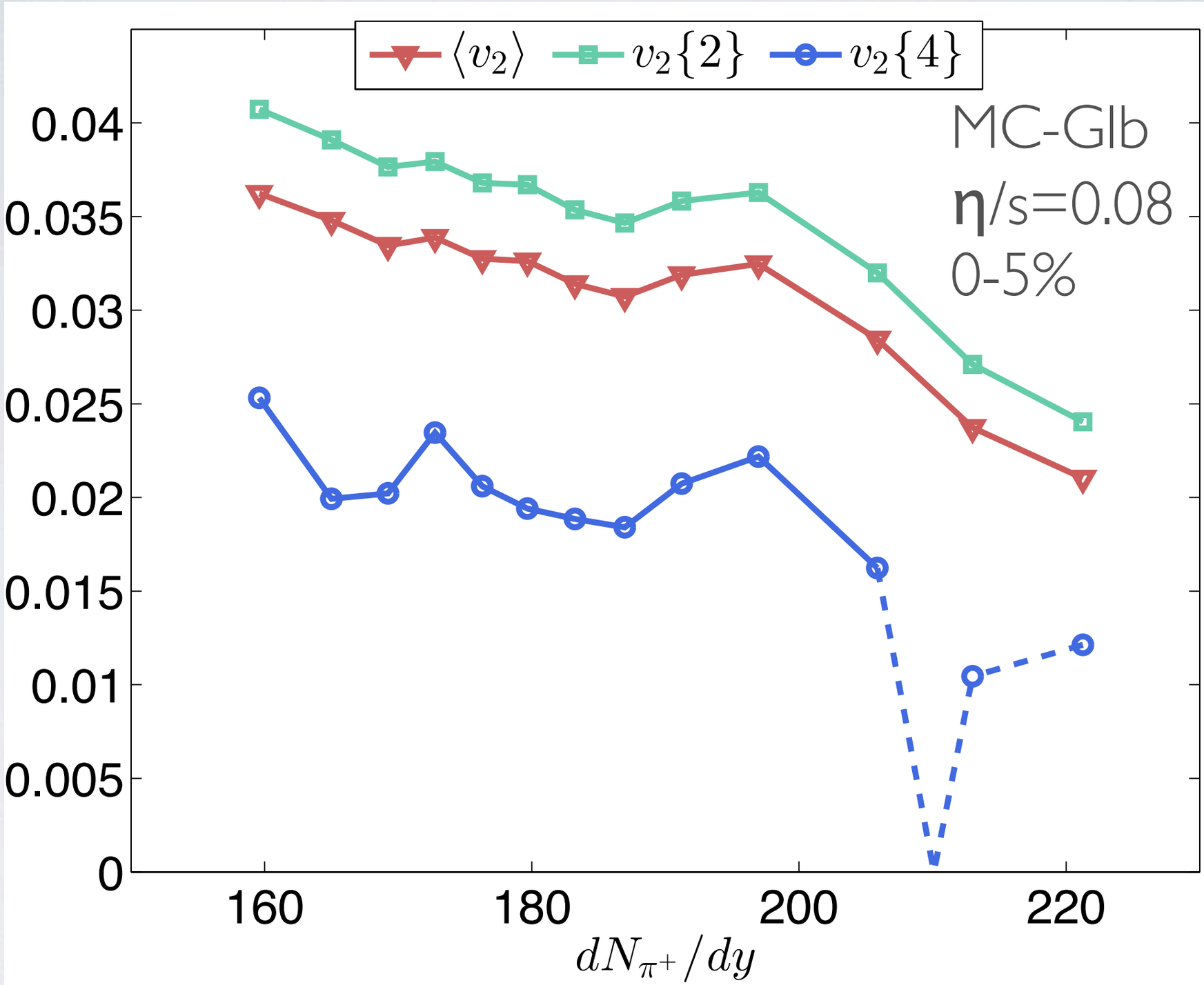


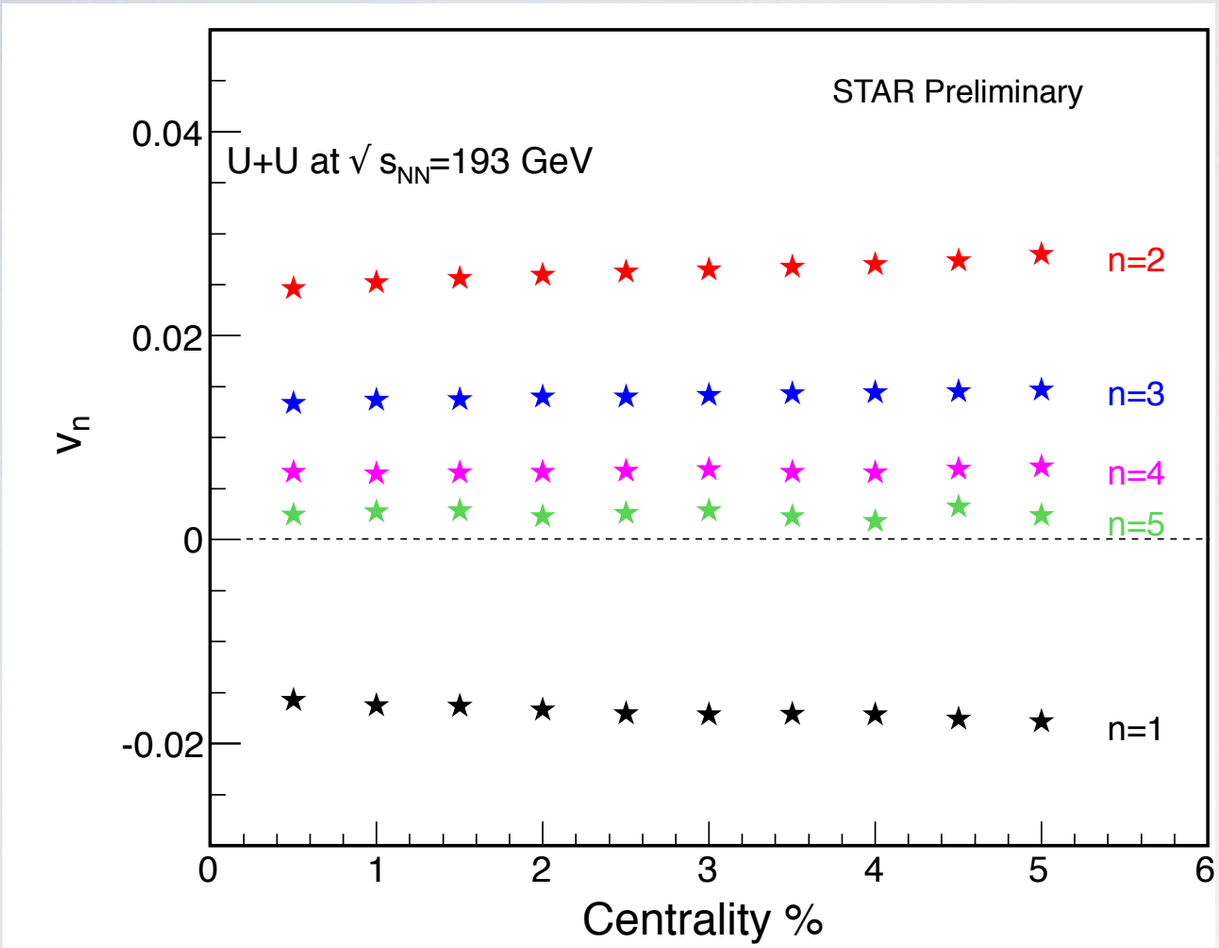
- v_2 has "knee" structure at ~0.5% centrality, when plotted against dN/dy.
- $v_{3,4,5}$ has no visible "knee" structures.

Anisotropic flows (II)



✳ Comparison among v_2, $v_2\{2\}$, and $v_2\{4\}$.

Anisotropic flows (III)

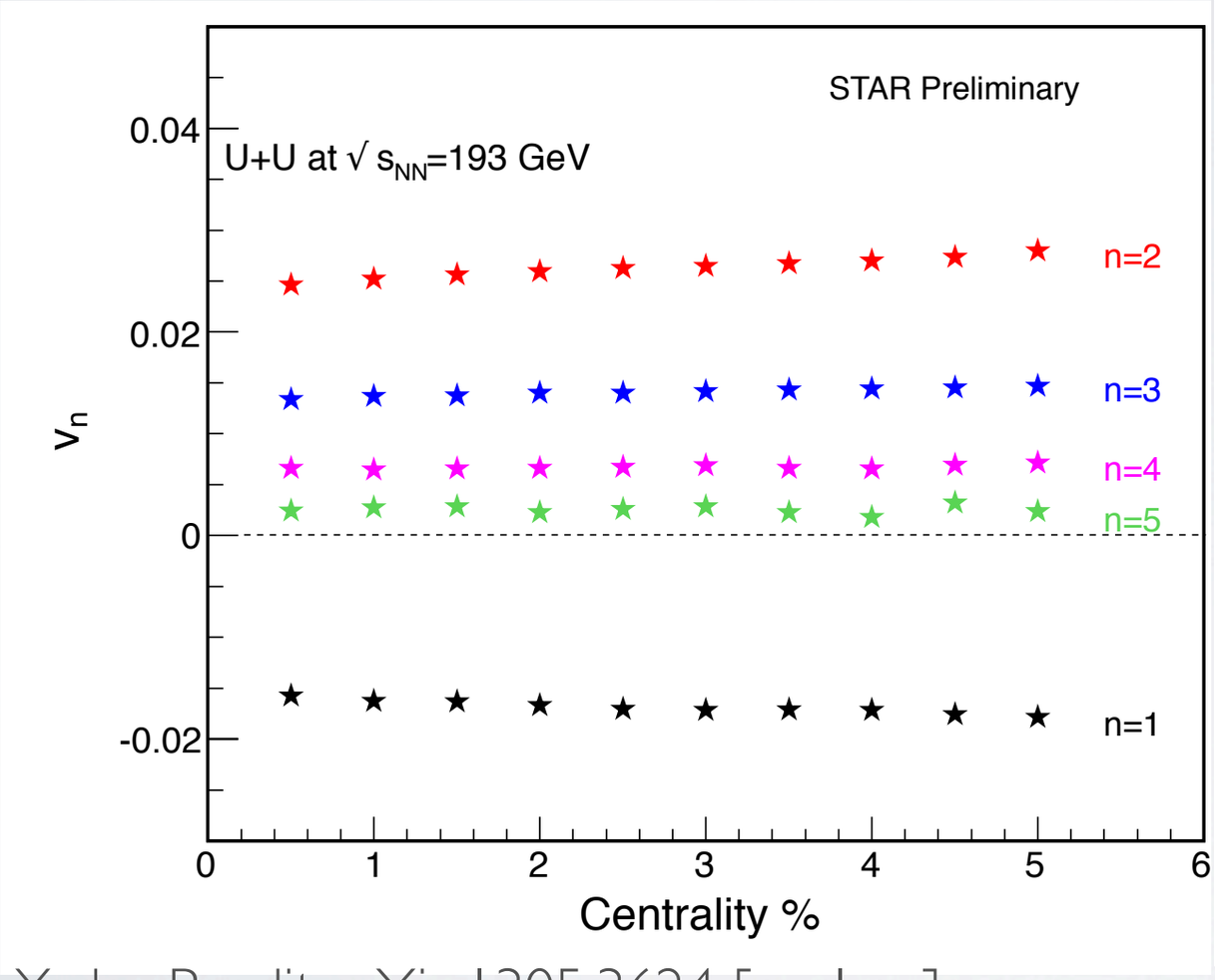


Yadav Pandit arXiv:1305.3624 [nucl-ex]

MC-Glb, η/s=0.08, 0-5%

✳ The data show no "knee" structure ---

Anisotropic flows (III)



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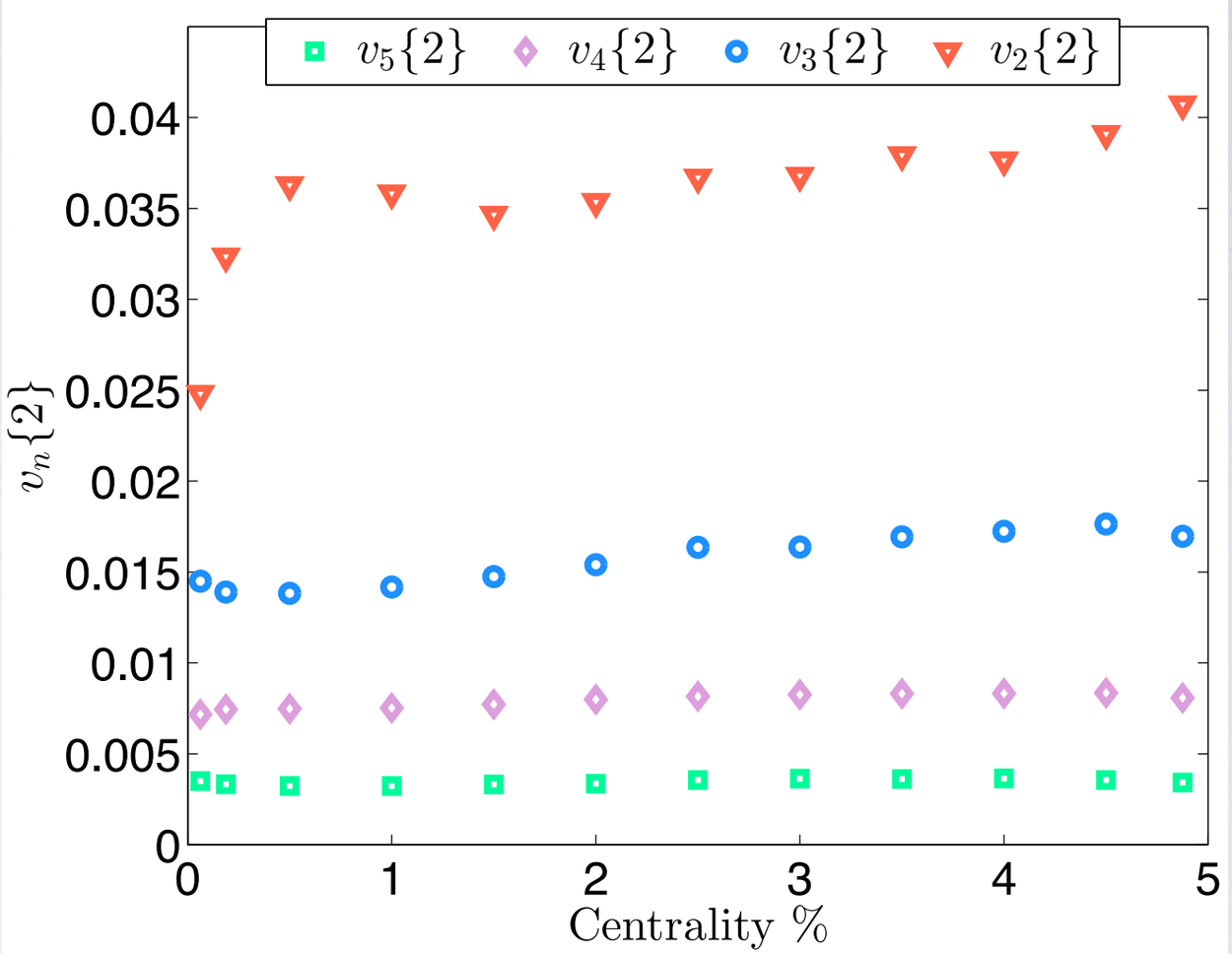

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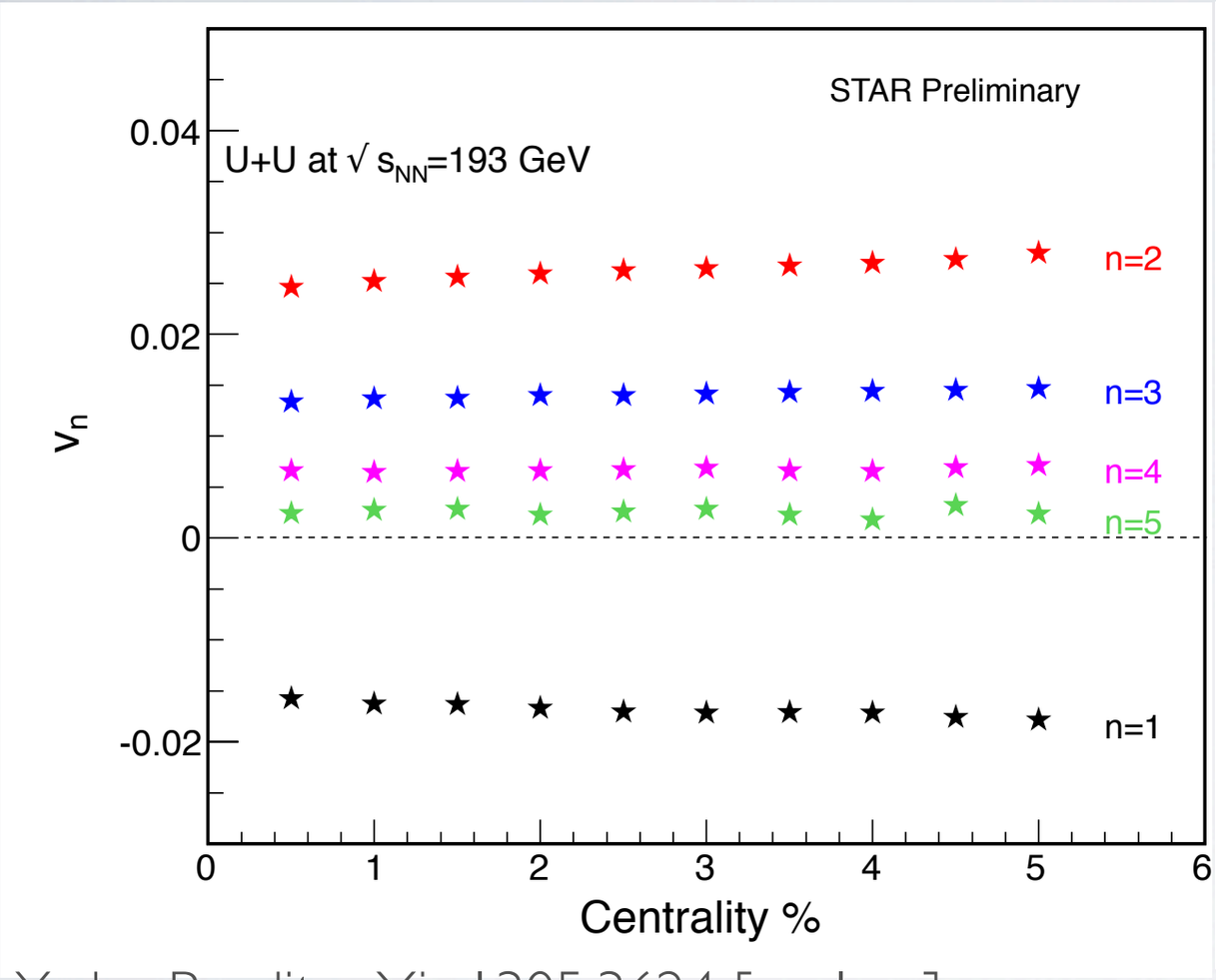

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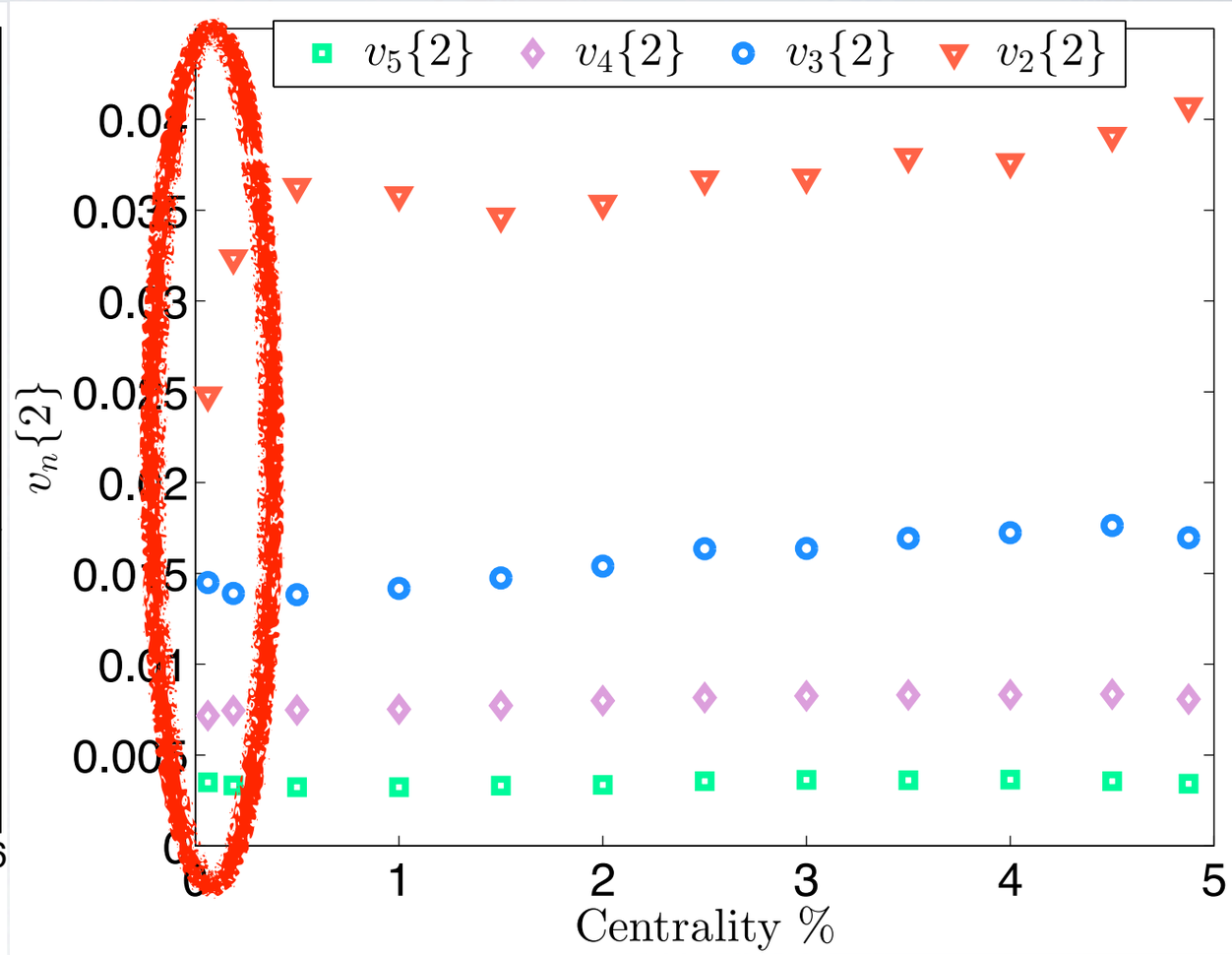
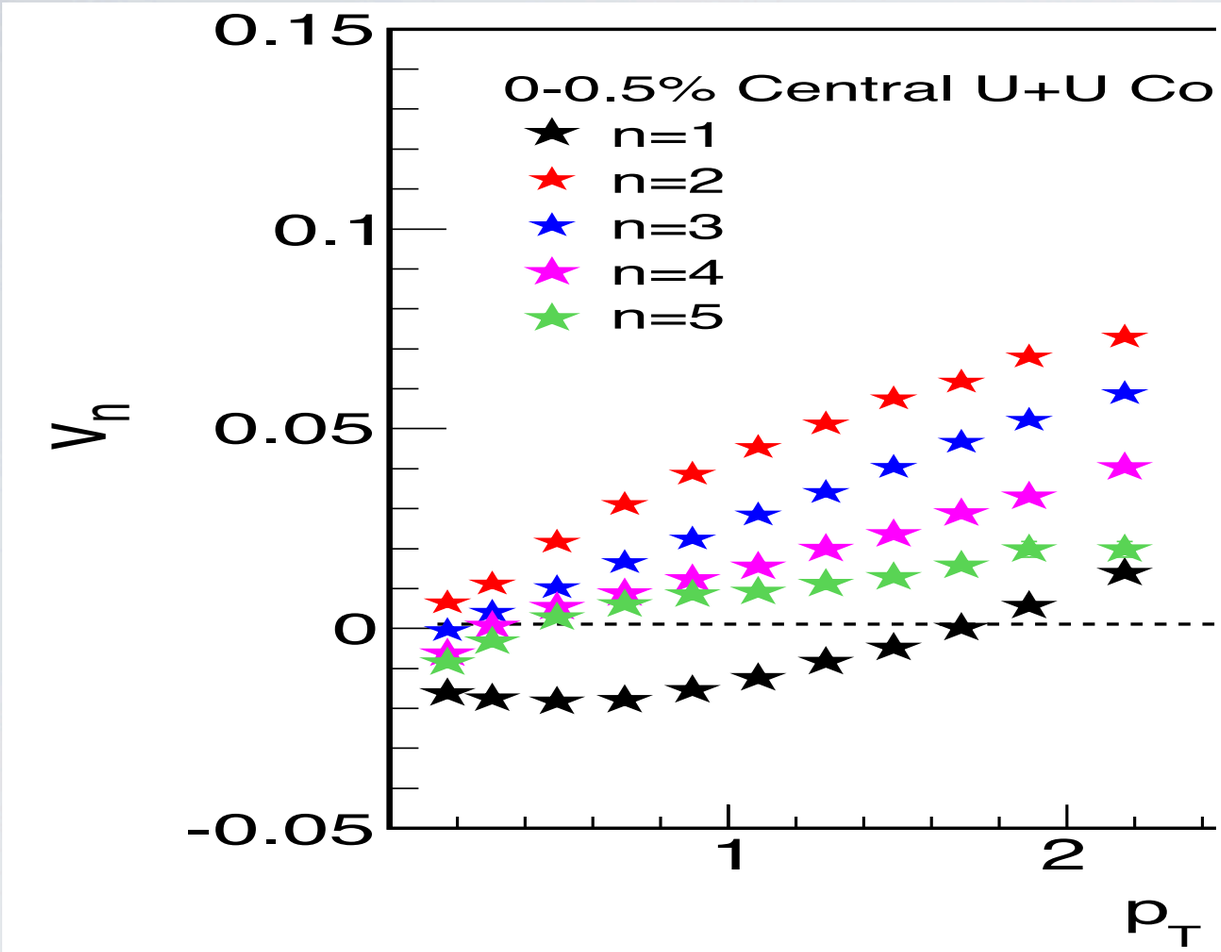


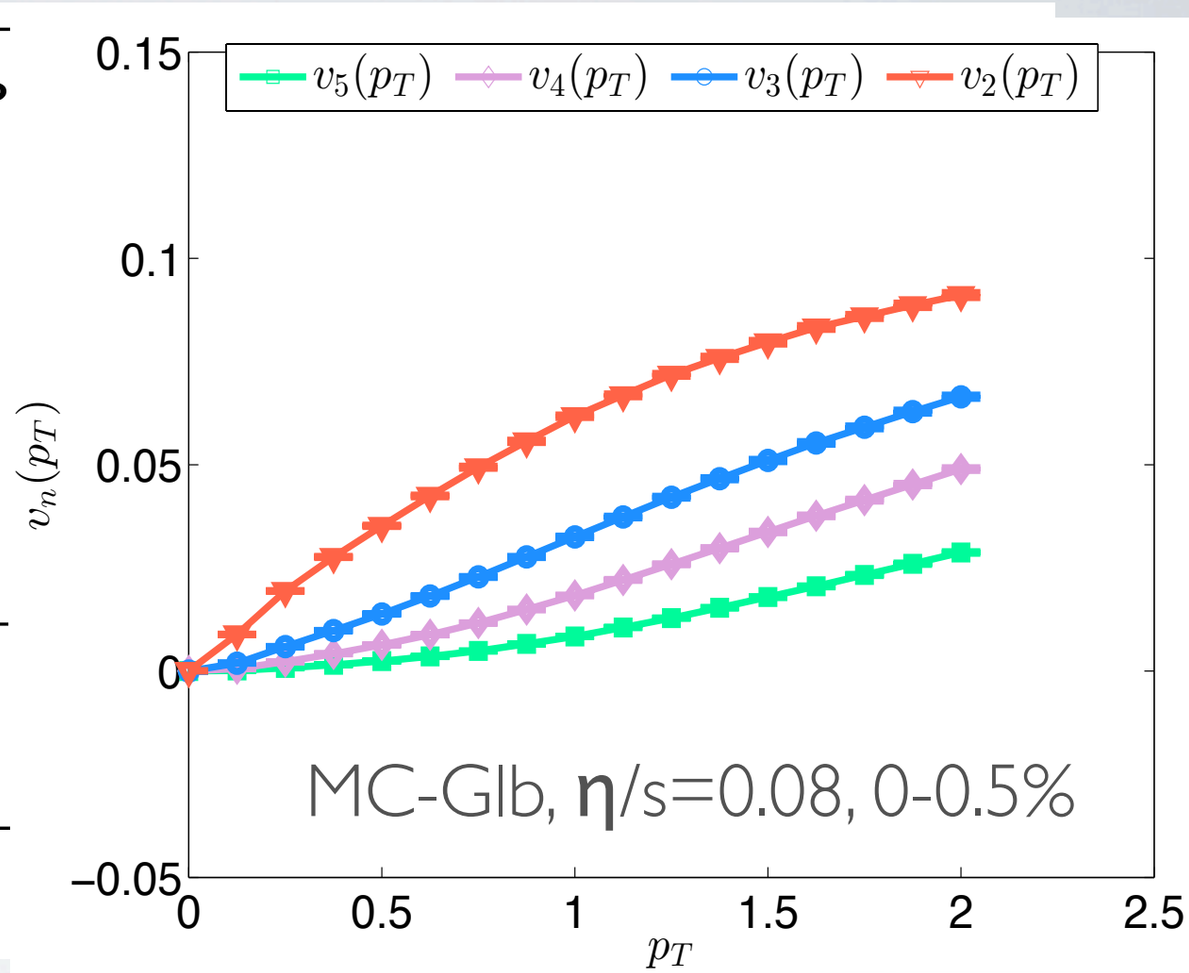
MC-Glb, η/s=0.08, 0-5%

✳ The data show no "knee" structure ---

--- but we suspect it is because they are not "central" enough. Need to go below ~0.5% centrality to see it.

Anisotropic flows (IV)





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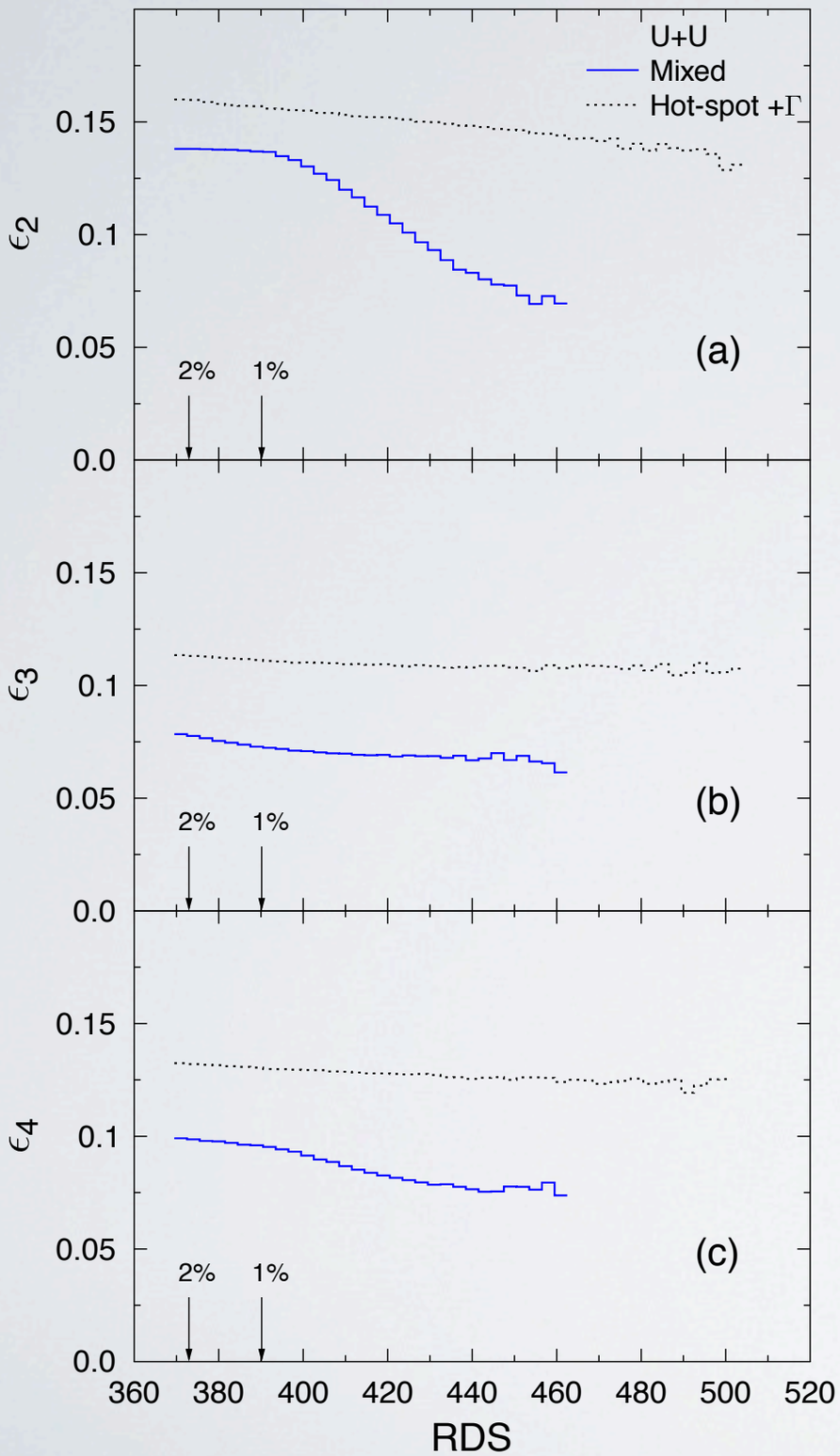
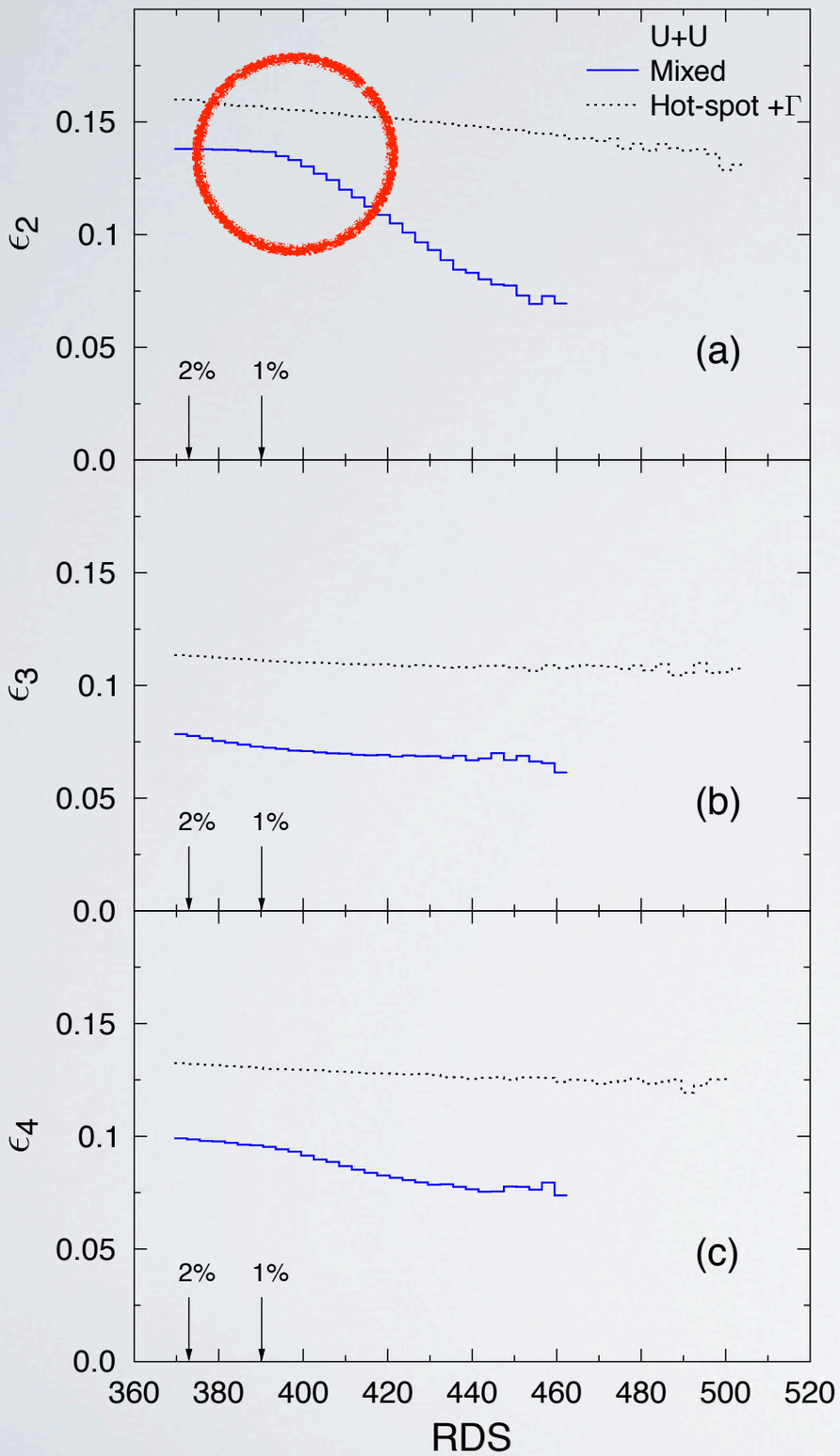
- The p_T-differential flows look qualitatively similar.

Fluctuation effects



M Rybczyński PRC87, 044908

Fluctuation effects



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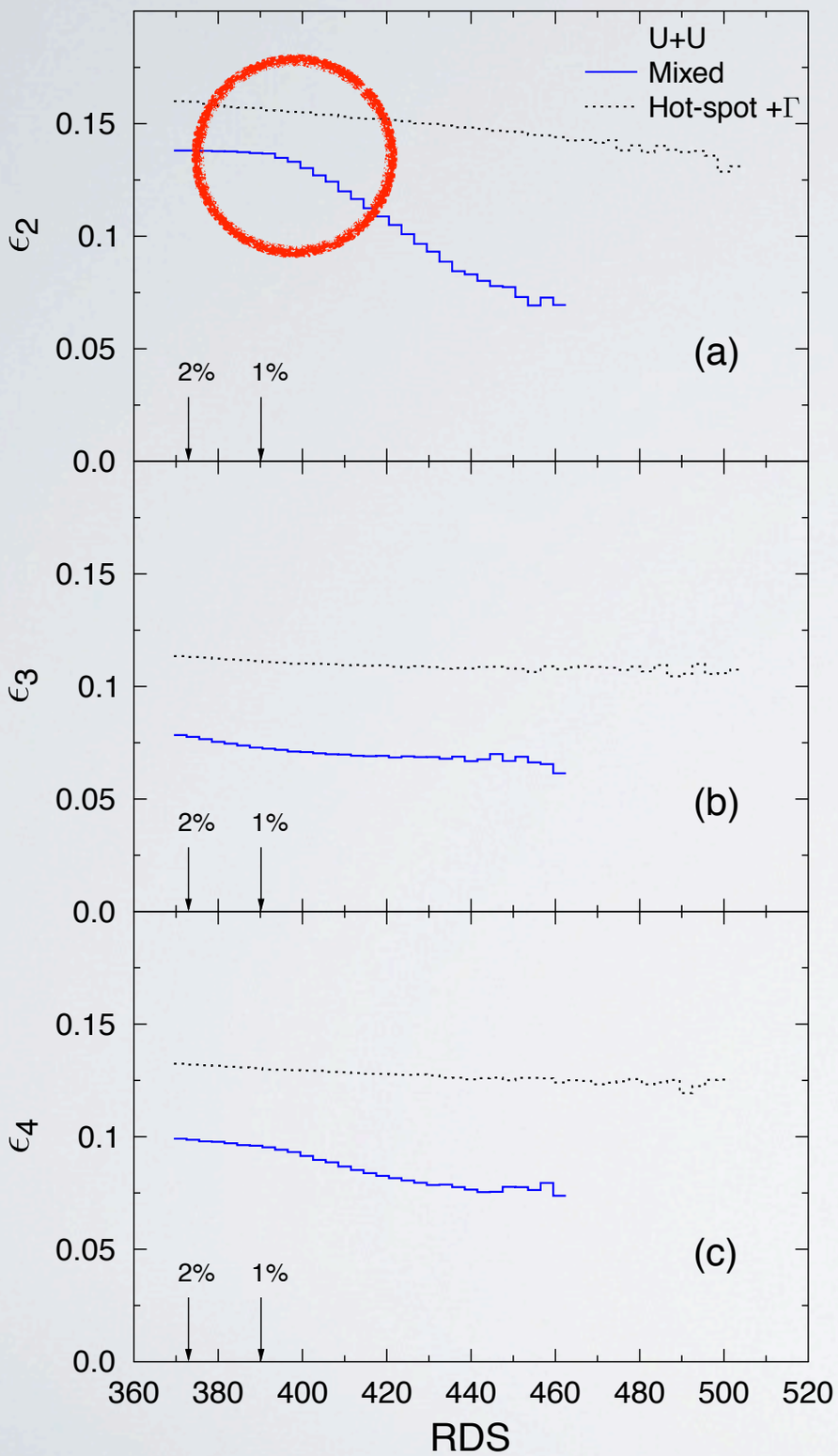

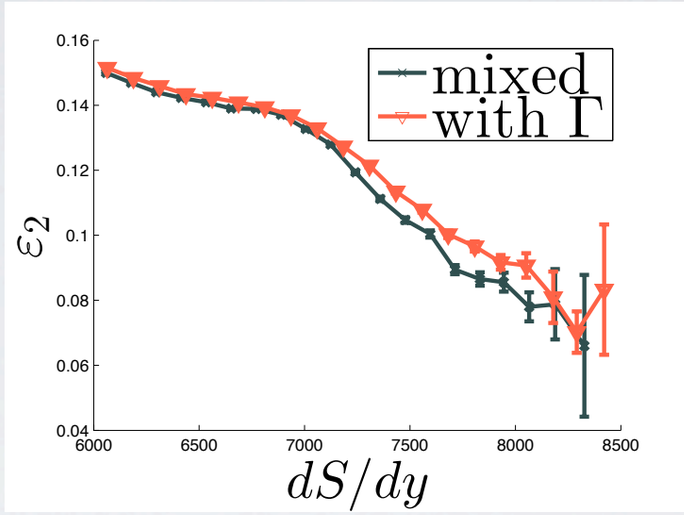

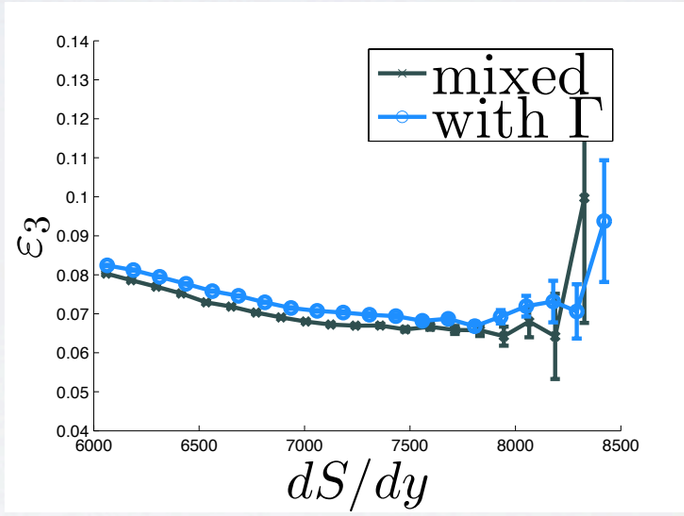

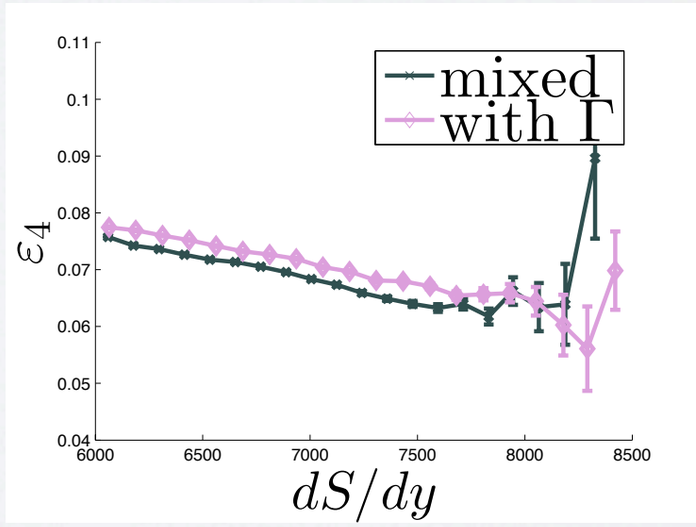

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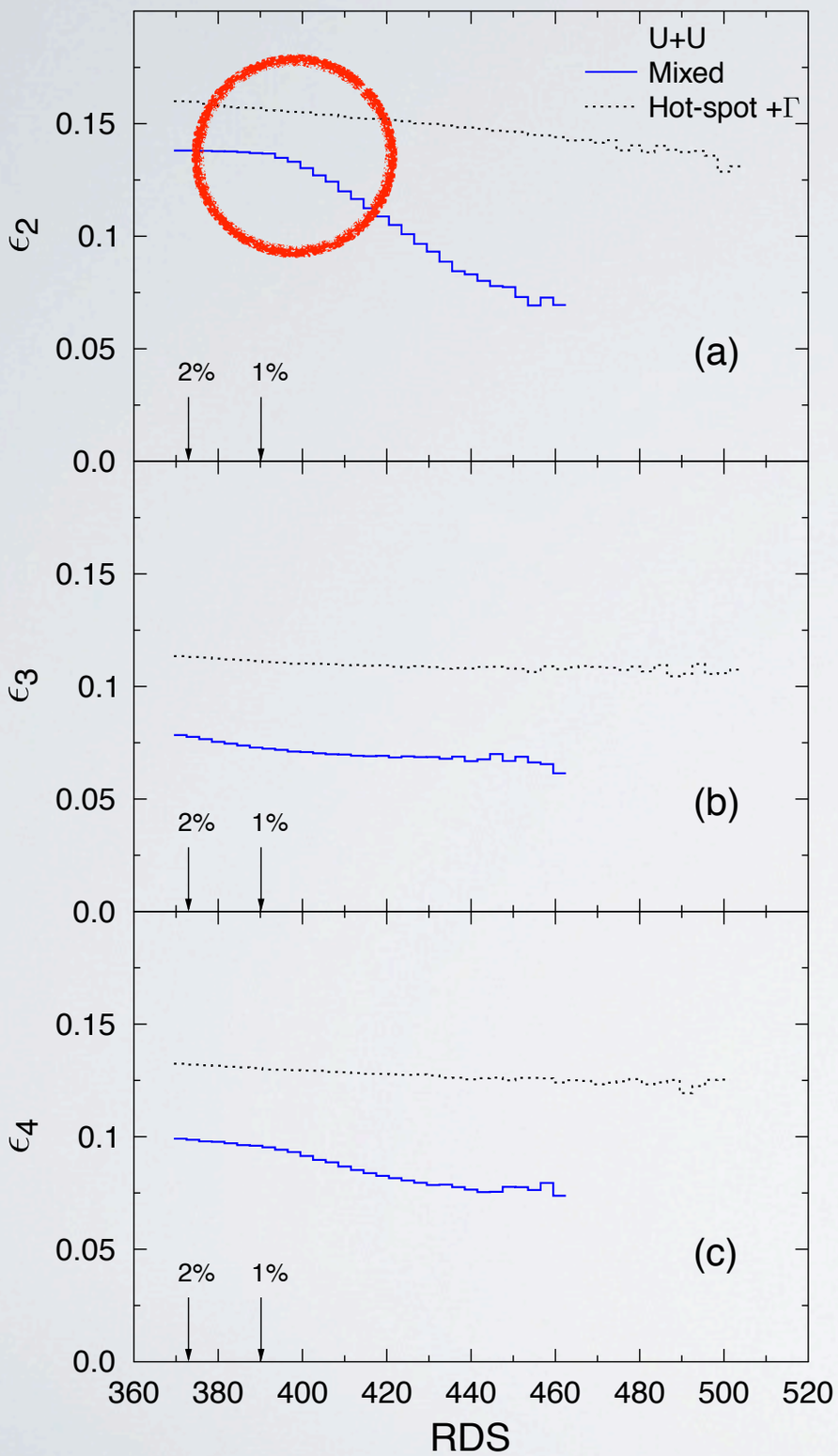

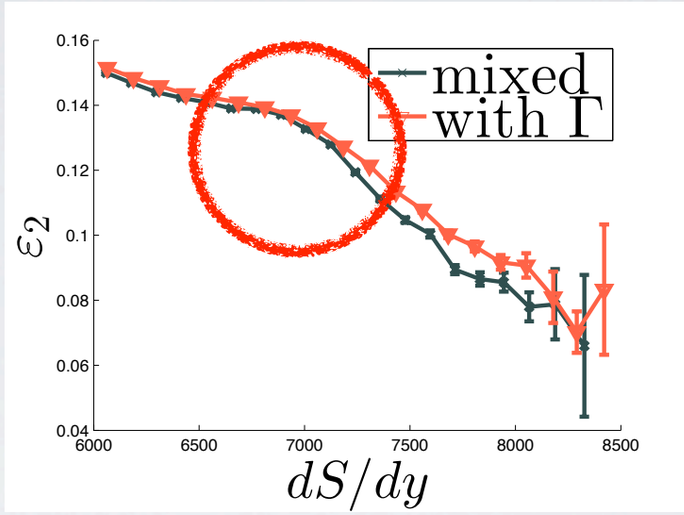

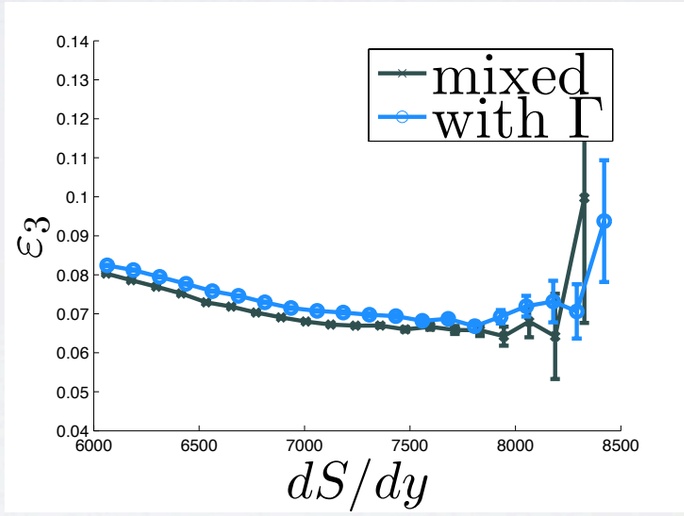

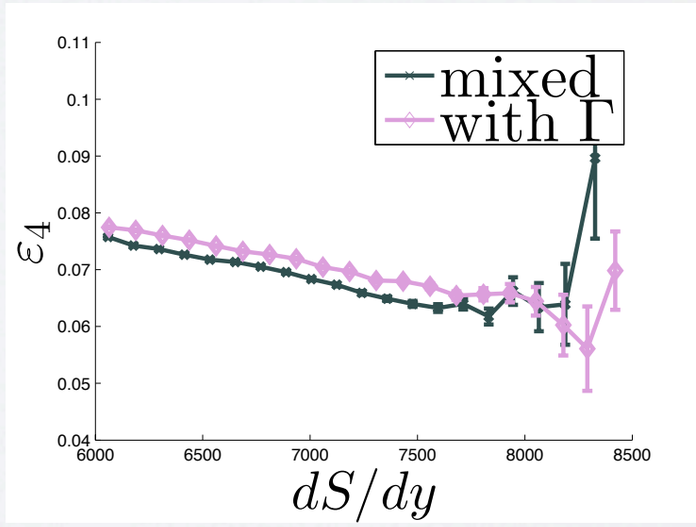

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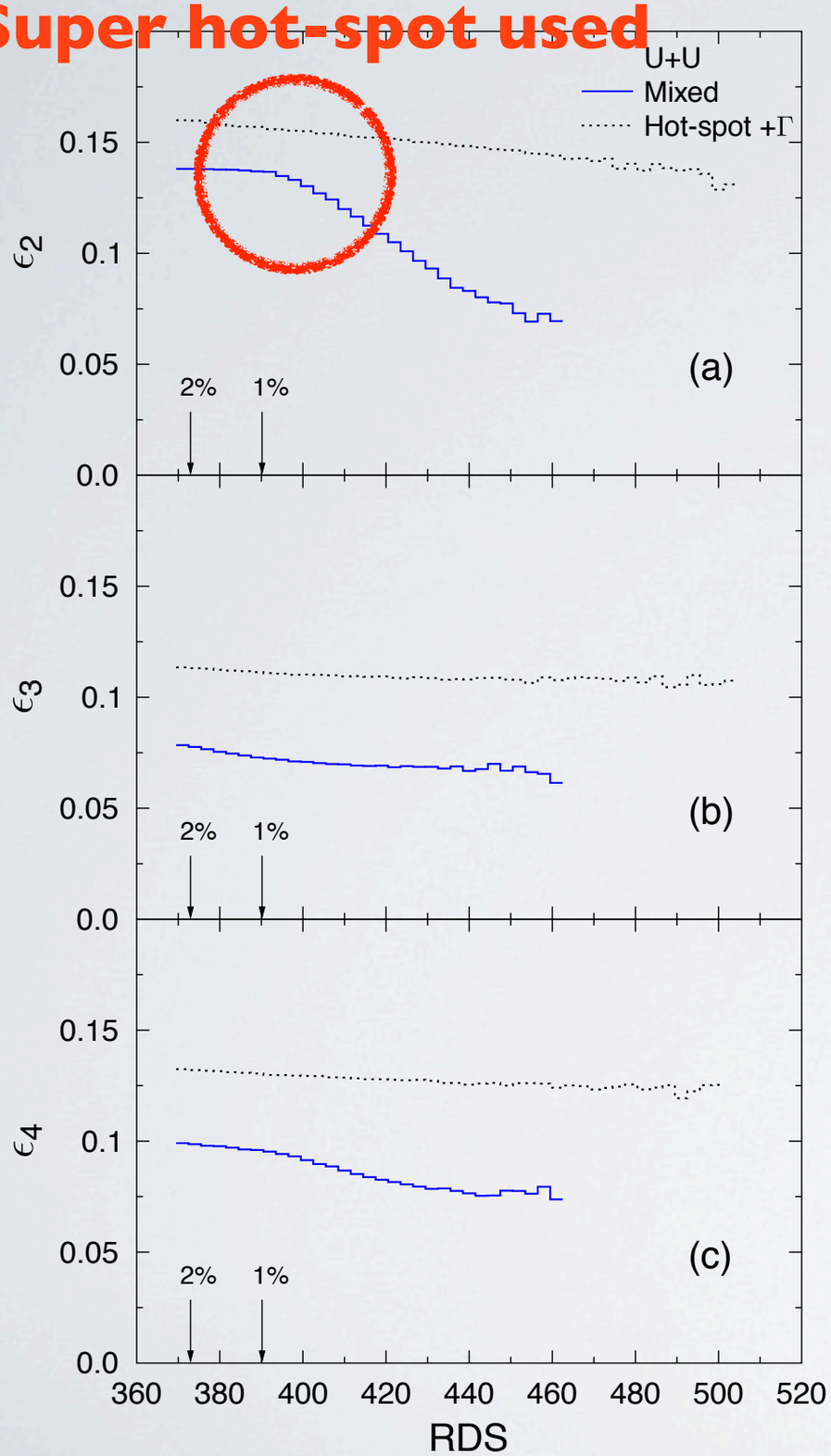
Fluctuation effects

Super hot-spot used



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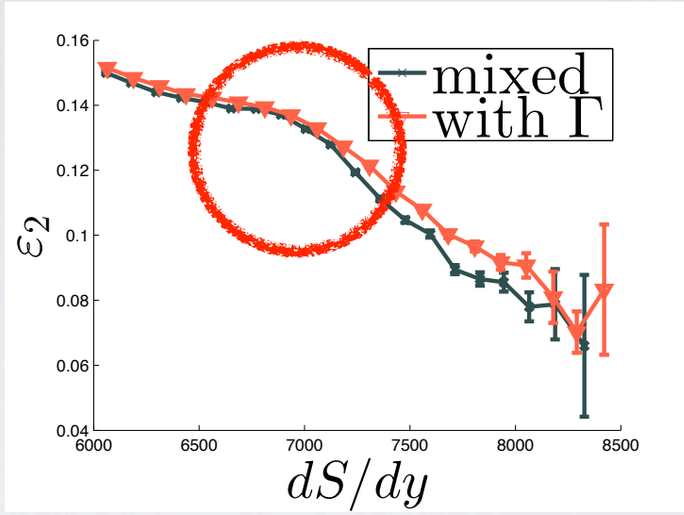

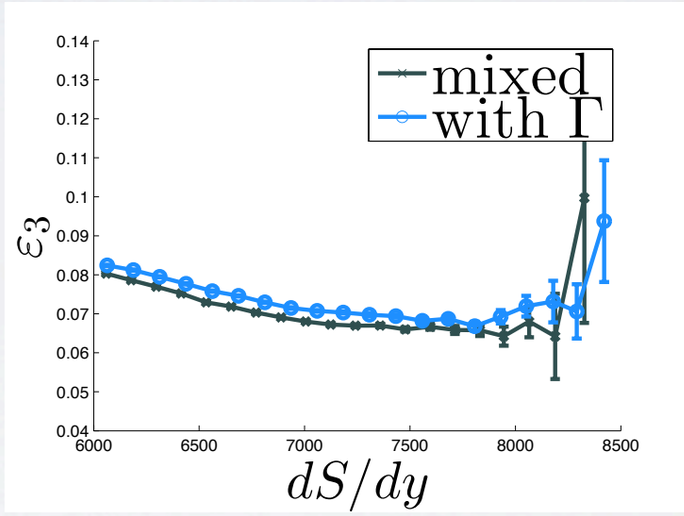

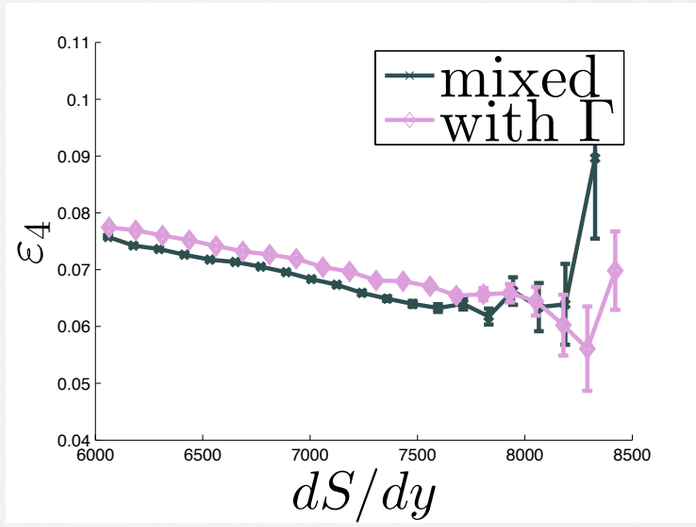

Conventional Glauber

Whether gluonic fluctuations will smooth out the "knee" structure depends on models.

Conclusions

- The ellipsoid shape of U generates "knee" structure in initial ellipticity.
- The "knee" structure in ellipticity is then transferred into v_2 by hydrodynamic evolution.
- The "knee" structure is only visible for ***very*** central collisions (~0.5% or less).
- No "knee" structure is visible for higher order harmonics.

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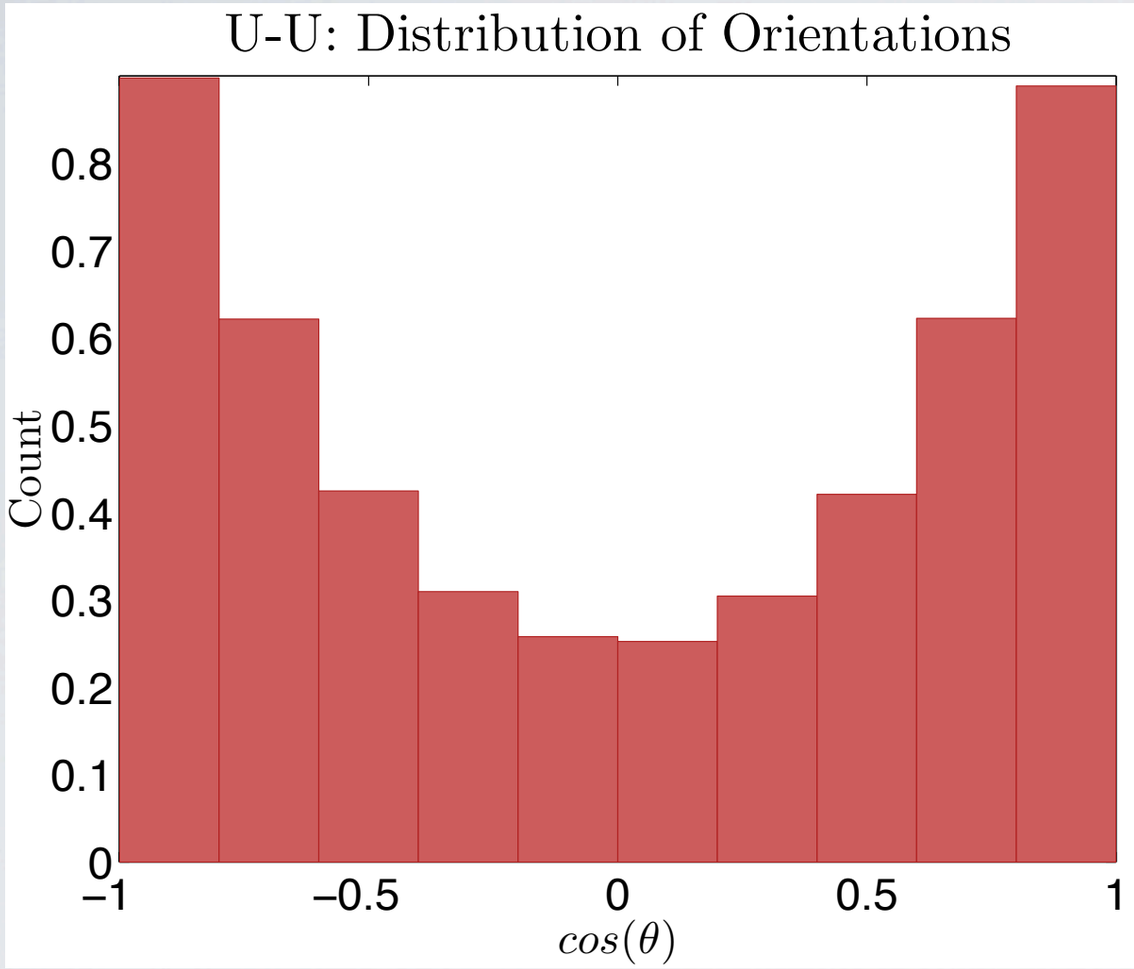
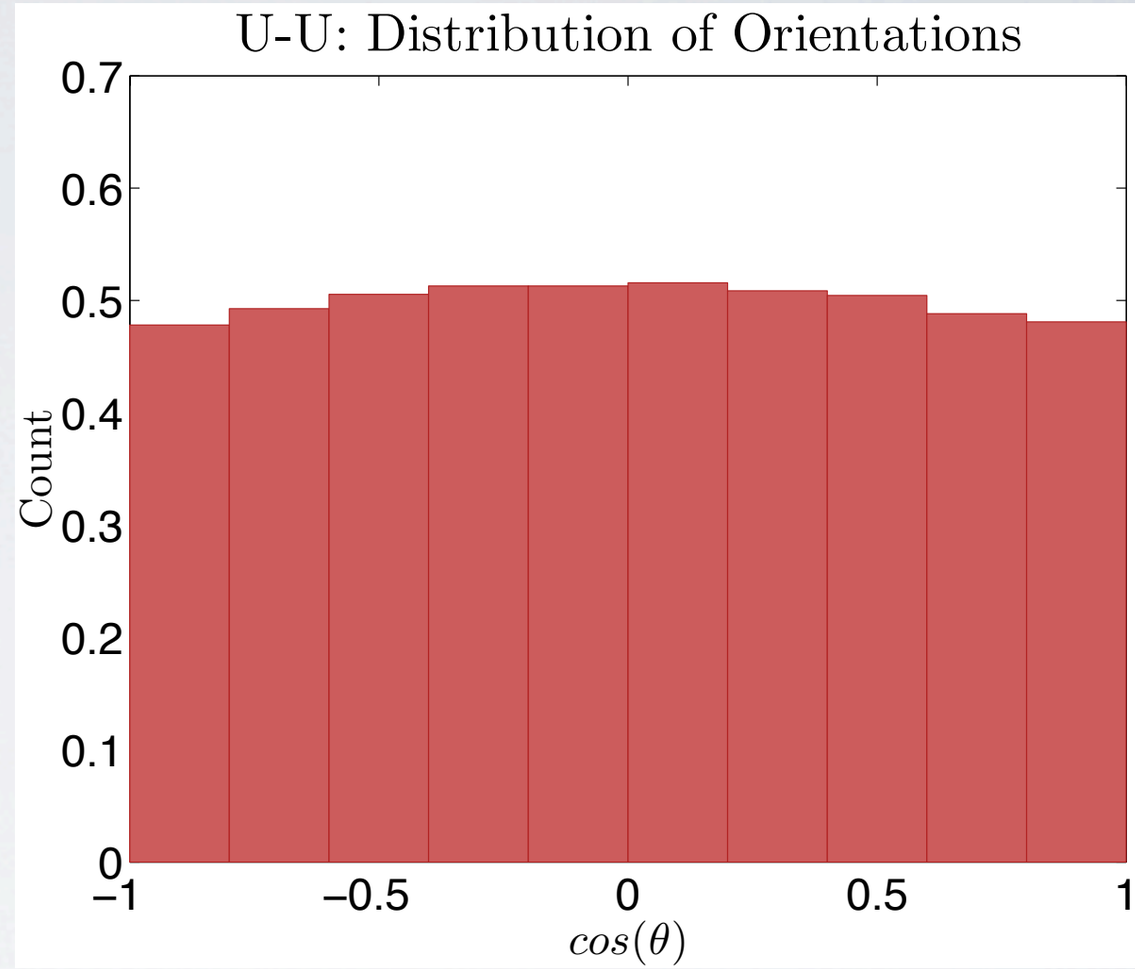
- Whether gluonic fluctuations will smooth out the "knee" structure is model-dependent.

Backup Slides

Start of backup slides

Angular distribution

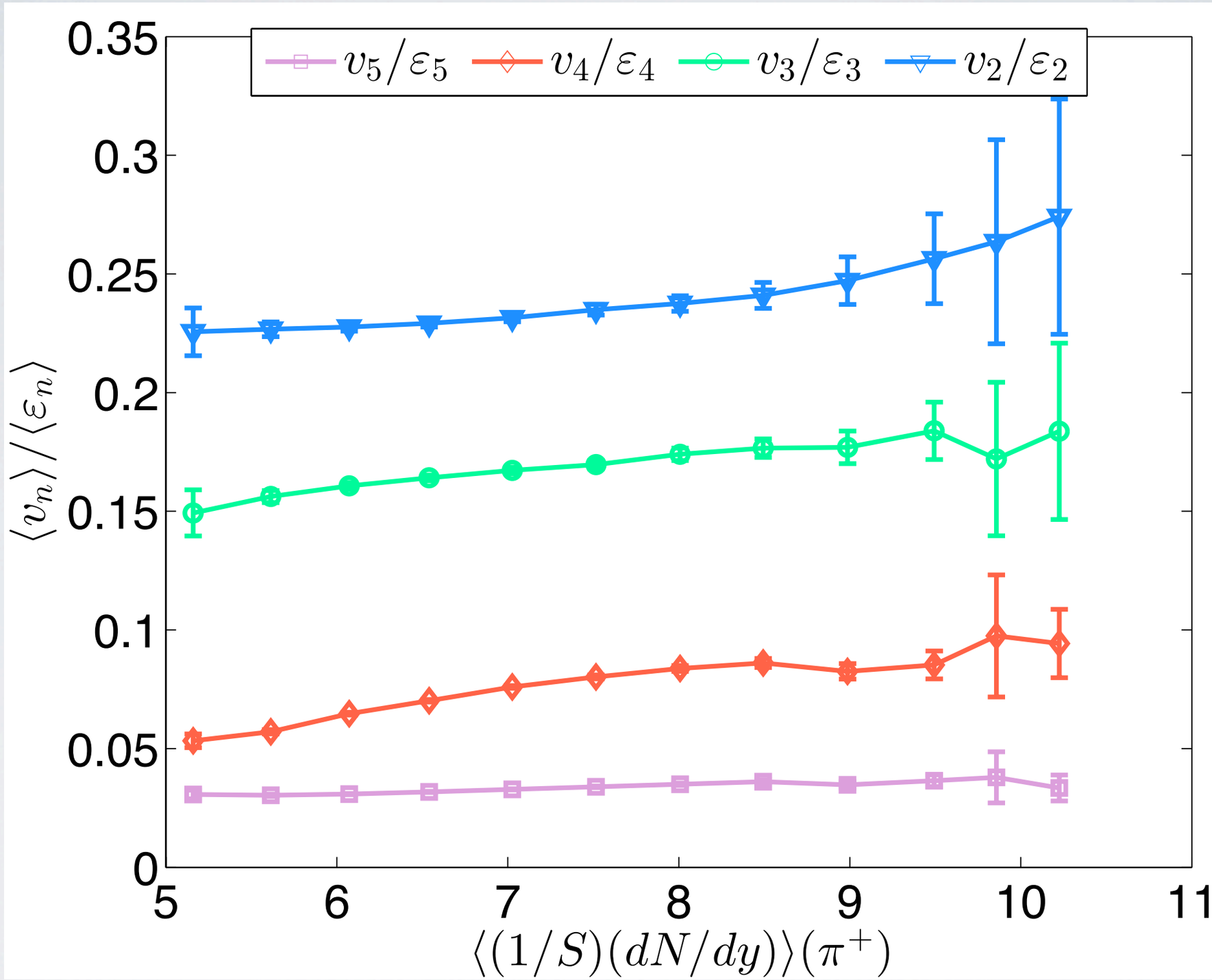




✳ Angular distribution from events having dN/dy larger (left) / smaller (right) than the value of the "knee".

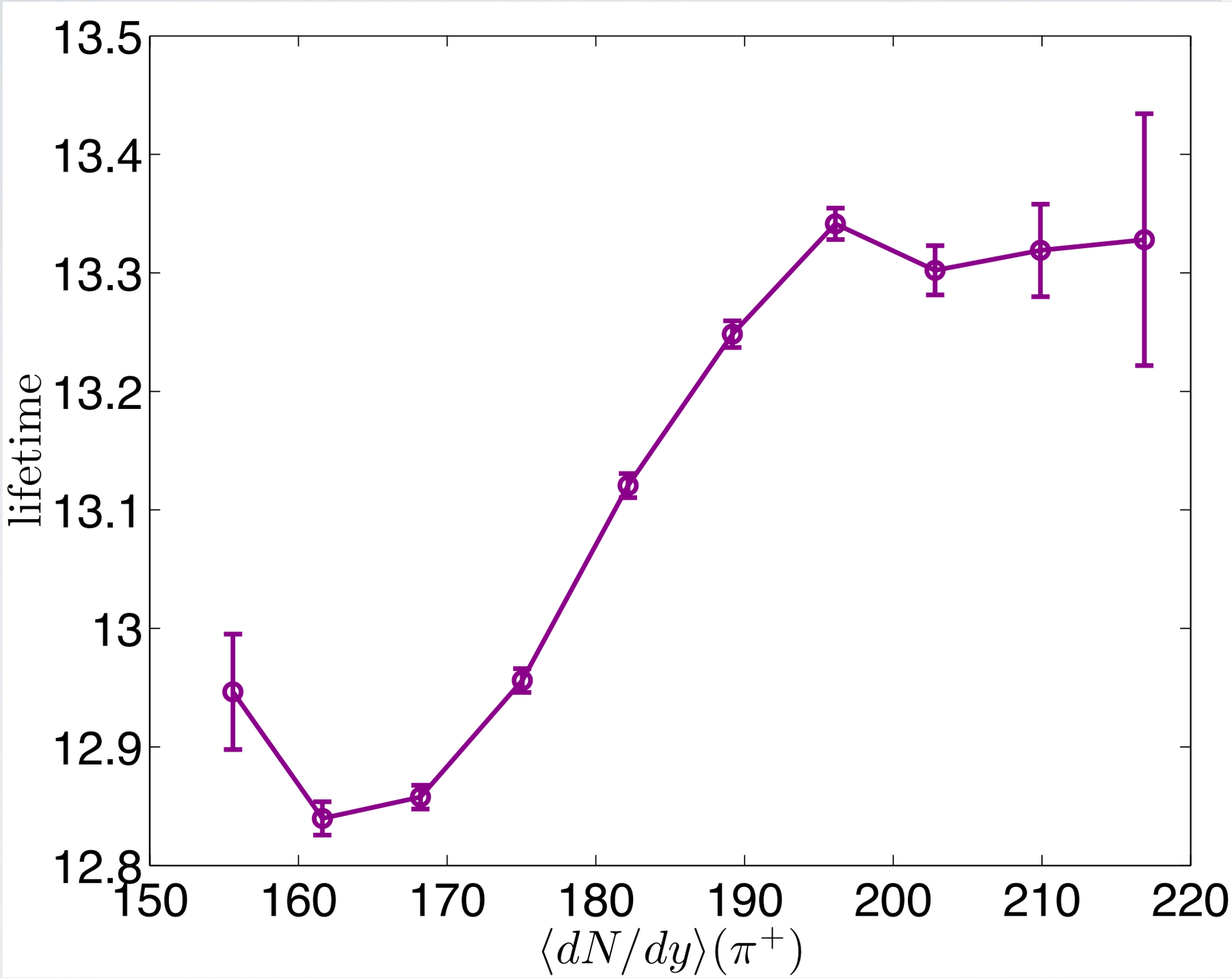
Tip-tip: $\cos(\theta) = \pm 1$ Side-side: $\cos(\theta) = 0$

Conversion coefficient (II)



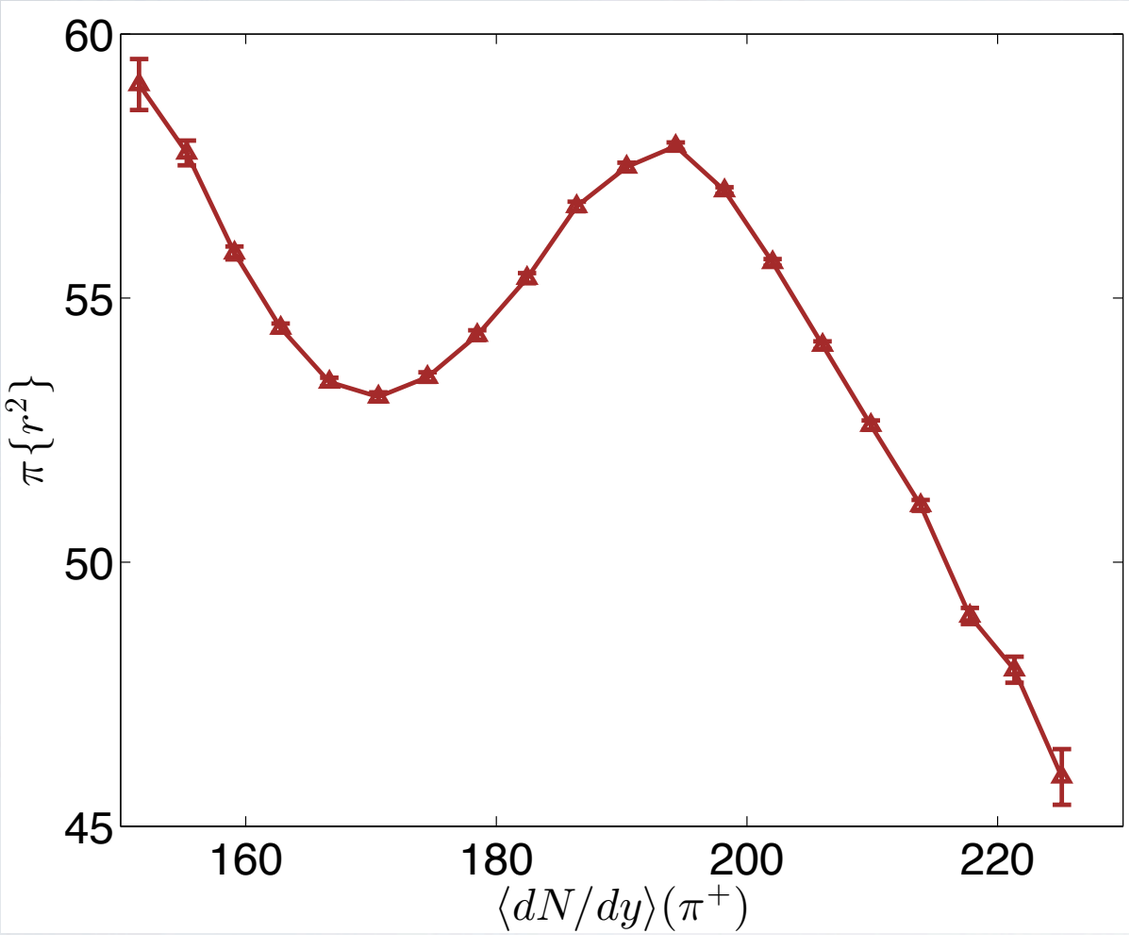
✳ The conversion coefficient has little dependence on (1/S)(dN/dy).

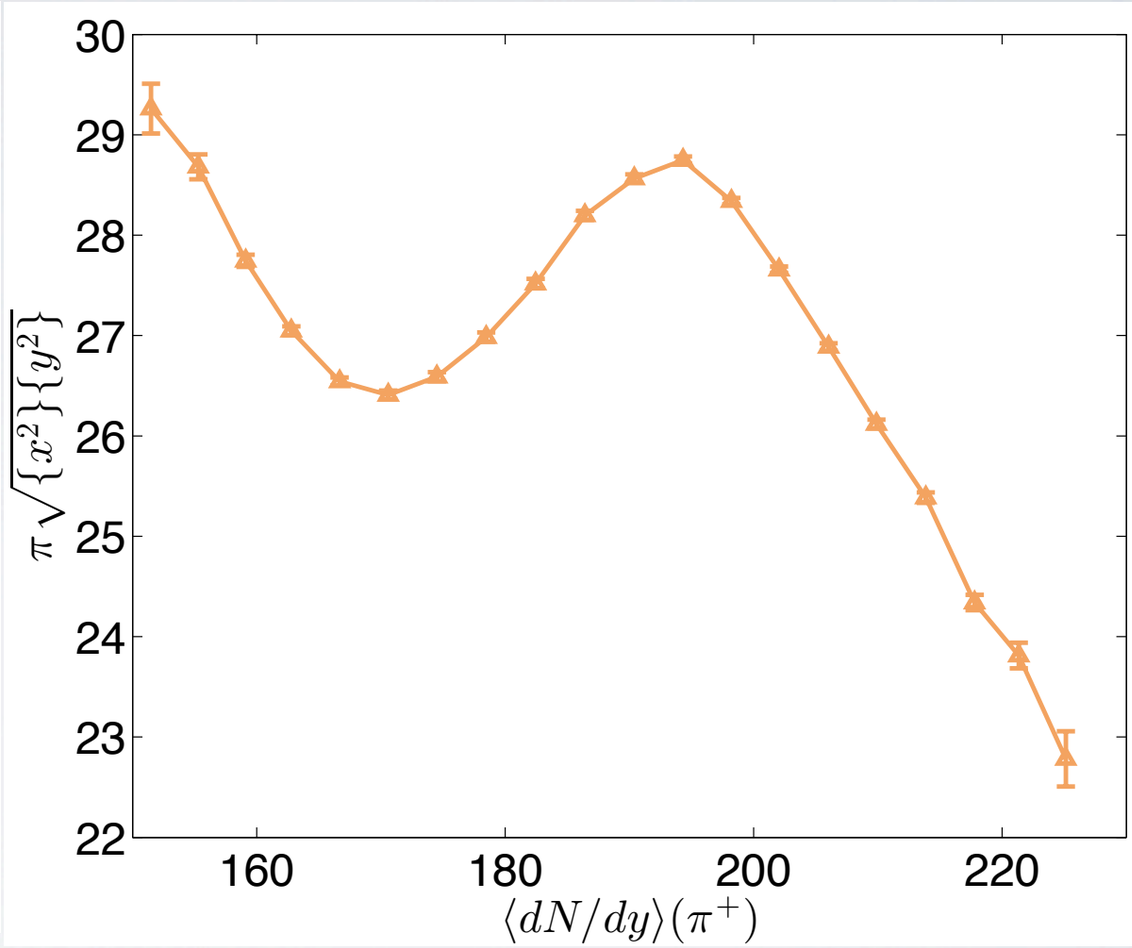
Lifetime



✳ Life time as a function of dN/dy.

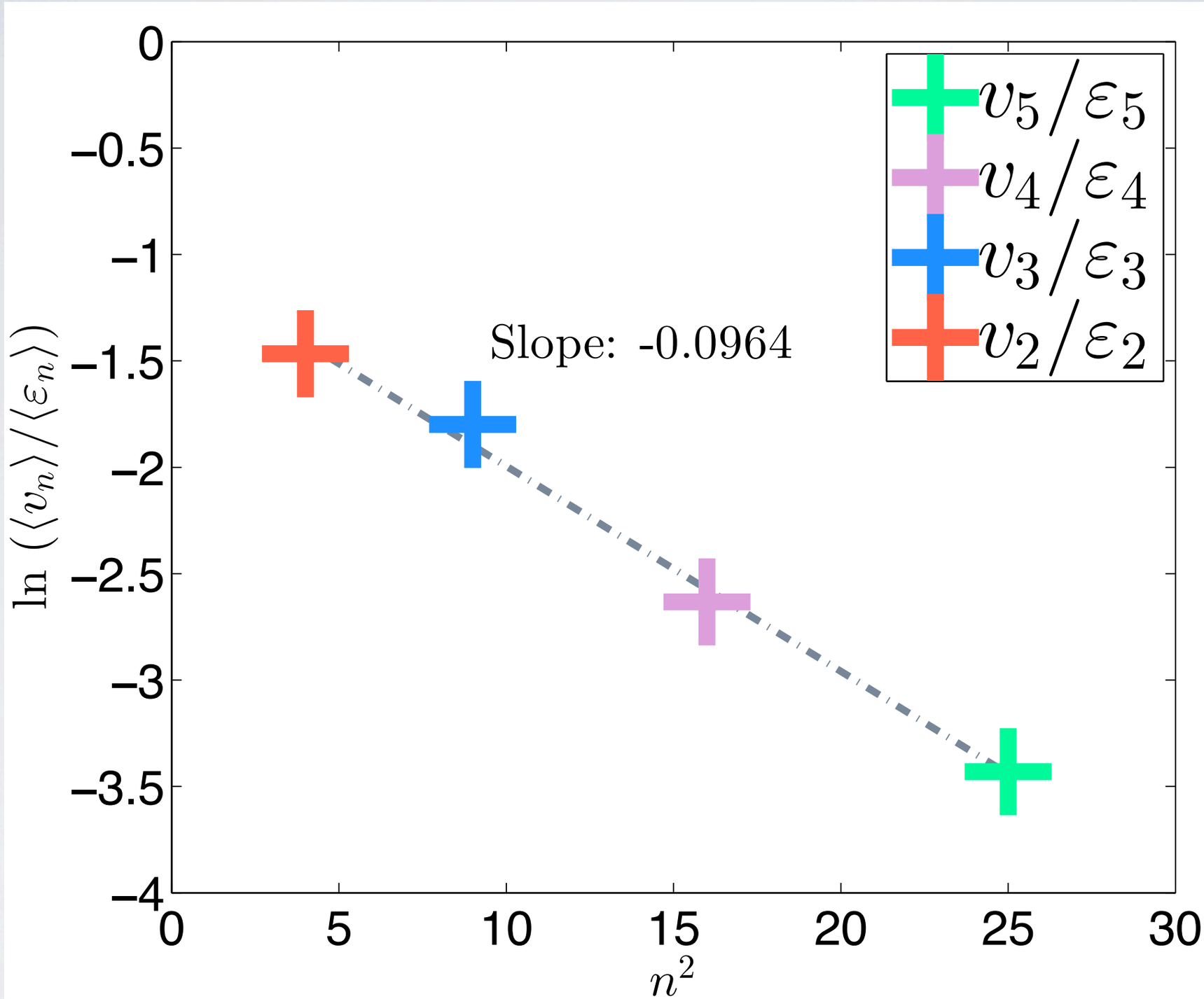
Overlap area





✳ The overlap area drops dramatically towards ultra-central region.

Scaling


v_5/ε_5
v_4/ε_4
v_3/ε_3
v_2/ε_2
Slope: -0.0964
$\ln(\langle v_n \rangle / \langle \varepsilon_n \rangle)$
n^2
0
−0.5
−1
−1.5
−2
−2.5
−3
−3.5
−4
0
5
10
15
20
25
30