



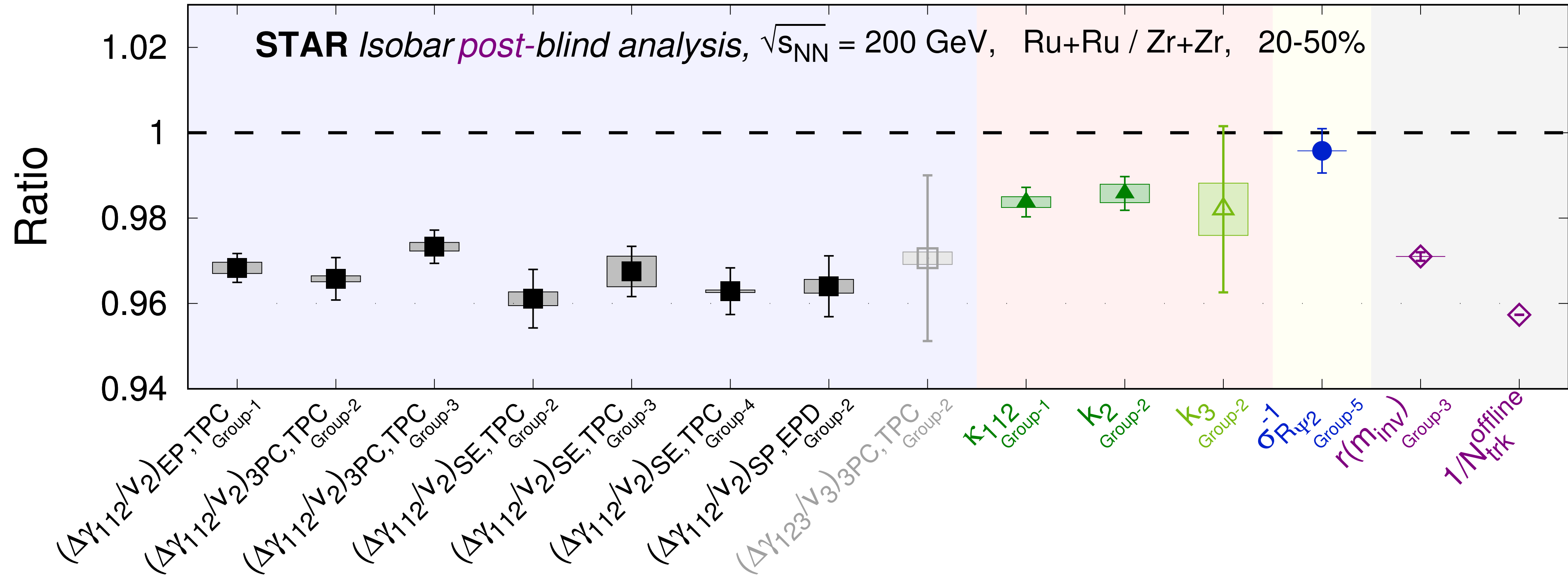
Baseline for CME in Isobar Collisions --- A Theorist's Perspective

Shuzhe Shi (Stony Brook University)

in collaboration with:

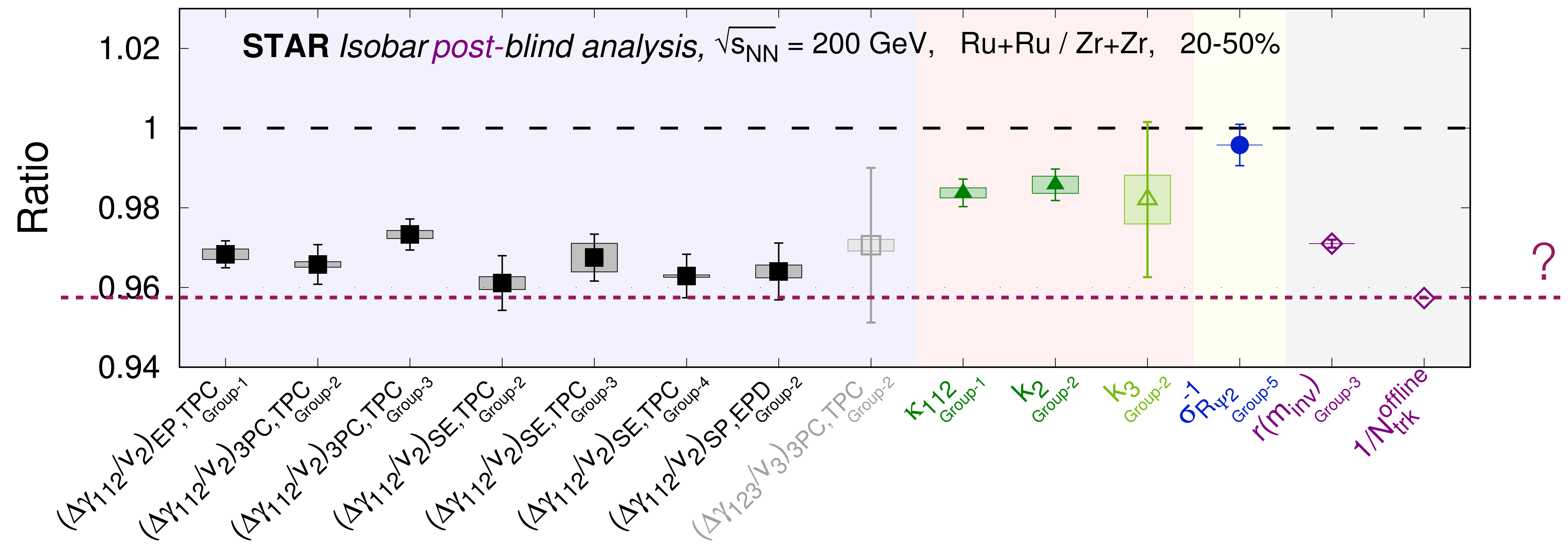
Dmitri Kharzeev and Jinfeng Liao

expectation of the baseline failed



- what causes the difference in background?
- what the no-CME baseline should be?

what is the appropriate baseline?



$$\Delta\gamma_{112, bkg} = \frac{4N_{2p}v_{2,2p}}{N_{ch}^2} \langle \cos(\phi_\alpha + \phi_\beta - 2\phi_{2p}) \rangle \propto \frac{v_2}{N_{ch}}$$

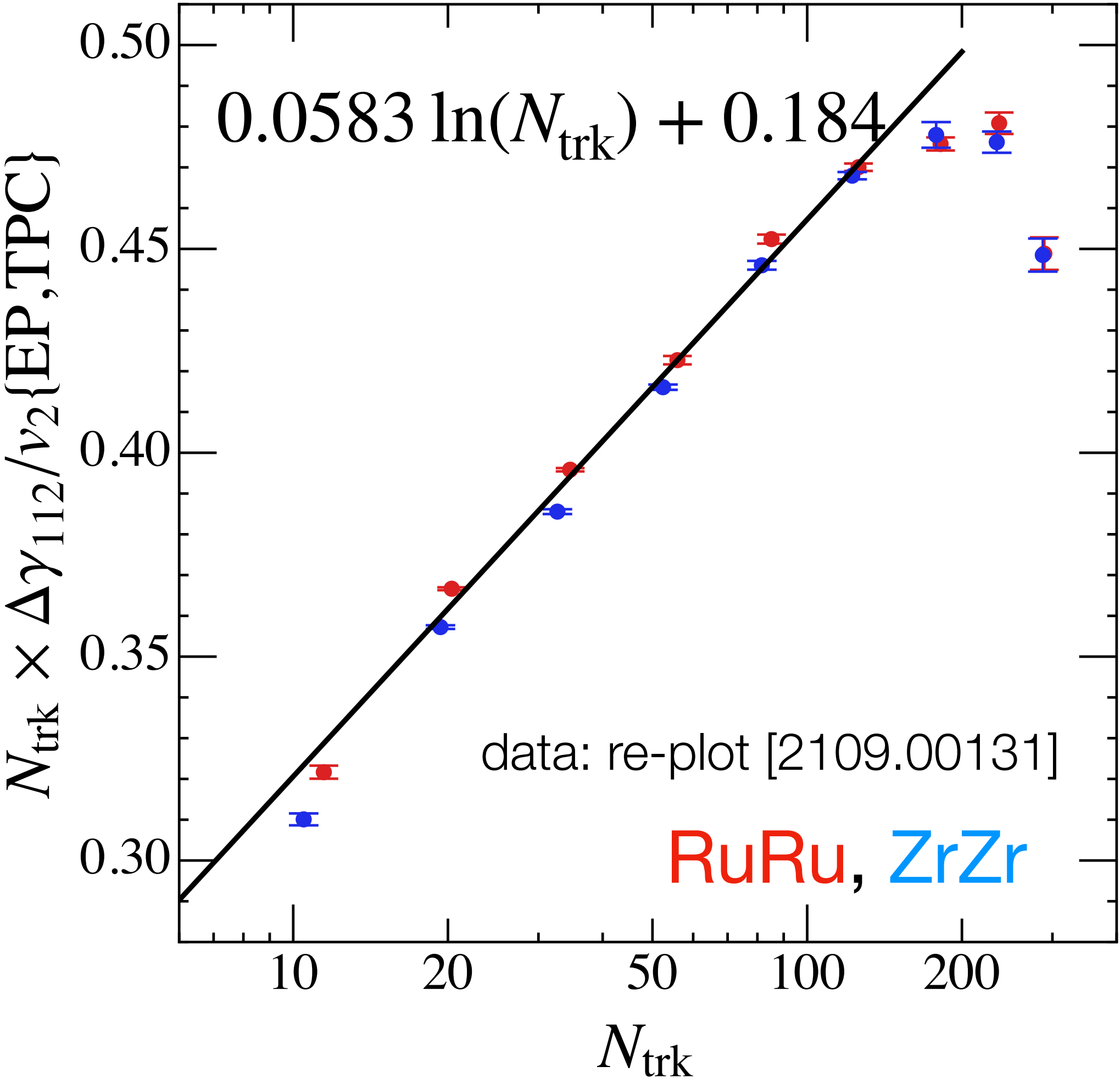
2p = 2-particle cluster

outline

what is the appropriate baseline?

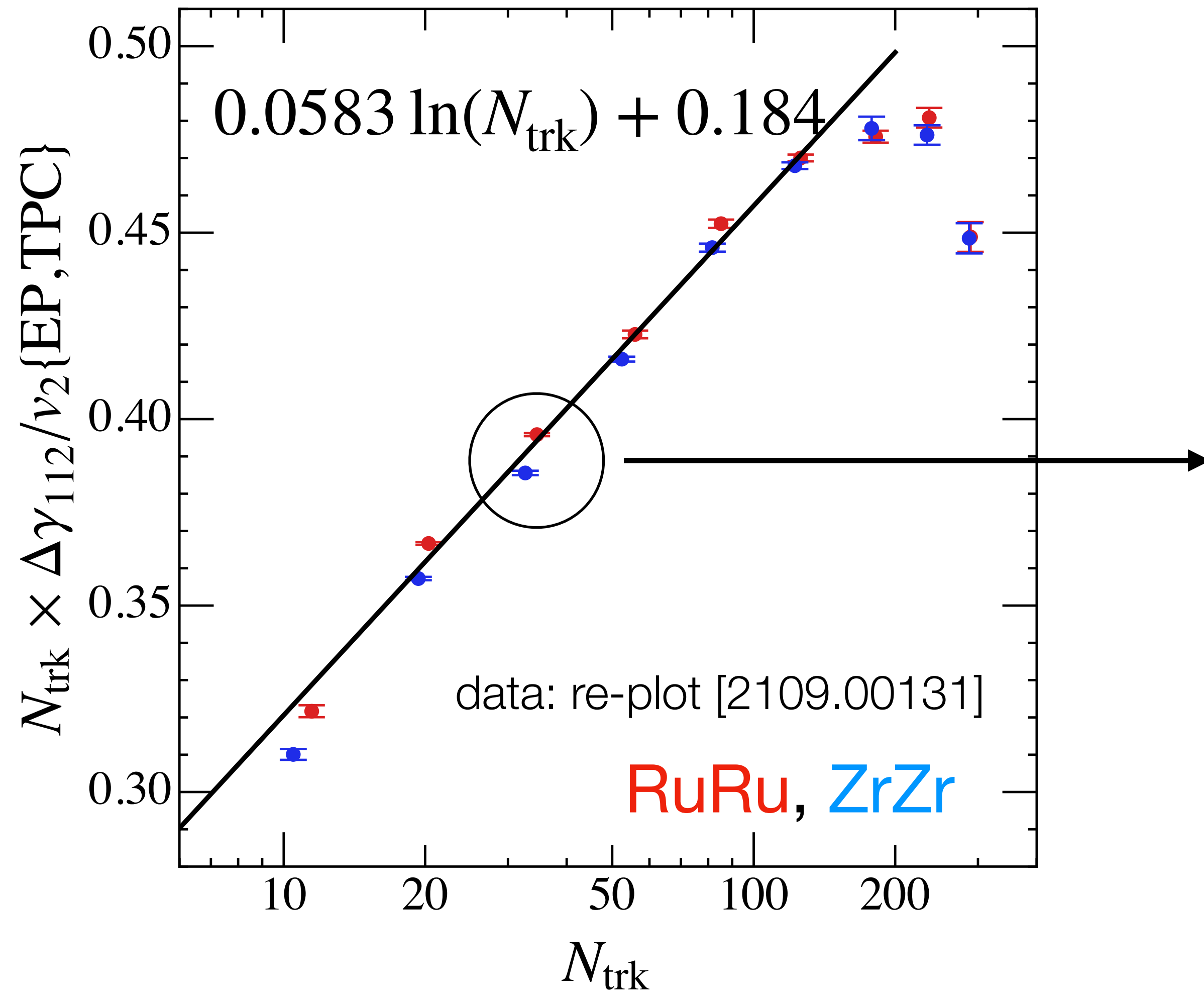
- what can we learn by relooking at the experimental results?
- how phenomenological simulations can help providing the baseline?

finding the appropriate baseline

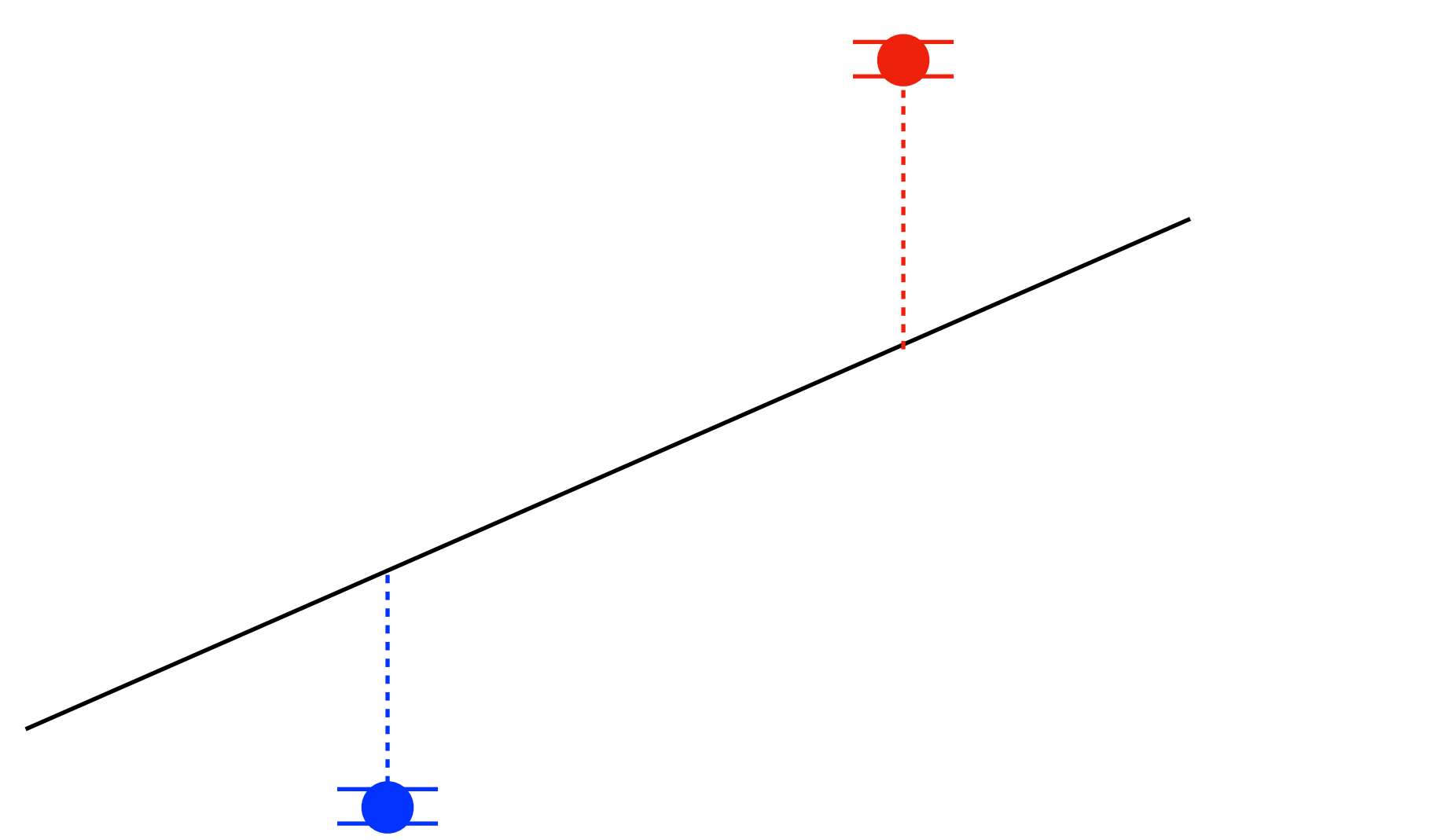


non-trivial centrality-dependence of the proportionality coefficient

$$\Delta\gamma_{112,\text{bkg}} \propto \frac{v_2}{N_{\text{ch}}}$$

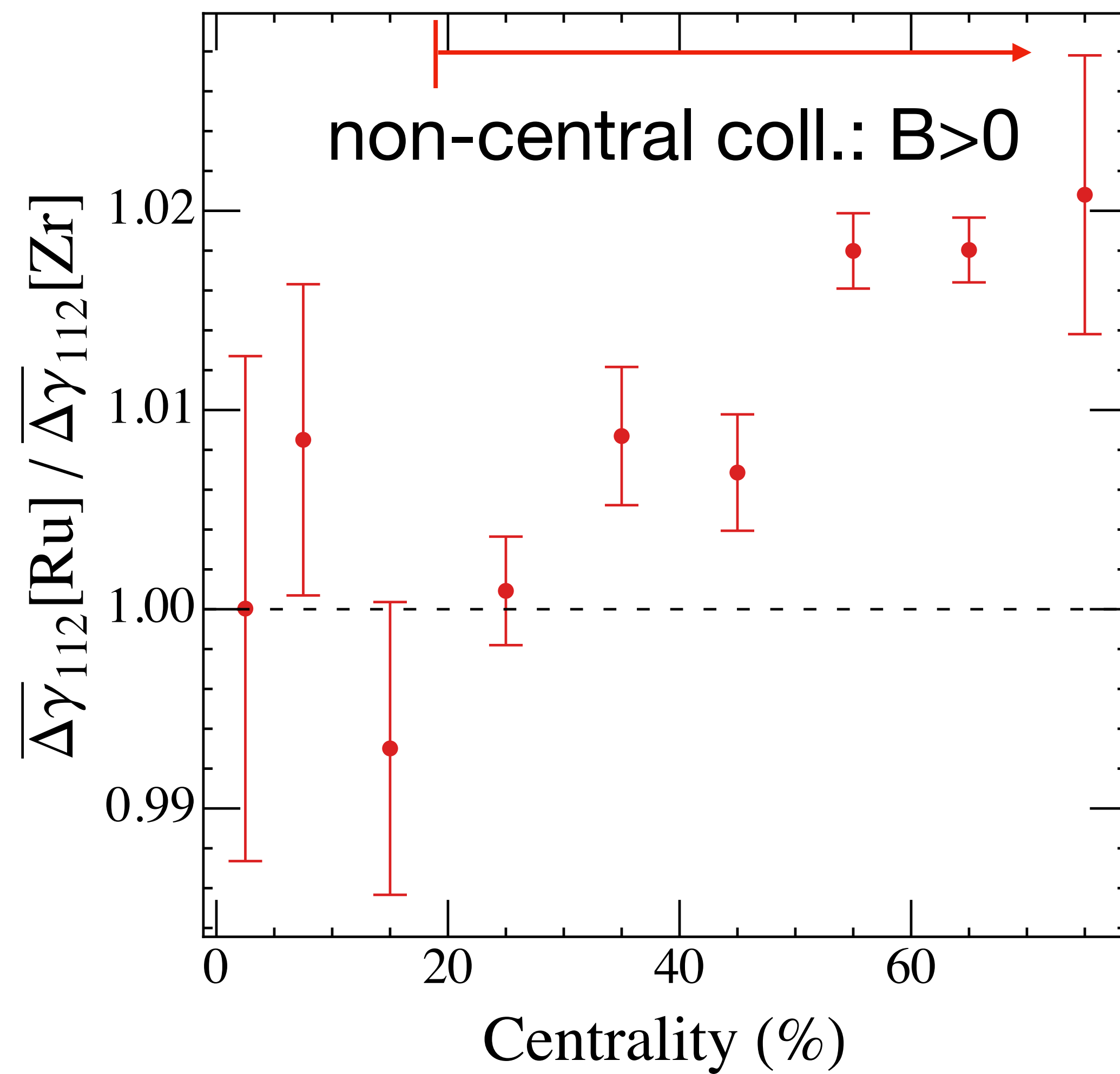
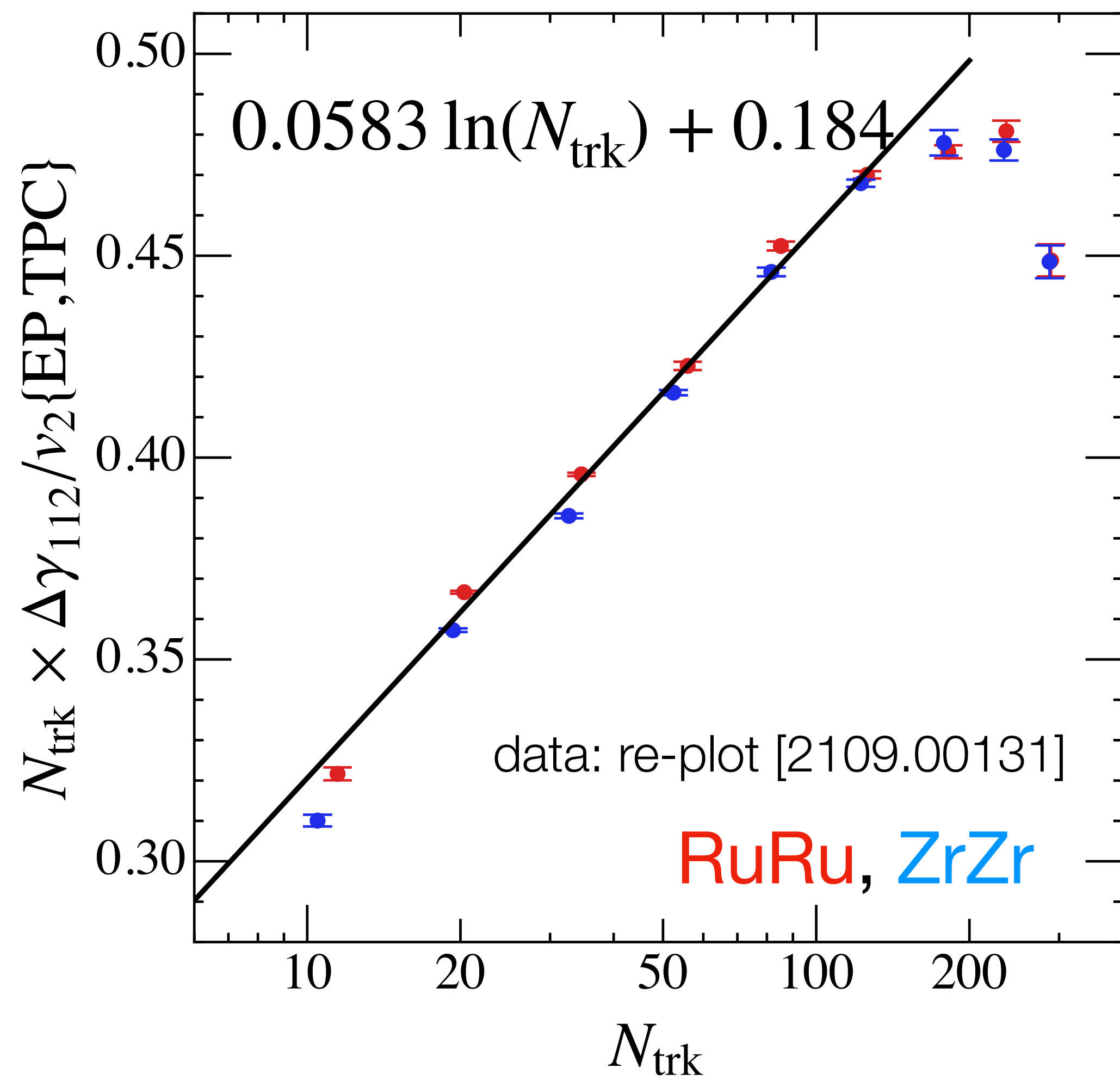


assume system-independent trend:



$$\overline{\Delta\gamma}_{112} \equiv (N_{\text{trk}} \Delta\gamma_{112}/v_2)/\text{line}$$

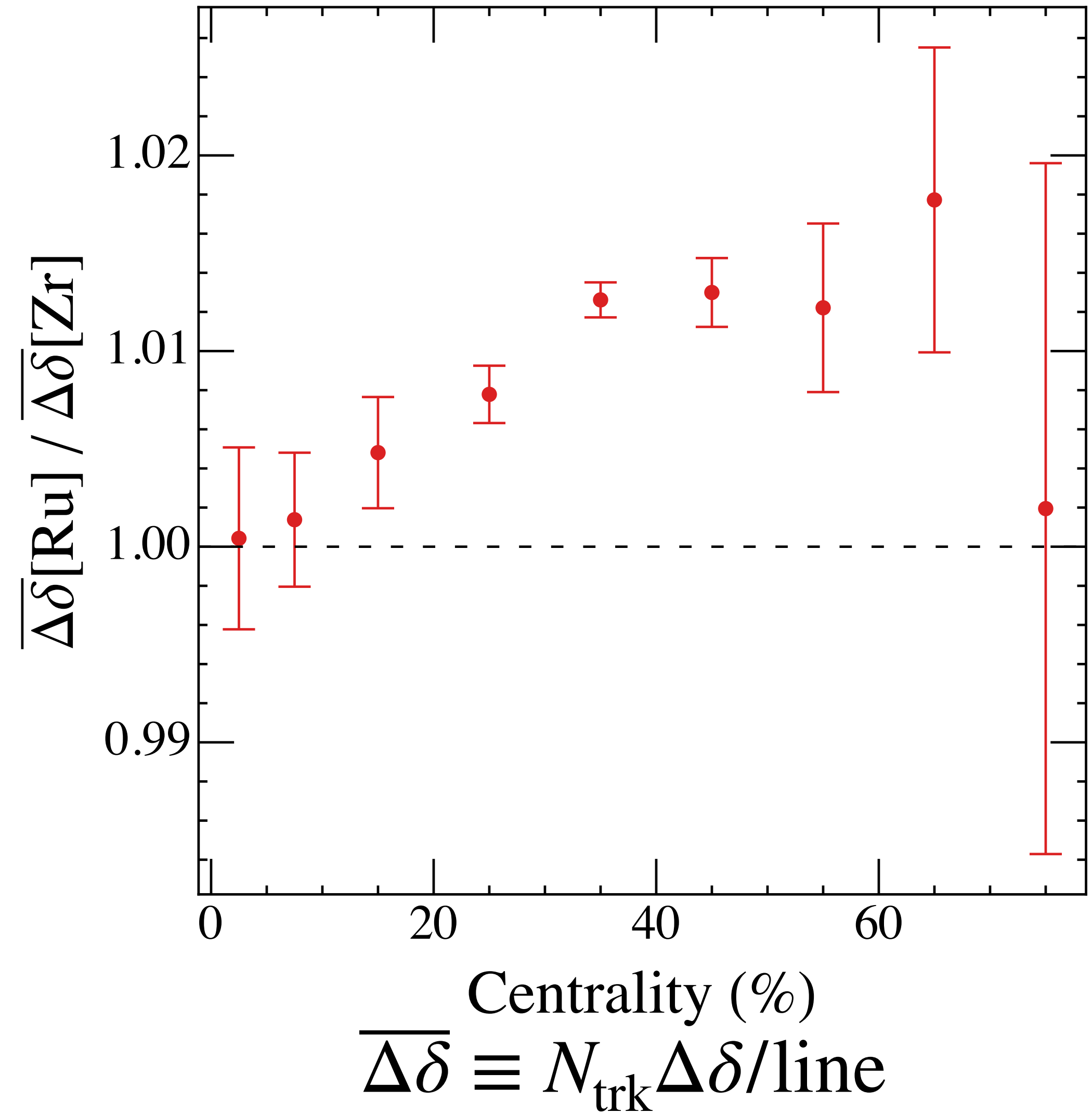
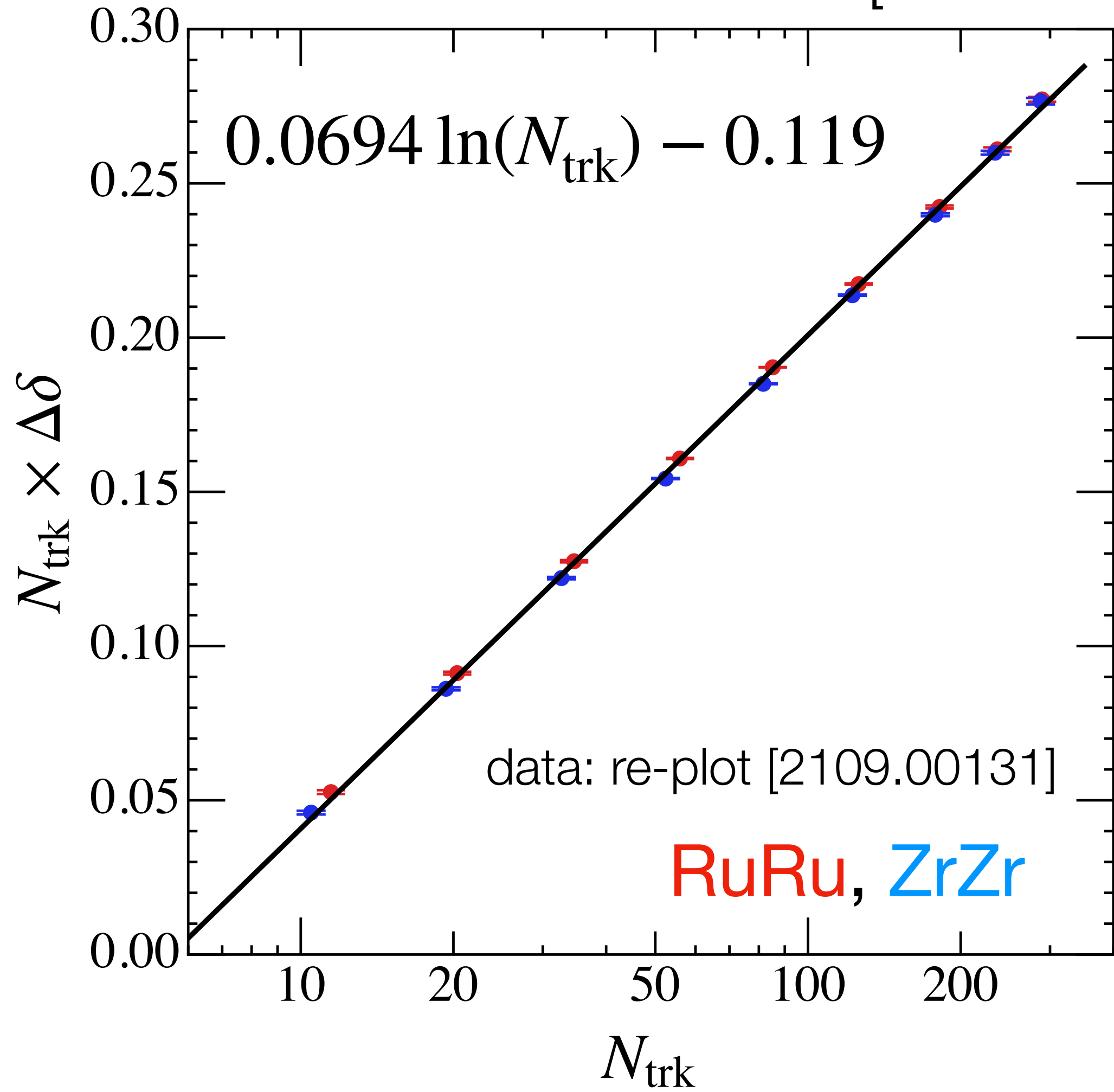
CME expectation: $\Delta\gamma_{112}[\text{Ru}] > \Delta\gamma_{112}[\text{Zr}]$



$$\overline{\Delta\gamma_{112}} \equiv (N_{\text{trk}} \Delta\gamma_{112}/v_2)/\text{line}$$

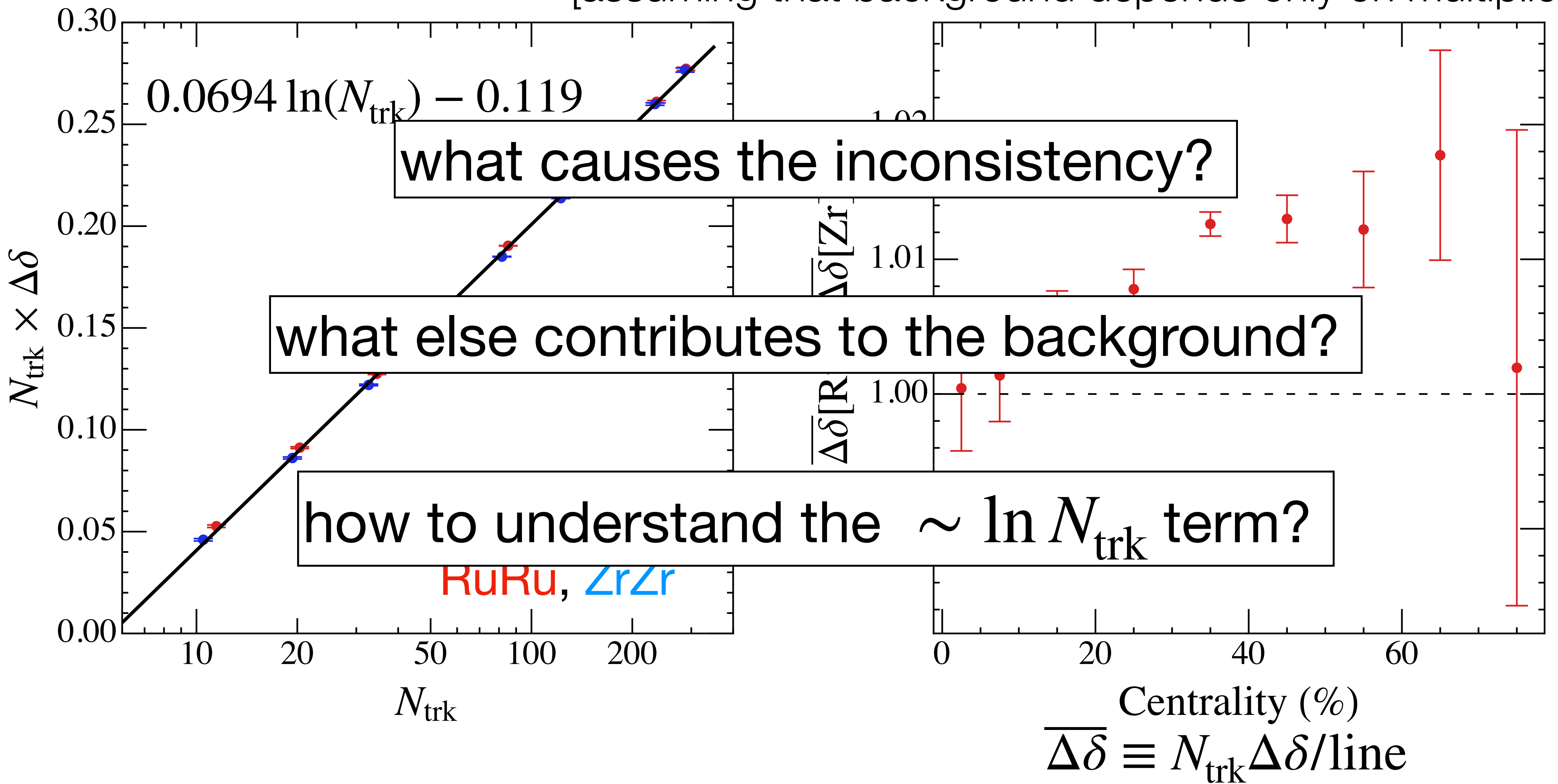
CME expectation: $\Delta\delta[\text{Ru}] < \Delta\delta[\text{Zr}]$

[assuming that background depends only on multiplicity]



CME expectation: $\Delta\delta[\text{Ru}] < \Delta\delta[\text{Zr}]$

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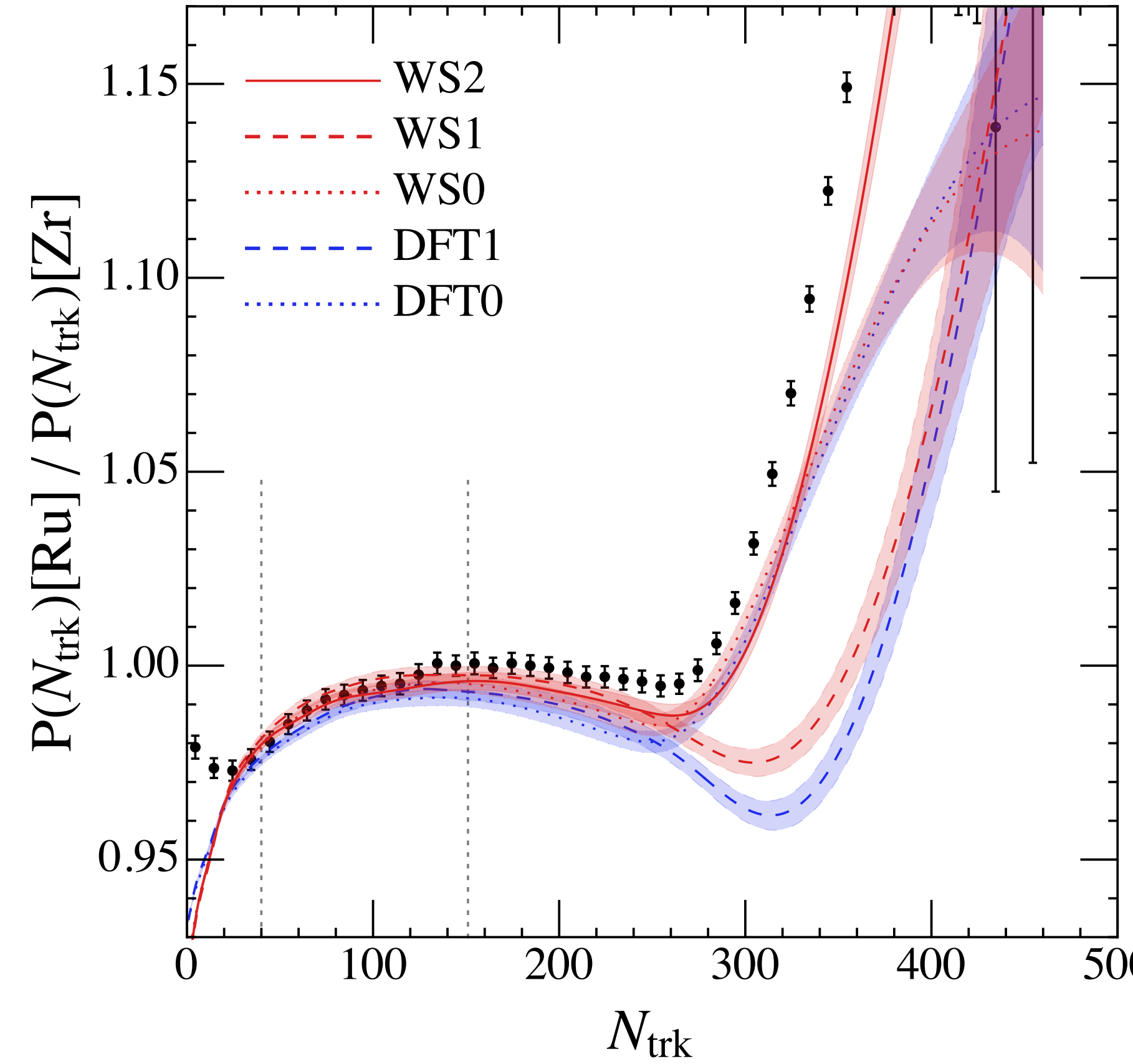
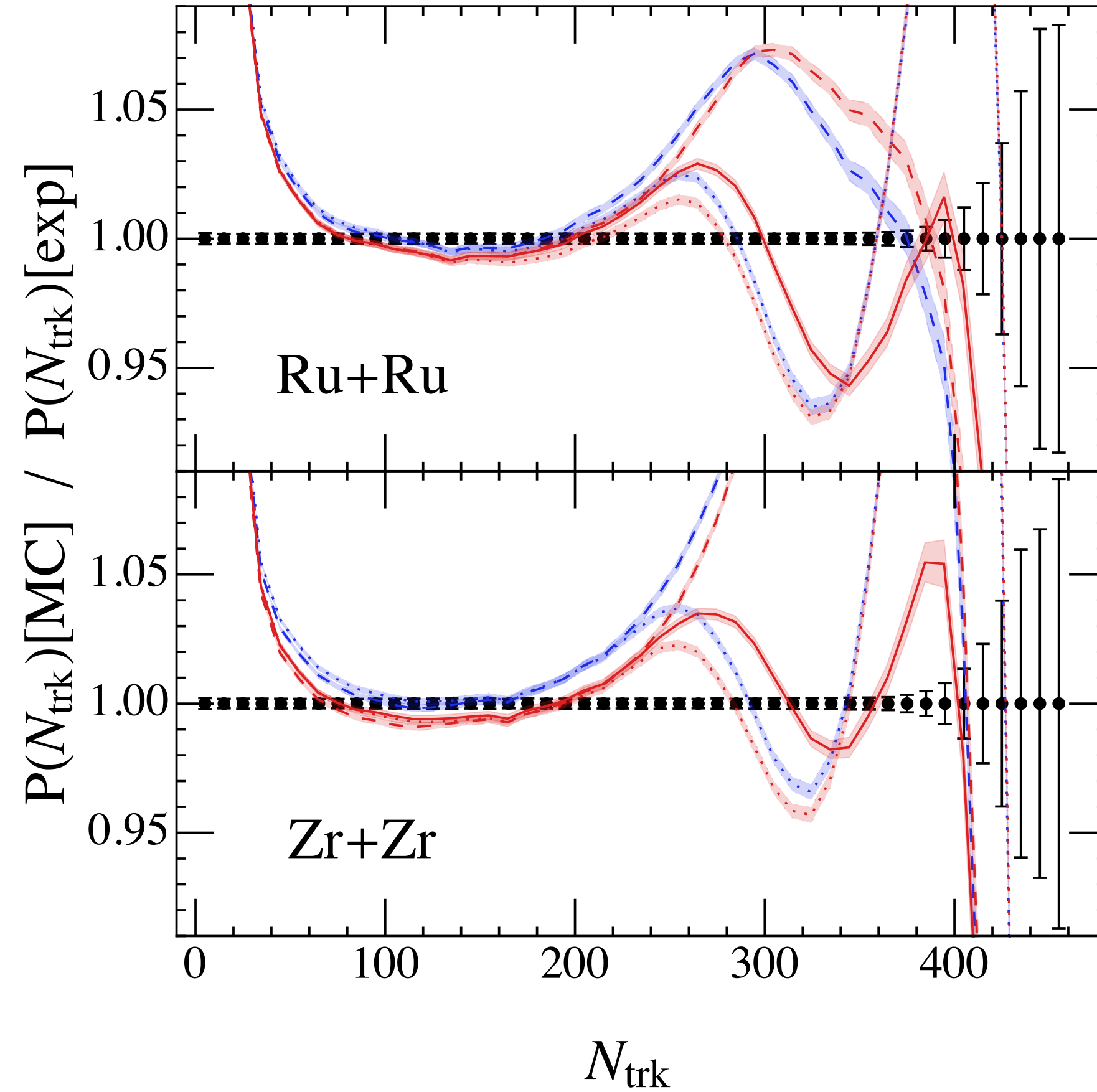
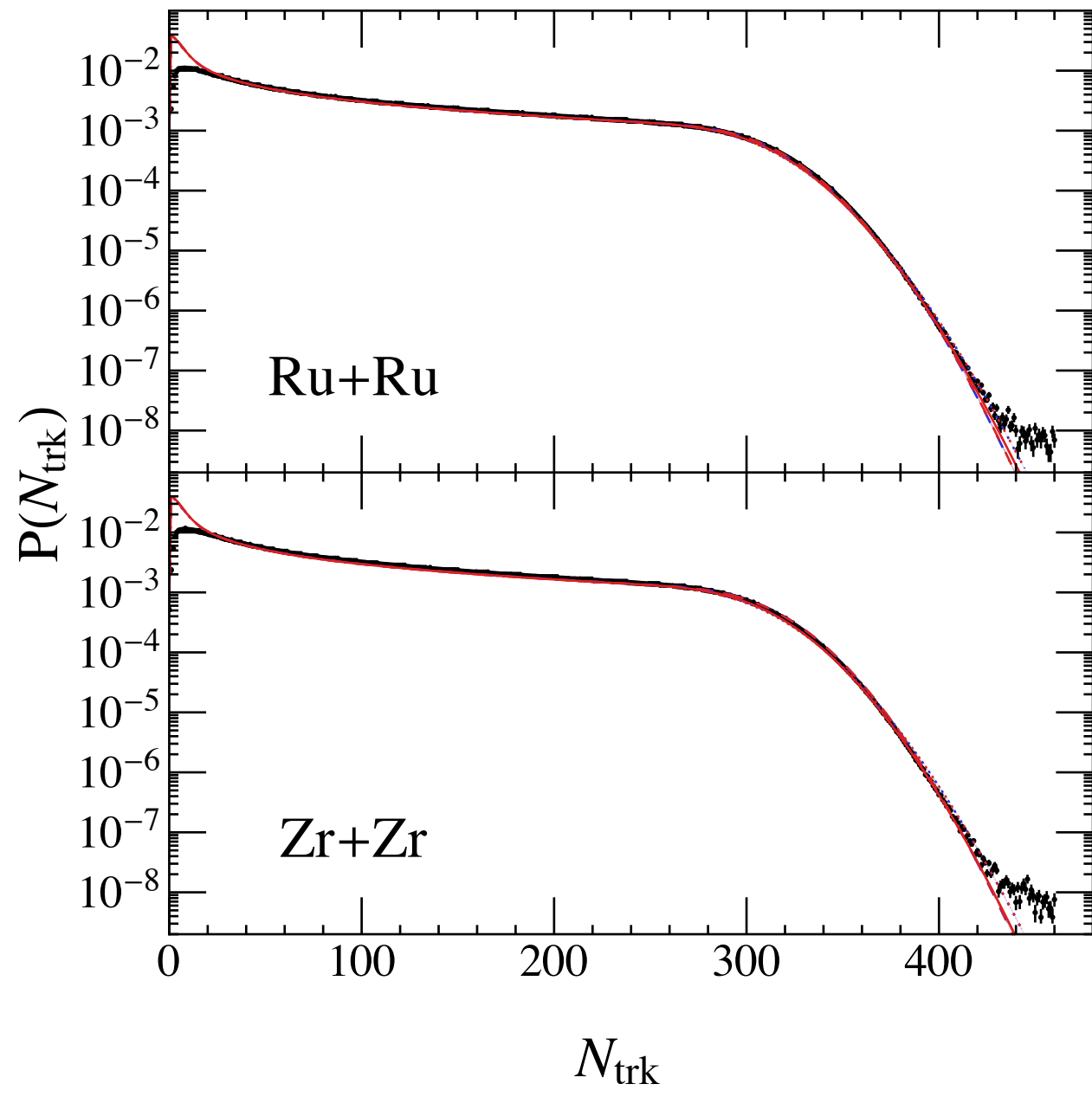


what we learned from hydro simulation

multiplicity distribution

[MC Glauber only]

data: re-plot [2109.00131]

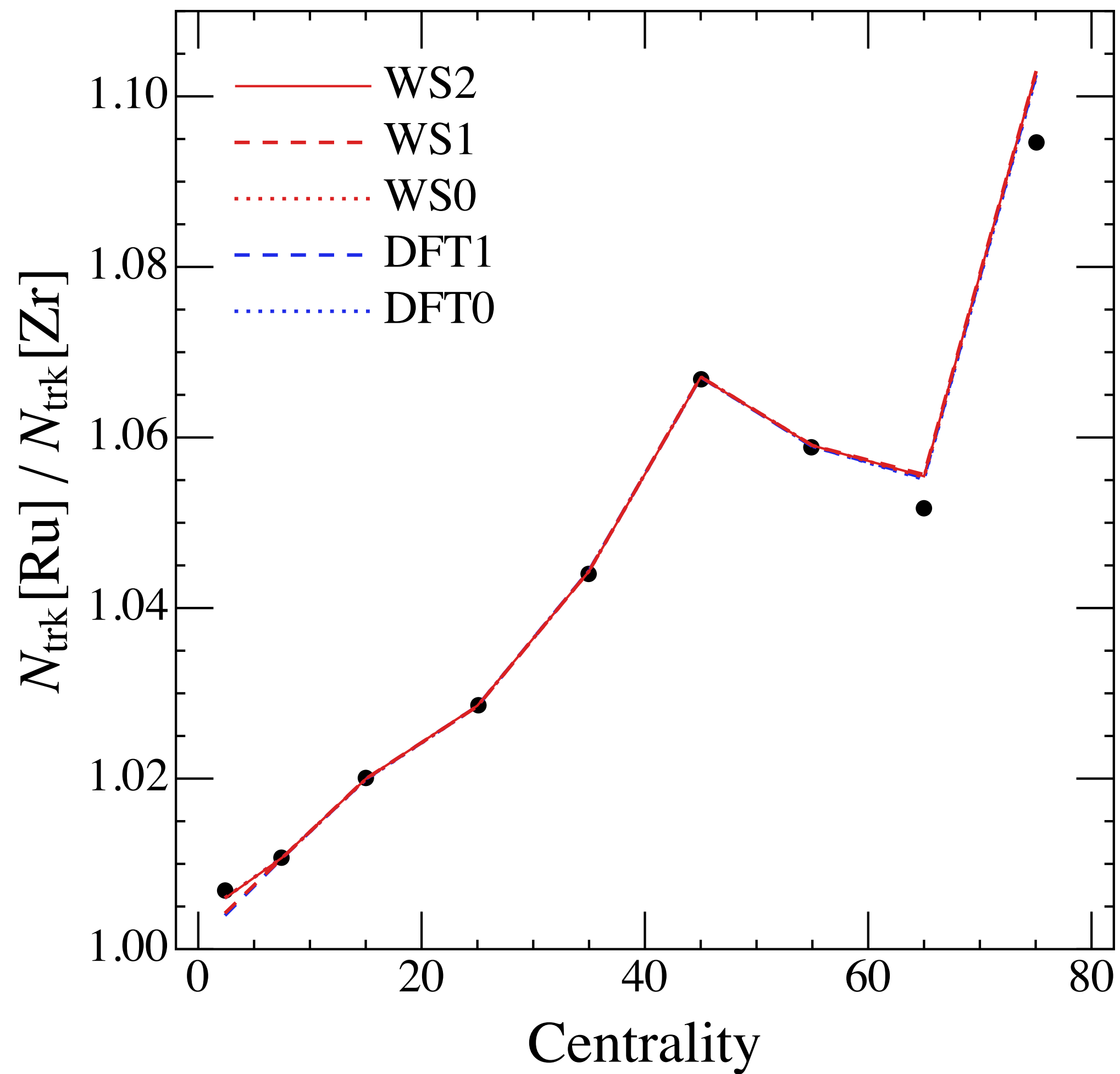
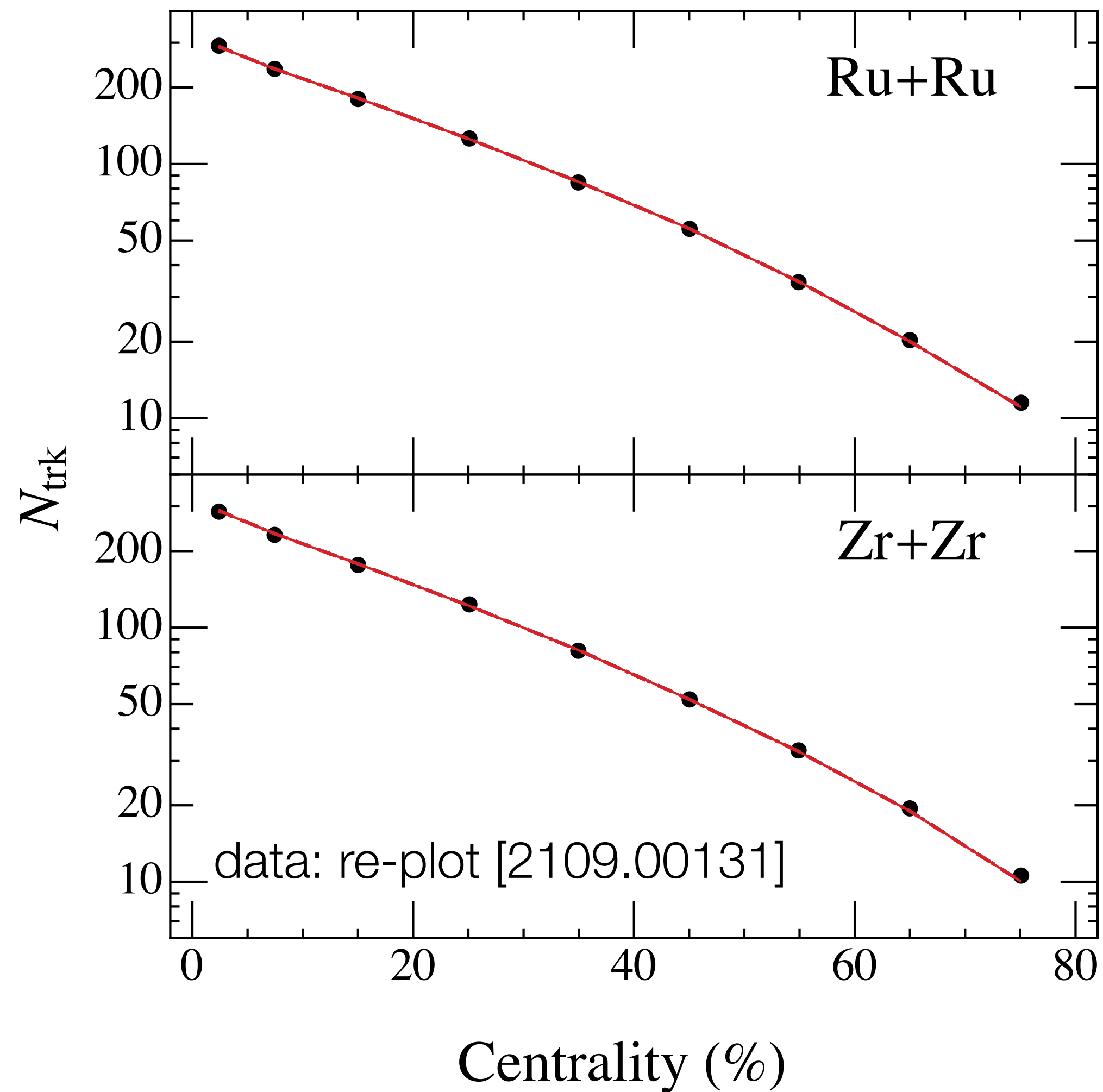


blue: SLy4 DFT
red: WS

dot: spherical

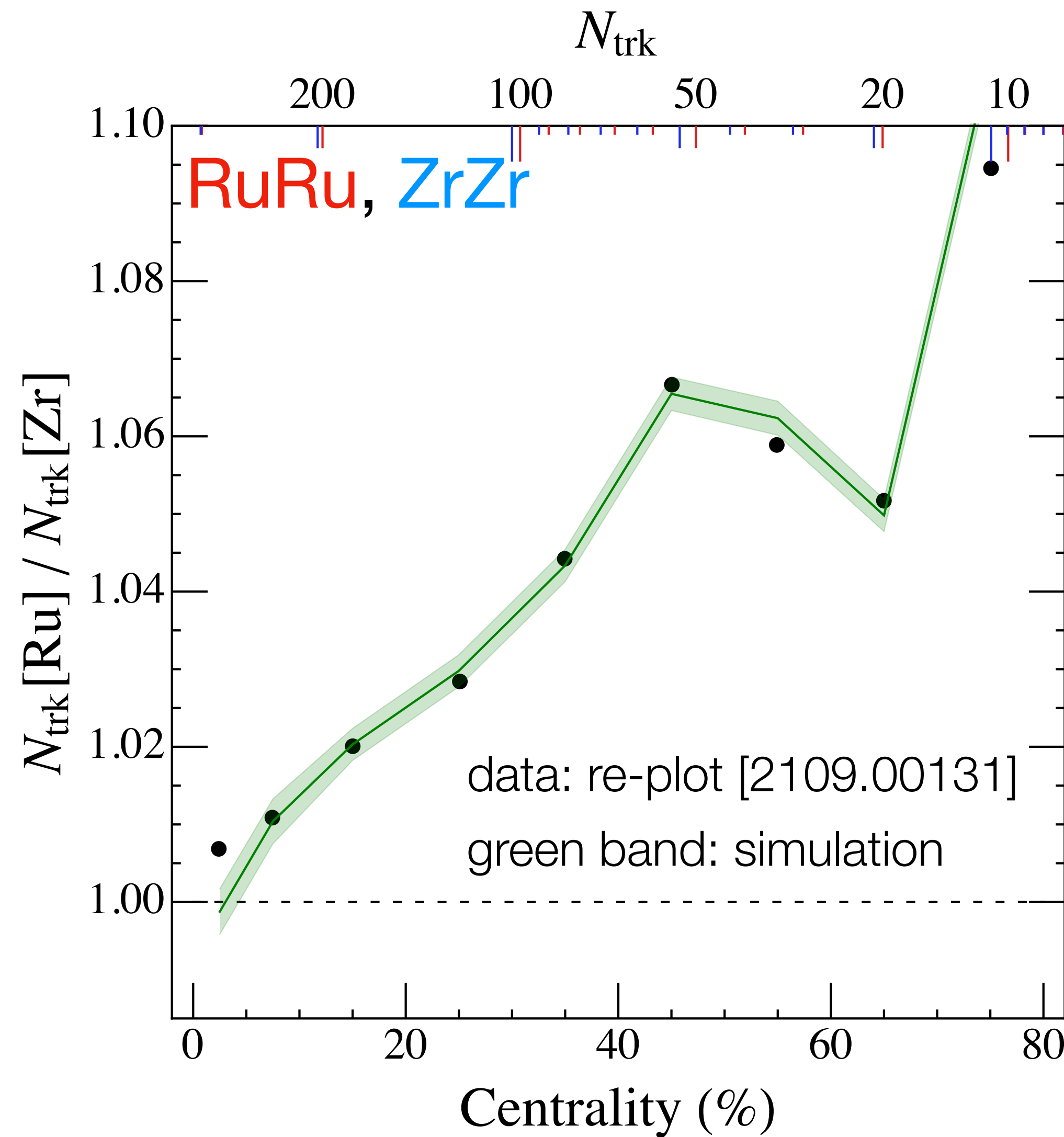
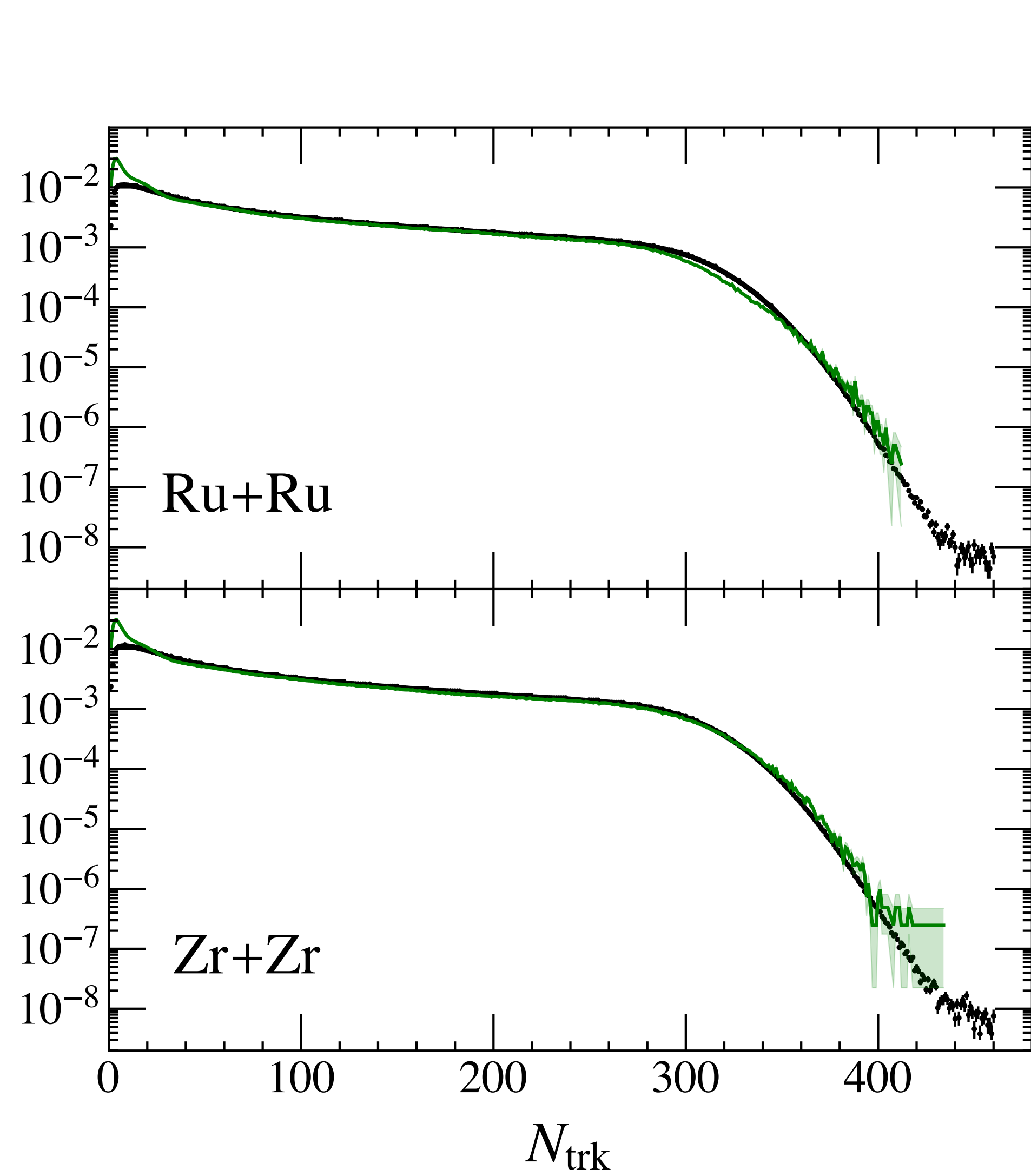
dash: deformed, same R and a as dotted lines

solid: deformed, new R and a to fit $\langle r \rangle$, $\langle r^2 \rangle$



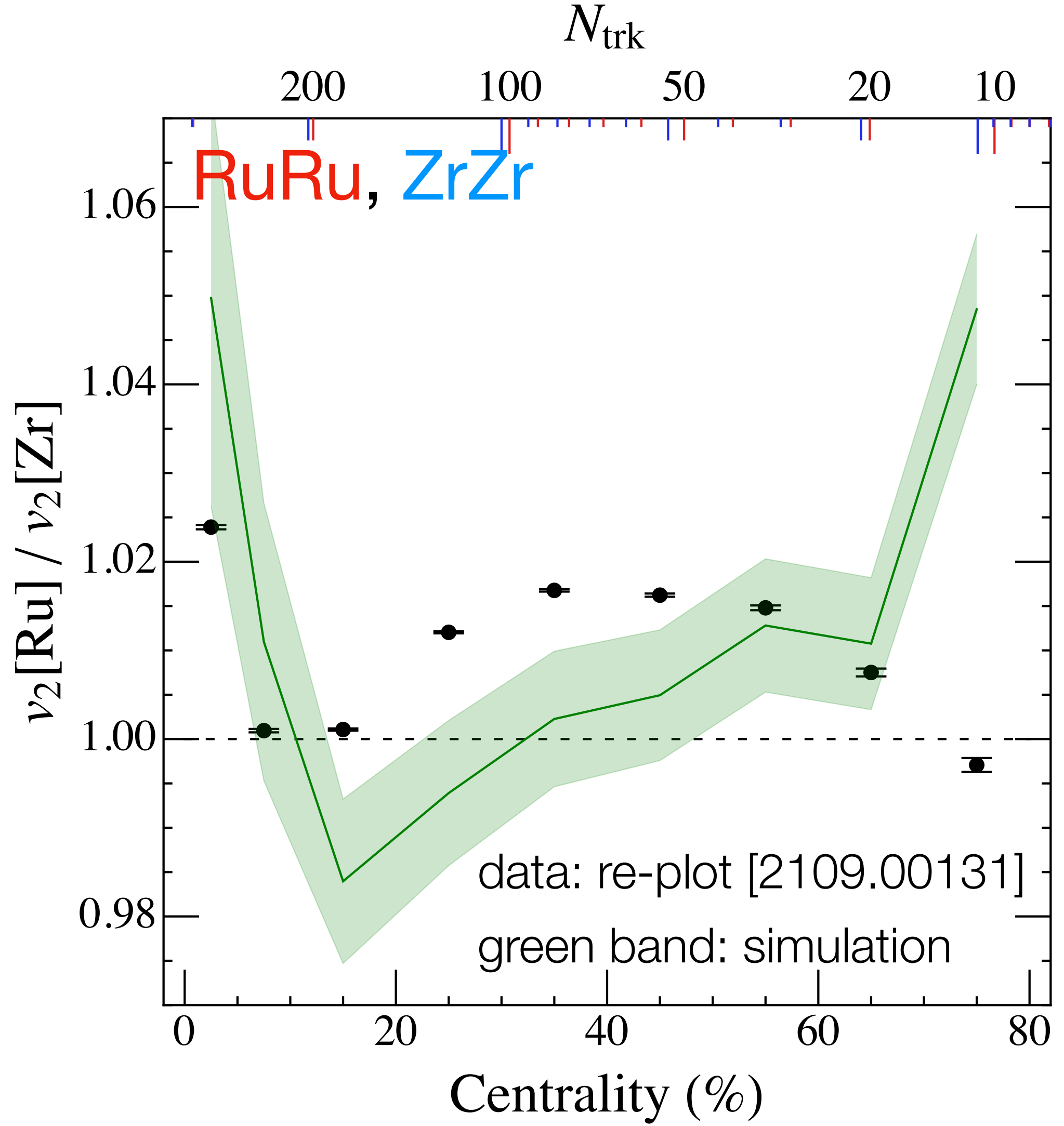
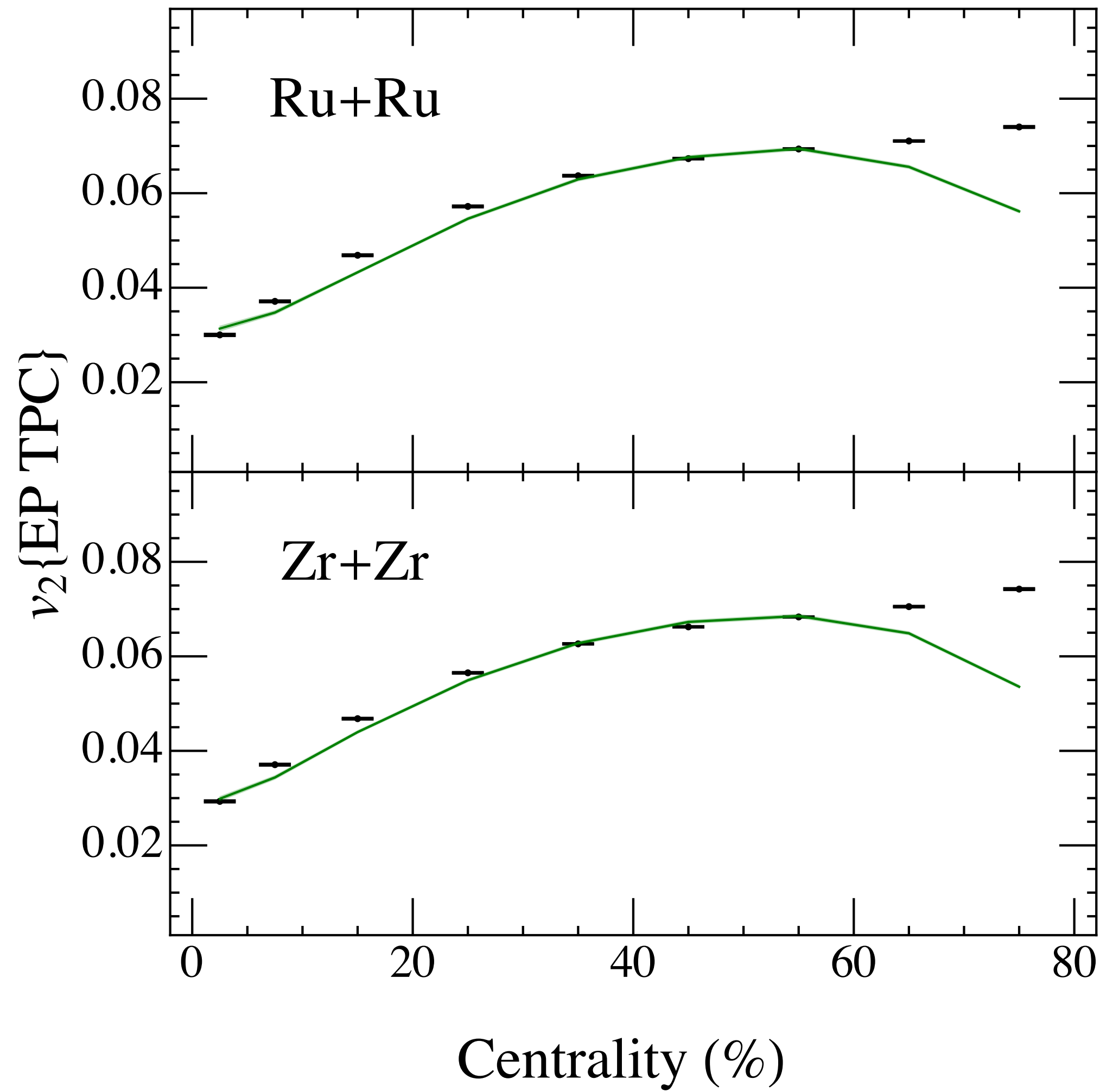
centrality determination based on the STAR N_{trk} -cut

multiplicity ratio [MC Glauber + hydro + hadron scattering]



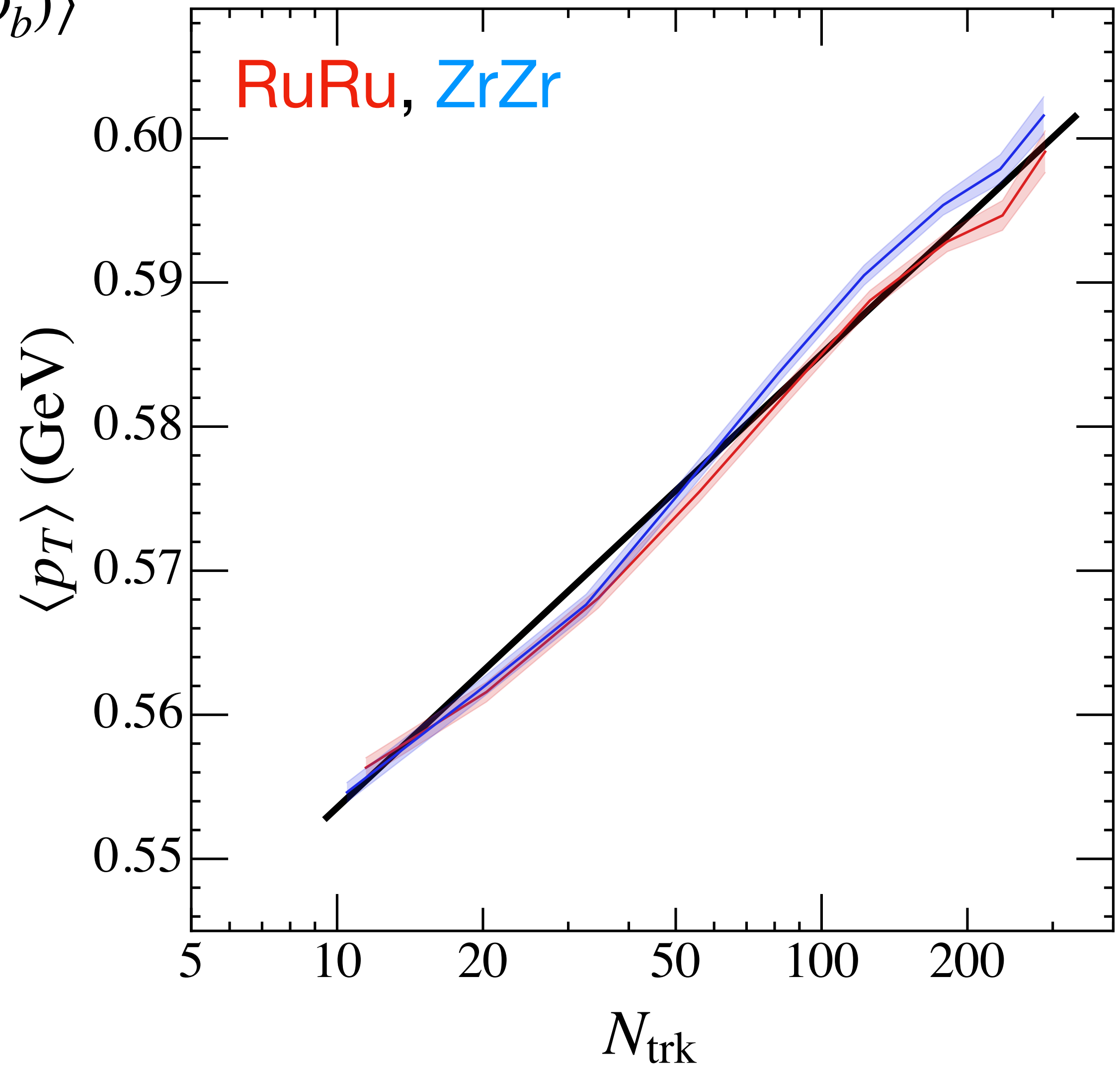
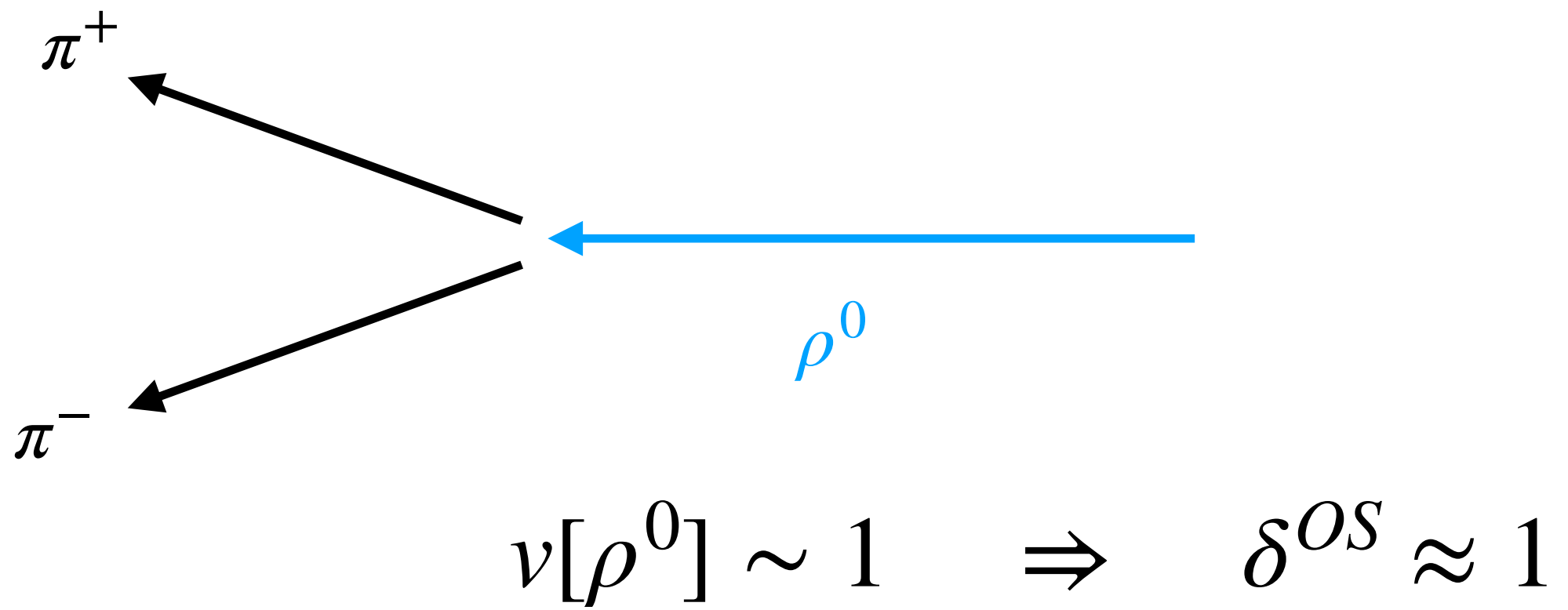
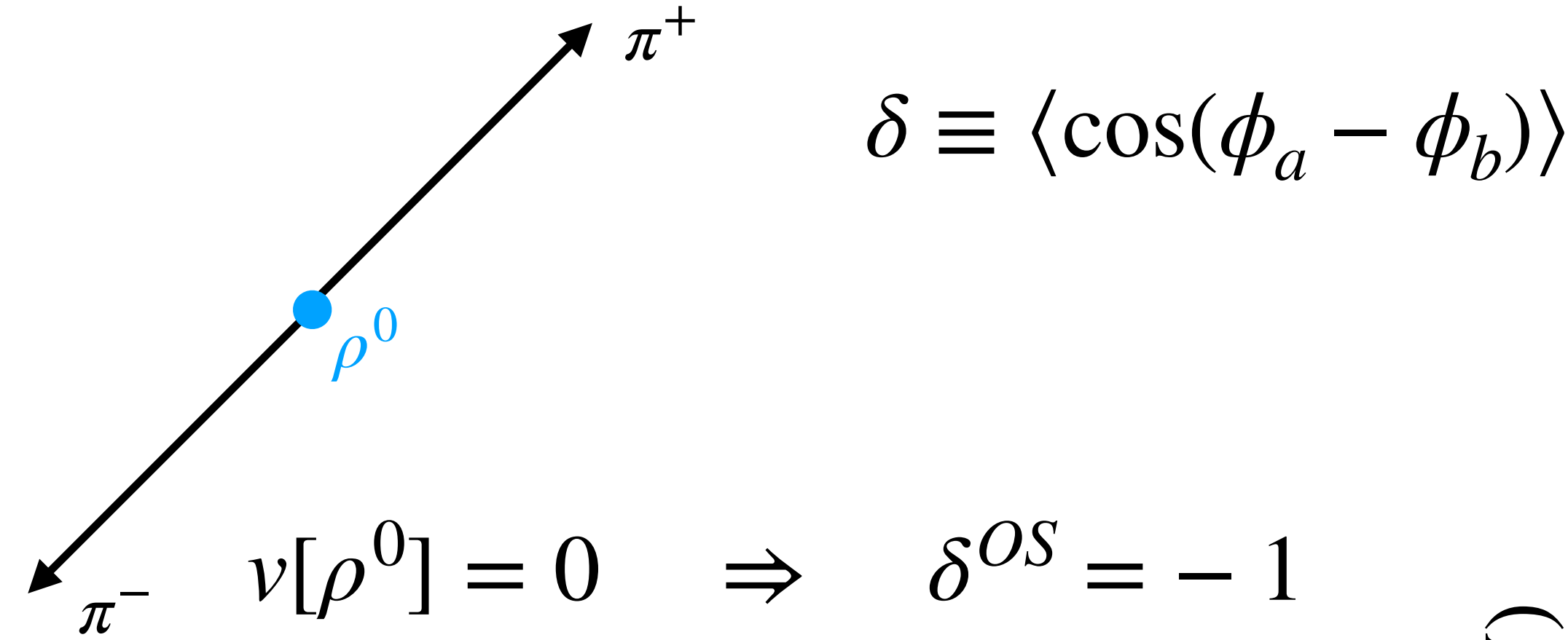
centrality determination based on the STAR N_{trk} -cut

elliptic flow ratio [MC Glauber + hydro + hadron scattering]



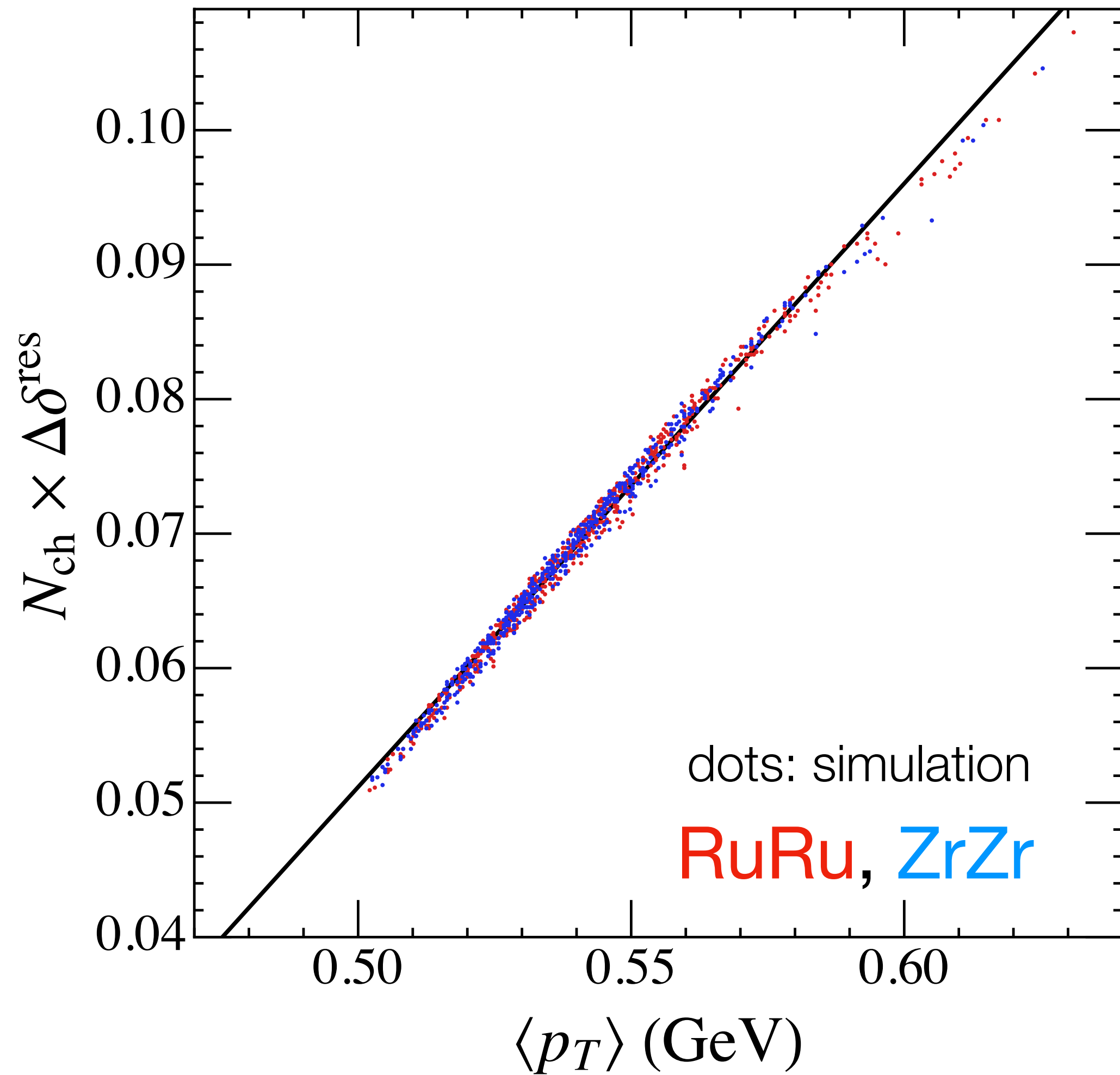
needs further understanding

centrality dependence of radial flow



pT-dependence of background

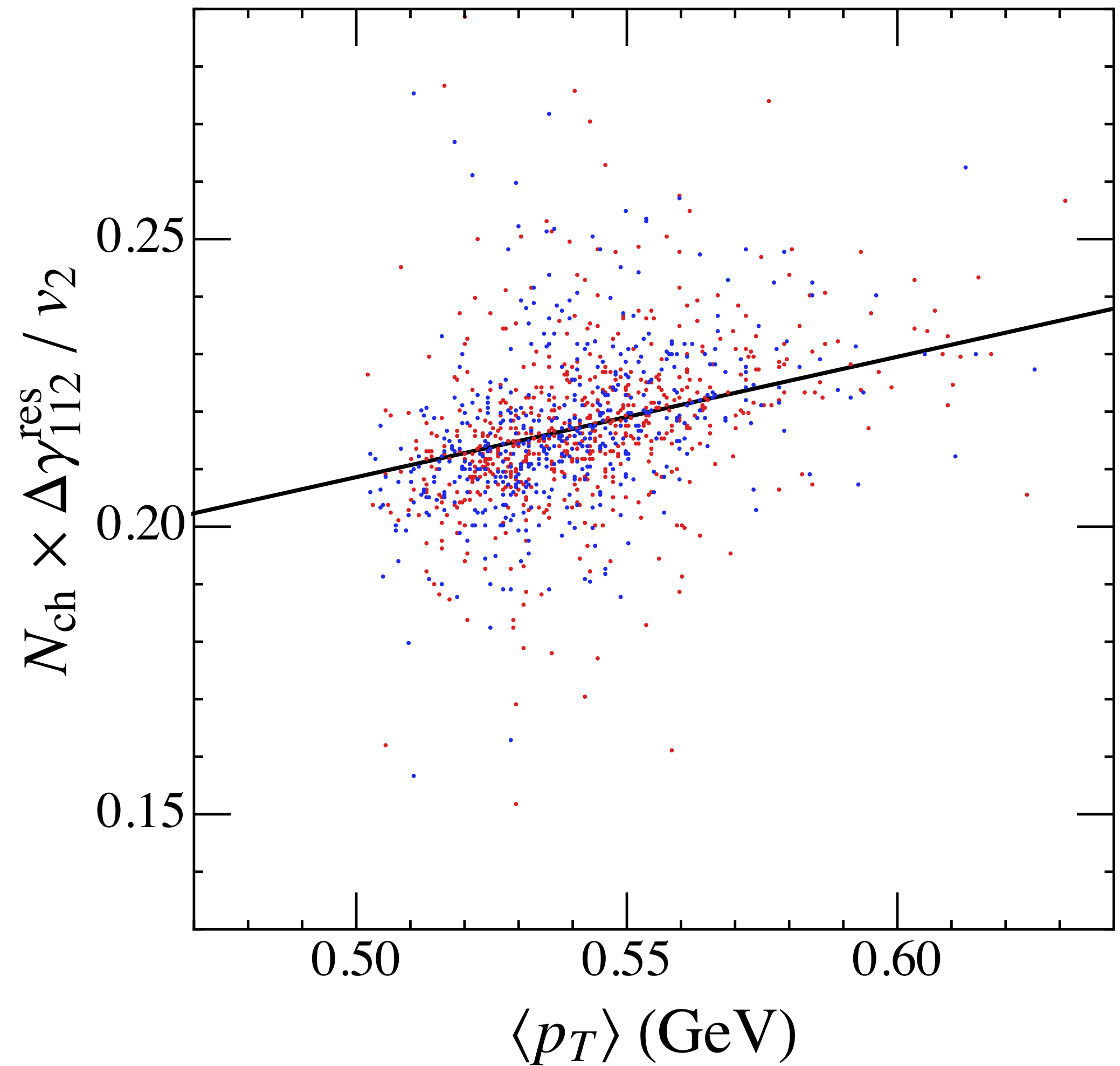
$$\Delta\delta_{\text{bkg}} = \frac{1}{N_{\text{ch}}} (d_0 + d_1 \times \langle p_T \rangle)$$



[hydro+CooperFrye+resonance]

09

$$\Delta\gamma_{\text{bkg}} = \frac{v_2}{N_{\text{ch}}} (g_0 + g_1 \times \langle p_T \rangle)$$

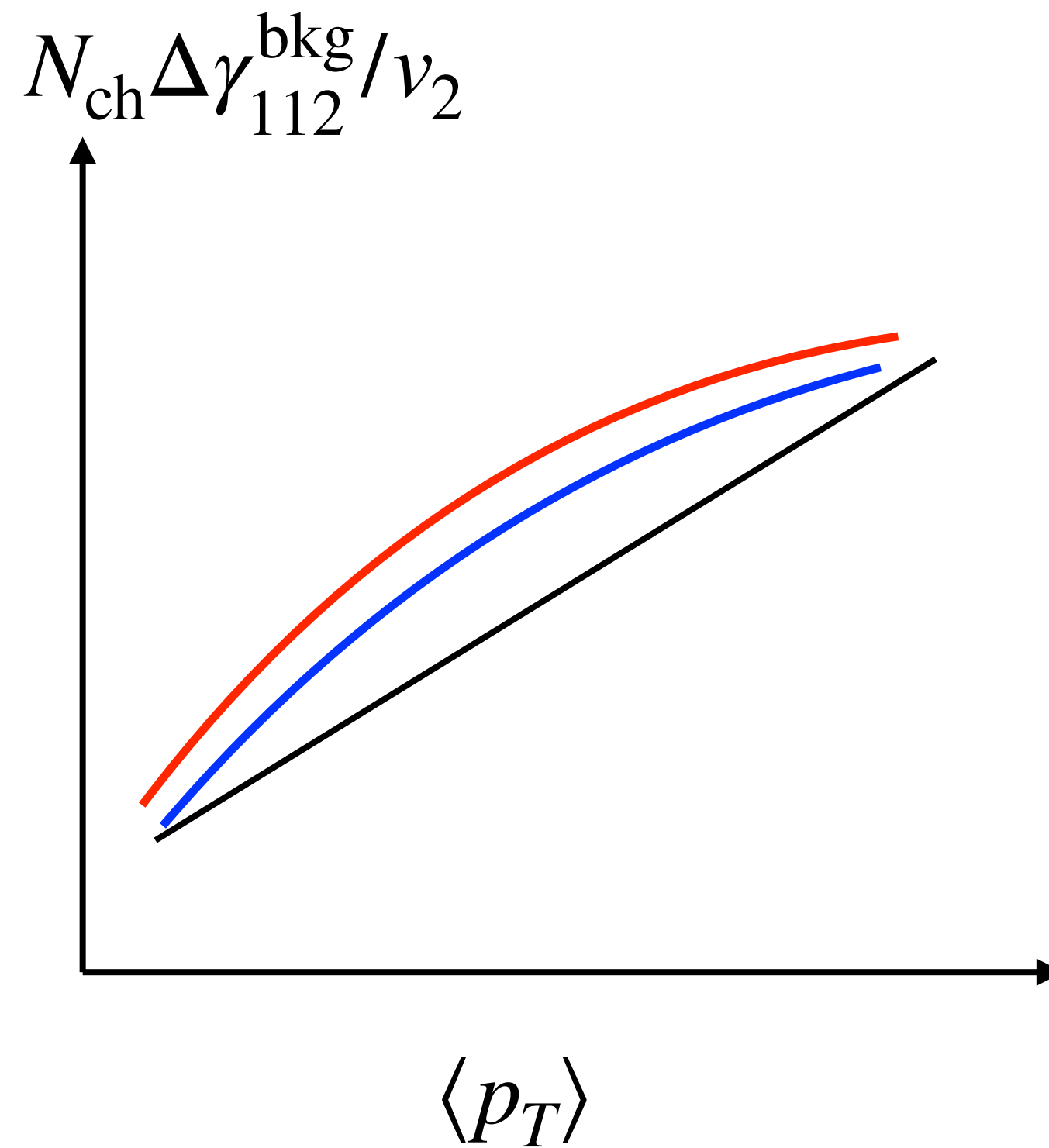
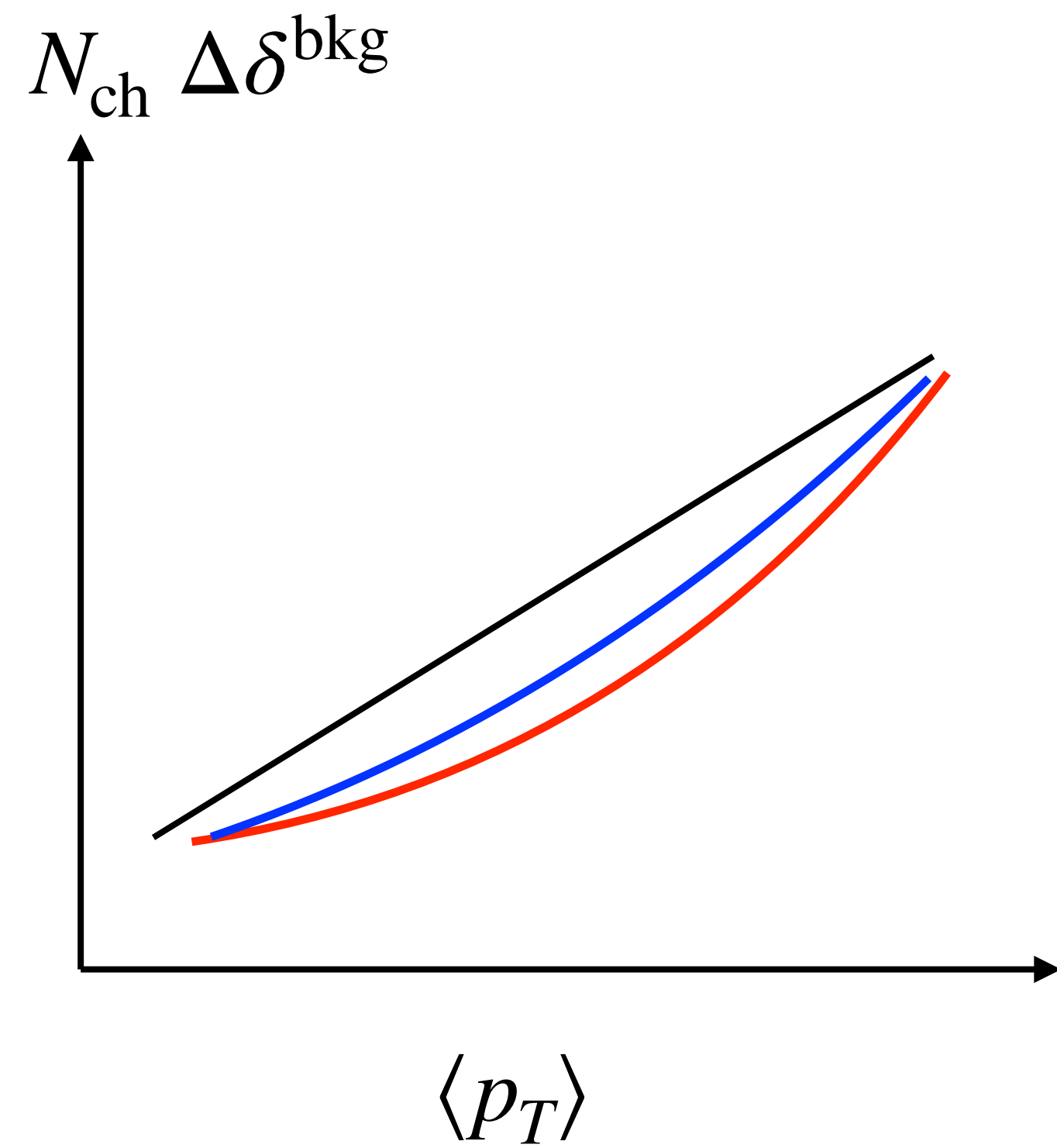


a new baseline

[if $\langle p_T \rangle$ is measured]

$$\Delta\delta_{\text{bkg}} = \frac{1}{N_{\text{ch}}} (d_0 + d_1 \times \langle p_T \rangle)$$

$$\Delta\gamma_{\text{bkg}} = \frac{v_2}{N_{\text{ch}}} (g_0 + g_1 \times \langle p_T \rangle)$$



CME: $\Delta\delta \downarrow$, $\Delta\gamma_{112} \uparrow$

red: CME[RuRu]

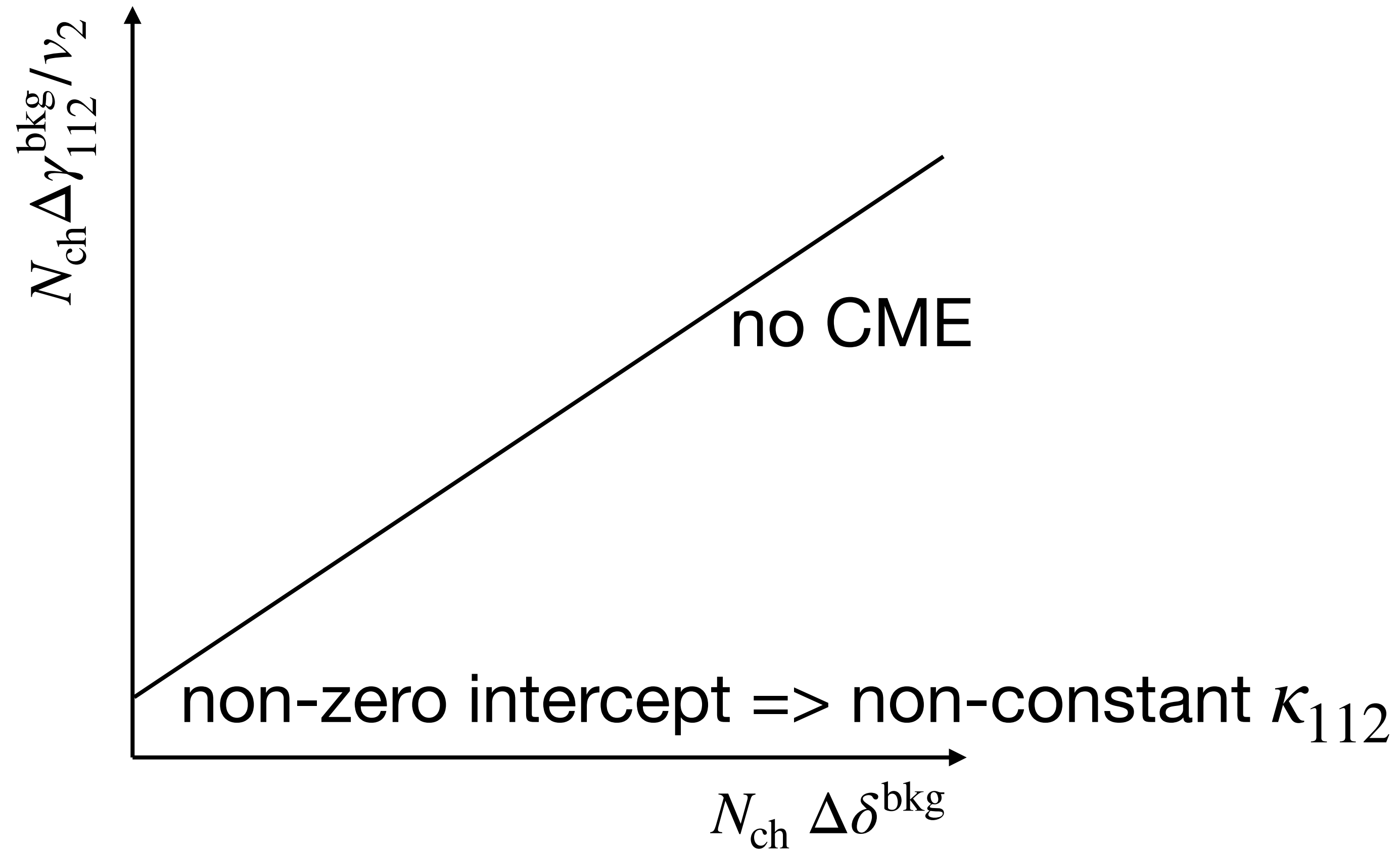
blue: CME[ZrZr]

black: no CME

a new baseline

$$\Delta\delta_{\text{bkg}} = \frac{1}{N_{\text{ch}}} (d_0 + d_1 \times \langle p_T \rangle)$$

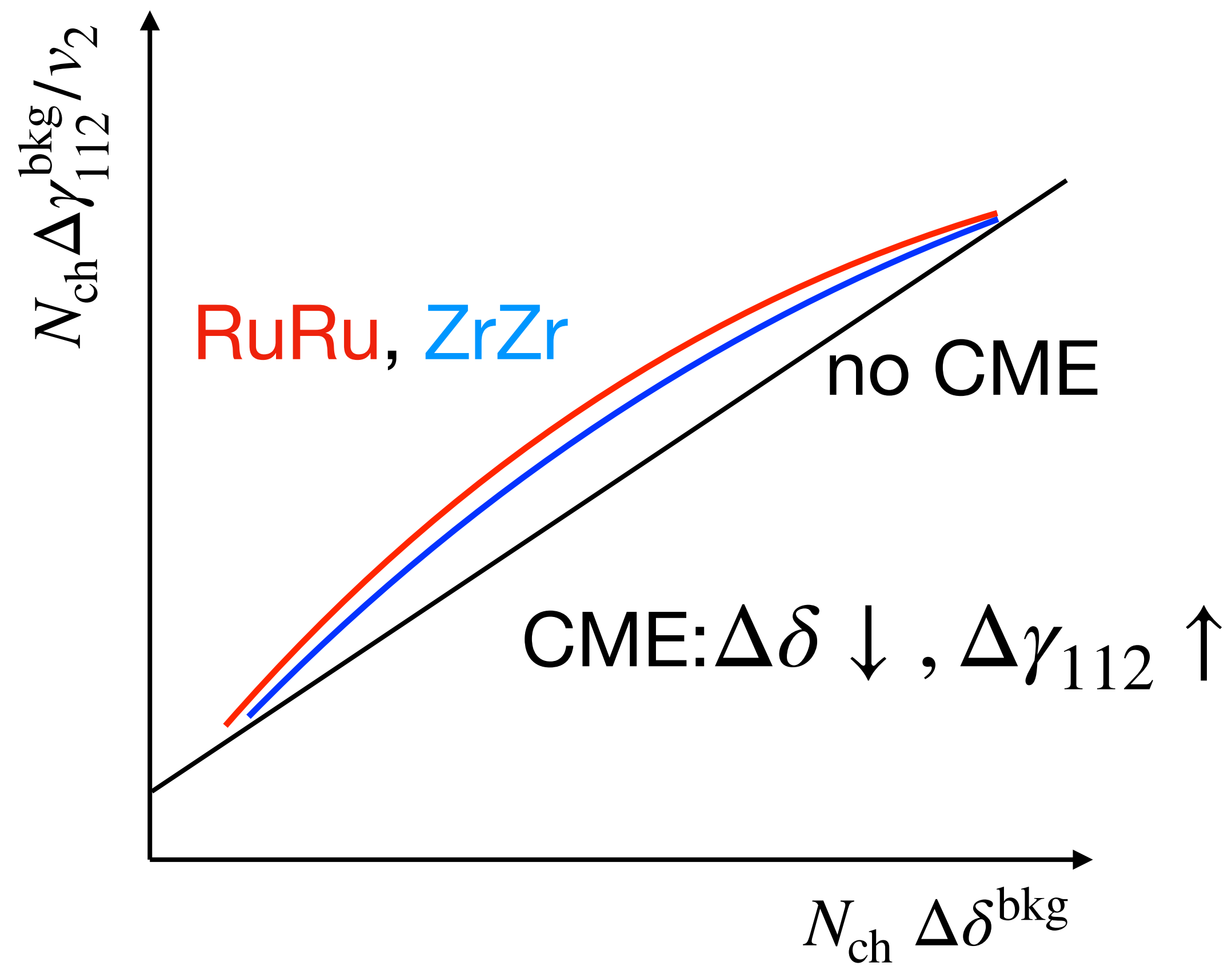
$$\Delta\gamma_{\text{bkg}} = \frac{v_2}{N_{\text{ch}}} (g_0 + g_1 \times \langle p_T \rangle)$$



a new baseline

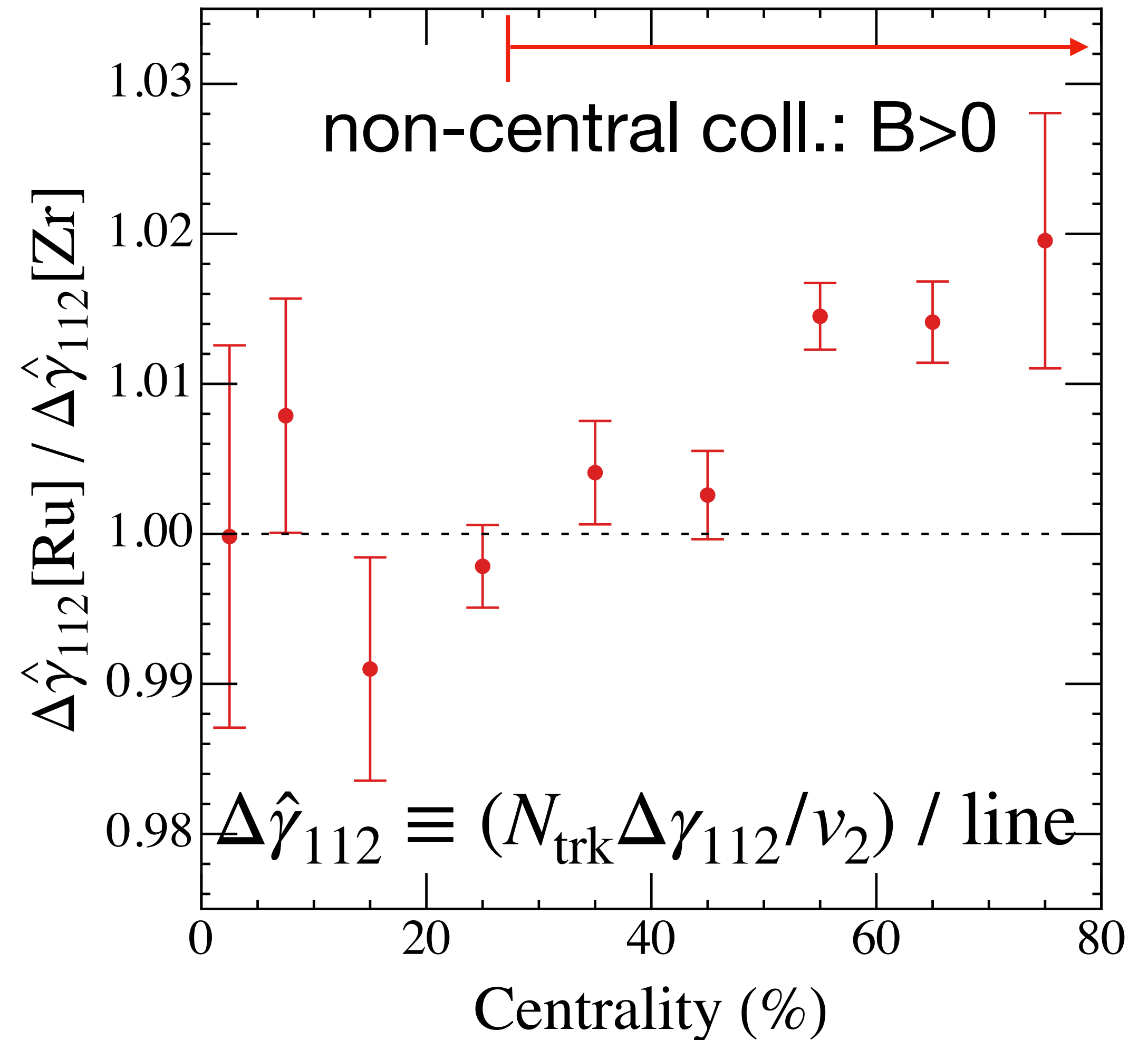
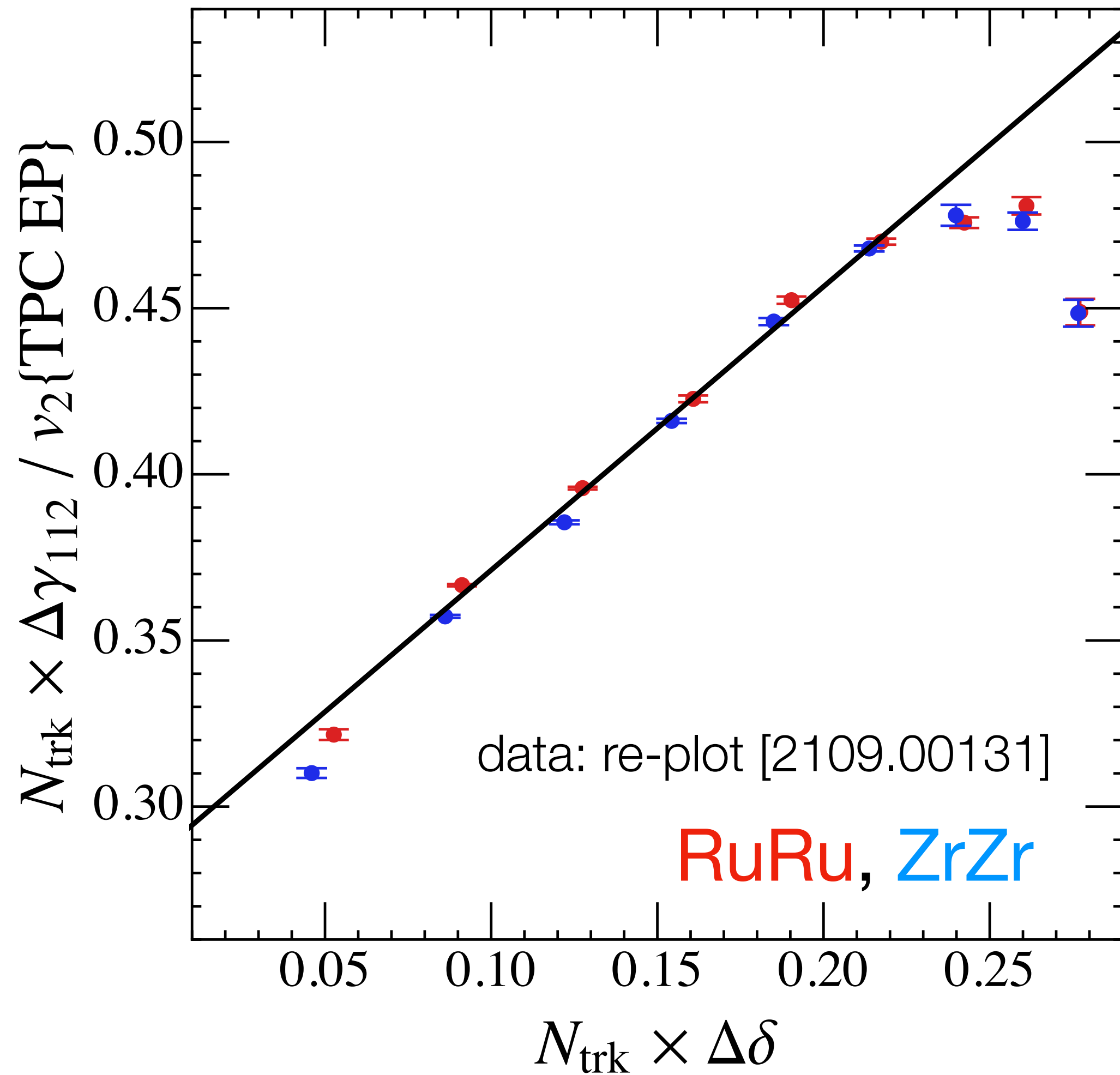
$$\Delta\delta_{\text{bkg}} = \frac{1}{N_{\text{ch}}} (d_0 + d_1 \times \langle p_T \rangle)$$

$$\Delta\gamma_{\text{bkg}} = \frac{v_2}{N_{\text{ch}}} (g_0 + g_1 \times \langle p_T \rangle)$$



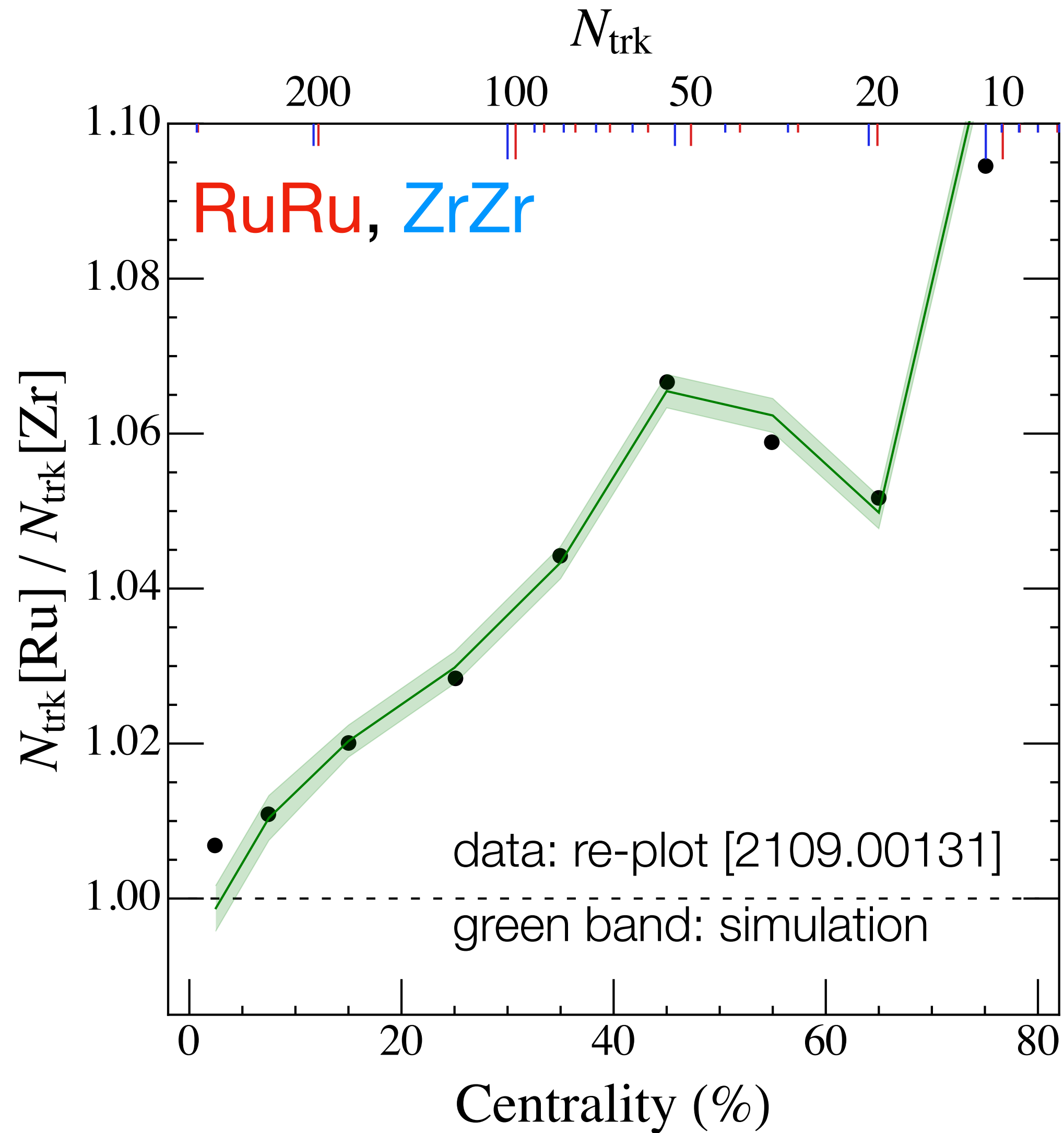
can the exp. result be understood by no-CME baseline?

experiment: inconsistent with pure background expectation in non-central collisions ---> CME?

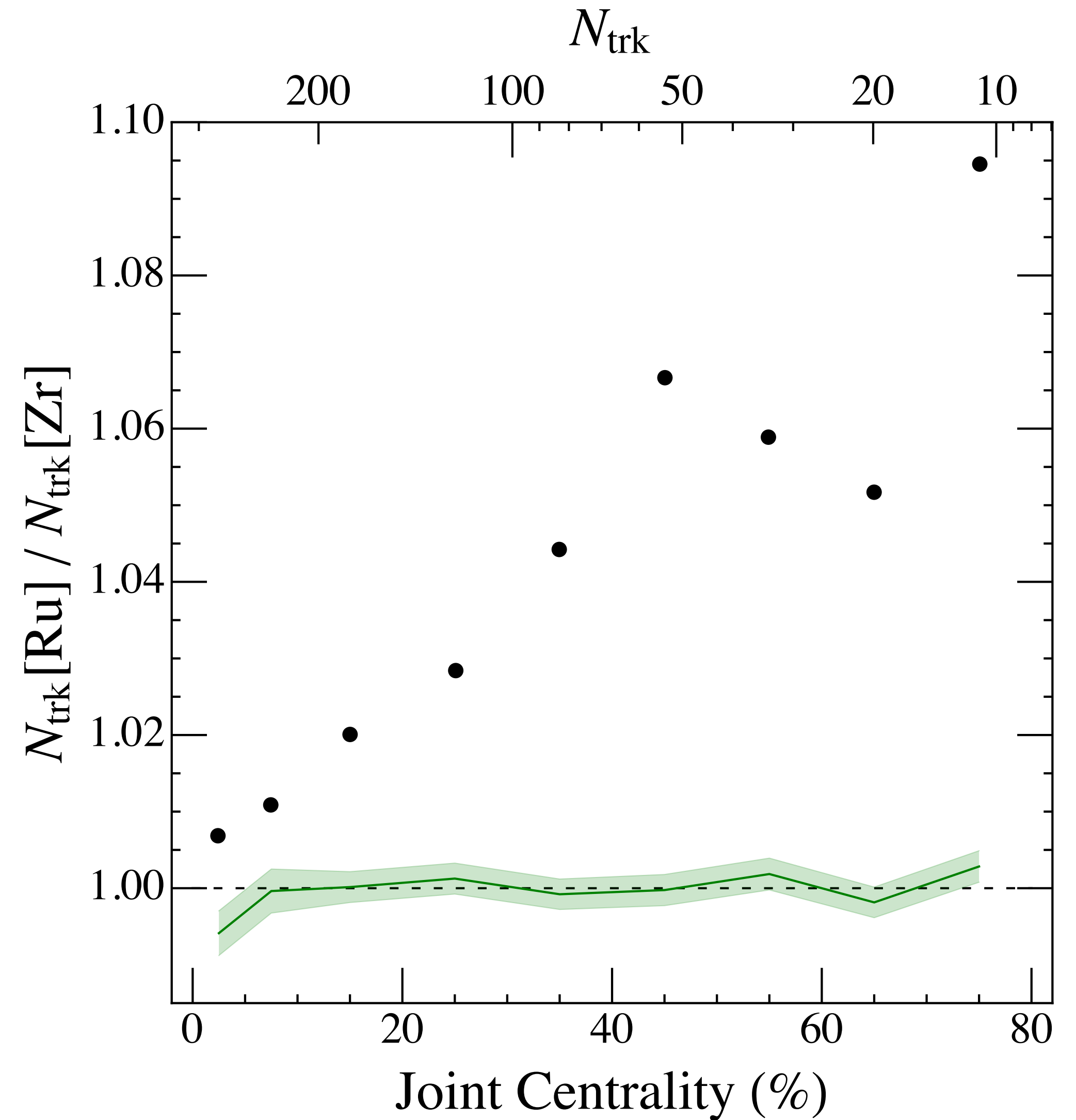


what else can we do?

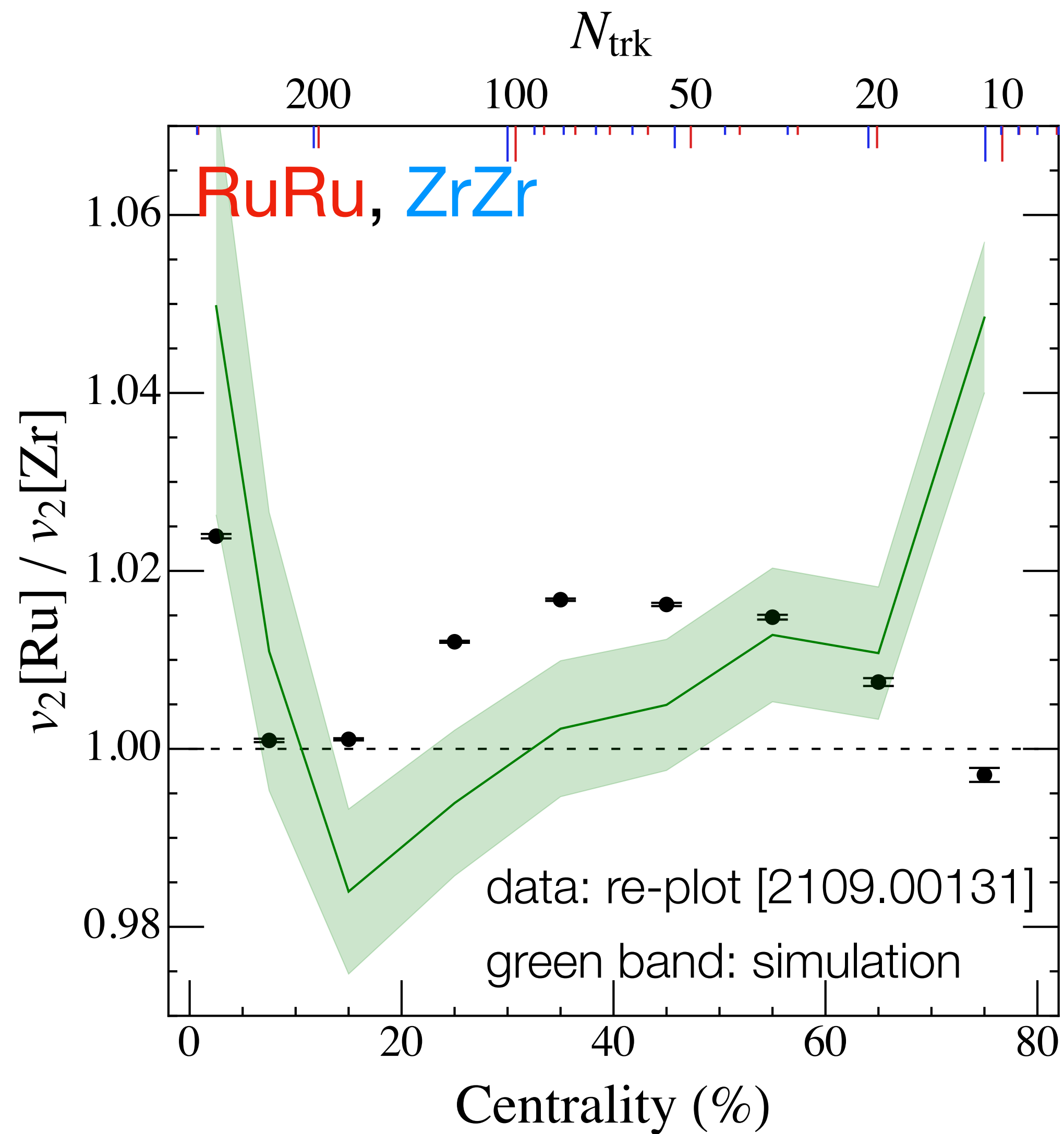
STAR $N_{\text{trk-cut}}$



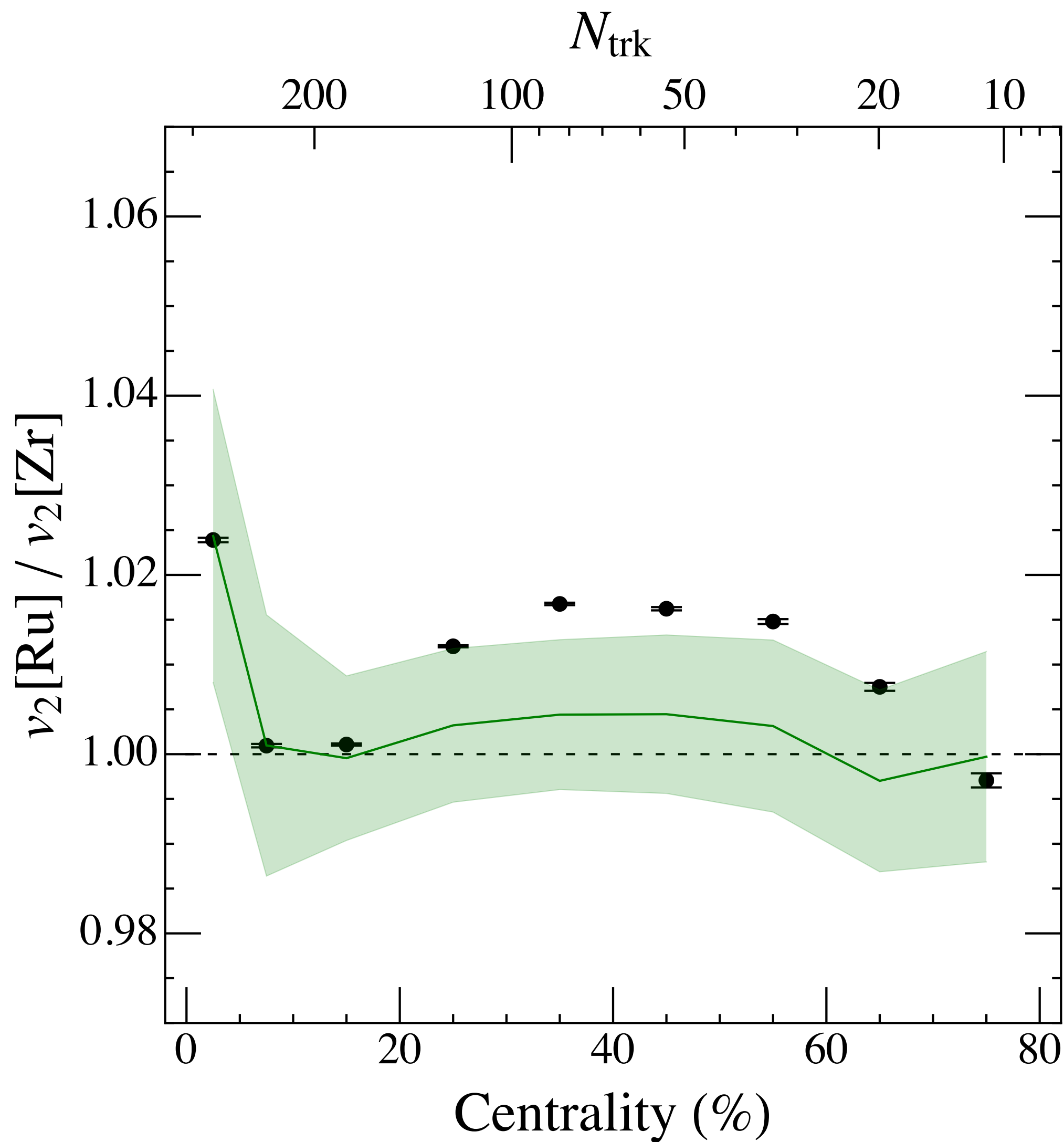
identical $N_{\text{trk-cut}}$



elliptic flow ratio



STAR N_{trk} -cut



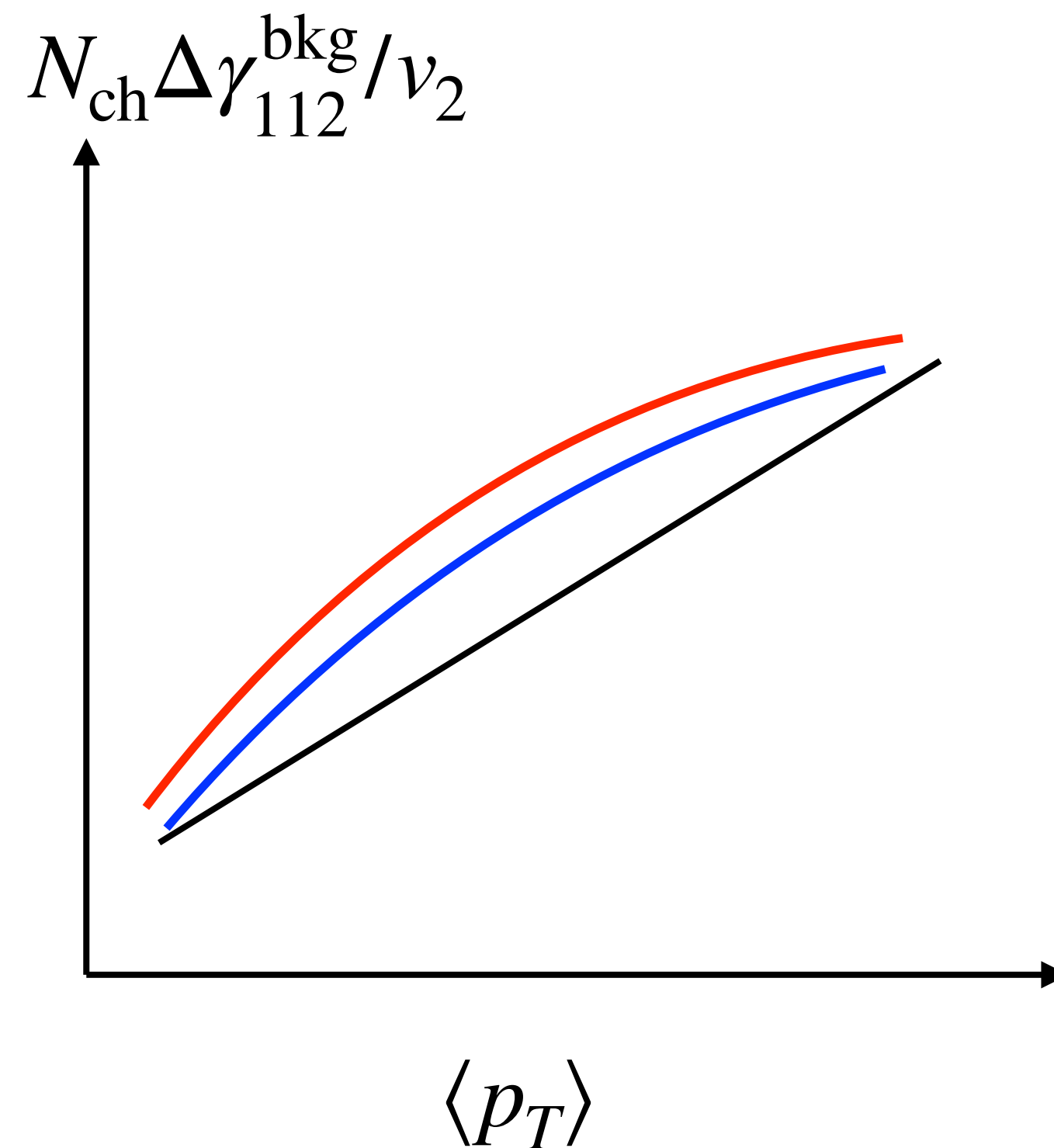
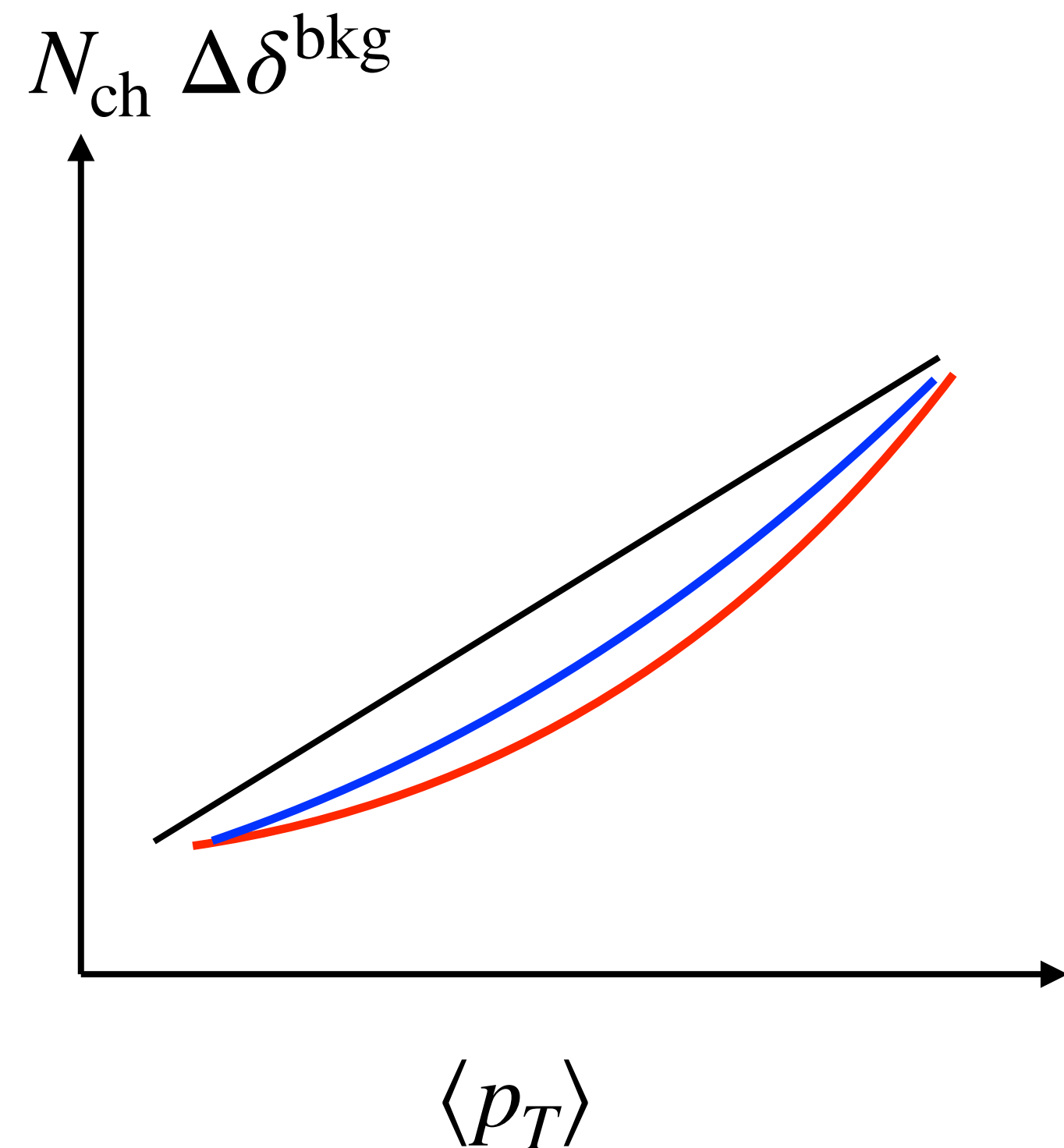
identical N_{trk} -cut + v_2 cut

summary

- non-CME baseline in isobar collisions is different from unity
- the multiplicity difference is understood theoretically
- simulation shows $\langle p_T \rangle$ -dependence of background
- present analysis is inconsistent with pure-background expectation, and indicates room for CME in non-central collisions where magnetic field should be present
- more experimental and theoretical work is needed

Take home messages for experimentalists:

- difference in $\langle N_{\text{ch}} \rangle$ and $\langle v_2 \rangle$ can be eliminated if applying identical N_{trk} -cut & v_2 selection, for both systems
- $\Delta\delta^{\text{bkg}}$ and $\Delta\gamma_{112}^{\text{bkg}}$ depend on radial flow --- need to compare $\langle p_T \rangle$



CME: $\Delta\delta \downarrow$, $\Delta\gamma_{112} \uparrow$

red: CME[RuRu]

blue: CME[ZrZr]

black: no CME