CME Baseline for RHIC Isobar Run

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in collaboration with:

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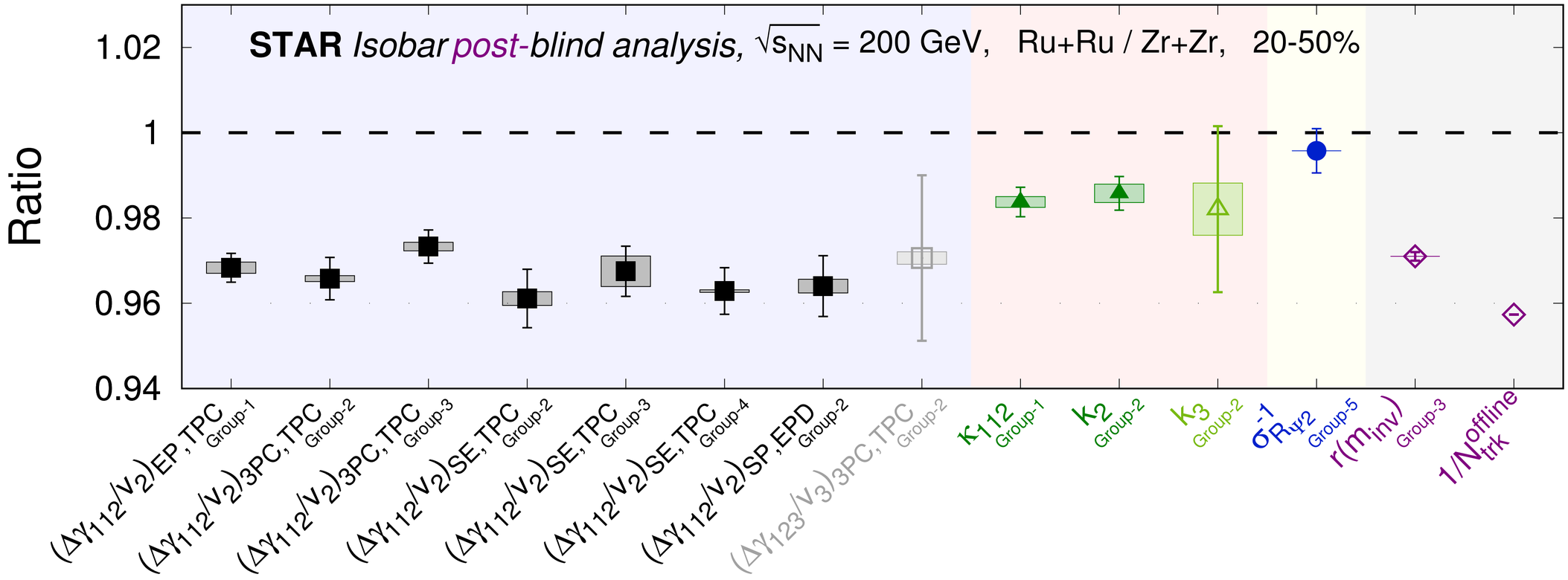
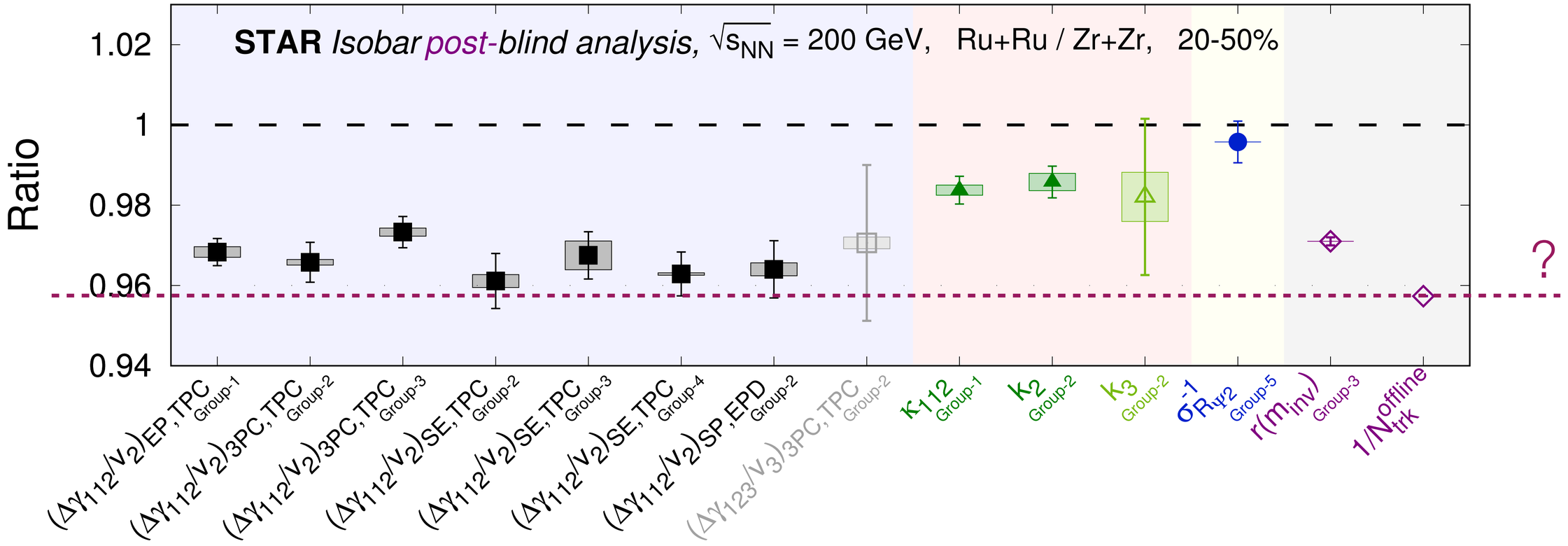
expectation of the baseline failed



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

what is the appropriate baseline?



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

2p = 2-particle cluster

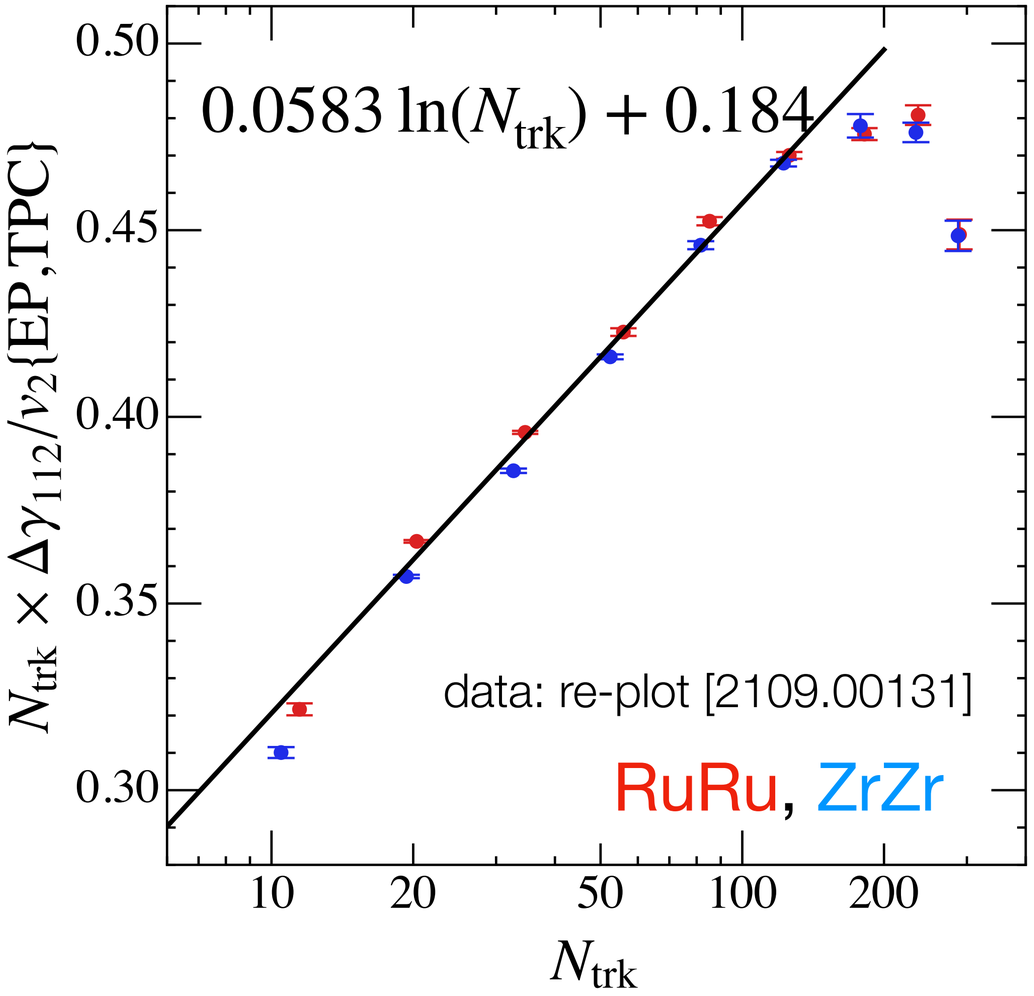
outline

what is the appropriate baseline?

- what can we learn by relooking at the experimental results?

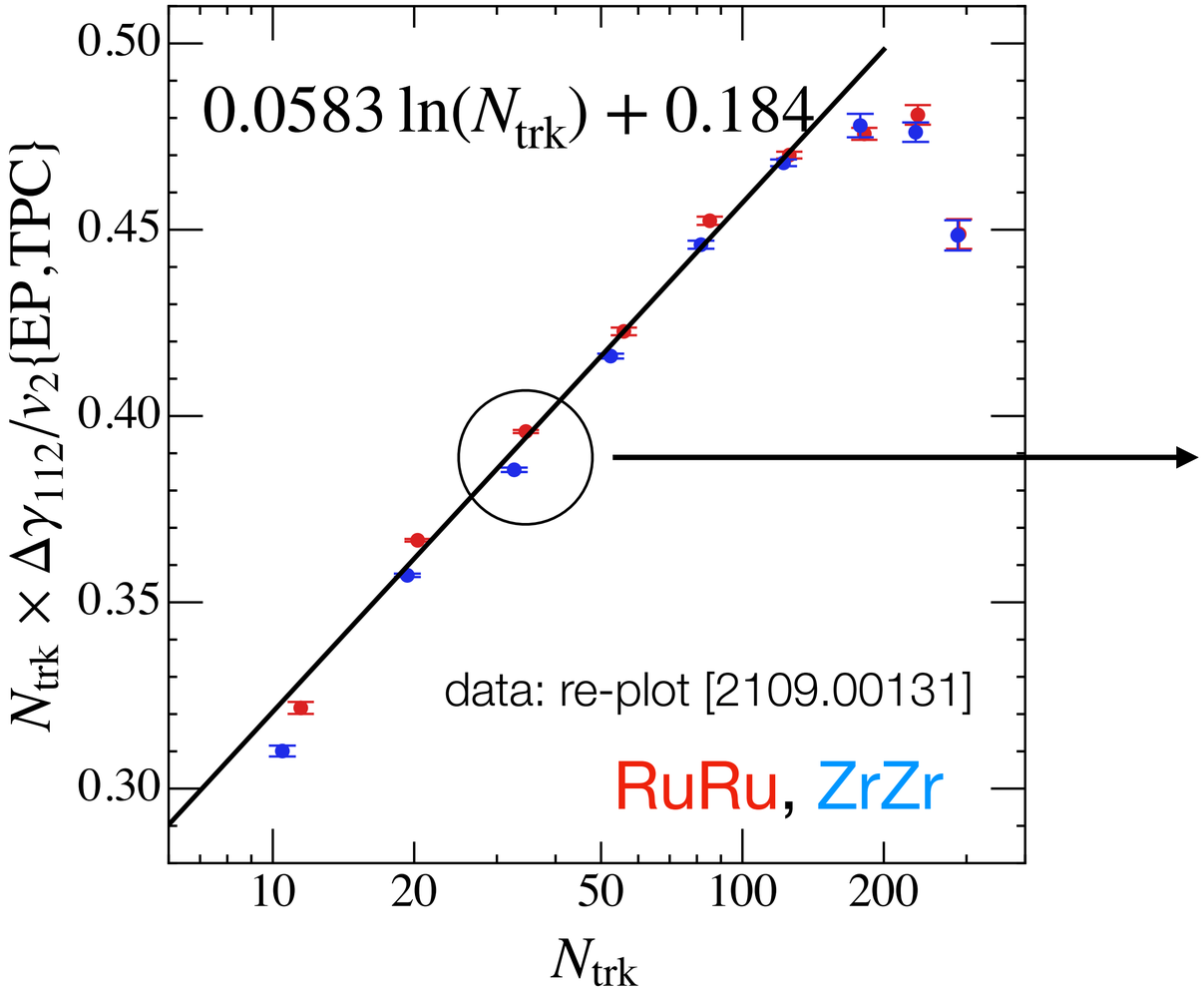
- how phenomenological simulations can help providing the baseline?

finding the appropriate baseline

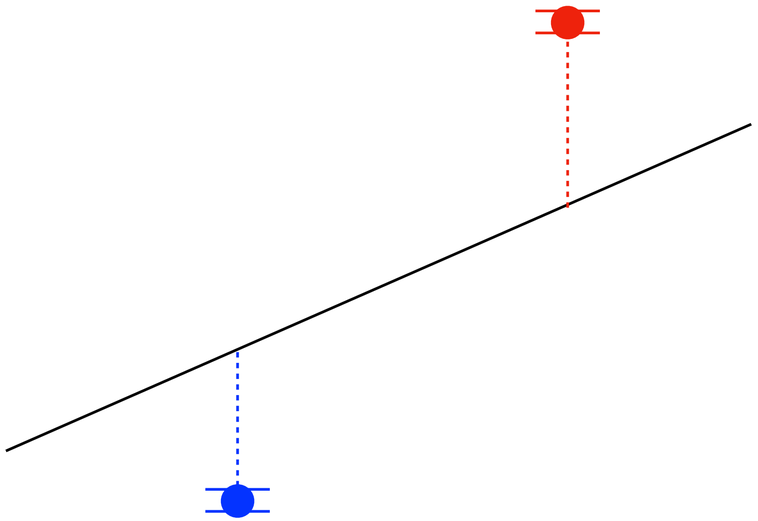


non-trivial centrality-dependence of the proportionality coefficient

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

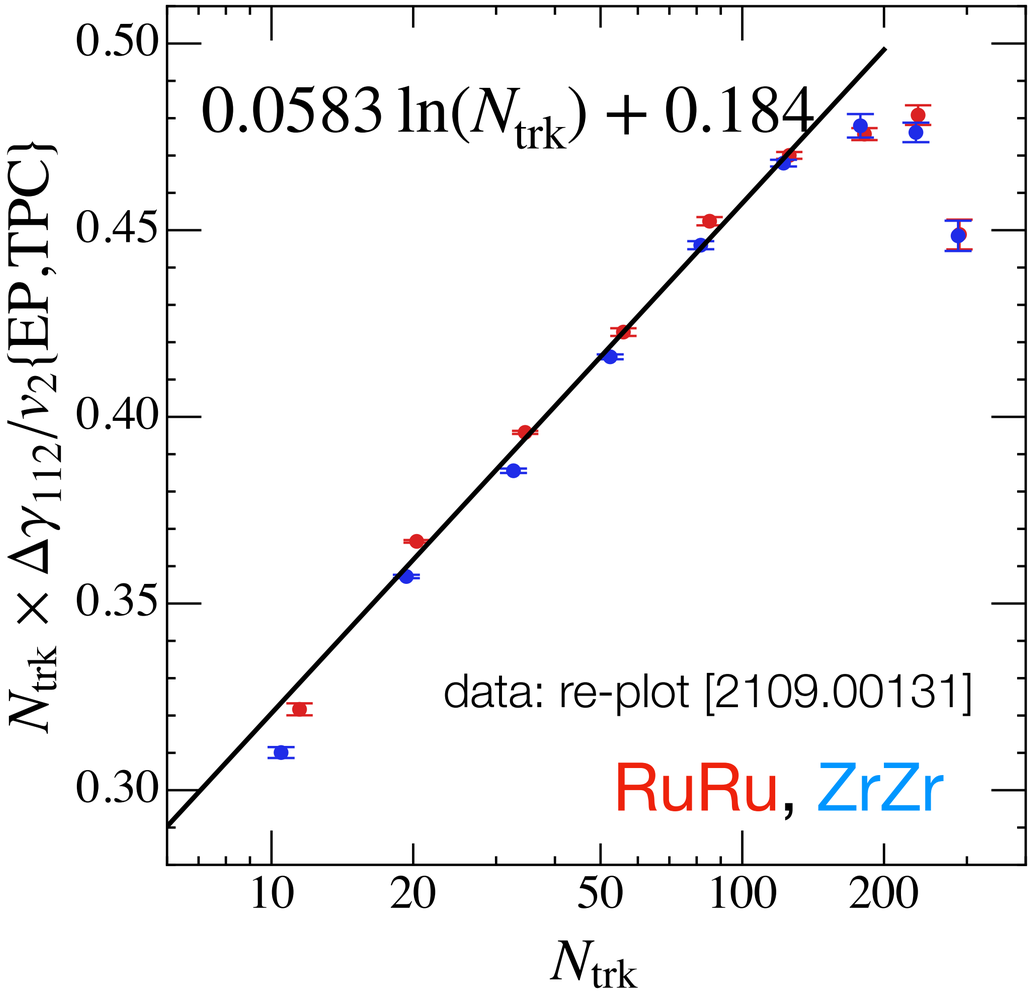


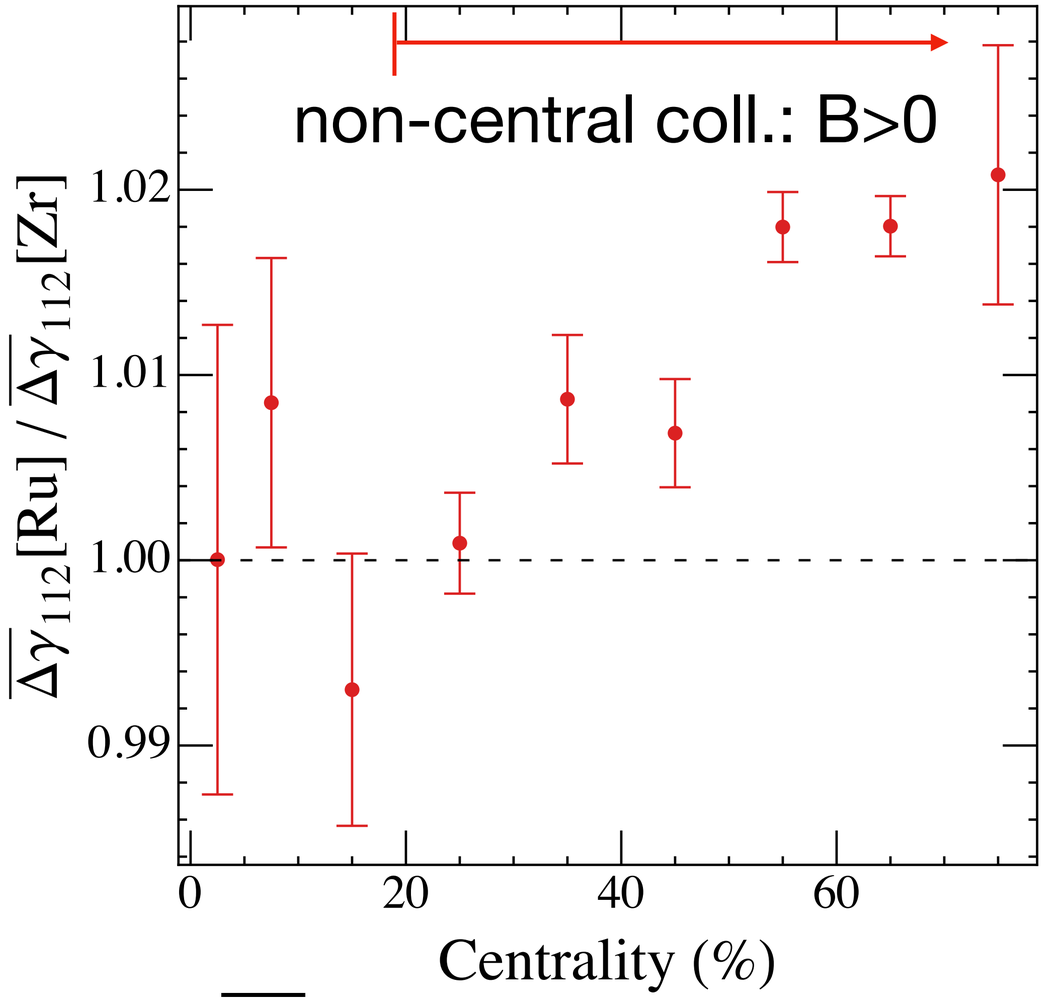
assume system-independent trend:



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

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

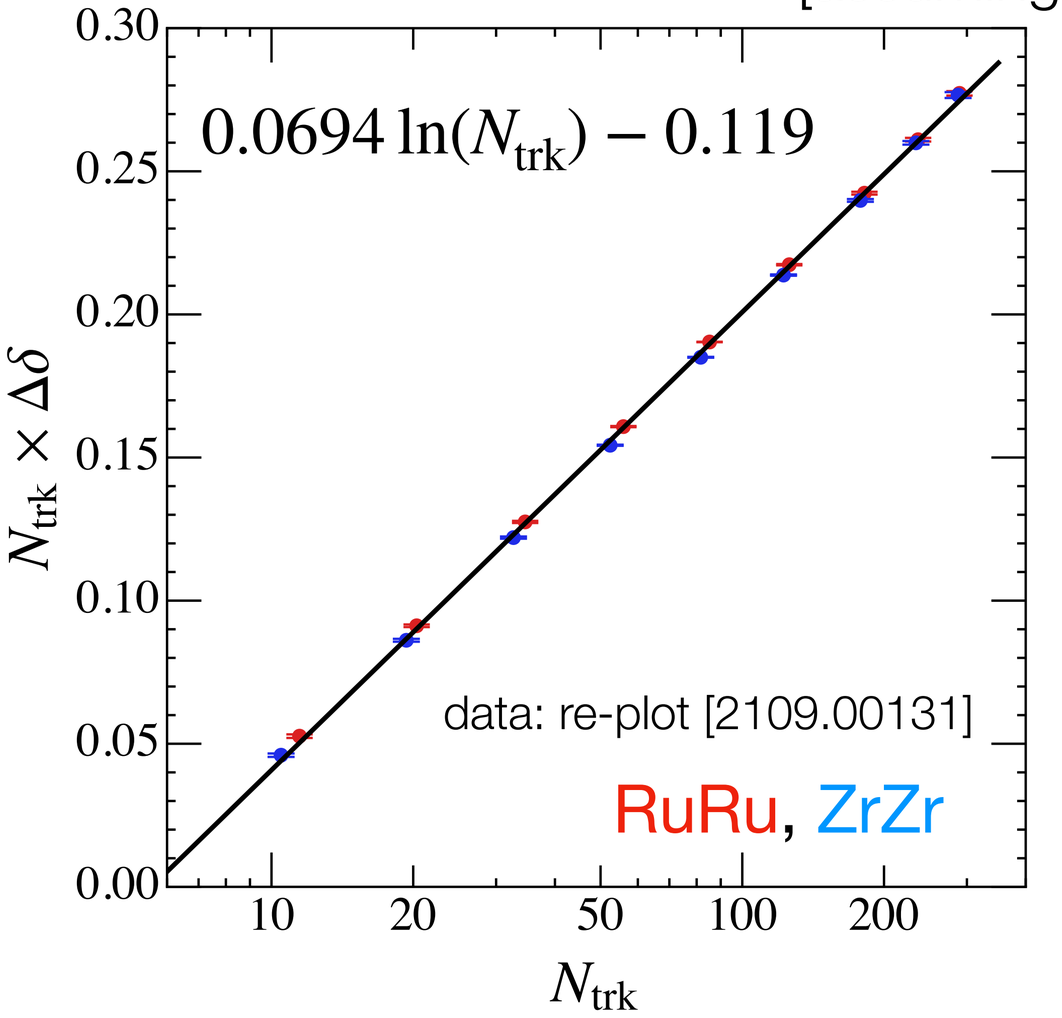


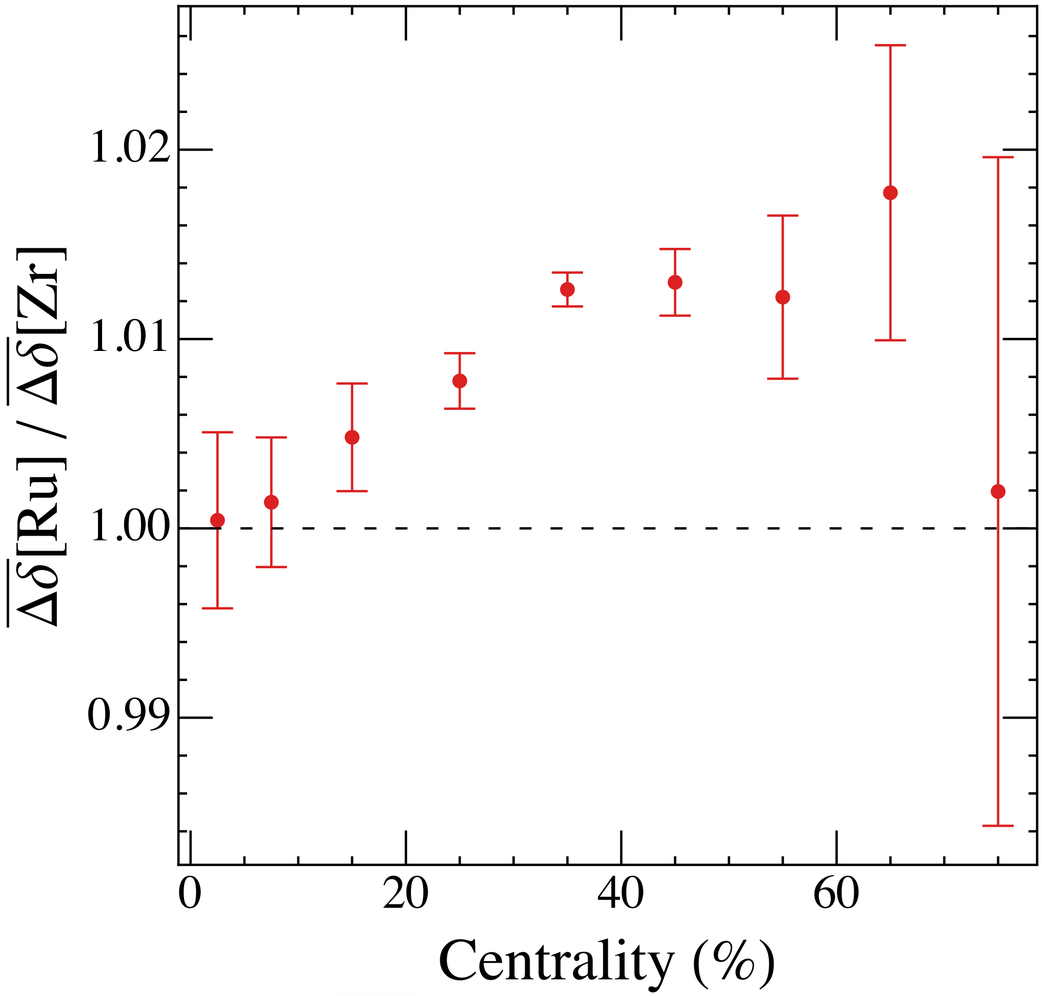


$$\overline{\Delta\gamma}_{112} \equiv (N_{\mathrm{trk}}\Delta\gamma_{112}/v_2)/\mathrm{line}$$

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

[assuming that background depends only on multiplicity]





$$\overline{\Delta\delta} \equiv N_{\mathrm{trk}}\Delta\delta/\mathrm{line}$$

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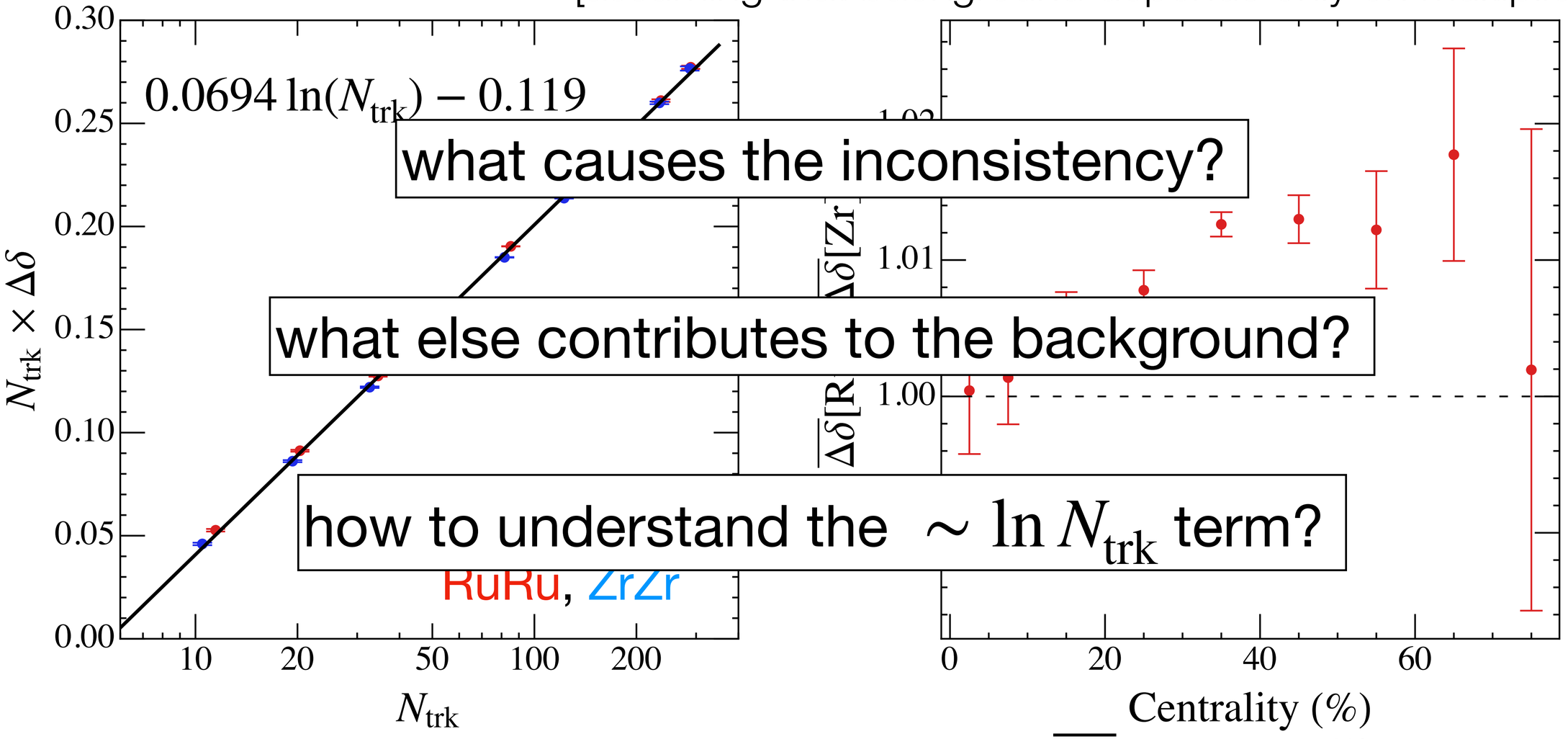


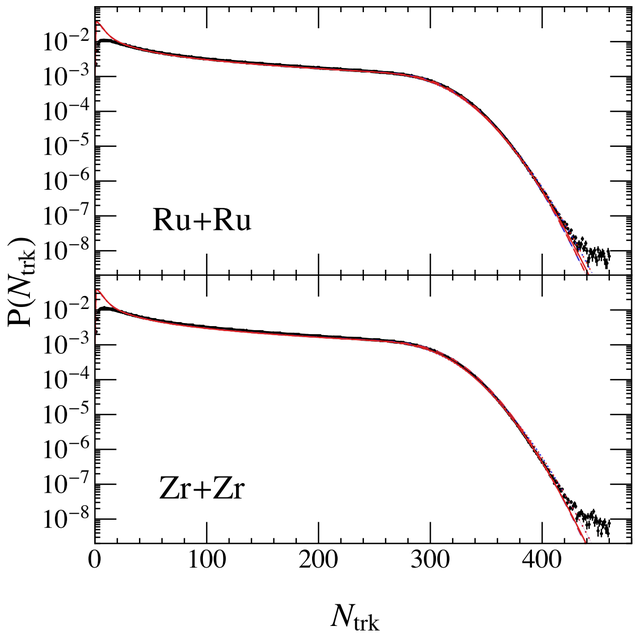
what causes the inconsistency?

what else contributes to the background?

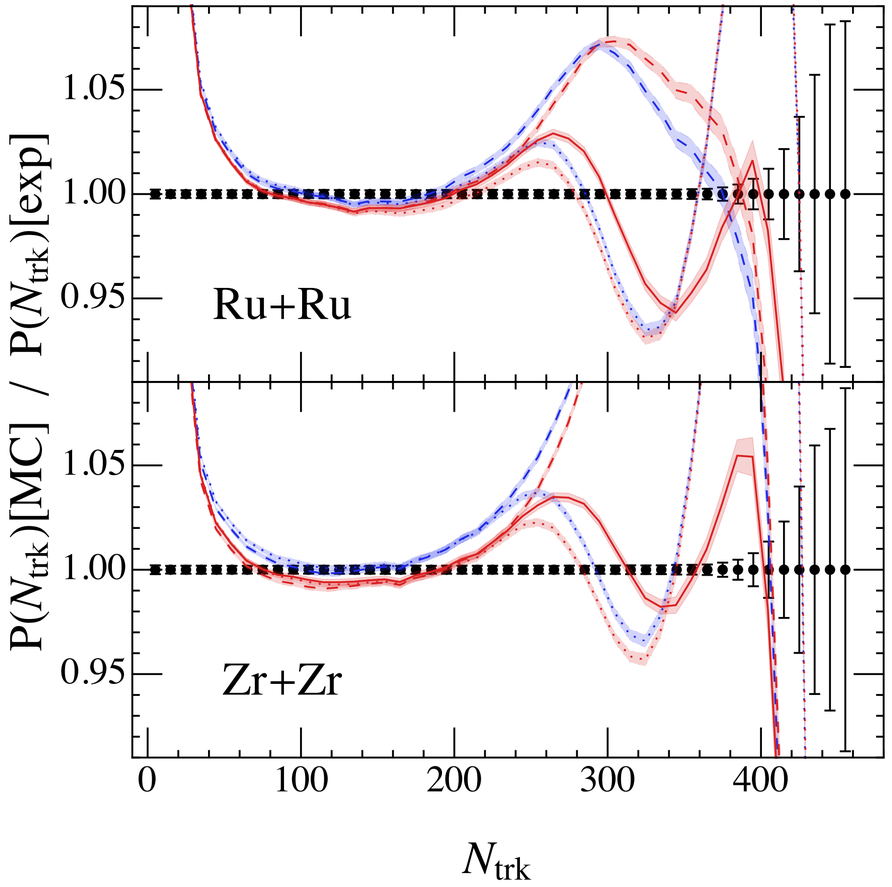
how to understand the $\sim \ln N_{\mathrm{trk}}$ term?

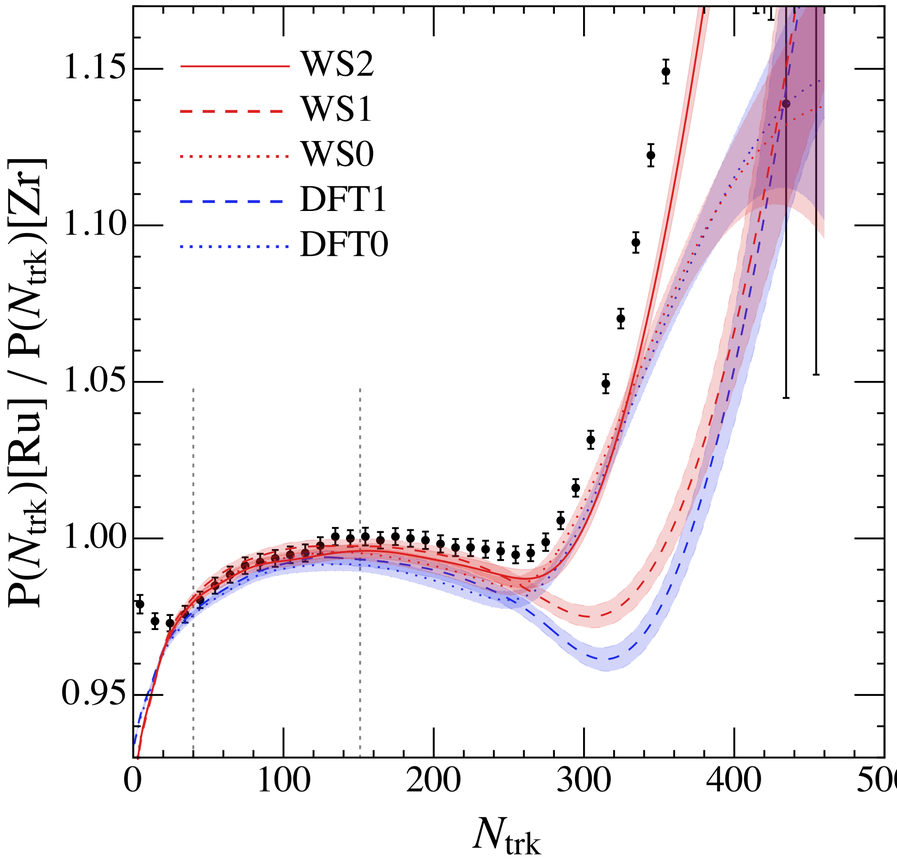
what we learned from hydro simulation

multiplicity distribution [MC Glauber only]



data: re-plot [2109.00131]





blue: SLy4 DFT

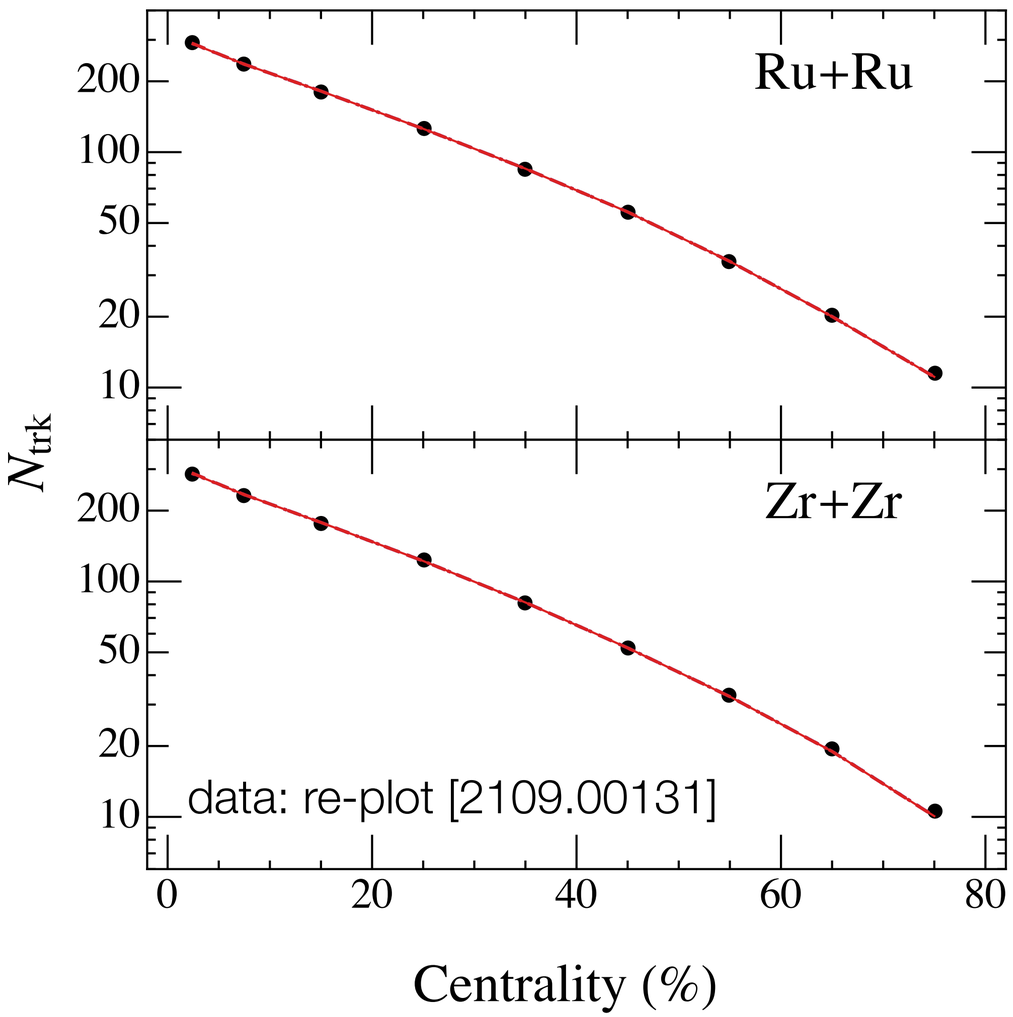
red: WS

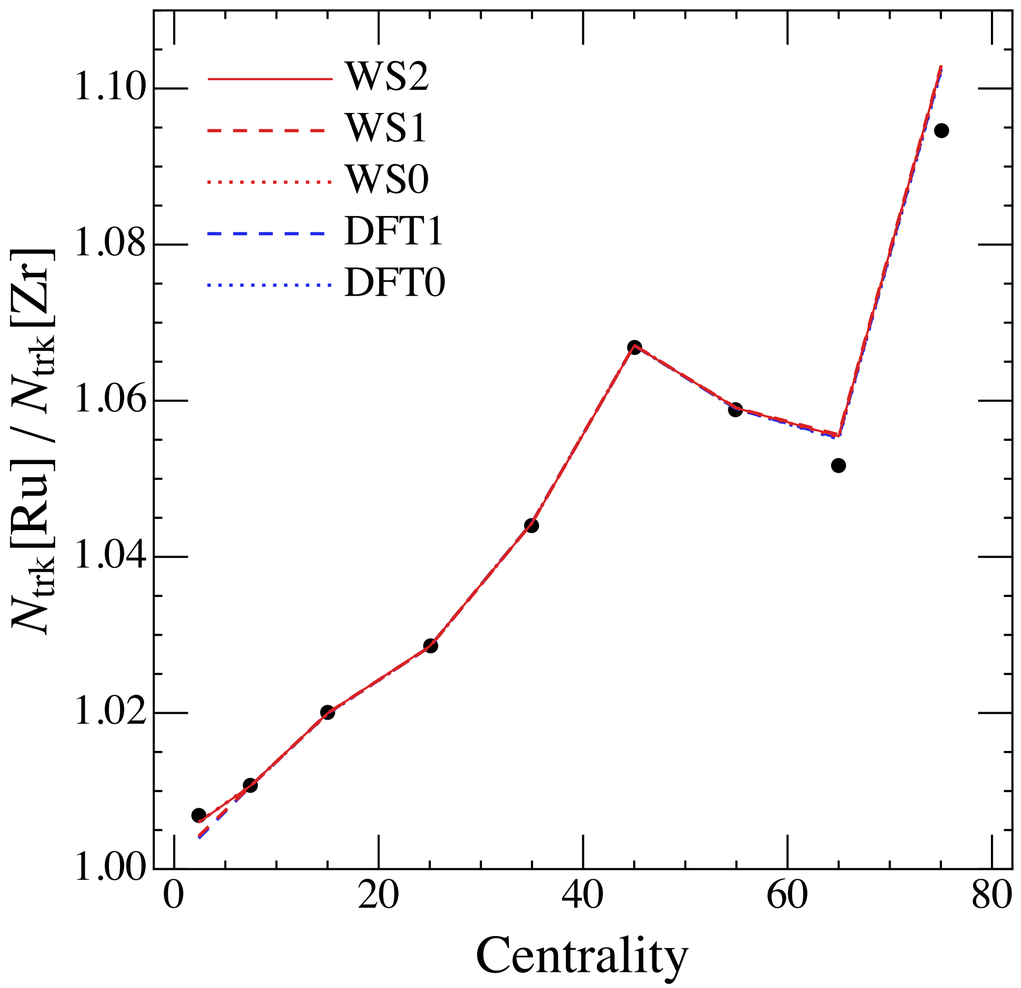
dot: spherical

dash: deformed, same R and a as dotted lines

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

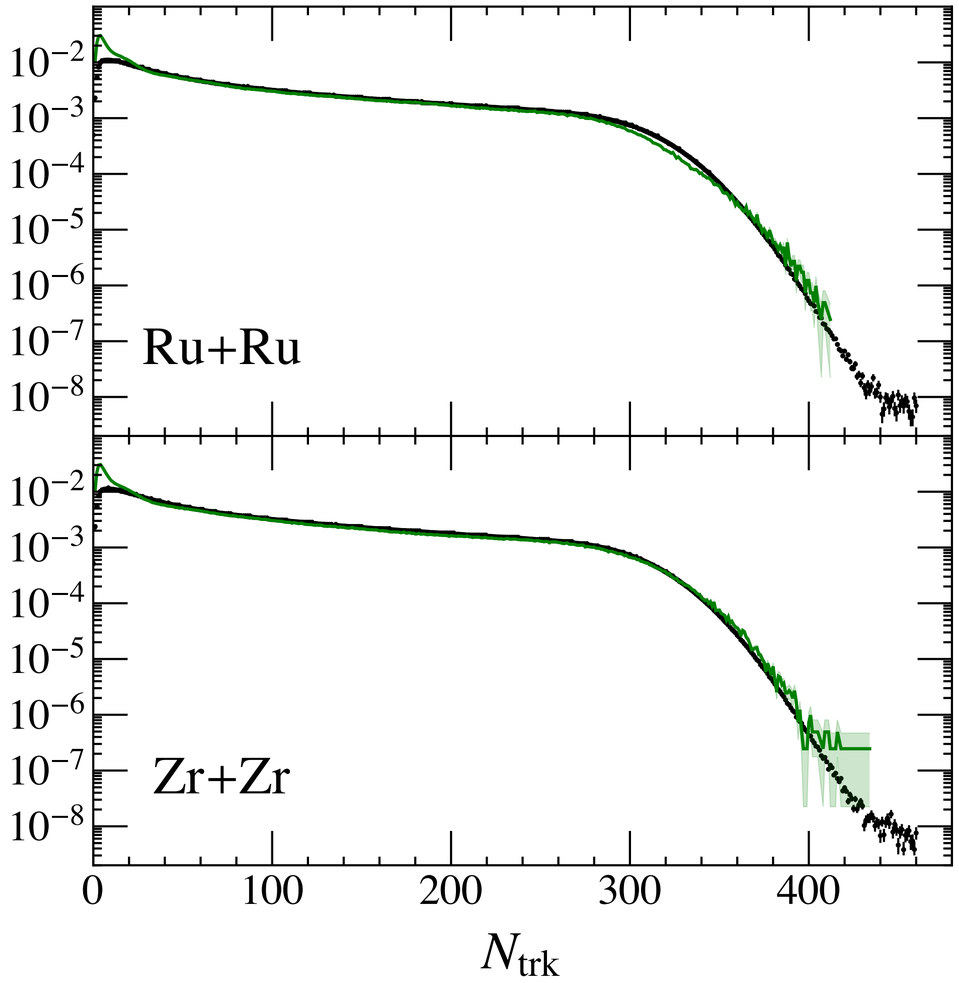
multiplicity ratio [MC Glauber only]

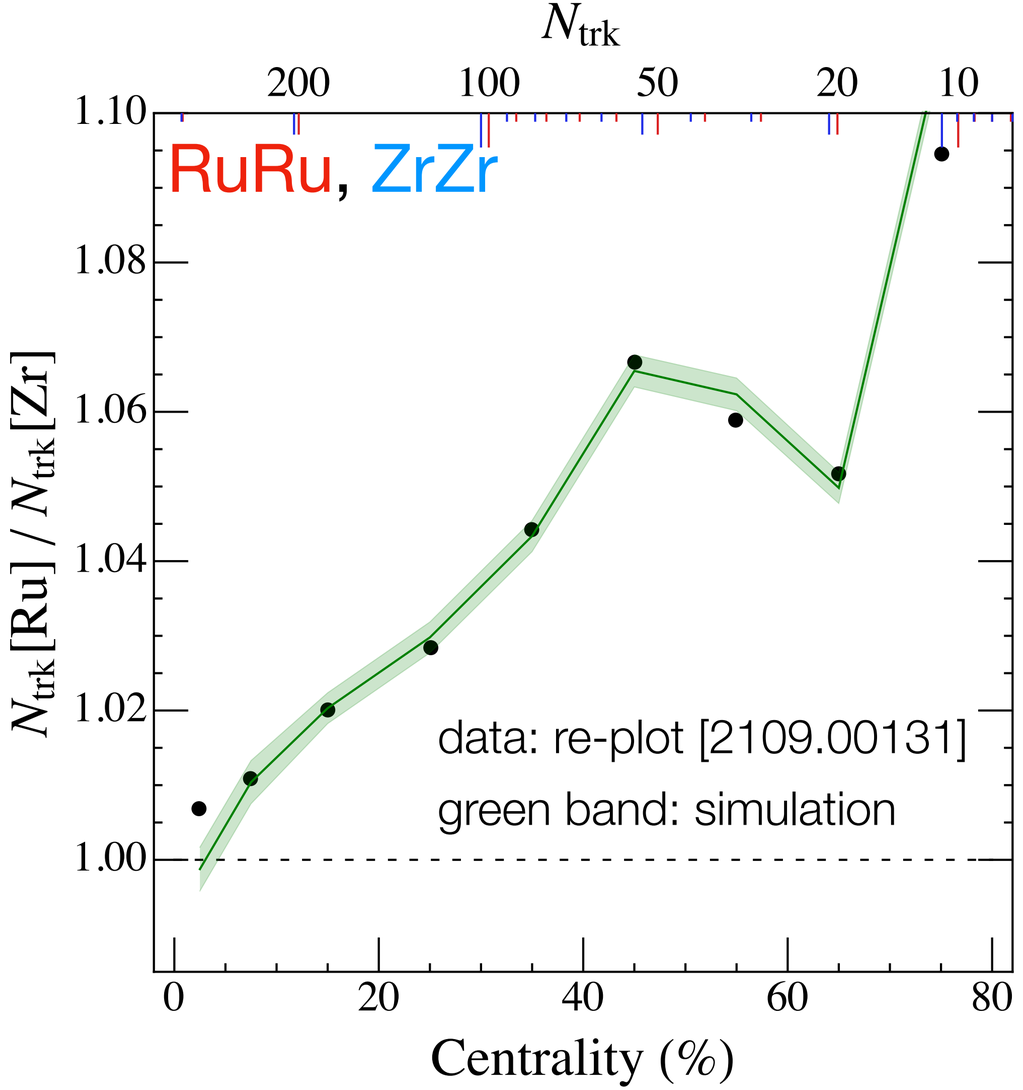




centrality determination based on the STAR N_{trk}-cut

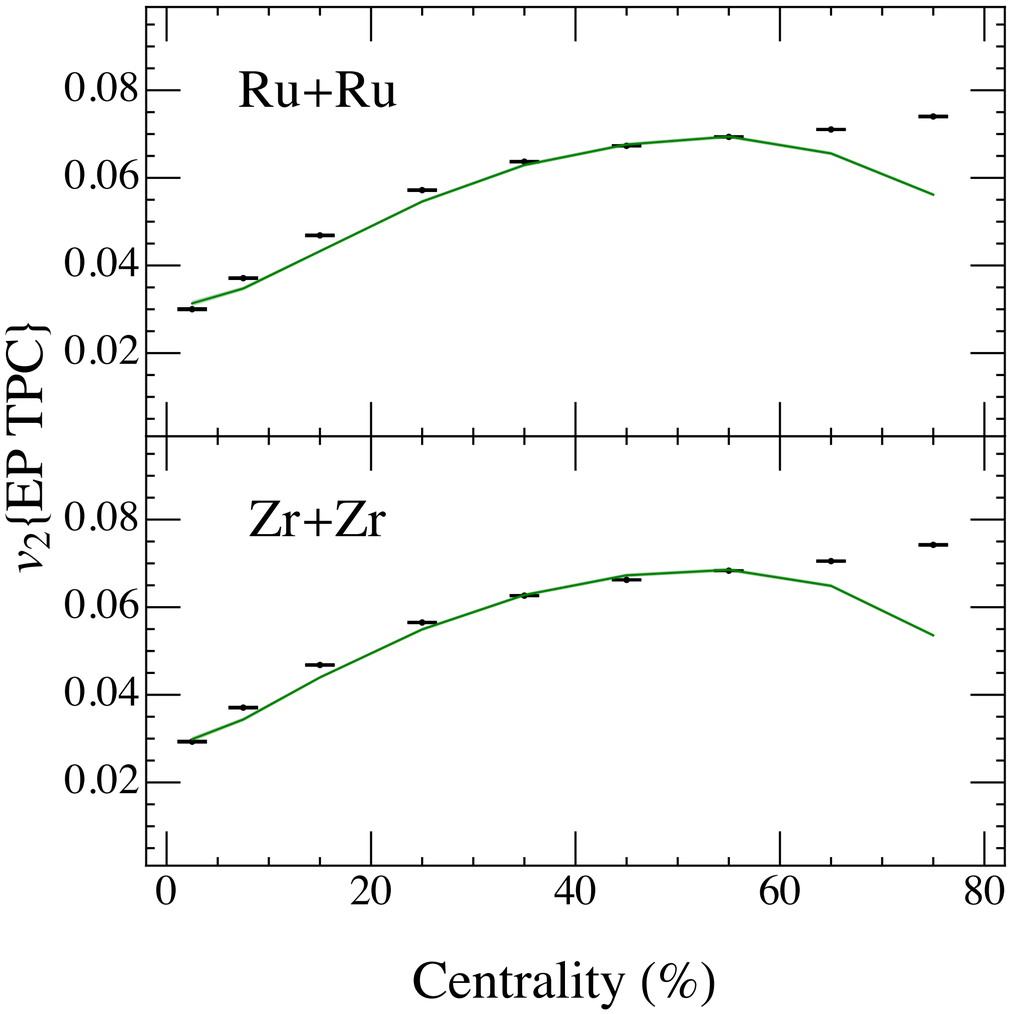
multiplicity ratio [MC Glauber + hydro + hadron scattering]

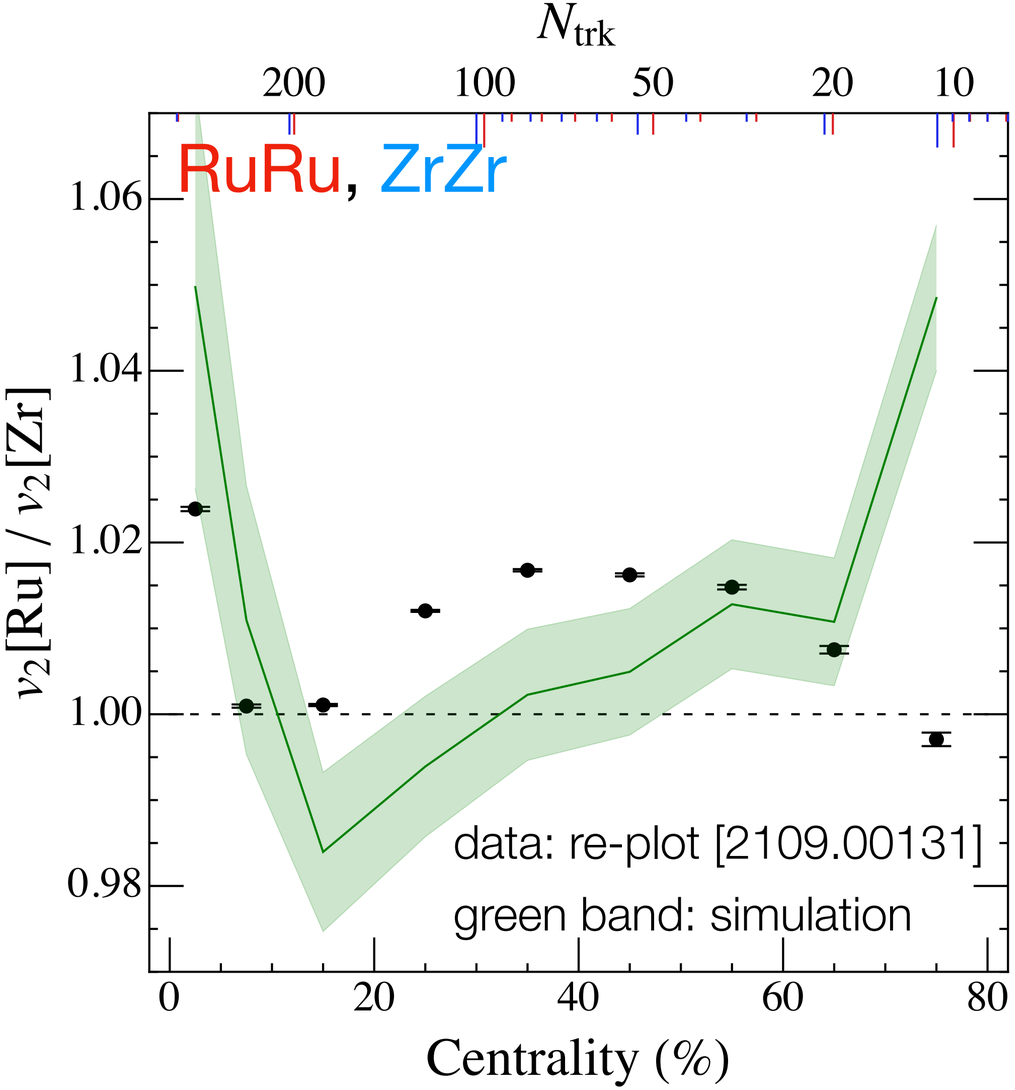




centrality determination based on the STAR $N_{\rm trk}$-cut

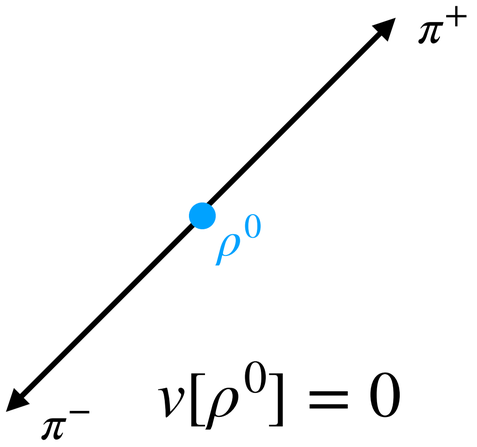
elliptic flow ratio [MC Glauber + hydro + hadron scattering]





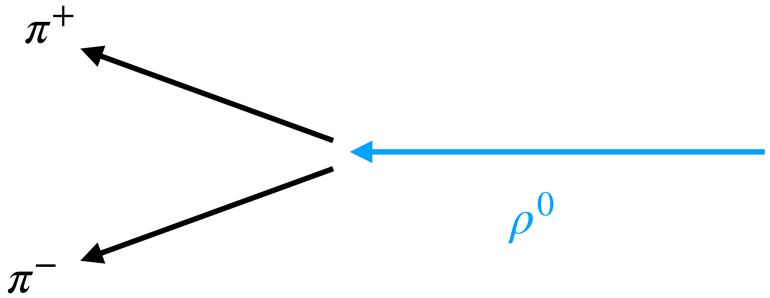
needs further fine-tuning

(extra) centrality dependence of background properties



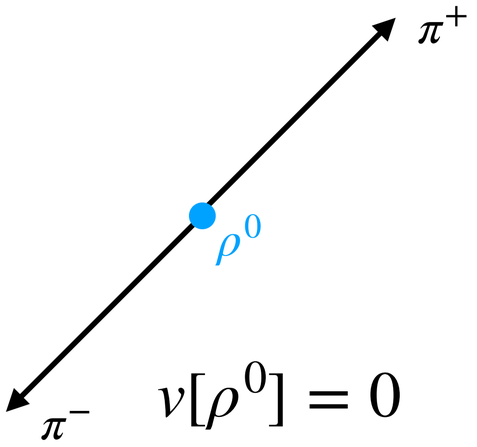
$$\delta \equiv \langle \cos(\phi_a - \phi_b) \rangle$$

$$v[\rho^0] = 0 \quad \Rightarrow \quad \delta^{OS} = -1$$



$$v[\rho^0] \sim 1 \quad \Rightarrow \quad \delta^{OS} \approx 1$$

(extra) centrality dependence of background properties



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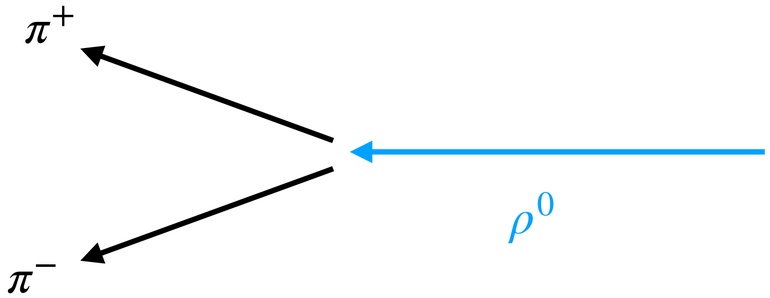

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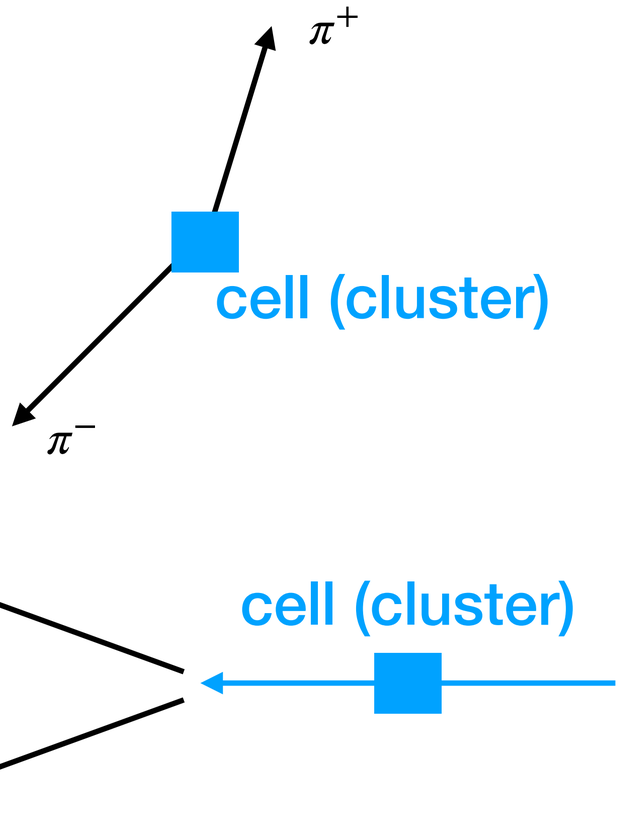
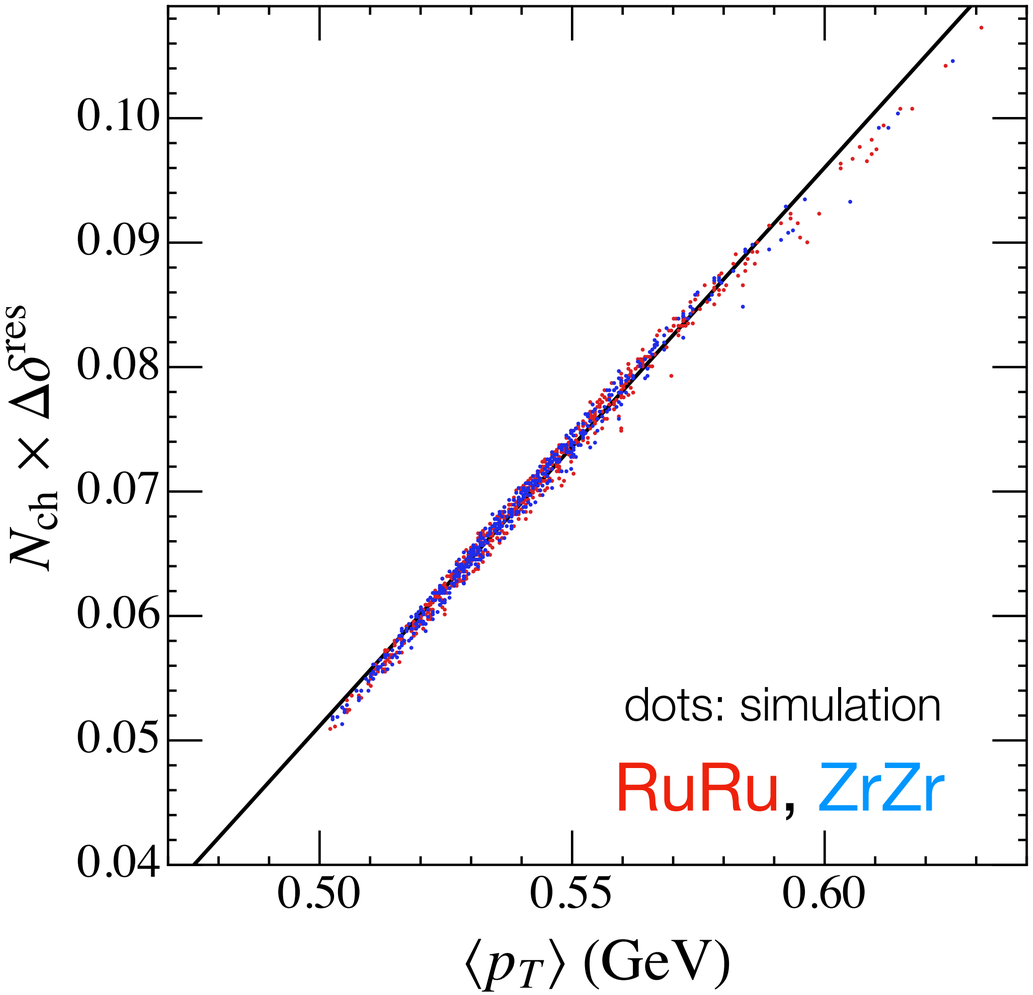
analog picture for
local charge conservation



$\langle p_T \rangle$-dependence of background [hydro+CooperFrye+resonance]

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



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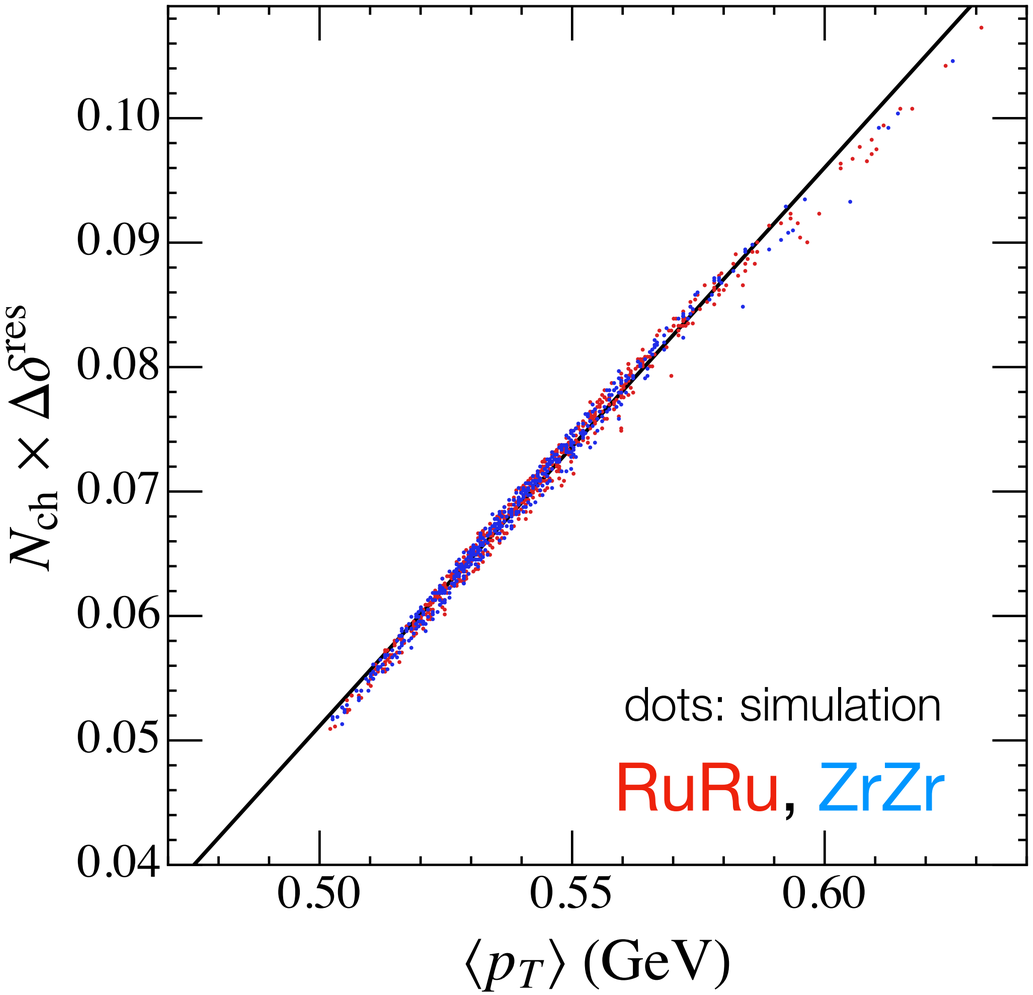
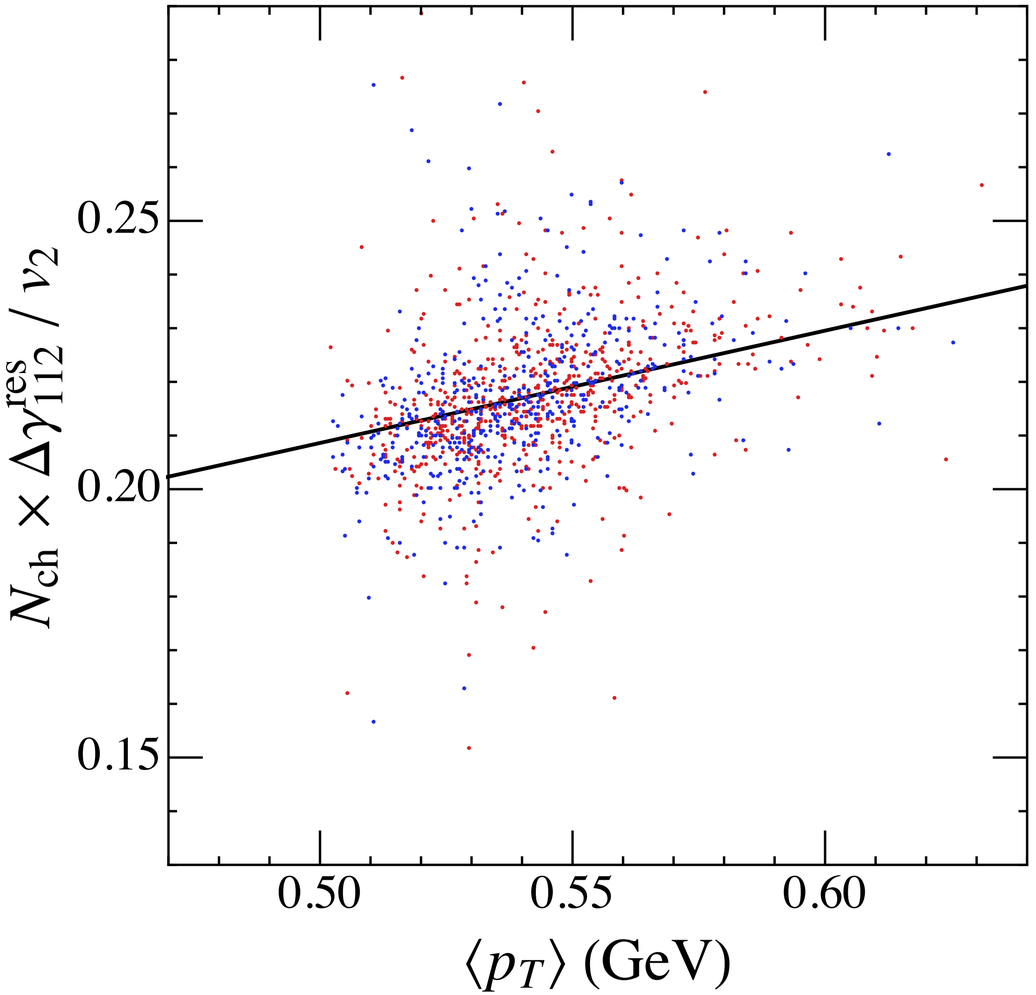


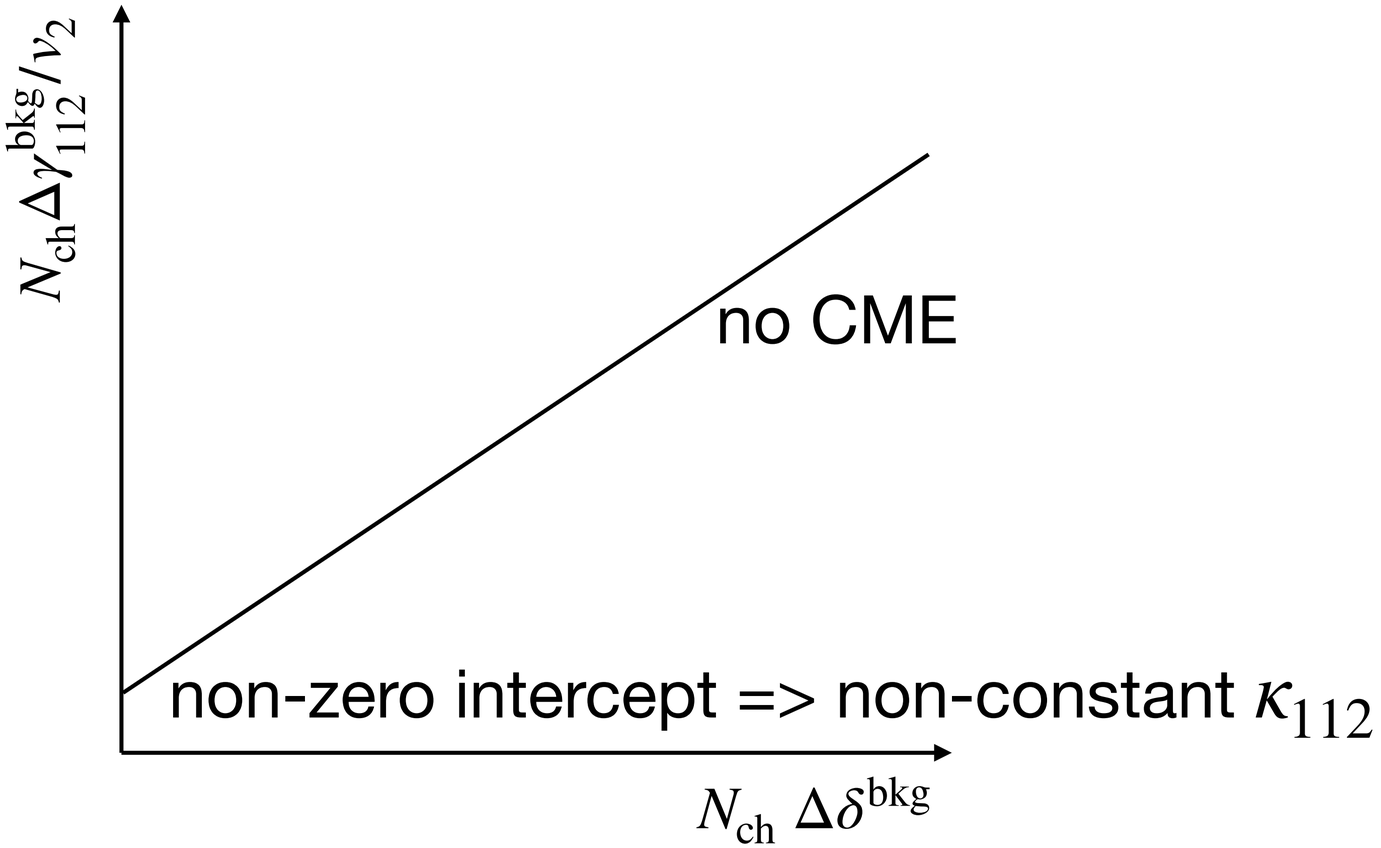
$$\Delta\gamma_{\mathrm{bkg}} = \frac{v_2}{N_{\mathrm{ch}}}\left(g_0 + g_1 \times \langle p_T \rangle\right)$$



a new baseline

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

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



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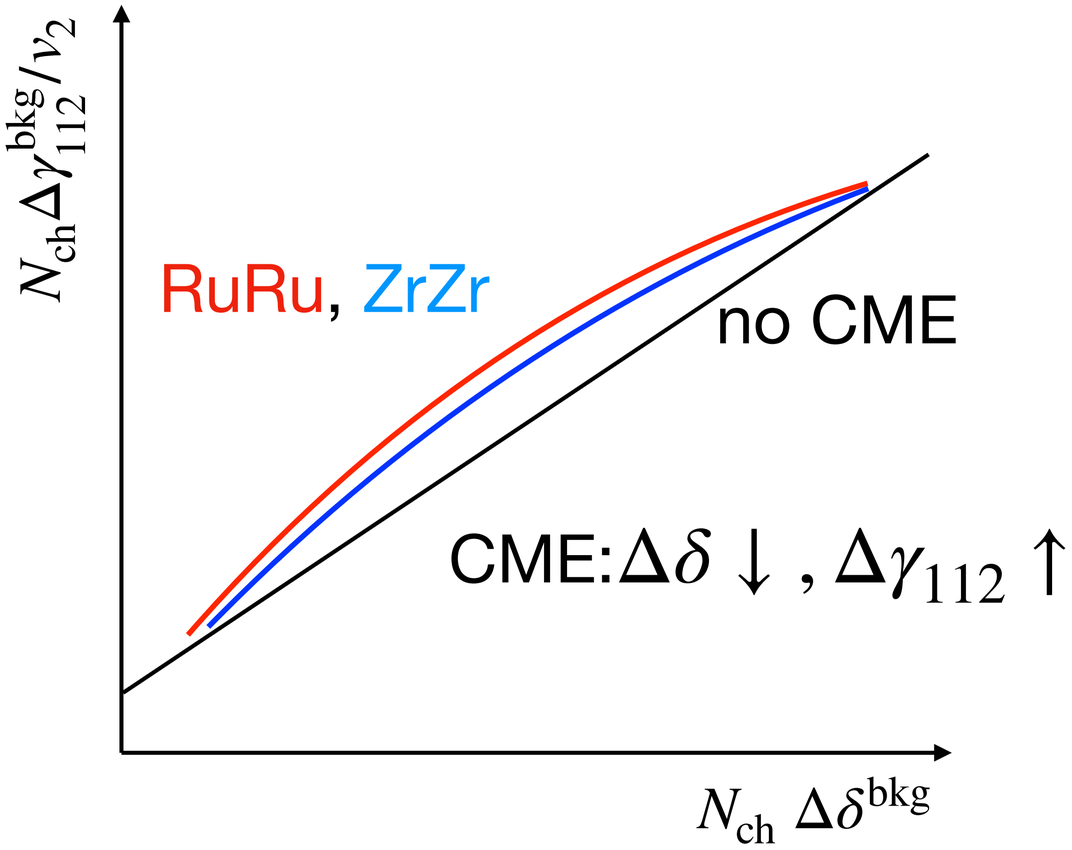
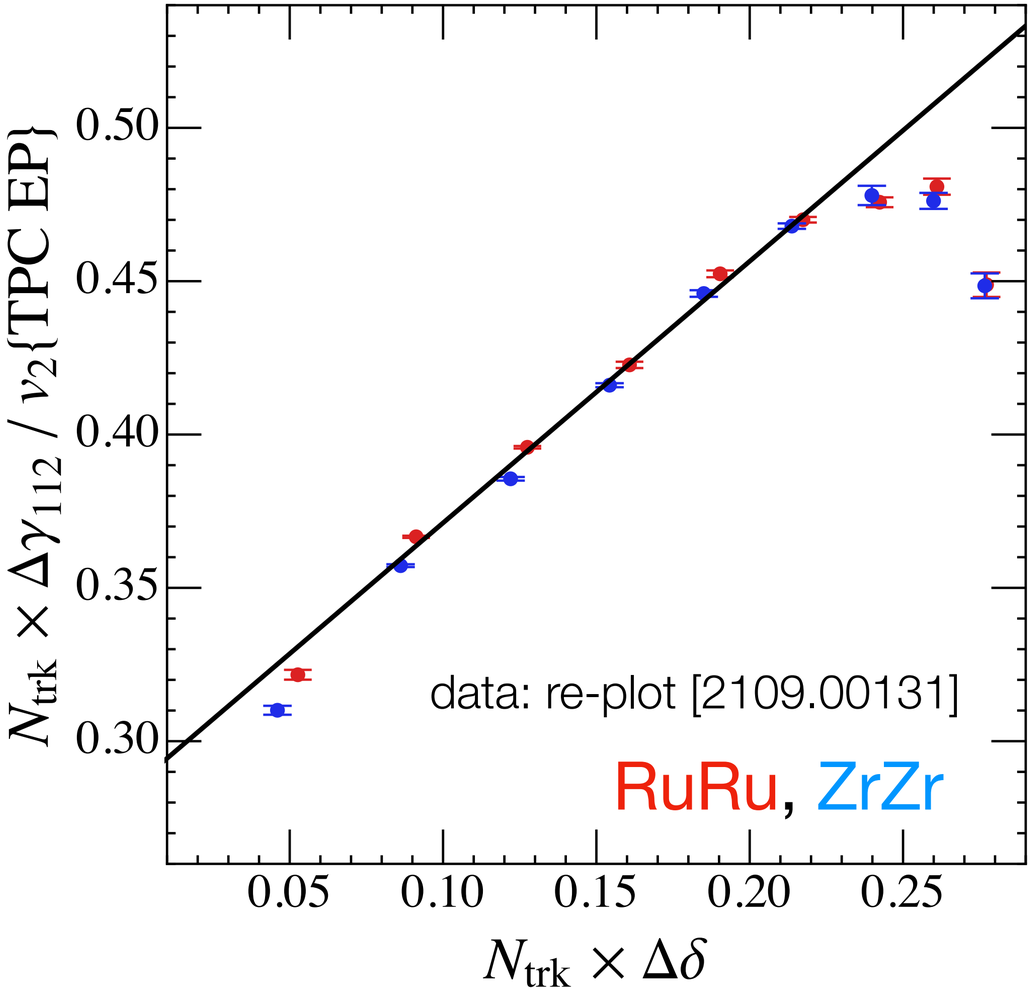
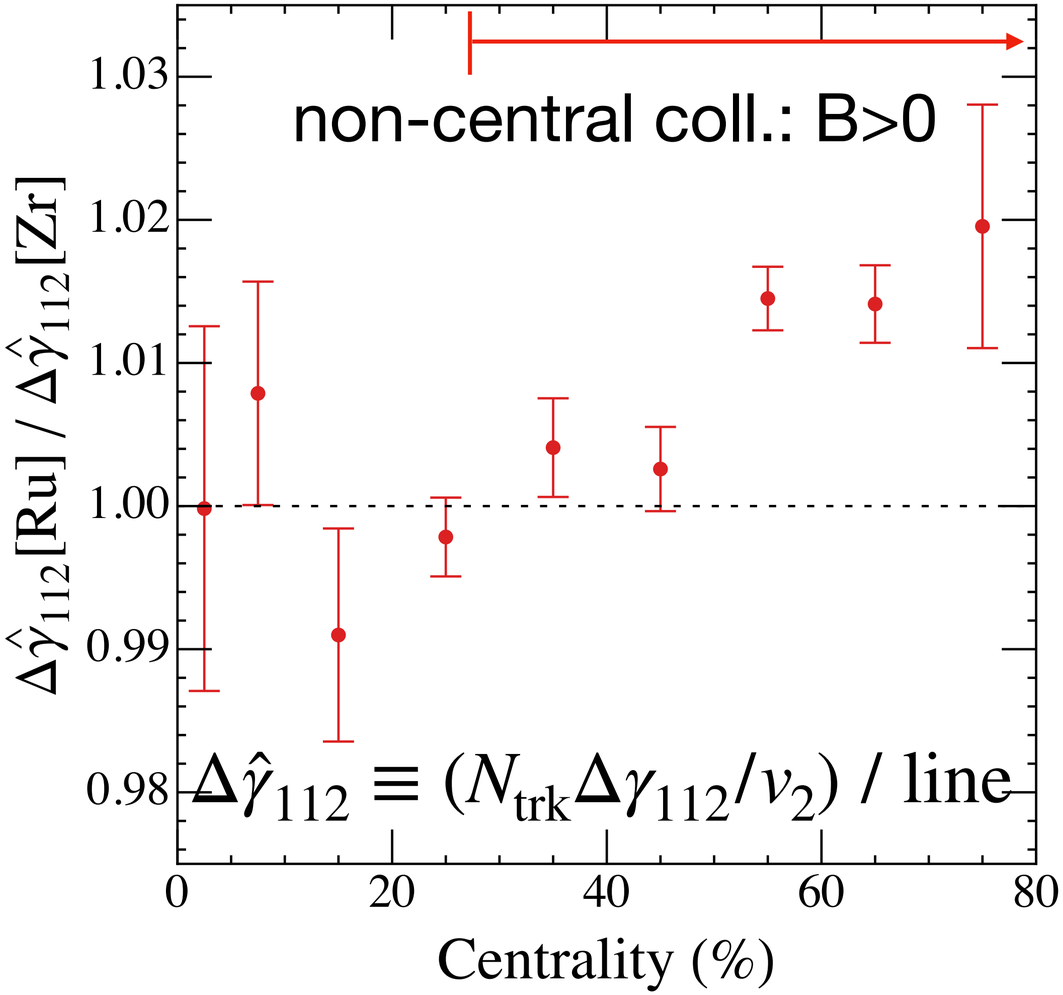


can the exp. result be understood by no-CME baseline?

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



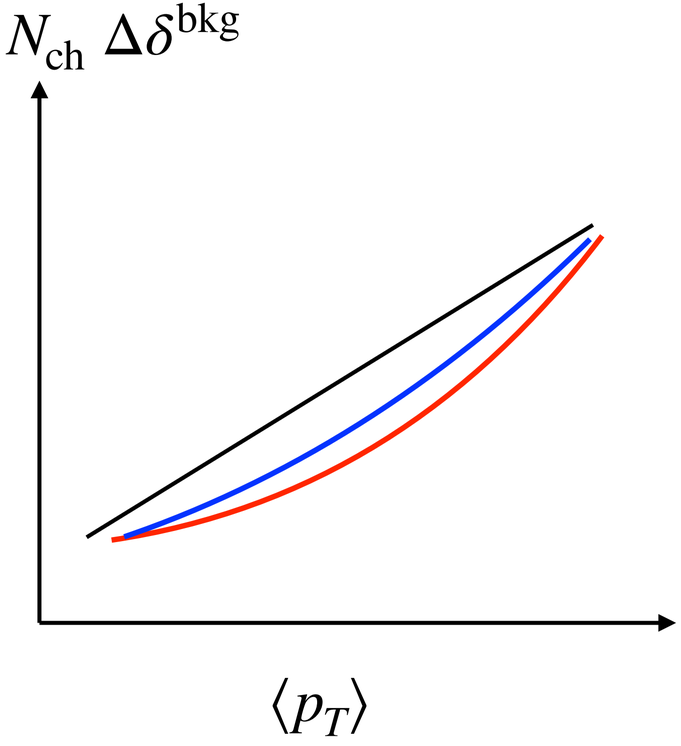


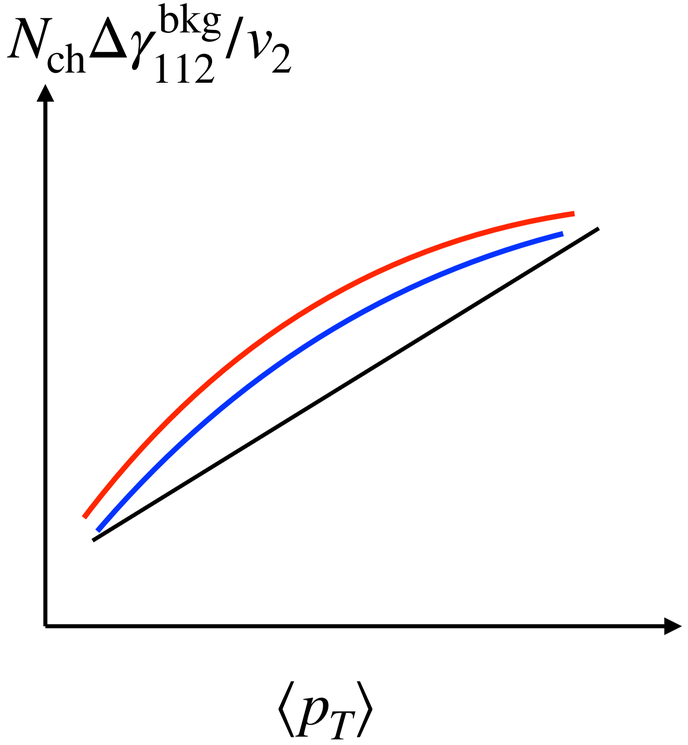
a new baseline

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

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

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





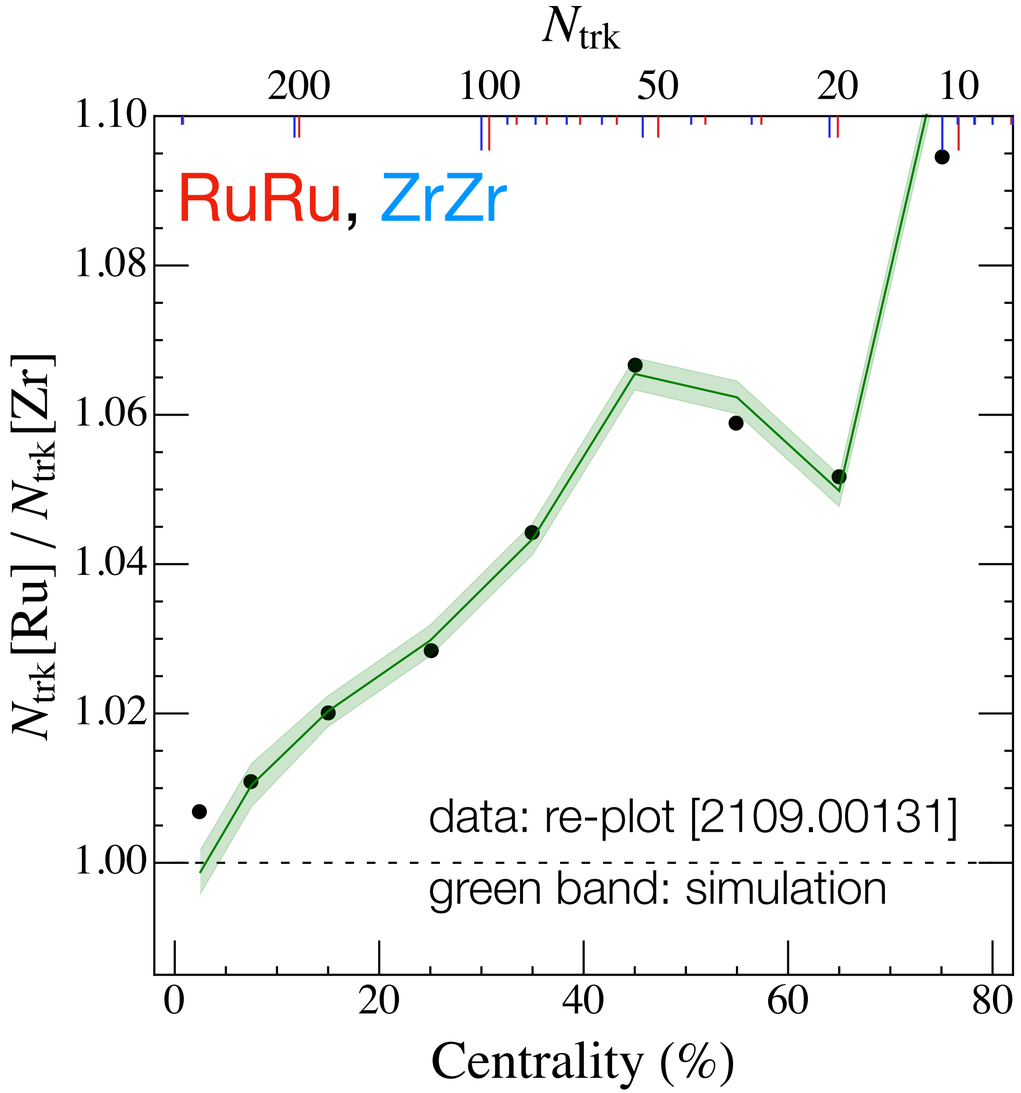
CME: $\Delta\delta \downarrow$, $\Delta\gamma_{112} \uparrow$

red: CME[RuRu]
blue: CME[ZrZr]
black: no CME

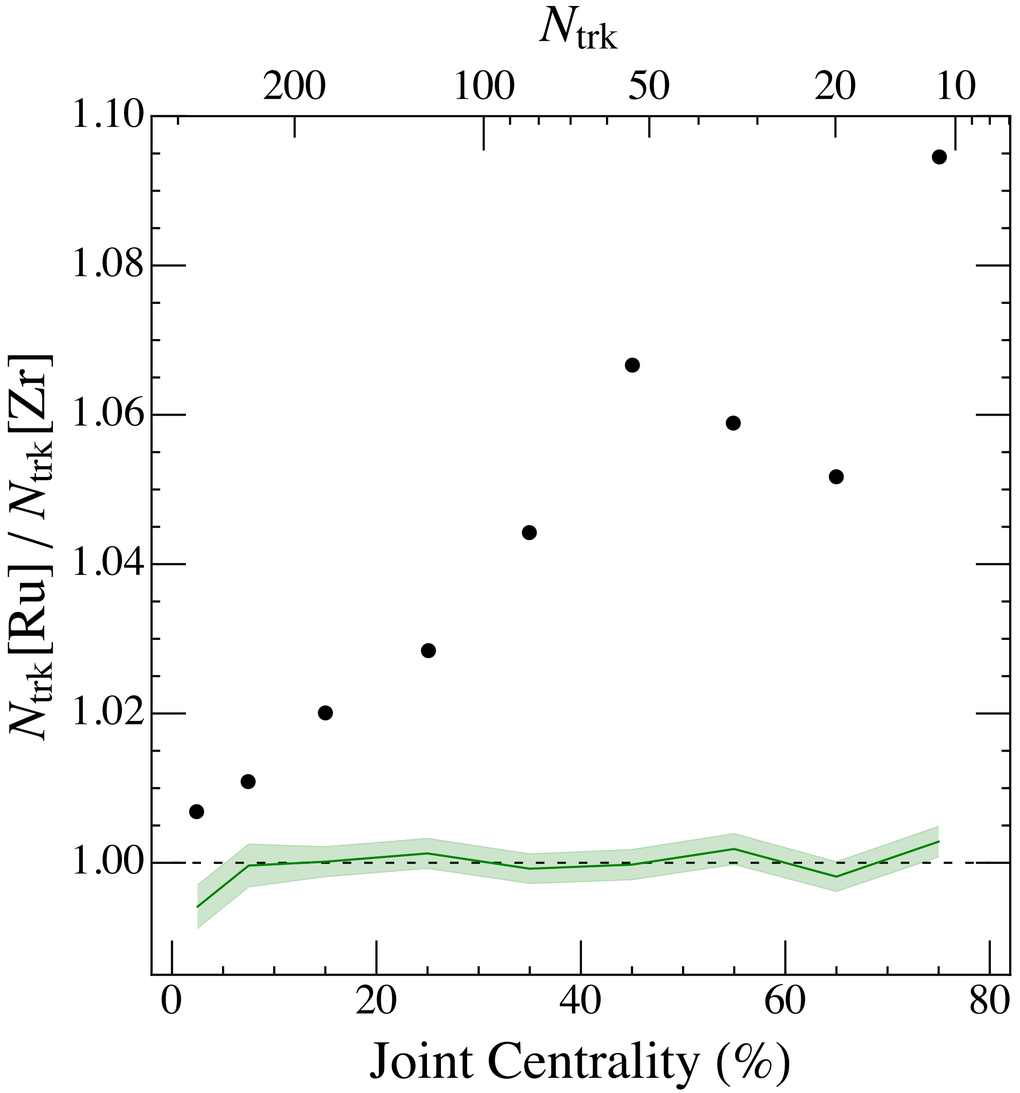
what else can we do?

multiplicity ratio [MCGlauber + hydro + hadron scattering]

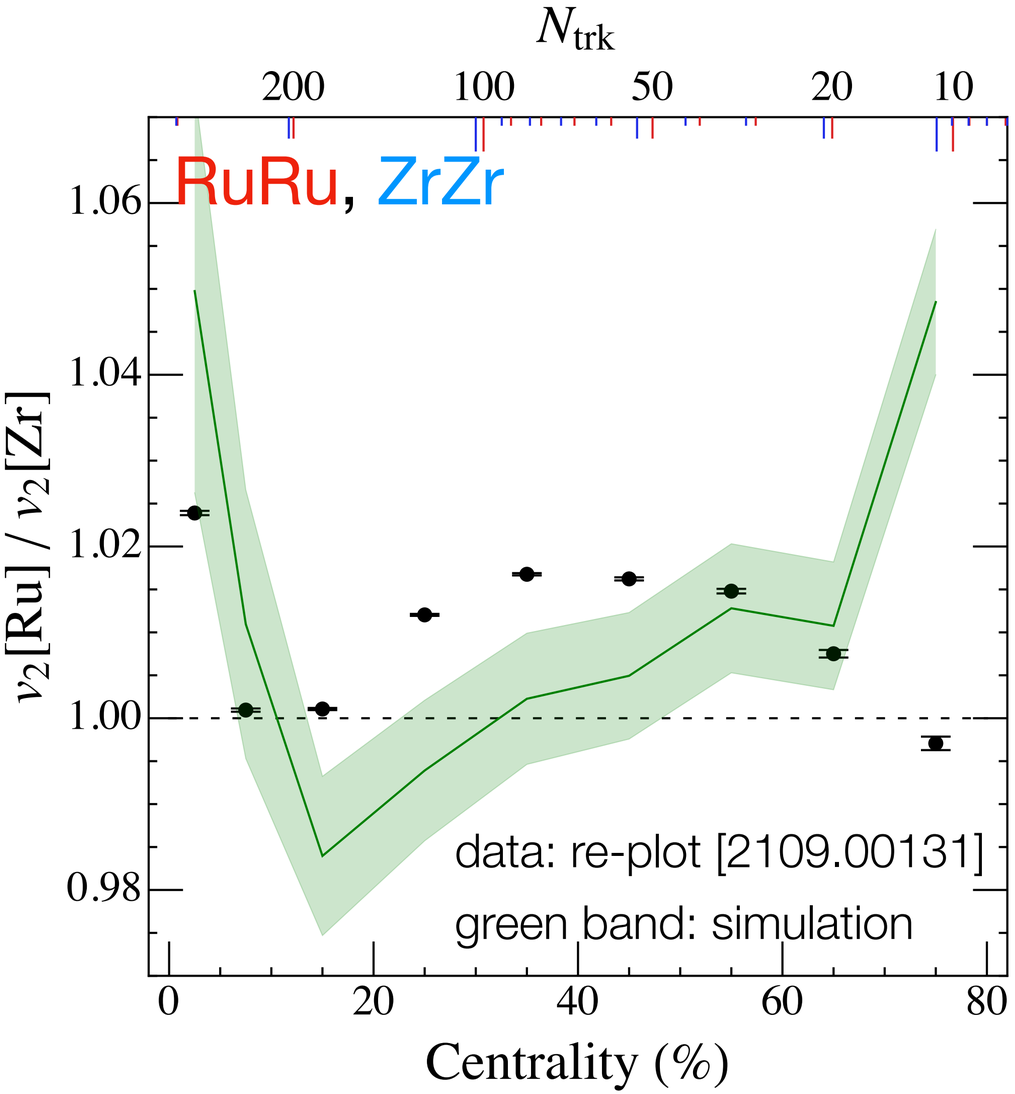
STAR $N_{\rm trk}$-cut



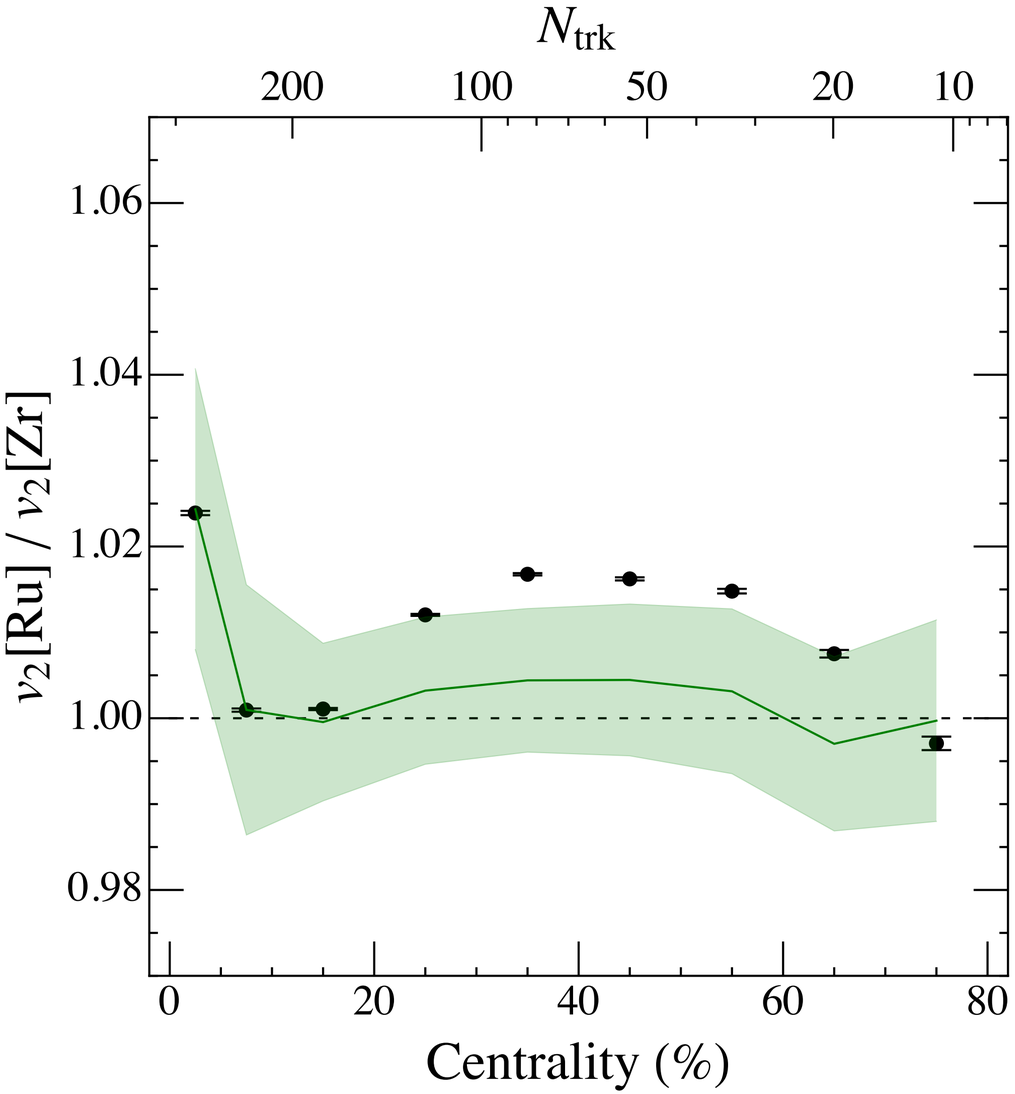
identical $N_{\rm trk}$-cut



elliptic flow ratio



STAR $N_{\rm trk}$-cut



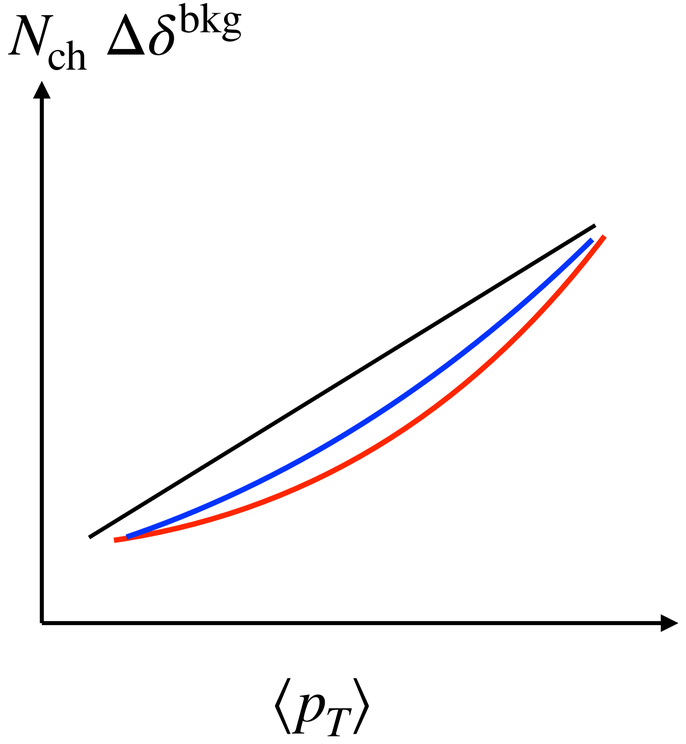
identical $N_{\rm trk}$-cut + v_2 cut

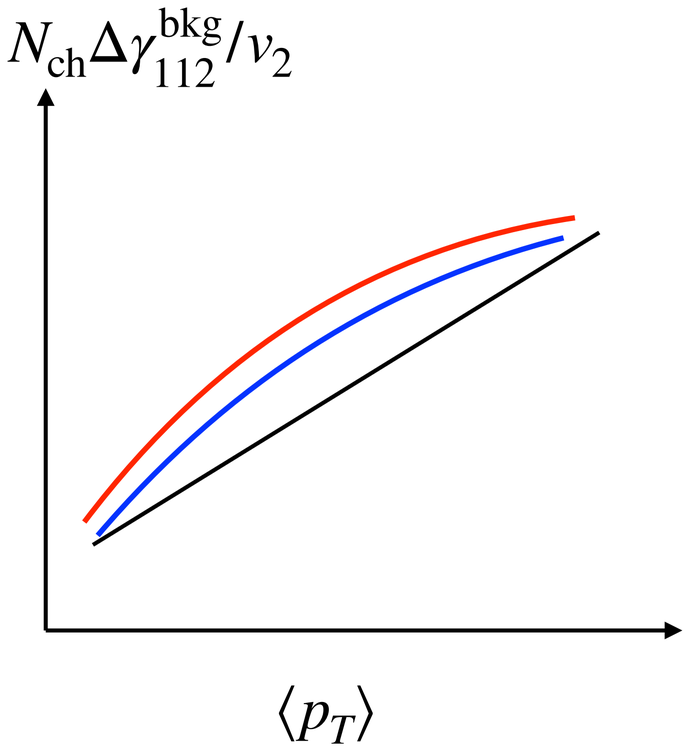
summary

- 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 $\langle N_{\rm ch}\rangle$ and $\langle v_2\rangle$ can be eliminated if applying identical $N_{\rm trk}$-cut & v_2 selection, for both systems
- $\Delta\delta^{\rm bkg}$ and $\Delta\gamma_{112}^{\rm bkg}$ 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]
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