CME signal & background study of 39 GeV Au+Au collisions and 200 GeV Cu+Cu collisions

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CME via event-shape engineering

$\frac{dN}{d\phi} \propto 1 + 2v_{1,\alpha}\cos(\Delta\phi) + 2v_{2,\alpha}\cos(2\Delta\phi) + 2a_{1,\alpha}\sin(\Delta\phi) + \ldots$

where $\Delta\phi = \phi - \Psi_{RP}$,

α(+ or -) denotes the charge sign of particle

v_2: elliptic flow

a_1: quantifies the charge separation due to CME

$$\gamma = \left\langle \left\langle \cos\left(\phi_\alpha + \phi_\beta - 2\Psi_{RP}\right)\right\rangle_P \right\rangle_E$$
$$= \left[\left\langle v_{1,\alpha} v_{1,\beta}\right\rangle + B_{in}\right] - \left[\left\langle a_{1,\alpha} a_{1,\beta}\right\rangle + B_{out}\right]$$

B_{in}-B_{out} :flow-related background γ_{os}- γ_{ss} :CME signal

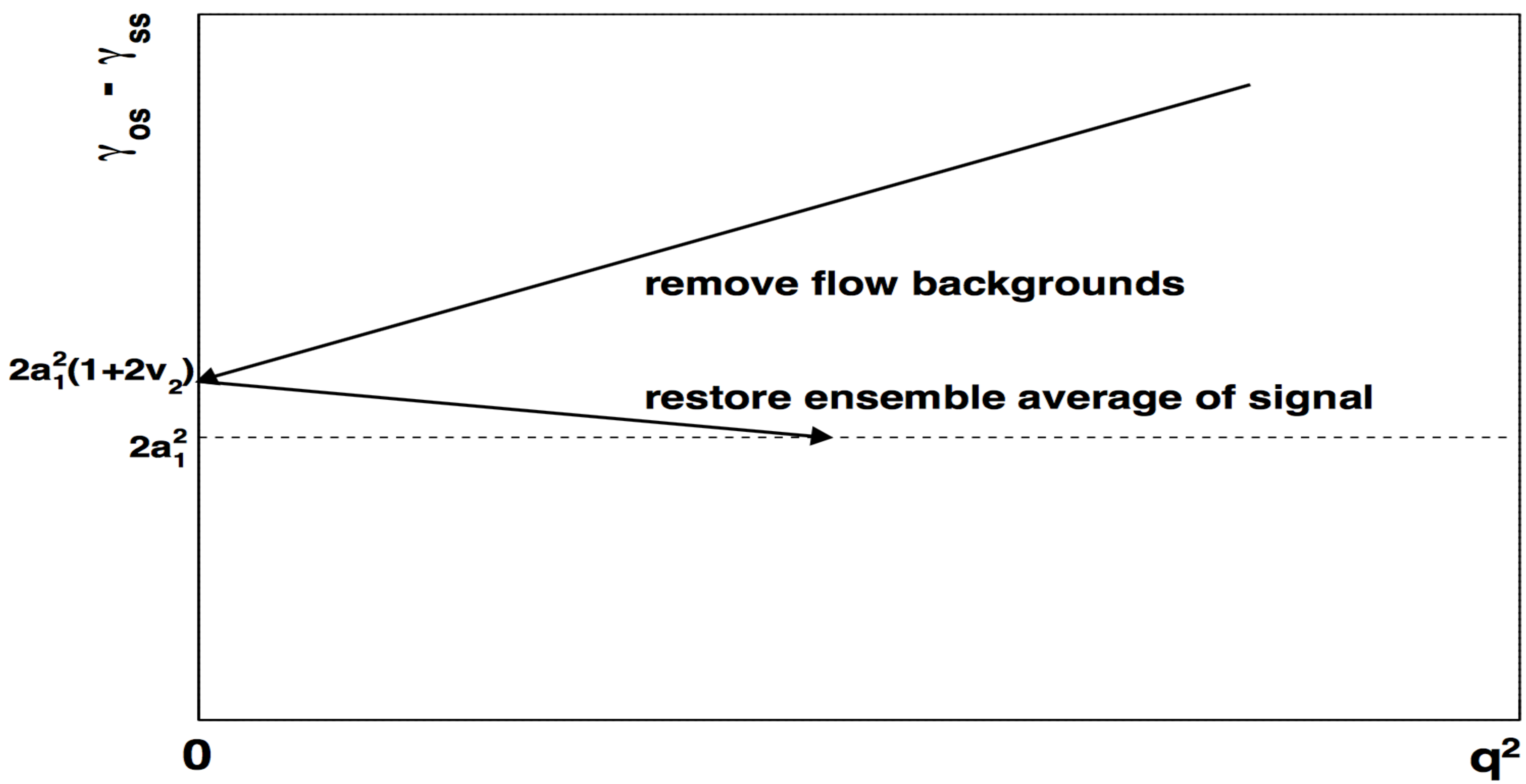
q^2 method is applied to select spherical event (zero v_2), so the flow-related background can be removed

$\vec{q}^A = \left(q_x^A, q_y^A\right)$ where $q_x^A = \frac{1}{\sqrt{N}}\sum_i^N \cos(2\phi_i^A)$

$q_y^A = \frac{1}{\sqrt{N}}\sum_i^N \sin(2\phi_i^A)$

event-shape engineering

A schematic diagram of how to reveal the ensemble average CME signal via event-shape engineering



- ensemble average CME signal can be restored from apparent signal by: $\Delta\gamma = \Delta\gamma(q^2 = 0)/(1 + 2v_2)$

[arXiv:1608.03205[nucl-th]](arXiv:1608.03205[nucl-th])

Cuts information

- Each event has been divided into 3 sub-events: A, B_1 and B_2.
- A: $|\eta| < 0.5$ contains particles of interest.
- B_1:$0.5 < \eta < 1$, B_2: $-1 < \eta < -0.5$ serve as reconstructed sub-event planes.

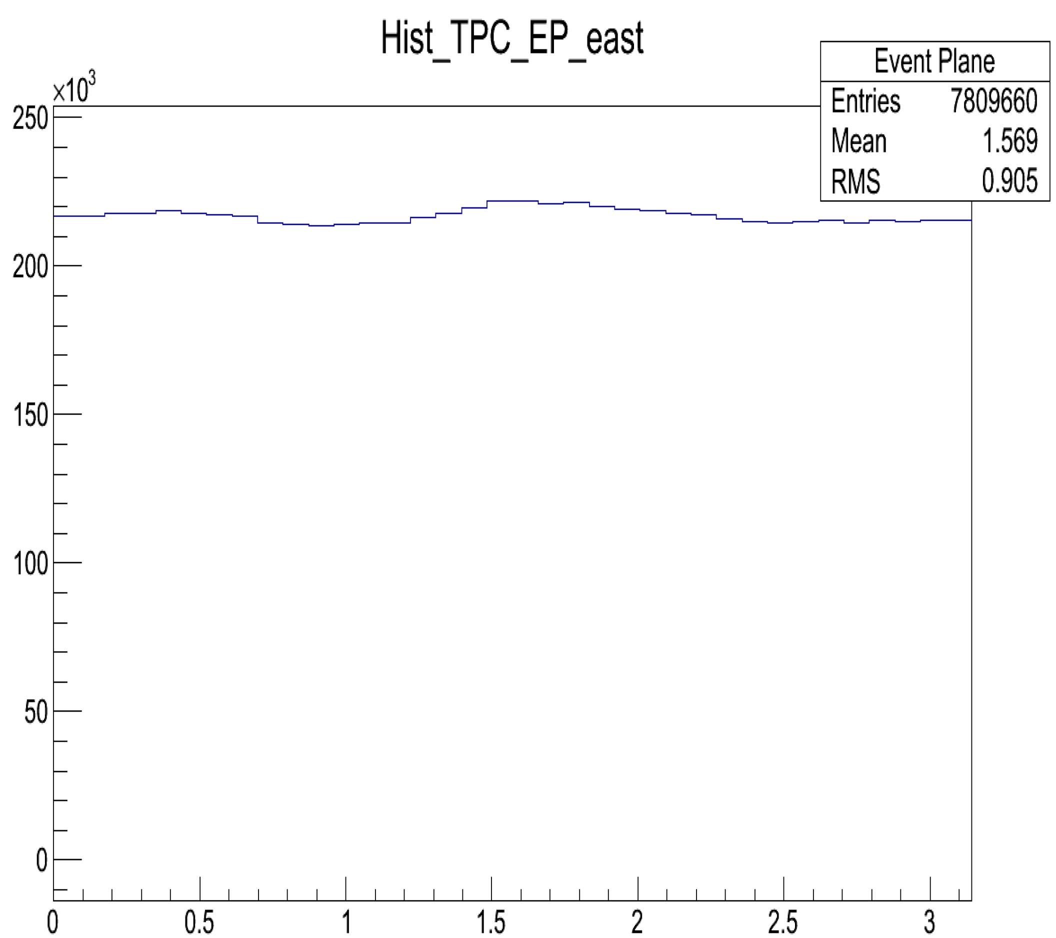
- Cuts:

	VertexZ(cm)	Dca(cm)	Pt(GeV/c)
Au+Au	(-40,40)	<2	(0.15,2)
Cu+Cu	(-30,30)	<2	(0.15,2)

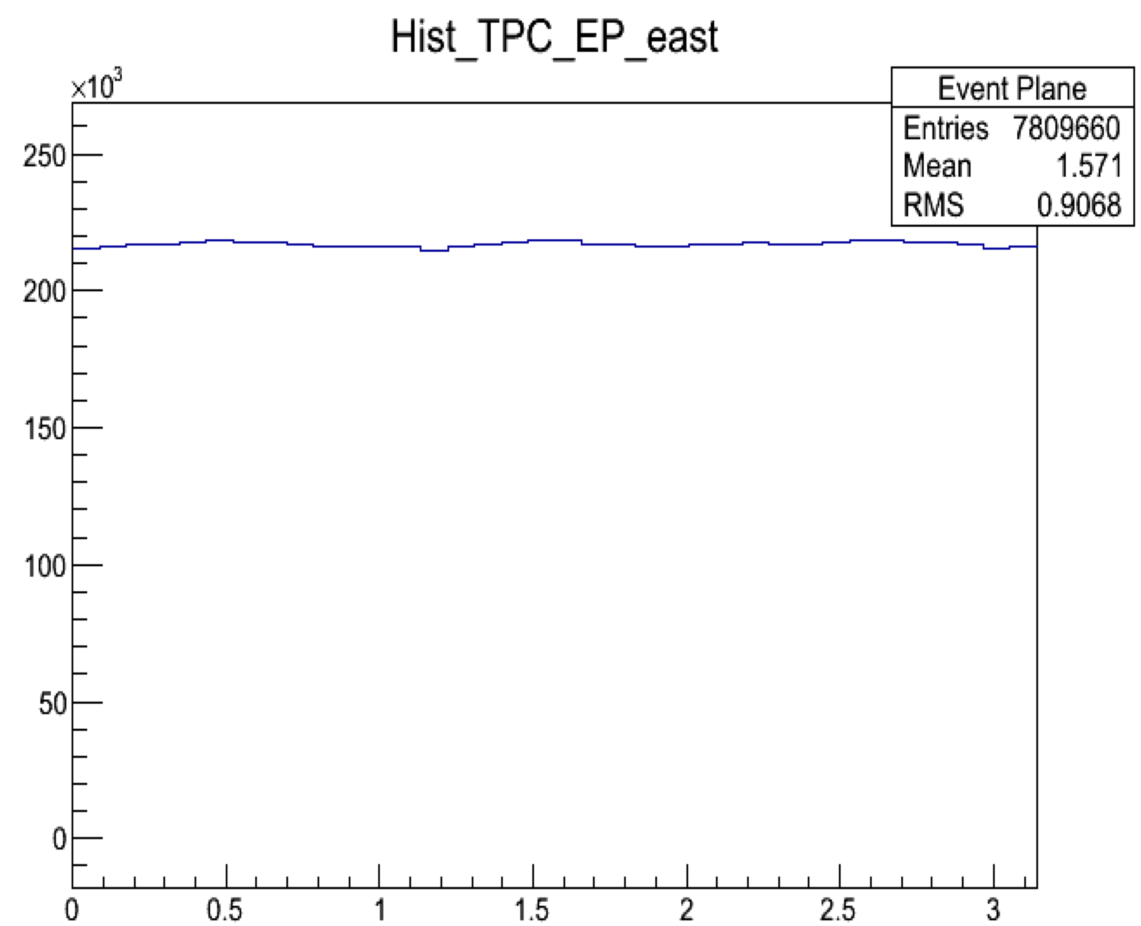
EP distribution in 200GeV Cu+Cu

- Shifting method is applied to flatten event plane distribution

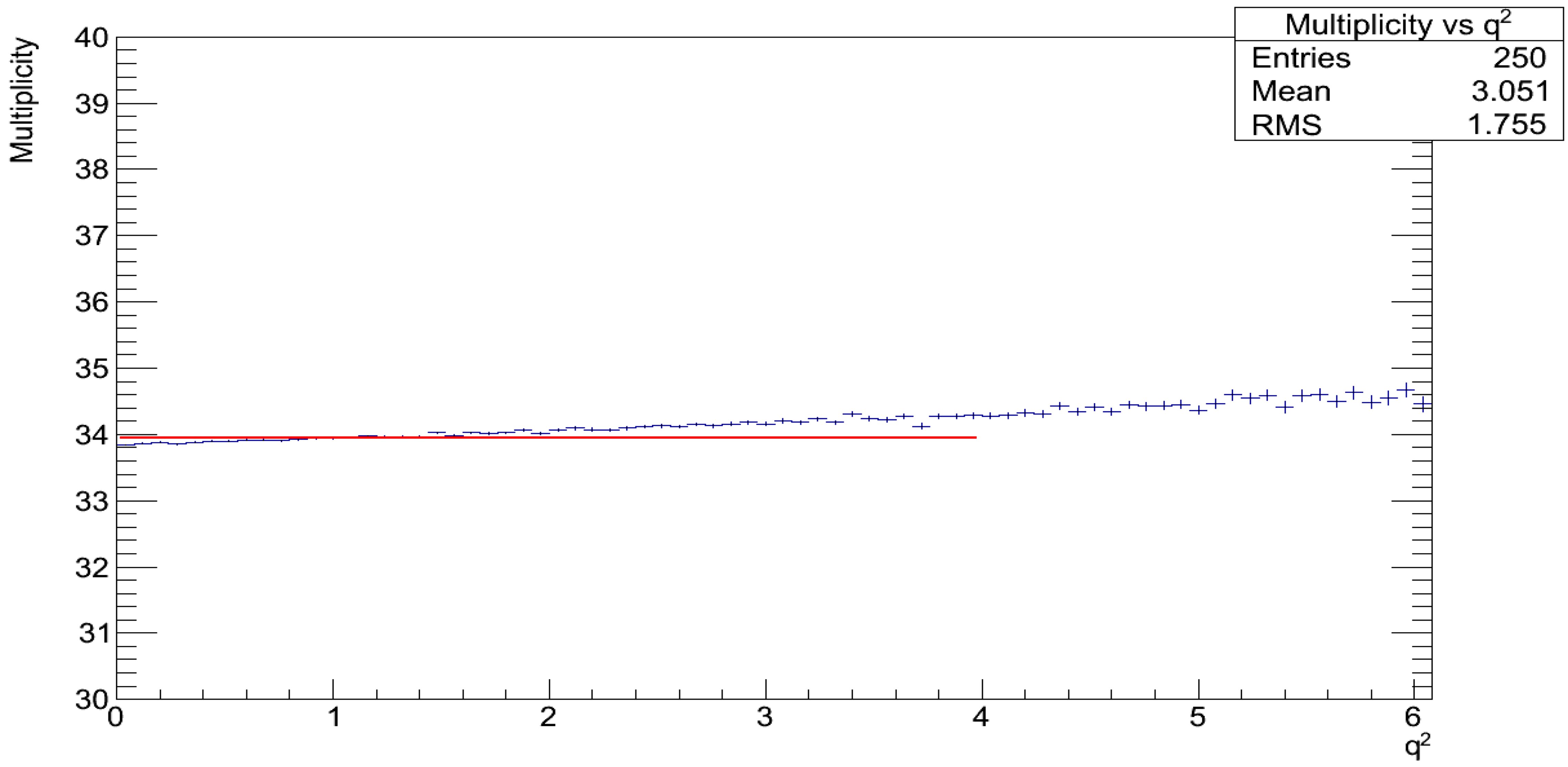
before



after

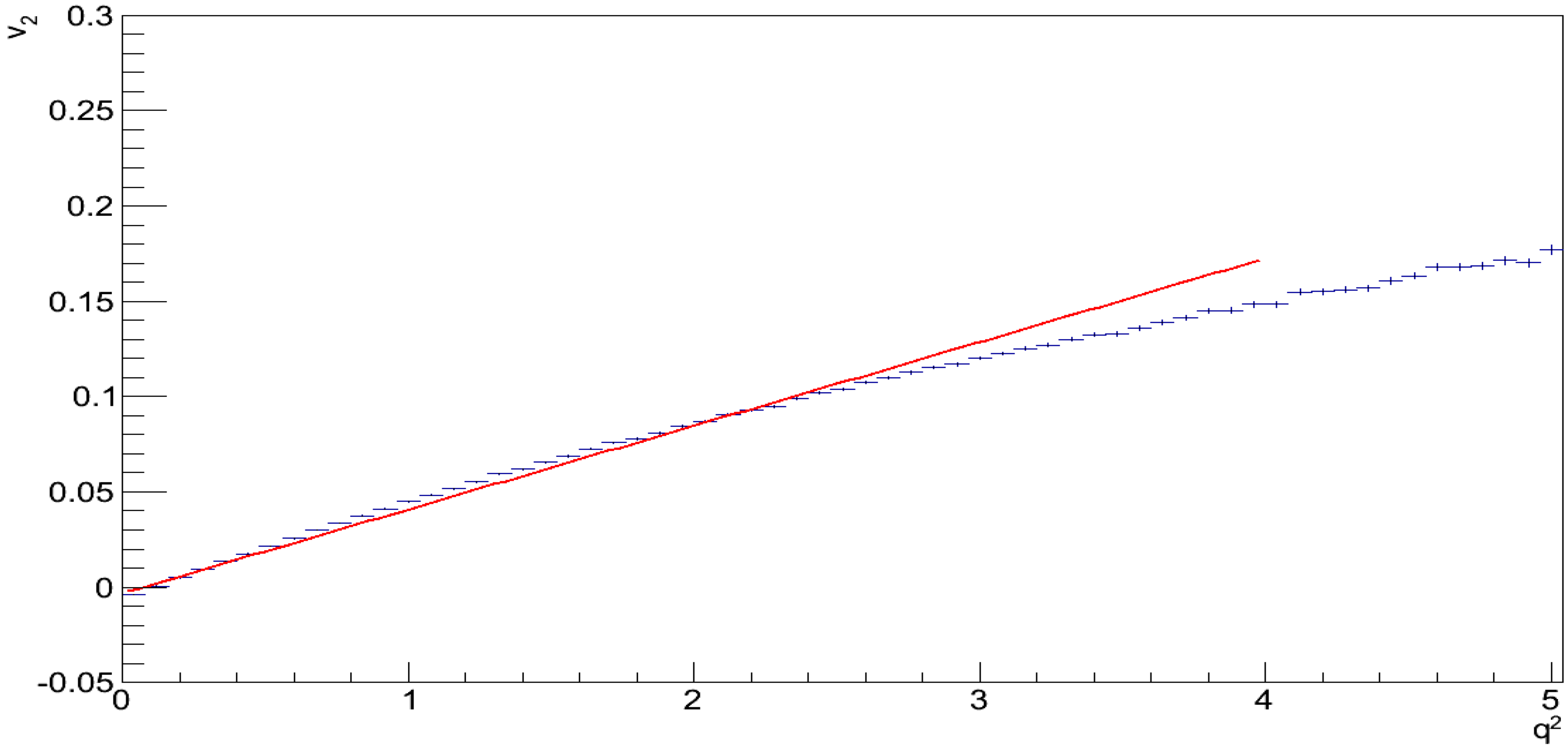


Multiplicity vs q^2 in 39GeV Au+Au(50%-60% most central)



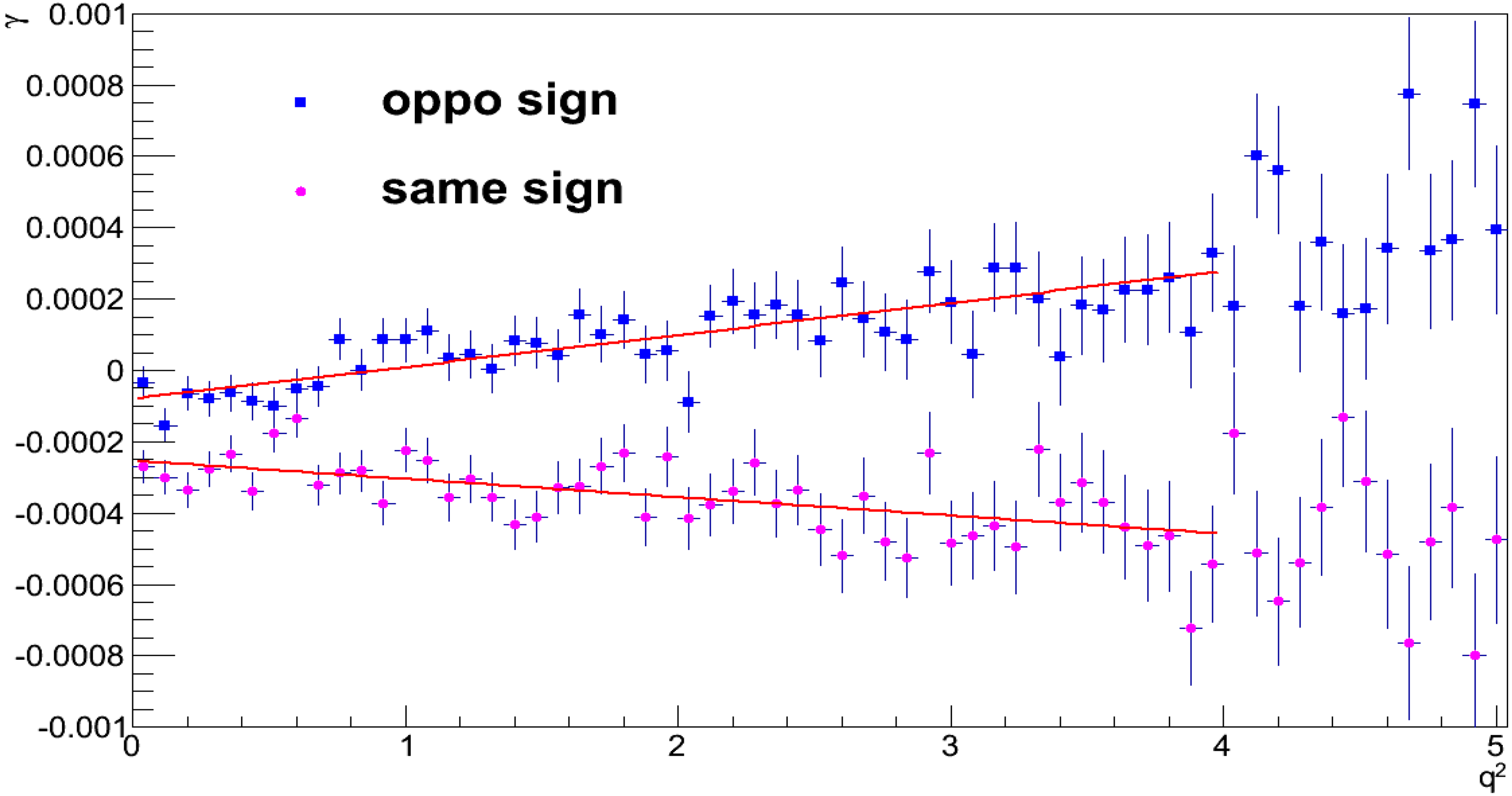
- Multiplicity is almost independent of q^2 in the range of interest for q^2 (0,4), so the handle does not bias multiplicity.

v_2 vs q^2 in 39GeV Au+Au (30%-40% most central)



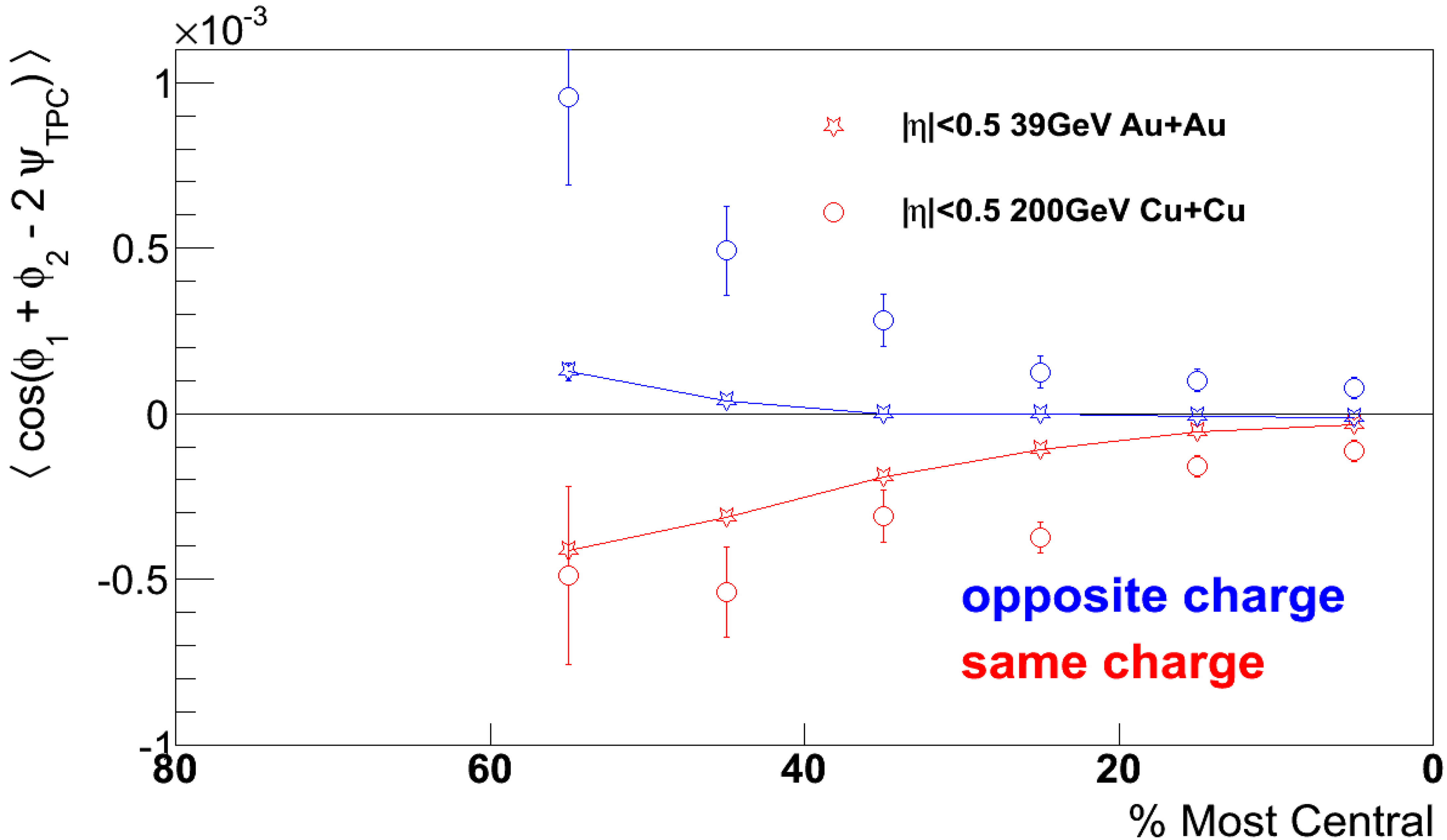
- It demonstrates the almost linear relationship of v_2 and q^2.
- The results are similar for other centralities.

γ vs q^2 in 39GeV Au+Au (30%-40% most central)



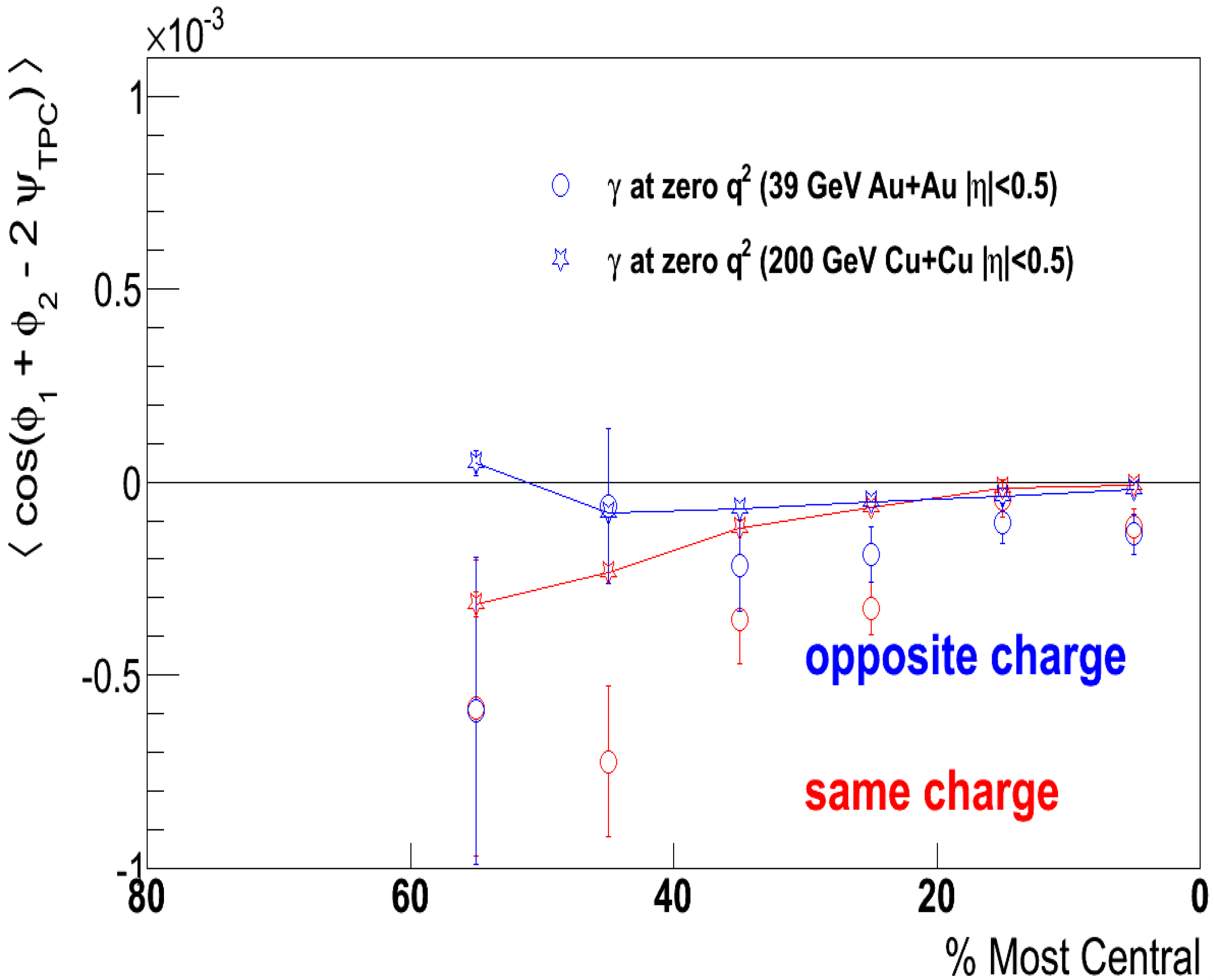
- Linear projection to remove the CME flow background.
- Ensemble average CME signal can be restored from intercepts by:
  $\Delta\gamma = \Delta\gamma(q^2 = 0)/(1 + 2v_2)$

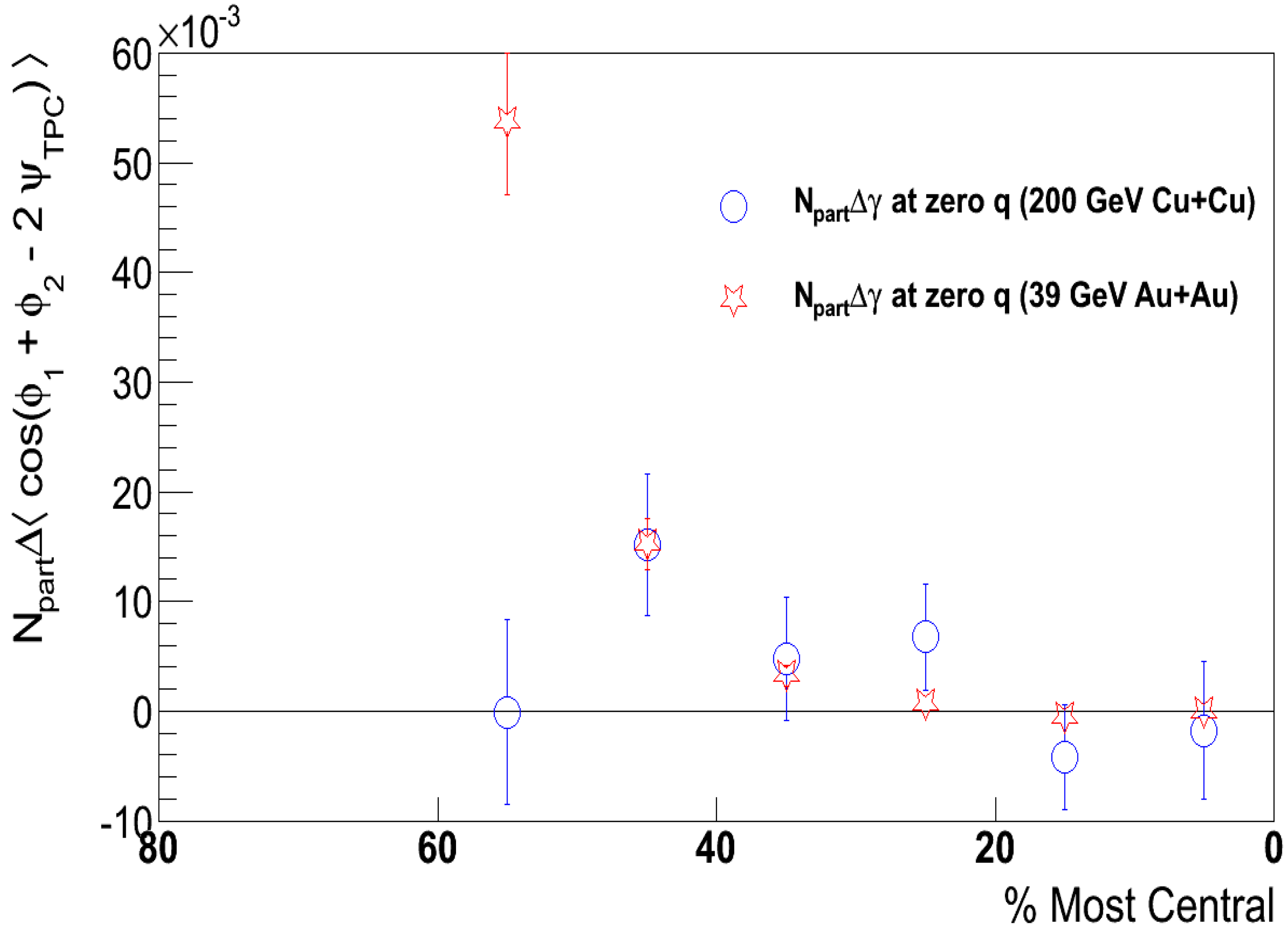
39GeV Au+Au and 200GeV Cu+Cu: without background removal



- Cu+Cu sig+bg is much larger than Au+Au.

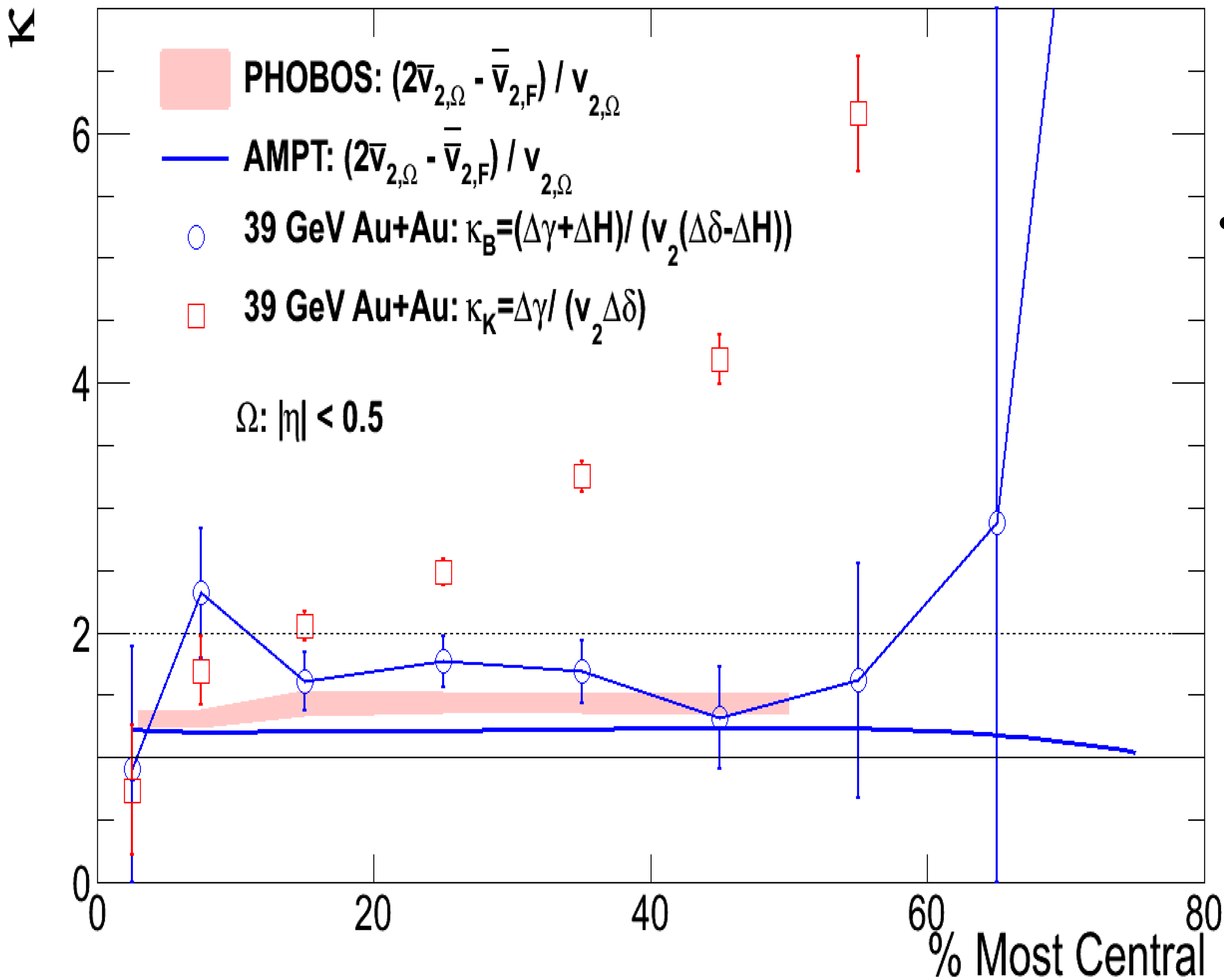
39GeV Au+Au and 200GeV Cu+Cu: with background removal





- Similar real CME signals for 0-50% Au+Au at 39GeV and Cu+Cu at 200GeV.
- In 50-60% Cu+Cu, the true signal may disappear.

κ comparison: Au+Au collisions



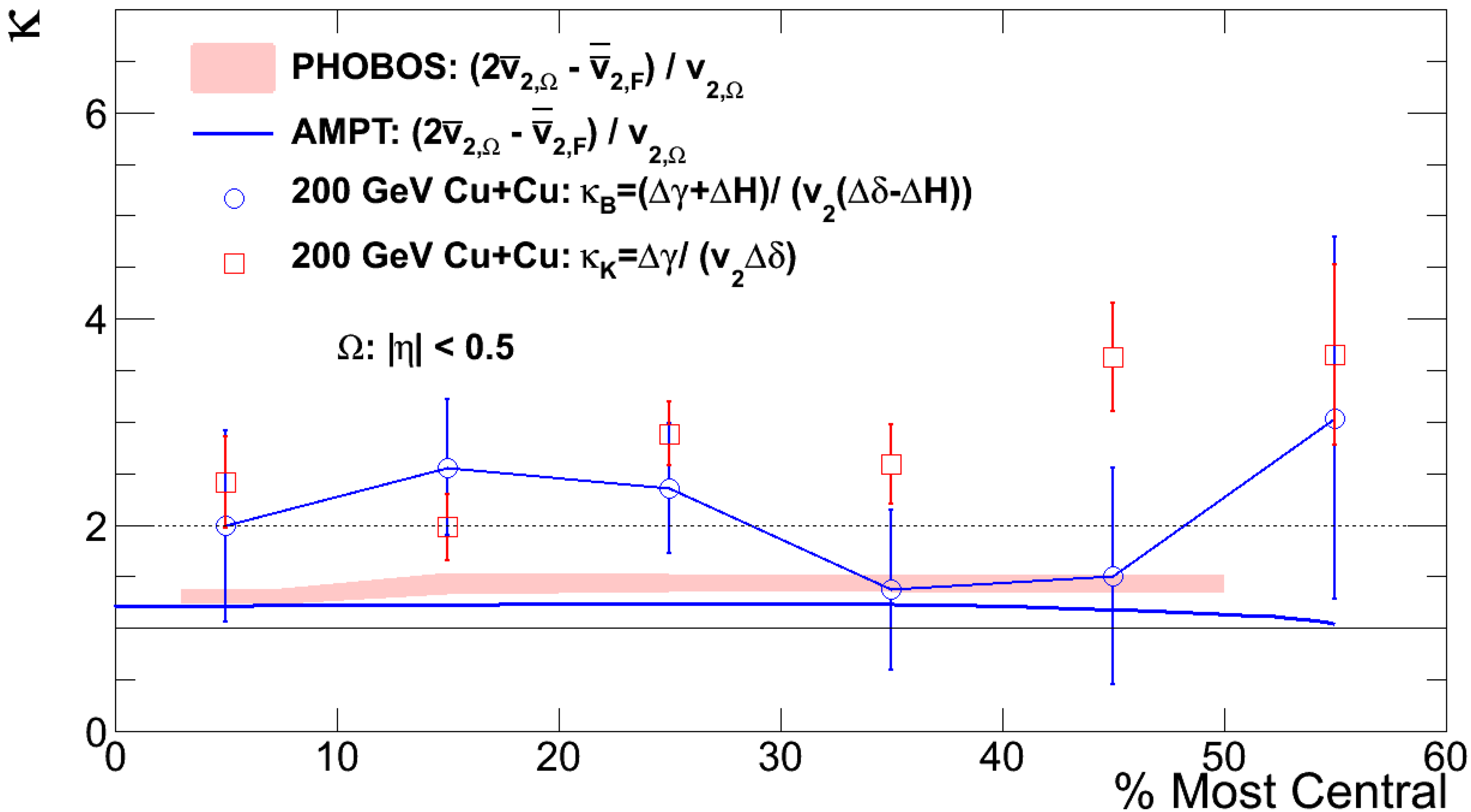
$$\gamma \equiv \ll \cos(\phi_\alpha + \phi_\beta - 2\Psi_{RP}) \gg = \kappa v_2 B - H$$

$$\delta \equiv \ll \cos(\phi_\alpha - \phi_\beta) \gg = B + H$$

- H and B are CME signal and flow background contributions respectively.

- Baseline κ_B for Au+Au collisions is around 1.5, determined from 3 approaches.
- Peripheral collisions have larger κ_K (signal killer), thus more significant CME signal.

κ comparison: Cu+Cu collisions



- κ_B for Cu+Cu collisions is around 2.

Summary

- q^2 is a good handle on event-shape.
- Projection of q^2=0 was carried out for Au+Au 39GeV and Cu+Cu 200GeV: finite CME signal is observed.
- After subtracting background, the CME signal of Cu+Cu 200GeV collisions is consistent with Au+Au 39GeV collisions.
- κ_B is around 1.5 for Au+Au collisons, 2 for Cu+Cu collisions, closed to the value estimated by other approaches.