Analysis Update on:
Search for the chiral magnetic effect with identified particles in 39 GeV Au+Au

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Outline

- PID results (Pion-Proton, Pion-Kaon)
- Flow Background Analysis
- Summary & Outlook

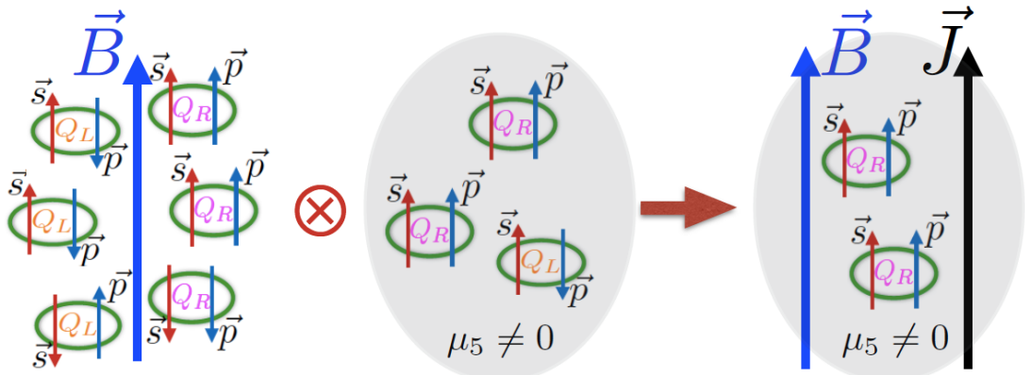
Chiral Magnetic Effect and Charge Separation

- An electric current will be induced in chiral domains along the B field: **Chiral Magnetic Effect (CME)**.
- **Charge separation fluctuations** for all charged particles have been experimentally observed.
- Identified particle analysis: Is there an indication of CME?
- Shifting method is used to make corrections to the event plane.

Observable: γ correlator

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

$$\begin{aligned}\gamma &= \langle\langle\cos(\phi_\alpha + \phi_\beta - 2\Psi_{\mathrm{RP}})\rangle\rangle \\ &= \langle\langle\cos(\Delta\phi_\alpha)\cos(\Delta\phi_\beta) - \sin(\Delta\phi_\alpha)\sin(\Delta\phi_\beta)\rangle\rangle \\ &= [\langle v_{1,\alpha}v_{1,\beta}\rangle + B_{\mathrm{IN}}] - [\langle a_{1,\alpha}a_{1,\beta}\rangle + B_{\mathrm{OUT}}],\end{aligned}$$



Kharzeev, D.E. et al. Prog.Part.Nucl.Phys. 88 (2016) 1-28 arXiv: 1511.04050 [hep-ph]

Cuts & Identification of Pions and Protons

- Event

VertexZ (cm)	(-30,30)

- Particles

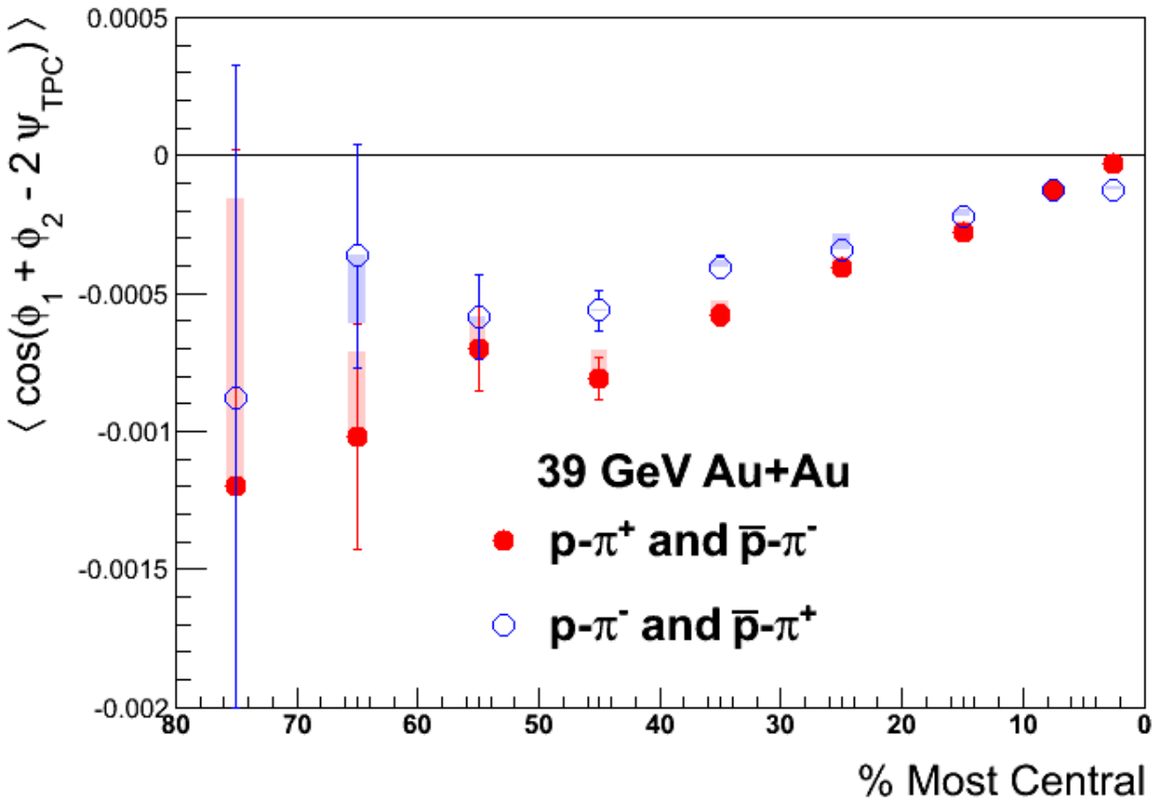
Eta	(-1,1)	
Dca (cm)	Proton	< 1
	Pion	< 2
Tof	β	> 0
	Ylocal	(-1.8,1.8)

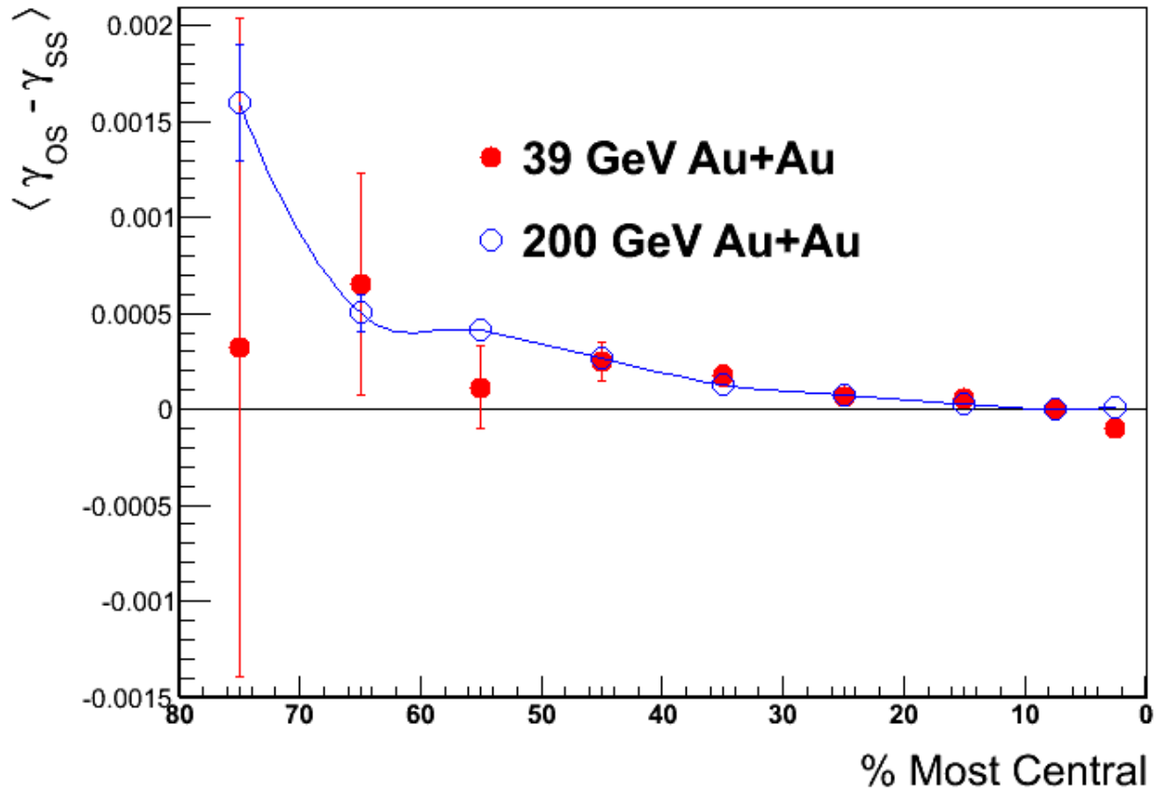
- Identified Particles

$Mass^2$ (GeV^2/c^4)	Proton	(0.8, 1)
	Pion	(-0.01, 0.1)
pT (GeV/c)	Proton	(0.4, 2)
	Pion	(0.15, 1.6)
nSigma of Proton		(-2, 2)
nSigma of Pion		(-2, 2)

- The cuts are from Gang and Liwen.

PID Results for Pion-Proton





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

- 39GeV results resemble in scale that of 200 GeV.
- Opposite sign signal above same sign; smaller signals with more central collisions.

Cuts & Identification of Pions and Kaons

- Event

VertexZ (cm)	(-30,30)

- Particles

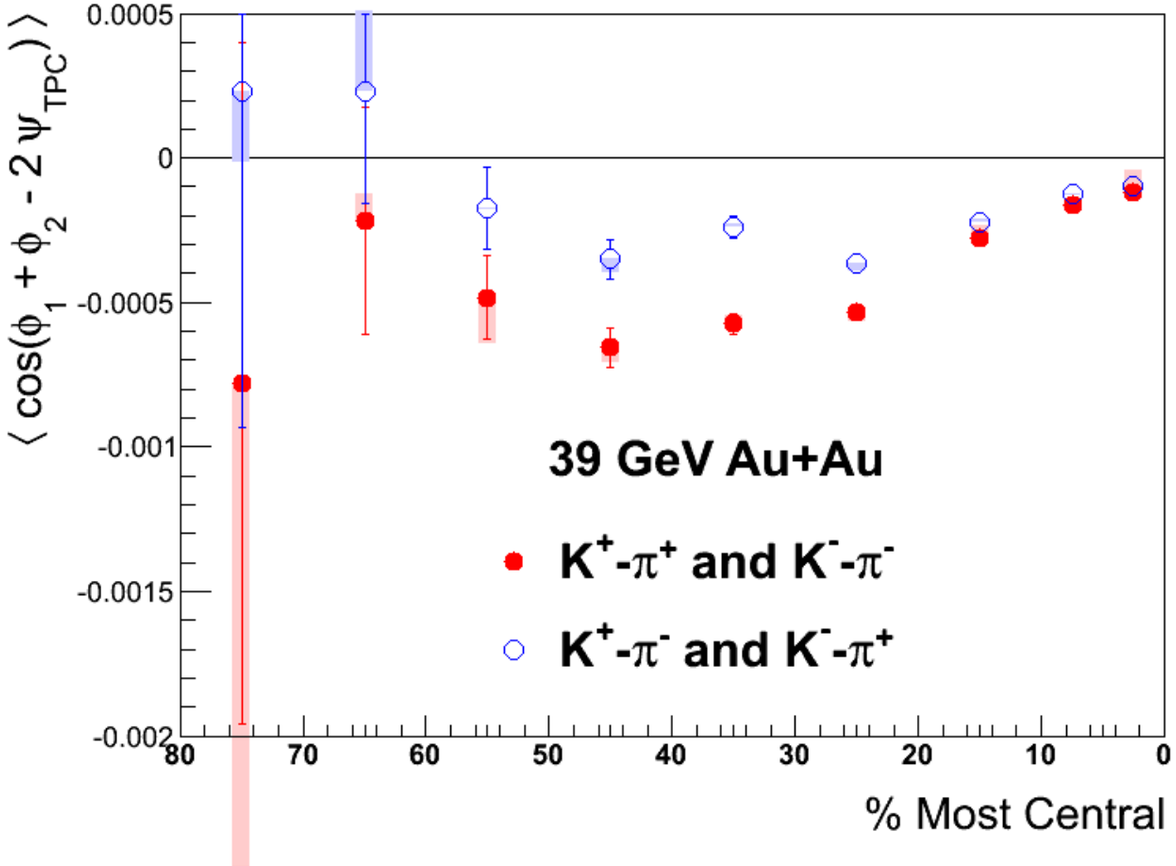
Eta	(-1,1)	
Dca (cm)	Kaon	< 1
	Pion	< 2
Tof	β	> 0
	Ylocal	(-1.8,1.8)

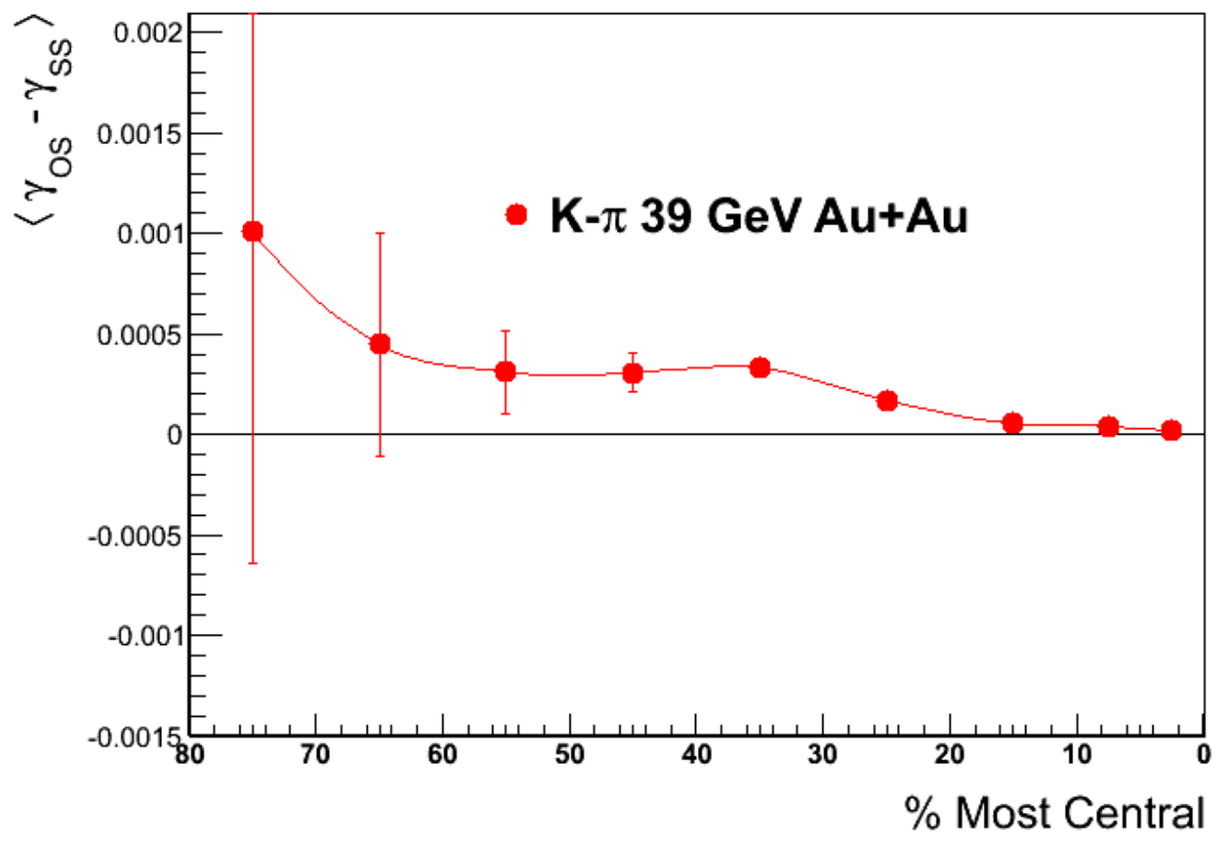
- Identified Particles

$Mass^2$ (GeV^2/c^4)	**Kaon**	**(0.2, 0.35)**
	Pion	(-0.01, 0.1)
P (GeV/c)	**Kaon**	**< 1.6**
pT (GeV/c)	**Kaon**	**> 0.2**
	Pion	(0.15, 1.6)
nSigma of Kaon		(-2, 2)
nSigma of Pion		(-2, 2)

- The cuts are from Gang and Liwen.

PID Results for Pion-Kaon (39 GeV)





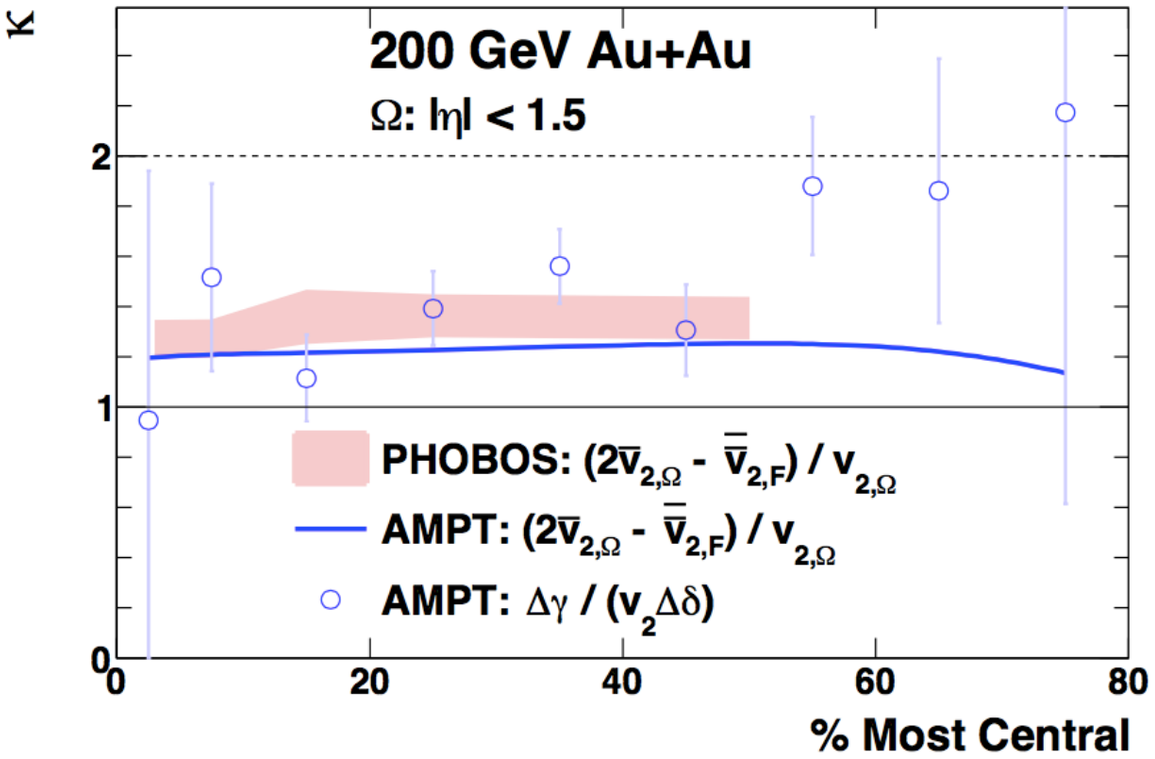
- Similar scale as pion-proton signal.

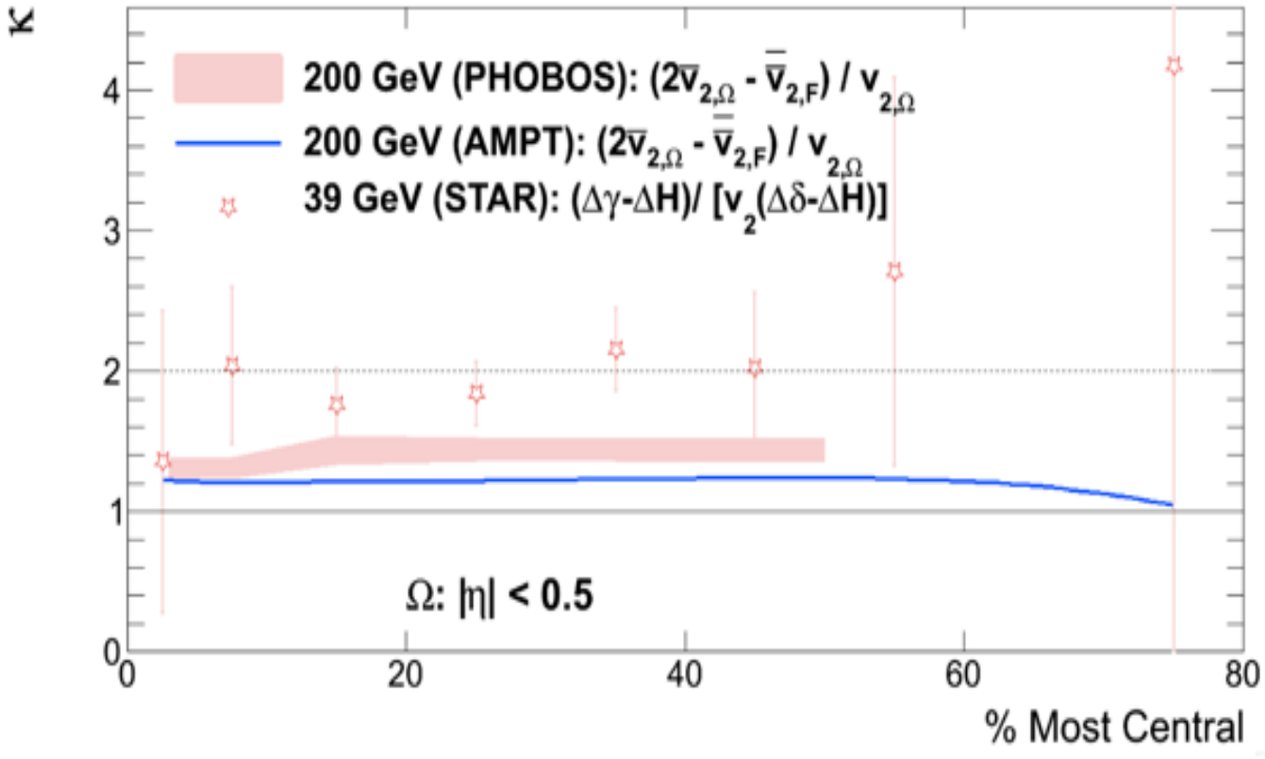
Flow Background

$$\delta \equiv \langle\langle \cos(\phi_\alpha - \phi_\beta) \rangle\rangle$$

$$H^\kappa = (\kappa v_2 \delta - \gamma)/(1 + \kappa v_2).$$

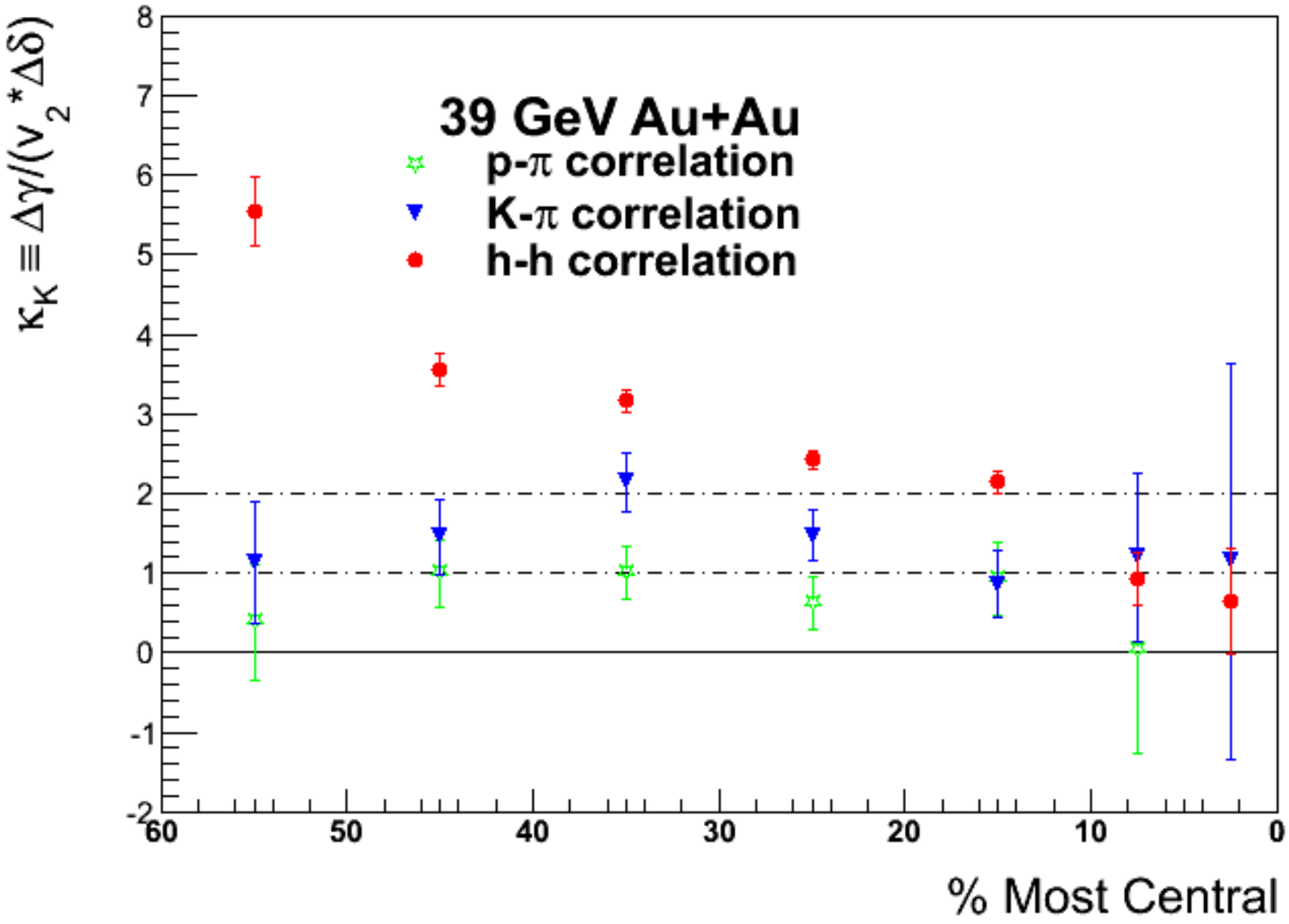
- H: background-subtracted correlator, CME contributions





- Correlation signal is contaminated with the **background contributions** due to collective motion of the collision system (flow)
  - decay of the clusters will contribute to the charge separation signal
  - elliptic flow coupled with transverse momentum conservation (TMC) and local charge conservation (LCC)
- **Baseline**: κ estimated to be (1.2,1.4) for three methods, ~2 for the fourth.

Flow Background in Identified Particles



$$\gamma \equiv \langle\langle\cos(\phi_\alpha + \phi_\beta - 2\Psi_{\mathrm{RP}})\rangle\rangle$$
$$\delta \equiv \langle\langle\cos(\phi_\alpha - \phi_\beta)\rangle\rangle$$
$$H^\kappa = (\kappa v_2 \delta - \gamma)/(1 + \kappa v_2).$$

$$\kappa_K \equiv \Delta\gamma/(v_2 * \Delta\delta)$$

- H: background-subtracted correlator, CME contributions
- Indication of signal if higher than baseline: κ_K that forces $\Delta H = 0$

Summary & Outlook

- It require more information to claim a charge-separation signal in proton-pion or in kaon-pion.
- Outlook:
  - Finish analysis on pion-pion.
  - Try the $q^2 = 0$ handle on event shape
    - q or q^2 reflects the sphericity property of the sub-event. q^2 distribution favors the projection of γ to zero q^2

      (arxiv.org/abs/1608.03205)
- Further background study.