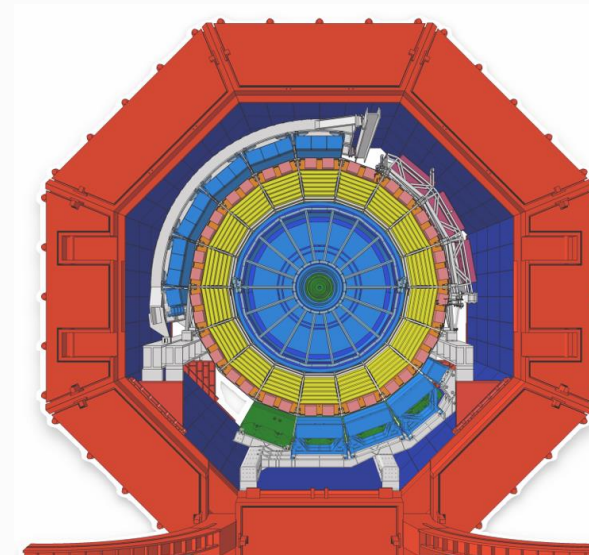
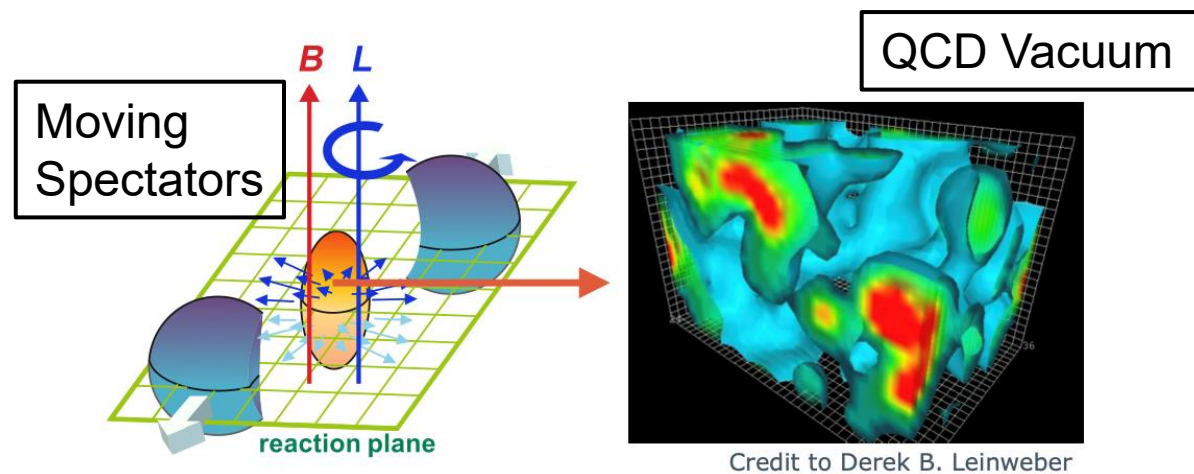


# Search for the quark flavor dependence of the Chiral Magnetic Effect through charge-dependent correlations with identified hadrons at ALICE

*Kegang Xiong (Fudan University)*

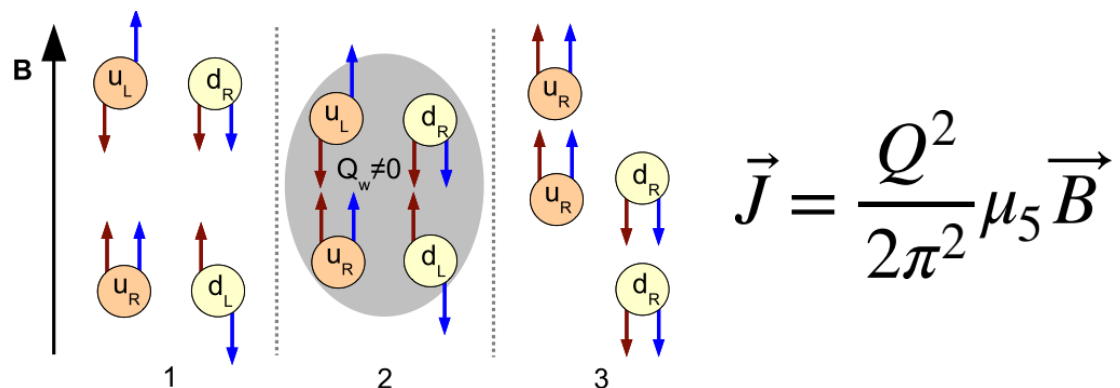
31 / Oct. / 2025





## Chiral Magnetic Effect (CME):

- Strong magnetic field  $\rightarrow$  chiral anomaly

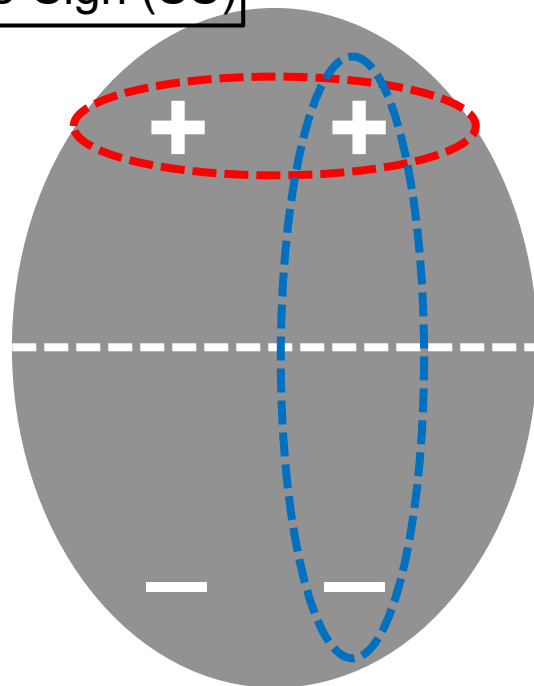


## Importance:

- Topological structure of vacuum gauge fields
- Possible local violation of P and/or CP symmetries in strong interactions
- Charge dependent collective motion of quark-gluon plasma (QGP)

 D. Kharzeev et al, NPA 797, 67 (2007)

Same-Sign (SS)



Opposite-Sign (OS)

**Observables for CME :**

$$\gamma = \langle \cos(\phi_a + \phi_b - 2\Psi) \rangle$$

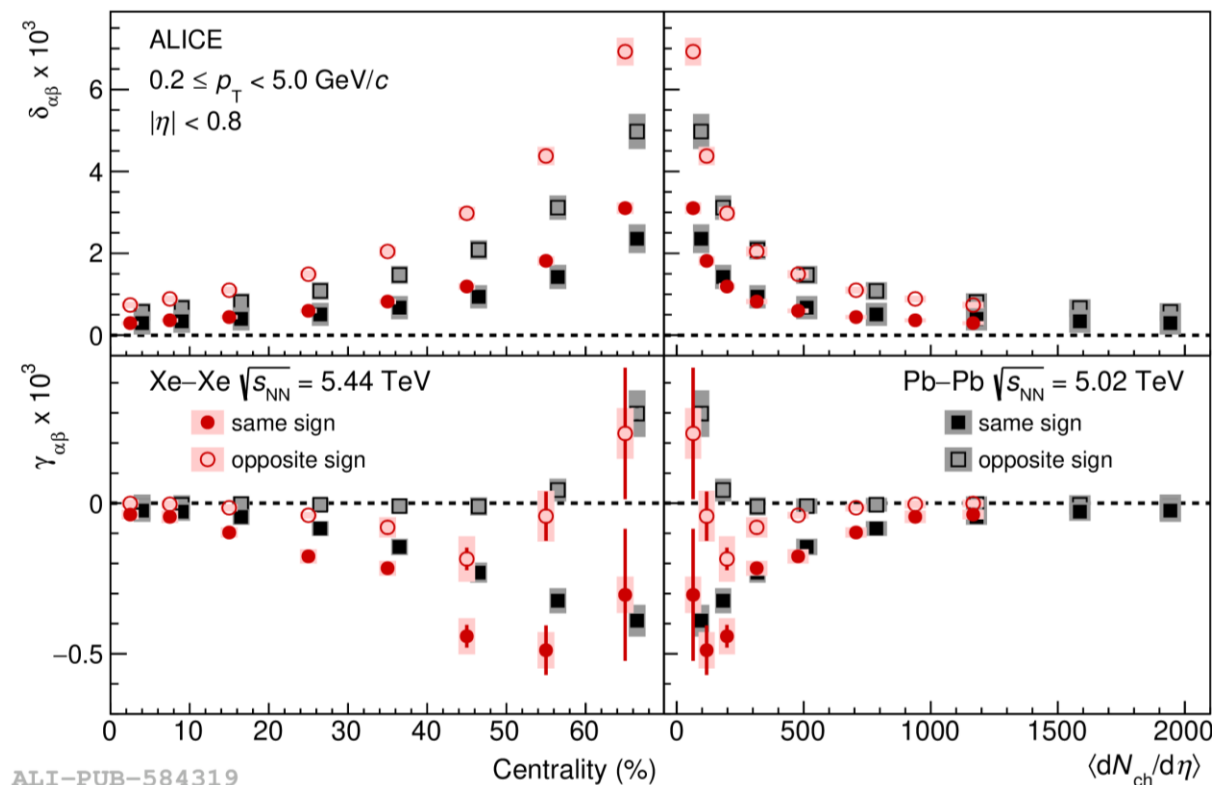
$$\Delta\gamma = \gamma_{\text{OS}} - \gamma_{\text{SS}}$$

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

$$\Delta\delta = \delta_{\text{OS}} - \delta_{\text{SS}}$$

- 📌 S. A. Voloshin, PRC 70, 057901 (2004)
- 📌 ALICE, PRL 110, 012301 (2013)

- Key, sensitive to the CME induced charge correlations
- Supportive, sensitive to the balance function



## Pb-Pb 2.76 TeV

ALICE, PRL 110, 012301 (2013)

ALICE, PLB 777, 151 (2018)

## Pb-Pb 5.02 TeV

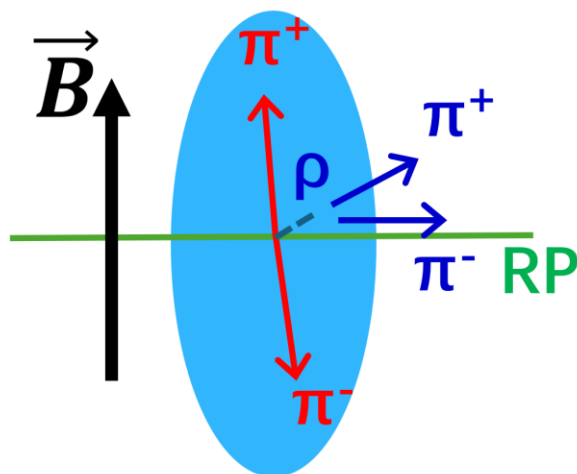
ALICE, JHEP 2020, 160 (2020)

## Xe-Xe 5.44 TeV

ALICE, PLB 856, 138862 (2024)

- CME has been extensively studied in ALICE with **charged hadrons**
- Non-zero  $\delta$ ,  $\gamma$  observed, clear centrality dependence

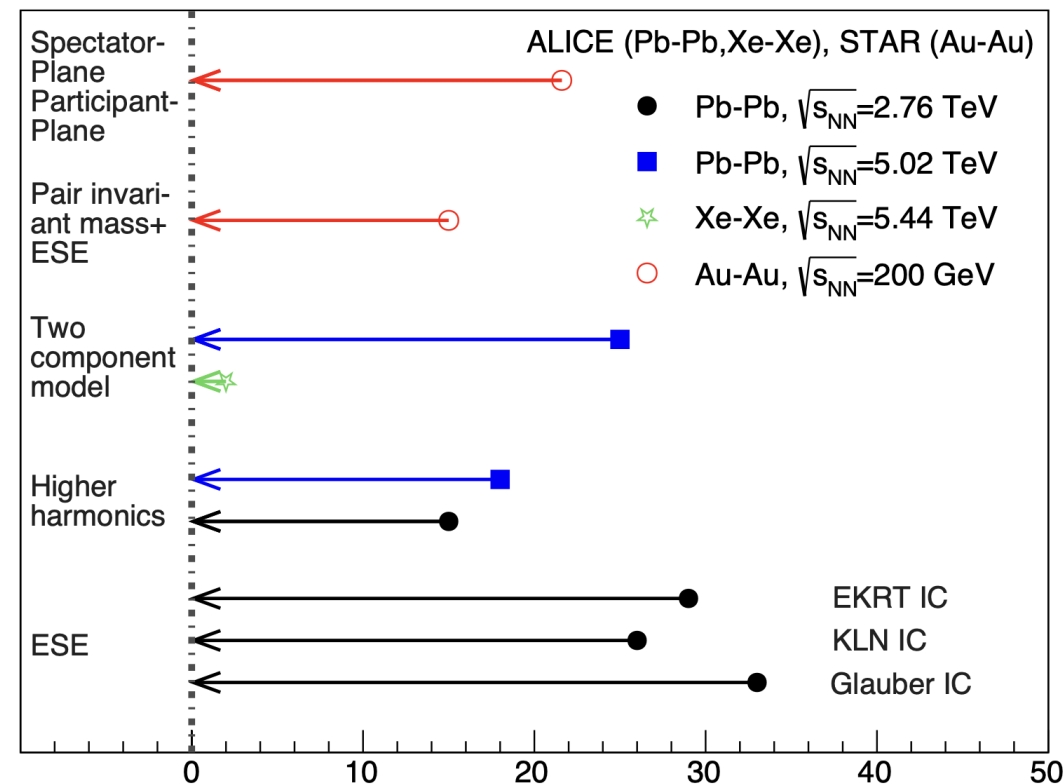
An example of the **local charge conservation** (LCC) background:

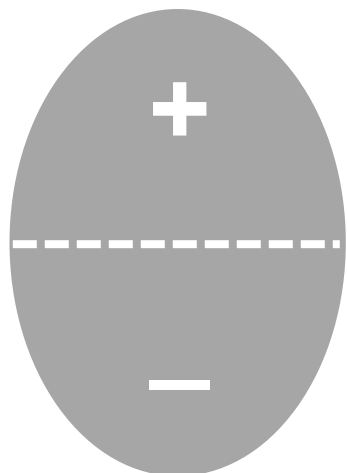


J. Zhao et al, PPNP 107, 200 (2019)

- Conclusion: no signal observed, dominated by **local charge conservation** (LCC) background
- Comparable with RHIC results

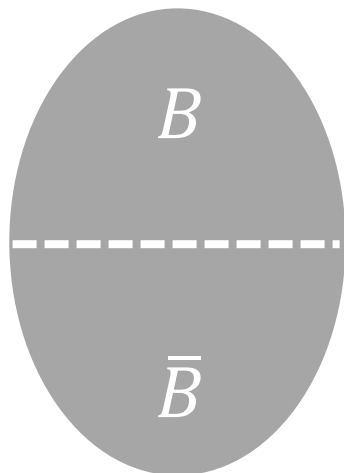
S. Qiu, EPJ Web of Conferences 274, 05001 (2022)





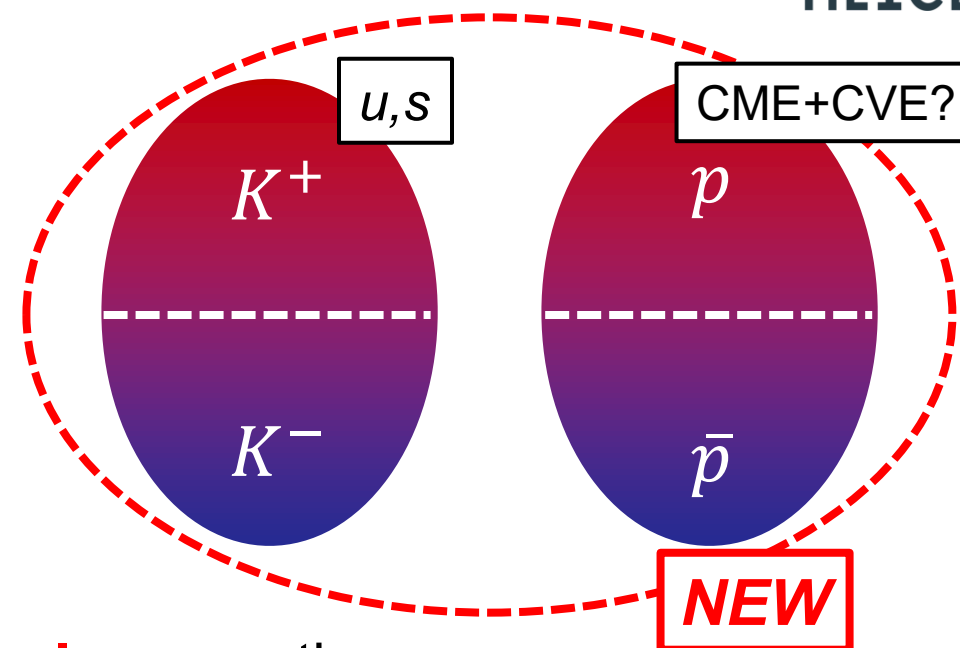
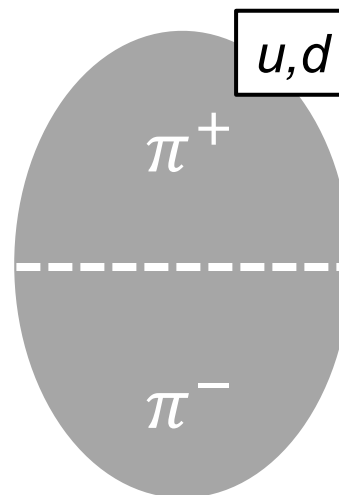
*Electric charge*

CME



*Baryonic charge ( $\Lambda$ -p)*

Chiral Vortical Effect  
(CVE)



➤ **Signal** perspective:

Can **s** be influenced by chiral anomaly?

Allowed in theory:

📌 S. Shi et al, AOP 394, 50 (2018)

➤ **Background** perspective:

How K, p are locally correlated?

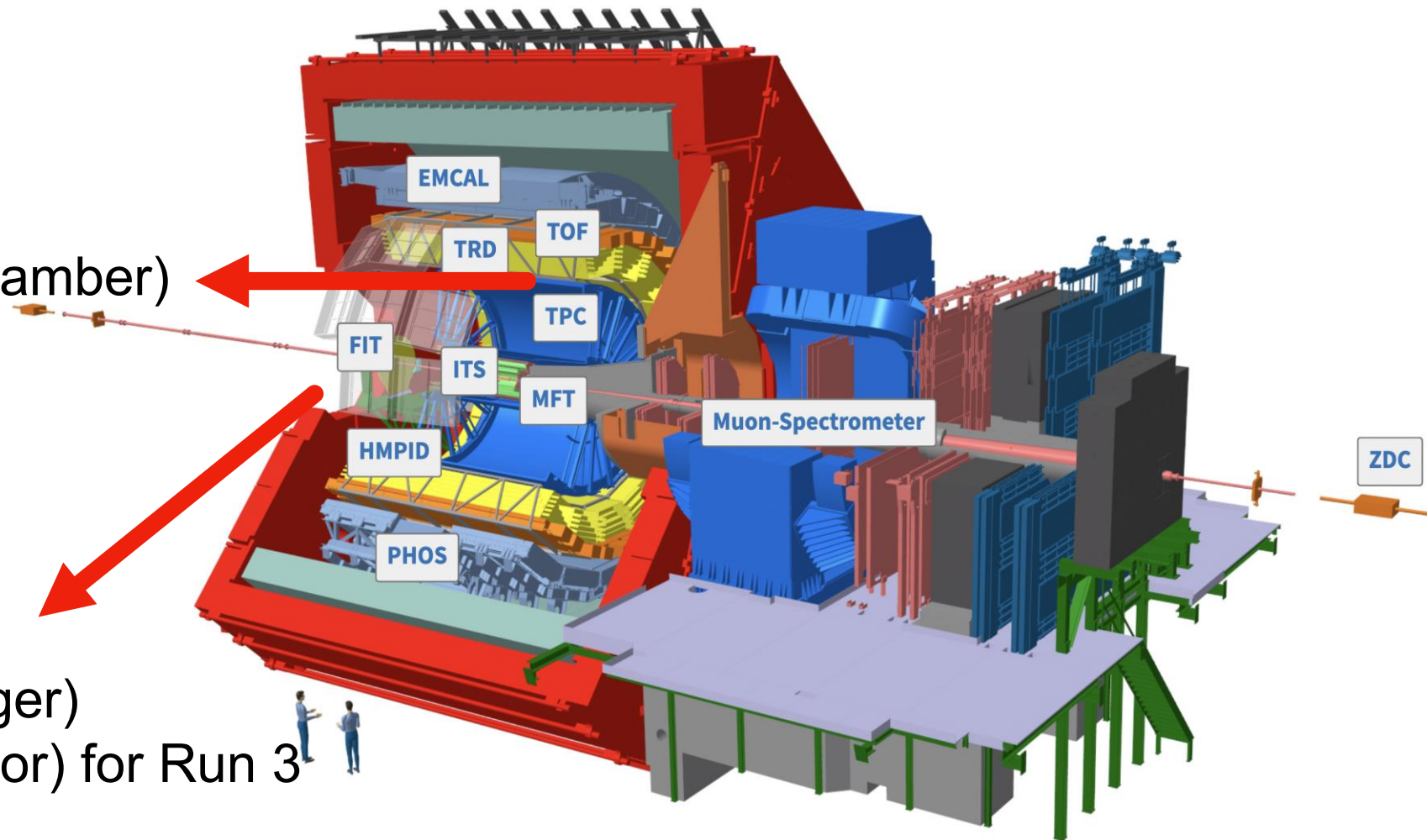


## PID:

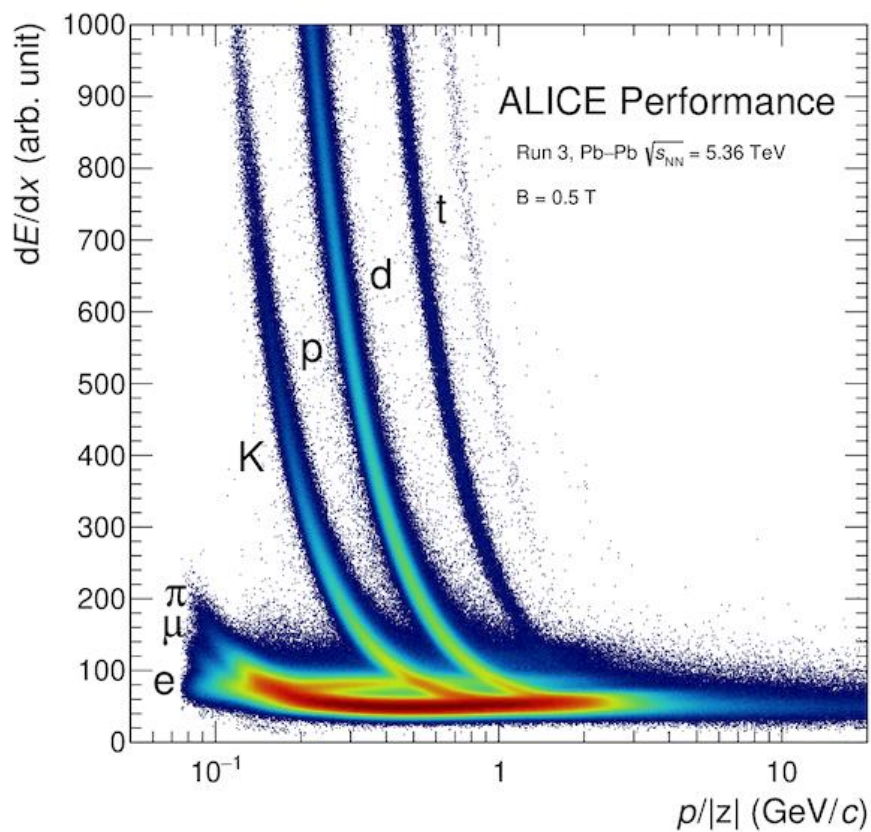
- TPC(Time Projection Chamber)
- TOF(Time Of Flight)

## Event plane:

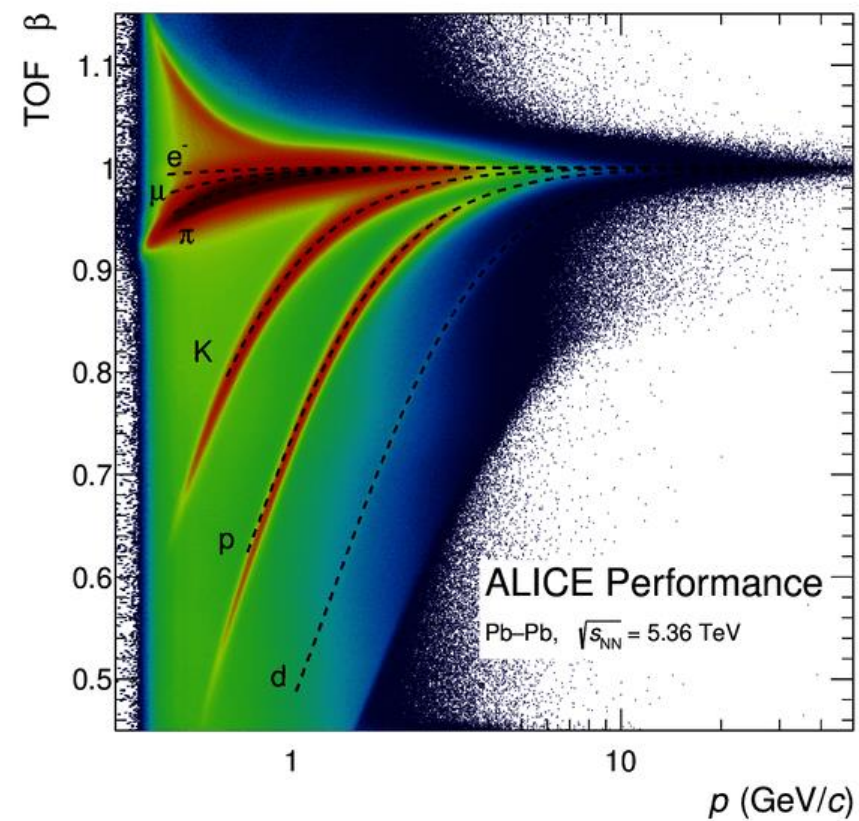
- V0 Detector for Run 2
- FIT(Fast Interaction Trigger)
  - FT0(Forward T0 Detector) for Run 3



TPC dE/dx in Run 3, Pb-Pb 5.36 TeV

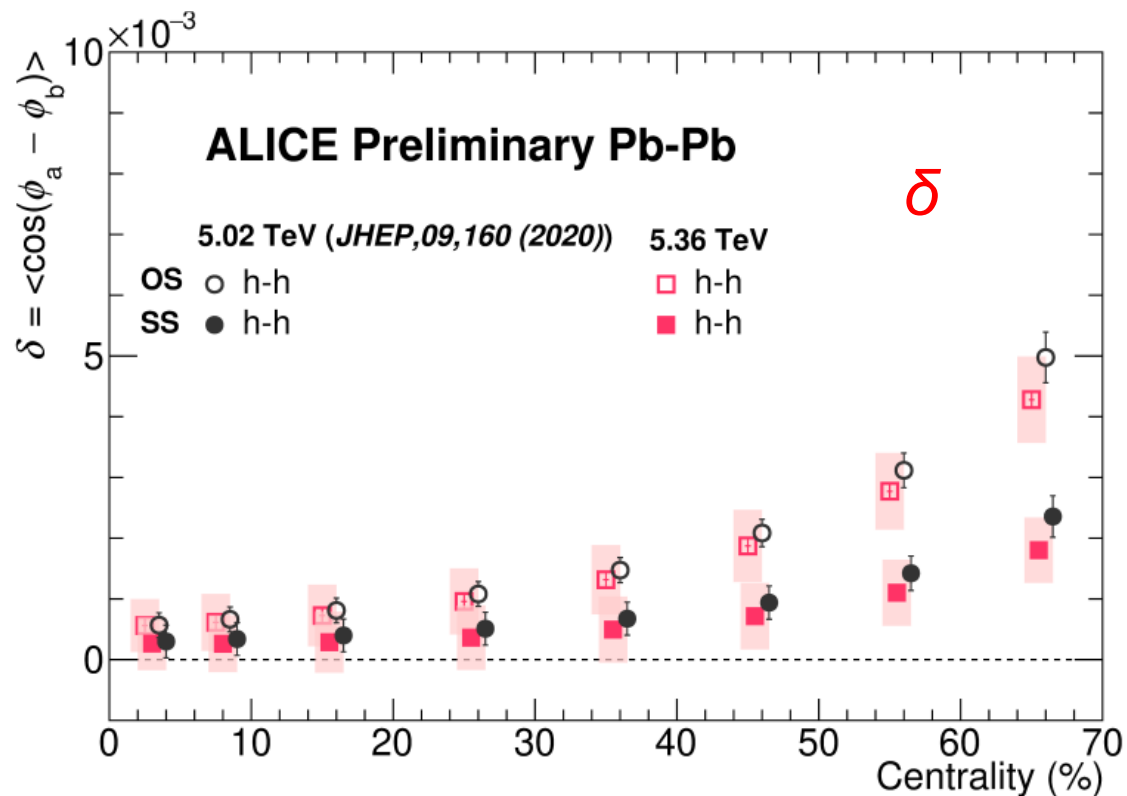


ALI-PERF-529714

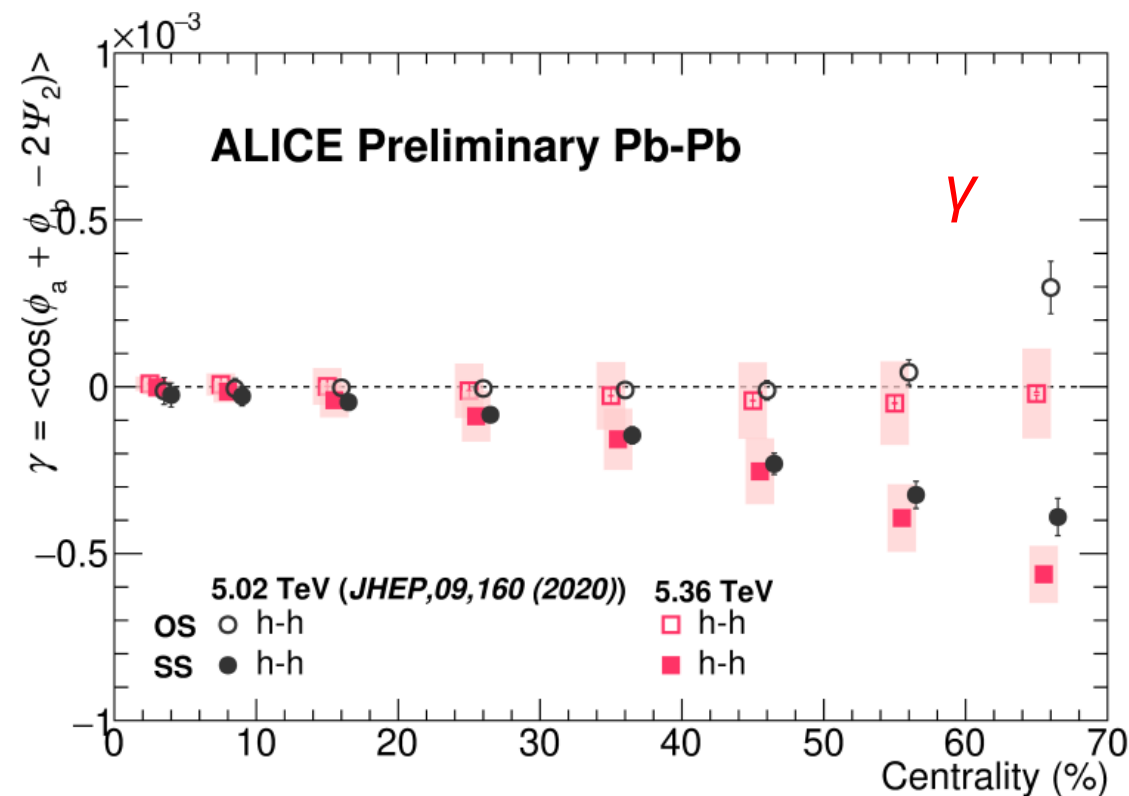
TOF  $\beta$  in Run 3, Pb-Pb 5.36 TeV

ALI-PERF-577978





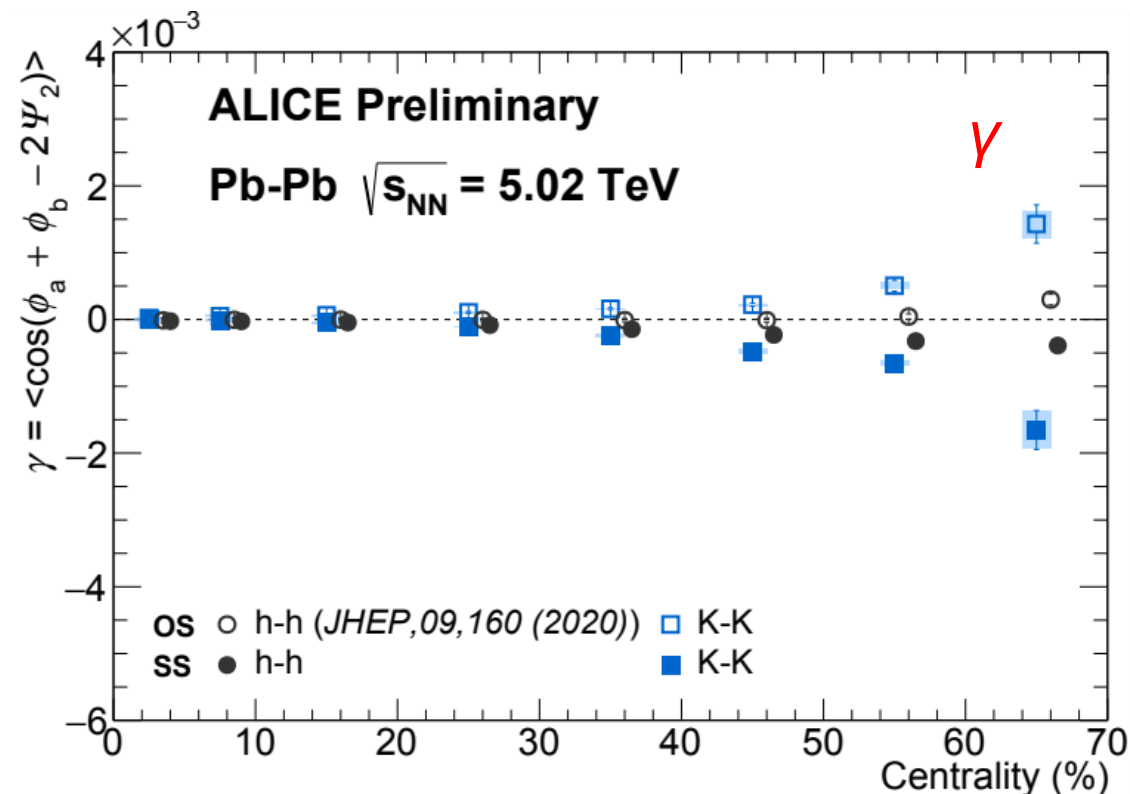
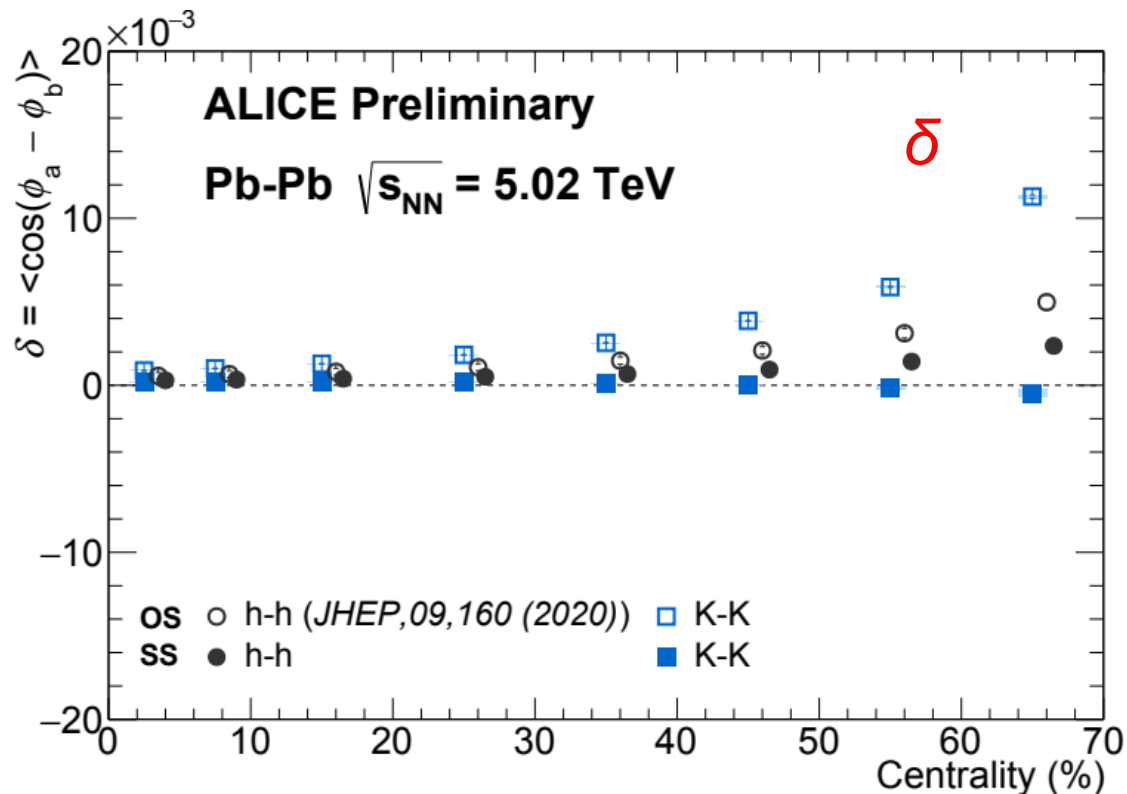
ALI-PREL-600064



ALI-PREL-600069

➤ The little collision energy difference does not affect h-h correlators

# $\delta$ $\gamma$ correlators for h-h, K-K

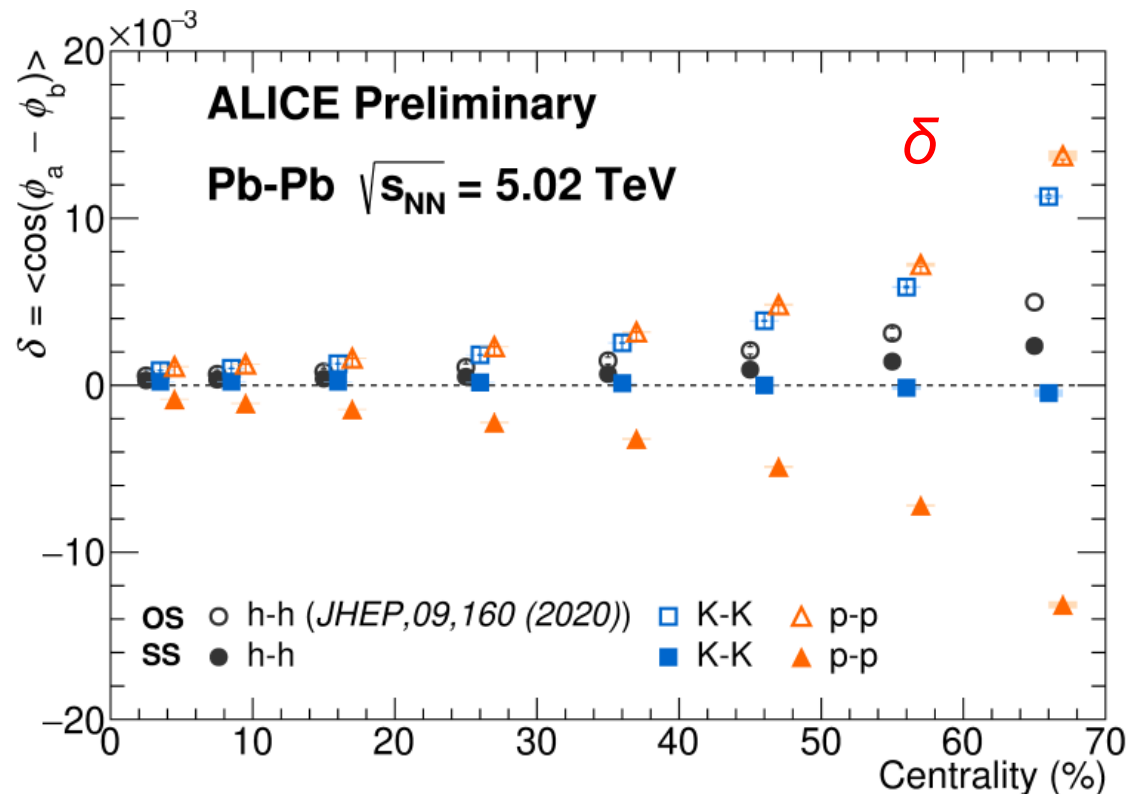


- $\delta_{SS}(K) \approx 0$
- $\delta_{OS}$  shows positive correlation, **K > h**

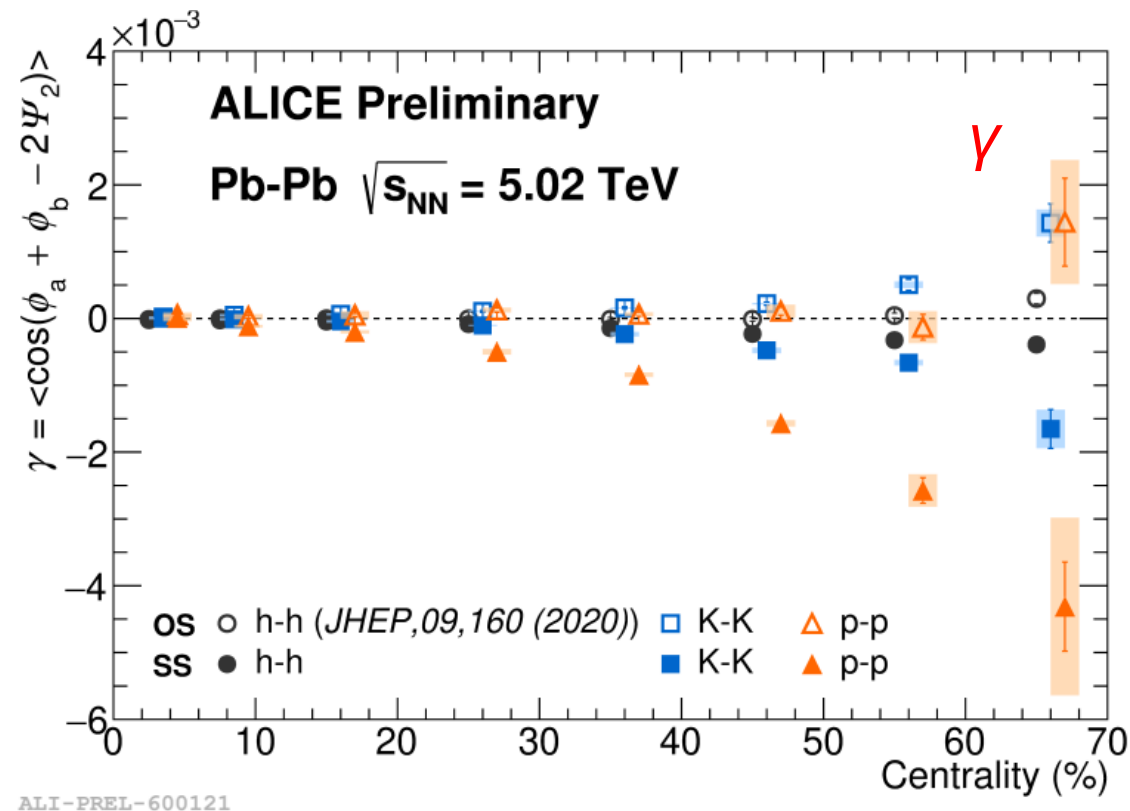
- $\gamma_{SS}(K) < 0$ ,  $\gamma_{OS}(K) > 0$
- Split between  $\gamma_{SS}/\gamma_{OS}$ , **K > h**

Possible mechanism: local charge conservation (LCC) for K-K

# $\delta \gamma$ correlators for h-h, K-K, p-p



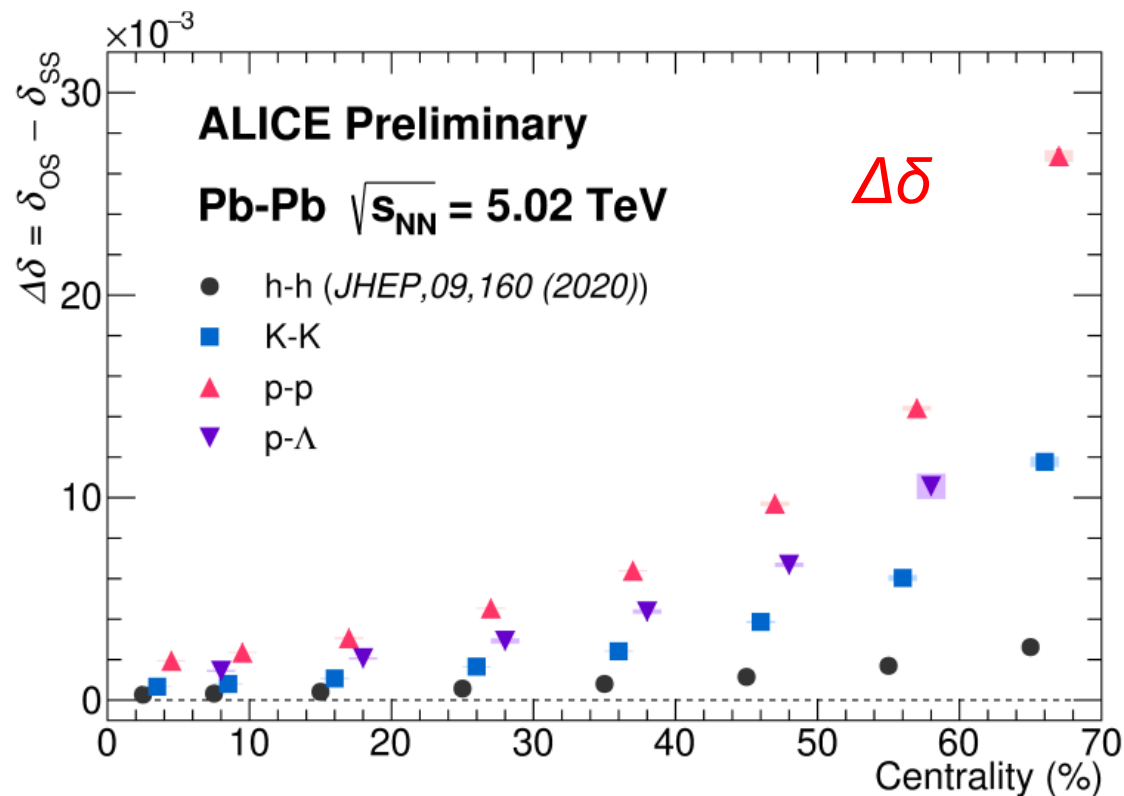
- $\delta_{SS}(p) < 0$ ,  $\delta_{OS}(p) > 0$
- Split between  $\delta_{SS}/\delta_{OS}$ , **p > K > h**



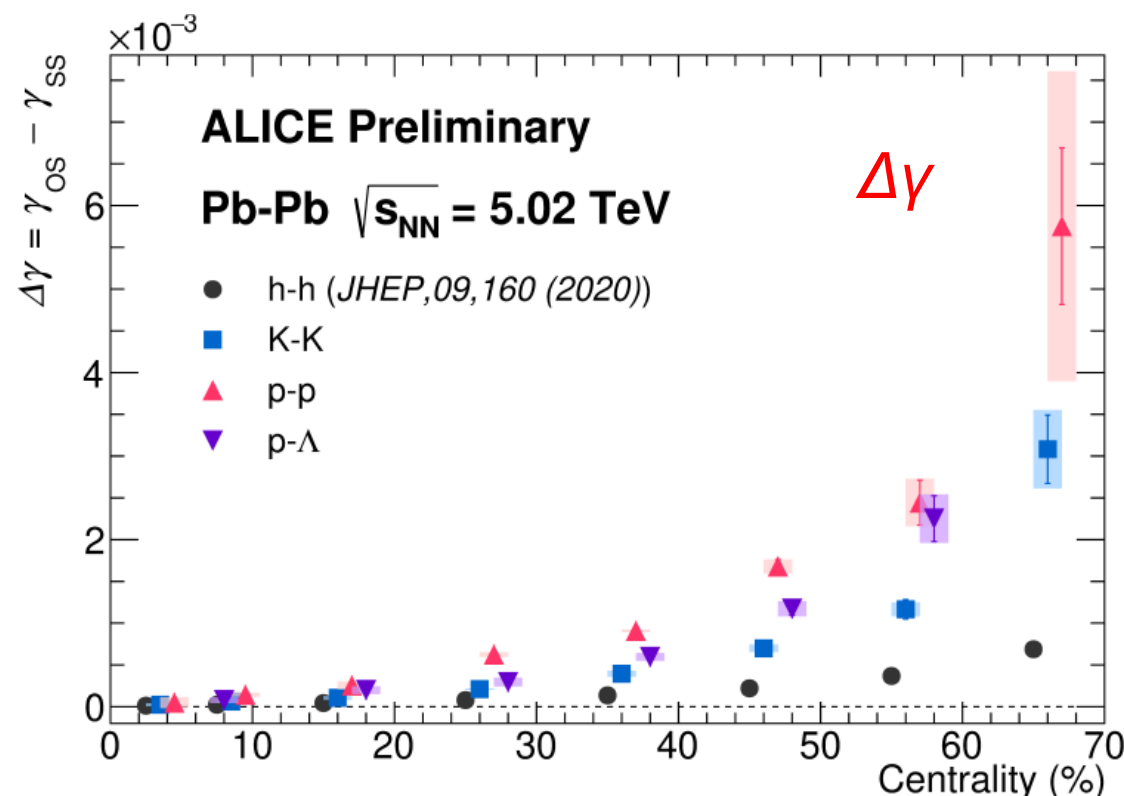
- $\gamma_{SS}(p) < 0$ ,  $\gamma_{OS}(p) \approx 0$
- Split between  $\gamma_{SS}/\gamma_{OS}$ , **p > K > h**

Coalescence induced local baryon conservation for p-p

# $\Delta\delta \Delta\gamma$ correlators for h-h, K-K, p-p, p- $\Lambda$



ALI-PREL-600126



ALI-PREL-600132

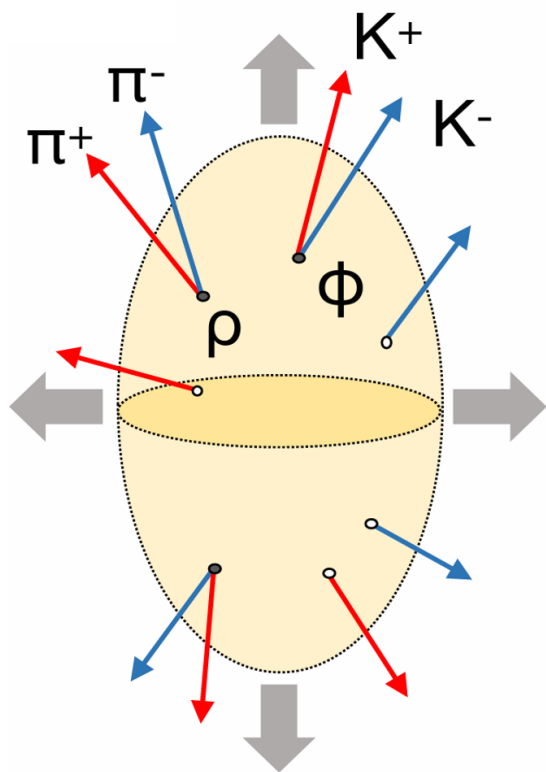
➤  $\Delta\delta$  and  $\Delta\gamma$  follow **p-p > p- $\Lambda$  > K-K > h-h**

# Possible interpretations



**h-h, K-K:**

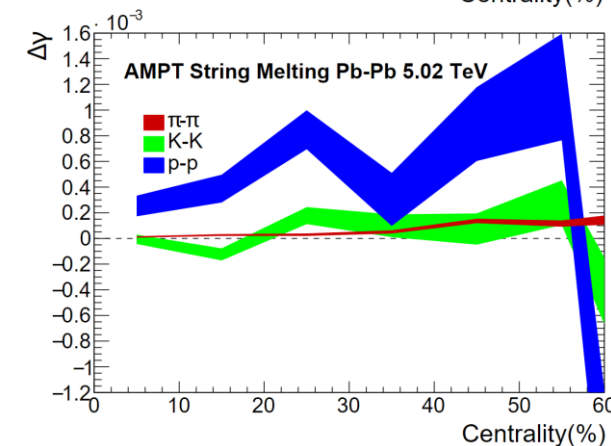
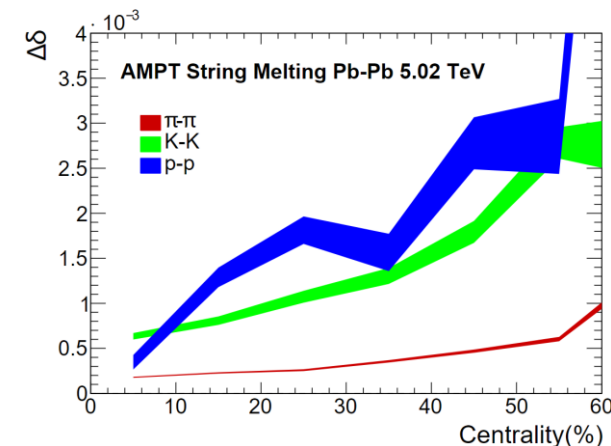
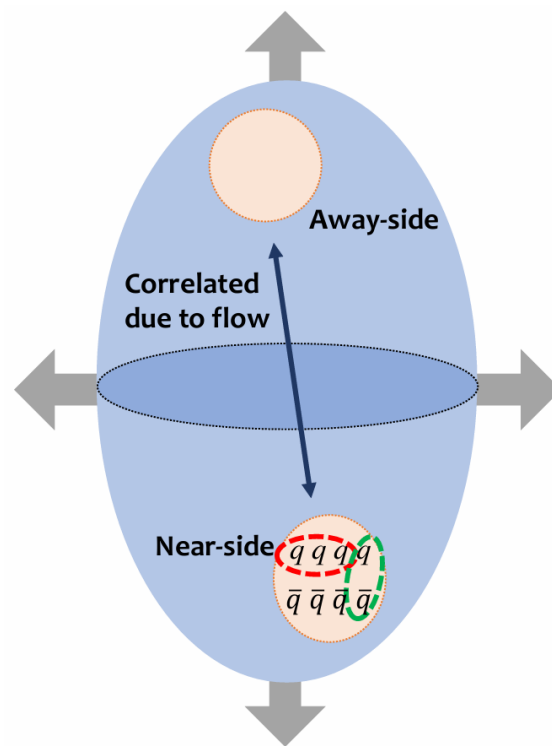
Local charge conservation  
(LCC) + ?



Theoretical inputs are highly welcome to understand data

**p-p, p-Λ:**

Coalescence induced  
local baryon conservation



- S. Shi et al, AOP 394, 50 (2018)
- L. Huang et al, PRC 97, 034909 (2018)
- W. Wu, PRC 107, L031902 (2023)



CME observables  $\delta$ ,  $\gamma$ ,  $\Delta\delta$ ,  $\Delta\gamma$  with identified hadrons (K, p) in 5.02 TeV and 5.36 TeV Pb—Pb collisions are measured at ALICE

- Significant non-zero values are observed for **K** and **p**, suggesting the **existence** of the charge-dependent correlations
- **$\Delta\delta$**  and  **$\Delta\gamma$**  follow  **$p\text{-}p > p\text{-}\Lambda > K\text{-}K > h\text{-}h$**
- Theoretical inputs are highly welcome to understand data

*Thanks for your attention!*

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*Back up*

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## ○ Run 2 Run 3 selection criteria comparison

| Period                                  | Number of Selected Events | Event Selection criterial               | Track Selction criterial                         | PID criterial                                              |
|-----------------------------------------|---------------------------|-----------------------------------------|--------------------------------------------------|------------------------------------------------------------|
| Pb-Pb $\sqrt{s_{NN}} = 5.36$ TeV(Run 3) | ~0.6 Billion              | Min_bias trigger                        | Track $\chi^2$ selection form ITS and TPC        | $\pi$ : $TOF(1.5\sigma)$ $ITS(3\sigma)$                    |
|                                         |                           | Pileup Rejection                        | Track DCA selection                              | K: $TOF(1.5\sigma)$ $ITS(2.5\sigma)$                       |
|                                         |                           | Other Rejection from multiple detectors | $NCl_{TPC,ITS}$ and other basic track selections | p: $TOF(1.5\sigma)$ $ITS(2\sigma)$                         |
| Pb-Pb $\sqrt{s_{NN}} = 5.02$ TeV(Run 2) | ~140 Million              | Min_bias + Central + Semicentral        | Track $\chi^2$ form TPC                          | $\pi$ : $\sqrt{n\sigma_{TPC}^2 + n\sigma_{TOF}^2} 3\sigma$ |
|                                         |                           | Pileup Rejection                        | Track DCA selection                              | K: $\sqrt{n\sigma_{TPC}^2 + n\sigma_{TOF}^2} 3\sigma$      |
|                                         |                           | Other Rejection from multiple detectors | $NCl_{TPC}$ and other basic track selections     | p: $\sqrt{n\sigma_{TPC}^2 + n\sigma_{TOF}^2} 3\sigma$      |

Table 1: DataSet and selection criterial event wise and track wise and PID method for Run 2 and Run 3