Probing local parity violation in strong interaction via CMW measurement with ALICE at the LHC

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National Institute of Science Education and Research
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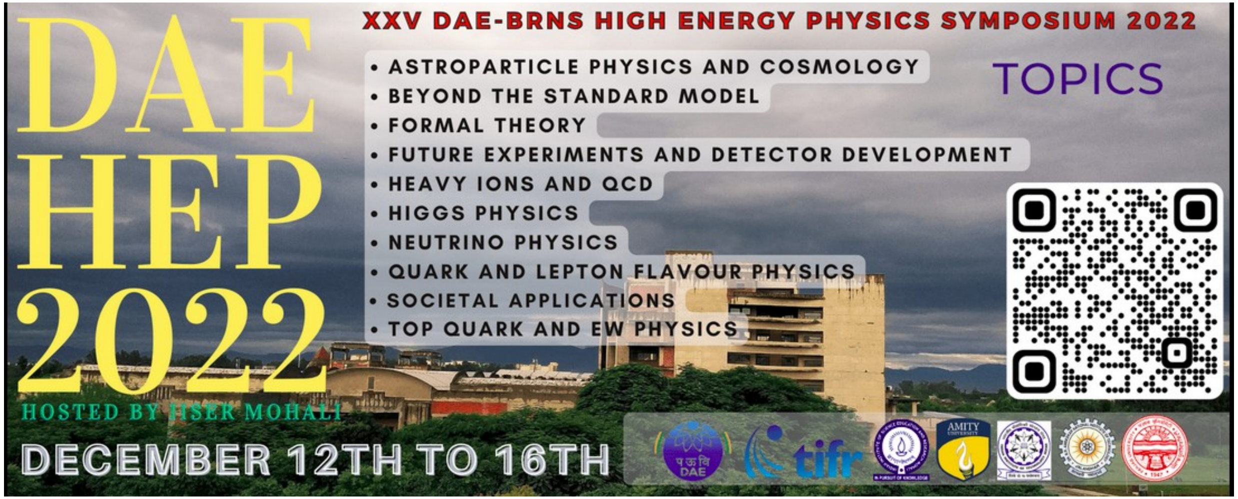

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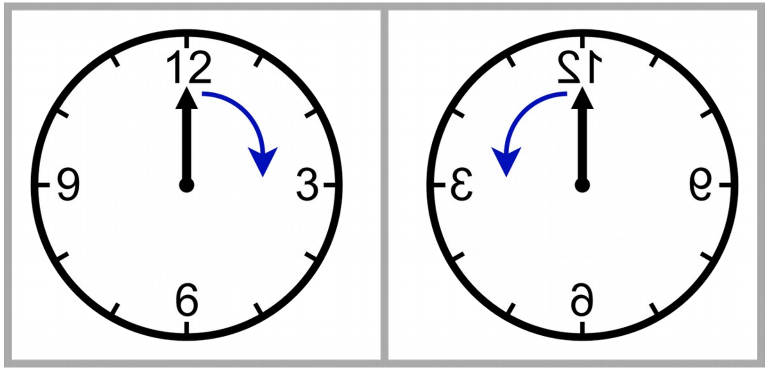

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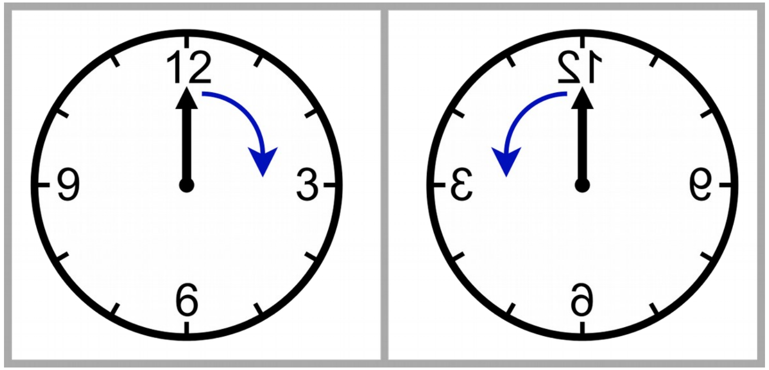
- ✔ Parity violation observed only in weak interactions [1]



[1] C. S. Wu et al., Phys. Rev. 105, (1957) 1413

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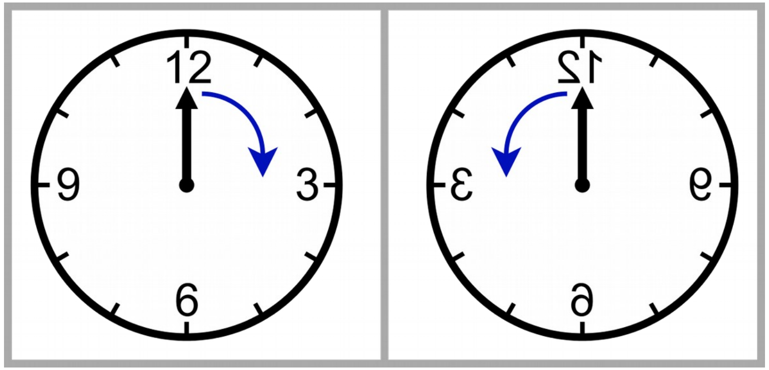

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[2] D. Kharzeev et al., Phys.Rev.Lett. 81 (1998) 512-515

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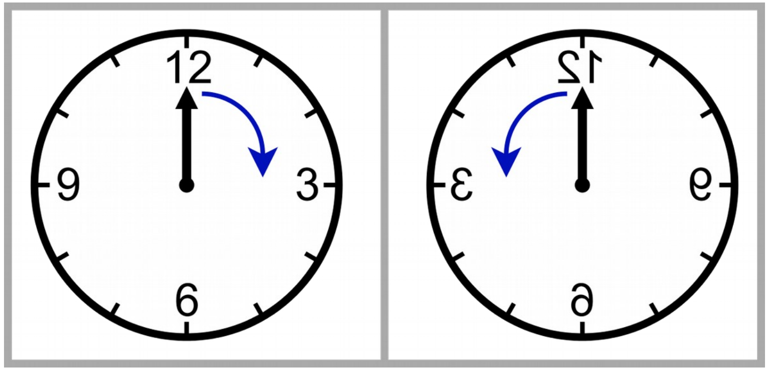
- ✔ Gives rise to chiral phenomena



(Chiral Magnetic Effect, Chiral Separation Effect, Chiral Magnetic Wave, ...)

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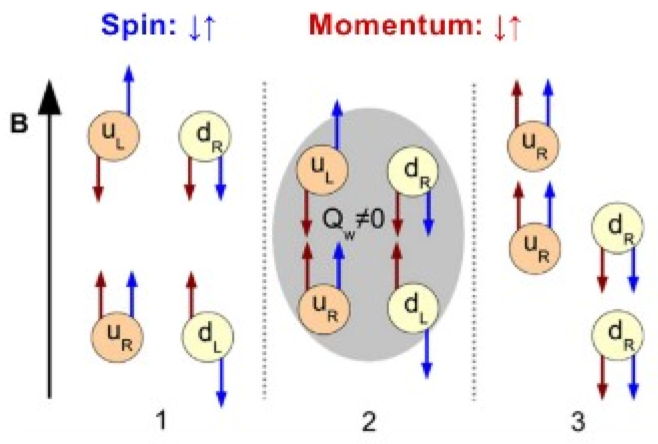
Introduction

Spin: →   **Momentum:** →



$$N_L^f - N_R^f = 2Q_W$$

Chiral Magnetic Effect (CME): $j_\nu = \frac{N_c e}{2\pi^2} \mu_A B$

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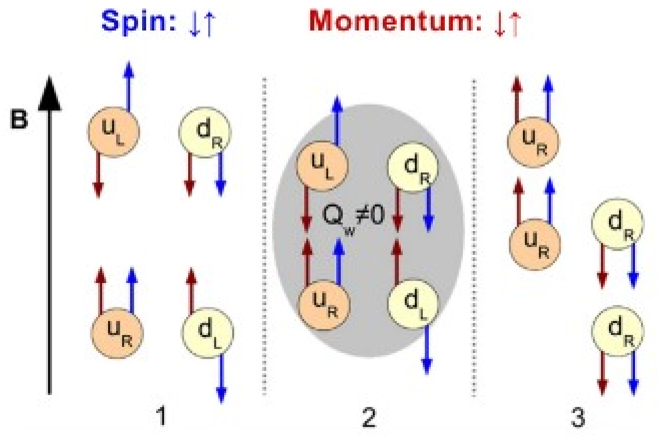

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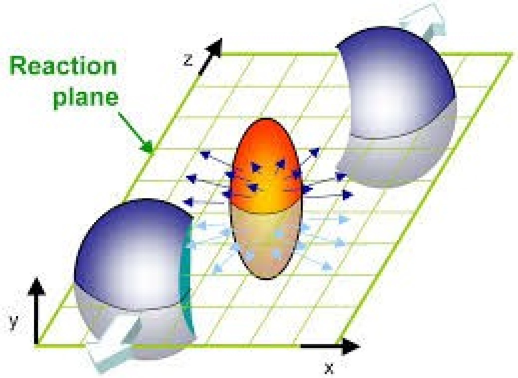

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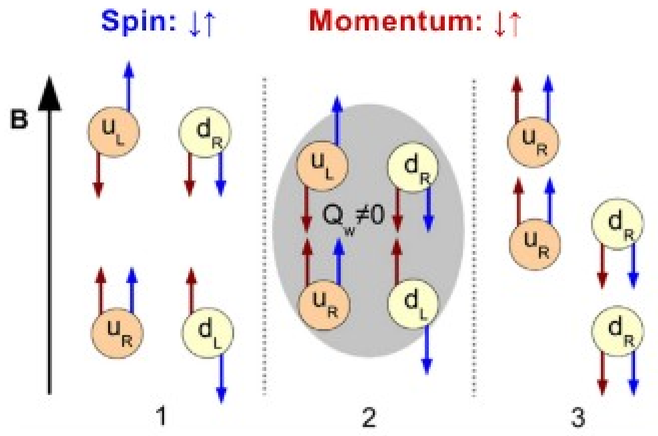

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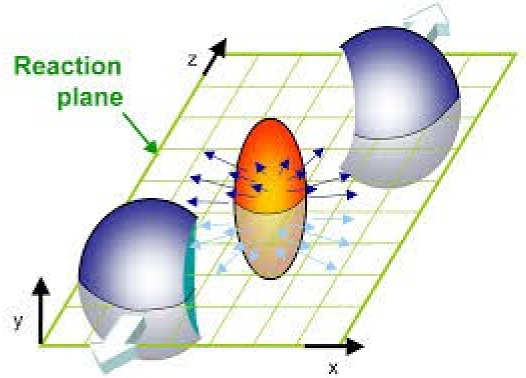

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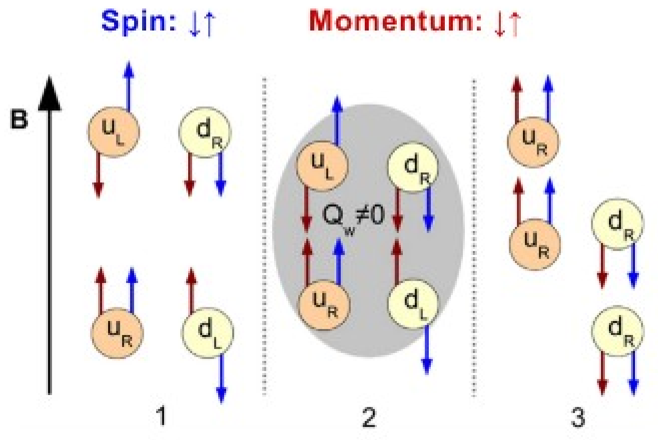

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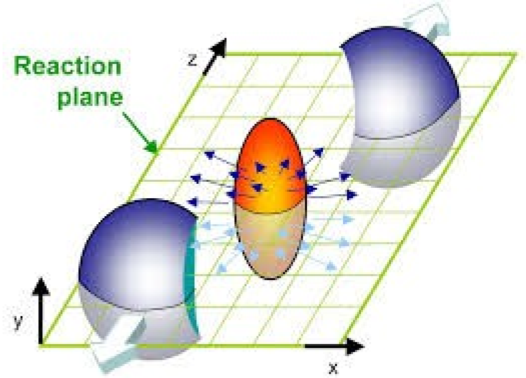

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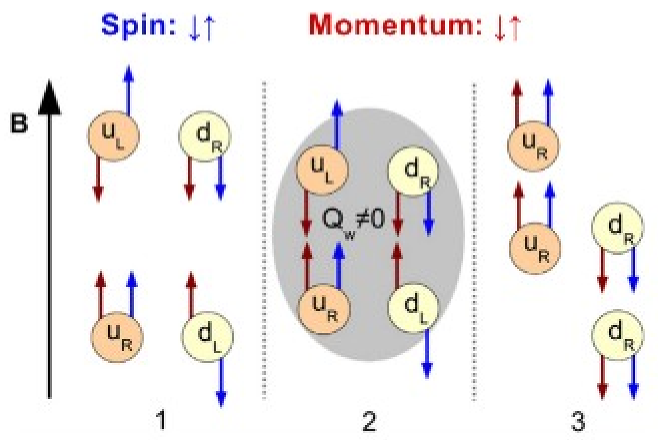

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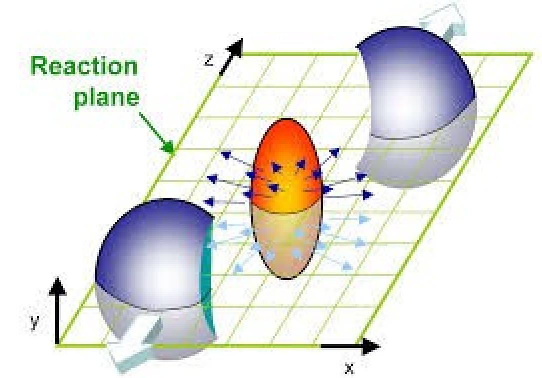

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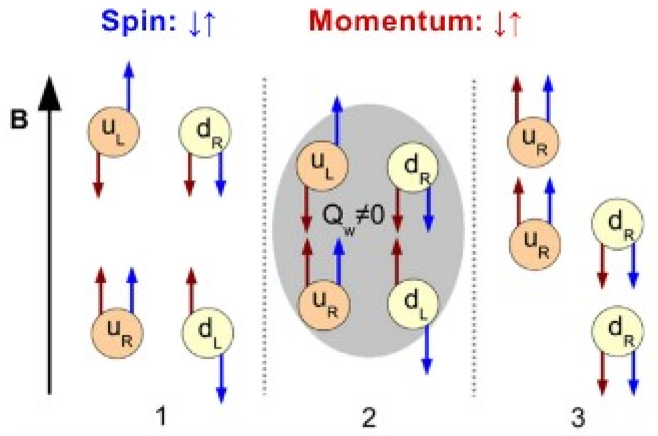

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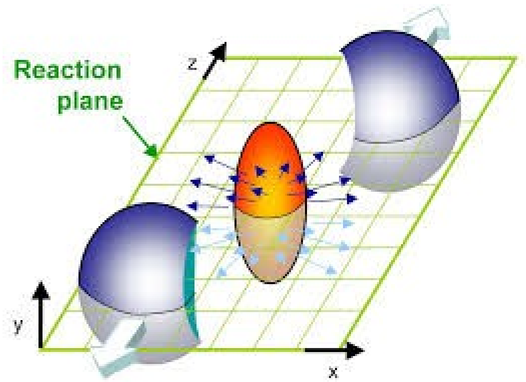

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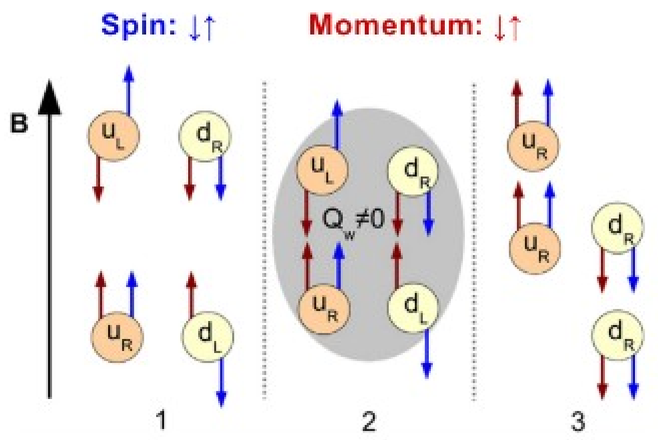

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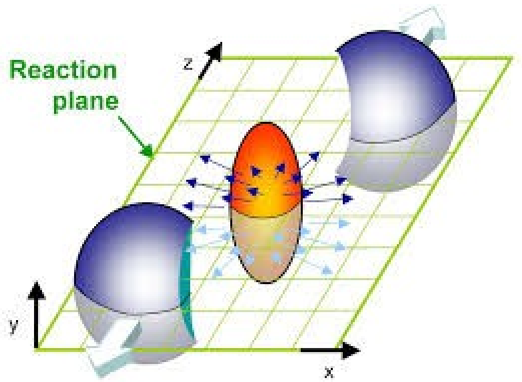

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All the necessary conditions can be achieved in heavy-ion collisions

Phys.Rev.Lett. 81 (1998) 512-515

Observable

✔ Charge dependent elliptic flow

$$v_2^{h^{\pm}} = v_2 \mp r \frac{A_{ch}}{2}, \qquad A_{ch} = \frac{N^+ - N^-}{N^+ + N^-}$$

✔ **CMW observable**:

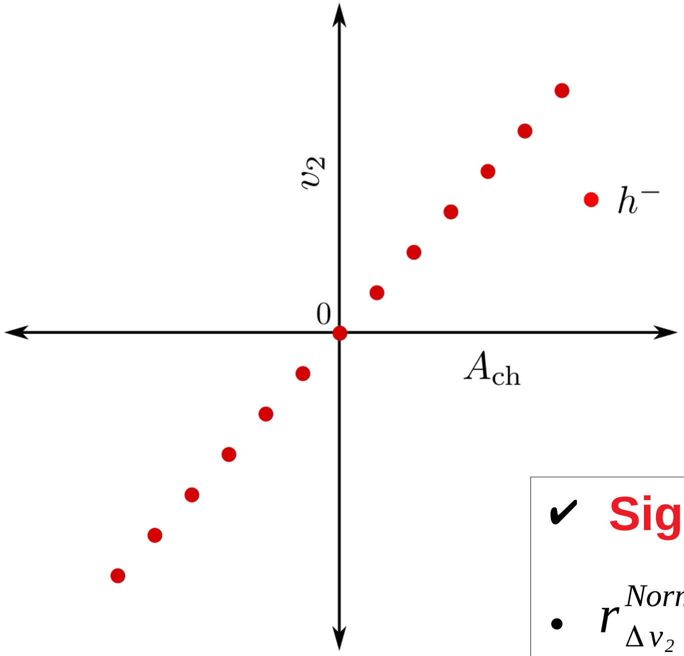
Normalised slope , $r_{\Delta v_2}^{Norm} = \frac{d\left(\frac{\Delta v_2}{\langle v_2 \rangle}\right)}{d A_{ch}}$

$$\Delta v_2 = v_2^{h^-} - v_2^{h^+} \qquad \langle v_2 \rangle = \frac{v_2^{h^-} + v_2^{h^+}}{2}$$

✔ **Possible background**:
Local charge conservation (LCC)

- Probe the background:
Similar measurement with v_3

For illustration purpose



✔ **Signal**:

- $r_{\Delta v_2}^{Norm} > 0$
- $r_{\Delta v_2}^{Norm} > r_{\Delta v_3}^{Norm}$

Phys. Lett. B 726, (2013) 239-243

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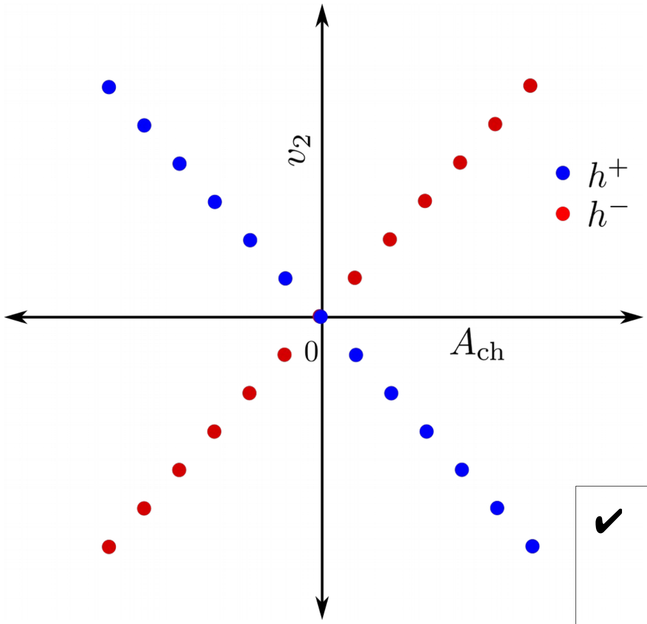

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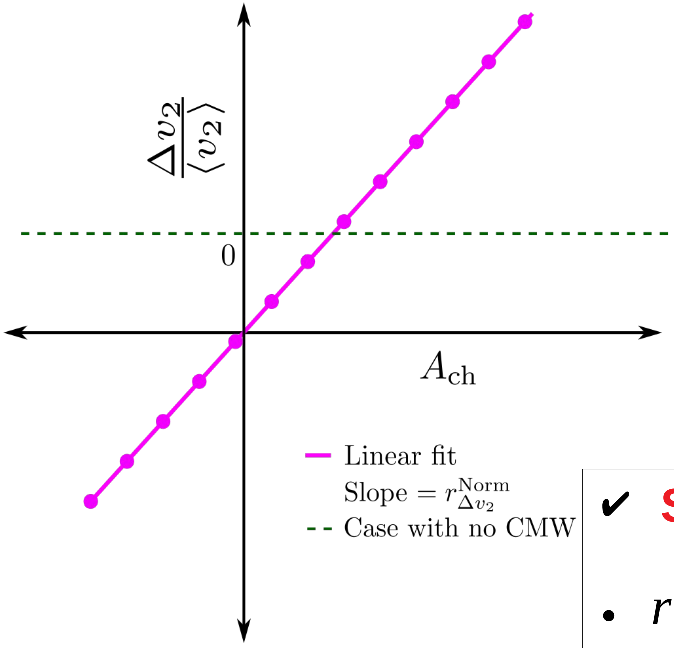

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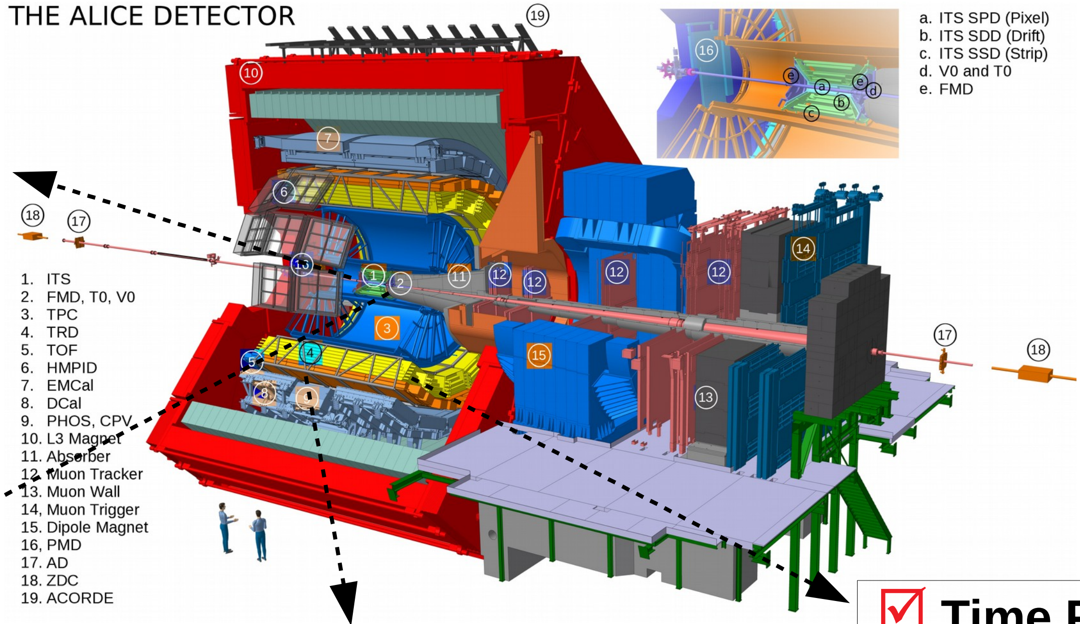
ALICE detectors

☑ **ITS (|η| < 0.9)**

- Tracking and vertexing



☑ **V0: V0A (2.8 < η < 5.1) & V0C (-3.7 < η < -1.7)**

- Trigger and centrality

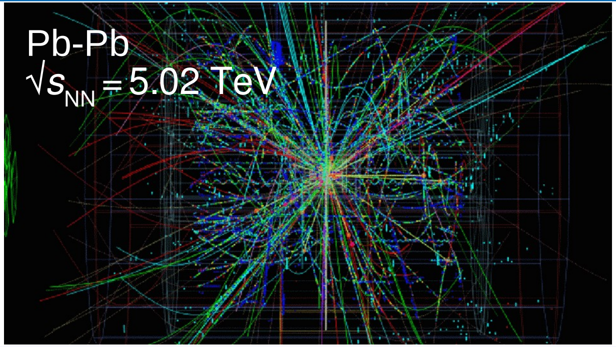
☑ **Time Of Flight (TOF): (|η| < 0.9)**

- Particle identification through time of flight measurement

☑ **Time Projection Chamber (TPC): (|η| < 0.9)**

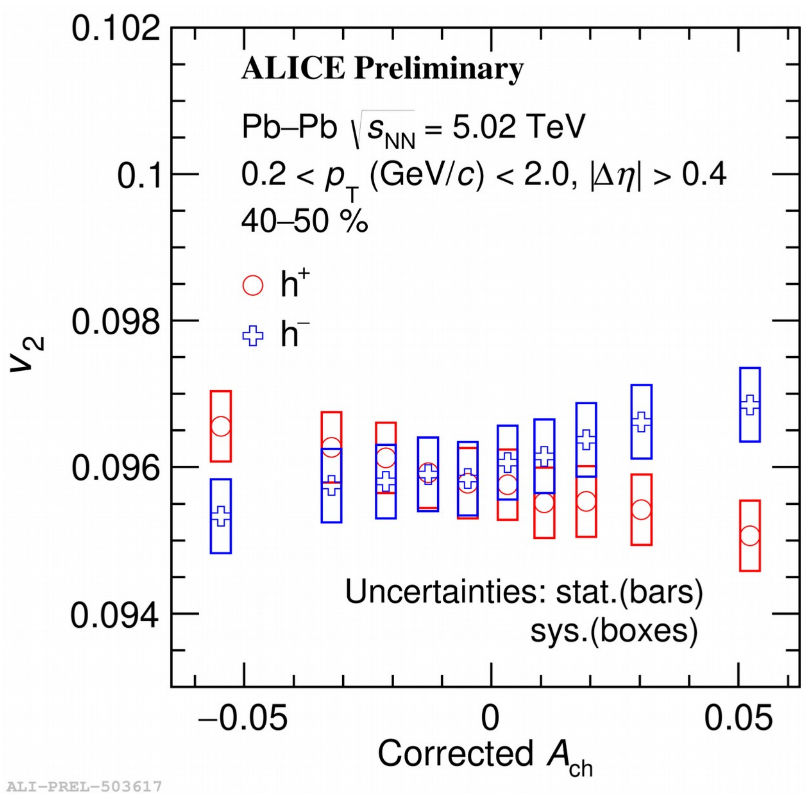
- Primary vertex and tracking
- Momentum measurement
- Particle Identification (PID) through dE/dx

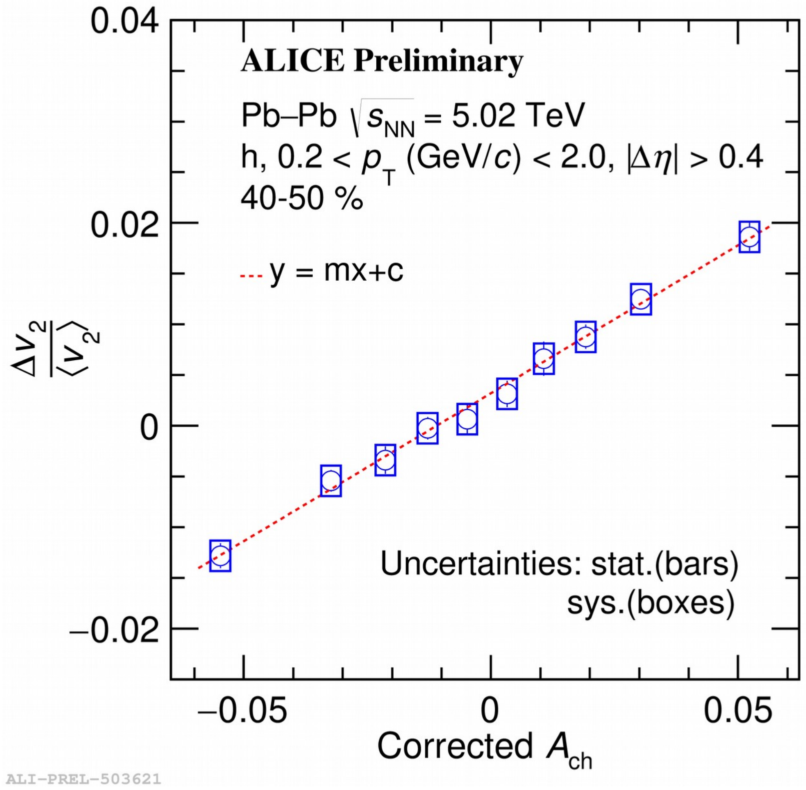
Analysis details



Number of events	~240×10^{6}
Particles	Hadrons, pions, kaons, protons
Kinematic range	$\lvert\eta\rvert<0.8$ $0.2<p_{T}<2.0$ GeV/c
Centrality (%)	0 - 80

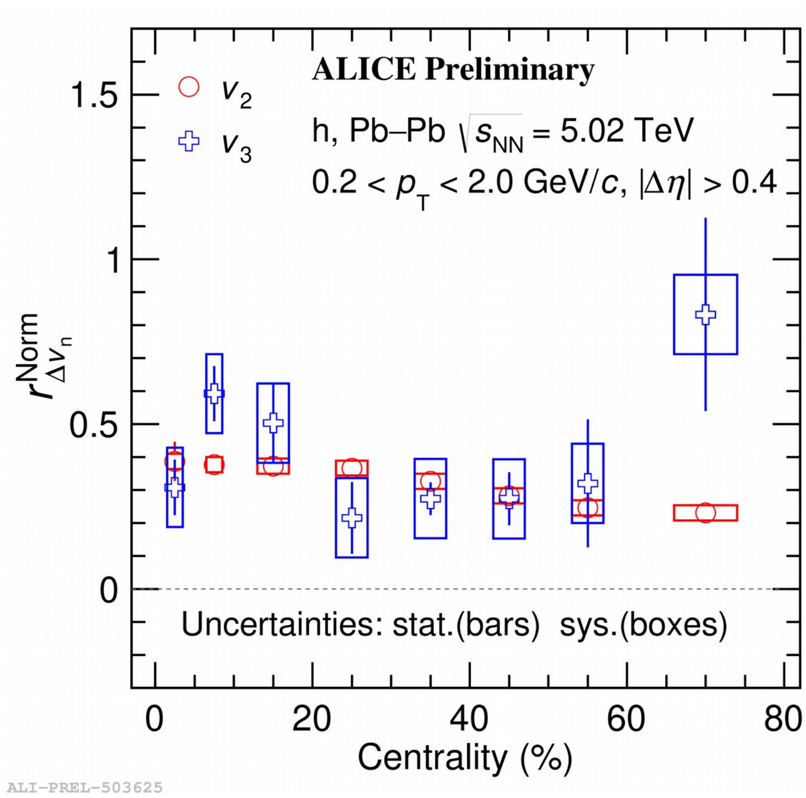
Elliptic flow vs charge asymmetry

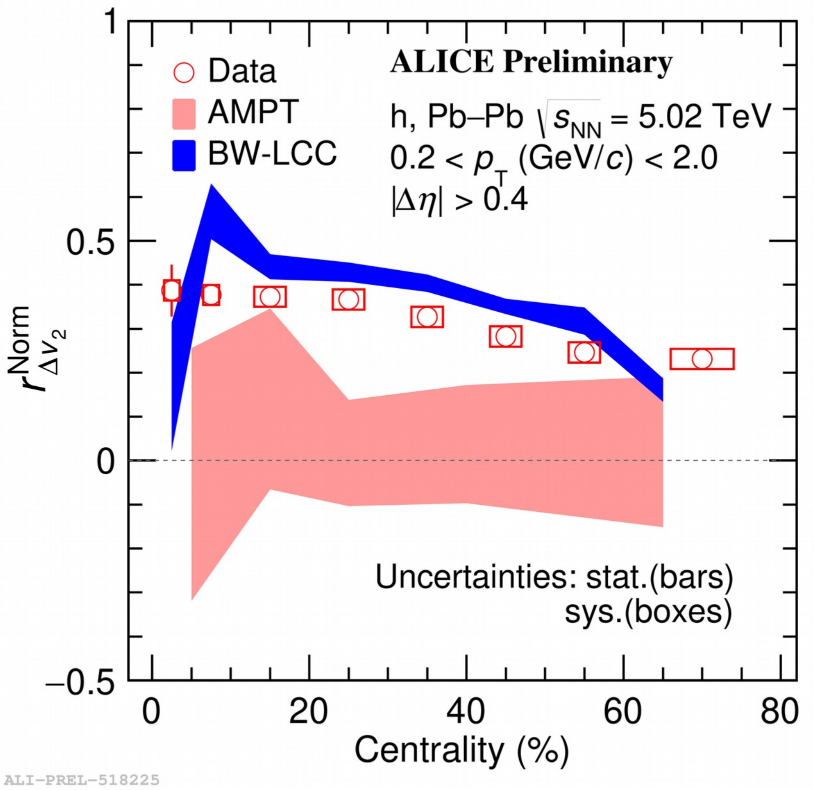




- ☑ v_2 of positive hadrons show a different trend compared to negative hadrons.
- ☑ Non-zero value of normalised slope is observed.

Comparison of $r^{Norm}_{\Delta v_n}$





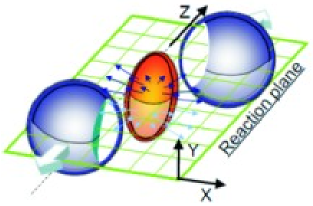
- ☑ $r^{Norm}_{\Delta v_2} \approx r^{Norm}_{\Delta v_3}$
- ☑ As expected in AMPT no CMW signal is observed.
- ☑ BW-LCC model overpredicts the measurements.

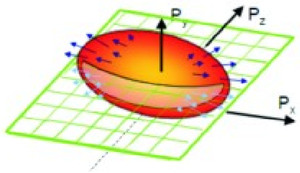
CMW signal is consistent with zero.

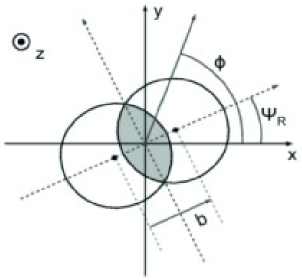
Summary

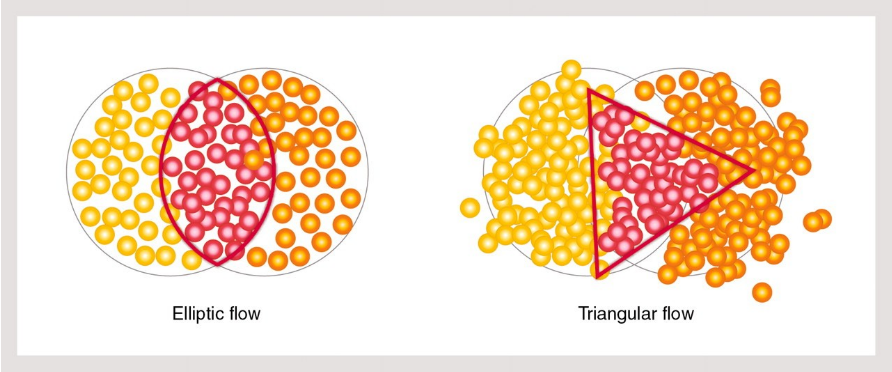
- ☑ $r^{Norm}_{\Delta v_2} \approx r^{Norm}_{\Delta v_3}$
- ☑ BW-LCC model overpredicts the experimental measurements.
- ☑ CMW signal is consistent with zero at the LHC energies.

Observable: Anisotropic flow







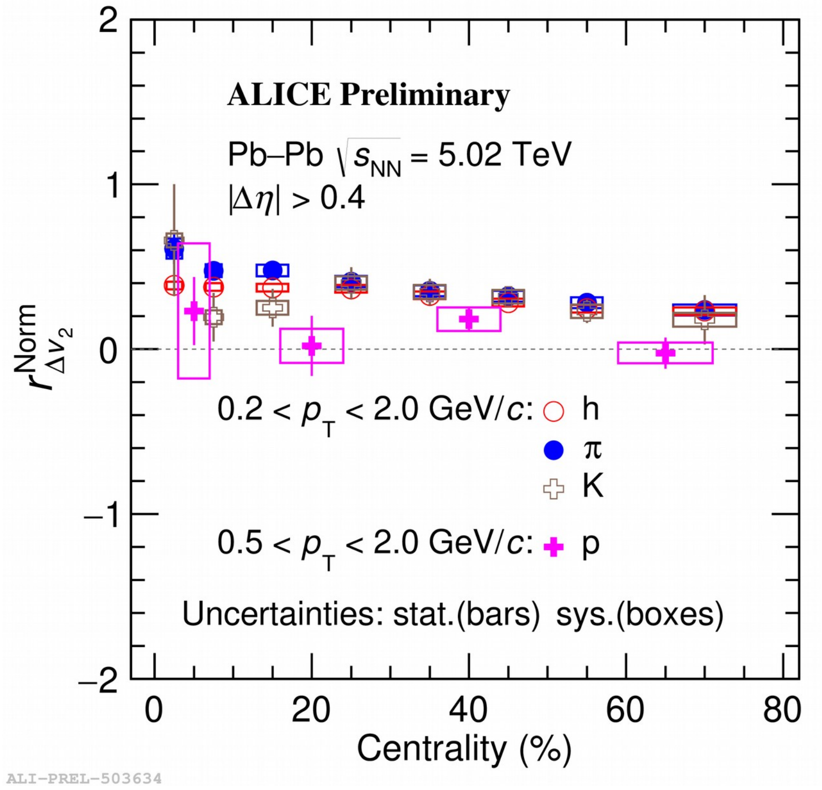


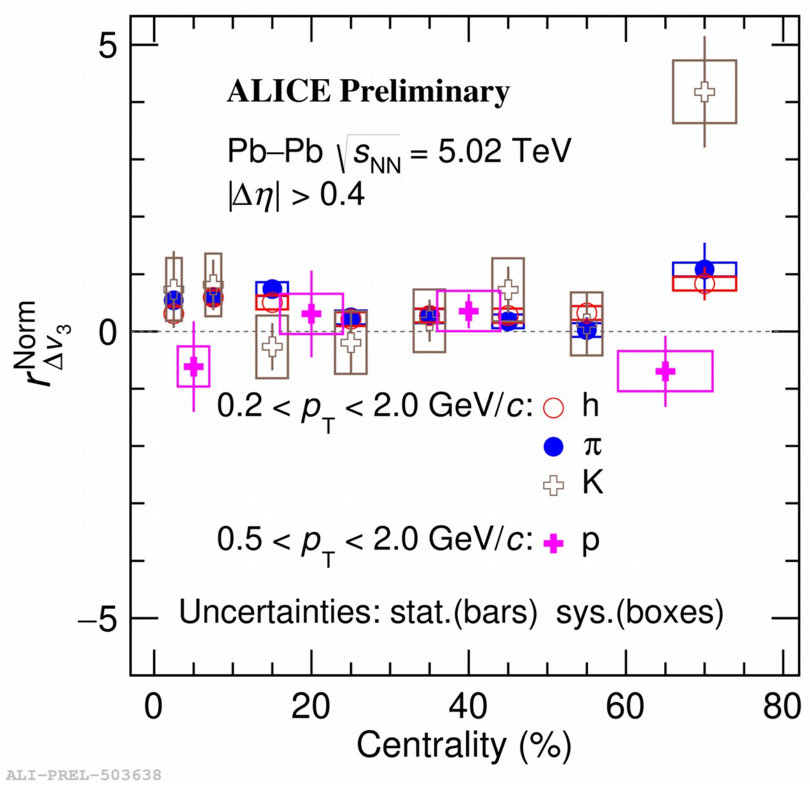
- ✔ Spatial anisotropy ➡ Momentum anisotropy
- ✔ Characterised by Fourier coefficients (v_n):

$$E\frac{d^3N}{d^3p}=\frac{d^2N}{2\pi p_T dp_T dy}\left(1+\Sigma 2 v_n \cos[n(\varphi-\Psi_{n,R})]\right)$$

Phys.Rev.C 58 (1998) 1671-1678

Centrality dependence of $r^{Norm}_{\Delta v_n}$





☑ Normalised slopes are comparable for all particles within uncertainties.