IMPORTANCE OF NON-FLOW BACKGROUND ON THE CHIRAL MAGNETIC WAVE SEARCH

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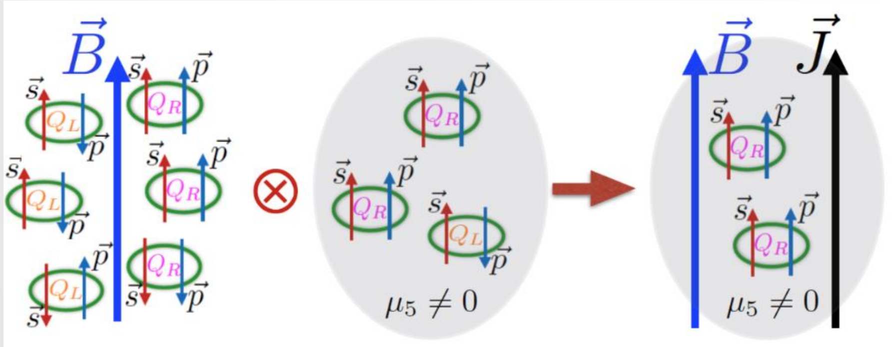
OUTLINE

- CMW and the $\Delta v_2(A_{ch})$ observable
- **Background Sources:**
  1. Trivial linear-A_{ch} term
  2. The multiple pion source effect
  3. Non-flow effect
  4. Local charge conservation, decay kinematics
     - Local charge conservation [A. Bzdak, PLB (2013)]
     - Isospin chemical potential [Y. Hatta et al, NPA (2016)]
- Summary

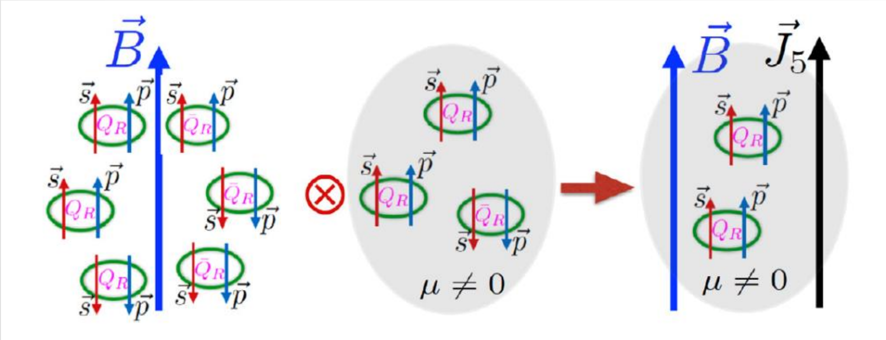
Based on: **arXiv:1910.02896**, HJX, J. Zhao, Y. Feng, F. Wang,
“Complications in the interpretation of the charge asymmetry dependent π flow for the chiral magnetic wave”

CHIRAL MAGNETIC WAVE

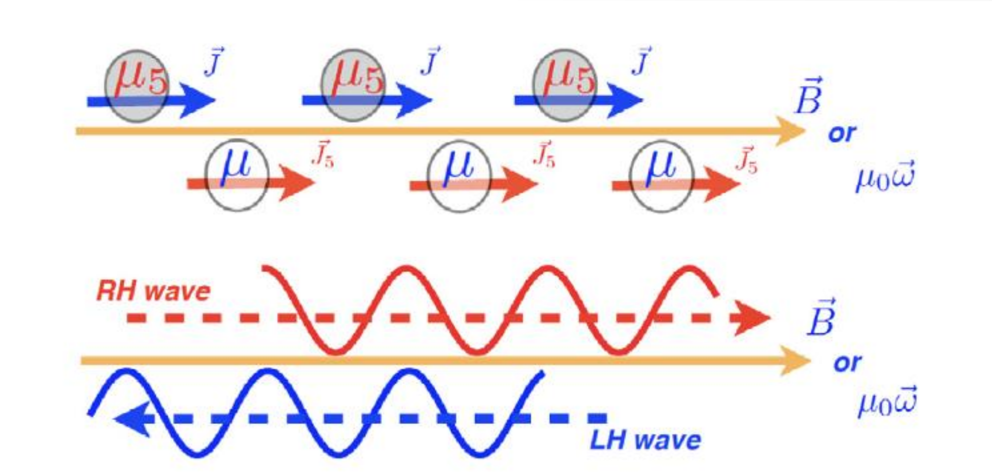


Chiral Magnetic Effect: $J = \left(\frac{(Qe)^2}{2\pi^2}\mu_5\right) B$

Chiral Separation Effect: $J_5 = \left(\frac{(Qe)^2}{2\pi^2}\mu\right) B$



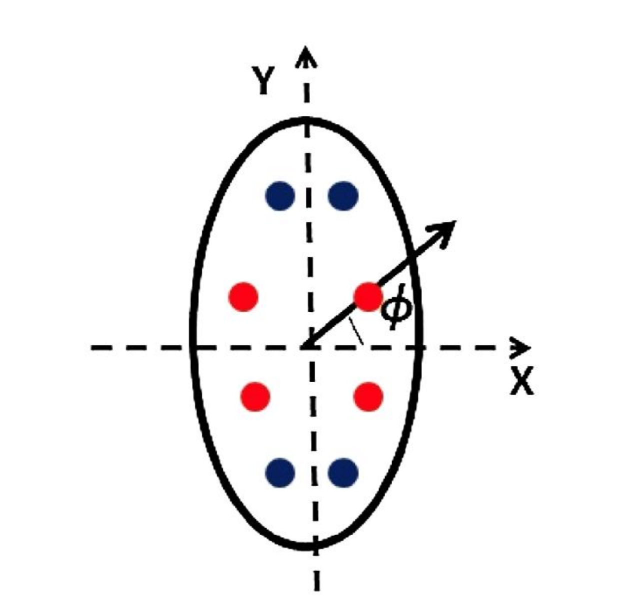
D. Kharzeev, PLB 633, 260 (2006)
D. Kharzeev, PRD 83, 085007 (2006)
D. Kharzeev, PPNP 88, 1 (2016)
…



The **Chiral Magnetic Wave (CMW)** is a gapless collective excitation of the QGP stemming from the interplay of the CME and CSE

THE CMW OBSERVABLE

Y. Burnier, PRL 107, 052303 (2011)



Charge quadrupole moment

The A_{ch}-dependent elliptic flow

$$v_2^{\pm} = v_2 \mp \frac{rA_{ch}}{2}$$

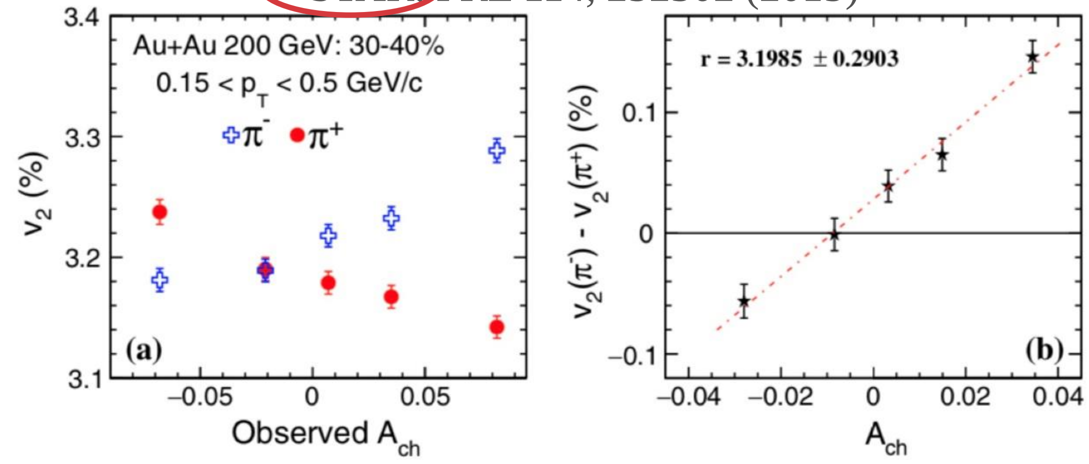
where

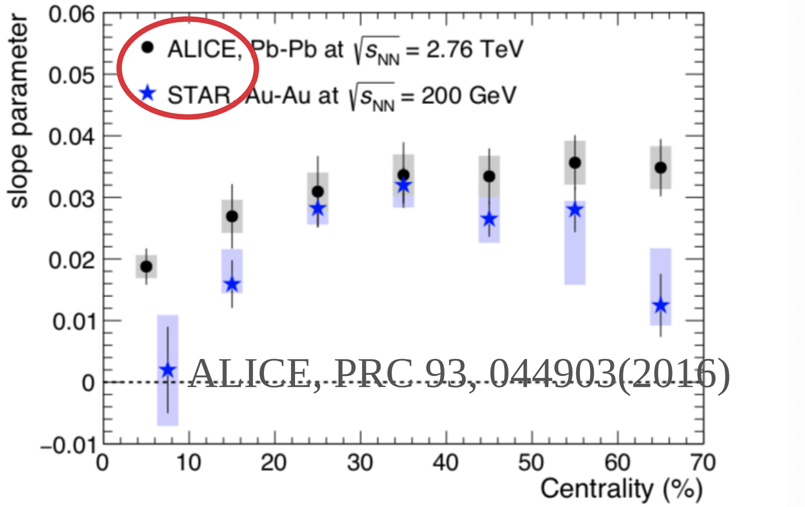
$$A_{ch} = \frac{N_+ - N_-}{N_+ + N_-}$$

The CMW observable: slope of $\Delta v_2(A_{ch}) \equiv v_2^-(A_{ch}) - v_2^+(A_{ch})$

EXPERIMENTAL MEASUREMENTS

STAR, PRL 114, 252302 (2015)

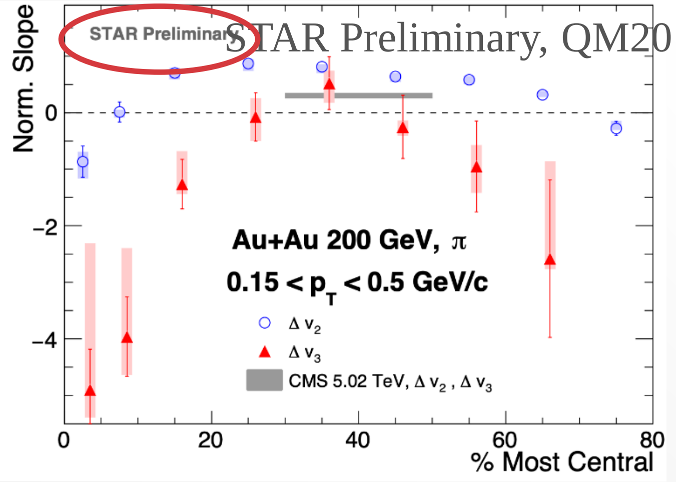




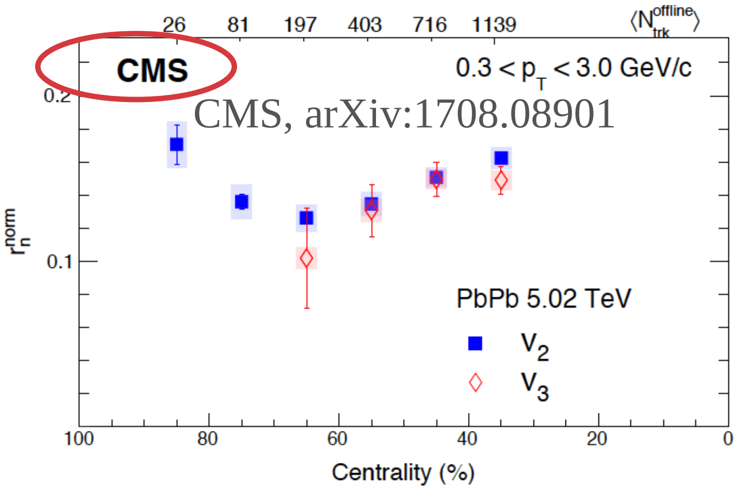
ALICE, PRC 93, 044903(2016)

Norm slope is extracted from

$$Norm.\Delta v_n = 2\frac{v_n^- - v_n^+}{v_n^+ + v_n^-}$$



STAR Preliminary, QM2018



CMS, arXiv:1708.08901

1) ANALYSIS FLAW: TRIVIAL LINEAR A_{ch} TERM

The two-particle Q-cumulant flow

$$v_n\{2\} = d_n\{2\}/\sqrt{c_n\{2\}}$$

For all charges as REF, $d_n\{2\}$ can be written as

$$d_n\{2;\pi^\pm h\} = \left\langle \frac{\sum q_n^{\pi^\pm} Q_n}{\sum mM} \right\rangle = \frac{1+A_{ch}}{2}\left\langle \frac{q_n^{\pi^\pm} Q_{n+}}{mN_+} \right\rangle + \frac{1-A_{ch}}{2}\left\langle \frac{q_n^{\pi^\pm} Q_{n-}}{mN_-} \right\rangle$$

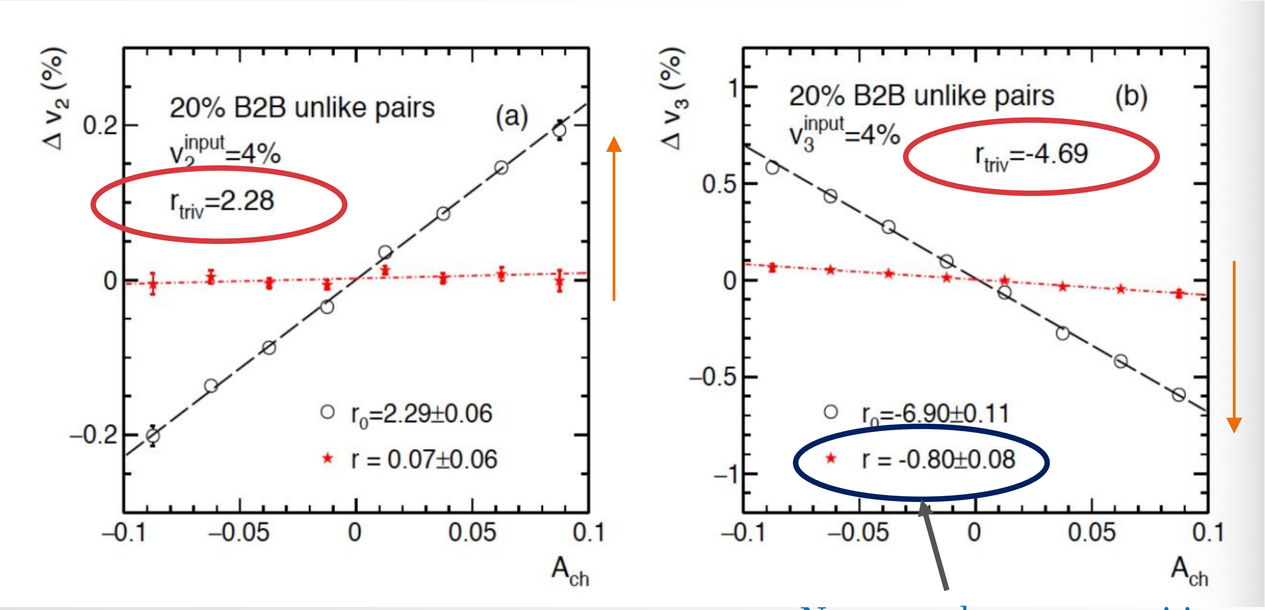
$$= \frac{d_n\{2;\pi^\pm h^+\} + d_n\{2;\pi^\pm h^-\}}{2} + \frac{d_n\{2;\pi^\pm h^+\} - d_n\{2;\pi^\pm h^-\}}{2} A_{ch}.$$

The trivial term arises when:

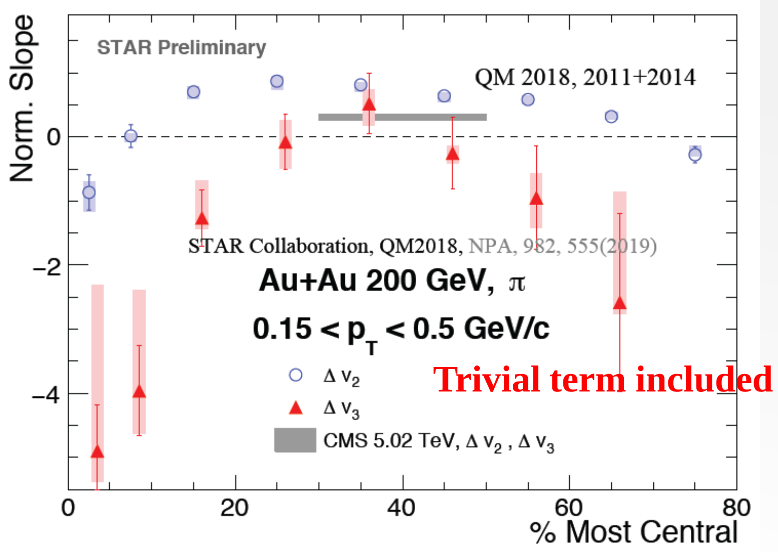
- **All charges are included in REF**
- **Non-flow differs between like- and unlike-sign pairs. (if only flow, then it vanishes)**

1) TRIVIAL LINEAR A_{ch} TERM: TOY MODEL STUDY

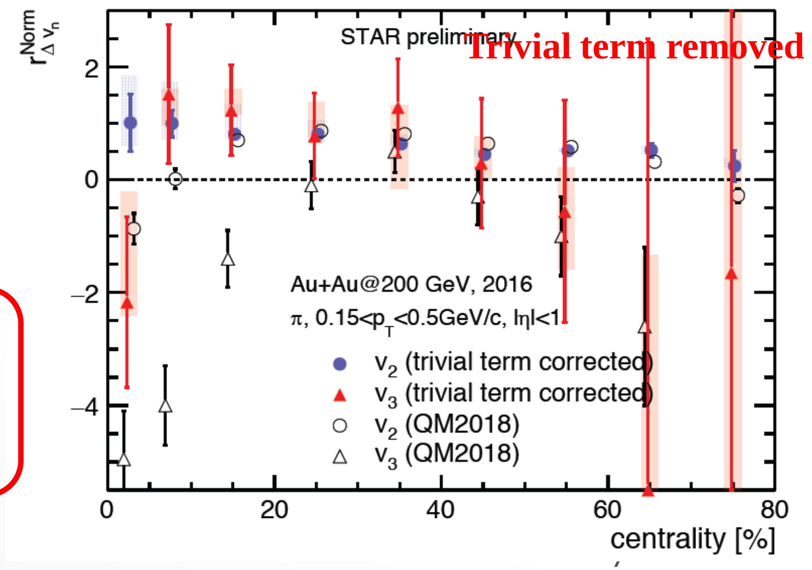
- Back-to-back unlike-sign non-flow correlations
- v_n= 4% is used for both π^+ and π^-, no input Ach dependence.
- r_0 (trivial term included), r (trivial term removed)



Non-zero due to competitions



H. Xu (STAR), poster #668, CH 26

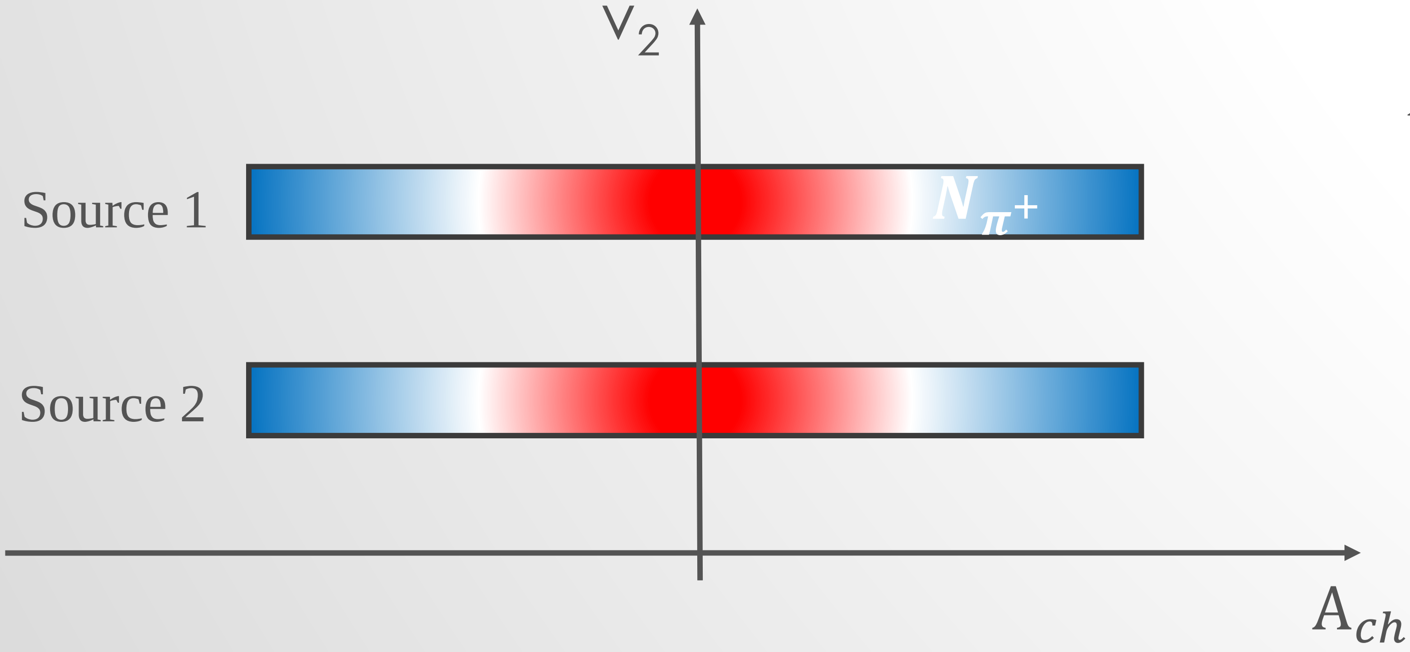


- The trivial slope is positive for $\Delta v_2(A_{ch})$ and negative for $\Delta v_3(A_{ch})$.
- Single-sign charges as reference to remove the trivial term

2) THE MULTIPLE PION SOURCE EFFECT

From the two-component model ($\epsilon = N_D/N_P$), assume the charge asymmetry distributions of each sources A_P and A_D are both normal distributions with width σ_P and σ_P,

$$\Delta v_n = \frac{2\epsilon(\epsilon\sigma_D^2 - \sigma_P^2)(v_{n,P} - v_{n,D})}{(1+\epsilon)(\epsilon^2\sigma_D^2 + \sigma_P^2)} A_{ch} \equiv r^{2C} A_{ch}$$



A_D and A_P differences

- ➔ different A_{ch}, different component ratio
- ➔ competition between different pion flow
- ➔ A_{ch} dependence pion flow
- ➔ slope parameter

3) NON-FLOW DILUTION EFFECT

For like-sign non-flow correlations:

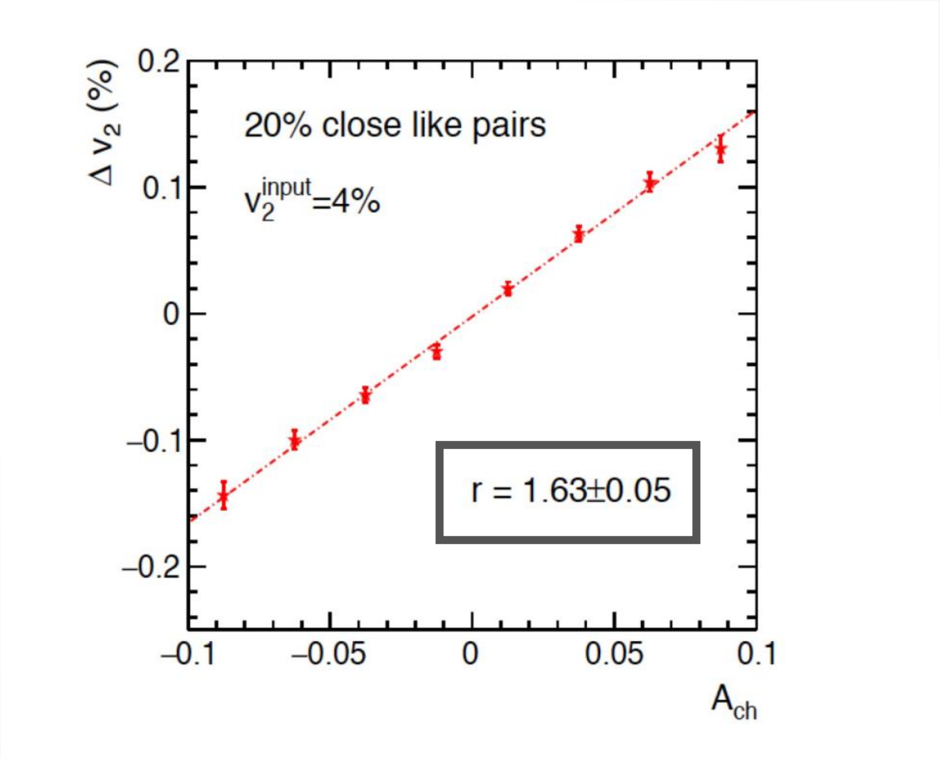
$A_{ch} > 0$

➔ large π^+ multiplicity

➔ more non-flow dilution

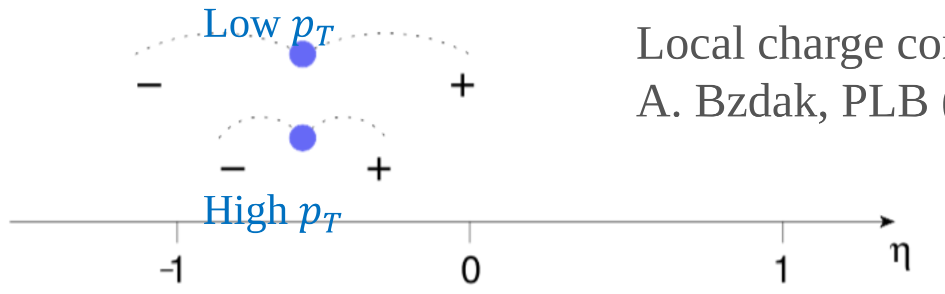
➔ smaller π^+ v_2

➔ positive slope



- ❑ Close-pair like-sign non-flow correlations
- ❑ Trivial term have been removed

4) LOCAL CHARGE CONSERVATION (LCC) EFFECT

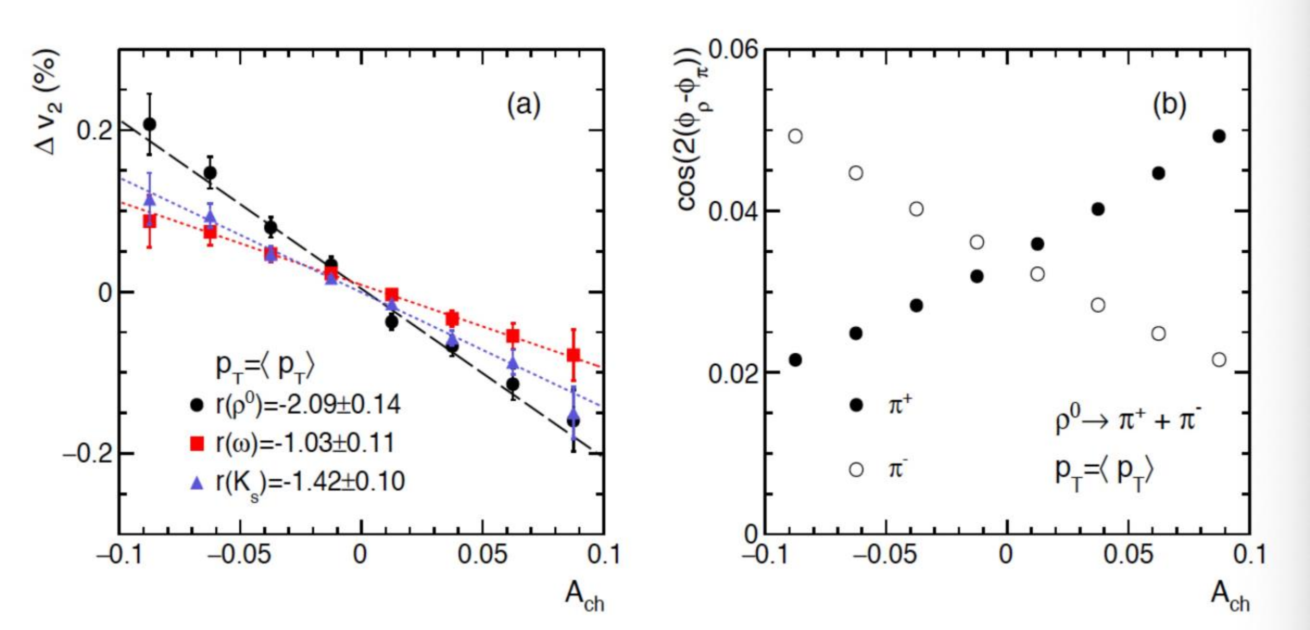


Local charge conservation
A. Bzdak, PLB (2013)

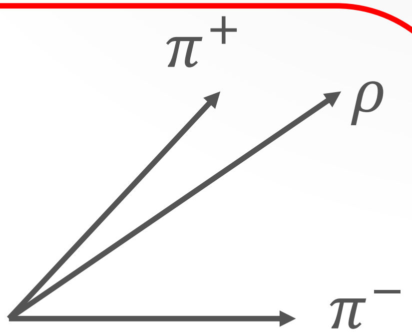
Fix resonance p_T (use mean value from data).

No effect from LCC.

DETOUR – EFFECT OF DECAY KINEMATICS



At $A_{ch} > 0$:



➔ π^+ in acceptance

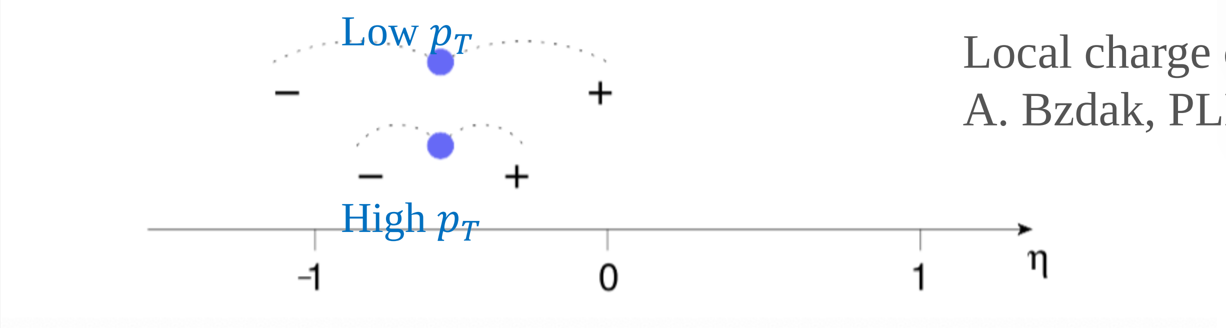
➔ π^+on average closer to ρ

➔ less azimuth dilution

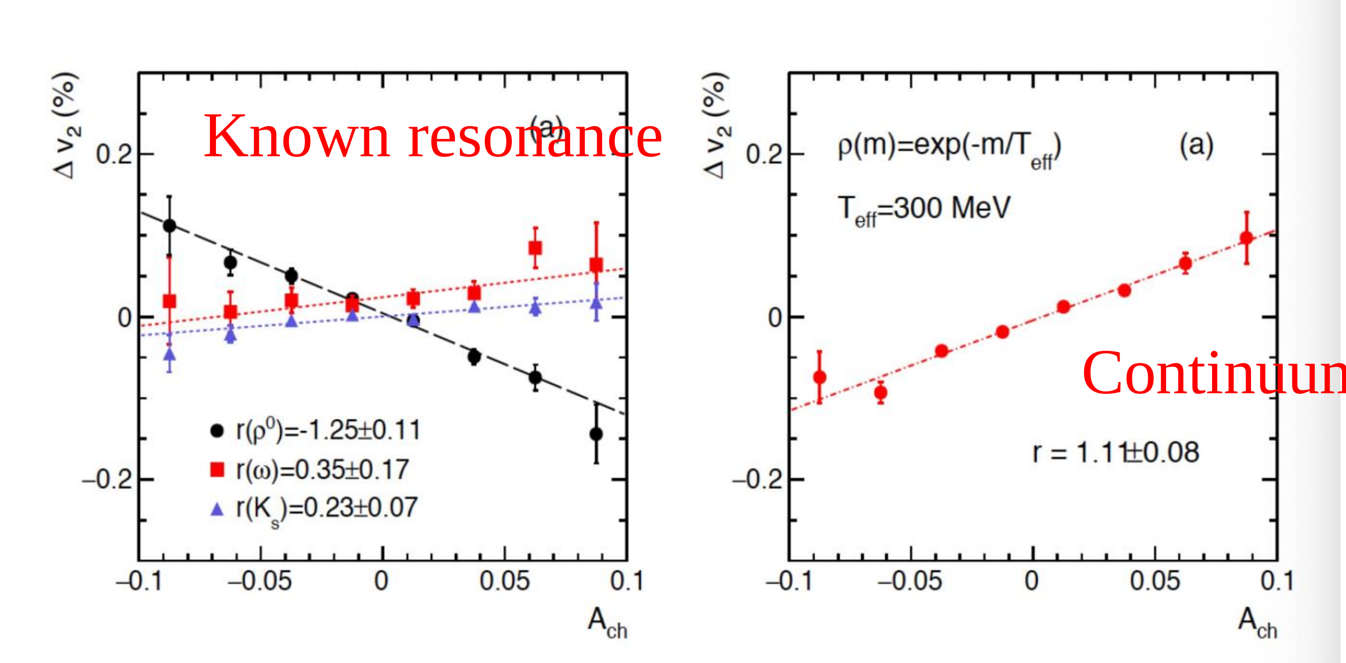
➔ larger π^+ v_2, negative slope

Without LCC effect, the slope parameter from decays is negative.

4) LCC: INDIVIDUAL SOURCE

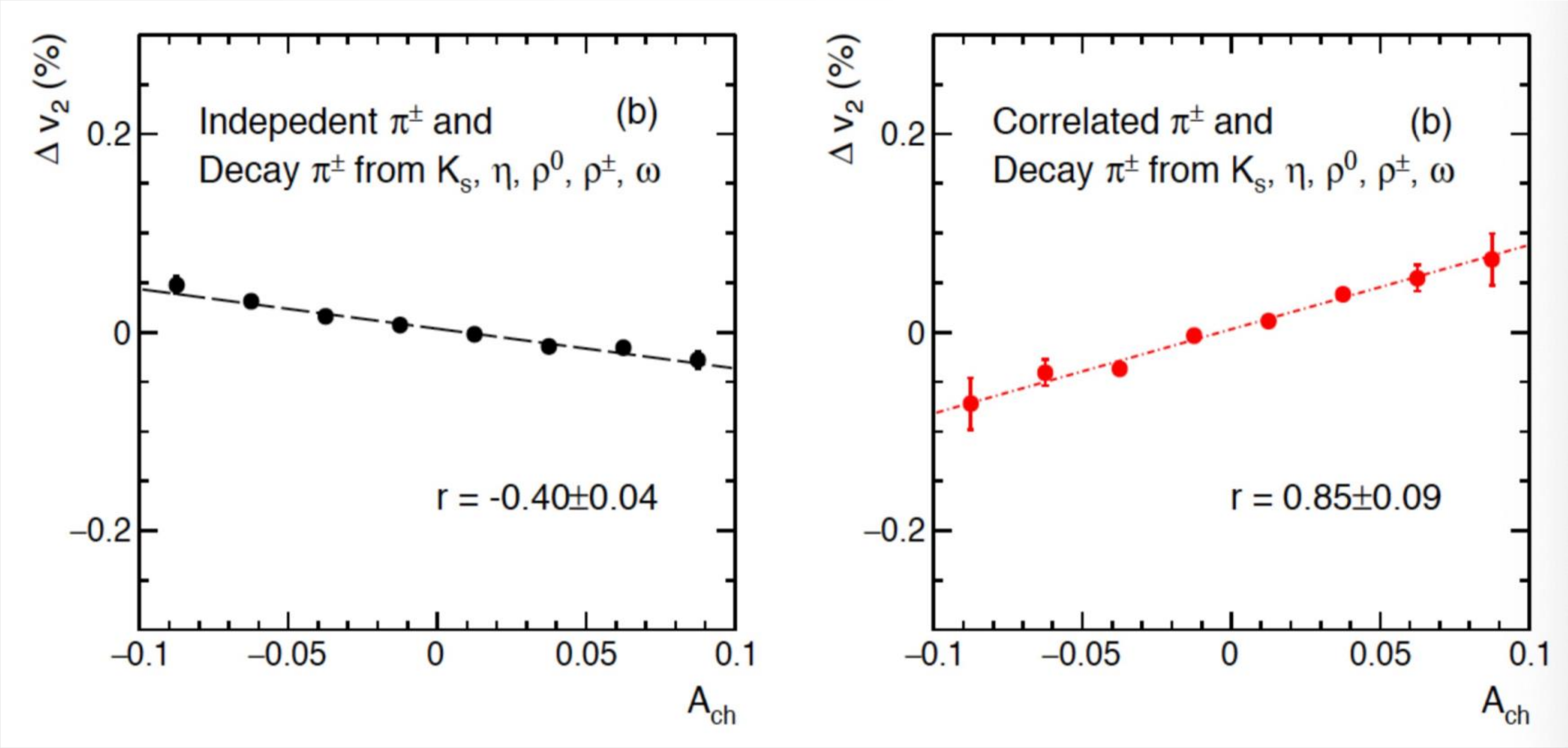


Local charge conservation
A. Bzdak, PLB (2013)



Mass effect, 2-body or 3-body decays

4) LCC: MULTIPLE SOURCE



Primordial π^+ and π^-:

- ❑ Independent production
- ❑ LCC correlations

SUMMARY

Non-CMW mechanisms can generate A_{ch}-dependent π flows

1. Trivial linear-A_{ch} term
2. The multiple pion source effect HJX et al, **arXiv:1910.02896**
3. Non-flow effect
4. Resonance decays, decay kinematics, Local Charge Conservation

- The A_{ch}-dependent pion flow v_2 difference CMW observable is awfully **complicated !!**
- In order to say anything about the CMW, a **precise modeling of all heavy-ion collision backgrounds** is a must-prerequisite.