

Charge Asymmetry Dependence of Proton Elliptic Flow in 200 GeV Au+Au

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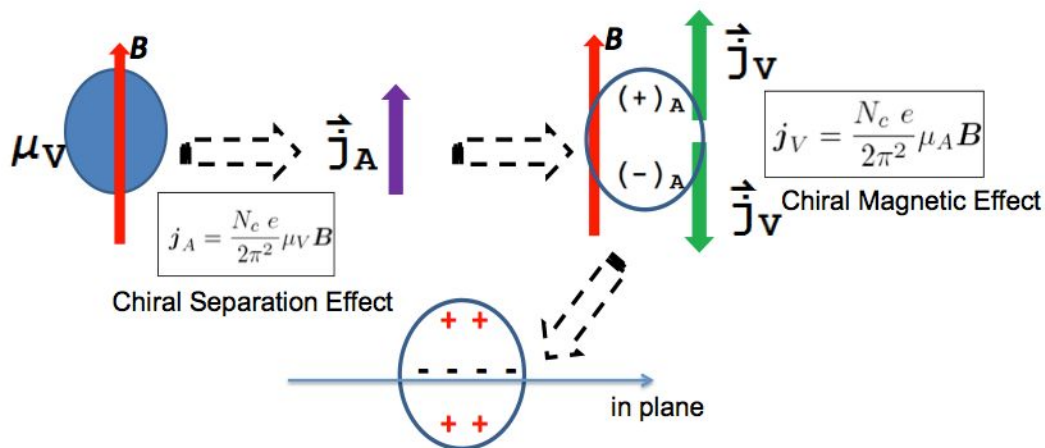
Outline

- Physics Motivation
- Analysis
- Results
- Outlook

Chiral Magnetic Wave (CMW)

- CSE + CME => CMW
- Signals observed in pions and kaons...

Y. Burnier, D. E. Kharzeev, J. Liao and H-U Yee, Phys. Rev. Lett. 107, 052303 (2011)



- At finite baryon density the CSE implies the separation of chiral charge
- The CME current flows in opposite directions at the poles
- A static electric quadrupole moment is produced

Observables: Elliptic Flow “ v_2 ” and Charge Asymmetry “ A_{ch} ”

- Electric quadrupole observed via the azimuthal anisotropy of charged particles
- Particle azimuthal distribution is expanded in Fourier series where second harmonic, elliptic flow (v_2), is dominant

$$E \frac{d^3 N}{d^3 p} = \frac{1}{2\pi} \frac{d^2 N}{p_T dp_T dy} \left(1 + \sum_{n=1}^{\infty} 2v_n \cos [n(\phi - \Psi_{RP})] \right)$$

$$v_n = \langle \cos [n(\phi - \Psi_{RP})] \rangle$$

- The v_2 of charged particles due to CMW is proportional to the A_{ch} of the system

$$v_2^{\pm} = v_2^{\text{base}} \mp \left(\frac{q_e}{\rho_e} \right) A_{ch} \quad A_{ch} = \frac{N_+ - N_-}{N_+ + N_-}$$

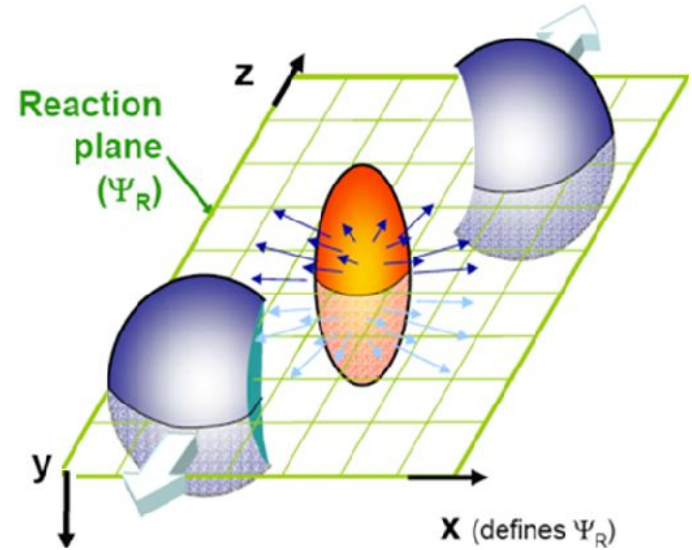
Event Plane Construction

- Events are separated into two sub-events by pseudo-rapidity with an η -gap of 0.3 to suppress non-flow
- The event plane in each sub-event is calculated by summing the flow vectors of the reference particles

$$Q_{n,x} = \sum_i w_i \cos(n\phi_i) = Q_n \cos(n\Psi_n),$$

$$Q_{n,y} = \sum_i w_i \sin(n\phi_i) = Q_n \sin(n\Psi_n).$$

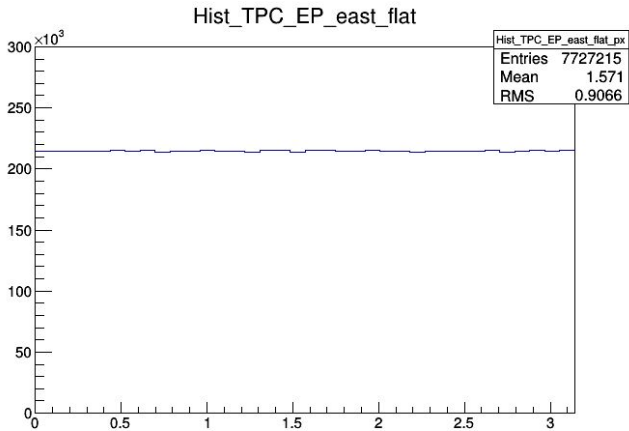
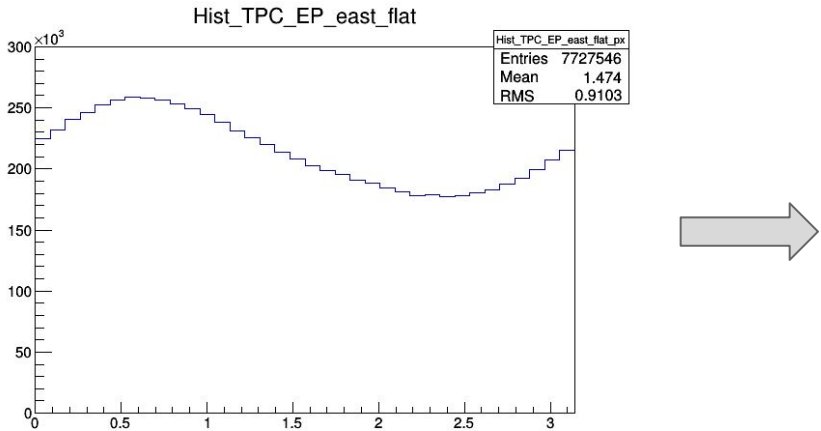
$$\Psi_n = \left(\tan^{-1} \frac{\sum_i w_i \sin(n\phi_i)}{\sum_i w_i \cos(n\phi_i)} \right) / n.$$



Event Plane Correction

- Corrections are made using the shifting method

$$\psi' = \psi + \sum_n \frac{2}{n} (-\langle \sin n\psi \rangle \cos n\psi + \langle \cos n\psi \rangle \sin n\psi)$$

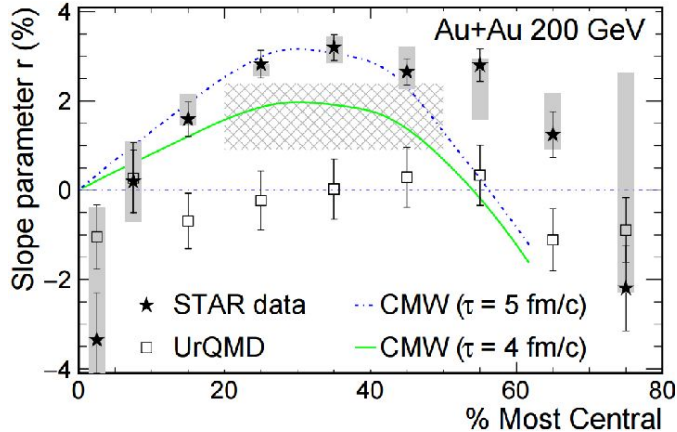
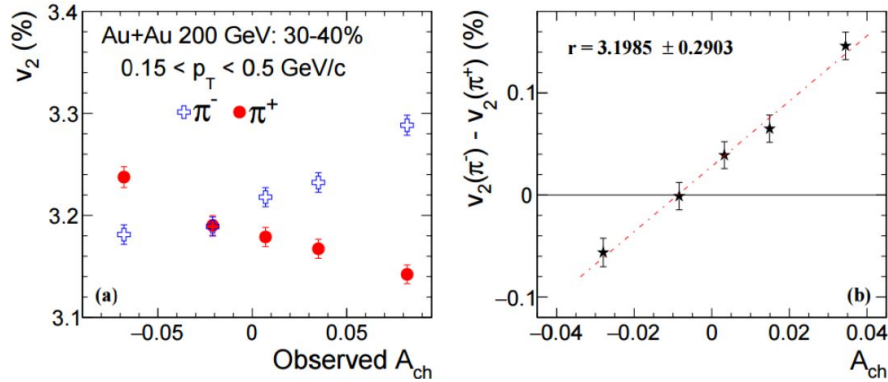


Proton Identification - Cuts

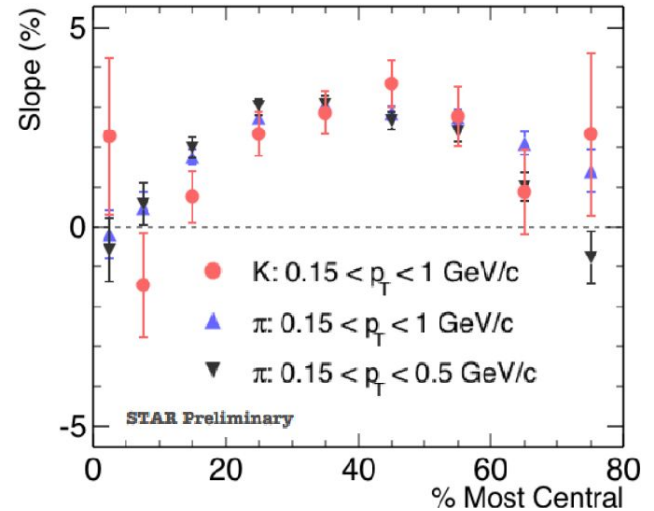
Event		Protons	
Vertex (cm)	(-30,30)	N dE/dx	≥ 10
Particles		Mass ² (GeV ² /c ⁴)	(0.8,1)
Dca (cm)	< 2	P _T (GeV/c)	(0.4,2)
Eta	(-1,1)	nσ of proton	(-2,2)
		ToF Flag	> 0
		ToF β	> 0
		ToF YLocal (cm)	(-1.8,1.8)

Pions & Kaons

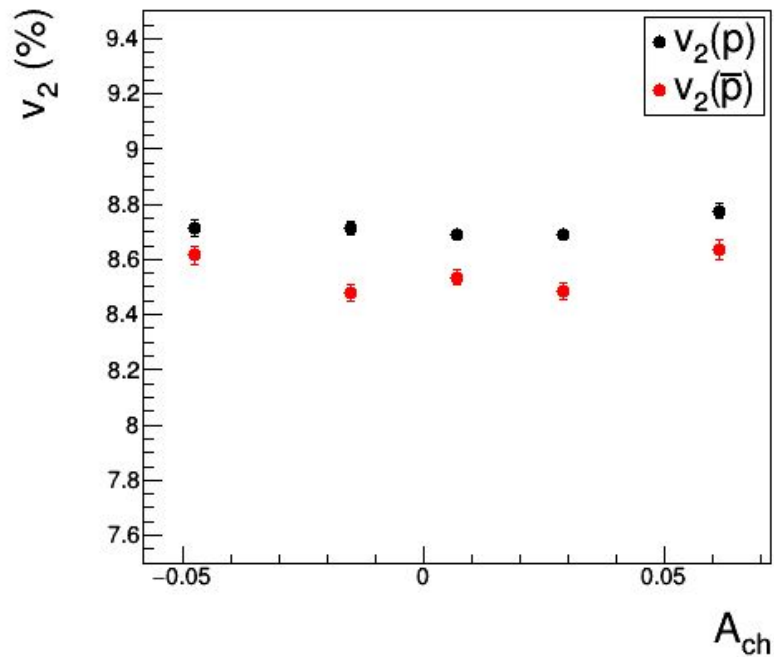
L. Adamczyk, *et al*, Phys. Rev. Lett. **114** (2015) 252302.
 Q.-Y Shou, Nucl. Phys. A 931 (2014) 758.



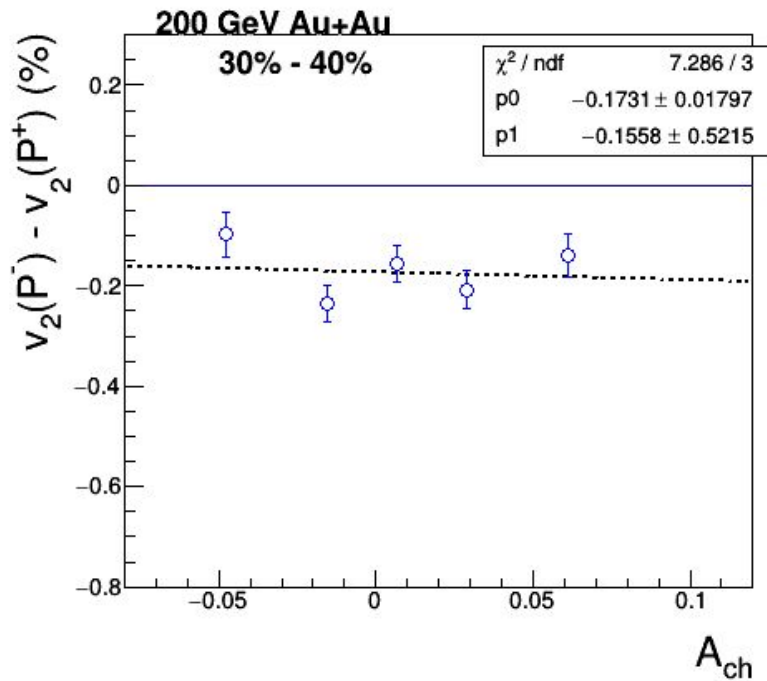
- Hydrodynamics with isospin symmetry suggest negative slope for kaons, with similar results for protons



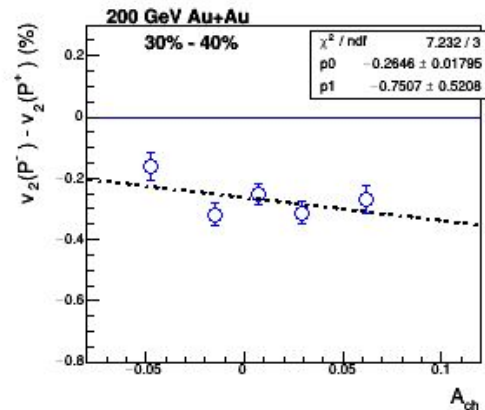
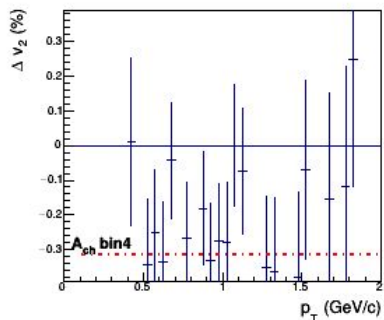
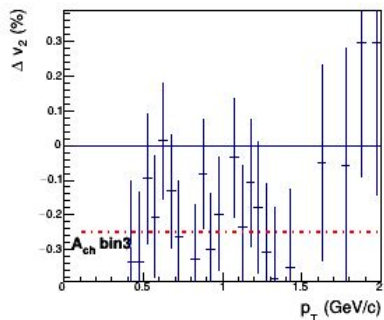
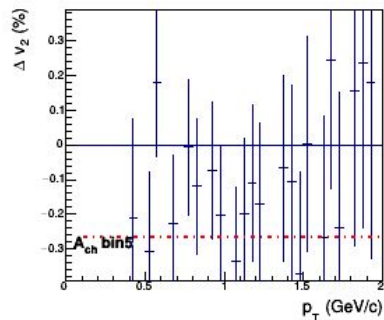
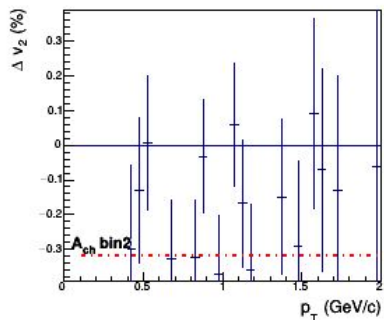
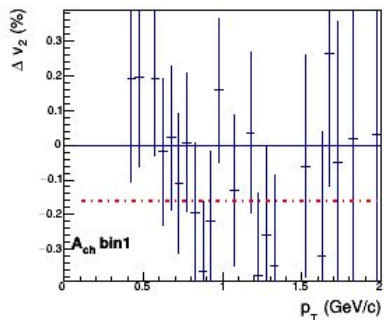
Results (so far just 30-40% centrality)



● Central value

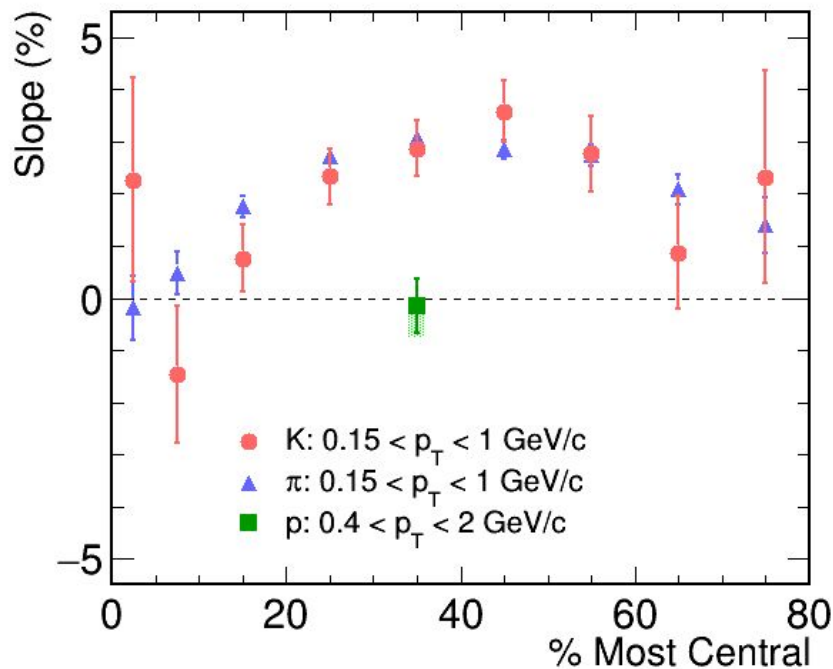


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● systematics

Results (so far just 30-40% centrality)



Outlook

- 3.3σ diff. between proton and kaon
- 5.3σ diff. between proton and pion
- Outlook:
 - Finish all data points for different centralities
 - Submit poster abstract for Conference Experience for Undergraduates (CEU) at the 2016 DNP Fall Meeting