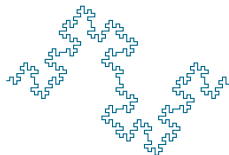# Charge-asymmetry dependence of kaon elliptic flow in 27 GeV Au+Au collisions from STAR.

Keenan Cabrera
UCLA

29 July 2015
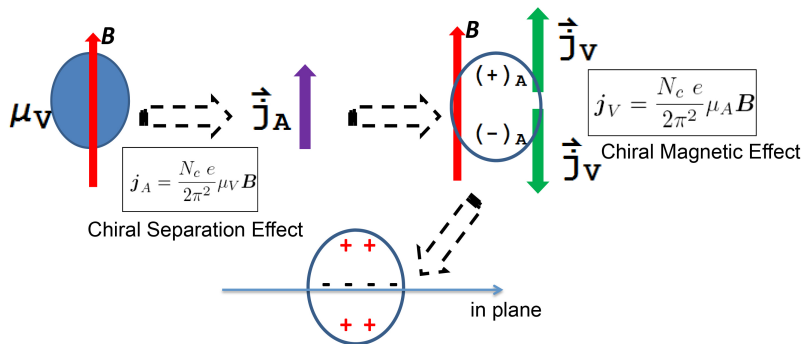
A BRIEF REVIEW OF ELLIPTIC FLOW (v_2) IN QGP

- ▸ Because the quark-gluon plasma created in non-central collisions isn't spherically symmetric, the plasma does not expand uniformly. v_2 is a measure of this anisotropy of expansion.
- ▸ Characterized by the second order Fourier coefficient in the expansion of the azimuthal distribution of particles with respect to the event plane.
  - ▸ $E\frac{d^3N}{d^3p} = \frac{1}{2\pi}\frac{d^2N}{p_T\,dp_T dy}\left(1 + \sum_{n=1}^{\infty} 2v_n \cos\left[n\left(\phi - \Psi_r\right)\right]\right)$
  - ▸ $v_2 = \langle cos\left[2\left(\phi - \Psi_{RP}\right)\right]\rangle$

THE CHIRAL MAGNETIC WAVE (CMW)

▶ The CMW is "a gapless collective excitation of QGP in the presence of [an] external magnetic field that stems from the interplay of Chiral Magnetic (CME) and Chiral Separation Effects (CSE)" [2].

$$j_A = \frac{N_c\, e}{2\pi^2} \mu_V \boldsymbol{B}$$

Chiral Separation Effect

$$j_V = \frac{N_c\, e}{2\pi^2} \mu_A \boldsymbol{B}$$
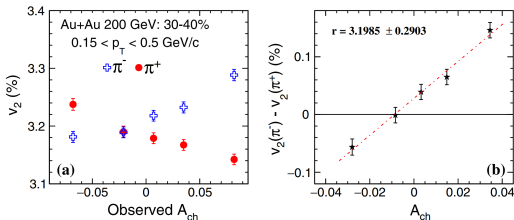
Chiral Magnetic Effect

in plane

[2] Burnier et al. (2011), "Chiral magnetic wave at finite baryon density and the electric quadrupole moment of quark-gluon plasma in heavy ion collisions".

THE CHIRAL MAGNETIC WAVE (CONT.)

▸ The CMW induces an electric quadrapole moment in the QGP that favors the elliptic flow of negative hadrons ($v_2^- > v_2^+$).

▸ In the presence of a CMW effect, the difference in elliptic flow between negative and positive hadrons is predicted to exhibit a linear dependence with positive slope on charge asymmetry $\left(A_{ch} = \frac{N_+ - N_-}{N_+ + N_-}\right)$.

EXPERIMENTAL SUPPORT FOR CMW EFFECTS IN HEAVY-ION COLLISIONS

▸ STAR has detected a positive signal for the CMW effect by analysis of pions in Au + Au collisions at $\sqrt{S_{NN}}$ [1]. This can be seen below.

A figure from the paper published by STAR referenced above. As can be seen, the dependence of v_2 difference on A_{ch} is positive and linear – a clear indication of the CMW effect.
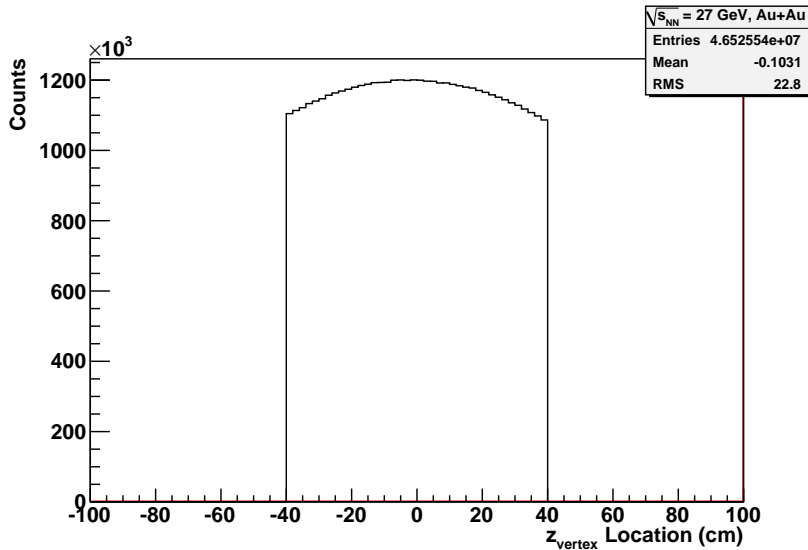
▸ The Kaon is a good candidate to confirm this finding, as for charge-asymmetry-integrated v_2, $v_2\left(\pi^-\right) > v_2\left(\pi^+\right)$ whereas $v_2\left(K^+\right) > v_2\left(K^-\right)$.

[1] Adamczyk et al. (2015), "Observation of Charge Asymmetry Dependence of Pion Elliptic Flow and the Possible Chiral Magnetic Wave in Heavy-Ion Collisions".
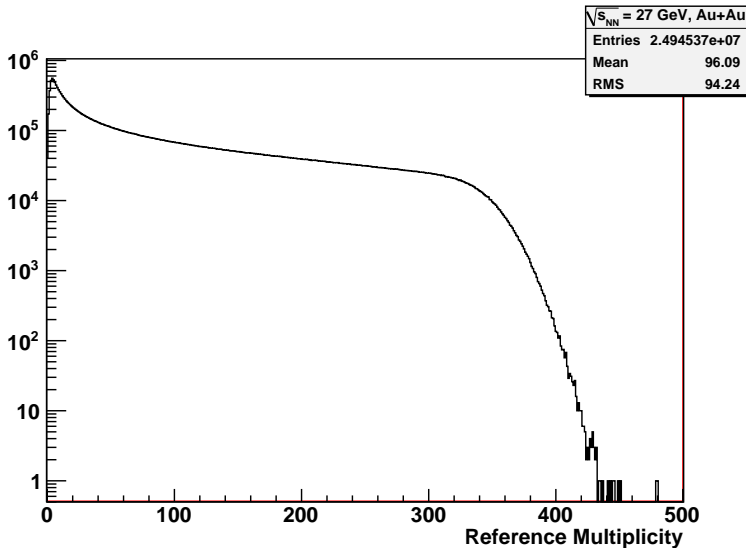
KAON CUTS

- $0.2\frac{GeV}{c} < p_T < 1.0\frac{GeV}{c}$
- $-2 < n\sigma_K < 2$
- $-1 < \eta < 1$
- ndEdxhits ≥ 10
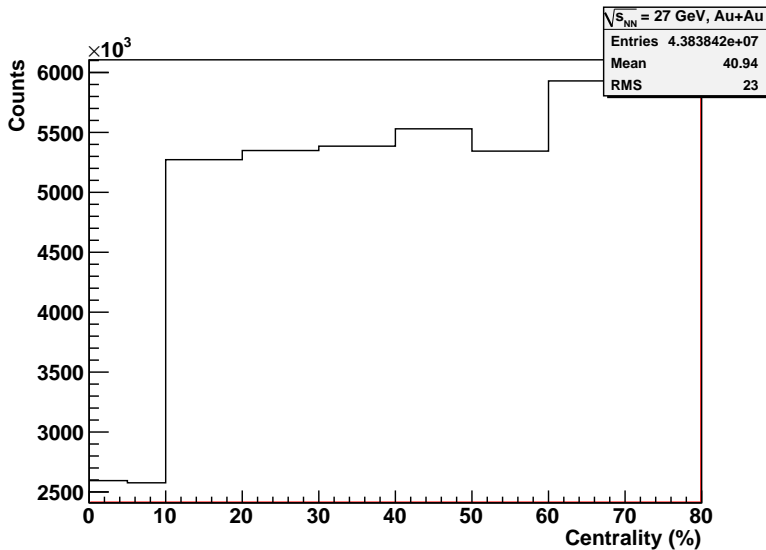- TOF flag > 0
- -1.8 < TOF yLocal < 1.8

VERTEX DISTRIBUTION (Z-COORDINATE)

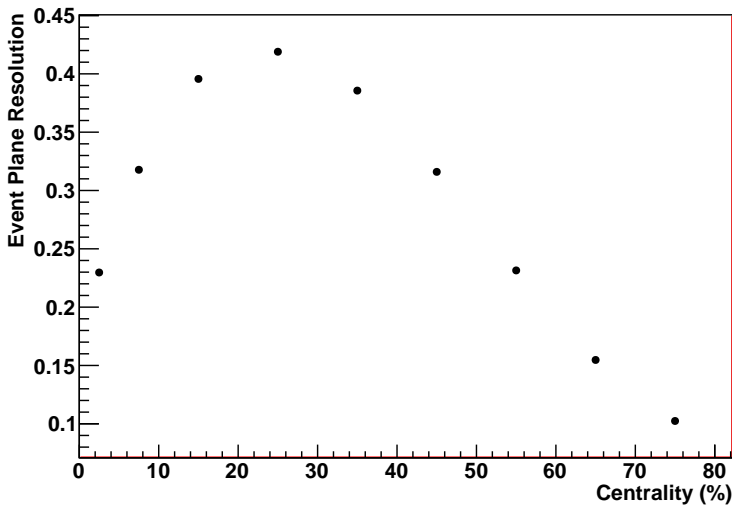## REFERENCE MULTIPLICITY DISTRIBUTION

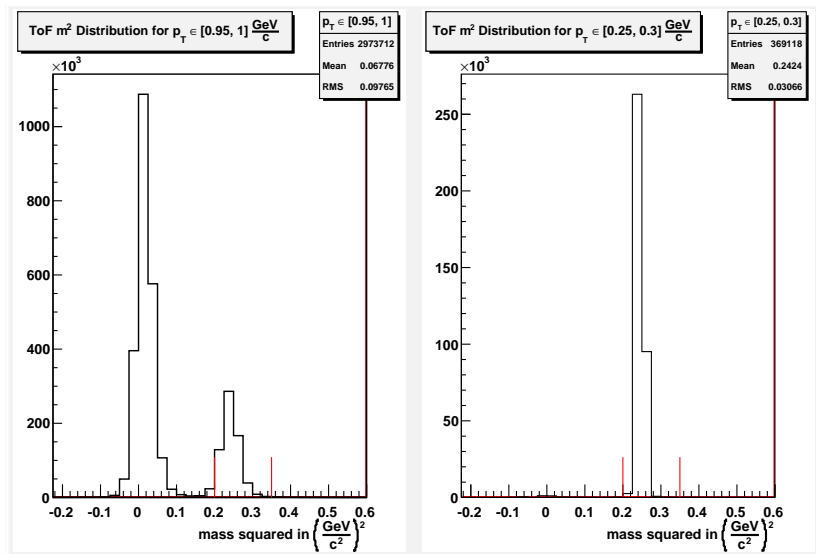## CENTRALITY DISTRIBUTION
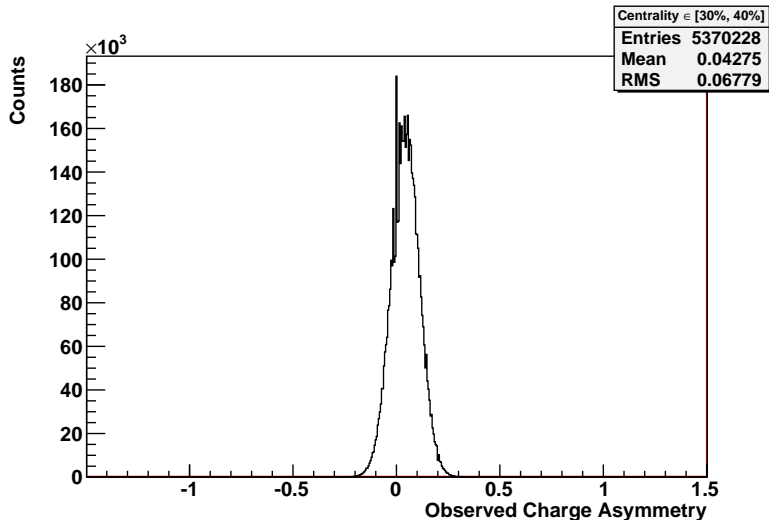
Ψ_{EP} DISTRIBUTION (η GAP BETWEEN -0.3 AND 0.3)
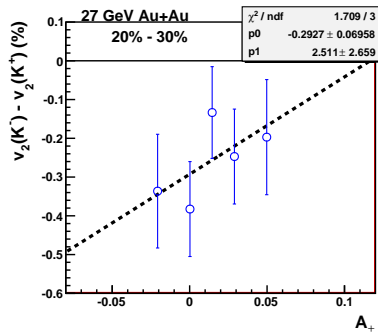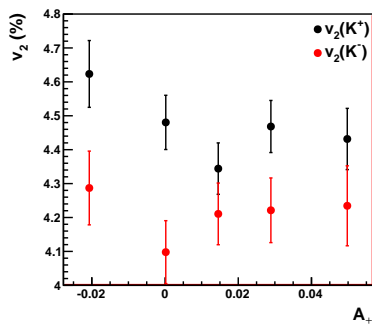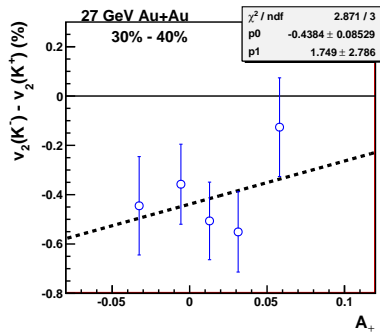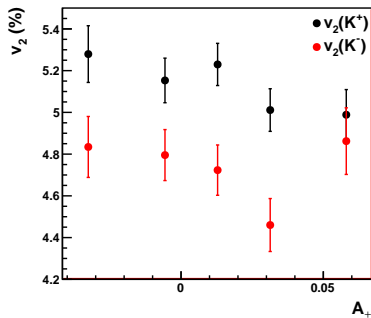
SUB-EVENT PLANE RESOLUTION VS. CENTRALITY

TOF CUTS

OBSERVED A_{ch} DISTRIBUTION $\left(A_{ch} = \frac{N_+ - N_-}{N_+ + N_-} \right)$
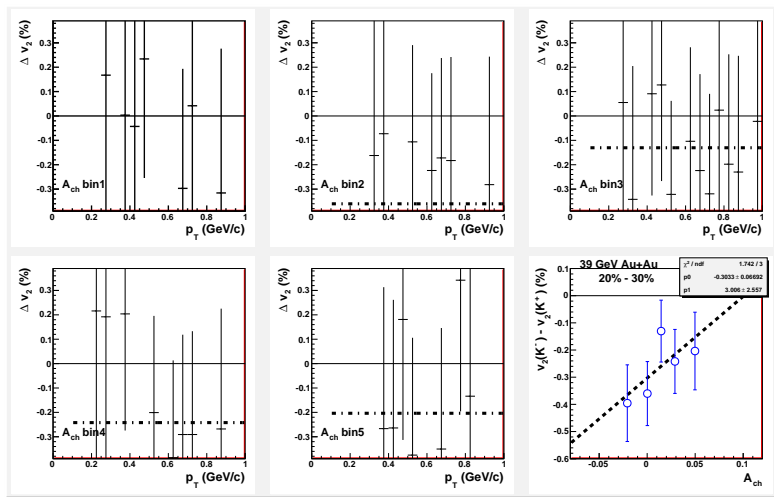
p_T INTEGRATED v_2 FOR 20% - 30% CENTRAL COLLISIONS

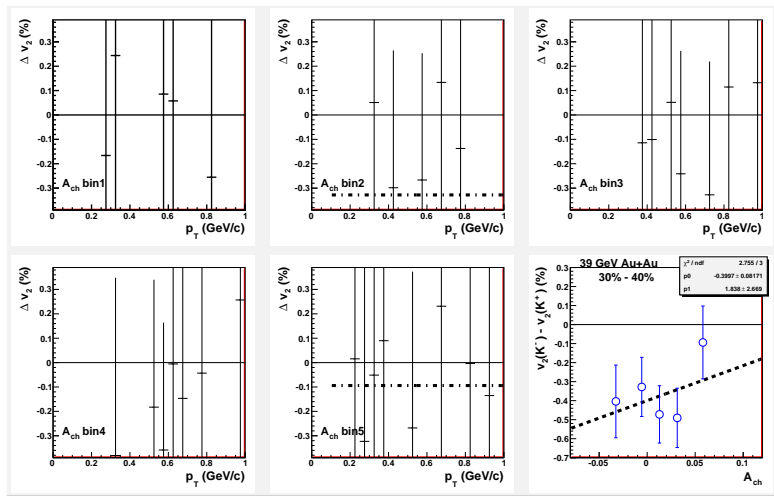# p_T INTEGRATED v_2 FOR 30% - 40% CENTRAL COLLISIONS
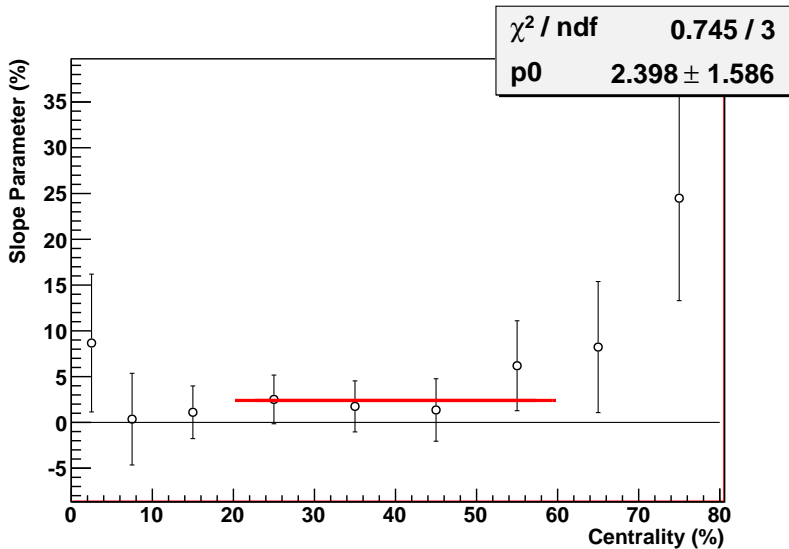
Δv_2 VS CHARGE ASYMMETRY FOR 20% - 30% CENTRAL COLLISIONS
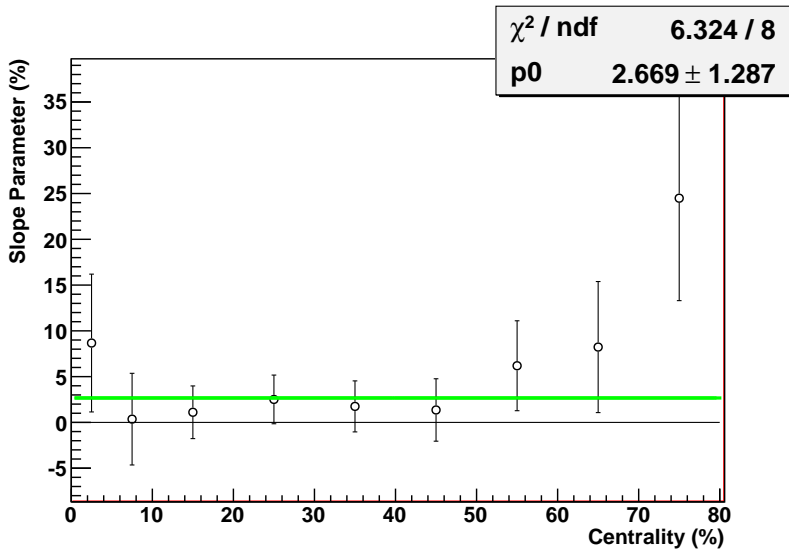
Δv_2 VS CHARGE ASYMMETRY FOR 30% - 40% CENTRAL COLLISIONS

CENTRALITY DEPENDENCE OF SLOPE PARAMETER

CENTRALITY DEPENDENCE OF SLOPE PARAMETER

SUMMARY AND FUTURE PLANS

- Preliminary findings show support for a positive v_2 vs A_{ch} slope (consistent with the CMW picture), though the error bars are very large.
- More data is needed to extract a statistically significant result.
- Future Plans:
  - Tighten DCA cut from 1 cm to 0.5 cm.
  - Include systematic errors:
    - Vary tracking efficiency and determine effect on corrected A_{ch}.

REFERENCES

[1] L. Adamczyk et al. "Observation of Charge Asymmetry Dependence of Pion Elliptic Flow and the Possible Chiral Magnetic Wave in Heavy-Ion Collisions". In: *Phys. Rev. Lett.* 114 (25 June 2015), p. 252302. DOI: 10.1103/PhysRevLett.114.252302. URL: http://link.aps.org/doi/10.1103/PhysRevLett.114.252302.

[2] Yannis Burnier et al. "Chiral magnetic wave at finite baryon density and the electric quadrupole moment of quark-gluon plasma in heavy ion collisions". In: *Phys. Rev. Lett.* 107 (2011), p. 052303. DOI: 10.1103/PhysRevLett.107.052303. arXiv: 1103.1307 [hep-ph].