Separate measurements of physics background and the possible chiral magnetic effect in p+Au and d+Au collisions at RHIC

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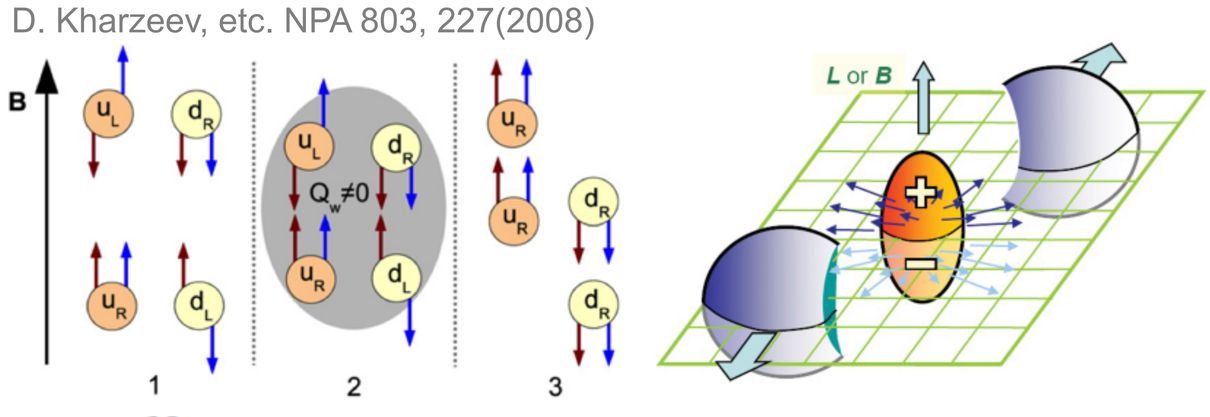
Abstract: Metastable domains of fluctuating topological charges can change the chirality of quarks and induce local parity violation in quantum chromodynamics. This can lead to observable charge separation along the strong magnetic field produced in relativistic heavy-ion collisions, a phenomenon called the chiral magnetic effect (CME). The magnetic field is generated by spectator protons and therefore best measured by the 1st-order harmonic plane (Ψ_1) using the spectator neutrons. The 2nd-order harmonic plane (Ψ_2), on the other hand, estimates the initial participant geometry, connected to the elliptic flow anisotropy (v_2). A major background source for CME measurements is the intrinsic particle correlation coupled with v_2. In heavy-ion collisions, the Ψ_1 and Ψ_2 are correlated, thus the CME and the v_2-induced background are entangled. In small system p+Au and d+Au collisions, the Ψ_2 is entirely due to geometry fluctuations, and thus Ψ_1 and Ψ_2 are uncorrelated. A correlation measurement w.r.t. Ψ_1 is only sensitive to CME while the v_2-induced background is averaged to zero. Likewise, a correlation measurement w.r.t. Ψ_2 is only sensitive to v_2-induced background while any CME is averaged to zero.

In this poster, we will present the STAR measurements of three-particle correlation in p+Au and d+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV with respect to Ψ_1 of spectator neutrons measured by the STAR ZDC-SMD detectors. Measurements with respect to Ψ_2 are also reported, which shed light on the background contamination in similar measurements in heavy-ion collisions.

Chiral Magnetic Effect(CME):

D. Kharzeev, etc. NPA 803, 227(2008)

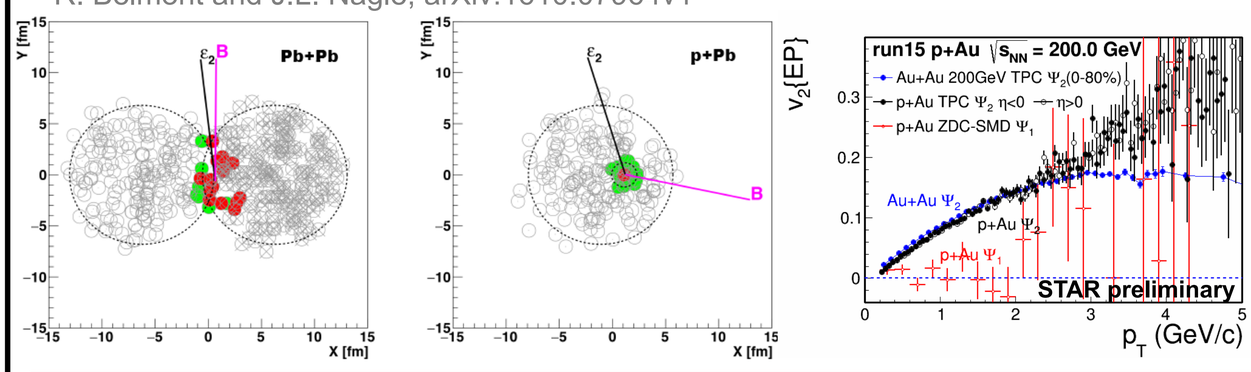


$$j_V = \frac{N_c e}{2\pi^2}\mu_A B, \Rightarrow$$ electric charge separation alone the B field

Configuration with non-zero topological charge converts left(right)-handed fermions to right(left)-handed fermions, generating electric current along B direction and leading to electric charge separation

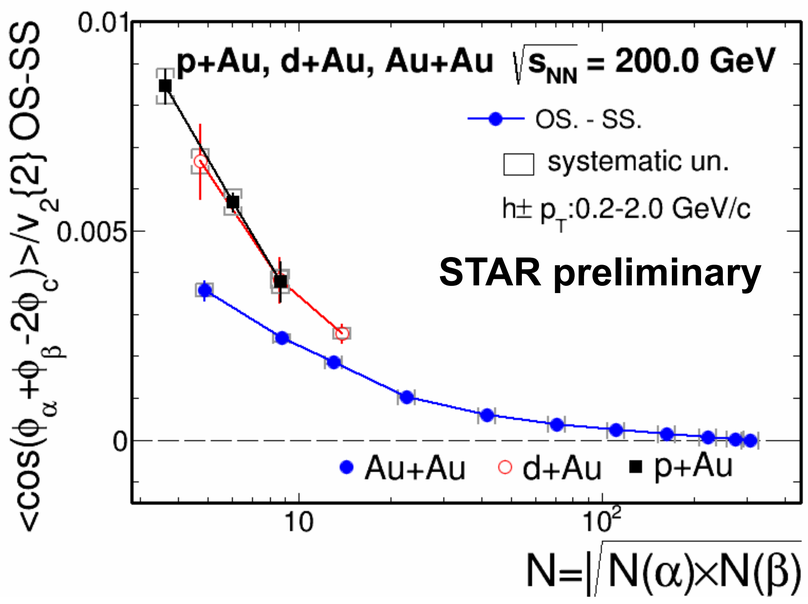
Harmonic planes in small systems:

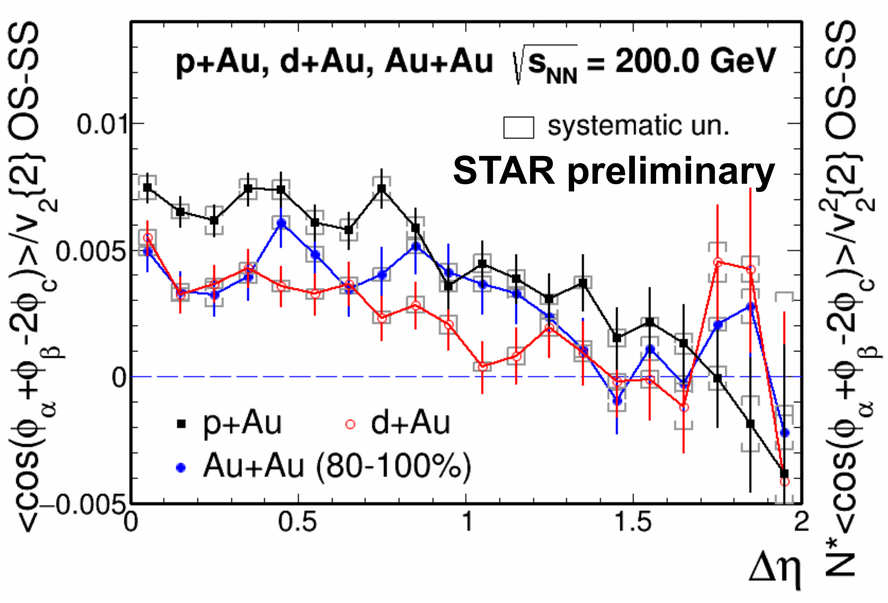
CMS collaboration, arXiv:1610.00263;
R. Belmont and J.L. Nagle, arXiv:1610.07964v1

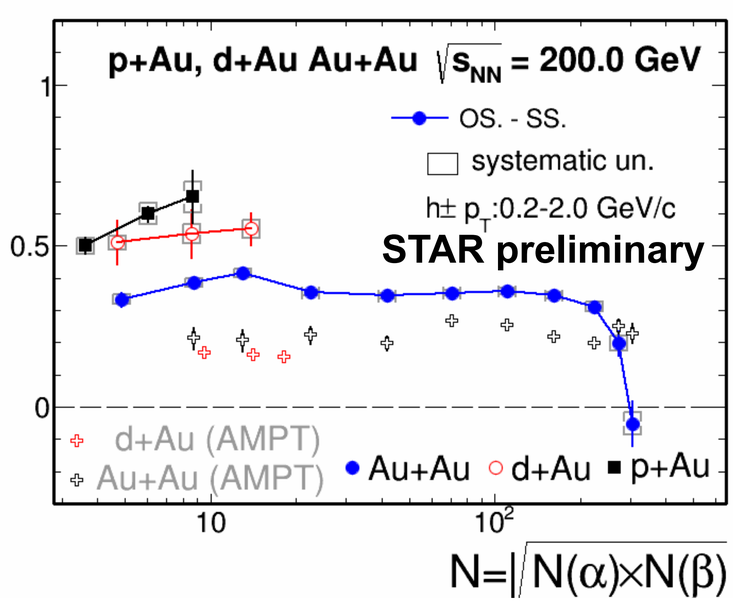


- Ψ_2 related to flow, related to -> flow bkg.
- Ψ_1 related to the magnetic direction (B), useful for -> CME signal
- Ψ_1 and Ψ_2 correlated in A+A, signal and background entangled
- Ψ_1 and Ψ_2 not correlated in p+A, d+A, signal and bkg. disentangled
- try p+Au, d+Au with ψ_1 to measure CME w/o flow bkg. contamination

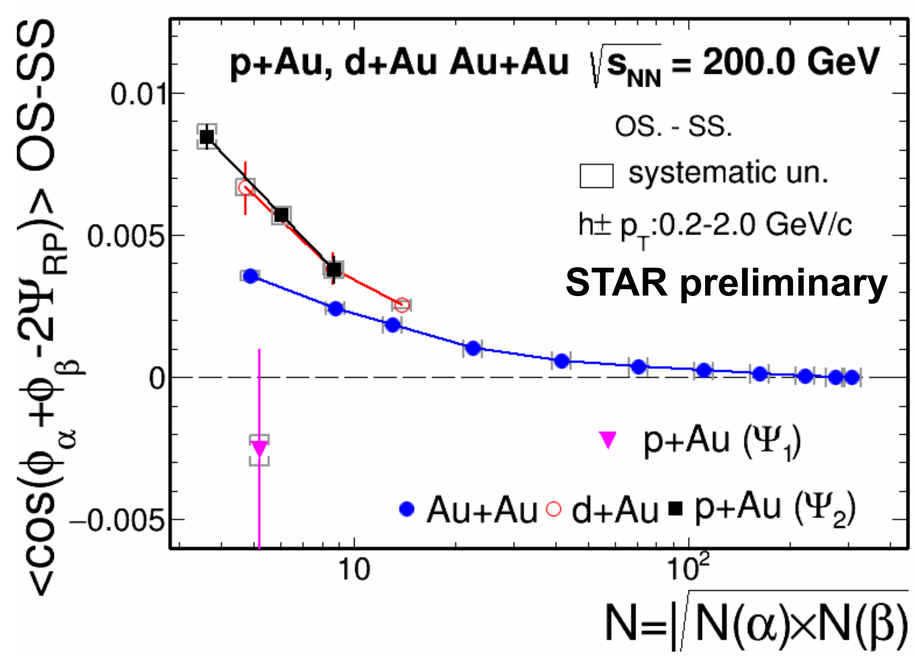
Results with respect to Ψ_2:







Results with respect to Ψ_1:



Summary:

- In small systems, anisotropy-related background and possible CME signal may be decoupled
- With respect to Ψ_2: p+Au and d+Au charge-dependent correlations are background. Peripheral Au+Au data are comparable to that of p+Au and d+Au. The scaled correlators from peripheral to mid-central Au+Au collisions indicate a significant contribution from background, with large uncertainties in the interpretation
- With respect to Ψ_1: charge dependent signal in p+Au and d+Au is free of anisotropic background. Within the present large uncertainty the signal is consistent with zero

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The STAR Collaboration: http://drupal.star.bnl.gov/STAR/presentations

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