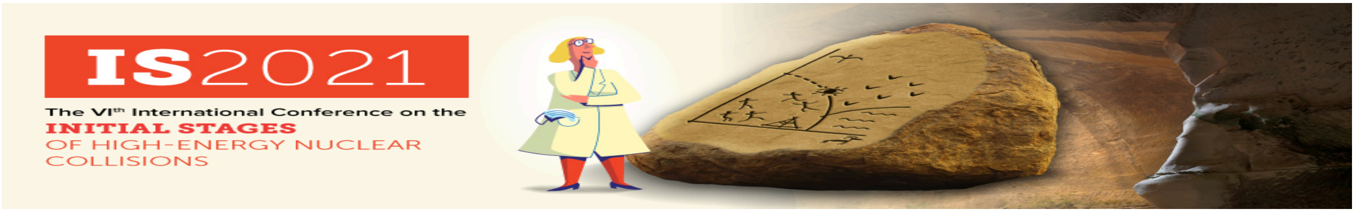

Searching for the chiral magnetic effect in heavy-ion collisions with the sliding dumbbell method

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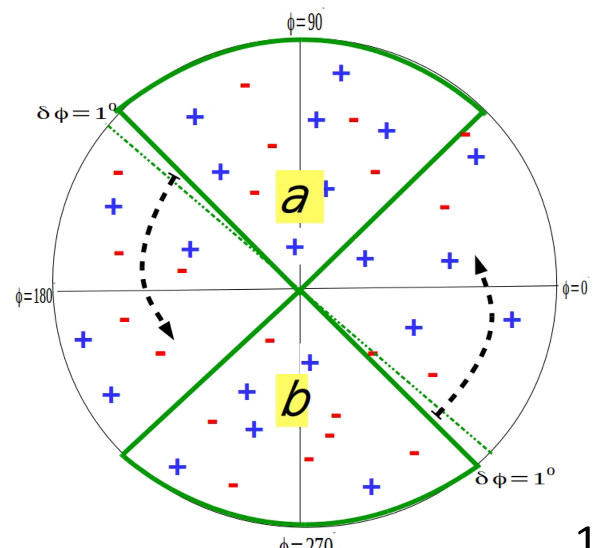
Motivation

Investigation of the Chiral Magnetic Effect (CME) which causes the charge separation in de-confined matter along the axis of magnetic field in the presence of the strong magnetic field.

Sliding Dumbbell Method (SDM)

The azimuthal plane displaying hits of positive/negative particles in an event is scanned by sliding the dumbbell of 90^0 in steps of 1^0 searching for maximum of the sum ($Db_{\pm}^{max}$) of positive charge fraction on one side (a) and negative charge fraction on other side (b) of the dumbbell **to search back-to-back charge separation on an event-by-event basis for the first time.**



Following condition is imposed on the charge asymmetry (Db_{asy}) of positive charge excess (Pos_{ex}) on (a) side of dumbbell and negative charge excess (Neg_{ex}) on (b) side of dumbbell:

$|Db_{asy}| = |(Pos_{ex} - Neg_{ex})/(Pos_{ex} + Neg_{ex})| < 0.25$, to get CME-like events.

Fractional charge separation across the dumbbell (f_{DbCS}) = $Db_{\pm}^{max} - 1$

Positive charge asymmetry across the dumbbell (A^{+}) = ($N^{+}_{a} - N^{+}_{b}$)/($N^{+}_{a} + N^{+}_{b}$)

f_{DbCS} distribution is sliced into 10 percentile bins to get CME-like events.

The CME sensitive 3-particle γ correlator defined as (Voloshin PRC 70, 057901(2004)) :

$$\gamma = \langle\cos(\phi_a + \phi_b - 2\psi_{RP})\rangle \approx (v_{1,a} v_{1,b} - a_a a_b) = \langle\cos(\phi_a + \phi_b - 2\phi_c)\rangle / v_{2,c}$$

here, ϕ_a, ϕ_b and ϕ_c are azimuthal angles of particle a, b and c ; ψ_{RP} is reaction plane angle, $v_{1,a(b)}$ is direct flow and $v_{2,c}$ is elliptic flow of third particle "c".

For symmetric rapidity direct flow, $v_{1,a} = v_{1,b} \sim 0$, so $\gamma \approx |a_a . a_b|$

Background estimation :

$$\gamma_{bkg} = \gamma_{ch.re} + \gamma_{correlated}$$

$\gamma_{ch.re}$ is obtained by reshuffling the charges of particles in an event and $\gamma_{correlated}$ from the AMPT events for a given collision centrality.

Following data of AMPT generated 16M Au + Au collisions at $\sqrt{s_{NN}}$ =200 GeV are analyzed.

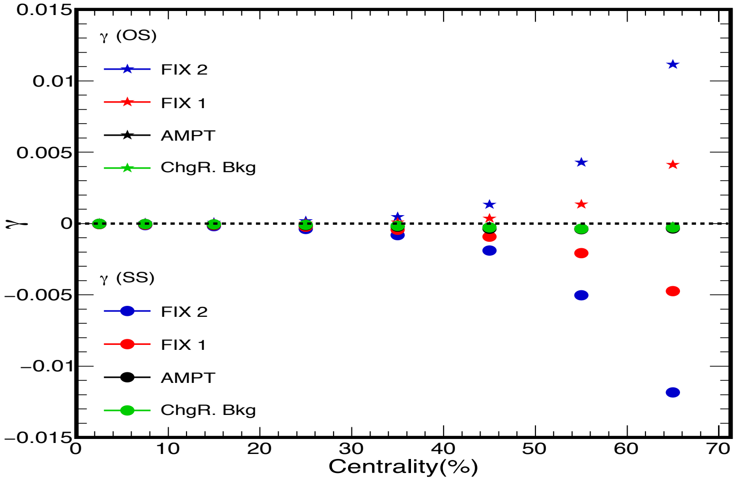
- AMPT with string melting ON.
- Externally injected CME-like signal in AMPT i.e., flipping one positive/negative particle to negative/positive particle perpendicular to the reaction plane denoted as Fix 1 sample.
- Fix 2 same as Fix 1 but two particles are flipped instead of one particle.

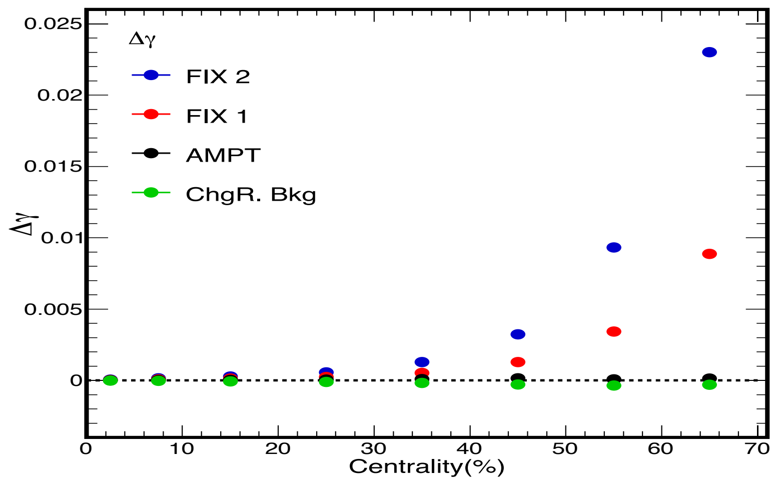
Collision centrality : Determined from the number of participant nucleons.

Track cuts: 0.15 GeV/c < p_T < 2.0 GeV/c and -1.0 < η < 1.0.

Results and Discussion

3-particle γ correlator dependences on collision centrality for same and opposite signed charged pairs and $\Delta\gamma$ (opposite sign- same sign) are shown below:

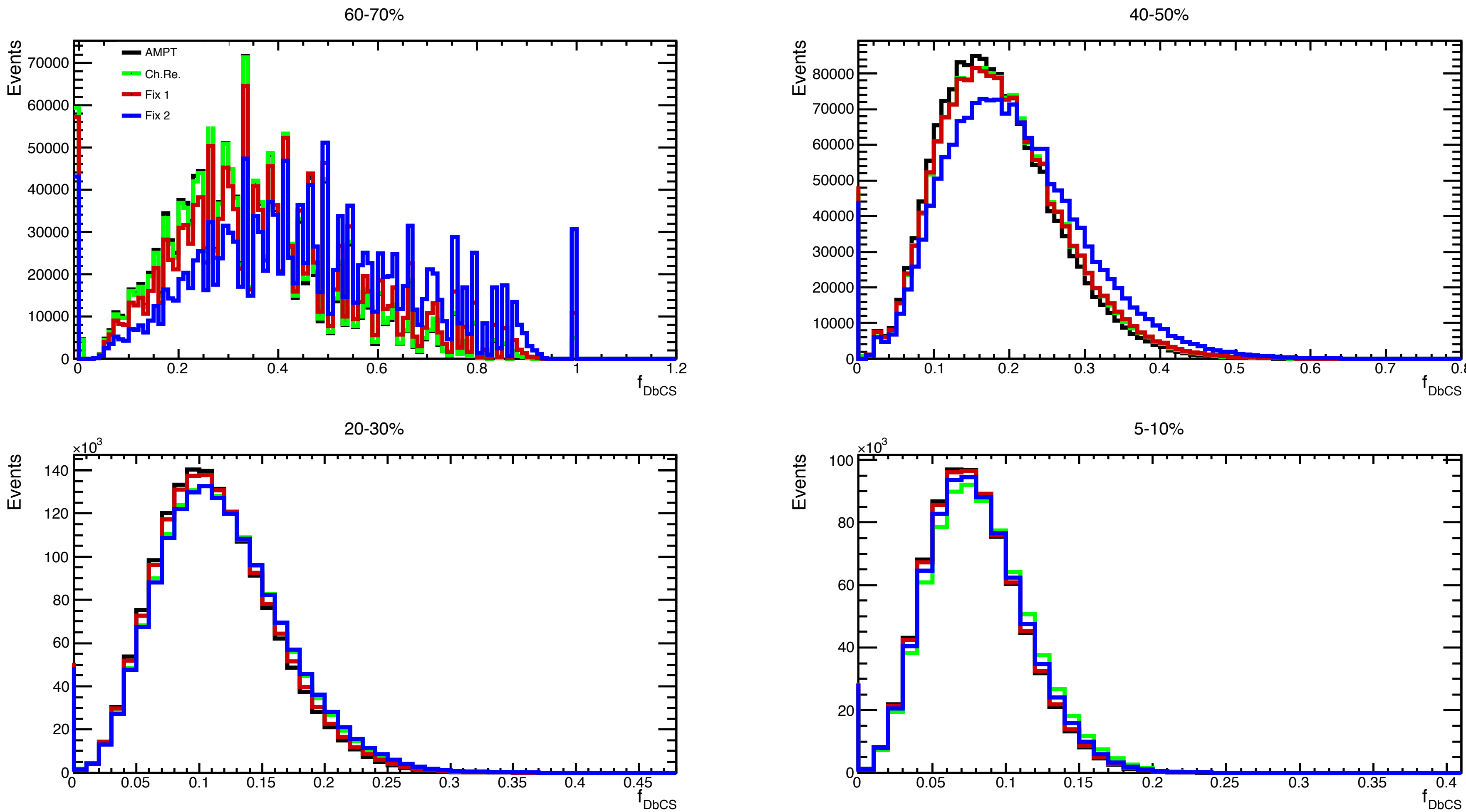




Same sign charged particles are strongly correlated and correlation increases with increasing injected CME-like signal. It deceases with increasing collision centrality. $\Delta\gamma$ increases with increasing externally injected CME-like signal and decreasing collision centrality.

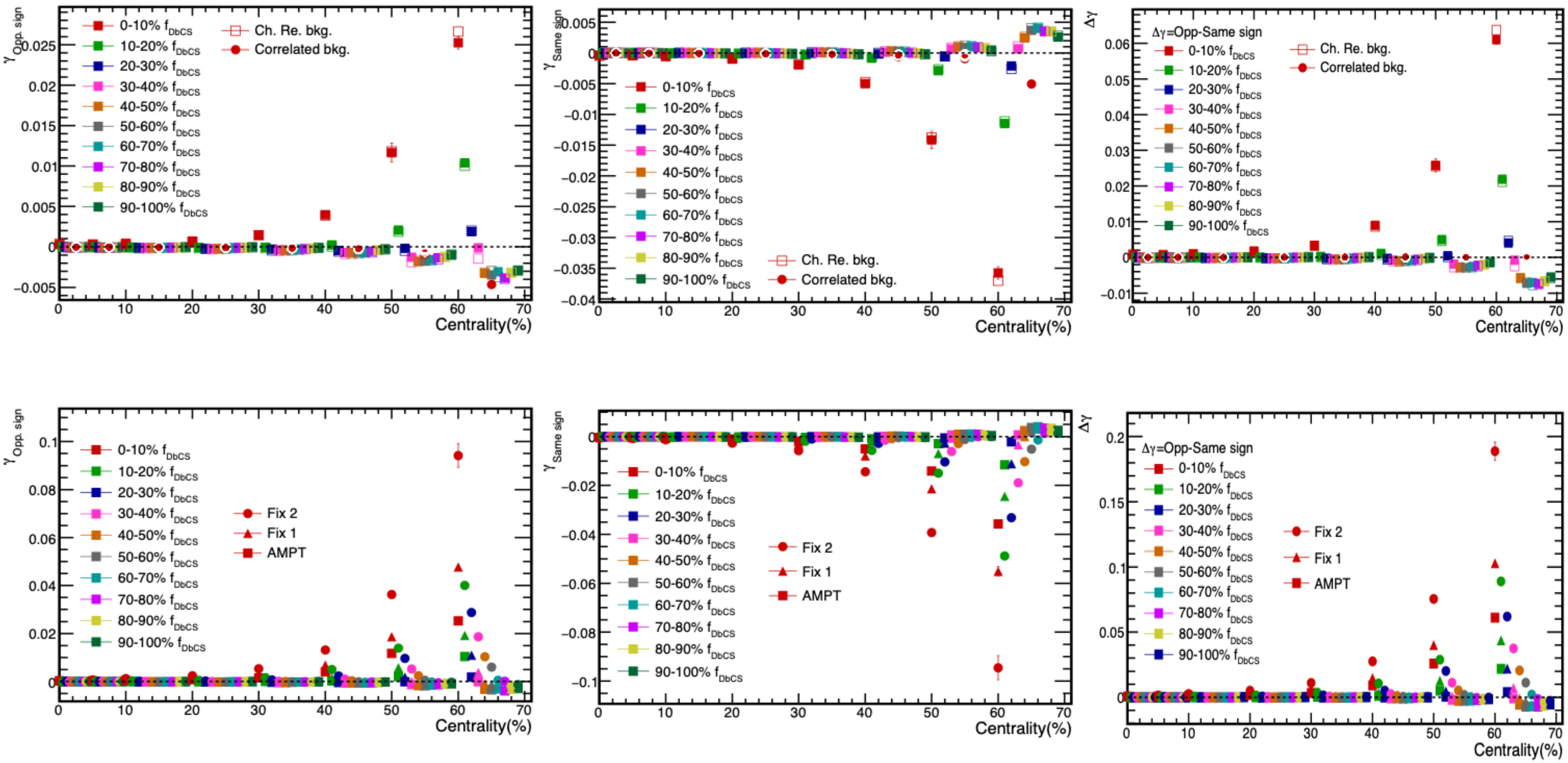
Analyzing with Sliding Dumbbell Method

f_{DbCS} distributions for different collision centralities for AMPT, charge reshuffle, Fix 1 and Fix 2

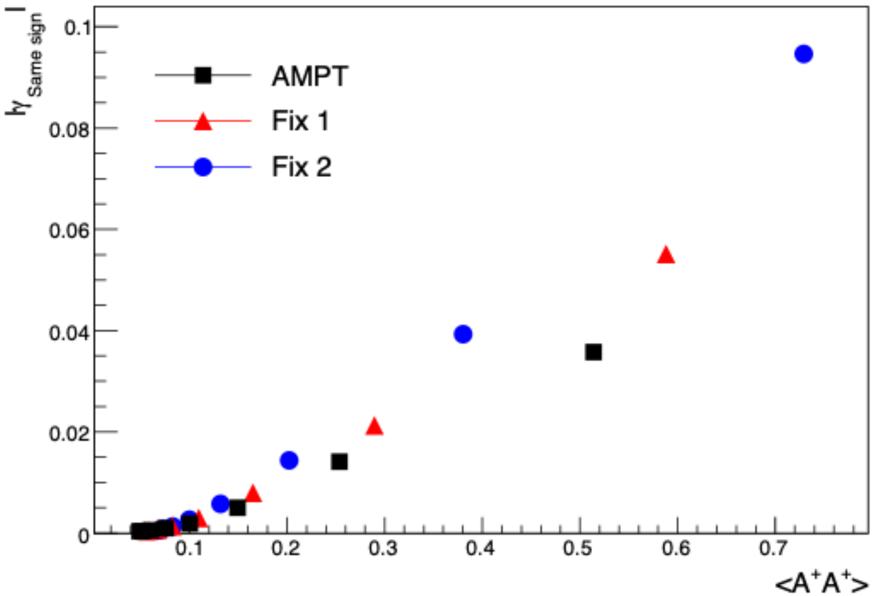


Distributions move towards $f_{DbCS}=1$ (i.e., 100% charge separation) with increasing externally injected signal and decreasing collision centrality.

γ for opposite and same signed charged pairs and $\Delta\gamma$ (opposite sign–same sign) dependences on collision centrality for different f_{DbCS} bins are shown below:



Strong correlations are seen for the top 0-20% f_{DbCS} which increase with increasing externally injected signal and decreases with increasing collision centrality as the signal injected was kept constant. Also it is observed that $|\gamma_{opp\text{-}sign}| \sim |\gamma_{same\text{-}sign}|$

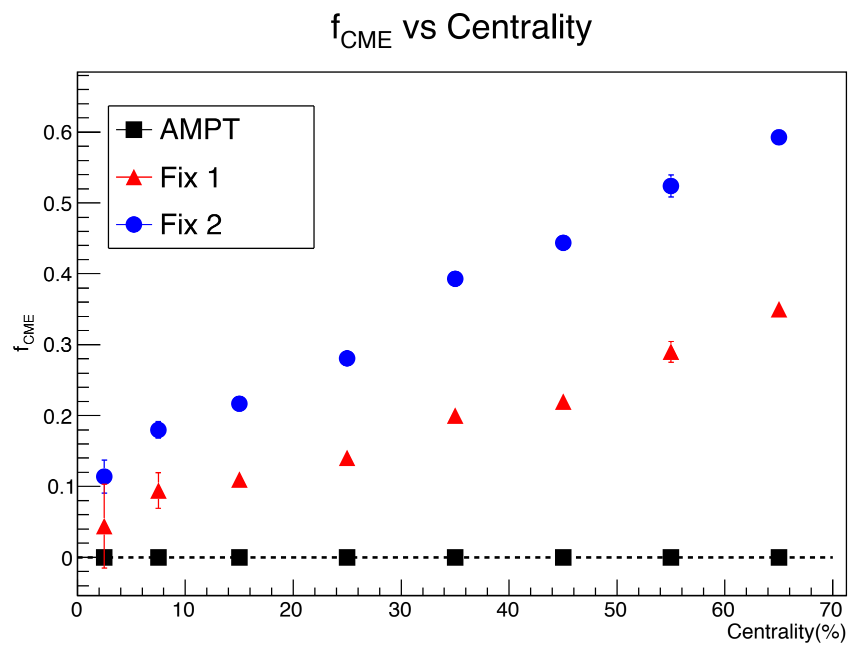


$$|\gamma_{\text{same-sign}}| \propto < A^+A^+ >$$

$$A^+ \propto a_+$$

$$f_{CME} = \frac{\sum N(\Delta\gamma - \Delta\gamma_{bkg.})}{N_{Total}}$$

Summation runs over 10 f_{DbCS} bins and N_{Total} is total number of events.



f_{CME} decreases with increasing collision centrality and increases with increasing externally injected signal. f_{CME} is zero for AMPT.

Summary

- It became possible with SDM for the first time to extract CME-like events corresponding to the top ~ 0-20% f_{DbCS} .
- For the top ~ 0-20% f_{DbCS} , $|\gamma_{opp-sign}|$ ~ $|\gamma_{same-sign}|$.
- $|\gamma_{same-sign}|$ varies approximately linearly with $<A^+A^+>$ for higher values of $<A^+A^+>$.
- f_{CME} decreases with increasing collision centrality as the signal injected was kept constant.
- f_{CME} increases with increasing injected signal and is approximately zero for the AMPT.

Thank you !