Charge dependent correlations with identified hadrons relative to the reaction plane with the ALICE experiment at the LHC*

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Conservation of parity in strong interactions is one of the fundamental open questions in QCD. The parity symmetry in QCD can be violated spontaneously via instanton and sphaleron transitions. Inside hot QCD matter created in a heavy-ion collision, these interactions in the presence of the strong magnetic field generated by the colliding ions may lead to a separation of charges [1] along the field. This phenomenon is known as the Chiral Magnetic Effect (CME). Since the magnetic field is aligned perpendicular to the reaction plane, which is spanned by the impact parameter and the beam direction, the separation of charges can be measured with a P-even two-particle correlation relative to the reaction plane [2]:

$$c_{\alpha\beta} = \langle\cos(\varphi_\alpha + \varphi_\beta - 2\Psi_{\mathrm{RP}})\rangle. \qquad (1)$$

Here α and β denote the charges of the particles with azimuthal angle φ. The reaction plane angle, Ψ_{RP}, can be estimated from the azimuthal distribution of particles created either in the collision overlap region or in the forward (spectator fragments) region. The ALICE experiment has several subdetectors with full azimuthal coverage which together cover a wide pseudorapidity range needed for reconstruction of the reaction plane and the CME study. Figure 1 shows the event plane resolution correction factor for the Time Projection Chamber (TPC), as well as for forward multiplicity detectors (V0-A/C, FMD-A/C and T0-A/C).
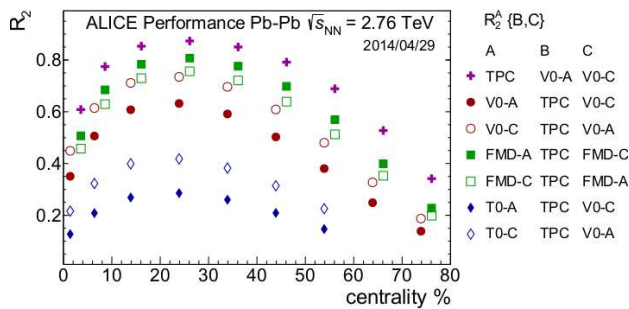

Figure 1: Resolution correction factor R_2 estimated for different ALICE subdetectors with the 3-subevent method [3].

The magnitude of the resolution correction factor depends on the particle multiplicity in the detector and the magnitude of the collective flow of those particles. Due to large number of particles produced at midrapidity, the large acceptance TPC has good sensitivity to the orientation of the reaction plane, while for forward detectors with smaller
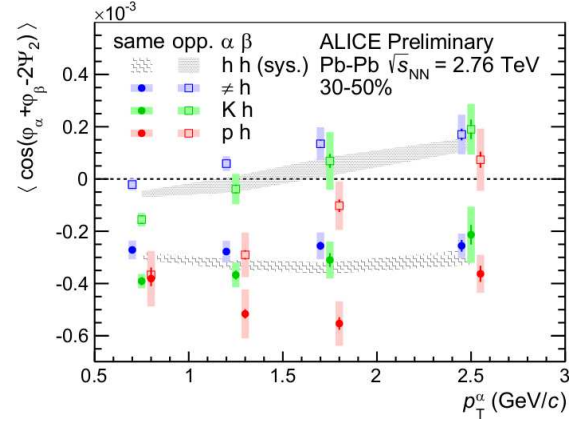

Figure 2: Results for $\langle\cos(\varphi_\alpha(p_{\mathrm{T}}^\alpha) + \varphi_\beta - 2\Psi_{\mathrm{RP}})\rangle$ in the 30-50% centrality range.

acceptance, such as T0, it is significantly reduced. These independent estimates of the collision symmetry plane in different kinematic ranges provide needed information for a systematic study of the correlation measurements relative to the reaction plane.

The ALICE experiment has previously measured the correlator in Eq. (1) for charged hadrons. While a significant charge dependence was observed, it likely contains contributions from other physics effects which are backgrounds to CME. The strongest background candidate is effects due interplay of Local Charge Conservation (LCC) with the anisotropic flow. The effect of flow on the charge dependent signal can be studied differentially with identified hadrons, for example:

$$c_{\alpha\beta}(p_{\mathrm{T}}^\alpha) = \langle\cos(\varphi_\alpha(p_{\mathrm{T}}^\alpha) + \varphi_\beta - 2\Psi_{\mathrm{RP}})\rangle. \qquad (2)$$

In Fig. 2 this correlation is shown for different charge combinations of one identified hadron α (pion, kaon, and proton) and one charged hadron β. Significant dependence of the charge separation as a function of the identified hadron transverse momentum p_{T}^α is observed. Detailed model calculations of the contributions from LCC and CME effects are needed to make a quantitative conclusion about possible CME signal in the observed charge correlations.

References

[1] D. Kharzeev Phys. Lett. B633 (2006) 260-264

[2] S. Voloshin Phys. Rev. C70 (2004) 052901

[3] A. Poskanzer and S. Voloshin Phys. Rev. C58 (1998) 1671-1678