First measurement of femtoscopic correlation function between D^0 mesons and charged hadrons in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV by STAR

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Introduction

Heavy quarks are produced in hard partonic scatterings at the very early stage of heavy-ion collisions and experience the whole evolution of the Quark Gluon Plasma medium. Femtoscopic correlations, i.e. two-particle correlations at low relative momentum, are sensitive to the final-state interactions and to the extent of the region from which the correlated particles are emitted. A study of such correlations between the charmed mesons (D^0) and identified charged hadrons could shed light on their interactions in the hadronic phase and the interaction of charm quarks with the medium. Moreover, D^0-hadron correlations can provide information about the emissions source's length and area of homogeneity [1].

Analysis details

This abstract shows the first measurement of femtoscopic correlations between D^0-$K^{+/-}$ pairs at mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV using the data taken by the STAR experiment. D^0 mesons are reconstructed via the K^--π^+ decay channel using topological criteria enabled by the Heavy Flavor Tracker (HFT) detector with excellent track pointing resolution. Centrality-inclusive femtoscopic correlation function was measured for D^0 transverse momentum, $p_T > 1$ GeV/c and K momentum, p < 1 GeV/c with D^0 rapidity (y) coverage of $|y| < 1.0$. Both Time of Flight (TOF) and Time Projection Chamber (TPC) information were used for identification of particles (PID).

Figure 1 shows successful reconstruction of D^0 candidates within a mass range of 1.82 -1.91 GeV/c^2 with help of HFT detector using Au+Au

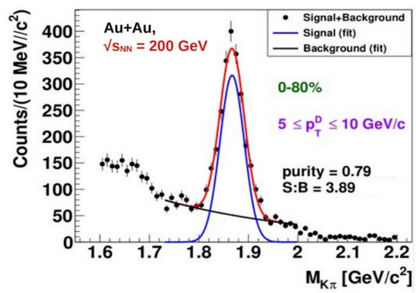

Fig. 1: Invariant mass distribution of opposite sign K-π pairs (D^0) for $5 < p_T < 10$ GeV/c, signal purity is 79% and signal/background is ~ 3.89 within 1.82 – 1.91 GeV/c^2 range.

collisions data of the year 2014. Ratio of reconstructed D^0 signal over combinatorial background increases with increasing p_T bin and background is dominant over D^0 signal for $p_T < 1$ GeV/c. Therefore, D^0 mesons with $p_T > 1$ GeV/c were taken into consideration for this measurement and purity was calculated for p_T bins of 1-2, 2-3, 3-5 and 5-10 GeV/c. We consider kaons with momenta < 1 GeV/c, as above this momentum value, they cannot be efficiency distinguished from electrons and other hadrons. The average purity of the kaon sample is ~ 0.97 ± 0.03, in the considered momentum range.

To calculate the correlation function $C(k^*)$, we took the ratio of reduced momentum difference (k^*) of correlated [$A(k^*)$] and uncorrelated [$B(k^*)$] pair of particles within the rest frame of their center of mass.

$$C(\vec{k}^*) = \mathcal{N}\frac{A(\vec{k}^*)}{B(\vec{k}^*)}. \quad \text{and, } k^* = ½\,(p_1 - p_2)$$

where p_1 and p_2 are momenta of D^0 and K particles in the pair-rest frame.

In this analysis, uncorrelated pairs were obtained using a mixed event technique.

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Results and Discussions

We considered and removed possible TPC detector effects (ex. self-correlation between D^0 daughters and hadron track splitting) which can influence the number of correlated pairs. Another possible detector effect is merging of two separate tracks as one, but we encountered negligible number of merged tracks. We also applied D^0-K pair purity correction using the formula below.

$$C_{\mathrm{measured}}^{\mathrm{corr}}(k^*) = \frac{C_{\mathrm{measured}}(k^*) - 1}{\mathrm{PairPurity}} + 1, \quad [2]$$

Pair purity is a product of p_T integrated D^0 signal purity and the average purity of kaon sample.

For systematic uncertainty studies, we applied different topological cuts for D^0 reconstruction [3] and included uncertainty on purity measurement for D^0-K pairs.

Table 1: D^0 S/B ratio and purity

$D^0{}_{pT}$ [GeV/c]	S/B	Purity
1-2	0.33	0.25
2-3	1.58	0.61
3-4	3.48	0.78
4-5	4.70	0.83
5-10	3.89	0.79

Purity = S/F where, F = S + B. Signal (S) and background (B) were taken from Gaussian and exponential fit, respectively, as presented in fig. 1.

Figure 2 shows the final correlation function for D^0-$K^{+/-}$ pairs. We made a comparison of data with available theory predictions of emission source size dependency of correlation functions for D^0-K^+ pairs. The results are consistent with no correlations, but also with a emission source size of 5 fm or larger. We expect the combined result using data from run 2014 and 2016 will decrease the statistical and systematic error and increase precision of measurement of the correlation functions and will provide more clear idea about the source size. We would also like to include results for other hadrons i.e. D^0-p and D^0-π pairs.

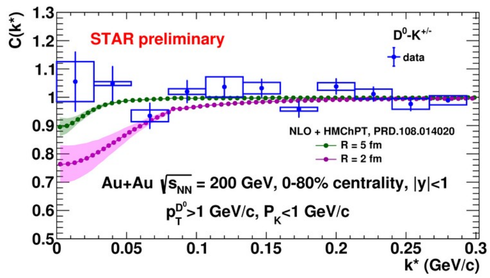

Fig. 2: Correlation functions between D^0-$K^{+/-}$ pairs and comparison with theoretical predictions

The reference predictions [4] considered lightest S-wave scalar open-charm mesons [$D_{(S)}$] and D^0-K^+ and D^+-K^0 channels. None of these channels involves Coulomb interaction. They obtained T-matrix using NLO (next-to-leading order) HMChPT (Heavy Meson Chiral Perturbation Theory) scheme. More theoretical inputs are welcome that include details of charm interactions with the QGP for the detail interpretation of the results.

Acknowledgments

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