Two-particle femtoscopic correlations between non-identical charged particles for different charge combinations are measured in Pb-Pb collisions at $\sqrt{s_{\text{NN}}} = 2.76$ TeV with ALICE at the LHC. The three-dimensional two-particle correlation functions are studied in different centrality bins. The femtoscopic source size parameter ($R_{\text{Out}}$) and emission asymmetry ($\mu$) are extracted. It is observed that the average source size of the system and emission asymmetry between particles increase from peripheral to central events.
Non-identical particle femtoscopy in Pb–Pb collisions at \( \sqrt{s_{NN}} = 2.76 \) TeV measured with ALICE
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1. Non-identical particle femtoscopy

Femtoscopic techniques, which analyze the momentum correlations of produced particles at small relative momenta, are used to study the space–time characteristics of the created system. Due to Final State Interactions (FSI) among the particles, the two-particle correlations for non-identical pairs are sensitive to space–time coordinates of the particle emission points as well as the difference in average emission points (emission asymmetry) of different particle species.

2. Method

The experimental correlation function is constructed as

\[
C(k^*) = \frac{N(p_a, p_b)}{D(p_a, p_b)}
\]

where \( k^* \) is the momentum of the first particle in the Pair Rest Frame (PRF), \( N(p_a, p_b) \) and \( D(p_a, p_b) \) are the distributions when both particles coming from the same event and from two different events, respectively.

The Koonin-Pratt equation \([1]\) is given by

\[
C(k^*) = \int d\mathbf{r}'|\psi(k^*, \mathbf{r}')|^2 S(\mathbf{r}').
\] (2.1)

where \( \psi(k^*, \mathbf{r}') \) is the pair wave function which contains all the interactions between both particles of pair. The emission point spatial distribution was parametrized by the following functional form:

\[
S(\mathbf{r}) = \exp\left(-\frac{(r_{\text{out}} - \mu_{\text{out}})^2}{R_{\text{out}}^2} - \frac{r_{\text{side}}^2}{R_{\text{side}}^2} - \frac{r_{\text{long}}^2}{R_{\text{long}}^2}\right)
\] (2.2)

where \( R_{\text{out}}, R_{\text{side}} \) and \( R_{\text{long}} \) are three different sizes in Out, Side and Long directions \([2]\), respectively, with the mean value \( \mu_{\text{out}} \) corresponding to the emission asymmetry, \( r_{\text{out}}, r_{\text{side}} \) and \( r_{\text{long}} \) are the components of the relative separation vector \( \mathbf{r} \) of the emission points.

3. Analysis details

The present measurements are based on the study of pion-kaon femtoscopic correlations in Pb–Pb collisions measured at \( \sqrt{s_{NN}} = 2.76 \) TeV by the ALICE detector \([3]\) in 2011. The analysis has been performed for central, semi-central and peripheral collisions determined by the forward V0 detector. The charged tracks were reconstructed using the TPC detector only. Tracks with a transverse momentum within \( 0.19 < p_T < 1.5 \) GeV/\( c \) measured in the pseudo-rapidity range \(|\eta| < 0.8\) are selected. Combined information from TPC and TOF is used to identify charged tracks as pions and kaons. The uncorrelated pair background is constructed by pairing tracks from different events in same trigger class.

4. Results

Using the mentioned source function as in Eq.(2.2), one can numerically integrate Eq.(2.1) with the corresponding wave function (indicating the type of interactions) to calculate the correlation function. The calculated correlation is compared to the measured via a \( \chi^2 \) test. In this work,
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Figure 1: Left: The pion-kaon correlation function for all charge combinations with their fits; Right: Source size (upper panel) and pion-kaon emission asymmetry (lower panel) from pion-kaon correlation functions for Pb−Pb collisions at $\sqrt{s_{\text{NN}}} = 2.76$ TeV as a function of $(dN_{ch}/d\eta)^{1/3}$.

the CorrFit software package [4] was used to perform the numerical fitting described above and extract the experimental $R_{\text{out}}$ and $\mu_{\text{out}}$.

The right plot in Fig. 1 shows the pion-kaon source size and emission asymmetry as a function of the cube root of charged particle multiplicity density in Pb−Pb collisions at $\sqrt{s_{\text{NN}}} = 2.76$ TeV. One observes that the system size and the extracted emission asymmetry increase with event multiplicity. This implies that pions are emitted closer to the centre of the source. The results are compared to the predictions from the Therminator2 model [5] and it was found that an introduction of a time delay of 2.1 fm/c in kaon emission time, the result [6] is in good agreement with the experimental measurement.

5. Conclusion

The first measurements of pion-kaon femtoscopy correlations in Pb−Pb collisions at $\sqrt{s_{\text{NN}}} = 2.76$ TeV have been performed. The radius of the source $R_{\text{out}}$ and an observed finite emission asymmetry show a decreasing trend from central to peripheral collisions. The results are consistent with the Therminator2 coupled with (3+1)D viscous hydrodynamic model calculations of pion-kaon emission asymmetry when an additional time delay of 2.1 fm/c is introduced for the kaons.

References

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