Qualitative comparison of source sizes from $\pi^{-}\Xi$ correlations analyses in d+Au and Au+Au collisions at $\sqrt{s_{NN}}=200$ GeV and $\sqrt{s_{NN}}=62$ GeV is presented. For the most central Au+Au collisions at $\sqrt{s_{NN}}=200$ GeV we report first quantitative results concerning size of the $\pi^{-}\Xi$ source and relative shift of the average emission points between $\pi$ and $\Xi$ showing that the homogeneity region of $\Xi$ source is smaller than that of pion and significantly shifted in the transverse direction.

1. Non-identical particle correlations

Important task in relativistic heavy ions research program carried out at RHIC is to study the space-time evolution of the strongly interacting matter created in the collisions. Measurements of momentum correlations of particles at small relative velocities are used to extract information about space-time extension of the particle-emitting source at the time of kinetic freeze-out. STAR has performed high statistics femtoscopic analyses for a wide variety of different identical and non-identical systems. General conclusion from these measurements is that the space-time structure of the source is strongly affected by collective expansion of the hot and dense matter. Non-identical particle measurements are sensitive not only to the size of the system, but also to an emission asymmetry between different particle species which can arise as a consequence of such an expansion. Since this effect is predicted to increase with a mass difference between the particles, studying correlations in system, such as $\pi^{-}\Xi$, where the mass difference is large, should provide rather sensitive test of transverse expansion of the matter.

2. Data selection and analysis technique

STAR detector is capable of tracking charged particles at full azimuthal coverage in pseudorapidity window of $|\eta| < 1.8$. The particles are identified via specific energy loss ($dE/dx$) in the gas of the main Time Projection Chamber. The detector is thus well suited to topologically reconstruct individual charged $\Xi(\bar{\Xi})$-hyperons using decay chain $\Xi \rightarrow \Lambda + \pi$, and subsequently $\Lambda \rightarrow \pi + p$. The high statistics of data collected by the STAR experiment has allowed to carry out $\pi^{-}\Xi$ femtoscopic
correlation analyses for three different data sets at two different collision energies: d+Au and Au+Au collisions at √sNN=200 GeV, and Au+Au collisions at √sNN=62 GeV.

Standard event mixing technique was used to obtain the π−Ξ correlation function C(k̂), where k̂ = pπ = −pΞ denotes three-momentum of the first particle in the rest frame of the pair. To remove correlations of non-femtoscopic origin the mixed pairs were constructed from events with sufficient proximity in primary vertex position along the beam direction, multiplicity and event plane orientation variables. Pair cuts were used to remove effects of track splitting and merging. The raw correlation function was then corrected for purity of π−Ξ pairs. Pair purity was calculated as a product of purities of both particle species. While Ξ-purity was obtained from reconstructed Ξ invariant mass plot as a function of transverse momentum, the purity of pion sample was estimated from √λ of the standard parametrization of the identical π−π correlation function. In order to take an advantage of already analyzed STAR π−π HBT data, we applied the same cuts to the pion sample as in 6 and used λ parameter from this analysis. The same rapidity selection cut y < |0.5| was also used for Ξ. The particle identification method together with acceptance of the STAR detector allows to reconstruct Ξs at mid-rapidity in the pt range of [0.7, 3.] GeV/c.

In order to further increase the number of pairs in the 200 GeV Au+Au data set cut |y| < 0.8 instead of |y| < 0.5 was employed for both particle species. To use the above described pion purity calculation procedure with new cuts, the π−π HBT analysis was repeated with high statistics data collected by the STAR experiment in RHIC Run IV with the same event centrality and pion cuts as those used in the π−Ξ analysis. The results, presented in Fig. 1 are consistent with previously published STAR π−π HBT analysis extending it to the region of low-kt which was not accessible before. This allows to perform more accurate purity correction in 200 GeV Au+Au data set done individually for each k̂ = (k̂, cosθ, φ) bin of the 3-dimensional correlation function, as explained in section 4.

3. 1D results - source size information

Correlation function in terms of a single variable - |k̂| only - carries information about the size of the emission source. The magnitude of the correlation effect increases with decreasing source size. The results for all analyzed systems are presented in Fig. 2. For all charge combinations the low-k̂ region is dominated by Coulomb interaction. In unlike-sign charge combination peak at k̂ ≈ 150 MeV/c is well visible. Since k̂ is connected directly to invariant mass (Minv) of the pair k̂ = [M2 inv − (mπ − mΞ)2]1/2[(M2 inv − (mπ + mΞ)2)1/2/(2M inv) the peak corresponds to a Ξ∗(1530) resonance. As can be seen (Fig. 2b) the region of the resonance is sensitive to the size of the source, and does not suffer from the low statistics like the Coulomb region. It can therefore be used to compare sizes of sources that would otherwise be impossible to compare via Coulomb part. In Fig. 2(c,d) we com-
\(\pi - \Xi\) correlations in \(d+Au\) and \(Au+Au\) collisions at \(STAR\)

Fig. 1. Parameters of 3D Gaussian fit to the correlation functions of identical charged pions produced in \(Au+Au\) collisions at 200 GeV. Previous (open symbols) and this analysis (full circles) with solid lines showing Blastwave fits. Error bars contain only statistical uncertainties.

4. 3D results - source shift information

The information about shift in the average emission points between \(\pi\) and \(\Xi\) can be extracted from the angular part of the 3D correlation function \(C(\vec{k}^*) = C(k^*, \cos \theta, \varphi)\). Decomposition of the correlation function into spherical harmonics can be used to access such an asymmetry. In Fig. 3 is shown centrality dependence for \(A_{00}\) and \(A_{11}\) coefficients of the spherical decomposition of \(C(\vec{k}^*)\) in the 200 GeV \(Au+Au\) collision. The coefficient \(A_{11}\) which is non-zero in all centrality bins shows that the average space-time emission point of the two particles is not the same. The experimental results for the most central, the highest statistics, bin are compared in Fig. 4 to theoretical predictions using calculation of Coulomb and strong final state interaction (FSI). For this calculation emission coordinates of both particles were generated using Blastwave model with parameters from the...
fit to the $\pi - \pi$ HBT results in Fig. [1]. The same parameters were used for both $\pi$ and $\Xi$ source, thus assuming significant flow of the $\Xi$. The correlation function in Coulomb region is in qualitative agreement with the data - the orientation of the shift and its magnitude agrees with the scenario in which $\Xi$ undergoes transverse expansion. However, the strong final state interaction calculation overpredicts both, $A_{00}$ and $A_{11}$, coefficients.

4.1. **Coulomb fit results**

Due to the discrepancy between the Coulomb and strong interaction region only the low-$k^*$, Coulomb dominated, part of the $C(k^*)$ was selected for fitting, excluding the region of the $\Xi^*$ peak. The same Gaussian parametrization as in previous STAR non-identical correlation analysis[3] was assumed to describe separation distribution $r^*$ in the pair rest frame. Two free parameters are then the Gaussian radius

$$
\sigma = \sigma_{r_{out}}^* = \sigma_{r_{side}}^* = \sigma_{r_{long}}^*
$$

and the mean (\Delta r_{out}^*) = \langle r_{out}^*(\pi) - r_{out}^*(\Xi) \rangle which is re-

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**Fig. 2.** Top: The centrality dependence of the correlation function in Au+Au collisions at $\sqrt{s_{NN}}=200$ GeV of (a) like-sign and (b) unlike-sign $\pi - \Xi$ pairs. Bottom: (c) Comparison of unlike-sign correlation function for mid-peripheral events at $\sqrt{s_{NN}}=200$ GeV and 62 GeV. (d) Correlation function for peripheral Au+Au and minimum bias d+Au at the same collision energy $\sqrt{s_{NN}}=200$ GeV.
\( \pi - \Xi \) correlations in \( d+Au \) and \( Au+Au \) collisions at STAR

Fig. 3. \( A_{00}(k^*) \) and \( A_{11}(k^*) \) coefficients of spherical decomposition of \( C(k^*) \) for (left) unlike-sign and (right) like-sign \( \pi - \Xi \) pairs from three different centrality bins in 200 GeV \( Au+Au \) collision.

related to the shift in the average emission points of the two particle species. The theoretical correlation function was calculated using momenta of pairs extracted from the real data. Emission coordinates were randomly generated using our two-parameter source description. Values of the source parameters were extracted by finding a minimum value of \( \chi^2 \) between calculated and real correlation function. Fitting was performed simultaneously for both like and unlike-sign correlation functions. For most central \( Au+Au \) collision at 200GeV, see Fig. 3 this method yields \( \sigma = (6.7 \pm 1.0) \) fm, \( \langle \Delta r_{out}^* \rangle = (-5.6 \pm 1.0) \) fm. The errors are purely statistical. Systematic error studies are under way and their values are expected to be of the order of the statistical ones. Note, that the size of the Gaussian radius is approximately equal to the size of the pion source itself, showing that homogeneity region of \( \Xi \) source is smaller than that of pions. The negative value of the shift means that \( \Xi \) average emission point is positioned more to the outside of the whole fire-ball than the average emission point of pions. Both these results are consistent with a scenario in which \( \Xi \) takes part in the rapid transverse expansion of the system.

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Fig. 4. Comparison of $A_{00}(k^*)$ and $A_{11}(k^*)$ coefficients from 10% most central 200 GeV Au+Au collisions with the FSI model predictions.

Fig. 5. Fit of the low-$k^*$ part of correlation function in the most central 200 GeV Au+Au data using Coulomb interaction only.

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