STAR results of pion-proton femtoscopy in spherical harmonics

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Abstract

Correlations between non-identical particles at small relative velocity probe asymmetries in the average space-time emission points at freezeout[1]. Such asymmetries may arise from long-lived resonances, bulk collective effects, or differences in the freezeout scenario for the different particle species. STAR has extracted pion-proton correlation functions from a high-statistics dataset of Au+Au collisions at $\sqrt{s_{NN}}$=200GeV. We present femtoscopic analysis using spherical-harmonics decomposition of this data for all charge combinations of pions and protons, for collisions of different centrality.

Introduction:

Traditional cartesian "Bertsh-Pratt" parametrization of the correlation function in k^*_{out}, k^*_{side} and k^*_{long} can be replaced by spherical harmonics representation where information about shapes and space-time asymmetries of the pair separation distributions are encoded most efficiently[2]. In spherical harmonics C^0_0 functions give information about overall size and the real C^1_1 component gives information about asymmetry. Presented correlation functions have been calculated directly in spherical harmonics using the method described in [3].

Data selection and analysis:

Au+Au collisions at $\sqrt{s_{NN}}$=200GeV (*year 4*)

Three centrality groups:
- central: 0-10%
- mid-central: 10-30%
- intermediate: 30-50%

Vertex position |z|<30cm

Particle identification based on dE/dx from Time Projection Chamber.

pions – p and p_T: 0.1-0.5 GeV/c

protons p and p_T: 0.5-1.25 GeV/c

Particles selected in mid-rapidity region |y|<0.7

So different ranges of p_T cuts for pions and protons (big difference between masses) are determined by the fact that in this analysis we need to correlate particles with similar velocities.

To ensure high quality of data samples, a pair topological cut is applied to remove correlated electron-positron pairs coming from gamma conversion. We also remove pairs with merged hits and pairs with low probability of being pion-proton pair.

Events with similar vertex position, multiplicity and event mean p_T are used to form mixed pair reference.

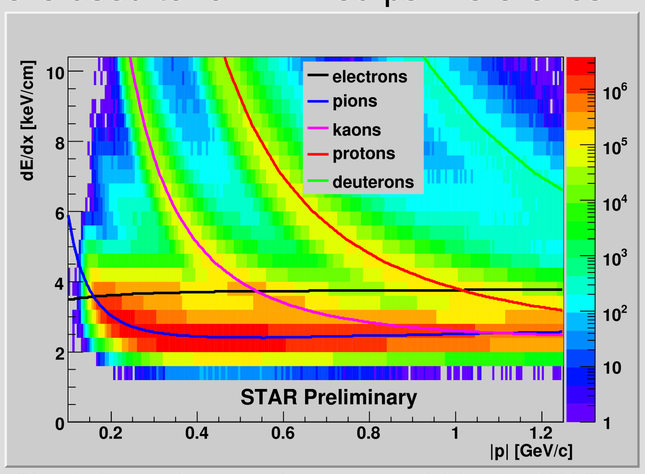

Fig. 1. Rate of energy loss versus |p| in the STAR Time Projection Chamber.

Probability of selecting electron-positron pairs is significantly increased by the fact that both pions and protons are selected from the regions where their dE/dx curves intersect with electron dE/dx.

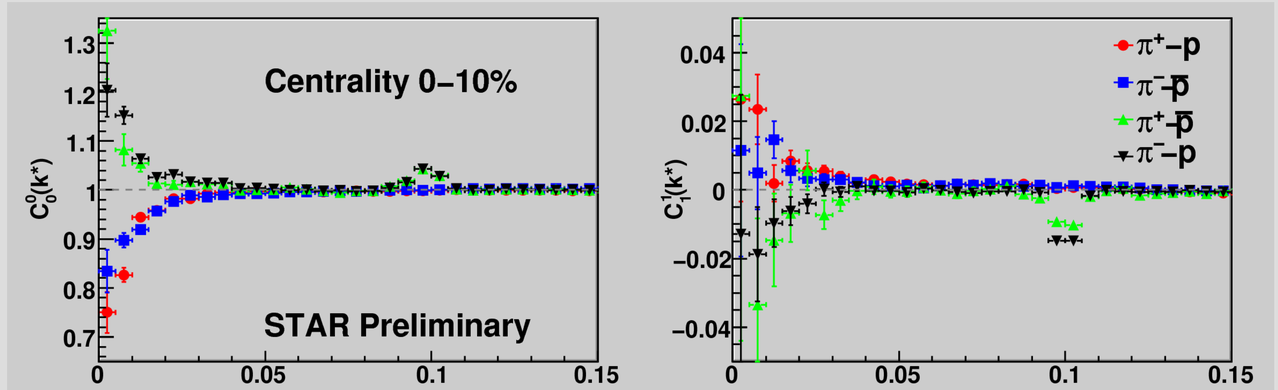

Fig. 2. Pion-proton correlation function in spherical harmonics for central events for all charge combinations. Left panel C^0_0 component, right panel real C^1_1 component.

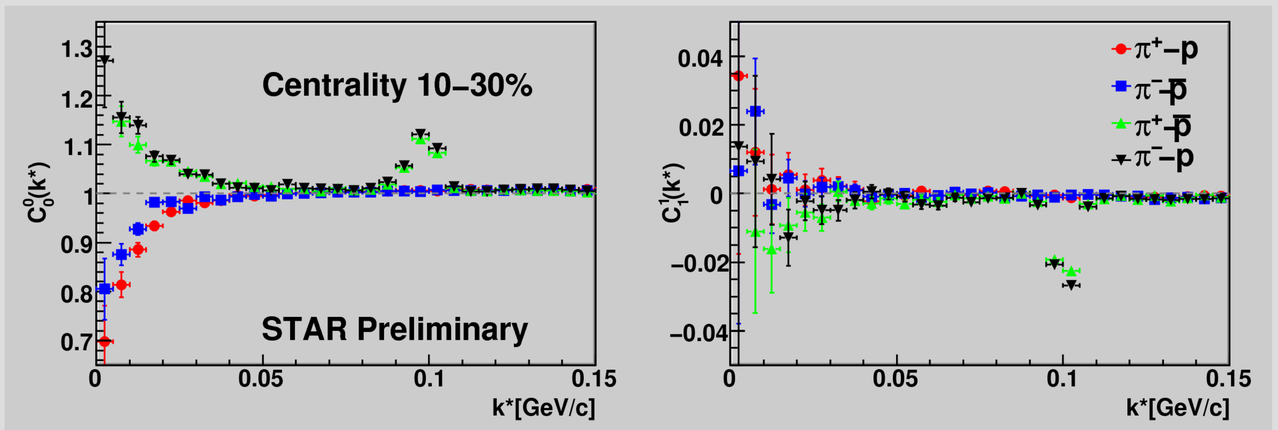

Fig. 3. Pion-proton correlation function in spherical harmonics for mid-central (10-30%) events for all charge combinations. Left panel C^0_0 component, right panel real C^1_1 component.

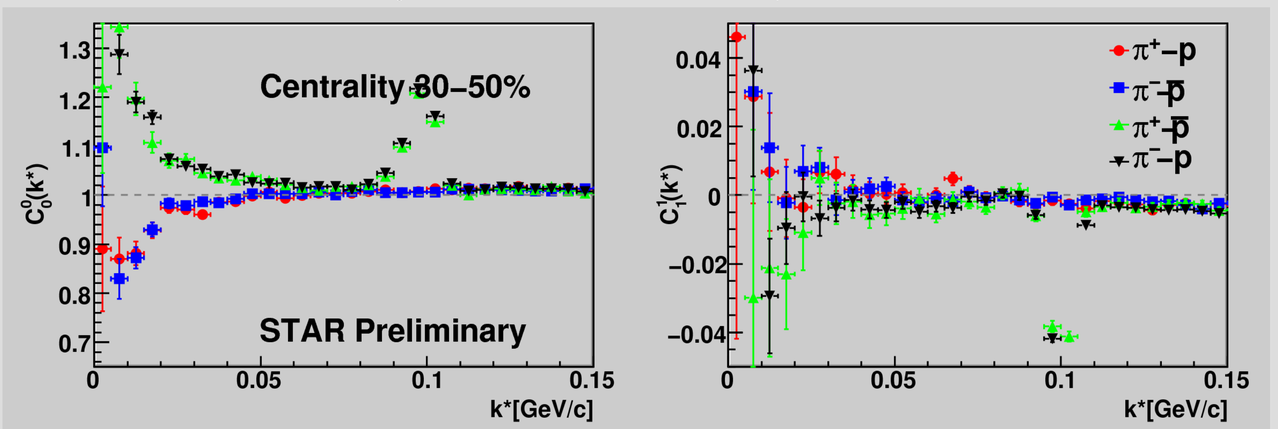

Fig. 4. Pion-proton correlation function in spherical harmonics for intermediate (30-50%) events for all charge combinations. Left panel C^0_0 component, right panel real C^1_1 component.

Conclusion:

Results for pion-proton femtoscopy in STAR are consistent between different charge sign combinations. Overall size represented by C^0_0 components of correlation functions show slight dependence on centrality. Size of the source is biggest for central collisions. Real C^1_1 parts of the correlation functions show space-time asymmetry between average emission point of pions and (anti-)protons. Emission points of pions are distributed over almost the whole source and average emission points of protons are shifted towards outside of the source.

References:

[1] R. Lednicky, V.L. Lyuboshitz, B. Erazmus, D. Nouais; Phys. Lett. B 373, 30 (1996).
[2] Z. Chajęcki, M. Lisa; Phys. Rev. C 78, 064903 (2008)
[3] A. Kisiel, D.A. Brown; arXiv:0901.3527v1 [nucl-th].