Investigation of two-particle correlations in p+^{93}Nb collisions at $\mathbf{E_{kin}} = 3.5\,\mathbf{GeV}^*$

O. Arnold[1,2], *L. Fabbietti*[1,2] *for the HADES collaboration*

[1]Physik Department E12, Technische Universität München, James-Franck-Str. 1, 85748 Garching, Germany;
[2]Excellence Cluster 'Origin and Structure of the Universe', Boltzmannstr. 2, 85748 Garching, Germany

With the HADES setup the reaction p+^{93}Nb was measured in September 2008, where the proton had a kinetic energy of $3.5\ \mathrm{GeV}$ ($\sqrt{s}_{\mathrm{NN}} = 3.18\ \mathrm{GeV}$). This rather moderate energy gives us the possibility to study the production and interaction of particles at small excess energies.

Studying two-particle correlation functions at small relative momenta provide information about the spatio-temporal extent of the particle emitting source. Originally, the formalism of intensity interferometry was developed for astrophysical investigations to measure the angular size of stars [1]. Nowadays, the technique is mainly applied in the field of heavy-ion physics to gain information about the highly excited matter state and its properties created during the collision of the two nuclei.

The basic idea of femtoscopy is to deduce effects of final state interactions (FSI) from phase-space correlations of emitted particles. In low energy p+A systems we expect no contributions from collective effects to the particle emission like flow or energetic jets. Because of this reason, we are in the position to study only FSI of different particle species and do not have to consider effects from physical non-femtoscopic sources.

FSI can be studied with correlation functions, which are defined as the ratio of the two-particle probability divided by the uncorrelated probabilities:

$$C(\mathbf{p}_1, \mathbf{p}_2) = \frac{P(\mathbf{p}_1, \mathbf{p}_2)}{P(\mathbf{p}_1)P(\mathbf{p}_2)}, \qquad (1)$$

where $\mathbf{p}_i$ is the single-particle momentum of the particle i. Whenever this ratio deviates from unity one measures particle correlations.

We started to study the correlation function between identical particles to have a benchmark for more complex correlation functions like p-Λ [2]. This would enable a study of the YN interaction in terms of scattering lengths. For protons, three correlation classes enter in Eq. (1): quantum statistics, Coulomb and strong interaction. The Pauli exclusion principle and Coulomb interaction both act repulsively between protons which shows up in the correlation function as a suppression of the correlation signal at very low relative momenta ($k < 10\,\mathrm{MeV/c}$). The attractive strong interaction acts mainly via the s-wave channel and leads to an enhancement of the correlation signal at around $k \approx 20\,\mathrm{MeV/c}$. The height of the correlation peak ($C(k = 20\ \mathrm{MeV/c})$) is inversely proportional to the length of homogeneity R_G (often called source size) which will be deduced in future work. Fig. 1 displays the preliminary result of proton-proton correlations measured in the p+Nb system, which shows the characteristic functional shape as discussed above.

For identical negative pions one expects a positive correlation signal at small relative momenta due to Bose-Einstein statistics, which leads to an attraction as is seen in Fig. 1 where the correlation function shows an increase at low k and stays positive. However, this signal is still distorted by the repulsive Coulomb interaction. For pions, one can correct this effect by folding the Coulomb wave function with a source parametrization. This correction will be part of our future work.

To summarize, we have reconstructed the correlation function for protons and negative pions. In the next step, we have to correct this functions for certain detector deficiencies and will then compare them to theoretical models. For the p-Λ correlation function we determined the number of Λs which can be used for the correlation study to about 5×10^5 with a signal-to-background ratio of 1.23.

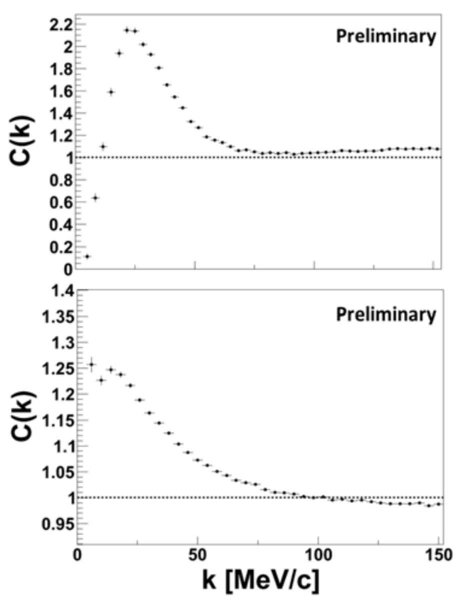

Figure 1: Proton-proton (upper) and $\pi^-\pi^-$ (lower) correlation function.

* Work supported by Helmholtz funds VH-NG-330 and Excellence Cluster 'Universe'

References

[1] R. Hanbury Brown and R. Q. Twiss, Nature 178, 1046 (1956).

[2] F. Wang and S. Pratt, Phys. Rev. Lett. 83, 3138 (1999).

doi:10.15120/GR-2014-1-NQM-HADES-01