Warsaw University of Technology
Faculty of Physics

Same sign pion femtoscopy in AgAg beam in the HADES Experiment

Autor:
Anna Kodym
for **HADES** Collaboration

Afiliations:

Warsaw University of Technology,
Faculty of Physics
HADES Collaboration

Presented work focuses on femtoscopic analysis of same sign charged mesons pi in Ag-Ag beam at $\sqrt{S_{NN}}$ = 2.55 GeV measured in HADES detector placed in GSI Helmholtzzentrum for Heavy Ion Research. Analysis was performed in one- and three-dimensional cases. As a results space-time emission source parametrization was obtained.

Motivation

Correlation femtoscopy is a tool for probing the short-lived fireball formed in heavy-ion collisions.
Fireball exists for only a fraction of a second but mimics conditions of high net-baryon-density nuclear matter (e.g., in neutron stars or neutron-star mergers).
Correlation analysis provides space–time emission source parameters, such as:

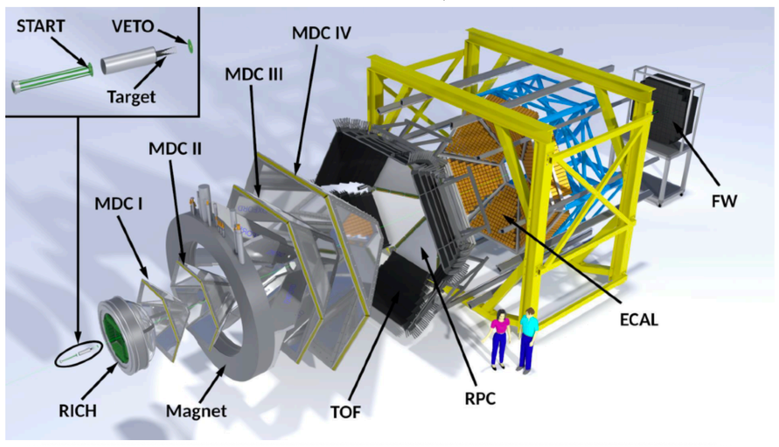
- Source radii
- Coherence factor

Two source parametrization were used:

- One dimensional (q_{inv})
- Three dimensional ($q_{out}, q_{side}, q_{long}$)

HADES Detector

High Acceptance Di-Electron Spectrometer, placed in GSI Helmholtzzentrum for Heavy Ion Research in Darmstadt-Wixhausen, Germany. It enables to study atomic collisions with energy at $\sqrt{S_{NN}}$ = 2-3 GeV.



Femtoscopy

Correlation femtoscopy bases on Koonin-Pratt equation:

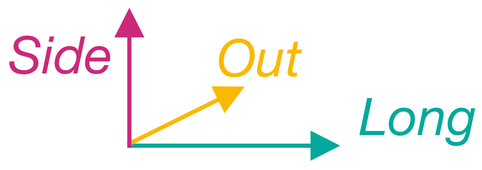
$$C(q) = \int S(r)\,|\psi(q,r)|^2 d^3r = \frac{Sgnl(q)}{Bckg(q)}$$

Where:

- $C(q)$ is correlation function
- $S(r)$ is source function - effect of analysis
- $\psi(q,r)$ is two-particle wavefunction obtained from quantum mechanics
- $Sgnl(q)$ - signal function made from pairs from same events
- $Bckg(q)$ - background function made from pairs of particles from different but similar events

One dimensional case use q_{inv} which is two particles momentum difference.
Three dimensional case use out, parametrization in longitudinal co-moving system (LCMS - total momentum along beam axis equals zero). Directions:

- Long is in beam direction
- Out is the same as pair transverse momentum
- Side is perpendicular to long

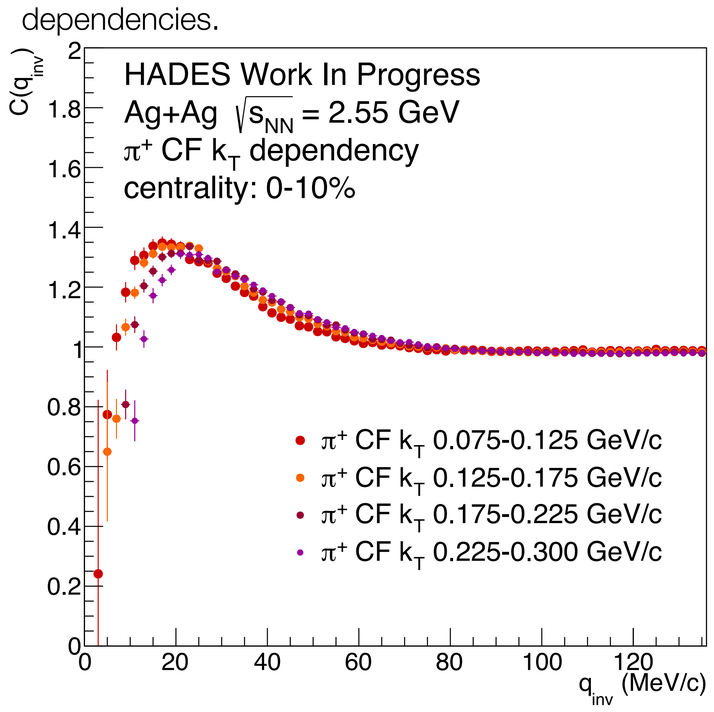


One dimensional analysis

Analysis was performed in bins for:

- centrality:
  - 0-10%, 10-20%, 20-30% and 30-40%
- k_T:
  - 0.075-0.125 GeV/c, 0.125-0.175 GeV/c, 0.175-0.225 GeV/c and 0.225-0.300 GeV/c.

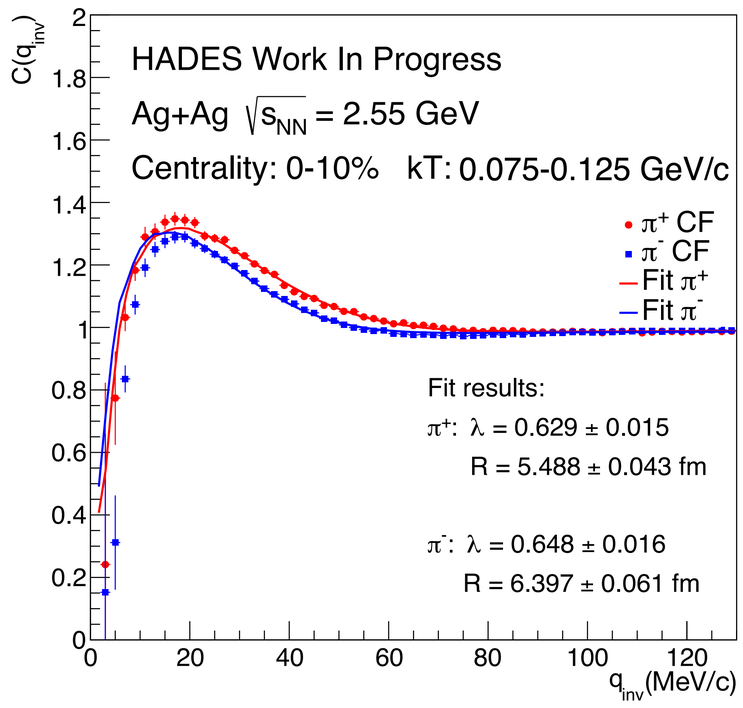
Source radii trends were observed in both dependencies.



Functions fitted using Bowler-Sinyukov formula:

$$C(q_{inv}) = (1-\lambda_{inv}) + \lambda_{inv} K_C(q_{inv}, r_{inv}) e^{-(q_{inv} r_{inv})^2}$$

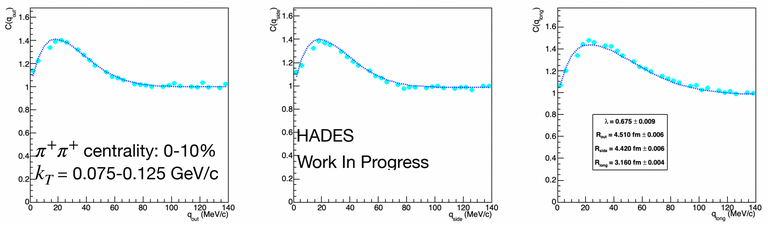
Where K_C is Coulomb function (generated using Daniel Wielanek's HAL framework).
This formula describes correlation function covering all q range.



Three dimensional analysis

Three dimensional correlation functions were fitted with three dimensional version of Bowler-Sinyukov function.
To visualise it was projected onto each axis with other values summed up to 10 MeV/c.

$$C(q_{out}, q_{side}, q_{long}) = (1-\lambda_{osl}) + \lambda_{osl} K_C(q, R_{inv})$$
$$(1 + e^{-(q_{out}R_{out})^2 - (q_{side}R_{side})^2 - (q_{long}R_{long})^2})$$

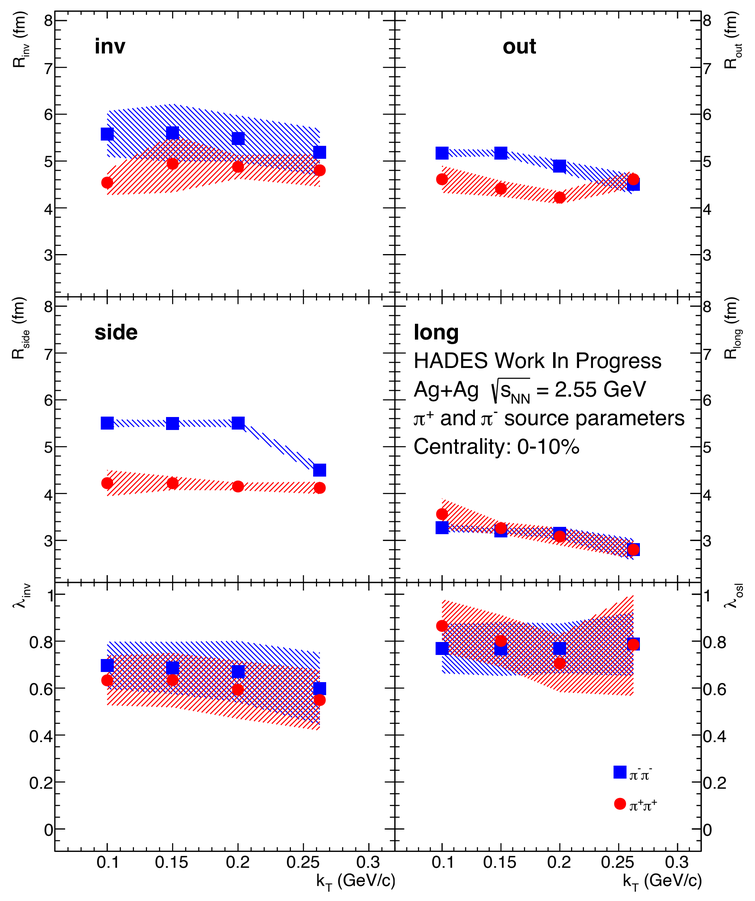


Results - source parametrization

Data corrected for detector effects:

- Splitting
- Merging
- Momentum resolution

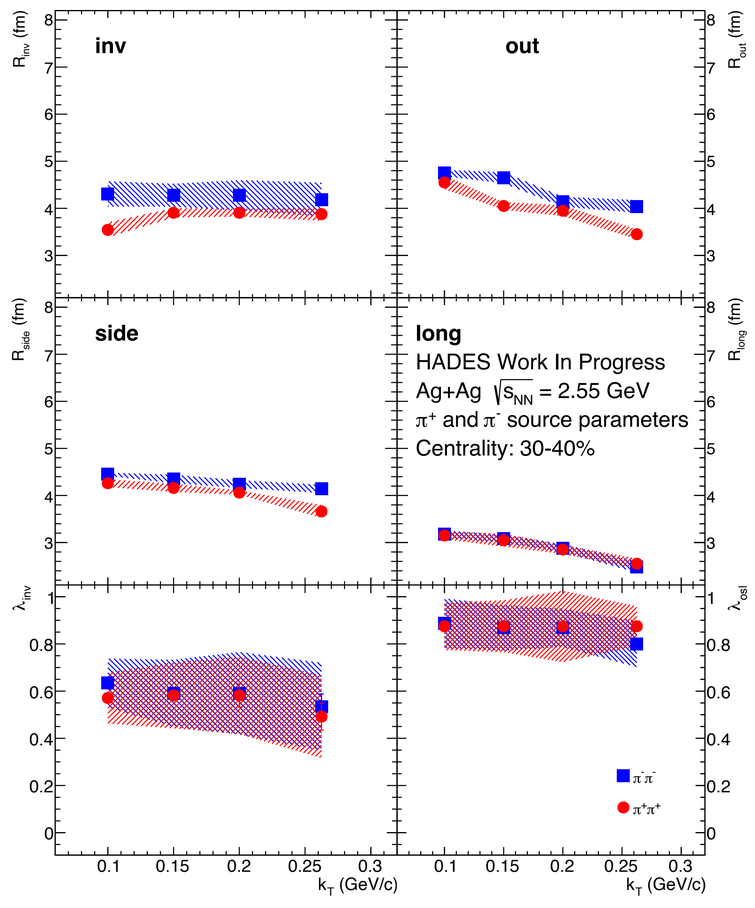
Observed slightly decreasing radii with increasing k_T while λ parameters stay similar.



In three dimensional case:

- R_{out}, R_{side} are quite similar (also to R_{inv})
- R_{long} is almost two-times smaller

Fixed-target experiment results in shortened length of homogeneity alongside beam direction.



Conclusions:

- Decreasing source radii with growing transverse momentum and more peripheral collisions
- Bowler-Sinyukov formula enables fitting in all q region, including low q with coulomb forces input

Plans for future

Study impact of Coulomb interactions from collision remnants and impact on correlation function

anna.kodym.stud@pw.edu.pl