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Bjorken expansion with gradual freeze out via HBT

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Introduction

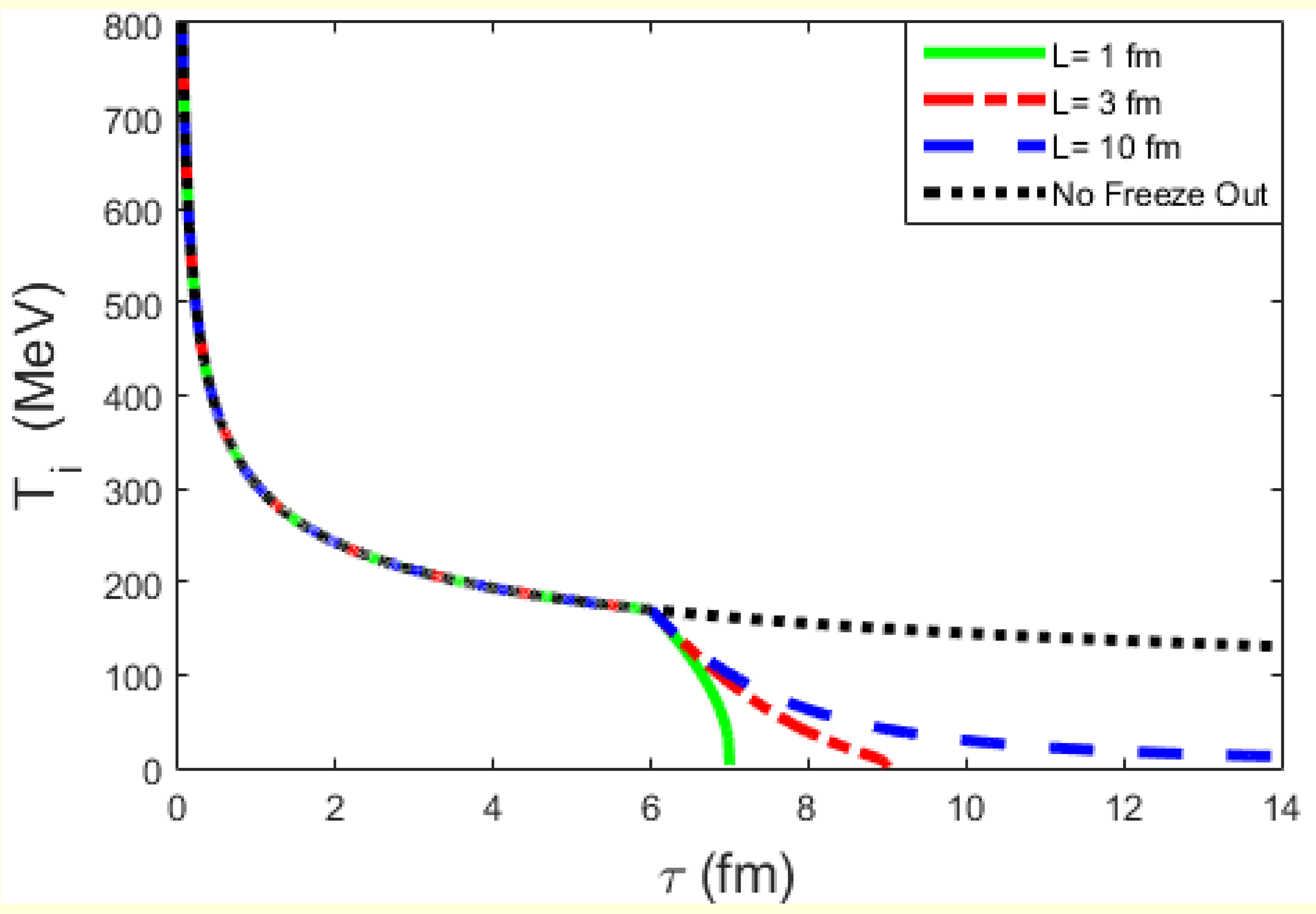
- Models with continuous freeze out in a finite-size layer yield single-particle momentum distributions with little dependence on the layer thickness[1].
- Going to two-particle distributions, correlations from the HBT effect will allow us to distinguish between long or short freeze out. We will perform our calculations for Pb+Pb collisions using Bjorken expansion for a gas of pions described by a Jüttner distribution.

Temperature Evolution

Temperature falls down due to system expansion until it reaches the freeze out temperature, then the system starts to cool down much faster due to both Bjorken-like expansion and freeze out. (One can express this evolution as follows (where $a = \frac{m}{T_i}$)):

$$\frac{dT_i}{d\tau} = -\frac{T_i}{\tau}\frac{4T_i^2K_2(a) + mT_iK_1(a)}{12T_i^2K_2(a) + 5mT_iK_1(a) + m^2K_0(a)} - \frac{T_i}{\tau_{FO}}\frac{L}{L+\tau_1-\tau}\frac{3T_i^2K_2(a) + mT_iK_1(a)}{12T_i^2K_2(a) + 5mT_iK_1(a) + m^2K_o(a)}$$

Depending on the freeze out thickness (L), this decrease could be very pronounced or not, as can be seen in the figure below.



We set freeze out to start at 6 fm and, as can be seen, temperature falls very quickly for thin freeze out layer but not that quick for long freeze out. We also added an only expansion line to show the temperature decrease due to expansion.

Conclusions

- Two-pion interferometry is a powerful method for extracting information about the space-time evolution of the particle source in heavy ion collisions. We calculated the pion correlation function using a model that allows us to vary the freeze out length. Such correlations allow us to distinguish between long and short freeze out since they appear to be sensitive to its thickness.
- We performed calculations for ALICE data and found a good agreement, at least qualitatively, and experimental averaged correlation functions appear to be more similar to that for long freeze out rather than sharp freeze out.

Correlation Function

- HBT is an effect that measures the correlation or anticorrelation of the intensities received by two detectors characterized by correlation function $C(q_{out}, q_{side}, q_{long})$. From this correlation function one can get information about space-time evolution of the emission source.
- To compare with data we need to apply experimental cuts. To simulate ALICE data we used: 0.6 < K_T < 0.7 GeV and -33 < $q_{out,side,long}$< 33 MeV.

Results

- Our results are also in qualitative agreement with the other kinetic continuous freeze out models[3].
- As can be seen in the figures below, the correlation function shows a clear dependence on the freeze out layer thickness and it becomes lower and narrower as the freeze out length increases.

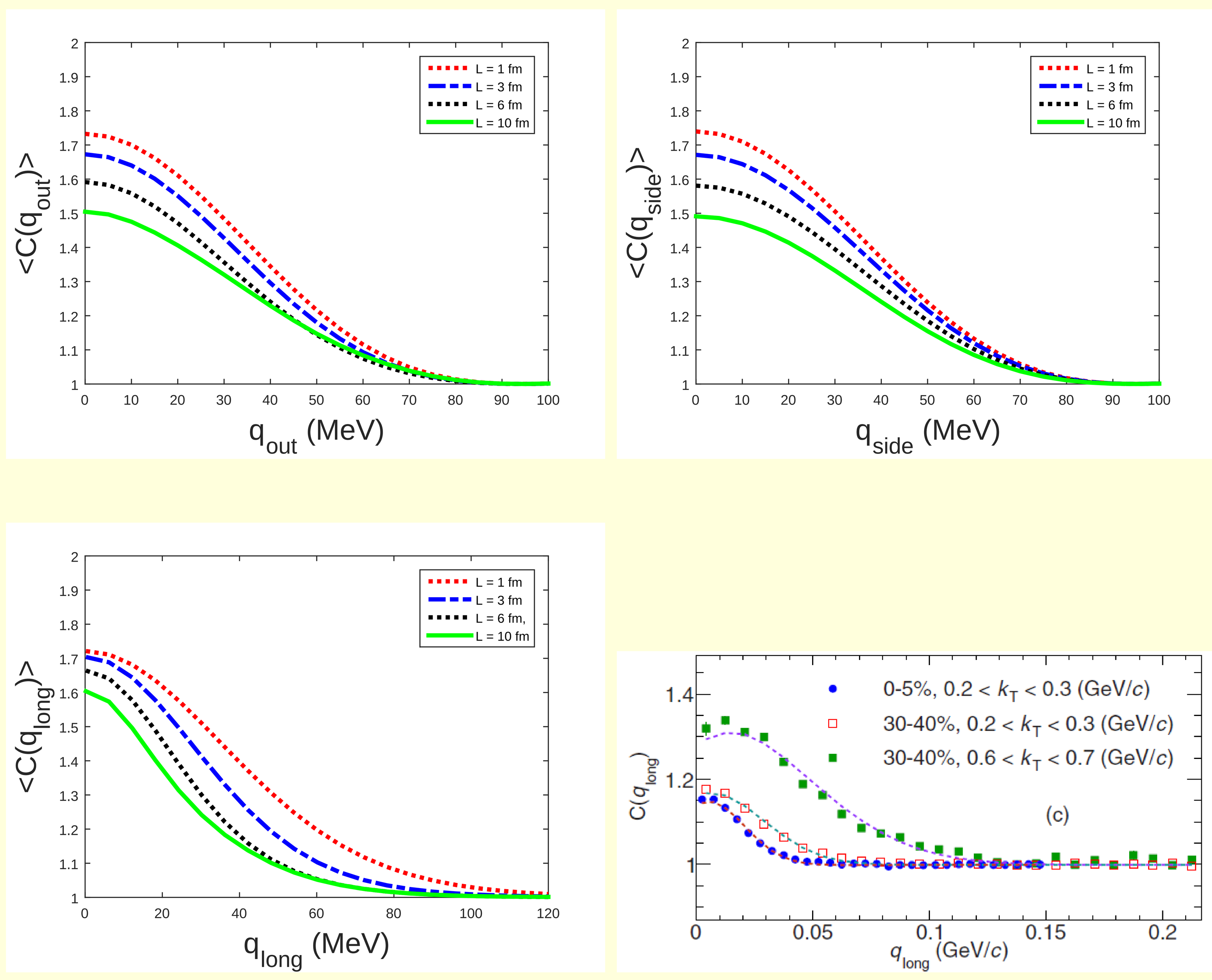


Figure 1: Averaged correlation function for differente freeze out layers (upper right and left and bottom left) and ALICE results[2] (bottom right).

- Our simulation for L = 10fm is in qualitative agreement with experimental points corresponding to Pb+Pb collisions at $\sqrt{S_{NN}}$=2.76 TeV, 30-40 % of centrality and 0.6 < K_T < 0.7 GeV. So, we can argue that the ALICE data seems to prefer longer freeze out rather than a short one.

References

[1] V. K. Magas and L. P. Csernai, Phys. Lett. B **663** (2008) 191.
[2] J. Adam *et al.* [ALICE Collaboration],Phys. Rev. C **93** (2016) 024905.
[3] F. Grassi et al., Phys. Rev. C **93** (2000) 044904.

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