Freeze out densities of spectators in Au+Au collisions

C. Schwarz and S. Fritz for the ALADIN collaboration

Expansion is a rather basic conceptual feature of the multifragmentation of heavy nuclei. In central collisions of heavy nuclei, rapid expansion is evident from the observation of radial collective flow. For the fragment decay of spectators following collisions at relativistic energies, the case studied in this report, significant radial flow has not been observed [1]. Here evidence for expansion has been obtained, indirectly, from model comparisons. Interferometry-type methods permit experimental determinations of the breakup volume or, more precisely, of the space-time locations of the last collisions of the emitted products. In the nuclear regime correlation functions for light charged particles, in particular proton-proton correlations, have been widely explored for that purpose. Both time scales and breakup radii have been inferred from the data, depending on the reaction scenario and energy regime. For the present case of spectator decays at relativistic energies the time scales should be rather short, and the correlation functions should be sensitive to the spatial extension of the source.

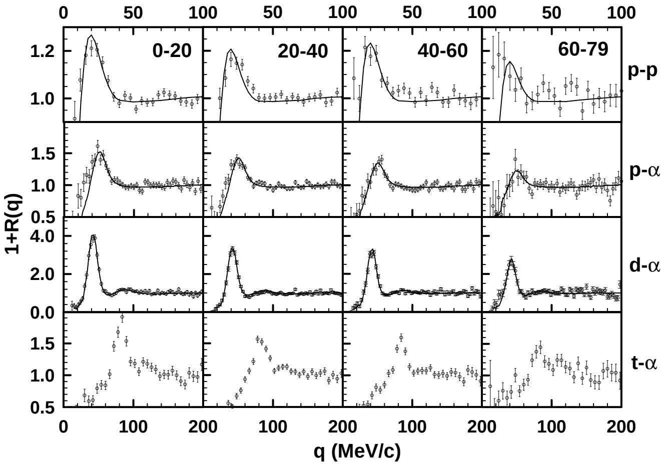

Figure 1: Correlation functions for p-p, p-^{4}He, d-^{4}He, and t-^{4}He, sorted into four bins of Z_{bound}. The lines represent best results of calculations (see text) accounting for geometrical acceptance, energy resolution, and angular straggling in the target.

We present the results of correlation measurements for spectator decays following collisions of ^{197}Au + ^{197}Au at a bombarding energy of 1000 AMeV. Two multi-detector hodoscopes, consisting of a total of 160 Si-CsI(Tl) telescopes in closely-packed geometry, were placed on opposite sides with respect to the beam axis. The angular range θ_{lab} from 122° to 156° was chosen with the aim of selectively detecting the products of the target-spectator decay [4]. The products of the projectile decay were measured with the time-of-flight wall of the ALADIN spectrometer [1] and the quantity Z_{bound} as a measure for the impact parameter was determined event-by-event. Correlation functions constructed for the four types of coincidences p-p, p-^{4}He, d-^{4}He, and t-^{4}He are shown in Fig. 1, sorted into four bins of Z_{bound} as indicated. The uncorrelated yields were obtained with the technique of event-mixing and normalized in the range of large relative momenta $q \geq 70$ MeV/c (p-p) and $q \geq 150$ MeV/c (p-α, d-α, and t-α), respectively. The off-line thresholds were set at $E_{lab} \geq 20$ MeV for all particles p, d, t, and α and all hodoscope detectors in order to suppress distortions from sequential side feeding. The analysis of the p-p correlation functions was performed with the Koonin-Pratt formalism [2] in the zero-lifetime limit. For the p-α and d-α correlation functions we determined breakup radii by comparing to the numerical results of Boal and Shillcock [3]. While the radii turn out to be fairly invariant, the derived densities decrease considerably with increasing centrality. This is caused by the changing number of spectator constituents. The mean relative density decreases from $\rho/\rho_0 = 0.4$ for the peripheral collisions to values below $\rho/\rho_0 = 0.1$ for the most central bin with the smallest Z_{bound} (Fig. 2). The deduced values compare well with the densities assumed in the statistical multifragmentation model. The variation with centrality is similar to that resulting from using a fixed cracking distance as criterion for the placement of fragments inside the breakup volume [5].

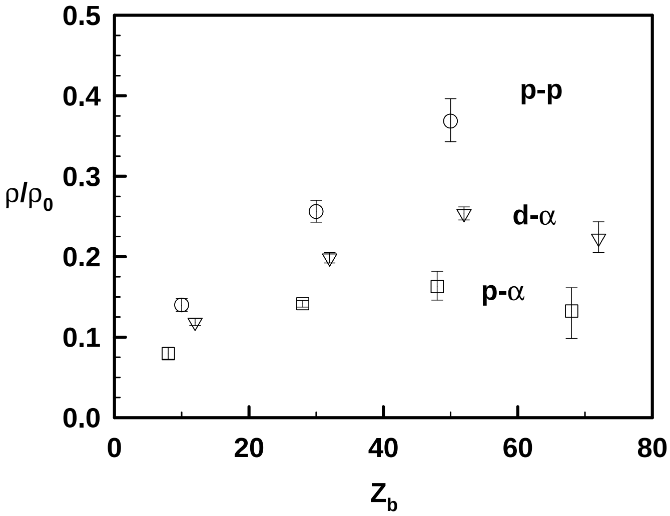

Figure 2: Freeze-out densities from pp- (circles), pα- (squares), and dα-correlation functions (triangles) for different Z_{bound} bins.

References

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[4] S. Fritz, thesis, Frankfurt University 1998, http://www-kp3.gsi.de/www/kp3/kp3_phd.html
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