Emission temperatures and freeze out densities from light particle correlations in Au+Au collisions at 1 A·GeV

S.Fritz for the ALADiN collaboration

In our latest experiment we compared the isotope thermometer T_{HeLi} ([1]) with temperatures derived from the relative yields of excited states in order to explore the liquid-gas phase transition of nuclear matter. We measured the system Au+Au at 1 A·GeV. The idea was to compare the isotope thermometer with temperatures from particle unbound states rather than deriving this calibration from theoretical calculations. Additionally extracted radii and freeze out densities from pp correlations are presented in order to explore the density dependence of the temperature determination.

We extracted the temperatures from the populations of ground and excited states in unstable ^{5}Li, ^{8}Be and ^{4}He fragments. The three analyzed thermometers yield consistently constant temperatures, T≈ 6 MeV, independent of impact parameter and hence excitation energy (figure 1). The relative differences between the different thermometers from particle unstable excited states are within statistical accuracy of this experiment. The temperature is somewhat higher than in experiments which measure the temperature of the midrapidity source in intermediate energy collisions (see for example [4]). On the other hand, the extracted temperatures from the excited states are in contradiction to the temperatures which were derived from the relative isotope ratios of Helium and Lithium (open symbols in figure 1 and GSI Scientific report 1994, frontpage and 1995, p.36). The discrepancy between the two different temperature measurements may come from strong feeding which according to dedicated calculations ([6]) brings the excited state thermometers into saturation above 5 MeV.

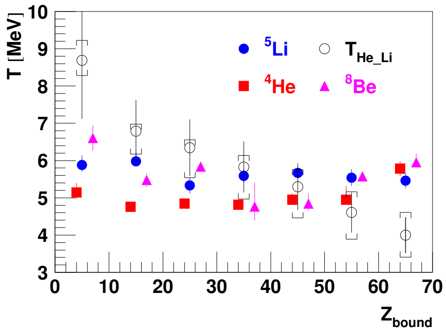

Figure 1: Temperatures from excited states for different thermometers vs Z_{bound} and comparison with Albergo thermometers ([2]) from the target spectator (without correction factor) — Only the systematic errors are shown for the excited state thermometers

For pp, $p\alpha$, and $d\alpha$ correlations no dependence of the peak height was found when varying the centrality of the reaction. When increasing the summed energy of the two particles the peak height increases (Fig. 2). The increase in peak height results in smaller extracted freeze out radii according to [5]. This may be interpreted as a signal for expansion.

From the known number of particles of the prefragment ([3]) and the fitted radii according to the Koonin–Pratt–formalism [5] we extracted mean freeze out densities (Fig. 3).

The apparent discrepancy of the two different methods of temperature measurement could be partly explained by the decreasing density for increasing centrality. According to a QSM model ([7]) the excited state thermometers are only weakly dependent on the freeze out density while the apparent temperature T_{HeLi} increases with decreasing density. The density dependent correction factor is 1.2 for the most peripheral and decreases to 1 for the most central collisions.

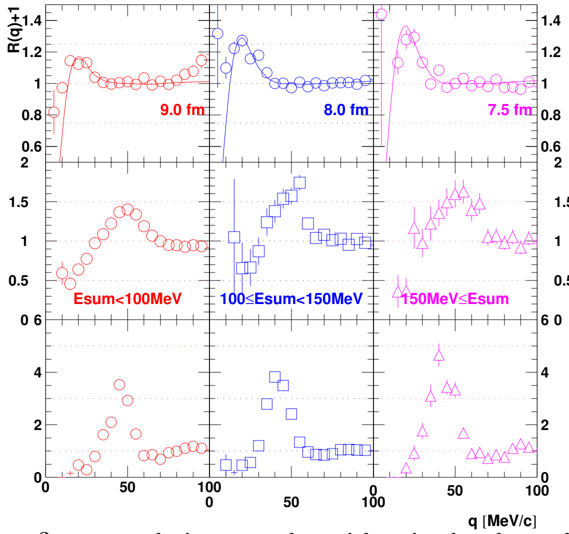

Figure 2: pp correlations together with a simulated correlation function from the Koonin–Pratt formalism (Upper row), $p\alpha$ correlation function (Middle row) and $d\alpha$ correlation function (Lower row) for three different cuts in summed energy

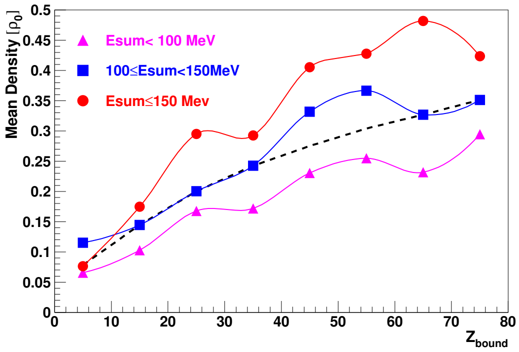

Figure 3: Extracted mean freeze out densities vs Z_{bound} from pp correlations for $\tau = 0$ fm/c

References

[1] J. Pochodzalla et al., Phys. Rev. Let. 75 (1995) 1040

[2] S. Albergo et al., Il Nuovo Cimento 89A (1985) 1

[3] C. Groß, PhD thesis, J.W.Goethe–Universität Frankfurt, 1997 (unpublished) and this report.

[4] C. Schwarz et al., Phys. Rev. C48 (1993) 676

[5] S.E. Koonin, Phys. Let.70B (1977) 43

[6] H. Xi et al., MSUCL-1040 (1996)

[7] D. Hahn and H. Stöcker, Nucl. Phys. A476 (1988) 718