Statistical Model Predictions for Particle Ratios at $\sqrt{s_{NN}}$ = 5.5 TeV

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The Statistical Model has described very successfully particle ratios measured in heavy ion collisions over a wide range of center of mass energies [1]. The extracted chemical freeze-out conditions, the temperature T and the baryon chemical potential μ_B, drawn in the QCD phase diagram, appear on a common curve [2]. The extrapolation of this curve according to the parametrisation given in [3] results in $\mu_B(\sqrt{s_{NN}}$ = 5.5 TeV) ≈ 1 MeV. The temperature T = 170 MeV was chosen in accordance with the chemical freeze-out temperatures at the top SPS and RHIC energies [1]. Predictions for different particle ratios are displayed in Table 1.

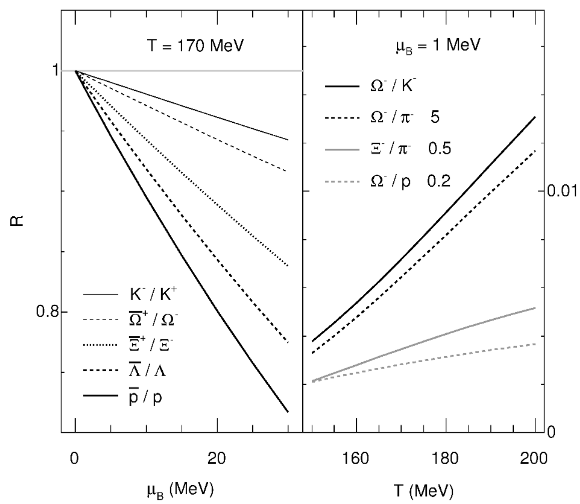

Figure 1: Antiparticle/particle ratios R as a function of μ_B for T = 170 MeV (left). The horizontal line at 1 is meant to guide the eye. Particle ratios R involving hyperons as a function of T for μ_B = 1 MeV (right). The calculations were carried out with the THERMUS package [4] in the grand canonical ensemble.

Table 1: Particle ratios in Pb+Pb collisions at freeze-out conditions expected at the LHC: T = (170±5) MeV and $\mu_B = 1^{+4}_{-1}$ MeV. The given errors correspond to the variation in the thermal parameters. Taken from [5].

$\bar{h}$/h Ratio		mixed Ratio	
π^+/π^-	$0.9998^{+0.0002}_{-0.0010}$	K^+/π^+	$0.180^{+0.001}_{-0.001}$
K^+/K^-	$1.002^{+0.008}_{-0.002}$	K^-/π^-	$0.179^{+0.001}_{-0.001}$
$\bar{p}/p$	$0.989^{+0.011}_{-0.045}$	p/π^-	$0.091^{+0.009}_{-0.007}$
$\bar{\Lambda}/\Lambda$	$0.992^{+0.009}_{-0.036}$	Λ/p	$0.473^{+0.004}_{-0.006}$
$\bar{\Xi}^+/\Xi^-$	$0.994^{+0.006}_{-0.026}$	Ξ^-/Λ	$0.160^{+0.002}_{-0.003}$
$\bar{\Omega}^+/\Omega^-$	$0.997^{+0.003}_{-0.015}$	Ω^-/Ξ^-	$0.186^{+0.008}_{-0.009}$

The ability to determine the freeze-out parameters experimentally is deduced from the sensitivity of well suited particle ratios on T and μ_B. Figure 1 (left) shows different antiparticle/particle ratios, $\bar{h}/h$ in dependence on μ_B. The decrease of the $\bar{h}/h$ ratios with increasing μ_B can be understood qualitatively from

$$\bar{h}/h \propto \exp[2(N_B\mu_B + N_S\mu_S)/T], \qquad (1)$$

with baryon number N_B and strangeness quantum number N_S of the antiparticle, $\bar{h}$, and strangeness chemical potential μ_S. In Eq. 1 feed-down contributions are neglected. In Antibaryon/Baryon ratios the dominating μ_B term is diluted by the μ_S term since N_S has the opposite sign of N_B. Consequently, the strongest sensitivity on μ_B can be observed in the $\bar{p}/p$ ratio.

Strong dependence on the temperature is expected in ratios built of particles with a large mass difference. Some ratios involving hyperons are shown in Fig. 1 (right). Here, the largest sensitivity is exhibited by the Ω^-/π^- ratio. However, hadronic decays of baryonic and, predominantly, from mesonic resonances contribute significantly to the pion yield. The large fraction of pions originating from heavier particles reduces the temperature dependence to the same level as the Ω^-/K^- ratio shows. For other particle ratios with smaller mass difference the sensitivity on temperature is weaker.

To summarise, the $\bar{p}/p$ ratio is best suited for the extraction of the baryon chemical potential μ_B. Two thermometers can be explored: The Ω^-/π^- and the Ω^-/K^- ratio exhibit the same sensitivity on the freeze-out temperature.

References

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