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Quarkonium suppression as a function of pT

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Heavy Ion Collisions at the LHC -- Last Call for Predictions
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1. Quarkonium suppression as a function of p_T

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We present a revised look at the predictions of Ref. [1], taking into account newer calculations of the screening mass with temperature and the quarkonia dissociation temperature based on both potential models and calculations of quarkonium spectral functions. The estimates of Digal *et al.* [2] predict lower quarkonium dissociation temperatures, $1.1T_c$ for the J/ψ and $2.3T_c$ for the Υ, with $\mu = 1.15T$. A later review by Satz [3], predicts higher values, more in line with the recent calculations of quarkonium spectral functions, $2.1T_c$ for the J/ψ and $4.1T_c$ for the Υ, as well as $\mu \sim 1.45T$ for $T > 1.1T_c$. We assume $700 < T_0 < 850$ MeV and $\tau_0 = 0.2$ fm [4]. The p_T dependence of the screening is calculated as first discussed in Ref. [5]. Since it may be unlikely for feed down contributions to be separated from the inclusive ψ and Υ yields in AA collisions, we present the indirect ψ'/ψ and Υ'/Υ ratios, with feed down included, in Fig. 1. While the individual suppression factors are smooth as a function of p_T, as shown in Fig. 2 for all four sets of initial conditions and dissociation temperatures, due to their different predicted dissociation temperatures and formation times, they contribute differently to the ratios in Fig. 1.

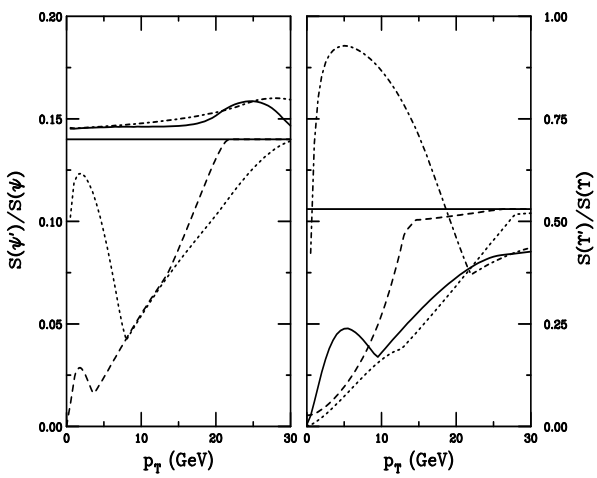

Figure 1. The indirect ψ'/ψ (left) and Υ'/Υ (right) ratios as a function of p_T in Pb+Pb collisions at 5.5 TeV for $T_0 = 700$ MeV (solid and dashed) and 850 MeV (dot-dashed and dotted). The ψ (Υ) results are shown for assumed dissociation temperatures of $1.1T_c$ ($2.3T_c$) (solid and dot-dashed) and $2.1T_c$ ($4.1T_c$) (dashed and dotted) respectively.

We have assumed that the ψ'/ψ and Υ'/Υ ratios are independent of p_T, as predicted in the color evaporation model [7]. However, if this is not the case, any slope of the p_T ratios in pp collisions can be calculated and/or evalulated experimentally and deconvoluted from the data. Quarkonium regeneration by coalescence [6] has not been included here. While it is unknown how coalescence production populates the quarkonium levels, since the p_T of quarkonium states produced by coalescence is lower than those produced in the initial NN collisions, higher p_T quarkonia should have a smaller coalescence contribution. The lower $B\overline{B}$ rates should reduce the coalescence probability of Υ production. By taking the ψ'/ψ and Υ'/Υ ratios, we reduce systematics and initial-state effects.

In the case where $T_D = 1.1T_c$ for the J/ψ, its shorter formation time leads to suppression over a larger p_T range than that for the χ_c and ψ', leading to a larger ψ'/ψ ratio than the pp value over all p_T. On the other hand, for the higher dissociation temperature, the p_T range of J/ψ suppression is shorter than for the other charmonium states, giving a smaller ratio than in pp. The low p_T behavior of the dashed and dotted curves in the left-hand side of Fig. 1 is due to the disappearance of χ_c suppression since the χ_c is suppressed over a shorter p_T range than the ψ'.

Since there are more states below the $B\overline{B}$ threshold for the Υ family, the suppression is more complicated, in part because there are also feed down contributions to the Υ', leading to more structure in the Υ'/Υ ratios on the right-hand side of Fig. 1. For $\mu = 1.15T$, the Υ itself is suppressed, albeit over a short p_T range. The dips in the solid and dashed curves occur at the p_T where direct Υ suppression ceases. In the case where $T_D = 4.1T_c$ for the Υ, the initial temperature is not large enough to suppress direct Υ production so that $\Upsilon'/\Upsilon < 1$ for all p_T. The χ_b contributions are responsible for the slopes of the ratios at $p_T > 12$ GeV.

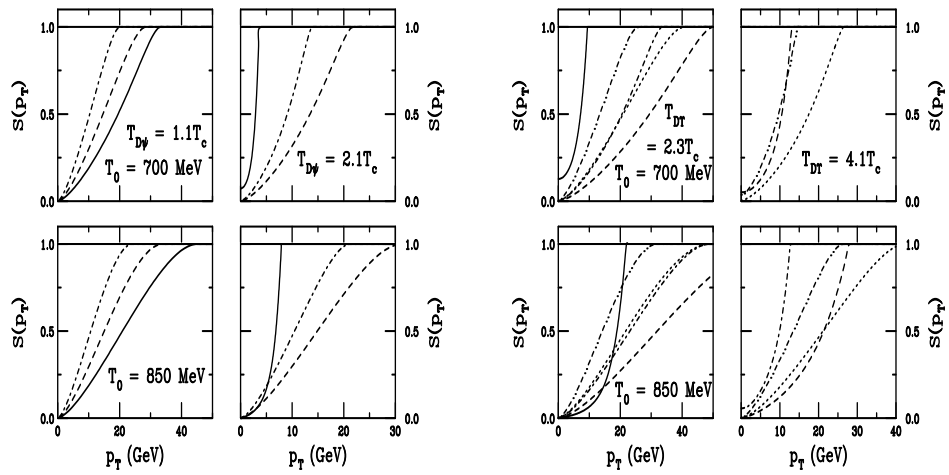

Figure 2. The survival probabilities as a function of p_T for the charmonium (left-hand side) and bottomonium (right-hand side) states for initial conditions at the LHC. The charmonium survival probabilities are J/ψ (solid), χ_c (dot-dashed) and ψ' (dashed) respectively. The bottomonium survival probabilities are given for Υ (solid), χ_{1b} (dot-dashed), Υ' (dashed), χ_{2b} (dot-dot-dash-dashed) and Υ'' (dotted) respectively. The top plots are for $T_0 = 700$ MeV while the bottom are for $T_0 = 850$ MeV. The left-hand sides of the plots for each state are for the lower dissociation temperatures, $1.1T_c$ for the J/ψ and $2.3T_c$ for the Υ while the right-hand sides show the results for the higher dissociation temperatures, $2.1T_c$ for the J/ψ and $4.1T_c$ for the Υ.

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