We study QGP hadronization at given $b, c$ quark content. We predict the yields of charm and bottom flavored hadrons within statistical hadronization model. The important new feature is that we take into account high strangeness content of QGP, conserving strangeness yield at hadronization.
Motivations

- Probe of strangeness content of QGP
- Heavy flavored particles yields ($B_c$, $J/?$, e.t.c) can indicate presence of QGP state.
- Information on temperature of hadronization of heavy flavored hadrons
- Better understanding of properties of phase transition between deconfinement phase and hadronic gas (HG) phase in strangeness rich QGP.
Statistical model

Assumed Boltzmann distribution for b, c, s, hadrons:

$$\frac{dN_i}{dy} = \gamma_i n_i^{eq} \frac{dV}{dy}, \quad n_i^{eq} = \lambda_i \frac{T^3}{2\pi^2} g_i W(m_i / T),$$

where $W(x) = x^2 K_2(x)$

- $\lambda=1$ ($\mu = T \ln \lambda = 0$) for all particles, for simplicity
- $n_i$ is phase space occupancy factor
- $n_i = n_i^{eq}$ is chemical equilibrium for particle $i$
- $Q$ is in QGP $i=c, b, s, q$ (q is u or d)
- $H$ after hadronization, for example for D mesons: $\gamma_D^H = \gamma_c^H \gamma_q^H$
Main model assumptions

- In our approach we do not assume chemical equilibrium for any quarks.
- We assume fast hadronization to final state. Physical conditions as system volume, temperature doesn’t change. And space occupancy factors $\gamma_s^H, \gamma_c^H, \gamma_b^H$ are fixed by flavor conservation:

\[
\frac{dN_i^H}{dy} = \frac{dN_i^Q}{dy}
\]

- From entropy conservation:

\[
\frac{dS_i^Q}{dy} = \frac{dS_i^H}{dy} \quad \gamma_q^H \neq 1
\]
Entropy after hadronization

- Because of liberation of color degree of freedom
  \[ \sigma^Q \geq 3\sigma^H \]

- The excess of entropy is observed in the multiplicity of particles in final state.

- After hadronization \( S^Q \sim S^H \), \( q^H > 1 \).

- Restriction on \( q^H \) because of Bose singularity for pions
Entropy in QGP

- Adiabatic flow? entropy conserved

(Bjørken)

\[ T^3 \frac{dV}{dy} \approx \text{const.} \]

\[ \frac{dV}{dy} = 1000 \text{fm}^{-3}, T = 200 \text{MeV} \rightarrow \frac{dN^H}{dy} \approx 4000 \]
Strangeness production

- Strangeness production in thermal gluon fusion follows in time entropy production
- $s/S$ depends on energy of collision, $s$ increases faster with energy then $S$. The hot state, where the threshold for $s$ production is exceeded, lives longer
- At RHIC energies $s/S \sim 0.03$, at LHC $s/S = 0.05$

<table>
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<tr>
<th>$s/S$</th>
<th>$s$</th>
<th>$dV/dy, fm^3$</th>
<th>$T, MeV$</th>
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</tr>
<tr>
<td>0.022</td>
<td>75</td>
<td>400</td>
<td>200</td>
</tr>
</tbody>
</table>
Strangeness conservation during hadronization

\[ s = \frac{dV}{dy} \left[ \gamma_s^H \left( \gamma_q^H n_{nK}^{eq} + \gamma_q^{H^2} n_{\gamma}^{eq} \right) + 2\gamma_s^{H^2} \gamma_q^H n_{\Xi}^{eq} \right] \]
Effect of strangeness on $D, D_s$ yields

$$\frac{D_s}{D} = \frac{\gamma_s^H}{\gamma_q^H} f(T)$$
Charm (bottom) hadronization

- c,b quarks produced in first nn collisions.
- c=10, b=1;
- Flavor conservation equation

\[ c = \frac{dV}{dy} \left[ \gamma_c n_{\text{open}}^c + \gamma_c n_{\text{hid}}^c \right] + 2 \gamma_q n_{\text{eq}}^{n_{\text{eq}}} + 2 \gamma_s n_{\text{eq}}^{n_{\text{eq}}} \];

\[ n_{\text{open}}^c = \gamma_q n_{\text{eq}}^{n_{\text{eq}}} + \gamma_s n_{\text{eq}}^{n_{\text{eq}}} + \gamma_q n_{\text{eq}}^{n_{\text{eq}}} + \gamma_s n_{\text{eq}}^{n_{\text{eq}}} + \gamma_q n_{\text{eq}}^{n_{\text{eq}}}; \]

\[ n_{\text{hid}}^c = \gamma_c n_{\text{eq}}^{n_{\text{eq}}}. \]

- \( b^H \gg c^H \gg s^H \)
- Equilibrium case when

\[ q^H = s^H = 1 \]
D(\(B\)), Ds(Bs) mesons yield as a function of T
\bar{c}c, B_c \text{ mesons}
Conclusions

- Large phase space occupancy factor of strange quarks has strong influence on heavy flavor hadron production.
- We observe large increase of the yields of strange quark-containing charm (bottom) mesons and baryons as compared to chemical equilibrium yields.
- The yield of hadrons without strangeness decreases compared to equilibrium yields.
- Ratios D/Ds and B/Bs may allow to determine the temperature of hadronization.
Baryons yields