Coalescence approach in phase space for HQ

Statistical factor colour-spin-isospin

Parton Distribution function

Hadron Wigner function

$$\frac{dN_{Hadron}}{d^2p_T} = g_H \int \prod_{i=1}^{n} p_i \cdot d\sigma_i \frac{d^3p_i}{(2\pi)^3} f_q(x_i, p_i) f_W(x_1, \ldots, x_n; p_1, \ldots, p_n) \delta\left(p_T - \sum_i p_{iT}\right)$$

Thermal+flow for **u,d,s** (p_T< 3 GeV)

$$\frac{dN_{q,\bar{q}}}{d^2p_T} \sim exp\left(-\frac{\gamma_T(m_T - p_T \cdot \beta_T \mp \mu_q)}{T}\right)$$

$$V = \pi R^2 \tau \cosh(y_z) \quad , R(\tau_f) = R_0(1 + 0.5\, \beta_{max} \tau_f)$$

$$\beta(r) = \frac{r}{R} \beta_{max}$$

Total V now set to SHM, A. Andronic JHEP(2021)035

+ quenched minijets for u,d,s (p_T >3 GeV)

For **Charm** from the studies of R_{AA} and v_2 of **D-meson** to determine the Space Diffusion coeff.: from parton simulations solving relativistic Boltzmann transport equation

In pp it is FONNL distribution

Coalescence evaluated in a fireball

Space-momentum-time correlation over the freeze-out hypersurface of a transport simulation are **not fully** transferred

→ dimension set by experimental constraints (if any)

Coalescence approach in phase space

Statistical factor colour-spin-isospin | Parton Distribution function | **Hadron Wigner function**

$$\frac{dN_{Hadron}}{d^2p_T} = g_H \int \prod_{i=1}^{n} p_i \cdot d\sigma_i \frac{d^3p_i}{(2\pi)^3} f_q(x_i, p_i) f_W(x_1, \dots, x_n; p_1, \dots, p_n) \delta\left(p_T - \sum_i p_{iT}\right)$$

Wigner function <-> Wave function

$$\Phi_M^W(\mathbf{r}, \mathbf{q}) = \int d^3r' e^{-i\mathbf{q}\cdot\mathbf{r}'} \varphi_M\left(\mathbf{r} + \frac{\mathbf{r}'}{2}\right) \varphi_M^*\left(\mathbf{r} - \frac{\mathbf{r}'}{2}\right)$$

$\varphi_M(\boldsymbol{r})$ *meson wave function*

Assuming gaussian wave function

$$f_M(x_1, x_2; p_1, p_2) = A_W \exp\left(-\frac{x_{r1}^2}{\sigma_r^2} - p_{r1}^2\sigma_r^2\right)$$

For baryon N_q=3

$$f_H(\dots) = \prod_{i=1}^{N_q-1} A_W \exp\left(-\frac{x_{ri}^2}{\sigma_{ri}^2} - p_{ri}^2\sigma_{ri}^2\right)$$

Note: only σ_r coming from $\varphi_M(\boldsymbol{r})$ or $\sigma_r * \sigma_p = 1$ valid for harmonic oscillator with V(r) → $\sigma_r * \sigma_p > 1$

Wigner function **width** fixed by root-mean-square charge radius from **quark model**

Meson	$\langle r^2\rangle_{ch}$	σ_{p1}	σ_{p2}
$D^+ = [c\bar{d}]$	0.184	0.282	—
$D_s^+ = [\bar{s}c]$	0.083	0.404	—
Baryon	$\langle r^2\rangle_{ch}$	σ_{p1}	σ_{p2}
$\Lambda_c^+ = [udc]$	0.15	0.251	0.424
$\Xi_c^+ = [usc]$	0.2	0.242	0.406
$\Omega_c^0 = [ssc]$	-0.12	0.337	0.53

C.-W. Hwang, EPJ C23, 585 (2002);
C. Albertus et al., NPA 740, 333 (2004)

$$\langle r^2\rangle_{ch} = \frac{3}{2}\frac{m_2^2 Q_1 + m_1^2 Q_2}{(m_1+m_2)^2}\sigma_{r1}^2 + \frac{3}{2}\frac{m_3^2(Q_1+Q_2) + (m_1+m_2)^2 Q_3}{(m_1+m_2+m_3)^2}\sigma_{r2}^2 \qquad (8)$$

$\sigma_{ri} = 1/\sqrt{\mu_i \omega}$ Harmonic oscillator relation

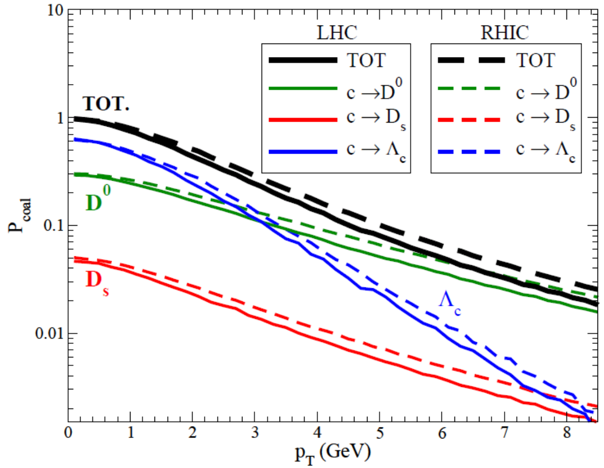
$$\mu_1 = \frac{m_1 m_2}{m_1+m_2}, \quad \mu_2 = \frac{(m_1+m_2)m_3}{m_1+m_2+m_3}.$$

Coalescence approach in phase space

Statistical factor colour-spin-isospin — Parton Distribution function — **Hadron Wigner function**

$$\frac{dN_{Hadron}}{d^2p_T} = g_H \int \prod_{i=1}^{n} p_i \cdot d\sigma_i \frac{d^3p_i}{(2\pi)^3} f_q(x_i, p_i) f_W(x_1, \dots, x_n; p_1, \dots, p_n) \delta\left(p_T - \sum_i p_{iT}\right)$$

$$f_H(\dots) = \prod_{i=1}^{N_q-1} A_W \exp\left(-\frac{x_{ri}^2}{\sigma_{ri}^2} - p_{ri}^2\sigma_{ri}^2\right)$$



- Normalization in $f_W(\dots)$ *fixed by requiring* $P_{coal}(p \rightarrow 0)=1$ Not in standard coalescence ….others modify by hand σ_r to enforce confinement for a charm at rest in the medium.

- The charm not "coalescencing" undergo fragmentation:

$$\frac{dN_{had}}{d^2p_T\,dy} = \sum \int dz \frac{dN_{fragm}}{d^2p_T\,dy} \frac{D_{had/c}(z, Q^2)}{z^2}$$

charm number conserved at each p_T

S. Plumari, V. Minissale et al., Eur. Phys. J. **C78** no. 4, (2018) 348