Semi-analytical method of calculating the nuclear collision trajectory in the QCD phase diagram

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- Central A+A collisions
- No transverse expansion... yet
- Only consider primary NN collisions
- Calculate densities in a narrow volume at time t
- Assume thermalized massless QGP
- Extract T, μ with BE-FD or MB stats.
- Compare “trajectories” in QCD phase diagram

\[
d_t = \frac{2 R_A}{\sinh y_{CM}}
\]

\[
z_F(x) = \sqrt{(t-x)^2 - \tau_F^2}
\]
\[ \epsilon(t) = \frac{1}{A_T} \int_{S(t)} \frac{dz_0}{dx} \frac{d^3 m_T}{t-x} \frac{dy}{dz_0} \frac{d^3 m_T}{dy} \frac{dz_0}{dx} \frac{dy}{dz_0} \cosh^3 y \]

- Factorize the \((z_0,x)\) and \(y\) dependence
- Normalize \((z_0,x)\) production over overlap region
- Data-based parameterization
- Satisfy conservation laws
- Good agreement with other models: \(\tau_F/d_t \gg 1\)

\[ n_B(t) = \frac{1}{A_T S(t)} \int \frac{dz_0 dx}{t-x} \frac{d^3 N_B}{dy dz_0 dx} \cosh^2 y \]

\[ n_S(t) = 0 \]

\[ n_Q(t) = \frac{Z}{A} n_B(t) \]

\[ \tau_F = 0.3 \text{ fm/c} \]

\[
\epsilon = \frac{19\pi^2}{12} T^4 + \frac{\mu_B^2}{3} T^2 + \frac{\mu_B^4}{54\pi^2}
\]

\[
n_B = \frac{2\mu_B}{9} T^2 + \frac{2\mu_B^3}{81\pi^2}
\]

Simple partial solutions
\[
\mu_s = \frac{\mu_B}{3} \quad \mu_Q = 0
\]

\[
\]

\[
\sqrt{s_{NN}} = 5, \ 200 \text{ GeV}
\]

\[
t_F = 0.3 \text{ fm/c}
\]

Quantum statistics
Bjorken
z-width

Boltzmann statistics
Bjorken
z-width
Bjorken $T_{\text{max}}$ at high collision energies is NOT much larger

Bjorken $\mu_B^{\text{max}}$ at low collision energies IS much larger

Formation time dependence “extends” or “shrinks” endpoints ALONG trajectories

Turning around behavior results in QGP lifetime between 3-5 fm/c

Search for signs of CEP below 5 GeV