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

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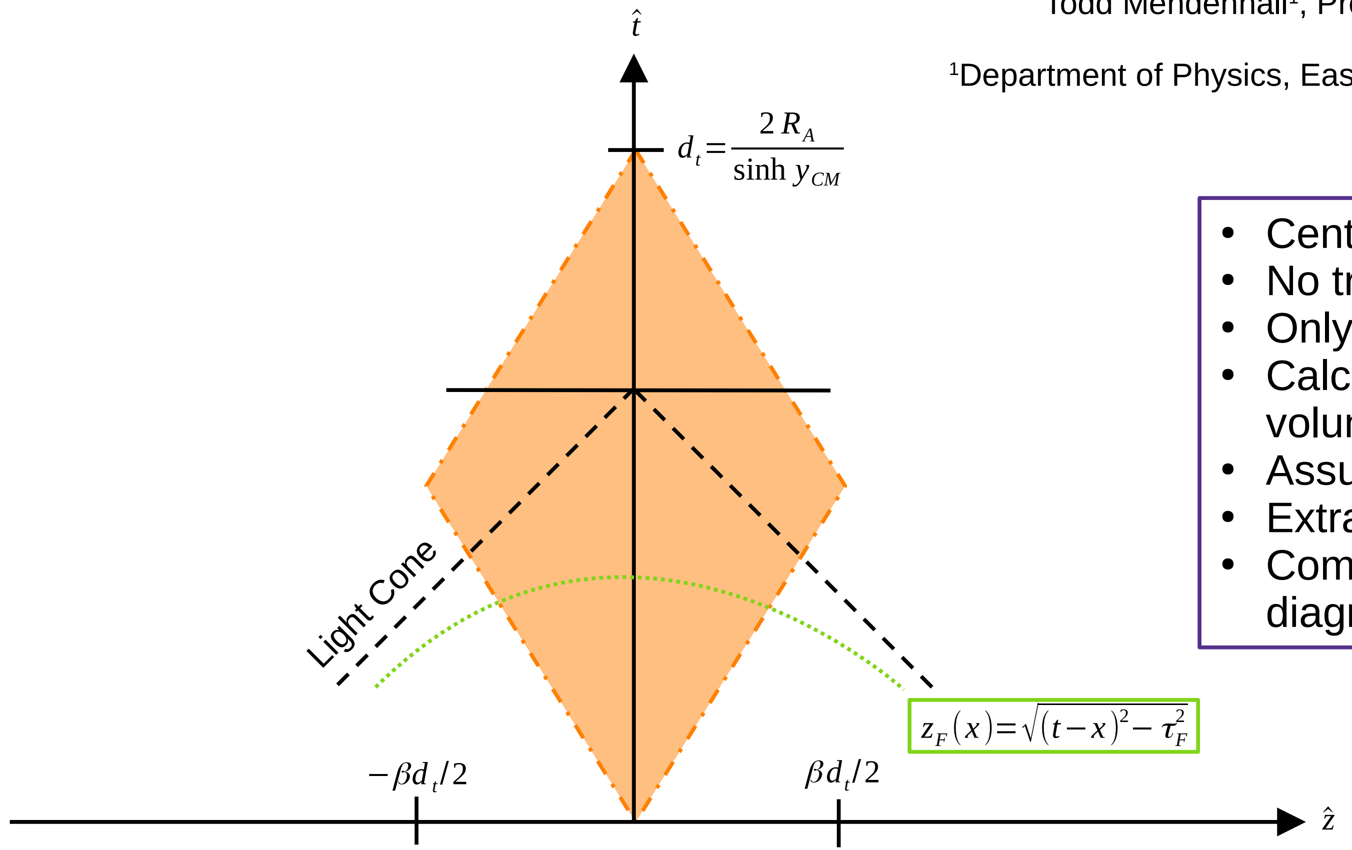

- Central A+A collisions
- No transverse expansion… yet
- Only consider primary NN collisions
- Calculate densities in a narrow volume at time t
- Assume thermalized massless QGP
- Extract T, μ with BE-FD or MB stats.
- Compare “trajectories” in QCD phase diagram

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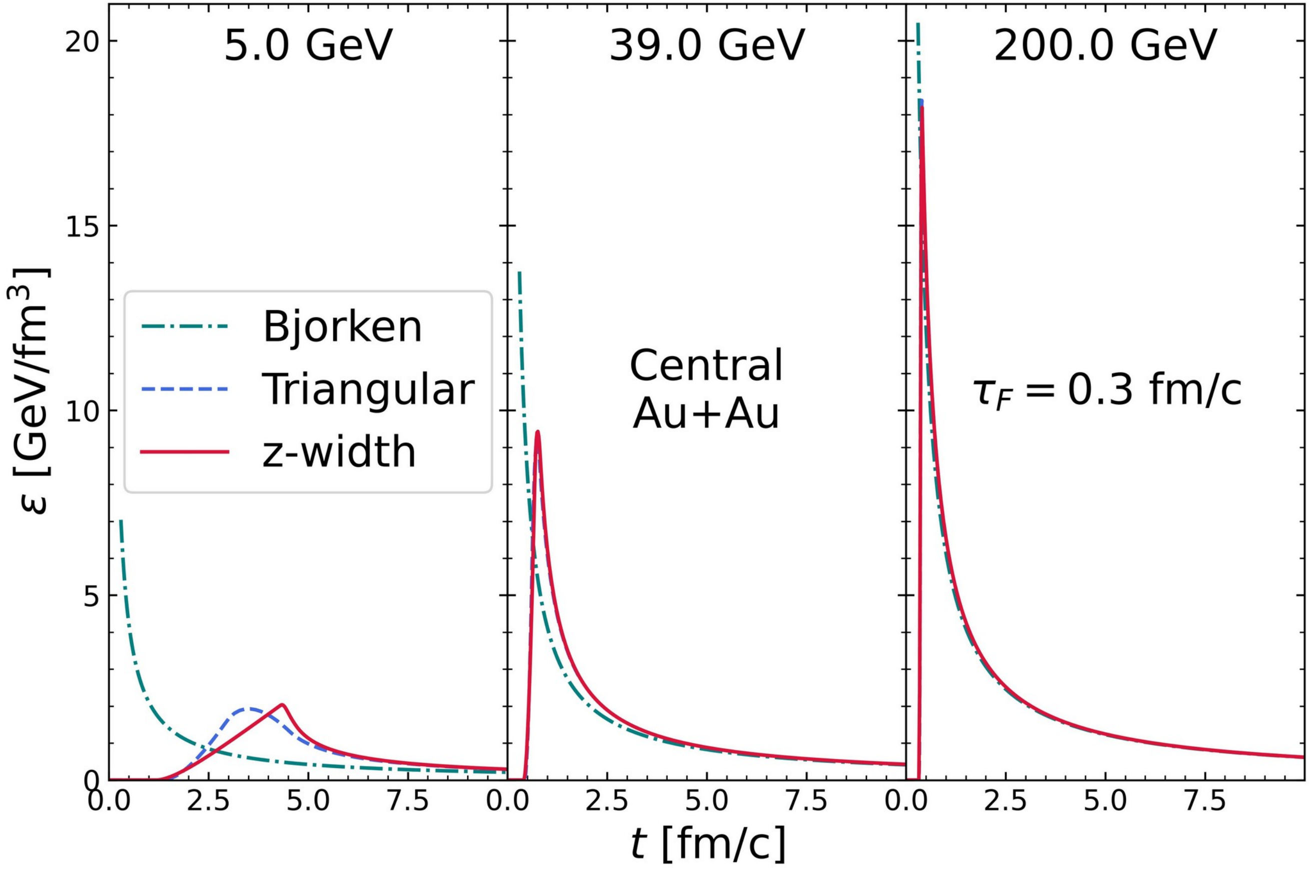


J. D. Bjorken, Phys. Rev. D27, 140 (1983).

Z.-W. Lin, Phys. Rev. C98, 034908 (2018).

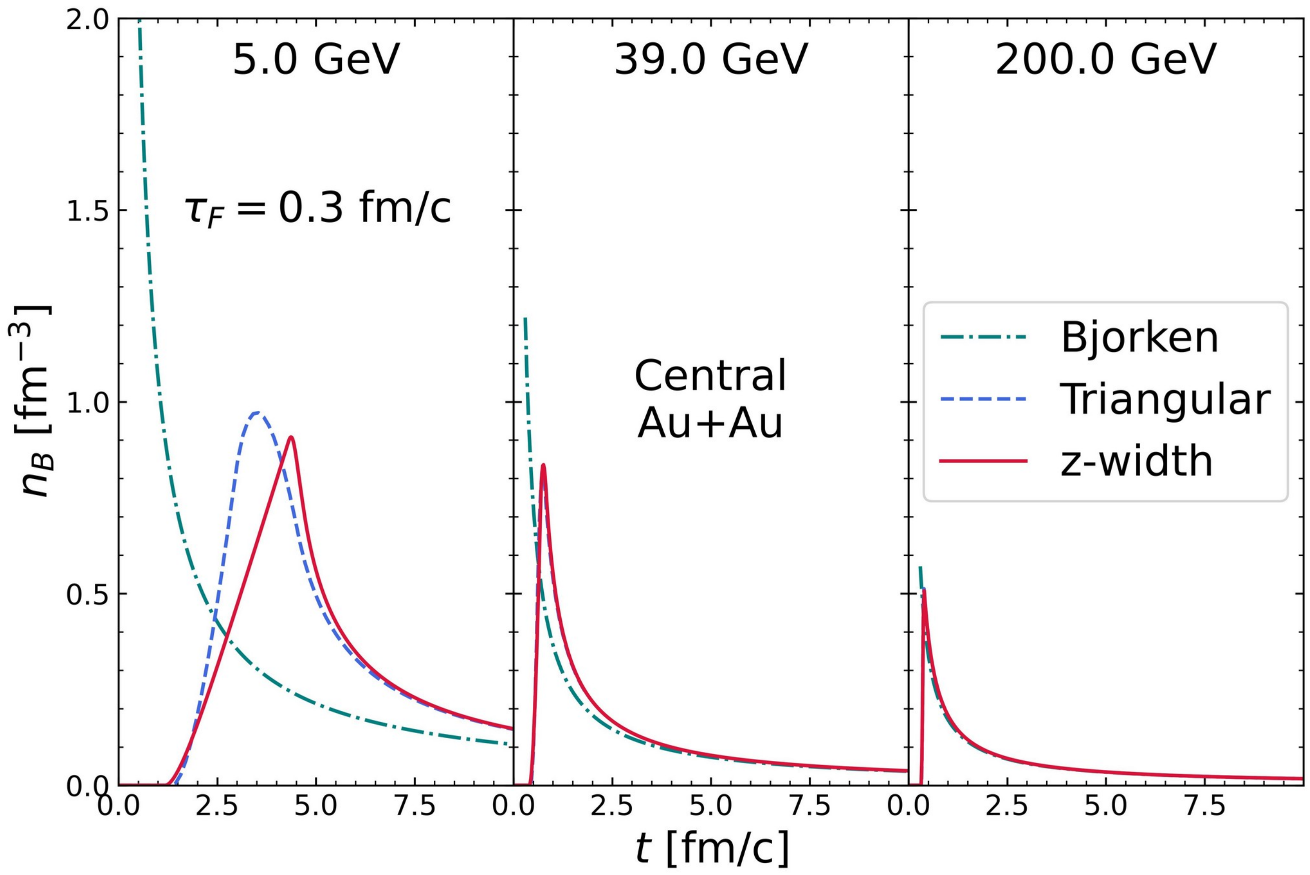
T. M. and Z.-W. Lin, Phys. Rev. C103, 024907 (2021).

$$\epsilon(t) = \frac{1}{A_T} \iint_{S(t)} \frac{dz_0\, dx}{t - x} \frac{d^3 m_T}{dy\, dz_0\, dx} \cosh^3 y$$

ϵ^{max} *is finite*

$$\frac{dm_T}{dy} = \frac{dE_T}{dy} + m_N \frac{dN_B}{dy}$$

- 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: $\tau_F / d_t \gg 1$



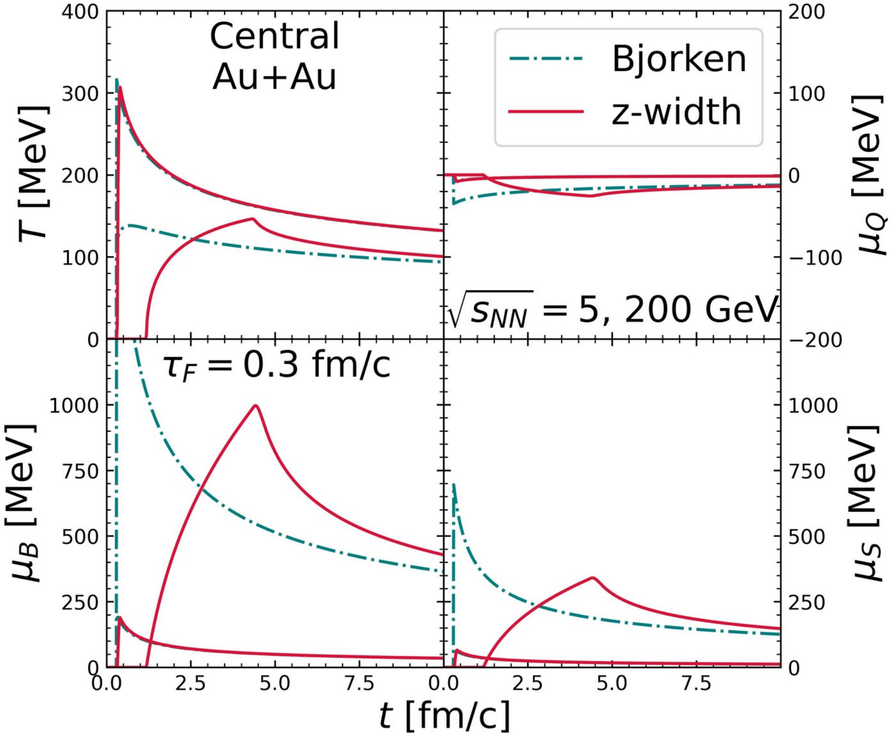
$$\boxed{n_B(t) = \frac{1}{A_T} \iint_{S(t)} \frac{dz_0\,dx}{t-x} \frac{d^3 N_B}{dy\,dz_0\,dx} \cosh^2 y}$$

$$\boxed{n_S(t) = 0}$$

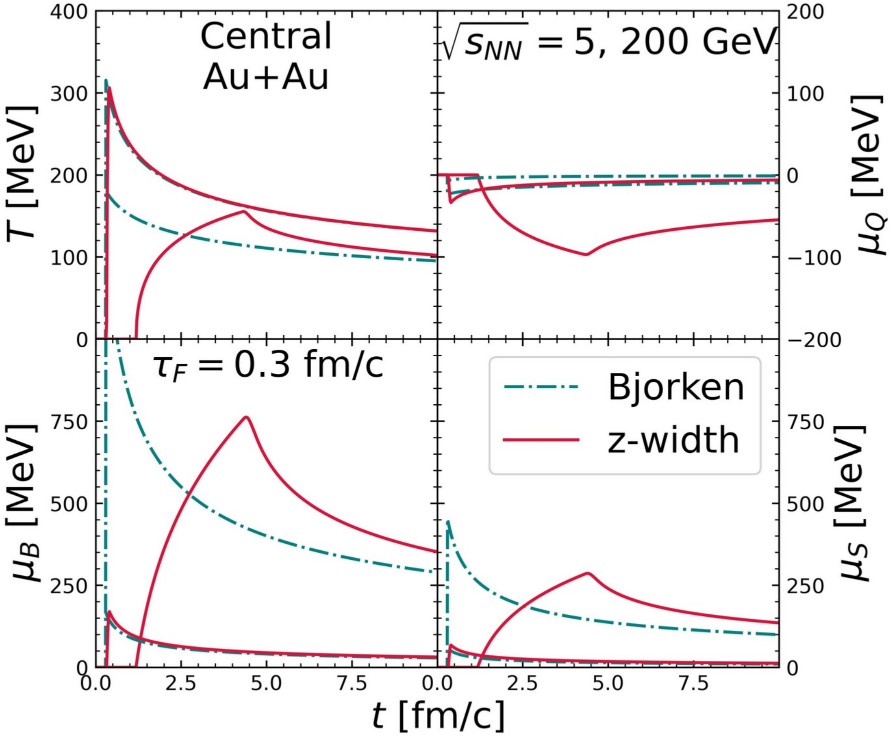
$$\boxed{n_Q(t) = \frac{Z}{A} n_B(t)}$$

T. M. and Z.-W. Lin, arXiv:2111.13932 [nucl-th].

Quantum statistics



Boltzmann statistics



Simple partial solutions

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

$$\mu_S = \mu_B/3 \qquad \mu_Q = 0$$

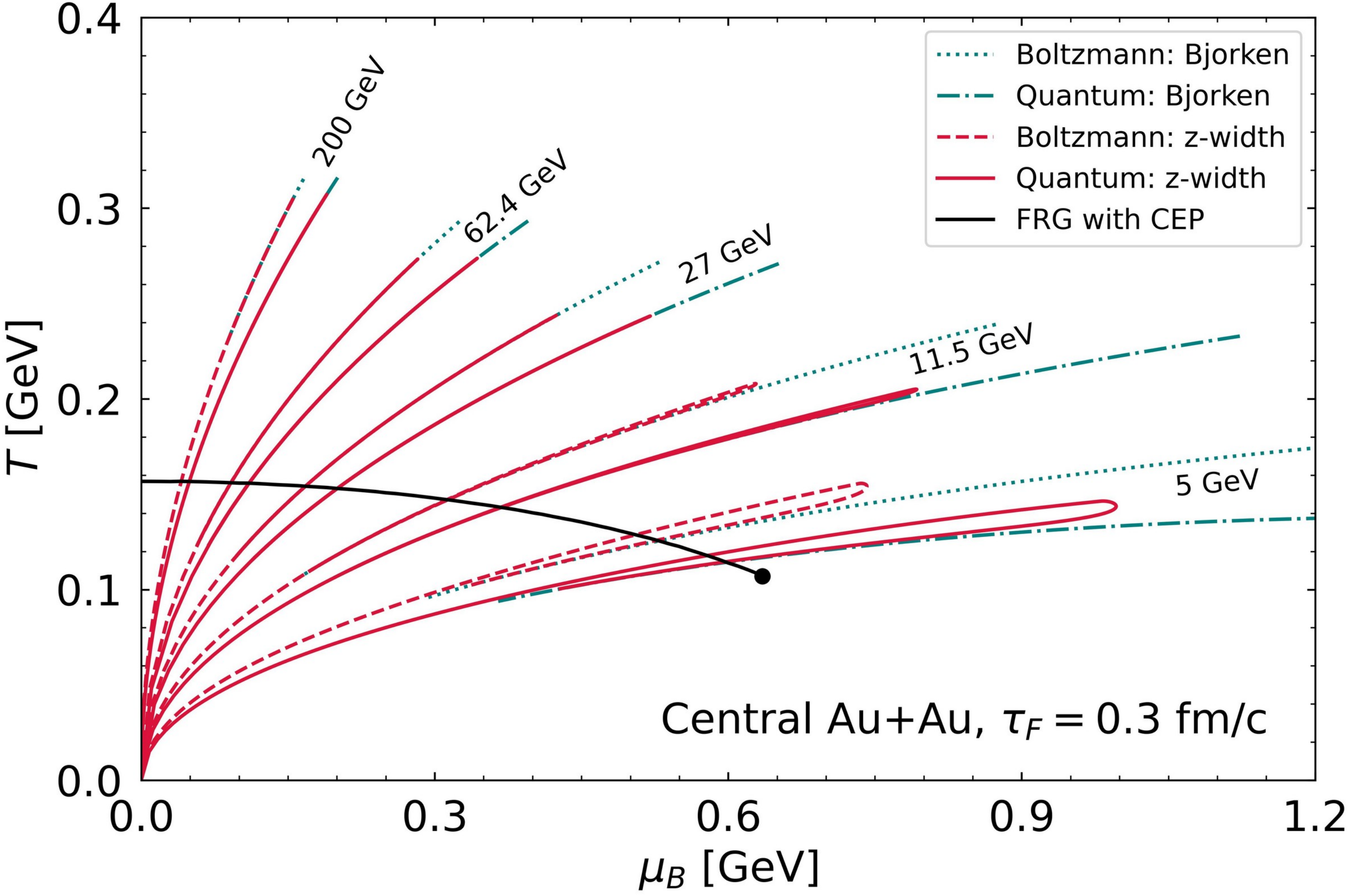
$$\epsilon = \frac{12 T^4}{\pi^2}\left[7 + 6\cosh\left(\frac{\mu_B}{3T}\right)\right]$$

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

T. M. and Z.-W. Lin, arXiv:2111.13932 [nucl-th].

H.-S. Wang, G.-L. Ma, Z.-W. Lin, and W.-J. Fu (2021), 2102.06937.

$$n_B = \frac{8T^3}{\pi^2}\sinh\left(\frac{mu_B}{3T}\right)$$



- Bjorken T max. at high collision energies is NOT much larger
- Bjorken μ_B 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

T. M. and Z.-W. Lin, arXiv:2111.13932 [nucl-th].