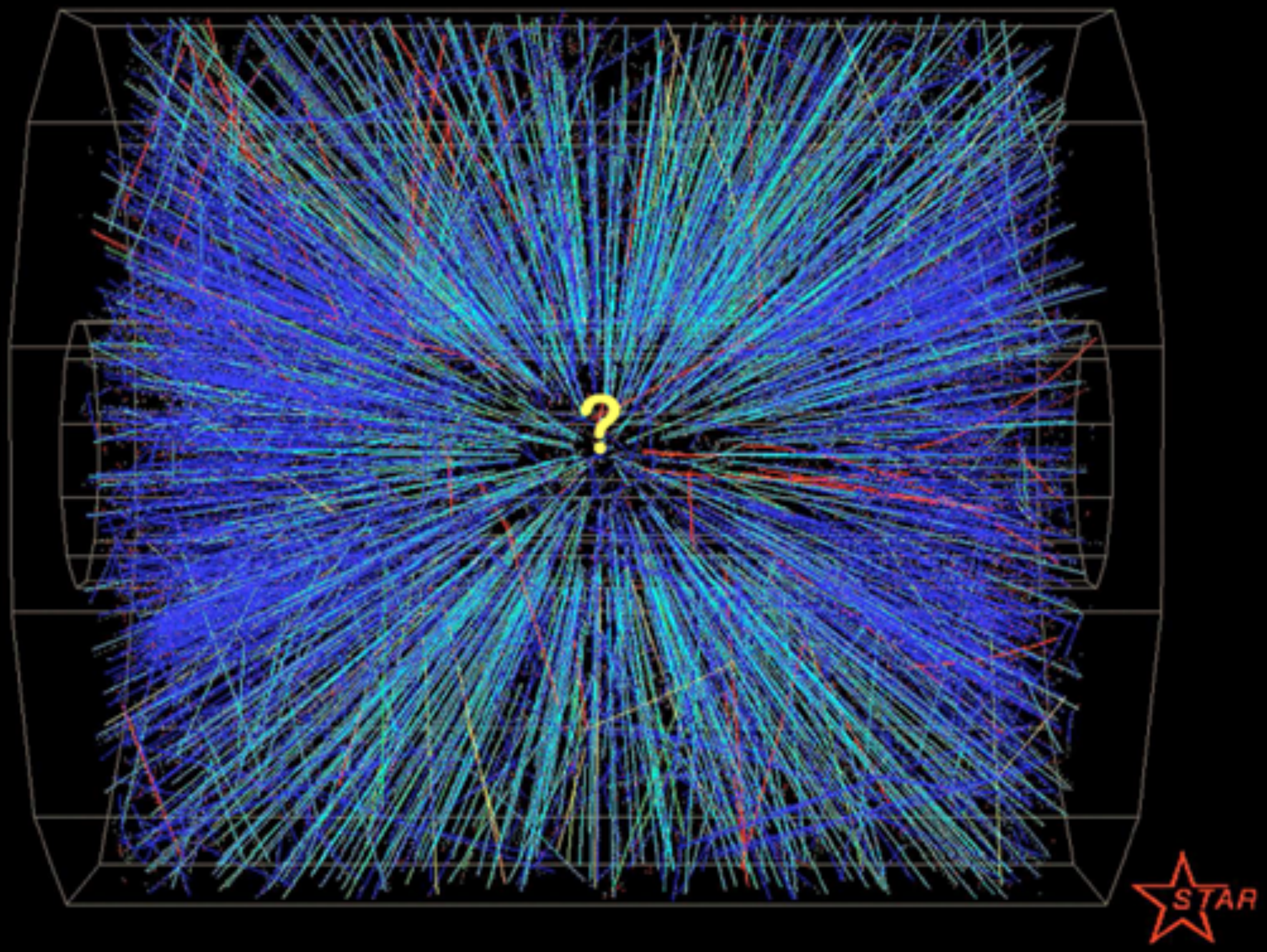
Monte Carlo Simulations of Freeze-out with Momentum Constraints in High Energy Nuclear Collisions

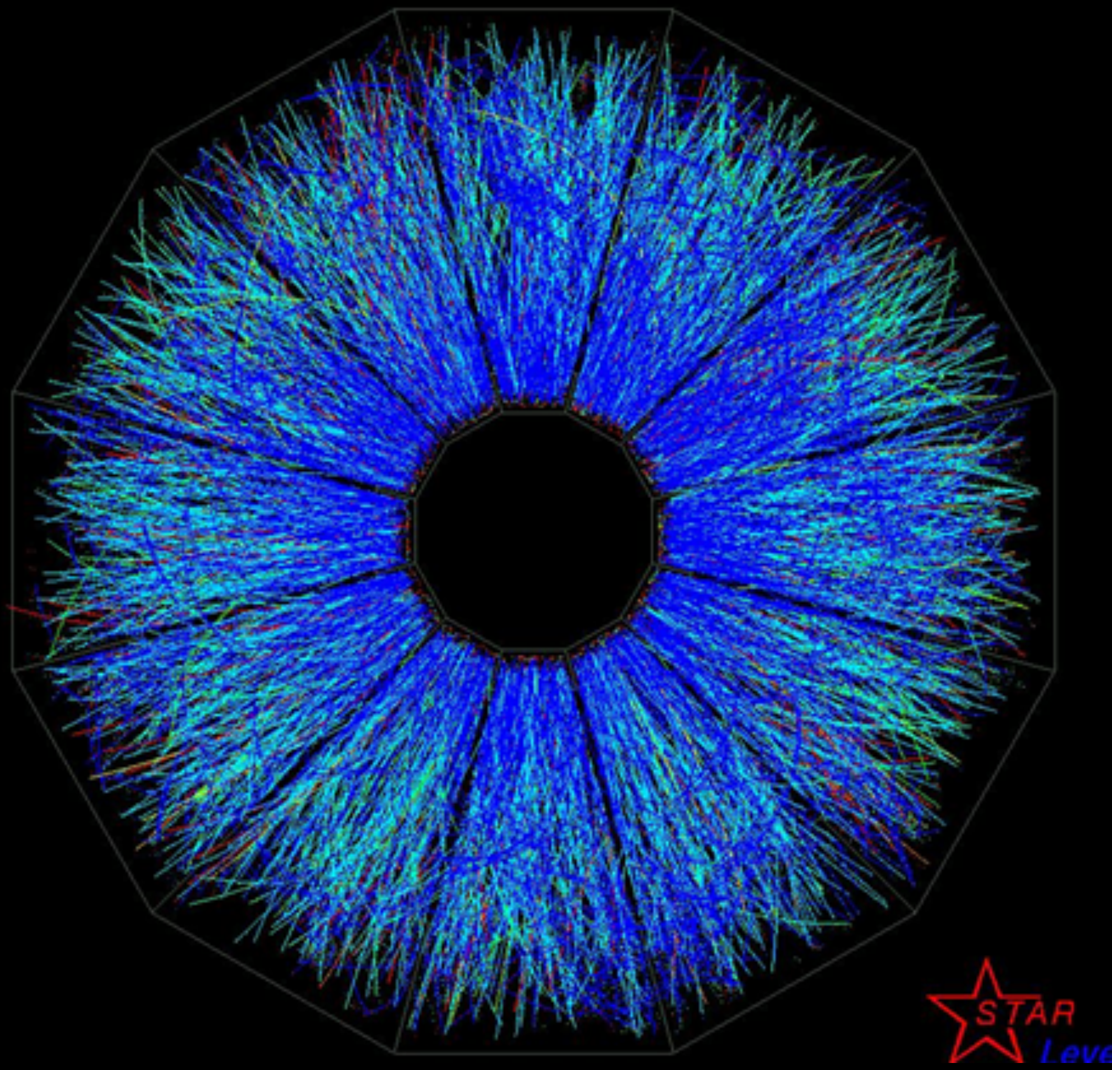
By John Harrison

Quark Gluon Plasma

Freeze-out

(100 AGeV) Au → ← (100 AGeV) Au





Phase Space Densities

Bose-Einstein

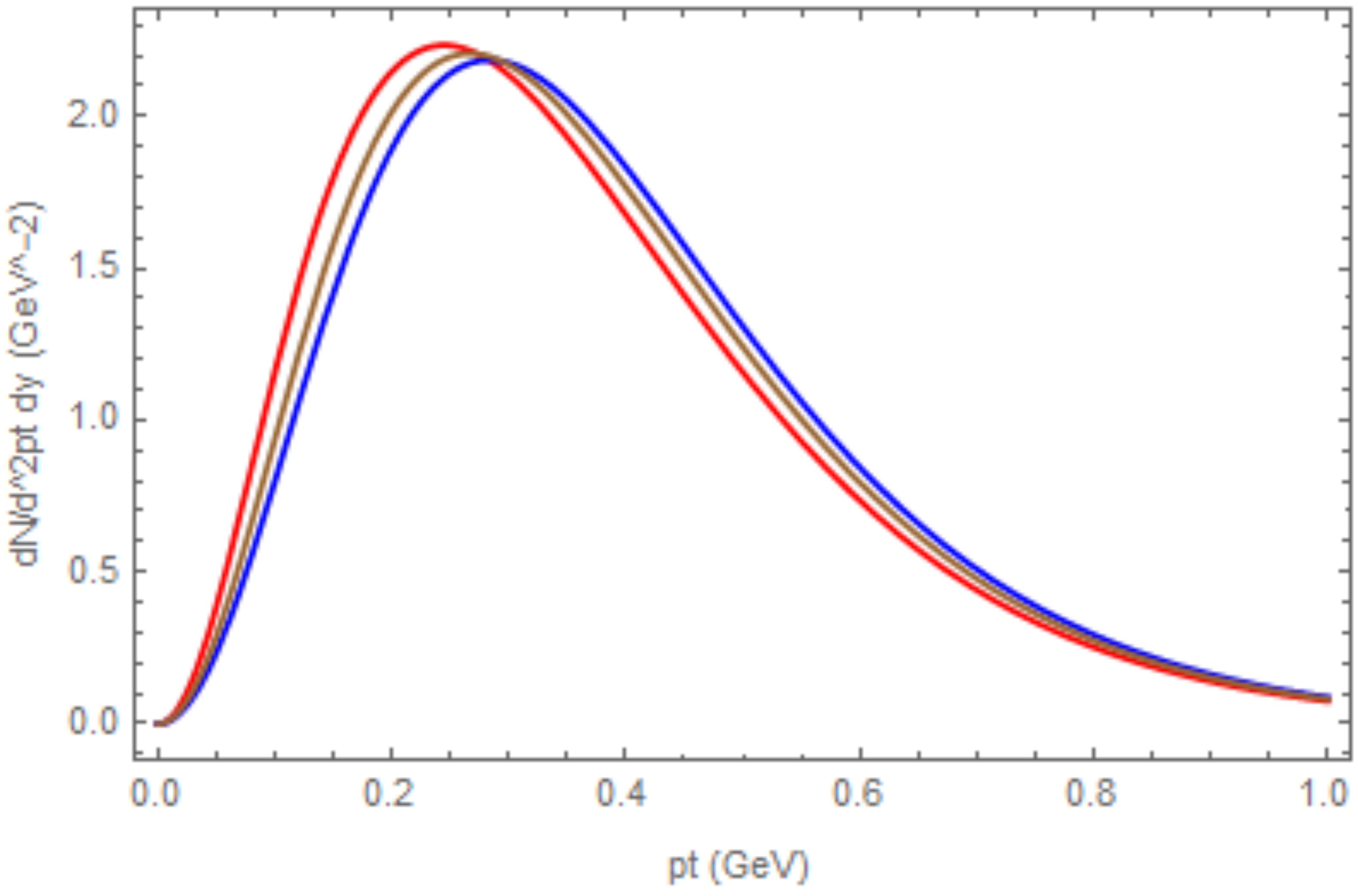
$$\frac{dn}{dp} = \frac{p^2}{e^{\frac{E}{T}} - 1}$$

Fermi-Dirac

$$\frac{dn}{dp} = \frac{p^2}{e^{\frac{E}{T}} + 1}$$

Maxwell-Boltzmann

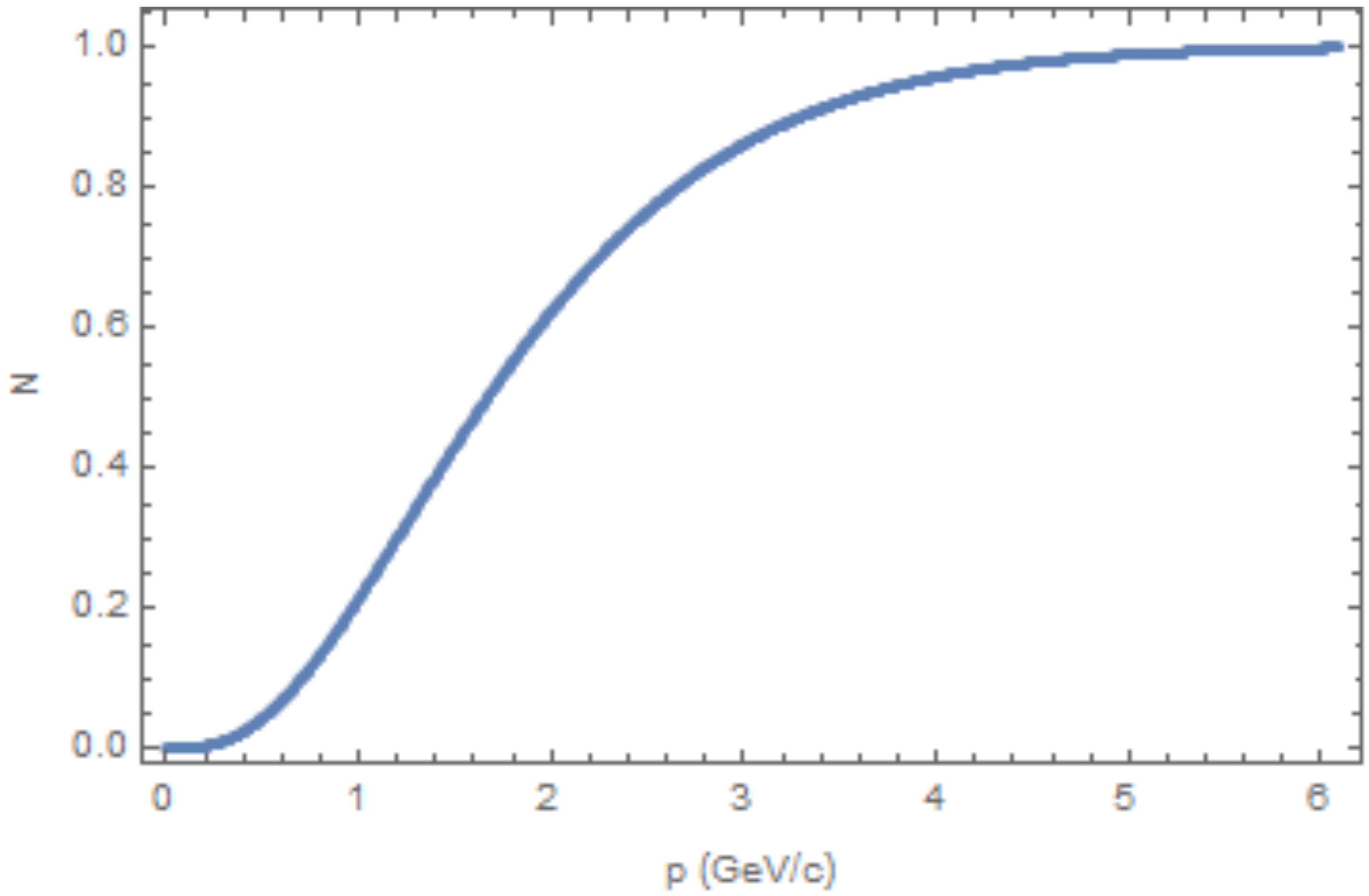
$$\frac{dn}{dp} = \frac{p^2}{e^{\frac{E}{T}}}$$



T=0.12 GeV, M=0.13 GeV

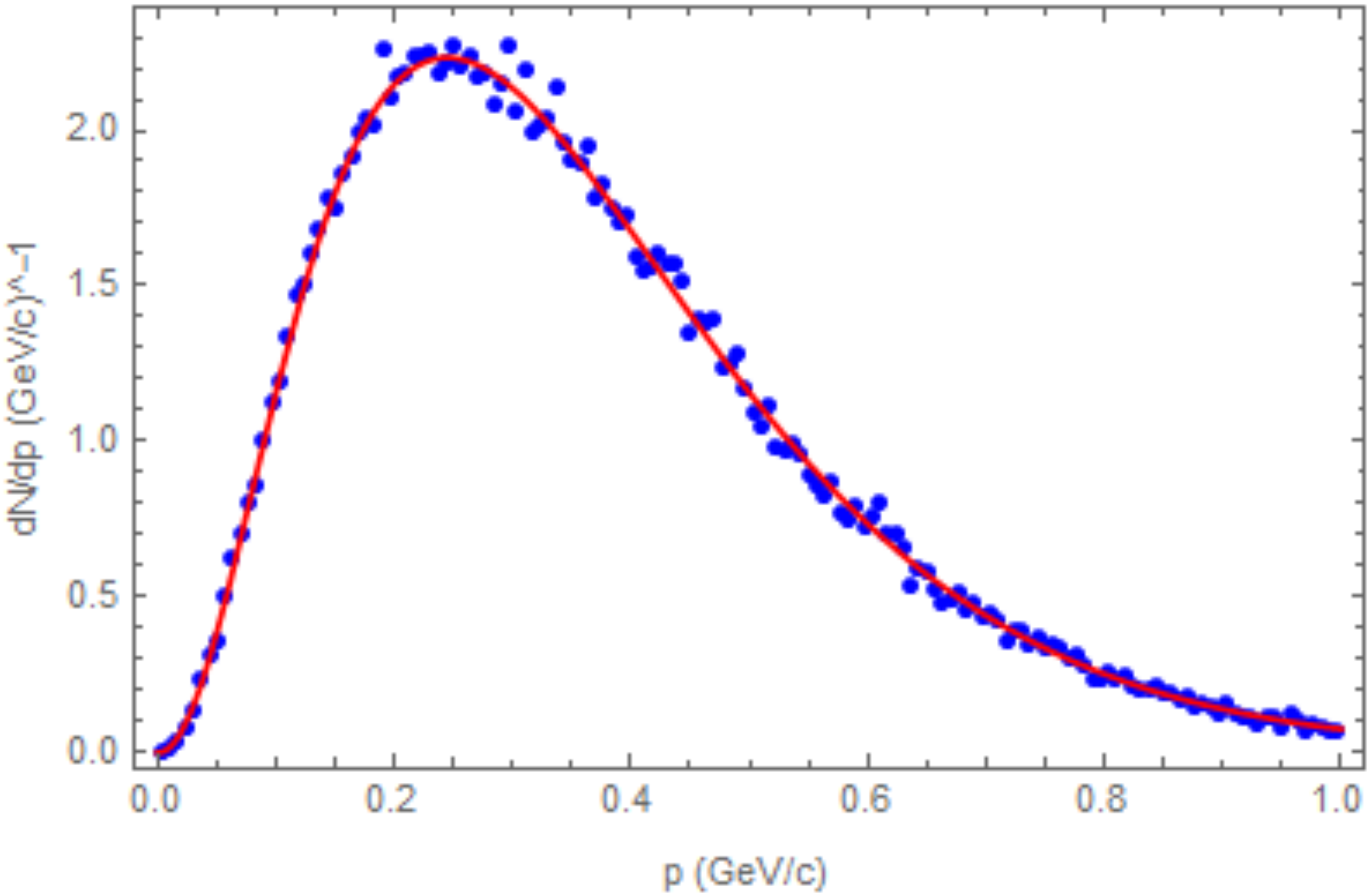
Cumulative Distribution Function

$$n=\int_0^p \frac{dn}{dp'}dp'$$



T=0.12 GeV, M=0.13 GeV, bosons

Simulation of a Pion Gas



T=0.12 GeV, M=0.13 GeV, N=100,000, bosons

Shortcomings

- Momentum not necessarily conserved
- Other conservation laws also ignored
- Error in conservation laws is O($\sqrt{N}$)
- Flow field and particle distribution not taken into account

Momentum Corrections

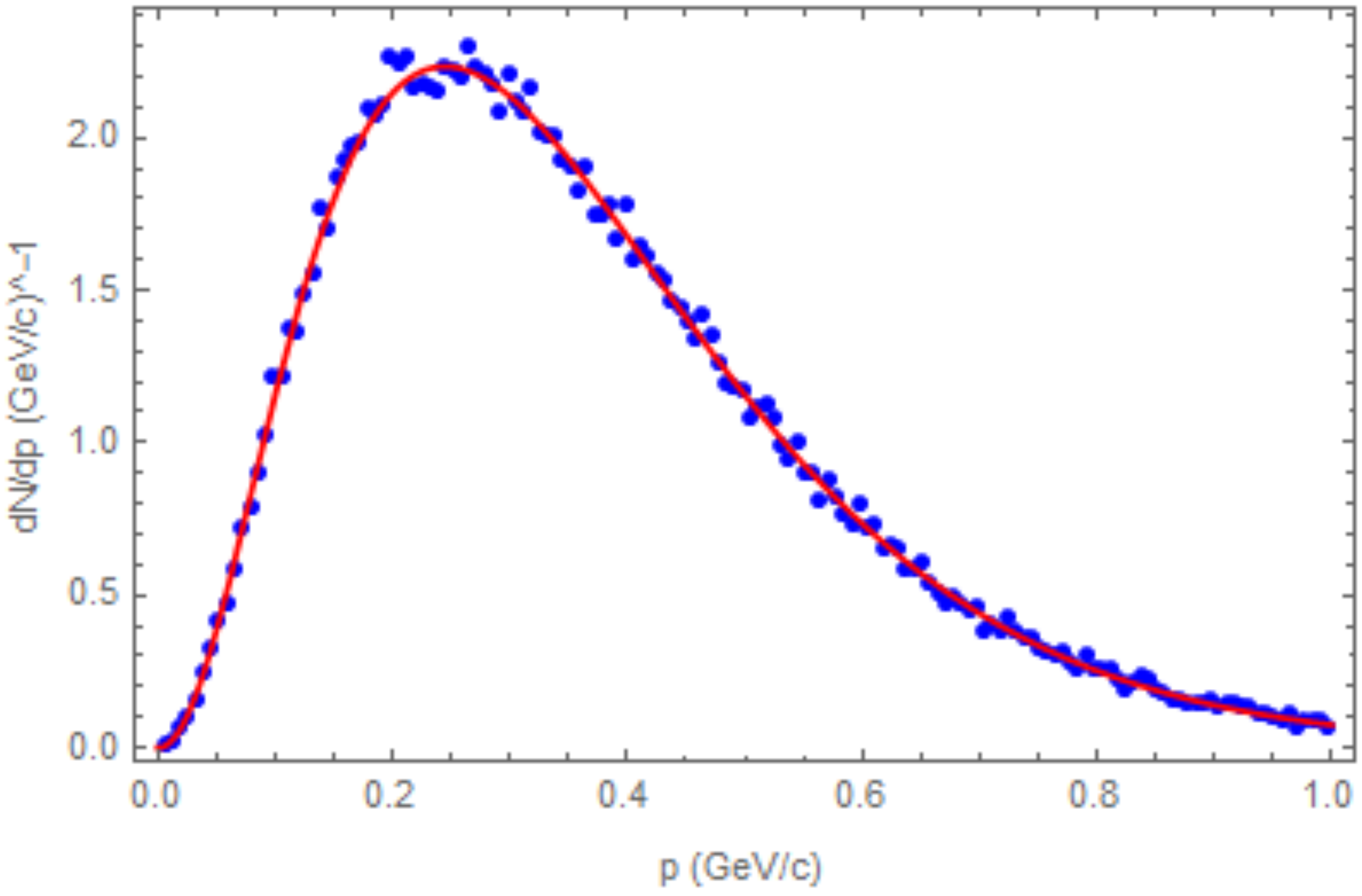
$$T_i = T\,\frac{N(N-(i-1)-1)}{(N-1)\big(N-(i-1)\big)}$$

$$\overrightarrow{p_i^{offset}} = -\overrightarrow{p_{i-1}^{net}} * \frac{1}{N-(i-1)}$$

Where p_{i-1}^{net} is the sum of all previous momenta

D. Molnar, Private Communication

Uniform Box

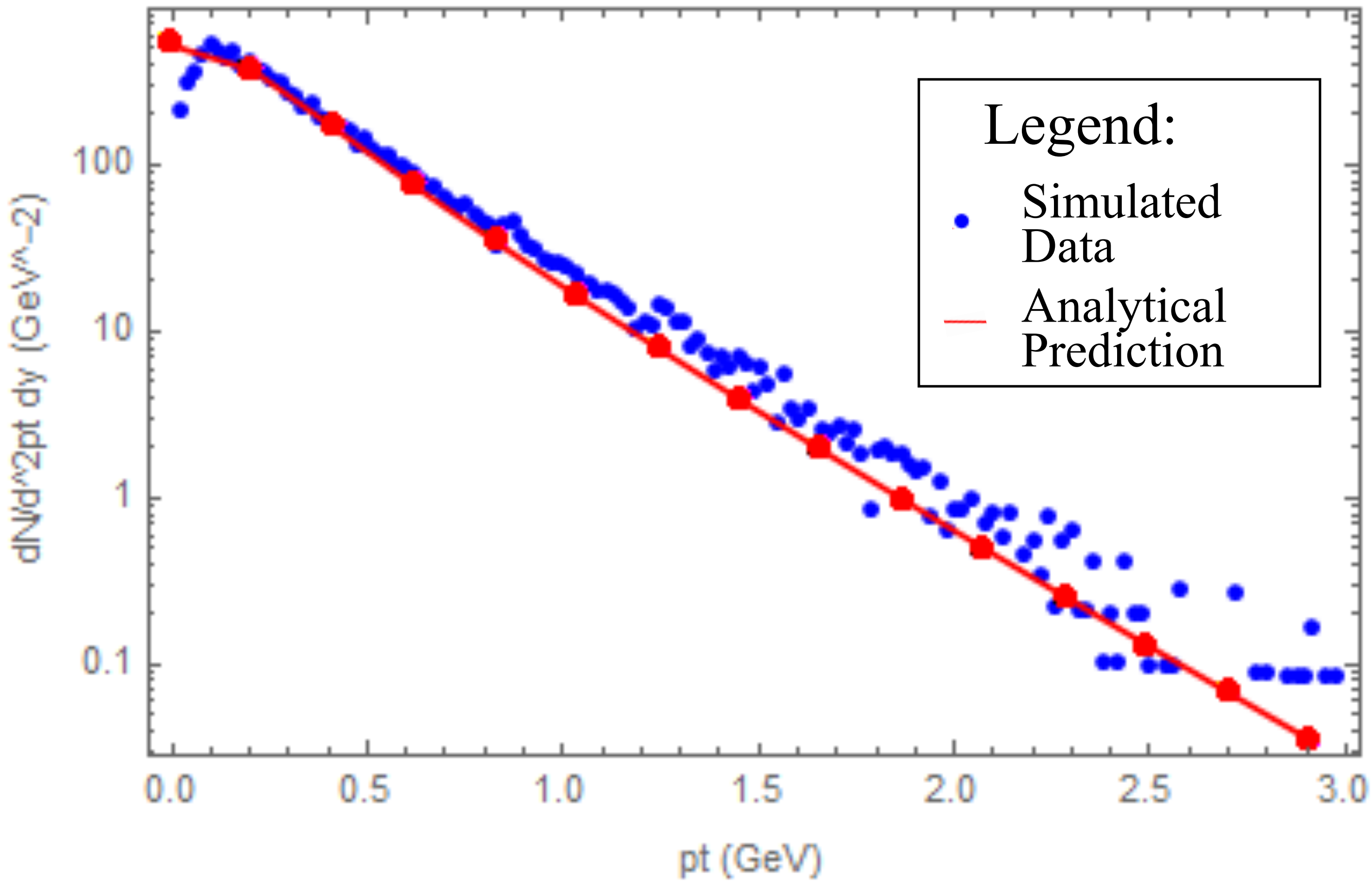


T=0.12 GeV, M=0.13 GeV, N=100,000, bosons

Cooper Frye Formula
(i.e. probability of having a particle in a given fluid cell)

$$< N_h^i > = \int \frac{d^3p}{E} \int \frac{p * d\sigma}{(2\pi)^3} \frac{\gamma_h}{e^{\frac{p*U}{T}} \pm 1}$$

Momentum Distribution Throughout Blast Wave



T=0.12 GeV, M=0.13 GeV, N=12,855, bosons, based on fireball data from a realistic simulation of a lead-lead collision

Future Developments

- Energy conservation
- Other conservation laws
- Multiple types of particles