Heavy flavor electron R_{AA} and v_2 in event-by-event relativistic hydrodynamics

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Introduction

In this work we investigate how event-by-event hydrodynamic fluctuations affect the nuclear suppression factor and elliptic flow of heavy flavor mesons and heavy-flavor electrons. Local temperature and flow profiles are computed using a 2D+1 Lagrangian ideal hydrodynamic code[1,2] on an event-by-event basis. We use a strong coupling inspired energy loss parametrization[3] on top of the evolving space-time energy density distributions to propagate the heavy quarks inside the medium until the freeze-out temperature is reached and hadronization (modeled using Phythia) takes place. The resulting D^0 and heavy-flavor electron yield, computed event by event[4], is compared with recent experimental data for R_{AA} and v_2 from the star and phenix collaborations[5–7]. We also present predictions for the higher order Fourier harmonic coefficients $v_3(p_T)$ of heavy-flavor electrons at rhic's $\sqrt{S_{NN}} = 200$ GeV collisions.

Simulation

The full simulation takes for granted the factorization on qcd in order to follow a modular paradigm. This allows one to replace part of the calculation without affecting the other ones and it can be useful in order to study different energy loss models for instance. We can therefore list the simulation modules as follows:

- Initial Conditions: based on Phobos Glauber Monte Carlo[8] and with normalization factor fixed by matching with the invariant yields of pions;
- Hydrodynamics: Smoothed Particle Hydrodynamics (sph) algorithm without viscosity (ideal)[1,2,9];
- Energy Loss Model: parametrized as $\frac{dE}{dx} = \alpha v \gamma(v) T^2$ with α factor fitted against experimental data[3,10];
- Fragmentation: Peterson Fragmentation Function;
- Decay: electron channels in Pythia8.

During the execution of the simulation it draws a quark from an initial energy density distribution with random φ direction, then it evolves by integrating the $\frac{dE}{dx}$ numerically and locally in the "medium frame". The final result of the simulation are quark, meson and electron p_T spectra we use to calculate the R_{AA}. We also obtain the φ distribution of quarks, mesons and electrons in order to calculate the collective flow harmonic coefficients.

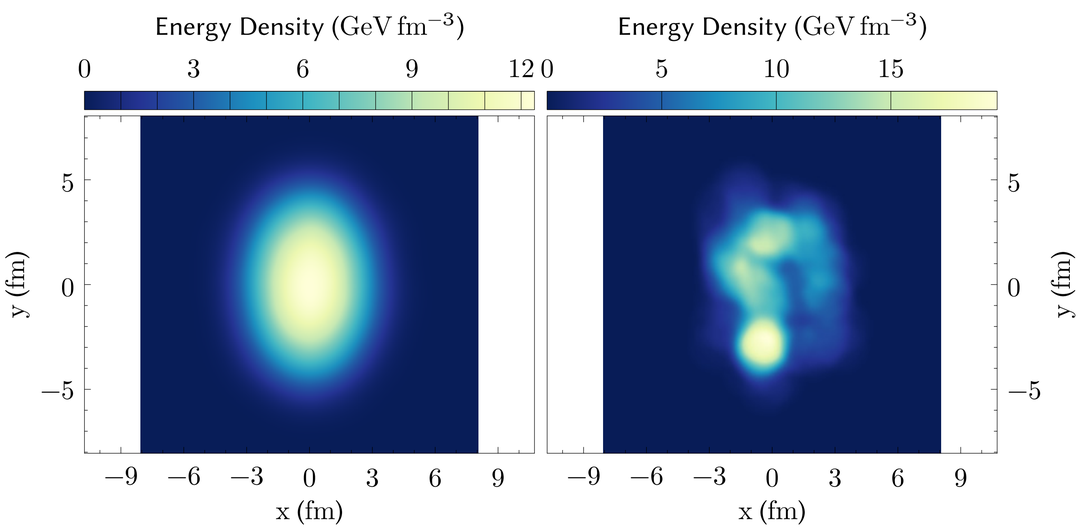

Figure 1: Fluctuating initial condition examples used during simulations, we show the average energy density for 1000 events (left) and the density for a single event (right).

The profiles presented in Figure 1 are examples of energy density distributions which are evolved during the simulation.

Results

We present some results from the simulation, Figure 2 shows two plots of electron spectra for different energies. Each plot compares the spectra with and without energy loss for both bottom and charm flavors. The ratio between them gives the nuclear modification factor.

The nuclear modification factor for central collisions is presented for different energies in Figures 3 and 4, after fitting the energy loss factor. We compare our results with experimental data and the plots show a good agreement between them, although at higher energies for Lhc it begins to fail.

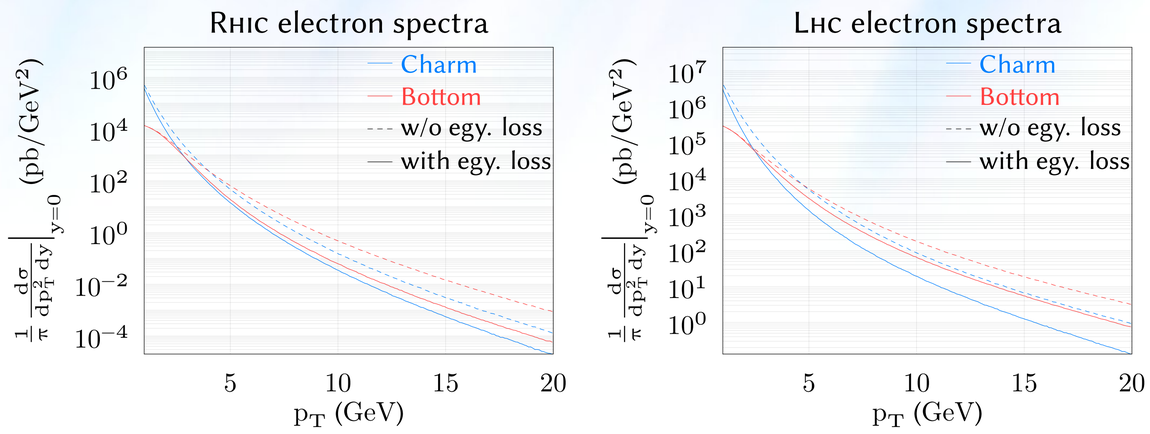

Figure 2: Electron spectra for Rhic ($\sqrt{S_{NN}} = 200$ GeV, left) and Lhc ($\sqrt{S_{NN}} = 2.76$ TeV, right) energies comparing charm and bottom flavors. The ratio of these spectra for each flavor is the nuclear modification factor.

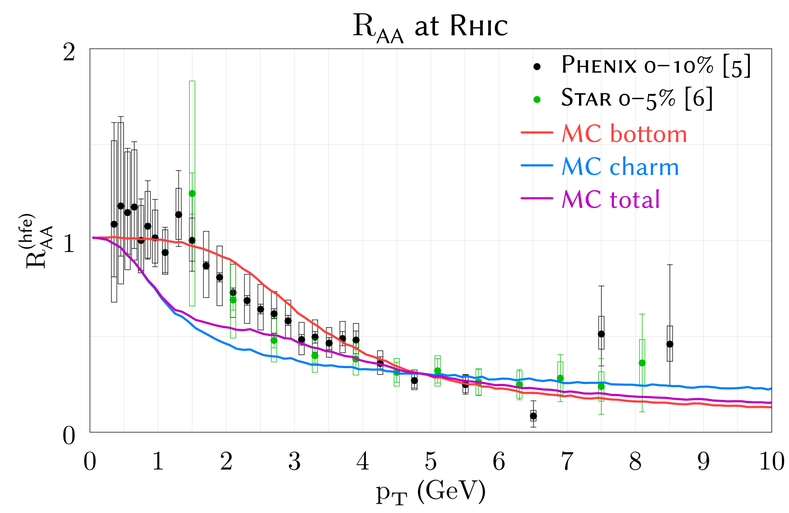

Figure 3: Electron nuclear modification factor for each quark flavor and the total one in comparison with experiment results for Rhic's energy $\sqrt{S_{NN}} = 200$ GeV.

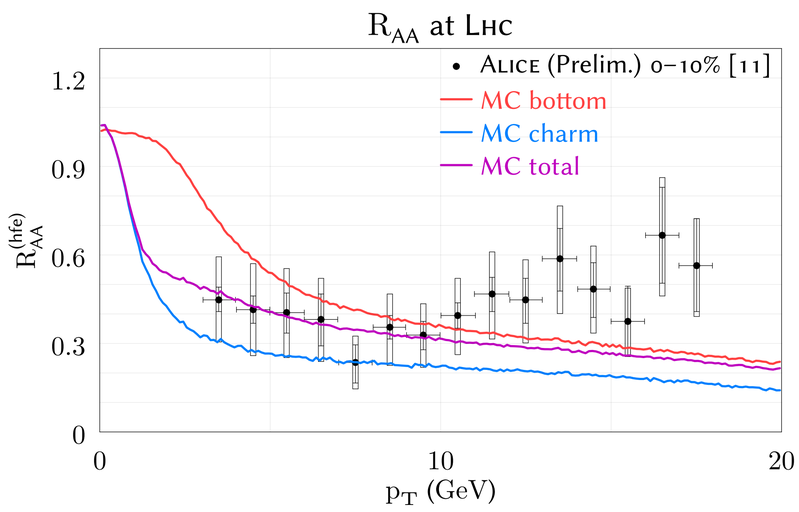

Figure 4: Electron nuclear modification factor for each quark flavor and the total one in comparison with experiment results for Lhc's energy $\sqrt{S_{NN}} = 2.76$ TeV.

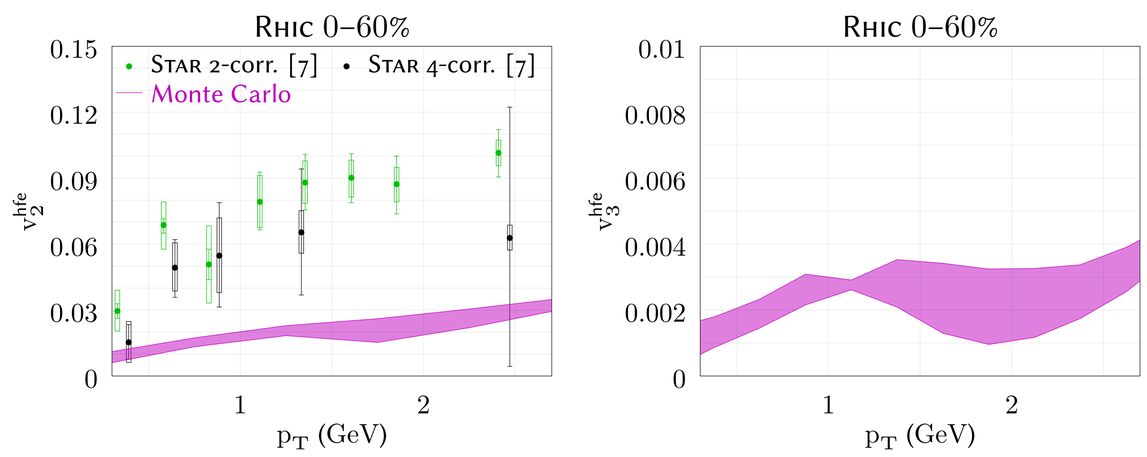

Figure 5: Calculation of electron v_2 (left) and v_3 (right) for Rhic energy.

Figure 5 shows the results for the harmonic coefficients v_2 and v_3 for minimum bias Rhic energy calculation. We calculate those coefficients by correlation function with pions in order to compare them with the presented experimental data from the Star experiment. The v_2 results is below the data, this fact could be related to the energy loss model or hydrodynamics. The right side of the figure shows non-zero v_3 values.

Conclusions

We performed simulations of the evolution of charm and bottom quarks inside an expanding plasma provided by Phobos Glauber Monte Carlo in order to study quark suppression and anisotropic flow. Although our R_{AA} spectra show good agreement with the experimental data, the same cannot be said about the v_2 results which was always below the data. We also presented some preliminary v_3 calculation which gave non-zero results.

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