Event-by-event jet quenching

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We have investigated the role of fluctuations and inhomogeneities on hard probes in nuclear collisions. Many jet quenching calculations in the past have used "averaged" events in which the density of the fireball is a smooth function of the coordinates. However, it has become increasingly clear that initial fluctuations of the positions of the nucleons inside the nuclei, and fluctuations of the nucleon-nucleon cross section can lead to very inhomogeneous fireballs. At the same time the position of the hard processes can be correlated in a non-trivial way with hot spots (i.e. local maxima of the density) in the fireball.

We have used our software package PPM to propagate quarks and gluons created in hard processes through the background fireball. Here we compared runs of PPM averaged over many individual events (i.e. spatial distributions of the fireball density and the distribution of hard processes) created with the Glauber event generator GLISSANDO [1], with runs using smooth events from an averaging of 500,000 GLISSANDO events. The latter resembles the current state-of-the-art in the field while the former is the more realistic scenario for comparison with data.

We have found that comparison of data on the nuclear modification factor R_{AA} to calculations from smooth fireballs leads to values of the quenching strength q which are above the real value. In the ASW energy loss model the error could be as large as 50%. If the size of fluctuations is taken to be a priori unknown this introduces a 50% uncertainty on the extraction of q from data. After adjusting q to fit event-by-event R_{AA} we arrive at a consistent picture in which both the momentum and centrality dependence of single hadron suppression data from the Relativistic Heavy Ion Collider (RHIC) can be described. We observe that residual deviation remains for both elliptic flow and di-hadron correlations, opening the possibility to distinguish different fluctuations strengths and therefore conduct something close to a true spatial tomography of the fireball. We have defined a correlation function $R(x,y)$ between fluctuations of hard processes and the surrounding fireball. Hard probes are sensitive to the integral of R taken along the trajectory of a hard probe. In principle R can be constrained from data and can provide tomographic information.

This project has been finished and results have been published in Physics Letters B [2]. Figure 1 shows a typical reslt for R_{AA}.
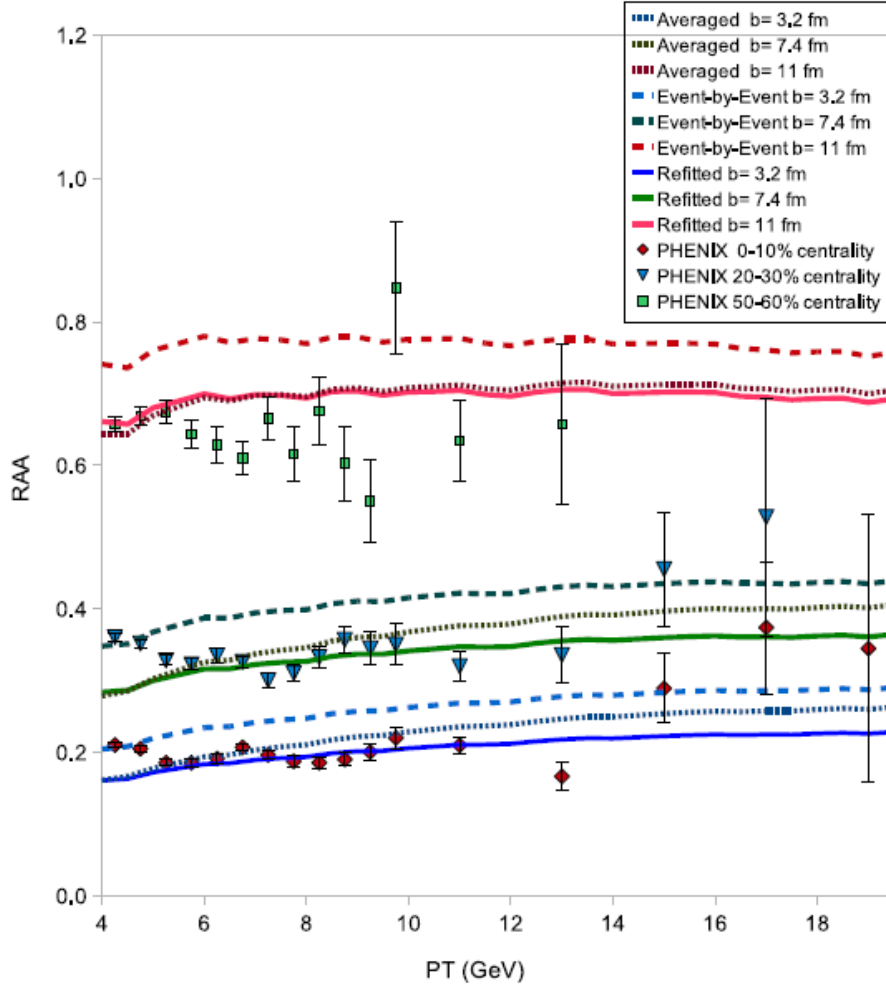
FIG. 1. R_{AA} at RHIC (data from the PHENIX experiment) calculated for 3 different centralities (or impact parameters) and with 3 different methods (averaged event, event-by-event with q as extracted from averaged event, event-by-event with q adjusted to fit R_{AA} data)

[1] W. Broniowski, M. Rybczynski, and P. Bozek, Comp. Phys. Comm. **180**, 69 (2009).

[2] R. Rodriguez, R.J. Fries, and E. Ramirez, Phys. Lett. B **693**, 108 (2010).