STAR Vertex Resolution with the Proposed Heavy Flavor Tracker

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Lattice QCD calculations predict a phase transition from normal nuclear matter to a deconfined state of quarks and gluons; current theory suggests that such a transition takes place at energy densities $\varepsilon_c = .8$ GeV/fm^3 [1]. Such energy densities can be reached by the RHIC collider, and current results suggest that the matter formed shows collective behavior at the parton level, rather than at a hadron level [2, 3]. The development of partonic collectivity, together with the degree of thermalization, are closely related to the Equation of State (EOS) of partonic matter. One possible indication of thermalization is the elliptic flow of charm quarks. If there is significant re-scattering in the medium, then the heavy charm quarks should develop flow reminiscent of the lighter flavor quarks. However, reconstruction of charm hadrons in AuAu collisions in STAR has a limited kinematic range. We propose a new tracking detector, positioned close to the collision vertex with excellent position accuracy to resolve the charm decay daughters from the primary interaction tracks [4].

The proposed HFT will need to distinguish between the daughter tracks of the charm decays from the tracks originating from the primary interactions between constituents of the beam ions. To do so requires reconstruction of the position of the decay from the reconstructed daughter tracks. To successfully separate the secondary vertex from the primary vertex, the resolution of both the reconstructed secondary vertex and the primary vertex are critical.

Also, in the prototype configuration, there will be a long extrapolation arm between the previous tracking layer in STAR and the HFT. The track resolution in this configuation will be broad enough that there will be significant ambiguities between candidate clusters on the HFT layer. We have investigated the use of a vertex constraint to help constrain the track and improve the track resolution at the HFT.

The impact of the HFT on the resolution of the reconstructed tracks has been discussed previously. We have investigated the impact on the primary vertex reconstruction.

We have used an iterative approach to identify and reconstruct the primary vertex. We use the vertex found through the TPC and SSD alone both for the vertex constraint to identify correct HFT hits, and as a seed for a new primary vertex. First, we find the distribution of the distance of closest approach between the TPC+SSD+HFT tracks and the current vertex in the three cardinal directions. These distributions have a peak which is off set from zero, indicating that the vertex position needs to be corrected. The mean of the distributions themselves can be used as this correction, and when applied the DCA distribution re-calculated. Such an iterative approach quickly settles on an improved primary vertex. The resolution of this new vertex is found by applying this algorithm to Monte Carlo simulations, and comparing the reconstructed vertex to the original Monte Carlo vertex position. The resulting resolution has the functional form:

$$\sigma = \frac{380\mu m}{\sqrt{N_{ch}}}$$

The vertex reconstruction resolution in STAR will improve by over an order of magnitude over the full range of multiplicity (see 1). This significant improvement will enable the resolution of charm hadron daughter tracks from the primary track background. This study is the first implementation of the vertex reconstruction with the full, detailed simulation of the STAR detector and environment.

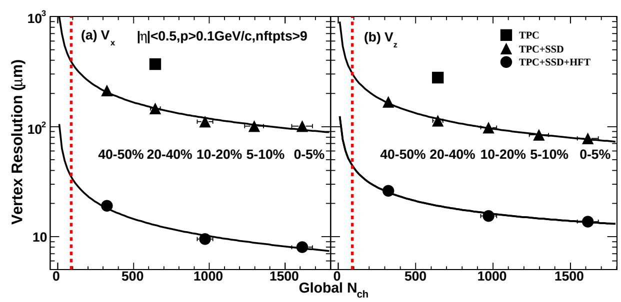

FIG. 1: The resolution of the reconstructed vertex in the STAR experiment. The current vertex resolution (TPC only, black square) is shown together with the anticipated vertex resolution when the SSD data is used in tracking (triangles). The proposed HFT will dramatically improve the vertex resolution (circles).

[1] F. Karsch, hep-ph/0103314 (2001)

[2] K. H. Ackermann *et al*, Phys. Rev. Lett. **86**, 402 (2001)

[3] J. Adams *et al*, Phys. Rev. Lett. **95**, 122301 (2005)

[4] Z. Xu *et al*, Preprint LBLN-PUB-5509, Lawrence Berkeley National Laboratory (2006)