Charged Hadron Suppression at High $p_T$ in AuAu Collisions at 200 GeV

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Motivation

The suppression of single hadrons still provides one of the strongest constraints on energy loss mechanisms in the Quark-Gluon Plasma. At RHIC, neutral pions have provided the best measurement of single particle suppression to date. Charged hadrons have independent sources of systematic uncertainty and can thus provide additional constraints. At PHENIX, the measurement of charged hadrons has been limited to $p_T < 10$ GeV/c by off-vertex background from photon conversions and weak decays mimicking high $p_T$ particles. The silicon vertex tracker upgrade (VTX) is used to reject this background allowing the measurement of the charged hadron spectrum out to a significantly higher momentum.

Background Limitations

- Conversions and weak decay products can mimic high $p_T$ particles
- Since momentum is calculated by projecting tracks from the drift chamber back to the collision vertex, it will be miscalculated for tracks not originating from the vertex
- For example, a photon originating from an heavy ion collision could convert into an $e^+e^-$ pair on the entrance window of the drift chamber (Fig. 1)
- Weakly decaying particles may also decay before reaching the drift chamber and be assigned an incorrect momentum
- These background tracks can be rejected by the silicon vertex tracking detector

The silicon vertex tracker (VTX)

- Consists of four layers of micropattern silicon tracking detectors close to the beam pipe
- Provides precision tracking near the collision vertex
- Drift chamber tracks are matched to hits in the VTX
- Much of the background from conversions and weak decays can be rejected by requiring that tracks have 4 associated hits in the VTX
- Further background can be rejected by requiring a small distance of closest approach (DCA)
- DCA is calculated by projecting a track back to the collision vertex and measuring the smallest distance between the vertex and the track
- Real particles originating from the collision are expected to have Gaussian distributed DCA centered around the origin with a sigma of approximately the VTX resolution of ~ 70 microns

A Priori Background Estimate

- The amount of background remaining after associating with VTX hits and cutting on DCA can be estimated a priori by taking into account the effects of occupancy and multiple scattering on the tracking algorithm
- The probability of associating an off-vertex drift chamber track with random hits or random tracks in the VTX is very small compared to the number of real tracks

$p_T$ Spectrum

- The uncorrected $p_T$ spectrum is calculated by integrating the Gaussian peak of the DCA distributions in each $p_T$ bin
- Background tracks are expected to have a randomly distributed or flat measured $p_T$ distribution
- Without matching in the VTX, the flat background spectrum seems to dominate after 6 GeV/c (Blue curve in figure 5)
- The spectrum of real tracks matched to the VTX extends to $p_T > 20$ GeV/c

Conclusions

Most of the background limiting the measurement of charged hadrons in PHENIX is from tracks which do not originate from the collision vertex. Using the VTX detector we can eliminate much of this background. Estimating the number of remaining background particles which do not originate from the collision vertex, but are still accidentally matched to hits in the VTX indicates that the number of such particles is very low, compared to the number of real tracks.

Figure 1: The PHENIX detector as configured in 2011. A signal particle is pictured on the right. The drift chamber measures additional constraints. At PHENIX, the measurement of charged hadrons has been limited to $p_T < 10$ GeV/c by off-vertex background from photon conversions and weak decays mimicking high $p_T$ particles. The silicon vertex tracker upgrade (VTX) is used to reject this background allowing the measurement of the charged hadron spectrum out to a significantly higher momentum.

Figure 2: Charge $\times$ Distance of closest approach (DCA) in the transverse plane after tracks with a large DCA in the longitudinal direction have been subtracted for $7 < p_T < 8$ GeV/c. Final DCA is fit to a Gaussian and integrated over $\pm 2$ sigma.

Figure 3: Charge $\times$ DCA in x-y Plane after Background Subtraction at 16x16x16 DCA in x-y Plane after Background Subtraction at 7x7x7

Figure 4: The probability of associating an off-vertex drift chamber track with random hits or random tracks in the VTX is measured. The uncorrected yield after DCA analysis is shown in blue. Without matching in the VTX, the flat background spectrum seems to dominate after 6 GeV/c (Blue curve in figure 5)

Figure 5: A Priori Background Estimate. The spectrum obtained without matching in the VTX is shown in blue. In red, the spectrum of tracks with associated hits in the VTX and with a low DCA is shown.

Figure 6: Comparison of measured signal and estimated background rates for tracks with both 3 and 4 hits in the VTX.

Figure 7: The PHENIX detector as configured in 2011. A signal particle is pictured on the right. The drift chamber measures additional constraints. At PHENIX, the measurement of charged hadrons has been limited to $p_T < 10$ GeV/c by off-vertex background from photon conversions and weak decays mimicking high $p_T$ particles. The silicon vertex tracker upgrade (VTX) is used to reject this background allowing the measurement of the charged hadron spectrum out to a significantly higher momentum.