Rencontre de Moriond, QCD and Hadronic Interactions, La Thuile (Italy), March 8–15, 2008
Oral

Where Feynman, Field and Fox failed and how we fixed it at RHIC

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Hard-scattering of point-like constituents (or partons) in p-p collisions was discovered at the CERN-ISR in 1972 by measurements utilizing inclusive single or pairs of hadrons with large transverse momentum (p_T). Due to the steeply falling power-law p_T spectrum of the hard-scattered partons, the inclusive single particle (e.g. π^0) p_{T_t} spectrum from jet fragmentation of a parton with $\hat{p}_{T_t}$ is dominated by trigger fragments with large $\langle z_t \rangle \sim 0.7-0.8$, where $z_t = p_{T_t}/\hat{p}_{T_t}$ is the fragmentation variable. It was generally assumed, following Feynman, Field and Fox [1], as shown by data from the CERN-ISR experiments, that the p_{T_a} distribution of away side hadrons from a single particle trigger [with p_{T_t}], corrected for $\langle z_t \rangle$, would be the same as that from a jet-trigger and follow the same fragmentation function as observed in e^+e^- or DIS. PHENIX [2] attempted to measure the fragmentation function from the away side $x_E \sim p_{T_a}/p_{T_t}$ distribution of charged particles triggered by a π^0 in p-p collisions and showed by explicit calculation that the x_E distribution is actually quite insensitive to the fragmentation function. A new formula for the distribution of an associated away-side particle with transverse momentum p_{T_a}, which is presumed to be a fragment of an away-jet with $\hat{p}_{T_a}$, with exponential fragmentation function $D(z) = Be^{-bz}$, triggered by a particle with transverse momentum p_{T_t}, presumably from a trigger-side jet with $\hat{p}_{T_t}$, invariant cross section, $Ed^3\sigma/dp^3 = A\hat{p}_{T_t}^{-n}$, was given [2]: $dP_{p_{T_a}}/dx_E|_{p_{T_t}} \approx \frac{\langle m \rangle}{\hat{x}_h} \frac{(n-1)}{(1+x_E/\hat{x}_h)^n}$, which relates x_E, the ratio of the transverse momenta of the measured particles, to $\hat{x}_h = \hat{p}_{T_a}/\hat{p}_{T_t}$, the ratio of the transverse momenta of the away-side to trigger-side jets, where $\langle m \rangle$ is the mean multiplicity of particles in the away jet. Many analyses of the away-jet p_{T_a} distributions in Au+Au collisions are available; but these tend to describe the effect of the medium with the variable $I_{AA}(x_E)$, the ratio of the x_E distribution in A+A collisions to that in p-p collisions, which typically shows an enhancement at low values of x_E and a suppression at higher values of x_E. Such behavior could be explained as a decrease in $\hat{x}_h$ in A+A collisions due to energy loss of the away jet in the medium. Fits of the above formula to the available data will be presented to establish whether: a) the away-jets simply lose energy; b) some of the away-jets lose energy, others punch-through without losing energy; etc.

References

[1] R. P. Feynman, R. D. Field, and G. C. Fox, Nucl. Phys. B **128** (1977) 1–65.
[2] S. S. Adler, et al., PHENIX Collaboration, Phys. Rev. D **74** (2006) 072002.