Shadowing Effects on Vector Boson Production*

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The Z^0 was suggested as a reference process for quarkonium suppression at the LHC. There are two difficulties with using the Z^0 as a baseline for quarkonium suppression: the large mass differences, $m_{Z^0} \gg m_\Upsilon, m_{J/\psi}$, and the difference in production mechanisms, predominantly $q\overline{q}$ for the Z^0 and gg for quarkonium. Both these differences are important as far as nuclear effects are concerned. However, the differences that reduce the value of the Z^0 as a baseline process are the same that make it an interesting object of study itself—the Z^0 provides a unique opportunity to study the modifications of the quark distributions in the nucleus at high Q^2.

The electroweak production and decay channels of the massive vector bosons make them excellent candidates for shadowing studies since no hadronic final-state rescattering is possible. The Z^0 itself, with a 3.37% branching ratio to lepton pairs, will be easily observable by reconstructing the peak. Full reconstruction of the leptonic $W^\pm$ decays, $W^\pm \to l^\pm \nu$, is not possible due to the missing energy given to the undetected neutrino but charged leptons with momenta greater than 40 GeV should be prominent. This decay channel has been used at the Tevatron to measure the asymmetry between W^+ and W^- production since this asymmetry is sensitive to the down to up quark ratio in the proton at intermediate values of x and high Q^2. If the charged leptons from $W^\pm$ decays can be identified in heavy ion collisions, such asymmetry measurements may also be employed at the LHC to reduce systematics and obtain a more meaningful determination of the Q^2 dependence of quark shadowing in the nucleus.

We calculate the total Z^0, W^+ and W^- cross sections in Pb+Pb collisions at $\sqrt{s} = 5.5A$TeV in the CMS and ALICE central acceptances, $|y| < 2.4$ and $|y| < 1$ respectively. The cross sections are larger than the virtual photon mediated Drell-Yan cross sections at lower masses [1]. We also calculate the expected rate in nucleus-nucleus collisions at $b = 0$ in a one month LHC run. Including the 3.37% lepton pair branching for Z^0 decays reduces the number produced with no shadowingto 2450 in CMS and 990 in ALICE. The 10% lepton branching ratio for W^+ and W^- leaves nearly 10^4 observable decays in CMS and 4000 in ALICE.

Once the basic nuclear shadowing effects on vector boson production have been understood, they can perhaps be used to study other medium effects in heavy ion collisions by comparing the leptonic and hadronic decay channels. The hadronic decays of the vector bosons, $\sim 70\%$ of all decays of each boson, may be more difficult to interpret. While the width of the Z^0 decay to l^+l^- is not expected to be modified in the quark-gluon plasma due to their weak coupling, the Z^0 has a 2.49 GeV total width and will decay in any quark-gluon plasma to two jets through $Z^0 \to q\overline{q} \to$ jet + jet in ~ 0.1 fm. Therefore, the decay jets could be modified in the medium which may still be progressing toward thermalization and will be subject to rescattering and jet quenching. Thus a comparison of a reconstructed Z^0 in the dilepton channel where no nuclear effects are expected and medium-modified jets should result in a broader width for the $q\overline{q}$ channel than the l^+l^- channel. In addition, the Z^0 could be used to tag jets through the $q\overline{q} \to Z^0 g$ and $gq \to Z^0 q$ channels to study jet properties in the quark-gluon plasma.

[1] V. Emel'yanov, A. Khodinov, S.R. Klein and R. Vogt, Phys. Rev. **C61**, 044904 (2000).

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