Chapter 6
Conclusion

The measurement of the gluon polarization in small Bjorken x is essential to determine the total gluon polarization $G(\mu)$. Previously, achievable Bjorken x was limited up to the minimum of $2 \times 10^{-2} \lesssim x$ due to a minimum p_T required from pQCD calculations. To extend the Bjorken x region, this double-spin asymmetry of the heavy flavor electron production is an ideal probe because enough energy scale in this production is guaranteed due to the large mass of the heavy quarks. In this work, we firstly measured the double-spin asymmetry in the PHENIX experiment at RHIC (BNL) using $\sqrt{s} = 200\,\mathrm{GeV}$ $p + p$ collisions, and obtained the constrain of the gluon polarization in the small Bjorken x region from the measured asymmetry.

The measurement of the heavy flavor electron production suffered large background of photonic electrons and K_{e3} decay electrons. In this work, we succeeded to significantly suppress the photonic background with the new detector, HBD, and improved the signal purity by a factor of $\sim$1.5 around $0.75 \lesssim p_T \lesssim 2.00$ GeV/c. Especially, the HBD also efficiently reduces the K_{e3} decay electrons by a factor of $\sim$0.4, because the HBD requires the position of the K_{e3} decay to be close to the beam vertex, $R < 20\,\mathrm{cm}$. The double-spin asymmetry of the K production is not well known, and therefore the reduction of the K_{e3} decay electrons is important to reduce uncertainty of the spin asymmetry of heavy flavor electrons. We also succeeded to confirm the reliability of the new analysis method using the HBD by comparing the obtained cross section of the heavy flavor electron with the previous result.

We have reported on the first measurement of the longitudinal double-spin asymmetry of heavy flavor electrons, which are consistent with zero. Using this result, we obtained a constraint of $|\Delta g/g(\log_{10} x = -1.6^{+0.5}_{-0.4}, \mu = m_T^c)|^2 < 3.0 \times 10^{-2}$ (1σ). The result covers unexplored Bjorken x region in other $\Delta g(x, \mu)$ measurements and gives comparable constraint compared with results from SIDIS experiments. This constraint is consistent with the existing theoretical expectations with GRSV and DSSV.

With improved statistics and polarization, the helicity asymmetry of heavy flavor electron production can provide more significant constraints on the gluon polarization, and complement other measurements of $\Delta G(\mu)$. In addition, A_{LL} measurements at higher energy collisions at the PHENIX mid-rapidity and forward-rapidity regions will also help to constraint $\Delta g(x)$ at small x region.

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