Neutral pion double helicity asymmetry†

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A major goal of the RHIC Spin program is to determine the gluon spin distribution in the proton. The quark spin contribution to the proton spin ($\Delta\Sigma$) is only about 25%[1], and so the remaining spin must be carried by the gluon spin (ΔG), or by the gluon and quark orbital angular momentum (L_q and L_g, respectively):

$$S_p = \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_q + L_g \quad (1)$$

written in units of $\hbar$.

At RHIC, ΔG can be probed directly through measurements of the double helicity asymmetry in polarized $p+p$ collisions, in this case for neutral pions:

$$A_{LL} = \frac{1}{P_B P_Y}\frac{N_{++} - RN_{+-}}{N_{++} + RN_{+-}} \quad (2)$$

where P_B and P_Y are the polarizations of the two proton rings at RHIC, N is the yield of neutral pions, π^0, $++$ and $+-$ indicate same and opposite helicity combinations of the two beam helicities, and R is the relative luminosity, defined as $R = L_{++}/L+-$, which is required to normalize differences in the luminosity L between RHIC proton bunches.

In 2009, RHIC PHENIX recorded 14 pb^{-1} with an average polarization of 56%. The π^0 A_{LL} was measured, and found to be consistent with previous results. The combined results from 2005[2], 2006[3] and 2009[4] are plotted in Fig. 1. The systematic uncertainty from relative luminosity in 2009 was larger than in previous years, and for the lowest π^0 transverse momentum, p_T, was larger than the statistical uncertainties.

The combined data set are shown in Fig. 1 and Fig. 2 compared to several theoretical expectations based on fits to the world polarized scattering data. In the case of[1], the RHIC 2005 and 2006 π^0 data are also included. In fits that do not use RHIC data, such as GRSV[5], LSS[6] and BB[7], there is large uncertainty in ΔG and therefore in the expected π^0 A_{LL}. Fits including some RHIC data, such as DSSV[1] and NNPDF[8] find a smaller range of possible ΔG. These data therefore offer significant constraint on ΔG. Recently, the RHIC 2009 data have been included in an updated version of DSSV[9], and indicate that the gluon spin contribution to the proton spin is about the same size as that of the quarks.

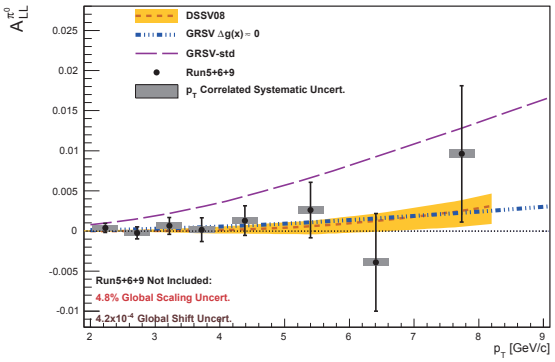

Fig. 1. Results for π^0 A_{LL} vs. p_T from the combined 2005, 2006 and 2009 PHENIX data sets. The data are compared with several theoretical expectations.

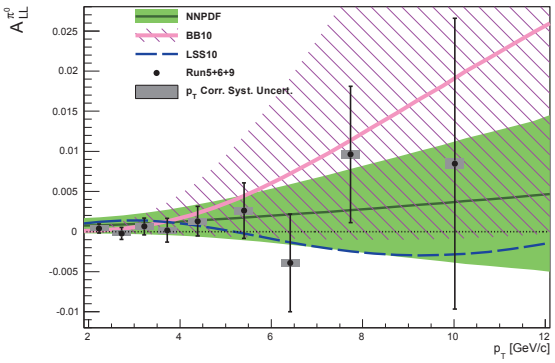

Fig. 2. Results for π^0 A_{LL} vs. p_T from the combined 2005, 2006 and 2009 PHENIX data sets. The data are compared with several theoretical expectations.

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